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Modeling self-shading in microphytobenthos

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Self-shading is widely known for primary producers, but it has been not addressed in detail for microphytobenthos (MPB). Upper layers of MPB biomass limit light availability to the layers below, reducing the thickness of the photic layer within the sediment (zphot) and likely limiting MPB primary production and growth. To test this hypothesis, we carried out a microcosm experiment in which intertidal MPB was grown in different nitrate concentrations (0, 25 and 100 μM) and under non-saturating light irradiance (200-300 μmol m-2 s-1) during 12 days. Growth, net production rate (Pn), the compensation depth (zcomp), zphot and pigment concentrations (chlorophyll a, phaeopigments and the D430/D665 index) were monitored. As expected, there was not significant differences in growth rates between nitrate treatments, thus supporting that light was the main limiting resource. During the culture development, production rates (1.5-6 mmol O_2 m-2 h-1) increased from net heterotrophic (0-2 days) to a maximum value in the 6th day, but decayed thereafter. Light availability was traced by the evolution of zcomp (0-0.8 mm), which exhibited an initial increase similar to Pn, but a late asymptote parallels to zphot. By assuming that biomass in the photic layer are saturated after 6th day, we worked out analytical expressions to predict both Zcomp (R2=0.70, p<0.001) and Pn (R2=0.88, p<0.001) as a function of the attenuation coefficient of sediment particles and chlorophyll a concentration. Whereas phaeopigment concentration remained constant during the experiment, the D430/D665 index decreased from 7.5 (day 0) to 2.0 (days >2), thus suggesting a decrease in the diversity of the MPB community. The complex relationship between chlorophyll a concentration and productivity contributes to explain the lack of linear correlation frequently observed in field studies.