



# UNDERSTANDING MUNICIPALITIES' ROLE IN THE MANAGEMENT AND PROTECTION OF BLUE CARBON ECOSYSTEMS

<https://beresford.ca/en/the-beresford-salt-marsh/>

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# ABSTRACT

Blue carbon ecosystems are marine vegetated ecosystems, such as mangroves, salt marshes, kelp forests and seagrass meadows, that naturally sequester and store atmospheric carbon in their deep sediments and biomass. Their ecosystem services extend from carbon capture and storage to coastline protection, flood mitigation and pollution buffering, making their management and protection a form of Nature-based Climate Solution (NbCS) as it helps to address social, environmental and economic challenges through the mitigation and adaptation to climate change. However, these ecosystems are subject to degradation and destruction from coastal development and land use change, releasing sequestered carbon back into the atmosphere. In Canada, although home to the largest coastline of any country in the world, neither federal nor provincial policy explicitly address the management or protection of blue carbon ecosystems, leaving them susceptible to these threats. Coastal municipalities, however, may play an important role in the current management and protection of blue carbon. Land-use planning decisions on the local level offer an opportunity to protect and conserve coastal ecosystems and the co-benefits these ecosystems provide may be symbiotic to address the climate threats faced by many coastal communities. This study explores the current role of municipalities in the management, protection and/or restoration of blue carbon ecosystems through interviewing municipal staff from coastal municipalities across Canada. The objective of this research is to identify why and how municipalities engage with blue carbon ecosystems management and the common challenges faced, and best practices used, when doing so. Additionally, this study aims to identify what municipalities need to better pursue blue carbon ecosystem management. Results of this study demonstrate an interest from municipalities to participate in the management of these ecosystems for their co-benefits, however, reveal many barriers that hinder municipal engagement. Municipalities present a number of interventions for provincial and federal government, as well as the role national Environmental Non-Governmental Organizations (ENGO's) can play, to address these barriers and support municipalities' in playing a more active role in future blue carbon ecosystem management strategies.

# 1.0 INTRODUCTION

## 1.1 BLUE CARBON AS A NATURE-BASED CLIMATE SOLUTION

Nature-based climate solutions (NbCS) have become a more prominent strategy in climate change mitigation and adaptation in recent years as they have the ability to address “social, environmental and economic challenges in sustainable ways” (Krull et al., 2015, p. 5). NbCS are strategies that protect, restore or manage ecosystems for their functional benefits, which are able to address social challenges such as disaster risk reduction, food and water security, biodiversity loss and human health (IUCN, n.d.).

Blue carbon ecosystems are an example of a NbCS for the wide range of ecosystem services they provide to address climate change mitigation and adaptation (Quevedo et al., 2021). ‘Blue carbon’ refers to the atmospheric carbon that is naturally sequestered by marine vegetated ecosystems, such as seagrass meadows, mangroves, salt marshes and kelp forests (Hilmi et al., 2021). Through photosynthesis, these ecosystems remove CO<sub>2</sub> from the atmosphere and convert it into carbon compounds and cellulose to store as biomass, ultimately burying the carbon locally and in deep marine sediments after plant decomposition (McCoy & Hughes, 2021). The long-term carbon storage potential of these ecosystems therefore occurs in the sediment, rather than the biomass itself (Williamson & Gattuso, 2022). Due to the nature of these ecosystems, the carbon stored in their sediments has remained sequestered for millennia (Vierros, 2017). Additionally, these ecosystems sequester carbon at much higher rates than their terrestrial counter parts (Wollenberg et al., 2018), with seagrasses estimated to bury carbon 35x faster than tropical rainforests (Macreadie et al., 2019). This leads them to play an outsized role in the global carbon cycle, as they are only estimated to only occupy 0.07-0.22% of the earth’s surface (Spivak et al., 2019).

Blue carbon ecosystems provide additional co-benefits outside of carbon sequestration storage, such as shoreline protection, flood attenuation, nutrient cycling and pollution buffering, habitat and biodiversity conservation, in addition to their social and cultural importance (Vierros, 2017). These services are estimated to contribute more than 20% of the global value of ecosystems services worldwide (Thorslund et al., 2017) and due to their relation to coastal resiliency, are of particular interest to coastal community climate change adaptation strategies (Quevedo et al., 2021).

Despite their socio-economic value, these coastal ecosystems are increasingly degraded or destroyed due to high pressures for coastal development and land-use change (Lau, 2013), resulting in global loss or degradation of 50% of salt marshes, 35% of mangroves and 29% of seagrasses spanning the last 50-100 years (Vierros, 2017). This destruction releases stored carbon back into the atmosphere (Hilmi et al., 2021). This presents a challenge to the Paris Climate Agreement 2015, which recognized that in order to maintain global temperature increase below 2oC, active carbon sequestration is essential (Moomaw et al., 2018). Accordingly, an entire chapter was dedicated to the role of blue carbon in mitigating the risk and impacts of climate change by enhancing resilience in the Intergovernmental Panel on Climate Change Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC). The report introduces two management approaches for blue carbon ecosystems in climate change adaptation and mitigation; i) actions to maintain the integrity of natural carbon stores, thereby decreasing their potential release of greenhouse gases, whether caused by human or climate drivers and ii), through actions that enhance the long term (century-scale) removal of greenhouse gases from the atmosphere by marine systems, primarily by biological means (IPCC 2022, p. 520). Meaning, management approaches for blue carbon ecosystems are either through restoration of degrading habitat or the conservation of the healthy ecosystem.

The efficiency of carbon sequestration and storage of these ecosystems has led to interest from national and international policy makers to explore the role of blue carbon in carbon offsets (Macreadie et al., 2019) and to restrict the release of sequestered carbon, known as carbon stock conservation (Hilmi et al., 2021). However, knowledge gaps and uncertainties, such as standardized methods for carbon accounting, variability in ecosystem impacts and governance strategies, have made it difficult for blue carbon ecosystem management to be incorporated in climate strategies on local, national and global scales (Macreadie et al., 2019; Williamson & Gattuso, 2022). Although questions have been raised about the cost-effectiveness of blue carbon ecosystems for carbon sequestration alone, when considering the wide-ranging co-benefits these ecosystems offer, their management and restoration is considered highly advantageous for coastal protection, climate change adaptation, food provisioning and biodiversity and therefore continued efforts to manage these ecosystems should be pursued as they are likely to play an important role in local, national and global sustainable development (Williamson & Gattuso, 2022).

## 1.2 BLUE CARBON MANAGEMENT IN CANADA

Blue carbon ecosystems in Canada include seagrass meadows, tidal salt marshes and kelp forests. As Canada has the longest coastline of any country in the world, there is the unique opportunity to protect immense amounts of coastally sequestered carbon stocks, in addition to protect coastal communities from increasing storm surges and rising sea levels. However, Canada, too, has lost much of their blue carbon ecosystems to coastal development and land-use change. In British Columbia, the Lower Mainland has lost an estimated 70% of their tidal wetlands due to urban and agricultural development (Government of British Columbia, 1978), while in Nova Scotia, 80% of the salt marshes in the Bay of Fundy have been lost since the 1700's as a result of diking practices (Government of Nova Scotia, 2009). This is largely a result of overlooking blue carbon ecosystems in policy creation (Brown et al., 2021). WWF-Canada recently released their federal policy review of blue carbon in Canada, which aimed to identify the extent to which blue carbon is addressed explicitly in federal policy, the extent that current policy applies to blue carbon ecosystem protection and management and to identify opportunities within federal policy to better integrate blue carbon concepts (WWF-Canada, 2022). Findings from the report confirmed a lack of explicit blue carbon ecosystem management law or policy at the federal level. Similar findings were presented in policy reviews conducted on the provincial level (ECE Law, 2022; Carlson, 2020), leaving management and protection of blue carbon ecosystems absent from Canadian and provincial law and policy. This leaves their protection in the hands of piecemeal law and policy that indirectly impacts the management of blue carbon ecosystems (WWF-Canada, 2022).

Across Canada, many municipalities have approached climate change adaptation and mitigation through climate action plans, largely focussed on mitigating carbon emissions in order to support provincial targets. Programs led by the province, such as the Municipal Climate Change Action Plan (Nova Scotia & Canada-Nova Scotia infrastructure Secretariat, 2011), and by the Federation of Canadian Municipalities (FCM), such as Partners for Climate Protection (Partners for Climate Protection, n.d.), are examples that have helped guide municipalities in their role in climate action, addressing both climate change mitigation and adaptation. In regards to blue carbon ecosystem management, local governments can play a key role in protecting blue carbon ecosystems through land-use planning and coastal development decisions, especially due to the lack of federal and provincial blue carbon protection law and policy currently in place. Additionally, municipalities must begin to consider methods of climate change adaptation and mitigation in their land-use planning to ensure a future for their community as many coastal communities are faced with the threat of rising sea levels, coastal flooding, and increased storm surge frequency due to climate change. Protection from these climate change threats aligns with the ecosystem services provided by blue carbon ecosystems, demonstrating a

potential synchronist relationship with local government and potential motivation for blue carbon ecosystem management on the local level. However, although these ecosystems present many co-benefits for coastal communities, there is still not a strong understanding of the role coastal municipalities currently play in the management, protection and/or restoration of blue carbon ecosystems in Canada.

This research aims to create a better understanding of how and why municipalities manage their blue carbon ecosystems and identify the best practices and challenges they face when doing so. Additionally, it intends to identify ways to engage municipalities and support municipal efforts in blue carbon ecosystem management. The data collected for this study was in partnership with WWF-Canada and will act to support their goal to fight climate change using nature based solutions to help meet national greenhouse gas emission targets by 2030, in addition to supporting wildlife and community adaptation to climate change (WWF-Canada, 2021).

## 1.3 RESEARCH QUESTIONS

The objective of this research is to understand how and why municipalities are engaging, or not engaging, with blue carbon ecosystem management, in efforts to better understand the role they can play in effective blue carbon ecosystem management. Through interviews with municipal staff from coastal municipalities across Canada, this paper will explore three major research questions related to this objective:

1. What are the barriers municipalities face when pursuing blue carbon ecosystem management?
2. What are the best practices they use to engage with blue carbon ecosystem management?
3. What do municipalities need to better engage with blue carbon ecosystem management?

## 2.0 METHODS

### 2.1 IDENTIFYING POTENTIAL PARTICIPATING MUNICIPALITIES

To account for the diverse range of experiences coastal municipalities have in regard to blue carbon ecosystem management across the country, municipal staff from across Canada's coasts and from municipalities outside and within Central Metropolitan Areas (CMA) were identified as potential participants to this study. CMA's must have a total population of at least 100,000 of which 50,000 or more must live in the core (Statistics Canada, 2018). This criteria was used to ensure representation of both rural and urban municipalities in the study. It is assumed that CMA's have greater resources to dedicate to environmental projects.

A snowball technique was used to first guide recruitment ("Snowball Sampling," 2018), starting with municipal staff connected to WWF-Canada's blue carbon community of practice. Then, coastal municipalities participating in initiatives such as the Federation of Canadian Municipalities Partners for Climate Protection program and Municipal Natural Assets Initiative (MNAI), were identified, as these communities demonstrate interest in creating climate action plans, reducing greenhouse gas emissions, and understanding and preserving the natural assets of their community.

Content analysis (Bengtsson, 2016) was then performed on municipal plans of coastal municipalities that were not yet represented, to identify potential participants. Municipal plans (e.g., climate adaptation plans, Municipal Climate Action Plans (MCCAP), coastal management strategies, Official Community Plans), which are created by the municipal planning staff or consultants and are reviewed on the provincial level to ensure alignment with provincial policies, describe the municipalities vision for the future and their priorities (Thompson et al., 2019). Therefore, these documents were used to identify coastal municipalities that mention the following: interest in blue carbon ecosystems and their protection, restoration and/or management; previous experience with blue carbon ecosystem protection; interest in addressing shoreline protection, sea level rise, or coastal flooding mitigation, which align with the ecosystem services of blue carbon ecosystems. These themes were identified to indicate which municipalities would be interested in participating in this study.

Efforts were made to connect with municipal staff and/or departments that were most involved with blue carbon ecosystem management in that particular municipality. This was done by asking to be directed to the most applicable department or staff member for blue carbon research during the introductory e-mail for participant recruitment. The purpose of this effort was to recruit participants that would be best informed on blue carbon ecosystem management in the municipality.

### 2.2 DATA COLLECTION METHODS

A questionnaire created for data collection was created by the principal investigator in collaboration with WWF-Canada staff and her academic advisor at Dalhousie, University. The formation of the questionnaire was largely informed by chapters from *Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method* (Dillman et al., 2014), particularly Chapter 4: The Fundamentals of Writing Questions. This included identifying the concepts of interest to the research questions and the goal of the study. This resulted in a qualitative questionnaire composed of nine open-ended questions (Appendix A), shaped by the project research questions and covered the following themes: 1) major themes in barriers faced by municipalities when pursuing



blue carbon ecosystem projects, 2) best practices and tools used to address these challenges and 3) what participants feel they need to better pursue blue carbon projects. Additional information was also collected, such as the number of municipalities actively leading blue carbon projects, participants department and background, familiarity with the term and concept of 'blue carbon', the role the municipality has played when participating in blue carbon projects and the reasons the municipality has been/is interested in blue carbon ecosystems.

A total of 51 coastal municipalities, regional districts and service commissions across Canada were contacted to participate in this study, resulting in 24 interviews from municipal staff within and outside of CMAs. The principal investigator recruited participants by sending an introductory e-mail or conducting phone calls to introduce the project and gauge participants initial interest in responding to a series of questions related to blue carbon ecosystems. Within the introductory e-mail, the principal investigator asked to be directed to the most applicable department or staff member for blue carbon research in that municipality, if the potential participant did not see themselves suitable for the project. Upon individuals' confirmation of their willingness to participate in the study, the principal investigator followed up with an e-mail outlining the project and its purpose more in depth, how the data will be used and any possible risks involved for the participant (Appendix B). Oral consent was obtained by participants for the purpose of data collection, analysis and reporting back during the interview.

### **2.2.1 DATA COLLECTION**

Remote interviews were conducted for 24 participants over Microsoft Teams during July and August, 2022, spanning 15 minutes to 1hr 15 mins in length, depending on the depth of participant responses to the interview questions (Appendix A). Interviews were transcribed verbatim using Microsoft Teams and then reviewed several times to correct grammatical and translational errors for quality assurance.

Raw interview data in its identifiable form was then coded to protect identity of participants during analysis. Metadata was provided to WWF-Canada, with participant consent, to identify potential future blue carbon project partners.

### **2.2.2 DATA COLLECTION LIMITATIONS**

Time constraints associated with this research resulted in multiple data collection limitations, including lack of triangulation of coding data to increase validity. Therefore, this study is considered exploratory research. Additionally, time constraints related to ethics approval of this research through Dalhousie University meant that the study was unable to include First Nations in this research. The inclusion of First Nations within the blue carbon ecosystem management conversation is imperative to the success and sustainability of these ecosystems and must be considered in further research.

Not all interested participants were interviewed for this study as a result of coordination issues. This acts as a limitation within data collection and analysis, as there may be coastal municipalities in Canada whose relationship with blue carbon ecosystem management is not realized within this report.

Lastly, although efforts were made to recruit participants that would be most knowledgeable of blue carbon ecosystem management in that municipality, there is the possibility that other municipal staff would have been more qualified to represent blue carbon work in that community.

## 2.3 QUALITATIVE ANALYSIS: NVIVO

A four stage process, presented in Bengtsson (2016), was used to guide content analysis for interview data; 1) decontextualization, 2) recontextualization, 3) categorization and 4) compilation. Decontextualization is the process of determining the coding systems and meaning units. Meaning units are sections of interview transcripts identified by the researcher that speak to the aim of the study. Each meaning unit is then associated with a code. Both deductive and inductive reasoning were used during coding analysis, as a general code list was created prior to analysis (deductive) and certain codes presented themselves during analysis (inductive) (Appendix C). The coding process was repeated to ensure that the meaning units are still clear. Table 1 provides an example of how raw data was coded into the resulting code.

Recontextualization is the process of stepping back from the coding system identified in decontextualization phase and comparing the codes to the research questions, ensuring that adequate context is given and determining if un-coded text also serves to answer research questions. If this is not the case, it can remain excluded from analysis. The research questions for this study are: What are the barriers municipalities face when pursuing blue carbon ecosystem management? What are the best practices they use to engage with blue carbon ecosystem management? What do municipalities need to better engage with blue carbon ecosystem management?

The third stage is categorization. This process identifies meaning units within the interview transcript, then continues to condense this unit, without losing the meaning it holds. This helps identify themes, categories and sub-categories within the data to delineate broad concepts for the writing stage. An example, using data from this study, is shown in Table 1.

The final stage, compilation, is the analysis and writing process of the data. A manifest analysis approach to the interview transcripts was used, as the codes created describe the visible and obvious within the text, staying very close to what the participants say (Bengtsson, 2016). Quantitative analysis of certain variables (e.g., response rate) can be used during this process as well, however, variables cannot be ranked in terms of importance.

**Table 1.** An example of an analysis schedule used for interview participants. Table template from Bengtsson (2016).

Meaning unit	Condensed meaning unit	Code	Theme
<i>"The numbers, the business case, the focusing solely on sequestration is not a good business case. The numbers are too small when you place them against the targets for GHG reductions."</i>	Not a strong business case to focus just on carbon sequestration	Not a strong business case	Barriers facing municipalities to engage with blue carbon

# 3.0 RESULTS

## 3.1 DESCRIPTIVE CHARACTERISTICS OF PARTICIPANTS

There appeared to be more interest in the topic of blue carbon on the west coast, where response rate was highest (76%) and only one respondent denied study participation. On the east coast (Nova Scotia, New Brunswick, Newfoundland and Labrador, PEI), the response rate was much lower (57%) and almost half of respondents denied study participation, claiming that blue carbon ecosystems were outside of municipal jurisdiction and therefore was not municipal responsibility. All respondents that denied study participation looked towards provincial and federal regulations for stewardship standards to direct any municipal work related to blue carbon ecosystems. Two potential participants were contacted on the north coast, with a 50% response rate.

Not all interested participants were able to participate in the study due to coordination conflicts. This is shown in the difference between the 'Participated' column and the difference between the values in '# of Municipalities Responded' and 'Denied Participation' in Table 2. Additionally, in some cases, multiple participants were interviewed from the same municipality, showing a difference in the '# Municipalities represented' column (Table 2).

Out of the 21 coastal municipalities represented from these interviews, none were actively leading a 'blue carbon' project.

**Table 2.** Descriptive characteristics of study participants by coast

Descriptive Characteristic	East Coast	West Coast	North Coast
# of Municipalities Contacted	28	21	2
# of Municipalities Responded	16	16	1
Response Rate	57%	76%	50%
Denied Participation	7 (43% of respondents)	1 (6.2 % of respondents)	0
Participated	8*	15*	1
# Municipalities represented	7	13†	1

# Regional Districts / Service Commission represented	1	1	0
# CMA represented	1	2	0
# Municipal led blue carbon projects	0	0	0

\* unable to coordinate interviews with all interested participants

† replicates from a municipality are present

As previously mentioned, efforts were made by the principal investigator to be directed to municipal departments that were most closely involved with blue carbon projects in that municipality. In British Columbia, blue carbon was primarily associated with the Planning Department, some of which had specific climate positions (Table 3). Land use services and Engineering were the following leading departments, with another participant from Parks and Environment.

East coast participants were from a wider range of departments, varying from administrative roles, planning department and climate specific roles (Table 3). This data helps demonstrate the variance in how municipalities relate their role to blue carbon ecosystem management.

**Table 3.** Study participants municipal department by province

Participant Department	BC (n=15)	NS (n=5)	NB (n=3)	NU (n=1)
CAO			1	
Administrative (Clerk)			1	
Planning Department	10 (4)*	2 (1)*	1	
Land Use Services	2			
Engineering	2			
Parks and Environment	1			
"Climate Action"		2 (2)*		
Community Development		1		1

\* The red number within brackets represents how many participant positions were directly related to climate change, out of the total listed in black

Familiarity of the term and concept of 'blue carbon' also ranged between participants (Table 4). Of the participants that were familiar with the term or concept, it was a result of their own research, academic background, or interests outside of their role with the municipality. In some cases, the term was brought to the attention of municipal staff through community members at stakeholder meetings. Overall, there was consensus among participants that it was not a term or concept that participants heard commonly throughout municipal government or felt they had a deep understanding.

**Table 4.** Study participants familiarity with the term or concept of 'blue carbon', by province

Code	BC (n=15)	NS (n=5)	NU (n=1)	NB (n=3)
Familiar with the term and concept of blue carbon	12	5	0	1
Unfamiliar with the term or concept of blue carbon	0	0	1	2
Unfamiliar with the term 'blue carbon' but introduced to the general concept	3	0	0	0

### 3.2 REASONS FOR MUNICIPAL INTEREST IN BLUE CARBON ECOSYSTEMS

Responses from participants demonstrate that municipal interest in blue carbon ecosystems was not related to carbon sequestration potential, but the other co-benefits these ecosystems provide. The co-benefits that had the most interest from participants were habitat protection and biodiversity, followed by coastal resiliency services (coastline erosion protection, sea level rise protection, general nature-based climate solutions). There was commonly overlap with municipalities that cited "habitat protection and biodiversity" as a reason to engage in blue carbon ecosystem management and "tourism", finding that the preservation of these ecosystems enhanced water front aesthetics, cultural value and ecotourism within the municipality. Additionally, the fact that protection of blue carbon ecosystems help support addressing other conventional issues was raised by participants (Figure 1). For example, protecting blue carbon ecosystems from pollution due to inadequate stormwater and waste management, derelict boats or live-a board's in the municipal harbour.

Codes	Coast = West (n=14)	Coast = East (n=8)	Coast = North (n=1)	Total (n=23)
<input type="radio"/> Carbon sequestration	1	1	0	2
<input type="radio"/> Coastline erosion protection	2	2	0	4
<input type="radio"/> Environmental research centres	0	1	0	1
<input type="radio"/> Habitat protection and biodiversity	8	4	0	12
<input type="radio"/> NbCS (general)	2	0	0	2
<input type="radio"/> Partner project with First Nations	1	0	0	1
<input type="radio"/> Sea level rise protection	2	1	0	3
<input type="radio"/> Secondarily supported conventional issues	2	0	0	2
<input type="radio"/> Tourism	0	2	0	2
<b>Total (Unique)</b>	<b>12</b>	<b>6</b>	<b>0</b>	<b>18</b>

**Figure 1.** Crosstab query created in NVivo to describe reasons for municipal interest in blue carbon, as described by participants, characterized by coast. Not all participants described reasons for specific interest in blue carbon ecosystems. NVivo 'heatmap' tool was used to show highest response frequency.

### 3.3 BARRIERS TO MUNICIPAL PARTICIPATION

The most commonly cited barrier to municipalities actively leading blue carbon projects was the understanding that these ecosystems were situated outside of their jurisdiction, presenting regulatory restraints. Seagrass meadows, for instance, are located below the ordinary low water mark and salt marshes are located in the intertidal zone, which despite being a jurisdictional grey area, is often viewed as the responsibility of the province (ECE Law, 2018). Although in British Columbia, municipalities and Capital Regional Districts authority reaches 200m offshore to allow for zoning of the surface water, the seabed is still managed by federal government. For study participants that have engaged in blue carbon ecosystem management projects, this barrier was also described as contributing to restricting municipalities' role active role.

Limited financial and human resources in municipalities was the second most common barrier. This included not having enough municipal staff to dedicate time and effort towards grant applications for blue carbon projects, as well as a lack of subject expertise staff to lead the projects themselves. This was a sentiment from all municipalities, both within and outside of CMA's, demonstrating that even larger municipalities found directing resources to blue carbon to be a barrier.

Competing municipal priorities for both funding and staff efforts was another obstacle, commonly mentioned by participants from smaller municipalities with limited resources to begin with. The most common competing municipal priorities to blue carbon ecosystem projects was providing affordable housing and encouraging industry development in the municipality.

The "business case" of the protection, restoration and management of blue carbon ecosystems was repeatedly referenced by participants as a barrier. One reason for this is related to the uncertainties of carbon accounting methods for blue carbon ecosystems and if the amount of carbon sequestered by these ecosystems is worth the investment of management strategies. For example, a participant had conducted preliminary research in partnership with local stewardship groups to determine the amount of carbon sequestered by the major estuaries in their municipality and found that in their case, the carbon sequestered was marginal compared to the amount stored by their terrestrial ecosystems. In other cases, for those municipalities that did actively pursue the restoration of blue carbon ecosystems, there was a perceived additional cost of the project, due to high maintenance and upkeep associated, challenging the already limited financial and human resources. Therefore, the "business case" barrier was closely related to the "risky investment" barrier, where many participants viewed blue carbon ecosystem management for the purpose of both carbon sequestration and coastal protection as having uncertain results and thus pursuing these projects as a risk of failure or unpredictable outcomes. As the majority of participants were from municipalities with a climate action plan focussing on GHG emission reduction, sequestration was also commonly viewed as a "crutch", because it does not address the root of the problem or play a strong role in helping municipalities towards their goal of carbon emission reduction. Instead, municipalities' focus on carbon emission reduction related to building retrofit and community transportation. Additionally, the question of 'Who's carbon is it?' was frequently raised, recognizing that the jurisdictional uncertainty of these ecosystems may lead the carbon sequestered by municipal efforts to be counted towards either provincial or federal targets, potentially leaving municipalities without recognition for their efforts.

Lastly, a general lack of knowledge was listed as a barrier, as most participants had only a high level understanding of what constituted a blue carbon ecosystem and were not strongly familiar with restoration or management strategies. This was recognized as a foundational obstacle to pursuing blue carbon projects and applying for grants, but also for advocating to include blue carbon ecosystems in planning policy, such as development permit area assessments. Additionally, it was a barrier that should be addressed on the

community and stakeholder level, as well as throughout Council, to encourage community buy-in of blue carbon. This barrier also included participants lack of knowledge and data on the location and type of local blue carbon ecosystems in the municipalities themselves, which acts as a barrier to effective management strategies.

**Table 5.** Barriers to municipal-led blue carbon projects identified by study participants and the frequency (# of interviews) they were referenced

Identified barriers	Description	Frequency
Blue carbon ecosystems are situated outside of municipal jurisdiction	Blue carbon ecosystems (kelp, eelgrass, salt marshes) are commonly found below the low water mark (federal jurisdiction) or in the intertidal zone (provincial jurisdiction)	24
Limited resources (HR and financial)	Limited financial and human resources make it difficult to set aside staff and money to pursue blue carbon ecosystem projects and apply for additional grants. A lack of subject expertise staff to lead blue carbon projects also fell in this category. Municipalities dependence on project-specific grant funding limit opportunity to pursue blue carbon.	18
Business case of carbon sequestration in blue carbon ecosystems	Difficult to “sell” Council and residents on the benefits of blue carbon, as there is not a standardized method of carbon accounting and it is unclear if sequestered carbon is municipal property	11
Lack of knowledge	A lack of understanding of blue carbon ecosystem management on municipal level and of local blue carbon ecosystems	11
Competing municipal priorities	Municipal priorities such as housing development, road access, and water accessibility compete for funding and staff	8
Risky investment	Blue carbon was understood as a “risky investment”. an unguaranteed award for the efforts and investment	4
Maintenance and upkeep	Perceived long-term maintenance of these projects	1

### 3.4 BEST PRACTICES USED BY MUNICIPALITIES FOR BLUE CARBON ECOSYSTEM MANAGEMENT

Due to jurisdictional issues creating regulatory obstacles and the restrictions of limited funding and staff, municipalities tend to play a supportive role to local ENGO’s by providing in-kind resources, such as GIS mapping and assisting in grant applications. Local ENGO’s were able to address resource barriers faced by the municipalities, as they had staff to dedicate to the projects, the subject expertise to lead them and were able to collect private funding to help towards the project. Creating partnerships for the purpose of assisting in blue carbon ecosystem protection, restoration and/or management was the most common best practice for active

municipal engagement, outside of policy created to protect coastline development. Collaborative partnerships with local ENGO's, neighbouring municipalities, First Nations and higher levels of government helped address many of the barriers listed above by expanding funding streams and grant options, increasing staff resource capacity, and in the cases of inter-governmental collaboration, relieving regulatory constraints. They also commonly resulted in allocating funds to data collection and ecosystem mapping to identify locations of blue carbon ecosystems and ultimately educate future policies. An example of this was the partnership between a municipality and a local ENGO to conduct ecosystem mapping in order to create accessible GIS mapping layers, which the municipality can use to inform future policies.

Municipal policies, such as development permits, zoning restrictions and coastal setbacks was the most commonly cited mechanism used by all municipalities that would impact the protection of blue carbon ecosystems. However, these were largely passive mechanisms that act similarly to current provincial and federal law and policy, which do not explicitly direct efforts towards the protection of these ecosystems.

A strategy many municipalities' used to extend their regulatory reach was through land acquisition, either through purchasing from the private property owner, donation by higher levels of government or creating a tenure agreement with the province. Once there was clarity that the land was municipal jurisdiction, protection measures or restoration projects could be applied to the area.

Restoring salt marshes as part of living shoreline pilot projects were the most credited blue carbon ecosystem restoration project led by municipalities. Pilot projects encouraged stakeholder engagement with First Nations and community members, providing education on the ecosystem services of these nature-based climate solutions. Educated stakeholders on these possible solutions to address climate change threats was also seen as an asset encouraging blue carbon projects in other municipalities, as they were able to advocate for them to Council. Additionally, piloting the project at a smaller site allowed for a major mitigation of risk, which made the projects easier to advocate to Council. As these projects are largely experimental and site specific, municipalities could learn from trial and error, such as how well native species are establishing, before pursuing a full-scale project.

The importance of "rolling project funding", practiced through the Federal Disaster Mitigation Adaptation Fund (DMAF), was mentioned in only one interview, but was critical to the success of the blue carbon ecosystem pilot project in that municipality. This funding stream was long term (9 years), multi-hazard, and rewarded applicants for having co-benefits and engagement with stakeholders. "Rolling project funding" or "bundling" also allowed flexibility in funding applications. As a lot of funding only supplies 80% of the finances for a project, "rolling funding" is a method used where the applicant can pile additional projects into the portfolio, so long as it relates to the original project, e.g. road widening (adjacent to a salt marsh) and salt marsh building. This also increased partnership incentives across municipalities through cost sharing, allowing ecosystem restoration efforts to extend outside of one municipal jurisdiction.

A strong scientific background of municipal staff was found to be an asset for one participant, as it played a strong role in communicating and collaborating with higher levels of government, particularly to compel them to address tough environmental issues. Their background was also an asset as it led to their recruitment from local stewardship groups to conduct a preliminary analysis of blue carbon sequestration capacity in the municipality. This was the only case of a participant actively investigating carbon sequestration potential in their municipality.

Lastly, the role of an Environmental Advisory Committees was a popular tool used by municipalities to address a lack of education on environmental issues in municipal Council. The ad-hoc committee educates stakeholders and council members on environmental issues, allowing Council to make more informed policy and development decisions without requiring a municipal staff be dedicated to that work. They were considered



vital to providing valuable information on emerging topics, such as blue carbon, and liaising with groups such as the Nature Trust, providing an easier gateway to Council to understand these important issues. It should be noted that blue carbon was not extensively covered by any of the environmental advisory committees in the municipalities interviewed, however, represents an opportunity for municipalities to more readily engage with the topic.

**Table 6.** Tools and best practices identified by study participants when they pursued the protection, restoration or management of blue carbon ecosystems and the frequency (# of interviews) they were referenced

Identified Tools and Best Practices	Description	Frequency
Policy	The use of coastal development setbacks, development permits and zoning areas to protect blue carbon ecosystems	14
Collaboration and partnerships	Collaboration with neighbouring municipalities, First Nations, local ENGO's	9
Data collection	Collecting data for local blue carbon ecosystem mapping	2
Research background in municipal role	Municipal staff with a scientific research background	1
Pilot projects	Leading living shoreline pilot projects	3
Planning support from Regional Districts	Regional planning capacity from Regional Districts in British Columbia	3
Stakeholder engagement	Facilitating workshops with community members, municipal staff and academic community	2
"Rolling project funding" or "bundling"	Federal Disaster Mitigation Adaptation Fund allowed multiple projects to be piled onto one portfolio	1
Environmental Advisory Committees	Ad-hoc committee established for the Council that provides feedback, and at times education, on environmental issues	2
Land Acquisition	Municipality acquiring the land through donation by higher levels of government, tenure agreement with the province or purchasing from private land owner	4

### 3.5 WHAT DO MUNICIPALITIES NEED AND FROM WHOM?

In response to what participants felt they needed to better pursue blue carbon projects, it was largely efforts that would address barriers listed above, such as delineating jurisdictional boundaries, improving education on blue carbon ecosystem management, restoration or protection, as well as addressing institutional capacity limitations, such as limited financial and human resources. Participants believed many of these issues could be addressed by regional districts, higher levels of government and national ENGO's, such as WWF-Canada.

Addressing jurisdictional barriers for blue carbon ecosystem management requires intergovernmental collaboration efforts between municipal, provincial and federal governments. Examples raised by participants included clarification of municipal jurisdictional boundaries by the provincial government in the case of blue carbon ecosystems located in tidal areas, as well as collaboration with federal government for managing those located on the seafloor. Additionally, participants requested higher levels of government to enforce current regulations protecting blue carbon ecosystems, as it would better support municipal conservation efforts. Lastly, collaboration between all levels of government in the form of coordinated government funding with longer funding streams, was another suggestion to address logistical barriers such as human and financial resource limitations.

To address knowledge gaps in blue carbon ecosystems, participants requested workshops, educational tools and resources for both municipal staff and Council, as well as community stakeholders. WWF-Canada was identified as a potential facilitator for this work by participants.

Regional Districts in British Columbia are responsible for regional planning initiatives across municipal boundaries and participants believed their unique position could help support regional data collection on blue carbon ecosystems. These services could include ecosystem mapping to delineate locations of blue carbon ecosystems. Regional Districts could also act as a facilitator between municipalities for collaboration on blue carbon initiatives that cross municipalities for more effective blue carbon ecosystem management and protection.

Participants focused on funding as a way to address institutional capacity, as increased funding could allow the municipality to hire on additional staff, in particular, subject expertise personnel or consultants, to help lead blue carbon projects. Participants pointed to higher levels of government to pursue coordinated government funding as well as longer funding streams for municipalities, similar to the Federal Disaster Mitigation Adaptation Fund (DMAF).

The idea of a toolkit was raised by one participant, which could combine information on best practices and be provided to municipalities. This toolkit could also include examples of blue carbon ecosystem management projects on a range of costs and direction to applicable funding streams. This is all in an effort to address the limited resources, both financial and human, and restricted powers that municipalities face when pursuing blue carbon ecosystem management.

**Table 7.** Major themes from participants when asked what they would need to better pursue the management, protection and/or restoration of blue carbon ecosystems. Frequency indicates the number of interviews

Theme	Description	Frequency
Leadership from higher levels of government	Clarify jurisdictional boundaries for municipalities, enforcement of current regulations, support and/or direction from Ministers, lead cross-jurisdictional collaboration	12
Education	Education on blue carbon ecosystems and blue carbon ecosystem management	8
Local ecosystem data	Ecosystem mapping data and local blue carbon ecosystem inventory	5
Financial support	Coordinated government funding, longer funding streams	5
Standardized carbon accounting method	Standardized methodology for counting carbon credits	4
HR Support	Support grant applications, leading blue carbon projects	3
Subject expertise	Having a staff member that is a subject expert in blue carbon ecosystems management, protection and/or restoration to lead these projects	2
Regional collaboration	Address blue carbon at a regional level	1
Blue Carbon Toolkit for municipalities	List applicable funding streams, projects for different price points, projects suited for different ecosystems, successful examples and pilot projects, potential partners (by region and nationally)	1

## 4.0 DISCUSSION

After interviewing 24 municipal staff, representing 21 Canadian coastal municipalities, Regional Districts and Service Commissions, this study has explored how and why municipalities currently engage in the management of blue carbon ecosystems, their best practices when doing so and the obstacles that limit their further engagement. Participants were also asked what they would need to better engage with blue carbon ecosystem management, in efforts to inform recommendations for stakeholders moving forward. Findings from this study indicate that municipal interest in blue carbon ecosystems is not for carbon sequestration services, but for other co-benefits. However, the fundamental barriers that municipalities face to pursue management or protection of blue carbon ecosystems restricts their level of engagement and best practices. That being said, there are opportunities for higher levels of government and national ENGO's, such as WWF-Canada, to play a role in supporting municipalities potential role in blue carbon ecosystem management.

### 4.1 MUNICIPALITIES ARE NOT INTERESTED IN BLUE CARBON ECOSYSTEMS FOR CARBON SEQUESTRATION, BUT FOR THEIR CO-BENEFITS

The data from this research suggests that municipal interest in blue carbon ecosystems is not related to carbon sequestration. There was consensus among participants that the term and concept 'blue carbon' was not commonly used within municipal government and that municipal efforts related to reducing carbon emissions focussed on point-source reduction, such as building retrofits and transportation. Carbon sequestration services were not a priority for municipalities as there was still uncertainty related to carbon accounting methodology and if carbon sequestered due to municipal efforts would be considered municipal carbon, if the ecosystem is located outside of municipal jurisdiction. In terms of carbon accounting, the schemes available can be very expensive (Williamson & Gattuso, 2022), and there is uncertainty related to carbon accounting for carbon fluxes and storage, jeopardizing its reliability (Williamson & Gattuso, 2022). These reasons align with why the management of blue carbon ecosystems for carbon sequestration is commonly undertaken on the national and international level, as there is wider opportunity for investment and carbon sequestration services are commonly acknowledged on those scales (Quevedo et al., 2021).

However, municipalities did engage in blue carbon ecosystem management, but for their co-benefits. The most cited co-benefits by participants, coastal resilience services and habitat protection and biodiversity, directly support municipal priorities, such as protection of coastal infrastructure and residents. Additionally, some participants related their interest in habitat protection and biodiversity to tourism, finding that the preservation of these ecosystems enhanced water front aesthetics and ecotourism. Coastal communities' interest in habitat conservation and coastal resilience services from blue carbon ecosystems is found throughout the literature (Foster et al., 2013; Saenger et al., n.d.). These tangible co-benefits to coastal communities, including provisioning services for the local fishing community due to habitat protection and biodiversity, have been found to resonate more readily at the local scale than carbon sequestration potential (Lukman et al., 2021; Quevedo et al., 2021). Carbon sequestration has a larger impact at the global scale and therefore is a climate mitigation strategy that is commonly pursued at the national and international level (Quevedo et al., 2021). Therefore, when engaging with local government in blue carbon ecosystem management in the future, the focus should be on the tangible co-benefits that the local community will experience as a result of a healthy blue carbon ecosystem.

## 4.2 MUNICIPALITIES FACE NUMEROUS BARRIERS TO ENGAGE IN BLUE CARBON ECOSYSTEM MANAGEMENT

Although participants demonstrated municipal interest in blue carbon ecosystems, local government faces numerous barriers to actively engage in their protection and management. The most cited barriers from participants were jurisdiction, limited financial and human resources, and lack of knowledge on blue carbon ecosystems.

Jurisdictional barriers are a fundamental obstacle to municipalities management of blue carbon ecosystems. These ecosystems are either located below the low ordinary water mark (e.g., kelp forests), which is considered federal jurisdiction in Canada, or in the intertidal area (e.g., seagrass meadows, tidal marshes), which is commonly considered provincial jurisdiction (ECE Law, 2018). Without clarity that these ecosystems are municipal responsibility, local government is unlikely to engage in their protection and management. This was demonstrated by respondents that denied participation, citing these jurisdictional restrictions as the reason why their municipality does not manage blue carbon ecosystems. This fundamental barrier is a symptom of municipal structures not having been created for environmental management, particularly to address marine environments. Municipalities are a tool created by the province to first and foremost provide services and infrastructure to the local community that is best addressed on the local level, such as waste disposal and drinking water availability (Plunkett et al., 2020). This role has shaped municipal regulatory framework and authority. Municipalities role in environmental management, therefore, is still limited in their regulatory reach and any environmental management is still closely associated to the services they are required to provide (Burström & Korhonen, 2001). These services include (i) provision of technical services, (ii) provision of social services, (iii) operation and management of infrastructure, real estates and facilities, (iv) purchase of products and goods and employment of personnel, (v) planning in relation to overall development of the local society, (vi) discharge of official authoritative duties and (vii) provision of information to citizens and other parties (Burström & Korhonen, 2001, p. 37). Therefore, it is unlikely that municipalities will play a strong role in blue carbon ecosystem management without clarification by provincial government on how it relates to the services they provide. This aligns with responses from participants when asked what municipalities need to better pursue blue carbon ecosystem management. All participants acknowledged that leadership on blue carbon ecosystem management strategies from higher level government was required, as well as clarifying the jurisdiction and role of municipalities in said management strategies. Clearly defined boundaries are a critical piece of effective ecosystem management (Brussard et al., 1998). Additionally, higher levels of government can facilitate intergovernmental coordination to address jurisdictional barriers, as well as take a regional management approach to blue carbon ecosystems. This coordination is commonly requested to encourage successful coastal ecosystem management projects (Chang et al., 2022).

A general lack of capacity within municipalities to manage blue carbon ecosystems due to limited financial and human resources was another common barrier. These limitations result in a lack of resources to dedicate to blue carbon projects, grant applications, hiring subject-expertise staff and consultants. Limited institutional capacities is a common barrier to effective blue carbon ecosystem management on the local level as it either limits or drives activities such as educational campaigns, site monitoring and evaluation (Quevedo et al., 2021; Chang et al., 2022). Therefore, the extent to which municipalities are able to engage in environmental management strategies is largely a reflection of the financial resources available to them, or the reallocation of staff time towards these projects. Limited resources force municipalities to sacrifice forward-thinking initiatives in order to provide immediate resources to the community and attend to short-term crisis management (Burström & Korhonen, 2001). The most common forward-thinking blue carbon initiative cited by participants were blue carbon restoration projects in the form of nature-based climate solutions, which are recognized as

still within the research and development phase, and thus further asks municipalities to take on risk of uncertain outcomes or failure with their limited resources (Krull et al., 2015). Participants largely called upon higher levels of government to address institutional capacity by creating long, flexible funding streams that closely resemble the Federal Disaster Mitigation Adaptation Fund, in order to increase personnel, technical staff and hire subject matter expertise. Municipalities could dedicate additional financial capacity towards conducting blue carbon ecosystem mapping and inventory of their coastline, to better inform municipal planning policy and engage in more effective blue carbon ecosystem management practices. National ENGO's, such as WWF-Canada, could also advocate to higher levels of government for these funding streams, on behalf of municipalities. Addressing these institutional capacity barriers will be incredibly important for municipalities to more effectively manage blue carbon ecosystems.

Lastly, a lack of knowledge surrounding blue carbon ecosystems was a major barrier to municipal engagement, based on the interviews. This included a general lack of understanding by local government on the carbon sequestration services of these ecosystems and management strategies municipalities could pursue, which acted as an overall barrier to grant applications and advocacy. Participants also acknowledged the lack of blue carbon knowledge likely within community stakeholders as a barrier to community buy-in for blue carbon projects. Lastly, the absence of carbon ecosystem inventory on the coastlines of these municipalities was another listed knowledge gap. This lack of a comprehensive understanding of the ecosystem being managed, as well as its location and conditions, is a fundamental barrier to effective ecosystem management (Birgé et al., 2016). Educating municipal staff and their communities on the importance of blue carbon ecosystem management is an integral task moving towards effective ecosystem management, as stakeholder acceptance and engagement has been found to be critical to the success of coastal ecosystem management (Vierros, 2017). To address this, participants suggested that WWF-Canada play a role in providing workshops for municipal staff and local ENGO's on blue carbon ecosystem management, as well as provide educational resources for the general public. Providing these resources to local government and communities aligns with WWF-Canada's *Fight Climate Change with Nature* goal within their 2020-2030 Strategic Framework, which includes partnering with and supporting leaders in blue carbon ecosystem management. Moreover, the organization's focus on supporting and integrating Indigenous traditional knowledge systems and leadership into blue carbon management with further encourage management success, as participation by these stakeholders will help alleviate social and economic hardships (Vierros, 2017).

### **4.3 MUNICIPAL ENGAGEMENT IN BLUE CARBON ECOSYSTEM MANAGEMENT IS RESTRICTED TO A SUPPORTIVE OR COLLABORATIVE ROLE**

The best ways municipalities represented in this study engaged with blue carbon ecosystem management within the confines of the barriers listed above are by playing a supportive and collaborative role with project partners and using planning policy mechanisms. Protection and conservation strategies for the purpose of habitat protection, biodiversity and coastline protection led municipal engagement with blue carbon ecosystems.

Municipalities commonly support local ENGO efforts on an in-kind basis who pursue active blue carbon ecosystem restoration projects. ENGO's were able to address many resource barriers municipalities face for blue carbon projects, as they have staff to dedicate to the project, subject expertise, and access to private funding streams. Although municipalities are not playing a prominent role in blue carbon ecosystem management in this case, supporting local initiatives is still understood as a best practice for blue carbon ecosystem management as they are important for providing the opportunity to educate and engage

community stakeholders, learning and utilizing traditional knowledge and management systems, which have been shown to play a critical role in the success of blue carbon ecosystem management strategies (Lukman et al., 2021; Vierros, 2017).

Municipalities have played a more active role in blue carbon ecosystem management by collaboration with neighbouring municipalities, First Nations, ENGO's and higher levels of government, by leading living shoreline pilot projects. Collaborative relationships are a recognized best practice for coastal adaptation projects (Chang et al., 2022), as they address resource limitations by expanding funding opportunities, increasing personnel and subject expertise staff, as well as address jurisdictional barriers. As blue carbon ecosystems commonly traverse jurisdictional boundaries, regional management schemes through collaborative partnership and stakeholder alliances is critical (Burström & Korhonen, 2001). Moreover, successful blue carbon projects have been found to incorporate the involvement of local stakeholders and their livelihoods (Lukman et al., 2021). Living shoreline projects, generally referring to the shoreline protection strategies that use habitat restoration either alone or in combination with built infrastructure (Smith et al., 2020), have become one of the most commonly used nature-based infrastructures for their role in enhancing coastal resilience through wave attenuation and erosion control (Shepard et al., 2011; Sutton-Grier et al., 2015) and have found to be more effective in shoreline protection from hurricanes than traditional protection measures such as bulkheads (Gittman et al., 2014). Therefore, investing in collaborative partnerships with key stakeholders on these projects is a strong example of blue carbon ecosystem management best practices, particularly for coastal resilience.

Small scale blue carbon pilot projects also play an integral role in informing regulatory schemes of best practices for tried-and-true procedures by acting as 'testing sites' for project design. Results from these projects have been the most successful blue carbon initiatives due to the smaller resource demands (Wylie et al., 2016). These sites can also act as education sites for stakeholders on the ecosystem services provided, raising awareness and support community efforts in ecosystem management (Lukman et al., 2021).

Lastly, planning policy, such as zoning, development permit areas or coastal setbacks, is a common best practice used by municipalities to protect coastal habitat from degradation and destruction due to new developments (Thompson et al., 2019). However, as blue carbon ecosystems are not currently explicitly considered in these policies, they remain vulnerable. Therefore, planning policy presents an opportunity for municipalities to better integrate the protection of blue carbon ecosystems within decision-making, but not a current best practice.

## 5.0 RECOMMENDATIONS FOR STAKEHOLDERS

Engagement from municipalities in this study demonstrate an interest in the role of local government for the management of blue carbon ecosystems for their co-benefits. However, jurisdictional and resource constraints limit their involvement in ecosystem management. In order for municipalities to be more effective in blue carbon ecosystem management, municipalities, higher government and WWF-Canada must understand the role they can play. A combination of participant responses on what municipalities need to better engage with blue carbon ecosystem management and their acknowledged best practices can be summarized in stakeholder recommendations to support further municipal engagement in blue carbon (Table 8).

**Table 8.** Recommendations for local, provincial and federal government and National ENGO's to support municipalities' management of blue carbon ecosystems

Higher Levels of Government	Municipal Government	WWF-Canada
Clearly communicate to municipalities their jurisdictional boundaries and role for blue carbon ecosystem management	Engage in collaborative partnerships when pursuing blue carbon projects (First Nations, neighbouring municipalities, ENGO's, higher government)	Highlight non-carbon benefits when talking to municipalities
Create long term, flexible funding streams for blue carbon projects	Pursue blue carbon pilot projects, such as living shorelines, as an educational tool for community stakeholders and to inform future blue carbon project protocols	Provide educational tools for municipalities (e.g., accessible workshops on blue carbon ecosystems and management strategies; Blue Carbon Toolkit)
Act as a facilitator for intergovernmental collaboration on blue carbon	Conduct ecosystem mapping and inventory for blue carbon ecosystems (Regional Districts)	Support municipalities conduct ecosystem mapping and inventory projects for blue carbon

## 6.0 CONCLUSION

This research demonstrates that Canadian coastal municipalities are not interested in the management and protection of blue carbon ecosystems for carbon sequestration services, but for the tangible co-benefits they provide coastal municipalities, such as coastal resilience and tourism. Municipalities across Canada are actively participating in blue carbon ecosystem management by supporting local ENGO's and engaging in collaborative partnerships to pursue living shoreline pilot projects. Their work plays an important role in informing future blue carbon regulations and procedures by acting as 'testing sites', as well as engaging and educating community stakeholders to encourage successful management practices. However, the extent to which local government can manage these ecosystems is limited by their institutional capacity and jurisdictional barriers, dissuading engagement from many coastal municipalities. In order for municipalities to play a more effective role in blue carbon ecosystem management, they require support and guidance from higher levels of government, as well as national ENGOs like WWF, to address institutional capacity limitations, jurisdictional boundaries and education gaps. Without this support, municipalities cannot be expected to play a strong role in blue carbon ecosystem management.

Future research on the role of municipalities in blue carbon ecosystem management should investigate how blue carbon ecosystem services could be more readily incorporated into municipal policy. Lastly, and most importantly, future research must expand beyond the municipality and engage with local First Nations groups to incorporate traditional knowledge systems and management into understanding and shaping future role of local government in blue carbon ecosystem management.



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# APPENDICES

## APPENDIX A. INTERVIEW QUESTIONS

**Context:** My name is Anna Murphy, and I am a Research Intern with WWF-Canada working on the Understanding Municipalities' Role in the Management and Protection of Blue Carbon Ecosystems project. Blue carbon ecosystems are vegetated marine ecosystems, such as salt marshes, kelp forests and seagrass meadows, that capture and store atmospheric carbon using natural processes. They play an important role in coastal protection, biodiversity and climate change mitigation. The purpose of this study is to identify the obstacles and best practices that municipalities experience when managing, protecting and/or restoring blue carbon ecosystems, to determine areas that require further support and identify possible legislative and policy gaps.

1. **Can you discuss your current role with the municipality and how your education and career has brought you here?**
2. **Have you ever heard the term blue carbon? (Y/N)**
  - a. **What do you know about blue carbon ecosystems?**
3. **Recognizing that blue carbon is a relatively new term to describe the carbon stored in certain coastal ecosystems, are there other terms used to describe these ecosystems that you are more familiar with? If so, what are they?**
4. **Is managing blue carbon ecosystems (tidal marshes, kelp forests, seagrass meadows) a priority in the municipality?**

**If blue carbon is not a priority in your municipality, why do you think that is?**
5. **Can you offer any examples of blue carbon projects you have worked on in your municipality? These could include wetland restoration, coastline development, managing stormwater runoff, roadbuilding in your municipality.**
  - i. **What challenges did you face when pursuing this work?**
  - ii. **What practices did you find most effective when pursuing this work?**
  - iii. **What lessons have you learned that will inform future projects?**
6. **Do you consider carbon sequestration when you undertake projects in coastal ecosystems?**
7. **What would you need, and from whom, to better pursue the management, protection and/or restoration of blue carbon ecosystems in your community?**
8. **Is there anything else you would like to tell me about your experiences managing blue carbon ecosystems?**
9. **Do you know anybody else who could be interested in participating in this study about blue carbon?**

## APPENDIX B. INTERVIEW CONSENT FORM

### CONSENT FORM (Interview)

#### Understanding Municipalities' Role in the Management and Protection of Blue Carbon Ecosystems

**Lead researcher:** Anna Murphy, Research Intern, WWF- Canada, [amurphy@wwfcanada.org](mailto:amurphy@wwfcanada.org)

#### Research Supervisor:

Sarah Saunders, Specialist, Marine Conservation, WWF-Canada, [ssaunders@wwfcanada.org](mailto:ssaunders@wwfcanada.org)

#### Key Points:

- This data is being collected for a research project at WWF-Canada and Dalhousie University.
- The interviews will take between 30-minutes to one-hour to complete.
- Data will be amalgamated in the final report to demonstrate common themes and patterns across interviewees. Select participants will also be chosen to feature as a case study within the report.
- Participant identity will be coded in collected data. This means participant names will be substituted with a keycode, which will be stored on a password protected file on an encrypted server at WWF-Canada. However, WWF-Canada will have access to participant's full information.
- There are negligible risks to participating in this study.
- Research findings will be shared with WWF-Canada and Dalhousie University in a final report and a presentation in December 2022.

You are invited to take part in a research study conducted by Anna Murphy, a Research Intern with WWF-Canada on the role of municipalities in the management and protection of blue carbon ecosystems. Blue carbon ecosystems are vegetated marine ecosystems, such as salt marshes, kelp forests and seagrass meadows, that capture and store atmospheric carbon in their biomass through natural processes. Municipalities are commonly interested in blue carbon ecosystems for their services in coastal protection, biodiversity, or cultural significance. **The purpose of this research is to determine areas where municipalities wish further support and identify possible legislative and policy gaps for managing, protecting and/or restoring blue carbon ecosystems (e.g. salt marshes, kelp forests).**

You may participate in the research study if you work with a coastal municipality in Canada and have experience in the management, protection and/or restoration of blue carbon ecosystems in your role. Your participation is entirely voluntary. Should you choose to participate, you will be asked to complete a **30-minute interview to one-hour** interview with the lead researcher, Anna Murphy, where you will **answer questions about your municipality's experience with blue carbon ecosystems**. The interview will take place remotely using Microsoft Teams or Zoom and will be **recorded and transcribed**. A summary of the interview will

be shared with you as a follow-up to provide basic feedback if you wish. WWF-Canada will retain a copy of these transcriptions to inform future projects and potential partners. You may withdraw at any time before data coding, after which stage data will be aggregated and it will be impossible for the researcher to extract individual's responses.

Data for this research will be amalgamated to determine patterns of opportunities and obstacles across municipalities, but some participants will be featured as a case study. Participant identification for case studies or quotations will be limited to "employee of xx (municipality)". Providing consent to participate in this study includes consent to be a potential case study within the final report for WWF-Canada and Dalhousie University.

There are no known risks for participating in this research and you are not required to provide any information that makes you uncomfortable or answer any questions you do not want to answer. A keycode, which is a combination of letters and numbers that can be used in place of your name, will be used to protect your identity during data analysis. This file will only be accessible to WWF-Canada and stored on a password protected computer on an encrypted server, meaning your participation will be known only to members of the research team. All responses will be saved on a secure WWF-Canada server and password protected computers and files. Only myself, Anna Murphy, my research supervisor, Sarah Saunders, and blue carbon protect lead Brianne Kelly will have access to the full interview results. After analysis, summary data of each interview and participant contact information will be retained by WWF-Canada, while transcriptions and recordings of interviews will be destroyed. Participant list information will remain with Sarah Saunders and Brianne Kelly at WWF-Canada for potential collaboration in future blue carbon ecosystem projects. If interested, a copy of the final report from WWF-Canada will be shared with you.

I am happy to talk with you about any questions or concerns you may have about your participation in this study. Please feel free to contact myself, Anna Murphy (at 902-403-4487, or [amurphy@wwfcanada.org](mailto:amurphy@wwfcanada.org)) or Sarah Saunders ([ssaunders@wwfcanada.org](mailto:ssaunders@wwfcanada.org)) at any time with questions, comments or concerns about the research study.

"If you have any ethical concerns about your participation in this research, you may also contact Research Ethics, Dalhousie University at (902) 494-3423, or email: [ethics@dal.ca](mailto:ethics@dal.ca) (and reference REB file # 20XX-XXXX)."

If you agree to complete the interview under the terms described above, please provide verbal confirmation at the beginning of the interview.

Thank you,

Anna Murphy  
Research Intern, Resilient Habitats Team, WWF-Canada

## APPENDIX C. NVIVO CODEBOOK

Bolded codes indicate deductive codes. Non-bolded codes indicate inductive codes.

Name	Files	References
ACTIVELY LEADING BLUE CARBON PROJECTS	0	0
blue carbon sequestration preliminary analysis	1	1
Indirectly, but not a blue carbon focus	3	3
Living Shoreline	2	3
No	14	16
<b>BEST TOOLS AND PRACTICES</b>	0	0
Collaboration	0	0
Cooperation and strong relationships with higher gov	2	2
Regional data collection	1	1
Creating collaborative relationships with neighboring municipalities	1	1
Incentivize coastal private property owners (Green Shores)	1	1
Partner with local NGO's	1	1
Policy consistency across municipalities	1	1
Strong relationship with local First Nations	1	1
Data Collection	0	0
Ecosystem mapping	1	1
Environmental Advisory Committee	3	5
Fed gov program on natural infrastructure	1	1
Land acquisition	0	0
Buy private land	2	2
Get province to donate the land	1	1

Name	Files	References
Tenure agreement with the province	1	1
Leading and facilitating workshops	1	1
Pilot Projects	2	2
<b>Policy</b>	0	0
Coastal development setbacks	2	4
Zoning	1	1
Designated protected area	2	3
Development by laws for habitat protection	1	1
Development permit area policy	7	8
mooring buoy	1	1
Regional Districts	3	3
Research background in municipal role	1	1
Blue Carbon a MUNICIPAL PRIORITY	0	0
No	19	25
<b>CHALLENGES</b>	0	0
Business case of carbon sequestration	5	6
No standardized method of carbon counting	3	4
Not municipal carbon	2	2
Competing municipal priorities	7	8
Salt marshes turned to farms	1	1
High Risk	0	0
Municipalities aren't research labs	1	1
No guarantee of success	2	2
Lack of knowledge	6	9



Name	Files	References
Subject expertise staff	3	3
<b>Limited financial resources</b>	7	8
Municipalities work on grant funding	2	2
<b>Limited human resources</b>	8	9
<b>Outside of jurisdiction</b>	14	20
Ecosystem on privately owned land	1	1
Pushback from property owners	1	1
Municipalities have no power	1	1
Requires cross-jurisdictional collaboration	4	4
GENERAL MUNICIPAL CONTEXT	12	36
INTERESTING	16	34
Derelict boats	2	2
Erosion	1	1
PART OF MUNICIPAL CONVO	0	0
Not part of the municipal conversation	10	11
Yes	5	7
<b>PARTICIPANT BACKGROUND</b>	0	0
Business	1	1
environmental studies	1	1
landscape architecture	1	1
law	1	1
Natural Resource management	3	3
Planning	6	7
public policy	1	1

Name	Files	References
Science	12	12
Social science or Geography	7	7
<b>PARTICIPANT POSITION</b>	0	0
CAO	1	1
Clerk	1	1
Climate change	3	3
Community Services	2	2
Development services	1	1
Environmental Specialist	1	1
Planner	13	14
<b>REASONS FOR INTEREST IN BLUE CARBON</b>	0	0
Carbon sequestration	2	2
Coastline erosion protection	4	4
Environmental research centres	1	2
Habitat protection and biodiversity	12	17
NbCS (general)	2	2
Partner project with First Nations	1	1
Sea level rise protection	3	3
Secondarily supported conventional issues	2	2
Tourism	2	3
<b>ROLE OF MUNICIPALITY</b>	0	0
Approving local development	6	7
managing designated sensitive areas	1	2
Partner with higher gov	1	1

Name	Files	References
Supportive	9	12
Financial	3	3
In-kind	3	3
Facilitator	2	3
Human resources	3	3
Participates in committee to protect natural area	1	1
Partner with First Nations	1	1
Permits	1	1
<b>TERMINOLOGY</b>	0	0
Familiar with term and concept of 'blue carbon'	17	17
Other Terms	1	1
Unfamiliar with concept of blue carbon	3	3
Unfamiliar with term 'blue carbon' but introduced to the general concept	3	3
Used in Municipality	0	0
No	7	8
Yes	2	2
<b>TYPE OF BLUE CARBON ECOSYSTEM</b>	0	0
eelgrass	4	4
estuary	1	1
kelp	1	1
salt marsh	8	9
<b>WHAT DO THEY NEED</b>	0	0
Carbon accounting logistics	3	3
Protocol for blue carbon accounting	1	1

Name	Files	References
Data	1	1
Ecosystem mapping and inventory	4	4
Education	7	7
Further understanding of blue carbon	1	3
Higher levels of government to take the lead	1	2
Better regulations from prov and fed	3	3
clarify jurisdiction	2	2
Cross-jurisdictional collaboration	4	5
Enforcement from higher gov	1	1
Support by Minister	1	1
HR Grant support	2	2
Indigenous stewardship	2	2
stakeholder engagement	1	1
Money	3	3
Coordinated gov funding	1	1
longer grants	1	1
More HR	1	1
Subject expertise	2	2
Regional committees for cross municipal lines	1	1
Toolkit	1	2