BIOACID Annual Meeting, September 2014, Kiel

Effects of global warming and ocean acidification on benthic communities in the German Wadden Sea

- examined with mesocosm experiments -

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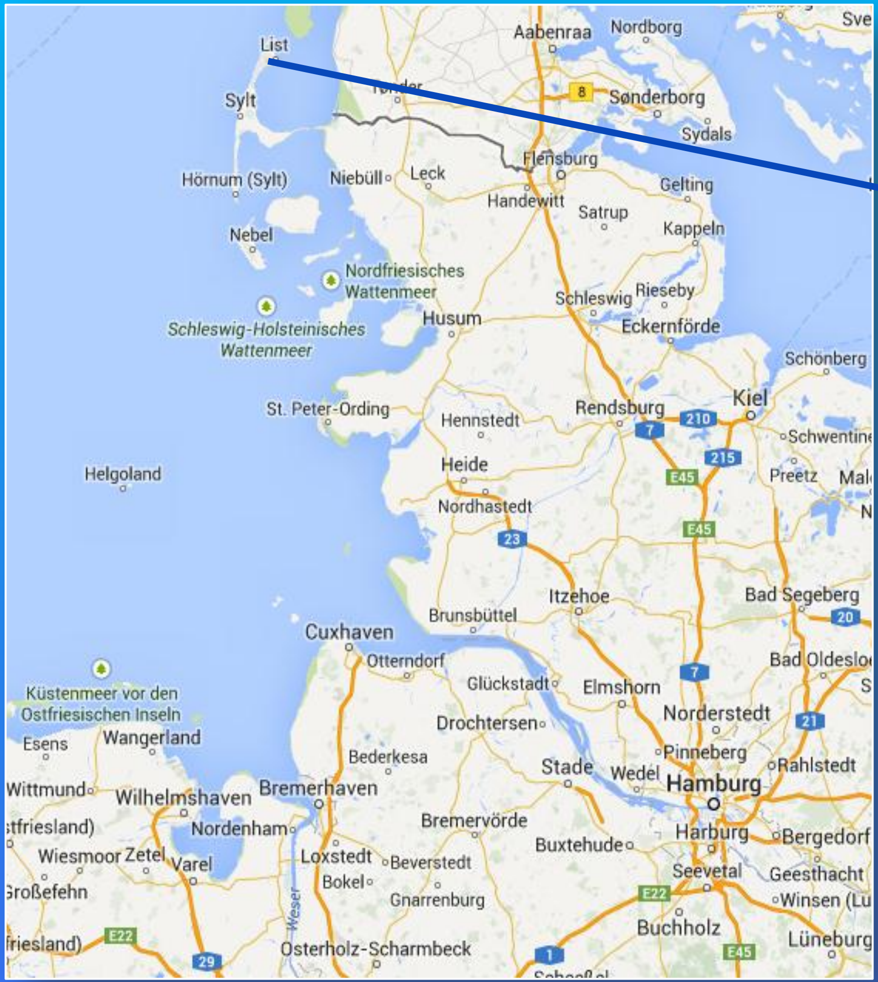
Bundesministerium für Bildung und Forschung

Why mesocosm studies ?

- Close the gap between small scale lab experiments and field studies
- Experiments with communities instead of single species under controlled conditions
- Investigation of species interactions and community structure under climate change

AWI Wadden Sea Station



www.google.de/maps

Mesocosms facilities - Sylt

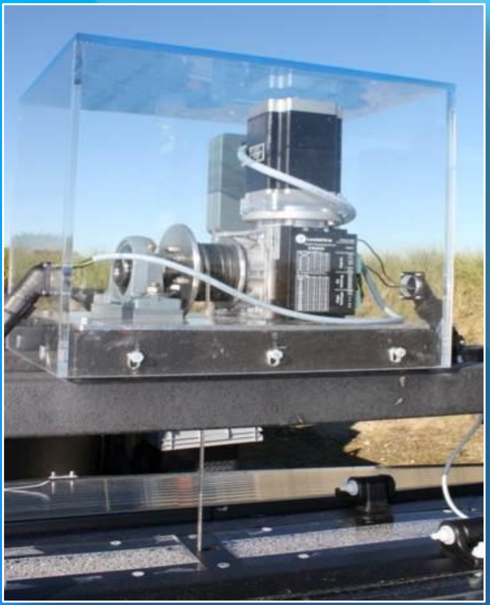
- Constructed by 4H-Jena Engineering
- Finished in August 2013
- 12 mesocosms → 12 independent experimental units
- Non filtered seawater from the Wadden Sea Station
- Connected with the CO_2-gas mixing facility of the institute

→ Made for climate change experiments at the ecosystem level

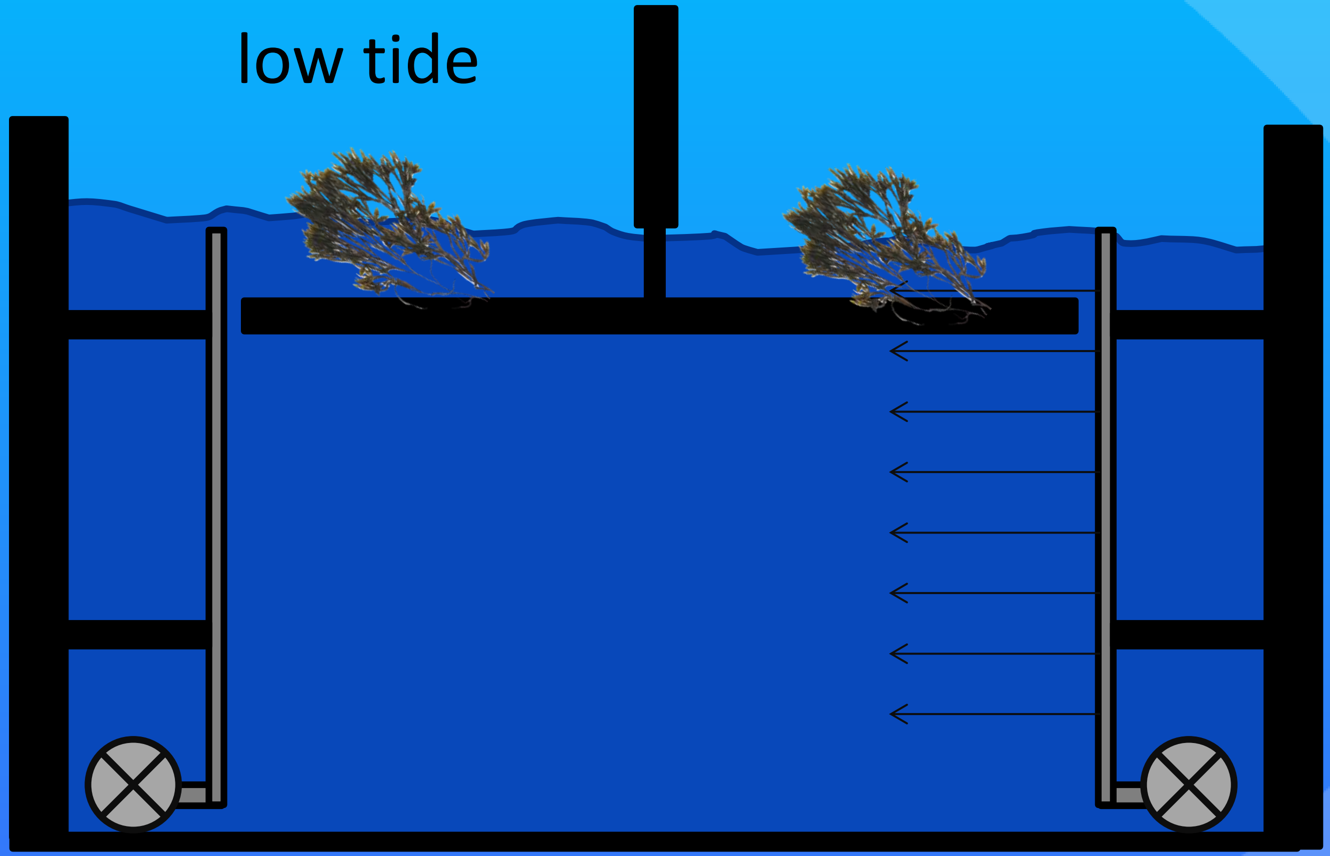
Single mesocosm

- 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

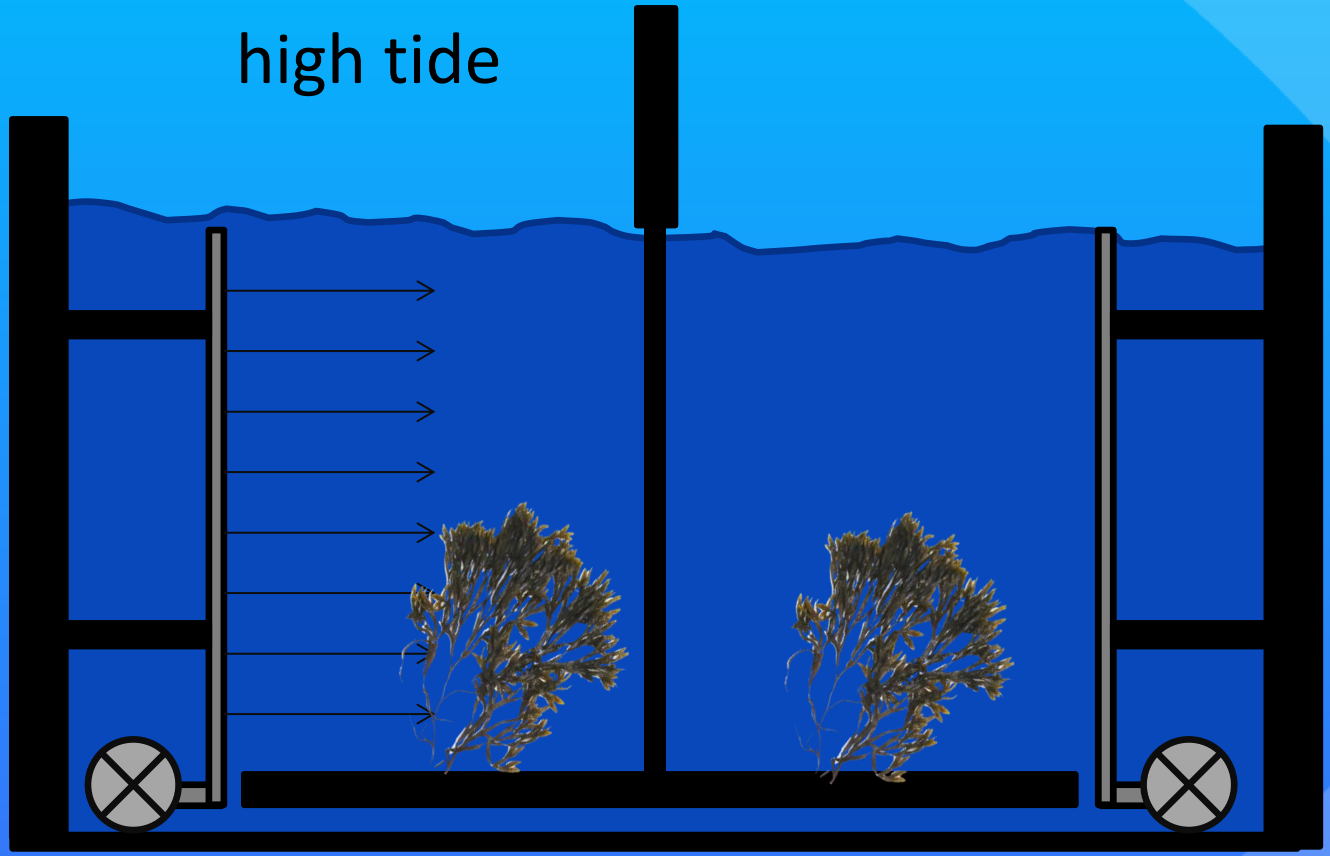
Tide simulation



Tide simulation



Tide simulation



Temperature regulation

Aqua medic®
Titanium heater
3 x 500 W

✚

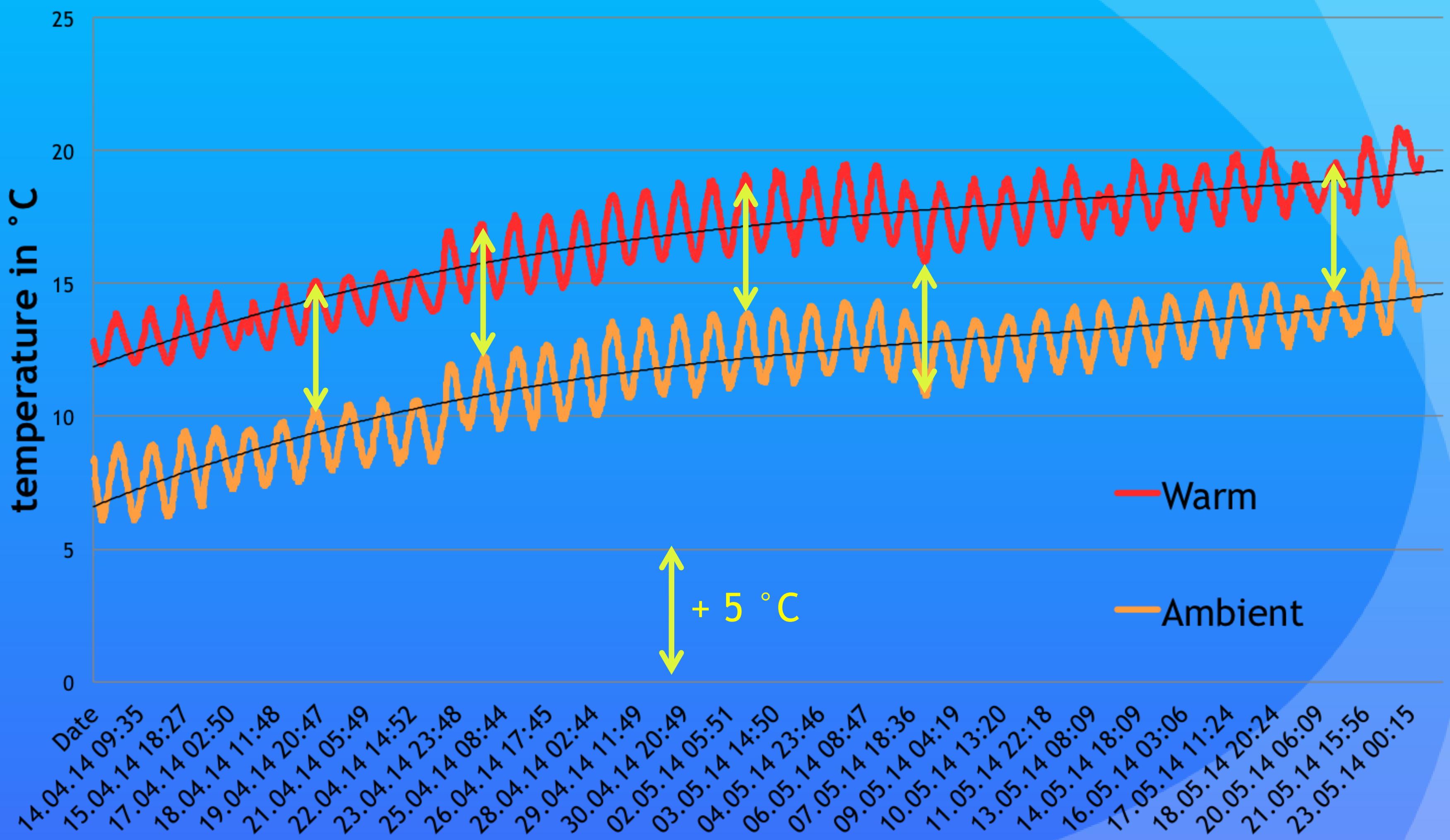
Aqua medic®
Titan 2000 cooler
550 W

✚

Software:

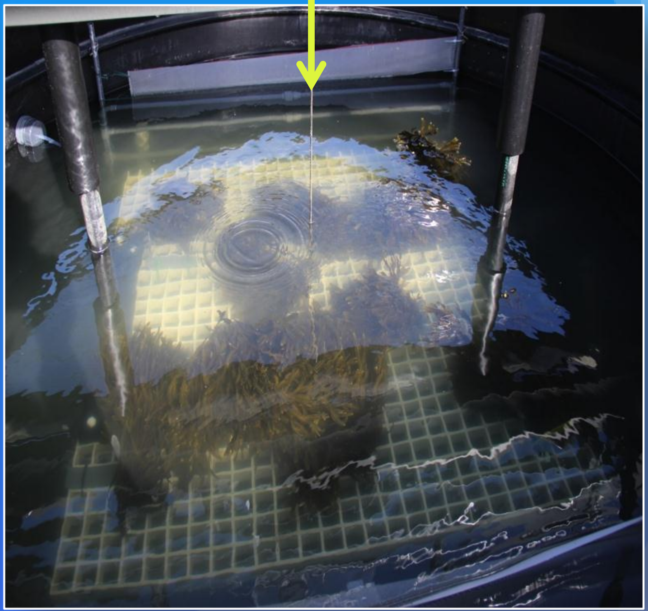
- yearly max/min
- daily max/min
- adjusted by measured temperatures in the field

Temperature regulation

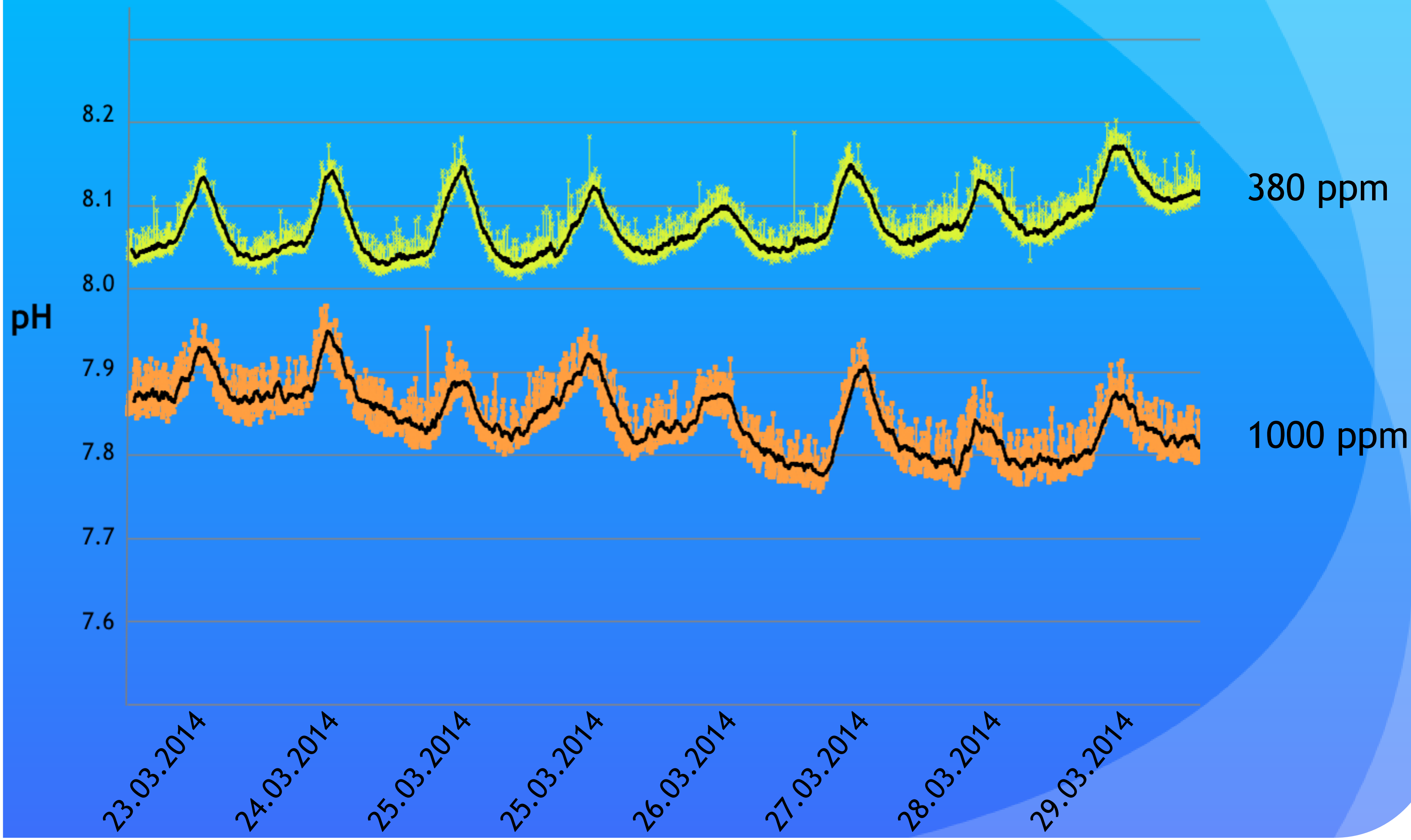


CO_2-gas mixing facility

Seawater in each mesocosm is directly aerated with pre-mixed gas



Seawater acidification

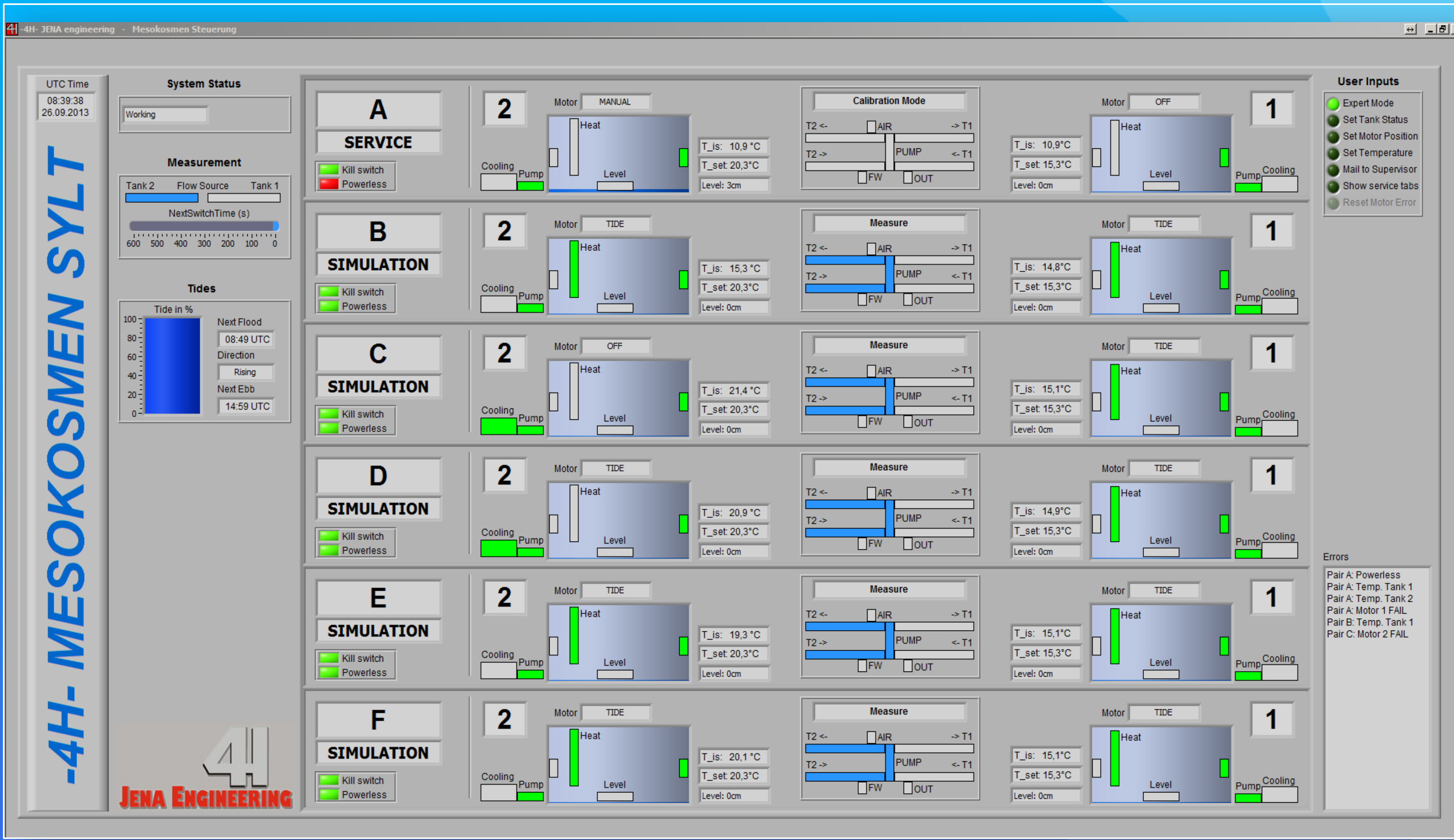


Multi-parameter measurements

One system for two mesocosms: Hydrolab DS5X

- Parameters measured at the moment
  - temperature
  - pH
  - oxygen (Clark cell)
  - conductivity
- Possible adjustments in the future
  - chlorophyll
  - turbidity
  - Ammonium etc.

Software



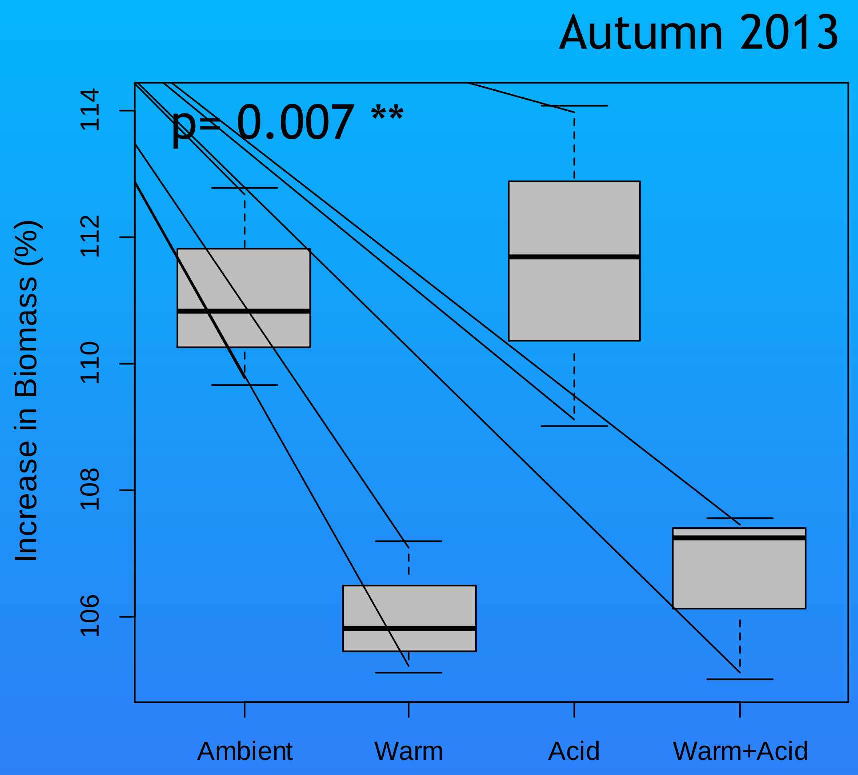
-4H- JENA engineering - Mesokosmen Steuerung
UTC Time
08:39:38
26.09.2013
-4H- MESOKOSMEN SYLT
System Status
Working
Measurement
Tank 2
Flow Source
Tank 1
NextSwitchTime (s)
600 500 400 300 200 100 0
Tides
Tide in %
100 80 60 40 20 0
Next Flood
08:49 UTC
Direction
Rising
Next Ebb
14:59 UTC
JENA ENGINEERING
A
SERVICE
Kill switch
Powerless
2
Motor MANUAL
Heat
Level
Cooling
Pump
T_is: 10,9 °C
T_set 20,3°C
Level: 3cm
Calibration Mode
T2 <-
AIR
-> T1
T2 ->
PUMP
<- T1
FW
OUT
T_is: 10,9°C
T_set 15,3°C
Level: 0cm
Motor OFF
1
B
SIMULATION
Motor TIDE
T_is: 15,3 °C
T_set 20,3°C
Level: 0cm
Measure
T_is: 14,8°C
T_set 15,3°C
Level: 0cm
C
SIMULATION
Motor OFF
T_is: 21,4 °C
T_set 20,3°C
Level: 0cm
T_is: 15,1°C
T_set 15,3°C
Level: 0cm
Motor TIDE
D
SIMULATION
T_is: 20,9 °C
T_set 20,3°C
Level: 0cm
T_is: 14,9°C
T_set 15,3°C
Level: 0cm
E
SIMULATION
T_is: 19,3 °C
T_set 20,3°C
Level: 0cm
T_is: 15,1°C
T_set 15,3°C
Level: 0cm
F
SIMULATION
T_is: 20,1 °C
T_set 20,3°C
Level: 0cm
T_is: 15,1°C
T_set 15,3°C
Level: 0cm
User Inputs
Expert Mode
Set Tank Status
Set Motor Position
Set Temperature
Mail to Supervisor
Show service tabs
Reset Motor Error
Errors
Pair A: Powerless
Pair A: Temp. Tank 1
Pair A: Temp. Tank 2
Pair A: Motor 1 FAIL
Pair B: Temp. Tank 1
Pair C: Motor 2 FAIL

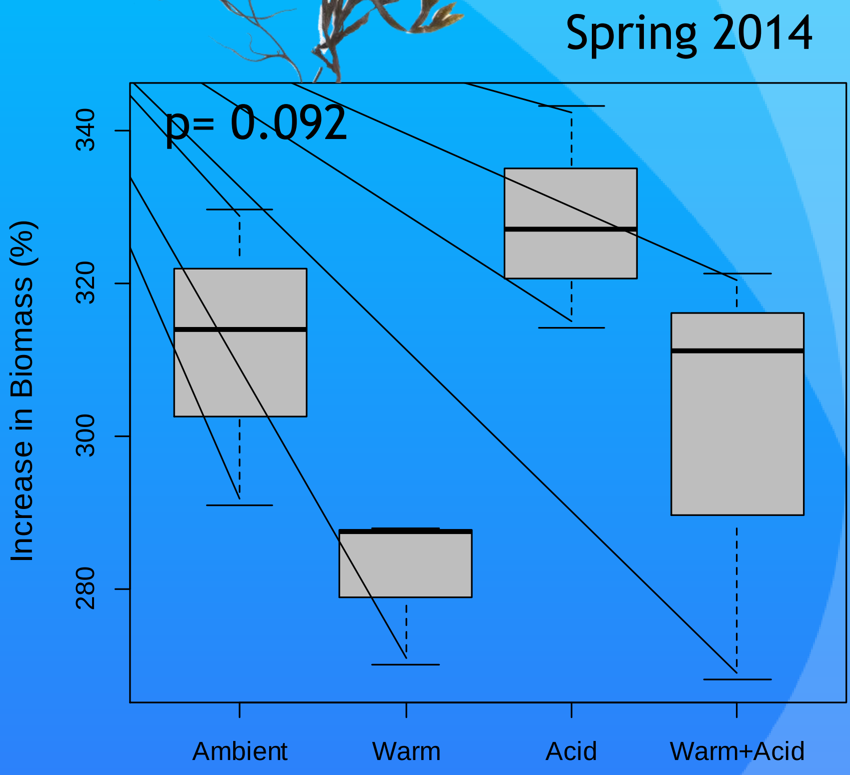
First experiments

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

Fucus vesiculosus

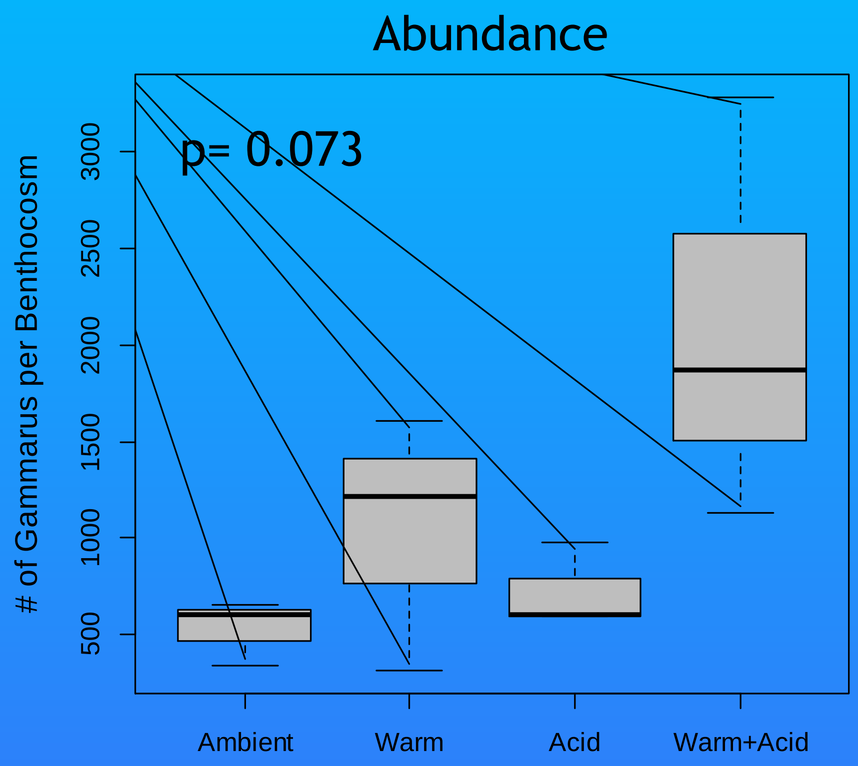


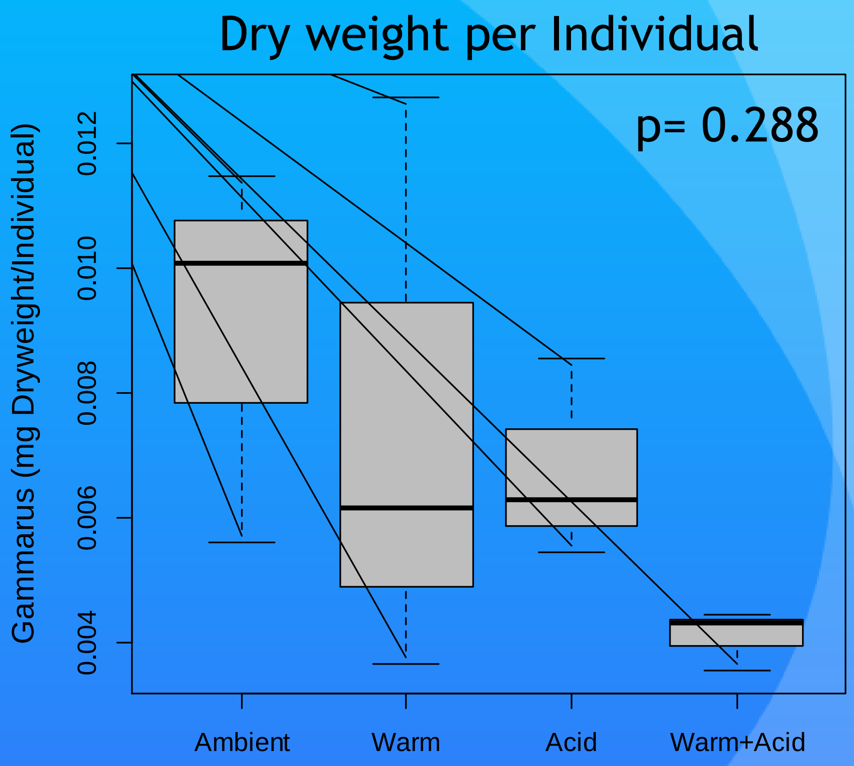


- Warming inhibited *Fucus* growth
- Elevated pCO_2 increased Biomass
- Stress combination acted antagonistically

Gammarus sp.

Spring 2014

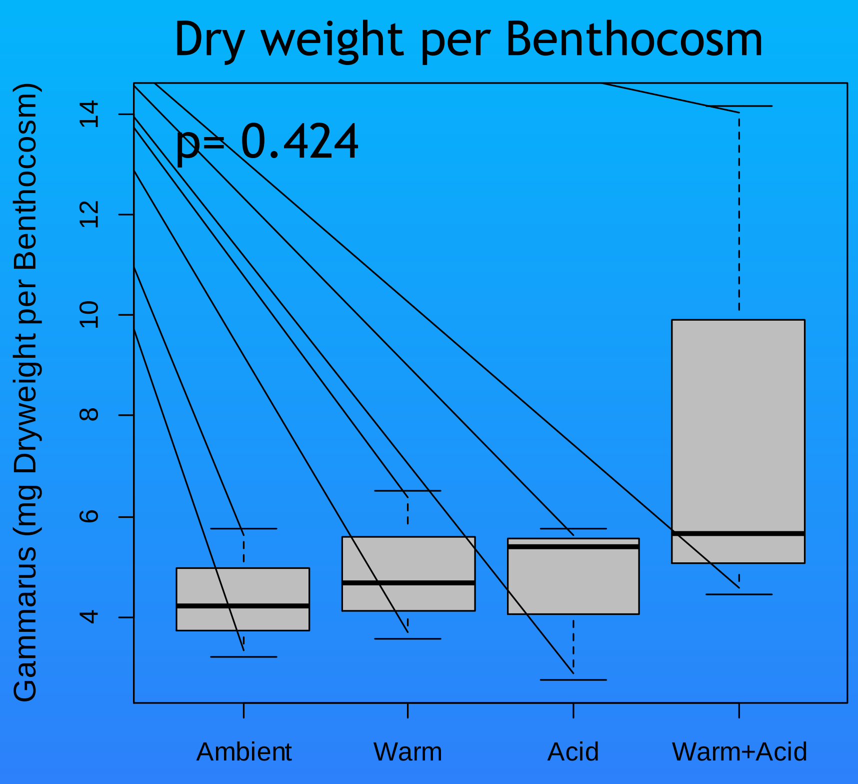




- Warming increased the number of *Gammarus* offspring

Gammarus sp.

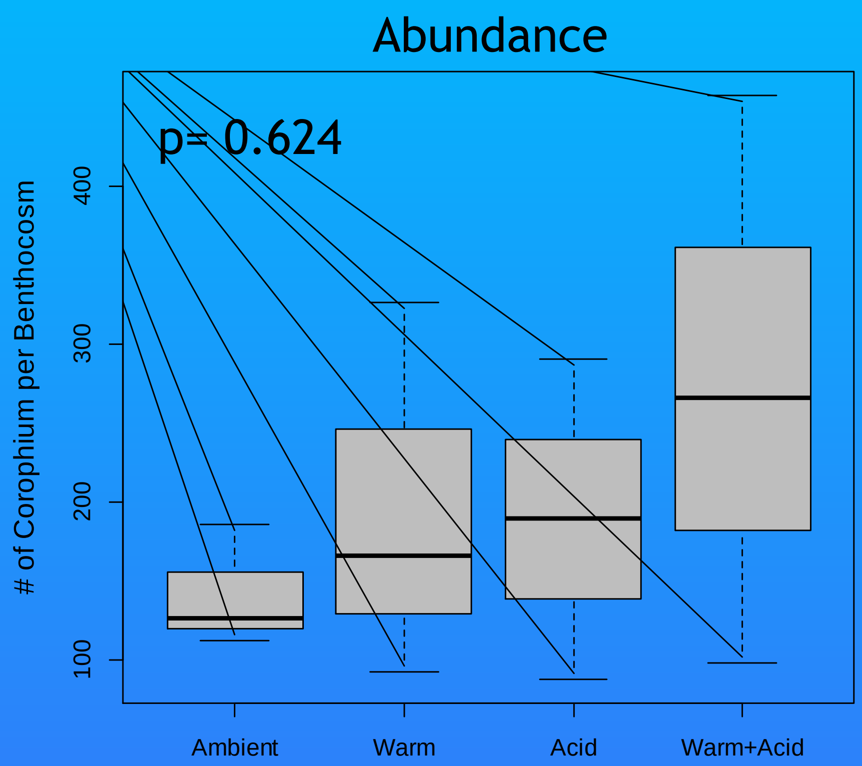
Spring 2014

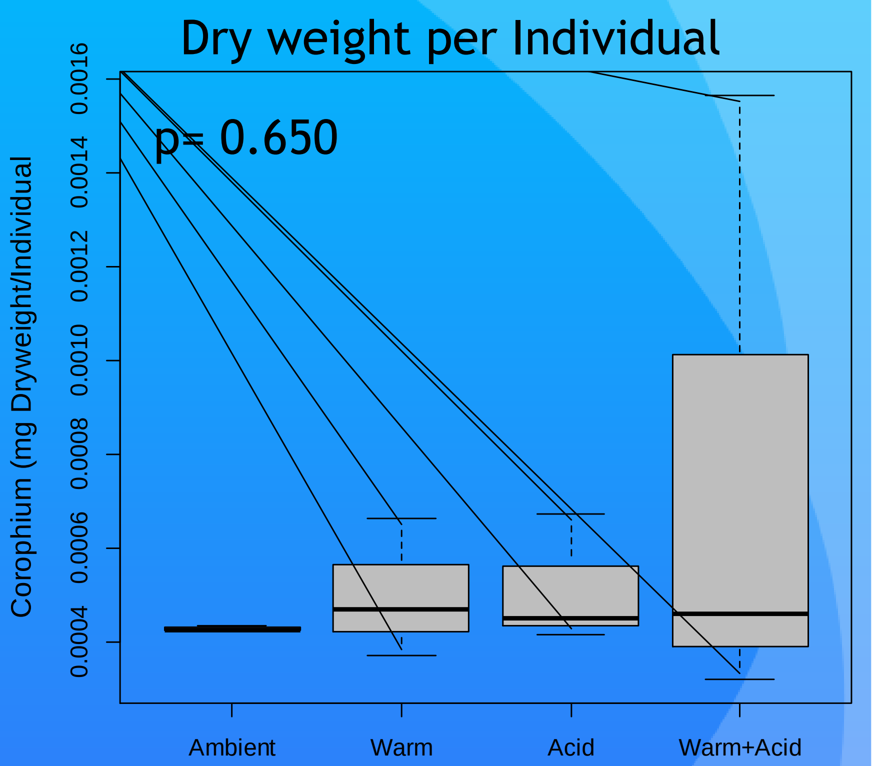


- Warming increased the number of *Gammarus* offspring

Corophium sp.

Spring 2014

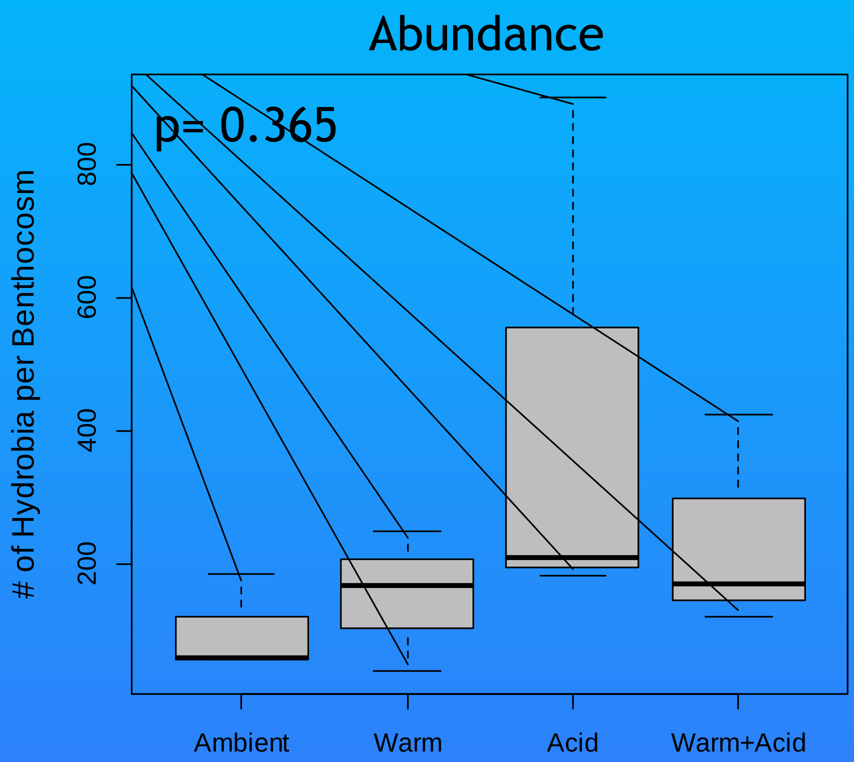


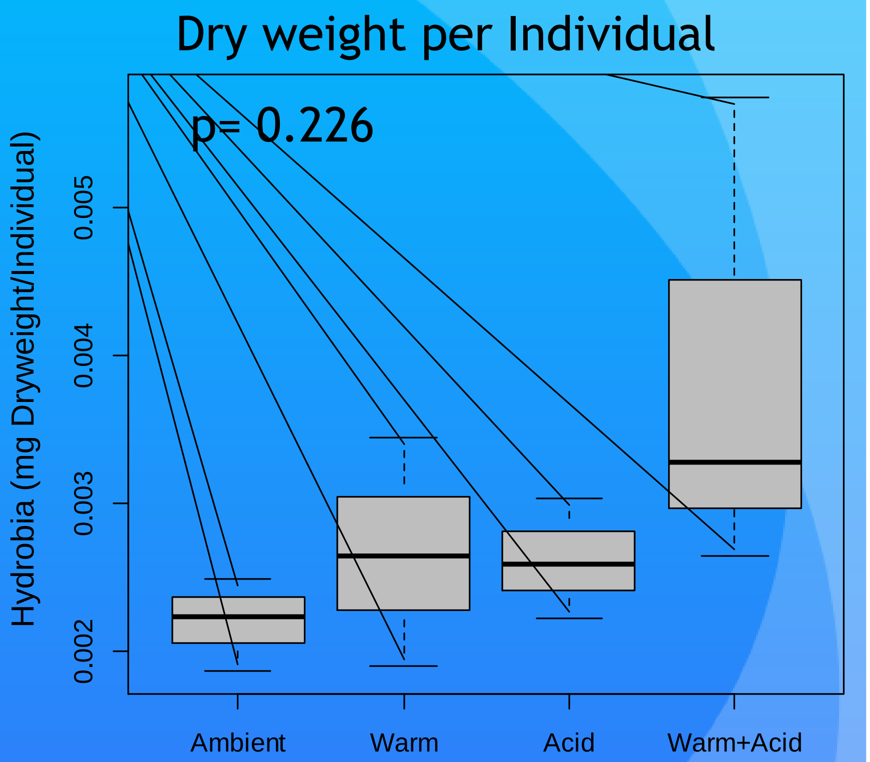


- Warming and acidification as well the combination of both increased the abundance of *Corophium* sp.

Hydrobia ulvae

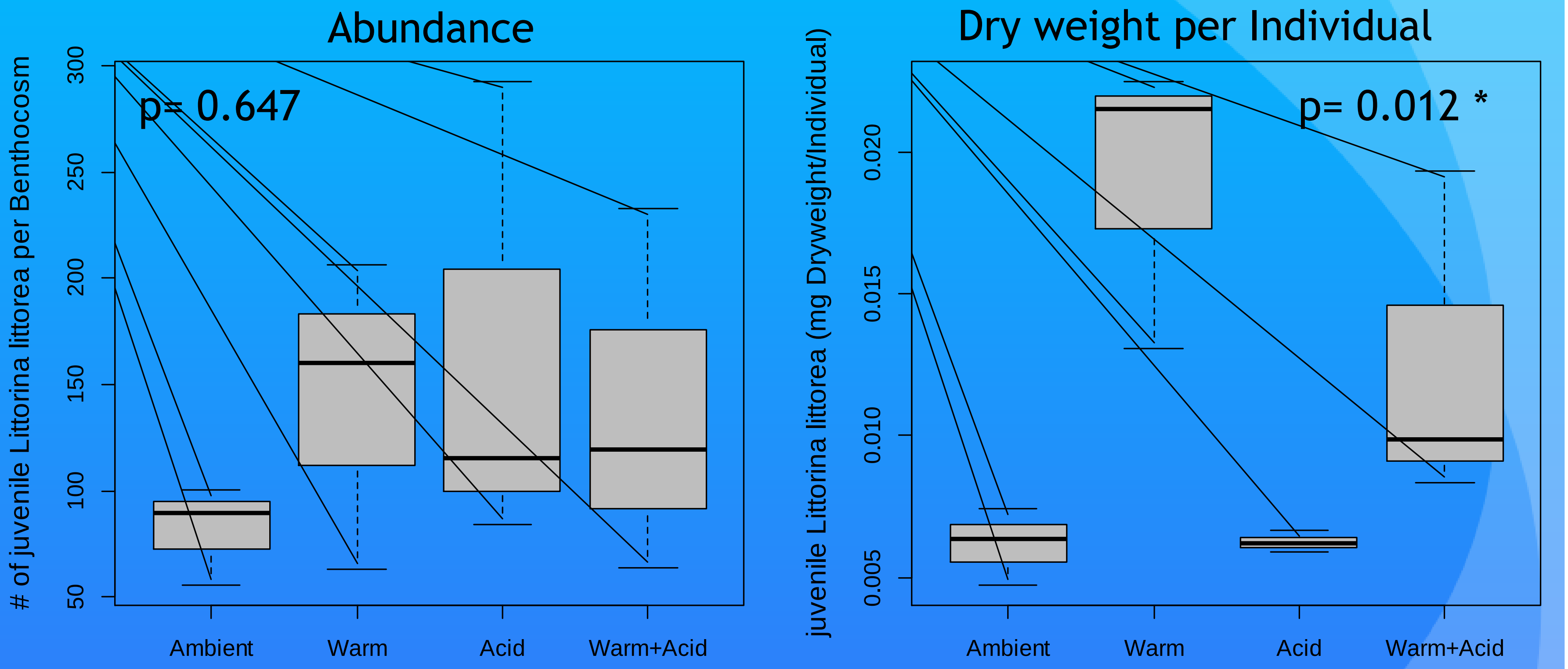
Spring 2014





- Warming and acidification as well the combination of both increased the abundance and growth of *Hydrobia ulvae*

Juvenile *Littorina littorea* Spring 2014



- Warming and acidification as well the combination of both increased the abundance of *L. littorea* offspring
- Warming increased the growth of juvenile *L. littorea*

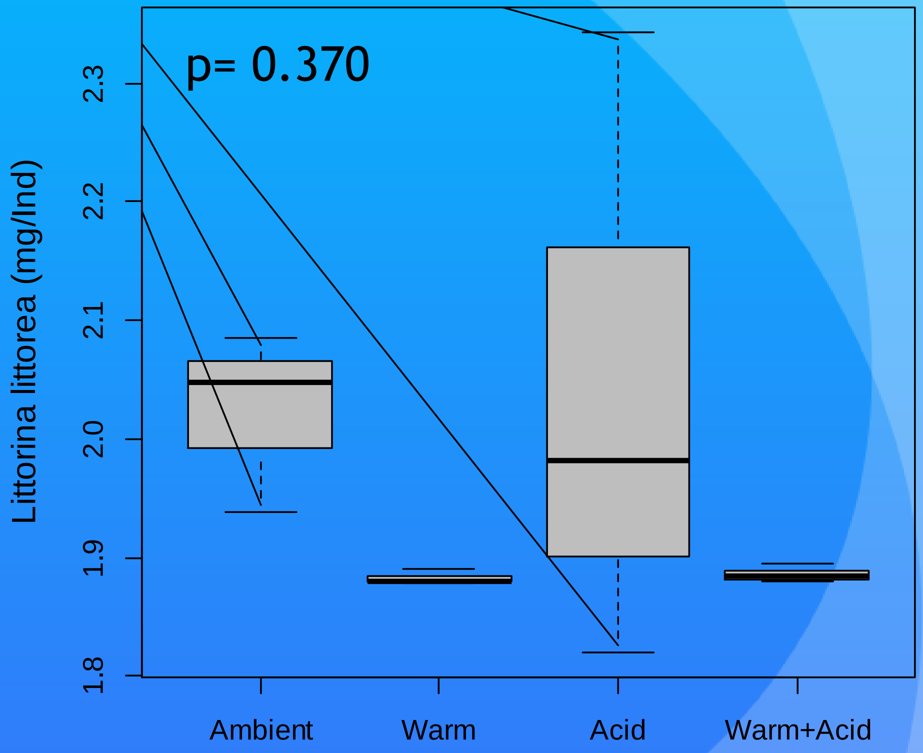
adult *Littorina littorea*

Spring 2014

Abundance

• No change in abundance

Dry weight per Individual

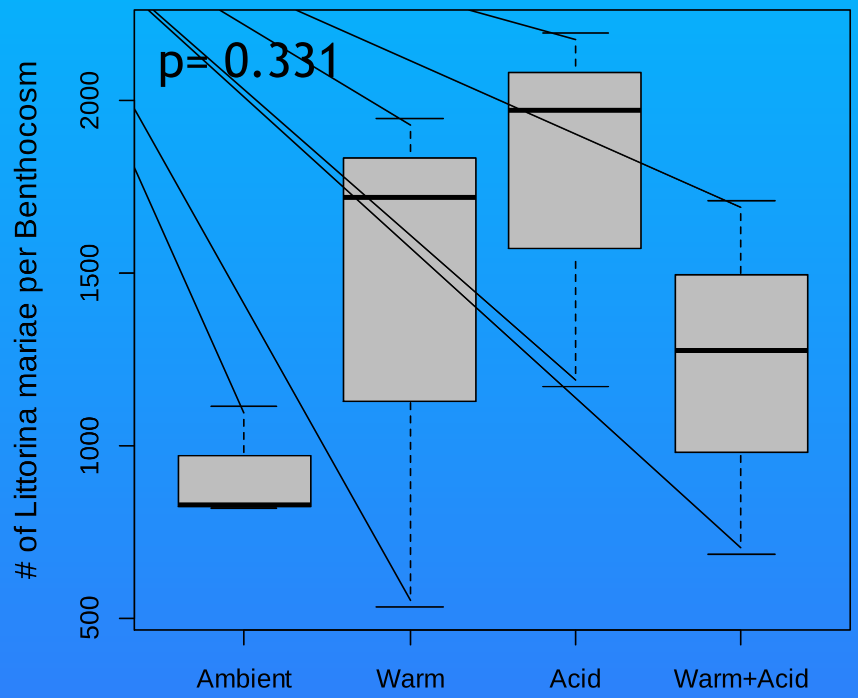


• Warming reduced the biomass of adult *L. littorea*

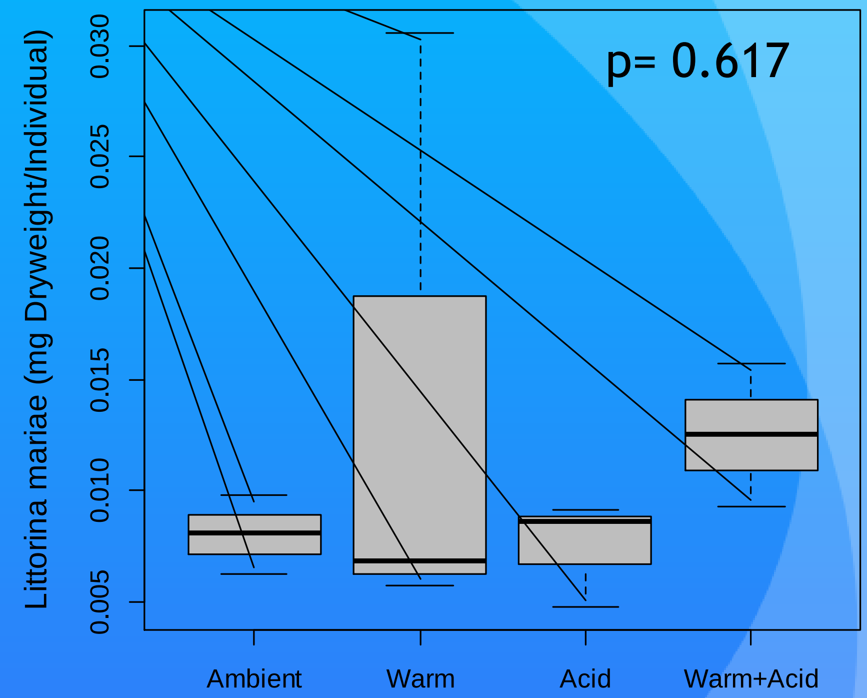
Littorina mariae

Spring 2014

Abundance



Dry weight per Individual

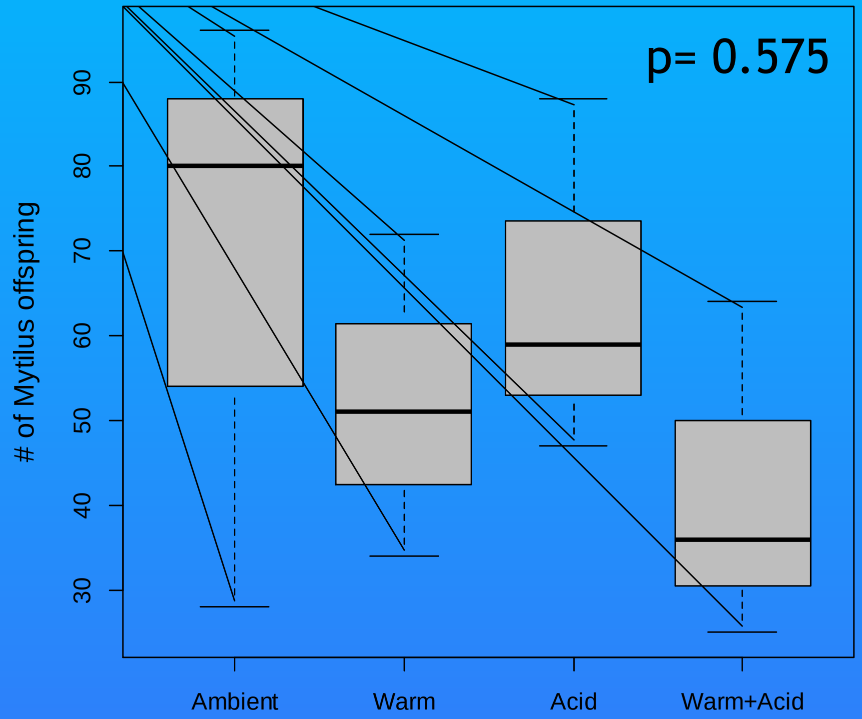


- Warming and acidification as well the combination of both increased the abundance of *L. mar*iae
- Growth increased under the combination of warning and high pCO_2

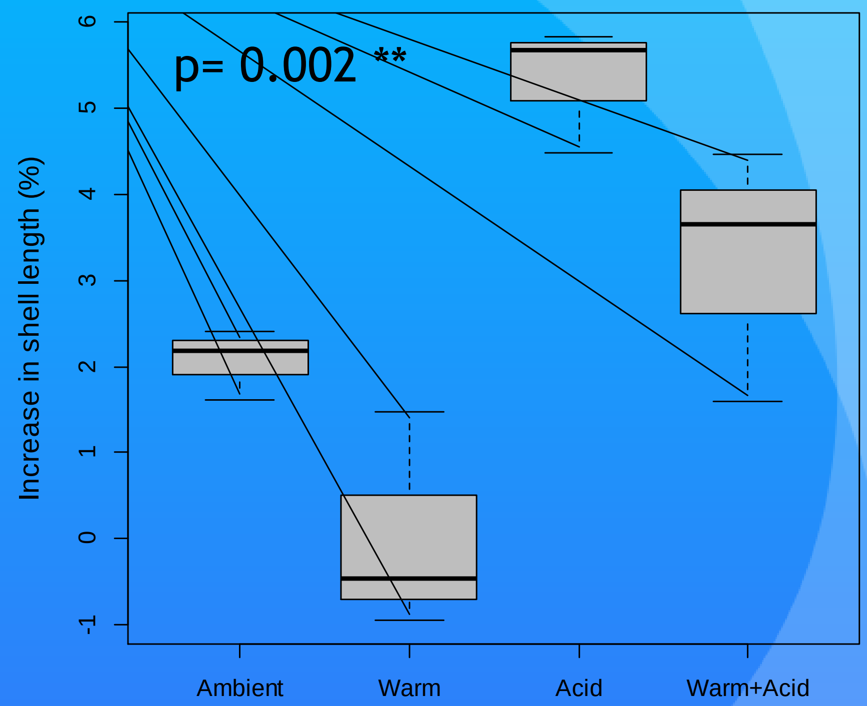
Mytilus edulis

Spring 2014

Abundance

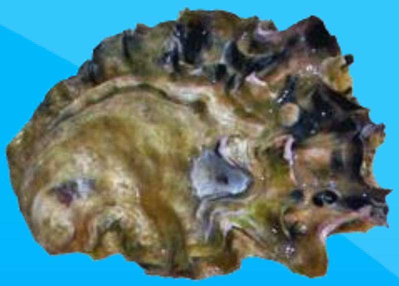


Shell length



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

Crassostrea gigas

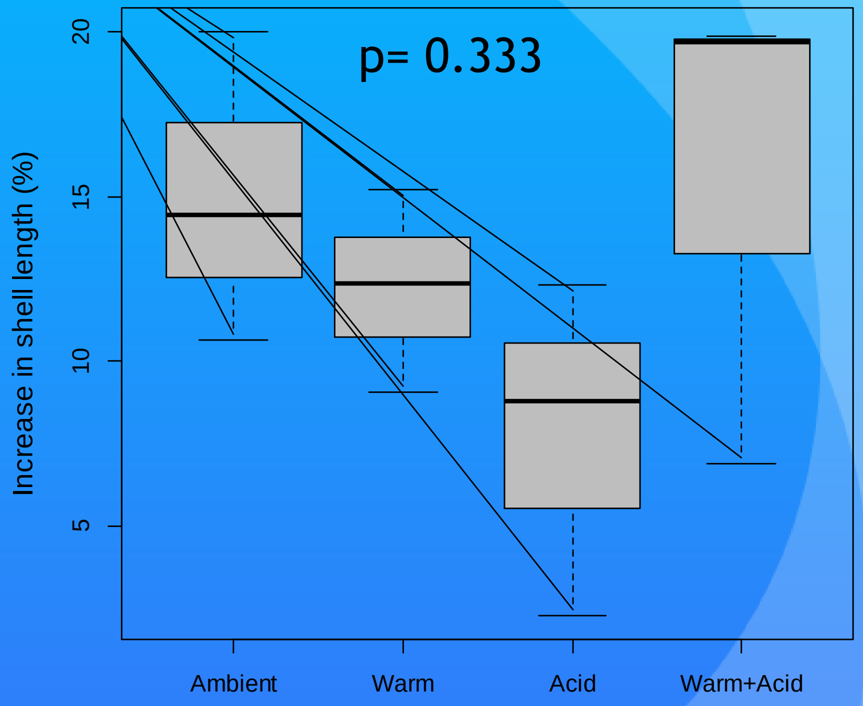


Spring 2014

Abundance

- No settled oysters were found

Shell length



- Elevated CO_2 decreased growth of *C. gigas*
- The combination of warming and elevated CO_2 led to control growth

Summary

	Warm	Acid	Warm+Acid
Fucus vesiculosus			
Gammarus sp.			
Corophium sp.			
Hydrobia ulvae			
Juv. L. littorea			
Adult L. littorea			
Littorina mariae			
Mytilus edulis			
Crassostrea gigas			

Conclusions

- No obvious negative effects at elevated pCO_2
- Warming impacted *Fucus* and *Mytilus* negatively
- Combination of warming and acidification acted antagonistically
  → Importance of multiple stressor experiments
- Important to differentiate between direct and indirect effects
- First results show higher impact of acidification on Wadden Sea community than on Baltic Sea communities

Although single species effects were shown widely in the literature, two of the main predicted future threats, warming and acidification, do not negatively impact benthic Wadden Sea assemblages

Future plans

Summer 2014 (still running)

❖ *Fucus vesiculosus* community
(CO_2 x temperature) x eutrophication

❖ Test with Ecological Network Analysis

❖ Experiments on *Seagrass* communities

❖ Test of more stressors, stress combinations, species, life stages and communities

- fish larvae, small fish
- turbidity, deoxygenation, hyposalinity, sedimentation, micro plastics

Thanks for your attention

BIOACID
Biological Impacts of Ocean ACIDification

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und Forschung