BUILDING CONNECTIONS FOR BLUE CARBON ACROSS CANADA

Ecosystem Approach Workshop Report

Building Connections For
Blue Carbon Across Canada
Ecosystem Approach Report
March 24th, 2021
4th in a Five Part Series
Summary Report
Prepared by WWF-Canada

WWF-Canada
4th Floor, 410 Adelaide Street West
Toronto, Ontario M5V 1S8

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SUMMARY

Blue carbon habitats are complex and require a holistic approach to the design and implementation of conservation and restoration projects. A growing number of individuals and organizations are working on research, restoration, conservation and policy related to blue carbon ecosystems in Canada. To bring the community of practice together and identify knowledge gaps and opportunities for collaboration, WWF-Canada is hosting a five-part virtual workshop series.

This report summarizes the fourth workshop in the series which focused on the Ecosystem Approach and took place on March 24th, 2021 and had 34 attendees. This workshop aimed to tackle the question **How do we develop blue carbon policy, research and practice with an ecosystem approach?**

The major key takeaways from the fourth workshop were:

- The ecosystem approach should be integrated, comprehensive and holistic, go beyond ecological considerations to include social, economic and cultural factors, embrace multiple sources of evidence and promote co-benefits in addition to carbon storage.
- Multiple people in coordinator roles are needed to connect people across sectors and regions to implement an ecosystem approach.
- Respect for Indigenous knowledge holders is very important and knowledge holders should control how their knowledge is applied.
- We need to rethink "blue carbon" terminology to ensure we are communicating in a meaningful and inclusive way.

Contact information for the attendees is provided, as well as additional links to blue carbon initiatives and resources and a copy of invited and speed talk presentations.

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INTRODUCTION

Blue carbon – carbon stored in coastal ecosystems, such as seagrass meadows, salt marshes and kelp forests – can play an important role in the fight against climate change. These coastal systems are interconnected and complex. Carbon and other nutrients are transported among blue carbon habitats; carbon sequestered in one habitat can be transferred, deposited and stored long-term in another habitat. Wildlife species can move among blue carbon ecosystems and rely on different habitats during different life stages. Human relationships to blue carbon habitats are also complex and differ depending on the economic, social and cultural significance of different landscapes.

Designing effective and impactful projects to conserve, steward or restore blue carbon ecosystems requires us to address not just ecological considerations, but to integrate social, economic and cultural considerations. It also means we need to take a systems perspective to ensure we account for ecosystem function and the transport of carbon, nutrients and wildlife among blue carbon habitats. To work effectively on blue carbon from an ecosystem approach we need to break down barriers and collaborate across sectors.

There are many researchers, practitioners and policy makers working on different aspects of blue carbon ecosystems across Canada. To bring the community of practice together and identify knowledge gaps and opportunities for collaboration, WWF-Canada is hosting a five-part virtual workshop series. The objectives of the sessions are to:

- Facilitate connections within the blue carbon community and share information on ongoing blue carbon work;
- Discuss key questions on blue carbon research, policy and application; and
- Identify areas of opportunity to advance collaboration on blue carbon across Canada.

The fourth workshop in the series focused on the ecosystem approach and aimed to tackle the question: **How do we develop blue carbon policy, research and practice with an ecosystem approach?**

At the workshop, a series of invited speakers provided talks to set the stage for a breakout group discussion session. Following the discussion session there were two speed talks aimed at introducing members of the blue carbon community.

During the breakout group discussion session, participants chose one of the following questions to explore with their fellow group members:

1. What **work is being done in Canada using the ecosystem approach** that can help inform blue carbon work?
2. How can we **encourage policymakers, funders, researchers and practitioners** to approach blue carbon work from an **ecosystem perspective**?
3. How do **we integrate wildlife management and conservation** into blue carbon policy, research and practice?
4. How do we build blue carbon projects to **support food security** and how do we make these projects **resilient to climate change**?
5. How can we ensure we include **multiple sources of evidence including local, Indigenous and scientific knowledge** to strengthen our blue carbon work?

This report summarizes the invited talks, speed talks and discussion sessions from the ecosystem approach workshop, highlighting key takeaways as identified by participants. The ecosystem approach workshop will be followed by a workshop focused on the next steps for the community of practice on April 14th, 2021.

INVITED TALK SUMMARIES

Marlow Pellatt, Parks Canada
Chantal Vis, Parks Canada

Blue Carbon in Canada National Parks and National Marine Conservation Areas

Healthy coastal ecosystems are important for wildlife habitat, recreation, and shoreline protection as well as for the storage and sequestration of carbon.

Blue carbon ecosystems, which primarily include tidal salt marshes, tidal forested wetlands (e.g., mangroves), and seagrass beds, can sequester carbon from the atmosphere continuously over thousands of years, building stocks of carbon in organic-rich soils and sediments. Recently, understanding carbon storage in coastal systems has become an exciting prospect for conservation and climate change work. The federal government has now committed to a reduction of greenhouse gases to 30 per cent of 2005 levels by 2030 and net-zero by 2050, and this commitment includes applying "natural solutions" to mitigate climate change. Although ambitious, this goal provides an opportunity for all aspects of climate change mitigation work to be included in the effort to reduce emissions and emphasizes the importance of municipalities in conservation.

The federal government also has a goal to protect 30 per cent of Canada's land and ocean area by 2030. Since 1990, the percent of protected terrestrial area in Canada has increased from less than six per cent to over 12 per cent in 2019. More dramatically, the percent of protected marine area has increased from one per cent to 14 per cent in just three years between 2016 and 2019. While this trend is positive, there is still a long way to go to meet national targets.

There is a tremendous opportunity to conserve carbon stocks and enhance sequestration by increasing our understanding of blue carbon systems. Through ecological restoration and reclamation, we can develop green coastal management and engineering projects such as soft shores and living dikes. We can take an approach to biodiversity conservation and protected area establishment that also provides for greenhouse gas mitigation (or at minimum reduces carbon mobilization).

However, to realize the potential of blue carbon work, we must address the lack of data available for blue carbon systems. Most available data currently come from the Pacific and Atlantic coasts, specifically from areas that are relatively easy to access, while significant data gaps remain for the Arctic. Collaboration is necessary for understanding blue carbon systems and many scientific contributions have come from connections between the government and academics (see Gailis et al. in press, Postlethwaite et al. 2018, Chastain et al. 2018).

For example, a recent study by Gailis et al. (in press) quantified carbon storage and accumulation rates for salt marshes in Boundary Bay, British Columbia. The average carbon stock of these salt marshes was approximately 80 Mg C ha^{-1}, while the average carbon sequestration rate was approximately 0.8 Mg C ha^{-1} yr^{-1}. This carbon sequestration rate is greater than rates measured for forests (0.6 Mg C ha^{-1} yr^{-1}) and seagrass meadows (0.1 Mg C ha^{-1} yr^{-1}) in British Columbia. Differences in accumulation rates should be considered when selecting blue carbon opportunities at the scale required to accumulate significant amounts of carbon.

As an agency, Parks Canada is using a pan-Canadian approach to understanding blue carbon in National Parks and National Marine Conservation Areas. Current work, although limited by the pandemic, is occurring in British Columbia at Pacific Rim National Park Reserve (NPR), Clayoquot Sound, the Gulf Islands NPR, Boundary Bay, and in New Brunswick at Kouchibouguac National Park. Future work is planned for Gwaii Haanas NPR, national parks in the Atlantic coast including PEI, Nova Scotia and Newfoundland and Labrador, with more exploratory work planned for the north.

In addition to National Parks and National Heritage Sites, Parks Canada has a Marine Conservation Areas (NMCA) program which will contribute to the goal of 30 per cent by 2030. Parks Canada is currently updating the NMCA program policy that supports the Marine Protected Areas (MPAs) program and is considering the inclusion of climate change adaptation and carbon storage. Federally, minimum protection standards were announced in 2019 for federal MPAs (e.g., prohibition on oil and gas, mining, bottom trawling, and ocean dumping). Parks Canada is also working with Mexico and the United States via the Commission for Environmental Cooperation (CEC) and North American MPA Network (NAMPAN); the focus of some of this work is on blue carbon.

While considering the protection and restoration of coastal blue carbon habitats, it is also important to look at management measures and the links to carbon (e.g., bottom trawling and its influence on marine carbon stocks). How MPAs are managed and their influence on carbon stocks, as well as the co-benefits to conservation, are coming to the forefront in policy discussions.

Key Takeaways:

- There are opportunities to position blue carbon as a nature-based solution, but we first need to improve the data type, quality and quantity (e.g., greenhouse gas fluxes, stocks, accumulation rates, lateral transport of material) before fully understanding the role of blue carbon in climate change mitigation. Significant data gaps exist in these areas in Canada.

- We need a top-down and bottom-up approach, including the grass roots approach. Blue carbon systems are small relative to terrestrial systems such as the boreal forest and will likely require collaboration with partners to get value from the carbon market.
- Locally, coastal salt marshes have potential for climate change mitigation and co-benefits alongside other ecosystem services (e.g., biodiversity, wildlife habitat).

Marc Dunn, Niskamoon Corporation
Ernie Rabbitskin, Niskamoon Corporation

Eelgrass Beds in Eastern James Bay – A First Nations Research Collaboration

Niskamoon Corporation is a non-profit organization run by the James Bay Eeyou (Cree). Their mandate is to remediate impacts from hydroelectric development on their territory; Eastern James Bay is responsible for approximately half of the total hydroelectric production in Quebec. The relationship with Hydro Quebec is complicated and is mediated by over 10 impact benefit agreements. Niskamoon Corporation manages and channels resources from the impact benefit agreements to address issues in support of Cree Land Users (hunters, fishers, and trappers). Between 20 to 30 per cent of Cree still live off of the land and it is an important part of their lifestyle. Niskamoon Corporation also works with academic researchers to understand complex, large-scale problems.

In the 1970s, the eelgrass beds in Eastern James Bay were identified as "significant" coastal habitat for waterfowl and fish. It is well known as a major staging habitat for waterfowl and is part of a complex system of wildlife management by Cree hunters. The eelgrass beds experienced a decline in the 1980s and an abrupt crash in the late 1990s when the population was reduced to almost zero. Although there has since been a slight recovery, the increase in eelgrass is difficult to understand as it does not follow clear patterns (i.e., eelgrass recovers in some areas but not others). Local hunters made it clear that focusing on the eelgrass beds is too narrow of an approach and that the eelgrass beds, wildlife, and the broader coastal processes all need to be considered.

To study this issue, the Coastal Habitat Comprehensive Research Program was formed and consists of six universities, four Cree communities, 480 km of coastline, five teams (Eelgrass, Oceanography, River Inputs, Waterfowl, Cree Traditional Ecological Knowledge and Land Use), and many partners. The study area in Eastern James Bay is large, remote, and difficult to access (there are only five access points across 480 km of coastline). The Coastal Habitat Comprehensive Research Program focuses on collaboration and co-creation of knowledge. Cree hold varied roles within the program, including boat drivers, guides, security officers, knowledge-keepers, peer-reviewers, key beneficiaries, SCUBA divers and friends. These relationships are personal and transcend research projects, which allows people to understand one another and facilitates the flow of knowledge.

Land Users apply complex knowledge systems to make decisions about how they will work within the constraints of nature to benefit from the resources that are available. This strategy approaches the system as a whole, is intuitive to Land Users, and promotes buy-in and participation from communities.

The greatest challenges of this program are:

- The study area is a large, open marine system that is difficult to understand.
- Climate change is a major factor driving conditions and is happening in real time.
- There are broad environmental changes in the territory that result from industrial projects.
- Access to the area is restricted to five points over 480 km of coastline.
- Jurisdictional issues are challenging (several governments overlap in responsibility, e.g., below the tide line, James Bay is in the territory of Nunavut).

Climate change is an issue of food security and safety. Researchers aiming to take an ecosystem approach need to include food security and safety in in their projects and work collaboratively with First Nations to be successful.

"It's important to remember that First Nations did not create this climate change problem, but we are living with the consequences, and we want to be part of the solution."

-Mr. Thomas Coon, Cree Elder from Mistissini


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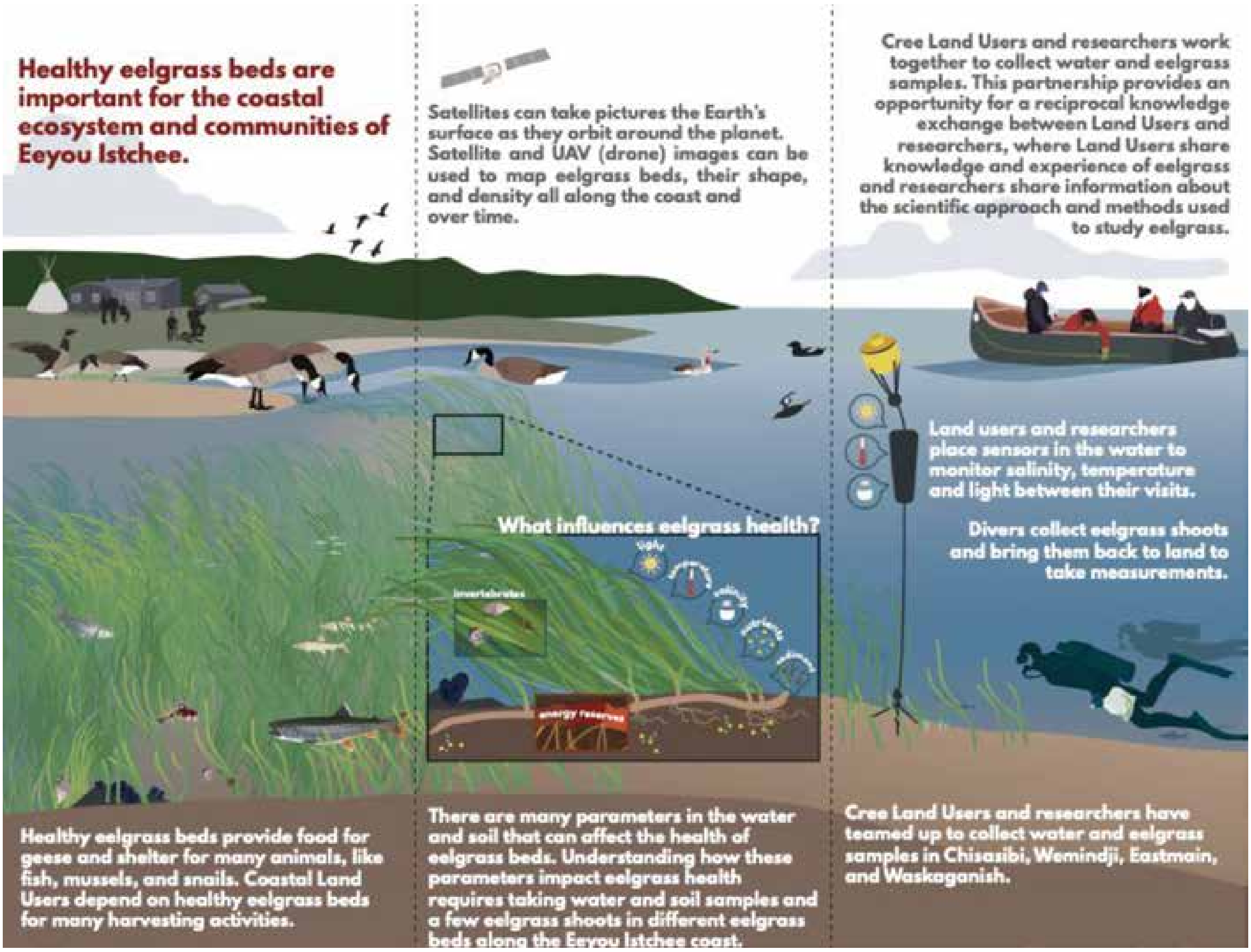

Infographic credit: Melanie Leblanc

Anuradha Rao, Ekalogical Connections, Contractor to Tsleil-Waututh Nation

How do we develop blue carbon policy, research and practice with an ecosystem approach?

Anuradha is a contractor who works for both Tsleil-Waututh Nation and SeaChange Marine Conservation Society. As a settler, Anuradha takes an ecosystem approach to her work on the unceded territories of the xʷməθkʷəy̓əm (Musqueam), Skwxwú7mesh (Squamish) and səl̓ilwətaʔɬ (Tsleil-Waututh) Nations. While Anuradha works with Tsleil-Waututh Nation, she does not speak for them, but is here today to share her perspective on working from an ecosystem approach.

The traditional territory of Tsleil-Waututh Nation includes səl̓ilwət, colonially called Burrard Inlet. As "People of the Inlet", Tsleil-Waututh have been stewarding səl̓ilwət since time immemorial. Prior to European contact, Tsleil-Waututh obtained roughly 90% of their diet from səl̓ilwət; however, industrialization and development have damaged the area such that it can no longer sustain their needs. This damage includes the loss of blue carbon habitats such as eelgrass beds, kelp forests and estuaries.

Working in səl̓ilwət is jurisdictionally complex; the area includes eight municipalities and one regional government as well as provincial and federal ministries and the Vancouver Fraser Port Authority. The watershed as a whole includes the shared territories of numerous First Nations. The approach taken by Tsleil-Waututh Nation to steward and restore their lands and waters is holistic and ecosystem-based. Part of their vision for their territory is outlined in the Burrard Inlet Action Plan, "a science-based, First Nations-led initiative to improve the health of the Burrard Inlet ecosystems by 2025". The Plan includes 66 actions and five broad goals for ecosystem recovery:

- Goal A: Improve water quality and reduce contamination
- Goal B: Protect and enhance fish and wildlife habitat
- Goal C: Protect and recover key species and populations and food webs
- Goal D: Protect and restore supporting biophysical processes/ecological integrity
- Goal E: Identify and track emerging issues

The plan has brought people together on an Inlet-wide scale, enabling the inclusion of multiple data sets and multiple sectors in Tsleil-Waututh Nation-led projects. These projects include the mapping of kelp (completed) and eelgrass (in progress) on an Inlet-wide scale, the restoration of eelgrass, beginning in areas around the Tsleil-Waututh Nation reserve, and restoration in the Indian River estuary. Blue carbon is just one reason to map, conserve and restore nearshore ecosystems; these ecosystems also provide food and habitat for many species, stabilize shorelines and improve water quality.

Taking an ecosystem approach to conservation and restoration work starts with connecting with the Indigenous Peoples whose land and water you are working on. A good example of how to work collaboratively with an ecosystem approach is the partnership between Tsleil-Waututh Nation and SeaChange Marine Conservation Society. SeaChange has been willing to deprioritize their agenda, support the work financially and enable Tsleil-Waututh Nation to lead. For example, on a nearshore restoration project in the Inlet, SeaChange supports 2 coordinators, Anuradha as well as an individual representing Tsleil-Waututh Nation, to co-lead the project. This partnership has enabled the implementation of projects that would not otherwise have been considered feasible.

The ecosystem approach requires understanding and incorporating many elements, including wildlife, social, economic, ecological and cultural values, climate change, and food benefits. Fundamentally, working from an ecosystem approach means supporting the Indigenous Peoples on whose land and waters we work, and who have been taking an ecosystem approach since time immemorial. These Indigenous Peoples hold stewardship and governance rights in their territories that we must all respect.

Nikki Wright, SeaChange Marine Conservation Society

Keeping it Living – Eelgrass Habitat Conservation

SeaChange Marine Conservation Society has been working on eelgrass restoration since 2000 and focuses on four regions within the Salish Sea. SeaChange works from an ecosystem approach to restore and conserve complex, intricate and dynamic marine habitats. Within these complex ecosystems, boat anchorages are specific threats to eelgrass beds which SeaChange works to mitigate using multiple approaches.

Encouraging the use of mid-line buoy systems through boater-to-boater communication is one such approach. As mooring chains shift with tides and currents, they scour the ocean floor, creating a wasteland around each boat. Mid-line buoy systems remove the need for an anchor chain, by suspending a rope between the mooring buoy and the mooring block with mid-line floats. This system would mitigate damage from anchorages by boaters who stay anchored in place for extended periods of time.

A second approach to protect eelgrass beds from boat mooring damage is to create voluntary eelgrass protection areas. SeaChange has deployed a series of marker buoys in Mannion Bay in Howe Sound, to encourage the protection of eelgrass in the bay. The marker buoys were designed with the same logo as those used in Puget Sound to make them easily recognizable to boaters sailing between borders. Onshore signage which encourages boaters to moor at depths beyond seven meters can also be an effective way to protect eelgrass beds.

SeaChange also works to restore eelgrass beds damaged by sunken ships. Currently, Transport Canada provides money to remove sunken derelict boats, but not the associated debris that remains on the ocean floor. SeaChange removes the debris to restore the eelgrass habitat in areas impacted by sunken ships.

Log booms also result in serious harm to eelgrass beds. SeaChange undertakes eelgrass restoration in many estuaries and bays used as former log storage areas.

Typically, when SeaChange conducts restoration projects they transplant ten shoots per meter squared along a transect line. The sites are monitored every six months for five years, with the inclusion of water quality sampling.

While restoration is important to improve degraded eelgrass habitats, it is not a long-term solution. Ultimately, conservation is the key to ensuring healthy ecosystems and the provision of all of their services.

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SPEED TALK SUMMARIES

Jacqui Levy, Simon Fraser University

Jacqui is a first-year Master's student at Simon Fraser University in the School of Resource and Environmental Management. She is supervised by Dr. Karen Kohfeld and is also working with Dr. Marlow Pellatt from Parks Canada.

Her three main research goals are to:

1. Measure greenhouse gas fluxes for water salinity and take soil cores in protected tidal marshes within Parks Canada sites (Pacific Rim National Park, Gulf Islands National Park) to understand carbon accumulation rates and storage, as well as the relationship between salinity and greenhouse gas fluxes;
2. Build a model of total net carbon storage for these marshes; and
3. Clarify the biogeochemical conditions that result in net carbon storage (i.e., high salinity may result in lower gas fluxes and greater net carbon storage).

Dr. Tim Webster, Nova Scotia Community College (NSCC)

Topo-Bathymetric Lidar: From Charting to Mapping Benthic Habitat

Topo-bathymetric lidar (TB-lidar) can be an important tool to map nearshore zones that cannot be accessed by boats or captured by other remote sensing methods (the "white ribbon" gap). The NSCC Leica Chiroptera 4X has a near infrared laser and green laser that penetrates the water column and maps the white ribbon gap. Since 2014, 4,303 km^2 of nearshore area around Maritime Canada has been mapped over 80 flights by the Chiroptera.

The workflow of this system starts with flight planning (airborne system); through processed trajectory, constructing discrete points from waveforms of the green laser, time segmented point clouds, point cloud tiles, and classified point cloud tiles; and finishing with raster tiles and raster analysis products (e.g., submerged aquatic vegetation). The original data is stored as the wave form of the green laser.

The efficacy of TB-lidar has been reported in three publications (see Webster et al. 2016a, Webster et al. 2016b, Webster et al. 2019). In Northern New Brunswick, an eelgrass density map was derived from TB-lidar data. The accuracy of eelgrass mapping was 86 per cent accurate when compared to quadrat drops and 92 per cent accurate when compared to biosonics echosounding. TB-lidar can also be used to map rockweed, an intertidal species that grows in southern Nova Scotia. By surveying rockweed at low tide (rockweed lays flat on the seabed) and high tide (rockweed is bladder-filled and floats, much like the tree canopy in terrestrial forest), TB-lidar can measure the seabed height directly from a single high tide flight and map the height of the rockweed, which can be further used to derive biomass.

Key takeaways:

- Topo-bathymetric lidar (TB-lidar) provides seamless elevation data across salt or fresh water-land boundary to depths of 15 meters, depending on water clarity. One benefit of TB-lidar is that it is not affected by salinity or water temperature like sound is and can be used to survey estuaries.
- TB-lidar is efficient and cost-effective. It can take a matter of hours to survey a whole bay.
- TB-lidar produces a 5 cm orthophoto (RGB, NIR), plus 2 points per square meter elevation data.
- There are more applications of TB-lidar than charting and more scientists are now using this method for benthic habitat, marine spatial planning, hydrodynamic models, storm surges, waves, waveform metric research, and improved point discretization.
- The Leica Chiroptera 4X has a significant increase in point density (4 times), improved target detail and detection limits, with potential for more direct benthic point classification (sea grass) with high accuracy (80-95 per cent accuracy) and expansion into the full benthic habitat.
- TB-lidar can also be used to map the biomass of floating submerged aquatic vegetation (e.g., rockweed, kelp).

GROUP DISCUSSIONS

Implementing an ecosystem approach

An ecosystem approach to blue carbon work means expanding work from ecological considerations to include social, cultural and economic concerns. It also involves working across blue carbon habitats; carbon is transported among systems and organic carbon stored in one system may have originated in another. Therefore, it is important to approach blue carbon work from a systems perspective, to understand how blue carbon ecosystems function as a whole. While some ecosystems may store more carbon than others, each system has value, contributes to carbon cycling and biodiversity and deserves focused attention.

Scaling blue carbon work up to the ecosystem-level, including a combination of salt marsh, seagrass and tidal forest habitats, would enable filling in data gaps across geographic scales rather than being singularly-focused. Connecting the landscape and seascape by considering the watershed-estuary connection and land-based threats would also support an ecosystem-based approach. Linking land and marine-based protections into one initiative could support protecting carbon stores from a systems perspective.

Building relationships with the land and ocean is an important part of taking an ecosystem approach. We can work towards this by learning from Indigenous approaches to living in relationship with land and water. By making the link between humans and their environment and building strong cultural, social and economic connections to our coastlines we can make progress towards conservation and sustainability. An important part of this is ensuring that everyone has access to the coastline; having access to the coast can change people's perspective on conservation and create an openness to the value of the ecosystem approach.

Challenges and opportunities

Blue carbon work occurs along the land-sea interface, increasing the complexity of projects that implement an ecosystem approach. Threats to blue carbon can originate in the terrestrial landscape or from offshore activity, which makes defining the boundaries of a project from an ecosystem perspective challenging. It can also be intimidating to engage with new sectors when developing multi-faceted projects. In addition, many organizations and departments have limited funding and capacity, which in turn acts as a barrier to innovation and integration and prevents people from exploring new topics and partnerships. Approaching land and marine use planning, and municipal climate change adaptation planning with an ecosystem approach could support working across complex landscapes and sectors while bringing together many stakeholders and rights holders.

Designing blue carbon projects to support food security results in several challenges. Climate change will lead to sea level rise, ocean acidification and large-scale system changes, all of which can influence the abundance and migration patterns of species used as food sources, such as waterfowl and fish. For example, there have been cases of mass die-offs of geese on the coasts and spikes of geese surviving in the Arctic, as well as changes in the productivity of the species depended upon for food. As well, designing restoration projects in blue carbon ecosystems to support food security can result in additional co-benefits and cascading effects, all of which need to be monitored long-term, increasing the complexity and cost of the project.

Jurisdictional complexity also poses a challenge to the ecosystem approach. Where multiple jurisdictions are involved, it is difficult to implement effective protection for ecosystems. As well, many municipalities are required to deal with issues that exist at a scale beyond what they can effectively address, such as sea level rise. We need a regional authority or organization to holistically address coastal flood protection, while still allowing for flexibility at the local government level.

Many data gaps related to blue carbon remain, constituting another key challenge to implementing the ecosystem approach. Filling carbon data gaps in the marine environment is difficult; unlike for terrestrial ecosystems, detailed models for metrics such as biomass growth and yield don't yet exist. These models are needed to understand the role that these systems play in reducing greenhouse gases. We also need a detailed understanding of ecosystem functioning, technical expertise to design solutions to climate change threats, social science-based knowledge to address social and economic issues and the perspectives of individuals and communities affected by climate change. This work needs to be value-based and include a wide variety of practitioners including biologists, landscape architects, and engineers.

Coordinated large scale data collection could be completed with leadership from the federal government. Inclusion of local communities and Indigenous governments is necessary to build projects and collect data that are meaningful at the local level. The inclusion of multiple levels of government would also help people navigate jurisdictional challenges and could support the adjustment of policies to make approaches more flexible. Hiring dedicated coordinators to create connections and facilitate networking would support breaking down silos and building collaborations across sectors.

RESEARCH NEEDS

Research is valuable and necessary to move forward with blue carbon work, however the goals of the research and its application need to be clear. Research should be used to understand the dynamics of ecosystems as well as move towards equity and social justice. Some areas where more research is needed include:

- Governance, including research related to the goals, approaches and implementation of blue carbon work;
- Social and behavioural science, to connect people with the conservation impacts of the decisions they make;
- Equity and justice in the marine environment, including how decisions are made and how decisions intersect with the social, economic and ecological components of the ecosystem approach; and
- Technical research on lateral fluxes of carbon, to understand the sources and sinks of carbon across ecosystems. This research should include the refinement of current methods used to measure carbon.

Encouraging an ecosystem approach

Some approaches that could encourage funders, researchers and policy makers to take an ecosystem approach include:

- Raising the profile of carbon and oceans to encourage more marine-based calls for proposals;
- Creating a best practices guide for practitioners on how to take an ecosystem approach;
- Generating interest in blue carbon ecosystems at the local level and facilitating a grass roots approach to blue carbon work;
- Making funding opportunities available for communities;
- Undertaking a needs assessment to guide researchers on the data needs of practitioners, policy makers and decision makers;
- Making information accessible, especially at the local level, and integrating concepts in an understandable way into maps, graphics and reports; and
- Selling the importance of blue carbon work to decision-makers and ensuring commitments for long-term work.

Supporting food security

Ecosystem health is particularly important for ensuring sustainable access to ocean-based foods. Climate change is a significant challenge for food security and will change the ecosystems we rely on for food. As a result of sea level rise existing infrastructure, such as dikes, will need to be moved, and areas between upland and marine systems will need to be demarcated to account for coastal squeeze. We need to work with communities to ensure that food sources from ecosystems threatened by sea level rise are maintained and integrated into the broader food system. We also need to maintain ecosystem health and functioning to ensure that harvesting is safe for communities. For example, blue carbon ecosystems provide valuable habitat for salmon and crab and could add filtering and sediment management benefits for shellfish fisheries that have shut down due to water quality issues. However, our current systems of decision-making are siloed, do not value ecosystem services that marine wetlands provide and do not account for cumulative effects.

The intersection of agriculture, wildlife habitat and climate change will become an increasingly important nexus as we work to support food security. Agricultural landscapes are under threat from climate change, affecting both food production and wildlife habitat. For example, in the Pacific Flyway, drained intercoastal wetland habitat that has been converted to agricultural lands has created tension between the goals of providing food security and maintaining wildlife habitat. Moving forward, tradeoffs between the value of coastal marsh habitat and compensation of the agricultural sector will need to be explored.

Multiple sources of evidence

Respect for local Indigenous knowledge is very important. Indigenous knowledge holders should not be grouped with other knowledge holders in a particular area, as outreach measures and conversations are unique to Indigenous Peoples. Each Indigenous knowledge holder should be treated with respect and consideration and their knowledge as its own entity with its own value. Indigenous knowledge should be incorporated in a way that is guided by the knowledge-holders' interests and intentions.

Collaboration and communication between Indigenous governments and interested stakeholders should be the starting point of any project. All organizations involved need to know which activities are being undertaken, by whom, and where collaboration can occur to have collective impact and avoid duplicative effort. Communication among groups needs to be improved, especially across regions and sectors.

There is a general lack of understanding on how to respectfully integrate Traditional Knowledge with western science. When working with Indigenous groups, relationship-building and co-creating project plans need to occur before project work starts. Including Indigenous Peoples and knowledge holders into blue carbon projects requires a fundamental shift in approach and adequate time for relationship-building must be included in funding proposals.

The terminology of "blue carbon" may be limiting and challenging. For example, biogeochemists working in coastal systems do not use blue carbon terminology but have substantial knowledge about carbon in these systems. As well, those who study fish in eelgrass systems do not commonly use blue carbon terminology. Indigenous governments and organizations may not use blue carbon terminology in reference to their work in coastal ecosystems. A major challenge in bringing people together who work in coastal systems is that the terminology is not consistent or widespread.

Platforms like these workshops and meetings that bring together people working in blue carbon systems to share challenges and knowledge, as well as discuss how to share this knowledge, are very beneficial. For example, meetings via Zoom during the covid-19 pandemic have demonstrated that information can still be shared across projects and areas, which can be used as a tool to bring groups together and communicate in the future.

KEY POINTS

Participants in the breakout sessions were asked to highlight key points that arose during their discussion. Included below is a summary of those key points. Note that no participants chose to discuss question 3.

What **work is being done in Canada using the ecosystem approach** that can help inform blue carbon work?

- Ecosystem approaches need to be integrated, comprehensive and holistic, including multiple threats to blue carbon ecosystems, overlapping jurisdictions, and different sources of carbon.
- Further research focused on technical science, behaviour and decision-making, governance, equity and justice is needed to support work on blue carbon. Understanding how people make decisions in relation to ecosystems will lead to more successful stewardship of blue carbon ecosystems.
- Multiple coordinator roles should be created and staffed to break down silos and bring people together to create meaningful change.

How do we build blue carbon projects to **support food security** and how do we make these projects **resilient to climate change**?

- The ecosystem approach is complicated and difficult to implement, but necessary, especially for tackling large scale issues such as climate change and ocean acidification.
- The ecosystem approach goes beyond ecological considerations and we should consider approaching governance, administrative and private sector activities from this perspective as well (e.g., insurance, land tenure, coastal businesses).
- Valuing people and their stories is important, especially as we work towards addressing future impacts of climate change.

How can we **encourage policymakers, funders, researchers and practitioners** to approach blue carbon work from an **ecosystem perspective**?

- The ecosystem approach and the role of blue carbon should be communicated in a way that is both meaningful and measurable.
- Projects need to be relevant to local communities to gain community buy-in.
- Carbon storage is just one co-benefit of blue carbon work, which provides many ecosystem services, such as protecting and restoring important habitats.

How can we ensure we include **multiple sources of evidence including local, Indigenous and scientific knowledge** to strengthen our blue carbon work?

- Collaboration, communication, and respect for knowledge holders is very important and knowledge holders should control how their knowledge is applied.
- Relationship and partnership building needs to be included in funding proposals. Relationships and shared goals need to be in place before moving forward with projects.
- "Blue carbon" terminology creates a challenge; we need to improve how we communicate about this work and how we make this work inclusive.

APPENDICES

Workshop Agenda

Building Connections for Blue Carbon Across Canada

Ecosystem Approach – March 24th 2021

10am-12:30pm PST, 1pm-3:30pm EST, 2pm-4:30pm AST, 2:30pm-5pm NST

How do we develop blue carbon policy, research and practice with an ecosystem approach?

Workshop Objectives

Through a series of focused workshops, these sessions will bring together a range of blue carbon researchers and practitioners from across Canada to:

- Facilitate connections within the blue carbon community and share information about ongoing blue carbon work
- Discuss key questions on blue carbon research, policy and application
- Identify areas of opportunity to advance collaboration on blue carbon across Canada

1:00 – 1:15pm EST	**Welcome**
1:15 – 2:05pm EST	**Invited Speakers** • Marlow Pellatt and Chantal Vis, Parks Canada • Ernie Rabbitskin and Marc Dunn, Niskamoon Corporation • Anu Rao, Ekalogical Connections, Contractor to Tsleil-Waututh Nation • Nikki Wright, SeaChange Marine Conservation Society
10 minute break	
2:15 – 3:15pm EST	**Breakout Groups – focused discussions**
3:15 – 3:25pm EST	**Speed Talks – getting to know our community** • Jacqui Levy, Simon Fraser University • Timothy Webster, Nova Scotia Community College
3:25 – 3:30pm EST	**Wrap Up**

Discussion questions:

1. What work is being done in Canada using the ecosystem approach that can help inform blue carbon work?
2. How can we encourage policymakers, funders, researchers and practitioners to approach blue carbon work from an ecosystem perspective?
3. How do we integrate wildlife management and conservation into blue carbon policy, research and practice?
4. How do we build blue carbon projects to support food security and how do we make these projects resilient to climate change?
5. How can we ensure we include multiple sources of evidence including local, Indigenous and scientific knowledge to strengthen our blue carbon work?

Next up:

Next Steps, April 14th

Participant List

Participants were asked upon registration if they would like their names, organizations and emails included in a summary report to facilitate connections within the blue carbon community. The participants who answered 'yes' to that question appear in the table below.

Name	Organization	Email
Hosts		
Brianne Kelly	WWF-Canada	bkelly@wwfcanada.org
Caroline Martin	WWF-Canada	cmartin@wwfcanada.org
Facilitation Team		
Genevieve Donin	Stratos Inc.	gdonin@stratos-sts.com
Barb Sweazey	Stratos Inc.	bsweazey@stratos-sts.com
Izak Weinstein	Stratos Inc.	iweinstein@stratos-sts.com
Discussion Leads and Notes Takers		
Jacklyn Barrs	WWF-Canada	jbarrs@wwfcanada.org
Jessica Currie	WWF-Canada	jcurrie@wwfcanada.org
Kim Dunn	WWF-Canada	kdunn@wwfcanada.org
Emily Giles	WWF-Canada	egiles@wwfcanada.org
Erin Keenan	WWF-Canada	ekeenan@wwfcanada.org
Sarah Saunders	WWF-Canada	ssaunders@wwfcanada.org
Invited Speakers		
Marlow Pellatt	Parks Canada	marlow.pellatt@canada.ca
Chantal Vis	Parks Canada	chantal.vis@canada.ca
Ernie Rabbitskin	Niskamoon Corporation	erabbitskin@niskamoon.org
Marc Dunn	Niskamoon Corporation	mdunn@niskamoon.org
Anu Rao	Ekalogical Connections	arao@twnation.ca
Nikki Wright	SeaChange Marine Conservation Society	nikki@seachangelife.org

Speed Talkers		
Jacqui Levy	Simon Fraser University	jacqui_levy@sfu.ca
Tim Webster	Nova Scotia Community College	timothy.webster@nscc.ca
Participants		
James Casey	Birds Canada	jcasey@birdscanada.org
Angela Danyluk	City of Vancouver	angela.danyluk@vancouver.ca
Charlynne Robertson	Clean Foundation	crobertson@clean.ns.ca
Julia Stoughton	Clean Foundation	jstoughton@clean.ns.ca
Anuja Kapoor	Fisheries and Oceans Canada	anuja.kapoor@dfo-mpo.gc.ca
Jack Daly	Fisheries and Oceans Canada	jack.daly@dfo-mpo.gc.ca
Lucianne Ceschini	Fisheries and Oceans Canada	lucianne.ceschini@dfo-mpo.gc.ca
Carolyn Prentice	Hakai Institute	carolyn.prentice@hakai.org
Sachiko Ouchi	Kitselas First Nation	MRSO@kitselas.com
Tanya Prystay	Marine Institute	tanya.prystay@mi.mun.ca
Evan Andrews	Memorial University	evana@mun.ca
Holly Booker	North Coast-Skeena First Nations Stewardship Society	holly.booker@ncsfnss.ca
Robyn Holwell	NunatuKavut Community Council	rholwell@nunatukavut.ca
Marie Fernandes	Parks Canada	marie.fernandes@canada.ca
Candace Newman	Parks Canada	candace.newman@canada.ca
Rémi Donelle	Shediac Bay Watershed Association	sbwa@nbnet.nb.ca
Jennie Wang	Statistics Canada	Jennie.Wang@canada.ca
Stéphane O'Carroll	Université de Moncton	stephane.o.carroll@umoncton.ca
Matt Christensen	University of British Columbia	msc01@zoology.ubc.ca

Blue Carbon Initiatives and Resources

Below is a list of blue carbon initiatives and resources mentioned by participants during the workshop.

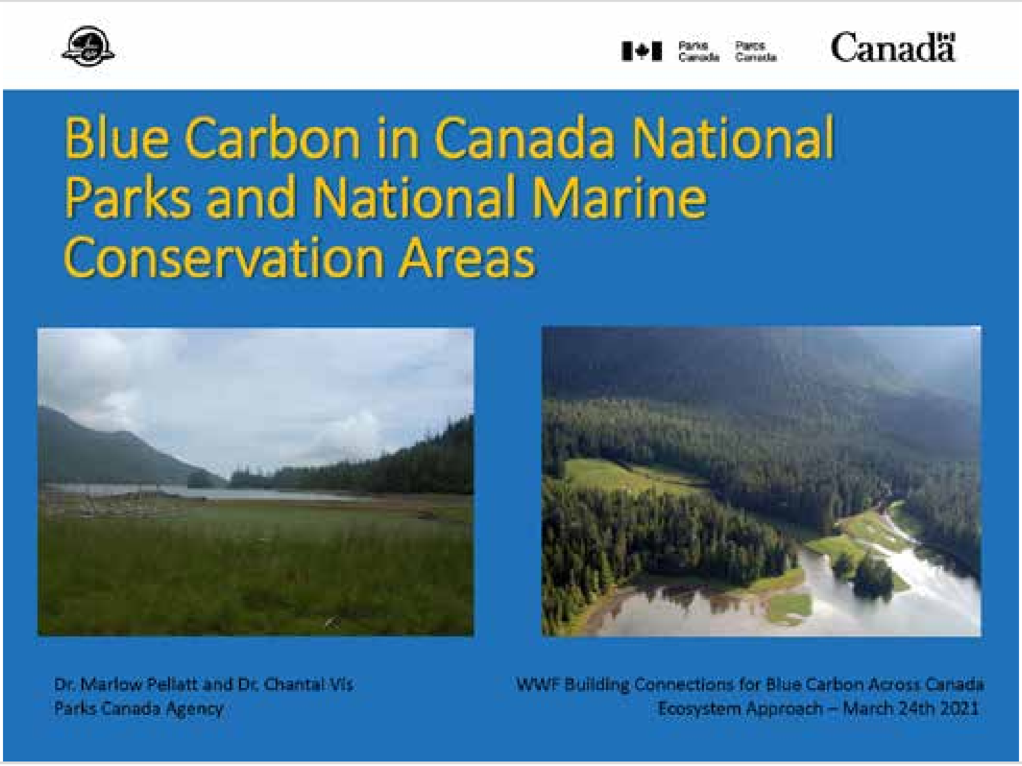
- Applied Geomatics Research Group YouTube Channel – ecosystem monitoring using topo-bathymetric lidar
- Burrard Inlet Action Plan
- Islands Trust Eelgrass Mapping
- Native Land – map of Indigenous territories
- Seagrass Conservation Working Group – Conservation, restoration and stewardship in British Columbia
- SeaChange Marine Conservation Society
- Towards Reconciliation: 10 Calls to Action to natural scientists working in Canada

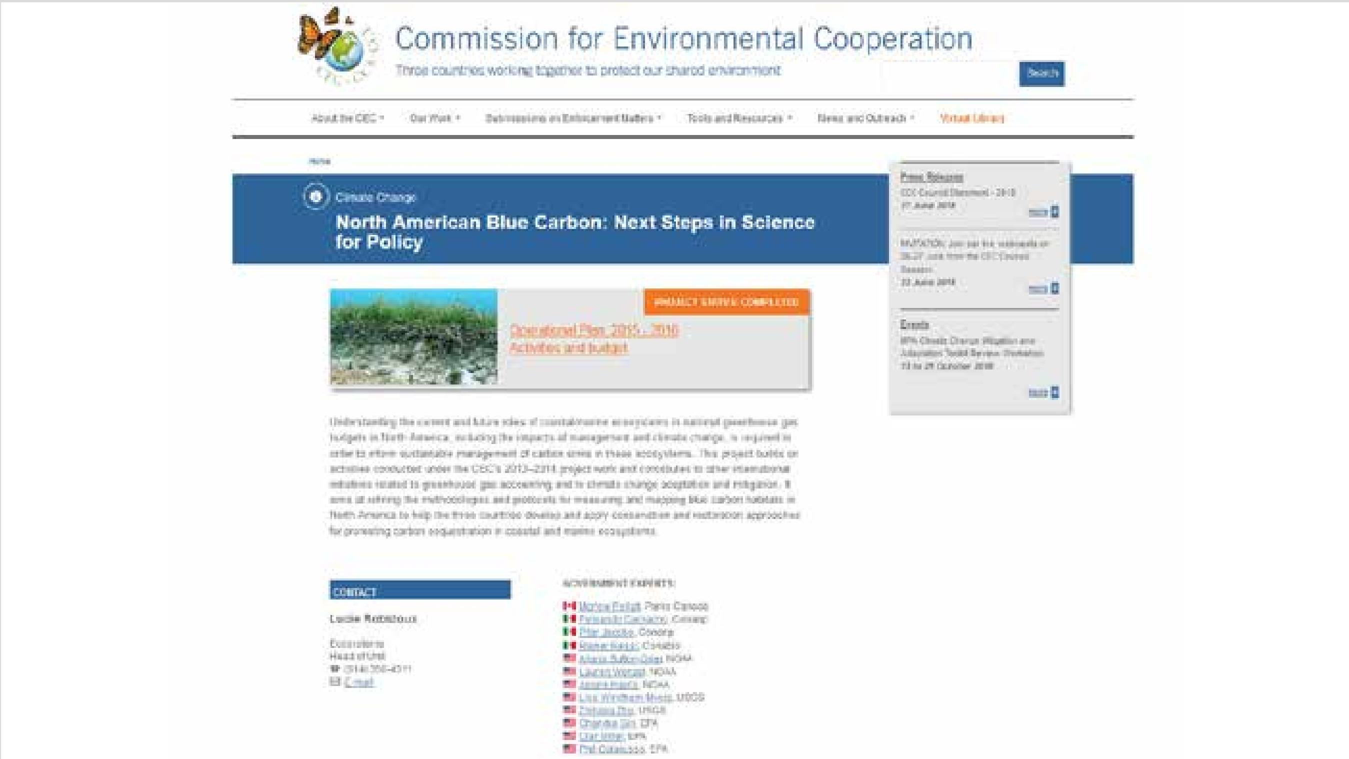
PUBLICATIONS

- Postlethwaite et al. 2018 Low blue carbon storage in eelgrass (Zostera marina) meadows on the Pacific Coast of Canada. PLOS One. doi.org/10.1371/journal.pone.0198348
- Chastain et al. 2018 Carbon stocks and accumulation rates in salt marshes of the Pacific Coast of Canada. Biogeosciences. doi.org/10.5194/bg-2018-166
- Webster et al. 2016a Optimization of data collection and refinement of post-processing techniques for Maritime Canada's first shallow water topographic-bathymetric Lidar survey. Journal of Coastal Research, 76: 31-43
- Webster et al. 2016b Webster, T., McGuigan, K., Crowell, N., Collins, K., & MacDonald, C. (2016). Remote Predictive Mapping 7. The Use of Topographic–Bathymetric Lidar to Enhance Geological Structural Mapping in Maritime Canada. Geoscience Canada, 43(3), 199–210
- Webster et al. 2019 Calculating macroalgal height and biomass using bathymetric LiDAR and a comparison with surface area derived from satellite data in Nova Scotia, Canada. Botanica Marina, 63: 43-59.

Presentation pdfs

Invited talks





Blue Carbon Project

Blue carbon is a term that recognizes the role of coastal wetlands in the global carbon cycle. Tidal marshes, tidal forested wetlands, and seagrasses sequester carbon dioxide from the atmosphere continuously over thousands of years, building stocks of carbon in organic-rich soils.

Government Initiatives

- Under the Paris Agreement, Canada committed to reduce GHG emissions to 30% of 2005 levels by 2030 and net-zero by 2050. This goal includes "natural solutions" for climate change mitigation.
- This pandemic has reminded Canadians of the importance of nature. The Government will work with municipalities as part of a new commitment to expand urban parks, so that everyone has access to green space. This will be done while protecting a quarter of Canada's land and a quarter of Canada's oceans in five years, and using nature-based solutions to fight climate change, including by planting two billion trees.

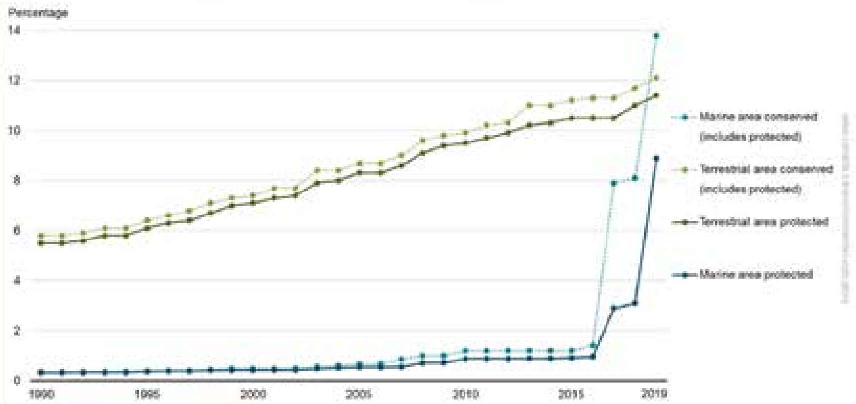
Status of Marine and Terrestrial Protection in Canada

National conserved areas

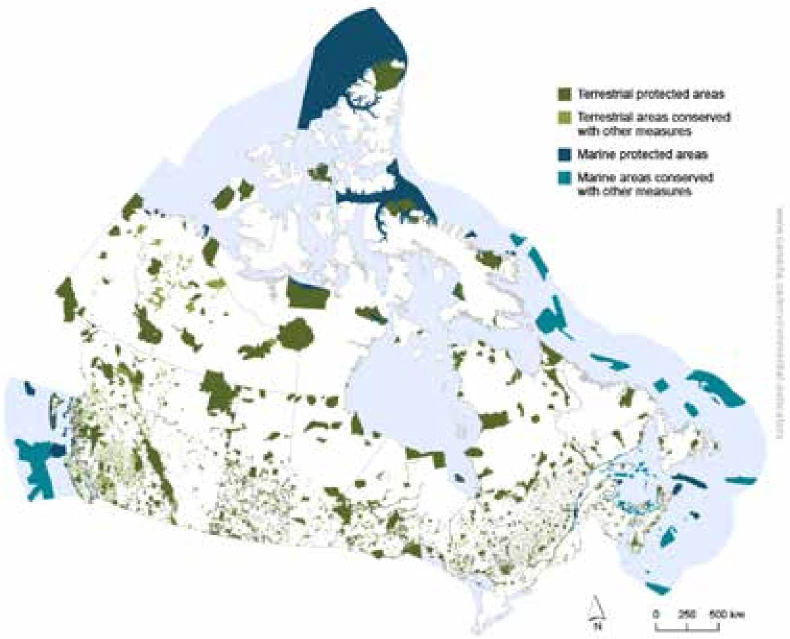
Key results

- At the end of 2019, Canada had
  - 12.1% of its terrestrial area (land and freshwater) conserved, including 11.4% in protected areas
  - 13.8% of its marine territory conserved, including 8.9% in protected areas

Proportion of area conserved, Canada, 1990 to 2019



Conserved areas, Canada, 2019



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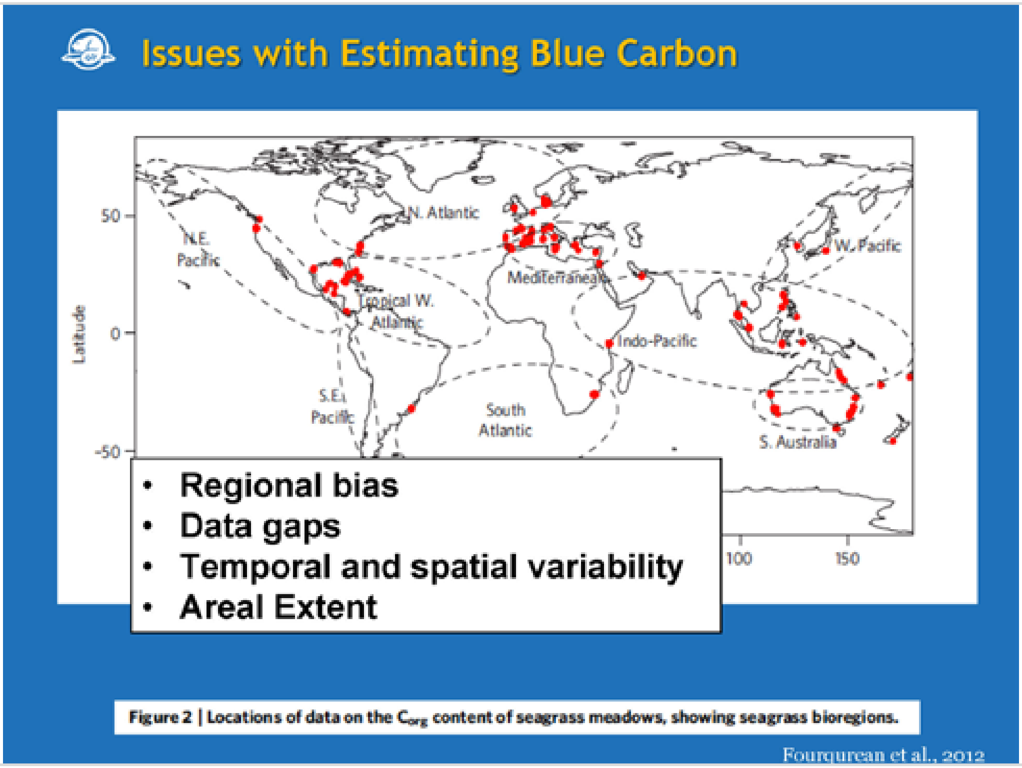
This presents us with a tremendous opportunity to understand "blue carbon" systems and develop mechanisms to conserve carbon stocks and enhance sequestration.

Through ecological restoration/reclamation, the development of "green" coastal management and engineering projects such as soft shores and living dikes, we can develop an approach to biodiversity conservation and protected area establishment that provides for GHG mitigation (or at minimum reduces carbon mobilization) as a co-benefit.


Issues with Estimating Blue Carbon
N. Atlantic
N.E. Pacific
W. Pacific
Mediterranean
Tropical W. Atlantic
Indo-Pacific
S.E. Pacific
South Atlantic
S. Australia
Latitude
50
0
-50
100
150
• Regional bias
• Data gaps
• Temporal and spatial variability
• Areal Extent
Figure 2 | Locations of data on the C_{org} content of seagrass meadows, showing seagrass bioregions.
Fourqurean et al., 2012


Ongoing Research
Quantifying blue carbon for the largest salt marsh in southern British Columbia: implications for regional coastal management
Low blue carbon storage in eelgrass (Zostera marina) meadows on the Pacific Coast of Canada
Carbon Stocks and Accumulation Rates in Salt Marshes of the Pacific Coast of Canada
• Four completed MRM thesis
• Three ongoing MRM/MSC projects

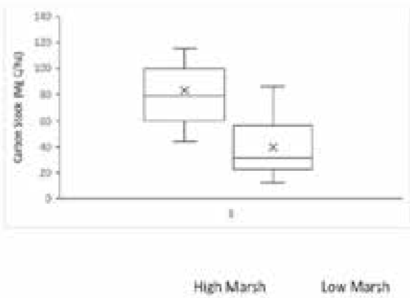
Team Effort

Researchers

Marlow Pellatt
Karen Kohfold
Cliff Robinson
Jenn Yakimishyn
Victoria Postlethwaite
Aimee McGowen
Stephen Chastain
Maija Gailis
Hasini Basnayake
Alison Martin
Jacob Demers
Jacqui Levy

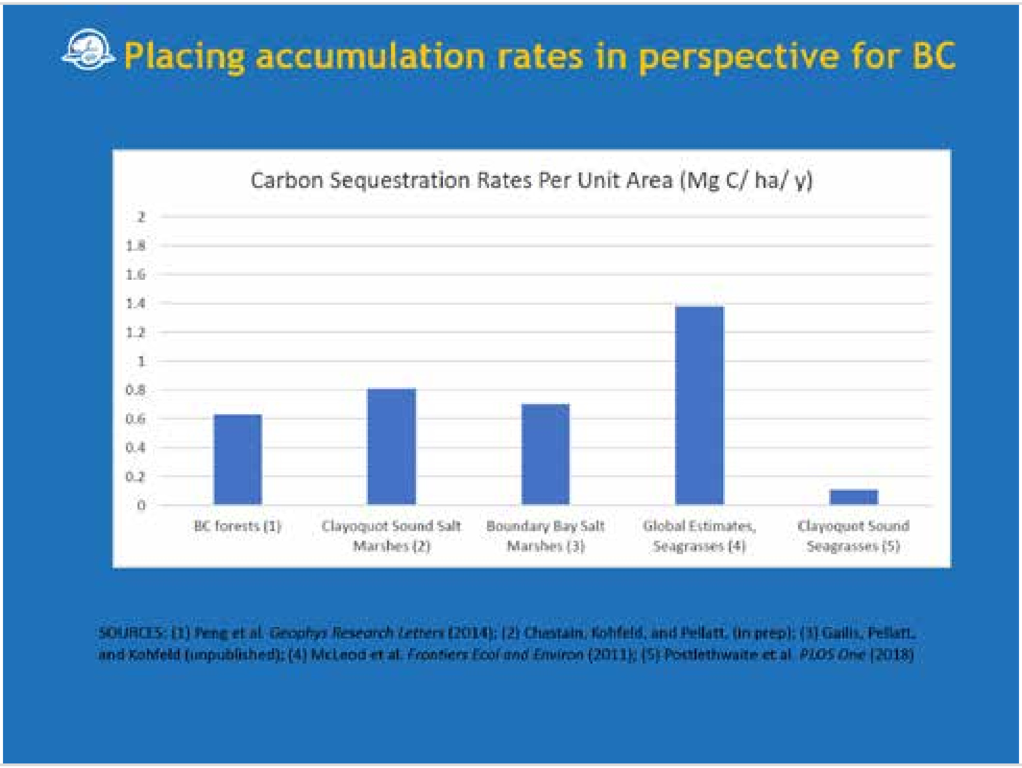
Funding
Parks Canada
NSERC (SFU)
CEC
MITACS

Boundary Bay Saltmarsh Carbon Stocks



Distribution of carbon stocks (MgC/ha) for high marsh (n=13) and low marsh cores (n=9). The middle line is the median and the top and bottom of the box are quantiles (Q1 and Q3); the error bar is the largest and smallest value, and the x is the mean. Differences between high and low marsh are statistically significant for percent organic carbon t-value=3.602, p-value=0.0009, $p<0.05$).

Gailis et al in press



Placing accumulation rates in perspective for BC
Carbon Sequestration Rates Per Unit Area (Mg C/ ha/ y)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
BC forests (1)
Clayoquot Sound Salt Marshes (2)
Boundary Bay Salt Marshes (3)
Global Estimates, Seagrasses (4)
Clayoquot Sound Seagrasses (5)
SOURCES: (1) Peng et al. *Geophys Research Letters* (2014); (2) Chastain, Kohfeld, and Pellatt, (in prep); (3) Gailis, Pellatt, and Kohfeld (unpublished); (4) McLeod et al. *Frontiers Ecol and Environ* (2011); (5) Postlethwaite et al. *PLOS One* (2018)

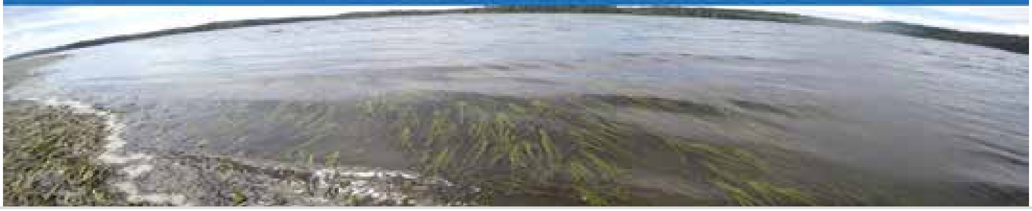
Parks Canada: Pan-Canadian Blue Carbon Project
Marine Regions
National Marine Conservation Area (NMCA) System
Proposed NMCA
NMCA
NMCA Reserve
Interim Protection
ARCTIC OCEAN
ATLANTIC OCEAN
PACIFIC OCEAN
Ongoing
Proposed

1. Significant Data gaps still exist for Canada.

2. Opportunities exist to position blue carbon as a nature based solution to climate change but a better understanding of GHG fluxes, stocks and accumulation rates are needed to determine the importance of blue carbon in Canada's coastal and marine ecosystems.

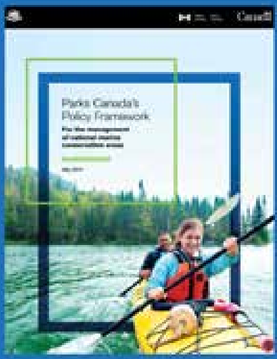
3. The regional role at the municipal level including restoration efforts are essential i.e., the Living Dike Project (WCEL).

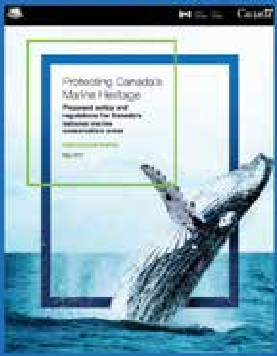
4. Increased interest at all levels of government is occurring - policy and management in Canada is beginning too catch up.



Marine Conservation at Parks Canada

- Establishment of new NMCAs – contribute to the 30% by 2030
- Currently updating National Marine Conservation Areas (MPA) program policy (e.g. Let's talk NMCAs)
  - Management
  - Regulations
  - Monitoring program
- Federal minimum protection standards for MPAs – prohibition on bottom trawling
- Working with Mexico and USA via NAMPAN (North American MPA Network) – including collaboration on blue carbon





National Marine Conservation Areas/ Coastal National Parks

- protection and restoration of coastal blue carbon habitats
- management measures and carbon (e.g. no bottom trawling)

Article — Nature

Protecting the global ocean for biodiversity, food and climate

We find that a substantial increase in ocean protection could have triple benefits

- by protecting biodiversity
- boosting the yield of fisheries
- securing marine carbon stocks that are at risk from human activities.

Bottom trawling releases as much carbon as air travel, landmark study finds

Dragging heavy nets across seabed disturbs marine sediments, world's largest carbon sink, scientists report

The Guardian March 17, 2021

Trawling for Fish May Unleash as Much Carbon as Air Travel, Study Says

The report also found that strategically conserving some marine areas would not only safeguard imperiled species but sequester vast amounts planet-warming carbon dioxide, too.

New York Times March 17, 2021

Parting Thoughts

1. LOCALLY, coastal salt marshes have potential as climate change mitigation co-benefit alongside other ecosystem services (biodiversity; wildlife habitat)
2. BUT we **need to improve data type, quality, and quantity** before truly understanding the role of blue-carbon in climate change mitigation.
   - Stocks, Accumulation rates, Area/Volume, Greenhouse Gas Budgets, Salinity gradients, Lateral Transfer of Carbon.
3. Projected sea level rise means many coastal salt marshes will be subject to "coastal squeeze." They are sandwiched between the ocean and hard infrastructure, such as seawalls and dykes, and will be constrained as sea level rises – hence creative infrastructure needs to be developed (e.g., living dyke – Deborah Carlson's talk).
4. Other sources of blue carbon.
5. Bottom up and Top down approach to maximize the use of blue carbon as a nature based solution to climate change mitigation.

Eelgrass Beds in eastern James Bay – A First Nations Research Collaboration

Presented by
Marc Dunn & Ernie Rabbitskin
Niskamoon Corporation, Eeyou Istchee (James Bay), Qc

Building Connections for Blue Carbon Across Canada

March 24, 2021

NISKAMOON CORPORATION

- Non-profit James Bay Eeyou (Cree) organization.
- Remediating impacts from hydroelectric development on the territory.
- Close collaboration with Cree land users (hunters, fishers and trappers).
- Work with academic researchers to understand complex, large-scale problems.

Eelgrass Beds in eastern James Bay

- Qualified in 1970s as “significant” coastal habitat (waterfowl, fish, etc.)
- Major staging habitat for waterfowl.
- Part of complex system of wildlife management by coastal hunters, designed to maximize short- and long-term objectives.
- Slow decline began in 1980s, followed by crash in late 1990s.

MISKAMOON CORPORATION

How to study eelgrass?

Focus on beds

Vs.

Eelgrass beds + wildlife

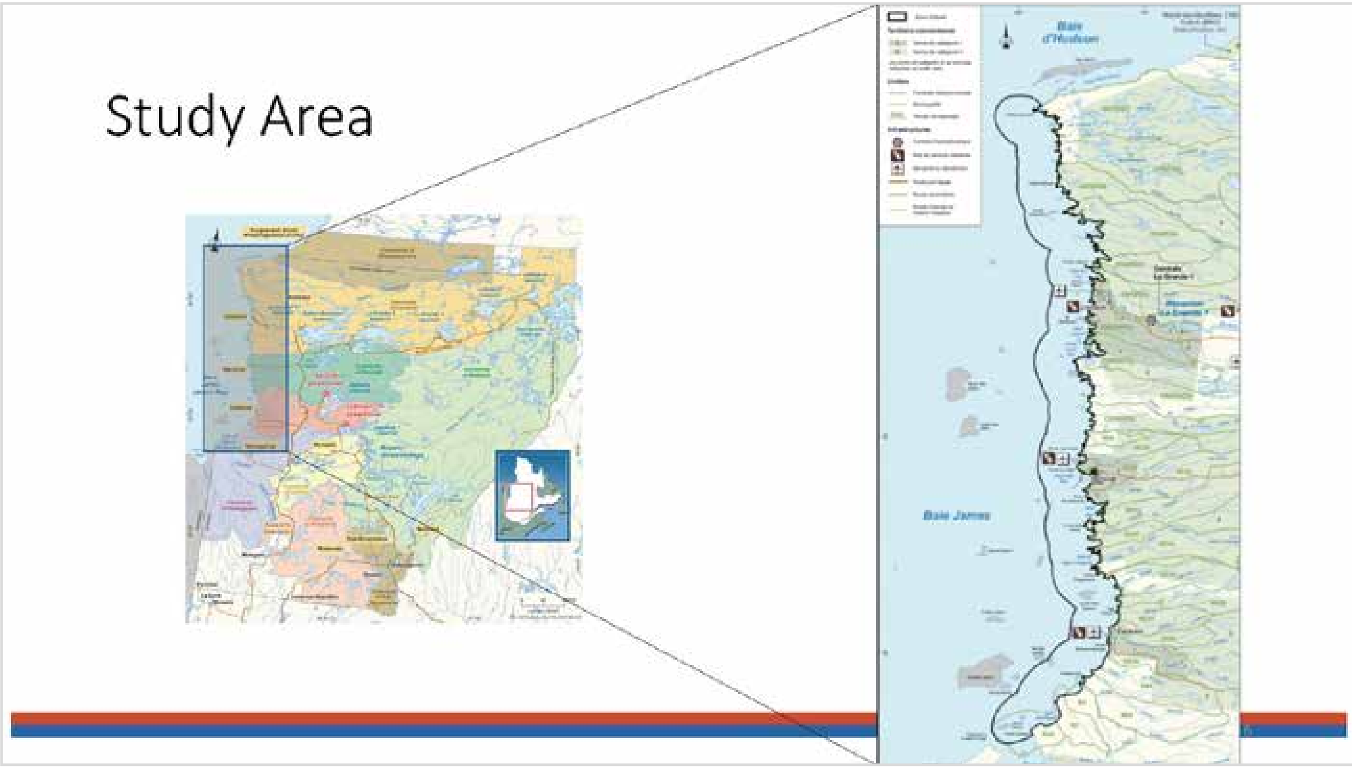
Vs.

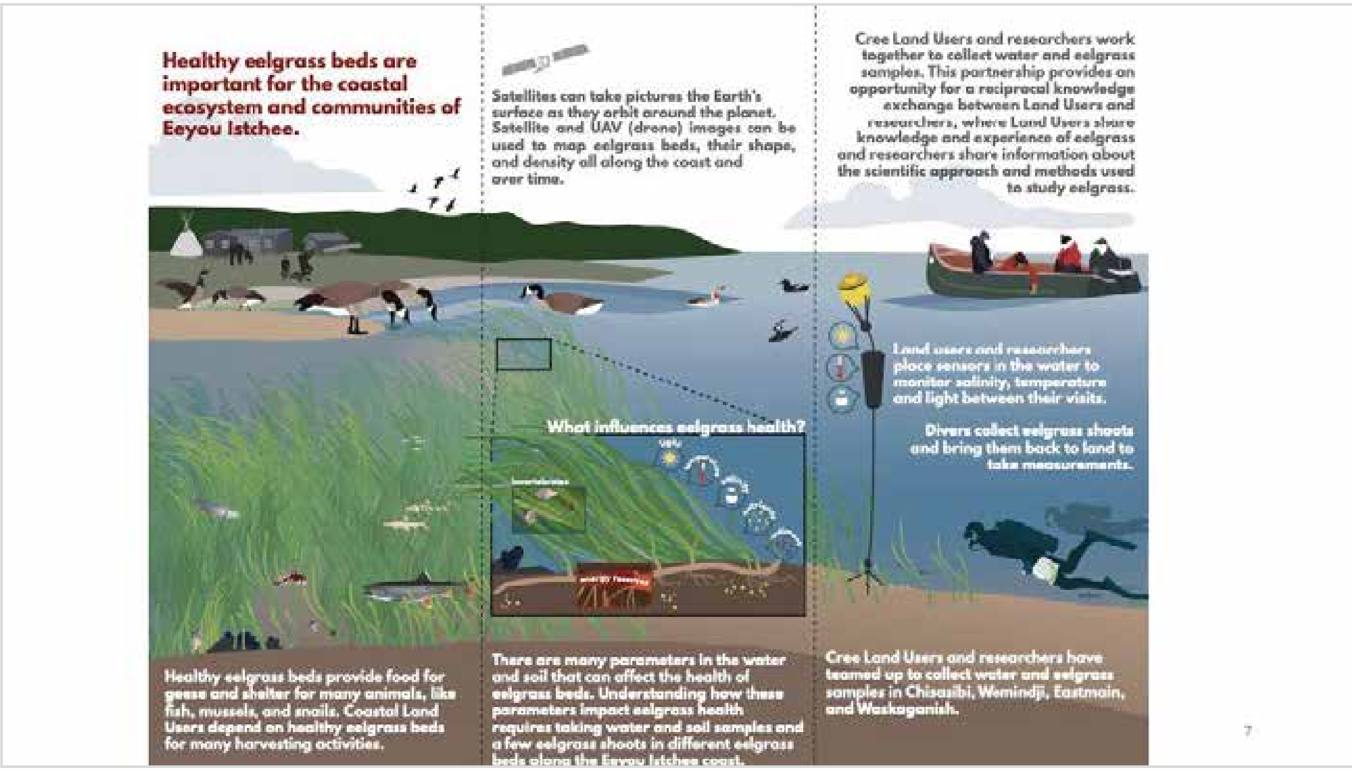
Eelgrass beds + wildlife + broader coastal processes

MISKAMOON CORPORATION

Coastal Habitat Comprehensive Research Program

- Six universities.
- Four Cree communities.
- 480-km of coastline
- Five teams:
  - ➢ Eelgrass team
  - ➢ Oceanography team
  - ➢ River inputs team
  - ➢ Waterfowl team
  - ➢ Cree Traditional Ecological Knowledge and Land Use Team


Study Area
Baie d'Hudson
Baie James


Healthy eelgrass beds are important for the coastal ecosystem and communities of Eeyou Istchee.
Satellites can take pictures the Earth's surface as they orbit around the planet. Satellite and UAV (drone) images can be used to map eelgrass beds, their shape, and density all along the coast and over time.
Cree Land Users and researchers work together to collect water and eelgrass samples. This partnership provides an opportunity for a reciprocal knowledge exchange between Land Users and researchers, where Land Users share knowledge and experience of eelgrass and researchers share information about the scientific approach and methods used to study eelgrass.
Land users and researchers place sensors in the water to monitor salinity, temperature and light between their visits.
What influences eelgrass health?
Divers collect eelgrass shoots and bring them back to land to take measurements.
Healthy eelgrass beds provide food for geese and shelter for many animals, like fish, mussels, and snails. Coastal Land Users depend on healthy eelgrass beds for many harvesting activities.
There are many parameters in the water and soil that can affect the health of eelgrass beds. Understanding how these parameters impact eelgrass health requires taking water and soil samples and a few eelgrass shoots in different eelgrass beds along the Eeyou Istchee coast.
Cree Land Users and researchers have teamed up to collect water and eelgrass samples in Chisasibi, Wemindji, Eastmain, and Waskaganish.
7

Focus on Collaboration and Co-Creation of Knowledge

- Cree Land Users are:

Boat drivers
Guides
Security Officers
Knowledge-keepers
Peer reviewers
Key beneficiaries
SCUBA Divers
Friends

Ecosystem Approach

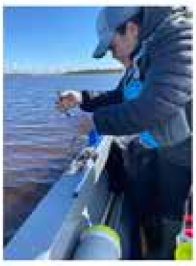
- Land users apply complex knowledge systems to make decisions about how they will work within the constraints of nature to benefit from the resources that are available.

- They can only look at the system as a whole.

- Ecosystem approach is therefore in line with their holistic scale of observation.

Challenges

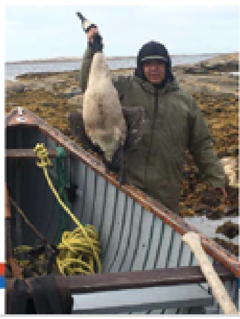
- Large study area in an open system.
- Climate change!
- Broad environmental change
- Access restricted to five points over 480 km.
- Jurisdictional issues…



Why Blue Carbon?

"It's important to remember that First Nations did not create this climate change problem, but we are living with the consequences, and we want to be part of the solution."

Ecosystem Approach + First Nations Collaboration = Food Security + Safety



Questions? Concerns?

Thank you • Meegwetch
• Ginskoumdinnaan •

MISKAMOON CORPORATION

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Speed talks

Research Goals 2021:

1) Greenhouse gas flux measurements and soil cores in protected tidal marshes within Parks Canada.

2) Build a model of total net carbon storage for these marshes.

3) Clarify the biogeochemical conditions that result in net carbon storage.

- Contact: Jacqui Levy, Simon Fraser University, Jacqui_levy@sfu.ca
- Partners and funding: Marlow Pellatt with Parks Canada and Karen Kohfeld, SFU COPE lab.

Topo-Bathymetric Lidar: From Charting to mapping Benthic Habitat

Research Scientist

Tim Webster, PhD

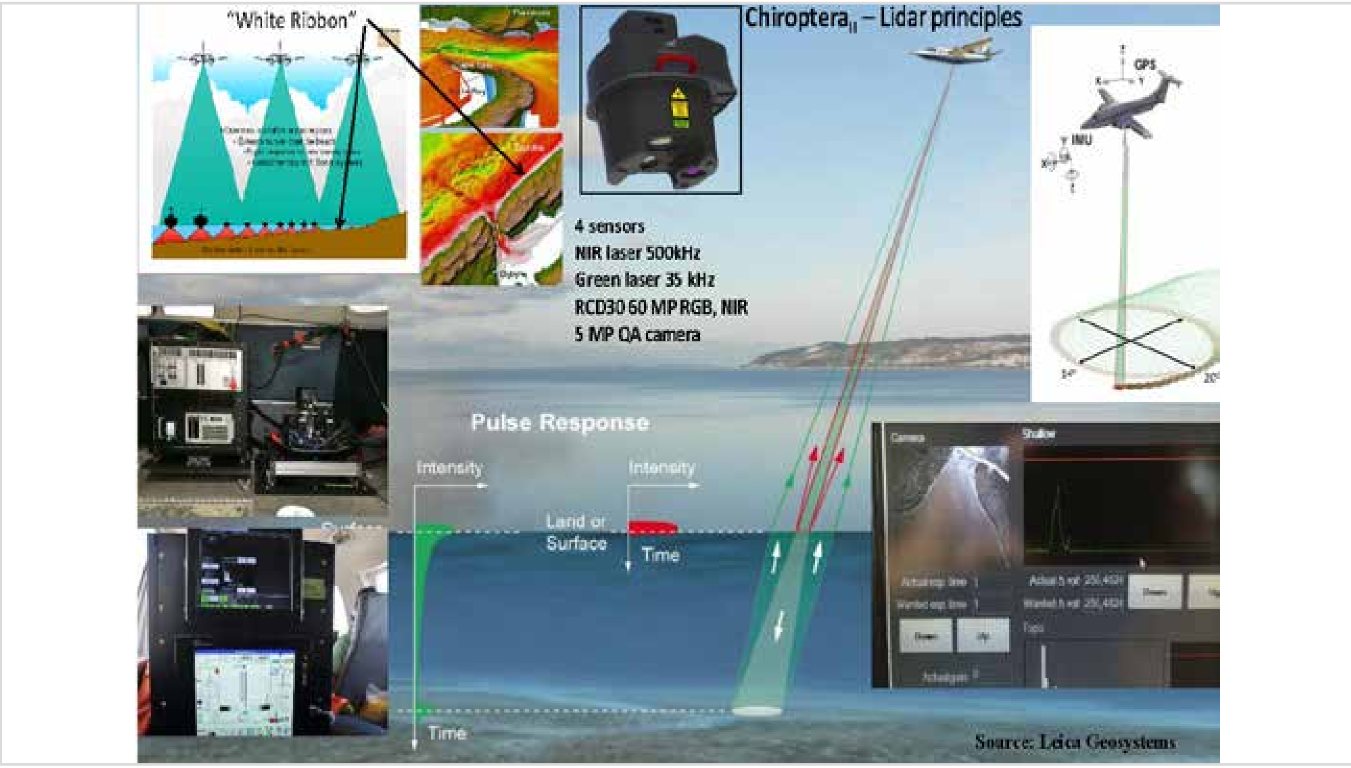
nscc Applied Research

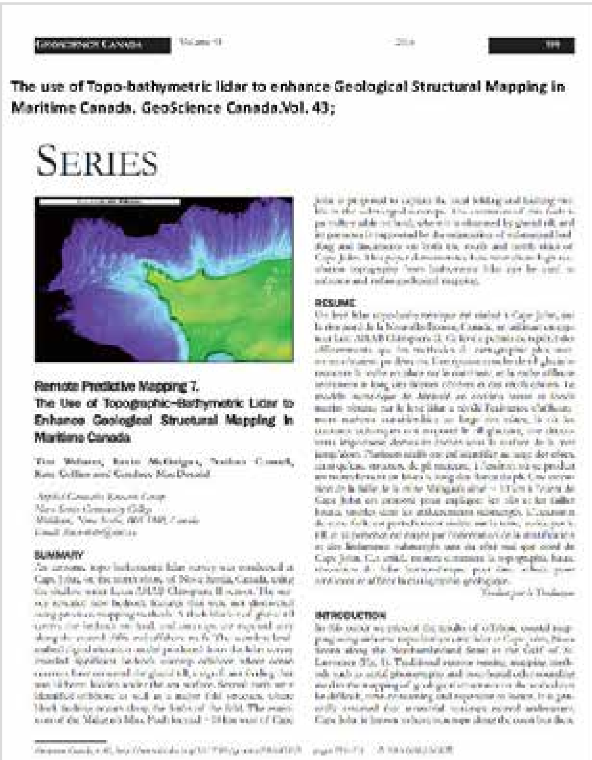
NSERC CRSNG

AGRG Applied Geomatics Research Group

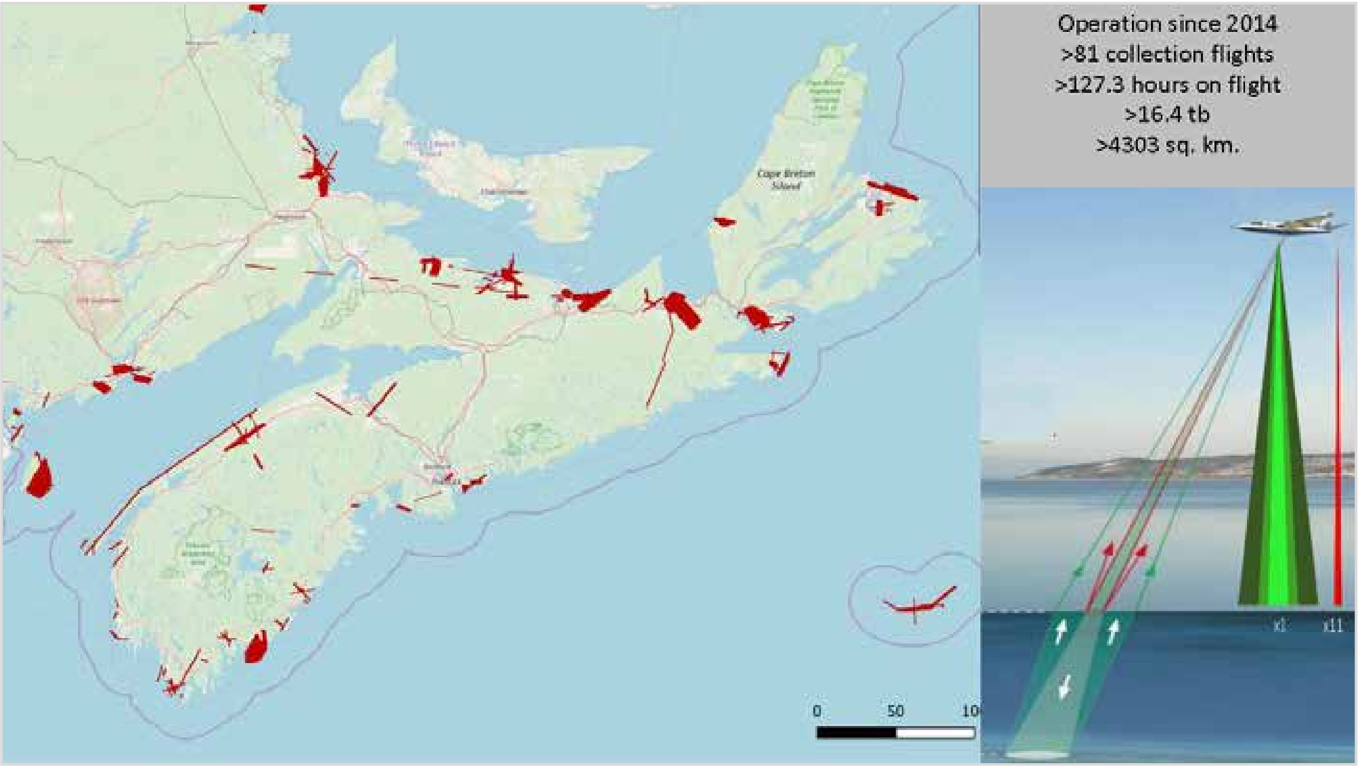
INNOVATION.CA CANADA FOUNDATION FOR INNOVATION | FONDATION CANADIENNE POUR L'INNOVATION

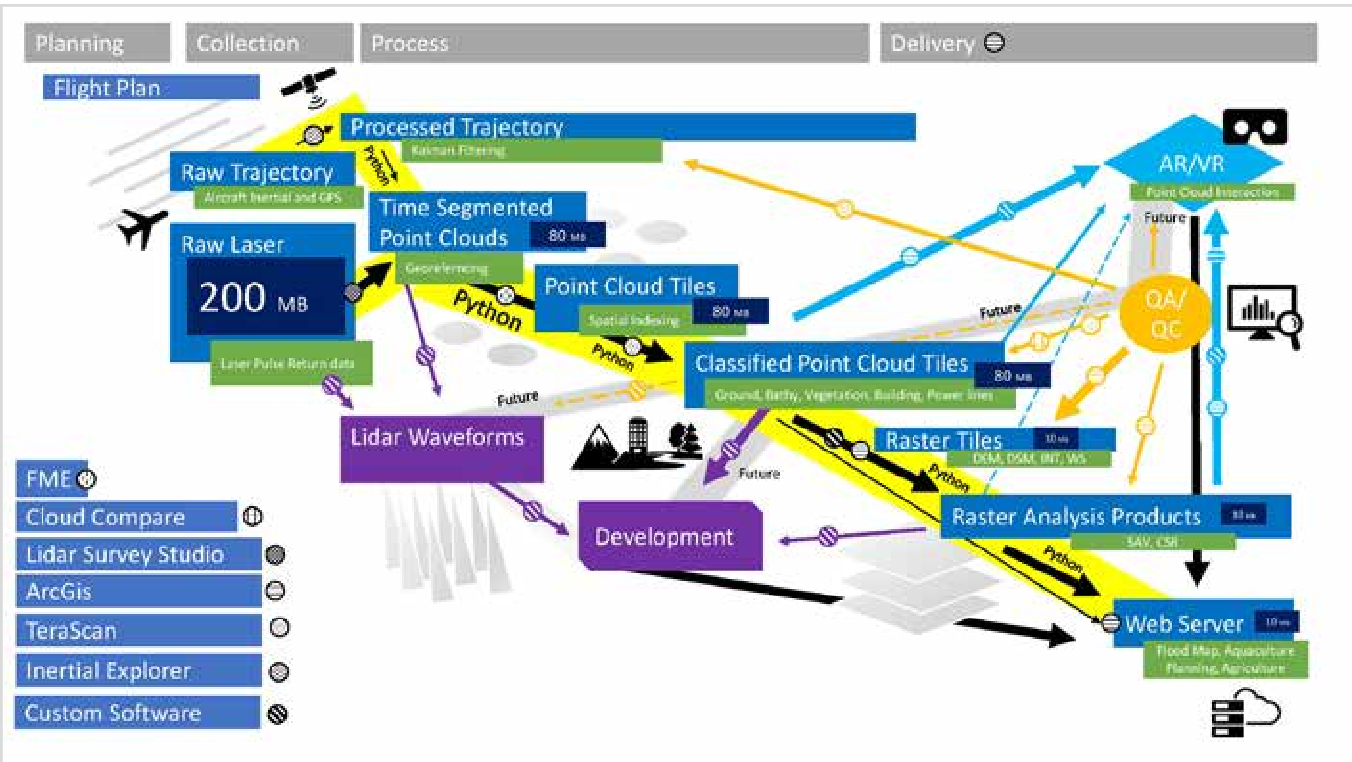
NSRIT Nova Scotia Research and Innovation Trust

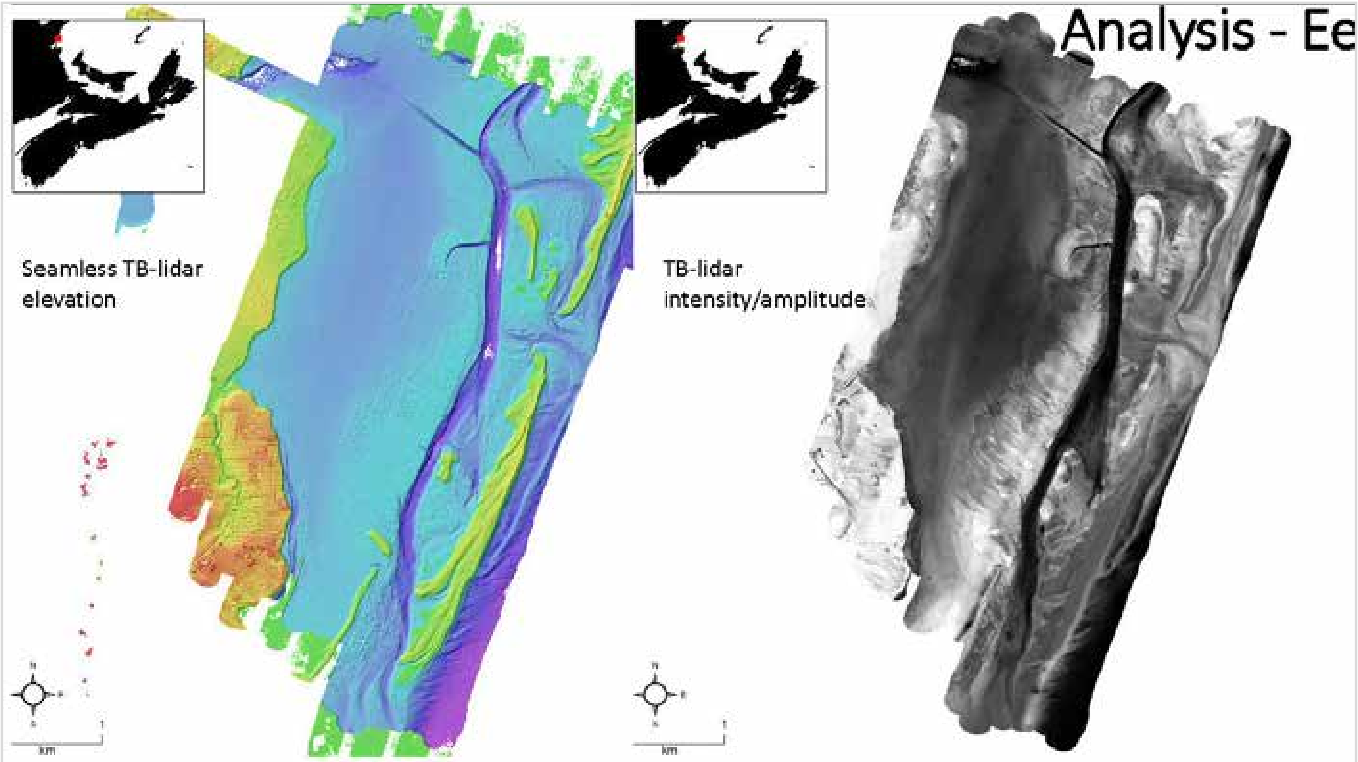

"White Ribbon"
Chiroptera II – Lidar principles
4 sensors
NIR laser 500kHz
Green laser 35 kHz
RCD30 60 MP RGB, NIR
5 MP QA camera
GPS
IMU
Pulse Response
Intensity
Intensity
Land or Surface
Time
Time
Source: Leica Geosystems

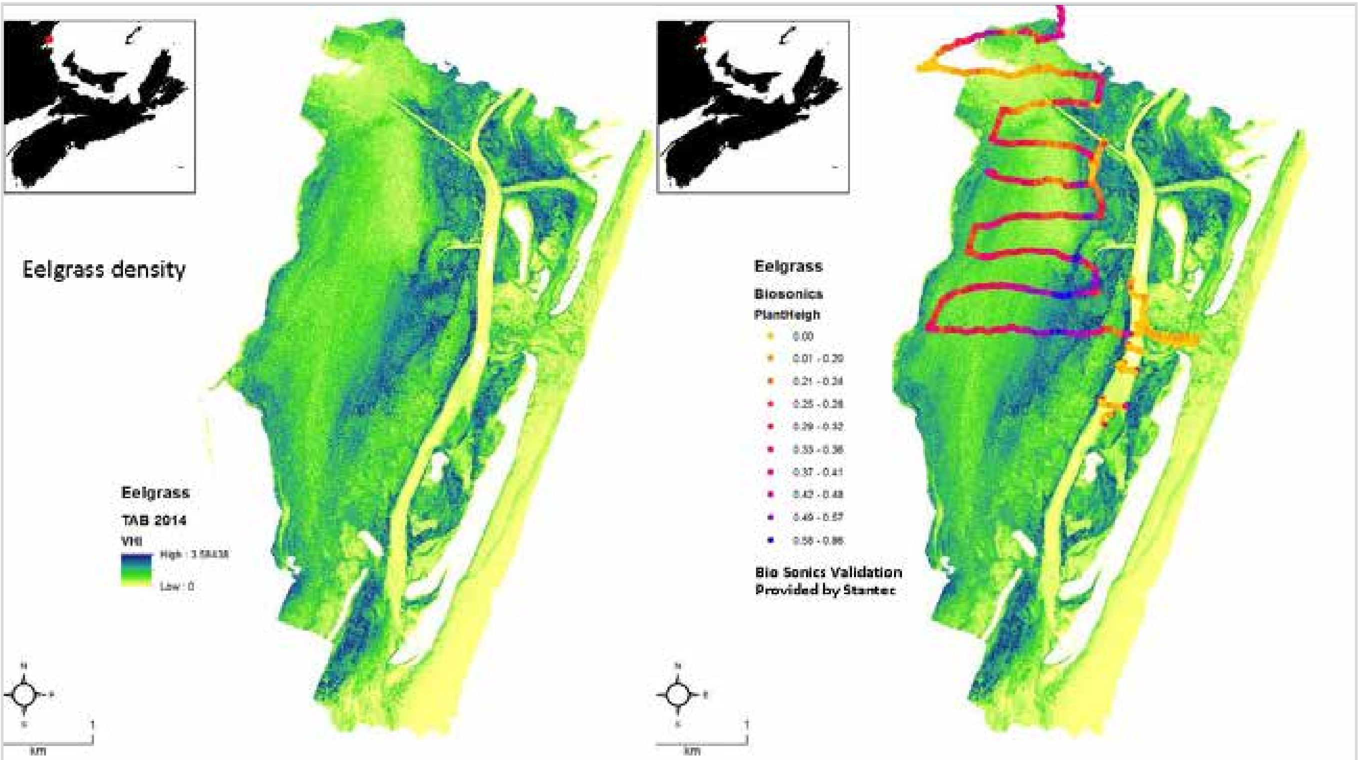

The use of Topo-bathymetric lidar to enhance Geological Structural Mapping in Maritime Canada. GeoScience Canada.Vol. 43;
SERIES
Remote Predictive Mapping 7.
The Use of Topographic–Bathymetric Lidar to Enhance Geological Structural Mapping in Maritime Canada
SUMMARY
RÉSUMÉ
INTRODUCTION

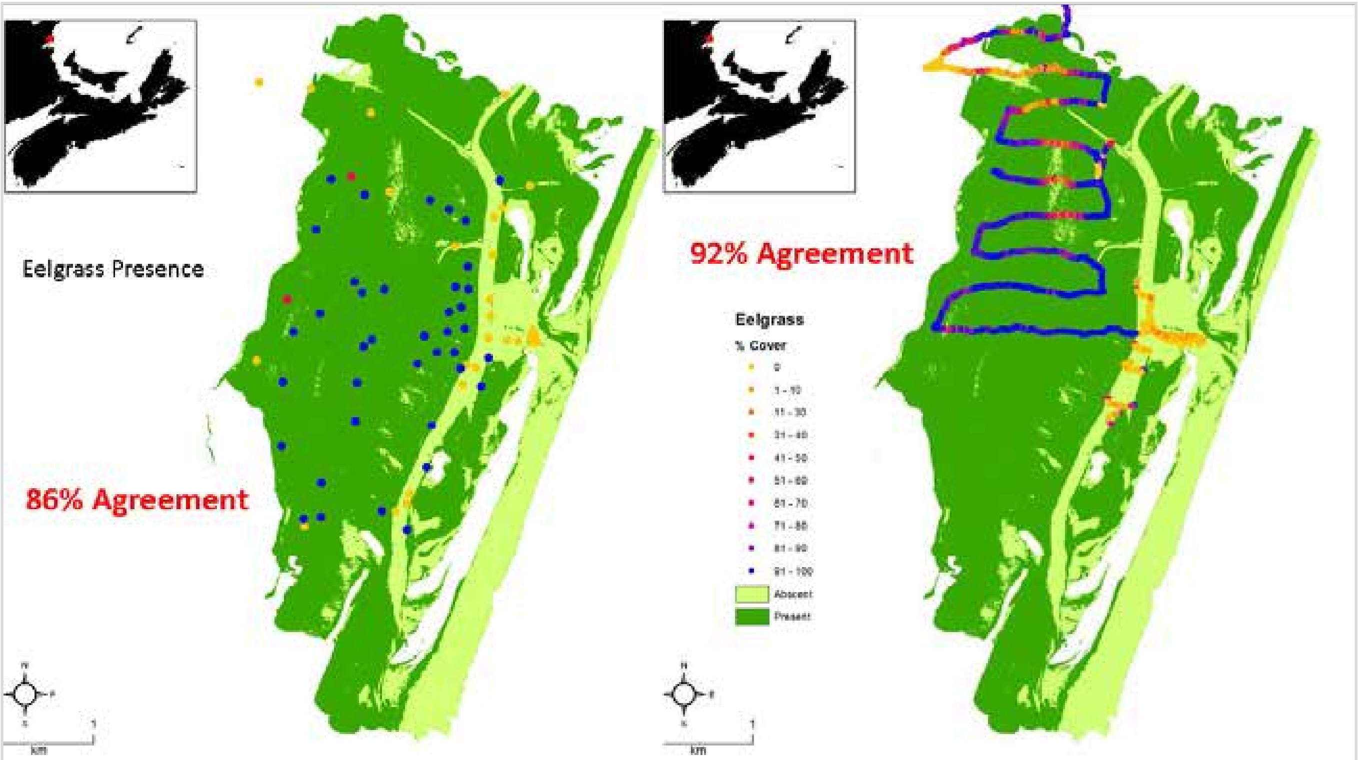

Optimization of Data Collection and Refinement of Post-processing Techniques for Maritime Canada's First Shallow Water Topographic-bathymetric Lidar Survey
ABSTRACT
INTRODUCTION

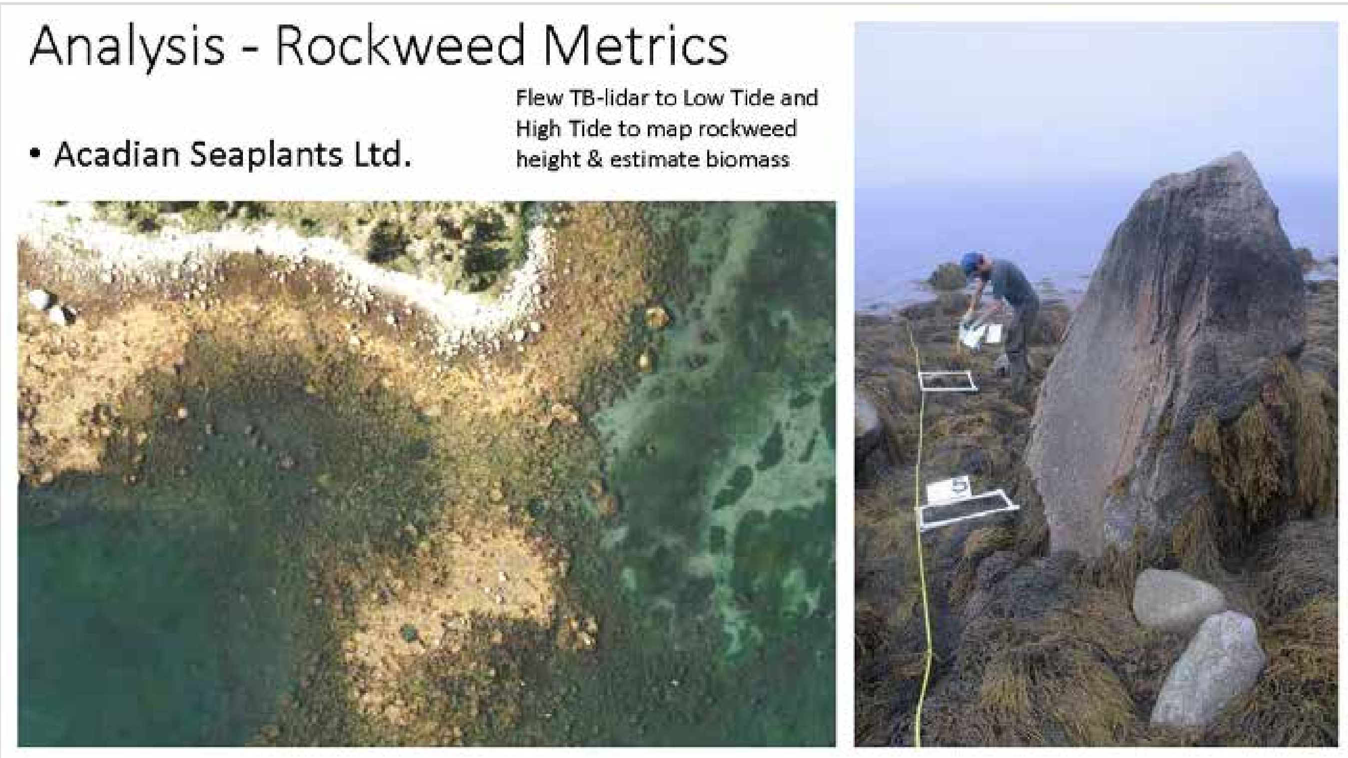

Operation since 2014
>81 collection flights
>127.3 hours on flight
>16.4 tb
>4303 sq. km.
0
50

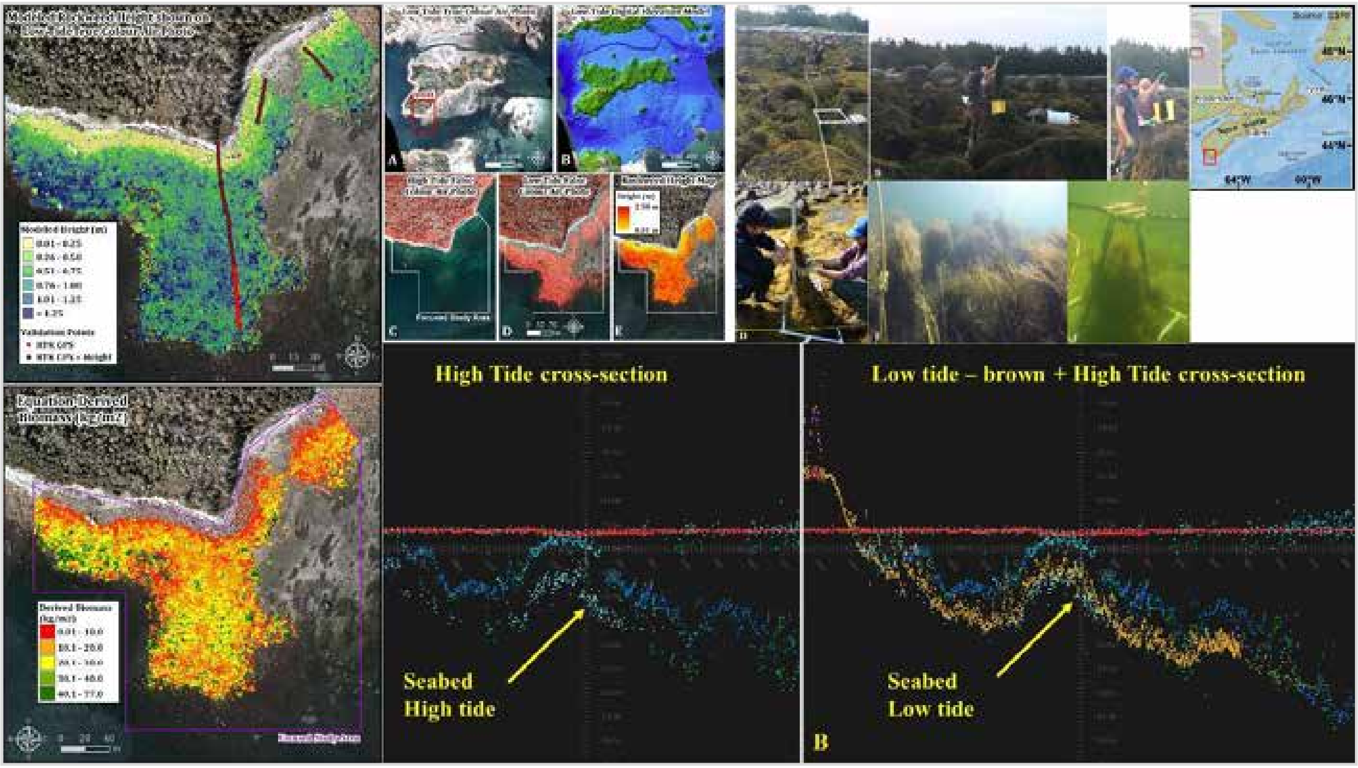

Planning
Collection
Process
Delivery
Flight Plan
Processed Trajectory
Kalman Filtering
Python
Raw Trajectory
Aircraft Inertial and GPS
Time Segmented
Point Clouds
80 MB
Georeferencing
Raw Laser
200 MB
Laser Pulse Return data
Point Cloud Tiles
80 MB
Spatial Indexing
Python
Python
Classified Point Cloud Tiles
80 MB
Ground, Bathy, Vegetation, Building, Power lines
Future
Lidar Waveforms
Future
Raster Tiles
DEM, DSM, INT, WS
Python
Raster Analysis Products
SAV, CSR
Development
Python
Web Server
Flood Map, Aquaculture
Planning, Agriculture
AR/VR
Point Cloud Interaction
Future
QA/
QC
Future
FME
Cloud Compare
Lidar Survey Studio
ArcGis
TeraScan
Inertial Explorer
Custom Software

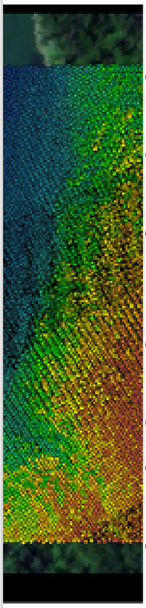

Analysis - Ee
Seamless TB-lidar elevation
TB-lidar intensity/amplitude
km


Eelgrass density
Eelgrass
TAB 2014
VHI
Low : 0
Eelgrass
Biosonics
PlantHeigh
0.00
Bio Sonics Validation
Provided by Stantec
km


Eelgrass Presence
86% Agreement
92% Agreement
Eelgrass
% Cover
Absent
Present
km


Analysis - Rockweed Metrics
• Acadian Seaplants Ltd.
Flew TB-lidar to Low Tide and High Tide to map rockweed height & estimate biomass





Conclusions

- Topo-bathymetric lidar – seamless elevation across the salt or fresh water–land boundary to depths of 15 m + depending on water clarity
- 5 cm RGB, NIR orthophoto, plus 2 pts/m-2 seamless elevation, rich dataset of imagery and elevation
- Multiple applications of the surveys beyond charting – benthic habitat, marine spatial planning, hydrodynamic models, storm surge, waves, research into waveform metrics and improved point discretization
- Chiroptera 4X significant increase in point density, improved target detail & detection limits, potential for more direct benthic point classification
- Mapping eelgrass at 80-95% accuracy, expended to full benthic habitat
- Can use bathy lidar to map biomass of floating SAV, e.g. rockweed, perhaps kelp forests as well
- YouTube Channel (Google AGRG Geomatics)

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Topo-Bathymetric Lidar: From Charting to mapping Benthic Habitat

Research Scientist
Tim Webster, PhD

AGRG Applied Geomatics Research Group

nscc Applied Research

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