From benthic communities to multiple drivers – an integrated multi-approach study of the Baie des Sept Îles

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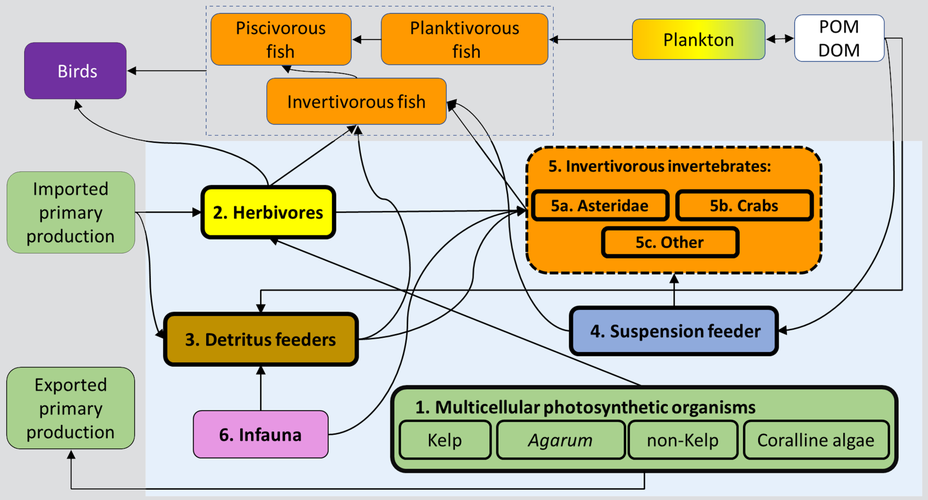

Figure 3: Proposed representation of ecological components and relationships for the coastal ecosystems in the Baie des Sept Îles. Components with bold borders have been selected to compute the Ecosystem-Based Quality Index.

EVALUATING

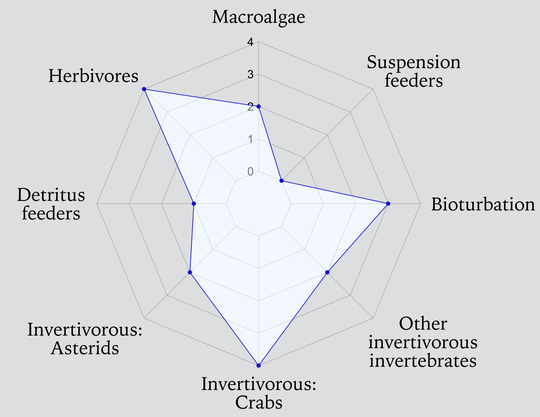

Figure 5: Example of the evaluation of ecological components at one site using the Ecosystem-Based Quality Index. Each component has a score from 0 (worst) to 4 (best) comparing sampled parameters to reference values obtained by literature review and/or expert opinion.

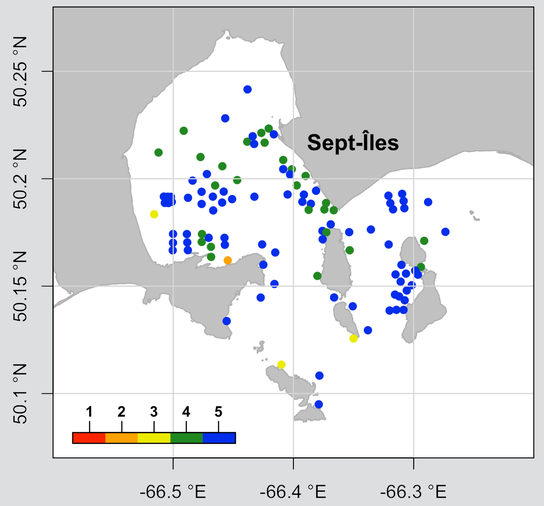

Figure 6: Determination of the environmental status for stations sampled in the Baie des Sept Îles from bad (1) to good (5) status, based on the multivariate AZTI Marine Biotic Index.

Characterize ecological components

- Coastal ecosystems are better characterized by considering their **interconnected components with holistic approaches** (Fig 3).
- An interesting example is the Ecosystem-Based Quality Index (EBQI), which focuses on **epifauna.** Its results can be complemented with the **infaunal communities**, which is known to **respond to human activities** (Fig 4).
- Improving knowledge of **how species respond to different environmental and anthropogenic drivers** is essential to develop and improve indices, by providing **reference levels** and **ecological responses** to individual and cumulative stress.

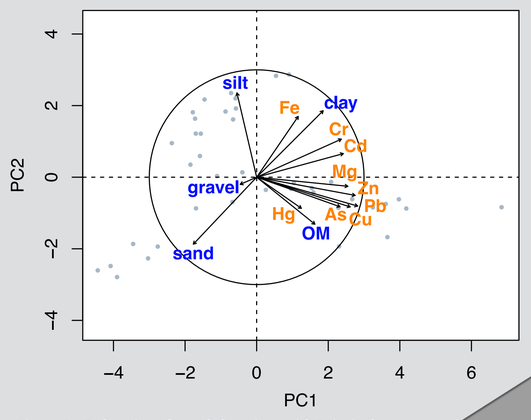

Figure 4: Ordination of sampled stations with Principal Component Analysis. Arrows represent the contribution of habitat parameters (blue) and heavy-metal concentrations (orange) to compute PC1 and PC2.

Assess the status of the environment

The Baie des Sept Îles, part of the provincial program "Plan Nord", hosts one of the largest deep water ports in North America. Many human activities (e.g. fisheries, ore transformation) occur in the bay, which can affect natural ecosystems and potentially modify services they provide. As coastal ecosystems rank among the most vulnerable ecosystems, benthic communities are an ideal marker of ecosystem status.

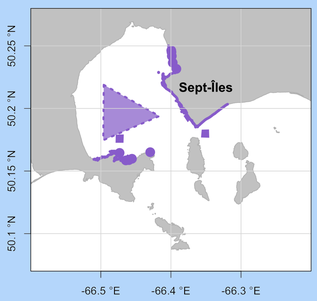

Figure 1: Sources of human activity identified in the Baie des Sept Îles.

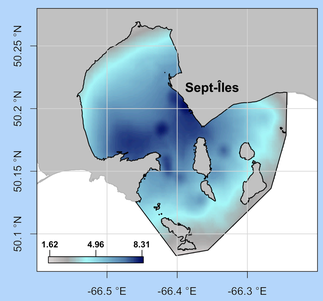

Figure 2: Values of the cumulative exposure index in the Baie des Sept Îles.

Here, we aim at integrating information on both benthic communities and potential drivers of impacts to monitor the ecosystem status and to identify management actions

- Assessing the status of **specific ecosystem components** can help understand global evaluations, in order to **highlight vulnerable systems** and **develop relevant management actions** (Fig 5).
- The multivariate AZTI Marine Biotic Index (m-AMBI) is frequently used in environmental assessements to detect **organic perturbation** based on the state of infaunal communities (Fig 6).
- **Biases** in assessments can arise due to the **definition of reference conditions** or the **criteria used to regroup species** with similar responses to stress.
- Indices such as the EBQI or the m-AMBI requires data from ***in situ* campaigns** and **experimental work** to test the behaviour and the physiological responses of organisms.
- More research is needed to be able to integrate **cumulative impacts** from multiple human activities, with both **additive and non-additive effects**.

TARGETING COMPONENTS

REFINING

INFORMING

TARGETING STRESSORS

Detect effects of multiple drivers

- Experimental approaches need to be designed based on **ecological components** that have been measured and evaluated on the field (Fig 7 & 8).
- It is possible to test the effect of environmental stressors on biological responses, based on different **individual responses**, **community responses**, **ecosystem functionning** and **services**.
- **Factorial designs** allow to interpert stressor interactions and to identify emerging effects such as **synergisms** and **antagonisms**. This can make environmental management adequate to the type of interaction between stressors.
- **Local-scale** management will benefit from experimental works and environmental assessments, in order to inform specific actions such as **mitigation** or **conservation**.

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Figure 7: Effect of combined stressors (salinity variation and nutrient enrichment) on mortality in Mytilus edulis. *Error bars represent the standard error.*

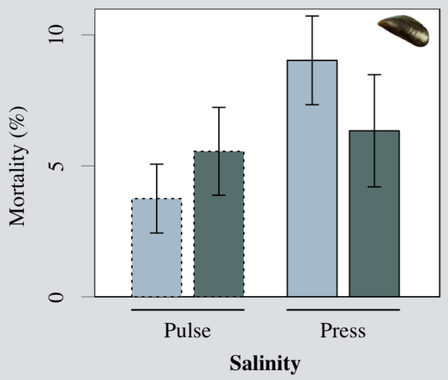
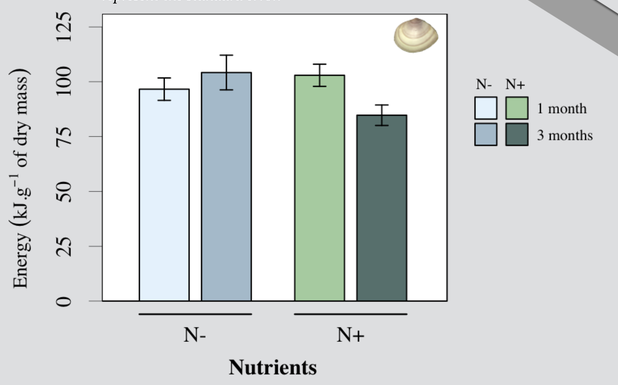


Figure 8: Effect of combined stressors salinity variation and nutrient enrichment) through time (1 month and 3 months of exposure) on energy content in the tissues in Limecola balthica. *Error bars represent the standard error.*



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