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Effects of ocean acidification on growth of juvenile Japanese surf clam *Pseudocardium sachalinense*

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- Introduction
- Experimental design
- Measurement 1: Shell growth
- Measurement 2: Stable carbon isotope
- Conclusion
- Future study

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Motivation

○ Marine calcifiers are sensitive to OA.

➡ Many previous studies

↓ However

Effects of OA on fishing industry

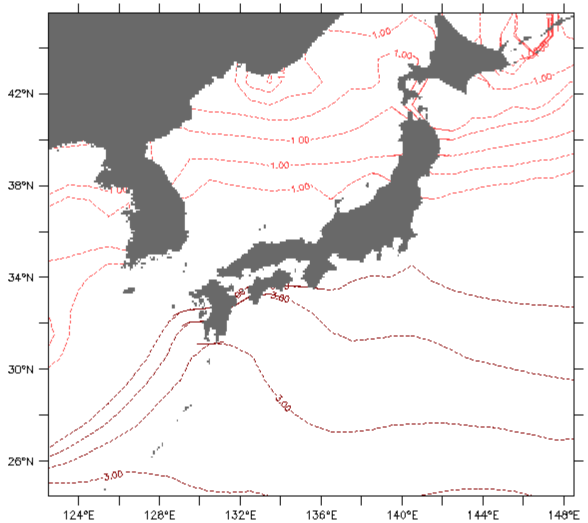
➡ Poor knowledge

○ High-latitude calcifying communities will suffer the lower aragonite saturation state (Ω).

↓ However

Effects of OA on cold-water species

➡ Poor knowledge



2000 ↓ Ω=1 2090

2000 ↓ Ω=3 2090

(*Yara et al., 2012*)

Target species

Japanese surf clam

Pseudocardium sachalinense

➡ The clam is important in local fisheries in northern Japan.

Tomakomai city in 2013

Annual catch：680 tons

Annual value of the landings：

About $ 3 million

Stable carbon isotope ($\delta^{13}C$)

In molluscan shells, $\delta^{13}C$ depends on both environmental ($\delta^{13}C$ of dissolved inorganic carbon (DIC) in seawater, temperature) and internal (metabolism) condition.

↓

Measure $\delta^{13}C$ of molluscan shell and DIC of seawater

↓

It might be possible to estimate the contribution of acidified seawater to calcification.

Purpose

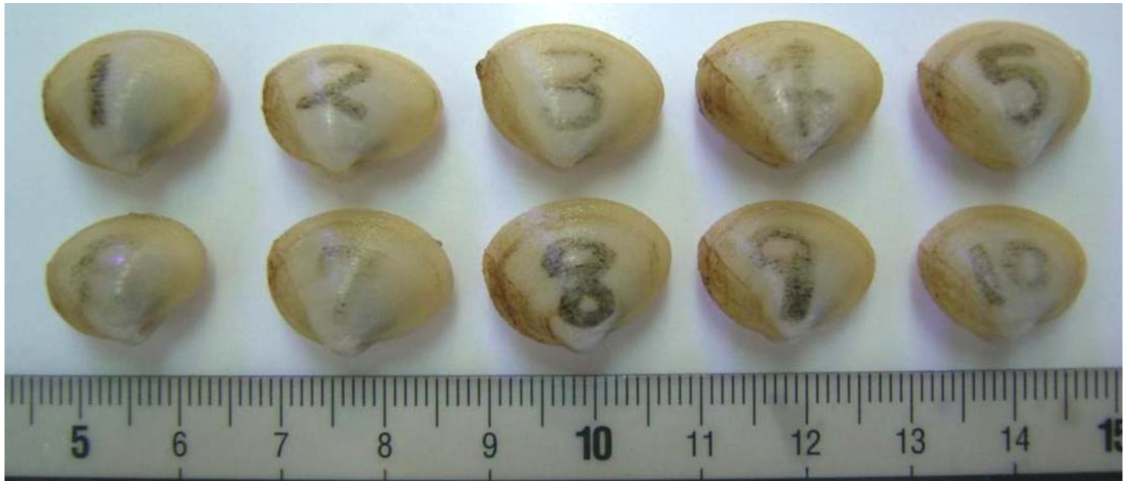
1. To study the effects of OA on growth in juvenile Japanese surf clam
2. To study the contribution of acidified seawater on shell calcification by $\delta^{13}C$

Contents

Materials and Methods

Experimental animal: Juvenile Japanese surf clam

(Yearling clam: Produced seeds in MERI)



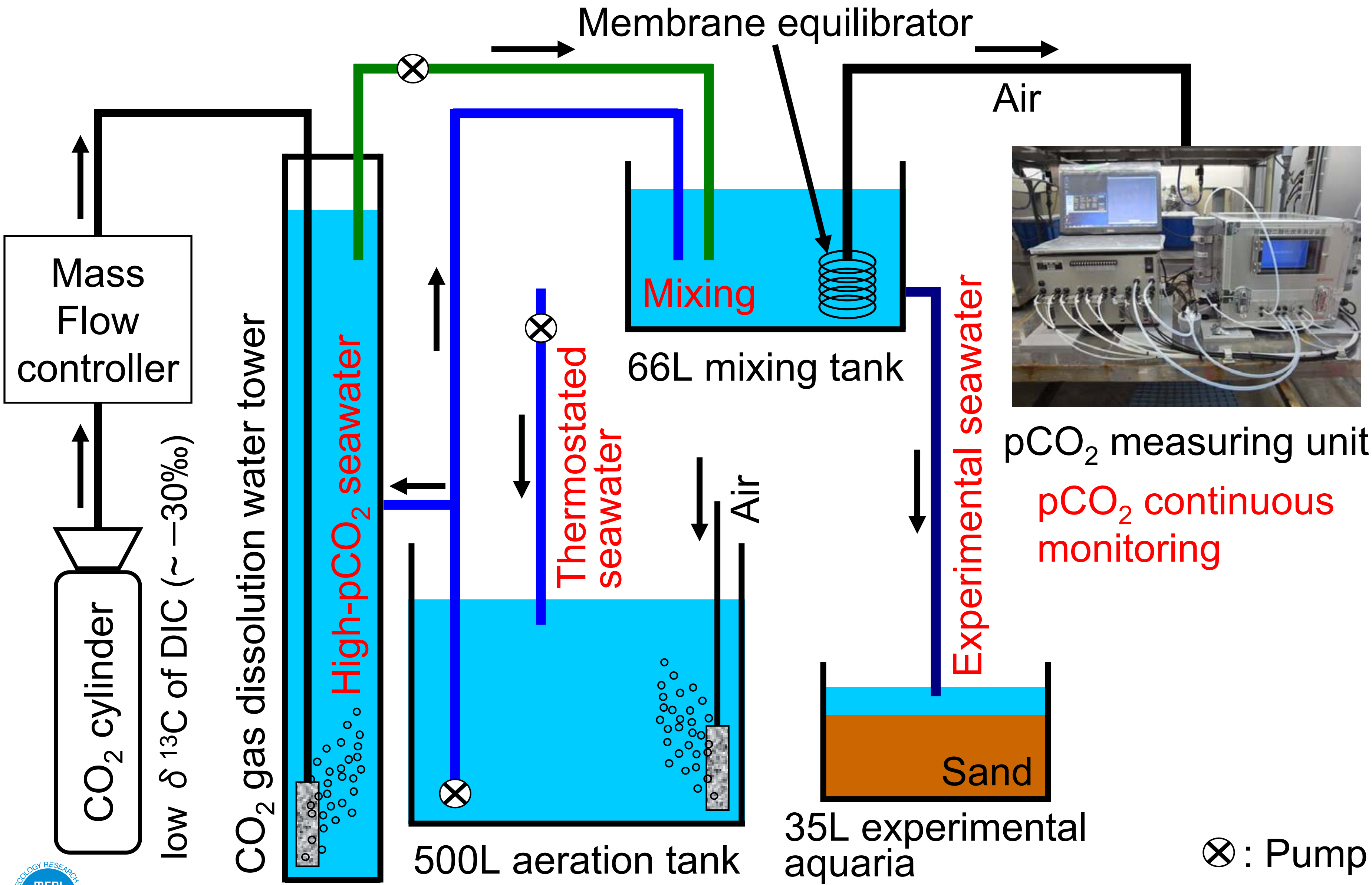
1L of *Pavlova lutheri* (4×10^6 cells/mL) of phytoplankton feed was provided twice a day.

Levels of pCO_2 (μatm): 400 (Control, ambient seawater), 600, 800, 1000, 1200

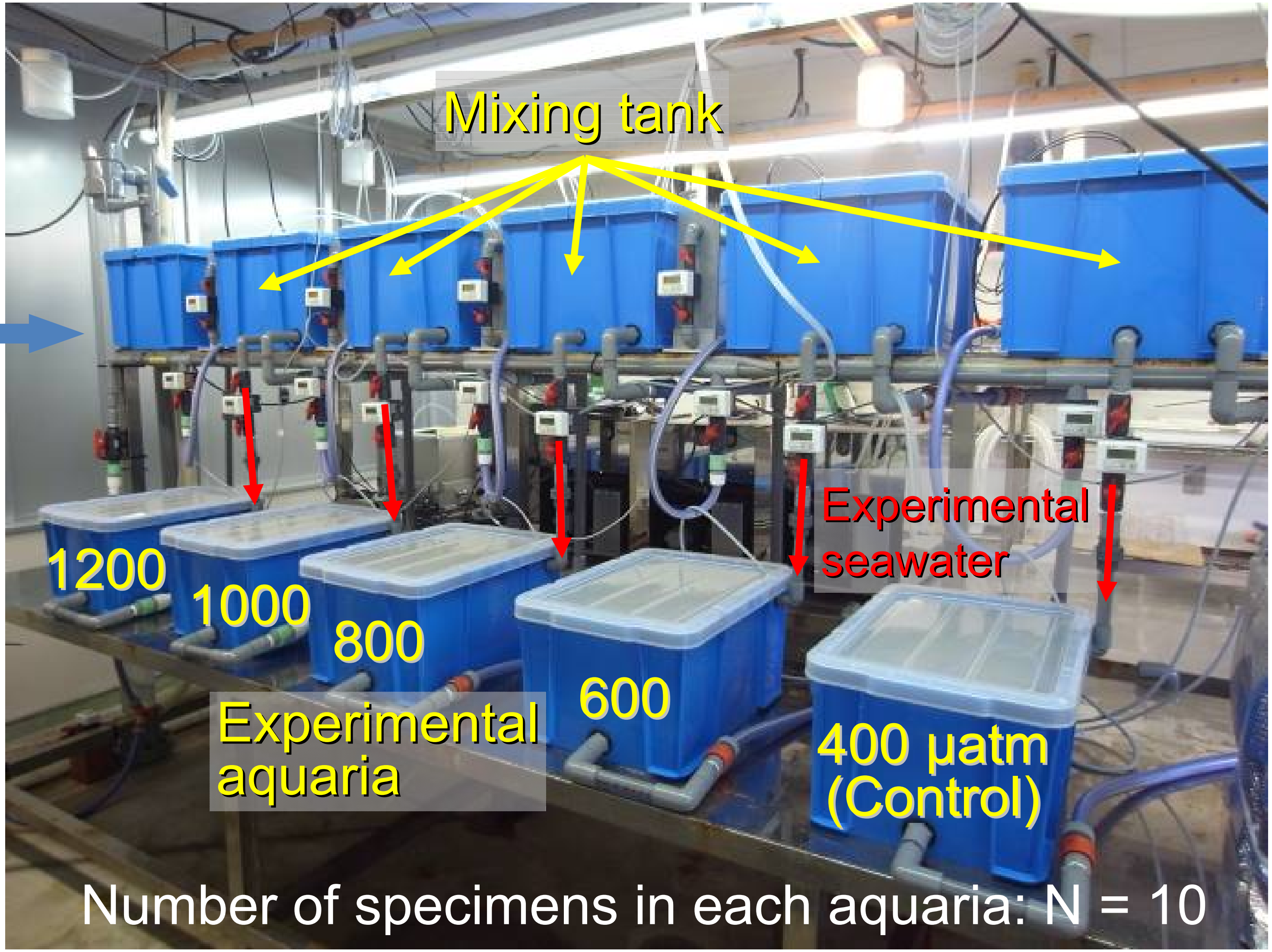
Water temperature: 17°C

Experimental duration: 20 weeks

pCO_2 Control system



pCO_2 Control system



Water parameters during experiments

Treatment	400	600	800	1000	1200
pCO_2 (µatm)	405.4 ±45.0	608.4 ±51.1	806.3 ±67.1	1014.1 ±87.1	1211.1 ±118.8
pH	8.134 ±0.021	7.978 ±0.019	7.868 ±0.023	7.773 ±0.030	7.692 ±0.038
W. Temp. (℃)	17.1 ±0.1	17.1 ±0.1	17.1 ±0.1	17.1 ±0.2	17.1 ±0.1
DO (mg/L)	8.01 ±0.21	8.00 ±0.22	8.02 ±0.21	8.03 ±0.22	8.05 ±0.23
Salinity	32.096 ±0.594				
TA (µmol/kg)	2182.4 ±37.7				

※ Volume: Mean±SD

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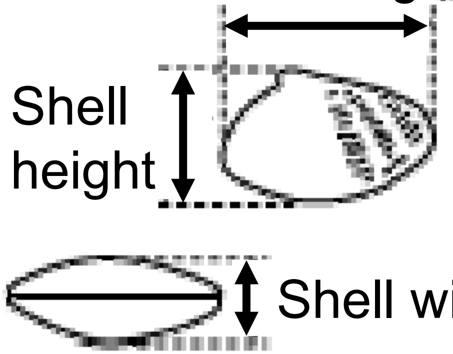
Sampling & measurement methods

○ Sampling schedule

Whole body weight, Shell length, Shell width, and Shell height

➡ Every 5 weeks



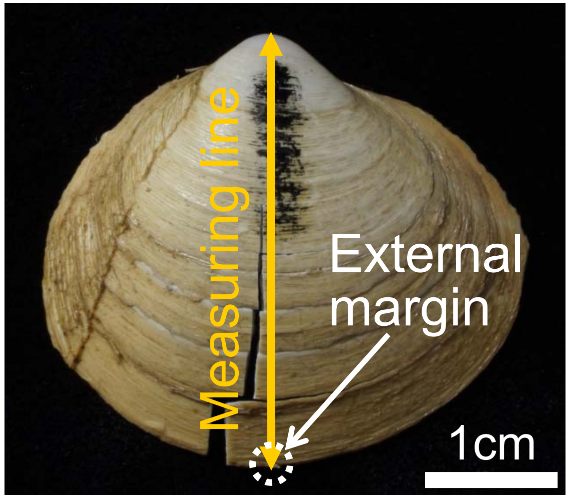
Shell thickness of external margin, Shell weight (wet/dry), and Soft tissue weight (wet/dry)

➡ After the experiment

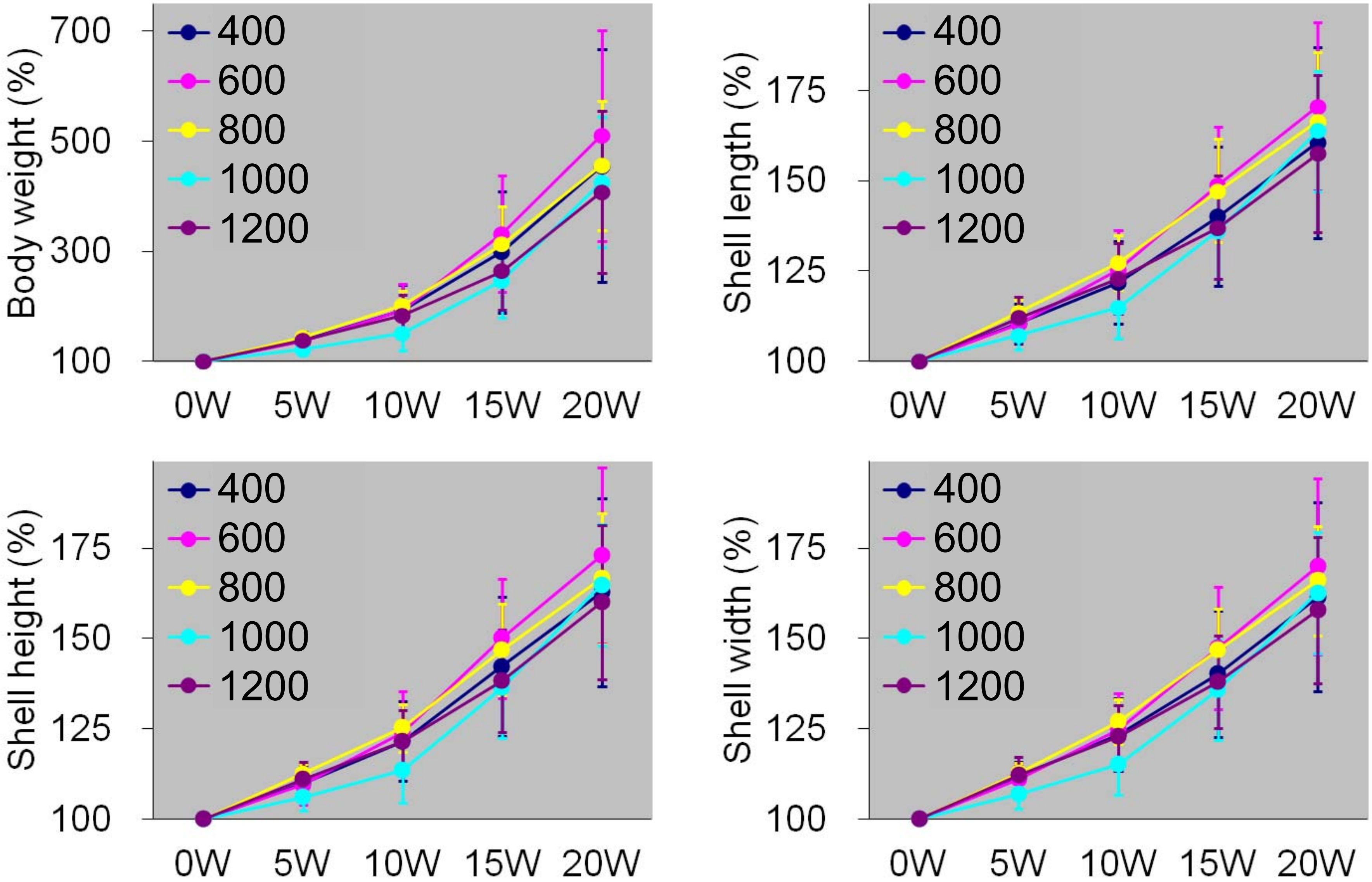
○ Measure of shell thickness

➡Interval: 1mm (on measuring line)

Determined with a digital caliper



Results of growth rate



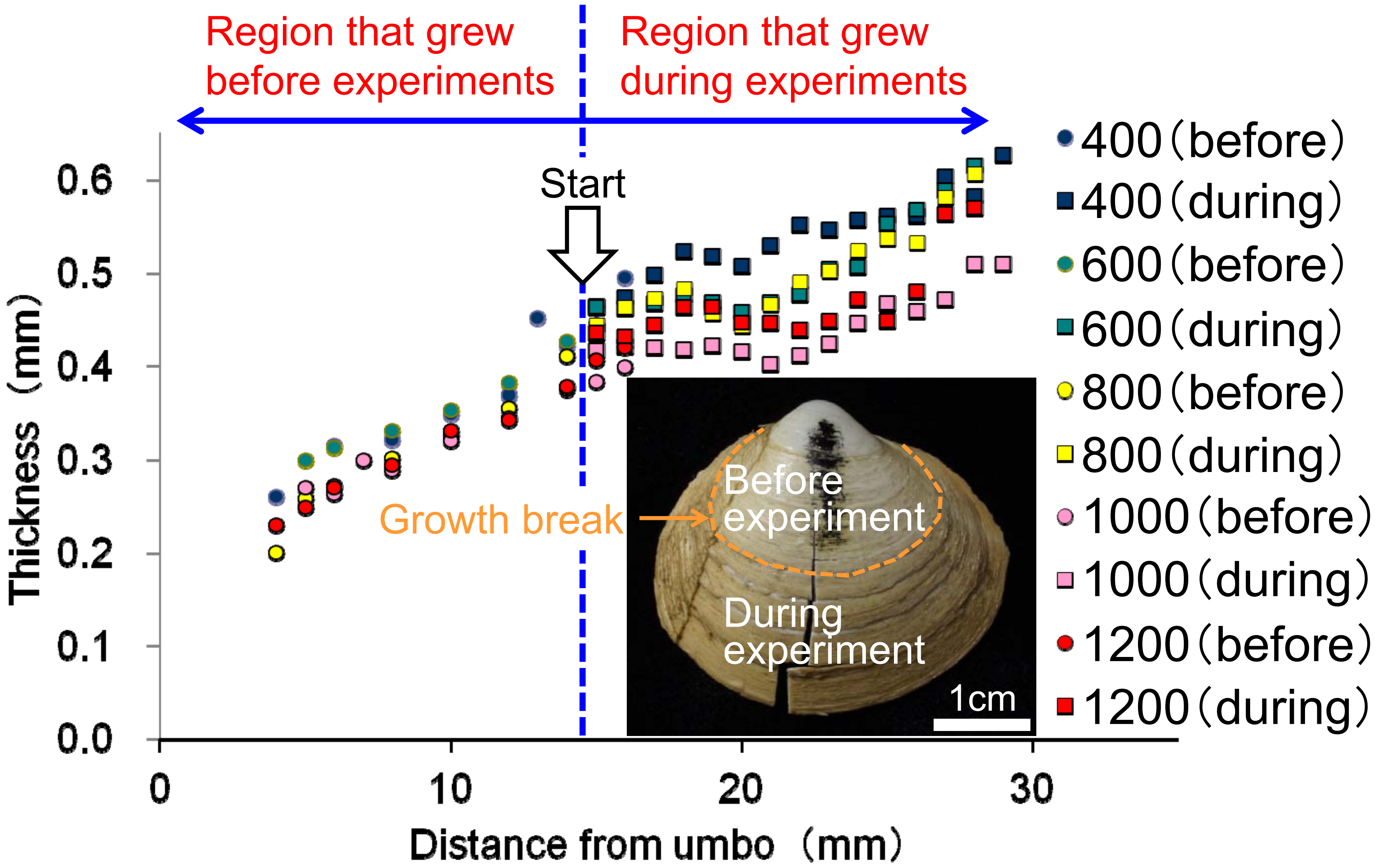
Mean±SD (N=10, 20W of 1000 μatm: N=9)

Results (End of the experiment)

Treatment	400	600	800	1000	1200
Wet weight of soft tissue (g)	0.94±0.45	1.06±0.46	1.01±0.27	0.95±0.30	**0.89±0.30**
Dry weight of soft tissue (g)	0.19±0.10	0.21±0.09	0.20±0.06	0.19±0.06	**0.17±0.06**
Wet shell Weight (g)	1.31±0.55	1.42±0.55	1.24±0.31	1.17±0.34	1.06±0.32
Dry shell Weight (g)	1.21±0.51	1.31±0.53	1.14±0.29	1.07±0.31	0.94±0.29
Thickness of external margin (mm)	0.72±0.14	0.66±0.09	0.62±0.03*	0.55±0.03**	0.56±0.06**

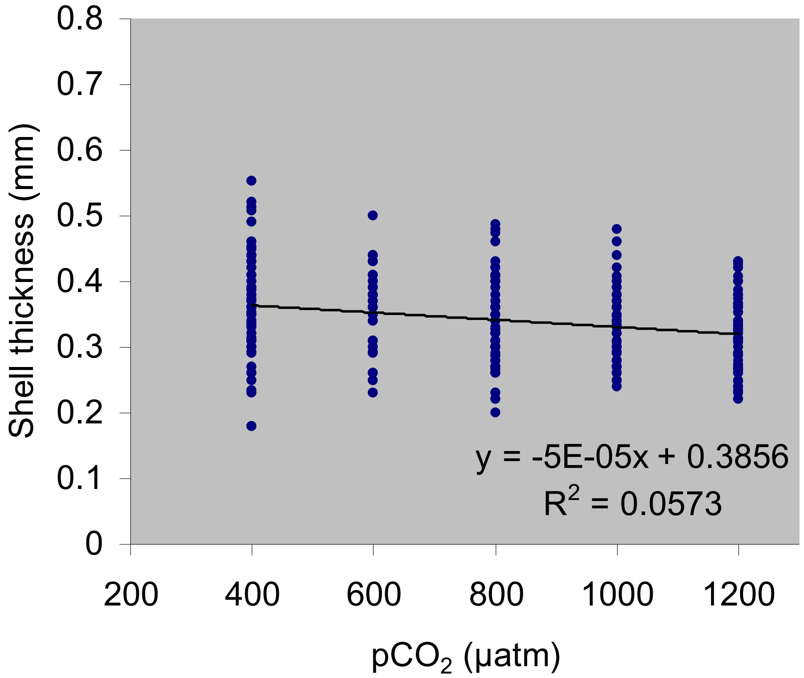
※ Mean±SD (N=10, Bold: N=9), **P<0.01, *P<0.05

Results of shell thickness



Results of shell thickness

Before experiment



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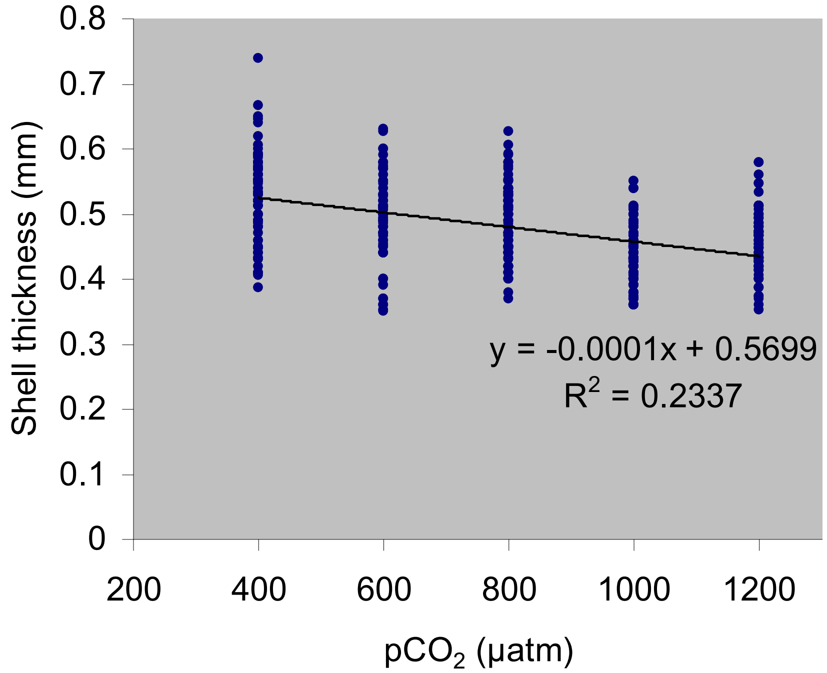
During experiment



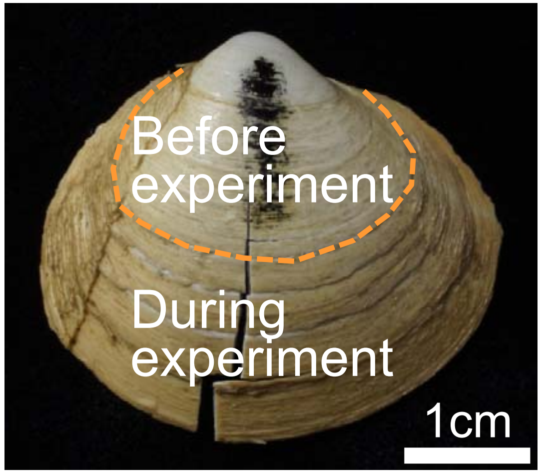
Nonparallel regression slopes (ANCOVA test for parallel slopes, $P < 0.01$)

Shell thickness at a region that grew during experiments thinned in a pCO_2-dependent manner.

Discussion

○ Shell thickness at a region that grew
before experiments
➡ Almost no change

○ Shell thickness at a region that grew
during experiments
➡ Thinned



Effects of OA:
Inhibition of shell formation > Shell dissolution

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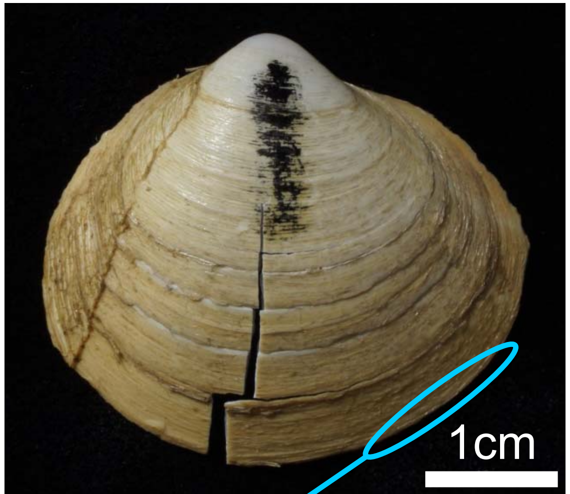
Methods

○ Stable carbon isotope composition ($\delta^{13}C$) of the shells collected from the external margin of the outer shell layer

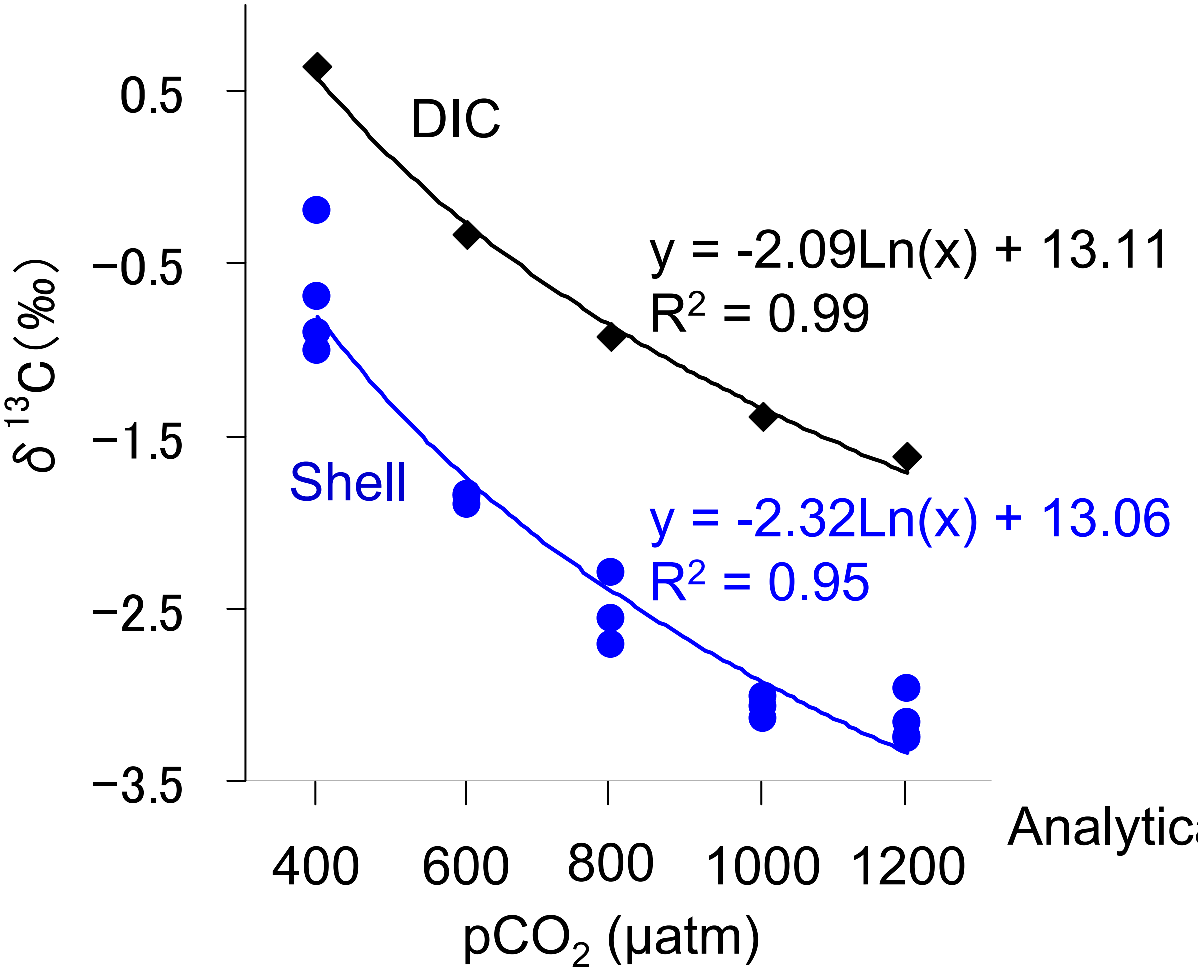
○ $\delta^{13}C$ of DIC in seawater sample



External margin

Determined with a Macromass Isoprime mass spectrometer

Results of δ^{13}C analysis

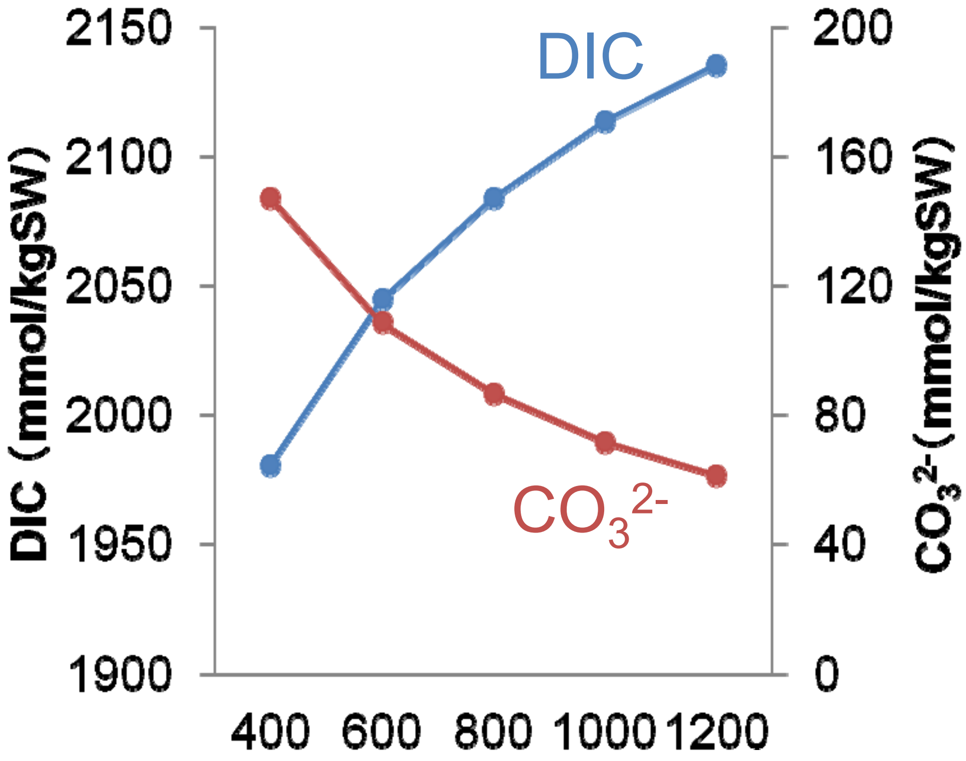


Analytical error < 0.1‰

The regression slope of the relationship between shell δ^{13}C and pCO_2 was roughly the same as that between δ^{13}C of DIC and pCO_2.

δ^{13}C of the shells was strongly dependent on δ^{13}C of seawater DIC.

Discussion



The influx of acidified seawater into the calcification fluid is the same as that of control seawater.

↓

The decrease in CO_3^{2-} (which is necessary for calcification) in the calcification fluid might induce a thinner shell formation.

Effects of OA:

In acidified seawater, Japanese surf clam might have a poor pH regulation of the calcification fluid.

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Conclusion

1. No significant effect of elevated CO_2 on growth rate.
   ➡ Large variations of growth in the yearling shell
2. Shell thickness at a region that grew during experiments thinned in a pCO_2-dependent manner.
   ➡ Inhibition of shell formation
3. $\delta^{13}C$ of the shells was strongly dependent on $\delta^{13}C$ of seawater DIC.

By the effects of OA, Japanese surf clam might have a poor pH regulation of the calcification fluid.

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Future study

○ Investigation into the strength of the shell

➡ Impacts on predation

○ Experiments in other species

➡ Effects of OA on growth of common scallop *Patinopecten yessoensis* (Important in local fisheries in northern Japan)

From Aomori prefectural government web site

Thank you for your attention!

URL: item. rakuten.co.jp

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Poster presentation:

No.11240 “The combined effect of high pCO_2 and warming on reproduction of Japanese whiting *Sillago japonica*”

Acknowledgements:

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