Report on blue carbon storage in eastern Eyre Peninsula coastal wetlands

Prepared for the Department for Environment and Water and Eyre Peninsula Landscape Board

By

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May 2021

Acknowledgements

This project was made possible by funding support from DEW Climate Change and Coasts Branch and the Eyre Peninsula Landscape Board. The results will help support the aims and outcomes of the SA Blue Carbon Strategy and Research Roadmap, as well as contributing to the Eyre Peninsula Saltmarsh Threat Abatement and Recovery project. The study was a collaboration with DEW Coast and Marine team and Doug Fotheringham, who provided both logistical support and expertise in vegetation surveys and coastal surveying (providing updated vegetation survey data, high-resolution location and elevation data, and important information on the vegetation and coastal management history of each of the sampled sites). These additional data will enable us to dig deeper into the details and drivers of the sediment carbon stocks as part of a postgraduate student project. We were also very lucky to receive on-the-ground support from the Eyre Peninsula Landscape Board (particularly Liz McTaggart, Barbara Murphy and Rachael Kanussaar), both in planning the project and with in-kind support for ongoing monitoring of the SETs, which would otherwise not be possible. The project is an example of the value added nature of committed government-researcher collaborations, which certainly produce outcomes that are more than the sum of their parts.

This research was undertaken on the lands of the Barngarla people. We are grateful to the Barngarla Determination Aboriginal Corporation who kindly granted us permission to undertake the fieldwork. We acknowledge and respect the Barngarla peoples' spiritual relationship with their country, their cultural and heritage beliefs and their rights as the Traditional Owners of the land.

Background:

Blue carbon refers to the carbon that is captured and stored in coastal vegetated ecosystems. This happens through two main pathways: 1) carbon dioxide (CO_2) is taken up (sequestered) directly from the atmosphere by coastal vegetated ecosystems during photosynthesis and converted into above and below-ground plant material and 2) organic matter (sourced both from within and outside the ecosystem) is trapped and buried in the sediment where it can be stored for millennia (Lo Iacono et al., 2008). Mangrove, tidal saltmarsh and seagrass ecosystems are very effective carbon stores because they constantly accrete sediment, which prevents carbon saturation, meaning they can continually sequester carbon from the environment. In addition, the sediment in these tidal systems is more likely to be waterlogged and anoxic than terrestrial soils, which decreases the breakdown and release of carbon back to the environment (Mcleod et al., 2011). Blue carbon ecosystems make a significant contribution to the global carbon cycle, with organic carbon (C_{org}) sequestration rates and storage periods orders of magnitude higher than in many terrestrial ecosystems (Mcleod et al., 2011). This, together with ongoing high rates of loss of blue carbon ecosystems globally, make them of significant interest for national and regional climate change mitigation strategies.

Study aims and scope:

The study aimed to measure sediment carbon stocks and accumulation in multiple saltmarsh and mangrove locations along the east coast of the Eyre Peninsula; an under-sampled region of the state for blue carbon (with no previous data). The study was linked to both the EP Saltmarsh Threat Abatement and Restoration (STAR) program and ongoing coastal monitoring (vegetation community and elevation) being undertaken by the DEW Coast and Marine Branch.

Methods:

We carried out coastal wetland sediment core sampling and installation of sediment elevation tables down the east coast of Eyre Penisula (west coast of Spencer Gulf) between 7th and 13th Sept 2020. The sampling and installation locations are shown on the map in Figure 1.

Carbon stocks:

Sediment core samples were collected from three study sites, described in detail below. Each of these sites has an established DEW coastal vegetation and elevation monitoring profile (transect) line. The core samples were taken from three or four different points along each transect, each representing a different vegetation community:

1) supratidal saltmarsh
2) intertidal saltmarsh
3) mangrove
4) dense mangrove (Tumby Bay only)

At each sampling point, we collected three replicate core samples to 50 cm depth (or occasionally deeper where sediment consistency allowed). Each core was sectioned at 0 – 5 cm, 5 – 10 cm, 10 – 20 cm, 20 – 30 cm, 30 – 40 cm and 40 – 50 cm (with two additional increments of 50 – 60 cm and 60 – 100 cm where deeper cores could be collected). In total 181 sediment samples were taken from 30 sediment cores collected across the three transect sites. The core dataset is described in detail in

Table 1.

<u>Mount Young</u>. A site seaward of the Eight Mile Creek road, approximately 14 kms south west of Whyalla, on the western shoreline of Spencer Gulf (Figure 1). The site is on an open area of the coast, which typically has low wave energy and is tidally dominated, although is exposed to ocassional storms and high wave energy (Bourman et al., 2016). The ~1.6 km DEW profile along which the cores were collected starts at ~ 3.6 m AHD at the landward end and grades to ~ 0.4 m AHD at the seaward end. This declining seaward elevation gradient is interrupted by vegetated sand/shell ridges, salt flats and inter-ridge corridors. As a result of this complex topography, the vegetation is varied due to differences in soils and exposure to seawater flooding with different plant communities occupying the ridge tops, ridge slopes, flats and inter-ridge corridors. Low marsh communities adapted to regular seawater flooding are confined to low lying areas at the seaward end of the profile and characterised by *Tecticornia arbuscula* and *Tecticornia halocnemoides* with some *Salicornia quinqueflora* and *Avicennia marina* (mangrove) in the lowest lying areas. The higher elevation parts of the profile were characterised by saltmarsh communities dominated by *Tecticornia indica*, *Atriplex vesicaria* and *Maireana oppositifolia*. The mid-elevation plant communities commonly included *Tecticornia indica*, *Tecticornia halocnemoides* and *Maireana oppositifolia*.

<u>Franklin Harbour</u>. A site within the relatively protected bay of Franklin Harbour, which is an almost completely landlocked, shallow lagoon that only has narrow access to the sea (Figure 1). As such the shore within the lagoon has been prograding (moving seaward) and aggrading (vertically accreting) since sea-levels stabilised ~ 7,000 years ago, indicating that this protected and tidalling influenced area is a highly depositional environment (Bourman et al., 2016). The DEW profile started at ~ 2.6 m AHD at the landward side and ended at ~ 0.5 m AHD at the seaward side (note this is a smaller elevation range than the Mount Young profile). The lowest parts of the profile were characterised by plant communities dominated by the mangrove *Avicennia marina*, and the samphires *Tecticornia arbuscula* and *Salicornia quinqueflora*. At the medium elevations the most common saltmarsh plants were *Tecticornia indica* and *Atriplex paludosa*.

<u>Tumby Bay</u>. A site approximately 3.5 km south of the Tumby Bay township (Figure 1), within a protected section of an extensive and complex tidal inlet with sandflats, mangroves and samphire (Bourman et al., 2016). The site is generally low lying (the lowest of the three sites sampled) with ridges and tidal creeks that lead to vegetation complexity. The ~ 1.2 km long profile starts at a landward elevation of approximately 2 m AHD and ends at a seaward elevation of ~ 0 m AHD. Although the elevation range sampled at this site is narrower than the other two sites, the mean elevation was higher than at Franklin Harbour. The highest elevation parts of the Tumby Bay site were characterised by high marsh vegetation communities dominated by Austrostipa stipoides, Atriplex paludosa and Maireana oppositifolia. Medium elevation parts of the site typically contained *Tecticornia indica*, *Tecticornia halocnemoides*, *Maireana oppositifolia*, *Tecticornia arbuscula*.

Table 1: Description of sediment core samples collected from each of the three sampling locations and vegetation types

Site	Vegetation	Depth range sampled	Samples
Mount Young	Supratidal samphire	0 - 50 cm	18
	Intertidal samphire	0 - 50 cm	18
	Mangrove	0 - 50 cm	18
Franklin Harbour	Supratidal samphire	0 - 50 cm	15
	Intertidal samphire	0 - 50 cm	18
	Mangrove	0 - 100 cm	22
Tumby Bay	Supratidal samphire	0 - 50 cm	18
	Intertidal samphire	0 - 50 cm	18
	Mangrove	0 - 50 cm	18
	Dense mangrove	0 - 50 cm	18
	Total samples		**181**

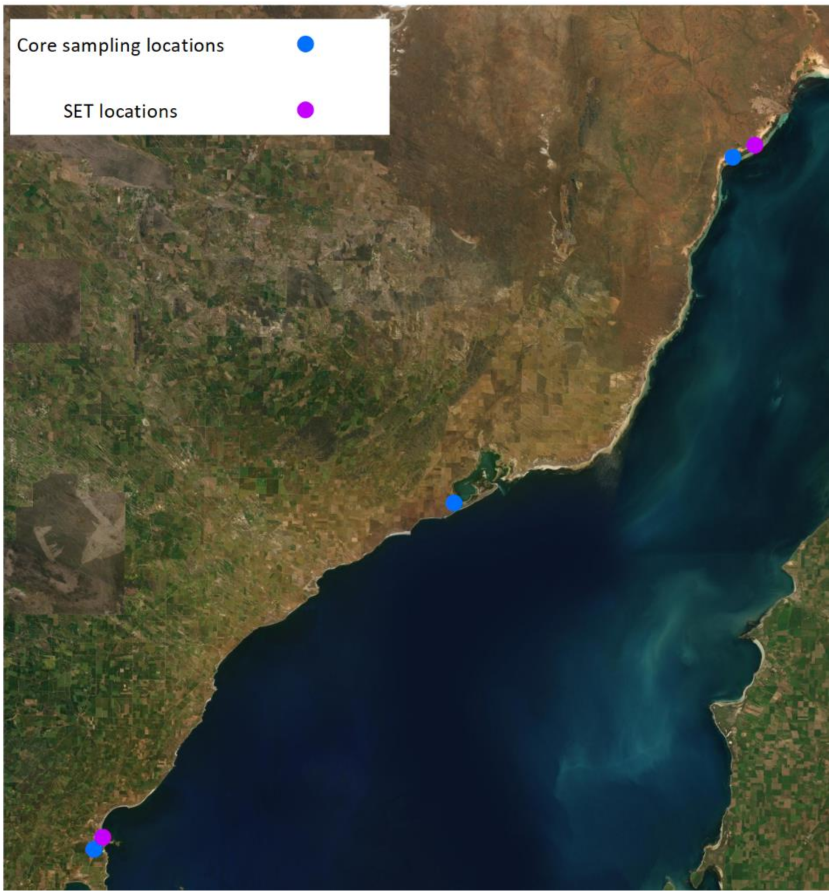

Figure 1: Map of sediment core sampling locations (purple) and sediment elevation table installation sites (blue) at three sites down the west coast of Spencer Gulf: Mount Young (furthest north), Franklin Harbour (middle) and Tumby Bay (furthest south).

Carbon accumulation:

Carbon accumulation is being measured using sediment elevation tables (SETs) that were installed at two of the three study sites: Mount Young and Tumby Bay (see map in Figure 1 and photos in Figure 2). SETs enable an assessment of sediment and carbon accumulation over time at high temporal resolutions. This is the most appropriate way to monitor carbon sequestration over periods of months to years, as this resolution is not possible from sediment core data. Using SETs also avoids the requirement for costly sediment core dating analyses (which at best can provide decadal temporal resolutions for sequestration rates).

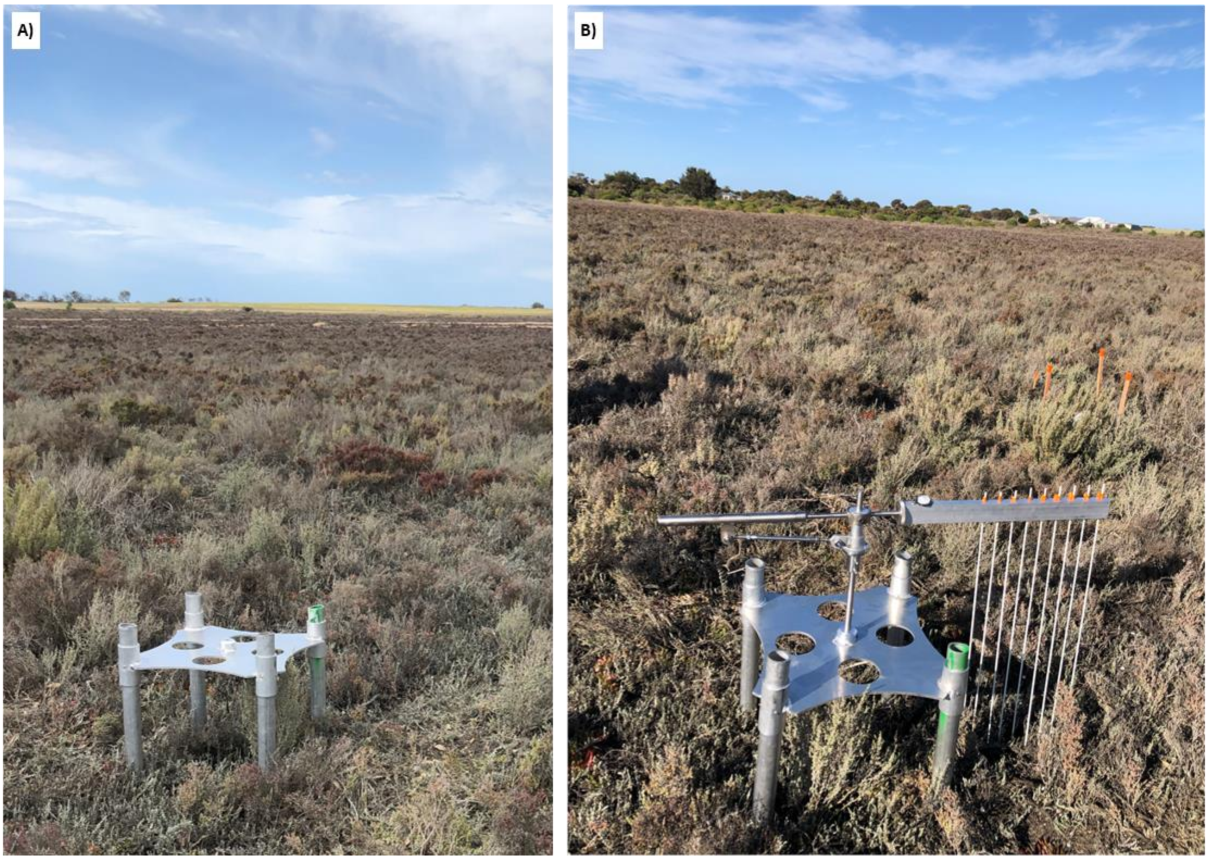

Figure 2: Sediment elevation tables installed in saltmarshes at A) Mount Young and B) Tumby Bay. A) shows the equipment that is left on-site and B) shows the additional instruments that are brought to site intermittently for taking measurements (and then removed).

As SETs can only provide useful data after monitoring periods of years to decades, their installation is speculative in terms of results, and requires ongoing, long-term monitoring. The SETs installed as part of this study will provide an excellent source of long-term monitoring data on both vegetation community and condition (as photos are taken at each measurement occasion), as well as sediment and carbon dynamics. Staff from the Eyre Peninsula Landscape Board are supporting this work by taking measurements from the SETs at regular intervals (approximately bi-monthly to quarterly, depending on capacity).

Tumby Bay SET:

The SET at Tumby Bay was installed in intertidal saltmarsh at a location where inundation is likely to increase due to widening of a nearby culvert (Figure 3). This increase in tidal connectivity is expected to be beneficial to the condition and functioning of saltmarshes at the site. Installation of the SET here will allow us to monitor baseline sediment/carbon accumulation before the culvert widening takes place, and any change over time after the tidal connection is improved due to the culvert widening. The culvert widening works are being undertaken by the local council and the time frame is currently unknown. So far measurements from the SET at Tumby Bay have been taken on the date of installation (11th Sept 2020) and on 18th Dec 2020.

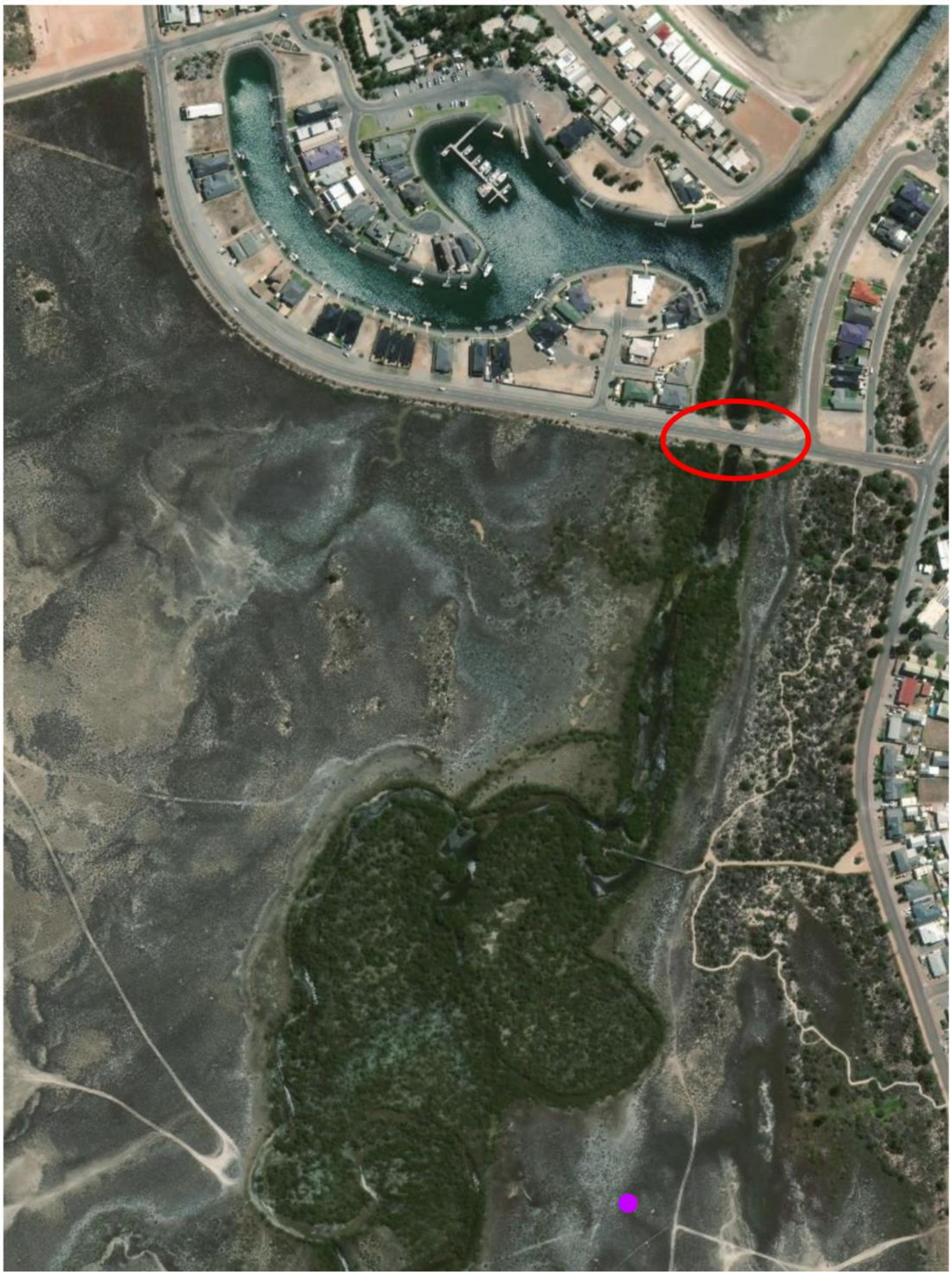

Figure 3: Location map of Tumby Bay sediment elevation table (purple point) and location of culvert that is scheduled for widening (red circle)

Mount Young (Cowled's Landing) SET:

The SET at Cowled's Landing near Mount Young was installed in intertidal saltmarsh at a location that has been degraded by off-road vehicle use (Figure 4). Just before installation, large boulders were placed nearby that are intended to block access to the area for off-road vehicles. Although we were unable to collect any data at this site from before the management intervention was undertaken, ongoing monitoring of this SET will provide data on sediment and carbon accumulation rates that may be tied back to the exclusion of the vehicles (which are likely to both physically damage saltmarshes and cause direct erosion and compaction of sediments). So far measurements from the SET at Cowled's Landing have been taken on the date of installation (8th Sept 2020) and on 4th Dec 2020.

Figure 4: Location map of Cowled's Landing (near Mount Young) sediment elevation table (purple point) and location of management controls (large boulders) that have been placed to prevent access to the saltmarshes by off road vehicles (red circle)

Results:

Sediment carbon stocks

The sediment organic carbon stocks (to a consistent depth of 50 cm; Figure 5) were highest in the mangroves (median = 77.9 t C_{org} ha^{-1}, MAD = 20.9 t C_{org} ha^{-1}), followed by intertidal samphire (median = 65.4 t C_{org} ha^{-1}, MAD = 44.4 t C_{org} ha^{-1}) and then supratidal samphire (median = 27.3 t C_{org} ha^{-1}, MAD = 13.1 t C_{org} ha^{-1}). The trend in relative magnitude of stocks associated with vegetation type (highest in mangrove and lowest in supratidal samphire) was consistent across all three sites. However, there were also site-based differences in carbon stocks, with Franklin Harbour consistently having greater organic carbon stocks than the other two sites (Figure 6). The high stocks in the mangrove samples from Franklin Harbour are particularly notable (Figure 6).

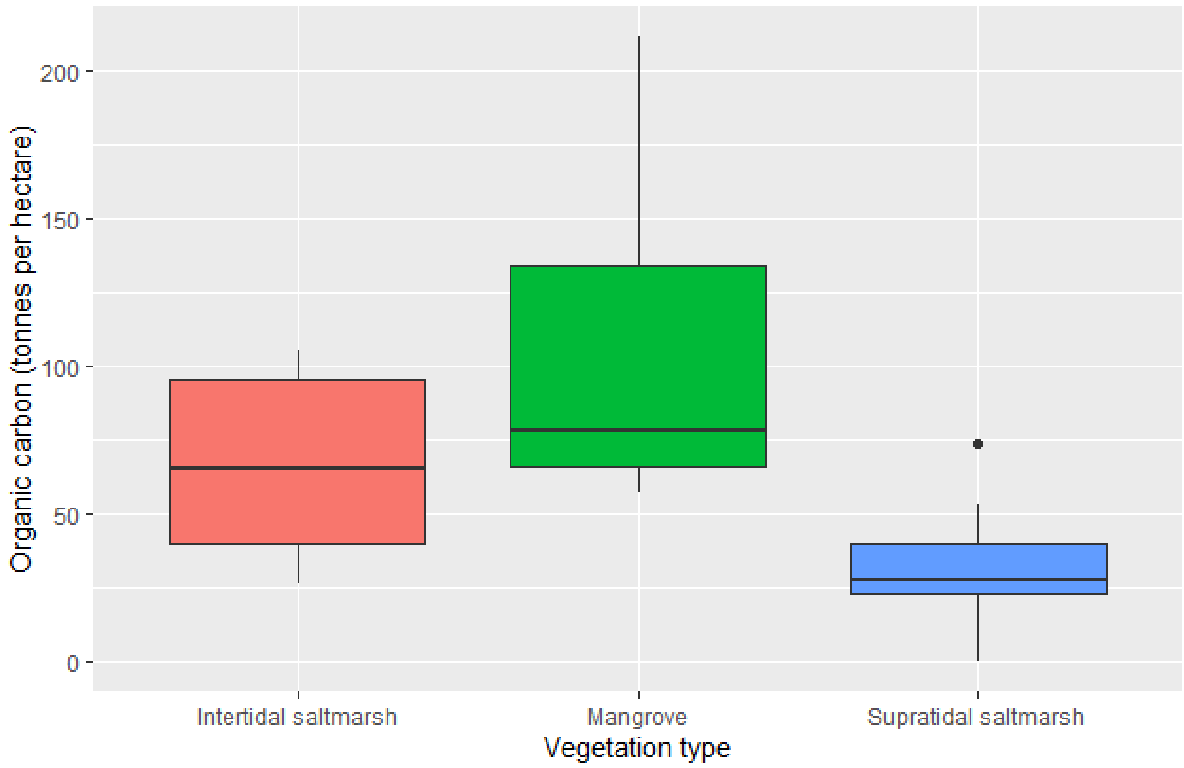

Figure 5: Organic carbon stocks in the top 50 cm of the soil. Samples from the three study sites (Mount Young, Tumby Bay and Franklin Harbour) have been pooled by vegetation type.

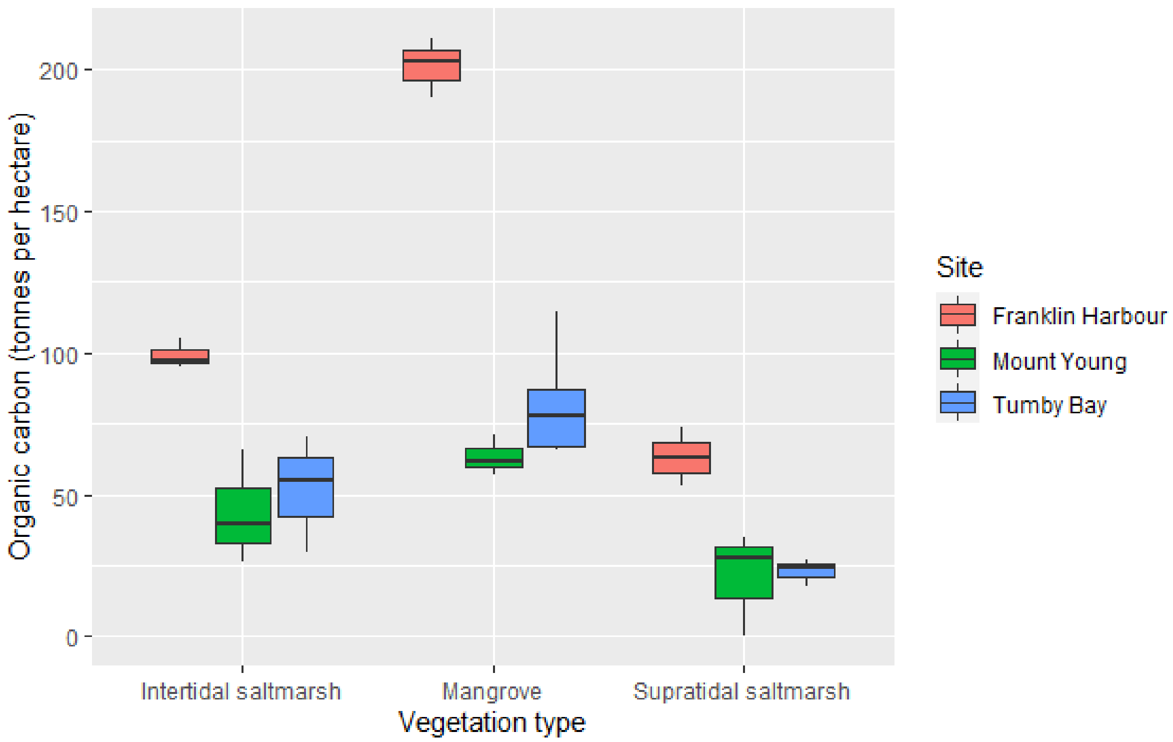

Figure 6: Organic carbon stocks in the top 50 cm of the soil. Samples from the three study sites (Mount Young, Tumby Bay and Franklin Harbour) are split by vegetation type.

There is a trend of higher organic carbon stocks at lower elevations (Figure 7), but this is not the whole story, as the highest carbon stocks were found at Franklin Harbour, which is not the lowest lying site. The average elevation was lowest at Tumby Bay (mean = 0.602 mAHD, sd = 0.439 mAHD), followed by Franklin Harbour (mean = 0.797 mAHD, sd = 0.691 mAHD), with Mount Young being the site with the highest overall average elevation (mean = 1.038 mAHD, sd = 0.585 mAHD) and the lowest carbon stocks across all vegetation types (Figure 6). Within each site, mangrove soil samples were taken at the lowest elevations, followed by intertidal samphire and supratidal samphire; although there was some overlap (see Table 2). Therefore, there is likely to be some confounding between the effect of elevation and the effect of vegetation type on carbon stock volumes.

Table 2: Average and standard deviation for elevation (m AHD) measured at each core sample site by RTK GPS

Vegetation type	Site	Mean elevation	SD elevation
Intertidal samphire	Franklin Harbour	0.442	0.028
Intertidal samphire	Mount Young	0.824	0.094
Intertidal samphire	Tumby Bay	0.409	0.017
Mangrove	Franklin Harbour	0.407	0.008
Mangrove	Mount Young	0.498	0.000*
Mangrove	Tumby Bay	0.335	0.022
Supratidal samphire	Franklin Harbour	1.916	0.021
Supratidal samphire	Mount Young	1.792	0.046
Supratidal samphire	Tumby Bay	1.327	0.019

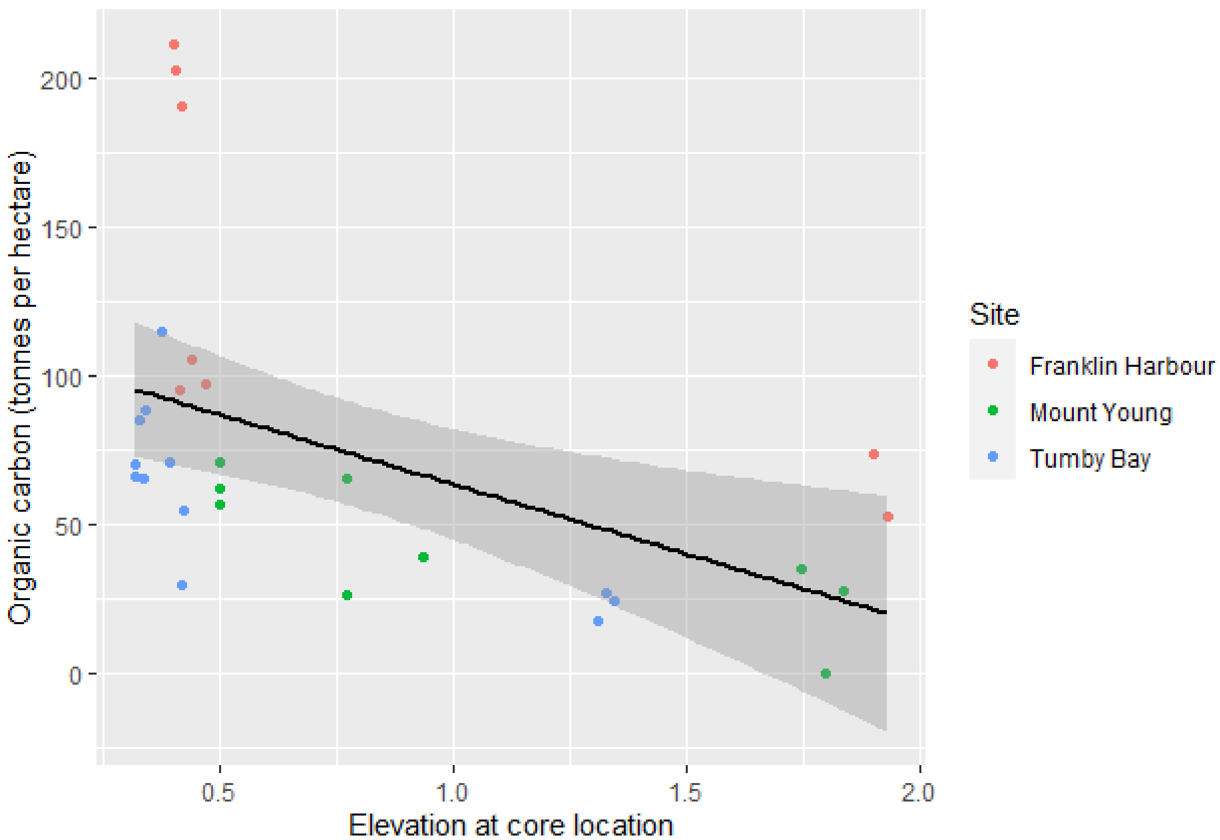

Figure 7: Sediment carbon stock (t C_{org} ha^{-1}) to 50 cm depth against elevation (m AHD) measured at each core sampling location using an RTK-GPS.

Comparison of mangrove and saltmarsh stocks with previously collected data

There is a growing suite of sediment core samples from South Australian coastal wetlands, which have been collected incrementally as part of previous collaborative studies. Here we compare the sediment carbon stock data from the Eyre Peninsula sites (collected as part of this study) with stocks reported in a recent SA blue carbon knowledge synthesis (Jones et al., 2019). Note that we have excluded the Eyre Peninsula supratidal samphire samples from this analysis, as these are not comparable with the saltmarsh systems that were sampled in the previous studies (which tended to target more intertidal/lower elevation samphires). This left a dataset of 21 sediment cores from mangrove (n = 12) and intertidal samphire (n = 9) vegetation types across the three Eyre Peninsula study sites (minimum of 3 sediment cores per vegetation type at each site), which were compared to data from 15 mangrove cores and 6 saltmarsh cores from the previous projects. Also note that for the purposes of this comparsion, we have re-calulcated the stocks from the Eyre Peninsula samples to 40 cm (which is different from the 50 cm stock reported in the sections above), so as to match the sampled/reported depths of the previous work.

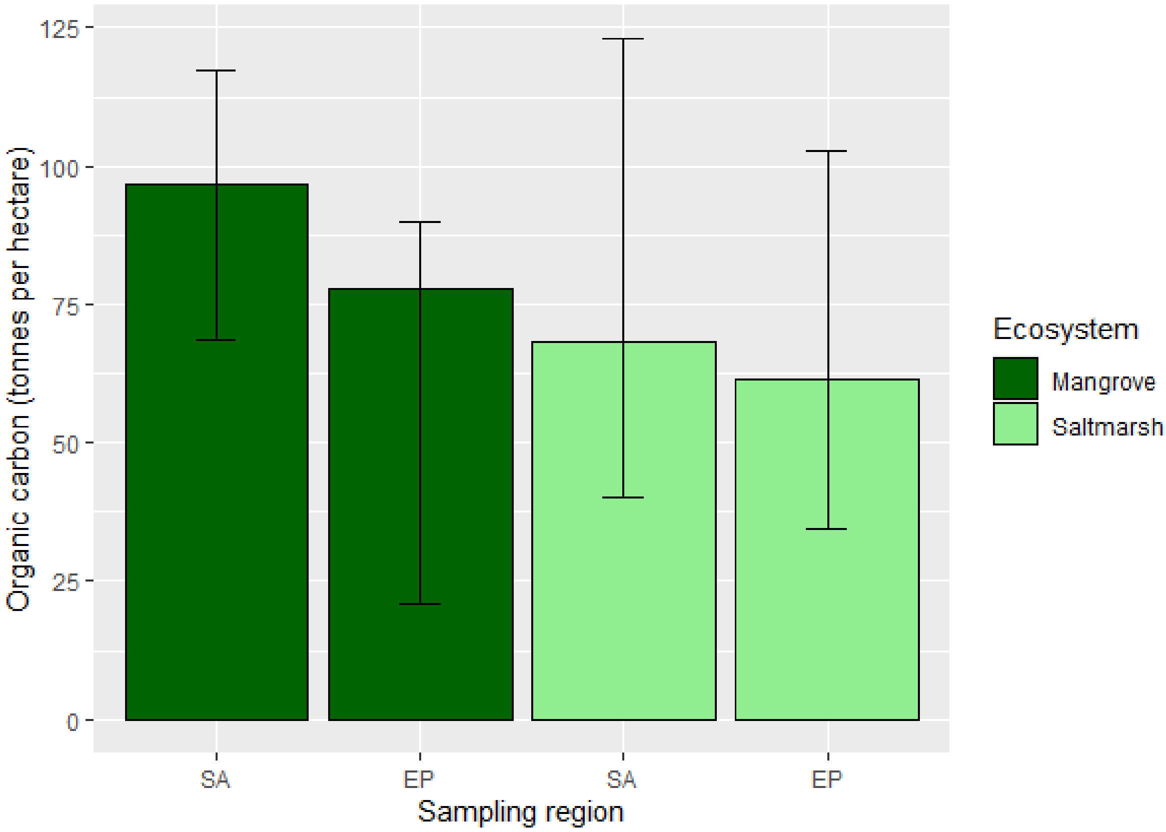

Figure 8: Median (and bootstrapped confidence intervals) sediment organic carbon stocks to 40 cm from mangroves and saltmarshes. Data are from the previous (SA) dataset and the Eyre Peninsula (EP) dataset.

The comparison shows that the median organic carbon stocks (to 40 cm depth) in both mangrove and saltmarsh sediments were lower at the Eyre Peninsula sites than the previously sampled sites (Figure 8). However, there is considerable site-based variation in these values (note the overlapping confidence intervals), with the samples from Franklin Harbour on the Eyre Peninsula having higher median stocks than the median stock value from the previous studies (Figure 9; Appendix **Error! Reference source not found.**).

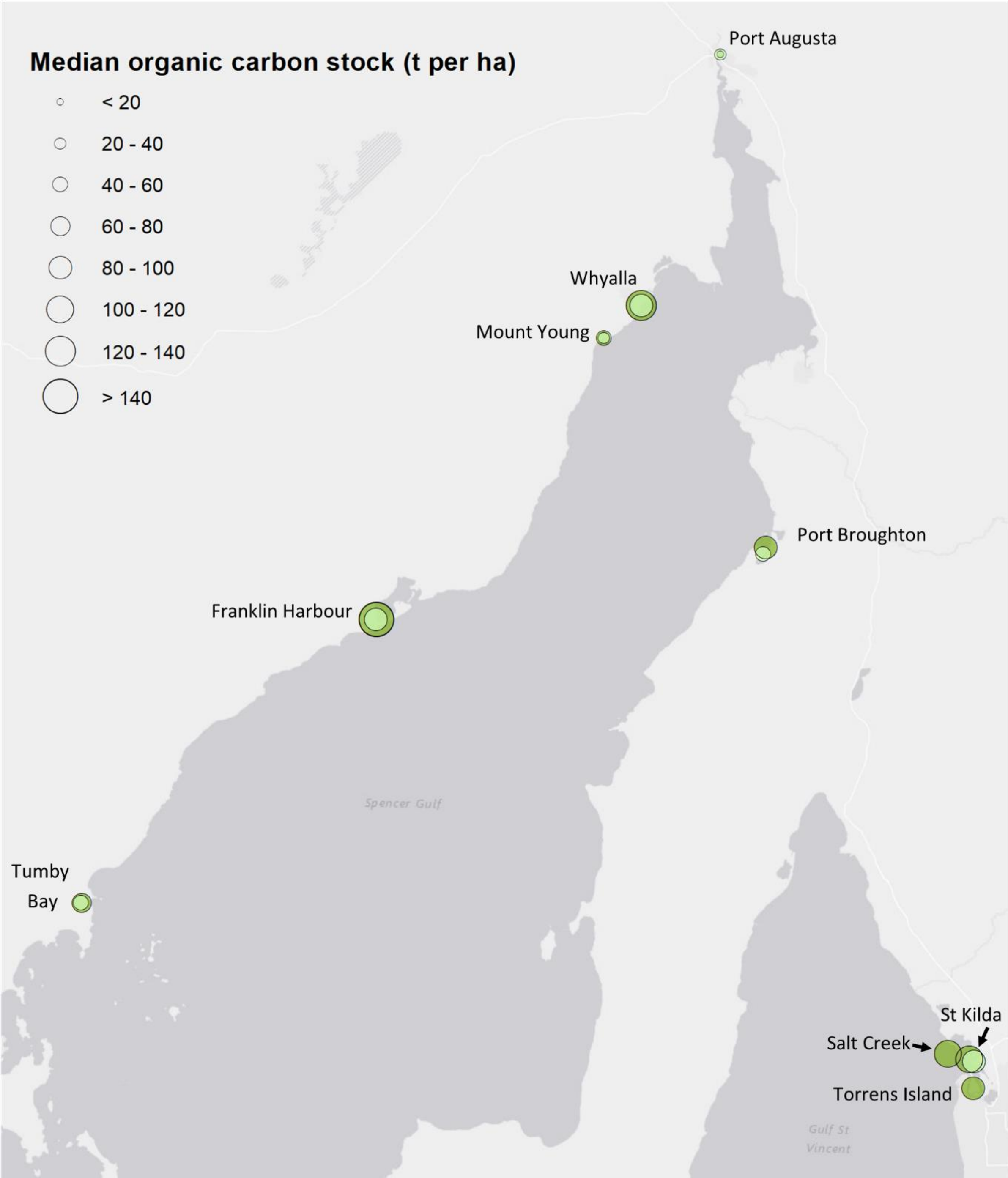

Figure 9: Map of site-based median sediment organic carbon stocks from all sampled sites in SA. Darker green filled circles represent mangrove stocks and lighter green filled circles represent saltmarsh stocks. The median values for each vegetation type and site are provided in the Appendix.

Discussion

This study from Eyre Peninsula sheds new light on the influence of vegetation community and elevation on carbon stocks in South Australia and highlights that there are both inter- and intra-site environmental drivers of sediment blue carbon stocks. Within a single site, vegetation communities that are higher in the tidal frame tend to have lower carbon stocks. We found a consistent pattern at all sites of supratidal samphire having the lowest stocks, followed by intertidal samphire and then mangrove having the greatest stocks (Figure 5 & Figure 7Figure 6). Further detailed modelling will be required to establish whether the vegetation community/condition or the elevation (or an interaction of both) are driving these intra-site carbon stock differences.

Our results also indicate that there are inter-site differences in carbon stocks across all vegetation types (Figure 6), which are likely to be driven by broader scale environmental variables (e.g. overall site elevation, tidal regime, coastal geomorphology). The considerably higher soil carbon stocks at Franklin Harbour (for all three vegetation types) cannot solely be explained by the site's elevation (Tumby Bay is at a slightly lower elevation), therefore it is likely that the coastal geomorphology (and potentially also the vegetation condition) plays a key role. Franklin Harbour is an enclosed bay and likely a depositional (high accumulation) environment (Figure 1).

When comparing the data collected at the Eyre Peninsula sites to the previously collected sediment carbon data (summarised in Jones et al., 2019), we found that when all sites were combined, the Eyre Peninsula has a lower median carbon stock in both mangrove and saltmarsh vegetation communities (Figure 8). However, this pooling of samples by vegetation type masks some interesting site-based differences, such as Franklin Harbour having a higher stock in the top 40 cm than many of the previously sampled sites in both Gulf St Vincent and Spencer Gulf (Figure 9 and Appendix **Error! Reference source not found.**). This again highlights how important site-based data are, and indicates the risk of missing nuance in carbon stock trends when pooling data from multiple locations based solely on vegation type.

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