Chinese Journal of Oceanology and Limnology
Vol. 35 No. 4, P. 833-843, 2017
http://dx.doi.org/10.1007/s00343-017-6054-0

Combined influence of sedimentation and vegetation on the soil carbon stocks of a coastal wetland in the Changjiang estuary*

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Received Mar. 2, 2016; accepted in principle May 3, 2016; accepted for publication May 17, 2016

Abstract Coastal wetlands play an important role in the global carbon cycle. Large quantities of sediment deposited in the Changjiang (Yangtze) estuary by the Changjiang River promote the propagation of coastal wetlands, the expansion of saltmarsh vegetation, and carbon sequestration. In this study, using the Chongming Dongtan Wetland in the Changjiang estuary as the study area, the spatial and temporal distribution of soil organic carbon (SOC) stocks and the influences of sedimentation and vegetation on the SOC stocks of the coastal wetland were examined in 2013. There was sediment accretion in the northern and middle areas of the wetland and in the *Phragmites australis* marsh in the southern area, and sediment erosion in the *Scirpus mariqueter* marsh and the bare mudflat in the southern area. More SOC accumulated in sediments of the vegetated marsh than in the bare mudflat. The total organic carbon (TOC) stocks increased in the above-ground biomass from spring to autumn and decreased in winter; in the below-ground biomass, they gradually increased from spring to winter. The TOC stocks were higher in the below-ground biomass than in the above-ground biomass in the *P. australis* and *Spartina alterniflora* marshes, but were lower in the below-ground biomass in *S. mariqueter* marsh. Stocks of SOC showed temporal variation and increased gradually in all transects from spring to winter. The SOC stocks tended to decrease from the high marsh down to the bare mudflat along the three transects in the order: *P. australis* marsh > *S. alterniflora* marsh > *S. mariqueter* marsh > bare mudflat. The SOC stocks of the same vegetation type were higher in the northern and middle transects than in the southern transect. These results suggest that interactions between sedimentation and vegetation regulate the SOC stocks in the coastal wetland in the Changjiang estuary .

Keyword: coastal wetland; sedimentation; soil organic carbon; spatial-temporal pattern; Changjiang estuary

1 INTRODUCTION

As one of the most productive ecosystem types on the earth, coastal wetlands play an important role in the global carbon cycle (Kathilankal et al., 2008; Sousa et al., 2010; Mcleod et al., 2011). These ecosystems are thought to be efficient carbon sinks because of organic matter accumulation and sediment deposition (Macreadie et al., 2013). It has been estimated that the total global accumulation of organic carbon of coastal wetlands ranges from 5 to 87 Tg/a (Mcleod et al., 2011). In the context of climate change, the carbon sink capacity of coastal wetlands has become a topic of interest in global carbon cycle studies (Kathilankal et al., 2008; Loomis and Craft, 2010; Mitsch et al., 2013).

Coastal wetlands are at the transition between the land and the ocean, and are characterized by unique spatial and temporal changes in geomorphology, hydrodynamics, and vegetation succession (Nahlik and Mitsch, 2008; Dussaillant et al., 2009; Mitsch et al., 2013). By their very nature, coastal wetlands are dynamic and their carbon sequestration capacity relies on efficient organic matter accumulation in

* Supported by the Marine Science Project of Shanghai Committee of Science and Technology, China (No. 14DZ1206004), the National Natural Science Foundation of China (No. 41571083), and the autonomous research fund of the State Key Laboratory of Estuarine and Coastal Research, China (No. 2015KYYW03)
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vegetation and sediments (Macreadie et al., 2013). Results of an integrated investigation of 158 saltmarshes showed that the average carbon accumulation rate in the sediments of coastal wetlands was 242.2 g/(m^2·a), with variation attributable to changing rates of carbon accumulation among different vegetation types and sedimentation zones (Ouyang and Lee, 2013; Lovelock et al., 2014). The spatio-temporal distribution of soil organic carbon (SOC) in coastal wetlands is strongly influenced by the vegetation, and, in particular, the below-ground production of roots and rhizomes (Chmura et al., 2003). Generally, more than 50% of the biomass produced in coastal vegetation is below-ground, and is buried deeper in the soil by sediments that are deposited by tides (Duarte et al., 2013). In addition, the sediments that are transported by the river or ocean and deposited in the coastal wetlands may also have an important influence on SOC stocks (Anderson and Mitsch, 2006; Zhou et al., 2007; Callaway et al., 2012).

The enormous quantities of sediment produced by the Changjiang River (ca. 200 Mt/a) have created saltmarshes and tidal flats that extend to more than 2 000 km^2 in its estuarine region (Yang et al., 2011; Ge et al., 2013). The carbon cycle and SOC storage in the coastal wetlands in the Changjiang estuary have been examined in several recent studies (Chen et al., 2005; Liao et al., 2007; Zhang et al., 2011; Yan et al., 2014). Zhou et al. (2007) reported that the SOC content in wetland surface sediment varied from the high tidal flat to the low tidal flat. Yan et al. (2008) assessed the carbon budget in the coastal wetlands at Chongming Dongtan using tower-based measurements and a MODIS time series. The effects of an invasive plant, *Spartina alterniflora*, on SOC stocks in the saltmarsh were estimated by Liao et al. (2007). The influence of microbial activities on the SOC contents of coastal wetland soils has also been reported (Li et al., 2010; Zhang et al., 2011, 2013). The spatial and temporal patterns of SOC storage in the Chongming Dongtan Wetland have been characterized (Yan et al., 2014). Previous studies have mainly focused on the spatial and temporal variations in SOC storage in coastal wetlands. To date, however, the combined effects of sedimentation and saltmarsh vegetation on SOC storage have not yet been fully explored.

Against this background, a study was carried out to explore the combined effects of sedimentation and vegetation on SOC stocks in coastal wetlands, using the coastal wetland at Chongming Dongtan in the Changjiang estuary as a case study. The aims of this study were 1) to characterize the spatial and temporal distributions of SOC stocks in the study area, and 2) to identify the importance of interactions between sedimentation and vegetation on the SOC stocks in the coastal wetland. The results of this study will provide information that will help support sustainable management of carbon stocks in the coastal wetlands.

2 MATERIAL AND METHOD

2.1 Study area

The study area is in the Chongming Dongtan Wetland (31°25′–31°38′N, 121°50′–122°05′E) in the Changjiang estuary (Fig.1). This estuary is a typical medium-sized tidal estuary with multi-order bifurcations, shoals, and sand bars (Yang et al., 2008). Data collected over a 30-year period (1978–2008) at the nearby Waigaoqiao tidal gauge station indicated that the local mean sea level was 2.17 m; the mean high water level was 3.5 m, and the mean low water level was 1.03 m, relative to the local Wushong bathymetric benchmark. The mean tidal level was 2.5 m and the mean tidal range was 2.47 m (Wang et al., 2014). The enormous quantities of sediment transported by the Changjiang River have created extensive areas of coastal wetlands in the estuarine region that have been colonized by various types of saltmarsh vegetation (Cui et al., 2015). The estuary has a northern subtropical ocean climate and a mean annual temperature of 15.3°C. The annual average precipitation is 1 022 mm, and occurs mainly (60%) from May to September. The average humidity is 82% (Gao and Zhang, 2006).

Saltmarsh expansion in the Changjiang estuary depends on the accretion of dynamic mudflats (Zhu et al., 2012). Three distinct zones of saltmarsh vegetation related to elevation have been identified in the Chongming Dongtan Wetland, stretching from the inland dyke built in 1998 and moving eastwards towards the low tide line (Fig.1). The tidal flats less than 2 m in elevation are bare mudflats without any vascular plants. The tidal flats between 2.0 and 2.9 m elevation are dominated by a *Scirpus mariqueter* community. Above 2.9 m, plant communities are dominated by a native plant, *Phragmites australis*. *Spartina alterniflora*, which was introduced to Chongming Dongtan in 1995, also dominates in this zone. Because of its highly competitive nature and wider ecological niche, and also the rapid accretion of the intertidal flats, *S. alterniflora* has invaded large

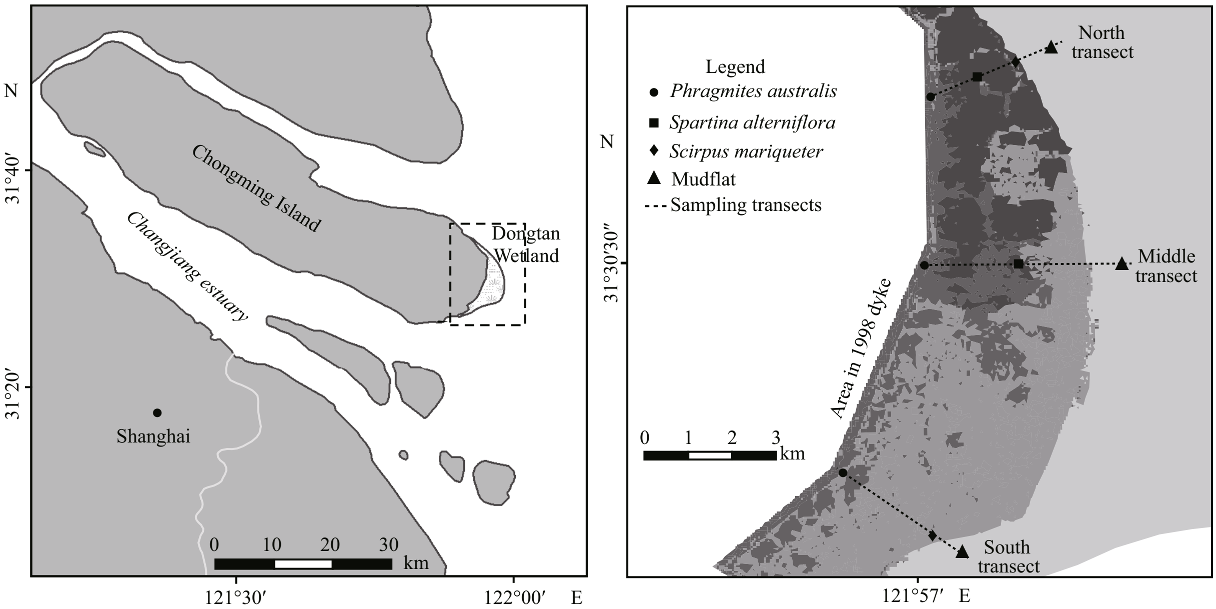


Fig.1 Location of the Chongming Dongtan Wetland and the sampling sites along the three transects

areas formerly covered by *P. australis* and *S. mariqueter* over the last 20 years (Zhu et al., 2012; Ge et al., 2015).

2.2 Sampling transects

In January 2013, three transects were laid out at the northern, middle, and southern parts of the Chongming Dongtan Wetland, running perpendicular from the inland dyke built in 1998 to the bare mudflat. The position, elevation, and vegetation of each sampling site along these transects was recorded (Fig.1). Four sampling sites, comprising the *P. australis* community, *S. alterniflora* community, *S. mariqueter* community, and the bare mudflat, were set up on an elevation gradient along the northern transect. Three sampling sites, comprising the *P. australis* community, *S. alterniflora* community, and bare mudflat were established on an elevation gradient along the middle transect. Three sampling sites, including the *P. australis* community, *S. mariqueter* community, and bare mudflat, were set up on an elevation gradient along the southern transect.

2.3 Measurement of sedimentation dynamics

To determine the sedimentation rates of the different transects, six wooden poles were inserted into the soil at 5-m intervals at each sampling site, leaving the top 30 cm of each pole exposed above the soil surface. The initial elevations of the soil surface were set to zero as a reference elevation and the accretion/erosion rates were measured as the relative positive or negative change from the initial elevations. The exposed height of each pole above the soil surface was measured monthly (approximately every 30 d) from January to December in 2013. Data collected from all six poles at each sampling site were combined to evaluate the accretion and erosion. Depending on the sedimentation dynamics, three 0.1 m×0.1 m squares were randomly selected in each sampling site and the surface sediments that had accrued over the preceding month were collected.

2.4 Plant and soil sampling

The plants and soil were sampled in March (spring), June (summer), September (autumn), and December (winter) of 2013. Three 0.25 m×0.25 m squares were randomly selected at each sampling site in which the above-ground biomass was determined. A soil core, 50 cm deep, was extracted from each clipped square using a steel corer with an inner diameter of 10 cm to determine the below-ground biomass. Three samples of both above-ground and below-ground biomass were collected from each vegetated sampling site. A total of 42 biomass samples (6 samples from 7 sites) were collected during each sampling season.

At each sampling site, five soil cores were randomly extracted using a steel corer with an inner diameter of 10 cm, and the soil cores from the same sampling site were sectioned vertically into 10 parts (0–50 cm at 5-cm intervals). The soils from each layer were mixed together to give a composite sample, resulting in ten soil samples for each sampling site. A total of 100 soil samples (10 samples at 10 sites) were obtained during each sampling season. The soil bulk density of each soil layer was determined from the dry weight of the soil sample and the volume of the soil corer (50 cm^3).

2.5 Measurement of organic carbon in soil and plant biomass

The sediment and soil samples were subjected to a series of pre-treatments in the laboratory. Samples were first air-dried and homogenized. After the roots were removed, the samples were ground with an agate mortar. About 10% of each sample was then passed through a 0.15-mm mesh sieve. To determine the total organic carbon (TOC) concentration, about 150 mg of each prepared sample was acidified with 0.1 N HCl to remove the carbonate minerals and oven-dried at 60°C to constant weight. The weight of each sample was recorded before and after acidification. Before determination of the soil bulk density, samples were oven-dried at 60°C to constant weight, and the dried weight of each sample was also recorded.

The above-ground plant samples were washed with clean water. The soil was removed from the below-ground root samples by rinsing in running water inside a 0.15-mm mesh sieve. After cleaning, the above-ground and below-ground biomass samples were weighed. All the biomass samples were first oven-dried at 105°C for 2 h to remove any enzymatic activity and then at 60°C until constant weight was reached. The dry weight of the biomass samples was recorded. Before determination of the TOC contents, the above-ground and below-ground biomass samples were pulverized to powder in a Wiley mill.

The organic carbon content of the samples (as % dry weight of the samples) was determined using an element analyzer (Elementar Vario EL III CHNOS). Each sample was analyzed in triplicate and the average of the measurements was used to calculate the TOC and SOC stocks in the study area.

The TOC stocks in the biomass (g/m^2) were calculated by multiplying the measured organic carbon concentrations by the dry weight (g/m^2) of the biomass samples. The TOC stocks (g/m^2) in the sediments were calculated by multiplying the measured organic carbon concentrations by the dry weight (g/m^2) of the sediment samples. The soil organic carbon (SOC) stock (g/m^2) of each soil layer (5 cm in depth) was calculated by multiplying the measured organic carbon concentration by the soil bulk density of the samples. The annual SOC increment (g/m^2) in each soil layer was calculated as the difference between the SOC stocks in the winter and spring of 2013. The total annual SOC increment (g/m^2) in the soil profile (0–50 cm) was calculated by adding the annual SOC increments in each soil layer.

2.6 Statistical analysis

The measured values of this study are expressed as the mean±standard deviation. The errors were indicated as the standard deviation (S.D.) of the mean of the replicate samples. The main and interactive effects between the sedimentation and saltmarsh vegetation on the SOC accumulation in each soil layer were analyzed using two-way ANOVA. The level for statistical significance was set at $P<0.05$. All of the statistical analyses were carried out with SPSS version 18.0 (SPSS Inc., Chicago, USA).

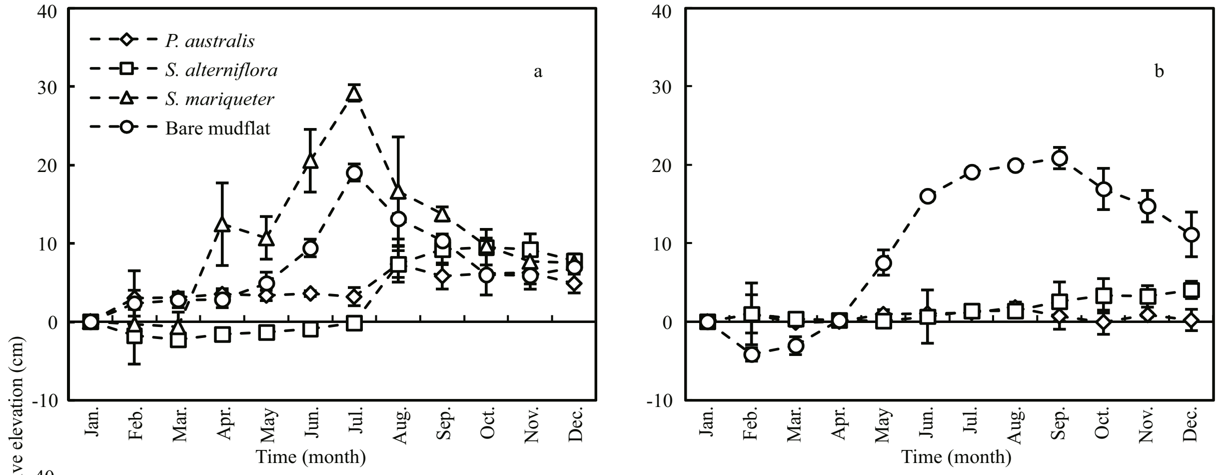
3 RESULT

3.1 Sedimentary dynamics and TOC accumulation

The sedimentary dynamics in the three transects in the Chongming Dongtan Wetland during 2013 are presented in Fig.2. Overall, there was sediment accretion in the northern and middle areas and in the *P. australis* marsh in the southern area; there was erosion in the *S. mariqueter* marsh and the bare mudflat in the southern area.

Along the northern transect, the annual vertical sediment accretions in the *P. australis* marsh, *S. alterniflora* marsh, *S. mariqueter* marsh, and the bare mudflat were 4.9±1.2 cm, 7.8±0.9 cm, 7.5±1.4 cm, and 6.9±1.7 cm, respectively, with accretion during the spring/summer and erosion during the autumn/winter (Fig.2a). Along the middle transect, the annual vertical sediment accretions in the *P. australis* marsh, *S. alterniflora* marsh, and the bare mudflat were 0.22±1.3 cm, 4.1±1.1 cm, and 3.6±2.8 cm, respectively. The accretion and erosion were relatively stable in the *P. australis* and the *S. alterniflora* marshes but fluctuated considerably in the bare mudflat (Fig.2b). Along the southern transect, the annual vertical sediment accretion in the *P. australis* marsh was relatively stable and amounted to 5.5±1.4 cm. However, there was annual vertical sediment erosion amounting to 2.8±1.3 cm and 3.5±0.7 cm in the *S. mariqueter* marsh and the bare mudflat, respectively (Fig.2c).

The TOC accumulation in sediment was calculated at each sampling site (Table 1). Along the northern transect, 3.6±0.7 g/m^2 and 6.6±2.1 g/m^2 of TOC accumulated in the sediments throughout 2013 in the



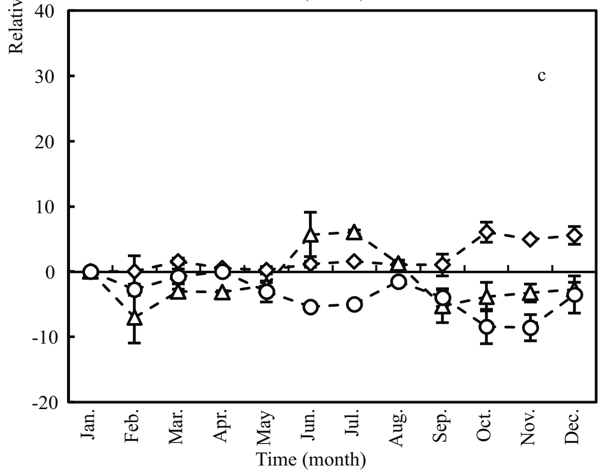


Fig.2 The monthly sedimentary dynamics (mean±S.D.) along the northern (a), middle (b) and southern (c) transects in the Chongming Dongtan Wetland through 2013

Table 1 The annual vertical accretion of sediment and TOC accumulation (mean±S.D.) along the northern, middle, and southern transects in the Chongming Dongtan Wetland during 2013

Transects	Sampling site	Annual vertical accretion (cm)	TOC accumulation (g/m^2)
Northern	*P. australis*	4.9±2.7	3.6±0.7
	S. alterniflora	7.7±2.5	6.6±2.1
	S. mariqueter	7.4±2.2	2.5±0.8
	Bare mudflat	6.9±1.9	1.3±0.4
Middle	*P. australis*	0.2±0.6	0.2±0.1
	S. alterniflora	4.1±2.7	6.1±4.5
	Bare mudflat	11.1±2.9	2.7±1.9
Southern	*P. australis*	4.7±2.3	3.4±1.5
	S. mariqueter	-2.8±1.3	None
	Bare mudflat	-3.5±0.7	None

P. *australis* and *S*. *alterniflora* marshes, respectively; lower amounts of 2.5±0.8 g/m^2 and 1.3±0.4 g/m^2 accumulated in the *S*. *mariqueter* marsh and the bare mudflat, respectively. Along the middle transect, the TOC accumulation in sediment through 2013 was higher in the *S*. *alterniflora* marsh (6.1±4.5 g/m^2) than in the *P*. *australis* marsh (0.2±0.1 g/m^2) and the bare mudflat (2.7±1.9 g/m^2). Along the southern transect, the annual TOC accumulation in sediment in the *P*. *australis* marsh was 3.4±1.5 g/m^2. There was no TOC accumulation in either the *S*. *mariqueter* marsh or the bare mudflat, both of which showed erosion (Table 1). In general, the high annual vertical sediment accretion resulted in higher TOC accumulations among the sampling sites. The TOC accumulations were higher in the vegetated marshes than on the bare mudflats.

3.2 Seasonal dynamics in the TOC stocks of biomass

Seasonal dynamics in the TOC stocks in above-ground and below-ground biomass of the *P*. *australis*, *S*. *alterniflora*, and *S*. *mariqueter* marshes in the three transects during 2013 are presented in Fig.3. Along the northern transect, the maximum TOC stocks in the above-ground and below-ground biomass of the *S*. *alterniflora* marsh were higher than that of *P*. *australis* and *S*. *mariqueter* marsh. Along the

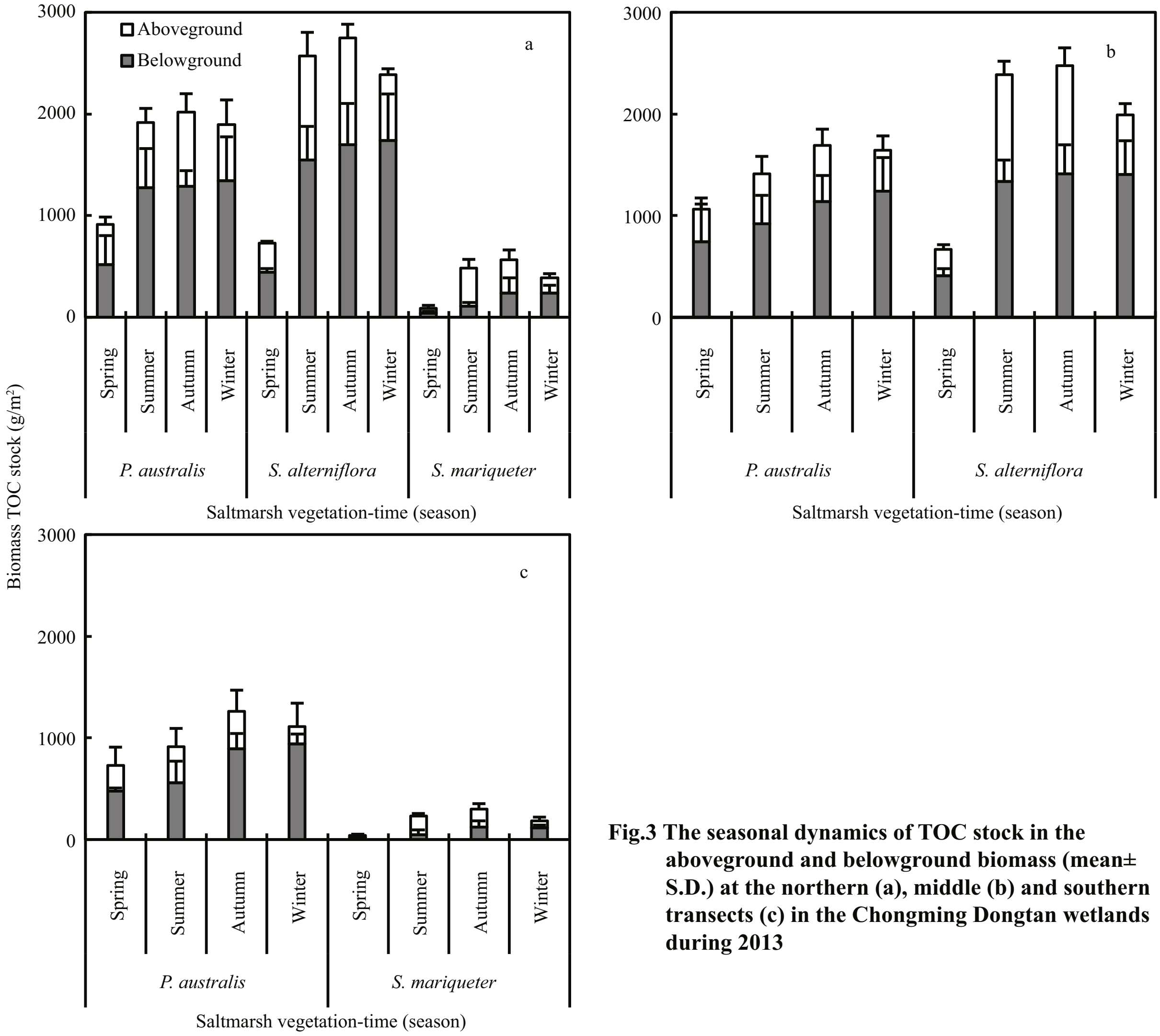


Fig.3 The seasonal dynamics of TOC stock in the aboveground and belowground biomass (mean± S.D.) at the northern (a), middle (b) and southern transects (c) in the Chongming Dongtan wetlands during 2013

Table 2 The maximum TOC stocks in above-ground and below-ground biomass at the northern, middle and southern transects in the Chongming Dongtan Wetland during 2013

Transects	Vegetation	Maximum TOC stocks of biomass (g/m²)	
		Above-ground	Below-ground
Northern	*P. australis*	731.4±180.9	1 347.3±428.7
	S. alterniflora	1 047.2±136.7	1 731.4±180.9
	S. mariqueter	374.3±84.8	240.8±77.7
Middle	*P. australis*	550.5±160.8	1 243.8±328.6
	S. alterniflora	1 060.5±173.7	1 405.5±332.1
Southern	*P. australis*	369.7±150.1	940.4±228.5
	S. mariqueter	184.8±47.5	119.8±37.7

middle transect, the maximum TOC stocks in the above-ground and below-ground biomass of the *S. alterniflora* marsh were higher than that of *P. australis* marsh. Along the southern transect, the maximum TOC stocks in the above-ground and below-ground biomass of the *P. australis* marsh were higher than that of *S. mariqueter* marsh (Table 2).

Examination of the temporal variations shows that the TOC stocks in the above-ground biomass increased from spring to autumn and decreased in winter. The TOC stocks in the below-ground biomass increased continually from spring to winter (Fig.3a–c). In general, more TOC was allocated to the below-ground biomass than to the above-ground biomass (P<0.01). The percentage of the TOC stock allocated to below-ground biomass was higher in the *P. australis* marsh (68.6%) than in the *S. alterniflora* marsh (59.7%) (P<0.01). However, the percentage of the TOC stock allocated to below-ground biomass was significantly lower in the *S. mariqueter* marsh (40.9%) than in the *P. australis* and *S. alterniflora* marshes (P<0.01). The TOC stocks in the biomass of the same

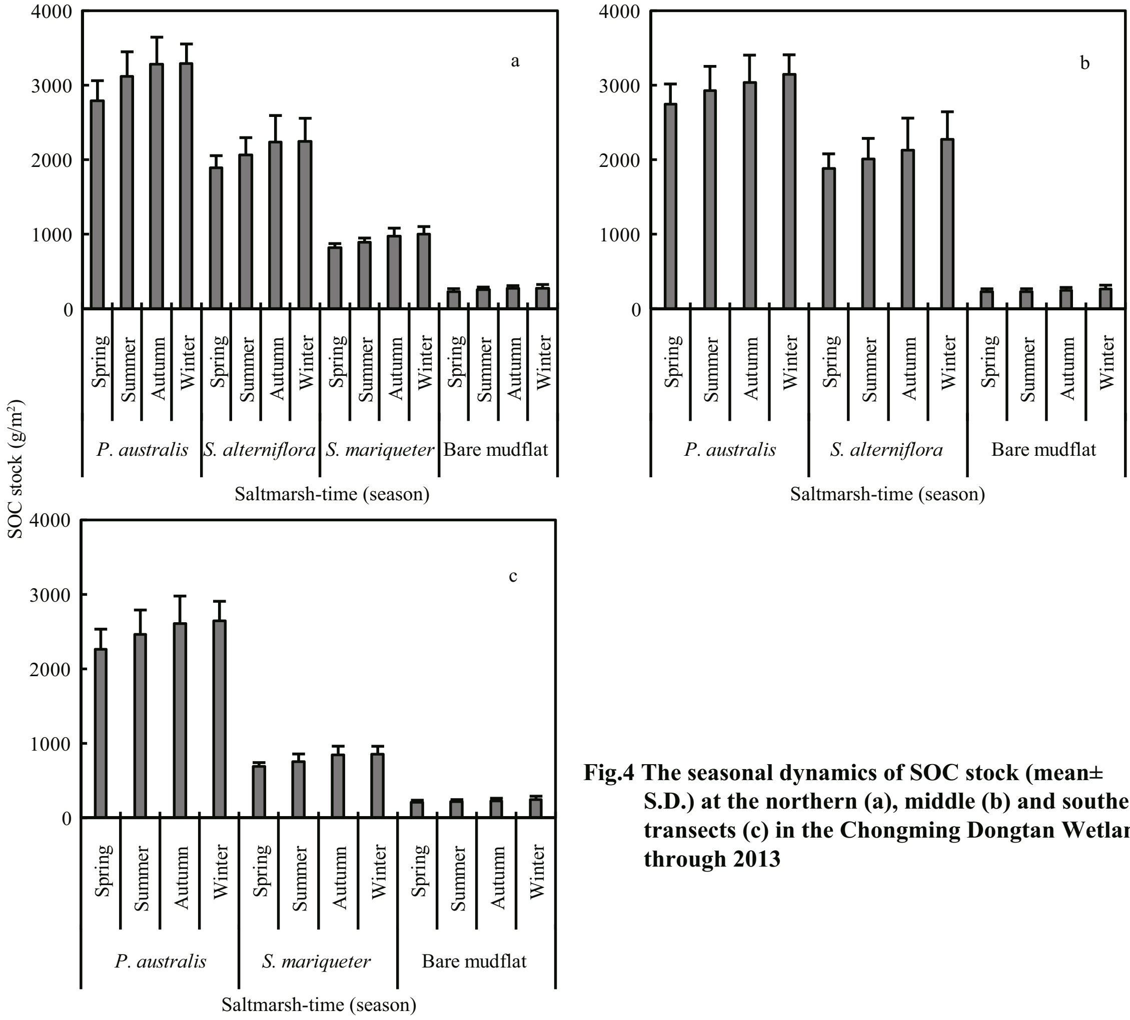


Fig.4 The seasonal dynamics of SOC stock (mean± S.D.) at the northern (a), middle (b) and southern transects (c) in the Chongming Dongtan Wetlands through 2013

vegetation type were higher in the northern and middle transects than in the southern transect (Fig.3).

3.3 Seasonal dynamics in SOC stocks

The seasonal dynamics of the soil organic carbon (SOC) stocks (0–50 cm) in the *P. australis*, *S. alterniflora*, and *S. mariqueter* marshes and the bare mudflat along the three transects are presented in Fig.4. Stocks of SOC increased continually from spring to winter at all the sampling sites. Along the northern transect, the maximum SOC stocks reached 3 293.4±259.5 g/m^2, 2 245.4±311.6 g/m^2, 1 001.2±103.2 g/m^2, and 271.4±56.5 g/m^2 in the *P. australis* marsh, *S. alterniflora* marsh, *S. mariqueter* marsh, and the bare mudflat, respectively (Fig.4a). Along the middle transect, the maximum SOC stocks in the *P. australis* marsh, *S. alterniflora* marsh, and the bare mudflat were 3 148.3±366.5 g/m^2, 2 270.7±373.2 g/m^2, and 262.3±42.5 g/m^2, respectively (Fig.4b). Along the southern transect, the maximum SOC stocks in the *P. australis* marsh, *S. mariqueter* marsh, and the bare mudflat were 2 646.1±305.9 g/m^2, 858.2±94.1 g/m^2, and 245.5±35.6 g/m^2, respectively (Fig.4c).

The SOC stocks tended to decrease from the higher level marsh down to the bare mudflat along the three transects as follows: *P. australis* marsh > *S. alterniflora* marsh > *S. mariqueter* marsh > bare mudflat. The SOC stocks of the same vegetation type were higher in the northern and middle transects than in the southern transect (Fig.4).

The annual increment in SOC in the soil profiles was obtained by calculating the differences between the SOC stocks in the winter and spring of 2013. The distributions of the annual increments in SOC along the soil profiles (0–50 cm) in the Chongming Dongtan Wetland are presented in Fig.5. In general, the annual SOC increments in the bare mudflat were low and the highest increment occurred at a depth of 0–10 cm. However, the maximum annual SOC increments in the *P. australis* marsh, *S. alterniflora* marsh, and the

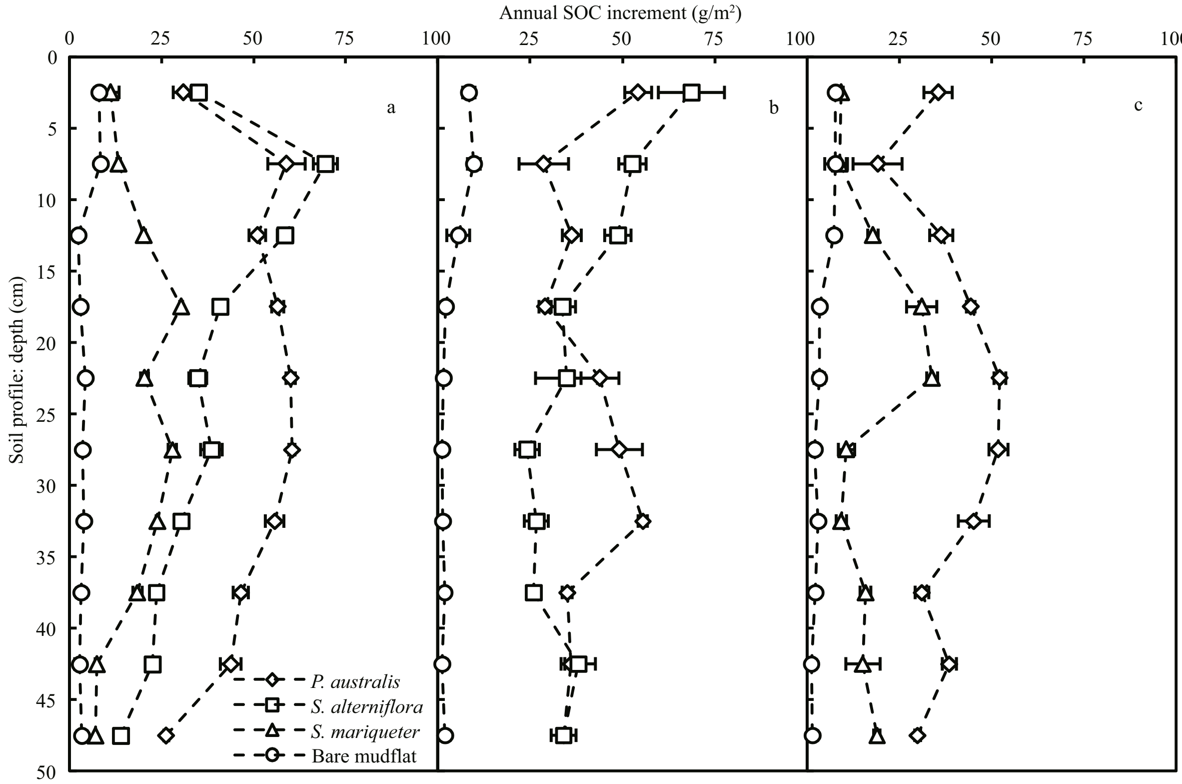


Fig.5 Annual increments in the SOC stocks (mean±S.D.) in the soil profile at each sampling site along the (a) northern, (b) middle, and (c) southern transects in the Chongming Dongtan Wetland through 2013

S. mariqueter marsh occurred between 20 and 50 cm deep.

The total annual SOC increments in the soil profiles (0–50 cm) in the *P. australis* marsh along the northern, middle, and southern transects amounted to 501.9±42.4 g/m^2, 401.6±33.6 g/m^2, and 383.7±64.1 g/m^2, respectively. In the *S. alterniflora* marsh, the total annual SOC increments in the soil profiles along the northern and middle transects amounted to 353.8±56.1 g/m^2 and 387.1±16.6 g/m^2, respectively. In the *S. mariqueter* marsh, the total annual SOC increments in the soil profiles along the northern and southern transects amounted to 179.4±21.6 g/m^2 and 170.2±48.3 g/m^2, respectively. In the bare mudflat, the total annual SOC increments in the soil profiles on the northern, middle, and southern transects amounted to 41.1±3.7 g/m^2, 34.2±6.5 g/m^2, and 38.9±2.9 g/m^2, respectively.

Overall, the SOC stocks and the total annual SOC increments in the soil profiles showed a tendency to decrease from the high marsh down to the bare mudflat along the three transects, as follows: *P. australis* marsh > *S. alterniflora* marsh > *S. mariqueter* marsh > bare mudflat. The SOC stocks and the total annual SOC increments in the same vegetation type were higher in the northern and middle transects than in the southern transect (Figs.4, 5).

3.4 Influence of interactions between vegetation and sedimentation on SOC

The results of the main and interactive effects between the sedimentation and saltmarsh vegetation types on SOC accumulation of each soil layer are presented in Table 3. The different vegetation types had a significant influence on SOC accumulation in each soil layer, while sedimentation mainly influenced the 0–5 cm soil layer. The interactive effects between vegetation types and sedimentation mainly affected the SOC accumulation in the 0–10 cm soil layer.

4 DISCUSSION

The spatial and temporal changes in the geomorphology, hydrodynamics, and vegetation succession of coastal wetlands are unique (Nahlik and Mitsch, 2008; Dussaillant et al., 2009; Mitsch et al., 2013). In this study, there were clear trends in the spatial and temporal distributions of SOC stocks in the Chongming Dongtan Wetland, with an obvious gradient from the high marsh down to the bare mudflat along the three transects. The SOC stocks of the same vegetation type were higher in the northern and middle transects than in the southern transect. The SOC stocks in the study area wetland ranged from 245.5 to 3 293.4 g/m^2. The annual SOC increments ranged from 34.2 to 501.9 g C/(m^2·a), and are consistent with the global range of between 18 and 1 713 g C/(m^2·a) reported by Mcleod et al. (2011).

The sediments transported from upstream by the river or by the ocean and then deposited on the coastal wetlands have an important influence on carbon sequestration (Anderson and Mitsch, 2006; Zhou et al., 2007; Callaway et al., 2012). Our results showed that there was accretion in the northern and middle transects, while there was erosion in the low-lying marsh and bare mudflat of the southern transect. The results were consistent with the presence of low runoff and a high tidal prism in the northern branch of the Changjiang estuary. The divergence and convergence of tides promoted the deposition of sediment in the northern and middle parts of the wetland at Chongming Dongtan (Shi et al., 2012; Li et al., 2014), while the high-velocity ebb tide and the Coriolis effect caused severe sediment erosion in the southern part (Li et al., 2014). In this study, the TOC contents in the sediment were between 0 and 6.6 g C/(m^2·a), indicating that carbon sequestration attributable to sedimentation in the wetland was low. However, high rates of sedimentation could result in progradation of the wetland and expansion of saltmarsh vegetation (Huang et al., 2007; Zhu et al., 2012), and could make a large contribution to carbon sequestration in the Chongming Dongtan Wetland.

Vegetation, and, in particular, the below-ground production of roots and rhizomes, had a very strong influence on the spatial and temporal distributions of SOC in the coastal wetland (Chmura et al, 2003). In general, more than 50% of the biomass production of plants was allocated to the below-ground, which was further buried in the soil because of sediment deposited by the tides (Duarte et al., 2013). In our study area, the SOC stocks were lowest in the bare mudflat that had no vascular plants, indicating that algae and sediment were the main sources of the SOC. The SOC stocks and the annual SOC increments tended to increase from the low *S. mariqueter* marsh to the high *P. australis* marsh, thereby highlighting variations in the quality and quantity of the organic matter provided by the saltmarsh plants (Marín-Muñiz et al., 2014). Although the biomass was generally higher in the *S. alterniflora* marsh than in the *P. australis* marsh (Fig.3), the SOC stocks were higher in the *P. australis* marsh than in the *S. alterniflora* marsh. The samples from the *P. australis* marsh may have been collected from an area with a long history of colonization (more than 15 years); the colonization history in the *S. alterniflora* marsh, however, may have been relatively short (about 10 a).

Table 3 Main and interactive effects between vegetation types and sedimentation on annual SOC increments in the soil profiles of the coastal wetlands (* *P*<0.05, ** *P*<0.01)

Depth (cm)	SOC		
	Vegetation type (Veg)	Sedimentation (Sed)	Veg×Sed
0–5	<0.001**	0.001**	<0.001**
5–10	0.002**	0.09	0.014*
10–15	<0.001**	0.35	0.14
15–20	<0.001**	0.80	1.00
20–25	0.001**	0.27	0.3
25–30	0.002**	0.53	0.65
30–35	0.002**	0.31	0.14
35–40	0.003**	0.61	0.97
40–45	0.005**	0.48	0.94
45–50	0.002**	0.10	0.06

5 CONCLUSION

Our results show sediment accretion in the northern and middle areas of the wetland and in the *P. australis* marsh in the southern area of the wetland; sediment erosion occurred in the *S. mariqueter* marsh and the bare mudflat in the southern area. The spatial and temporal distribution patterns in the SOC stocks during 2013 in the Chongming Dongtan Wetland showed a tendency to decrease from the high marsh down to the bare mudflat along the three transects as follows: *P. australis* marsh > *S. alterniflora* marsh > *S. mariqueter* marsh > bare mudflat. The saltmarsh vegetation was the main contributor to carbon sequestration in the wetland. Although sedimentation made a lower contribution to carbon sequestration in the wetland, the high sedimentation rate resulted in progradation of the wetland and expansion of the saltmarsh vegetation. Consequently, the interactions between sedimentation and vegetation may significantly contribute to carbon sequestration in these coastal wetlands.

6 ACKNOWLEDGEMENT

The authors would like to thank members of the Wetland Ecology Section of the State Key Laboratory of Estuarine and Coastal Research, East China Normal University, for their assistance with data collection.

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