



# Shifting Perspectives: From Marine Macrophyte Collapses to Global Environmental Change Mitigation Agents

*Boada J, Barrera A, Aillouane S, Carbonne C, Carlot J, Cebrian E, Comeau S, Esposito V, Galobart C, García-Gonzalez F, Gattuso J P, Mangialajo L, Marbà N, Procaccini G, Verdura J, de Vittor C, Teixidó N.*

[jboada@ceab.csic.es](mailto:jboada@ceab.csic.es)

## SHIFT<sup>2</sup>SOLVE

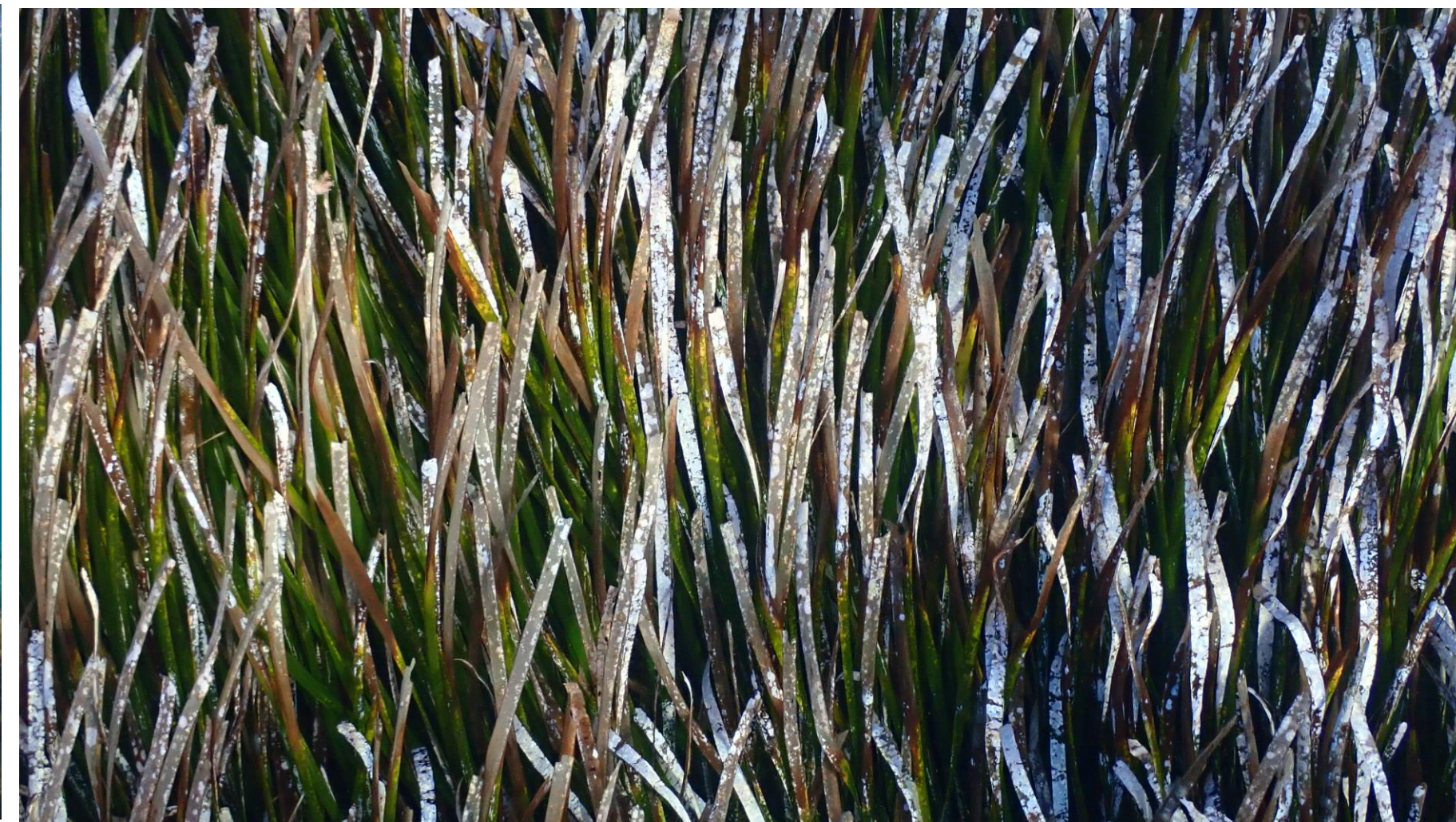


**Jordi Boada**  
(@jordiocean)

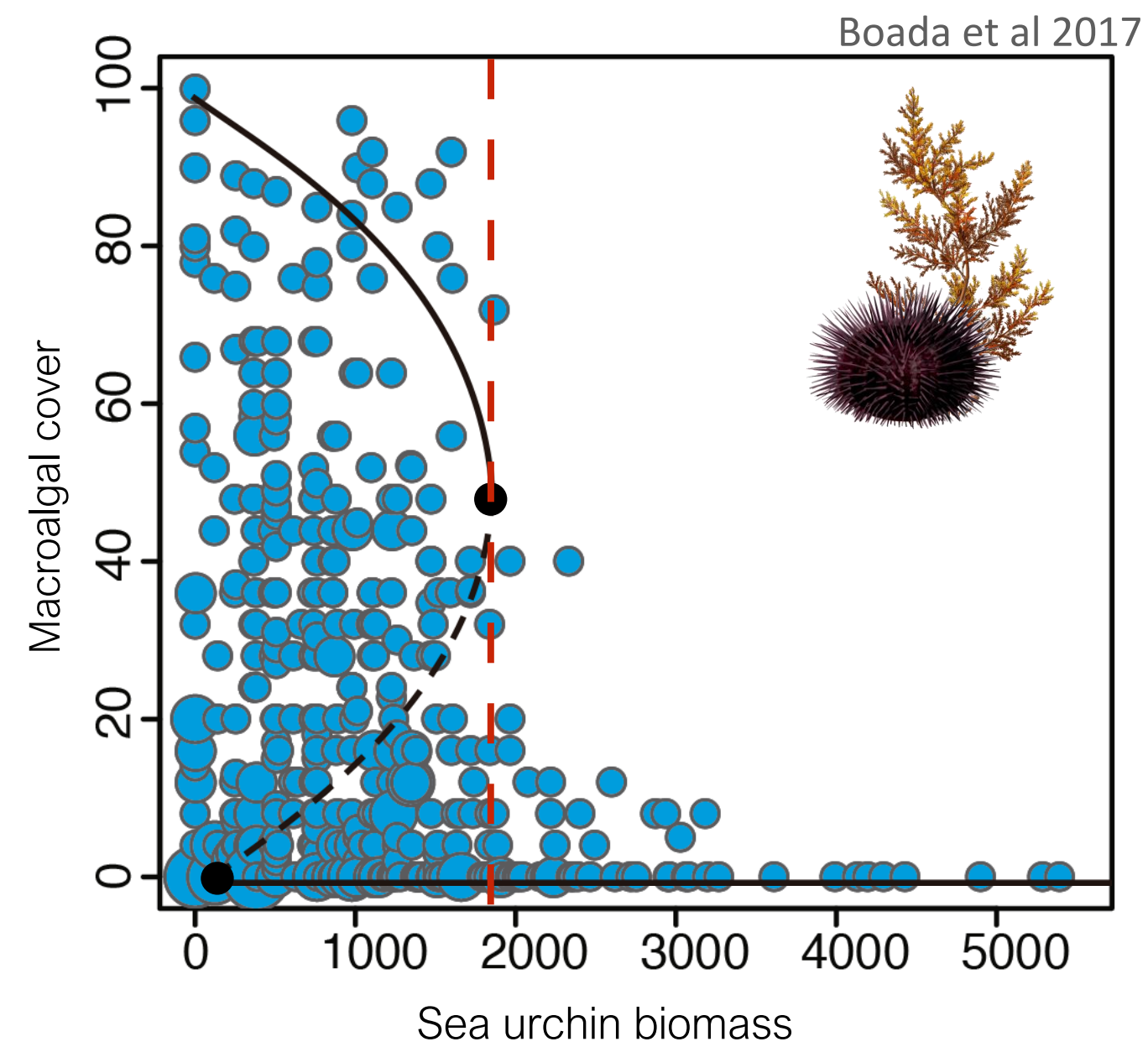
Current: RyC Fellow Past: MSCA IF Fellow  
National Research Council Spain (CEAB-CSIC)



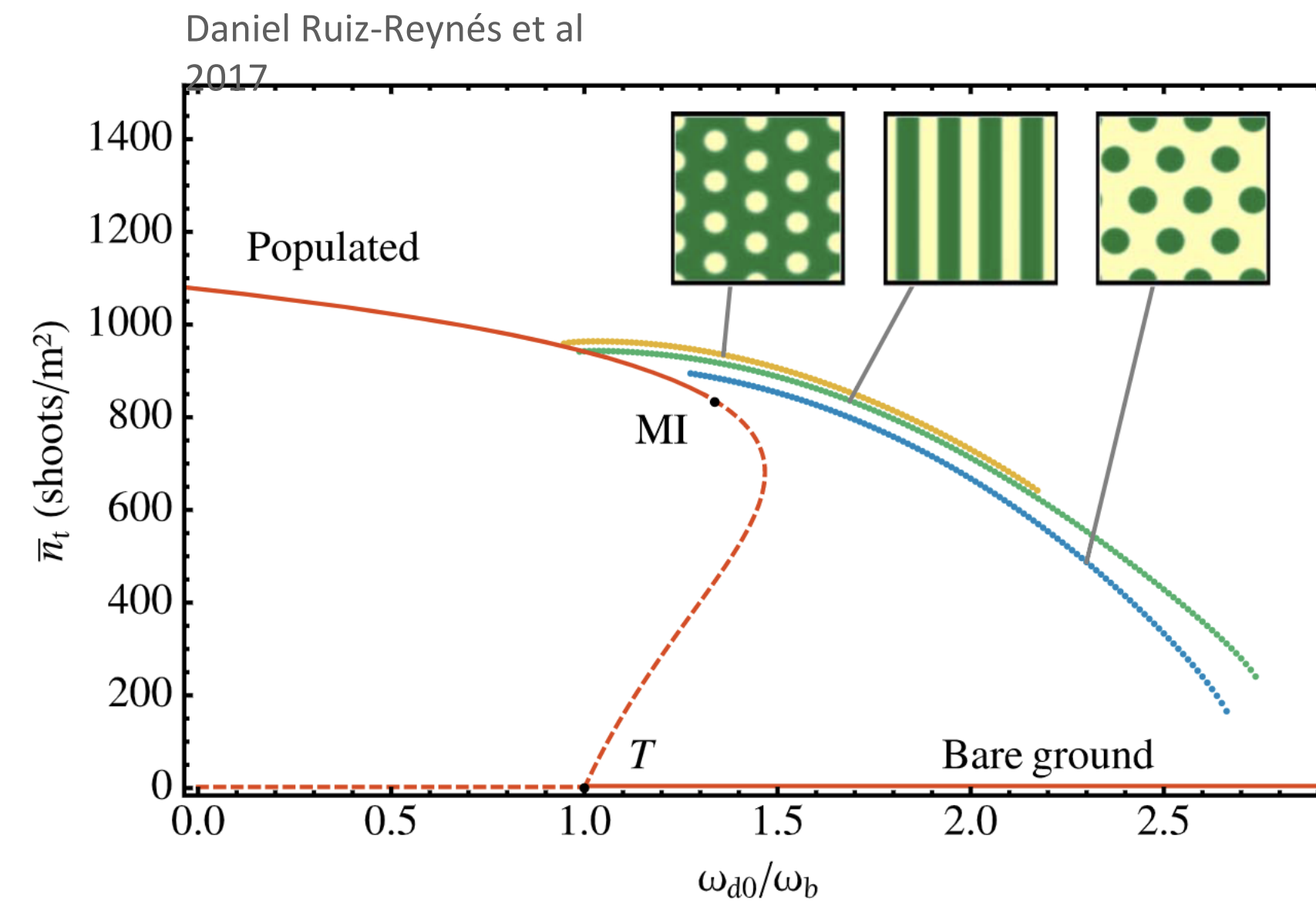
## Non-linear transitions in marine vegetated systems



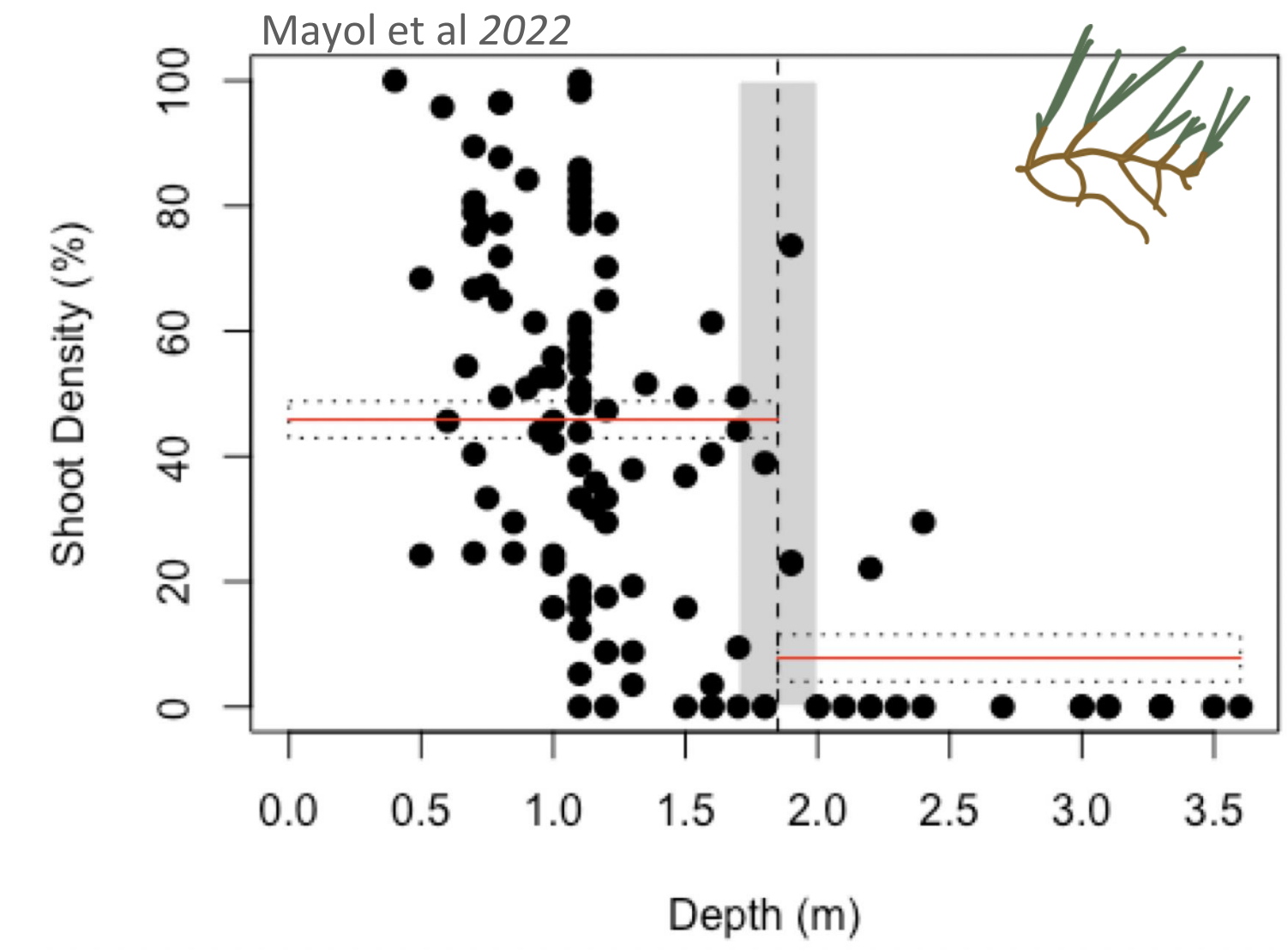
# Non-linear transitions in marine vegetated systems



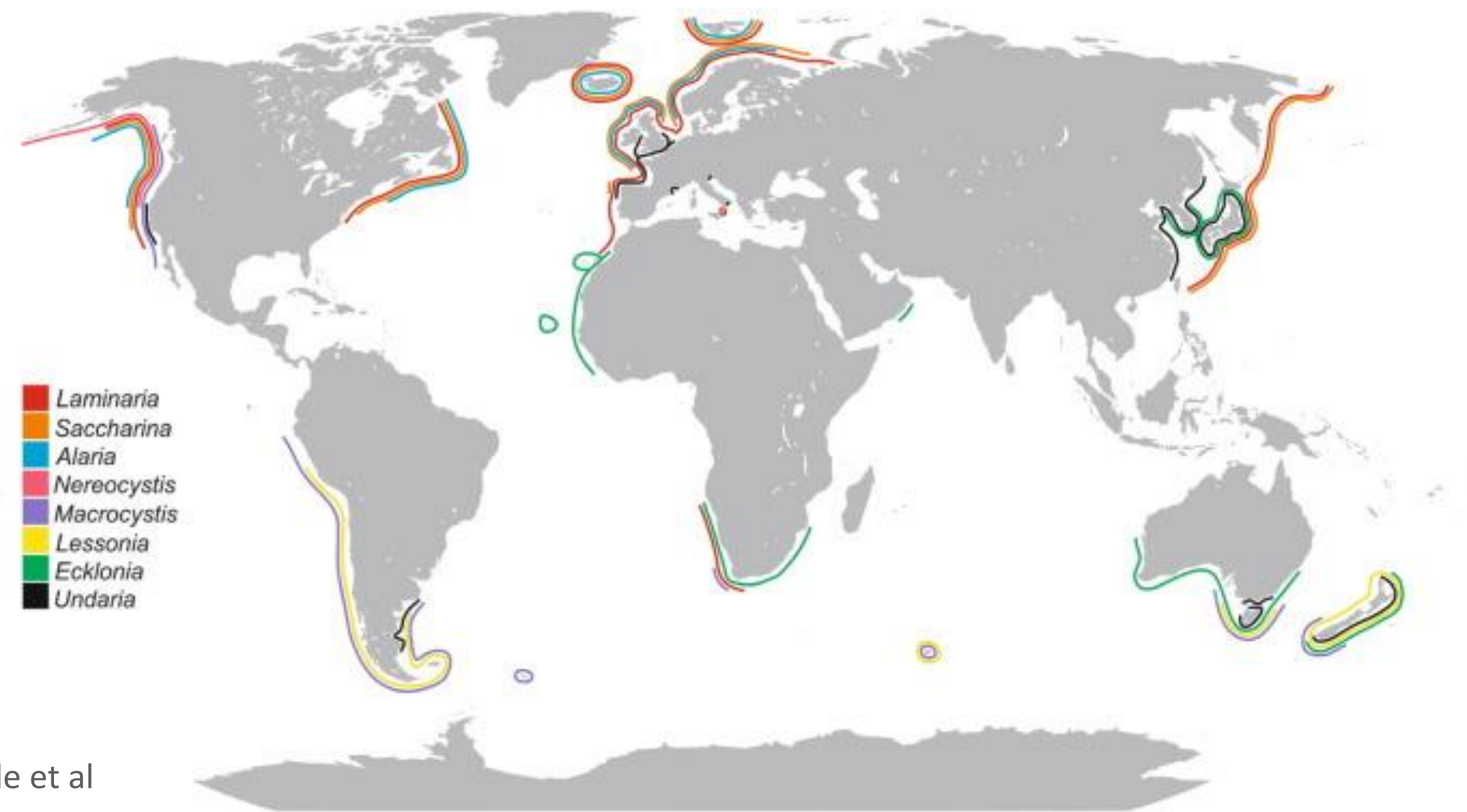
# Non-linear transitions in marine vegetated systems



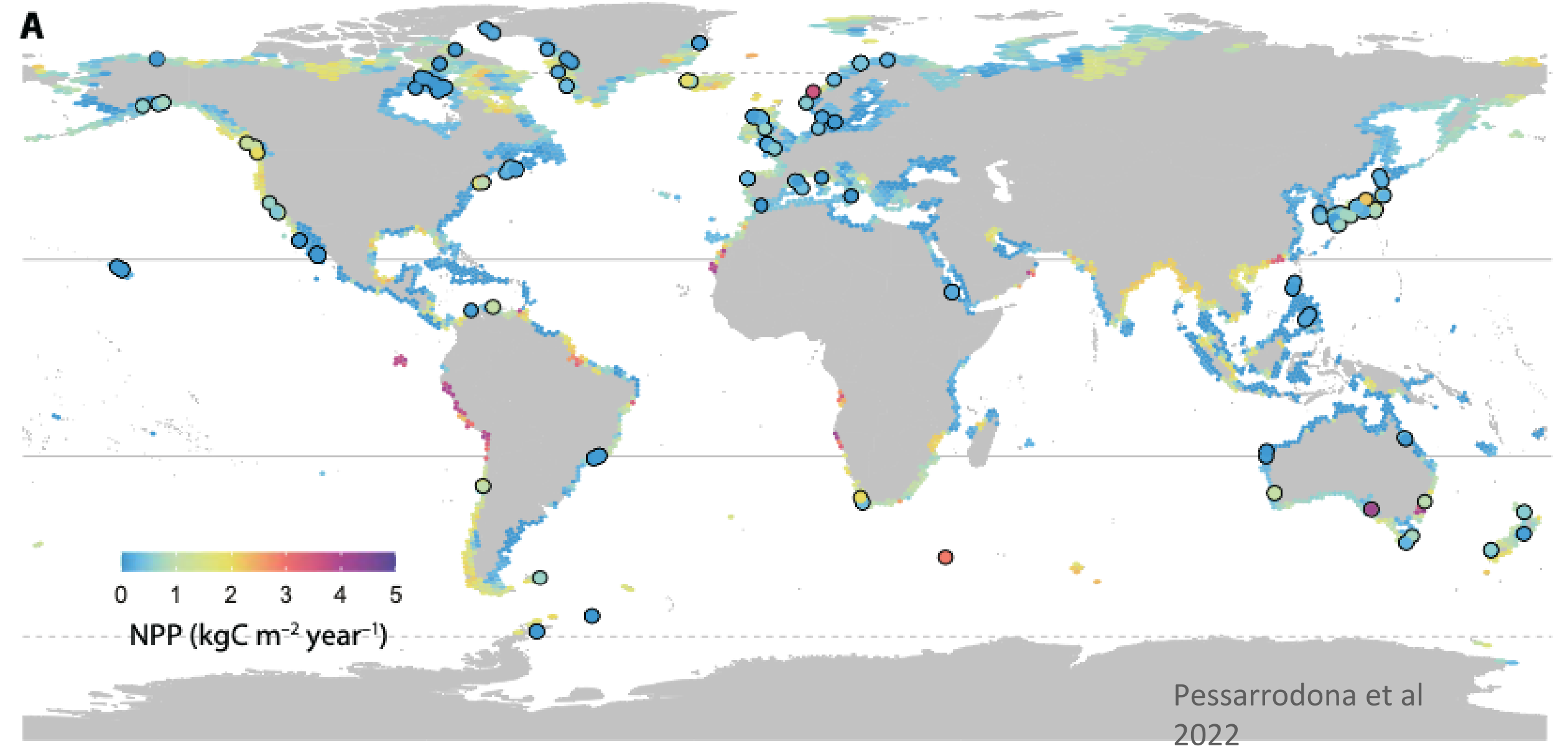
## Non-linear transitions in marine vegetated systems



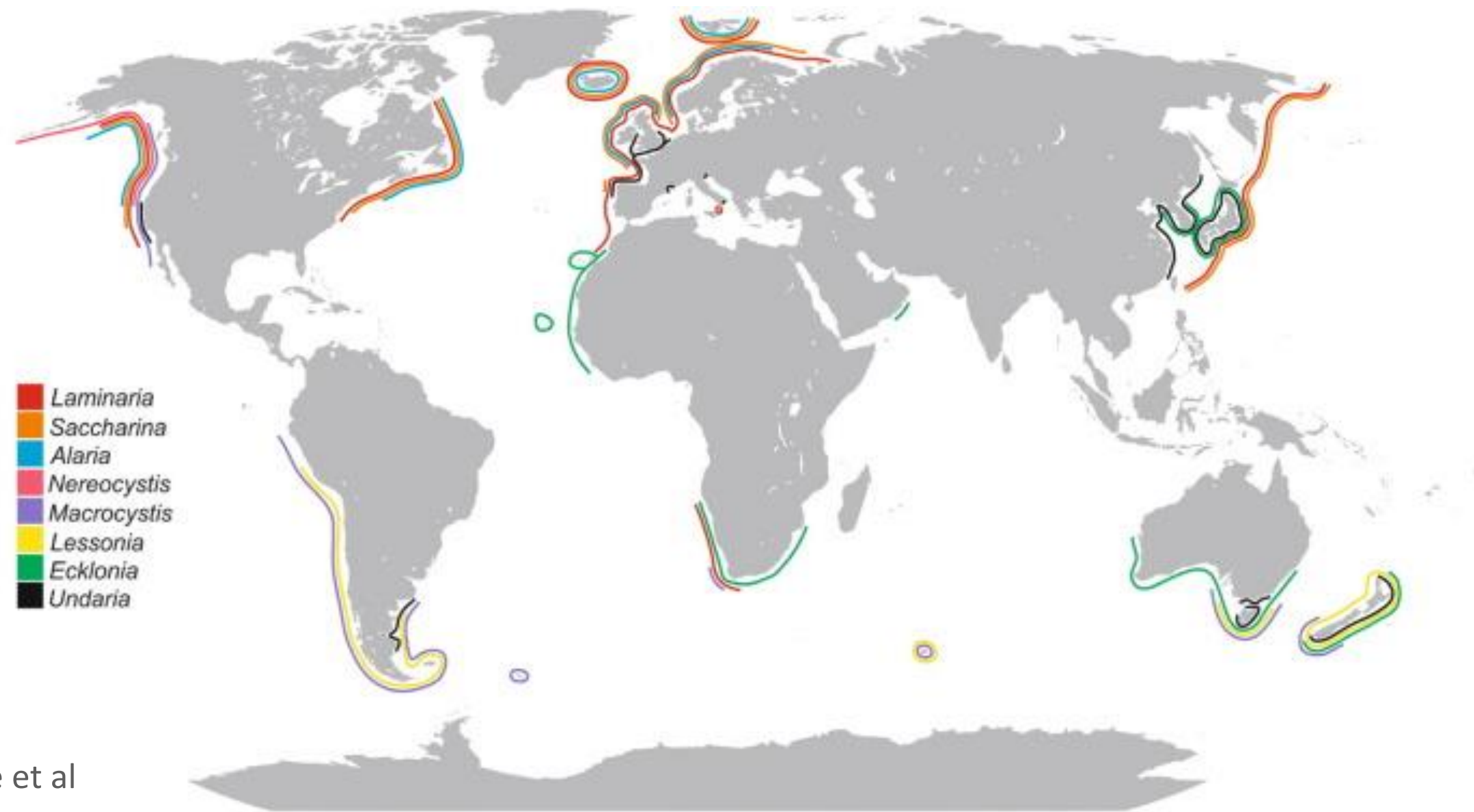
## Marine macrophytes - Key component of the global carbon cycle



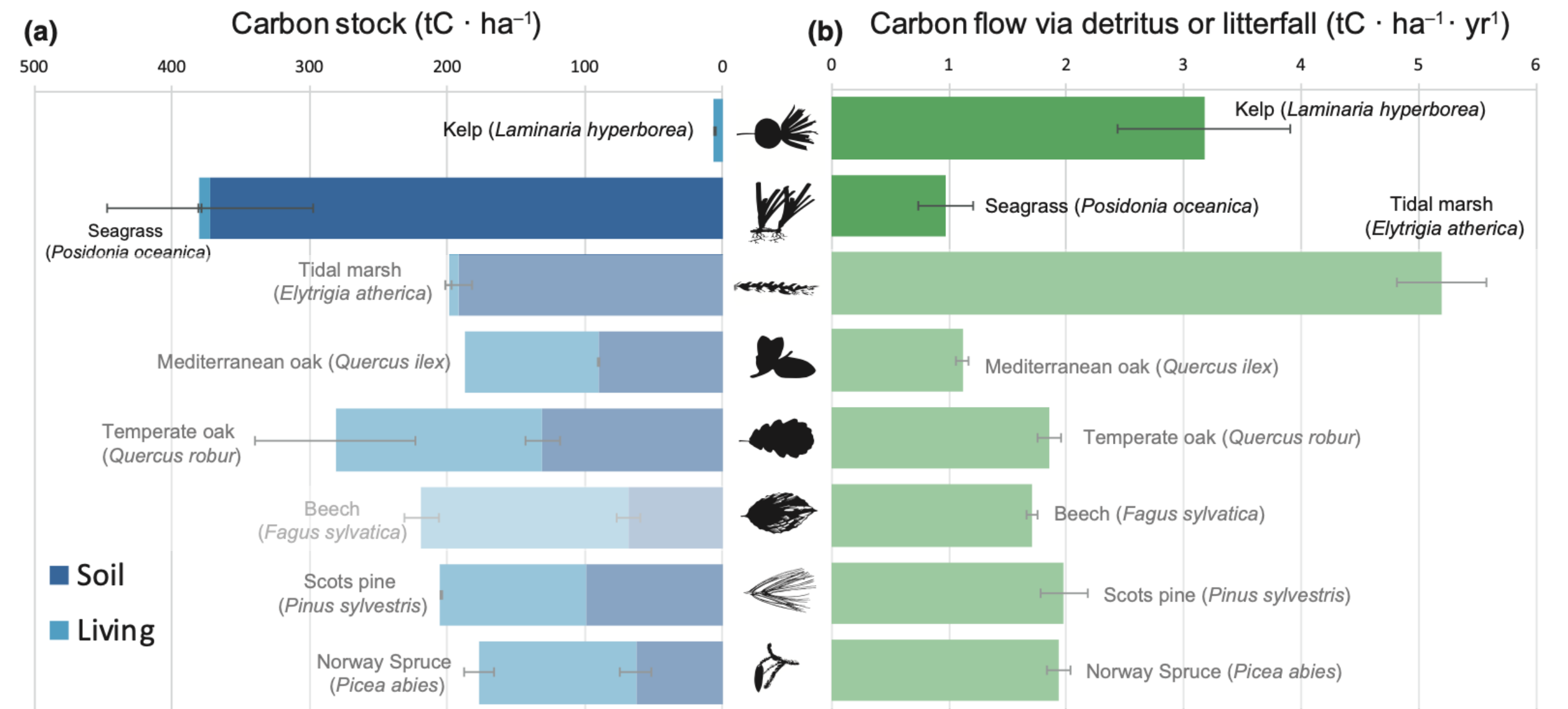
Teagle et al  
2017



# Marine macrophytes - Key component of the global carbon cycle

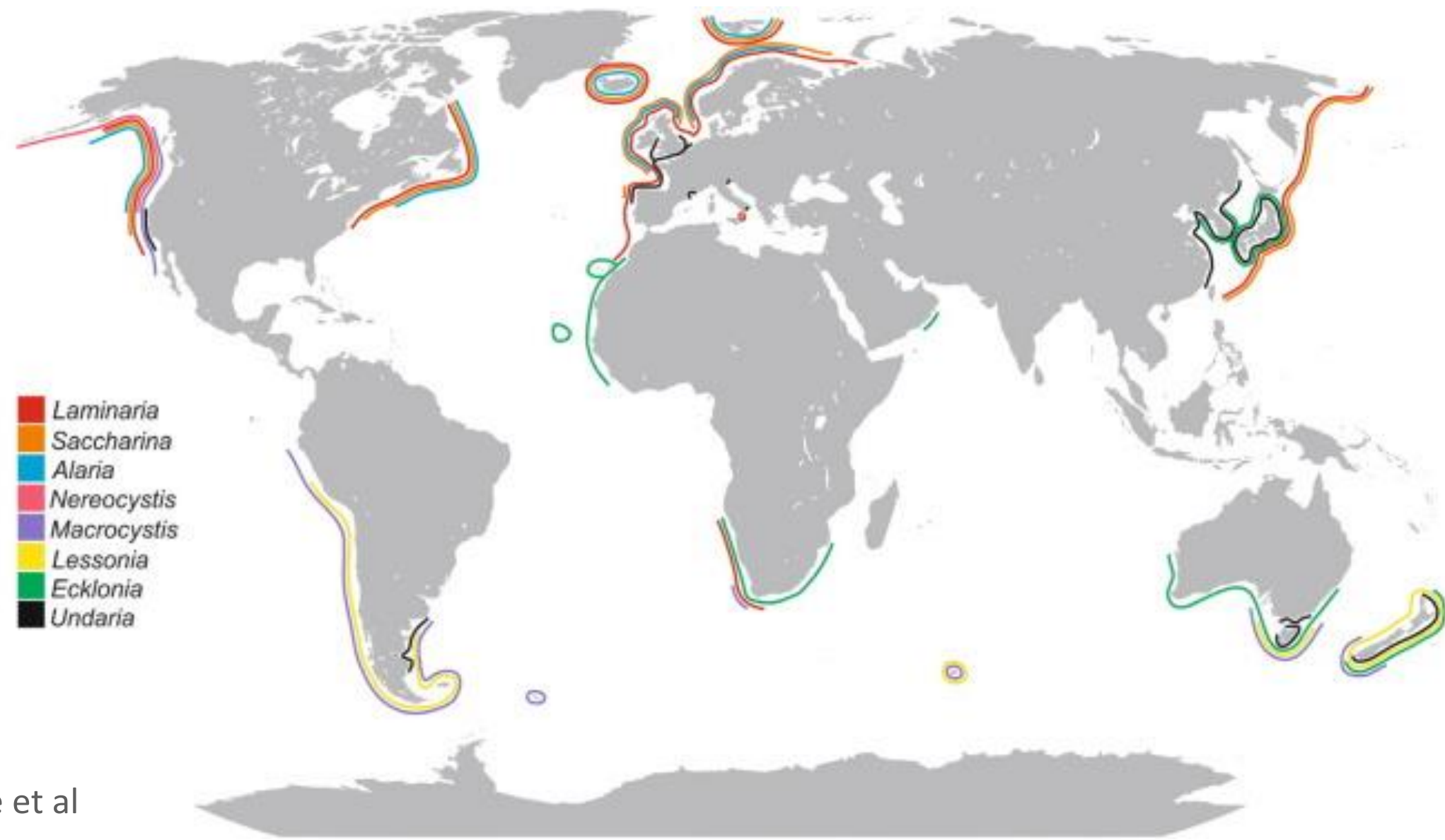


Teagle et al  
2017



Pessarrodona et al  
2018

# Marine macrophytes - Key component of the global carbon cycle



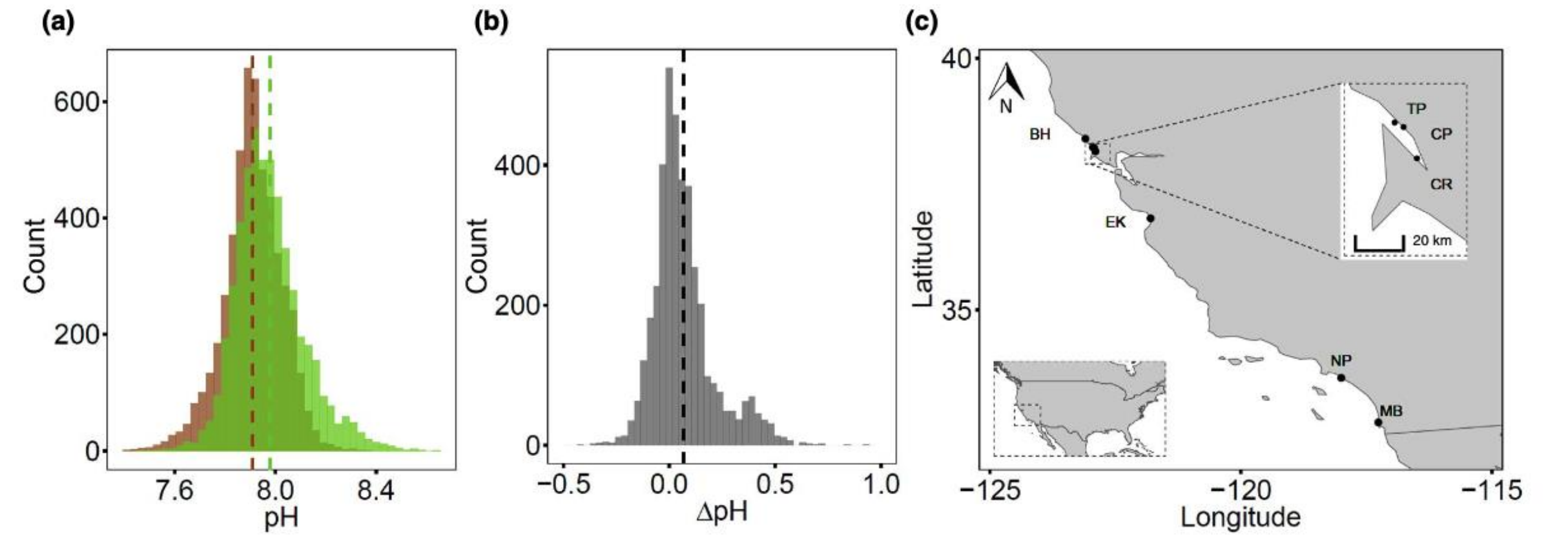
Teagle et al  
2017

PRIMARY RESEARCH ARTICLE

Global Change Biology WILEY

## Coast-wide evidence of low pH amelioration by seagrass ecosystems

Aurora M. Ricart<sup>1,2</sup> | Melissa Ward<sup>1</sup> | Tessa M. Hill<sup>1,3</sup> | Eric Sanford<sup>1,4</sup> |  
Kristy J. Kroeker<sup>5</sup> | Yuichiro Takeshita<sup>6</sup> | Sarah Merolla<sup>1</sup> | Priya Shukla<sup>1</sup> |  
Aaron T. Ninokawa<sup>1</sup> | Kristen Elsmore<sup>1</sup> | Brian Gaylord<sup>1,4</sup>



RESEARCH ARTICLE

CLIMATE CHANGE

# Exceeding 1.5°C global warming could trigger multiple climate tipping points

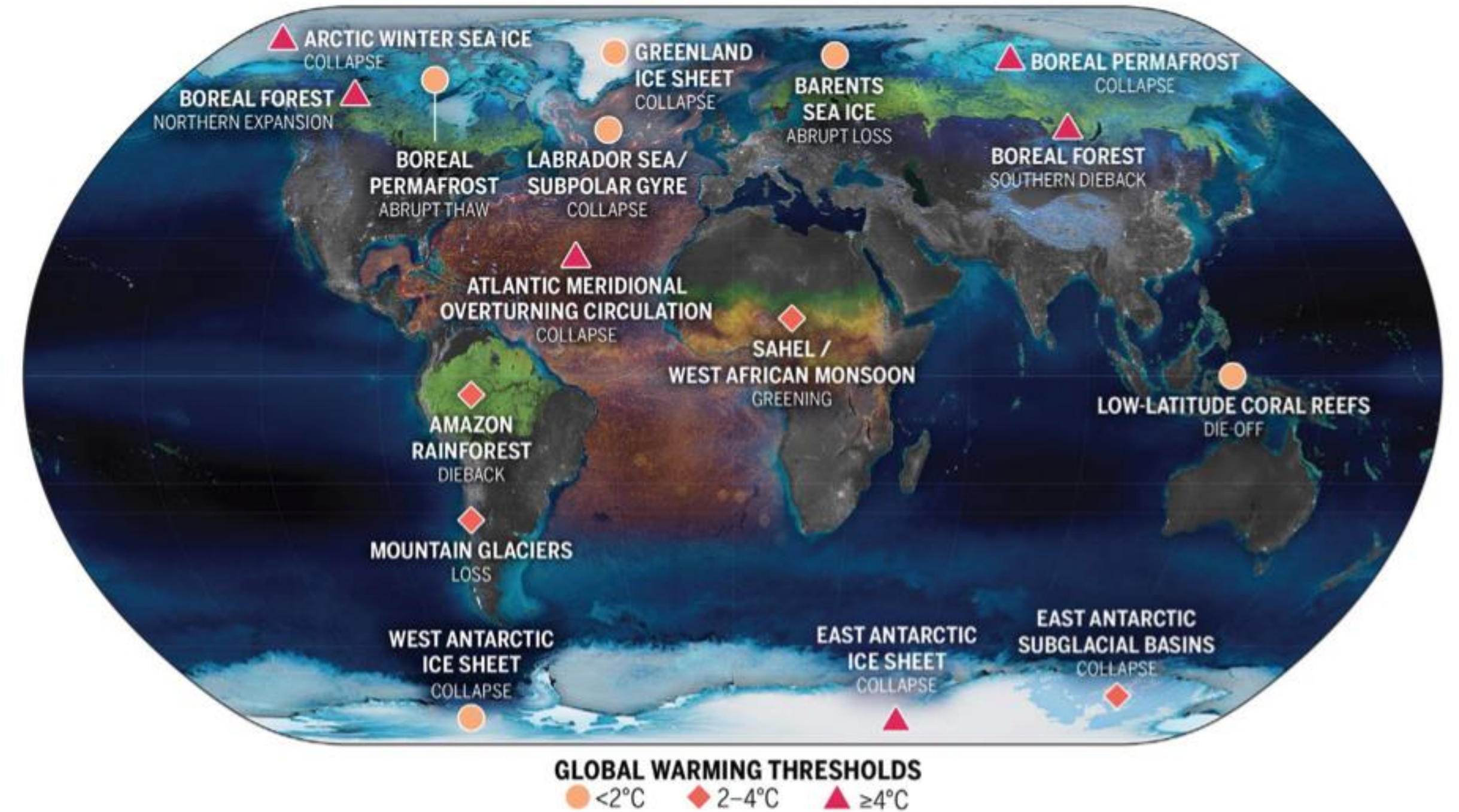
David I. Armstrong McKay<sup>1,2,3,4\*</sup>, Arie Staal<sup>1,2,5</sup>, Jesse F. Abrams<sup>3</sup>, Ricarda Winkelmann<sup>6</sup>, Boris Sakschewski<sup>6</sup>, Sina Loriani<sup>6</sup>, Ingo Fetzer<sup>1,2</sup>, Sarah E. Cornell<sup>1,2</sup>, Johan Rockström<sup>1,6</sup>, Timothy M. Lenton<sup>3\*</sup>

## Testing for thresholds of ecosystem collapse in seagrass meadows

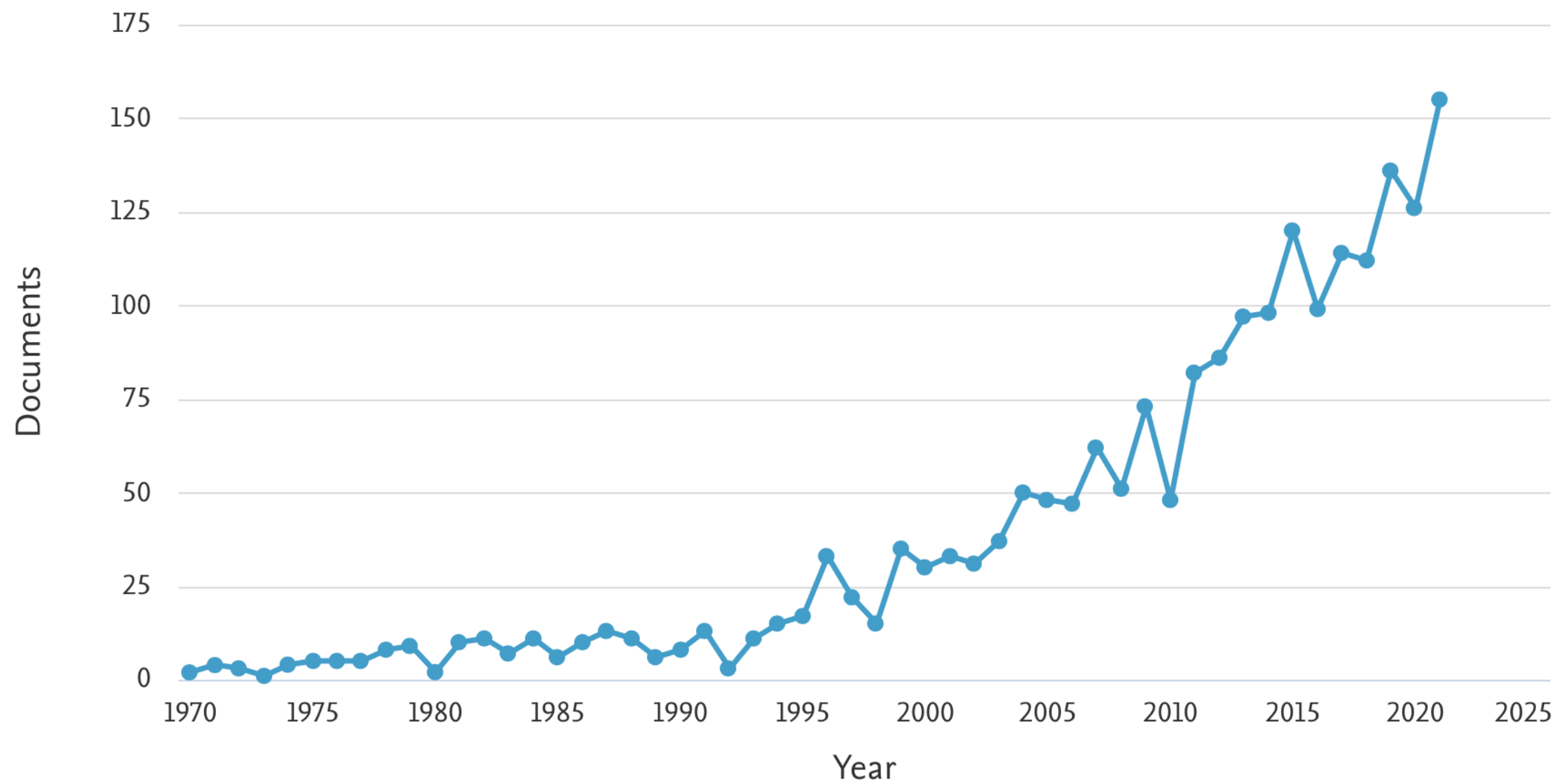
Sean D. Connel, Kingsley J. Grif and Laura J. Fal **Global regime shift dynamics of catastrophic sea urchin overgrazing**

S. D. Ling, R. E. A. K. Salomon, K. L. K. Blamey, B. H. D. Fujita and L. E. **Climate-driven regime shift of a temperate marine ecosystem**

Thomas Wernberg<sup>1,\*†</sup>, Scott Bennett<sup>1,2,3†</sup>, Russell C. Babcock<sup>1,4</sup>, Thibaut de Bettignies<sup>1,5</sup>, Katherine Cure<sup>1,6</sup>, Martial Depczynski<sup>6</sup>, Francois Dufois<sup>7</sup>, Jane Fromont<sup>8</sup>, Christopher J. Fulton<sup>9</sup>, Renae K. Hovey<sup>1</sup>, Euan S. Harvey<sup>2</sup>, Thomas H. Holmes<sup>1,10</sup>, Gary A. Kendrick<sup>1</sup>, Ben Radford<sup>6,11</sup>, Julia Santana-Garcon<sup>1,2,3</sup>, Benjamin J. Saunders<sup>2</sup>, Dan A. Smale<sup>1,12</sup>, Mads S. Thomsen<sup>1,13</sup>, Chenae A. Tuckett<sup>1</sup>, Fernando Tuya<sup>1,4</sup>, Mathew A. Vanderklift<sup>7</sup>, Shaun Wilson<sup>1,10</sup>

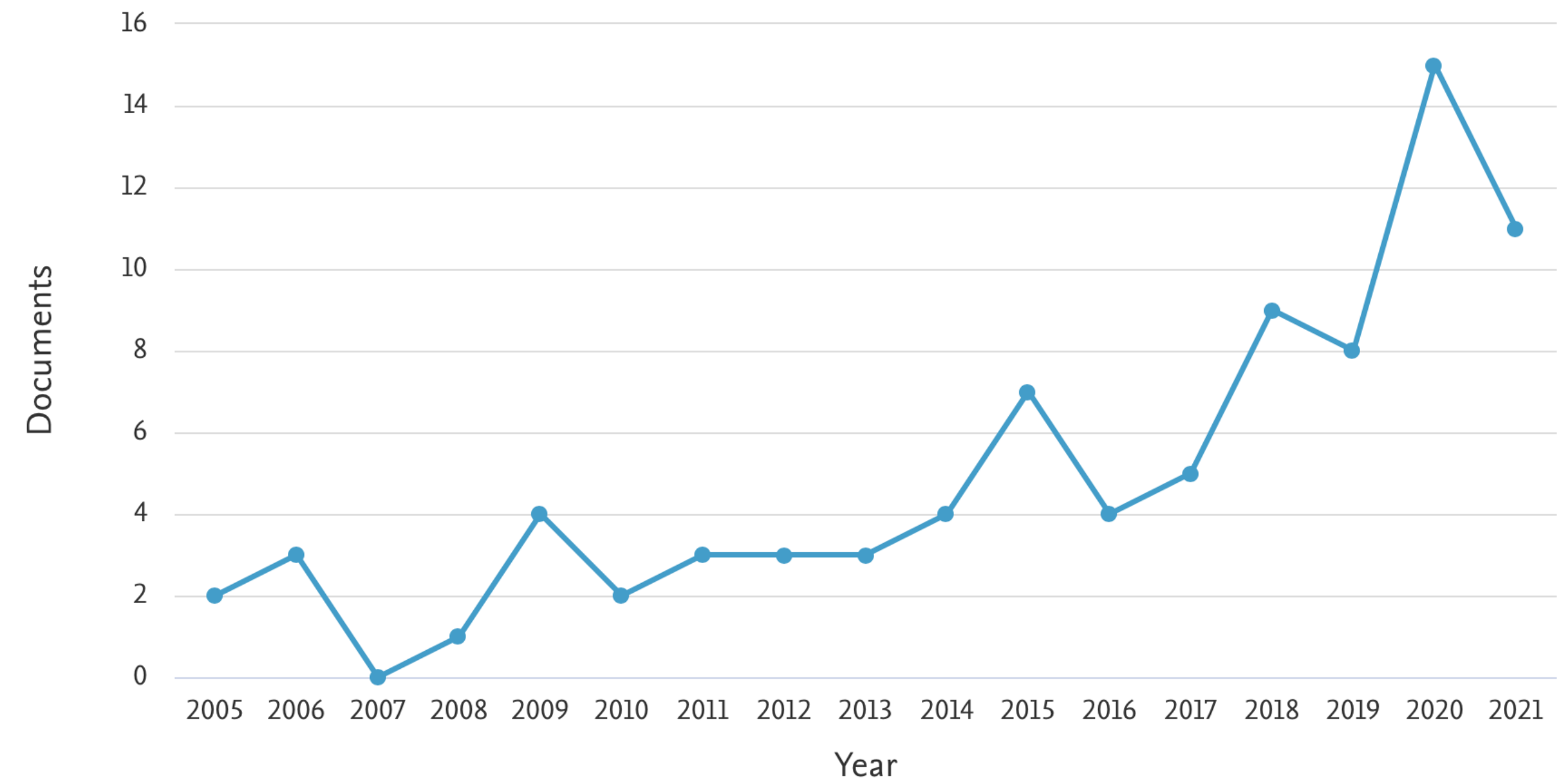


Documents by year



TITLE-ABS-  
 KEY ( acclim\* OR adapt\* AND macrophy\* OR seagrass OR eelgrass OR algae OR sea weed OR kelp AND marine OR ocean OR estuar\* )

Documents by year

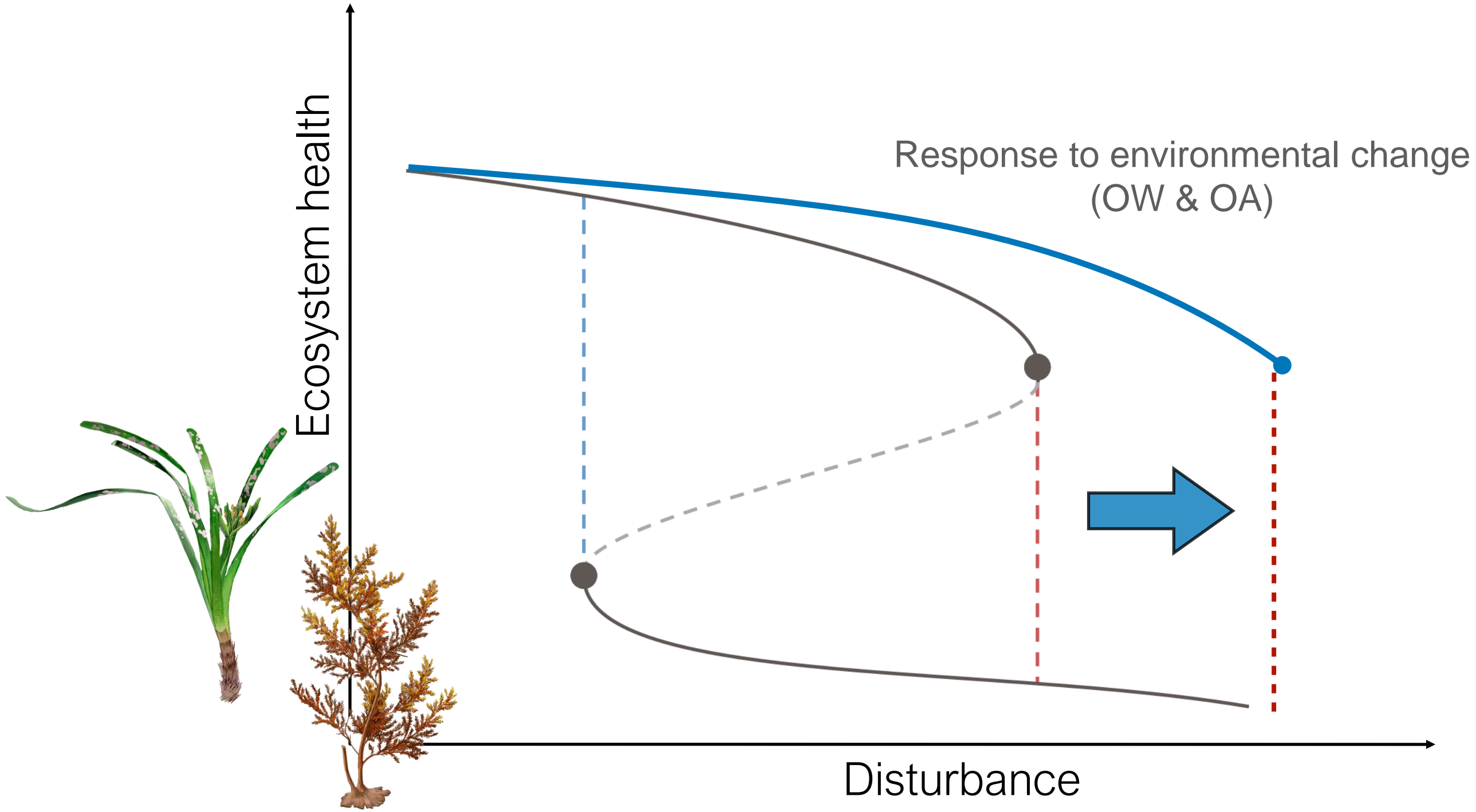
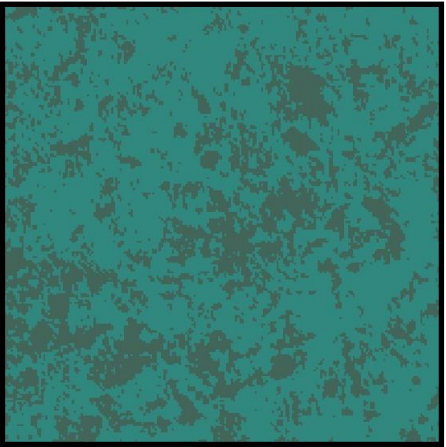
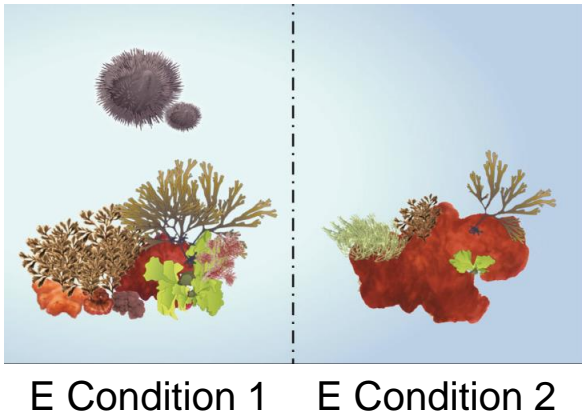
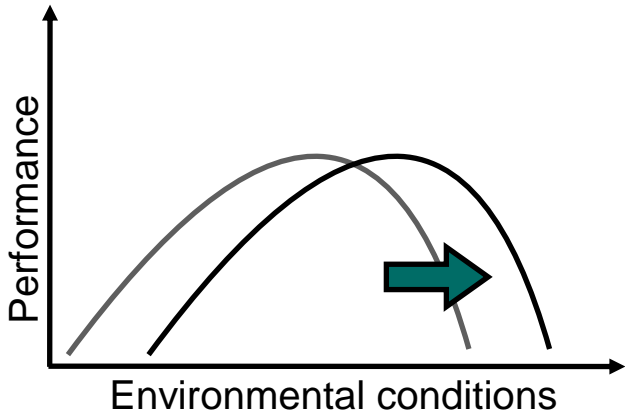


TITLE-ABS-  
 KEY ( acclim\* OR adapt\* AND macrophy\* OR seagrass OR eelgrass OR algae OR seaweed OR kelp AND marine OR ocean OR estuar\* AND [resilience](#) )

# SHIFT2SOLVE

Non-linear transitions in marine vegetated systems  
Marine macrophytes - Key component of the global carbon cycle  
Marine macrophytes - A tipping element

What are the implications to future oceans?



Natural Temperature and OA gradients - Ischia CO2 vents

Extreme Low pH<sub>T</sub>  
6.9

Low pH<sub>T</sub>  
7.76

Ambient pH<sub>T</sub>  
8.01



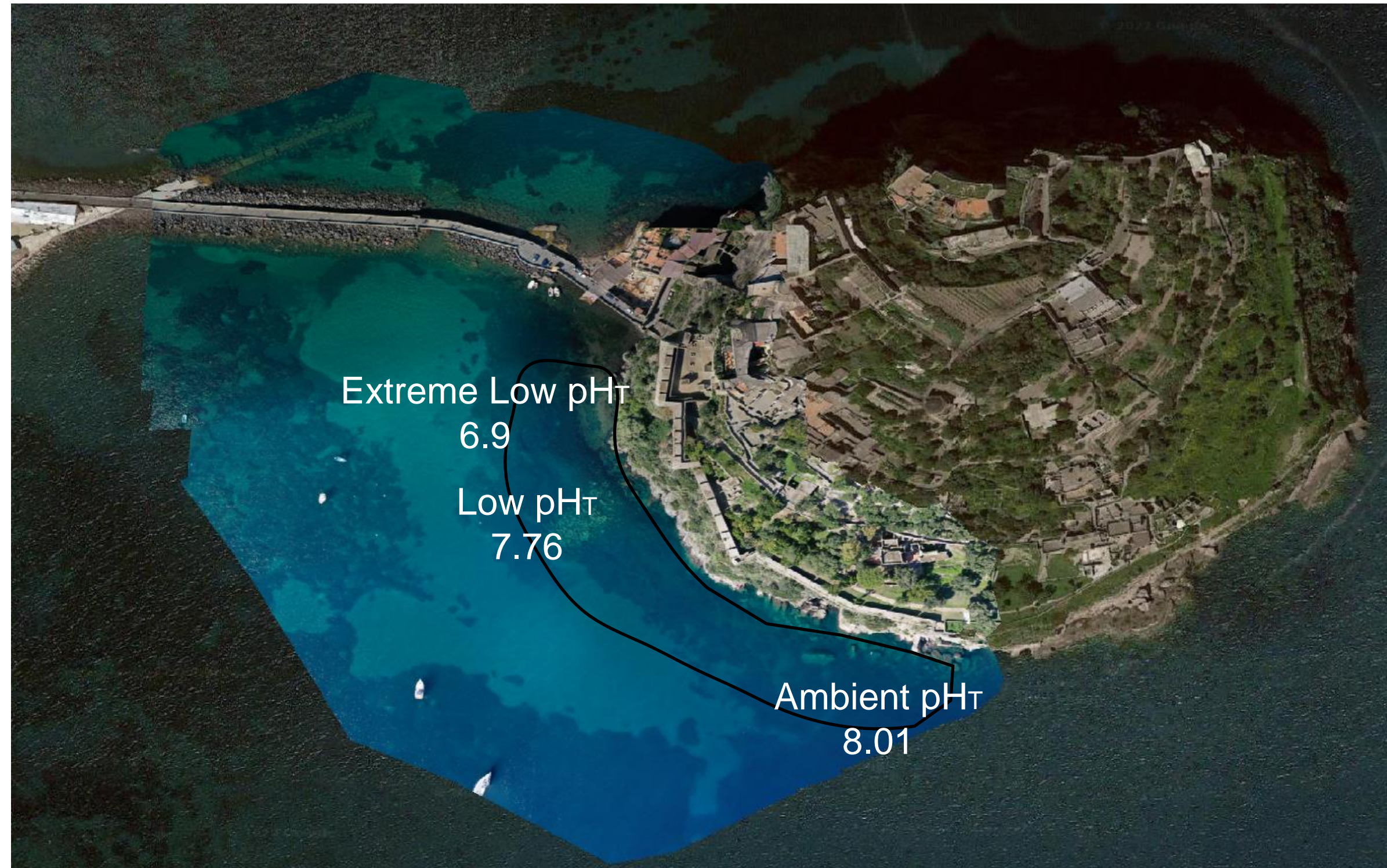


Natural Temperature and OA gradients - Ischia CO2 vents



Evaluating macrophytes performance under future ocean scenarios

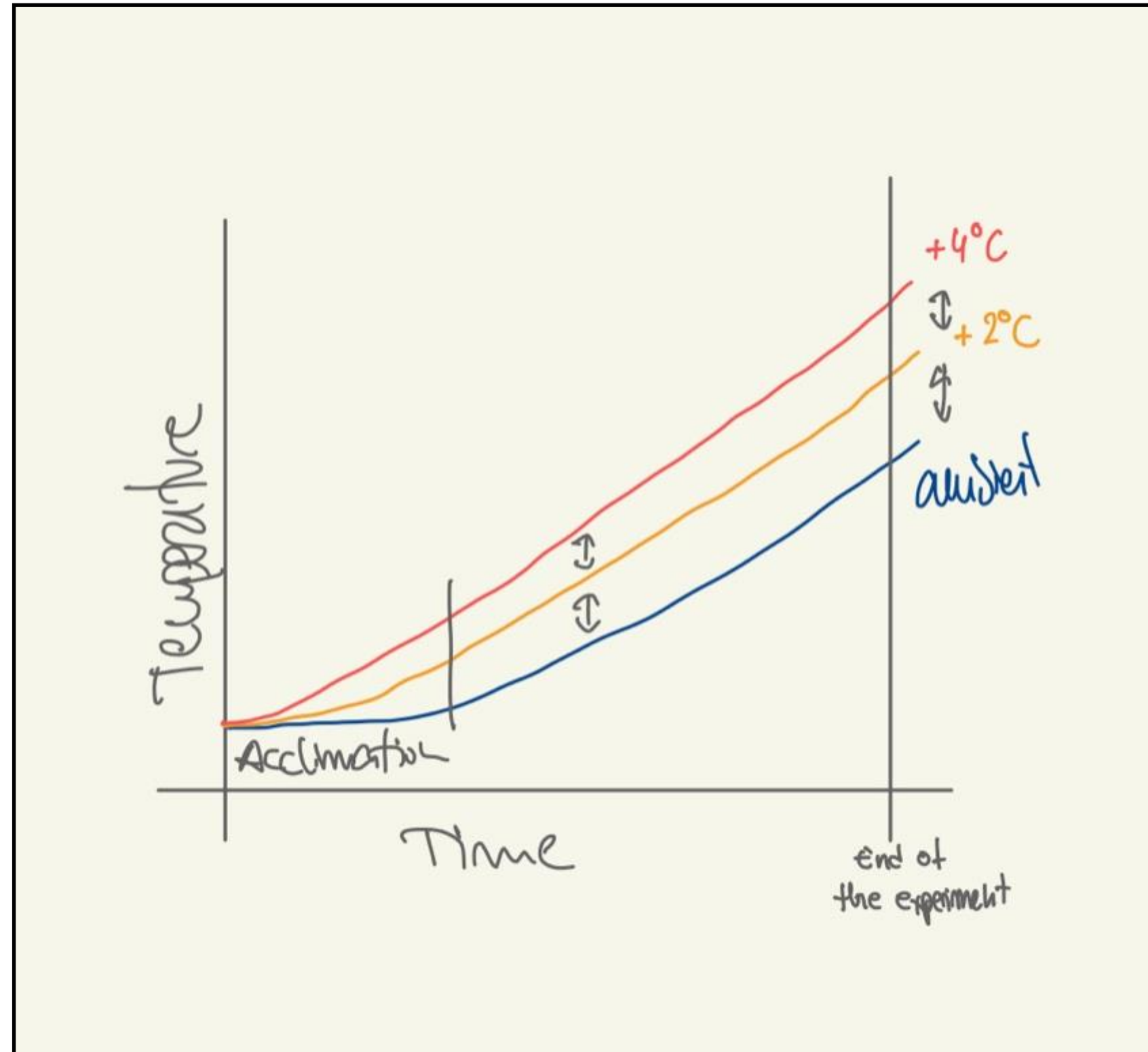
Aim: understanding the performance of *P. oceanica* under future OA and OW



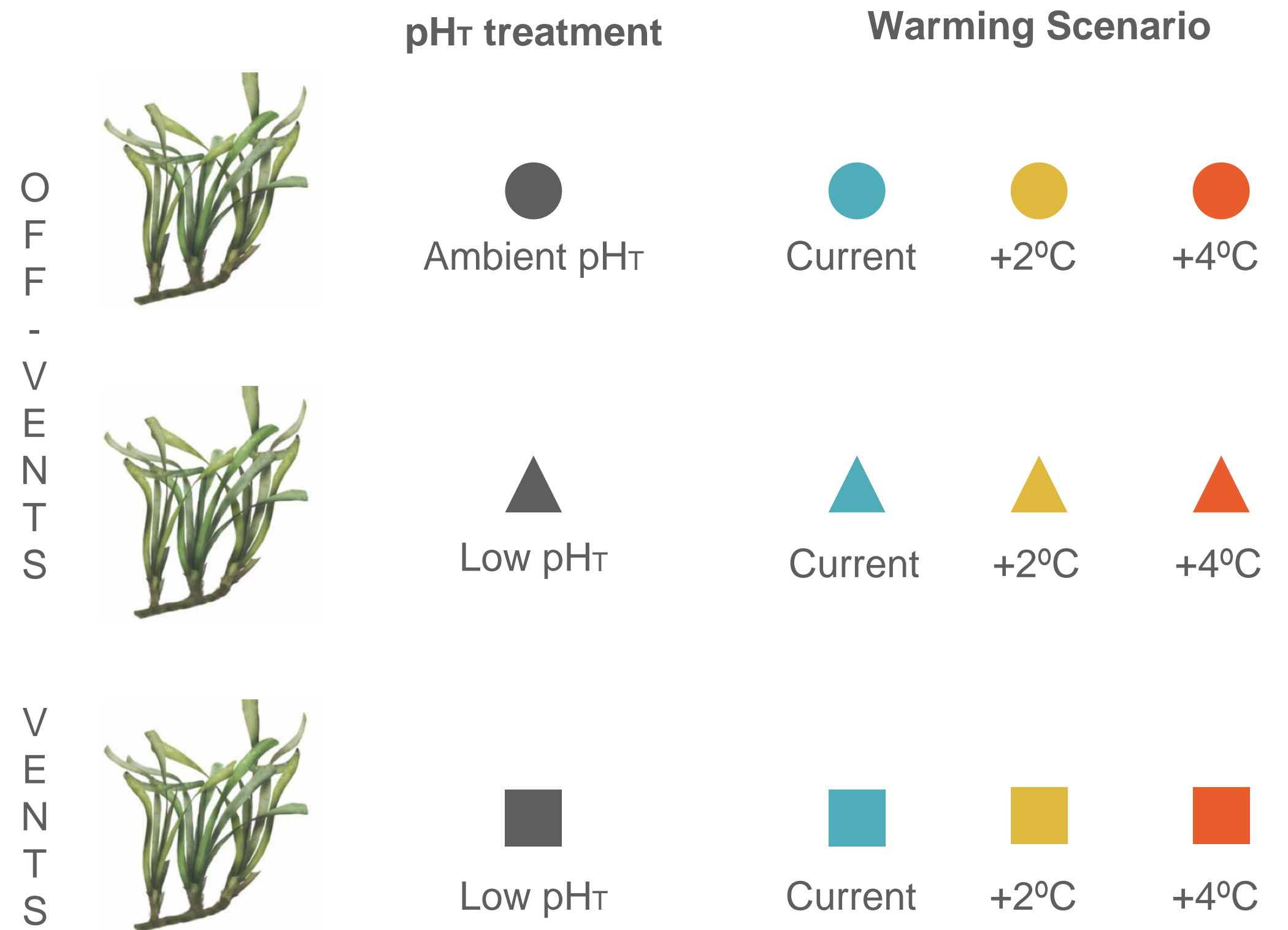
O  
F  
F  
-  
V  
E  
N  
T  
S



Evaluating macrophytes performance under future ocean scenarios

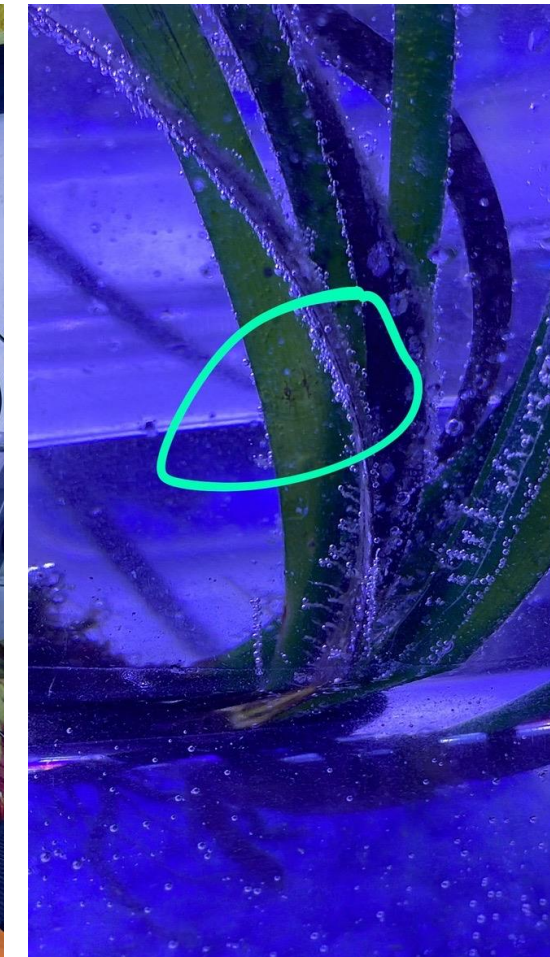
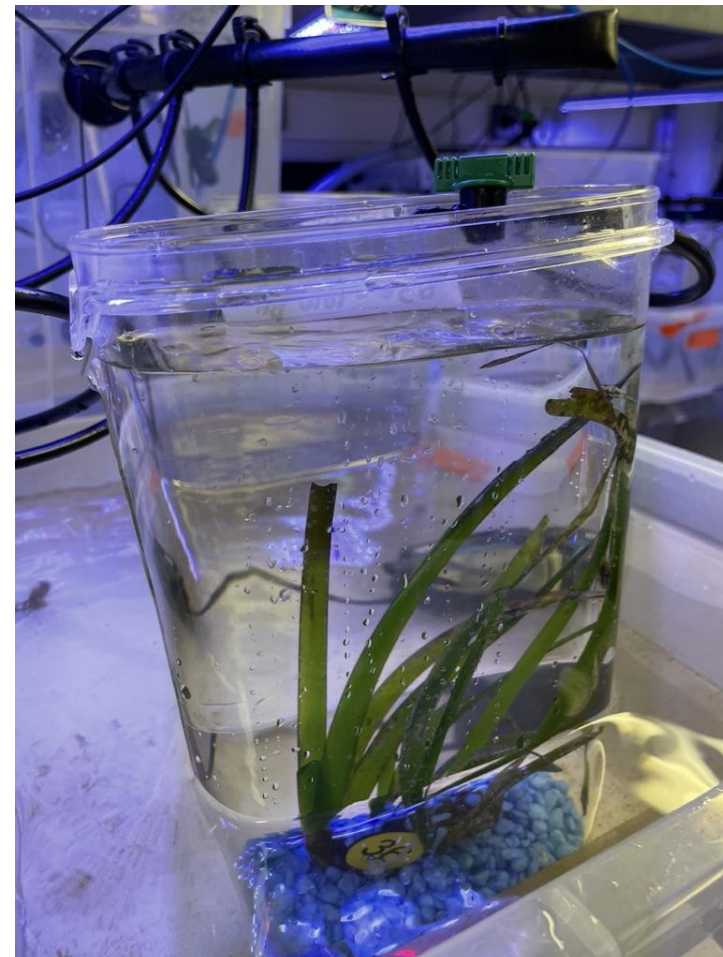
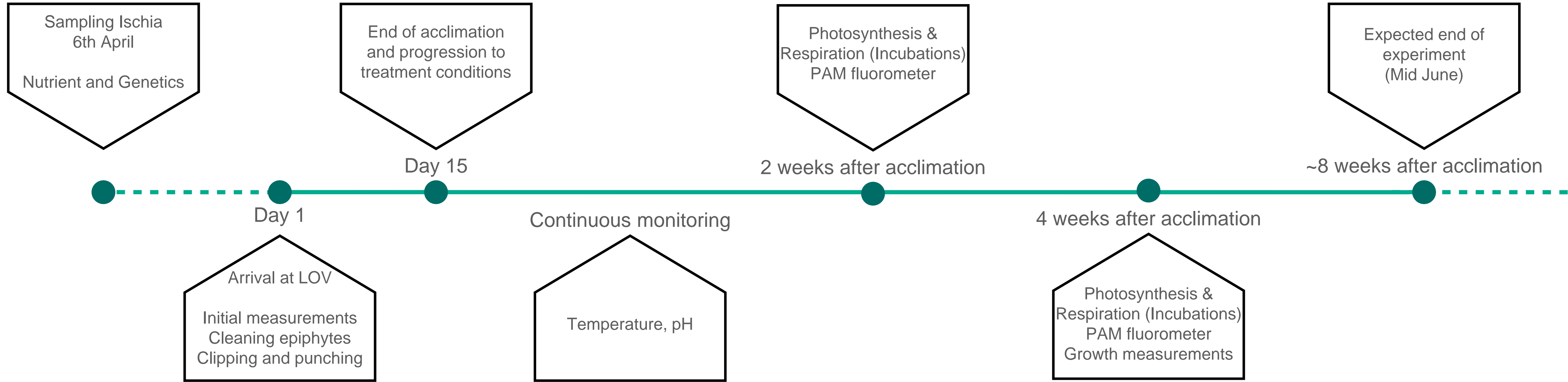


**Aim:** understanding the performance of *P. oceanica* under future OA and OW





## Evaluating macrophytes performance under future ocean scenarios

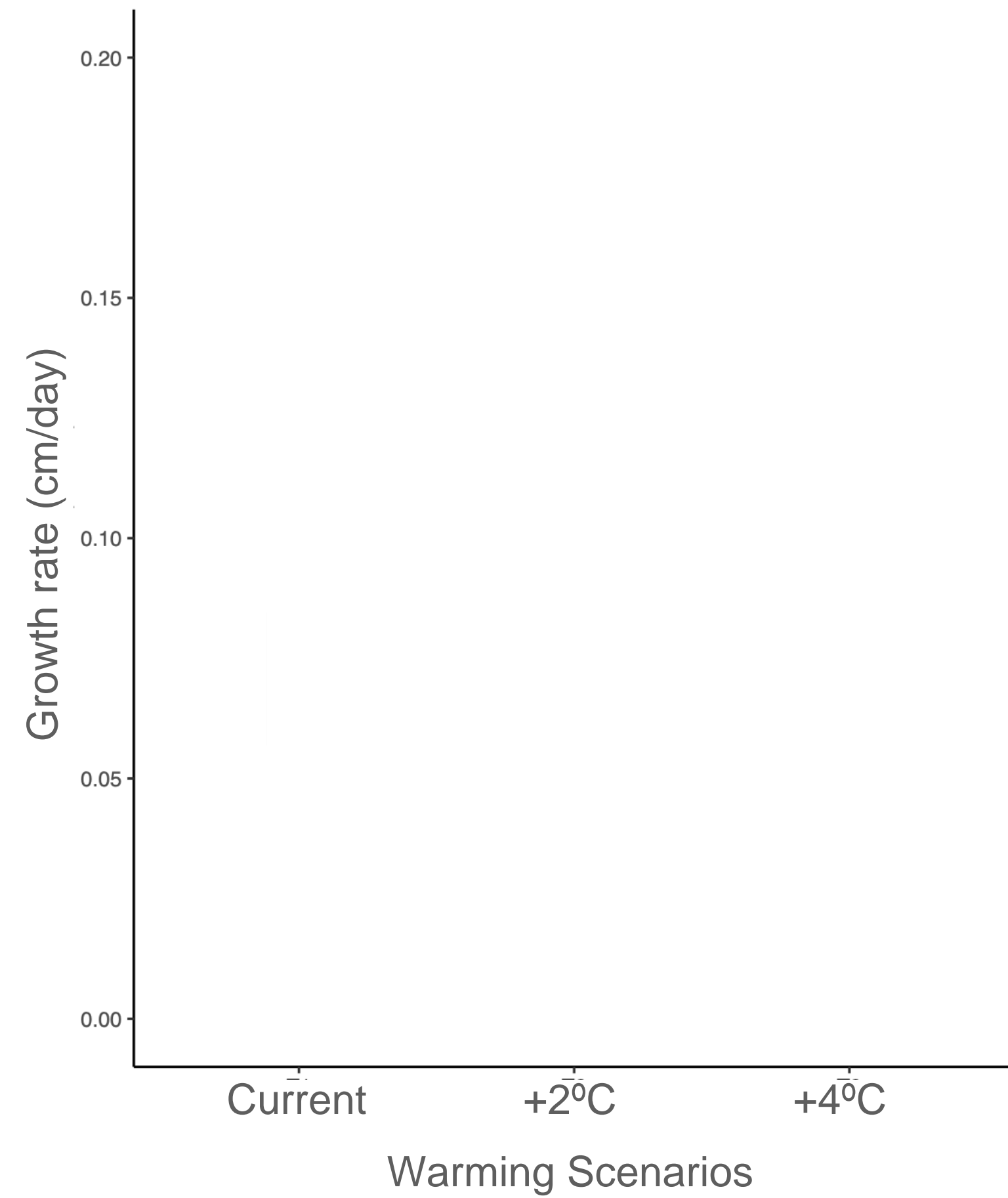


# Evaluating macrophytes performance under future ocean scenarios

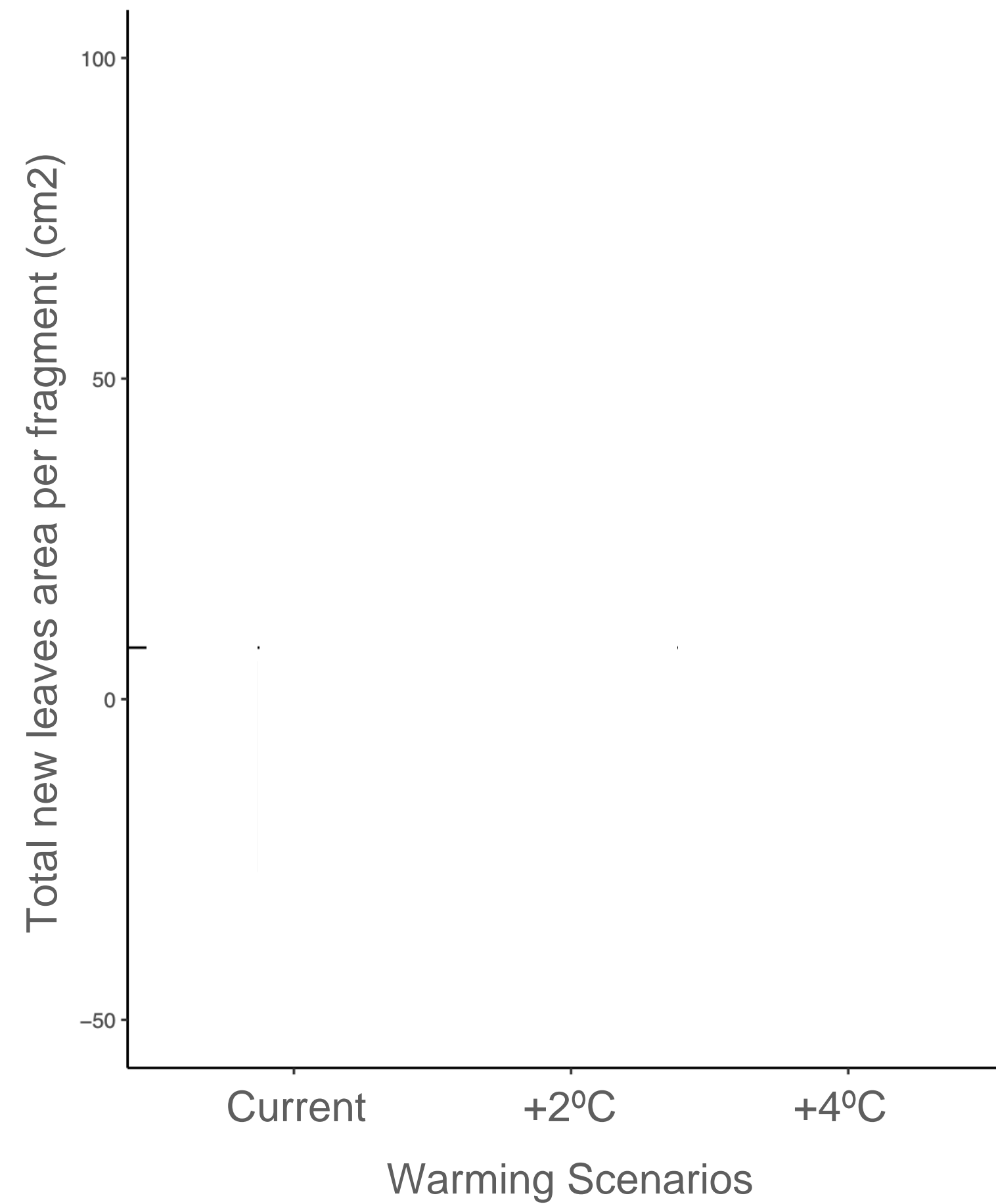
**Source**  
Off-vents

**pH<sub>T</sub>**  
Ambient ●

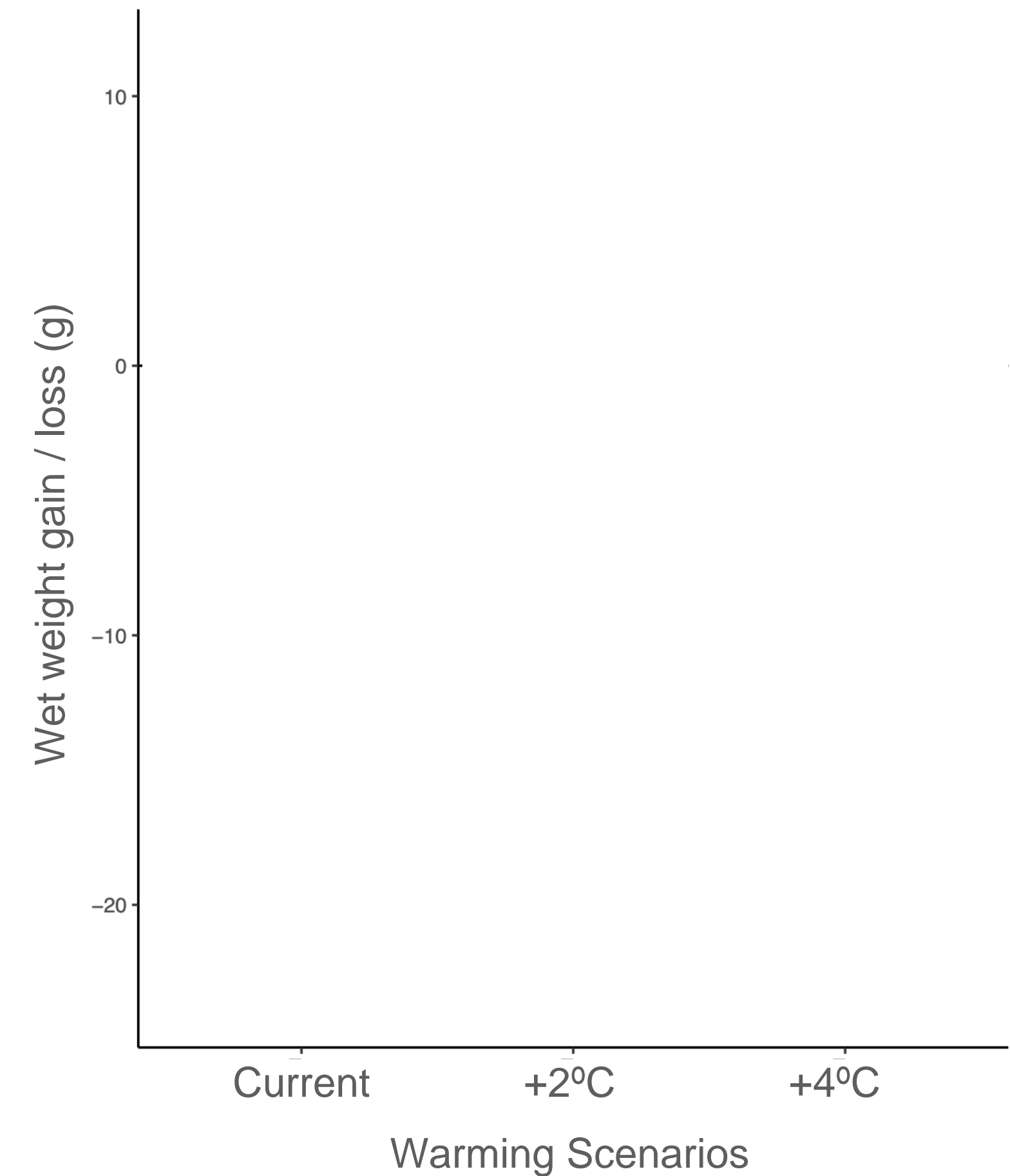
## Leaves elongation rates



## New photosynthetic tissue



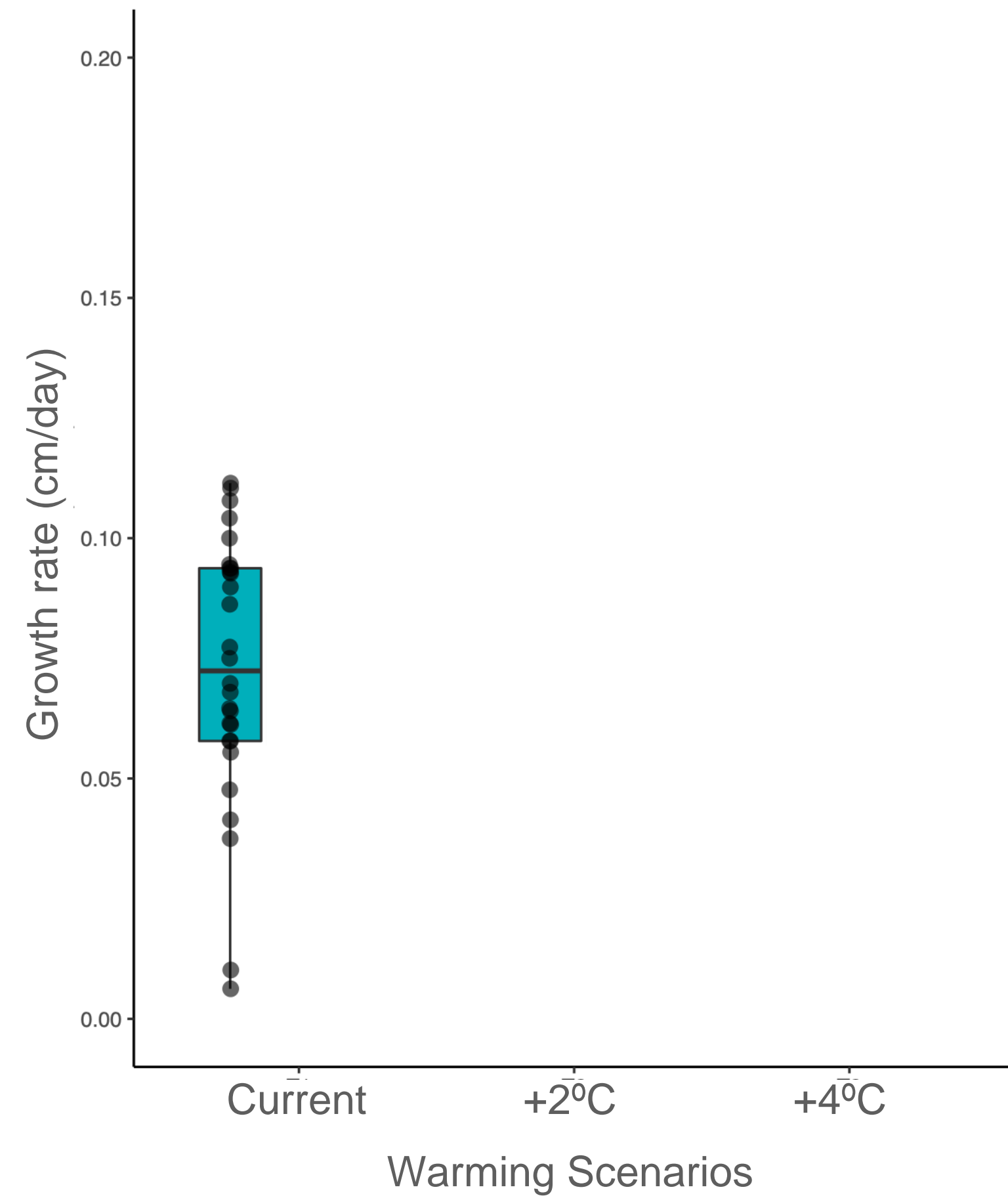
## Wet weight gain / loss



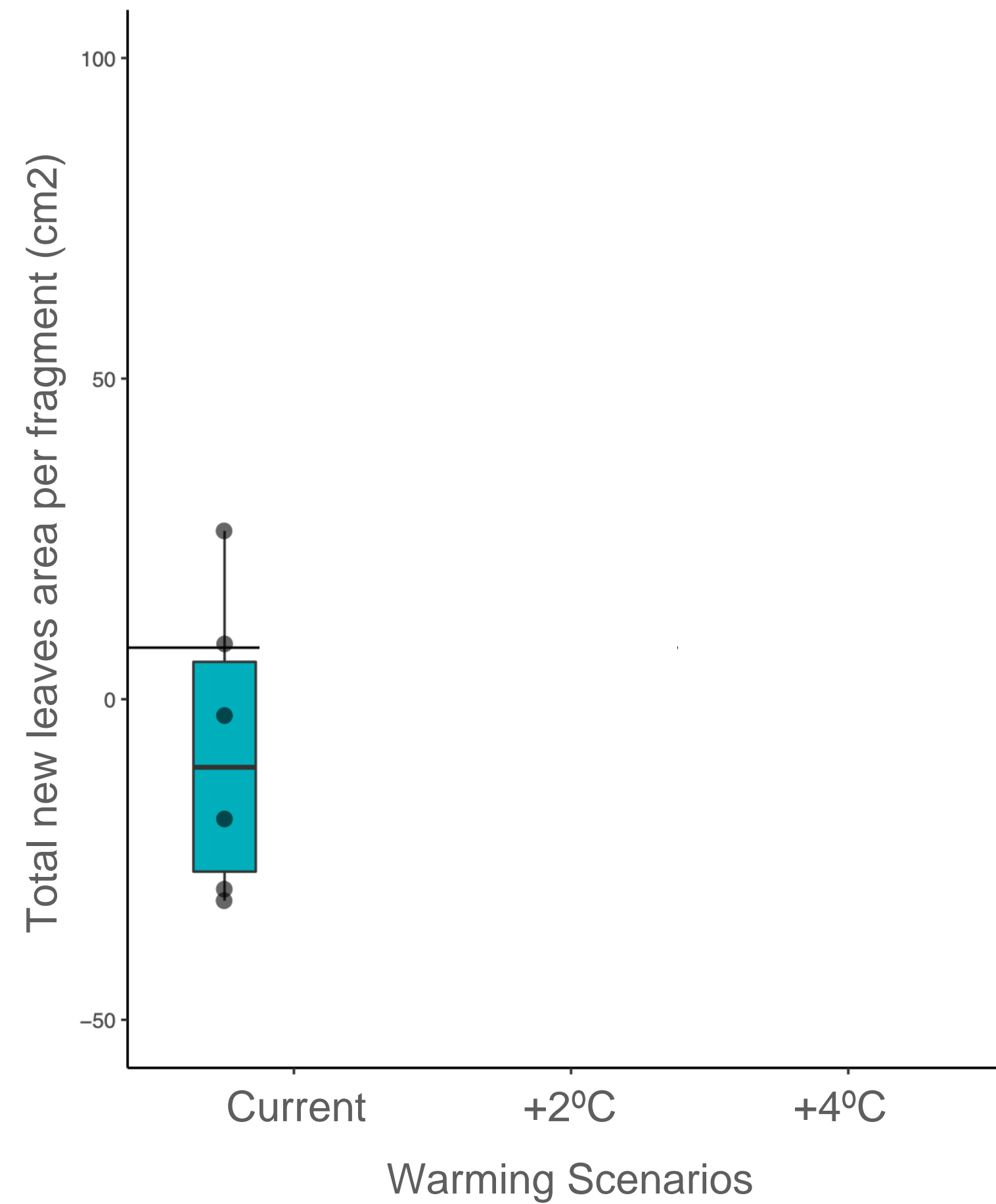
Source  
Off-vents  
pH<sub>T</sub>  
Ambient ●

# Evaluating macrophytes performance under future ocean scenarios

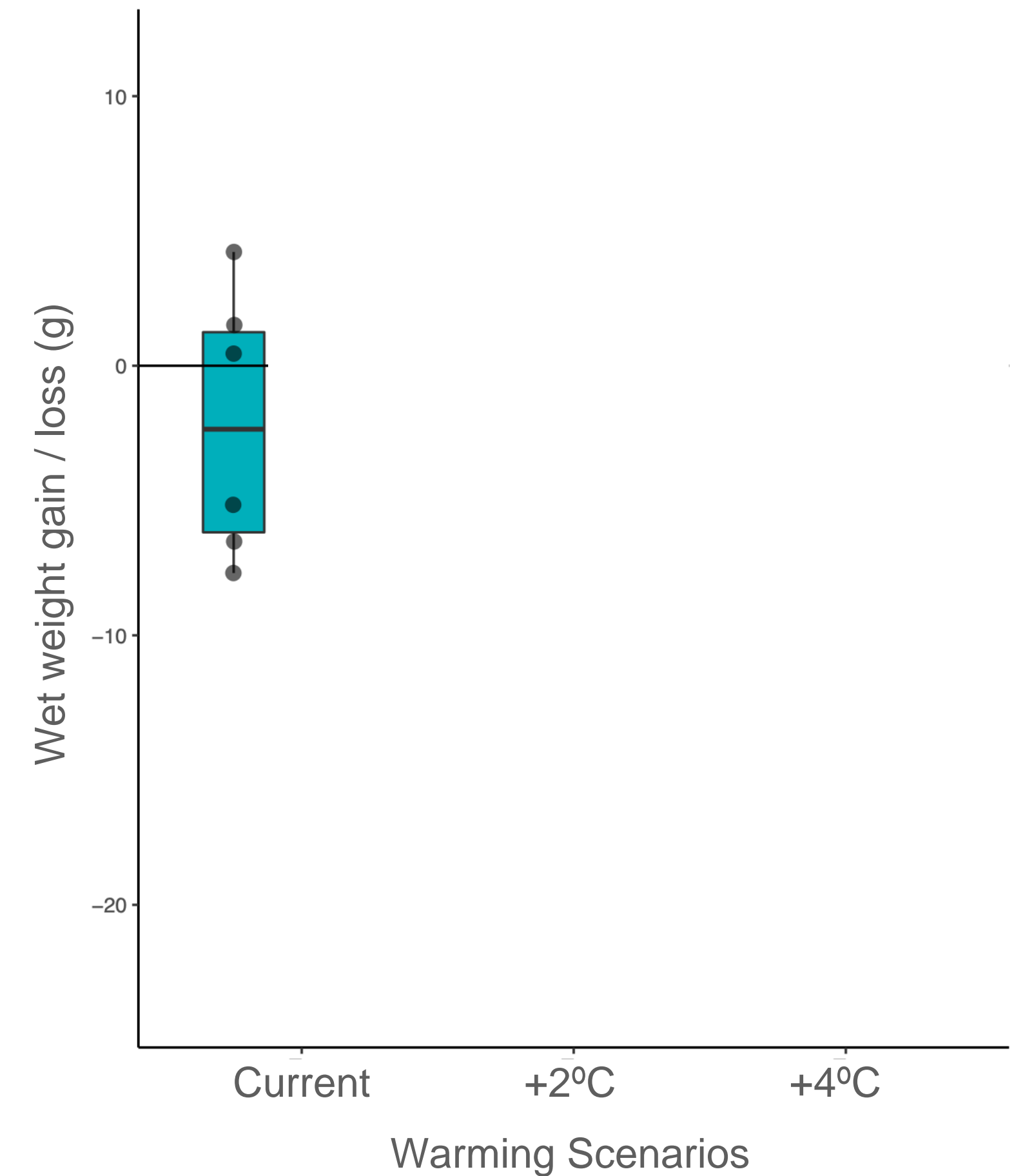
## Leaves elongation rates



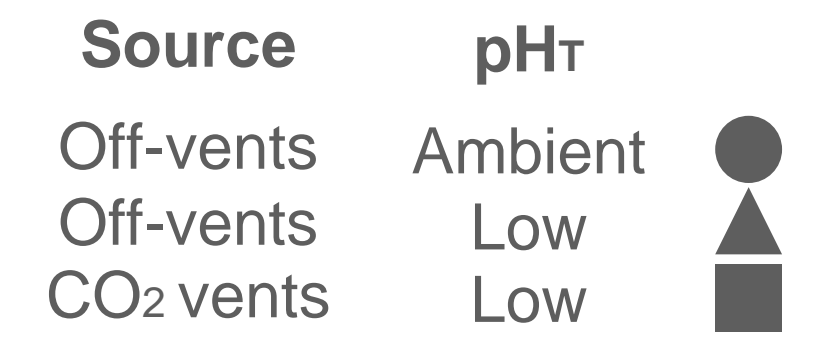
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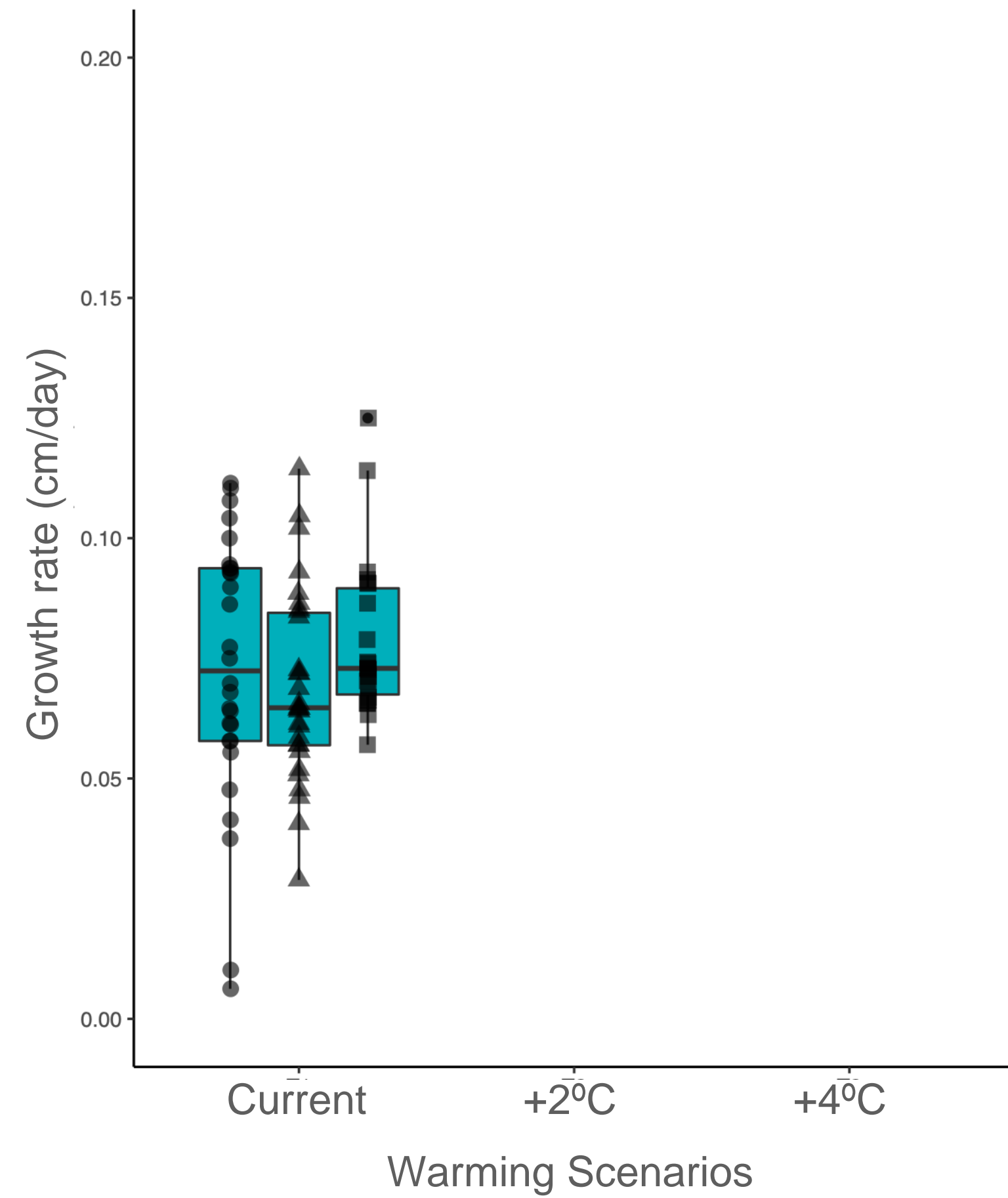
## Wet weight gain / loss



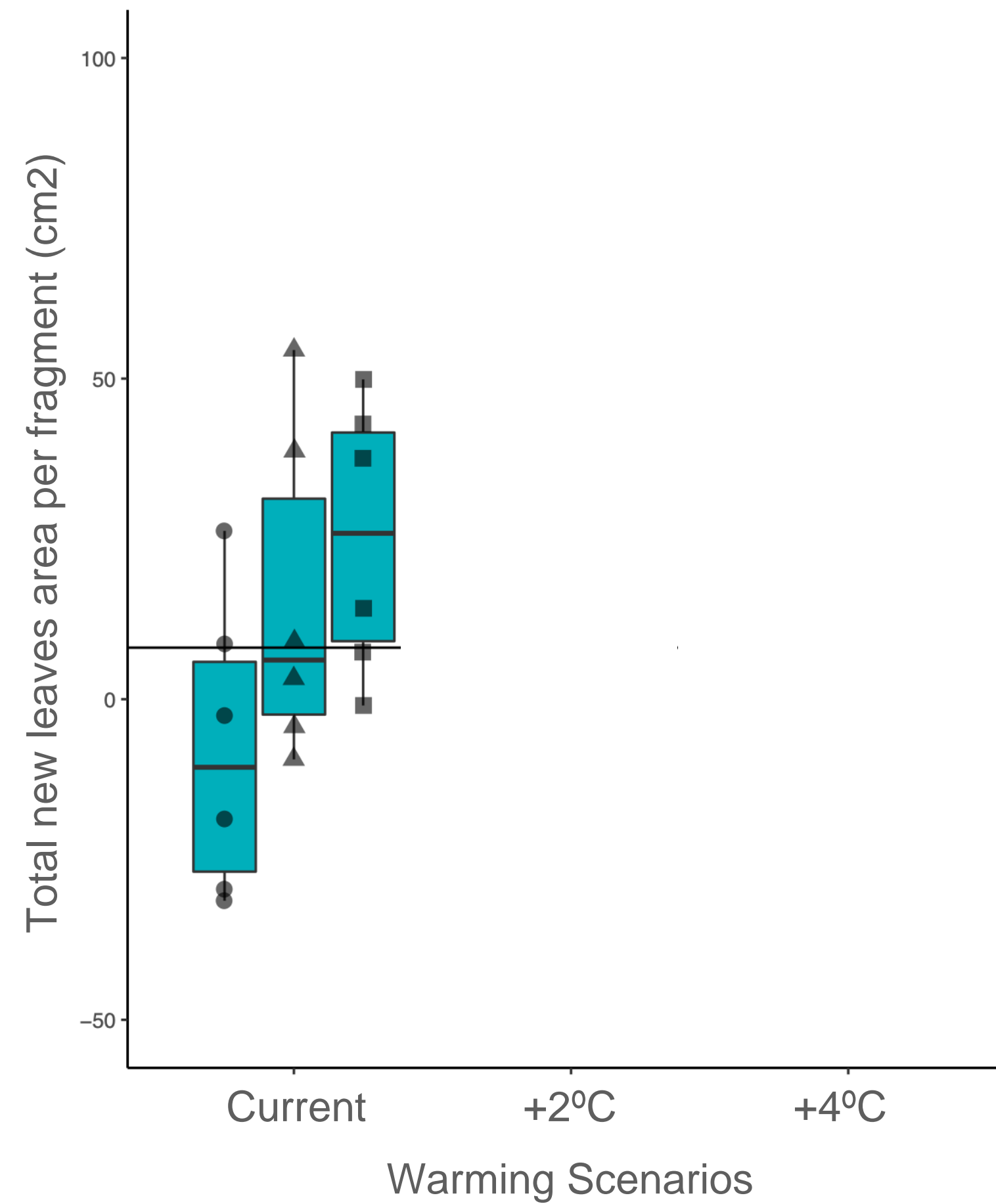
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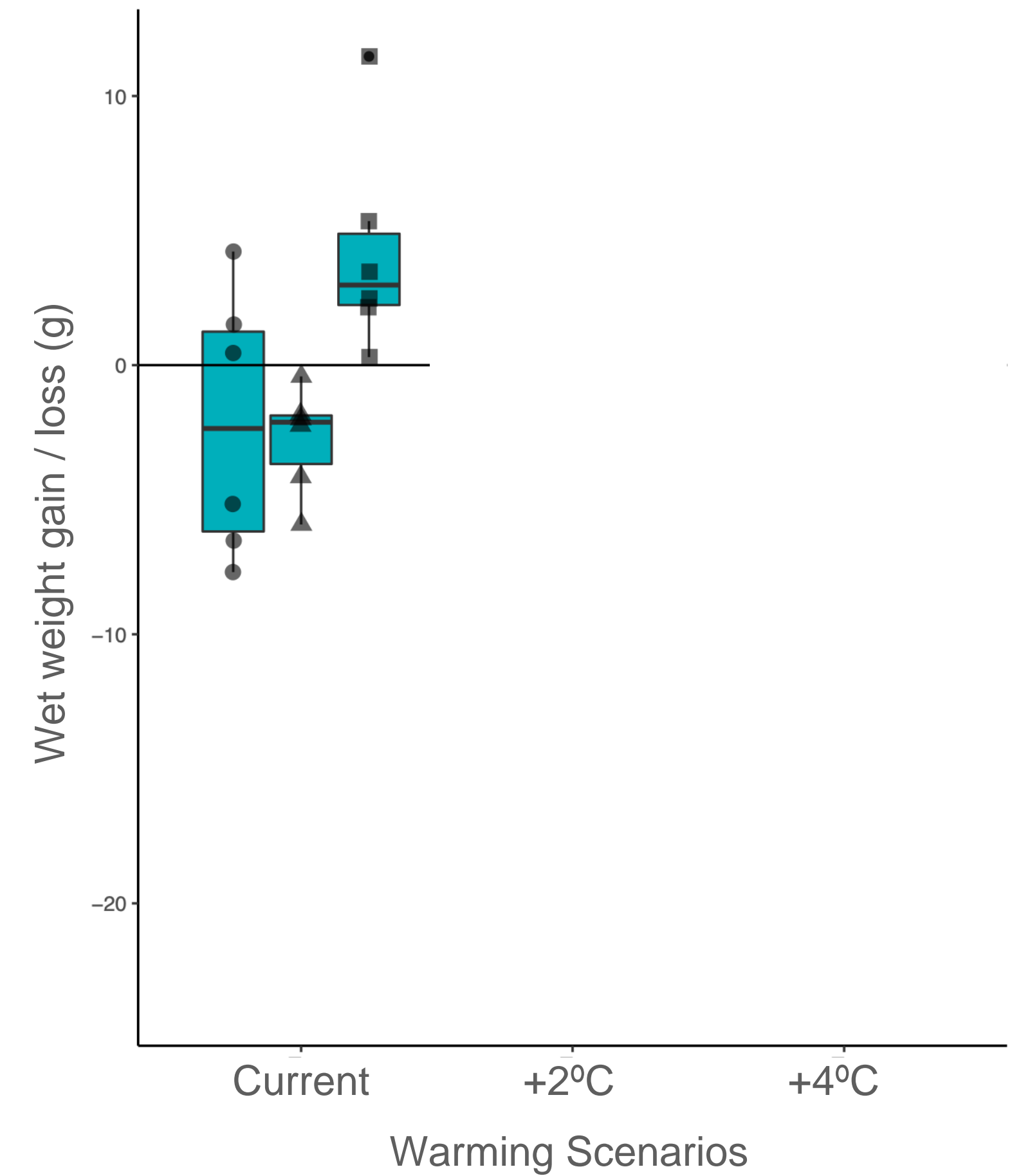
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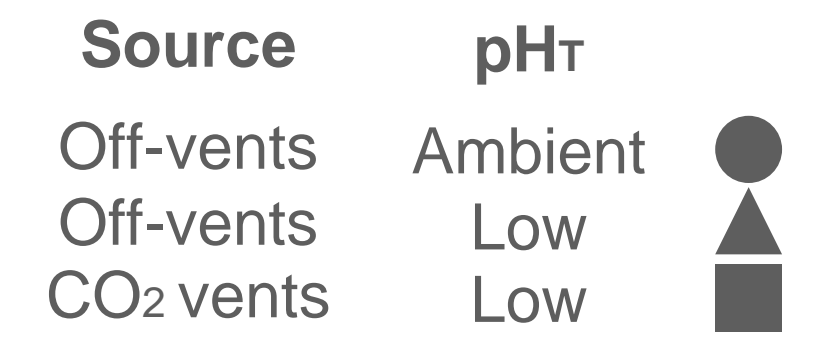
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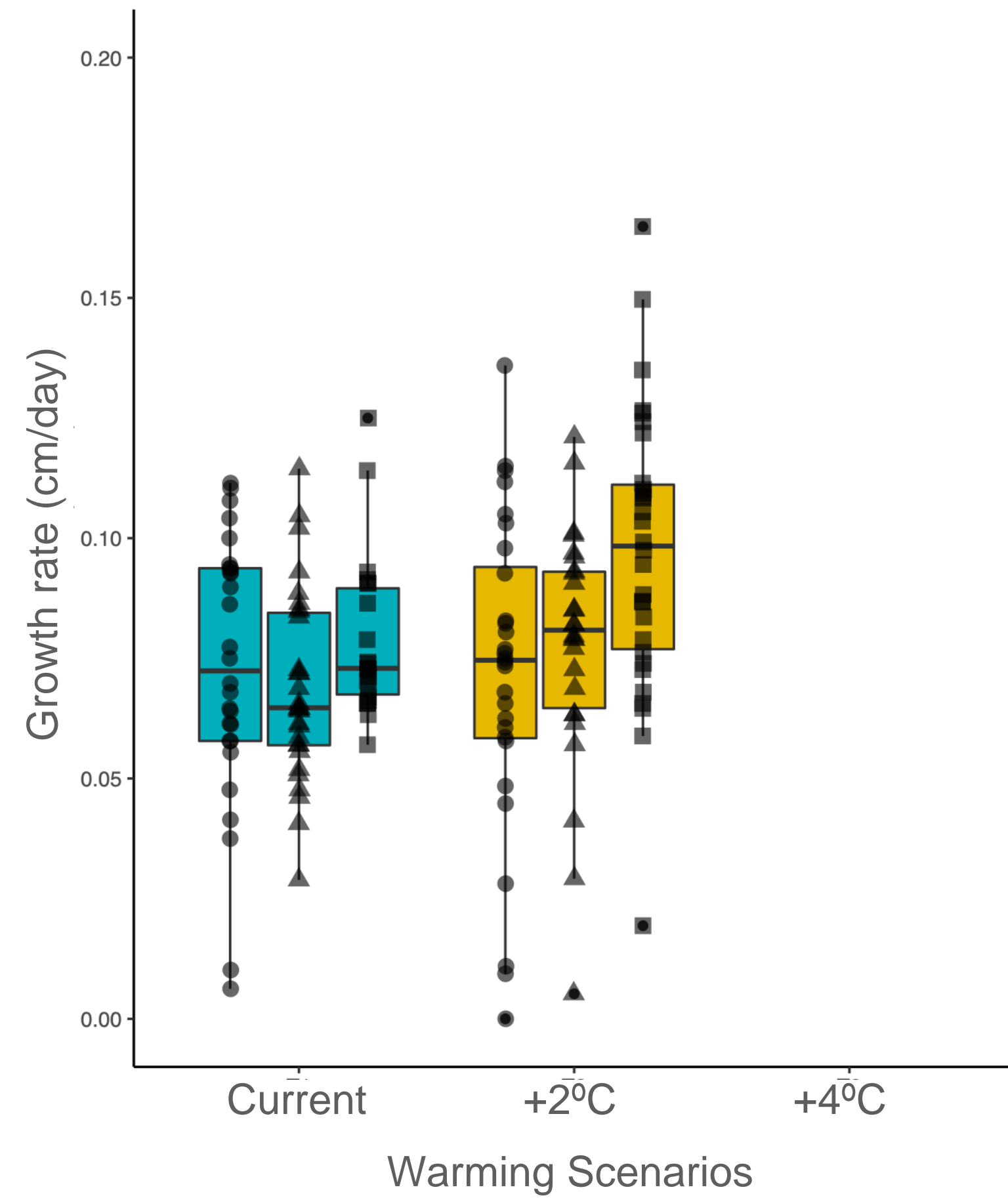
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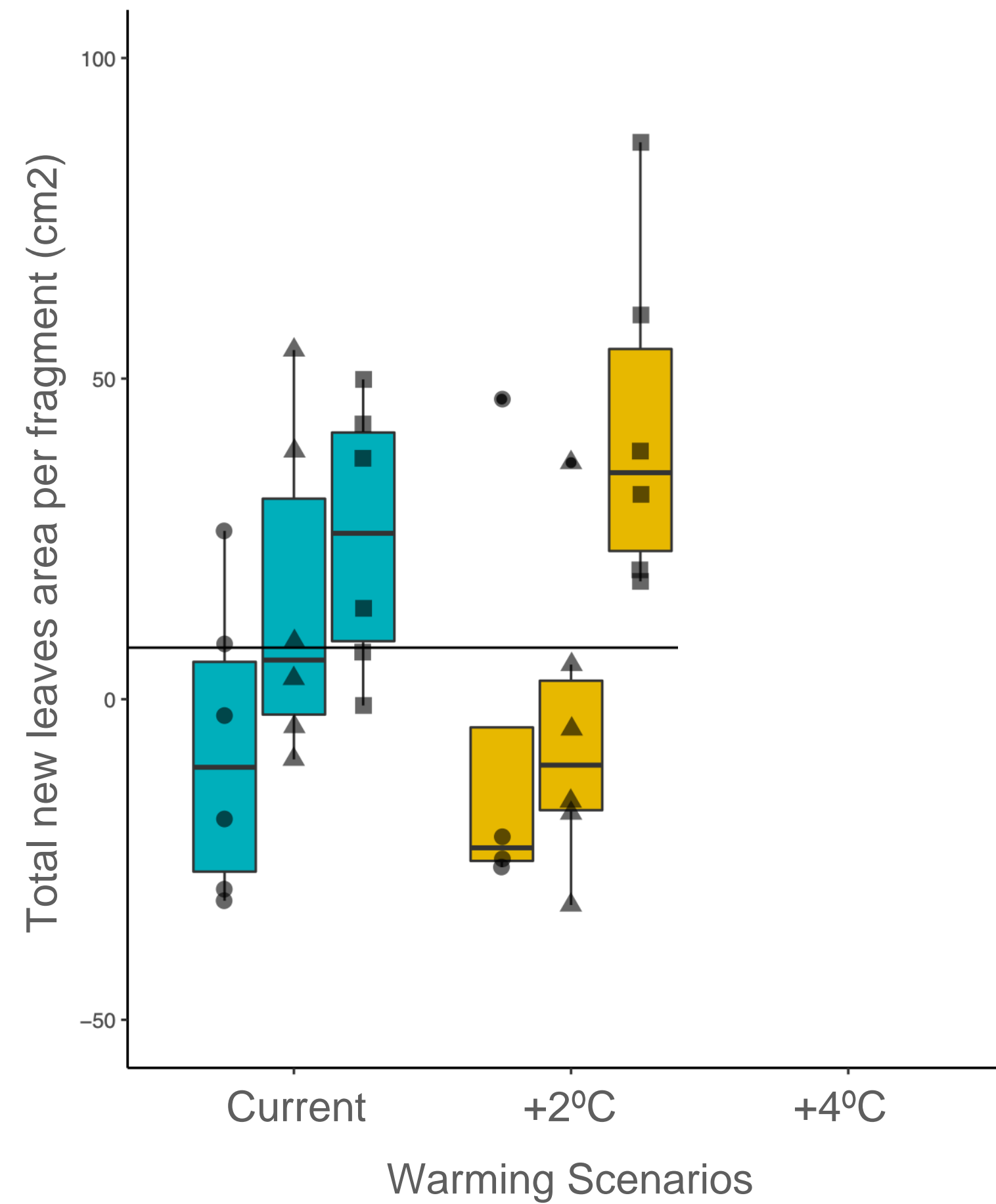
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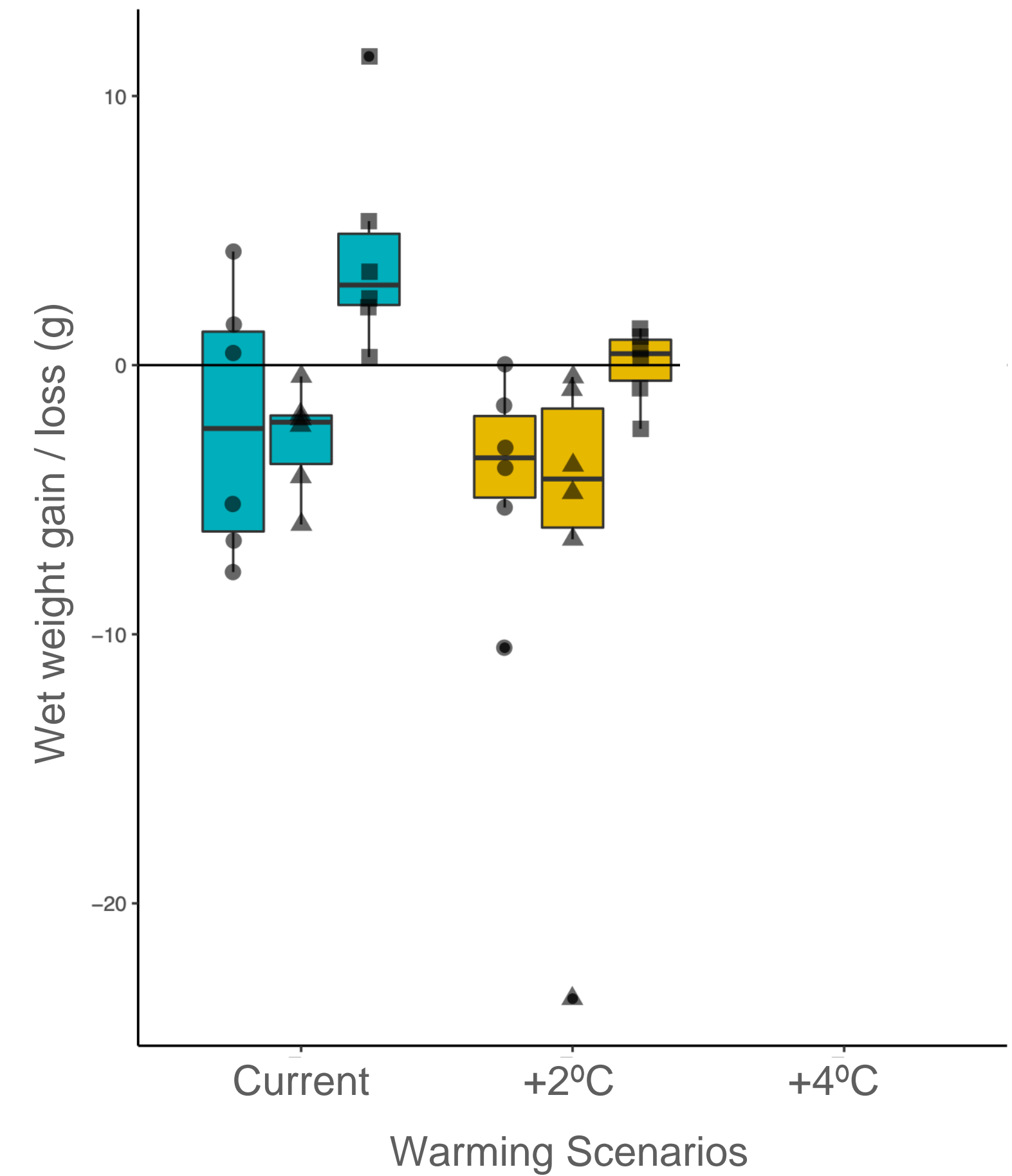
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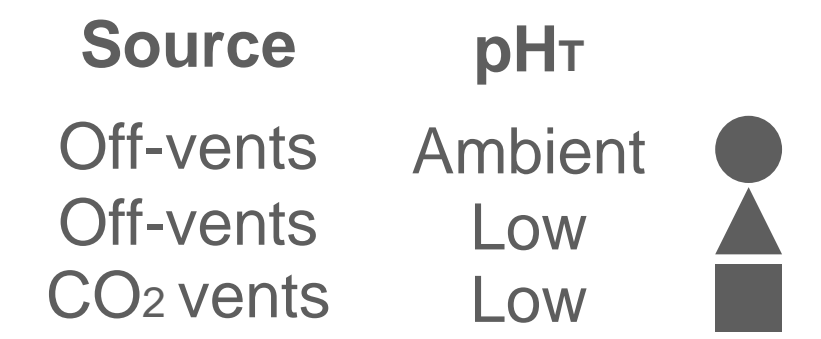
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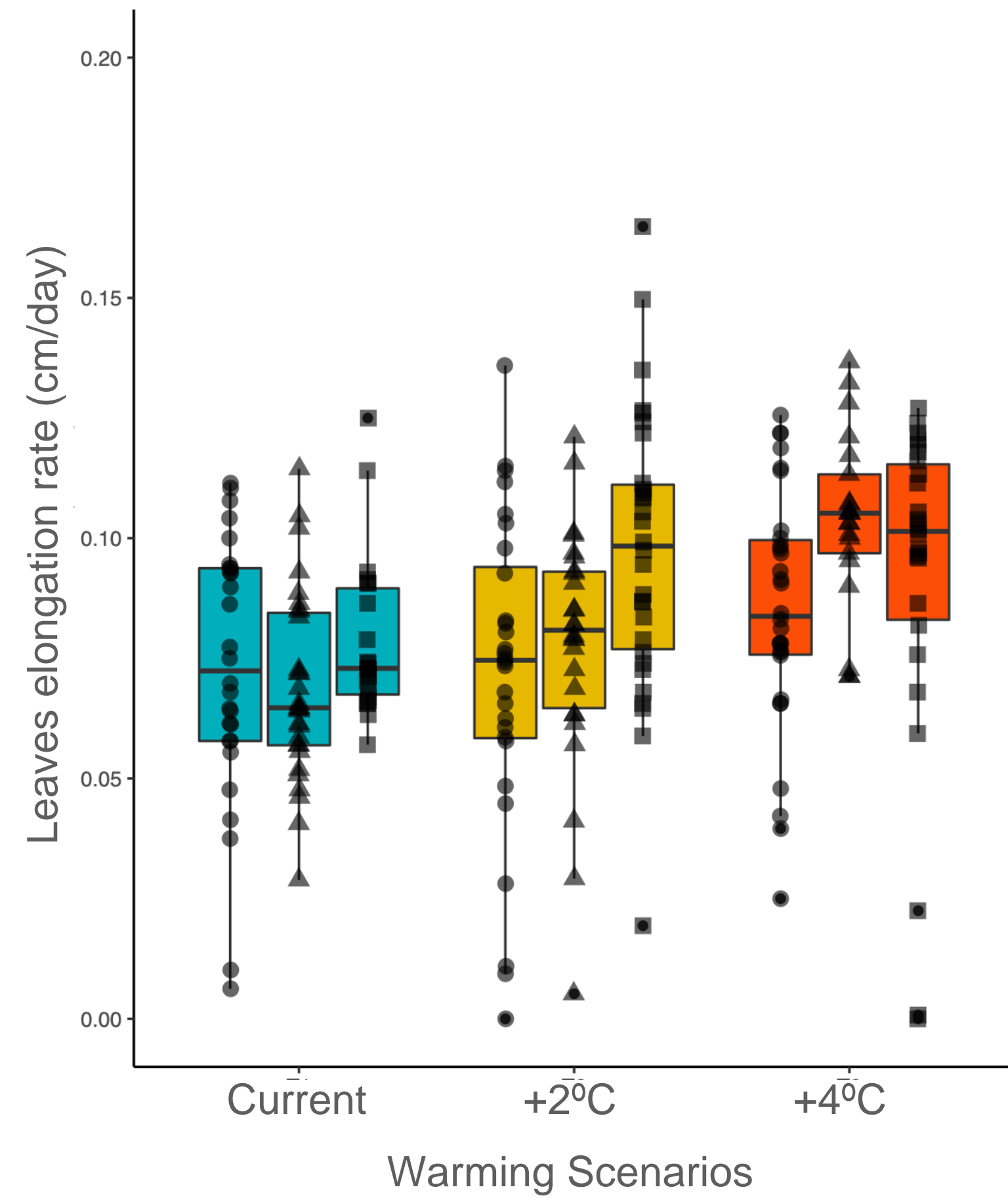
## Wet weight gain / loss



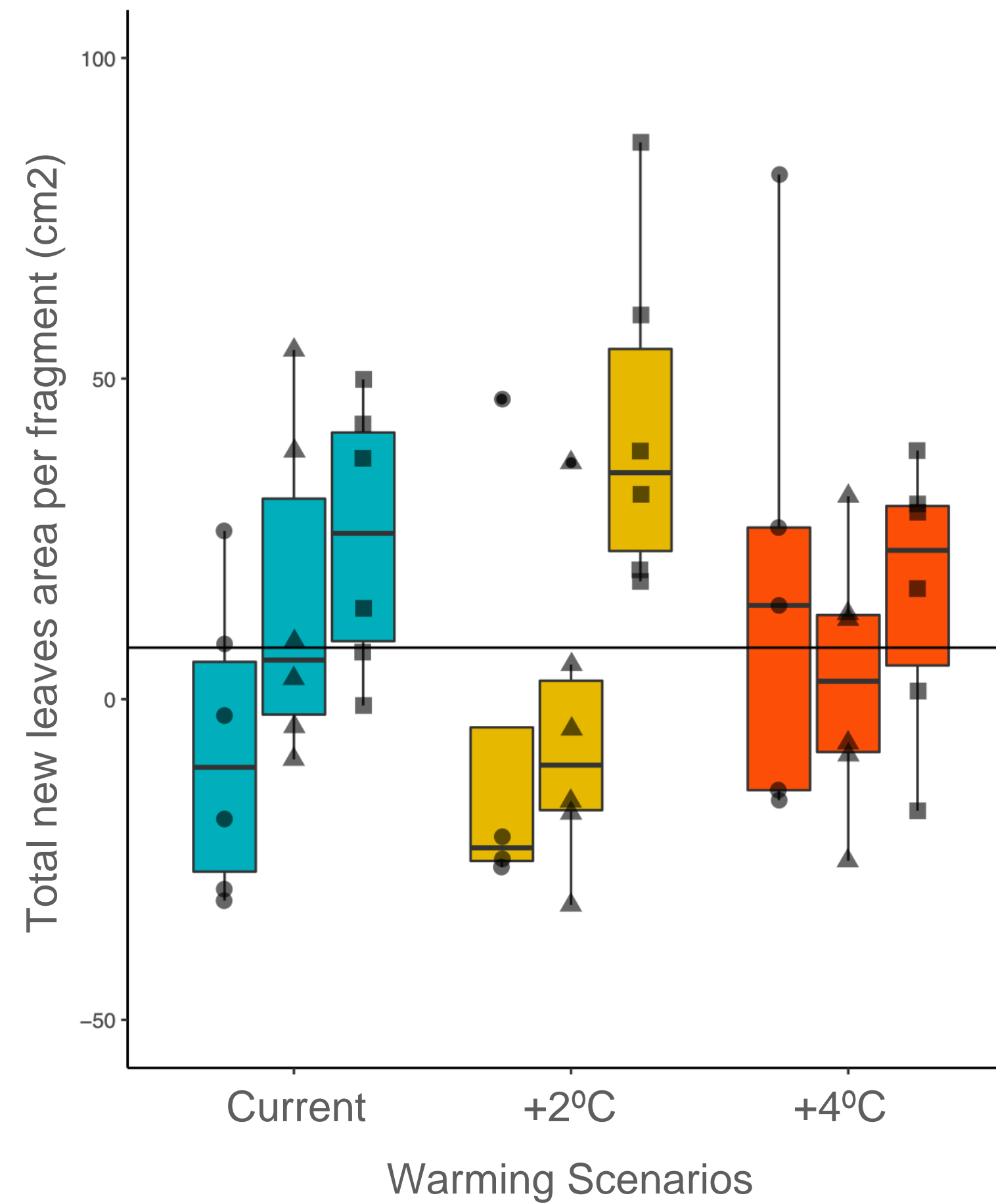
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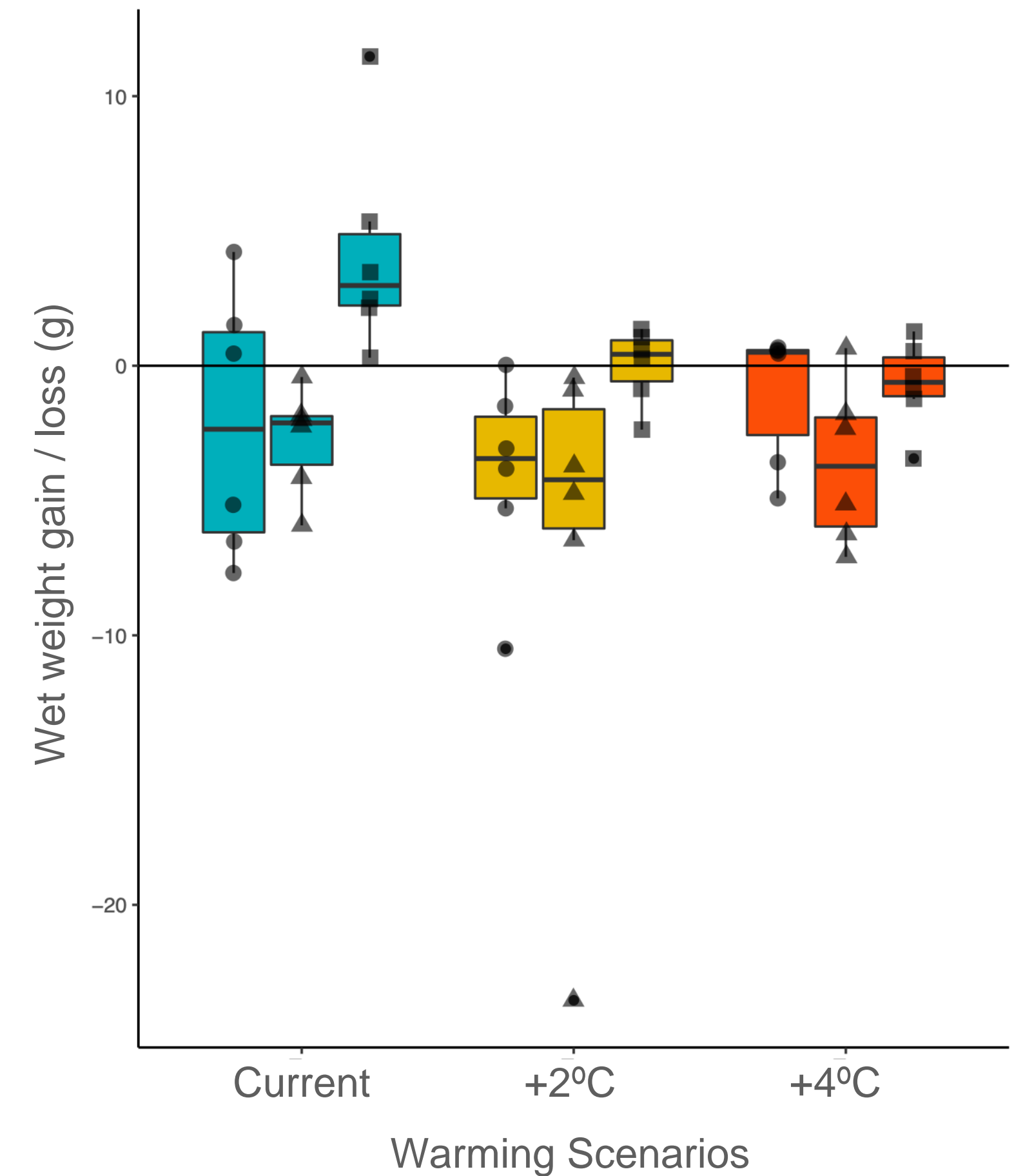
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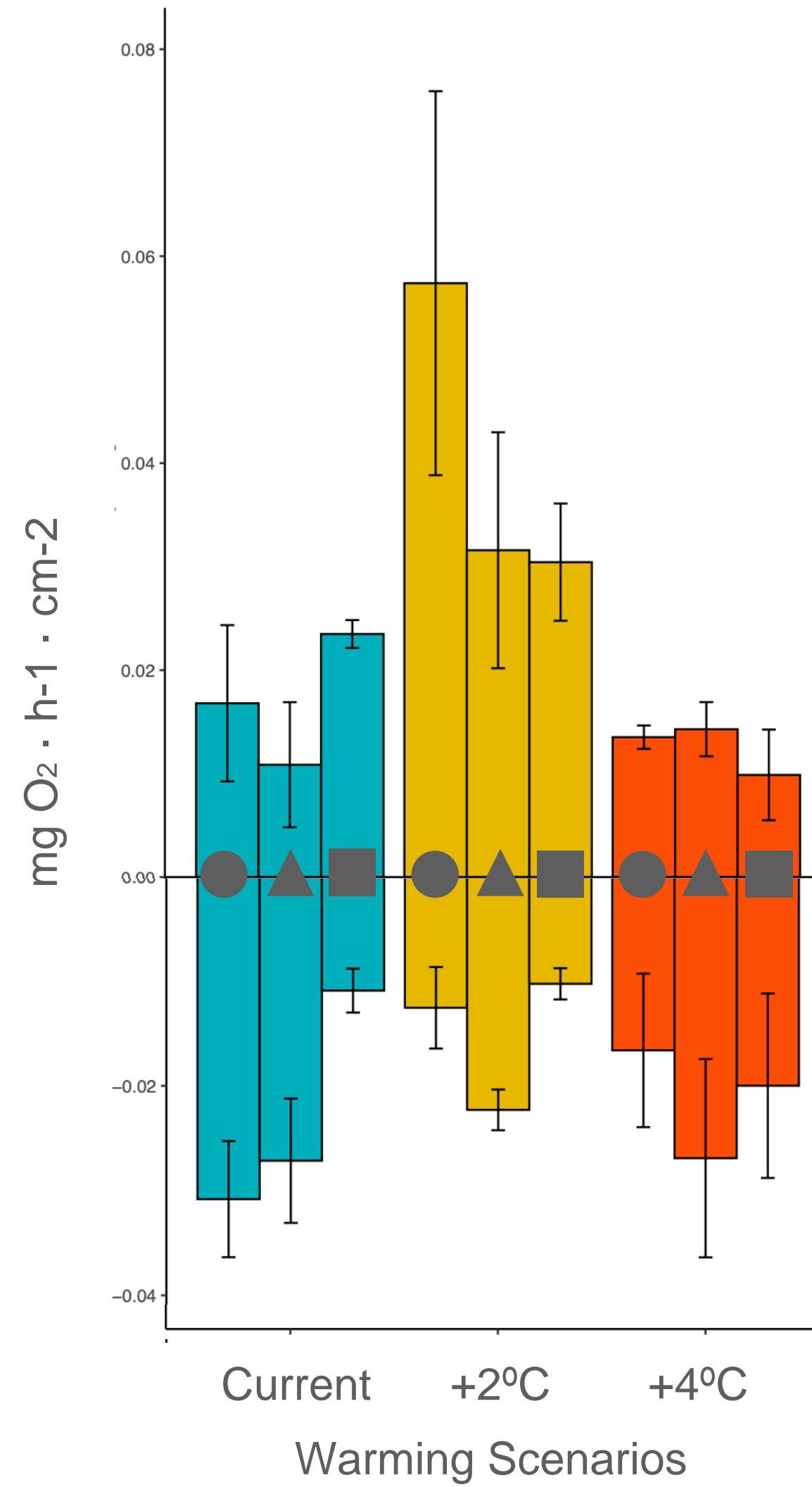
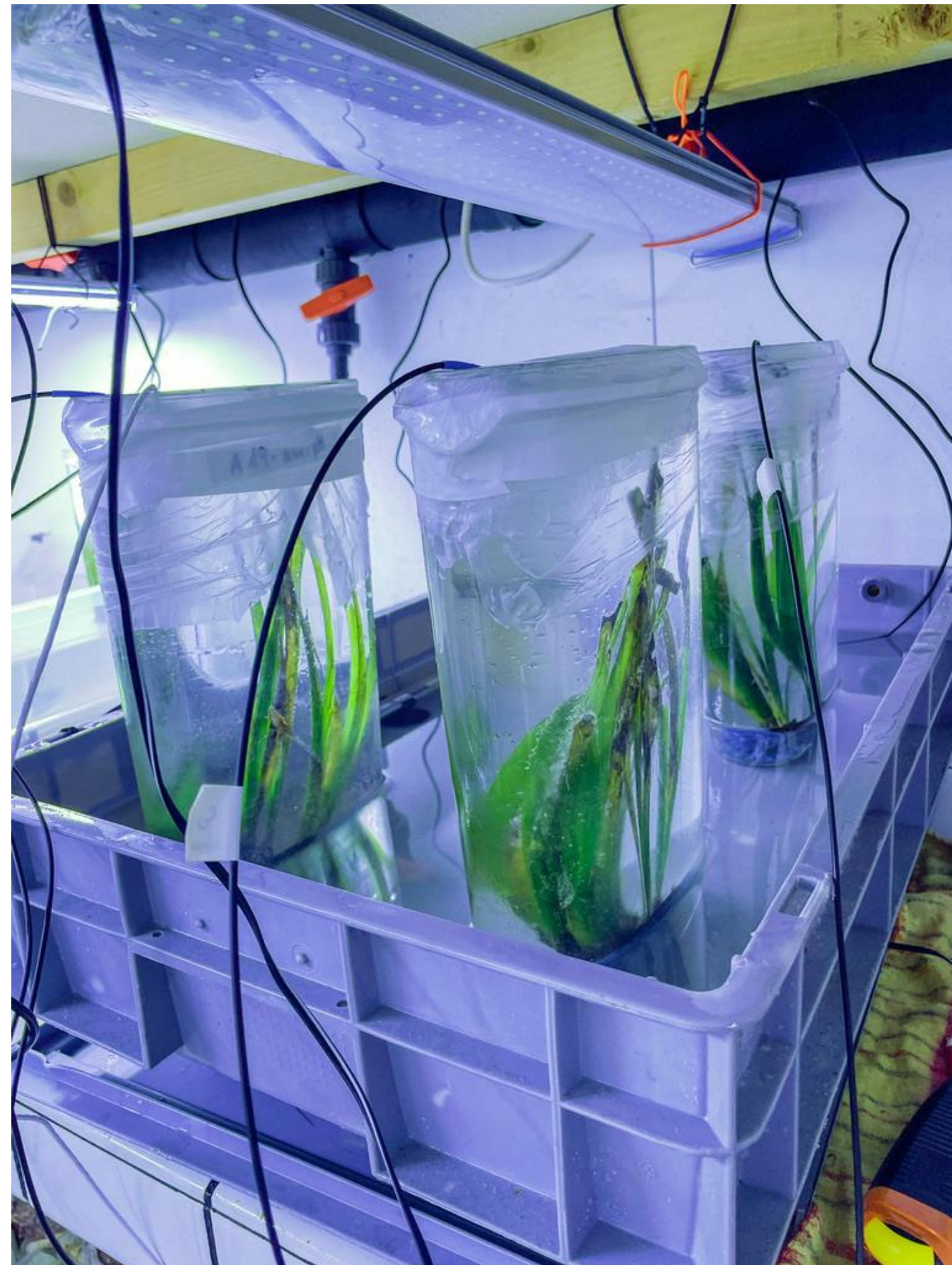


## Wet weight gain / loss



# Evaluating macrophytes performance under future ocean scenarios

Source	pH <sub>T</sub>	Symbol
Off-vents	Ambient	●
Off-vents	Low	▲
CO <sub>2</sub> vents	Low	■



Net photosynthesis peaked at +2°C scenarios

Dark respiration minimum for plants from vents both at current and +2°C scenarios

## Evaluating macrophytes performance under future ocean scenarios



General increase in performance (productivity) under low pH

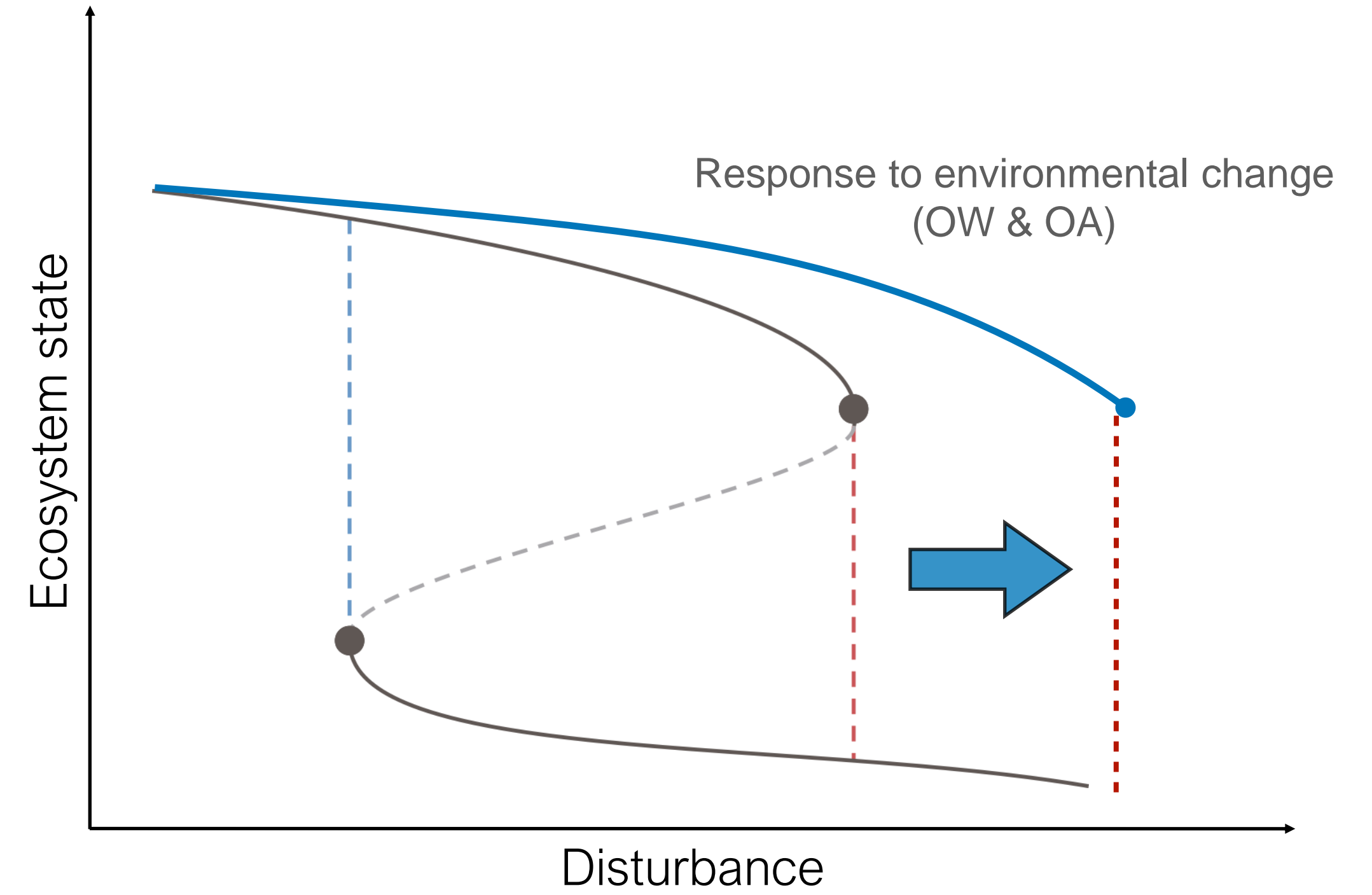


Maximized at T2 (probably larger exposure to optimal t conditions)



Pattern not maintained at high temperature scenarios (+4°C)

Source	pH <sub>T</sub>	Symbol
Off-vents	Ambient	●
Off-vents	Low	▲
CO <sub>2</sub> vents	Low	■



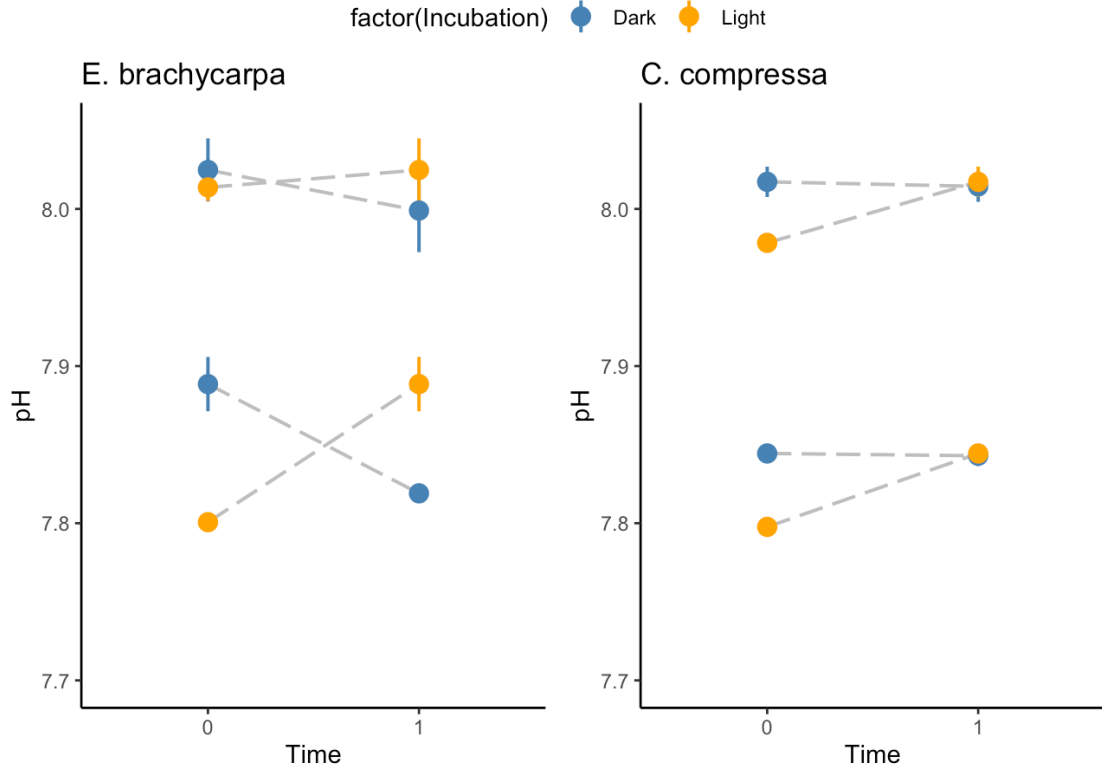
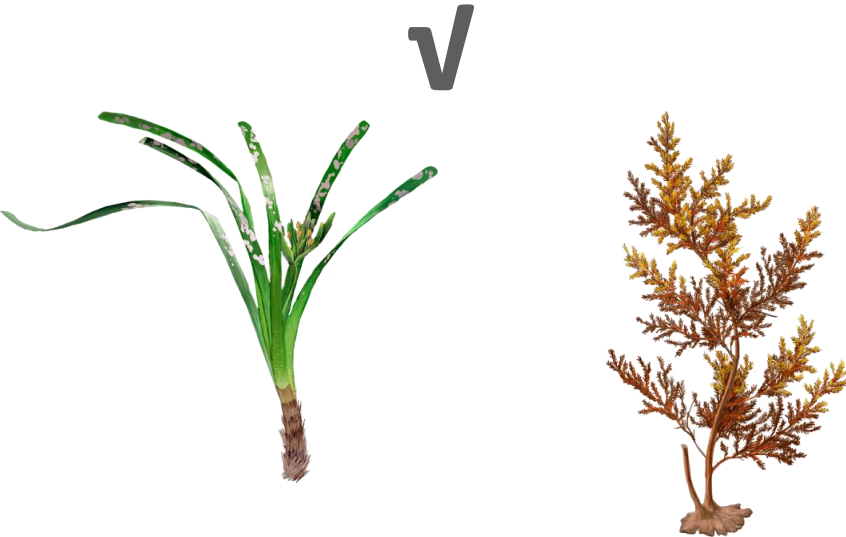
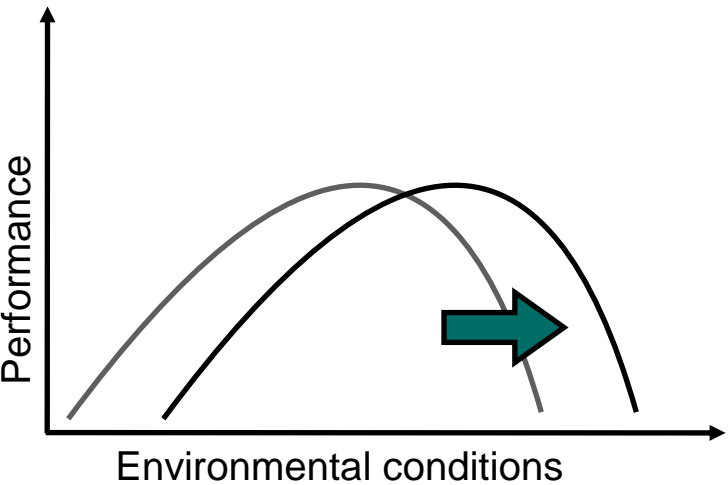
Use this information in models to forecast future resilience

# SHIFT2SOLVE

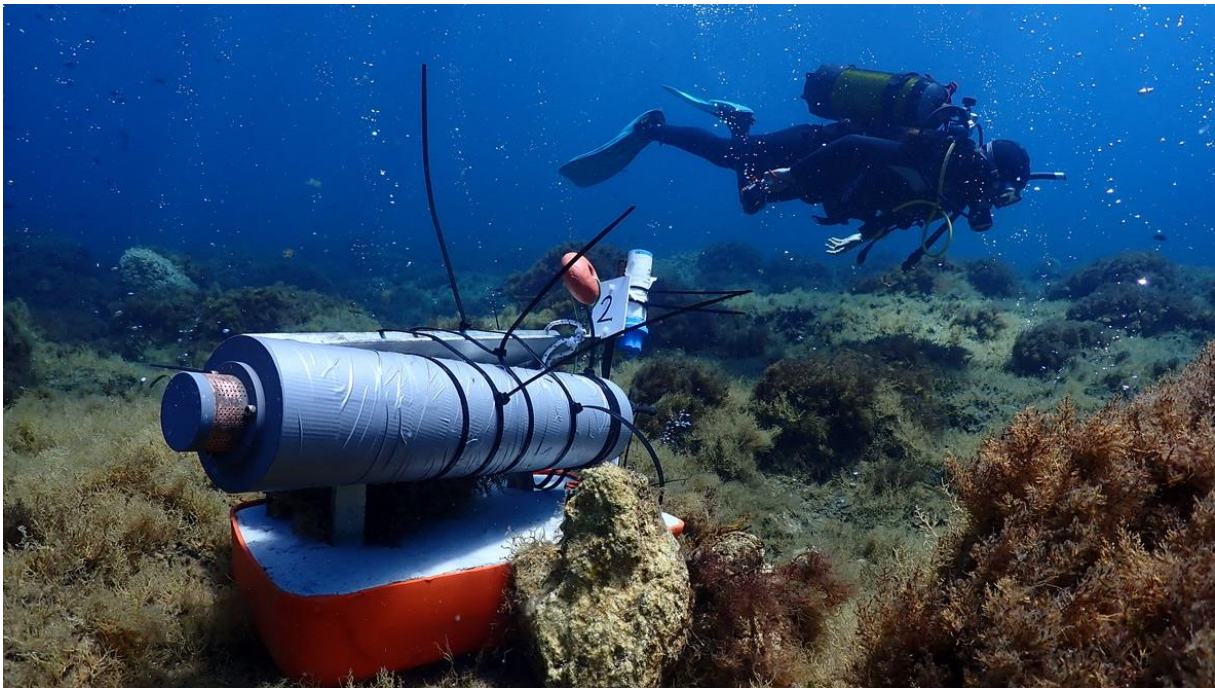
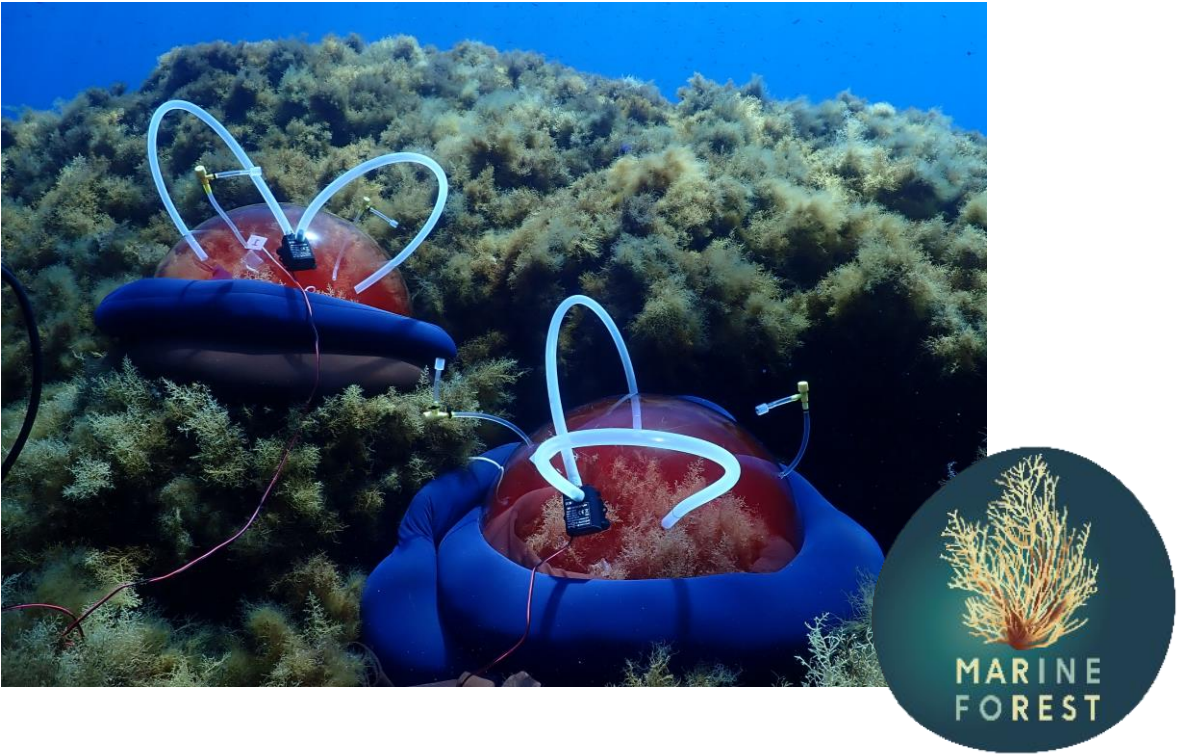
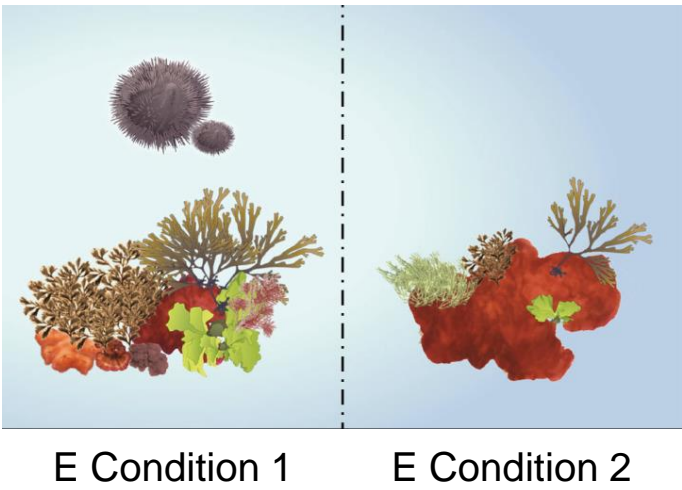
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Population



Community





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## SHIFT<sup>2</sup>SOLVE



**Jordi Boada**  
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Current: RyC Fellow Past: MSCA IF Fellow  
National Research Council Spain (CEAB-CSIC)

