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Thresholds for morphological response to light reduction for four tropical seagrass species

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ABSTRACT

Seagrasses worldwide are highly vulnerable to, and at increasing risk from reduced light availability, and robust light thresholds are required for evaluating future impacts of changing light conditions. We tested the morphological response (shoot density and growth) of four Indo-West Pacific seagrass species (*Cymodocea serrulata*, *Halodule uninervis*, *Halophila ovalis* and *Zostera muelleri*) to six daily light levels ranging from 0 to 23 mol m^{-2} d^{-1} (0–70% surface irradiance) in cool (∼23 °C) and warm temperatures (∼28 °C) over 14 weeks. The impact of light limitation on shoot densities and growth rates was higher at warm than at cool temperatures, and for *Z. muelleri* and *H. ovalis* than for *C. serrulata* and *H. uninervis*, in terms of both the time taken for the low light treatment to take effect and the predicted time to shoot loss (e.g. 17–143 days at 0 mol m^{-2} d^{-1}). Using fitted curves we estimated temperature-dependent thresholds (with estimates of uncertainty) for 50% and 80% protection of growth and shoot density, defined here as "potential light thresholds" in recognition that they were derived under experimental conditions. Potential light thresholds that maintained 50% and 80% of seagrass shoot density fell within the ranges 1.1–5.7 mol m^{-2} d^{-1} and 3.8–10.4 mol m^{-2} d^{-1}, respectively, depending on temperature and species. Light thresholds calculated in separate in situ studies for two of the same species produced comparable results. We propose that the upper (rounded) values of 6 mol m^{-2} d^{-1} and 10 mol m^{-2} d^{-1} can be used as potential light thresholds for protecting 50% and 80% of shoot density for these four species over 14 weeks. As management guidelines should always be more conservative than thresholds for biological declines, we used error estimates to provide a quantitative method for converting potential light thresholds into guidelines that satisfy this criterion. The present study demonstrates a new approach to deriving potential light thresholds for acute impacts, describes how they can be applied in management guidelines and quantifies the timescales of seagrass decline in response to light limitation. This method can be used to further quantify cumulative impacts on potential light thresholds.

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1. Introduction

Water quality affects benthic light and has been linked to globally accelerating decline in seagrass (Waycott et al., 2009). Terrestrial input and dredging, which re-suspends fine sediments, are two processes that drive declines in benthic light (Brodie et al., 2012; Erftemeijer and Robin Lewis, 2006). Seagrasses can acclimate to changing light levels but under extreme reductions in light availability, photosynthetic carbon fixation is directly reduced (McMahon et al., 2013; Ralph et al., 2007). Therefore, reductions in light can cause light limitation which de-stabilises seagrass carbon budgets (Collier et al., 2011) and limits the amount of carbon that is available for growth and biomass production (Ralph et al., 2007). Given the ecological importance of seagrass as food, structural habitat and for carbon sequestration (Coles et al., 1993; Costanza et al., 1997; Cullen-Unsworth and Unsworth, 2013; Fourqurean et al., 2012; Unsworth et al., 2012), changes to seagrass biomass and growth caused by light limitation are of critical concern to environmental managers.

Setting light guidelines for seagrass survival in reduced benthic light is an essential prerequisite in preventing local-scale seagrass

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