

Interactive comment on “The submarine groundwater discharge as a carbon source to the Baltic Sea” by B. Szymczycha et al.

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“The submarine groundwater discharge as a carbon source to the Baltic Sea” by B. Szymczycha et al.

===== Answers to comments by A. Karageorgis

General comments The manuscript discusses the mechanism of submarine groundwater discharges (SGD) as source of carbon (dissolved inorganic carbon-DIC and dissolved organic carbon-DOC) to the marine environment. Point and diffused SGDs constitute an important, yet little studied, pathway of nutrients, contaminants, and other

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substances to the marine environment; as such, the subject of the paper is relevant to the scopes of Biogeosciences. The study area is the Puck Bay (Gdansk Gulf) in the Baltic Sea, where several recent studies have studied SGD seepage rates, nutrient and heavy metals (mercury) concentrations. The authors attempt to relate carbon inputs of the Puck Bay to the Baltic Sea, making some assumptions which are questionable. The structure of the document is generally good but often 'Results' are mixed with 'Discussion' (see Specific comments below). Although the language needs polishing, the views of the authors are easy to follow and clearly stated. The methodology should be improved and more details are required in some parts (see Specific comments below). The quality of data is overall good, but I have major reservations whether results presented are sufficient to support the interpretations and conclusions.

Comment At first, the location of sampling stations is not given in text or figures, and also the number of sampling stations is unknown.

Answer Details of sampling strategy, SGD rates calculation, and the mode of averaging is given in Szymczycha et al., 2012. In this manuscript information regarding DIC/DOC measurements and quality control of the measurements are provided. In short: data used for establishing carbon loads delivered via SGD to the study area were collected in the course of four sampling campaigns within 13 months. Three to five sampling locations were occupied in each of the campaigns, SGD rates were measured by means of seepage meters, DIC and DOC concentrations were measured in samples collected by means of groundwater lances. This set of information is given in the discussed manuscript "The submarine groundwater discharge as a carbon source to the Baltic Sea" by B. Szymczycha et al., while further details can be found in Szymczycha et al.(2012).

Comment Therefore it becomes impossible to evaluate the sampling strategy's quality and efficiency, and moreover if the results obtained represent the entire study area. Having so many uncertainties from the very beginning, it is striking that the authors have chosen to extrapolate DIC and DOC flux estimates to the entire Baltic Sea, and

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furthermore to the world ocean.

Answer Extrapolating, results to the entire ocean is not a part of the results section. It is a part of discussion, and serves the purpose of showing the possible importance of the phenomenon of DIC/DOC delivery to the marine environment via SGD. Surly, establishing carbon loads delivered to the marine environment via SGD accurately would require much effort. Thus the purpose is to resolve the problem: 'is it worth spending the effort?'; the message from our manuscript is the following 'yes, it is worth taking the burden' since the carbon load is substantial, and not really accounted for.

Comment The study area covers a minor part of the southern Baltic, and there is no solid evidence that the Puck Bay may be representative of the entire Baltic Sea in terms of SGDs chemical composition.

Answer. Most SGD, in the Baltic Sea, is delivered along the southern coast. The Bay of Puck is a part of the Gdańsk Basin- believed to be an active and representative area for the Baltic SGD. However, the necessity to be aware of uncertainties on upscaling is clearly stated in the manuscript. Moreover, results related to upscaling that are not directly related to the actual measurements are moved to the discussion section, as they are meant as indications of possible importance of SGD, please see above.

Comment I believe fragmenting the data set between a number of short papers (e.g. Szymczycha et al., 2012-nutrients, Szymczycha et al., 2013-mercury) is not useful, as it favors repetition and weakens the value of the data sets.

Answer Chemical constituents analyzed in sediment pore water samples cover a range of ecologically and biogeochemistry relevant substances. Combining results in one complex manuscript would make it overloaded with data and with topics as was already pointed out on submitting manuscripts accepted for publication (nutrients, mercury). The common feature of the separate manuscripts is sampling. This is described briefly in each of manuscripts, while the extensive description is provided in the paper reporting nutrients loads. Thus repetitions are avoided by presenting strategy and

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details of sampling in the first paper of the series (Szymczycha et al., 2012).

Comment On the basis of the problematic issues stated above, I conclude that this manuscript is not recommended for publication in Biogeosciences.

Answer We are sorry to have failed to convince the reviewer about the usefulness of our approach to indicate the importance of SGD as the carbon delivery to the marine environment.

Specific comments

P2071, L2 State which recent findings question earlier estimations regarding carbon dioxide sequestration;

Answer. For example Kuliński and Pempkowiak (2011) have proven the Baltic sea to be a source of CO₂ to the atmosphere. However they did not consider SGD as a carbon source to the Baltic. Data presented in this manuscript do not question budget of carbon in the Baltic, instead they make it more accurate.

L13 Emelyanov; L15 Kulinski. Answer. Indeed

P2072, L20 I'm not sure what 'richest' means

Answer: Gdańsk hydrological system is suggested to be the most abundant groundwater resource in Poland, and the most intensive SGD delivery area along the Baltic coast.

P2073, L25 The sampling points are not shown in Fig. 1 or elsewhere; L26 Pore water salinity profiles: it is unclear how the measurements were made

Answer. Sediment pore water samples were collected by means of a 'Groundwater lances' from several depth below the sediment-seawater interface, then concentrations of DIC and DOC in the collected samples were analyzed and the profiles were constructed as the concentrations vs depth dependences. A suitable explanation may be added to the manuscript if required.

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P2074, L2-3 Briefly describe seepage meters and groundwater lances principles of operations;

Answer. Seepage meter is a plastic chamber that cover some area of the sea bottom. It is inserted into sediments and left for a certain time period to collect seepage water upflowing from sediments. Pore water lances are tubes of small diameter inserted into sediments to a certain depth. A suitable explanation may be added to the manuscript if required

L25 'Craterous' should probably read Cretaceous Answer. Indeed

P2075, L27 Which is the original method (reference) that was modified by Kaltin et al. (2005)?

Answer. A modified method described by Kaltin et al (2005) was used for DOC measurements

P2076, L4 Scaling up to the entire Baltic Sea is misleading. The Bay of Puck is a small area relatively to the entire Baltic Sea, and this is clearly reflected in the SGD discharges (Table C19492). There is no supportive evidence that SGDs around the Baltic Sea exhibit similar carbon concentrations to the Bay of Puck;

Answer. Estimates of carbon loads delivered to the Bay of Puck via SGDs are based on actual measurements (four sampling campaigns, eight SGD rates, 172 DIC/DOC measurements- of these 46 used for establishing DIC/DOC concentrations in groundwater), they are representative for the bay. Data regarding upscaling might be moved to the discussion section. The upscaling is done to indicate possible importance of SGD with respect to carbon budget in the marine environment. It is stressed in the manuscript that the aim of upscaling is to indicate 'an order of magnitude' of this mode of carbon delivery to the marine environment.

L15-20 This part belongs to Discussion section; Answer: Perhaps.

L22 Again, the location of GL I is not shown in Fig. 1

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Answer. The location is described and presented in Figure 1 in the paper by Szymczycha et al., 2012; please see above for explanation why presenting results has been organized in a series of papers.

P2077, L8 provenience? Maybe provenance; L25-27 I would like to see a detailed description of the end-members approach

Answer. Provenance, indeed. The extensive description of the 'end members approach' is provided in Szymczycha et al., 2012. In short, salinity of seepage water results from mixing of the groundwater end member (0.5 salinity), and the seawater end member (7.1 salinity). Proportion of each of the end members is calculated from the actual (measured) salinity.

P2088, L8-11 Should be moved to Discussion Answer. Perhaps.

P2079, L5-16 This is also part of Discussion P2079-2080 section 4.1: This section explains that high DIC loads via SGD in the southern Baltic are related to the carbonate structures. But this is basic knowledge and is not justified to be the first part of the Discussion section. I would rather move the geology of the Baltic to the Introduction.

Answer. Possibly

P2083, L25 Shirshov Answer. Indeed

P2090, Fig. 1 What is the meaning of the rectangle on the map?

Answer. It shows the study area where the following devices were located: ground-water lances, push-point lances and seepage meters. The details have been already described by Szymczycha et al., 2012.

P2091, Fig. 2 The small size makes it impossible to read. Please consider other ways to present the data or split in more than one Figures-

Answer. The figure incorporates all data on DIC, DOC, Salinity and pH resulting from the measurements. The purpose is to show the carbon profiles shapes, and substan-

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tiate the conclusion that DIC concentrations in groundwater are several times larger than these in river water and seawater, while DOC - are close to these in seawater and river water. The average values of concentrations used for calculations of carbon loads delivered to the study area are given in tables. Also values used for upscaling, in the discussion, are given in tables. Figure 2 might be presented in a better resolution.

Interactive comment on Biogeosciences Discuss., 10, 2069, 2013.

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