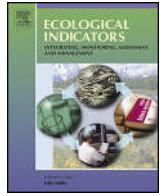




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Zostera noltii development probing using chlorophyll a transient analysis (JIP-test) under field conditions: Integrating physiological insights into a photochemical stress index

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ABSTRACT

Beyond their undeniable role, nowadays we also must look to seagrass beds as endangered environments with urgent monitoring and conservation needs. In the present study *Z. noltii* photochemical performance of under different stages of development/recovery was assessed and its results applied in the development of a photochemical stress index (PSI) to classify and efficiently assess the physiological condition of seagrass beds. In order to investigate deeper into this metabolic network the JIP-test was applied, allowing to identify the reasons underlying the first signs of stress. Less developed beds low connectivity between PS II antennae leading inevitably to an impairment of the energetic transport. Associated to this also the quinone pool showed severe depletion both in number and function. Alongside the K-step presence in the Kautsky curve points to severe damage at donor side of the PS II, where the Oxygen Evolving Complexes (OECs) are located. All these negative impacts increase the quantum yield of the non-photochemical reactions in stressed/less developed seagrass beds. In sum, more developed beds show proportionally higher light use efficiencies promoted by a higher number of oxidized reaction centres coupled with an enhanced capacity in using the generated electron potential and relatively lower energy dissipations. Coupling all the photochemical into an Integrated Biomarker Response (IBR) approach, a photochemical stress index (PSI) was produced. The PSI showed that more developed sites present lower photochemical stress values with inverse significant correlation with biomass coverage, reinforcing the applicability of this non-invasive index as a reflex of the seagrass bed development stage.

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1. Introduction

Seagrass beds are one of the most productive marine ecosystems on the planet, providing numerous services to all its inhabitants (Hemminga and Duarte, 2000; Les et al., 2002; Ralph et al., 2006; McGlathery et al., 2007), delivering food, shelter and nursery habitats for a variety of animal species (Hogarth, 2007; Vizzini, 2009; Heide et al., 2012; Connolly and Waltham, 2015). Additionally, they promote sea floor stabilization, nutrient cycling, and act as environmental status sentinels of coastal ecosystems (Krause-Jensen et al., 2005; Marbà et al., 2012; Pergent et al., 2015). Seagrasses are present in all latitudes, presenting key ecological functions in

all of them, making them comparable to highly productive terrestrial ecosystems (i.e. rain forests and mangroves), namely as carbon sinks and biodiversity sanctuaries (Duarte and Chiscano, 1999; Hemminga and Duarte, 2000; Duarte et al., 2004; Fourqurean et al., 2012). Nevertheless, the coastal location of these ecosystems make them vulnerable to anthropogenic pressures. Approximately 65% of the world seagrass ecosystems are now at risk due to human activities, with already some estimations pointing out to losses of approximately 30% since the 1980s (Duarte, 2002; Orth et al., 2006). Among others, these ecosystems are especially prone to dredging activities and hydrodynamic shifts, nutrient and chemical runoff from urban and agriculture areas, commercial/recreational human activities (e.g. fishing, boat groundings) and inevitably climate change derived impacts (Hastings et al., 1995; Holmer and Bondgaard, 2001; Koch and Erskine, 2001; Uhrin and Holmquist, 2003; Campbell and McKenzie, 2004; Hale et al., 2004; Hauxwell

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