Response to Anonymous Referee #1

We would like to thank Anonymous reviewer #1 for his/her time and insightful thoughts on our manuscript. Here, we address all the major and minor comments highlighted by reviewer #1. Reviewer's comments are in Arial font and italicised, responses are in Times font, and suggested additions if necessary are in bold, italic Times font within inverted commas:

1. *"In the introduction the authors ………. Nevertheless, when attempting to explain what drives the variability in the fluxes they ignore this species-specific behaviour and only describe the total PF flux. This needs to be addressed. At the minimum the authors need to discuss the different patterns in the three groups of species they distinguish (surface, intermediate and deep dwellers), but ideally they also attempt to explain what drives the differences between the individual species in these groups"*

The citation of Kuroyanagi and Kawahata (2004) in its current form is perhaps a bit misleading considering we do not concentrate on species-specific responses in this paper. We propose to remove the species-specific comment in Section 1, page 12225, line 16: "***in addition, different environmental variables may induce species-specific responses (Kuroyanagi and Kawahata (2004)***"

We agree with the reviewer that the species-specific variability is interesting as we observe in section 4.2, page 12231, lines 12-15. However, for a detailed discussion of seasonal species-specific variability and assemblage shifts at this site, the remaining 15 species present need to be taken into account. Such a detailed study is ongoing by Prof. Warren Prell at Brown University from the 3200m-depth trap, which will include our overlapping species-specific data (for 11 PF species) from the shallower trap. This combined long-term data from two different depths will be published separately and would make a more comprehensive comparison with previous time-series work from same location.

We deliberately wanted to focus on what causes interannual changes in total PF flux as a whole in this specific manuscript because it better describes the overall biological response to distinct oceanographic features such as eddies. Seasonal variations in PF species have been extensively studied at this site (Fairbanks et al.,1980, Deuser et al. 1981, Deuser 1987, Deuser and Ross 1989 and Tolderlund and Bé 1971) and flux changes in groups of PF species have been previously linked to phytoplankton succession here and at other sites (Tolderlund and Bé 1971, Thunell and Reynolds, 1984, Deuser and Ross 1989, Sautter and Thunell, 1989) so we found it unnecessary to include a separate discussion on individual species groups and instead focus our study on an interannual-based total PF flux which makes a unique and perhaps valuable contrast to the species-specific seasonal-based studies previously published.

For current purposes, we hope that figures 4-6 show readers how the species selected for this study relate to one another on a seasonal and interannual timescale (species studied= 11 and total PF species present= 26). In addition, we have added a brief discussion of surface dweller variability in contrast to deeper dweller variability in answer to comment 4.

2. *"Moreover, the division into the groups in terms of depth habitat is in this respect perhaps not the most useful and the authors may want to divide the species into groups that share similar shell flux patterns."*

In general, we observe that the depth-habitat grouping also tends to describe similar flux patterns, but will be willing to change "***Figures 4-6"*** according to the similar flux patterns as below, if essential:

"Group 1: ***G. ruber*** **(white and pink),** ***G. sacculifer***
Group 2: ***N. dutertrei, G. siphonifera O. universa***
Group 3: ***P. obliquiloculata, G. truncatulinoides, G. hirsuta, G. crassaformis, G. inflata"***

3. *"When it comes to the species specific flux patterns, the difference between the timing of the peak flux of the deeper dwellers is interesting and something the authors point out, but do not discuss"*

We agree with the reviewer that it is interesting that *G. truncatulinoides* flux peaks before other deeper dwelling species. We will add the following text to section 5.1.1, page 12233, line 2:

"from the spring phytoplankton bloom (Hemleben et al. 1989). ***The discrepancy in timing of peaks between the deeper dwellers (Figure 7) is likely due to subtle changes in food availability and diet of species and phytoplankton succession (Deuser and Ross, 1989, Hemleben et al. 1989). Overall, the seasonal PF species succession is broadly similar to previous observations from 1959-63 and 1978-84 (Tolderlund and Bé, 1971, Deuser 1987, Deuser and Ross, 1989) which suggests that despite long-term environmental change, there has been no significant shift in species seasonality and environmental controls have remained consistent over the past 50 years."***

As mentioned above in response to comment 1, we hope to explore these relationships in more detail with long-term species seasonality data set in a separate manuscript.

4. *"Similarly, there seem to be clear changes in variability in the flux between years for several species (G. sacculifer, G. ruber (white) and G. siphonifera) and (surprisingly) apparent absence of seasonal variability in some surface dwellers (large changes in temperature and other environmental parameters)."*

We suggest the interannual changes in surface dwellers may be due to the relatively 'stable' environmental variables prevalent within an oligotrophic subtropical gyre. For instance, the thermal tolerance of the surface-dwelling species are never exceeded throughout the ~8°C seasonal surface temperature changes at BATS and the nutrient content of the upper mixed layer is almost always negligible. In addition, their shorter lifecycles (~couple of weeks compared to months for deeper dwellers) suggests they may be more adaptable to environmental changes in the surface ocean and therefore their fluxes may reflect more environmental noise when compared to deeper-dwelling species.

As we mentioned in response to comment 1 above, species-specific seasonal and interannual responses will be described in detail in a different manuscript but we will add a brief explanation on the interannual flux changes in the surface dwellers, section, 5.1.1, page 12233, line 5:

"…and the export flux of phytodetritus to depth. ***The surface-dwelling symbiont-bearing foraminifera have lifecycles which benefit from strongly stratified surface waters in order to photosynthesise so they can succeed in low nutrient conditions (Hemleben et al. 1989) and do not bloom when the mixed layer is deepest. Surface dwellers generally bloom in late summer when sea surface temperatures are at a maximum and dinoflagellates are abundant (Tolderlund and Bé, 1971).*** We thus conclude that the depth of the mixed layer plays an important role in regulating PF flux….."

5. *"I find this section of the manuscript (5.1.1 and 5.1.2) difficult to understand, or rather, difficult to understand the mechanisms that would underlie the observed relationships. At the beginning of the authors mention observations from the high latitudes that show a relation between MLD deepening rate and deepening timing and productivity. Subsequently the deepening rate and its potential influence on PFF is discussed and another parameter (shoaling rate) is introduced, but the timing of the MLD deepening is not discussed. I find this confusing and have several comments on this section: First of all, the mechanism the authors use to explain how MLD can exert an influence on the PFF is indirect and via export productivity, which they derive from surface chl-a concentrations and carbon fluxes at different depths. Since the authors state that the foraminifera rely on the organic matter flux from the surface ocean for food (and hence growth and hence flux), it would make sense to explore this relation first and then focus on the relations between OM export and MLD dynamics. The relation between PFF and MLD is only indirect and correlations between PFF and MLD could therefore be misleading."*

We only acknowledge the fact that the seasonal flux in export fluxes of organic carbon may fuel PF production in section 5.1.1, page 12232, section 5.1.1, line 19.

However, we realise that export fluxes of organic carbon will only benefit the symbiont-barren foraminifera with herbivorous diets, in particular deeper dwelling foraminifera. Therefore, Chlorophyll *a* is a much more inclusive indicator for foraminifera food concentration; it is generally correlated with copepods, a prey of spinose foraminifera (*O. universa, G. ruber, G. sacculifer,* Hembleben et al. 1989), and non-spinose foraminifera with herbivorous or detritivorous diets generally feed on prey which contain chlorophyll *a* (Lombard et al. 2011). It therefore follows that environmental controls on Chlorophyll *a* should also control the abundance of planktonic foraminifera (if not light-limited, and within thermally favourable conditions- Ortiz et al. 1995). There may be some light-limitation at this site as suggested by Lombard et al. 2009 but there was not enough data to confirm this during their study. Our findings are consistent with other PF flux studies where seasonal changes in the mixed layer depth and associated changes in chlorophyll *a* concentrations show strong association to seasonal changes in species fluxes (King and Howard, 2003, Thunell and Reynolds, 1984).

We will change section 5.1.1, Page 12232, line 17 to clarify this (changes in bold italic):

"Here, we also observed a simultaneous seasonal peak in chlorophyll a and maximum depth of the MLD ***as seen by previous studies at BATS (Cianca et al. 2012)***, the timing and amplitude of which coincides with the maximum PF flux (Fig. 2c and d). ***This observation is consistent with previous findings in other ocean basins where seasonal changes in mixed layer depth are closely associated with changes in foraminifera production (Thunell and Reynolds, 1984, Sautter and Thunell, 1989, Pujol and Vergnaud Grazzini 1995, Schmuker and Sciebel 2002) and chlorophyll a concentrations (King and Howard, 2003, 2005). Siegel et al. (2002) proposed that south of 40^{o}N, the initiation and extent of the spring bloom is dominantly limited by nutrients rather than light, and this is supported by the simultaneous increase in phytoplankton concentrations with mixing depth at BATS (Treusch et al. 2012***). Vertical mixing in late winter and spring distribute nutrients into the euphotic zone to support the spring phytoplankton bloom ***which fuels foraminifera production***, as indicated by the seasonal peak in export fluxes of organic carbon (Fig. 1d)"

6. *“Secondly, while the observed relationships the authors identify in Fig. 9 are statistically convincing, I struggle to grasp what the actual mechanism(s) explaining these observation is (are). Does it mean that the spring bloom has always approximately the same length (relation between Dr and MLD)?”*

In this study, the seasonal peak in PF flux is always of approximately the same length. The spring bloom only starts when the MLD penetrates the nitricline and deep chlorophyll maximum which lies at 80-100m at this site. The MLD starts to deepen with increased wind stress and decreased heat flux at the surface and this can vary due to changes in the North Atlantic Oscillation (NAO). For instance, winter 2009 experienced the deepest MLD (and fastest deepening rate) driven by the negative NAO causing increased wind stress and convective mixing. However, slower deepening rates such as in 2007-2008, led to the formation of a shallow mixed layer depth. The deepening rate is controlled by wind forcing and heat fluxes in the surface ocean and thus it primarily reflects the maximum depth reached by the mixed layer and therefore concentration of nutrients entrained into the euphotic zone and consequent size of the following spring bloom. We will re-write section 5.1.2. to incorporate this explanation.

7. *And if Sr has a major influence on productivity and PFF why do fluxes increase when conditions are changing to less optimal conditions (stratification) more rapidly?*

There are potentially two factors, which could control the size of the phytoplankton spring bloom at BATS and therefore the food availability for PF that we will clarify in section 5.1.2, page 12233.

1. The dominant control is the depth of the mixed layer (determined by the strength of convective mixing reflected in the deepening rate)
2. There is some evidence that light availability could be a secondary, weaker control (Dutkiewicz et al. 2001, Cianca et al. 2012, Lomas et al, 2009) as the euphotic zone at this site lies ~100m (Steinberg et al. 2001).

The shoaling rate reflects the rate at which the nutrients mixed in the water column are entrained to the surface where they can be utilised by phytoplankton, which require light to bloom. A faster shoaling rate will also concentrate the food for foraminifera in the euphotic zone, producing a shorter and sharper bloom, as mentioned in section 5.1.2, page 12233, line 11, or as we see here, a larger bloom. Years with quicker shoaling rates (1998-99 and 2009-10), have greater fluxes of thermocline dwelling species such as *N. dutertrei, P. oblquiloculata, G. siphonifera*, and in 2009-10, *O. universa* suggesting that during higher rates of shoaling, the seasonal thermocline is nearer to the surface which is beneficial for these symbiont-bearing and symbiont-facultative species. We will re-write section 5.1.2. to incorporate this explanation.

8. *"This needs more explanation and the authors need to be clear about whether it is absolute MLD, Dr, Sr, or their ratio (or something else) that controls the PFF (see also P12233, L28 and beyond where in one year the large flux is suggested to be related to Dr and MLD and in another year only to MLD, whereas in Fig. 9 and on P12233, L 21-23 PFF is said to depend on the Dr/Sr, which mainly reflects the Sr)."*

We have re-written section 5.1.2, page 12233-34 discussing the explanations written above and will alter references to the D_r/S_r to just discussing the shoaling and deepening rates in this section of the text. We will more fully describe the controls of deepening and shoaling rate and how this relates to the depth of the mixed layer by including some of the explanations in answers to comments 6-7.

9. *"1. What is the basis of the 80m limit used to determine the relation between MLD and PFF? It seems arbitrary. "*

The '80m' limit corresponds to the Deep Chlorophyll Maximum Layer (DCLM), where many species of PF reside in association with other zooplankton (Fairbanks and Wiebe, 1980) is ≥ 80m for the majority of the year (Steinberg et al. 2001). This is supported by Treusch et al. 2012, who found that the DCML developed between 80-120m during the summer stratification period. In addition, Steinberg et al. 2001 found that deeper mixed layers (>100m) are associated with higher chlorophyll *a* values. >80m is also the depth horizon at which the nitrate concentrations exceed 0.1 umol/kg which defines the nitricline (Sciebel et al. 2001) (see page 12232, line 22).

This means that unless the mixed layer penetrates at least 80m, then access to the food supply for PF is limited and this is why we see a correlation in Figure 3c.

We will add the following to section 5.1.1, Page 12232, line 21:

" In contrast, there is no correlation during the late spring to autumn when the MLD is less than ~80m (Fig. 3d), ***the minimum depth of the deep chlorophyll maximum layer where many species of planktonic foraminifera reside in association with other zooplankton and algal cells (Fairbanks and Wiebe, 1980). During summertime, the mixed layer fails to penetrate this layer also known as the nitricline (defined as nitrate concentrations > 0.1 umol kg^{-1} "***

10. *"2. The shoaling rate in year 2000 represents only a minimum value since there is a month missing during the decrease of the MLD. This could affect the results of the regression. "*

This is true. We will omit this value from the regression and in Table 2.

11. *"3. The deepening rate is defined as the average of the rate between Oct and Jan. Why this interval and not the average rate over the entire period of MLD deepening (which extends beyond Jan)?"*

The deepening rate used in Table 2 does in fact represent the entire period of deepening regardless of the month. This will be re-written on Section 5.1.2, page 12233, line 13:

"At our subtropical study site, the mean rate of deepening of the mixed layer is strongly correlated to the maximum MLD reached ($r^2 = 0.88$)"

12. *"4. How are the start and end of the spring bloom period defined? And therefore the average winter-spring flux? This needs to be done objectively in order to compare different years.*

Currently the spring bloom and winter-spring flux varies in its start, length and end point each year but is always within approximately the same 6-month period (end of November to April). The spring bloom average here was calculated based on the time when the PF flux began to first increase dramatically (which varies year to year, see table below). We therefore calculated the duration of the bloom and the average flux based the table below:

Year of bloom	**Month of bloom 'start'**	**Month of bloom 'finish'**
1998	February	April
1999	February	April
2000	January	April
2008	December	February
2009	December	March
2010	January	March (but continued to May due to eddy interference)

We make each year comparable by integrating the total PF flux over the spring bloom so it is independent of the start, finish and duration of the bloom.

13. *And in addition, wouldn't the integrated flux be a better parameter to investigate?"*

We do use integrated flux - we will change the legend in Table 2 to describe this as 'integrated winter-spring PF flux' and on the y-axis labels on figures 9b and 9d.

14. *"5. What is the physical reason the fit a logarithmic curve to the data in Fig. 9D? Would one expect such a relationship with decreased sensitivity at faster rates?"*

There is no physical mechanism to explain why higher rates of shoaling should cause lower sensitivities of the PF flux. The logarithmic relationship was simply applied to include an anomalously quick shoaling rate in spring 1999 (Table 2). We will apply a linear relationship in Figure 9D.

15. *“The suggestion that eddies can under certain circumstances prolong and/or enhance primary productivity and PFF is very interesting. Discussing what these circumstances are exactly would contribute to the quality of the paper. There are several times when the passing of an eddy did not have an effect on the PFF (e.g. winter 98/99, 07/08). Where they too early? Or were other conditions not met?”*

We will put our findings on eddies into more context with other observations of PF flux changes within eddies in section 5.2, page 12234, line 12 (changes in bold italic):

The negative sea level anomalies in spring 2009 and 2010 indicate that the large (and in 2010 prolonged) PF fluxes in these years are clearly associated with the passage of cyclonic eddies (Fig 2b). ***Eddy pumping of nitrate into the euphotic zone has been extensively studied at BATS and shown to significantly increase new production (Oschlies and Garçon, 1998) although estimates of eddy nitrate contribution range from*** ~30-70% in the Sargasso Sea. ***The upwelling/downwelling of nutrients by cyclonic/anticyclonic eddies have been shown to either*** promote ***or suppress*** phytoplankton blooms (Eden et al., 2009; Goldthwait and Steinberg, 2008; McGillicuddy et al., 1998, 1999, 2007; Sweeney et al., 2003; McGillicuddy and Robinson, 1997, ***Lomas et al. 2013, Cianca et al. 2012***) and ***therefore affect the PF food source (Schmuker and Schiebel, 2002)***. ***In addition, eddy pumping may vary on decadal timescales in concert with NAO changes as suggested by Cianca et al. 2007. Previous studies have found higher fluxes of certain PF species such as Globigerinita glutinata associated with cyclonic eddy structures in the Caribbean Sea (Schmuker and Schiebel, 2002), North Atlantic (Beckman et al. 1987), in conjunction with upwelling frontal regions in the Mexican Pacific (Machain-Castillo et al. 2008) and deep mixed layers during winter in the Mediterranean (Pujol and Vergnaud Grazzini, 1995). We see a similar response in our record in spring 2009 particularly for deeper dwelling species, which was the largest PF flux observed over the entire record, even though the maximum MLD was modest, and the average rates of mixed layer deepening and shoaling were similar to lower flux years (Table 2).***

And in Section 5.2, page 12235, line 4:

…during the seasonal flux of deeper dwellers (Fig. 6). ***This observation is in agreement with findings from the Eastern Basin of the Mediterranean where greater numbers of grazing species such as G. truncatulinoides and G. inflata are found in association with numerous eddy structures and deep mixed layers (Pujol and Vergnaud Grazzini, 1995). These findings suggest that cyclonic eddies enhance the abundance of deeper dwelling species through aiding their annual reproductive migration through mixing of the water column in addition to driving large carbon export flux.***

Section 5.2, page 12235, line 8:

Occurrence of cyclonic eddies synchronous with deep MLDs act to enhance the existing seasonal cycle of certain PF species associated with mixed water columns by increasing cyclonic mixing, and therefore chlorophyll concentrations and organic carbon flux. From our results, we observe no biological response when cyclonic eddies do not occur synchronously with deep MLDs, such as in winter 2007-08 when the mixed layer barely penetrated the nitricline. This suggests that the extent of the spring bloom and PF flux is dominantly controlled by the mixed layer dynamics and cyclonic eddies act to enhance this existing seasonal cycle. For instance, spring 2010 experienced the deepest mixed layer observed during the entire BATS time series (Lomas et al. 2013), enhanced by a cyclonic eddy. Our observations also suggest that eddies need to be present for a minimum of 1 month to elicit responses in PF which have minimum lifecycles of two weeks. For instance, in winter 1998-99 a cyclonic eddy passed over the sediment trap site in only one month but elicited no biological response, compared to cyclonic eddies in 2009 and 2010, which both remained over the site for a minimum of 2-3 months and elicited large biological responses. Similarly, recent studies have found that biological responses differ depending on the type and age of the eddy (Mouriño-Carballido and McGillicuddy, 2006) and eddies that are a minimum of 1-2 months old are more likely to induce a larger biological response (Sweeny et al. 2003). In our record, spring 2010 experienced the deepest mixed layer observed during the entire BATS time series (Lomas et al. 2013), when the deepest MLD and fast shoaling rate was combined with a particularly negative NAO index and a large cyclonic eddy ***which remained at the trap site for up to 3 months***. ***The deep MLD and fast shoaling rate during spring 2010 caused elevated chlorophyll a***

concentrations in the surface 25m (Figure 2d) and the following cyclonic eddy caused a large peak in chlorophyll a concentrations at 80-100m (the level of the deep chlorophyll maximum), similar to elevated subsurface chlorophyll a concentrations following a cyclonic eddy observed by Cianca et al. 2007. These conditions prolonged the PF flux and all other mass fluxes in 2010 (Figure 1)**.**

16. *It is interesting that the eddy in 2010 seems to be associated with increased PFF and organic carbon fluxes, but not with higher chl-a (i.e. no bloom?). Could this perhaps point to lateral advection of foraminifera or of organic matter (which would fuel foraminifera growth without requiring an increase in primary productivity) within the eddy?"*

Although the concentrations in the surface (0-25m) chlorophyll *a* are not elevated, the subsurface chlorophyll *a* concentrations within the province of the deep chlorophyll maximum and nitricline (80-100m) are the highest recorded at BATS since 1990. This is similar to observations of eddies made by Cianca et al. 2007 who found elevation of chlorophyll *a* and nutrients at 100m during a cyclonic eddy in the Eastern North Atlantic. This increase in primary productivity during spring 2010 is also supported by the high, prolonged fluxes of all the mass fluxes (Figure 1).

We will change Section 5.2, page 12235, line 10 (as stated in answer to comment 15):

The deep MLD and fast shoaling rate during spring 2010 caused elevated chlorophyll a concentrations at the surface (Figure 2d) and the following cyclonic eddy caused a large peak in chlorophyll a concentrations at 80-100m (the level of the deep chlorophyll maximum), similar to elevated subsurface chlorophyll a concentrations following a cyclonic eddy as observed by Cianca et al. 2007. These conditions prolonged the PF flux and all other mass fluxes (Figure 1)**.**

The increased subsurface Chl *a* suggests that the cyclonic eddy caused an isopycnal uplift which increased primary productivity to drive the sustained PF flux, rather than lateral advection of the foraminifera population. This corresponds to increases in thermocline species such as *O. universa* coincident with the subsurface Chl *a* peak. This argues against a PF population being laterally advected independent of any primary productivity increase, although we do acknowledge that eddies could provide a mechanism to transport foraminifera in other instances.

17. *The influence of the NAO: “The suggested link with NAO is very interesting. It is based on two years with positive- neutral NAO and one year of negative NAO. Of the years of positive/neutral NAO one is from a trap more than 1500m further down and it has often been shown that PFF recorded at different depths can differ significantly. Therefore the suggestion that NAO might have an influence on the PFF is effectively based on only two years of observations (what about the other years in this study? How do they relate to NAO?)””*

We will add a new figure 10 incorporating all PF flux from this study and Deuser, (1987), Deuser and Ross, (1989) (NAO vs. PF flux) and rewrite section 6, page 12236, line 6:

“To test this, ***we compare PF fluxes covering a range in NAO indexes, from this study using the 1500m sediment trap to those made by Deuser and Ross, (1989) between 1978-84 using the 3200m sediment trap. Despite comparing traps from different depths, the annual integrated PF fluxes are comparable and all are plotted in Figure 10 against the wintertime (DJFM) NAO index, the months coinciding with the period of maximum PF flux. In this comparison, the wintertime NAO index from the previous year (before the PF flux) was used because there is likely to be a time lag of between 6-12 months before the ocean responds to atmospheric forcing (Bates, 2001, 2007, Cianca et al. 2012). Generally PF fluxes are higher during negative NAO phases and lower during positive phases, consistent with correlations between NAO and chlorophyll a variability (Lomas et al. 2010) and MLD (Bates, 2012). The regression in Figure 10 does not include the year 1978-79 because the NAO index for February 1978 is skewed towards an anomalously negative sign in February, despite a positive sign in January and March. The PF flux may not have responded as expected in 1978 due to a shallow MLD or even an anticyclonic eddy which can suppress the spring bloom and hence PF flux, as seen in 1994 at BATS by Lomas et al. (2013). Furthermore, we find on average a 28% reduction in PF flux in NAO positive compared to NAO negative years ($p < 0.025$), when combining PF flux data with those from 1979-84 in Deuser and Ross (1989).”***

*NAO data available from http://www.cpc.ncep.noaa.gov/data/teledoc/nao.shtml

18. *"While it is an interesting suggestion that the NAO can have an influence on the PFF and therefore on the C-pump I think it's only that: a suggestion and the conclusions should be toned down accordingly (also in abstract)."*

We would be happy to include figure 10 (NAO vs. PF flux) to strengthen the implications section (section 6, page 12236) but include a statement to acknowledge the limitation of the dataset such as on page 12236, section 6:

"***We do recognise that the data set used in this example is limited and a more flux data collected over a longer time period is needed to fully test the observed decadal changes between NAO and PF flux."***

And on page 12237, section 7, line 22:

"Our findings suggest that the North Atlantic Oscillation, via its influence on mixed layer depth, ***eddy pumping and nutrient upwelling could act to modulate the total PF flux*** and the foraminiferal component of the carbonate pump in the subtropical North Atlantic on decadal timescales. ***However, this finding is only based on 8 years of PF flux data and a much longer-term dataset will be needed to fully understand if the NAO can modulate the PF flux on decadal timescales."***

19. The shell flux data should be made available, either as a table in the paper or through an on-line database such as Pangaea.de.

Yes, this will be done (available from Pangeaa.de after acceptance)

20. P12224, L2: oligotrophic regions are by definition nutrient poor.

Changed

21. P12226, L20: warm temperatures should be high temperatures and similarly cold should be low. Please change throughout the manuscript.

Changed

22. P12229, L9-16: this should be part of the paragraph describing the OFP time-series (3.1).

This section has been added to Section 3.1, page 12228, line 22.

23. P12229, L19: perhaps change ‘relative’ to ‘in relation’?

Done.

24. P12229, L24: ‘deep spring fluxes’ is not clear.

We have changed ‘deep spring fluxes’ to ‘spring mass fluxes’.

25. P12231, L20: t is not clear that the timing of the maximum is really later. I suspect that given the inter-annual variability this difference is insignificant.

We have changed section 4.2, page 12231, line 18 to read:

G. truncatulinoides is then followed by *G. hirsuta, G. crassaformis* ***and G. inflata which all peak between March and April.***

26. P12234, L11: mesoscale eddies are also an environmental control on the PF, the §should therefore be 5.1.3.

Changed to 5.1.3.

27. Fig. 2: please be consistent in the use of symbols for the parameters other then PF.

Fig. 2 c,d,e have all been changed to the same symbol

28. Fig. 3c,d: what is the criterion for splitting at 80m?

Please see response to Comment 9.

29. Fig. 4-6: please add SST curve to graphs to provide clearer information about when the peaks occurred. There is no gap in the time-series of G. sacculifer in Fig. 4.

Done.

30. Fig. 7: place G. crassaformis on its own axis to show the variability.

Done.

31. Fig. 9c: I assume that the extreme chl-a datum has been excluded from the regression. Please indicate this clearly.

Done.

New References

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