Additive and antagonistic effects of multiples disturbances and stresses on benthic eelgrass communities

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Context and Objectives

Many ecosystems are facing environmental changes and anthropogenic pressures that may affect communities in terms of structure and/or function. Disturbances and stresses are commonly co-occurring in nature. However their interactions are generally considered as being additive without knowing the true *in situ* effects. The presence of structuring species may play a major role in the effects that disturbances will have on communities. The inclusion of multiple disturbances and stresses in field experiments, to assess their potential interactive effects, will help disentangle the mechanisms structuring communities following disturbances.

AIM: measure the response of macrobenthic assemblages dominated by eelgrass (*Zostera marina*) facing multiple disturbance and stresses (canopy reduction, light reduction and sediment nutrient enrichment)

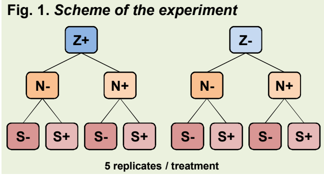
Methods

Eelgrass density – 80 % reduction in **Z-**

Sediment enrichment – 75 g N m^{-2} in **N+**

Shading – 70 % reduction PAR in **S+**

Fig. 1. *Scheme of the experiment*



Experiment:

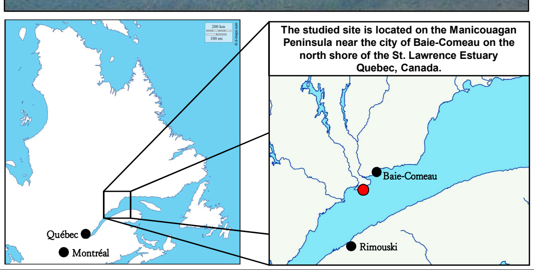
- Treatments were applied in 1 x 1 m plots and all measures were taken in their centers
- Experiment took place from early July to mid-September 2015
  - Week 0: density reduction
  - Week 2: shading + enrichment added, first community sampling
  - Week 5: shading removed (19 days), second community sampling
  - Week 10: end of the experiment, last community sampling

Variables measured:

- Abundances: number of individuals collected with mesh bag (200 µm; 18 cm diameter)
- Community indices were calculated based on the number of individuals / *Zostera* dry mass
- *Zostera* density was measured three times : before, at week 5 and at week 10
- *Zostera* relative growth was evaluated once from weeks 2 to 5 during shading

A total of 29 invertebrates and 3 fishes taxa were identified:

5 gastropods, 5 bivalves, 2 mysids, 1 shrimp, 8 amphipods, 3 isopods, 4 polychaete and 1 crab



Acknowledgments

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Results

Single effect of density reduction

Bars with asterisk or different letters are significantly different (p<0.05)

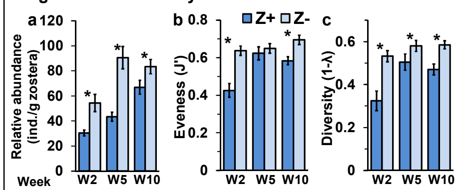


Fig. 2. Average values (±SE; n=20) of invertebrates relative abundance (nb. of individuals/DW zostera (g)) **(a)**, Pielou's evenness (J') **(b)**, and Simpson's diversity (1-λ) **(c)** for eelgrass density reduction treatment 2, 5 and 10 weeks after starting the experiment.

Z+ density 100%; Z- density 20%

Density reduction increased abundances, evenness, diversity and eelgrass relative growth (fig. 8)

There were more periwinkles, isopods and amphipods when density was reduced

Single effect of sediment nutrient enrichment or shading

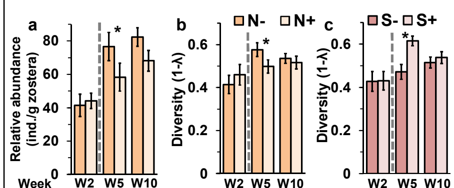


Fig. 3. Average values (±SE; n=20) of invertebrates relative abundance **(a)** and Simpson's diversity (1-λ) **(b-c)** for sediment enrichment **(a-b)** and shading **(c)** treatments before (W2), 3 (W5) and 8 (W10) weeks after applying the treatment (dash line).

N- no enrichment; N+ enriched

S- natural light; S+ light reduced

Enrichment decreased abundances, diversity and richness (fig. 5)

Polychaeta and bivalves being affected the most

Shading increased diversity and evenness and decreased eelgrass density (fig. 7) and relative growth (fig. 8)

Generally amphipods and isopods were more abundant under shading

Multivariate results

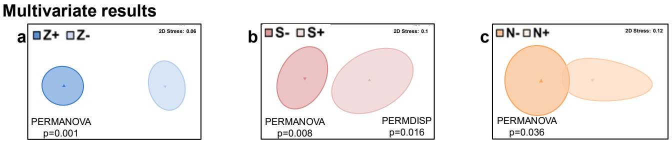


Fig. 4. nMDS of estimate 95% region of bootstrap averages (n=150) from replicates (Bray-Curtis; dispersion weighted and square-root transformed) of control and **(a)** density reduced plots (week 10), **(b)** enriched plots (week 5), and **(c)** shaded plots (week 5). Bootstrapping performed in m=10 dimensional nMDS space.

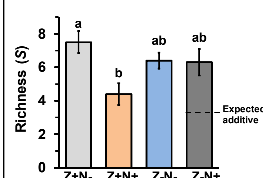
Density reduction affected community structure over the course of the entire experiment (10 weeks).

Enrichment and shading individually affected community structure after 3 weeks (week 5) but the effects disappeared by week 10.

For details see single effect results in Fig. 2 and 3.

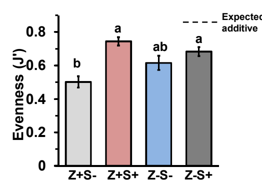
Interaction effect on community indices – week 5

***Zostera* density reduction compensated the loss in richness by enrichment and the decreasing in dominance by shading**



Antagonistic effect of density reduction and enrichment on richness

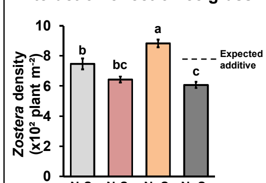
Fig. 5. Average values (±SE; n=10) of invertebrates richness (*S*) for the interaction of eelgrass density reduction (Z-) and enrichment (N+) treatments.



Antagonistic effect of density and shading on evenness

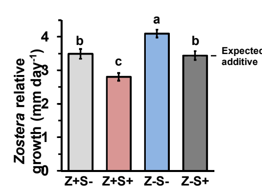
Fig. 6. Average values (±SE; n=10) of invertebrates Pielou's evenness (*J'*) for the interaction of eelgrass density reduction (Z-) and shading (S+) treatments.

Interaction effect on eelgrass measures –week 5



Antagonistic effect of enrichment and shading on eelgrass density. The increased density by enrichment was cancelled by shading

Fig. 7. Average values (±SE; n=10) of eelgrass density for the interaction of enrichment (N+) and shading (S+) treatments.



Additive effect of density reduction and shading on relative growth

Fig. 8. Average values (±SE; n=10) of eelgrass relative growth (mm day^{-1}) for the interaction of eelgrass density reduction (Z-) and shading (S+) treatment.

Conclusions

- **Eelgrass density reduction affected community characteristics through time.**
- **Twenty days were enough to induce a community response to the sediment enrichment and shading, though the effects were gone 5 weeks later. This demonstrated a potential of resilience of the eelgrass system.**
- **Antagonistic effects between treatments were observed on community indices and eelgrass density.**
- **Our results suggest that eelgrass bed can be resistant to multiple disturbances and stresses as no effect was observed on measured variables from the community and plant when all our treatments were applied.**

Our results show the importance of field experiments that include multiple disturbances and stresses and their interactions in order to estimate the impacts on community assemblages and the fact that interactions are not always additive and therefore impossible to predict.