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Biogeosciences
Discussions

Interactive comment on "East Siberian Sea, an arctic region of very high biogeochemical activity" *by* L. G. Anderson et al.

Anonymous Referee #2

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Review

1. Overall quality of the discussion paper

The manuscript by Anderson et al. evaluates biogeochemical data collected on the shallow continental shelf of the East Siberian Sea (ESS). The 2008 "International Siberian Shelf Study, ISSS-08" was undertaken to investigate the flux and transformation of carbon from land over the shelf seas and into the deep Arctic basins. The results presented in the manuscript on the ESS are informative and interesting. The paper should be published after revision of both the text grammar and improvement of the quality of the figures.

2. Individual scientific questions/issues

This manuscript is more descriptive than hypothesis testing; however, the data are very valuable based on the paucity of biogeochemical collections in the past for the ESS. The results and discussion sections address issues of nutrient profiles and impacts on primary production, sediment carbon cycling, and methane production.

Hydrography-Good section, but I have suggestions to improve the understanding of this data (see technical corrections below). The authors emphasize the freshwater input from the west vs. the more saline, Pacific water input form the east, primarily providing descriptions of the region.

Biogeochemistry-The authors discuss the role of river runoff on the chemical signatures of the waters, especially its total alkalinity, dissolved inorganic carbon contents, and the role of nutrients. This section discusses the conservative nature of total alkalinity and the little impact that biological production and decay of organic matter has on its components. By comparison, dissolved inorganic carbon (DIC) is less conservative. Low levels of DIC are impacted by high oxygen concentrations, indicative of primary production, whereas high levels of DIC are associated with low oxygen concentrations, indicative of microbial decay of organic matter. An important finding was that the formation and dissolution of calcium carbonate is not very important in the ESS. This section goes on to relate the fugacity (f) of CO2 with salinity, showing that the highest values are associated with the Pacific water (S=32-33, T near freezing), and suggest these values are a signal of decay products at the sediment surface released during remineralization of organic matter to the cold bottom waters in the region. The lowest fCO2 are associated with the fresher water (S$\sim$27-$\sim$32) at the surface and subsurface waters to the north and east of the ESS, with a signature of recent primary production as indicated by seawater that are consuming CO2 as well as nutrients. The other extreme are the high fCO2 waters with an oversaturation of CO2 in the low S-SW region of the area near the riverine inflow, suggesting heterotrophic activity exceeds that of autotrophic activity. These findings using fCO2 and nutrients, along with physical T and S measurements, provide a reasonable basis for deductions to describe the biogeochemical

regime and associated processes in the ESS.

Notably, the authors do a calculation of primary production for the ESS and estimate 6 x 1012 gC annually, basically 50% of previous estimates, although these earlier estimates are very limited.

Fate of Organic matter

A key finding is that degradation of terrestrial organic matter dominates the western sector with higher freshwater content versus degradation of marine organic matter dominating in the northern and eastern ESS where Pacific water content is greatest.

The issue of methane efflux was discussed, which is a reasonable probability in the layer of the sediments just above the subsea permafrost layer. The methanogenesis section was interesting, but the data available in the manuscript does not provide a strong data set supporting its importance to the ESS system. Only a few points drive the "warm" orange bullet of methane efflux in Fig. 10b, which suggests further sampling is required before a conclusion can be made. The methane section is too long (from pg. 1148-bottom through pg. 1149). The discussion about the fault zones seems unnecessary. The authors should tighten up this section and discuss only the actual data set collected with a few supportive references.

The section on the impact of pH and acidification was good (pg. 115O). However, the final paragraph (lines 13-19) has some very speculative statements that have no basis in the data provided. Some revision of this text is necessary.

The summary statements are good and highlight the points of the paper.

3. Technical Corrections

There are some technical corrections that would enhance the quality of the manuscript. A thorough reading would smooth the grammar and flow of the text. Below are specific comments that should be considered in a revised version of the manuscript:

Abstract Pg. 1138, lines 10-13 would be better as "The microbial decay of this organic matter produces carbon dioxide (CO2) that oversaturates all waters from the surface to bottom relative to atmospheric level, even when primary production, inferred from low surface water nutrients, has occurred.

Line 18: change to, ". . .it dominates processes at the sediment "interface" (not surface) where the majority of organic matters ends up, "thus" more of the decay products are "recycled (not added) to the bottom water".

Other statements in the abstract could be grammatically improved.

Introduction Pg. 1139, line 10, change "However, especially the latter. . ." to "However, Atlantic water entering in the western regions of the East Siberian Sea are heavily diluted by upstream river runoff, specifically the Lena River, even before entering the ESS. In addition, river runoff is also added directly into the ESS form the Indigirka and Kolyma rivers. . .."

Line 24: change to "The sea ice motion is also affected by the wind pattern resulting in sea ice generally moving in the winds direction, except within the near shore zone during winter when stationary land fast ice occurs."

Line 27: change to "The large decrease in summer sea ice coverage during recent years has also had a major impact on ice conditions in the ESS, resulting in the area being largely ice covered even in summer to one now largely ice free . . ."

Pg. 1140, line 3: add Figure 1 at end of the first sentence 'The current system in the ESS is controlled both by strong baroclinic forcing by river runoff and wind (Fig. 1). You can then delete the last sentence of this paragraph (lines 14-15). It is informative to direct the reader to the map at the start of the paragraph describing currents. Note for Fig. 1, you need to add an arrow for the direction of currents from the Laptev Sea (LS).

Pg 1140, line 16: Start the sentence with "Seawater temperature is generally close to the freezing point. . .."

Line 20-25. You also might look at Khim, B.K. et al. "Seasonal discharge of estuarine freshwater to the western Chukchi Sea shelf identified in stable isotope profiles of mollusk shells, 2003, JGR 108:3300-33092003 for some maps of 1995 ESS and western Chukchi Sea hydrography and stable isotopes.

Pg. 1140, line 30 to pg. 1141, line 2: This sentence is a repeat of pg. 1139, line 10 where you already discuss the roll of the Lena River input from the Laptev Sea in the west and the Pacific water inflow to the east. Please delete this duplicate statement.

Methods: The methods section is informative, with a few minor changes.

Pg. 1141, line 16, start a sentence by spelling out "57" stations. . .and then end the sentence with just "(Fig. 2a) and delete descriptor "for station locations see.." because the figure caption states that the map is of the stations.

line 23: a reference on nutrient analysis would be good.

Results and Discussion

Pg. 1143, what do you mean by "fairly favorable?" You should be more explicit, e.g. calm weather, low sea ice, etc.

Line 6-I suggest you give a range of salinity in the text when make descriptive statements of low salinity in west and high in the east.

Lines 10-13: I suggest you identify which panel in Fig. 3 you refer to when mentioning surface and bottom water T and S parameters. This designation will help the reader track your statements against the figures. E.g., line 12, end reference to surface water temperatures with. . .coldest to the northeast (Fig. 3a).

line 28: Why isn't the warming close to the coastline just indicative of seasonal thermal warming? Is it really necessary to invoke sediment warming as you do in the next sentence? The discussion of heating the bottom sediments seems out of place here.

Figures: Generally, the content of the figures is fine, but higher quality figures should

be made.

Fig. 1-Add the arrow of the Laptev Sea current flow. Also, in the caption, remove all the "the" before Wrangel Island, Dmitry Laptev Strait, etc. You only need to put "the" once in front of New Siberian Islands. . .

Fig. 2. State the (b) map is courtesy of xxx from the University of Bremen. Also, the maps should be redrawn for better clarity of land and bathymetry.

Fig. 3-Better quality versions of the figures are necessary.

Fig. 4- Spell out all acronyms the first time they are used, whether in the text or figure captions, e.g., spell out NCEP.

Fig. 6,-in the caption give the abbreviation of total dissolved inorganic carbon (CT) as it is used as CT in the figure.

Fig. 7-Please add the nutrient units to the vertical axis for each nutrient and uatm for the fCO2 in panel d.

Fig. 10- Very few points make up the orange bulls-eye for methane efflux. The points for the individual depths of collections should be more visible on maps a and b, like they are in map c.

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