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Biogeosciences Discussions

Interactive comment on "The significance of nitrogen fixation to new production during early summer in the Baltic Sea" *by* U. Ohlendieck et al.

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This is a high quality, information-rich and valuable piece of work. While previous work has established both the ecological and biogeochemical importance of nitrogen (N_2) fixation in the N budget of the Baltic Sea (c.f. Niemistö et al. 1989, Larssen et al. 2001), this study is one of the more thorough, spatially and (to a lesser extent) temporally intensive efforts using a direct (^{15}N) measurement of N_2 fixation. Blooms of dominant heterocystous N_2 fixing cyanobacterial genera (*Nodularia*, *Aphanizomenon*, *Anabaena*) are known to be quite patchy when observed by ship and remote sensing. It is therefore not surprising to see substantial variability among sampling locations. This is one of the few studies to thoroughly document such variability. The current results also point out that there is likely to be year-to-year variability in rates and total

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amounts of N_2 fixation. The variability may be as high as the differences observed between this and previous studies. One possible explanation is that current studies focused on the early, most actively growing and "healthy" phases of blooms (June-July), when N_2 fixation rates are likely to be high (either as absolute rates or rates per unit biomass) to meet rapid growth demands. It is noted that other studies with which the data were compared took place at somewhat later dates (July- mid-October), when rates may have been lower due to several factors, including senescence and recycling of previously fixed N.

The study nicely shows the strong effects of interannual (1998 vs. 1999) differences in water column temperature and vertical stratification on cyanobacterial production and N_2 fixation rates. The study clearly shows temperature and seasonality to an important "driver" of the observed rates of these processes.

The work was carefully conducted and up-to-date techniques for determining N_2 fixation were utilized. In particular, the use of the high sensitivity ^{15}N technique is commended. Data were thoroughly analyzed and clearly presented, and the authors did a good job of placing their research in both historic and technical contexts. The work shows that most, if not all, the new N inputs via N_2 fixation are by planktonic organisms >5 μm in size. This would tend to rule out the picocyanobacteria that were previously suggested as active N_2 fixers in this system (c.f. Wasmund et al. 2001) and have been found to be active elsewhere, including open ocean environments (Zehr et al. 2001, Montoya et al. 2004). It is still possible that such N_2 fixers (as well as heterotrophic bacteria) exist, but that rates of N_2 fixation attributable to them were too low to detect relative to rates at which the heterocystous filamentous cyanobacterial were fixing. Also, a possible role of microheterotrophs in Baltic Sea N_2 fixation, especially in association with suspended aggregates, cannot be ruled out. These potential diazotrophs were apparently not very significant in the current study. In future work, it would be useful to complement rate measurements with assays examining transcription (mRNA) and translation of the well-characterized *nifH* gene in order to more accurately assess

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the microbial sources of newly fixed N.

Specific comments and suggested changes:

Paerl is misspelled on P. 1282, line 8 (you are not the first one to have done this!).

On P. 1284, line 23, “Nitex” is misspelled.

The same is true on P. 1285, line 22 and P. 1286, line 5 and throughout the manuscript.

P. 1291, line 15, change “compliment” to “complement”.

P. 1291. On a diel scale, periods of excess C fixation, relative to N_2 fixation, are commonly observed in bloom-forming cyanobacteria. Presumably, this occurs because the cyanobacteria use fixed C as a source of reductant to support N_2 fixation. It would make sense that excess cellular fixed C relative to N is observed during morning to mid-day hours, when conditions are optimal for C fixation and C fixed serves as the “fuel” for N_2 fixation. Other field studies have shown that C fixation commonly “peaks out” before N_2 fixation in heterocystous bloom-forming cyanobacteria (c.f. Paerl and Kellar. 1978. Science 204:620–622).

P. 1293, line 9. Substitute “exude” or “release” for “exudate” (the latter is not a verb).

P. 1294, line 3. Omit “pathway”. You haven’t really identified the “pathway” and “source” alone is fine.

In summary, this is a highly informative, well thought-out and clearly articulated manuscript that is worth publishing. It adds significantly to our knowledge base of N_2 fixation dynamics, especially the microbial sources of newly fixed N, spatial and temporal variability, and the role this process plays in supporting primary production of the Baltic Sea.

Interactive comment on Biogeosciences Discuss., 3, 1279, 2006.