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

Climate change in the Baltic Sea

Global Fossil Carbon Emissions

- Total
- Petroleum
- Coal
- Natural Gas
- Cement Production

Million Metric Tons of Carbon / Year

1800 1850 1900 1950 2000

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
Triple Upscaling:

1. Multiple Factors
2. Multi-Species Communities
3. Multi-seasonal approach
Kiel Benthocoms
Kiel Benthocoms – the infrastructure

- Autonomous energy supply by wind and sun
- Experimental units of 2000 - 4000 L
- Remote video control
- Wave generator
- Thermally insulated containers
- Wave and current control
- Outlets for water samples
- Reactor for CO2 und O2 treatments
- Bypass for pH, O2, salinity, and temperature sensors
- CO2 neutral cooling with deep fjord water
- Automated control of (delta-) temperature, pH, pO2, pCO2, flow-through, waves,...
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

Ambient temperature
Delta treatment of pH

The pCO2 treatment interacts with the temperature treatment

Δ 5°C

Δ 0°C
Bioacid II

Benthic consortium:
Responses of benthic assemblages to interactive stress
Benthic consortium: Structure
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<tr>
<th>WP</th>
<th>Topic</th>
<th>PhD</th>
<th>Name (of PI)</th>
<th>Affiliation</th>
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<td>2.1</td>
<td>Re-structuring and re-functioning <strong>macrophyte</strong> communities</td>
<td>Andreas Pansch</td>
<td>Ragnild Asmus</td>
<td>AWI</td>
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<td>2.2</td>
<td>Re-structuring and re-functioning in <strong>bacterial</strong> communities on Fucus</td>
<td>Birte Mensch</td>
<td>Ruth Schmitz-Streit</td>
<td>CAU Kiel</td>
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<td>Re-structuring in (micro-) <strong>epiphytic</strong> communities on Fucus</td>
<td>Franziska Werner</td>
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<td><strong>Physiological</strong> responses of Fucus to environmental shifts</td>
<td>Angelika Graiff</td>
<td>Ulf Karsten</td>
<td>University of Rostock</td>
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<td><strong>Genetic</strong> responses of Fucus to stress</td>
<td>Balsam Al Janabi</td>
<td>Inken Kruse</td>
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<td>2.6</td>
<td><strong>Biogeochemical</strong> responses to environmental shifts</td>
<td>Vera Winde</td>
<td>Michael Böttcher</td>
<td>IOW</td>
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<td><strong>Interaction</strong> shifts in Fucus communities</td>
<td>Steffanie Raddatz</td>
<td>Martin Wahl</td>
<td>GEOMAR</td>
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</table>
Benthic consortium
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**
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

Biogeochemistry responds on environmental shifts

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

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

Biofilm swabs from *Fucus vesiculosus*

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

→ PRELIMINARY RESULTS

→ IN PROCESS...
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

+CO2 +Temp  +Temp  +CO2  ambient

Spring

Summer

Fall

Winter

PFD (µmol m-2 s-1)

PFD (µmol m-2 s-1)
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

2. Quartetts

3. Oktetts

Diversity levels:

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)

![Graph showing survival rates under different conditions with means ± SD, n=3](image)

- Diversity level:
  - low
  - medium
  - high

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 \(\rightarrow\) Ambient + 5 °C
  • Acid \(\rightarrow\) 1000 ppm
  • Warm + Acid \(\rightarrow\) + 5 °C, 1000 ppm
• **Warming decreased the abundance** of *M. edulis* offspring and growth of *M. edulis* adults

• Elevated **CO₂ increased** the abundance of offspring
Comparative sensitivity of Baltic versus Mediterranean communities to climate change
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