

Dear Editor,

Thank you for considering our paper for publication in *Biogeosciences*. We have revised the manuscript incorporating virtually all comments provided by the reviewers during the open discussion.

Mainly, an alternative hypothesis suggested by Reviewer #1 has been added. Also the potential role of current is included as suggested by Reviewer #2. All minor comments have been incorporated.

There was a minor mistake in the results of the manuscript. We did not include the area of the trap opening (0.5 m^2) in the calculation of total particle flux and POC flux at Station K4. In the revision, this mistake has been corrected. Specifically, we corrected Figure 1a (simply, the left y-axis scale was doubled) and the flux values in Table 1, and a few places in the result section where the flux values were mentioned. We believe that this correction does not affect the main content and claims made in the paper.

We hope that our revision has successfully incorporated all comments raised by reviewers.

If there are any additional comments or questions, please contact Minkyung Kim, who can be reached by email, mini324@snu.ac.kr.

We appreciate again your effort and time.

Best regards,

Minkyung Kim and co-authors

Response to reviewers' comments.

Reviewer 1

The alternative hypothesis suggested by the reviewer is added in the discussion. It reads as follows:

“Another hypothesis is that the benthic animals actually spend their juvenile period in a habitat underneath the sea ice and fall down to the seafloor. This idea was suggested by a reviewer, Dr. Paul Dayton, and we agree that this can be a possibility. This hypothesis is based on his visual inspections in numerous dives at McMurdo Sound that no baby nemerteans were observed and tiny sea urchins and scallops were rare. The undersurface of the sea ice can harbor a thick layer of frazil ice platelets formed by supercooled water, and cavities and tunnels formed by brine flow. Diatoms and other algae growing in and/or underneath the sea ice would supply food for juvenile sea urchins and pectins. Also amphipods and small invertebrates would provide food for juvenile nemertean recruits. These organisms may passively sink to the seafloor upon melting of the platelets or actively abandon the sea ice habitat due to depletion of algal food in the winter. This kind of habitat with large populations of these animals has not been observed yet and needs to be verified.”

Reviewer 2

Short introduction about anchor ice

- We have added a few sentences in the introduction and also in the discussion.

Transport by current?

- Agreeing with the reviewer, we have added the following in the discussion: “Strong currents, especially near Station K3, may have been responsible for swiping and transporting these organisms to the trap sites. Stations K3 and K4 were within ~10 km from the nearest coast. Small juvenile scallops may be particularly affected by strong currents. In addition, scallops may use the current as a means of dispersal and translocation (Picken, 1980). The large size of the worms precludes the possibility that they were passively lifted but they may actively use the current. The collection of worms in April-August and the period of relatively strong current in July-September partly overlap. However, Station K1 was 200–500 km away from the coast where these worms presumably inhabit and are too remote for transport by current alone.”

Information on bathymetry and distance from the coast

- Distance of the mooring sites from the nearest coast has been added as follows:

“Stations K3 and K4 were within ~10 km from the nearest coast.”

“Station K1 was 200–500 km away from the coast where these worms presumably inhabit and too remote for transport by current alone.”

Sediment trap tilting

- The traps were not equipped with tilt sensors. However, the pressure registered by Microcats (Seabird Electronics, SBE37SM-RS232), current meters, and ADCPs provides indirect information on the vertical position of the traps. For example, at station K3 the pressure fluctuated daily with an amplitude of <1.6 dbar (RCM moored at 490 m) because of the tide and did not show any out-of-phase signal caused by tilting of the mooring line. Considerable tilting of the whole mooring line would be necessary to position the traps near the seafloor for allowing benthos to reach. That kind of change in sediment trap position was not observed in the pressure monitoring. We have added the following:

“According to the pressure registered to the current meters, ADCPs (Acoustic Doppler Current Profilers), and Microcats (Seabird, SBE-37SMP) moored with the sediment traps did not show any sign for considerable tilting of the mooring lines to facilitate better access for the benthos (Kim et al., 2016).”

Timing for sea ice concentration reduction.

- The timing for sea ice reduction has been corrected from October to late November.

Reviewer 3

Adding detailed reviews on sea ice or anchor ice transport, their importance to the Antarctic, environmental setting of the Amundsen Sea etc. in the introduction.

- We have added a paragraph for general introduction of the Amundsen Sea. There are already several good review papers stemming from major field campaigns. Therefore, instead of providing detailed review of the Amundsen Sea biogeochemistry, we opted to add a short general introduction with relevant references for the interested reader. In addition, intense review on anchor ice is already provided in the discussion section. The following paragraph has been added in the introduction.

“The majority of the Amundsen Shelf in the Antarctic is perennially covered with sea ice, except for the two seasonal polynyas. The Amundsen Sea polynya in the west Amundsen Sea is the most productive polynya around Antarctica (Arrigo and van Dijken, 2003). Intensive flux of particulate organic carbon to the seafloor occurs in the austral summer while the sea interior is in starvation in the other seasons (Ducklow et al., 2015; Kim et al., 2015; Kim et al., 2019). Biogeochemical processes related to biological pump in the Amundsen Sea have been investigated by recent field campaigns (Arrigo and Alderkamp, 2012; Yager et al., 2012; Meredith et al., 2016; Lee et al., 2017).”

“The distinct environmental conditions and characteristics of the polar seas relative to temperate and tropical oceans probably explain the unusual occurrence of benthic invertebrates in sediment traps. For example, starvation in the winter due to a reduced supply of organic matter from the overlying water column may stimulate the relocation of benthos. The undersurface of the sea ice may provide a habitat for juvenile benthos before they settle to the seafloor. Anchor ice, which forms at the seafloor in supercooled water, can lift benthos to the overlying sea ice for further transport by ice rafting (Dayton et al., 1969).”

Broader implication of benthic material dispersal by anchor ice for Antarctic ecosystem

- Dispersal of organic matter, nutrients, and detrital materials through anchor ice formation and ice rafting can potentially be very important as the reviewer pointed out. Unfortunately, the role of anchor ice in transporting sediment particles not to mention benthic animals has not been studied or reported in the Antarctic, in contrast to the Arctic where this phenomenon has been reported to be a main mechanism for sediment particle entrainment into sea ice and dispersal. Our paper is the first one suggesting the potential importance of anchor ice formation in the Antarctic in this sense. We hope that more studies focus on this topic in the future and our paper provides a seed for that.

Traditional taxonomic approach

- In addition to DNA analysis, we have also put effort for species identification based on conventional approaches asking benthos experts. Unfortunately, we have not been successful. For example, Dr. Chernyshev Alexei Viktorovich in Russia provided his opinion. But the general consensus was that specimens preserved in formalin for an extended time period (> 1 year) are very difficult to identify.

Gut content and contribution of zooplankton

- We have not examined the gut content unfortunately. We only measured POC content of the specimens, which was about 44 %. Based on this we believe that the specimen is mainly organic matter. It is definitely possible that they contain some sedimentary particles.
- Regarding the zooplankton collection in sediment traps, we observed a few krills. The reviewer is right that these large zooplanktons can form a significant portion of particle flux. However, discussion whether to include zooplankton as a part of particle flux or not is beyond the focus of our paper.