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INSTITUTIONEN FÖR MARINA VETENSKAPER

# Carbon and nitrogen fluxes associated to marine and estuarine phytoplankton

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**Abstract**

Globally, mainly nitrogen or phosphorus is limiting the primary production. New nitrogen can enter estuarine ecosystems as nitrate from upwelling events, from river runoff, atmospheric deposition, or by nitrogen fixation. Primary production driven by new sources of nitrogen is generally referred to as new production and suggested to equal the size of export production. Nitrate-based new production has been reported to range between 8 % and 40 % in tropical and temperate regions. Regenerated sources of nitrogen can be either ammonium or urea, recycled within the euphotic zone. Biological available phosphorus usually occurs as orthophosphate, entering the euphotic zone from river runoff, upwelling events or recycled within the pelagic zone. Carbon is biologically available mainly as dissolved carbon dioxide or as bicarbonate, and is usually not limiting in the euphotic zone. By using a combination of stable isotopic tracers, secondary ion mass spectrometry (SIMS) and elemental analysis isotope ratio mass spectrometry (EA-IRMS), we determined species-specific contributions to the total carbon and nitrogen assimilation rates and, thus, linked small- and large-scale fluxes within phytoplankton communities under varying abiotic conditions.

Every summer, extensive blooms of filamentous cyanobacteria occur in the Baltic Sea. We revealed that *Aphanizomenon* sp. with its long growth season and high biomass contributed with up to 80 % to the overall nitrogen fixation, even though *Nodularia spumigena* and *Dolichospermum* spp. had higher specific nitrogen fixation rates. The cyanobacteria contributed to the overall carbon fixation by 20 %, i.e. the new production in the area during summer. With lower fixation rates at the offshore station as compared to the coastal, we suggest phosphorus-limitation. In a laboratory study using natural Baltic Sea water, we demonstrated that the toxic cyanobacterial species *N. spumigena* and total nitrogen fixation increased exponentially when amended with small pulses of phosphate (1 μM). Differences in phosphorus storage capacity and affinity for ammonium were observed between strains.

Diatoms represent another functional phytoplankton type, which is key in nitrate-based new production in the pelagic ecosystem, producing 20 % of the oxygen on the planet. They can use either nitrate or ammonium as nitrogen source. During late summer on the Swedish west coast, nitrate-based new production ranged between 12 % and 27 %. The large chain-forming diatoms comprised 7 % of the carbon biomass, but assimilated 54 % of the available nitrate and 30 % of the ammonium. Their ammonium assimilation exceeded the diffusion-limited supply by 4.4 times, suggesting microbial interaction within the phycosphere to facilitate ammonium uptake. In a phytoplankton community in the tropical Mozambique, the nitrate-based new production was 10 % of the total primary production and varied largely between tides. In order to address diversity in nutrient demands in the diatom *Skeletonema marinoi* across a century of increased eutrophication, we revived 80 and 15 yrs old resting stages. The carbon and nitrate assimilation correlated significantly within strains, but with a very large diversity at single cell level within and between strains independent of age. We suggest this diversity as a key to the large success by *S. marinoi* when spreading into new areas and being resistant to environmental changes. This thesis will contribute to the quantitative understanding of how tidal mixing, eutrophication, nitrogen fixation, and nitrate- and phosphate-limitation impact primary production in various estuarine ecosystems.

**Keywords:** Nutrient assimilation; Stable isotopes; Single cell diversity; Phytoplankton