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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

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List of abbreviations

ABP	Associated British Ports
APA	Antwerp Port Authority
BD	Birds Directive
CRT	Controlled Reduced Tide
EA	Environment Agency
EII	Environmental Integrative Indicator
ES	ecosystem services
EU	European Union
FCA	Flood Control Area
HAG	Humber Advisory Group
HD	Habitat Directive
HERAG	Humber Estuary Relevant Authority Group
HMS	Humber Management Scheme
HPA	Hamburg Port Authority
IMP Elbe	Integrated Management Plan Elbe
IMP Weser	Integrated Management Plan Weser
m NN	Altitude above sea level in Germany
m OD	Altitude above sea level in United Kingdom
m TAW	Altitude above sea level in Belgium
MHWL	Mean High Water Level
Mio	Million
MLWL	Mean Low Water Level
MR	Managed Re-alignment
MRM	Managed Re-alignment Measures
NLWKN	Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency
RTE	Reduced Tidal Exchange
RWG	Regional Working Group
TWG Measures	Transnational Working Group Measures
UK	United Kingdom
WFD	Water Framework Directive

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1. Aim of the study

The aim of this TIDE study was to collect, analyse and compare examples of practical management measure planned or realised in the Weser, Humber, Elbe and Scheldt estuary (hereinafter called TIDE estuaries). The results of this exercise should be used to exchange experience and to improve future planning and implementation processes of estuarine management measures.
A set of well-documented and educative measures aiming at different development targets was selected for the analysis. It was based on a set of criteria which was executed for each measure example and which founded the basis for an in depth comparison of measures in terms of certain aspects of interest (e.g. measures influencing sedimentation, managed realignment measures). As an overall result, recommendations addressed to estuary managers in view of future measure planning and implementation processes were formulated.
Additionally, this report contains a list of the pilot projects realised at the estuaries of Weser, Elbe, Humber and Scheldt during the runtime of TIDE. The pilot projects primarily address a question of specific interest in view of the estuary they refer to, but they also provide results transferable to other estuaries of the North Sea region.

2. Work organisation

2.1 Transnational Working Group Measures (TWG Measures)

The study was led by the Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency (NLWKN) and accompanied and executed by a 'Transnational Working Group' (TWG Measures) consisting of one representative per TIDE estuary (Table 1).

Table 1: Members of Transnational Working Group Measures (TWG Measures)

Estuary	Working Group Member	Project Partner
Weser	Sonja Saathoff (lead)	Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency (NLWKN)
Elbe	Johanna Knüppel	Hamburg Port Authority (HPA)
Humber	Susan Manson	Environment Agency (EA)
Scheldt	Els van Duyse/ Annelies Boerema	Antwerp Port Authority (APA)

2.2 Regional Working Groups

The involvement of estuarine specific expert groups (Regional Working Groups, RWGs) represents an integral part of several TIDE studies (Jacobs 2013, Cutts & Heminingway 2013). For each study, the composition of the RWGs was defined according to the respective subject of discussion. In the frame of this study, RWGs at Weser, Elbe, Humber and Scheldt were involved in identifying the main pressures affecting the estuary zones of the TIDE estuaries as a basis to estimate measure effects in relation to the aims of the Water Framework Directive (see 3.2.2.1).

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3. Working steps and methods

The study was elaborated according to the following working steps.

Step 1: Measure collection and basic info compilation

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Step 2: Analysis approach development

↓

Step 3: Application of analysis approach to measure examples

↓

Step 4: Consistency check of analysis results

↓

Step 5: Develop concepts for cross estuary comparison of measures

↓

Step 6: Execute cross estuary comparison of measures

↓

Step 7: Deduce recommendations for estuary managers

Figure 1: Overview on working steps

3.1 Measure collection and compilation of basic information

The first working step consisted of collecting basic information on a set of chosen measures from the four TIDE estuaries.

The measure compilation took place based on a measure category list structuring the range of possible development targets and therefore assuring a systematic compilation of examples (Table 2). The choice of examples to be included in the study (Table 4) was left to the respective TIDE estuary representative of the TWG (Table 1) provided that the examples were judged as well documented (e.g. by available monitoring results or modelling results) and educative in view of potential future measure planning and implementation processes.

Table 2: Measure categories and assigned development targets

Measure category	**Development target**
Biology/Ecology	Measure to develop and/or to protect specific habitats
	Measure to develop and/or to protect specific species
	Other measure to develop natural gradients and processes, transition and connection
	Measure to prevent introduction of or to fight invasive species
Hydrology/Morphology	Measure to reduce tidal energy, tidal range, tidal asymmetry and tidal pumping effects
	Measure for flood protection
	Measure to improve morphological conditions
	Measure to decrease the need for dredging
Physical/Chemical Quality	Measure to reduce pollutant loading (point and diffuse sources)
	Measure to reduce nutrient loading (point and diffuse sources)
	Measure to improve oxygen conditions
	Measure to reduce physical loading (e.g. heat input by cooling water entries)
	Other measure to improve self-purifying power

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As a preparatory step of the subsequent measure analysis, a survey requesting fundamental and extended information on the selection of measure examples was developed and filled in by the members of the TWG (Table 3).

Table 3: Overview on fundamental and extended information requested in measure surveys

Fundamental information	Description of measure
	Location of measure
	Status of measure
	Legislative assignment of measure
	Cost estimation
Extended information	Monitoring
	Initial assessment of effectiveness and sustainability
	Assessment of conflict potential and synergistic effects
	Site selection criteria
	Lessons learned
	Additional materials

Table 4: List of measure examples and reference

1	Elbe	Spadenlander Busch/Kreetsand	HPA (2012a)
2	Elbe	Underwater relocation area ‘Medemrinne Ost‘	HPA (2012b)
3	Elbe	Current deflection wall ‘Köhlfleet‘	HPA (2012c)
4	Elbe	Study on ´Investigation on freshwater current direction control at Bunthaus and possible impact on sedimentation patterns in the Port of Hamburg´	HPA (2012d)
5	Elbe	Sediment-Trap near Wedel	HPA (2012e)
6	Elbe	Compensation channel ‘Hahnöfer Nebenelbe’	HPA (2012f)
7	Elbe	Realignment Wrauster Bogen	HPA (2012g)
8	Elbe	Compensation measure Hahnöfer Sand (2002)	HPA (2012h)
9	Elbe	Spadenländer Spitze	HPA (2012i)
10	Elbe	Settlement of reed at the harbour location´Haken´	HPA (2012j)
11	Elbe	Land treatment of dredged material including MEchanical Treatment and Dewatering of HArbour-sediments (METHA)	HPA (2012k)
12	Elbe	Managing the ´Reiherstieg´ sluice to improve oxygen conditions	HPA (2012l)
13	Scheldt	Lippenbroek - flood control area with controlled reduced tide (FCA-CRT)	APA (2012a)
14	Scheldt	Groynes at Waarde	APA (2012b)
15	Scheldt	Ketenisse wetland - small scale tidal wetland restoration in the brackish part of the estuary	APA (2012c)
16	Scheldt	Paddebeek wetland- small scale tidal wetland restoration in the freshwater zone of the Seascheldt	APA (2012d)
17	Scheldt	Paardenschor- small scale brackish tidal wetland restoration in the Seascheldt	APA (2012e)
18	Scheldt	Heusden LO -small scale tidal wetland restoration in the freshwater zone of the Seascheldt	APA (2012f)
19	Scheldt	Schelde pilot project 2: Relocation of dredged sediment to deep areas of the navigation channel	APA (2012g)
20	Scheldt	TIDE pilot: Relocation of dredged sediment to a shallow water area at the edge of the Walsoorden sandbar (2004)	APA (2012h)
21	Scheldt	TIDE pilot: Relocation of dredged sediment to a shallow water area at the edge of the Walsoorden sandbar (2006)	APA (2012i)

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22	Scheldt	TIDE pilot: Relocation of dredged sediment to four shallow water areas at the edge of sandbars (2010)	APA (2012j)
23	Scheldt	Vispaaiplaats – Fish spawning pond	APA (2012k)
24	Weser	Tegeler Plate- Development of tidally influenced brackish water habitats	Saathoff, S. ,M. Wernick. (2012)
25	Weser	Shallow water area Rönnebecker Sand	Saathoff , S. and J. Lange. 2012c
26	Weser	Tidal habitat Vorder- und Hinterwerder	Saathoff , S. and H. Klugkist. 2012
27	Weser	Shallow water area Kleinensieler Plate	Saathoff , S. and J. Lange. 2012b
28	Weser	Cappel-Süder-Neufeld	Saathoff , S. and J. Lange. 2012a
29	Weser	TIDE pilot: Restoration of a dike foreland in Werderland – Feasibility study	Saathoff , S. and D. Hürter. 2012
30	Humber	Alkborough Managed Realignment and flood storage – Creation of ~440 a of intertidal habitat	EA (2012a)
31	Humber	Paull Holme Strays Managed Realignment – creation of ~80 ha of intertidal habitat	EA (2012b)
32	Humber	Hydromotion MudBug – determine the density of 'fluid' mud to determine the depth of the navigable channel (1250 kg/m³)	EA (2012c)
33	Humber	Creation of ~13 ha of intertidal habitat at Chowder Ness	EA (2012d)
34	Humber	Creation of ~54 ha of intertidal habitat at Welwick	EA (2012e)
35	Humber	Kilnsea Wetlands	EA (2012f)
36	Humber	South Humber Gateway Roosting Mitigation	EA (2012g)
37	Humber	Training walls Trentfalls	EA (2012h)
38	Humber	Donna Nook and Skeffling	EA (2012i)
39	Humber	Tunstall Realignment	EA (2012j)

3.2 Analysis approach development

The measure analysis focussed on describing the effects that can be obtained by the measures and on roughly estimating the effectiveness of a measure in view of different aspects and targets (e.g. development targets, ecosystem services (ES), Natura 2000 objectives, WFD objectives). In addition, lessons learned were collected and gaps of knowledge were identified, partly by involving the organisations in charge of measure planning and implementation. The set of analysis criteria was defined in consultation with all TIDE partners.
The analysis process was based on the contents of the measure surveys including basic measure related information and an initial assessment of effectiveness (see 3.1) added by a more detailed, goal oriented study of available monitoring reports and/or modelling results as well as expert knowledge.

3.2.1 Main effectiveness criteria

The measure effectiveness was primarily analysed in view of the criteria 'Effectiveness according to development targets of measure', 'Impact on ecosystem services (ES)' and 'Conflict potential and synergistic effects regarding uses' (chapters 3.2.1.1 to 3.2.1.3).

3.2.1.1. Effectiveness according to development targets of measure

The definition of development targets forms an integral part of the measure planning. Therefore, development targets were available for all measure examples considered. In order to roughly estimate the degree of target

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achievement (high, medium, low), the effectiveness of a measure related to its development targets was described and estimated.

3.2.1.2 Impact on ecosystem services (ES)

To analyse the measures regarding potential effects on different ecosystem services (ES) as defined in the frame of TIDE (JACOBS 2013), a two-step approach was executed.

First step: Targeted ES

In a first step, the ES targeted by a measure were determined by comparing the measure development targets with the descriptions of ES (JACOBS 2013). Some measures target several ES while others aim at one single ES (Table 5). Only the ES "biodiversity" (category habitat services) is targeted by many TIDE management measures.

Table 5: First step of the ecosystem services (ES) analysis: Indication of targeted ES for each measure example based on the development targets.

Ecosystem service*		Number of TIDE measures with this ES as target
S	"Biodiversity"	21
R1	Erosion and sedimentation regulation by water bodies	6
R2	Water quality regulation: reduction of excess loads coming from the catchment	1
R3	Water quality regulation: transport of pollutants and excess nutrients	2
R4	Water quantity regulation: drainage of river water	0
R5	Erosion and sedimentation regulation by biological mediation	0
R6	Water quantity regulation: transportation	0
R7	Water quantity regulation: landscape maintenance	3
R8	Climate regulation: Carbon sequestration and burial	0
R9	Water quantity regulation: dissipation of tidal and river energy	6
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	4
P1	Water for industrial use	0
P2	Water for navigation	5
P3	Food: Animals	0
C1	Aesthetic information	0
C2	Inspiration for culture, art and design	0
C3	Information for cognitive development	5
C4	Opportunities for recreation & tourism	3

Second step: Involved habitats

In a second step, the relative involvement of different habitats was evaluated following the habitat delineation as defined in the frame of TIDE (JACOBS 2013). The evaluation included both habitat surface (in % of measure site) and functional quality (scores from 1 to 5; see Table 6, Figure 2). Some measures create surface of a certain habitat while other measures improve the functional quality of a habitat without altering the surface. These factors were evaluated both for the starting situation and the situation after measure implementation. In the latter case, estimations are based on monitoring or modelling results.

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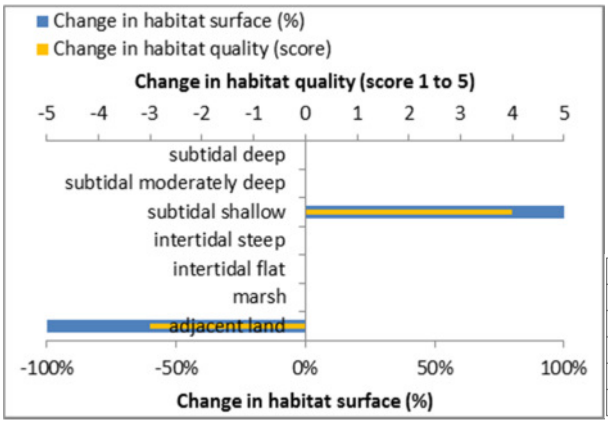
Table 6: Second step of the ecosystem services analysis: Indication of habitat surface and quality before and after measure implementation (Example: APA 2012k)

Habitat quality score
1 = very low quality
2 = low quality
3 = medium quality
4 = high quality
5 = very high quality

		before		after	
		surface (%)	quality (1-5)	surface (%)	quality (1-5)
Marsh habitat	above mean high water, floods at spring tide	**0**	**0**	**0**	**0**
Intertidal steep habitat	floods every tide, mainly steep zones at marsh edges	**0**	**0**	**0**	**0**
Intertidal flat habitat	floods every tide, flat zones	**0**	**0**	**0**	**0**
Subtidal shallow habitat	never surfaces, less deep than 2m	**0**	**0**	**100**	**4**
Subtidal moderately deep habitat	never surfaces, 2m-5m	**0**	**0**	**0**	**0**
Subtidal deep habitat	never surfaces, deeper than 5m	**0**	**0**	**0**	**0**
ADJACENT LAND	NON FLOODED LAND	**100**	**3**	**0**	**0**
		100		100	



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

Figure 2: Second step of the ecosystem services analysis: Indication of habitat surface and quality change, i.e. situation before versus after measure implementation. Example APA (2012k): The measure 'Fish spawning pond ('Vispaaiplaats')' in the mesohaline zone of the Scheldt estuary was about the creation of a fish spawning pond connected to a harbour dock by transforming adjacent land into subtidal shallow habitat with a high change in the habitat quality.

Assessment of ecosystem services: Indication of expected impact

These data (s. a.) was combined with the results of JACOBS 2013 that include an indication of the contribution of each habitat to the supply of ecosystem services (per estuary and per zone). The habitat contribution for the supply of ES is represented as a delivery score per habitat for each ES (JACOBS 2013).

An indicator for the expected increase or decrease in ES supply by the measure is provided by multiplying the delivery score (from the habitat-ES matrix, see JACOBS 2013) with the relative habitat change from the implementation of a measure (change in habitat surface and/or in habitat quality). For each TIDE measure, the analysis result is represented in a table (Table 7) with a score that maps the expected impact of the measure on the supply of each ES: from very negative (score -3, in dark red) to very positive (score +3, in dark green). Also the targeted ES are indicated in the table (orange box). A positive expected impact on ES that were not targeted indicates co-benefits of the measure.

It is important to emphasise that the resulting scores only apply within the boundary of the measure, since effects on adjacent land are not included. Hence, a conversion from adjacent land into estuarine habitat will cause positive effects on the supply of ES in the measure area. Negative effects will consequently only occur

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from a conversion from one estuarine habitat type into another, with the latter less suitable to supply certain ES.

Calculations: **Expected ES supply from the implementation of a measure**

Per habitat type:

Expected supply per ES per habitat type

=

Delivery score per habitat type (score 1 to 5, see JACOBS 2013)

×

Habitat change in the measure site per habitat type (= surface (%) × quality (score))

Overall:

Expected supply per ES

=

Sum expected ES supply of all habitat types together within the measure site

Result:

The resulting (dimensionless) score of expected ES supply is transformed to a scale of -3 (very negative expected impact) to +3 (very positive expected impact).

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Table 7: Second step of the ecosystem services (ES) analysis: (1) expected impact on ES supply in the measure site and targeted ES indicated by an orange box (Example: APA (2012k)). Expected impact on ES supply and on beneficiaries from very negative (score -3, in dark red) to very positive (score +3, in dark green). Overall, the measure generates a positive expected impact for many ES; mainly for 'biodiversity' and for various regulating services. The expected impact on the development target 'biodiversity' is very positive. For a correct interpretation of the ES assessment it is important to verify the expected results with the local context and put the non-relevant ES between brackets.

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	1
R3	Water quality regulation: transport of polutants and excess nutrients	2
(R4)	(Water quantity regulation: drainage of river water)	(1)
(R5)	(Erosion and sedimentation regulation by biological mediation)	(1)
(R6)	(Water quantity regulation: transportation)	(0)
(R7)	(Water quantity regulation: landscape maintenance)	(2)
R8	Climate regulation: Carbon sequestration and burial	1
(R9)	(Water quantity regulation: dissipation of tidal and river energy)	(3)
(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)	(0)
(P1)	(Water for industrial use)	(0)
(P2)	(Water for navigation)	(0)
(P3)	(Food: Animals)	(1)
C1	Aesthetic information	2
C2	Inspiration for culture, art and design	2
C3	Information for cognitive development	2
C4	Opportunities for recreation & tourism	2

X Targeted ES

Legend: expected impact*

3	very positive
2	positive
1	slightly positive
0	neutral
-1	slightly negative
-2	negative
-3	very negative

Based on the ES concept, the analysis described above gives an indication of the impact which can potentially be expected due to a measure. Additionally, it gives an indication of the measures' contribution to various beneficiaries as well as an idea of the potential impact regarding the measure targets intended to be achieved. Also, the analysis indicates which co-benefits can potentially be expected from the measure. Moreover, aimed at and co-benefits obtained by the measures in view of different ES were distinguished by the combination with the targeted ES (First step: Targeted ES). This step actually visualizes win-win opportunities for measures planned and implemented in estuaries.

The supply of a certain service by a habitat can be multiplied by its surface to get this qualitative statement. However, the surface-supply relationship is not the same for all habitats and services. Differences exist in the quantity of this relationship: e.g. one hectare of tidal flat will not supply the same 'amount of benefit' for nutrient capture as for sedimentation regulation. Also, surface-supply curves might be linear, exponential or saturated: e.g. deeper water will increase navigation service, but after a certain amount is reached and demand is met, the service will not further increase.

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It is important to emphasize that in this analysis, similar ES supplies per habitat and zones are assumed. However, habitats might differ substantially in quality and hence in ES supply. Therefore, a score for the local habitat quality as indicated by the members of the Transnational Working Group Measures (TWG Measures) was included in the calculation. This is however only a first rough qualitative estimation and it is recommended to compare the results with more local specificities of the measure to get an overall realistic view of the gained or lost ecosystem services. This analysis should be interpreted as a first indication of the expected impact on ES supply when implementing a certain measure.
For the measure 23 'Fish spawning pond" (APA2012k) it is for example important to compare the result of the ES assessment with the local context. The Fish Spawning Pond is located adjacent to a harbour dock and is hence not directly connected to the estuary. Although with this measure some subtidal shallow habitat is created, it will evidently not impact all estuarine ES since it is not directly connected. More specifically, this means that most of the considered regulating and provisioning services are not relevant for this measure (such as erosion control regulation of extreme events and water provisioning). Hence it is important to verify the resulting expected impact of the ES assessment with the local context of the measure and put the non-relevant ES between brackets (Table 7).

Expected impact on beneficiaries
In a last part, the expected impact in view of different beneficiaries is analysed. Two types of beneficiaries are included. One set of beneficiaries depends on the users' typology (direct, indirect and future use), and one set of beneficiaries depends on the spatial scale (local, regional and global use).
The first set of beneficiaries (direct, indirect and future users) is based on the widely used concept of Total Economic Value (TEV):

- Direct use is obtained through a removable product in nature (i.e. timber, fish, water); the outputs can be consumed directly.
- Indirect use is obtained through a non-removable product in nature (i.e. sunset, waterfall), i.e. societal or functional benefits.
- Future use (non-use) is the potential future ability to use a resource even though it is not currently used and the likelihood of future use is very low. This reflects the willingness to preserve an option for potential future use.

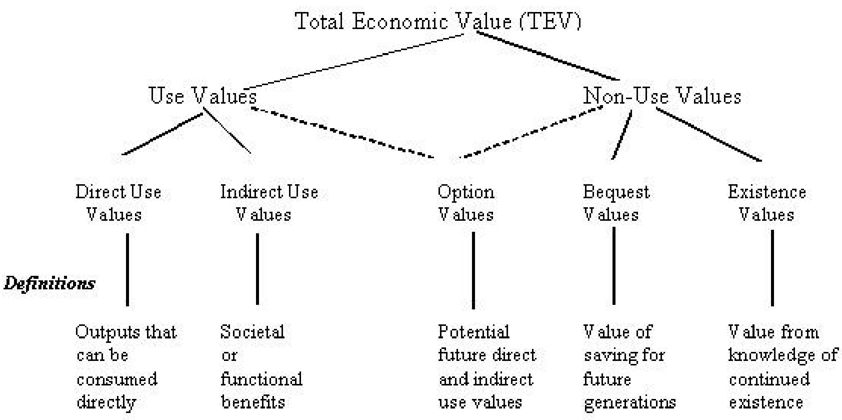

Figure 3: Concept of Total Economic Value (TEV) with different subcategories depending on the type of use (direct or indirect) or non-use

The expected contribution of each ES to the different beneficiaries is based on assigned values (Table 8). Habitat, regulating and cultural services are most beneficial for indirect and future use, while provisioning services are typically linked with direct use. Furthermore, most ES are beneficial at a local and regional scale and only a limited number of ES are beneficial at a global scale (mainly climate regulation).
This is combined with the expected impact of the measure on the supply of each ES (see above) to assess the expected impact of the measure on the various beneficiaries. The resulting dimensionless score of expected

impact on the different beneficiaries is also transformed to a scale of -3 (very negative impact) to +3 (very positive impact).

Table 8: Expected contribution of each ES to different beneficiaries (in %)

Ecosystem services*		Beneficiaries: users typology**			Beneficiaries: spatial typology**		
		Direct use	Indirect use	Future (non-use)	Local	Regional	Global
S	"Biodiversity"	0	20	80	30	30	40
R1	Erosion and sedimentation regulation by water bodies	0	50	50	70	30	0
R2	Water quality regulation: reduction of excess loads coming from the catchment	0	70	30	30	40	30
R3	Water quality regulation: transport of pollutants and excess nutrients	0	70	30	30	40	30
R4	Water quantity regulation: drainage of river water	0	30	70	30	70	0
R5	Erosion and sedimentation regulation by biological mediation	0	50	50	70	30	0
R6	Water quantity regulation: transportation	0	70	30	20	70	10
R7	Water quantity regulation: landscape maintenance	0	50	50	70	30	0
R8	Climate regulation: Carbon sequestration and burial	0	0	100	10	10	80
R9	Water quantity regulation: dissipation of tidal and river energy	0	30	70	70	30	0
R10	Regulation extreme events or disturbance: Wave reduction	0	30	70	70	30	0
R11	Regulation extreme events or disturbance: Water current reduction	0	30	70	70	30	0
R12	Regulation extreme events or disturbance: Flood water storage	0	30	70	70	30	0
P1	Water for industrial use	100	0	0	70	30	0
P2	Water for navigation	20	80	0	20	70	10
P3	Food: Animals	100	0	0	70	30	0
C1	Aesthetic information	0	50	50	40	40	20
C2	Inspiration for culture, art and design	0	50	50	40	40	20
C3	Information for cognitive development	0	50	50	40	40	20
C4	Opportunities for recreation & tourism	20	40	40	40	40	20

* Habitat services (S); Regulating services (R); Provisioning services (P); Cultural services (C)
**in %

Calculations:
<u>Expected impact for different beneficiaries from the implementation of a measure</u>

<u>Per ES</u>:

Expected impact per ES per beneficiary
=
Expected supply per ES
×
Contribution of every ES over the different beneficiaries (%)

<u>Beneficiaries</u>:

Expected impact per beneficiary
=
Sum expected impact per beneficiary for all ES together

<u>Result</u>:
The resulting (dimensionless) score of expected impact per beneficiary is transformed to a scale of -3 (very negative expected impact) to +3 (very positive expected impact).

The beneficiaries' analysis is represented per measure in a table (Table 9) with a score per beneficiary group representing the expected impact of the measure: from very negative (score -3, in dark red) to very positive (score +3, in dark green).

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Table 9: Step 2 of ecosystem services (ES) analysis: (2) expected impact on different beneficiaries as a consequence of measure implementation. Expected impact on beneficiaries from very negative (score -3, in dark red) to very positive (score +3) in dark green. Overall, the expected impact for the different beneficiary groups is positive with a specific positive impact for indirect and future use and for local use. Scores for ES supply from Table 7 (Example: APA 2012k)

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

Legend: Beneficiaries

3	very positive
2	positive
1	slightly positive
0	neutral
-1	slightly negative
-2	negative
-3	very negative

3.2.1.3 *Conflict potential and synergistic effects regarding uses*

Conflicts and synergistic effects were described and estimated that occurred during the planning stages or after implementation of a measure in view of different uses and interests. Conflicts and synergistic effects in view of agriculture, fishery, shipping and ports, leisure and local recreation, tourism, nature conservation, housing development, coastal defence, flood protection and industry were taken into account.

3.2.2 Additional evaluation criteria in view of EU environmental law

In addition to the main effectiveness criteria (chapter 3.2.1), additional evaluation criteria in view of EU environmental law (WFD, Natura 2000) were defined (chapters 3.2.2.1, 3.2.2.2).

3.2.2.1 *Conflicts and synergistic effects regarding WFD*

At this point in time, the majority of the European surface water bodies do not meet WFD requirements (NLWKN 2010). In order to achieve the directive's aims until 2015/2021, suitable measures have to be designed, planned and implemented. To do so successfully, the specific pressures a water body is affected by are to be taken into account. This means that a measure is the most effective if it tackles the main pressures of the respective surface water section. In order to estimate potential effects of the measure examples considered in terms of WFD, a relationship to existing pressures was made and the resulting deficits in view of WFD quality elements were described.
To identify the main pressures, different categories of Environmental Integrative Indicators (EIIs) as defined by Aubry and Elliott (2006) were taken as a basis. An environmental indicator is a qualitative or quantitative parameter characterising the current condition of an element of the environment (e.g. tonnage of material dredged). After Aubry and Elliott 2006, environmental indicators have the following three basic functions:

- **To simplify:** Amongst diverse components of an ecosystem, few indicators are selected according to their perceived relevance for characterising the overall state of the estuary
- **To quantify:** The value of the indicator is compared with reference values considered to be characteristic of 'pristine' or heavily impacted ecosystems. For example, the ecological status of water bodies assigned under the WFD related to the determination of changes from reference to expected conditions.
- **To communicate:** The use of indicators facilitates communication on environmental issues to stakeholders and policy makers by promoting information exchange and comparison of spatial and temporal patterns.

Being subdivided into 'State Indicators' and 'Driver Indicators' (Table 10), the relevance of EIIs in view of the respective estuary zone was indicated:

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- **State Indicator:** Indicates the current state of a system (= estuary zone) looking at the changes that took place in the past.
- **Driver Indicator:** Indicates the processes and activities which caused the current state of the system (= estuary zone)

Table 10: State and driver indicators used to identify potential main pressures for TIDE estuaries (changed and added after AUBRY & ELLIOTT 2006)

Indicator category*	Code**	Description
State Indicator	1.1	Habitat loss and degradation during the last about 100 years: Intertidal
	-	Habitat loss and degradation during the last about 100 years: Subtidal
	1.4	Gross change in morphology during the about 100 years
	1.5	Gross change in hydrographical regime during the last about 100 years
	3.1/3.2	Decrease of water and sediment chemical quality
	3.3	Increased chemical loads on organisms
	3.4	Decrease of microbial quality
	3.8	Aesthetic pollution
Driver Indicator	1.3	Land claim during the last about 100 years
	1.7	Relative Sea Level Rise
	2.3	Discharge of nutrients and/or harmful substances
	2.4	Maintenance dredging
	2.5a	Relocation of dredged material
	2.8	Wind farm development
	2.9	Aquaculture
	2.10	Fisheries activities
	2.11	Marina development
	2.12	Port developments
	-	Industrial development
	2.13	Installation of pipelines and cables
	2.14	Oil and gas exploration and production
	2.16	Tourism and recreation

*Subdivision into state and driver indicators took place in the frame of TIDE.
**Codes for EIIs according to AUBRY AND ELLIOTT 2006; EIIs without indication of code were added in the frame of TIDE.

First step: Pressures screening
The identification of pressures was based on surveys filled in by Regional Working Groups (RWGs) at the TIDE estuaries. The RWG composition at Weser, Elbe, Humber and Scheldt can be taken from annex 10.1. Details on the WFD survey can be taken from annex 10.2.
An EII scored highly or very highly relevant was supposed to map potential main pressures of the respective estuary zone. The zonation schemes used in the frame of TIDE can be taken from GEERTS et al. 2011. For each estuary zone, not more than six main pressures were to be named.

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Second step: Evaluation of measure effects

In a second step, the results of the pressures screening were taken as a basis to produce template tables referring to the different estuary zones defined for Weser, Elbe, Humber and Scheldt. These were used to indicate and describe the measure effects regarding the main pressures identified for the estuary zone where the measure was planned or implemented (Tables 11 - 12).

Table 11: Effects of measure 'Tidal habitat Vorder- und Hinterwerder' (SAATHOFF AND KLUGKIST 2012) on main pressures identified for freshwater zone of 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.

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

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Table 12: Effects of measure 'Tegeler Plate – development of tidally influenced brackish water habitats' (Saathoff und Wernick 2012) on main pressures identified for oligohaline zone of Weser estuary

Indicator Group	Code	Main pressures **oligohaline** zone Weser	Effect?					Description
			- -	-	0	+	++	
S.I.	-	Habitat loss and degradation during the last 100 years: Subtidal					X	As a result of measure implementation, additional subtidal areas were created.
S.I.	1.1	Habitat loss and degradation during the last 100 years: Intertidal					X	As a result of measure implementation, additional intertidal areas were created.
S.I.	1.4/ 1.5	Gross change in morphology/hydrographic regime during the last about 100 years				X		Natural erosion and sedimentation processes were promoted.
D.I.	1.3	Land claim during the last about 100 years					X	Due to measure implementation, the tidal influence on the project area was increased and the Tegeler Plate – formerly used for agricultural purposes- was nearly completely left to natural succession.
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.
D.I.	2.4	Maintenance dredging				X		Due to measure implementation, the Tegeler Plate provides additional sedimentation area. As a consequence, this may lead by trend to less maintenance effort in the river Weser.

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

3.2.2.2 Conflicts and synergistic effects regarding Natura 2000

Major parts of the TIDE estuaries belong to the European Natura 2000 network (NLWKN, SUBV 2012). The Natura 2000 network includes protected areas after the Habitat Directive (RL 92/43/EWG) and the Birds Directive (RL 2009/147/EG). The Habitat Directive (HD) wants to contribute to biodiversity within the member states of the European Union (EU) by protecting natural habitats and species (see HD, Article 2 (1)). The Birds Directive (BD) aims at protecting all native bird species. After both directives, protected areas with specific conservation objectives are to be declared. These conservation objectives were taken into account to estimate the synergistic effects of a measure in view of Natura 2000 aims. If a measure was not planned or implemented in a Natura 2000 site and has no effect on adjacent Natura 2000 sites, no analysis according to this criterion took place.

The analysis of potential synergistic effects and conflicts of measures in view of Natura 2000 was designed to follow a two-step approach. In fact, the two-step approach was exclusively realised for measures planned and implemented at the Weser estuary. The individual proceedings realised at the different TIDE estuaries are described below.

First step: Effectiveness regarding conservation objectives for defined spatial units

The first analysis step represents a rough screening of the effectiveness of measures in view of Natura 2000 objectives for certain spatial units (Table 13). Potential positive and negative measure effects in view of the objectives defined were estimated by combining the development targets of the measures (including the degree of target achievement, see 3.2.1.1) with the conservation objectives of the spatial unit where the measure was planned or implemented. The Natura 2000 site where the respective measure is situated can be taken from the measure survey (see 3.1).

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Table 13: First step of Natura 2000 analysis: Indication of potential effects on Natura 2000 objectives defined for a certain spatial unit following a simple valuation system (++, +, 0, -, --)

Conservation objective for spatial unit	**Effects of measure**				
	very positive (++)	positive (+)	no effects (0)	negative (-)	very negative (--)
Conservation objective 1					
Conservation objective 2					
Conservation objective 3					
…					

Second step: Effectiveness regarding overall conservation objectives
The second analysis step comprises a comparison with overall Natura 2000-conservation objectives ideally referring to the entire tidally influenced river sections (Table 14). If a measure tackles an overall Natura 2000 objective, its effectiveness increases.

Table 14: Step 2 of Natura 2000 analysis: Indication of potential effects on overall conservation objectives following a simple valuation system (++, +, 0, -, --)

Overall conservation objective	**Effects of measure**				
	very positive (++)	positive (+)	no effects (0)	negative (-)	very negative (--)
Conservation objective 1					
Conservation objective 2					
Conservation objective 3					
…					

Regarding both analysis steps, the indication of positive and negative effects followed a simple valuation system (very positive, positive, no effects, negative, very negative).

Analysis proceeding for measures planned or implemented at the Weser estuary
The analysis of the Weser measures in view of Natura 2000 is based on the contents of the Integrated Management Plan Weser (NLWKN, SUBV 2012). The plan refers to Natura 2000 sites of the tidally influenced river sections of the Weser and was set up based on administrational agreements of the bordering federal states and the federal waterways administration.
The Integrated Management Plan Weser (IMP Weser) aims at describing ecological and economic conditions, interests and planning and at deriving possible solutions for a successful implementation of the Natura 2000 directives within the investigation area. The plan is based on an extensive participation process in order to give stakeholders the chance to hold their view (see also BOYES, CUTTS 2012)
The federal state governments of Lower Saxony and Bremen were assigned to coordinate the interdisciplinary stakeholder groups and to work out a program of targets and measures in order to preserve the Natura 2000 subjects of protection.
The IMP Weser is not legally binding, but is to serve as guidance for future state action in Lower Saxony and Bremen.
The investigation area of the IMP Weser is subdivided into the following seven operational areas (Figure 4):

- **Operational area 1:** Meso-/polyhaline zone in the outer Weser estuary (Weser-km 40 - 65)
- **Operational area 2:** Oligohaline zone in the lower Weser (Weser-km 40 - 65)
- **Operational area 3:** Fresh water zone in the lower Weser (Weser-km 12 - 32)
- **Operational area 4:** Side branches of the oligohaline zone (Schweiburg and Rechter Nebenarm)
- **Operational area 5:** Side branches of the fresh water zone (Rekumer Loch, Woltjenloch, Westergate, Warflether Arm)
- **Operational area 6:** Tributary Hunte (fresh water)
- **Operational area 7:** Tributary Lesum (fresh water)

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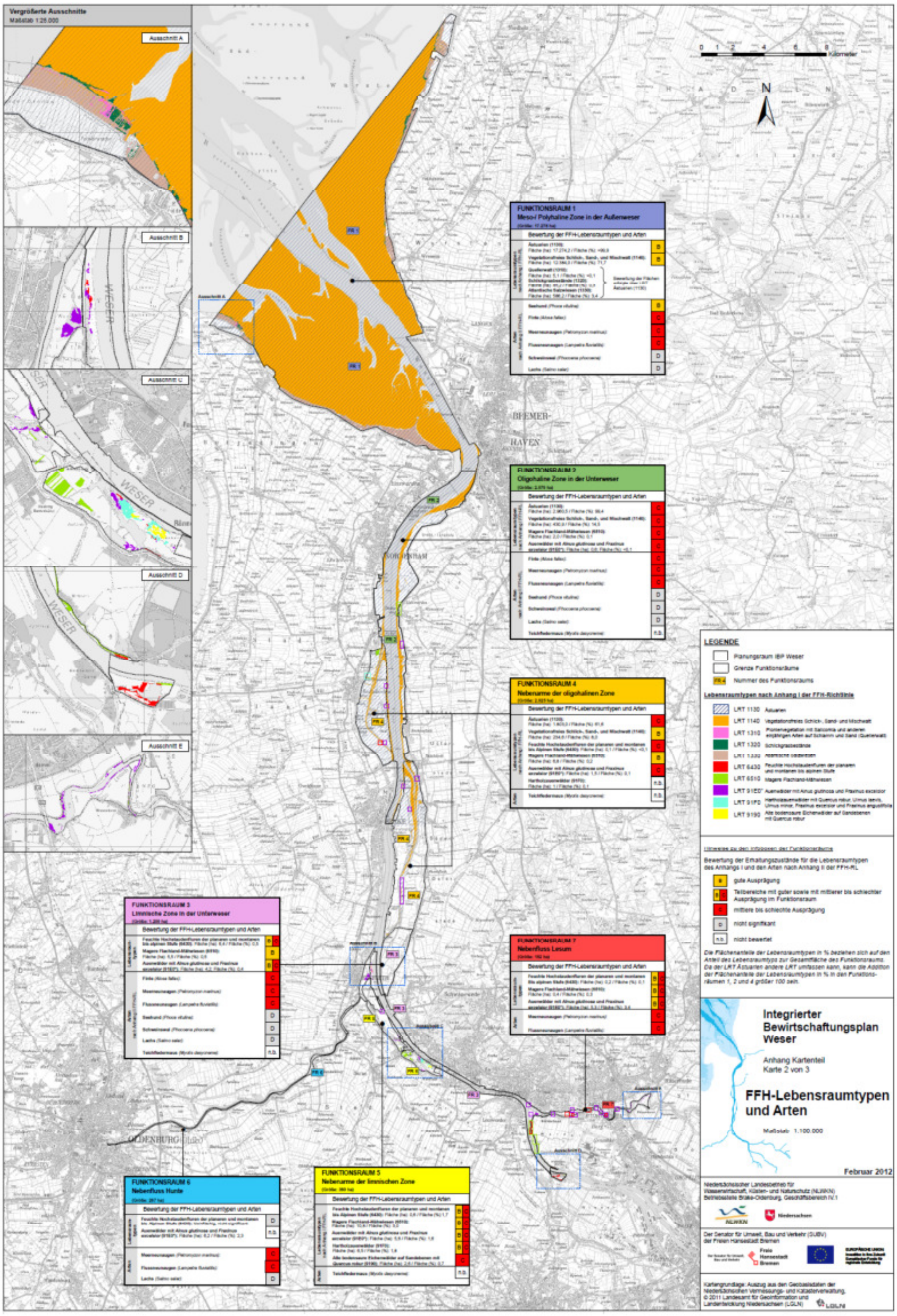

Figure 4: Operational areas ('Funktionsräume') according to Integrated Management Plan Weser (NLWKN, SUBV 2012)

Each operational area represents an ecologically consistent subunit of the IMP Weser investigation area, which can be described and assessed. For each operational area, Natura 2000 conservation objectives were formulated (for example see 'Shallow water area Rönnebecker Sand' within operational area 3/freshwater zone, Table 15). The conservation objectives for the operational areas relevant in the frame of TIDE (operational areas 1 - 3) can be taken from annex 8.3

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Table 15: Natura 2000-objectives with specifications for operational area 3 in the lower Weser estuary after NLWKN, SUBV 2012 (Example: Saathoff and Lange 2012c). In the frame of the measure analysis, the measure effects were indicated following a simple valuation system (very positive (++); positive (+); no effects (0); negative (-); very negative (--))

Operational area 3: Freshwater zone in the lower Weser (Weser km 12 - 32)				
Specifications for operational area 3	**Effect of measure 'Shallow water area Rönnebecker Sand' 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 shallow water zone is connected to the Weser River by an overflow barrier that is basically 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 shallow water area Rönnebecker Sand takes over various functions of tidal floodplain backwaters.
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)	+			The project area represents a breeding site of importance for the federal state of Lower Saxony (Bios 2007a)
Conservation and development of undisturbed resting and moulting areas for migratory bird populations (high diversity, many individuals) considering all necessary functions	+			The migratory bird population can be described as species and individuals rich due to structure diversity (e.g. shallow and deep water, grassland) and due to few disturbances (Bios 2007a)
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*)	+			Not investigated, but the occurrence of Pond bat is likely.
Preservation and development of spawning ground function for Twaite shad (e.g. by avoiding disturbances during spawning season)	+			In 2009, some spawn of Twait shad was found in the shallow water zone. Due to low current velocities, the shallow water zone itself is not supposed to serve as spawning ground for Twaite shad. However, discharges of oxygen, zooplankton (*Eurytemora affinis*) and Mysida from the shallow water zone directly into the main spawning ground of Twaite shad take place and contribute to improving the growing conditions (Haesloop 2009).
Conservation and development of spawning ground function for Smelt (*Osmerus eperlanus*) (e.g. by avoiding disturbances during spawning season)	+			Larvae and juveniles were found in the shallow water zone in 2004/2005 and in 2009 (Haesloop 2009).

Additionally, Natura 2000 objectives for the entire IMP investigation area Weser were formulated (for example see 'Shallow water area Rönnebecker Sand', Table 16).

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Table 16: Natura 2000-objectives with specifications for entire investigation area of the Integrated Management Plan Weser after NLWKN, SUBV 2012 (Example: Saathoff and Lange 2012c). In the frame of the measure analysis, the measure effects were indicated following a simple valuation system (very positive (++); positive (+); no effects (0); negative (-); very negative (--)).

Specifications for entire investigation area of IBP Weser	**Effect of measure 'Shallow water area Rönnebecker Sand' 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	+		
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 as well as 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	+		
Conservation and development / reestablishment of passability of the tidal river Weser and its tributaries for migratory fish and benthic invertebrates		0	

The Natura 2000 analysis of the Weser measures refers to the conservation objectives on both levels. The most effective measures tackle both the overall conservation objectives and the area specific conservation objectives.

Analysis proceeding for measures planned or implemented at the Elbe estuary

The analysis of the Elbe measures in view of Natura 2000 is based on the contents of the Integrated Management Plan Elbe (AG ELBE 2012).The plan refers to Natura 2000 sites of the tidally influenced river sections of the Elbe and was set up based on administrational agreements of the bordering federal states, the port and waterways administrations.

The Integrated Management Plan (IMP) for the tidally influenced section of the river Elbe aims at describing ecological and economic conditions, interests and planning and at deriving possible solutions for a successful implementation of the Natura 2000 directives within the investigation area. The plans are based on an extensive participation process in order to give stakeholders the chance to hold their view (see also BOYES, CUTTS 2012).

The IMP Elbe is not legally binding, but is to serve as guidance for future state action.

The investigation area of the IMP Elbe is subdivided into seven operational areas:

- **Operational area 1:** from Geesthacht to Hamburg
- **Operational area 2:** Hamburger Hafen
- **Operational area 3:** Hamburg to Lühesand
- **Operational area 4:** Lühesand to Brokdorf
- **Operational area 5:** Brokdorf to Oste tributary
- **Operational area 6:** Oste tributary to Cuxhaven/Neufeld
- **Operational area 7:** Tributaries Pinnau, Krückau, Stör and Oste

For each operational area, conservation objectives including overall objectives as well as area specific development targets were formulated. Consequently, the evaluation of the Elbe measures in view of the Natura 2000 was preceded in one step. For the detailed list of management targets per functional zone please refer to annex 10.3.

Analysis proceeding for measures planned or implemented at the Scheldt estuary

The analysis of the Scheldt measures in view of Natura 2000 is based on the contents of the Long Term Vision (LTV 2001) for the Scheldt estuary for 2030 and Development plan 2010 (*Ontwikkelingsschets* – OS; PROSES 2004). These bilateral agreements fit in the long-term cooperation between both neighbour states. The overall target of LTV includes the conservation of the physical characteristics of the estuary and the optimal balance between safety, accessibility and environment. Regarding the environmental aspect, this means specifically the sustainable preservation of a large diversity of habitats with associated species communities until 2030. Therefore, ecological objectives were developed regarding the naturalness aim from the LTV:

- A large diversity in estuarine habitat (marshes, mudflats, shallow water and sandbars in fresh, brackish and saline water) with sustainable associated life communities;
- Space for natural dynamical physical, chemical and ecological processes. Maintenance of the multiple-channel system in the Westerschelde;
- The water quality may not be a limiting factor anymore.

An environmental development plan (*Natuurontwikkelingsplan* – NOP; VAN DEN BERGH et al 2005) was developed for the realisation of the ecological objectives. For the further implementation of LTV (including the Development plan 2010; PROSES 2004) and the Natura 2000 directives, management is divided between the two nations: the Netherlands for the Westerschelde and Belgium (Flanders) for the Zeeschelde.

The conservation objectives were developed separately for both parts of the Scheldt estuary. For the Westerschelde (The Netherlands), conservation objectives were developed within the general Natura 2000 management plan. For the Zeeschelde (Flanders), conservation objectives were developed separately for the Scheldt estuary already in 2005.

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Conservation objectives Zeeschelde (Flanders, Belgium)

The objectives for the different EU directives (WFD, BHD) and the LTV for the Scheldt are interrelated and integrated in three hierarchical levels including the ecosystem level, the habitat level and the species level. The carrying capacity of the ecosystem is the highest level. The objectives for habitats and species are subordinated to that, but therefore not less important.

On the **habitat level**, conservation objectives are defined depending on the relative importance of habitats (essential, important, locally important). For all listed habitats, a good condition should be guaranteed including a minimal surface and specific abiotic conditions (Table 17).

Table 17: Important habitats defined for the Zeeschelde (Flanders, Belgium) according to Habitat Directive (RL 92/43/EWG); Adriaensen et al 2005

Importance of the habitat in Flanders	
"Essential"	• 1130: estuary • 1140: Mudflats and sandflats not covered by seawater at low tide (subtype fresh) • 1330: Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) • 91E0: Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae) (subtype willow)
"Important"	• 1140: Mudflats and sandflats not covered by seawater at low tide (subtype brackish) • 1310: *Salicornia* and other annuals colonizing mud and sand • 1320: *Spartina* swards (*Spartinion maritimae*) • 1330: Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) (subtype brackish) • 3150: Natural eutrophic lakes with Magnopotamion or Hydrocharition – type Vegetation • 6430: Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels (subtype wet) • 6430: Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels (subtype dry) • 6510: Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*) • 7140: Transition mires and quaking bogs • 91E0: Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae) (subtype Alder) • Caltha grassland • Reed bed
"Locally important"	• 2310: Dry sand heaths with *Calluna* and *Genista* • 2330: Inland dunes with open *Corynephorus* and *Agrostis* grasslands • 4030: European dry heaths • 6410: *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) • 9120: Atlantic acidophilous beech forests with *Ilex* and sometimes also *Taxus* in the shrublayer (*Quercion robori-petraeae* or *Ilici-Fagenion*) • 9160: Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli* • 9190: Old acidophilous oak woods with *Quercus robur* on sandy plains • *Cyperaceae*

On the **species level**, conservation objectives referring to pelagial, mudflats, marshes as well as structural diversity and connectivity are formulated. A detailed list of the conservation objectives defined on the species level can be taken from 10 8.3.

Conservation objectives Westerschelde (The Netherlands)

General objectives are to conserve or restore

- the contribution of the Natura 2000-area to the ecological consistency of Natura 2000 both in the Netherlands and in the European Union,
- the contribution of the Natura 2000-area to the biological diversity and to the favourable state of conservation of natural habitats and species in the European Union,
- the natural characteristics of the Natura-2000 area, including the consistency of the structure and functions of the habitat types and of the targeted species
- and the area-relevant ecological objectives of the targeted habitat types and species.

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Specific objectives according to Habitat Directive (RL 92/43/EWG) are to conserve, restore or expand the following habitat types:

- Sandbanks which are slightly covered by sea water all the time (H1110)
- Estuaries (H1130)
- *Salicornia* and other annuals colonizing mud and sand (H1310)
- *Spartina* swards (*Spartinion maritimae*) (H1320)
- Atlantic salt meadow (*Glauco-Puccinellietalia maritmae*) (H1330)
- Embryonic shifting dunes (H2110)
- Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes") (H2120)
- Dunes with *Hippophaë rhamnoides* (H2160)
- Humid dune slacks (H2190)

Also, habitat surface and quality to preserve or improve the following populations are to be conserved:

- Narrow-mouthed whorl snail (*Vertigo angustior*) (H1014)
- Sea lamprey (*Petromyzon marinus*) (H1095)
- European river lamprey (*Lampetra fluviatilis*) (H1099)
- Twaite Shad (*Alosa fallax*) (H1103)
- Earless seal (*Phocidae*) (H1365)
- *Liparis loeselii* (H1903)

Specific objectives according to Birds Directive (RL 2009/147/EG) are to conserve habitat surface and quality with a carrying capacity for a minimum population of the breeding bird and minimum numbers of non-breeding bird species represented in tables 18 and 19.

Table 18: Conservation objectives formulated for the Westerschelde (The Netherlands) in view of breeding birds according to the Birds Directive (RL 2009/147/EG) with indication of minimum population

Code	**Specie name**	**Scientific name**	**Conservation Objective: Minimum number of bird couples**
A081	Western Marsh Harrier	*Circus aeruginosus*	20
A132	Pied Avocet	*Recurvirostra avosetta*	2000
A137	Common Ringed Plover	*Charadrius hiaticula*	100
A138	Kentish Plover	*Charadrius alexandrines*	220
A176	Mediterranean Gull	*Ichthyaetus melanocephalus*	400
A191	Sandwich Tern	*Thalasseus sandvicensis*	4000
A193	Common Tern	*Sterna hirundo*	6500
A195	Little Tern	*Sternula albifrons*	300
A272	Bluethroat	*Luscinia svecica*	450

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Table 19: Conservation objectives formulated for the Westerschelde (The Netherlands) in view of non-breeding birds according to the Birds Directive (RL 2009/147/EG) with indication of minimum numbers

Code	**Specie name**	**Scientific name**	**Conservation Objective: average number of birds (seasonal average)**
A005	Grebe	*Podicipedidae*	100
A026	Little Egret	*Egretta garzetta*	40
A034	Eurasian Spoonbill	*Platalea leucorodia*	30
A041	Greater White-fronted Goose	*Anser albifrons*	380
A043	Greylag Goose	*Anser Anser*	16600
A048	Common Shelduck	*Tadorna tadorna*	4500
A050	Eurasian Wigeon	*Anas penelope*	16600
A051	Gadwall	*Anas strepera*	40
A052	Eurasian Teal	*Anas crecca*	1100
A053	Mallard	*Anas platyrhynchos*	11700
A054	Northern Pintail	*Anas acuta*	1400
A056	Northern Shoveler	*Anas clypeata*	70
A069	Red-breasted Merganser	*Mergus serrator*	30
A075	Fish Eagle	*Haliaeetus*	2
A103	Peregrine Falcon	*Falco peregrinus*	7500
A130	Eurasian Oystercatcher	*Haematopus ostralegus*	7500
A132	Pied Avocet	*Recurvirostra avosetta*	540
A137	Common Ringed Plover	*Charadrius hiaticula*	430
A138	Kentish Plover	*Charadrius alexandrines*	80
A140	European Golden Plover	*Pluvialis apricaria*	1600
A141	Grey Plover	*Pluvialis squatarola*	1500
A142	Northern Lapwing	*Vanellus vanellus*	4100
A143	Red Knot	*Calidris canutus*	600
A144	Sanderling	*Calidris alba*	1000
A149	Dunlin	*Calidris alpina*	15100
A157	Bar-tailed Godwit	*Limosa lapponica*	1200
A160	Eurasian Curlew	*Numenius arquata*	2500
A161	Spotted Redshank	*Tringa erythropus*	270
A162	Common Redshank	*Tringa totanus*	1100
A164	Common Greenshank	*Tringa nebularia*	90
A169	Ruddy Turnstone	*Arenaria interpres*	230

Summarised, the Natura 2000 analysis of the Scheldt measures refers to both the overall ecological objectives for the estuary (LTV and OS) and the regional conservation objectives for the region in which the measure is situated (Westerschelde or Zeeschelde).

Analysis proceeding for measures planned or implemented at the Humber estuary
The analysis of the Humber measures in view of Natura 2000 is based on the Humber Management Scheme (HMS) which aims to deliver sustainable management of the Humber Estuary European Marine Site (HMS 2011). The Humber European Marine Site, which the HMS was set up to manage, covers the marine areas (land covered continuously or intermittently by tidal waters) of the Humber Estuary SAC, the SPA and Ramsar sites. The objectives of the HMS 2011A are five-fold as outlined below:

- To manage the estuary to meet the requirements of the conservation objectives
- To bring people and organizations together to deliver the sustainable management of the Humber Estuary European Marine Site
- To raise awareness and educate stakeholders about the Humber Estuary European Marine Site and increase participation in its management
- To identify information gaps and research requirements and to promote sharing and availability of data for the management of the Humber Estuary European Marine Site
- To ensure a coordinated approach to the management of the estuary and its hinterlands including planning for the future in respect to the features of the Humber Estuary European Marine Site

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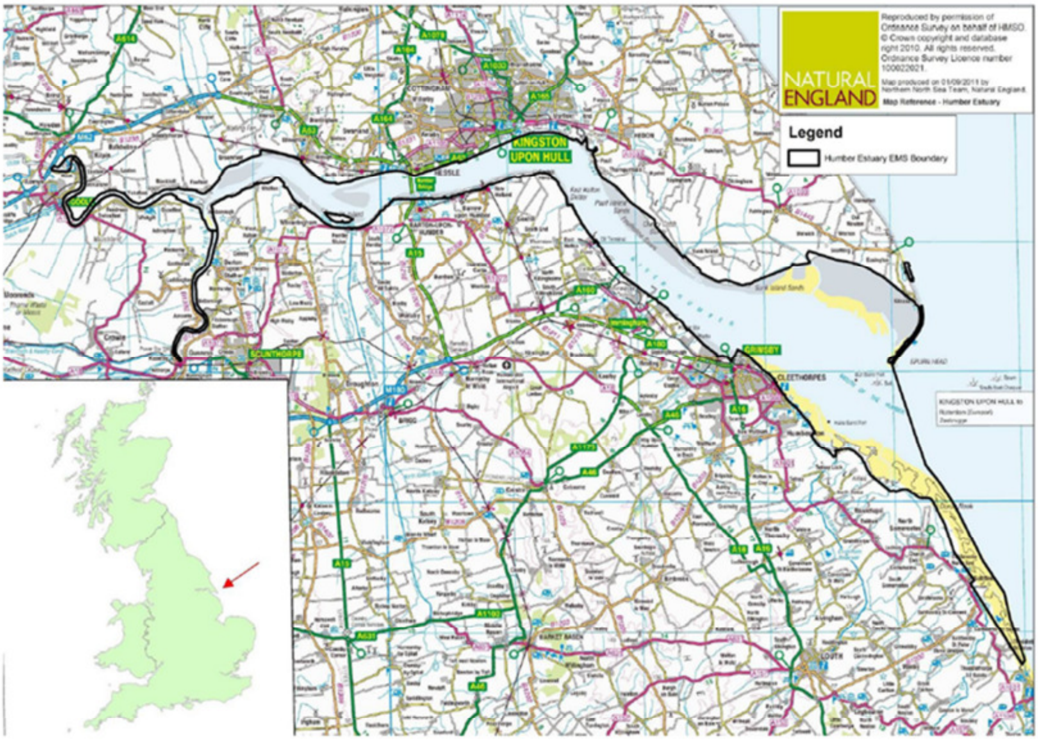
Whilst updating the HMS Action Plans during 2010 and 2011, consultation with stakeholders was undertaken. A workshop was held in late 2010 which was attended by nearly 20 people including statutory organisations, industry, voluntary sector, recreational users, academics and those with an interest in the estuary. The group discussed the future priorities of the Humber Management Scheme and tools to help deliver the Scheme in the future which led to the publication of the objectives outlined above and the Action Plans (HMS 2011A).



Map 1: Humber Estuary European Marine Site Designation

Figure 5: Humber Estuary European Marine Site (HMS 2011b)

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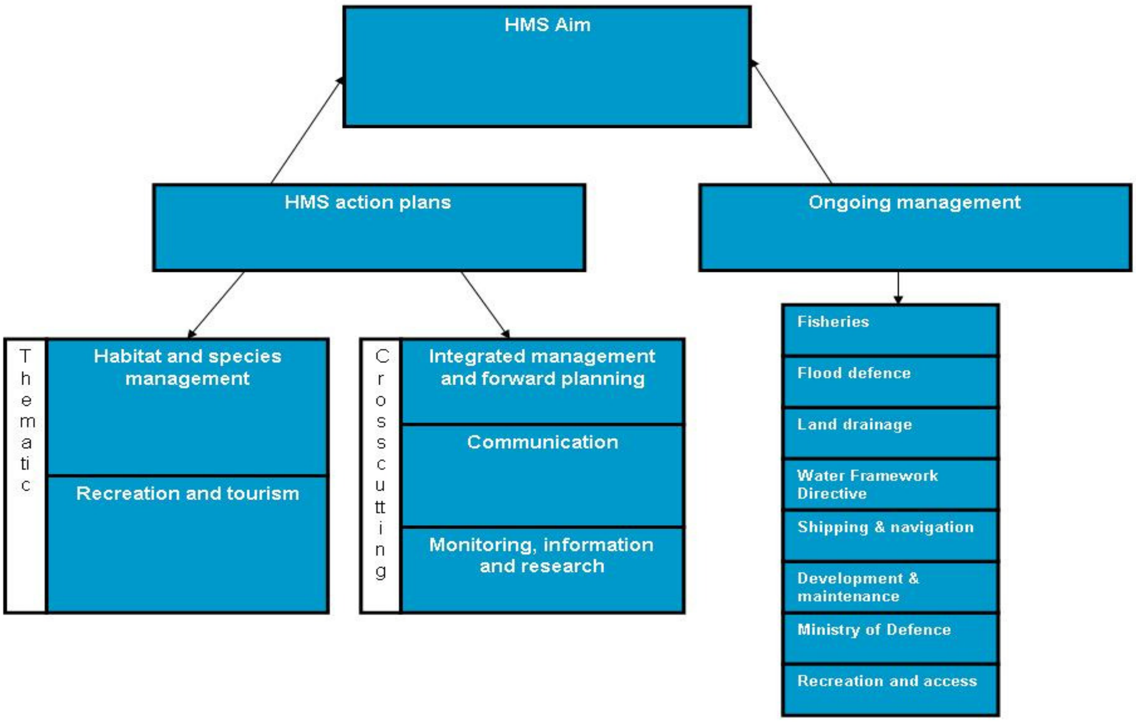

Figure 6: The Humber Management Scheme structure to deliver aims and objectives (HMS 2011b)

Through the consultation the HMS action plans were developed for the sustainable management of the Humber Estuary European Marine Site (Figure 5). The actions will be delivered by both statutory and non-statutory organizations individually or as a partnership through the Humber Estuary Relevant Authorities Group (HERAG) and the Humber Advisory Group (HAG). Some actions will also be lead by the Humber Management Scheme. Through consultation the HMS has identified five key areas for delivery to ensure the sustainable management of the Humber Estuary European Marine Site (HMS 2011a):

- Habitat and species management
- Recreation and tourism
- Communication
- Monitoring, information and research
- Integrated management and forward planning

Each key area of delivery has an overall objective with specific detailed objectives. For example the habitat and species management overall objective is to manage the estuary to meet the requirements of the conservation objectives. This is delivered by the detailed objectives set out below, which is turn is delivered via the specific management plans identified in annex 10.3.

Detailed objectives:

- Habitat management: To identify and deliver habitat management to meet the conservation objectives
- SPA birds: To identify and deliver management for SPA birds to meet the conservation objectives including the management of high tide roosting and feeding areas.
- Sub-tidal: To identify and deliver management for the sub-tidal to meet the conservation objectives

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- Grey seals: To identify and deliver management for the grey seals to meet the conservation objectives
- Lamprey: To identify and deliver management for the river and sea lamprey to meet the conservation objectives

The Natura 2000 analysis of the Humber measures refers to the overall objectives of the Natura 2000 site and some of the unit specific objectives. The most effective measures are those that tackle both to SPA and SAC conservation objectives, as well at the unit specific conservation objectives.

3.2.3 Crux of the matter

Finally, the individual frame conditions and the lessons learned in the process of planning and implementing a measure were taken into account. An initial description of the lessons learned is an integral part of the measure surveys (see 3.1). These were taken as a basis for more comprehensive descriptions ideally based on the experiences of people directly involved in the planning and implementation process.

3.3 Consistency check of analysis results

In order to ensure the consistency of results in terms of structure and layout, a consistency check was executed based on a guidance document prepared by NLWKN. The TWG members reworked the analysis results respectively. The content-related responsibility for the analysis results rests with the authors.

3.4 Develop concepts for cross estuary comparison of measures

Based on the results of the measure analysis, the members of the TWG Measures had the chance to develop and subsequently apply individual concepts to compare the selected and analysed measures according to the interests of the respective project partner represented. Respective concepts were elaborated by HPA and APA (see table 20).

Table 20: Subjects and responsibilities for cross estuary comparison studies

Subject	Author
Measures influencing sedimentation processes	HPA
Managed re-alignment measures	APA

3.5 Deduce recommendations for estuary managers

In line with the overall aim of the TIDE project to make contributions to an integrated estuary management, recommendations addressed to estuary managers in terms of future measure planning and implementation processes were deduced (Chapter 7 and 8).

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4. Pilot projects

In the runtime of TIDE, several pilot projects were realised at the estuaries of Weser, Elbe, Humber and Scheldt (Table 21). The pilot projects primarily address a question of specific interest in view of the estuary they refer to, but they also provide results transferable to other estuaries of the North Sea region. The reports on the pilot projects are available via www.tide-toolbox.eu.

Table 21: Pilot projects implemented at Weser, Elbe, Humber and Scheldt in the runtime of TIDE, reports available via www.tide-toolbox.eu

Estuary	**Title of pilot project**	**Responsible project partner, Reference**
Weser	Identification of potential areas for the development and creation of subtidal Hard Substrate Habitats in the Outer Weser Estuary – Pilot study in the framework of the Interreg IVB project TIDE	NLWKN, KÜFOG&NLWKN (2011)
	Ecological requirements for revitalizing anabranches of the Lower Weser Estuary against the backdrop of WFD and Natura 2000 using the Schweiburg as an example – Feasibility study in the framework of the Interreg IVB project TIDE	NLWKN, Bioconsult & NLWKN (2012)
	Occurrence and Importance of Secondary Channels in European Estuaries - Literature study in the framework of the Interreg IVB project TIDE	NLWKN, Küste und Raum & NLWKN (2012)
	Restoration of a tidal foreland in the Werderland region (Feasibility study)	SWH, Birkhoff (2012)
Scheldt	Sediment relocation to shallow water near Walsoorden sandbar	MOW, Vos et al. (2009)
	Morphological management of estuaries: case study of the Scheldt estuary	APA, APA (2012)
Elbe	Evaluation of the sediment trap near Wedel by Hamburg	HPA, HPA (2013)
Elbe/ Scheldt	Joint study on mitigation measures in the estuary mouth	MOW & HPA, MOW & HPA(2013)
Humber	The Potential Alternative uses of Dredged Material in the Humber Estuary	EA, Lonsdale (2012)

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5. Results of measure collection and analysis

5.1 Measure collection and basic info compilation

In total, 39 measures planned or implemented at the four TIDE estuaries were collected (Table 22).

Table 22: Overview on measure examples collected, analysed and compared with indication of short titles and status. The full measure titles can be taken from annex 10.4.

No.	Estuary	Measure example	Status	
			planned	implemented
01	Elbe	Spadenlander Busch		x
02	Elbe	Medemrinne Ost	x	
03	Elbe	Current deflection wall		x
04	Elbe	Bunthaus		x
05	Elbe	Sediment trap Wedel		x
06	Elbe	Hahnöfer Nebenelbe		x
07	Elbe	Wrauster Bogen		x
08	Elbe	Hahnöfer Sand		x
09	Elbe	Spadenlander Spitze		x
10	Elbe	Reed settlement Haken		x
11	Elbe	METHA		x
12	Elbe	Managing Reiherstieg sluice	x	
13	Scheldt	Lippenbroek		x
14	Scheldt	Groynes Waarde		x
15	Scheldt	Ketenisse wetland		x
16	Scheldt	Paddebeek wetland		x
17	Scheldt	Paardenschoor wetland		x
18	Scheldt	Heusden LO wetland		x
19	Scheldt	Sediment relocation Ketelplaat		x
20	Scheldt	Walsoorden 2004		x
21	Scheldt	Walsoorden 2006		x
22	Scheldt	Sandbars 2010		x
23	Scheldt	Fish pond		x
24	Weser	Tegeler Plate		x
25	Weser	Rönnebecker Sand		x
26	Weser	Vorder- und Hinterwerder		x
27	Weser	Kleinensieler Plate		x
28	Weser	Cappel-Süder-Neufeld		x
29	Weser	Werderland	x	
30	Humber	Alkborough		x
31	Humber	Paull Holme Strays		x
32	Humber	MudBug		x
33	Humber	Chowder Ness		x
34	Humber	Welwick		x
35	Humber	Klinsea Wetlands		x
36	Humber	South Humber Gateway Roosting	x	
37	Humber	Trent falls		x
38	Humber	Donna Nook and Skeffling	x	
39	Humber	Turnstall Realignment	x	

The majority (64%) of measure examples aims at biological and ecological development targets. Approximately one third (29%) was assigned to the measure category 'Hydrology/Morphology'. Only three measure examples belong to the measure category 'Physical/Chemical Quality' (Table 23). A detailed list can be taken from annex 10.5.

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Table 23: Number of measure examples collected and assignment to measure category and TIDE estuary

Measure category	**TIDE estuary**				**Total (%)**
	Weser	Elbe	Humber	Scheldt	
Biology/Ecology	06	06	08	07	27 (64)
Hydrology/Morphology	-	05	02	05	12 (29)
Physical/Chemical Quality	-	03	-	-	03 (07)
Total	06	14	10	12	**42* (100)**

*Measures not assignable to one single measure category are listed multiply. This refers to 3 of 39 measures.

Since the choice of measure examples to be included in the study was left to the members of the TWG measures, the results of the measure collection as compiled in table 22 only show a small part of the totality of measures planned and implemented at the four TIDE estuaries. Additionally, the choice of measures seems to depend on the organisation the respective working group member represents and the connected availability of measure examples: Since the representatives of NLWKN (Weser) and EA (Humber) as organisations in charge of nature conservation and water quality concerns mainly introduced measure examples aiming at biological and ecological development targets, the measure examples introduced by representatives of port authorities (Elbe and Scheldt) belong in almost equal parts to the categories 'Biology/Ecology' and 'Hydrology/Morphology'.
Table 24 shows the measure distribution along the TIDE estuaries according to the estuary zones. Figure 7 shows the location of the measure examples collected in the area of the Elbe estuary. Maps showing the measure locations for all TIDE estuaries can be taken from annex 810.6.

Table 24: Distribution of measure examples collected according to estuary zones

TIDE estuary	**Estuary zone**				**Total**
	limnic	oligohaline	mesohaline	polyhaline	
Weser	3	2	-	1	06
Elbe	11	1	-	-	12
Humber	-	2	1	7	10
Scheldt	3	-	4	4	11
Total	17	5	5	12	**39**

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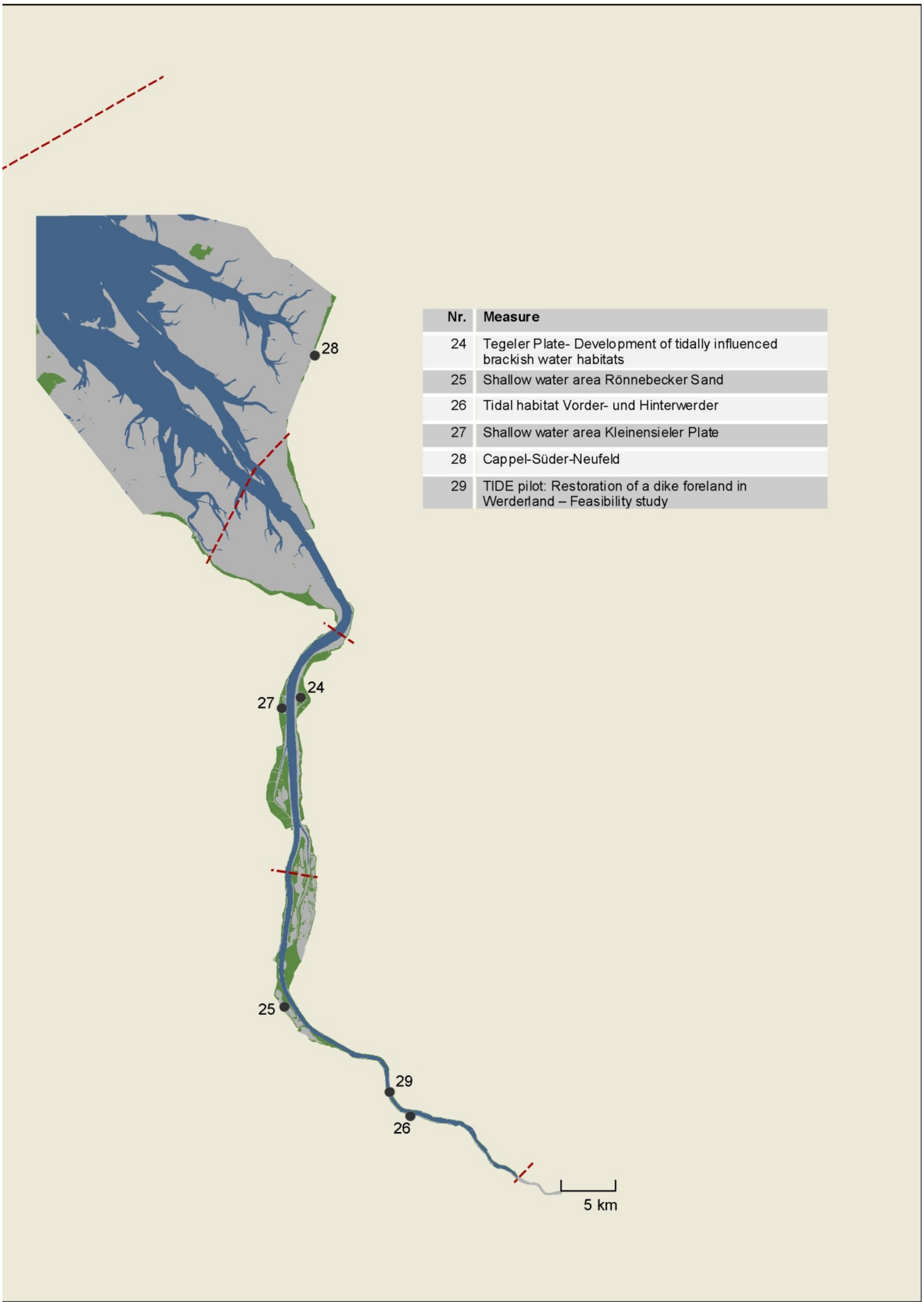

Figure 7: Locations of management measures collected according to the Weser estuary with indication of the estuary zones. Similar maps for all 4 estuaries can be taken from annex 10.6

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5.2 Measure analysis

The detailed results of the measure analysis in application to the collected measure examples on a case by case basis (Table 22) are available via www.tide-toolbox.eu. Hereinafter, overall results of the measure analysis in view of main and additional evaluation criteria are presented (chapters 5.2.1, 5.2.2).

5.2.1 Results of execution of main effectiveness criteria

5.2.1.1 Effectiveness according to development targets of measure

The aim of this part of the measure analysis was to roughly estimate the degree of target achievement (high, medium, low, not clear yet) by describing and estimating the effectiveness of a measure related to its development targets. Table 25 gives an overview on the results.

*Table 25: Degree of target achievement indicated for measure examples collected classified by measure categories**

TIDE estuary	Degree of target achievement			
	high	medium	low	not clear yet
Weser	**6**	**-**	**-**	**-**
Hydrology/Morphology	-	-	-	-
Biology/Ecology	6	-	-	-
Physical/Chemical Quality	-	-	-	-
Elbe	**4**	**5**	**2**	**3**
Hydrology/Morphology	1	1	1	2
Biology/Ecology	2	3	-	1
Physical/Chemical quality	1	1	1	-
Humber	**2**	**4**	**-**	**4**
Hydrology/Morphology	1	1	-	-
Biology/Ecology	1	3		4
Physical/Chemical Quality	-	-	-	-
Scheldt	**8**	**3**	**-**	**1**
Hydrology/Morphology	2	2	-	1
Biology/Ecology	6	1	-	-
Physical/Chemical quality	-	-	-	-
Total	**20**	**12**	**2**	**8**

*Measures not assignable to one single measure category are listed multiply. This refers to 3 of 39 measures.

For most of the executed measures (32 of 42), a high or medium degree of target achievement was indicated. Only for few measures (2 of 42), the measure effectiveness in view of the development targets was indicated as low. Mainly for measures still in the planning stages (e.g. measure 02, 36, 28, 39), the degree of target achievement was indicated as not clear yet.

The high number of measures positively assessed proves that mostly good practice examples were integrated into the measure compilation.

Another observation made according to the vast majority of measures is the exclusively qualitative definition of development targets without clear indication of a time plan for the target achievement. As a consequence, a transparent scientific evaluation in terms of development targets hardly takes place in the frame of the monitoring investigations. Therefore, it has to be stated that the estimation of the measure effectiveness considering the development targets undertaken in this study is mostly based on expert judgment, i.e. individual interpretation of available monitoring results.

5.2.1.2 Impact on ecosystem services

The aim of this analysis step was to roughly assess the expected measure impacts in view of the range of ecosystem services as defined by JACOBS 2012 based on an estimation of habitat surface and functional quality before and after measure implementation. Also, the expected measure impacts regarding different beneficiary groups were assessed. Both approaches allow illustrating potential co-benefits of management measures using the ecosystem services concept.

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The assessment of ES for estuarine management measures is provided by multiplying the habitat changes realised by the measure with the scores for ES supply per habitat type (JACOBS 2013). The result is a score that maps the expected impact of the measure on the supply of ES (see § 3.2.1.2 Impact on ecosystem services (ES)).

The expected impact on the targeted ES is limited or positive for most TIDE measures. It can be stated that the measures generate overall many co-benefits, i.e. many not targeted ES are positively impacted.

In detail, the expected impact on the habitat services ('biodiversity') and on cultural services is positive for most measures while the impact on the provisioning services is mostly negligible. Regarding the regulating services, the expected impact is positive on one part of the services (e.g. R1, R2, R5, R7, R8, R12) and negligible on the other part (e.g. R3, R4, R6).

The positive results on ES for most TIDE measures could be a consequence of the measure selection. Since most of the measures considered are biodiversity-targeted and examples of good practice, high scores for habitat, regulating and cultural services are expected while the anticipated impact on provisioning services is limited.

The dominance of positive scores could also be explained by the fact that the ES assessment is restricted to the boundary of the measure. Effects on adjacent land are not included. Hence, a conversion from adjacent land into estuarine habitat will cause positive effects on the supply of ES in the measure area. Negative effects will consequently only occur from a conversion from one estuarine habitat type into another, with the latter less suitable to supply certain ES. Most TIDE management measures are about the conversion of adjacent land into estuarine habitats.

For a specific type of measures that are aiming at regulating sedimentation patterns or altering sedimentation, sediment quality and erosion processes in a beneficial way (e.g. measure 12 Reiherstieg HPA (2012l), Pilot project Walsoorden (VOS et al. 2009), measure 02 Medemrinne (HPA 2012b), measure 19 Ketelplate (APA 2012g), measure 11 METHA (HPA 2012l), the chosen method to indicate the impact on ES delivery do not archive the best results. Even a positive effect on the targeted ES could not be approved in some examinations.

Based on the ecosystem services concept, the ES assessment realized in the frame of this study represents a first screening in order to show the co-benefits that are generated by implementing the measure.

It would be interesting to apply the assessment approach to measures to other measure types such as fairway deepening, maintenance dredging and creation of barriers because the global image of the expected impact on ES would probably be a different one. The scope of this study was however limited to the selected TIDE measures.

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Table 26: Overview on the results of the ecosystem services assessment in view of expected measure impacts on ES. Targeted ES indicated by orange boxes (habitat services (S); Provisioning services (P); Regulating services (R), Cultural services (C))

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

				Ecosystem services																			
				"Biodiversity"	Erosion and sedimentation regulation by water bodies	Water quality regulation: reduction of excess loads coming from the catchment	Water quality regulation: transport of pollutants and excess nutrients	Water quantity regulation: drainage of river water	Erosion and sedimentation regulation by biological mediation	Water quantity regulation: transportation	Water quantity regulation: landscape maintenance	Climate regulation: Carbon sequestration and burial	Water quantity regulation: dissipation of tidal and river energy	Regulation extreme events or disturbance: Wave reduction	Regulation extreme events or disturbance: Water current reduction	Regulation extreme events or disturbance: Flood water storage	Water for industrial use	Water for navigation	Food: Animals	Aesthetic information	Inspiration for culture, art and design	Information for cognitive development	Opportunities for recreation & tourism
Estuary	**Measure**	**Zone**	**Categ.**	S	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	P1	P2	P3	C1	C2	C3	C4
Elbe	Spadenlander Busch	Fresh	HB	3	3	1	1	1	1	0	1	1	1	0	1	1	1	0	0	2	3	3	2
Elbe	Medemrinne Ost	Meso	H	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	1
Elbe	Current deflection wa	Fresh	H	1	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1
Elbe	Current direction cont	Fresh	H	1	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1
Elbe	Sediment trap Wedel	Fresh	H	1	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1
Elbe	Hahnöfer Nebenelbe	Fresh	HB	-1	0	0	1	0	-1	0	-1	-1	1	-1	0	-1	0	0	1	-1	0	0	1
Elbe	Wrauster Bogen	Fresh	B	3	3	3	0	0	2	0	2	3	0	1	1	3	0	0	0	3	3	3	2
Elbe	Hahnöfer Sand	Fresh	B	3	3	1	0	1	2	0	2	2	1	1	1	1	0	0	0	2	2	2	1
Elbe	Spadenlander Spitze	Fresh	B	3	3	3	0	0	2	0	2	3	0	1	1	3	0	0	0	3	2	2	2
Elbe	Reed settlement Hake	Fresh	B	3	2	3	0	0	2	0	2	3	-1	1	1	3	0	0	0	2	2	2	2
Elbe	METHA	Fresh	B	1	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1
Elbe	Managing Reiherstieg	Fresh	P	1	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1
Schelde	Lippenbroek	Fresh	HB	3	3	3	0	0	2	0	2	3	0	1	1	3	0	0	0	3	2	2	2
Schelde	Groynes Waarde	Meso	B	2	1	1	0	0	1	0	1	1	1	1	1	0	0	0	0	1	1	1	1
Schelde	Ketenisse wetland	Meso	B	2	2	1	0	0	1	0	1	1	1	1	1	1	0	0	0	1	2	1	1
Schelde	Paddebeek wetland	Fresh	B	3	3	3	0	0	2	0	2	3	0	1	1	3	0	0	0	3	2	2	2
Schelde	Paardenschor wetlanc	Meso	B	3	3	2	0	0	2	0	2	2	2	2	1	0	0	0	0	3	3	2	2
Schelde	Heusden LO wetland	Fresh	B	3	3	3	0	0	2	0	2	3	0	1	1	3	0	0	0	3	2	2	2
Schelde	Sediment relocation K	Meso	H	1	1	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	1	1	1
Schelde	Walsoorden 2004	Meso	B	1	0	1	-1	0	1	-1	1	1	2	0	1	0	0	0	0	0	0	0	0
Schelde	Walsoorden 2006	Meso	B	0	0	1	-1	0	0	-3	1	0	1	0	0	0	-2	-3	1	0	0	0	0
Schelde	Sandbars 2010	Poly	B	1	0	1	-2	0	1	-3	2	1	3	0	1	0	-2	-3	1	0	0	0	0
Schelde	Fish pond	Meso	B	3	3	1	2	1	1	0	2	1	3	0	1	0	0	0	1	2	2	2	2
Weser	Tegeler Plate	Oligo	B	3	3	2	0	0	2	0	3	3	2	2	2	3	0	0	1	3	3	3	2
Weser	Shallow water area Rö	Fresh	HB	3	3	3	1	0	2	1	2	2	0	1	1	2	0	1	0	2	2	2	2
Weser	Vorder- und Hinterwe	Fresh	HB	3	3	2	1	0	1	1	1	2	0	0	1	1	1	1	0	2	2	2	2
Weser	Kleinensieler Plate	Fresh	B	3	3	3	0	0	2	0	2	2	0	1	1	2	0	0	0	2	2	2	2
Weser	Cappel-Süder-Neufel	Poly	B	3	3	3	1	0	3	0	3	3	1	2	1	1	0	0	0	3	3	3	3
Weser	Werderland	Poly	B	3	3	3	1	0	3	0	3	3	2	1	1	1	0	0	0	3	3	3	3
Humber	Alkborough SM	Meso	HB	3	2	2	0	0	2	0	2	2	1	1	1	1	0	0	0	2	2	2	2
Humber	PHS SM	Poly	B	3	3	3	1	0	3	0	2	3	1	1	1	1	0	0	0	2	2	2	3
Humber	MudBug SM		B	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Humber	Choweder Ness ABP n	Meso	B	2	2	1	0	0	1	0	1	1	2	1	1	0	0	0	0	2	2	1	1
Humber	sluice at Doigs Creek at Grimsby		B	2	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	2	1
Humber	Welwick		B	3	2	2	0	0	2	0	2	2	1	1	1	0	0	0	0	2	1	2	2
Humber	Beacon Lagoon		B	1	1	1	0	0	1	0	0	1	0	1	0	0	0	0	0	1	1	1	1

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Expected impact on beneficiaries

The results of the ecosystem services assessment regarding different beneficiary groups can be taken from table 27.

The expected measure impact for indirect and future use of ES is neutral to very positive. More measures are expected to be very positive in view of future use meaning that they generate a more long term positive expected impact. Since there is almost no impact on the provisioning services, no expected impact on direct ES use has to be stated.

Regarding the local, regional and global use of ES, neutral to very positive impact for local and regional use is expected while the anticipated impact for global use of ES is neutral or slightly positive.

Table 27: Overview on the results of the ecosystem services assessment in view of expected measure impacts on beneficiaries.

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

				Beneficiaries					
Estuary	Measure	Zone	Categ.	Direct use	Indirect use	Future use	Local use	Regional use	Global use
Elbe	Spadenlander Busch	Fresh	HB	0	2	3	2	2	1
Elbe	Medemrinne Ost	Meso	H	0	1	1	1	1	0
Elbe	Current deflection wall	Fresh	H	0	1	1	1	1	0
Elbe	Current direction control	Fresh	H	0	1	1	1	1	0
Elbe	Sediment trap Wedel	Fresh	H	0	1	1	1	1	0
Elbe	Hahnöfer Nebenelbe	Fresh	HB	0	0	-1	0	0	0
Elbe	Wrauster Bogen	Fresh	B	0	2	3	3	2	1
Elbe	Hahnöfer Sand	Fresh	B	0	2	3	2	1	1
Elbe	Spadenlander Spitze	Fresh	B	0	3	3	3	3	2
Elbe	Reed settlement Haken	Fresh	B	0	2	3	2	1	1
Elbe	METHA	Fresh	B	0	2	3	2	1	1
Elbe	Managing Reiherstieg sluice	Fresh	P	0	1	1	1	1	0
Schelde	Lippenbroek	Fresh	HB	0	2	3	3	2	1
Schelde	Groynes Waarde	Meso	B	0	1	1	1	1	1
Schelde	Ketenisse wetland	Meso	B	0	1	2	1	1	1
Schelde	Paddebeek wetland	Fresh	B	0	2	3	2	2	1
Schelde	Paardenschor wetland	Meso	B	0	2	3	2	1	1
Schelde	Heusden LO wetland	Fresh	B	0	2	3	3	2	1
Schelde	Sediment relocation Ketelplaat	Meso	H	0	1	1	1	1	0
Schelde	Walsoorden 2004	Meso	B	0	0	1	1	0	0
Schelde	Walsoorden 2006	Meso	B	0	-1	0	0	-1	0
Schelde	Sandbars 2010	Poly	B	0	-1	1	0	-1	0
Schelde	Fish pond	Meso	B	0	2	2	2	1	1
Weser	Tegeler Plate	Oligo	B	0	2	3	3	2	1
Weser	Shallow water area Rönnebecke	Fresh	HB	0	2	3	2	2	1
Weser	Vorder- und Hinterwerder	Fresh	HB	0	2	2	2	1	1
Weser	Kleinensieler Plate	Fresh	B	0	2	3	2	1	1
Weser	Cappel-Süder-Neufeld	Poly	B	0	3	3	3	2	1
Weser	Werderland	Poly	B	0	2	3	3	2	1
Humber	Alkborough SM	Meso	HB	0	2	3	2	1	1
Humber	PHS SM	Poly	B	0	2	3	2	2	1
Humber	MudBug SM		B	0	1	1	1	1	0
Humber	Choweder Ness ABP mer SM	Meso	B	0	1	2	1	1	1
Humber	sluice at Doigs Creek at Grimsby		B	0	1	1	1	1	0
Humber	Welwick		B	0	1	2	2	1	1
Humber	Beacon Lagoon		B	0	1	1	1	1	0

The expected impact of the TIDE measures on the different beneficiaries is very similar (mainly indirect and future and mainly local and regional). This is also a consequence of the measures selection (s.a.), but moreover of the list of ES considered. The selected list of the 20 most relevant ES for estuaries consists of 1 habitat service, 3 provisioning services, 12 regulating services and 4 cultural services. Hence, the overall expected impact on the beneficiaries is dominated by the regulating services (which is mostly linked to indirect and future use and to local and regional use). If -for instance- the regulating services would be more clustered and provisioning services would be split up into more categories, this would also change the global image of the expected impact.

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5.2.1.3 Conflicts and synergistic effects regarding to uses

The indication of conflicts and synergistic effects regarding uses that occurred in the course of measure planning and implementation was estimated on a case-by-case level based on expert judgement (insider perspective). The results for the TIDE measures can be taken from the measure surveys (chapter 3.1) and the measure analysis results (chapter 3.2).

In 13 out of 39 measure examples the main conflicts that derived from the measure implementation were specified.

Most of the conflicts (~60%) that were observed during the implementation of the examined measures, occurred between the new management targets of the site and former uses that were now impossible or restricted (e.g. agricultural use, hunting, recreation). Regarding the realignment sites were new dykes had to be build safety concerns of the local inhabitants were seen as conflicts.

Additionally the insufficient attainment of the stated development targets because of too high sedimentation rates on the sites was seen as a conflict.

The synergistic effects that can be high-lighted in almost every measure are the combination of flood protection, nature conservation and recreational purposes. In four measure examples synergistic effects between maintenance dredging (sediment management) and nature conservation can be observed.

5.2.2 Results of execution of additional evaluation criteria in view of EU environmental law

5.2.2.1 Conflicts and synergistic effects regarding WFD

The aim of this part of the measure analysis was to roughly estimate possible measure effects in view of WFD aims in order to map potential benefits and conflicts that can be expected due to the implementation of management measures in estuaries.

First step: Pressures screening

The estimation of potential conflicts and synergistic effects of measures in view of WFD aims was based on the identification of the main pressures the estuary zones of the TIDE estuaries are affected by (pressures screening). To identify the main pressures, a survey was developed by NLWKN and filled in in the course of expert meetings (Regional Working Group meetings) held at the four TIDE estuaries. The survey can be taken in detail from annex 10.2 (Table 38 - 42). As a result, the main pressures indicated in table 28 were identified.

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Table 28: Results of expert meetings held at the TIDE estuaries to identify main pressures regarding different salinity zones (f = freshwater zone, o = oligohaline zone, m = mesohaline zone, p = polyhaline zone). Relevant main pressures for the TIDE estuaries highlighted in grey

State Indicators		**Main pressure for**			
Code*	**Indicator**	**Humber**	**Scheldt**	**Elbe**	**Weser**
1.1	Habitat loss and degradation during the last 100 years: Intertidal	+ (m,p)	+ (f,o,m,p)	+ (f,o,m,p)	+ (f,o,m,p)
-	Habitat loss and degradation during the last 100 years: Subtidal	-	-	+ (f,o,m,p)	+ (f,o,m,p)
1.4	Gross change in morphology during the last about 100 years	+ (o,m)	-	+ (f,o,m)	+ (f,o,m)
1.5	Gross change of the hydrographic regime during the last 100 years	-	+ (f,o,m)	+ (f)	+ (f,o,m)
3.1/3.2	Decrease of water and sediment chemical quality	+ (o)	+ (f,o,m,p)	+ (f,o,m,p)	+ (p)
3.3	Increased chemical loads on organisms	-	+ (p)	-	-
3.4	Decrease of microbial quality	-	-	-	-
3.8	Aesthetic pollution	-	-	-	-
Driver Indicators		**Main pressure for**			
Code*	**Indicator**	**Humber**	**Scheldt**	**Elbe**	**Weser**
1.3	Land claim during the last about 100 years	-	+ (f,o,m)	+ (f,o)	+ (f,o,m)
1.7	Relative Sea Level Rise	+ (m)	+(f,o,m,p)	+ (p)	+ (f,p)
2.3	Discharge of nutrients and/or harmful substances	-	-	+ (f,o,m,p)	+ (p)
2.6	Capital dredging	+ (p)	+ (p)	+ (f,o,m,p)	+ (f,o,m,p)
2.4	Maintenance dredging	+ (m,p)	+ (f,o)	+ (m)	+ (o,m)
2.5a	Relocation of dredged material	+ (m,p)	-	-	-
2.9	Aquaculture	-	-	-	-
2.10	Fisheries activities	-	-	-	-
2.8	Wind farm development	-	-	-	-
2.11	Marina developments	-	-	-	-
2.12	Port developments	+ (m,p)	+ (m,p)	-	-
-	Industrial development	-	-	-	-
2.13	Installation of pipelines and cables	+ (m)	-	-	-
2.14	Oil and gas exploration and production	-	-	-	-
2.16	Tourism and recreation	-	-	-	-

*Codes for EII according to AUBRY AND ELLIOTT 2006; EII without indication of code were added in the frame of TIDE

The results of the pressures screening as represented in table 28 show that the range of potential main pressures in view of the TIDE estuaries was well covered by the EIIs given. This statement can be underpinned by the fact that the option of introducing additional EIIs was not seized at the four TIDE estuaries.

Second step: Estimation of measure effects

For each TIDE measure, potential effects in view of the main pressures identified for the estuary zone where the measure is situated were indicated according to a simple valuation system (very positive, positive, no effects, negative effects, very negative effects) and additionally briefly described. A potential positive measure effect in view of a main pressure is interpreted as an indication of effectiveness in view of WFD objectives respectively in view of WFD quality elements. A potential negative effect is interpreted as an indication of conflicts in view of WFD requirements respectively in view of WFD quality elements. This interpretation is based on the hypothesis that a measure is the most effective if it tackles the main pressures the respective estuary zone is affected by and consequently in that case also has positive effects in view of the WFD quality elements. The results of the estimation of measure effects for all TIDE measures are compiled in table 29.

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Table 29: Indication of measures with very positive and positive effects on main pressures of the TIDE estuaries (classification by measure categories). Measures without indication of effects in view of WFD aims not included; measures assigned to more than one measure category highlighted in grey.

Measure category	No.	Estuary	Measure example	Number of pressures positively effected by measure	Percentage of pressures positively affected by measure (%)
Hydrology/Morphology	01	Elbe	Spadenlander Busch	5/7	71
	02	Elbe	Medemrinne Ost	3/7	43
	03	Elbe	Current deflection wall	0/7	0
	04	Elbe	Bunthaus	0/7	0
	05	Elbe	Sediment trap Wedel	0/7	0
	13	Scheldt	Lippenbroek	5/6	83
	19	Scheldt	Sediment relocation Ketelplaat	1/6	17
	20	Scheldt	Walsoorden 2004	1/6	17
	21	Scheldt	Walsoorden 2006	1/6	17
	22	Scheldt	Sandbars 2010	3/6	50
				Average percentage (%)	**21***
Biology/Ecology	01	Elbe	Spadenlander Busch	5/7	71
	06	Elbe	Hahnöfer Nebenelbe	2/7	29
	07	Elbe	Wrauster Bogen	2/7	29
	08	Elbe	Hahnöfer Sand	2/7	29
	09	Elbe	Spadenlander Spitze	1/7	14
	10	Elbe	Reed settlement Haken	2/7	29
	13	Scheldt	Lippenbroek	5/6	83
	14	Scheldt	Groynes Waarde	1/6	17
	15	Scheldt	Ketenisse wetland	4/6	67
	16	Scheldt	Paddebeek wetland	6/6	100
	17	Scheldt	Paardenschoor wetland	6/6	100
	18	Scheldt	Heusden LO wetland	6/6	100
	23	Scheldt	Fish pond	2/6	33
	24	Weser	Tegeler Plate	5/6	83
	25	Weser	Rönnebecker Sand	5/6	83
	26	Weser	Vorder- und Hinterwerder	5/6	83
	27	Weser	Kleinensieler Plate	5/6	83
	28	Weser	Cappel-Süder-Neufeld	3/6	50
	29	Weser	Werderland	5/6	83
	30	Humber	Alkborough	2/2	100
	31	Humber	Paull Holme Strays	2/5	40
	33	Humber	Chowder Ness	6/6	100
	34	Humber	Welwick	6/6	100
	35	Humber	Klinsea Wetlands	6/6	100
	36	Humber	South Humber Gateway Roosting	6/6	100
				Average percentage (%)	**67***
Physic al/ Chemi	11	Elbe	METHA	1/7	14
	12	Elbe	Managing Reiherstieg sluice	1/7	14
	05	Elbe	Sediment trap Wedel	0/7	0
				Average percentage (%)	**14***

*Calculation of average percentage does not include measures assigned to more than one measure category (highlighted in grey)

Summarising, the vast majority of measures originally was not designed to meet WFD requirements. However, multiple very positive or positive measure effects in view of main pressures were indicated and described or neutral effects were stated while an indication of negative effects did not take place. Thus, in many cases several potential synergistic effects in view of WFD requirements can be stated although the measure design did not specifically consider these. This especially refers to measures assigned to measure category 'Biology/Ecology' (67% of the pressures are positively affected, Table 29).

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5.2.2.2 Conflicts and synergistic effects regarding Natura 2000

In order to map possible conflicts and synergistic effects of management measures in view of Natura 2000 aims, potential measure effects on available conservation objectives were estimated.

Since large parts of the TIDE estuaries are designated as Natura 2000 sites, most TIDE measures are situated within protected areas according to the Birds and the Habitat Directive (Table 30, Figure 8). This also means that Natura 2000 requirements necessarily will have to be considered in the course of future measure planning and implementation processes.

Table 30: Measures situated and not situated in Natura 2000 sites with indication of geotype (area, point, line), measures outside of Natura 2000 sites highlighted in grey

No.	Estuary	Measure example	Geotype	Measure situated in Natura 2000 site(s)?			Site code(s)
				yes		no	
				HD	BD		
01	Elbe	Spadenlander Busch	Area	x	-	-	DE 2526-305
02		Medemrinne Ost	Area	x	x	-	DE 2323-392; DE 2323-401
03		Current deflection wall	Line	-	-	x	DE 2526-305
04		Bunthaus	Point	-	-	x	-
05		Sediment trap Wedel	Area	x	-	-	DE 2323-392
06		Hahnöfer Nebenelbe	Area	x	x	-	DE 2018-331; DE 2424-302; DE 2424-401
07		Wrauster Bogen	Area	-	-	x	DE 2526-305
08		Hahnöfer Sand	Area	x	x	-	DE 2424-302
09		Spadenlander Spitze	Area	x	-	-	DE 2526-305
10		Reed settlement Haken	Area	-	-	x	-
11		METHA	Point	-	-	x	-
12		Managing Reiherstieg sluice	Area	-	-	x	-
13	Scheldt	Lippenbroek	Area	x	x	-	BE 2300-006; BE 2301-235
14		Groynes Waarde	Line	x	x	-	NL 9803-061; NL 9802-026
15		Ketenisse wetland	Area	x	x	-	BE 2300-006; BE 2301-336
16		Paddebeek wetland	Area	x	-	-	BE 2300-006
17		Paardenschoor wetland	Area	x	x	-	BE 2300-006; BE 2301-336
18		Heusden LO wetland	Area	x	-	-	BE 2300-006
19		Sediment relocation Ketelplaat	Area	x	-	-	BE 2300-006
20		Walsoorden 2004	Area	x	x	-	NL 9803-061; NL 9802-026
21		Walsoorden 2006	Area	x	x	-	NL 9803-061; NL 9802-026
22		Sandbars 2010	Area	x	x	-	NL 9803-061; NL 9802-026
23		Fish pond	Area	-	-	x	-
24	Weser	Tegeler Plate	Area	x	x	-	DE 2316-331; DE 2617-401
25		Rönnebecker Sand	Area	x	-	-	DE 2516-331
26		Vorder- und Hinterwerder	Area	-	x	-	DE 2918-401
27		Kleinensieler Plate	Area	x	-	-	DE 2316-331
28		Cappel-Süder-Neufeld	Area	x	x	-	DE 2306-301; DE 2210-401
29		Werderland	Area	-	x	-	DE 2817-401
30	Humber	Alkborough	Area	x	x	-	UK 0030-170; UK 9006-111
31		Paull Holme Strays	Area	x	x	-	UK 0030-170; UK 9006-111
32		MudBug	Area	x	x	-	UK 0030-170; UK 9006-111
33		Chowder Ness	Area	x	x	-	UK 0030-170; UK 9006-111
34		Welwick	Area	x	x	-	UK 0030-170; UK 9006-111
35		Klinsea Wetlands	Area	x	x	-	UK 0030-170; UK 9006-111
36		South Humber Gateway Roosting	Area	-	x	-	UK 9006-111
37		Trent falls	Area	x	x	-	UK 0030-170; UK 9006-111
38		Donna Nook and Skeffling	Area	x	x	-	UK 0030-170; UK 9006-111
39		Turnstall Realignment	Area	-	-	x	-

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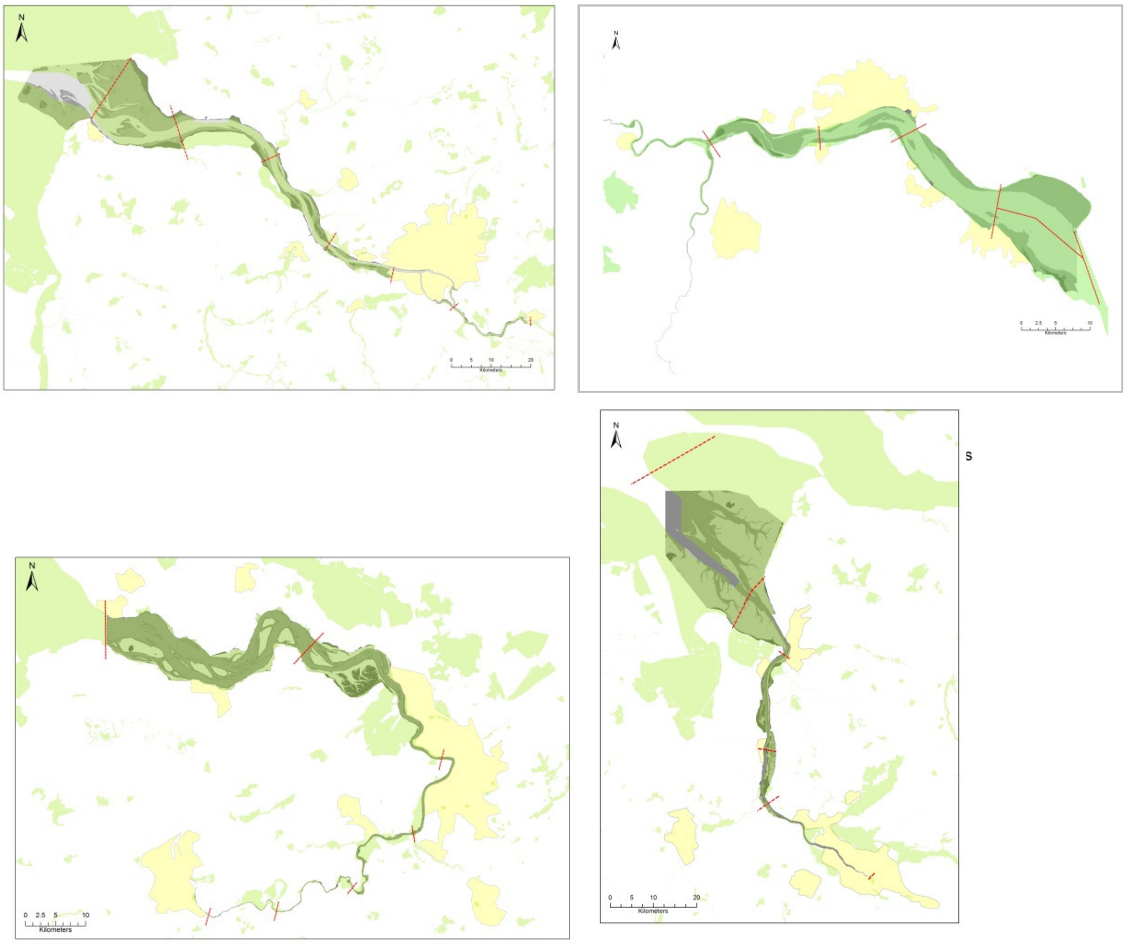

Figure 8: Natura 2000 areas along the TIDE estuaries (CUTTS &HEMINGWAY 2012)

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First and second step: Effectiveness regarding conservation objectives for defined spatial units and overall conservation objectives

The results of the measure effect estimation regarding Natura 2000 conservation objectives for all TIDE measures are compiled in table 31.

Table 31: Overview on measures with potential very positive or positive effects on Natura 2000 conservation objectives (classification by measure categories)

Measure category	No.	Estuary	Measure example	Number of conservation objectives positively effected by measure	Number of conservation objectives very positively effected by measure	Percentage of conservation objectives very positively or positively affected by measure (%)
Hydrology/Morphology	01	Elbe	Spadenlander Busch	5/6	0/6	83
	02	Elbe	Medemrinne Ost	1/6	0/6	17
	03	Elbe	Current deflection wall	0/6	0/6	0
	04	Elbe	Bunthaus	0/6	0/6	0
	05	Elbe	Sediment trap Wedel	1/8	0/8	13
	13	Scheldt	Lippenbroek	0/2	2/2	100
	19	Scheldt	Sediment relocation Ketelplaat	0/1	0/1	0
	20	Scheldt	Walsoorden 2004	1/5	0/5	20
	21	Scheldt	Walsoorden 2006	1/5	0/5	20
	22	Scheldt	Sandbars 2010	6/11	0/11	55
Average percentage (%)						**16***
Biology/Ecology	01	Elbe	Spadenlander Busch	5/6	0/6	83
	06	Elbe	Hahnöfer Nebenelbe	4/8	0/8	50
	07	Elbe	Wrauster Bogen	4/6	0/6	67
	08	Elbe	Hahnöfer Sand	6/8	0/6	75
	09	Elbe	Spadenlander Spitze	4/6	0/6	67
	10	Elbe	Reed settlement Haken	0/6	0/6	0
	13	Scheldt	Lippenbroek	0/2	2/2	100
	14	Scheldt	Groynes Waarde	2/3	1/3	100
	15	Scheldt	Ketenisse wetland	1/27	9/27	37
	16	Scheldt	Paddebeek wetland	1/1	0/1	100
	17	Scheldt	Paardenschoor wetland	10/27	0/27	37
	18	Scheldt	Heusden LO wetland	1/1	0/1	100
	23	Scheldt	Fish pond	2/7	0 of 7	29
	24	Weser	Tegeler Plate	11/24	11/24	92
	25	Weser	Rönnebecker Sand	16/22	5/22	95
	26	Weser	Vorder- und Hinterwerder	15/22	4/22	86
	27	Weser	Kleinensieler Plate	16/24	4/24	83
	28	Weser	Cappel-Süder-Neufeld	9/24	2/24	91
	29	Weser	Werderland	14/22	6/22	91
	30	Humber	Alkborough	0/1	1/1	100
	31	Humber	Paull Holme Strays	0/1	1/1	100
	33	Humber	Chowder Ness	1/1	0/1	100
	34	Humber	Welwick	1/1	0/1	100
	35	Humber	Klinsea Wetlands	1/1	0/1	100
	36	Humber	South Humber Gateway Roosting	1/1	0/1	100
Average percentage (%)						**78***
Physical/ Chemical Quality	11	Elbe	METHA	0/6	0/6	0
	12	Elbe	Managing Reiherstieg sluice	2/6	0/6	33
	05	Elbe	Sediment trap Wedel	1/8	0/8	13
Average percentage (%)						**37***

*Calculation of average percentage does not include measures assigned to more than one measure category (highlighted in grey)

Summarizing, the vast majority of measures originally was not designed to meet Natura 2000 requirements. However, especially for measure of category 'Biology/Ecology', various potential positive or very positive effects in view of the available conservation objectives were stated and described.

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5.2.3 Crux of the matter

The results of this part of the measure analysis on a case-by-case basis can be taken from the measure surveys or the measure analysis results available via www.tide-toolbox.eu.
In summery it can be stated that within every estuary comparable experiences were made. In the context of the executed management measures (almost realignments) it is announced very often that unpredictable changes in the persistence of the new-built sides occur (e.g. through high sedimentation rates on the side). A conflict of aims between targeted habitat type and the idea of self-preserving nature occurred then very often. A recommendation that is given in a lot of measure examples is, that an adaptive management is needed (measures no.14, 16, 26 & 08) in order to react on changing conditions and additionally accept that some habitats could not exists without management, especially on realignment sides where a lack of natural dynamics occurred (measures no.30, 31 & 05). It may be necessary to consider the creation of compensatory mudflat or shallow water area, as a temporary solution which may not persist forever (measures no 31, 30 & 06). If the management targets were formulated with a wider perspective favourable conditions could evolve without a lot of management effort (measure no 09). Positive experiences like the self-preserving creek system at the Tegeler Plate (measure no 19) as well as the Walsoorden examinations (measures no 19-22) should be analysed in detail to make it possible to transfer the experiences to other projects within the estuary and among other estuaries. To enhance the success of a measure an early stakeholder involvement is necessary (measure no 01).
In almost every "crux of the matter" description the necessity of the enhancing knowledge on estuarine functioning and the development of side specific conditions for a beneficial measure implementation is highlighted.

6. Specific issues of cross estuary comparison of measures

6.1 Managed re-alignment measures (APA)

The topic of this chapter is an inter-estuarine comparison (for the elaborate report see APA 2013) of estuarine habitat restoration measures. These measures seem to be commonly implemented since nearly half of the estuarine measures studied in TIDE are related to estuarine habitat restoration. Two specific types of measures are analysed:

- Managed Realignment Measures (MRM) whereby restoration is operated by dike breaching or defence removal. Managed realignment (MR) - or 'dike-realignment', 'de-polderisation' – involves "setting back the line of actively maintained defences to a new line inland of the original and promoting the creation of intertidal habitat between the old and new defences" (Burd 1995).
- Restricted Tidal Exchange (RTE) with a Controlled Reduced Tide (CRT) as a specific example.

In the first part, general aspects of the 17 MRMs (Table 32) are analysed and compared. The second part focuses on the sedimentation rate on these MR sites and determining site selection and site design aspects. Overall, the aim of this chapter is to conclude with recommendations for future nature restoration measures hence to improve the success of estuarine management.

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Table 32: List of the 17 TIDE managed realignment measures. Basic information and effectiveness analysis of the measures is available in the respective measure reports

No.	Estuary	Measure name	Code
1	Elbe	Spadenlander Busch/Kreetsand	E-Sp.B.
7	Elbe	Realignment Wrauster Bogen	E-Wr.B.
8	Elbe	Compensation measure Hahnöfer Sand	E-Hahn.S.
9	Elbe	Spadenlander Spitze	E-Sp.Sp.
13	Scheldt	Lippenbroek FCA-CRT	S-Lip.
15	Scheldt	Ketenisse wetland	S-Ket.
16	Scheldt	Paddebeek wetland	S-Pad.
17	Scheldt	Paardenschor wetland	S-Paard.
18	Scheldt	Heusden LO wetland	S-Heusd.
24	Weser	Tegeler Plate – Development of tidally influenced brackish water habitats	W-Tegl.P.
25	Weser	Shallow water area Rönnebecker Sand	W-Ronn.S.
26	Weser	Tidal habitat Vorder- und Hinterwerder	W-VorHin
27	Weser	Shallow water zone Kleinensieler Plate	W-Kl.P.
28	Weser	Cappel-Süder-Neufeld	W-Cap.S.N.
30	Humber	Alkborough Managed Realignment and flood storage: Creation of ~440 a of intertidal habitat	H-Alk.
31	Humber	Paull Holme Strays Managed Realignment: creation of ~80 ha of intertidal habitat	H-PHS
33	Humber	Creation of ~13 ha of intertidal habitat at Chowder Ness	H-Ch.N.

6.1.1 General aspects of Managed Realignment Measures (MRMs)

The 17 TIDE MRMs are all implemented in the last 21 years. The **average size** of the TIDE MRM is 63 ha, ranging from 1.6 ha to 440 ha (Figure 9). However, only two cases are larger than 100 ha. Half of the TIDE MRMs are **located** in the freshwater zone and the other half is spread along the three other salinity zones according to the Venice System (mesohaline, oligohaline and polyhaline) (GEERTS et al. 2011).

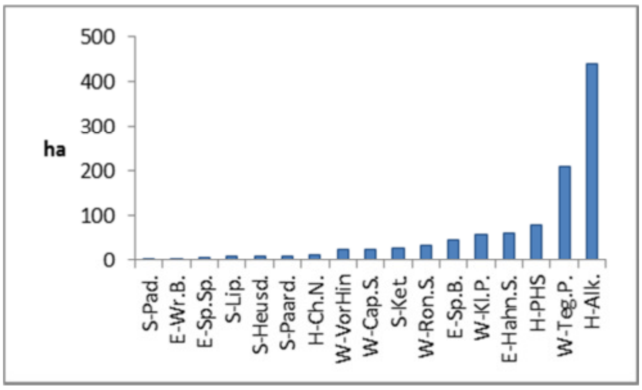

Figure 9: Restored surface

The MRM have been implemented **for different reasons**. The most common measure target is habitat conservation, restoration or creation. Only a few cases combine this conservation target with a safety target (flood storage capacity), research target, and/or recreation opportunities. Half of the cases are driven by a compensation reason. The **degree of target achievement** is overall high: almost half of the measures are considered to have a high degree of target achievement, the other part a medium degree meaning that not all

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targets are completely reached. However in some cases it was proved that the degree of target achievement could be improved by making some adaptations to the MR site.
An MRM could be executed **by different techniques**. Half of the TIDE cases are implemented by dike breach and half by defence removal (large dike breach), with a dike breach between 3m and 2650m
Another type of estuarine habitat restoration is by Reduced Tidal Exchange (RTE). Within TIDE we have only one RTE example (S-Lip.). In half of the measures, the dike breach or defence removal is combined with land lowering. In many cases it was proven that different design aspects such as initial site elevation, slope of the area and hydrodynamics do influence habitat development and the success of the measure. In some cases the initial design was not optimal, but adaptations to the site were possible to improve the success of the measure.

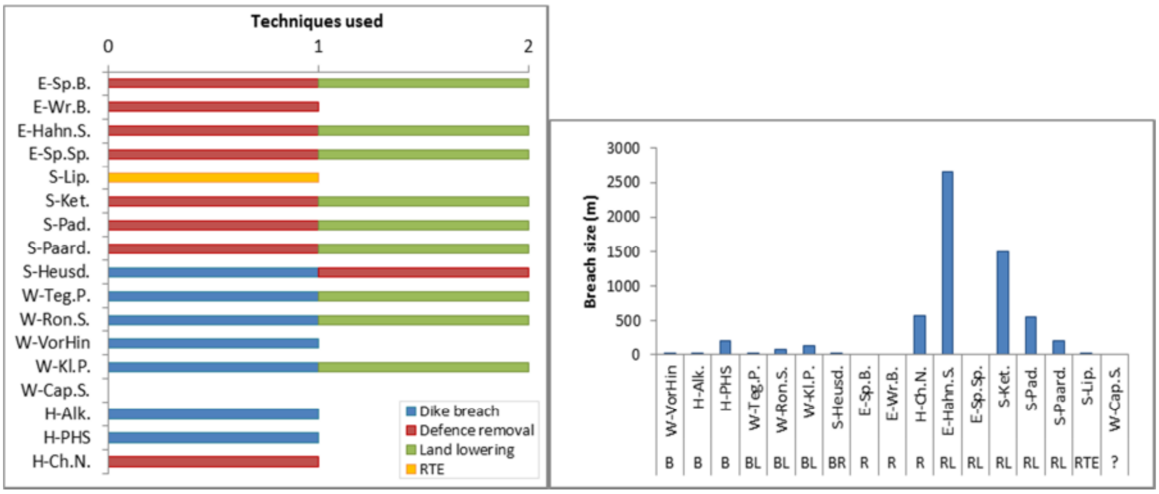

Figure 10: Overview implementation techniques used for the different TIDE examples (LEFT) and link between implementation technique and breach size (m) (RIGHT). Implementation techniques: dike breach (B), dike breach + land lowering (BL), dike breach + defence removal (BR), defence removal (R), defence removal + land lowering (RL), RTE.

The TIDE MRMs together transformed about 1000 hectares **adjacent land into estuarine habitat**, consisting mainly of marsh land and intertidal flat habitat (Figure 11). For the TIDE cases, about 90% of the created habitat surface (approx. 900 ha) was however implemented for compensation reasons meaning that it is not really new habitat because it was lost first somewhere else.

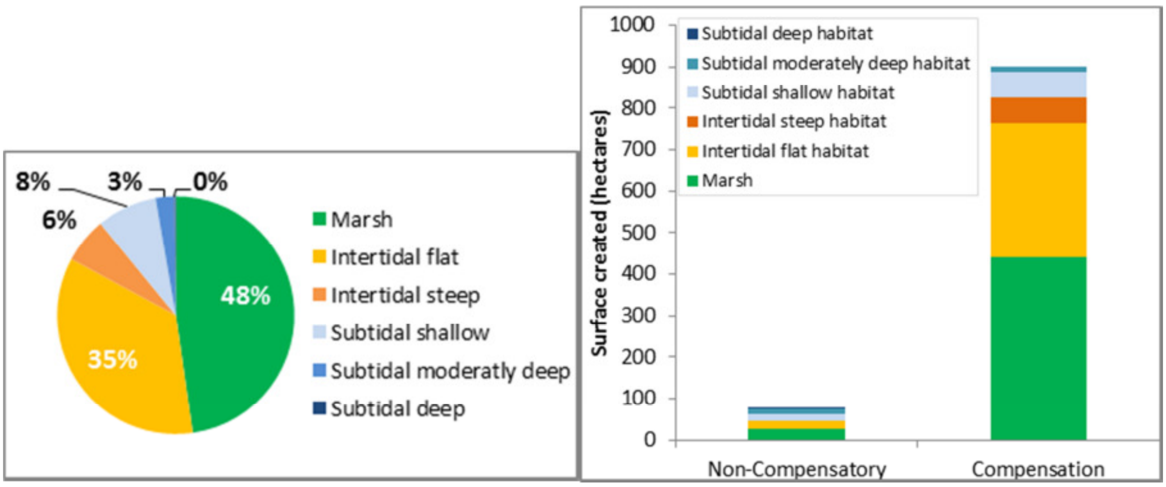

Figure 11: Distribution of different habitat types created by the TIDE cases (Left), and overview habitat creation per habitat type by the TIDE compensation measures and non-compensatory measures (Right)

All TIDE MRMs have a **monitoring program** with duration between 3 to 15 years. The parameters mostly monitored (in at least half of the TIDE cases) are: vegetation, accretion and sedimentation on site, invertebrates, birds and fish.

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MRMs generate many **synergies** between nature, flood protection, port development, recreation and natural resources, but also **conflicts** with agriculture and local inhabitants.
MRMs are **expensive** but could also generate **large benefits**. The **relative implementation cost** of the TIDE MRM cases amounts 280,000 €/ha with a large range between 16,000 and 1.4 Million €/ha. For some measures, only a rough estimation was available.

- Three TIDE MRMs are considered as outliers with a remarkable high relative implementation cost, because of a high amount of soil that had to be removed out of the area (**E-Hahn.S.**) and that had to be treated because of contamination (**E-Sp.B.**), or uncertainty about the total implementation cost (**S-Pad.**).
- Furthermore, different measure characteristics are studied to find reasons for the large variance in the relative implementation cost.
  - Size and age: No significant relationship is observed between the relative implementation cost and the size of the measures, nor could we observe a temporal evolution in the relative implementation cost.
  - Implementation techniques: A significant difference in the relative implementation cost is observed between the TIDE measures implemented by dike breach or by defence removal. The latter technique is, evidently, much more expensive. A positive relationship with the breach size was however not significant. Furthermore, measures with land lowering are expected to be more expensive but this difference was also not significant.
  - Creek system implemented: Measures with the implementation of a creek system are expected to be more expensive but this difference was not observed for the TIDE cases.
- Overall it is not possible to give a clear indication about what causes a higher or lower relative implementation cost. It depends too much on local conditions.
- **Critical note**: By comparing measure characteristics with the relative implementation cost nothing could be concluded about the success of the measure. Indeed, the effectiveness of the measure to reach the objectives/requirements and to be sustainable is more important when considering the measure design than the implementation cost.

Besides the implementation cost of the measures, also the **benefits** are studied based on the Ecosystem Services (ES) concept. However, no scientific consensus exists yet on the monetary valuation of ES. Different approaches are explored with often also different outcomes.

- A simple approach was applied to get a rough idea of the order of magnitude of the monetary benefits of the MRMs. A recent overall literature review with global monetary data for different biomes was used and multiplied with the habitat creation in the MRMs. Based on this approach, the TIDE examples generate an average benefit of 133,000 € per hectare and year, ranging from 70,000 to 155,000 € per hectare and year. The monetary benefit calculated here is however an overestimation because it is limited to the benefits generated within the estuary itself without counting for the lost adjacent land. (See APA 2013 page27-28 for calculation method)
- A more detailed approach to calculate the local benefits of a measure is however recommended. Therefore, a guidance document is developed to support managers and decision makers in how to quantify and monetary value the changes in ecosystem services specifically for the study site (LIEKENS BROEKX 2013).

By comparing the costs and benefits of the measures, the **cost-efficiency** of the TIDE cases is analysed:

- The first method is the earn-back time, i.e. the average time that the measure should be operational before the total implementation cost is earned back. For the TIDE MRMs this amounts on average 2.3 years, ranging from 0.1 year to 15 years.
- The second method is the benefit/cost ratio, i.e. the annual benefit (as calculated above) generated for every 1€ invested (as calculated above). For the TIDE cases the benefit/cost ratio is on average

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2.82:1, meaning a benefit of 2.82 €/y for every 1€ invested. The benefit/cost ratio for the TIDE cases ranges from 0.07 to 13.35 €/y for every 1€ invested.

- The earn-back time and benefit/cost ratio both give an indication of the cost-efficiency of a measure, assuming that the measure targets are met completely. However, in reality the latter assumption is rarely the situation. It is therefore recommended to first check the success of measures to meet the development targets and additionally the cost-efficiency estimate could be used to make a selection between measures that are expected to be successful.

In the final section, the results of an **ES assessment** for the MRMs are analysed (based on the TIDE ES study (JACOBS 2013)).

- In a first part, the target ES are indicated per measure based on the development targets (Table 33). Most TIDE MRMs target the habitat and habitat services. In a few cases, this target is combined with a regulating service (flood water storage, dissipation of tidal and river energy), and/or a cultural services (opportunities for recreation and tourism, and information for cognitive development).
- The TIDE MRMs have a positive expected impact (from slightly positive to very positive) on at least 12 of the 20 considered ES. (Measures of table 32 in table 26)
- The expected impact on the targeted ES is in most cases very positive. On average, only 10% of the ES with a positive expected impact (slightly positive to very positive) are also targeted. This means that the MRMs are expected to generate many co-benefits! (Measures of table 32 in table 26)
- Regarding the beneficiaries, the TIDE MRMs are mainly beneficial in an indirect way, at a longer term (for future use), and at a local and regional scale. (Measures of table 32 in table 27)

Table 33: Translation of measure targets in terms of ES

Target	Corresponding Ecosystem Service
Safety	R1 - Erosion and sedimentation regulation by water bodies R4 - Water quantity regulation: dissipation of tidal and river energy R12 - Reg. of extreme events: flood water storage
Habitat conservation/restoration	S - Habitat services (biodiversity)
Compensation	S - Habitat services (biodiversity)
Access opp. and education	C4 - Cult. Opportunities for recreation and tourism
Research	C3 - Cult. Information for cognitive development

6.1.2 Optimisation of MRMs with a focus on the sedimentation rate

The second part of the MRM report focusses on issues related to the sedimentation rate at MR sites. Sedimentation and erosion processes have an important role in the development of MR sites and hence in the success of the MRMs. It is however a complex issue and difficult to predict and anticipate on in practice. Although for many measures some modelling work on this topic was done in the planning stage, the reality after measure implementation turned out to be different and does not always suit the development goals. In some TIDE cases the sedimentation rate was therefore considered as a problem, e.g. because tidal water areas silted up quickly due to unexpectedly high sedimentation rates or because habitat development was curtailed due to unexpectedly strong erosion. However, if the situation arises where we require a system which is not in equilibrium this might be more a problem of setting the goal than of the sedimentation rate that is “too high”. Meaning: the project might be in the wrong place, the objectives might be unrealistic or the design of the project might be suboptimal.
Managers have to deal with the unpredictability of the dynamic estuarine system but this does however not mean that managers do not have the possibility to improve the success of the measure and for example reduce the need to dredge the sites. Different aspects of the MRsites are studied to analyse their relationship with the sedimentation rate on the site. It is the aim of this study to better understand the link between the MRsites (both the location within the estuary and the design of the site) and the sedimentation rate and to formulate

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recommendations to enable managers to improve the selection and design of the site and hence the success of the measure.

Sedimentation rate TIDE cases

In general, the sedimentation rate is highest immediately after implementation and then levels off after some years. The overall average sedimentation rate on the TIDE MR sites is 9 cm/yr, with the highest sedimentation rate measured at parts of the Kleinensieler Plate (75 cm/yr, **W-Kl.P.**) and the strongest erosion in some parts of Ketenisseschor (-30 cm/yr, **S-Ket.**). The average accretion at Kleinensieler Plate (**W-Kl.P.**) is very high compared to all other TIDE cases, and without **W-Kl.P.** the overall average sedimentation rate is only 5 cm/yr.

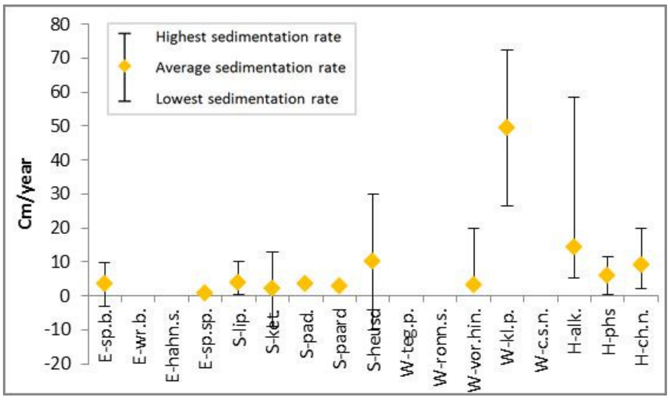

Figure 12: Average sedimentation rate per TIDE MRM with indication of the highest and lowest measured (or monitored) sedimentation rate as error bars

Impact of site selection and site design aspects on the sedimentation rate

Outer-dike vs inner-dike measures

A first difference is made between outer-dike and inner-dike areas. In this study, outer-dike sites are defined as the areas that are under direct influence of the river and hence under influence of the full tidal range. Most TIDE cases are outer-dike sites. The inner-dike sites are defined as areas with a hydraulic constriction by a (narrow) construction (eg. sluice, sill or overflow barrier) in between the site and the estuary, resulting in a dampened tidal range on the site. A special case of inner-dike measures is a Controlled Reduced Tide (CRT), of which one example is analysed within TIDE (**S-Lip.**). It is expected that the sedimentation and erosion processes will differ between outer- and inner-dike sites due to the different site conditions, depending on water depth, residence time, concentration of suspended matter in the water column, erosion forces etc.. The Kleinensieler Plate is an example for a measure with more or less outer-dike character at the beginning which later on has been converted into an inner-dike site. By this water exchange, sediment entry and sedimentation rate has decreased significantly.
Indeed, based on the TIDE measures no significant relationship was found between the average sedimentation rate at the MR site and whether the site is located outer- or inner-dike (See APA 2013 page45).

Factors related to the location of the MR site in the estuary

Overall, the following location characteristics are considered as determining both global and local sedimentation and erosion processes: salinity gradient (TIDE-km and estuarine zone), Suspended Particulate Matter (SPM) and turbidity maximum, location at inner or outer side of a river bend, and hydrodynamics in the area.

Salinity gradient (TIDE-km and estuarine zone)

The first factor is the location of the MR site along the **salinity gradient**: at a certain TIDE-km or certain estuarine zone (freshwater, oligohaline, mesohaline and polyhaline). No relation with the average sedimentation rate at the MR site was found.

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Suspended Particulate Matter (SPM) and turbidity maximum
The second factor is the **SPM** near the MR site and the location of the site at a **turbidity maximum**. For the TIDE cases, the average SPM amounts 200 mg/l, ranging from 38 mg/l to 700 mg/l. As expected, the sedimentation rate is higher at sites with a high SPM supply (Figure 13).

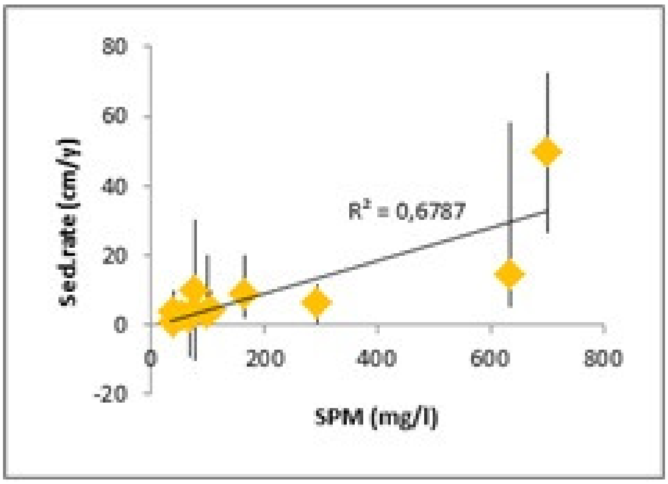

Figure 13: Correlation between SPM and the average sedimentation rate on the site (R^2=0,6787; T=4,6; p<0,001).

Location at inner or outer side of a river bend
The third factor is the location of the MR site at the **inner or outer side of a river bend**. It is expected that the sedimentation rate will be higher at sites located at the inner side of a river bend, because here current velocity is lower. This is however mainly expected for outer-dike sites because only these sites are under full influence of the river. Based on the TIDE data we are not able to verify this assumption (small dataset).

Hydrodynamics in the area
Sedimentation and erosion processes are also influenced by the **exposure of the area** to the turbulence of the estuary: tidal wave action (large in case of a wide connection to the estuary; essentially a very wide breach); wave action from wind (large in case of exposure to significant fetch from the predominant wind direction); and wave action from ships (large in case of relatively high waves from ships). Firstly, it is possible to select a location along the estuary that is more exposed or sheltered to the hydrodynamic turbulences (e.g. close to the navigation channel will give more ship waves). Secondly, it is also possible to influence the hydrodynamics in the measure site by adapting the site design, e.g. by the size of the opening to the river.
Highly exposed zones with high tidal dynamisms could be characterised by inadequate sedimentation or even erosion which could lead to only bare mudflats without marsh development (e.g. S-Paard black circled zone). In contrast, sheltered zones, depressions and completely embanked inner-dike areas (such as a CRT) could be characterised by higher sedimentation rates by which mudflats could disappear and only marshes remain (e.g. S-Paard, Figure 14, red circled zones).

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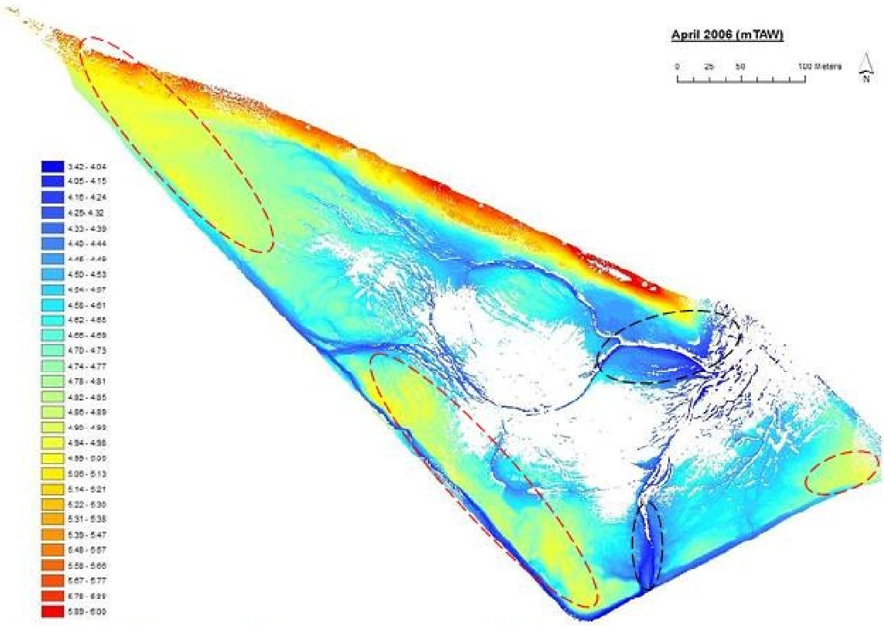

Figure 14: 3D-picture of the Paardenschor in April 2006 (m TAW). The red circled zones are low hydrodynamic zones, the black circled zones high hydrodynamic zones. (Brys et al. 2005)

<u>Factors related to the design of the MR site</u>

Overall, the following site characteristics are considered as determining both global and local sedimentation and erosion processes: initial elevation (lower vs. higher zones), inundation (flood frequency and duration high vs low), slope (weak vs steep), opening to the river, vegetation at the site, drainage and creek system development.

Site topography: elevation and inundation

Spatial differences in elevation in the area will have an influence on spatial patterns of accretion and saltmarsh vegetation, with implications for the habitat development on the site such as benthic invertebrate diversity and bird usage of the site. It has previously been shown that an inverse relationship exists between elevation and accretion rates inside the realignment site. This is a consequence of the tidal regime in the area, i.e. lower parts will be flooded more frequent and for a longer time and hence more sediment could be deposited. It is proved that there is a positive relationship between inundation (frequency and duration) and the accretion rate and hence with elevation. This is also observed at the TIDE cases: sedimentation rates are higher at the lower areas (e.g. S-Lip., Figure 15 and W.Kl.P, Figure 16).

Inappropriate elevation could result in specific site objectives (e.g. marsh development) not being met. Areas that are located much lower than mean high water level (MHWL) for example are quasi constantly flooded and hence vegetation development is difficult. Old polders, frequently used as project sites, are however often located much lower than MHWL as a consequence of increasing water levels and alignment of the areas. In general, an elevation of the site at MHWL is considered as an optimal condition for realignments. The elevation of most TIDE cases is indeed situated around MHWL.

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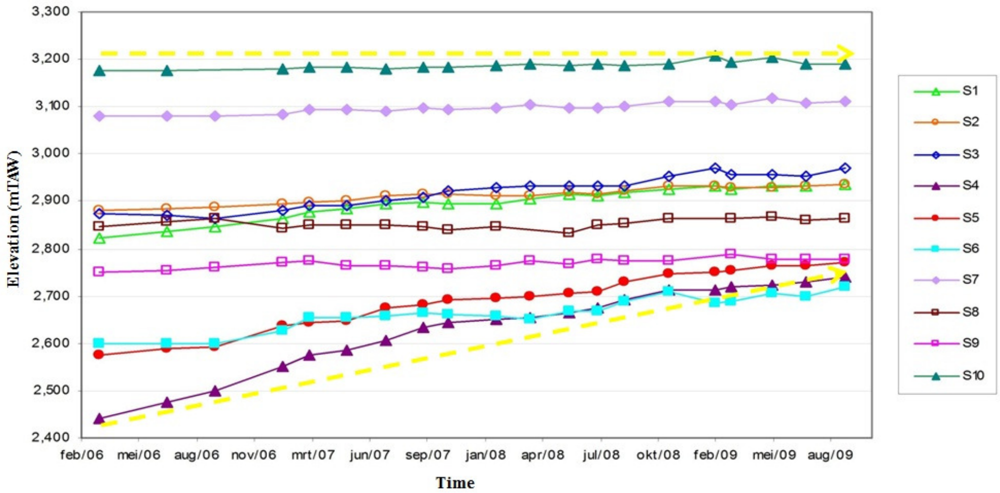

Figure 15: Comparison of sedimentation in the time at the 10 sites of Lippenbroek, February 2006-August 2009: elevation changes (m TAW) (MARIS ET AL. , MARIS ET AL. 2008). Lower sites (eg. 4 and 5) are characterised by higher sedimentation rates and hence elevate much more over time than higher sites (eg. 7 and 10), indicated by the yellow arrows

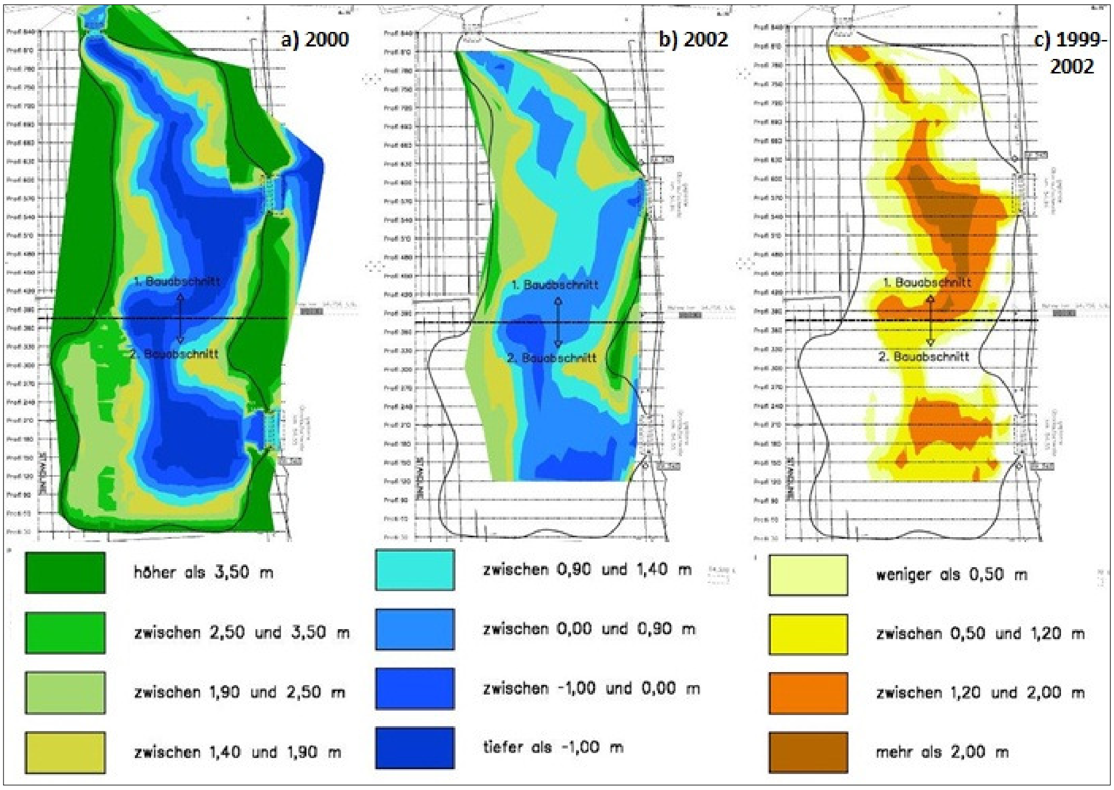

Figure 16: Topography and bathymetry (elevation in m NN) at Kleinensieler Plate: (a) in 2000; (b) in 2002; (c) difference between 1999 and 2002: largest difference in the deepest zones

Slope

A causal relationship exists between the percentage of slope grade of the mudflat and the intensity of sedimentation and erosion: flat areas are characterised by more sedimentation and steep areas by less sedimentation or even erosion. In the TIDE example S-Ket., a sedimentation shift to erosion from a critical slope grade of 2.5% or more was determined. This also corresponds to the difference between the TIDE habitat types intertidal flat habitat (slope rate <2.5%) and intertidal steep habitat (slope rate >2.5%).

Opening to the river

The connection of the site with the river proved to influence the sedimentation and erosion processes in the site. The dimensions of the opening (width and elevation) will (partially) determine to which extent the site is under influence of the tidal prism. In addition, this will influence currents and water levels in the site and hence also the inundation and correspondingly the sediment inflow and the accretion rates. A larger opening (wider and/or low in elevation) can correspond with a larger water volume flowing in the area potentially bringing in also more suspended material. In addition, it is expected that a more or less proportion of suspended material that enters the area will also be deposited there and not return to the river. Hence, to control the sedimentation in the area it might be crucial to control the inflow of suspended material. From the TIDE cases no clear relationship was observed between the average sedimentation rate and the breach size (both absolute and relative to site surface), nor with the elevation of the opening. However, in the TIDE case W-Kl.P. the overflow barriers were heightened to reduce tidal range and by this the amount of suspended matter entering the project area, and indeed siltation tendencies were slowed down (see above). In another TIDE case (S-Heusd) it occurred however that the elevation of the opening was too high to properly drain the area, but this was solved by making an extra breach at MLWL.

As the dimensions of the breach are important for the development of the area, much attention is addressed during the planning phase to create optimal dimensions. For specific measures it might be necessary that at a long term perspective dimensions remain stable. For instance, sedimentation and erosion processes could, depending on the dynamics, enlarge or diminish the opening and change the hydromorphological characteristics in the area. To improve the stability, breaches are frequently enforced by a sill. Also a sluice system (such as in case of the FCA-CRT **S-Lip.**) could offer a solution, because the dimensions are constructed in detail and fine-tuning is possible.

Another aspect of the opening to the river is the number of breaches. If only one breach connects the site to the river, the site will function as a reservoir which will cause a different hydrodynamic situation compared to a site with at least two openings by which the site will function as a flow through (e.g. S-Lip. with high inlet and low outlet to improve the flow through characteristic). In a flow through case, hydrodynamics will be higher causing less sedimentation. However, flow current could also be too strong causing strong erosion obstructing habitat development. This was the case in the TIDE example E-Wr.B. where one site of the creek had to be closed to stop erosion and make habitat development possible.

Overall, managers have several possibilities to control, at least to a certain extent, the sedimentation in the MR site and hence improve the success of the MRM. In the site selection phase, it is advised to take into account the location of the turbidity maximum in the estuary, the SPM concentrations along the estuary and the location of river bends. In the designing phase, many factors could be controlled: outer- or inner dike area with full or dampened tidal influence; initial elevation of the area relative to the tidal prism; elevation differences within the MR site to improve habitat diversity; the slope of the area (a slope of 2.5% and more has to be avoided to make habitat development possible); sheltered sites have higher sedimentation rates compared to exposed sites; and with a larger opening more suspended matter could enter the area and could hence be deposited.

6.1.3 General recommendations for successful MRMs

The overall success of a MRM depends on the possibility to meet the different development targets. Hence the targets have to be specific, measurable and achievable within the context of the project (IECS 2008). MRMs executed in an estuary have to deal with the dynamic and complex context of the estuary. Biotic and abiotic factors of the estuary interact constantly, ultimately resulting in a dynamic equilibrium situation. When intervening in the estuary, e.g. by implementing a MRM, the system is disturbed will evolve towards a new dynamic equilibrium. For a successful MRM, the development targets have to be in accordance with what can be expected to become the new situation in the long term. The manager has however also the opportunity to guide the development of the MR site towards a targeted equilibrium situation by a well-considered design and location. When understanding the impacts of a MRM it will become easier to manipulate the ecological and hydromorphological processes in such a way that the MRM will evolve to the targeted equilibrium situation. In practice it is however difficult to predict the resulting equilibrium situation when implementing a certain measure and hence if this will be in accordance with the development targets.

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To limit the unpredictability of the success of MRMs it is recommended to formulate dynamic goals with a time trajectory that corresponds to the perceived and predicted changes in the project area and in the estuary, rather than a fixed target without temporal consideration. That implies that the goals do not only contain a qualitative description of the desired situation (eg. which habitat types and which species communities), but also a time frame to reach the target (eg. at year t, t+10 and t+20) (IECS 2008). Since the development of the restoration project does not end after the completion of the engineering phase, it is recommended to incorporate realistic predictions of the time frame of evolution in tidal wetland restoration planning (Williams and Orr 2002). Existing and on-going projects in similar conditions could be used as reference to estimate the evolution of habitat development and to determine feasible performance criteria for different habitats.
Formulating dynamic goals (eg. marshland with mudflats and creek development) has to follow from the understanding of both the ecological and the hydromorphological changes (IECS 2008). As sedimentation, erosion and the development of the vegetation are natural processes of the restored estuarine habitats, changes will occur (eg. mudflat will evolve to marsh). The character of the estuarine habitat will therefore inevitably change. The goals of restoration projects should hence be formulated with the ecological and the hydromorphological (desired and undesired) changes in mind because they are intrinsic aspects of the estuarine habitats. This means that it is advised to target certain habitat types and species communities, but not in quantitative terms (exact number of hectares of each habitat type or exact number of species).

Optimisation of measure success
To optimise the success of the MRMs it is recommended to start in the planning phase with incorporating lessons learned from previous and on-going projects. Indeed, the general knowledge on how to develop realignment sites has already been greatly advanced through practical experiences in many case studies. Knowledge sharing could be improved by an iterative approach, i.e. follow and further develop best practices established in the past. The evaluation of previous and on-going projects will provide valuable information on the short- and long-term development of restoration projects. This could help to understand the impact of management interventions on overall developments and this can also indicate which other tools are required to guide restoration projects towards their goals (IECS 2008). A deeper going analysis of comparable successful measures realized under similar conditions could also minimize the risk of associated problems (eg. additional maintenance effort after measure implementation; reconstruction of overflow barriers; etc.). Exchange of experiences, also across estuaries, is hence necessary to improve the overall success of MRMs and this TIDE report aims to be a first step in that direction.
The success of MRMs also depends on the pre- and post-project monitoring.

- This is indeed necessary in order to check whether the targeted results finally have been achieved. And more important to identify unwanted changes or a lack of change in certain aspects for which interventions may be required to steer the development in the aimed direction (IECS 2008).
- Adaptive management, both during and after implementation, forms an important part of the management strategy to improve the overall success of the restoration project.
- Previous and on-going projects could also help to identify which factors are important to monitor, as well as identifying which monitoring techniques should be used.
- Regarding the success of MRMs, it is recommended to consider (at least) tidal prism, breach design (and breach flow speeds), the role of site morphology in delivering particular habitats, and how future accretion may influence site development (Scott et al.).
- The time-scale of the monitoring program has to follow the time-frame of project and hence of the development goals. Because long-term monitoring is in practice often difficult to establish within the project, it is recommended to incorporate the monitoring and possibly the evaluation in a regular long-term monitoring program (IECS 2008).

MRMs generate many ecosystem services and many synergies, but also conflicts between different stakeholders could occur. An effective, clear, honest and early communication strategy with the public, stakeholders and regulators is hence also a key aspect in the overall success of MRMs. It is indeed important to optimise the social support for the measure: by securing landowner involvement and allow sufficient time for

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landowner negotiations (Scott et al.), by emphasizing the multiple socio-economic benefits of the measure, and if necessary by explaining that the design has changed as far as possible to minimise negative effects on public.

Success related to sedimentation issues

The success of MRMs depends, among many others, on the induced sedimentation and erosion processes (Vandenbruwaene et al. 2011) because these processes are key factors in realising most development goals, i.e. to ensure a site is at the right elevation and receives sufficient tidal inundation for habitat development and for flood storage capacity. However, the real sedimentation and erosion processes on the site are not always in favour of the development goals. When sedimentation rates are higher or lower than expected this could be a disadvantage for certain goals. Reduction of the sedimentation rate in the realignment site could be beneficial to meet for instance the goal flood water storage and additionally this could also reduce the need for maintenance efforts in the future which is then beneficial for vegetation, fauna and water structures.

The presented study (part 2) illustrates that by considering certain aspects of the site selection and design, the expected sedimentation and erosion processes could be manipulated to a certain extent in favour of specific development goals. A first recommendation is to evaluate existing and on-going projects to use one or several reference states from a comparable setting (in terms of geomorphology, tidal range and elevation) as basis to establish the design on a target state for the restoration site (IECS 2008). Furthermore, the conclusions from the presented study (part 2) could be used as guideline for optimal site selection and design. Depending on the development goals (habitat development and/or safety), the sedimentation and erosion processes could be guided in a favourable way by designing certain site aspects in a specific way. For many realignment sites the development goals are however a combination of the development of different habitat types. It is therefore recommended to adapt the design of different zones of the site in favour of the different goals. This means a large spatial variation in elevation, slope, etc.

An overall rule for designing realignment sites should be to minimise land manipulation and work with the existing topography as far as possible. It is hence recommended to maximise the advantage from natural physical and vegetative processes and natural sources from the site (e.g. materials for dike enforcement). Furthermore, the extent of any landform manipulation must be justified due to the consideration of project objectives, the potential gains and the likely cost (Scott et al.)

Overall, it is important to keep always in mind that the estuary is a highly dynamic ecosystem and the most important rule for successful management is to work with the system, not against it!

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6.2 Measures influencing sedimentation processes (HPA)

6.2.1 Introduction

High amounts of suspended sediments are a common feature in estuaries. These suspended solids settle mainly in areas of low current velocities like harbour basins or anabranches. High sedimentation rates are an important issue for ports and waterways administrations, because the costs for maintenance dredging often sum up to millions of euros. Therefore port and waterways operators are interested in solutions leading to the reduction of the maintenance dredging needs, as well inside the port areas as in the fairway. Maintenance dredging is therefore a big issue in the four TIDE estuaries.

The occurrence of high sedimentation is also a topic in many realignment measures and in projects that cope with the revitalization of anabranches and former side channels (BIOCONSULT & NLWKN 2012). With the on-going sedimentation, necessary ecological functions cannot be provided anymore, e.g. valuable shallow water areas which provide food and spawning ground for fish species silt up and develop into mudflats.

Within the TIDE project, measures which are or will be conducted in the four estuaries are collected and evaluated. Some of these measures aim to reduce sedimentation and the dredging necessities respectively. This paragraph first gives an overview on potential measures being able to reduce or avoid sedimentation and subsequently describes what has been done at the four TIDE estuaries in this context so far.

As sedimentation processes are governed by a lot of different factors, there are various starting points in the development of measures to control sedimentation (PIANC 2008):

- Keep the sediments out
- Keep the sediments suspended
- Keep the sediments navigable

These targets can be matched by different approaches:

- Influencing the sedimentation process directly by preventing the entry of sediments in a certain area, by altering the current dynamics or by trapping the sediments before they can enter a sedimentation hot spot
- Influencing the sedimentation process indirectly by altering general transport patterns within the estuary in a way that leads to lower sedimentation rates

6.2.2 Direct approaches of sedimentation control

Current control

In estuaries, sediment transport is controlled by the tides and the resulting currents and by freshwater discharge. Therefore some measures focus on influencing or inhibiting the currents. In a port, the most obvious measure is to close a harbour basin via a dock or a jetty construction in order to reduce or prevent the occurrence of waves and currents within these areas. This measure keeps the water navigable and locks out undesired currents and sediments. Most of the harbour basins at the TIDE ports of Antwerp, Hull and Bremerhaven are located behind the locks. In contrast, the port of Hamburg is completely open to the tides and related currents.

The currents can be controlled by a current deflecting wall, for instance. The deflector structure modifies the flow patterns resulting in the diminishment of eddy flows which cause high sedimentation rates (Figure 17).

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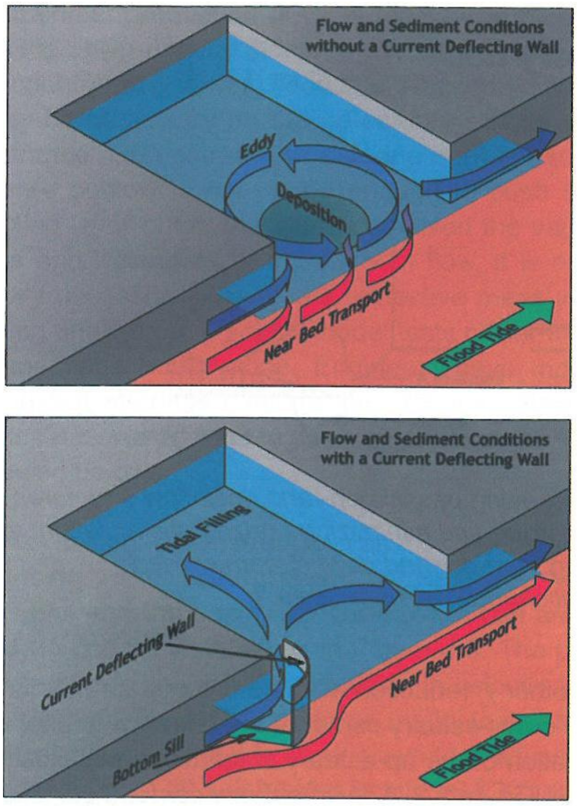

Figure 17: Scheme of current deflecting wall (PIANC, 2008)

A current deflecting wall was successfully installed in the port of Hamburg (HPA 2012c). The applicability of this method was tested for the Port of Antwerp as well. Although the boundary conditions in Antwerp differed from those in Hamburg (e.g. salinity gradient and density gradient), the modelling exercise showed that a current deflecting wall could reduce the sedimentation rates inside the new build Deurganckdok harbour basin (VAN MAAREN et al. 2010). The deflecting wall in Antwerp was implemented in 2011 (Figure 18); it is expected to lead to a 15 - 20 % reduction of sedimentation.

Figure 18: Construction of current deflecting wall at Deurganckdok (http://www.hye.be/nl/news/show/one/9/)

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Additionally, the freshwater discharge coming from upstream could be affected in a beneficial way. At the Elbe estuary, there is less sedimentation in the harbour area during periods of high fresh water discharge in winter and spring due to the flushing effect of the freshwater. Therefore an investigation on the possibilities of avoiding sedimentation via freshwater discharge control, between the two Elbe branches was conducted (HPA 2012d). This study was contracted out with regard to the specific situation at the Elbe estuary (high freshwater discharge and division in northern and southern Elbe branch), but regulating the freshwater current might be possible to be implemented at other estuaries as well.
The study on the revitalization of the anabranch ´Schweiburg´ at the Weser estuary (BIOCONSULT & NLWKN 2012) lists several options for the maintenance of the shallow water area. However, it became clear that by means of some limited technical measures the aim of self-preservation and – therefore – comprehensive revitalisation of the area could not be achieved. In order to revitalise some of the ecological functions of the anabranch and to improve the prediction of the desired effects, further research is needed.

Sediment trapping

Sedimentation can be avoided by trapping the sediments before they reach a critical area by widening or deepening some parts of the river channel. The current will decline and a part of the suspended sediment will settle within the sediment trap. If the transport regime mostly consists of bed load transport, the sediments will also sink at the abrupt depression and finally settle in the trap.
This measure does not reduce the dredging amounts, but it is an advantage that the necessary dredging can be planned and therefore will interfere to a lesser extent with the vessel traffic and the port operation. Additionally the sediments inside the trap will consolidate over a longer period of time leading to a more effective dredging due to higher sediment densities in the trap (DAVIS & MCANALLY 2010).
Sediment trapping is a well-known management option for rivers, but not for estuaries. The changing flow directions of the tides and the different ways of sediment transport make the effects of sediment trapping difficult to predict.
Therefore, HAYDEL & MCANALLY (2002) pointed out that the trap design should be adapted to the specific site characteristics (sediment and flow characteristics, river hydrography and facility size).
In 2008, HPA and WSV (Federal Administration of Waterways and Navigation) installed a sediment trap adjacent to the port of Hamburg (measure 5; HPA 2012e) Functioning and impacts on the environment were reported and evaluated within the TIDE project (HPA 2013).

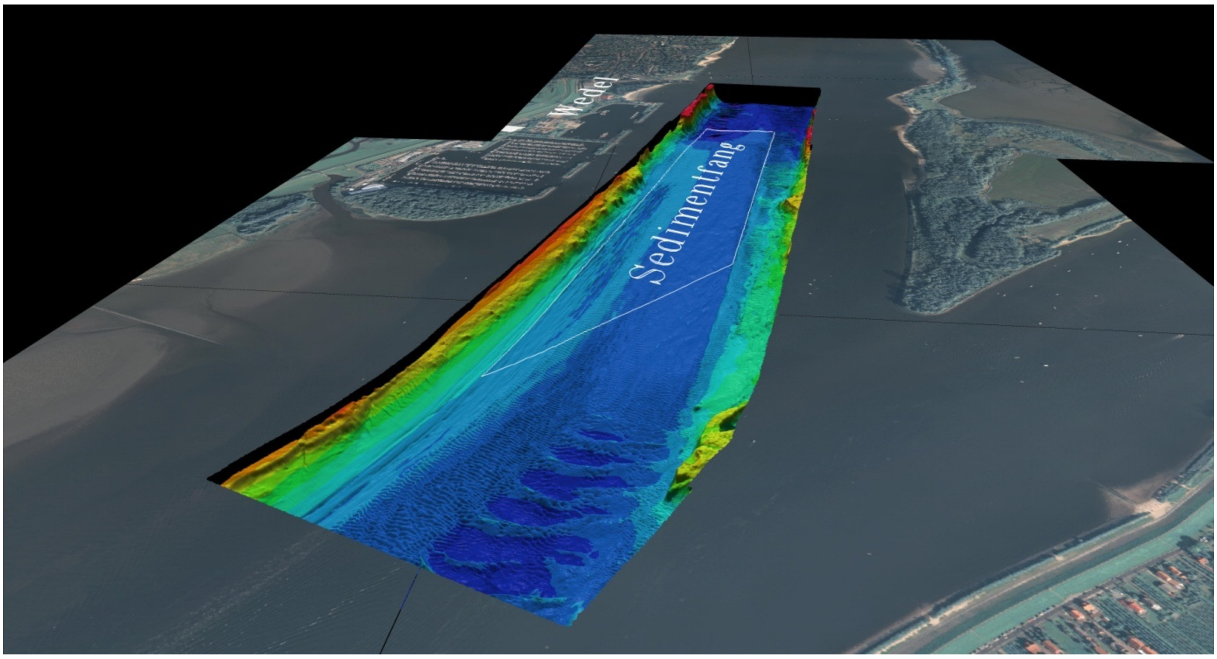

Figure 19: Position of the sediment trap at the river Elbe (source: HPA)

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Determining and using the navigable depth in fluid mud layers
In estuaries with a high amount of fine sediments, very often a thick, more or less mobile layer of fluid mud can be observed in the riverbed. For systems with high turbidity regimes and fluid mud layers, it is convenient to determine the thickness of the fluid mud layer which can be passed through by ships. If this certain thickness at a determined water depth (nautical depth) is not exceeded, dredging activities will not be necessary.
The prediction of the nautical depth through the fluid mud layers (density up to 1.25 t/m³), i.e. detecting the depth at which the fluid mud reaches this critical density, is not simple. It is difficult to obtain a useful profile of fluid mud density by acoustic methods. Any abrupt change in density, e.g. at the interface between 'dirty water' and freshly settled fluid mud, will give a signal, but progressive density changes cannot be registered. As a result, an echo sounder will often return at least two signals: a 'hard' echo from the denser, well-consolidated mud of the riverbed, and a 'soft' echo from the interface between the water and the top of the fluid mud.
Associated British Ports (ABP) is using a new technique to determine the navigable depth in their ports and the shipping channel of the Humber: they measure the density of 'fluid mud' with a device called Hydromotion MudBug (Figure 20; EA 2012c). The technique, which is still new, allows the determination of the navigable depth more accurately. Therefore unnecessary dredging activities can be avoided.

Figure 20: Hydromotion MudBug, Mud density measurement device (http://www.engineerlive.com/HydrographicSeismic/Hydrographic_Survey/Mud_density_measurement_saves_dredging_costs/22030/)

Sediment conditioning
Further, unnecessary dredging can be avoided by sediment conditioning. That means that the method of water-injection is applied to keep the water navigable. Air is introduced in already consolidated mud in order to transform it to fluid mud (in-situ conditioning). This method is successfully used in the port of Emden as well as in Bremerhaven (Weser estuary) and Rotterdam (Greiser 2004, Wurpts 2005). However, this method cannot be applied in estuaries in which the sediment is dominated by sand. Besides, this suspended sediment loading in the water column will probably not be reduced by this method.

6.2.3 Indirect approaches of sedimentation control (mitigation)

Most of the estuaries of the North Sea Region have been altered to a great extend over the last century (Hamer 2013). The tidal range has typically increased in the upper estuary which leads often to an increase in upstream sediment transport and higher sedimentation rates in anabranches and port areas. The mitigation of these – negative – effects is also considered as an option.
Investigations at the Scheldt estuary showed that dredged material can be used to positively affect estuarine currents (eg TIDE measures 20-23 (Walsoorden) and measure 19 (Navigation channel near Ketelplaat).
In relation to the planned deepening of the fairway of the Elbe several underwater relocation areas will be constructed with dredged material. They should dissipate the tidal energy, which should lead to a decrease of the tidal range and subsequently to a lower upstream sediment transport (see measure 02 “Medemrinne Ost”).
Additionally the implementation of the measure Spadenlander Busch in the Elbe estuary (see measure 01) is meant to work against the increased sediment transport by dissipating tidal energy and therefore positively affecting the tidal conditions.

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Within the framework of TIDE possible mitigation measures in the estuary mouth of the rivers Elbe (Figure 21) and Scheldt were studied (see MOW & HPA 2013) that showed a possible basis for future research.

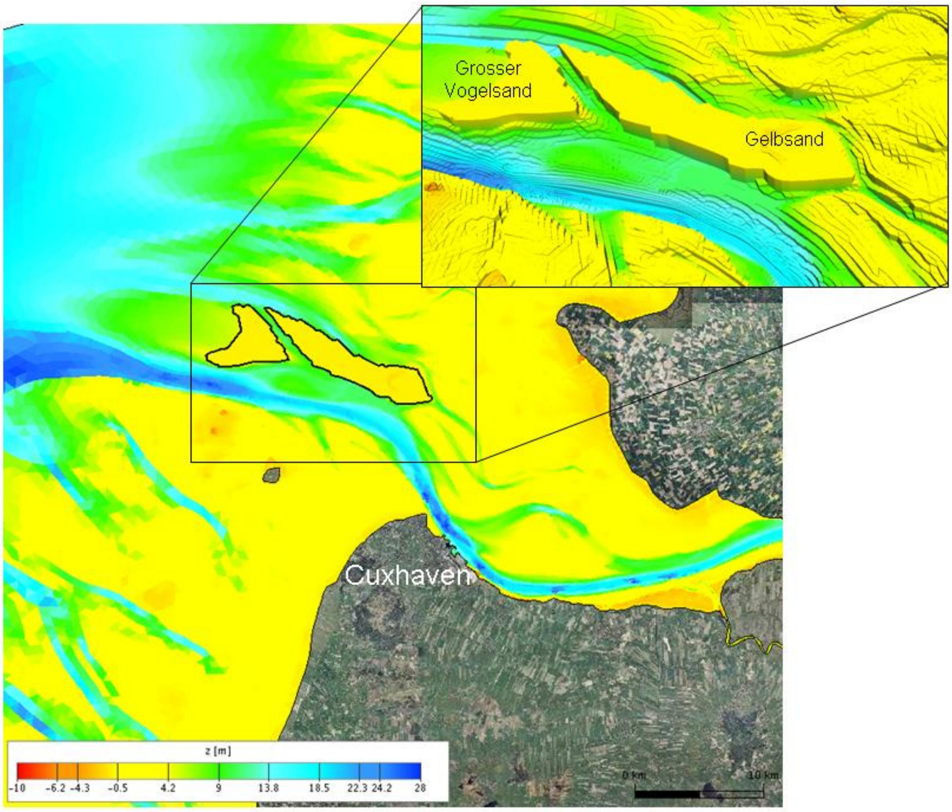

Figure 21: Overview on possible mitigation measures in the mouth of the Elbe estuary

6.2.4 Recommendations

There are several ways of positively influencing the negative consequences of changes in the tidal regime and related sedimentation processes in estuaries. For choosing the most successful measure it is necessary to carefully study the specific relations between currents, tidal range and sediment transport before it is possible to alter the system in a beneficial way.

7. Summary and conclusions

It is the aim of this TIDE study to make the experiences with management measures at the TIDE estuaries Elbe, Humber, Scheldt and Weser available to estuary managers, in order to generally improve the future planning and implementation processes of estuarine management measures. For this purpose examples of practical management measures planned or implemented in these estuaries have been collected and systematically analysed. Based on the results and conclusions recommendations to address estuary managers have been formulated.

7.1 Procedure

Measures have been selected and compiled for comparative analysis. The measures selected were those that it was judged were well documented, and that had the potential to be educative as a consequence, for future measure planning and implementation in the light of the measure categories and development targets (3 categories and 13 development targets). Overall 39 measure examples have been selected most of them belonging to the categories Biology/Ecology (25) and Hydrology/Morphology (9). Only two measure examples have been addressed to the category Physical/Chemical Quality, three examples have been allocated to two categories each. The Elbe is represented by 12 measures, Humber by 10, Scheldt by 11 and Weser by 6 measure examples. For all these measures fundamental and extended information has been compiled according to an agreed scheme.
The comparative analysis focused on the effectiveness of a measure in view of different aspects and targets: initial development targets, ecosystem services (ES), Natura 2000 objectives, Water Framework Directive objectives. In addition, lessons learned were collected and gaps in knowledge were identified, partly by involving the organisations in charge of measure planning and implementation. The set of analysis criteria was defined in consultation with all TIDE partners. The analysis process was based on the contents of the measure surveys followed by a more detailed, goal oriented analysis of available monitoring reports and/or modeling results as well as expert knowledge.
Additionally cross estuary comparison focusses on two significant aspects - managed realignment measures and the control of sedimentation processes.

7.2 Results

7.2.1 Compilation of measures within the TIDE estuaries

The database on management measures and further documentations on applied management activities within the TIDE estuaries have been integrated in the TIDE toolbox. Overall, the compiled information gives a broad overview on various management activities, covering all TIDE estuaries and estuarine zones.

Database on management measures
The management measure database contains at present (state 03/2013) the information on those 39 measures being analysed within this study. For each measure there is a factsheet which contains a description and evaluation of the measure following a unique scheme which includes information regarding e.g. location, status, responsible authorities, initial management objectives, description of construction work, specific boundary conditions, costs, etc. The measure factsheet also contains evaluation results, as there is information on the degree of target achievement, synergies and conflicts with regard to ecosystem services, Water Framework Directive and the Birds and Habitats Directive. The location and design of each measure is visualized by pictures and maps.
The measures within the database represent a diverse spectrum of development targets; for example they refer to the reduction of tidal energy, range and asymmetry, to flood protection and the improvement of

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morphological conditions, to the development of habitats, natural gradients and processes, to the protection of species, to the reduction of pollutant loadings and the improvement of oxygen conditions.

Further documentations on TIDE management measure studies
Within the Tide project a couple of pilot projects have been undertaken at the estuaries of Elbe, Humber, Scheldt and Weser. They deal with management measure issues which are of particular concern at the specific estuary but which provide valuable experience for other estuaries. These studies refer e.g. to the revitalization of anabranches, to the morphological management of estuaries, to the alternative use of dredged material.
The development of dredging volumes, the handling of polluted sediments as well as dredging and relocation strategies have been documented within four estuary specific studies on sediment management at Weser, Elbe, Scheldt and Humber. An overall fifth study compares the different approaches on sediment management, presents examples of good practice, elaborates demands and opportunities, and at least give recommendations.
All reports are available in the TIDE toolbox.

7.2.2 Planning and implementing management measures: Résumé

The reasons for planning a management measure may be manifold, e.g. the demand for compensation, the requirement for improvement referring to the objectives of the WFD and Natura 2000, or a low performance and productivity of the estuarine system with regard to other deliveries for society. Nevertheless - for making measure planning and implementation successful attention should be paid to some crucial aspects.

Conception, planning
The overall success of a management measure depends on the possibility to meet specific development targets. In order to plan a target-oriented measure and to minimize the risk of failing, each measure should start with planning a systematic and comprehensive analysis of the actual status and the requirements and potentials for improvement. Current and target state have to be determined as accurately as possible and necessary, as well as the dominant counteracting factors (e.g. pressures and impacts on the estuarine functions) and other boundary conditions hindering or supporting target achievement. Based on this analysis process, development targets and measures can be selected and prioritized. In principle, these targets should be concrete, measurable and achievable within the context of the project (IECS 2008). In order to improve the implementation chances for management measures, already in the planning phase estuary mangers should analyse the potential co-benefits and synergies as well as conflicts that are derived from the respective measure (see following chapter).
Nonetheless, management in estuaries has to deal with the dynamic and complex environment which means a particular challenge for measure planning and realization. Biotic and abiotic factors of the estuary interact constantly. For a successful management measure, the development targets have to be in accordance with what can be expected to develop into the long-term environment. Hence it is recommended to formulate dynamic goals with a time trajectory that corresponds to the perceived and predicted changes in the project area and in the estuary. That implies that the goals do not only contain a qualitative description of the desired situation (eg. which habitat types and which species communities), but also a time frame to reach the target.
Formulating dynamic goals (eg. marshland with creek development) has to follow from the understanding of both the ecological and the hydro-morphological changes. Because of interlinking physical, chemical and biological processes within a highly dynamic environment influences the measure development at a site specific location. The character of an estuarine habitat will therefore inevitably change. The goals of restoration projects for example, should be formulated with the ecological and the hydro-morphological (desired and undesired) changes in mind because they are intrinsic aspects of natural estuarine habitats. This means that it is advised to target certain habitat types/surfaces and species communities for example, but to be realistic and to a certain degree flexible regarding goal state and time scale.
An overall rule for designing measures should be to minimise land manipulation and work with the existing topography as far as possible, to use the natural resources from the site and to maximise the advantage from

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natural physical and biological processes. Hence, the most important rule for successful management is to work with the system, not against it!

To optimise the success of the management measures it is recommended to start in the planning phase with incorporating lessons learned from previous and on-going projects. Existing and on-going projects in similar conditions could be used as reference to estimate the evolution of habitat development and to determine feasible performance criteria for different habitats. The general knowledge on how to develop realignment sites for example, has already been greatly advanced through practical experiences in many case studies.

Realization: Use of synergies

The Water Framework Directive and the Birds and Habitats Directives represent environmental directives of the European Union. Since EU member states are legally obliged to reach the related objectives, responsible governments and subordinated administrations necessarily have a strong interest in designing and supporting targeted management measures. In order to bring forward measures in favour of the ecosystem, it is worthwhile for estuary managers to make some efforts to prove, map and communicate potential positive measure effects in view of WFD and Natura 2000 aims.

The vast majority of TIDE measures was not designed to meet the requirements of WFD and Natura 2000. However, two simple approaches to roughly evaluate potential positive and negative effects in view of WFD and Natura 2000 were described and executed on a case-by-case basis.

Measure effects in terms of WFD aims were estimated based on identifying the main WFD pressures the different estuary zones are affected by. Building on the hypothesis that positive or negative measure effects in view of the main pressures may result in positive or negative impacts regarding WFD quality elements, potential synergistic effects and conflicts were indicated and briefly described. As anticipated, the analysis showed that especially measures assigned to measure category 'Biology/Ecology' with habitat, species or process related development targets are supposed to have very positive or positive effects since they show large intersections with the main pressures derived from the state indicators (e.g. "Habitat loss and degradation during the last 100 years: Intertidal" and "Habitat loss and degradation during the last 100 years: Subtidal"). The average percentage of pressures positively influenced by measures of category 'Biology/Ecology' amounts to 67 percent. But also for measures of category 'Hydrology/Morphology' e.g. aiming to reduce tidal pumping effects or to improve morphological conditions, several positive effects in view of the main pressures were stated. Here, the average percentage of pressures positively impacted amounts to 21 percent (for details of the calculations see chapter 5.2.2.1).

The evaluation of potential synergistic effects and conflicts in view of Natura 2000 was based on a comparison with Natura 2000 objectives defined for certain spatial units and/or conservation objectives formulated for the entire tidally influenced river sections of Weser, Elbe, Humber and Scheldt (e.g. conservation objectives for operational areas and according to the Integrated Management Plan Weser (NLWKN, SUBV 2012)). Although the estuary specific evaluation proceedings differ slightly depending on availability and spatial reference of Natura 2000 conservation objectives, potential synergistic effects were stated for most management measures considered. Analogous to the results of the WFD evaluation, the analysis showed that especially measures of category 'Biology/Ecology' are supposed to have positive impacts on the conservation objectives. The average percentage of objectives positively or very positively effected by the measures amounts to 78 percent, while the average percentage according to measures of category 'Hydrology/Morphology' amounts to 16 percent.

Another approach developed and executed in this study in order to estimate and describe potential impacts of management measures on the estuarine ecosystem is derived from the concept of ecosystem services which was refined and applied to the TIDE estuaries by JACOBS 2013. In the frame of the measure analysis, potential measure impacts on ES as defined by JACOBS 2013 were estimated considering the development targets of the TIDE measures and the surface and quality change of habitats due to measure implementation. Since most of the TIDE measures are biodiversity-targeted and examples of good practice, the expected impact especially on supporting and habitat services is positive for most measures. Also, the TIDE measures generate overall many co-benefits, i.e. a positive expected impact on many ES which were not targeted.

In order to improve the implementation chances for effective future management measures in favour of the ecosystem, estuary mangers should analyse potential synergistic effects and conflicts regarding WFD and Natura 2000 aims as well as the expected impact on ecosystem services.

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Communication

Management measures generate many ecosystem services and many synergies, but also conflicts between different stakeholders could occur. An effective, clear, honest and early communication with administrations in charge, affected private individuals, stakeholders and the public is a key aspect in developing and implementing a management measure concept. Hence it is recommended to allow sufficient time for negotiations with landowners/users (e.g. with regard to agriculture, hunting, fisheries, recreation), for communicating safety concerns, for explaining and - if applicable – adapting the design of the measure.

It is recommended to communicate the findings of benefits and – moreover – of not-targeted co-benefits (ES, WFD, BHD) to stakeholders, responsible administrations, politicians and the broad public. As a result, the willingness to participate, pay and support the measure implementation, but also the general acceptance of respective projects could be increased. In the frame of this study, three possible approaches for the estimation of measure impacts were developed and tested on a case-by-case basis which could be used as a starting point for practical application.

Accompanying management and monitoring

Adaptive management, both during and after implementation, form an important part of the management strategy to improve the overall success of the management measure. Adaptive management depends on a monitoring program being suitable to identify unwanted changes or a lack of change in certain aspects for which interventions may be required to steer the development in the aimed direction (IECS 2008). Last not least, the monitoring has to deliver the basis to check whether the targeted results finally have been achieved.

The measure analysis realized in the frame of this study included a rough estimation of the degree of target achievement which was mainly based on expert judgment and monitoring or modeling results. Partly, insider knowledge of people was considered who were involved in the planning and implementation process but not mentioned in available reports. For the majority of the TIDE measures, the defined development targets and the way they are reflected in the available monitoring reports did not turn out to be usable instruments to come to a sound statement on the measure success due to the following reasons:

- In most cases, the monitoring targets are not formulated specifically enough to be scientifically proven in the course of monitoring programs.
- As a consequence, monitoring reports often do not explicitly refer to the available development targets.
- Additionally, the structure of the monitoring program is regularly determined and structured by the different ecosystem components that are taken into account (e.g. flora, fauna, water quality) and not by the development targets that should be proven.

To sustainably improve the success of management measures managers should pay enhanced attention to the implementation of a specific target oriented measure monitoring. Previous and on-going projects could help to identify which factors are important to monitor, as well as identifying which monitoring techniques should be used. At least, the informative value of this monitoring might considerably increase when the program is well linked to an integrated and representative estuary monitoring.

The time-scale of the monitoring program has to follow the time-frame of the project and hence of the development goals. Nonetheless, it might be appropriate to get information on the further development of the site. In this case it should be proven if the measure monitoring or parts of the program could be continued in the context of the regular estuary monitoring.

Analysis and assessment

In order to check whether the targeted goals have been achieved the monitoring data have to be systematically analysed and assessed. If the targets have not or have only been partly achieved it has to be proven if improvements within the measure design would be possible and constructive or if the goals would be achievable by means of other measures. If the targets are not achievable, in the end it has to be checked which consequences must arise from it for the overall management within the estuary.

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Publication, exchange of experience

For successful implementation of future measures it is crucial to further enhance the knowledge on estuary functioning and good practice of measure implementation. In order to progressively improve the effectiveness of measures in estuaries, estuary managers should make sure that an evaluation of the measure success in terms of lessons learned takes place and the results will be made available to other estuary managers/other organisations.

Challenges

There are various challenges in planning and implementing successful management measures in estuaries. Hence, the success of several measures depends, among many others factors, on the induced sedimentation and erosion processes (Vandenbruwaene et al. 2011) because these processes are key factors in achieving most development goals, i.e. to ensure a site is sustainably providing habitats with certain water depths and velocities or receives sufficient tidal inundation for habitat development and for flood storage capacity. However, the real sedimentation and erosion processes on the site are not always in alignment with the development goals. When sedimentation rates are higher or lower than expected this could be a disadvantage for certain goals. Reduction of the sedimentation rate within a the realignment site for example, could be beneficial to meet a target for flood water storage and additionally this could also reduce the need for maintenance efforts in the future which is then beneficial for vegetation, fauna and water structures.

This study illustrates with regard to managed realignment measures that by considering certain aspects of the site selection and design, the expected sedimentation and erosion processes could be manipulated to a certain extent in favour of specific development goals. Furthermore, the conclusions from this study could be used as guideline for appropriate site selection and design (e.g. habitat development and/or safety). A crucial point is to take use of the natural physical and biological processes and to work with the system (see above). For many realignment sites the development goals are however a combination of the development of different habitat types. It is therefore recommended to adapt the design of different zones of the site in favour of the different goals. This means a large spatial variation in elevation, slope, etc. and corresponding requirements for land area.

Outlook

The evaluation of previous and on-going projects will provide valuable information on the short- and long-term development of management measures and minimise the risk of associated problems. This could also help to understand the impact of management interventions on overall development and this can indicate which other tools are required to guide restoration projects towards their goals (IECS 2008). Exchange of experiences, also across estuaries is hence necessary to improve the overall success of management measures, and this TIDE report aims to be one step in that direction. One product of this work is the management measure database. The continuous extension of this database or a follow-up product (especially filled by current and future projects) might seriously further the process of exchange of experiences.

Feasibility and success of several measure approaches, especially those referring to the dominant pressures and impacts, depend on an in-depth understanding on estuary functioning and, in the end, on the question if estuary management will have the ability to limit and partly trace back these impacts.

Vice versa, the specific management measure shall and can contribute that the estuary obtain respectively regain its performance and productivity. This study worked out that management measures besides the targeted benefits mostly provide a couple of co-benefits for the society and the estuarine environment which can be visualised, e.g. by applying the ecosystem services concept.

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8. Recommendations

1. Estuary managers should select and prioritize management measures based on a **systematic deficit analysis of the respective estuary zone**. This analysis has to include the description of the targets aimed at, the actual status, the dominant pressures and impacts, the expected development and the requirements and potentials for improvement.
   Inasmuch as different sectoral demands might be affected this analysis will be best delivered by collaborative working.

2. The **definition of** specific **development targets** based on this deficit analysis is a crucial step in the initial stages of the planning process of each management measure.

3. Measures executed in an estuary have to **be designed to work with the dynamic and complex context** of the estuary. The targets have to be able to adapt to natural changes within the environment in the long-term: realistic and to a certain degree flexible regarding goal state and time scale.

4. For measure design it is strongly recommended to **maximize the advantage available from natural physical and biological processes** and the natural sources from the site. Work with the system, not against it!

5. To optimize the success of the measures it is recommended to **incorporate into the planning phase an extensive review on lessons learned** from previous and on-going projects.
   Indeed, the general knowledge on how to develop realignment sites for example has already been greatly advanced through practical experiences in many case studies.
   A comprehensive set of information on a broad spectrum of measure examples has been compiled within the TIDE measure database. Further information is available within the reports on TIDE pilot studies and sediment management. You are invited to use these databases within the TIDE toolbox!

6. In order to improve the chances of implementation for management measures in favour of the ecosystem, estuary mangers should **analyze the potential co-benefits and synergies as well as conflicts** that are derived from the respective measure.
   In the frame of this study, three possible approaches for the estimation of measure impacts were developed and tested on a case-by-case basis: impacts on Ecosystem Services, on management targets of the Birds and Habitats Directive and on pressures related to management targets related to the Water Framework Directive. These approaches could be used as a starting point for further practical application. The description of how to determine the co-benefits can be found in the "TIDE tools".

7. The **findings on benefits, beneficiaries and conflicts should be communicated to e.g. stakeholders, responsible administrations, affected private persons.** An early involvement of stakeholders, etc. and an appropriate communication strategy are recommended in order to optimize social support for the measure and to minimize conflicts that may arise during the implementation process of a management measure (e.g. conflicts with former uses or safety concerns).

8. To sustainably improve the success of management measures managers should pay enhanced attention to the consequent verification of the development targets regarding the design and implementation of monitoring programs: A specific **target oriented measure**

monitoring programme which is well linked to integrated and representative estuary monitoring is the essential basis for success control and adaptive measure management.

9. In order to progressively improve the effectiveness of measures in estuaries, estuary managers should make sure that an **evaluation of the measure success** in terms of lessons learned takes place.

10. For successful implementation of future measures it is crucial to further **enhance the knowledge on estuary functioning and good practice of measure implementation**. Hence, the results of measure evaluation should be made available to other estuary managers/other organizations.

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10. Annex

10.1 Composition of Regional Working Groups identifying main pressures and resulting deficits for the estuary zone using Environmental Integrative Indicators (EII)

Table 34: Participants of RWG Weser (Meeting date: 13/04/2012)

Name	Organisation	Position	Expertise
Wilfried Heiber	Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency (NLWKN)	Scientific assistant	Ecology-hydromorphology interactions, water quality, WFD implementation, ICZM
Sonja Saathoff	Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency (NLWKN)	Scientific assistant	Ecology, measure planning and implementation, WFD, focus: Weser estuary

Table 35: Participants of RWG Elbe (Meeting date: 16/04/2012)

Name	Organisation	Position	Expertise
Sonja Wild-Metzko	Hamburg Port Authority	Scientific assistant	Implementation WFD focus Elbe estuary
Boris Hochfeld	Hamburg Port Authority	Scientific assistant	Integrated Management Plan Elbe estuary
Johanna Knüppel	Hamburg Port Authority	Scientific assistant	Measure planning within the Elbe estuary

Table 36: Participants of RWG Scheldt (Meeting date: 03/05/2012)

Name	Organisation	Position	Expertise
Sander Jacobs	University of Antwerp	Scientific researcher	Ecosystem services
Annelies Boerema	Antwerp Port Authority	Technical manager Environment	Estuarine management, environmental economics

Table 37: Participants of RWG Humber (Meeting Date: 08/03/2012)

Name	Organisation	Position	Expertise
Sue Manson	Environment Agency	FCRM Advisor	Hydrology, hydro and geomorphology, flood risk management
Nick Cutts	Institute of Estuarine and Coastal Studies, University of Hull	Deputy Director	Ornithology
Krystal Hemmingway	Institute of Estuarine and Coastal Studies, University of Hull	Senior Coastal Ecologist	Coastal ecology
Emma Hawthorne	Natural England	Senior Advisor	Marine Environment, Habitat Regulations
Tom Jeynes	Associated British Ports	Sustainable Development Officer	Environmental Regulations and port development
Gordon Kell	Humber Management Scheme	Project Officer	Partnership management
Belan Hay	Humber Management Scheme	Project Officer	Stakeholder Engagement
Tim Page	Natural England	Advisor	Marine Environment, Habitat Regulations, Ornithology
Jemma Lonsdale	Associated British Ports	Support Officer	EIA Regulations, environmental science

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10.2 Templates for evaluation of measures in terms of WFD aims: Identification of pressures and explanation of resulting deficits for the estuary zones using Environmental Integrative Indicators (EII)

Table 38: Step 1a of WFD pressures evaluation (template): Identification of main pressures per estuary zone by estimating the relevance of state indicators (scoring from no relevance for the system (0) to very highly relevant for the system (4)). State indicators highly or very highly relevant indicate potential main pressures of the respective estuary zone.

State Indicators		**FRESHWATER**	**OLIGOHALINE**	**MESOHALINE**	**POLYHALINE**
Code	**Indicator**				
1.1	Habitat loss and degradation during the last about 100 years: Intertidal	0	0	0	0
xxx	Habitat loss and degradation during the last about 100 years: Subtidal	0	0	0	0
1.4	Gross change in morphology during the last about 100 years	0	0	0	0
1.5	Gross change of the hydrographic regime during the last about 100 years	0	0	0	0
3.1/3.2	Decrease of water and sediment chemical quality	0	0	0	0
3.3	Increased chemical loads on organisms	0	0	0	0
3.4	Decrease of microbial quality	0	0	0	0
3.8	Aesthetic pollution	0	0	0	0

Table 39: Step 1b of WFD pressures evaluation (template): Identification of main pressures per estuary zone by estimating the relevance of driver indicators (scoring from no relevance for the system (0) to highly relevant for the system (4)). Driver indicators highly or very highly relevant indicate potential main pressures of the respective estuary zone.

Driver Indicators		**FRESHWATER**	**OLIGOHALINE**	**MESOHALINE**	**POLYHALINE**
Code	**Indicator**				
1.3	Land claim during the last about 100 years	0	0	0	0
1.7	Relative Sea Level Rise	0	0	0	0
2.3	Discharge of nutrients and/or harmful substances	0	0	0	0
2.6	Capital dredging	0	0	0	0
2.4	Maintenance dredging	0	0	0	0

2.5a	Relocation of dredged material	0	0	0	0
2.9	Aquaculture	0	0	0	0
2.10	Fisheries activities	0	0	0	0
2.8	Wind farm development	0	0	0	0
2.11	Marina developments	0	0	0	0
2.12	Port developments	0	0	0	0
xxx	Industrial development	0	0	0	0
2.13	Insallation of pipelines and cables	0	0	0	0
2.14	Oil and gas exploration and production	0	0	0	0
2.16	Tourism and recreation	0	0	0	0

Table 40: Valuation system for estimating the relevance state and driver indicators for the system

Relevance of indicator
0 = No relevance for the system
1 = Low relevance for the system
2 = Medium relevance for the system
3 = Highly relevant for the system (= potential main pressure)
4 = Very highly relevant for the system (= potential main pressure)

Table 41: Results of step 1a of WFD pressures evaluation (template): List of potential three main pressures per estuary zone added by description of the resulting deficits with special focus on WFD quality elements (main pressure = highly or very highly state indicator OR additional pressure)

RESULTS SURVEY_1				
ESTUARY ZONE	**MAIN PRESSURES**		**COMMENTS** (to be added by RWG members)	**DEFICIT DESCRIPTION** (to be added by project partner after RWG meeting)
	State Indicators OR additional pressure			
	Code (if available)	**Indicator**		
FRESHWATER				
Main Pressure 1				
Main Pressure 2				
Main Pressure 3				
OLIGOHALINE				

Main Pressure 1				
Main Pressure 2				
Main Pressure 3				
MESOHALINE				
Main Pressure 1				
Main Pressure 2				
Main Pressure 3				
POLYHALINE				
Main Pressure 1				
Main Pressure 2				
Main Pressure 3				

Table 42: Results of step 1b of WFD pressures evaluation (template): List of potential three main pressures per estuary zone added by description of the resulting deficits with special focus on WFD quality elements (main pressure = highly or very highly driver indicator OR additional pressure)

RESULTS SURVEY_2				
ESTUARY ZONE	**MAIN PRESSURES**		**COMMENTS** (to be added by RWG members)	**DEFICIT DESCRIPTION** (to be added by project partner after RWG meeting)
	Driver Indicators OR additional pressure			
	Code (if available)	**Indicator**		
FRESHWATER				
Main Pressure 1				
Main Pressure 2				
Main Pressure 3				
OLIGOHALINE				
Main Pressure 1				
Main Pressure 2				
Main Pressure 3				
MESOHALINE				
Main Pressure 1				

Main Pressure 2				
Main Pressure 3				
POLYHALINE				
Main Pressure 1				
Main Pressure 2				
Main Pressure 3				

Table 43: Zonation schemes defined for the estuary zones of Weser, Elbe, Humber and Scheldt in the frame of TIDE (Geerts et al. 2011.)

TIDE ZONATION SCHEMES											
Estuary zone				**Chlorinity range**	**Elbe**		**Weser**		**Schelde**		**Humber**
FRESHWATER 1				**<300 mg Cl^-/l**	0 - 91	0-24 (1)	0-44	0-31 (1)	0-58	0-31 (1)	Trent: 0-45 $TIDE_{Trent}$-km + Ouse till confluence with the Aire : 0-34 $TIDE_{Ouse-Humber}$-km
	(FRESHWATER 2)					24-46 (2)		31-44 (2)		31-58 (2)	
		(FRESHWATER 3)				46-64 (3)					
			(FRESHWATER 4)			64-91 (4)					
OLIGOHALINE				**300-3.000 mg Cl^-/l**	91-118		44-69		58-89		Trent: 45- 85 $TIDE_{Trent}$-km + Ouse further downstream: 34-60 $TIDE_{Ouse-Humber}$-km
MESOHALINE				**3.000-11.000 mg Cl^-/l**	118-141		69-84		89-116		Humber: 60-93 $TIDE_{Ouse-Humber}$-km
POLYHALINE				**>11.000 mg Cl^-/l**	141-171		84-119		116-160		Humber: 93-123 $TIDE_{Ouse-Humber}$-km

10.3 Templates for evaluation of measures in terms of Natura 2000 aims: Conservation objectives for relevant operational areas based on the Integrated Management Plan Weser (IBP Weser)

Table 44: Natura 2000 objectives with specifications for operational area 1 in the outer Weser estuary and indication of potential measure effects following a simple valuation system (++, +, 0, -, --), template (source: simplified after NLWKN, SUBV 2012)

Operational area 1: Meso-/polyhaline zone in the outer Weser (Weser-km 65 - 85)				
Specifications for operational area 1	**Effect of measure xyz on conservation objectives**			**Short explanation**
	positive effects	no effect	negative effects	
Conservation and development of specific estuarine habitats and (tidal) floodplains and their dynamic changes				
Conservation and development of typical habitats of operational area 1 (e.g. mudflats, reed, salt marshes, extensively used and salt- influenced grasslands) in a dimension, spatial distribution and interconnection ensuring long-term appearance of typical species				
Development, enlargement and upgrade of shallow water zones with moderate current climate (e.g. Wurster Arm)				
Development of passable shore structures				
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 and development of undisturbed resting and moulting areas for migratory bird populations (high diversity, many individuals) considering all necessary functions				
Conservation of adequate habitat quality and undisturbed resting areas for Harbour seals (*Phoca vitulina*) in order to realise a long term stable population				
Conservation of adaption and feeding grounds for Twaite shads (*Alosa fallax*) and Lampreys, especially during main migration phases				
Development of preferential conditions for settlement of Seagrass, eulittoral and sublittoral mussel beds (*Mytilus edulis*) and Sabellaria-reefs with associated fauna				
Conservation of typical breeding bird communities and associated habitats (breeding birds of salt marshes, extensively used, salt- influenced grasslands and reeds)				
Conservation of site specific requirements and area percentages of aquatic structures as habitats for typical benthic invertebrate fauna				
Conservation and development of favorable conditions on estuary grassland in order to promote long term establishment of Bulbous Foxtail.				
Preservation and development of the Weser estuary mouth as passable migration and feeding area for Harbors porpoise (*Phocoena phocoena*)				

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Table 45: Natura 2000 objectives with specifications for operational area 2 in the lower Weser estuary and indication of potential measure effects following a simple valuation system (++, +, 0, -, --), template (source: simplified after NLWKN, SUBV 2012)

Operational area 2: Oligohaline zone in the lower Weser (Weser-km 40 - 65)				
Specifications for operational area 2	**Effect of measure xyz 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				
Development of passable shore structures				
Conservation and development of typical habitats of operational area 2 (e.g. mudflats, reeds, extensively used and salt-influenced grasslands, tidal floodplains) in a dimension, spatial distribution and interconnection ensuring long-term appearance of typical species				
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 and development of undisturbed resting and moulting areas for migratory bird populations (high diversity, many individuals) considering all necessary functions				
Conservation of typical breeding bird communities and associated habitats (breeding birds of extensively used, salt-influenced grasslands and reeds)				
Preservation and development of nursery ground function for Twaite shad (e.g. preferential water quality for juveniles and larvae)				
Preservation and development of undisturbed resting and moulding areas for Pied avocet				
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*) (e.g. creek systems on Tegeler Plate, on Einswarder Plate, shallow water zone Kleinensieler Plate….),				
Conservation of site specific requirements and area percentages of aquatic structures as habitats for typical benthic invertebrate fauna				
Conservation and development of favorable conditions on estuary grassland in order to promote long term establishment of Bulbous foxtail				
Conservation of wide, salt-influenced reeds representing habitats for specialized invertebrate fauna (e.g. typical Auchenorrhyncha species)				

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Table 46: Natura 2000 objectives with specifications for operational area 3 in the lower Weser estuary and indication of potential measures effects following a simple valuation system (++, +, 0, --, -), template (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 xyz 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				
Development of passable shore structures				
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				
Conservation and development of tidal floodplains at the upper tidal border				
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)				
Conservation and development of undisturbed resting and moulting areas for migratory bird populations (high diversity, many individuals) considering all necessary functions				
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*)				
Preservation and development of spawning ground function for Twaite shad (e.g. by avoiding disturbances during spawning season)				
Conservation and development of spawning ground function for Smelt (*Osmerus eperlanus*) (e.g. by avoiding disturbances during spawning season)				

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Table 47: Natura 2000-objectives with specifications for entire investigation area of the Integrated Management Plan Weser and indication of measure effects following a simple valuation system (++, +, 0, --, -), template (source: simplified after NLWKN, SUBV 2012)

Specifications for entire investigation area of IBP Weser	**Effect of measure xyz 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			
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 as well as 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			
Conservation and development / reestablishment of passability of the tidal river Weser and its tributaries for migratory fish and benthic invertebrates			

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Table 48: Natura 2000 objectives for operational areas 1 – 6 according to Integrated Management Plan Elbe (AG Elbe , 2012)

Operational area	Natura 2000-conservation objective
1	Prevention of further increase and/or reduction of tidal range (energy)
	Conservation and development of primarily floodplain/alluvial forest (*91E0)
	Conservation and improvement of alluvial meadows of river valleys (6440) and lowland and hay meadows (6510)
	Conservation of the primarily Elbe Water Dropwort (Oenanthe conioides) with species specific dynamic, development of further habitats to improve the habitat network
	Conservation and development of spawn and growth habitats for asp, ensuring the habitat potential for the twaite shad
	Conservation and development of the transition functionality between the Middle Elbe and the Estuary downstream for migratory fish species of Annex II BHD
2	Reestablishment of natural sediment- and tidal-dynamics
	Development of alluvial forests and species-rich aggregates of tidal reeds and tall herb communities
	Development of a network of step-stone habitats for the Elbe Water Dropwort
	Conservation and development of adequate rest-habitats for migratory fish and lamprey species along their route
	Conservation of relevant functions for bird protection, esp. in the nature protected areas Westerweiden for roosting goose and Holzhafen for roosting ducks.
	Strengthening the NATURA 2000 network, particularly the construction of an ecological valuable bypass to avoid the port of Hamburg.
3	Improvement of the hydro morphological habitat conditions of the habitat type Estuaries, if possible conservation and improvement of estuary typical dynamics
	Conservation and development of tidal reeds, hydrophilous tall herb fringe communities (6430) and floodplain/alluvial forest (*91E0) esp. on islands.
	Conservation, reestablishment and development of meadows with vegetation typical for the Elbe region, like lowland hay meadows (6510) with respect to their avifaunistical function.
	Conservation and partly reestablishment of the primarily Elbe Water Dropwort (Oenanthe conioides) populations with typical dynamics, esp. on the island of Neßsand and Hanskalbsand, as well as Hahnöfersand, development of additional habitats for the improvement of the habitat network.
	Conservation and reestablishment of the outstanding relevance of the functional zone for the reproduction of the twaite shad.
	Conservation, partly reestablishment and development of the brooding function esp. for the species on extensive used meadows, large-scale reeds and grassland-ditch complexes of the marshes and the associated habitats.
	Conservation and development of the resting function esp. for Nordic goose and swans, as well as for waders (Limikolen) on the widespread, low disturbed grasslands.
	Conservation of the resting occurrence of ducks, gulls and sea swallows
4	Improvement of the hydro morphological habitat conditions of the habitat type Estuaries, if possible conservation and improvement of estuary typical dynamics
	Conservation and development of tidal reeds, hydrophilous tall herb fringe communities (6430) and floodplain/alluvial forest (*91E0).
	Conservation, reestablishment and development of meadows with vegetation typical for the Elbe region, like lowland hay meadows (6510) with respect to their avifaunistical function.
	Conservation and partly reestablishment of the primarily Elbe Water Dropwort (Oenanthe conioides) populations with typical dynamics additional to the main occurrence in the functional zones 1 and 3, development of additional habitats for the improvement of the habitat network.
	Conservation and reestablishment of the importance of the functional zone 4 for the reproduction of the twaite shad in connection with the functional zone 3.
	Conservation, partly reestablishment and development of the brooding function esp. for the species on extensive used meadows, large-scale reeds and grassland-ditch complexes of the marshes and the associated habitats.
	Conservation and development of the resting function esp. for Nordic goose and swans, as well as for waders (Limikolen) on the widespread, low disturbed grasslands.
5	Improvement of the hydro morphological habitat conditions of the habitat type Estuaries, if possible conservation and improvement of estuary typical dynamics
5	Conservation and development of tidal reeds, hydrophilous tall herb fringe communities (6430) and floodplain/alluvial forest (*91E0).
5	Conservation, reestablishment and development of meadows with vegetation typical for the Elbe region, like lowland hay meadows (6510) with respect to their avifaunistical function.
5	Conservation and partly reestablishment of the primarily Elbe Water Dropwort (Oenanthe conioides) populations with typical dynamics additional to the main occurrence in the functional zones 1 and 3, development of

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	additional habitats for the improvement of the habitat network.
5	Conservation and reestablishment of the importance of the functional zone 4 for the reproduction of the twaite shad in connection with the functional zone 3.
5	Conservation, partly reestablishment and development of the brooding function esp. for the species on extensive used meadows, large-scale reeds and grassland-ditch complexes of the marshes and the associated habitats.
5	Conservation and development of the resting function esp. for Nordic goose and swans, as well as for waders (Limikolen) on the widespread, low disturbed grasslands.
6	Conservation of the near-natural hydro morphological habitat conditions of the habitat type Estuaries (11309, if possible conservation and improvement of estuary typical dynamics
6	Conservation and development of broad mudflats and near-natural land-water intersection with tidal-creeks, tidal reeds and hydrophilous tall herb fringe communities (6430), reestablishment of tidal influence in the "Sommerpolder Belum"
6	Conservation, reestablishment and development of meadows with vegetation typical for the Elbe region, like lowland hay meadows (6510) with respect to their avifaunistical function.
6	Conservation of the function as growth habitat for the twaite shad.
6	Stabilizing of the population of gull-billed tern and common tern.
6	Conservation, partly reestablishment and development of the brooding function esp. for the species on extensive used meadows, large-scale reeds and grassland-ditch complexes of the marshes and the associated habitats.
6	Conservation and development of the resting function esp. for Nordic goose and swans, as well as for waders (Limikolen) on the widespread, low disturbed grasslands.

Table 49: Conservation objectives defined for the Zeeschelde (Flanders, Belgium) on the species level

Category	Species with extra attention concerning conservation	Scientific name
Mammals	Pond bat	*Myotis dasycneme*
	Beaver	*Castor fiber*
	Otter	*Lutra lutra*
	Eurasian harvest mouse	*Micromys minutus*
	Common Noctule	*Nyctalus noctula*
	Nathusius's pipistrelle	*Pipistrellus nathusii*
	Daubenton's bat	*Myotis daubentonii*
	Harbor seal	*Phoca vitulina*
	Eurasian water shrew	*Neomys fodiens*
Amphibians and reptiles	Great Crested Newt	Triturus cristatus
	Natterjack Toad	Bufo calamita
Fishes	Misgurnus fossilis	Misgurnus fossilis
	European river lamprey	Lampetra fluviatilis
	Allis shad	Alosa alosa
	Twait Shad	Alosa fallax
	European eel	Anguilla anguilla
	European bitterling	Cyprinus amarus
	Spined loach	Cobitis taenia
	European bullhead	Cottus gobio
	Wels catfish	Silurus glanis
	Trout	Salmo trutta
Invertebrates	Large White-faced Darter	Leucorrhina pectoralis
	Vertigo angustior	Vertigo angustior
	Desmoulin's whorl snail	Vertigo moulinsiana
Breeding birds	Corn Crake	Crex crex
	Fish Eagle	Haliaeetus albicilla
	Bluethroat	Luscinia svecica
	Western Marsh Harrier	Circus aeruginosus
	Common Kingfisher	Alcedo atthis
	Eurasian Bittern	Botarus stellaris
	Little Bittern	Ixobrychus minutus
	Black Kite	Milvus migrans
	Montagu's Harrier	Circus pygargus
	Red-backed Shrike	Lanius collurio
	Little Egret	Ergetta garzetta
	Baillon's Crake	Porzana pusilla
	Pied Avocet	Recurvirostra avosetta

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	Black-crowned Night Heron	Nycticorax nycticorax
	Eurasian Spoonbill	Platalea leucordia
	White Stork	Ciconia ciconia
	Spotted Crake	Porzana porzana
	Purple Heron	Ardea purpurea
	Red Kite	Milvus milvus
	Peregrine Falcon	Falco peregrinus
	Black-winged Stilt	Himantopus himantopus
	Osprey	Pandion haliaetus
	Common Tern	Sterna hirundo
	European Honey Buzzard	Pernis apivorus
	Black Woodpecker	Dryocopus mertius
	Mediterranean Gull	Larus melanocephalus
	Mute Swan	Cygnus olor
	Gadwall	Anas strepera
	Tufted Duck	Aythya fuligula
	Kentish Plover	Charadrius alexandrines
	Common Redshank	Tringa tetanus
	Sedge Warbler	Acrocephalus schoenobaenus
	Bearded Reedling	Panurus biarmicus
	Common Shelduck	Tadorna tadorna
	Common Ringed Plover	Charadrius hiaticula
	Black-tailed Godwit	Limosa limosa
	Little Ringed Plover	Charadrius dubius
	Black-headed Gull	Larus ridibundus
	Sand Martin	Riparia riparia
	Eurasian Oystercatcher	Haematopus ostralegis
	Northern Shoveler	Anas clypeta
	Great Reed Warbler	Acrocephalus arundinaceus
	Whinchat	Saxicola rubetra
	Savi's Warbler	Locustella luscinioides
	Northern Wheatear	Oenanthe oenanthe
	Common Snipe	Gallinago gallinago
	Common House Martin	Delichon urbica
	Common Nightingale	Luscinia megarhynchos
	Eurasian Skylark	Alauda arvensis
	Meadow Pipit	Anthus pratensis
	Corn Bunting	Miliaria calandra
	Reed Bunting	Emberiza schoeniclus
	Eurasian Golden Oriole	Oriolus oriolus
	Garganey	Anas querquedula
	Eurasian Penduline Tit	Remiz pendulinusa
	Little Grebe	Trachybaptus ruficollis
	Great Crested Grebe	Podiceps cristatus
	Black-necked Grebe	Podiceps nigricollis
	Northern Pintail	Anas acuta
	European Stonechat	Saxicola torquata
	Common Grasshopper Warbler	Locustella naevia
	Common Pochard	Aythya ferina
Migratory and wintering birds (Zeeschelde and Blokkersdijk)	Great Cormorant	Phalacrocorax carbo
	Common Shelduck	Tadorna tadorna
	Grey Heron	Ardea cinerea
	Common Ringed Plover	Charadrius hiaticulata
	Dunlin	Calidris alpine
	Wood Sandpiper	Tringa glareola
	Common Goldeneye	Bucephala clangula
	Little Grebe	Tachybaptus ruficolis
	Sanderling	Calidris alba
	Slender-billed Curlew	Numenius tenuirostris
	Lesser White-fronted Goose	Anser erythropus
	Little Gull	Larus minutus
	Little Tern	Sterna albifrons
	Great Crested Grebe	Podiceps cristatus

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	Black-necked Grebe	Podiceps nigricollis
	European Golden Plover	Pluvialis apricaria
	Greylag Goose	Anser anser
	Common Greenshank	Tringa nebularia
	Great Black-backed Gull	Larus marinus
	Sandwich Tern	Sterna sandvicensis
	Common Merganser	Mergus merganser
	Velvet Scoter	Melanitta fusca
	Great Egret	Egretta alba
	Great Northern Loon	Gavia immer
	Ruff	Philomachus pugnax
	Northern Lapwing	Vanellus vanellus
	Lesser Black-backed Gull	Larus fuscus
	Little Ringed Plover	Charadrius dubius
	Pink-footed Goose	Anser brachyrhynchus
	Little Egret	Egretta garzetta
	Tundra Swan	Cygnus columbianus
	Pied Avocet	recurvirostra avocetta
	Mute Swan	Cygnus olor
	Black-headed Gull	Larus ridibundus
	Greater White-fronted Goose	Anser albifrons
	Gadwall	Anas strepera
	Horned Grebe	Podiceps auritus
	Tufted Duck	Aythya fuligula
	Eurasian Spoonbill	Platalea leucorodia
	Eurasian Coot	Fulica atra
	Red-breasted Merganser	Mergus serrator
	Smew	Mergus albellus
	Arctic Tern	Sterna paradisaea
	Common Sandpiper	Actitis hypoleucos
	Black-throated Loon	Gavia arctica
	Northern Pintail	Anas acuta
	Whimbrel	Numenius phaeopus
	Eurasian Bittern	Botarus stellaris
	Red-necked Grebe	Podiceps grisegena
	Red-breasted Goose	Branta ruficolis
	Red-throated Loon	Gavia stellate
	Bar-tailed Godwit	Limosa lapponica
	Brant Goose	Branta bernica
	Eurasian Oystercatcher	Haematopus ostralegus
	Northern Shoveler	Anas clypeata
	Eurasian Wigeon	Anas Penelope
	Ruddy Turnstone	Arenarea interpres
	Black-winged Stilt	Himantopus himantopus
	Common Gull	Larus canus
	Common Pochard	Aythya farina
	Bean Goose	Anser fabalis rossicus
	Greater Scaup	Aythya marila
	Common Redshank	Tringa tetanus
	Osprey	Pandion haliaetus
	Common Moorhen	Gallinula chloropus
	Common Snipe	Gallinago gallinago
	Mallard	Anas platyrhynchos
	Whooper Swan	Cygnus Cygnus
	Eurasian Teal	Anas crecca
	White-headed Duck	Oxyura leucocephala
	Ferruginous Duck	Aythya nyroca
	Eurasian Curlew	Numenius arquata
	Fish Eagle	Haliaeetus albicilla
	Grey Plover	Pluvialis squatorola
	Spotted Redshank	Tringa erythropus
	Black Tern	Chlidonias niger
	Common Scoter	Melanitta nigra

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Table 50: Habitat and species management objectives and management delivery for 2012-2014 (HMS 2011A)

Objective	Action
HSM1. Habitat management: To identify and deliver habitat management to meet the conservation objectives	**Humber managed realignment projects** (Link to ongoing management: Flood defence & Development and maintenance) HSM1.1: Share best practice on realignment sites.
	HSM1.2: Support and encourage, where possible, a long term rolling programme of realignment site delivery.
	HSM1.3: Facilitate dialogue between organisations undertaking realignment to develop larger more cost effective realignment sites
	HSM1.4: To agree the process to designate realignment sites and include them in the Humber designations
	HSM1.5: To disseminate progress on the realignment projects to the wider estuary community
	HSM1.6: To use information gained from HMS recreational disturbance study to design public access to realignment sites
	Stewardship HSM1.7: Natural England works with landowners and farmers to encourage and deliver HLS targets. However, the Humber habitats and species are not included in the target statement for the area. Lobby for Higher Level Stewardship targeting for the management of the features connected with the Humber Estuary EMS and important associated features such as high tide roosting and feeding areas and wintering birds e.g. wet grasslands/grazing marsh, winter stubbles. Work with other sectors e.g. archaeology, to ensure targets are multi- objective.
	Intertidal and land management HSM1.8: Organisations involved in grazing projects to communicate progress to Humber Estuary community through the HMS to share best practice and to consider a whole estuary approach.
	HSM1.9: Establish a HERAG & HAG sub-group and scope options for a project to summarise historic and current intertidal and HTR management to identify management required for habitats to be or remain in favourable condition e.g. equipment share, flying flock, composting scheme.
	HSM1.10: Identify funding sources to support land management projects.
	HSM1.11: Identify mechanisms to make management for biodiversity economically viable and explore options such as biodiversity offsetting
	HSM1.12: Encourage cooperative working for land management to provide opportunities for Humber designated species e.g. Breeding Little Tern
	HSM1.13: Identify approaches on other estuaries (worldwide) to identify innovative solutions
	HSM1.14: Awareness raising and engagement with landowners, farmers and associated organisations e.g. FWAG
	HSM1.15: Promote exemplar sites and share best practice e.g. Alkborough
	Invasive species HSM1.16: Monitor and put appropriate management in place for invasive species e.g. Himalayan balsam, Japanese Knotweed, Japanese mitten crab

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HMS2. SPA birds: To identify and deliver management for SPA birds to meet the conservation objectives including the management of high tide roosting and feeding areas	**Understanding bird population fluctuations to identify management actions** HSM2.1: To determine actions required to understand bird fluctuations in order to put management measures in place. To engage and consult with HERAG and HAG as part of the process.
	HSM2.2: Study to be undertaken tounderstand national changes in bird numbers.
	High tide roosts HSM2.3: Update to Natural England Report on high tide roosts
	HSM2.4: Identify important sites and key areas for HTR enhancement and creation.
	HSM2.5: Identify critical areas for SPA functioning which require designation such as managed realignment sites and high tide roosts.
	HSM 2.6 To develop a mitigation strategy for the creation and management of high tide roosting and feeding areas in the South Humber Gateway area
HSM3. Sub-tidal: To identify and deliver management for the sub-tidal to meet the conservation objectives	HSM 3.1: NE sub-tidal report to be completed and evaluated to understand habitat resource and importance, gaps in information and threats and opportunities
	HSM 3.2: Draft possible objectives and identify mechanisms to take actions forward
HSM4. Grey seals: To identify and delivery management for the grey seals to meet the requirements of the conservation objectives	HSM4.1: Support continued wardening of the seal population during the seal season
	HSM4.2: Gather evidence on disturbance to the grey seal population, especially on the outer bank
	HSM4.3: Develop appropriate management measures on access to the grey seal population, particularly relating to photographers
HSM5. Lamprey: To identify and delivery management for the river and sea lamprey to meet the requirements of the conservation objectives	HSM5.1: To obtain funding to undertake monitoring of lamprey. Annual adult sea lamprey spawning monitoring funded by Environment Agency from 2003 through to 2017. Rivers surveyed – Swale, Ure, Nidd, Wharfe, Swale. NE seeking funding for river lamprey monitoring. Environment Agency may be able to carry out some adult river lamprey monitoring internally in 2011/12.

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10.4 List of collected measure examples from Weser, Elbe, Humber and Scheldt with indication of development targets

Table 51: List of measure examples collected, analysed and compared with indication of short title, status, measure category and development targets

No.	Estuary	Measure example	Short title	Status		Development Targets													
						Hydrology/Morphology				Biology/Ecology				Physical/Chemical Quality					
				planned	implemented	Measure to reduce tidal energy, tidal range, tidal asymmetry and tidal pumping effects	Measure for flood protection	Measure to improve morphological conditions	Measure to decrease the need for dredging	Measure to develop and/or to protect specific habitats	Measure to develop and/or protect specific species	Other measure to develop natural gradients and processes, transition and connection	Measure to prevent introduction of or to fight invasive species	Measure to reduce pollutant loading (point and diffuse sources)	Measure to reduce nutrient loading (point and diffuse sources)	Measure to improve oxygen conditions	Measure to reduce physical loading (e.g. heat input by cooling water entries)	Other measure to improve self-purifying power	Other development target(s).
01	Elbe	Spadenlander Busch/Kreetsand	Spadenlander Busch		x	x		x		x		x							
02	Elbe	Underwater relocation area ‚Medemrinne Ost'	Medemrinne Ost	x		x		x	x										
03	Elbe	Current deflection wall ´Köhlfleet´	Current deflection wall		x			x	x										
04	Elbe	Study on ´Investigation on freshwater current direction control at Bunthaus and possible impact on sedimentation patterns in the Port of Hamburg´	Bunthaus		x			x	x										
05	Elbe	Sediment-Trap near Wedel	Sediment trap Wedel		x			x	x										
06	Elbe	Compensation channel 'Hahnöfer Nebenelbe'	Hahnöfer Nebenelbe		x					x						x			
07	Elbe	Realignment Wrauster Bogen	Wrauster Bogen		x					x		x							
08	Elbe	Compensation measure Hahnöfer Sand (2002)	Hahnöfer Sand		x					x	x	x							
09	Elbe	Spadenlander Spitze	Spadenlander Spitze		x					x	x	x							
10	Elbe	Settlement of reed at the harbour location´Haken´	Reed settlement Haken		x					x									
11	Elbe	Land treatment of dredged material including MEchanical Treatment and Dewatering of HArbour-sediments (METHA)	METHA		x									x					
12	Elbe	Managing the ´Reiherstieg´ sluice to improve oxygen conditions	Managing Reiherstieg sluice	x												x			
13	Scheldt	Lippenbroek - flood control area with controlled reduced tide (FCA-CRT)	Lippenbroek		x		x			x									x
14	Scheldt	Groynes at Waarde	Groynes Waarde		x					x									x
15	Scheldt	Ketenisse wetland - small scale tidal wetland restoration in the brackish part of the estuary	Ketenisse wetland		x					x		x							x
16	Scheldt	Paddebeek wetland- small scale tidal wetland restoration in the freshwater zone of the Seascheldt	Paddebeek wetland		x					x		x							x

17	Scheldt	Paardenschor- small scale brackish tidal wetland restoration in the Seascheldt	Paardenschoor wetland		x					x		x							x
18	Scheldt	Heusden LO -small scale tidal wetland restoration in the freshwater zone of the Seascheldt	Heusden LO wetland		x					x		x							x
19	Scheldt	Schelde pilot project 2: Relocation of dredged sediment to deep areas of the navigation channel	Sediment relocation Ketelplaat		x	x													
20	Scheldt	TIDE pilot: Relocation of dredged sediment to a shallow water area at the edge of the Walsoorden sandbar (2004)	Walsoorden 2004		x			x		x									
21	Scheldt	TIDE pilot: Relocation of dredged sediment to a shallow water area at the edge of the Walsoorden sandbar (2006)	Walsoorden 2006		x			x		x									
22	Scheldt	TIDE pilot: Relocation of dredged sediment to four shallow water areas at the edge of sandbars (2010)	Sandbars 2010		x			x		x									x
23	Scheldt	Vispaaiplaats – Fish spawning pond	Fish pond		x					x	x								
24	Weser	Tegeler Plate- Development of tidally influenced brackish water habitats	Tegeler Plate		x					x		x							
25	Weser	Shallow water area Rönnebecker Sand	Rönnebecker Sand		x					x									
26	Weser	Tidal habitat Vorder- und Hinterwerder	Vorder- und Hinterwerder		x					x		x							
27	Weser	Shallow water area Kleinensieler Plate	Kleinensieler Plate		x					x		x							
28	Weser	Cappel-Süder-Neufeld	Cappel-Süder-Neufeld		x					x	x								
29	Weser	TIDE pilot: Restoration of a dike foreland in Werderland – Feasibility study	Werderland	x		x				x		x							
30	Humber	Alkborough Managed Realignment and flood storage – Creation of ~440 a of intertidal habitat	Alkborough		x		x			x									
31	Humber	Paull Holme Strays Managed Realignment – creation of ~80 ha of intertidal habitat	Paull Holme Strays		x					x									
32	Humber	Hydromotion MudBug – determine the density of 'fluid' mud to determine the depth of the navigable channel (1250 kg/m³)	MudBug		x				x										
33	Humber	Creation of ~13 ha of intertidal habitat at Chowder Ness	Chowder Ness		x					x	x								x
34	Humber	Creation of ~54 ha of intertidal habitat at Welwick	Welwick		x					x	x								
35	Humber	Kilnsea Wetlands	Klinsea Wetlands		x					x	x								
36	Humber	South Humber Gateway Roosting Mitigation	South Humber Gateway Roosting	x							x								
37	Humber	Training walls at Trent falls	Trent falls		x	x			x										
38	Humber	Donna Nook and Skeffling	Donna Nook and Skeffling	x			x		x	x									
39	Humber	Turnstall Realignment	Turnstall Realignment	x			x		x	x									

10.5 Assignment of collected measure examples from Weser, Elbe, Humber and Scheldt to measure categories

Table 52: List of measure examples collected, analysed and compared with indication of assigned measure category. Assignment was based on identification of main development targets per measure. Assignment was undertaken by members of the TWG Measures (expert judgment). Measures 1 and 13 are assigned to two different measure categories because respective development targets were weighted equally by TWG members.

No.	Estuary	Measure example	Measure Category		
			Hydrology/Morphology	Biology/Ecology	Physical/Chemical Quality
01	Elbe	Spadenlander Busch/Kreetsand	x	x	
02	Elbe	Underwater relocation area ‚Medemrinne Ost'	x		
03	Elbe	Current deflection wall ´Köhlfleet´	x		
04	Elbe	Study on ´Investigation on freshwater current direction control at Bunthaus and possible impact on sedimentation patterns in the Port of Hamburg´	x		
05	Elbe	Sediment-Trap near Wedel	x		x
06	Elbe	Compensation channel 'Hahnöfer Nebenelbe'		x	
07	Elbe	Realignment Wrauster Bogen		x	
08	Elbe	Compensation measure Hahnöfer Sand (2002)		x	
09	Elbe	Spadenlander Spitze		x	
10	Elbe	Settlement of reed at the harbour location´Haken´		x	
11	Elbe	Land treatment of dredged material including MEchanical Treatment and Dewatering of HArbour-sediments (METHA)			x
12	Elbe	Managing the ´Reiherstieg´ sluice to improve oxygen conditions			x
13	Scheldt	Lippenbroek - flood control area with controlled reduced tide (FCA-CRT)	x	x	
14	Scheldt	Groynes at Waarde		x	

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15	Scheldt	Ketenisse wetland - small scale tidal wetland restoration in the brackish part of the estuary		x	
16	Scheldt	Paddebeek wetland- small scale tidal wetland restoration in the freshwater zone of the Seascheldt		x	
17	Scheldt	Paardenschor- small scale brackish tidal wetland restoration in the Seascheldt		x	
18	Scheldt	Heusden LO -small scale tidal wetland restoration in the freshwater zone of the Seascheldt		x	
19	Scheldt	Schelde pilot project 2: Relocation of dredged sediment to deep areas of the navigation channel	x		
20	Scheldt	TIDE pilot: Relocation of dredged sediment to a shallow water area at the edge of the Walsoorden sandbar (2004)	x		
21	Scheldt	TIDE pilot: Relocation of dredged sediment to a shallow water area at the edge of the Walsoorden sandbar (2006)	x		
22	Scheldt	TIDE pilot: Relocation of dredged sediment to four shallow water areas at the edge of sandbars (2010)	x		
23	Scheldt	Vispaaiplaats – Fish spawning pond		x	
24	Weser	Tegeler Plate- Development of tidally influenced brackish water habitats		x	
25	Weser	Shallow water area Rönnebecker Sand		x	
26	Weser	Tidal habitat Vorder- und Hinterwerder		x	
27	Weser	Shallow water area Kleinensieler Plate		x	
28	Weser	Cappel-Süder-Neufeld		x	
29	Weser	TIDE pilot: Restoration of a dike foreland in Werderland – Feasibility study		x	
30	Humber	Alkborough Managed Realignment and flood storage – Creation of ~440 a of intertidal habitat		x	
31	Humber	Paull Holme Strays Managed Realignment – creation of ~80 ha of intertidal habitat		x	
32	Humber	Hydromotion MudBug – determine the density of ‘fluid’ mud to determine the depth of the navigable channel (1250 kg/m³)	x		
33	Humber	Creation of ~13 ha of intertidal habitat at Chowder Ness		x	
34	Humber	Creation of ~54 ha of intertidal habitat at Welwick		x	
35	Humber	Kilnsea Wetlands		x	
36	Humber	South Humber Gateway Roosting Mitigation		x	
37	Humber	Training walls at Trent falls	x		
38	Humber	Donna Nook and Skeffling		x	
39	Humber	Turnstall Realignment		x	

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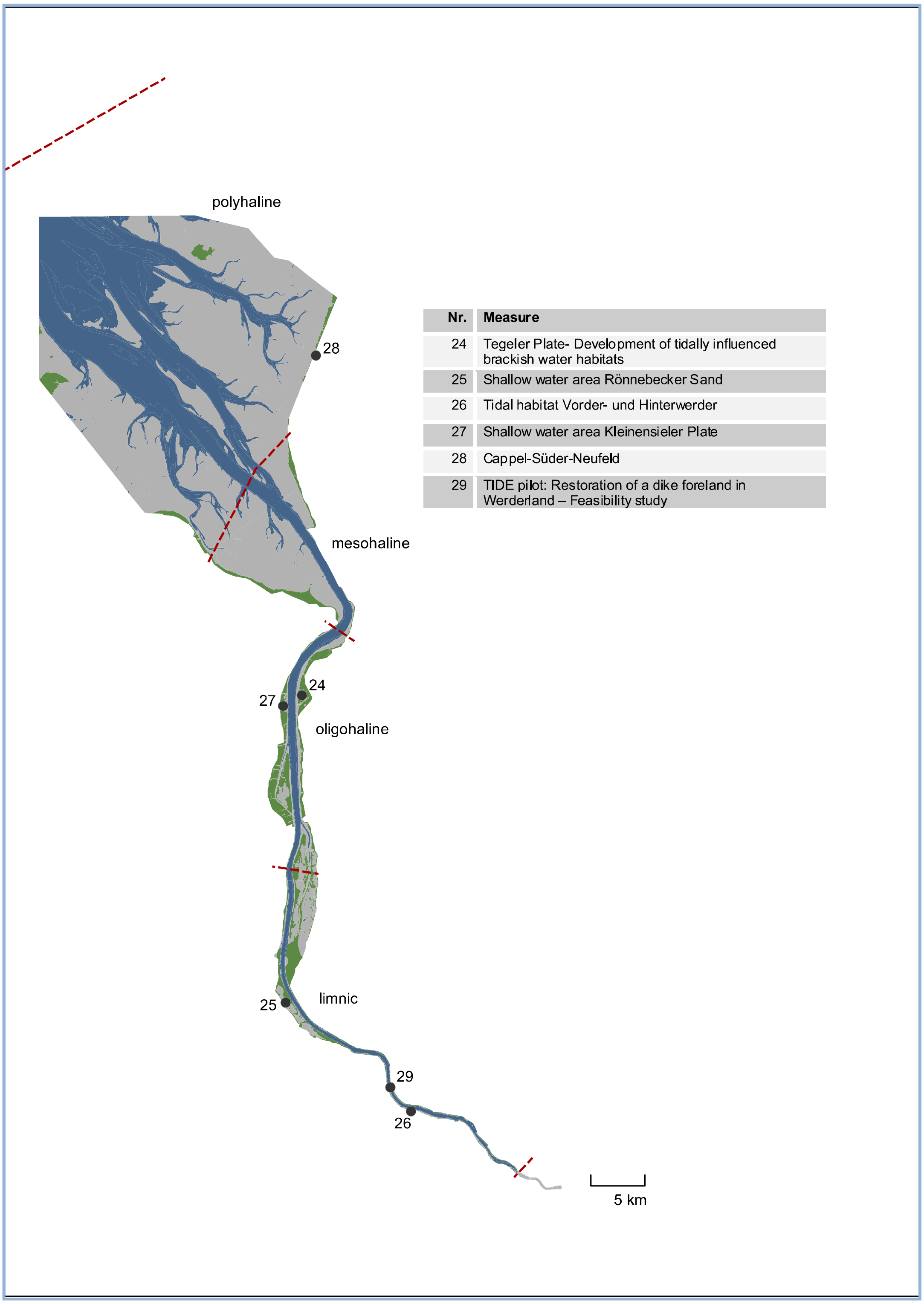
10.6 Overview maps on measure titles and locations



Nr.	Measure
24	Tegeler Plate- Development of tidally influenced brackish water habitats
25	Shallow water area Rönnebecker Sand
26	Tidal habitat Vorder- und Hinterwerder
27	Shallow water area Kleinensieler Plate
28	Cappel-Süder-Neufeld
29	TIDE pilot: Restoration of a dike foreland in Werderland – Feasibility study

Figure 22: Locations and titles of management measures collected according to the Weser estuary with indication estuary zones (limnic, oligohaline, mesohaline, polyhaline)

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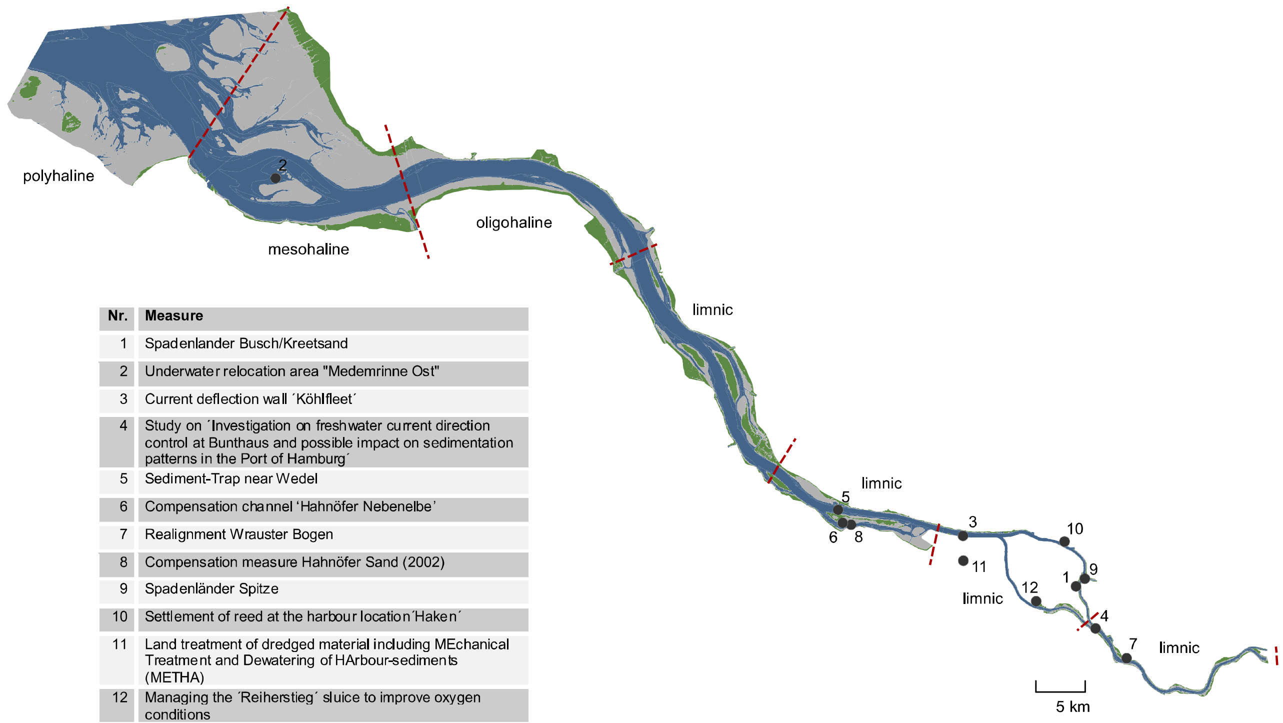
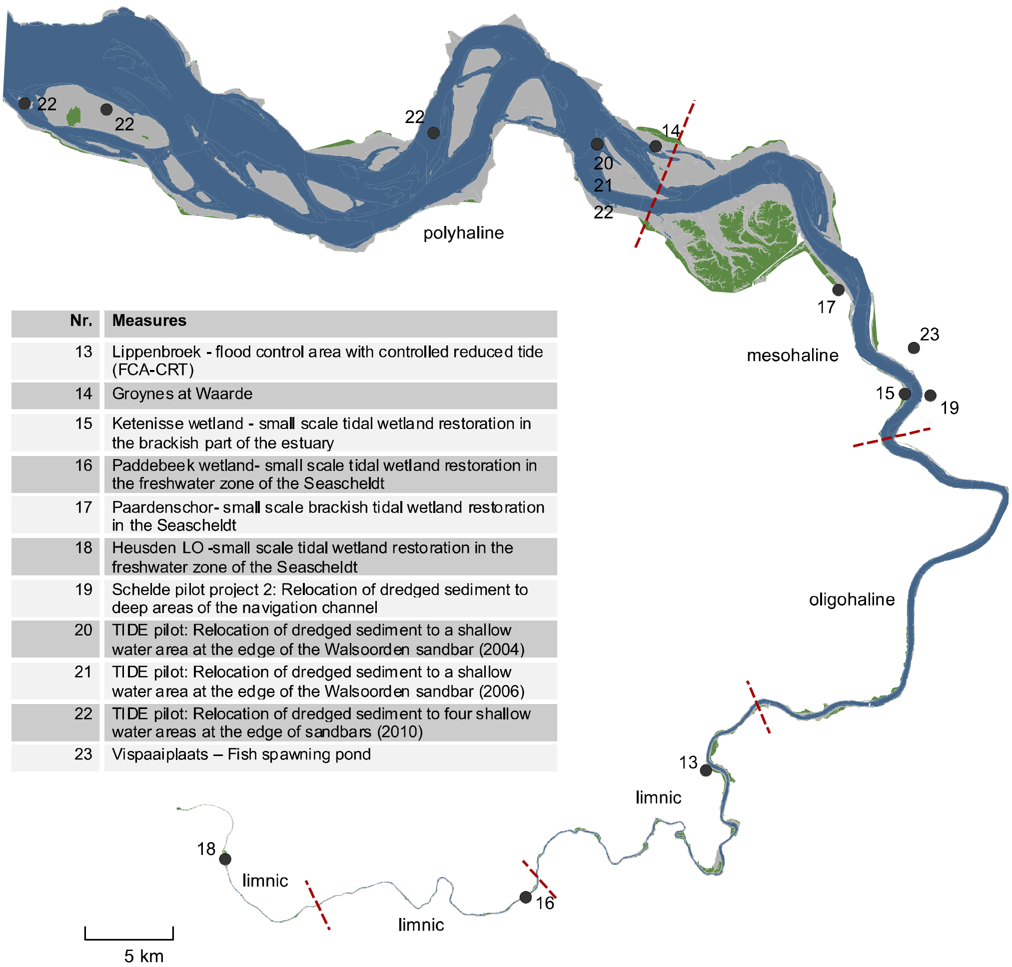


Nr.	Measure
1	Spadenlander Busch/Kreetsand
2	Underwater relocation area "Medemrinne Ost"
3	Current deflection wall ´Köhlfleet´
4	Study on ´Investigation on freshwater current direction control at Bunthaus and possible impact on sedimentation patterns in the Port of Hamburg´
5	Sediment-Trap near Wedel
6	Compensation channel 'Hahnöfer Nebenelbe'
7	Realignment Wrauster Bogen
8	Compensation measure Hahnöfer Sand (2002)
9	Spadenländer Spitze
10	Settlement of reed at the harbour location´Haken´
11	Land treatment of dredged material including MEchanical Treatment and Dewatering of HArbour-sediments (METHA)
12	Managing the ´Reiherstieg´ sluice to improve oxygen conditions

Figure 23: Locations and titles of management measures collected according to the Elbe estuary with indication estuary zones (limnic, oligohaline, mesohaline, polyhaline)



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 24: Locations and titles of management measures collected according to the Scheldt estuary with indication estuary zones (limnic, oligohaline, mesohaline, polyhaline)

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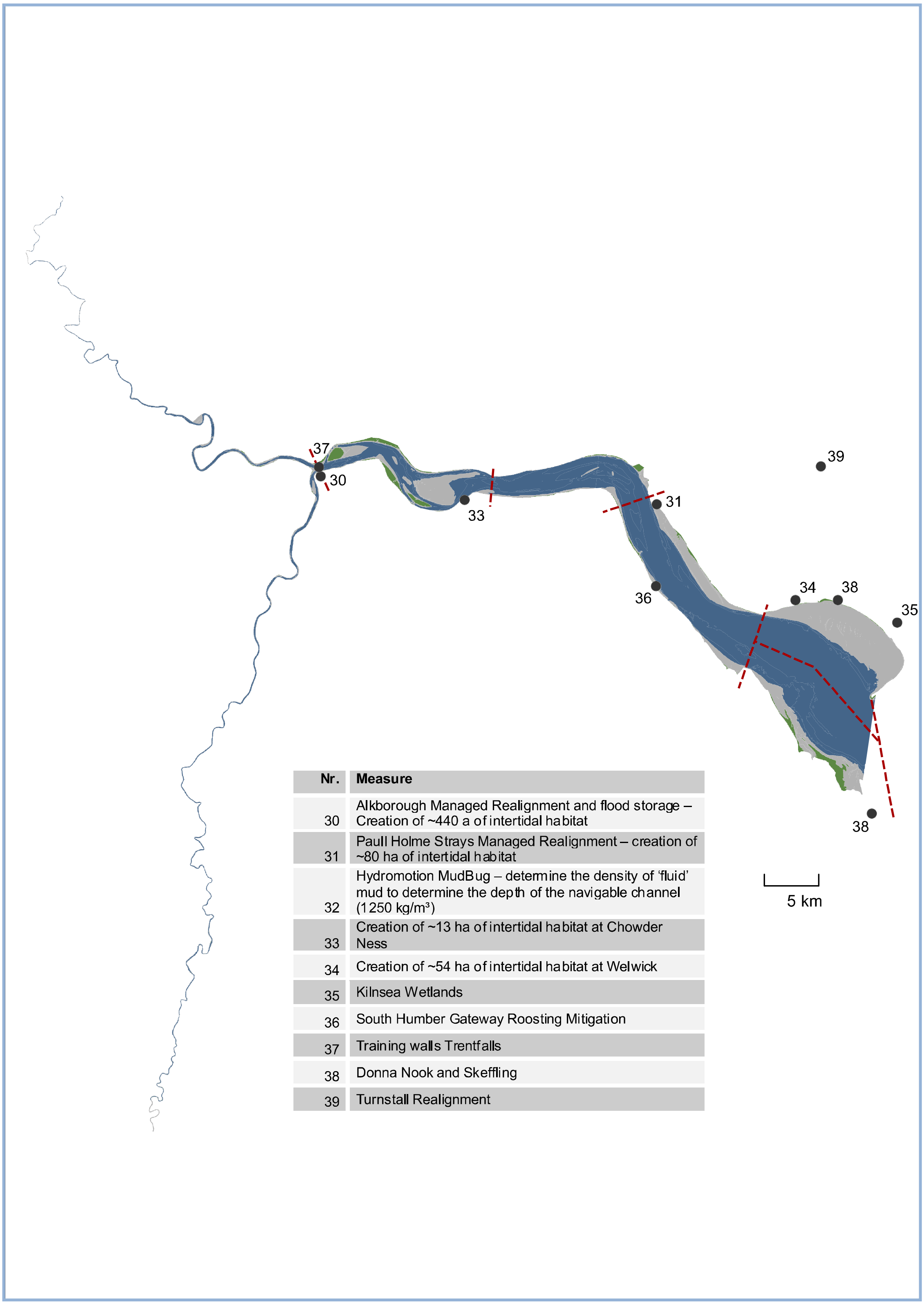

Nr.	Measure
30	Alkborough Managed Realignment and flood storage – Creation of ~440 a of intertidal habitat
31	Paull Holme Strays Managed Realignment – creation of ~80 ha of intertidal habitat
32	Hydromotion MudBug – determine the density of 'fluid' mud to determine the depth of the navigable channel (1250 kg/m³)
33	Creation of ~13 ha of intertidal habitat at Chowder Ness
34	Creation of ~54 ha of intertidal habitat at Welwick
35	Kilnsea Wetlands
36	South Humber Gateway Roosting Mitigation
37	Training walls Trentfalls
38	Donna Nook and Skeffling
39	Turnstall Realignment

Figure 25: Locations and titles of management measures collected according to the Humber estuary with indication estuary zone borders by red lines

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10.7 Assignment of collected measure examples from Weser, Elbe, Humber and Scheldt to measure types

Table 53: Assignment of measures of measure category 'Biology/Ecology' to one or more measure type(s); assignment was undertaken by members of the TWG measures (expert judgment)

No.	Estuary	Measure example	Salt marsh development by building groynes	Restoration of not embanked foreland areas	Shallow water zone construction	Revitalisation or construction of side branch systems	Opening of summer dikes	Relocation of main dikes	Development of site specific conditions in favour of sublitoral habitats and species	Development of brackish water habitats at sluices	Reestablishment of species	Deconstruction or alteration of bank reinforcements	Deconstruction or alteration of other constructions (island, port, fairway)	Measures to improve the passability of sluices: modified sluice management	Measures to improve the passability of sluices: technical measures
01	Elbe	Spadenlander Busch/Kreetsand			x			x	x						
06	Elbe	Compensation channel 'Hahnöfer Nebenelbe'			x	x			x						
07	Elbe	Realignment Wrauster Bogen		x	x	x		x	x						
08	Elbe	Compensation measure Hahnöfer Sand (2002)			x			x	x						
09	Elbe	Spadenlander Spitze			x			x	x		x				

10	Elbe	Settlement of reed at the harbour location´Haken´		x					x		x				
13	Scheldt	Lippenbroek - flood control area with controlled reduced tide (FCA-CRT)		x			x							x	
14	Scheldt	Groynes at Waarde	x												
15	Scheldt	Ketenisse wetland - small scale tidal wetland restoration in the brackish part of the estuary		x			x								
16	Scheldt	Paddebeek wetland- small scale tidal wetland restoration in the freshwater zone of the Seascheldt		x				x							
17	Scheldt	Paardenschor- small scale brackish tidal wetland restoration in the Seascheldt		x			x								
18	Scheldt	Heusden LO -small scale tidal wetland restoration in the freshwater zone of the Seascheldt		x				x							
23	Scheldt	Vispaaiplaats – Fish spawning pond			x				x						
24	Weser	Tegeler Plate- Development of tidally influenced brackish water habitats													
25	Weser	Shallow water area Rönnebecker Sand													
26	Weser	Tidal habitat Vorder- und Hinterwerder													
27	Weser	Shallow water area Kleinensieler Plate													
28	Weser	Cappel-Süder-Neufeld													
29	Weser	TIDE pilot: Restoration of a dike foreland in Werderland – Feasibility study													
30	Humber	Alkborough Managed Realignment and flood storage – Creation of ~440 a of intertidal habitat		x					x		x	x			

No.	Estuary	Measure example	Salt marsh development by building groynes	Restoration of not embanked foreland areas	Shallow water zone construction	Revitalisation or construction of side branch systems	Opening of summer dikes	Relocation of main dikes	Development of site specific conditions in favour of sublitoral habitats and species	Development of brackish water habitats at sluices	Reestablishment of species	Deconstruction or alteration of bank reinforcements	Deconstruction or alteration of other constructions (island, port, fairway)	Measures to improve the passability of sluices: modified sluice management	Measures to improve the passability of sluices: technical measures
31	Humber	Paull Holme Strays Managed Realignment – creation of ~80 ha of intertidal habitat		x	x				x		x	x			
33	Humber	Creation of ~13 ha of intertidal habitat at Chowder Ness		x	x				x			x			
34	Humber	Creation of ~54 ha of intertidal habitat at Welwick		x	x	x			x			x			
35	Humber	Kilnsea Wetlands		x	x				x	x	x	x			
36	Humber	South Humber Gateway Roosting Mitigation									x				
38	Humber	Donna Nook and Skeffling							x		x	x			
39	Humber	Turnstall Realignment							x		x	x			

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