TIDE
Tidal River Development

Project part-financed by the European Union (European Regional Development Fund)

The Interreg IVB North Sea Region Programme

‘Tidal habitat Vorder- und Hinterwerder’

Measure analysis 26
in the framework of the Interreg IVB project TIDE

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NLWKN

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Part 1: Measure description

Measure Category: Ecology/Biology
Estuary: Weser
Salinity zone: Limnic
Pressure: Habitat loss and degradation
Measure status: implemented
River-km: Weser-km 12
Country: Germany
Specific location: Free Hanseatic City of Bremen, near Hasenbüren
Responsible authority: bremenports GmbH und Co. KG
Costs: ca. 400.000 €
Cost category: 250.000 – 1.000.000 €
Picture/Map:

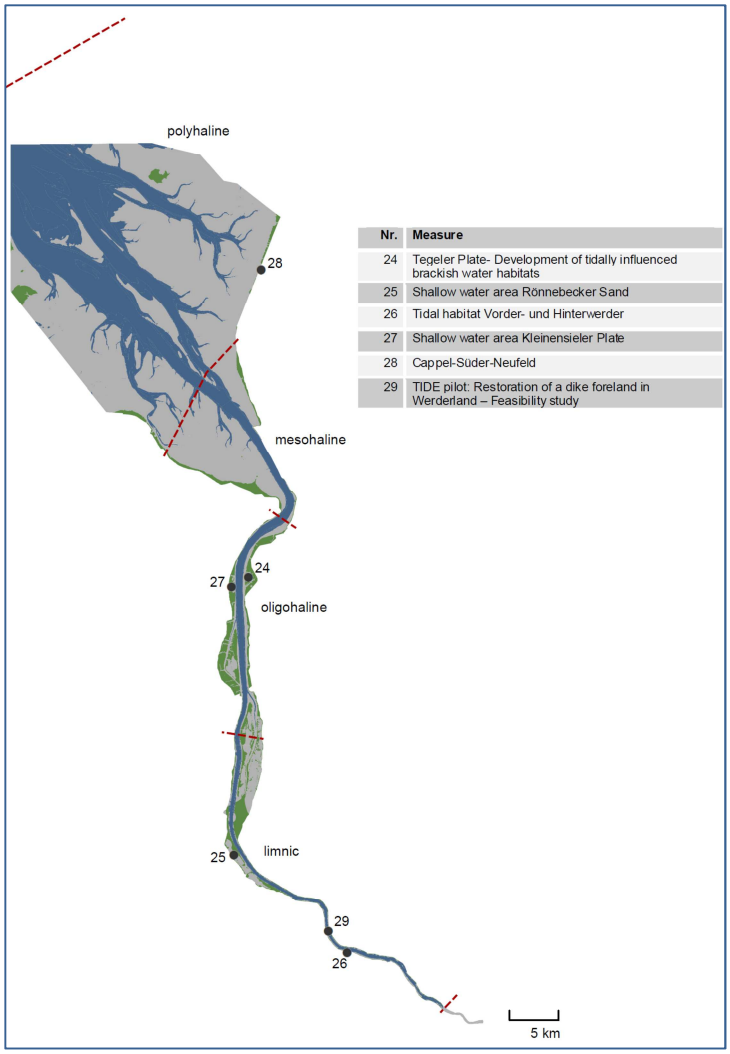

Figure 1: Location of compensation measure 26: ‚Tidal habitat Vorder- und Hinterwerder‘

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1.1 Measure description

The measure 'Tidal habitat Vorder- und Hinterwerder' was designed and implemented as a compensation measure after national environmental law for establishing an integrated disposal area for dredged material in Bremen-Seehausen.
A tidal habitat on a scale of 27 ha (Figure 2) was realized in a northern German estuary for the first time. The compensation measure therefore had a pilot nature for several similar compensation measures implemented after 1997 (e.g. Kleinensieler Plate, Rönnebecker Sand).

Figure 2: Aerial photograph of project area

In order to increase the tidal influence on the project area, the summer dike was partly lowered over a length of 25 m down to 1.7 m above sea level and an in- and outlet structure was installed 1.9 m above sea level. As a result, the mean tidal range on the project area amounts to approximately 0.7 m (4 m in the lower Weser River).
The 5 ha shallow water area is permanently covered with water. At low tide, water depths between 0.2 – 0.5 m were observed. Additionally, deeper areas of the Vorderwerder were established by ground excavation in order to improve the situation for fish and to slow down the natural siltation of the shallow water area by serving as a sediment trap (Figure 3). On higher areas, grassland was milled to initiate grazing land development.

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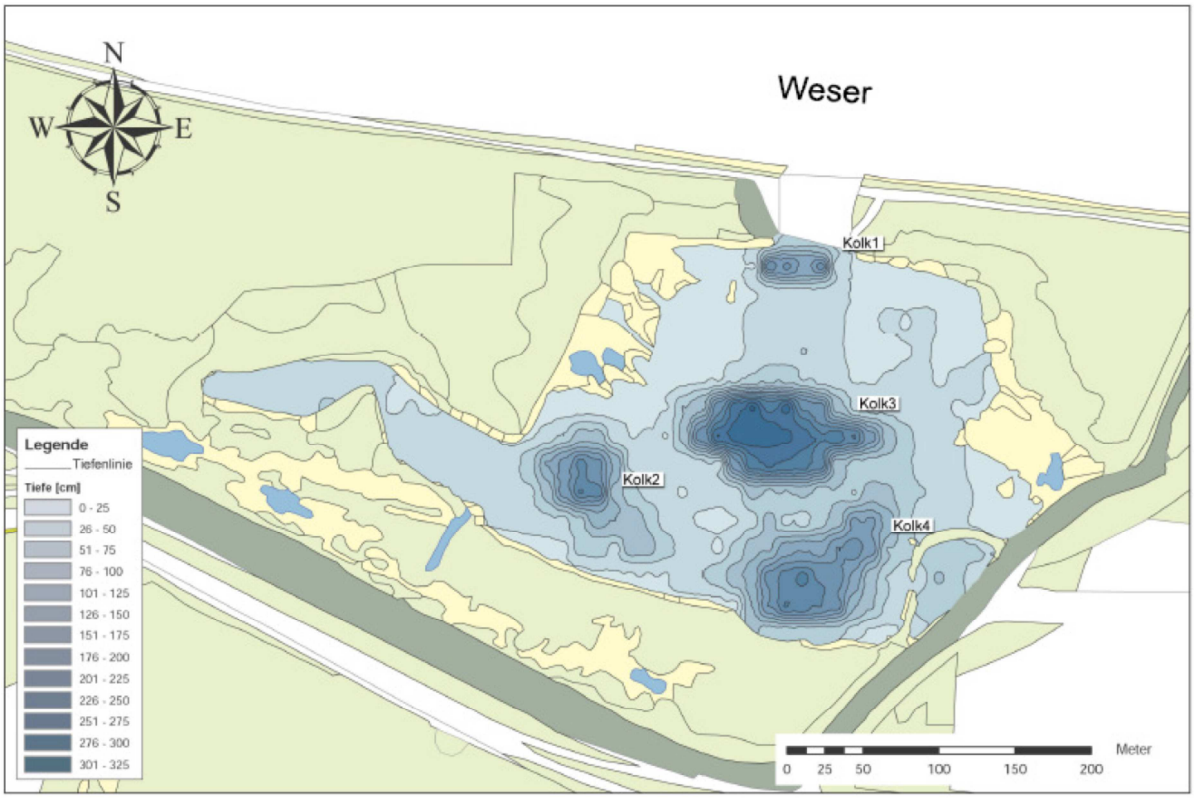

Figure 3: Bathymetry of project area in 2004. The depths refer to the threshold level (+ 1.70 m above sea level). The measurements did not consider the small standing water bodies around the shallow water zone. Source: HANEG 2011

1.2 Monitoring

The monitoring program ran ten years and was –with an extension- completed in 2010. The aims of the monitoring program were

- to control the achievement of development targets after ten years (success monitoring) and
- to support in terms of managing the project area (management monitoring, e.g. regarding land use, water drainage, maintenance, disturbances).

The monitoring program included the following aspects:

- Vegetation mapping (aerial photographs, transects, point mapping, drift line, permanent grassland areas)
- Fauna (breeding birds, beetles, herbivores and insects)
- Water (suspended matter, sedimentation, echo sounding, water quality, pollutants, zooplankton, fish)

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1.3 Monitoring results

The monitoring results described in the following are based on HANEG 2011.

Tidal range and hydraulic stress

The creation of habitats with reduced tidal range due to lowering the summer dike around the in- and outlet structure was successful. The in- and outlet structure effectively prevented the decrease of low tide; the chosen construction therefore is able to withstand existing hydraulic pressures. A habitat in large parts independent from the hydraulic pressures of the lower Weser River (e.g. high tidal range, increased current velocities) developed which overtakes characteristic functions of floodplain back waters.

However, a minor increase of tidal range on the project area took place since 1997 due to increases of mean high water levels in the main river as a consequence of deepening measures.

Siltation

Due to relatively high suspended matter concentrations and low energy input, tidal polders as substitution habitats for natural floodplains in estuaries are strongly affected by siltation. Sedimentation depends on both suspended matter concentration and the amount of water exchanged per tide. The polder design including a relatively high in- and outlet structure did not only aim at tidal range reduction, but also at reducing the inflowing water amounts and therefore suspended matter loads. Bathymetry recordings of the polder proved this approach to be basically successful: water volume slightly decreased between 2004 and 2011. However, figure 4 shows that the suspended matter input to the polder exceeds the output. The resulting siltation tendencies within the polder lead by trend to an ongoing decrease of shallow water areas and intertidal mudflats. However, comparisons of bathymetry show that the distribution of shallow and deep water areas created in 1997 did not basically change until 2010 (Figure 5).

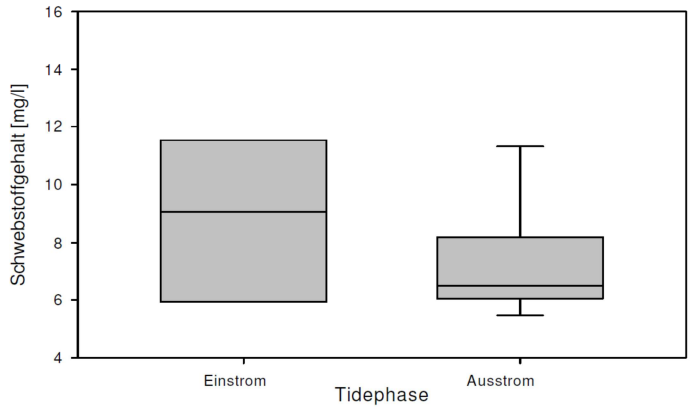

Figure 4: Averaged suspended matter concentration of water flowing in (Einstrom) and out (Ausstrom) the polder. Data covers one tidal cycle (23.09.2010, every 15 min). Source: HANEG 2011

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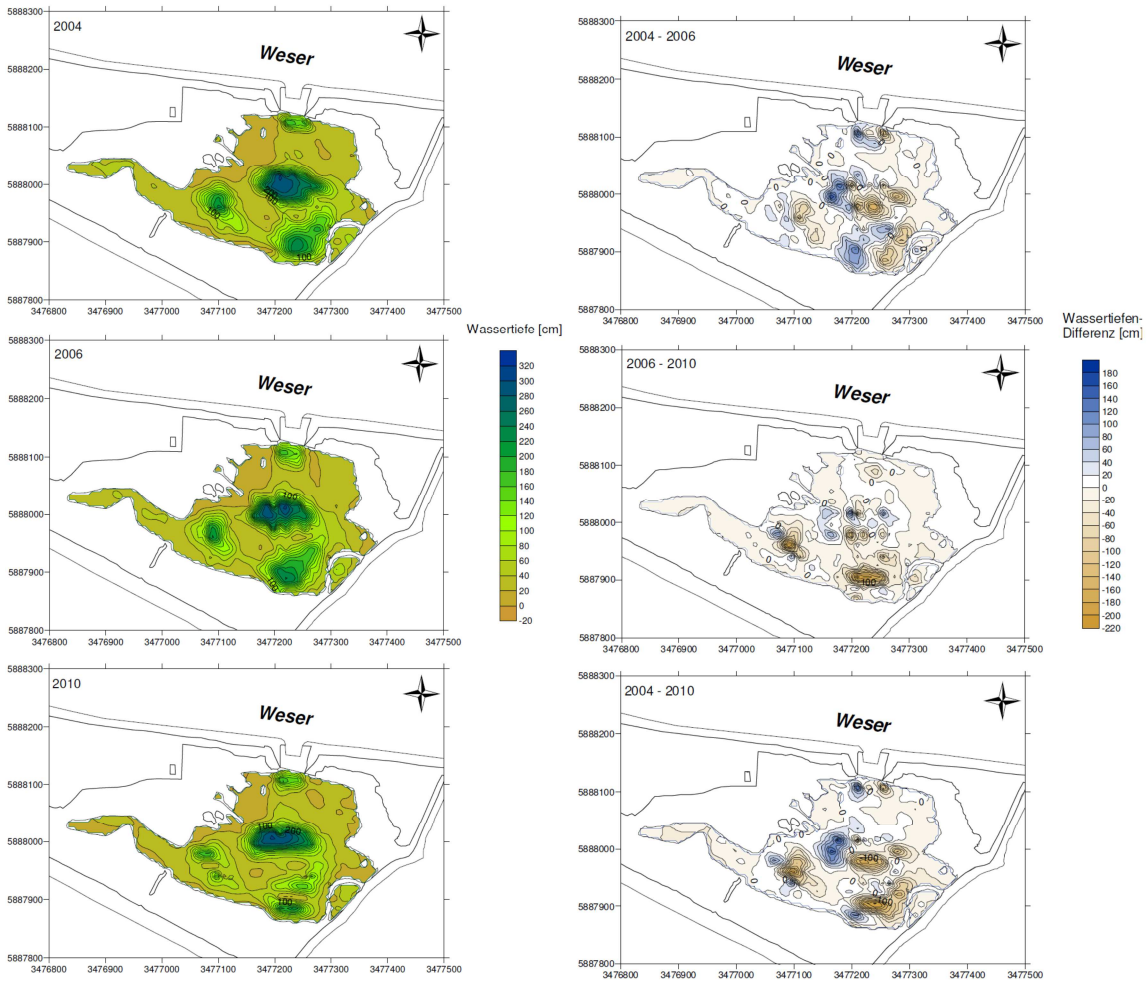

Figure 5: Results of depth measurements in 2004, 2006 and 2010 (left) and water depths differences in comparison to 1997 for the years 2004, 2006 and 2010 (right); source: HANEG 2011

Functions

So far, submersed macrophytes did not establish on the project area. The reasons are not clear yet. A possible reason could be the lower, but still existing tidal range. This frame condition may prevent especially the shallow, regularly uncovered side areas from being settled by under-water-vegetation. In the deeper areas, the light conditions are probably not sufficient. Turbidity is promoted e.g. by phytoplankton development in spring.

Zooplankton

Between 2004 and 2010, the function of the polder in terms of the Weser River changed. In 2010, considerably more zooplankton was found in the water flowing out of the polder than in 2004. Referring to the amounts of inflowing and outflowing water, it has to be noted that the results only represent snapshots. In order to formulate a scientifically sound statement, a time series including a sequence of several tidal cycles would be necessary.

The recorded zooplankton occurrences make the tidal habitat Vorder- and Hinterwerder a potentially suitable living space for fish (nursery ground).

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Phytoplankton

From 2004 to 2010, the function of the polder in terms of the Weser River changed in summer and autumn. In 2010, less phytoplankton both on a species and on a community level was found in the water flowing out of the polder compared to the situation in 2004. Besides sedimentation, increased predation by zooplankton and fish larvae is estimated to be a reason.

In terms of the Weser River, this result means that there is still significant phytoplankton input coming from the polder in spring. In summer and autumn, phytoplankton is used as food resource by zooplankton and probably fish larvae. This development of the polder can be considered positive and is estimated to stabilize until sedimentation will lead to a slow reduction of water covered area and to the development of fresh water mudflats.

Benthic invertebrate fauna

By 2010, 66 taxa of benthic invertebrate fauna were proven on the project area. Compared to the limnic lower Weser River, the tidal habitat Vorder- and Hinterwerder shows a species rich benthic invertebrate fauna.

On the one hand, the benthos community consists of characteristic species of slow flowing waters including insect species (e.g. Odonata, Heteroptera, Caddisfly and Mayfly) and gastropoda (snails). These species are generally common, but no longer present at the strongly anthropogenically influenced lower Weser River. Behind this background, the polder initiates a significant diversification of species which is presently restricted to the Vorder- and Hinterwerder area.

Besides the taxa exclusively recorded in the polder, the species spectrum on the other hand recruits from a second, smaller group of current 'Weser species' especially including estuarine shrimps (e.g. *Neomysis integer*), amphipoda (e.g. *Gammarus zaddachi*) and bivalvia (*Corbicula*). Mobile crustaceans visit the polder for recreational and feeding purposes, possibly also for reproduction. Snails arrive at the polder by means of tidal currents as larvae and are able to settle.

Starting with a comparatively high number of taxa in 1998, species diversity decreased until 2004 (Figure 6). In 2010, the settlement consolidated and stabilized on the level of 1998 (50 taxa). In comparison, the benthic invertebrate species spectrum in the river section bordering on the project area consists of 15 taxa. It is not possible to predict if the number of species in the project area will continue increasing. Thinkable is an expansion of fauna typical for slow flowing waters. The establishment of typical fauna also depends on a possible establishment of submersed macrophytes.

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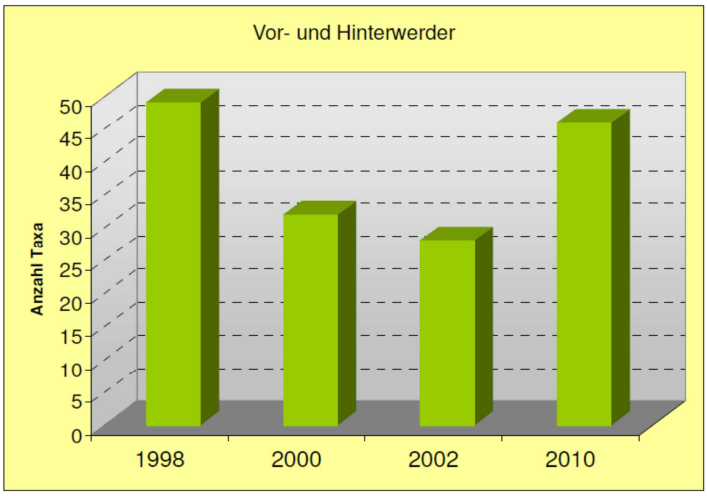

Figure 6: Changes in amounts of benthic invertebrate fauna taxa from 1998 to 2010 (source: HANEG 2011)

Fish

The project area functions as feeding, recreational and reproduction ground for fish. Additionally, the polder's function for overwintering is proven. Between 2004 and 2010, larvae or juveniles of 11 fish species were found.

In the polder, the conditions for the listed functions are presently given by e.g. comparatively well water quality, shallow and deeper subtidal areas and suitable spawning substrates (reeds) as well as low tidal range. Relatively high numbers of larvae found in 2010 show that the polder is probably used as spawning ground mainly by Cypriniformes and Perciformes. Additionally, the polder is temporarily used by immigrating larvae and juveniles of smelt, flounder and goby. The reproduction and nursery ground functions taken over by the polder are presently defective in the lower Weser River.

Part 2: Execution of main effectiveness criteria

2.1 Effectiveness according to development targets of measure

-Step 1: Definition of development targets

- Development of natural floodplain habitats with tidal waters, specific shore vegetation, reed beds and willow groves
- Reestablishment of natural gradients from aquatic to terrestrial habitats. The deeper areas of the shallow water zone are designed to improve the situation for fish and to serve as sediment traps to slow down the expected siltation.
- Protection and enhancement of higher located poor grassland areas (grazing land with extensive use)

-Step 2: Degree of target achievement

The degree of target achievement for the compensation measure 'Tidal habitat Vorder- und Hinterwerder' can be considered as high. The development target according to the grassland areas

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was reached satisfactorily. The area left to natural succession developed faster than expected. The aims for fish were reached one year after measure implementation already.

2.2 Impact on ecosystem services

The measure 'Tidal habitat Vorder- und Hinterwerder' in the freshwater zone of the Weser estuary was about the creation of estuarine habitats by transforming adjacent land into marshland, subtidal shallow and subtidal moderately deep habitat connected with a high change in the habitat quality (Figure 7). From the ecosystem services (ES) assessment, it is concluded that this measure generates overall a positive expected impact for many ES, mainly for 'biodiversity' and erosion and sedimentation regulation by water bodies. The expected impact on both development targets ('biodiversity' and 'erosion and sedimentation regulation by water bodies') is very positive. The expected impact for the different beneficiary groups is overall positive, with a positive expected impact for indirect and future use and for local use (Table 1).

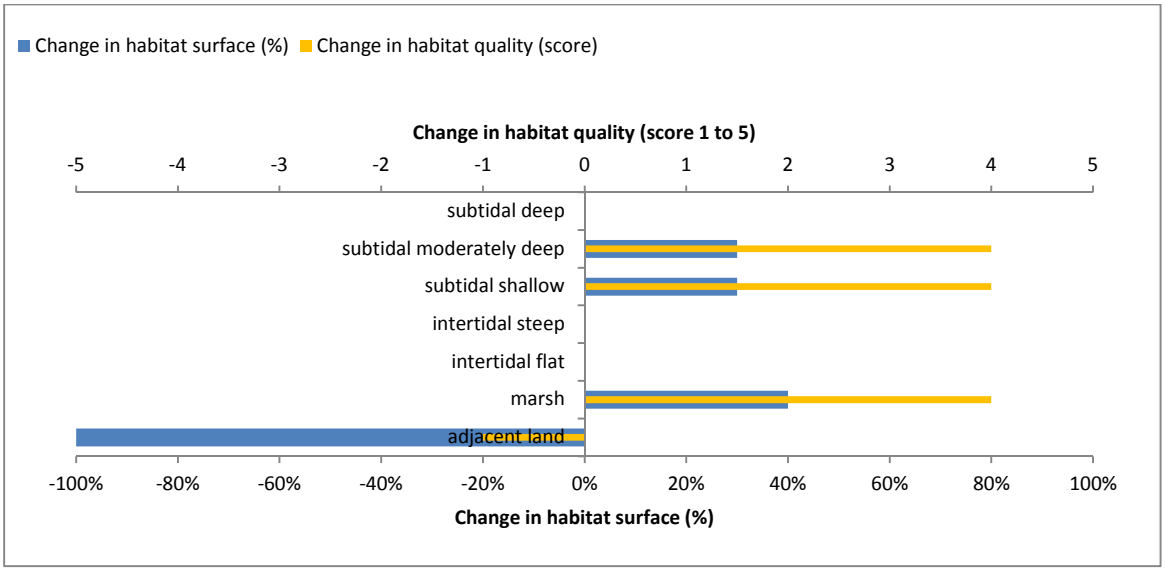

Figure 7: Ecosystem services analysis for measure ‚Tidal habitat Vorder- and Hinterwerder': Indication of habitat surface and quality change, i.e. situation before versus after measure implementation.

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Table 1: Ecosystem services analysis for measure ‚Tidal habitat Vorder- and Hinterwerder': (1) expected impact on ES supply in the measure site and (2) expected impact on different beneficiaries as a consequence of the measure.

Tidal habitat Vorder- und Hinterwerder

Cat.	Ecosystem Service	Score
S	"Biodiversity"	3
R1	Erosion and sedimentation regulation by water bodies	3
R2	Water quality regulation: reduction of excess loads coming from the catchment	2
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	1
R6	Water quantity regulation: transportation	1
R7	Water quantity regulation: landscape maintenance	1
R8	Climate regulation: Carbon sequestration and burial	2
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	1
R12	Regulation extreme events or disturbance: Flood water storage	1
P1	Water for industrial use	1
P2	Water for navigation	1
P3	Food: Animals	0
C1	Aesthetic information	2
C2	Inspiration for culture, art and design	2
C3	Information for cognitive development	2
C4	Opportunities for recreation & tourism	2

Beneficiaries:	
Direct users	0
Indirect users	2
Future users	2
Local users	2
Regional users	1
Global users	1

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

Not the compensation measure itself, but the integrated disposal area Bremen-Seehausen was intensively discussed in public.
The project area Vorder- und Hinterwerder has been a popular area for leisure, local recreation and tourism already before the compensation measure was implemented. That is why the general public was skeptical first. But since the natural scenery improved significantly after measure implementation, positive effects on leisure, local recreation and tourism can be stated.

Part 3: Additional evaluation criteria in view of EU environmental law

3.1 Degree of synergistic effects and conflicts according to WFD aims

The compensation measure 'Tidal habitat Vorder- und Hinterwerder' was implemented before the Water Framework Directive (WFD) came into force in 2000. Thus, it was not designed to meet WFD aims. However, the measure tackles five of six main pressures the limnic zone of the Weser estuary is affected by (Table 2).

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Table 2: Measure effects on main pressures of the freshwater zone of the Weser estuary

Indicator Group	Code	Main pressures **freshwater** zone Weser	Effect?					Description
			--	-	0	+	++	
S.I.	-	Habitat loss and degradation during the last 100 years: Subtidal					X	Additional subtidal area was created (shallow water zone).
S.I.	1.1	Habitat loss and degradation during the last 100 years: Intertidal				X		Intertidal habitats were developed (e.g. reeds and mudflats).
S.I.	1.4/ 1.5	Gross change in morphology/hydrographic regime during the last about 100 years					X	Due to Weser deepening, many side habitats of the river including shallow water got lost. The compensation measure creates new side habitats and therefore contributes to mitigating negative effects of the gross changes in morphology/hydrographic regime.
D.I.	1.3	Land claim during the last about 100 years				X		By partly lowering a summer dike and increasing the tidal influence on the project area, land formerly used for agricultural purposes was given back to the river.
D.I.	1.7	Relative Sea Level Rise				X		Project area provides additional holding capacity.
D.I.	2.6	Capital dredging			X			There are no direct effects to be stated, but measure generally contributes to mitigating the negative effects of capital dredging.

3.2 Degree of synergistic effects according to Natura 2000 aims

The Vorder- und Hinterwerder is located in a Special Protection Area (SPA) after the Birds Directive (Site name: Niedervieland, site code: DE 2918-401). According to the Integrated Management Plan Weser (IBP Weser), the Vorder- und Hinterwerder is assigned to operational area 3. Although the compensation measure was not designed to meet the requirements of Natura 2000, potential positive effects on several conservation objectives defined for operational area 3 (Table 3) and for the entire investigation area of the IBP Weser (Table 4) can be stated.

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-Step 1: Estimate potential measure effects on conservation objectives for certain special units

Table 3: Natura 2000-objectives with specifications for operational area 3 (source: simplified after NLWKN, SUBV 2012)

Operational area 3: Freshwater zone in the lower Weser (Weser km 12 - 32)				
Specifications for operational area 3	**Effect of measure 26 on conservation objectives**			**Short explanation**
	positive effect	no effect	negative effect	
Conservation and development of specific estuarine habitats and (tidal) floodplains and their dynamic changes				
Development, enlargement and upgrade of shallow water zones with moderate current climate	++			A shallow water zone with reduced tidal range was created.
Development of passable shore structures	+			The passability of shore structures was improved by partly lowering a summer dike and by installing an in- and outlet structure principally passable for organisms.
Conservation and development of typical habitats of operational area 3 (e.g. river flats, reeds and typical shore vegetation not being affected by neophytes, tidal floodplains and extensively used grasslands) in a dimension, spatial distribution and interconnection ensuring long-term appearance of typical species	++			Typical habitats of operational area 3 were developed (e.g. reeds, extensively used grassland).
Conservation and development of tidal floodplains at the upper tidal border	++			The tidal habitat Vorder- and Hinterwerder takes over the functions of tidal floodplain back waters.
Conservation and development of habitats for viable populations and estuary and (tidal) floodplain specific species as well as species after Annex II Habitats Directive and bird species after Birds Directive				
Conservation of typical breeding bird communities and associated habitats (breeding birds of grasslands, reeds and tidal floodplains)	+			Reeds represent important breeding grounds for birds.
Conservation and development of undisturbed resting and moulting areas for migratory bird populations (high diversity, many individuals) considering all necessary functions	+			Many resting birds were observed.
Conservation and development of well-structured bordering waters and shore areas with wood, typical shore vegetation and reeds as hunting and feeding ground for Pond bat (*Myotis dasycneme*)	+			Pond bat was observed.
Preservation and development of spawning ground function for Twaite shad (e.g. by avoiding disturbances during spawning season)		0		Spawning grounds of Twaite shad are situated downstream the project area.
Conservation and development of spawning ground function for Smelt (*Osmerus eperlanus*) (e.g. by avoiding disturbances during spawning season)		0		Spawning ground of Smelt is situated upstream the project area.

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-Step 2: Estimate potential measure effects on overall conservation objectives

Table 4: Natura 2000-objectives with specifications for entire investigation area of the Integrated Management Plan Weser (IBP Weser); source: simplified after NLWKN, SUBV 2012

Specifications for entire investigation area of IBP Weser	Effect of measure 26 on conservation objectives?		
	positive effect	no effect	negative effect
Conservation and development of specific functions and processes of estuaries and (tidal) floodplains to reach favourable abiotic conditions and typical hydromorphological structures			
Conservation and development of favourable water structures and water bed dynamics	+		
Development of evenly distributed and reduced current energy and tidal parameters	+		
Conservation and development of favourable gradients of specific aspects regarding estuaries and (tidal) floodplains (e.g. salinity, sediments, current conditions, tidal range, close-to-nature zonation of shore vegetation…); refers to inner estuary and to area between estuary and floodplain within fresh water zone.	+		
Improvement of water and sediment quality		0	
Conservation and development of specific estuarine habitats and (tidal) floodplains and their dynamic changes			
Conservation and development of habitats and communities which strongly depend on the natural dynamics of morphological processes (e.g. mudflats, shallow waters, creeks…)	++		
Development of balanced area percentages regarding mudflats, shallow waters, shallow and deep sublitoral	+		
Conservation and development of tidal floodplains with typical vegetation structures and biocoenosis and favourable tidal and flooding dynamics; especially floodplain enlargement	+		
Conservation and development of habitats for viable populations and estuary and (tidal) floodplain specific species of Annex II Habitats Directive and bird species of Birds Directive			
Conservation of habitat functions for breeding and migrant birds especially as feeding grounds (also for bordering or networked areas)	+		
Conservation and development of habitat requirements for migratory fish stocks and cyclostomata within present territories and networked areas	+		
Conservation and development of habitat requirements for autochthon fish communities with typical age composition and typical percentage of estuarine species and diadromous migratory fish species	+		
Conservation and development of long-term viable populations of typical fish species and cyclostomata (estuarine and diadromous guilds)	+		
Reaching of favourable water quality for reproduction, larval development and viability of typical fish communities of different salinity zones	+		

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Conservation and development / reestablishment of passability of the tidal river Weser and its tributaries for migratory fish and benthic invertebrates	+		

Part 4: Crux of the matter

The compensation measure 'Tidal habitat Vorder- und Hinterwerder' is a flagship measure, because several experienced partners worked together during the planning and implementation stages, the social status of nature conservation was very strong at that time and there were no conflicting plans to be considered.
The tidal waters at Vorder- and Hinterwerder were flooded longer than projected by the hydraulic models used. To optimize future measure planning and implementation processes, the hydraulic calculations undertaken during the planning stages should be analyzed in order to improve the predictability of tidal influence on potential project areas along estuaries. This is crucial in order to estimate e.g. the degree of siltation and thus the maintenance effort to expect.
The monitoring results show that reconnecting river and floodplain by opening summer dikes is principally possible within certain limits. The opening of summer dikes initiates the development of habitats which have been in place on a large scale before the first deepening and straightening measures took place at the Weser River (e.g. intertidal habitats, shallow water areas and back waters). An essential precondition in view of developing shallow water areas was reducing the tidal range on the project area by suitable constructional measures (summer dike opening, in- and outlet structure installation). It has to be accepted that there is no permanent connection between river and polder during the entire tidal cycle.
Although the aimed at habitats were successfully developed, a lack of natural morphodynamics has to be accepted. As a consequence, certain habitats cannot exist in the long term without anthropogenic management. This concerns for example intertidal mudflats and shallow water areas which silt up and overgrow in the course of the development. Eroding forces can only be expected on a small scale. The present frame conditions (e.g. dike safety, shipping) and the small scale of measures prevent or at least restrict the recreation of natural eroding forces which contribute to preserve different habitat structures. Thus, there is development need to be stated for concepts balancing decreased tidal ranges and close-to-nature morphodynamics in a way to minimize management efforts.

Part 5: Literature

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