Does kelp need help? Influences of variation in local environmental conditions on macroalgal community composition and diversity

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Background

Kelp, Heat, and Turf Algae

Kelp are one of the most vulnerable temperate marine ecosystems to climate change, with recent marine heatwaves causing considerable kelp losses in many regions.[1,2] Due to heat stress, phase shifts often occur to more heat-tolerant turf ecosystems, in which a dense layer of shorter algae with less structural complexity than kelp dominates the substrate.[3]

Climate Change Implications

In coastal oceans, local environmental conditions can vary over small spatial scales. Understanding the influence of fine-scale abiotic heterogeneity in the intertidal could provide insight into how continued warming might impact these kelp ecosystems under future climate change.


Kelp-Dominated Site


Turf-Dominated Site

Research Questions

1. Do local environmental conditions explain composition and diversity of intertidal kelp communities?
2. Are turf algae common in the absence of kelp?

Hypotheses

1. Kelp abundance and diversity will be negatively influenced by temperature, but more wave exposed sites will mediate this negative effect
2. Algal turf presence will respond in an opposing manner to kelp presence

Study System

Barkley Sound

- Temperature increases by ~6ºC from outer to inner coast
- Wave energy tends to decrease from outer to inner coast

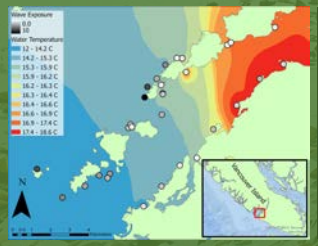


Figure 1. Map of (n=31) study sites in Barkley Sound, Vancouver Island, B.C, in the traditional unceded territory of the Huu-ay-aht peoples. Map shows a colour gradient of water temperature as well as relative wave exposure in greyscale at each site.

Methods

Field Protocol – Summer 2021

1. Photographs were taken of ~12 quadrats placed 1m apart at n=31 sites
2. Temperature loggers were drilled into the substrate, recording every 10 min for 2 weeks
3. Maximum barnacle height was used as a proxy for wave energy

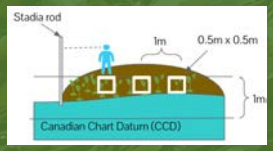



Image Collection

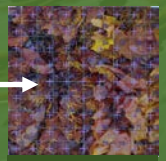

Photoquadrat

Image Analysis - Fall 2021

1. Images were cropped and aligned using Adobe Lightroom
2. 81 points were uniformly placed on each photoquadrat using the online image analysis software CoralNet, and substrates were identified to species as possible

Results

Kelp Cover and Richness is Greater at Sites with Cool Water and High Wave Energy

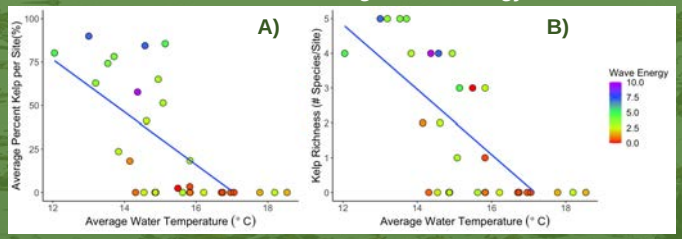


Figure 2. Scatter plot with linear regression of A) average percent kelp cover per site and B) number of species at each site (species richness), with average water temperature for each site measured over two weeks. Relative wave energy is represented as a colour scale gradient from 0 to 10.

Where Kelp is Absent, Turf Algae Dominates the Substrate

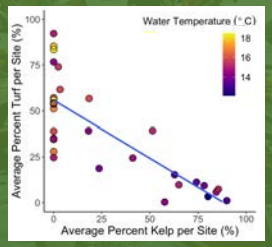


Figure 3. Scatter plot with linear regression showing the relationship of percent turf cover with percent kelp cover at each site. Average water temperature for each site presented as colour scale gradient from 12 °C to 18.5 °C.

The Big Picture

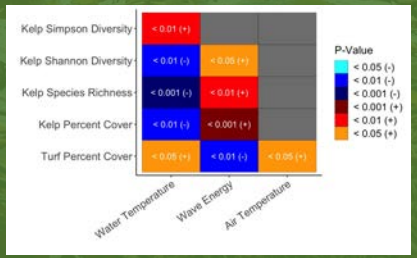
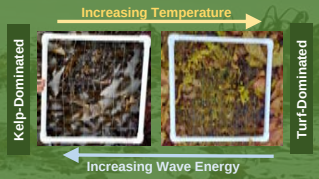


Figure 4. Results of model selection analysis using best AICc values, displayed as a heatmap of p-values depicting the effects of environmental variables on community metrics. Environmental variables not used in the best model are shown in grey. Species richness is the number of species per site, while Shannon diversity shows how the number of species is distributed in abundance, and Simpson diversity is similar but less influenced by species richness. Cool colours indicate negative effect and warm colours indicate positive effect.

Discussion



Kelp cover and measures of diversity that neglect rarity are found to decline with increasing temperature within the sound. Contrastingly, turf cover is positively influenced by air and water temperature, which can be explained by relatively high heat tolerance of many turf species.[3] In high temperature regions, wave energy could be acting as a form of amelioration from heat stress for kelp, since water motion has physiological impacts on the growth of kelp, influencing the rate of nutrient delivery by altering the diffusion boundary layer thickness.[4] Given the ecological importance of canopy-forming kelp ecosystems, these results could have further implications for how climate change might be influencing seaweed community structural complexity.

Next Steps

- Temporal comparisons with past data on kelp cover in Barkley Sound
- Monitor additonal sites with similar temperature and varying wave energy to disentangle interactions

References

1. Starko, S. *et al.*, 2019. *PLoS ONE* 14: e0213191.
2. Filbee-Dexter, K. *et al.*, 2016. *Mar. Ecol. Prog. Ser.* 543: 141–152.
3. Filbee-Dexter, K. and T. Wernberg. 2018. *BioScience* 68: 64–76.
4. Millar, R. V. *et al.*, 2020. *J. Phycol.* 56: 198–207.

- Images of photoquadrats and study sites from Baum Lab field team 2021
- Backdrop image taken by Kevin Bruce 2021

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