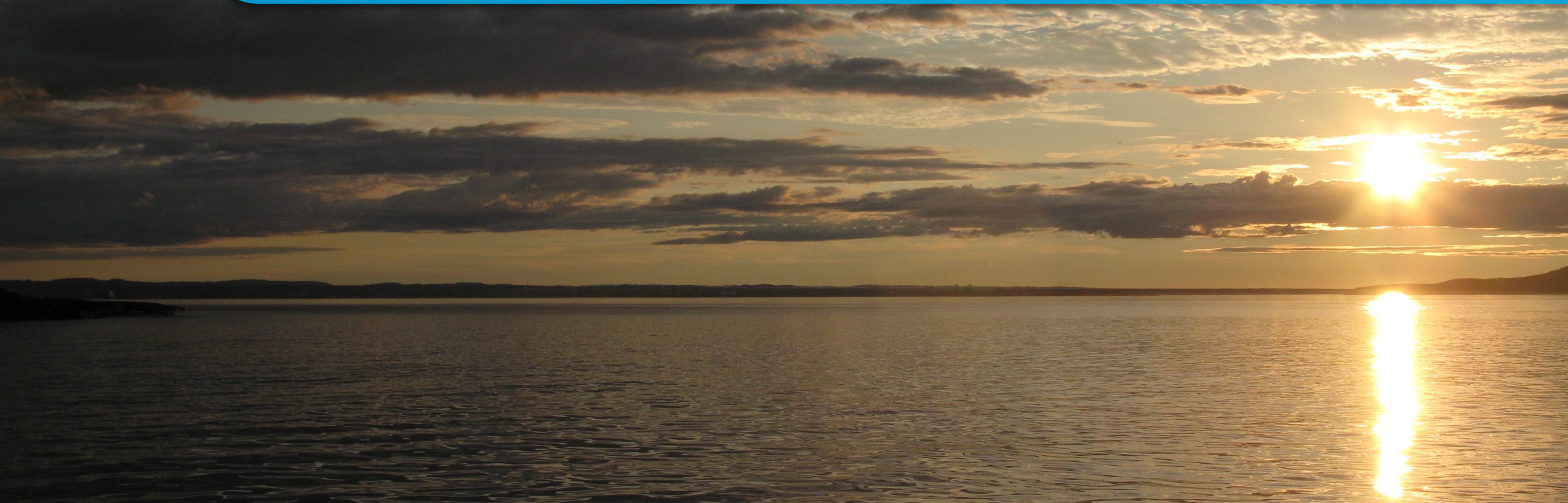


AN EXPOSURE SCORE TO ASSESS ANTHROPOGENIC FOOTPRINT ON COASTAL ECOSYSTEMS AT THE LOCAL SCALE

Elliot Dreujou, Rémi M Daigle, David Beauchesne,
Julie Carrière, Fanny Noisette, Philippe Archambault



UNIVERSITÉ
LAVAL



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Inrest



ECOSYSTEMS AND PERTURBATIONS



Biological communities 

ECOSYSTEMS AND PERTURBATIONS



Natural processes



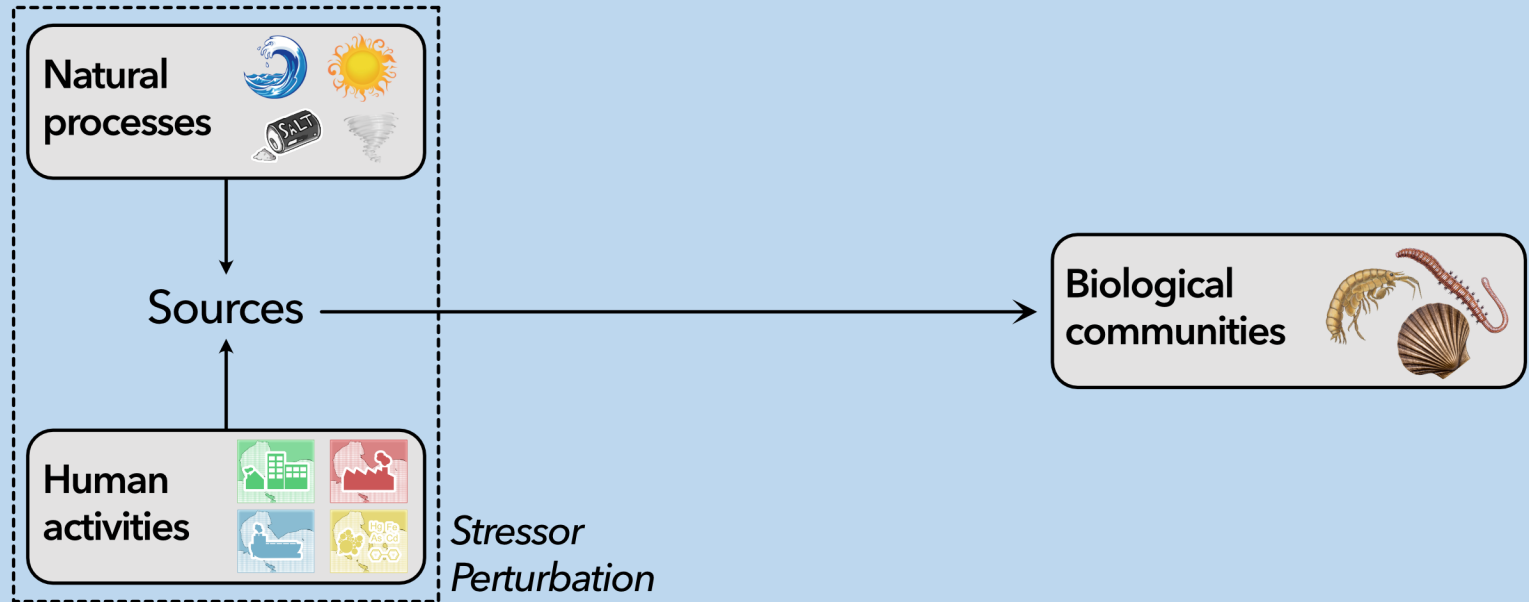
Biological communities



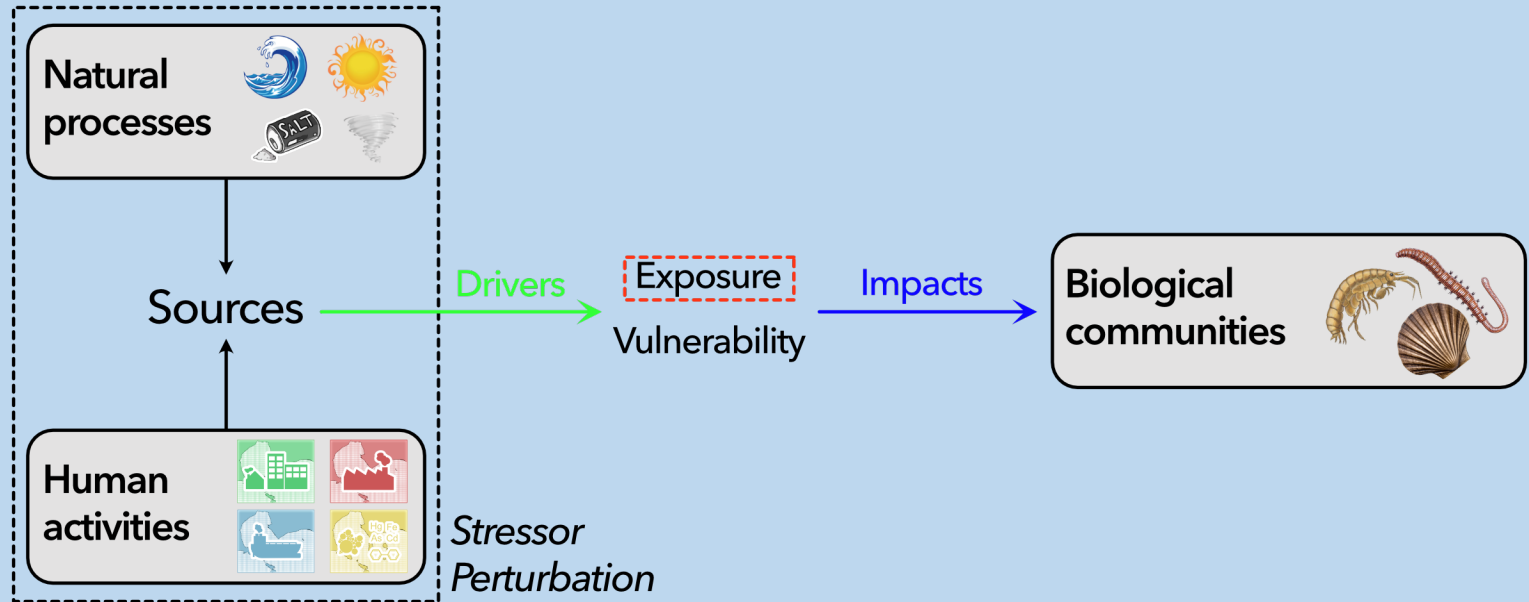
Human activities



ECOSYSTEMS AND PERTURBATIONS



ECOSYSTEMS AND PERTURBATIONS





Recent pace of change in human impact on the world's ocean

Benjamin S. Halpern^{1,2}, Melanie Frazier¹, Jamie Afflerbach¹, Julia S. Lowndes¹, Fiorenza Micheli^{3,4}, Casey O'Hara², Courtney Scarborough¹ & Kimberly A. Selkoe^{1,2}

Sci Rep, 2019

Response of benthic assemblages to multiple stressors: comparative effects of nutrient enrichment and physical disturbance

Joseph M. Kenworthy^{1,2,3,*}, David M. Paterson¹, Melanie J. Bishop²

Mar Ecol Progr Ser, 2016

What are the major global threats and impacts in marine environments? Investigating the contours of a shared perception among marine scientists from the bottom-up.

W.J. Boonstra^{a,*}, K.M. Ottosen^b, A.S.A. Ferreira^c, A. Richter^{d,e}, L.A. Rogers^e, M.W. Pedersen^c, A. Kokkalis^c, H. Bardarson^f, S. Bonanomi^{g,l}, W. Butler^f, F.K. Diekert^{e,k}, N. Fouzaiⁱ, M. Holma^h, R.E. Holtⁱ, K.Ø. Kvile^e, E. Malanski^c, J.I. Macdonald^f, E. Nieminen^h, G. Romagnoni^e, M. Snickars^j, B. Weigel^j, P. Woods^f, J. Yletyinen^a, J.D. Whittington^e

Mar Policy, 2015

Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being

Gretta T. Pecl,^{*} Miguel B. Araújo,[†] Johann D. Bell, Julia Blanchard, Timothy C. Bonebrake, I-Ching Chen, Timothy D. Clark, Robert K. Colwell, Finn Danielsen, Birgitta Evengård, Lorena Falconi, Simon Ferrier, Stewart Frusher, Raquel A. Garcia, Roger B. Griffiths, Alistair J. Hobday, Charlene Janion-Scheepers, Marta A. Jarzyna, Sarah Jennings, Jonathan Lenoir, Hlif I. Linnetved, Victoria Y. Martin, Phillipa C. McCormack, Jan McDonald, Nicola J. Mitchell, Tero Mustonen, John M. Pandolfi, Nathalie Pettorelli, Ekaterina Popova, Sharon A. Robinson, Brett R. Scheffers, Justine D. Shaw, Cascade J. B. Sorte, Jan M. Strugnell, Jennifer M. Sunday, Mao-Ning Tuanmu, Adriana Vergés, Cecilia Villanueva, Thomas Wernberg, Erik Wapstra, Stephen E. Williams

Science, 2017

Spatial and temporal changes in cumulative human impacts on the world's ocean

Benjamin S. Halpern^{1,2,3}, Melanie Frazier³, John Potapenko⁴, Kenneth S. Casey⁵, Kellee Koenig⁶, Catherine Longo³, Julia Stewart Lowndes³, R. Cotton Rockwood⁷, Elizabeth R. Selig⁶, Kimberly A. Selkoe^{3,8} & Shaun Walbridge⁹

Nat Commun, 2015

A review of the combined effects of climate change and other local human stressors on the marine environment

Elena Gissi^{a,*}, Elisabetta Manea^a, Antonios D. Mazaris^b, Simonetta Fraschetti^{c,d,e}, Vasiliki Almpanidou^b, Stanislao Bevilacqua^{f,d}, Marta Coll^{g,h}, Giuseppe Guarneri^{i,d}, Elena Lloret-Lloret^{g,h}, Marta Pascual^j, Dimitra Petza^{k,l}, Gil Rilov^m, Maura Schonwald^m, Vanessa Stelzenmüllerⁿ, Stelios Katsanevakis^k

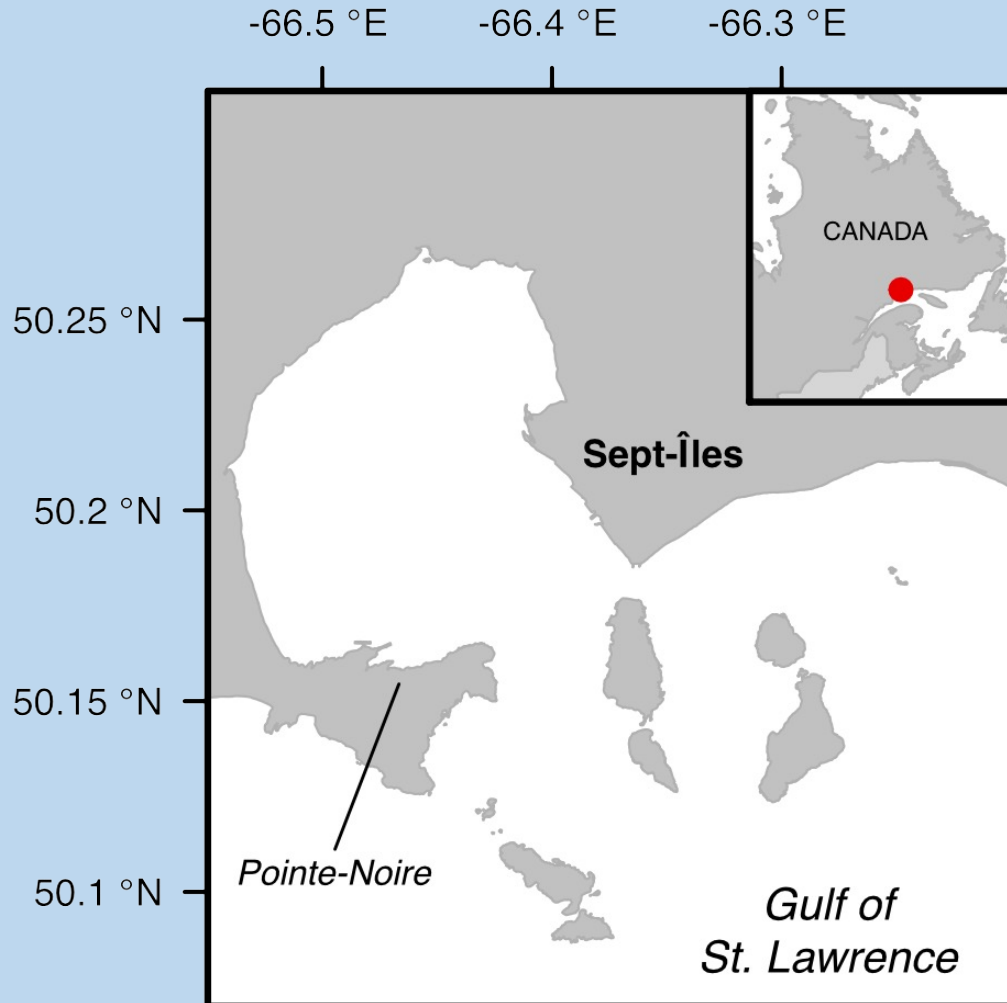
Sci Total Environ, 2021





- Develop a tool to **characterize** human influence on coastal ecosystems at the local scale
- Test its **performance** on macrofaunal benthic communities in a Canadian industrial harbour area

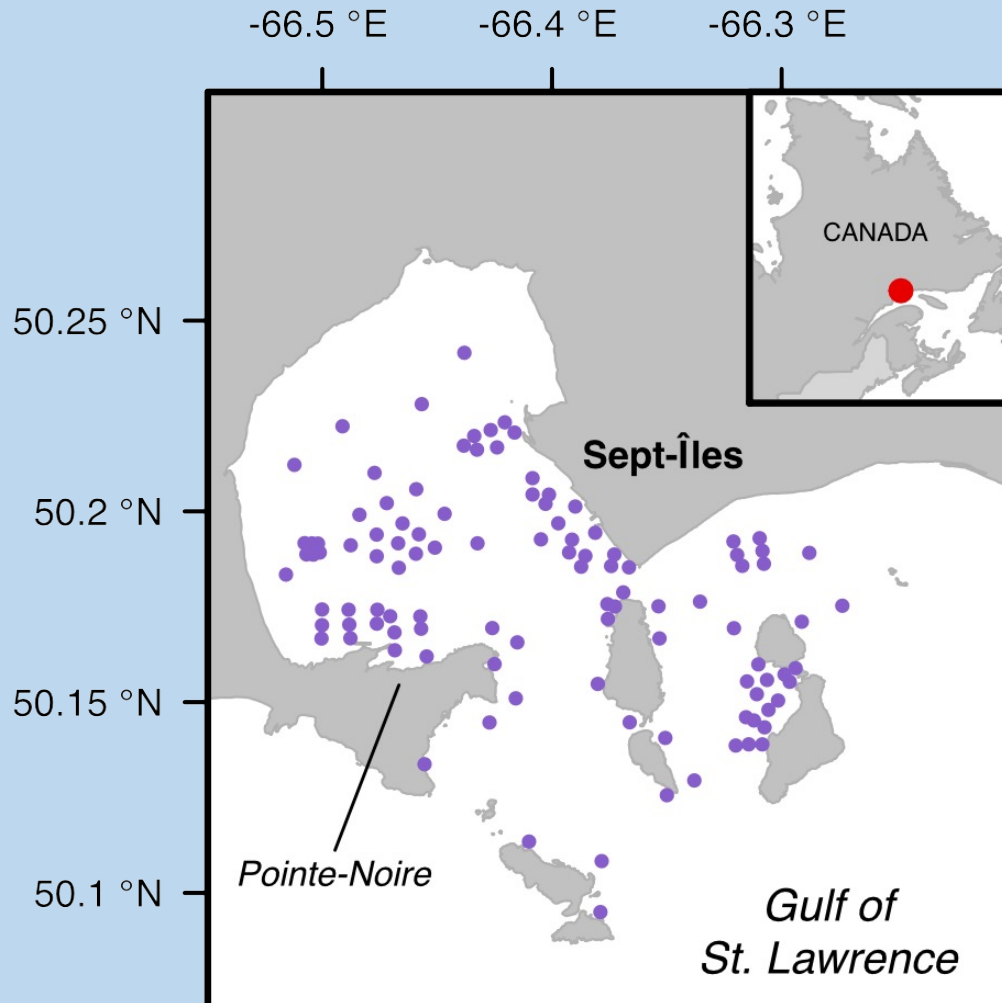
STUDY AREA



Baie des Sept Îles:

- 3rd harbour of Québec province
- Major industrial area with ore transformation and worldwide exportation

STUDY AREA



Baie des Sept Îles:

- 3rd harbour of Québec province
- Major industrial area with ore transformation and worldwide exportation

Semi-randomization sampling in the whole bay, with **108 stations** sampled in Summer 2017

Ecological database with **sediment** and **biological** parameters:

- organic matter content
- grain-size classes
- heavy-metal concentrations
- macrofauna diversity
- biodiversity indices
- environmental indicators

HUMAN ACTIVITIES



Literature review and expert opinion to identify relevant human activities in the Baie des Sept Îles

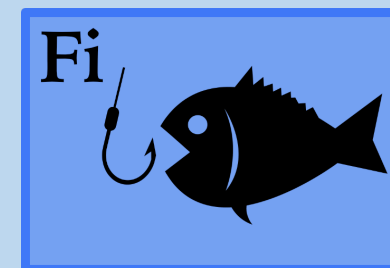
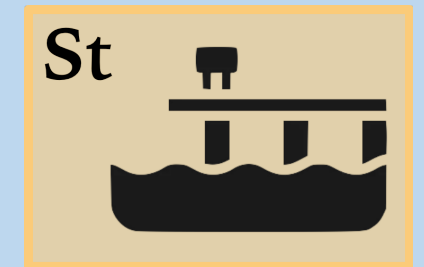
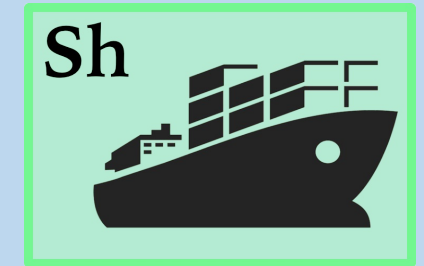
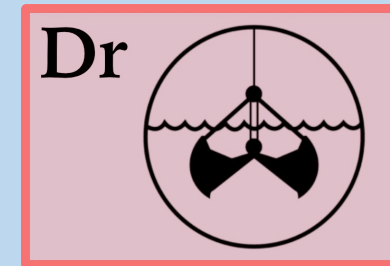
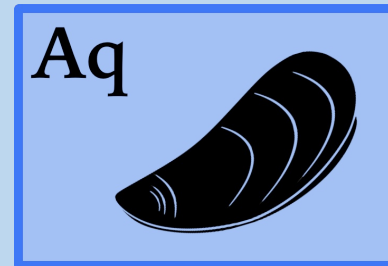
HUMAN ACTIVITIES



Literature review and expert opinion to identify relevant human activities in the Baie des Sept Îles

~30 drivers identified in **7 categories**:

- aquaculture operations
- industrial fisheries
- sediment dredging
- municipal and industrial runoff
- wastewater and rainwater sewers
- artificial structures
- commercial shipping



Spatial analyses with a **100 x 100 m** cell raster

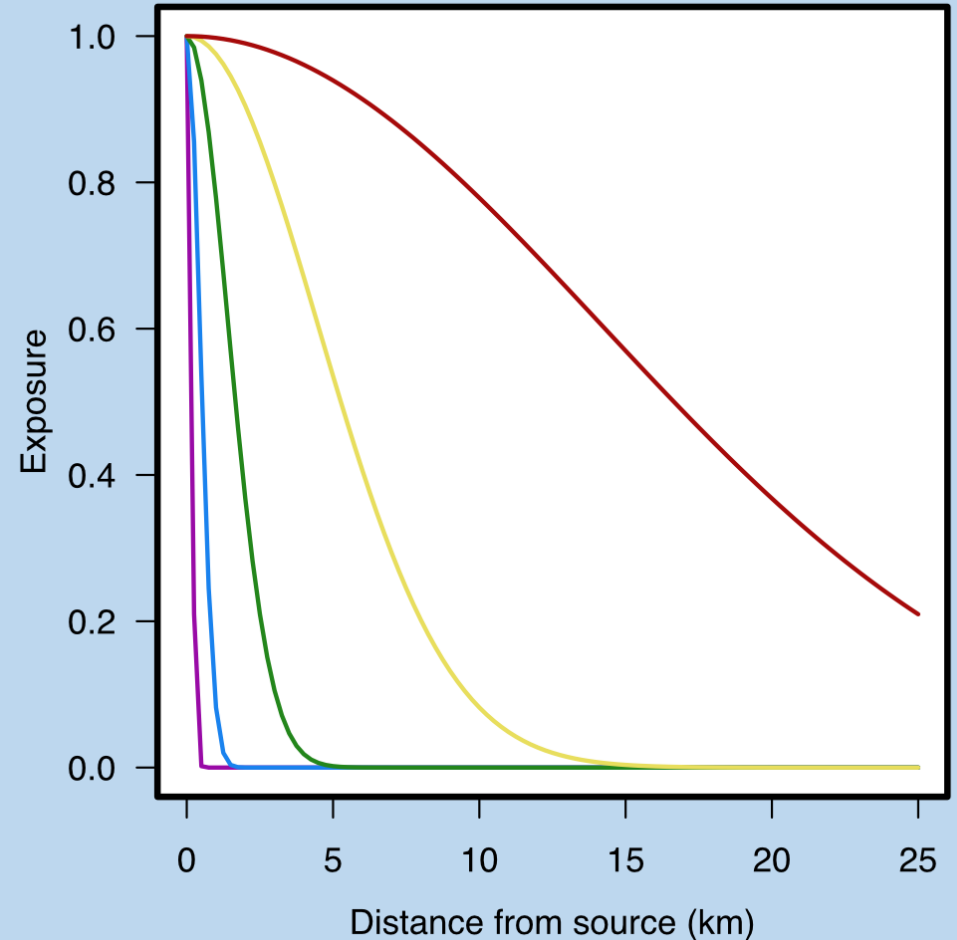
CALCULATION OF EXPOSURE SCORES



Land/sea- based activities:

- Identification of sources in the study area
- Exposure as a function of **distance from the source** (i.e. low distance = high exposure)
- Custom **particle diffusion** with a gaussian kernel model (quadratic relationship)

$$E_{ij} = \exp\left(\frac{A_j \cdot D_{ij}^2}{r}\right)$$



CALCULATION OF EXPOSURE SCORES



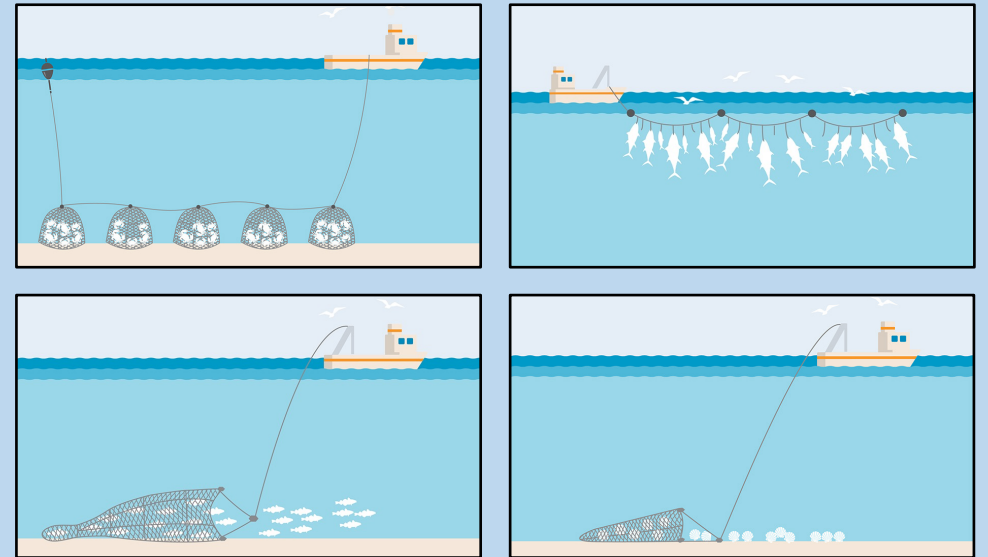
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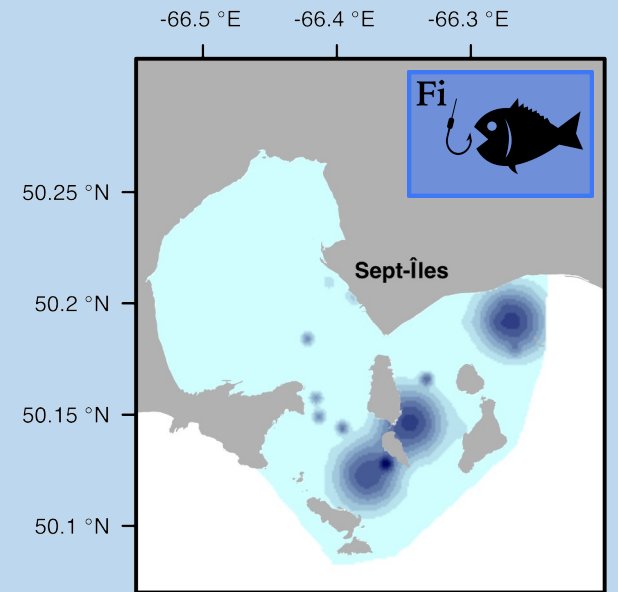
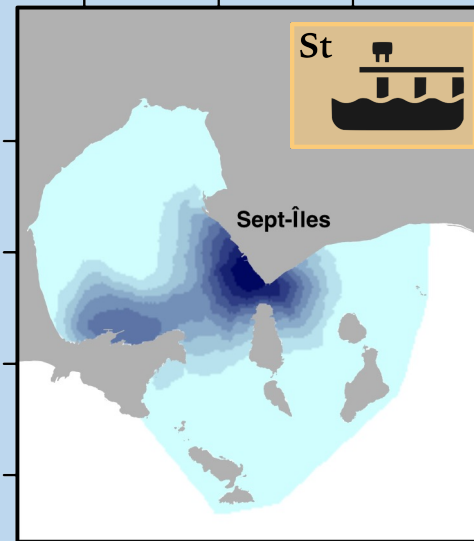
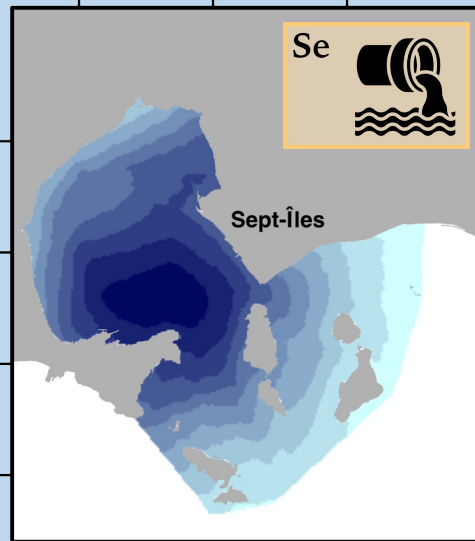
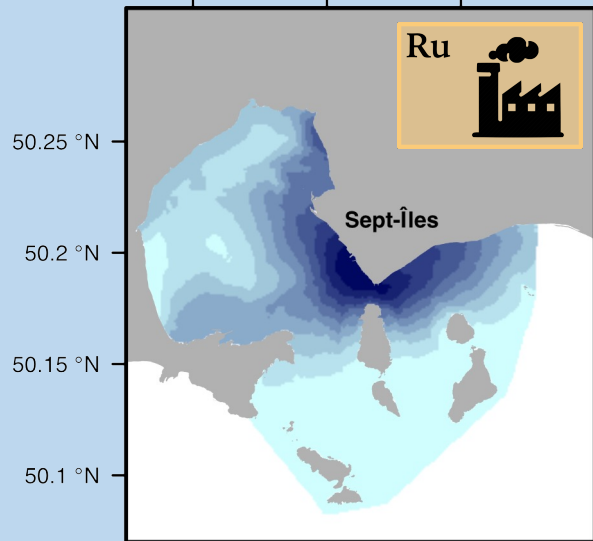
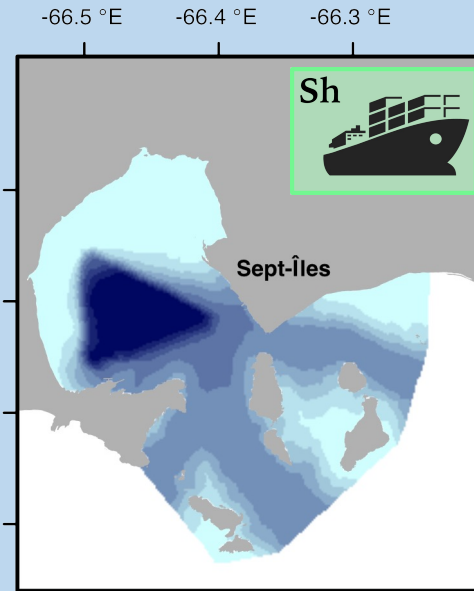
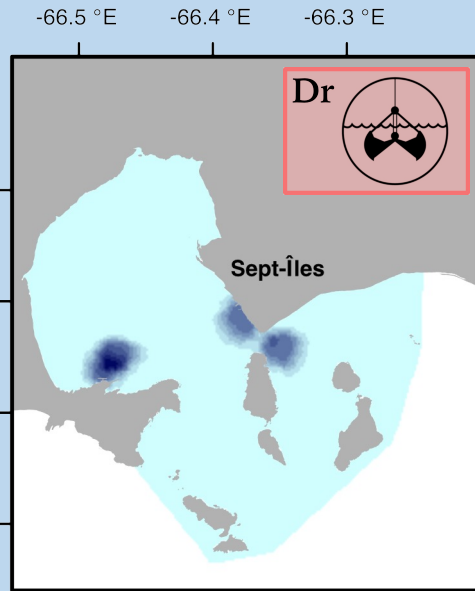
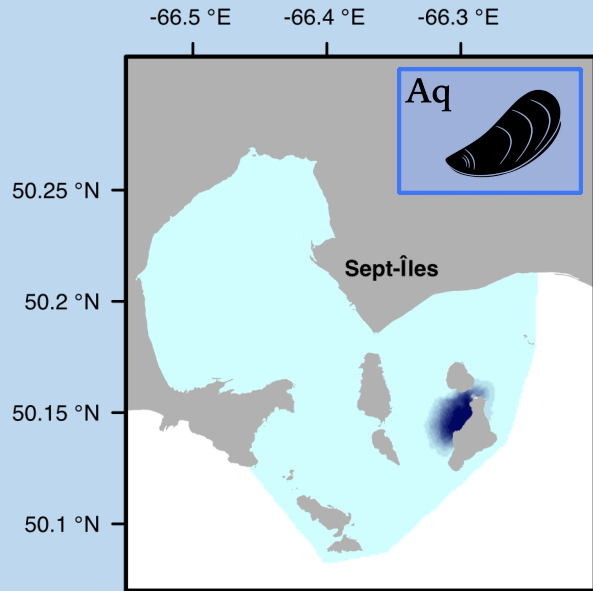
Fisheries:

- Data extraction from DFO surveys between 2010 and 2015
- Exposure as a function of **fishing events** (i.e. high number of events = high exposure)
- **Four** gear types: traps, bottom-trawls, nets, dredges

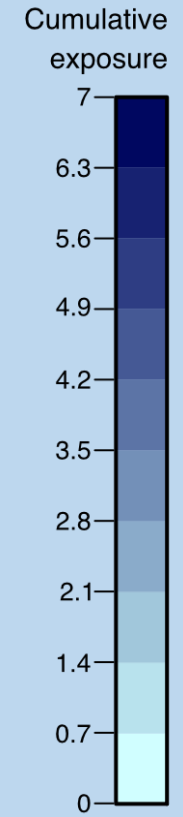
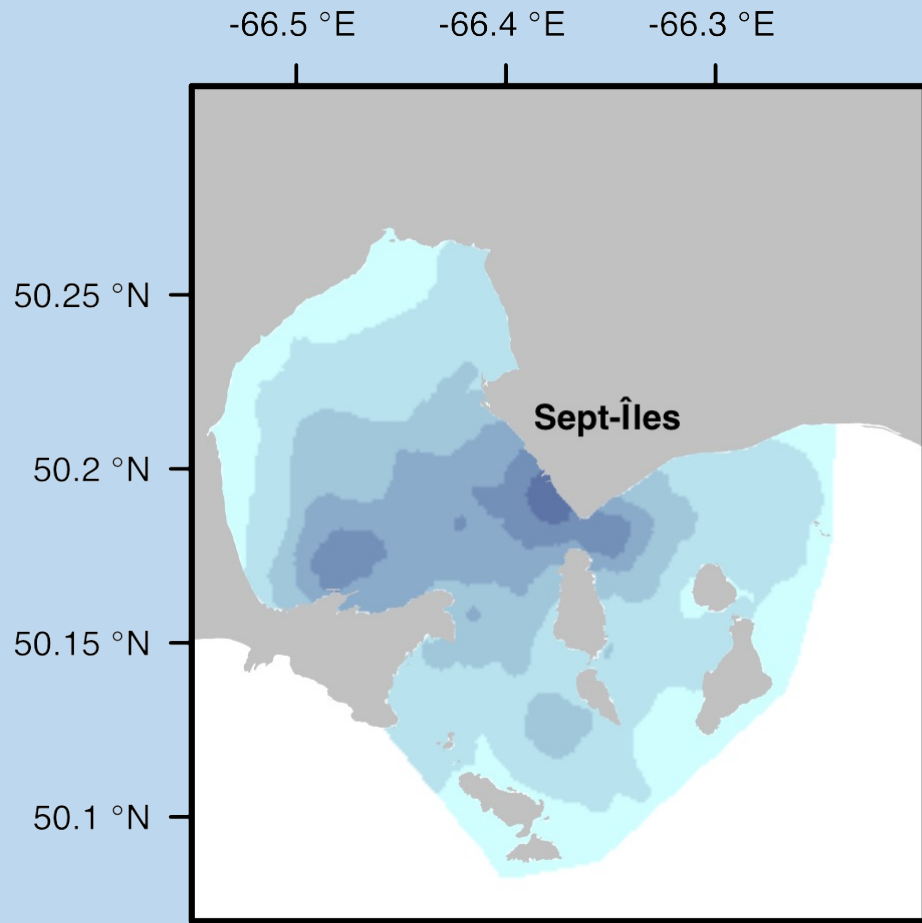


$$E_i = \frac{\sum_k G_{ik}}{4}$$

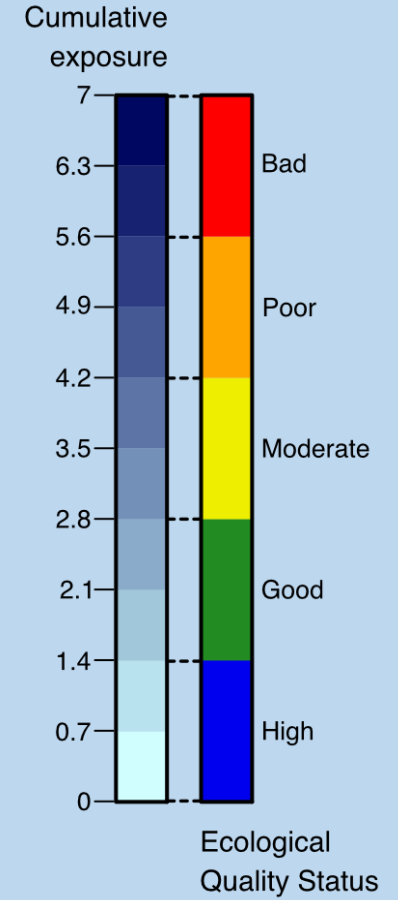
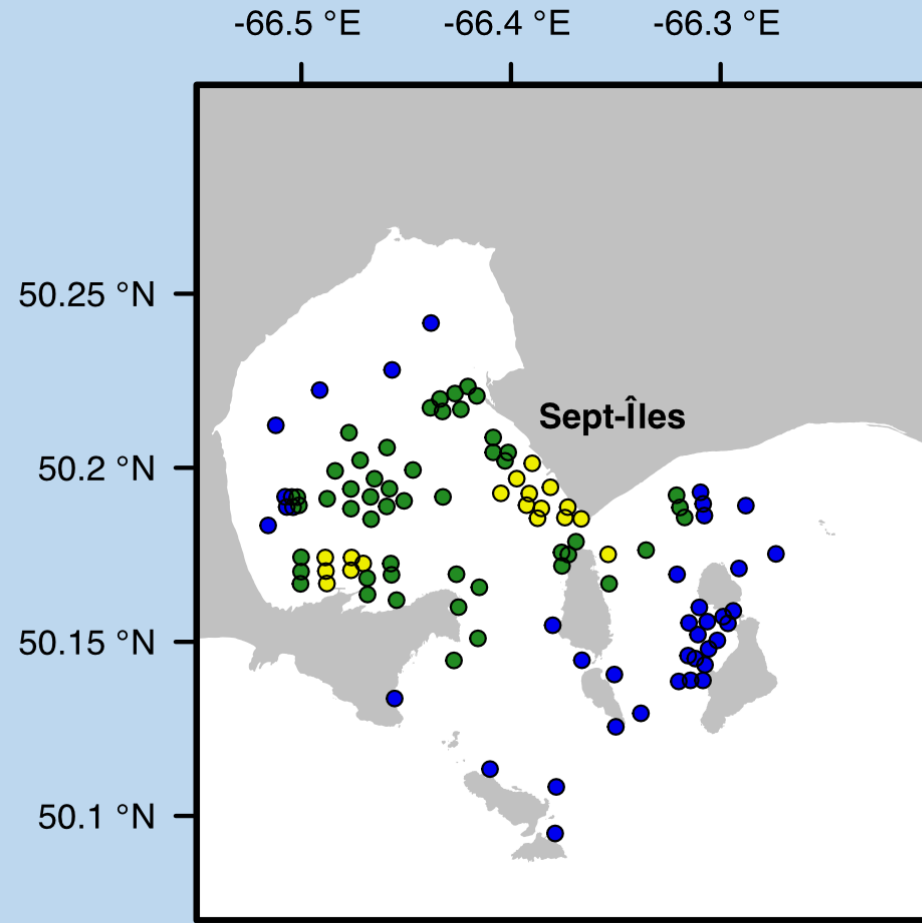
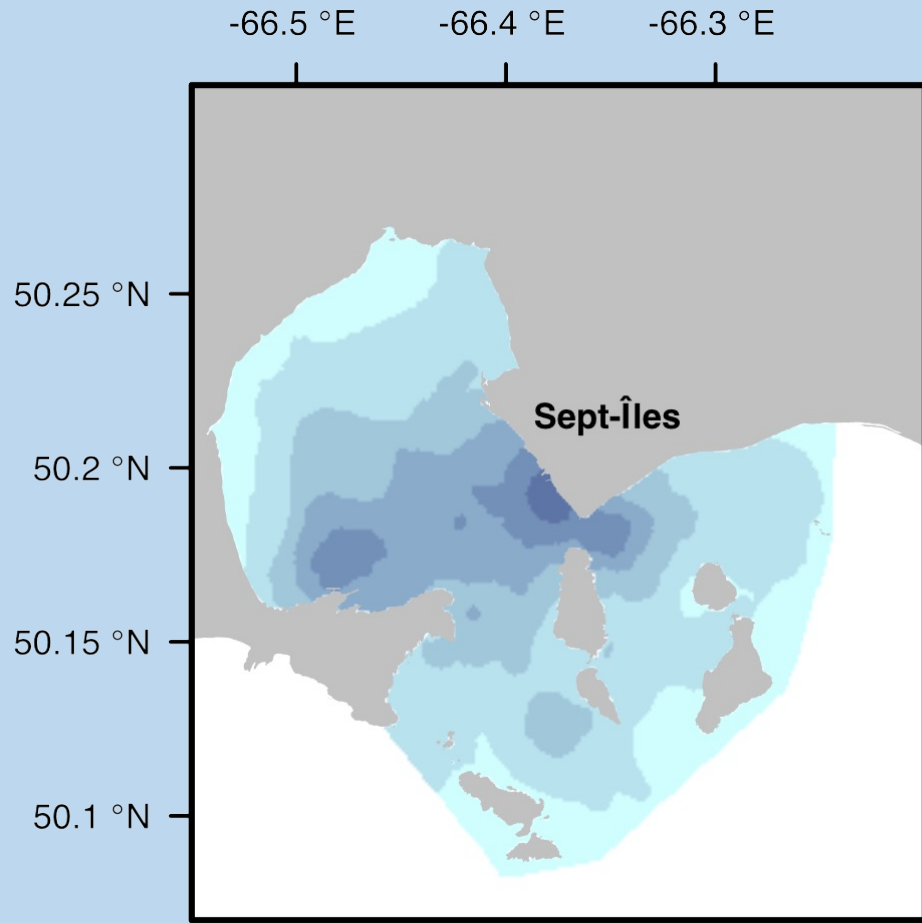
INDIVIDUAL EXPOSURE



CUMULATIVE EXPOSURE



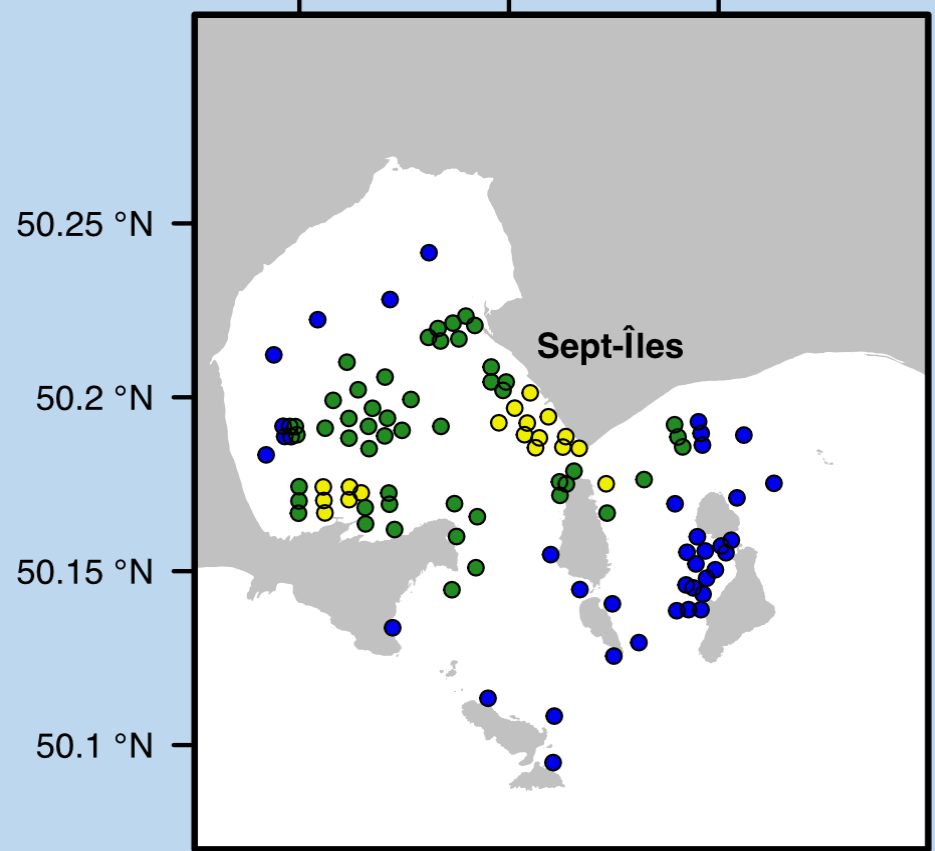
CUMULATIVE EXPOSURE



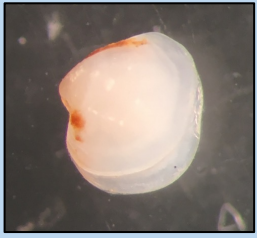
LINKS WITH COMMUNITIES



-66.5 °E -66.4 °E -66.3 °E



High status :

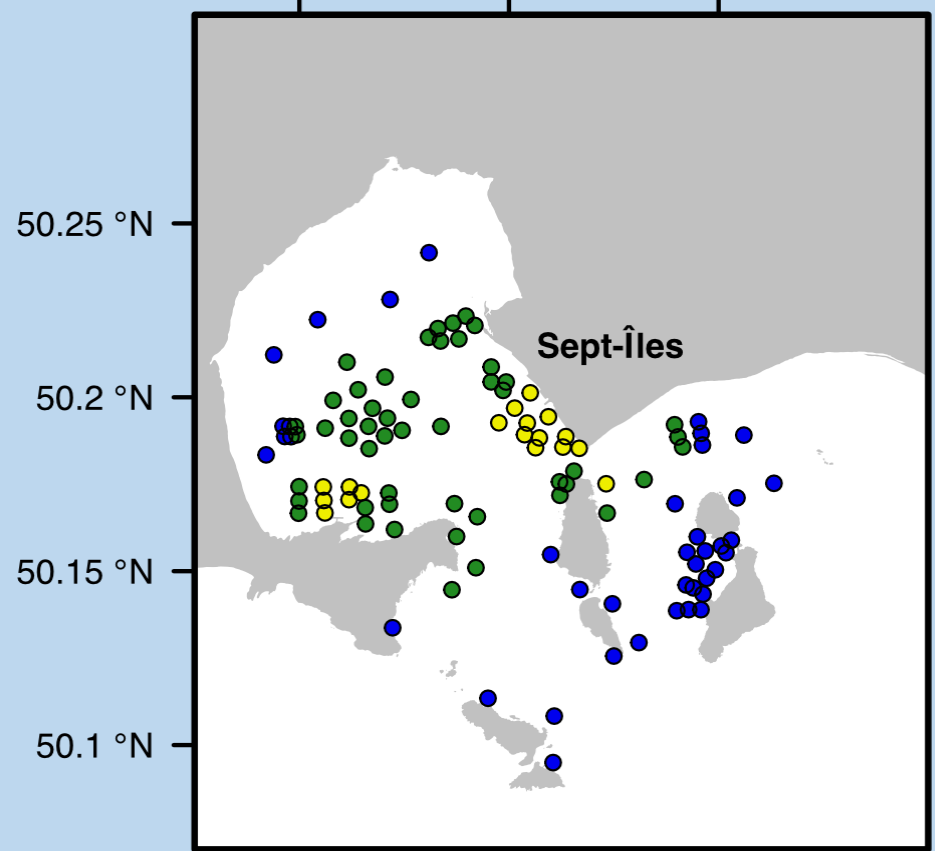


- Highest biomass of **echinoderms**
- Lowest biomass of **annelids**
- Highest density of **nematods**

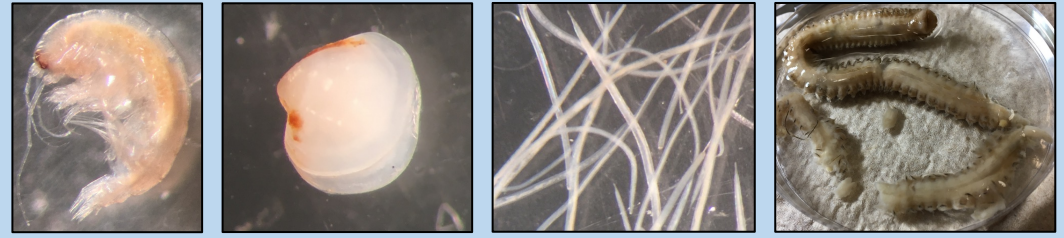
LINKS WITH COMMUNITIES



-66.5 °E -66.4 °E -66.3 °E



High status :



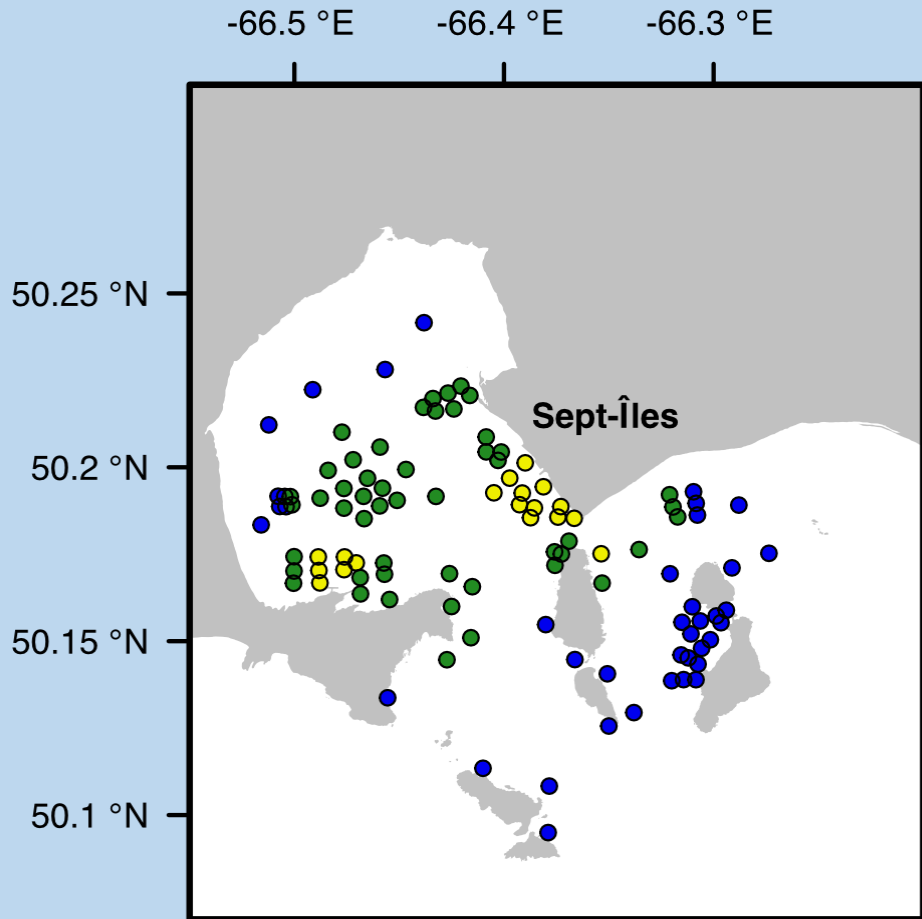
Highest biomass of **echinoderms**
Lowest biomass of **annelids**
Highest density of **nematods**

Good status :

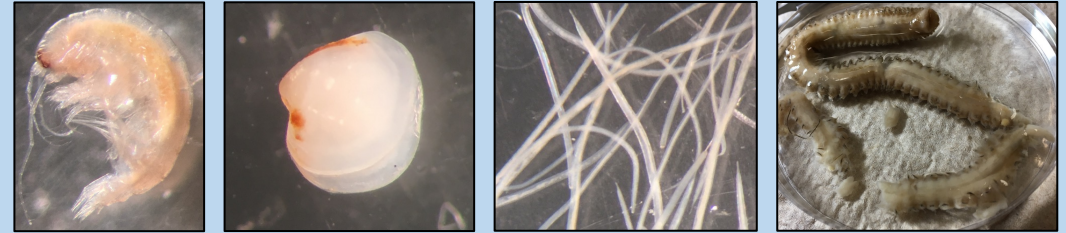


Highest biomass of **molluscs**
Highest density of **arthropods**

LINKS WITH COMMUNITIES



High status :



Highest biomass of **echinoderms**
Lowest biomass of **annelids**
Highest density of **nematods**

Good status :



Highest biomass of **molluscs**
Highest density of **arthropods**

Moderate status :

No characteristic species detected
Highest density of **annelids**

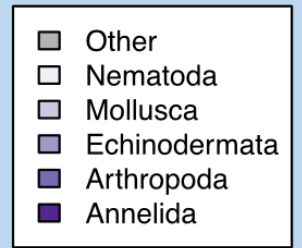
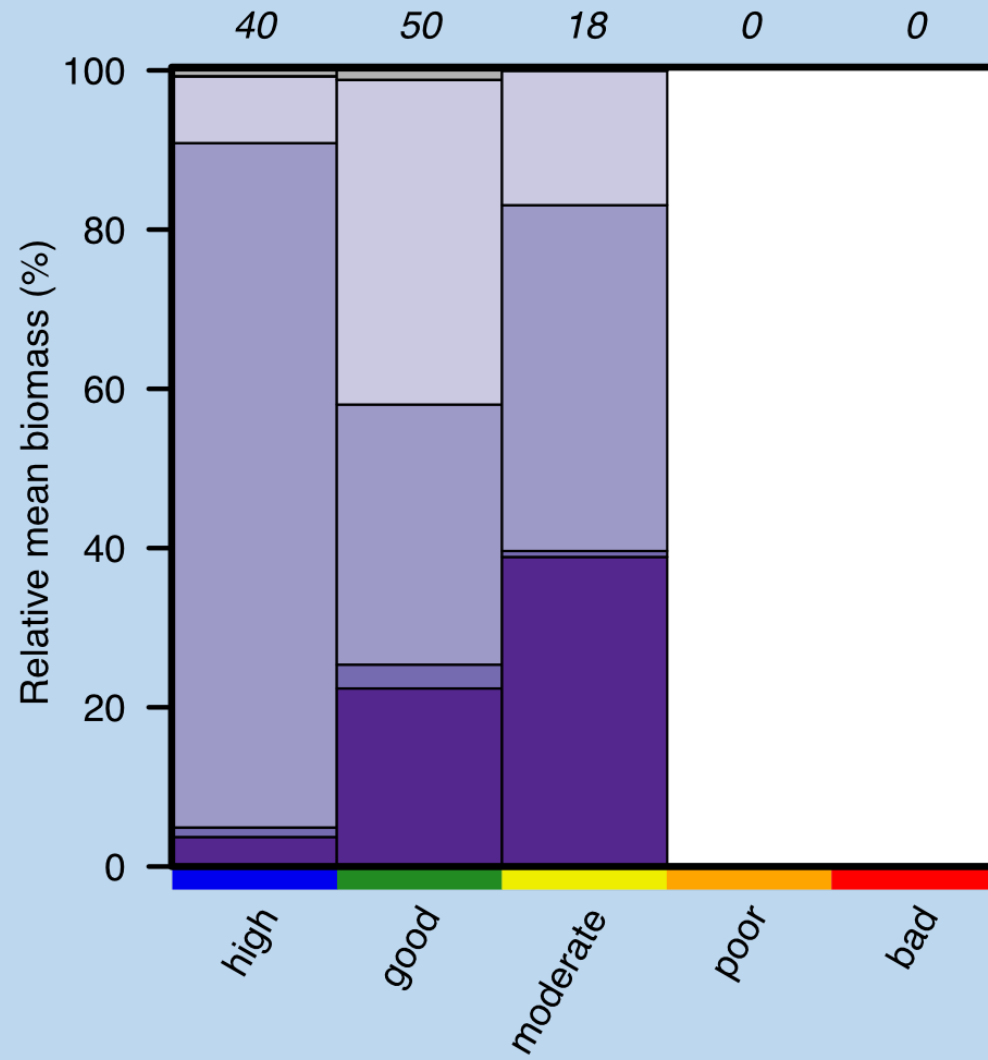
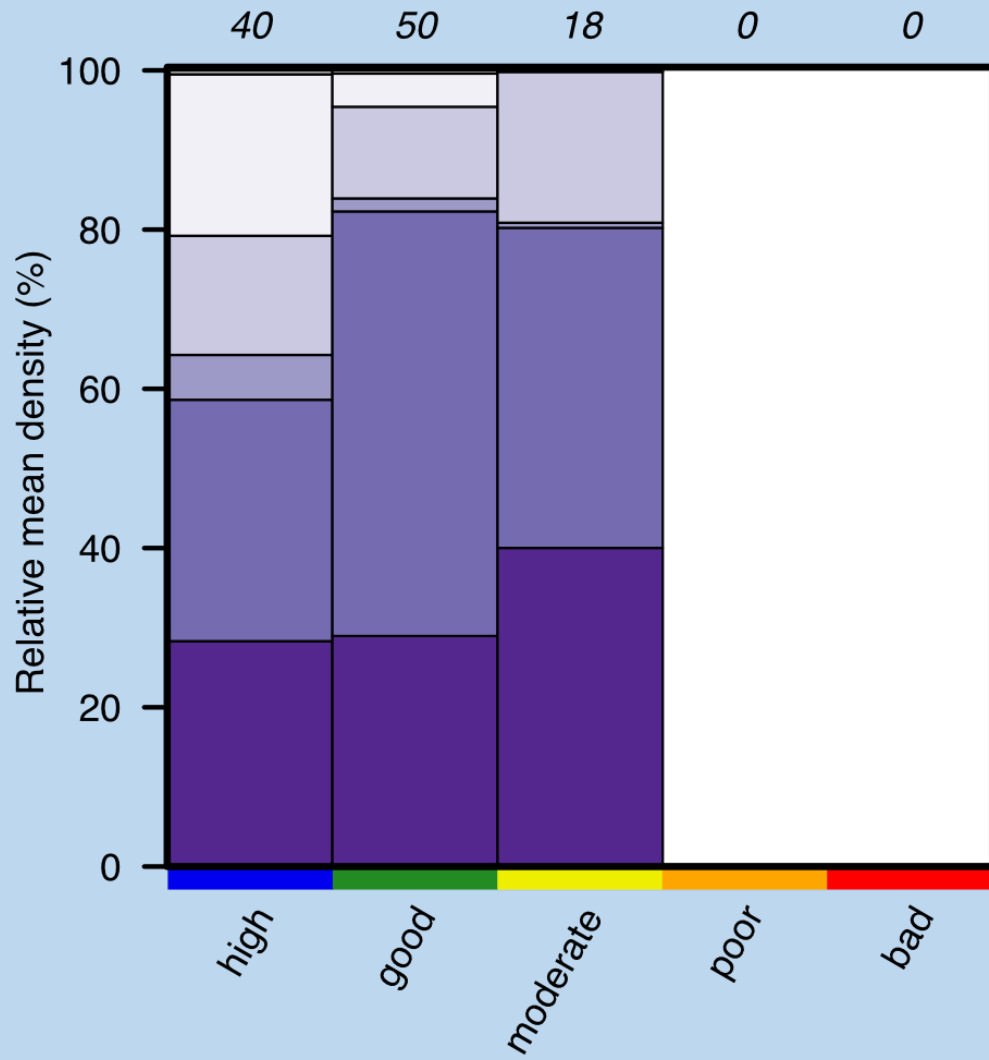
- ✓ Exposure score applicable in **any coastal environment**, proxy of human footprint
- ✓ Coherent with previous studies in our study area
- ✓ Potential to **detect benthic community changes** along cumulative exposure score

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THANKS FOR YOUR ATTENTION!

✉ elliott_dreujou@uqar.ca | 🌐 <https://eldre.github.io>

COMMUNITY CHANGES



REGRESSION WITH WHOLE COMMUNITY

