

Anonymous Referee #1

The manuscript “Changing sources and burial of organic carbon in the Chukchi Sea sediments with retreating sea ice over recent centuries” by Su et al. describes the response of the organic matter in Chukchi Sea sediments to arctic environmental changes based on the biomarkers in their surface sediments and sediment core. Overall, their manuscript is generally well written and organized. Methods seem to be appropriate. Results are illustrated with relevant Graphs and Tables. Discussion is focused on the main findings and comprehensive. However, I would encourage the authors to slightly improve their manuscript according to my suggestions as follows:

We appreciate the constructive review of our manuscript and addressed comments thereafter in blue.

Line 251-252: “The presence of IP₂₅ throughout R1 indicates that sea ice cover has been seasonal at least since the 1820s at this location”- As IP₂₅ can also be detected at sea ice edge (Müller et al., 2011), and under sea ice blooms have been reported (Arrigo et al., 2012), is it possible that the IP₂₅ in R1 comes from the sympagic algae from sea ice edge, rather than from seasonal sea ice? Besides, this is contrary to the conclusion of permeant sea ice in line 288-289. This part needs further discussion.

Seasonal sea ice comprises sea ice formation in winter and melting during summer. IP₂₅ produced in sea ice is exported during melting. To our knowledge sea ice edge production of IP₂₅ has not been strictly demonstrated, and thus in absence of evidence, these productions are undistinguishable. Nevertheless, we slightly re-phrased this sentence but tuned it to a more general statement. Under sea ice bloom (UIB) has been reported by Arrigo et al. (2012) and Coupel et al. (2012, 2015), but to our knowledge it is however unrelated to the production of IP₂₅.

We agree that Lines 288-289 requires further discussion which has now been incorporated in the revised manuscript.

Arrigo, K.R., Perovich, D.K., Pickart, R.S., Brown, Z.W., van Dijken, G.L., Lowry, K.E., Mills, M.M., Palmer, M.A., Balch, W.M., Bahr, F., Bates, N.R., Benitez-Nelson, C., Bowler, B.,

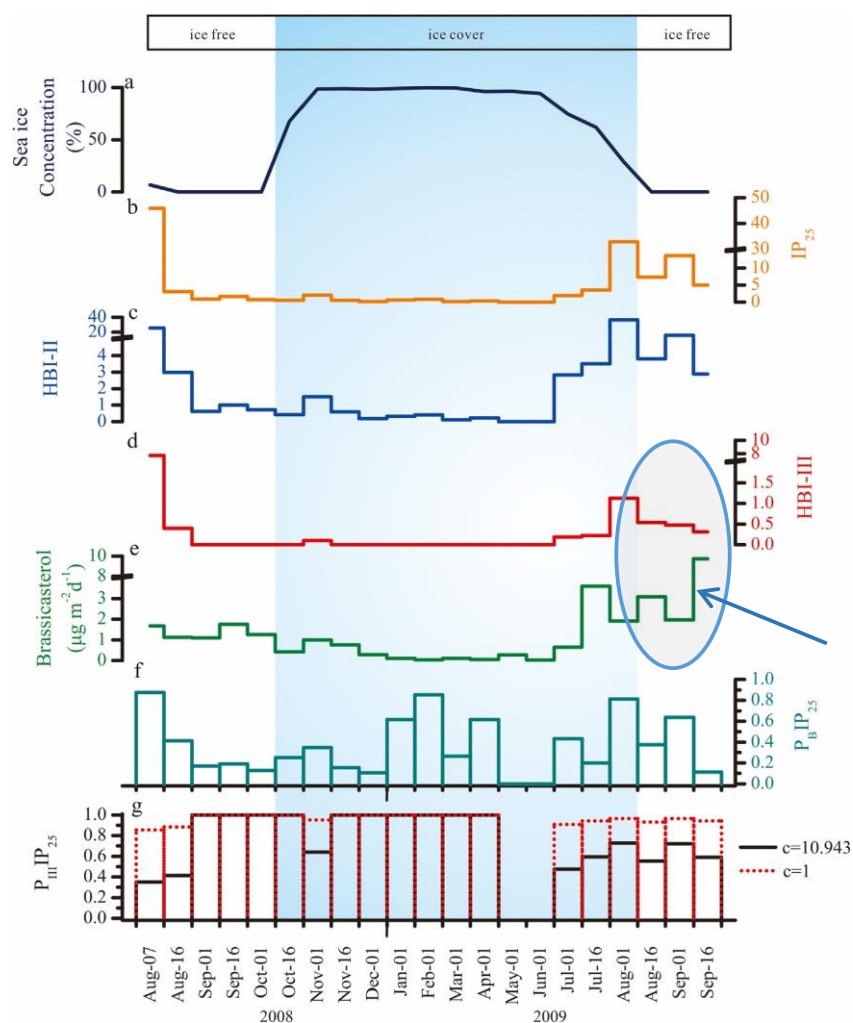
Brownlee, E., Ehn, J.K., Frey, K.E., Garley, R., Laney, S.R., Lubelczyk, L., Mathis, J., Matsuoka, A., Mitchell, B.G., Moore, G.W.K., Ortega-Retuerta, E., Pal, S., Polashenski, C.M., Reynolds, R.A., Schieber, B., Sosik, H.M., Stephens, M. and Swift, J.H.: Massive Phytoplankton Blooms Under Arctic Sea Ice, *Science*, 336(6087), 1408-1408, <https://doi.org/10.1126/science.1215065>, 2012.

Coupel, P., Jin, H.Y., Joo, M., Horner, R., Bouvet, H.A., Sicre, M.A., Gascard, J.C., Chen, J.F., Garçon, V. and Ruiz-Pino, D.: Phytoplankton distribution in unusually low sea ice cover over the Pacific Arctic, *Biogeosciences*, 9, 4835–4850, 2012.

Coupel, P., Ruiz-Pino, D., Sicre, M.A., Chen, J.F., Lee, S.H., Schiffrine, N., Li, H.L. and Gascard, J.C.: The impact of freshening on phytoplankton production in the Pacific Arctic Ocean, *Prog. Oceanogr.*, 131, 113-125, <https://doi.org/10.1016/j.pocean.2014.12.003>, 2015.

Line 282-283: “This result further confirm that HBI-III producers proliferate at the sea ice edge rather than in ice free waters.”- Is it possible the low HBI-III is a result of limited nutrient which was deleted by the blooms, rather than different producers?

This is a good question. However, the results from the time-series sediment trap at the Northwind Ridge, western Arctic Ocean (see the figure below; Bai et al., 2019) suggest



that the low values of HBI-III in summer are unlikely to be primarily caused by nutrient depletion, because during this period, brassicasterol is high, indicating favorable nutrient conditions for phytoplankton blooming, which precludes nutrient depletion.

Bai, Y., Sicre, M.-A., Chen, J., Klein, V., Jin, H., Ren, J., Li, H., Xue, B., Ji, Z., Zhuang, Y., and Zhao, M.: Seasonal and spatial variability of sea ice and phytoplankton biomarker flux in the Chukchi sea (western Arctic Ocean), Prog. Oceanogr., 171, 22–37, <https://doi.org/10.1016/j.pocean.2018.12.002>, 2019.

Line 379-380: “higher light penetration and nutrients supply (both from river and via wind driven mixing)” – do you mean river and mixing will result in higher light penetration and much more nutrient?

This part of the discussion is on riverine input and wind driven mixing as sources/drivers of nutrient supply, not light penetration. We revised the sentence to avoid misleading. Primary production is controlled by light and nutrients. Subsequently sea ice retreat results in higher light penetration triggering higher rates of primary production. As sea ice cover reduces, nutrients supply from rivers can spread in larger areas. In addition, wind driven mixing can exert stress in the upper ocean and replete surface layers with nutrients from deeper layers. Finally, longer ice free season as well contribute to enhance production and export to the sea floor (Ouyang et al., 2022; Zhuang et al., 2022).

Ouyang, Z., Li, Y., Qi, D., Zhong, W., Murata, A., Nishino, S., Wu, Y., Jin, M., Kirchman, D., Chen, L., and Cai, W.-J.: The Changing CO₂ Sink in the Western Arctic Ocean From 1994 to 2019, Global Biogeochem. Cycles, 36, <https://doi.org/10.1029/2021gb007032>, 2022.

Zhuang, Y., Jin, H., Cai, W.-J., Li, H., Qi, D., and Chen, J.: Extreme Nitrate Deficits in the Western Arctic Ocean: Origin, Decadal Changes, and Implications for Denitrification on a Polar Marginal Shelf, Global Biogeochem. Cycles, 36, e2022GB007304, <https://doi.org/10.1029/2022GB007304>, 2022.

Line 437-440: Why would wind driven vertical mixing lead to nutrient limitation? Why would these changes in phytoplankton lead to CO₂ drawdown?

The sentence has been rephrased. Surface freshening and thus enhanced summer

stratification as in open sea systems, is what was meant here. Changes in phytoplankton as for example from micro- to nano-plankton has implication of the uptake of CO₂ and export.

Line 296: spring/summer sea ice – should be summer/fall sea ice as the sea ice in this area starts to melt in summer (line 124 “receding as the summer season (July) begins”) It is hard to define a uniform seasonality in the study region covering from 67°N to 80°N, as the southern area may experience summer, meanwhile the northern part enters spring. IP₂₅ is a proxy for seasonal sea ice, therefore the concentration of sea ice is the key information.

- In Fig. 7d ii) and iii), why was the winter sea ice edge (in March) in the Chukchi Sea (ARC04-C07), rather than the Bering Sea? And why was there abundance HBI-III (+) under the permanent sea ice cover in Fig. 7d i)?

Thanks for pointing out this error, we have corrected Figure 7 and amended the corresponding sentence in the revised manuscript. Under sea ice phytoplankton blooms (UIB) were evidenced in the Arctic Ocean (e.g. Arrigo et al., 2012, 2014; Coupel et al., 2012, 2015). It is possible that the production of HBI-III under permanent sea ice was produced from UIBs, which has been recently evidenced by Gal et al (2022). Also, biomarker signals transported by sea ice and currents cannot be ignored.

Arrigo, K.R., Perovich, D.K., Pickart, R.S., Brown, Z.W., van Dijken, G.L., Lowry, K.E., Mills, M.M., Palmer, M.A., Balch, W.M., Bahr, F., Bates, N.R., Benitez-Nelson, C., Bowler, B., Brownlee, E., Ehn, J.K., Frey, K.E., Garley, R., Laney, S.R., Lubelczyk, L., Mathis, J., Matsuoka, A., Mitchell, B.G., Moore, G.W.K., Ortega-Retuerta, E., Pal, S., Polashenski, C.M., Reynolds, R.A., Schieber, B., Sosik, H.M., Stephens, M. and Swift, J.H.: Massive Phytoplankton Blooms Under Arctic Sea Ice, Science, 336(6087), 1408-1408, <https://doi.org/10.1126/science.1215065>, 2012.

Arrigo, K. R., Perovich, D. K., Pickart, R. S., Brown, Z. W., van Dijken, G. L., Lowry, K. E., Mills, M. M., Palmer, M. A., Balch, W. M., Bates, N. R., Benitez-Nelson, C. R., Brownlee, E., Frey, K. E., Laney, S. R., Mathis, J., Matsuoka, A., Greg Mitchell, B., Moore, G. W. K., Reynolds, R. A., Sosik, H. M., and Swift, J. H.: Phytoplankton blooms beneath the sea ice in the Chukchi sea, Deep Sea Res., Part II, 105, 1–16, <https://doi.org/10.1016/j.dsr2.2014.03.018>, 2014.

Coupel, P., Jin, H.Y., Joo, M., Horner, R., Bouvet, H.A., Sicre, M.A., Gascard, J.C., Chen, J.F., Garçon, V. and Ruiz-Pino, D.: *Phytoplankton distribution in unusually low sea ice cover over the Pacific Arctic*, *Biogeosciences*, 9, 4835–4850, 2012.

Coupel, P., Ruiz-Pino, D., Sicre, M.A., Chen, J.F., Lee, S.H., Schiffrine, N., Li, H.L. and Gascard, J.C.: *The impact of freshening on phytoplankton production in the Pacific Arctic Ocean*, *Prog. Oceanogr.*, 131, 113-125, <https://doi.org/10.1016/j.pocean.2014.12.003>, 2015.

Gal, J.-K., Ha, S.-Y., Park, J., Shin, K.-H., Kim, D., Kim, N.-Y., Kang, S.-H., and Yang, E. J.: *Seasonal Flux of Ice-Related Organic Matter During Under-Ice Blooms in the Western Arctic Ocean Revealed by Algal Lipid Biomarkers*, *J. Geophys. Res.: Oceans*, 127, <https://doi.org/10.1029/2021jc017914>, 2022.

Line 26: “ δ ” should be italic throughout the text.

Done.

Line 28: “were also” should be “are also”.

Done.

Line 32: summer sea ice

Done.

Line 120: “is summer” should be “in summer”

Done.

Line 120: “seasonal” should be deleted.

Done.

Line 103-104: “The dynamics of the Beaufort Gyre (BG) also impacts on the characteristics of the CS water mass.” - provide references here.

We’ve added *Timmermans and Toole, 2023* as the reference.

Timmermans, M.-L. and Toole, J. M.: The Arctic Ocean’s Beaufort Gyre, *Annu. Rev. Mar. Sci.*, 15, 223–248, <https://doi.org/10.1146/annurev-marine-032122-012034>, 2023.

Line 107-109: “This basin is connected to the Pacific Ocean through...”- sentence needs to be restructured

Thanks. We revised the sentence accordingly.

Line 123-125: “Remote sensing data evidence strong seasonal variations, with sea...”- awkward sentence

Done. We revised the sentence to “Remote sensing data (1979 to 2020) reveal considerable seasonal variations of sea ice extent in the CS (Cavalieri et al., 1996). The CS is heavily covered by sea ice from November to June. Sea ice gradually decreases in July and reaches its minimum extent in September.”

Cavalieri D J, Parkinson C L, Gloersen P, Zwally H J. Sea Ice Concentrations from Nimbus-7 SMMR and DMSP SSM/I-SSMIS Passive Microwave Data, Version 1. Boulder, Colorado USA: NASA National Snow and Ice Data Center Distributed Active Archive Center (Digital media, updated yearly), 1996.

Line 139: “excess ^{210}Pb ($^{210}\text{Pbex}$)” should be put in line 137

Done.

Line 178: 3 β -ol)).

Done.

Line 181: What is “cholesterol-d6”? Do you mean “cholest-5-en-3 β -ol-D6”?

Revised.

Line 192: “The H-print values were also calculated to infer the...”- should come before formula (3)

Done.

Line 202: Please using R1 for ARC11-R1 in the text after line 130.

We have double checked the entire manuscript and have used R1 consistently.

Line 221: varies

Done.

Line 232: present

Done.

Line 236: why “they”?

Done.

Line 238: spans

Corrected.

Line 239-240: - sentence needs to be restructured.

We fully revised the sentence.

Line 244: “our core” should be instead by “R01” throughout the text.

Done.

Line 250: lower export of sympagic OC

Added.

Line 268: found in North of Iceland

Added.

Line 292: Wu et al. (2019)

Done.

Line 333: freshwater discharge as lowering salinity water can suppress HBI-III production.

Revised to ...*by lowering water salinity*...

Line 337: within our study area – should be deleted.

Done.

Line 339-341: “Apart from permafrost thawing, sea ice retreat likely accelerated coastal erosion...” - provide references here

We’ve added *Overeem et al., 2011* as the reference.

Overeem, I., Anderson, R. S., Wobus, C. W., Clow, G. D., Urban, F. E., and Matell, N.: Sea ice loss enhances wave action at the Arctic coast, Geophys. Res. Lett., 38, <https://doi.org/10.1029/2011GL048681>, 2011.

Line 353: Schubert and Calvert, 2001

Corrected.

Line 362: The abbreviation of SuSIC has already appeared in the previous paragraph.

Corrected.

Line 365: Fig. A5

Corrected.

Line 404: “the concentrations of” should be deleted.

Done.

Line 414: northern CS

Done.

Line 418: Ardyna and Arrigo, 2020

Corrected.

- “Figure” or “Fig.” please be consistent throughout the text (but the figure caption).
- CO₂ with “2” in lower case, please check it throughout the text including references.
- “Pacific water inflow” or “Pacific Water Inflow”, “Siberian coastal current” or “Siberian Coastal Current”, “11th” or “11th”, “sea ice edge” or “sea-ice edge”, “Figure” or “Fig.” -please keep these be consistent throughout the text.

We are very grateful to the reviewer for the thorough and deep examination of our manuscript. We have carefully examined the manuscript to rectify and harmonize the wordings.