Nitrogen cycling in coastal Gulf of Finland I:

Denitrification and DNRA

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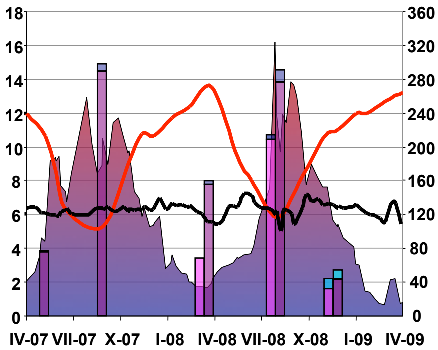
Coastal areas act as filters for nitrogen (N) loading coming from the drainage basin to the sea. Microbes transform N and finally mediate N removal. Nitrogen can also be retained and recycled in the water ecosystem. We studied the different nitrogen cycle processes in a coastal area at the northern Gulf of Finland over the seasons. Additionally we investigated the microbial community behind the processes. This poster presents results from denitrification, anammox and DNRA measurements. Two interrelated posters present results from nitrification measurements and research on the molecular biology aspects of the N processes.

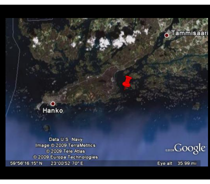
The sampling stations represent typical coastal transportation and accumulation areas, consisting mainly of soft mud with a small share of sand in the shallower station. The water depths at the sampling stations are 10 m and 33 m. Water column is thermally stratified from June to September. The highest bottom water temperatures, up to 17 °C, are found in late autumn when thermal stratification breaks, and the lowest, below 1 °C, in early spring after ice-out. During stratification oxygen is depleted, with lowest measured concentrations in late summer at 4.6 mg/l. Salinity in the area is fairly stable at 6.3, with random upwelling events increasing the salinity temporarily up to 7.3. About 80% of the sedimenting carbon reach the bottom at the end of the spring bloom in May, with little sedimentation during the rest of the year [4,5].

Denitrification and **anammox** are the processes that, in addition to permanent burial, remove N from the water ecosystem. Denitrification, using nitrate and nitrite as substrates, is a heterotrophic process that is regulated in the study area by nitrite/nitrate and carbon availability as well as by temperature[1]. Anammox, using nitrite and ammonium as substrates, is an autotrophic process. It has been detected in the Gulf of Finland, but its role in this dynamic brackish water ecosystem is still unclear [1,2]. It has also been suggested that in the Baltic Sea a considerable amount of N enter a process called dissimilatory nitrate reduction to ammonium, **DNRA**[3]. Instead of removing N from the water ecosystem it recycles N in the water in bioavailable form.

Environmental conditions and N_2 production



Left axis:
Temperature (ºC, area)
Salinity (blue line)
Oxygen (mg l^{-1}, red line)
at the deeper station
Right axis:
Denitrification based on *in situ* nitrification (Dn, pink and lila bars for shallower and deeper stations)
Denitrification based on NO_3^- in water column (Dw, blue bars)
Anammox (turquoise bars),
all µmol N m^{-2} d^{-1}.



Denitrification, anammox and DNRA were measured using the ^{15}N-isotope pairing techniques [6,7,8]. On both stations N_2 production followed a seasonal pattern similar to that observed in the area[1] and in the Gulf of Finland[9] earlier, showing highest rates in late summer (temperature and bioavailable carbon maximum) and lowest in early spring (temperature and bioavailable carbon minimum). The rates are not significantly different between the stations despite differences in water depth and sediment quality, and are comparable to those at the open Gulf of Finland[9]. Accordingly, the near-coast areas are not any better filters for N loading than are the accumulation basins in the open sea – **about 30% of the N loading is removed annually by denitrification and anammox in the Gulf of Finland.**

On the deeper station that has been studied intensively both 2003-2004[1] and 2007-2008 [this study] only minor fluctuations in total N_2 production take place from year to year[1]. Anammox was in this study only detected in November 2008 when it contributed 25% at the shallower and 19% at the deeper station to the total N_2 production. In an earlier study[1] anammox was detected in April and August 2003 at the deeper station, contributing 10 and 15%, respectively, to the total N_2 production. Why anammox emerges and again disappears seemingly randomly remains to be studied.

DNRA varied largely with no clear seasonal pattern, showing extremely high rates in September 2007, April 2008 and November 2008, clearly dominating the nitrate reduction, but low rates in May 2007 and August 2008. No clear explanation for the changes in rates was found. The measured high DNRA rate however suggests **an active "N loop",** recycling N between NH_4^+ and NO_3^- in the sediments, and highlights the important role of the nitrifying bacteria in the area.

1. Hietanen S & Kuparinen J 2008, Hydrobiologia 596
2. Hietanen S 2007 Aqua Microb Ecol 48
3. Karlsson K et al 2005 Mar Ecol Prog Ser 294
4. Heiskanen A-S & Leppänen J-M 1995, Hydrobiologia 316
5. Heiskanen A-S & Tallberg P 1999, Hydrobiologia393
6. Nielsen LP 1992, FEMS Microb Ecol
7. Risgaard-Petersen N et al 2004, Limnol Oceanogr Methods 1,2
8. Christensen PB et al 2000, Aquat Microb Ecol 21
9. Tuominen L et al 1998, Mar Ecol Prog Ser 172