Dissolution: the Achilles' heel of gastropods in an acidifying ocean

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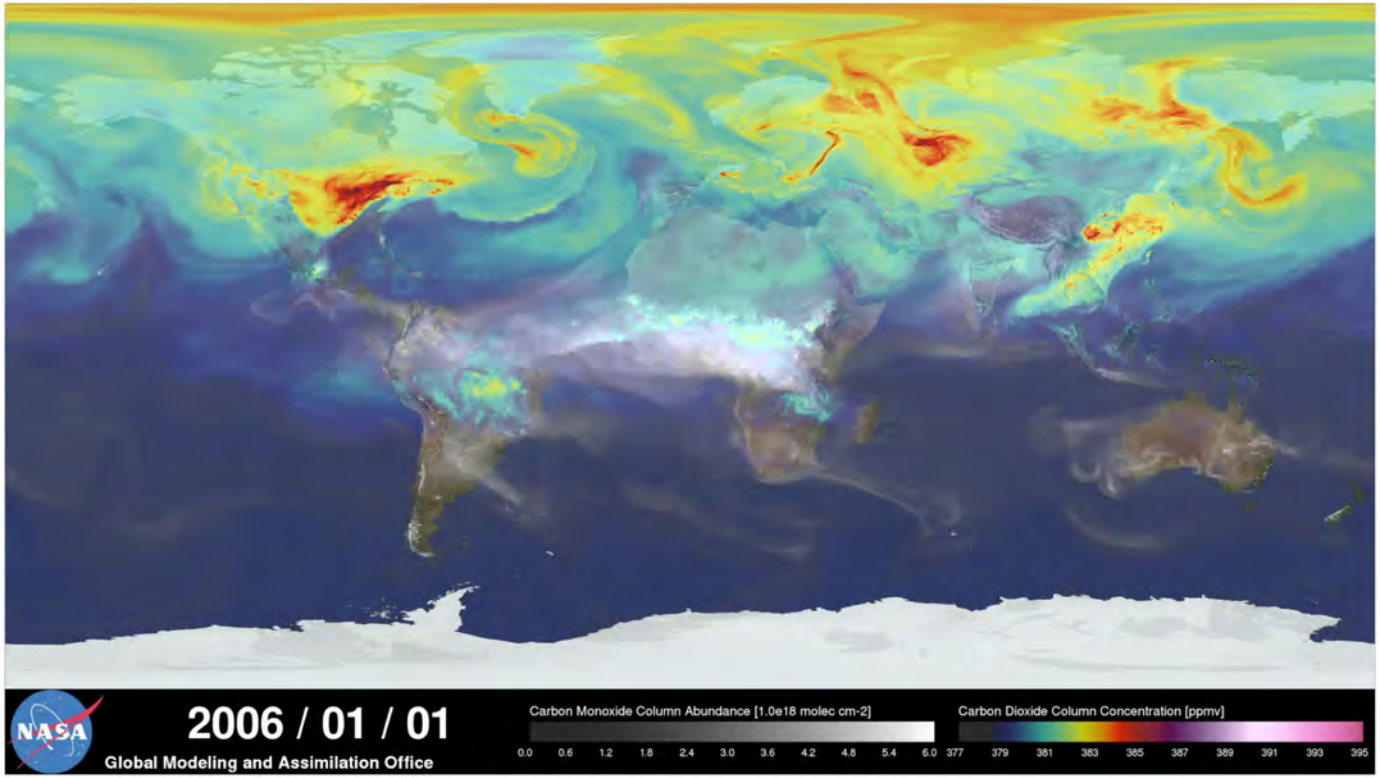
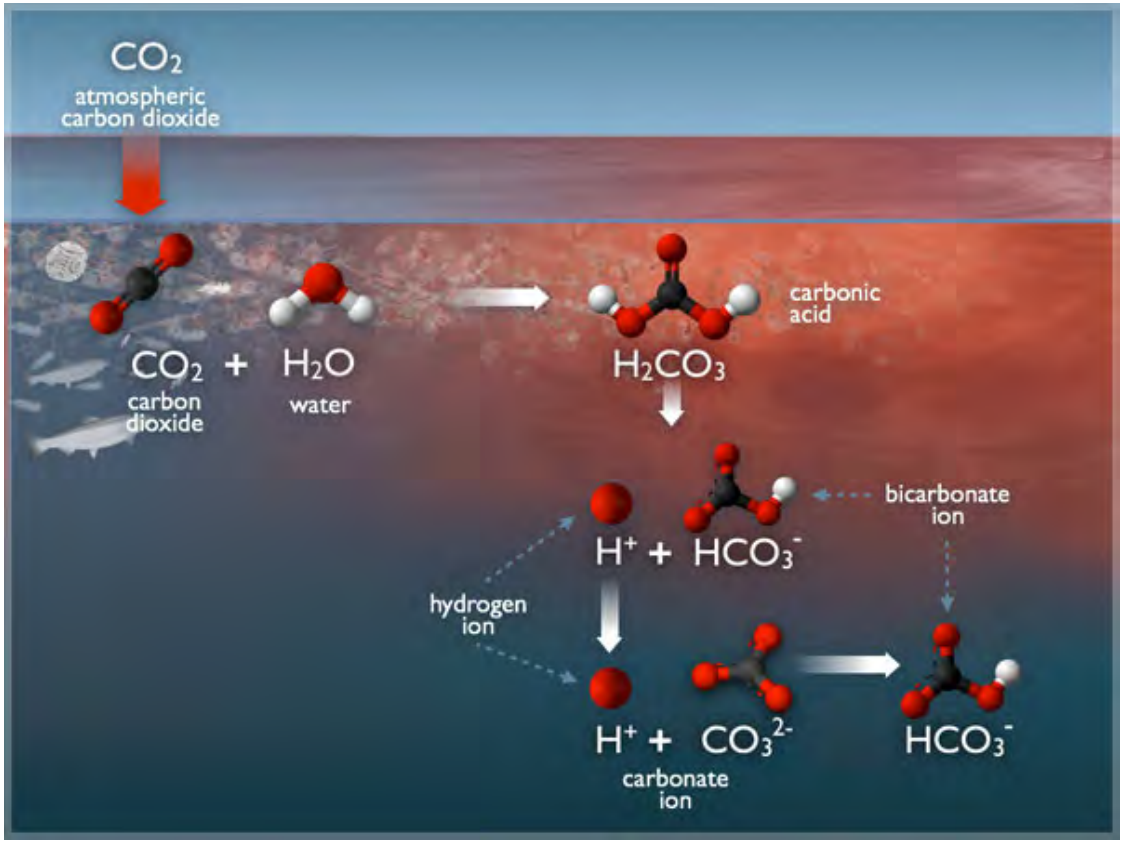
Atmospheric Carbon Dioxide



Ocean Acidification

Ocean acidification alters the carbonate chemistry of the oceans



Credit: NOAA

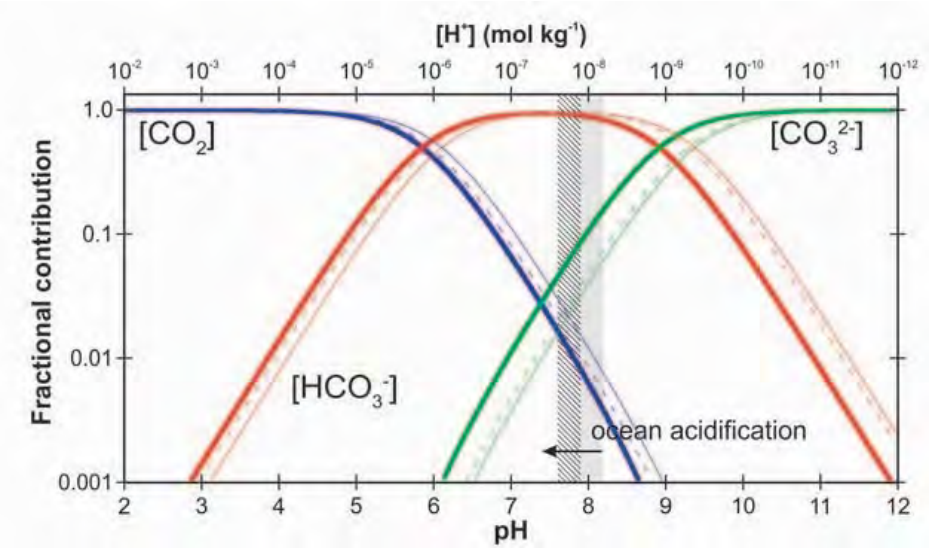
Some generalisations have emerged for OA

OA results in ‘winners and losers’ due to differences in their physiological and ecological traits

Plants and Algae may benefit due to increased availability of CO_2 (aq) and HCO_3^-

Calcifying organisms are generally sensitive to OA

Calcification and dissolved ions



$Ca^{2+} + CO_3^{2-} = CaCO_3$

The amount of Carbonate [CO_3^{2-}] will decrease with OA

- Does this affect their ability to construct $CaCO_3$?

Most organisms don't use CO_3^{2-} directly from seawater

- They use CO_2 or HCO_3^- and transform it into CO_3^{2-} internally

Calcification and Dissolution

Calcification – biological process where dissolved ions are used to build calcium carbonate ($CaCO_3$) shells and skeletons

Calcification – Dissolution = Net Calcification Rate

Dissolution – an abiotic process where the $CaCO_3$ shell or skeleton can be broken down.

$CaCO_3 \rightarrow Ca^{2+}_{(aq)} + CO_3^{2-}$

Calcification and Dissolution

Important to consider
both calcification and dissolution!

Dissolution will occur throughout lifetime, so need long-term exposure to ocean acidification

→ Volcanic CO_2 seeps

frontiers in Marine Science

ORIGINAL RESEARCH
published: 12 October 2018
doi: 10.3389/fmars.2018.00371

Dissolution: The Achilles' Heel of the Triton Shell in an Acidifying Ocean

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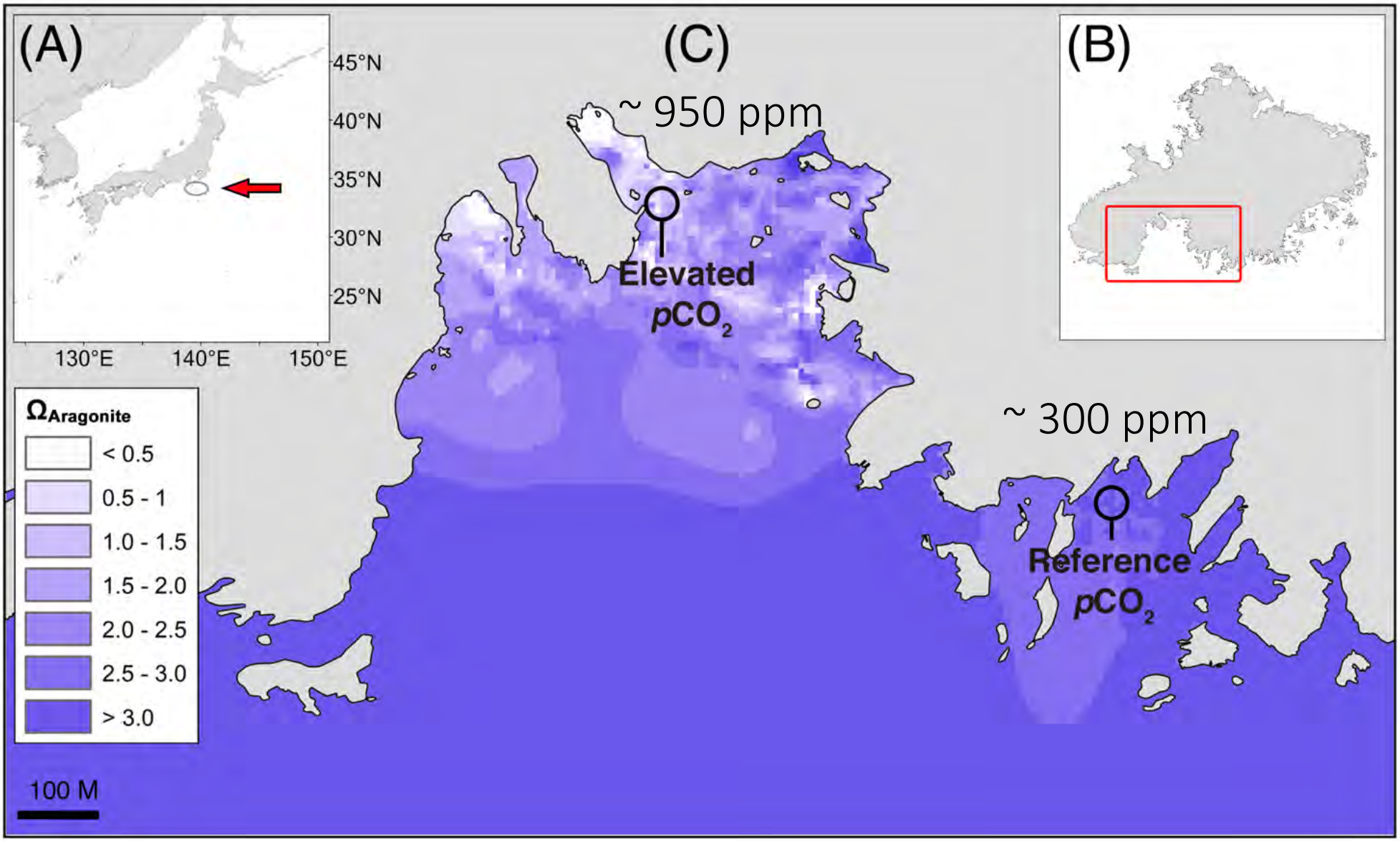
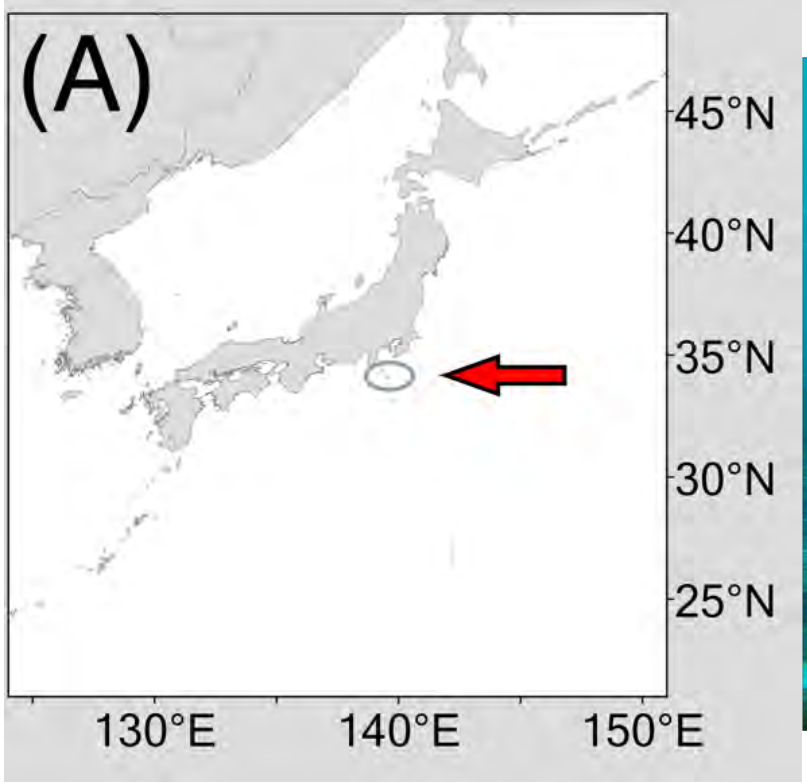
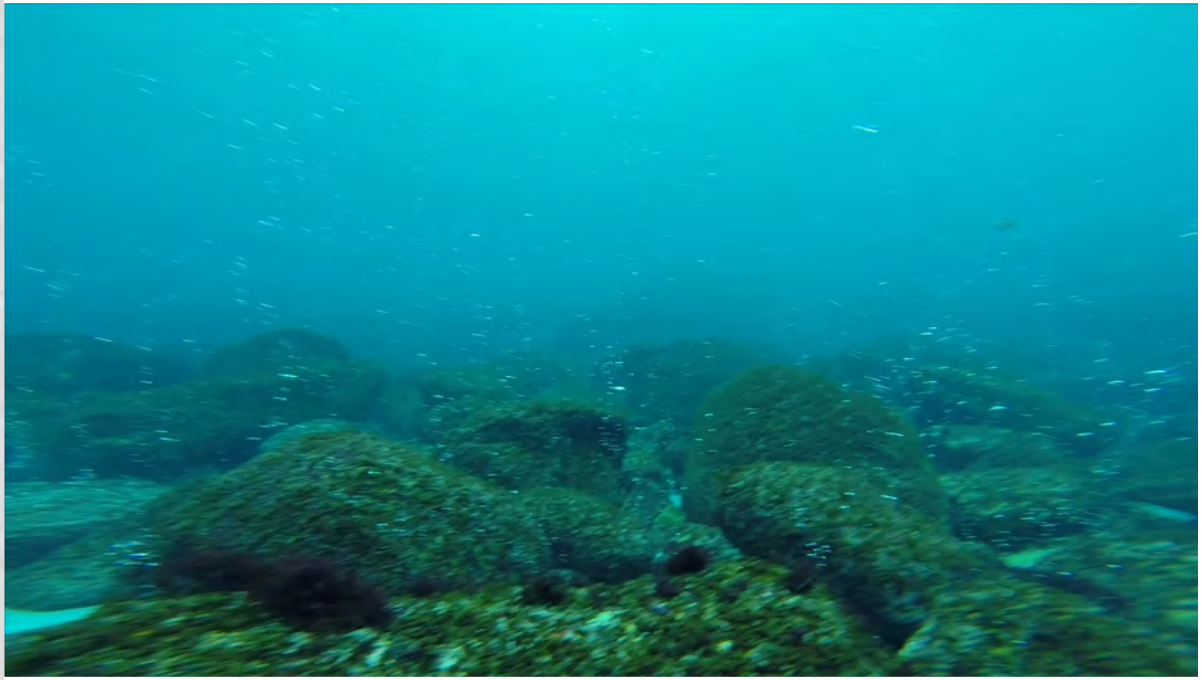
Shikine-Jima CO_2 seep



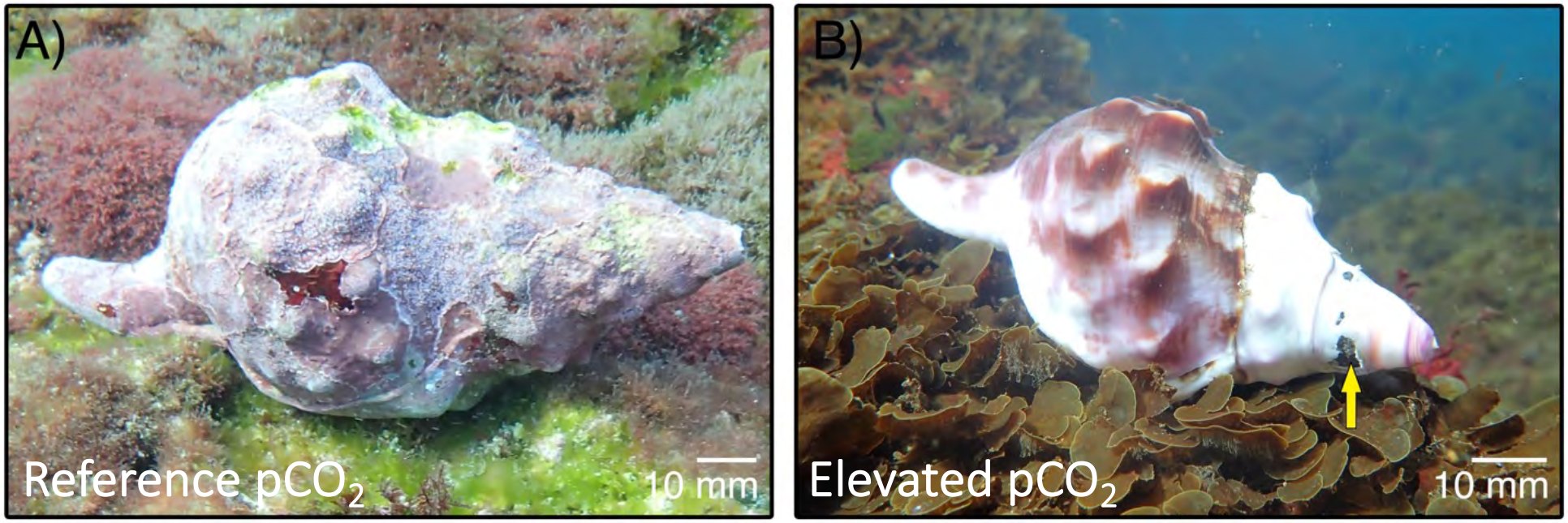
Shikine-Jima CO_2 seep

~ 950 ppm





Gastropod (*Charonia lampas*)

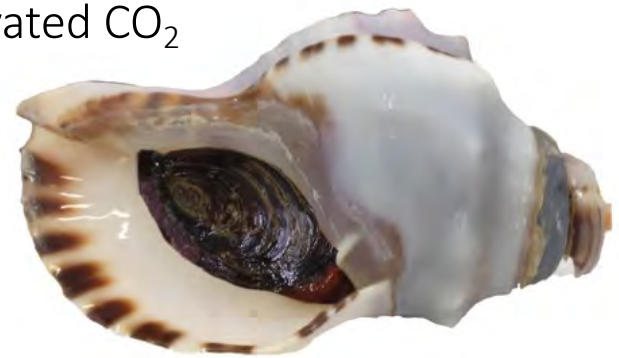


Note extensive coverage of encrusting organisms and intact apex region. At the elevated pCO_2 site shells had a smooth bare shell surface and severely eroded apex regions (arrow).

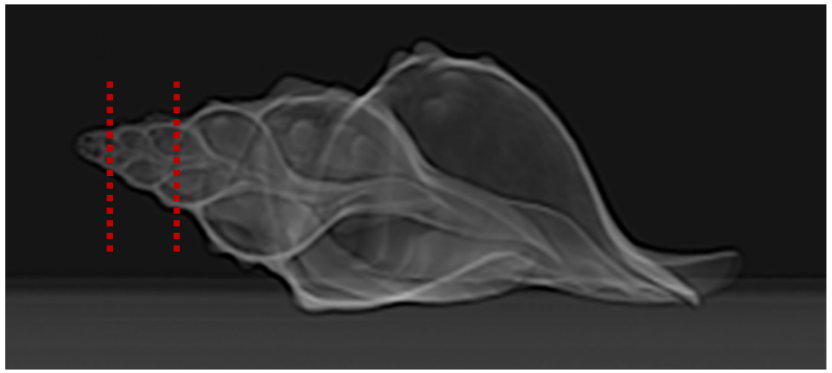
3D models from CT Scanning

Reference CO_2

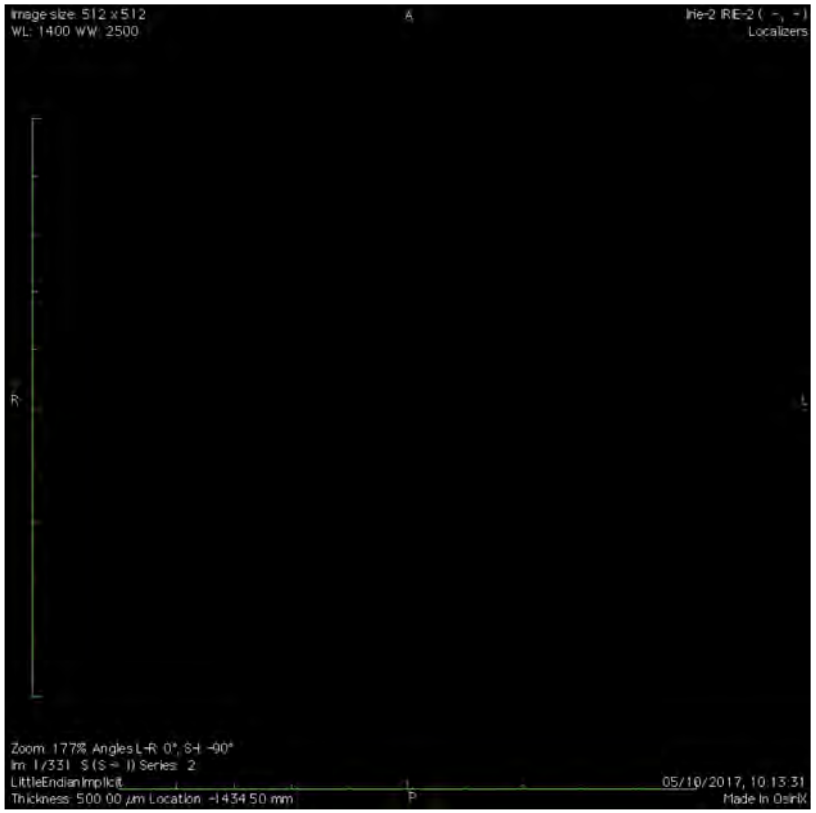
Elevated CO_2



5mm Slices



3D models from CT Scanning

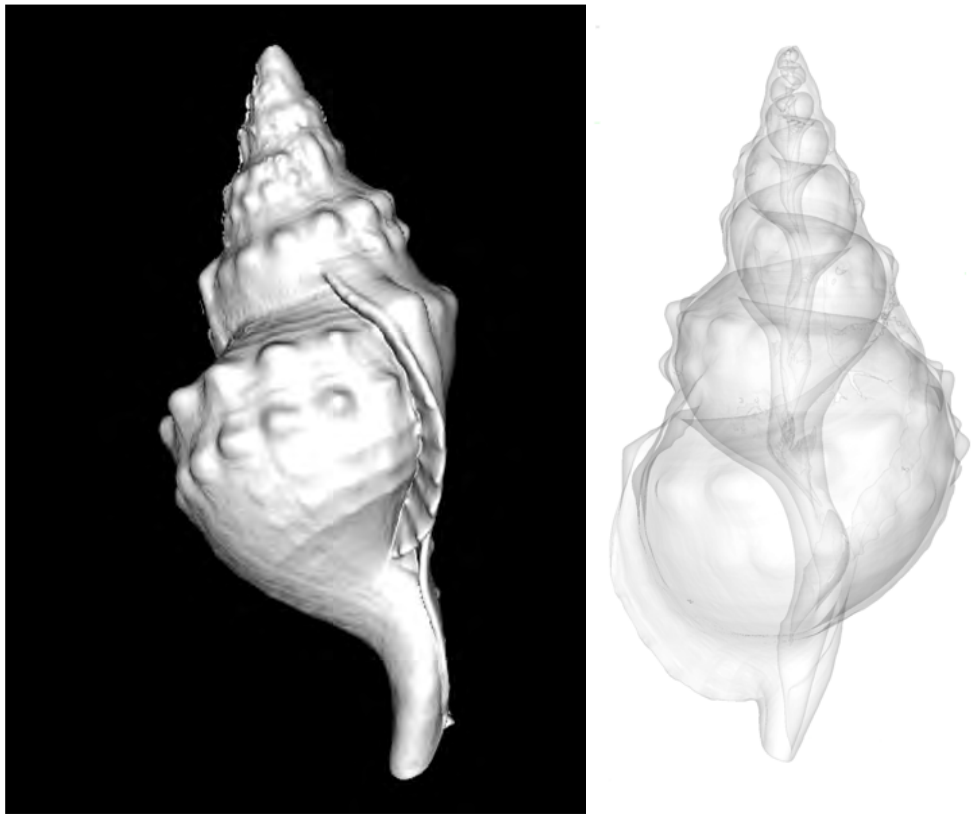


Reference pCO_2

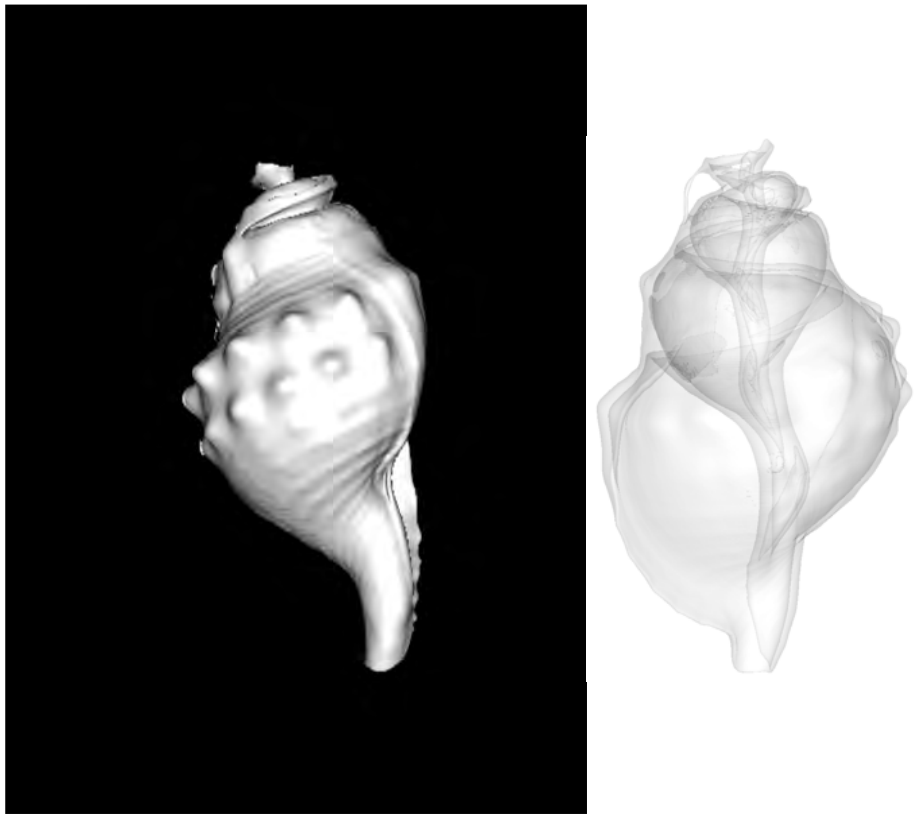
Elevated pCO_2

Can see the density and thickness of the shell

3D models from CT Scanning



Reference pCO_2

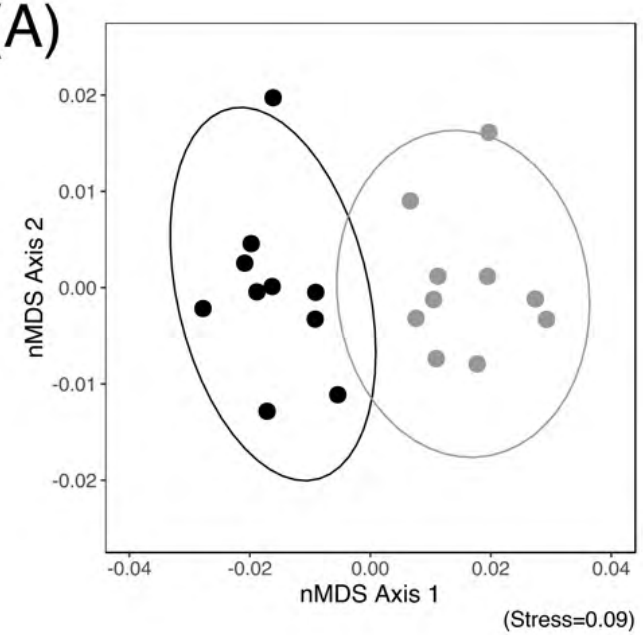


Elevated pCO_2

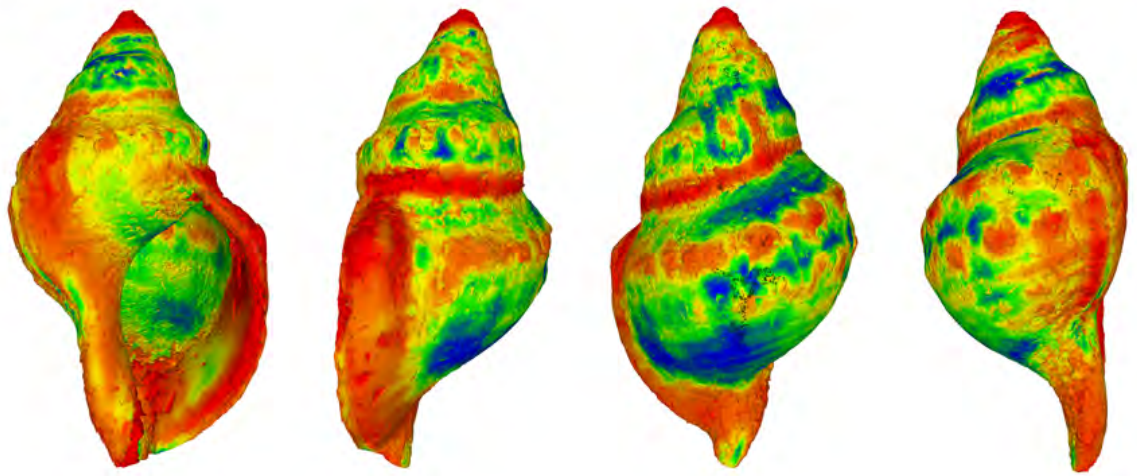
Geometric Morphometric Surface Analysis

We calculated differences in the shape of the surface between specimens using the 3D surface rendering.

(A)



(B)

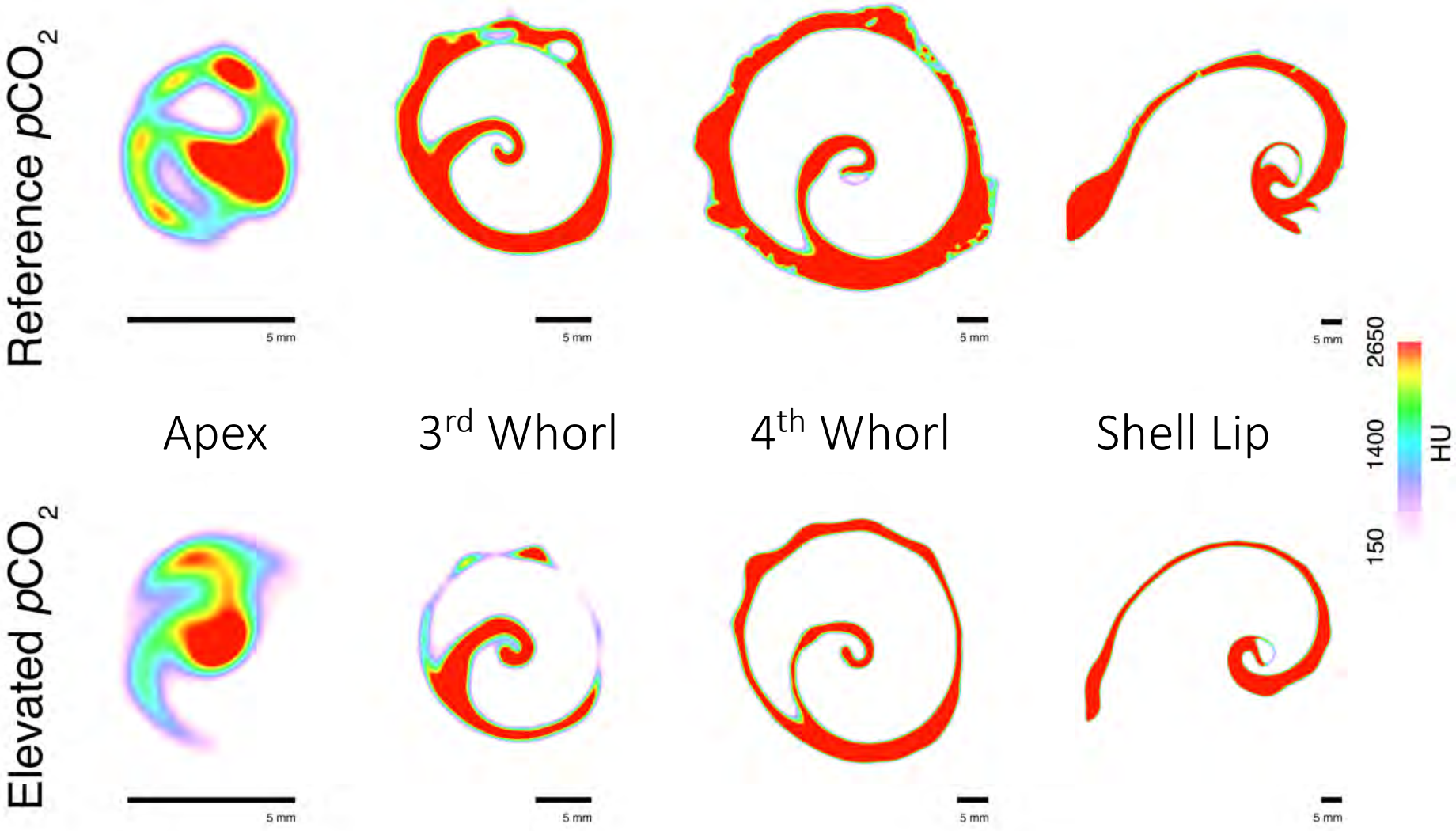


Reference pCO_2

Elevated pCO_2

The shape of the surface significantly differed between sites

Shell Thickness and Density

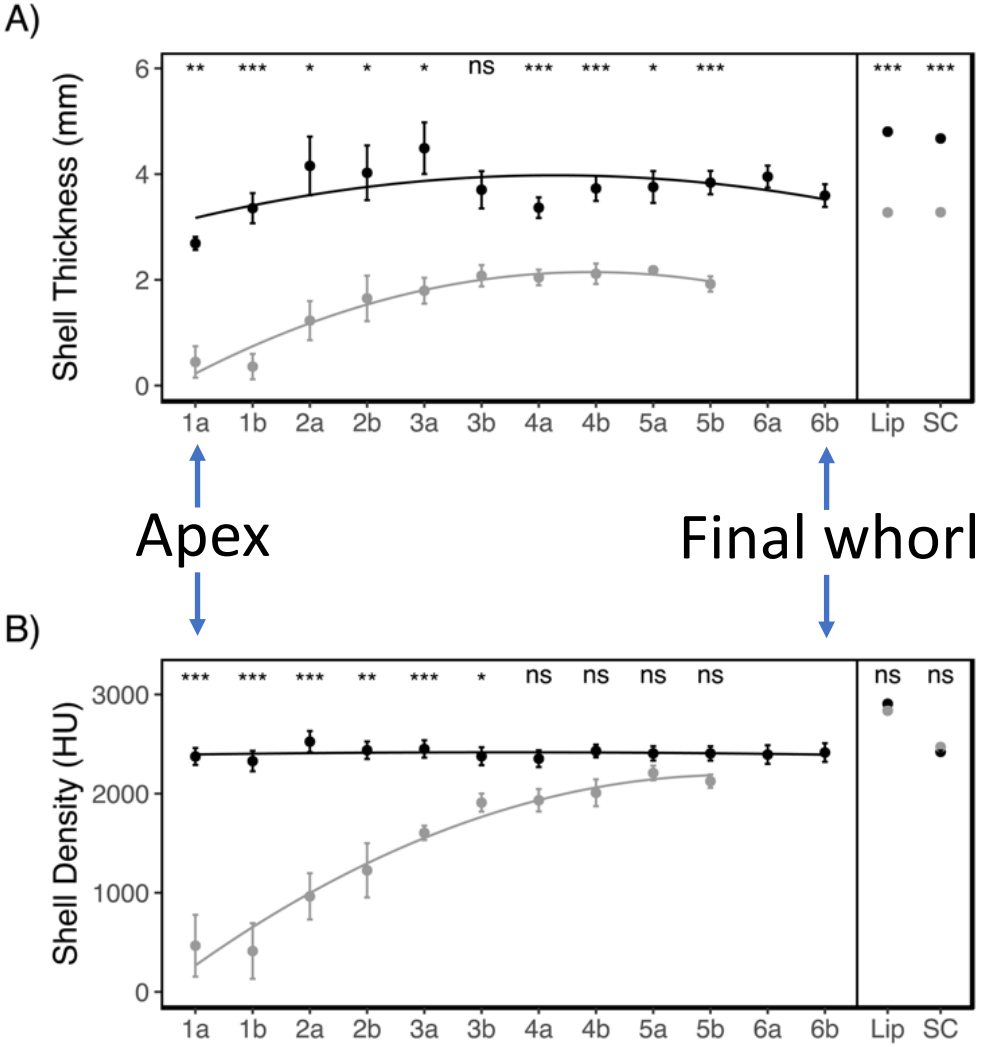


Thinner and less dense

Charonia lampas shell thickness and density

Reference pCO_2 ●

Elevated pCO_2 ●



Consistently thinner shell suggesting physiological constraint on their ability to calcify

Shell dissolution and damage most pronounced in the oldest parts of the shell, but similar in newer shell

Results Summary

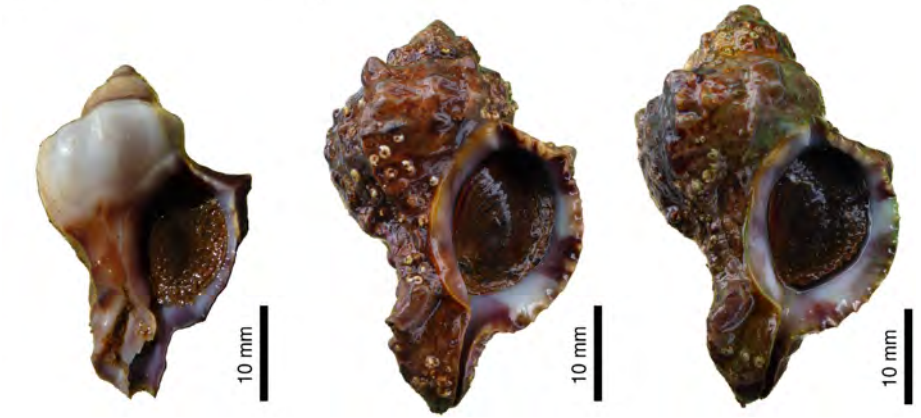
The results suggest:

- Reduced calcification rates
  - Reduced size
  - Reduced shell thickness
- Increased dissolution rates
  - Reduced shell density
  - Apex truncation and shell damage
- Loss of epiphyte coverage

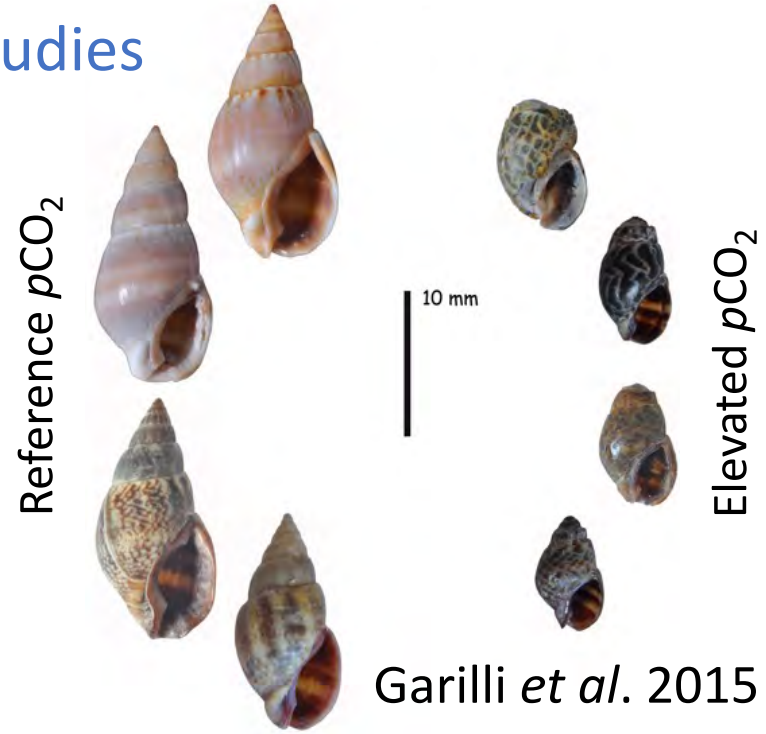
Results Summary

Similar to other CO_2 seep gastropod studies

Elevated pCO_2 Reference pCO_2



Harvey et al. 2016, Scientific Reports



Garilli *et al*. 2015 NCC

Ecological Consequences

If our findings are observed across a range of gastropods

Ocean acidification could lead to:

- Reduced Growth and Size
  - Reduced top-down control?
  - Reduced reproduction (energy deficit)
  - Reduced seafood production
- Greater risk of predation
  - due to thinner shell, and higher visibility

Conclusion

- Both calcification and dissolution need to be considered in order to understand the long-term impact of OA.

- Dissolution is often overlooked, but may be particularly important as not biologically-controlled
  - Thereby limiting acclimation and adaptation potential

- Therefore, although many marine organisms might be able to upregulate calcification rates to counter ocean acidification, they may not be able to maintain their shells or skeletons due to dissolution.