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Climate changes (ocean acidification and warming) may impact the reproduction of the sea urchin *Hemicentrotus pulcherrimus*

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Gaps in Knowledge:

1. Long-term effects
（months, years, over generations）

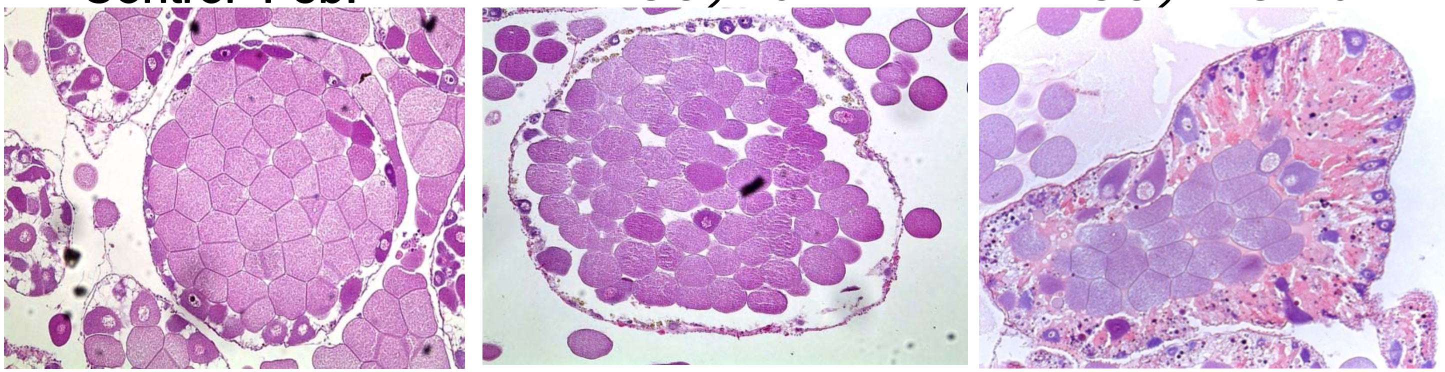
2. Combined effects (ocean acidification & warming)

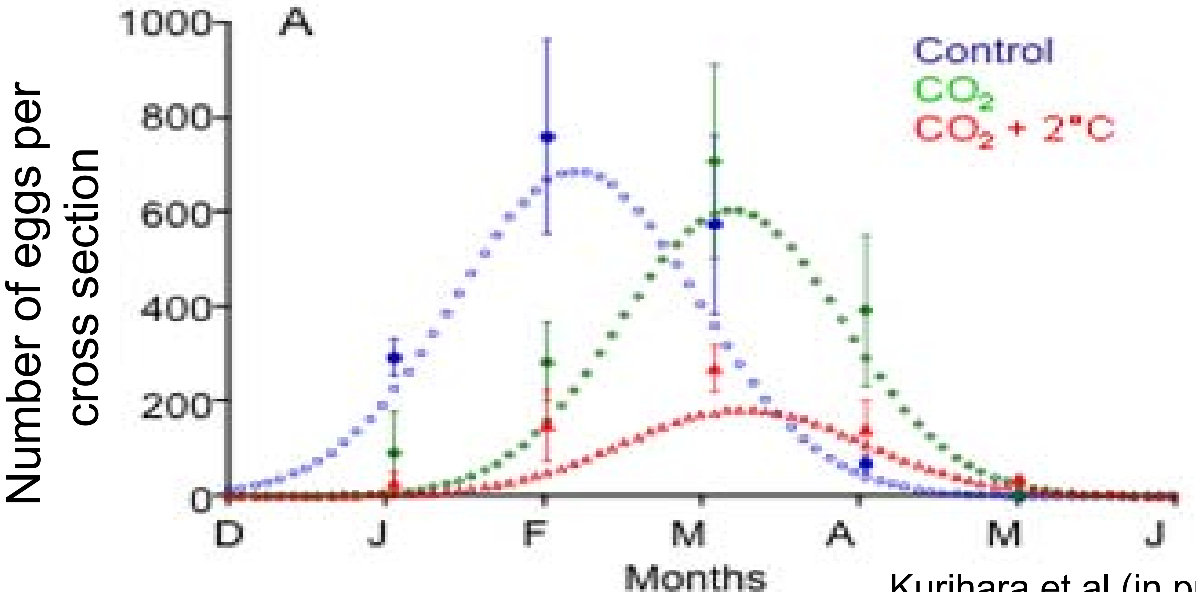
3. Effects on reproduction
Reproduction including the procedures of
development of gametes, spawning
and early embryos

4. Effects on behavior

Results of Our Earlier Experiment

Control Feb. | CO_2 Mar. | CO_2+2℃ Mar.





Kurihara et al (in preparation)

However, it is unknown:

- How and if high temperature alone affects gonad development?
- How actual egg spawning is affected?
- What is the underlying mechanism for the suppression of gonad development?

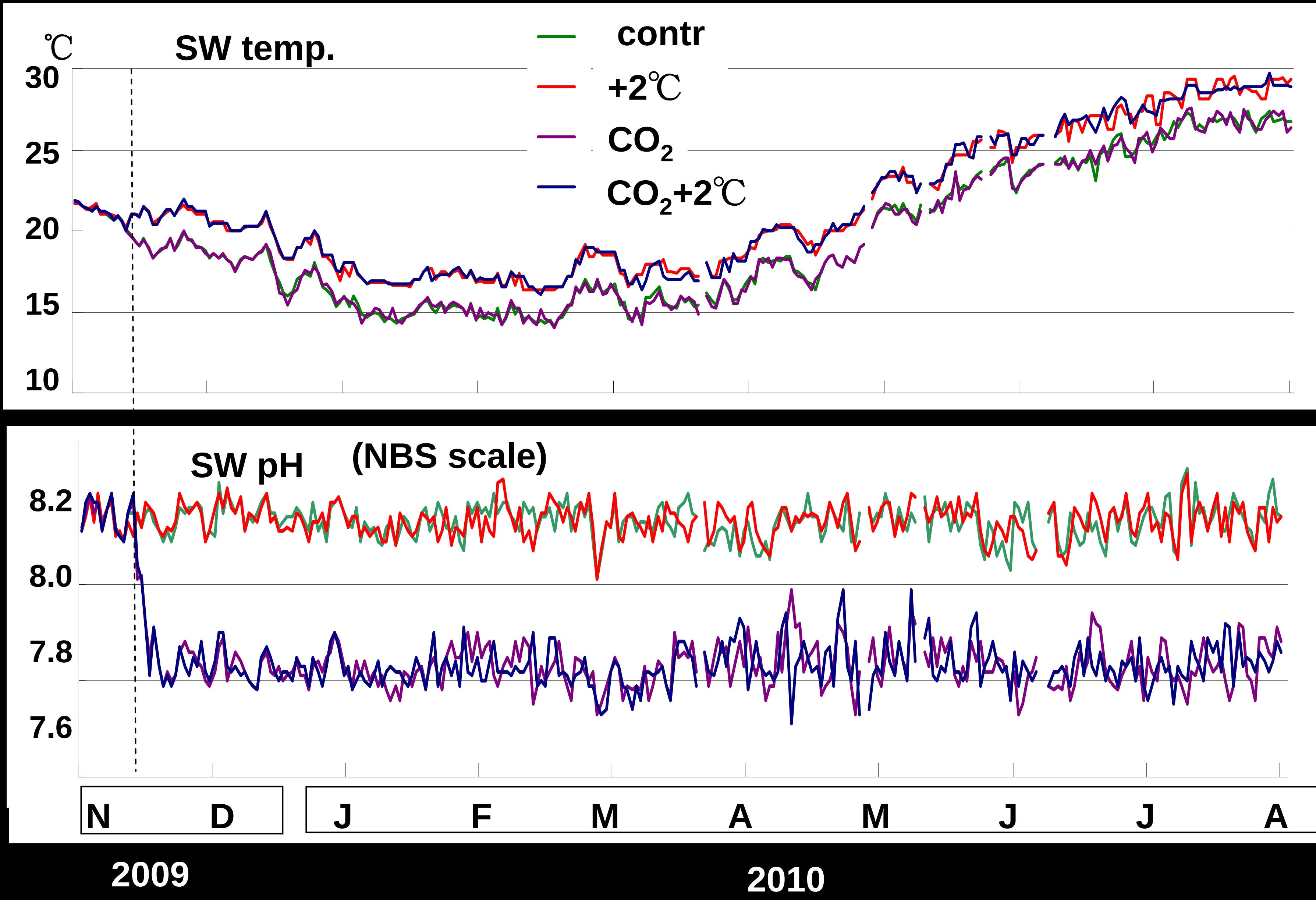
To answer these questions, we have conducted the following experiment.

Experimental Design

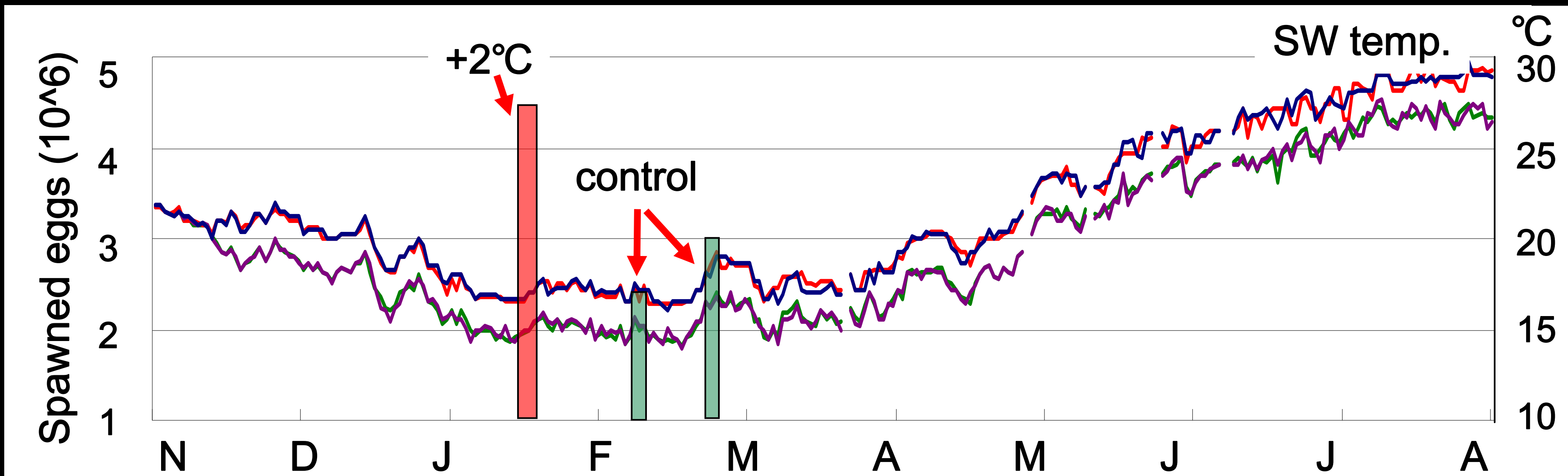
Group	$[CO_2]$ (ppm)	Temp. (℃)
control	380	ambient (Nagasaki)
+2℃	380	ambient +2
CO_2	1,000	ambient
CO_2+2℃	1,000	ambient +2

Each group
- 10 ind. . . . . . Spawning observation
- 10 ind. . . . . . Feeding, O_2 consumption and behavior, morphological analysis

Results: Seawater Conditions

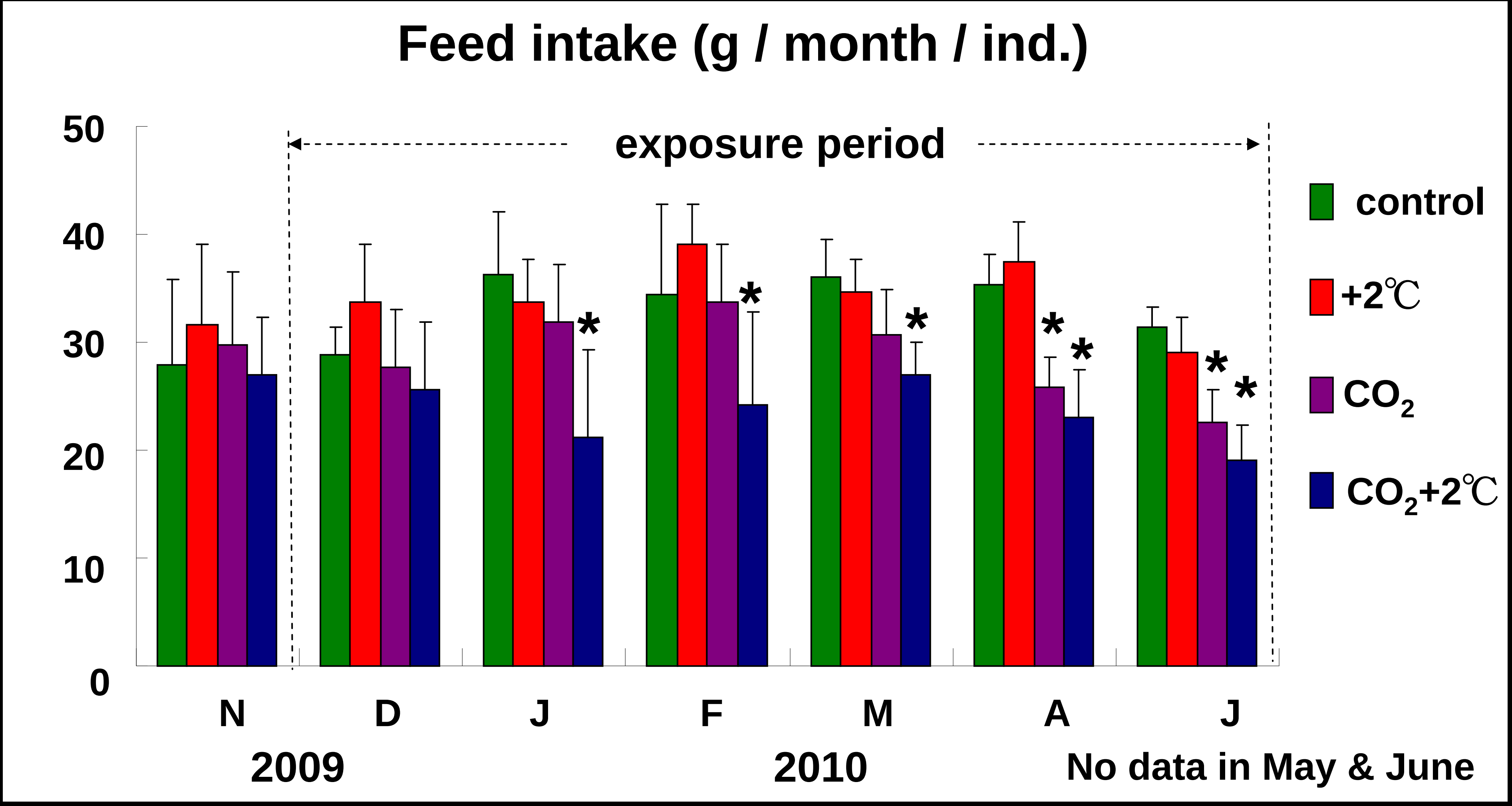


Results: Spawning



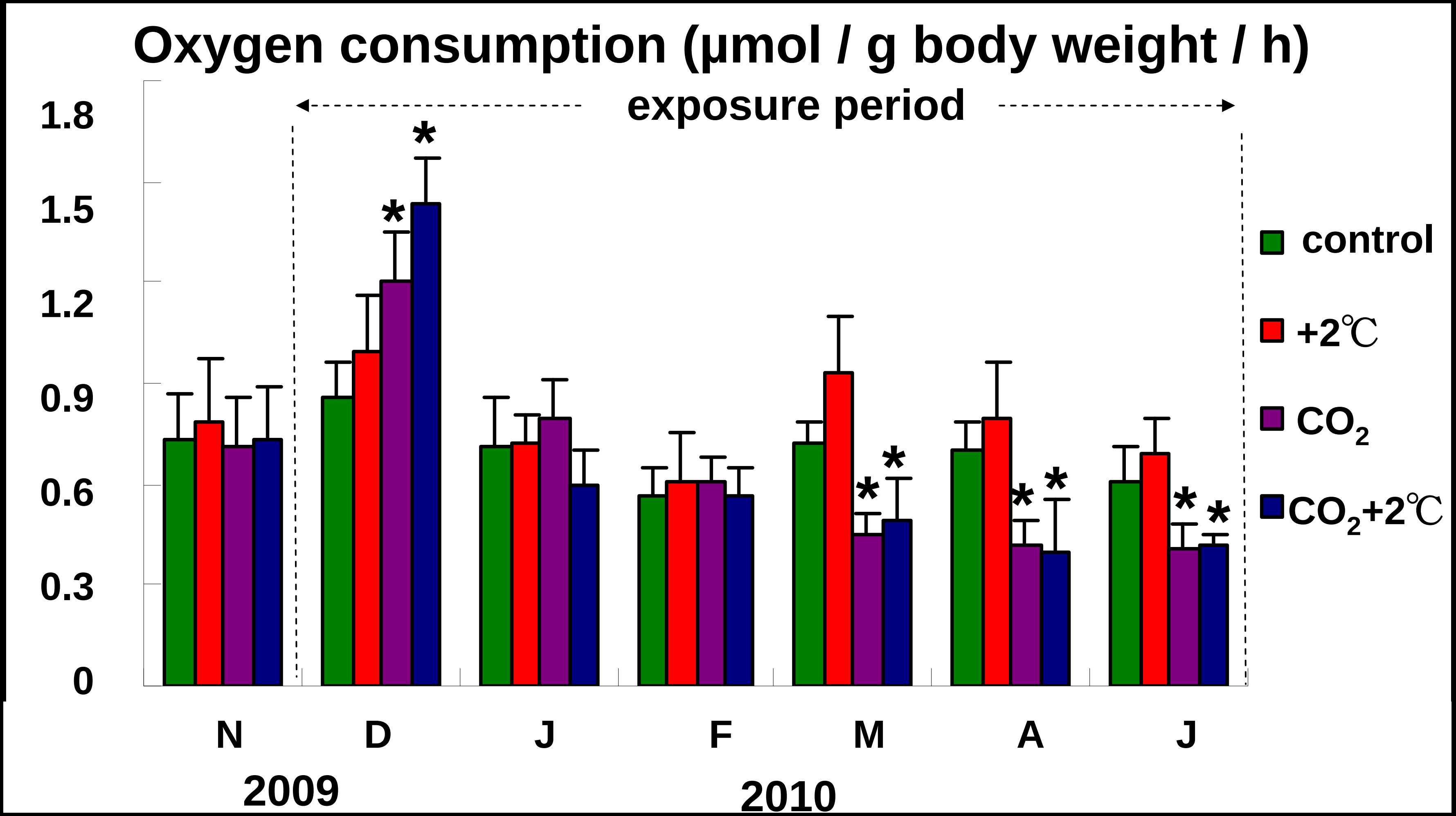
	Date	Female	Spawned eggs / ind.	Fertilization
control	Feb. 9th/25th	4	1.4×10^6	>95%
+2℃	Jan. 15th	4	1.1×10^6	>95%
CO_2	-	3	-	-
CO_2+2℃	-	6	-	-

Results: Feed Intake



* : significant difference from control (p<0.05)

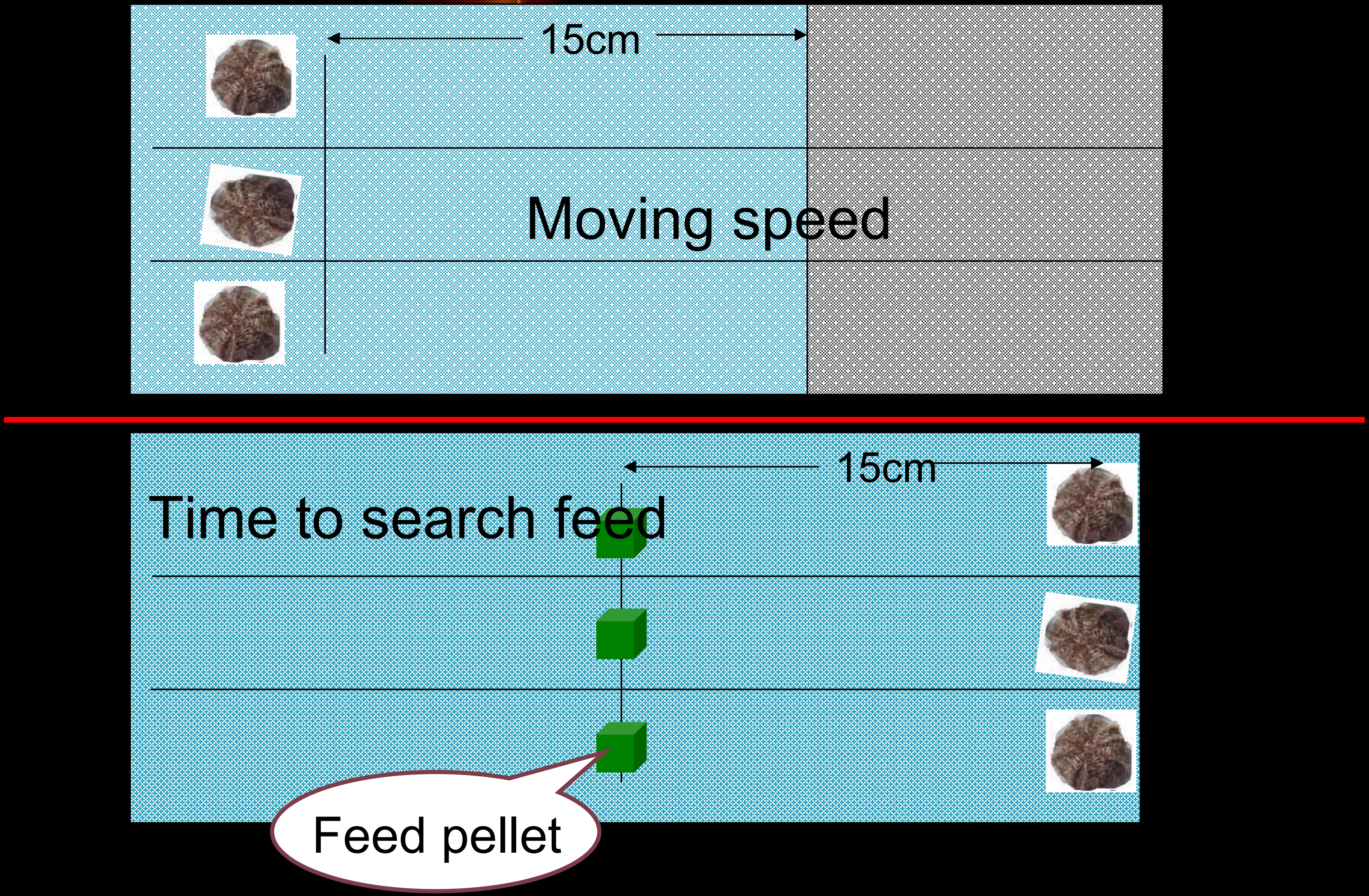
Results: Oxygen consumption



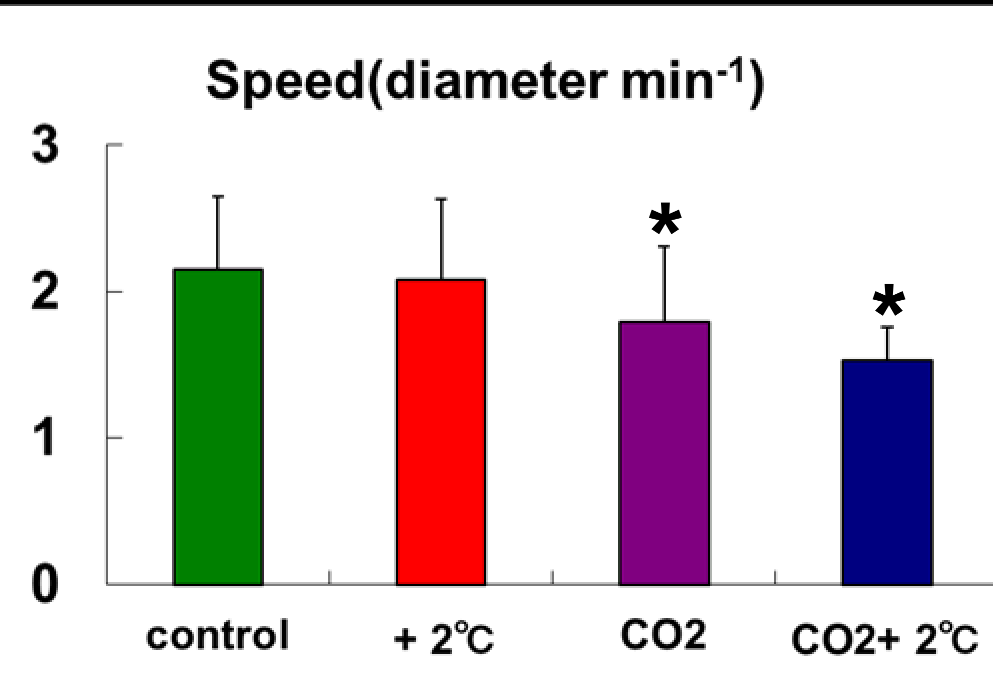
* significant difference from control (*p*<0.05)

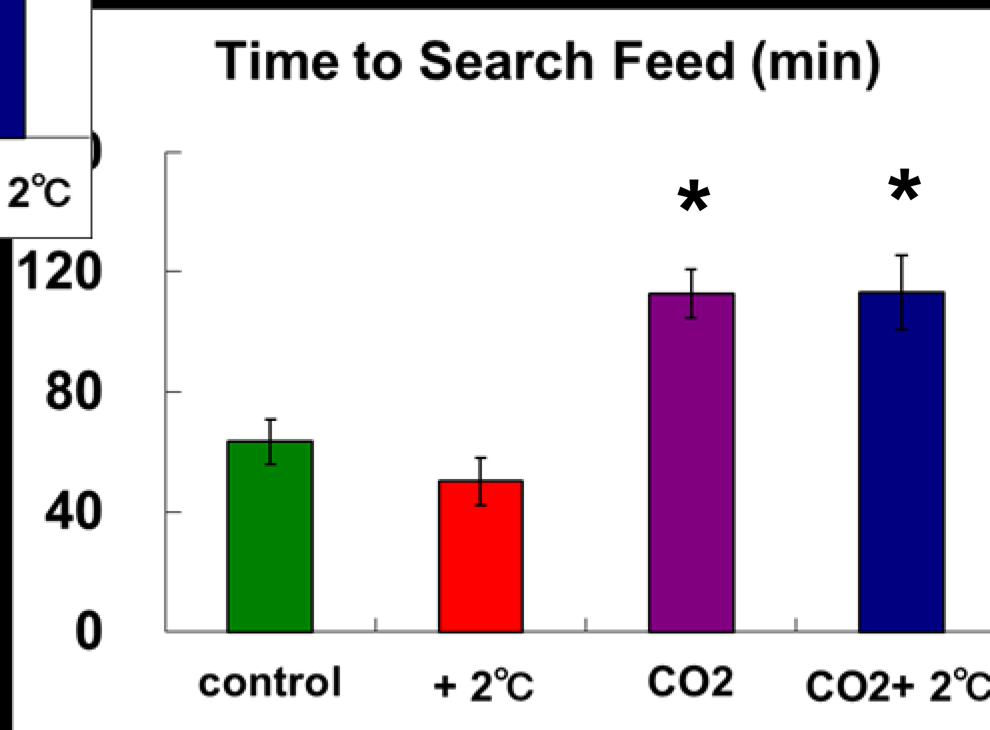
Motility

42 μphotons $m^{-2}s^{-1}$



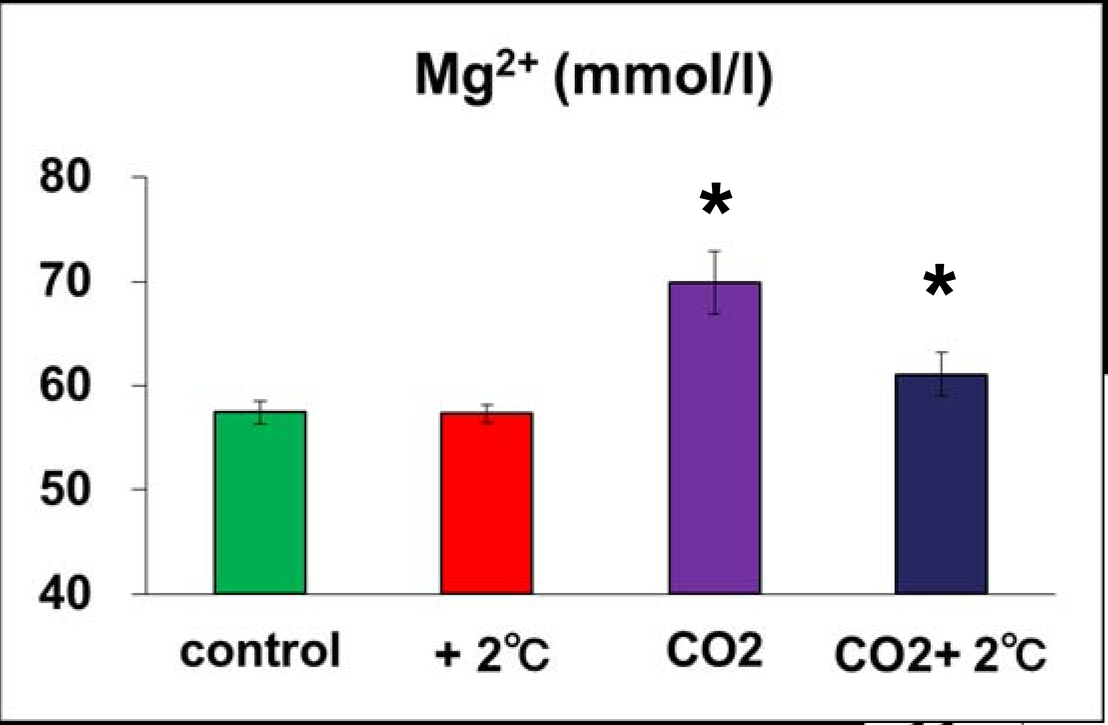
Results: Motility

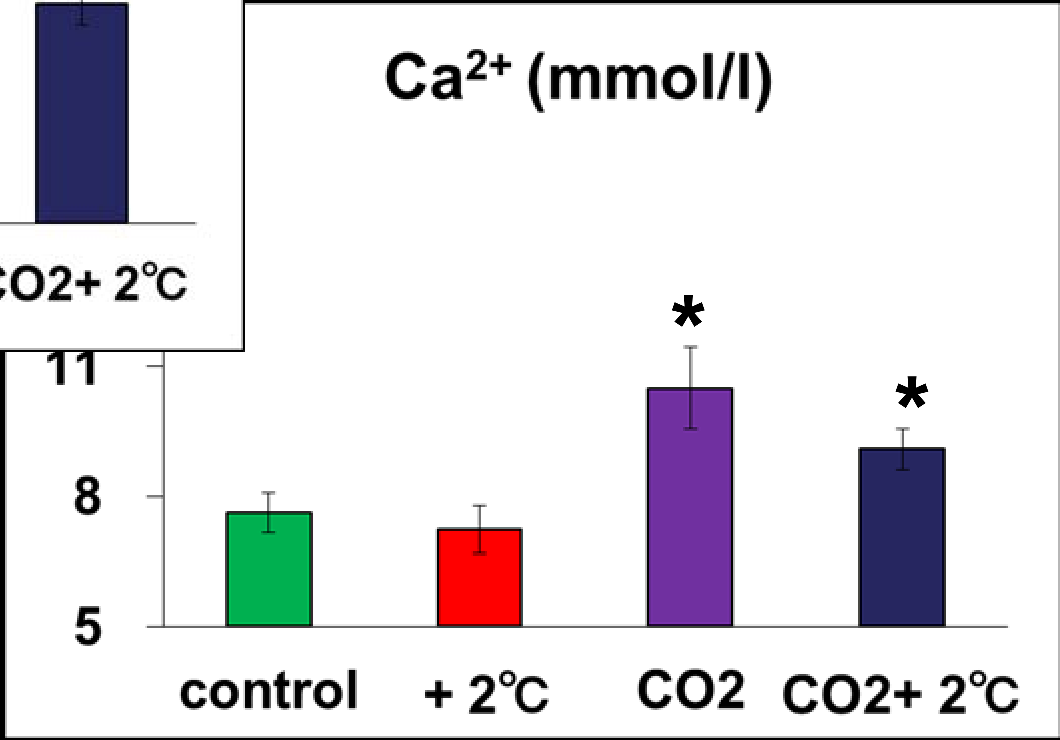




* : significant difference from control (p<0.05)

Results: Cations in Coelomic Fluid

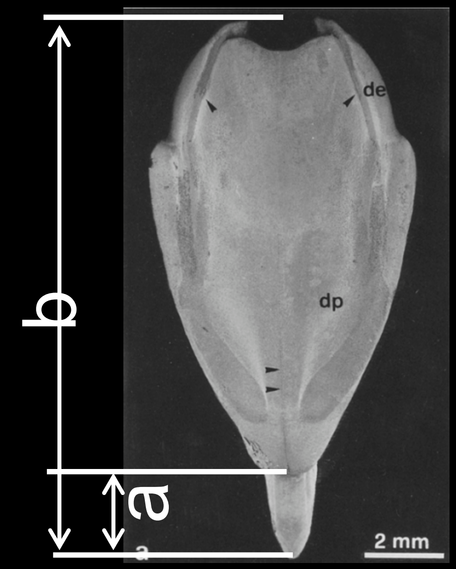


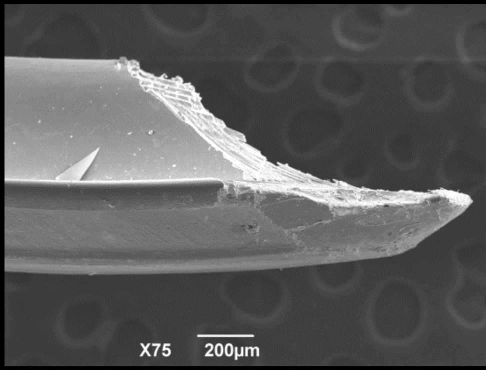


* : significant difference from control (p<0.05)

Morphology of Aristotle's Lantern

1. Weight index of lantern (lantern/ body weight)
2. Length index of tip (a/b).
3. Concentration of ions in tip (Mg^{2+} & Ca^{2+})
4. Fine structure of tooth (by SEM).



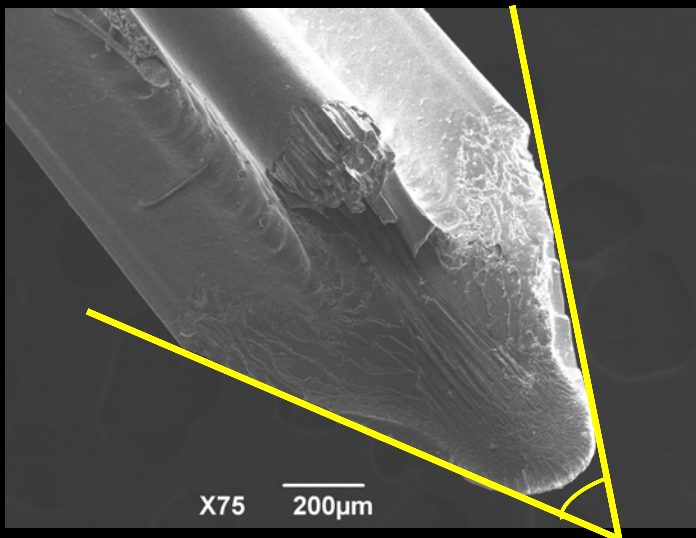


had been detected.

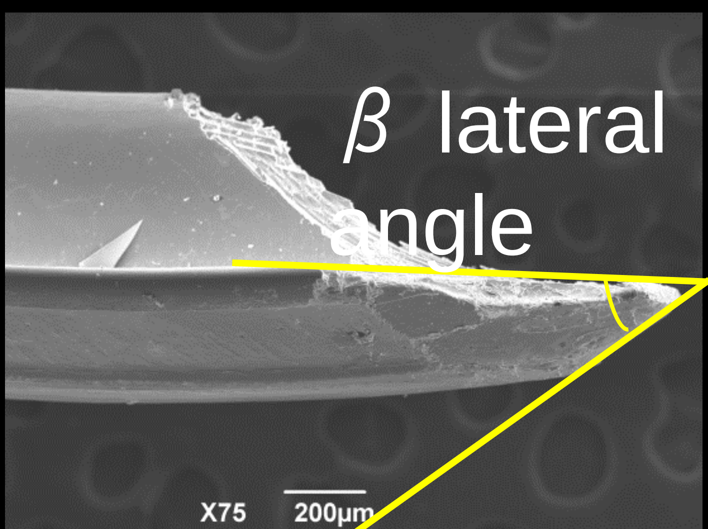
Results: Morphology of Aristotle's Lantern

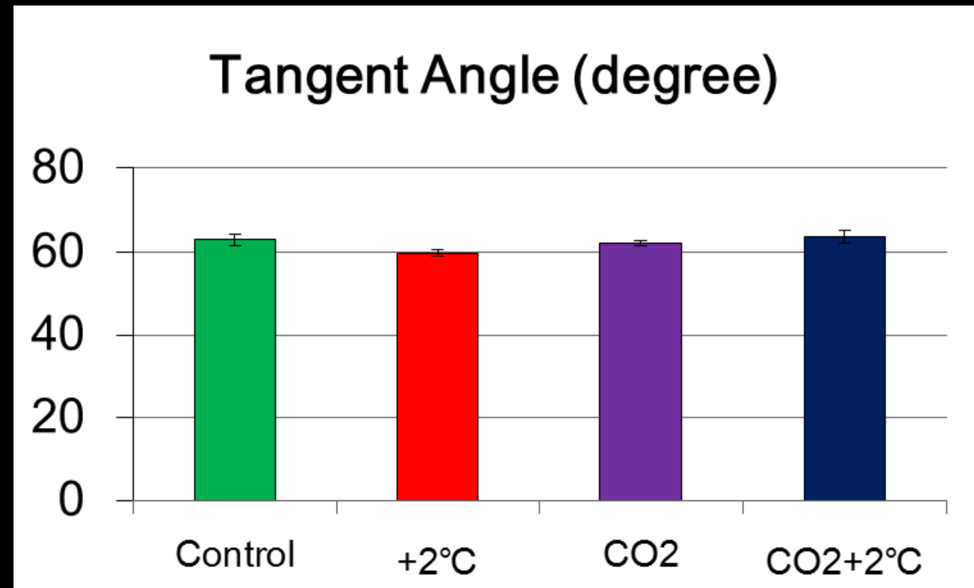
Treatment	Lantern weight index (%)	Lantern length index (%)	Mg/Ca mol/mol
Control	1.68 ± 0.07	26.08 ± 0.25	0.132 ± 0.003
+2°C	1.69 ± 0.07	24.75 ± 0.58	0.134 ± 0.003
CO_2	1.74 ± 0.05	26.11 ± 0.39	0.134 ± 0.002
CO_2 +2°C	1.77 ± 0.07	26.24 ± 0.55	0.132 ± 0.003

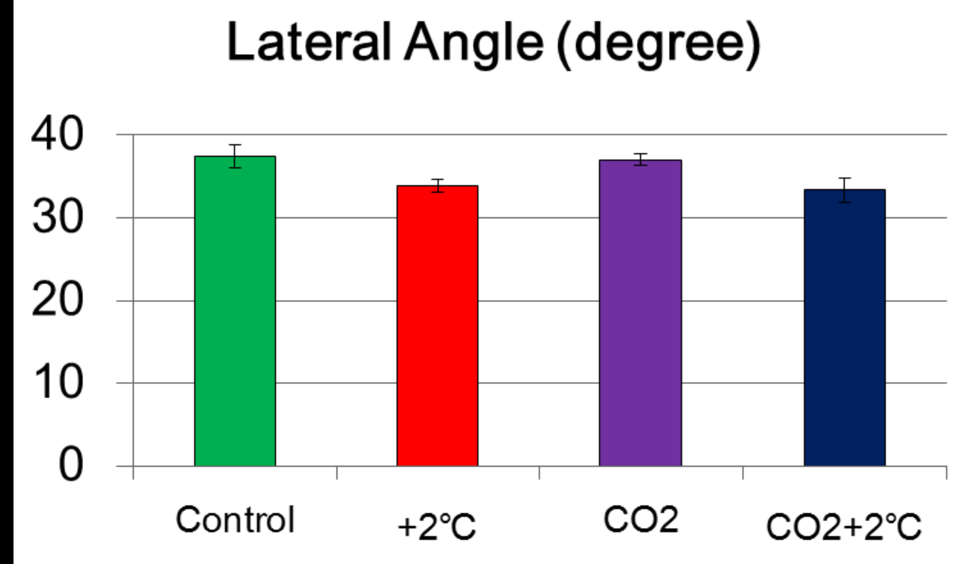
Results: Morphology of Aristotle's Lantern



α tangent angle







Discussion and Summary

1. Combined with the response of early development, inhibition of gonad development and spawning may disrupt the fecundity of sea urchins in future oceans under climate changes.
2. Reduced feed intake combined with suppression of O_2 consumption may lead to the malnutrition or physiological disorder.

Discussion and Summary

3. The three observed inhibition in sea urchin ‘s performance: gamete release, food intake, and mobility may be all effected by neuromuscular activities in respective structures.
4. Sea urchins under environmental stresses (CO_2 and temp.) may shift their energy allocation (reproduction and calcification).

Thank you for your attention!