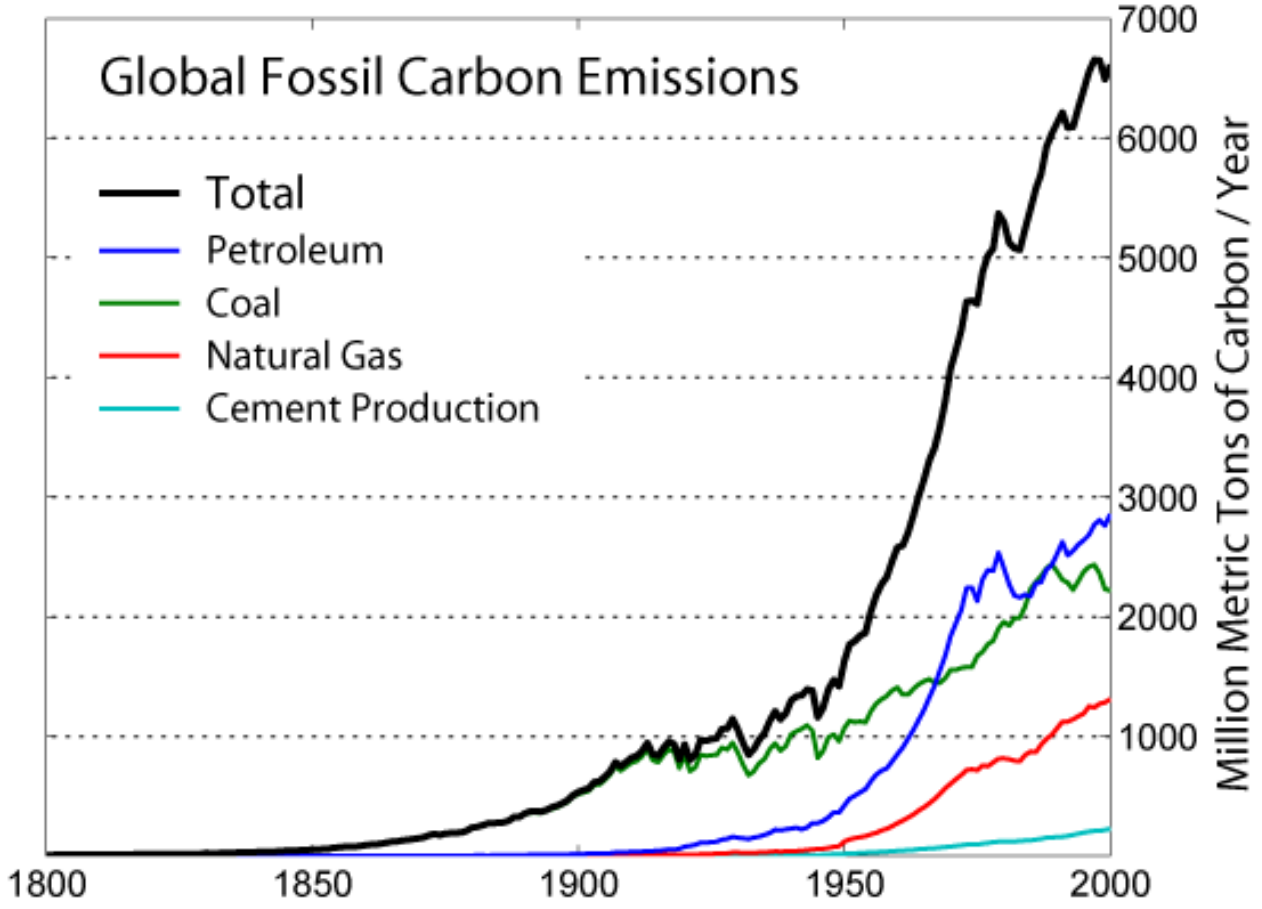
Effects of climate change on benthic communities in the Baltic Sea – Kiel Benthocosms

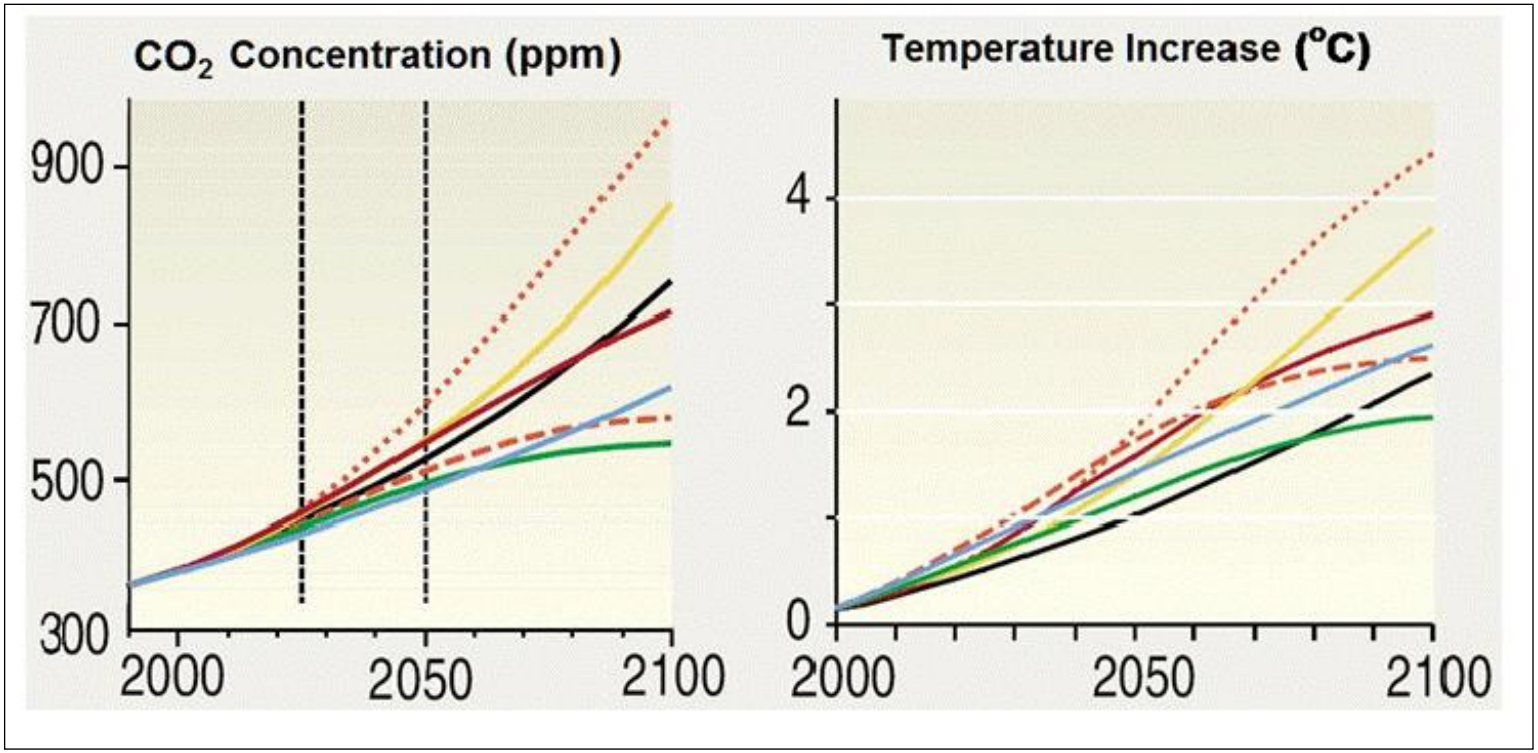
B. AL Janabi, R. Asmus, H. Asmus , I. Bartsch, F. Böhm, M. Böttcher, A. Eisenhauer, ***A. Graiff,*** L. Gutow, U. Karsten, I. Kruse, B. Matthiessen, ***B. Mensch***, A. Pansch, ***S. Raddatz***, R. Schmitz-Streit, I. Tauber, M. Wahl, ***F. Werner***, V. Winde

Climate change in the Baltic Sea



Robert A. Rohde

Climate change in the Baltic Sea



- 0,1 units of the pH scale
- 0,7 °C temperature increase

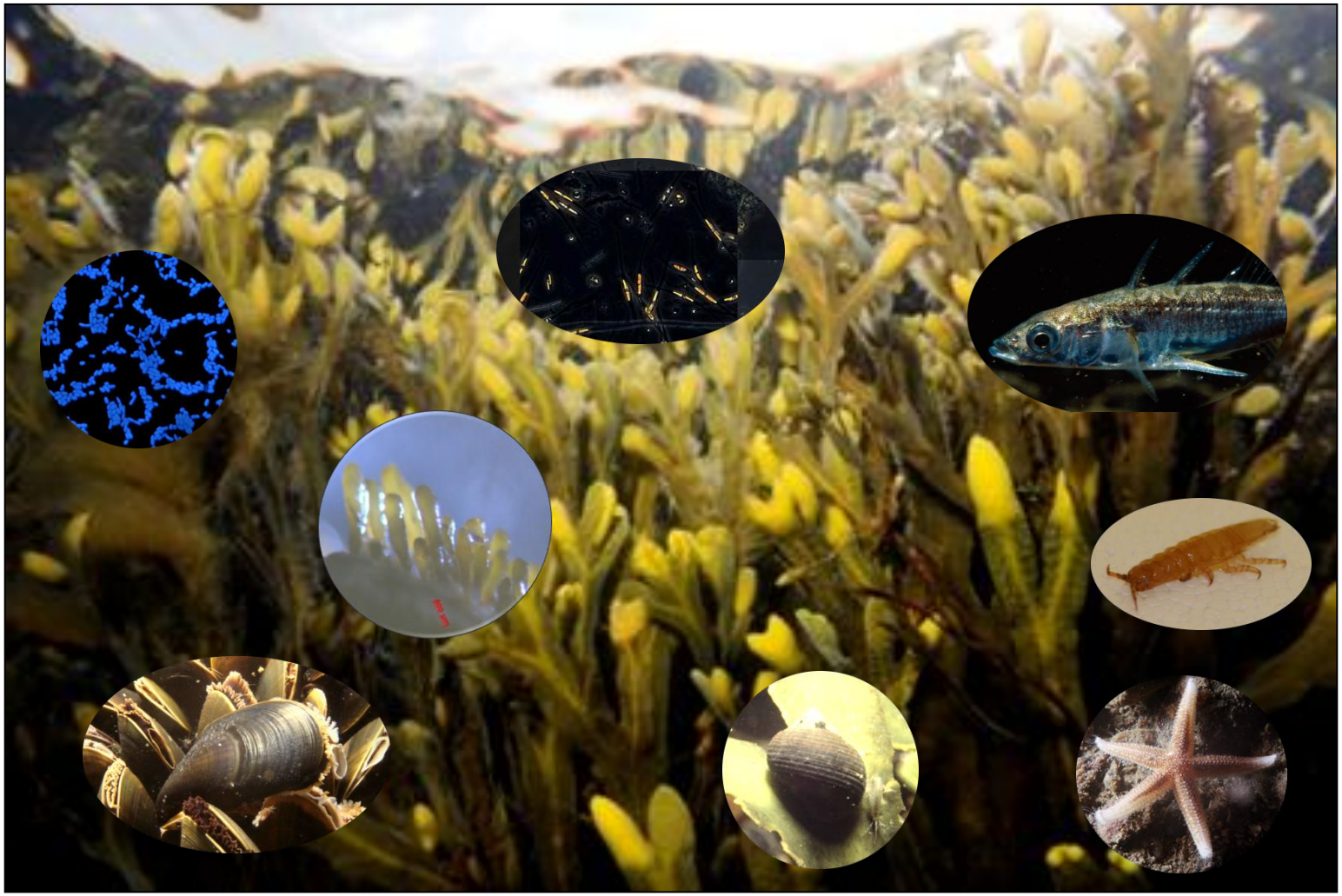
Climate change in the Baltic Sea

Predictions for the year 2100:

- **Temperature:** + 5 °C
- **pCO2** + 600 ppm
- **Eutrophication:** Nutrient concentrations
- **Upwelling:** Higher frequency of hypoxia events

1. How will communities re-organize?

(structure, interactions, services, fluxes)



2. How will biotic interactions modulate Global Change effects?

- synergistic, additive, and/or antagonistic interactions
  => amplification or buffering?

- Warming is **not biotically modulated** but acidification and eutrophication is

- Climate change factors are **abiotically modulated by** season, weather, currents, upwelling, etc.

Mesocosm studies

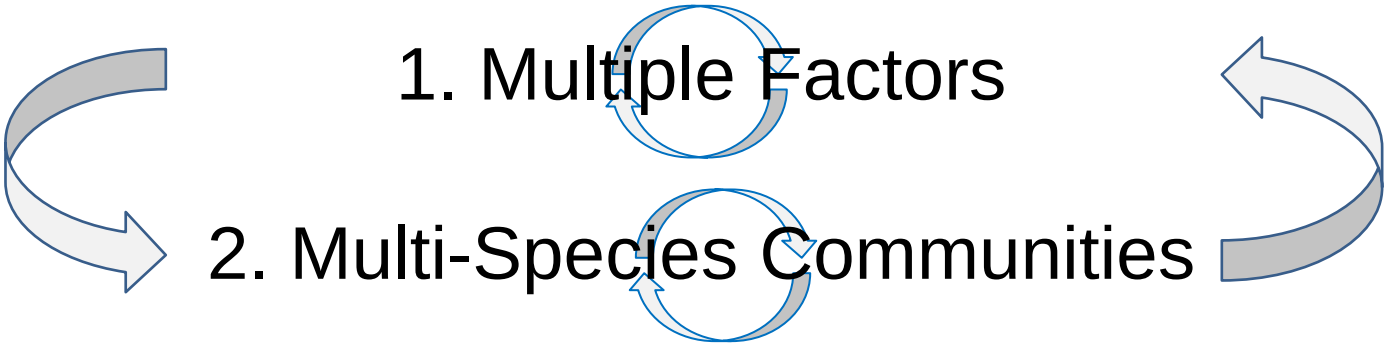
- **Experiments with communities** instead of single species experiments

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

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

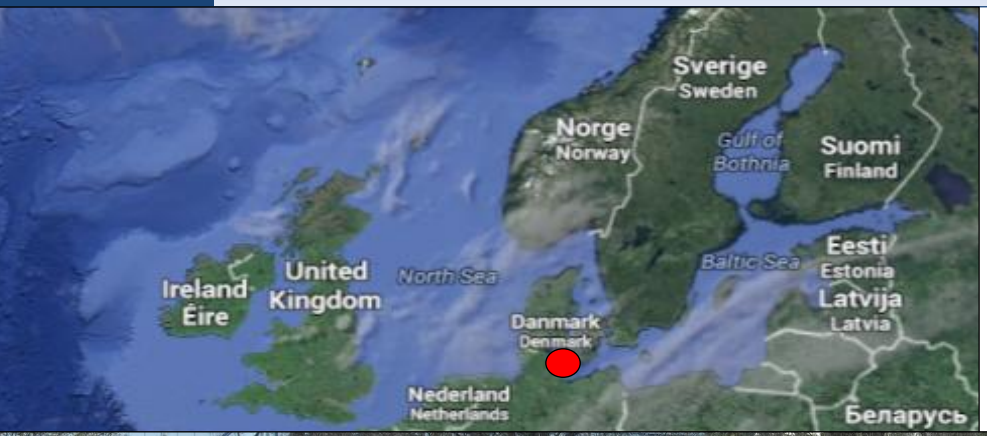
Kiel Benthocoms

Triple Upscaling:



3. Multi-seasonal approach

Kiel Benthocoms



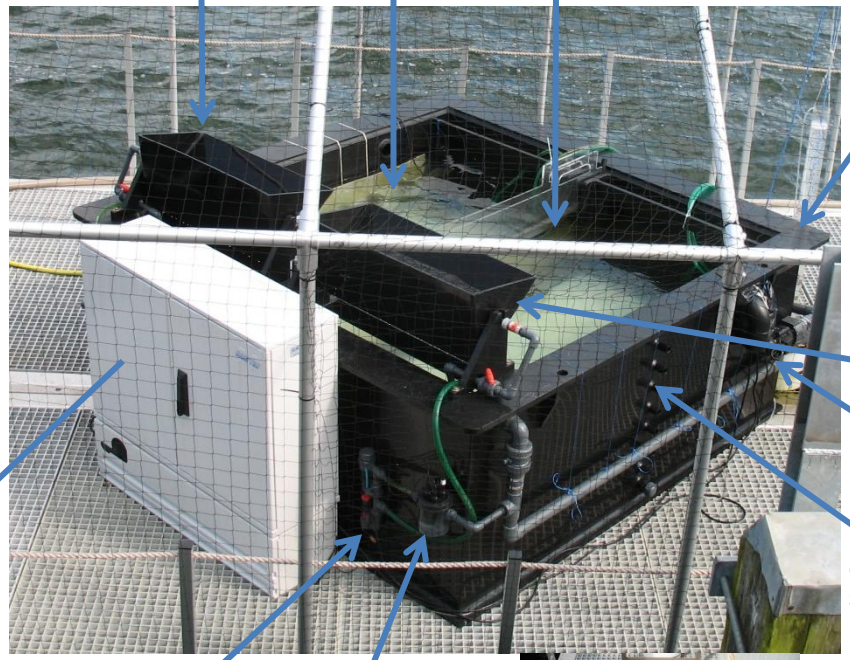
Kiel Benthocoms – the infrastructure

autonomous energy supply by wind and sun

automated control of (delta-) temperature, pH, pO_2, pCO_2, flow-through, waves,...

experimental units of 2000 - 4000 L

wave generator



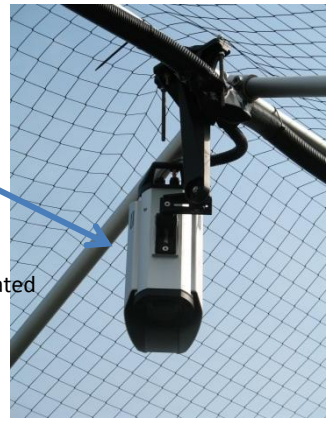
thermally insulated containers

Reactor for CO_2 und O_2 treatments

Bypass for pH, O_2, salinity, and temperature sensors

CO_2 neutral cooling with deep fjord water

remote video control



wave and current control

outlets for water samples

Kiel Benthocoms – experiments

2013: A seasonal comparison

4 treatment levels

Ambient
High temperature
High pCO2
High Temperature + pCO2

n = 3

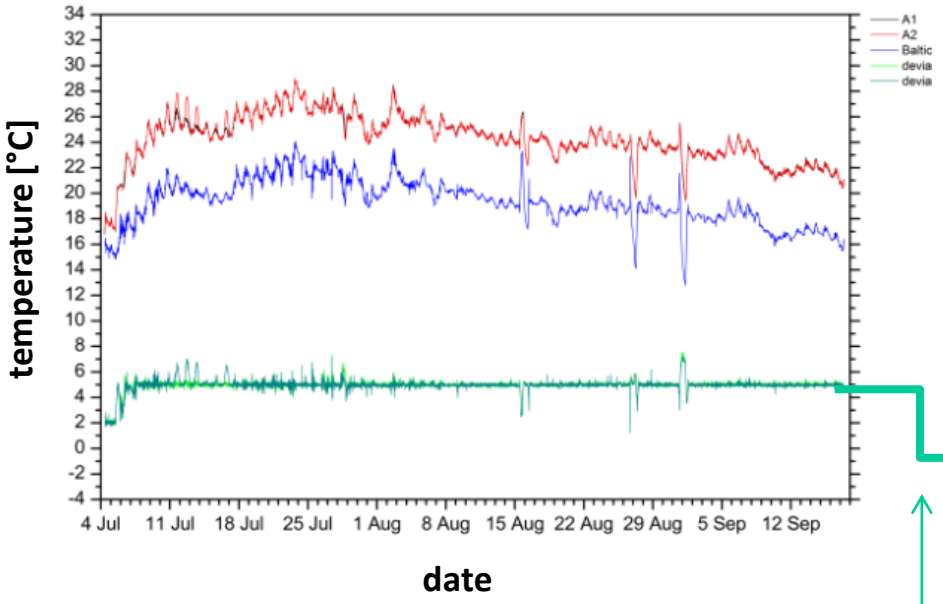
Summer 2014: Eutrophication

4 treatment levels

High T + CO2	x	high N
High T + CO2	x	low N
Low T + CO2	x	high N
Low T + CO2	x	low N

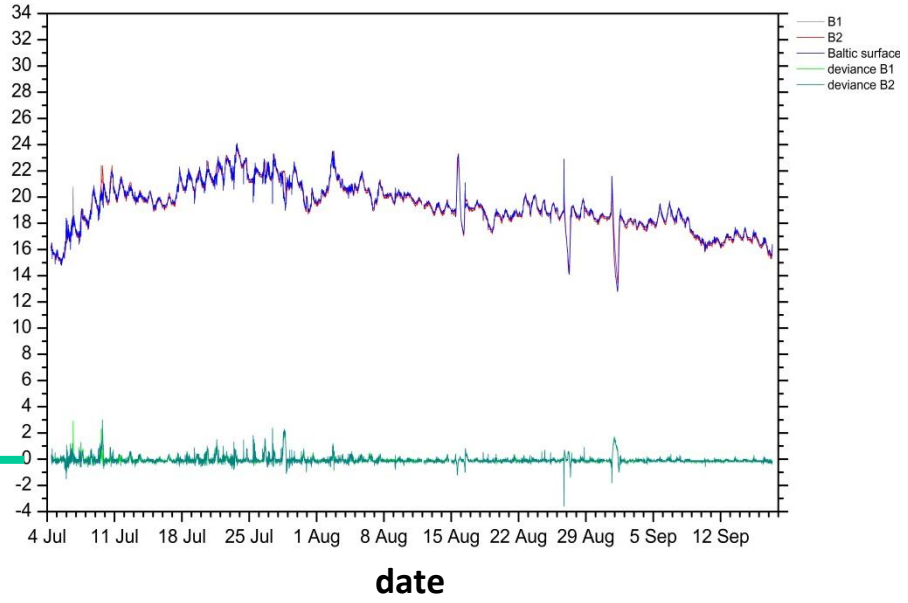
Delta treatment of temperature:
A near natural scenario

High temperature



Δ 5°C

Ambient temperature



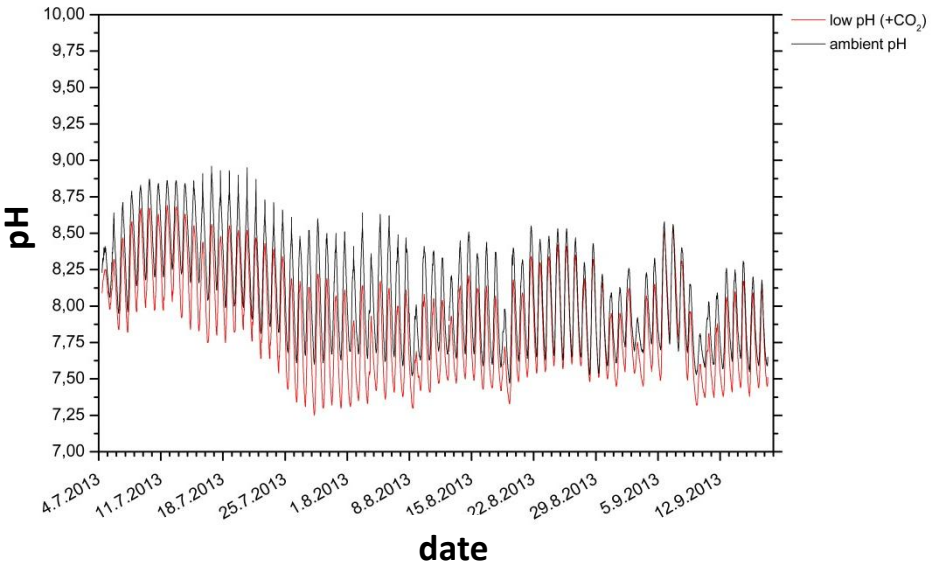
Δ 0°C

DELTA!

Delta treatment of pH

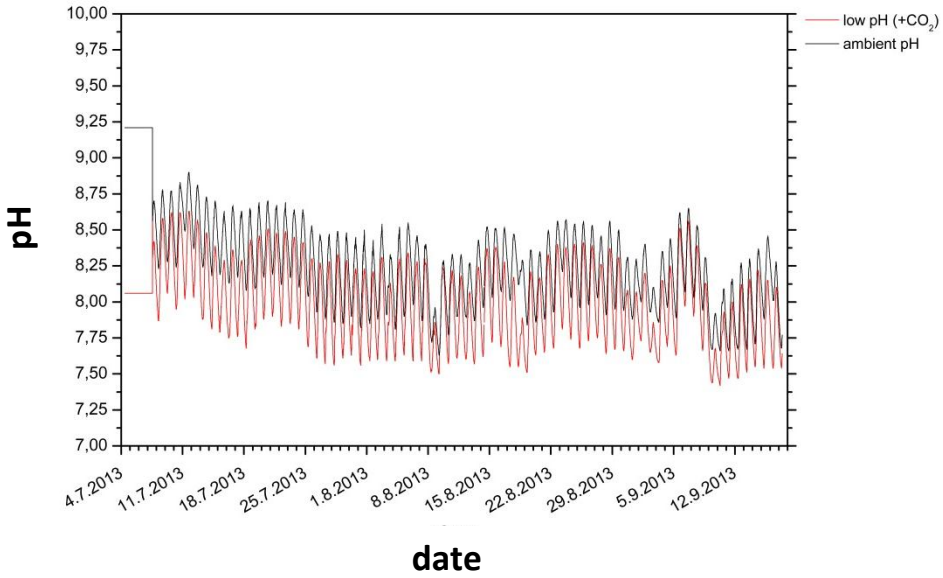
The pCO2 treatment interacts with the temperature treatment

pH Benthocosms (A1 & A2)



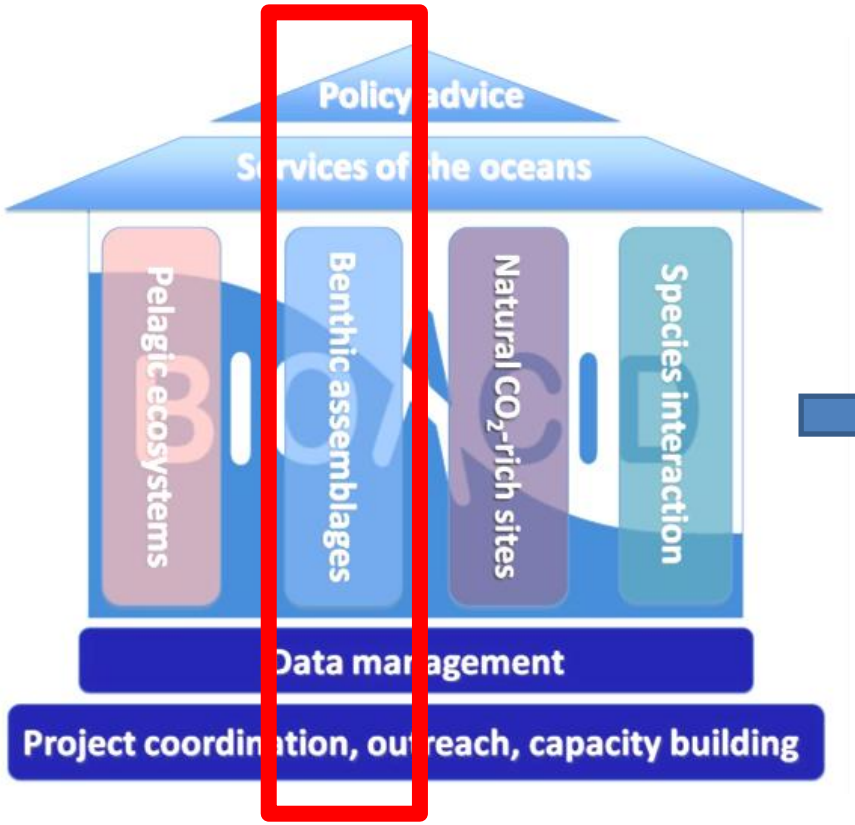
Δ 5°C

pH Benthocosms (D1 & D2)



Δ 0°C

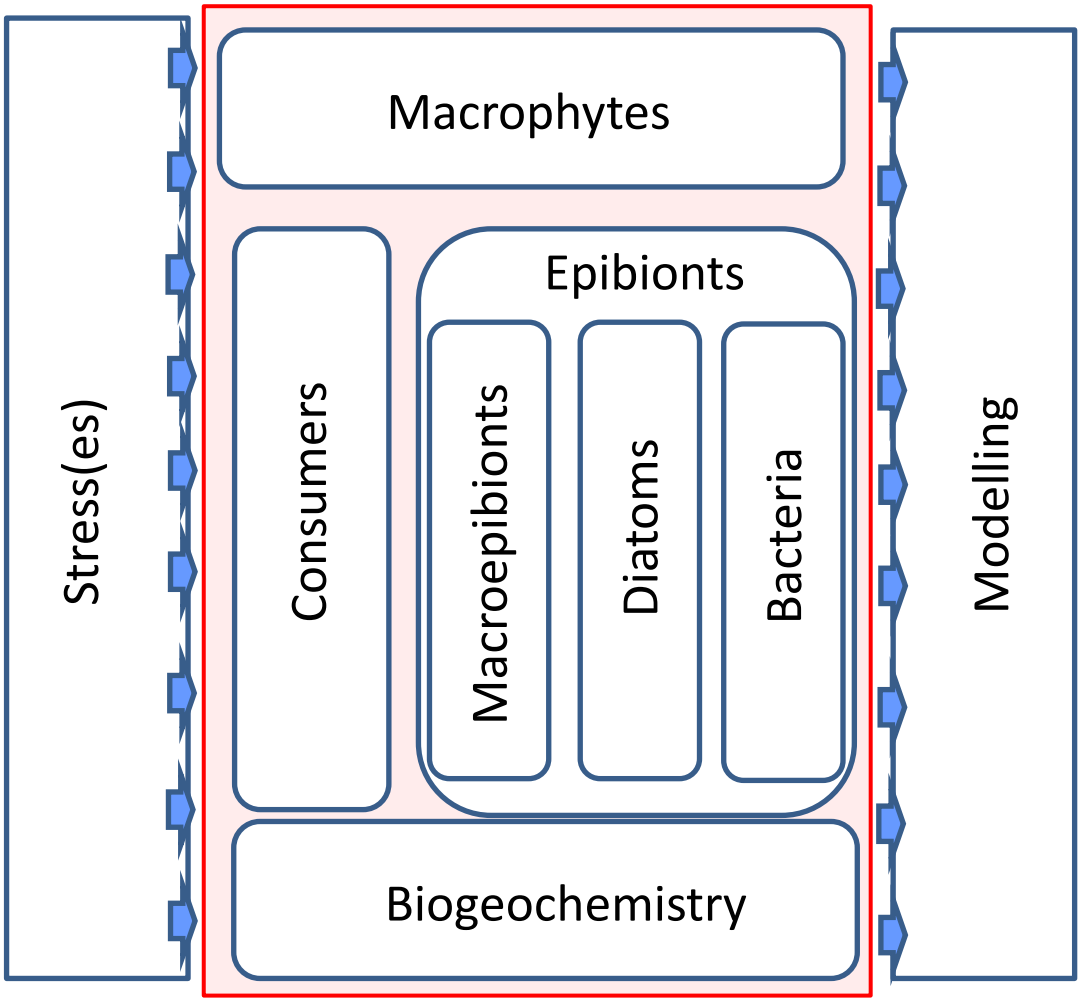
Bioacid II



Benthic consortium:

Responses of benthic assemblages to interactive stress

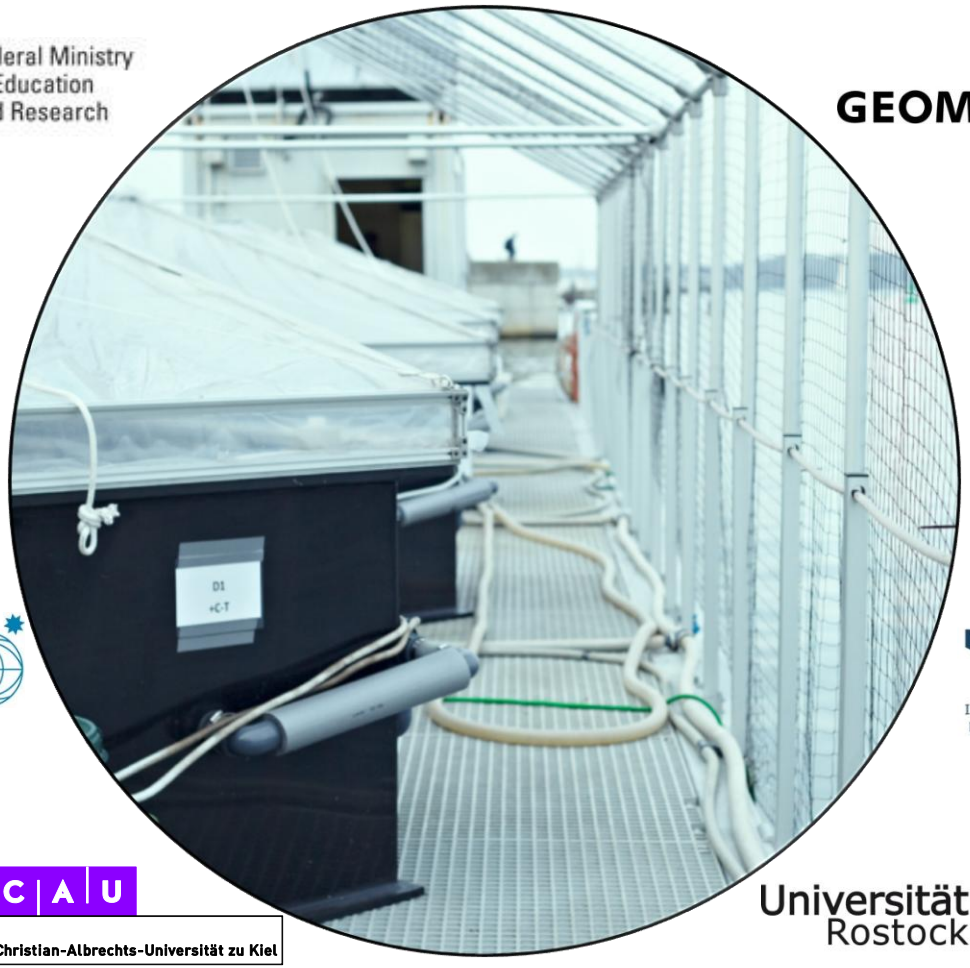
Benthic consortium: Structure



Benthic consortium

WP	Topic	PhD	Name (of PI)	Affiliation
2.1	Re-structuring and re-functioning **macrophyte** communities	Andreas Pansch	Ragnild Asmus	AWI
2.2	Re-structuring and re-functioning in **bacterial** communities on Fucus	Birte Mensch	Ruth Schmitz-Streit	CAU Kiel
2.3	Re-structuring in (micro-) **epiphytic** communities on Fucus	Franziska Werner	Birte Matthiessen	GEOMAR
2.4	**Physiological** responses of Fucus to environmental shifts	Angelika Graiff	Ulf Karsten	University of Rostock
2.5	**Genetic** responses of Fucus to stress	Balsam Al Janabi	Inken Kruse	GEOMAR
2.6	**Biogeochemical** responses to environmental shifts	Vera Winde	Michael Böttcher	IOW
Balt Med	(**Interaction** shifts in Fucus communities)	Steffanie Raddatz	Martin Wahl	GEOMAR

Benthic consortium



Biogeochemistry responds on environmental shifts

(F. Böhm, M. Böttcher, A. Eisenhauer, I.Taubner, V. Winde)

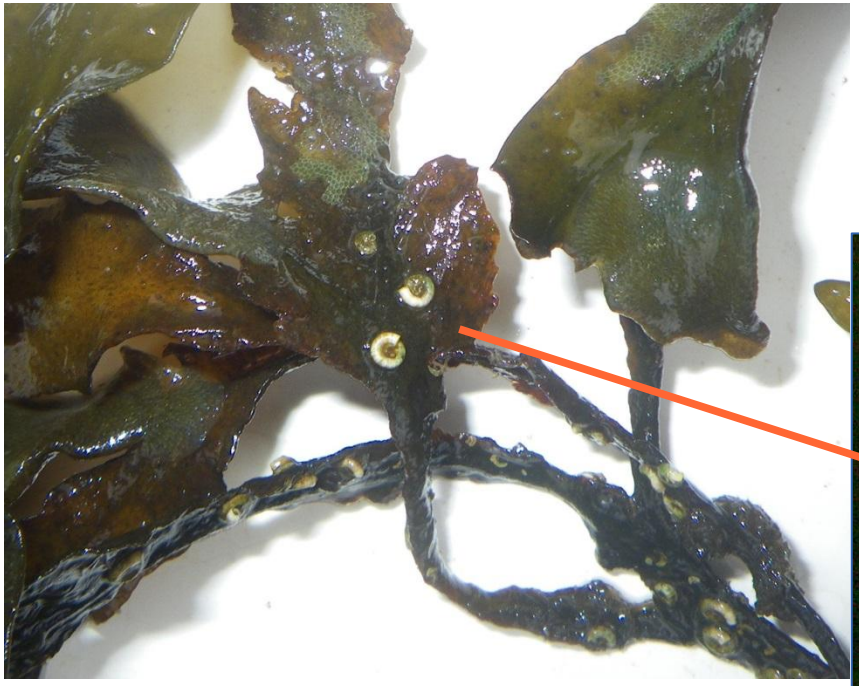
Regular measurements of biochemical parameters

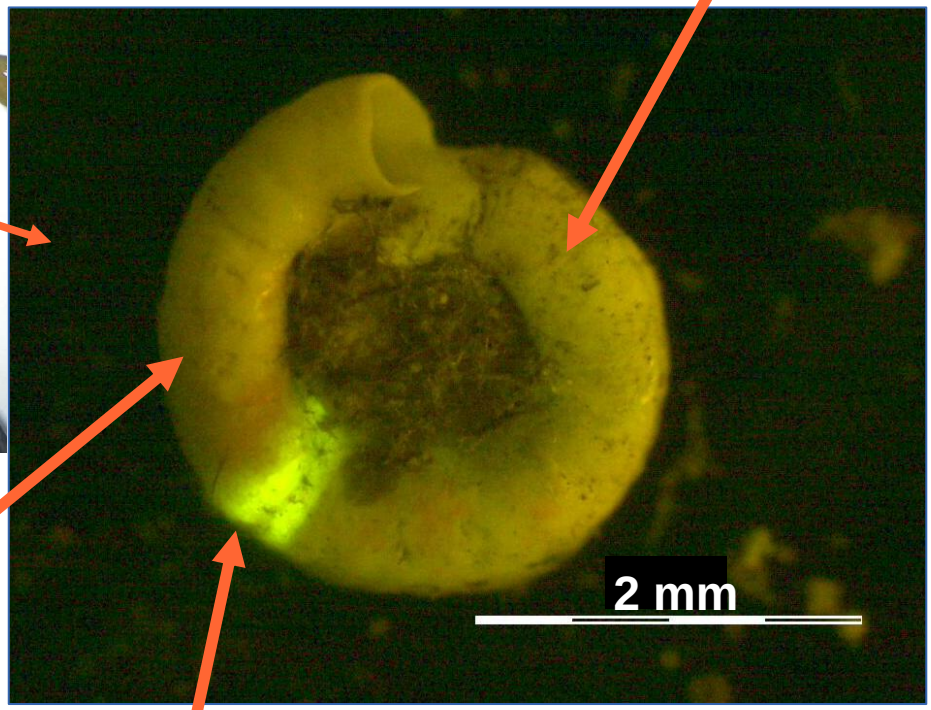
- **Carbon system:** DIC, Alcalinity, pH
- **Metals**
- **Trace metals:** Mg/Ca and Sr/Ca
- **Isotopes:** Oxygen and carbon isotopes
- **Nutrients:** Silicate, Nitrate, Nitrite, Phosphate
- **C:N ratio analysis**

Biogeochemistry responds on environmental shifts

(F. Böhm, M. Böttcher, A. Eisenhauer, I.Taubner, V. Winde)

Spirorbis





grown before experiment

grown during experiment

Measurements of
- Growth rate
- C, O, Ca, Sr isotopes
- Trace elements (Mg, Sr, Ba...)

Calcein staining at start of experiment

Re-structuring of the bacterial biofilm

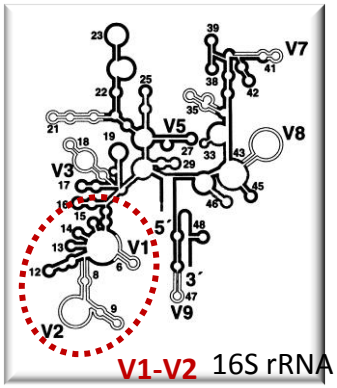
(B. Mensch, R. Schmitz Streit)

→ **Epibacterial communities on *Fucus vesiculosus* react to simulated climate stress**

How does the epibacterial community on *Fucus* react to single and combined T and pCO_2 stress?

Biofilm swabs from *Fucus vesiculosus*

PCR amplification of the bacterial V1-V2 hypervariable region of 16S rRNA genes



V1-V2 16S rRNA

High-throughput 16S rDNA amplicon sequencing for bacterial phylogeny analyses

→ PRELIMINARY RESULTS

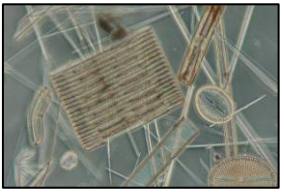
Roche 454 SEQUENCING

→ IN PROCESS…

illumina MiSeq

Re-structuring in (micro-) epiphytic communities

(B. Matthiesen, F. Werner)



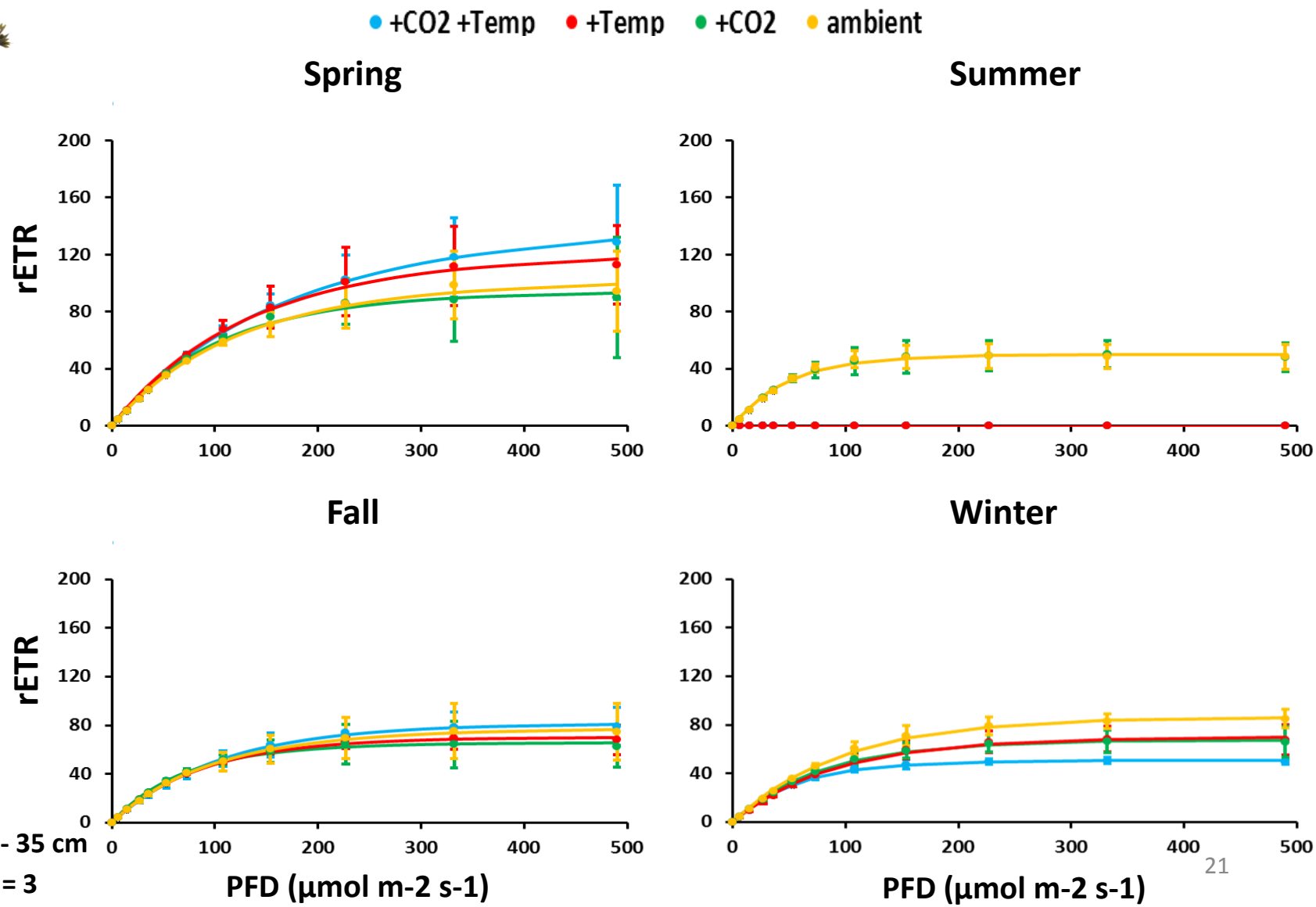
- **Restructuring** of the microepibiotic community (dominated by diatoms)
  - At different seasons
  - Under different environmental conditions

- Analysis of the **grazer community** of macrophytes (Crustaceans, Gasteropods, etc.)

- Interaction between **microepiphytic fouling** and grazers.

Fucus physiological responses to environmental shifts: **rETR**

(A. Graiff, U. Karsten)

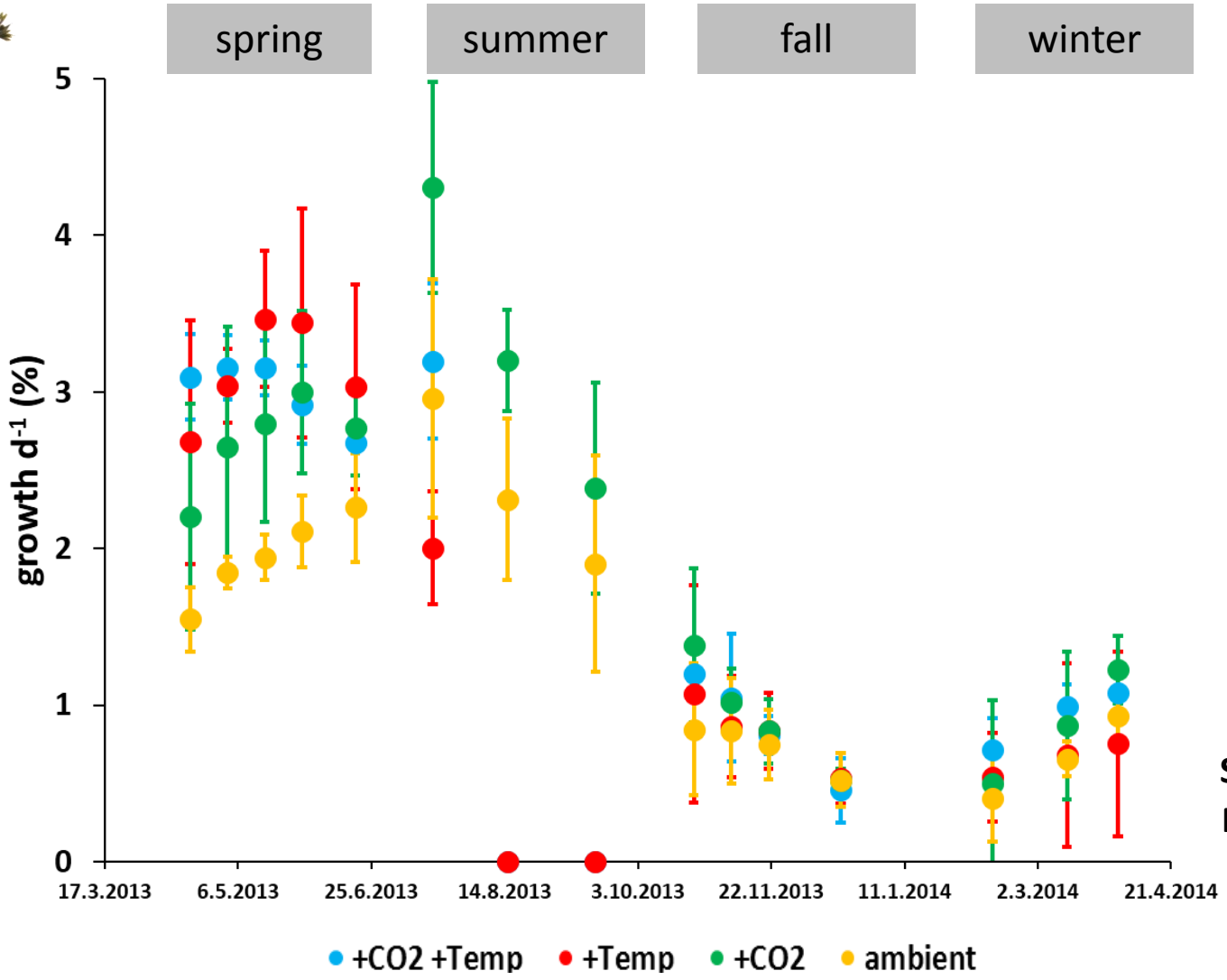


Size range 20 - 35 cm

Mean ± SD, *n* = 3

Fucus physiological responses to environmental shifts: **Growth**

(A. Graiff, U. Karsten)

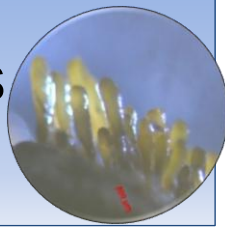


Size range < 20 cm

MW ± SD, *n* = 3

Genetic diversity of early life-stage *Fucus* confers stress resistance (B. Al-Janabi, I. Kruse, M. Wahl)

Genetic diversity of early life-stage *Fucus* confers stress resistance



Diversity level:

1. Sibling groups

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

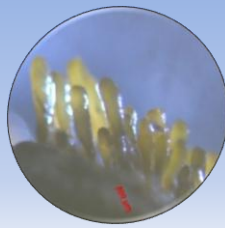
2. Quartetts

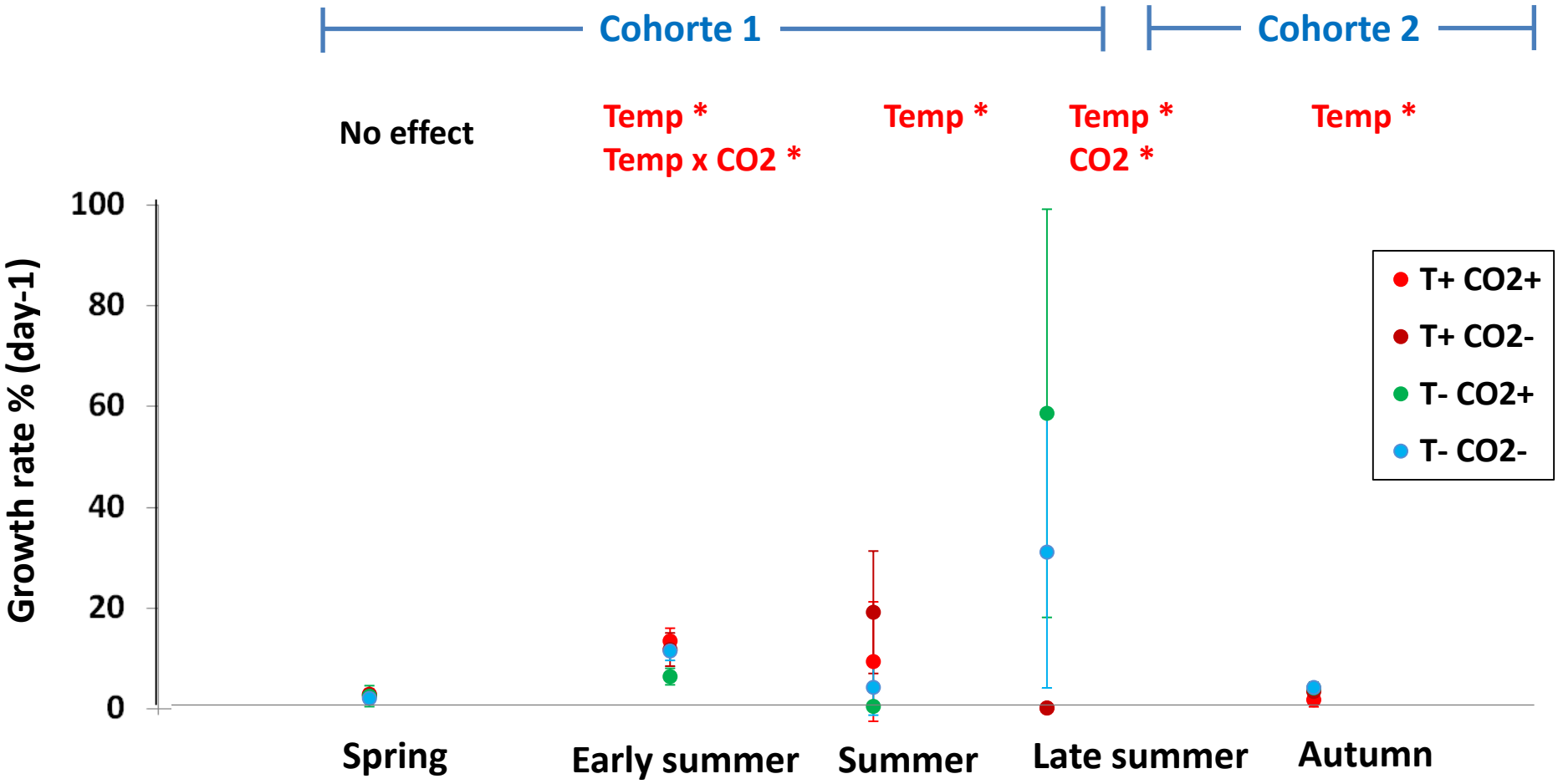
1, 2, 3, 4	5, 6, 7, 8	9, 10, 11, 12	13, 14, 15, 16

3. Oktetts

1, 2, 3, 4, 5 , 6, 7, 8	9, 10, 11, 12, 13, 14, 15, 16

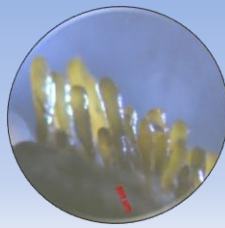
Climate change effects on seaweed germlings' **growth depends on season**



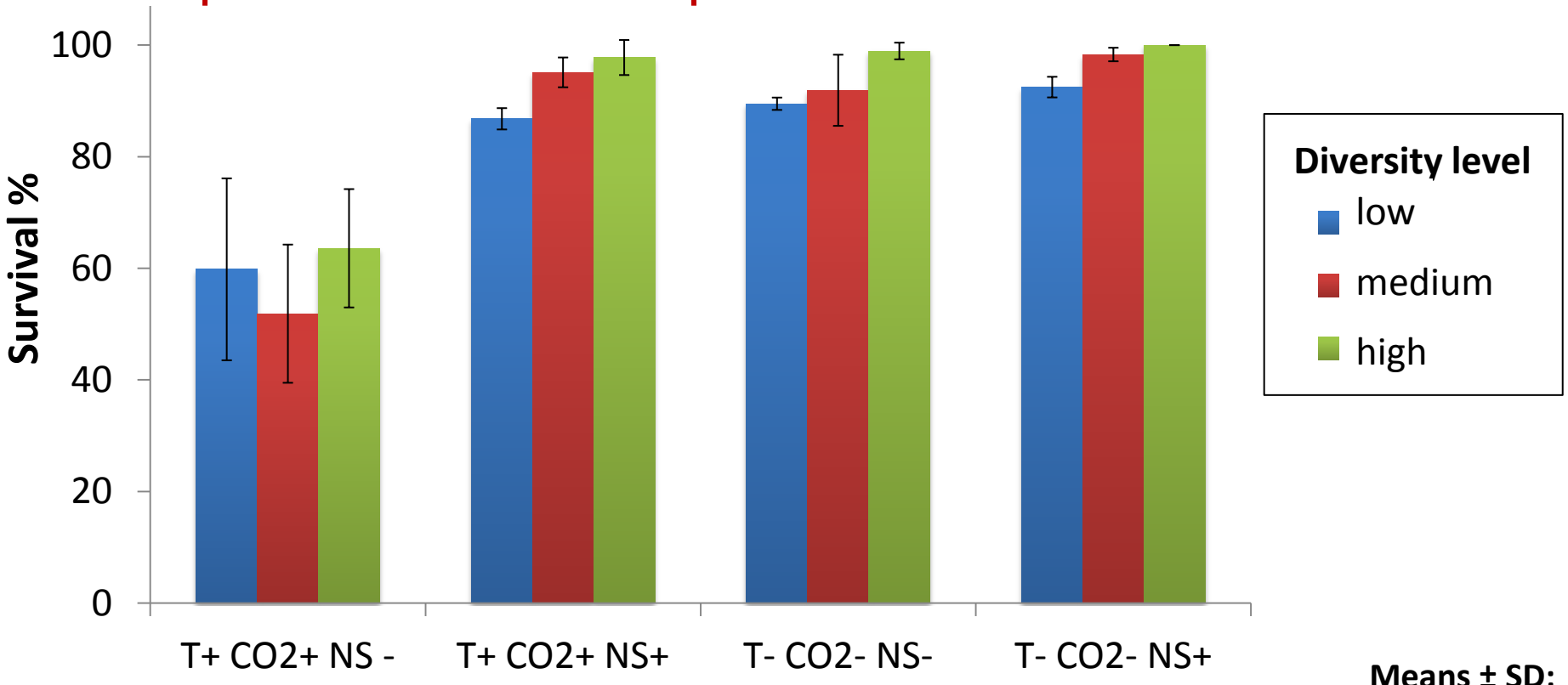


Means ± SD; n=3

Survival differences after **eutrophication** between three genetic diversity levels



Nutrients **Survival during heat wave** (p-value < 0,05)

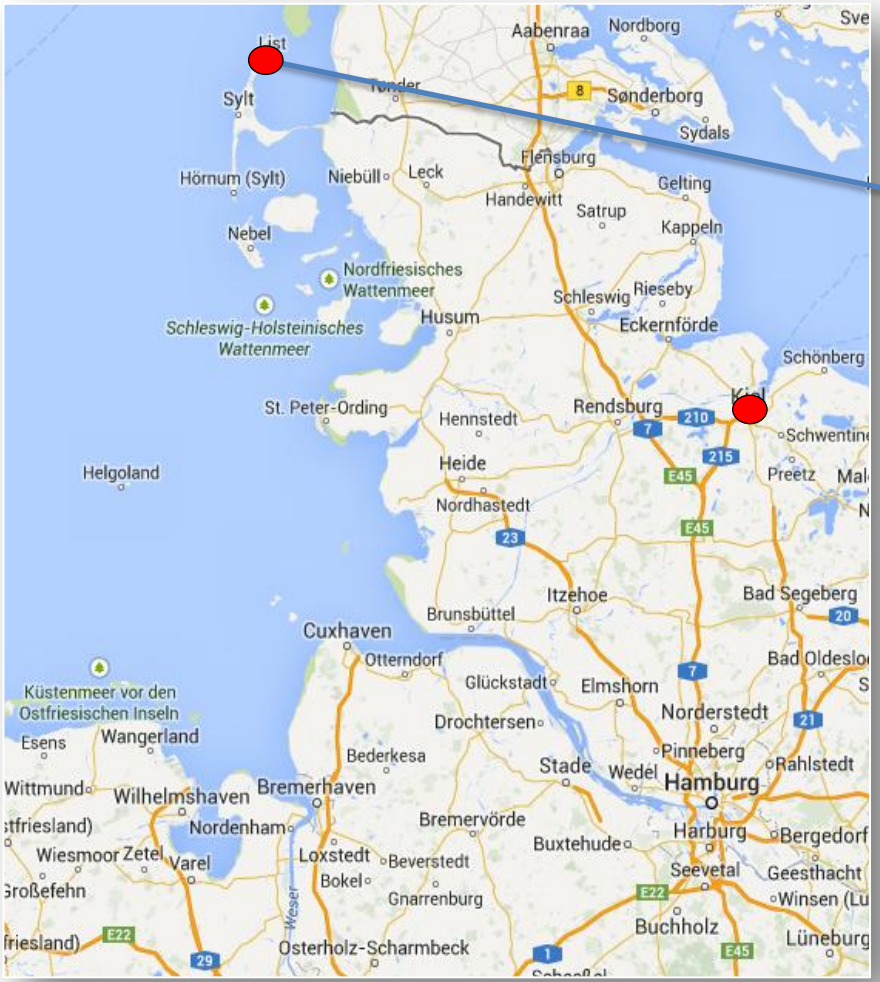


Means ± SD; n=3

Sylt Benthocosms: Effects of climate change on benthic communities in the German Wadden Sea

(H. Asmus, R. Asmus, A. Pansch)

AWI Wadden Sea Station



Sylt Benthocosms: Single mesocosms

(H. Asmus, R. Asmus, A. Pansch)

- 170 cm in diameter x 80 cm height
- 1800 l volume
- Insulated wall construction
- Translucent lid
- Temperature regulation
- Multiparameter measurement system
- Flow through
- Tide simulation
- Software

Sylt Benthocosms: First experiments

(H. Asmus, R. Asmus, A. Pansch)

autumn 2013 **+ spring 2014**

- Macro algal community (*Fucus vesiculosus*)
- 3 month
- CO_2 x temperature

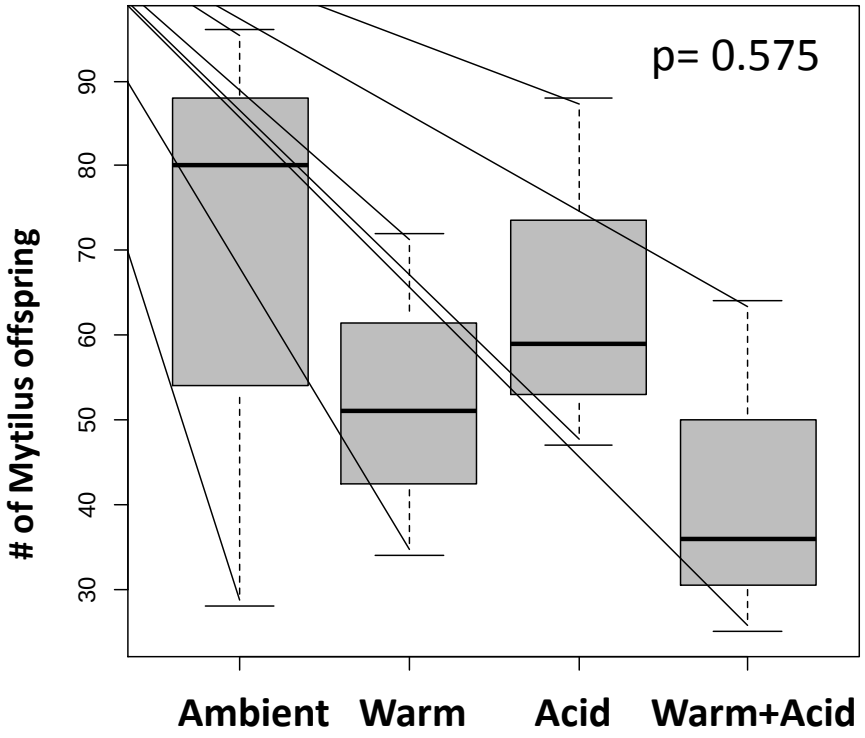
- 4 treatments (3 replicates)
  - Ambient
  - Warm → Ambient + 5 °C
  - Acid → 1000 ppm
  - Warm + Acid → + 5 °C, 1000 ppm

Sylt Benthocosms: *Mytilus edulis*

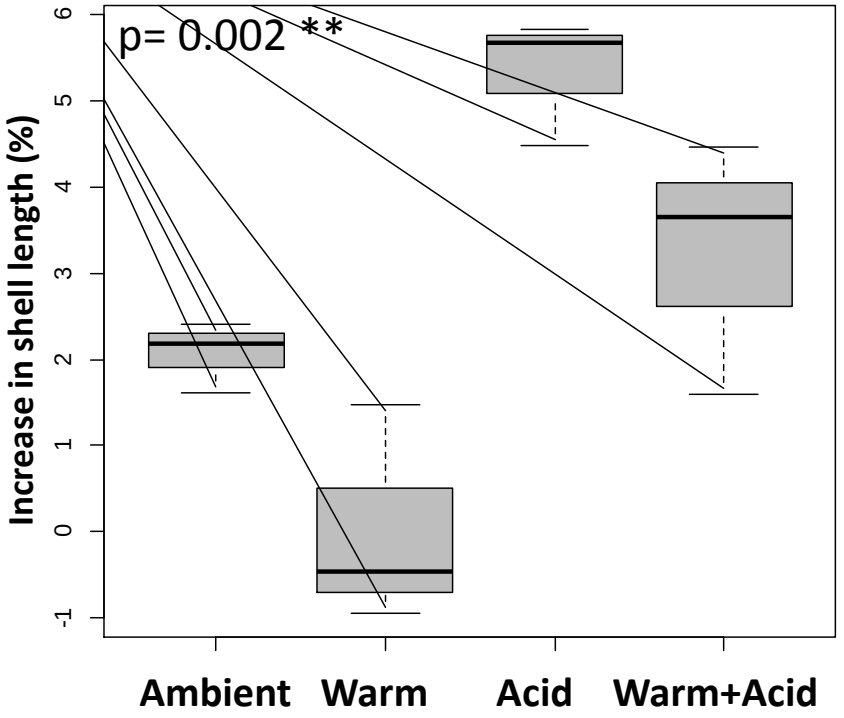
(H. Asmus, R. Asmus, A. Pansch)

Spring 2014

Abundance



Shell length

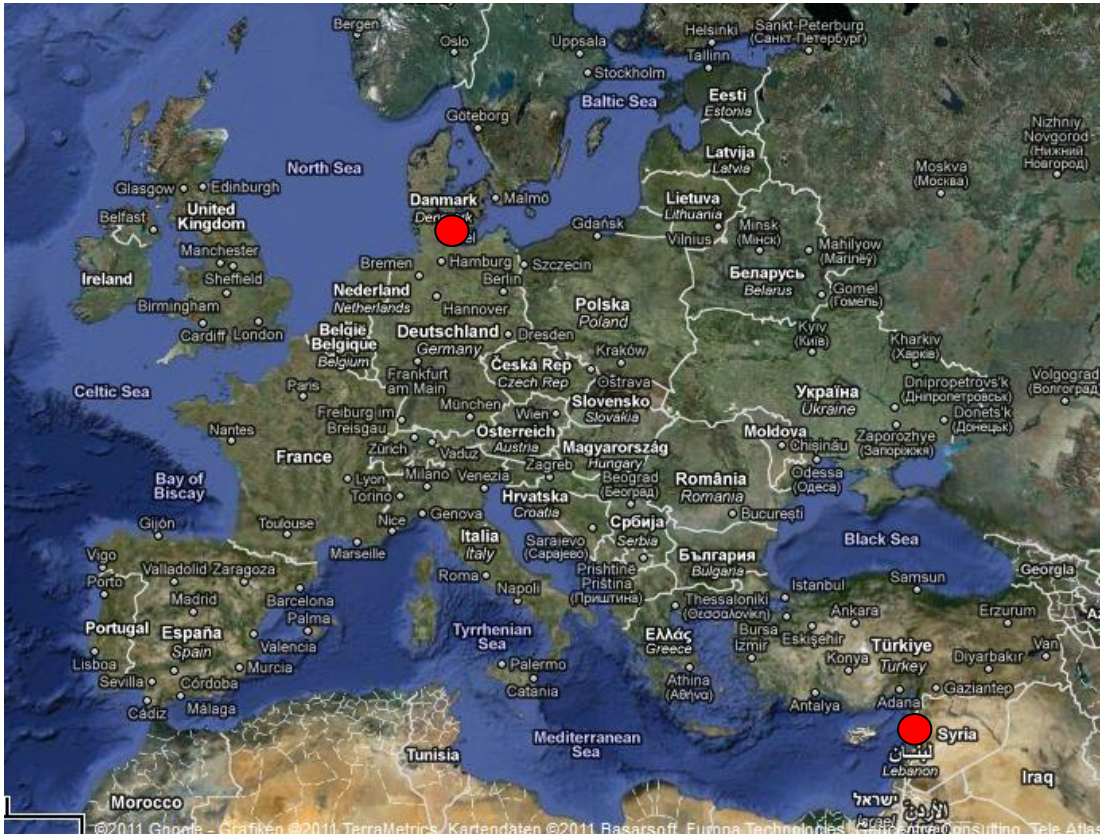


- **Warming decreased the abundance** of *M. edulis* offspring and growth of *M. edulis adults*
- Elevated **CO_2 increased** the abundance of offspring

BaltMed: Eastern Med Benthocosms

Haifa, Gil Rilov (Stefanie Raddatz)

Comparative sensitivity of Baltic versus Mediterranean communities to climate change



Israel Oceanographic & Limnological Research

BIOACID

BaltMed: Eastern Med Benthocosms

Haifa, Gil Rilov (Stefanie Raddatz)

Conclusion of the **Results** and **experiences:** Kiel Benthocosms

- **Infrastructure** with automated system, adjustable for experimental designs.
- **High number of cooperation** between the different groups.
- **Warming affects** the macro algal community stronger than pCO2 does.
- **Seasonality** does influence the performance of algae and the grazer community.
- Community shifts may differ between the **different locations.**
- Modelling and Synthesis is planned for the **Bioacid III phase.**

Thank you for your attention

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