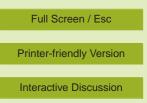**Biogeosciences
Discussions**

Interactive
Comment

Interactive comment on **"Sub meso scale phytoplankton distribution in the north east Atlantic surface waters determined with an automated flow cytometer"** *by* **M. Thyssen et al.**

M. Thyssen et al.

Received and published: 27 September 2008

Anonymous Referee #3

Received and published: 24 June 2008 General comments: The authors present an excellent dataset, providing one of the few currently available for pico- and nanoplankton at this high resolution. They analyse this in an attempt to explain the large amount of variability witnessed within it. At larger scales they relate variability to hydrographic properties. At smaller scales they see the variability as predominantly temporal in origin. My main concerns relate to the interpretation of the data at these two scales. My first concern with the manuscript is that the analysis appears to make a bold assertion regarding the source of small scale variability (with the consequence that the title

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and last but one sentence of the paper may be misleading). Most people would take 'sub-mesoscale' to refer to physical length-scales, and the excellent dataset presented here is of a high enough spatial resolution to do this. However, the only analysis carried out on the small scale variability focuses on interpreting it as temporal variability. If the variability is predominantly temporal (and synchronised across regions as the correlation analysis implicitly assumes) then the implication is that there is little spatial variability at sub-mesoscales. However, it is difficult to see how such significant fluctuations in abundance could be explained by diel cycles of reproduction as each reproduction can only change the abundance by a factor of 2 at most. I suspect that both diel cycles in physiology and submesoscale spatial variability are present and that the authors face the difficult task of separating the two. This is exacerbated by the fact that I have concerns about the technique used to infer periods of temporal variability (please see below). My second concern is that the analysis at larger scales is purely qualitative: no attempt is made to establish the strength of the relationships between hydrography, nutrients and organisms abundance/properties quantitatively in the 5 sub-regions, even using correlation analysis. Furthermore, I have a concern regarding comparisons to mixed layer depth (please see below).

Reply: The referee made evidence of the main difficulty of this work, separating the physical from the biological processes at sub meso scale that define the distribution of the observed phytoplankton cells. Correlations at the sub meso scale between temperature, salinity and abundances, FLR and FWS did not give significant results compared to that from autocorrelation calculations. A sentence was added in the Results section and discussed. A table representing the correlations between temperature, salinity, and the cellular parameters was added. Salinity did not change cyclically compared to temperature or abundances, suggesting that good correlations with salinity is a mark of meso scale relationships, while the amplitude of temperature variations was high, suggesting that a good correlation with temperature reflects a sub meso scale relationship. But this does not give sufficient information to discriminate between cellular cycle and physically triggered patches in the abundance variability observed at the sub meso

scale.

Specific comments: 1. I have reservations about the technique used to infer correlation times. First, Fig.8 should also show the data so that it can be seen how well the 'low span loess' fits the data.

Reply: The data were added on figure 8 concomitantly with other modification asked below.

Second, more information should be given regarding the fitted polynomial - what order is used? How sensitive are estimates to the choice of order? Third, it is vital that estimates of the correlation scales are reported with associated errors as they may be large and have obviously major consequences for the interpretation of correlation scales. These are currently not calculated. One method of doing so would be via a bootstrap approach: choose 90% of the data at random (allowing multiple sampling of the same data point) and calculate the correlation length; repeat this several thousand times to build up a distribution of estimates for the correlation scale from which both mean and errors can be calculated.

Reply: The local polynomial regression fitting process was of degree 2. The degree 1 does not give such a good model. This is now mentioned in the Material and Methods section. Bootstrap is a good method in order to make evidence of the error linked to the smoothing process. As proposed, the loess's were bootstrapped, for each bootstrapped loess result (using 90 % of the data at random), the autocorrelation, resulting in the difference between low loess and high loess, was calculated. The average of the autocorrelation and the standard error were used in order to define the variability of the correlation. The Figure 8 was complemented with an illustration of the bootstrap results. Significant levels of the autocorrelation values in Table 3 were represented.

2. The authors use a model to estimate mixed layer depth. Interpretation of this in conjunction with the observations clearly requires great care, particularly at the scales

that the authors are addressing. Do they have any evidence that the model matches the provinces they define on the basis of their observations? What are the errors associated with the model predictions? How rapidly do the spatial distributions of mixed layer depth change - it can be as rapidly as a day at the sub-mesoscale.

Reply: Some details about the Mercator model were added to the Material and Methods section. The data illustrated on Figure 1 is an average value of the week corresponding to the transect. The purpose of the illustration is to highlight the interpretation on the physical nature of the crossed areas, since no vertical data were collected. The resolution of this Mercator model (PSY2V2) is of 3 to 5 km, which does not give the possibility to compare directly the distribution of the samples with the mixed layer depth grid. When needed, daily mixed layer depth was extracted from the model outputs to compare with higher accuracy the samples and the physical properties of the crossed waters. The open access model outputs of the Mercator Ocean group do not propose a definition strong enough to get the hourly/km scale and enable direct comparison with our data.

3. What checks were done to ensure that the process of pumping water onto the boat did not damage the cells. On a related note, how far was the intake for the pump below the bottom of the vessel? Given the movement of sailing ships would the intake have always been in the water?

Reply: Before leaving, manually collected samples from the harbour and samples from pumped waters were analysed with no difference between clusters structures. The pump used the flexible impeller technology that does not squeeze the water passing through, avoiding the damaging of the cells. The intake was put on a non toxic inlet situated in the middle of the boat, in order to keep the sampling always under the water. Those technical characteristics were added in the Material and Methods section.

4. How did the authors avoid the temperature of the water changing from intake to analysis?

Reply: The filling of the black container took 3 min. and the SBE measured the temperature 2 min. after. The water passed through the inside of the boat before going in the black container were the SBE was fixed, avoiding increase of temperature during the pumping due to solar radiation. The inside of the boat was not warmed and ambient temperature is mostly close to the surrounding water temperature. But, indeed, we did not measure water temperature out of the boat. Surface temperature variations are higher and faster than deep water temperature variations, and we were not looking for mixed layer depths of water mass changes such as those observed in deeper waters. Thus, small variations of temperature due to the intake process were not considered to be of importance relatively to the short time scale of the sampling and to the interpretation of the results.

5. Was the conductivity cell pre or post cruise calibrated?

Reply: The conductivity cell was checked by the constructor before the cruise and one month after the cruise. No calibration was needed. A sentence about that was added in the Material and Methods section.

6. What relationship between the cycles for abundance, fluorescence and scatter would be expected on physiological grounds e.g. presumably the abundance cycle should lag the scatter cycle as the cell increases in size before splitting? Are these relationships seen in the data? If not, why not?

Reply: Indeed, as observed in Thyssen et al., 2008, JPR, the size and the fluorescence of the cells increased before the increase of abundance, mostly for the groups C3 and C4. It is less obvious for groups C1 and C2, regarding abundance, and for groups C5 and C6, regarding all the parameters. Explanations are multiple. The abundance variations are strongly linked to other regulation processes like grazing and mixing (as for C1 and C2 presumably). Furthermore, the red fluorescence and the size of one cluster may not correspond to a single species, particularly for the largest cells, and division may not be synchronous (as for C5 and C6 presumably).

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7. How did the definition of the clusters take into account the diel variability? Presumably the cluster 'boundaries' had to be moved?

Reply: Indeed, the boundaries of each cluster were readjusted sample after sample. A small sentence about that was added in the Material and Methods section.

8 p2483, lines 7-8 from bottom: the authors have presented no evidence for the influence of submesoscale physical processes. Mixed layer deepening is only a submesoscale process if such changes in depth are consistent over a scale of 1-10km, and there would still remain the question of what is causing the deepening.

Reply: Indeed, the sentence should be more speculative. The hypotheses that a portion of the short scale variability of the abundances are not linked to cellular cycles comes from the observation of red fluorescence and size cycles, that are twice slower than abundance variations (mostly for C1, C2, C3 and C4; C5 and C6 are larger cells with certainly a sum of other factors controlling abundances) . At the scale of the abundance changes, sub meso scale physical processes or grasing pressure may cause such abundance variations,

9. p2488, line 10 from bottom: it is currently pure conjecture to state that the observations are reminiscent of some isolated eddy interior'. What characteristics would you expect from such an environment, and what evidence is there for such characteristics here?

Reply: Some eddies in the north Atlantic Ocean have specific signatures in the surface layers such as a difference in salinity and temperature due to advection of deep waters into the surface. At approx. $20°W$, the salinity increased compared to the surrounding, as described p2477 l22 to 25: "No diel oscillation in salinity was detected but a small increase of salinity was observed between $20.65°W$ and $19.45°W$, with an average value of 35.97, corresponding to the area with the lowest temperature diel variation, also characterised by a low mixed layer depth of about 10m (MERCATOR Ocean)." and further, p2486, l 22 to 25: "The C3 phytoplankton cells

seemed to be under favourable development despite the little nutrient depletion, and salinity signature suggests that we may have crossed an eddy at a specific stage of the north Atlantic bloom evolution (Karrash et al. 1996, Garçon et al., 2001; Fernandez et al., 2005).” The sentence was modified in order to let it as a conjecture.

Technical corrections: I have a number of technical corrections. However, it would seem sensible to only communicate these once the more significant issues with the manuscript have been addressed.

Interactive comment on Biogeosciences Discuss., 5, 2471, 2008.

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