

Revision Note on the revised manuscript, Sinking fate and carbon export of zooplankton fecal pellets: insights from time-series sediment trap observations in the northern South China Sea (by Wang et al.), manuscript no. bg-2023-112, submitted for publication in Biogeosciences.

We would like to thank the Editor and two anonymous referees for their positive feedback and thoughtful comments concerning our manuscript. We have revised our manuscript in response to all the comments, and we sincerely hope the Editor and referees will be satisfied with our revision. This Revision Note is written based on the annotated (using track changes) version of the manuscript (uploaded in the system). Below, the notes (in blue) explain how and where each point of comments has been addressed. The line numbers mentioned are new numbers in the annotated version of the manuscript.

RC1: 'Comment on bg-2023-112', Anonymous Referee #1, 31 Jul 2023

Review of a manuscript by H. Wang et al. entitled: “Sinking fate and carbon export of zooplankton fecal pellets: insights from time-series sediment trap observation in the northern South China Sea” submitted to Biogeosciences.

This is an interesting manuscript, which should become acceptable for publication after minor English editing. Suggestions for editing are listed below by line number.

Reply: Thank you for your effort reviewing our manuscript and your positive feedback, which have helped to improve the quality of the manuscript. We have read through all the comments carefully and have made related modifications. We highly appreciate your time and consideration.

Comment #1:

2: in the title, change “time-series sediment trap observation” to “time-series sediment-trap observations” and hyphenate all other double-word adjectives

Reply: We thank you for this comment. We followed the suggestion given by the Editor (see page 16 of this Revision Note) and checked the policy of the journal Biogeosciences. We found that hyphens are not required between double-word adjectives, for examples of the papers of Miquel et al. (2015), Rembauville et al. (2015), and Belcher et al. (2017). Therefore, we have changed “time-series sediment trap observation” to “time-series sediment trap observations” in **Line 2** in the revised manuscript. **Here’s how I modified Line 2:** *Sinking fate and carbon export of zooplankton fecal pellets: insights from time-series sediment trap observations in the northern South China Sea*

Comment #2:

11: hyphenate “fecal-pellet-numerical (FPN) flux” and “fecal-pellet-carbon (FPC) flux” and

hyphenate all other more-than-one-word adjectives

Reply: Thank you for this comment. As the reply to Comment #1, following the policy of Biogeosciences, more-than-one-word adjectives do not need to be hyphenated. For example, hyphens are not used between “fecal pellet carbon flux” in Rembauville et al. (2015) and Miquel et al. (2015). Therefore, we did not modify more-than-one-word adjectives in the revised manuscript.

Comment #3:

80: change “Hydrological system” to “The hydrological system”

Reply: Thank you for pointing out this problem. We have changed “Hydrological system” to “The hydrological system” in **Line 118–119** in the revised manuscript. **Here’s how I modified it:** *The hydrological system of the northern SCS is complex due to the seasonal shift of the East Asian monsoon winds and the interplay of waters from the Kuroshio Current (Su, 2004; Caruso et al., 2006).*

Comment #4:

84: change “Combination” to “A combination”

Reply: Thank you for this comment. We have changed “Combination” to “A combination” in **Line 123** in the revised manuscript. **Here’s how I modified it:** *A combination of strong winter winds, water mixing, and surface cooling in the northern SCS drives winter convective overturning, leading to higher primary productivity during the winter monsoon than during other periods (Liu et al., 2002; Chen, 2005; Tseng et al., 2005).*

Comment #5:

165: delete “of”

Reply: Thank you for raising this question. We have deleted “of” in **Line 205** in the revised manuscript. **Here’s how I modified it:** *The major elements composing the fecal pellets were O, Si, C, and Ca, with minor proportions of Al and K, indicating that terrigenous minerals such as quartz and clay minerals may also be important components of fecal pellets (Figs. 4h, 5b).*

Comment #6:

Figures 4 and 5: the micrographs are too dark, with no contrast. If these had been taken using film and printed in a darkroom (as in the past) I would have used a different F-stop to take the micrographs, and different F-stops and contrast filters to print these photos. I do not know how to do this now, using digital photography, but these micrographs need to be re-taken.

Reply: We are grateful to you for pointing out this problem. We have adjusted the brightness

and contrast of the photographs in **Figures 4 and 5**. We hope this correction meet your requirements.

Comment #7:

239: change “Besides,” to “However,”

Reply: Thank you for this comment. We have changed “Besides,” to “However,” in **Line 286** in the revised manuscript. **Here’s how I modified it:** *However, the negative linear relationship was weaker at 1970 m compared to 500 m.*

Comment #8:

243: change “5 Discussions” to “5 Discussion”

Reply: Thank you for the advice. We have changed “5 Discussions” to “4 Discussion” in **Line 309** in the revised manuscript. **Here’s how I modified it:** *4 Discussion*

Comment #9:

246: change “The FPC flux” to “The FPC flux was”

Reply: We are so sorry for the incorrect writing here. We have changed “The FPC flux” to “The FPC flux was” in **Line 313** in the revised manuscript. **Here’s how I modified it:** *The FPC flux was also elevated, and the average flux during this period was 2 to 4 times higher than the average flux over the whole deployment period (Fig. 10b).*

Comment #10:

263: change “though in the oligotrophic seas” to “although in oligotrophic seas”

Reply: Thank you for this comment. We have changed “though in the oligotrophic seas” to “although in oligotrophic seas” in **Line 330** in the revised manuscript. **Here’s how I modified it:** *Therefore, although in oligotrophic seas, the monsoon system can increase the marine primary productivity, which allows for increased zooplankton biomass and promotes the export of carbon from their fecal pellets.*

Comment #11:

278: change “this additional nutrient” to “these additional nutrients”

Reply: Thank you for your suggestion. We have modified the sentence in **Lines 345–349** in the revised manuscript. **Here’s how I modified it:** *Summer precipitation can bring terrestrial organic matter from land into the ocean, resulting in the increased POC fluxes. This organic matter can also serve as a nutrient supply, contributing to the marine primary productivity, thus increasing zooplankton biomass and FPC fluxes (Fig. 10b; Meyers, 1997; Vizzini et al., 2005).*

Comment #12:

297: change “literatures,” to “literature,”

Reply: Thank you for this advice. We have changed “literatures,” to “literature,” in **Line 369** in the revised manuscript. **Here’s how I modified it:** *According to the literature, ellipsoidal pellets could be attributed to copepods, pteropods, appendicularia, and larvae (González et al., 1994, 2004; Wilson et al., 2008; Wexels Riser et al., 2010; Gleiber et al., 2012).*

Comment #13:

309: change “number” to “amount”

Reply: Thank you for your constructive suggestion. We have changed “number” to “amount” in **Line 382** in the revised manuscript. **Here’s how I modified it:** *Therefore, it is likely that a large amount of fecal pellet production still occurs in the mesopelagic/bathypelagic zones to increase the export of fecal pellets to the deep sea, and these fecal pellets are characterized by strong cycling within the water column.*

Comment #14:

317: change “fecal pellet” to “fecal pellets”

Reply: Thank you for raising this question. We have changed “fecal pellet” to “fecal pellets” in **Line 390** in the revised manuscript. **Here’s how I modified it:** *Analysis of the internal composition of fecal pellets identified the presence of terrigenous minerals like quartz and clay minerals, with an elemental composition characterized primarily by O, Si, C, Ca, Al, and K (Figs. 4, 5).*

Comment #15:

322: hyphenate “laterally transported”

Reply: We are grateful to you for reviewing the manuscript so carefully. We checked the policy of the journal Biogeosciences, where hyphens are not required between an adverb ending in -ly and the word it is modifying (e.g. “statistically based results”, not “statistically-based results”). Therefore, we did not modify this sentence in the revised manuscript.

Comment #16:

323: hyphenate “highly-adaptable”

Reply: Thank you for this comment. As the reply to Comment #15, according to the policy of Biogeosciences, hyphens are not required between an adverb ending in -ly and the word it is modifying (e.g. “statistically based results”, not “statistically-based results”). Therefore, we did not modify this sentence in the revised manuscript.

Comment #17:

334: change “may play” to “and may play”

Reply: We feel sorry for our carelessness. We have changed “may play” to “and may play” in [Line 407](#) in the revised manuscript. [Here’s how I modified it:](#) *This highly adaptable species is widespread throughout the northern SCS in all water layers (Gong et al., 2017), and may play a critical role in fecal pellet fragmentation.*

Comment #18:

336: change “at K2 station” to “at Station K2”

Reply: Thank you for pointing out this problem. We have changed “at K2 station” to “at Station K2” in [Line 409](#) in the revised manuscript. [Here’s how I modified it:](#) *Similarly, studies conducted at station K2 also provided evidence of fecal pellet fragmentation by repackaging of mesopelagic sinking debris (Wilson et al., 2008).*

Comment #19:

352: change “form the larger aggregate.” to “form larger aggregates.”

Reply: Thank you for this advice. We have changed “form the larger aggregate.” to “form larger aggregates.” in [Line 425](#) in the revised manuscript. [Here’s how I modified it:](#) *Phytoplankton cells, zooplankton moults, and fecal pellets together form larger aggregates.*

Comment #20:

353: change “basin” to “basins”

Reply: Thank you for the comment. We have changed “basin” to “basins” in [Line 427](#) in the revised manuscript. [Here’s how I modified it:](#) *Presence of deep-sea dwelling zooplankton communities and lateral inputs from the slope into the deep basins tend to increase the export of fecal pellet to the deep sea.*

Comment #21:

358: hyphenate “hydrodynamically-induced”

Reply: Thank you for this comment. As the reply to Comments #15 and #16, according to the policy of Biogeosciences, hyphens are not required between an adverb ending in -ly and the word it is modifying (e.g. “statistically based results”, not “statistically-based results”). Therefore, we did not modify this sentence in the revised manuscript.

Comment #22:

394: change “twice higher” to “twice as high”

Reply: Thank you for this advice. We have changed “twice higher” to “twice as high” in

Line 471 in the revised manuscript. **Here's how I modified it:** *Zooplankton fecal pellet fluxes were twice as high at 1970 m than at 500 m.*

Comment #23:

478: italicize “Oithona”

Reply: We feel sorry for our carelessness. We have italicized “Oithona” in **Line 560** in the revised manuscript. **Here's how I modified it:** *González, H. E. and Smetacek, V.: The possible role of the cyclopoid copepod Oithona in retarding vertical flux of zooplankton fecal material, Mar. Ecol. Prog. Ser., 113, 233–246, <https://doi.org/10.3354/meps113233>, 1994.*

Comment #24:

478, 480, 484, 490: change “Gonzalez” to “González”

Reply: Thank you very much for pointing out the error here. We have changed “Gonzalez” to “González” in **Lines 560, 562, 566, and 572** in the revised manuscript. **For example, this is how I modified Line 561:** *González, H. E., Daneri, G., Iriarte, J. L., Yannicelli, B., Menschel, E., Barria, C., Pantoja, S., and Lizarraga, L.: Carbon fluxes within the epipelagic zone of the Humboldt Current System off Chile: The significance of euphausiids and diatoms as key functional groups for the biological pump, Prog. Oceanogr., 83, 217–227, 1 <https://doi.org/10.1016/j.pocean.2009.07.036>, 2009.*

Comment #25:

503: change “Paffenhofer” to “Paffenhöfer”

Reply: We are very grateful to you for reviewing the manuscript so carefully. We have changed “Paffenhofer” to “Paffenhöfer” in **Line 585** in the revised manuscript. **Here's how I modified it:** *Köster, M., Sietmann, R., Meuche, A., and Paffenhöfer, G. A.: The ultrastructure of a doliolid and a copepod fecal pellet, J. Plankton. Res., 33, 1538–1549, <https://doi.org/10.1093/plankt/fbr053>, 2011.*

RC2: 'Comment on bg-2023-112', Anonymous Referee #2, 28 Sep 2023

This is all in all a well written and interesting article, providing new insights into fecal pellet fluxes and their contribution in POC export in the northern SCS. Very nice figures, photographs of pellets, and generally thorough and very well explained text. I have minor comments and adjustments that should be addressed before publication.

Reply: We really appreciate your time and efforts to provide a detailed review. We would like to thank you for your valuable and constructive comments that have been so helpful to improve the manuscript.

Comment #1:

Title: This is the only place in the manuscript that “time-series” sediment traps are mentioned. Sediment trap details (Producer, etc.) missing from the Materials and Methods section.

Reply: Thank you very much for pointing out this problem. To better highlight the concept of “time-series” sediment trap samples, we have changed “sediment traps” to “time-series sediment traps” in Lines 9, 78–79, 129, 148, 190, 200, 211, 216, 232, 248, 280, 288, 306, 335, 385, 420, and 436 in the revised manuscript. For example, this is how I modified Line 9 in the abstract: *Here, we analysed zooplankton fecal pellets collected by two time-series sediment traps deployed on mooring TJ-A1B in the northern South China Sea (SCS) from May 2021 to May 2022.*

In addition, we have added detailed information of sediment traps in the “Material and Methods” section in Line 148 in the revised manuscript. Here’s how I modified it: *Samples were collected by time-series sediment traps (McLane Parflux Mark78H-21 sediment trap) deployed on mooring TJ-A1B (20.06°N, 117.39°E, 2000 m water depth) in the northern SCS (Fig. 1).*

Comment #2:

Line 19: “by marine surface productivity” - this paper does not outline directly marine surface productivity, especially as shallowest trap is at 500 m. Recommend to focus on the papers findings in the abstract.

Reply: Thank you for raising this question. We have changed “by marine surface productivity” to “by marine primary productivity” in Line 19 in the revised manuscript. To investigate the environmental factors regulating the sinking and export of fecal pellets, we downloaded daily net primary production (PP) data of biomass expressed as carbon per unit volume in sea water from the Operational Mercator Ocean biogeochemical global ocean analysis and forecast system (https://data.marine.copernicus.eu/product/GLOBAL_ANALYSIS_FORECAST_BIO_001_028). Strong northeast monsoon and surface water cooling led to the mixing of the upper water column, importing nutrients from subsurface into the epipelagic layer, stimulating phytoplankton growth and increasing FPC flux in winter. As shown in Figure 10, significantly higher concentrations of productivity in winter corresponded to high POC fluxes and FPC fluxes. Therefore, we suggest that primary productivity is one of the important factors regulating the sinking fate of zooplankton fecal pellets in the northern South China Sea. The significance of primary productivity is mentioned in the abstract. Here’s how I modified it: *This study highlights that the sinking fate of fecal pellets is regulated by marine primary productivity, deep-sea dwelling zooplankton community, and deep-sea currents in the tropical marginal sea, thus providing a new perspective for exploring the carbon cycle in the world ocean.* We hope this correction meet your requirement.

Comment #3:

Line 22: change “a process” with “a collection of processes” or similar. The BCP is not one process but a collection of many processes (correctly used in line 24).

Reply: Thank you for pointing out this problem. The BCP is indeed a collection of many processes. Therefore, we agree to the comment and replaced “a process” with “a collection of processes” in **Line 23** in the revised manuscript. **Here’s how I modified it:** *The marine biological carbon pump (BCP) is a collection of processes whereby marine organisms mediate the transfer of carbon from the atmosphere to the deep ocean.*

Comment #4:

Line 27: Sentence starting with “As a key process” - consider rewording. Is it the zooplankton fecal pellets that reduced dissolution and degradation, or the zooplankton themselves that do by packaging the material into fecal pellets that are harder to degrade? Also, fecal pellets themselves are not a process, so consider wording.

Reply: Thank you for this correction. We think it’s the zooplankton themselves that package the material into fecal pellets that are harder to degrade. We agree with you in pointing out that fecal pellets themselves are not a process. Therefore, we have modified this sentence by following your suggestion in **Lines 28–29** in the revised manuscript. **Here’s how I modified it:** *As a key process of the BCP, zooplankton feed on phytoplankton and other materials and pack them into fecal pellets, thereby reducing the dissolution and degradation of organic matter during the sinking process and subsequently increase the particle sinking flux in the mesopelagic and bathypelagic zones (Wilson et al., 2008; Turner, 2015).*

Comment #5:

Line 32: first mention of amorphous pellets – define or mention that these are mostly fragmented pellets.

Reply: Thank you for the comment, we have defined amorphous fecal pellets in **Line 34** in the revised manuscript. **Here’s how I modified it:** *Several studies have revealed that the concentration of fecal pellets in the deep sea is significantly lower compared to the production rate of fecal pellets in the surface waters, and the presence of amorphous fecal pellets (mostly fragmented pellets) has been observed, indicating significant consumption during the sinking process (Juul-Pedersen et al., 2006; Wilson et al., 2008; Goldthwait and Steinberg, 2008; Kobari et al., 2010, 2016; Stukel et al., 2013; Miquel et al., 2015).*

Comment #6:

Line 36: define or explain coprorhexy, coprophagy and coprochaly if mentioned.

Reply: Thank you for the comment, we have defined coprorhexy, coprophagy and coprochaly in **Lines 37–39** in the revised manuscript. **Here’s how I modified it:** *Noji et al.*

(1991) categorized copepod behaviour in fecal pellet consumption into three different types: coprorhexy (fragmentation of fecal pellets), coprophagy (ingestion of fecal pellets), and coprochaly (loosening of fecal pellets).

Comment #7:

Line 40: “may affect the POC export” - remove “the”; define/explain efficiency of the BCP otherwise it is difficult for reader to understand.

Reply: Thank you for your constructive suggestion. In order to be able to give the reader a better understanding, we have removed “the” and explained the “efficiency of the BCP” in **Lines 44–46** in the revised manuscript. **Here’s how I modified it:** *The efficiency of the BCP depends on the carbon export flux and the retention of remineralized carbon in the deep ocean. As a key component of the carbon cycle, fragmentation, decomposition, and repackaging of fecal pellets may affect POC export and regulate the efficiency of the BCP.*

Comment #8:

Line 41: you introduce studies focusing on biogeochemical mechanisms but the rest of the paragraph describes FP fluxes with depth, which is not a biogeochemical mechanism. Consider rewording.

Reply: We apologize for the inappropriate expression here. Thank you for the advice. The point of this paragraph is to illustrate that numerous studies on fecal pellets have focused on their production, sinking, degradation, and recycling processes. Previous studies have found that changes in fecal pellet characteristics and fluxes at different depths can serve as an indicator of zooplankton behaviour. As a ubiquitous component of sinking particles, the numerical and carbon flux of fecal pellet in the water column is influenced by multiple factors, including zooplankton community structures, marine dynamic processes, and even bacterial activities. Therefore, we have revised the sentence in **Lines 47–48** and added a more detailed interpretation in **Lines 49–50** to discuss the variation trend of FP fluxes with depth, which requires specific analysis in different ocean regions. **Here’s how I modified it:** *Numerous studies have been conducted in the global ocean to explore the production, sinking, degradation, and recycling processes of zooplankton fecal pellets (González et al., 2000; Gleiber et al., 2012; Belcher et al., 2017; Le Moigne, 2019). Changes in the characteristics and fluxes of fecal pellets at varying depths can be utilized as an indicator of zooplankton behaviour (Wilson et al., 2008). We hope this correction meet your requirements.*

Comment #9:

Line 42: avoid use of the word “obvious”. Reword to “clear” or other words that are less definite. Please consider changing or removing this word throughout the manuscript (e.g. lines 281 and 285).

Reply: Thank you for your comment, we have checked out the manuscript and changed all

the “obvious” to “clear” in [Lines 51, 351, and 355](#) in the revised manuscript. [For example, this is how I modified Line 51:](#) *Previous studies have observed clear differences in fecal pellet flux with increasing water depth, mostly showing a decreasing trend (Viitasalo et al., 1999; Wexels Riser et al., 2007).*

Comment #10:

General introduction: Perhaps mention active flux / zooplankton mediated injection pump (Boyd et al. 2019 *Nature*).

Reply: Thank you for this helpful suggestion. The carbon export of organic particles in the ocean is not only dependent on gravitational settling, but “particle injection pumps” also contribute to the increase in deep-sea carbon export flux. Diurnal vertical migration behaviour of zooplankton can directly transport carbon from epipelagic zones to mesopelagic and bathypelagic zones, by passing rapid remineralization zone. zooplankton mediated injection pump is indeed an important mechanism for BCP to drive carbon storage in the deep ocean. Therefore, we have added zooplankton mediated injection pump and added relevant reference (Boyd et al. 2019 *Nature*) in [Lines 42–44](#) in the revised manuscript. [Here’s how I modified it:](#) *In addition, diurnal vertical migration results in active subsurface transport, and thus, zooplankton mediated injection pump is considered an important mechanism for BCP to increase deep-sea carbon export flux (Boyd et al., 2019).*

Comment #11:

Line76/ “2. Study Area”: Nice summary, but this should be part of the Methods (2.1) instead of its own section?

Reply: Thank you for your advice. We have moved “2. Study Area” to “2.1 Study area” in Material and Methods section in [Lines 115–145](#) in the revised manuscript.

Comment #12:

Section 2.1 Sediment trap deployment: Information lacking about the sediment traps. No make/producer. Also, why was a different concentration of fixative added to the different trap depths? If this is common practice, please provide reference.

Reply: Thank you for raising this question. We have added detailed information of sediment traps in the “Material and Methods” section in [Line 148](#) in the revised manuscript. [Here’s how I modified it:](#) *Samples were collected by time-series sediment traps (McLane Parflux Mark78H-21 sediment trap) deployed on mooring TJ-A1B (20.06°N, 117.39°E, 2000 m water depth) in the northern SCS (Fig. 1).*

Prior to deployment of the sediment traps, we added mercury chloride to the sample bottles in order to retard microbial activity in the trapped material. There are significantly more particles such as phytoplankton, zooplankton and microorganisms in the UP trap at 500 m, so more mercury chloride should be used, resulting in different concentration of fixative

added to the different trap depths. Our group has been deploying sediment traps in the South China Sea for 12 years, and this method has been used well. The addition of different concentrations of mercury chloride has proved to be very necessary in favor of better preservation of the samples, as used in articles such as Li et al. (2022) and Blattmann et al. (2018, 2019). We hope this reply meet your requirement.

Comment #13:

Section 4. Results: Hydrological results missing from the results section. Since it is outlined in methods and included in figures in the discussion, a brief results section is missing. Lines 248–253 could be considered as results instead of discussion.

Reply: Thank you for pointing out this problem. Because the hydrological parameters are outlined in methods and included in figures in the discussion, their data results are necessary to be presented. We agree to the comment and added “3.4 Hydrological conditions” section in **Lines 291–308** in the revised manuscript. **Here’s how I modified it:** *Southwest winds prevailed in the study area from June to September and northeast winds from late October to May (Fig. 9a). During the observation period, wind speed ranged from 0.2 to 19.8 m s⁻¹. Wind speed was low during the inter-monsoon period (6.4 ± 3.2 m s⁻¹) and increased in late October, reaching up to 8–10 m s⁻¹ in winter (Fig. 9a). Sea surface temperature (SST) varied between 24 to 31°C, with an average of 27 ± 2°C, and showed distinct seasonal variation (Fig. 9b). SST was generally high during summer and autumn (>28°C), declined continuously after November, reaching a minimum (24°C) in January and March. Mixed layer depth (MLD) ranged from 11 to 95 m, with an average value of 35 ± 22 m (Fig. 9c). MLD was typically shallow (<40 m) during spring and summer, increased in autumn and reached its maximum (95 m) in late December (Fig. 9c). Primary productivity (PP) varied between 4 to 34 mg m⁻³ d⁻¹ with an average value of 12 ± 6 mg m⁻³ d⁻¹ (Fig. 9d). PP showed a weak peak in December (25 mg m⁻³ d⁻¹) and a strong peak in February. Precipitation ranged from 0 to 32 mm d⁻¹ with an average value of 3 mm d⁻¹ (Fig. 9e). Precipitation throughout the year was concentrated during June to October (7 ± 8 mm d⁻¹), with a maximum value occurred in August and low precipitation during winter (1 ± 2 mm d⁻¹). Sea water velocity fluctuated throughout the year (0.01–0.38 m s⁻¹), averaging 0.17 ± 0.07 m s⁻¹ (Fig. 9f). The maximum value occurred during the winter monsoon period.*

Comment #14:

Line 154: “significantly different between two depths” - how so? Which depth was darker? Or Refer to Fig. 3

Reply: We are so sorry for the incorrect writing here. There was no significant difference in the color of fecal pellets between two depths. We have deleted this part of the sentence in **Lines 193–194** in the revised manuscript. **Here’s how I modified it:** *Fecal pellets were often brown in appearance.*

Comment #15:

Lines 176–184: Where there any size/biovolume changes across seasons (i.e. were they smaller or bigger on average during certain times of the year?)

Reply: Thank you for raising this question. We checked at the data and found that the seasonal variation in fecal pellet biovolume at 1970 m was not significant. Changes in the biovolume of fecal pellets across seasons were observed at 500 m. The biovolume of ellipsoidal, cylindrical and spherical pellets was higher on average in June-August and December-February, and the biovolume of amorphous pellets was elevated in December-April. We have added the corresponding contents in **Lines 226–229** in the revised manuscript. **Here's how I modified it:** *At 500 m, the average biovolume of ellipsoidal, cylindrical, and spherical pellets was higher during June to August and December to February. The average biovolume of amorphous pellets was elevated from December to April at 500 m. Whereas, at 1970 m, the seasonal variation in biovolume for all shape was not significant.*

Comment #16:

Lines 191–192: Which months had minimum and maximum? "... from a minimum of 216 pellets $m^{-2} d^{-1}$ in __ (month) __, to a max.. __ (month). Was it the same for both depths?

Reply: Thank you for the question. The minimum value of FPN flux at 500 m was in May and the maximum value was in December. Whereas, the minimum value of FPN flux at 1970 m was in October and the maximum value was in May. The months corresponding to the two depths are not the same. We have added the months corresponding to the minimum and maximum values of fluxes in **Lines 237–239** in the revised manuscript. **Here's how I modified it:** *FPN flux varied considerably throughout the year, from a minimum of 216 pellets $m^{-2} d^{-1}$ in May to a maximum of 2518 pellets $m^{-2} d^{-1}$ in December at 500 m, while at 1970 m, this value spanned a range of 597–4573 pellets $m^{-2} d^{-1}$, with the minimum value occurring in October and the maximum in May.*

Comment #17:

Line 246: "of the total POC flux", consider changing to "of the total annual POC flux"

Reply: We agree to the comment and changed "of the total POC flux" to "of the total annual POC flux" in **Line 312** in the revised manuscript. **Here's how I modified it:** *The POC flux during this period constituted over 75% of the total annual POC flux (Fig. 10a).*

Comment #18:

Line 278: "this additional nutrient" - terrestrial OM is not just bring in one additional nutrient so this sentence is slightly confusing to read. Consider rewording.

Reply: Thank you for pointing out this issue, and we apologize for any confusion caused by this unclear expression. Terrestrial OM can directly supplement POC fluxes, resulting in an increase in POC fluxes. Meanwhile, these organic matters can also act as a nutrient

supply to promote marine primary productivity, resulting in increased zooplankton biomass and elevated FPC fluxes. We have modified the sentence in **Lines 346–349** in the revised manuscript. **Here's how I modified it:** *Summer precipitation can bring terrestrial organic matter from land into the ocean, resulting in the increased POC fluxes. This organic matter can also serve as a nutrient supply, contributing to the marine primary productivity, thus increasing zooplankton biomass and FPC fluxes (Fig. 10b; Meyers, 1997; Vizzini et al., 2005).*

Comment #19:

Line 283: “southwestern Taiwan have been transported” - how sure are you of their origin? Perhaps change to “are likely transported” or similar.

Reply: Thank you for the valuable comment. It is true that there is no direct evidence of their origin, but it is still a possibility. We agree to the comment and changed “have been transported” to “are likely transported” in **Line 353** in the revised manuscript. **Here's how I modified it:** *These fecal pellets from southwestern Taiwan are likely transported to the northern SCS by deep-sea currents, which coincided with the previously reported high FPC flux recorded in May 2014 (Gao et al., 2020).*

Comment #20:

Line 287: “Role of zooplankton repackage in fecal pellet export” - Repackage? Reworking? The grammar here doesn't make sense and hard to know what you mean. Consider rewording.

Reply: Thank you for pointing out this problem. We further investigated the literatures and learned how to express it clearly. We believe the word “repackaging” is more accurate (Wilson et al., 2008; Gleiber et al., 2012; Belcher et al., 2017). Thus, we have changed “repackage” to “repackaging” in **Line 357** in the revised manuscript. **Here's how I modified it:** *4.2 Role of zooplankton repackaging in fecal pellet export*

Comment #21:

General section 5.2: Consider adding one sentence about uncertainty in using the same carbon conversion factor for the whole year and for all fecal pellet shapes and zooplankton producers. This could change the FPC export quite a bit, so worth a mention.

Reply: We think this is an excellent suggestion. Measurement of the carbon-volume conversion factor requires sufficient sample amount; however, there were insufficient numbers of fecal pellets in the samples. Therefore, we used the conversion factor of 0.036 mg C mm⁻³ measured in the southern SCS (Li et al., 2022). Many fecal pellet studies used the same carbon: volume conversion factor for different types of fecal pellets (e.g., González and Smetacek, 1994; González et al., 2000; Wilson et al., 2008). Although using the same conversion factor, regardless of sampling season, site, water depth, and fecal pellet type, it can still provide adequate information of the fecal pellet carbon flux and its contribution to

the overall POC flux. In fact, most of the fecal pellet studies didn't measure the carbon: volume conversion factor by themselves, but directly used the conversion factor from previous studies (e.g., Carroll et al., 1998; Shatova et al., 2012; Wilson et al., 2013). The reality is that this method is widely used in the phytoplankton and zooplankton fecal pellet research. We have added the sentences in **Lines 360–363** in the revised manuscript. **Here's how I modified it:** *Admittedly, using the same carbon conversion factor for the whole year and for all fecal pellet shapes and zooplankton producers could lead to uncertainty. Despite this uncertainty, our data still provide adequate information on FPC flux and its contribution to total POC flux in the northern SCS.*

Comment #22:

Line 288: should read “repackaging by deep-sea dwelling zooplankton”

Reply: Thank you for the comment. We have changed “repackaging of deep-dwelling zooplankton” to “repackaging by deep-sea dwelling zooplankton” in **Lines 358–359** in the revised manuscript. **Here's how I modified it:** *Assemblage of different types and sizes of fecal pellets varied with depth, providing an indication of the repackaging by deep-sea dwelling zooplankton in the water column (Wilson et al., 2008).*

Comment #23:

Line 344: “zooplankton grazing” - do you mean grazing here or reworking/fragmentation?

Reply: Thank you for pointing out this problem. We mean that zooplankton reworking (ingestion and other behaviours) and hydrodynamic changes combine to cause fragmentation of fecal pellets in the northern South China Sea. Therefore, we have changed “grazing” to “reworking” in **Line 417** in the revised manuscript. **Here's how I modified it:** *Therefore, the fragmentation of fecal pellets in the northern SCS shows the joint effect of zooplankton reworking and hydrodynamic changes.*

Comment #24:

Line 350: change “variable” to “various”

Reply: Thank you for your comment, we have changed “variable” to “various” in **Line 423** in the revised manuscript. **Here's how I modified it:** *In the northern SCS, various mechanisms affect the carbon export of zooplankton fecal pellets (Fig. 13).*

Comment #25:

Line 350: Here you use “euphotic zone” but in Figure 12 you use “Epipelagic”. Be consistent.

Reply: Thank you for your advice. We have modified this throughout the manuscript. With these two words, we are trying to convey the same concept. Thus, for consistency with Figure 13, we have changed “euphotic” to “epipelagic” in **Lines 25, 343, 380, 424, and 469**

in the revised manuscript. **For example, this is how I modified Line 25:** *Marine organisms inhabiting the upper water column can fix atmospheric CO₂ through photosynthesis, producing particulate organic carbon (POC) in the epipelagic zone.*

Comment #26:

Line 355-356: “consumed and reworked by zooplankton grazing and strong hydrodynamic activities” seems to imply hydrological activities consume and rework the pellets. Consider changing to “consumed and reworked by zooplankton grazing and fragmented by strong hydrodynamic activities”

Reply: Thank you very much for raising this point. We agree to the comment and have modified this sentence following your suggestion in **Lines 427–429** in the revised manuscript. **Here’s how I modified it:** *However, amorphous pellets are fragmented during the sinking process, indicating that surface-produced pellets are likely to be consumed and reworked by zooplankton grazing and fragmented by strong hydrodynamic activities.*

Comment #27:

Line 357: “repackaging”, change to “repackaging and fragmentation”

Reply: Thank you for this constructive advice. We have changed “repackaging” to “repackaging and fragmentation” in **Lines 431–432** in the revised manuscript. **Here’s how I modified it:** *The evolving picture regarding the sinking fate of fecal pellets is therefore a coupling between the marine primary productivity, repackaging and fragmentation by mesopelagic and bathypelagic zooplankton, lateral input and removal by deep-sea currents and hydrodynamically induced fragmentation.*

Comment #28:

Line 366: Remove “However,” and switch sentence around to read “The contribution of fecal pellets to the total annual carbon flux was lower in the northern SCS compared to the southern SCS, possibly due to...”

Reply: Thank you for this comment. We removed “However,” and switched sentence around to read “The contribution of fecal pellets to the total annual carbon flux was lower in the northern SCS compared to the southern SCS, possibly due to...” in **Lines 441–443** in the revised manuscript. **Here’s how I modified it:** *The contribution of fecal pellets to the total annual carbon flux was lower in the northern SCS compared to the southern SCS, possibly due to their higher degree of fragmentation and degradation (Li et al., 2022).*

Comment #29:

Line 369: Replace “biospheric” with “biogenic”

Reply: Thank you for this comment. We have replaced “biospheric” with “biogenic” in **Line 446** in the revised manuscript. **Here’s how I modified it:** *Even though 87% of the sinking*

POC in the northern SCS was from marine biogenic origin, the majority may have come from phytoplankton cells such as Prochlorococcus and Synechococcus, zooplankton moults, zooplankton carcasses, and large aggregates (Zhang et al., 2019, 2022).

Associate editor decision: Publish subject to minor revisions (review by editor) 30 Oct 2023

Dear Zhifei Liu and co-authors,

I would like to thank both reviewers for their comments and you for your reply. It might be a cultural thing, but please do not hyphenate everything as reviewer 1 suggests. I know, it seems to be the hip thing to do, but personally I am not a fan and I know many other people are also not fans of hyphenation and I think it should be limited to things like “co-authors”. If you are unsure of the use of hyphens, check with Biogeosciences for their policy. When you change your manuscript according to the reviewer’s comments as you have indicated in your answers your manuscript will be acceptable for publication after I have another look at it. I do have one or two comments based on your answers to the reviewer’s comments. In your reply to comment #2 of reviewer 2 you mention “that the sinking fate of fecal pellets is regulated by primary productivity”. I would think that the sinking fate of primary productivity is largely regulated by fecal pellet production? Do mean that zooplankton follow algal blooms as in higher primary productivity, higher zooplankton numbers, more fecal pellets? In your reply to comment #18, reviewer 2, this organic matter, not these organic matters. In your reply to comment #28 of reviewer 2 you mention that a higher degree of fragmentation reduces the flux of fecal pellets. This is true since after fragmentation they are not fecal pellets anymore, but does this also reduce the flux of carbon, or do the fragments also, eventually, reach the sea floor? Or is the idea more that it becomes dissolved organic matter that stays in solution until it is degraded, consumed, ending up as marine snow etc. etc.? Associated with this, you mention lateral input in your reply to comment #27, but could there also be lateral removal, material leaving the SCS ending up in different basins?

I am looking forward to your more formal rebuttal and the revised version of your manuscript.

Marcel

Reply: Thank you for your letter. We have read through all the comments carefully and have made related modifications. All responses to your comments are followed below. We hope that the revision has strengthened the manuscript in terms of clarity, accuracy, and overall quality.

Comment #1:

It might be a cultural thing, but please do not hyphenate everything as reviewer 1 suggests. I know, it seems to be the hip thing to do, but personally I am not a fan and I know many other people are also not fans of hyphenation and I think it should be limited to things like “co-authors”. If you are unsure of the use of hyphens, check with Biogeosciences for their policy.

Reply: We thank you for this correction. Following your suggestion, we checked the policy of the journal Biogeosciences, where hyphens are not required between more-than-one-word adjectives and an adverb ending in -ly and the word it is modifying (e.g. “statistically based results”, not “statistically-based results”). Therefore, we have not added hyphens as Referee #1 suggests in the revised manuscript.

Comment #2:

Line 19: In your reply to comment #2 of reviewer 2 you mention “that the sinking fate of fecal pellets is regulated by primary productivity”. I would think that the sinking fate of primary productivity is largely regulated by fecal pellet production? Do mean that zooplankton follow algal blooms as in higher primary productivity, higher zooplankton numbers, more fecal pellets?

Reply: Thank you for this comment. Zooplankton produces fecal pellets after ingesting phytoplankton and other materials. Therefore, when phytoplankton such as algal blooms, as in higher marine primary productivity, there is more zooplankton biomass, and therefore more fecal pellets are produced. During the East Asian winter monsoon period in the northern SCS, strong northeast winds and surface cooling strengthened the water column mixing and promoted the marine primary productivity. At this time, zooplankton biomass reaches high values, when fecal pellet numerical and carbon fluxes are higher. Therefore, the seasonal variation of fecal pellet carbon export in the northern SCS suggested that fecal pellet production and sinking process were largely linked to the marine primary productivity in the epipelagic zone, which was mainly controlled by the East Asian monsoon system.

Temporal variability of fecal pellet flux is influenced by the seasonal cycle forcing of marine primary production and zooplankton community structure (Ramaswamy et al., 2005; Roman et al., 2000). The Scotia Sea in the Southern Ocean (Manno et al., 2015) and upwelling zones like the Chilean upwelling (González et al., 2004) are proven to have higher primary productivity and zooplankton biomass, where fecal pellets play a significant role in determining the level of carbon flux (Le Moigne, 2019). Therefore, we suggest that marine primary productivity allows for increased zooplankton biomass and promotes the export of carbon from their fecal pellets. **Here’s how I modified it (Lines 18-21):** *This study highlights that the sinking fate of fecal pellets is regulated by marine primary productivity, deep-sea dwelling zooplankton community, and deep-sea currents in the tropical marginal sea, thus providing a new perspective for exploring the carbon cycle in the world ocean.* We hope this correction meet your requirement.

Comment #3:

Line 19: In your reply to comment #18, reviewer 2, this organic matter, not these organic matters.

Reply: Thank you for pointing out this problem. We have modified the sentence in **Lines 345–348** in the revised manuscript. **Here's how I modified it:** *This organic matter can also serve as a nutrient supply, contributing to the marine primary productivity, thus increasing zooplankton biomass and FPC fluxes (Fig. 10b; Meyers, 1997; Vizzini et al., 2005).*

Comment #4:

Line 19: In your reply to comment #28 of reviewer 2 you mention that a higher degree of fragmentation reduces the flux of fecal pellets. This is true since after fragmentation they are not fecal pellets anymore, but does this also reduce the flux of carbon, or do the fragments also, eventually, reach the sea floor? Or is the idea more that it becomes dissolved organic matter that stays in solution until it is degraded, consumed, ending up as marine snow etc. etc.?

Reply: Thank you for this constructive advice. During the sinking process, most zooplankton fecal pellets are susceptible to being ingested by other zooplankton or degraded by bacteria. These fragments may combine with other organic matters to form larger aggregates that reach the sea floor, or they may continue to be degraded into dissolved organic matter. These processes are thought to reduce the carbon export of fecal pellets in the deep sea. We have added detailed interpretations in **Lines 443–446** in the revised manuscript. **Here's how I modified it:** *After being fragmented, fecal pellets will become small fragments and eventually reach to the sea floor. During the sinking process, they may form larger aggregates with other materials, or they may continue to be degraded and become dissolved organic matter.*

Comment #5:

Associated with this, you mention lateral input in your reply to comment #27, but could there also be lateral removal, material leaving the SCS ending up in different basins?

Reply: Thanks for your valuable suggestion. Higher fecal pellet fluxes combining with the presence of extra-large pellets at 1970 m compared to those at 500 m suggested lateral input of fecal pellets by deep-sea currents. We only considered possible mechanisms for the increased fecal pellets flux in deep sea and did not take lateral removal into account. We agree that there may also be lateral removal, material leaving the SCS ending up in different basins. We have added the sentence in **Lines 429–430** and modified the sentence in **Line 432** in the revised manuscript. **Here's how I modified it:** *Also, lateral removal by deep-sea currents can transport fecal pellets away from the northern SCS eventually to different basins. The evolving picture regarding the sinking fate of fecal pellets is therefore a coupling between the marine primary productivity, repackaging and fragmentation by mesopelagic and bathypelagic zooplankton, lateral input and removal by deep-sea currents and*

hydrodynamically induced fragmentation.

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