Production and dynamics of cold-temperate intertidal benthic communities

      

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UQAC
UNIVERSITÉ DU QUÉBEC
À CHICOUTIMI

UQAR
Université du Québec
à Rimouski

ITRS January 9th
Hobart, Australia

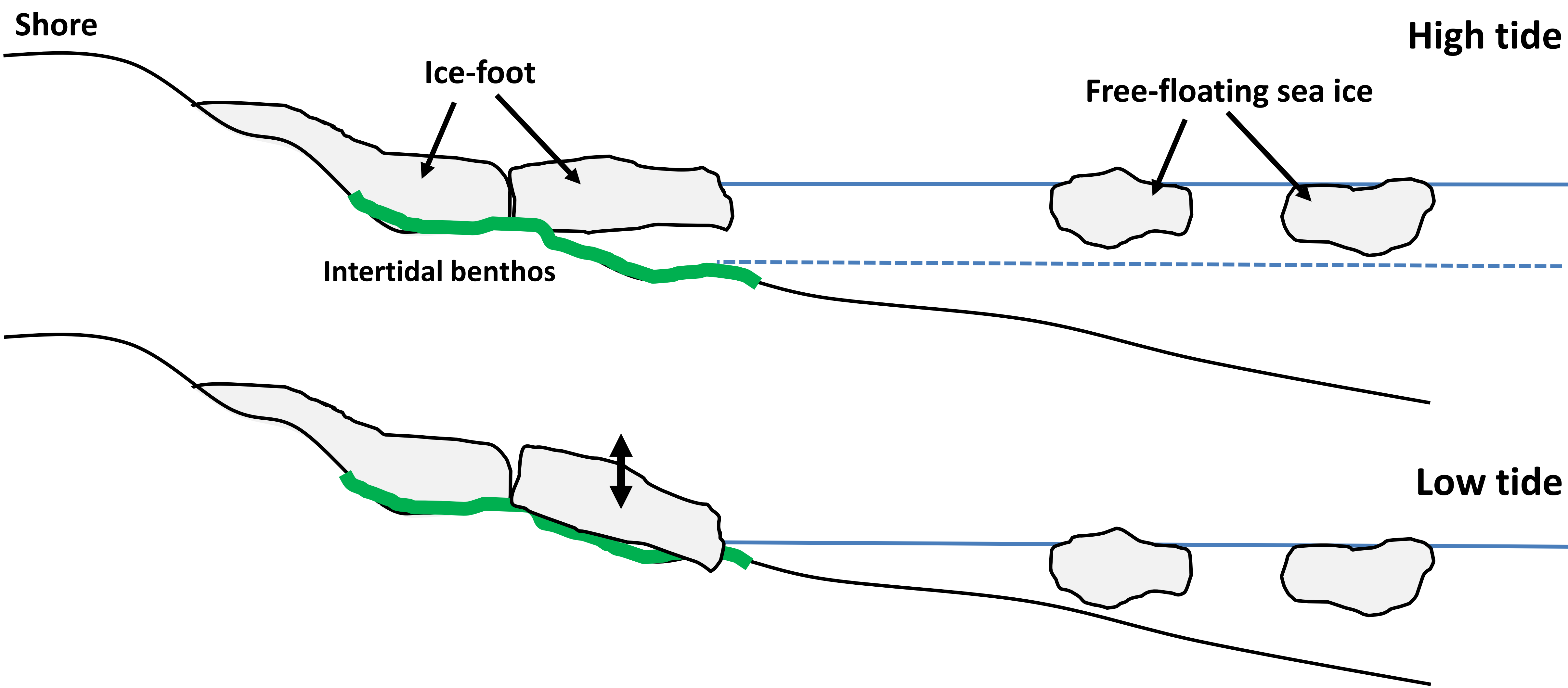
Macroalgal dynamics in a cold-temperate/subarctic environment

Protection and or disturbance from ice during winter/spring

St. Lawrence estuary and gulf, Quebec (Canada)

Macroalgal dynamics in a cold-temperate/subarctic environment

Protection from ice during winter/spring



Macroalgal dynamics in a cold-temperate/subarctic environment

Protection/disturbance from ice during winter/spring

Continuous ice-foot, Pointe-Lebel Feb 20th 2018

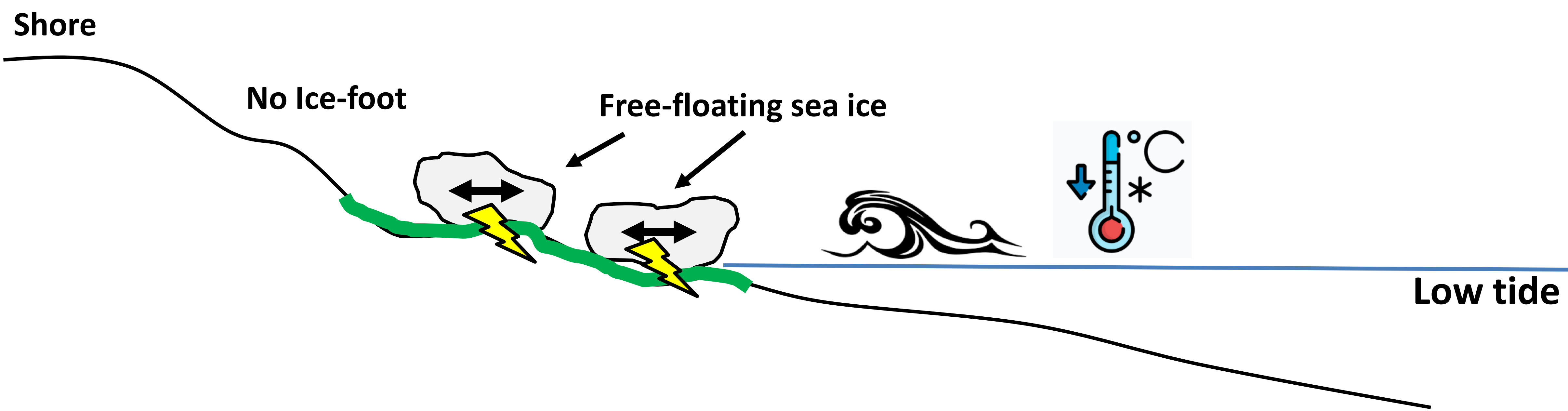
Photos: P. Bernatchez

Coastal ice accretion in the Baie des Chaleurs

Photo: C. Fraser

Macroalgal dynamics in a cold-temperate/subarctic environment

Disturbance from ice during winter/spring



Macroalgal dynamics in a cold-temperate/subarctic environment

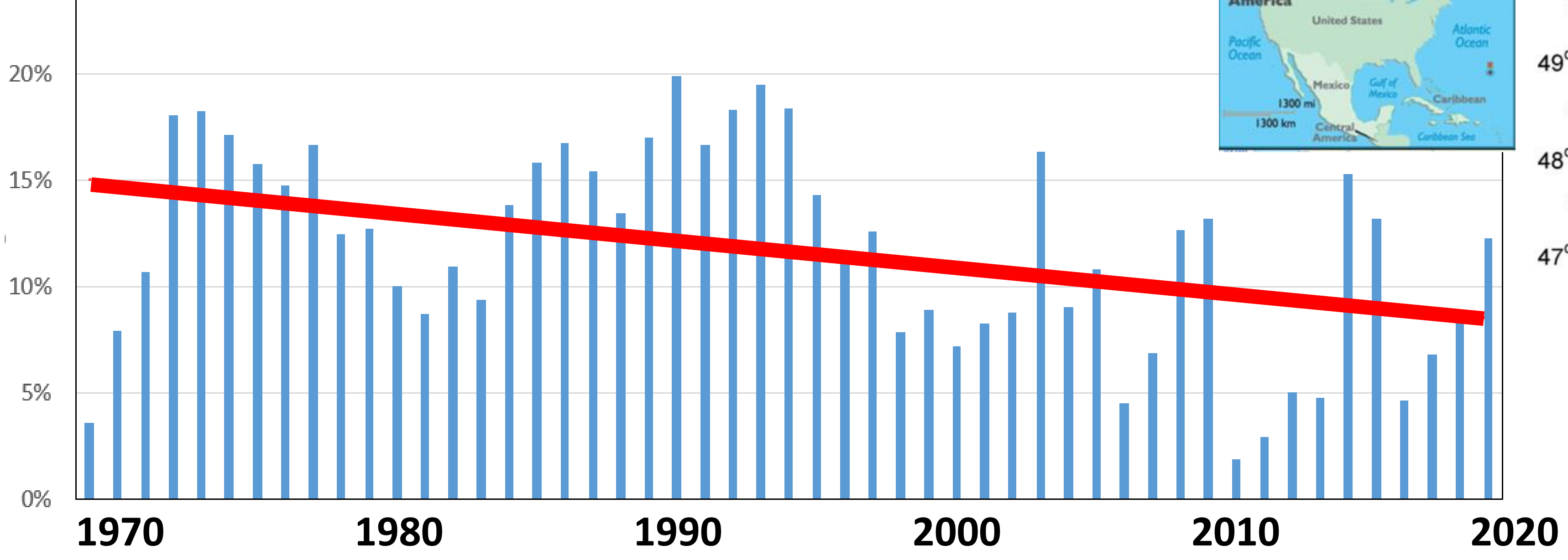
Disturbance from ice during winter/spring

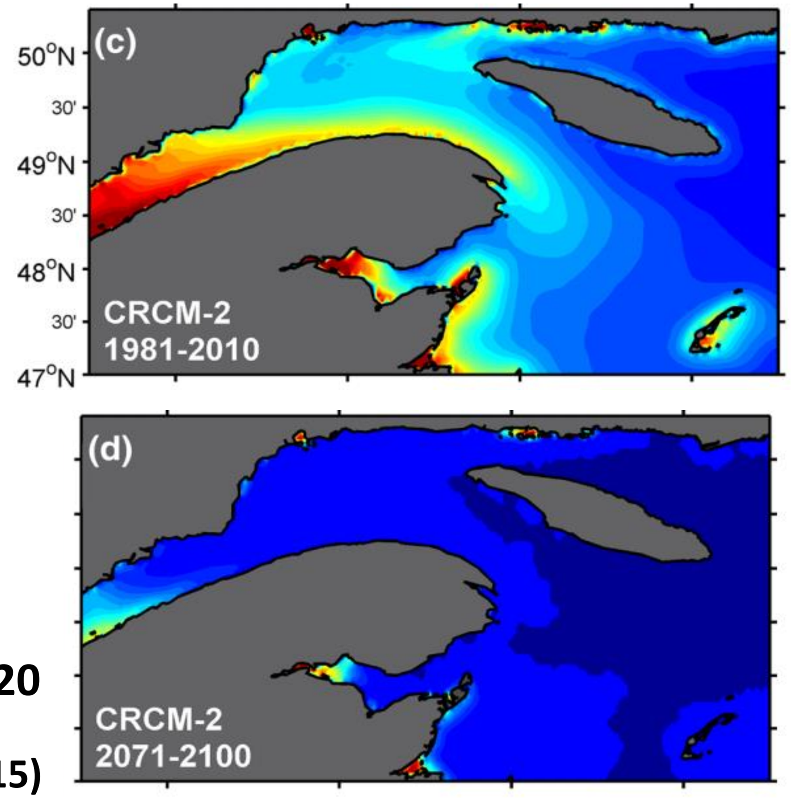
Macroalgal dynamics in a cold-temperate/subarctic environment

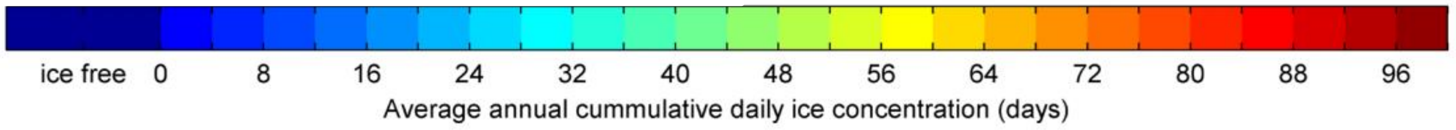
Protection and or disturbance from ice during winter/spring

Decrease of 30 to 67 days of the ice season between the recent past and the 2055 horizon

Total accumulated ice cover from 1969 to 2019
Source: Canadian Ice Service







Ruest et al. (2015)

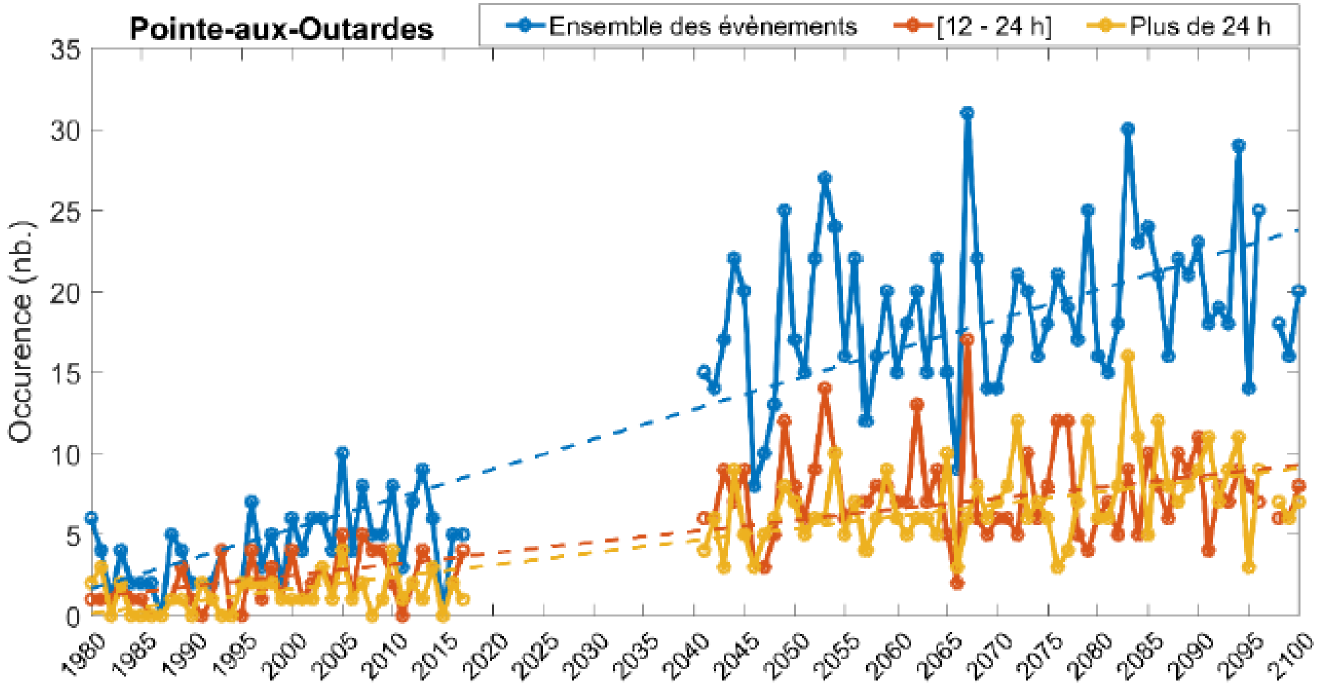
Macroalgal dynamics in a cold-temperate/subarctic environment

Protection and or disturbance from ice during winter/spring

Decrease of 30 to 67 days of the ice season between the recent past and the 2055 horizon

Models predicts increasing number of wave storms (1980-2100)

Percé (Quebec), during the strong 2015 winter storm
Photo: Steven Melanson



Macroalgal dynamics in a cold-temperate/subarctic environment

Protection and or disturbance from ice during winter/spring

Decrease of 30 to 67 days of the ice season between the recent past and the 2055 horizon

Models predicts increasing number of wave storms (1980-2100)

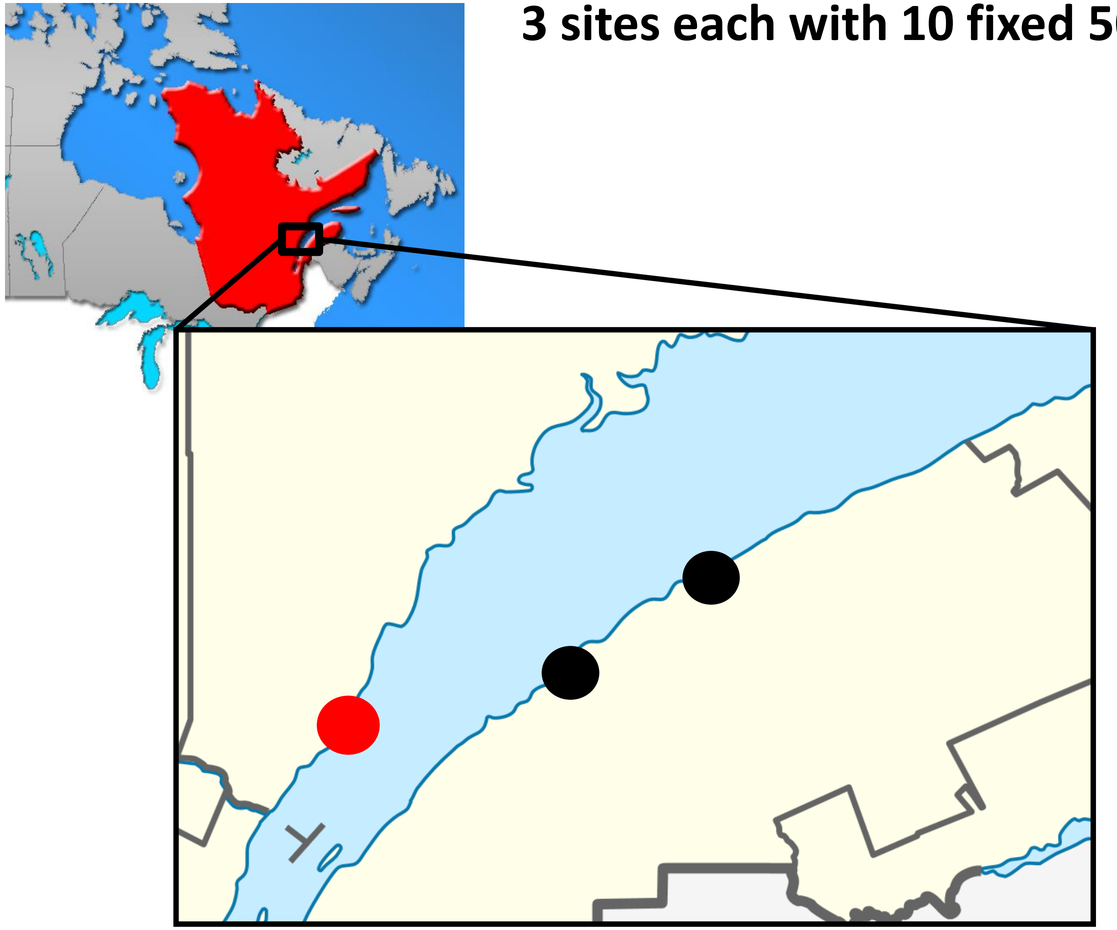
Fortunately, very rapid recovery is seen in the St Lawrence marine system

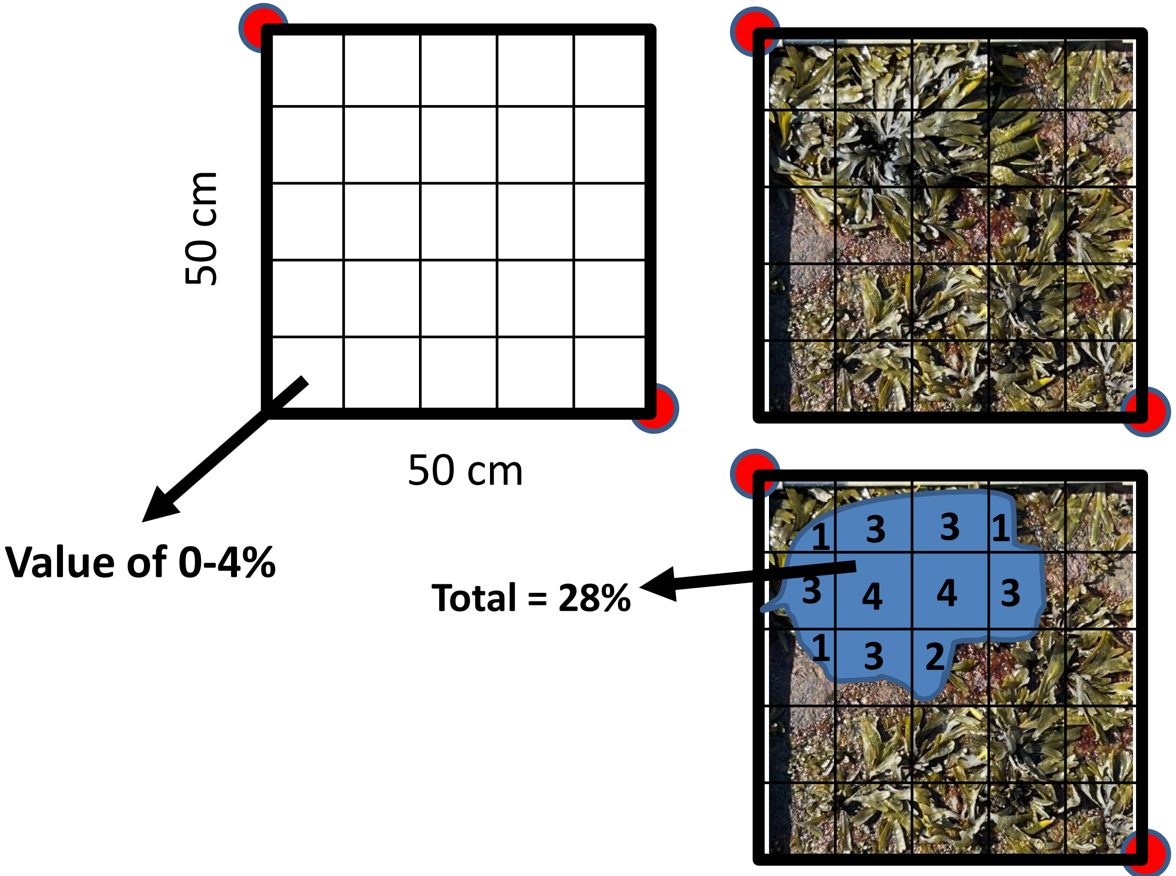
Macroalgal dynamics in a cold-temperate/subarctic environment

Strong effects of ice-souring on intertidal benthic communities.

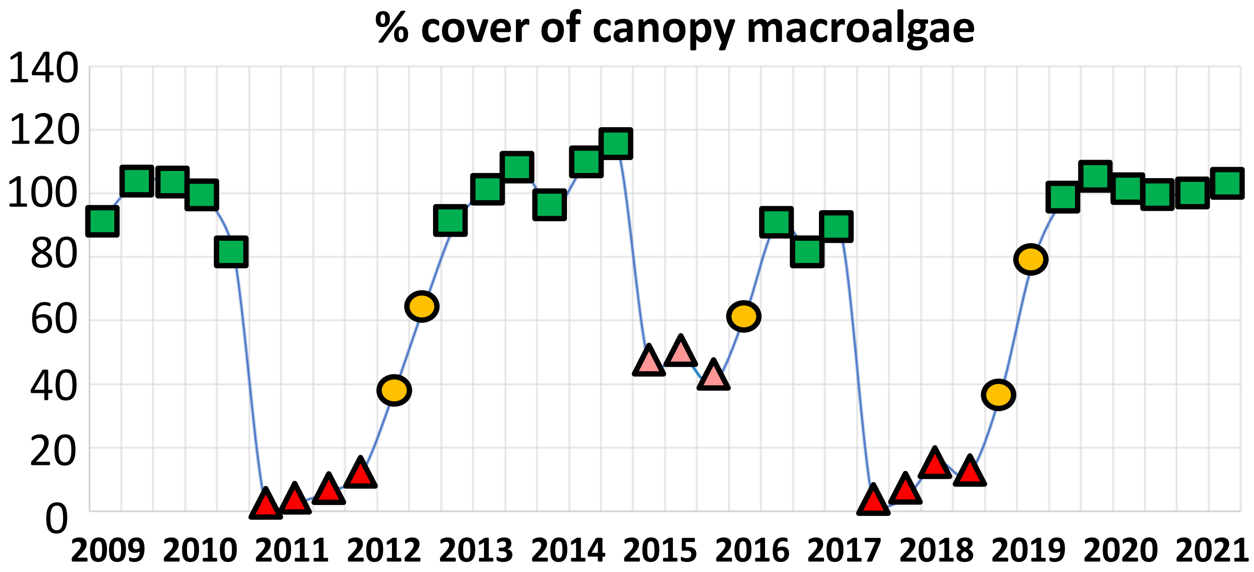
Non-destructive method for monitoring the % cover of benthic communities since 2009:

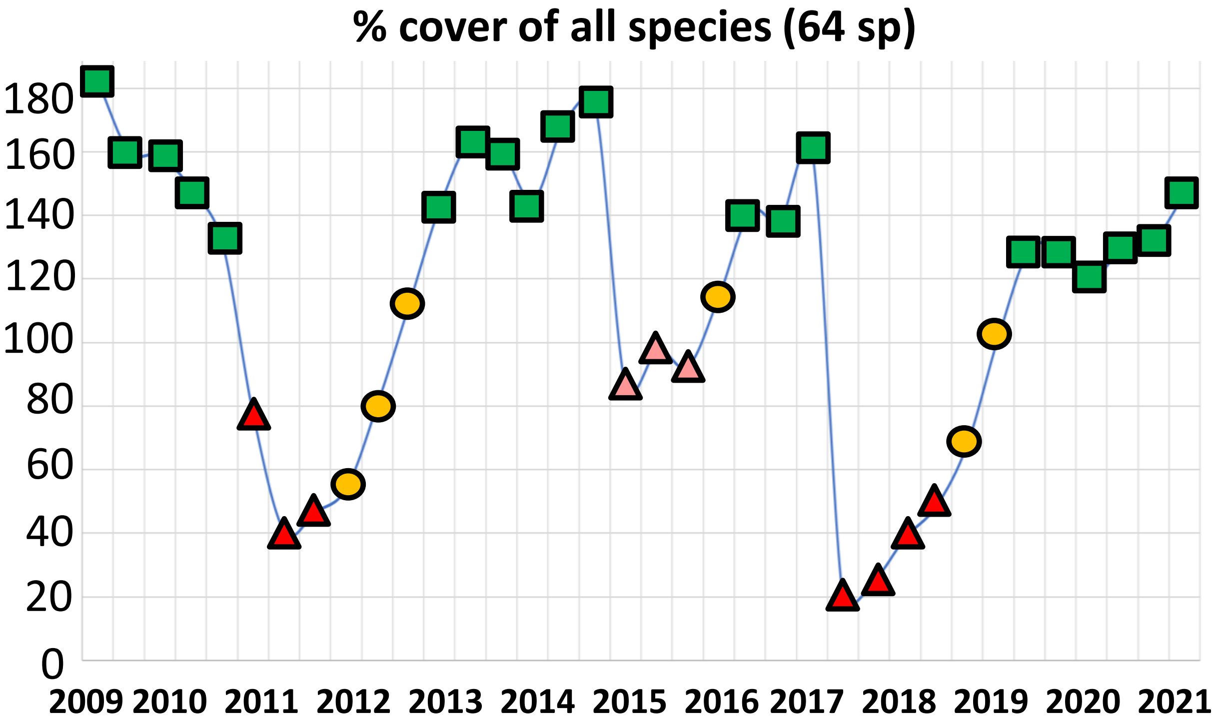
3 sites each with 10 fixed 50 x 50 cm quadrats, 3 dates per year. Over 704 quadrats.



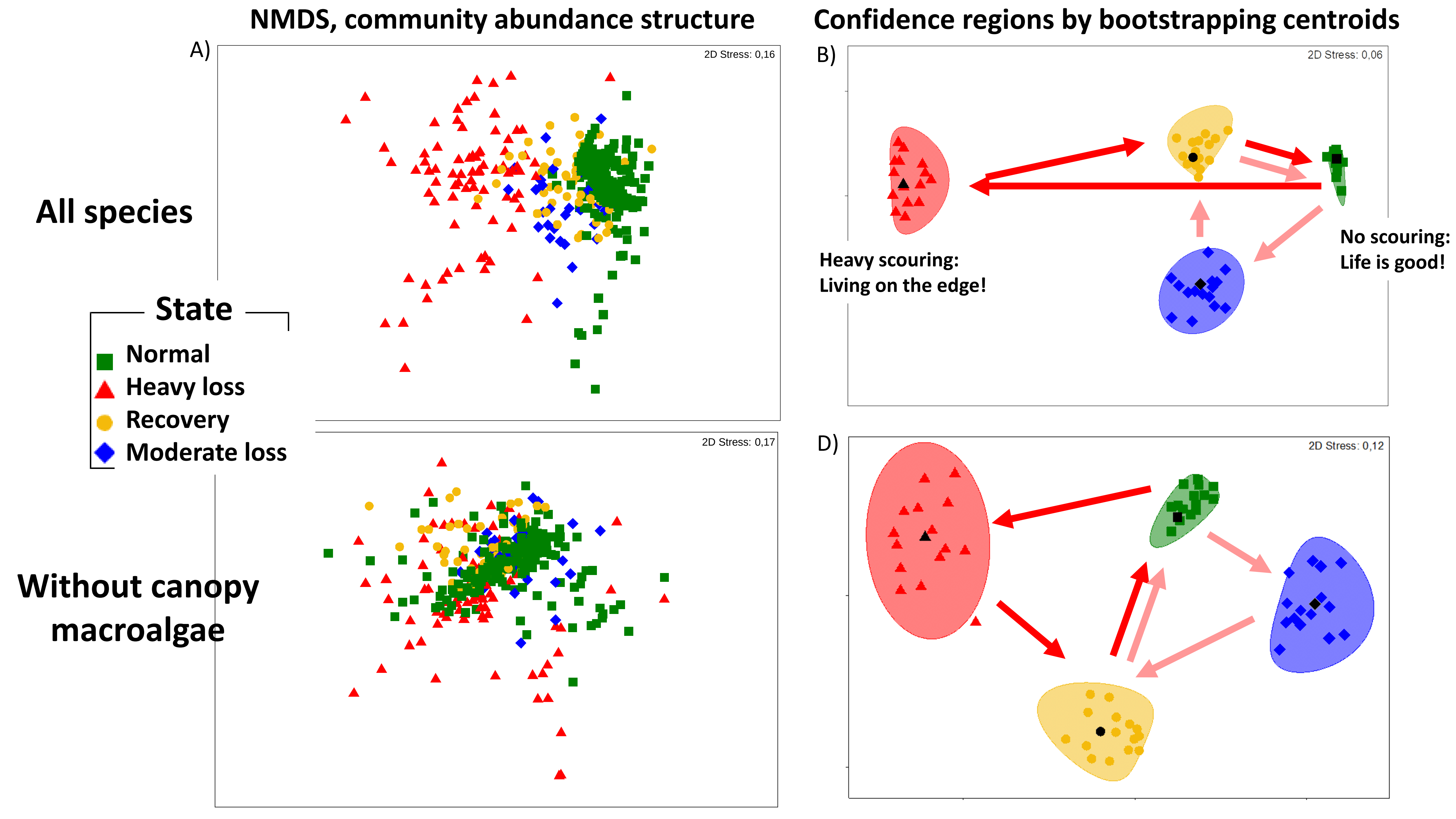


Average % cover between 2009 and 2021





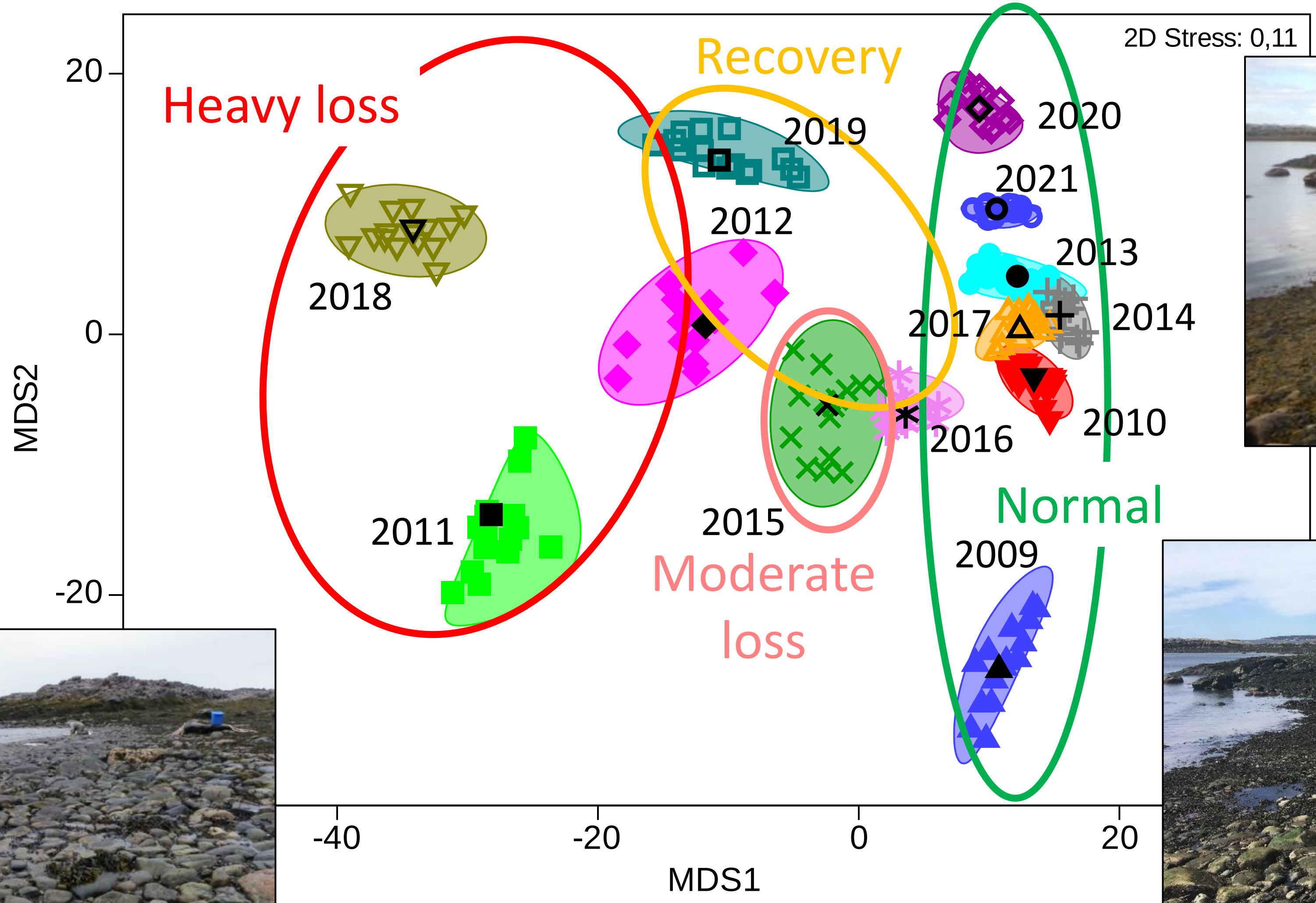
2020 : Normal | 2011 : Heavy loss | 2015 : Moderate loss | 2016 : Recovery



NMDS, community abundance structure
Confidence regions by bootstrapping centroids
A)
2D Stress: 0,16
B)
2D Stress: 0,06
All species
Heavy scouring:
Living on the edge!
No scouring:
Life is good!
State
Normal
Heavy loss
Recovery
Moderate loss
2D Stress: 0,17
D)
2D Stress: 0,12
Without canopy
macroalgae

Macroalgal community dynamics in a cold-temperate/subarctic environment

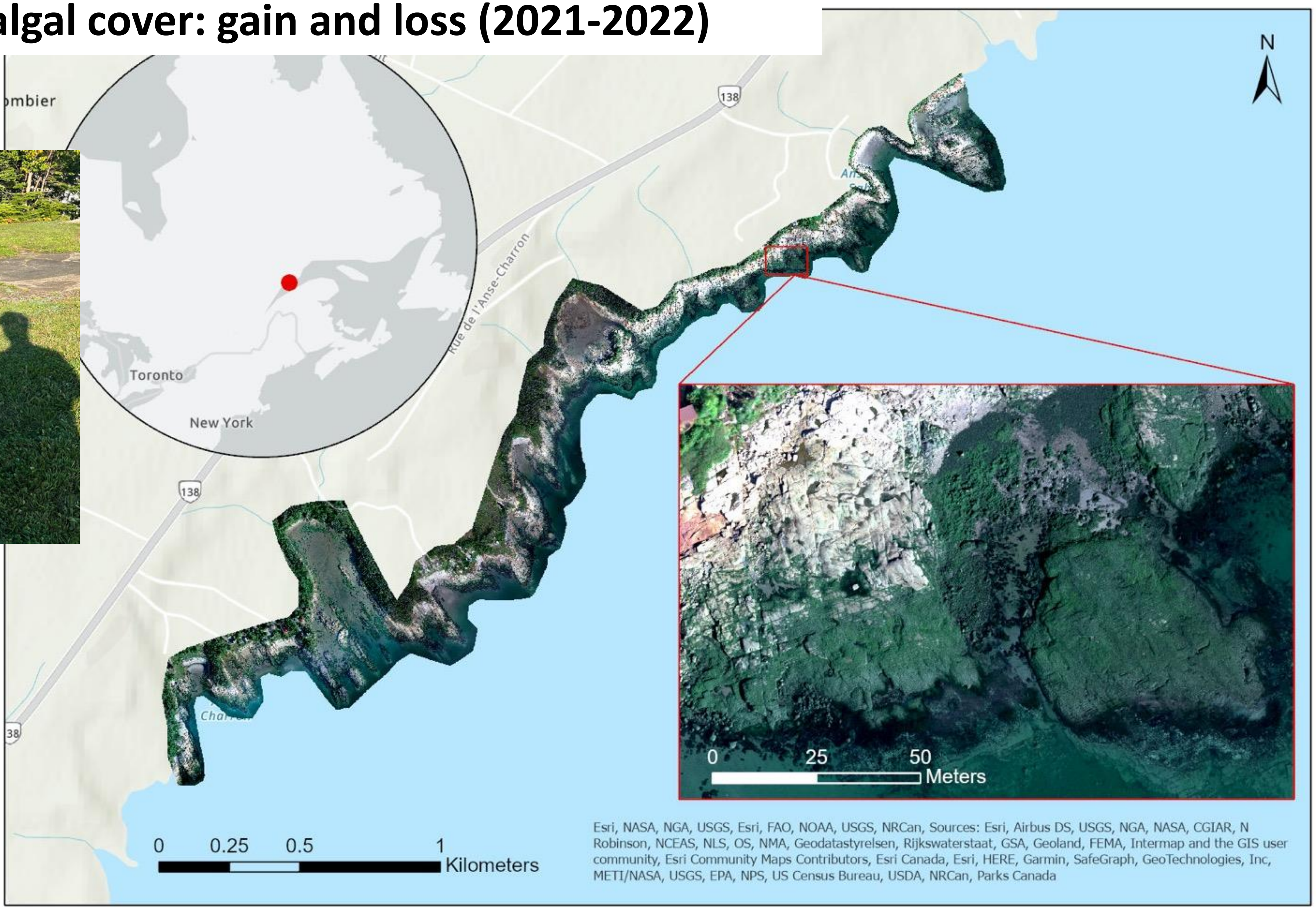
Community structure between 2009 and 2021

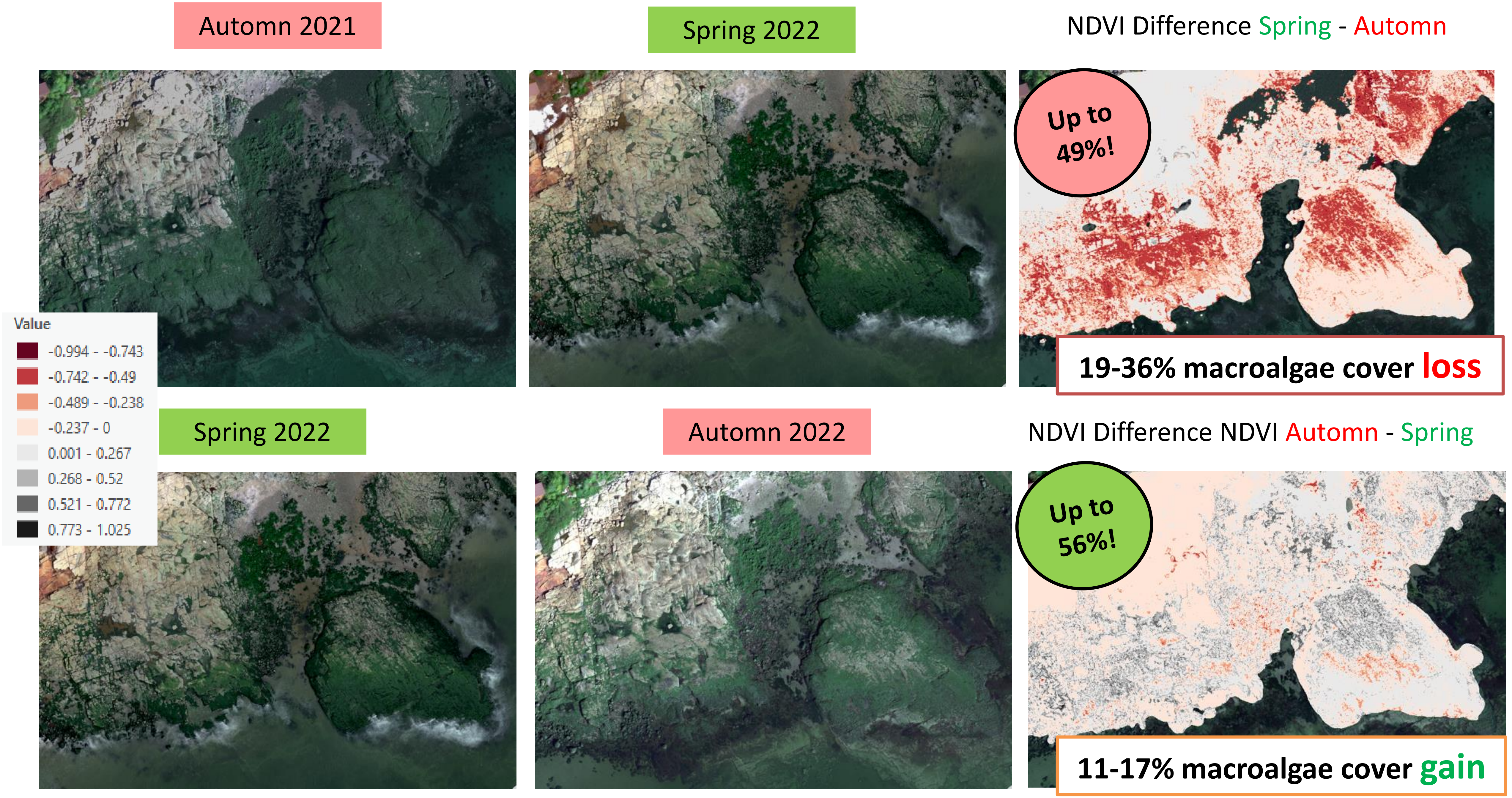


Macroalgal community dynamics in a cold-temperate/subarctic environment

Ice-scouring on macoalgal cover: gain and loss (2021-2022)

3 km of coastal survey with drones equipped with multispectral and Lidar sensors.



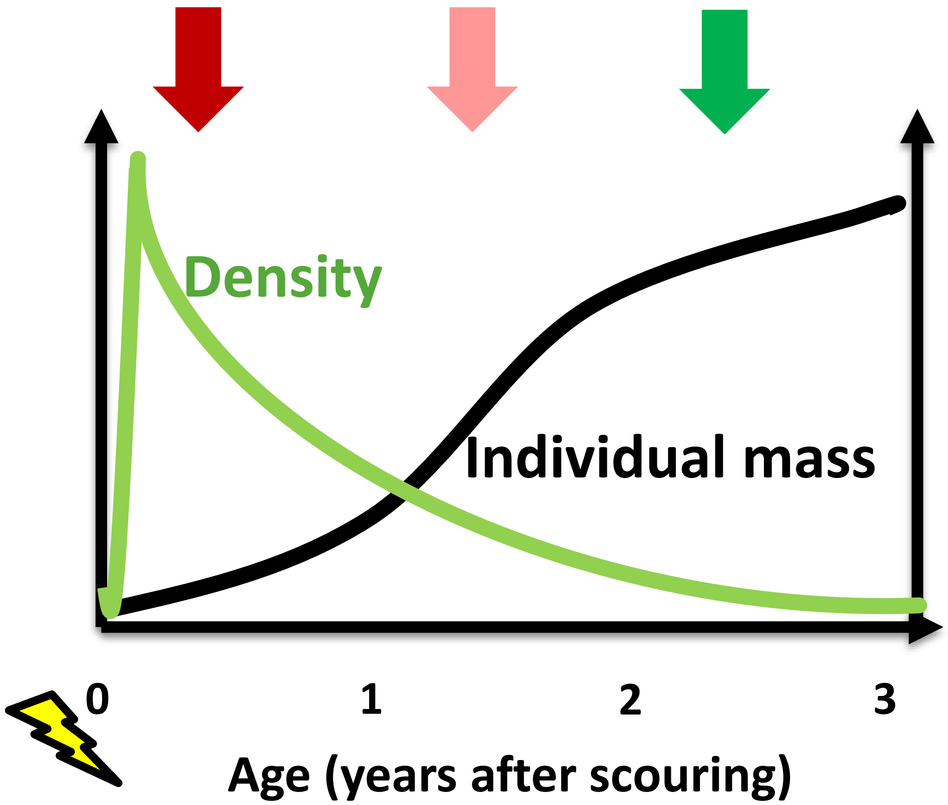


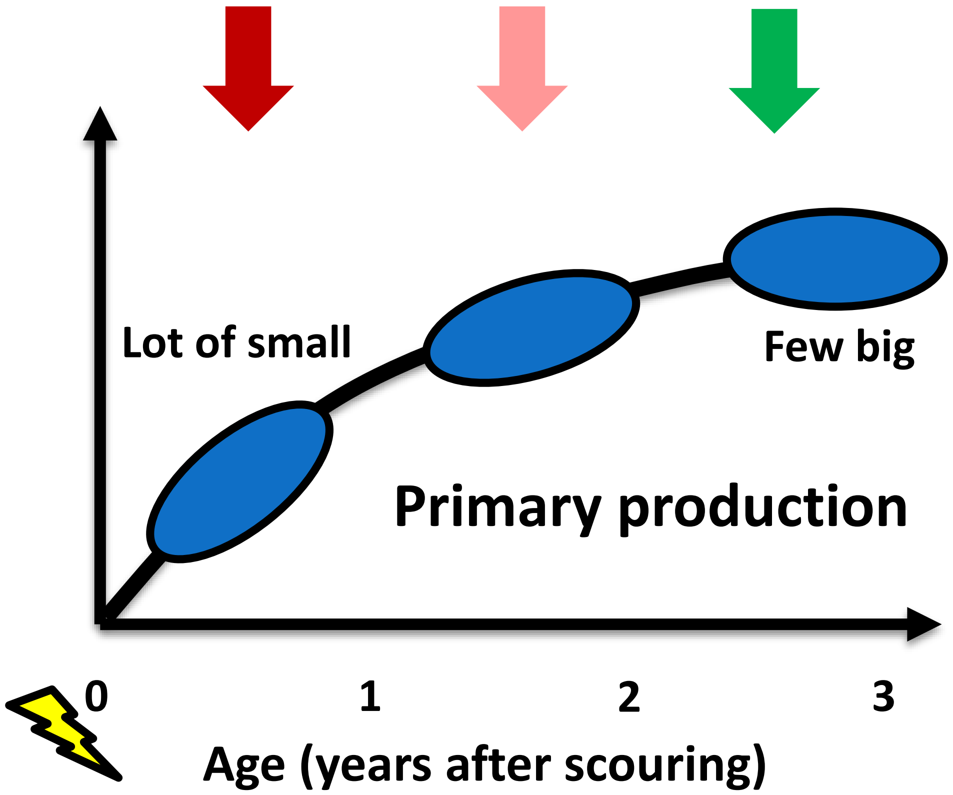
Automn 2021
Spring 2022
NDVI Difference Spring - Automn
Up to 49%!
19-36% macroalgae cover loss
Value
-0.994 - -0.743
-0.742 - -0.49
-0.489 - -0.238
-0.237 - 0
0.001 - 0.267
0.268 - 0.52
0.521 - 0.772
0.773 - 1.025
Spring 2022
Automn 2022
NDVI Difference NDVI Automn - Spring
Up to 56%!
11-17% macroalgae cover gain

Objectives

1. Estimate the macroalgal primary production in function of ice-scouring

   Characterize the dynamics of density and individual mass through recovery (short-term, mid-term after scouring and unaffected zones as controls)





Methods for monitoring macroalgae in various recovery states

Monitoring of macrolgae *Fucus distichus edentatus* density and individual mass changes during 5 months in 10 quadrats in 3 recovery states during the growth season of 2021

Short-term recovery

Surfaces scoured in spring 2021

Mid-term recovery

Surfaces scoured in 2020/2019

Controls

Not scoured for years

Method for production estimation

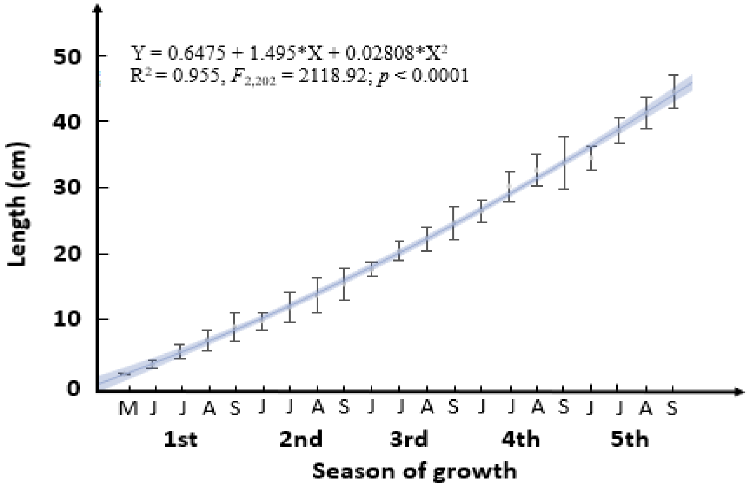
Using density and individual biomass in a specific growth rate method for production

Fucus distichus edentatus

Specific growth rate method[1, 2]

$$P = \sum_{t=1}^{T} \sum_{0}^{n} \overline{n}_k \bullet G_k \bullet \overline{w}_k \bullet \Delta t$$

Independently measured using >300 individuals during the growing season (~ 5 months)



Primary production

=

Average density

X

Growth rate

X

Individual mass

These were measured within 7 size classes :

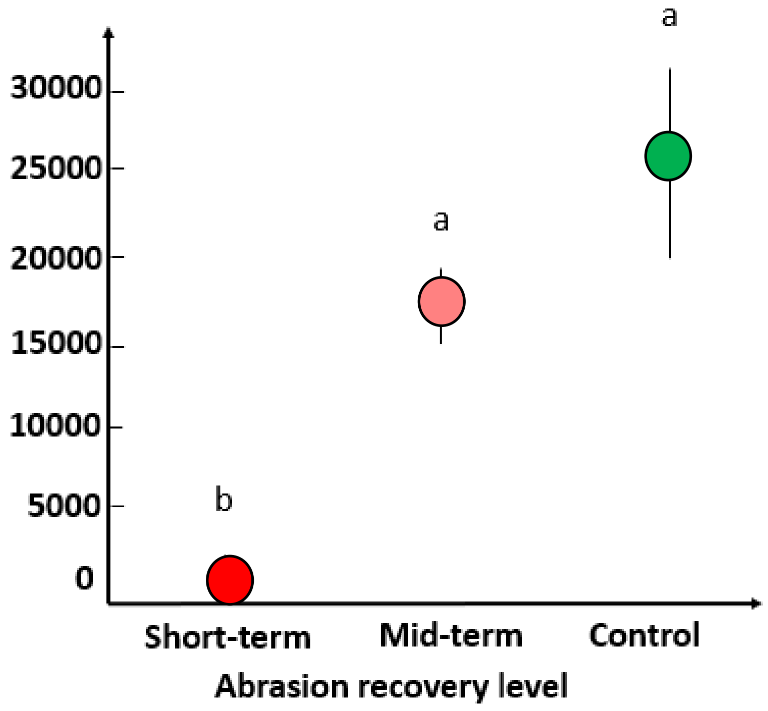
0-3 cm
3-6 cm
6-10 cm
10-15 cm
15-20 cm
20-30 cm
30+ cm

[1] Crisp, 1984 ; [2] Cusson, 2004

Results for production estimation

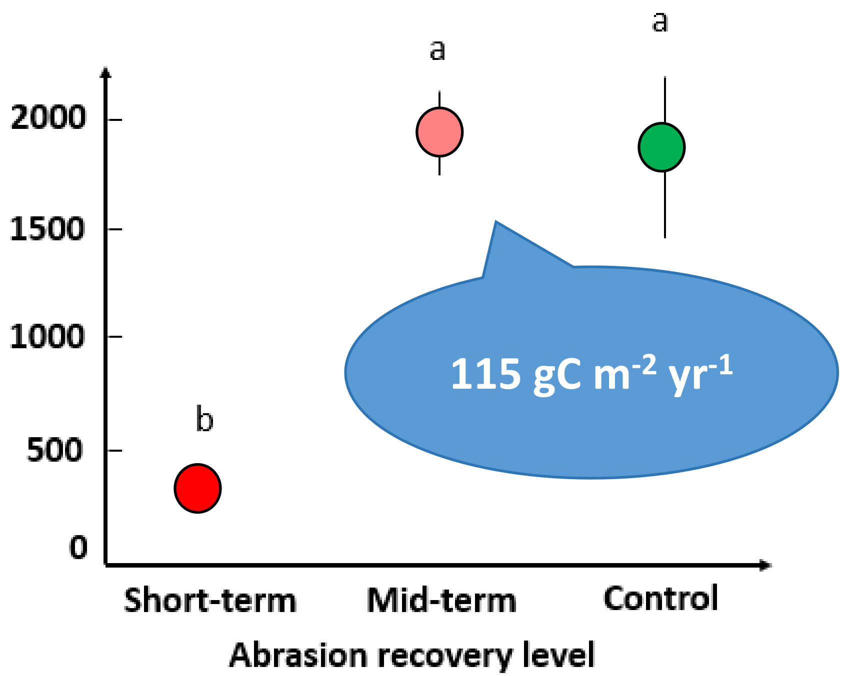
Biomass

(WWg m^{-2})



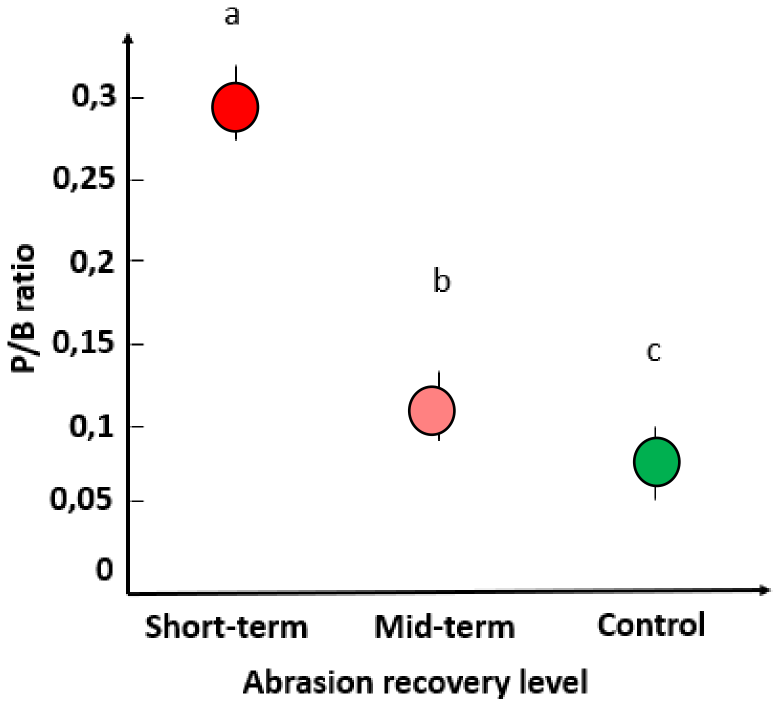
Primary production

(WWg m^{-2} yr^{-1})



P/B ratio

(yr^{-1})



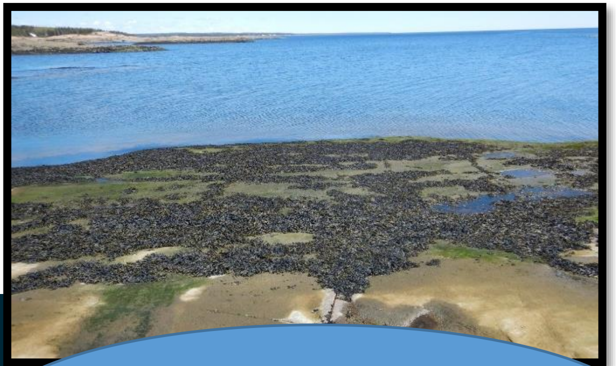
- **Biomass and annual primary production become equal after one year of recovery**
- **In their first growth season following a heavy ice-scouring, the PP is low (15% of control values) but are not negligible.**

Summary

- The St. Lawrence estuary intertidal benthic communities are driven by ice-scouring events.
- The sea ice may remove up to 50% of the macroalgae cover (and its associated communities) but fast recovery is observed within months after disturbance.
- The macroalgae associated community can fully recover within 2 years.
- Primary production and biomass of macroalgae recover after the second growth season.
- Macroalgae production reaches 0.3 WWkg m^{-2} yr^{-1} and ~2 WWkg m^{-2} yr^{-1} afterward.

This is a great news!

To our knowledge, this is the first study that used inferred growth And community density changes to estimate annual macroalgal primary productionin subarctic environments



PP may increase in future

Perspectives

- Scaling up the monitoring of macroalgae to larger scale with satellite imagery.
- With expected changes of ice regime ahead, it's interesting (and important) to document how disturbance from sea ice or protection from ice-foot will shape future benthic intertidal communities.

Thank you!

Benthic monitoring: Thank you to those who participated!

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Dominic Gauthier
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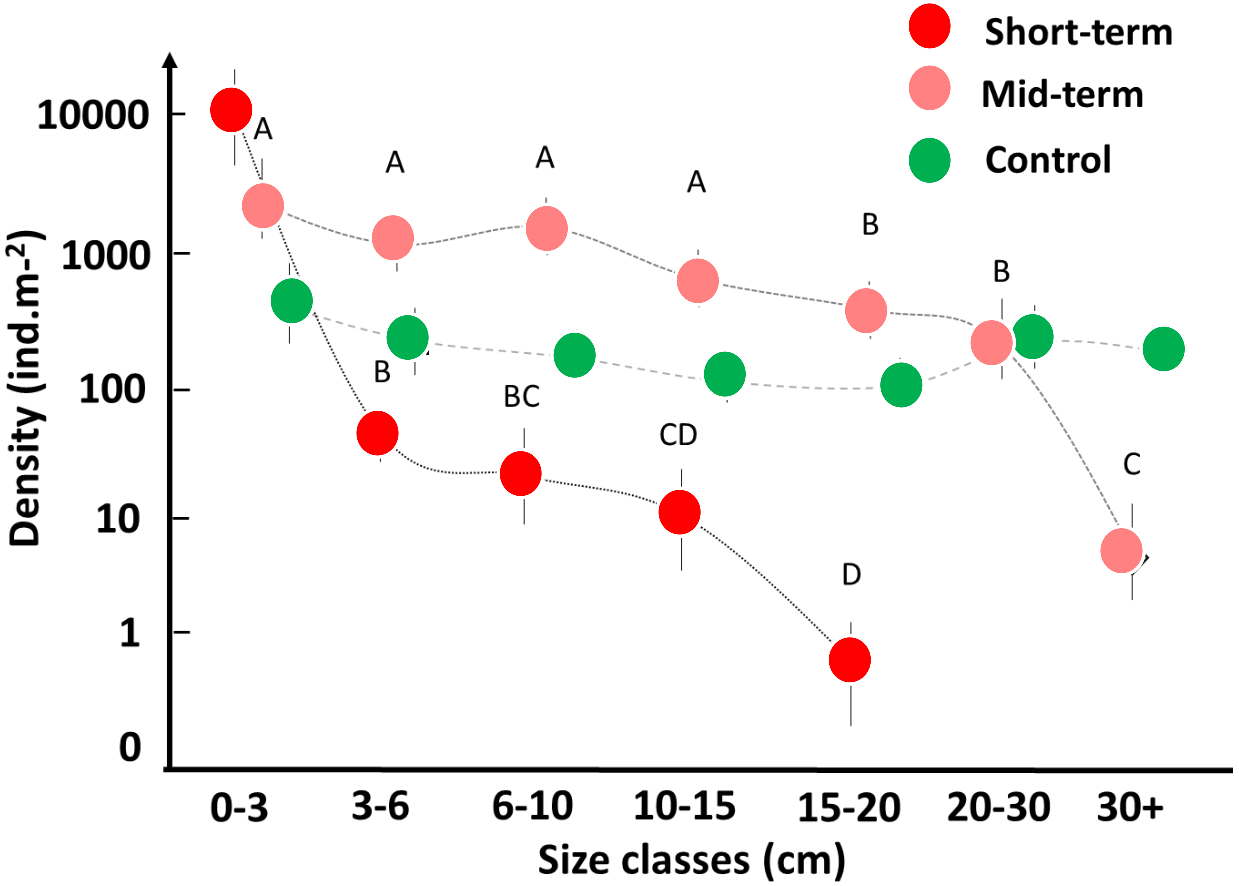
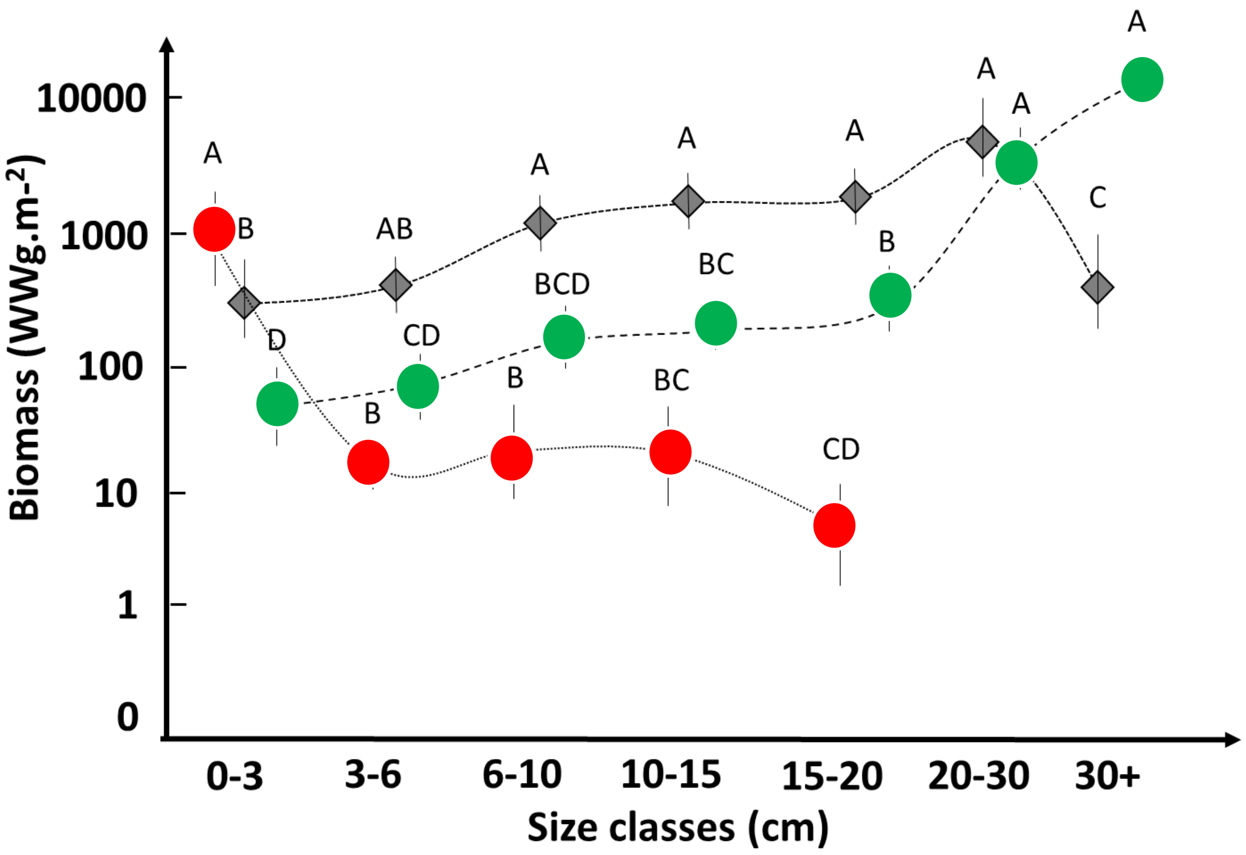
Fonds de recherche Nature et technologies Québec

CRSNG NSERC

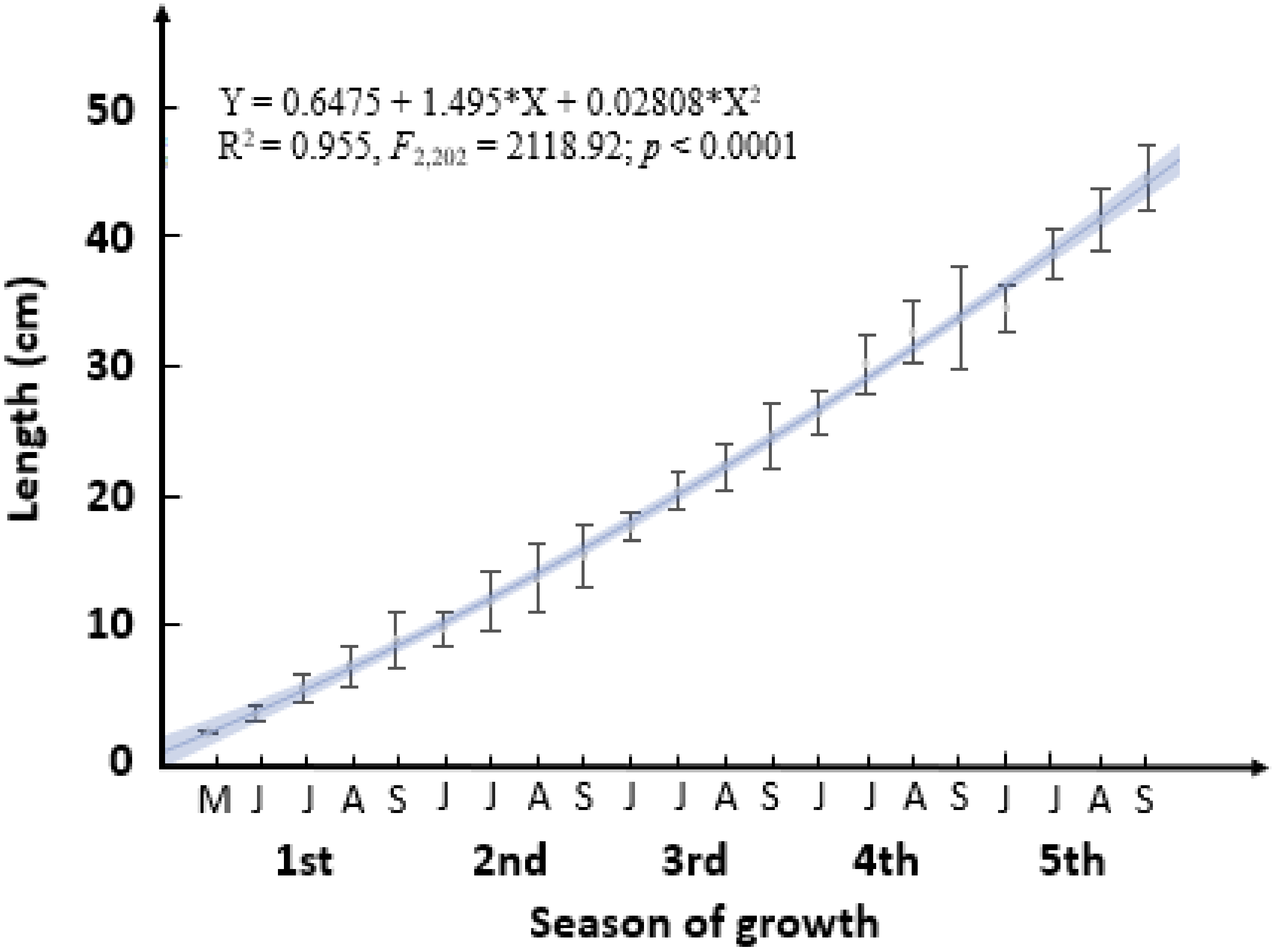
Pêches et Océans Canada

Results : density and biomass across size classes



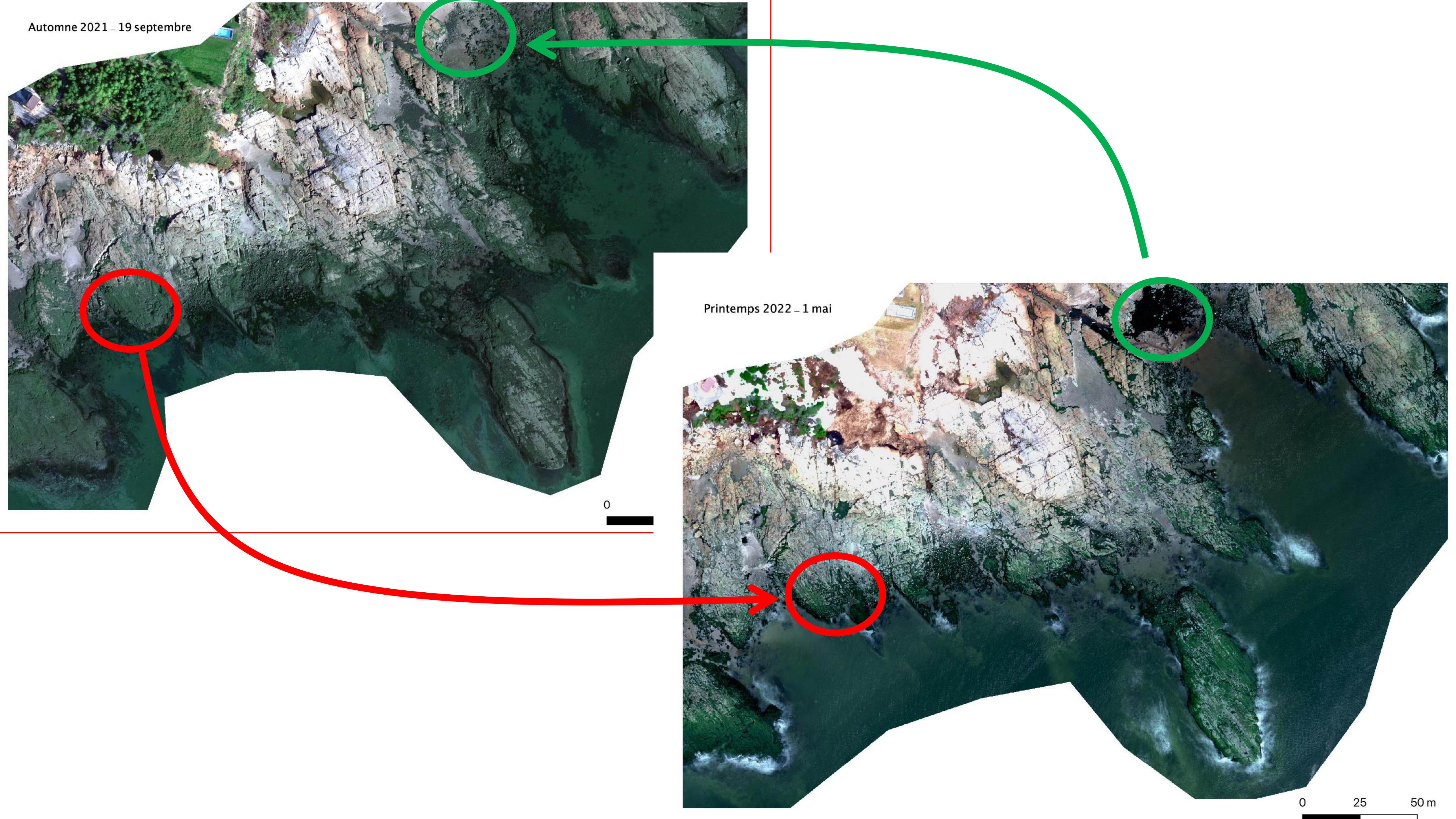


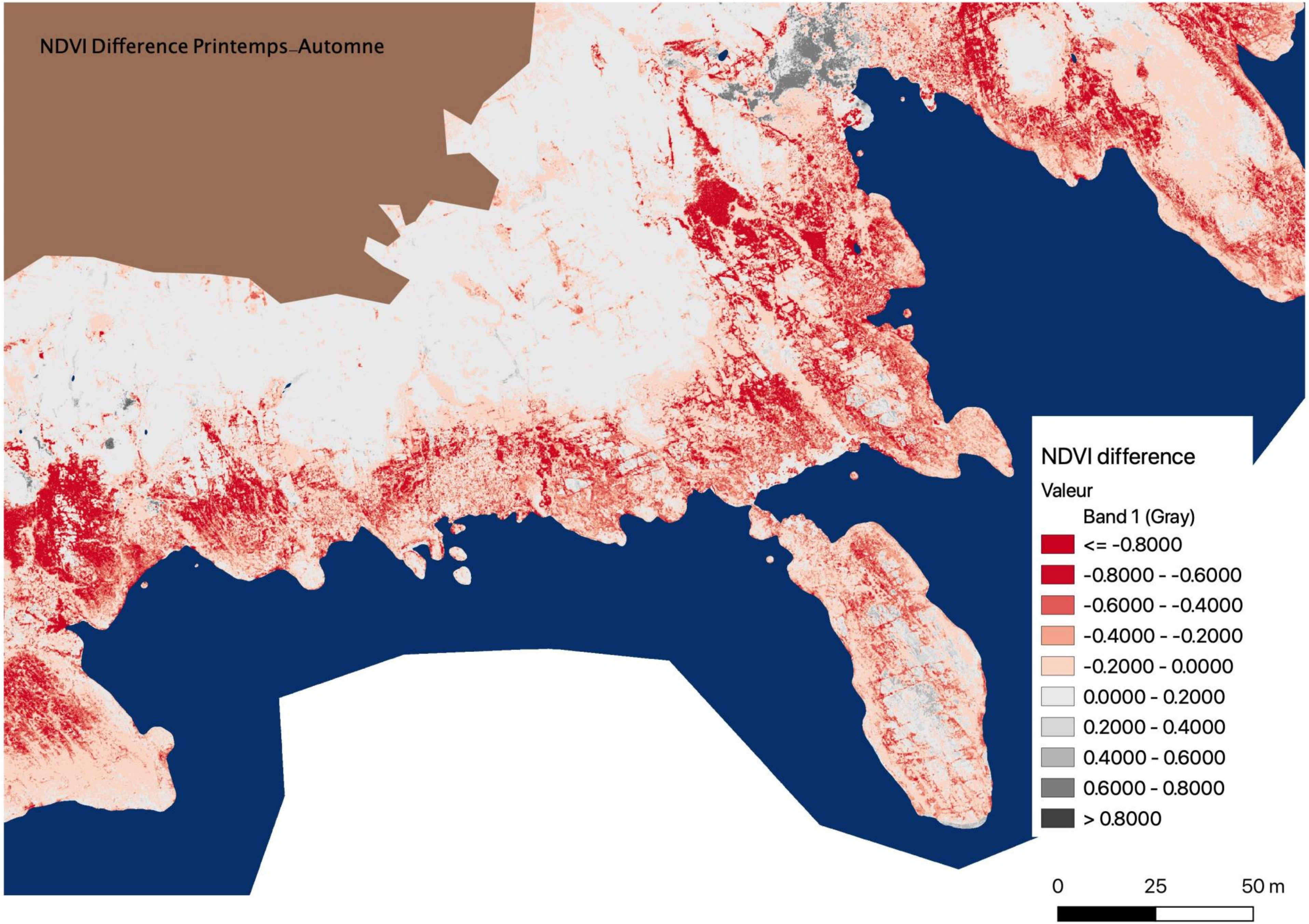
Reconstruction de la croissance observée en 2021 dans chacune des classes de tailles



Effets de l'abrasion par les glaces sur la présence d'algues
(Jonathan Godin)


Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2022 TerraMetrics
Image © 2022 CNES / Airbus


Automne 2021 – 19 septembre
0
Printemps 2022 – 1 mai
0
25
50 m



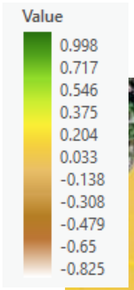
NDVI Difference Printemps_Automne
NDVI difference
Valeur
Band 1 (Gray)
<= -0.8000
-0.8000 - -0.6000
-0.6000 - -0.4000
-0.4000 - -0.2000
-0.2000 - 0.0000
0.0000 - 0.2000
0.2000 - 0.4000
0.4000 - 0.6000
0.6000 - 0.8000
> 0.8000
0
25
50 m

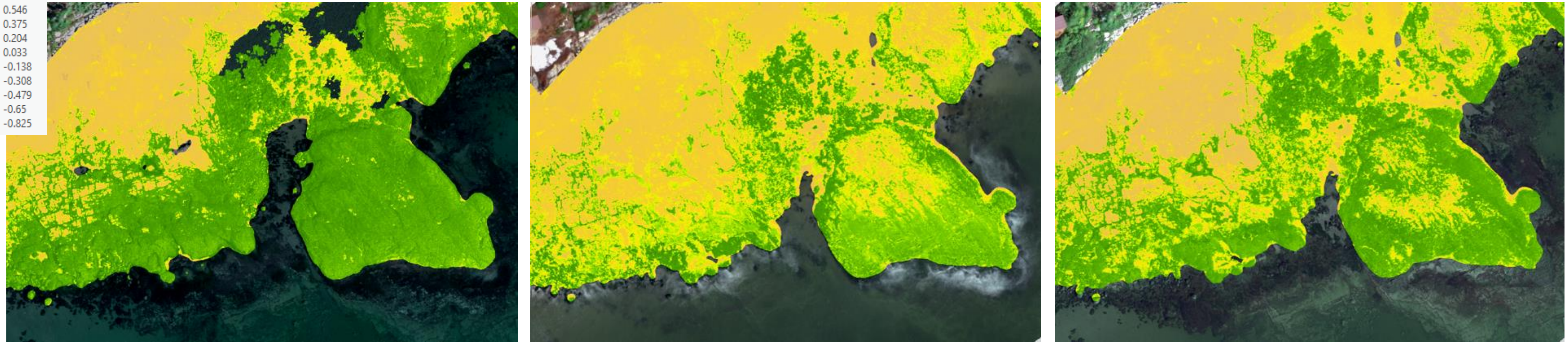
Automne 2021
19 sept

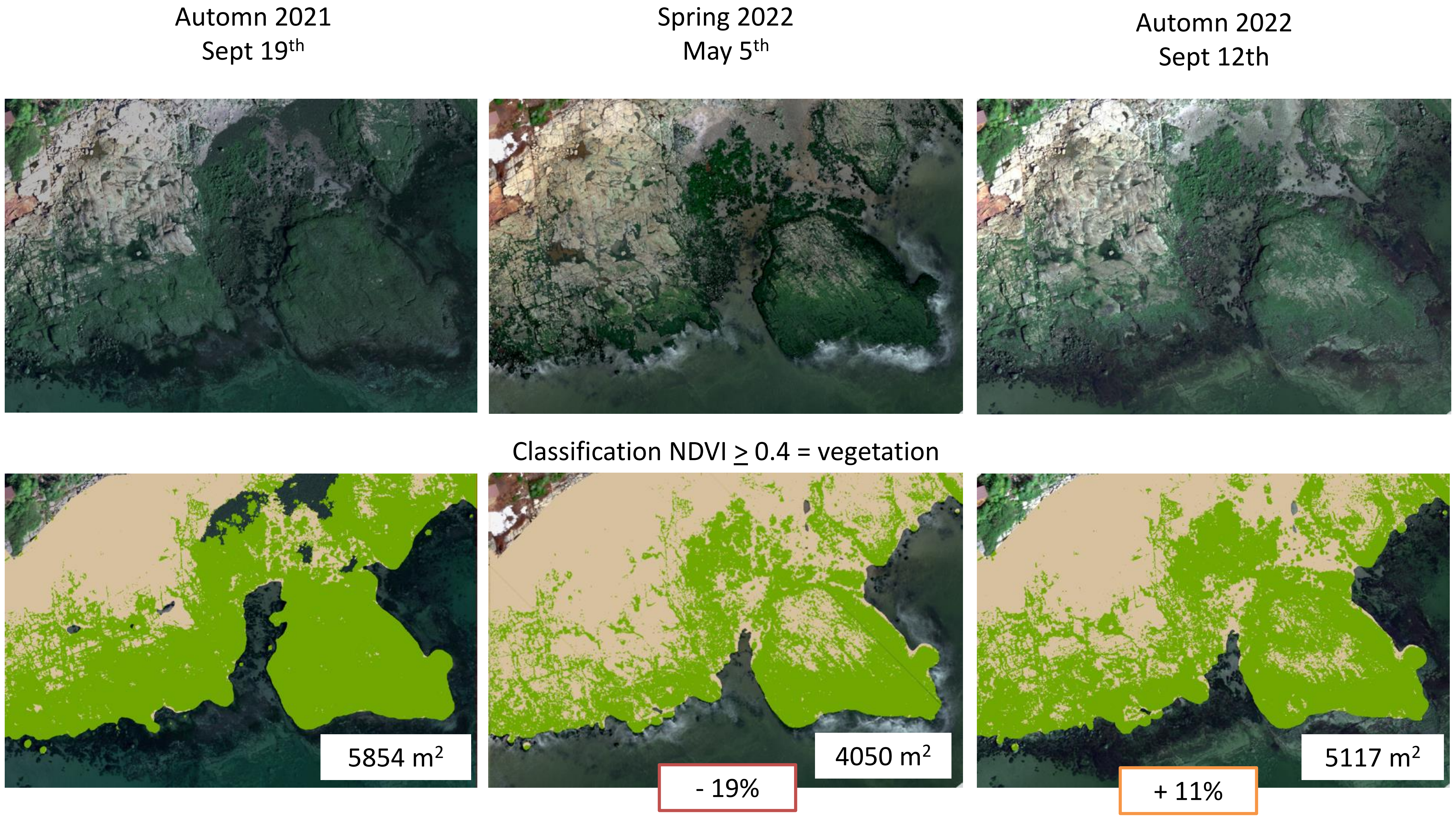
Printemps 2022
5 mai

Automne 2022
12 sept

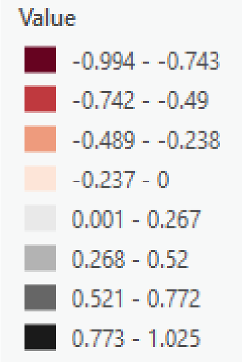
$$NDVI = NIR-RED / NIR+RED$$






Automn 2021
Sept 19th
Spring 2022
May 5th
Automn 2022
Sept 12th
Classification NDVI ≥ 0.4 = vegetation
5854 m²
4050 m²
- 19%
5117 m²
+ 11%

- Pour le calcul des surfaces avec les analyses de différence en NDVI, c’est un peu plus subjectif. Je ne crois pas que toute différence négative représente une perte de “chlorophylle” ou de végetation. Par exemple, sur les images de la diapo avant, on voit de faibles valeurs négatives (rose pale) sur les surfaces de roche. Si j’intègre ces différences dans les calculs, je vais surestimer les pertes. Vice-versa pour les faibles valeurs positives. Donc, idéalement il faudrait determiner des “threshold” à partir desquels on considère les différences de NDVI significatives. Bref, je te donne ici les % que chacune des classes de NDVI/couleurs représente en % de surface. À titre d’exemple, on pourrait dire que tout ce qui est entre les classes 4 et 5, c’est-à-dire de faibles différences, on ignore. Dans ce cas, il y aurait un cumul de (15+16+1) 36% de surface où on perçoit une perte en NDVI, et (14+3) 17% de gain. Bref, cette partie de l’analyse est à peaufiner.



Classe	Debut	Fin	Perte	Gain
1	-0.99	-0.74	1%	0%
2	-0.74	-0.49	15%	0%
3	-0.49	-0.24	16%	3%
4	-0.24	0	33%	42%
5	0	0.27	34%	38%
6	0.27	0.52	1%	14%
7	0.52	0.77	0%	3%
8	0.77	1.03	0	0%