Response of the photosynthetic rate of macrophytes to increased CO_2 concentrations in a brackish-water ecosystem

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BACKGROUND

- Macrophytes are important structural components in the coastal brackish-water Baltic Sea ecosystems.
- In the Baltic Sea macrophytes live in a highly variable environment caused by seasonality and rapid changes in metereological conditions.
- However, the combined effects of elevated $p(CO_2)$ and other limiting environmental factors on the photosynthesis of macrophytes is not well understood.

RESEARCH QUESTION

- The main aim of the current study was to detect the effect of elevated $p(CO_2)$ on the net photosynthesis of macrophytes in the NE Baltic Sea under summer conditions.
- Our hypotheses are that the phototsynthetic rate of macrophytes would benefit from elevated $p(CO_2)$ and that the response is affected by different environmental factors.
- The second objective examines the short-term variability of carbonate chemistry in shallow-water macroalgal habitats.

STUDY AREA

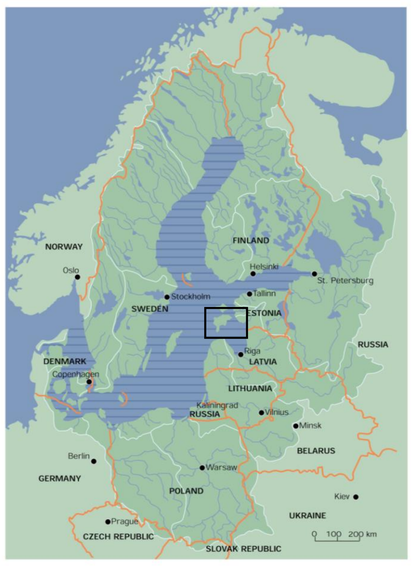
Abiotic factors affecting the growth and life cycle of macrophytes in Northern Baltic Sea

➢ High seasonal variation of environmental factors:

- Light conditions (duration of light day 6 to 19 hours; low water transparency: local variation in maximum values of PAR at 5m depth 10 – 400 µmol/m²/s)
- Water temperature (0 – 24°C, ice cover up to 100 days)
- Nutrients

➢ Low salinity (2 – 7 psu)

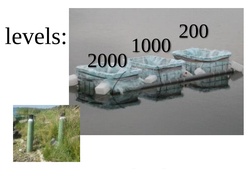
Location of the study area – Kõiguste Bay, N Gulf of Riga (salinity 4-6 PSU)



EXPERIMENTAL SETUP

Mesocosm experiments: June-July 2011-2014

- Mesocosm experiments were carried out with three macroalgal species: *Ulva intestinalis*, *Fucus vesiculosus*, *Furcellaria lumbricalis* and seagrass *Zostera marina*.
- Macrophytes were incubated in mesocosms with manipulated different $p(CO_2)$ levels:
  $p(CO_2)$ ~200 µatm (control)
  $p(CO_2)$ ~1000 µatm
  $p(CO_2)$ ~2000 µatm



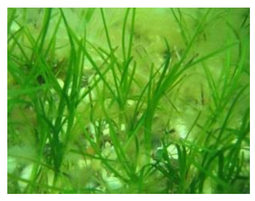
- As a response variable – net photosynthetic rate was measured every day by the oxygen method.
- During experiments other environmental factors were also monitored (salinity, light, nutrients and temperature).
- In parallel, the diurnal natural fluctuation of seawater $p(CO_2)$ and pH were measured in the shallow water macroalgal habitat.

- The $p(CO_2)$ was measured by underwater (sensor) automatic CO2 data logger (CONTROS™ DETECT 2.0, Germany). Water temperature, oxygen saturation, pH_{NBS} and salinity were measured continuously using a YSI 6600V2 environmental multiprobe (pH electrode YSI 6589FR).

Ulva intestinalis

Fucus vesiculosus

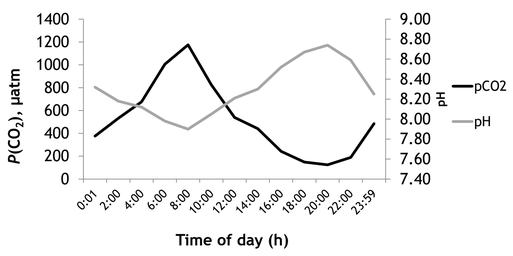
Furcellaria lumbricalis



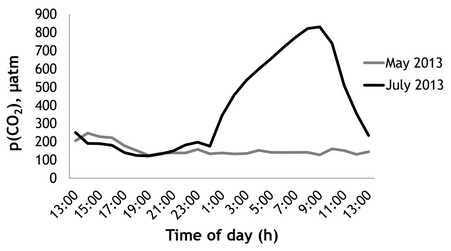
Zostera marina

RESULTS

Environmental variables



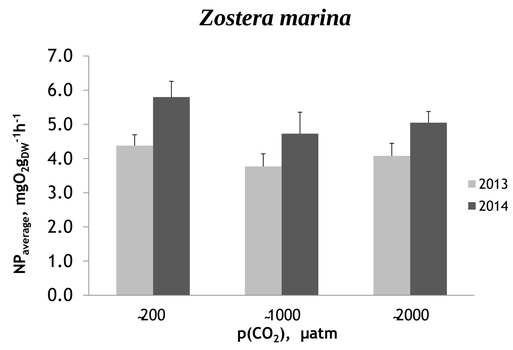
Example of measurements performed: 25-26, July 2015



Example of measurements performed in May and in July 2013

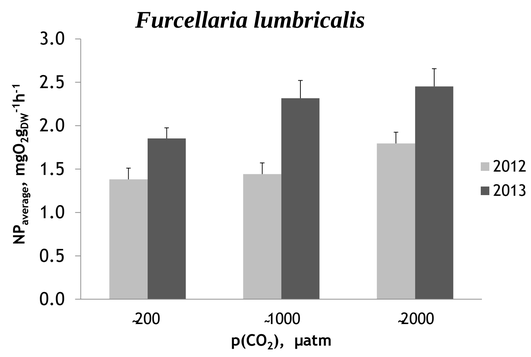
Diurnal changes in $p(CO_2)$ and pH in shallow water macroalgal habitats in summer may be of a larger magnitude than those predicted due to ocean acidification over the next 100 years.

Zostera marina



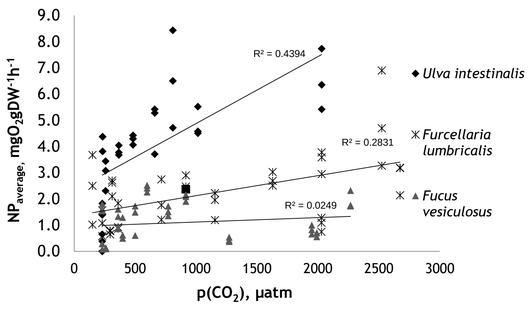
The elevated $p(CO_2)$ levels showed no significant effect on the photosynthetic rate of *Zostera marina*.

Furcellaria lumbricalis



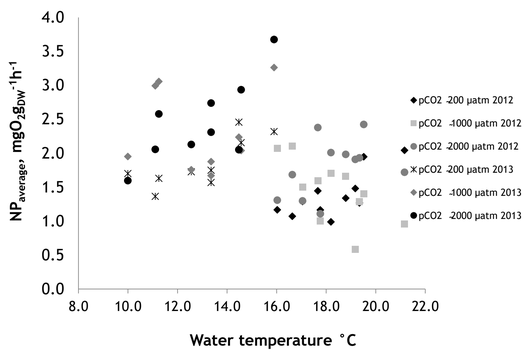
The elevated $p(CO_2)$ levels may enhance the photosynthetic rate of *Furcellaria lumbricalis*.

Ulva intestinalis, Furcellaria lumbricalis* and *Fucus vesiculosus



The elevated $p(CO_2)$ levels may enhanced the photosynthesis of macroalgae *Ulva intestinalis* and *Furcellaria lumbricalis*, but *Fucus vesiculosus* showed no response to elevated $p(CO_2)$.

The favorable effect of elevated $p(CO)_2$ on the photosynthesis of *Furcellaria lumbricalis* was more pronounced at lower water temperatures



CONCLUSIONS

- The elevated water $p(CO_2)$ can be expected to increase photosynthetic rates of macroalgae in the north-eastern Baltic Sea. However, the magnitude of this effect, will be affected by different environmental factors, mainly by water temperature.
- This effect had species-specific response and thus may cause shifts in the species composition of macrophyte communities.
- The elevated $p(CO_2)$ is not favourable for seagrass *Zostera marina*.
- In the shallow coastal Baltic Sea, macrophytes are adapted to living in a highly variable environment and thus may tolerate the effects of future changes in pH.

ACKNOWLEDGEMENT

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