Estuarine, Coastal and Shelf Science 167 (2015) 427–435

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss

Species specific effects of three morphologically different belowground seagrasses on sediment properties

Ekkalak Rattanachot, Anchana Prathep*

Seaweed and Seagrass Research Unit, Excellence Centre for Biodiversity of Peninsular Thailand, Department of Biology, Faculty of Science, Prince of Songkla University, Hat Yai, Songkhla, 90112, Thailand

ARTICLE INFO

Article history:
Received 28 April 2015
Received in revised form
30 September 2015
Accepted 16 October 2015
Available online 20 October 2015

Keywords:
Root
Sediment properties
Ecosystem engineer
Organic carbon
Dry bulk density
Redox potential

ABSTRACT

Roots and rhizomes of seagrass play an important role in coastline zone by anchoring the substrate firmly which prevent resuspension and also controlling sediment biogeochemistry. The aim of this study was to compare the physical and chemical differences of sediments for 3 seagrass species, which have different root morphology between summer (February 2013) and the monsoon month (September 2013). Seven seagrass communities were studied and are: the mono stand of *Halophila ovalis*, *Thalassia hemprichii*, and *Cymodocea rotundata*, the mixed patches of *H. ovalis* with *T. hemprichii*, *H. ovalis* with *C. rotundata*, and *T. hemprichii* with *C. rotundata* and the mixed patches of 3 seagrass species. The roots of seagrasses were the main driver of differences in sediment properties; the branched, long root species, *C. rotundata*, showed an increasing redox potential by means of oxygen releasing from their roots. The unbranched, long root with dense root hair species, *T. hemprichii*, tended to cause more poorly sorted sediments. The carbon storage was also estimated and results showed a trend of higher organic carbon density was in the multispecific patches, the mono specific patches and bare sand, respectively. Season also influenced the sediment properties; high wave action in the monsoon stirred up the sediments, this led to lower organic carbon density and high redox potential. Our results suggest that the roots of seagrass species both increase and decrease sediment properties.

1. Introduction

Seagrass are specialised marine flowering plants that have adapted to the nearshore environment of most of the world's continents (Short et al., 2001). They play an important role in the coastal ecosystem by providing nursery habitat and refuge for many associated animals and supporting high primary productivity in the coastal ecosystem (Hemminga and Duarte, 2000). Seagrasses act as ecosystem engineers; they modify both the physical and chemical conditions of the environments which they colonise (Jones et al., 1997). For instance, the aboveground parts of seagrass have been shown to reduce water velocity (Koch et al., 2006), which promotes the deposition of fine suspended particles (Agawin and Duarte, 2002) that are a source of organic matter in the beds. Additionally, their rhizome and root networks anchor the substrate firmly and prevent resuspension and erosion (Gacia and Duarte, 2001). Oxygen transported from the leaves to roots of seagrass (which diffuse to the rhizosphere) have an effect on the chemical conditions in the rhizosphere such as oxygen concentration (Pedersen et al., 1998), redox potential (Enriquez et al., 2001; Marbá et al., 2010) and sulphide concentration (Lee and Dunton, 2000).

Seagrasses grow in submerged conditions where sediments are typically anoxic a few centimetres below the surface and oxygen circulation is limited (Terrados et al., 1999). The roots and rhizomes of seagrasses at different depths depend on the morphology of each species (Kiswara et al., 2009; Marbá et al., 2010). The layers of sediment that have extensive root mats influence the chemical condition by releasing oxygen and organic substances that promote microbial activities in the rhizosphere zone (Devereux, 2013; Duarte et al., 2013). However, studies of seagrass belowground are limited, even though more than half of the total seagrass biomass is belowground (Duarte et al., 1998).

The root and rhizome morphology of seagrasses vary across species. They range from small, unbranched, and shallow penetrating (e.g., *Halophila* spp.) to coarse, robust and deep penetrating rhizomes (e.g., *Enhalus acoroides* L.f (Royle) and *Thalassia* spp.). Previous studies of the root architecture of 6 tropical seagrass

---

* Corresponding author.
E-mail address: anchana.p@psu.ac.th (A. Prathep).

http://dx.doi.org/10.1016/j.ecss.2015.10.019
0272-7714/

species showed that all seagrass root systems had relatively simple branching, which results in minimal path length for oxygen transport from the aboveground parts to the roots (Kiswara et al., 2009) and is important because sediment is often anoxic. Previous studies on biogeochemistry in seagrass beds examined the difference between the rhizosphere condition in the vegetative and unvegetative area (Enriquez et al., 2001; Lee and Dunton, 2000; Marbá et al., 2010), but little is known on the effect of the different root morphology on sediment properties.

Nowadays, the estimations of carbon storage in seagrass habitat are still developing and most studies were carried out in the monospecific stand of temperate species (Fourqurean et al., 2012). Compare to Indo-Pacific region where there is high diversity of seagrass (Short et al., 2007), information of carbon storage in the multispecific meadows are very limited (Lavery et al., 2013). Generally, organic carbons are stored in the sediment, which colonised by root and rhizome of seagrasses, thus the study of the belowground parts (i.e. root morphology) on the potential of carbon storage in segrasses will provide additional information on carbon sequestration in vegetated coastal systems.

Seasonal changes are well known to affect the seagrass population and biomass. During the wet season, tropical seagrass were mostly influenced by high wave action and nutrient loading, while in the dry season, seagrass are mostly influenced by exposure to high temperature during the day time (Erftemeijer and Herman, 1994; Wirachwong and Holmer, 2010; Rattanachot and Prathep, 2011). *Halophila ovalis* (R. Brown) Hooker *f.* and *Cymodocea rotundata* Ehrenberg & Hemprich ex Ascherson had greater aboveground and belowground biomass in the wet season because of land runoff (Wirachwong and Holmer, 2010). However, biomass decreased during the summer season, which might be due to the relatively higher temperature (Prathep et al., 2010). A few studies have examined the seasonal variation on the belowground morphology of seagrass. Rhizome internode lengths of *H. ovalis* increased in the wet season suggesting that its adaptation to anchor itself to withstand high wave action occurred during this season (Kaewsrikhaw and Prathep, 2014). Temperate seagrasses, *Posidonia australis* Hooker f. and *Posidonia sinuosa* Cambridge et Kuo, also showed a variation in root architecture between seasons with more branching roots in the summer than in the winter (Hovey et al., 2012).

Our study examined the effect of 3 morphologically different seagrass roots and rhizomes on the physical (grain size composition, sorting, sediment density and porosity) and chemical (redox potential, organic matter content, percent of organic carbon and organic carbon density) properties of sediment occupied by the belowground parts of seagrass; and then estimated the carbon storage in each community. Seagrass species are *H. ovalis* (small, unbranched root), *Thalassia hemprichii* (Ehrenberg) Ascherson (long, unbranched root with dense root hair) and *C. rotundata* (long and branched root) which grow in both mono and multispecific meadows in Haad Chao Mai National Park, Thailand.

2. Materials and methods

2.1. Study location

The experiment was conducted at Laem Yong Lam (7° 23′ N, 99° 20′ E) in the Haad Chao Mai National Park, Trang Province, southwestern Thailand. The seagrasses at this site were diverse, 10 of 13 species were reported in Thailand (Tuntiprapas et al., 2015). At our study site, the meadows were heterogeneous, extensive and large (approximately 18 km^2, Supanwanid and Lewmanomont, 2003) and they grow from the intertidal to subtidal zone. The study area was in the upper intertidal zone, 200 m from the upper tidal mark. The site was exposed in the morning and evening during the spring low tide, and the exposure time was approximately 4.7 h and 1 h in the summer and monsoon seasons, respectively (Rattanachot and Prathep, 2011). *H. ovalis*, *T. hemprichii* and *C. rotundata* were the most abundant seagrass species and commonly grow together. Eight seagrass communities, which were defined as communities were categorised into: 1) pure *H. ovalis* patch (Ho), 2) pure *T. hemprichii* patch (Th), 3) pure *C. rotundata* patch (Cr), 4) mixed *H. ovalis* with *T. hemprichii* patch (HoTh), 5) mixed *H. ovalis* with *C. rotundata* patch (HoCr), 6) mixed *T. hemprichii* with *C. rotundata* patch (ThCr), 7) mixed *H. ovalis*, *T. hemprichii* and *C. rotundata* patch (HoThCr) and 8) the adjacent bare sand (BS). The samples were collected 2 times, first in February 2013, representing the summer season and again in September 2013, representing the monsoon season.

2.2. Samplings

The samplings were conducted in patches of healthy seagrass with low epiphytes and more than 80–90% seagrass coverage. The specimens were collected within the patches and in the same meadow to avoid the edge effect, and the patches were 200 m^2 to limit the confounding factors from the differences of vertical environmental gradients. Animal nests, such as those of gobies and snapping shrimp, were avoided. The samples were collected when the water covered the bed at least 30 cm to avoid air intrusion. Two sets of samples were collected; the first set was collected to examine seagrass biomass and redox potential (as a chemical property of sediment); the second set was collected to examine the physical properties of sediment (grain size composition, sorting, dry bulk density and porosity) and the organic matter content as a chemical property of sediment.

2.3. Seagrass biomass and the redox potential measurement

For the redox potential measurement, four core samples were collected using 50 cm long × 7 cm diameter PVC corers, longitudinally perforated with 1.2 cm diameter holes at 2 cm intervals. The holes along the cores were covered with duct tape during sampling to avoid leakage of pore water and sediment and oxygen intrusion (Marbà et al., 2010). Sediments were collected to 20 cm depth, immediately after sampling, the sediment redox potential profiles were measured by inserting a Crison Pt electrode (Crison Instrument, S.A., Spain) connected to a portable pH meter, horizontally into the sediment. The electrode was regularly calibrated with a redox standard solution (220 mV) and cleaned and polished to prevent accumulation of Pt-oxides (Marbà et al., 2010). After measuring the redox potentials, the large species (*T. hemprichii* and *C. rotundata*) were counted for shoot density estimation (shoots m^{-2}), and shoots were removed to measure the aboveground biomass; because *H. ovalis* is the small species, which is impossible to count in the field, thus the samples were brought back to the laboratory to examine the number of shoot density as leaf pairs m^{-2}. The contents were extruded from the cores then sliced at 2 cm thick intervals of the 20 cm cores and sieved through 1 mm mesh to remove fine particles. The seagrass parts were collected and kept cool for the biomass measurement.

2.4. Sediment properties

In the second set, samples (3 replicates) were collected at least 30 cm apart from the first set with similar species composition and coverage by using core samples (the same size as cores in the first set). The contents were sliced at 2 cm thick intervals and the sediments were collected using 5 ml plastic syringes in which the tips were cut off, to analyse the Dry Bulk Density (DBD, g cm^{-3}),