Influencing mechanisms of eutrophication on sediment organic carbon sequestration within a typical tropical seagrass meadows

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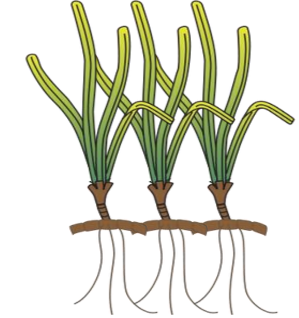
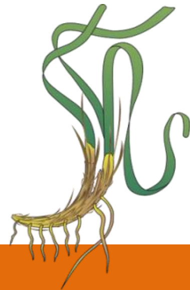
Outline



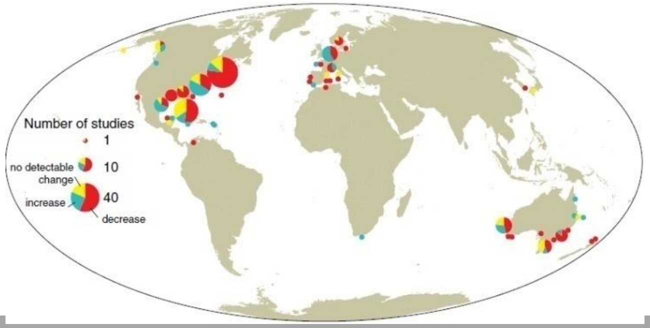
- Research significance
- Current research progress
- Materials and methods
- Research results
- Ecological implications

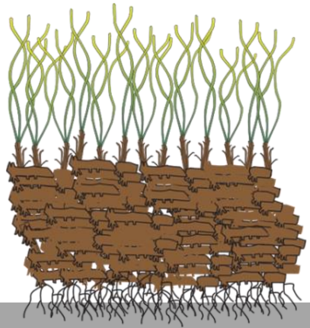


Research significance

- Seagrass ecosystems have the important carbon sequestration function with referring as **'blue carbon'** ;
- Seagrass meadows contributed to **10%** of the yearly OC storage in the oceans, despite only covering **< 0.2%** of global sea surface area (Fourqurean et al.2012); SOC storage was influence by the **source, composition, and transformation** (Macreadie et al.2014)
- Seagrass decline **7%/year**, **nutrient enrichment** (Waycott et al.2009)

To explore the SOC storage mechanism of seagrass bed and its response to nutrient load -- provide scientific and technological support **for promoting global carbon sink**

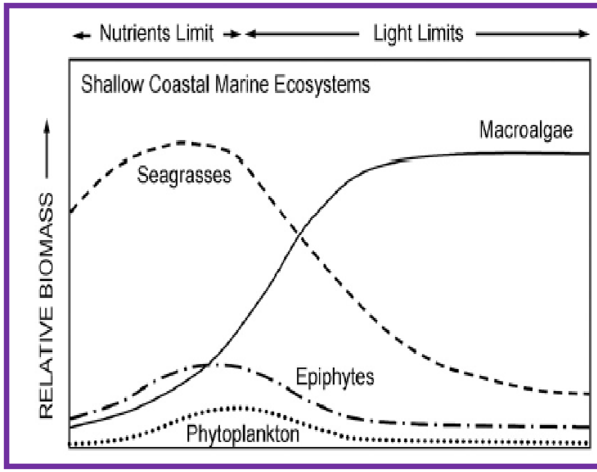




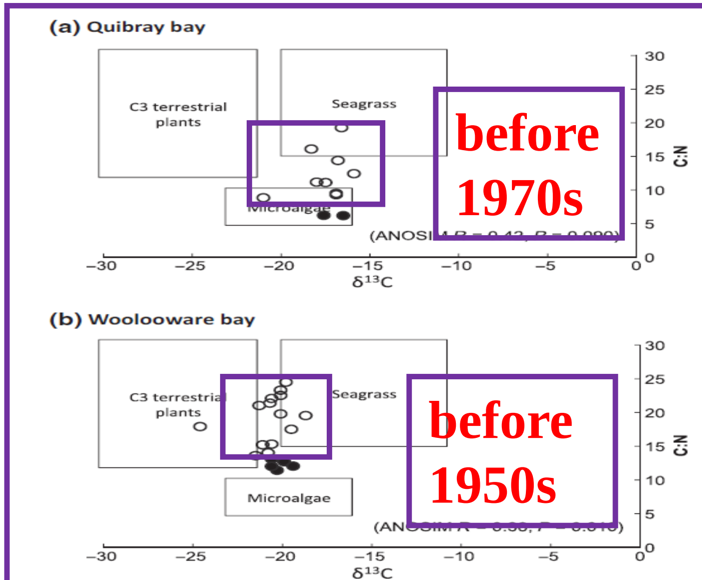
Current research progress

➢Increased nutrient loads trigger the overgrowth of algae, in the form of epiphytes and macroalgae but decrease seagrass biomass (Burkholder et al., 2007) , change the primary community (Schmidt et al., 2012), induced SOC sources variation

➢The organic carbon burial rate of benthic microalgae (6%)、phytoplankton(3.9%) andmacroalgae (0.4%) lower than seagrass(15.9%) (Duarte and Cebrian, 1996), weaken the carbon sink capacity (Macreadie et al., 2012)



Nutrient loading change the primary community (Burkholder et al.2007)



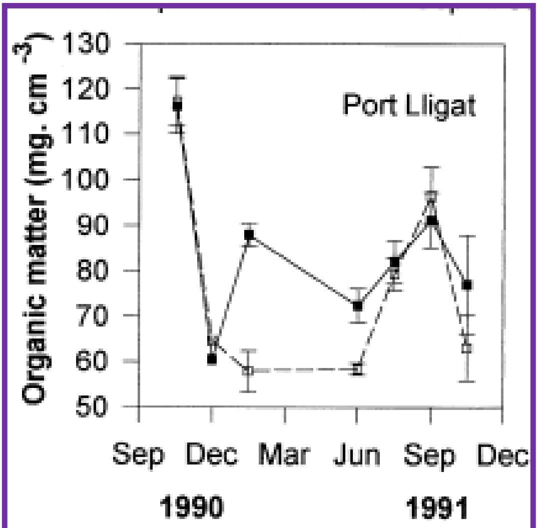
Macreadie et al (2012) found that nutrient loading lead to SOC source from seagrass to algal OC

Current research progress

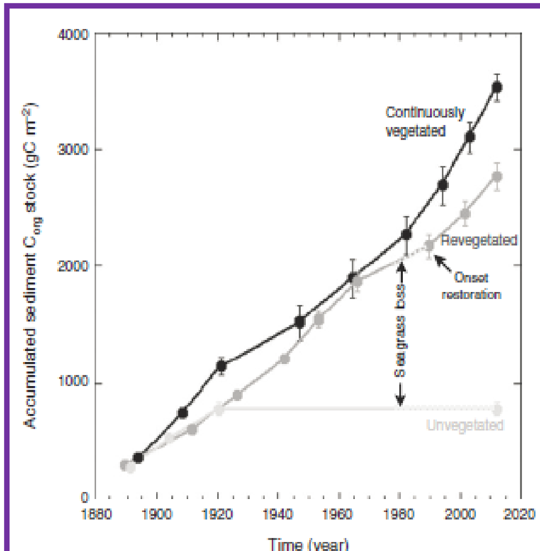
➢**SOC algal OC contribution increasing change microbial OC sources, and then induced sulfate reduction rate variation** (Holmer et al., 2004);

➢**Nutrient loading——seagrass biomass decline** (Hauxwell and Valiela, 2004); **decrease the ability to capture OC** (Gacia et al., 2002);

➢**Seagrass decline——the stored OC release and escape** (Pendleton et al., 2012; Marbà et al., 2015)



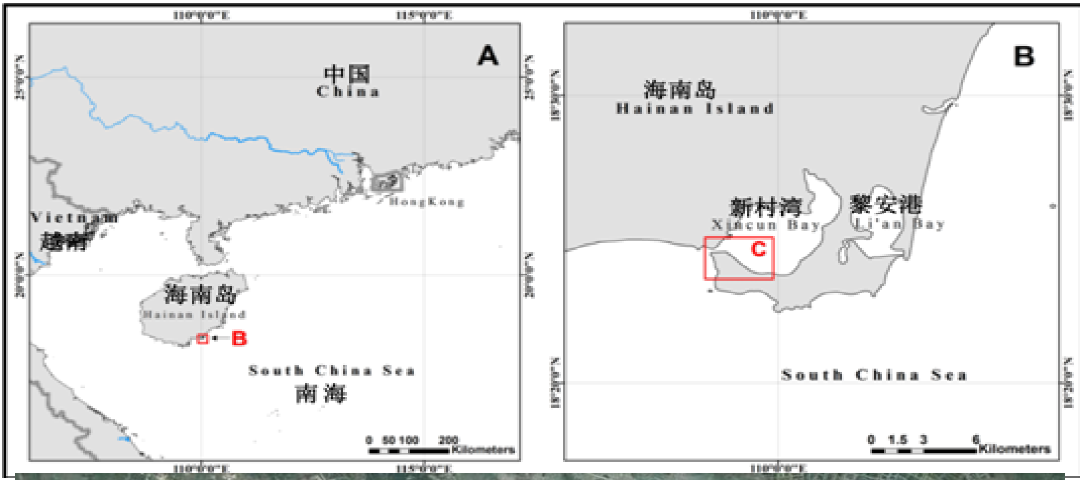
Nutrients load increase bacterial and enzyme activities, lead to decrease 33% of sediment organic matter (Lopez et al. 1998)

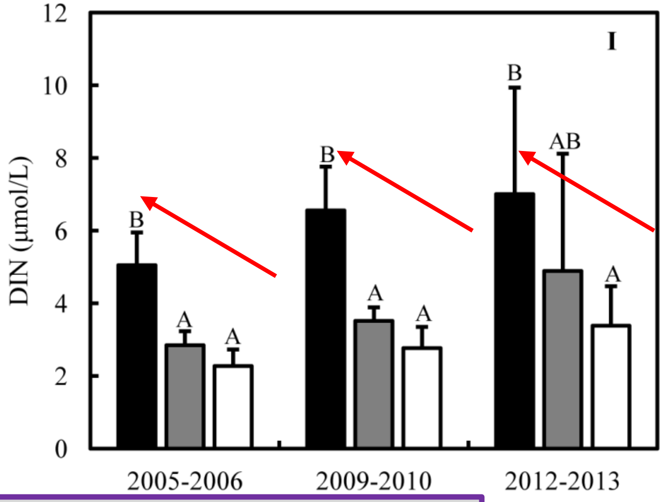


Seagrass decline lead to the stored OC release and escape (Marba et al., 2015)

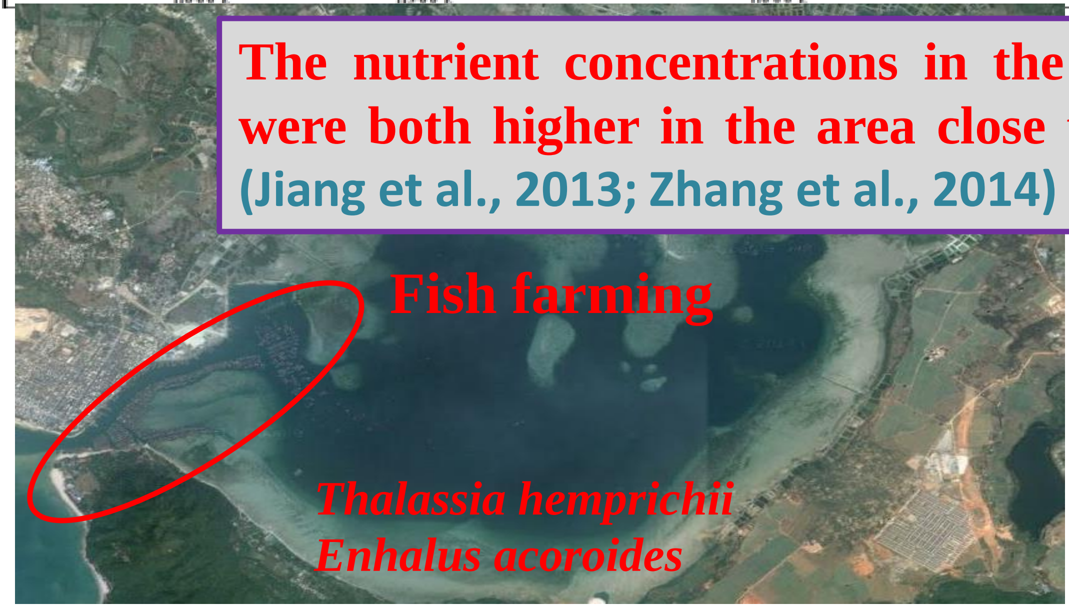
Materials and methods

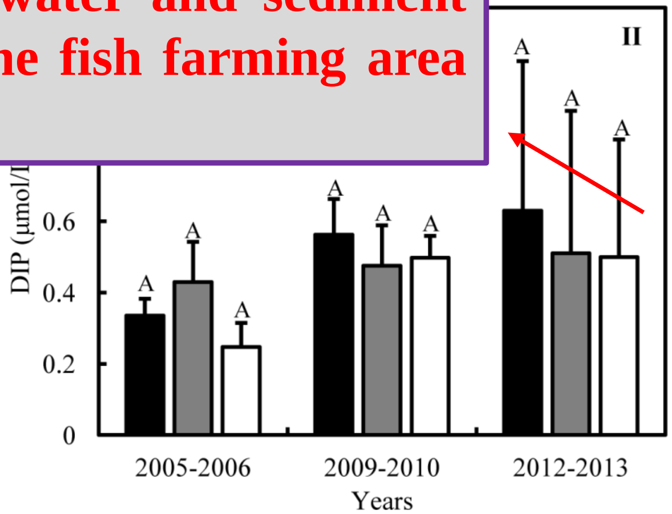
Study area





The nutrient concentrations in the seawater and sediment were both higher in the area close to the fish farming area (Jiang et al., 2013; Zhang et al., 2014)

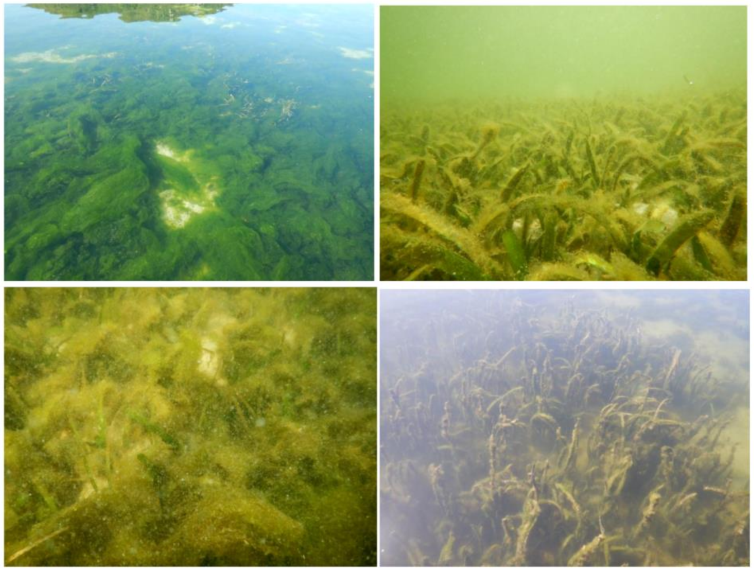




Materials and methods

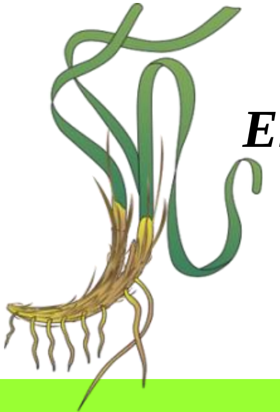
Study area

Fish farming in Xincun Bay



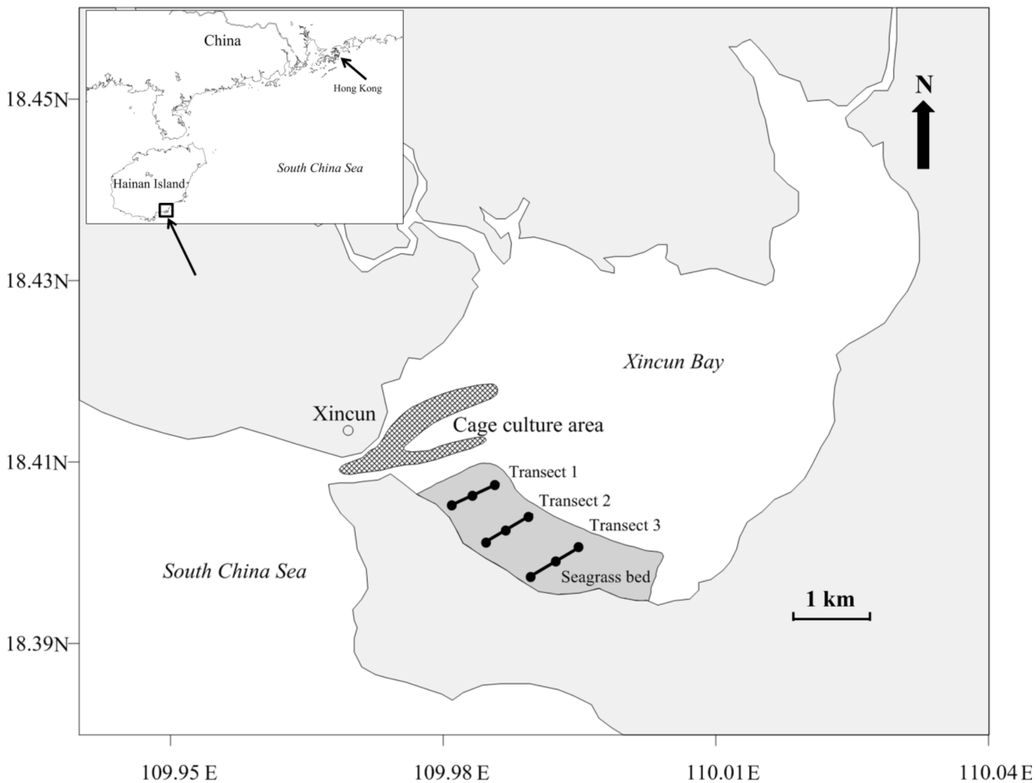
Algae bloom within seagrass meadows

Thalassia hemprichii



Enhalus acoroides

Materials and methods



Sampling sites in Xincun Bay

Three transects were selected according to the distance to the fish farming:

Surface sediment (0-3 cm);

Core sediment (0-30 cm)

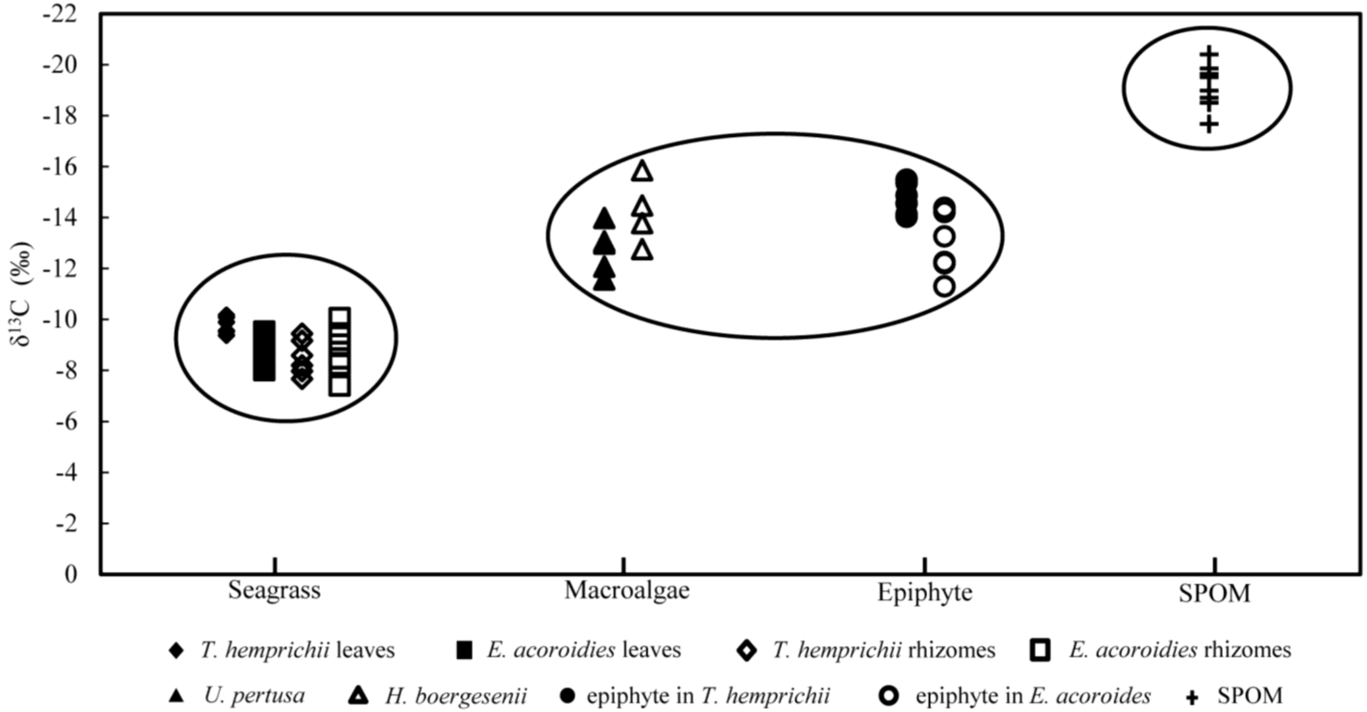
Primary communities (seagrass, macroalgae, phytoplankton and epiphyte)

Analysis parameters：

SOC contents, labile organic carbon, $\delta^{13}C$ of SOC and primary communities, PLFA composition, $\delta^{13}C$ of PLFA, enzyme activities

Research results

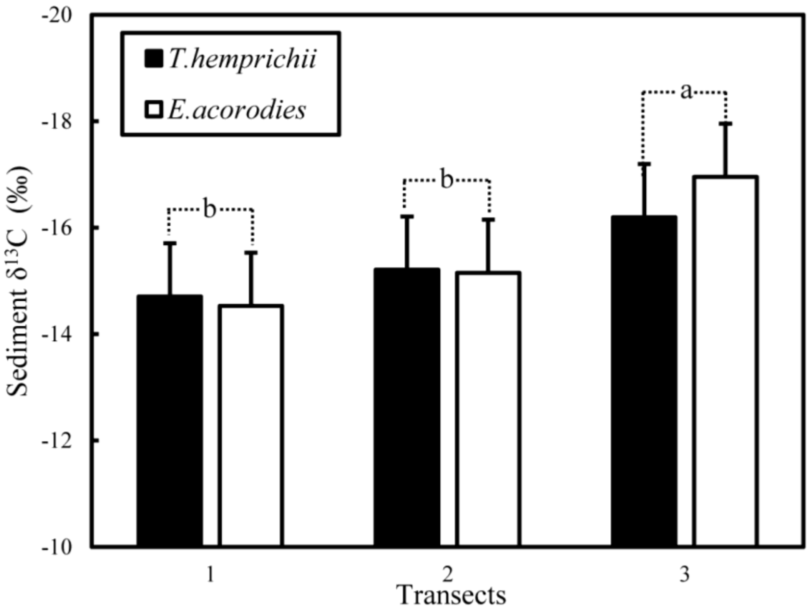
1.Surface SOC sources



$\delta^{13}C$ of SOC possible sources.

9 possible OC sources were seperated into seagrass, macroalgae & epiphytes, and SPOM based on variations of $\delta^{13}C$.

Research results



Variations of the sediment $\delta^{13}C$ (‰) among the three transects

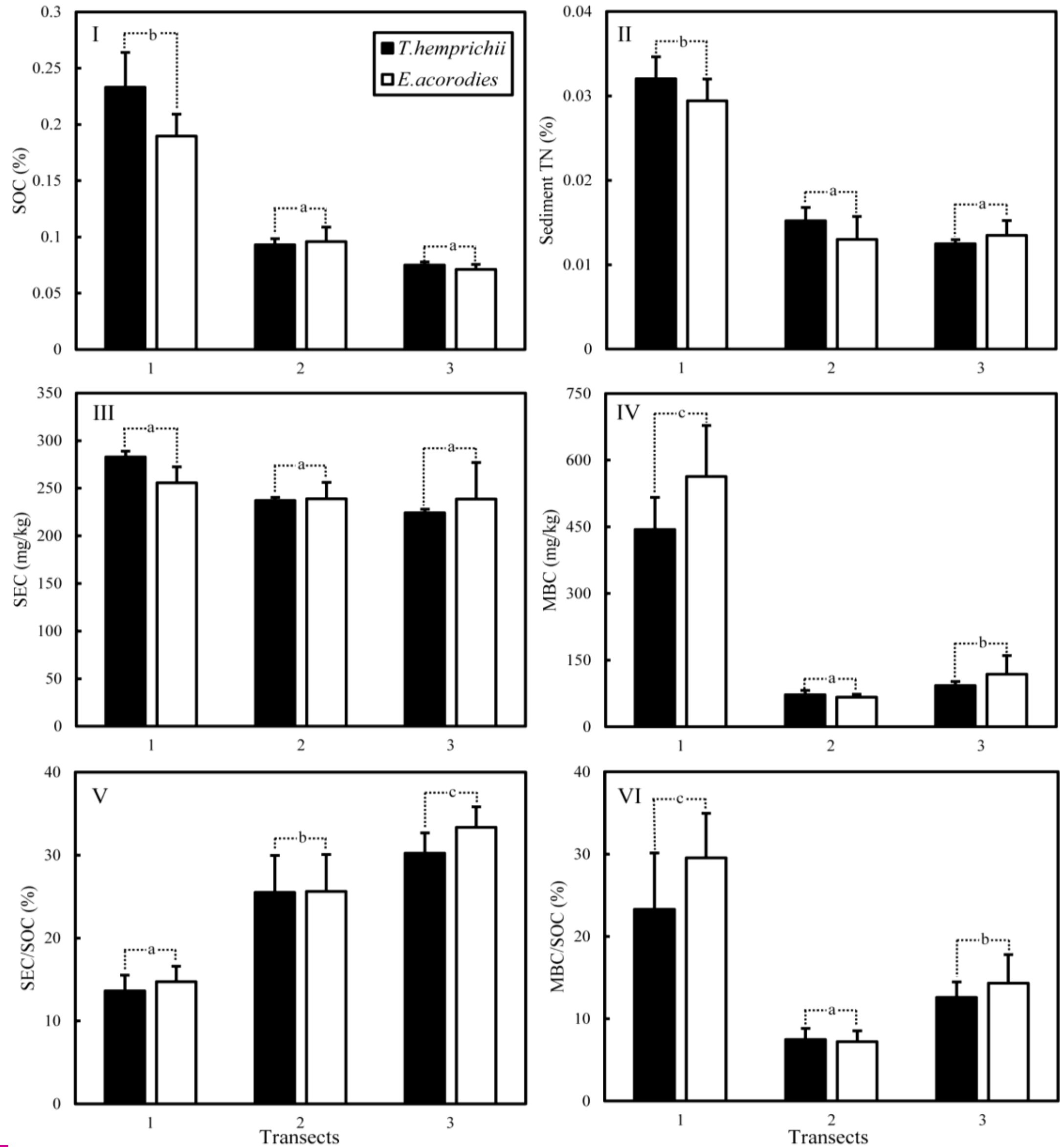
	Sources	<95%	>95%	mean
	Saegrass	0.00	0.31	0.14
A	Algae	0.00	0.60	0.33
	SPOM	0.29	0.78	0.53
	Saegrass	0.00	0.27	0.12
B	Algae	0.00	0.57	0.29
	SPOM	0.34	0.84	0.59
	Saegrass	0.00	0.18	0.07
C	Algae	0.00	0.43	0.17
	SPOM	0.52	0.96	0.76

the relative contribution of seagrass, and macroalgae & epiphytes to SOC increased from transect 3 to 1, with the relative contribution of macroalgae & epiphytes increasing by 16%, while that of SPOM decreased

Research results

2.Surface SOC compositions

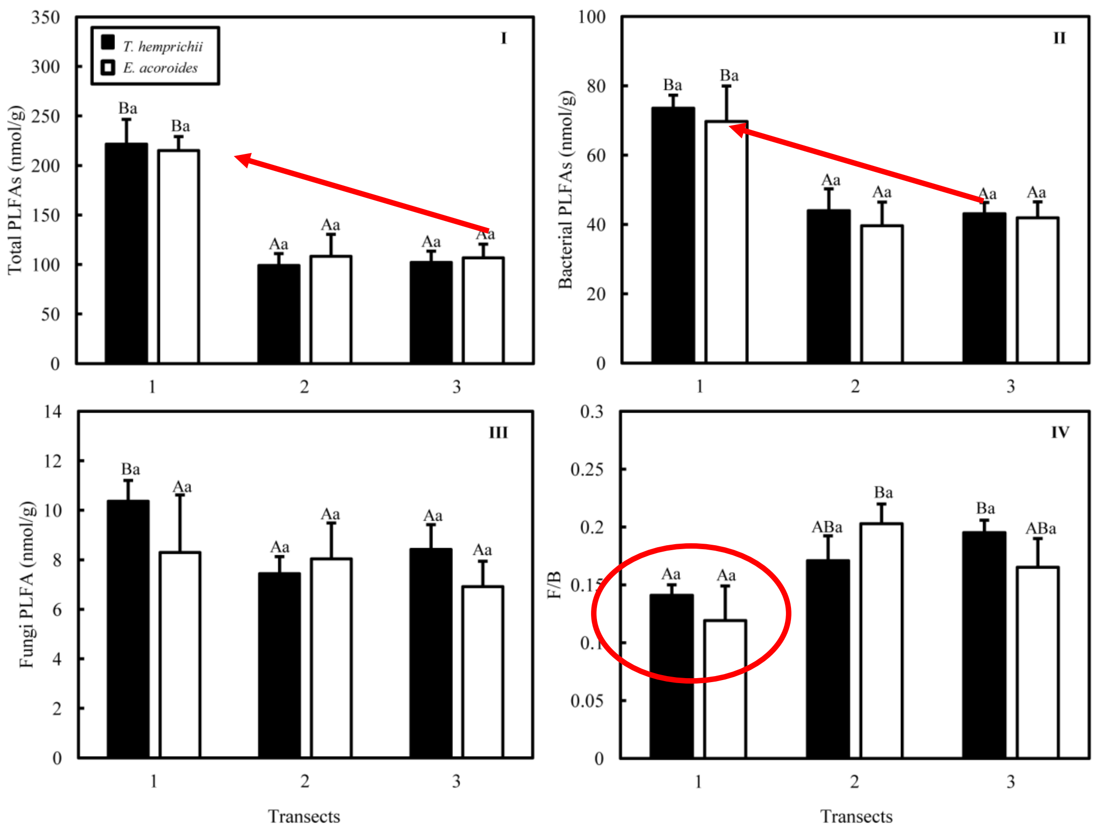
- **Differences of the SOC compositions under the two seagrass communities were not significant;**
- **SOC 、 MBC showed significantly higher in transect 1 than other two transects;**



Variations of the SOC content (I), the TN content (II), the SEC content (III), the MBC content (IV), the SEC/SOC (V), and the MBC/SOC (VI)

Research results

3.Surface sediment microbial communities

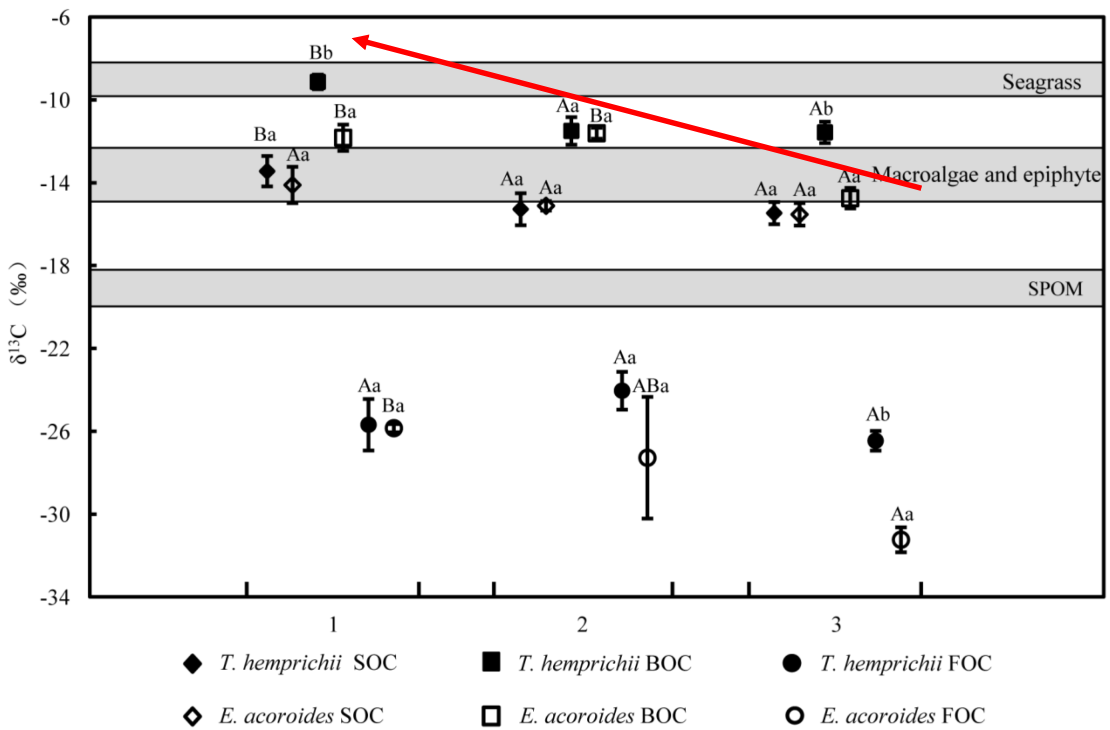


Variations of total PLFAs (I), bacterial PLFAs (II), fungi PLFA (III) and F/B ratio (IV)

- **Bacterial PLFAs and fungal PLFA accounted for about 40% and 7% of total PLFAs；**
- **PLFA compositions were not significant differences between *T. hemprichii* and *E. acoroides*；**
- **Total PLFA and bacterial PLFA in transect 1> other transects**
- **F/B in transect 1 < other transects**

Research results

4. $\delta^{13}C$ of SOC, i+a15:0 and18:2ω6,9c



$\delta^{13}C$ of SOC, bacterial biomarker i + a 15:0 PLFA and fungal biomarker 18:2ω6, 9c among the stations

- **Average $\delta^{13}C_{bacteria}$ -11.73‰, higher than $\delta^{13}C_{SOC}$ (-14.82‰)。 $\delta^{13}C_{bacteria}$ showed significant difference between transects;**
- **$\delta^{13}C_{fungi}$ showed lower than the possible OC sources**

Research results

Isotopic mixing models results based on $\delta^{13}C$ (%) values

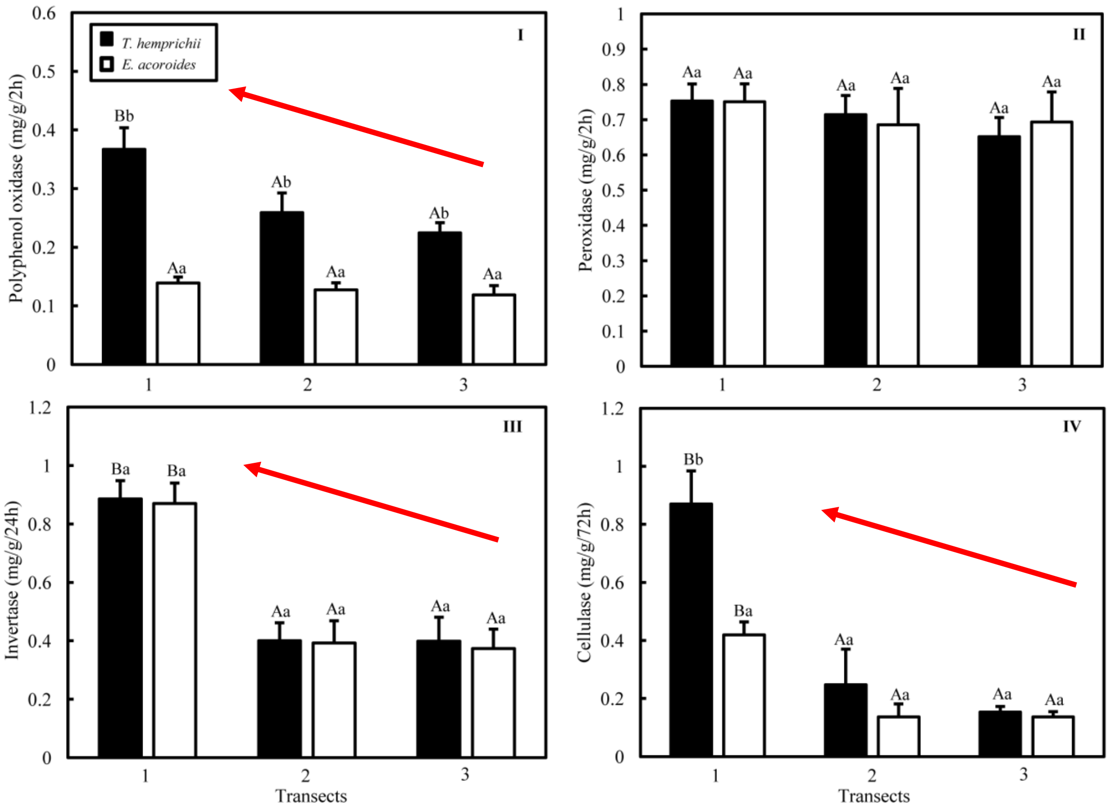
Species	Transect	Seagrass	Macroalgae and epiphyte	SPOM
T. hemprichii	1	32%-88% (60%)	0%-59%(30%)	0%-23%(10%)
	2	13%-62% (39%)	0%-68%(35%)	4%-46%(26%)
	3	13%-62%(38%)	0%-67%(35%)	5%-47%(27%)
E. acoroides	1	11%-59% (36%)	0%-67% (35%)	6.6%-50% (29%)
	2	12%-61% (38%)	0%-68% (35%)	4.5%-47% (27%)
	3	0%-27% (12%)	0%-57% (30%)	34%-84% (58%)

- **Relative contribution of seagrass-derived carbon to bacteria ($\delta^{13}C_{bacteria}$) increased with nutrient loading;**

- **The relative contribution of seagrass plant material to sediment BOC in *E. acoroides* meadows were half that of *T. hemprichii* meadows living side-by-side.**

Research results

5. Sediment enzyme activities



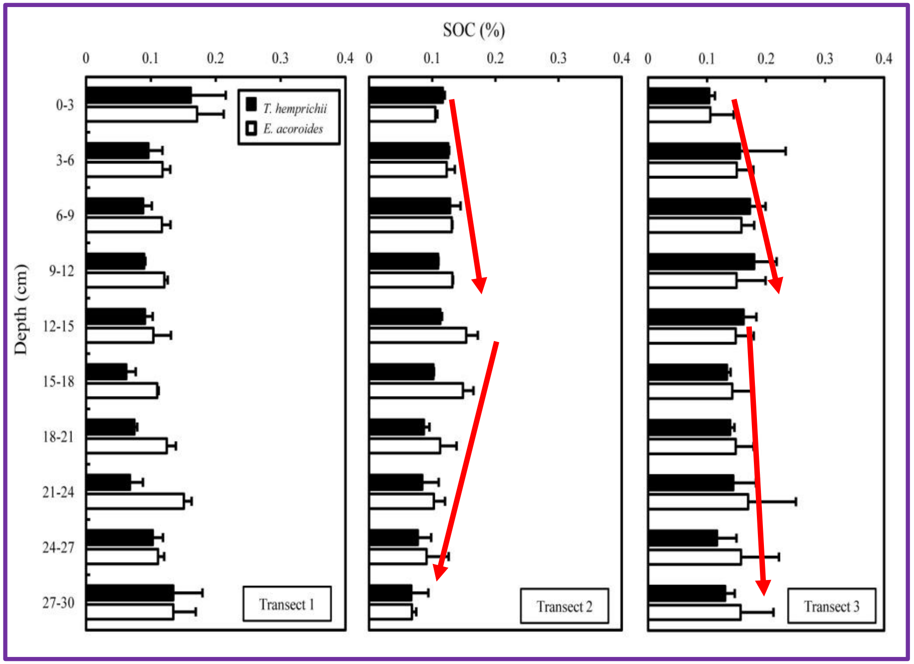
Variations of polyphenol oxidase (I), peroxidase (II), invertase (III) and cellulas (IV) activities

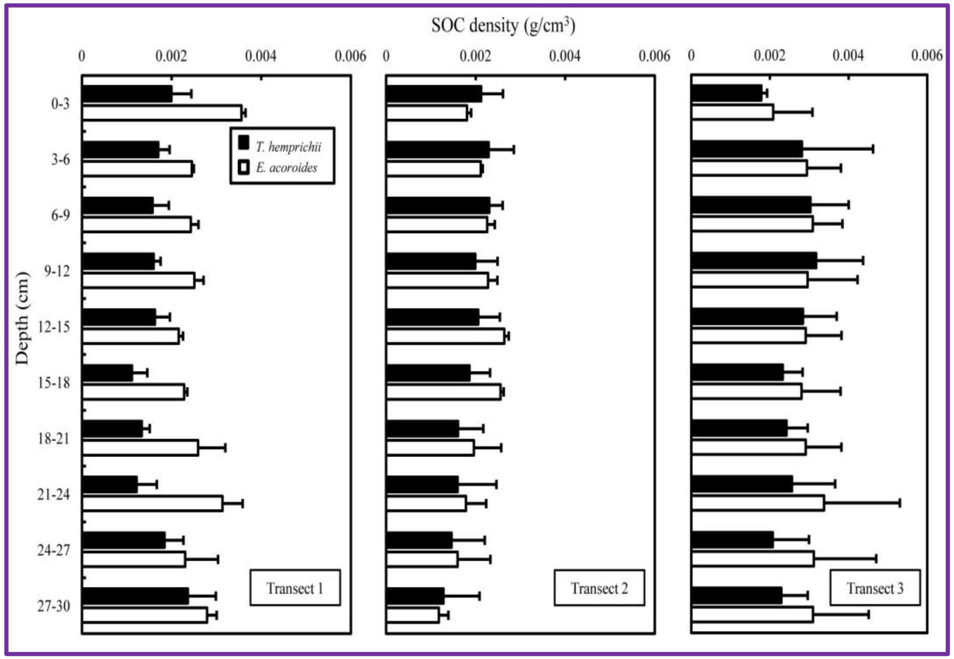
- **Polyphenol oxidase, invertase, and cellulases showed significantly higher in transect 1 than other transects**

- **Polyphenol oxidase and cellulases in *T. hemprichii* observed higher than *E. acoroides*;**

Research results

6. SOC compositions in core sediment

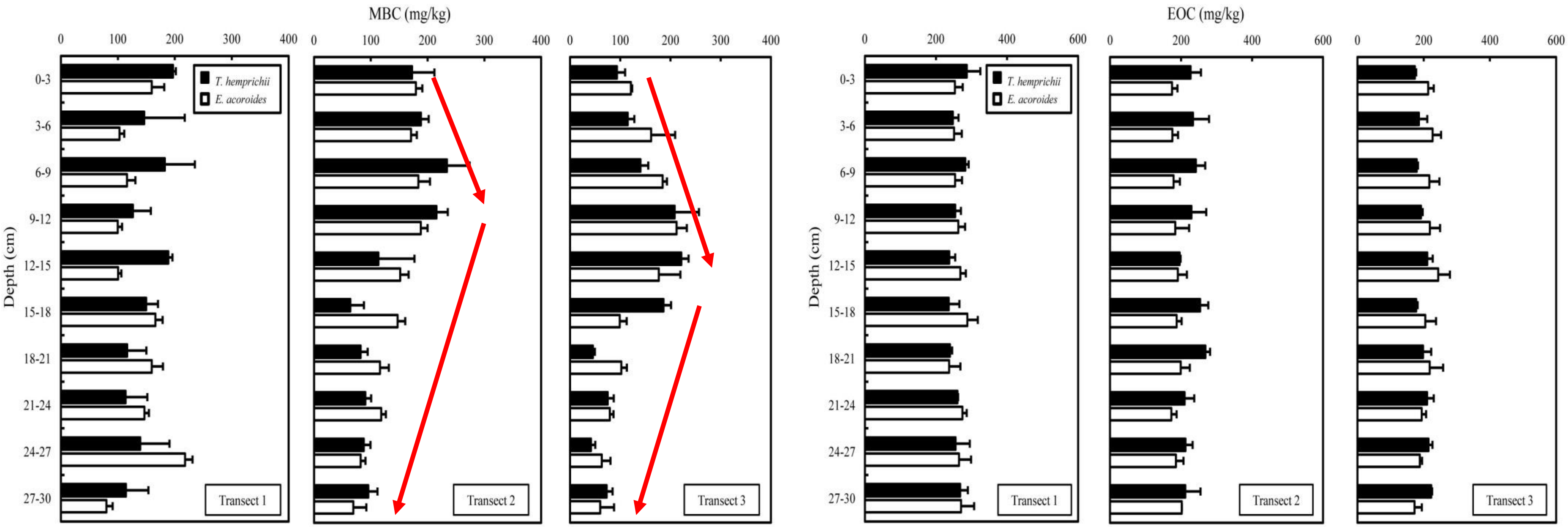




Vertical distributions of organic carbon concentration and density in the sediment cores

- **No significant difference of SOC between *T. hemprichii* and *E. acoroides*;**
- **higher values of SOC and SOC density in T3**
- **SOC and SOC density increased with depth in T 3 but not in other transects**

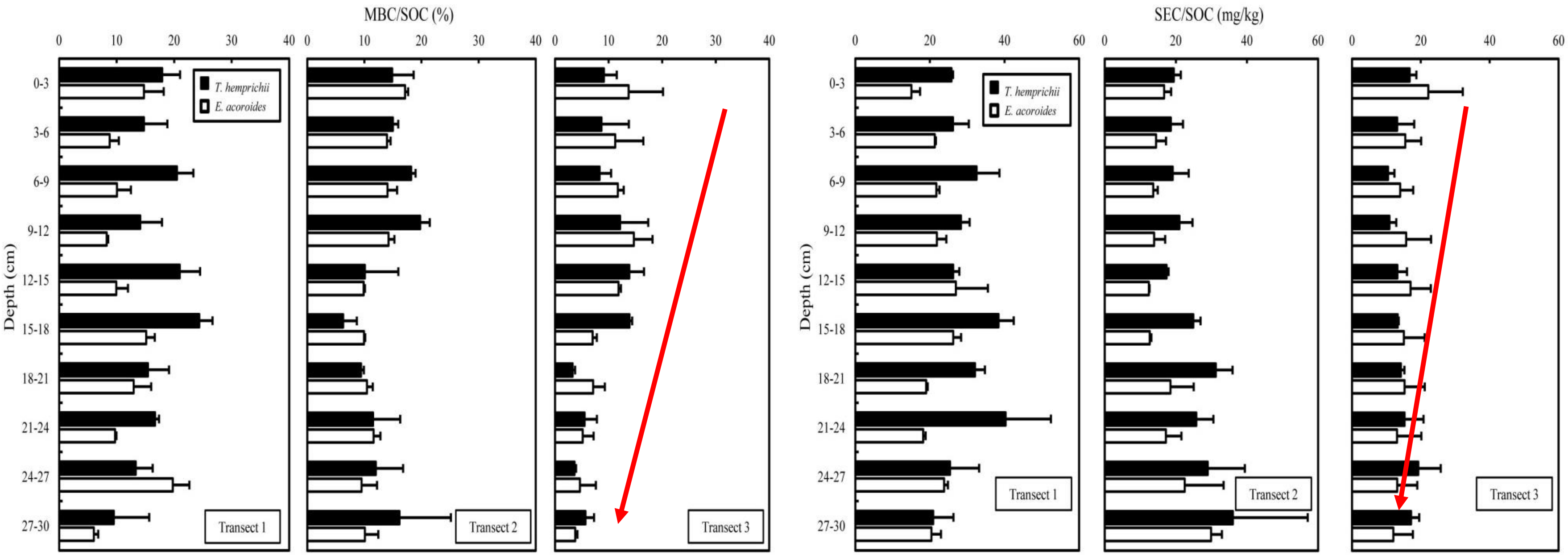
Research results



Vertical distributions of MBC and SEC in the sediment cores

- **The MBC showed significantly higher in T1 and T2 than T3;**
- **MBC was shown the highest in the layer of 6–9 cm and 9–12 cm in T2 and T3 due to OC releasing from root;**
- **SEC in T1 (260 mg/kg) > other transects (200 mg/kg)**
- **MBC and SEC were shown higher in *T. hemprichii* than *E. acoroides***

Research results

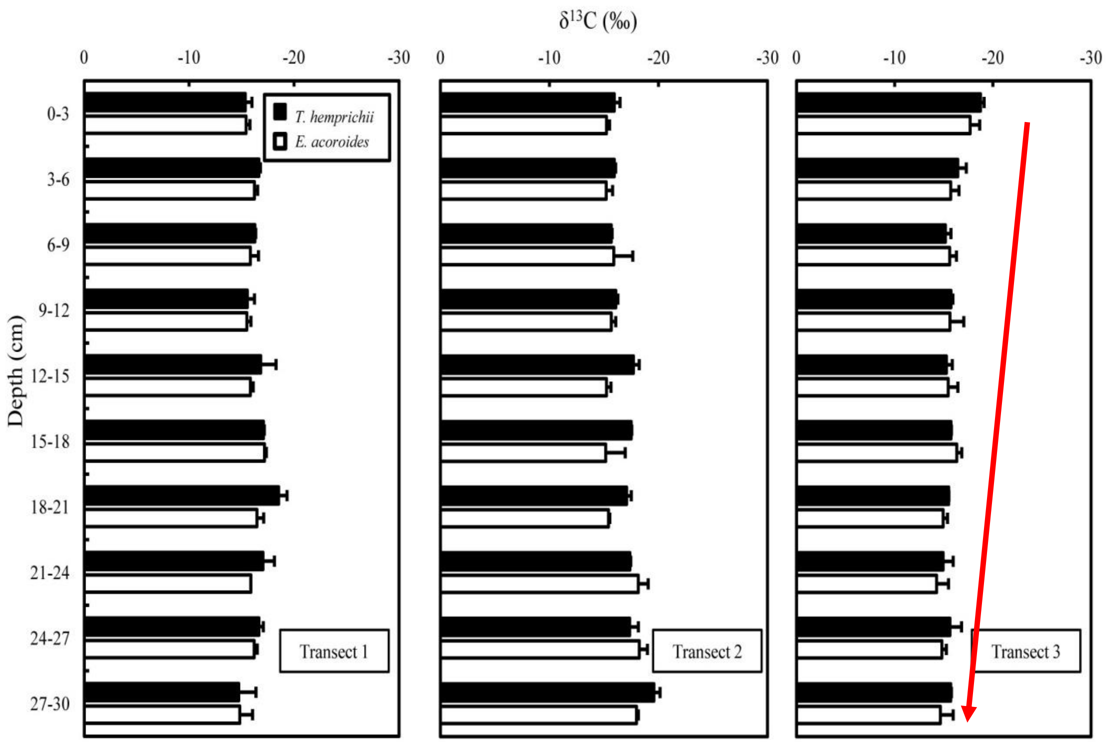


Vertical distributions of ratio of MBC and SEC to SOC

- **MBC/SOC and SEC/SOC in T3 showed much lower than T1, the MBC/SOC 和 SEC/SOC in *T. hemprichii* generally higher than *E. acoroides*;**
- **MBC/SOC and SEC/SOC decrease with depth in T3, while other transects were similar or increase with depth.**

Research results

7. δ^{13}C in sediment cores



Vertical distributions of δ^{13}C of SOC in the sediment cores

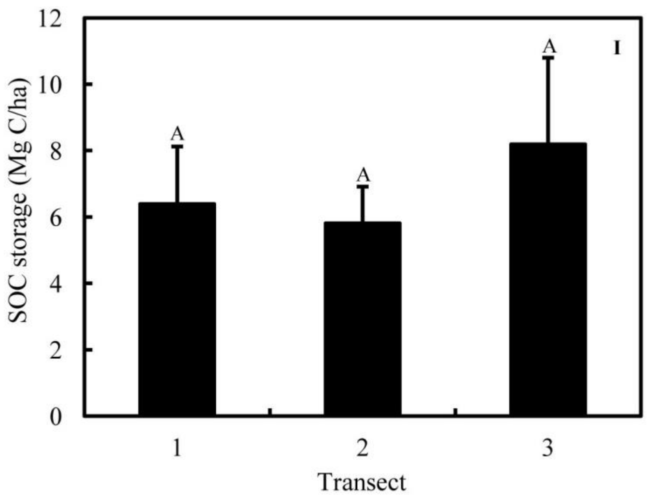
- δ^{13}C in *E. acoroides* generally showed higher than *T. hemprichii*, and the δ^{13}C in T3 showed higher than other transects;

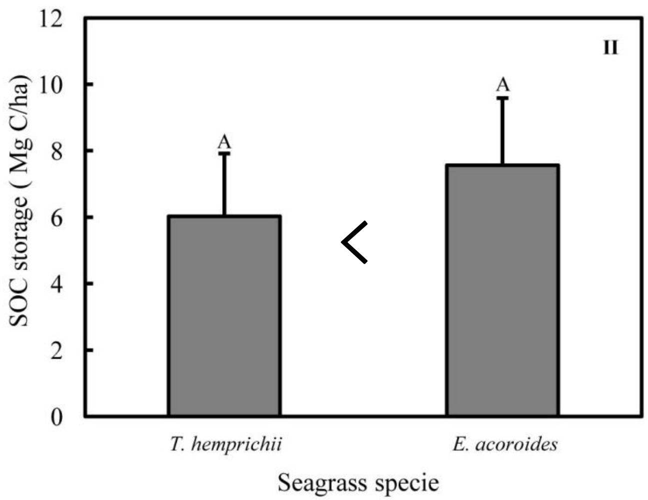
- δ^{13}C in T3 increase with depth but not other transects

- Higher seagrass contribution in T3 than other transects

Research results

8. SOC storage





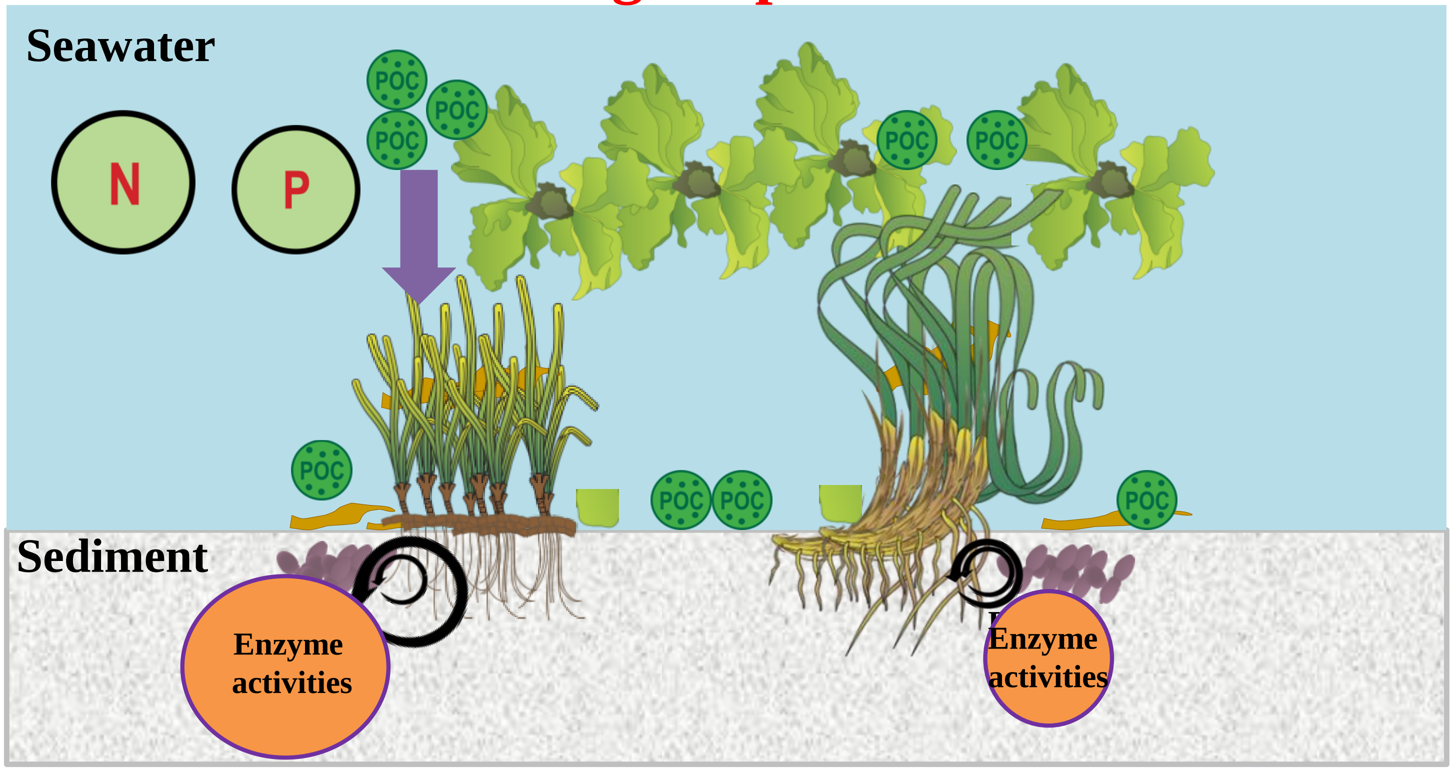
SOCstock in the seagrass bed in Xincun Bay

➢**The estimated SOC stock of the top 30 cm of sediment in the seagrass bed in Xincun Bay was 6.80 Mg C/ha;**

➢**The SOC storage in T3 showed higher 28% than other transects, SOC storage of *E. acoroides* showed higher 1.54 Mg C/ha than *T. hemprichii.***

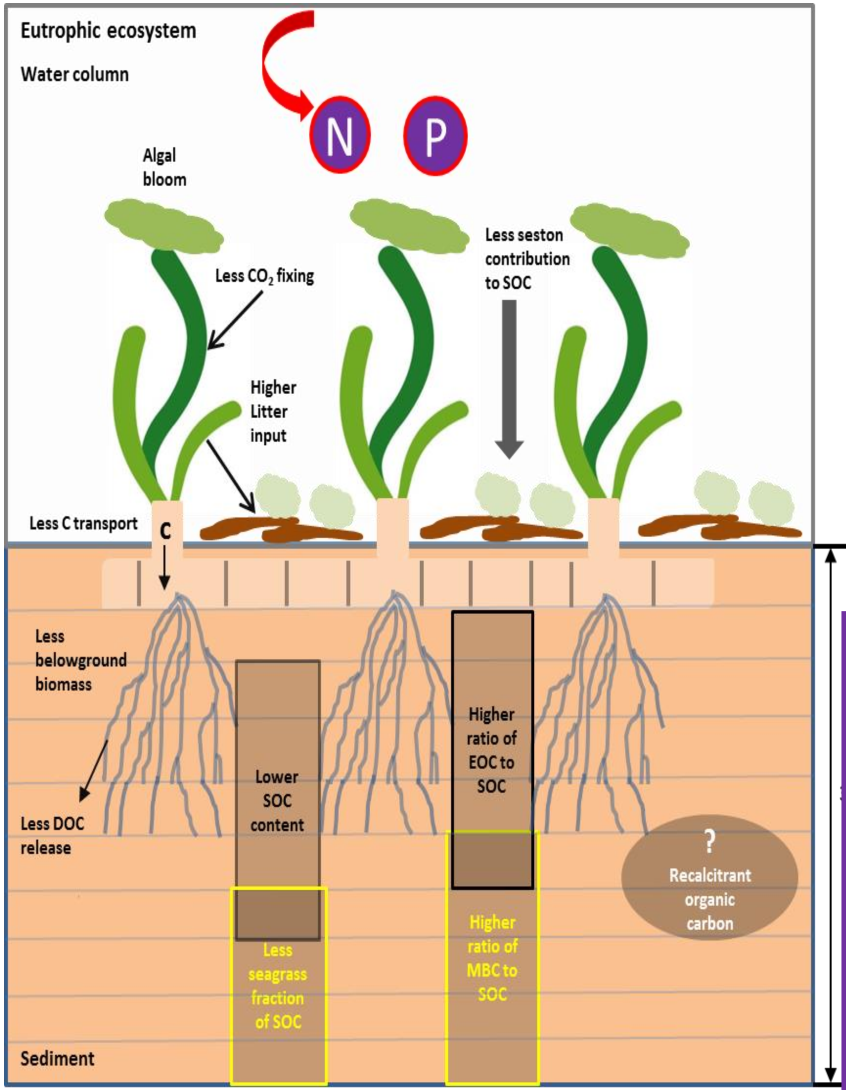
Research results

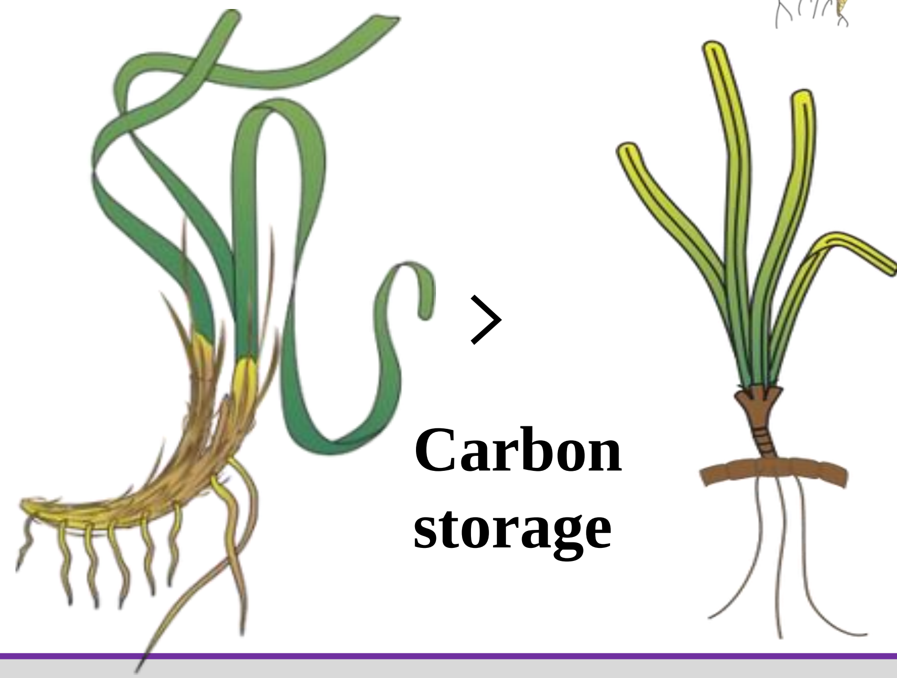
Ecological process



Nutrient loading changes the relative contribution of seagrass and algal sources to SOC pools, boosting sediment microbial biomass and extracellular enzyme activity, thereby enhancing SOC transformation

Research results





Nutrient load increase the labile organic carbon and transformation in the whole sediment core, thus would weaken the SOC sequestration. In addition, the carbon storage potential in *E. acoroides* showed higher than *T. hemprichii*.

Ecological implications

1. To control the nutrient discharge to seagrass meadows

Nutrient enrichment decrease the carbon storage potential, but previous study reported that long-term changes in the nutrient supply to oligotrophic coastal ecosystems could increase C storage (Armitage and Fourqurean 2016). Non-linear and hysteretic nature response of SOC to eutrophication occurred, and a nutrient threshold may also exist with distinct effects on seagrass SOC.

Determine the nutrient threshold that nutrients do not lead to the loss of seagrasses at each seagrass meadows.

eg. Rough estimation, the DIN and DIP in the seagrass meadows of Xincun Bay were 5~7 μmol/L and 0.5~0.7 μmol/L, respectively.

Ecological implications

2. How to evaluate the SOC storage potential?

Most of the previous studies merely used the SOC contents to estimate the carbon sequestration potential (Fourqurean et al., 2012; Marbà et al., 2015; Trevathan-Tackett et al., 2018b). However, nutrient enrichment can enhance SOC contents in the surface sediment, which can not indicate that the SOC storage potential increasing.

The labile organic carbon (eg. MBC and DOC) and enzyme activities (eg. Polyphenol oxidase and cellulases) should be taken as the important indicators to evaluate the carbon sequestration.

Ecological implications

3. How to amplified the 'Blue carbon' of seagrass meadows ?

To recovery the seagrass meadows is the good way to amplify the blue carbon, which has been attempted as shown in previous studies (Marba et al., 2015).

According to this study, we can select that higher carbon sequestration capacity seagrass species to amplify the 'Blue carbon' on condition that this seagrass sepcies is favorable for the local environment.

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Thank you !

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