

## ***Interactive comment on “Hydrodynamics and light climate structure alongshore phytoplankton blooms in spring” by G. Brandt and K. W. Wirtz***

**Anonymous Referee #2**

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### **General comments**

The study by Brandt Wirtz is an interesting approach to use autonomous instruments e.g. ferry box systems of biotic and abiotic parameters in marine systems in order to detect general patterns like bloom formation. Compared to the use of traditional methods which are usually highly time-consuming, such continuous measurements have a high potential to be used for long-term observations in the plankton with a high temporal and spatial resolution. In general, this study is of interest to biogeoscientists as well as plankton ecologists as the combination of a simple, one-dimensional Lagrangian particle tracking model with a NPZ model allowed the reproduction of chlorophyll distribution patterns along a transect in shallow, well-mixed regions in the southern German Bight, North Sea. The field data used is based on Ferry Box-derived

C1083

measurements during two consecutive years (2004 + 2005) showing contrasting chlorophyll dynamics. The manuscript stresses the importance of hydrodynamic processes involved during bloom formation rather than light being the only trigger of phytoplankton growth in such shallow water systems. In order to reconstruct general patterns in spring bloom dynamics and to elucidate the role of different forcing factors triggering seasonal events in the plankton, long-term observations over at least several consecutive years are pivotal. As it stands, the authors should mitigate their conclusions and stress that their findings indicate the relevance of hydrodynamic processes during bloom formation and that further investigations are needed. Overall, the general structure of the manuscript is not concise and the discussion section rather wordy lacking a clear structure. Most of the aspects discussed are just touched and a discussion in a broader ecological context is missing.

### **Specific remarks**

#### **Abstract**

L.22: The term “Ecosystem functioning” is mis-/overused in the ms. ‘Ecosystem functioning’ refers to complex interactions between species in relation to abiotic parameters in whole ecosystems. It would be better to state something like “for a proper understanding of ecosystem functioning factors such as light and hydrodynamics need to be taken into account. ...”.

#### **Introduction**

P. 4995 L. 5ff: In general, temperature is considered as being of minor importance for the onset of phytoplankton spring blooms in moderately deep, well-mixed water bodies where bloom formation can start already before the onset of thermal stratification. This is especially true for the southern German Bight where tide- and wind-induced strong vertical mixing occurs throughout the year. However, temperature is known to play an indirect role in affecting the timing of blooms via an accelerated growth of overwintering zooplankton populations and an enhanced grazing under elevated thermal conditions

C1084

(see e.g. Wiltshire Manly, 2004, Sommer et al. 2007, Aberle et al. 2007, Wiltshire et al 2008 for details). Thus the statement that physical parameters (temperature, transparency, stratification, light) are considered as more important than biological ones (e.g. grazing) is not evinced yet. Furthermore, light has been shown to be a major trigger for the initiation of the phytoplankton growth in spring (e.g. Siegel et al. 2002, Sommer Lengfellner 2008) and thus, apart from indirect temperature effects on the initiation of phytoplankton blooms, the role of the light climate should be stressed more specifically in the introduction section. P. 4995 L. 11: It is stated that biological forcing is mainly due to turbidity and/or benthic grazing. However, this is not what one would typically expect as major biological trigger mechanisms in the plankton. Indeed, grazing by zooplankton (e.g. copepods, meroplanktonic larvae, microzooplankton) on bloom-forming phytoplankton species is considered as of major importance in coastal as well as oceanic regions. It is not doubted that benthic grazers, e.g. filter feeders, can suppress phytoplankton abundances substantially, however, their impact cannot be regarded as of utmost importance. P. 4995 L. 16-20: The section on the role of mixing is unclear. What is meant by stating that “site-specific-mechanisms e.g. freshwater induced stratification, resuspension of benthic diatoms or species composition are of importance” in the context of bloom retardation? How are these factors involved in the retardation of the spring bloom especially with respect to benthic diatoms, as they do not contribute to bloom-formation? The same is true for the following sentence: please rephrase and specify what is meant by “the establishment of general rules for biological responses to various physical forcing”. P. 4996 L. 1: The sentence about patchiness is out of context. What was its intention? P. 4996 L. 4: Please comment on how satellite imagery derived chlorophyll abundances data enhanced our understanding on ecosystem function. References should be added like e.g. Platt T. et al. (2003), Nature 423:398.

#### Material and methods

P. 4998 L.6: How is chlorophyll measured in the Ferry Box system? Fluorometrically I guess, but it should be stated in the methods section. P. 4998 L. 5: Please state

C1085

why only data from 2004 and 2005 was used. Was data available only for these two years or was the intention to compare data from 2 contrasting years? P. 4999 L. 19ff: Where are the estimates for zooplankton grazing and zooplankton assimilation efficiencies derived from? On P. 5000 L. 19ff. it is stated that zooplankton biomass at the initial position is estimated as a fraction of phytoplankton biomass at a previous time. What does that exactly mean- how was zooplankton biomass estimated in detail? In addition, the so called “near-by” station Helgoland Roads cannot really serve as a reference site since different conditions are given off the coast when compared to coastal regions in the southern German Bight. P. 5000 L. 21-23: The assumption that zooplankton is lagging behind phytoplankton development holds true for mesozooplankton e.g. copepods. When the term ‘zooplankton’ additionally includes microzooplankton this statement is incorrect since microzooplankters show an instantaneous numerical response in relation to increases in food availability thus showing only a short time-lag to phytoplankton growth.

#### Results

P. 5003 L. 18 ff: Are you sure that zooplankton had a minor impact on phytoplankton biomass? Apart from sedimentation, grazing by micro- and mesozooplankton is considered as one of the main factors controlling phytoplankton biomass leading to a clear-water phase right after the bloom. I would rather reconsider whether grazing estimates used in the model were appropriate or would need some fine-tuning. This could also be the reason why the simulation showed still increasing phytoplankton biomass while phytoplankton data indicated already the collapse of the bloom (see statement P. 5004 L. 6ff.). P. 5004 L. 9: Please specify the thresholds for light levels (e.g. daily light dose) allowing bloom formation. The term ‘favourable light levels’ is not precise.

#### Discussion

P. 5006 L. 10 ff: This section is weak. What do turbidity, the clear water phase and a spring bloom development despite unfavourable light conditions have in common? I don't get what the authors intended to state. Please rephrase the paragraph. P. 5007

C1086

L. 10 ff: The section on the 'inflow hypothesis' is quite wordy but not very convincing. Please rephrase. P. 5007 L. 24-26: I agree that initial nutrient concentrations are of importance for the initiation of the phytoplankton bloom. The duration of the bloom is, however, strongly affected by remineralisation via the microbial loop since microbial degradation favours a rapid recycling of nutrients thus extending bloom duration. Other nutrient sources than the initial nutrient pools should therefore not be neglected. P. 5008 Grazing section: The section on grazing and zooplankton abundances is quite speculative and not plausible. It does not hold true that the factor grazing during the phytoplankton spring bloom can be considered as negligible since especially microzooplankters play a significant role as phytoplankton controllers especially during spring bloom formation as they show a rapid numerical response to increasing phytoplankton biomass. The grazing impact is in addition dependant on the overwintering success of zooplankton and accelerated when temperatures in spring are comparably high. These aspects should be included. The whole section on grazing needs a thorough revision. P. 5010 23ff: The impact of different light requirements on specific algal groups is stressed in this paragraph. Indeed, different light climates can result in dominance shifts during bloom formation. Typically, however, temperate marine regions are characterized by an early spring diatom bloom occurring in March/ April followed by a bloom of *Phaeocystis* thereafter. Another possible explanation for a shift from a diatom to a *Phaeocystis* bloom would be that during warm winter-spring conditions a strong grazing on diatoms suppresses diatom bloom formation thus leading to a bloom of inedible phytoplankton species (like *Phaeocystis*, see Irigoien et al. 2005 for details).

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