

Response to Reviewer #2

Review of manuscript bg-2020-17: "Persistent effects of sand extraction on habitats and associated benthic communities in the German Bight"

General comments:

This paper investigates the recovery of benthic invertebrate fauna following dredging for beachreplenishment in the German Bight. The underlying premise of this work is that eventually the habitat condition will return to pre-dredging condition, and this will allow the re-establishment of predredging benthic fauna, which is found in nearby undisturbed areas. The author suggests that any benthic assemblage that differs from the unimpacted zones is a successional stage.

This premise has 2 flaws:

1. The author states that the sands being dredged are Pleistocene in age, and that the existing hydraulics of the system and sediment supply limits deposition to very fine sand and mud at very low rates of deposition. This information highlights that the hydraulics and sediment supply of the area has fundamentally changed since the sands were deposited in the Pleistocene, so it is difficult to understand how the author expects these conditions to be restored, even over many decades/centuries/millenia. In effect, Pleistocene marine conditions and sediment supply would need to be re-established for the pre-mining conditions to be re-established. What these changes do highlight is that the dredging is an unsustainable mining activity – e.g. the material being extracted will not be replenished, so the dredging is resulting in a permanent change in habitat conditions. The implications of this permanent change should be the focus of the paper.

2. The benthic assemblages present at the mined sites are not a successional stage that will ultimately lead back to the pre-mining assemblage. If the muds are not replaced by sand (which is highly unlikely given the quiescent hydraulics and limited sediment supply), then the mud loving assemblage will remain in perpetuity. The paper suggests that there is a successional order of benthic infauna, while at the same time saying the infauna reflects the sediment characteristics. Mud is not a successional stage to sand. The change in benthos due to the change in sediment, and why this matters, should be the focus of the discussion, not that it is an intermediate step leading back to the original assemblage.

This work should be re-framed to highlight the permanent changes that are occurring to the sediments, how the infauna has changed due to these impacts, and what are the implications of these changes. The author states that the sandy benthos is wide-spread and the mining is not a threat to the prevailing species – so the question is what are the implications, if any, of the conversion of sandy habitat to muddy habitat and the loss of sessile habitat? Discussing how these changes might affect other trophic levels or food webs, such as through the uptake of PAHs or other contaminants from the mud, would be more relevant than focusing on the (lack of) re-establishment of the original fauna.

It would also provide more context for the comment about monitoring PAH's which is otherwise unrelated to anything discussed in the paper.

The introduction and presentation of the scientific question should be revised and strengthened, and the aim of the investigation should be clearly stated earlier in the paper. It would also be useful to provide more discussion about why deeper extraction pits might have a different recolonization trajectory as compared to shallower disturbances. Providing some hypothetical examples of how deeper disturbance could have different impacts as compared to shallow extraction would provide more context for the results. The paper would benefit from additional, and more recent references.

Dear Reviewer #2,

Thank you for your revision and your helpful comments.

You are right. Investigations show, that something like a new ice age with strong glacification and interglacials are necessary to reach pre-dredging conditions. However, this knowledge is relatively new regarding this study area. When sand mining started in 1984, it was assumed, that the so-called “Wanderfeinsand” (freely translated: moving fine sand, Tabat, 1979; Köster 1979) would refill the pits relatively quick. Of course, the Pleistocene material is gone forever, but a refill with fine sand would not indicate such a strong change in habitat characteristics when compared to muddy domains, since fine sand domains are relatively common west of Sylt. When you have a look at Figure 4, you can see, that the fine sand superimposes the Pleistocene material quite regularly. Hence, also a complete refill with fine sand (maybe after many decades?) might be a re-establishment towards pre-dredging conditions. However, this recovery did not take place until now. A refill with muddy material at very low sedimentation rates seems to be the major problem, which was not predicted in the 1980s. However, maybe after many decades, the pits are flattened enough, that current velocity might be high enough to prevent an accumulation of muddy material. This might lead to a higher accumulation-rate of fine sand. However, we will provide the information that Pleistocene material cannot be re-established.

We will change the aims of this paper and the refill-processes will not be in the focus of this manuscript anymore (as also claimed by reviewer #1). We will try to set the objectives on the habitat change and the associated benthic communities.

Moreover, a re-framing of the introduction and the discussion (using more references, making more statistical analysis regarding a combination of the two datasets hydroacoustic and benthos analysis) is planned. This will be done by taking all your suggestion (e.g. PAH and the effect on foodwebs) into account.

Specific comments in chronological order:

- 1. This paper discusses regeneration whereas it might be more applicable to use re-establishment.**

“Regeneration” will be replaced with “recovery” or “re-establishment”.

- 2. Line 29 – has reached a high level? Examples of the growth in extraction rates would be useful if it is considered that ongoing sand mining will pose a threat.**

Here are the numbers from recent ICES reports to reinforce this statement, which we will also add to the manuscript:

While between 1998 and 2002 approximately 53 million m³ was extracted, a total of 73.2 million m³ was extracted from the northern European Continental Shelf in 2018 (ICES, 2016, ICES, 2019).

3. Line 36 – activities have led

Ok, thank you. This will be revised.

4. Line 54 - sonars allow the analysis of backscatter intensity – how? This needs more explanation.

Sonar systems such as sidescan sonars allow to investigate the backscatter intensity by transmitting a hydroacoustic wave, which will be reflected by the seafloor and then received by the transceiver. The intensity of this reflection is used for seafloor classification by distinguishing between hard (strong backscatter response from the seafloor) and soft substrates (low backscatter response from the seafloor (Blondel and Murton, 1997; Blondel, 2003; Mielck et al., 2014, Mielck et al., 2015)).

Further explanation will be added to the manuscript.

5. Line 59 – poor English

The sentence will be removed from the manuscript because it is a repetition.

6. Line 64 introduces aim of paper – should be presented much earlier

This can be done easily.

7. Line 67 -will be used? Have been used.

Yes, indeed. Can be revised.

8. 53 grab samples for 55 x 5 km transects are not a lot of samples. A more detailed description of the sampling strategy should be presented to demonstrate the samples are representative of the different areas.

The size of the study area is approx. 5 x 3 km. It would be possible to survey the whole study site using sidescan sonar with ~12 transects, since our sidescan sonar could measure with a swath range of ~250 m. The reason for the high amount of transects was the multibeam echosounder. It has only a small swath range in shallow water. In order to reach full-cover bathymetry, 55 transects were necessary.

Regarding the sampling strategy we already mentioned in the manuscript:

“The sampling positions generally followed a regular grid, but some positions were also selected on the basis of the bathymetric information in order to take samples both from the older dredging pits (older than 10 years) and the newer ones (see Fig. 4). “

The area and the occurring surface sediments are well known due to a prior study (Mielck et al. 2018). In the manuscript presented here, we aimed to describe the habitats including the benthic communities. We will add more details to the manuscript.

Mielck, F., Hass, H. C., Michaelis, R., Sander, L., Papenmeier, S., and Wiltshire, K. H.: Morphological changes due to marine aggregate extraction for beach nourishment in the German Bight (SE North Sea), *Geo-Mar. Lett.*, 39(1), 47–58, doi:10.1007/s00367-018-0556-4, 2018.

10. Line 99 - area was collected

Revisable

11. Some justification should be provided that all of the past mining pits are still visible. Were the locations compared to maps? How would you know if a pit was no longer visible?

We did previous investigations, which focused on morphological changes due to marine aggregate extraction in this study area using bathymetric and seismic data between 1993 and 2017 (see above). Additionally, other investigations took place in this area (e.g. Zeiler et al. 2004). Moreover, the mining locations are well known by the coastal authorities (LKN-SH), so we can be sure that there are no complete refilled mining pits, which are not visible anymore.

We will clarify this in the revised introduction.

Zeiler M, Figge K, Griewatsch K, Diesing M, Schwarzer K (2004): Regenerierung von Materialentnahmestellen in Nord- und Ostsee. Die Küste 68:67–98.
<https://doi.org/10.2314/GBV:599000627>

12. Benthos -line 159 – what is class 1 lower than? Class 0?

Yes, it is lower than in class “0”. We will rephrase the sentence like this:

After sand extraction, the macrozoobenthic abundance and species density was significantly lower in class “1” than in the unaffected area (class “0”), whilst after >10 years (class “2”) only a minor increase became apparent when compared to class “1” (Fig. 5 and Table 1).

13. Line 169: Polychaete profited? Polychaete exploited suitable environment.

We will revise this sentence.