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Hard Substrate Habitats Outer Weser Estuary

Identification of Potential Areas for the Development and Creation of Subtidal
Hard Substrate Areas in the Outer Weser Estuary
– Pilot study in the framework of the Interreg IVB project TIDE

Long version

In charge of the project:
Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency,
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1 Objectives

The INTERREG IV B project „Tidal River Development“ (TIDE) under the leadership of the Hamburg Port Authority (HPA) focuses on different aspects of a sustainable, integrative management of four economically important estuaries along the North Sea.

One of the involved partners is the Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency (NLWKN), which is responsible for the workstream “practical measures”. Among these measures the planning as well as preparing steps for the implementation of three pilot projects in the Weser estuary are intended. In the following study, as one of the pilot projects the development and creation of subtidal hard substrate habitats in the Outer Weser is introduced.

Naturally occurring hard substrata such as subtidal blue mussel beds and reefs of *Sabellaria spinulosa* represent important habitats for numerous macrobenthic species and fishes, among them especially endangered species. These habitats are potentially suited to contribute significantly to the improvement of structural diversity within the transitional and coastal waters of Lower Saxony. Therefore the realisation of measures for the creation or development of such habitats is recommended by several expert reports in order to achieve the objectives given by the binding directives of the European Union (Water Framework Directive, Habitats Directive).

2 Study Area

The study area comprises the meso- and polyhalinic part of the Outer Weser between Weser-km 65 (Bremerhaven, Geeste estuary) and km 105 (below the tidal flat Tegeler Plate). In the German Bight the river is split up by the tidal flats Robbenplate and Tegeler Plate into the Fedderwarder Arm, which is the main channel and the Wurster Arm as a second branch. Dams and groynes are ensuring the stability of the fairway in the inner part of the Outer Weser. Watering and dewatering of the extensive sand flats is achieved by a system of tidal channels with a depth of up to -16 m CD, the two largest ones being Fedderwarder Priel and Robinsbalje. Except for the navigation channel the investigation area is part of the Lower Saxony Wadden Sea National Park. A major part is also designated as a protected area within the Natura 2000 network.

The subtidal sediments of the Outer Weser estuary mainly consist of coarse to fine sands. Especially the river fairway is characterised by a high morphological activity which can be observed in form of sub-aqueous dunes of several meters in height. The Fedderwarder Priel marks an area of naturally increased sediment dynamics, where silt sediments are accumulating and a shifting of the channel of around 50 m p.a. takes place (GFL et al. 2006). Increased sedimentation and erosion processes can be noticed as well near the sand bars Tegeler Plate, Robben- and Mellumplate. In contrast, the fairway in the southern part of the Outer Weser is kept comparatively constant by measures of coastal protection (ECOFYS 2009).

At present natural hard substrata in the Weser estuary occur only in small areas and widely scattered, for example in the form of loose aggregations of stones (KÜFOG GMBH & OSAE 2006). Consolidated subtidal sediments such as clay and marl are likewise rarely found. Hard bottoms settled by epifauna are mainly detected in the southern part of the Outer Weser, though larger and consistent mussel beds are scarcely distributed. An extensive reef of the tube-building polychaete *Sabellaria spinulosa* existed west of the Tegeler Plate until the beginning of the 1980s, yet currently there are no records of this species in

the Weser estuary. The nearest occurrence of living *Sabellaria* reefs was last observed in the 1990s in the Inner Jade (VORBERG 2005).

3 Selection Factors

In order to select potentially appropriate locations for hard bottom habitats in the Outer Weser the following criteria were considered:

- **Morphology**

With respect to the morphological situation areas with a high stability and solid ground like marlstone or consolidated fine sands are suitable. Especially stable positions on the slope with a moderate exposure to the currents were looked for. Areas with prevailing sedimentation or increased sediment displacement were accounted as unfavourable. A more detailed investigation of the potential sites was enabled by computed data on relevant parameters such as bedload transport, bottom shear stress, transport and concentration of suspended matter provided by the Federal Waterways Engineering and Research Institute (Bundesanstalt für Wasserbau) as well as information about the morphodynamic processes provided by Ecofys. These data were used for basic information on exposure and stability. However, due to the morphodynamics prevalent in the estuary stable areas with low sediment displacement occur only on a small scale. Marine organisms are also endangered by smothering around dumping sites of dredged material, therefore potential hard substrate locations should be placed in a distance of some hundred meters from dumping sites.

- **Hydrology**

In order to avoid sedimentation of hard bottom habitats potential sites should feature an increased current velocity. Blue mussel beds are said to favour a current velocity of about 0.5 m/s (AHRENDT 2003). Water depth should add up to at least -3 m CD. Below depth of around -10 m the increasing current velocity as well as the shear stress in the fairway may prevent the constant settlement of sessile epifaunal organisms.

- **Biology**

Currently existing and populated hard substrate habitats may serve as starting points for the colonisation of newly created structures. Areas with former reef structures are likewise to be considered, as for example the polychaete *Sabellaria spinulosa* prefers settling on existing reefs or reef clumps, even if they are already dead (VORBERG 2005).

- **Exploitation by fisheries**

Negative impacts of bottom or beam trawling can be observed especially on long-living epifaunal species such as blue mussels and their associated fauna. Furthermore, destruction by trawl gear is one of the factors held responsible for the decline of the formerly extensive subtidal *Sabellaria* reefs in the Wadden Sea.

In the study area the prevailing form of fishery is beam trawling with mostly small, traditional fishing boats in mixed coastal fishery. The main target species is the common shrimp. Catch areas are mainly found along special morphological structures such as steeps between shallow waters and deeper regions as well as slopes of fairways and bigger channels. Round fish and flatfish trawling is nowadays no longer of importance in the Weser estuary due to declining populations of these species. Fishery

on blue mussels in this area is likewise negligible. Another traditional form of fishery in the Outer Weser is the “Hamen” fishery, which is performed at fixed positions beside the fairway down to around km 87 (VOIGT & FUHR 2006).

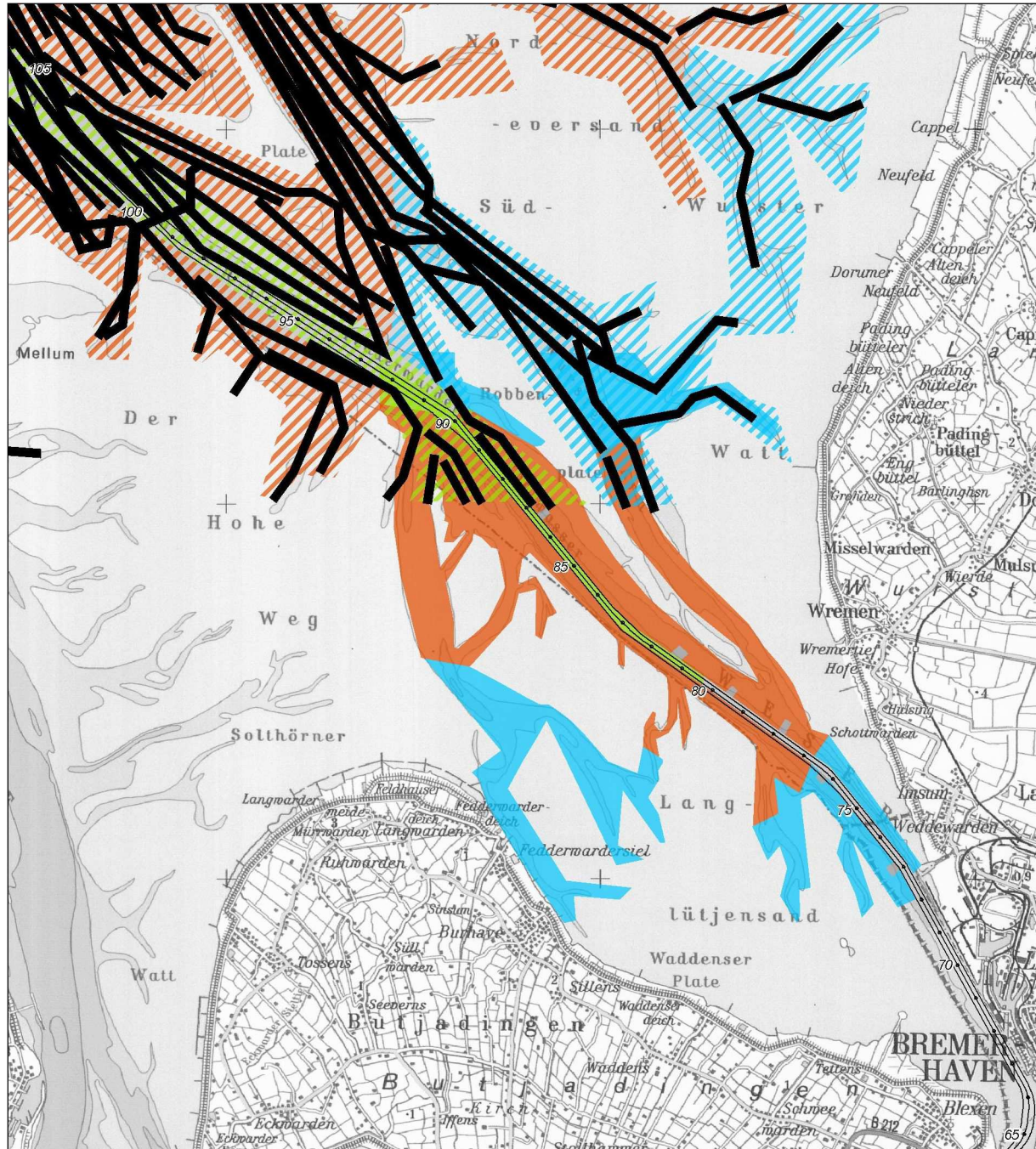


Fig. 1: Fishing grounds of the Outer Weser.

Hatched: fishing area of Lower Saxony fishery companies, solid: fishing area of local companies (Spieka, Dorum, Wremen, Bremerhaven, Fedderwardersiel).

Red = main fishing area (exploited by >60 % of companies), blue = exploited by 50-60 % of companies, green = exploited by 30-50 % of companies, not shaded = exploited by <30 % of companies.

Black lines = potential fishery routes.

Modified according to VOIGT & FUHR (2006).

The major fishing areas in the Outer Weser cannot be exactly illustrated as the fishing vessels have to follow their migrating target species and therefore annual variations are likely to occur. The areas around Nordergründe and Tegeler Plate are main fishing grounds of mixed coastal fishery, not only for local fisheries but also for neighbouring regions, whereas the Robbenplate represents a major fishing area solely for local fisheries (see fig. 1). Local fisheries refers to companies from the harbours of Spieka, Dorum, Wremen, Bremerhaven and Fedderwardersiel. This comprises around 25 companies respectively shipping vessels (VOIGT & FUHR 2006).

4 Results

The selected sites are presented below with a description of the hydrological, morphological and biological characteristics as well as information on exploitation by fisheries. Table 1 summarises the results and classifies the potential sites according to their suitability for the planned measures. In the appendix an overview map of all potential areas is shown.

Site 1: Langlütjensand

The site is located between km 67 and 68 at the western edge of the navigation channel in front of the tidal flat Langlütjensand (see fig. 2). The area is designated as a Natura 2000 protected site and is situated at the border of the national park. The prevailing substrate is marlstone, but various stones embedded in fine sands can also be found. Towards the fairway and farther to the south sediment changes to consolidated silt, while northward the marlstone bank extends to around km 70 (KÜFOG GMBH & OSAE 2006). The slope is comparatively steep and has proved to be stable during the course of the last decades, whereas from km 67,5 on the channel is secured by groynes. Subsequent to the widening of the turning area at km 71 in 2006 there were sediment accretions of several metres predicted in the south of the turning area. However, until now sedimentation has mainly taken place in the navigation channel. In the selected site sediment displacement has been restricted to a few centimetres between 2006 and 2009 and erosion processes seem to predominate (BREMENPORTS GMBH & CO. KG 2009). Nevertheless an increased sedimentation of the selected site cannot be excluded due to the morphodynamic changes presumably occurring in the turning area and as a consequence of the planned deepening of the fairway.

Water depth comprises approximately -4 m to -10 m CD, current velocity amounts to around 0.4-0.6 m/s. The selected area is situated at the edge of the turbidity zone, where the average concentration of suspended matter adds up to 0.06-0.07 kg/m³ (BAW 2006a).

In 2004 a biological survey detected diverse sessile epifaunal organisms such as hydrozoans and bryozoans on the marlstone bank (BREMENPORTS GMBH & CO. KG 2004). WITT (2004) recorded a large subtidal occurrence of blue mussels further north of the selected site.

Fishery is of no importance in this area, only a few companies use the site as catch area (VOIGT & FUHR 2006).

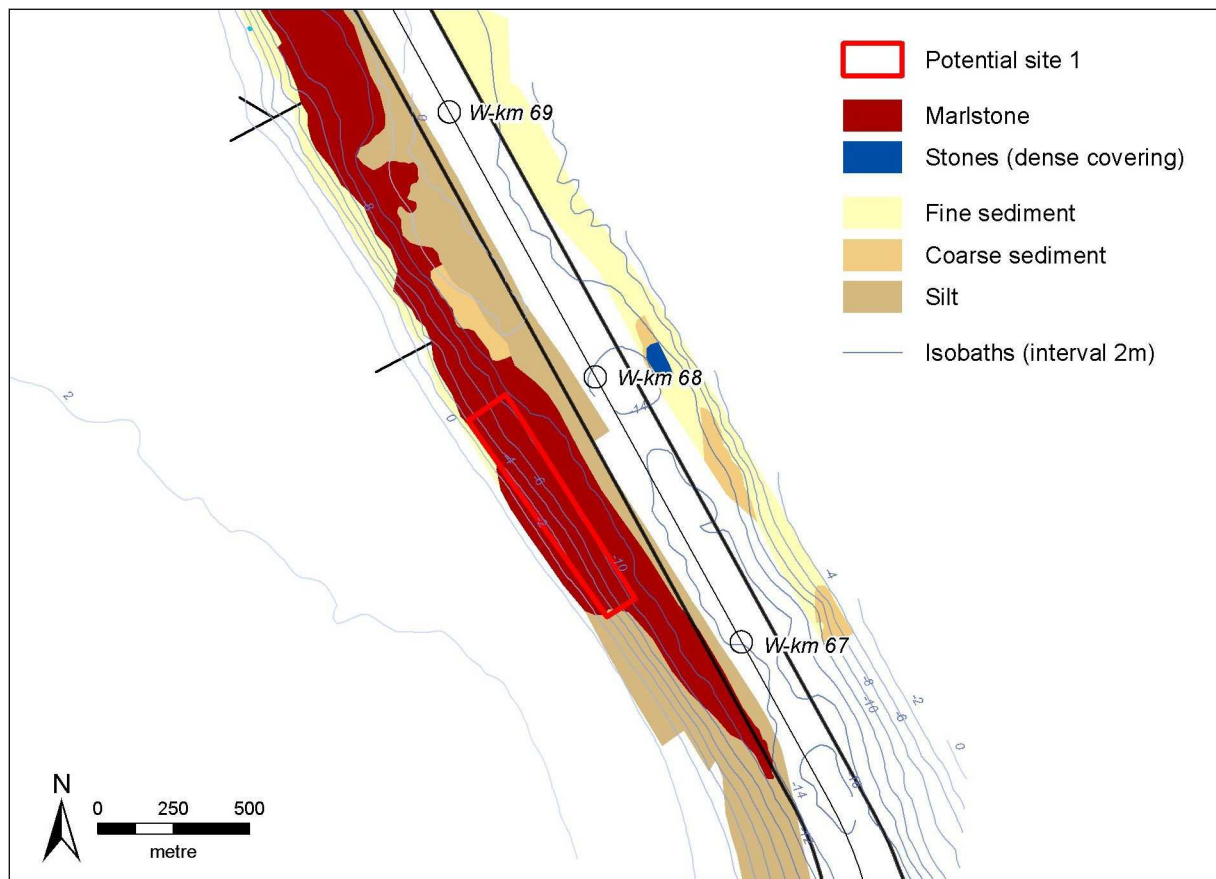


Fig. 2: Site 1 Langlütjensand.

Site 2: Weddewarden

The selected location lies adjacent to the container terminal IV at km 75 near Weddewarden (see fig. 3). A narrow area between the groynes and the fairway shows some hard structure and therefore seems appropriate. The area is a designated Natura 2000 site. A sonar survey detected loose accumulations of stones in fine sands in the southern part of the selected site, while in the northern part fine sediment dominates (KÜFOG GMBH & OSAE 2006). The slope rapidly drops in front of the groynes down to the channel and is predominantly subject to erosion processes. Subsequent to the widening of the turning area in 2006 sediment accretions of up to 3-4 m were recorded south of the potential site. At the selected site sediment erosion of at most 1 m prevails, only in a small southern part of the site a slight deposition of sediments (< 1 m) was noticed (BREMENPORTS GMBH & CO. KG 2009). Further erosions processes on a small scale are predicted for the area around the selected site as a consequence of the deepening of the fairway (BAW 2006a).

Along a narrow strip between -6 and -14 m the average current velocity is around 0.5 m/s (BAW 2006a) and should provide good conditions for the settlement of epibenthic organisms. In the course of the last years surveys such as the estuary monitoring of the BfG regularly detected adult blue mussels and associated fauna on the existing hard substrates.

The area is regularly exploited by 50-60% of the local fishing companies (VOIGT & FUHR 2006).

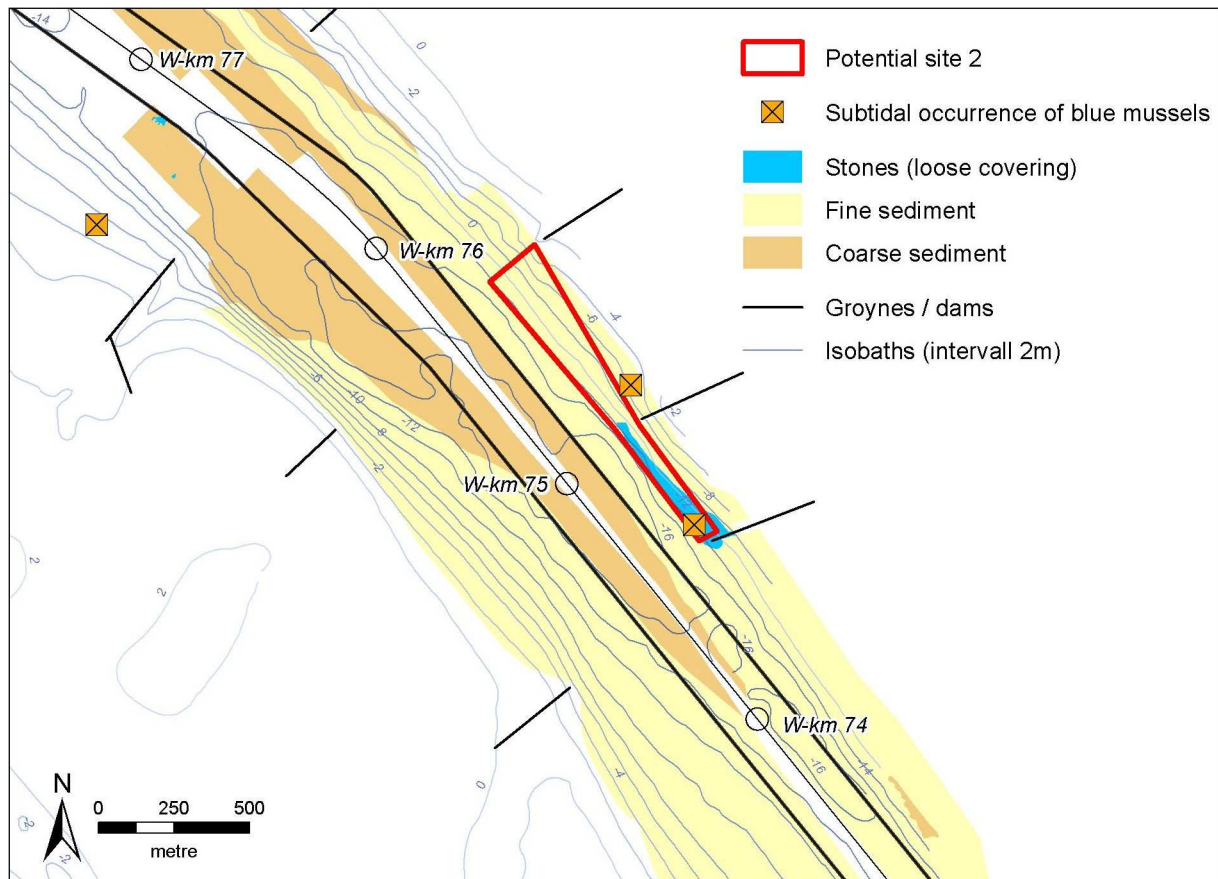


Fig. 3: Site 2 Weddewarden.

Site 3: Robbensüdsteert

The potential area is situated east to the Robbenplate dam in the Wurster Arm, close to the dumping site K1 at km 80-81 (see fig. 4). The channel Wurster Arm belongs to the Wadden Sea National Park and is a protected area by the Natura 2000 network. In 1997 some scattered stones in coarse sands were mapped at the selected site, furthermore clay soil and adjoining silt was found in the eastern part (BREMENPORTS GMBH & CO. KG 2000). The western slope drops down more steeply than the eastern one, maximum water depth amounts to -8 m CD. Current velocity is approximately 0.5 m/s (BAW 2006a). The area is considered as comparatively stable with respect to morphology, as during the last years no sizeable processes of sediment displacement were observed.

From 1996 until 1999 extensive biological surveys were conducted in the Wurster Arm. As a result, a large bed of blue mussels with small and middle-sized shells was recorded in the eastern part of the selected site. The occurrence of a diverse sessile epibenthic community consisting of hydrozoans, moss animals and barnacles indicates that this mussel bed might exist already for some years (BREMENPORTS GMBH & CO. KG 2000). Some smaller clusters of stones with blue mussels can be found south to the potential area at the fork of the channel, however, mainly juvenile mussels were recorded there and the area is subject to considerable morphodynamic processes (BREMENPORTS GMBH & CO. KG 2004).

The potential site is a main fishing area for the local coastal fishery, that is more than 60% of the local companies regularly work in this area (VOIGT & FUHR 2006).

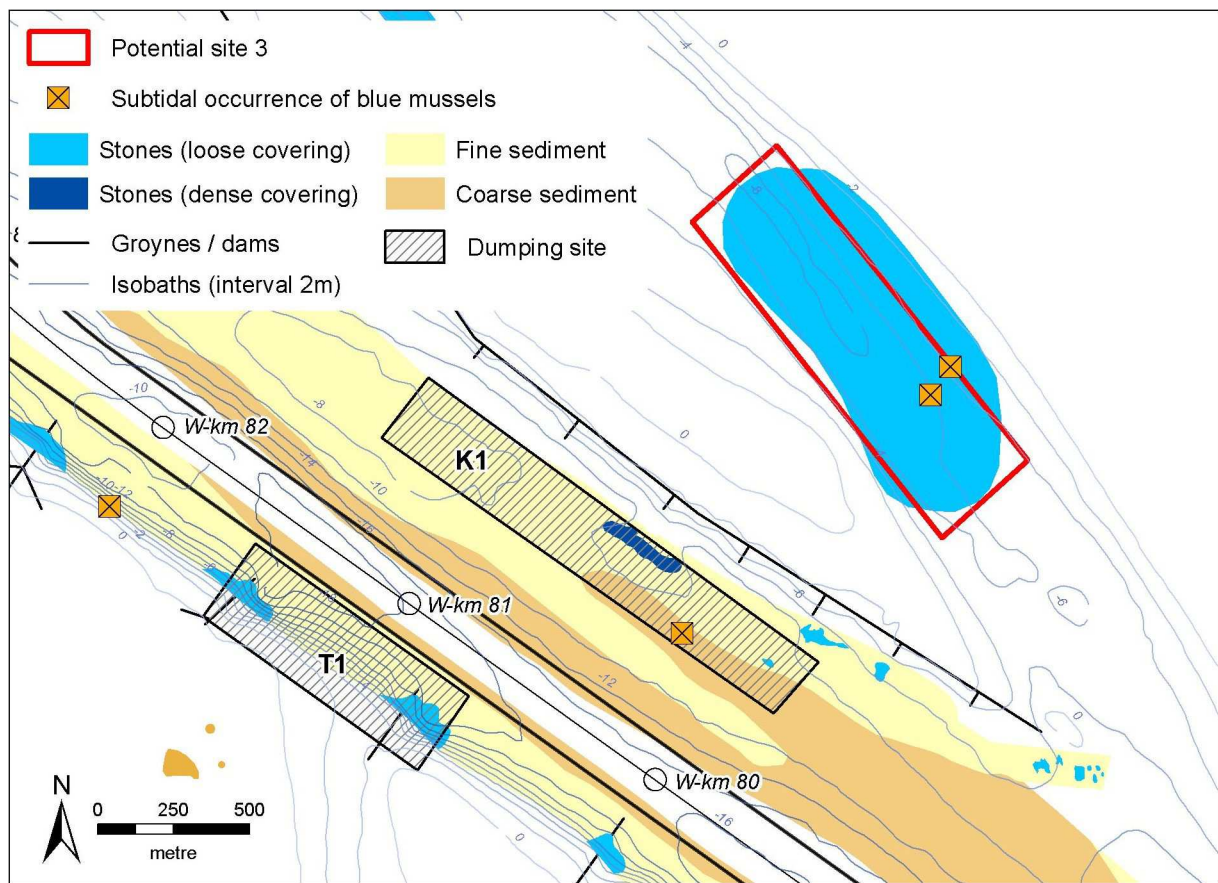


Fig. 4: Site 3 Robbensüdsteert.

Site 4: Robbenplate

This location is farther north of site 3 at km 84 in the Wurster Arm (see fig. 5). The comparatively steep slope contains stones in coarse sands as well as silt in some places. Clay and shell deposits were found in a small part of the northern section (BREMENPORTS GMBH & CO. KG 2000). Hydrological and morphological characteristics of this location correspond to those of site 3, with the exception of a slightly higher current velocity (BAW 2006a).

A small area with adult blue mussels as well as other epibenthic organisms like barnacles and hydrozoans exists in the northern part of the site (BREMENPORTS GMBH & CO. KG 2000).

The selected site belongs as well to the main fishing area of local companies (VOIGT & FUHR 2006).

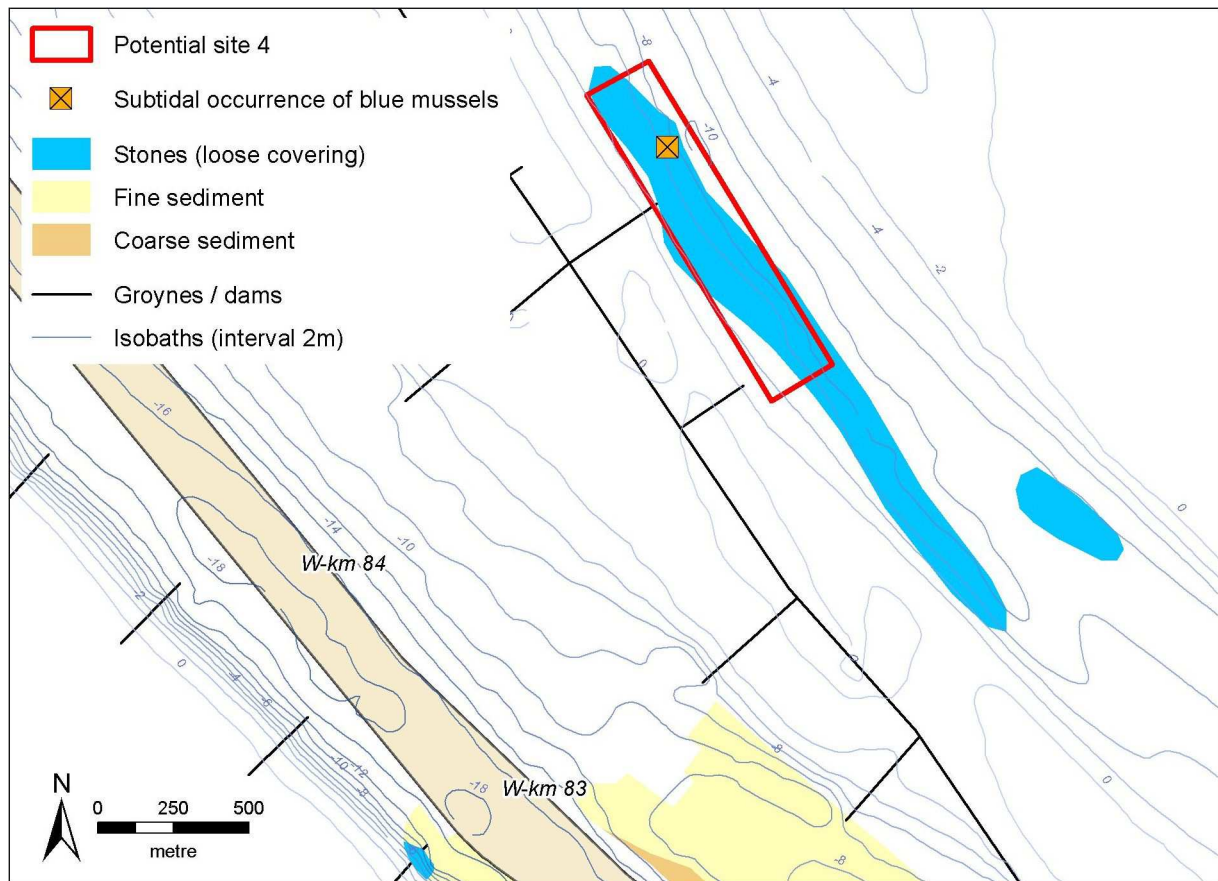


Fig. 5: Site 4 Robbenplate.

Site 5: Mellum East

The potential site is located to the northeast of the island Mellum, at the western side of the main channel Hohewegrinne between km 98 and 100 (see fig. 6). This site neither belongs to the national park nor is a designated Natura 2000 site. The slope drops down steeply to the fairway, where it borders to extensive marlstone structures at a depth of more than 15 m. Sonar surveys detected loose aggregations of stones with gravel and shell fragments as well as soft bottoms, however, the boundaries of the various structures could not be defined exactly (KÜFOG GMBH & OSAE 2006). The sonar survey did not include sediments of the potential site itself, therefore no information on the prevailing structures is available at present. Current velocity amounts up to 0.8 m/s at a water depth of -10 m, while in deeper regions it is increasing rapidly (BAW 2006a).

The location seems to be comparatively stable with respect to morphodynamics, though it lies adjacent to an area with increased sediment fluctuations (ECOFYS 2009). The distance to the deep water dumping site T3 may be sufficient to exclude negative impacts of dumping.

Biological surveys were conducted within the monitoring of dumping site, lastly in 2005 at the dumping site as well as north of it in the fairway. A diverse sessile benthic fauna with sea anemones and hydrozoans as well as juvenile blue mussels was found (BIOCONSULT 2006). The importance of the location is based on a former reef of *Sabellaria spinulosa*, which stretched out over an extensive area between km 101 to km 103 until the 1980s. A smaller reef was situated in the northern section of the potential site. Dead reef structures may still exist at this spot.

Beside eutrophication and changes in the hydrodynamic regime, one of the factors held responsible for the loss of the *Sabellaria* reefs is fishery with trawl nets. The slopes of the Hohewegrinne are major fishing areas of the coastal fisheries from Lower Saxony, that is more than 60 % of these companies are regularly fishing here (VOIGT & FUHR 2006).

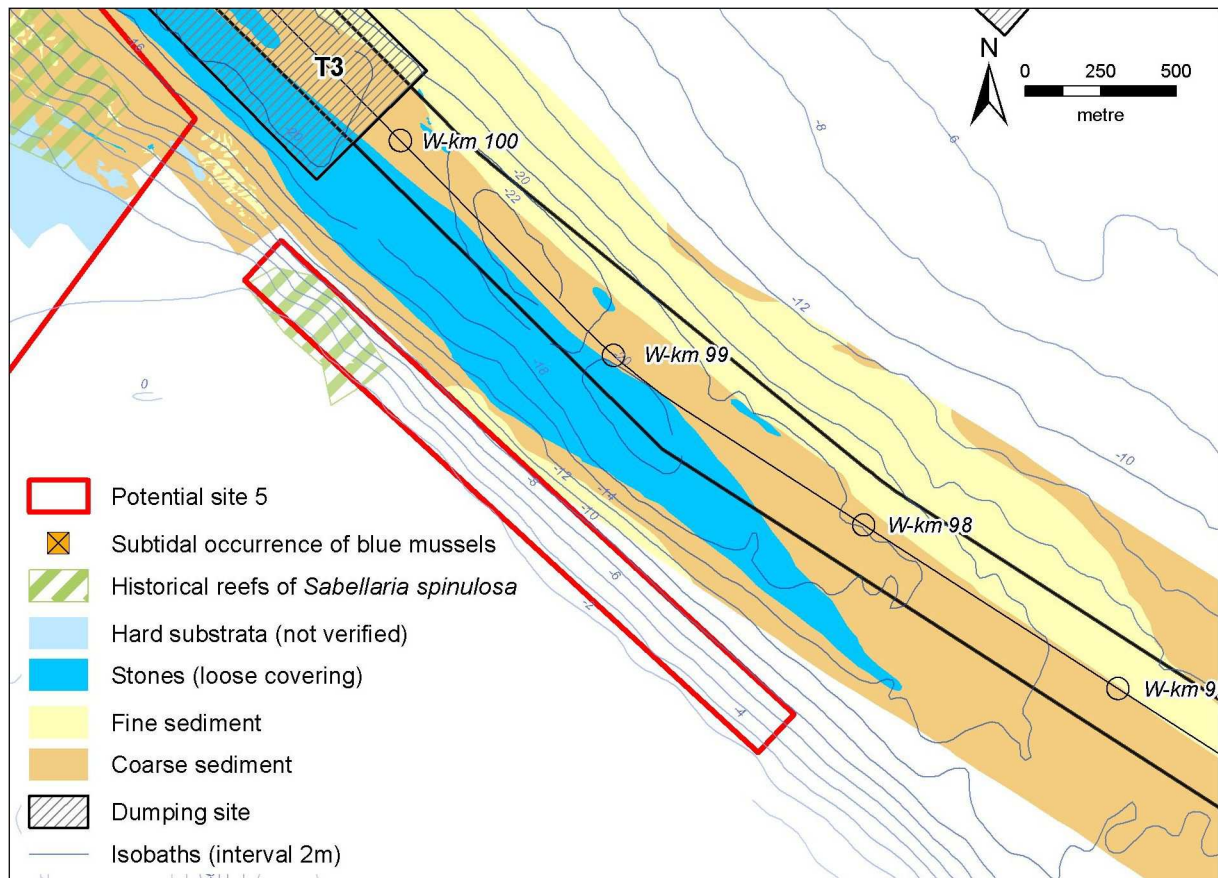


Fig. 6: Site 5 Mellum East.

Site 6: Mellum North

The selected area is located in the north of site 5 between km 101 and 103 (see fig. 7). The upper shallow section belongs to both the national park and the Natura 2000 network. Even though the slope drops down gently to the fairway, current velocity rapidly increases at -6 m and adds up to 1.2 m/s at deeper regions (BAW 2006a). A sonar survey showed indistinct hard structures at the bottom, which were verified by additional grab samples as sand with shell deposits and smaller stones. Nearer to the fairway an area with scattered stones embedded in coarse sands as well as megaripfels could be identified (KÜFOG GMBH & OSAE 2006).

With respect to morphology the slope appears comparatively stable, though closer to the fairway the tendency to sediment shifting increases (ECOFYS 2009). Furthermore, the potential site lies adjacent to the deep water dumping site T3. Until now only slight changes in sediment height were measured near the dumping site, but only small amounts of dredge spoil were dumped there so far (BIOCONSULT 2006). The quantity of dredged material dumped at T3 will presumably increase subsequent to the deepening of the Weser.

The potential site covers large parts of the former extensive *Sabellaria* reef described above. Possibly still existing reef fragments could not be identified by sonar surveys. Another part of the historical reef lies within the main channel and is therefore subject to a strong current and morphodynamic processes. With respect to morphology and hydrology there is no evidence of considerable changes in habitat conditions between the 1970s and 1980s, where living reefs were documented in the area, and today. Neither are future changes regarding hydromorphology predicted in this area due to the deepening of the fairway (BAW 2006a, b).

The biological monitoring of dumping sites detected a very diverse epibenthic community settled on scattered hard structures at the edge of the selected location as well as at the dumping site itself. Sea anemones, *Lanice conchilega* (sand mason worm) and juvenile blue mussels were locally abundant, however, the populations showed a great interannual and spatial variation (BIOCONSULT 2006).

The area is subject to considerable exploitation as a main catch area of the coastal fisheries from Lower Saxony (VOIGT & FUHR 2006).

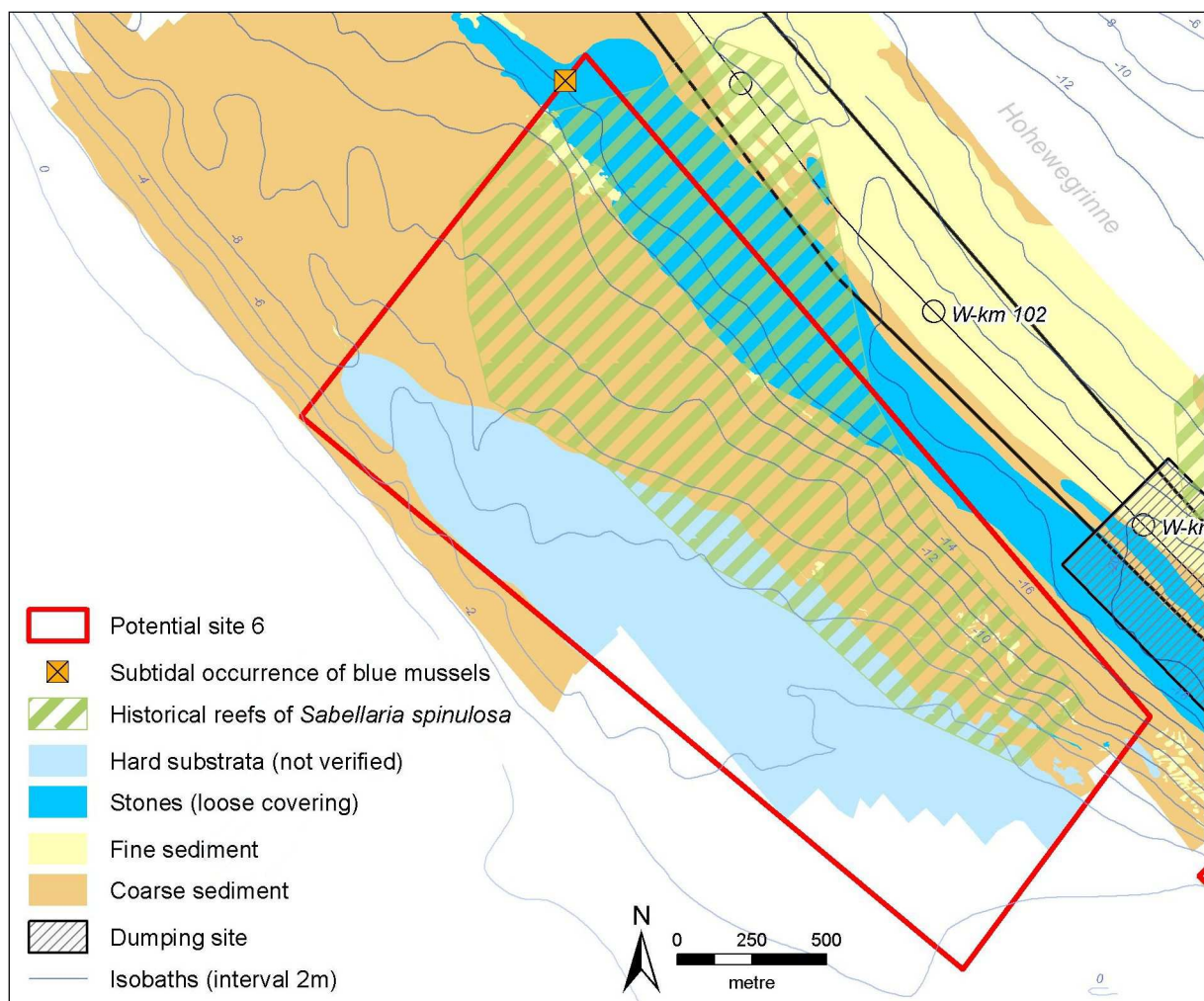


Fig. 7: Site 6 Mellum North.

Alternative Site: Robbennordsteert

This location is potentially appropriate due to the vicinity to hard substrates with a diverse sessile epifauna, but it is situated close to the dumping sites T2 and K4. A loss of hard bottom habitats has already been recorded near this dumping sites. The site was selected as an area presumably less affected by negative impacts of dumping, in order to compensate for the reduction of these habitats.

The potential site extends between the dumping site T2 at the end of the dam and the tidal flat Robbenplate from km 91 to 92 (see fig. 8). The area is designated as part of the Natura 2000 network and the intermediate zone of the national park. Fine sands with a loose covering of stones were recorded east of the dumping site, at a depth of -6 m to -10 m (KÜFOG GMBH & OSAE 2006). No information is available on the sediments of the shallower parts. The exposed position is located on a steep slope with an average current velocity of 0.3 to 0.5 m/s (BAW 2006a). Next to the deep water dumping site considerable sediment dynamics could be recorded, whereas to the east of the dumping site less distinct erosion processes prevail. Furthermore, the site is influenced by the entry of the Fedderwarder Priel, which is an area of increased morphological instability (BIOCONSULT 2006).

Biological surveys of the area were conducted during the monitoring of dumping sites. Stones with a diverse sessile fauna like hydrozoans and sea anemones were found between the fairway and the dumping site. However, the area with hard substrata has decreased between 2000 and 2005, presumably due to effects of dumping (BIOCONSULT 2006). Similar results were obtained by a sonar survey of the surrounding area (KÜFOG GMBH & OSAE 2006). Juvenile blue mussels were found repeatedly, but a constant settlement could not be confirmed (BIOCONSULT 2006).

The area is important for the coastal fishery of Lower Saxony. 50-60 % of the companies are regularly fishing in the area (VOIGT & FUHR 2006).

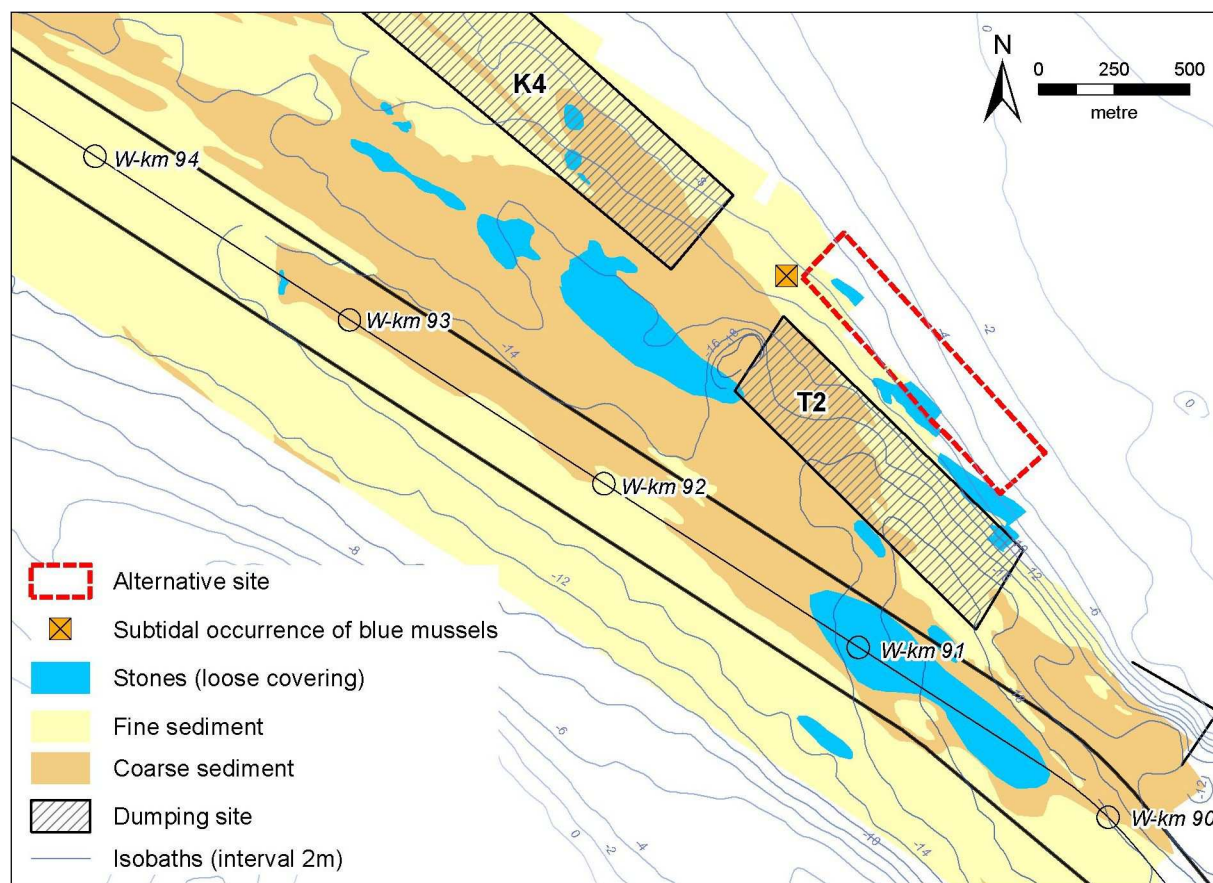


Fig. 8: Alternative site Robbennordsteert.

Table 1: Summary and assessment of the potential sites for hard substrate habitats concerning morphology, hydrology, biology and exploitation by fishery.

+++ = well suited, ++ = suited with restrictions, + = less suited.

	Site 1 Langlütjensand	Site 2 Weddewarden	Site 3 Robbensüdsteert	Site 4 Robbenplate	Site 5 Mellum East	Site 6 Mellum North	Alternative site Robbennordsteert
Morphology							
Exposure	exposed steep slope	exposed steep slope	slope and channel	exposed steep slope	exposed steep slope	flat slope	exposed steep slope
Substrate	marl, stones	stones in fine sands	stones in sand, clay	stones in sand, shell deposits, clay, as well as silt	adjacent marl, loose covering with stones, gravel, shell deposits	hard substrate with small stones, sand and shell deposits	parts with loose covering of stones in sand
Stability	until now mostly stable, sedimentation possible due to effects of deepening of the fairway	erosion processes prevailing, next to an area with increased sedimentation, further sediment displacement predicted subsequent to the deepening of the fairway	comparatively stable	comparatively stable	comparatively stable, adjacent to an area with increased morphodynamics	comparatively stable, in deeper regions increased morphodynamic processes, next to dumping site	sediment displacement possible due to proximity to dumping site and entry of Fedderwarder Priel
	++	++	+++	+++	+++	+++	++
Hydrology	current velocity adequate	current velocity adequate	current velocity adequate	current velocity adequate	current velocity down to -10 m adequate	strong increase in current velocity at -6 m	current velocity adequate
	+++	+++	+++	+++	+++	+++	+++
Biology	populated hard substrate, blue mussel bed lies adjacent	occurrence of adult blue mussels	extensive blue mussel bed in parts, sessile epifauna	occurrence of adult blue mussels, sessile epifauna	next to hard substrate settled with juvenile blue mussels, former <i>Sabellaria</i> reef in the potential site	next to hard substrate settled with juvenile blue mussels, comprises large parts of an extensive former <i>Sabellaria</i> reef	populated hard substrates in the vicinity, accumulations of juvenile blue mussels
	+++	+++	+++	+++	+++	+++	+++
Exploitation	low	catch area of local coastal fisheries (50-60% of companies)	main catch area of local coastal fisheries (> 60% of companies)	main catch area of local coastal fisheries (> 60% of companies)	main catch area of coastal fisheries from Lower Saxony (> 60% of companies)	main catch area of coastal fisheries from Lower Saxony (> 60% of companies)	catch area of coastal fisheries from Lower Saxony (50-60% of companies)
	+++	++	++	++	+	+	+

5 Conclusion

Selection of potential sites for the development and creation of subtidal hard substrate habitats in the Outer Weser is constricted by a number of factors. Appropriate locations were found along the slopes of the main channel Fedderwarder Fairway respectively Hohewegrinne as well as in the second channel Wurster Arm. No sites were designated in the larger tidal channels, due to strong morphodynamics as in the Fedderwarder Priel or the lack of information as in the area around the Robinsbalje.

Seven areas could be identified where the implementation of measures is possible. All of the selected sites prove to be well suited concerning biological and hydrological characteristics. A morphological stability cannot be guaranteed for every location. Some sites are subject to natural sediment dynamics, others are situated next to dumping sites or may be affected by presumable effects of the deepening of the Weser channel. Further conflicts arise where areas are fishing grounds for coastal fisheries, especially the catch areas with importance for fisheries from Lower Saxony around Mellum and Tegeler Plate. Particularly with regard to the resettlement of the historical *Sabellaria* reefs as well as other locations with a potential of development it is recommended to designate areas without or with little exploitation by fisheries.

Based on the high diversity of invertebrates and the functional importance of hard substrate habitats as spawning area and feeding ground for fishes as well as a nursery ground for juvenile fishes it is considered reasonable to implement measures for the development and creation of subtidal hard substrate habitats in the Outer Weser.

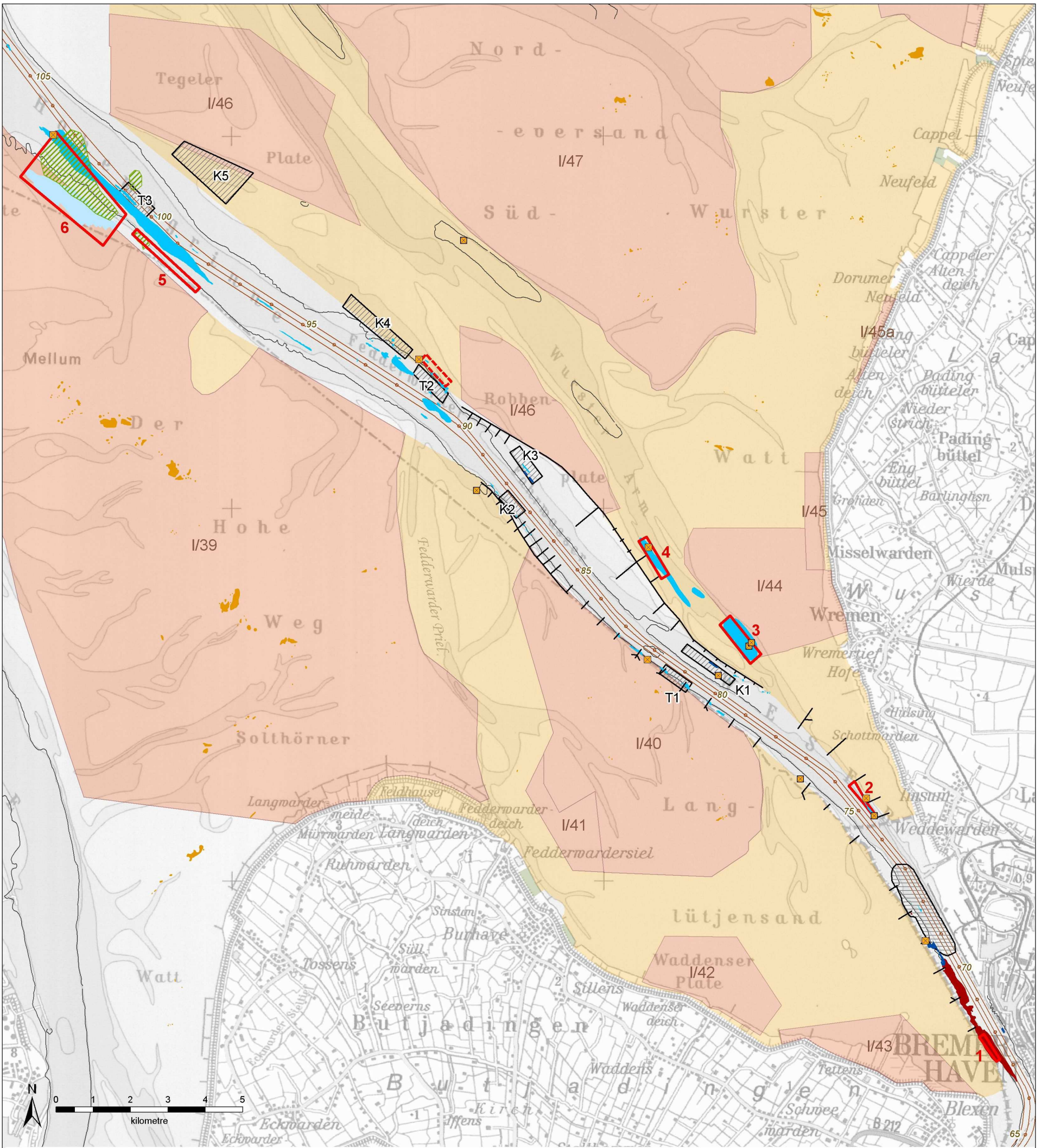
Within the framework of this study an extensive subtidal section of the Outer Weser was surveyed for its potential as habitat for hard bottom communities for the first time. However, the data currently available are not sufficient for a reliable assessment of large parts of the estuary. Especially information on the tidal channels should be improved and the potential of adequate locations should be investigated there.

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Appendix



Legend

Potential Sites

- Potential sites (1 to 6)
- | | |
|-------------------|--------------|
| 1 Langlütjensand | W-km 67-68 |
| 2 Weddewarden | W-km 75 |
| 3 Robbensüdsteert | W-km 80-81 |
| 4 Robbenplate | W-km 84 |
| 5 Mellum East | W-km 98-100 |
| 6 Mellum North | W-km 101-103 |

- Alternative site
Robbennordsteert W-km 91-92

Fauna

- Intertidal occurrence of blue mussels (as of 2007)
- Subtidal occurrence of blue mussels
- Historical reefs of *Sabellaria spinulosa*

Sidescan-interpretation (2006)

- Hard substrate (not verified)
- Marlstone
- Stones (dense covering)
- Stones (loose covering)

Wadden Sea National Park of Lower Saxony

- Restricted zone
- Intermediate zone
- Recreation zone

Miscellaneous

- Turning area
- Dumping site (K1 to K5, T1 to T3)
- 10m - isobath
- Line of leading lights

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Client:



Lower Saxony Water Management,
Coastal Defence and Nature Conservation Agency,
Branch Office Brake-Oldenburg

Identification of Potential Areas for the Development and
Creation of Subtidal Hard Substrate Habitats in the Outer Weser
Pilot study within the framework of the INTERREG IV B Project
"Tidal River Development" (TIDE)

Potential Sites for Hard Substrate Habitats

Scale 1:100 000	Date March 2011	Edited by P. S.	Plotted by N. M.	Size A3
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**Landschaftsökologische
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