HELCOM BalticBOOST Workshop on the development of joint principles to define environmental targets for pressures affecting the seabed habitats

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Document title	Effects of non-fishery pressures on seabed: two case studies from German waters
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Background

Within Theme 3 of the BalticBOOST project a series of test cases were set up early on with the general aim to groundtruth the linkages between pressures arising from human activities and the environmental status of seafloor habitats. Test cases were selected based on the availability of data from different areas and discussed and confirmed during the BalticBOOST Theme 3 WS 1-2016, held in Copenhagen, Denmark, 2-3 June 2016.

The case studies in German waters for non-fisheries pressures affecting seabed habitats are not meant to be exact analyses of localized impacts and do not claim to be exhaustive. They are exemplary calculations based on readily and "not-so-readily" available data from HELCOM, ICES or national data services. Also, they intend to test some rather debatable assumptions regarding the concept of damage and loss. No consideration was given to the temporal aspect of data availability, because up-to-date information was only available in very few cases.

In the Plantagenetgrund, the rare communities like mussel beds have so far been spared from damage, presumably due to recommendations stemming from the Environmental Impact Assessments, which are part of the permission process. Even if we classify the impacts as loss, impacts do not reach a magnitude where the Good Ecological Status may be compromised. However, we have to keep in mind that additional effects from fishing and coastal installations have not been included in this consideration. Should a complete exploitation of fossil sediment layers be contemplated (worst case scenario) more than a half of two rarer habitats will be affected, probably lost. On a broad scale, relevant for MSFD, also a severe impact on about 8 % of photic sands can be expected.

In the Mecklenburg Bight, the results showed that human activities affected the habitats to a very low extent even if the "rare" habitat type sublittoral till is potentially damaged to a degree relevant for GES discussion. However, the most extensive sediment type, sublittoral sand, was affected to a comparably large extent by extraction and a GES boundary of 5 % loss, which has been discussed (and rejected) at EU level, would have been reached. This may mean that physical damage and loss of non-fisheries human activities has been underestimated in comparison to fisheries effects in the Baltic Sea.

The information derived from these, and the other case studies, can thus be used to estimate the relative significance of different human activities on the benthic habitats and support the setting of principles for environmental targets.

The meeting is invited to consider the information provided in this document.

Case Study Plantagenetgrund

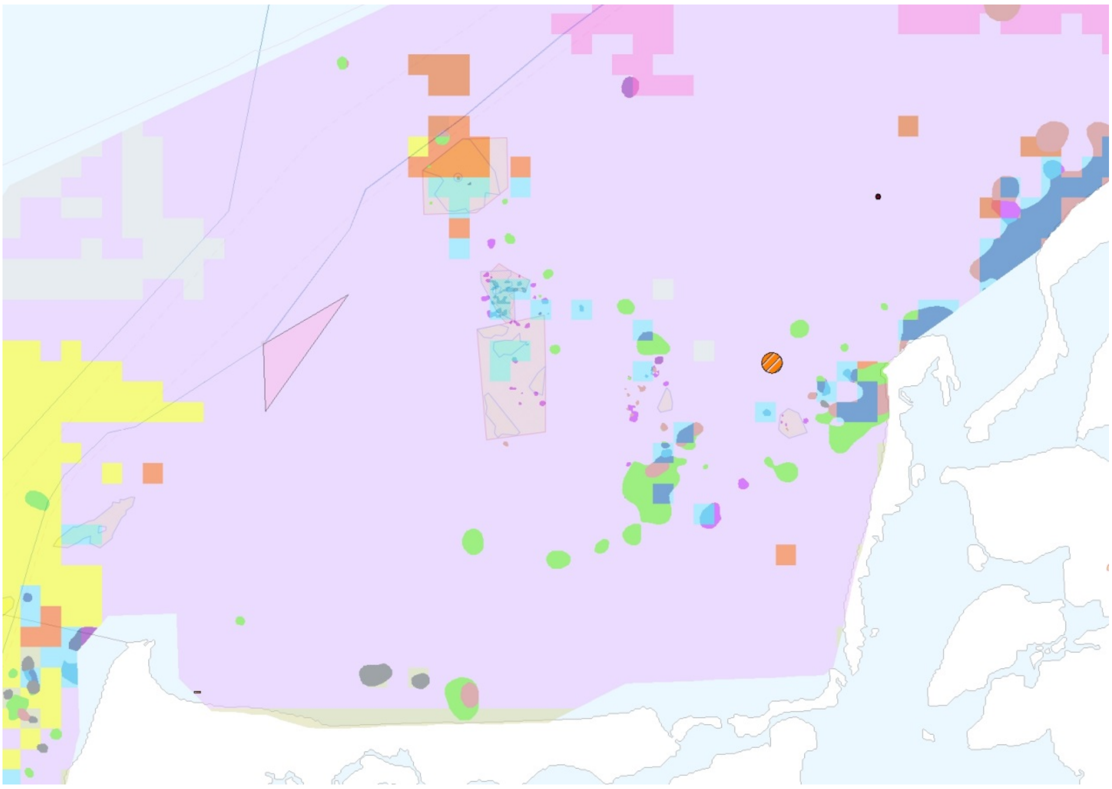

Image 1: Plantagenetgrund with fine scale habitat map (Schiele et al 2015) and representations of human activities

The case study Plantagenetgrund aims at exploring information from sources, that are not usually publicly available, applied to the most accurate small scale habitat map. However, even though voluminous EIAs (environmental impact analyses) for construction or excavation projects are accessible upon request, the underlying data, like species or biomass tables, are not. Therefore no concrete comparison between communities in affected or unaffected areas can be carried out and the analyses have to remain on a theoretical level.

I. human activities

The first step of selecting the relevant human activities already leaves us with decisions that cannot be completely satisfactory. In their GES advice, the European Commission lists the following activities relevant for D6:

1. Coastal infrastructures (ports, defenses against erosion, etc.) and offshore installations (oil and gas platforms, wind farms, etc.);
2. Offshore mining and sand extraction;
3. Release of dredged sludge;
4. Moorings;
5. Some fishing practices (trawling, dredging, etc.);
6. Aquaculture (unused fish feed, fish feces, etc.);
7. Introduction of non-indigenous species (trough ballast water for instance);
8. Pollution (chemical pollution, litter);
9. Changes in riverine inputs (organic enrichment of particulate matter, etc.);
10. Sediment remobilization by fishing equipment (trawls, dredges);
11. Changes in freshwater riverine inputs as a consequence of damming and irrigation;
12. Changes in solid matter riverine inputs; and

13. Release of large quantities of warm (power plant cooling) or salty water (from desalination facilities)

source: http://ec.europa.eu/environment/marine/good-environmental-status/descriptor-6/index_en.htm; 08.06.2016)

Of these, only points 1 - 6 and 10 directly apply to physical damage and loss. Several activities (ship traffic, tourism etc.) have also been considered, but not selected here. The area was chosen to evaluate wind farm construction, cables, sediment extraction and dumping grounds. Even if we exclude eutrophication, pollution and other non-physical pressures, a totally comprehensive evaluation of seafloor integrity is not achievable at the moment and we have to restrict ourselves to the estimation of the most relevant effects.

I.a. wind farms

Detailed information about wind farms is readily available (most up-to-date on http:\\www.4coffshore.com), often including number of engines, details of constructions, length of cables, etc.. The wind farm Baltic I was completed in 2010, but construction at the converter station seems to be ongoing.

Image 2: Wind farms are notoriously hard to capture from sea level. However, this perspective gives an idea about the low density of installations in the area

Image 3: Maintenance work (here at the converter station in 2016) can also lead to seafloor damage.

The area covered by the constructions is determined mainly by the amount of scour protection in place. The sealed area can definitely considered to be lost, even though it is “transformed” to a new habitat type (typically from sand to rock) and the new habitat may have a higher biodiversity than the old one. Even though detailed information about possible construction types were examined in the project application documents, the finally employed technique is not known. The turbines themselves are grounded by monopole constructions, which supposedly need scour protection in place.

OSPAR (2008) described an average of 30 m diameter per turbine (or 5 times the pile diameter) and this number was confirmed by data from Nysted I (Danish Energy Authority 2006). This number was used here. Similarly, effects of the electrical cables in Baltic I have to be approximated. There are two types of wind farm cables. First there is an array of cables connecting the turbines to each other and to a converter station and second the converter station sends the current to a terrestrial receiver station on shore. Baltic I shares its shore cable with another wind farm that in turn will be connected to a station in Sweden.

Tab. 1: wind farm Baltic I

Name	country	turbines	area (km²)	**loss** (m²)	loss compared to windfarm area (%)
Baltic I	DE	21	2	14.844	0,2
cables		length (km)	depth (m)	affected area (m²)	
array cable	DE	21	unknown	42.000	0,6
shore cable	DE	122	1,5	244.000	-

During the process leading to the installation of the wind farm Baltic I, extensive impact analyses and prediction have been produced, including an evaluation of impacts on the seafloor in the construction areas for several types of turbine foundations, cable trenches etc.. The overall result was that the impact can be considered not to be severe and rather short-lived. Disappointingly, the investigation was not continued in the construction phase, nor were the prognoses reviewed afterwards. Also, the construction methods finally chosen from a number of possibilities were not documented. And whereas the project application is accessible (with a special application process), the underlying data are not.

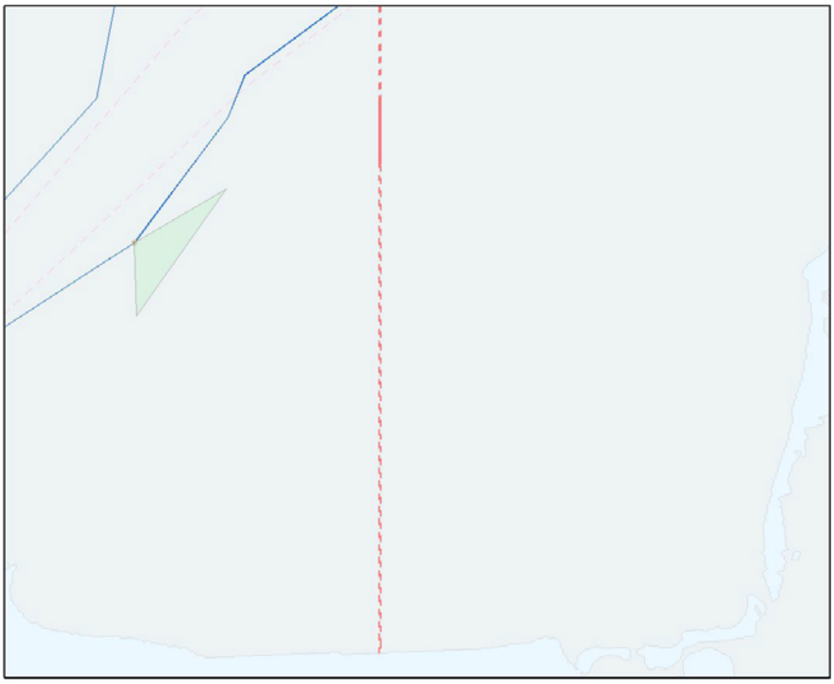

Image 4: wind farm and cables at Plantagenetgrund (green triangle - wind farm, blue lines - power cables, red lines - data cables, vertical red line from an undocumented cable found in an EIA (solid line) and theoretically continued dotted line))

I.b. cables

In addition to the wind farm cables a number of data cables can be found in the case study area. Again, the exact nature of the impact they have is unknown, so that for the sake of this study they are presumed to have been established decades ago, using even more invasive methods than used nowadays.

Several methods are used to protect the cables from damage by anchoring ships or ground-touching fisheries. On hard bottoms cables can be covered by concrete or steel casings, and most often they are buried at 1 to 2 m depth in sediments. Depending on the burial technique, cable trenches can be visible as **2 m wide disturbances** after decades, indicating a long term change of sediment characteristics.

In addition to “known” cables an investigation for sediment extraction permits identified two “lost” cables in the study area bathymetrically and by side scan sonar.

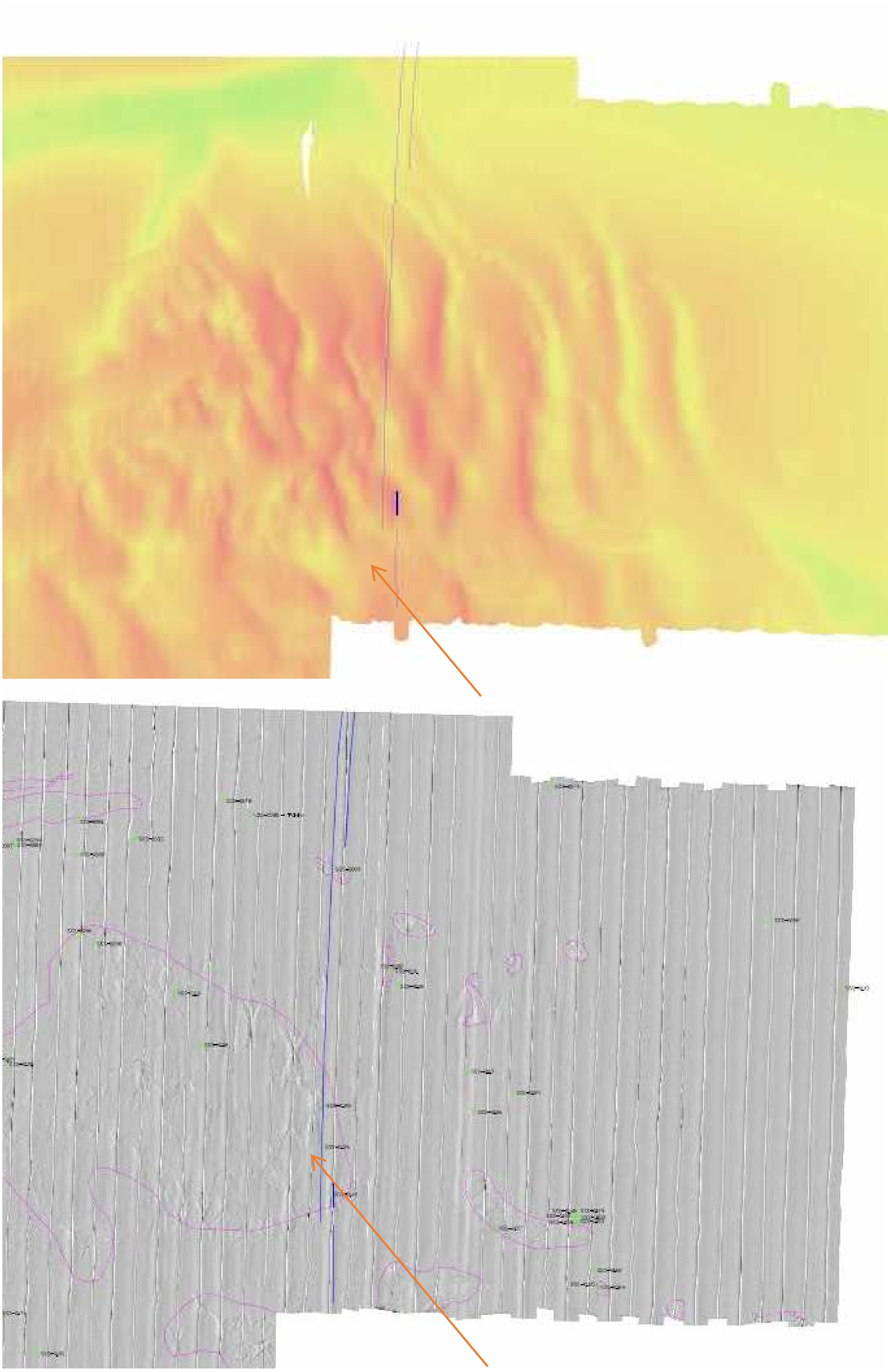

Image 5 and 6: Bathymetric and side scan sonar images showing two parallel cables (arrows) in the Plantagenetgrund NW sand extraction area (corresponding to the full part of the vertical red line in Image 4)

Even though information about the origin of the cables is missing, they nicely demonstrate that cable can have a lasting impact on the seafloor. Experts at the national maritime organization were surprised, that cables, which supposedly were buried deep enough not to be an obstacle, are now, decades later, (partly) visible and affecting the seafloor.

Tab 2: Data cables in Plantagenetgrund area

Name	country	length (km)	length in cs area (km)	area affected (m²)	comment
BalticCable	DE/DK/SE	279	10,5		
“lost cable”	DE/DK?	?	2 x 29,1	117.280	assumed, based on records for 2,8 km in EIA
SE-D4	DE/SE	44	13,8	27.600	out of use
SE-D5	DE/SE	94	21	41.960	null

I.c. extraction

Areawise, in north-eastern Germany the most intense physical use of seafloor habitats is the exploitation of fossil sediment deposits. Several size classes of sand and gravel are of interest for industrial use and coastal protection (dyke building and beach replenishment). The layers need to be strong and pure enough, close enough to harbor facilities and in acceptable water depths to be considered as “industrial deposits”. Of these, according to Schwarzer (2006) in 2004 already all deposits in Germany (Mecklenburg-Westpommerania) had been exploited by 31 %. Intuitively, this should have a significant effect on the abundance of certain habitat types. However, on a broad scale (EUNIS level 3) the percentage loss/damage may not be as obvious. Permits for sediment extraction are subject to a range of environmental impact assessments, and the results are part of a public consultation process, during which they are available in the internet. However, after the process these data are hard to get.

It is very hard to judge what kind of physical loss and damage is caused by sediment extraction. On a broad habitat scale extraction fields do not differ from the surrounding areas of fine or mixed sediments. Also, regulations in Germany (and HELCOM Recommendations) state that the deposits are not to be depleted to the underlying clay or till layer. The older, more harmful methods of stationary dredging with the resulting 8 - 10 m deep holes, which locally lead to permanent oxygen deficiency, have been banned for a long time. The use of trailing suction hoppers is supposed to be more environmentally friendly by more gradually reducing the wanted layer and leaving undisturbed areas in between the extraction lanes, which can help with the resettlement of newly exposed layers.

Still, during the extraction process the sediments are treated in several ways. The hopper itself is protected by a mesh cage, which stops larger particle and rocks from entering and damaging the device. Finer particles are dispersed on the ground during the process and also released directly as in the ship hold´s overflow. Finally, undesired size fractions are sieved and released from the ship. Most of those sediments fall directly back to the extraction area, but some particles are subject to transportation with local currents. Therefore, a degree of change in sediment composition is unavoidable.

The extraction area “Plantagenetgrund” consists of several extraction fields with slightly differing uses and granulometric distributions. It has been in use for several decades and Plantagenetgrund SE in the south has almost been depleted (2012). The northern and middle east (the irregular red polygon in Image 7) fields have assumedly not been used yet and exploitation of the field in the middle (Plantagenetgrund NW) is ongoing until 2050. The two additional polygons (yellow in Image 7) are potential extraction fields for use in coastal protection.

According to a data point in the CONTIS online information system, the northernmost field is also used as a dumping ground for dredged materials (see I.d). However, upon closer inspection no information about dumping dates and amounts of material were forthcoming (yet?) from the responsible offices for maritime or mining affairs.

For the purpose of this case study, we have taken an assumed percent-wise approach (see also Case Study Mecklenburg Bight) for Plantagenetgrund SE. Unfortunately, this can only be applied to one of the extraction fields, where information for the amount of harvested material was available.

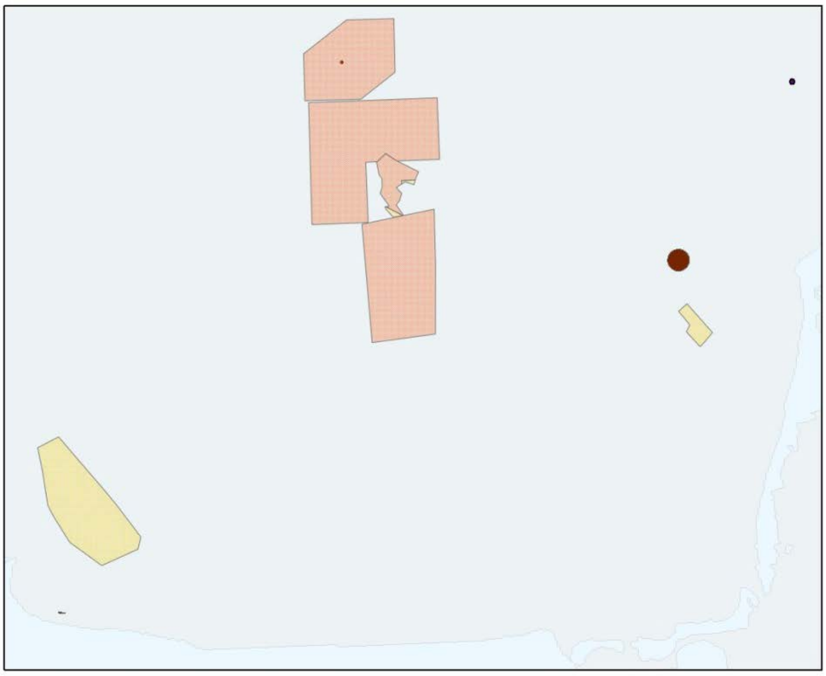

Image 7: extraction fields (yellow and red polygones) and dumping grounds (dark brown points and one tiny polygone in the lower left) at Plantagenetgrund

In addition to the known exploitation status of the sediment fields a second calculation covers the potential impact should all industrial deposits be depleted. At least for the largest extraction field “Plantagenetgrund NW” a license for exploitation exist until 2050, so that this assumption is not very far-fetched.

Tab 3: Extraction fields in Plantagenetgrund

name	area km²	volume (industr.) m³	extracted m³	*impact km² (approx.)*
Plantagenetgrund Nord	18,4	10.620.000	0	*0*
Plantagenetgrund NW	26,2	40.970.000	?	*?*
Plantagenetgrund SE A	2,7	?	?	*?*
Plantagenetgrund SE	17,5	2.919.996	2.715.025	*16,2*
Ostsee-4-6-Sa-V2 / SWK: S 3	13,5	?	?	*?*
Ostsee-5-6-Sa-V1 / SWK: S 3	1,3	?	?	*?*

sum	*128.87*	*3.535.698*	*1.511.980*	***16,2 (up to ca. 110)***

I.d. disposal

Dredging and dumping is an important subject for HELCOM policies and the information available for the amount of dredged and dumped material is better than for sediment extraction. Many locations of dredged harbor channels or deposit sites etc. are available, but the timeliness, sufficiency and accuracy of the information were found to be questionable. Even in local administrative accounts inconsistencies in reporting appeared, for example due to partial use of dredged sediments in construction. One has to be aware, that the amount of dumped materials is given in differing units. Numbers from the HELCOM data service are given in tons of dry weight, whereas maritime agencies often calculate in cubic meters, a more practical unit when it comes to accounting for shiploads of sediments. The conversion factors vary depending on the minerals and the water content. As a rule of thumb, for “sea sand” a density of 1,66 t /m³ is assumed (Bergamt MV).

The spatial effects of dumping vary very much with the methods employed, with local conditions and the accuracy of the barge pilots. More environmentally friendly methods have been invented in the last decades, but no information about their availability and actual use is readily available. Typically, the material is carried in several shiploads to a more or less exact position and dumped at once. In low current situations almost all the sediment will be deposited in “one place” and only small amounts of fine sediments will affect habitats in the vicinity. According to local authorities (pers. com.) an area up to 400 m from the deposit “point” will be measurably “affected” and after 500 m no effects can be observed at all.

For the case study, areas affected by dumping were available from the HELCOM data service for two cases (“northern approach to Stralsund” and „Join_ID 22013165“). A third dumping site, “Wieker Bodden/Arcona Sea”, was approximated by comparing it to „Join_ID 22013165“. The last site, „dumpin_p (OID 375)“, originates from an probably outdated data set by CONTIS and could not be verified.

It is not possible to calculate the thickness of the layers resulting from the disposal and to approximate the likely difference between original sediment structure and the new layer. Therefore, for the time being the affected areas are considered as lost, due to the application of a precautionary ecosystem approach. The disproportionate error margin is considered to be negligible (for the time being), because total numbers are very small.

Tab. 4: Disposal sites in and around Plantagenetgrund

name	country	year	amount (t dry weight)	*area (until 2013) km² (approx.)*
Northern approach to Stralsund	DE	2006	139.263	0,785
Wieker Bodden/Arkona Sea	DE	2009	33.110	*0,009*
„Join_ID 22013165“	DE	2013	68.645	0,019
„dumpin_p (OID 375)“ (located in extraction field Plantagenetgrund Nord)	DE	"in use"	-	-
sum				***ca. 0,8km²***

The shipping channel leading from our case study area to Stralsund (see **I.e.** below) has to be maintained by almost yearly dredging (*Tab. 5*). The numbers available for the years 1990 - 2013 show, that the amount deposited at the dumping site "Northern approach to Stralsund" varies a lot from year to year. Also, the one number given in the GIS system for 2006 does not exactly match the number derived from the local authority (WSA Stralsund), nor does it at all match an average yearly number (66.000 m³). The area of 0,785 km² is consistent, however, so that a permanently disturbed area of this size can safely be accounted for. The channel itself can be approximated by comparing satellite images to the GIS maps.

Tab. 5: Material dredged for "Northern approach to Stralsund"

year	amount (m³)	year	amount (m³)	year	amount (m³)
1990	54.377	1997	-	2004	-
1991	85.483	1998	69.115	2005	178.043 (100.000 for construction)
1992	13.118	1999	38.859	2006	103.158
1993	98.643	2000	82.994	2007	87.776
1994	130.369	2001	60.172	2008	200.000 (all for dyke construction)
1995	40.975	2002	101.337	2009	200.000
1996	47.551	2003	-	2010 - 13	0

I.e. coastal infrastructure

The Darß area and the island of Hiddensee, that border the case study are in the East and South, are subject to coastal erosion on one hand and recreational use on the other. Therefore, of ca. 56 km of coastline about 24,1 km are protected by wooden groyne systems and rocks, significantly changing the naturally variable near shore habitats. Even though the groynes extend only about 100 m perpendicularly into the sea, they are supposed to alter the sediment transport regime much further. In addition to this, there are two piers and an artificial harbor. For this harbor and for the connection to the harbor of Stralsund two shipping lanes have been dredged and are maintained by more or less continuous dredging (see **I.d.** above). For coastal infrastructure an assessment is under discussion and not added here yet, because the conceptual basics are missing.

Image 8: coastal infrastructure in cs area: brown - groyne systems (dotted = inactive), black - enrockment, lilac - piers, blue - dredged channels

I.f. beach replenishment

For coastal protection and recreational beach use large areas on and in front of beaches are covered with sediments stemming from **I.c.**, some of them regularly following erosion after storm surge events. They are not subject to this case study, because they often concern areas outside the scope of the MSFD and typically affect areas of natural rearrangement of substrates. Furthermore, data for this pressure are not at all easily accessible. Anyway, it is not likely that beach replenishment is needed in the case study area.

II. habitat maps

IIa. scale

For the evaluation of habitat damage and loss precise maps of benthic maps are necessary. Fairly precise maps are available for German Baltic waters and they will are used in this case study. In a broad scale study however, sediment maps comparable to EUNIS level 3 (EUSeaMap 2011) are used due to several reasons. They are the “lowest common denominator”, having been modeled for all Baltic waters and allowing for a regional assessment. Also, the MSFD assessment is supposed to be based on this very low resolution scale (i.e. “broad scale habitats”). The case studies are expected to demonstrate the possibilities and shortcomings of this approach by comparing two types of maps.

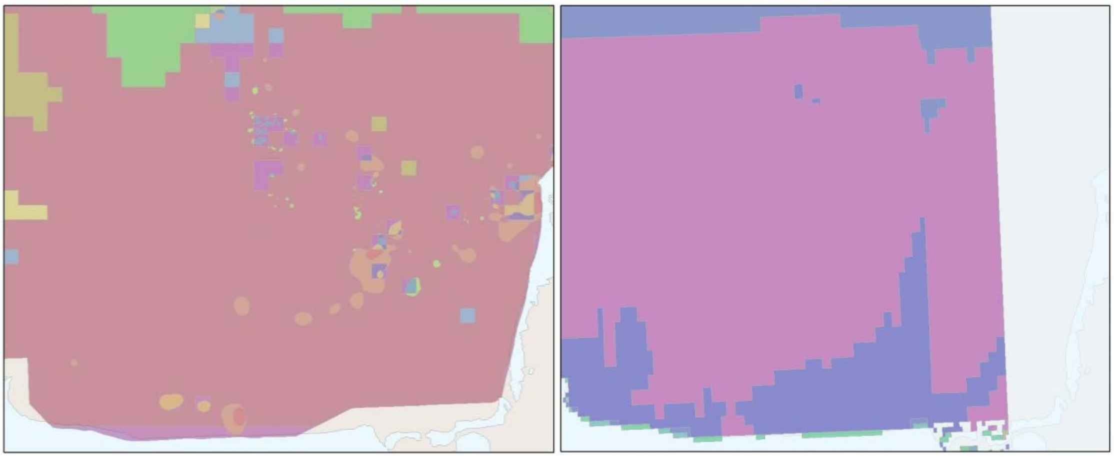

Image 9: Plantagenetgrund with fine scale habitat map (Schiele et al 2015, left) and EUSeaMap broad scale habitats (right, only partly covering the area)

IIb. the maps

The habitat map by Schiele et al (2015) is currently the finest map available in Mecklenburg. In contrast, the versions of the EU Seamap project from 2011/2012 only represent habitats in a very broad resolution (http://www.emodnetseabedhabitats.eu/default.aspx?page=1974& LAYERS= HabitatsEnBaltic). In some places its accuracy is questionable, for example some sand extraction areas are represented as mud habitats. A preliminary version of the forthcoming new version (2016) yielded a different, but also not satisfying result (not demonstrated in the case study).

IIc. calculation

Calculations were based on an ESRI ArcView GIS containing data from HELCOM, EmodNet, IOW, BSH, MV data service and others. Most numbers were taken manually with the "Measure"-tool for distance (cables) and area (wind farms etc.), habitat area was calculated using the clip tool inside ArcView.

Tab 5: "Fine scale" habitats affected by physical impacts; worst case is a situation when all designated extraction fields have been exploited.

habitat, HUB code level 6 (where possible)	area in German Baltic waters (km²)	area in cs (km²)	affected area in cs (km²)	**percentage**	affected area in cs (km²) ("worst case")	**percentage** ("worst case")
mixed bivalves CMM, AA.J3L9	2304	872,1	18,43	**2,11**	61,90	**7,10**
mixed bivalves CMM, AB.J3L9	1923,1	43,6	0,0062	0,01	0,006	0,01
AA.J3L	596,8	16,7	0,0258	0,15	0,03	0,15
AA.M1C/S	541,6	19,1	0,0012	0,01	0,400	2,10
Mytilidae, AA.J1E1	*243,3*	*18,5*	0	0	9,753	**52,72**
AA.J3	194,6	13,1	0,0032	0,02	0,003	0,02
Mya arenaria, AA.J3L4	160,7	4,9	0,01	0,18	0,01	0,18
mixed bivalves CMM, AA.I3L9	47,2	1,9	0,0045	0,24	0,004	0,24

Ophelia/Travisia , AA.J3L11	127,9	11,46	0,0066	0,06	5,650	**49,30**
AB.M1	172,5	0,14	0,0009	0,65	0,001	0,65
AA.M*1	*136,1*	*3,5*	*0*	0	0,013	0,36
AA.G	*5,2*	*2,1*	-	-	-	-
sum	*6453*	*1.007*	18,49	1,84	77,77	**7,72**

Tab 6: "Broad scale" habitats affected by physical impacts (by summing Tab. 5 l6 habitats to broader typology); worst case is a situation when all designated extraction fields have been exploited.

broad scale habitat	area in German Baltic waters (km²)	area in cs (km²)	affected area in cs (km²)	**percentage**	affected area in cs (km²) (worst case)	**Percentage** (worst case)
photic sand	4357,4	963,36	18,48	**1,92**	77,76	**8,07**
aphotic sand	2095,6	43,74	0,007	0,016	0,007	0,016

conclusion

When comparing the status quo in Tab. 5 and 6 we can see that in the end both results are not dramatically different. We can see that the more rare communities like mussel beds have so far been spared from damage, presumably due to recommendations stemming from the Environmental Impact Assessments, which are part of the permission process. If we classify the impacts as loss, they are with a proportion of about 2 % fairly substantial in this small assessed area, but not yet in a magnitude where the Good Ecological Status may be compromised. However, we have to keep in mind that additional effects from fishing and coastal installations have not been included in this consideration.

This situation changes, should a complete exploitation of fossil sediment layers be contemplated (worst case scenario). On a small scale, half of two rarer habitats will then be affected, likely wiped out. More relevant for MSFD purposes, even on a broad scale a severe impact on about 8 % of photic sands can be expected. If the responsible agencies are not bound by national regulations in this respect anyway, they will have to also keep the larger MSFD point of view regarding damage and loss of seabed habitats in mind.

Case Study Mecklenburg Bight

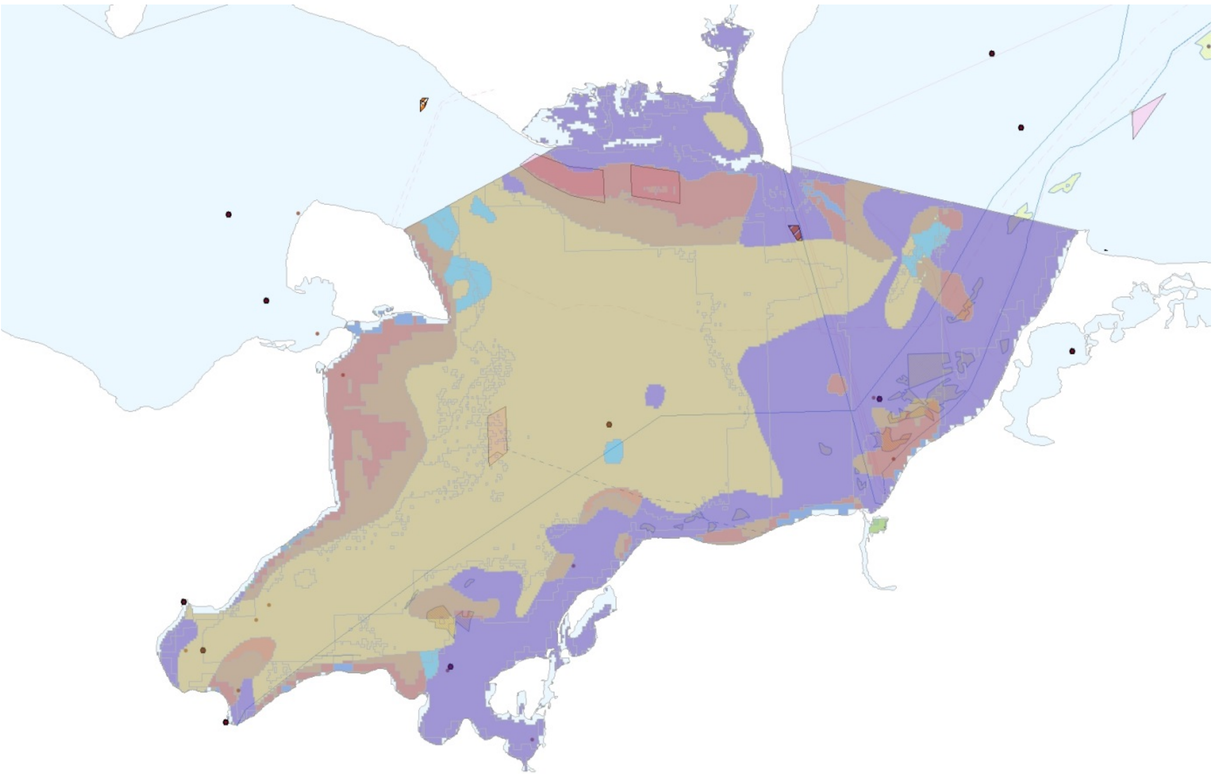

Image 1: Mecklenburg Bight with broad scale habitat map (EUSeaMap 2011) and representations of human activities

The case study Plantagenetgrund aims at exploring information from sources, that are publicly available, applied to a broad scale habitat map. It is meant to explore ways to assess (non fisheries) physical impacts from human activities on a scale comparable to the approach expected to be taken by the upcoming MSFD assessment.

I. human activities

The first step of selecting the relevant human activities already leaves us with decisions that cannot be completely satisfactory. In their GES advice, the European Commission lists the following activities relevant for D6:

1. Coastal infrastructures (ports, defenses against erosion, etc.) and offshore installations (oil and gas platforms, wind farms, etc.);
2. Offshore mining and sand extraction;
3. Release of dredged sludge;
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5. Some fishing practices (trawling, dredging, etc.);
6. Aquaculture (unused fish feed, fish feces, etc.);
7. Introduction of non-indigenous species (trough ballast water for instance);
8. Pollution (chemical pollution, litter);
9. Changes in riverine inputs (organic enrichment of particulate matter, etc.);
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11. Changes in freshwater riverine inputs as a consequence of damming and irrigation;
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source: http://ec.europa.eu/environment/marine/good-environmental-status/descriptor-6/index_en.htm; 08.06.2016)

Of these, only points 1 - 6 and 10 directly apply to physical damage and loss, but moorings and coastal infrastructure have not been included in this study (see **I.e.** and **f.**). Several other activities (ship traffic, tourism etc.) have also been considered, but not selected here. Even if we exclude eutrophication, pollution and other non-physical pressures, a totally comprehensive evaluation of seafloor integrity is not achievable at the moment and we have to restrict ourselves to the estimation of the most relevant effects.

I.a. wind farms

Detailed information about wind farms is readily available, most current on 4coffshore.com, often including number of engines, details of constructions, length of cables, etc.. However, some assumption have to be made for the 1100 turbines deployed or planned to be deployed in the Baltic in the near future. Whereas in early wind farm projects various foundation designs were employed, lately it seems that monopiles will be the by far most commonly used type of construction.

For the case study I selected not only the fully commissioned Danish farms (*Nysted* I and II), but also the German *Beta Baltic*, that is in an advanced planning stage. However, *Vineta* and *Beltsee* were excluded, because their planning is in a stage much too premature for consideration.

The area covered by the constructions themselves is determined mainly by the amount of scour protection in place. The area sealed can definitely considered to be lost, even though it is “transformed” to a new habitat type (typically from sand to rock) and the new habitat may have a higher biodiversity than the old one. OSPAR (2008) described an average of 30 m diameter per turbine (or 5 times the piling diameter) and this number was confirmed by data from Nysted I (Danish Energy Authority 2006). It is futile to try and determine each and every foundation in the park individually. The numbers are only fractional amounts of the wind farm area, and the wind farm itself typically only covers part of a suitable sand bank or other ecosystem component.

Tab. 1: wind farms in Mecklenburg Bight

Name	country	turbines	area (km²)	**loss** (m²)	loss of windfarm area (%)
Nysted	DK	72	26	50.400	0,2
Nysted II	DK	90	34	63.000	0,2
Baltic Beta	*DE*	*50*	*12*	*35.000*	*0,3*

I.b. cables

There are two types of wind farm cables. First there is an array of cables connecting the turbines to each other and to a converter station and second the converter station sends the current to a terrestrial receiver station on shore. Often, several wind farms are interconnected and share a common shore cable. In addition to these there are a number of sea cables for electricity or data connecting countries through the Baltic Sea.

Several methods are used to protect the cables from damage by anchoring ships or ground-touching fisheries. On hard bottoms cables can be covered by concrete or steel casings, and most often they are buried at 1 to 2 m depth in sediments. Depending on the burial technique, cable trenches can be visible as 2 m wide disturbances after decades, indicating a long term change of sediment characteristics. Therefore, for the sake of this broad scale study, cables are considered to lead to loss of original habitats. Modern entrenching methods may have less of an imprint on the seafloor by covering the cables with the (more or less) original sediment. In those cases the temporary (several months to one year) damage to the seafloor has to be assessed. However, compared to North Sea sediments the seafloor in the Baltic Sea is much less uniform, so that boulders, clay deposits etc. often prohibit the use of more environmentally friendly cable laying methods.

Tab 2: Cables in Mecklenburg Bight, connecting wind farm to the mainland and Germany to Danmark and Sweden

Name	country	length to shore (km)	array length (km)	windfarm area (km²)	area affected m²	compared to windfarm area (%)
Nysted	DK	21,5		26	43.000	0,2
			55		110.000	0,4
Nysted II	DK	56		34	112.000	0,3
			80		160.000	0,5
Baltic Beta	*DE*	ca. 37,5		*12*	*75.000*	*0,6*
(not yet in operation)			*ca 25*		*50.000*	*0,4*
cable to Baltic I	DE	41		-	82.000	-
DE-DK	DE/DK	44			88.000	-
DE-SE	DE	94	-		188.000	-

I.c. extraction

Areawise, in Mecklenburg Bight the most intense physical use of seafloor habitats is (was) the exploitation of fossil sediment deposits. Several size classes of sand and gravel are of interest for industrial use and coastal protection (dyke building and beach replenishment). The layers need to be strong and pure enough, close enough to harbor facilities and in acceptable water depths to be considered as “industrial deposits”. Of these, according to Schwarzer (2006) in 2004 already all deposits in Germany (Mecklenburg-Westpommerania) had been exploited by 31 % and deposits in the eastern Gulf of Finland by 45 % (for building purposes in St. Petersburg and Leningrad). Intuitively, this should have a significant effect on the abundance of certain habitat types. However, on a larger scale (EUNIS level 3) the percentage loss of habitats may not be as obvious.

Still, it is very hard to judge what kind of physical loss and damage is caused by sediment extraction. On a broad scale extraction fields do not differ from the surrounding areas of fine or mixed sediments. Also, regulations in Germany (and HELCOM Recommendations) state that the deposits are not to be depleted to the underlying clay or till layer. Also, the older, more harmful methods of stationary dredging with the resulting 8 - 10 m deep holes, which can lead to permanent oxygen deficiency, have been banned for a long time. The use of trailing suction hoppers is supposed to be more environmentally friendly by more gradually reducing the wanted layer and leaving undisturbed areas in between the extraction lanes, which can help with the resettlement of newly exposed layers.

Still, during the extraction process the sediments are treated in several ways. The hopper itself is protected by a mesh cage, which stops larger particle and rocks from entering and damaging the device. Finer particles are dispersed on the ground during the process and also released directly as in the ship hold´s overflow. Finally, undesired size fractions are sieved and released from the ship. Most of those sediments fall directly back to the extraction area, but some particles are subject to transportation with local currents. Therefore, a degree of change in sediment composition is unavoidable.

No information is available for the detailed spatial extent of sediment extraction. The ICES working group WGEXT only collects yearly tonnage of national extraction on a voluntary basis. In Germany, extraction fields are known with an expected amount of usable sediment and statistics as to how much has been extracted to date (in our case until 2012). We could assume that for example 50 % of sediment extraction will result in the use of 50 % of the area in question, but this may lead to overestimation, if some deposits have been harvested to a greater depth than others. Likewise, it is also possible that all the area has been used, but only to half the depth possible. In fact, the extraction companies are encouraged to utilize rather all the surface layer in a field instead of taking all the sediment in one part of the field at a time.

Tab 3: Extraction fields in Mecklenburg Bight (to my knowledge no extraction in Danish waters, inquiry to Danish authorities pending)

name	area km²	volume (industr.) m³	extracted m³	*impact (until 2012) km² (approx.)*
Wismargrund	93,64	591.928	560.058	*88,6*
Trollegrund	7,15	1.236.250	357.650	*4,1*
Kühlungsborn	6,58	639.500	150.000	*3,1*
Heiligendamm	21,5	1.068.020	444.272	*17,9*
sum	*128.87*	*3.535.698*	*1.511.980*	***ca. 113,7***

For the purpose of this case study, we have taken an “assumed percentwise approach”. This means that three of the fields that have been harvested to 29, 23 and 42 %, respectively, of the volume are assumed to have lost twice the percentage of surface. However, the biggest extraction field in Mecklenburg Bight (Wismargrund, now closed), where 95 % of the “industrial deposits” has been extracted, is assumed to have lost 95 % of the surface, because it is not likely that 100 % the area can indeed be reached in the extraction process. Wismargrund is also by far the most relevant case for physical loss or damage in Mecklenburg Bight, with approximately 88,6 km² of sandy habitat lost or damaged. This equals more than 84 % of the affected seafloor in this study.

I.d. disposal

Dredging and dumping is an important subject for HELCOM policies and the information available for the amount of dredged and dumped material is better than for sediment extraction. Many locations of dredged harbor channels or deposit sites etc. are available, but the timeliness, sufficiency and accuracy of the information were found to be questionable. Data for dredged areas was hard to verify and this case study concentrates on the physical effect of dumping sites. Even in local administrative accounts inconsistencies in reporting appeared, for example due to partial use of dredged sediments in construction. One has to be aware, that the amount of dumped materials is given in differing units. Numbers from the HELCOM data service are given in tons of dry weight, whereas maritime agencies often calculate in cubic meters, a more practical unit when it comes to accounting for shiploads of sediments. The conversion factors vary depending on the minerals and the water content. As a rule of thumb, for “sea sand” a density of 1,66 t /m³ is assumed (Bergamt MV).

The spatial effect of dumping varies very much with the methods employed, with local conditions and the accuracy of the barge pilots. More environmentally friendly methods have been invented in the last decades, but no information about their availability and actual use is readily available. Typically, the material is carried in several shiploads to a more or less exact position and dumped at once. In low current situations almost all the sediment will be deposited in “one place” and only small amounts of fine sediments will affect habitats in the vicinity. According to local authorities (pers. com.) an area up to 400 m from the deposit “point” will be measurably “affected” and after 500 m no effects can be observed at all.

For the case study, a radius of 400 m has been calculated for the points of minor dumping and 500 m for the larger amounts of deposited sediments. It is not possible to calculate the thickness of the resulting layer and to approximate the likely difference between original sediment structure and the new layer. Therefore, for the time being the affected areas are considered as lost, due to the application of a precautionary ecosystem approach. The disproportionate error margin is considered to be negligible (for the time being), because total numbers are very small.

The Danish dumping site is treated differently due to the large amount of material dumped there and to the exact areal information provided by HELCOM.

Tab. 4: Disposal sites in Mecklenburg Bight (according to HELCOM maps and data service), DE area approximated in 2 classes, 400 and 500m m, respectively; DK area provided by HELCOM

name	country	year	amount (t dry weight)	*area (until 2013) m² (approx.)*
Approach channel of Timmendorf	DE	2006 - 2008	4.300 - 10.800	*125.660*
Approach channel of Timmendorf/Poel	DE	2012	8.265	*125.660*
Ancora Marina Neustadt/ Bay of Mecklenburg	DE	2009	20.757	*125.660*
Trave (approach Luebeck)	DE	2010 - 2011	21.120 - 217.536	*196.344*
Harbour Rostock-Warnemuende	DE	2006 - 2013	5.250 - 93.835	*196.344*
Gedser Færgehavn Indsejling, map sign 196	DK	2010	798.994	*1.800.000*
sum				***ca. 1 km²***

I.e. coastal infrastructure

The discussion, whether all coastal construction like port facilities, dredging of harbor approaches, groynes, piers etc. should also be assessed, has not been concluded yet, but for the time being damage and loss from these pressures is not included in the case study.

I.f. beach replenishment

For coastal protection and recreational beach use large areas on and in front of beaches are covered with sediments stemming from **I.c.**, some of them regularly following erosion after storm surge events. They are not subject to this case study, because they often concern areas outside the scope of the MSFD and typically affect areas of natural rearrangement of substrates. Furthermore, data for this pressure are not at all easily accessible.

II. habitat maps

IIa. scale

For the evaluation of habitat damage and loss precise maps of benthic maps are necessary. Fairly precise maps are available for German Baltic waters and they will be used in the second case study Plantagenetgrund. In this broad scale case study however, sediment maps comparable to EUNIS level 3 (EUSeaMap 2011) are used due to several reasons. They are the "lowest common denominator", having been modeled for all Baltic waters and allowing for a regional assessment. Also, the MSFD assessment is supposed to be based on this very low resolution scale (i.e. "broad scale habitats"). The case studies are expected to demonstrate the possibilities and shortcomings of this approach by comparing two types of maps.

IIb. the map

A Baltic Sea map is available at the EUSeaMap data portal (http://www.emodnet-seabedhabitats.eu/default.aspx?page=1974&LAYERS=HabitatsEnBaltic). However, a big part of Mecklenburg Bight is missing there. The reason for this is that Mecklenburg Bight areas were modelled as part of the original North and Celtic Sea dataset back in 2011, but it looks like these areas were erroneously missed when the model was run back in 2012. The Emodnet project provided the 2011 data layer (many thanks go to Graeme Duncan at JNCC England). This map gives a very rough picture of sediment distribution. For example, in the sediment extraction field the seafloor is partly mapped as "sublitoral mud", but we know that only sand and gravel have been extracted there and the numbers have been applied accordingly in the calculation. The map is expected to be substituted by a better model in the near future and a prototype is available, but not used here due to several shortcomings.

IIc. calculation

Calculations were based on an ESRI ArcView GIS containing data from HELCOM, Emodnet, BSH and others. Most numbers were taken manually with the "Measure"-tool for distance (cables) and area (wind farms etc.), habitat area was calculated using the clip tool inside ArcView.

Tab 5: Broad scale habitats affected by physical impacts

EUNIS 3 habitat/ area in MB (km²)	Affected by sediment extraction (m²)	Affected by dumping (m²)	Loss from wind turbines (m²)	Affected by cables (m²)	Sum (m²)/ **percentage**
sublittoral sand / 1432,7	113.700.000	2.122.004	-	706.600	116.528.604/ **8,1**
sublittoral mud / 2075,4	-	447.664	35.342	401.400	884.406/ **0,04**
sublittoral mixed sediments/ 72,3	-	-	-	18.400	18.400/ **0,03**
shallow sublit. rock/biogenic reef/ 867,6	-	-	114.508	270.000	384.508/ **0,04**
sublittoral till / 4,09	-	-	-	106.800	106.800/ **2,6**

conclusion

The results for sublittoral mud, sublittoral mixed sediments and sublittoral rock (the broad scale habitats available in this map) are in line with the expectation, that human activities on this scale affect the habitats to a very low extent. However, the “rare” habitat type sublittoral till is potentially damaged to a degree relevant for GES discussion. However, the biggest surprise was that spatially largest sediment type, sublittoral sand, is affected to a comparably large extent by one human use targeting this sediment. A GES boundary of 5 % loss, which has been discussed (and rejected) at EU level, would have been reached in this respect, so that a more rigorous discussion of sediment extraction should be initiated. Also, this may mean that physical damage and loss of non-fisheries human activities has been underestimated in comparison to fisheries effects in the Baltic Sea.