Supplementary Information

Eelgrass ecosystem collapse and social-ecological regime shift driven by hydropower development and climate change

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This Supplementary Information document contains eight Supplementary Figures, two Supplementary Tables, and Supplementary References.

Supplementary Figures

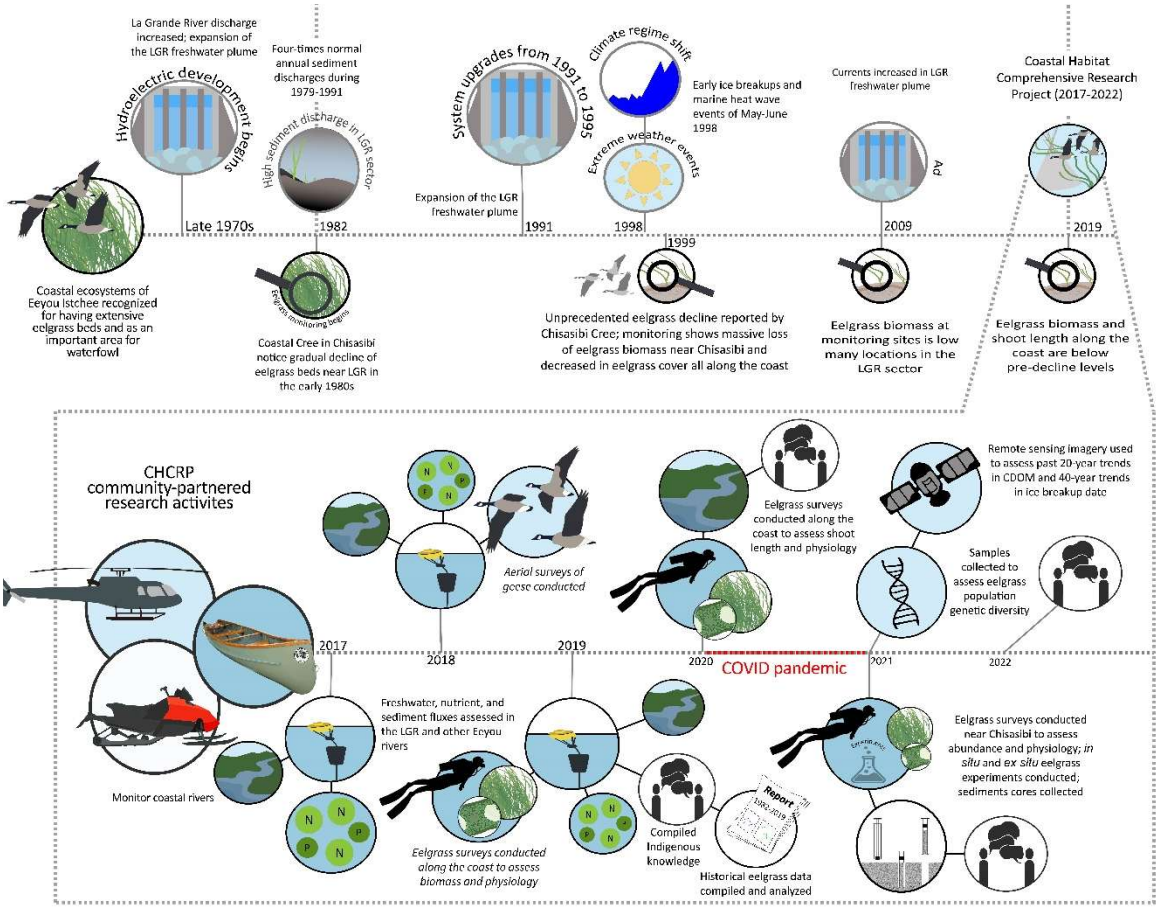

Figure S1. Timeline of environmental changes and monitoring along the Eeyou Istchee coast.

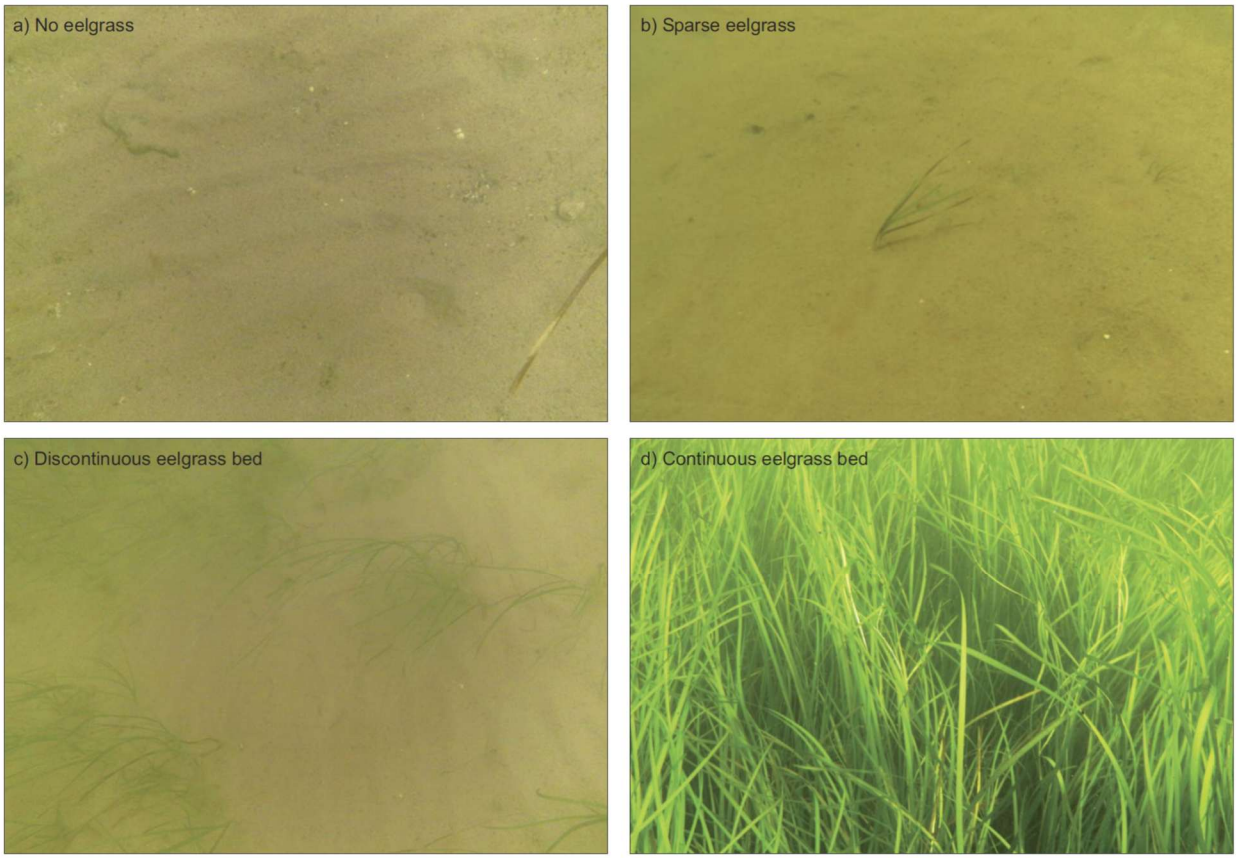

Figure S2. Eelgrass abundance classes from Hydro-Québec eelgrass cover monitoring as illustrated in a 2017 report prepared by Consortium GENIVAR-Waska for Hydro-Québec Production[1]. Panels are as follows: a) No eelgrass, b) Sparse eelgrass, c) Discontinuous eelgrass bed, d) Continuous eelgrass bed.

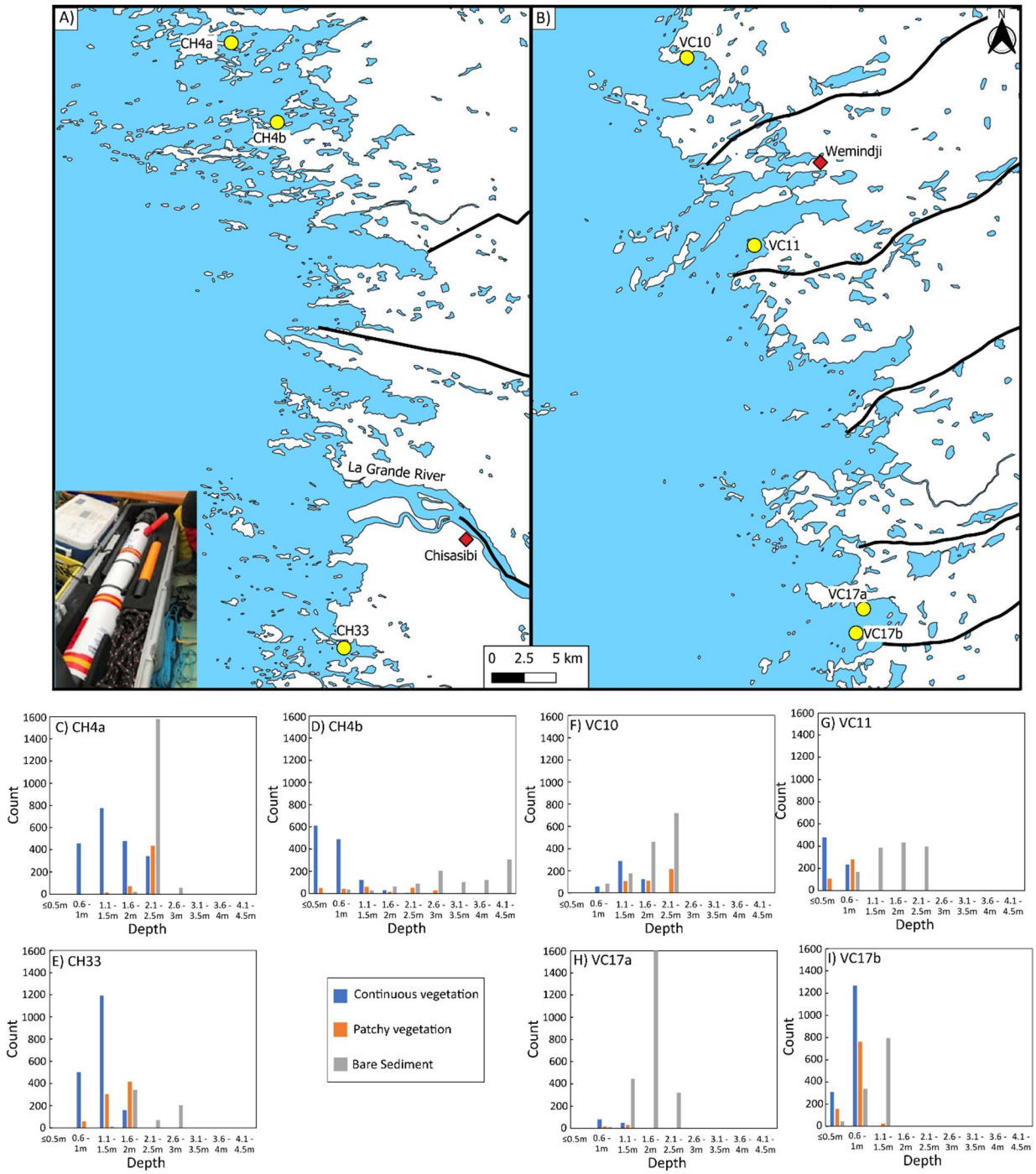

Figure S3. Sites (yellow circles) surveyed by side-scan sonar mounted on an autonomous underwater vehicle (AUV) and processed in A) the La Grande sector of the coast and B) the Wemindji sector. Panels C-I show counts of the number of grid cells (20 m x 20 m) containing bare seabed (grey bars), patchy eelgrass (orange bars), or continuous eelgrass (blue bars) in each water-depth bin based on the side-scan sonar imagery. Courtesy: C.J. Peck. Map created using ArcGIS® software by Esri. Copyright © Esri. All rights reserved.

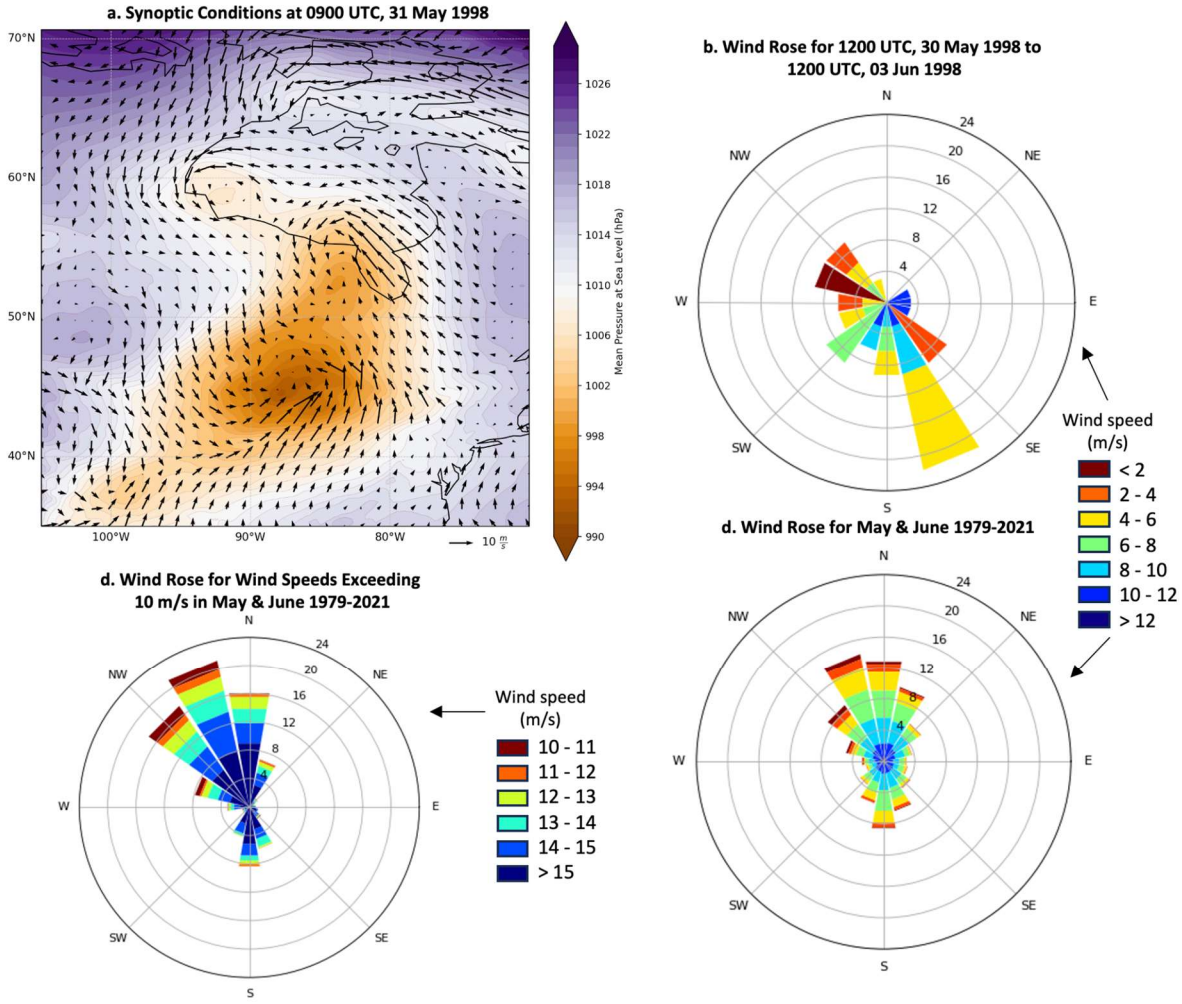

Figure S4. Spring storm event from 30 May to 3 June 1998. (a) Sea-level pressure (shading) and 10-m wind vectors for 0900 UTC on 31 May 1998. (b-d) Wind roses for northeast James Bay (average of 53.25 - 54.75°N, 79.5 - 81.0°W) for (b) the 30 May to 3 June 1998 storm, (c) all strong wind events (wind speed > 10 m/s) in May or June 1979-2021, and (d) all data May or June 1979-2021. Courtesy: A. Crawford.

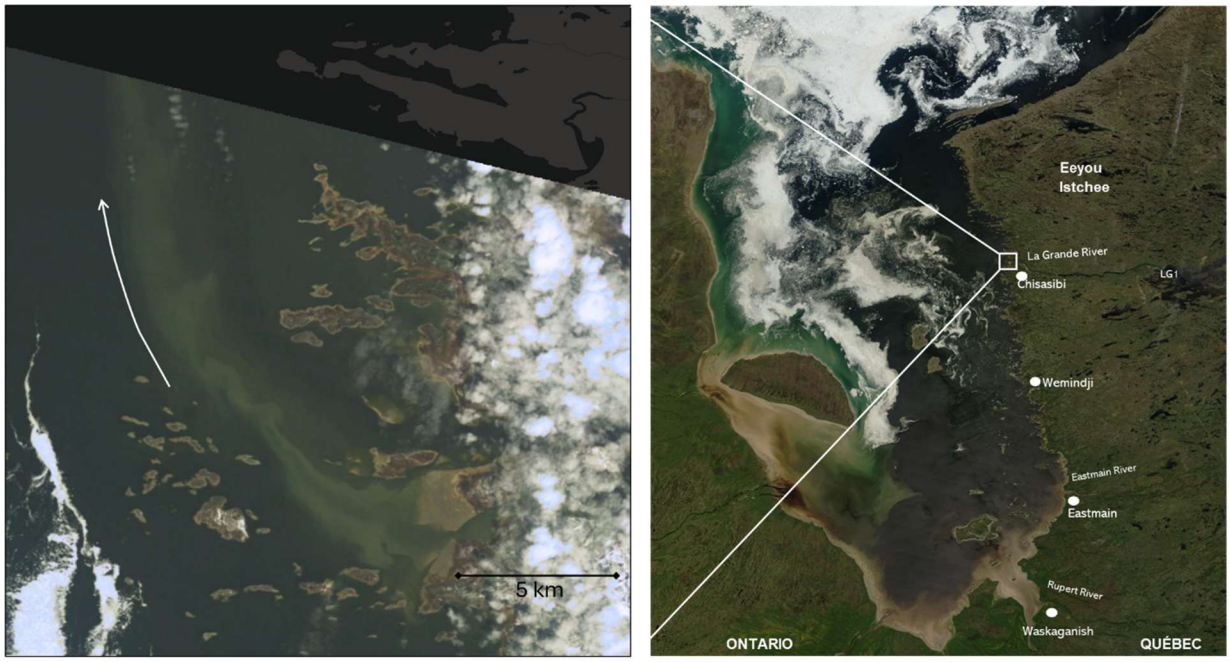

Figure S5. Landsat-5 image captured on 1–2 June 1998 showing northward transport of suspended sediment in the LGR freshwater plume following early ice breakup and a spring storm. This Landsat-5 Natural Color image was downloaded from Explore — LandsatLook, U.S. Geological Survey, July 15, 2010. (Path-Row 32-07). On the right is an image of James Bay, Canada, on June 28, 2002. This MODIS/Terra True color image was acquired from the LAADS DAAC, Goddard Space Flight Center, Greenbelt, Maryland (NASA Land Rapid Response Team, June 28, 2002).

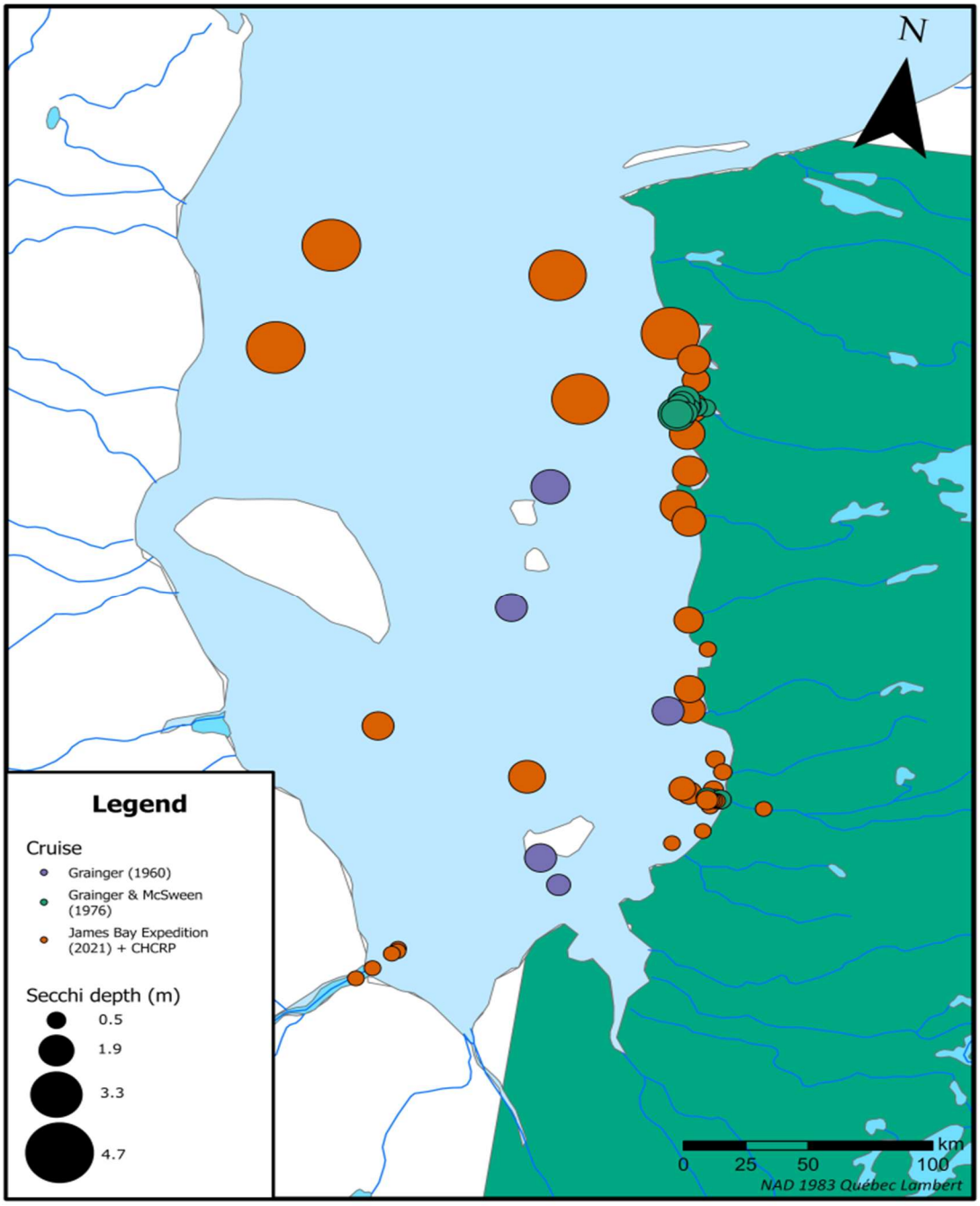

Figure S6. Secchi depth measurements in James Bay from historical data sources[2,3], the 2021 James Bay Expedition (https://doi.org/10.34992/vbx3-fr18), and the Eeyou Coastal Habitat Comprehensive Research Project (CHCRP). Courtesy: C. Fink-Mercier and M. Gosselin. Map created using ArcGIS® software by Esri. Copyright © Esri. All rights reserved.

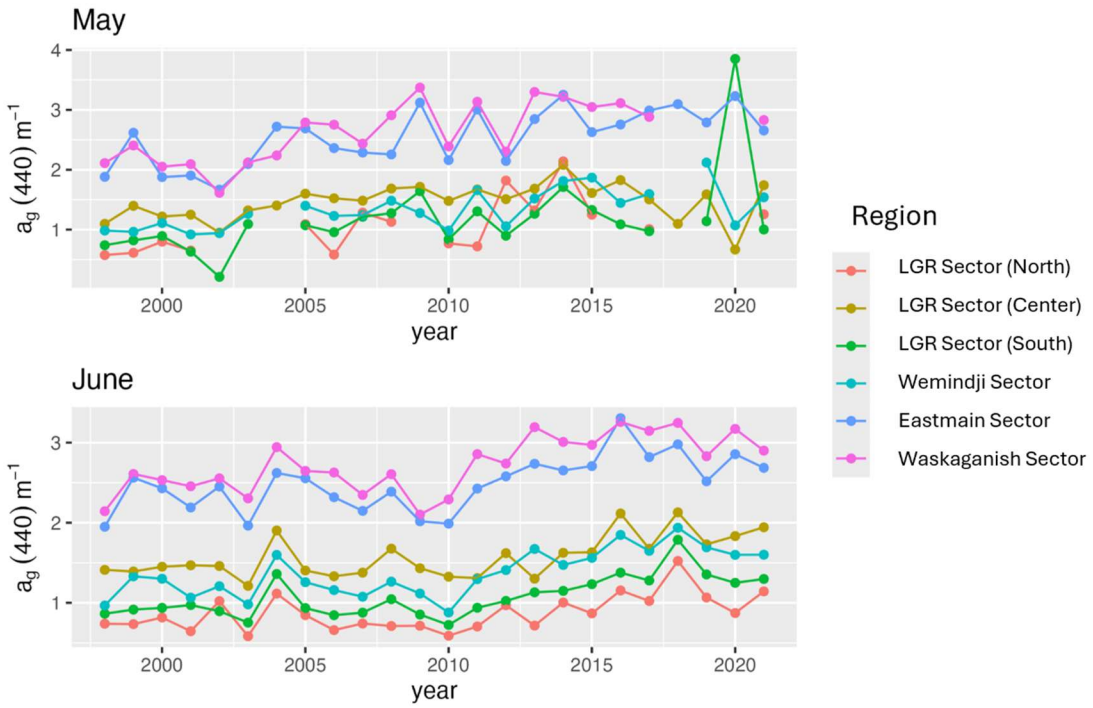

Figure S7. Time series of the variation in absorption by colored dissolved organic matter (CDOM) at 440 nm (a_g(440 nm)) during May (top panel) and June (bottom panel) in three northeastern JB subregions (i.e., LGR Sector (North), LGR Sector (Center), and LGR Sector (South), and the Wemindji, Eastmain, and Waskaganish Sectors from 1998 to 2021. Locations are shown on Figure 1. a_g(440 nm) was computed using combined SeaWiFS and MODIS-Aqua data. Courtesy: S. Bélanger based on data provided by R.K. Singh.

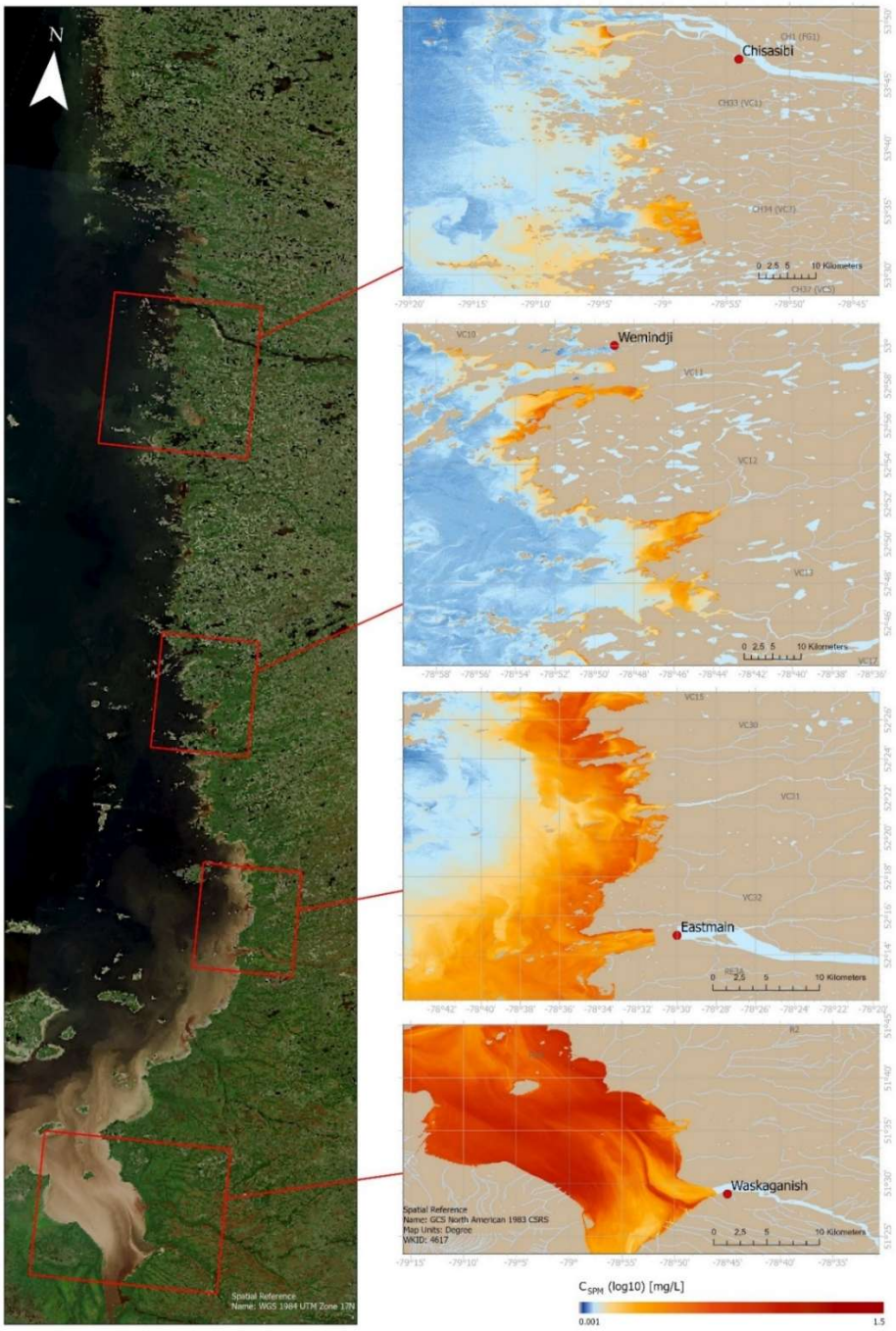

Figure S8. Turbidity plumes in nearshore waters along the east coast of James Bay. Left: RGB image as observed by Sentinel-2A on August 8, 2016. Right: Suspended particulate matter concentration ($\log_{10} C_{SPM}$) estimated using an empirical algorithm[4]. Image contains modified Copernicus Sentinel data (2024), information licensed under the Open Government License – Canada (https://open.canada.ca/en/open-government-licence-canada), and public data from Natural Earth (https://www.naturalearthdata.com/). Map created using ArcGIS® software by Esri. Copyright © Esri. All rights reserved.

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Supplementary Tables

Table S1. Statistical results for Pettitt tests used to identify change points in time series reported in Figure 4. The estimated p-values are based on a two-sided test.

Variable (units)	Best Change-Point Year	p-value
NEJB Discharge (km^3y^{-1})	1986	< 0.001
Ice Breakup Day	1998	0.027
NEJB SST (Jun-Oct; °C)	1996	< 0.001
Days of MHWs	1998	0.024
May-Jul 10-m Windspeed ($m\ s^{-1}$)	1998	0.226

Table S2. Statistical results for two-sided Mann-Whitney tests used to compare the medians of different periods in Figure 4.

Variable (units)	p-value	Period 1	Median	Period 2	Median
NEJB Discharge (km^3y^{-1})	< 0.001	1951-1985	65	1986-1997	103
NEJB Discharge (km^3y^{-1})	0.003	1986-1997	103	1998-2023	130
Ice Breakup Day	0.003	1985-1997	174	1998-2019	160
NEJB SST (Jun-Oct; °C)	< 0.001	1982-1995	3.5	1998-2020	5.4
Days of MHWs	0.001	1982-1997	0	1998-2021	14
May-Jul 10-m Windspeed ($m\ s^{-1}$)	0.037	1979-1997	5.8	1998-2021	6.1

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Supplementary References

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