Effects of ocean acidification on net community production in coastal ecosystems: *In situ* assessment in natural CO_2 seeps

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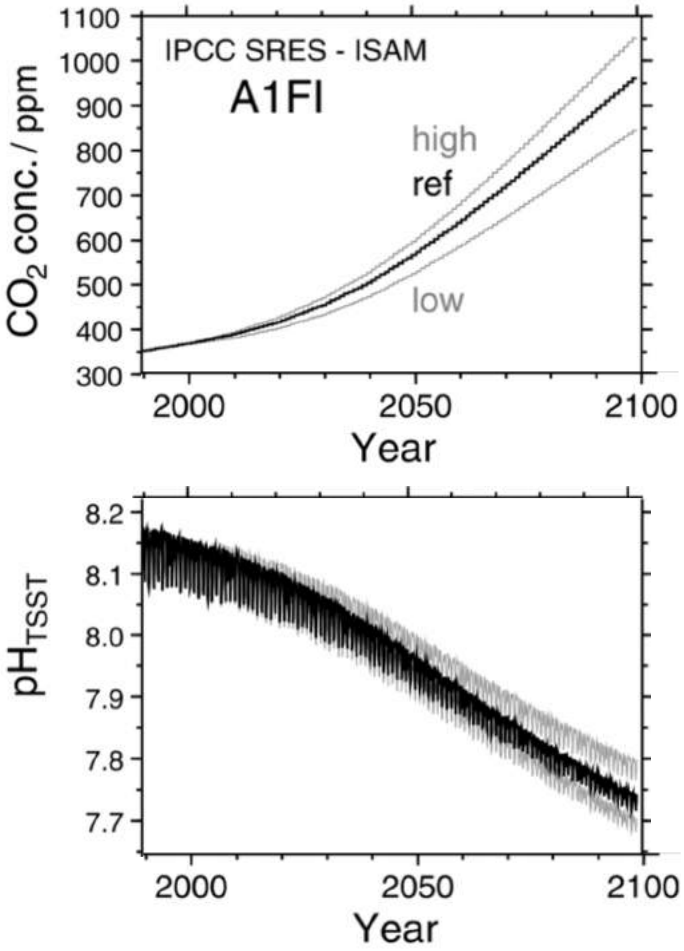
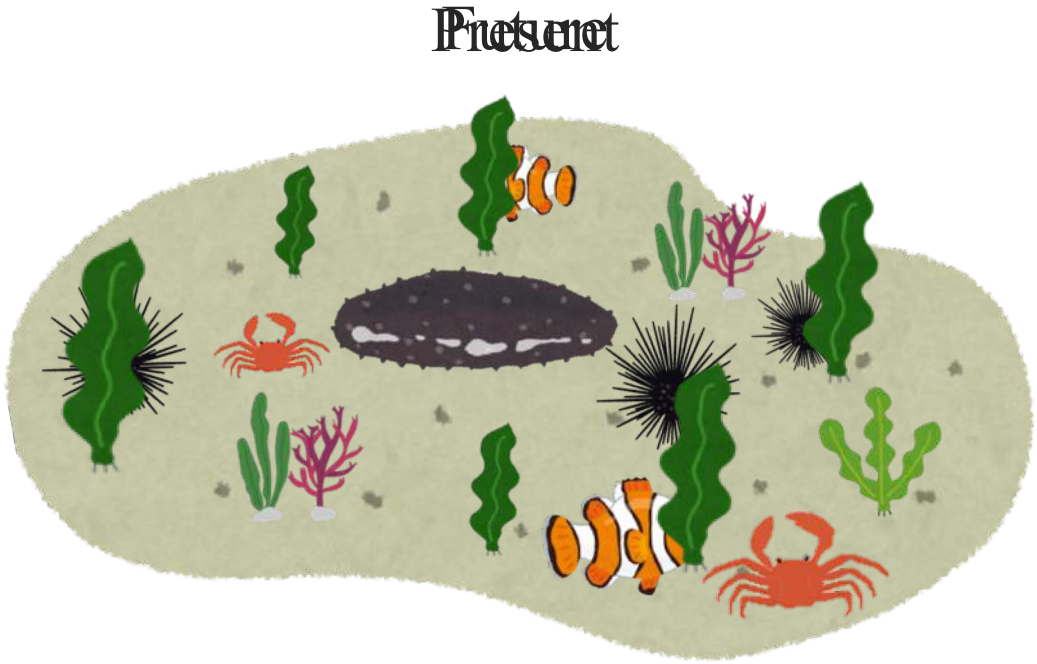
Ocean acidification



(Ishii et al., 2011)



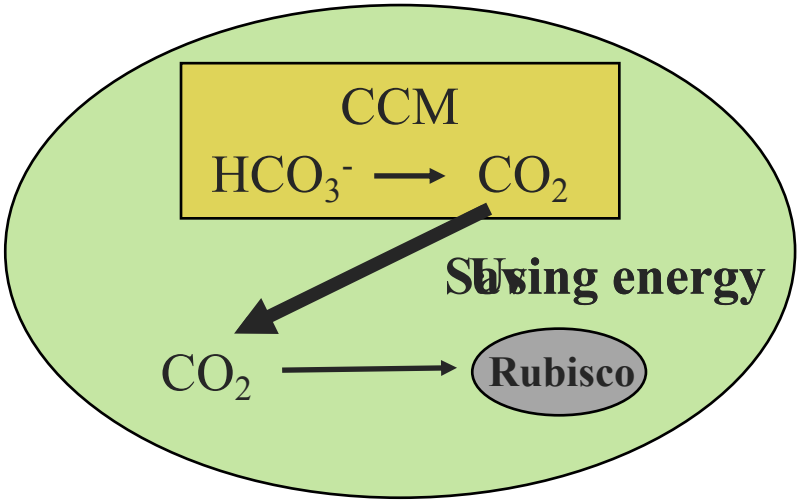
- Decreases in calcifying organisms
- Increases in photosynthetic organisms

Effects of ocean acidification on algae

$$CO_2 + H_2O \rightleftarrows H_2CO_3 \rightleftarrows H^+ + HCO_3^- \rightleftarrows 2H^+ + CO_3^{2-}$$

(0.5 %) (90 %)

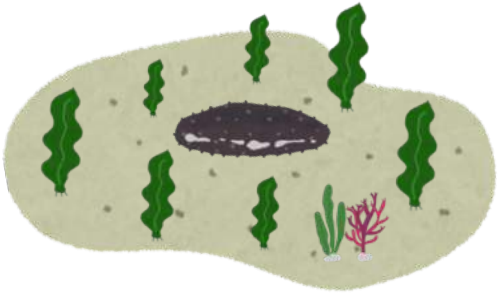
CO_2 Concentrating Mechanism (CCM)



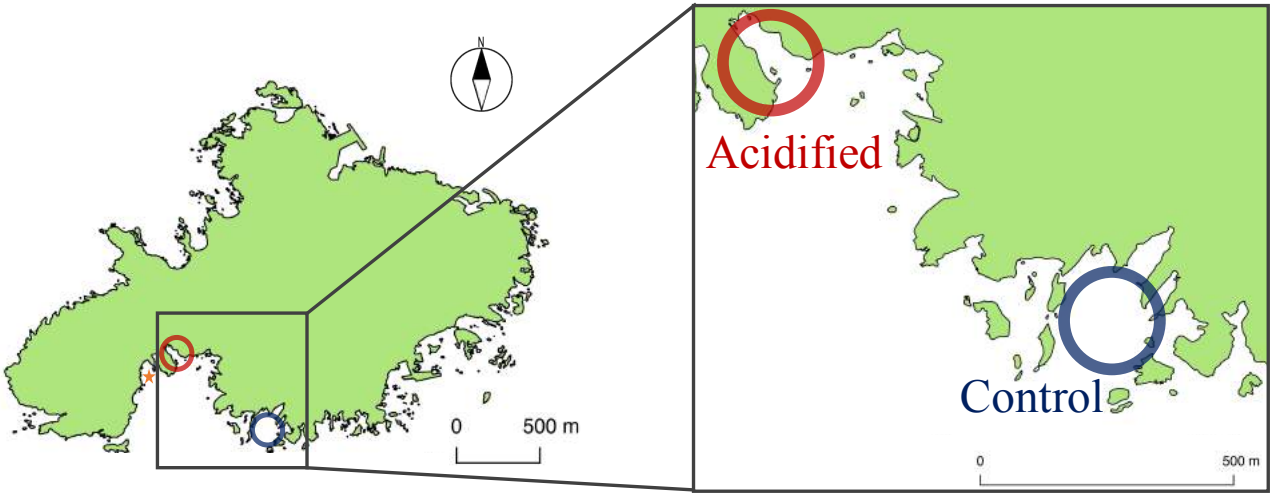
Ocean acidification ⇨ Save energy normally invested in CCM

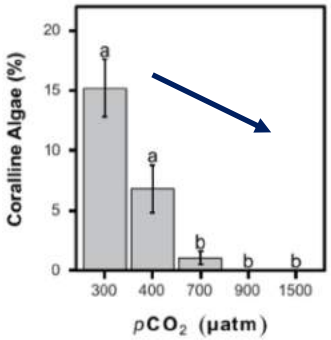
Shift in benthic flora

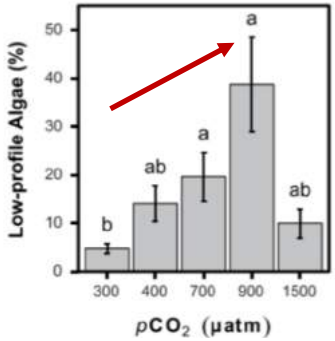
Necessary to consider change of species composition



CO_2 seep: Shikine Island, Tokyo







- Decreases in coralline algae
- Increases in Low-profile algae and Turf algae

(Agostini et al., 2018)

Acidified site
(pH≒7.9)

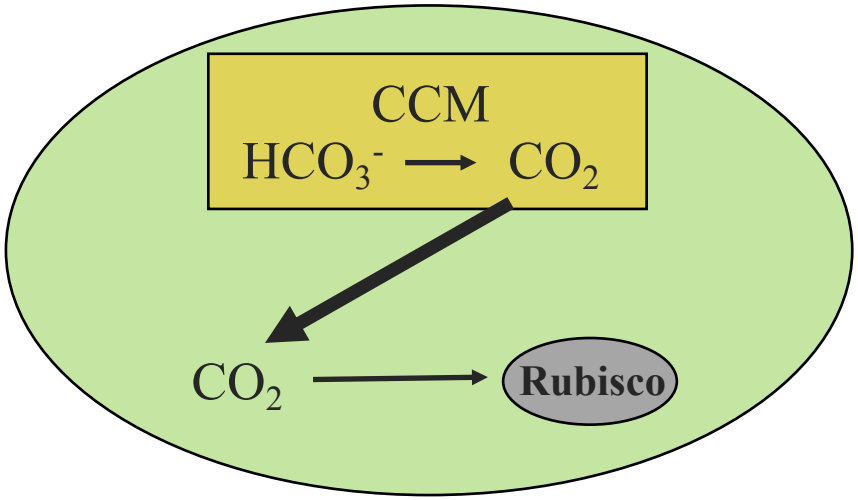
Control site
(pH≒8.1)

Objective

We investigate changes in the physiological function of algae will affect *in situ* community primary production

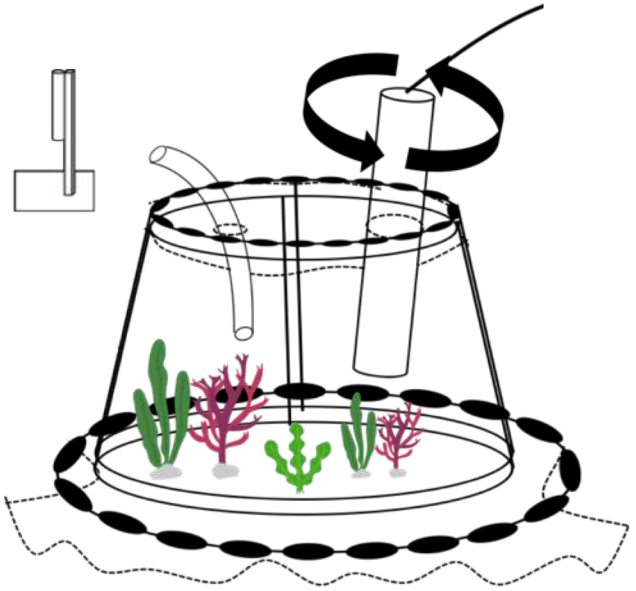
Physiological experiment

Carbon stable isotope analysis



Community net production

In situ flexible chamber experiment



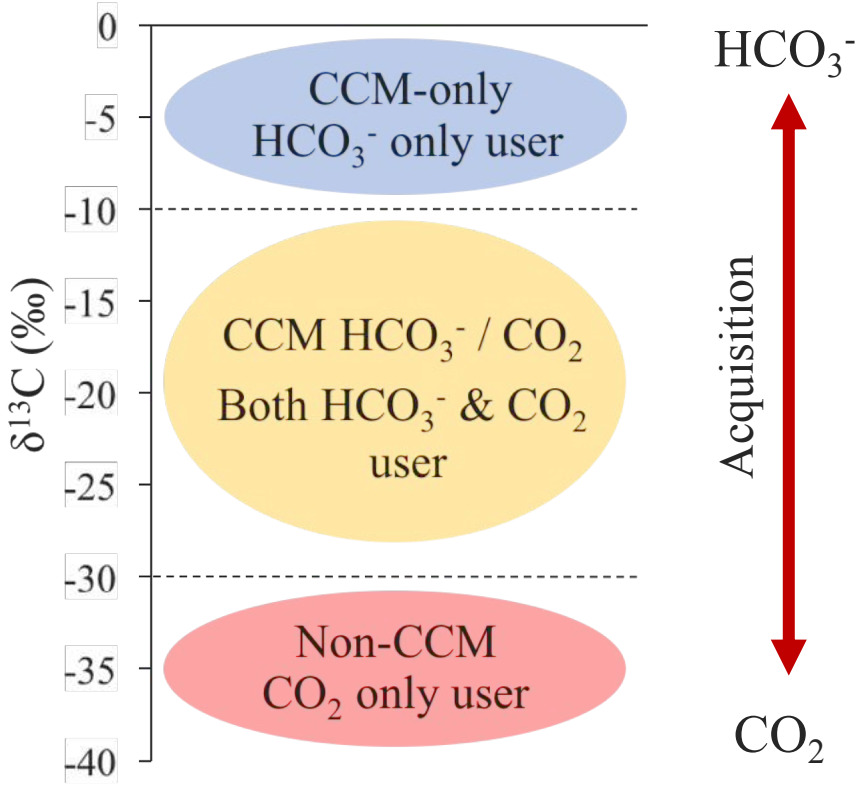
Carbon stable isotope analysis by EA/IRMS

CO_2 and HCO_3^- in seawater have different carbon stable isotope ratios

($HCO_3^- > CO_2$)

$\delta^{13}C$ can be used to determine the presence or absence of a CCM

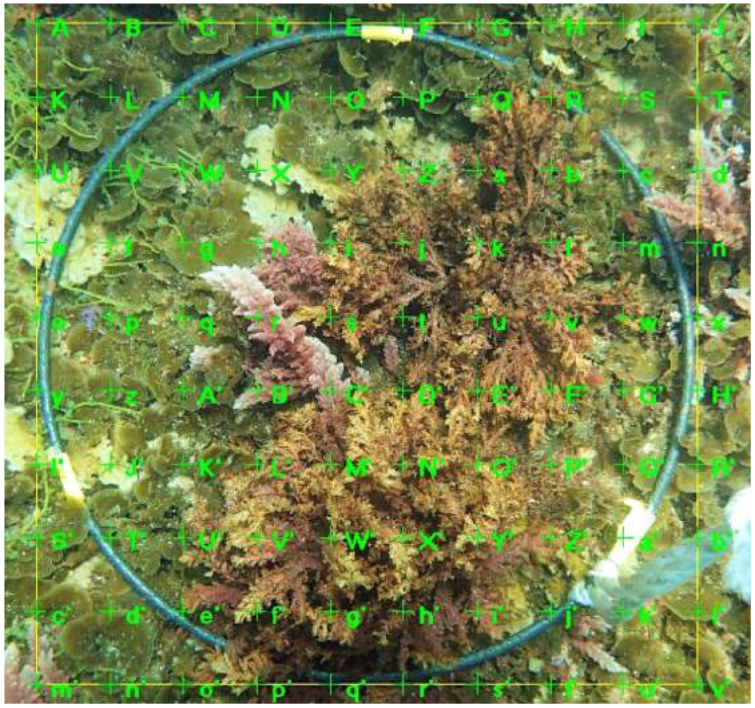
(Raven et al., 2002; Cornelisen et al., 2007)



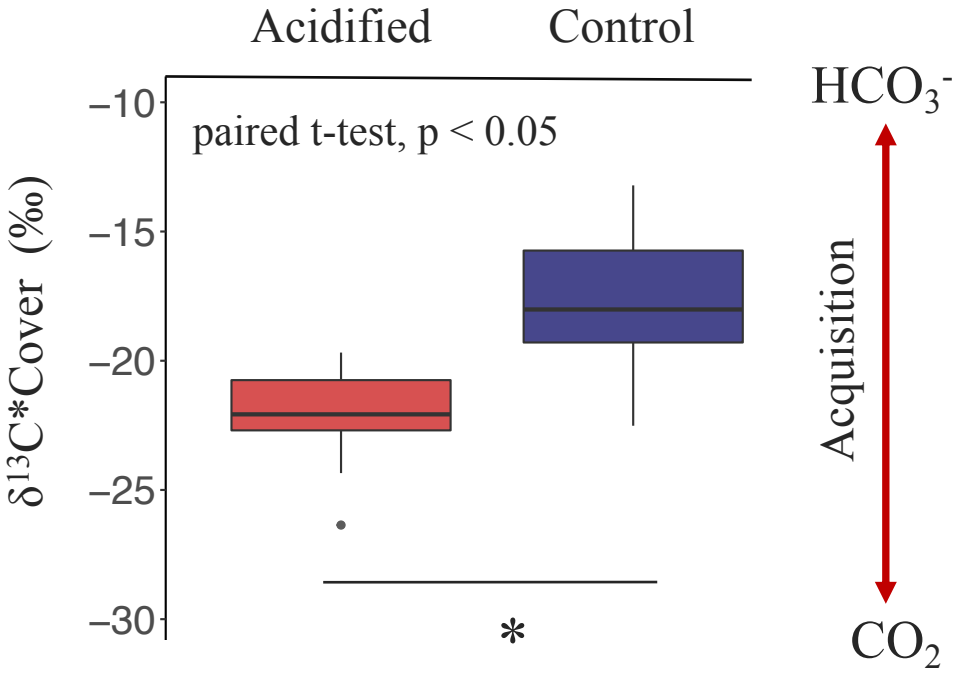
(Diaz-Pulido et al., 2016)

Samples (June 2017, 2018) → Dry 24 h, Grind dry samples → Wrap tin foil (300～500 μg)

Algae are more likely to utilize CO_2 in acidified site



CPCe ver. 4.1



Species	δ13C (‰)	Cover (%)	δ13C*Cover (‰)
Lobophora sp.	-18.3	35.7	-6.52
Zonaria sp.	-19.5	3.57	-0.70
Delisea sp.	-24.1	53.6	-12.91
Asparagopsis sp.	-30.1	7.14	-2.15
			-22.28

In other study in CO_2 seep

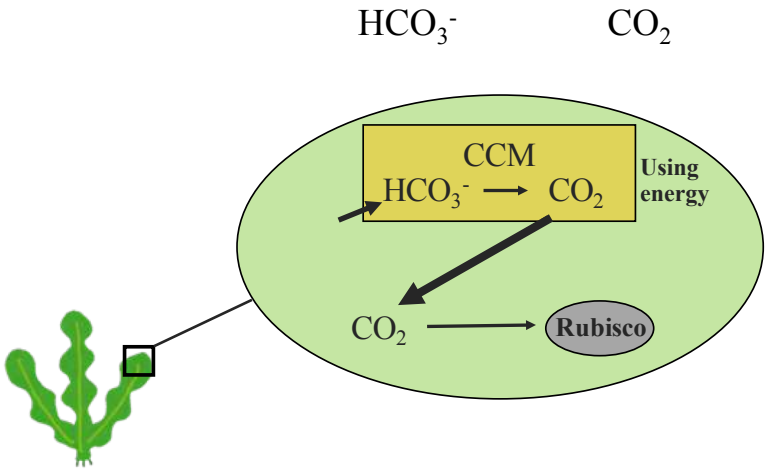
Species	pH 7.69	pH 7.89	pH 8.04
	δ13C	δ13C	δ13C
Caulerpa prolifera	− 16.1 ± 1.3	− 15.4 ± 0.8	− 13.2 ± 1.1
Dictyota dichotoma	− 24.8 ± 0.3		− 22.0 ± 0.1
Dilophus fasciola	− 22.1 ± 0.1	− 18.4 ± 1.3	
Padina pavonica	− 14.0 ± 0.2	− 12.7 ± 0.1	− 12.0 ± 0.2

(Cornwall et al., 2017)

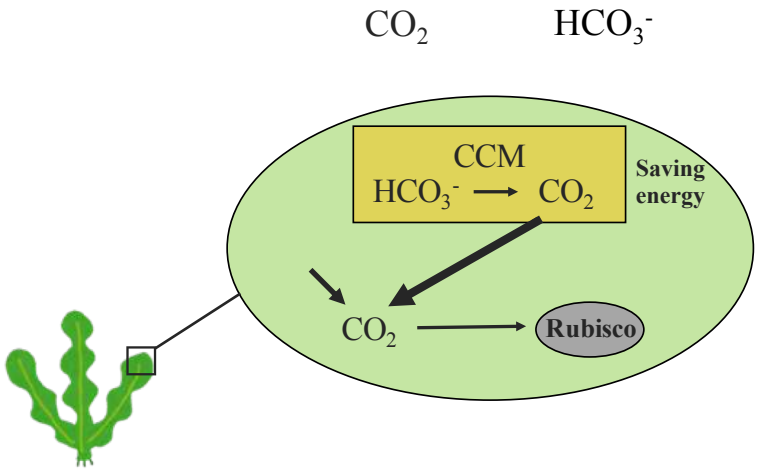
two-way ANOVA, $p < 0.05$

Hypothesis: Community net production in the Acidified site will increase due to changes in physiological functions

Present



Future



Using energy (HCO_3^- → CO_2)

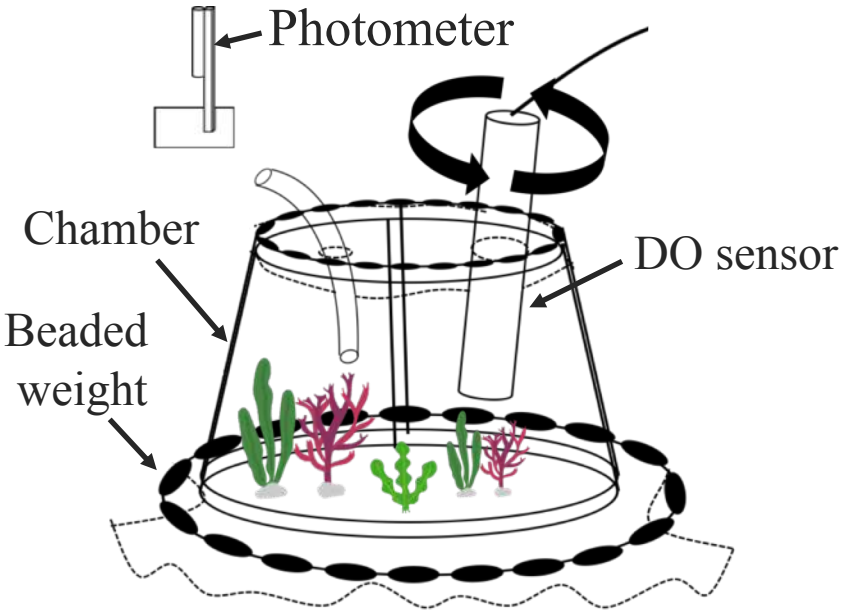
Photosynthesis ➡

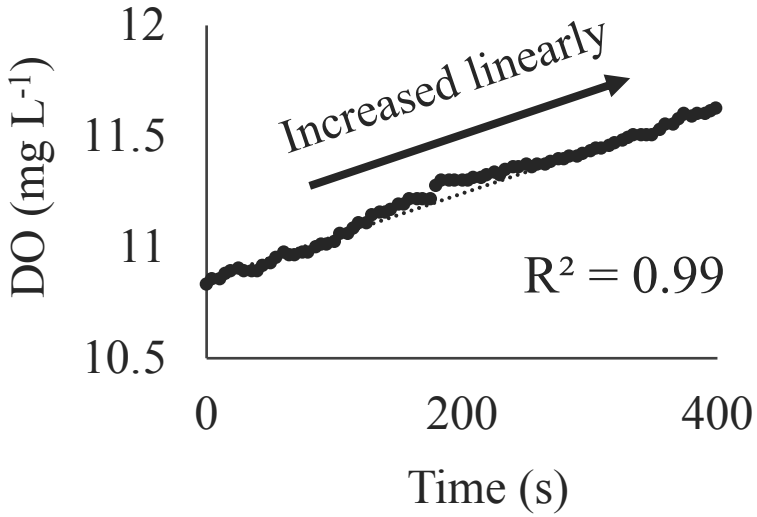
Saving energy

Photosynthesis ⬆

In situ chamber experiment can estimate
net community production while considering change benthic flora

The flexible chamber experiment





$$NP\ (mg\ O_2\ g^{-1}h^{-1}) = (S \times V \times 3600)/W$$

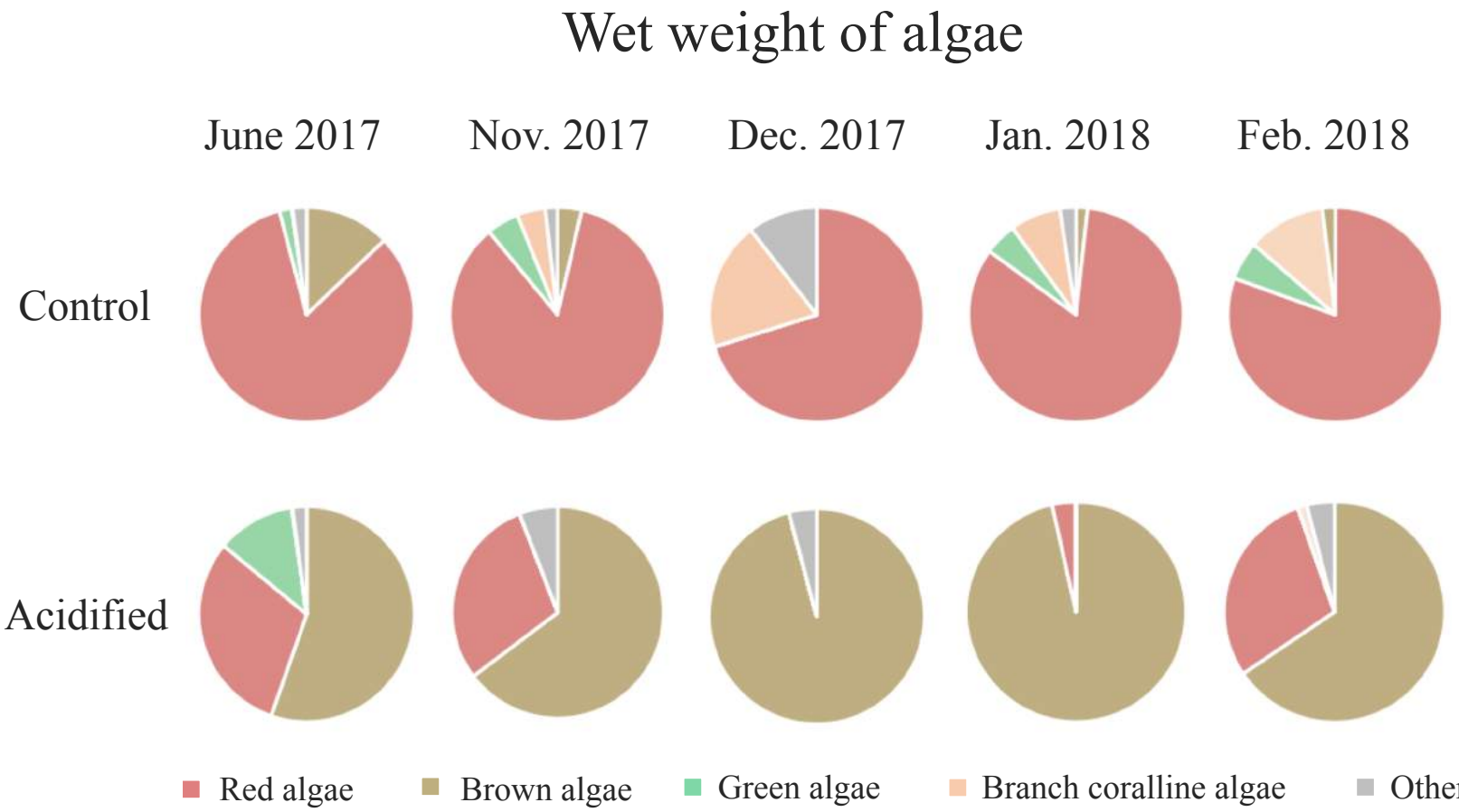
$$NP\ (mg\ O_2\ m^{-2}h^{-1}) = (S \times V \times 3600)/A$$

S : Slope (mg O_2 L^{-1}) V : Volume (L)

W : Wet Weight (g)

A : Bottom area of chamber (m^2)

Species composition was significantly different

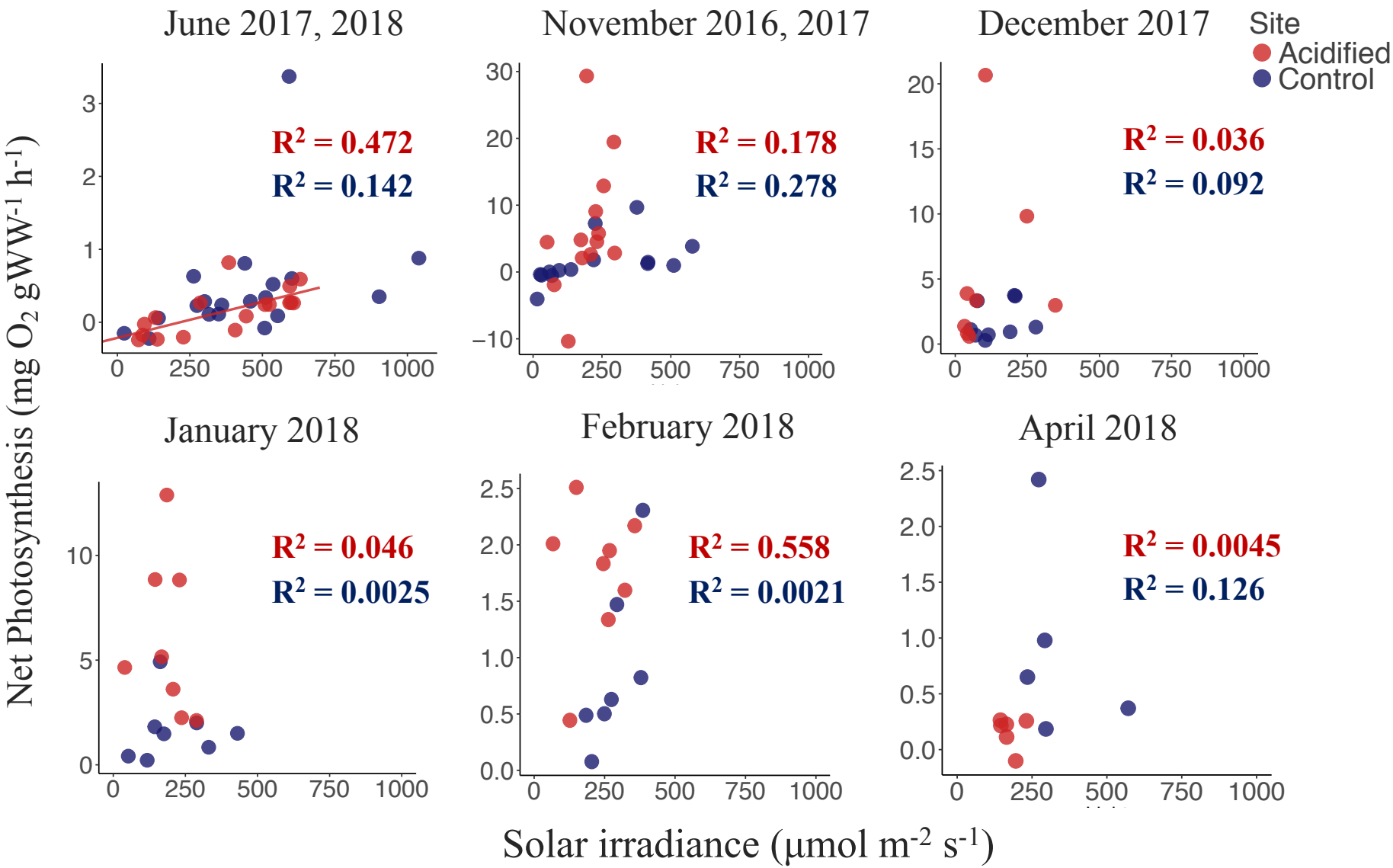


(PERMANOVA, $p < 0.05$)

Increase in the abundance of Brown algae in acidified conditions

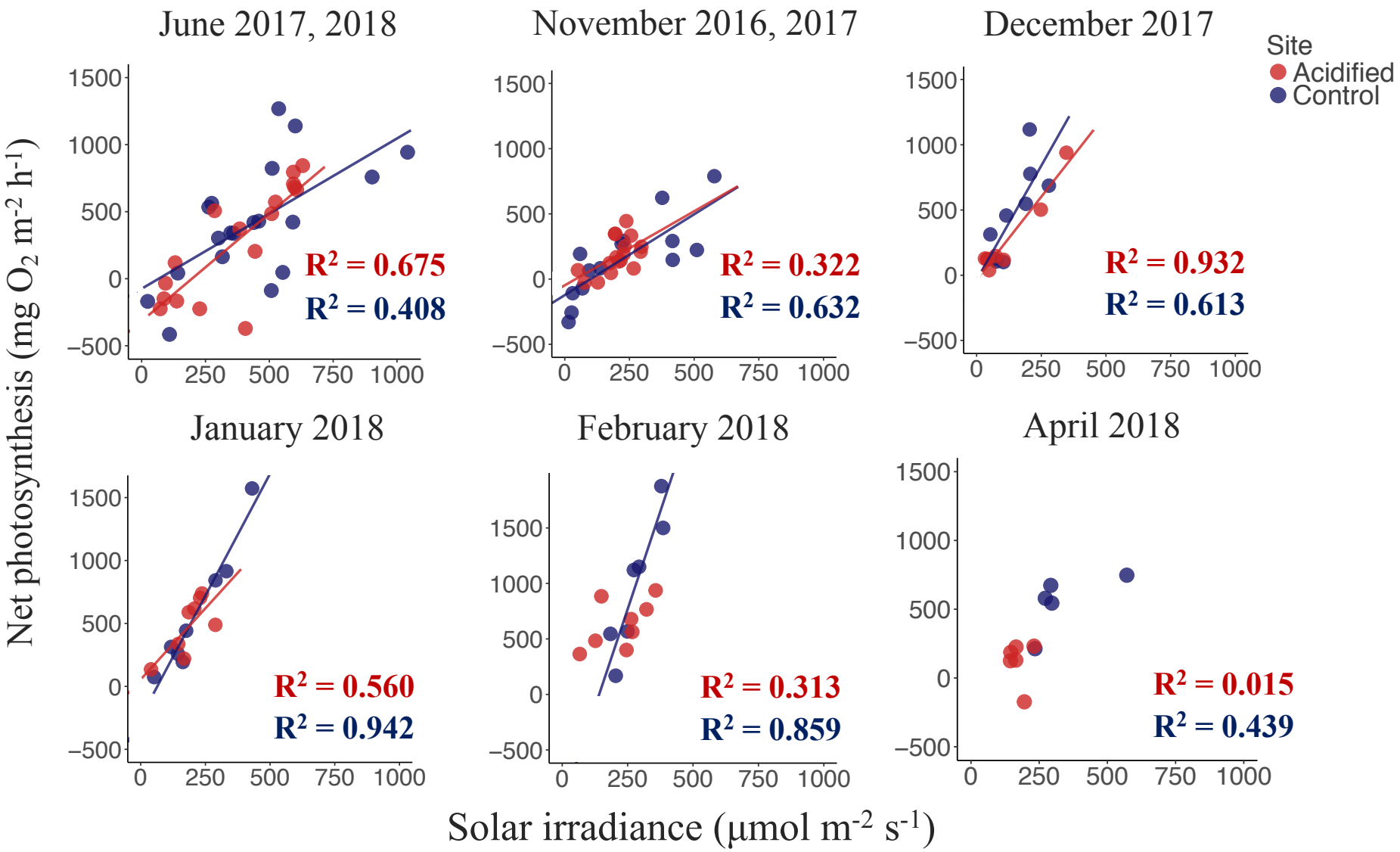
(Johnson et al., 2012; Cornwall et al., 2017)

Net photosynthesis rate per biomass: Non-significant relationship with solar irradiance



Net photosynthesis rate per area: Demonstrated a clear relationship with solar irradiance

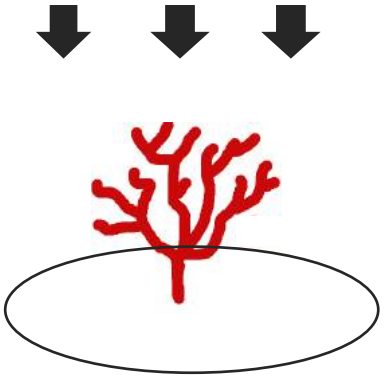
ANCOVA, $p > 0.05$



Why does areal net photosynthesis values show a relationship with irradiance ?

Incubation experiment

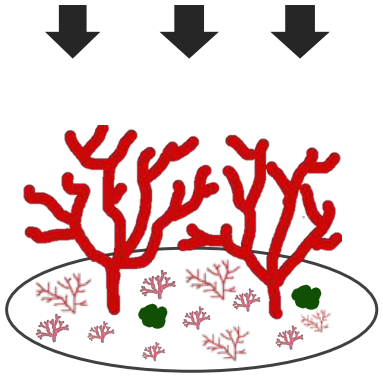
Solar irradiance



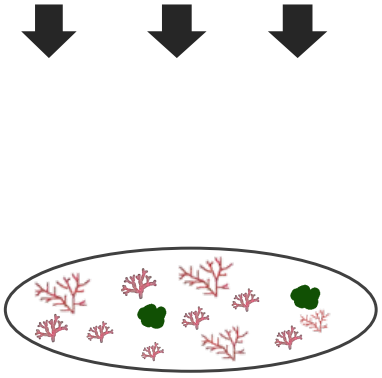
The amount of irradiance per biomass is unchanged

Ecosystem

Solar irradiance

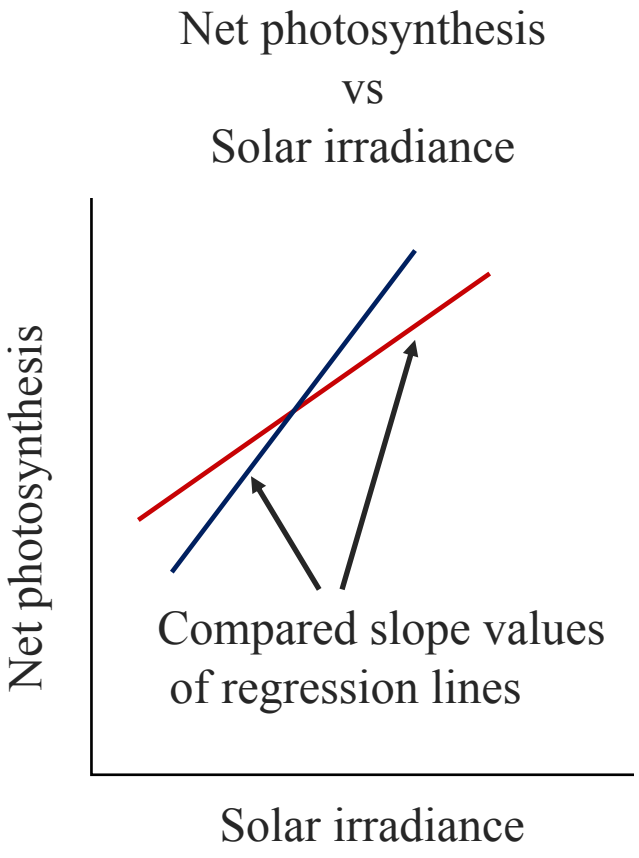


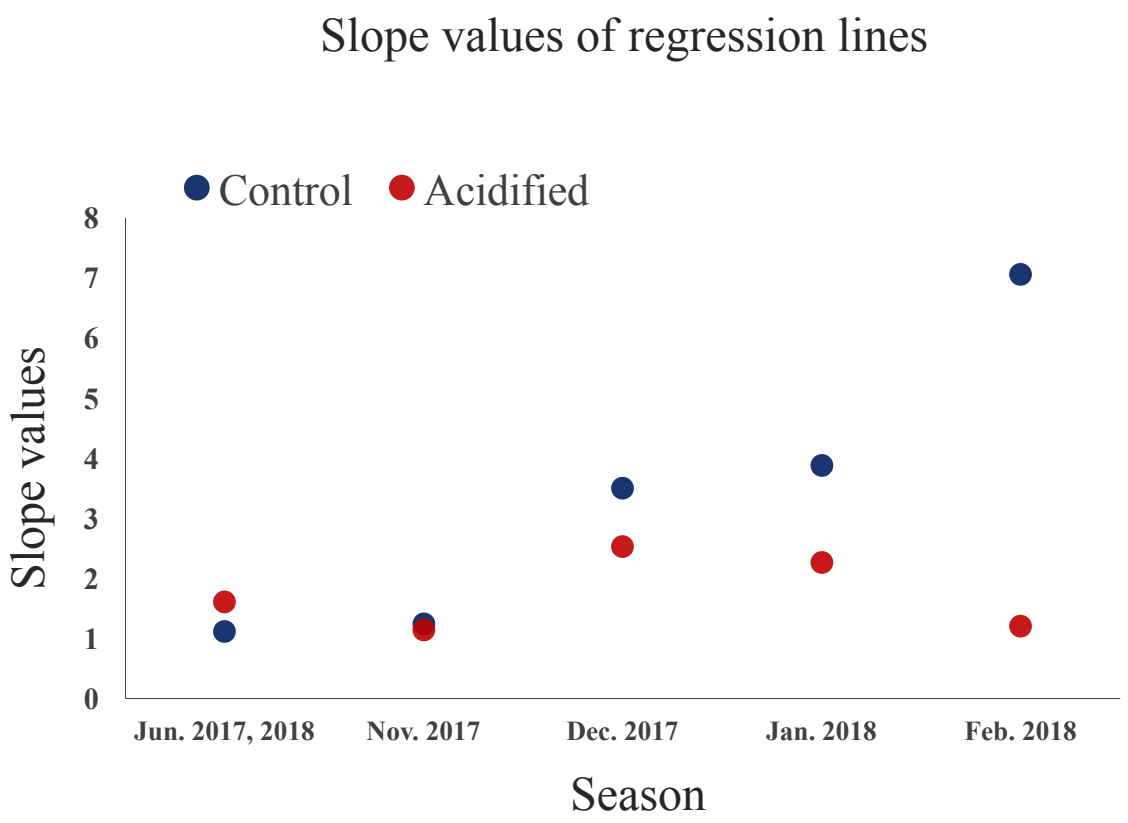
Solar irradiance



The amount of irradiance per area is the unchanged

Net photosynthesis rate per area does not increase

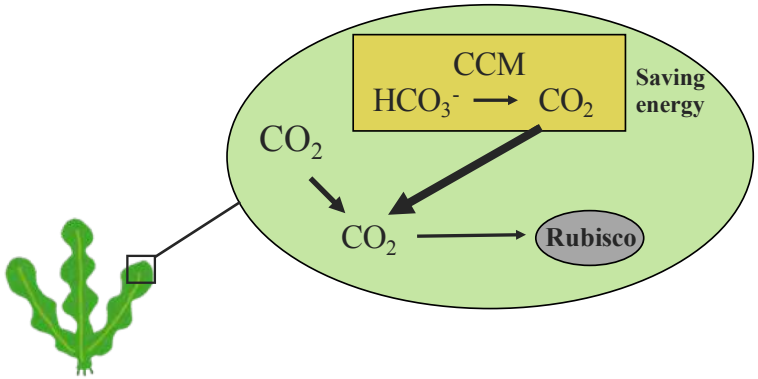




Summary

Changes in physiological effects (CCM) due to ocean acidification do not affect scale up to net community production in coastal ecosystem

Hypothesis

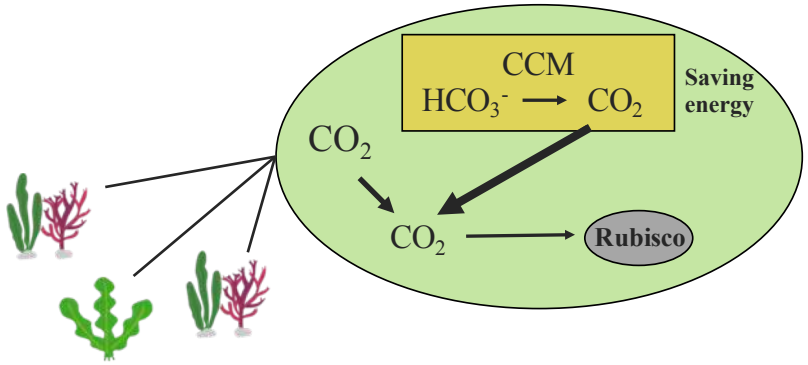


Individual

CCM ($HCO_3^- < CO_2$)

NP (Physiology) ? (↑)

Result



Community

CCM ($HCO_3^- < CO_2$)

NP (Community) ➡

Conclusion

- Ocean acidification will make easier for algae to take up CO_2 than HCO_3^-
- Ocean acidification will alter the species composition of algae
  (Red algae→Brown algae)
- When ocean acidification occurs, algae can adapt to the direction of photosynthesis without using CCM, but *in situ* net community production does not change

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