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Discussions

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Interactive comment on "Modelling biogeochemical processes in sediments from the north western Adriatic Sea: response to enhanced POC fluxes" *by* Daniele Brigolin et al.

Daniele Brigolin et al.

brigo@unive.it

Anonymous Referee #2

General Comments First let me apologies for the late submission of these comments as I lose the original document with the formal comments. This is a quick summary of what I remember by going through the draft again. Additionally let me add to this that my experience is with physical marine numerical modelling and data analysis, and I am not particularly familiar with the application on mussel farming. These aspect will be noticed by the focus of my comments. The approached ideas and objectives are interesting, however I see issues (disagree) with some of the method and ways that

the data was used. This could be as I am unfamiliar to this particular application and a good answer could quickly clarify these aspects (see specific comments). At this point I will not recommend to publish this work if not further improvements are completed. It was difficult to follow the document at the beginning (until section 2.3), after this it was easier to follow the structure. However improving figures 1 and 2 will help to create a clear big picture at the start (please, see specific comments). The specific comments and technical corrections start with the page (P) number and line (L) number to indicate the specific place in the text that is commented.

We thank the reviewer for the useful comments. Our answer to specific points are reported below. We remark that in order to improve the readability of the work we followed the suggestions by editing figures 1 and 2, and largely re-writing captions of these figures. Based on a specific point made by referee #1 we enlarged the description of the work steps in the last part of the introduction, and removed the bullet point description present in the first version of the ms at pg 2 lns 30-40. We tried to track within this document most of the changes performed on the text, when this was not possible, changes were implemented only on the manuscript (ms), and reference reported in the present document. Reference to the initial submission and to the updated version of the manuscript were detailed. When not stated, we imply reference to the revised version. The revised version of the ms is provided as a supplement.

Specific Comments P4 L38: How reliable is the Chla and SST data when the study area is near the coast (at âĹij 2km and the data resolution is 4km)? We agree with the reviewer on the importance of this aspect. First, we would like to remark that the simulation predicting growth and faeces and pseudofaeces production at the farm throughout the year was aimed at characterizing the behavior of a typical farm in this area during one decade (2002-2012).

In the present work we adopted two precautions aimed at smoothing possible artificial variability of Chla and SST data originated by the use of earth observation algorithms at coast, from which, in river influenced coastal areas, one could expect an overestimation

of Chla concentration induced by confounding non-phytoplanktonic color particulate matter. These were: 1) data were averaged over spatial domain wider than the area covered by the mussel farm (10km x10km=100 km2 versus 4 km2 of the farm - 2x2 pixels from satellite images included in the area); 2) 10 different runs were performed with the mussel growth model (population), and only the median trajectories (for faeces and pseufofaeces) were considered in the following deposition and early diagenesis model.

Therefore, one possible issue could have been the excessive smoothing of chlorophyll-a peaks (blooms), inducing an under-estimation of mussel growth. However, in terms of growth trajectories the model reported results which are comparable two growth patterns previously observed for mussels in this area (a comment about this is present in the results, section 3.1).

A further important point to mention is that similar approaches, based on satellite derived chlorophyll-a concentrations (Chl-a) and sea surface temperature data (SST) were reported for modeling the growth of the mussels in coastal areas (e.g. Filgueira et al., 2013; Thomas et al. 2011). In terms of growth and metabolic rates predictions, also these shellfish models were able to perform adequately, although being forced with time series of satellite data.

Y. Thomas, J. Mazuri, M. Alunno-Bruscia, C. Bacher, J.-F. Bouget, F. Gohin, S. Pouvreau, C. Struski. Modelling spatio-temporal variability of Mytilus edulis (L.) growth by forcing a dynamic energy budget model with satellite-derived environmental data J. Sea Res., 66 (2011), pp. 308–317

Filgueira, R., Comeau, L.A., Landry, T., Grant, J., Guyondet, T., Mallet, A.: Bivalve condition index as an indicator of aquaculture intensity: A meta-analysis. Ecol. Indic., 25, 215-229, 2013.

If you imply that the average of certain number of Chl-a and SST data points is representative of the study area, Where is explain in the methodology? Thanks, lat and long

edges of the domain in which data were collected were reported in the ms. Based on the reviewer comment we decided to add a sentence in the new version of the ms, in order to make the process more clear: "Chlorophyll-a and SST data were derived from the sensor Modis (Moderate Resolution Imaging Spectroradiometer) Aqua and Terra respectively, with a spatial resolution of 4km. Data were spatially averaged over the area defined above. "

For the coordinates mentioned in P4 L37 the number can be guessed, but it will be better to see the number. And finally, Is it representative for the 2km2 study area the Chla and SST time series if they were constructed based on an area of app. 100Km2?

Please see our reply to the two previous comments.

P4 L38: How do you address the problem of color particulate matter, optical shallow waters and water turbidity, where the river could have a major role to play? As example please see: * Cannizzaro and Carder (2006)â ÌÍA ÌE a [optical shallow waters]

Thanks, again, we believe that this is related with the use that was done of Chla data, which were provided as input to characterize the typical growth trajectory of a mussel over one decade, and in order to assess the mean Delta in POC flux induced by the presence of the farm. Based on this comment from the reviewer, we decided to add a specific sentence regarding the perspective use of the model (section 4.3 "Integrated model features"). The sentence reads as follows: "We underline that the application presented in this work could be extended, in order to include the evaluation of the uncertainties related to spatial inconsistencies of nearshore-offshore remote sensing products."

P5 L6: Could you show the current meter data? as you say that you are using the residual current edited. Why did you add storms? How many storms did you add in this random process? (You say that this method should be preferred for forecasting, however you are reproducing a period where you have data to validate and calibrate, Is not this closer to a hind-casting than a forecasting). Why you are not using the current

due to tides? Tidal currents will have an impact on particles that represent the faeces and pseudofaeces

Thanks. Based on the reviewer's comment, lines 5-13 at pg 5 of the previous draft were rewritten. A compass plot showing the time series of currents data was added to the supporting materials (Figure A2).

The number of storms was added on the basis of the incidence of storms detected within the time series analyzed (for the months from March to September), which was integrated by the analysis of current meter data deployed nearby the study area within previous studies (Rampazzo et al., 2013; Giovanardi et al., 2003 – in Italian). These latter data refer to year 2006 (July-September) and 2007 (April-May), and years 2001-2002 (from October 2000 until August 2002). With respect to the currents time series analysis, we extracted the residual current and the slowly varying tidal components, in order to separate the short-period fluctuations related to turbulence, which were accounted in the model by random displacement. We followed the procedure as described in the paper by Jusup et al. (2007), which was the source publication for our deposition model. For completeness, we report that a subsequent validation of the algorithm proposed by Jusup et al. (2007) in the Adriatic Sea was reported by Jusup et al. (2009), and therefore the model was coupled with a model of the mussel farm population in Brigolin et al. (2014).

We removed the reference to hind-casting and forecasting, since we think that this could generate confusion in the reader. With respect to the referee's question, we believe that the experiment performed in this work is closer to a forecasting simulation, since: - Currents are not provided directly from the current meter; - Sediment traps used for comparing model outputs (corroboration) were not deployed at the same time than current meter, and are therefore used to compare the typical deposition of the farm, and not with the aim of performing a strict model validation experiment. We believe that this type of simulation is in line with the other methodological choices previously explained, aimed at assessing the "typical" behavior of the farm, in terms of

deposition.

With respect to this point, the text included in the new version of the manuscript is the following: "Modelling deposition requires an input time series of water velocity at an hourly time step. These data were provided on the basis of a current meter deployment carried out between March and September 2010 at a station located approximately 500 m from the NE edge of the farm (Boldrin A. pers. comm). Current meter data were first processed by means of a classical harmonic analysis, in order to extract tidal components as well as long-term residual means (Pawlowicz et al., 2002). On the basis of the procedure proposed by Jusup et al. (2007), the residual currents were therefore edited randomly for short periods of time in order to reproduce the variability recorded from current meter measurements during extreme events (i.e. storms). Number of events was imposed on the basis of the 2010 current time series, and of previous current meter deployments available for this area (Rampazzo et al., 2013; Giovanardi et al., 2003). Effects of tide and storm events were therefore accounted in the final time series, while short-period fluctuations related to turbulence were accounted for by the deposition model, as reported by Jusup et al. (2007)."

Rampazzo, F., Berto, D., Giani, M., Brigolin, D., Covelli, S., Cacciatore, F., Boscolo, R., Bellucci, L. G., Pastres, R.: Impact of mussel farm biodeposition on sediment biogeochemistry in the north-west Adriatic Sea. Estuar., Coast. Shelf S., 129, 49-58, 2013.

Giovanardi, O., Cornello, M., Tiozzo, K., Casale, M., Franceschini, G., 2003. Effetti degli aggregati mucillaginosi sulle comunità macrozoobentoniche al largo di Chioggia. Programma di monitoraggio e studio sui Processi di formazione delle Mucillagini nell'Adriatico e nel Tirreno (MAT) Rapporto finale vol. II. ICRAM, Roma, pp. 351-366.

P6 L11: Please explain further in the method section that the mean of Chl-a and SST is spatial and temporal, resulting in a mean or characteristic year for each variable. This means that strong events of Chla are smooth as shows figure A1b, which means

implication for the model individual growth and population model.

Thanks. As reported above, the sentence – data were spatially averaged over the area defined above – was added, bringing to the following specification: "Chlorophyll-a and SST data were derived from the sensor Modis (Moderate Resolution Imaging Spectroradiometer) Aqua and Terra respectively, with a spatial resolution of 4km. Data were spatially averaged over the area defined above.". As far as the temporal average is concerned, this was not performed on SST and Chl-a data, and one different model trajectory was provided for each simulated year (see plates in Figure 3). Results of the mussel population growth model were therefore summarized as a median value in order to provide an average input for the deposition model (this step is specified at lines 23-24 pg 5 "The median daily value of faeces and pseudofaeces fluxes from the 10 simulations was used as an input for the deposition model.". We also attempted to resume this within the cartoon presented in Figure 2. With respect to the influence that this could have on the growth model, please see our reply to comment P4 L38 above.

P6 L34: If you are going to use cm here, then please use cm in the figure. Thanks. Units were uniformed to mm for porosity.

P7 L36: Are the features and methods of Weise et al, (2009) comparable to yours? Depth of the study area, mean velocity (if they are considering residual current or not), size of the farm, etc The same comment goes of the Hatstein and Steven (2005) reference.

Thanks, as mentioned in the text, Hatstein and Steven (2005) and Weise et al (2009) were reported in our work as examples of previous studies focusing on modeling shell-fish deposition. Concerning methods, models are comparable, being all based on a Lagrangian approach, however, in both cases, POC originated from the farm was not modeled, but prescribed to the model a-priori. This aspect was underlined in the last section of this ms (section 4.3).

As regards bathymetries there are differences, 14 m in this work, 20 m in the exposed

site located in Cascapedia (Weise et al., 2009), 20 m in the more sheltered site considered by Hatstein and Stevens (2005), New Zealand. Our average current velocity was 5.4 cm s-1, in the exposed farm in Cascapedia 10 cm s-1, while in New Zealand the velocity was 3.4 cm s-1.

The comparison that was reported at the beginning of the discussion, was aimed at underlining this potential variability in the extent of the dispersal area, and the fact that our case study represents an intermediate between the other two reported. The sentence is the following - for the sake of clarity, we added details about our case study, depth and mean current velocity in brackets on the first line:

"The extent of the depositional area obtained in this study (on average 50 m from the edge of the farm; 14 m depth; mean current velocity of 5.4 cm s-1) can be compared with the results obtained in previous studies. In an exposed site, Weise et al. (2009) (Cascapedia Bay, Canada; 20 m depth; mean current velocity of 10 cm s-1), constrained the area of higher organic enrichment within 90 m from the edge of the farm. Dispersal area reported by Hatstein and Stevens (2005) was smaller, extending with a radius of approximately 30-40 m from the edge of the farm (20-30 m depth; mean current velocity of 3.4-4.0 cm s-1). These differences in extent of the dispersal areas seem to be primarily associated to the action of currents and wave energy inducing resuspension of biodeposits accumulated on the seabed (see Cromey et al., 2002)."

Figure 1 : The figure does not explain itself. It is not possible to know the meaning of the rectangle and and points in the figure. In my first look at the figure, the river was a road and I have to google the river to find out where it was.

Thanks. The caption was rewritten, including information on the different elements of the figure, and distinguishing station under the influence of the farm from nearby stations, located outside the influence of the farm (as suggested by reviewer #1). Colors of the river and the lagoon waters were also changed, in order to improve the figure readability.

Figure 2 : The figure caption is not good. Please give to the reader enough information for the "Information flow". Please add to the boxes in the diagram the reference to each represented/used model. Thanks for this useful suggestion. This was implemented it in the new version of the caption. Why are you using the word reanalysis for the current input in the particle tracking model (faeces and pseudofaeces)? Here wording was a mistake, and text was rephrased. "Reanalysis" did not refer to the procedures used by studies using data assimilation techniques.

Figure 3 : What is the meaning of the sharp changes shown by graph a? It will better If the caption has more information about the figure. As example, if this represented data are modeled results or measurements. Discontinuities shown by graph-a are due to weight loss after spawning events. These are all model results, and details about model theory are available on the paper by Brigolin et al. (2009). Based on this comment we added additional explanations to the figure caption.

Figure 5: Squares and triangles without legend. Y-axis without label just units. Thanks, the figure caption was rewritten, in order to clarify these aspects.

Figures in general: Improve caption for the figures to stand by themselves. Thanks. We worked on this aspect throughout figures and tables.

P6 L23: Does this agree with the mean current velocity, mean vertical velocity for the particles to sink and mean depth? considering the free fall of a particle, an average depth of 10m (particle released at the middle farm), and the fastest particle sinking velocities (1.0 cm s-1 for faeces), the 200m displacement means an average current velocity for that day of approximately 20 cm s-1, which is in agreement with the current meter observations during storm events (see fig A2).

Technical Corrections

P3 L27: Define acronym POC earlier. There are few times before this where the acronym is used. Thanks, in the new version of the ms POC is independently de-

fined in the introduction and in the abstract. In the title, the acronym POC has been substituted by the extended name.

P4 L16: Reference Cappellen and Wang, 1996 is not listed in the references The reference is Van Cappellen and Wang, 1996. The name of the first author was reported with the capital V in the text and in the reference.

P5 L 26: Define the acronym PVC. done

P6 L6: Define acronym HPLC done

Boudreau (1996) and Sanchez-Jerez et al (2016) listed in the reference but I did not find them in the text un-cited references were removed.

Please also note the supplement to this comment:
https://www.biogeosciences-discuss.net/bg-2017-206/bg-2017-206-AC2-supplement.pdf

Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2017-206, 2017.