Massive developments of microbial mats following phytoplankton blooms in a naturally eutrophic bay: Implications for nitrogen cycling

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Limnol. Oceanogr., 46(4), 2001, 821-832 | DOI: 10.4319/lo.2001.46.4.0821

ABSTRACT: Benthic nitrogen processes have received substantial attention because the release of nutrients from sediments can contribute to the requirements of pelagic primary production; their study can also give an estimation of the importance of the sediment as a source or a sink of nutrients. Concepcio´n Bay is located in central Chile and is the largest (167.4 km²) and most enclosed embayment on the Chilean coastline. The bay is characterized by a strong hydrographic variability produced by the spring/summer seasonal upwelling of Equatorial subsurface waters (ESSW), rich in nutrients (~25 μM NO_3^-) and poor in oxygen (<44.6 μM). The area was studied in order to understand the consequences of phytodetrital deposition and oxygen deficiency on the environment and benthic communities. The study was carried out by sampling at a single station (28-m depth) in the inner part of the bay during winter (June 1998) and spring/summertime (November 1998 and January and March 1999). It was focused on measurements of benthic nitrogen fluxes, sulfate reduction, and denitrification rates before and after a phytoplankton bloom. Additionally, samples from the flocculent layer and from a semipurified bacterial mat were incubated under controlled oxygen conditions to determine NH_4^+ production. NH_4^+ exchange showed a clear seasonal pattern, with influxes during the winter (27.6 $\pm$ 4.9 mmol m^{-2} d^{-1}) and high effluxes during the summer (36.6 and 20.8 mmol m^{-2} d^{-1}) when the accumulation of fresh organic matter (evidenced as chlorophyll a) produced a flocculent layer over the sediments. Besides natural hypoxia of the bottom water associated with ESSW, the large input of organic matter resulted in anoxia within the sediment, as a consequence of respiration processes, and an enhancement in sulfate reduction rates (up to 200 mmol m^{-2} d^{-1}). The flocculent layer then provided a favorable environment for the extensive development of *Beggiatoa* spp. mats. Overall, during the sampling period, NO_3^- was consumed at an average rate of 1.33 mmol m^{-2} d^{-1}. In the summer, denitrification appeared to be partially inhibited by the very negative redox conditions and could explain only 24% of the NO_3^- uptake by the sediment. The balance may be due to NO_3^- incorporation into Beggiatoa spp. Short incubations with these bacteria suggest that they are able to produce NH_4^+ by dissimilatory NO_3^- reduction, taking advantage of their ability to store NO_3^-, though its uptake was not observed in these experiments. The NH_4^+ flux obtained using *Beggiatoa* spp. mat cultures was 5 mmol m^{-2} d^{-1}, which accounts for 17% of the total NH_4^+ efflux during the summer period (January and March). The ecological implications of a large input of organic matter, evidenced by the presence of a flocculent benthic layer and Beggiatoa spp., are discussed in relation to their contribution, during the upwelling season, toward the long-term eutrophication of Concepcion Bay.

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