MINUTES OF THE MEETING
STEERING COMMITTEE (SC)

Meeting Nº 70
Wednesday, January 29, 2025
9:00 AM to 12:00 PM
In Person – Maison du Développent Durable- 50 rue Sainte Catherine
Montreal
And Videoconference – TEAMS

Present:	Felix Boulanger	Hydro-Québec
	Marc Dunn	Niskamoon Corporation
	Luc Duquette	Hydro-Québec
	Louie Kanatewat	Cree Nation of Chisasibi
	Mélanie Leblanc	Niskamoon Corporation
	Josée Lefebvre	Canadian Wildlife Service
	Marie-Eve Lemieux	Hydro-Québec
	Geraldine Mark	Cree Nation of Wemindji
	Ernest Moses	Cree Nation of Waskaganish
	Mimie Neacappo	Niskamoon Corporation
	John Lameboy	Cree Nation of Chisasibi
	Manon Sorais	Eeyou marine region wildlife board
	Ernie Rabbitskin	Niskamoon Corporation
	Robbie Tapiatic	Cree Nation of Chisasibi
	Cassandra Weapenicappo	Cree Nation of Eastmain
Guest:	Paul del Giorgio	UQAM
	Zou Zou Kuzyk	University of Manitoba
	Michaela de Melo	UQAM
	Fanny Noisette	UQAR
	Mary O'Connor	University of British Colombia
	Mila Oser (Secretary)	Hydro-Québec
Absent:	Daniel Brosseau	Hydro-Québec
	Jean-Philippe Gilbert	Hydro-Québec
	Graeme Morin	Cree nation Government
	Roderick Pachano	Cree Nation of Chisasibi

MEETING CHAIR AND SECRETARY

Marc Dunn chaired the meeting, and Mila Oser acted as the meeting secretary.

PROPOSED AGENDA

1. Approval of the Agenda
2. Approval of the minutes from the previous meeting – December 4, 2024
3. Presentation of research paper "Riverine influence on physicochemical properties of coastal waters along a latitudinal gradient in the eastern James Bay
4. Update of the Landscape Change project of Phase II
5. Presentation of research paper "Winter to summer transition in seawater salinity, temperature, and light at Eelgrass Bed Habitats in northeastern James Bay"
6. CHCRP Eelgrass Team Final Report 2022-2024
7. Miscellaneous
8. Summary and Next Steps
9. Next Meeting

1. Approval of the Agenda

The Chair reviewed the agenda, and no additional points were proposed. Thus, the agenda was approved as presented

2. Approval of the minutes from the previous meetings

The Chair and Luc Duquette (Mr. Duquette) discussed the approval of the minutes from the previous meeting held on December 4, 2024. They emphasized that until the minutes are officially approved, they should not be shared with non-committee members. This is to prevent the dissemination of potentially inaccurate or incomplete information. The minutes were approved.

3. Presentation of research paper "Riverine influence on physicochemical properties of coastal waters along a latitudinal gradient in the eastern James Bay”

Paul del Giorgio (Mr. del Giorgio) delivered a presentation titled "Riverine influence on physicochemical properties of coastal waters along a latitudinal gradient in the eastern James Bay, and a copy of the presentation and document is appended to these minutes for reference.

Mr. del Georgio acknowledged the support and collaboration from various stakeholders, including land users, communities, Hydro Québec, Niskamoon, and fellow researchers. The presentation highlighted the importance of partnerships and the ongoing collaboration that has enabled this research. Mr. del Georgio introduced his colleague, Michaela de Melo from UQAM, who also worked on this research and manuscript and was joining the meeting in person.

Mr. del Georgio presented an update on a manuscript that has been submitted for publication. The manuscript focuses on the river team's collaboration with the coastal team to understand the influence of rivers on the coastal water quality in the James Bay area. The study leverages datasets collected during Phase 1 of the Coastal Habitat Comprehensive Research Project (CHCRP) to determine the links between river and coastal properties. The main aim is to assess how rivers influence the coastal system beyond their immediate plumes, addressing a complex question that has not been widely studied globally.

Key findings include:

- Rivers in the James Bay area cluster based on their water quality, with southern rivers being murkier and northern rivers having more organic matter.
- The coastal sites also cluster based on water quality, and these clusters align with the river clusters, indicating that rivers influence coastal water quality along the entire James Bay.
- The river La Grande – Chisasibi stands out as it has a unique water quality profile, different from other rivers in the area.

Mr. del Georgio said that the manuscript concludes that rivers significantly influence the coastal water quality along the entire James Bay, not just at the plume but also beyond it. This finding is important as it suggests that changes in river conditions due to landscape or climate changes can impact the coastal water quality.

Mr. Duquette asked for clarification on what a cluster of coastal sites means in the context of the presentation. Mr. del Georgio explained that the sites cluster based on a set of environmental variables and that this clustering is statistical rather than geographical.

Mr. Dunn mentioned that although he had not seen the manuscript yet, he wanted to make sure it included a Cree perspective, as the Crees have long recognized the link between the coast and rivers. This paper should mention their acknowledgment of this connection.

Mrs. de Melo said that during Phase 1, they installed hydrometric stations, which are still operating. In winter, ice causes problems, and adjustments are made in spring, resulting in some data gaps. This data is downloaded weekly and uploaded to the website for everyone to view. Mrs. de Melo also shared the link to the Eeyou River discharge website explaining its format and the available data.

In relation to data collection along the river, Mr. Duquette also mentioned that following a conversation with the geomatic team the day before, some concerns were raised about the hydrometric stations along the river and their maintenance. One of the main concerns was the need for regular maintenance and calibration of the hydrometric stations to ensure accurate data collection. Mr. Dunn suggested that a dedicated team should be responsible for the upkeep of these stations to prevent any discrepancies in the data.

Additionally, there was a discussion about the accessibility of the data collected by these stations. And after discussions among the members of the steering committee members, the creation of a centralized database where all the data from the hydrometric stations could be stored and accessed easily by researchers and stakeholders was proposed. Another suggestion was to enhance the existing hydrometric stations with advanced sensors and technology to improve the quality and range of data collected. This would help in better understanding the river's behavior and its impact on the surrounding environment.

4. Update of the Landscape Change project of Phase II

It is noted that Mr. del Georgio covered Phase 2 in the above part of his presentation

Mr. del Georgio said that during CHCRP Phase 2, the focus was on understanding the influence of rivers on coastal water quality in the James Bay area. The study aimed to determine the links between river and coastal properties, addressing the complex question of how rivers influence the coastal system beyond their immediate plumes.

Key findings include:

- Rivers significantly impact coastal water quality along the entire James Bay, not just at the plume but also beyond it.
- Southern rivers are murkier with more sediments, while northern rivers have more organic matter.
- The river La Grande has a unique water quality profile, different from other rivers in the area.

The study leveraged datasets collected during CHCRP Phase 1 to determine the links between river and coastal properties. The findings suggest that changes in river conditions due to landscape or climate changes can impact the coastal water quality.

Mr. del Georgio mentioned that they were hoping to submit the Alliance NSERC proposal during the course of the winter and get a reply by this summer.

5. Presentation of research paper "Winter to summer transition in seawater salinity, temperature, and light at eelgrass bed habitats in northeastern James Bay"

Zou Zou Kuzyk (**Mrs. Kuzyk**) gave an update of the research and findings from the document «Winter to summer transition in seawater salinity, temperature, and light at eelgrass bed habitats in northeastern James Bay that was already circulated by Mrs. Leblanc.

Mrs. Kuzyk explained that in early 2019, during the winter, they collaborated with community members and were able to deploy instruments in March 2019, with a second deployment on April 4. They placed the instruments at the bottom near eelgrass beds because we were concerned about ice, which could cause jams in the spring, so they positioned the instruments deeper to avoid losing them.

They remained deployed from March until the following August, and the data presented in this document are from that period.

Mrs. Kuzyk said that one of the main things they learned in CHCRP phase 1 is that the conditions in the spring seem to be particularly important.

Mrs. Kuzyk mentioned the take home messages:

Eelgrass requires a significant amount of light, and their studies indicate that neither of the sites they examined provide the maximum light needed for eelgrass. At this stage, Mrs. Kuzyk said that they are unable to develop a universal model that provides exact outcomes, but they have gained substantial knowledge and established a solid foundation.

During the meeting, there was a discussion about the feedback on the CHCRP Phase 1 synthesis document, which had been circulated by Mrs. Leblanc. Mrs. Kuzyk provided comments on this document, highlighting the need for a more comprehensive synthesis of the research findings.

In response to Mrs. Kuzyk's comments, it was agreed that the synthesis document would be revised to incorporate her feedback. The steering committee team decided to work on improving the document to ensure it accurately reflects the research findings and addresses the points raised by Mrs. Kuzyk.

6. **CHCRP Eelgrass Team Final Report 2022-2024**

Fanny Noisette, (Mrs. Noisette) delivered a presentation titled "Presenting CHCRP Phase II (2023-2024),"and a copy of the presentation and document is appended to these minutes for reference.

Mrs. Noisette gave a reminder of the timeline: phase 1 (2019-2021), the interim phase (2022-2024), and phase 2 (2024-2029) and said this is a joint effort between stakeholders.

Mrs. Noisette mentioned that eelgrass persists but has not fully recovered.

Mrs. Noisette mentioned that the most important aspect of CHCRP phase 1 was reported in the final eelgrass report in phase 1.

One of the objectives of the interim phase was to follow eelgrass growth in five locations to understand the connection with early summer conditions.

Mrs. Noisette mentioned that between these interim phases, several events occurred, such as the forest fires in the summer of 2023, which put the study on standby. During this time, the team piloted new methods focusing on rhizome growth and sugar content. Fieldwork took place in Eeyou Istchee in summer 2024.

Mrs. Noisette said that their findings showed that although more sugar coincides with more growth, the sugar itself was not directly correlated to growth. As rhizomes grow, sugar is present simultaneously, and this helped them understand how eelgrass can grow during winter.

In the summer interim phase, from the end of June to July 2024, Mrs. Noisette said they conducted samplings and held community meetings to discuss the project and priorities and continued monitoring through additional samplings.

Assessment of eelgrass condition in key locations:

Mrs. Noisette said that eelgrass shoot lengths, density, and biomass were comparable to regional averages in recent years but generally remain below pre-decline levels.

The researchers followed eelgrass growth in five locations in the Chisasibi and Wemindji areas to understand the link between early summer growth and environmental conditions. Shoots were pricked to monitor and measure growth over ten days. At the CH3 site, growth was faster. They also observed a significant number of algae mats in several locations this year, which could affect eelgrass growth.

Mrs. Noisette mentioned that Niskamoon requires this report to be approved to release the final payment.

7. Miscellaneous

Following a request from Chief Daisy House to share steering committee documents with the CTA and CERRI, extend an invitation to Dante Torio (CERRI) as an observer at the next steering committee meeting.

8. Summary and Next Steps

Approval of Minutes: Ensure that the minutes from the previous meeting (December 4, 2024) are approved and not shared with non-committee members until they are officially approved.

Video Script and Narration Review: Approve the video script and narration review comments in January.

Data Finalization: Finalize the data from the Long Island project.

Synthesis Document Revision: Revise the CHCRP Phase 1 synthesis document to incorporate feedback from Mrs. Kuzyk.

Review the manuscript submitted by Michaela de Melo and Paul del Georgio and give feedback to Mila Oser by February 20th.

9. Next Meeting

Following the exchange on the availability of each, it was agreed that the next meeting will be held on Friday, February 28, 2025, from 9:00 AM to 12:00 PM, via Teams.

ADJOURNMENT OF THE MEETING

Considering that all items on the agenda were addressed, the meeting is adjourned at12:30 PM.

The meeting secretary,	The meeting Chair,
Mila Oser	Marc Dunn

Riverine influence on physicochemical properties of coastal waters along a latitudinal gradient in the eastern James Bay

Michaela L. de Melo[1*], Caroline Fink-Mercier[2], Virginie Galindo[2], Michel Gosselin[2], Urs Neumeier[2], Huixiang Xie[2], and Paul A. del Giorgio[1]

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Abstract

Rivers integrate climate signals, landscape gradients and environmental disturbances at the watershed scale, motivating the effort to better understand the influence of riverine exports on downstream ecosystems. Here we aim to establish connections between the physicochemical properties of rivers draining into the eastern James Bay (JB), and of the coastal waters along its entire eastern shore. We clustered 17 river outlets and over 140 coastal sites along the latitudinal gradient (~300 km shoreline) of JB sampled during two consecutive summers according to trends in nutrients, suspended particulate matter (SPM), colored dissolved organic matter (CDOM) absorbance, freshwater discharge and salinity. The transition zones, where significant latitudinal changes in water physicochemical variables occur, were generally spatially consistent between rivers and coastal waters. Average material concentrations were overall higher in rivers than in adjacent coastal waters. We conclude that rivers broadly shape the coastal physicochemical

conditions along eastern JB, and that the riverine influence varies among areas as a function of streamflow and of the variable considered.

Keywords: CDOM, turbidity, nitrogen, phosphorus, cluster analysis, transition zones

Running head: Riverine influence on eastern James Bay coast

Scientific Significance Statement

The subarctic James Bay is the most river-affected water body of the Hudson Bay system and represents a major compartment to study riverine influence on coastal biogeochemistry. Although freshwater exports to the James Bay have previously been quantified, we still lack an integrated perspective on how river exports affect coastal biogeochemistry. This study identified transition zones of salinity, nutrients, turbidity, and colored dissolved organic matter (CDOM) absorbance along the coast of the eastern James Bay and estimated river influence on coastal waters in distinct areas during summer as a function of streamflow and variable considered.

Introduction

Rivers are major conduits for the transport and processing of dissolved and particulate materials (e.g., nutrients and suspended particles) from land to the ocean. By integrating climate signals (e.g., precipitation), watershed properties (e.g., land cover) and environmental disturbances (e.g., wildfires), rivers act as sentinels of landscape and climatic changes and influence downstream ecosystems through export of terrestrial organic matter, sediments, contaminants, and macro- and micronutrients (Dupas et al., 2017; Li Yung Lung et al., 2018). Such exports are critical to biogeochemical cycling and biological productivity in coastal ecosystems (Grimes 2001; Terhaar et al. 2021). Research to date has focused on characterizing seasonal and long-term dynamics of individual river watersheds, as well as identifying major underlying drivers of material concentration and export (Tank et al. 2012; McClelland et al. 2014; Moquet et al. 2016; Li Yung Lung et al. 2018), but less attention has been paid on how these riverine exports shape coastal material budgets.

It has been well established that rivers exert strong local influence along their respective coastal plumes, and there has been extensive research on the processes that mediate the export of materials to open oceans, such as flocculation, deposition, and other biogeochemical processes (Emmerton et al. 2008; Bauer et al. 2013; Asmala et al. 2017). However, few studies have assessed the extent to which broad hydrologic and environmental gradients involving multiple watersheds at regional scales may generate patterns in physical and biogeochemical properties in marine coastal areas over large spatial scales (Zhang and Blomquist 2018; Frigstad et al. 2020).

This is certainly the case for understudied regions of the Canadian Arctic (Li Yung Lung et al. 2018), where freshwater exports are an important fraction of the nearshore marine volume (McClelland et al. 2012). Located in the southern end of Hudson Bay, the James Bay (JB) is the most river-influenced water body of the Hudson Bay system (Déry et al. 2005), receiving a river runoff from its eastern shore of about 227 km^3 per year (de Melo et al. 2022). Regional hydrology has been significantly altered by river diversions (about 65 km^3 per year) and damming for hydropower production, and there are large climatic and environmental gradients within the territory that result in a wide range of watershed landscape properties (de Melo et al. 2022). It has been shown that hydrologic export from these watersheds directly shape river plumes and surrounding coastal habitats in the JB, influencing local salinity, turbidity, nutrients, and dissolved organic matter (Peck et al. 2022; Évrard et al. 2023; Kuzyk et al. 2023; Leblanc et al. 2023; Meilleur et al. 2023). Beyond these localized riverine effects, there is also evidence of larger scale latitudinal physicochemical gradients (Évrard et al. 2023; Lee et al. 2023; Guzzi et al. 2024) along the entire eastern JB coast, yet the underlying drivers of these patterns are unclear, and so is the potential contribution of regional rivers to these patterns.

The objective of this study is to assess potential links between broad gradients in river properties and large-scale physicochemical patterns along the eastern JB, mediated by river transport of water and materials from land to the coast. This exploration is fundamental because the terrestrial landscape and the hydrology of the region are drastically changing (Royer and Herrmann 2013; Déry et al. 2016; de Melo et al. 2022), but it is uncertain how these shifts will impact the biogeochemical functioning of the JB beyond very localized river plume effects. Yet, there are potential far-reaching implications of these impacts on coastal productivity and biodiversity. The aim is to determine large-scale physicochemical gradients and identifying discontinuities in relevant variables, such as turbidity, nutrients, and CDOM absorbance, in both rivers and coastal habitats at comparable spatial and temporal scales along the entire eastern JB, and to subsequently explore potential connections. Here, we identified transition zones where significant changes in both riverine and coastal water physicochemical properties occur following the regional ocean circulation pattern, and we have assessed the degree to which these transitions in rivers and coastal sites overlap along the Bay.

Methods

Study area

This study was conducted along the eastern coast of James Bay (JB), the southern extension of Hudson Bay in northern Quebec, Canada, within the traditional Cree territory (Eeyou Istchee), as part of the Coastal Habitat Comprehensive Research Project (CHCRP, Kuzyk et al. 2023), an interdisciplinary, Cree-driven community-academic partnership.

JB is characterized by a cyclonic circulation during the open water season (Prinsenberg 1986) and a moist continental subarctic climate (Koeppen Climate Classification System) with contrasting seasons: ice-covered cold winters and warm to cool summers, with a short growth season from June to November (Davis et al. 2024). Ice formation in the Hudson Bay system progresses from northwest to southeast, with JB ice-covered by early December. Ice breakup starts in late May or early June near river mouths and marine inflows, and JB is usually ice-free by early July (Taha et al. 2019).

The eastern JB drainage basin lies predominantly within the Canadian Shield physiographic region, shaped largely by glaciation, and consists mainly of a coastal plain with many lakes, ponds, peat bogs, and swamps (The Atlas of Canada, Canada 1978). The Great Clay Belt, the largest clay pocket within the Canadian Shield (Dresser 1913), extends across watersheds in the southern region of the Bay, with several rivers flowing into Rupert and Hannah bays. Several river watersheds draining an area over 350 000 km^2 discharge a total water volume of 227 km^3 yearly into the eastern JB (de Melo et al. 2022). The La Grande (LG) River contributes to over 50% of total freshwater inputs to the JB during all seasons due to several watershed diversions for hydropower production in the past decades, resulting in over doubling its natural mean annual discharge and inverting its seasonal flow pattern with now the discharge peaking in winter (Déry et al. 2016).

River and coastal habitat sampling

A total of 17 rivers were sampled close to their mouth from the Harricana River in the south (48°34’13” N, 78°07’17” W) to the Salmon River in the north (54°33’35” N, 79°25’05” W) covering more than 400 km of coastline (Figs. 1A and S1). They were accessed by boat or helicopter in summer 2018 (July 17-27) and 2019 (July 31 - August 13). Coastal marine sites were sampled from the Jolicoeur River (~52° N) to near the mouth of the Piagochioui River (~54° N), along approximately 250 km of coastline, by freighter canoes guided by Cree guides (Fig. 2A). The coastal team sampled over 140 sites in summer 2018 (August 01-18) and 2019 (July 05 – August 14), providing a robust latitudinal coverage of the coast (Fig. S1; comparison between years in Table S1).

Environmental variables

Water samples were collected at depth of 0.5 m using a peristaltic pump and stored in 20 L acid washed polycarbonate containers (river) or using a 5 L Niskin bottles (coast). Samples were then properly filtered (for dissolved fractions) and stored in pre-cleaned polypropylene specimen containers for nutrients and in glass bottles for CDOM absorbance measurements within hours before being transported for analytical laboratories. The total nitrogen concentration (TN, unfiltered water sample) of river samples was analyzed in duplicate using the alkaline persulfate digestion in an Alpkem Flow-Solution IV autoanalyzer (O I Analytical, College Station, TX, USA). For dissolved nitrogen concentration (DN), coastal water was filtered onto a pre-combusted Whatman GF/F filter (450°C for 5 h, 25 mm, nominal porosity of 0.7 μm) and analyzed in a Shimadzu TOC-V_{CPN} analyzer (Kyoto, Japan) with a chemiluminescent nitrogen detector (TNM-1 module). Here, TN from rivers is compared to DN from coastal sites because no reliable TN data was available for coastal sites. The dissolved fraction has been shown to be the dominant fraction in coastal surface waters (Guo et al. 2004; Duan et al. 2016) and possibly accounted for 99% (sd = 12%) of TN in the present study (Fig. S2).

The total phosphorus (TP) concentration in river samples was determined in duplicate after persulfate digestion as orthophosphate with the molybdenum blue spectrophotometric technique (890 nm, Ultrospec 2100 pro, Biochrom Ltd., Cambridge, UK), while dissolved inorganic phosphorus samples (i.e., phosphate, PO_4^{3-}) from the coast were filtered onto pre-combusted Whatman GF/F filters and analyzed using a Bran-Luebbe autoanalyzer 3 (Bran+Luebbe GmbH, Norderstedt, Germany - adapted method from Hansen and Koroleff 1999).

For determination of CDOM absorbance, water was filtered through 0.45 or 0.2 μm polyethersulfone membranes for river and coastal waters, respectively and stored in pre-cleaned glass flasks in 4 °C in the dark until analysis within one month of sample collection (for coast, see Évrard et al. 2023) and no more than 2 months (for rivers). Previous studies have shown negligible differences when using filters of different pore sizes for CDOM absorbance measurements in waters with significant terrestrial inputs (0.7 and 0.2 μm, Massicotte et al. 2017). Samples were scanned over 200-800 nm using an Ultrospec3100 pro spectrophotometer for riverine samples (Biochrom) and a Lambda-35 dual beam UV–visible spectrophotometer (PerkinElmer, Waltham, MA, USA) for coastal samples, both fitted with 1 or 5 cm quartz cells and referenced to nanopure water. A baseline correction was applied by subtracting the absorbance at 690 nm for river samples or the average absorbance value between 683 and 687 nm for coastal samples (680-690 nm, Babin et al. 2003). The Napierian absorption coefficient at 440 nm ($a_{CDOM}(440)$ (m^{-1})), calculated as 2.303 times the absorbance at 440 nm divided by the cell's pathlength in meters, was chosen as an indicator of CDOM abundance in the eastern JB (Mabit et al. 2022; Évrard et al. 2023).

Suspended particulate matter (SPM) was determined by filtering water samples onto pre-combusted and pre-weighed 0.7 µm Whatman GF/F filters in duplicate for river sites or triplicate for coastal sites. Filters were dried at 80ºC for 24 h and weighed on an analytical balance (adapted method from Neukermans et al. 2012). We averaged the dry weights of the material collected in the replicates.

Chlorophyll *a* (chl *a*) in river samples were filtered in duplicate on Whatman GF/F filters and extracted with 90% hot ethanol in the dark. Chl *a* concentrations were determined spectrophotometrically in ethanol extracts (Wintermans and De Mots 1965). A turbidity correction (665 nm-750 nm) and phaeophytin correction after acidification (0.01 N HCl final concentration) were performed (Lorenzen 1967; Nusch 1980). Concentrations from coastal sites were measured using a Turner Designs AU-10 fluorometer (San Jose, CA, USA) after 24 h extraction in 90% acetone at 4° C in the dark (acidification method, Parsons et al. 1984).

Summer freshwater discharge (from July to September) was determined using high-frequency data from autonomous hydrometric stations installed in river mouths as described previously (de Melo et al. 2022). Salinity was measured at the coastal sites as conductivity using a SBE 19plus V2 CTD (Sea-Bird Scientific, Bellevue, WA, USA) and with a Cond 330i conductivity meter (WTW, Weilheim, Germany) calibrated against a KCl solution (1413 µs cm^{-1}), both validated with discrete samples analysed in the laboratory, with an 8410A Portasal salinometer (Guildline Instruments, Smiths Falls, CA, USA). Both approaches for determining the salinity agreed well (Évrard et al. 2023).

Statistical analyses

The variables retained to perform the clustering analyses were selected by their potential influence on the coastal environment: 1) light penetration (a_{CDOM}(440) and SPM); 2) nutrient concentrations (nitrogen – DN and TN for coastal and river sites, respectively; phosphorus – PO_4^{3-} and TP for coastal and river sites, respectively); and 3) water salinity (coastal sites) or summer freshwater total discharge (rivers). Hierarchical clustering constrained by latitude order (of Euclidean distances of normalized data matrices, Camêlo Aguiar et al. 2020) was used to group rivers and coastal sites, separately, based on the similarity of their physicochemical variables. Choosing the optimal number of clusters is subjective due to the unsupervised nature of clustering (Liu et al. 2022). Here, we checked the total within sum of squares and compared the dispersion of our hierarchical classifications to that obtained from a broken stick model (bstick function) to guide the choice of cluster groups (Bennett 1996, Fig. S3). For hierarchical clustering, we first ordered sampling sites following a latitudinal gradient from south to north, we then normalized the data using the function decostand (method= "standardize") in R (version 4.0.2) and computed Euclidean distance matrices using the function vegdist(). Then, we performed a constrained hierarchical clustering of the distance matrices using the function chclust() (package "rioja") with clusters constrained by latitudinal order. Principal component analysis (PCA) was used to summarize differences among clusters based on physicochemical variables and to assess the percentage of variation explained.

We tested for differences in physicochemical variables between clusters within rivers and coastal sites using One-way ANOVA or Kruskal-Wallis tests followed by post-hoc Dunn's or Tukey tests (after assessing for data normality and homoscedasticity). Due to the small number of river samples per cluster (n = 1 to 5), we used values from the two summers separately (while maintaining the same cluster classification) to achieve more robust statistics (n = 2 to 10). We calculated relative differences between the average observed concentration of each variable (nutrients (i.e., TN vs. DN and TP vs. PO_4), $a_{CDOM}(440)$, and SPM) measured in river clusters and the corresponding coastal cluster as a proxy for the degree of river influence. Differences in mean concentrations were divided by river mean concentrations, and then multiplied by 100 to obtain percentages of riverine decoupling. Negative relative differences indicate higher values at coastal sites than at river sites. All analyses were conducted in R and maps were created using ArcGIS 10.

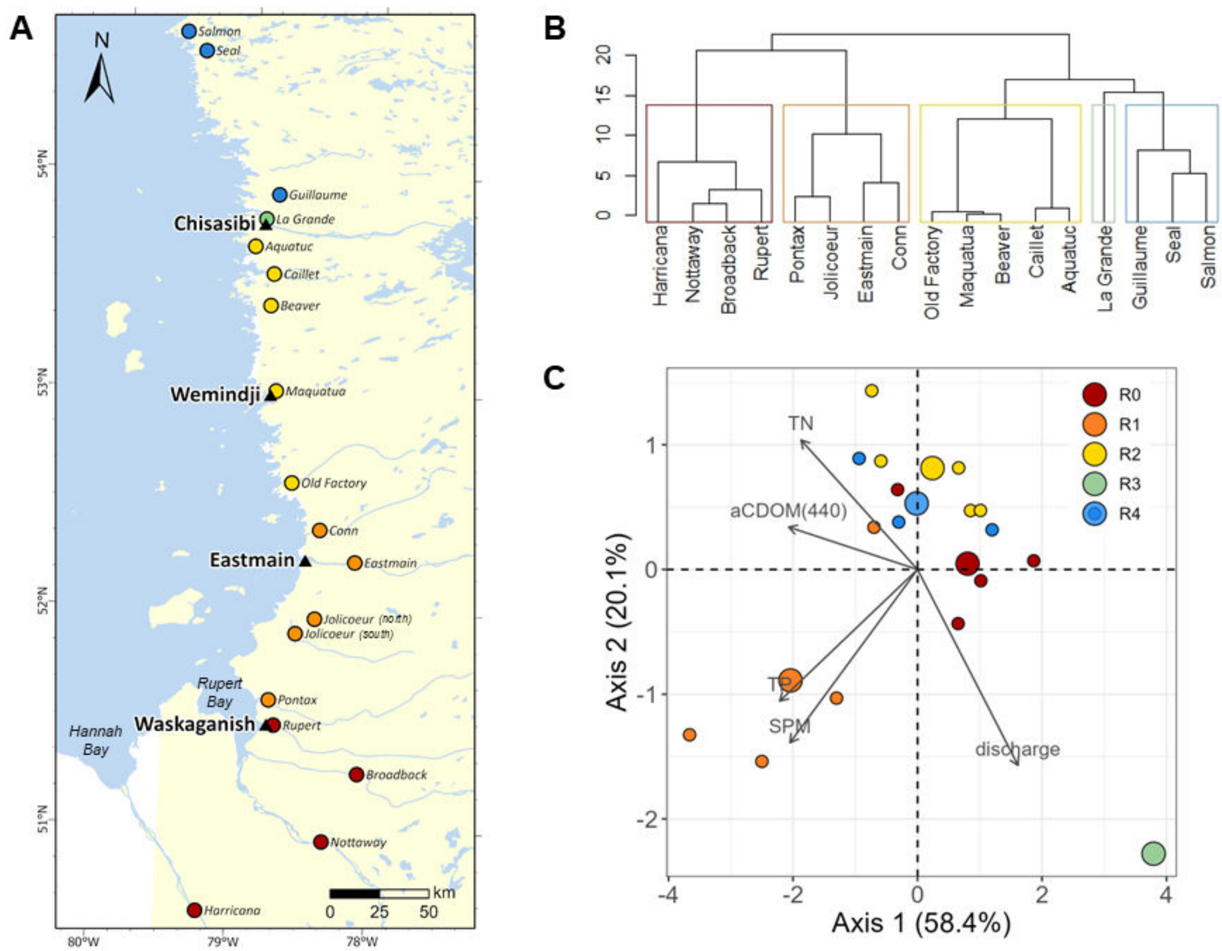

Figure 1. (**A**) Map of the sampled rivers with dot colors representing river clusters R0 to R4; (**B**) Dendrogram of the hierarchical clustering based on physicochemical variables (TN, TP, $a_{\mathrm{CDOM}}(440)$, SPM , and summer freshwater discharge) and constrained by latitudinal order of river sites sampled in summers 2018 and 2019; (**C**) Principal component analysis (PCA) of clusters based on the same physicochemical variables as in panel (B), with larger dots representing the centroid of each cluster. Colours used in dots in panels (**A**) and (**C**) and rectangles in (**B**) indicate different clusters.

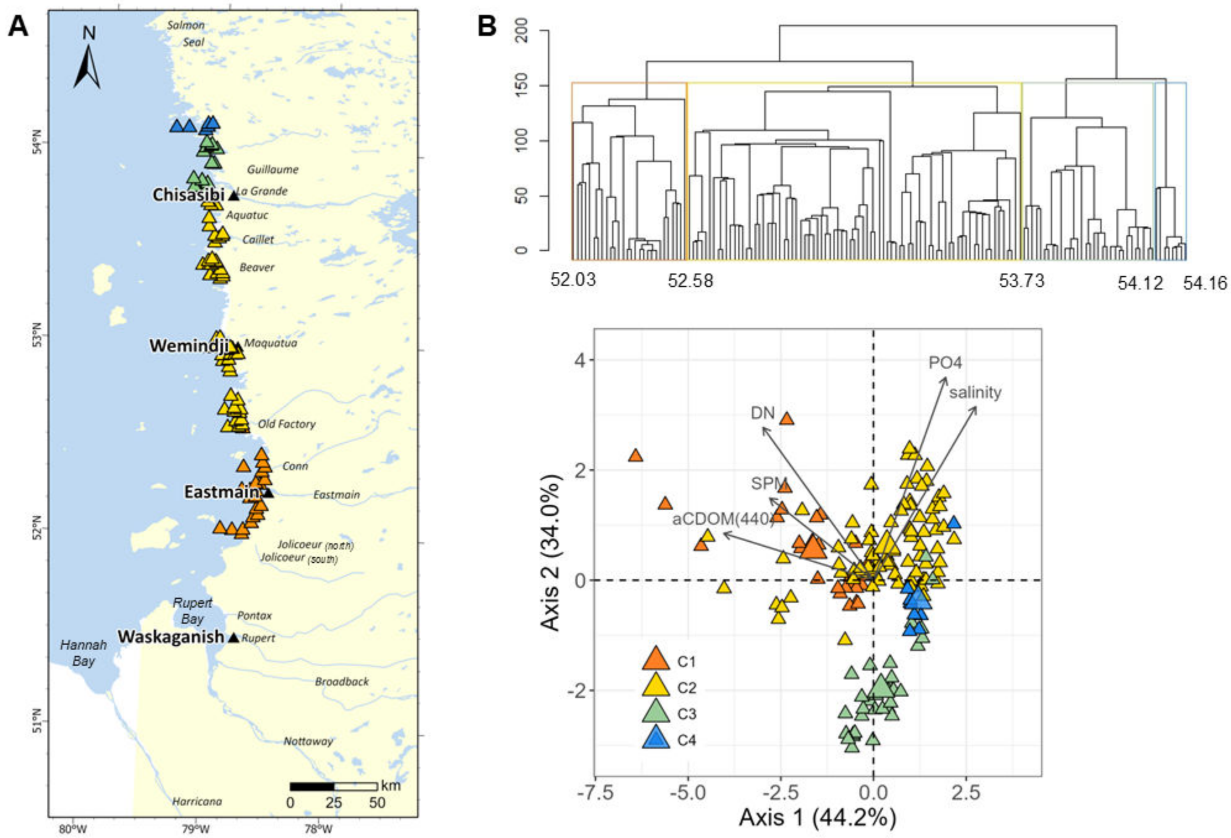

Figure 2. (**A**) Map of the sampled coastal sites with triangle colors representing clusters C1 to C4; (**B**) Dendrogram of the hierarchical clustering based on physicochemical variables (DN, PO_4^{3-}, $a_{CDOM}(440)$, SPM, and salinity) and constrained by latitudinal order of coastal sites sampled in summers 2018 and 2019; (**C**) Principal component analysis (PCA) of clusters based on the same physicochemical variables as in panel (**B**), with larger triangles representing the centroid of each cluster. Colours used in triangles in panels (**A**) and (**C**) and rectangles in (**B**) indicate different clusters.

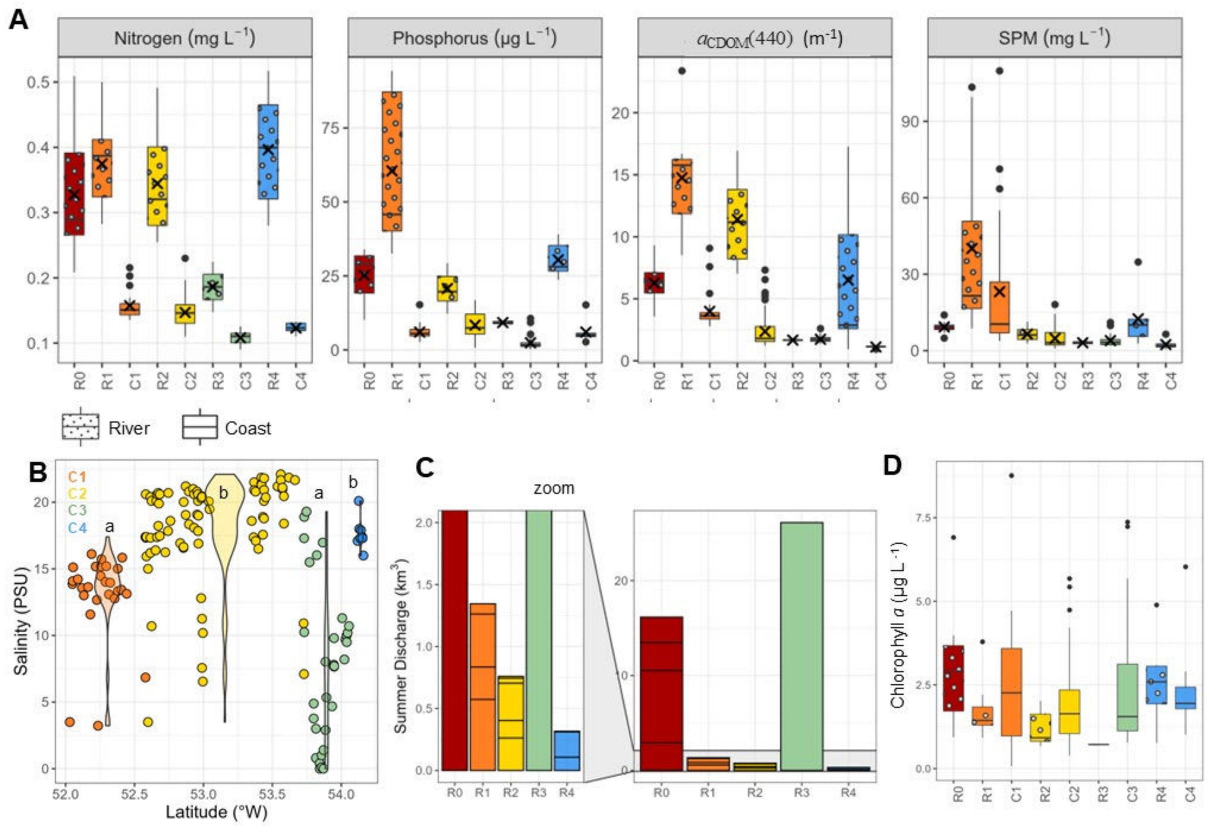

Figure 3. (**A**) Boxplots comparing nitrogen (TN or DN), phosphorus (TP or PO_4), $a_{\mathrm{CDOM}}(440)$ and SPM values at river (R) and coastal (C) sites. Horizontal lines represent the median and x the mean, first and third quartiles, and whiskers extend to the furthest data point within 1.5 times the interquartile range; statistics are presented in Table S3 and S4. Colours and textures represent cluster and system types (i.e., river vs coastal sites), respectively. (**B**) Salinity at coastal sites along the latitudinal gradient, where dots represent individual values and violin plots represent variation within each coastal cluster (represented by colours), letters *a* and *b* represent significant differences in salinity between clusters (Kruskal-Wallis - Table S4); (**C**) Histogram representing total summer freshwater discharge per cluster. Segments within bars represent the contribution of each river individually. (**D**) Chlorophyll *a* concentration in river and coastal clusters.

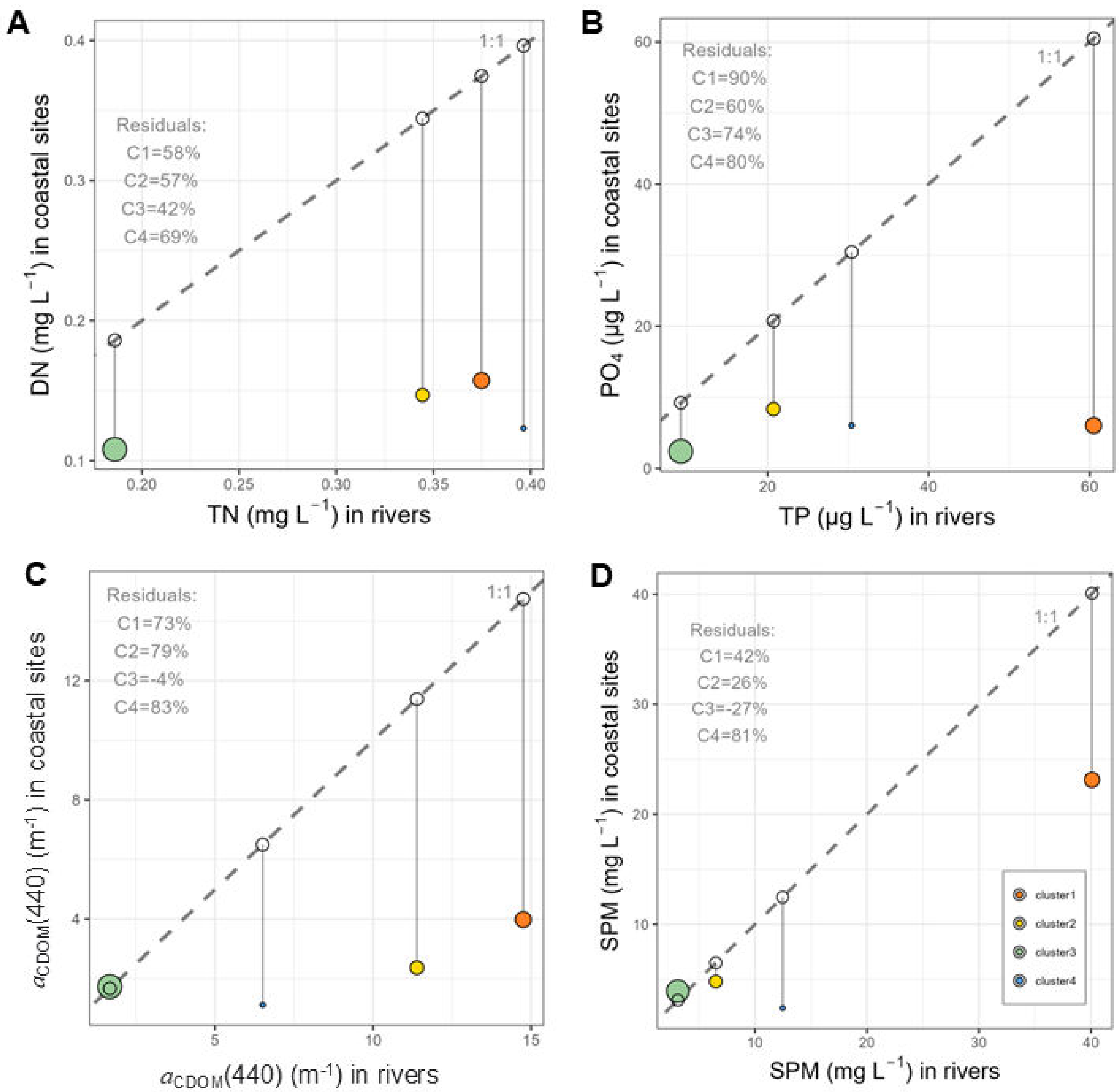

Figure 4. Relative differences between mean (**A**) nitrogen concentrations, (**B**) phosphorus concentrations, (**C**) $a_{CDOM}(440)$ and (**D**) SPM in each river cluster, and its corresponding coastal cluster (i.e., R1-C1). Small differences (close to the line 1:1) represent a strong river influence on the coastal waters. Values above the 1:1 line (also presented as negative % in the text box) represent higher mean values in coastal waters than in rivers, and values below the 1:1 line represent lower mean values in coastal waters than in rivers (positive % in the text box). Dot colors

represent the clusters, while sizes represent the sum of river discharge for each cluster (log 10 transformed).

Results

Latitudinal clustering of rivers and coastal sites

Variation in river physicochemical variables (Table S2) were captured by hierarchical clustering analysis, which suggests the existence of five distinct river clusters along the latitudinal gradient from south to north (Fig. 1A, B). More specifically, river cluster 0 (R0) includes the rivers from Harricana to Rupert, R1 includes the rivers from Pontax to Conn, R2 includes the rivers from Old Factory to Aquatuc, R3 is represented exclusively by La Grande (LG) River, and R4 includes Guillaume, Seal, and Salmon rivers. The variability in biogeochemical conditions among rivers was captured along two principal axes in the PCA, which collectively explained 78.5% of the variance in their physicochemical properties (Fig. 1C). Axis 1 (i.e., 58.4% of the total variance) primarily reflected differences in $a_{\mathrm{CDOM}}(440)$ and TP, whereas axis 2 (20.1%) was predominantly related to TN and summer freshwater discharge. SPM was similarly related to both axes.

Coastal sites (Fig. 2A) clustered into four distinct groups and followed a very similar latitudinal pattern to the one observed for rivers (Figs. 1B and 2B). Distinct transition zones were observed at latitudes 52.03ºN (C1), 52.58ºN (C2), 53.73ºN (C3), and ca. 54.1ºN (C4). The two main PCA axes explained 78.2% of the variance in physicochemical variables collected at the coastal sites. Axis 1 (i.e., 44.2% of the total variance) was mainly related to $a_{\mathrm{CDOM}}(440)$ and secondarily to SPM, whereas axis 2 (34%) was mainly related to PO_4, salinity, and DN.

Figure 3 compares the average physicochemical properties of the river (R) and coastal (C) clusters, as well as average river discharge and coastal salinity. Cluster R0 represents southern rivers characterized by high summer discharge and intermediate values of TN, TP, $a_{CDOM}(440)$, and SPM compared to the other rivers studied (Fig. 3A). The transition zone between river clusters R0 and R1 is characterized by a significant increase in TP and SPM concentrations and $a_{CDOM}(440)$ (p-values < 0.05, Fig. 3A, Table S3) and a decrease of total summer freshwater discharge (Fig. 3C). River clusters R1 and R2 had similarly high $a_{CDOM}(440)$, but R1 had the highest SPM of all eastern JB rivers, likely reflecting drainage over the Canadian Great Clay Belt, and the highest TP concentrations, likely associated to these high particulate loads, whereas R2 had significantly lower average TP and SPM (p-value < 0.05) concentrations.

LG River itself formed a cluster (R3), mainly because it exports more than half of the total summer freshwater discharge to the eastern JB (~26 km^3), and seasonally transports large amounts of freshwater and dissolved and particulate materials to the Bay, despite having lowest concentrations or $a_{CDOM}(440)$ values per volume unit (Fig. 3A). All the material concentrations were consistently lower in the LG River, a pattern observed previously (de Melo et al. 2022), although we were unable to adequately test the significance of this pattern due to the small number of samples (n = 2). Finally, rivers in the northernmost cluster (R4) had consistently higher TN and TP concentrations and $a_{CDOM}(440)$ relative to the LG River and intermediate values relative to southern river clusters (Fig. 3A, Table S3). TN concentrations were not consistently different among river clusters (ANOVA test, p-value > 0.05), except between R3 and R4, however, such statistical difference could be an artifact of the small number of R3 samples (Table S3).

The coastal site clusters were also characterized by different combinations of physicochemical variables. Coastal C1 had overall higher SPM, $a_{CDOM}(440)$ and lower PO_4 (note that for rivers we report TP), and salinity than C2 (p-values < 0.05, Fig. 3A, Table S4), but similar DN concentrations. The transition between C2 and C3 is related to a significant decrease in salinity, most likely associated to the greater distance to the high-discharge rivers Nottaway, Broadback, and Rupert, and a decrease in DN and PO_4, but no systematic change in $a_{CDOM}(440)$ and SPM (p-values > 0.05). We observed a significant decrease in $a_{CDOM}(440)$ and an increase in PO_4 and salinity, but no significant changes in DN and SPM (p-values > 0.05) at sites located north of LG River plume (C4). It is worth mentioning that neither the coastal waters of the southernmost sector (C0-river) nor the northern border with Hudson Bay (C4-river) were sampled in summer, limiting the possibility to effectively determine river-coast coupling in these areas.

Figure 3D shows the average chl *a* concentration for each of the river and coastal clusters. There was a marked northward decrease in average river chl *a* concentration from R0 (around 2.5 $\mu g\ L^{-1}$) to R3, which had the lowest concentrations of all sites (< 0.7 $\mu g\ L^{-1}$), with a subsequent increase in R4. This trend was slightly mirrored in the coastal sites, which showed more variable chl *a* concentration within clusters. Overall, chl *a* was generally higher in coastal sites than in rivers, except in the northernmost region (C4).

River influence along the coast

With few exceptions, the average material concentrations were higher in the river clusters than in their coastal counterparts. To further explore these river / coastal links, we estimated the relative difference between the average material concentration in the river versus the corresponding coastal cluster for the different biogeochemical variables (Fig. 4). Overall, coastal cluster C3 appears more closely aligned to the corresponding river cluster R3 for all four materials (low % difference), consistent with the LG River exerting a strong local influence due to its very large discharge as seen in the low coastal salinities. At the other extreme, coastal zone C4 was overall the most decoupled (high % difference) from river conditions, but this sector had also the lowest total river discharge. In addition, only one of the three rivers in cluster R3 can potentially influence the coastal sites of zone C4 (Fig. 1A and Fig. 2A).

There was an overall positive relationship between mean riverine and coastal SPM (Fig. 4D), suggesting a riverine influence on coastal turbidity throughout the eastern JB. The high positive relative differences for coastal C1 and C4 also suggest fast SPM deposition at the mouth of rivers with highest sediment loads. Conversely, the negative relative difference for coastal C3 suggests a dilution of marine water turbidity in C3 by very low SPM riverine water from R3 (due to long water residence time within upstream reservoirs).

Likewise, there was a weak but positive relationship between river and coastal $a_{\mathrm{CDOM}}(440)$ (Fig. 4C), suggesting a potential influence of riverine inputs on coastal waters, particularly of extremely high $a_{\mathrm{CDOM}}(440)$ loads in C1. High positive relative differences for C1, C2 and C4 indicate significant dilution, processing, and/or flocculation of CDOM at the coastal margin.

Discussion

Our study identified significant latitudinal variability in the physicochemical properties of both rivers and coastal sites along the eastern JB, captured by distinct clusters (5 for rivers and 4 along the coast). This variability resulted in transition zones (changes from one cluster to another) that were spatially coherent between river and coastal waters. For instance, the transition between the Conn and Old Factory rivers (R1-R2, C1-C2) translates into a decrease in SPM and

$a_{CDOM}(440)$, and an increase in coastal salinity due to decrease in the total freshwater discharge. The highest coherence between the LG River (cluster 4) and nearby coastal waters is due to the very large freshwater export to the Bay, which strongly influences coastal conditions through the large plume extension (Peck et al. 2022; Kuzyk et al. 2023). This results in consistently low material concentrations and low salinity, in contrast to the overall Bay conditions (Évrard et al. 2023).

Conversely, when rivers carry higher coloured and turbid waters, as in C1 and C3, this translates into coastal waters with somewhat higher colour and turbidity as well. This coherence in the location of transition zones and decreasing or increasing (or constant) pattern of material concentrations between river-coast clusters suggests a widespread influence of rivers on coastal biogeochemistry, consistent with previous studies describing the highly river-influenced nature of JB (Déry et al. 2005; Évrard et al. 2023). Other studies have emphasized that land cover and climate change strongly influence river exports to the coast, and consequently limit light penetration in the Skagerrak Sea along the Norwegian coastline. These patterns were associated with riverine CDOM and with the long-term (centennial) increase in vegetation cover (or greening over agriculture and grazing) across northern Europe (Opdal et al. 2023).

Although higher riverine concentrations generally translate into higher coastal concentration, high relative differences and overall lower material concentrations in coastal sites than in their riverine counterparts indicate that most of materials are diluted and/or processed within coastal areas during summer. To better investigate the role of dilution (conservative mixing) and processing (e.g., removal, transformation, production) in coastal waters, we used mixing plots (Fig. 5) for the four coastal sectors, with each variable plotted against salinity. We observed clear differences in mixing patterns across coastal sectors, depending on the variable considered. When the relationship with salinity was negative and linear ($p < 0.05$), we interpreted this as a dominance of conservative mixing. In contrast, no relationship (or a positive one) suggests the influence of other processes. It is clear that phosphate behaves non-conservatively in all coastal sectors, which may explain its decoupling from river inputs. Conservative mixing of DN was more pronounced in the southern coastal sectors of the bay (C1 and C2), and seems to be the main driver of $a_{CDOM}(440)$, the later being previously observed in the JB and Hudson Bays (Évrard et al. 2023; Meilleur et al. 2023).

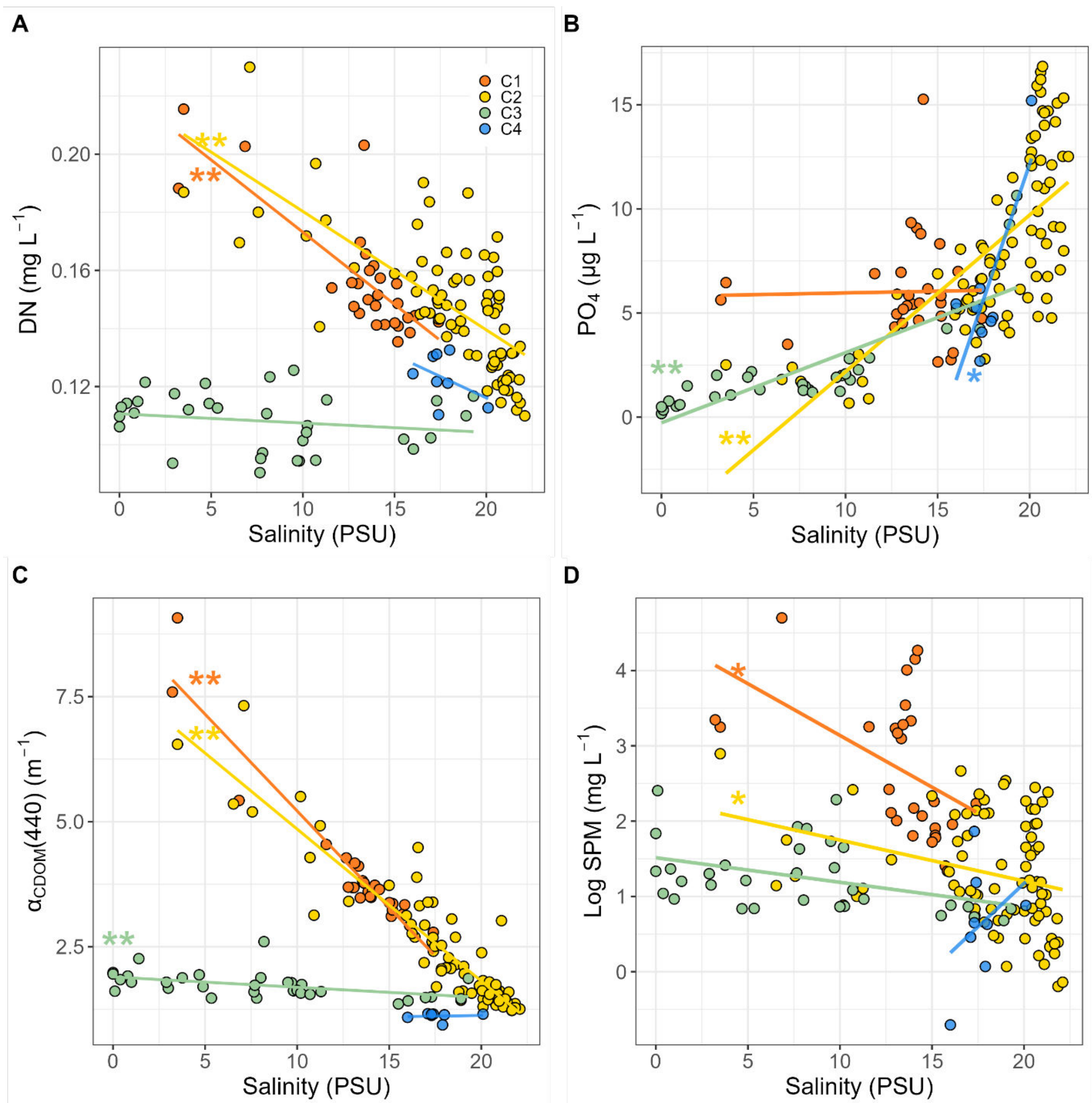

Figure 5. Mixing plots of (**A**) dissolved nitrogen (DN), (**B**) phosphate, (**C**) $a_{\mathrm{CDOM}}(440)$ and (**D**) SPM in each coastal sector (represented by different colors). The lines indicate linear regressions, with significant relationships denoted by * ($p < 0.05$) and ** ($p < 0.01$).

Losses through flocculation and sedimentation (resulting in non-conservative mixing) of riverine organic matter and particles may also play an important role in decreasing CDOM and turbidity in JB coastal waters, as demonstrated in previous studies in the region (Stross and Sokol 1989). An empirical-experimental study in Finland boreal estuaries showed that flocculation processes, induced also at low salinities, can remove up to 16% of dissolved organic carbon (DOC) (Asmala et al. 2014). Using an experimental approach, these authors demonstrated that a significant portion of DOC and dissolved iron pools are converted into particulate matter and can therefore settle through sedimentation (Asmala et al. 2014). Processing of the material can also influence properties of the dissolved organic matter (DOM), such as CDOM absorbance, and nutrients (Asmala et al. 2014, 2017).

Although we did not observe a clear relationship between river and coastal clusters with respect to both nutrients analyzed (N and P), potentially due to the different fractions collected (total for rivers, dissolved for the coast), we nevertheless observe a consistently 2 to 3-fold higher riverine TN concentration relative to measured coastal DN concentration for all clusters, and a lack of relationship between riverine and coastal concentrations. This might result from high rates of N_2 fixation by freshwater diazotrophs in rivers compared to marine waters (Blais et al. 2012), and from the rapid uptake of inorganic N by primary producers in nearshore regions (Tank et al. 2012). Likewise, coastal PO_4 and riverine TP appeared to be largely decoupled along the eastern JB as concentrations increase along the salinity gradient following a non-conservative pattern (Fig. 5D).

The lack of correlation between river and coastal conditions in the northern Bay sector (high relative differences for cluster 4) may be due to a mismatch in sampling locations north of the LG River due to logistical constraints. The small northernmost rivers of JB (Seal and Salmon) and the small Guillaume River were sampled, but the intermediate rivers were not (Fig. 1). Coastal sampling was limited to the vicinity of the Guillaume and Piagochioui rivers (Fig. 2). Therefore, low material concentrations in coastal cluster C4 could be the result of both the dilution effect of the LG River plume and the low discharge of the Guillaume and Piagochioui rivers.

Coastal cluster C1 in southeastern JB receives direct and advective freshwater inputs from several large rivers. This sector of the Bay has the highest $a_{CDOM}(440)$ and SPM, limiting light availability along the coast for primary producers such as phytoplankton, microphytobenthos, macroalgae, and the eelgrass *Zostera marina*. Despite this limitation, the surface chl *a* concentration is the highest among the different coastal sectors, with a mean value of 2.7 μg L^{-1} compared to 1.9 μg L^{-1} in C2 and 2.4 μg L^{-1} in C3. This indicates that the phytoplankton community is well acclimated to the low light conditions in these waters. R1 (and R0) rivers, which themselves had high chl *a* concentrations, may also contribute to the enhanced phytoplankton biomass along the coast. However, this pattern of chl *a* concentration was not the same between other coastal and river clusters, with overall higher values in coastal waters than in rivers (on average ~9% higher). This suggests that rivers enrich coastal waters with dissolved inorganic and organic nutrients and promote the growth of coastal primary producers, rather than simply exporting chl *a*.

We acknowledge several limitations of this study. First, samples were not taken simultaneously in rivers and coastal sites, which could introduce temporal decoupling in physicochemical conditions and noise in the relationship between rivers and nearshore environments. To mitigate this issue, we averaged data from two consecutive summers for rivers and included data from multiple sites. We recognize that processes such as shoreline erosion and sediment resuspension, particularly by storm waves or fast streamflow associated with hydroelectric production in the LG River, could contribute additional SPM and nutrients to the coastal waters. It is important not to disregard the role of LG as a sporadic source of sediments to the coastal system due to high erosion of downstream riverbanks close to the mouth during high flow events (Lefebvre et al. 1991).This could explain the few observations where mean SPM or phosphorus in coastal clusters were higher in coastal waters than in the paired river cluster (cluster 3 and 2, respectively). Secondly, this study only covered the summer season, because there was no matching oceanographic data for spring and fall due to logistic impediments in sampling the Bay waters, and we acknowledge that seasonality can play an important role in determining riverine influence on the coast. During winter, the typically low discharge or complete freezing of unregulated rivers may lead to reduced riverine influence along the coast, whereas in spring, increased river discharge due to snowmelt likely enhances the influence of rivers on coastal waters. A recent study demonstrated that nitrate and phosphate distributions in the La Grande plume (extended north and to a lesser extent south of the LG mouth) is driven by conservative mixing in winter, while that in summer, both water mass mixing and biological nutrient uptake contribute to their availability (Guzzi et al. 2024).

In conclusion, our study identified significant latitudinal variability in the physicochemical properties of both rivers and coastal sites along the eastern James Bay. While the volume of river water discharged into the bay plays a key role—where greater discharge leads to a stronger riverine influence on coastal waters—it is not only discharge that drives this variability. The distinct physicochemical differences between watersheds along the latitudinal gradient also play a crucial role, resulting in well-defined transition zones between river and coastal waters.

Given the complex interactions between terrestrial and marine systems, this study presents an integrated approach to identify transition zones and assess the impact of river exports on physicochemical conditions of coastal waters along the eastern JB, which can be adapted to river-coast continua elsewhere. Given the anticipated influence of climate and environmental changes on river exports globally, forthcoming research should focus on assessing the effects of short- and long-term disturbances on coastal health, resilience, and the key ecosystem services provided by these environments.

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Author Contribution Statement

PdG, UN and MG acquired the funds. PdG, MLG and CFM designed the field survey for rivers, while UN, MG, VG and HX designed the field survey along the coast. CFM, VG, and MLG along other contributors conducted field work. MdM and CFM designed the study approach, analysed the data, and conducted the statistical analyses. MdM wrote the first draft, and all co-authors discussed and edited the subsequent versions.

Conflict of Interest

Authors declare no conflict of interest.

Data Availability Statement

Metadata will be published in an open access repository (Borealis platform).

Additional Supporting Information may be found in the online version of this article.

References

Asmala, E., D. G. Bowers, R. Autio, H. Kaartokallio, and D. N. Thomas. 2014. Qualitative changes of riverine dissolved organic matter at low salinities due to flocculation. J Geophys Res Biogeosci **119**: 1919–1933. https://doi.org/10.1002/2014JG002722

Asmala, E., J. Carstensen, D. J. Conley, C. P. Slomp, J. Stadmark, and M. Voss. 2017. Efficiency of the coastal filter: Nitrogen and phosphorus removal in the Baltic Sea. Limnol Oceanogr **62**: S222–S238. https://doi.org/10.1002/lno.10644

Babin, M., D. Stramski, G. M. Ferrari, H. Claustre, A. Bricaud, G. Obolensky, and N. Hoepffner. 2003. Variations in the light absorption coefficients of phytoplankton, nonalgal particles, and dissolved organic matter in coastal waters around Europe. J Geophys Res Oceans **108**. https://doi.org/10.1029/2001JC000882

Bauer, J. E., W.-J. Cai, P. A. Raymond, T. S. Bianchi, C. S. Hopkinson, and P. A. G. Regnier. 2013. The changing carbon cycle of the coastal ocean. Nature **504**: 61–70. doi:10.1038/nature12857

Bennet, K. D. 1996. Determination of the number of zones in a biostratigraphical sequence. New Phytol **132**: 155–170. https://doi.org/10.1111/j.1469-8137.1996.tb04521.x

Blais, M., J.-É. Tremblay, A. D. Jungblut, J. Gagnon, J. Martin, M. Thaler, and C. Lovejoy. 2012. Nitrogen fixation and identification of potential diazotrophs in the Canadian Arctic. Global Biogeochem Cycles **26**: GB3022. https://doi.org/10.1029/2011GB004096

Camêlo Aguiar, D., R. Gutiérrez Sánchez, and E. L. Silva Camêlo. 2020. Hierarchical clustering with spatial constraints and standardized incidence ratio in tuberculosis data. Mathematics **8**: 1478. doi:10.3390/math8091478

Canada, F. and E. 1978. Hydrological Atlas of Canada. 142.

Davis, K. E., F. Noisette, J. K. Ehn, Z. Z. A. Kuzyk, C. J. Peck, and M. I. O'Connor. 2024. Effects of light and water column nutrient availability on eelgrass Zostera marina productivity in Eeyou Istchee, eastern James Bay, Quebec. Mar Ecol Prog Ser **738**: 103–117.

de Melo, M. L., M.-L. Gérardin, C. Fink-Mercier, and P. A. del Giorgio. 2022. Patterns in riverine carbon, nutrient and suspended solids export to the Eastern James Bay: links to climate, hydrology and landscape. Biogeochemistry **161**: 291–314. doi:10.1007/s10533-022-00983-z

Déry, S. J., T. A. Stadnyk, M. K. MacDonald, and B. Gauli-Sharma. 2016. Recent trends and variability in river discharge across northern Canada. Hydrol Earth Syst Sci **20**: 4801–4818. doi:10.5194/hess-20-4801-2016

Déry, S. J., M. Stieglitz, E. C. McKenna, and E. F. Wood. 2005. Characteristics and Trends of River Discharge into Hudson, James, and Ungava Bays, 1964–2000. J Clim **18**: 2540–2557. doi:10.1175/JCLI3440.1

Dresser, J. A. 1913. The Clay Belt of Northern Ontario and Quebec. J Geogr **11**: 250–255. doi:10.1080/00221341308985818

Duan, L.-Q., J.-M. Song, H.-M. Yuan, X.-G. Li, and N. Li. 2016. Distribution, partitioning and sources of dissolved and particulate nitrogen and phosphorus in the north Yellow Sea. Estuar Coast Shelf Sci **181**: 182–195. https://doi.org/10.1016/j.ecss.2016.08.044

Dupas, R., A. Musolff, J. W. Jawitz, P. S. C. Rao, C. G. Jäger, J. H. Fleckenstein, M. Rode, and D. Borchardt. 2017. Carbon and nutrient export regimes from headwater catchments to downstream reaches. Biogeosciences **14**: 4391–4407. doi:10.5194/bg-14-4391-2017

Emmerton, C. A., L. F. W. Lesack, and W. F. Vincent. 2008. Mackenzie River nutrient delivery to the Arctic Ocean and effects of the Mackenzie Delta during open water conditions. Global Biogeochem Cycles **22**. https://doi.org/10.1029/2006GB002856

Évrard, A., C. Fink-Mercier, V. Galindo, U. Neumeier, M. Gosselin, and H. Xie. 2023. Regulated vs. unregulated rivers: Impacts on CDOM dynamics in the eastern James Bay. Mar Chem **256**: 104309. https://doi.org/10.1016/j.marchem.2023.104309

Frigstad, H. and others. 2020. Influence of riverine input on Norwegian coastal systems. Front Mar Sci **7**: 332. doi:10.3389/fmars.2020.00332

Grimes, C. B. 2001. Fishery Production and the Mississippi River Discharge. Fisheries (Bethesda) **26**: 17–26. https://doi.org/10.1577/1548-8446(2001)026<0017:FPATMR>2.0.CO;2

Guo, L., J.-Z. Zhang, and C. Guéguen. 2004. Speciation and fluxes of nutrients (N, P, Si) from the upper Yukon River. Global Biogeochem Cycles **18:** GB1038. https://doi.org/10.1029/2003GB002152

Guzzi, A. C., J. K. Ehn, C. Michel, J.-É. Tremblay, J. P. Heath, and Z. Z. A. Kuzyk. 2024. Influence of altered freshwater discharge on the seasonality of nutrient distributions near La Grande River, northeastern James Bay, Québec. Elem Sci Anth **12**: 00133. doi:10.1525/elementa.2023.00133

Hansen, H. P., and F. Koroleff. 1999. Determination of nutrients, p. 159–228. *In* K. Grasshoff, K. Kremling and M. Ehrhardt [eds.], Methods of seawater analysis, 3rd ed. Wiley-VCH.

Kuzyk, Z.A., Leblanc, M.L., O'Connor, M., Idrobo, J., Giroux, J.-F., del Giorgio, P., Bélanger, S., Noisette, F., Fink- Mercier, C., de Melo, M., Walch, D., Ehn, J., Gosselin, M., Neumeier, U., Sorais, M., Davis, K., and Leblon, B., 2023. Understanding Shkaapaashkw (ᔑᑳᐹᔥᒄ): Eelgrass Health and Goose Presence in Eastern James Bay. Final Report from the Eeyou Coastal Habitat Comprehensive Research Project (CHCRP). Prepared for Niskamoon Corporation. University of Manitoba, Winnipeg MB Canada. https://doi.org/10.34992/4K4Z-TF96

Leblanc, M.-L. and others. 2023. Limited recovery following a massive seagrass decline in subarctic eastern Canada. Glob Chang Biol **29**: 432–450. https://doi.org/10.1111/gcb.16499

Lee, J., A. Tefs, V. Galindo, T. Stadnyk, M. Gosselin, and J.-É. Tremblay. 2023. Nutrient inputs from subarctic rivers into Hudson Bay. Elem Sci Anth **11**: 1. https://doi.org/10.1525/elementa.2021.00085

Lefebvre, G., P. Rosenberg, J. Paquette, and J. G. Lavallée. 1991. The September 5, 1987, landslide on the La Grande River, James Bay, Quebec, Canada. Can Geotech J **28**: 263–275. doi:10.1139/t91-032

Li Yung Lung, J. Y. S., S. E. Tank, C. Spence, D. Yang, B. Bonsal, J. W. McClelland, and R. M. Holmes. 2018. Seasonal and geographic variation in dissolved carbon biogeochemistry of rivers draining to the Canadian Arctic Ocean and Hudson Bay. J Geophys Res Biogeosci **123**: 3371–3386. https://doi.org/10.1029/2018JG004659

Liu, T., H. Yu, and R. H. Blair. 2022. Stability estimation for unsupervised clustering: A review. WIREs Computational Statistics **14**: e1575. https://doi.org/10.1002/wics.1575

Lorenzen, C. J. 1967. Determination of chlorophyll and pheo-pigments: spectrophotometric equations. Limnol Oceanogr **12**: 343–346. https://doi.org/10.4319/lo.1967.12.2.0343

Mabit, R., C. A. S. Araújo, R. K. Singh, and S. Bélanger. 2022. Empirical remote sensing algorithms to retrieve SPM and CDOM in Québec coastal waters. Front Remote Sens **3**: 834908. doi:10.3389/frsen.2022.834908

Massicotte, P., C. Stedmon, and S. Markager. 2017. Spectral signature of suspended fine particulate material on light absorption properties of CDOM. Mar Chem **196**: 98–106. https://doi.org/10.1016/j.marchem.2017.07.005

McClelland, J. W., R. M. Holmes, K. H. Dunton, and R. W. Macdonald. 2012. The Arctic Ocean Estuary. Estuar Coast **35**: 353–368. doi:10.1007/s12237-010-9357-3

McClelland, J. W., A. Townsend-Small, R. M. Holmes, F. Pan, M. Stieglitz, M. Khosh, and B. J. Peterson. 2014. River export of nutrients and organic matter from the North Slope of Alaska to the Beaufort Sea. Water Resour Res **50**: 1823–1839. https://doi.org/10.1002/2013WR014722

Meilleur, C., M. Kamula, Z. A. Kuzyk, and C. Guéguen. 2023. Insights into surface circulation and mixing in James Bay and Hudson Bay from dissolved organic matter optical properties. J Mar Syst **238**: 103841. https://doi.org/10.1016/j.jmarsys.2022.103841

Moquet, J.-S. and others. 2016. Amazon River dissolved load: temporal dynamics and annual budget from the Andes to the ocean. Environ Sci Pollut R **23**: 11405–11429. doi:10.1007/s11356-015-5503-6

Neukermans, G., K. Ruddick, H. Loisel, and P. Roose. 2012. Optimization and quality control of suspended particulate matter concentration measurement using turbidity measurements. Limnol Oceanogr Methods **10**: 1011–1023. https://doi.org/10.4319/lom.2012.10.1011

Nusch, E. A. 1980. Comparison of different methods for chlorophyll and phaeopigment determination. Arch Hydrobiol Beih Ergebn Limnol **14**: 14–36.

Opdal, A. F., T. Andersen, D. O. Hessen, C. Lindemann, and D. L. Aksnes. 2023. Tracking freshwater browning and coastal water darkening from boreal forests to the Arctic Ocean. Limnol Oceanogr Lett **8**: 611–619. https://doi.org/10.1002/lol2.10320

Parsons, T. R., Y. Maita, and C. M. Lalli. 1984. A manual of chemical and biological methods for seawater analysis. Pergamon.

Peck, C. J., Z. Z. A. Kuzyk, J. P. Heath, J. Lameboy, and J. K. Ehn. 2022. Under-Ice Hydrography of the La Grande River Plume in Relation to a Ten-Fold Increase in Wintertime Discharge. J Geophys Res Oceans **127**: e2021JC018341. https://doi.org/10.1029/2021JC018341

Prinsenberg, S. J. 1986. Chapter 10 The Circulation Pattern and Current Structure of Hudson Bay, p. 187–204. *In* I.P. Martini [ed.], Elsevier Oceanography Series. Elsevier.

Royer, M.-J. S., and T. M. Herrmann. 2013. Cree Hunters' Observations on Resources in the Landscape in the Context of Socio-Environmental Change in the Eastern James Bay. Landsc Res **38**: 443–460. doi:10.1080/01426397.2012.722612

Stross, R. G., and R. C. Sokol. 1989. Runoff and flocculation modify underwater light environment of the Hudson River Estuary. Estuar Coast Shelf Sci **29**: 305–316. https://doi.org/10.1016/0272-7714(89)90030-9

Taha, W., M. Bonneau-Lefebvre, A. Cueto Bergner, and A. Tremblay. 2019. Evolution from past to future conditions of fast ice coverage in James Bay. Front Earth Sci **7**: 254. doi: 10.3389/feart.2019.00254

Tank, S. E., M. Manizza, R. M. Holmes, J. W. McClelland, and B. J. Peterson. 2012. The Processing and Impact of Dissolved Riverine Nitrogen in the Arctic Ocean. Estuar Coast **35**: 401–415. doi:10.1007/s12237-011-9417-3

Terhaar, J., R. Lauerwald, P. Regnier, N. Gruber, and L. Bopp. 2021. Around one third of current Arctic Ocean primary production sustained by rivers and coastal erosion. Nat Commun **12**: 169. doi:10.1038/s41467-020-20470-z

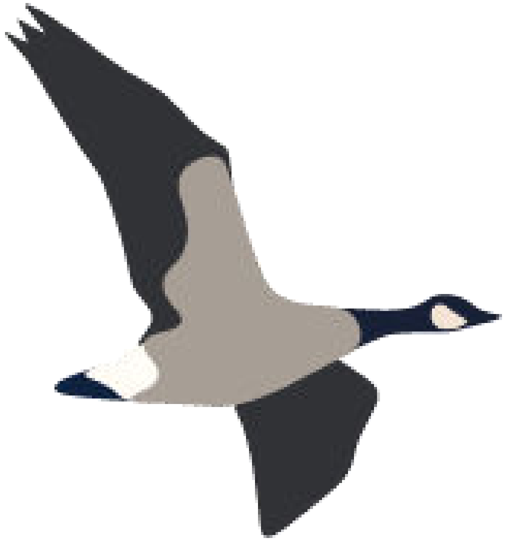
Wintermans, J. F. G. M., and A. De Mots. 1965. Spectrophotometric characteristics of chlorophylls *a* and *b* and their phenophytins in ethanol. Biochimica et Biophysica Acta (BBA) - Biophysics including Photosynthesis **109**: 448–453. https://doi.org/10.1016/0926-6585(65)90170-6

Zhang, Q., and J. D. Blomquist. 2018. Watershed export of fine sediment, organic carbon, and chlorophyll-a to Chesapeake Bay: Spatial and temporal patterns in 1984–2016. Sci Total Eviron **619–620**: 1066–1078. https://doi.org/10.1016/j.scitotenv.2017.10.279

Steering Committee

January 29 2025

PRESENTING CHCRP PHASE II (**2023-2024**)
FINAL REPORT



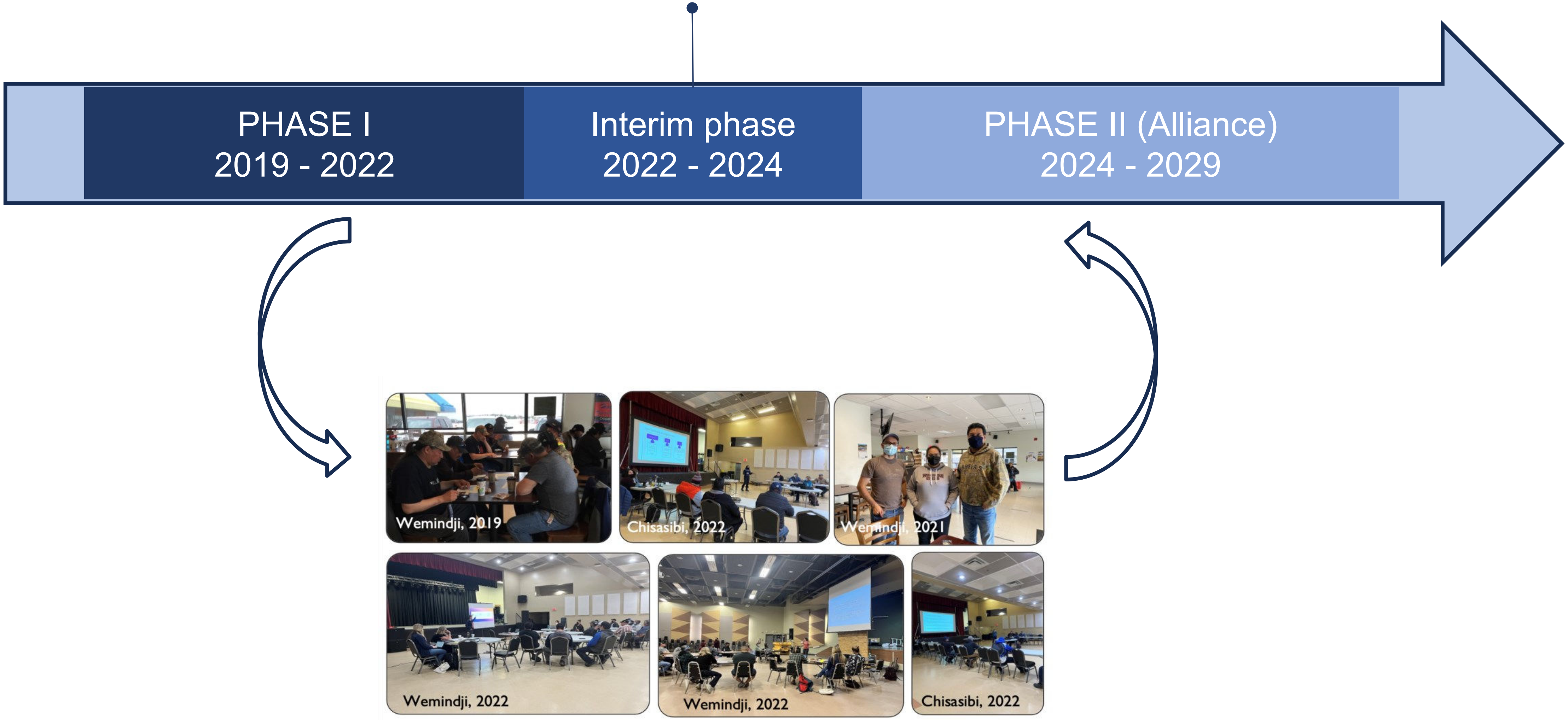

Mary O’Connor, Fanny Noisette, Zou Zou Kuzyk, Jens Ehn, Simon Bélanger, Caroline Fink-Mercier, Nicole Knight

Timeline of the different phases of the CHCRP

Building Alliance project in response to community priorities

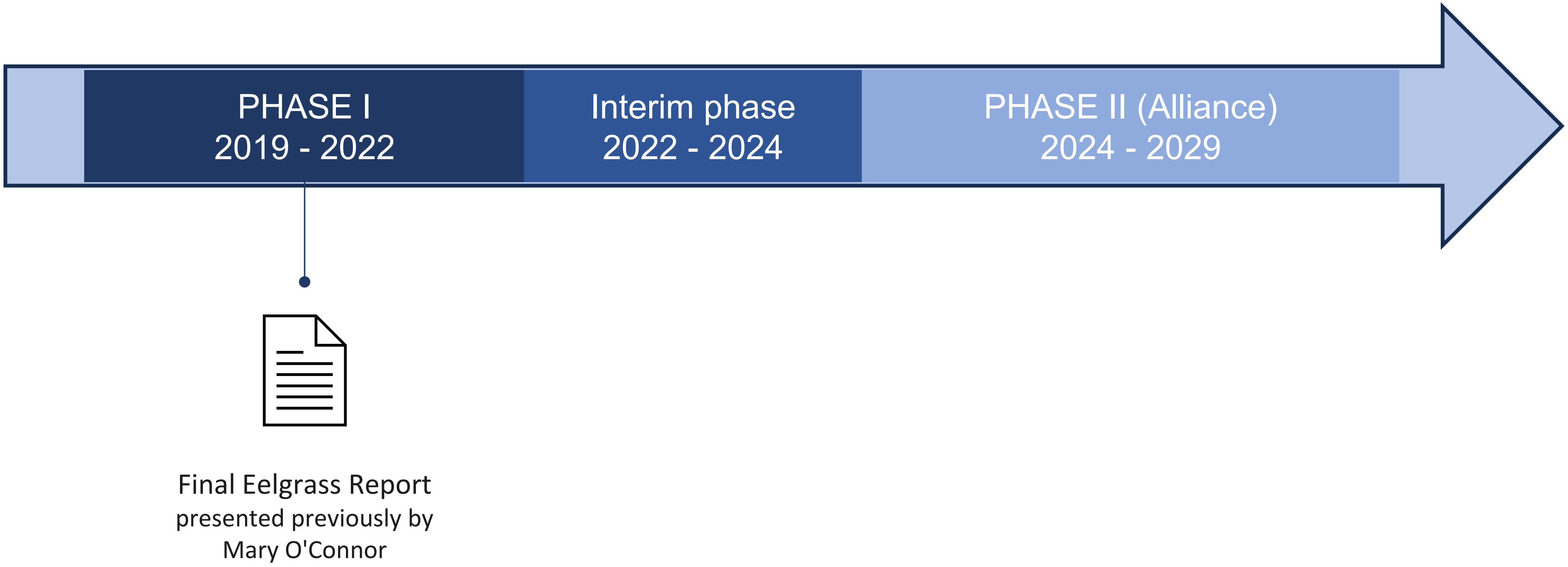
Timeline of the different phases of the CHCRP

Continue monitoring efforts started in Phase I
and prepare the Alliance proposal



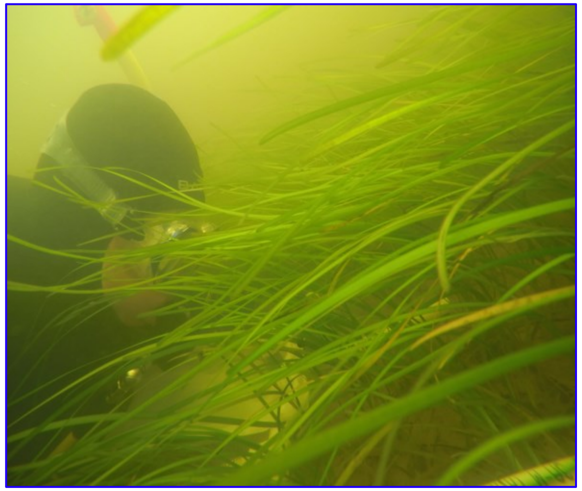
Building Alliance project in response to community priorities

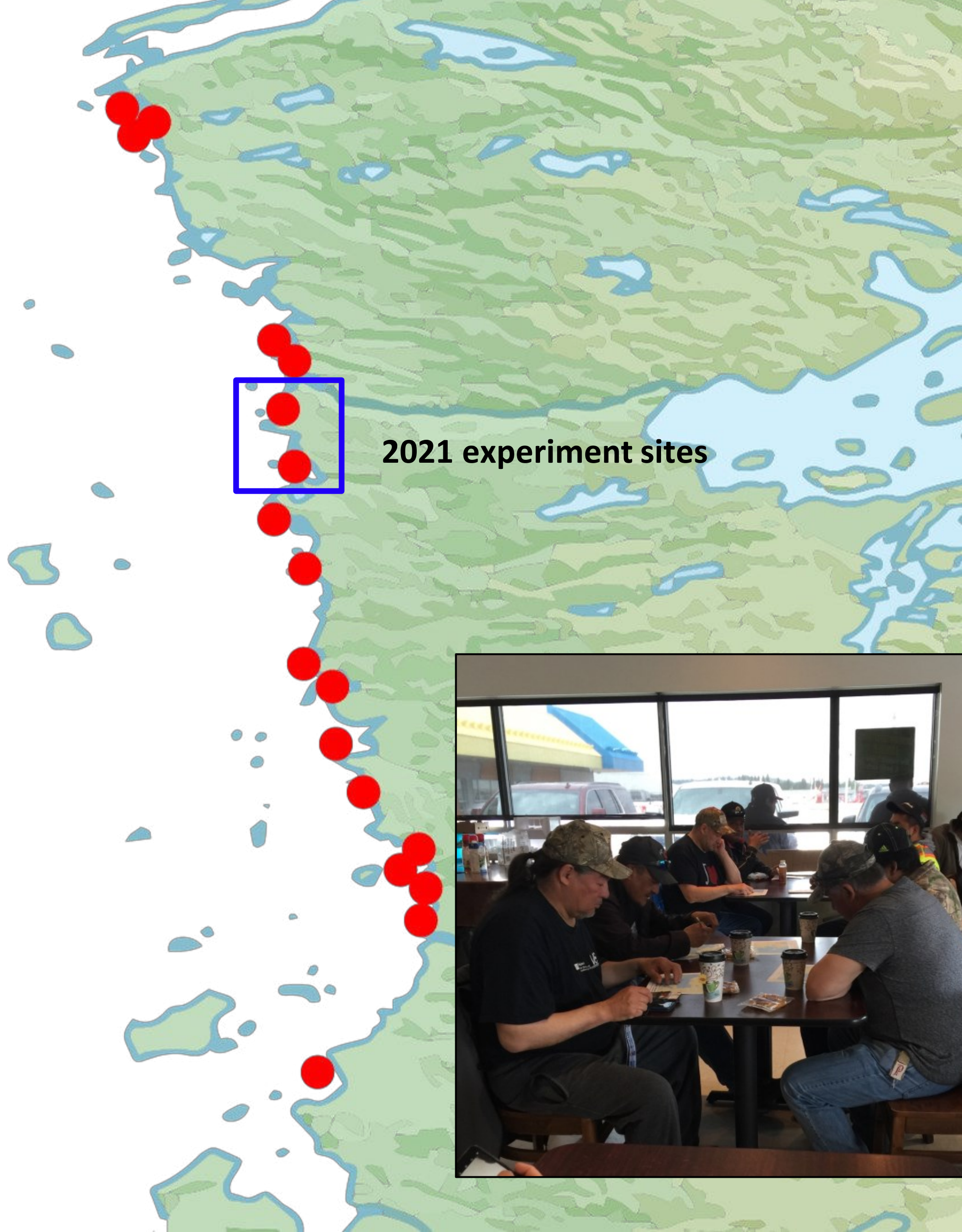
Timeline of the different phases of the CHCRP



Eelgrass condition, causes of decline

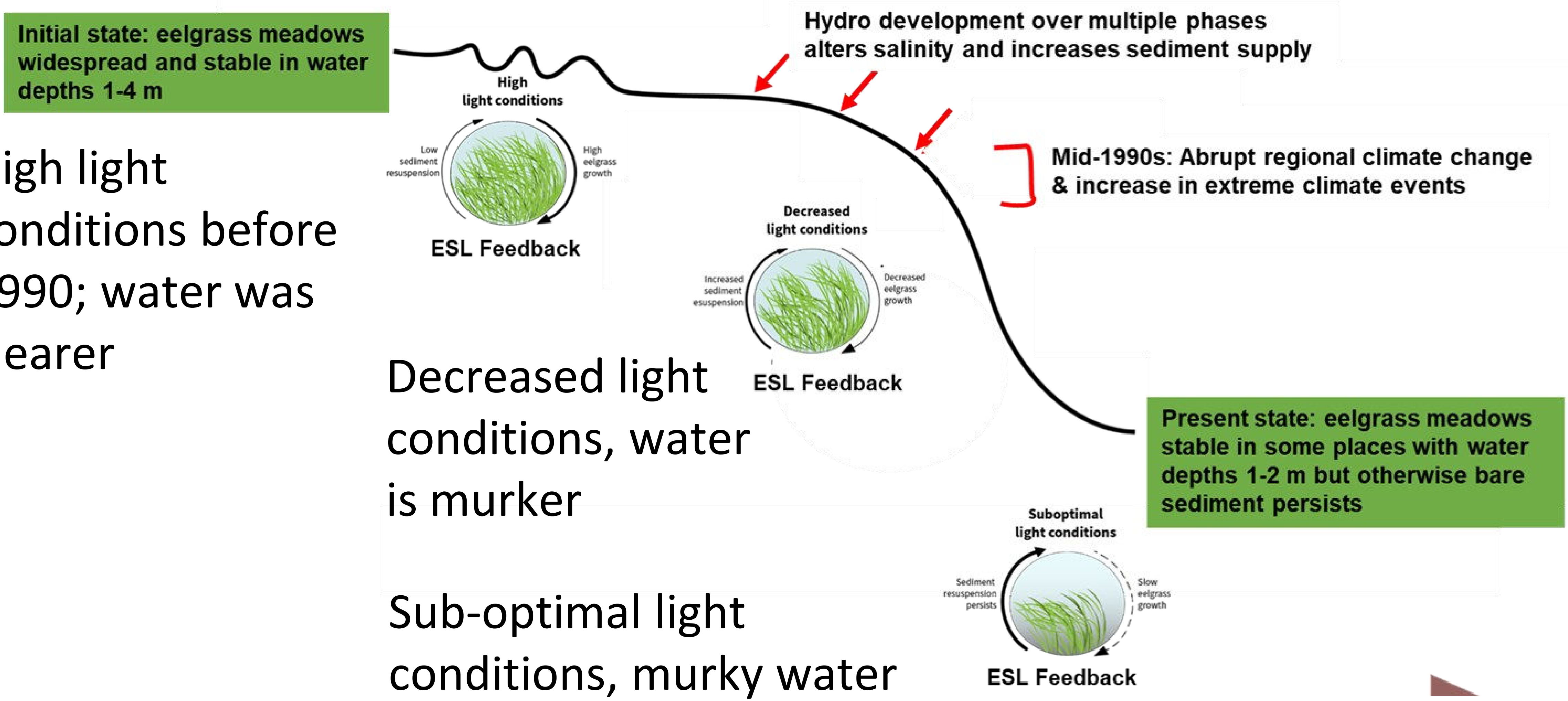
- 124 sites (2019, 2020, 2021) - eelgrass team
- > 700 sites (2017-2021) - ocean team
- We did experiments to test for effects of light and nutrient changes
- We measured eelgrass and biodiversity





PHASE I
2019 - 2022

Eelgrass persists but is not recovered

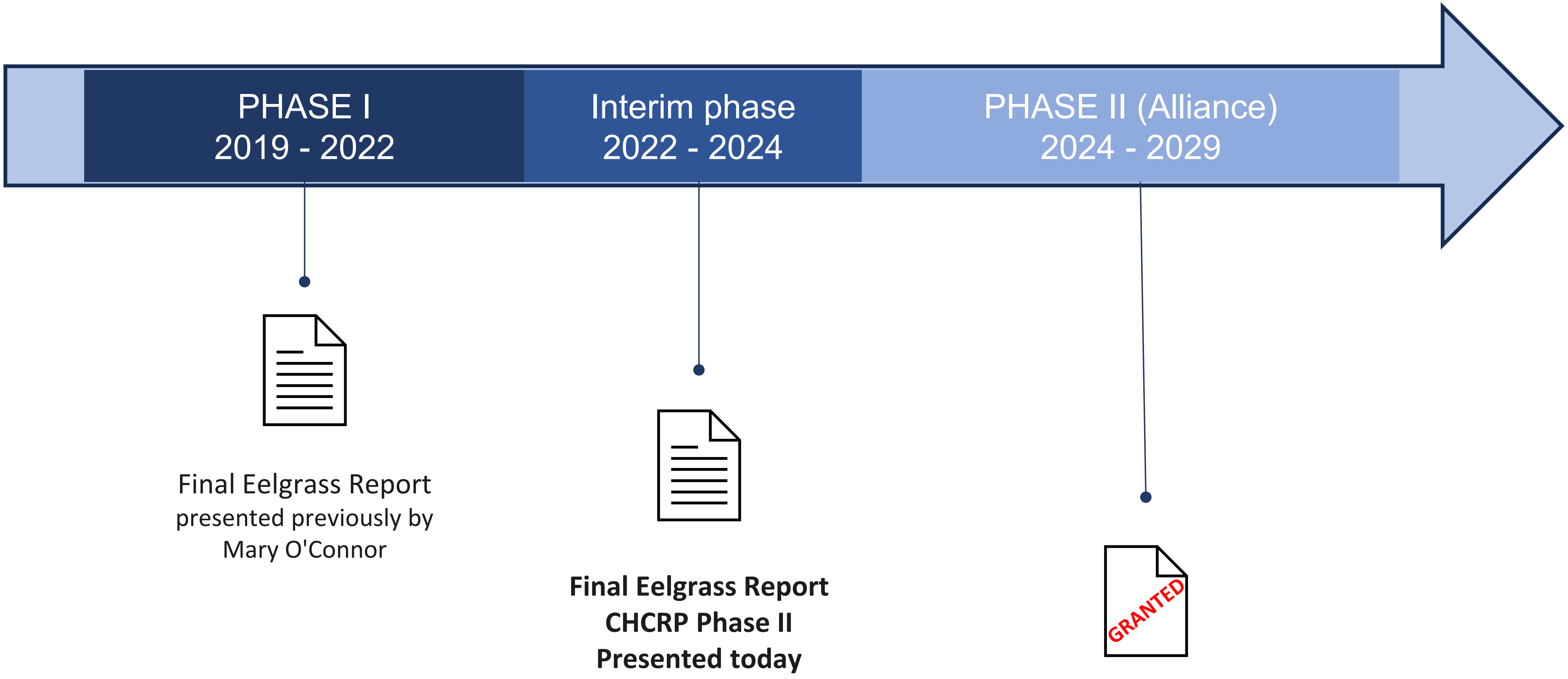


High light conditions before 1990; water was clearer

Decreased light conditions, water is murker

Sub-optimal light conditions, murky water

Timeline of the different phases of the CHCRP



Objectives

- **Obj 1:** To pilot field and laboratory methods that will be used to address Phase II goals

- **Obj 2**: To assess eelgrass condition at key locations by visiting monitoring sites that have been visited several times during the previous years and/or that were of particular interest to land users

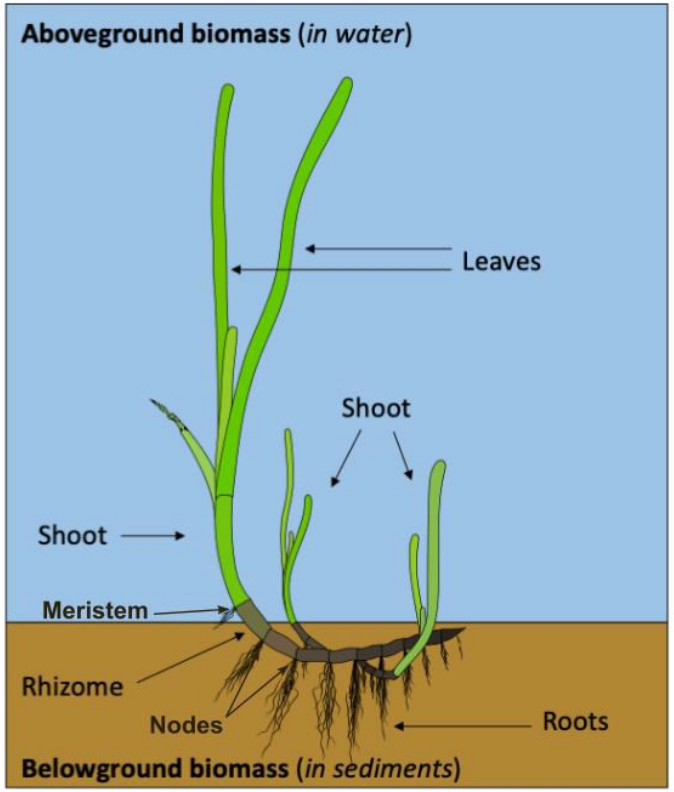
- **Obj 3:** To follow eelgrass growth at 5 locations to understand the link between early summer growth and environmental conditions

- **Obj 4:** To co-develop overall goals and objectives of Phase II with land users, university partners and community leadership, and write and submit a NSERC/CRSNG proposal for funding.

Interim phase
2022 - 2024

Summer 2023

- Fieldwork in Eeyou Istchee cancelled because of forest fires
- Pilot methods usefull for phase 3: Rhizome growth and sugar contents (obj 1)



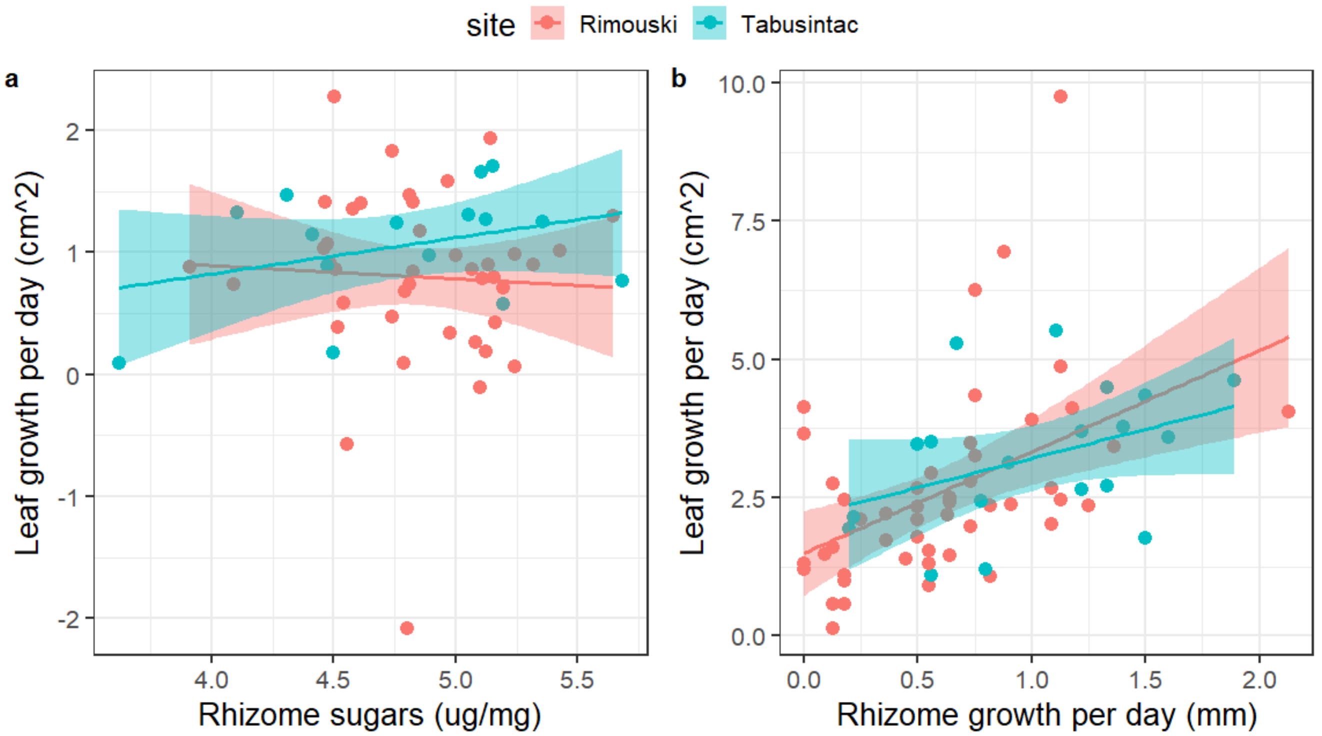
Rhizome growth: tool to understand the influences of environment on eelgrass growth and survival even during time periods when sampling is difficult (e.g. winter)

Rhizome sugar content: to quantify storage that can be used to overwinter and start growth in early spring

Interim phase
2022 - 2024

Summer 2023

- Fieldwork in Eeyou Istchee cancelled because of forest fires
- Pilot methods usefull for phase 3: Rhizome growth and sugar contents (obj 1)



Interim phase
2022 - 2024

Summer 2024

Interim phase
2022 - 2024

Summer 2024

- Fieldwork in Eeyou Istchee (June 24-July 22)
- Community meetings to discuss project and priotities

Interim phase
2022 - 2024

Summer 2024

- To assess eelgrass condition at key locations (obj 2)

Seagrass measurements
Presence/Absence
Leaf morphometry
Biomass
Rhizome morphometry
Leaf physiology
Density
% Cover

Water column measurements
Nutrients
CDOM
Chla
SPM (suspended particulate matter)

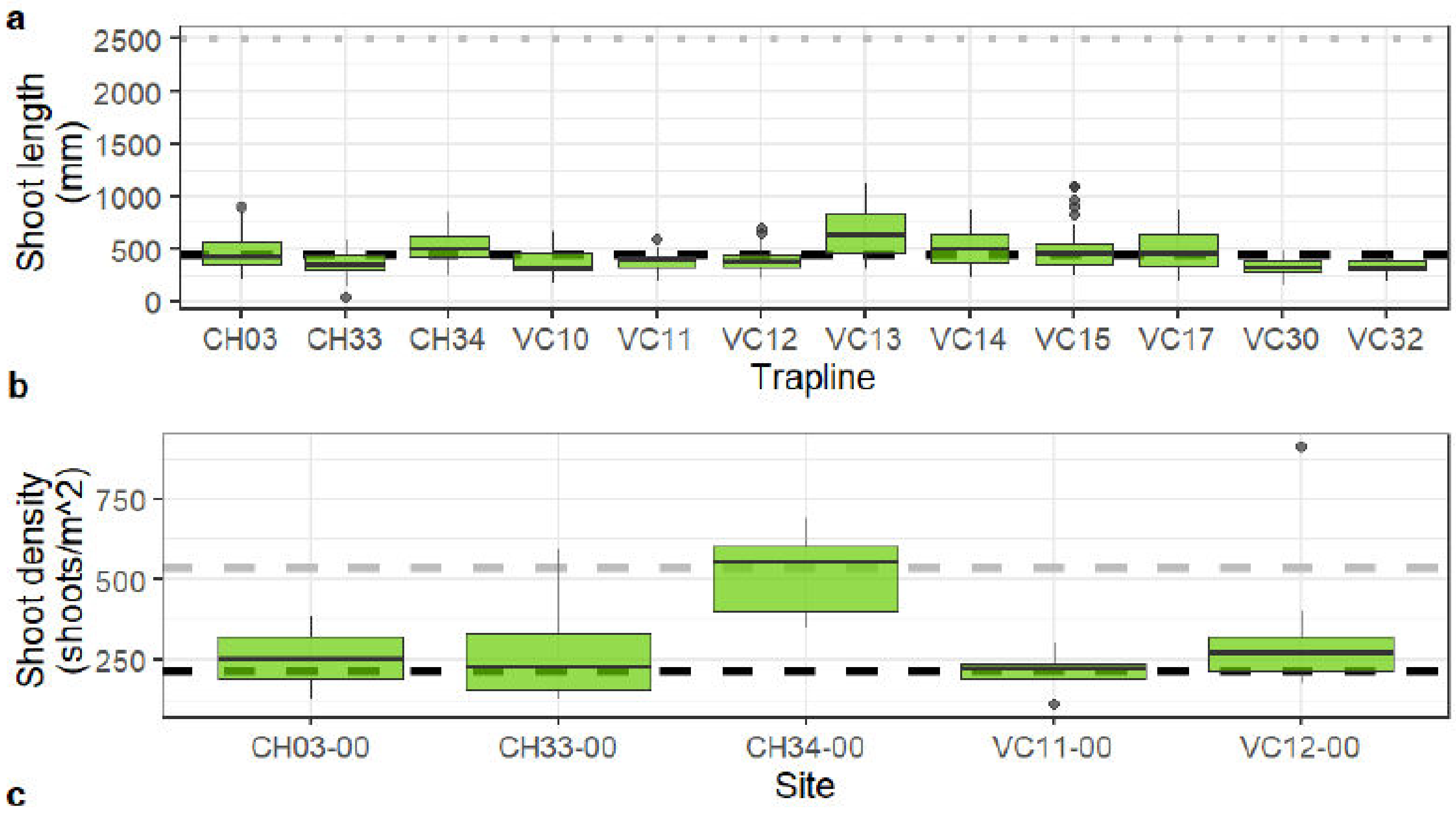
Sediment measurements
Pore water nutrients
Sediment hardness
Sediment core (for grain size)
Temperature, salinity, pH, Oxygen

Trapline	Participating tallymen and land users
CH34	Louis House, Charles House, Lawrence Napash, Darren Stephen
CH33	John Sam
CH03	John Rupert, Ronnie Rupert, Lawrence Napash
VC10	Rene Atsynia, Henry Stewart, Leonard Asquabaneskum
VC11	Rene Atsynia, Henry Stewart, Leonard Asquabaneskum, Roland Tomatuk
VC12	Roland Tomatuk, Abraham Matches, Cody Mark, Rene Atsynia
VC17	Ernie Hughboy, Stanley Shashaweskum
VC14	Henry Stewart, Leonard Asquabaneskum
VC13	Henry Stewart, Leonard Asquabaneskum
VC32	Marcel Moses, Wilfred Cheezo
VC15	Marcel Moses, Wilfred Cheezo
VC30	Marcel Moses, Wilfred Cheezo

Interim phase
2022 - 2024

Summer 2024

- To assess eelgrass condition at key locations (obj 2)

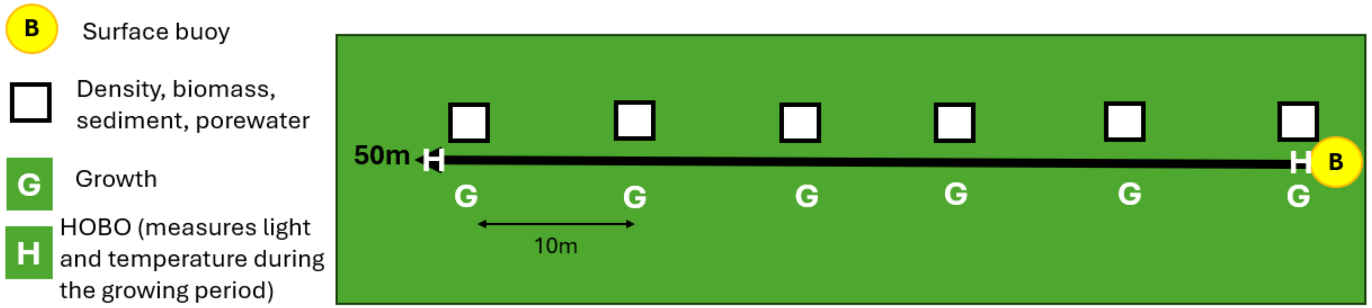


Eelgrass shoot lengths, density, and biomass were all comparable to regional averages in recent years but generally remain below pre-decline regional averages

Interim phase
2022 - 2024

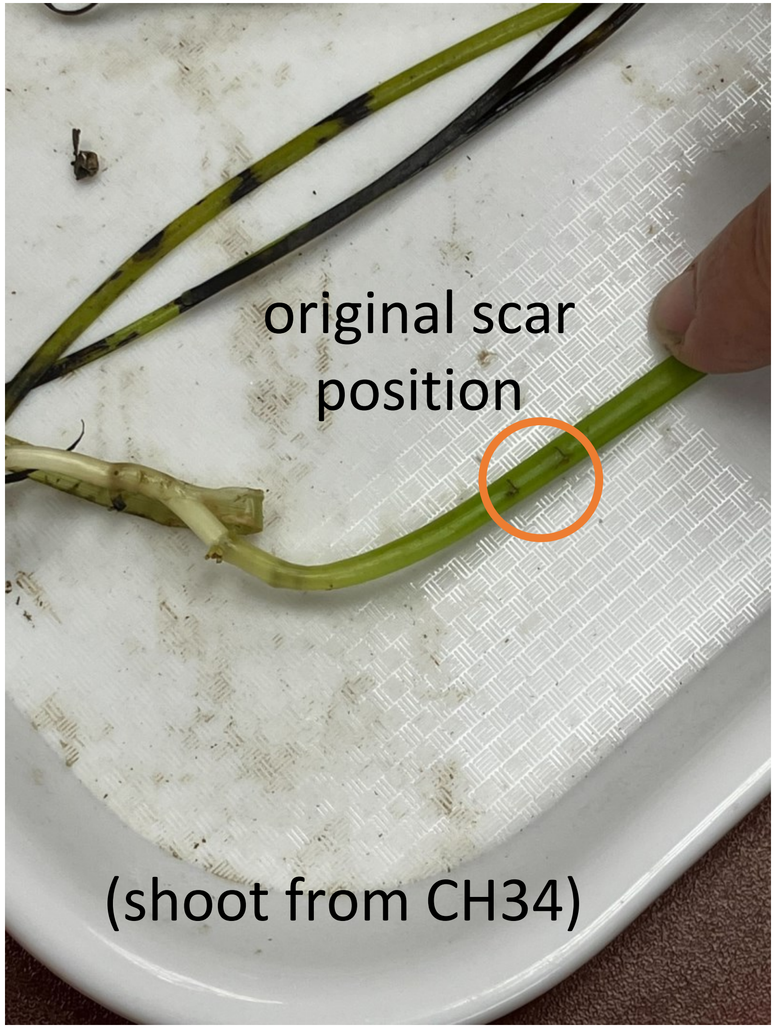
Summer 2024

- To follow eelgrass growth at 5 locations to understand the link between early summer growth and environmental conditions (obj 3)



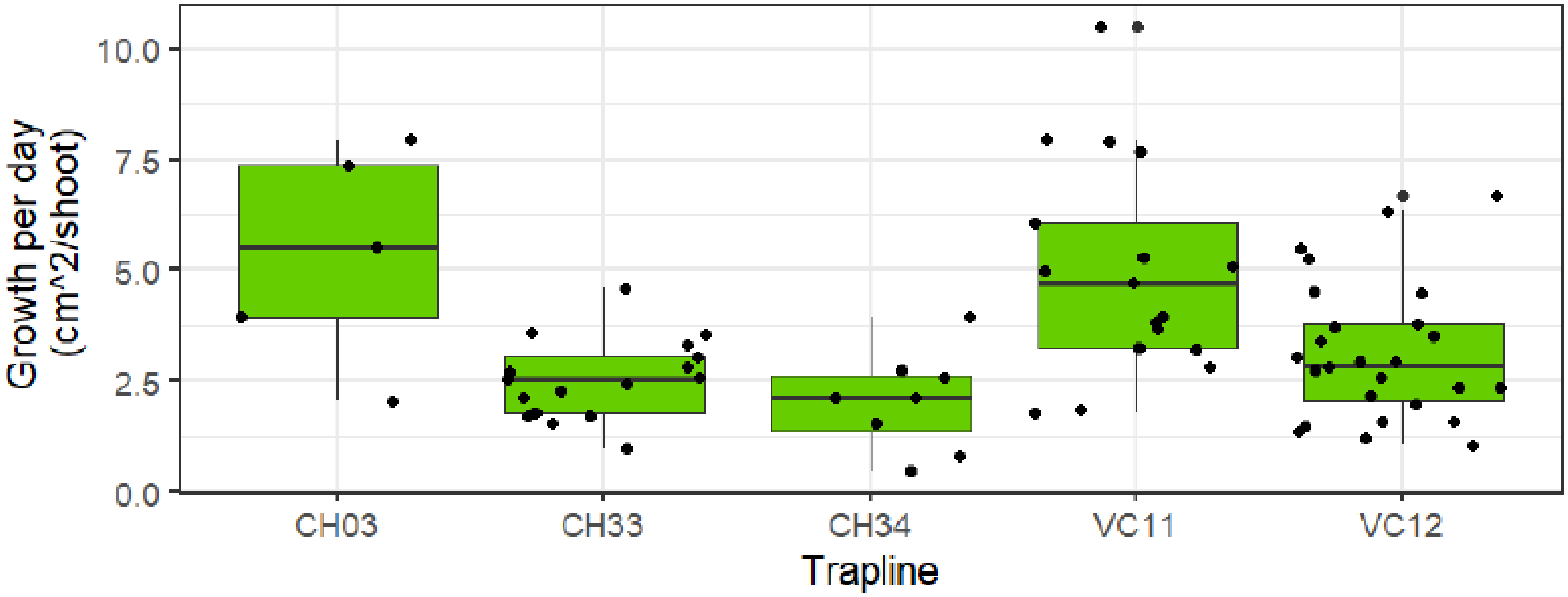
Summer 2024

- To follow eelgrass growth at 5 locations to understand the link between early summer growth and environmental conditions (obj 3)



Summer 2024

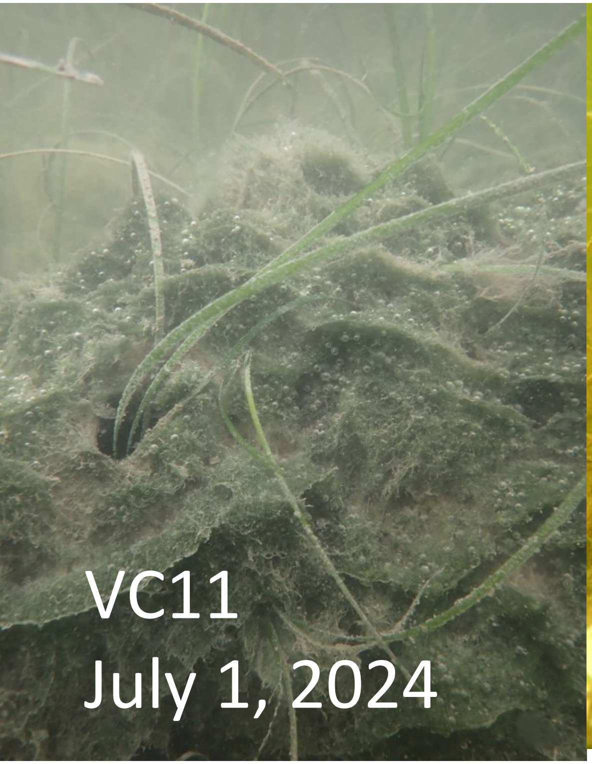
- To follow eelgrass growth at 5 locations to understand the link between early summer growth and environmental conditions (obj 3)

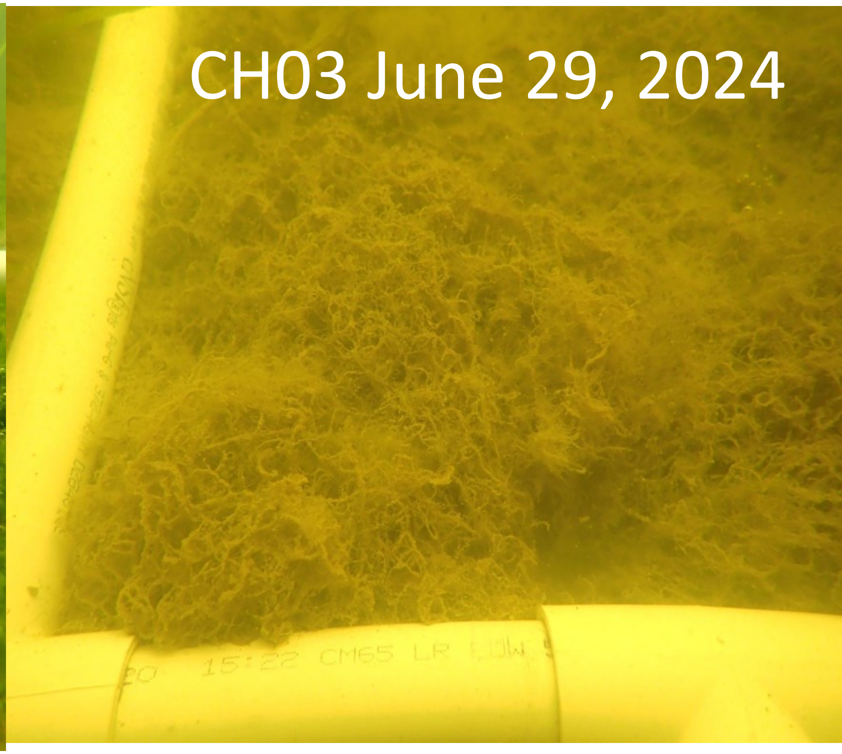


Interim phase
2022 - 2024

Summer 2024

- We have seen many algal mats that may be affecting eelgrass growth





PHASE II (Alliance)
2024 - 2029

CHCRP Phase II: A 5-year program

- Duration: Fall 2024-Fall 2029
- Summer 2024 is an inter-rim trip to connect with communities and check on eelgrass
- Jointly funded through a collaborative grant:

NSERC CRSNG

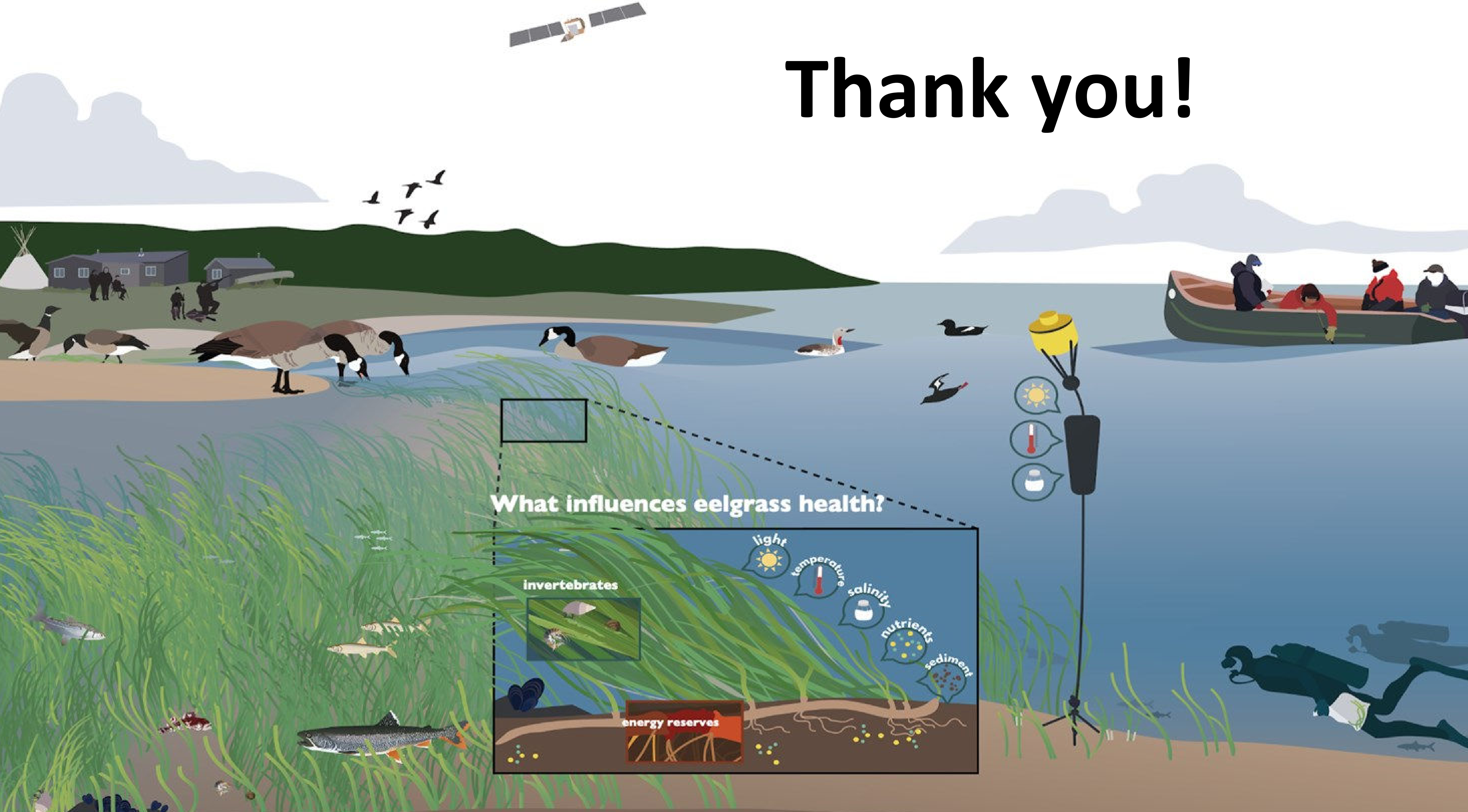
MISKAMOON CORPORATION

Hydro Québec

Canada

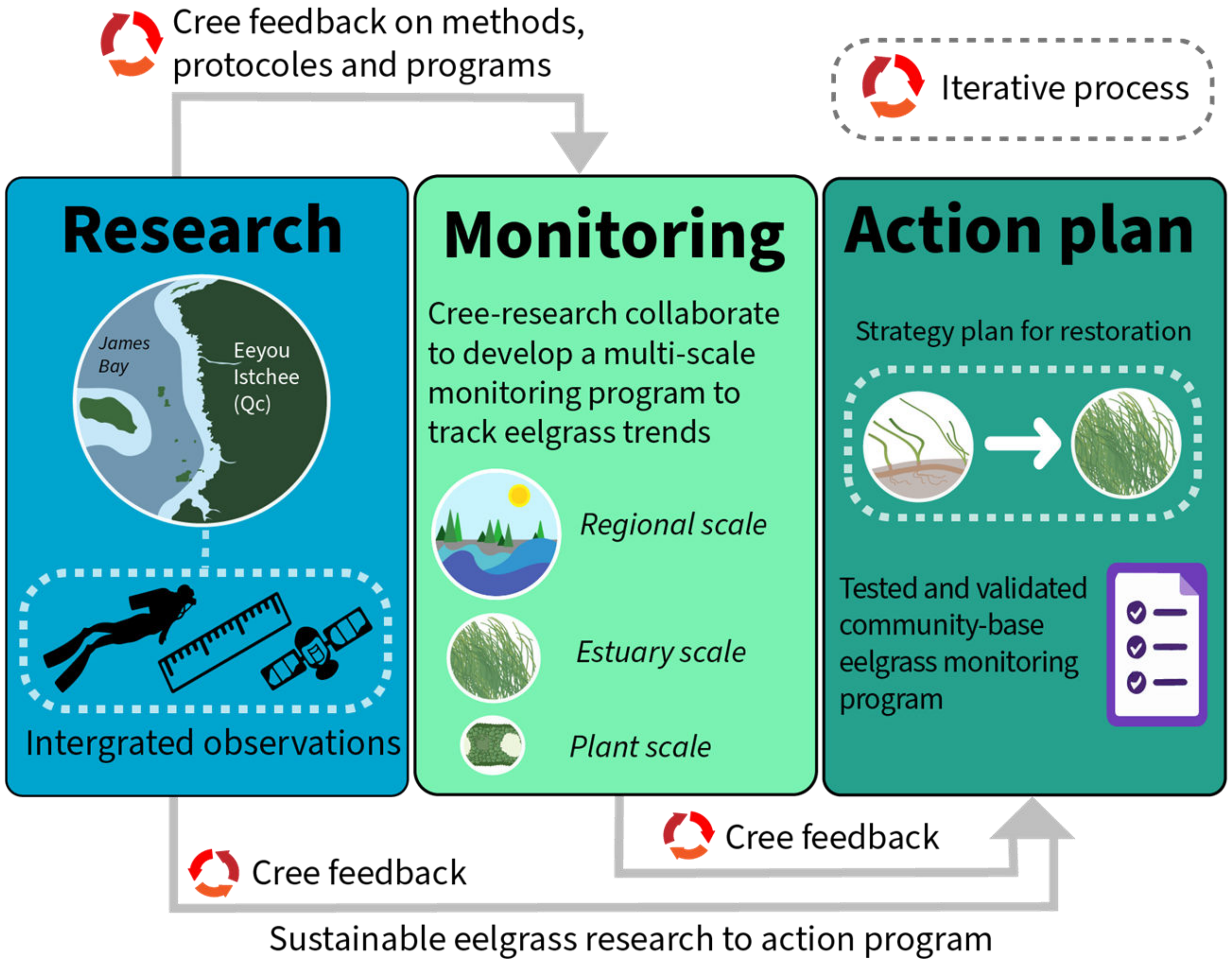
EEYOU MARINE REGION WILDLIFE BOARD
CONSEIL DE GESTION DES RESSOURCES FAUNIQUES DE LA RÉGION MARINE D'EEYOU

Thank you!



What influences eelgrass health?
invertebrates
light
temperature
salinity
nutrients
sediment
energy reserves

Coastal Ecosystems Project Goals



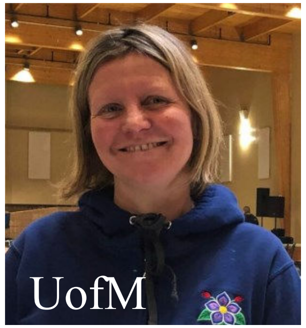
Coastal Ecosystems Project Team

co-PI

Mary O'Connor

Jens Ehn

Zou Zou Kuzyk



Fanny Noisette

Simon Bélanger

Partners (current)

Melanie Leblanc (Niskamoon)

Eeyou Marine Region Wildlife Board
Parks Canada
CEGRIM
Hydro Québec

Project coordinator

Caroline Fink-Mercier

Post-doc fellow

Nicole Knight

Collaborators:
Murray Humphries,
Ally Menzies,
Paul del Giorgio

Coastal Ecosystems Project: Goals

1: To understand how the ocean, river plume, and ice environment affects eelgrass health (current and future).

2. To identify opportunities to enhance recovery and restoration.

3: To support the development of a sustainable Cree-led eelgrass ecosystem monitoring and early action program