

Reviewer#1

General Comments

I appreciated your further explanations regarding my questions. Concerning the structure of the Methods and Results sections, I understand why you prefer to keep the original order: the cruises were not planned to sample the extraordinary bloom, as it was unexpected, and your focus is on finding the physical explanations for your observations!

Based on your revision, I would still suggest making minor adjustments to the manuscript.

Author reply: We are thankful for your thoughtful feedback and for understanding the reasoning behind the structure of the Methods and Results sections. We appreciate your recognition of the unexpected nature of the bloom and our focus on investigating the physical explanations behind our observations. We believe that maintaining the original order helps to highlight the context and the nature of the data collection. Thanks again for your constructive input.

Specific Comments

Figures: I am still concerned about the colormap used in the figures. As the references I initially sent you mentioned:

e.g. Michael Stoelzle and Lina Stein 2021: "The rainbow color map attracts attention but distorts and misleads scientific visualizations. Major rainbow pitfalls are the non-linear data encoding, steps and disorder in luminance, and minor perceptual accessibility for people with CVD or other vision impairments. Here we investigated the use of rainbow color maps in around 1000 papers in different environmental journals and found that the misleading rainbow color map or red–green color issues are present in around 44 % of all papers ..."

This is even more problematic for studies like yours, as rainbow colormaps distort fine-scale current analysis by masking gradients, amplifying irrelevant features, misrepresenting continuity, excluding colorblinds... I believe the rainbow colormap hinders rather than helps in visualizing key features. I strongly recommend using perceptual colormaps like viridis.

Author reply: From our perspective, the features we wish to highlight are more effectively visualized using the 'jet' colormap, which we initially selected. However, we understand that this may be a matter of preference, and therefore, we do not consider it a critical issue for further discussion. In light of this, we have updated the colormaps for Figures 8, 9, and Figure D01, which display Absolute Dynamic Topography maps, from 'jet' to 'parula' in the revised manuscript. The 'parula' colormap is a sequential variant similar to 'viridis' and, in our opinion, better emphasizes the features presented in the figures

- Part 2.7: How do you obtain vertical velocities? Is not your model in 2D (only horizontal velocities)?

Author reply: We are uncertain about this comment, as we do not reference vertical velocities in Section 2.7 or elsewhere in the manuscript.

- I appreciated that you added more discussion about results of your lagrangian experiments. However the sentence line 527: "...no fronts separated..." is a bit strong, because as you mentioned later you do not investigated the submesoscale dynamics. I suggest just to add the scale you refer to: "no mesoscale front ..".

Author reply: We have modified the sentence accordingly by specifying the spatial scale, as suggested.

- Same as above, the sentence on line 533, "...this situation is improbable..." seems a bit too strong. Do you mean that it is improbable for peculiar conditions to independently lead to two similar blooms? If so, it is not entirely evident that this is improbable. I agree that a single bloom occurring at both stations seems more likely. However, the distinction between the 'Same bloom patch' scenario in the heterogeneous case and the 'Independent bloom' scenario is not entirely clear. Similar optimal bloom conditions could have occurred at both stations, potentially leading to either heterogeneous patches or independent blooms, as you do not have data between the both stations.

Author reply: We have revised this explanation to strengthen the argument that it is highly unlikely for the same phytoplankton bloom—in terms of species composition and relative abundances—to develop independently (which means that they were never connected as the heterogeneous same patch scenario) at two separate locations. Essentially, both physical and biological components play a determining role in bloom development. The revised text reads as follows:

“A less likely scenario is that (3) two Amphidomataceae blooms developed independently at both locations (Fig. 12d). This scenario is highly improbable given the complex interplay of physical and biological processes that govern bloom development. On the physical side, advection, accumulation, and stirring of water masses act as selective forces, favoring the proliferation of certain species or functional groups over others, depending on local and transient conditions (Abraham et al., 2000; Lehan et al., 2007; Della Penna et al., 2015). Biologically, additional layers of variability—including interspecific competition, grazing pressure, successional dynamics, toxin production, and cyst formation—further shape bloom composition and trajectory. Considering the influence of such dynamic and site-specific factors, the independent development of blooms with identical species composition and relative abundances at two separate locations is unlikely. Furthermore, no dormant cysts of Amphidomataceae have been reported, ruling out the possibility of localized population outbreaks from a resting stage, as has been observed for other dinoflagellates forming HABs in frontal systems (Smayda, 2002; Akselman et al., 2015).”

Technical corrections

Some of the mistakes I raised in my initial feedback still appear in the revised manuscript. For example, in the abstract, the abbreviation AZA-2 is still missing after first mention of the full name (line 31), "metre" is still write instead of "meter" and "litre" instead of "liter". Line 73 the first "h" of thermohaline is still missing. Please refer to the previous file I sent to ensure all these corrections are made.

Author reply: We have amended these mistakes in the revised version.

- Part 2.2: It would be better if the objectives of the cruises are presented before the strategies

We have modified this part according to the reviewer's suggestion.

- Line 245: You say "two complementary analyses: Lagrangian advection ...", while in the discussion you refer to both analyses as Lagrangian experiments. I would suggest using "Lagrangian analysis" to describe both analysis as you refer in the discussion.

We have kept the use of analysis and experiments as to our understand, this writing is not confusing to refer to the Lagrangian studies shown in Figs. 8, 9 and in Fig. D.

We appreciate the reviewer's attention to detail. However, we are not entirely sure we understand the suggestion. In our view, the current phrasing—"two complementary analyses: Lagrangian advection..." as well as Lagrangian experiments or Lagrangian simulations — accurately describes the approach taken and is consistent with the way the methods, results and discussion are presented. We believe the current terminology does not introduce confusion, and for this reason, we prefer to retain the original wording.

- Line 266: "FSLE... exponential rate (λ [d⁻¹])" include the units. The equation is $\lambda(\delta) = 1/\tau(\delta) * \ln(\delta_o/\delta f)$, where both λ and τ depend on δ . Also, since FSLE are defined as λ , I suggest modifying the sentence on line 266, "FSLE are strongly linked..." to something like "FSLE are defined by..."

Corrected.

- Lines 333 and 334: Are the two numbers after the point (31.68 and 13.69) necessary?

We believe it is worth indicating these two decimal values. Including decimals allows for a more precise comparison between sampling stations, especially when dealing with high cell concentrations. For this reason, we prefer to retain the values as originally presented.

- Line 38: "100 km in diameter", "in" to remove

Corrected.

- Line 383: Which figure?

Figure 9, now added.

- Figure 10: "Fronts identified" – which fronts are you referring to? FSLEs identify the separation rate of a fluid. I agree that they also identify fronts (included within the Lagrangian coherent structures), but it's not entirely accurate to say it this way, especially because you are not focusing on fronts in this paper. I would suggest simply stating "FSLE ridges computed..." instead.

Corrected.

Is there a possibility of negative FSLE values? If so, why were they not displayed on the colorbar? Positive and negative values indicate the convergence or divergence of the flow (i.e., whether particles are getting closer or moving away)

Thank you for pointing this out. You are absolutely right—our FSLE values are indeed negative, and we inadvertently overlooked the negative sign in the colorbar. We have now corrected the color scales in Figures 10 and 11 to explicitly include the negative sign, and we have revised the corresponding section in the materials and methods and discussion sections to reflect this correction.

As you correctly mentioned, negative FSLE values indicate divergence of particles transverse to the filaments, which aligns well with our interpretation. In our case, the sampling stations are surrounded by strong negative FSLE values, suggesting that the phytoplankton bloom remains retained in place, rather than being advected away.

- Figure 11: I still don't see the clear purpose of this figure. Moreover, you already have the GIF video to demonstrate this

We consider Figure 11 important to include in the main manuscript, as it provides key information to support the daily evaluation of FSLEs and helps demonstrate that the sampling stations remained within the same water mass throughout the entire study period. While we agree that the GIF video offers a more dynamic representation of this process, it serves as a complementary digital resource. Figure 11, on the other hand, is essential for understanding and supporting the discussion within the main body of the text.

- Lines 424-434: As I already mentioned, it's better to avoid simply listing "factors"

We have decided to retain this paragraph in its current form, as we find the structure effective and the listing of key factors helpful for summarizing the main findings. In our view, this format contributes to the clarity and organization of the discussion.

- Line 572: "...acted as the physical driver", change "the" by something like "a crucial" as although your study demonstrates the crucial role of mesoscale circulation in bloom formation, other physical factors could also act in synergy to create optimal bloom conditions

Corrected.

Reviewer#2

As I indicated in my first review, I believe the proposed paper should be published, and in this opportunity the paper's presentation and organization of the various aspects considered have been improved. It is well written and has many relevant details, particularly for blooms that do not occur in the coastal sector, harmful blooms that are less documented in the scientific literature.

Author reply: We sincerely thank the reviewer for the positive and encouraging feedback. We appreciate the recognition of the manuscript's improvements and the relevance of documenting less-studied, offshore harmful algal blooms.

In the introduction my suggestion when the authors refer to the negative effects of harmful blooms, that productive activities such as coastal fisheries, aquaculture, and tourism should also be included among the activities affected by these phenomena.

Author reply: We appreciate the reviewer's suggestion to explicitly mention productive activities such as coastal fisheries, aquaculture, and tourism among those affected by harmful algal blooms. As noted, the negative impacts of HABs are introduced early in the manuscript (lines 46–48), where we refer to their effects on marine biota, ecosystems, and human health. We consider that these broad categories implicitly encompass the impact on ecosystem services, including biodiversity, food quality, tourism, and aquaculture. However, we chose not to include specific examples of coastal activities in this context, as our study focuses on offshore waters, where such impacts are less direct or may differ in nature.

And in the discussion, it would be interesting if the authors could provide comments regarding the interaction of microalgal assemblages and bacterial assemblages, particularly interactions between bacterial assemblages and harmful microalgae. The authors address physical interactions, biological interactions such as predation, and chemical interactions, but there is no mention of the aforementioned aspects, given the specific nature of the blooms described.

Author reply: We appreciate the reviewer's comment highlighting the importance of interactions between microalgal and bacterial assemblages, particularly in relation to harmful microalgae. We fully agree that microbial processes, especially during the advanced and senescent stages of phytoplankton blooms, play a key role in bloom dynamics and ecosystem functioning. However, given the specific focus and scope of our study, which does not include bacterial data, we believe that incorporating a detailed discussion of this topic would go beyond the objectives of the current manuscript. For this reason, we have chosen not to expand on these interactions in the discussion section.

Finally, when metabarcoding results are delivered, it is not clear if the presented results are exclusively oriented to *Azadinium* and *Amphidoma* species, since a very low diversity is noted in the results, the fraction of sequences that could not be assigned to any specific taxon should be discussed.

Author reply: We appreciate the reviewer's comment, as we had not fully addressed this aspect regarding the genetic analysis of the samples. In response, we have now added a note in the Appendix, below the Table, with the following information, as suggested by the reviewer:

“A total of 849 ASVs were identified; however, only 118 of these were successfully annotated at the species level (with over 97% similarity). This limitation may be attributed to the inadequacy of the ITS region database used in our study, which may have affected the taxonomic resolution of certain sequences.”