BLUE CARBON IN HOBSONS BAY CITY COUNCIL

Estimating coastal wetland natural capital and the flow of ecosystem services











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CITATION

Costa MDPC, Wartman M & Macreadie Pl. 2021. Blue Carbon in Hobsons Bay City Council. A report submitted to the Hobsons Bay City Council. Deakin University, Australia, Deakin University, Melbourne, 34pp.

ACKNOWLEDGEMENTS

This project was funded by Hobsons Bay City Council. We are thankful to Imogen Butler, Sandra Wilson, Marilyn Olliff, Nick Olliff, Dr M Palacios, Dr Paul Carnell, Dr Pawel Waryszak and Dr Noyan Yilmaz who made valuable contributions to this project.

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EXECUTIVE SUMMARY

Coastal blue carbon ecosystems (seagrass meadows, saltmarshes and mangrove forests) are among the most efficient natural carbon sinks, effectively reducing atmospheric carbon dioxide and mitigating climate change. They can accumulate carbon faster than terrestrial forests and lock it away in the soil for centuries to millennia. Furthermore, blue carbon ecosystems provide several other ecosystem services, such as supporting fisheries and biodiversity, filtering water, provide ecotourism revenues and protect our coast against erosion and extreme weather events.

It has been estimated that blue carbon ecosystems in Victoria store over 2.31 million tonnes of carbon in the top 30 cm of sediments across Victoria's coastline. Hobsons Bay City Council (HBCC) contain substantial blue carbon ecosystems, which are likely playing an important role in carbon sequestration and other additional benefits (e.g., fisheries, recreation, coastal protection). In alignment with HBCC Environmental Strategy, this project addressed four Sustainable Development Goals (SDG) by linking a stakeholder partnership with wetland science.

The blue carbon ecosystems found in Hobsons Bay have the potential to provide opportunities for the HBCC to demonstrate sustainability through their management, protection, and enhancement of blue carbon storage within its region. This is likely to occur through a combination of demonstrating how current management practices are keeping these carbon sinks protected as well as new opportunities to improve management.

Therefore, this project explored the blue carbon opportunities in the HBCC area. It mapped the former, current, and potential future distribution of blue carbon ecosystems in the area and estimated the opportunity for restoration and creation of blue carbon ecosystems. The project also investigated the potential co-benefits (e.g., coastal protection, fisheries enhancement, recreation) generated by these ecosystems.

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KEY FINDINGS

(I) DISTRIBUTION OF BLUE CARBON ECOSYSTEMS

- This study revealed that, despite being a highly urbanised area, there remains substantial areas of blue carbon ecosystems along the HBCC coastline (~360 ha).
- Considering pre-European extent distribution, HBCC was home of approximately 425 ha of saltmarshes and less than 1 ha of mangroves.
- Current extents encompass ~108 ha of seagrasses, ~251 ha of saltmarshes (~41% loss) and ~2 ha of mangroves (100% gain).

(II) BLUE CARBON STOCKS & CO-BENEFITS IN EXISTING ECOSYSTEMS

- Existing blue carbon ecosystems within the region potentially store 48,500 tonnes CO₂e
- Stocks in the top 30 cm of the sediment vary from 24.3 ± 1.82 tonnes organic carbon (C) ha⁻¹ in seagrasses, 65.6 ± 4.17 tonnes C ha⁻¹ in mangroves, and 87.1 ± 4.90 tonnes C ha⁻¹ in saltmarshes.
- Existing mangroves, saltmarshes and seagrasses are also expected to deliver additional co-benefits, including, for example, providing coastal protection of important assets (> \$100 million in estimated cost savings from infrastructure protected by blue carbon ecosystems), and improving fisheries (\$13 per recreational fishing trip, biomass enhancement of more than 450,000 kg per year).

(III) BLUE CARBON OPPORTUNITIES IN HBCC

- This local study estimated the potential contribution of coastal restoration, with greater opportunity for carbon gain if blue carbon ecosystems are protected against erosion. In this case, the conservation of existing blue carbon ecosystem has the potential to protect ~17,200 tonnes CO₂e (high coastal erosion areas) and ~44,290 tonnes CO₂e (high and moderate coastal erosion areas) that would otherwise be released to the atmosphere if these ecosystems were to be lost.
- Restoration projects, such as levee removal and managed retreat, also bring additional opportunities for blue carbon projects in the HBCC region.

INTERACTIVE STORYMAP

For this project, we have developed an interactive StoryMap summarising all the results produced in this study.

Through the StoryMap we tell the story of this project and the Hobsons Bay City Council region's blue carbon ecosystems through photos, maps and text.



GRAPHICAL ABSTRACT

Blue carbon in Hobsons Bay City Council



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INTRODUCTION

Coastal wetlands (e.g., saltmarshes, mangroves and seagrasses) are collectively known as 'blue carbon' ecosystems (Mcleod et al. 2011). These ecosystems are among the most efficient natural carbon sinks, effectively reducing atmospheric carbon dioxide and mitigating climate change (Duarte et al. 2013). They can accumulate carbon faster than terrestrial forests and lock it away in the soil for centuries to millennia (Duarte et al. 2013, Mcleod et al. 2019). Furthermore, blue carbon ecosystems provide several other ecosystem services, such as supporting fisheries and biodiversity, filtering water, provide ecotourism revenues and protect our coast against erosion and extreme weather events (Barbier et al. 2011, Himes-Cornell et al. 2018, Friess et al. 2020). Despite their importance and valued contribution to climate change mitigation and adaptation, these ecosystems have degraded worldwide.

Australia is one of the world's richest blue carbon countries, storing approximately 5-11% of global blue carbon stocks (Serrano et al. 2019, Bertram et al. 2021). However, challenged with unprecedented degradation, an increase in pressure from exponential growth of the human population and climate change, wetland ecosystems and the services they provide are at risk. When degraded, coastal wetlands stop capturing carbon and can become significant sources of greenhouse gases (e.g., methane, nitrous oxide, carbon dioxide; Pendleton et al. 2012). In this case, there is a growing understanding of the potential for restoring and protecting blue carbon ecosystems (Waltham et al. 2020). If Australia's coastal wetlands are restored, they could become a tremendous asset in achieving the Sustainable Development

SUSTAINABLE DEVELOPMENT GALS



Figure 01. Sustainable Development Goals (SDGs) considered in the current project by linking a stakeholder partnership with wetland science.

Goals (SDGs) and delivering Nationally Determined Contributions (NDCs) through carbon sequestration (Kelleway et al. 2020). Currently, the Clean Energy Regulator is developing the first blue carbon method to be considered by the multi-billion dollar Emissions Reduction Fund and create opportunities to generate blue carbon credits (Clean Energy Regulator 2021).

It has been estimated that blue carbon ecosystems in Victoria store over 2.31 million tonnes of carbon in the top 30 cm of sediments across Victoria's coastline (Ewers Lewis et al. 2020). Hobsons Bay City Council contain substantial blue carbon ecosystems, which are likely playing an important role in carbon sequestration and other additional benefits (e.g., fisheries, recreation, coastal protection). In alignment with Hobsons Bay City Council Environmental Strategy, this project addressed four SDG's by linking a stakeholder partnership with wetland science (Figure 1). The blue carbon ecosystems have the potential to provide opportunities for Hobsons Bay City Council to demonstrate sustainability through their management, protection, and enhancement of blue carbon storage within its region. This is likely to occur through a combination of demonstrating how current management practices are keeping these carbon sinks protected as well as new opportunities to improve management.

Therefore, this project explored the blue carbon opportunities in the Hobsons Bay City Council area. It mapped the former, current, and potential future distribution of blue carbon ecosystems in the area and estimated the opportunity for restoration and creation of blue carbon ecosystems. The project also investigated the potential co-benefits (e.g., coastal protection, fisheries enhancement, recreation) generated by these ecosystems.



PAST AND CURRENT DISTRIBUTION OF BLUE CARBON ECOSYSTEMS

Currently, the HBCC region encompasses ~108 ha of seagrasses, ~251 ha of saltmarshes and ~2 ha of mangroves

Hobsons Bay City Council (hereafter HBCC, Figure 2) is a coastal region (~64 km²) in Port Phillip Bay that fringes Melbourne's Central Business District. As a council area, Hobsons Bay is home to 9 conservation areas within the HBCC region including the Truganina Swamp, Truganina Explosives Reserve, Cherry Lake, the Altona Coastal Park, Jawbone Reserve, Rifle Range, Newport Lakes, Sandy Point Nature reserve, and the RAMSAR site Cheetham Wetlands.

All these conservations areas are key to maintaining the condition of current blue carbon ecosystems and the co-benefits they provide to people. They are managed by a range of organisations including HBCC, Parks Victoria, Melbourne Water and the Department of Environment Land Water and Planning.

We used existing information on the past and current distribution extent of blue carbon ecosystems to estimate its area within the HBCC region. For the purpose of this study we used current and past distribution mapped by Boon et al. (2011) for mangroves and saltmarshes, and the seagrass mapped distribution available in the Seamaps (Lucieer et al. 2019). Spatial analyses were undertaken in ArcGIS Pro 2.4.3 (ESRI 2011) and R version 3.6.1 statistical software (R Core Team 2019). Unfortunately, there is no detailed information on historical distribution of seagrasses in the region.



Figure 02. Location and limits of the Hobsons Bay City Council in Victoria, Australia. Basemap sources: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community; Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community The blue carbon ecosystems within the HBCC play an important role in the region's carbon cycle. Mangroves, saltmarshes and seagrasses are distributed along the HBCC coastline and account for different Ecological Vegetation Classes (EVCs) within mangroves and saltmarshes (e.g., mangrove shrubs, coastal dry saltmarsh, coastal tussock saltmarsh) and seagrass species (Figure 3).

Overall, HBCC was home to approximately 425 ha of saltmarshes and less than 1 ha of mangroves (Boon et al. 2011, Figure 4A). Currently, the HBCC region encompasses ~108 ha of seagrasses, ~251 ha of saltmarshes and ~2 ha of mangroves (Boon et al. 2011, Lucieer et al. 2019) (Figure 4B).



Figure 03. Main species occurring along blue carbon ecosystems in Victoria, including the following: saltmarshes A) *Sarcocornia quinqueflora* (Source: BCL), B) *Distichlis distichophylla* (Source: BCL), and C) *Sueda australis* (Source: BCL); mangrove D) *Avicennia marina* (Source: Maria Palacios); and seagrasses E) *Zostera noltii* (Source: Noyan Yilmaz) and F) *Zostera muelleri* (Source: Peter Macreadie).





Figure 04. Past (A) and current (B) distribution of blue carbon ecosystems within the Hobsons Bay City Council area based on existing spatial data. Sources: mangroves and saltmarshes (Boon et al. 2011) and seagrasses (Lucieer et al. 2019). Basemap source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

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FIRST-PASS ESTIMATE OF BLUE CARBON STOCKS AND SEQUESTRATION

Blue carbon ecosystems within the HBCC region potentially store ~13,200 tonnes of organic carbon

Blue carbon ecosystems accumulate carbon at different rates, depending on ecosystem type, species, climate location and geomorphological setting. Here, we undertook a first-pass estimate of blue carbon stocks and sequestration in the HBCC based on previous studies conducted in the region. Our study focused on carbon accumulated in the sediment, which is the carbon pool holding the majority (~70%) of carbon accumulated by blue carbon ecosystems.

Ewers Lewis et al. (2020) conducted a detailed study on blue carbon stocks along Victoria's coastal wetlands where they identified the main variables associated with blue carbon stock variability and mapped blue carbon stocks along Victoria's coastline. This study was based on carbon data collected along 96 sites across the state which were integrated with environmental data to understand the main drivers explaining carbon variability. Therefore, we used the blue carbon heatmap developed by Ewers Lewis et al. (2020) and extracted the carbon stocks data for the HBCC region.

Based on the data available, we estimate that existing blue carbon ecosystems within the HBCC region potentially store approximately 13,200 tonnes (Figure 5) of organic carbon (or 48,500 tonnes CO_2e).

3 Km



60 Mg C ha⁻¹ 24 Mg C ha⁻¹

Figure 05. Total blue carbon stocks (in the top 30 cm of the sediment) in the Hobsons Bay City Council region extracted from the Victoria blue carbon heatmap modelled by Ewers Lewis et al. (2020). Basemap source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

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Furthermore, previous studies conducted by the Blue Carbon Lab in coastal wetlands in Victoria looked at carbon stocks and sequestrations rates (Figure 5). Carbon stocks in natural ecosystems in the top 30 cm of the sediment vary from 24.3 ± 1.82 tonnes C ha-1 in seagrasses, 65.6 ± 4.17 tonnes C ha⁻¹ in mangroves, and 87.1 ± 4.90 tonnes C ha⁻¹ in saltmarshes (Figure 6; Ewers Lewis et al. 2018). Mangroves accumulate carbon at a higher rate (1.74 \pm 0.34 tonnes C ha⁻¹ yr-'; Ewers Lewis et al. 2018) than saltmarshes (0.66 ± 0.18 tonnes C ha⁻¹ yr⁻¹; Ewers Lewis et al. 2018) and seagrasses (0.11 \pm 0.01 tonnes C ha⁻¹ yr⁻¹; unpublished data from the Blue Carbon Lab).

Despite the growing interest in restoring blue carbon ecosystems, there are still gaps of knowledge on how much carbon is accumulated by restored ecosystems (Figure 6). A recent study developed by the Blue Carbon Lab in the Avalon Coastal Reserve revealed that restored saltmarshes still accumulate carbon at relatively high rates (0.54 ± 0.27 tonnes C ha⁻¹ yr⁻¹; Gulliver et al. 2020).



Figure 06. Average carbon stocks (tonnes ha⁻¹) and carbon sequestration (tonnes ha⁻¹ yr⁻¹) for each blue carbon ecosystem (mangroves, saltmarshes and seagrasses) in Victoria based on previous studies in the region.

ADDITIONAL CO-BENEFITS FROM BLUE CARBON ECOSYSTEMS

Seagrasses, saltmarshes and mangroves protect **over \$100 million** in infrastructure assets along the HBCC coastline.

In addition to acting as efficient carbon sinks, existing blue carbon ecosystems within the HBCC also provide several other co-benefits to people.

Although co-benefits are usually difficult to estimate in economic values, here we used existing data on valuation of cobenefits generated by blue carbon ecosystems in Australia to develop a first-pass assessment for the HBCC region. Table 1 shows a detailed list of the studies used to extract data for our assessment (Table 1). Then, we used the information available in Table 1 to calculate the potential value of blue carbon ecosystems in the HBCC region by multiplying the value of each co-benefit by the existing area of each blue carbon ecosystem.

Based on existing information, we found that blue carbon ecosystems in the HBCC are extremely valuable in providing co-benefits to people in the region (Figure 7).

These ecosystems provide key habitats for commercially important fish species, with seagrasses and saltmarshes contributing to enhancing fish biomass by 439,000 kg yr⁻¹ and 16,096 kg yr⁻¹, respectively. Mangroves also contribute to increasing fish biomass, but at a smaller scale (617 kg yr⁻¹) due to the limited habitat extent (2 ha) within the HBCC region (Figure 7). Furthermore, seagrasses, saltmarshes and mangroves protect property along the HBCC coastline to the value of > AUD 100 million (Carnell et al. 2019).

If we consider the total value of cobenefits provided by blue carbon ecosystems in the HBCC region using the System of Environmental-Economic Accounting(SEEA) framework (Carnell et al. 2019), we found that mangroves, seagrasses and saltmarshes are potentially worth AUD750 yr⁻¹, AUD136,240 yr⁻¹ and AUD 42,250 yr⁻¹ respectively, with carbon stocks and coastal protection combined valued at AUD45.5 million (Figure 7).

It is important to highlight that this firstpass valuation of co-benefits provided in this study is based on existing blue carbon ecosystems only, and future studies should aim to estimate the potential benefits of restored ecosystems. **Table 01**. Studies used to extract reference values for our first-pass assessment on additional co-benefits provided by blue carbon ecosystems in the HBCC region. Values presented in table below are at the original scale (e.g., national, regional, local) used in each study.

		BLUE CARBON ECOSYSTEMS		
Study	Co-Benefit	Seagrasses	Mangroves	Saltmarshes
Jänes et al. 2020a	Average annual gross production for each blue carbon ecosystem in Victoria	AUD 39 ha-' yr-'	AUD 54.4 ha-' yr-'	AUD 7.1 ha-' yr-'
Jänes et al. 2020b	Average increase of fish individuals and biomass across Australia	55,589 individuals ha-' yr-' (or 4,064 Kg ha-' yr-')	19,234 individuals ha-' yr-' (or 265 Kg ha-' yr-')	1,712 individuals ha-' yr-' (or 64 Kg ha-' yr-')
Jänes et al. 2020b	Economic valuation of blue carbon ecosystems based on the additional fish biomass available to the fishery in Victoria	AUD 1,542 ha-' yr-'	NA	NA
Huang et al. 2020	Recreational value of seagrasses in Port Phillip Bay	AUD 13 per fishing trip (AUD7.6 million per year in the entire Port Phillip Bay area)	NA	NA
Carnell et al. 2019	Coastal protection value across south- eastern Australia: estimated in replacement costs	AUD 2.7 million	AUD 1.86 billion	AUD 702 million
Carnell et al. 2019	Non-market value of saltmarshes and mangroves for birdwatchers across south-eastern Australia	NA	AUD 158 per trip	
Carnell et al. 2019	Total value for five co- benefits (e.g., soil carbon sequestration, commercial fisheries, recreational fisheries, recreational fishing, and birdwatching) using the SEEA framework in the Port Phillip Bay	AUD 1,261 ha-' yr-'	AUD 321 ha-1 yr-1	AUD 168 ha-' yr-'
Carnell et al. 2019	Asset value for carbon storage and coastal protection using the SEAA framework in Port Phillip Bay	AUD 18,003 ha-1	AUD 5.1 million ha-1	AUD 126,376 ha-1

*SEEA: System of Environmental-Economic Accounting framework, which sets accounting principles for measuring the relationship between people and the environment.



Ecosystem Service (ES) - value of blue carbon ecosystems based on ecosystem services (e.g., soil carbon sequestration, commercial and recreational fisheries, birdwatching).

Asset Value (AV)- value of blue carbon ecosystems based on the stock (carbon storage) and asset (coastal protection) values.

Figure 07. First-pass estimate of additional co-benefits for the HBCC region: 1) Fisheries (average gross production and average enhancement of fish biomass); 2) Recreation (non-market value of tidal marshes and mangroves for birdwatchers and recreational value of seagrass in Port Phillip Bay); 3) Coastal Protection value estimated to the existing blue carbon ecosystems based on the estimated property value protected by blue carbon ecosystems within 1 km of the coastline within the HBCC; and 4) Ecosystem valuation (ES - total value of ecosystem services for each blue carbon ecosystem and AV - total asset value for carbon storage and coastal protection for each blue carbon ecosystem using the System of Environmental-Economic Accounting framework). Notes: + estimate represents the value in Port Phillip Bay. These values were based on the findings from Carnell et al. (2019)

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POTENTIAL AREAS AVAILABLE FOR SALTMARSH RESTORATION

Approximately 180 ha of saltmarshes have been lost from past distribution, which could be amenable for restoration within the HBCC region

Saltmarshes have decreased by 41% since European settlement (Figure 4) within the HBCC region, with coastal restoration being a powerful approach to recover these ecosystems and their potential co-benefits.

Therefore, given their ecological importance and potential for climate change adaptation and mitigation, it is key to understand how management actions might influence current and future carbon sequestration potential. If blue carbon ecosystems are restored, they could serve as a key asset in achieving the Sustainable Development Goals (SDGs) and delivering Nationally Determined Contributions (NDCs) through carbon sequestration.



Here, we estimated, based on existing studies, the potential area available for restoration in the HBCC region based on four scenarios:

<u>Scenario 1</u>

Active restoration of saltmarsh area lost from historic distribution (Boon et al. 2011)

<u>Scenario 2</u>

Restoration by tidal reintroduction through gradual sea-level rise in 2050 and 2070 (Moritsch et al. 2021)

<u>Scenario 3</u>

Restoration by tidal reintroduction through levee removal (Moritsch et al. 2021)

<u>Scenario 4</u>

Avoided erosion-related emissions from the top 20% (high risk) and 50% (high and intermediate-risk) erosion risk areas within the HBCC region, defined by the Victorian Coastal Hazard Assessment (DELWP, 2015) and based on the existing distribution of blue carbon ecosystems (Boon et al. 2011, Lucieer et al. 2019). High and moderate erosion risk areas were identified based on the vulnerability scores in the Victorian Coastal Hazard Assessment (DELWP, 2015), which were then overlapped with existing blue carbon ecosystems to identify where these ecosystems would be potentially lost due to erosion

In this case, we extracted the area available for restoration in each scenario from the state-wide study realized by Moritsch et al. (2021), where a full description of the methods and assumptions used in the study is available. Here, we only included saltmarsh restoration since mangroves had a small past distribution within the HBCC region, and therefore, we did not find any potential site suitable for mangrove restoration. However, future studies focusing on modelling mangrove suitability under future environmental conditions could help identifying other areas suitable for mangrove restoration in the area.

Following the approach used by Moritsch et al. (2021), we found that approximately 180 ha of saltmarshes have been lost from past distribution, which could be amenable for restoration within the HBCC region (Figure 8A). Furthermore, we found that approximately 105 ha of saltmarshes could be restored by tidal reintroduction through levee removal (Figure 8B). If managing for gradual sea-level rise, ~333 ha could be available for saltmarsh restoration in 2050, with an increase of 154 ha in 2070 (Figure 8C and D). In addition, managing high erosion risk areas also provide opportunities for blue carbon in the HBCC region. In this case, we estimate that 118 ha and 356 ha would be available for avoiding erosion-related emissions in the top 20% and 50% of coastal erosion risk areas within the HBCC region, respectively (Figure 8E and F).







Figure 08. Potential area available for restoration in the Hobsons Bay City Council based on: A) active restoration of saltmarsh area lost from historic distribution (Boon et al. 2011); B) restoration by tidal reintroduction through levee removal (Moritsch et al. 2021); C) restoration by the tidal reintroduction through gradual sea-level rise in 2050 and D) in 2070; E) avoided erosion-related emissions from the top 20% and F) top 50% coastal erosion risk areas (Moritsch et al. 2021) as defined by the Victorian Coastal Hazard Assessment (DELWP, 2015). Basemap source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Potential carbon gains from saltmarsh restoration

Restoration efforts look to identify threats and pressures causing degradation to an ecosystem and undertake management actions to remove those

threats/pressures, helping to restore back the natural ecosystem function and condition. A functioning blue carbon ecosystem is capable of removing carbon from the atmosphere and storing it in its above-ground biomass (plant tissue) and below-ground biomass (soil carbon stocks). Blue carbon ecosystems store the majority (70%) of carbon sequestered in their anoxic below ground storage (soil carbon).

We estimated the potential carbon gain from blue carbon restoration by multiplying the sequestration rate of 0.54 ± 0.27 tonnes of organic carbon per ha (or 1.98 CO₂e tonnes per ha) (Gulliver et al. 2020) by the area available for saltmarsh restoration under each scenario tested in this study. In this case, Figure 9 show the results for each restoration action considered in this study (results are shown in tonnes of CO₂ equivalent).

Overall, restoring all the historic distribution provides an opportunity to generate ~360 tonnes $CO_2e y^{-1}$, while the removal of levees could potentially generate 205 tonnes $CO_2e y^{-1}$ within the HBCC region. Restoration by tidal reintroduction through gradual sea-level rise in 2050 and 2070 would have the greatest opportunity in the region, with restored and/or created saltmarshes generating ~660 tonnes $CO_2e y^{-1}$ from 2050 and an additional ~290 tonnes CO_2e y^{-1} from 2070.

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Figure 09. First-pass estimate of potential carbon gains (in tonnes CO_2e) if saltmarshes are restored in the HBCC region, considering 1) active restoration of saltmarsh area lost from historic distribution (Boon et al. 2011); 2) restoration by the tidal reintroduction through levee removal (Moritsch et al. 2021); and 3) through gradual sea-level rise in 2050 and in 2070. Here, we show the potential carbon gains per year generated through the saltmarsh restoration based on the carbon sequestration rate estimated for restored saltmarshes by Gulliver et al. (2020), then we calculate how much carbon could be accumulated in a 30-years' timeframe and its representation of an equivalent number of cars off the road (based on the carbon emissions of passenger cars at 4.6 metric tons pa.).

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Potential avoided erosion-related emissions

Coastal erosion, landward shore retreat, is caused by waves, currents, sea-level rise, and human activities. Climate change impacts causing rising sea levels and changing storm patterns are likely to cause accelerated erosion along the Victorian coastline, impacting blue carbon ecosystems.

In this project, potential carbon emissions from blue carbon ecosystem loss due to coastal erosion were calculated based on carbon stocks estimates for each ecosystem from Ewers Lewis et al. (2018) (Figure 5) and the area estimate of these ecosystems located within the top 20% and 50% of coastal erosion risk areas. Then, we multiplied the average carbon stocks for each ecosystem by the area of the expected loss of blue carbon ecosystems, and then by a demineralization rate (assumed that 50% of the carbon stored in the top 30 cm of the sediment would be converted back into CO₂, Donato et al. 2011). For this calculation, we converted our carbon stocks values from organic carbon to CO₂ equivalent by multiplying them by 3.67 (i.e., conversion factor that represents the molecular weight ratio of CO2 to organic carbon).

Here, we found that a total of ~17,000 tonnes CO₂e or 44,295 tonnes CO₂e could potentially be released back to the atmosphere if blue carbon ecosystems within the top 20% of coastal erosion risk areas within the HBCC are lost due to erosion. Figure 10 shows the area that could be potentially lost in each erosion scenario and the expected emission for each blue carbon ecosystem.

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Figure 10. First-pass estimate of potential avoided erosion-related emissions (tonnes CO₂e) from the top 20% and 50% areas within the HBCC region based on the existing distribution of blue carbon ecosystems (Boon et al. 2011, Lucieer et al. 2019) and the Victorian Coastal Hazard Assessment (DELWP, 2015). Here, we assumed that 50% of carbon stored in the top 30 cm of the sediment would be converted back into CO₂. For this calculation we converted our carbon stocks values from organic carbon to CO₂ equivalent by multiplying them by 3.67.

EVALUATING THE FEASIBILITY OF DEVELOPING A BLUE CARBON RESTORATION PROJECT WITHIN THE REGION

A major hurdle to overcome to develop a blue carbon restoration project is securing finance for the project.

As highlighted by this study, there is plenty of scope within the Hobsons Bay City Council to develop blue carbon restoration projects. However, this is just the first of many steps (design, evaluate, register, implement, audit, and monitor) needed to develop a blue carbon project (IUCN 2021). There are many examples of successful blue carbon restoration projects in Australia (Tomago Wetland in New South Wales), and even in HBCC (Stony Creek Backwash- see case study and Figure 11).

Despite current advances in blue carbon science, restoration projects in Australia aiming for credits under the carbon market still face major challenges. For example, the current carbon price set under compliance or voluntary markets are not high enough to cover project costs. In this case, a major hurdle to overcome to develop a blue carbon restoration project is securing finance for the project. There are many finance opportunities to support restoration work including philanthropic giving, government funding, and private investment (Ward and Lassen 2018). In some cases, there might be the potential to achieve higher carbon prices by considering co-benefits associated with the blue carbon project. Other challenges include land tenure and ownership rights.

Stony Creek Backwash Restoration Case Study

Stony Creek Backwash has been subjected to high levels of degradation since European settlement. The area was once a quarry, and noxious industries (tannery, meat processing and glue works) established along its shores. Even over the past several decades there are still major threats to this area (urbanisation, ink, oil, detergent and fertilizer spill).

In 1984, Mark Adams, a graduate student in ecological horticulture from LaTrobe University, began rehabilitation efforts at Stony Creek Backwash by actively planting over 15,000 grey mangroves seedlings (Figure 11). This area was subjected to oil spills throughout 1980s, which killed many of the mangrove seedlings. The surviving mangroves (only about 2%!) from a major oil spill in 1987, spread throughout the entire embayment (Waryszak et al. 2021). Today, these mangroves immobilise contaminated sediments, therefore, help to improve water quality in the bay (Waryszak et al. 2021)

Stony Creek Backwash Restoration Case Study



Figure 11. Stony Creek estuary within the HBCC region showing the mangrove saplings of Avicennia marina in 1984, and further expansion from surviving mangroves throughout the embayment.

In Australia, the Clean Energy Regulator is currently developing a new methodology under the multi-billion-dollar Emissions Reduction Fund (ERF) to allow for carbon credits be issued by restoring blue carbon ecosystems. The focus of the first method is the restoration of mangroves, saltmarshes and seagrasses through the reintroduction of tidal flow, with expectations of new methods to be developed in the near future.

With the release of the Clean Energy Regulator first Blue Carbon Method in late 2021, there will be the ability to collect carbon credits when restoring coastal wetlands through the reintroduction of tidal flow. However, there are several critical steps to complete before a project can become shovel ready. A cost-benefit analysis and a feasibility assessment would be the logical next steps for sites identified as amenable for restoration.

If HBCC is considering investing in blue carbon projects, a cost-benefit analysis should be undertaken to look at the direct financial costs and benefits of wetland restoration from current land uses from the perspective of a potential investor, such as the landholder or an external party (carbon developer). This data is critical information needed to inform on additionality for both blue carbon and other benefits that can be achieved. Outputs from this analysis would allow the benefits of alternative land-use scenarios to be evaluated quantitatively to find the most costeffective options across ecosystem types and management alternatives.

The next step is then to evaluate the eligibility and feasibility of potential project sites in respect to the certification standard (e.g., ERF blue carbon method). The critical information that needs to be collected for specific restoration sites under the feasibility assessment include the financial analysis (including expected costs and revenues), potential barriers (e.g., legal, administrative), project boundaries, estimates of blue carbon additionality, methods of achieving additionality, land history, land tenure and carbon ownership, stakeholders and cultural overlays, community perceptions towards wetlands, land values, and any other data that may help support blue carbon projects.



CONCLUSIONS & RECOMMENDATIONS

The Hobsons Bay City Council is one of the first councils within Australia to have assessed its blue carbon potential.

There has been a growing increase in global recognition of blue carbon ecosystems as vital nature-based solutions to climate change mitigation and adaptation. While Australia is at the forefront of blue carbon science, there still remain many knowledge gaps that need to be addressed to make a strong business case for their use as an effective climate mitigation strategy.

THIS STUDY, WHICH EXPLORES BLUE CARBON OPPORTUNITIES ON A LOCAL SCALE, HELPS PUT HOBSONS BAY CITY COUNCIL AT THE FOREFRONT OF NATIONAL EFFORTS TO CONSERVE AND RESTORE BLUE CARBON ECOSYSTEMS.

This study revealed that, despite being a highly urbanised area, there remains substantial areas of blue carbon ecosystems along the HBCC coastline (~360 ha). These blue carbon ecosystems are providing significant cobenefits to the local Hobsons Bay community, by not only acting as a valuable and efficient carbon sinks (stocks at ~48,500 tonnes CO₂e), but also providing coastal protection of important assets (> \$100 million in infrastructure assets protected by blue carbon ecosystems), and improving recreational fishing (\$13 per trip).



THIS PROJECT IS STRONGLY ALIGNED WITH KEY ACTIONS IN THE STRATEGY OF THE UN DECADE ON ECOSYSTEM RESTORATION INCLUDING INVESTING IN RESEARCH AND BUILDING CAPACITY.

The UN Decade is a rallying call for the protection and revival of ecosystems all around the world, with the aim to halt the degradation of ecosystems and restore them over the next 10 years. While there currently are significant areas of blue carbon ecosystems in the HBCC region, this study has highlighted there is still plenty of opportunities to restore these ecosystems. The area available for restoration will be dependent on the management action selected (e.g., restoring past distribution of saltmarshes, restoration by tidal reintroduction, etc), but we found that the restoration of these ecosystems can help play a major role in mitigating carbon emissions in the HBCC region

THIS STUDY EXPLORED BLUE CARBON POTENTIAL AND A RANGE OF MANAGEMENT OPPORTUNITIES FOR ADDITIONALITY (LEVEE REMOVAL, EROSION MANAGEMENT, AND MANAGED SEA-LEVEL RISE) IN THE HBCC REGION.

It is important to highlight that there are several alternative additionality options (e.g., the beneficial use of dredged material to restore or create coastal wetlands, biochar, and active seagrass restoration) we have not been included in this study due to lack of data. Future studies could evaluate these emerging methods that have not been rigorously investigated by research. This would potentially increase the blue carbon opportunities for the HBCC region, while at the same time, contributing to blue carbon science.

THE HOBSONS BAY CITY COUNCIL WILL BE ONE OF THE FIRST COUNCILS WITHIN AUSTRALIA TO HAVE ASSESSED ITS BLUE CARBON POTENTIAL.

The results of this study have highlighted, there is plenty of scope and potential to protect current blue carbon ecosystems and restore and rehabilitate others within the Hobsons Bay City Council region. To get restoration projects 'shovel ready' for investment, we recommend a costbenefit analysis and feasibility assessments be undertaken. These next steps will inform on the restoration of specific sites and help entice significant investment into the restoration of local wetlands, while providing the opportunity to collect the resulting carbon credits, through the multi-billion-dollar Emissions **Reduction Fund.**

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