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Global environmental change

Aquatic Biodiversity & Ecosystems
Evolution, interactions & global change
Liverpool 2015

The interaction between intraspecific genetic diversity and global environmental change in early life-stage *Fucus vesiculosus*

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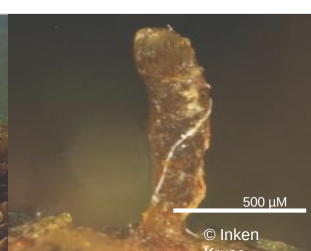
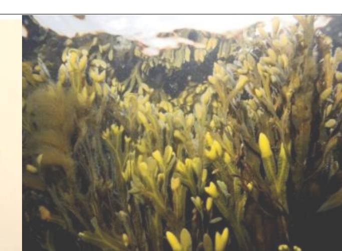




Global change impact on *Fucus vesiculosus*

Main driver: Ocean acidification, warming

Other environmental changes: Eutrophication, hypoxic areas, upwelling events, pollution…

F. vesiculosus can **buffer adverse environmental changes**

Populations: **evolutionary adaptation** or **range shifts** = expansions and retractions

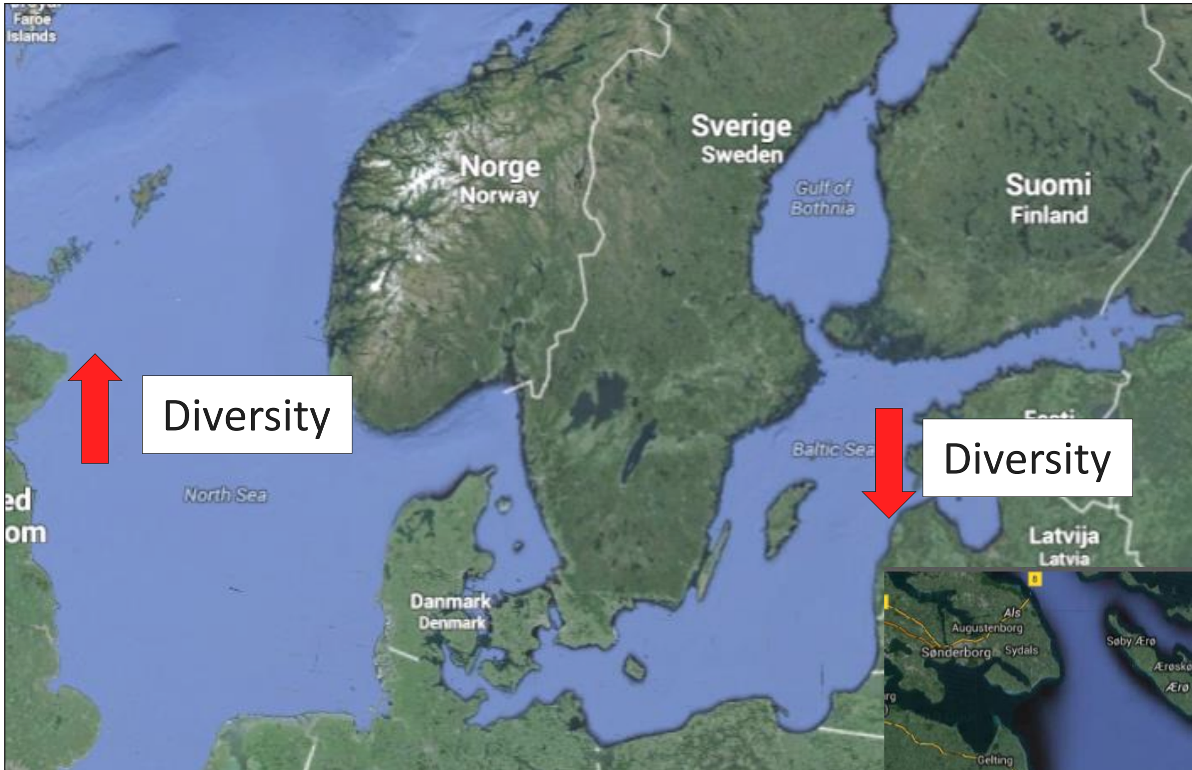
The **combined effect of multiple stressors** will impact marine populations

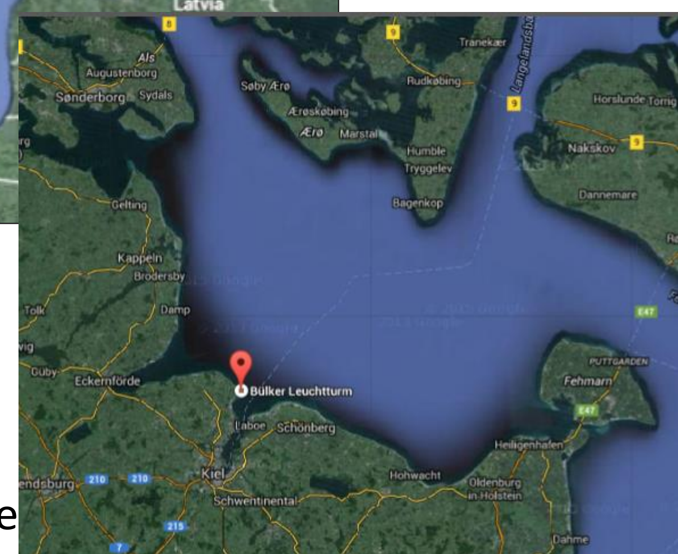
Wahl et al. 2015 *Perspectives in Phycology*

Investigations have often been limited regarding: single stressors, ontogenic stages, constant conditions, one season…

Wahl et al. 2015 *Marine and Freshwater Research*

Genetic diversity of *Fucus vesiculosus*





Confers potential for adaptation through selection

Allows for resilience and ecosystem services

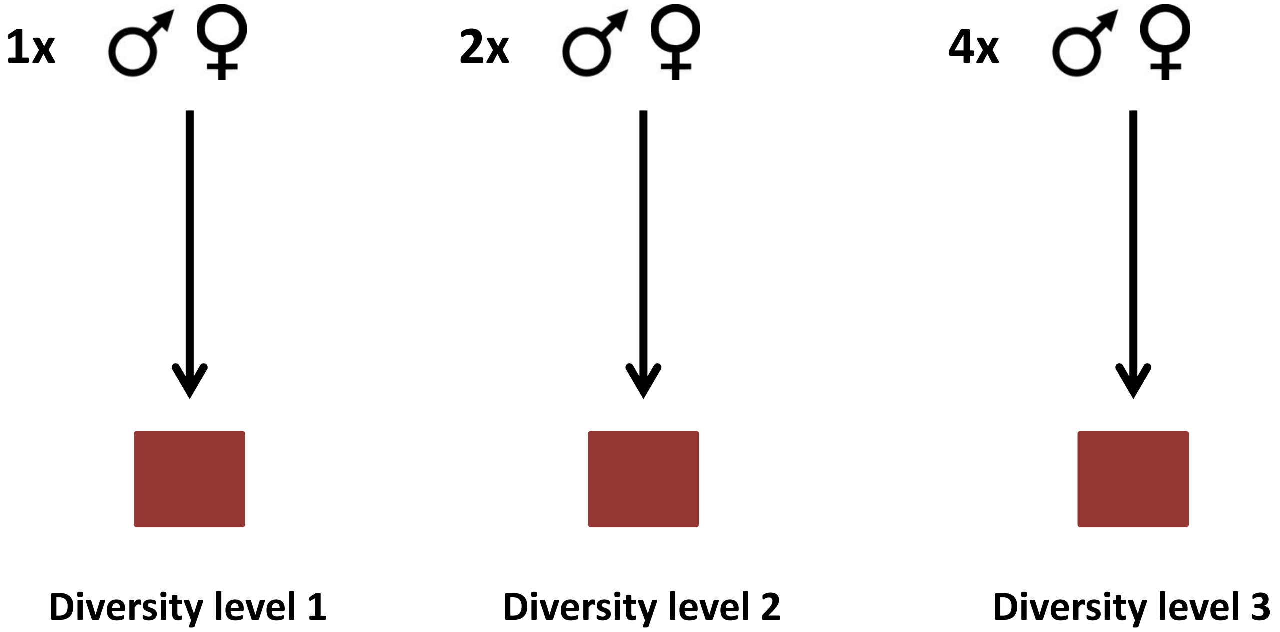
Hypothesis: Populations of high genetic diversity perform bette

Genetic diversity of *Fucus vesiculosus*

Collection of **fertile adult** *Fucus vesiculosus*

Induction of **gamete release**

Settling of germlings on limestones cubes: edge length 2 cm.



Three levels of genetic diversity

Diversity level

offspring of 1 parental pair each

Low

1	2	3	4	5	6	7	8

versus

offspring of 2 parental pairs each

Medium

1, 2	3, 4	5, 6	7, 8

versus

offspring of 4 parental pairs each

High

1, 2, 3, 4	5, 6, 7 , 8

Climate change scenario: Kiel Benthocosms

Investigation of **species interactions** and **community structure** under climate change

Upscaling of: Multiple **factors**, Multi-**species** communities, Multi-**seasonal** approach

Flow-through system allows a near natural scenario

Closing the gap **between laboratory and field** experiments

Wahl et al. 2015 *Limnology and Oceanography: Methods*

Warming and acidification: natural conditions

Seasonal variation - 2013

Temperature: + 5 °C

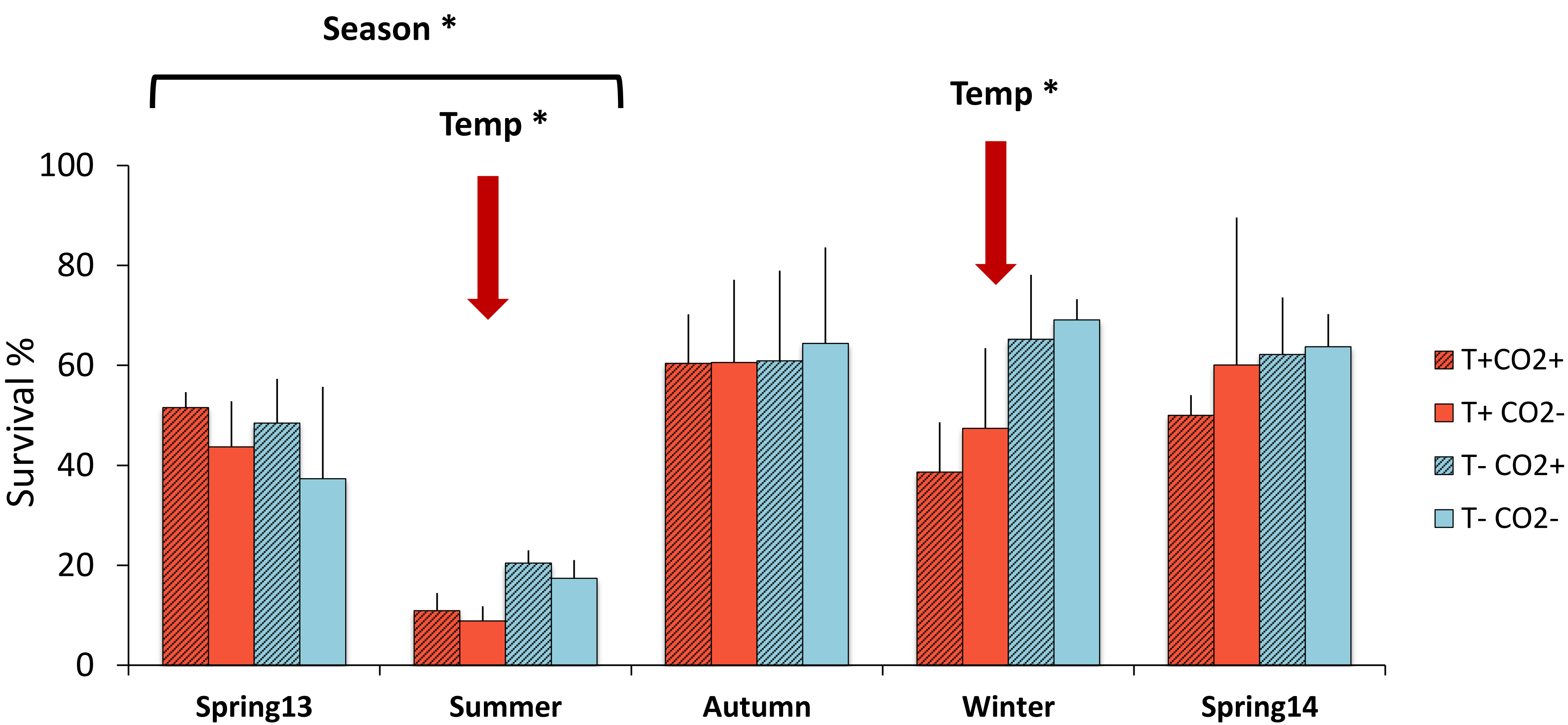
pCO_2: 1100 µatm

4 treatment levels

High Temperature + pCO_2
High Temperature
High pCO_2
Ambient (Fjord conditions)

n = 3

Warming and OA impacts depend on the season



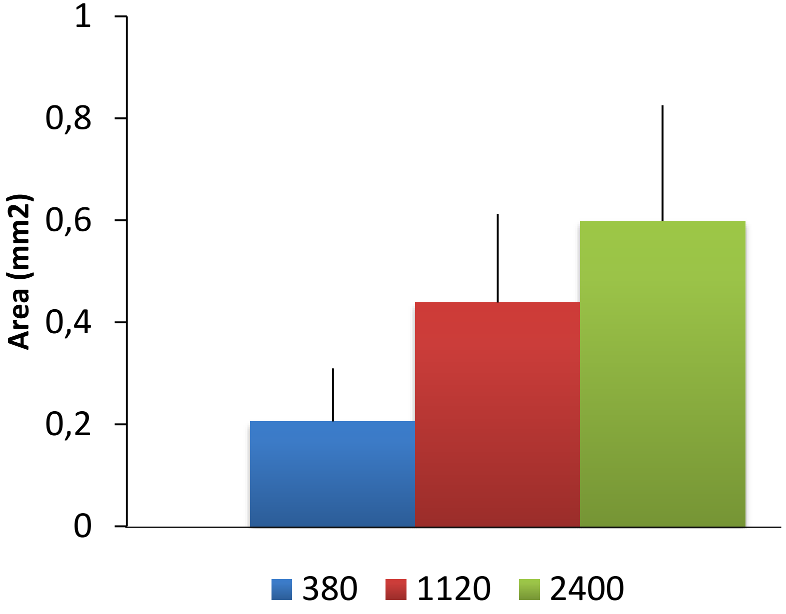
Seasonal differences between spring and summer (p-value < 0.05)

Means +SD
n=3

Warming decreases survival in **summer** and also in **winter** (p-value < 0.05)

Acidification effects on growth: laboratory conditions

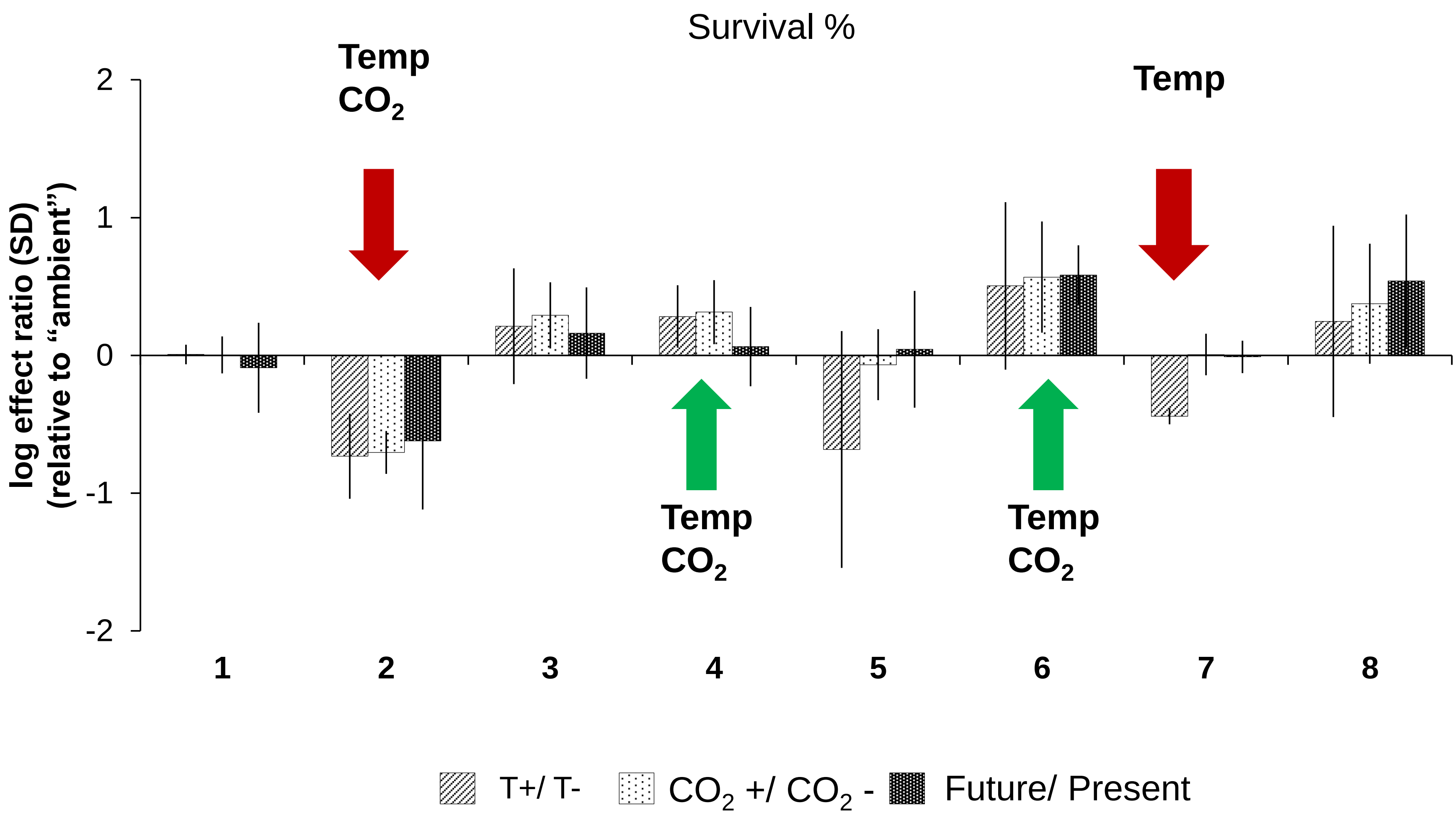
pCO_2 effect on growth



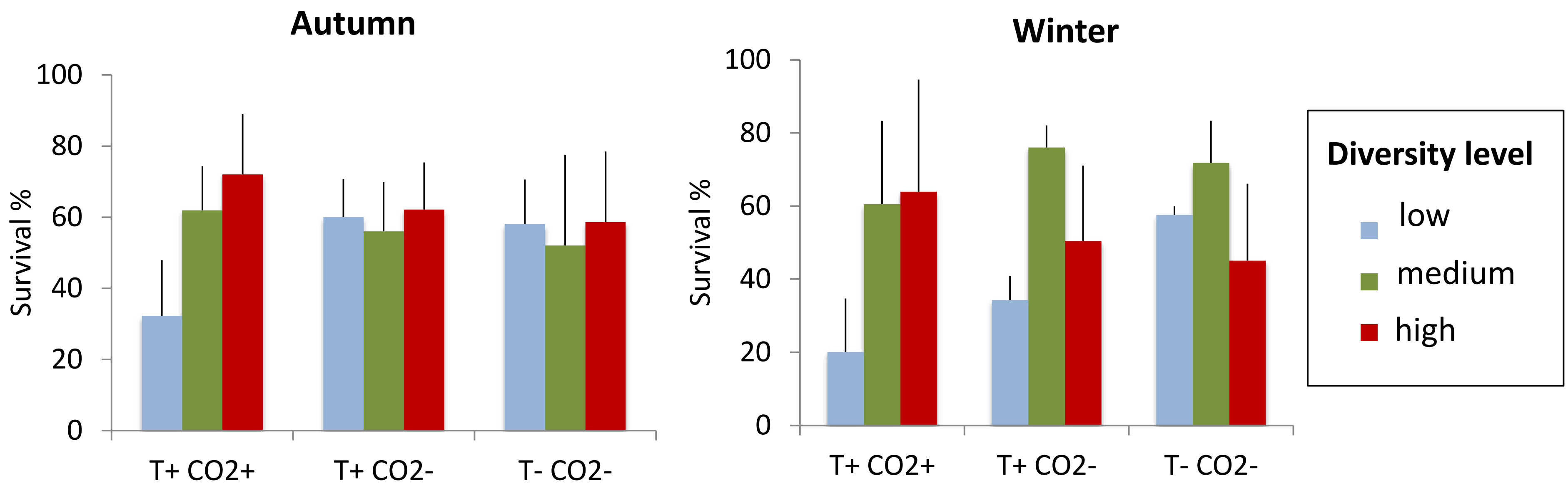
High pCO_2 levels increase growth of *Fucus* germlings (p-value < 0.05) = **fertilisation effect**

Means +SD
n=3

Siblings vary in their response to warming and acidification



Higher diversity level survive better under warming



Means +SD
n=3

Survival high diversity level **>** survival low diversity level at **high temperatures** (p-value < 0.05)

Increased survival for a group of high diversity level indicated **facilitation** processes among different genotypes

Warming, acidification and nutrient enrichment

Temperature: + 5 °C

pCO_2: 1100 µatm

[Temperature + pCO_2] x **Nutrients**

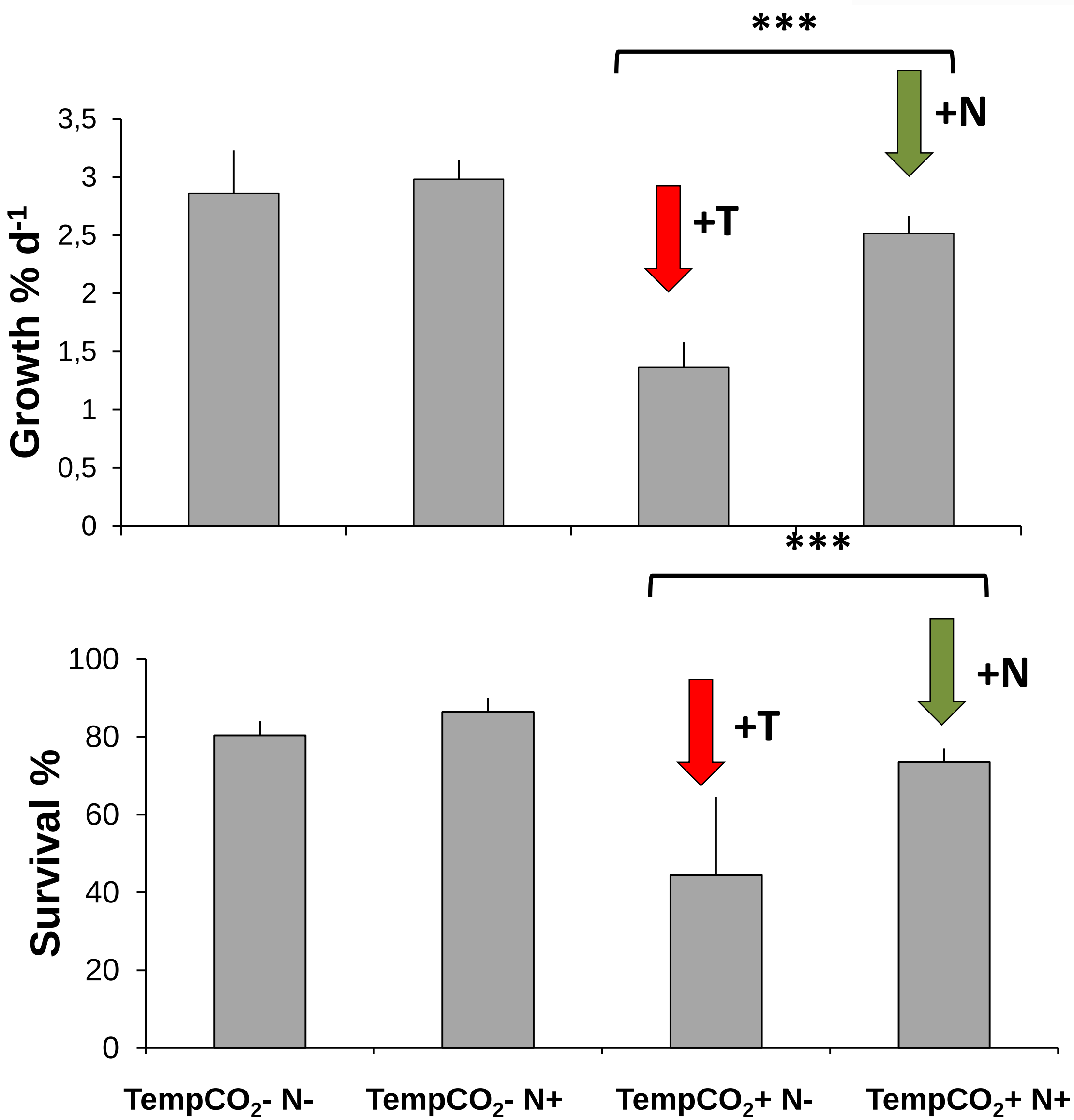
[NO_2 NO_3 PO_4]

Nutrient enrichment mitigates heat wave stress

Warming during a heat wave decreased survival and growth significantly ($p < 0.0001$)

Nutrient enrichment **attenuates** the high mortality and growth reduction ($p < 0.0001$)

Warming+Acidification interacts with the factor **nutrients** ($p < 0.0001$)



Local Upwelling event

↑ [Temperature + pCO_2] x ↑ Nutrients

[NO_2 NO_3 PO_4]

+ [Temperature + pCO_2] + Nutrients

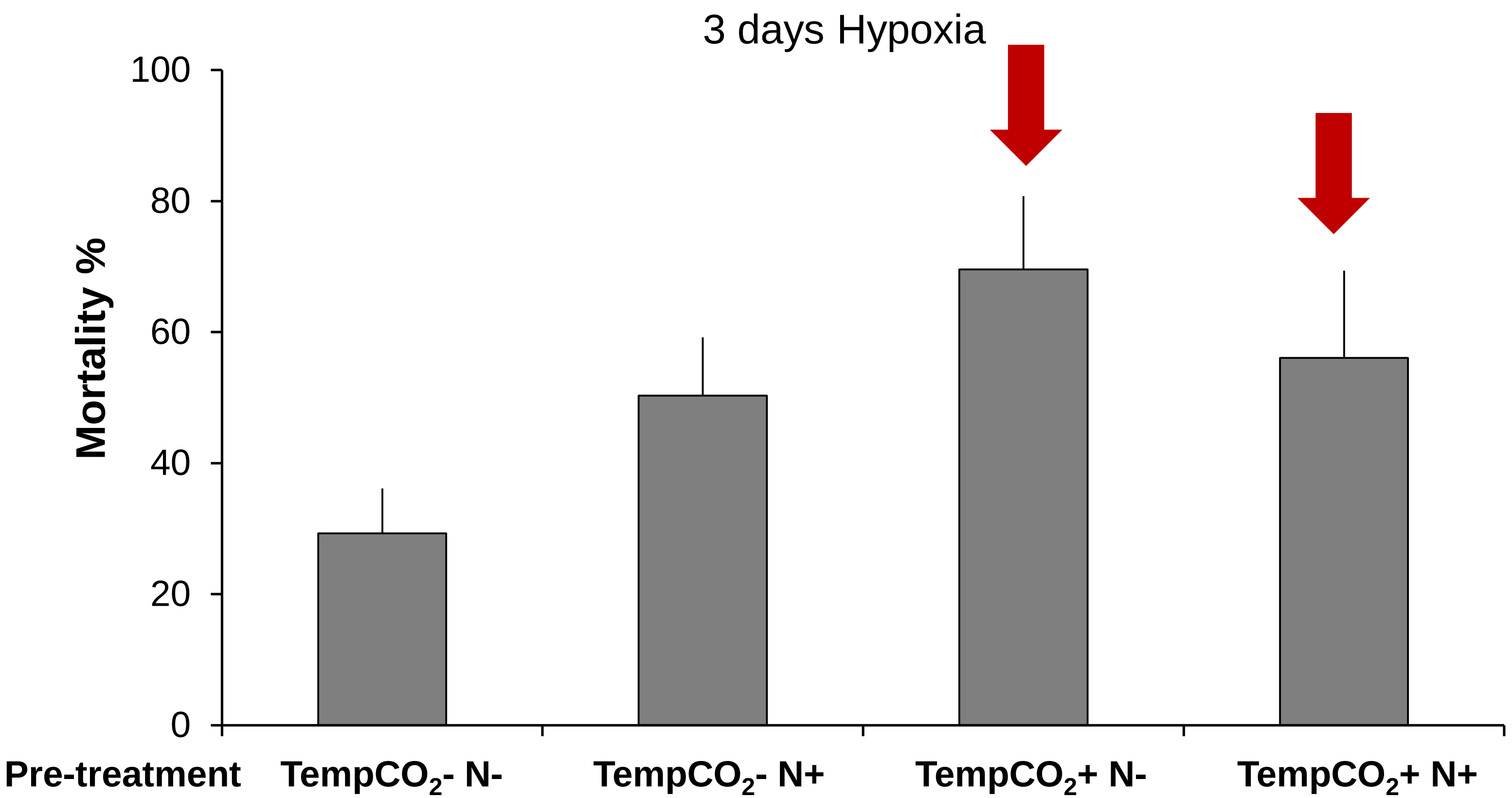
+ [Temperature + pCO_2] - Nutrients

- [Temperature + pCO_2] + Nutrients

- [Temperature + pCO_2] - Nutrients

→ **3 days Upwelling**

Sensitivity to hypoxia is enhanced by previous warming



Mortality of *F. vesiculosus* germlings is **strongly increased under hypoxia** in all groups of pre-treatments

Previous exposure to **warming and acidification decreased the tolerance** to hypoxia stress ($p < 0.001$)

Genotypic correlations determine the direction of selection

Populations resistance to multiple factors depend on **trade correlation**

Analysis of **sibling groups sensitivity** towards **multiple stressors** was performed

Sibling groups sensitivity to stressor A and stressor B **may correlate**

→ **genotypic correlations**

Vinebrook et al. (2004) *OIKOS*

Sibling groups were ranked according to the different sensitivities:

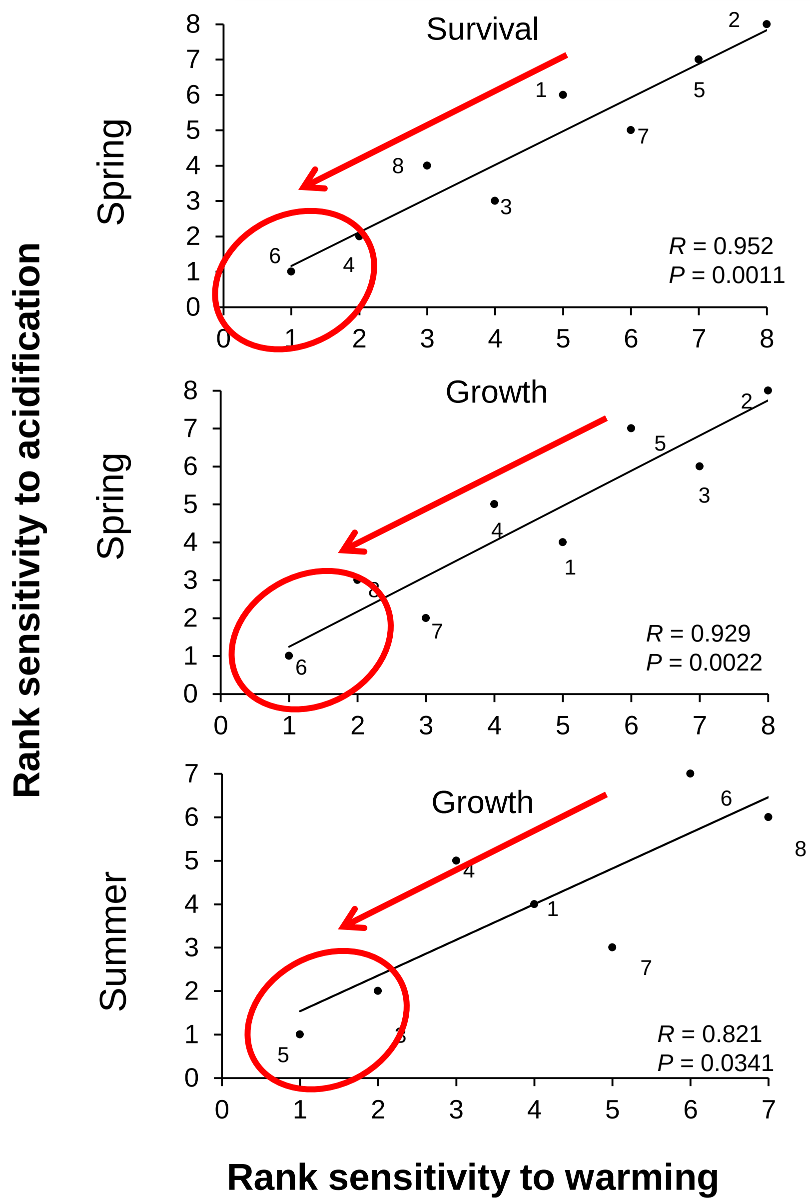
Warming

Acidification

Warming + acidification

Hypoxia

Siblings correlations of sensitivities to warming and OA



Sensitivity to warming and acidification is **positively correlated** ($p < 0.05$)

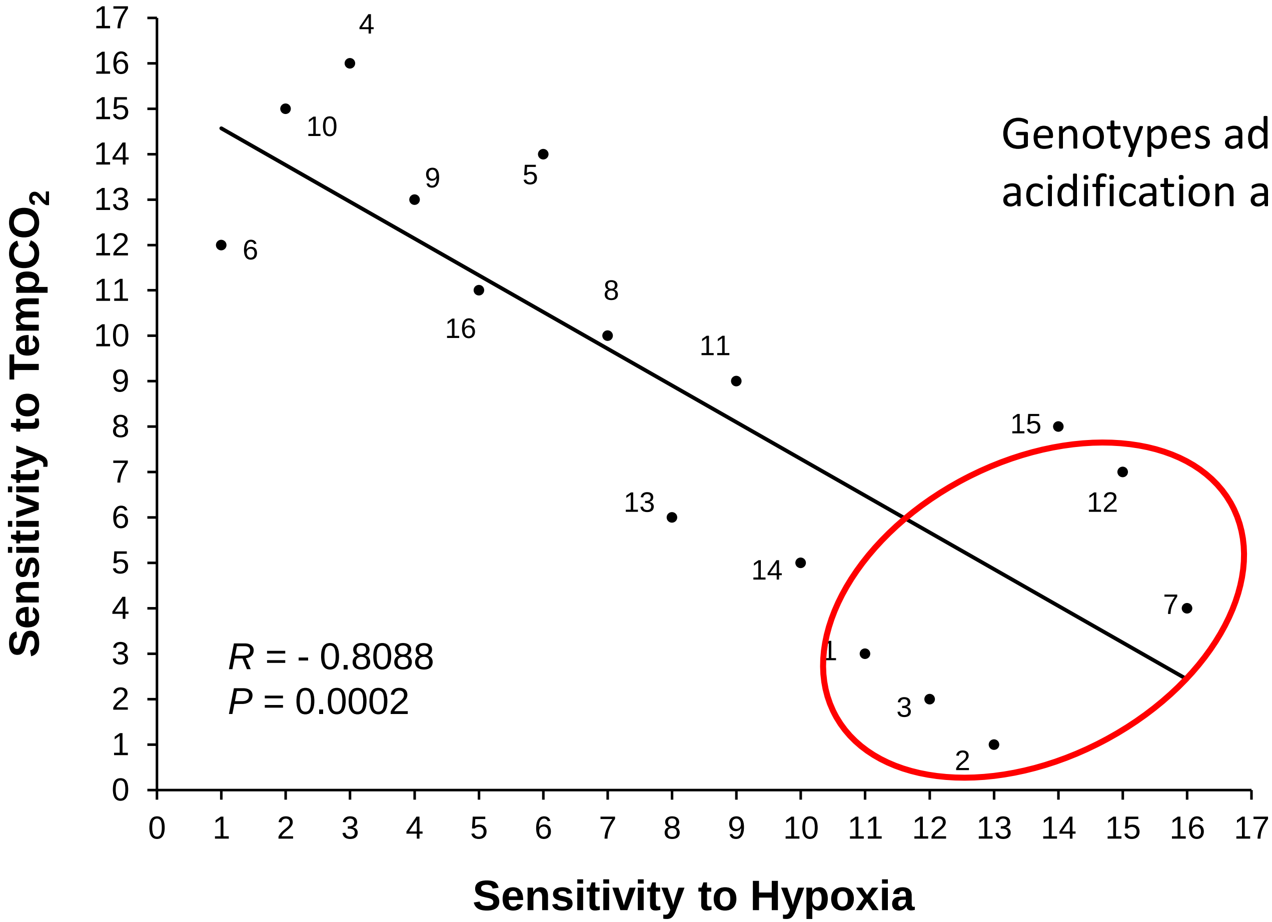
Direction of selection goes towards the more tolerant genotypes to warming and acidification

Positive correlation will accelerate selection processes towards these genotypes

Correlations of sensitivities to OAW and hypoxia

Sensitivity towards warming+acidification and hypoxia is **negatively correlated** ($p < 0.001$)

Genotypes adapted to warming and acidification are **most sensitive to hypoxia**

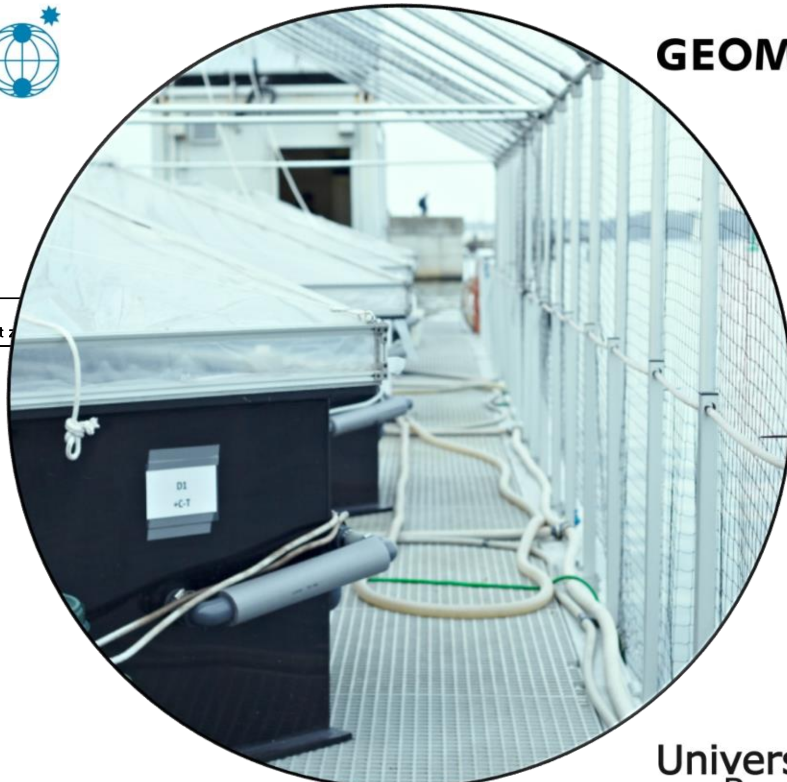


Conclusions

- **Warming** enhances **growth** in summer, but **reduces survival** in late summer = **seasonal variation**
- **Sibling groups vary** in their response to warming and acidification

  -> **potential for adaptation**
- **Heat wave stress** is mitigated under **nutrient enrichment** but enhances the **sensitivity to hypoxia**
- **Positive correlation of sensitivities** towards warming and acidification determines the **direction of selection**
- **Populations adapted to warming and acidification** are most sensitive to hypoxic upwelling
- **An upscaling is required**: number of stressors, natural fluctuations, ontogenic stages, no of seasons; to **predict impacts** on marine populations

Acknowledgements



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