Effects of high-CO_2 and temperature on the dynamics of plankton communities in the subarctic Pacific

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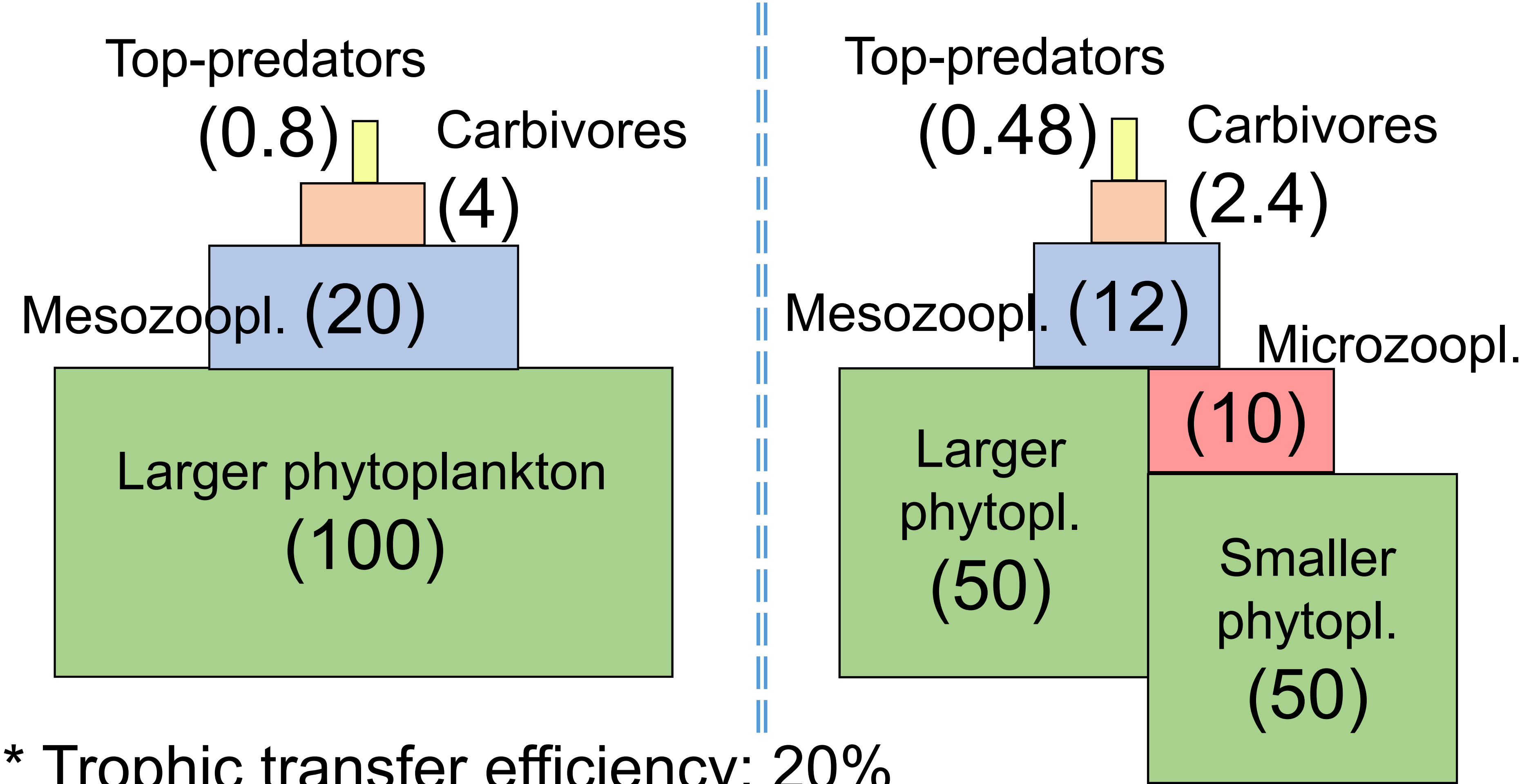
INTRODUCTION

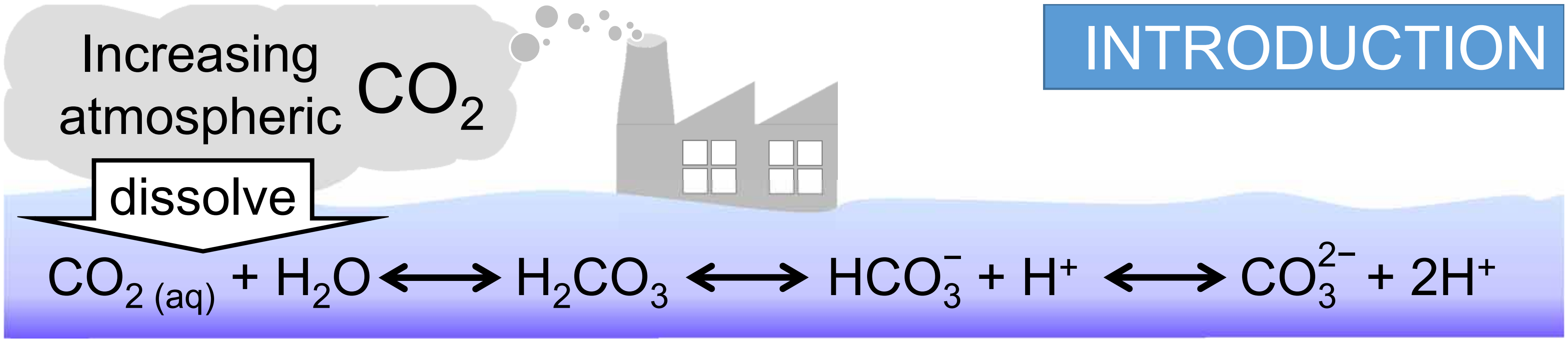
S9: Resilience, Transitions and Adaptation in Marine Ecosystems under a Changing Climate

Why phytoplankton community structure?

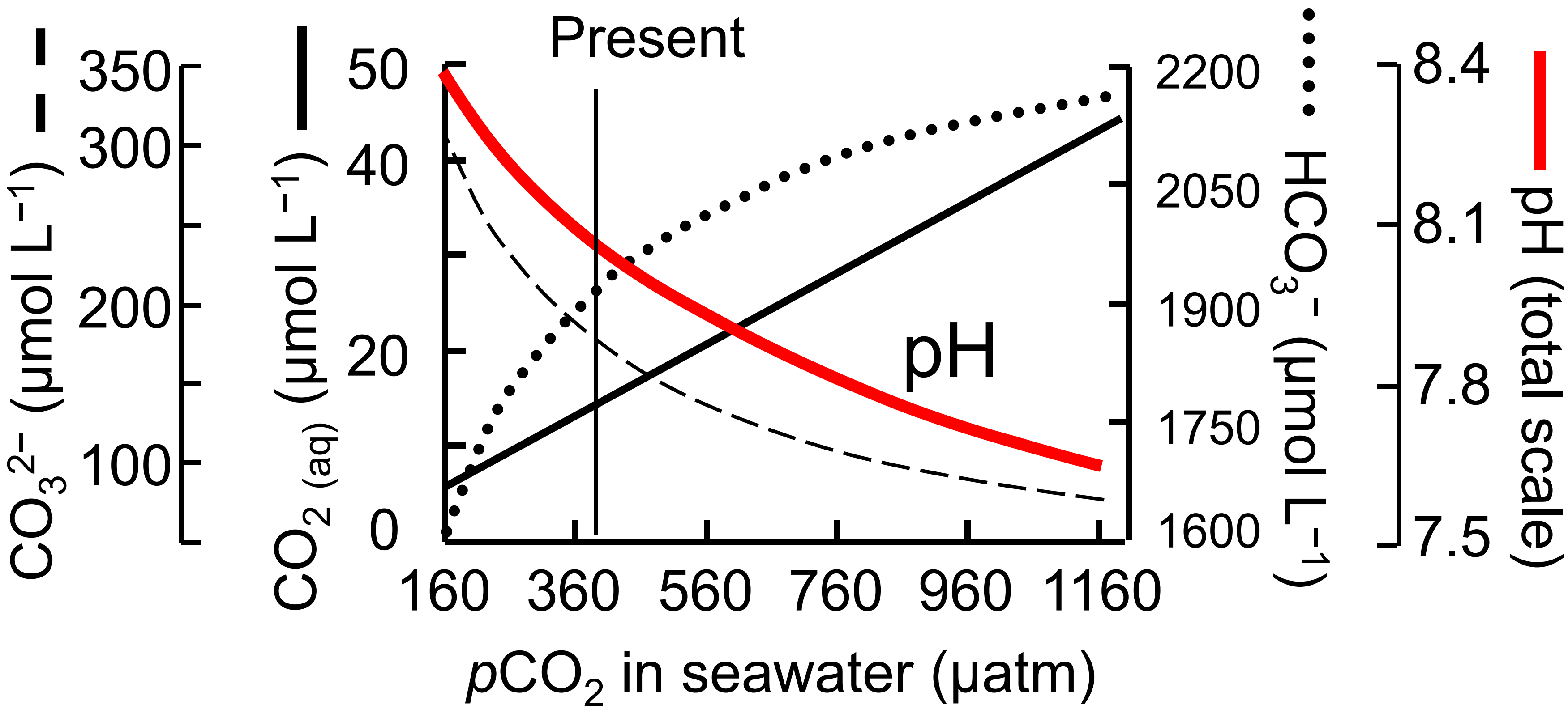


* Trophic transfer efficiency: 20%

INTRODUCTION

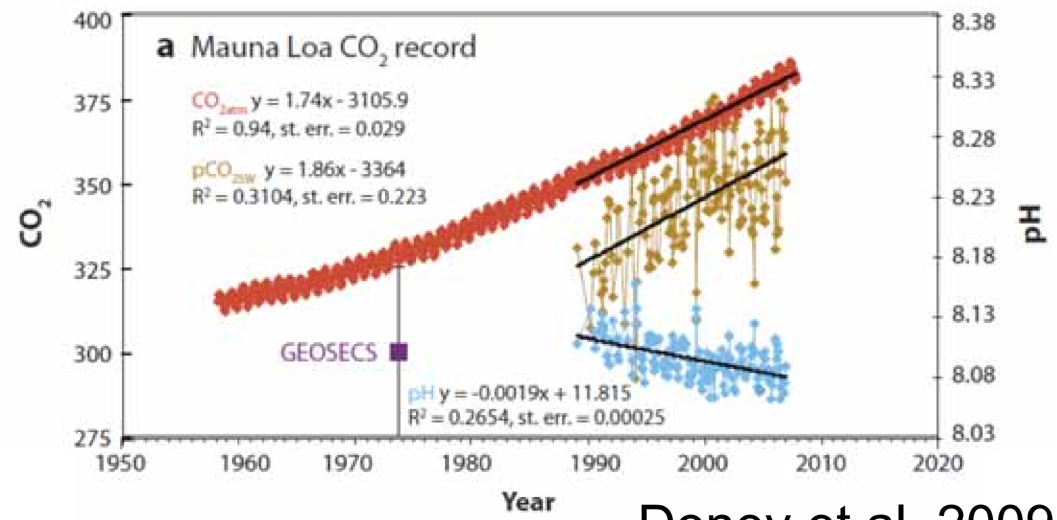


Change in pH as a result of increasing pCO_2

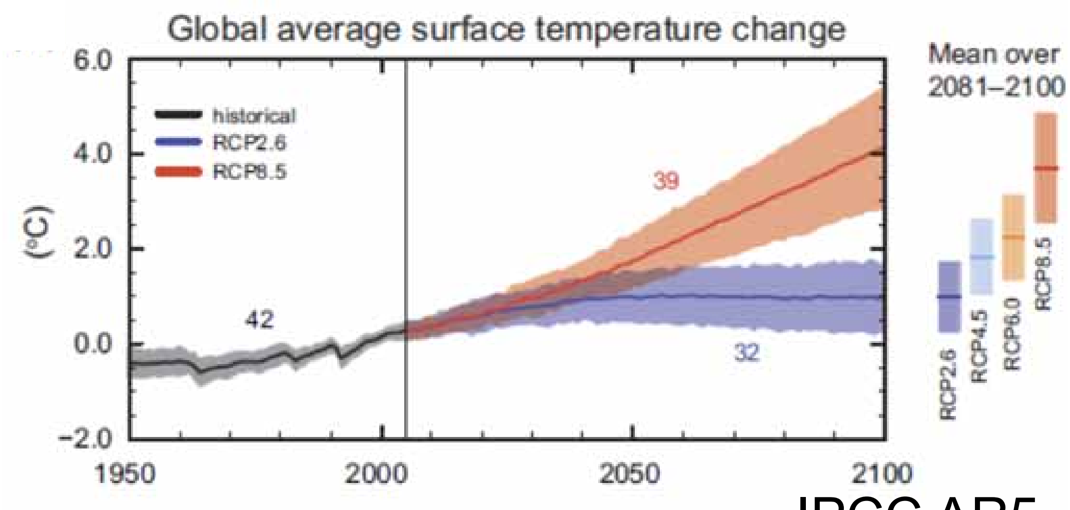


INTRODUCTION

- $x\mathrm{CO}_{2atm}$ & $p\mathrm{CO}_{2SW}$ are increasing simultaneously
- pH is decreasing with an increase in $p\mathrm{CO}_{2SW}$
- Global mean temperature could rise up to 2–4°C
- High latitude ocean might severer compared to the global mean
  (e.g., Johannessen et al. 2004)



Doney et al. 2009



IPCC AR5

High CO_2 & temp. can disturb lower trophic levels

INTRODUCTION

Previous manipul … e individual effect of CO_2 or tempera…

● High CO_2 tests…

Chain-forming … 2008)

Change in eler… d and particulate matters (Sugie e…

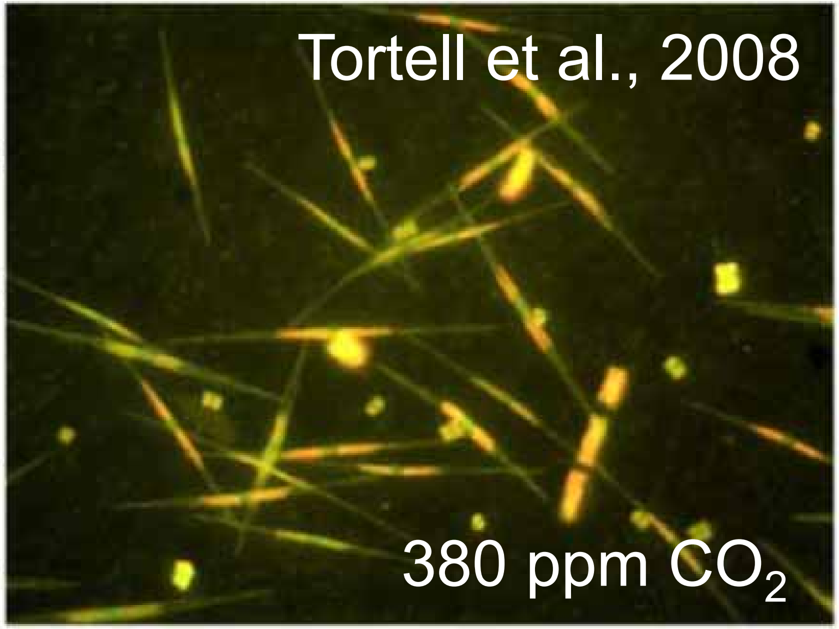
Decreasing CC… ıdo et al. 2016)

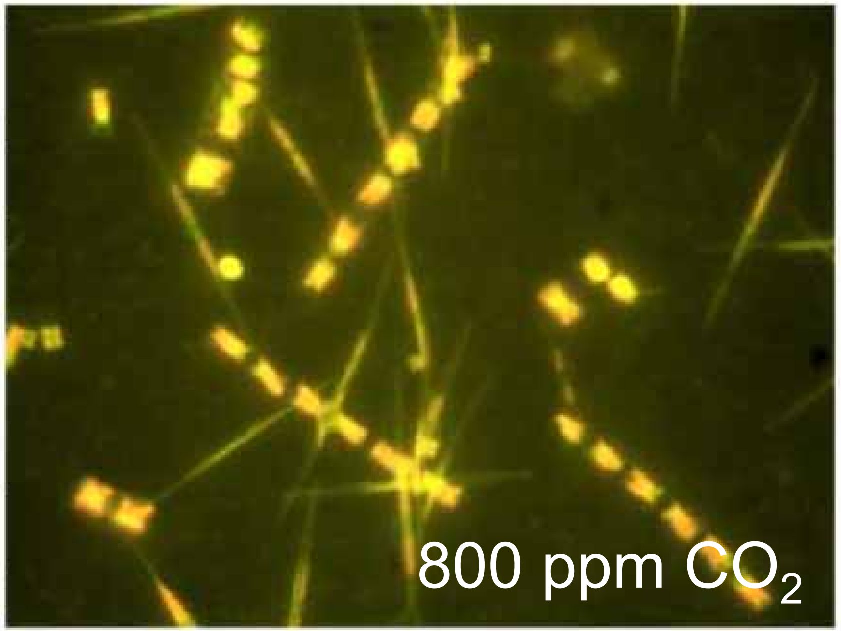
● High temperatu…

Increased resp… olding et al., 2013)

Increased sma… 2005)

However, very lim… cerning the effects of high CC… phytoplankton





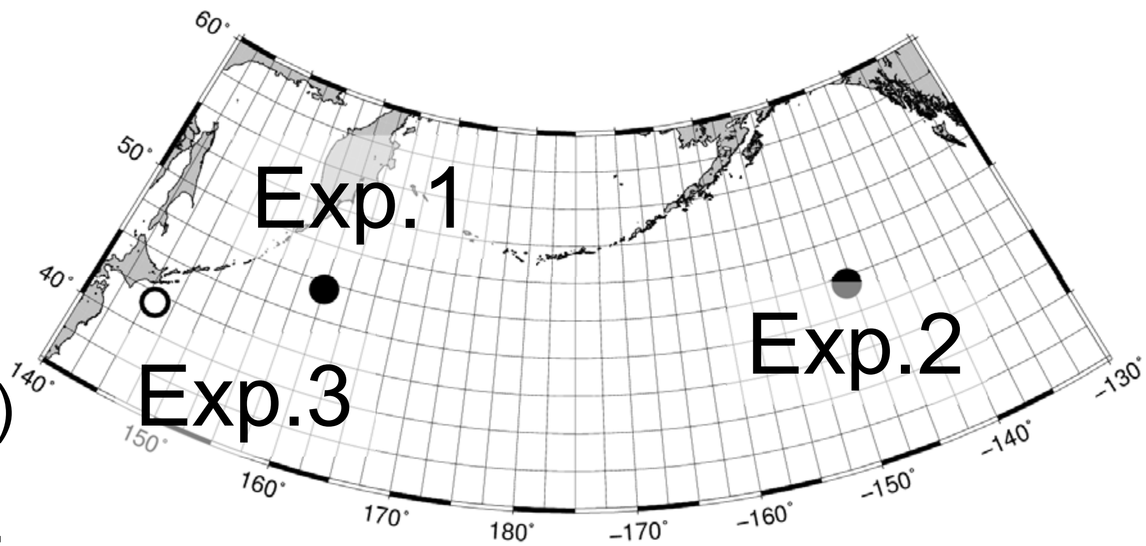
METHODS

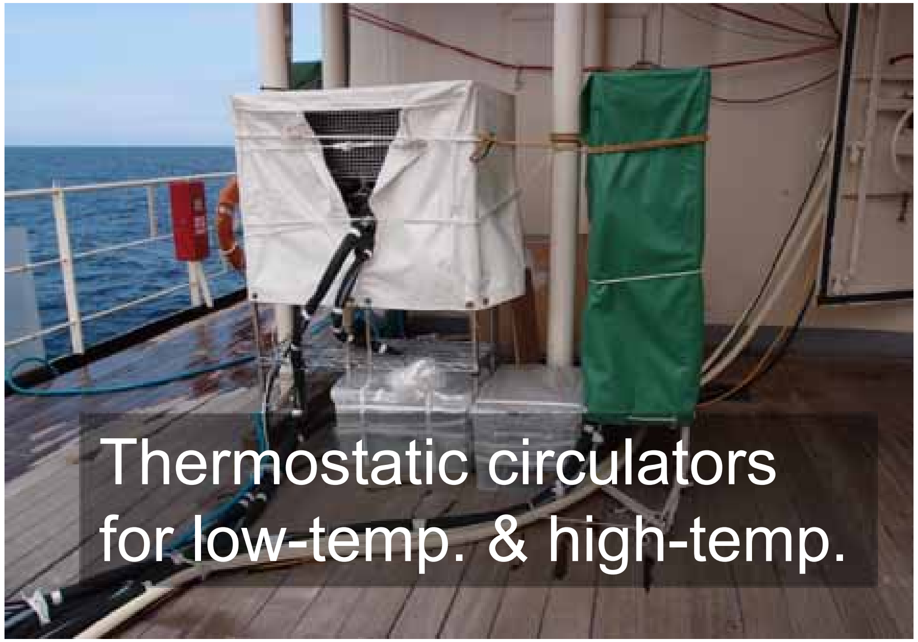
Sampling locations

Exp. 1: 47°N, 160°E
(July 27, 2014)

Exp. 2: 47°N, 148°W
(August 15, 2014)

Exp. 3: 41.9°N, 146°E
(March 9, 2015)





METHODS

Temperature

Exp. 1: 11 & 15°C

Exp. 2: 14 & 18°C

Exp. 3: 2 & 6°C

Treatment

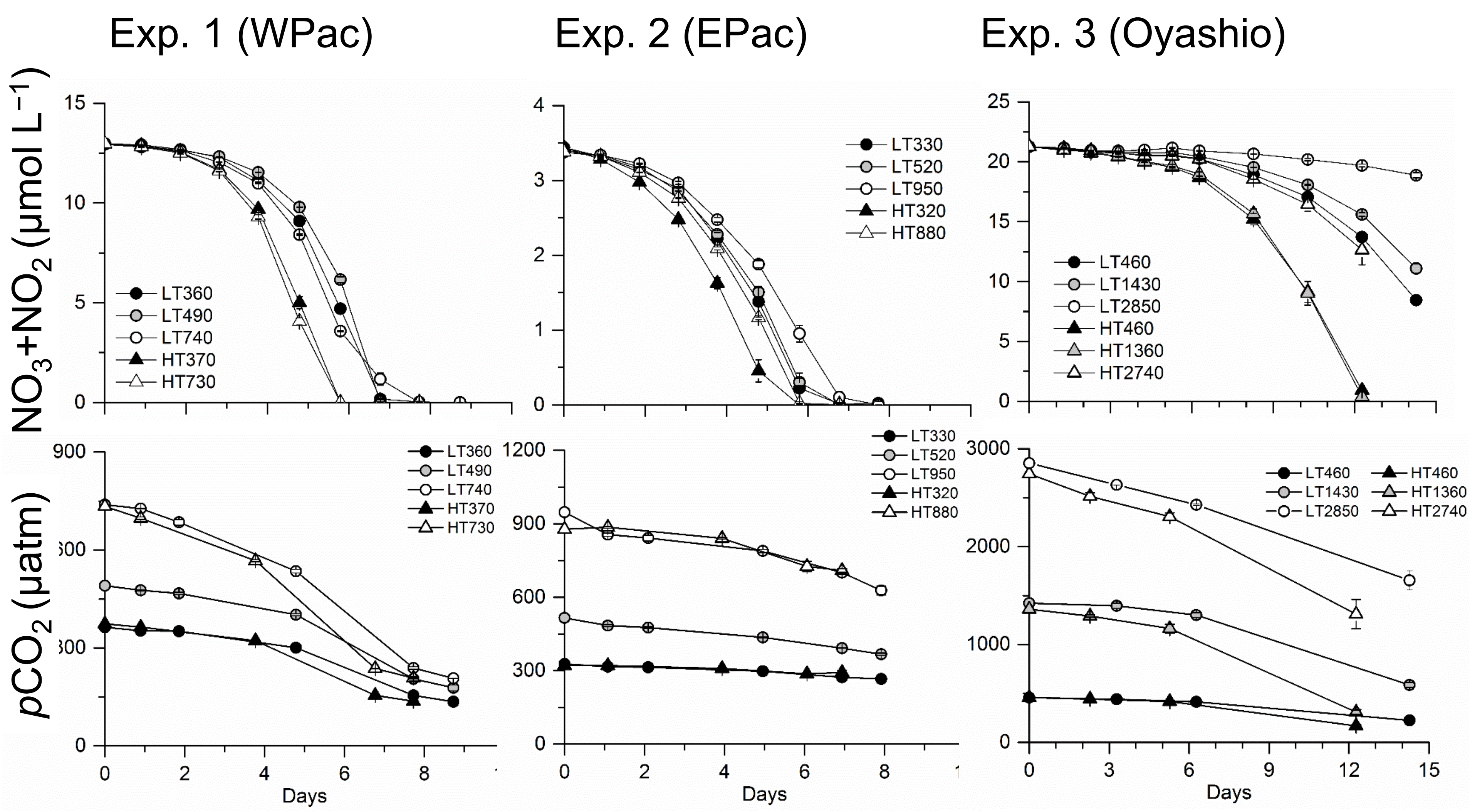
LT-control	HT-control
LT-CO_2-1	HT-CO_2-1
LT-CO_2-2	HT-CO_2-2

Added Fe in all exp. to mask any uncertainty concerning Fe bioavailability (Shi et al. 2010; Sugie et al. 2013)

Measurement items

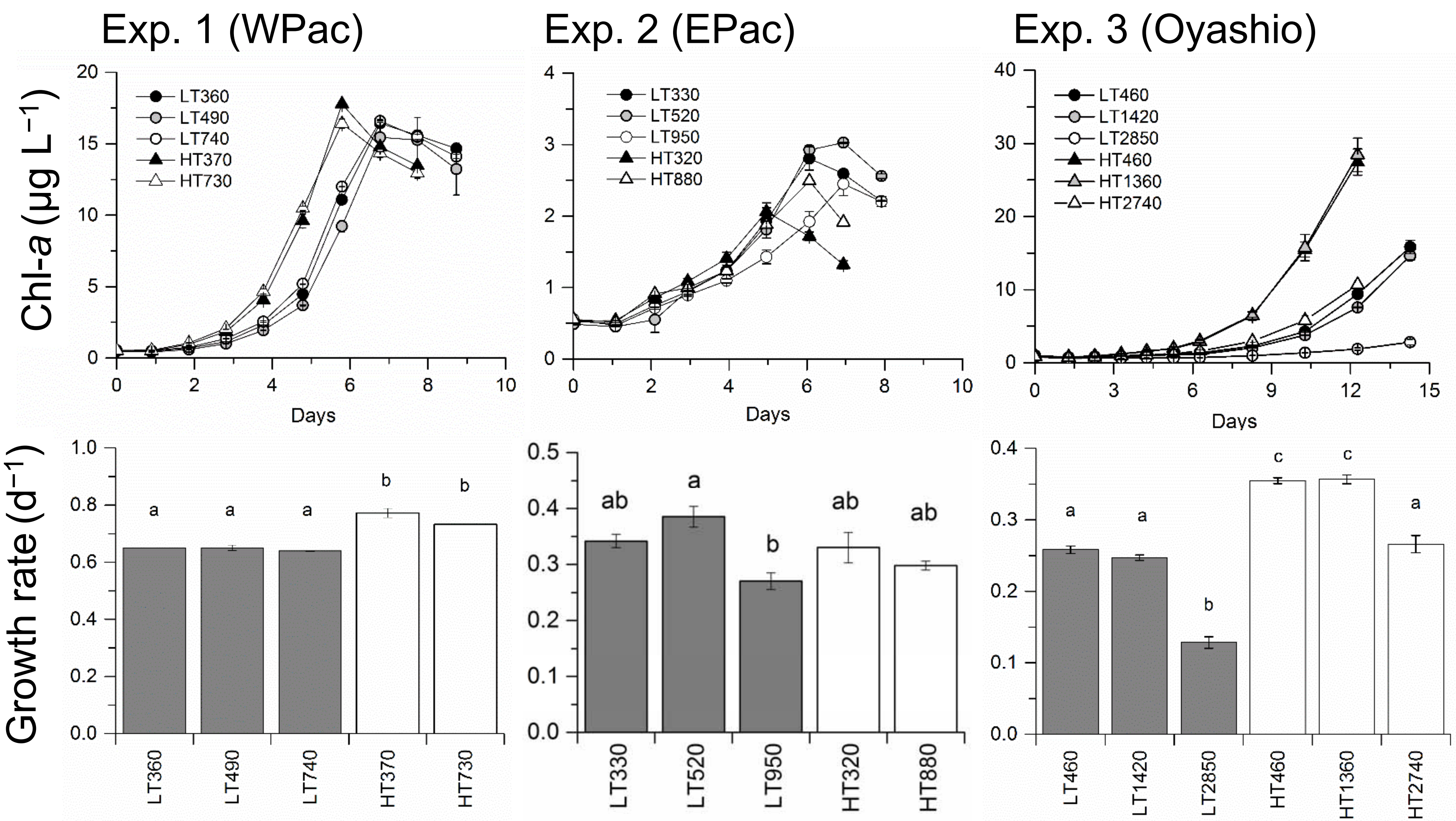
Temperature, PAR, DIC, TA, Nutrients, Chl-*a*, Pico-, nano- and micro-sized phytoplankton

RESULTS



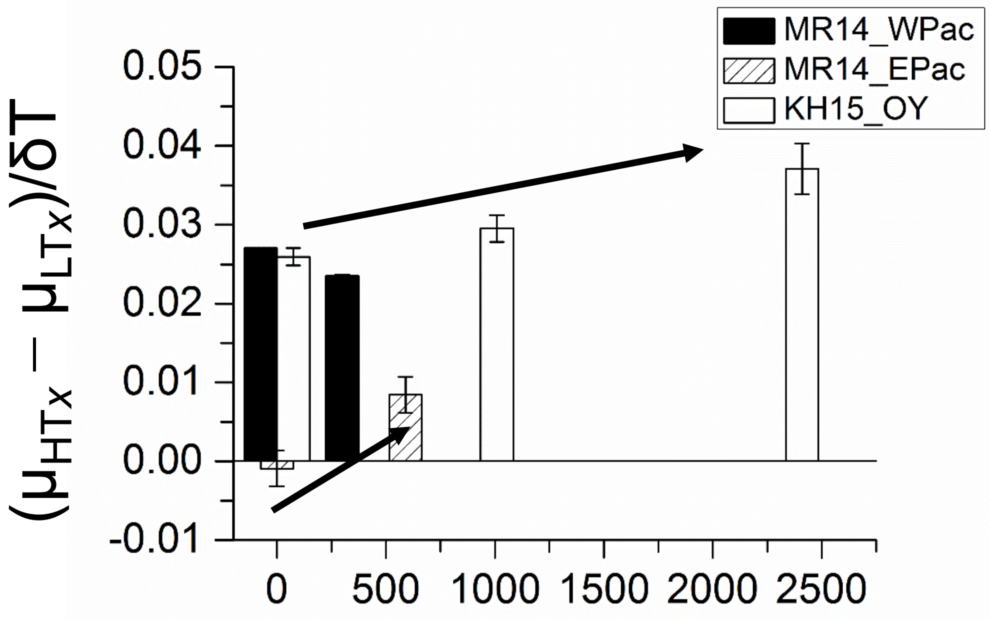
- NO_3+NO_2 often depleted and $p$$CO_2$ decreased
- Data analyzed were before collapsing $p$$CO_2$ gradients

RESULTS



- Higher temperature enhanced specific growth rate
- pCO_2 did not affect or decreased in higher levels

RESULTS & DISCUSSION

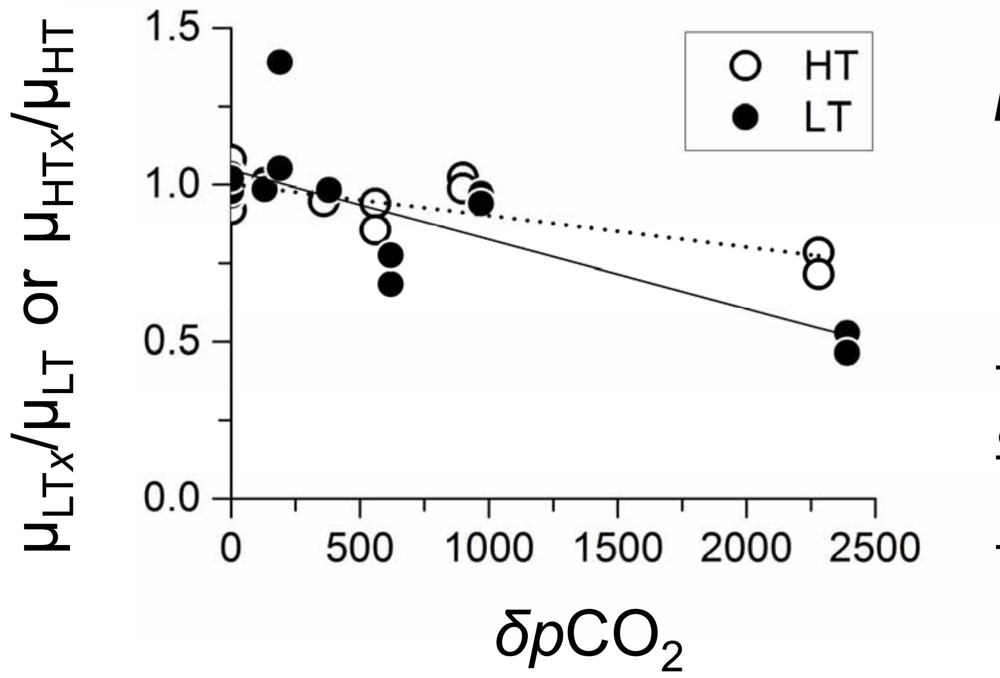


Temperature sensitivity

$(\mu_{HTx} - \mu_{LTx})/\delta T$

(Montagnes et al. 2003)

<u>Temperature sensitivity increased with *p*CO_2</u>

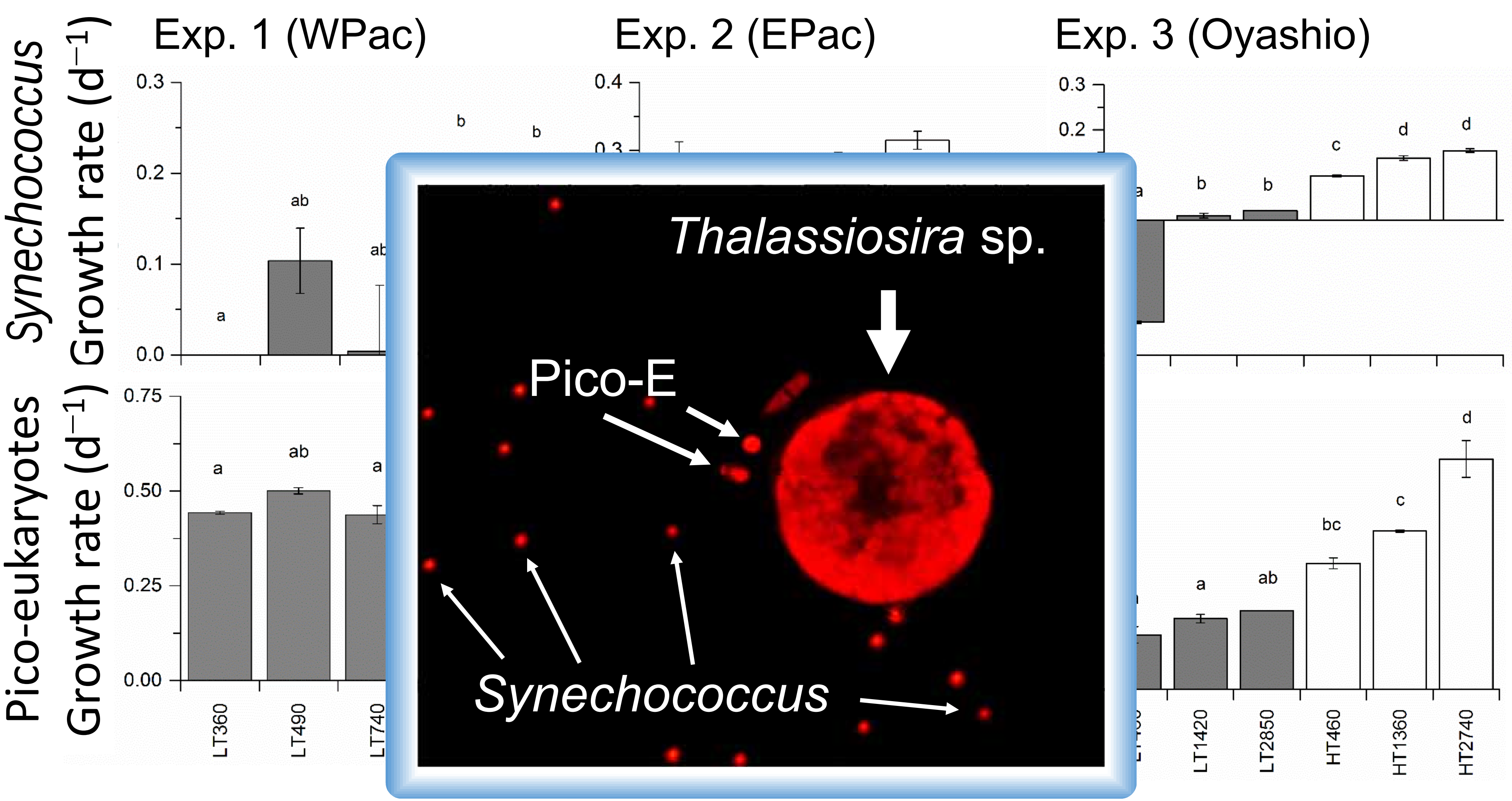


***p*CO_2 sensitivity**

μ_{LTx}/μ_{LT} or μ_{HTx}/μ_{HT}

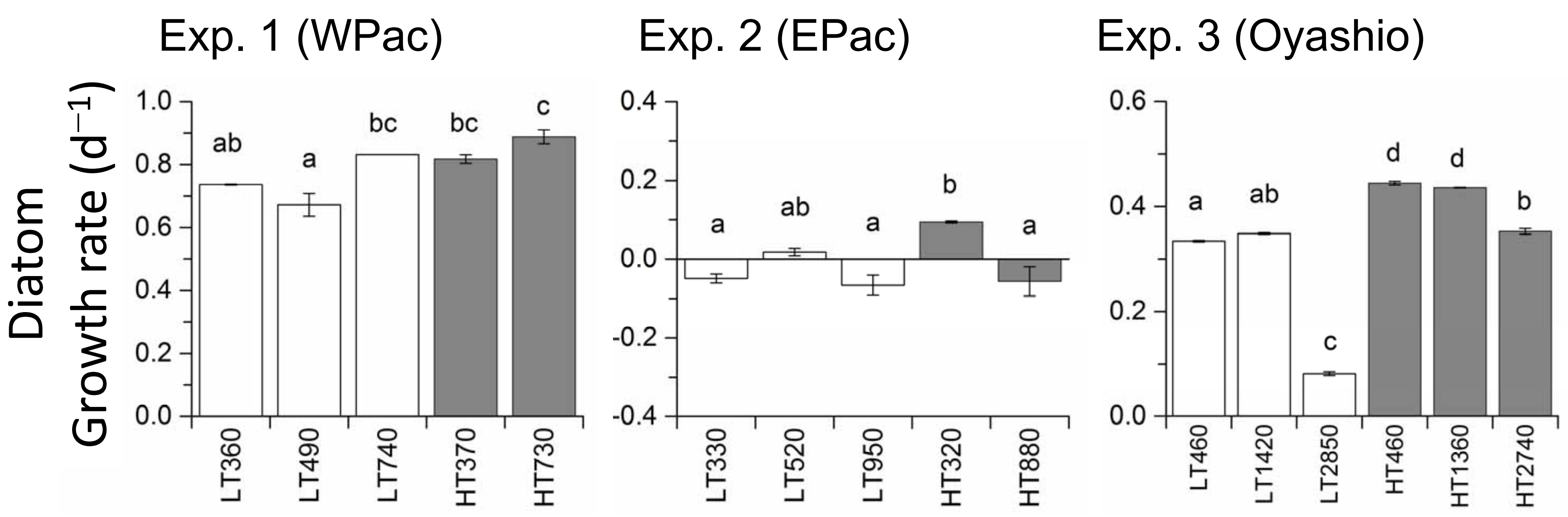
<u>High temperature could ameliorate the negative impact of high *p*CO_2.</u>

RESULTS



Synechococcus & pico-eukaryotes responded positively to high temperature and *p*CO_2

RESULTS



Diatom

WPac: *Pseudo-nitzschia*

EPac: Si-depleted (very low biomass)

Oyashio: *Chaetoceros*, *Thalassiosira*, *Neodenticula*

Temperature: positive

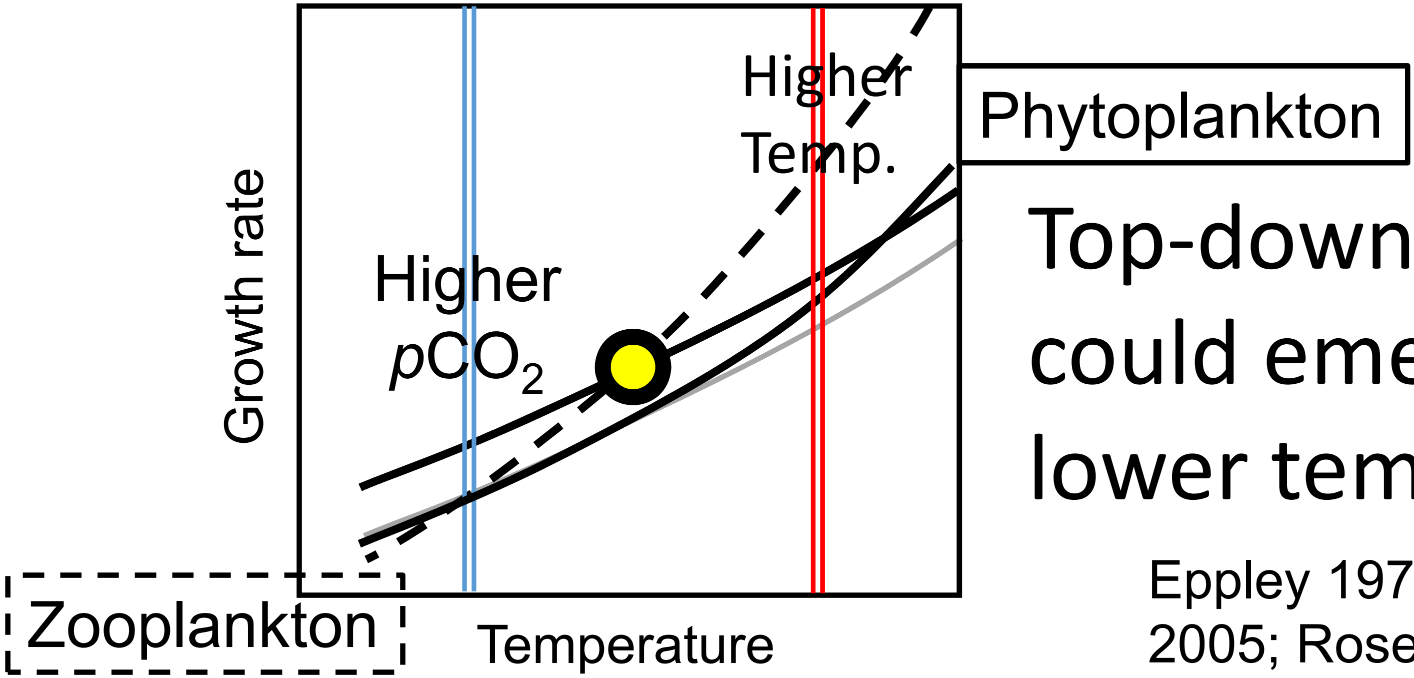
High CO_2: negative or little positive

DISCUSSION

Effects of higher pCO_2 levels

- Enhanced the growth of *Synechococcus* (Fu et al. 2007), Pico-eukaryotes (*Micoromonas*-like, *Ostoreocuccus*) (Meakin & Wyman, 2011; Schaum et al., 2012)

→ Pico-phytoplankton growth is co-limited by CO_2 and temperature especially for the winter Oyashio community.



Top-down system could emerge even lower temperature

Eppley 1972; Irigoien et al. 2005; Rose & Caron 2007

CONCLUSION

- Extremely high pCO_2 levels (>1400 µatm) could depress diatom growth
- Higher temperature and pCO_2 could synergistically enhance the growth of pico-sized phytoplankton
- The negative impact of high pCO_2 levels could ameliorate under higher temperature.

Synergistic negative impacts on the trophic transfer efficiency and on atmospheric CO_2