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ORIGINAL PAPER

Respiratory oxygen consumption in the seagrass *Zostera marina* varies on a diel basis and is partly affected by light

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Abstract The seagrass *Zostera marina* is an important marine ecosystem engineer, greatly influencing oxygen and carbon fluctuations in temperate coastal areas. Although photosynthetically driven gas fluxes are well studied, the impact of the plant's mitochondrial respiration on overall CO_2 and O_2 fluxes in marine vegetated areas is not yet understood. Likewise, the gene expression in relation to the respiratory pathway has not been well analyzed in seagrasses. This study uses a combined approach, studying respiratory oxygen consumption rates in darkness simultaneously with changes in gene expression, with the aim of examining how respiratory oxygen consumption fluctuates on a diel basis. Measurements were first made in a field study where samples were taken directly from the ocean to the laboratory for estimations of respiratory rates. This was followed by a laboratory study where measurements of respiration and expression of genes known to be involved in mitochondrial respiration were conducted for 5 days under light conditions mimicking natural summer light (i.e., 15 h of light and 9 h of darkness), followed by 3 days of constant darkness to detect the presence of a potential circadian clock. In the field study, there was a clear diel variation in respiratory oxygen consumption with the highest rates in the late evening and at night (0.766 and 0.869 µmol O_2 m^{-2} s^{-1}, respectively). These repetitive diel patterns were not seen in the laboratory, where water conditions (temperature, pH, and oxygen) showed minor fluctuations and only light varied. The gene expression analysis did not give clear evidence on drivers behind the respiratory fluxes; however, expression levels of the selected genes generally increased when the seagrass was kept in constant darkness. While light may influence mitochondrial respiratory fluxes, it appears that other environmental factors (e.g., temperature, pH, or oxygen) could be of significance too. As seagrasses substantially alter the proportions of both oxygen and inorganic carbon in the water column and respiration is a great driver of these alterations, we propose that acknowledging the presence of respiratory fluctuations in nature should be considered when estimating coastal carbon budgets. As dark respiration in field at midnight was approximately doubled from that of midday, great over-, or underestimations of the respiratory carbon dioxide release from seagrasses could be made if values are just obtained at one specific time point and considered constant.

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Introduction

Zostera marina L. (eelgrass) is the most abundant seagrass species in temperate coastal areas of the northern hemisphere (den Hartog and Kuo 2006) with a substantial yet declining coverage (e.g., Baden et al. 2003; Nyqvist et al. 2009). Seagrasses establish habitats of high

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