BUILDING CONNECTIONS FOR BLUE CARBON ACROSS CANADA

Mapping Workshop Report

Building Connections For
Blue Carbon Across Canada
Mapping Workshop Report
January 13th 2021
1st in a Five Part Series
Summary Report
Prepared by WWF-Canada

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SUMMARY

Blue carbon habitats can rival or exceed terrestrial carbon stores in terms of total extent and on a per-area basis, and therefore can play an important role in the fight against climate change with Nature-based Solutions.

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 first workshop in the series, Mapping, which took place on January 13th, 2021 and had over 60 attendees. This workshop aimed to tackle the question **How can we work towards fully mapping past and current blue carbon stocks and the threats they face?**

The key takeaways from the first workshop are:

- It is vital to develop a strategic and unified approach to data collection. The approach should include clear leadership and communication, guidance resources with standardized protocols, draw on best practices from international work and the development of an integrated data portal for existing and new data.
- Having a strategic, multidisciplinary and stepwise approach could ensure we capitalize on all sources of knowledge and bring non-government organizations (NGO)'s, provinces, territories, Indigenous governments and the federal government together.
- There is a need for more coordinated funding across jurisdictions, organizations, ecosystems and knowledge systems. Funding is especially important for Indigenous communities for capacity building, education and supporting local economies.

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

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"We all know that Canada has the largest coastline in the world. But if you really take a step back and think about what that means for blue carbon habitats, which are found along the coast, it means that Canada probably has the most blue carbon habitats in the world. So, it is critical to understand their extent and how they are changing to get an idea of how these natural ecosystems could be either accelerating or buffering climate change. Canada's blue carbon budget is going to be a globally relevant number."

-Dr. Karen Filbee-Dexter

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. Blue carbon habitats can rival or exceed terrestrial carbon stores in terms of total extent and on a per-area basis. These habitats also provide numerous ecosystem services in addition to carbon storage. Conserving, restoring and sustainably managing blue carbon ecosystems can provide valuable Nature-based Solutions to help address climate change, reverse biodiversity loss and benefit communities.

Canada has the longest coastline of any country, and therefore a great potential for sequestering carbon in blue carbon ecosystems. 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. 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 first workshop in the series focused on mapping and aimed to tackle the question: **How can we work towards fully mapping past and current blue carbon stocks and the threats they face?** A series of five invited speakers provided talks to set the stage for a breakout group discussion session. Following the discussion session there was a series of four 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 are the **best practices and what are the limitations for collecting spatial data** on the distribution, sequestration and accumulation rates of blue carbon?
2. How can we ensure we include **multiple sources of evidence including local, Indigenous and scientific knowledge** to strengthen our mapping efforts?
3. What are the **best ways to share and store blue carbon distribution knowledge** and what steps are needed to facilitate this?
4. How can we **identify and map the ecosystem services** provided by blue carbon systems?
5. How can we **map threats to blue carbon** and how can we **incorporate spatial data on threats within the design of blue carbon projects**?

This report summarizes the invited talks and discussion sessions from the mapping workshop, highlighting key takeaways as identified by participants. The mapping workshop will be followed by workshops focused on restoration and monitoring, policy, ecosystem approach and next steps.

INVITED TALK SUMMARIES

Matt Christensen, University of British Columbia (UBC)

Blue Carbon - Estimating the Storage Potential in Canada's Eelgrass Beds

As a MSc student at UBC, Matt's work aims to quantify the amount of carbon stored in Canada's eelgrass beds and make the results available to support marine spatial planning[1] and ocean accounting[2].

Around 190,000 ha along Canada's coastline have been mapped for eelgrass, however much of the north coastline has not yet been surveyed. New resources coming available within the next year include new eelgrass maps for James Bay and the Gulf of St. Lawrence, as well as species distribution models for British Columbia and Atlantic Canada. Through this project, Matt and collaborators will:

1. Quantify the total known and estimated eelgrass habitat area in Canada while working closely with the National Eelgrass Task Force (NETForce);
2. Generate estimates of carbon sequestration in eelgrass beds through a meta-analysis, literature review and field sampling on all three coasts; and
3. Use a modeling approach to explore and quantify drivers of carbon storage (e.g. above ground biomass or wave exposure) across environmental gradients.

KEY TAKEAWAYS:

- There are multiple groups working on blue carbon at different scales and communication among these groups will accelerate progress.
- Carbon accumulation and sequestration rates are cost prohibitive to obtain, but these rates are the key to understanding carbon storage permanence (at depth and time scales).

Dr. Karen Filbee-Dexter, Université Laval and Institute of Marine Research Norway

Kelp Forests & Blue Carbon Mapping

Karen's work focuses on kelp forests globally (with the Norwegian Blue Forest Network) and in the Eastern Canadian Arctic (with ArcticKelp Canada).

Kelp forests cover about 24 per cent of the world's coasts and are incredibly productive[3]. The per area productivity of kelp forests is equivalent to a terrestrial tropical forest[4], although their standing biomass is lower. Much of the carbon kelp forests produce is exported as detritus and sequestered in deep ocean sediments. It is important to note that kelp forest distribution is changing globally and many forests are in decline, including along areas of Canada's coastline.

The ArcticKelp project is a field-based project aimed at determining the extent and species composition of kelp forests in the Canadian Arctic and how kelp is influenced by environmental conditions. Researchers conducted dive surveys to collect data and work with local communities to integrate traditional knowledge of kelp distribution.

The Arctic is one of the most rapidly changing areas of the world and kelp forests are predicted to increase along the coast as the sea ice retreats. Given the extent of the coastline and the significant standing biomass (carbon stock) of kelp forests currently in the Arctic, the Arctic marine environment could increasingly become a substantial carbon sink. Kelp forests provide a variety of ecosystem services in addition to carbon sequestration, which will be important to the Arctic coastal ecosystem if the range of kelp forests is expanded as a result of climate change.

KEY TAKEAWAYS:

- We understand the environmental niche of kelp forests, so now the main challenge for mapping these forests is knowledge of where hard bottom reefs are located.
- We know that the extent and productivity of kelp forests is high; the next research priority is understanding how much of the carbon produced by kelp forests is sequestered.
- A first estimate of the blue carbon stock and sequestration rates along Canada's coastlines would be incredibly valuable and can then be subsequently refined.
- Canada has the longest coastline in the world, and therefore, we may have the most blue carbon habitat. We need to understand blue carbon ecosystems and the extent to which they are either accelerating (e.g., through declines) or buffering climate change.

[1] A framework for integrated management and structured evidence-based decision making
[2] A method of standardizing information and evaluating overall performance
[3] Wernberg and Filbee-Dexter (2019) Marine Ecology Progress Series, 612: 209-215
[4] Karen Filbee-Dexter (2020) One Earth, 2: 398-401

Dr. Margot Hessing-Lewis, Hakai Institute

Mapping Marine-based Natural Climate Solutions in Canada

Hakai Institute and partners are developing and applying several tools to map the spatial extent of blue carbon habitats including kelp and seagrass and will be expanding their program to include salt marsh habitats.

There is a growing interest in developing and applying natural climate solutions, which is being driven by policy needs. For example, blue carbon stocks are now being included by some countries in their Nationally Determined Contributions (NDC) submitted to the United Nations Framework Convention on Climate Change (UNFCCC). Canada has not yet included blue carbon in their NDCs; to do so, more information on carbon stocks and their permanence is needed.

The Hakai Geospatial Team is developing several remote sensing tools involving the use of drones, planes (airborne coastal observatory) and satellite imagery. Remote sensing tools will be coupled with the collection of in situ metrics (ocean surface, intertidal and subtidal habitats) to take a coupled approach to mapping. Pairing spatial extent data with in situ field-based measurements enables an understanding of biomass, productivity and changes over time in seagrass beds and kelp forests.

The development of mapping tools is being done in partnership with Marine Plan Partnership (MaPP) and has a strong community focus. Training initiatives are being developed to make these mapping tools available to all. Hakai Institute and the Quadra Centre for Coastal Dialogue are also hosting a series of workshops on monitoring tools and methods for nearshore habitats in British Columbia.

A key next step is working to accurately scale up the spatial extent of field-based measurements to obtain regional estimates of blue carbon extent and metrics. To predict the regional extent of seagrass beds, the linear extent of the coastline, knowledge of seagrass depth extent and presence/absence information was used to calculate an estimate of total seagrass extent along the British Columbia coastline. This data will be published soon in a national report by Nature United on the natural climate solutions in Canada.

KEY TAKEAWAYS:

- Data collection on the extent of blue carbon habitats, their carbon storage and the flux of carbon over time is necessary for national policy work such as Canada's NDCs and for the development of natural climate solutions.
- Remotely sensed spatial data must be paired with in situ field measurements to gain an understanding of seagrass bed and kelp forest extent and carbon storage.

Dr. Brigitte Leblon, University of New Brunswick and Coalition-SGSL

Eelgrass Mapping in Atlantic Canada and James Bay (Québec)

Brigitte Leblon and Angela Douglas lead the Atlantic Eelgrass Monitoring Consortium, which focuses on facilitating communications and networking, organizing and facilitating meetings, monitoring the progress of implemented strategies and assisting communities in building capacity. The Consortium monitors sites in the four Atlantic provinces using permanent transects sampled annually. They monitor 30 sites with sonar to assess eelgrass distribution and health, as well as help plan restoration projects. Examples of projects include:

- Mapping of eelgrass extent with sonar in Prince Edward Island (PEI);
- Analyzing eelgrass extent with WorldView-2 imagery in New Brunswick to assess losses and gains in eelgrass extent from 1984 to 2017; and
- A comparison of biosonic sonar, Sentinel 2 satellite imagery, and unmanned aerial vehicles (UAV) imagery in Souris (PEI).

The comparison of remote sensing tools showed that sonar data are limited to transects and does not produce the same quality images as satellite or UAV imagery. And while the satellite imagery has a 78 per cent accuracy, the presence of algae can interfere with accurately mapping eelgrass extent. The UAV imagery had an accuracy of 90 per cent and has the benefit of providing images within 10 minutes.

Mapping eelgrass in James Bay is being done in partnership with the Cree Nations of Wemindji and Chisasibi. Turbidity in marine waters driven by events on land such as forest fires increases the difficulty of accurately mapping eelgrass extent in this area. For example, turbidity from a forest fire in 2013 is still visible in satellite imagery from 2019. However, it is still possible to map eelgrass extent in some coastal locations in James Bay using satellite imagery.

KEY IDEA:

- Two current forest-themed National Sciences and Engineering Research Council (NSERC) funded projects could be used as models to develop a large scale funding proposal for blue carbon research in Canada that can be funded by Fisheries and Oceans Canada (DFO) and NSERC.

Dr. Allison Schmidt, Dalhousie University

Blue Carbon: Making the Case for Standing Stock

Published blue carbon literature focuses mainly on long-term sequestration, with limited attention placed on short-term sequestration in living biomass. However, there is a precedent for including living biomass in carbon budgets, as it is included in terrestrial-based carbon budgets. Species of marine vegetation can be long-lived (rockweed can live up to 120 years), and the longevity of these habitats rivals the stand age of terrestrial forests. Therefore, the standing stock of marine plants should be considered when mapping blue carbon habitat extent and carbon sequestration.

A literature review including 183 studies from 1950 to 2019 revealed that of blue carbon components including macroalgae, mangroves, salt marsh and seagrasses, macroalgae and seagrasses have the largest extent, with the macroalgae extent being double that of seagrasses. The global carbon standing stock of macroalgae is almost as high as mangroves and larger than saltmarsh and seagrasses combined. When compared with other ecosystem types, macroalgae cover a larger area than coniferous forests and they rival boreal and deciduous forests in terms of carbon storage even though they only cover one third of the area. The extent of macroalgal stands, their longevity over time and their high carbon storage relative to area all highlight their importance within the blue carbon realm and the need to include them in blue carbon research and mapping.


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KEY TAKEAWAYS

- Given the stability of stands of marine vegetation over time and their disproportionately high carbon storage relative to their extent, their standing stock needs to be considered in blue carbon budgets.
- More coastal marine protected areas are needed to protect blue carbon ecosystems and the services they provide, including, but not limited to carbon storage.
- We need rapid assessments as well as ground-truthing to complete initial assessments and monitoring over time of blue carbon standing biomass.
- Community science initiatives could be developed to support both initial assessments and long-term monitoring.


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GROUP DISCUSSIONS

Discussions held in breakout rooms are summarized below according to key themes that emerged across the set of five discussion questions.

Spatial Information

There is a diversity of knowledge on the spatial extent of blue carbon habitats in Canada held by many different groups and individuals. Given the extent of our coastlines, mapping blue carbon habitats will require broad participation and coordination. Currently, researchers and practitioners are unsure of who is working in this space, what data gaps remain, and the best way to strategically and cost-effectively address them. To date there is a patchwork of mapping efforts along the coastline, which poses a challenge when trying to apply data that have been collected in different ways and for different purposes. **As a community of practice, we need to work together collaboratively and strategically to improve our understanding of blue carbon habitats along the coasts.** Moreover, local organizations and communities are key to scaling up mapping efforts, highlighting the need to engage communities and citizen scientists in our work.

Spatial data on blue carbon habitats are being collected remotely at different scales, using unmanned aerial vehicles (UAVs), planes, helicopters and satellites. There are trade-offs among remote sensing methods related to cost, scale, and imagery resolution, with each method posing specific constraints. For example, while UAVs are cost-effective, they require identifying markers on land and therefore cannot be used to map habitat in the open ocean. In addition, remote sensing approaches suffer from limitations on their ability to penetrate water, especially in areas with high turbidity, subtidal areas or areas of more than 10 m depth.

Smaller scale in *situ* mapping is required to ground truth remotely sensed data sets and provide information on carbon sequestration and fluxes. For example, UAV and satellite surveys along with historical kelp mapping are being used in British Columbia to map the extent of blue carbon habitat but coupled in *situ* measurements of carbon storage and accumulation rates would provide a deeper understanding of blue carbon stocks along the coast. Organizations are working extensively from coast to coast to coast to collect data at the local level which can be used to ground-truth remote sensing data and large-scale mapping initiatives. However, **strategic planning is needed to effectively collect and integrate data at multiple scales in a cost-efficient way**.

The main challenges for collecting spatial data on the distribution, sequestration and accumulation rates of blue carbon include logistics, cost and capacity. The complexity of blue carbon ecosystems also poses a challenge; carbon metrics can vary within ecosystems and within individual field sites. Understanding the marine biogeochemistry of ecosystems and how blue carbon habitats interact with the broader seascape is also important.

A multidisciplinary approach which includes engaging directly with communities will facilitate the inclusion of different types of information, **including qualitative information**, and strengthen our knowledge and understanding of blue carbon ecosystems. **It is important to listen to and respect all sources of knowledge** and to treat all sources as equal, while also remembering that not all data can be or needs to be standardized.

Engagement

Providing information and educational resources to communities on blue carbon and the co-benefits associated with healthy blue carbon ecosystems will increase interest in the topic and facilitate the participatory collection of data. To effectively engage communities, we need to develop and employ respectful and effective forms of outreach that include listening to communities and learning about their priorities and needs. Many people can contribute to our understanding of blue carbon ecosystems and have different skill sets and knowledge bases (e.g., youth, Elders, businesspeople, fisherfolk, tourism providers, outdoorspeople). **The greatest challenge with integrating multiple sources of knowledge is the lack of capacity**. Engaging and collaborating with people who already work in blue carbon habitats can also be a cost-effective way to collect information. Engagement with communities should be an ongoing process whereby researchers and practitioners regularly return to communities to continue building capacity and knowledge and to share new understandings.

Engaging with municipalities will also support blue carbon work. Municipalities work on climate change planning and natural asset management. The integration of blue carbon stores and ecosystem services into natural asset management could support the planning for and adaptation to climate change as well as facilitate the protection of blue carbon habitats.

Data Standardization and Management

The standardization of some key blue carbon metrics and data collection methods could facilitate the collection of information from coast to coast to coast. This could include **specific protocols by ecosystem type** to collect data that are comparable and contribute to area-based carbon sequestration estimates. Where applicable, data collection standards should be aligned with global practices; for example, the common practice in Canada is to report carbon data to a depth of 30 cm, while in other parts of the world data to depths greater than 30 cm are reported. Data attributes should also be standardized within ecosystems types (i.e., above ground or below ground carbon, depth of sample, etc.). Limitations of methods should also be acknowledged. For example, area-based estimates of carbon metrics assume that a given habitat is intact across the entire area, resulting in overestimates of carbon accumulation and storage. A succinct summary of best practices from different institutions would be a useful start (based on Canadian or international practices) and can be adapted to build standards at the national level to achieve cohesiveness and consistency.

For better and more efficient data management, **we need to coordinate the building and use of an accessible data portal**. The portal should be **open source, easy to access and easily discoverable** to reduce redundancies and duplication of mapping efforts. This portal can build on ongoing efforts to compile mapping data (e.g., DFO and NETForce) and should be **integrated across marine and freshwater environments**. The portal should include existing data and new data as it becomes available, as well as additional resources such as herbaria and community data. **Metadata is key** – blue carbon data portals should store information that includes context, such as where and how the data was collected. And, ideally, the blue carbon data portal should be designed for both accessibility and application. **We need application-oriented data tools** to further our blue carbon work. Maintaining a data portal and associated metadata will require ongoing capacity and funding.

While it is important to have open and accessible databases, there are ethical issues to consider. There can be privacy concerns around particular project types, such as carbon offset projects. **Respecting Indigenous territorial boundaries** while collecting and sharing data is imperative.

Ecosystem Services

Healthy ecosystems provide many benefits in addition to carbon sequestration. We need to understand these benefits and share the link between blue carbon habitats and ecosystem services with communities to create interest, increase capacity and leverage funding. For example, food security is important to many Indigenous partners so we need to understand and make the link between healthy blue carbon ecosystems and how they can support food security. Ecosystem service mapping should be based on many types of knowledge and on the priorities of local communities. The results of ecosystem mapping should be accessible and applicable by a broad range of people.

To map ecosystem services, a **stepwise approach** could allow for manageable work by tackling "bite-sized" pieces. This approach would involve a natural progression of work by building on current information and integrating multiple knowledge sources, such as Traditional Knowledge, into projects. **The first step is to identify which ecosystem services are to be mapped**, based on the desired application of the information. Second, determine what information is already available and what overlap exists between the mapping of blue carbon resources and other values (e.g. maps of eelgrass overlapped with maps of high abundances of birds). Overlaps among maps of different parameters will highlight information on the ecosystem services provided in specific locations.

Challenges with mapping ecosystem services include seasonal changes, spatial overlap among vegetation types (and therefore vegetation-specific services) and site-specific services within an ecosystem type. For example, very dense continuous eelgrass beds may provide high carbon storage but may not result in ideal fish nursery habitat. **Ground truthing, engaging with local communities and working with social scientists is key**, but mapping approaches will need to be adjusted depending on the ecosystem services of interest.

Threats

Blue carbon habitats face both direct and indirect threats. Direct threats to blue carbon habitats, such as coastal squeeze[5], **have been mapped** in Nova Scotia, and mapping efforts are now expanding to New Brunswick. Satellite imagery, modelling and lidar have been used to map and predict threats to blue carbon ecosystems. However, high quality lidar data used to accurately map threats can be costly. Modeling approaches, such as the Sea Level Affecting Marshes Model (SLAMM), have been used to map future salt marshes based on sea level rise and erosion, providing planning opportunities for the future. Most mapping of threats to salt marshes has focused on threats related to the seaward edge, while mapping threats to the inland edges has proved more challenging.

Indirect threats, including those originating on land, **are not often considered because they are difficult to identify**. Current work includes mapping the threat of nutrient loading on salt marshes and eelgrass beds next to agricultural fields. While protections against direct threats to salt marsh and eelgrass are in place in New Brunswick, the protections do not extend to indirect threats.

5 e.g. blue carbon habitat such as salt marsh is squeezed between sea level rise and fixed barrier on the landward side

Leadership

Many participants highlighted that a coordinated data portal is needed, but there is currently no consensus on who or which organization should lead this effort. **A unified approach to data collection and sharing could be led or facilitated by the federal government with participation at the provincial and community levels**. Ideally, the responsibilities would be shared across government agencies, with each agency having unique skill sets to contribute. Other forms of support from government entities include assisting local communities and organizations on data collection and monitoring protocols.

Just as we need a strategic approach to mapping and data sharing, we need a strategic approach to access funding across jurisdictions. There is a need for **more coordinated funding across jurisdictions, organizations, ecosystems and knowledges**. Having a strategic approach could ensure we capitalize on all sources of knowledge and bring NGO's, provinces, territories, Indigenous governments and the federal government together. A more coordinated approach to funding could be modeled on ArcticNet or the NSERC funded large-scale forestry initiative. **Funding is especially important for Indigenous communities for capacity building, education and supporting local economies**.

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.

What are the **best practices and what are the limitations for collecting spatial data** on the distribution, sequestration and accumulation rates of blue carbon?

- Given Canada's vast coastline, it is vital to develop a strategic and unified approach to data collection. The approach should include clear leadership and communication, guidance resources, draw on best practices from international work and the development of an integrated data portal for existing and new data.
- Develop and adopt standard metrics and methods for data collection, including community-based monitoring and harmonise reporting across jurisdictions.
- Conduct cost-benefit analyses of integrating data from different sources / scales (e.g. field, drone, aerial, satellite).

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

- Adopt a multidisciplinary approach that values quantitative and qualitative data, breaks down silos, values multiple types of knowledge and better integrates communities (Indigenous, tourism, academic, non-profit, government etc.) who have knowledge.
- A strategic approach to funding across-jurisdictions, organizations, ecosystems and knowledges is needed. Funding is especially key for Indigenous communities for building capacity, providing education, developing skill sets and supporting local economies.
- Broaden the conversation beyond carbon to establish other relevant linkages related to ecosystem health such as food security for Indigenous communities.

What are the **best ways to share and store blue carbon distribution knowledge** and what steps are needed to facilitate this?

- Ensure good governance of blue carbon data through a centralized group (e.g. NETForce). The group could be responsible for reducing duplication of mapping efforts.
- Establish standardized guidelines for blue carbon metadata (e.g. context, location, collection methodology) and maintain quality metadata.
- Develop a user-friendly and searchable database or portal to access blue carbon data from multiple sources.

How can we **identify and map the ecosystem services** provided by blue carbon systems?

- Blue carbon ecosystems are complex and subject to seasonal and long-term changes. As a result, identifying and mapping ecosystem services will require a stepwise approach.
- Using multiple types of knowledge, identify regionally and locally relevant ecosystem services by first building on existing mapping work. Ground truth the results by working with local communities and through fieldwork.
- Ensure that the end products are accessible and usable by a broad range of people.


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How can we **map threats to blue carbon** and how can we **incorporate spatial data on threats within the design of blue carbon projects?**

- Some threats to blue carbon have been mapped, for example threats from coastal squeeze and threats relating to the seaward edge of blue carbon habitat.
- Mapping of indirect threats and inland threats is less developed because they are often more difficult to identify. Work on mapping inland threats such as agricultural runoff in PEI is in progress.


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APPENDICES

Workshop Agenda

Building Connections for Blue Carbon Across Canada

Mapping – January 13th 2021

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

How can we work towards fully mapping past and current blue carbon stocks and the threats they face?

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** • Matt Christensen, UBC • Dr. Karen Filbee-Dexter, Laval University and Institute of Marine Research, Norway • Dr. Margot Hessing-Lewis, Hakai Institute • Prof. Dr. Brigitte Leblon, UNB and President of the Coalition-SGSL • Dr. Allison Schmidt, Dalhousie University
Five minute break	
2:10 – 3:00pm EST	**Breakout Groups – focused discussions**
3:00 – 3:20pm EST	**Speed Talks – getting to know our community** • Hasini Basnayake, Simon Fraser University • Sarah Cook, ShoreZone • Ronnie Drever, Nature United • Jesica Goldsmit, DFO • Jordy Thomson, Ecology Action Centre
3:20 – 3:30pm EST	**Wrap Up**

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		
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Margot Hessing-Lewis	Hakai Institute	margot@hakai.org
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Haley MacDonald	Nature Conservancy of Canada	haley.macdonald@natureconservancy.ca
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Bryan Martin	Maritime Aboriginal Peoples Council	bmartin@mapcorg.ca
Jamylynn McDonald	ACAP Saint John	jlm@acapsj.org
Pat Nussey	Nature Conservancy of Canada	patrick.nussey@natureconservancy.ca
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Troy Pretzlaw	Parks Canada	troy.pretzlaw@canada.ca
Tanya Prystay	Fisheries and Marine Institute of Memorial University of Newfoundland	tanya.prystay@mi.mun.ca
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Charlynne Robertson	Clean Foundation	crobertson@clean.ns.ca
Lucie Robidoux	Commission for Environmental Cooperation	lrobidoux@cec.org
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Christel Sisson	Tsleil-Waututh Nation	csisson@twnation.ca
Alena Wachmann	University of Victoria, SPECTRAL Remote Sensing Lab	acwachmann@gmail.com
Tim Webster	Applied Geomatics Research Group, Nova Scotia Community College	timothy.webster@nscc.ca
Jennifer Yakimishyn	Pacific Rim National Park Reserve	jennifer.yakimishyn@canada.ca

Blue Carbon Initiatives and Resources

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

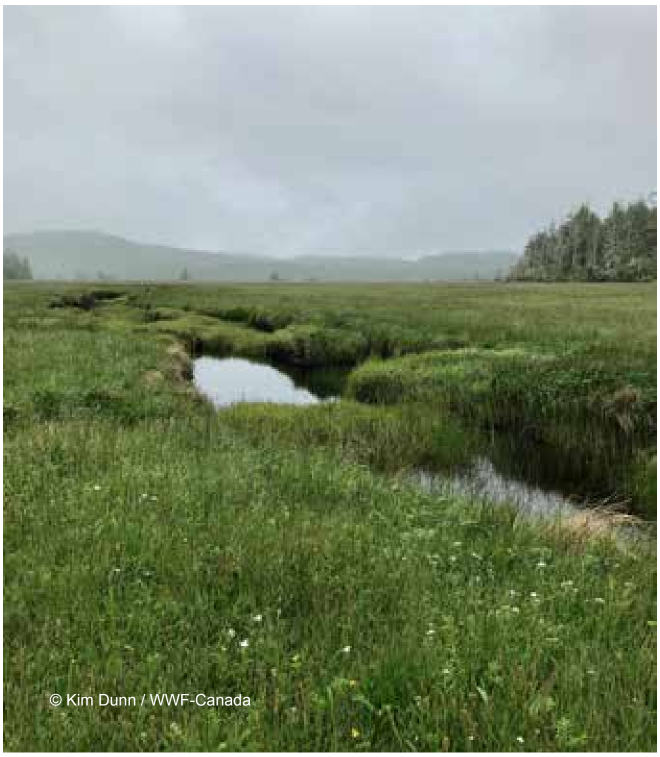
- Atlantic Eelgrass Monitoring Consortium
- ArcticKelp Canada
- Eelgrass bed monitoring in James Bay (QC) funded by Niskamoon Corporation
- Euromarine Group on global seaweed habitats
- HSBC Blue carbon citizen science program
- Quadra Centre for Coastal Dialogue Monitoring BC Nearshore Habitats Web Series
- Norwegian Blue Forests Network
- Sea Level Affecting Marshes Model (SLAMM)
- The Maritime Ringlet and its Marshes, English French
- Towards a Regional Monitoring Framework for Cumulative Impacts Assessment in the Northumberland Strait

Data Sources and Portals

Below is a list of data sources and portals mentioned by participants during the workshop.

- Atlantic DataStream
- Canadian Integrated Ocean Observing System (CIOOS)
- Canadian Institute of Ecology and Evolution Living Data Project
- Coastal & Ocean Information Network Atlantic (COIN Atlantic)
- Commission for Environmental Cooperation (CEC) (North American blue carbon dataset and mapping initiative)
- Ducks Unlimited Canada (wetland mapping, kept in-house with data sharing agreements)
- eOceans
- Hakai Institute
- National Eelgrass Task Force (NETForce) (upcoming)
- Ocean Biodiversity Information System (OBIS)
- ShoreZone

© Kim Dunn / WWF-Canada



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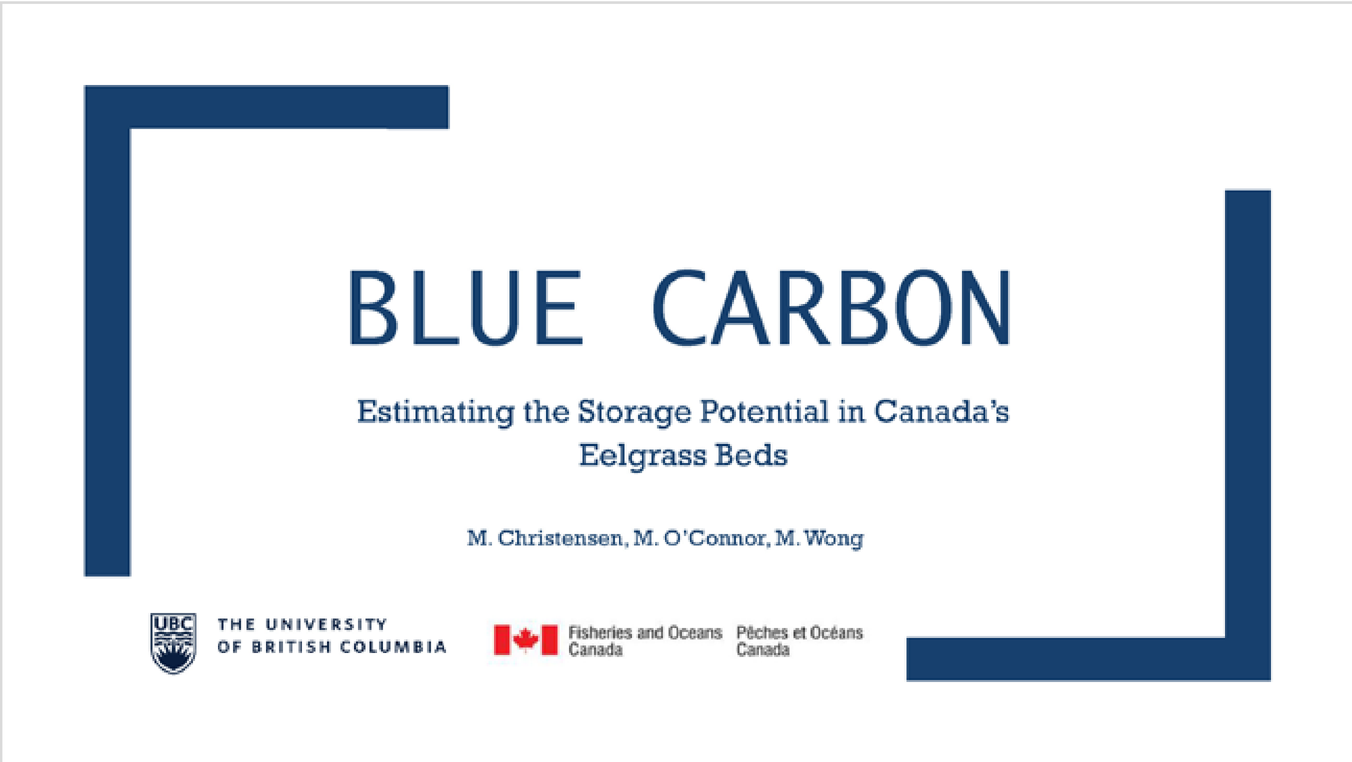
Presentation pdfs

Invited talks



The Approach

01

Quantify total known and estimated eelgrass habitat area on all three Canadian coastlines.

02

Generate estimates of how much carbon is sequestered in Canada's eelgrass beds

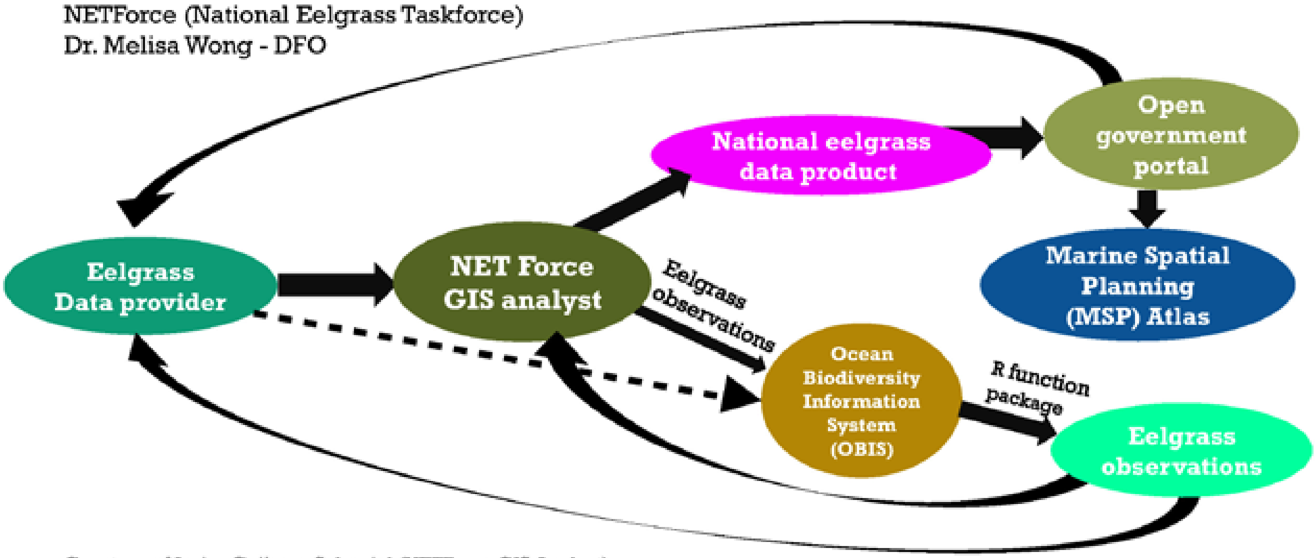
03

Quantify variation in carbon storage in eelgrass beds across different environmental conditions

The Approach

01 Quantify total known and estimated eelgrass habitat area on all three Canadian coastlines

NETForce (National Eelgrass Taskforce)
Dr. Melisa Wong - DFO



Courtesy of Javier Guijarro-Sabaniel (NETForce GIS Analyst)

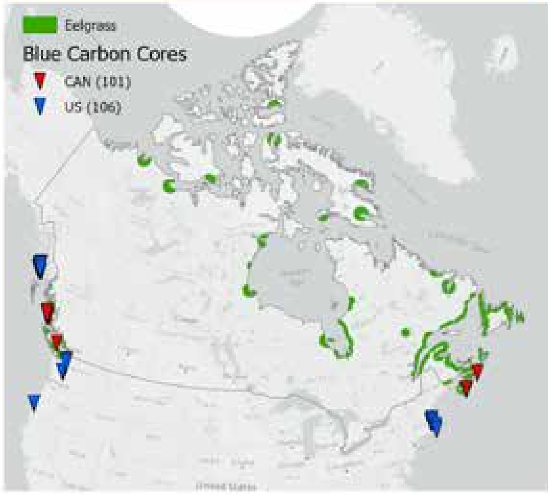
Graphical depiction only. Not to scale.

- Confirmed eelgrass locations (generalized); much of the north has not been surveyed for eelgrass with 10's of 1000s of km of coastline with the potential to support eelgrass habitats (and Blue Carbon)
- **The mapped extent is more than 190,000 ha**
- New Species Distribution models in BC and Atlantic Canada will inform Blue Carbon potential
- New eelgrass mapping in James Bay and the Gulf of St. Lawrence will come online over the next year

The Approach

02 *Generate estimates of how much carbon is sequestered in Canada's eelgrass beds*

- Meta-analysis of existing field sampling of Carbon storage
- Literature review
- Field sampling on all three coasts

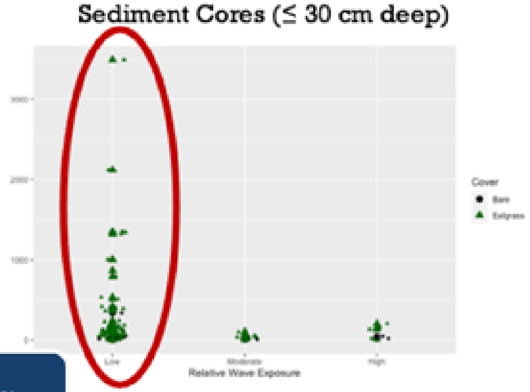


The Approach

03 Quantify variation in carbon storage in eelgrass beds across different environmental conditions

Assess and select potential drivers → Create models → Validate → Predict

Sediment Cores (≤ 30 cm deep)



Adapted from Lewis et al 2020

Final Thoughts

Networking, Collaboration and Data Sharing

Coastal Carbon Research Coordination Network

PNW Blue Carbon Working Group

CEC · CCA · CCE

Community Science

Award-winning Citizen Science program

By Blue Carbon Lab | HSBC, News | Comments are Closed | 13 September, 2019 | 3

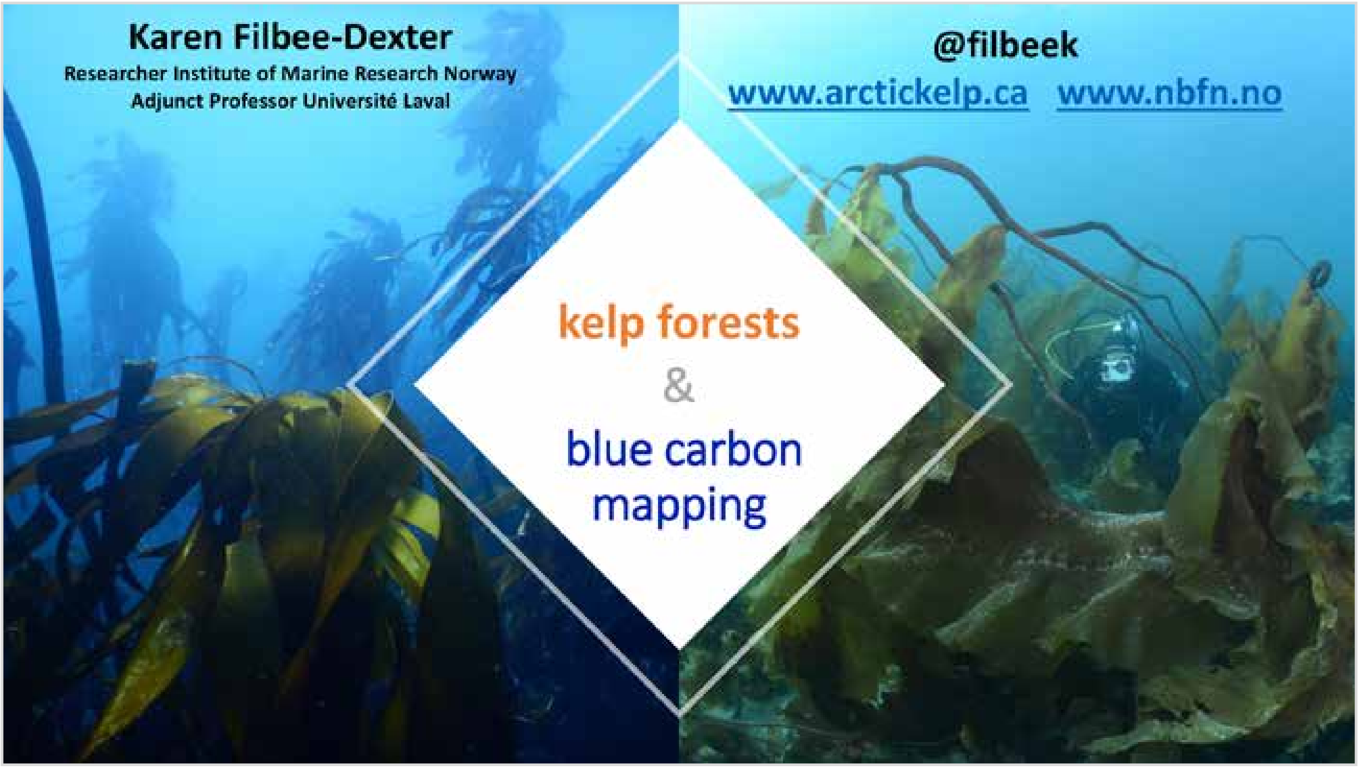
The HSBC Blue Carbon citizen science program received the Industry Engagement award at the 2019 Australian Financial Review (AFR) Higher Education awards ceremony held in Brisbane (27/08/2018).

Accumulation and Sequestration Rates

- **cost is a barrier**
- **understanding permanence (what time scales and at what depth is secured)**

GET IN TOUCH TO COLLABORATE

Email: msc01 at zoology.ubc.ca



Norwegian Blue Forests Network | INSTITUTE OF MARINE RESEARCH
HAVFORSKNINGSINSTITUTTET

Global extent and production of seaweed forests

Global estimates of C sequestration by seaweed forests

How does kelp forests shift with climate change?

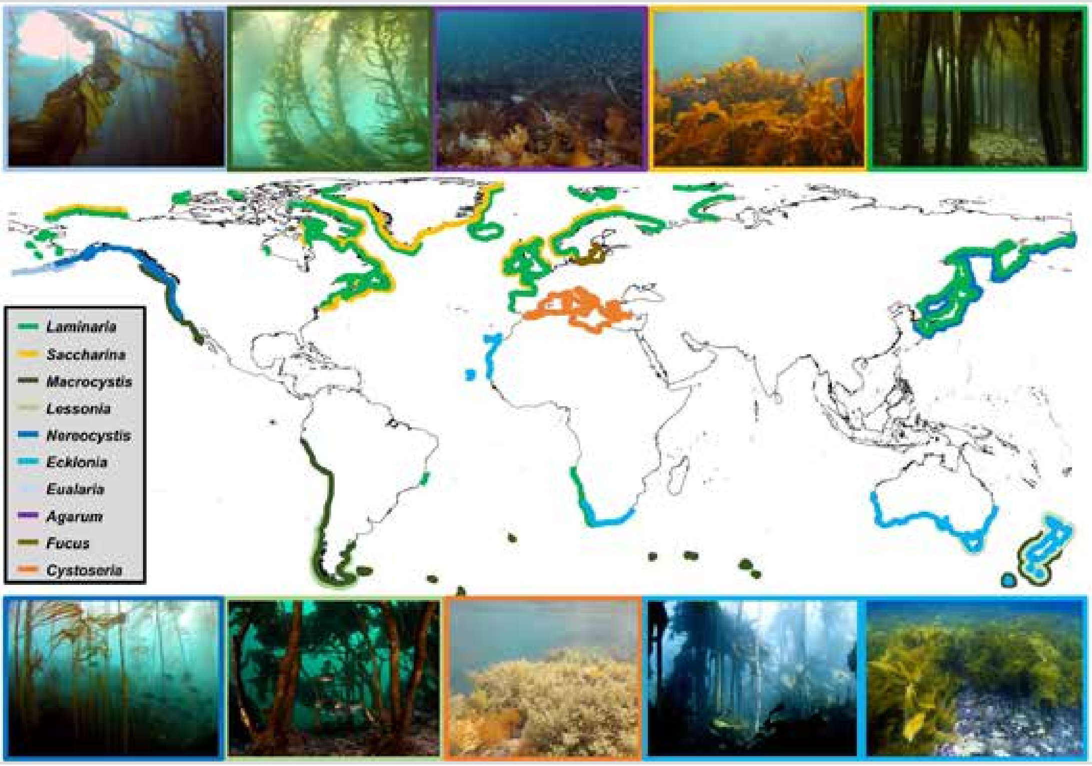
arctickelp Canada

ArcticNet

Distribution of kelp forests in the Canadian Arctic

Standing biomass and production

Effects of climate change and possible expansion



Kelp forests

24% all coasts

Wernberg & Filbee-Dexter. 2019. *MEPS*

Global Estimates of the Extent and Production of Macroalgal Forests

Carlos M. Duarte[1,2], Jean-Pierre Gattuso[3,4], Kasper Hancke[5], Hege Gundersen[5], Karen Filbee-Dexter[6,7], Morten F. Pedersen[8], Jack J. Middelburg[9], Michael T. Burrows[10], Kira A. Krumhansl[11], Thomas Wernberg[7,12], Pippa Moore[12], Albert Pessarrodona[12], Sarah Bachmann Ørberg[2,13], Isabel Sousa Pinto[14], Jorge Assis[15], Ana M. Queirós[16], Dan A. Smale[17], Trine Bekkby[5], Ester A. Serrão[15], Dorte Krause-Jensen[2,13]

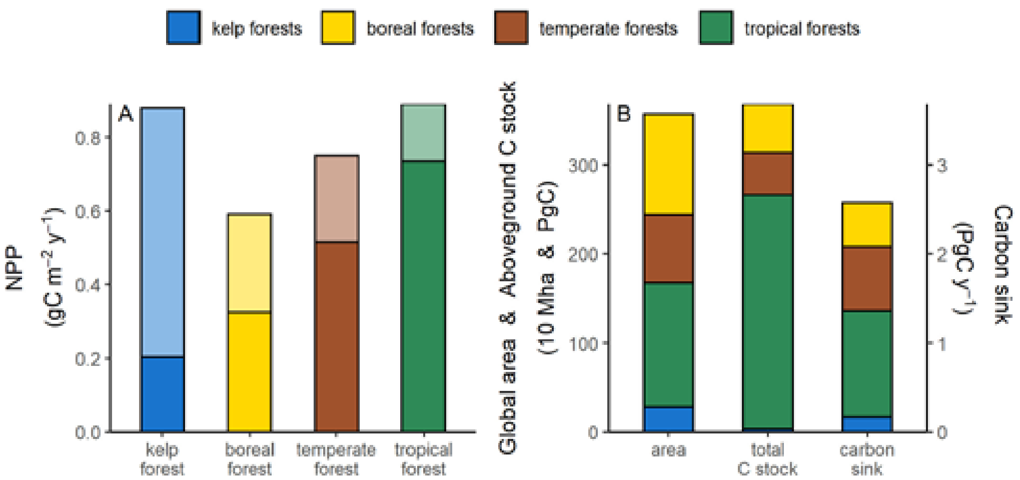
Global area = 2 500 000 km^2
Global NPP = ~1 Pg C y^{-1}

Norwegian Blue Forests Network

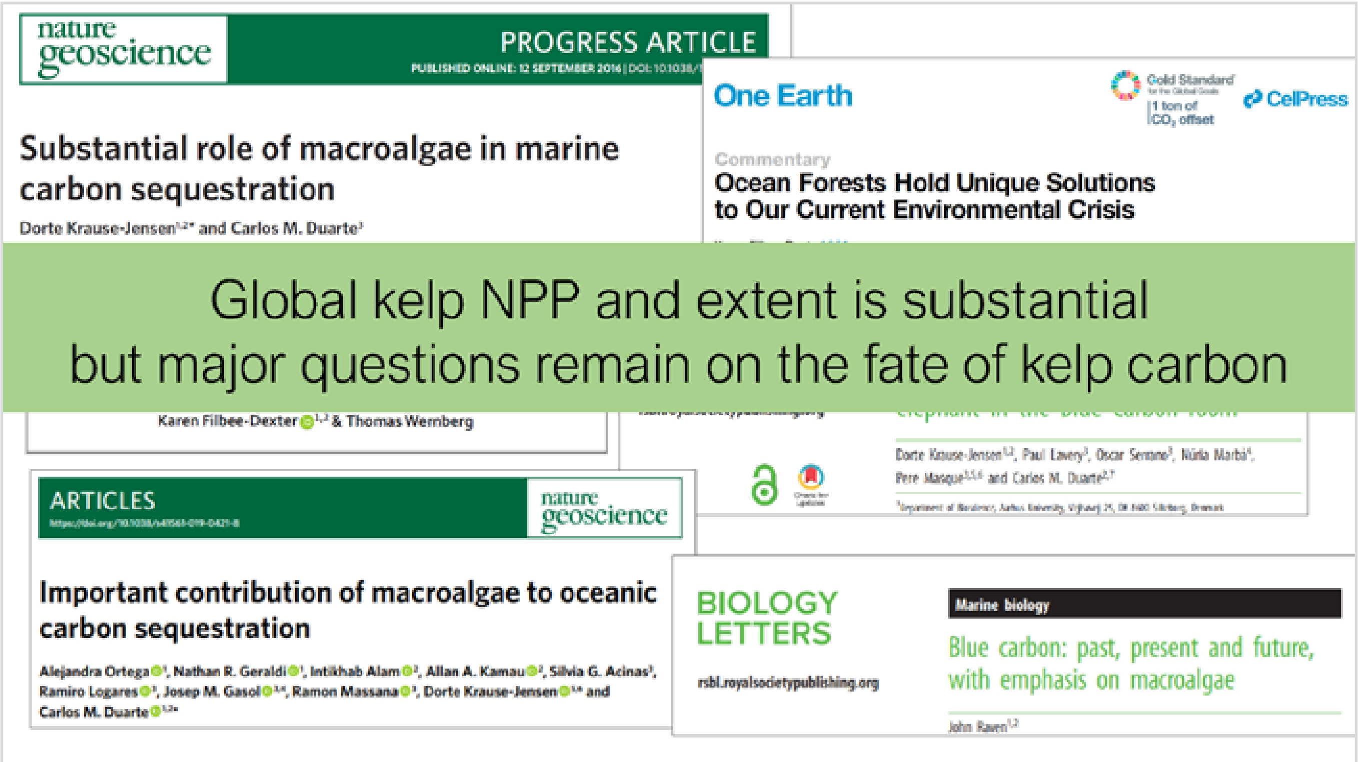
Challenge – maps of hard bottom

Global area = 2 500 000 km^2
Global NPP = ~1 Pg C y^{-1}

Challenge – maps of hard bottom



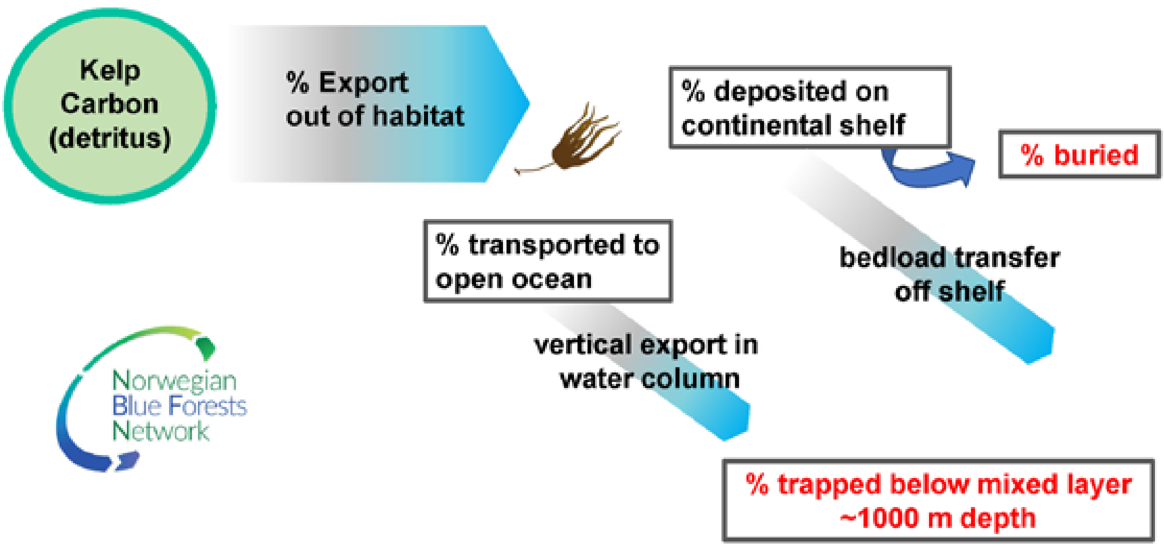
Filbee-Dexter (2020). Ocean forests hold solutions to our current environmental crisis. **One Earth**



nature geoscience
PROGRESS ARTICLE
Substantial role of macroalgae in marine carbon sequestration
Dorte Krause-Jensen and Carlos M. Duarte
One Earth
CelPress
Commentary
Ocean Forests Hold Unique Solutions to Our Current Environmental Crisis
Global kelp NPP and extent is substantial
but major questions remain on the fate of kelp carbon
Karen Filbee-Dexter & Thomas Wernberg
ARTICLES
nature geoscience
Important contribution of macroalgae to oceanic carbon sequestration
Alejandra Ortega, Nathan R. Geraldi, Intikhab Alam, Allan A. Kamau, Silvia G. Acinas, Ramiro Logares, Josep M. Gasol, Ramon Massana, Dorte Krause-Jensen and Carlos M. Duarte
BIOLOGY LETTERS
rsbl.royalsocietypublishing.org
Marine biology
Blue carbon: past, present and future, with emphasis on macroalgae
John Raven

Potential kelp export to deep marine sinks
Export
80%
Norwegian Blue Forests Network
Detritus exported > 1000 m, or buried in deep sediments, can take 100s-1000s years to re-enter the atmosphere as CO_2
Pedersen, Filbee-Dexter et al. (2019). Carbon production and export in high latitude kelp forests.

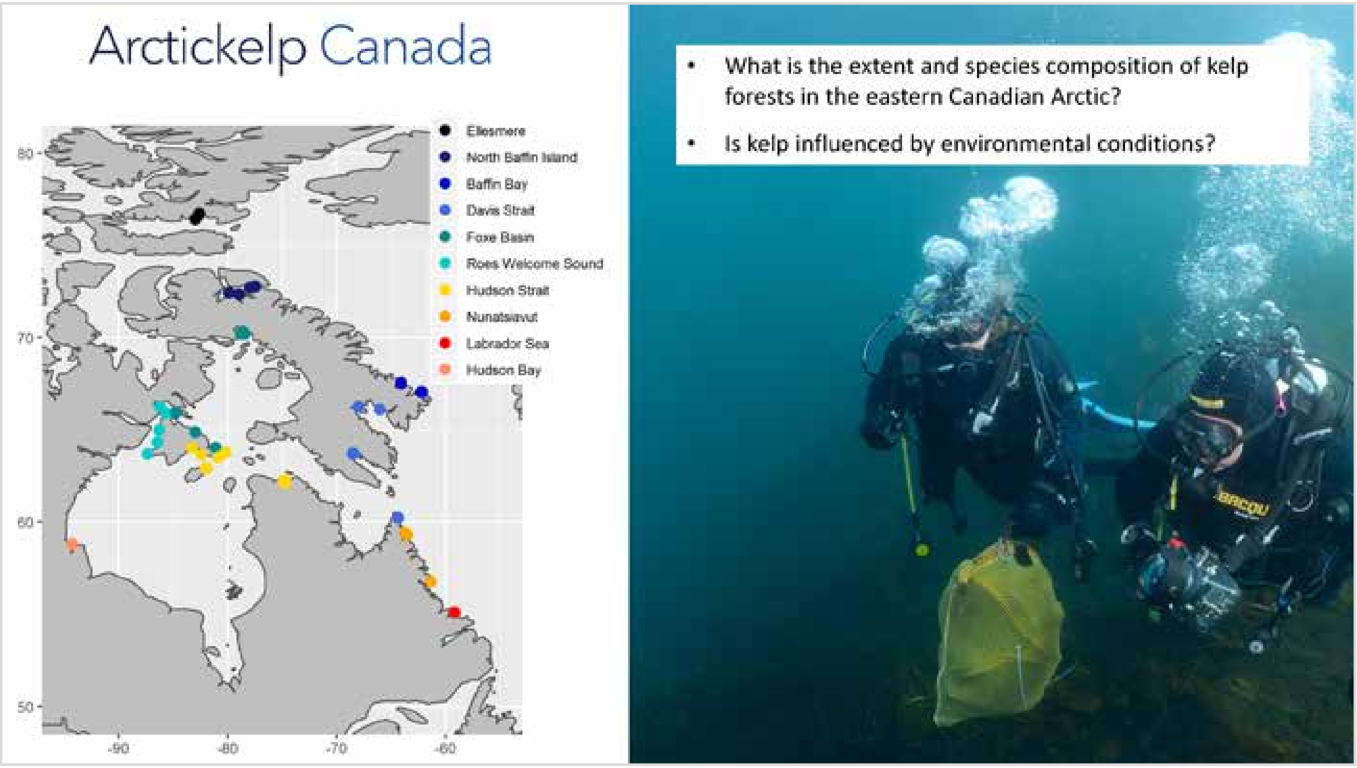
Need to measure export of carbon to deep marine sinks

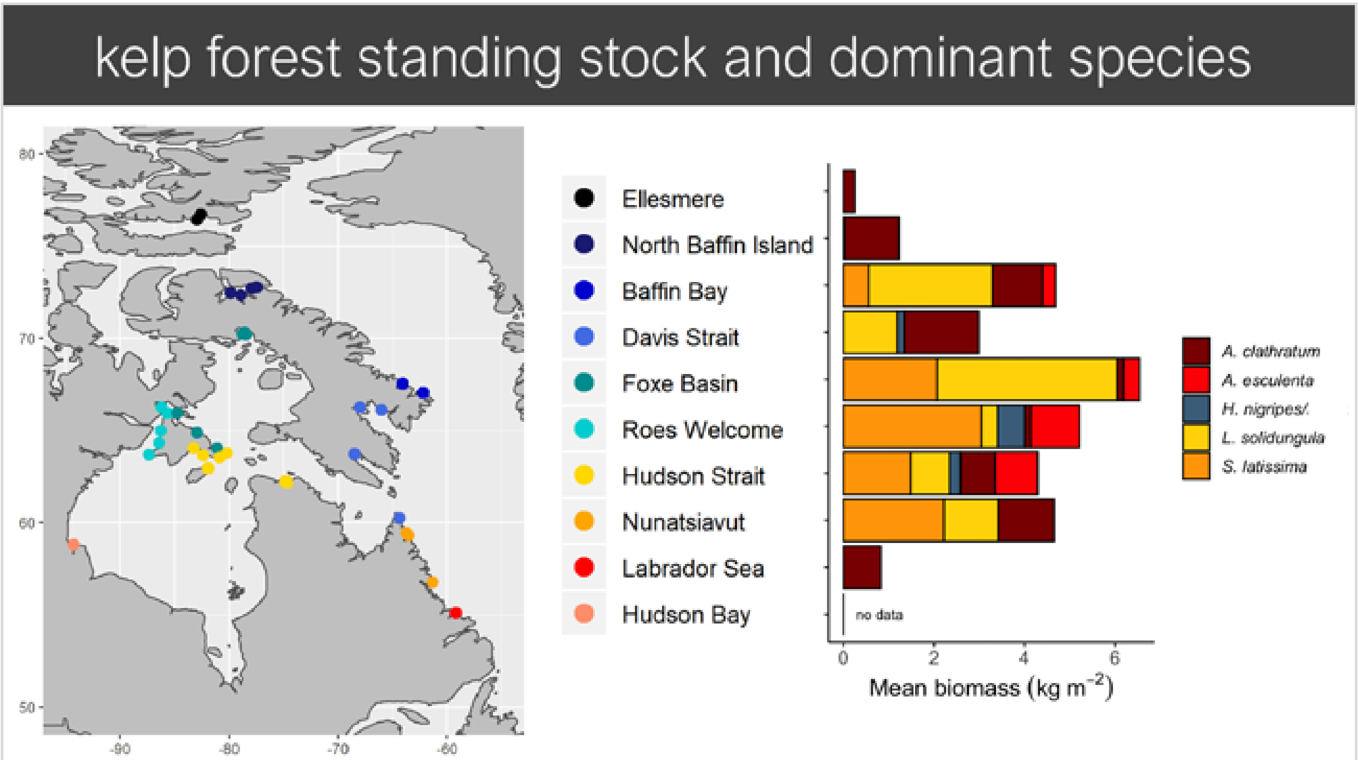


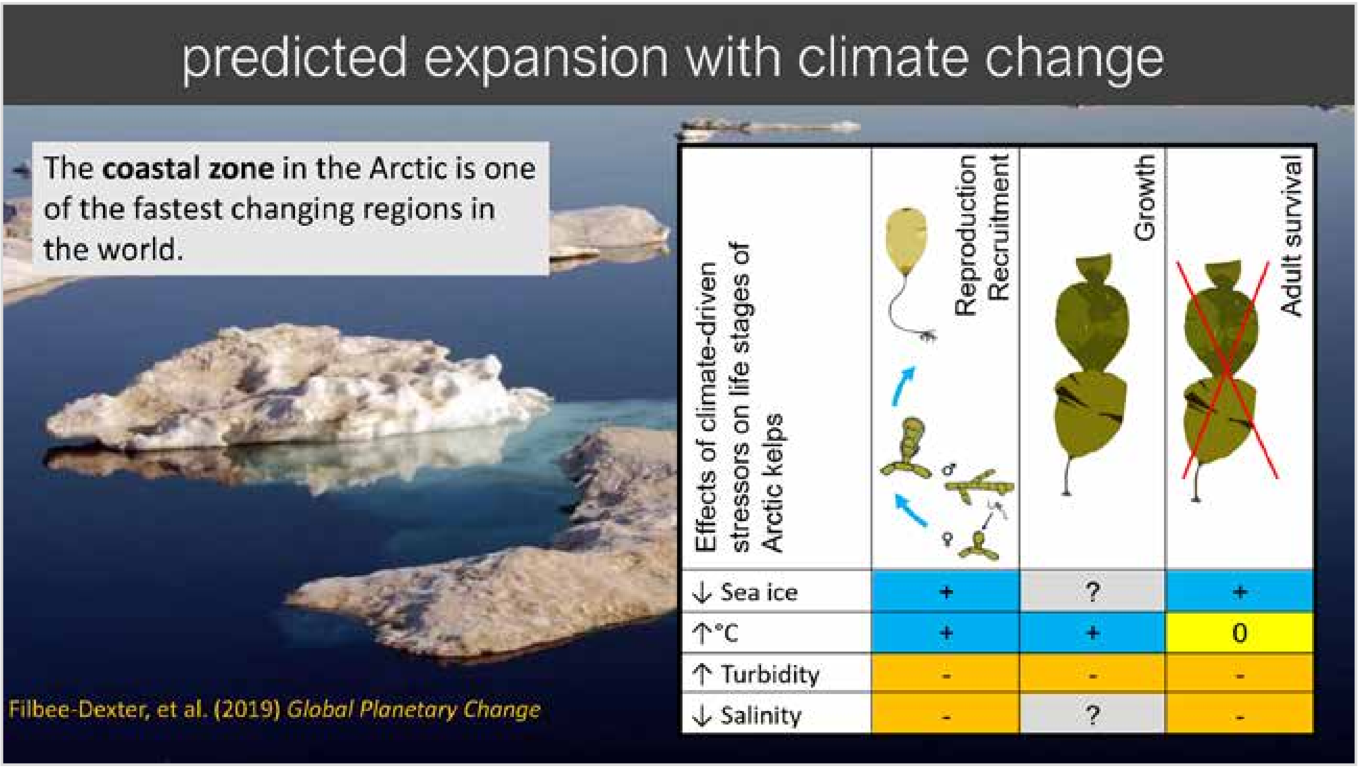
arctickelp Canada

ArcticNet

Karen Filbee-Dexter, Kathleen A MacGregor, Camille Lavoie, Rob Schlegel, Jesica Goldsmit, Ignacio Garrido, Laura Castro de la Guardia, Kimberley Howland, Katrin Iken, Brenda Konar, Christopher W. McKindsey, Christopher J Mundy, Robert Schlegel, Thew Suskiewicz, Ladd E Johnson, Philippe Archambault

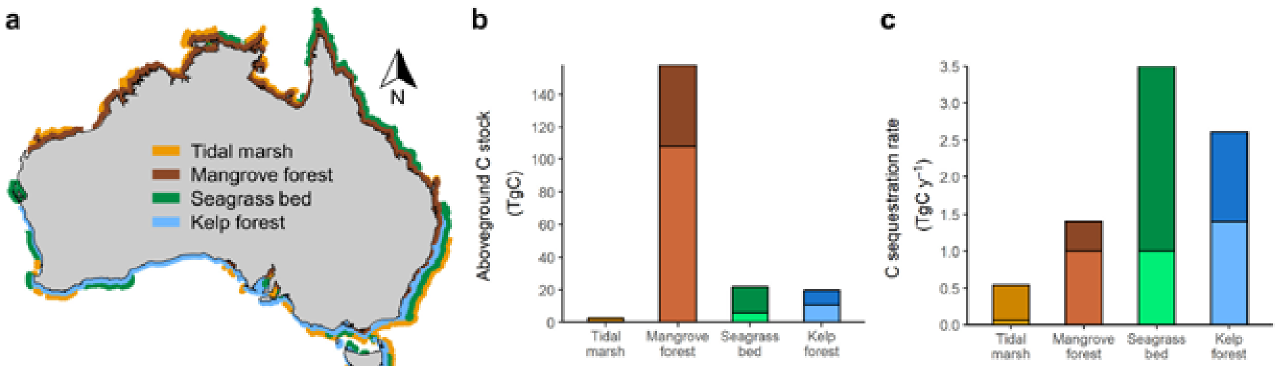

Arctickelp Canada
Ellesmere
North Baffin Island
Baffin Bay
Davis Strait
Foxe Basin
Roes Welcome Sound
Hudson Strait
Nunatsiavut
Labrador Sea
Hudson Bay
80
70
60
50
-90
-80
-70
-60
• What is the extent and species composition of kelp forests in the eastern Canadian Arctic?
• Is kelp influenced by environmental conditions?


kelp forest standing stock and dominant species
80
70
60
50
-90
-80
-70
-60
Ellesmere
North Baffin Island
Baffin Bay
Davis Strait
Foxe Basin
Roes Welcome
Hudson Strait
Nunatsiavut
Labrador Sea
Hudson Bay
no data
0
2
4
6
Mean biomass (kg m-2)
A. clathratum
A. esculenta
H. nigripes/.
L. solidungula
S. latissima


predicted expansion with climate change
The **coastal zone** in the Arctic is one of the fastest changing regions in the world.
Filbee-Dexter, et al. (2019) *Global Planetary Change*
Effects of climate-driven stressors on life stages of Arctic kelps
Reproduction Recruitment
Growth
Adult survival
↓ Sea ice | + | ? | +
↑°C | + | + | 0
↑ Turbidity | - | - | -
↓ Salinity | - | ? | -


ArcticNet
sources of knowledge
ARCTICKELP CANADA
Nunavut Fisheries Association
MITTIMATALIK
HUNTERS & TRAPPERS ORGANIZATION

Blue carbon opportunities – first order estimates are important



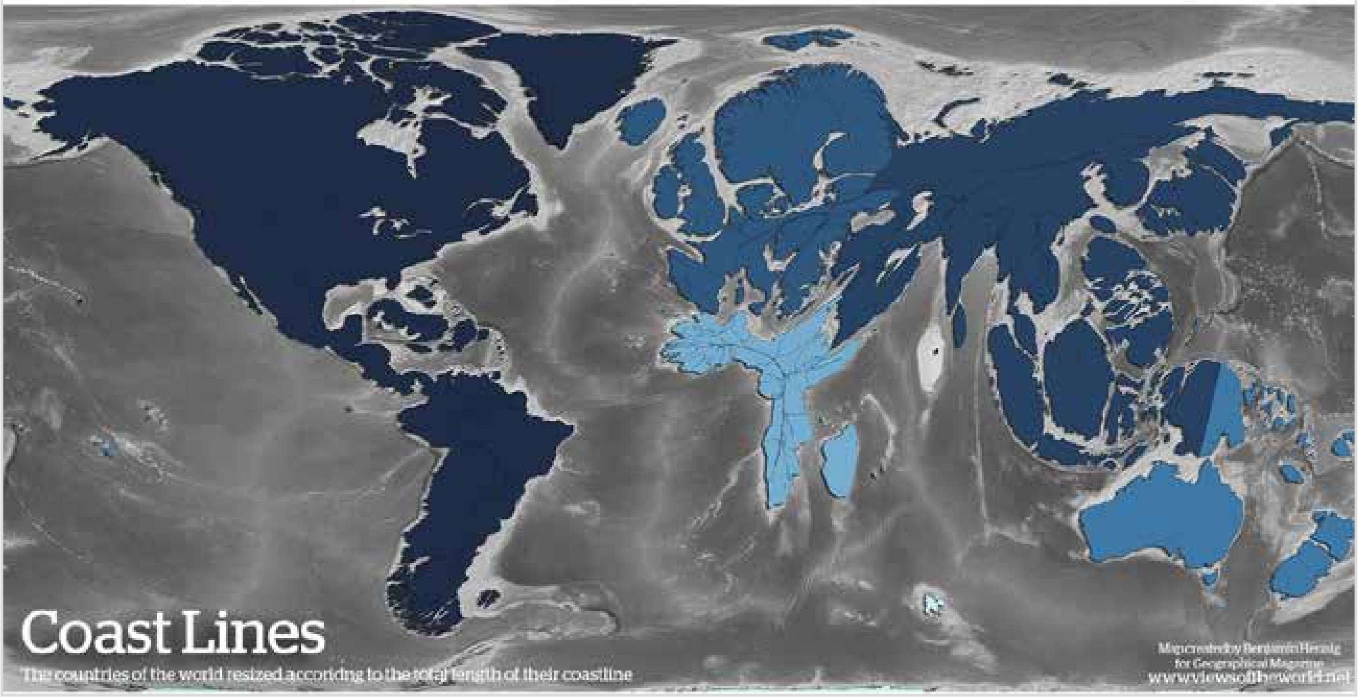
e.g. Australia

Filbee-Dexter and Wernberg 2020. Scientific Reports.

Blue carbon opportunities – ecosystem service approach

Blue forests do not only store carbon, they also support biodiversity, coastal fisheries, cycle nutrients, and other benefits.

Blue carbon opportunities– Canada's longest coastline in the world



Hakai
Science on the Coastal Margin

Mapping Marine-based Natural Climate Solutions in Canada

WWF Webinar Presentation by
Margot Hessing-Lewis, Hakai Institute, 2020

MaPP

NATURE TRUST BRITISH COLUMBIA · MarineGEO THE TENNENBAUM MARINE OBSERVATORIES NETWORK · NSF · UBC · Nature United

Regional Climate Impacts on Ecosystems

- Growing interest in NCS (Natural Climate Solutions)

- Included in NDCs of 28 countries

MITIGATION

Angola **Antigua and Barbuda** Australia **Bahamas** Bahrain **Bangladesh** Belize **Brunei** China **Comoros** Cook Islands **Ecuador** El Salvador **Guinea** Guyana **Haiti** Iceland **Kiribati** Marshall Islands **Mexico** Philippines **Saudi Arabia** Senegal **Seychelles** Sri Lanka **Suriname** **United Arab Emirates** United States of America

- Data needs: habitat extent,

Hakai
Science on the Coastal Margin

Cross-scale, Cross-habitat Monitoring Tools

Luba Reshitnyk,
Hakai Habitat Mapping

Aerial Imagery:
Hakai Geospatial & MaPP

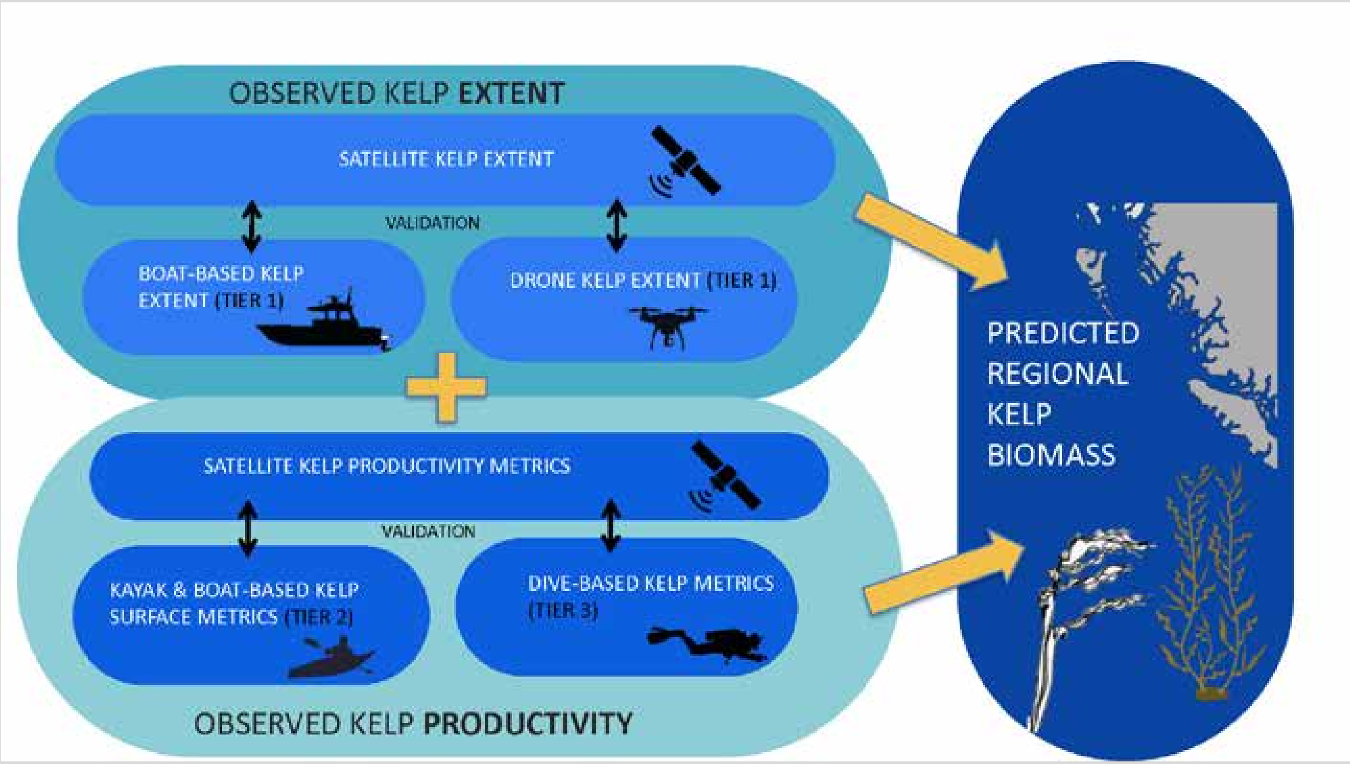
Satellite Imagery:
Hakai Geospatial & SPECTRAL LAB (UVic), UCSB/Wood's Hole (Tom Bell)

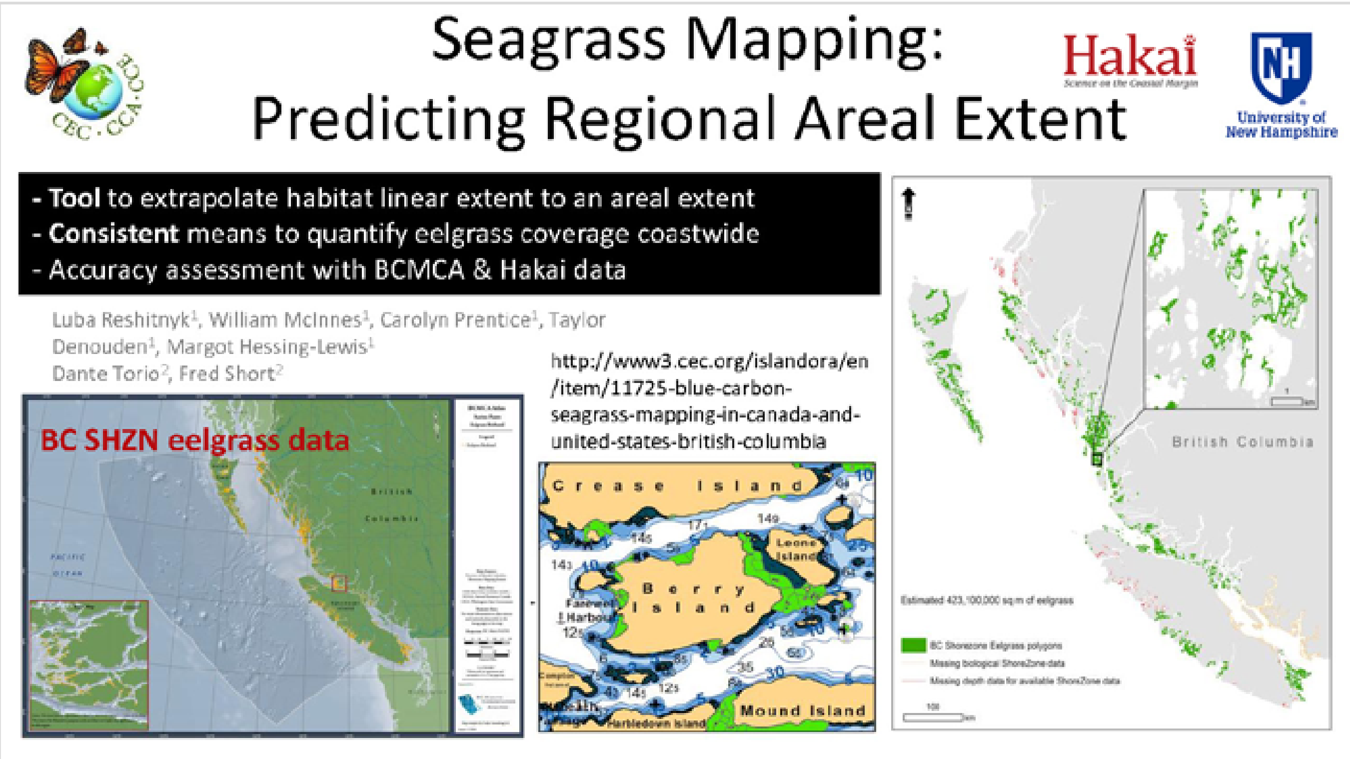
Surface Work:
MaPP & Coastal Guardians

Intertidal/Subtidal Work:
Hakai Nearshore Team

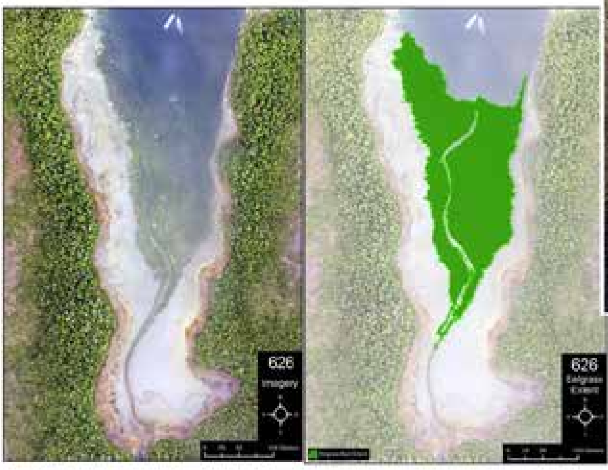
Kelp Mapping & Integrated Modeling

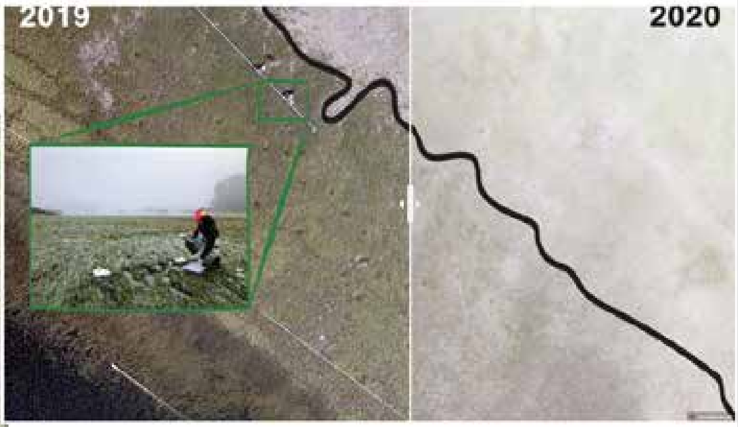
MaPP
Hakai
Science on the Coastal Margin


OBSERVED KELP EXTENT
SATELLITE KELP EXTENT
VALIDATION
BOAT-BASED KELP EXTENT (TIER 1)
DRONE KELP EXTENT (TIER 1)
SATELLITE KELP PRODUCTIVITY METRICS
VALIDATION
KAYAK & BOAT-BASED KELP SURFACE METRICS (TIER 2)
DIVE-BASED KELP METRICS (TIER 3)
OBSERVED KELP PRODUCTIVITY
PREDICTED REGIONAL KELP BIOMASS


Seagrass Mapping:
Predicting Regional Areal Extent
Hakai
Science on the Coastal Margin
University of New Hampshire
CEC · CCA · CCE
- Tool to extrapolate habitat linear extent to an areal extent
- Consistent means to quantify eelgrass coverage coastwide
- Accuracy assessment with BCMCA & Hakai data
Luba Reshitnyk1, William McInnes1, Carolyn Prentice1, Taylor Denouden1, Margot Hessing-Lewis1
Dante Torio2, Fred Short2
http://www3.cec.org/islandora/en/item/11725-blue-carbon-seagrass-mapping-in-canada-and-united-states-british-columbia
BC SHZN eelgrass data
Crease Island
Berry Island
Leone Island
Farewell Harbour
Mound Island
Harbledown Island
British Columbia
Estimated 423,100,000 sq m of eelgrass
BC Shorezone Eelgrass polygons
Missing biological ShoreZone data
Missing depth data for available ShoreZone data

Local Seagrass Mapping & Monitoring





Mapping Underwater Meadows From the Skies
https://www.hakai.org/mapping-underwater-meadows-from-the-skies/

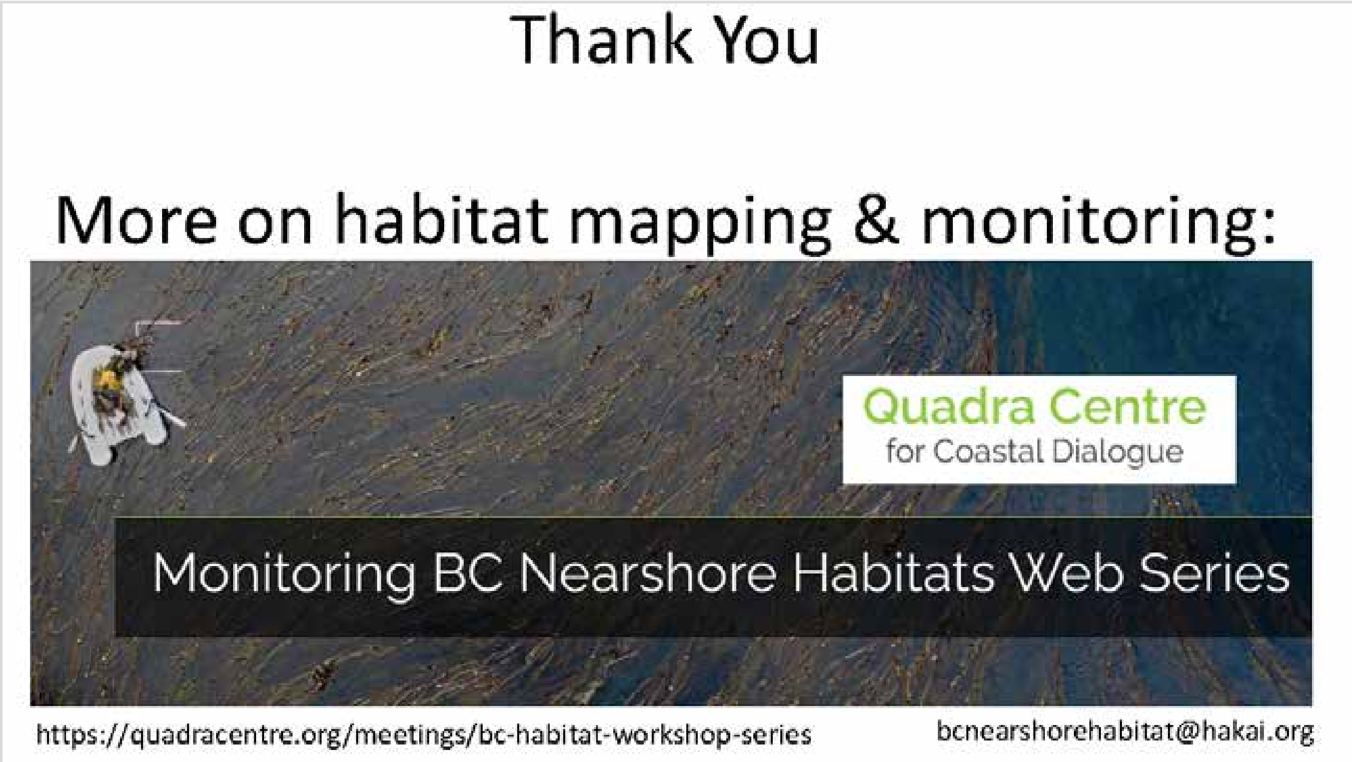
Slide: Luba Reshitnyk

NCS Canada-wide Seagrass Extent

Nature United

- Major spatial datasets
  - Canada-wide: CEC 2016 (Chmura & Short)
  - Pacific: Torio et al. *resubmission* (BC CEC work)
  - Atlantic: CWS Marine Wetland Inventory (Allard et al. 2014)
  - James Bay, St. Lawrence: Open Canada QC data
  - NFLD: Arnault LeBris

CEC currently updating CEC 2016 (Chmura & Short)


Thank You
More on habitat mapping & monitoring:
Quadra Centre
for Coastal Dialogue
Monitoring BC Nearshore Habitats Web Series
https://quadracentre.org/meetings/bc-habitat-workshop-series
bcnearshorehabitat@hakai.org


Thank you!
Field Participation
HIRMD, Richard Reid, Jordan Wilson, Carey, Mike Vegh, Robert Johnson
Hakai Collaborators
Luba Reshitnyk, Keith Holmes, Will McInnes, Derek Heathfield, Brian Hunt, Jennifer Jackson, Wiley Evans, Ian Giesbrecht, Matt Lemay
Photo Credits
Tristan Blaine, Derek VanMaanen, Angeleen Olson, Keith Holmes, Derek Heithfield, Luba Reshitnyk
Hakai Nearshore Team

Acknowledging some of our research partners

Heiltsuk Nation

Heiltsuk Integrated Resource Management (HIRMD)

Wuikinuxv Nation

MaPP

MarineGEO
THE TENNENBAUM MARINE OBSERVATORIES NETWORK
Smithsonian Institution

ROYAL BC MUSEUM

UBC

UNBC UNIVERSITY OF NORTHERN BRITISH COLUMBIA

VANCOUVER ISLAND UNIVERSITY

SFU

CIOOS
CANADIAN INTEGRATED OCEAN OBSERVING SYSTEM

University of Victoria

Fisheries and Oceans Canada
Pêches et Océans Canada

BCParks

Canada

Eelgrass mapping in Atlantic Canada and James Bay (QC)

BRIGITTE LEBLON, UNIVERSITY OF NEW BRUNSWICK AND COALITION- SGSL

Atlantic Eelgrass Monitoring Consortium Atl-EMC

Coalition pour la viabilité du sud du Golf du Saint-Laurent
Southern Gulf of St-Lawrence Coalition on Sustainability

Angela Douglas & Brigitte Leblon

Coalition-SGSL

Coalition pour la viabilité du sud du Golf du Saint-Laurent
Southern Gulf of St-Lawrence Coalition on Sustainability

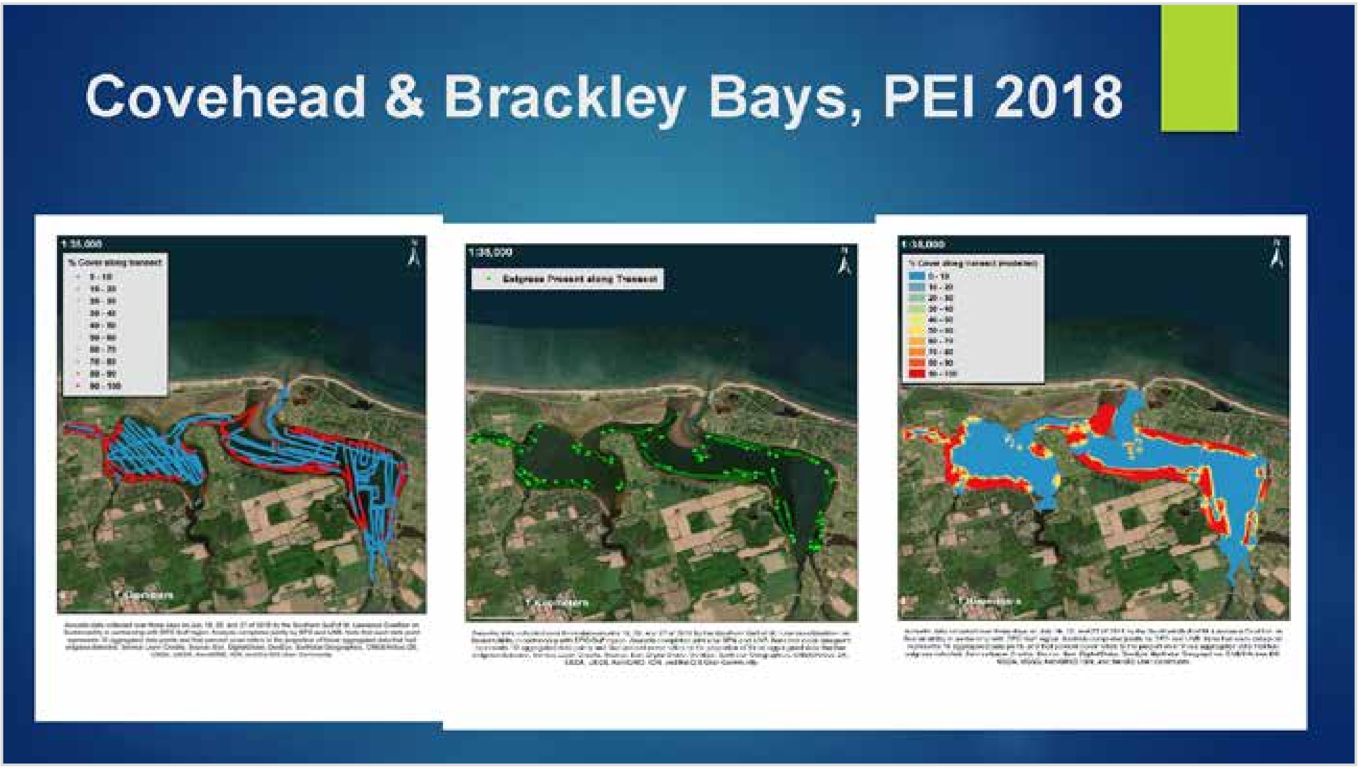
The coalition is a multi-province, multi-stakeholder, NGO.

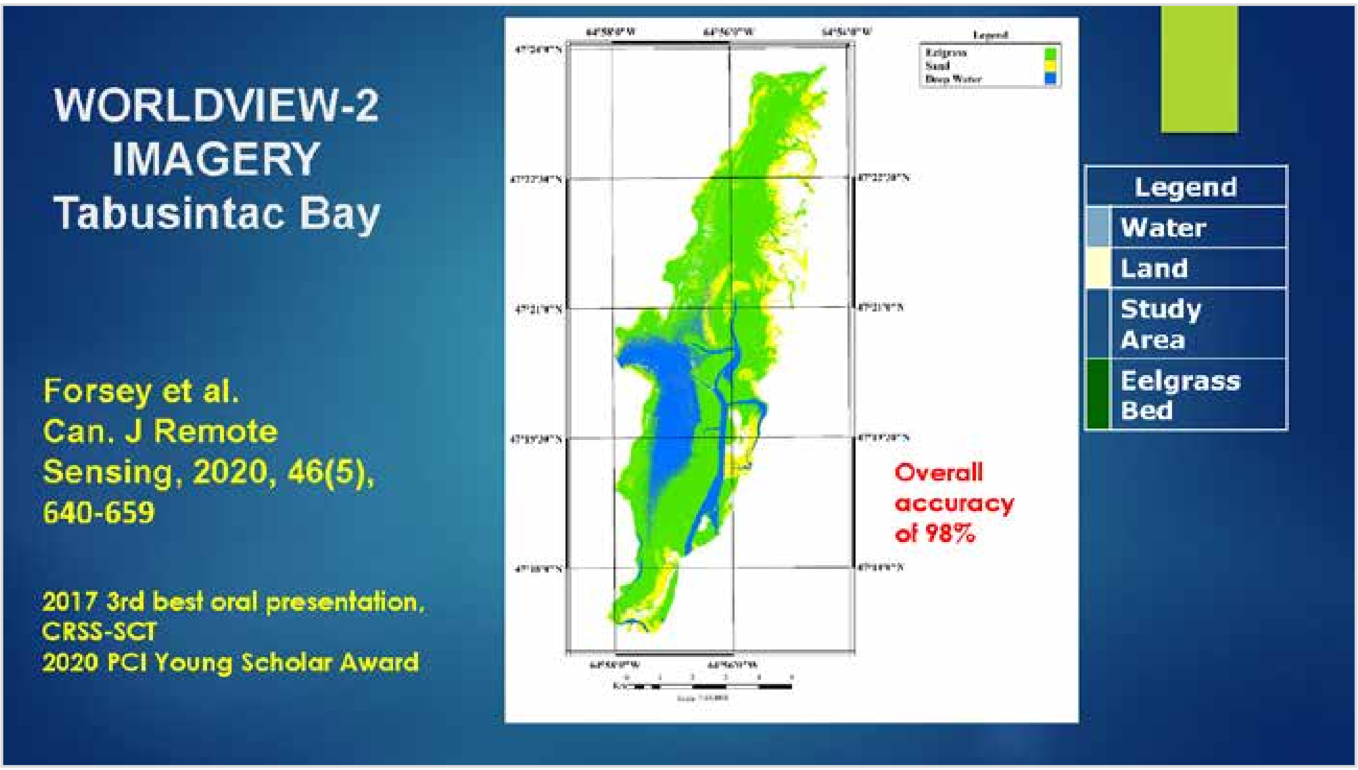
Objectives include:

- Facilitate communication, networking and information sharing.
- Organize and/or facilitate meetings, workshops, forums or working groups.
- Monitor the progress of implemented strategies, policies and regulations.
- Assist communities to build their capacity for achieving their sustainability goals.

Atlantic Eelgrass Monitoring Consortium (Atl-EMC)

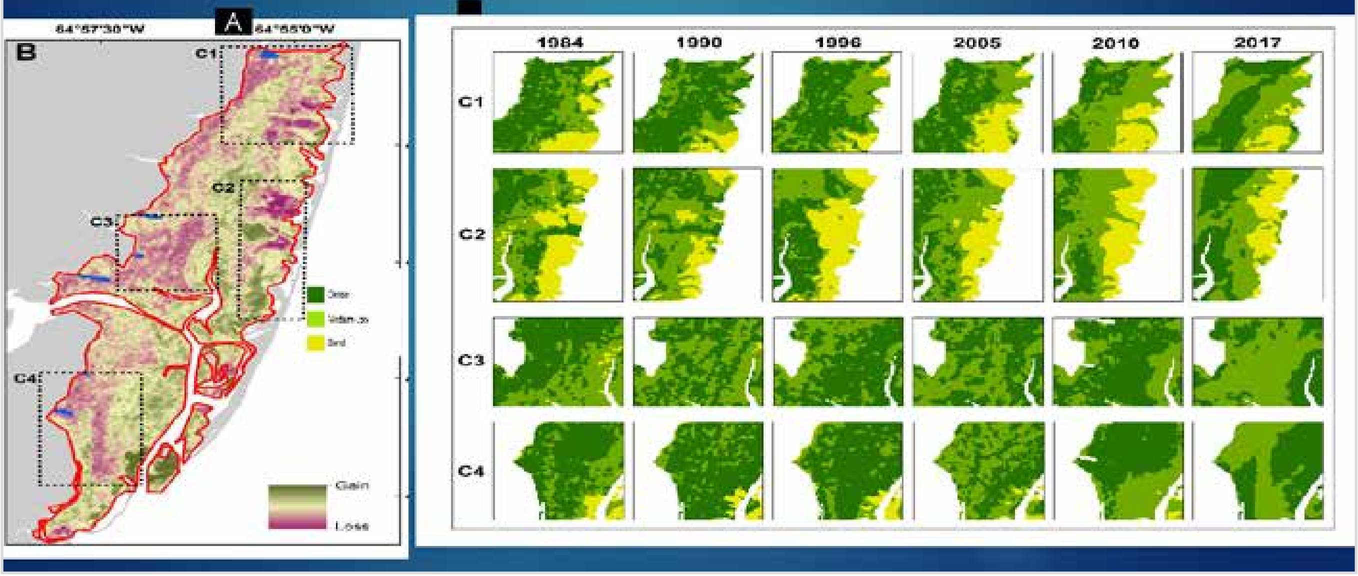
- SeagrassNet sites set up in four provinces using permanent transects sampled annually.
- Sonar acquisition at 30 sites (with assistance from DFO)
- Satellite and Drone (UAV) remote sensing to map eelgrass distribution.
- Identification of factors impacting eelgrass health and distribution.
- Addressing issues impacting eelgrass health
- Planning and executing restoration projects in areas with suitable habitat via transplant suitability index.


Covehead & Brackley Bays, PEI 2018


WORLDVIEW-2
IMAGERY
Tabusintac Bay
Forsey et al.
Can. J Remote
Sensing, 2020, 46(5),
640-659
2017 3rd best oral presentation,
CRSS-SCT
2020 PCI Young Scholar Award
Overall
accuracy
of 98%
Legend
Water
Land
Study
Area
Eelgrass
Bed

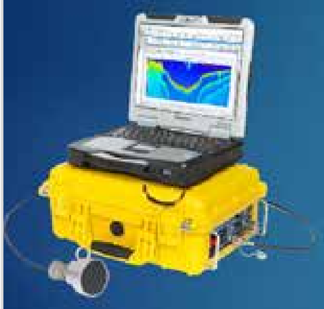
Landsat time-series to evaluate seagrass dynamics: a case study in northeastern New Brunswick, Canada.

Leblanc et al. 2021 CJRS



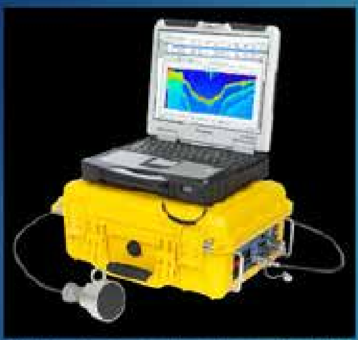
UAV-Sonar-Satellite

Gallant et al. 2021, ISPRS World Congress

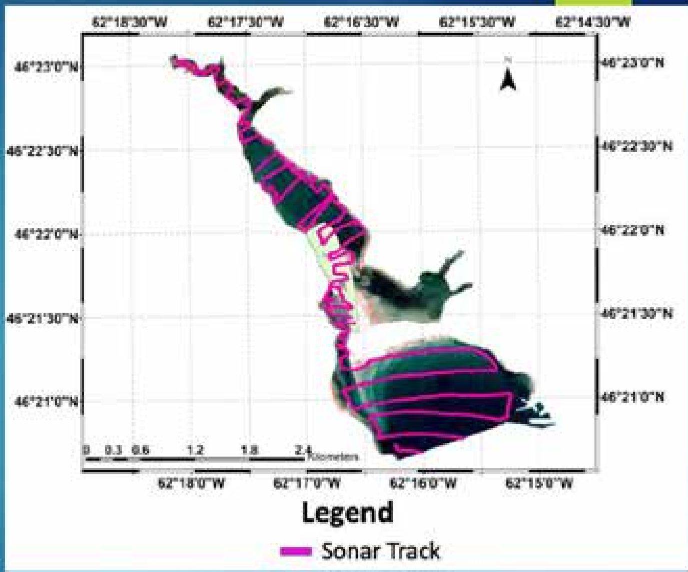


Sonar

BioSonics MX Aquatic Habitat Echosounder

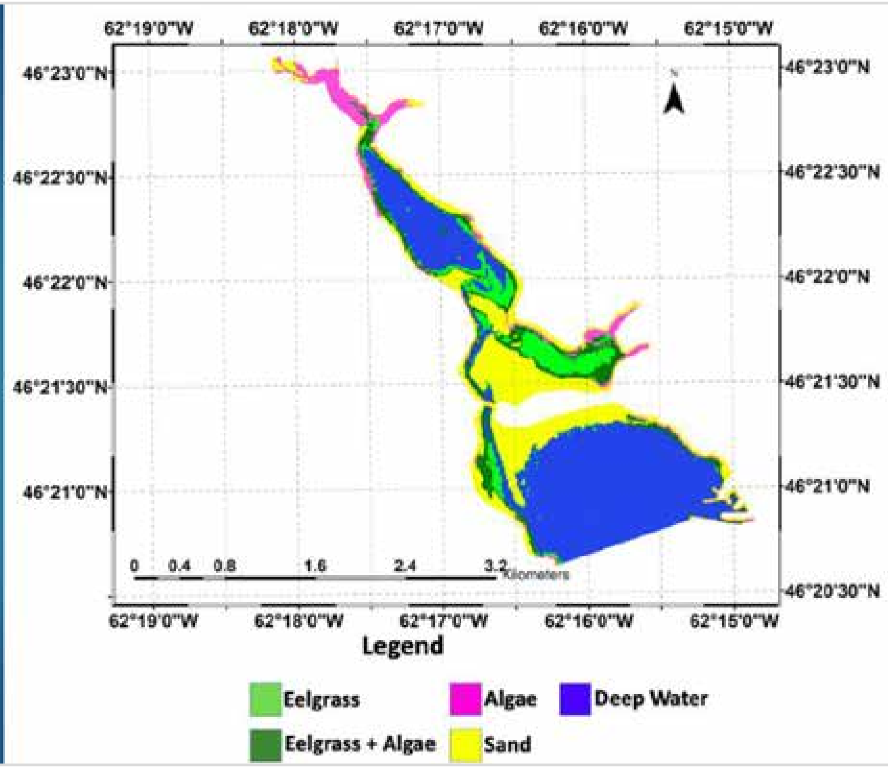


https://www.biosonicsinc.com/products/mx-aquatic-habitat-echosounder/



Sonar Acquisition Date	Time (UTC Standard)	Tide Height (m)
August 6th, 2019	16:30	1.6

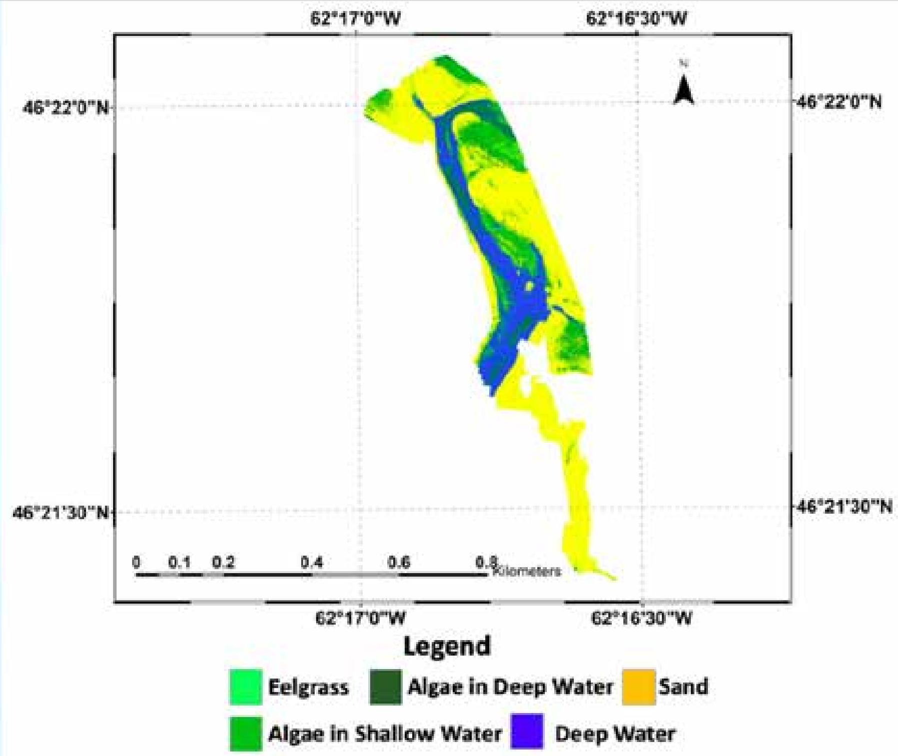
Classified Sentinel-2 Image



Validation Accuracy of 77.66%

Classified UAV Image

Validation Accuracy of 90.82%



Project Partners

PAYS DE COCAGNE

acap Humber Arm

Prince Edward Island Wildlife Conservation Fund

BBEMA

GAMS • CMAG

Kensington North Watersheds Association

Kouchibouguac Watershed Association

COINAtlantic Coastal and Ocean Information Network

MREAC

Shediac Bay Association — Protection · Education

Mitacs Accelerate

New Brunswick / Nouveau-Brunswick — Your Environmental Trust Fund at Work

UNB University of New Brunswick

University of Prince Edward Island

Stantec

Environment and Climate Change Canada / Environnement et Changement climatique Canada

Fisheries and Oceans Canada / Pêches et Océans Canada


SFU
SIMON FRASER UNIVERSITY
Parks Canada Parcs Canada
Quantifying Blue Carbon at Boundary Bay, the largest salt marsh in southern British Columbia
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ShoreZone Mapping of Sensitive Habitat Polygons on BC's North Coast
Canopy Kelps (BUKE, GIKE)
Eelgrass (EELG)
Dune Grass (DUGR)
Salt Marsh (SAMB)
ShoreZone
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Jesica Goldsmit, PhD in Oceanography
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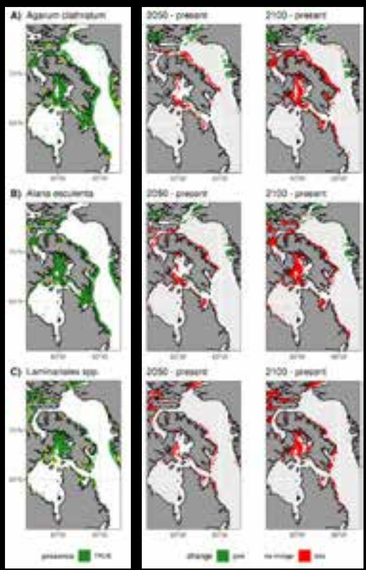
Main Collaborators:
- Robert Schlegel, Dalhousie University/Institut de la Mer de Villefranche
- Karen Filbee-Dexter, Institute of Marine Research
- Kathleen MacGregor, DFO/ULaval
- Amanda Savoie, Canadian Museum of Nature
- Philippe Archambault, ULaval
- Christopher McKindsey, DFO
- Kimberly Howland, DFO



ARCTICKELP CANADA

Schlegel - Goldsmit et al (*in prep*)

Projects related to blue carbon:

Mapping the habitat suitability of different macroalgae/seagrass species in Arctic environments and predicting their changes under climate change scenarios:

Ongoing Projects

1- Arctic Kelp Canada

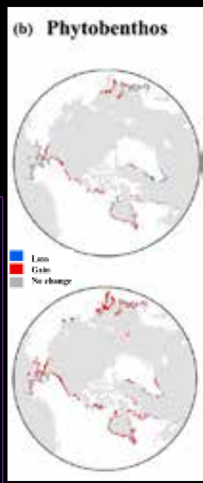
2- *Zostera marina* suitability, overlap/mismatch with other trophic levels

Past projects

3- Invasion hotspot of macroalgae

Biggest challenge:

Collection of good quality and complete datasets (occurrence and environmental data)



Potential aquatic invasive species:
1- *Codium fragile*
2- *Dumontia contorta*
3- *Sargassum muticum*
4- *Undaria pinnatifida*

Goldsmit et al 2020, *Global Change Biology*

Citizen science eelgrass monitoring in Nova Scotia

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