Effects of increased pCO_2 on phytoplankton community compositions in the NW subarctic Pacific and Bering Sea in summer

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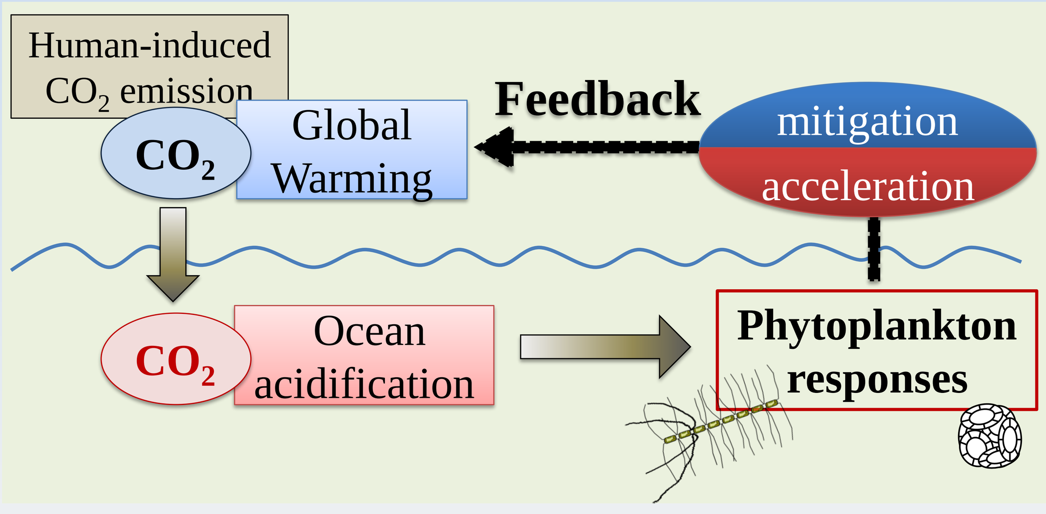
1. Introduction

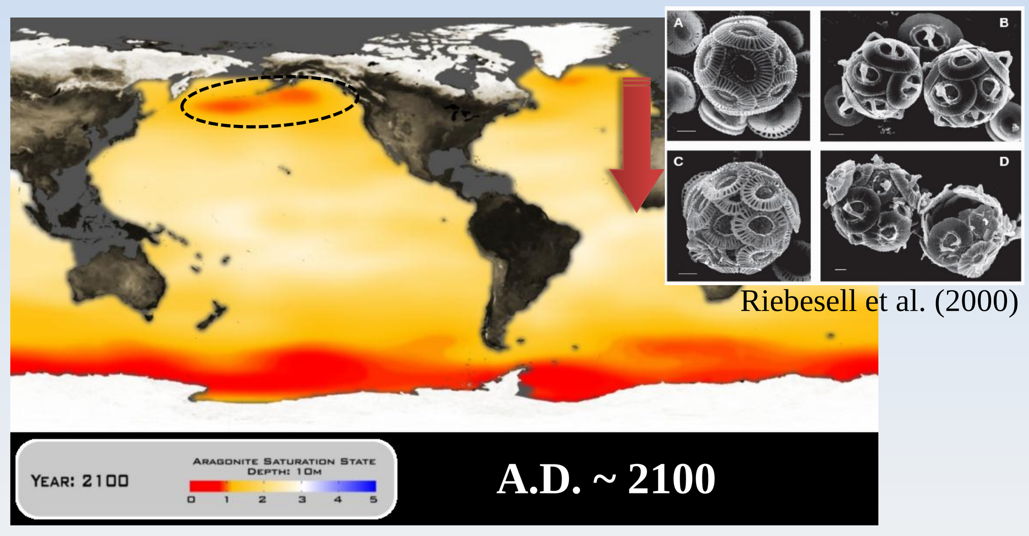
- Rising atmospheric CO_2 concentration have led to decrease in pH (i.e. **ocean acidification**, Caldeira and Wickett, 2003).
- Since marine phytoplankton play an important role on CO_2 fixation through photosynthesis, **they have feedback effects on climate change** (Cermeno et al., 2008).
- However, effects of ocean acidification on phytoplankton community compositions are still largely unknown.
- Hence, quantitative estimations of ocean acidification would allow us to **predict future climate change** precisely.
- We examined the effects of projected changes in CO_2 on phytoplankton community compositions in the NW subarctic Pacific and Bering Sea.

✓ Marine phytoplankton could change the magnitude of climate change.



• Interactions between ocean acidification and phytoplankton.

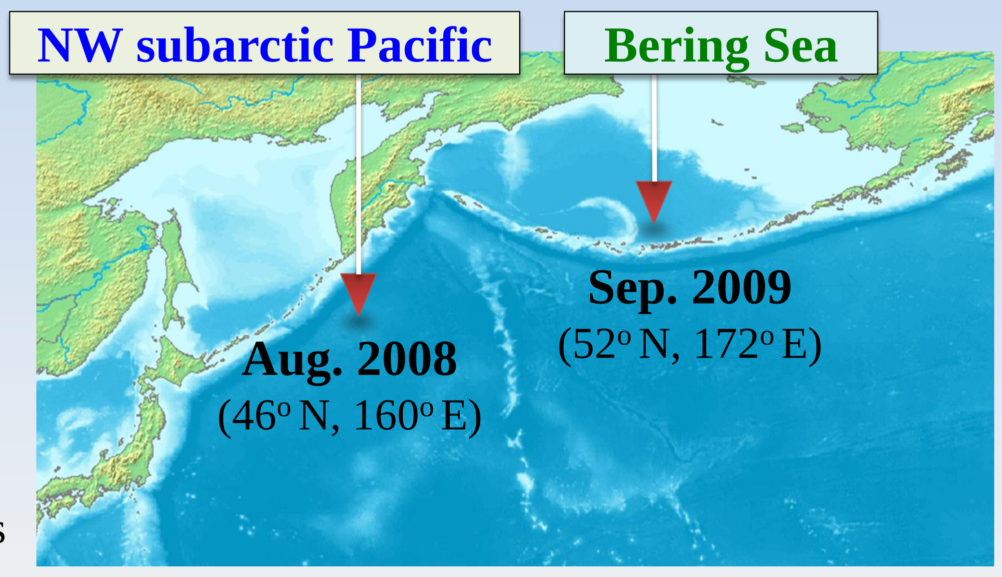
✓ Decrease in pH will affect $CaCO_3$ biogeochemistry such as calcification processes.



•Predicted saturation state of aragonite (Orr et al., 2005).

2. Methods

1. Water samples were collected from ~10 m depth and filtered through 197 μm Teflon net to remove large plankton.
2. Subsamples were poured into acid-cleaned 12 L polycarbonate bottles for incubation.
3. Prior to incubation, a $FeCl_3$ solution was added into the several bottles (5 nM in final conc.) in order to reduce the growth limitation of phytoplankton.
4. In the laboratory, phytoplankton pigment concentrations and algal community structure were estimated using HPLC pigment analysis with the program CHEMTAX (Mackey et al., 1996), respectively.



• Sampling sites of seawater for incubation.

• Incubation periods were 11 days in 2008 and 6days in 2009.

CO_2 concentration
- 180 ppm (Past)
- 380 ppm (Present)
- 750/600 ppm (~2100)
- 1,000 ppm (~2150)

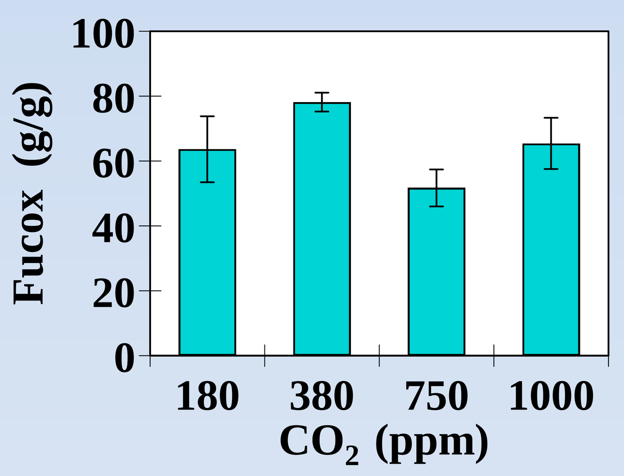
• On-deck bottle incubations under different CO_2 (ppm) levels.

3. Results and discussion

• All figures show the data sampled at the end of incubation (i.e. day 11 in 2008 and day 6 in 2009) and error bars denote ±1SD.

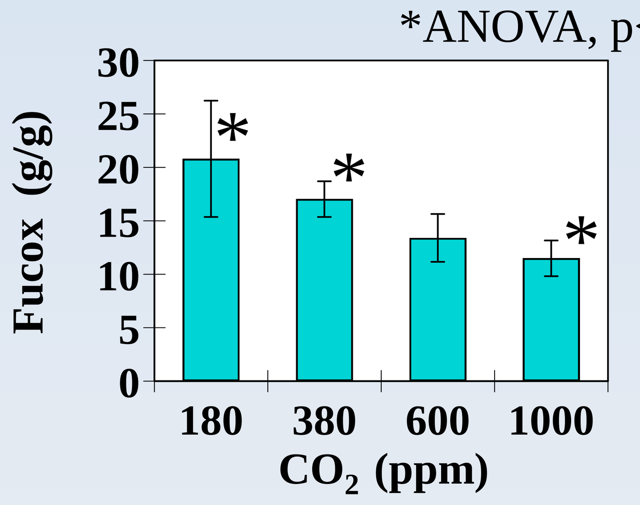
Diatoms

NW subarctic Pacific (2008)



Bering Sea (2009)

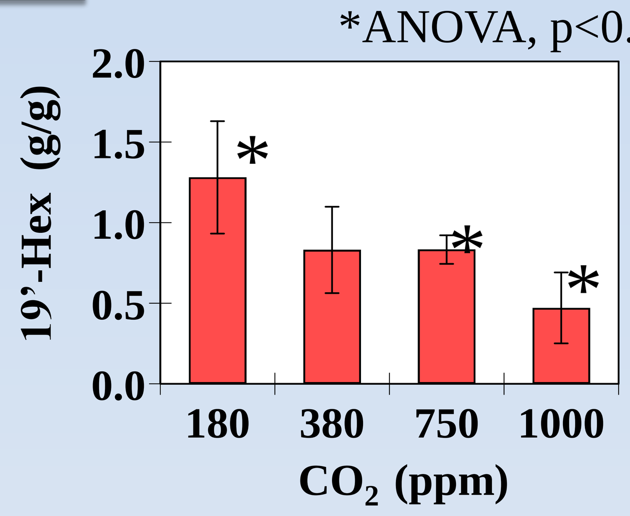
*ANOVA, $p<0.05$



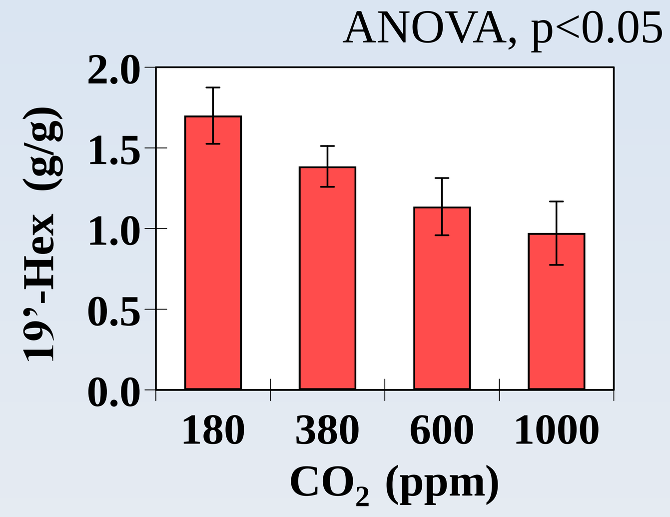
- No significant trends in the levels of fucoxanthin (Fucox) , a diatom marker, were observed in the NW subarctic Pacific, but significant decrease in the Bering Sea.
- What kind of factor down-regulate the diatoms' biomass?

Haptophytes

*ANOVA, $p<0.05$

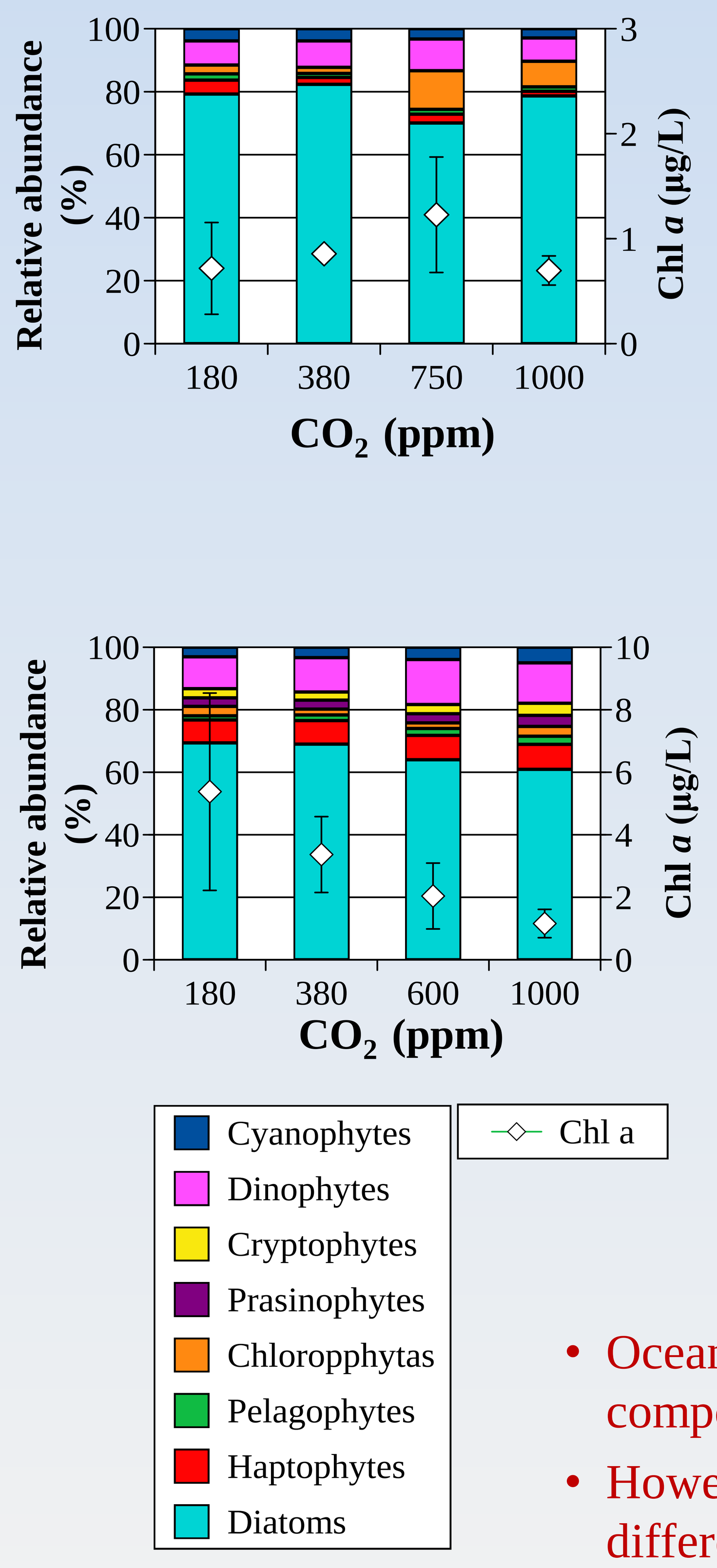


ANOVA, $p<0.05$



- Significant decreases in the level of 19'-hexanoyloxyfucoxanthin (19'-Hex), a haptophyte marker, were observed with increasing CO_2 in both experiments.
- Decrease in coccolithophores' abundance in high CO_2 bottles were also observed by microscopy.

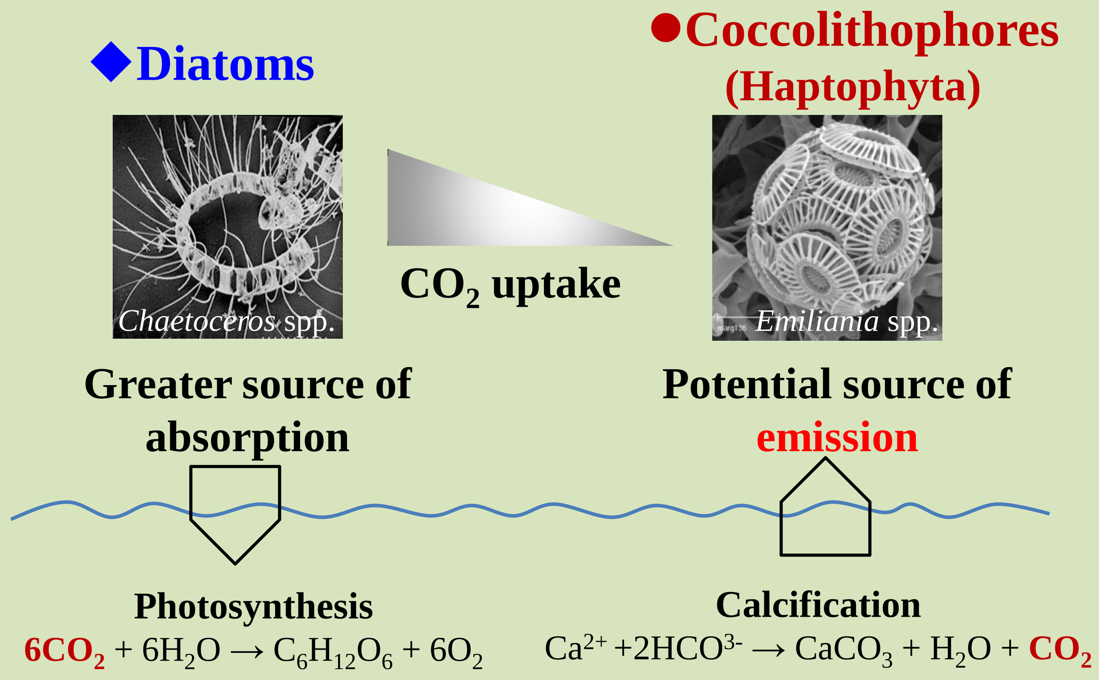
Relative abundance



• Changes in relative phytoplankton abundance with the increment of CO_2 concentrations (180 ppm →1000 ppm).

	Diatoms	Haptophytes	Others
NW subarctic Pacific	—	− 55 %	+ 25 %
Bering Sea	− 12 %	+ 46 %	+ 27 %

• **Ability of CO_2 uptake by the ocean depends on the dominant group of phytoplankton.**

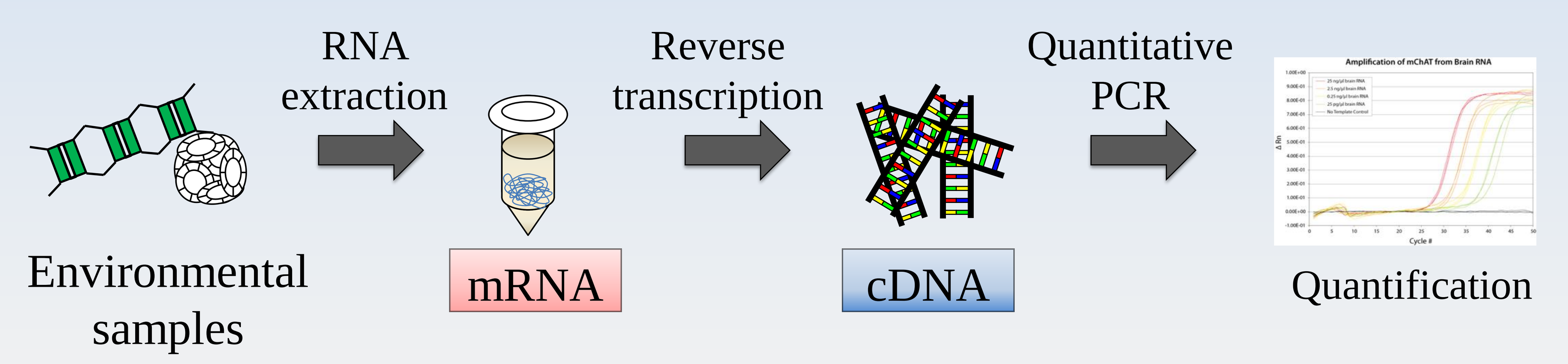


- Ocean acidification may alter the phytoplankton community compositions in both areas.
- However, the magnitude and directions of CO_2 effects differed between the study sites.

4. Future challenge

- To clarify the physiological responses of phytoplankton to CO_2, the expression of *rbcL* gene, which encodes the large subunit of RubisCO playing a major role in CO_2 fixation, will be examined in both laboratory and field experiments.

◆Quantitative RT-PCR



5. Conclusions

- Concentrations of 19'-Hex decreased along with increasing CO_2 in both study sites, suggesting the decrease in haptophytes including coccolithophores.
- In the Bering Sea, significant decreases in fucoxanthin concentration along with increasing in CO_2, and that was possibly due to a decrease in diatom biomass.
- Our results shows that ocean acidification might have a significant impact on phytoplankton community compositions, resulting in changes of CO_2 absorption ability in the study area.
- The responses of phytoplankton to the ocean acidification would differ among sea areas. Therefore, more detailed field studies including physiological researches on phytoplankton would be required.

References

Caldeira and Wickett, 2003, *Nature*, 425, 365; Cermeno et al., 2008, *Proceeding of the National Academy of Science*, 105, 20344-20349; Riebesell et al., 2000, *Nature*, 407, 634-637; Orr et al., 2005, *Nature*, 437, 681-686; Mackey et al., 1996, *Mar. Ecol. Prog. Ser.*, 144, 265-283.