Received Date : 10-May-2016
Revised Date : 31-May-2016
Accepted Date : 01-Jun-2016
Article type : Letters to Editor

Seagrass meadows are threatened by expected loss of peatlands in Indonesia

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Seagrass meadows provide one of the most productive stores of carbon in our oceans. They also support marine biodiversity and global food security through their role as fish nurseries and fish foraging grounds. Globally their rate of loss is at least as high as that experienced by tropical rainforests. In SE Asia, due to a paucity of long-term data it is difficult to assign such rates of change but significant loss has occurred, possibly up to 40% (Nadiarti *et al.*, 2012, Tomascik *et al.*, 1997). Risks to these meadows continue, with urban development (including coastal development and run-off) being one of the major risks in the region (Grech *et al.*, 2012, Unsworth & Cullen, 2010). Seagrass meadows in Indonesia have also lost their trophic balance due to overexploitation, placing their resilience to poor water quality at risk (Unsworth *et al.*, 2015, Unsworth *et al.*, 2014).

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/gcb.13392

The article by Abrams et al 2016 utilises a biogeochemical box model to evaluate the downstream effects of the release of Indonesian peat carbon on coastal ecosystems, one of which is seagrass. Their model estimates that the accumulation of detritus in the benthic layer of the coastal environment will lead to an increase in pore water DIN and, therefore to a 31.8% increase in seagrass biomass over the next 60 years (Abrams *et al.*, 2016). This is based on the broad assumption that seagrass in Indonesia is all nutrient limited. In order to reach this conclusion the authors utilise information from just two research papers that examine the mass-balance of nutrients in two Indonesian seagrass meadows conducted in the early 1990's (Erftemeijer & Middelburg, 1995, Erftemeijer *et al.*, 1993).

We applaud the authors for trying to understand the impacts of such a huge problem but feel their conclusions do not reflect the current status and threats to seagrass in Indonesia. We believe that the assumptions in their model and their conclusions could be improved by considering the following:

1) Due to rapid population expansion since the early 1990's and increasing loss of rainforest cover coastal water quality in Indonesia is already in decline, peatland loss will add to this. Some seagrass meadows in the country are likely nutrient limited (van Katwijk *et al.*, 2011) but the evidence suggests that these are the minority with threats to seagrass growing (Nadiarti *et al.*, 2012). The seagrass nutrient data used by Abrams et al to develop their model are insufficient to be used as an indication of the current nutrient status of seagrass throughout Indonesia (Erftemeijer & Middelburg, 1995, Erftemeijer *et al.*, 1993). Data on seagrass nutrient condition in Indonesia is limited, but our understanding of nutrient impacts upon seagrasses

stems from a much bigger broader global literature (Burkholder *et al.*, 2007). We also know that throughout the wider Indo-Pacific region seagrass nutrient levels (from similar species) are commonly elevated (Ambo-Rappe, 2014, McKenzie *et al.*, 2012). An improved model needs to consider this wider body of literature and data.

2) Seagrass diversity in Indonesia is high, as a result these seagrasses live across varied environments (estuarine, reef and coastal environments of either an intertidal or subtidal depth) where species have different adaptations. Some reef seagrass meadows in Indonesia far from land will be nutrient poor and therefore increased DIN from peatland degradation will be of benefit resulting in increased growth, but most seagrass meadows (especially coastal and estuarine meadows) in Indonesia are probably already in states of elevated DIN and are at risk. We also know that many short-term experimental enrichment studies on nutrient limited seagrass result in short term increases in biomass but long-term studies find elevated nutrients to result in declining seagrass biomass and density (Cabaço *et al.*, 2013). The model created by Abrams et al could be enhanced by classifying seagrass meadows according to habitat type and modelling impacts accordingly utilising recent seagrass nutrient data from throughout the region across varied environments and species (e.g. from the Great Barrier Reef seagrass monitoring program).

3) The addition of a detrital layer to seagrass benthos will not just result in increased DIN to the sediments and potentially have a negative impact on light attenuation. The addition of detritus will have a whole stimulatory impact upon the microbial, fungal and detrital feeding community. To expect that the detritus would simply end up as DIN in sediment pore water is at best naïve. Furthermore, a likely additional effect of increased organic detritus is to increase the levels of anoxic sulphide stress

within the sediments with follow on effects upon the seagrass growth and productivity (Marbà *et al.*, 2006). In addition the deposition of organic detritus will also likely bring with it increased sediments, known to alter and seagrass community composition (Terrados *et al.*, 1998).

A large biogeochemical model for how terrestrial degradation impacts the coastal environment in the centre of the Worlds biodiversity has potentially far reaching policy implications. We believe that with further refinement the model by Abrams et al could achieve this and determine a more likely response of seagrass to land degradation. The creation of such a model needs to be based on sound scientific knowledge of the response of biota to environmental change. Such a model would therefore be of wide use for the management of the terrestrial and coastal environment in Indonesia and beyond.

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