Response (in blue) to Reviewers

Manuscript Title: Diatom community assemblages and microbial degradation resistance modulate local heterogeneity in diatom contribution to carbon export in the western North Pacific Subtropical Gyre

Journal: Biogeosciences

Authors: Feng Li, Hongzhen Jiang, et al.

Response to Reviewers 1

General Comments

Reviewer's comment:

This manuscript addresses an important question regarding diatom-driven carbon export in the western North Pacific Subtropical Gyre. However, the strength of the evidence does not match the ambition of the conclusions. The study relies on very limited spatial and temporal coverage, substantial methodological assumptions, and indirect inference to support claims of a "regional hotspot" and a trait-based mechanistic framework. Given the extremely small effective sample size—particularly the reliance on a single station (K2b) to define a "regional hotspot"—the conclusions appear overstated and insufficiently supported. In its current form, the study reads more as a preliminary case observation than as robust evidence for a regional-scale ecological pattern.

Response: Thanks for your honest assessment. We agree that our sample size is limited and that the term "regional hotspot" was too strong. Accordingly, we have reframed the study objective to investigate whether and how diatoms maintain a high contribution to export (defined as more carbon exported relative to their production) in such regions, and what factors may be involved. We have substantially revised the manuscript to present our findings as preliminary support that diatom community assemblages (shaped by hydrodynamics and nutrient supply) and microbial degradation resistance (via limited FCSP-targeting enzymes) modulate local heterogeneity in diatom export contribution. This is presented rather than as definitive conclusions. Specifically:

1) The term “regional hotspot” has been replaced throughout with “local heterogeneity”.
2) We have added a new “Limitations of the study” subsection in the Discussion, explicitly acknowledging the small number of stations, lack of winter flux data, and methodological biases.
3) All conclusions have been toned down, and we now emphasize the need for future multi-season, multi-year, and multi-station observations.
4) We have also revised the title and abstract accordingly. Detailed changes are provided below.

We hope these revisions adequately address the reviewer’s concerns

Updated title

Diatom community assemblages and microbial degradation resistance modulate local heterogeneity in diatom contribution to carbon export in the western North Pacific Subtropical Gyre

Updated Abstract

Diatoms typically make a high contribution to carbon export (defined as more carbon exported relative to their production) in productive coastal and upwelling regions. However, oligotrophic subtropical gyres are vast but uniformly nutrient-poor, supporting only very low diatom abundances. **This raises a critical question: can diatoms still achieve a high contribution to carbon export in such nutrient-limited regions, and if so, what factors enable this?** Here, we integrated taxonomic, sediment trap, and metagenomic analyses at five stations in the western North Pacific Subtropical Gyre. Our observations reveal distinct niche partitioning: *Navicula* and *Rhizosolenia* tend to be enriched in the nutrient-depleted surface mixed layer, while *Nitzschia*, *Chaetoceros*, and *Thalassiosira* prevail in the deep chlorophyll maximum, reflecting hydrographic and nutrient influences on community assembly. **Within our limited station coverage**, measured intact cell fluxes ranged from 10^3 to 10^5 cells m^{-2} d^{-1}, with estimated carbon fluxes of 0.11–313.03 μg C m^{-2} d^{-1}. The total fluxes of diatom cells, biogenic silica, and carbon export were highest at Station K2b, which is influenced by the Kuroshio. At this station, the contribution of diatom export remained high, with the

large, carbon-rich *Rhizosolenia* species dominating the sinking flux. Community assembly, characterized by functional traits such as cell size, carbon content, and fucose-containing sulfated polysaccharides (FCSPs) production, influences export composition and magnitude. Metagenomic analyses indicate a widespread capacity for degrading common diatom polysaccharides, but genes encoding the essential enzyme (GH107) for cleaving FCSPs are nearly absent across all stations. This deficit, together with the prevalence of FCSP-producing diatoms, suggests that biochemical resistance **may assist** carbon export. **Our findings provide preliminary support that** diatom community assemblages (shaped by hydrodynamics and nutrient supply) and microbial degradation resistance (via limited FCSP-targeting enzymes) modulate **local heterogeneity in diatom export contribution.** We conclude that predicting the biological pump's response to global change may require accounting not only for which diatoms are present, but also for which organic byproducts are protected from rapid remineralization. **These results are based on a limited number of stations and a single season, and therefore warrant further testing.**

Specific Comment 1

Reviewer's comment:

Only five stations were sampled in summer, and sediment trap data were successfully obtained at just three stations (K2b, M22, K8a). Winter observations were limited to two stations and lacked sediment trap measurements entirely.

Response: Thanks for your comment. We agree that the number of stations with sediment trap data is limited. Accordingly, we have reframed the study objective to investigate whether and how diatoms maintain a high contribution to export (defined as more carbon exported relative to their production) in such regions, and what factors may be involved. In the revised manuscript, we argue that the three stations with trap data (K2b, M22, K8a) are suitable for exploring this question, as they represent the main distinct hydrodynamic regimes within the western NPSG (Kuroshio, gyre interior, and North Equatorial Current, respectively). Despite its vast expanse, the NPSG is uniformly nutrient-poor, with extremely low diatom abundances. Under these constraints, focusing on representative stations allows a meaningful comparison of the

local diatom export contribution. The following modifications have been made:

1) In Section 2.2, we state the reasons for the unsuccessful deployment of traps in winter (due to rough sea conditions).
2) Throughout the Abstract, Results, and Discussion, we have replaced terms like "regional heterogeneity" with "local heterogeneity" and added qualifiers such as "Within our limited station coverage."
3) In the Abstract and "4.5 Limitations of this study", we now add: "These results are based on a limited number of stations and a single season, and therefore warrant further testing." and "Our conclusions are based on five stations sampled in a single summer cruise, with sediment trap data at only three stations; winter trap data are absent. Thus, the observed patterns may not represent full spatial or temporal variability."

Specific Comment 2

Reviewer's comment:

Carbon biomass was estimated using genus-level average carbon content, largely derived from literature compilations and biovolume-to-carbon conversions. Oligotrophic regions are typically dominated by small and fragile diatom taxa, whose cellular carbon content may deviate substantially from literature averages derived under different conditions.

Response: We thank you for this valid concern. We acknowledge that estimating carbon biomass from genus-level averages and biovolume conversions introduces uncertainty, especially in oligotrophic systems. In the revised manuscript, we have improved our method to estimate carbon content as follows:

1) Recognizing that the same diatom species may exhibit variations in cell size between oligotrophic and coastal regions, and consequently differences in cellular carbon content, we directly measured cell sizes from scanning electron micrographs of diatom cells from our samples.
2) Biovolume was then calculated based on cell dimensions using appropriate geometric models (Sun & Liu, 2003).

3) Carbon content was subsequently estimated using the empirical formula of Eppley et al. (1970). Alternatively, carbon content was derived using the volume-to-carbon conversion relationship proposed by Menden-Deuer & Lessard (2000).
4) For several rare genera for which micrographs were not available, carbon biomass was estimated using genus-level average carbon content largely derived from literature compilations.

This combined approach greatly improves the reliability of our carbon biomass estimates. In addition, we have added a new "Limitations of the study" subsection in the Discussion, explicitly acknowledging methodological biases. We also note that our approach accounts for site-specific variations in cell size and thus more accurately reflects oligotrophic diatoms, and that this methodological choice has limited impact on the comparative conclusions regarding export contribution.

We hope these revisions adequately address the reviewer's concern

Specific Comment 3

Reviewer's comment:

Diatom counts were conducted after sedimentation concentration and 8 μm mesh filtration. The authors acknowledge that this procedure may underestimate large or fragile taxa such as *Rhizosolenia*. However, *Rhizosolenia* is precisely the dominant contributor to the proposed K2b "hotspot".

Response: Thanks for your raising this critical point. Indeed, the sedimentation concentration process may cause damage to large or fragile taxa such as *Rhizosolenia*, and this applies to both water and sediment trap samples, as both underwent concentration steps. Despite this potential bias, the extremely high DEP/DPP ratio observed at K2b suggests that the underestimation of *Rhizosolenia* in both water and trap samples does not affect our main conclusion that K2b exhibits the highest diatom contribution to carbon export.

To transparently address this methodological limitation, we have added a Methodological note in Section 2.4 (Diatom taxonomy and counting), stating: "This

procedure likely underestimates the water-column abundance of large or fragile taxa (e.g., *Rhizosolenia*) due to cell damage during concentration handling. Consequently, our reported abundance of *Rhizosolenia* in water samples should be considered a lower bound. Sediment trap samples also underwent concentration steps; therefore, trap fluxes for these taxa are likewise underestimates."

Additionally, in Section 4.5 (Limitations of this study), we now note: "The diatom enumeration method (sedimentation concentration) likely underestimates large or fragile taxa such as *Rhizosolenia* in both water and trap samples; however, this does not substantially affect the interpretation of K2b's high export contribution due to the high value of DEP/DPP ratio (12.3-64.8) at K2b."

We believe these revisions address the reviewer's concerns and provide a more robust interpretation of our carbon export estimates.

Additional changes

1) The carbon biomass in both water column and sediment trap samples was re-estimated using improved methods (see above). Accordingly, the corresponding text, tables, figures, and supplementary materials have been revised. Importantly, our main conclusions remain unchanged.
2) A new "Limitations of the study" subsection has been added to the Discussion, explicitly addressing the small sample size, single-season sampling, methodological biases, and the indirect nature of the FCSP degradation evidence.
3) The Abstract, Results, and Discussion have been rewritten to adopt a more cautious, hypothesis-generating tone throughout.

We believe these revisions substantially address your concerns and hope the manuscript is now acceptable for publication.

Response to Reviewer 2

General comment

In their paper 'Trait-based mechanisms underpin regional hotspot of diatom-driven carbon export in an oligotrophic gyre' the authors seek to connect the vertical structure of diatom populations in the western North Pacific Subtropical Gyre to the magnitude and composition of export flux. The topic is really interesting as the drivers of export flux in the oligotrophic ocean remain open for discussion. The main strengths of the manuscript are the dataset and the ability to interface the vertical structure of the populations with flux observations. It is difficult to generate a dataset like this, despite the small number of stations. Unfortunately, the current claims in the manuscript are extremely strong and not directly supported by the data. However, part of this could be the presentation. The figures were difficult to connect to the main text because of the many small squares and the lack of direct connection between the visuals and the processes discussed in the main text. The manuscript really needs a set of clear figures which show the proposed mechanisms and connect to the oceanographic context of the problem.

Response: Thanks for recognizing the interest and strength of our dataset, as well as the inherent difficulty of collecting such measurements in the oligotrophic ocean. We also appreciate the candid assessment that our original claims were too strong relative to the data, and that the figures were difficult to interpret. In response, we have substantially revised the manuscript to address these concerns, specifically by toning down our conclusions and claims and improving the figures to better connect with the text and the proposed mechanisms. We are grateful for the reviewer's constructive feedback, which has significantly improved the clarity and rigor of our manuscript.

Comment 1 (Lines 26-27)

Lines 26-27: It is unclear what is meant by 'trait-based'. Are you claiming 'depth' is a trait? If so, I normally think about traits in connection to nutrient uptake etc.

Response: Thanks for your comments. We have revised the abstract and main text to

define “trait-based” explicitly as functional biological traits, for example, cell size, carbon content, and FCSP production. Depth is not a trait. The revised abstract now reads: “Community assembly, characterized by functional traits such as cell size, carbon content, and fucose-containing sulfated polysaccharides (FCSPs) production, influences export composition and magnitude.”

Comment 2 (Lines 32-36)

Lines 32-36: This seems out of place with the rest of the abstract.

Response: Thanks for this observation. The abstract has been reorganized to improve its logical flow. Specifically, we now define “traits” early in the abstract as referring to functional traits such as cell size, carbon content, and fucose-containing sulfated polysaccharides (FCSPs) production. In addition, we have revised the sentence in question to read: “Metagenomic analyses indicate a widespread capacity for degrading common diatom polysaccharides, but genes encoding the essential enzyme (GH107) for cleaving FCSPs are nearly absent across all stations. This deficit, together with the prevalence of FCSP-producing diatoms, suggests that biochemical resistance may assist carbon export.” These revisions integrate the sentence more naturally with the surrounding text, and we believe it is now well placed within the abstract.

Updated title

Diatom community assemblages and microbial degradation resistance modulate local heterogeneity in diatom contribution to carbon export in the western North Pacific Subtropical Gyre

Updated Abstract

Diatoms typically make a high contribution to carbon export (defined as more carbon exported relative to their production) in productive coastal and upwelling regions. However, oligotrophic subtropical gyres are vast but uniformly nutrient-poor, supporting only very low diatom abundances. **This raises a critical question: can diatoms still achieve a high contribution to carbon export in such nutrient-limited regions, and if so, what factors enable this?** Here, we integrated taxonomic, sediment

trap, and metagenomic analyses at five stations in the western North Pacific Subtropical Gyre. Our observations reveal distinct niche partitioning: *Navicula* and *Rhizosolenia* tend to be enriched in the nutrient-depleted surface mixed layer, while *Nitzschia*, *Chaetoceros*, and *Thalassiosira* prevail in the deep chlorophyll maximum, reflecting hydrographic and nutrient influences on community assembly. **Within our limited station coverage**, measured intact cell fluxes ranged from 10^3 to 10^5 cells m^{-2} d^{-1}, with estimated carbon fluxes of 0.11–313.03 µg C m^{-2} d^{-1}. The total fluxes of diatom cells, biogenic silica, and carbon export were highest at Station K2b, which is influenced by the Kuroshio. At this station, the contribution of diatom export remained high, with the large, carbon-rich *Rhizosolenia* species dominating the sinking flux. Community assembly, characterized by **functional traits such as cell size, carbon content, and fucose-containing sulfated polysaccharides (FCSPs) production,** influences export composition and magnitude. **Metagenomic analyses indicate a widespread capacity for degrading common diatom polysaccharides, but genes encoding the essential enzyme (GH107) for cleaving FCSPs are nearly absent across all stations.** This deficit, together with the prevalence of FCSP-producing diatoms, suggests that biochemical resistance **may assist** carbon export. **Our findings provide preliminary support that diatom community assemblages (shaped by hydrodynamics and nutrient supply) and microbial degradation resistance (via limited FCSP-targeting enzymes) modulate local heterogeneity in diatom export contribution. We conclude that predicting the biological pump's response to global change may require accounting not only for which diatoms are present, but also for which organic byproducts are protected from rapid remineralization. These results are based on a limited number of stations and a single season, and therefore warrant further testing.**

Comment 3 (Lines 36-39) – *need a mechanism*

Lines 36-39: There needs to be a mechanism to make this convincing.

Response: Thanks for this comment. We now explicitly state a mechanism in the updated Abstract and Section 4.1-4.4. The relevant sentence in the abstract has been revised to: "Our findings provide preliminary support that diatom community assemblages (shaped by hydrodynamics and nutrient supply) and microbial degradation

resistance (via limited FCSP-targeting enzymes) modulate local heterogeneity in diatom export contribution." The updated Section 4.1-4.4 further breaks down each step of the mechanism. We believe this addresses the concern.

Comment 4 (Lines 39-41)

Lines 39-41: It is unclear how the study does this, and if it did, what the 'interacting controls' are.

Response: Thanks for your pointing out the lack of clarity regarding "interacting controls." To address this, we have removed this ambiguous term from the manuscript and toned down the conclusions accordingly. The relevant sentence in the Abstract has been revised to: "We conclude that predicting the biological pump's response to global change may require accounting not only for which diatoms are present, but also for which organic byproducts are protected from rapid remineralization. These results are based on a limited number of stations and a single season, and therefore warrant further testing." We believe this revision eliminates the confusion and presents a more cautious, evidence-aligned conclusion.

Comment 5 (Lines 72-87)

Lines 72-87: There has been a lot of work out of the Hawaii Ocean Timeseries looking at export with a focus on Nitrogen Fixation. The authors really need to engage with these ideas I think.

Response: Thanks for your comment. We have expanded engagement with the Hawaii Ocean Time-series (HOT). A new paragraph in the introduction explicitly cites Karl et al. (2012) and others on diatom-diazotroph associations (DDAs). We now compare our western NPSG findings with those from Station ALOHA.

Comment 6 (Section 2.1)

Section 2.1 – Given there are only 5 stations, more care should be provided to explain why they were chosen at these sites.

Response: Thanks for your comment. To better justify the selection of the five stations,

we have added explanations in both the Introduction and Section 2.1. In the Introduction, we now state: “Furthermore, the western NPSG features distinct hydrodynamic regimes, including the Kuroshio-influenced, Kuroshio Extension, gyre interior, and North Equatorial Current. These regimes, together with the vertical physicochemical gradient, may promote differentiation in diatom community structure.” In Section 2.1, we have added: “Stations were chosen to represent four main distinct hydrodynamic regimes in the western NPSG: Kuroshio-influenced (K2b, 125°E, 20°N), Kuroshio Extension (M35, 155°E, 33°N), gyre interior (M22, 155°E, 20°N; WPS, 140°E, 20°N), and North Equatorial Current (K8a, 155°E, 12.5°N). These regions differ in hydrodynamic conditions, which may influence nutrient supply, mixed layer depth, diatom community composition, and carbon export.” These revisions clarify the rationale for station selection. We hope this addresses the reviewer’s concern.

Comment 7 (Lines 123-126)

Lines 123-126: Given the lack of citations, more care should be given to discussion of design.

Response: Thanks for your comment. Relevant methodological citations have been added.

Comment 8 (Line 136) – *nutrient flux data underutilized*

Line 136: Nutrient fluxes etc. have strong importance to the plankton community. It is confusing why this manuscript was not leveraged more.

Response: Thanks for your comment. We agree that nutrient flux data are highly relevant and should be better integrated. Accordingly, we have now more thoroughly incorporated the nutrient flux data from Du et al. (2024) throughout the manuscript. Specifically:

1) We have added a new Section 3.1. “Description of environmental gradients among the four hydrodynamic regimes”
2) Spearman correlations between nutrient fluxes and dominant diatom taxa are presented in Fig. 5.

3) In the Discussion (Section 4.2 Local hydrodynamic conditions may influence the assemblages of diatom communities), we have added further interpretation of how nutrient supply may shape the observed community composition and export potential at different stations.

Comment 9 (Lines 147-158)

Lines 147-158: The description was confusing to read.

Response: Thanks for your comment. The section has been completely rewritten with step-by-step numbering. A simplified flow diagram (new Fig. S1) has been added.

Comment 10 (Lines 162-164)

Lines 162-164: cite references

Response: Thanks for your comment. Standard taxonomic references have been added.

Comment 11 (Lines 182-194)

Lines 182-194: Is there any estimate as to the error bounds?

Response: Thanks for your comment. The error bounds for estimating carbon at each station are now presented in the new Table S3. We acknowledge that estimating carbon biomass from genus-level averages and biovolume conversions introduces uncertainty, especially in oligotrophic systems. In the revised manuscript, we have improved our method to estimate carbon content as follows:

5) Recognizing that the same diatom species may exhibit variations in cell size between oligotrophic and coastal regions, and consequently differences in cellular carbon content, we directly measured cell sizes from scanning electron micrographs of diatom cells from our samples.
6) Biovolume was then calculated based on cell dimensions using appropriate geometric models (Sun & Liu, 2003).
7) Carbon content was subsequently estimated using the empirical formula of Eppley et al. (1970). Alternatively, carbon content was derived using the volume-to-carbon conversion relationship proposed by Menden-Deuer &

Lessard (2000).

8) For several rare genera for which micrographs were not available, carbon biomass was estimated using genus-level average carbon content largely derived from literature compilations.

Comment 12 (Lines 203-210)

Lines 203-210: The methods, and what they conceptually mean needs to be explained clearly.

Response: Thanks for your comment. The section has been rewritten to explain the ecological meaning of richness, Simpson index, and Pielou evenness, and how they relate to export stability.

Comment 13 (Fig. 2)

Fig 2: It is really hard to decipher this plot. You need smaller numbers of panels and representative profiles to make your points clear.

Response: Thanks for your comment. Fig. 2 has been simplified to show only representative stations (K2b, M22, K8a) and key parameters (T, S, Chl a, N, P, Si). Full profiles are moved to new Fig. S2.

Comment 14 (Fig. 3)

Fig 3: Again, this is very hard to decipher. The NMSDS plot is really busy and it is hard to see the conclusions being drawn. All plots have all stations and depths. The authors need to think carefully about presentation and the point they are trying to make. The remaining figures share these problems.

Response: Thanks for your comment. To improve clarity, Fig. 3 has been completely redesigned:

1) The NMDS plot (originally Fig. 3a) has been removed, as it was overly complex and did not clearly convey the main conclusions.
2) The abundance and estimated carbon biomass panels are now faceted by depth (5 m, DCM, 200 m) to allow easier comparison across stations within each depth

layer (shown as updated Fig. 3).

3) The heatmap has been simplified to show only the dominant diatom genera.

Comment 15 (Section 3.3)

Section 3.3: Many things co-vary with depth. This section is confusing as it is unclear which data is used in the correlations. If all data is used unmixing the actual drivers requires careful consideration as many things vary with depth.

Response: Thanks for your comment. We now perform Spearman correlations separately for each depth layer (5 m, DCM). This is stated in the Methods and reflected in updated Fig. 5.

Comment 16 (Lines 402-409)

Lines 402-409: Do flux ratios match composition ratios?

Response: Thanks for your comment. A new analysis comparing water-column and trap compositions has been added (new Fig. S6). Flux ratios generally match composition ratios. This consistency in dominance between water column and trap samples suggests that water-column taxonomic composition largely determines export composition, with these species sinking passively.

Comment 17 (Lines 412-417)

Lines 412-417: This all needs to be explained more.

Response: Thanks for your comment. Section 3.6 “Local heterogeneity in the contribution of diatom to export” now clearly defines DEP and DPP with examples. A step-by-step calculation is provided in the text.

Comment 18 (Lines 421-423)

Lines 421-423: I do not believe that this claim is supported. The system is heterogeneous both in space and time. This paper really needs clear biophysical reasoning to work.

Response: Thanks for your comment. We have softened the claim. The revised text

reads: “Among the three stations studied, diatom carbon export was not directly correlated with total POC flux (Table 1), suggesting that different factors may regulate these two quantities. However, this observation is based on a small number of stations and requires further testing with larger datasets. If this decoupling is confirmed, it would imply that the community structure of diatoms and the functional traits of dominant species, rather than the total production, are primary drivers of the diatom's contribution to export.”

Comment 19 (Lines 483-488)

Lines 483-488: Is this claim derived from the data in this paper? If so, there is not enough data to claim this. However, I believe this is well established, starting with Karl et al 2012, the references within it and the bank of work which cites it.

Response: Thanks for your comment. We agree that this claim is not directly supported by our data and is already well established in the literature (e.g., Karl et al., 2012). We revise the text to remove the claim. We have revised the discussion section.

Comment 20 (Lines 493-495) – *vertical structuring is well established*

Lines 493-495: I believe that the vertical structuring of diatom populations is well established.

Response: Thanks for your comment. We have revised the discussion section.

Comment 21 (Section 4.3) – *define “trait-based”*

Section 4.3: The authors need to define what they mean by ‘trait-based’.

Response: Thanks for your comment. We have now added a definition of “traits” in **Section 4.1**. Specifically, we state: “This indicates that cell size and carbon content are key functional traits associated with diatom contribution to export.”

Comment 22 (Lines 509-511) – *nitrogen fixation appears too late*

Lines 509-511: It is unclear to me why nitrogen fixation makes its first appearance in the manuscript here. The standard argument for enhanced export in the NPSG comes

from invoking DDAs.

Response: Thanks for your comment. The introduction now encompasses the information regarding DDAs and their well-known role in the NPSG.

Comment 23 (Line 547) – *carbon density vs. cell size*

Lines 547: Is it true that *Rhizosolenia* has a large carbon density or is this due to the giant cell size?

Response: Thanks for your comment. We have corrected "high carbon density" to "high cellular carbon content due to its large cell volume" throughout.

Comment 24 (Line 562)

Line 562: The authors really need to work harder to connect their data to the mechanisms invoked.

Response: Thanks for your comment. To better connect our data to the proposed mechanisms, we have substantially revised the Discussion. Specifically, we now walk through each causal step explicitly, with the following subsections:

4.1 Local heterogeneity in diatom export contribution are associated with diatom community assemblages

4.2 Local hydrodynamic conditions may influence the assemblages of diatom communities.

4.3 Microbial degradation resistance may enhance the contribution to exports

4.4 A framework for local heterogeneity in the western NPSG

These revisions make the mechanistic linkages transparent and directly supported by our data. We believe this addresses the reviewer's concern.

Additional changes

1) The carbon biomass in both water column and sediment trap samples was re-estimated using improved methods (see above). Accordingly, the corresponding text, tables, figures, and supplementary materials have been

revised. Importantly, our main conclusions remain unchanged.

2) A new “Limitations of the study” subsection has been added to the Discussion, covering small sample size, single season, methodological biases, and the indirect nature of FCSP degradation evidence.
3) All figures have been simplified or reorganized as described above; the revised figure set is provided in the supplementary materials.
4) The Abstract, Introduction, Results, and Conclusions have been rewritten to reflect a more cautious, hypothesis-generating tone.

We believe these revisions substantially address your concerns and hope the manuscript is now acceptable for publication.