Marine Ecology & Fisheries Enhancement Funds Trustee Limited
改善海洋生態及漁業提升基金信託有限公司

Marine Ecology Enhancement Fund

MEEF2023008

Completion Report

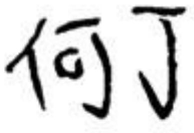
(01/07/2023-30/6/2024)

Assessing the ecological impacts of anthropogenic activities on the coastal wetlands in Hong Kong from the optical properties of sedimentary dissolved organic matter

The Hong Kong University of Science and Technology

I hereby irrevocably declare to the MEEF Management Committee and the Steering Committee of the relevant Funds including the Top-up Fund, that all the dataset and information included in the completion report has been properly referenced, and necessary authorisation has been obtained in respect of information owned by third parties.

Any opinions, findings, conclusions or recommendations expressed in this report do not necessarily reflect the views of the Marine Ecology Enhancement Fund or the Trustee.

Signature： 

Date： 22/08/2024

(i) Executive Summary (1-2 pages)

Hong Kong's coastline is home to diverse coastal wetlands, including mangroves, seagrass meadows, and tidal flats. These wetlands play a crucial role in supporting biodiversity, fisheries, shoreline protection, tourism, education, and even carbon sequestration. However, the rapid urbanization and human activities in Hong Kong pose significant threats to the health of these wetlands, particularly in terms of organic matter composition in sediments. Pollution from sewage, microplastics, and fuel oil further exacerbates the challenges. To address these issues and facilitate wetland conservation, there is a need for scientific research to develop a rapid and efficient diagnostic approach. Dissolved organic carbon (DOM) in coastal wetland sediments is an effective indicator of the composition of organic matter. Industrialization and urbanization have led to a large input of allochthonous DOM in the coastal environment, further complicating the composition and properties of DOM. This makes DOM an ideal indicator for assessing anthropogenic impacts on coastal wetlands. The development of three-dimensional excitation-emission matrix (3D-EEM) fluorescence spectroscopy has allowed us to measure the composition of sediment DOM in a few minutes without complex sample preparation. To have a comprehensive understanding of the impact of anthropogenic activities on the DOM in coastal wetlands in Hong Kong, we conducted our research at nine places around Hong Kong SAR. These sampling sites encompass comprehensive and unique coastal wetland ecosystems, including unvegetated mudflats, mangroves, and seagrass meadows. We monitored the physicochemical properties and DOM content of different coastal wetland sediments, and based on this data, we estimated the organic carbon and nitrogen stocks in these nine coastal wetlands sediments. We found that the organic carbon and nitrogen reserves in the Hong Kong mangroves are significantly higher than those in the unvegetated mudflats and seagrass meadows. Furthermore, we monitored the optical properties of DOM in coastal wetland sediments and developed a 3D-EEM method to trace anthropogenic inputs and calculate their contribution. We identified five sources of DOM in Hong Kong’s coastal wetlands. The DOM related to human activities showed a significant difference among habitats and wetlands. To investigate whether there are seasonal variations, we also conducted seasonal surveys in some wetlands, which revealed no significant seasonal differences. We used the collected data and environmental factors to establish a structural equation model, identifying the main factors influencing DOM chemistry. These results have significant implications for the conservation of coastal wetlands in Hong Kong. Our study is the first assessment that investigates the ecological value of coastal wetland sediments in the carbon and nutrient cycle of Hong Kong's coastal areas. We hope the results of this project will provide decision support and a baseline for the government and related stakeholders.

(ii) Project title and brief description of the Project

Project Title: Assessing the ecological impacts of anthropogenic activities on the coastal wetlands in Hong Kong from the optical properties of sedimentary dissolved organic matter

Applicant Organization: The Hong Kong University of Science and Technology

Project Leader: Ding HE

Brief description of the Project

This one-year project aims to assess the ecological impact of anthropogenic activities on the sediments of Hong Kong coastal wetlands (e.g., mangroves, seagrass meadows, and tidal flats), by monitoring the optical and biochemical properties of sedimentary dissolved organic matter (DOM) in the coastal wetlands. Using the most advanced and rapid fluorescence spectrometer, the study will trace the source of DOM—an indicator of ecosystem health—in the sediment. In addition, by combining the carbon and nitrogen stable isotopes, chemical and physical bulk properties of DOM, the ecological impact of anthropogenic activities on the sediments in the coastal wetlands of Hong Kong are also evaluated. The results provide a theoretical basis for predicting and regulating the material cycle in the coastal wetlands, as well as formulating policy on the conservation and management of the Hong Kong coastal wetland ecosystem.

(iii) Completed activities against the proposed Work Schedule

We conducted the research and related tasks regarding the tasks in the section 9 of application form:

1. A full research of this project based on our methodology in proposal: **Done**
2. Recruit one research assistants and one postdoctoral fellow: **Done**
3. Sediment Sampling on different coastal wetlands in Hong Kong: **Done**
4. Total organic carbon, total nitrogen, and isotopes analysis of sediments: **Done**
5. Optical properties of DOM from sediments: **Done**
6. Data analyses and model development: **Done**
7. Paper writing: **Midterm Report was done, one paper is under review by the journal, other papers are in progress. We will inform you when the paper is published.**

(iv) Results/ descriptions on the completed activities with appropriate analysis, with the support of photos, videos, social media platform, etc., if any

1. Introduction

Located at the boundary between marine and terrestrial environments, terrestrial materials, such as organic matter, can be transported to the ocean (Yu et al., 2019). Therefore, coastal wetlands contribute significantly to global biogeochemical cycles and nutrient dynamics (Ward et al., 2020), with profound implications for climate change mitigation. Coastal wetlands (e.g., mangroves, seagrass meadows, and tidal flats) are regarded as blue carbon ecosystems due to their high capacity for carbon (C) sequestration and storage and represent long-term sinks for atmospheric C. In addition, coastal wetlands, for example, have complex vegetation structures that may provide additional ecological functions and value (e.g., the aerial roots of mangroves are important nursing sites and shelters for juvenile fish). In recent decades, coastal wetlands have been widely considered to be a natural solution to climate change migration (Macreadie et al., 2021).

However, how natural or anthropogenic events (e.g., pollution, urbanization, reclamation, and habitat replacement) could influence the sediment C sequestration capacity of coastal habitats is still poorly understood, particularly events on peri-urban coastlines where threats are most imminent. Hong Kong, with its 260 islands, is located at the eastern estuary of the Pearl River in southern China (22.08° to 22.35° N, 113.49° to 114.31° E). Hong Kong has a total land area of 1,108 km^2 with a long coastline of 1,180 km and a diverse coastal ecosystem, including mangroves, seagrasses meadows, and tidal flats. However, coastal wetlands are highly disturbed by human activities. As a result of population growth and economic development, CO_2 emission levels in Hong

Kong have remained at 40-45 million tons in recent years. Natural C sinks in Hong Kong took up 465,000 tons of CO_2-equivalent, about one percent of the total CO_2 emissions. It is estimated that the sediment of tidal flats in Mai Po Nature Reserve (MPNR) alone can sequester over 677 tons of CO_2-equivalent annually, equivalent to 0.15% of Hong Kong's annual emissions of CO_2 (Chen & Lee, 2022). This percentage may seem small, but the fact is that the tidal flats in MPNR only cover 0.09 % of the area in Hong Kong. Therefore, better conservation and study of coastal wetlands in peri-urban areas can help the Hong Kong and Chinese governments to meet their long-term goal of achieving carbon peak and neutrality.

Dissolved organic matter (DOM) is a widely occurring C source that present in water, and sediment. DOM involves in the transport and transformation of different substances. Coastal wetlands are susceptible to deposition of pollutants of terrestrial and marine origins (Andrady, 2011; Luo et al., 2020; Ouyang & Guo, 2016; Paduani, 2020). Sourced from land-based, maritime activities, river discharge and even atmospheric dust, plastic pollution, sewage discharge, and fuel leaking make coastal sediments vulnerable to contamination (Zhang, 2017; Zhang et al., 2020). These persistent organic pollutants, once buried, are almost impossible to remove from the coastal sediment (Martin et al., 2019; Yao et al., 2019). Sequestration in coastal sediments is regarded as an important and efficient removal process for organic pollution (Martin et al., 2019, 2020). DOM within coastal wetland sediments can reflect the properties and sources of organic matter, especially in peri-urban coastal wetlands vulnerable to anthropogenic activities. Algal and microbial metabolites and plant root exudates provide the main source of autochthonous DOM in coastal wetlands, while river discharge and human activities are responsible for allochthonous DOM inputs (Derrien et al., 2017). This makes DOM an ideal indicator for detecting anthropogenic impacts on coastal wetlands.

Economic growth has exacerbated the anthropogenic disturbance of coastal environments in the last decades. A large input of allochthonous DOM in the peri-urban coastal wetlands was caused by rapid industrialization and urbanization, which makes the composition and characterization of DOM more complicate. In the coastal water environment, the input of anthropogenic pollution has increased the production of autochthonous DOM in the Chinese Coastal Delta (He et al., 2022). In Peral River Estuary, people found a higher protein-like DOM composition, which may be caused by the sewage input form upstream (Zhang et al., 2022). Similarly, a higher level of protein-like DOM indicated that the water DOM was affected by human activity (He et al., 2019). These studies mainly investigated the effects of anthropogenic disturbances on the composition and characteristics of DOM in water bodies, while little is known about their effects on sedimentary DOM in coastal wetlands. A comprehensive study of the nature and composition of sedimentary DOM and their relationship with intertidal socioeconomic development indicators is necessary. Understanding how the DOM dynamics of sediments from tidal flats and adjacent wetland habitats respond to the effects of urbanization will help elucidate the future C sequestration capacity of peri-urban coastal wetlands. These data are also essential for improving the conservation and restoration of coastal wetlands and establishing a C sequestration baseline for further managing highly urbanized coastal areas.

The development of three-dimensional excitation-emission matrix (3D-EEM) fluorescence spectroscopy has allowed us to measure the composition of sediment DOM in a few minutes without complex sample preparation. UV-visible spectroscopy and excitation-emission matrix coupled parallel factor analysis (EEMs-PARAFAC) are widely used in studying DOM sources and transformations. Coloured DOM (CDOM) and fluorescent DOM (FDOM) allow us not only to identify DOM sources but also to further evaluate their transformation processes. These methods have been used to clarify the contribution of DOM from different sources in studies of freshwater, estuarine, and marine areas. Therefore, we applied 3D-EEM fluorescence spectroscopy and EEMs-PARAFAC) for the first time in Hong Kong coastal wetlands to analyse DOM from coastal wetland sediments. In this study, we focused on the linkages between DOM and anthropogenic activities along the Hong Kong coastline. The potential importance of different factors also be evaluated by considering relevant environmental factors, bulk properties, and the level of urban development in the surrounding area.

2. Methods

2.1. Sampling Sites

Sampling efforts across the Hong Kong SAR have successfully collected 25 sediment cores at both summer and winter seasons, comprising 412 layers of subsamples from nine coastal wetlands: Mai Po (MP), Tung Chung (TC), Ting Kok (TK), Lai Chi Chong (LCC), Fung Wong Wat (FWW), Ham Tin (HT), Lai Chi Wo (LCW), Kuk Po (KP), and Tai Tam (TT) **(Figure 1)**. These sites represent a wide array of blue carbon ecosystems throughout the region, each with unique characteristics and ecological importance.

MP, a Ramsar site (site number: 750) managed by WWF-Hong Kong since 1983, is in Deep Bay and spans a total area of 1,500 hectares. This site includes three primary blue carbon ecosystems: tidal flats, mangroves, and *gei wai* (tidal aquaculture ponds), with the mangroves dominated by seven species, namely *Kandelia obovata*, *Avicennia marina, Aegiceras corniculatum, Bruguiera gymnorhiza, Excoecaria agallocha,* *Acrostichum aureum*, and *Acanthus ilicifolius*. MP is not only critical for its biodiversity, hosting numerous migratory birds as part of the East Asia-Australasia Flyway, but it also faces significant threats from the rapid urbanization surrounding Deep Bay.

TC, located in Tung Chung Bay on Lantau Island, represents a successful example of mangrove restoration. Following disturbances caused by the construction of Hong Kong International Airport, this mangrove ecosystem has been revitalized, with distinct zones dominated by different species. The waterfront zone is primarily composed of *Avicennia marina* shrubs, while the landward zone features taller trees such as *Kandelia obovata* and *Excoecaria agallocha*. TC serves as a vital study area for understanding restoration success and the resilience of mangrove ecosystems.

TK, LCC, and FWW are situated in Tolo Harbour, a semi-enclosed bay known for its distinct environmental conditions. TK, home to the fourth-largest mangrove forest in Hong Kong, is characterized by its shrub-like mangrove communities, which have adapted to the sandy substrates and higher salinity levels of this oceanic-influenced environment.

LCW and KP, located in Yantian Harbor, represent some of the least disturbed mangrove habitats in the region. These areas are characterized by smaller, shrub-like communities that have remained relatively untouched by urbanization, offering invaluable insights into the natural state of mangrove ecosystems in more exposed, oceanic environments.

HT, positioned in Sai Kung East, and TT, located on Hong Kong Island, provide contrasting examples of mangrove ecosystems under varying degrees of human influence. HT, influenced by relatively pristine oceanic waters, offers a baseline for understanding natural mangrove dynamics, while TT, surrounded by intense urbanization, highlights the impacts of land reclamation and urban runoff on coastal wetlands.

Sediment cores were obtained in nine important coastal wetlands using a Kajak corer (KC-Denmark) with a diameter of 52 mm (at least 30cm), from the mangroves and their tidal flats in target areas (for MP and TC, we further collected additional sediment cores from *gei wai* (traditional fish pounds in Hong Kong with mangroves) and seagrass meadows, respectively. After collection, each core was immediately transferred to the laboratory and sliced into between 17 and 18 intervals. The top 10 cm of each core was sliced into 1-cm intervals, while the 10 to 20 cm section was sliced into 2-cm intervals, and the remaining portion was sliced into 5-cm intervals. We also record relevant environmental parameters in the field. A total of 25 sediment cores with 412 layers of subsamples were obtained and stored at -20 °C before further processing.

2.2.Bulk analysis of sediment samples

In the laboratory, approximately 5 g of fresh sediment from each sample were freeze-dried until constant weight. All litter and detritus from freeze-dried samples were removed before they were ground and then passed through a 2-mm sieve. For each sample, approximately 20 mg of the ground material were weighted in silver capsules, and inorganic carbon was removed by 6 M HCl. After drying, the total OC (OC), total nitrogen (TN) content, the OC stable isotopes ($\delta^{13}C$) and nitrogen stable isotopes ($\delta^{15}N$)

values of different sediment samples were determined by a continuous flow EuroVector EA-Nu Perspective isotope-ratio mass spectrometer.

For each sediment section, samples will be dried until constant weight (W_{dry}) (g). Then the bulk density (BD) (g cm^{-3}) of each sample was calculated using the following equation:

$$BD = \frac{W_{dry}}{V} \tag{1}$$

where V is sample volume (cm^3), determined by the auger's internal diameter (cm) and the thickness of the sediment slice. Sediment samples were ground and passed through a 2-mm mesh. Sediment C stock (CS) (Mg C ha^{-1}) at each depth was calculated using the following equation, where L is the thickness of the slice (cm):

$$CS = BD \times C\% \times L \tag{2}$$

2.3. DOC and optical analysis of SDOM

The water-extractable SDOM of each sample was obtained by mixing 10 g of fresh sediment sample with Milli-Q water at a ratio of 1:10 (w:v). The mixture was shaken on a shaker at 4°C for 24 hours and then sequentially filtered using pre-combusted (450°C, 4h) GF/F membranes (pore size of 0.7 μm) and polycarbonate membrane filters (pore size of 0.22 μm). The DOC concentration of each SDOM sample (pre-acidified to pH 2) was measured by a TOC analyzer (Shimadzu TOC-L, with an uncertainty of ±1.5‰). The absorption and fluorescence EEMs were then analyzed using 5 ml of each SDOM sample to assess and trace the source of chromophoric DOM (CDOM) and fluorescent DOM (FDOM). This was conducted by the Aqualog absorption-fluorescence spectrometer (Horiba, Japan) with a scan range of 240 to 600 nm at 3 nm intervals. Milli-Q water was used as the blank and the interference from Rayleigh and

Raman scatter peaks was removed. A calibration scan of the water Raman peak at an excitation wavelength of 350 nm was performed, and the EEMs were normalized to Raman units (R.U.). Optical indices, like the humification index (HIX) (Ohno, 2002), the biological index (BIX) (Huguet et al., 2009), and the fluorescence index (FI)(McKnight et al., 2001), were also calculated in this study. PARAFAC was used to determine the components of EEMs based on split-half validation. All components were compared to the OpenFluor database (http://www.openfluor.org) (Murphy et al., 2014).

3. Results

3.1. Bulk Characteristics of Sediments in Hong Kong Coastal Wetlands

After collecting all sediment core samples from coastal wetlands, we first conducted basic elemental and isotopic analyses. This is a conventional method in previous studies of coastal wetlands and serves as an effective approach to assess OC and N content and organic matter sources. Our results show that the OC and N content, as well as $\delta^{13}C$ and $\delta^{15}N$ values, in sediments from nine coastal wetlands in Hong Kong, exhibit significant variations with depths (**Figure 2**). Overall, surface sediments have higher OC and N levels, largely due to the presence of more detritus, which is often a key source of OC and N. The stable isotope results indicate similar conclusions, with $\delta^{13}C$ values in surface sediments being more depleted, suggesting input and contribution from terrestrial sources.

We further compared the bulk parameters across different habitats and found that the OC (8.1±3.2 %) and N (0.6±0.2 %) in *gei wai* (in MP) were significantly higher than in other habitats, primarily due to the poor water exchange rate in the pond, leading to substantial accumulation of detritus from vegetation such as mangroves. This trend is particularly pronounced in vegetated areas, where OC and N contents are significantly higher compared to unvegetated areas, showing a stronger terrestrial signal (more depleted $\delta^{13}C$ values and more enriched $\delta^{15}N$ values) (**Figure 3**). However, seagrass beds in TC are an exception, displaying a stronger autochthonous signal ($\delta^{13}C$ values range from -23.5‰ to -20.2‰) due to their growth below the lower tidal area, which is influenced more by marine organic matter and microbial activity. Overall, mangroves in Hong Kong have higher OC and N content compared to unvegetated tidal flats. In most coastal wetlands, mangrove sediments show more depleted $\delta^{13}C$ values and more enriched $\delta^{15}N$ values (**Figure 4**).

Given that coastal wetlands are considered important OC sinks, we also calculated the OC stocks in sediments (top 1 m) across different habitats in Hong Kong based on their bulk characteristics. The results indicate that the OC stock in the MP is much higher than in other habitats, mainly due to the very high OC content in *gei wai* sediments (303.6 Mg OC ha^{-1}). Overall, vegetated coastal wetlands, such as mangroves, have significantly higher carbon storage than intertidal flats (**Figure 5**).

3.2. Optical Characteristics of DOM in Hong Kong Coastal Wetlands

However, using bulk parameters to assess and trace the sources of organic matter in Hong Kong coastal wetlands has significant limitations. First, sample preparation and testing can be time-consuming, which hampers rapid detection. Second, once the parameters are obtained, accurately tracing the sources of organic matter becomes challenging, making it hard to identify specific origins. We developed a method that incorporates UV-visible spectroscopy alongside bulk parameters to obtain insights into DOM in various wetland sediments. This approach yields three key parameters:

1. Humification Index (HIX): Indicates humic content and is positively correlated with the aromaticity of DOM; higher values reflect greater degrees of humification.

2. Biological Index (BIX): Indicates autotrophic productivity, where values above 1 suggest recently produced autochthonous DOM.

3. Fluorescence Index (FI): Helps distinguish DOM sources, with microbial sources indicated by FI > 1.8 and terrestrial sources by FI < 1.2.

We projected these three parameters onto the depth profiles of different wetlands and habitats, revealing significant regional and habitat differences.

Overall, these parameters varied with depth and exhibited regional differences (**Figure 6**). The HIX indicates humic content, with mangroves often showing higher HIX values than intertidal zones, particularly in the MP, where mangrove detritus is more abundant (**Figure 6A**). This finding aligns with our conclusions based on OC and other parameters. In contrast, BIX values are higher in the tidal flats (**Figure 6B**), suggesting a greater proportion of fresh autochthonous sources. The highest BIX values were recorded in the tidal flats of HT and the seagrass beds of TC, indicating that these habitats are more influenced by marine factors, consistent with their geographical locations and environmental characteristics. Generally, surface layers exhibit higher FI values, reflecting more active microbial activity and potential water pollution (**Figure 6B**). Overall, the FI values in the nine tidal flats of Hong Kong are higher than those in mangroves, with notably elevated FI values observed only in the tidal flats of TC and FFW. The research area in TC is close to the Hong Kong Airport where under construction, which may introduce anthropogenic input. However, pollution from upstream sources in the Pearl River cannot be ignored. The FFW, located in northern Tolo Harbour, displays significant differences from other coastal wetlands in the area, suggesting that environmental factors such as water flow may play a role in these places.

3.3. 3D-EEMs-PARAFAC Modeling of DOM in Hong Kong Coastal Wetland Sediments

We also performed 3D-EEMs-PARAFAC modeling on these samples, identifying five fluorescent components: three humic-like components (C1, C2, and C3) derived from coastal microbial activity, algal exudates, and coastal waters, alongside two protein-like components (C4 and C5) linked to water pollution and vegetation degradation (**Table 1 & Figure 7**). By mapping the intensity and relative proportions of these components onto the depth profiles of various regions and habitats, we observed significant differences.

Since C1 and C3 belong to marine humic-like components and share similar sources, we analyzed them together here. C1 and C3 both primarily originate from nearby marine waters and are linked to microbial activity, resulting in higher intensity in most tidal flats compared to mangroves (**Figure 8**), as tidal flats are more influenced by marine environments. C2, on the other hand, mainly derives from terrestrial humic sources and sourced from algae, leading to greater intensity and relative abundance in mangroves and *gei wai*, where the surface is rich in microphytobenthic algae, potentially enhancing the intensity of this component (**Figure 8**). In contrast, the protein-like components associated with water pollution and vegetation degradation (C4 and C5) showed higher intensity in mangroves than in tidal flats, except in the MP (**Figure 8**). This may be attributed to the mangrove area's proximity to land, making it more vulnerable to freshwater and upstream wastewater pollution. However, the exception in MP indicates that components from anthropogenic wastewater sources are more prevalent in the tidal flats. It is probably due to the high anthropogenic impact from Deep (Shenzhen) Bay.

Our analysis of DOM components across different depths revealed that surface intensities were generally higher than those at the bottom, particularly for C2, which was more pronounced in vegetated systems like mangroves. This suggests a significant contribution of algae to surface DOM. Similarly, C4, associated with wastewater, exhibited higher surface intensities, indicating surface runoff as a key pathway for wastewater introduction (**Figure 9**). Comparing DOM components across different coastal wetlands, we observed greater microbial activity signals in TC tidal flats and seagrass beds, particularly in the tidal flats (**Figure 10**). This suggests that DOM in TC tidal flat sediments is more labile and readily degraded by microbes. However, C4 intensities related to wastewater were relatively low in TC tidal flats and seagrass beds, indicating minimal pollution despite TC's proximity to construction areas and dense anthropogenic activity. Overall, mangroves exhibited higher levels of wastewater pollution compared to tidal flats, likely due to the more frequent water exchange in tidal flats, which facilitates the flushing of pollutants by tides.

After classifying all sediment samples from the nine coastal wetlands by habitat, we observed that overall, the intensity of C1-C3 was highest in *gei wai*. Since C1-C3 are humic-like components, the leaf litter in the surface layers of *gei wai* serves as a major source of humic substances, resulting in significantly higher intensities in MP compared to other habitats. However, the wastewater-associated component C4 only showed differences directly in tidal flats and mangroves (**Figure 11**), consistent with our earlier discussions that mangroves in Hong Kong are likely more affected by wastewater than adjacent tidal flats.

3.4. Seasonal Differences of DOM in Hong Kong Coastal Wetlands

Hong Kong is located in a subtropical region with no distinct seasons, but there are significant temperature and precipitation differences between winter and summer. To investigate potential seasonal variations in DOM characteristics within Hong Kong coastal wetland sediments, we first conducted winter sampling at MP and TK, following our initial summer sampling. These sites were chosen due to their high OC storage and notable DOM parameters, particularly the intensity of wastewater-associated C4, observed during the summer sampling (**Figure 5**). Our findings revealed that winter environmental changes did not significantly impact the variation of bulk parameters across different habitats in MP and TK. The depth variation trends remained consistent with those observed in summer (**Figure 12**), indicating no discernible seasonal fluctuations (**Figure 13**). Further comparisons of the five DOM components between the two wetlands across seasons had similar results, with consistent depth variations across seasons (**Figure 14)** and no significant seasonal differences (**Figure 15**). This suggests that seasonal variations do not directly influence the intensity of different DOM components. Overall, our findings indicate minimal seasonal differences in bulk and DOM parameters within Hong Kong coastal wetlands, suggesting the stability of organic matter. Given the lack of seasonal differences in MP and TK, and the consistency of our findings, we did not proceed seasonal sampling in other wetlands.

3.5. Contribution of anthropogenic impact on coastal wetlands in Hong Kong

To assess the influence of anthropogenic activities on DOM in Hong Kong's coastal wetland sediments, we analyzed the contributions of five different PARAFAC components, focusing on C4, which is associated with watewater pollution. Our results, presented in a pie chart (**Figure 16**) and **Table 2**, showed that C4 contributions range from 4.86% to 26.35% across nine coastal wetlands and four habitats. The tidal flat at

LCW exhibited the lowest watsewater impact, likely due to its location in eastern Hong Kong with minimal anthropogenic influence and high water exchange facilitated by tidal flushing. Conversely, the highest C4 contributions were observed at HT and MP. While HT is also in the eastern region, our sampling area is affected by upstream rivers and nearby human activities, potentially contributing to higher pollution levels. Compared to LCW, the mangroves and adjacent tidal flats at HT are farther from the coast, with lower water exchange frequencies that may promote pollutant accumulation. Similarly, the high proportion of C4 in the tidal flats at MP aligns with our previous findings that intense human activities in Shenzhen Bay are likely a significant source of pollution. Our study also investigated TC, located opposite the airport construction area, which could be subject to greater anthropogenic influence. However, both the tidal flats and seagrass at TC showed lower levels of wastewater pollution, likely due to higher water exchange. Despite this, the DOM from wastewater sources in TC's mangroves still accounts for approximately 19%, highlighting the significant role of water exchange in coastal wetlands' ability to process pollutants. To further investigate the factors regulating DOM components, we developed a structural equation model incorporating environmental and human influence factors (**Figure 17**). The model results indicate that natural environmental factors are the primary drivers of DOM composition in Hong Kong's coastal wetlands. However, anthropogenic activities exert a positive influence on C4 and a negative influence on C2, potentially due to disruptions in algal activity, leading to a decrease in the contribution of algal-derived C2 to sediment DOM.

4.Project activities

To better document and promote our MEEF project, we have created a dedicated section on our laboratory website (https://hkustdinghe.github.io/meef/) that provides detailed information about the MEEF project and our work (**Figure 18**). Currently, our website receives around 100-150 visits per day. On our website, we showed the project objectives and technical approach of our MEEF project, alongside records and photos from our field sampling. This will help us exhibit relevant research information to the public and interested academic communities. To further explain and disseminate our methods and findings related to the study of sediment DOM, we have also created videos documenting our field sampling and laboratory work. These videos are now available on our website. Our research not only focuses on laboratory studies but also aims to inspire young people's interest in science and conservation. To achieve this, undergraduate and MSC students are involved in our project. They contribute not only to field sampling but also participate in laboratory work, gaining valuable hands-on experience (**Figure 19**). To better promote our project results, we proactively shared our preliminary findings at the 9th National Youth Geoscience Forum in Xiamen at May 2024. At the forum, one of the project participants, Dr. Zhaoliang Chen, gave an oral presentation on the project's progress and engaged in discussions with scholars, students, and government officials involved in coastal wetland research (**Figure 20**). We look forward to expanding the methods of this study to a larger geographical scale. Here we also presented more photo examples of our project in Tung Chung, Mai Po, Ting Kok and Ham Tin (**Figures 21 to 24**). For more information about the project (e.g., introduction, photos and video), please find out on our lab website, https://hkustdinghe.github.io/meef/ **(Figure 25)**.

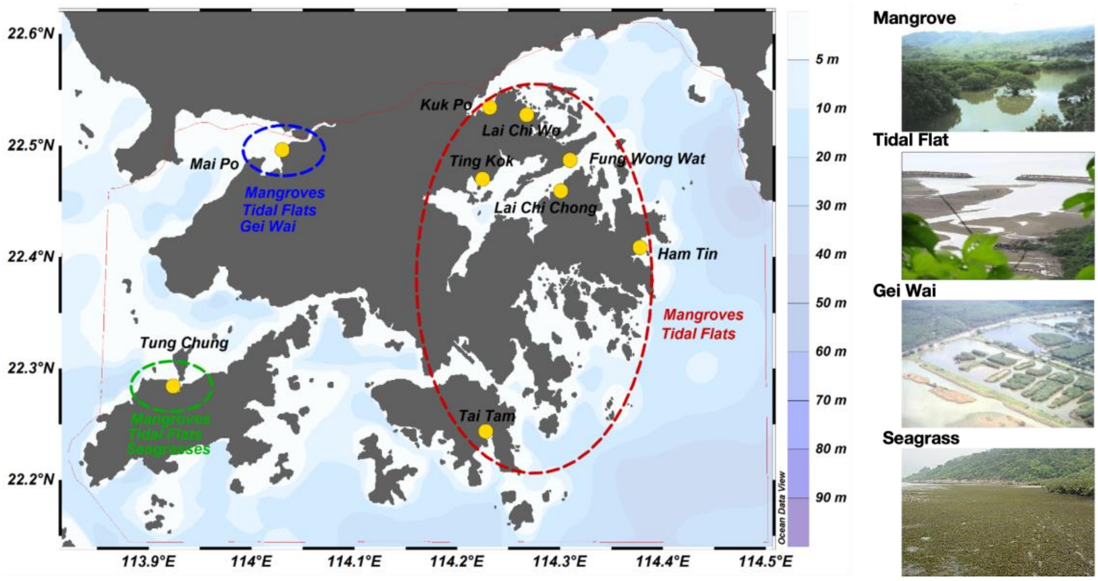


Figure 1. Sampling map for the project in Hong Kong. Yellow dots on the map indicated the locations of the study wetlands. The red circle marks areas where sediment samples were collected exclusively from mangroves and tidal flats. The blue circle highlights regions where samples were taken from mangroves, tidal flats, and *gei wai*. The green circle indicates areas where sediment samples were collected from mangroves, tidal flats, and seagrass meadows. The four pictures on the right are the 4 types of blue carbon ecosystems in Hong Kong.

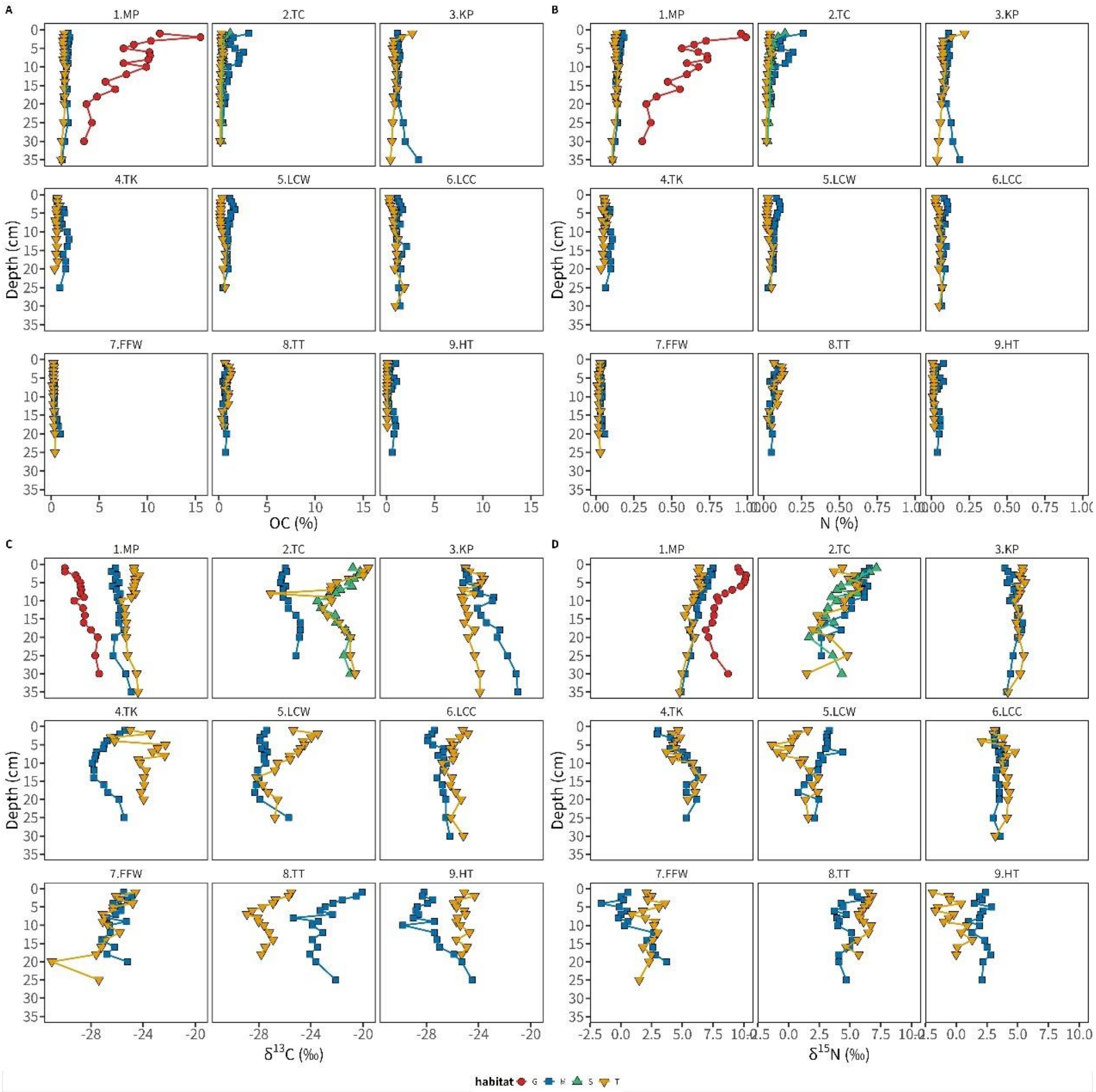


Figure 2. Vertical profiles and comparison of bulk characteristics including A) total organic carbon (OC); (B) total nitrogen (N); (C) δ13C values; and (D) δ15N values from *gei wai* (G, red), mangroves (M, blue), seagrass meadows (S, green) and tidal flats (T, yellow) in nine coastal wetlands in Hong Kong.

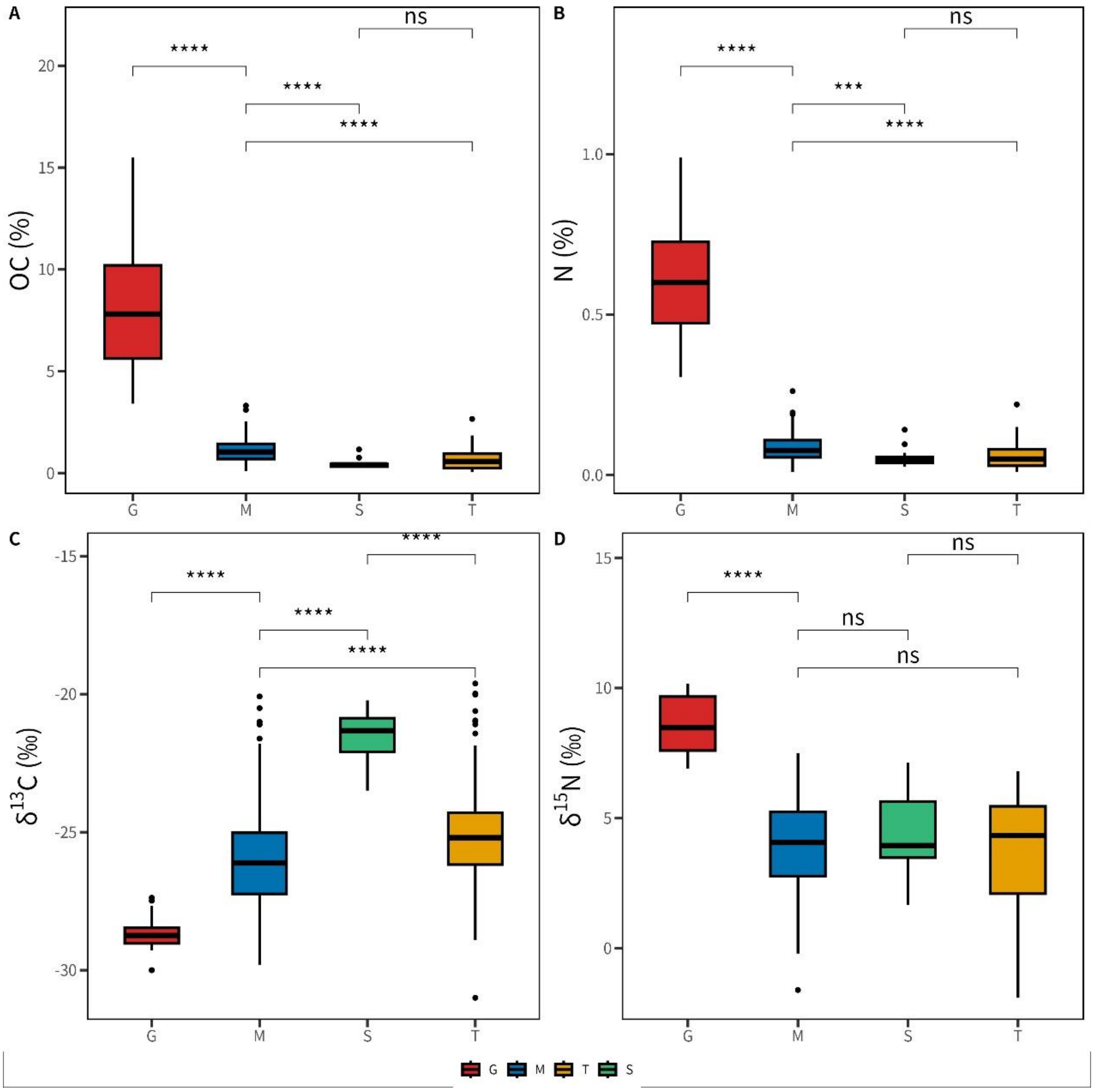


Figure 3. Comparison of bulk characteristics including (A) total organic carbon (OC); (B) total nitrogen (N); (C) $\delta^{13}C$ values; and (D) $\delta^{15}N$ values from *gei wai* (G, red), mangroves (M, blue), tidal flats (T, yellow), and seagrasses (S, green) in coastal wetlands in Hong Kong. Mann–Whitney *U*-test is applied. Significant differences are indicated as * ($p < 0.05$), ** ($p < 0.01$), *** ($p < 0.001$), **** ($p < 0.0001$), and ns ($p \geq 0.05$).

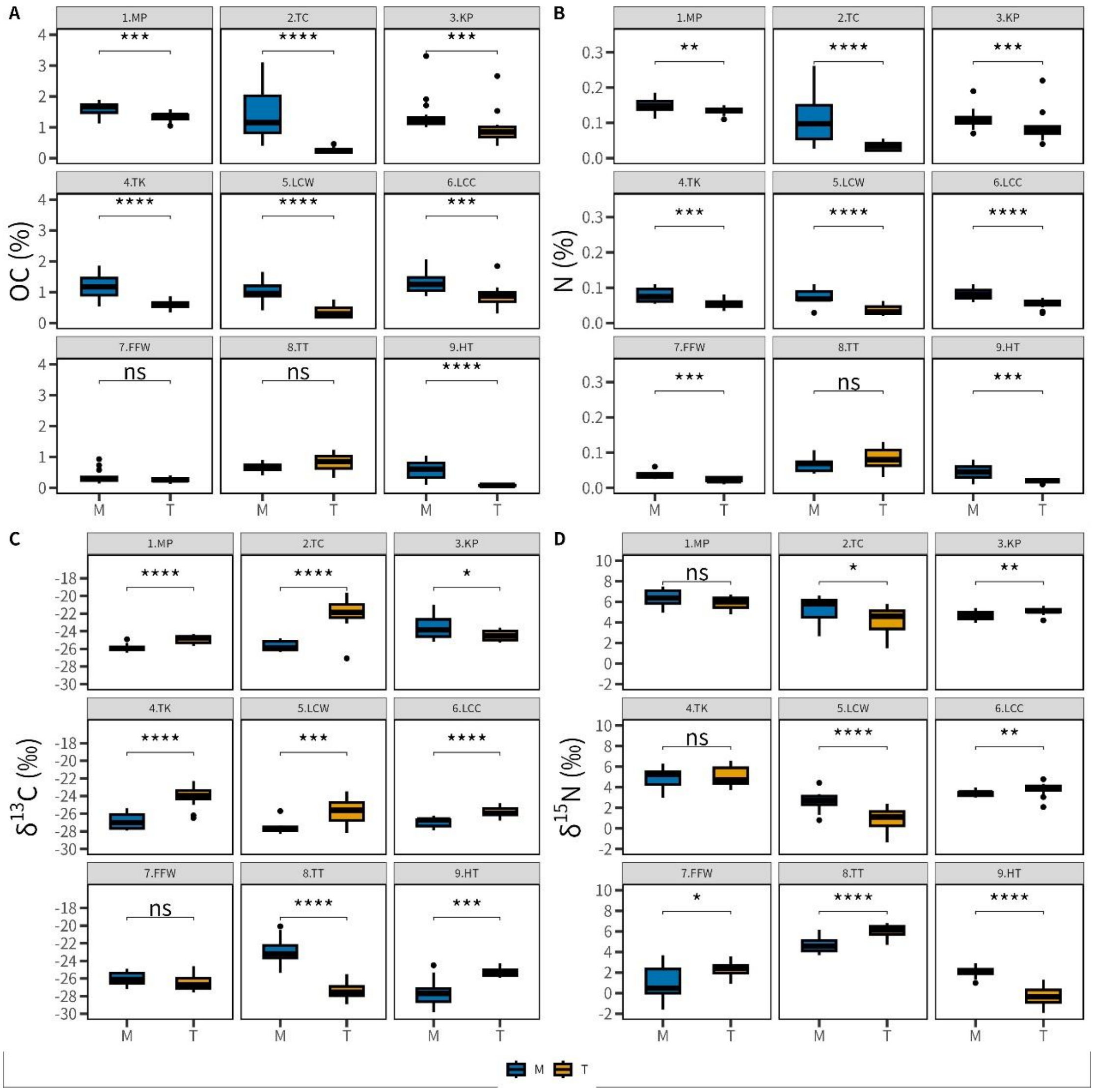


Figure 4. Comparison of bulk characteristics including (A) total organic carbon (OC); (B) total nitrogen (N); (C) $\delta^{13}C$ values; and (D) $\delta^{15}N$ values from mangroves (M, blue) and tidal flats (T, yellow) in nine coastal wetlands in Hong Kong. Mann–Whitney *U*-test is applied. Significant differences are indicated as * ($p < 0.05$), ** ($p < 0.01$), *** ($p < 0.001$), **** ($p < 0.0001$), and ns ($p \geq 0.05$).

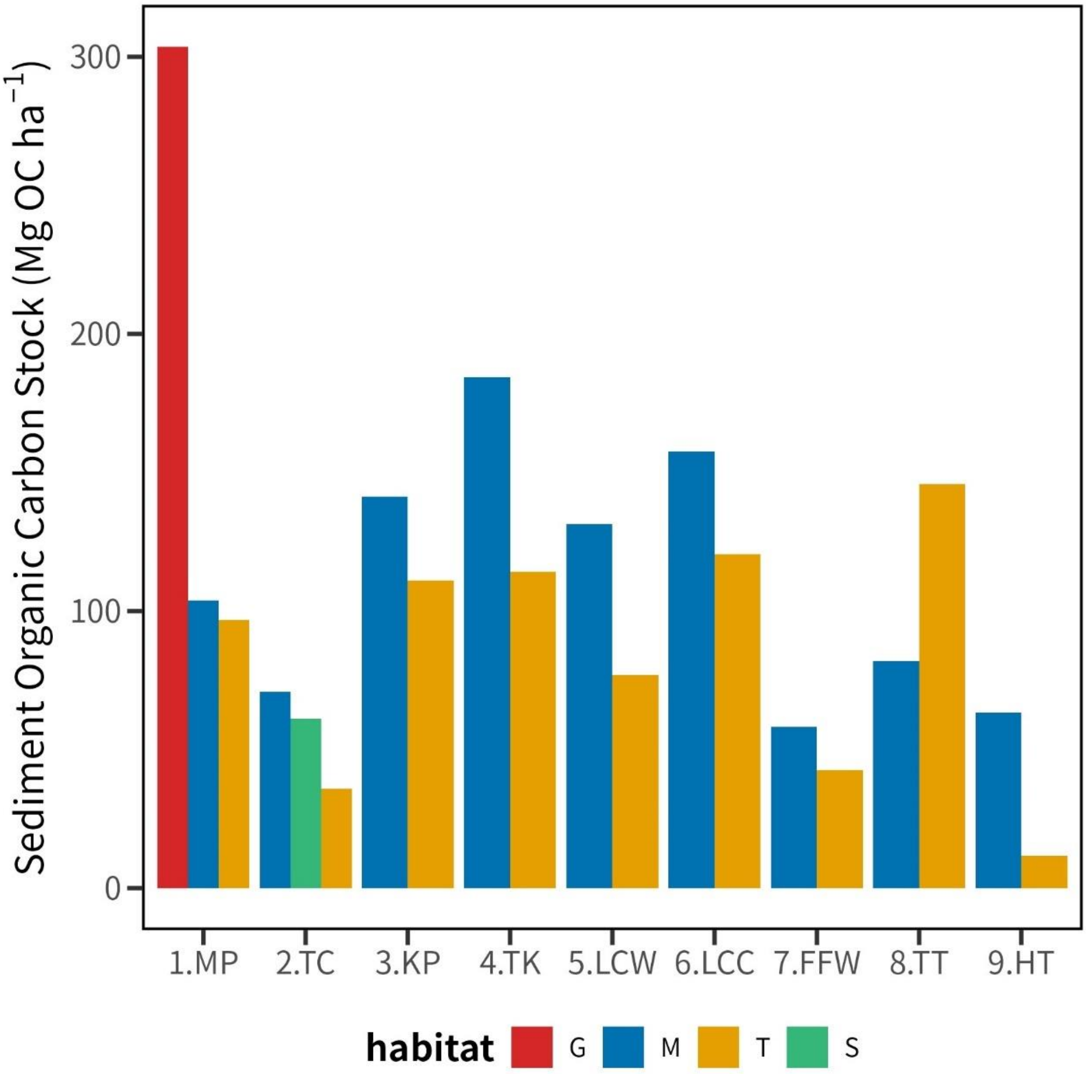


Figure 5. Sediment organic carbon stock (top 1 m) in *gei wai* (G, red), mangroves (M, blue), tidal flats (T, yellow), and seagrasses (S, green) in nine coastal wetlands in Hong Kong.

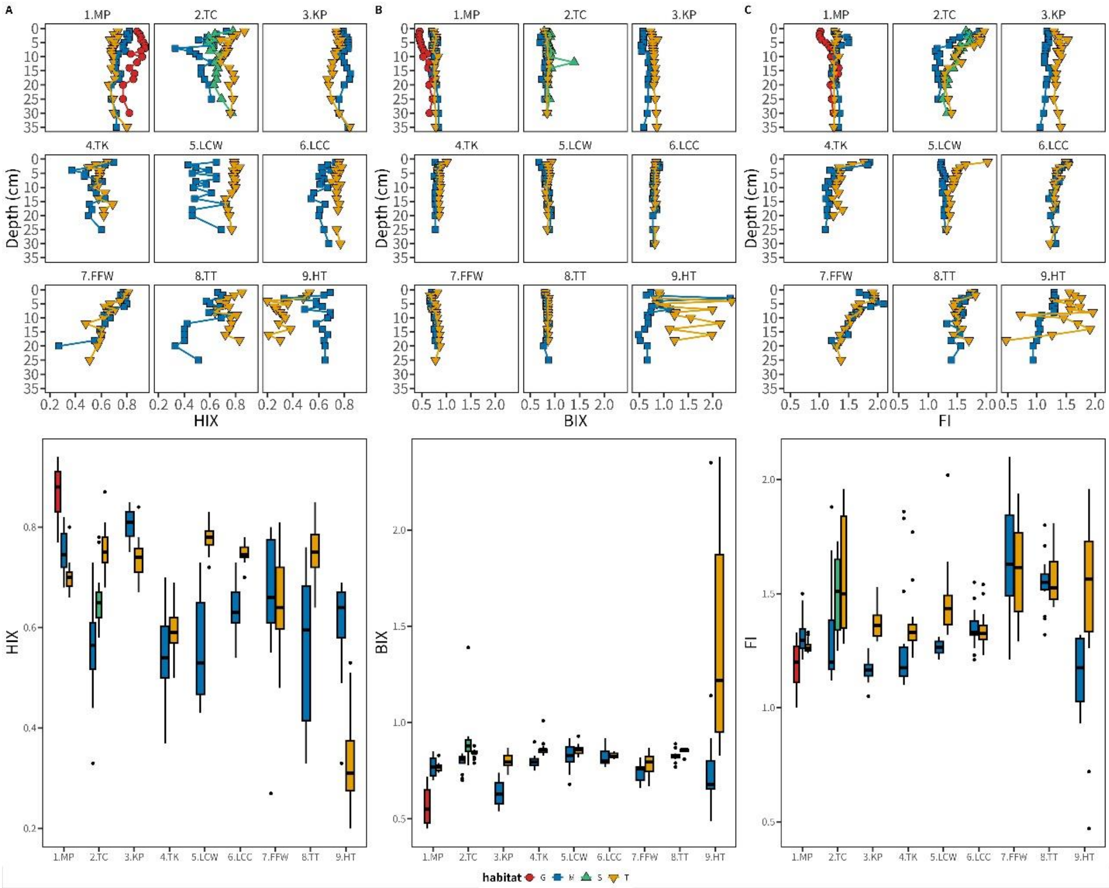


Figure 6. Vertical profiles and comparison of optical characteristics including (A) humification index (HIX); (B) biological index (BIX); and (C) fluorescence index (FI) from *gei wai* (G, red), mangroves (M, blue), seagrass meadows (S, green) and tidal flats (T, yellow) in nine coastal wetlands in Hong Kong.

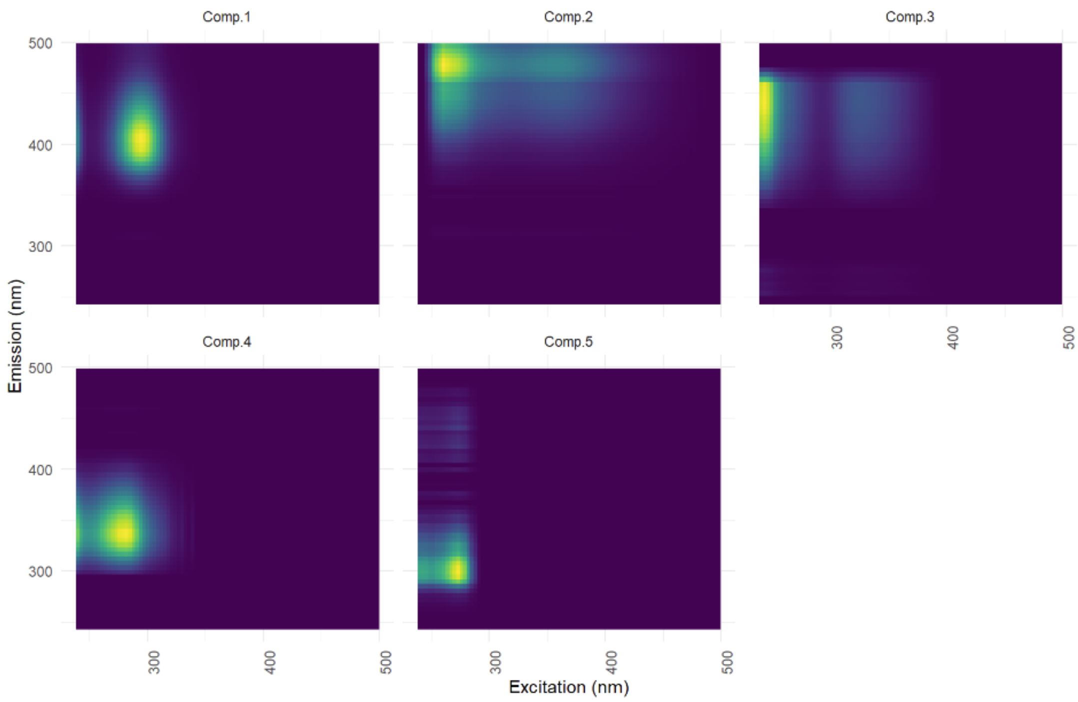


Figure 7. Five PARAFAC components of DOM in nine coastal wetlands in Hong Kong.

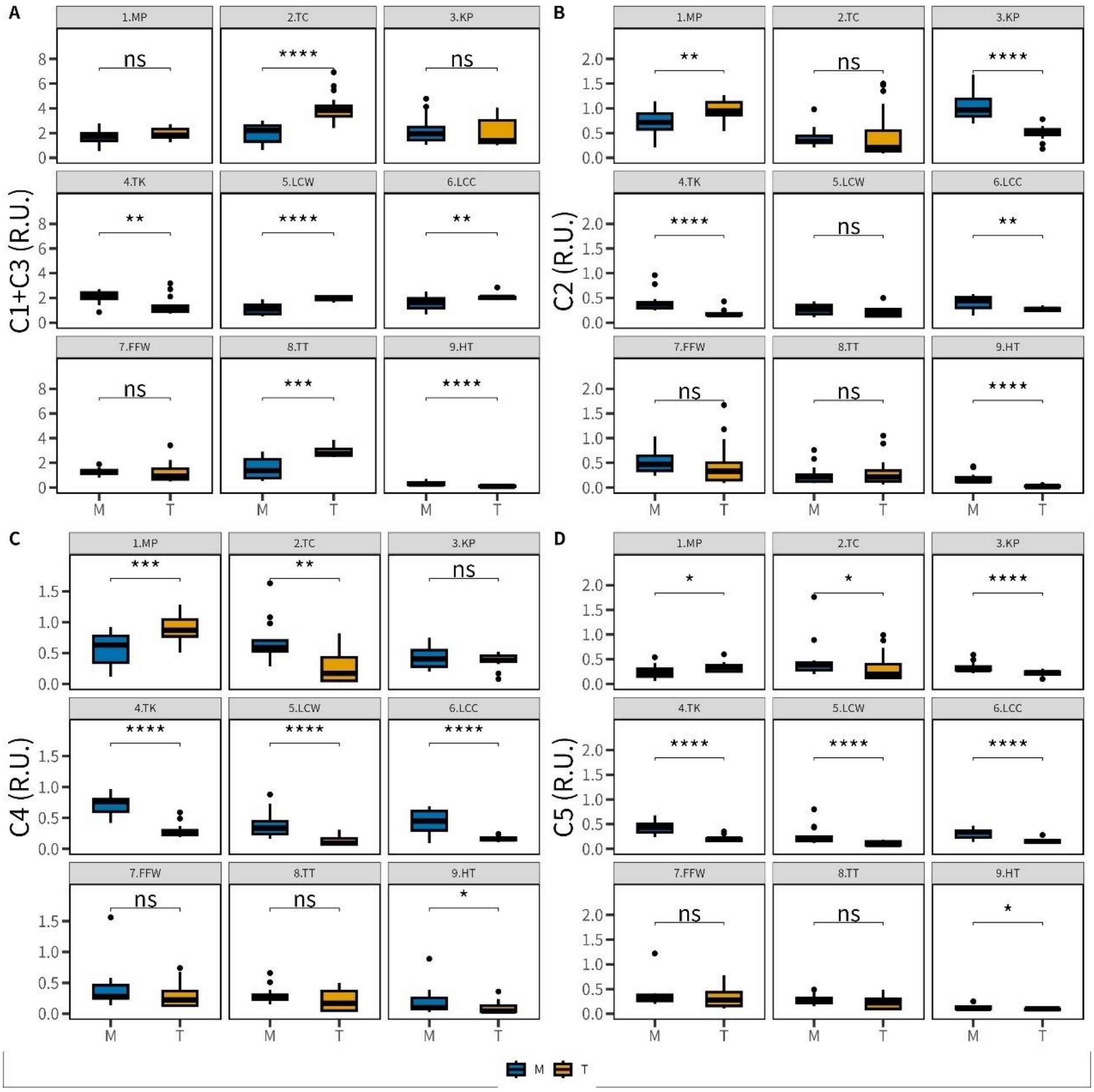


Figure 8. Comparison of five 3D-EEMs-PARAFAC components including (A) Component 1 and Component 3(C1+C3); (B) Component 2 (C2); (C) Component 4 (C4) and (D) Component 5 (C5) from mangroves (M, blue) and tidal flats (T, yellow) in nine coastal wetlands in Hong Kong. Mann–Whitney *U*-test is applied. Significant differences are indicated as * ($p < 0.05$), ** ($p < 0.01$), *** ($p < 0.001$), **** ($p < 0.0001$), and ns ($p \geq 0.05$).

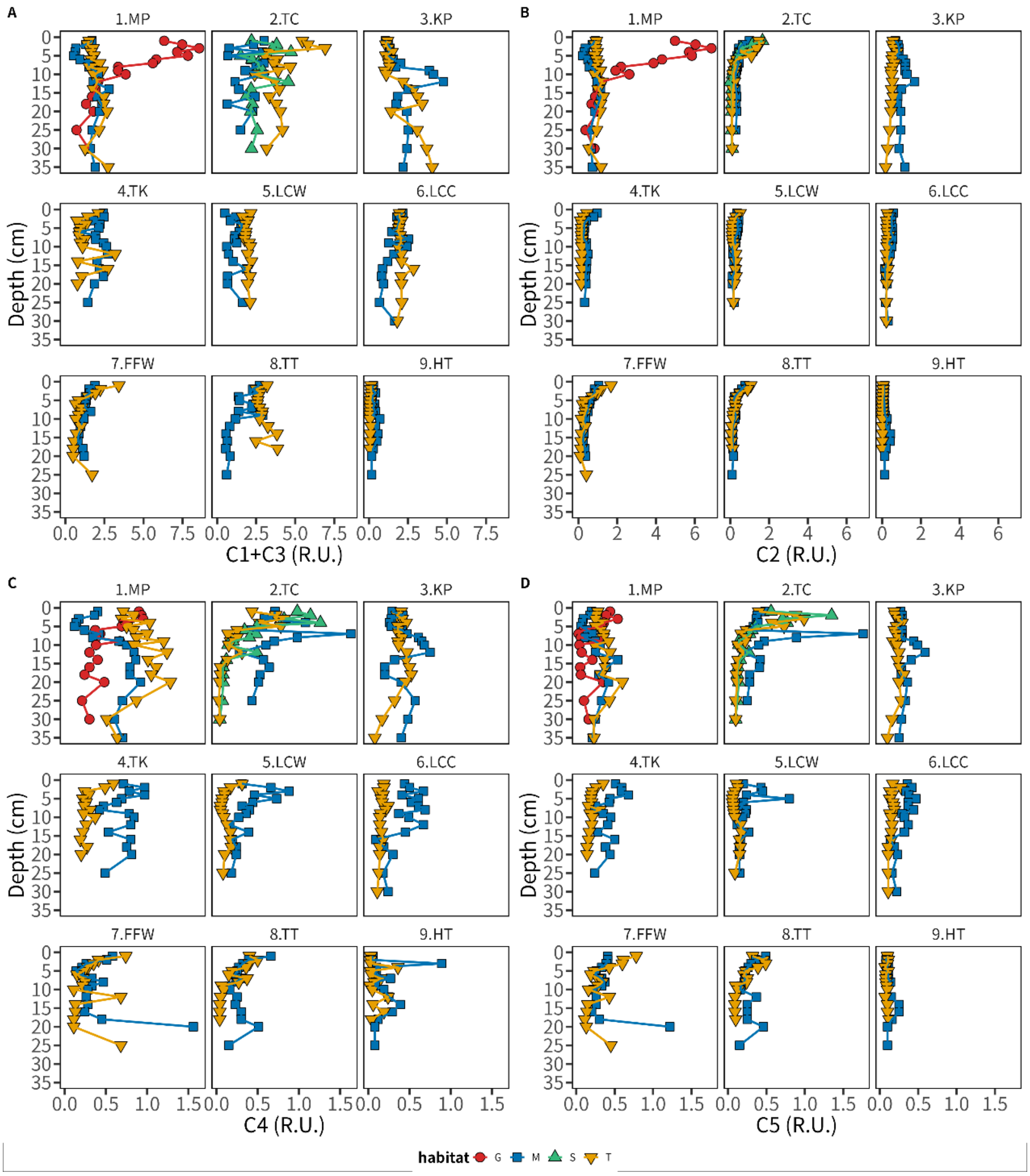


Figure 9. Vertical profiles of five 3D-EEMs-PARAFAC components including (A) Component 1 and Component 3(C1+C3); (B) Component 2 (C2); (C) Component 4 (C4) and (D) Component 5 (C5) from *gei wai* (G, red), mangroves (M, blue), seagrass meadows (S, green) and tidal flats (T, yellow) in nine coastal wetlands in Hong Kong.

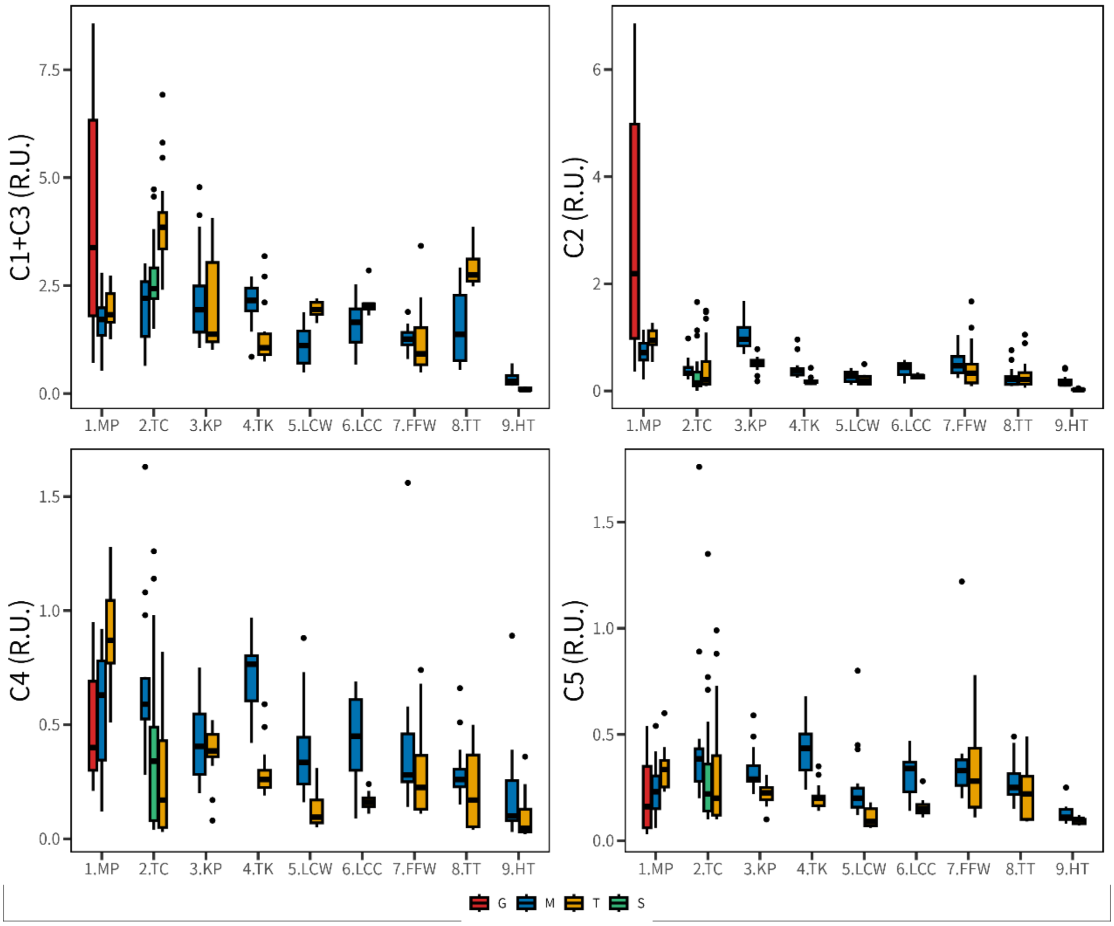


Figure 10. Comparison of five 3D-EEMs-PARAFAC components including (A) Component 1 and Component 3(C1+C3); (B) Component 2 (C2); (C) Component 4 (C4) and (D) Component 5 (C5) from *gei wai* (G, red), mangroves (M, blue), seagrass meadows (S, green) and tidal flats (T, yellow) in nine coastal wetlands in Hong Kong.

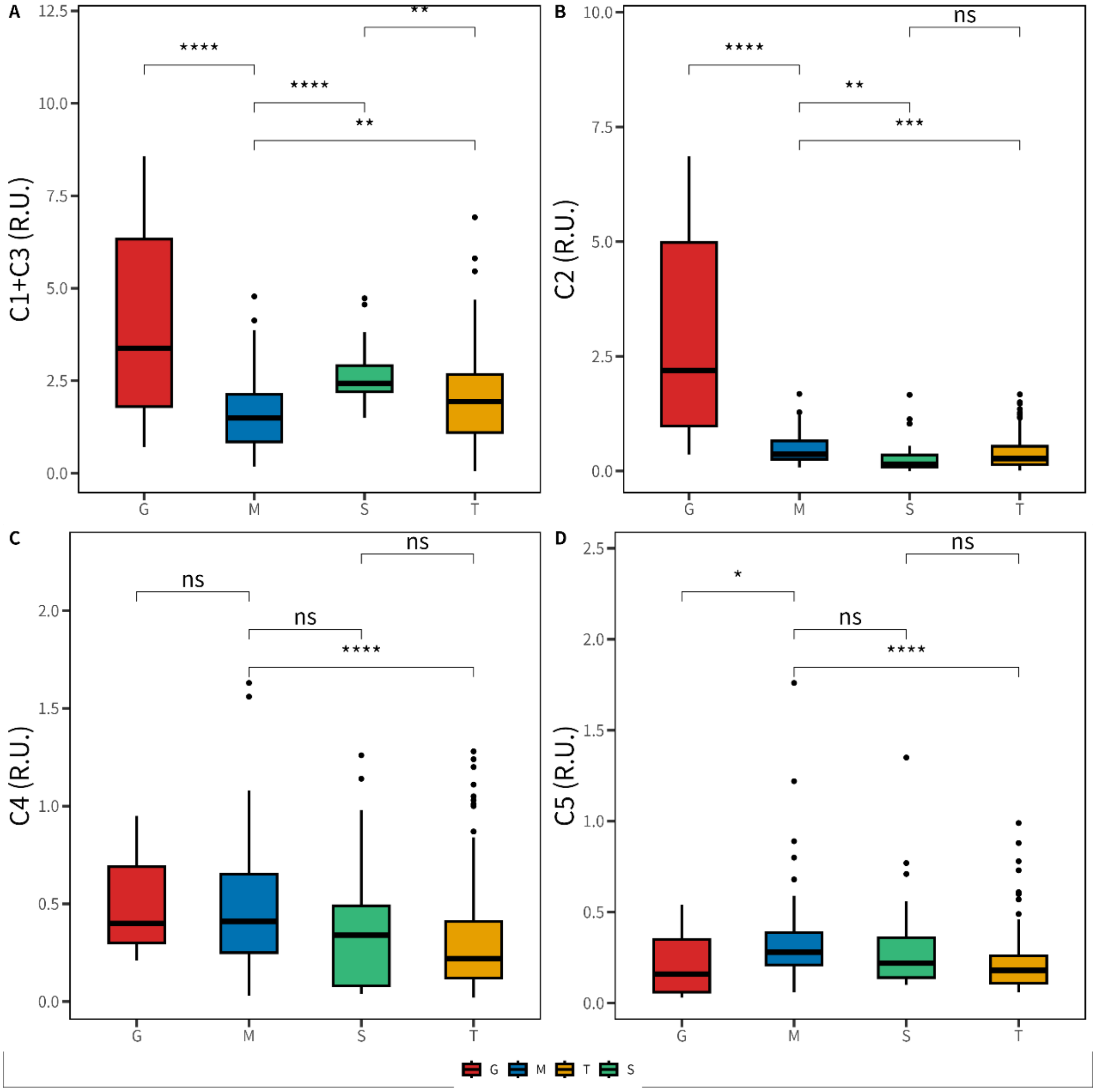


Figure 11. Comparison of five 3D-EEMs-PARAFAC components including (A) Component 1 and Component 3(C1+C3); (B) Component 2 (C2); (C) Component 4 (C4) and (D) Component 5 (C5) from *gei wai* (G, red), mangroves (M, blue), seagrass meadows (S, green) and tidal flats (T, yellow) in coastal wetlands in Hong Kong. Mann–Whitney *U*-test is applied. Significant differences are indicated as * ($p < 0.05$), ** ($p < 0.01$), *** ($p < 0.001$), **** ($p < 0.0001$), and ns ($p \geq 0.05$).

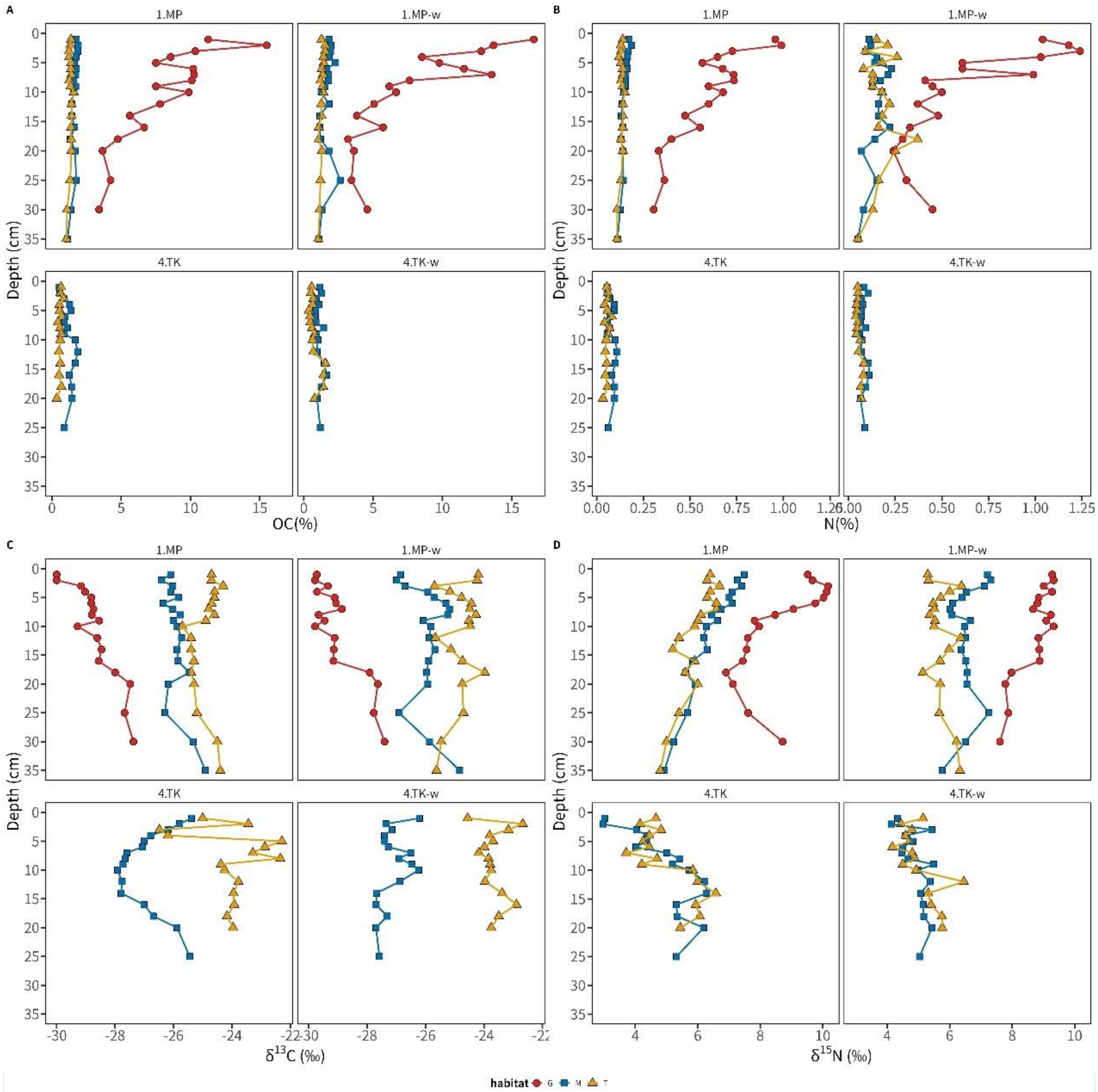


Figure 12. Vertical profiles of bulk characteristics including (A) total organic carbon (OC); (B) total nitrogen (N); (C) $\delta^{13}C$ values; and (D) $\delta^{15}N$ values from *gei wai* (G, red), mangroves (M, blue), tidal flats (T, yellow) and seagrass meadows (S, green) in nine coastal wetlands in Hong Kong.

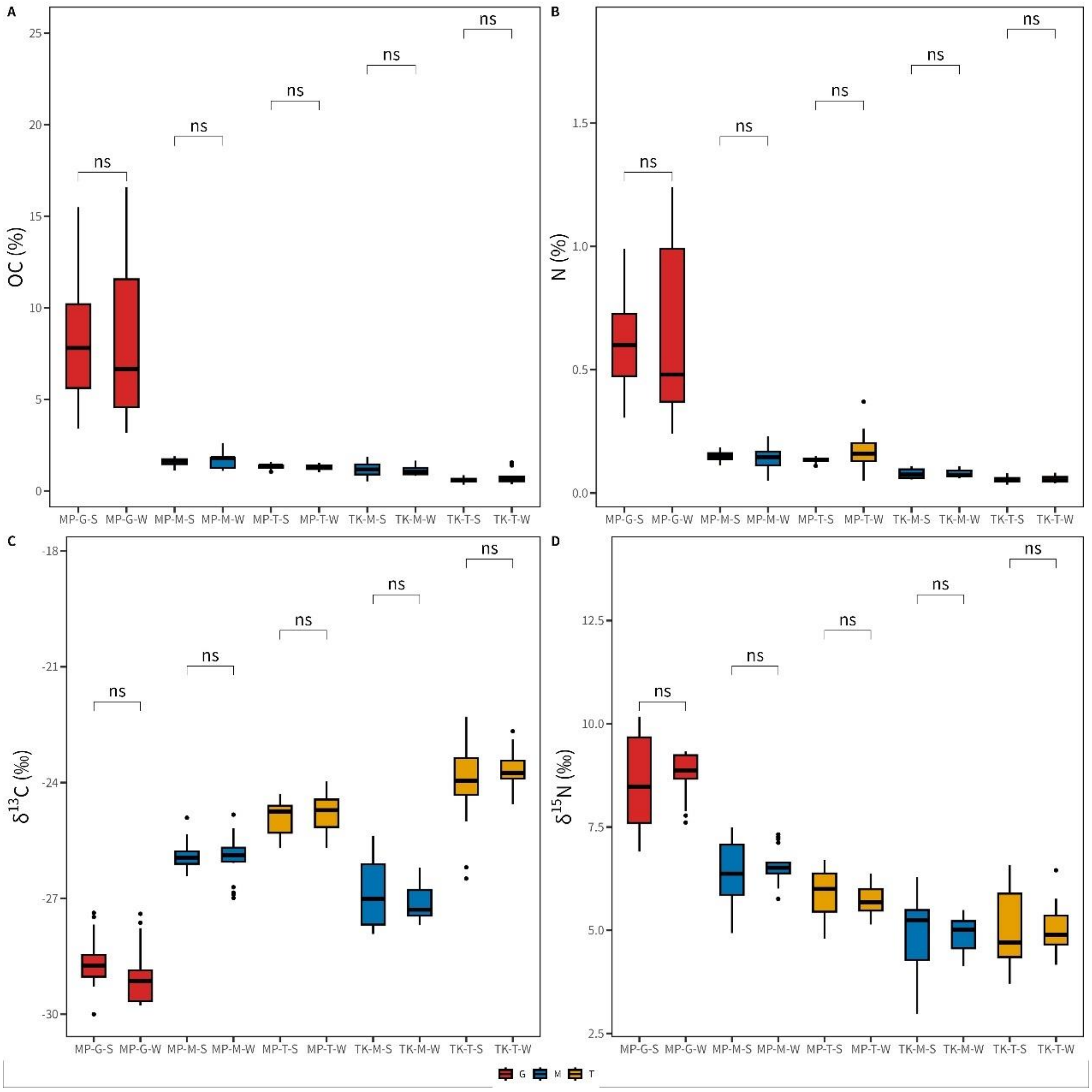


Figure 13. Seasonal (S, summer; W, winter) comparison of bulk characteristics including (A) total organic carbon (OC); (B) total nitrogen (N); (C) $\delta^{13}C$ values; and (D) $\delta^{15}N$ values from *gei wai* (G, red), mangroves (M, blue), and tidal flats (T, yellow) in Mai Po (MP) and Ting Kok (TK) in Hong Kong. Mann–Whitney *U*-test is applied. Significant differences are indicated as * ($p < 0.05$), ** ($p < 0.01$), *** ($p < 0.001$), **** ($p < 0.0001$), and ns ($p \geq 0.05$).

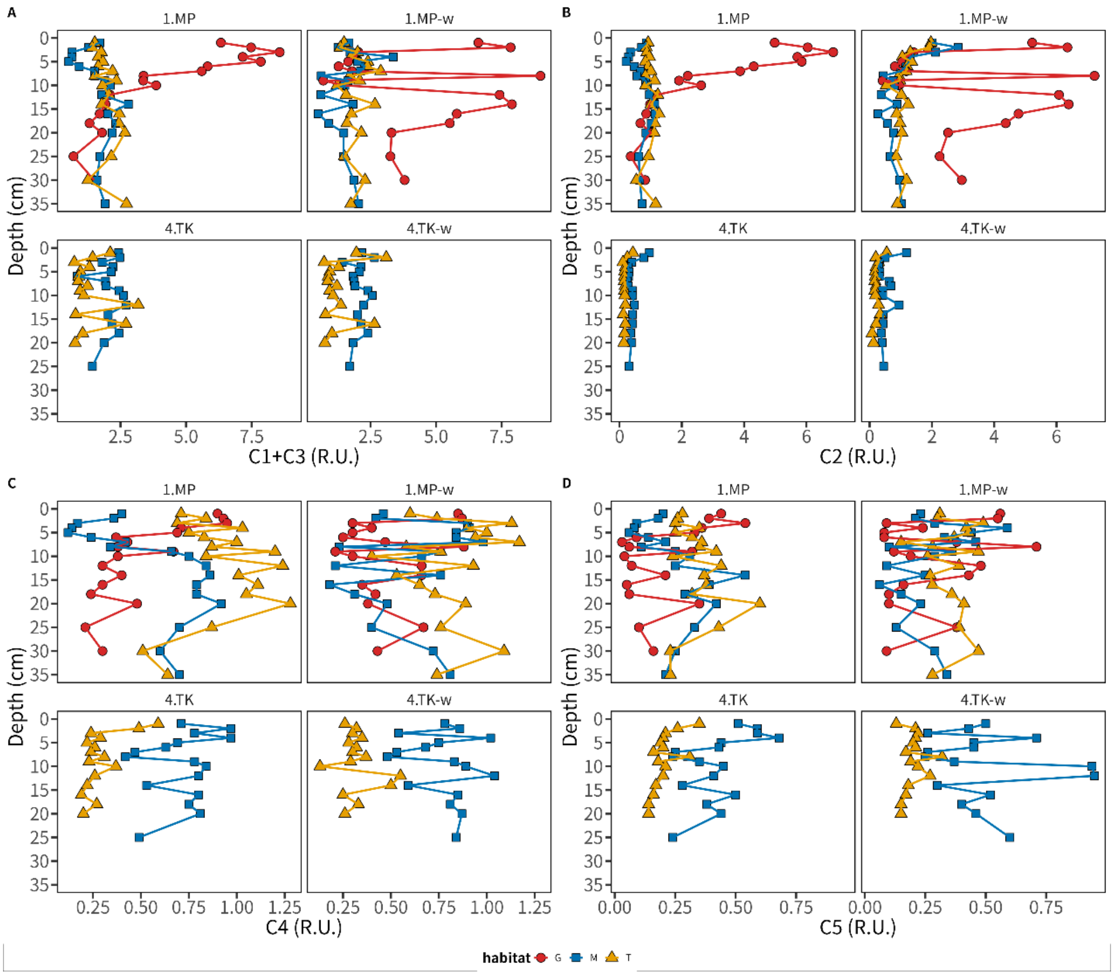


Figure 14. The seasonal (S, summer; W, winter) depth profiles of intensity of three 3D-EEMs-PARAFAC components including (A) dissolved organic carbon concentration (DOC); (B) Component 1 (C1); (C) Component 2 (C2); and (D) Component 3 (C3) from *gei wai* (G, red), mangroves (M, blue), and tidal flats (T, yellow) in Mai Po (MP) and Ting Kok (TK) in Hong Kong.

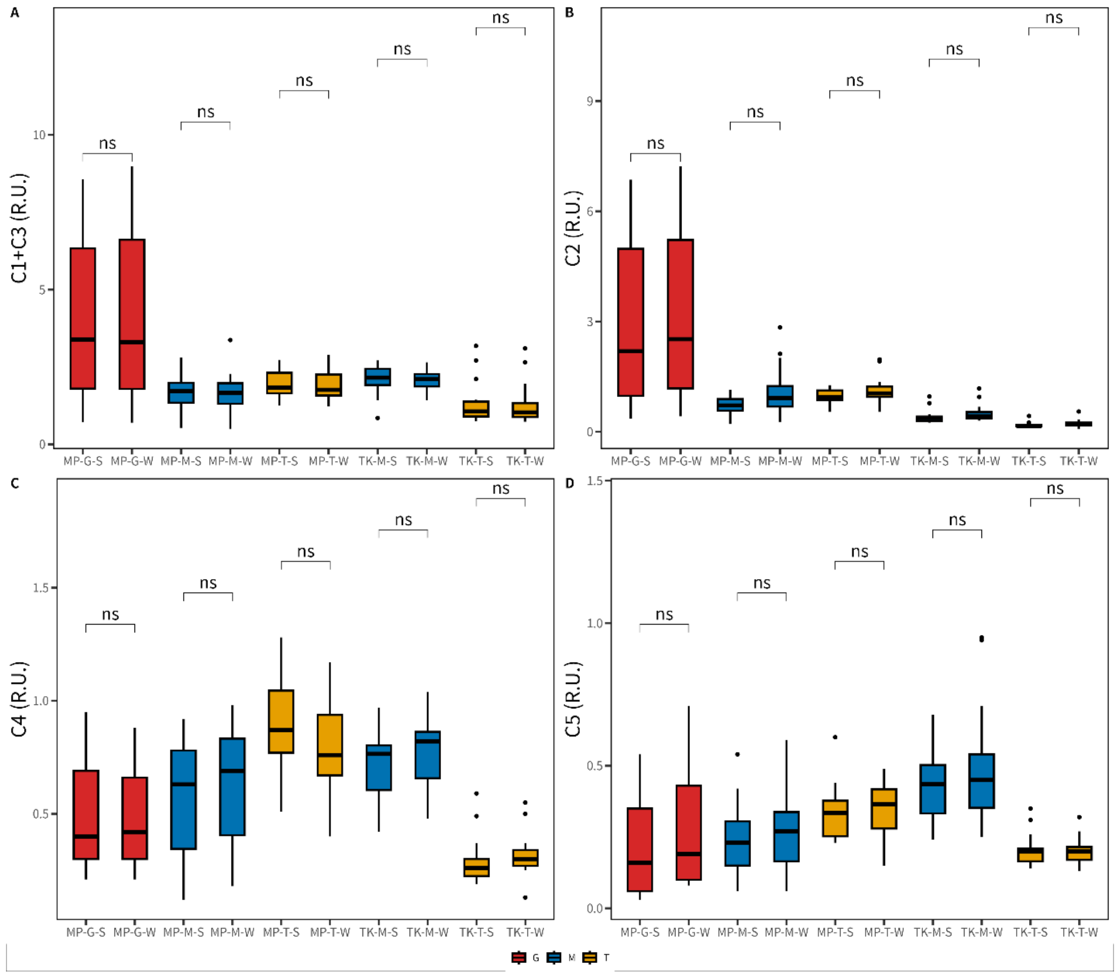


Figure 15. Seasonal (S, summer; W, winter) comparison of optical characteristics including (A) dissolved organic carbon concentration (DOC); (B) Component 1 (C1); (C) Component 2 (C2); and (D) Component 3 (C3) from *gei wai* (G, red), mangroves (M, blue), and tidal flats (T, yellow) in Mai Po (MP) and Ting Kok (TK) in Hong Kong. Mann–Whitney *U*-test is applied. Significant differences are indicated as * ($p < 0.05$), ** ($p < 0.01$), *** ($p < 0.001$), **** ($p < 0.0001$), and ns ($p \geq 0.05$).

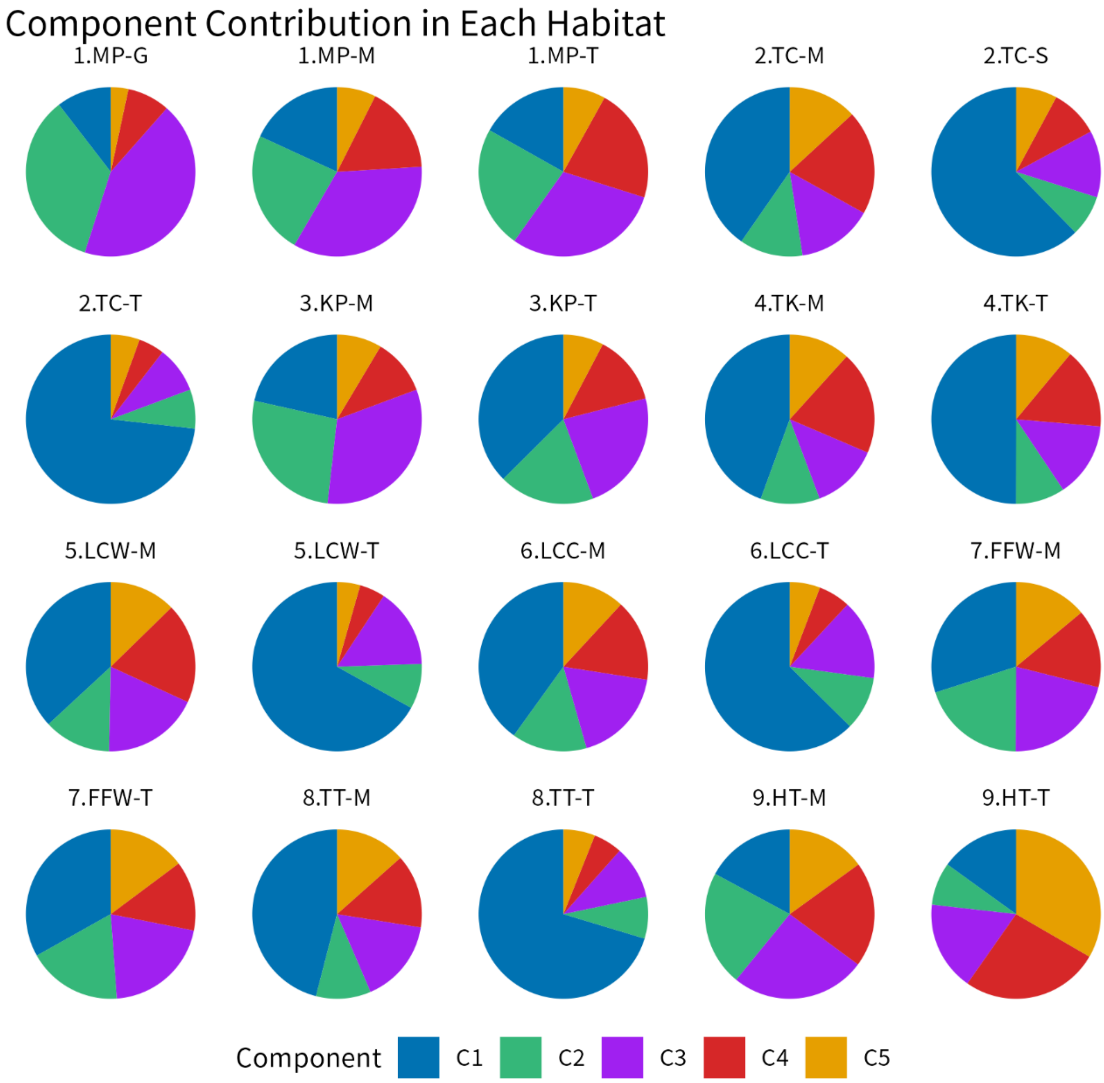


Figure 16. DOM components contribution in each habitat in nine coastal wetlands in Hong Kong.

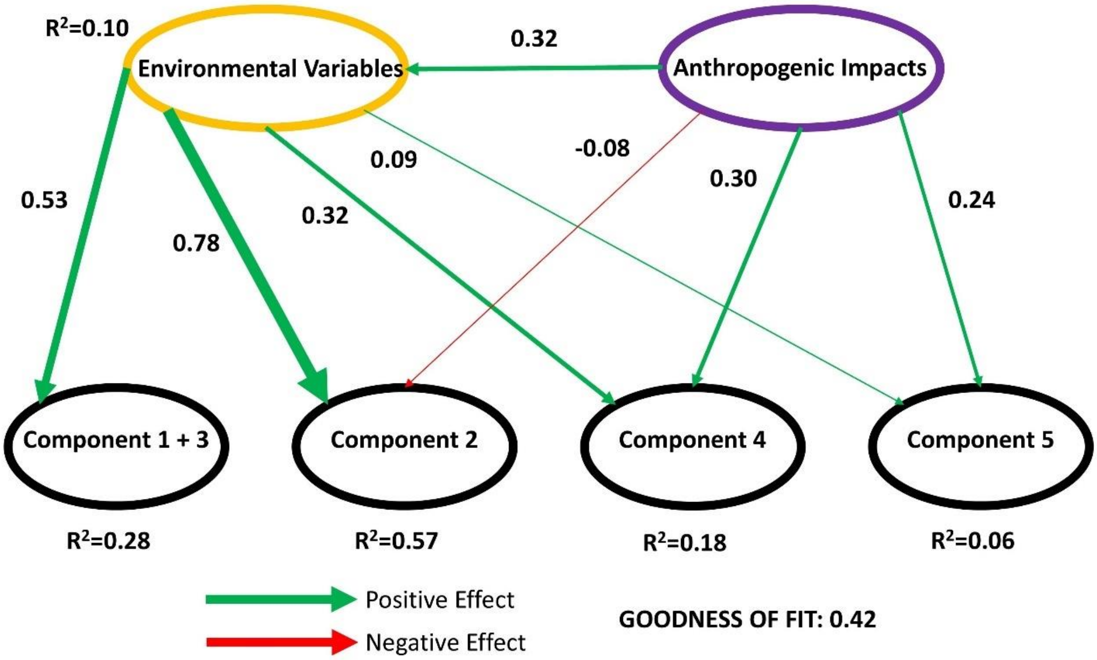


Figure 17. PLS-SEM model.

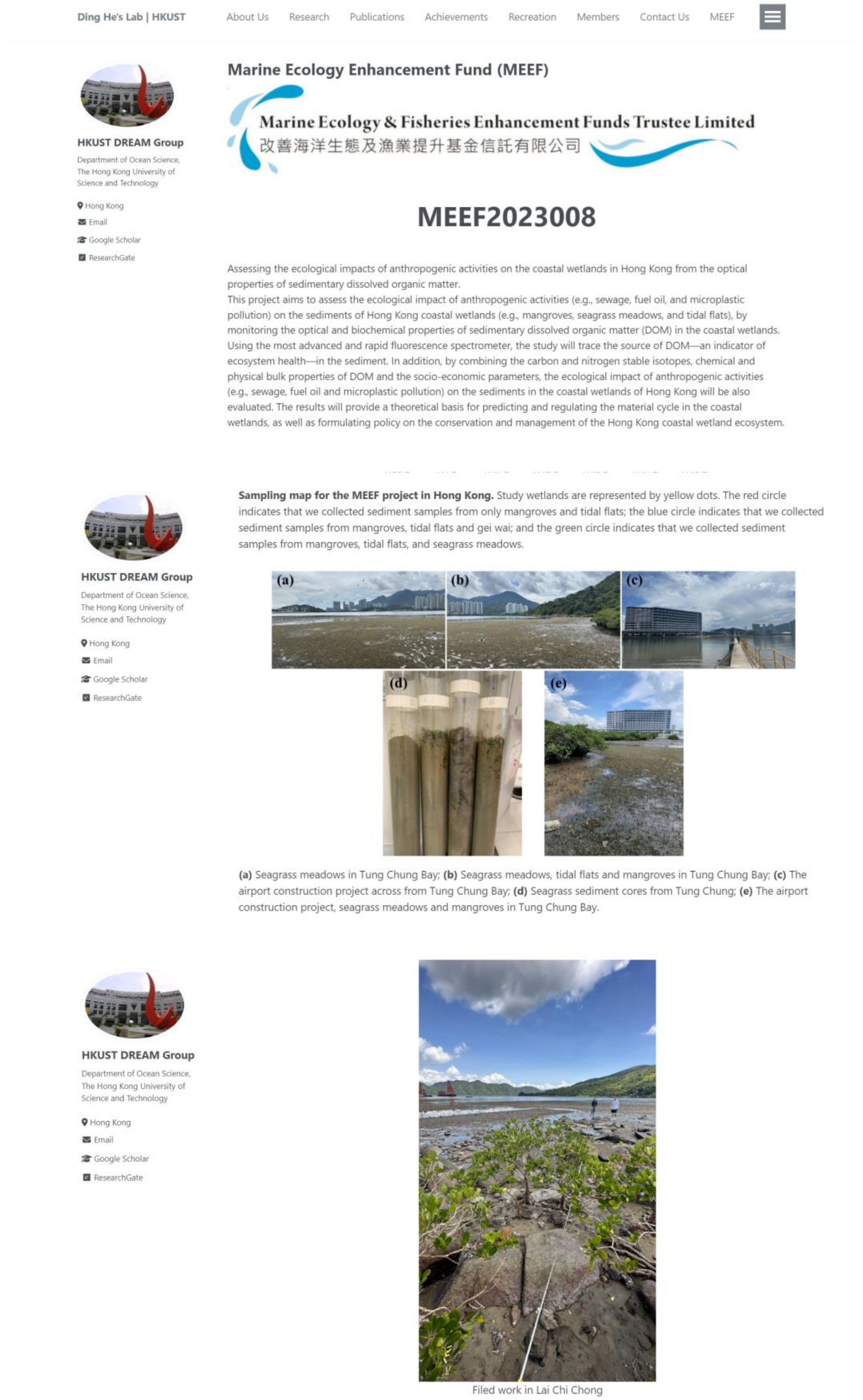


Figure 18. A series of screen shots of the MEEF Project on our website (https://hkustdinghe.github.io/meef/**)**

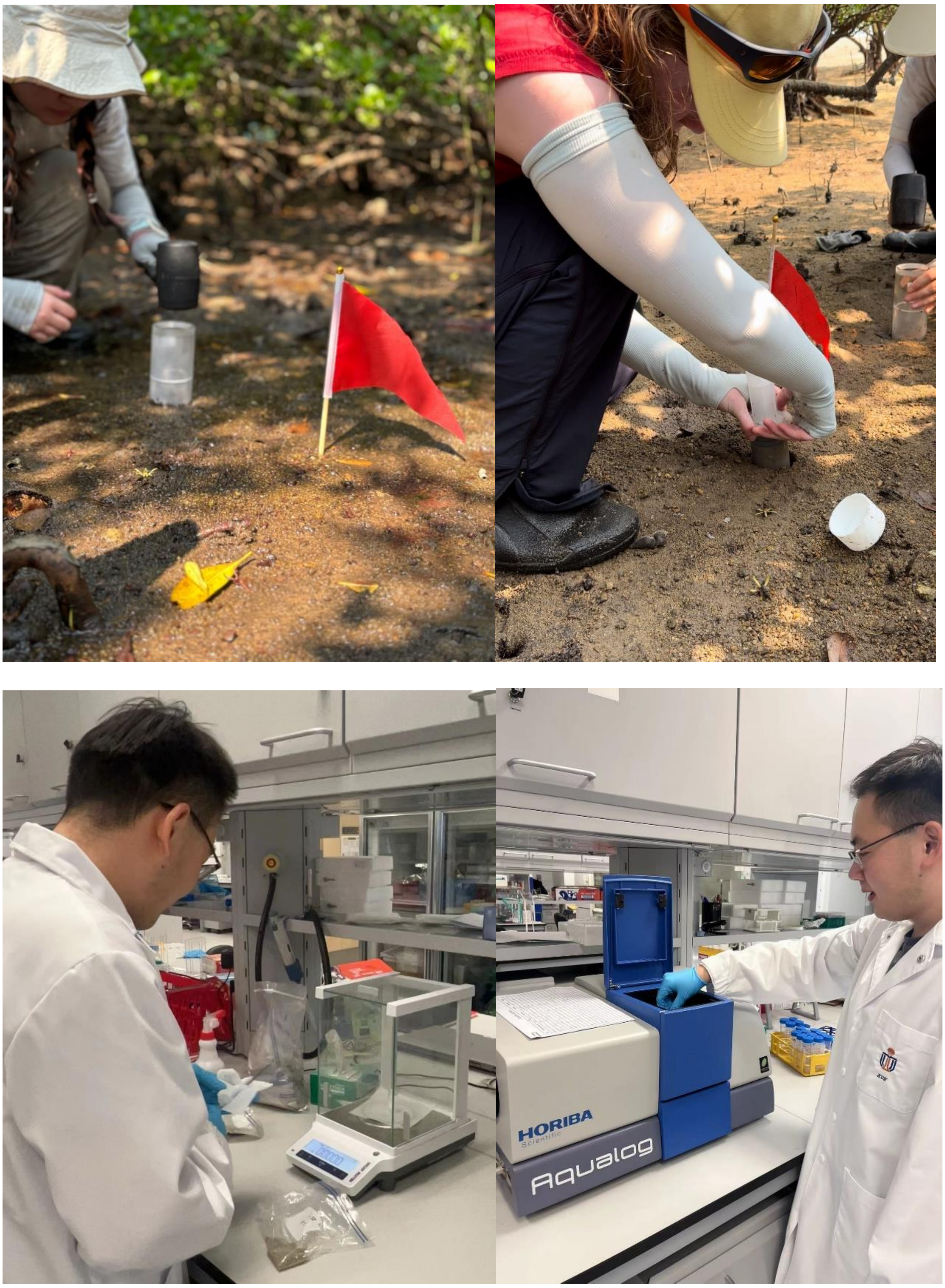


Figure 19. Undergraduate students were helping us work on the sediment sampling in Ting Kok and Msc students were working on the fluorescence spectrometer.

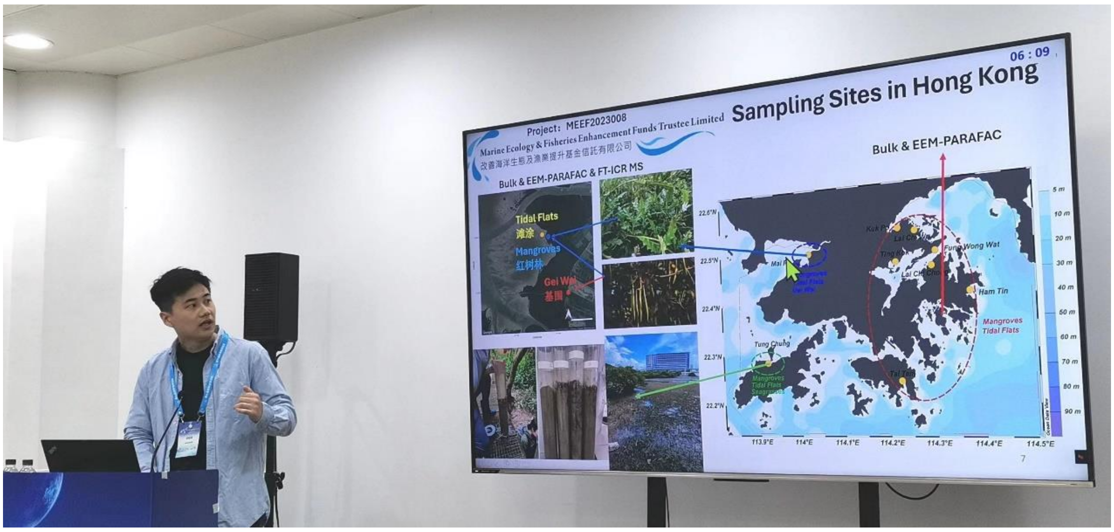


Figure 20. Oral presentation of the MEEF project on the 9th National Youth Geoscience Forum.

Figure 21. Mangroves and seagrass meadows in San Tau Tung Chung, where opposite to the HK International Airport

Figure 22. Collecting sediment cores within mangroves in Mai Po Nature Reserve.

Figure 23. A short sampling cores collected at Ting Kok

Figure 24. Group photos with anther research team from the Chinese University of Hong Kong at Ham Tin

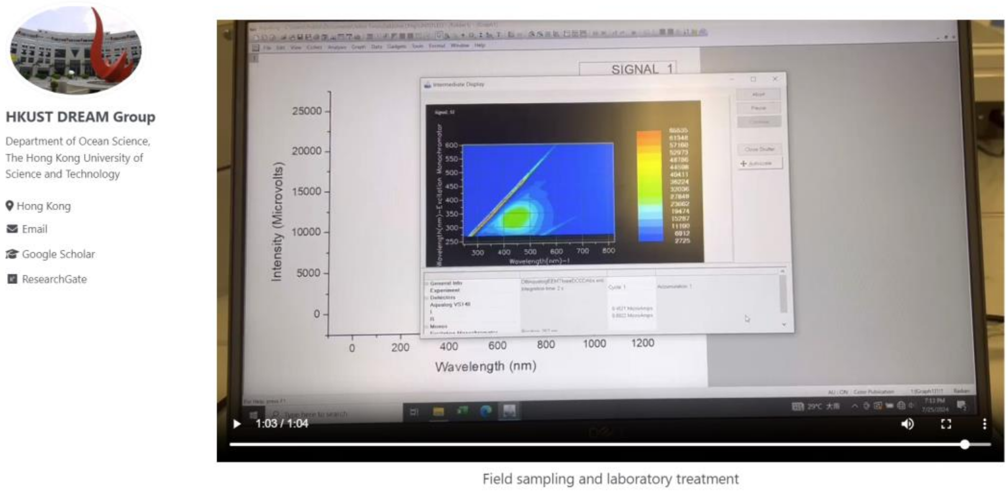


Figure 25. A field sampling and laboratory treatment video is in our lab website.

Table 1. The optical properties of DOM components identified by the PARAFAC model.

	Max. wavelength (Ex/Em, unit: nm)	*Description*	*Source*	*Previous studies*
C1	296 / 408	Marine humic-like	Microbial Production	C4 Kim et al (2022)
C2	260 (360) / 486	Humic-like	Algal Exudates	C2 Amaral et al (2016)
C3	<250 (320) / 422	Marine humic-like	Coastal Environment	C1 Yamashita et al (2011)
C4	274 / 335	Tryptophan-like	Recycled Water/ Wastewater/ Treated Water/ Greywater	C4 Batista-Andrade et al (2023) C5 Murphy et al (2011)
C5	270 / 304	Tyrosine-like	Leaf Leachate	C2 D'Andrilli et al (2019)

Table 2. The bulk, DOM components and contribution of each sample in nine coastal wetlands in Hong Kong.

Sites	*Depths (cm)*	*$\delta^{15}N$ (‰)*	*$\delta^{13}C$ (‰)*	*N (%)*	*OC (%)*	*DOC (mg/L)*	*C1 (R.U.)*	*C2 (R.U.)*	*C3 (R.U.)*	*C4 (R.U.)*	*C5 (R.U.)*	*C1 (%)*	*C2 (%)*	*C3 (%)*	*C4 (%)*	*C5 (%)*
1.MP-gei wai	1	9.5	-30.0	0.96	11.27	25.70	1.08	4.98	5.25	0.90	0.44	8.54	39.35	41.51	7.10	3.50
	2	9.7	-30.0	0.99	15.49	28.32	1.17	6.04	6.31	0.93	0.39	7.87	40.69	42.53	6.27	2.65
	3	10.2	-29.2	0.73	10.35	30.48	1.34	6.86	7.23	0.95	0.54	7.92	40.57	42.74	5.59	3.17
	4	10.1	-29.0	0.65	8.57	26.05	1.17	5.71	5.99	0.71	0.36	8.38	40.96	42.99	5.12	2.55
	5	10.0	-28.8	0.57	7.50	27.75	1.39	5.85	6.46	0.69	0.33	9.43	39.75	43.91	4.67	2.23
	6	9.8	-28.8	0.68	10.20	21.67	0.98	4.31	4.84	0.37	0.09	9.24	40.70	45.75	3.47	0.84
	7	9.1	-28.7	0.73	10.26	18.88	0.98	3.87	4.62	0.43	0.03	9.85	39.00	46.56	4.30	0.30
	8	8.5	-28.8	0.74	10.09	13.24	0.62	2.19	2.77	0.38	0.06	10.25	36.50	46.04	6.25	0.96
	9	7.8	-28.5	0.60	7.51	14.27	0.72	1.91	2.65	0.67	0.32	11.44	30.42	42.31	10.66	5.17
	10	8.0	-29.3	0.68	9.87	14.39	0.68	2.62	3.17	0.38	0.04	9.88	37.96	46.06	5.48	0.62
	12	7.6	-28.6	0.60	7.81	8.47	0.41	1.19	1.69	0.30	0.07	11.26	32.52	46.23	8.19	1.80
	14	7.6	-28.5	0.47	5.62	8.62	0.45	0.98	1.48	0.40	0.21	12.87	27.79	42.06	11.33	5.95
	16	7.4	-28.6	0.55	6.65	6.26	0.37	0.86	1.34	0.30	0.05	12.73	29.51	45.84	10.11	1.80
	18	6.9	-28.0	0.40	4.75	4.94	0.28	0.67	1.04	0.24	0.06	12.26	29.36	45.17	10.55	2.65
	20	7.1	-27.5	0.33	3.65	11.61	0.37	1.01	1.43	0.48	0.35	10.28	27.85	39.16	13.14	9.57
	25	7.6	-27.7	0.36	4.23	5.48	0.18	0.36	0.53	0.21	0.10	13.39	25.90	38.23	15.08	7.41
	30	8.7	-27.4	0.31	3.40	6.88	0.33	0.82	1.15	0.30	0.16	11.96	29.54	41.65	10.89	5.95
1.MP-Mangroves	1	7.5	-26.1	0.17	1.77	5.39	0.49	0.86	1.22	0.40	0.20	15.49	27.01	38.47	12.78	6.26
	2	7.3	-26.4	0.19	1.90	4.89	0.28	0.71	1.01	0.36	0.18	10.95	27.97	39.72	14.21	7.14
	3	7.4	-26.0	0.17	1.86	3.86	0.14	0.35	0.52	0.17	0.09	10.74	27.71	41.10	13.12	7.34
	4	7.1	-26.1	0.17	1.73	2.99	0.17	0.29	0.48	0.14	0.08	14.37	25.44	41.21	12.19	6.78
	5	7.0	-25.8	0.16	1.61	3.10	0.17	0.21	0.36	0.12	0.06	18.41	22.60	39.76	12.76	6.47
	6	7.1	-26.4	0.16	1.77	4.42	0.24	0.48	0.69	0.24	0.14	13.36	26.55	38.74	13.64	7.72
	7	6.8	-26.0	0.16	1.71	4.90	0.60	0.67	0.91	0.42	0.21	21.19	23.94	32.39	15.05	7.43
	8	6.4	-25.8	0.15	1.58	4.70	0.71	0.56	0.81	0.34	0.11	28.07	22.10	32.06	13.33	4.44
	9	6.6	-26.0	0.15	1.72	7.85	0.78	0.84	1.12	0.66	0.25	21.46	22.94	30.58	18.10	6.91
	10	6.3	-25.9	0.15	1.58	8.71	0.89	0.90	1.22	0.75	0.31	21.87	22.04	30.02	18.53	7.53
	12	6.2	-25.7	0.14	1.44	9.95	0.46	0.96	1.33	0.84	0.25	11.89	24.96	34.68	21.94	6.53
	14	6.3	-25.9	0.13	1.43	18.11	1.23	1.13	1.58	0.86	0.54	23.01	21.23	29.52	16.08	10.16
	16	5.8	-25.8	0.14	1.64	7.79	0.56	1.14	1.45	0.79	0.39	12.89	26.26	33.57	18.32	8.96
	18	5.6	-25.5	0.13	1.32	6.92	0.91	1.02	1.41	0.79	0.29	20.68	23.06	31.90	17.83	6.52
	20	5.9	-26.2	0.14	1.69	7.33	0.90	0.85	1.29	0.92	0.42	20.50	19.40	29.51	21.11	9.48
	25	5.7	-26.3	0.14	1.74	6.09	0.72	0.62	0.99	0.70	0.33	21.38	18.51	29.48	20.89	9.74

	30	5.2	-25.3	0.13	1.37	8.31	0.55	0.65	1.04	0.60	0.25	17.81	20.97	33.66	19.48	8.08
	35	4.9	-24.9	0.11	1.13	7.99	0.78	0.72	1.14	0.70	0.21	21.95	20.35	32.01	19.71	5.99
1.MP-Tidal Flats	1	6.4	-24.7	0.14	1.38	7.77	0.32	0.92	1.20	0.71	0.28	9.46	26.81	34.99	20.71	8.03
	2	6.3	-24.7	0.13	1.32	6.67	0.30	0.86	1.12	0.84	0.26	8.74	25.46	33.04	24.94	7.82
	3	6.7	-24.3	0.13	1.24	8.12	0.62	0.88	1.15	0.69	0.25	17.17	24.62	32.14	19.15	6.92
	4	6.4	-24.6	0.12	1.24	8.82	0.44	0.96	1.21	1.03	0.35	11.09	23.98	30.27	25.87	8.79
	5	6.3	-24.6	0.13	1.39	8.13	0.76	0.83	1.07	0.75	0.25	20.77	22.78	29.26	20.48	6.71
	6	6.6	-24.7	0.14	1.38	6.33	0.47	0.92	1.18	0.83	0.32	12.65	24.74	31.69	22.37	8.55
	7	6.6	-24.8	0.14	1.40	7.75	0.96	1.01	1.24	1.00	0.36	21.08	21.99	27.08	21.91	7.94
	8	6.1	-24.6	0.13	1.25	6.94	0.52	0.83	1.01	0.87	0.35	14.58	23.25	28.22	24.20	9.75
	9	6.0	-24.9	0.14	1.35	7.62	0.94	1.13	1.41	1.20	0.42	18.36	22.13	27.72	23.48	8.31
	10	5.9	-25.7	0.15	1.58	6.35	0.70	0.84	1.12	0.84	0.24	18.79	22.39	29.92	22.48	6.42
	12	5.4	-25.4	0.14	1.41	6.27	0.52	1.23	1.55	1.24	0.44	10.43	24.77	31.07	24.98	8.76
	14	5.2	-25.4	0.14	1.42	5.72	0.56	1.01	1.23	1.01	0.37	13.30	24.15	29.54	24.16	8.86
	16	5.9	-25.3	0.14	1.39	8.74	0.85	1.27	1.61	1.11	0.38	16.33	24.23	30.77	21.35	7.33
	18	5.6	-25.4	0.13	1.38	7.82	1.00	1.13	1.44	1.05	0.32	20.26	22.91	29.04	21.27	6.52
	20	6.0	-25.3	0.14	1.40	6.86	1.27	1.11	1.39	1.28	0.60	22.53	19.68	24.63	22.61	10.56
	25	5.4	-25.2	0.13	1.32	7.32	0.97	0.93	1.18	0.87	0.43	22.16	21.31	26.93	19.85	9.76
	30	5.0	-24.5	0.11	1.10	5.64	0.52	0.54	0.74	0.51	0.23	20.34	21.16	29.39	20.02	9.08
	35	4.8	-24.4	0.11	1.05	5.64	1.18	1.16	1.55	0.64	0.23	24.86	24.32	32.64	13.38	4.80
1.MP- gei wai	1	9.3	-29.7	1.04	16.59	29.80	1.28	5.22	5.34	0.85	0.56	9.63	39.43	40.30	6.39	4.25
Winter	2	9.3	-29.8	1.18	13.69	25.36	1.39	6.35	6.45	0.87	0.55	8.91	40.71	41.31	5.56	3.51
	3	9.0	-29.3	1.24	12.80	24.00	0.50	1.41	1.53	0.30	0.09	13.12	36.67	39.89	7.89	2.43
	4	9.3	-29.7	1.03	8.52	17.45	0.53	1.19	1.31	0.40	0.24	14.55	32.30	35.75	10.93	6.47
	5	8.9	-29.1	0.61	9.78	19.38	0.45	1.05	1.20	0.30	0.08	14.62	34.17	38.93	9.80	2.48
	6	8.8	-29.1	0.61	11.56	22.10	0.34	0.81	0.94	0.25	0.08	14.03	33.50	39.00	10.14	3.33
	7	8.7	-28.9	0.99	13.55	25.15	0.44	1.18	1.35	0.47	0.38	11.55	30.73	35.28	12.39	10.05
	8	9.2	-29.7	0.41	7.63	16.09	1.60	7.22	7.37	0.88	0.71	9.02	40.59	41.46	4.94	3.98
	9	9.1	-29.5	0.45	6.17	13.85	0.21	0.42	0.49	0.21	0.12	14.77	28.99	33.71	14.44	8.08
	10	9.3	-29.8	0.50	6.66	14.60	0.39	0.95	1.08	0.30	0.19	13.42	32.58	37.15	10.33	6.51
	12	8.8	-29.1	0.37	5.07	12.17	1.39	6.08	6.03	0.66	0.48	9.48	41.55	41.18	4.51	3.28
	14	8.9	-29.1	0.48	3.82	10.25	1.67	6.39	6.23	0.66	0.43	10.85	41.53	40.49	4.30	2.83
	16	8.9	-29.2	0.33	5.72	13.16	1.20	4.78	4.59	0.35	0.16	10.83	43.11	41.44	3.18	1.45
	18	8.0	-27.9	0.29	3.19	9.29	1.20	4.37	4.32	0.42	0.10	11.57	42.00	41.46	4.04	0.93
	20	7.8	-27.6	0.24	3.62	9.95	0.76	2.52	2.55	0.38	0.10	12.00	40.03	40.41	5.96	1.59
	25	7.9	-27.8	0.31	3.44	9.67	0.86	2.25	2.40	0.67	0.38	13.09	34.34	36.62	10.20	5.75
	30	7.6	-27.4	0.45	4.58	11.42	0.84	2.96	2.96	0.43	0.09	11.49	40.66	40.66	5.94	1.25
1.MP-Mangroves	1	7.2	-26.9	0.11	1.81	7.18	0.55	2.01	1.13	0.46	0.23	12.52	45.88	25.78	10.61	5.22

Winter	2	7.3	-27.0	0.12	1.96	7.41	0.33	2.84	0.93	0.42	0.21	6.93	60.07	19.74	8.92	4.34
	3	7.1	-26.7	0.09	1.93	7.36	0.51	2.12	1.20	0.90	0.29	10.23	42.23	23.88	17.84	5.81
	4	6.5	-25.9	0.15	1.83	7.21	1.90	1.30	1.47	0.91	0.59	30.70	21.06	23.88	14.74	9.62
	5	6.4	-25.7	0.14	2.29	7.91	0.61	1.27	1.40	0.84	0.44	13.38	27.93	30.69	18.45	9.55
	6	6.1	-25.3	0.23	1.66	6.95	0.97	1.17	1.31	0.84	0.33	20.93	25.36	28.38	18.20	7.13
	7	6.0	-25.2	0.21	1.79	7.15	0.95	1.01	1.16	0.98	0.46	20.83	22.16	25.47	21.43	10.11
	8	6.1	-25.2	0.17	1.79	7.15	0.16	0.44	0.45	0.23	0.10	11.84	31.71	32.53	16.61	7.30
	9	6.7	-26.1	0.13	1.54	6.76	0.76	0.76	0.89	0.76	0.36	21.62	21.45	25.07	21.57	10.29
	10	6.5	-25.8	0.18	1.25	6.32	0.60	0.80	0.92	0.66	0.29	18.50	24.42	28.02	20.31	8.74
	12	6.5	-25.9	0.16	1.82	7.19	0.19	0.37	0.41	0.21	0.09	15.29	29.64	32.09	16.24	6.73
	14	6.4	-25.7	0.16	1.15	6.17	0.83	0.88	1.00	0.76	0.25	22.36	23.62	26.91	20.43	6.68
	16	6.5	-25.9	0.22	1.14	6.15	0.19	0.27	0.31	0.18	0.06	18.76	26.57	30.44	17.82	6.40
	18	6.6	-26.0	0.14	1.22	6.27	0.27	0.58	0.62	0.31	0.15	14.21	29.84	32.22	15.92	7.81
	20	6.6	-25.9	0.07	1.81	7.18	0.63	0.77	0.85	0.48	0.23	21.33	26.03	28.58	16.19	7.86
	25	7.3	-26.9	0.15	2.62	8.42	0.75	0.66	0.73	0.40	0.13	28.02	24.76	27.30	14.94	4.98
	30	6.5	-25.9	0.08	1.31	6.41	0.83	0.96	1.03	0.72	0.29	21.71	25.15	26.88	18.76	7.50
	35	5.8	-24.8	0.05	1.10	6.09	0.94	1.03	1.11	0.81	0.34	22.16	24.41	26.26	19.11	8.06
1.MP-Tidal Flats	1	5.3	-24.2	0.15	1.28	7.07	0.37	1.97	1.12	0.60	0.31	8.55	45.04	25.50	13.79	7.13
Winter	2	5.3	-24.2	0.21	1.55	7.48	0.34	1.92	1.01	0.74	0.30	7.93	44.53	23.36	17.14	7.03
	3	6.4	-25.7	0.09	1.53	7.45	0.57	1.31	1.44	1.13	0.49	11.57	26.47	29.18	22.82	9.96
	4	6.0	-25.2	0.26	1.42	7.28	0.60	1.05	1.15	0.90	0.42	14.50	25.56	27.98	21.84	10.13
	5	5.7	-24.8	0.18	1.44	7.31	0.91	1.35	1.49	1.00	0.43	17.56	26.04	28.66	19.37	8.38
	6	5.5	-24.4	0.08	1.30	7.10	1.05	1.20	1.33	0.94	0.37	21.45	24.51	27.15	19.24	7.65
	7	5.5	-24.5	0.13	1.37	7.20	1.61	1.17	1.28	1.17	0.15	30.00	21.78	23.72	21.65	2.85
	8	5.4	-24.3	0.13	1.21	6.96	0.66	0.94	1.05	0.58	0.28	18.89	26.63	29.83	16.60	8.05
	9	5.5	-24.5	0.13	1.36	7.19	1.01	0.97	1.08	0.76	0.47	23.47	22.64	25.27	17.65	10.97
	10	5.5	-24.5	0.18	1.41	7.27	0.54	0.54	0.68	0.40	0.26	22.42	22.19	28.22	16.63	10.55
	12	6.4	-25.7	0.22	1.27	7.05	0.49	1.02	1.08	0.93	0.39	12.54	26.04	27.66	23.70	10.06
	14	6.0	-25.1	0.18	1.27	7.05	1.25	1.24	1.43	0.53	0.27	26.38	26.35	30.25	11.24	5.78
	16	5.7	-24.7	0.16	1.08	6.76	0.80	0.87	0.97	0.65	0.28	22.45	24.45	27.19	18.09	7.82
	18	5.1	-24.0	0.37	1.09	6.78	0.52	0.98	1.08	0.73	0.36	14.09	26.69	29.58	19.87	9.76
	20	5.7	-24.7	0.25	1.31	7.11	1.00	1.04	1.15	0.89	0.41	22.28	23.19	25.64	19.82	9.06
	25	5.7	-24.7	0.16	1.20	6.94	0.55	0.85	0.95	0.76	0.39	15.82	24.30	27.19	21.64	11.06
	30	6.2	-25.5	0.13	1.15	6.87	0.98	1.19	1.31	1.09	0.47	19.45	23.70	25.90	21.54	9.41
	35	6.3	-25.6	0.05	1.04	6.70	0.75	0.89	1.00	0.74	0.28	20.39	24.45	27.44	20.13	7.59
2.TC-Mangroves	1	6.6	-26.0	0.26	3.10	7.01	2.01	0.98	1.00	0.71	0.48	38.67	18.98	19.35	13.78	9.22
	2	6.1	-25.9	0.13	1.46	7.44	1.69	0.62	0.65	0.70	0.38	41.72	15.44	16.06	17.29	9.50
	3	6.3	-26.2	0.11	1.25	10.99	0.31	0.44	0.46	0.58	0.37	14.20	20.37	21.28	26.98	17.17

	4	5.5	-26.3	0.09	1.06	8.98	2.43	0.44	0.49	1.08	0.39	50.43	9.07	10.11	22.37	8.02
	5	6.1	-26.3	0.11	1.66	8.83	0.21	0.35	0.46	0.56	0.33	11.09	18.35	24.20	29.27	17.09
	6	6.4	-26.0	0.19	2.54	11.34	1.74	0.32	0.39	0.42	0.28	55.51	10.04	12.30	13.27	8.87
	7	6.2	-26.1	0.17	2.14	11.74	2.42	0.44	0.56	1.63	1.76	35.46	6.48	8.26	23.95	25.85
	8	6.2	-26.1	0.17	2.14	8.08	1.87	0.37	0.61	0.98	0.89	39.63	7.88	13.00	20.75	18.75
	9	6.2	-26.1	0.14	1.98	6.58	1.41	0.31	0.39	0.70	0.47	42.97	9.52	11.80	21.26	14.45
	10	5.1	-25.8	0.08	0.96	7.12	2.68	0.28	0.33	0.60	0.40	62.54	6.43	7.72	14.06	9.25
	12	5.1	-25.8	0.07	1.01	6.97	0.87	0.21	0.27	0.28	0.20	47.31	11.63	14.69	15.24	11.13
	14	4.6	-25.1	0.06	0.86	7.68	0.99	0.30	0.40	0.57	0.42	36.97	11.26	14.76	21.20	15.81
	16	2.9	-24.8	0.03	0.40	5.56	1.99	0.33	0.43	0.64	0.41	52.34	8.78	11.23	16.88	10.76
	18	4.3	-24.8	0.05	0.72	4.46	0.28	0.30	0.36	0.53	0.28	15.83	17.27	20.65	30.36	15.90
	20	2.7	-24.9	0.04	0.57	5.68	1.87	0.33	0.41	0.51	0.28	55.11	9.74	11.95	15.02	8.18
	25	2.7	-25.2	0.03	0.42	4.46	1.13	0.29	0.36	0.43	0.25	45.84	11.93	14.58	17.51	10.14
2.TC-Seagrasses	1	7.1	-20.8	0.14	1.16	10.81	0.45	1.66	1.75	0.98	0.56	8.40	30.75	32.34	18.17	10.34
	2	6.6	-20.2	0.10	0.76	14.72	2.43	1.13	1.38	1.14	1.35	32.67	15.21	18.53	15.38	18.22
	3	6.0	-20.3	0.05	0.40	7.25	2.93	0.55	0.61	0.82	0.71	52.06	9.86	10.91	14.51	12.65
	4	5.6	-20.7	0.07	0.51	7.70	3.70	1.03	1.03	1.26	0.77	47.46	13.26	13.28	16.13	9.88
	5	5.0	-21.1	0.06	0.42	5.32	1.13	0.35	0.36	0.49	0.36	42.11	12.82	13.51	18.33	13.23
	6	4.3	-20.9	0.04	0.30	4.64	1.88	0.27	0.36	0.34	0.31	59.53	8.49	11.51	10.69	9.79
	7	3.9	-21.8	0.06	0.41	4.96	2.15	0.28	0.48	0.48	0.28	58.75	7.54	13.08	13.01	7.62
	8	5.7	-22.1	0.05	0.44	5.13	2.21	0.19	0.47	0.40	0.22	63.43	5.37	13.40	11.46	6.34
	9	3.5	-22.7	0.06	0.45	3.75	2.58	0.15	0.33	0.20	0.14	75.73	4.36	9.83	5.94	4.14
	10	3.9	-23.5	0.05	0.44	3.45	2.21	0.12	0.22	0.14	0.14	78.08	4.36	7.78	4.95	4.83
	12	3.2	-23.2	0.04	0.35	4.33	2.79	0.00	1.77	0.49	0.27	52.48	0.00	33.32	9.20	5.00
	14	3.0	-22.1	0.04	0.32	4.22	1.89	0.09	0.29	0.12	0.16	74.21	3.52	11.22	4.87	6.19
	16	3.7	-22.1	0.04	0.34	3.21	1.75	0.08	0.11	0.08	0.13	81.36	3.78	4.98	3.80	6.09
	18	2.4	-21.3	0.04	0.31	3.34	2.15	0.09	0.11	0.08	0.12	84.14	3.50	4.18	3.32	4.85
	20	1.7	-21.0	0.04	0.30	3.35	2.03	0.08	0.12	0.08	0.14	82.43	3.40	4.91	3.40	5.86
	25	3.6	-21.5	0.03	0.33	3.44	2.36	0.07	0.22	0.07	0.12	82.99	2.43	7.57	2.62	4.37
	30	4.3	-21.0	0.03	0.27	3.12	2.05	0.10	0.15	0.04	0.10	83.77	4.13	6.33	1.78	4.00
2.TC-Tidal Flats	1	4.4	-19.6	0.04	0.29	5.44	3.92	1.47	1.54	0.43	0.40	50.53	18.91	19.82	5.54	5.19
	2	3.7	-20.0	0.04	0.27	4.88	4.23	1.50	1.58	0.72	0.88	47.42	16.82	17.74	8.09	9.92
	3	5.5	-20.0	0.04	0.25	6.51	5.52	1.35	1.40	0.82	0.99	54.73	13.42	13.89	8.13	9.83
	4	4.9	-21.1	0.03	0.27	5.34	2.75	0.55	0.56	0.52	0.57	55.45	11.16	11.37	10.44	11.57
	5	5.8	-22.0	0.04	0.34	7.16	1.93	1.09	1.12	0.78	0.73	34.08	19.32	19.85	13.84	12.91
	6	5.5	-22.4	0.05	0.40	4.46	3.48	0.34	0.37	0.25	0.24	74.49	7.27	7.87	5.30	5.07
	7	5.8	-22.5	0.06	0.46	4.17	3.36	0.17	0.26	0.14	0.17	81.76	4.18	6.43	3.38	4.24
	8	5.1	-27.1	0.04	0.27	4.50	4.27	0.27	0.42	0.25	0.24	78.18	4.99	7.74	4.66	4.43

	9	4.9	-22.5	0.03	0.28	5.03	3.64	0.21	0.26	0.17	0.22	80.87	4.57	5.83	3.75	4.98
	10	4.5	-22.4	0.03	0.22	3.23	2.24	0.14	0.17	0.15	0.13	79.44	4.80	6.04	5.25	4.47
	12	4.6	-23.1	0.03	0.22	4.87	3.28	0.21	0.42	0.31	0.20	74.18	4.86	9.53	6.95	4.48
	14	2.3	-22.7	0.02	0.18	4.21	3.67	0.13	0.31	0.13	0.13	83.88	3.08	7.07	3.02	2.94
	16	2.7	-21.9	0.02	0.16	3.21	3.20	0.12	0.15	0.05	0.12	88.05	3.25	4.26	1.27	3.17
	18	2.0	-21.4	0.02	0.17	3.41	3.62	0.13	0.17	0.05	0.11	88.88	3.15	4.06	1.13	2.77
	20	3.4	-21.0	0.02	0.20	3.24	3.93	0.09	0.11	0.04	0.12	91.62	2.17	2.60	0.89	2.72
	25	4.8	-21.0	0.02	0.14	2.75	4.07	0.09	0.11	0.03	0.10	92.37	2.11	2.59	0.69	2.24
	30	1.5	-20.6	0.02	0.14	3.23	3.04	0.10	0.13	0.04	0.10	89.17	2.84	3.77	1.22	3.01
3.KP-Mangroves	1	4.0	-25.0	0.11	1.11	0.83	0.20	0.69	0.86	0.29	0.27	8.79	29.70	37.12	12.62	11.76
	2	4.2	-24.9	0.11	1.25	0.96	0.23	0.83	1.00	0.42	0.29	8.31	29.98	36.22	15.10	10.39
	3	4.7	-25.0	0.09	1.09	0.82	0.27	0.88	1.10	0.28	0.29	9.59	31.26	39.00	9.84	10.31
	4	4.3	-24.7	0.12	1.19	0.75	0.25	0.86	1.06	0.26	0.27	9.14	32.01	39.39	9.47	9.99
	5	4.2	-25.2	0.10	1.14	0.88	0.23	0.77	0.95	0.28	0.22	9.38	31.58	38.83	11.38	8.83
	6	4.9	-24.1	0.11	1.28	1.02	0.30	1.10	1.27	0.41	0.29	8.96	32.56	37.68	12.09	8.72
	7	4.7	-24.2	0.12	1.41	0.96	0.59	1.22	1.45	0.47	0.29	14.73	30.35	35.98	11.68	7.26
	8	4.9	-23.9	0.11	1.33	1.02	0.40	1.19	1.32	0.61	0.28	10.43	31.35	34.74	16.00	7.49
	9	4.6	-22.8	0.11	1.15	12.97	2.40	1.19	1.47	0.65	0.44	39.07	19.36	23.92	10.53	7.11
	10	4.4	-22.9	0.10	1.01	1.99	2.61	1.28	1.52	0.68	0.49	39.63	19.50	23.12	10.32	7.43
	12	5.1	-24.1	0.10	1.25	1.06	2.88	1.68	1.90	0.75	0.59	36.92	21.54	24.39	9.62	7.52
	14	5.0	-23.8	0.09	1.13	1.03	1.11	0.99	1.41	0.32	0.41	26.13	23.44	33.16	7.58	9.69
	16	5.4	-23.4	0.08	1.03	0.85	0.71	0.81	1.13	0.20	0.28	22.67	25.98	36.15	6.31	8.89
	18	5.3	-22.4	0.07	1.05	0.86	0.72	0.80	1.03	0.20	0.28	23.73	26.30	33.99	6.74	9.24
	20	5.0	-22.6	0.10	1.22	0.95	1.25	0.96	1.17	0.40	0.36	30.14	23.13	28.20	9.74	8.79
	25	4.6	-21.8	0.13	1.71	1.02	1.42	0.97	1.11	0.57	0.33	32.27	22.04	25.30	12.89	7.50
	30	4.4	-21.1	0.14	1.91	1.02	1.41	0.87	1.03	0.48	0.28	34.60	21.47	25.32	11.79	6.83
	35	4.1	-21.0	0.19	3.31	0.98	0.89	1.18	1.30	0.40	0.25	22.22	29.33	32.28	9.86	6.31
3.KP-Tidal Flats	1	5.4	-25.0	0.22	2.66	0.87	0.43	0.58	0.77	0.40	0.19	18.02	24.70	32.58	16.76	7.95
	2	5.4	-24.7	0.13	1.53	1.09	0.41	0.54	0.69	0.35	0.20	18.55	24.58	31.44	16.20	9.23
	3	5.1	-23.8	0.08	0.82	1.13	0.45	0.62	0.77	0.41	0.24	18.20	24.93	31.01	16.31	9.54
	4	5.3	-23.6	0.08	0.70	1.08	0.48	0.78	1.00	0.46	0.29	15.99	26.00	33.18	15.29	9.53
	5	5.6	-23.8	0.07	0.61	1.04	0.41	0.55	0.67	0.36	0.22	18.69	24.70	30.20	16.42	9.99
	6	4.9	-24.2	0.08	0.80	1.01	0.68	0.52	0.64	0.36	0.19	28.43	21.91	26.93	14.92	7.82
	7	5.2	-25.2	0.08	0.98	0.97	0.50	0.64	0.78	0.37	0.21	20.00	25.48	31.19	14.78	8.55
	8	5.2	-24.3	0.07	0.68	0.95	0.67	0.55	0.66	0.41	0.24	26.46	21.60	26.20	16.28	9.46
	9	5.0	-25.3	0.09	1.02	0.99	0.43	0.46	0.58	0.36	0.17	21.34	23.17	29.18	17.95	8.36
	10	4.7	-25.2	0.09	0.98	1.12	0.49	0.49	0.62	0.37	0.22	22.60	22.23	28.36	16.92	9.89
	12	5.0	-25.0	0.09	1.06	1.40	1.47	0.54	0.71	0.47	0.25	42.80	15.79	20.64	13.63	7.13

	14	5.1	-24.8	0.08	0.97	1.10	2.24	0.49	0.63	0.46	0.23	55.32	12.11	15.52	11.30	5.75
	16	4.9	-25.1	0.09	1.09	1.39	2.37	0.58	0.74	0.50	0.26	53.19	12.98	16.71	11.18	5.94
	18	5.1	-24.3	0.07	0.74	1.13	2.81	0.48	0.61	0.52	0.31	59.42	10.10	12.82	11.08	6.58
	20	5.1	-24.8	0.07	0.88	1.38	0.80	0.46	0.62	0.45	0.25	31.05	17.92	23.91	17.28	9.85
	25	5.5	-24.3	0.06	0.62	1.13	2.57	0.39	0.52	0.32	0.28	63.06	9.53	12.72	7.91	6.78
	30	5.2	-23.9	0.05	0.54	0.86	3.28	0.28	0.43	0.17	0.16	75.91	6.57	9.85	3.95	3.72
	35	4.2	-23.9	0.04	0.40	0.69	3.76	0.18	0.30	0.08	0.10	85.23	4.02	6.75	1.74	2.27
4.TK-Mangroves	1	3.0	-25.4	0.06	0.53	1.49	1.46	0.96	0.97	0.71	0.51	31.73	20.91	20.93	15.28	11.16
	2	3.0	-25.8	0.06	0.58	1.05	1.68	0.78	0.78	0.97	0.59	35.01	16.15	16.31	20.26	12.28
	3	4.0	-26.2	0.07	0.85	1.18	1.31	0.39	0.49	0.78	0.59	36.96	10.88	13.76	21.89	16.50
	4	4.4	-26.8	0.09	1.28	2.39	1.83	0.28	0.38	0.97	0.68	44.29	6.66	9.08	23.44	16.53
	5	4.4	-27.0	0.09	1.35	1.04	1.78	0.30	0.37	0.69	0.44	49.67	8.45	10.29	19.37	12.22
	6	4.0	-27.1	0.07	0.96	1.13	0.50	0.29	0.35	0.63	0.43	22.66	13.02	16.07	28.75	19.51
	7	5.0	-27.6	0.06	0.89	0.68	1.65	0.25	0.28	0.47	0.25	56.97	8.69	9.61	16.15	8.58
	8	5.4	-27.7	0.07	1.11	0.69	1.65	0.27	0.30	0.42	0.24	57.31	9.36	10.37	14.63	8.33
	9	5.2	-27.7	0.06	0.90	0.96	2.01	0.41	0.44	0.78	0.35	50.40	10.33	11.01	19.56	8.71
	10	5.7	-27.9	0.10	1.68	1.40	2.16	0.41	0.46	0.84	0.45	49.96	9.56	10.63	19.36	10.48
	12	6.2	-27.8	0.11	1.86	0.92	2.18	0.48	0.52	0.80	0.41	49.51	11.00	11.90	18.19	9.39
	14	6.3	-27.8	0.10	1.68	0.82	1.57	0.42	0.46	0.53	0.28	48.14	12.82	14.21	16.28	8.55
	16	5.3	-27.0	0.08	1.24	1.85	1.68	0.41	0.49	0.80	0.50	43.28	10.57	12.71	20.59	12.85
	18	5.3	-26.7	0.10	1.45	1.13	2.04	0.36	0.40	0.75	0.38	51.76	9.25	10.17	19.12	9.70
	20	6.2	-25.9	0.10	1.46	2.04	1.39	0.38	0.47	0.81	0.44	39.86	10.76	13.57	23.27	12.53
	25	5.3	-25.4	0.06	0.90	0.95	1.07	0.31	0.36	0.49	0.24	43.39	12.44	14.65	19.70	9.83
4.TK-Tidal Flats	1	4.7	-25.0	0.05	0.66	0.92	1.51	0.43	0.60	0.59	0.35	43.32	12.22	17.23	17.05	10.18
	2	4.2	-23.4	0.06	0.62	0.73	1.12	0.25	0.31	0.49	0.26	46.20	10.30	12.92	20.00	10.58
	3	4.8	-26.5	0.06	0.86	0.71	0.55	0.11	0.20	0.24	0.21	41.51	8.68	15.05	18.42	16.34
	4	4.4	-26.2	0.04	0.54	0.81	1.06	0.19	0.26	0.29	0.20	52.97	9.39	13.00	14.69	9.95
	5	4.3	-22.3	0.06	0.57	0.92	0.72	0.16	0.25	0.22	0.19	46.69	10.11	16.26	14.43	12.51
	6	4.4	-22.9	0.08	0.72	0.89	0.64	0.16	0.28	0.26	0.20	41.36	10.50	17.94	16.91	13.29
	7	3.7	-23.3	0.04	0.44	0.76	0.65	0.15	0.24	0.24	0.16	45.23	10.50	16.45	16.62	11.20
	8	4.7	-22.3	0.07	0.59	1.03	0.96	0.18	0.29	0.31	0.31	47.01	8.86	14.10	15.10	14.94
	9	4.2	-24.4	0.06	0.68	0.76	0.73	0.16	0.24	0.23	0.18	47.33	10.24	15.55	15.16	11.73
	10	5.8	-24.3	0.05	0.60	0.76	0.85	0.17	0.25	0.37	0.21	46.02	9.01	13.56	19.94	11.47
	12	6.0	-23.8	0.05	0.51	0.72	2.90	0.19	0.29	0.26	0.20	75.68	4.87	7.50	6.71	5.24
	14	6.6	-24.0	0.05	0.60	0.70	0.60	0.12	0.19	0.22	0.17	46.13	9.49	14.80	16.60	12.97
	16	5.9	-23.9	0.05	0.52	0.61	2.43	0.19	0.28	0.19	0.16	74.58	5.95	8.69	5.79	5.00
	18	6.1	-24.2	0.06	0.69	0.57	0.84	0.16	0.22	0.27	0.14	51.53	9.73	13.70	16.45	8.58
	20	5.4	-24.0	0.03	0.35	0.66	0.55	0.14	0.22	0.20	0.14	43.98	11.23	17.38	15.93	11.48

4.TK-Mangroves	1	4.3	-26.2	0.08	1.14	0.84	1.49	1.18	0.69	0.78	0.50	32.06	25.39	14.89	16.89	10.78
Winter	2	4.1	-27.4	0.10	1.29	0.86	2.18	0.50	0.47	0.86	0.43	49.02	11.30	10.64	19.27	9.77
	3	5.4	-27.1	0.07	0.90	0.99	1.07	0.32	0.35	0.54	0.26	42.27	12.52	13.66	21.35	10.19
	4	4.6	-27.4	0.08	1.09	1.19	1.83	0.30	0.31	1.02	0.71	43.77	7.15	7.49	24.51	17.07
	5	4.8	-27.4	0.07	0.85	1.23	1.77	0.33	0.31	0.75	0.45	49.10	9.02	8.53	20.78	12.56
	6	4.5	-27.3	0.07	0.83	1.04	1.50	0.31	0.33	0.68	0.45	45.84	9.62	9.97	20.89	13.68
	7	4.5	-26.5	0.06	0.88	1.01	1.65	0.64	0.23	0.53	0.26	49.86	19.27	7.06	15.96	7.85
	8	4.7	-26.9	0.09	1.43	1.11	1.64	0.68	0.27	0.48	0.25	49.54	20.38	8.05	14.43	7.59
	9	5.5	-26.5	0.06	0.93	1.01	2.00	0.42	0.40	0.83	0.37	49.80	10.50	9.83	20.75	9.12
	10	5.0	-26.2	0.07	1.01	1.38	2.15	0.42	0.42	0.89	0.94	44.63	8.78	8.65	18.45	19.50
	12	5.4	-26.9	0.07	0.96	1.46	1.69	0.95	0.54	1.04	0.95	32.65	18.36	10.48	20.18	18.33
	14	5.1	-27.7	0.11	1.48	1.38	1.57	0.43	0.44	0.59	0.30	47.23	13.09	13.16	17.61	8.91
	16	5.2	-27.7	0.11	1.66	1.17	1.68	0.43	0.46	0.85	0.52	42.62	10.89	11.59	21.62	13.27
	18	5.2	-27.3	0.09	1.25	1.27	2.03	0.37	0.36	0.81	0.40	51.09	9.38	9.08	20.31	10.14
	20	5.4	-27.7	0.06	0.96	1.28	1.39	0.40	0.44	0.87	0.46	39.17	11.12	12.41	24.30	13.00
	25	5.0	-27.6	0.09	1.19	1.01	1.32	0.45	0.39	0.84	0.60	36.60	12.59	10.84	23.23	16.74
4.TK- Tidal Flats	1	5.1	-24.6	0.05	0.57	0.69	1.52	0.55	0.44	0.26	0.13	52.59	18.93	15.09	9.00	4.39
Winter	2	4.4	-22.7	0.05	0.51	0.73	2.89	0.20	0.21	0.32	0.21	75.57	5.17	5.48	8.39	5.40
	3	4.8	-23.2	0.05	0.68	0.89	0.55	0.29	0.18	0.30	0.22	35.71	18.88	11.47	19.49	14.44
	4	4.6	-23.8	0.04	0.64	0.79	1.06	0.21	0.22	0.35	0.21	51.76	10.16	10.75	17.21	10.13
	5	4.7	-23.7	0.05	0.36	0.73	0.73	0.18	0.22	0.28	0.20	45.29	10.96	13.73	17.58	12.44
	6	4.2	-24.0	0.04	0.46	0.91	0.65	0.19	0.24	0.32	0.21	40.12	11.61	15.16	19.85	13.27
	7	4.8	-24.2	0.05	0.48	1.09	0.66	0.17	0.21	0.30	0.17	43.75	11.33	13.89	19.88	11.15
	8	4.9	-23.8	0.05	0.59	0.88	0.97	0.21	0.25	0.37	0.32	45.94	9.92	11.65	17.43	15.06
	9	4.5	-23.8	0.04	0.80	0.71	0.73	0.17	0.21	0.29	0.19	45.87	10.90	13.22	18.28	11.74
	10	4.9	-23.8	0.06	0.63	0.67	0.85	0.19	0.22	0.13	0.22	53.12	11.52	13.57	7.95	13.85
	12	6.5	-24.0	0.05	0.69	0.63	1.13	0.29	0.24	0.55	0.27	45.49	11.85	9.74	22.11	10.80
	14	5.3	-23.4	0.08	1.56	0.67	0.60	0.34	0.17	0.50	0.18	33.66	18.91	9.75	27.91	9.77
	16	5.4	-22.9	0.08	1.42	0.63	2.43	0.21	0.22	0.25	0.17	74.14	6.28	6.76	7.69	5.13
	18	5.8	-23.5	0.07	1.40	0.71	0.84	0.08	0.19	0.33	0.15	53.15	4.77	12.09	20.76	9.23
	20	5.8	-23.8	0.07	0.78	0.55	0.56	0.13	0.20	0.26	0.15	43.00	9.73	15.67	20.00	11.60
5.LCW-Mangroves	1	3.3	-27.4	0.08	1.14	0.84	0.09	0.35	0.40	0.31	0.20	6.76	25.76	29.50	23.14	14.85
	2	3.1	-27.6	0.10	1.29	1.92	0.83	0.28	0.38	0.66	0.43	32.28	10.73	14.84	25.52	16.62
	3	3.1	-27.9	0.11	1.48	1.21	0.36	0.43	0.47	0.88	0.45	14.01	16.58	18.27	33.76	17.37
	4	3.2	-27.9	0.11	1.66	0.99	1.18	0.36	0.41	0.46	0.24	44.57	13.63	15.59	17.30	8.91
	5	3.2	-27.5	0.09	1.25	1.45	1.13	0.40	0.40	0.73	0.80	32.75	11.58	11.52	21.09	23.06
	6	3.0	-27.8	0.09	1.19	1.24	0.94	0.37	0.49	0.44	0.20	38.39	15.36	19.97	18.11	8.17
	7	4.4	-27.3	0.07	0.90	0.82	0.72	0.31	0.41	0.31	0.18	37.18	15.88	21.47	15.91	9.57

	8	2.6	-27.6	0.08	1.09	1.52	0.76	0.21	0.33	0.40	0.24	38.98	10.82	17.22	20.51	12.47
	9	2.8	-27.6	0.07	0.85	1.76	0.89	0.27	0.37	0.36	0.23	42.05	12.79	17.57	16.95	10.65
	10	2.5	-27.5	0.07	0.83	1.23	0.40	0.13	0.21	0.27	0.19	33.44	10.79	17.20	22.39	16.19
	12	2.4	-28.1	0.07	0.96	0.93	0.50	0.13	0.23	0.16	0.12	43.68	11.39	20.04	14.04	10.85
	14	1.7	-28.0	0.07	0.89	2.82	0.67	0.19	0.35	0.39	0.27	35.77	10.21	18.74	20.85	14.43
	16	1.3	-28.2	0.06	0.87	1.03	1.43	0.28	0.45	0.19	0.16	57.06	11.17	17.74	7.68	6.35
	18	0.8	-28.3	0.06	0.86	1.48	0.44	0.11	0.22	0.24	0.15	38.09	9.56	18.52	20.66	13.18
	20	2.4	-27.9	0.06	0.96	1.48	0.44	0.11	0.22	0.24	0.15	38.09	9.56	18.52	20.66	13.18
	25	2.1	-25.7	0.03	0.41	1.15	1.24	0.20	0.39	0.18	0.15	57.23	9.43	18.09	8.24	7.01
5.LCW-Tidal Flats	1	1.6	-25.4	0.03	0.37	1.00	1.34	0.50	0.81	0.31	0.11	43.52	16.16	26.42	10.18	3.72
	2	0.7	-23.5	0.03	0.17	0.17	1.20	0.30	0.43	0.17	0.13	53.92	13.46	19.18	7.70	5.74
	3	0.4	-24.0	0.03	0.21	0.67	1.60	0.21	0.36	0.09	0.09	67.92	9.04	15.30	4.00	3.74
	4	0.3	-24.6	0.02	0.20	0.69	1.58	0.13	0.27	0.10	0.07	73.03	6.04	12.71	4.84	3.39
	5	-1.4	-24.5	0.03	0.14	0.68	1.46	0.12	0.25	0.07	0.06	74.38	6.12	12.92	3.59	2.98
	6	0.1	-24.8	0.02	0.16	0.80	1.56	0.11	0.28	0.07	0.06	75.02	5.39	13.45	3.37	2.76
	7	-0.9	-25.0	0.03	0.17	0.70	1.60	0.11	0.22	0.05	0.07	78.04	5.43	10.58	2.64	3.31
	8	-0.4	-25.6	0.03	0.19	0.81	1.54	0.12	0.23	0.05	0.07	76.71	5.80	11.28	2.61	3.60
	9	1.2	-25.6	0.02	0.23	0.91	1.79	0.14	0.24	0.07	0.08	76.82	6.16	10.48	3.02	3.52
	10	1.0	-26.6	0.04	0.39	0.95	1.78	0.19	0.34	0.09	0.09	71.66	7.59	13.69	3.53	3.52
	12	1.7	-26.8	0.03	0.42	0.95	1.54	0.27	0.40	0.13	0.16	61.53	10.90	16.04	5.23	6.30
	14	2.4	-28.2	0.06	0.76	1.15	1.75	0.28	0.45	0.17	0.18	61.87	9.94	16.05	5.87	6.28
	16	2.0	-27.7	0.06	0.71	1.23	1.41	0.26	0.47	0.17	0.15	57.33	10.62	19.14	6.93	5.98
	18	2.4	-27.3	0.05	0.70	1.27	1.59	0.29	0.52	0.18	0.16	58.15	10.55	18.87	6.65	5.78
	20	1.4	-26.6	0.05	0.45	0.88	1.59	0.19	0.36	0.10	0.15	66.32	8.03	15.00	4.36	6.29
	25	1.6	-26.8	0.05	0.62	0.91	1.81	0.16	0.29	0.08	0.09	74.43	6.49	12.09	3.33	3.67
6.LCC-Mangroves	1	3.3	-27.4	0.08	1.14	0.93	1.48	0.58	0.68	0.44	0.36	41.97	16.31	19.15	12.35	10.23
	2	3.1	-27.6	0.10	1.29	1.03	1.16	0.51	0.62	0.50	0.42	36.11	15.86	19.29	15.67	13.07
	3	3.1	-27.9	0.11	1.48	1.03	1.38	0.49	0.59	0.67	0.34	39.82	14.06	17.05	19.28	9.79
	4	3.2	-27.9	0.11	1.66	0.91	1.28	0.50	0.61	0.41	0.38	40.36	15.68	19.11	13.01	11.84
	5	3.2	-27.5	0.09	1.25	1.10	1.17	0.53	0.65	0.61	0.47	34.16	15.50	19.05	17.68	13.62
	6	3.9	-26.7	0.07	1.04	0.95	0.96	0.44	0.50	0.52	0.37	34.37	15.66	18.06	18.77	13.15
	7	3.5	-26.7	0.06	0.88	1.07	1.38	0.54	0.63	0.61	0.37	39.18	15.22	17.89	17.15	10.56
	8	3.7	-27.1	0.09	1.43	1.19	1.91	0.54	0.63	0.69	0.44	45.38	12.86	14.88	16.49	10.40
	9	3.5	-26.7	0.06	0.93	0.96	0.89	0.32	0.37	0.37	0.29	39.61	14.43	16.57	16.34	13.06
	10	4.0	-26.4	0.07	1.01	1.03	1.87	0.49	0.58	0.49	0.32	49.84	13.13	15.34	13.07	8.63
	12	3.3	-26.7	0.06	1.05	0.94	1.15	0.42	0.45	0.67	0.37	37.66	13.86	14.74	21.79	11.94
	14	3.2	-27.2	0.10	2.06	1.15	0.84	0.30	0.35	0.45	0.32	37.11	13.22	15.48	19.95	14.24
	16	3.5	-26.8	0.08	1.55	0.86	0.64	0.14	0.23	0.09	0.14	51.46	11.48	18.40	7.66	10.99

	18	3.5	-26.7	0.06	1.11	1.03	0.47	0.17	0.34	0.19	0.19	34.46	12.71	24.75	13.94	14.15
	20	3.5	-26.5	0.09	1.48	0.94	0.59	0.26	0.34	0.30	0.23	34.34	14.89	19.84	17.35	13.58
	25	3.0	-26.5	0.07	1.25	0.83	0.42	0.19	0.25	0.18	0.16	35.03	15.94	20.83	15.04	13.17
	30	3.6	-26.2	0.07	1.43	0.97	1.22	0.31	0.43	0.24	0.22	50.34	12.81	17.78	9.83	9.25
6.LCC-Tidal Flats	1	3.1	-25.2	0.03	0.32	0.81	1.60	0.27	0.37	0.19	0.17	61.61	10.41	14.16	7.21	6.61
	2	3.0	-24.8	0.03	0.31	1.06	1.48	0.35	0.48	0.19	0.28	53.43	12.52	17.20	6.79	10.06
	3	3.8	-25.4	0.03	0.38	0.85	1.73	0.24	0.37	0.12	0.13	66.66	9.35	14.24	4.68	5.06
	4	2.1	-26.1	0.04	0.64	0.97	1.54	0.29	0.42	0.18	0.16	59.56	11.16	16.18	7.06	6.04
	5	3.7	-25.9	0.06	0.77	0.88	1.51	0.26	0.41	0.16	0.13	61.07	10.53	16.74	6.30	5.36
	6	4.0	-26.2	0.06	0.91	0.90	1.45	0.27	0.42	0.17	0.17	58.66	11.03	16.77	6.85	6.69
	7	4.8	-25.9	0.05	0.70	1.16	1.51	0.34	0.48	0.24	0.18	54.83	12.26	17.52	8.75	6.64
	8	4.1	-25.9	0.06	0.88	0.94	1.63	0.29	0.41	0.21	0.19	59.76	10.67	15.11	7.60	6.86
	9	3.8	-26.0	0.05	0.77	0.99	1.61	0.27	0.44	0.15	0.13	61.88	10.46	16.72	5.84	5.10
	10	3.8	-26.8	0.06	0.91	0.79	1.50	0.26	0.37	0.14	0.15	62.24	10.60	15.26	5.76	6.14
	12	3.8	-26.6	0.07	1.16	0.93	1.73	0.23	0.35	0.14	0.16	66.33	8.82	13.26	5.52	6.07
	14	4.2	-26.0	0.06	0.99	0.83	1.68	0.29	0.42	0.16	0.15	61.96	10.79	15.62	6.09	5.54
	16	4.0	-26.2	0.06	1.07	1.02	2.42	0.30	0.43	0.18	0.15	69.49	8.74	12.43	5.07	4.27
	18	4.3	-25.8	0.07	1.14	0.60	1.70	0.24	0.38	0.14	0.11	66.27	9.36	14.64	5.32	4.41
	20	4.2	-25.3	0.05	0.85	0.83	1.70	0.24	0.38	0.14	0.11	66.27	9.36	14.64	5.32	4.41
	25	4.1	-26.1	0.07	1.85	0.81	1.75	0.22	0.36	0.13	0.11	67.99	8.63	14.13	4.95	4.30
	30	3.2	-25.2	0.05	0.92	0.83	1.48	0.22	0.34	0.11	0.11	65.66	9.77	14.91	4.80	4.87
7.FFW-Mangroves	1	0.6	-25.5	0.04	0.32	0.95	0.79	1.04	1.10	0.58	0.41	20.22	26.58	28.03	14.81	10.36
	2	0.0	-24.9	0.04	0.20	1.03	0.64	0.82	0.86	0.51	0.41	19.67	25.39	26.62	15.62	12.70
	3	0.2	-25.2	0.02	0.19	0.93	0.78	0.82	0.78	0.26	0.39	25.82	26.92	25.65	8.68	12.92
	4	-1.6	-26.3	0.03	0.14	0.87	0.61	0.69	0.66	0.21	0.33	24.47	27.36	26.44	8.53	13.19
	5	-0.1	-25.7	0.04	0.22	0.79	0.77	0.59	0.56	0.14	0.26	33.19	25.46	24.33	5.88	11.15
	6	0.5	-25.7	0.03	0.26	1.07	0.71	0.57	0.54	0.19	0.25	31.50	24.93	23.95	8.51	11.11
	7	0.0	-26.1	0.04	0.30	0.94	0.81	0.47	0.47	0.33	0.33	33.66	19.72	19.37	13.64	13.60
	8	-0.2	-26.8	0.03	0.30	0.89	1.11	0.48	0.52	0.47	0.37	37.59	16.38	17.49	15.98	12.56
	9	0.6	-25.3	0.04	0.33	0.95	0.74	0.36	0.41	0.33	0.33	34.16	16.71	18.71	15.24	15.18
	10	0.3	-26.6	0.04	0.32	0.97	0.80	0.36	0.37	0.28	0.22	39.68	17.74	18.13	13.64	10.80
	12	2.7	-26.5	0.03	0.29	0.83	0.64	0.29	0.32	0.26	0.26	35.89	16.51	18.26	14.50	14.84
	14	2.1	-27.2	0.03	0.37	0.98	0.54	0.27	0.31	0.28	0.26	32.71	16.08	18.68	16.78	15.74
	16	2.6	-26.2	0.04	0.58	1.05	0.51	0.24	0.29	0.24	0.20	34.75	16.23	19.59	16.11	13.32
	18	2.8	-26.8	0.04	0.73	2.02	0.71	0.33	0.40	0.45	0.30	32.25	15.29	18.27	20.54	13.65
	20	3.7	-25.2	0.06	0.93	10.17	0.58	0.35	0.62	1.56	1.22	13.34	8.15	14.32	36.05	28.13
7.FFW-Tidal Flats	1	2.1	-24.6	0.03	0.22	1.21	1.47	1.67	1.95	0.74	0.78	22.26	25.30	29.50	11.22	11.72
	2	2.5	-26.1	0.03	0.29	0.99	1.05	1.18	1.18	0.41	0.61	23.67	26.55	26.67	9.36	13.76

	3	2.2	-25.8	0.03	0.22	0.93	0.91	0.98	1.00	0.35	0.60	23.80	25.52	25.99	9.16	15.53
	4	3.6	-24.8	0.02	0.25	0.95	0.75	0.71	0.71	0.28	0.43	26.18	24.59	24.65	9.59	14.99
	5	3.1	-26.3	0.02	0.23	0.88	0.51	0.32	0.33	0.23	0.23	31.53	19.75	20.50	14.02	14.21
	6	1.8	-26.3	0.03	0.30	0.78	0.41	0.21	0.25	0.15	0.19	33.72	17.12	20.68	12.41	16.08
	7	0.9	-27.1	0.01	0.13	0.91	0.57	0.43	0.47	0.22	0.28	29.07	22.08	23.63	11.07	14.15
	8	2.0	-26.9	0.03	0.26	0.74	0.63	0.35	0.40	0.25	0.34	32.16	17.65	20.48	12.56	17.16
	9	2.8	-27.1	0.02	0.24	0.80	0.51	0.30	0.34	0.22	0.28	30.84	18.10	20.91	13.37	16.78
	10	2.7	-26.7	0.02	0.23	0.75	0.48	0.15	0.19	0.11	0.16	44.18	14.06	17.43	10.11	14.22
	12	3.0	-25.8	0.02	0.21	1.04	0.62	0.34	0.37	0.68	0.43	25.56	14.05	15.00	27.90	17.49
	14	2.6	-26.9	0.03	0.31	0.77	0.53	0.15	0.20	0.13	0.15	45.80	12.76	17.08	11.30	13.06
	16	1.8	-27.2	0.02	0.28	0.71	0.37	0.13	0.18	0.13	0.14	38.73	13.57	19.43	13.40	14.88
	18	2.5	-27.6	0.02	0.32	0.63	0.34	0.12	0.16	0.11	0.11	40.22	13.58	19.27	13.46	13.47
	20	2.3	-31.0	0.02	0.40	0.67	0.35	0.09	0.14	0.11	0.13	43.13	11.55	16.82	13.13	15.37
	25	1.5	-27.4	0.03	0.38	1.08	1.28	0.40	0.44	0.68	0.45	39.40	12.31	13.47	21.08	13.74
8.TT-Mangroves	1	5.2	-20.1	0.08	0.70	1.27	1.93	0.76	0.78	0.66	0.49	41.79	16.55	16.81	14.32	10.52
	2	5.6	-20.5	0.11	0.86	0.87	1.68	0.58	0.60	0.39	0.36	46.58	16.00	16.56	10.80	10.05
	3	6.2	-21.6	0.09	0.90	0.87	2.10	0.41	0.47	0.32	0.30	58.16	11.37	13.06	8.99	8.42
	4	4.3	-22.3	0.07	0.57	0.83	1.10	0.22	0.27	0.27	0.26	51.92	10.44	12.52	12.80	12.33
	5	4.4	-22.9	0.08	0.72	0.71	1.16	0.21	0.26	0.25	0.22	55.23	10.03	12.33	11.84	10.58
	6	3.7	-23.3	0.04	0.44	0.78	1.97	0.26	0.32	0.22	0.23	65.79	8.75	10.62	7.28	7.56
	7	4.7	-22.3	0.07	0.59	0.72	1.83	0.26	0.39	0.30	0.22	61.12	8.61	13.04	9.87	7.35
	8	3.9	-25.4	0.07	0.88	0.81	1.09	0.20	0.28	0.24	0.21	53.75	9.94	14.02	12.02	10.27
	9	4.2	-23.4	0.07	0.62	0.76	2.52	0.28	0.39	0.15	0.17	71.77	7.97	11.24	4.27	4.76
	10	4.0	-23.9	0.07	0.71	0.84	0.84	0.24	0.33	0.16	0.16	48.92	13.88	18.86	9.26	9.07
	12	5.1	-23.1	0.04	0.40	1.59	0.52	0.12	0.28	0.25	0.37	33.96	7.62	18.21	16.20	24.00
	14	5.2	-23.9	0.04	0.53	1.68	0.34	0.11	0.22	0.23	0.25	29.97	9.36	18.89	19.91	21.87
	16	5.0	-23.5	0.05	0.59	3.03	0.36	0.12	0.29	0.30	0.25	27.45	9.40	21.58	22.45	19.12
	18	4.1	-24.1	0.04	0.59	2.73	0.30	0.12	0.26	0.30	0.25	24.16	10.15	20.83	24.26	20.60
	20	4.1	-23.6	0.06	0.81	6.17	0.48	0.16	0.35	0.51	0.46	24.62	8.32	17.76	25.89	23.41
	25	4.7	-22.1	0.05	0.66	1.97	0.40	0.09	0.20	0.15	0.15	40.75	9.06	20.10	15.35	14.74
8.TT-Tidal Flats	1	6.5	-25.5	0.07	0.65	1.18	2.06	1.05	1.13	0.40	0.32	41.53	21.23	22.76	8.03	6.45
	2	6.8	-25.7	0.12	1.04	1.25	1.57	0.89	0.94	0.50	0.46	36.03	20.40	21.69	11.38	10.49
	3	6.5	-26.7	0.12	1.15	1.07	2.13	0.51	0.63	0.40	0.49	51.20	12.22	15.19	9.54	11.85
	4	6.5	-26.9	0.13	1.23	1.14	2.13	0.36	0.48	0.36	0.39	57.24	9.76	13.00	9.58	10.42
	5	6.2	-27.7	0.11	1.06	1.03	2.21	0.27	0.38	0.19	0.23	67.39	8.13	11.70	5.79	6.99
	6	6.0	-28.5	0.07	0.77	0.87	2.21	0.24	0.35	0.15	0.21	69.78	7.63	11.01	4.82	6.76
	7	5.7	-28.9	0.07	0.75	0.89	2.31	0.29	0.39	0.37	0.25	63.91	7.92	10.86	10.32	6.99
	8	5.8	-28.1	0.06	0.62	0.77	2.63	0.19	0.26	0.27	0.24	73.20	5.24	7.36	7.63	6.57

	9	6.1	-28.0	0.10	0.98	0.68	2.64	0.15	0.21	0.06	0.10	83.54	4.66	6.57	2.03	3.21
	10	6.7	-27.6	0.09	0.93	0.74	2.51	0.16	0.23	0.09	0.13	80.50	5.04	7.24	2.93	4.29
	12	6.5	-27.2	0.09	0.95	0.70	3.10	0.08	0.15	0.05	0.09	89.50	2.32	4.29	1.43	2.47
	14	5.6	-26.9	0.04	0.40	0.66	3.72	0.06	0.11	0.04	0.09	92.43	1.60	2.67	0.94	2.36
	16	4.7	-27.5	0.03	0.33	0.65	2.38	0.06	0.09	0.04	0.09	89.40	2.09	3.54	1.58	3.39
	18	5.7	-27.8	0.05	0.54	0.57	3.66	0.12	0.19	0.04	0.10	88.87	3.00	4.69	1.04	2.39
9.HT-Mangroves	1	2.4	-28.2	0.08	0.95	0.59	0.12	0.13	0.17	0.06	0.11	19.58	22.55	29.26	10.36	18.25
	2	1.9	-28.3	0.04	0.44	0.56	0.06	0.08	0.11	0.03	0.08	16.17	22.21	30.82	8.49	22.32
	3	2.1	-27.5	0.03	0.29	0.94	0.21	0.11	0.21	0.89	0.11	13.75	7.15	13.69	58.09	7.33
	4	1.5	-27.9	0.03	0.35	0.65	0.08	0.10	0.13	0.10	0.09	16.67	19.84	27.04	19.07	17.39
	5	2.9	-28.7	0.06	0.77	0.65	0.08	0.10	0.13	0.10	0.09	16.67	19.84	27.04	19.07	17.39
	6	2.2	-28.8	0.08	1.04	0.54	0.19	0.12	0.17	0.08	0.11	28.28	17.95	25.25	12.36	16.16
	7	2.0	-28.6	0.05	0.63	0.49	0.11	0.12	0.17	0.27	0.11	14.84	14.92	21.42	34.41	14.41
	8	1.9	-29.0	0.04	0.50	0.56	0.24	0.14	0.17	0.08	0.14	31.28	18.33	22.59	10.17	17.63
	9	1.0	-27.4	0.01	0.10	0.65	0.08	0.16	0.19	0.09		15.38	31.48	35.87	17.27	0.00
	10	1.9	-29.8	0.01	0.15	0.68	0.43	0.26	0.27	0.19		37.25	22.62	23.65	16.48	0.00
	12	1.3	-27.4	0.02	0.24	0.74	0.21	0.21	0.20	0.25	0.15	20.45	20.21	19.51	24.70	15.12
	14	2.3	-27.2	0.05	0.71	0.90	0.14	0.43	0.44	0.39	0.25	8.71	26.09	26.80	23.32	15.09
	16	2.5	-27.0	0.06	0.88	0.85	0.10	0.41	0.40	0.29	0.25	6.89	28.44	27.59	19.90	17.18
	18	2.8	-25.9	0.06	0.92	0.68	0.06	0.20	0.21	0.12	0.16	8.52	26.26	28.47	16.19	20.56
	20	2.2	-25.3	0.05	0.78	0.64	0.05	0.13	0.13	0.08	0.10	9.64	27.11	26.52	15.95	20.79
	25	2.1	-24.5	0.04	0.58	0.64	0.05	0.13	0.13	0.08	0.10	9.64	27.11	26.52	15.95	20.79
9.HT-Tidal Flats	1	-1.9	-25.1	0.01	0.10	0.69	0.04	0.05	0.10	0.03	0.10	13.30	15.96	29.09	10.37	31.28
	2	-0.6	-24.3	0.02	0.08	0.48	0.06	0.05	0.07	0.03	0.11	18.65	15.21	21.37	10.22	34.54
	3	-0.5	-25.5	0.02	0.09	0.63	0.09	0.04	0.07	0.03	0.10	27.88	11.25	22.34	8.84	29.69
	4	0.4	-25.9	0.02	0.11	0.68	0.06	0.03	0.06	0.36	0.07	10.08	5.20	10.23	62.04	12.45
	5	-1.5	-25.7	0.01	0.08	0.61	0.05	0.02	0.04	0.03	0.11	21.74	8.25	14.67	12.78	42.55
	6	-1.7	-25.1	0.02	0.08	0.53	0.03	0.01	0.04	0.04	0.08	13.19	3.52	19.02	22.60	41.66
	7	-0.2	-25.0	0.02	0.07	0.58	0.04	0.02	0.05	0.15	0.08	11.52	5.96	13.62	44.68	24.22
	8	-0.6	-25.6	0.02	0.06	0.54	0.03	0.02	0.05	0.07	0.08	12.74	7.01	19.74	27.68	32.83
	9	-1.0	-25.7	0.02	0.07	0.43	0.03	0.01	0.03	0.02	0.09	17.89	5.37	15.39	12.53	48.81
	10	0.9	-25.4	0.01	0.06	0.60	0.03	0.02	0.04	0.05	0.10	10.58	10.02	15.66	20.14	43.60
	12	0.4	-24.7	0.02	0.09	0.63	0.06	0.03	0.07	0.24	0.07	12.93	6.48	14.63	51.81	14.14
	14	1.3	-25.7	0.02	0.08	0.62	0.03	0.03	0.05	0.06	0.10	12.79	11.31	16.97	21.10	37.82
	16	0.1	-24.9	0.02	0.07	0.63	0.04	0.02	0.05	0.19	0.10	11.20	4.14	12.55	48.32	23.79
	18	0.0	-25.3	0.02	0.07	0.54	0.04	0.01	0.03	0.04	0.12	15.81	4.98	13.48	15.76	49.97

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(v) Evaluation of the project's effectiveness in achieving the proposed objectives as well as the impact (benefits) of the Project.

The main purpose of this project is to monitor DOM in coastal wetland sediments, which will benefit the future conservation and management of coastal wetland ecosystems in Hong Kong. This study provided the first analysis of DOM in coastal wetland sediments in Hong Kong and will link its optical properties to anthropogenic activities. Proposed objectives are achieved. Firstly, this project used fluorescence spectroscopy to discriminate the components and characteristics of DOM in detail, and trace the sources of sediment DOM. We have found that the DOM characteristics at different habitats and wetlands in Hong Kong showed spatial variances. The 3D-EEMs-PARAFAC model has shown that the sedimentary sediments in Hong Kong are don minted by five different components, mainly from coastal water, algae, wastewater and plants. A better understanding of DOM characteristics in sediments has benefited our understanding of organic matter cycling in coastal wetlands in Hong Kong and provided the first insight into the DOM characteristics on material cycling in peri-urban coastal wetlands. This project has provided a technical backup to improve the efficiency of coastal wetland conservation and management in Hong Kong in the future. In addition, this study provided a rapid method to trace the DOM source in coastal wetland, which will be useful for the academic community and the government to assess the impact of anthropogenic activities in peri-urban coastal wetlands. What's more, the methodology developed in this project can be applicable not only to coastal wetlands, but also to other marine ecosystems, such as coastal waters, aquaculture areas, and open waters. The methodology will enhance the conservation and management of marine ecosystems in the future.

(vi) Summary and Way Forward

This study investigating the bulk and optical characteristics of sediments in Hong Kong's coastal wetlands revealed significant variations in OC and N content with depth. Surface sediments exhibited higher levels, particularly in *gei wai*, where limited water exchange led to notable accumulations of OC and N. Optical parameters indicated regional differences in DOM, with mangroves showing higher humification and tidal flats reflecting fresher sources. 3D-EEMs-PARAFAC identified five DOM components: three humic-like (C1, C2, C3) and two protein-like (C4, C5). C1 and C3 were more intense in tidal flats, while C2 dominated in mangroves. Components C4 and C5, linked to pollution, were elevated in mangroves near urban areas. Seasonal sampling indicated stability in DOM characteristics across winter and summer. The study further assessed the impact of anthropogenic activities on DOM, focusing on C4, which ranged from 4.86% to 26.35% across nine wetlands. The tidal flat at LCW exhibited the lowest pollution, while HT and MP had higher C4 levels due to upstream pollution sources. A structural equation model revealed that natural factors primarily drive DOM composition, while human activities positively affect C4 and negatively impact algal-derived C2. Overall, these findings highlight the complex interplay between environmental factors and organic matter dynamics in these coastal ecosystems.

The findings of this study offer a valuable framework for future research and policy recommendations aimed at safeguarding Hong Kong's coastal wetlands. A key direction is to implement a comprehensive monitoring program that tracks the composition and changes in DOM, particularly focusing on pollution-related components like C4. This will facilitate early detection of pollution risks and enable timely intervention. Additionally, strategies to optimize water exchange, such as dredging channels and improving sluice gate management, should be explored, especially in areas with high pollution levels. Reducing pollution at its source is essential, necessitating stricter regulations on urban wastewater discharges and minimizing industrial and agricultural runoff.

Government recommendations include establishing tailored effluent standards for the sensitive coastal wetland environment, alongside robust enforcement measures. Public awareness campaigns are crucial for educating the public about the ecological importance of coastal wetlands and encouraging active participation in conservation efforts. Finally, implementing an ecological compensation mechanism can reward businesses and individuals for their contributions to wetland protection, fostering sustainable practices. By adopting these measures, Hong Kong can effectively protect its coastal wetlands, promoting their health and ensuring the continued provision of valuable ecosystem services.

(vii) Audited statement of account

Financial statement is not disclosed due to confidentiality reasons.

(viii) A list of all project assets (as defined in Section 5.14) with photos (see Appendix 4) enclosed as an appendix to the completion report

NA. There are no project assets.

(ix) Staff attendance record

Staff attendance record is not disclosed due to confidentiality reasons.

(x) Staff recruitment record

Staff recruitment record is not disclosed due to confidentiality reasons.