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WP5 Measures

Basic analysis reports

Measure nr° 21. Walsoorden pilot part B (2006): relocation of dredged sediment to a shallow water area at the edge of the Walsoorden sandbar

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- Measure Category: Biology/Ecology
- Estuary: Scheldt
- Salinity zone: Polyhaline
- Pressure: Gross change in morphology and hydrographic regime
- Status: Implemented (in 2006-2007)
- River km: TIDE-km 120
- Country: the Netherlands
- Specific location: Western Scheldt, seaward of the Walsoorden sandbar
- Responsible authority: Flemish government, Department of Mobility and Public Works (MOW), Maritime Access Division
- Costs: /
- Cost category: 1,000,000 – 5,000,000 €

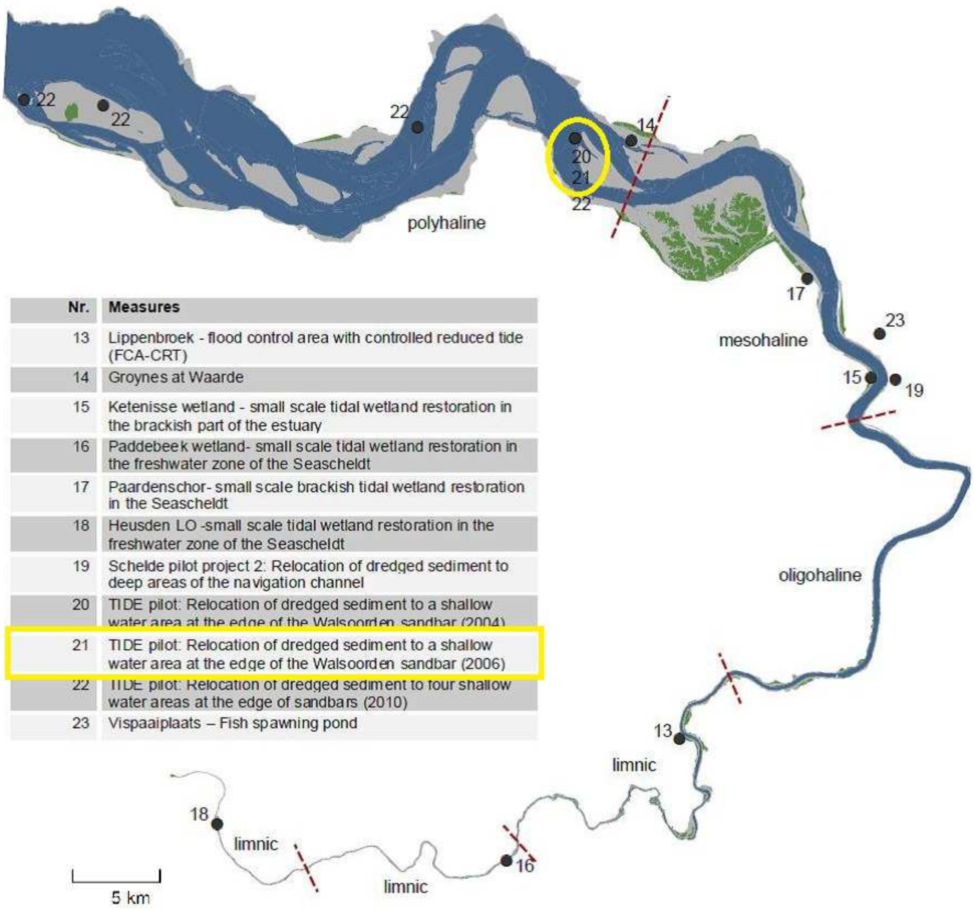

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Figure 1. Location of the Walsoorden sandbar

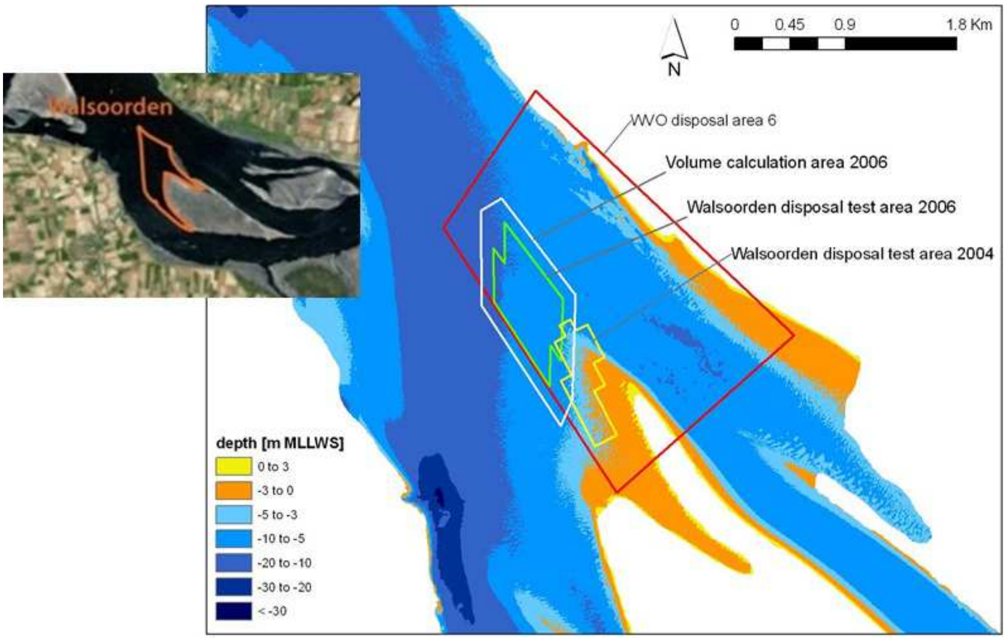


Figure 2. Relation area at the Walsoorden sandbar, test site 2006 (Vos et al. 2009).

1.1 Measure description

This project fits in with "The Long Term Vision 2030 (LTV) for the Scheldt estuary" which presents a view on the preferred functioning of the system, accepted by both the Dutch and the Flemish government. One of the main questions considered in the LTV was where to relocate the large volumes needed for further deepening and widening of the navigation route, respecting the preservation of the estuary's physical system characteristics. An international expert team proposed that strategic relocation of dredged sediment could fit in a proactive morphological management strategy as an instrument to improve the morphology of the Western Scheldt, for instance by steering the development of channels and shoals. As a pilot project to test this strategy, the expert team proposed to relocate sediment at the eroded tip of the Walsoorden sandbar.

The Walsoorden small-scale in-situ relocation test 2006 was a follow-up of the first, and successful, small-scale in-situ relocation test of 2004. The 2006 test was different in that way that another relocation technique was studied: traditional "clapping" technique (instead of the diffuser). The diffuser has the advantage to allow a very precise relocation, the clapping technique on the other hand can realise a higher time-efficiency in execution, using the flood current to transport the material towards the sandbar.

The traditional dumping or "clapping" technique involves the hopper of the dredging vessel being opened so that the material can sink to the bottom (Figure 3). Compared to the 2004 test with the diffuser technique, another relocation location had to be chosen further away from the sandbar because the draught of the dredging vessel is greater than that of the pontoon. The new area was not only much deeper but also characterised by higher dynamics, both hydrodynamic (currents) as morphodynamic (sediment transports).

The 2006 relocation test occurred in two phases: relocation of 500,000 m³ in the first phase (phase A: January – March 2006) and another 900,000 m³ in the second phase (phase B:

September 2006 – March 2007). These relocations were carried out within continuous maintenance dredging works in the Western Scheldt. Therefore a larger spreading in time is found for this test compared to the test of 2004, where the relocations were concentrated in time.

The morphological target was again to test the stability of the relocated material (including the wanted transportation of the relocated material towards the sandbar). The relocation test was however again small-scale (1,400,000 m³) and set-up as a research project. The ecological monitoring was executed in order to detect possible effects of the relocation test on the local ecology.

Figure 3. A few photographs of the trailing suction hopper dredger Jade River: trailing suction hopper dredger Jade River (above left), detail of the suction head (below left), and detail of the hopper (right) (Vos et al. 2009)

1.2 Monitoring

The extensive morphological and ecological monitoring program that was started at the beginning of the first relocation test (2004) was continued in time. The same criteria to evaluate the relocation test were incorporated from the first test, both morphologically (a new control area was defined to evaluate the stability of the relocated material) as ecologically. The topobathymetric surveys were continued using the **multibeam echo sounder technique** at a regular basis (weekly soundings in a smaller area around the relocation area and monthly soundings in a larger area around the relocation area). These surveys allowed volume computations for the control area. Additionally, the altitude of the Walsoorden sandbar was measured twice from an airplane (**LIDAR technique**). Sediment transport was also monitored with a measurement campaign (before, during and after the relocation test), as well as with a sediment tracing test after the relocation. The ecological monitoring program, with both subtidal and intertidal monitoring, of the first pilot study (2004) was continued considering both the first and the second relocation area as an impact zone (Figure 4: I1 and I2). A new control area was defined with similar hydrodynamic characteristics as the relocation areas (zone C1). Important aspects that were studied are related to the consistency of the soil (grain size and mud-percentage) and macrobenthos colonisation (biomass, diversity and density). To observe the developments of the Walsoorden sandbar as a whole, a flight was executed while using remote sensing and hyperspectral analysis. The goal of this extensive ecological monitoring program was to see whether the in situ relocation test caused a significant effect on all measured parameters, thus affecting the local ecology.

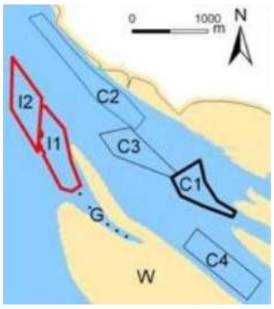


Figure 4. Study area: impact areas (I1 for relocation 2004; I2 for relocation 2006), control areas (C1-4), Walsoorden sandbar (W) and washout channel (G).

1.3 Monitoring results

Table 1. Overview of morphological and ecological criteria of the relocation test and the observed effects (Vos et al. 2009)

Predefined criteria	**Observed effects**
1. Morphological criteria	
1.1 Stability of the relocated material. Maximum 20% of the total relocated quantity may have left the relocation site 2 weeks after completion of the relocation test. Between 20 and 40% of the material may disappear from the relocation site, if extreme conditions have led to this. Over 40% loss of material will be regarded as a failure of the test.	Two weeks after the end of relocation phase A, there is evidence of a limited material decrease (+0.5%), two weeks after relocation phase B no measurements were conducted but around 2 months after the relocation test, around 15% of the material had disappeared. After 2 weeks, therefore, less than 20% had disappeared. Figure 6
1.2 Sedimentation of Schaar van Valkenisse. Maximum 15% of the transverse profile of the Schaar van Valkenisse (at the location of the bar that now lies at the head of the Schaar) may have been occupied by sand 2 weeks after the completion of the relocation test.	Two weeks after the end of relocation phase A, there is a limited decrease (-2.8% and -1.1% respectively) of the transverse profile for the 2 selected transverse sections. Two months after relocation phase B, there is a decrease of -7.1% and -5.2% respectively. This is, however, attributable to the targeted relocations that took place during the same period in the Schaar van Waarde.
2. Ecological criteria	
2.1 Height increases on the Walsoorden sandbar. On 25% of the sandbar more than 4 cm, on 50% of the sandbar more than 2 cm or on 100% of the sandbar more than 1 cm will be regarded as a problem.	Fixed point measurements indicated that the western edge of the sandbar was undergoing a reduction in height of 3.3 to 3.6 cm/year; the central part of the sandbar is increasing at a rate of 2.5 cm/year. This trend is also clear from the MOVE measurements.
2.2 Changes to percentage of inter-tidal mud. On 50% of the sandbar more than 40% change in the mud level or on 100% of the	The granular analyses from samples taken on the sandbar indicate that there is no significant deviation as a result of the relocation test. Seasonal deviations in

sandbar more than 20% change in the mud level will be regarded as a problem.	the mud level were clear from the measurements.
2.3 Changes in inter-tidal macrobenthos. The density, biomass and diversity of the inter-tidal macrobenthos may not deviate from the long-term trends.	No significant deviations of the inter-tidal macrobenthos were observed as a result of the relocation test. A shift towards a lower dynamic environment was observed but this was also the case in the control zone and cannot, therefore, be attributed to the relocation test.

(1) Morphological analysis

1.1 Morphological evolution relocation area (criterium 1)

The stability of the relocation test does fulfil the criteria: less than 20% of the total relocated quantity had left the relocation site two weeks after completion of the relocation test. Two weeks after the end of relocation phase A, there is evidence of a limited material decrease (-0.5%). Two weeks after relocation phase B no measurements were conducted but around 2 months after the relocation test, around 15% of the material had disappeared. The transportation of material out of the polygon is oriented towards the sandbar (Figure 5 & Figure 6) which was also the purpose of the relocation at a deeper and more dynamic area further from the sandbar. The larger depth was necessary for the trailing suction hoppers dredger and the relocation area was therefore also located further from the sandbar. This area is also characterized by a higher dynamism, both hydrodynamically (currents) as morphodynamically (sediment transports).

This trend becomes clearer from the long-term results. For phase A of the relocation test, 6 months after the execution of the test ca. 30% of the sediment is transported out of the polygon. For phase B ca. 35% of the relocated material is transported out of the control polygon after 10 months. At the end of 2007 only 50% (or circa 700,000 m³) of the relocation is still in the control polygon. Further analysis in 2008 even showed that in September 2008 (1.5 years after completion of the relocation test) 60% of the relocated material had disappeared [1]. Nevertheless this is a positive result since the material seems to have settled mainly between the relocation area and the sandbar (at the relocation area of 2004 and the area near the Walsoorden sandbar) (Figure 5 & Figure 6).

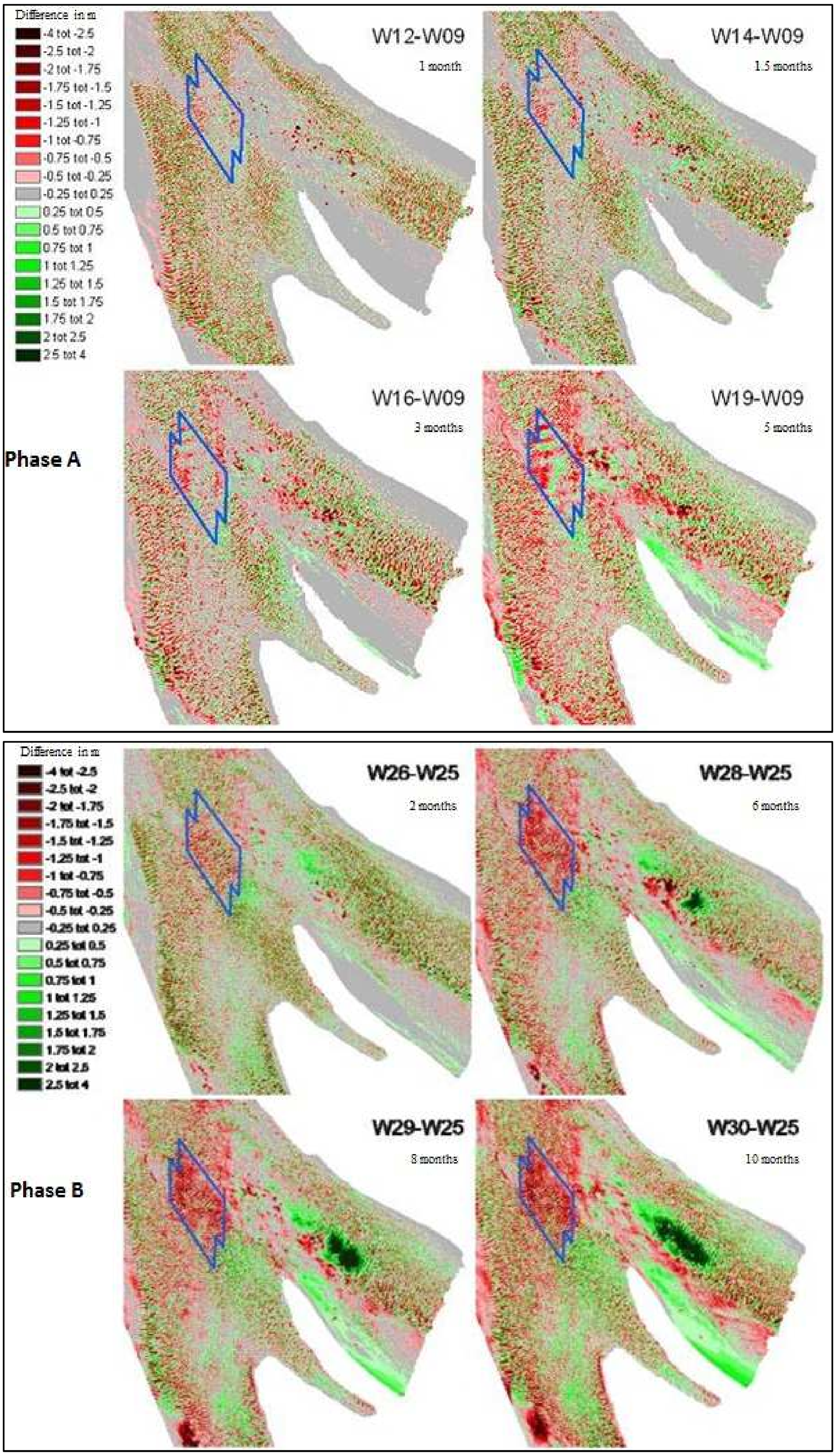


Figure 5. Difference after phase A (up) and B (down) of the relocation test: phase A after 1 month, 1.5 months, 3 months and 5 months; phase B after 2 months, 6 months, 8 months and 10 months (Vos et al. 2009).

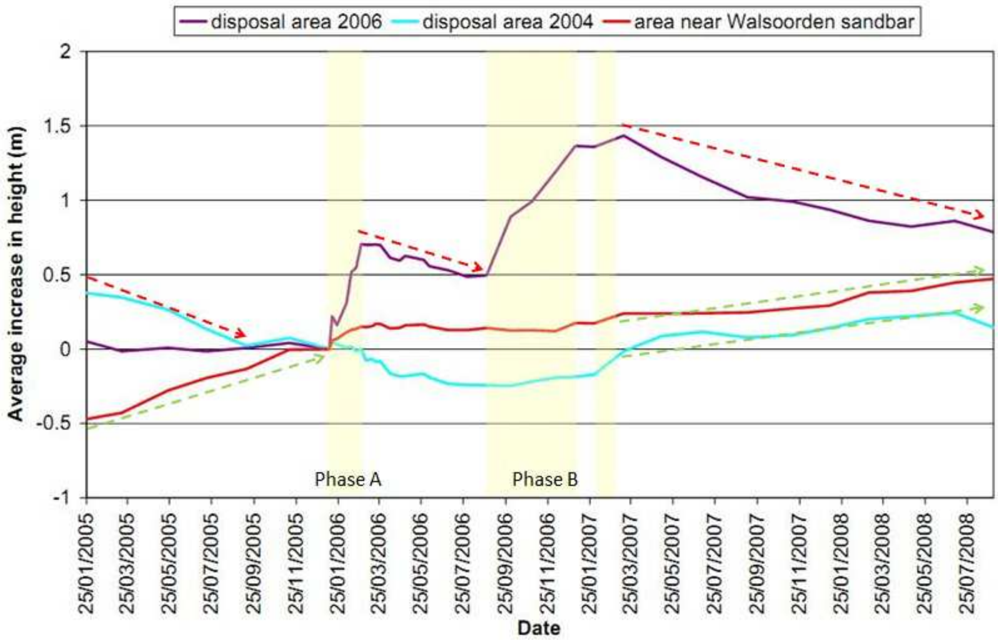


Figure 6. Volume calculations in some major zones for both in situ relocation tests 2004 (light blue line) and 2006 (purple line), as well as the area near Walsoorden sandbar (red line). Both 2006 relocation periods (A and B) are indicated by an orange background colour. (Vos et al. 2009, Plancke et al. 2010, Vos 2010)

1.2 Criterium 2: *Morphological trend at "Schaar van Waarde" and "Schaar van Valkenisse"*
Transverse sections were selected at the Schaar van Waarde and Schaar van Valkenisse to control a potential effect of the relocation test: max. 15% of the transverse profiles may have been occupied by sand 2 weeks after the completion of the relocation test. The results show a positive trend: Two weeks after the end of relocation phase A, there was a limited decrease of the transverse profile for the 2 selected transverse sections (-2.8% and -1.1% respectively). Even two months after relocation phase B this criteria was met: the transverse profile decreased with 7.1% at Waarde and 5.2% at Valkenisse compared to the beginning of phase B. From then, the sedimentation at the Schaar van Valkenisse was stable: 6.1% after one year and 5.1% after 1.5 years since the beginning of phase B. Sedimentation at the Schaar van Waarde was however more intense: 5% after one year and 14.3% after 1.5 years since the beginning of phase B. This is, however, attributable to the targeted relocations that took place during the same period in the Schaar van Waarde.

<u>(2) Ecological analysis</u>
The ecological monitoring **did not reveal any significant negative impact**, neither in the intertidal areas, nor in the subtidal areas. None of the results from this monitoring indicated that the in situ relocation test was responsible for a significant change in ongoing trends. The result of this relocation test could however not be extrapolated to other areas because the effects could differ depending on local characteristics. For every relocation measure and for every area new location monitoring is needed (van der Wal 2010)!
In the *intertidal area*, no negative effects were detected due to the relocation test. All criteria were fulfilled and changes (mainly at the central part of the sandbank) were in line with the long term trends (elevation, sedimentation, marsh formation, and composition macrobenthos (Figure 7)). The trends in macrobenthos composition are however not similar for every

species and based on the analysis of shifts in species diversity, the sandbar tends to shift towards a lower dynamic environment (Vos et al. 2009). This was also the case in the control zone and cannot, therefore, be attributed to the relocation test. The dominant intertidal macrobenthos species on the Walsoorden sandbank are presented in Figure 8.

In the *subtidal area*, the relocation test has resulted in a significant local change in the sediment composition: the mud content decreased at C1 and I1 (Figure 9). At the impact area I1 (corresponds to relocation area 2004) this trend was already visible during the monitoring of the 2004 monitoring program. From the new data, the development to more sandy sediment seems to continue. This was not really a surprise since the dredged material was poorer in mud content compared to the sediment that was present at the relocation area, and in addition dredging and relocation may lead to suspension of mud from which the relocated material could become even more poor in mud content. A comparable analysis for the new relocation area (I2) was not possible because sediment was not sampled before the relocation test and only two samples were taken in total.

At location I1, a significant decrease in macrobenthos biomass was measured (Figure 10). However, this was also measured at the control area C1 (as well as a decrease in diversity and density). The significant change was hence due to a general evolution and not due to the relocation test. This is surprising since the changes in sediment composition. This may be explained by the fact that the benthos community was already poor before the relocation test (Forster et al. 2006). The dominant subtidal macrobenthos species at Walsoorden are presented in Figure 11.

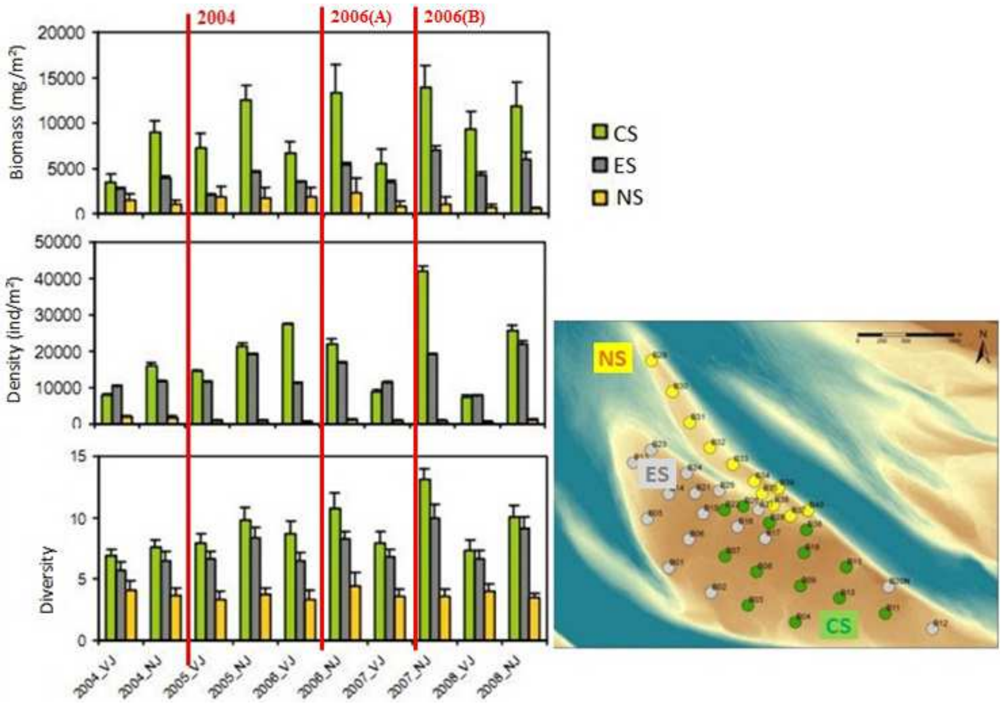


Figure 7. Spatial variation in biomass, density and diversity of intertidal macrobenthos. The coloured bars give the average value for biomass, density and diversity. The small black lines on top of the coloured bars represent the standard error. The vertical red lines indicate the relocation test of 2004 and phase A and B of the 2006 relocation test. 'VJ'=spring, 'NJ'=autumn, NS=northern spit, ES=edge of the sandbar, CS=central sandbar (van der Wal 2010)

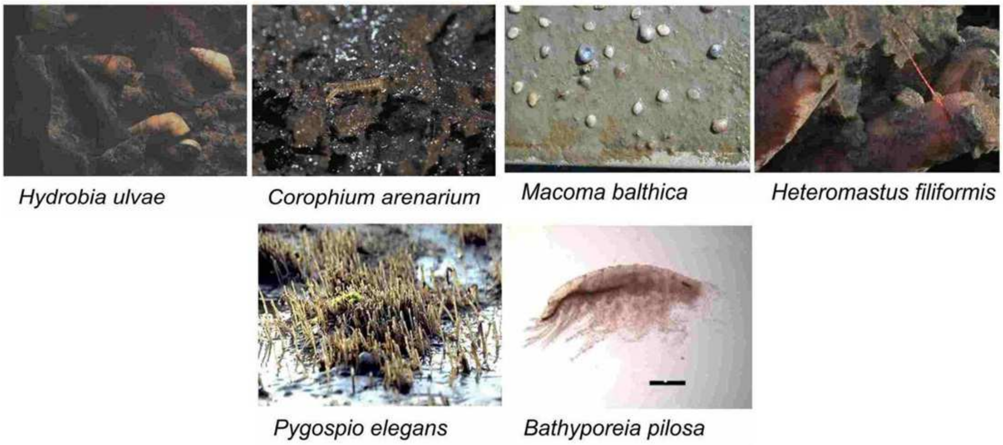


Figure 8. Dominant intertidal macrobenthos species on the Walsoorden sandbank (Forster et al. 2006)

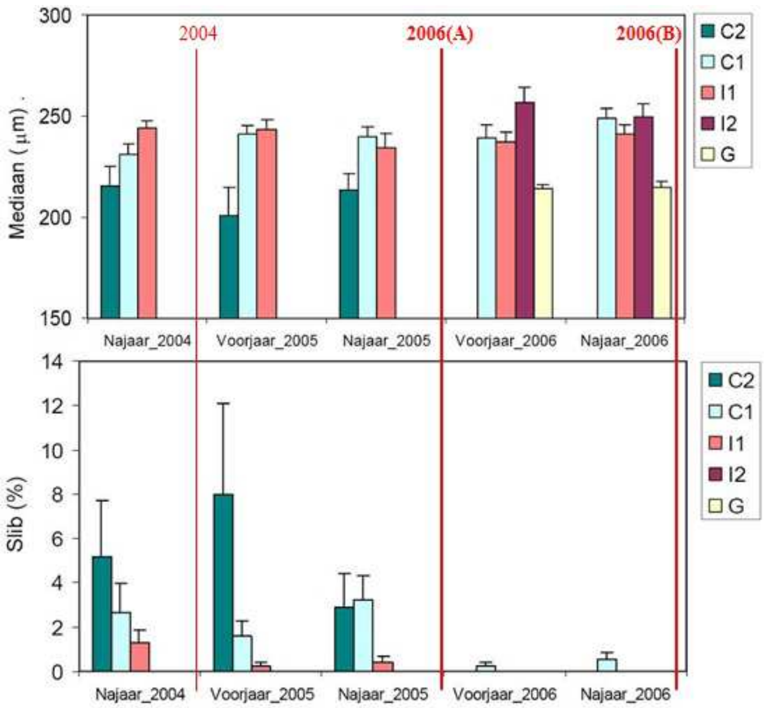


Figure 9. Median grain size (up) and silt content (down) of the subtidal sediment, with indication of standard error (small black lines on top of the coloured bars). The vertical red lines indicate the relocation test of 2004 and phase A and B of the 2006 relocation test. (Forster et al. 2006)

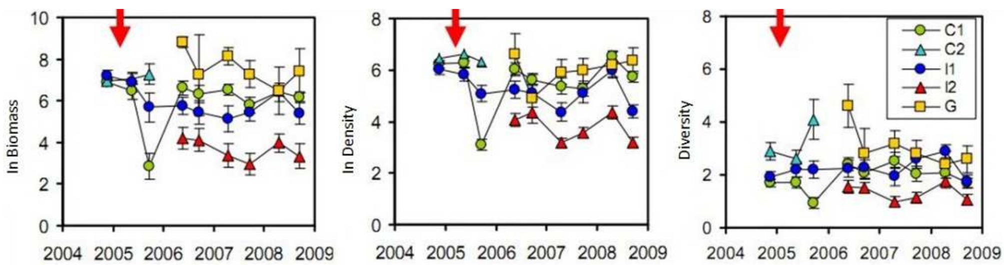


Figure 10. Trend in biomass, density and diversity of subtidal macrobenthos in the study area. The red arrows indicate the relocation tests of 2004 and 2006 (phase A and B). (van der Wal 2010)

Heteromastus filiformis (Dutch: Rode draadworm)	Macoma balthica (English: Baltic tellin) (Dutch: Nonnetje)	Nephtys cirrosa (Dutch: Zandzager)	Bathyporeia pilosa (Dutch: Kniksprietkreeftje)

Figure 11. Subtidal macrobenthos in the study area.

2 Execution of main effectiveness criteria

2.1 Effectiveness according to development targets of measure

Step 1: Definition of development targets
The morphological target was to test the stability of the relocated material and if the transportation of the relocated material was towards the sandbar.
The ecological target was to test if the measure did not lead to significant negative effects.

Step 2: Degree of target achievement
On a morphological level, it can be concluded that the relocation test **has been a success**. The material seems to be stable despite the stability being slightly lower than the relocation test of 2004. This was, however, an expected effect given the different relocation technique that was used in 2006 and the more dynamic conditions in the deeper relocation location. The movement of the material is also mainly in the direction of the sandbar. The results of the feasibility study are therefore confirmed in this in situ trial. The sediment is placed into an area that has been eroding for several decades. The quantity of dredged material (1.4 million m^3) is however low regarding the capacity of the eroded area and will therefore not significantly change the erosive hydrodynamic conditions.
On an ecological level it can be concluded that the relocation test **did not lead to significant, detrimental consequences**. Large-scale effects on the macrobenthos as a result of the relocation test in 2006 seem to have been avoided. This cannot, however, be stated with certainty in relation to the relocation location because no prior sampling was carried out in order to characterise the natural habitat and macrobenthos community.

Comparison with the relocation test of 2004: Both the morphological and ecological criteria were met in both tests, but from the results it was concluded that the traditional relocation technique (used in 2006) has a lower efficiency compared to the diffuser (used in 2004). This is confirmed by a comparison between the amount of dredged material (in hopper) and the amount of material (in situ) found based on volume calculations between topo-bathymetric surveys. It can be noted that the correction for density differences was not applied for this comparison. The diffuser technique has an efficiency of ca. 85%, while the traditional relocation technique has an efficiency of 75-80%. However, the criteria were met so both techniques are useful.

2.2 Impact on ecosystem services

<u>Step 1</u>: Involved habitats

According to expert judgment, we do not have the possibility to indicate the relative involvement of different habitats in percentages and even less to indicate the quality. The reason for this is the fact that the in situ relocation test is just a small scale test to study the feasibility of the large scale relocation along a sandbar, and as such not a goal in itself.

Based on Figure 12, we can however qualitatively conclude that the area is elevated. Most of the area is still subtidal deep habitat, but also a very small area of subtidal moderately deep habitat was created at the sandbar side of the relocation area.

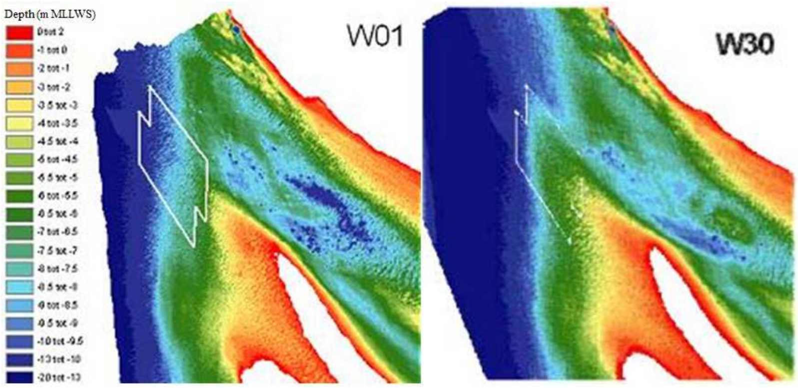
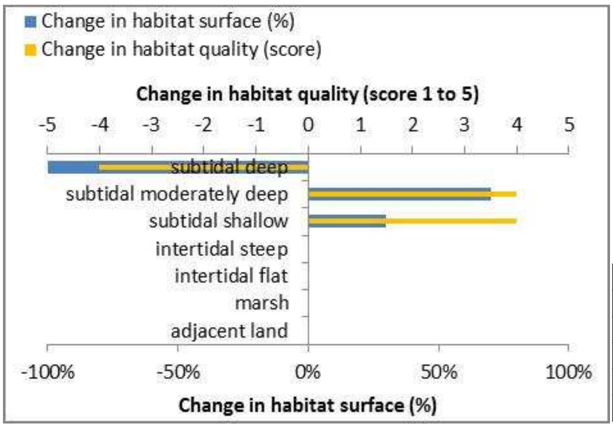


Figure 12. Morphological trend (bathymetry before relocation (W01) and two years later (W30)); MLLWS=Mean lower low water spring. (Forster et al. 2006)



Score habitat quality
1 = very low quality
2 = low quality
3 = medium quality
4 = high quality
5 = very high quality

Figure 13. Ecosystem services analysis for TIDE pilot: Relocation of dredged sediment to a shallow water area at the edge of the Walsoorden sandbar (2006): 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.

<u>Step 2</u>: 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 both positive and negative expected impacts. A slightly positive expected impact is indicated for some regulating services Water quality regulation: reduction of excess loads coming from the catchment; water quantity regulation: landscape maintenance; and water quantity regulation: dissipation of tidal and river energy; as well as for the provisioning service Food: animals. A slightly to very negative expected impact is indicated for Water quality regulation: transport of pollutants and excess nutrients; Water quantity regulation: transportation; Water for industrial use; and Water for navigation.

The transformation from subtidal deep to subtidal shallow water is in general indeed negative for transportation. But in the local context of the relocation of dredged material at the edges of the Walsoorden sandbar it was proven that it contributes to the maintenance of the multiple channel system, which is positive for transportation.

(2) Expected impact on targeted ES
As this measure was only a test case, the target was limited to studying the stability of the relocated material (ES 'Information for cognitive development' and 'Erosion and sedimentation regulation by water bodies'). The expected impact on both development targets is neutral.

(3) Expected impact on beneficiaries
The expected impact for the different beneficiary groups is slightly negative for indirect use and regional use. This is mainly the consequence of the negative expected impact for the transportation related ES, which could be questioned based on the local context of the measure.

Table 2. Ecosystem services analysis for TIDE pilot: Relocation of dredged sediment to a shallow water area at the edge of the Walsoorden sandbar (2006): (1) expected impact on ES supply in the measure site and (2) expected impact on different beneficiaries as a consequence of the measure

TIDE pilot: Relocation of dredged sediment to a shallow water area at the edge of the Walsoorden sandbar (2006)

Cat.	Ecosystem Service	Score
S	"Biodiversity"	0
R1	Erosion and sedimentation regulation by water bodies	0
R2	Water quality regulation: reduction of excess loads coming from the catchment	1
R3	Water quality regulation: transport of polutants and excess nutriënts	-1
R4	Water quantity regulation: drainage of river water	0
R5	Erosion and sedimentation regulation by biological mediation	0
R6	Water quantity regulation: transportation	-3
R7	Water quantity regulation: landscape maintenance	1
R8	Climate regulation: Carbon sequestration and burial	0
R9	Water quantity regulation: dissipation of tidal and river energy	1
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	-2
P2	Water for navigation	-3
P3	Food: Animals	1
C1	Aesthetic information	0
C2	Inspiration for culture, art and design	0
C3	Information for cognitive development	0
C4	Opportunities for recreation & tourism	0

Beneficiaries:	
Direct users	0
Indirect users	-1
Future users	0
Local users	0
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

No conflicts were observed. This pilot project was executed within the framework of the existing license for relocating sediments in the Western Scheldt. At a larger scale, this measure could give the possibility to combine dredging and port development with habitat creation and nature conservation.

3 Additional evaluation criteria in view of EU environmental law

3.1 Degree of synergistic effects and conflicts according to WFD aims

The relocated sediment was stable and moved towards the sandbar, expanding the shallow area around the sandbar and also changing the bathymetry at a local scale. The sediment is placed into an area that has been eroding for several decades. The quantity of dredged material (1.4 million m³) is low regarding the capacity of the eroded area and will therefore not significantly change the erosive hydrodynamic conditions. Also, this measure tackles the effect (eroded area), not the cause!

Indicator Group	Code	Main pressures **polyhaline** zone Scheldt	Effect?					Description
			--	-	0	+	++	
S.I.	1.1	Habitat loss and degradation during the last about 100 years: Intertidal				X		Enlargement of the sandbar and local change of bathymetry (small scale test)
S.I.	3.1/3.2	Decrease of water and sediment chemical quality			X			
S.I.	3.3	Increased chemical loads on organisms			X			
D.I.	1.7	Relative Sea Level Rise			X			
D.I.	2.6	Capital dredging			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

This measure is located in the Natura-2000 area Western Scheldt (Westerschelde) & Saeftinghe (code 122). The relocation of dredged material at a sandbar had the ambition of creating new, and more divers habitat in the estuary. However, the measure as described here is only a small scale test with the aim of studying the stability of the relocated material. This has no impact on the Natura-2000 aims.

CO	**Specification**	**Effect?**					**Short explanation**
		- -	-	**0**	+	++	
<u>Estuarine habitat</u>: Western	Improvement of the quality of the estuary (H113 0) Western Scheldt				X		More habitat diversity: subtidal moderately deep habitat was created (small

Scheldt (Westerschelde) & Saeftinghe	(Westerschelde)						scale test)
	Preserve and increase the quality of marshes, mud flats and salt grasslands.			X			
	Preserve and develop the quality of inner dike brackish areas for breeding birds, marshes, etc.			X			
	Preserve undisturbed resting places and optimal breeding habitat.			X			Small scale test: no effects
Bird directive				X			Small scale test: no effects

4 Crux of the matter

This second relocation test also proved that the new relocation strategy is feasible. When relocating sediment near the Walsoorden sandbar, the sediment is stable. Due to larger currents in the relocation area, a higher percentage of the material was transported towards the Walsoorden sandbar. This morphological evolution was seen as positive within the objectives of the relocation strategy. From ecological viewpoint no significant negative changes in trends have been identified.

Further analysis is needed on the applicability of this measure to several other locations in the Western Scheldt (Westerschelde). Commonly known knowledge gaps are on the understanding of sediment transport pathways and resulting sedimentation and erosion patterns and on the inhabitation of benthic macrofauna of new shallow areas.

The second relocation test (2006) proved that also the traditional clapping technique is successful. This technique has the advantage to execute the relocation much quicker compared to the diffuser technique used for the first relocation test in 2004. In this way the relocation along sandbars can be integrated in the continuous maintenance dredging works. The disadvantage of the clapping technique is however that a minimum depth is needed depending on the draft of the used hopper. The technique with the diffuser can, in contrast, be used at shallow water and is much more precise to relocate material at certain spots.

Both relocation tests were successful (all criteria were met), but both tests involved however only very limited relocation quantities which amount to just part (20%) of the relocation quantities that are necessary for full reconstruction of the sandbar point. Extensive monitoring is therefore still required to further investigate the impact of full-scale relocations on the local morpho- and hydrodynamic conditions (Vos et al. 2009). Initially, this would be to see whether the results remain positive with larger volumes of relocated material and, on the other, to evaluate a number of desired effects that could not have been checked during the relocation tests due to their limited nature. Some examples (WL 2006, Vos et al. 2009):

- Improved distribution of the tidal flow between the ebb and flood channel;
- An increase of the velocities in secondary channels adjacent to the Walsoorden sandbar, particularly above the Hansweert sill. This will allow the self-eroding capacity to increase and dredging efforts to be reduced;
- Enrichment of the shallow water and inter-tidal areas with finer granular fractions as a consequence of a reduction of the flow speeds in these areas.

In addition to the alternative relocation strategy, attention must also focus on morphological dredging and the management of hard boundaries (dikes, hard layers) in the estuary in order to manage the Scheldt estuary in a morphologically balanced manner (i.e. reduce the cause of the erosion) (Vos et al. 2009).

As a result of the success of the relocation tests in 2004 and 2006, it was decided that this new relocation strategy (whereby dredged material is relocated along sandbar edges) would be expanded to multiple locations in the Western Scheldt (Westerschelde) (Vos et al. 2009). This is analysed as a separate measure: sandbar relocations 2010 (‘plaatrandstortingen’).

5 References

Forster, R. M., F. Rossi, K. Bonnie, C. H. R. Heip, and P. M. J. Herman. 2006. Alternatieve stortstrategie voor de Westerschelde. Ecologisch Monitoringsprogramma proefstorting Walsoorden. Rapport 11/11. Nederlands Instituut voor Ecologie, Yerseke, Nederland.

Plancke, Y. M. G., S. J. Ides, G. R. Vos, F. Roose, and J. J. Peters. 2010. A new disposal strategy for the Western Scheldt, conciliating port accessibility and nature preservation. PIANC MMX Congress Liverpool UK 2010.

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.

van der Wal, D. 2010. Evaluatie van de ecologische monitoring op en rond de Plaat van Walsoorden. Studiedag 21-06-2010 “Alternatieve stortstrategie in de Westerschelde: het pilootproject Walsoorden als aanleiding voor het concept van plaatrandstortingen”. Nederlands Instituut voor Ecologie (NIOO-KNAW).

Vos, G. 2010. Evaluatie van de morfologische evolutie van de proefstorting op basis van bathymetrische monitoring. Studiedag 21-06-2010 “Alternatieve stortstrategie in de Westerschelde: het pilootproject Walsoorden als aanleiding voor het concept van plaatrandstortingen”. Vlaamse Overheid, departement Mobiliteit en Openbare Werken (MOW).

Vos, G., Y. Plancke, S. Ides, T. De Mulder, and F. Mostaert. 2009. Alternative disposal strategy Western Scheldt Disposal Test Walsoorden. Final evaluation of disposal test 2006. WL2009R754_03b_rev5_0 (in Dutch: Alternatieve stortstrategie Westerschelde, proefstoring Walsoorden. Eindevaluatie proefstorting 2006). Waterbouwkundig Laboratorium, Antwerp, Belgium.

WL. 2006. Alternatieve stortstrategie Westerschelde proefstorting Walsoorden, Eindevaluatie monitoring. MOD. 754/2C. project nr 006_172. Vlaamse overheid, Departement Mobiliteit en Openbare Werken, Afdeling Waterbouwkundig Laboratorium.