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Light thresholds derived from seagrass loss in the coastal zone of the northern Great Barrier Reef, Australia

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ABSTRACT

There is a world-wide trend for deteriorating water quality and light levels in the coastal zone, and this has been linked to declines in seagrass abundance. Localized management of seagrass meadow health requires that water quality guidelines for meeting seagrass growth requirements are available. Tropical seagrass meadows are diverse and can be highly dynamic and we have used this dynamism to identify light thresholds in multi-specific meadows dominated by *Halodule uninervis* in the northern Great Barrier Reef, Australia. Seagrass cover was measured at ~3 month intervals from 2008 to 2011 at three sites: Magnetic Island (MI) Dunk Island (DI) and Green Island (GI). Photosynthetically active radiation was continuously measured within the seagrass canopy, and three light metrics were derived. Complete seagrass loss occurred at MI and DI and at these sites changes in seagrass cover were correlated with the three light metrics. Mean daily irradiance (I_d) above 5 and 8.4 mol m^{-2} d^{-1} was associated with gains in seagrass at MI and DI, however a significant correlation ($R = 0.649$, $p < 0.05$) only occurred at MI. The second metric, percent of days below 3 mol m^{-2} d^{-1}, correlated the most strongly (MI, $R = -0.714$, $p < 0.01$ and DI, $R = -0.859$, $p = <0.001$) with change in seagrass cover with 16–18% of days below 3 mol m^{-2} d^{-1} being associated with more than 50% seagrass loss. The third metric, the number of hours of light saturated irradiance (H_{sat}) was calculated using literature-derived data on saturating irradiance (E_k). H_{sat} correlated well ($R = 0.686$, $p < 0.01$; and DI, $R = 0.704$, $p < 0.05$) with change in seagrass abundance, and was very consistent between the two sites as 4 H_{sat} was associated with increases in seagrass abundance at both sites, and less than 4 H_{sat} with more than 50% loss. At the third site (GI), small seasonal losses of seagrass quickly recovered during the growth season and the light metrics did not correlate ($p > 0.05$) with change in percent cover, except for I_d which was always high, but correlated with change in seagrass cover. Although distinct light thresholds were observed, the departure from threshold values was also important. For example, light levels that are well below the thresholds resulted in more severe loss of seagrass than those just below the threshold. Environmental managers aiming to achieve optimal seagrass growth conditions can use these threshold light metrics as guidelines; however, other environmental conditions, including seasonally varying temperature and nutrient availability, will influence seagrass responses above and below these thresholds.

1. Introduction

Seagrass meadows are a critical element in tropical coastal ecosystems for a number of reasons: they form habitat for diverse fauna and flora and they are food for herbivores, including endangered turtles, dugongs and manatees (Sheppard et al., 2010); they support the productivity of adjacent coral reefs and mangroves through energy and material subsidies (Heck et al., 2008); and, they support fauna that are critical for the food security of many tropical nations (Unsworth and Cullen, 2010). In addition, their primary productivity drives coastal nutrient cycling (Costanza et al., 1997), they stabilize sediment and they are biochemical and hydrodynamic modifiers of their local environment (Marbà et al., 2006). Their role in the coastal zone is therefore unquestionable and yet, we do not know enough about their basic growth requirements to provide environmental managers with the information needed to protect them, particularly so for tropical seagrass meadows (Waycott et al., 2005).

Seagrass loss has become a global concern with accelerating rates of loss over the previous decades placing them amongst

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