Stronger top-down trophic interactions in summer vs. winter drive altered seagrass community responses to marine heatwaves

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Background:

- Marine heatwaves (MHWs) are **anamolous warming events** above the regional seasonal 90th percentile for 5 or more days.
- By affecting species interactions, MHWs have the ability to drive **trophic alterations**, such as through **top-down** (grazer to 1° producer), **bottom-up** (1° producer to grazer) and **indirect effects** in seagrass meadows.
- However, there is **little empirical testing** of MHW impacts on multiple levels of organisation in seagrass meadows and in different seasons.

Research Questions

1) How does the seagrass *H. ovalis* physiologically respond to summer and winter MHWs?

2) Does this affect the seagrass' nutrient content and the growth of epiphytes?

3) How are grazers affected by a MHW and is this driven by top-down or bottom-up alterations?

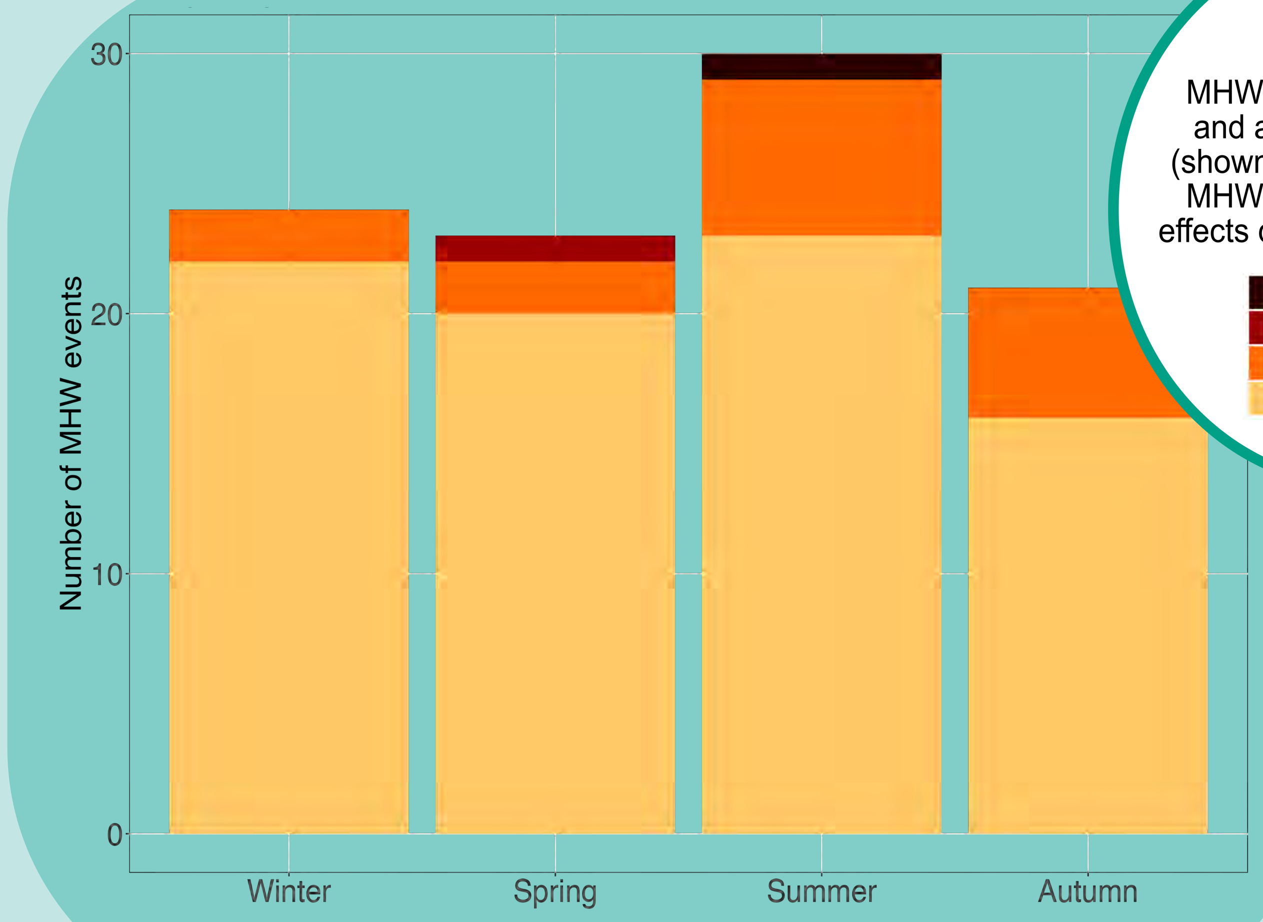


Figure 1: Number and severity of marine heatwaves in Hong Kong 1982-2023

MHWs occur in all seasons and at varying severities (shown in different colours). MHWs can exert different effects depending on season.

- IV Extreme
- III Severe
- II Strong
- I Moderate

Top

<u>*Batillaria zonalis*</u>

Herbivore that grazes on epiphytic algae which grows on the seagrass shoots/ leaves. Can indirectly affect seagrass

<u>Epiphytic algae</u>

Food for *B. zonalis*

Grows on seagrass shoots

Can affect seagrass' access to light, alter gas exchange, but can increase total net primary productivity

<u>*Halophila ovalis*</u>

Foundation species, habitat former and a substrate for epiphytic algae

Bottom

Figure 2: Representation of the community interactions

Methods:

- *H. ovalis* and *B. zonalis* were collected from Tung Chung Bay (N22º17.10' E113º55.60').
- Seagrass was planted into 20 tanks and exposed to control or MHW temperature for 10 days. Grazers were added to half of the tanks.
- Experiment carried out in two seasons: summer 2022 and winter 2023.

Measurements

- Seagrass growth, biomass, C and N content and stable isotope signatures
- Epiphyte biomass
- Grazer biomass, grazing rate

1. Collection → 2. Sort, transplant & start measurements → 3. 10 day experiment → 4. End measurements

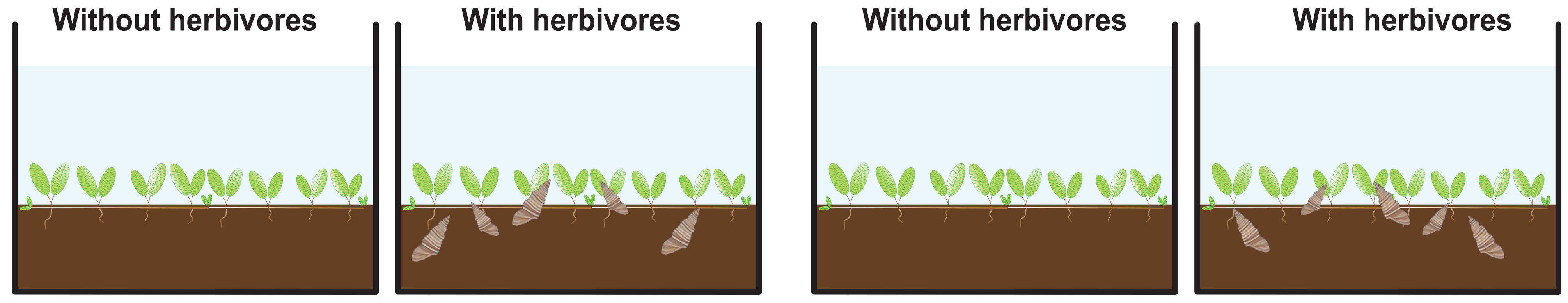
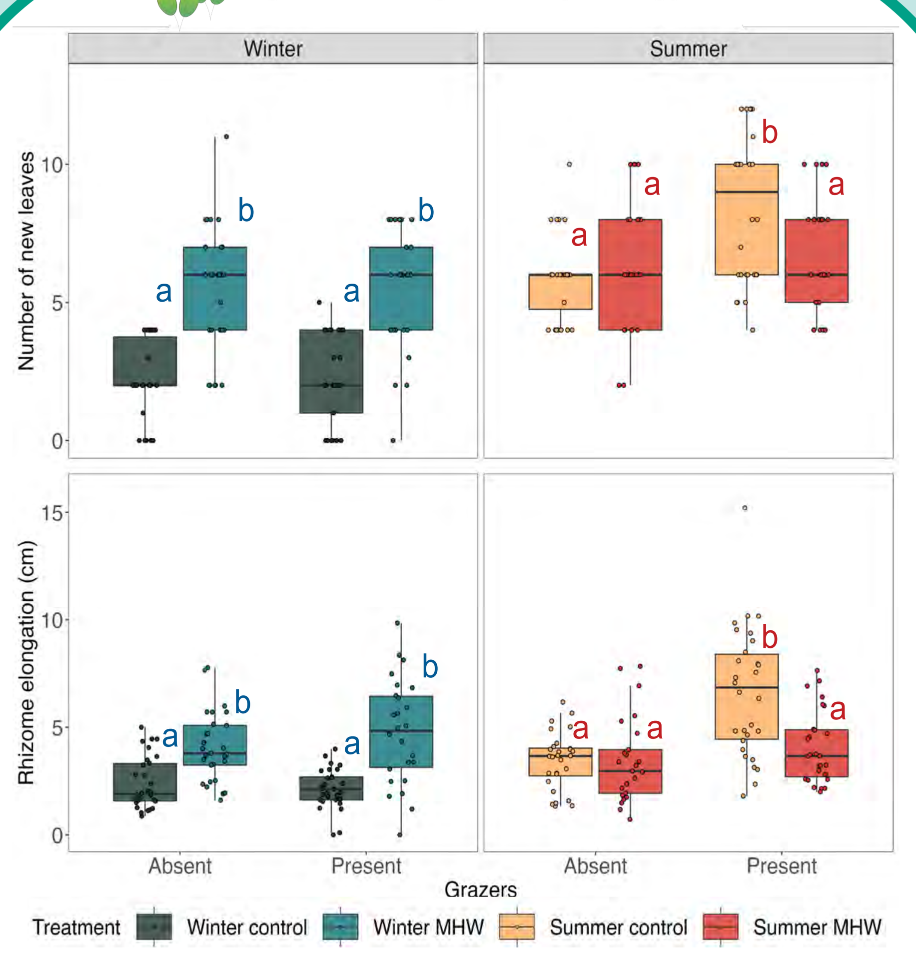


Figure 3: Experimental design, lasting for 10 days + 4 days for acclimation. N = 5 replicate tanks per treatment

Results:

Separate statistical analyses were performed for each season and response variable. Letters indicate significant differences for each season (in different colours).

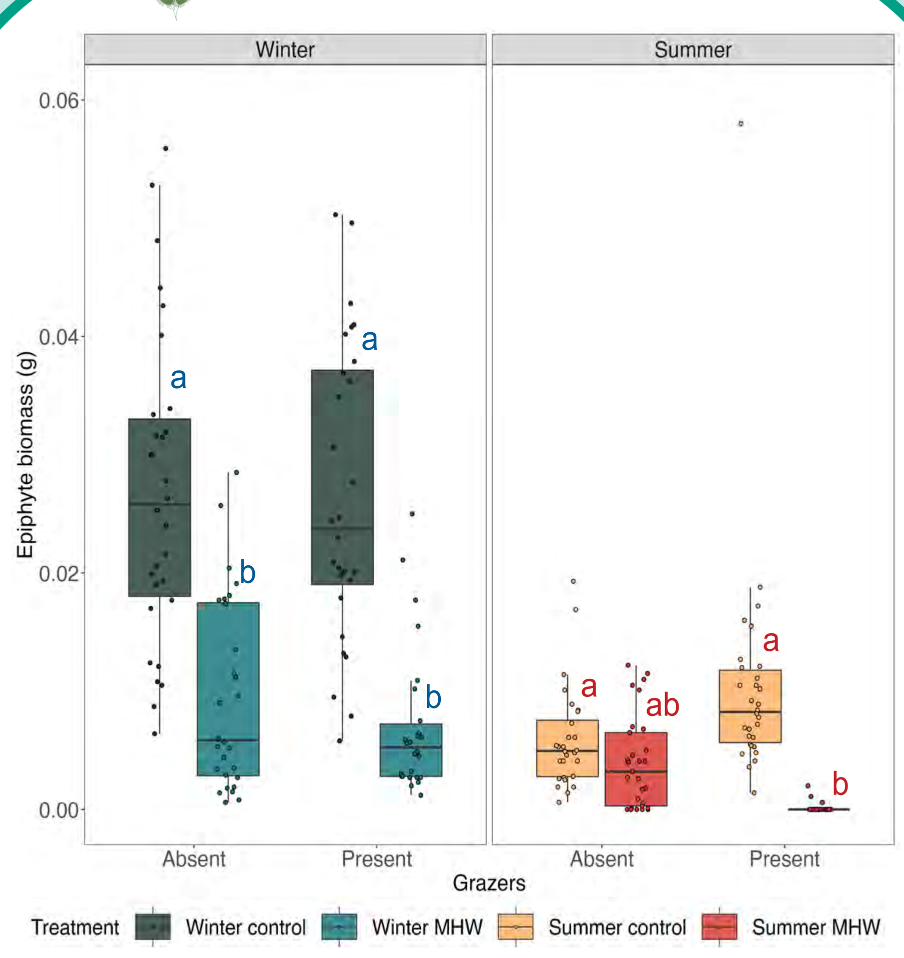
Figure 4: Seagrass physiology



Winter: The MHW treatment boosted seagrass growth, i.e. leaf production as well as rhizome elongation. Grazer presence had no effect on seagrass growth.

Summer: Growth was highest at control temperature, with grazer presence. No increased growth under MHW, unlike in winter.

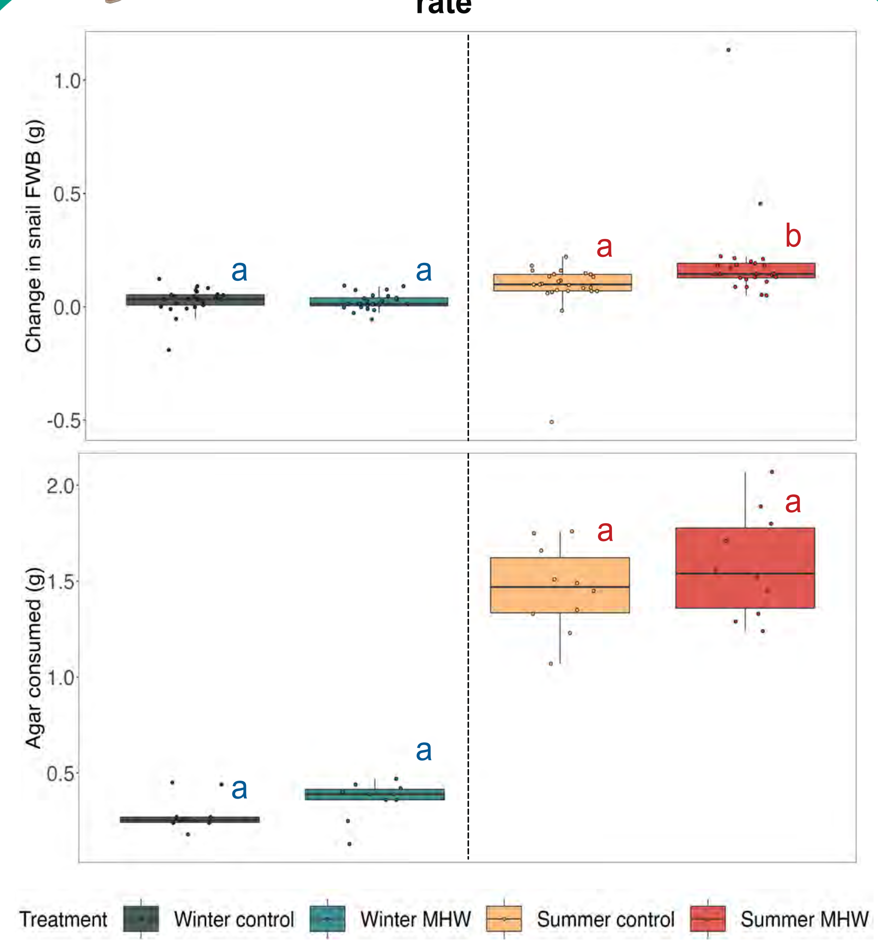
Figure 5: Epiphyte biomass



Winter: The MHW treatment led to less epiphytic algal growth on seagrass leaves. There was a trend towards further decreases with grazer presence.

Summer: There was a strong interactive effect of grazer presence and MHW temperature, causing little epiphyte growth.

Figure 6: Grazer biomass & Grazing rate



Winter: There were very weak grazer responses of snail biomass and grazing rate to MHW treatment.

Summer: Snail biomass increased with MHW treatment, and there was a trend towards increases in grazing rate (i.e. agar consumed in six hours).

Conclusion:

From this study, we see that **the season in which the marine heatwave occurs**, as well as **the heatwave** itself, can **affect the strength of species interactions.** In winter, increased temperature (driven by the MHW) had strong positive effects on seagrass growth and strong negative effects on epiphytic algae growth. However, the change in temperature did not affect grazers or their ability to elicit strong top-down trophic responses. In summer, the increased temperature did not drive changes to seagrass growth as in winter, however the **presence of grazers** boosted the seagrass growth under ambient temperature conditions. For epiphytic algae growth, patterns were similar between seasons, but there was a stronger interaction in summer between grazer presence and increased temperature leading to decreased epiphyte growth. This correlated with increased snail biomass and slight increases in grazing rate. For **future projects**, I hope to examine whether shifts in trophic interactions are **driven by fine-scale processes**, such as microbiome shifts.

References

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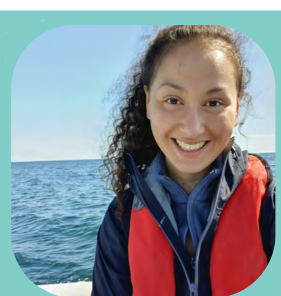

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