Ecophysiological responses of marine macrophytes to simulated heatwaves

Two studies on seagrasses and kelps

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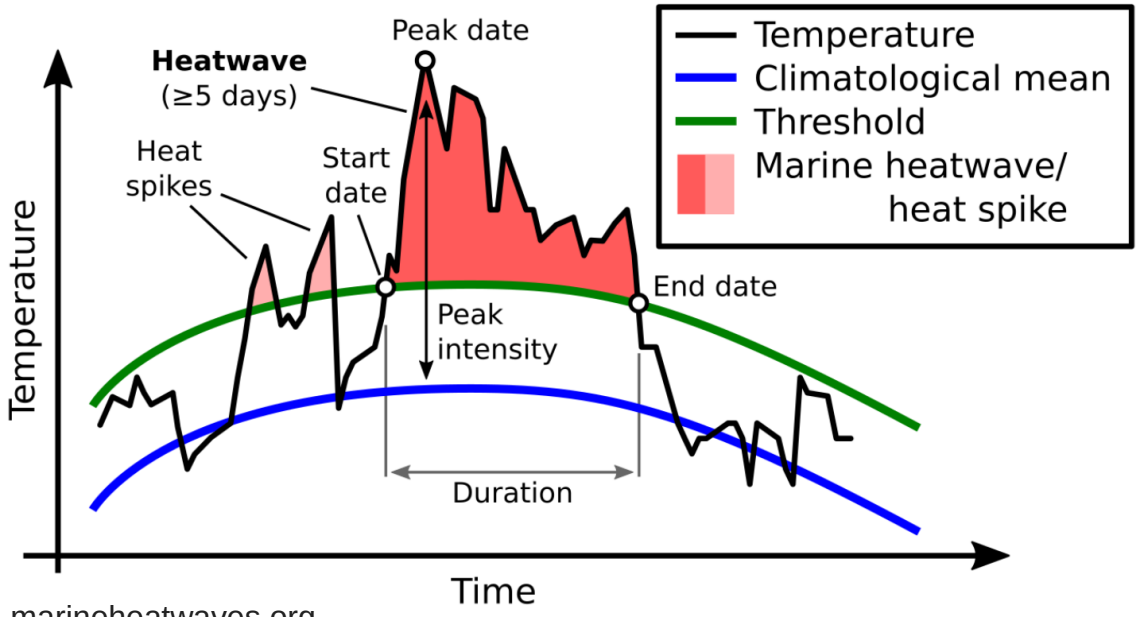
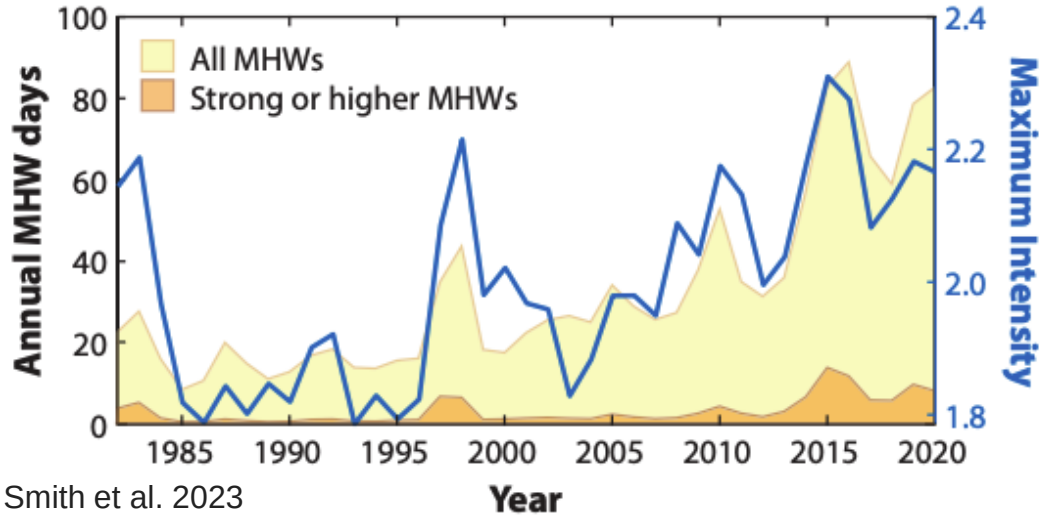
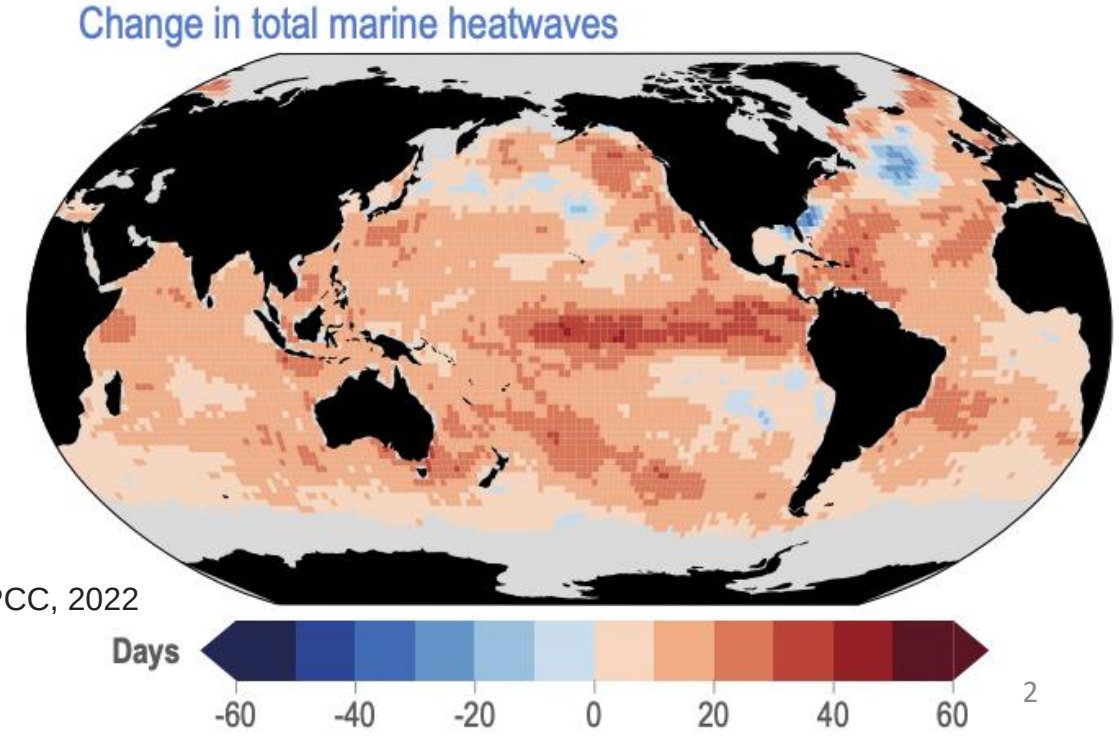
Marine Heatwaves



marineheatwaves.org



Smith et al. 2023



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Effects on foundation species

- Driving collapse of kelp forests globally
- Decrease in seagrass density
- May lead to loss of biodiversity, ecosystem function losses or even ecosystem collapse

Study 1: Effects of MHW on two *Halophila* seagrass species – Bass & Falkenberg, in rev. *Oecologia*

Study 2: Effects of MHW and light limitation on three *Laminaria* kelp species – Bass, Smith & Smale, in rev. *J. Phycol.*

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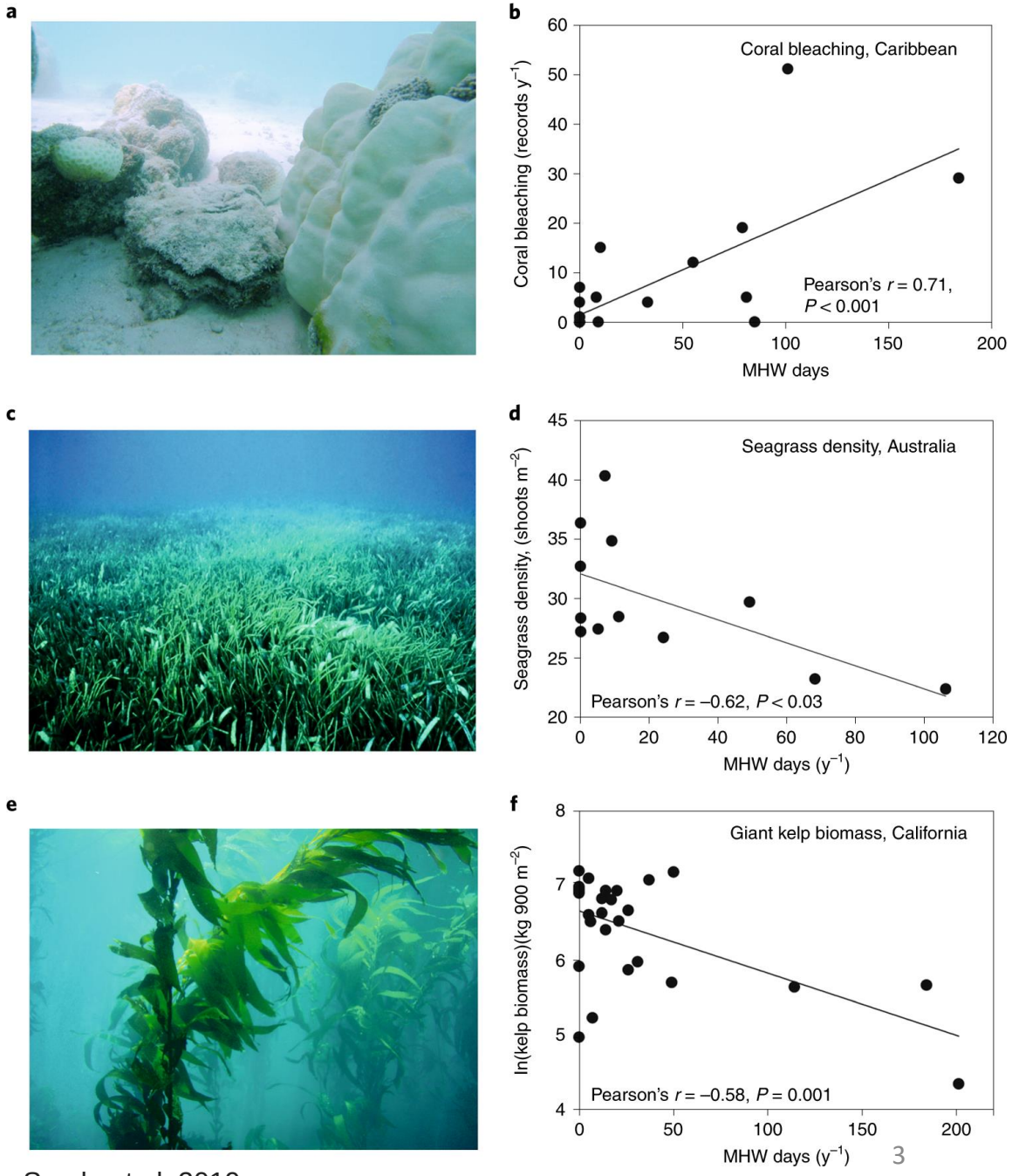
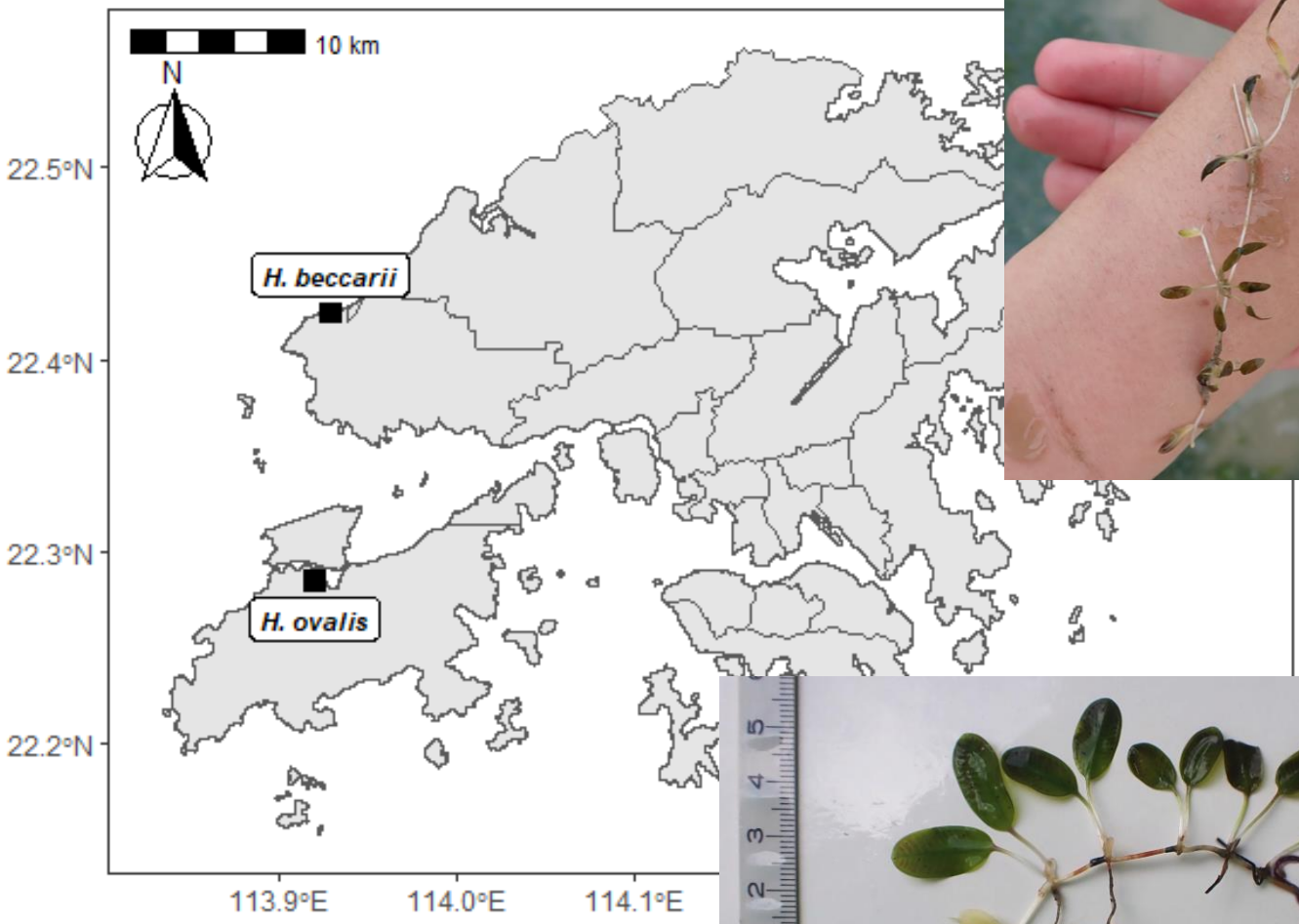


Smale et al. 2019

Study 1

Objectives

- Investigate the vulnerability or resistance of two tropical seagrasses to a spring marine heatwave
- Identify the parameters of seagrass growth and morphology that are the most affected by a marine heatwave
- Consider if there is a difference in responses between seagrass species



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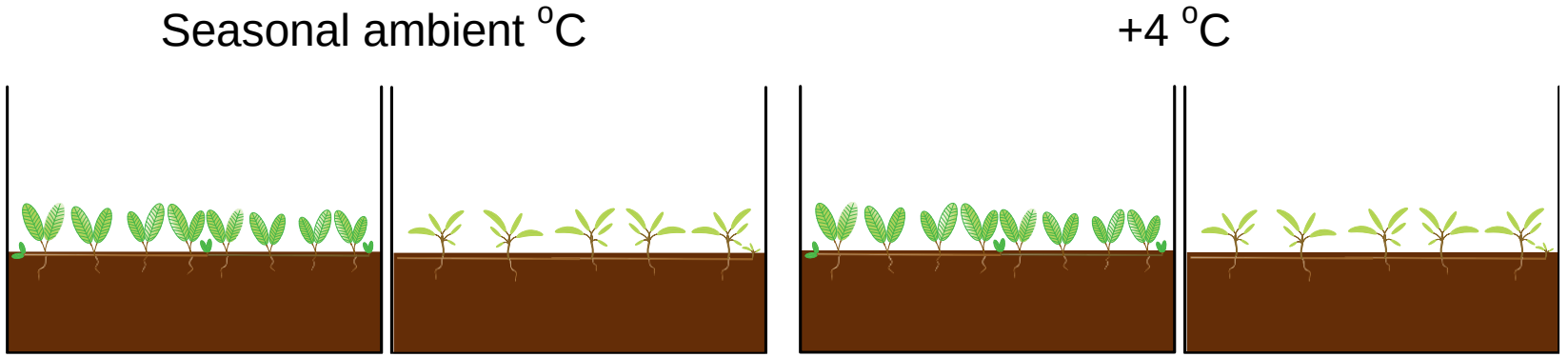
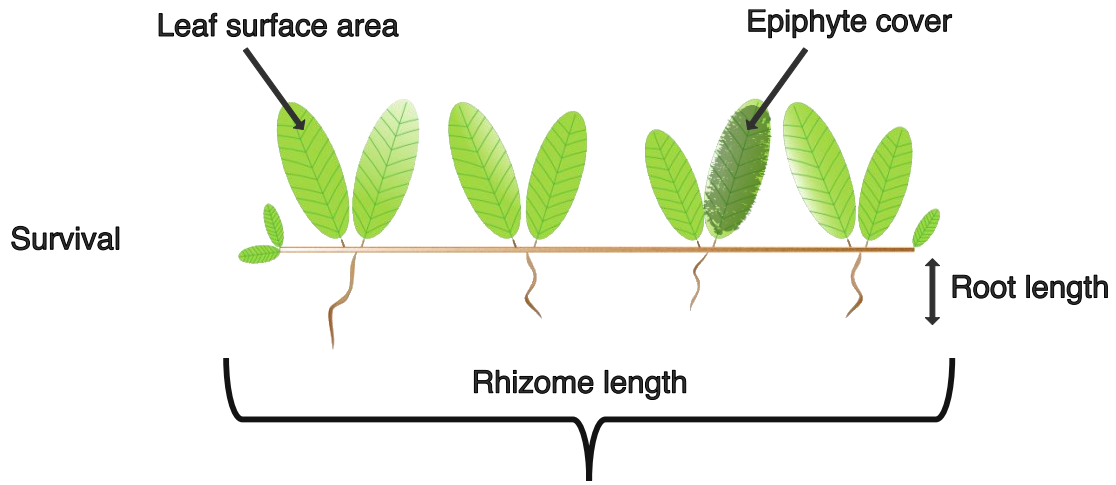
Experimental Design

- Two temperature treatments
- Six ramets for each tank (5 replicates)
- 10-day MHW with 4-day ramping
- Growth
- Biomass
- Epiphyte cover and biomass





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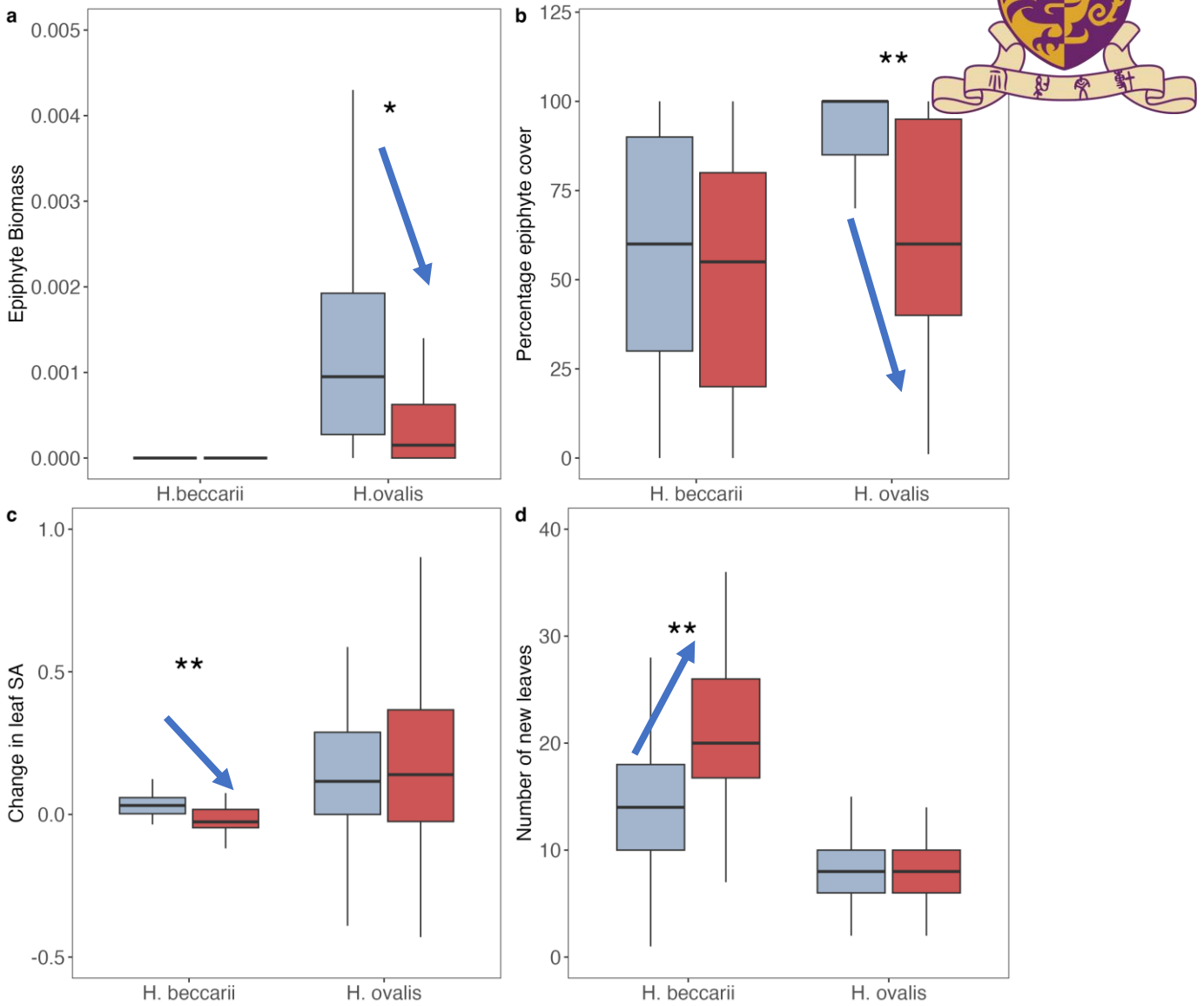
Results

- For both species there was no significant impact of MHW on dry weight biomass of any of the ramet sections
- Epiphyte dry weight biomass and percentage cover attached to *H. ovalis* were significantly lower under the MHW treatment
- *H. beccarii* leaves decreased more in surface area under the MHW treatment
- However, the number of new leaves was substantially boosted under MHW conditions



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Conclusion

- **Spring MHWs** pose **no significant additional threat** to the survival or growth of these two seagrass species
- **Increased performance** under the MHW
- **Differences** between the species' responses
- Their contrasting responses, and the **responses of the epiphytes** which grow on them, may have **bottom-up influences** on the biotic environment of the habitats

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Other human driven impacts – Light limitation

- i.e., “Coastal darkening” from decreased water quality and clarity
- Interaction between temp x light limitation is increasingly important
- Few studies have experimentally examined the combined effects on the performance of multiple macrophyte species

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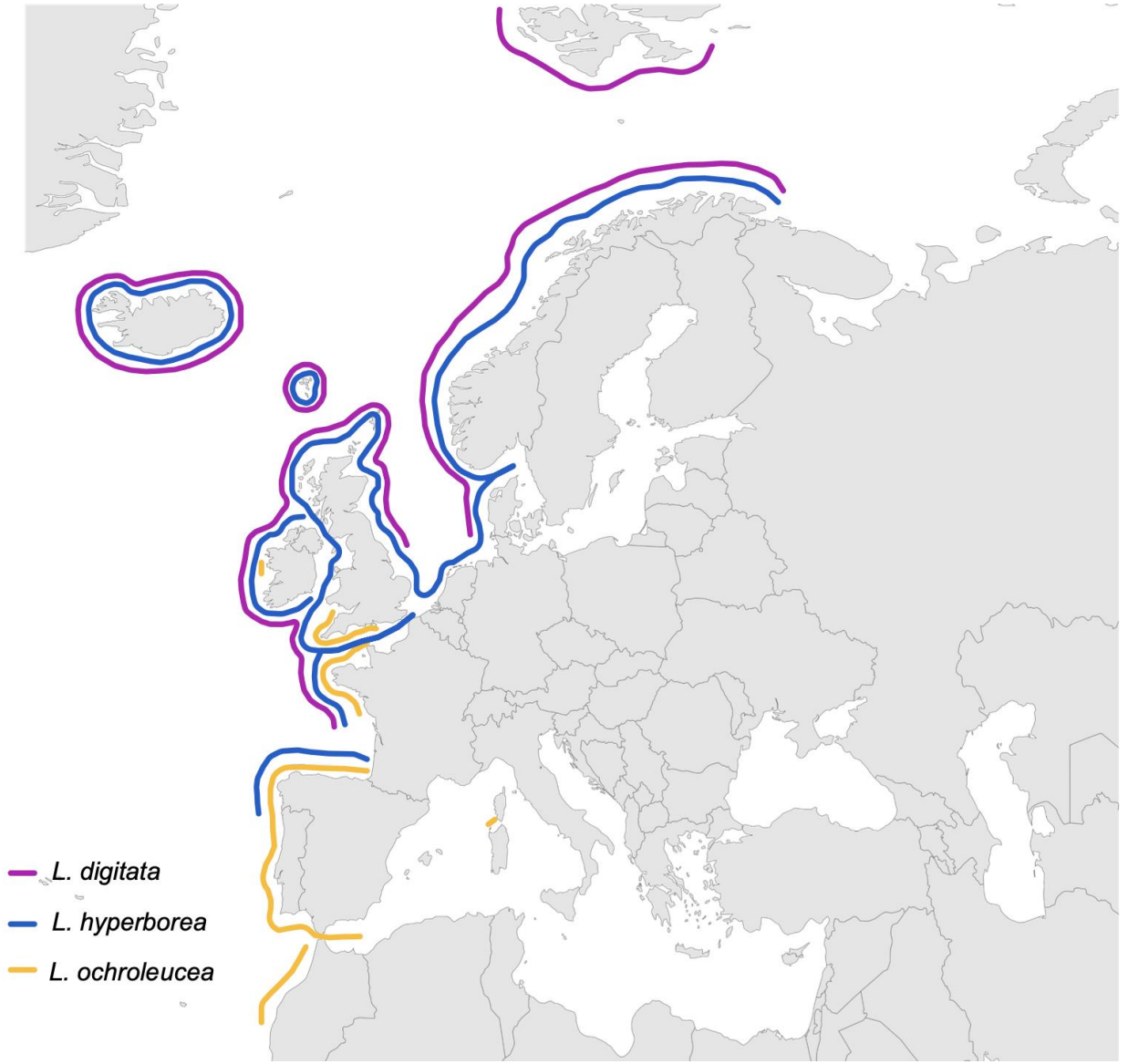
Study 2

Differences in latitudinal distributions and thermal niches between Laminariales



Adapted from Araújo et al. 2016

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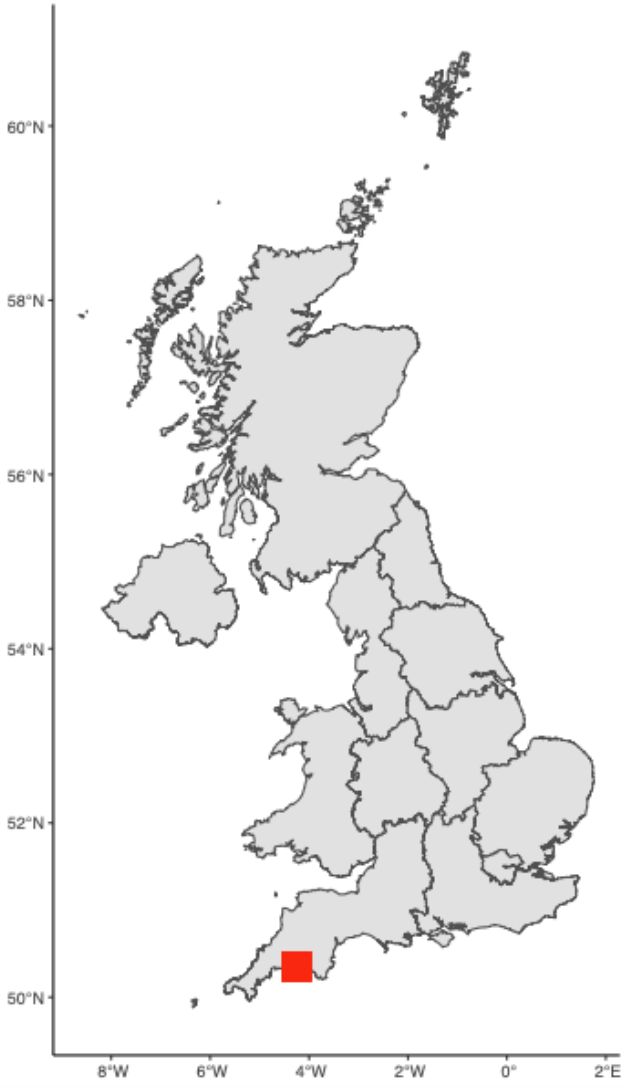
Research objectives

- To examine the influence of temperature and light availability on the ecophysiological performance of kelp species
- Determine whether species have different tolerances to light limitation and temperature stress
- Explore differences across seasons



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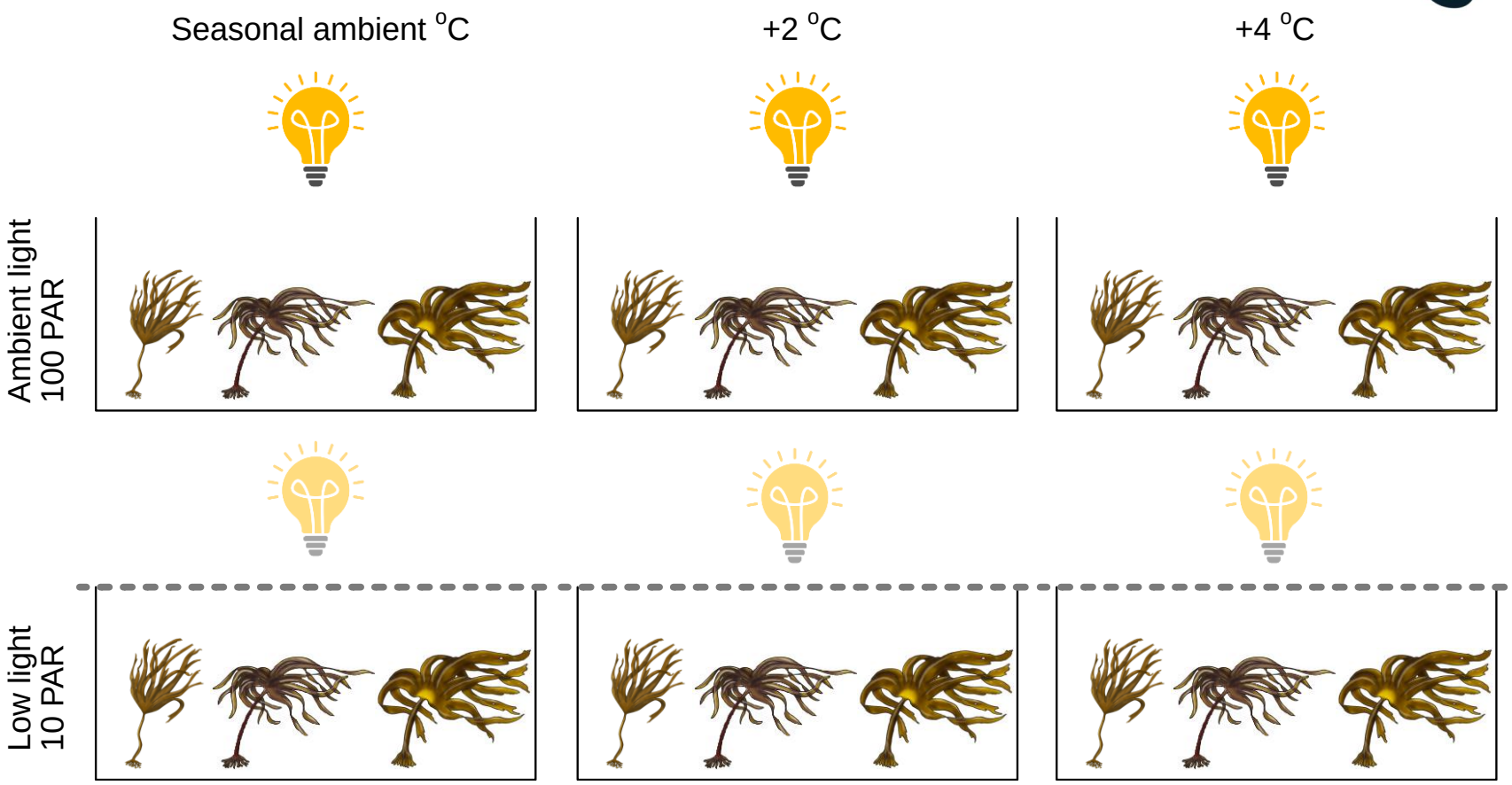
Experimental Design

- Over 4 weeks
- Change in wet weight biomass
- Change in blade surface area
- Change in photosynthetic efficiency (Fv/Fm)
- Spring and summer



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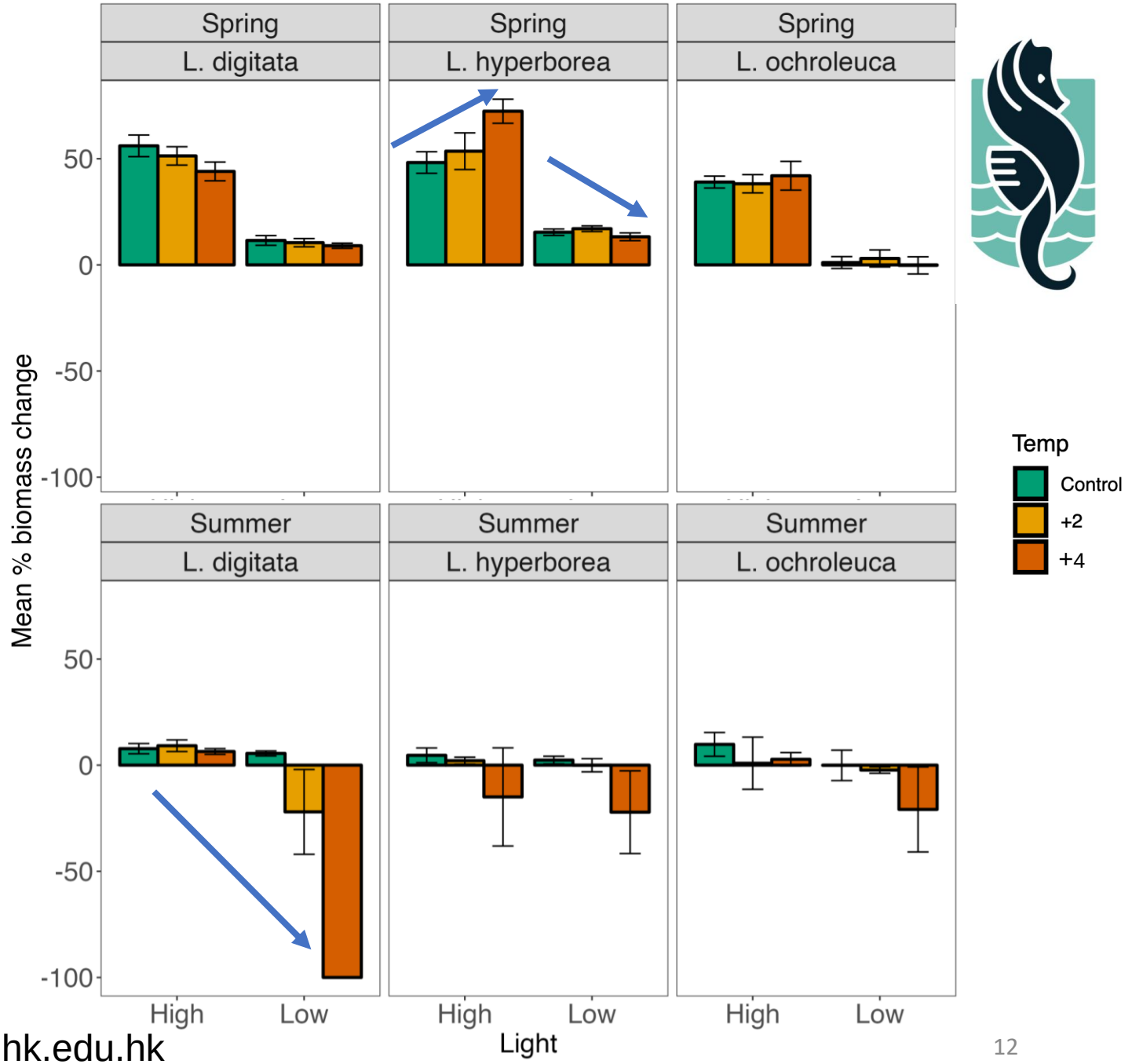
Results

Mean % biomass change

Summer

- Under high light conditions, all three species exhibited minimal change in biomass at any temperature
- At low light levels, all species lost biomass, with the magnitude of loss generally increasing at higher temperatures
- *L. digitata* held at +4°C at low light levels disintegrated- All other species were not impacted



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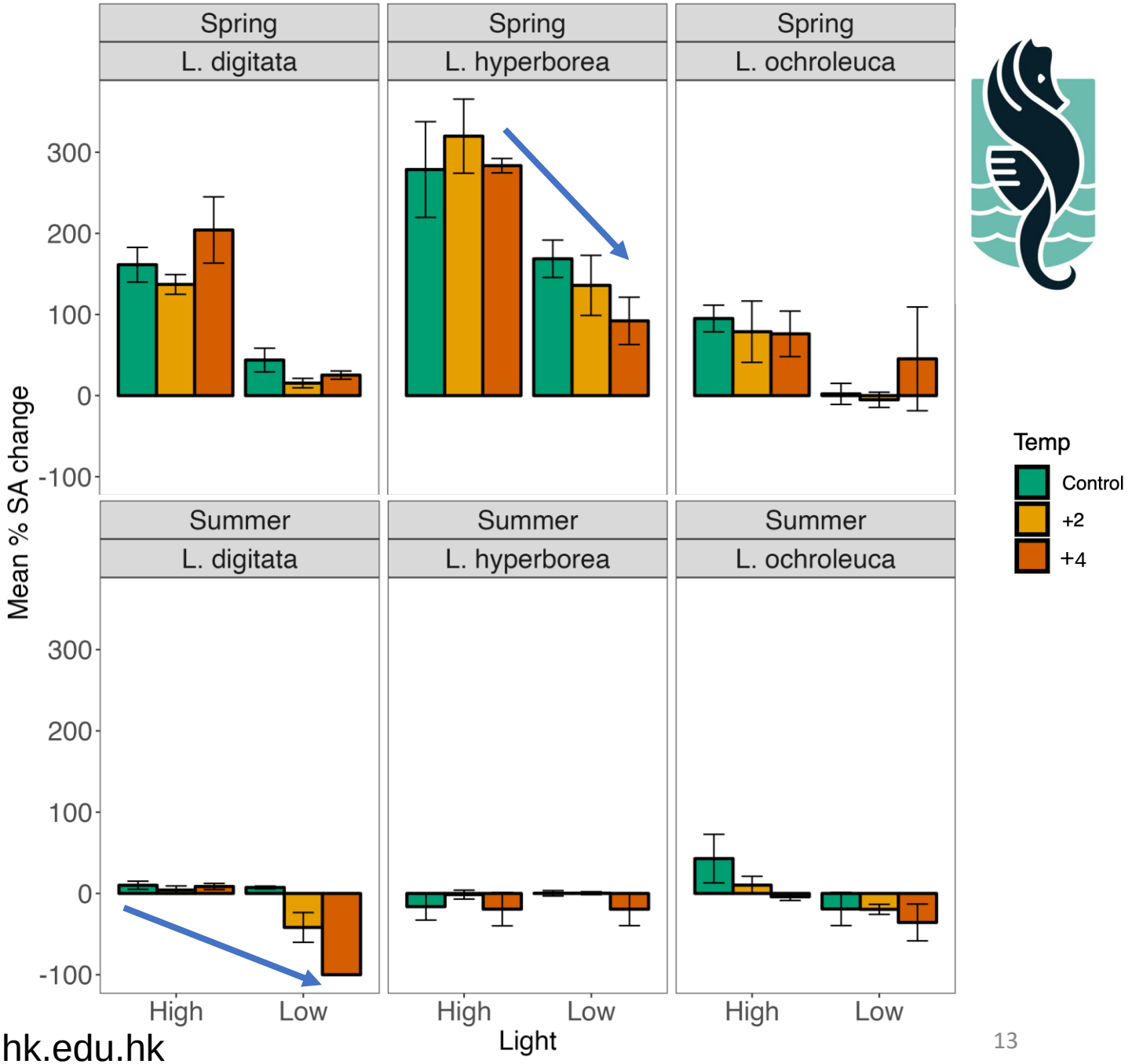
Results

Mean % surface area change

Summer

- Under high light all three species showed minimal responses to temperature
- Under low light conditions, all species displayed decreases in surface area, particularly at the higher temperature
- *L. digitata* exhibited relatively greater rates of decline at low light with increasing temperature



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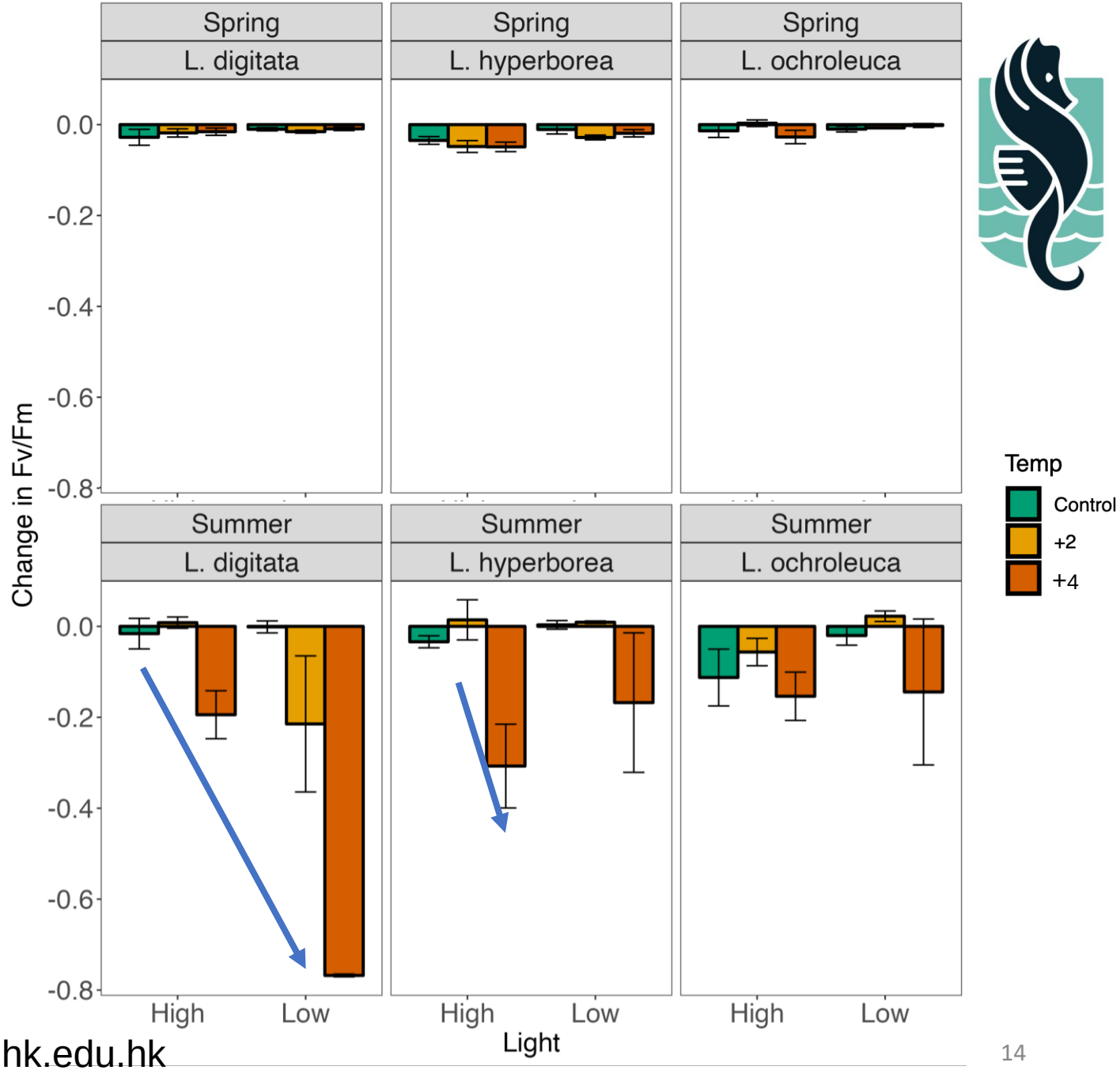
Results

Mean change in Fv/Fm

Summer

- Variation was markedly greater in summer compared with spring
- Increasing temperature under low light levels had a negative effect on Fv/Fm on *L. digitata*
- For *L. hyperborea*, significant reductions in Fv/Fm were recorded between +2°C and +4°C
- There was no significant reduction for *L. ochroleuca*



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Results

Mortality, bleaching, tissue necrosis

Spring

- No mortality during the spring experiment
- Some *L. ochroleuca* plants exhibited signs of bleaching and tissue loss at low light

Summer

- *L. digitata* had the highest mortality rates at +4°C temperature treatment
- Bleaching for *L. ochroleuca* across most treatment combinations
- Tissue loss at low light and high temperature treatments for all species

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Conclusion

Under **low light** conditions, **summertime MHWs** induced significant declines in all measured variables **in all species, albeit to varying degrees**

Under **high light conditions**, all species were **largely resistant** to simulated MHW activity. In **springtime**, MHWs had comparatively **minimal impacts** on kelp performance, while reduced light availability resulted in lower growth rates

Despite differences in latitudinal distributions and thermal niches, **all species were negatively affected by summer MHWs under low light conditions** (although *Laminaria digitata* was particularly impacted) but were generally resilient to MHWs under high light conditions

Maintaining good environmental quality and water clarity may increase resilience of populations to summertime MHWs

Clearly, seasonality in MHW activity is an important factor determining their impacts on individuals, populations and communities

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Conclusion

- Seagrasses and kelps of the same genus have different ecophysiological responses to MHWs
- Negative impacts are exacerbated with compounding stressors
- Season is important to consider – not always negative impacts

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