Climate Change – Good News For Toxic Filamentous Cyanobacteria?

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Aim

To test the business as usual (A1FI) scenario predicted for the Baltic Sea area in the year 2100, on summer- and spring-bloom phytoplankton communities.

Introduction

Climatic change is a potential threat to all ecosystems. For the Baltic Sea area, precipitation[(1)], temperature and atmospheric CO_2 levels[(2)] are expected to increase. Salinity may therefore decrease from current 6 to 3, water temperature during spring may increase from 1°C to 5°C and CO_2 levels increase from current 380 ppm to 960 ppm by year 2100. Every summer filamentous cyanobacteria (*Nodularia spumigena*, *Aphanizomenon* sp. and *Dolichospermum* sp.) form huge toxic blooms in the Baltic Sea (Fig 1).

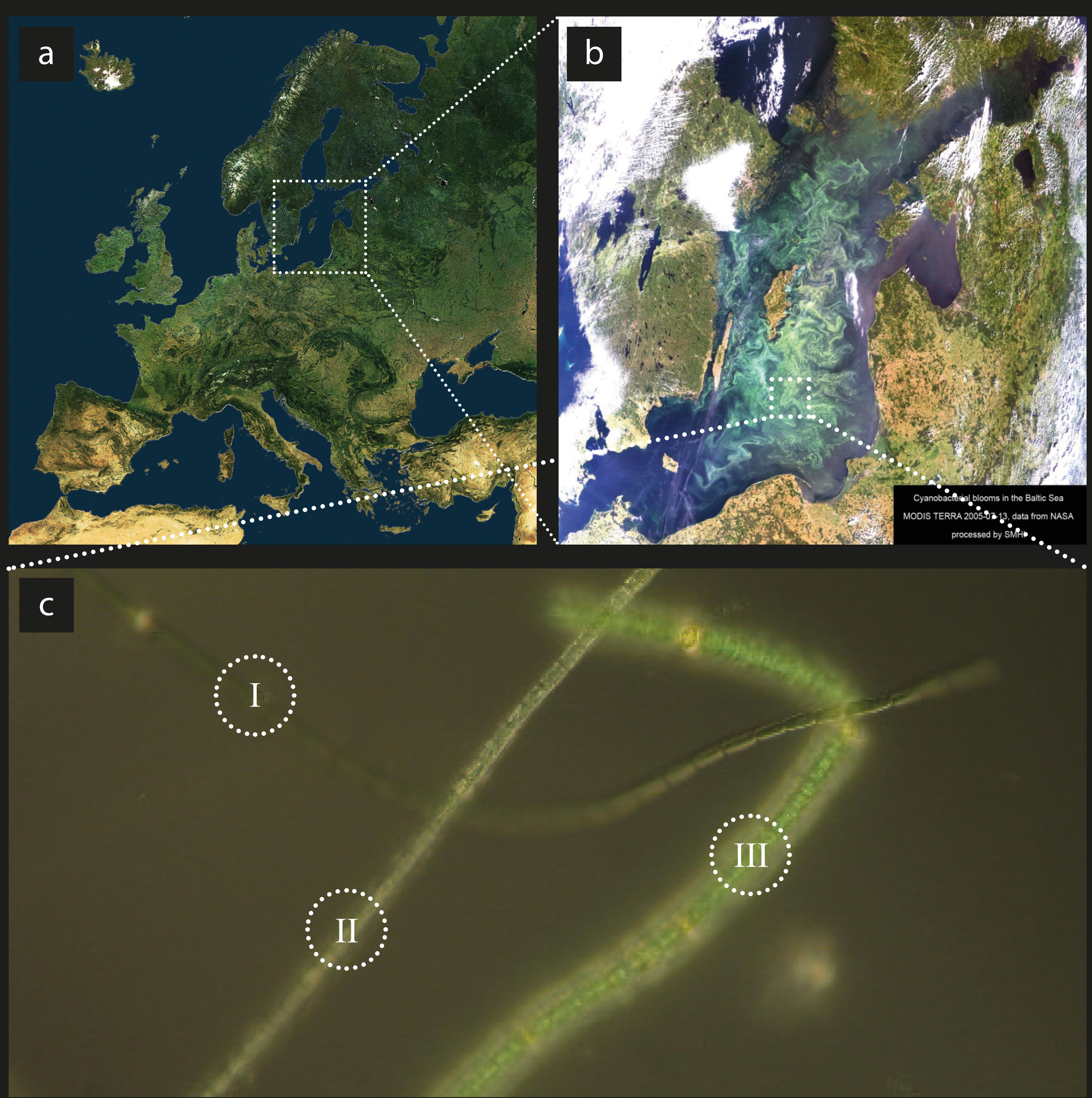

Fig. 1 (a) Map of Europe, (b) cyanobacterial summer-blooms in the Baltic Sea and (c) the cyanobacteria species (I) *Dolichospermum* sp., (II) *Aphanizomenon* sp. and (III) *N. spumigena*.

Method

Expt A: interactive effects of elevated CO_2 and decreased salinity on a natural summer-bloom phytoplankton community (Tab 1, Fig 3).

Expt B: interactive effects of elevated CO_2 and increased temperature on a natural spring-bloom phytoplankton community, dominated by diatoms but with inoculated cyanobacteria (Tab 2, Fig 3).

Table 1. Expt A setup.

Salinity	6	6	3	3
CO2 (ppm)	380	960	380	960
Label	S+ C-	S+ C+	S- C-	S- C+

Table 2. Expt B setup.

Temperature	1	1	5	5
CO2 (ppm)	380	960	380	960
Label	T- C-	T- C+	T+ C-	T+ C+

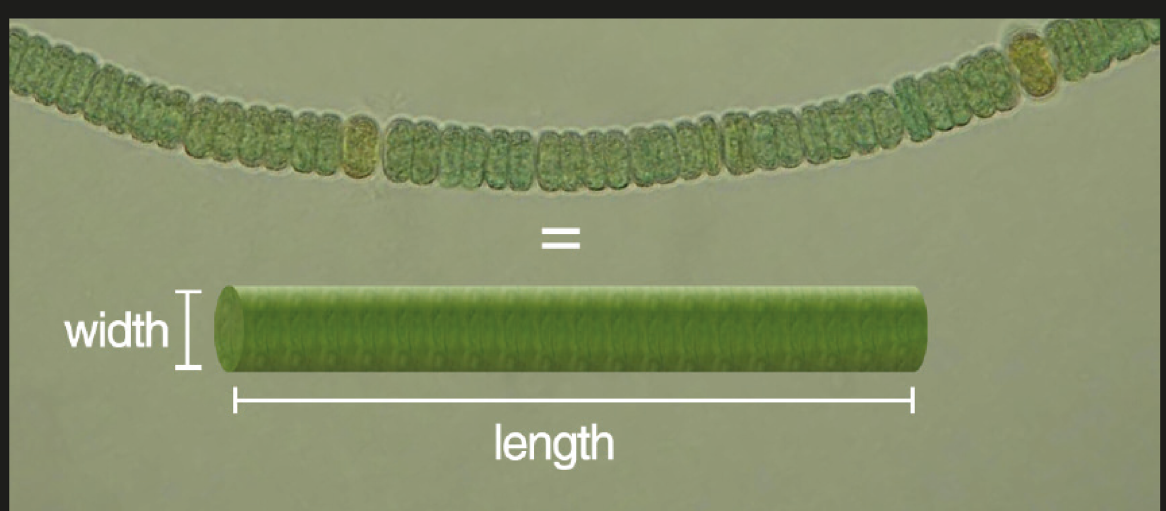

Fig. 2 Calculating biovolume by considering each filament as a cylinder. Biovolume = $\pi/4 \times \text{width}^2 \times \text{length}$

Fig. 3 Experimental setup with 4 litre aquaria, sealed with lids to create headspace and bubbled with synthetic air containing either 380 ppm CO_2 or 960 ppm. Green mesh covers to reach PAR values similar to a depth of ~5m.

Conclusion

Future summer-blooms of cyanobacteria may start earlier in the summer, but not as early as during the spring-bloom, and last longer into the autumn. The blooms may also cover larger areas and extend more north into the less saline northern part of the Baltic Sea.

Presently, only *N. spumigena* produces toxin, but fresh water strains of both *Aphanizomenon* sp. and *Dolichospermum* sp. are toxin producers. If the water becomes less saline, these toxic strains may be able to invade the Baltic Sea. Increased atmospheric CO_2 levels may be further advantageous for *Dolichospermum* sp.

Result Expt A

Aphanizomenon sp. was initially dominating the cyanobacterial community, but after 12 days a shift to *Dolichospermum* sp. had occurred (Fig 4) with highest biovolume in the A1FI treatment (S- C+).

N. spumigena, dinoflagellates, pennate and centric diatoms had significantly higher biovolume in present day salinity of 6 (S+) (Fig 4 and 5). CO_2 had only an effect on *Dolichospermum* sp. with increased biovolume.

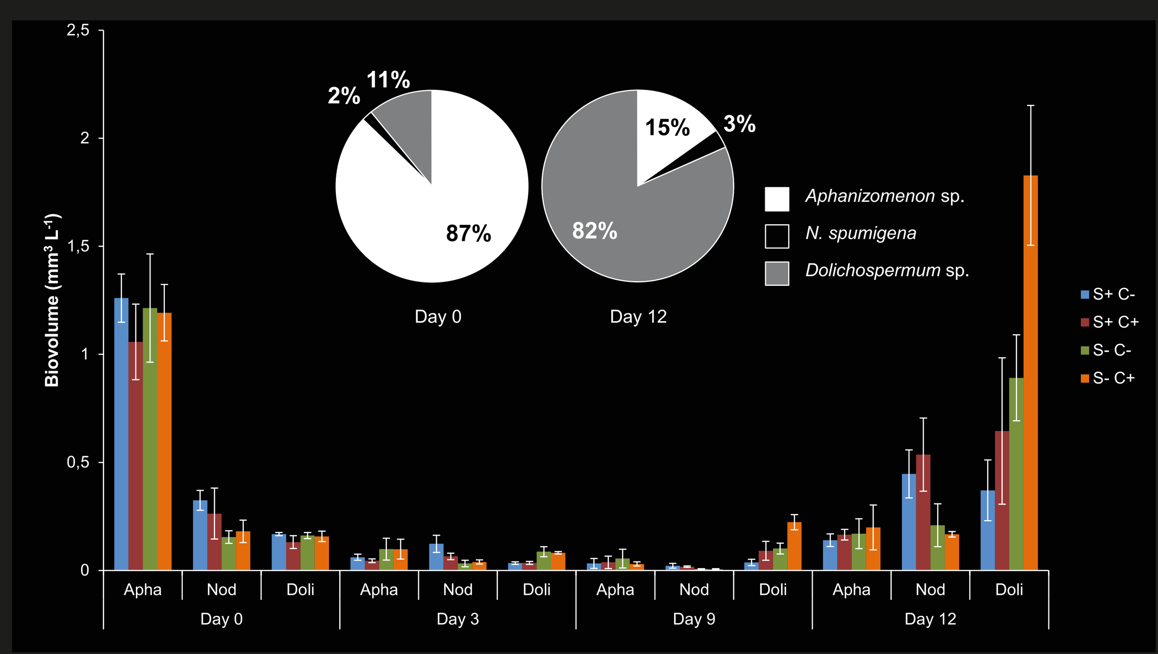

Fig. 4 Cyanobacterial biovolume during Expt A and percental distribution on Day 0 and Day 12. Salinity treatments are S+ (salinity 7) and S- (salinity 4) and CO_2 treatments are C+ (960 ppm) and C- (380 ppm). Error bars show standard error (n=4)

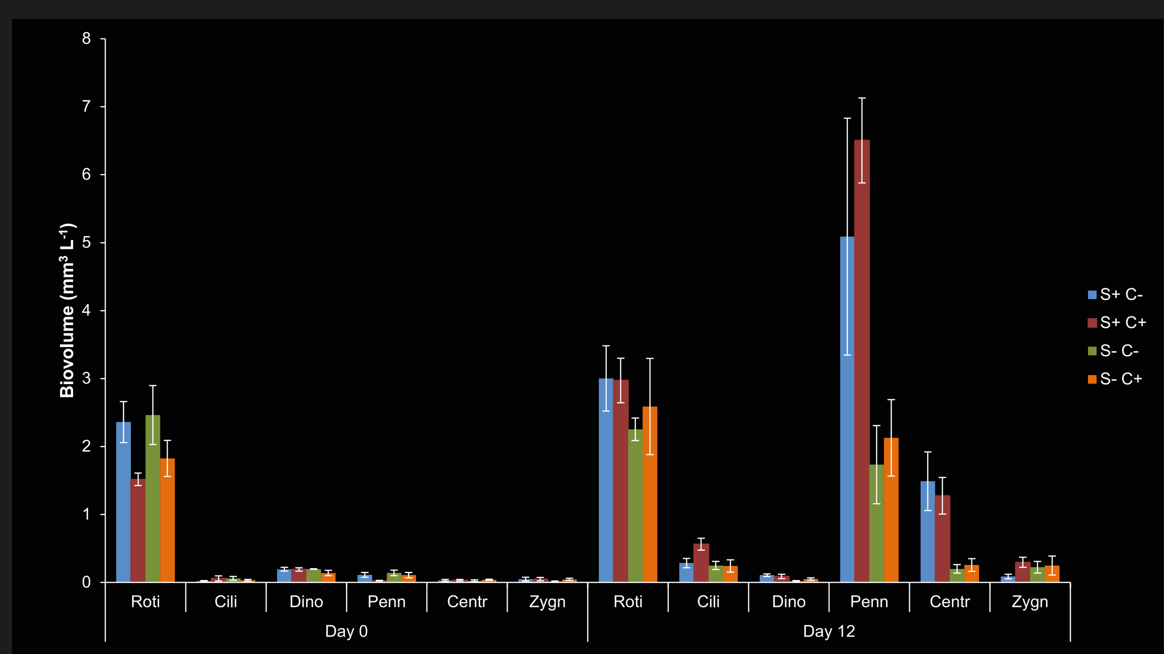

Fig. 5 Biovolume of other phytoplankton groups during Expt A on Day 0 and Day 12. Salinity treatments are S+ (salinity 7) and S- (salinity 4) and CO_2 treatments are C+ (960 ppm) and C- (380 ppm). Error bars show standard error (n=4)

Result Expt B

Among the cyanobacterial species, only *N. spumigena* was able to survive the experiment, but there was no effect of temperature or CO_2 on any cyanobacterial species (Fig 6) or other phytoplankton groups (Fig 7).

Previous laboratory experiments have shown an increase of cyanobacterial biovolume while increasing water temperature during summer (data not shown)[(3)].

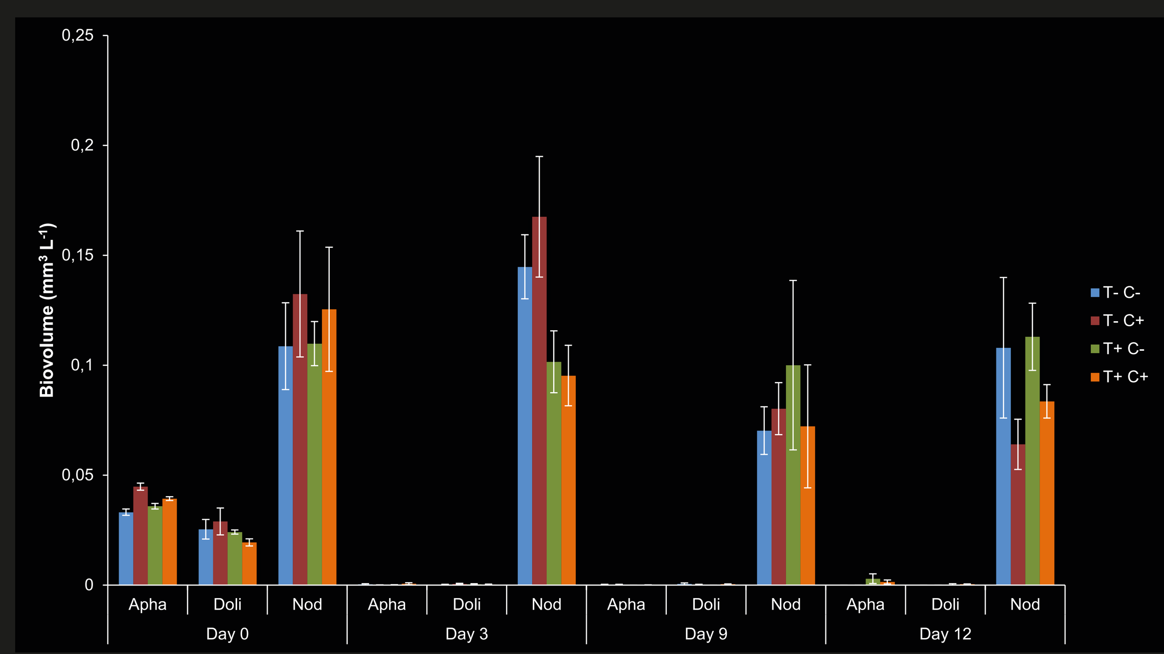

Fig. 6 Cyanobacterial biovolume during Expt B. Temperature treatments are T+ (5°C) and T- (1°C) and CO_2 treatments are C+ (960 ppm) and C- (380 ppm). Error bars show standard error (n=3)

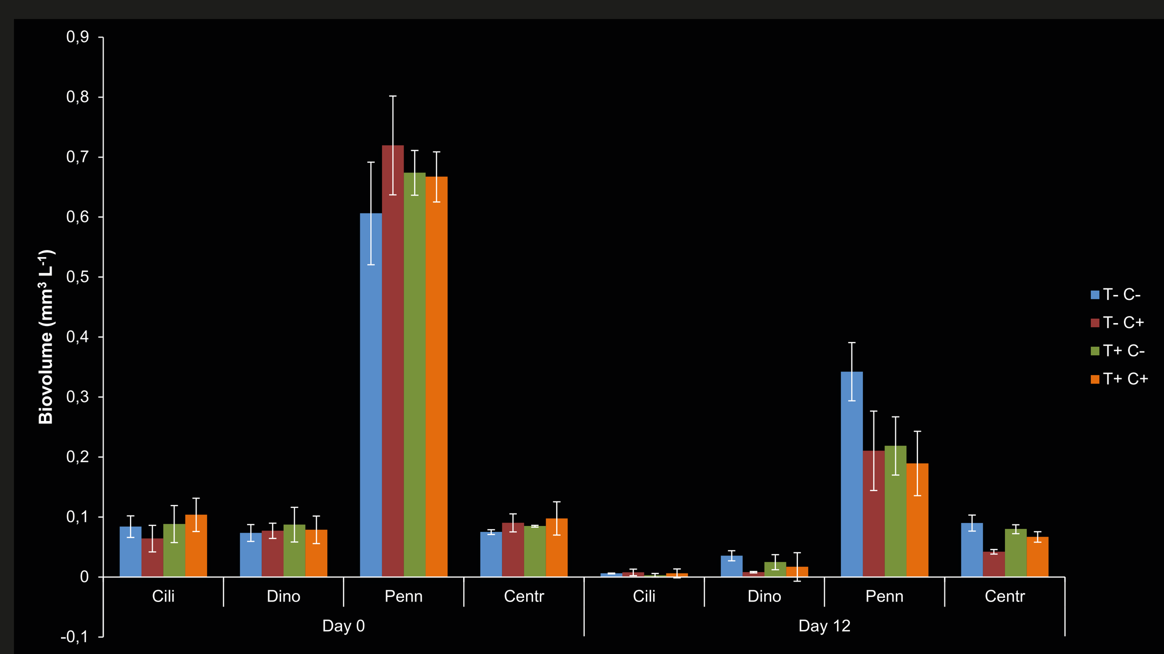

Fig. 7 Biovolume of other phytoplankton groups during Expt B on Day 0 and Day 12. Temperature treatments are T+ (5°C) and T- (1°C)and CO_2 treatments are C+ (960 ppm) and C- (380 ppm). Error bars show standard error (n=3)

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Poster Article Webpage

References

[1] HELCOM. 2007. Climate change in the Baltic Sea area – HELCOM Thematic Assessment 2007. Baltic Sea Environment Proceedings No. 111

[2] Meehl G et al. 2007. Climate Change 2007: The Physical Science Basis. Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

[3] Karlberg M, Wulff A 2013 Impact of temperature and species interaction on filamentous cyanobacteria may be more important than salinity and increased pCO_2 levels. Mar. Biol. (160) DOI:10.1007/s00227-012-2078-3.

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