We would like to thank the reviewer for their thoughtful comments and suggestions. NOTE: In the following, we have used blue text to highlight our responses to the Reviewers' comments.

REVIEWER 2

Review of EGU 2251, An upper mesopelagic zone carbon budget for the subarctic North Pacific

In this study the authors used multiple approaches to constrain the magnitude of the processes contributing to the mesopelagic zone carbon budget as well as its uncertainties. A snapshot of the budget in August, based on ship measurements showed an imbalance between the estimated organic carbon supply and demand. Instead, the amount of organic carbon necessary to cover the estimated carbon demand in late summer must have come from previous production in spring. This finding challenges the idea of a "steady state carbon budget" in the region of study for timescales of weeks. Independent measurements of the same process (e.g., particulate organic carbon flux) as well as measurements over different timescales (e.g., week-long ship-based measurements vs long-term moorings) provide robustness to the estimated budget and its uncertainties.

This is a relevant and robust study worth publishing, as addressing the range of methodological uncertainties to constrain the carbon budget in the mesopelagic region is important in view of rapidly developing technologies that aim to sequester carbon from the atmosphere via enhancement of the biological carbon pump.

Specific comments:

L45: The line about NCP seems to be missing a verb: "Net community production (NCP) rates measured during the preceding spring and early summer of 2018 based on long-term mooring estimates of dissolved inorganic carbon concentrations."

Response: Thank you for catching this mistake. The sentence will be rewritten as follows: "*Net community production (NCP) rates measured during the preceding spring and early summer of 2018 based on long-term mooring estimates of dissolved inorganic carbon concentrations were higher than those measured during the EXPORTS field campaign*"

L98-100: Since the conditions were typical for late summer, I find this sentence a bit confusing, were temperatures warmer than expected in 2018? or warmer as compared to when?

Response: The sentence will be clarified as follows: "*The oceanographic setting encountered during the EXPORTS North Pacific field campaign was typical of late-summer conditions at Ocean Station Papa but captured slightly warmer mixed layer temperatures and lower nitrate concentrations compared to historical data from this site (Siegel et al., 2021).*"

L152: I would suggest to change "collected" to "selected from" or something similar, to leave no place for ambiguity as to what was newly sampled in EXPORTS and what was already publicly available. Same goes for L156.

Response: We will use "obtained" instead of "collected" to avoid confusion.

L152: "*In addition, three profiles for DOC concentrations were obtained on July 27th near OSP from the Ocean Observatories Initiative (OOI)-supported cruise (SR1811).*"

L156: "*Continuous surface observational data from January through December 2018 were obtained from the National Oceanic and Atmospheric Administration Pacific Marine Environmental Laboratory's OOI OSP surface mooring*"

L204: although the Po-based POC flux at 500 m was, within uncertainty, similar to the Th method (1.2 ± 1.2), as per the uncertainty ranges shown in Fig. 2b and 2c.

Response: Agreed. We will rephrase the sentence as follows: "*210Po measurements resulted in cruise-mean POC fluxes that, within uncertainties, were similar to 234Th at 100 m (2.6 ± 0.3 mmol C m-2 d-1, Fig. 2c) and at 500 m (0.4 ± 0.2 mmol C m-2 d-1), leading to a flux attenuation of 2.2 ± 0.4 mmol C m-2 d-1*".

L241: Is it possible that 53.7 is 56.7 mmolCm3 maybe? (as per Figure S1a) Otherwise I do not understand how the july-sept difference is more than twice the instrumental uncertainty of 1.4mmolCm3.

Response: Apologies for the confusion there. Instrumental uncertainty was actually 0.7 mmol C m-3, so twice uncertainty was 1.4 mmol C m-3, which is less than the difference between the July and September values (1.7 mmol C m-3). This will be revised to "*DOC concentration differences for samples collected at 95 m between July and September (53.7 and 52.0 mmol C m-3, respectively) were more than twice the mean instrumental uncertainty (e.g., cruise mean coefficient of variation (CV) was 1.3%, resulting in 2x instrumental uncertainty of 1.4 mmol C m-3 at 95 m).*"

L279: The authors mention that "the oxygen-based NCP measurements are of higher spatial and temporal coverage" The temporal coverage of the glider seems to be smaller than the mooring, I wonder if the authors mean, resolution, rather than coverage?

Response: That is correct. We will replace "coverage" with "resolution": "*Given that oxygen-based NCP measurements are of higher spatial and finer temporal resolution, we only use glider-based integrated (0-100 m) NCP during the cruise period*".

L450: typo in the first word "th1e"

Response: Thanks for catching the typo. We will correct it.

Figure 1. Initially, I thought the numbers in the X-axis represented the day of the month

Response: We will replace 18 with 2018 and 19 with 2019 in the x-axis of Fig. 1 to avoid confusion.

Figure 3. A vertical line for March could potentially help the reader, as this is a time that was considered to demonstrate NCP contributions (L281).

Response: Thanks for the suggestion. We will add a vertical line for March.

Throughout the text, I had some questions relative to the regional variability of the samples collected by the different platforms. I feel that these could be clarified with a simple map of the location of the different campaigns/platforms (e.g. to add in the supp). These are examples of the questions:

Response: Thanks for the suggestion. Maps of the different campaigns and platforms considered in this manuscript were provided in the EXPORTS North Pacific overview paper by Siegel et al. (2021). We have asked permission from Elementa to use Figures 5 and 9 from Siegel et al. (2021) in the Supplemental Material for the reader's reference.

- Were the DOC profiles sampled at the same location? I understand that the three DOC profiles were collected during the OOI cruise, was the OOI cruise also within the eddy that the EXPORT cruise was sampling? Were all the stations less than 70 km apart? (as that is the maximum distance for water movement according to your L451) Is this relevant for your uncertainty assumption of minimal lateral advection?

Response: That is a good question. The collection of OOI cruise DOC profiles were planned by Craig Carlson's project group (UCSB) as part of the EXPORTS project. The samples were collected at Ocean Station Papa, which was the starting location of the EXPORTS field campaign in August. These OOI DOC samples were analyzed in Craig Carlson's lab. The eddy that we sampled during the EXPORTS field campaign was not likely at Ocean Station Papa during the OOI Cruise in July. However, the focus of our comparison in the current study is below the euphotic zone, where the water mass velocities at 100-500 m are much slower and likely to be isolated from any of the surface eddy water movements.

- I understood that the 2 cruises were moving because they were following a float. How does this look in space? Do I interpret right that all the epochs represent the same water parcel (because the cruise was following the float)?

Response: The process ship followed a drifting Lagrangian float deployed at approximately 100 m while the survey ship conducted spatial surveys around the process ship (L150).

We will provide further details on the EXPORTS sampling strategy as follows: "*Operations were conducted in three consecutive time intervals or "Epochs" (Siegel et al., 2021). Epoch 1 spanned August 14th to August 23rd, Epoch 2 spanned August 23rd to August 31st, and Epoch 3 spanned August 31st to September 9th, 2018. Each Epoch began with a positioning of the process ship near the Lagrangian float. The spatial scales covered by the process and survey ships are illustrated in Figures 9 and 10 from Siegel et al. (2021).*"