Importance of carbon as limiting nutrient for bacterioplankton in a boreal sub-arctic coastal system.

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IMPORTANCE OF CARBON AS LIMITING NUTRIENT FOR BACTERIOPLANKTON IN A BOREAL SUB-ARCTIC COASTAL SYSTEM

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- **Although nutrient stoichiometry predicted phosphorus (P) limitation, carbon (C) strongly limited bacterioplankton respiration (BR)**
- **Increases in organic C loading may exacerbate coastal oxygen (O_2) depletion**

Results and discussion

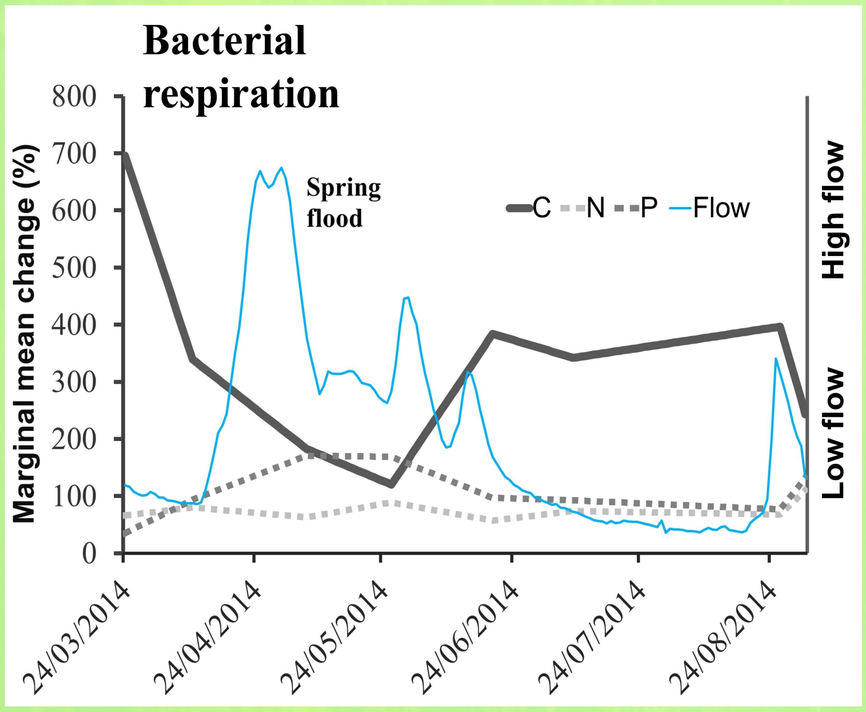

Figure 2. Relative impact (%) of additions of C, N and P, shown as the change in marginal mean (response of bacterial respiration adjusted for all other variables in the model). The nutrient enrichment experiments were performed on a total of 8 dates, and the results were interpolated for the whole period. Flow data was obtained from the Swedish national monitoring programme.

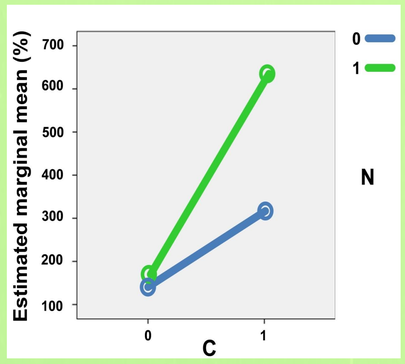

Figure 3. Change in marginal means for C and N factors when added (1 line) and not added (0 line).

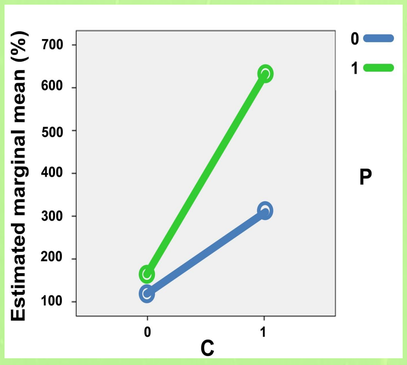

Figure 4. Change in marginal means for C and N factors when added (1 line) and not added (0 line).

All three C, nitrogen (N) and P elements increased BR when added alone (Fig. 2) or combined (Fig. 3 and 4). Among single element additions, C had the strongest effects on BR ranging from a 6 % increase at high flow to a 700% increase at winter low flow. Combined additions of C and P and C and N had similar impacts on BR (~660%).

Table 1. In situ concentrations of dissolved organic carbon (DOC), total nitrogen, total phosphorus (TP).

Date	DOC mgL^{-1}	TN mgL^{-1}	TP μgL^{-1}	C:N:P (molar)
24/03/2014	3.5	0.33	12	753:61:1
09/04/2014	2.9	0.24	6	1249:89:1
06/05/2014	3.1	0.14	6	1335:52:1
26/05/2014	4.1	0.28	15	706:41:1
19/06/2014	3.7	0.29	8	1195:80:1
08/07/2014	3.8	0.57	7	1402:180:1
26/08/2014	3.9	0.31	6	1679:114:1
01/09/2014	3.3	0.21	7	1218:66:1

Nutrient stoichiometry predicted P as main limiting nutrient (Table 1), however BR was mostly C limited.
Our study underscores the role of terrestrial dissolved organic carbon (tDOC) fluxes on coastal oxygen concentrations, which is expected to increase in face of global changes (Wikner and Andersson 2012). Our findings further evidence the shortcomings of nutrient stoichiometry in predicting ecologically available nutrient pools.

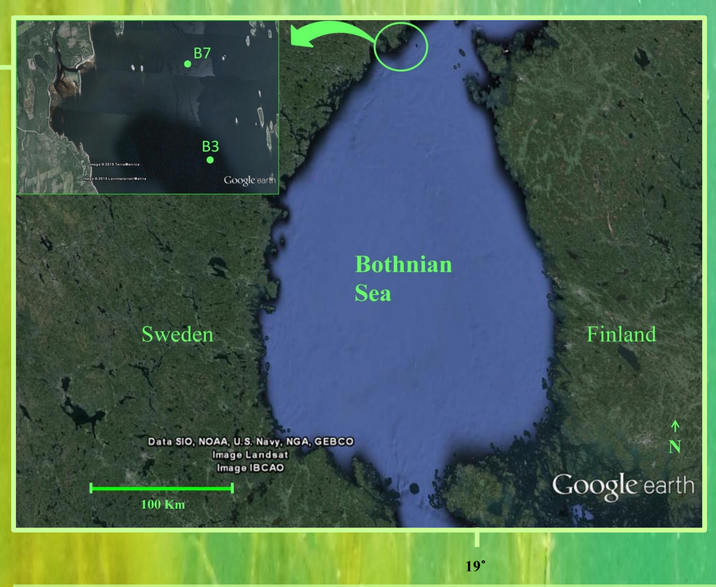

Figure 1 Study area.

Methods

Samples were obtained from the Öre river estuary (Fig.1; 1m depth) on 8 different dates (March-September) alterning between sites B3 (63°29.98N; 19°49.14E) and B7 (63°31.50N; 19°48.49E). We performed multifactorial nutrient bioassays (Fig. 2) in which we added C as $C_6H_{12}O_6$ (5 mgL^{-1}), N as NH_4NO_3 (0.5 mgL^{-1}), P as Na_2PO_4 (50 μgL^{-1}) and salt as an artificial salt mixture (Kester et al. 1967; 5 psu). Duplicates of BR were measured continuously during 72h at 20˚C.

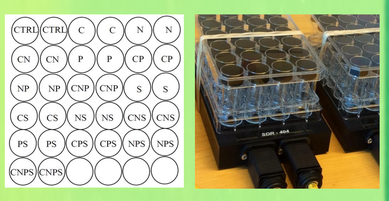

Figure 2. Multifactorial experiments design, bacterial respiration assays.

Background

Dissolved O_2 concentrations in coastal waters are related to the influx of inorganic N and P which promotes primary productivity and BR (Bianchi et al. 2010). Particularly heterotrophic bacterioplankton is affected by fluxes of N and P directly through resource regulation and indirectly through control on primary producers. Additionally, heterotrophic BR may be constrained by inflows of tDOC to coasts (Nydahl et al. 2013). However, consensus on whether BR in aquatic systems is controlled by C or P is missing (Dorado-García et al. 2014). In the northern Baltic Sea, coastal waters are recipients of large shares of tDOC (Gustafsson et al. 2014) and typically show high C:P ratios. In such systems it is hypothesized that BR is limited by P rather than by C .

Bianchi TS, DiMarco SF, Cowan Jr JH, Hetland RD, Chapman P, Day JW, Allison MA. 2010. The science of hypoxia in the Northern Gulf of Mexico: A review. Science of The Total Environment 408: 1471-1484.
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