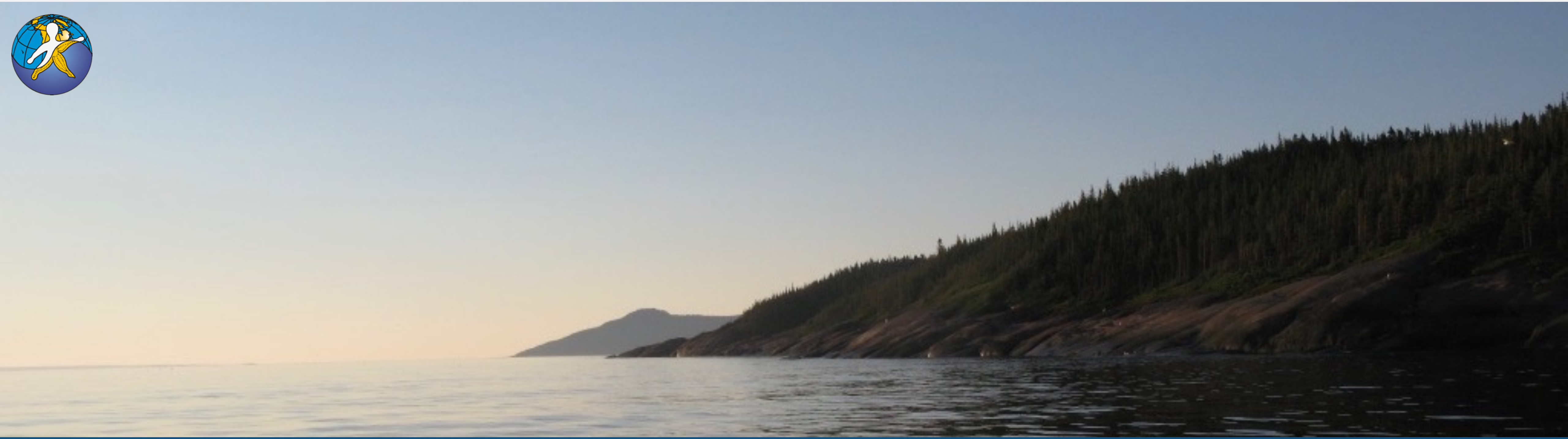


How to characterize human influence on coastal benthic ecosystems?

Elliot Dreujou, Christopher W McKindsey, Nicolas Desroy, Natalie Ban, Aurélie Foveau, Philippe Archambault

November 5th 2019, Bordeaux

Context

Connecting ocean and human activities

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

Benjamin S. Halpern[1,2,3], Melanie Frazier[3], John Potapenko[4], Kenneth S. Casey[5], Kellee Koenig[6], Catherine Longo[3], Julia Stewart Lowndes[3], R. Cotton Rockwood[7], Elizabeth R. Selig[6], Kimberly A. Selkoe[3,8] & Shaun Walbridge[9]

Nat Commun, 2015

Review

An effective set of principles for practical implementation of marine cumulative effects assessment

A.D. Judd [a,*], T. Backhaus [b], F. Goodsir [a]

Environ Sci & Policy, 2016

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

Benjamin S. Halpern[1,2], Melanie Frazier[1], Jamie Afflerbach[1], Julia S. Lowndes[1], Fiorenza Micheli[3,4], Casey O'Hara[2], Courtney Scarborough[1] & 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. Paterson[1], Melanie J. Bishop[2]

Mar Ecol-Progr Ser, 2016

Multiple Stressors in a Changing World: The Need for an Improved Perspective on Physiological Responses to the Dynamic Marine Environment

Alex R. Gunderson, Eric J. Armstrong, and Jonathon H. Stillman

Annu Rev Mar Sci, 2016

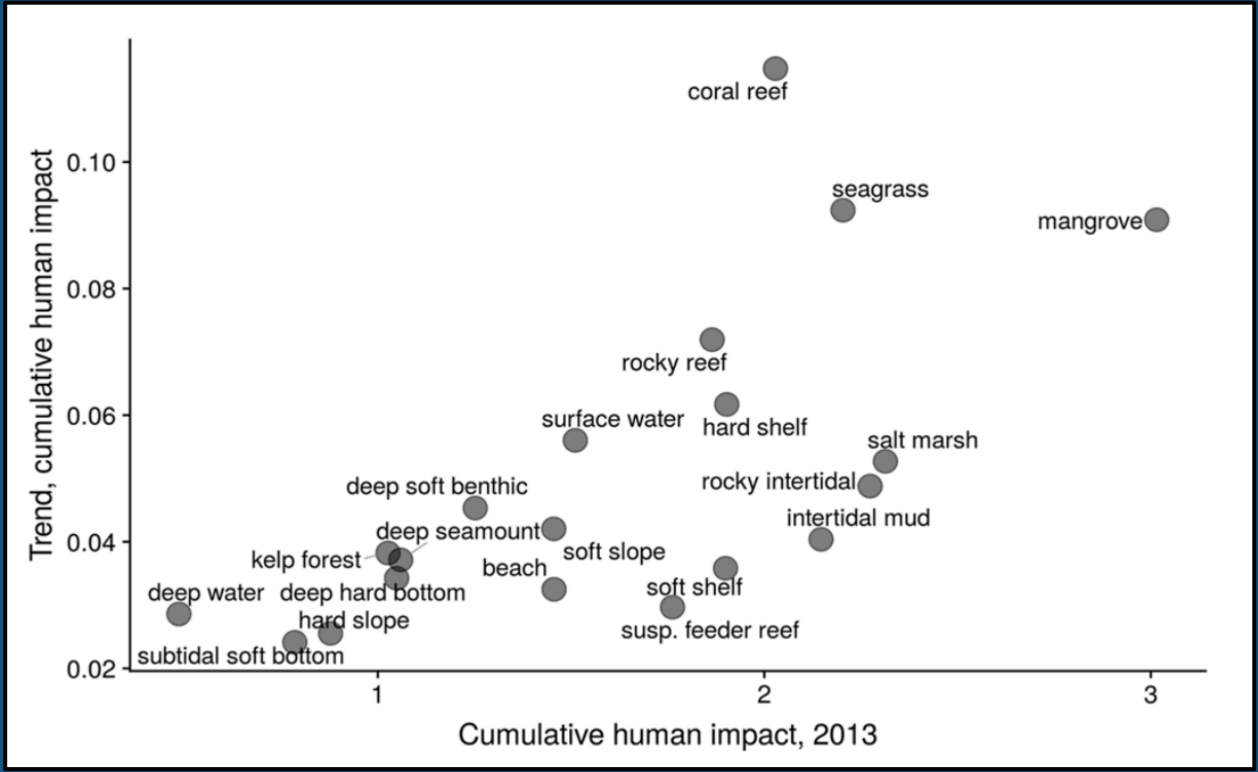
Cumulative impact mapping: Advances, relevance and limitations to marine management and conservation, using Canada's Pacific waters as a case study

Natalie C. Ban [a,b,*], Hussein M. Alidina [c], Jeff A. Ardron [d]

Mar Policy, 2010

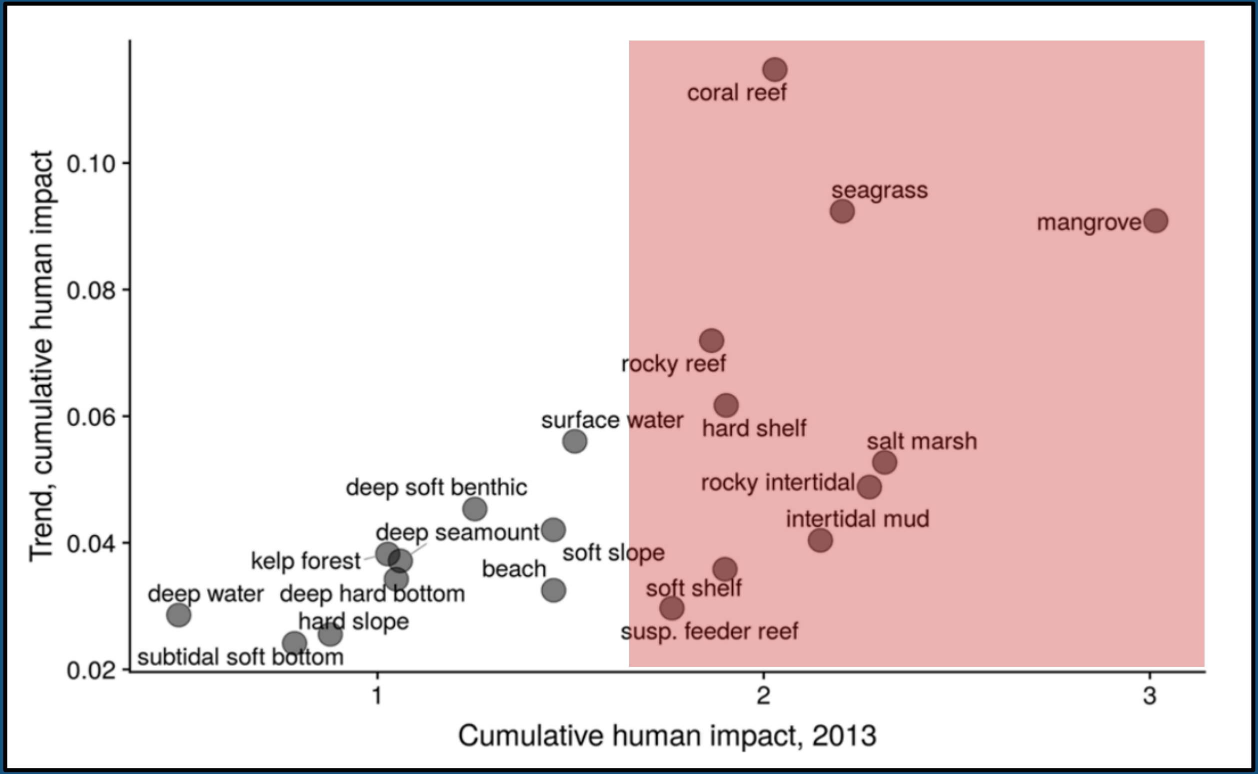
➢ The majority of the oceans is influenced by multiple human activities

Some ecosystems are more vulnerable



Halpern et al. (2019)

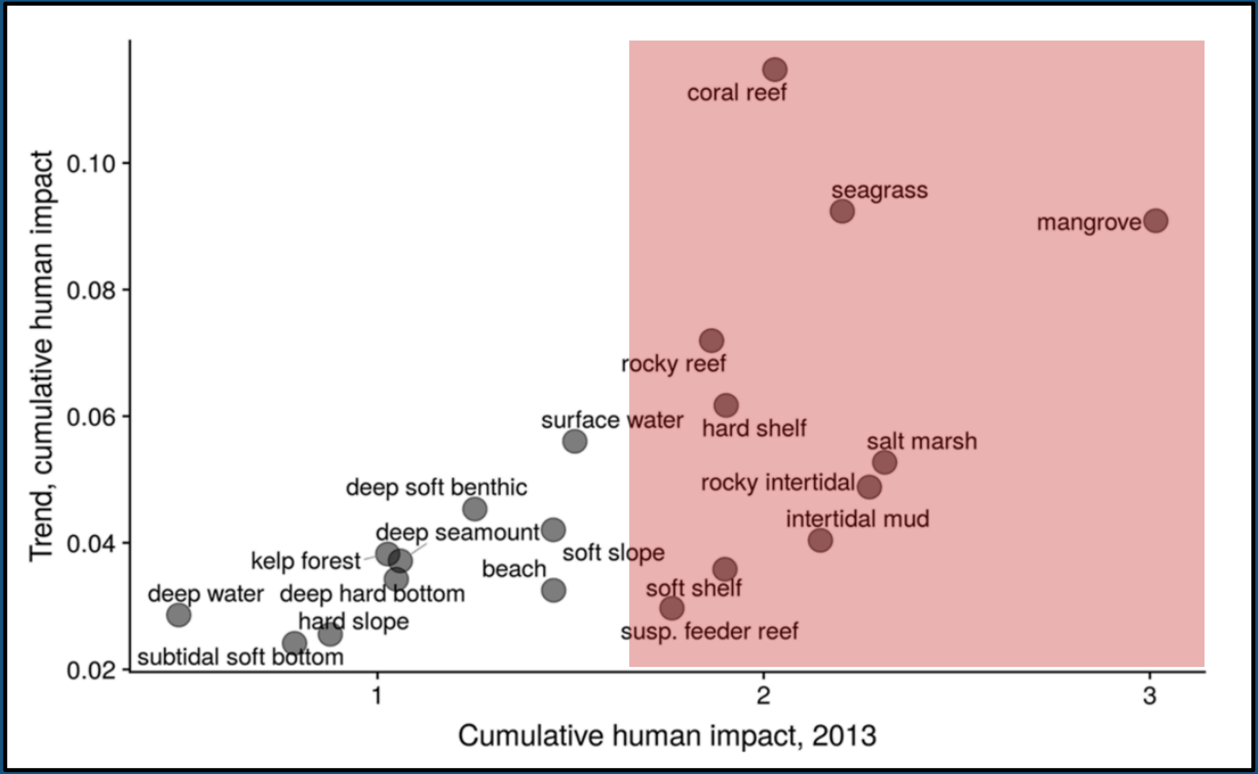
Some ecosystems are more vulnerable



- Many coastal ecosystems are among the most influenced by cumulative impacts

Halpern et al. (2019)

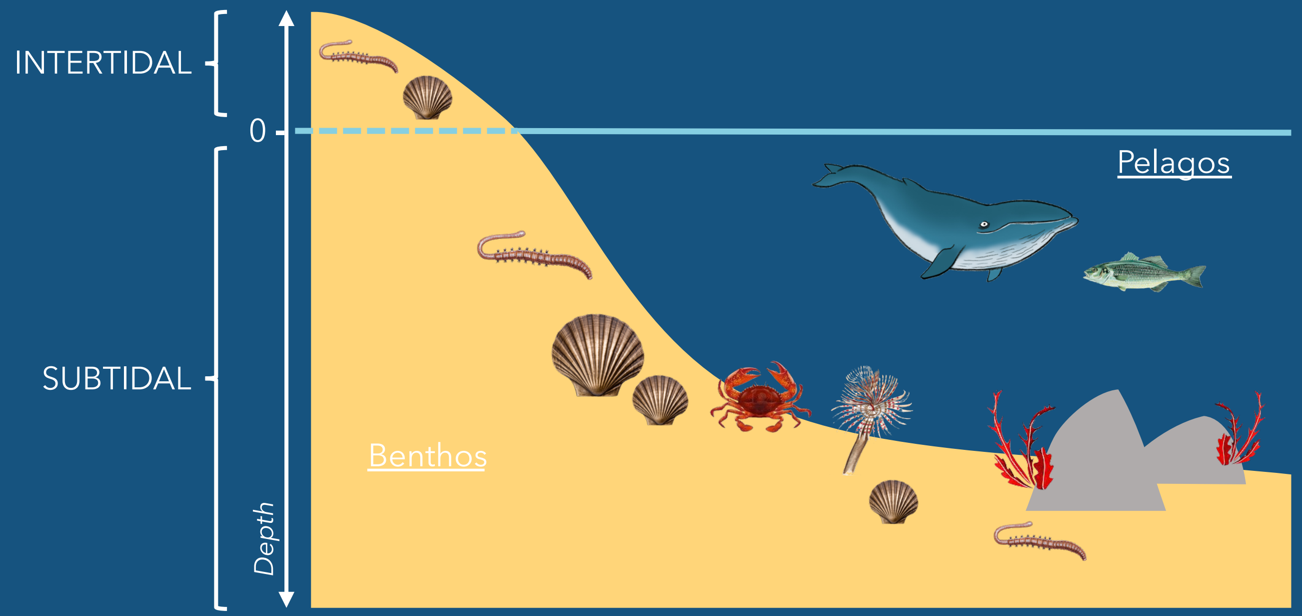
Some ecosystems are more vulnerable



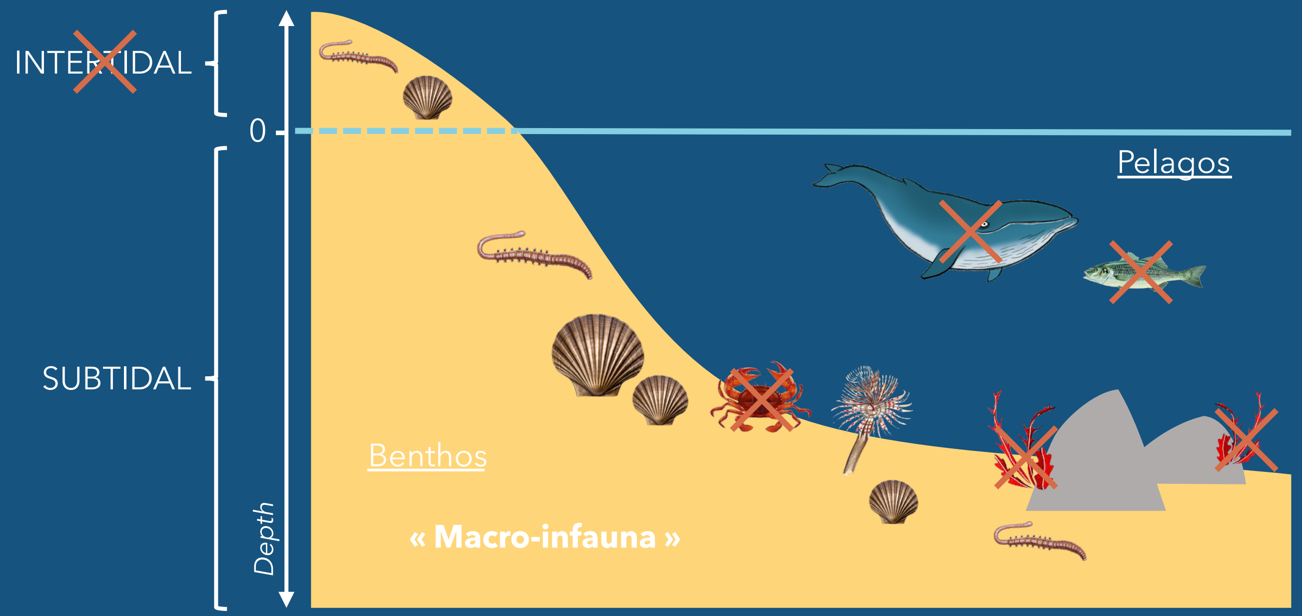
- Many coastal ecosystems are among the most influenced by cumulative impacts
- Importance of monitoring programs and ecological studies to predict evolution (e.g. REBENT)

Halpern et al. (2019)

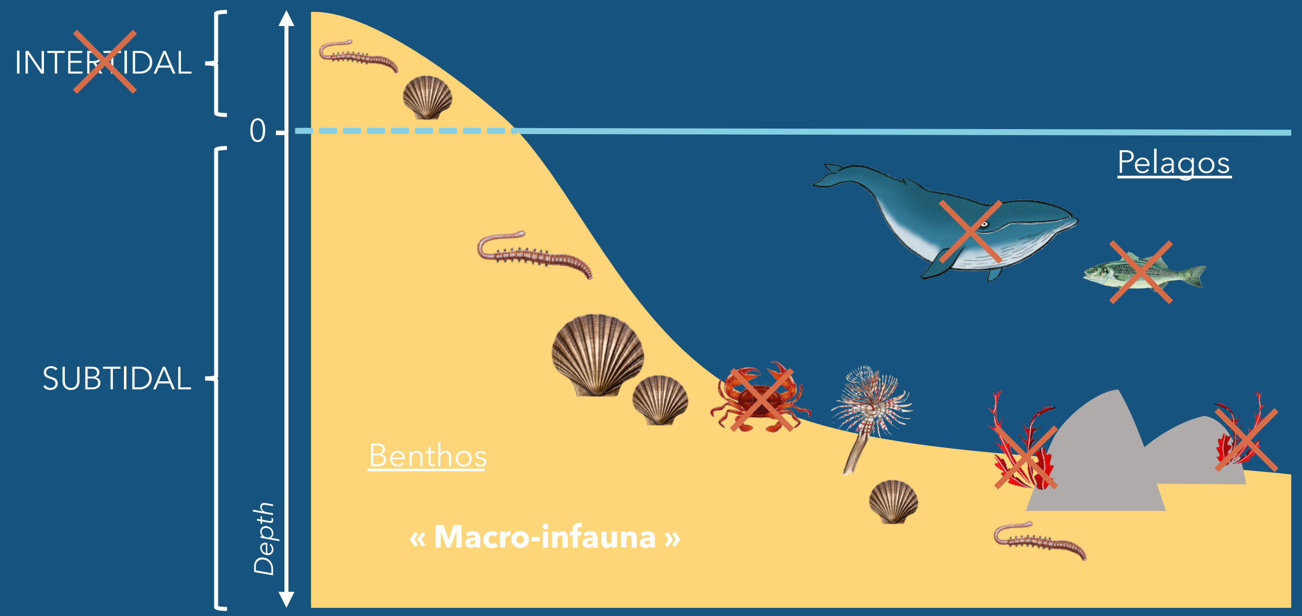
Why study benthic species?



Why study benthic species?

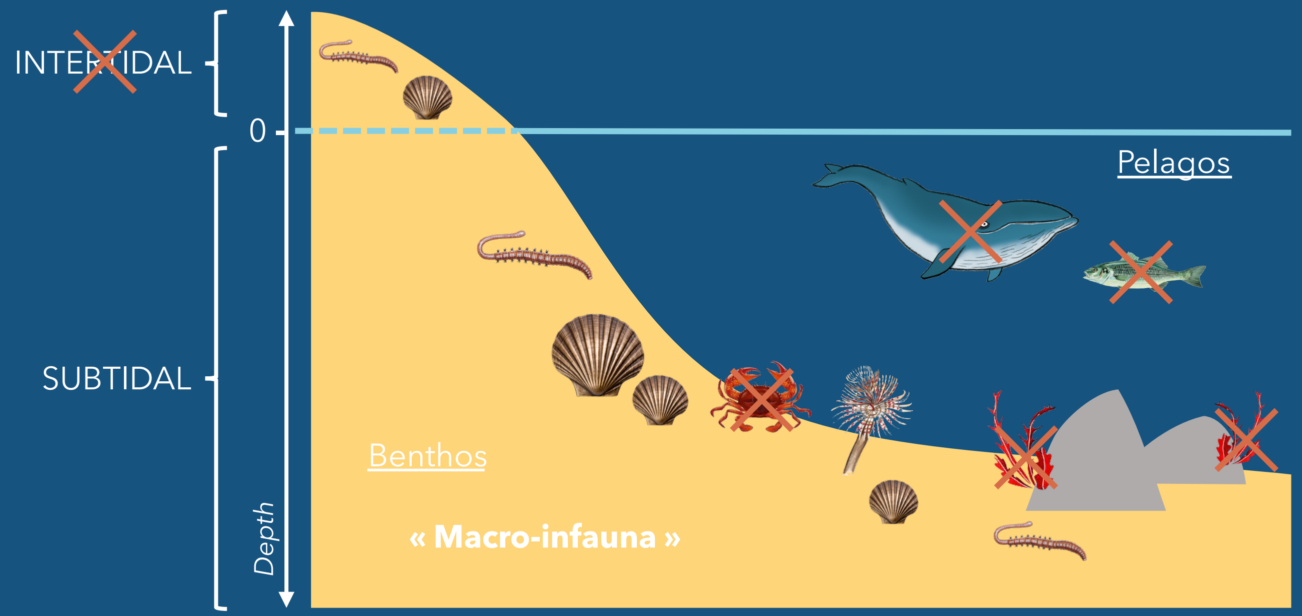


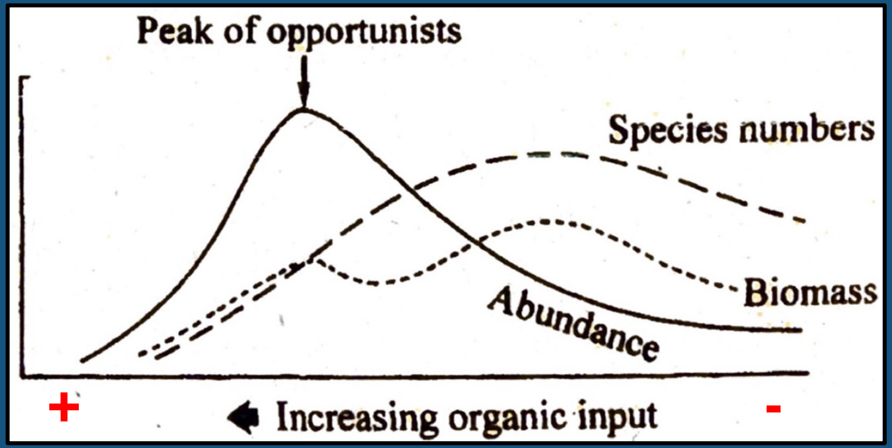
Why study benthic species?



- Importance for the ecosystem
- Importance for mankind

Why study benthic species?





- Importance for the ecosystem
- Importance for mankind
- Sessile species (sensitive to perturbation)

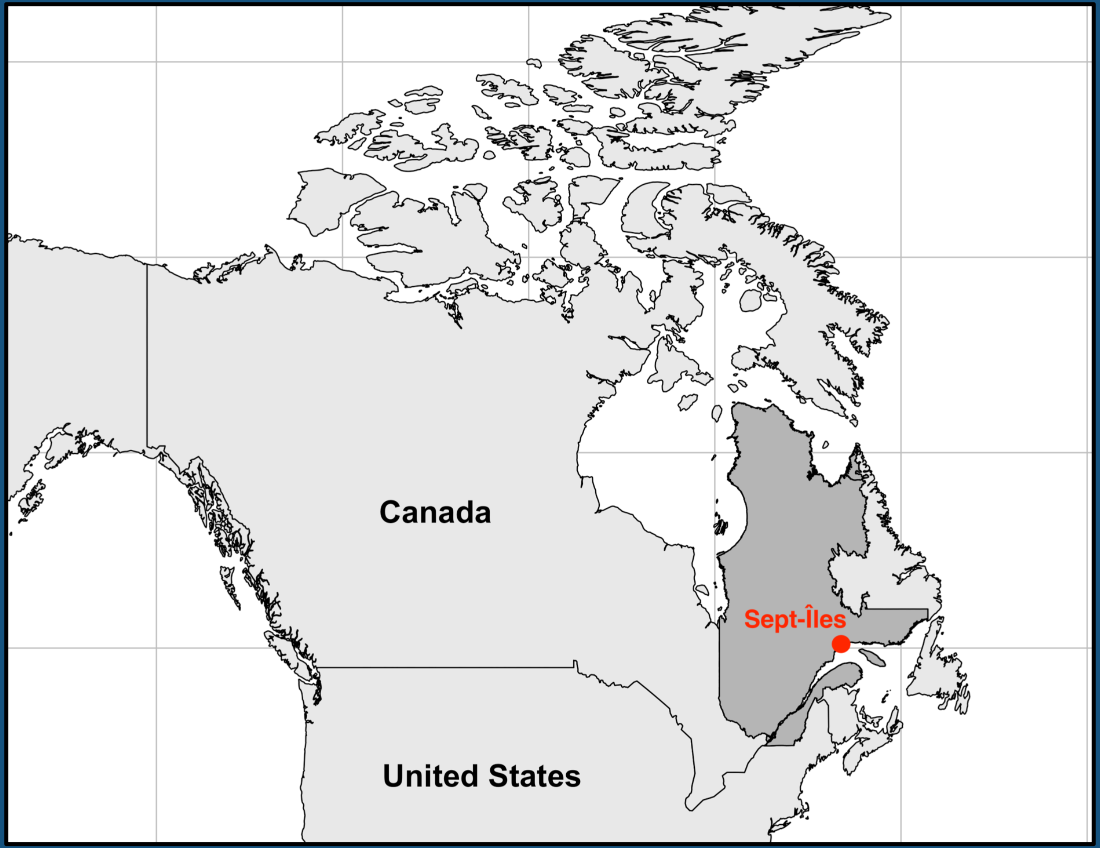
Pearson & Rosenberg (1978)

GOAL

Characterize cumulative impacts of human activities on benthic coastal ecosystems

Methods

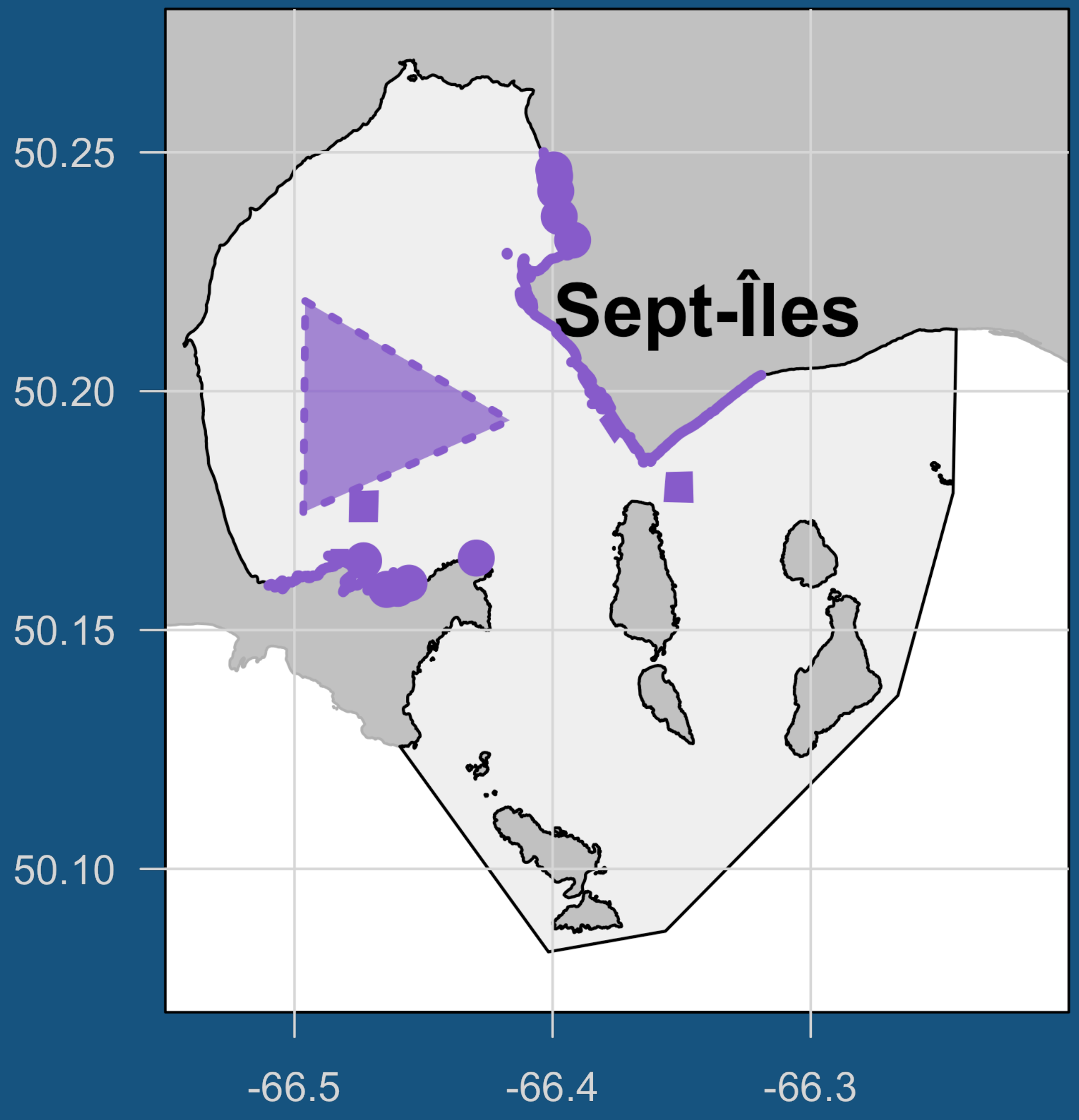
Study area



Sept-Îles, Canada

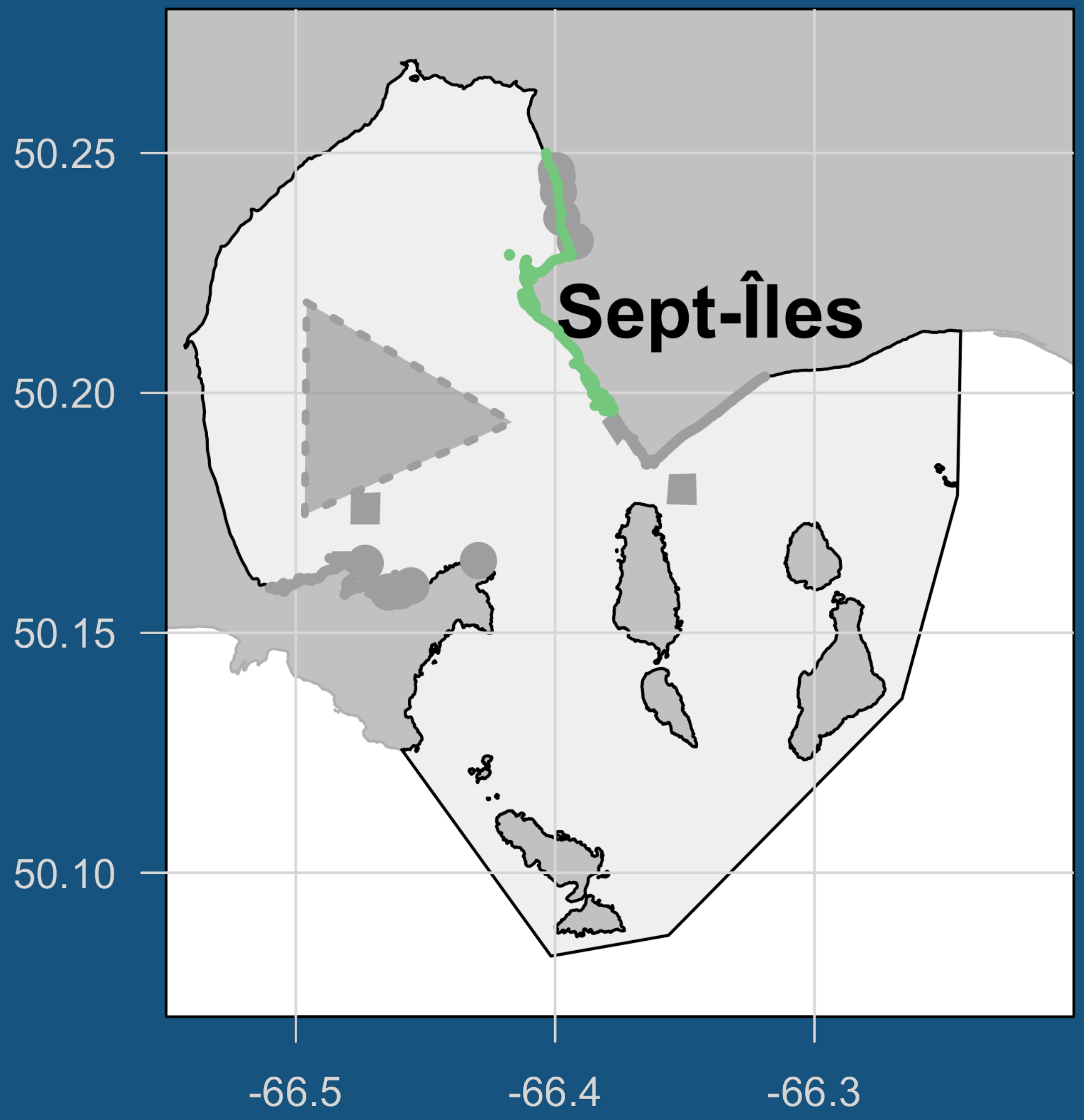
- 5th Canadian harbour (25.3 MT of exchanged goods in 2018)
- Various industrial and harbour activities

Human activities



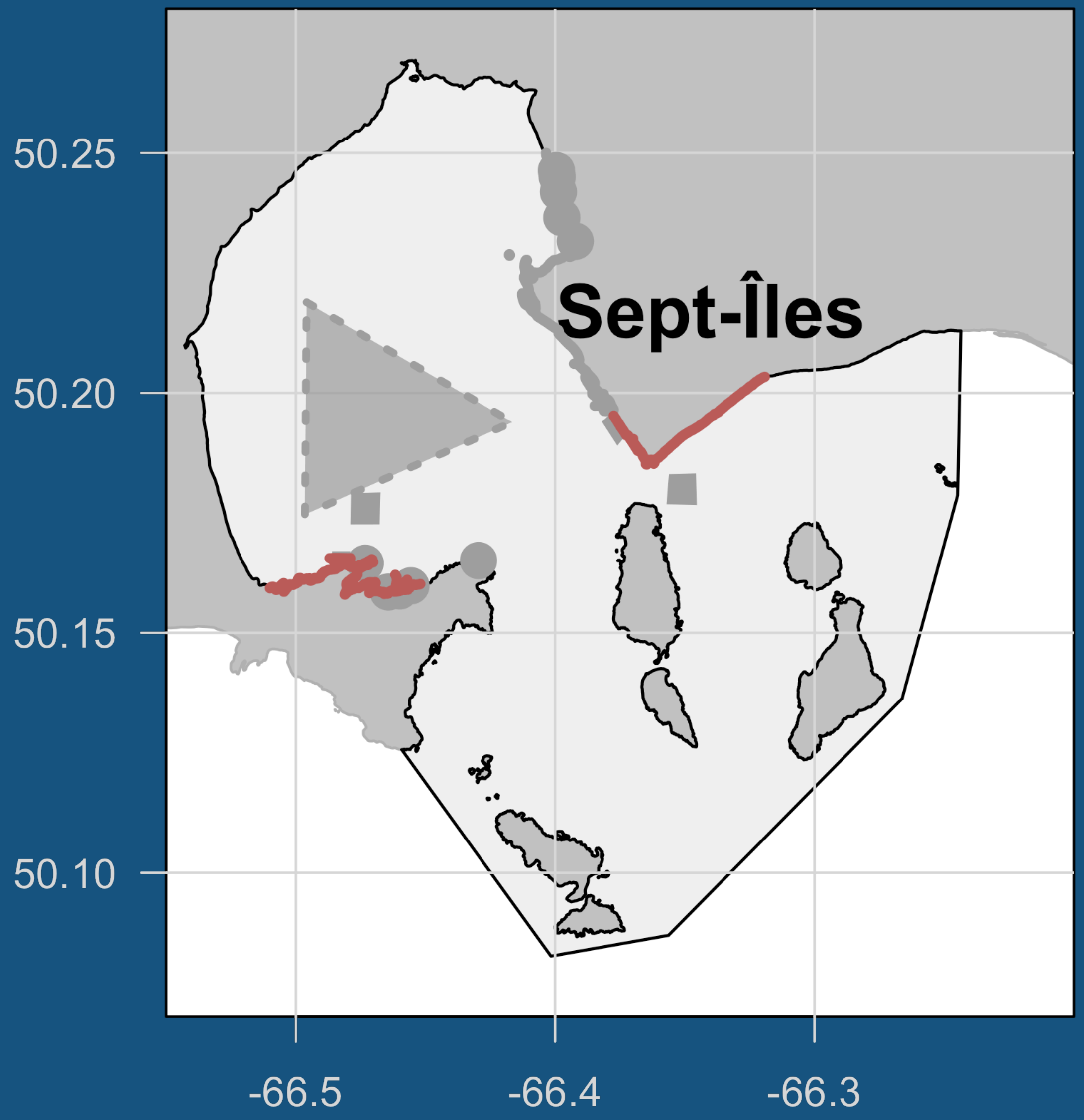
- 9 different human activities
- Classified under 4 categories

Human activities



- city influence
- municipal wharves

Human activities



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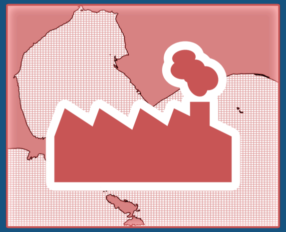
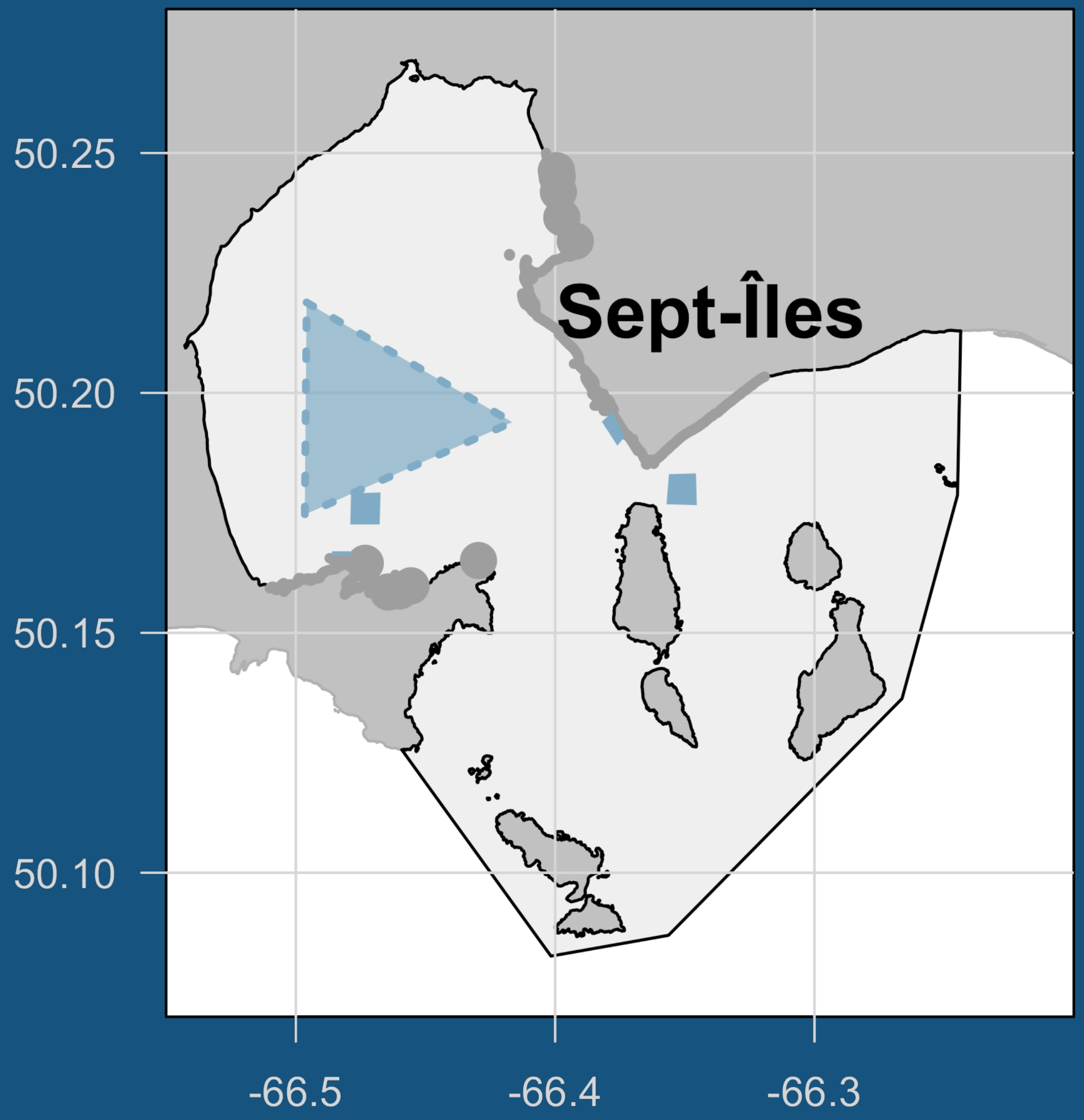


- industries influence
- industrial wharves

Human activities



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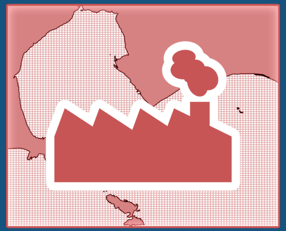
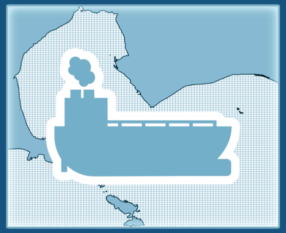
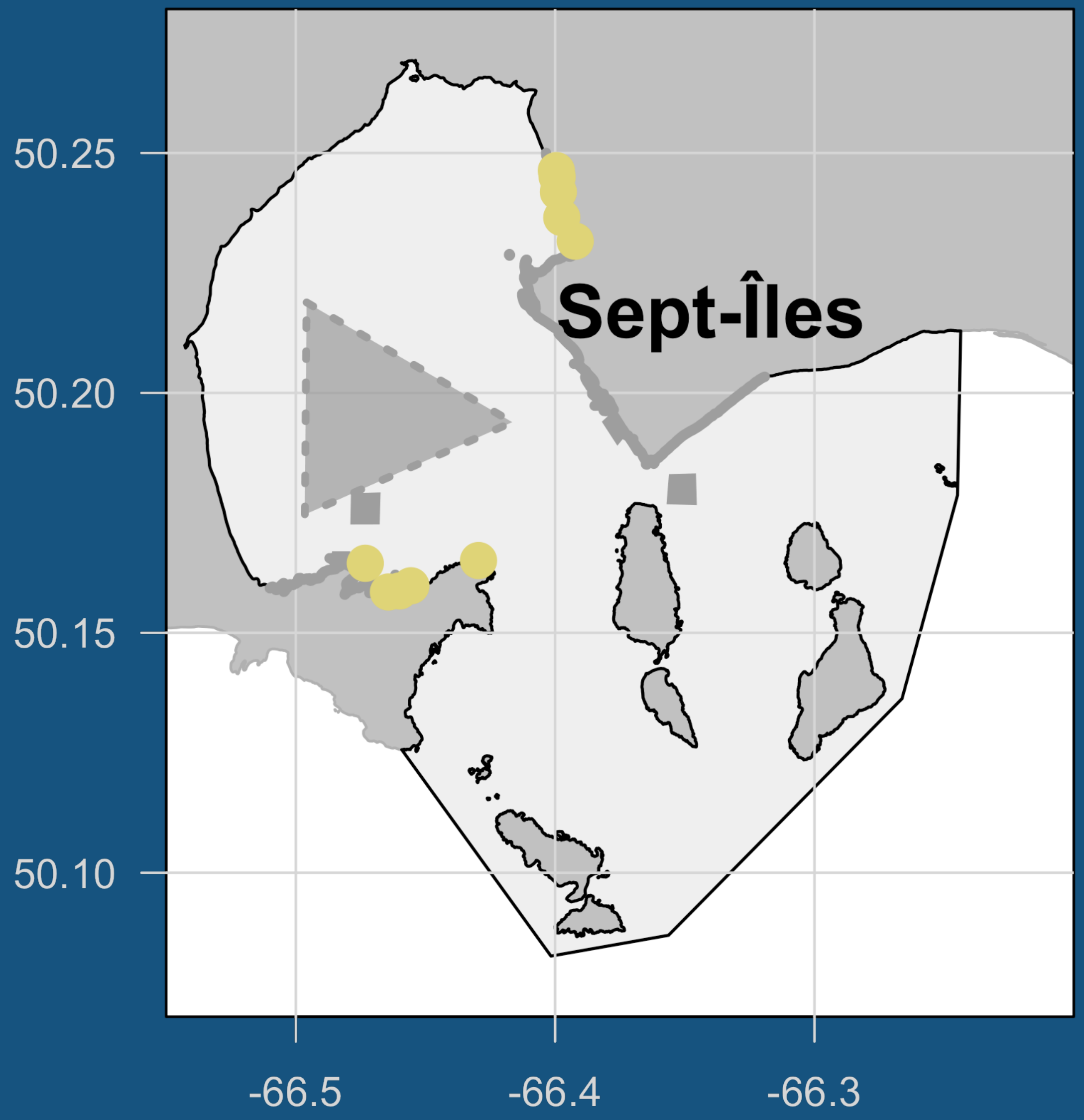


- industries influence
- industrial wharves



- dredging dumping sites
- dredging collect sites
- commercial ship mooring sites

Human activities



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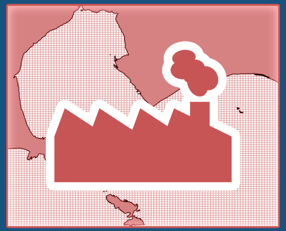

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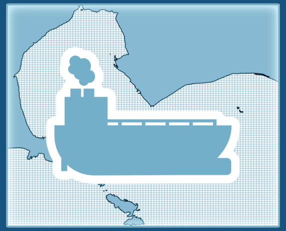

- dredging dumping sites
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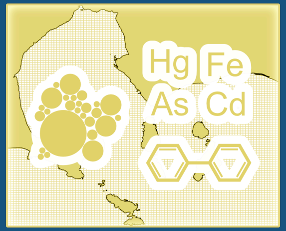
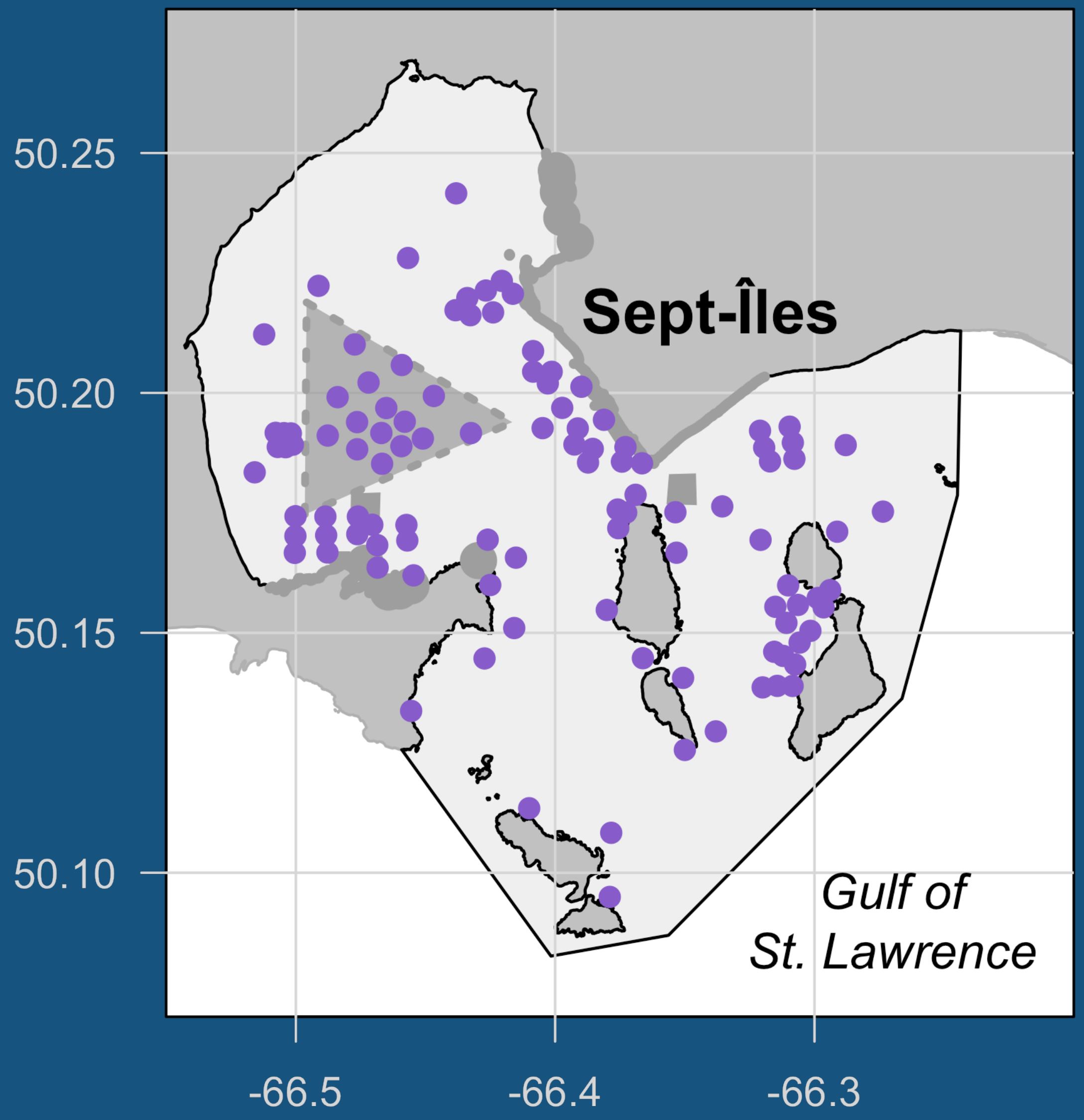


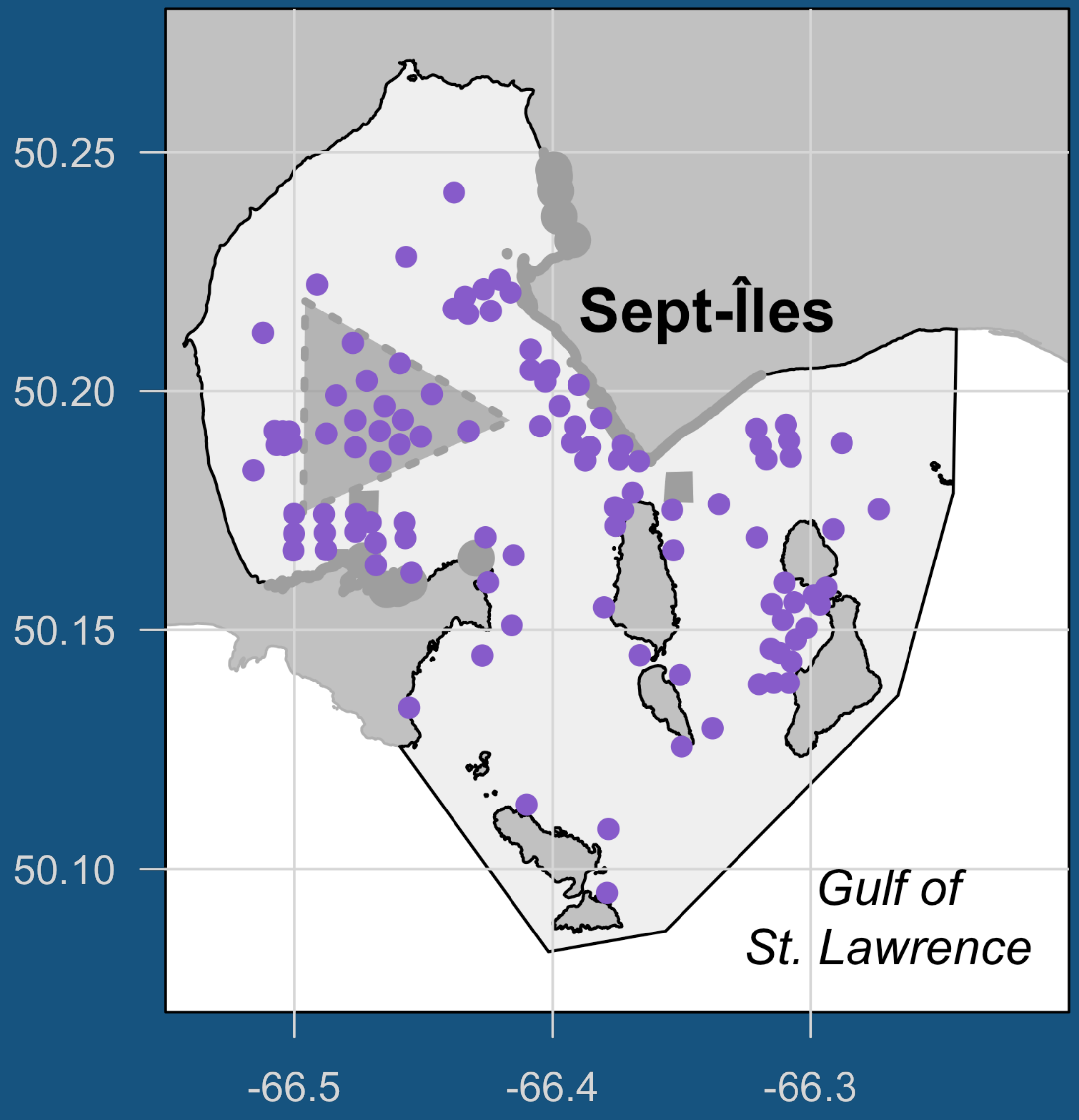
- rainwater sewers
- wastewater sewers

Data collection



- 108 stations sampled in 2017
- Between 0 and 70 m deep

Data collection



- 108 stations sampled in 2017
- Between 0 and 70 m deep

- Benthic communities sieved with a 0.5 mm mesh
- Habitat parameters considered:
    - organic matter
    - sediment grain-size
    - heavy metal concentrations

Modelling human influence

- Calculation of an index of influence with connectivity functions based on particle dispersion models:

$$I_{ij} = f_j(D_{ij}, Z_i)$$

i: station, j: activity
D_{ij}: distance from the source
Z_i: depth
f_j: connectivity function

Modelling human influence

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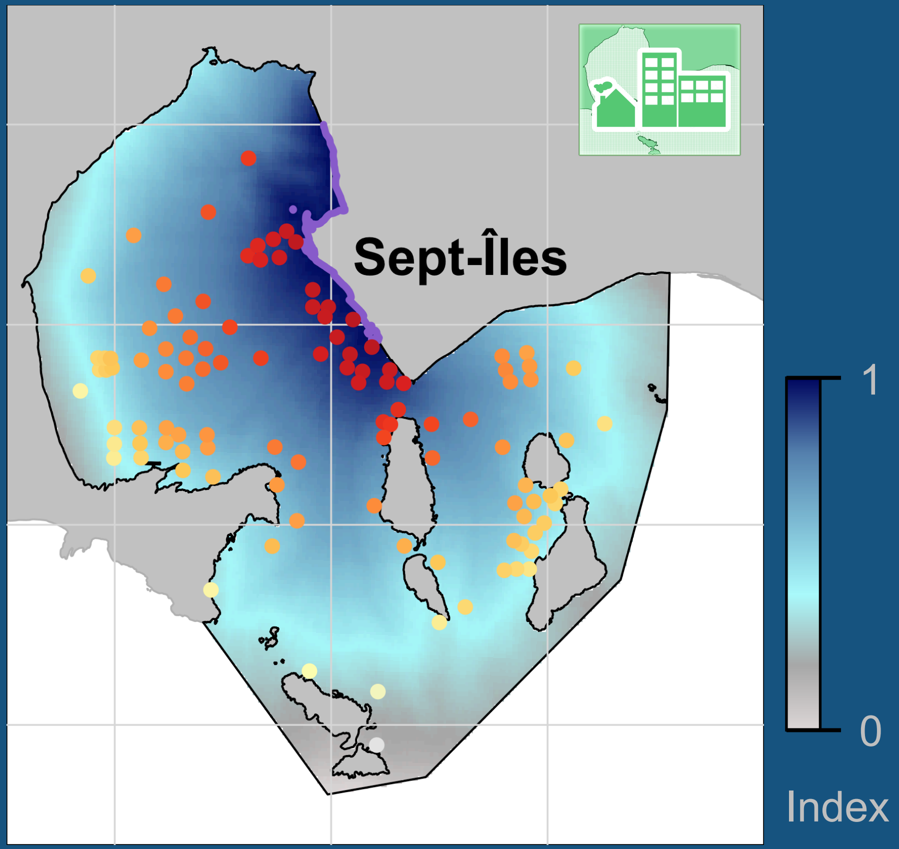
example for city influence:



Modelling human influence

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$$I_{ij} = f_j(D_{ij}, Z_i)$$

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D_{ij}: distance from the source
Z_i: depth
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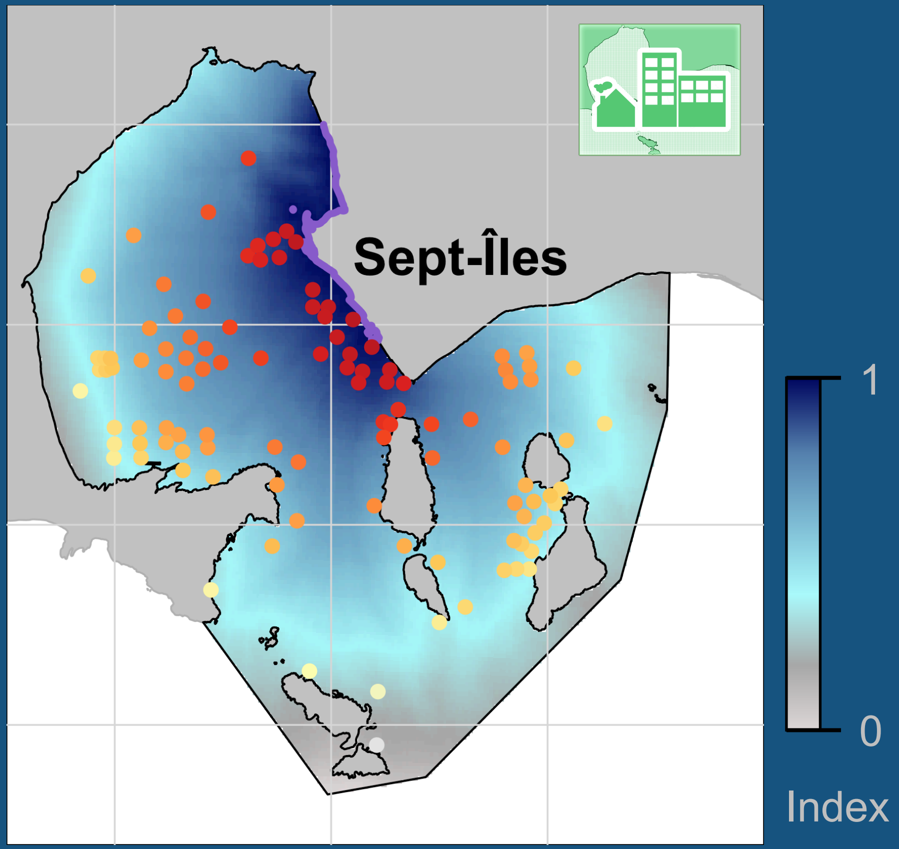
- Cumulative influence computed with an additive model:

$$CI_i = \sum_j I_{ij}$$

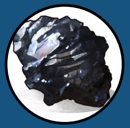
example for city influence:



Predicting benthic communities

Organic matter

Gravel, Sand, Silt, Clay



Arsenic, Cadmium, Chromium, Copper, Iron, Manganese, Mercury, Lead, Zinc

Human influence indices

Habitat parameters

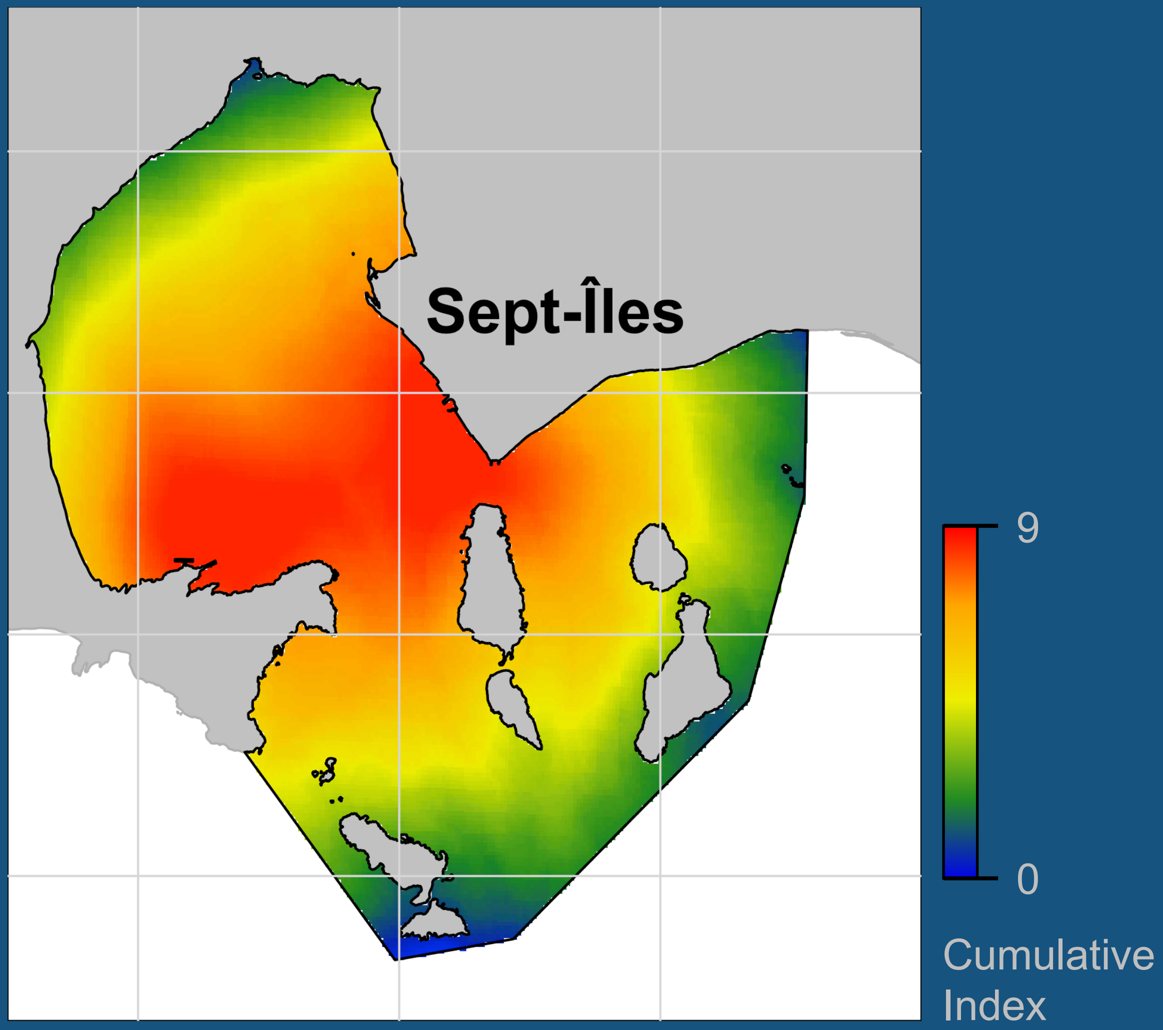
Correlation

Prediction

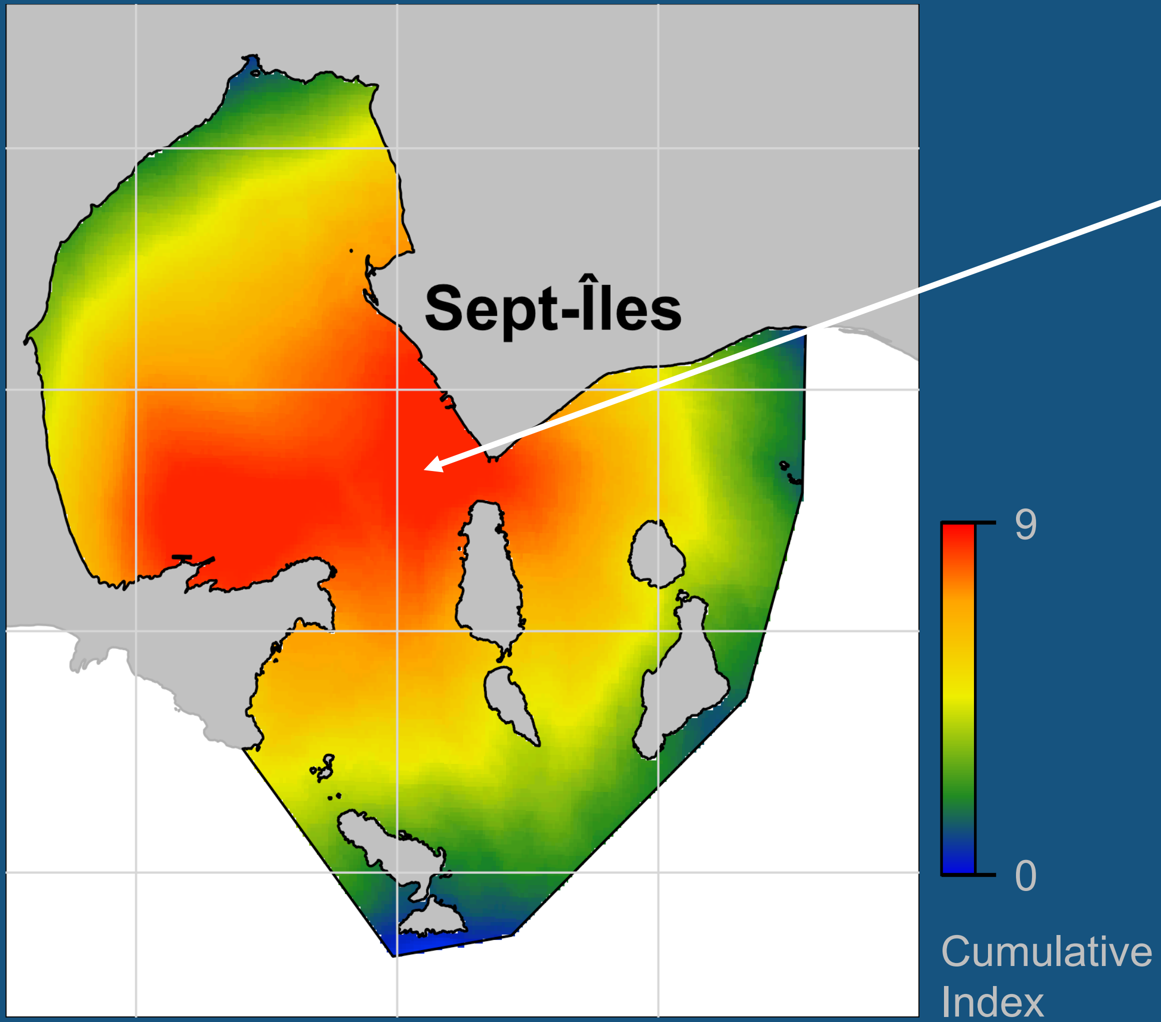
Benthic infauna

Results & Discussion

Human influence distribution

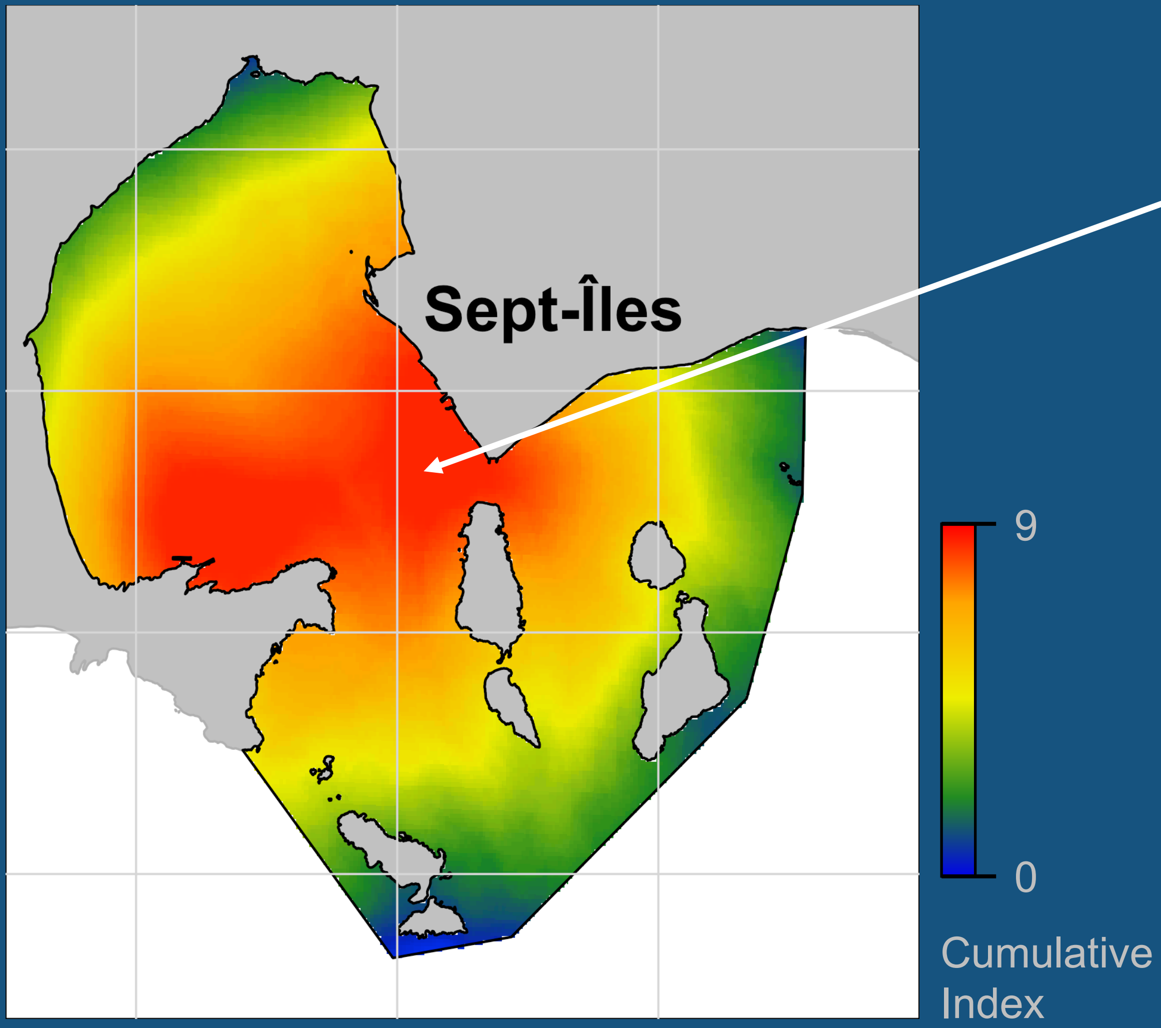


Human influence distribution



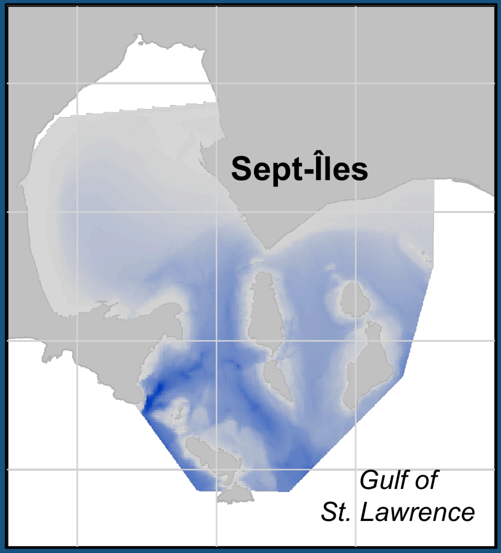
"Hotspot" of human influence

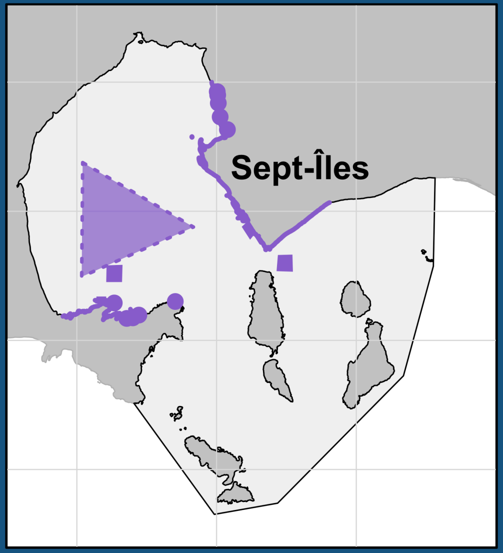
Human influence distribution



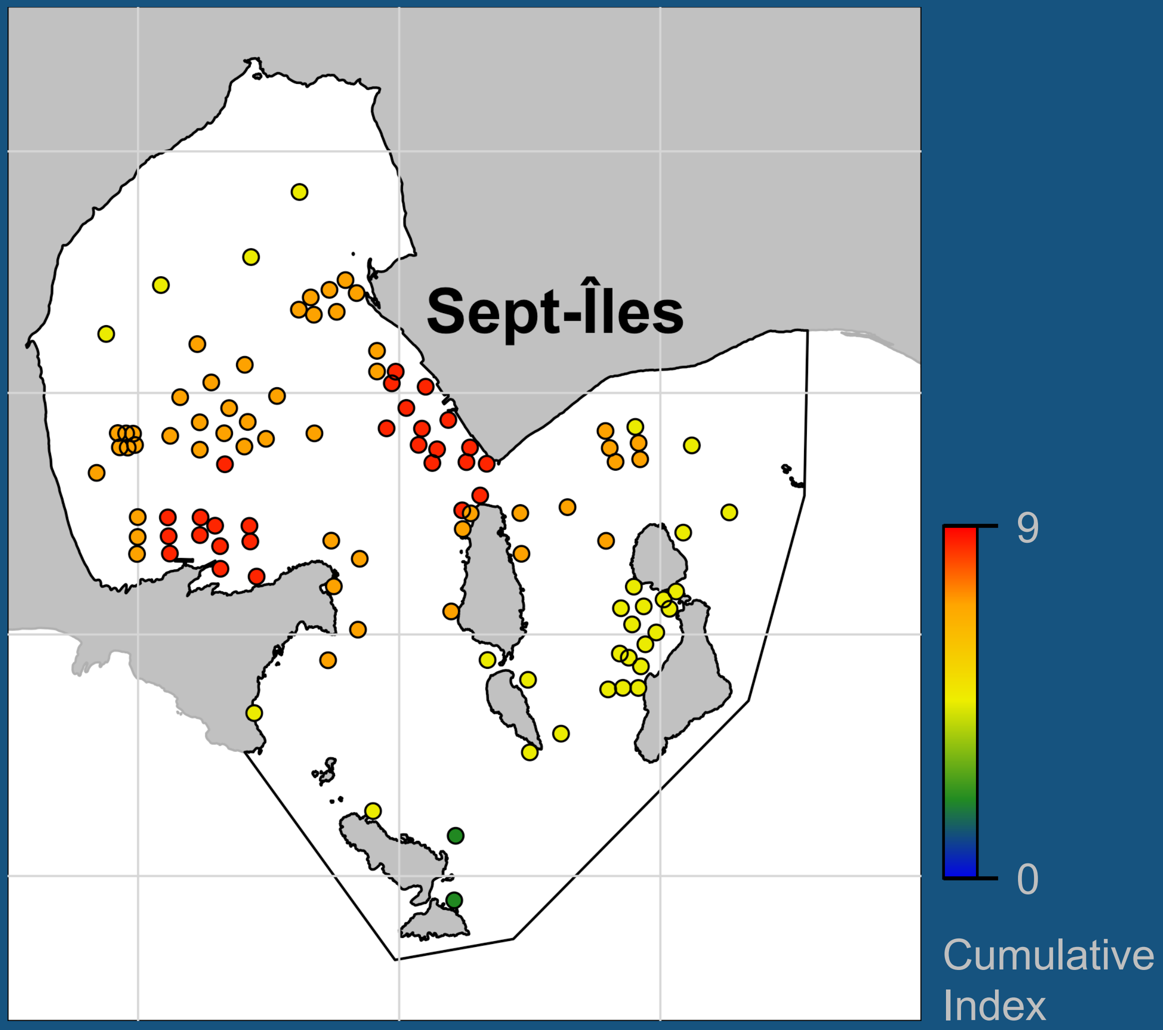
"Hotspot" of human influence

Coherent with the bathymetry and the sources of human activity :

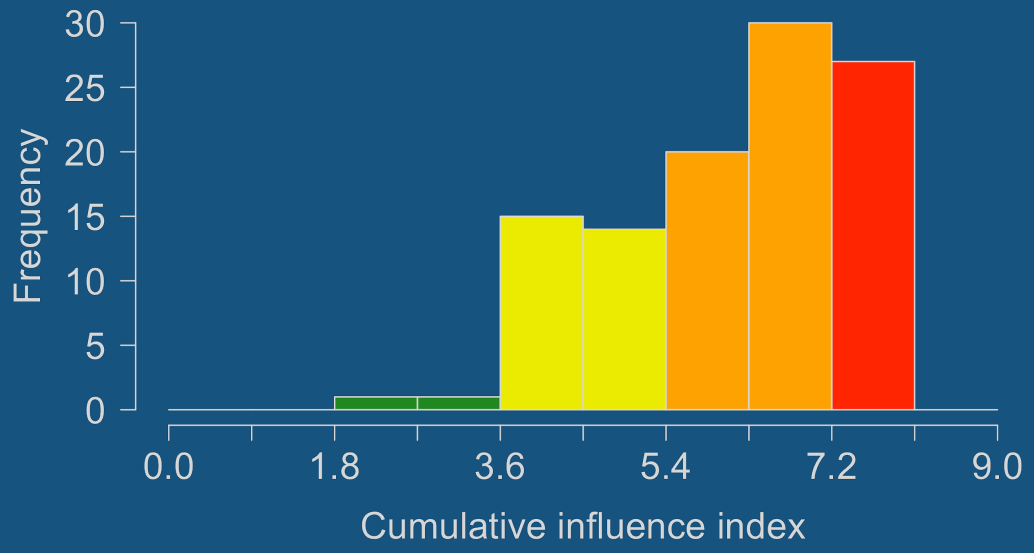




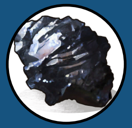
Human influence distribution



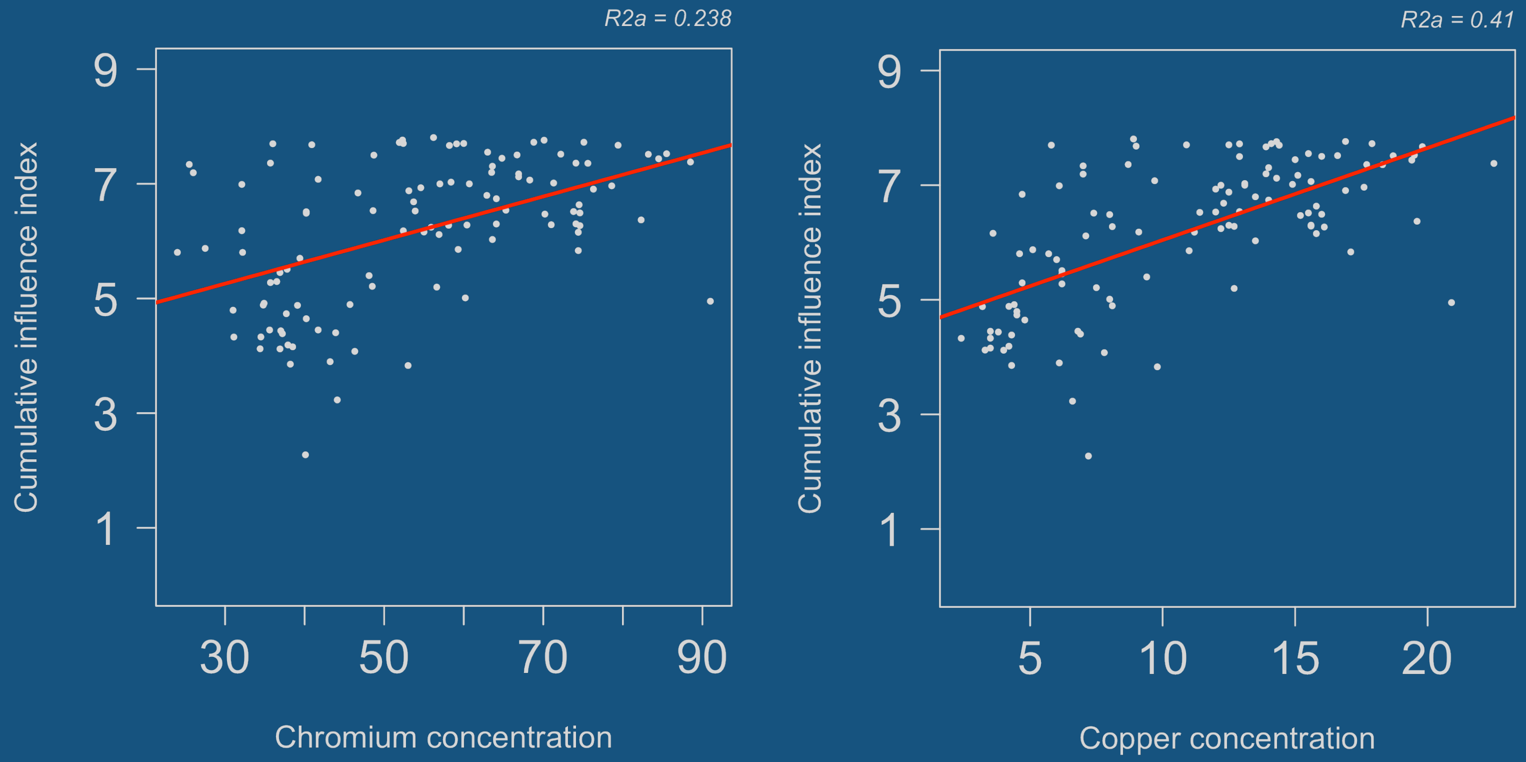
Most stations have a moderate to high cumulative influence index



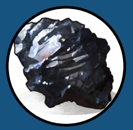
Links with abiotic parameters



Highest correlation with metals concentrations

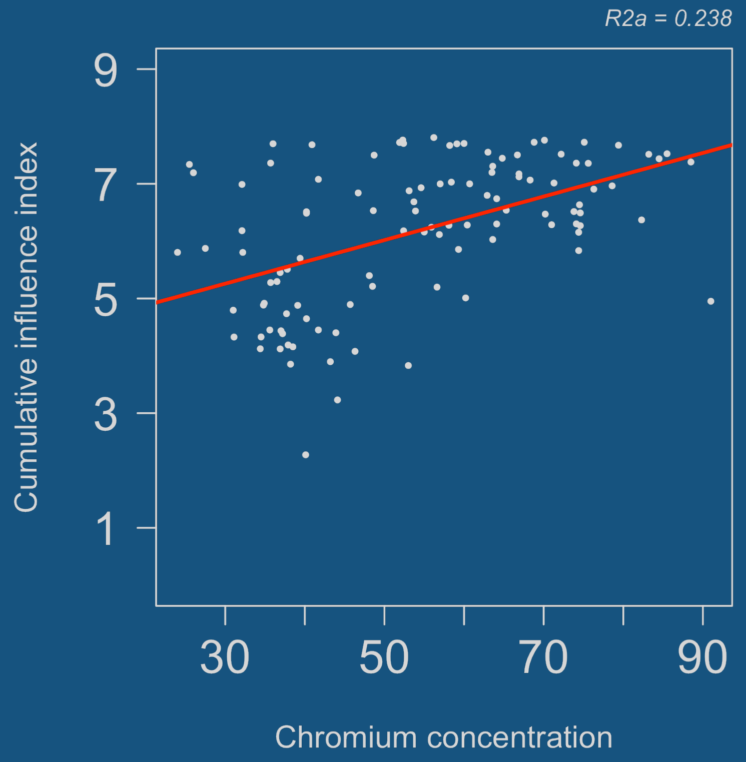


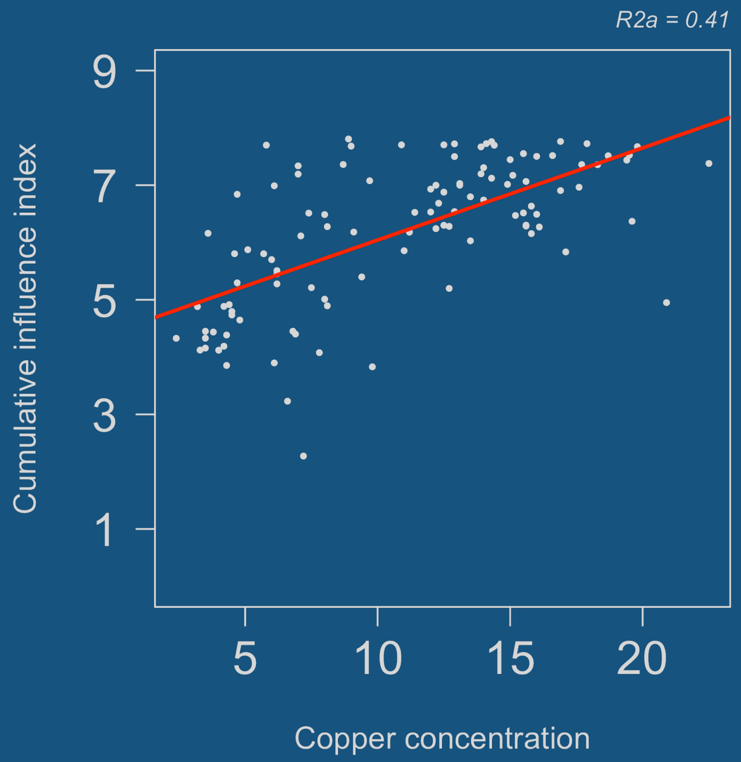
Links with abiotic parameters

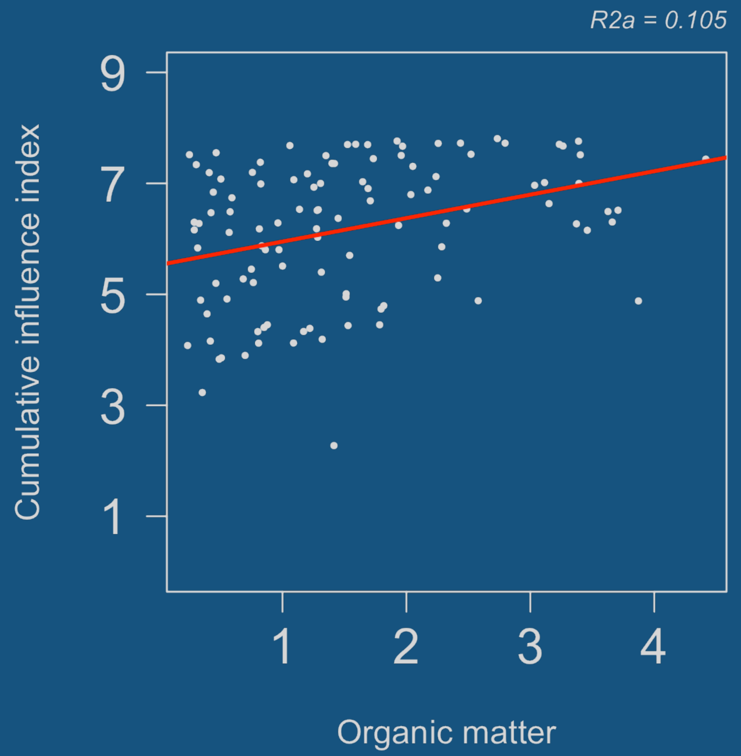


Highest correlation with metals concentrations

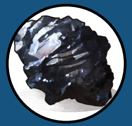

Low correlation with most habitat parameters







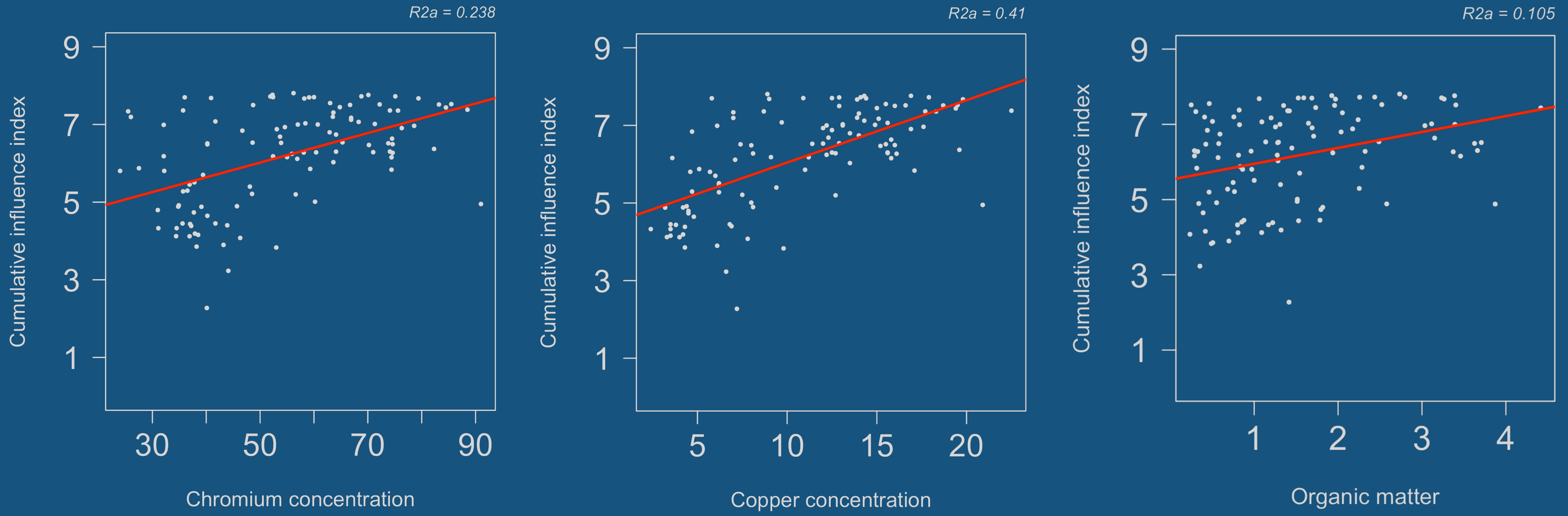
Links with abiotic parameters



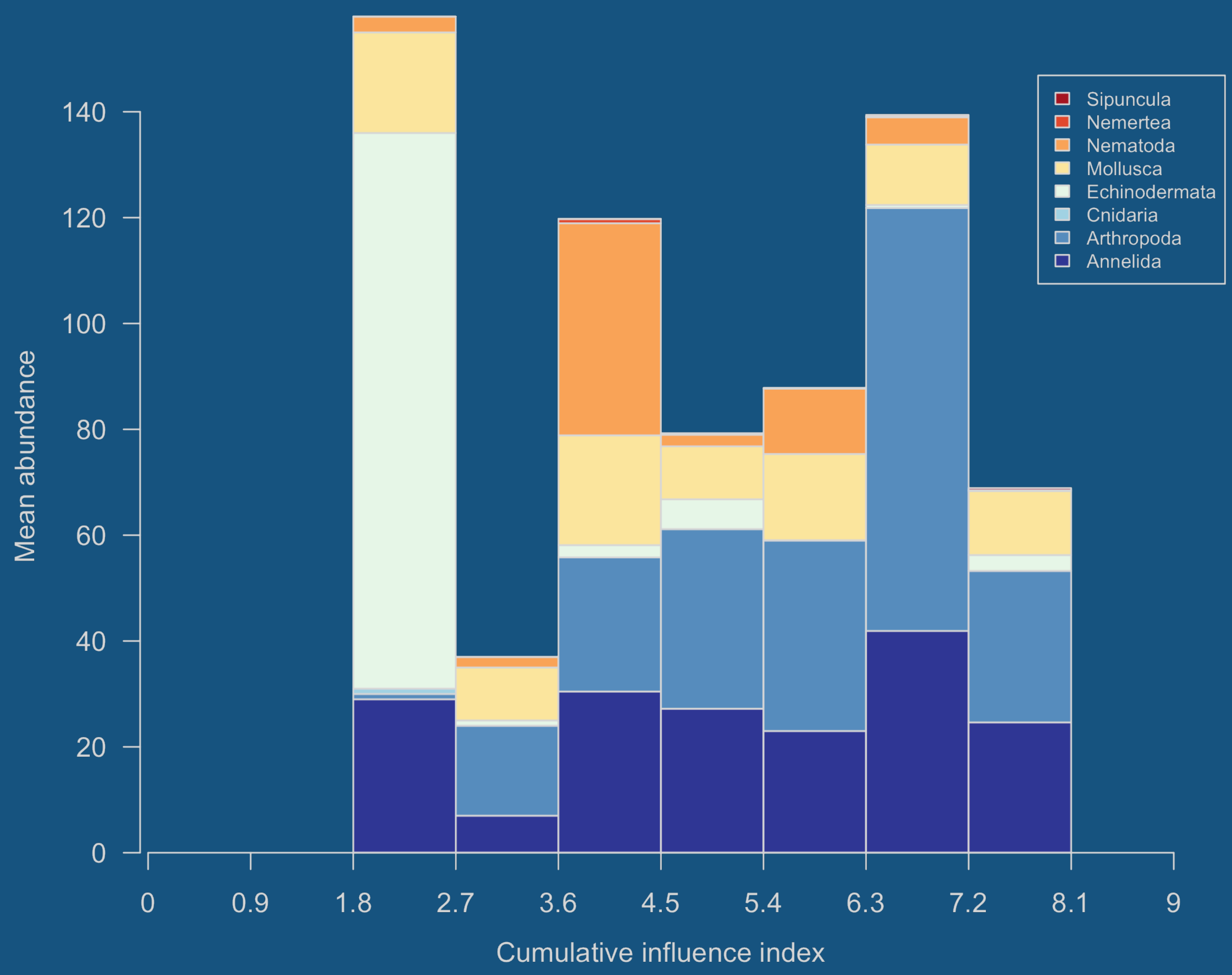
Highest correlation with metals concentrations ⟵ *Human activities?*

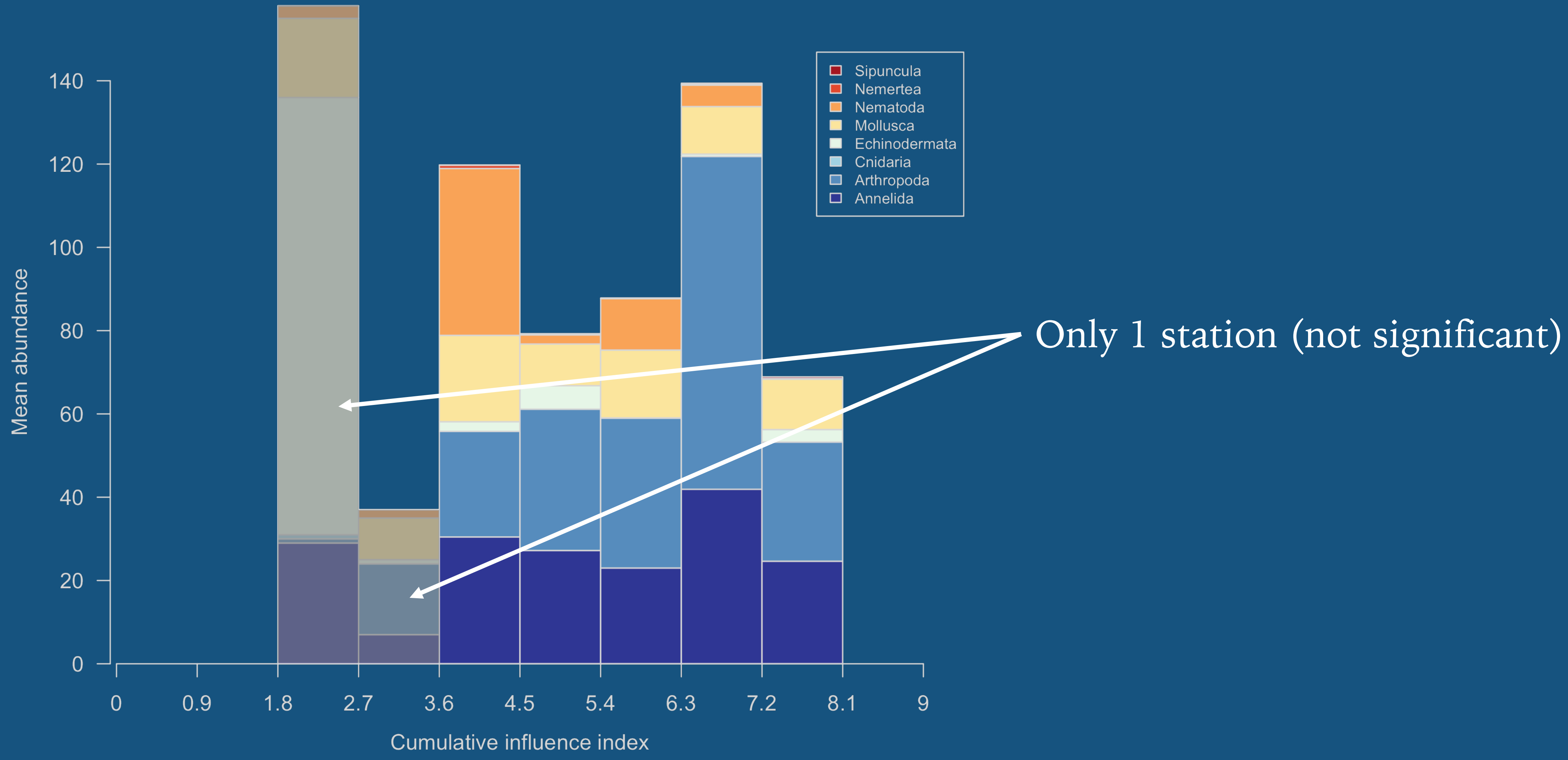
Low correlation with most habitat parameters



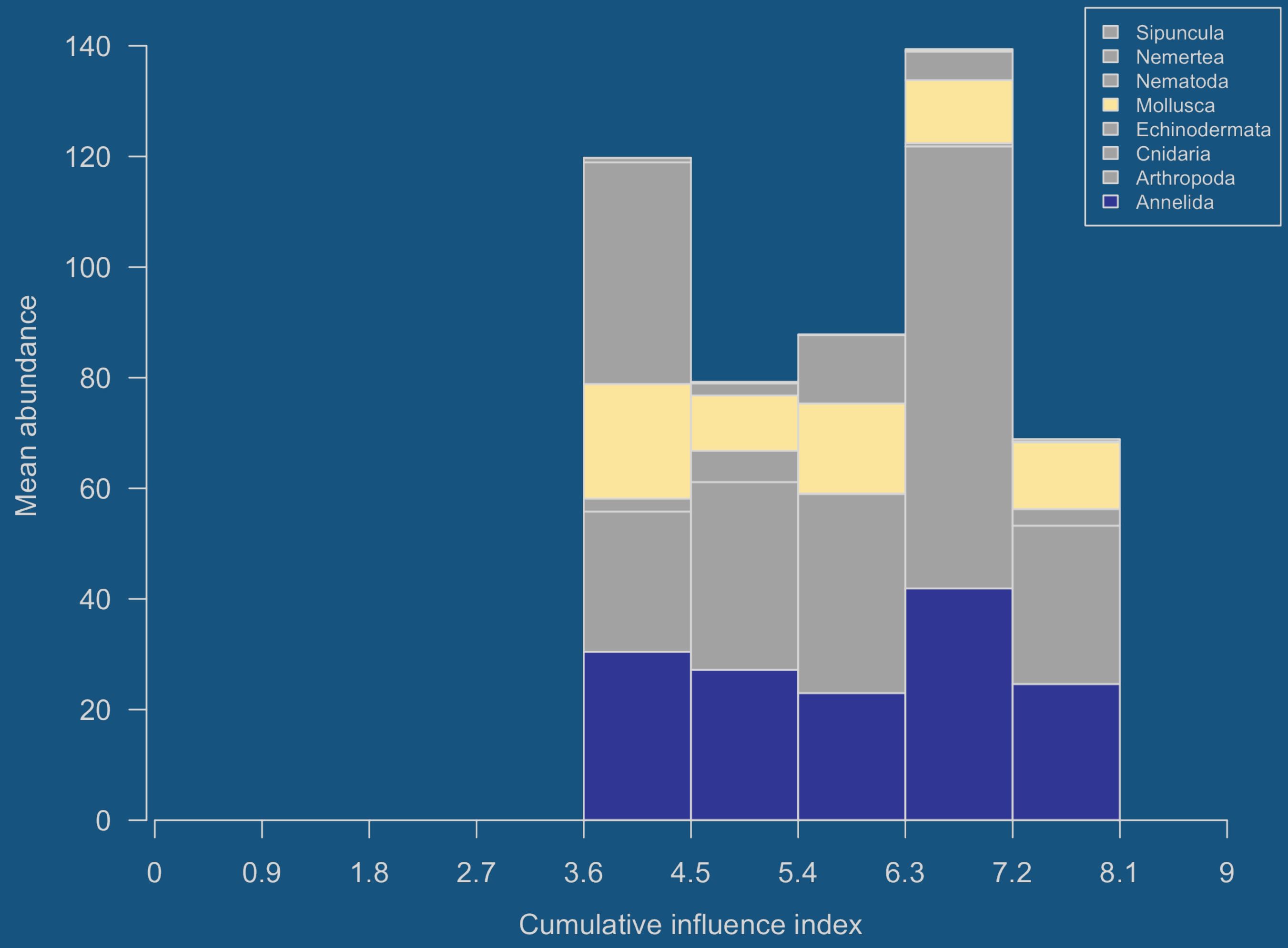
Links with benthic communities



Links with benthic communities

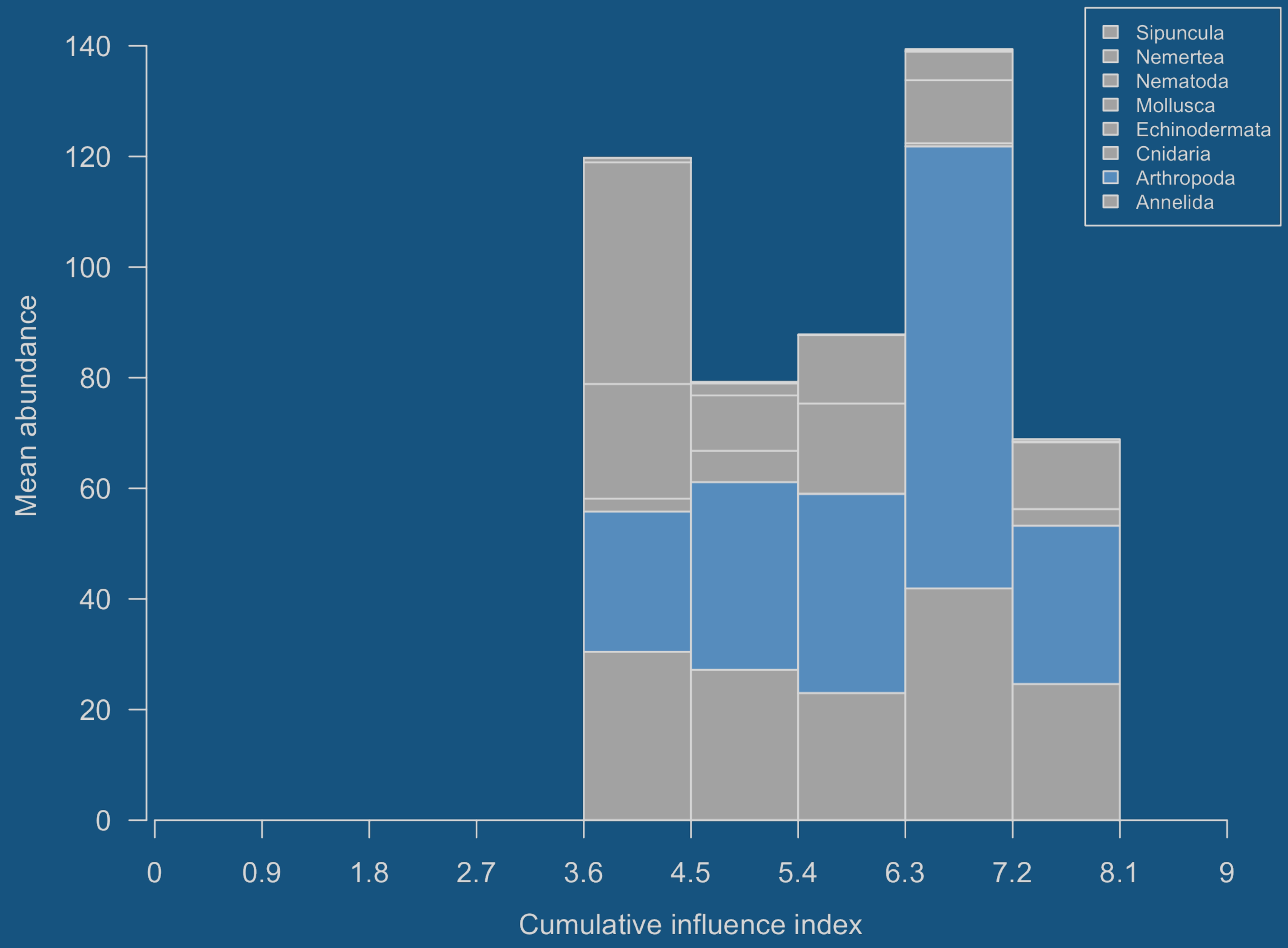


Links with benthic communities



No visible effects on annelids or molluscs

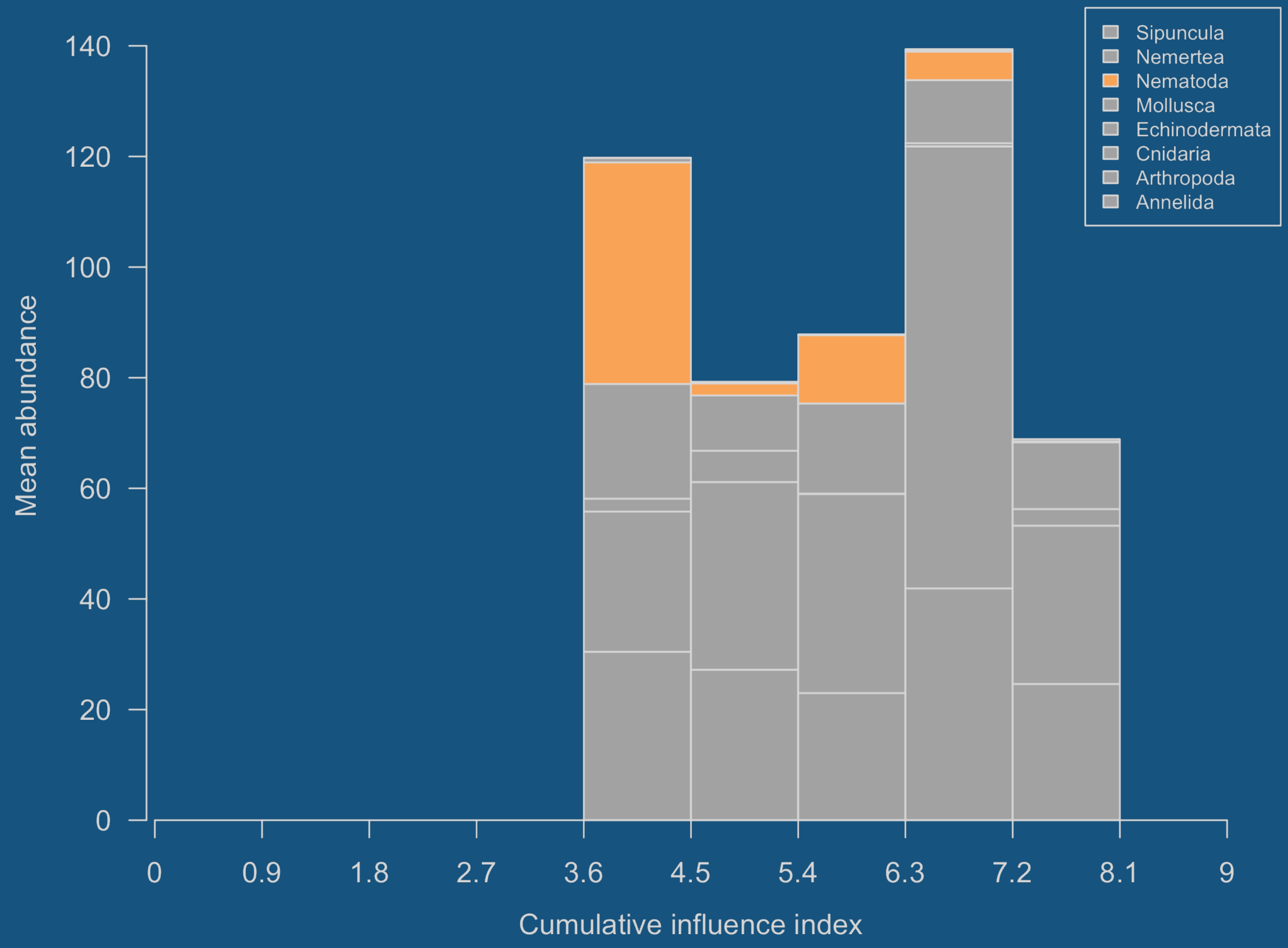
Links with benthic communities



No visible effects on annelids or molluscs

More arthropods with higher intermediate influence, then drops

Links with benthic communities



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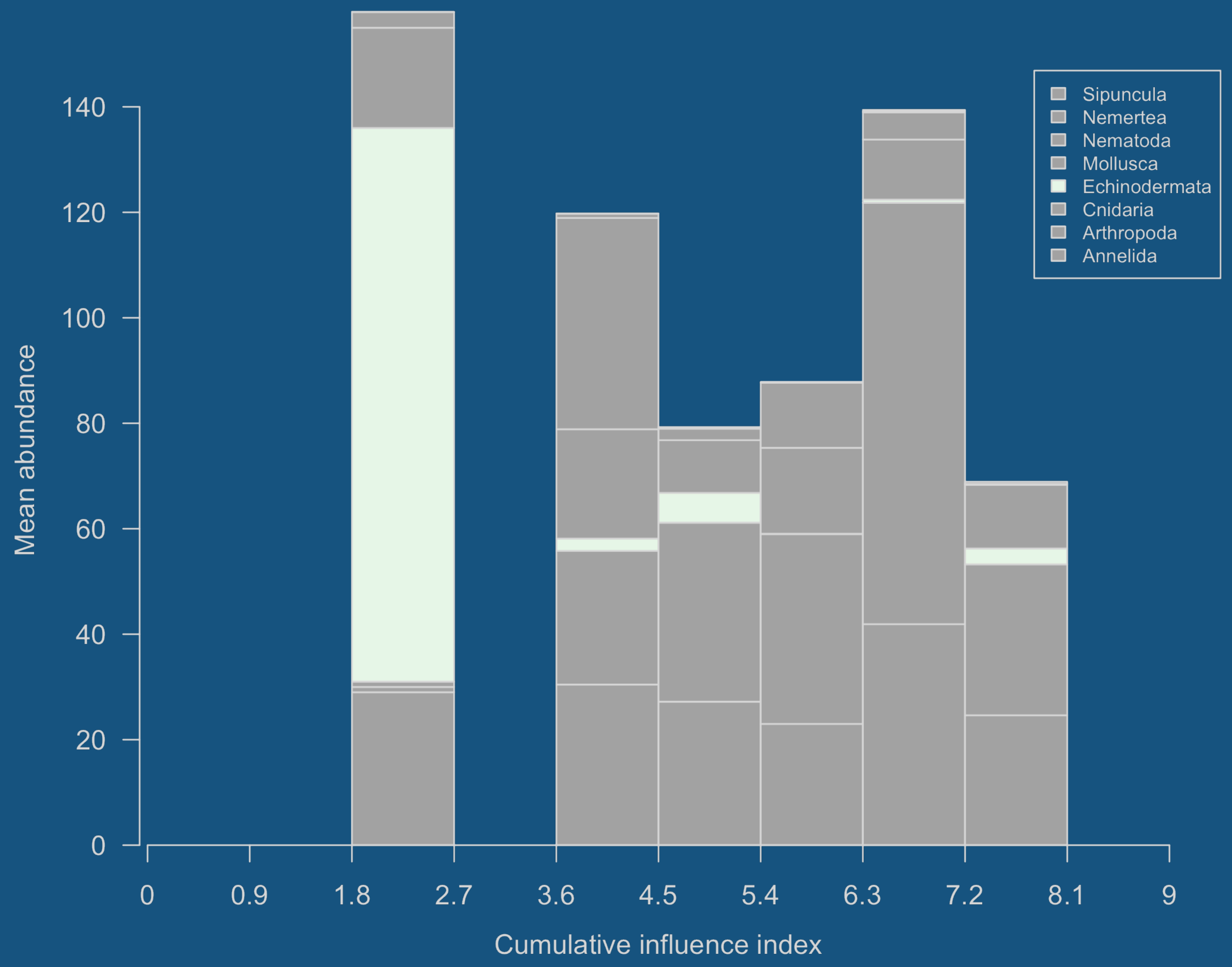
More arthropods with higher intermediate influence, then drops

More nematodes with moderate influence, then drops

Links with benthic communities



No visible effects on annelids or molluscs

More arthropods with higher intermediate influence, then drops

More nematodes with moderate influence, then drops

Echinoderms only with low influence?

To conclude:

- Development of an human influence score based on the activities' sources and the environment parameters

To conclude:

- ➢ **Development of an human influence score based on the activities' sources and the environment parameters**

- ➢ **The influence score can be linked to habitat and communities' responses :**
  - **correlations with organic matter and some metals**
  - **variation of phylum abundances**

Next steps…

- Increase representativity of the influence index with different particle models
- Add more human activities (e.g. fisheries)

Next steps…

- Increase representativity of the influence index with different particle models
- Add more human activities (e.g. fisheries)
- Use prediction techniques (like HMSC) to predict change under different human activity scenarios

Next steps...

- ➢ Increase representativity of the influence index with different particle models

- ➢ Add more human activities (e.g. fisheries)

- ➢ Use prediction techniques (like HMSC) to predict change under different human activity scenarios

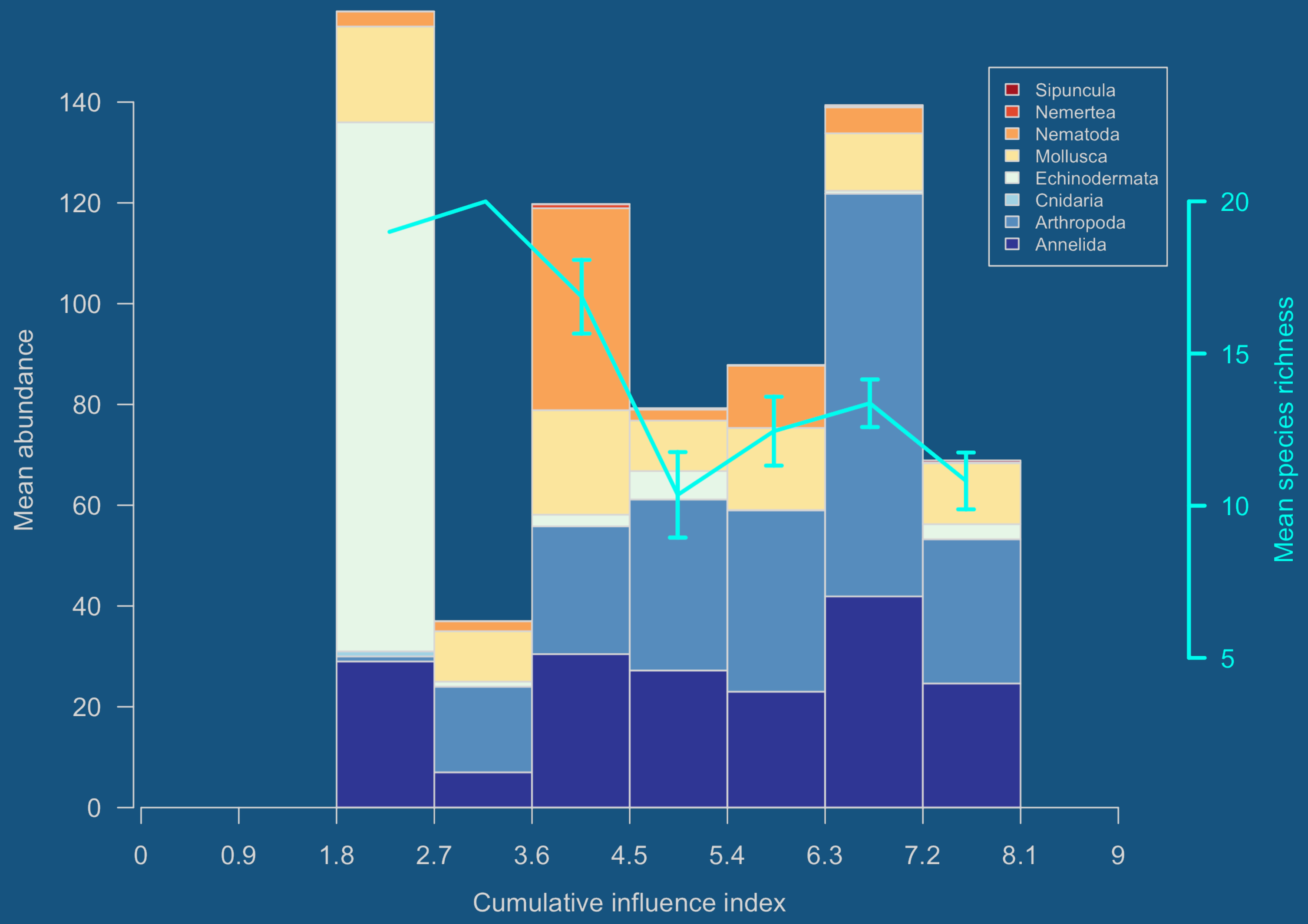
- ➢ Study different spatial scales (e.g. St. Lawrence)

This project is supported by NSERC program CHONe II and its Partners: DFO Canada and INREST (representing Port de Sept-Îles and Ville de Sept-Îles)

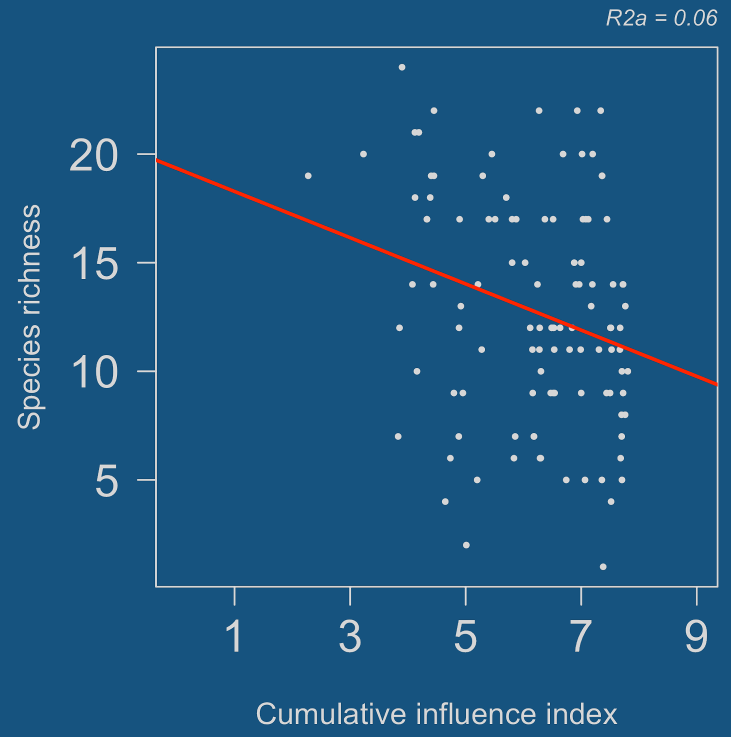
Thanks for your attention!

https://eldre.github.io

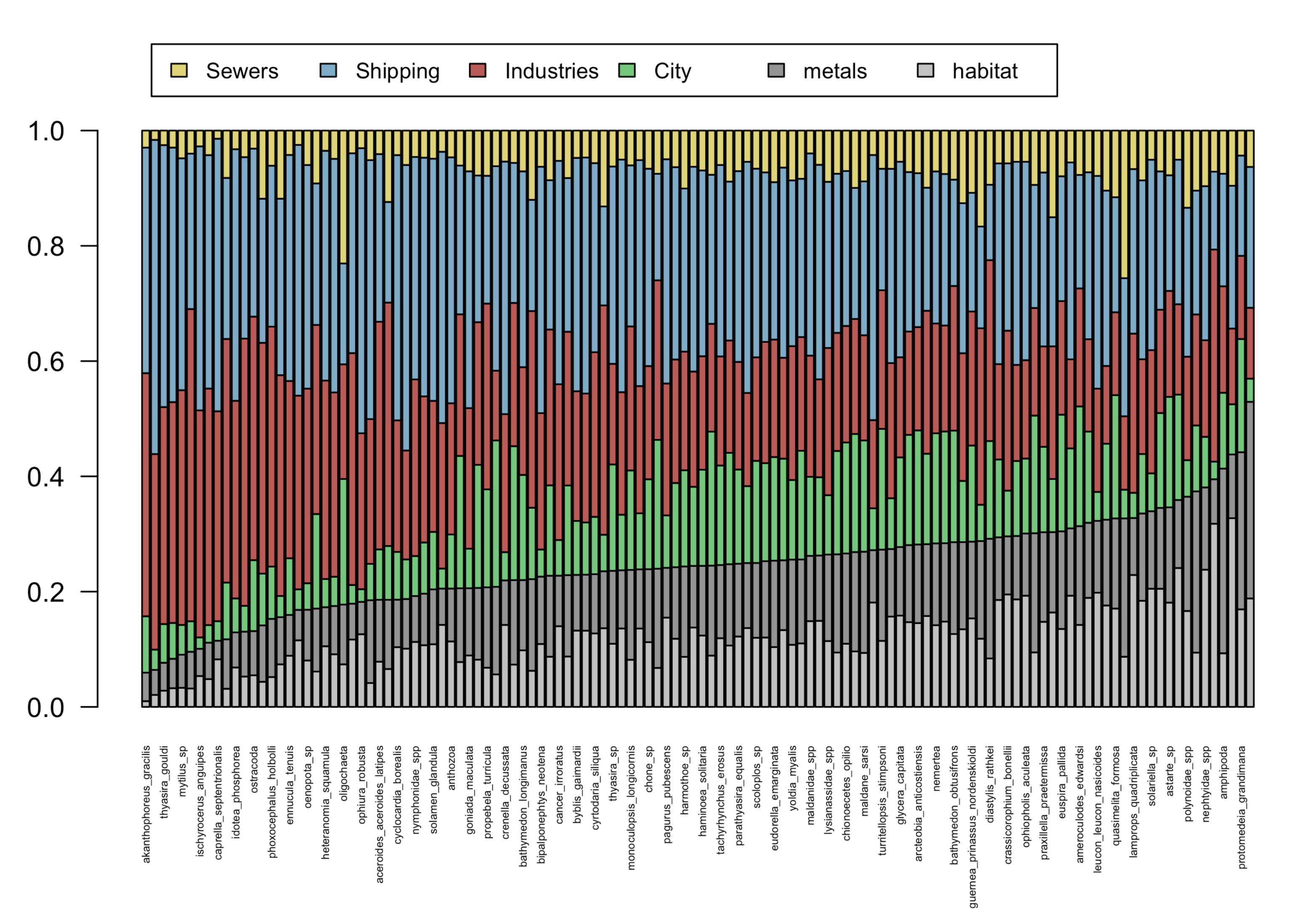
Links with benthic communities



Possible decrease of species richness along the cumulative influence score (low correlation)



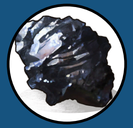
HMSC: variance partitioning



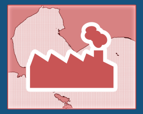
R^2 of 19.7 %

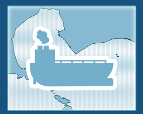
Mean species abundance variances explained by:

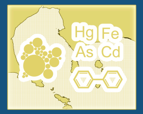
  12.1%

 12.4%

 12.3%

 24.7%

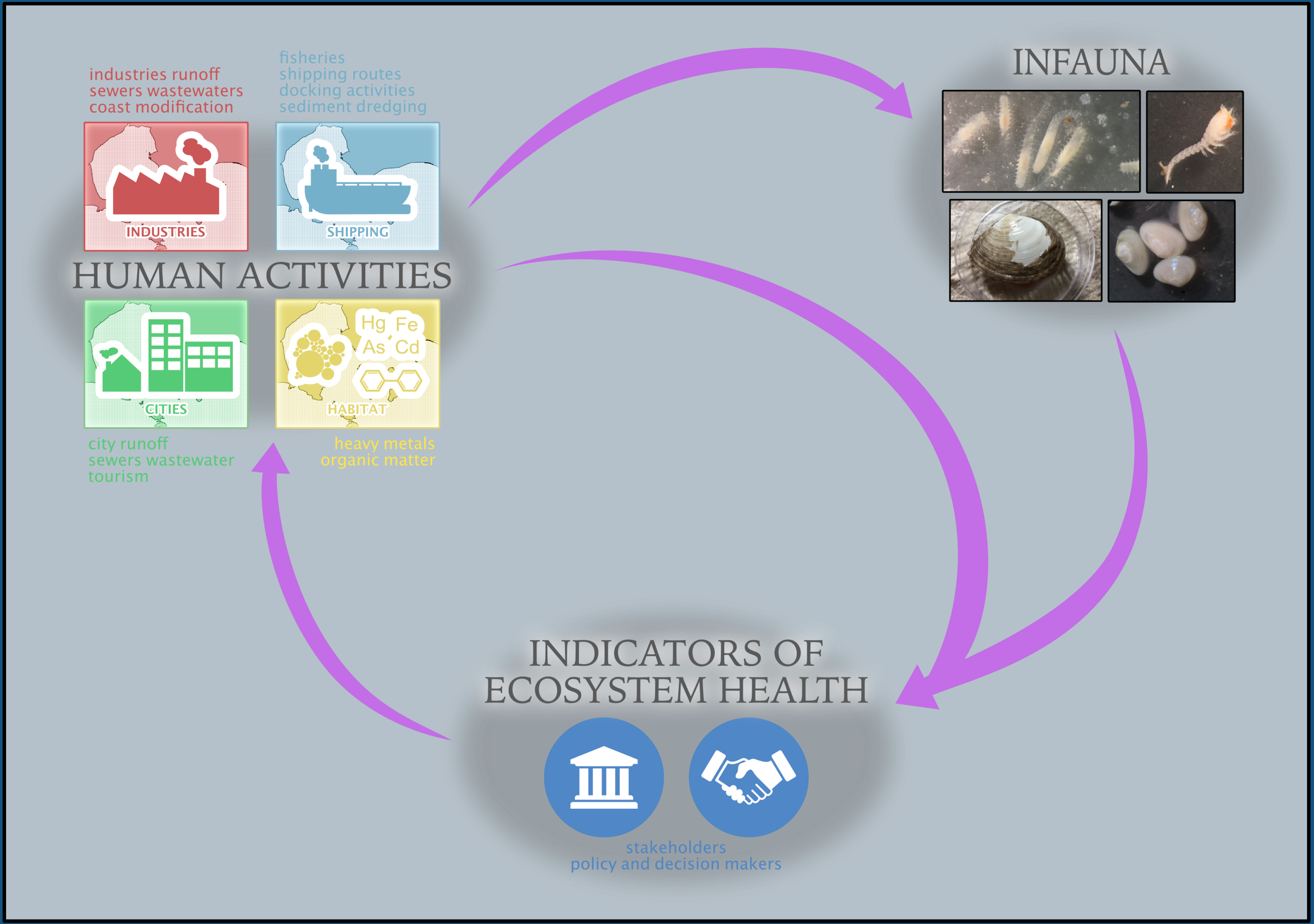
 31.4%



7.1%

Graphical abstract

Chapter 2



Chapter 1

Chapter 3