Does calcification reduce grazing on coralline algae?

Patrick T. Martone
University of British Columbia, Botany Department
International Temperate Reefs Symposium, 10 Jan 2023

Coralline algae

- Calcifying red algae that deposit $CaCO_3$ in cell walls

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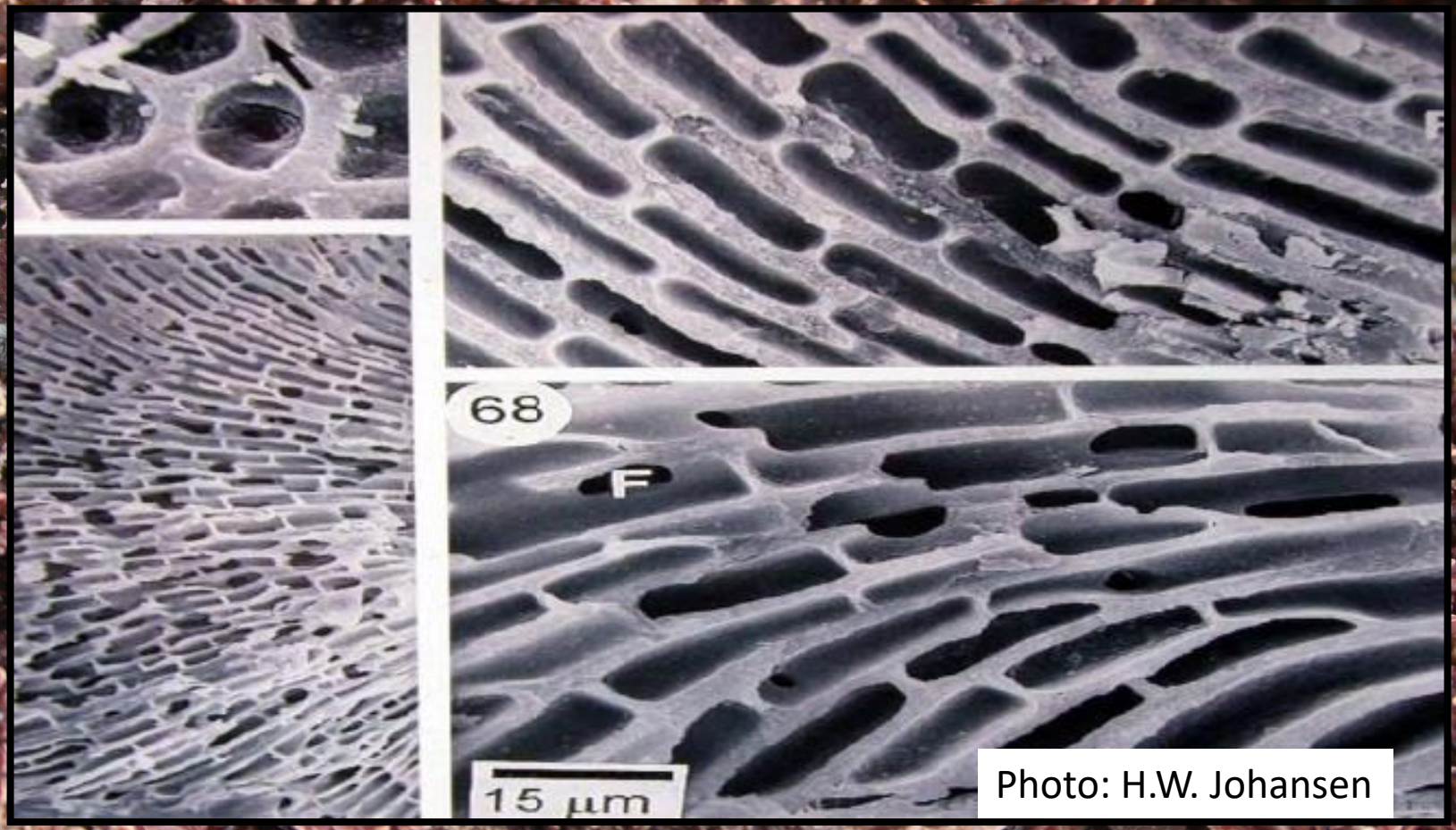
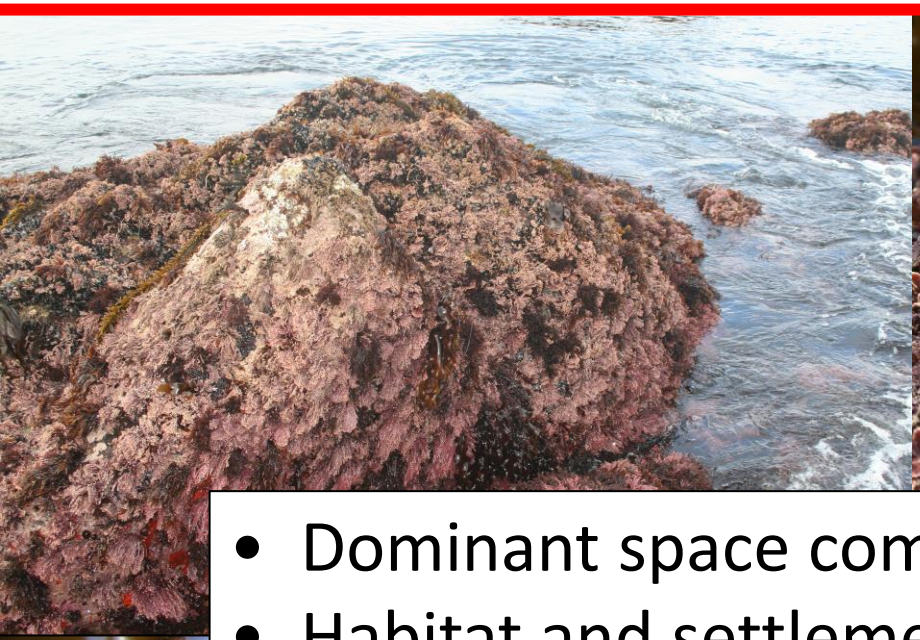
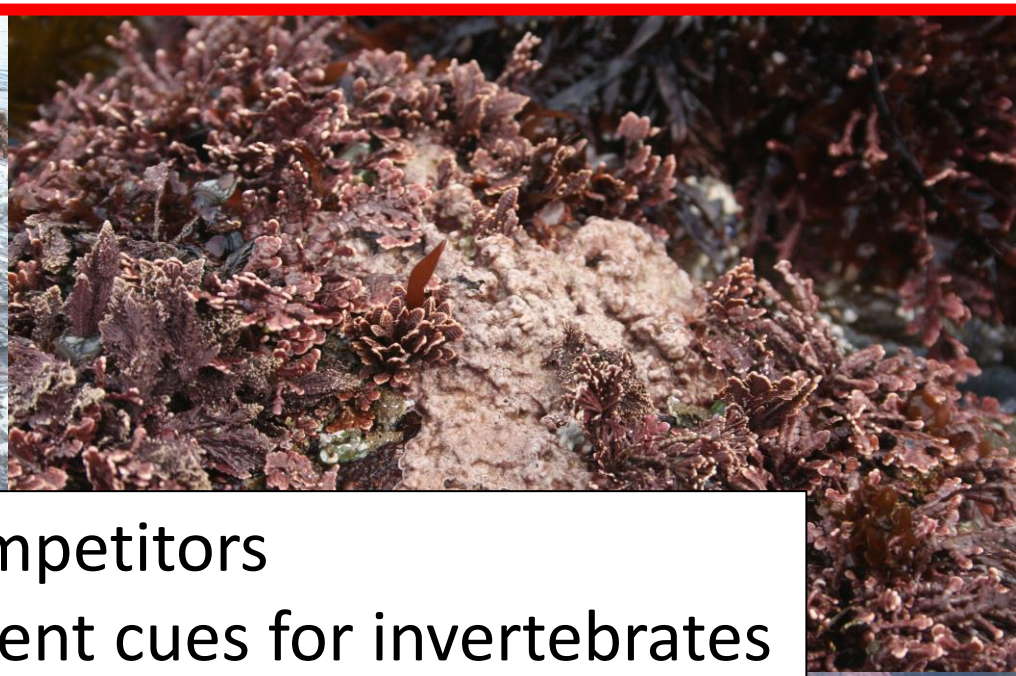


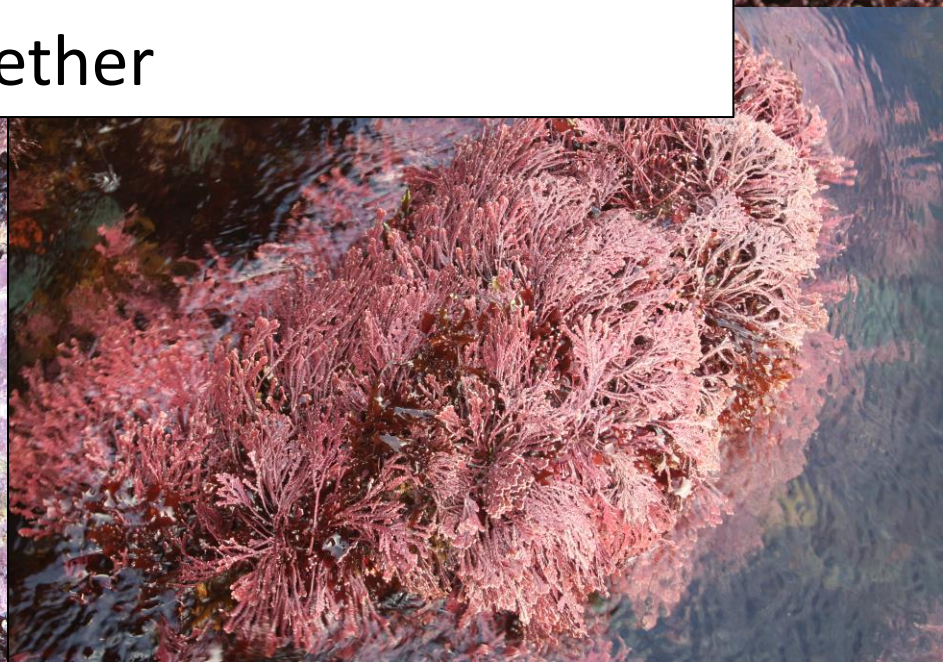
Photo: H.W. Johansen

Ecological importance of coralline algae





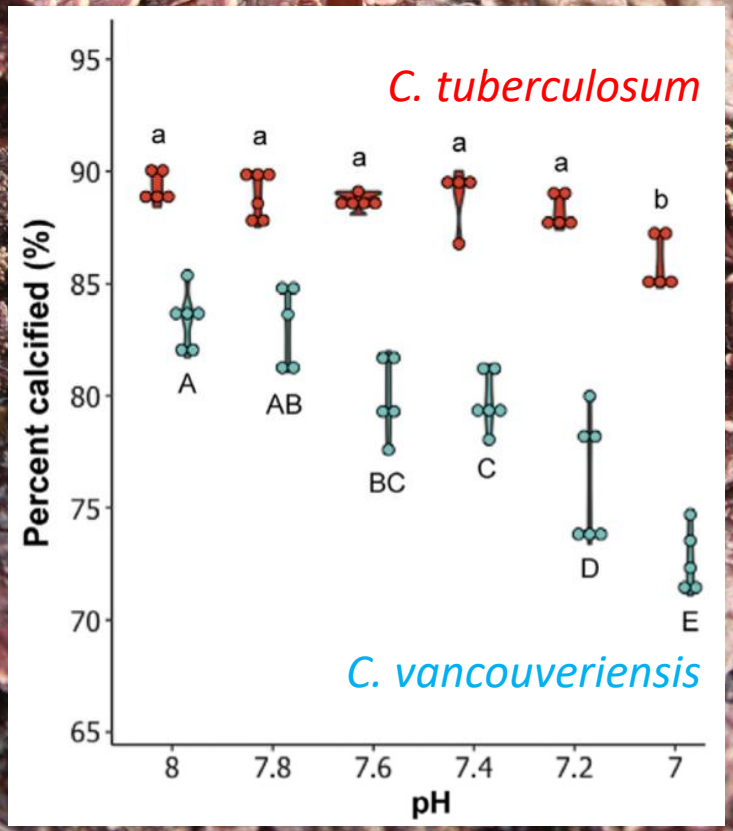
- Dominant space competitors
- Habitat and settlement cues for invertebrates
- Help cement reefs together



Ocean acidification may negatively impact corallines

- Atmospheric CO_2 dissolves into the ocean, lowering the pH, complicating the production and maintenance of calcium carbonate

- ***If calcifying coralline algae are affected***, would there be cascading effects on marine communities?



Guenther et al. 2022, *MEPS*

Adaptive significance of calcification

Anti-herbivory (e.g., Steneck 1985)

Prevent breakage / crack propagation (e.g., Padilla 1993)

Protection from UV (e.g., Gao and Zheng 2010)

Detoxification (e.g., Simkiss 1977)

Byproduct of photosynthesis (e.g., Borowitzka 1987)

…or some combination

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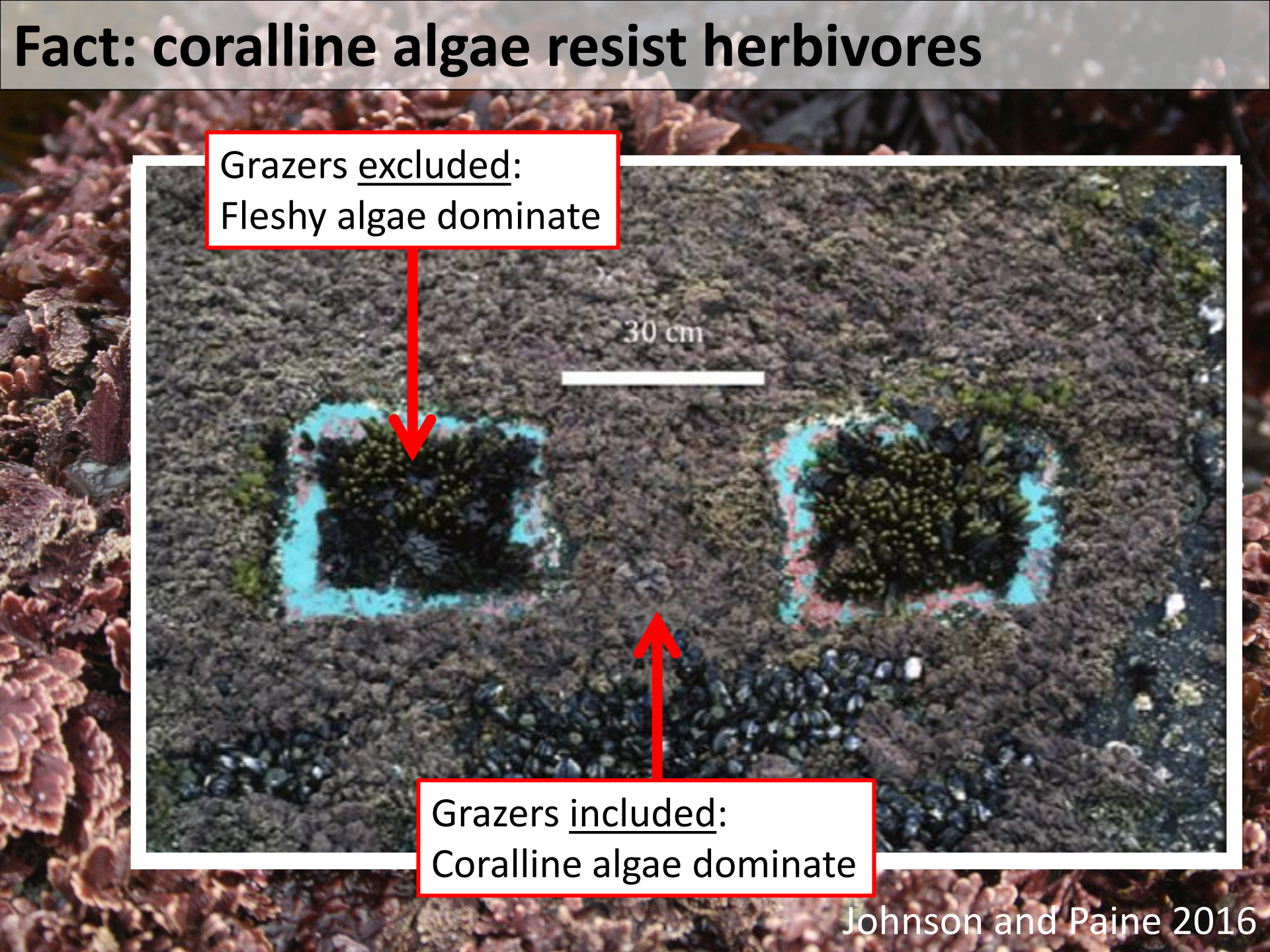
Fact: coralline algae resist herbivores



Johnson and Paine 2016

Fact: coralline algae resist herbivores

Photos: @underwaterpat, J. Burt, R. Wolf

Fact: coralline algae resist herbivores

”Urchin barren”
Dominated by
coralline algae

Photos: @underwaterpat, J. Burt, R. Wolf

Coralline algae resist herbivores … thanks to calcification?

Photo: J. Burt

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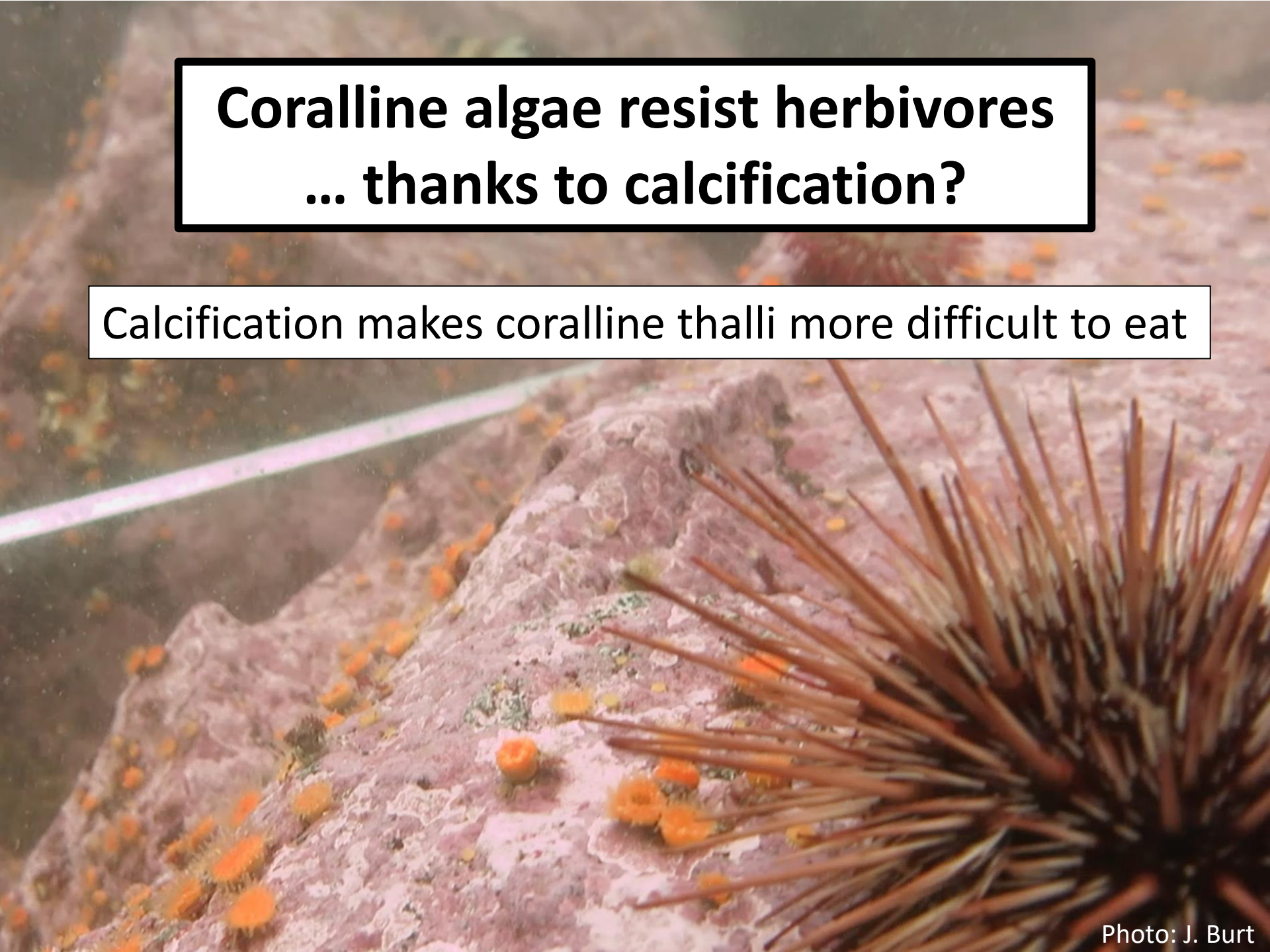
Calcification makes coralline thalli more difficult to eat



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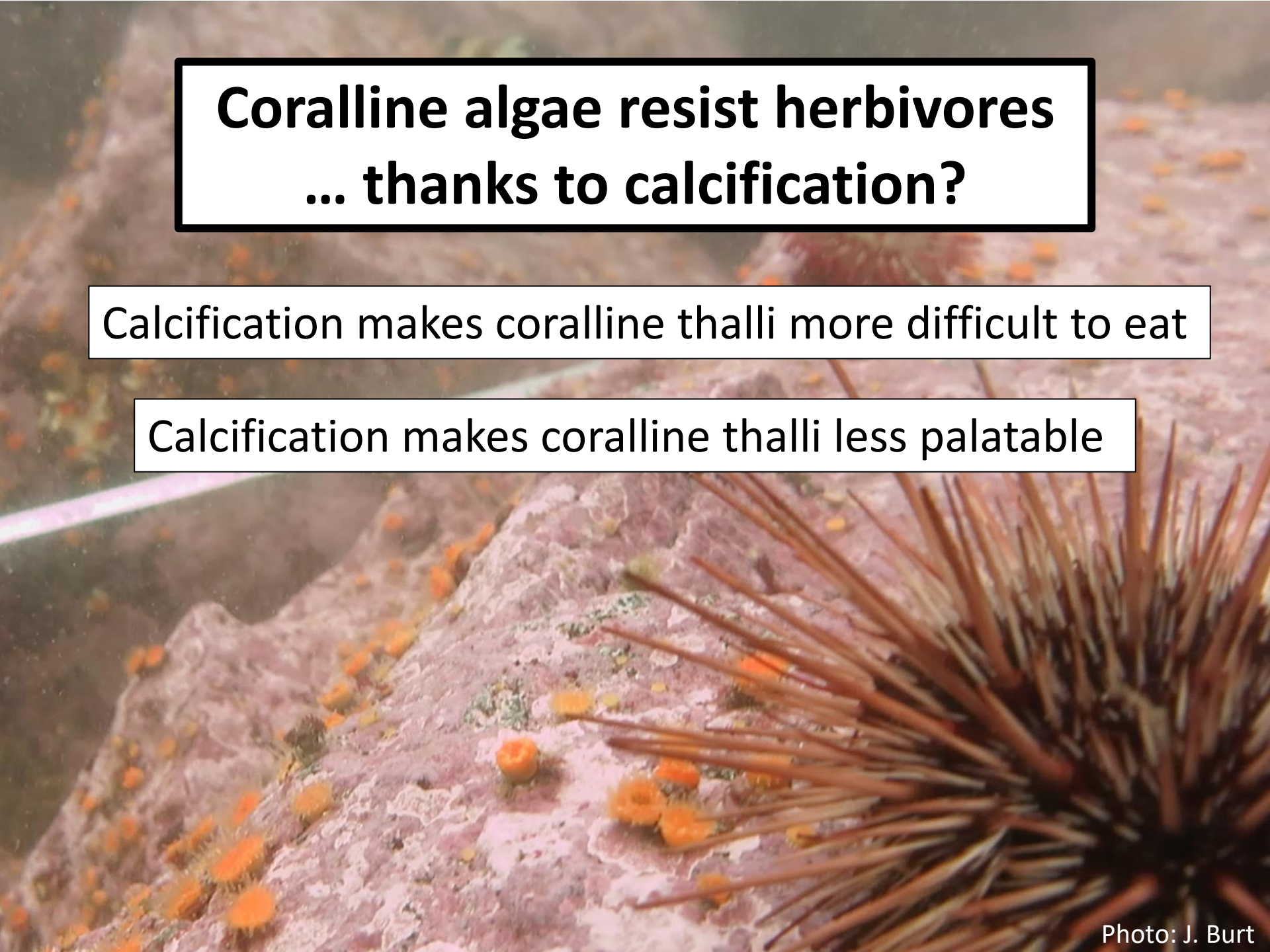

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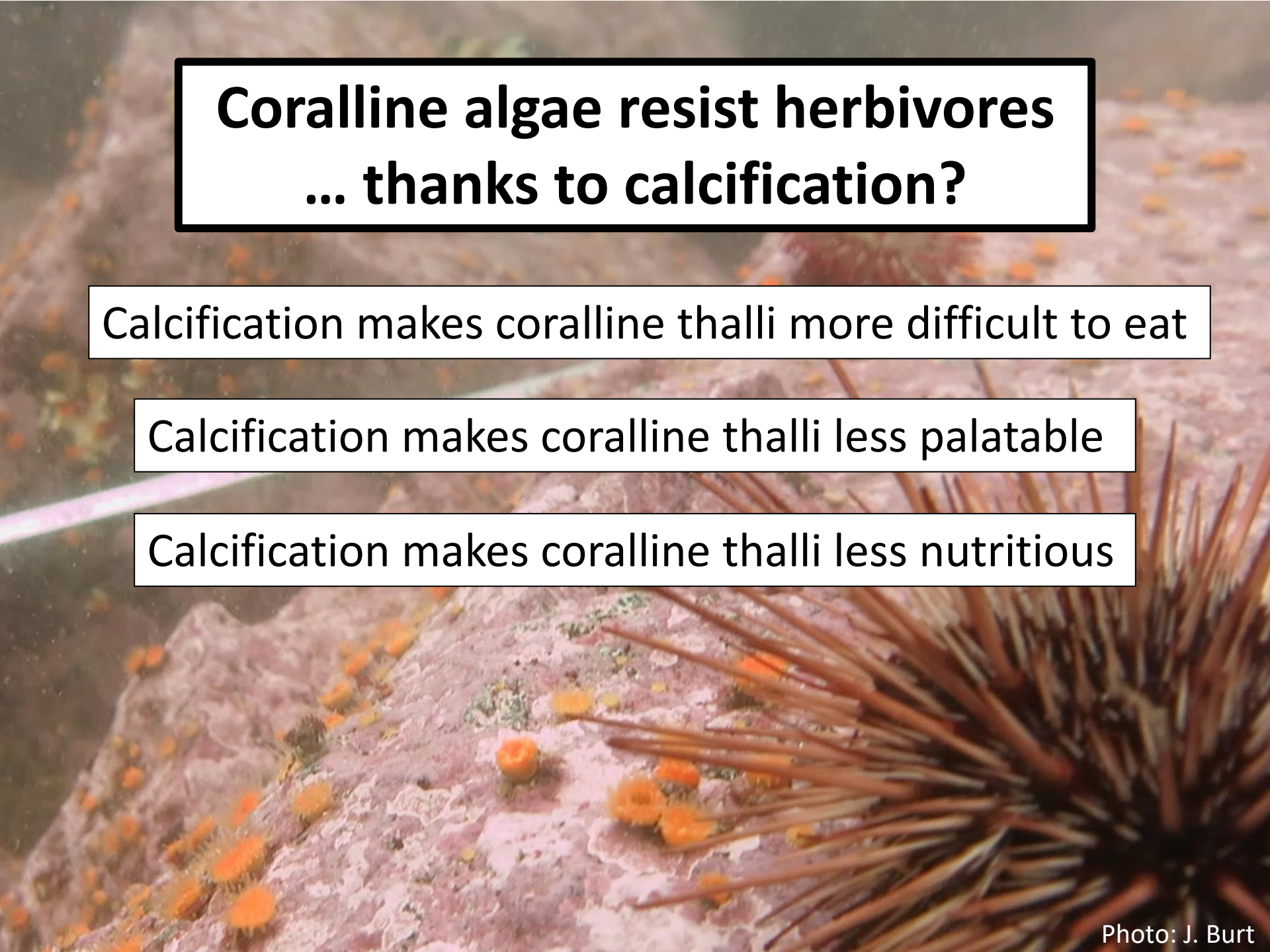

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Big assumptions, scant evidence.

Photo: J. Burt


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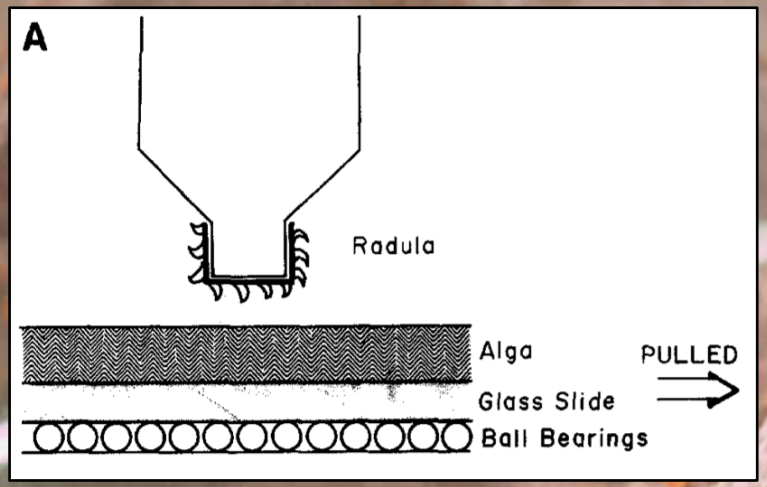
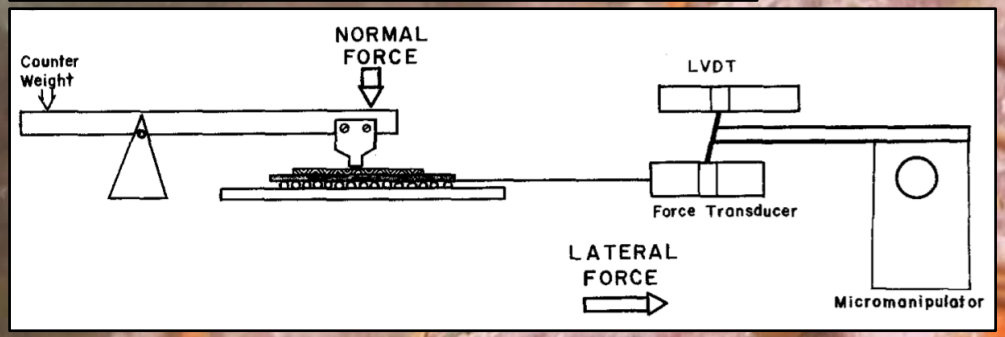
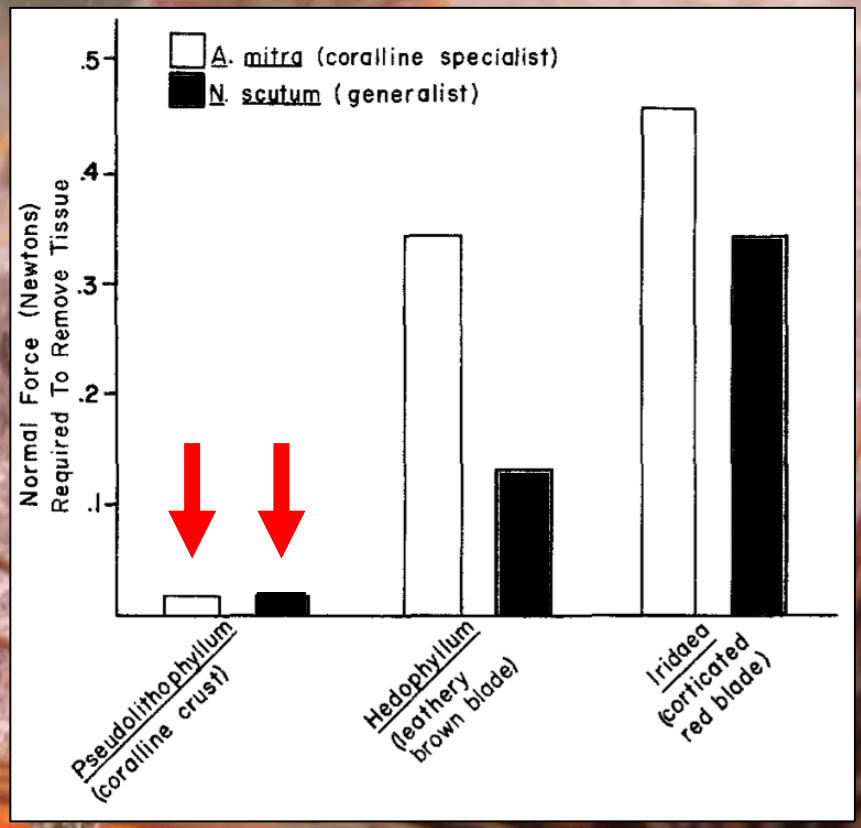
Photo: J. Burt

Coralline thalli are easier for limpets to eat







Padilla 1985, *Mar. Biol.*

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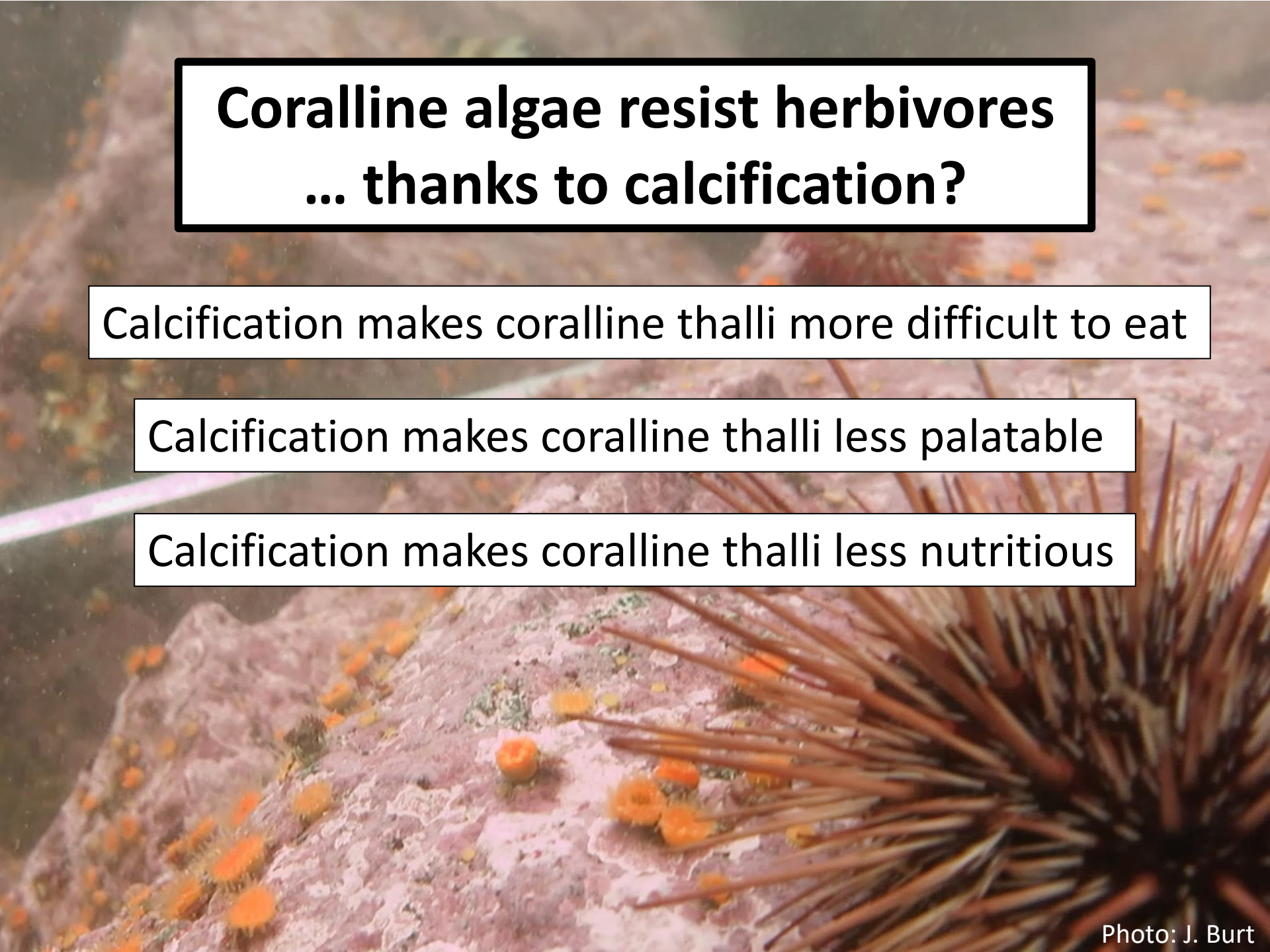

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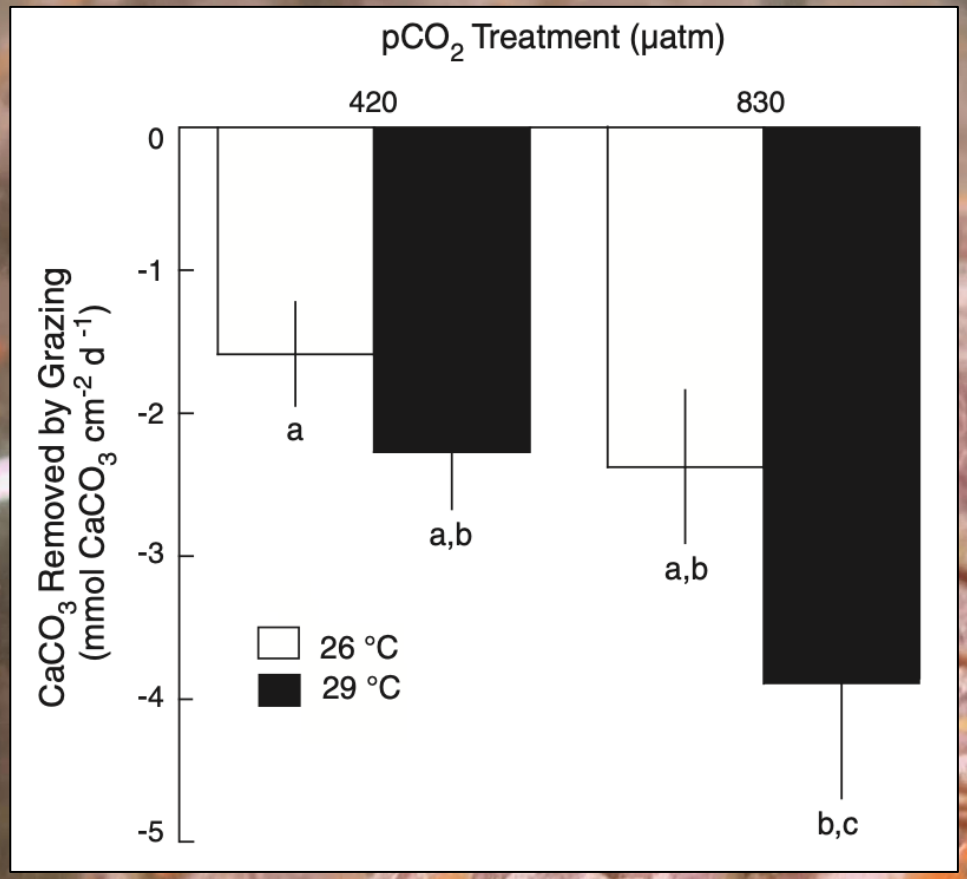
Little evidence to show that loss of CaCO3 increases palatability



In high temp X high CO2 conditions, tropical coralline crust *Hydrolithon*

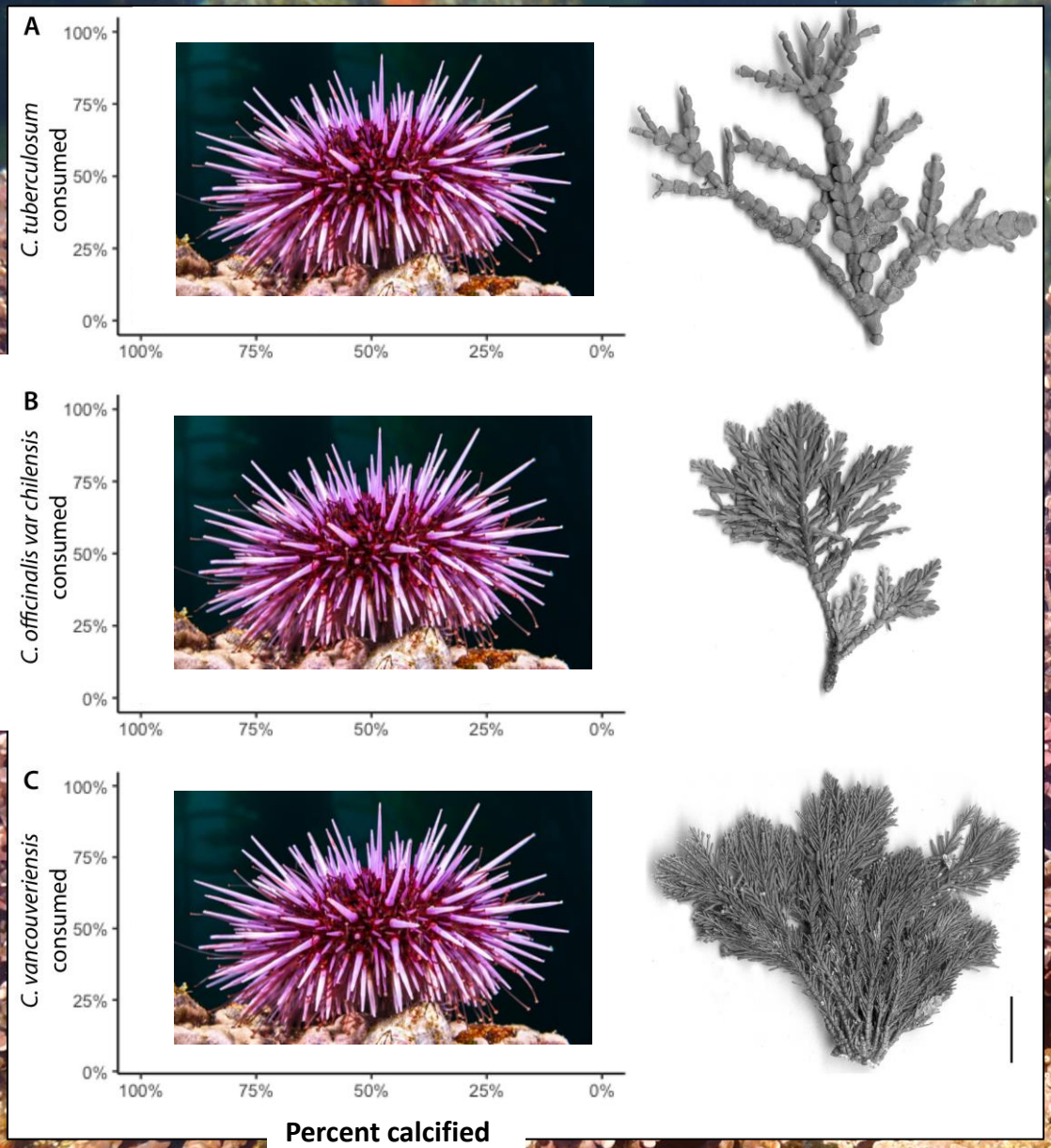
(1) deposited less CaCO3

(2) eaten **more** by urchin *Echinothrix*

…**but only when stresses combined**

Johnson and Carpenter 2012, *JEMBE*

Altered $CaCO_3$ with HCl, then fed to urchins (*S. purpuratus*)



Urchin grazers

Calliarthron tuberculosum

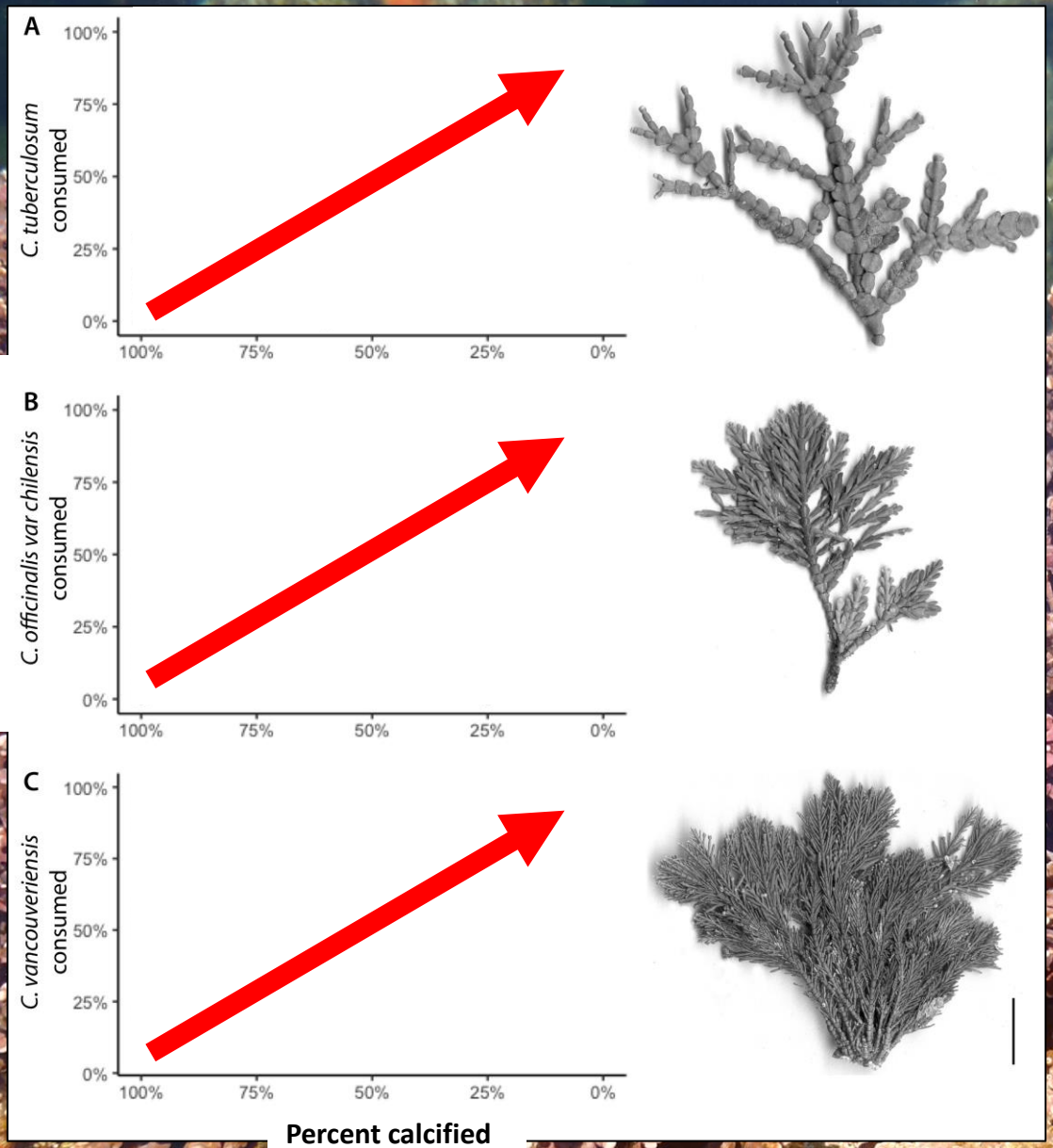
Corallina officinalis var. chilensis

Corallina vancouveriensis

Urchin photo: Oceana.org

Martone et al. 2021, *JEMBE*

Expected grazing rates to increase as CaCO3 removed



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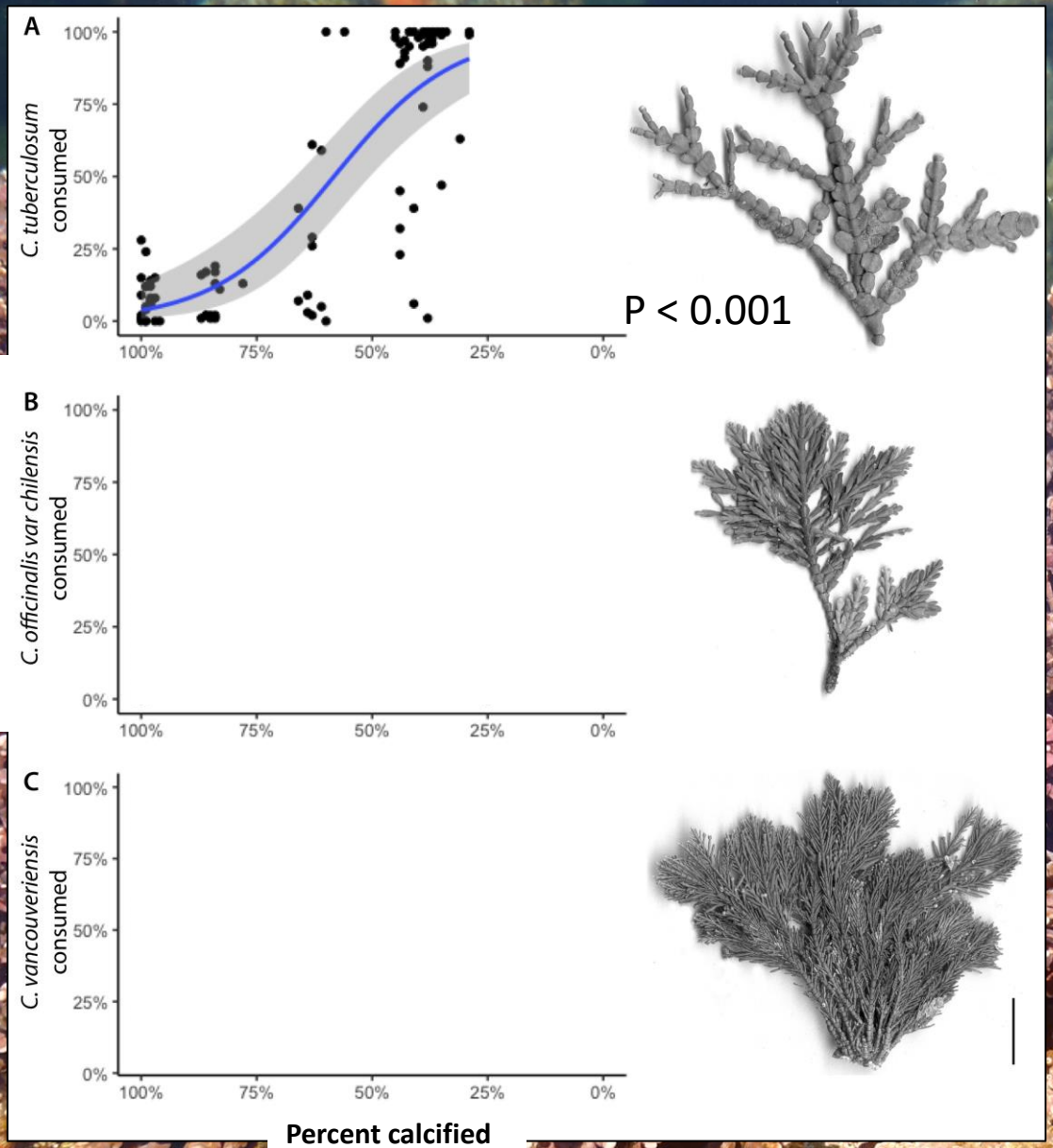
Martone et al. 2021, *JEMBE*

Loss of CaCO3 increased grazing rates on *Calliarthron*



P < 0.001

Urchin grazers

Reducing $CaCO_3$ <u>increased</u> urchin grazing rates

Martone et al. 2021, *JEMBE*

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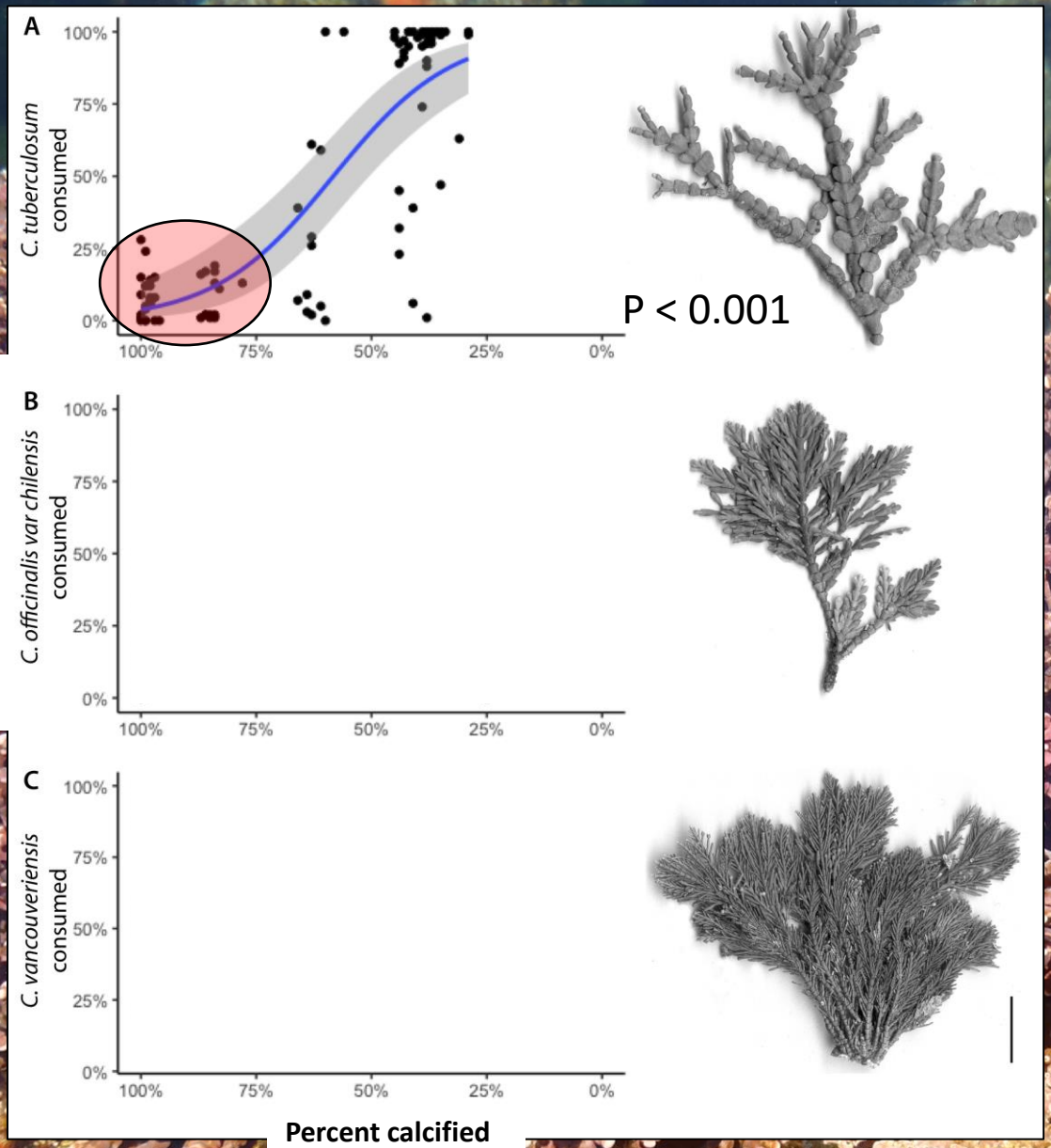

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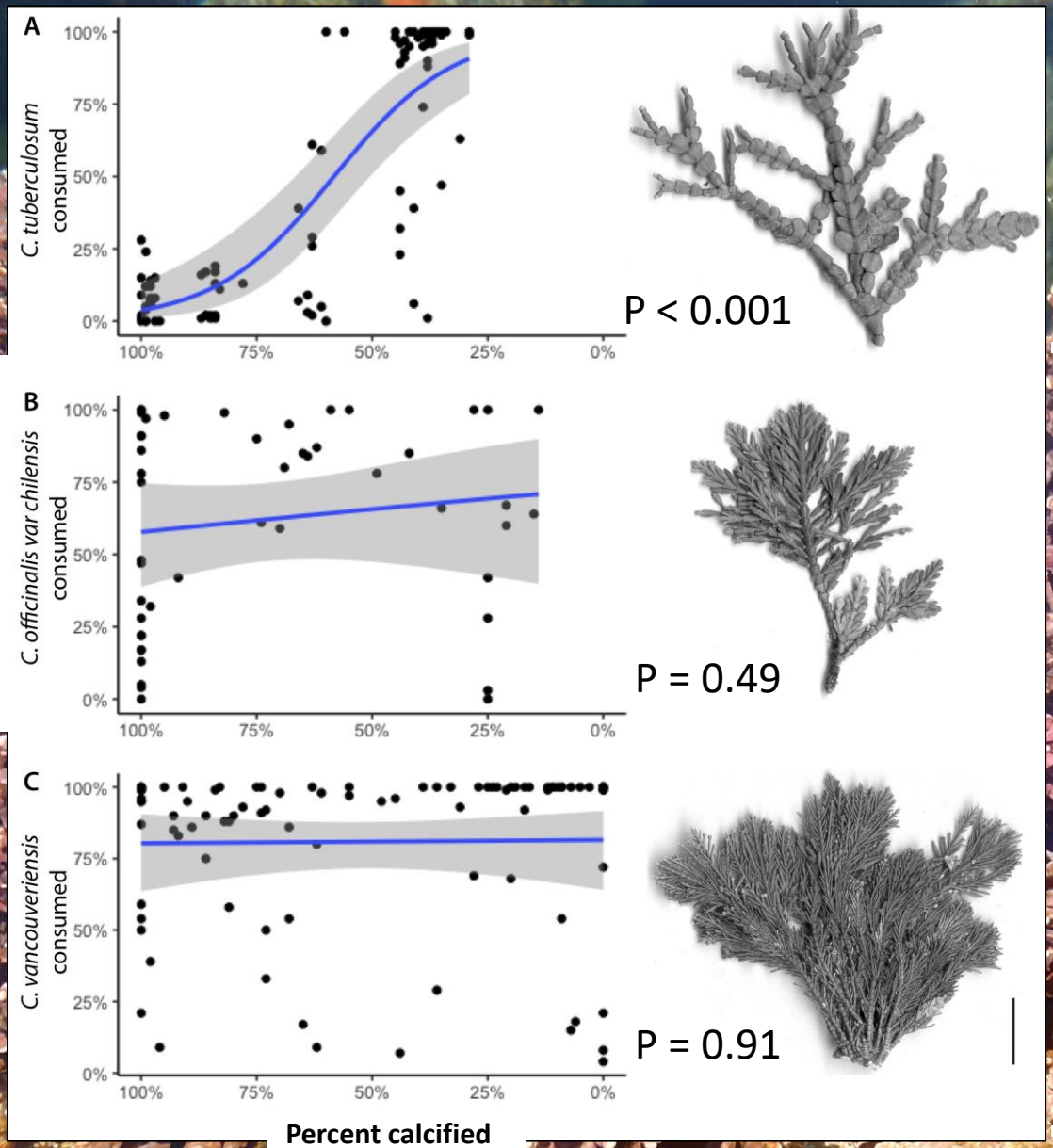
Urchin grazers

Reducing $CaCO_3$ <u>increased</u> urchin grazing rates

Martone et al. 2021, *JEMBE*

Loss of CaCO3 did not affect grazing on *Corallina* spp.



Urchin grazers

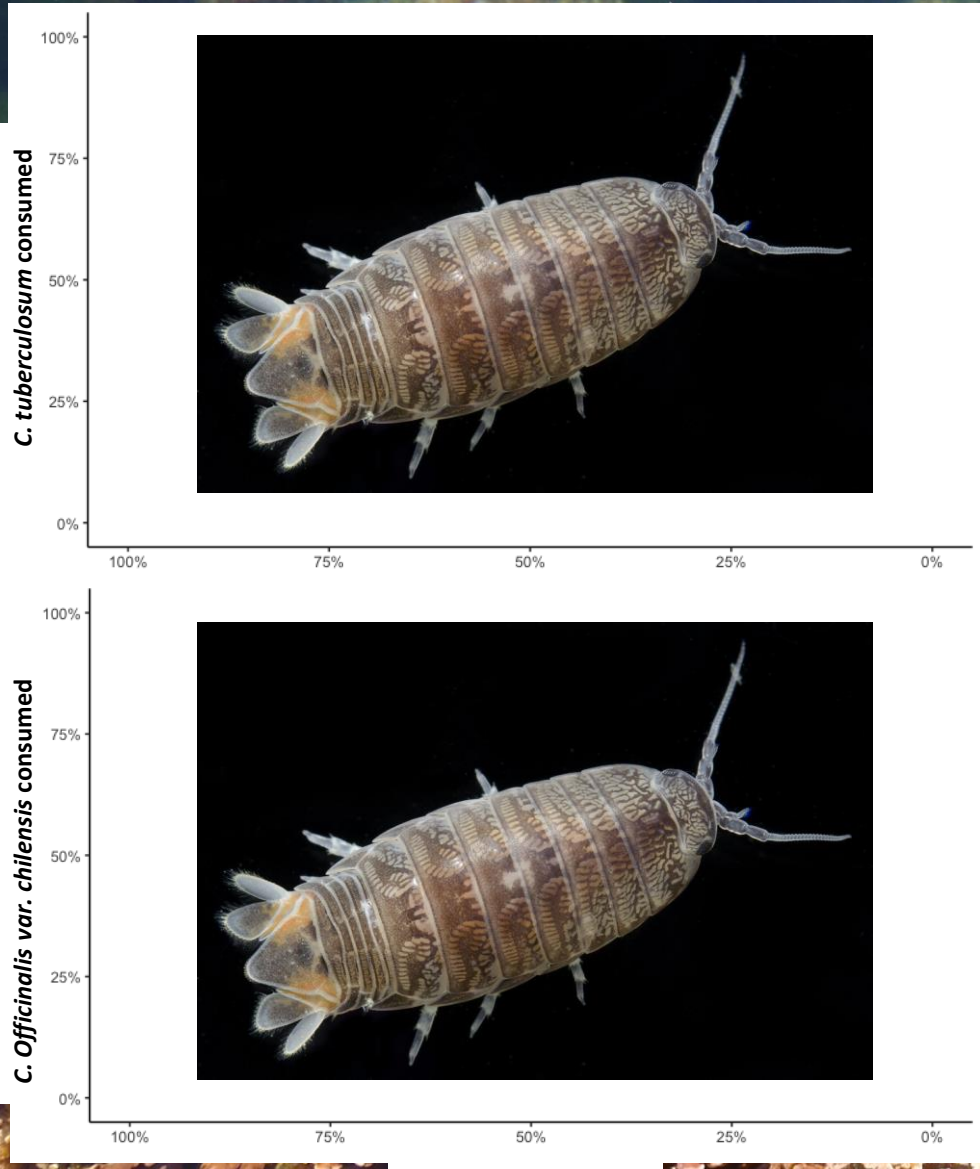
Reducing $CaCO_3$ increased urchin grazing rates

Reducing $CaCO_3$ did not affect urchin grazing rates

Martone et al. 2021, *JEMBE*

Repeated experiment with isopods (*Cirolana harfordi*)

Isopod grazers



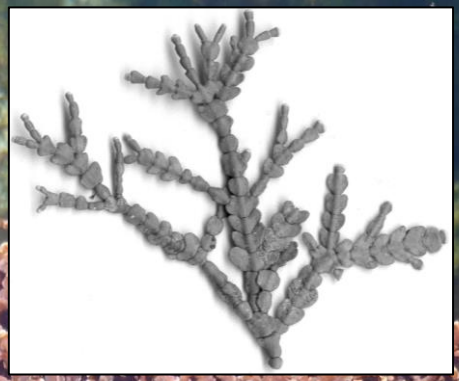
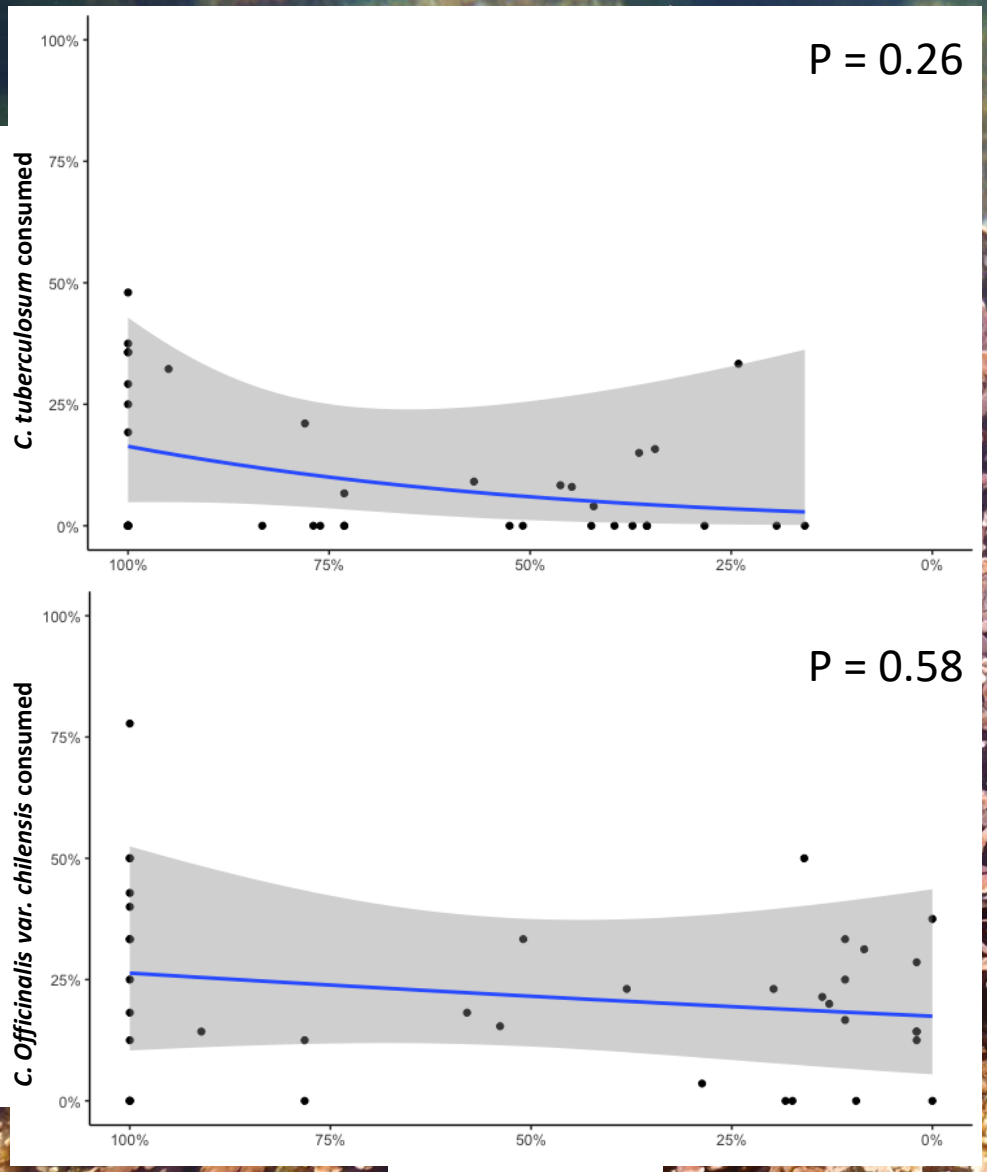


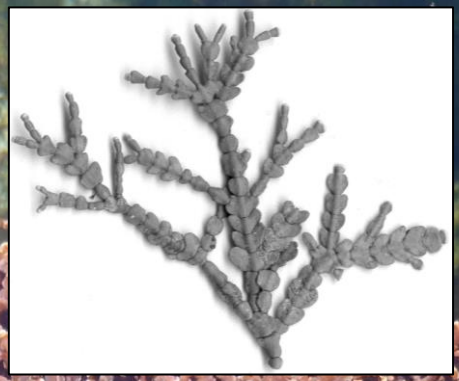
Photo: Hakai Institute

Ethel Wai, Directed Studies
Bamfield MSC 2022

Loss of $CaCO_3$ did not affect isopod grazing on either species

Isopod grazers





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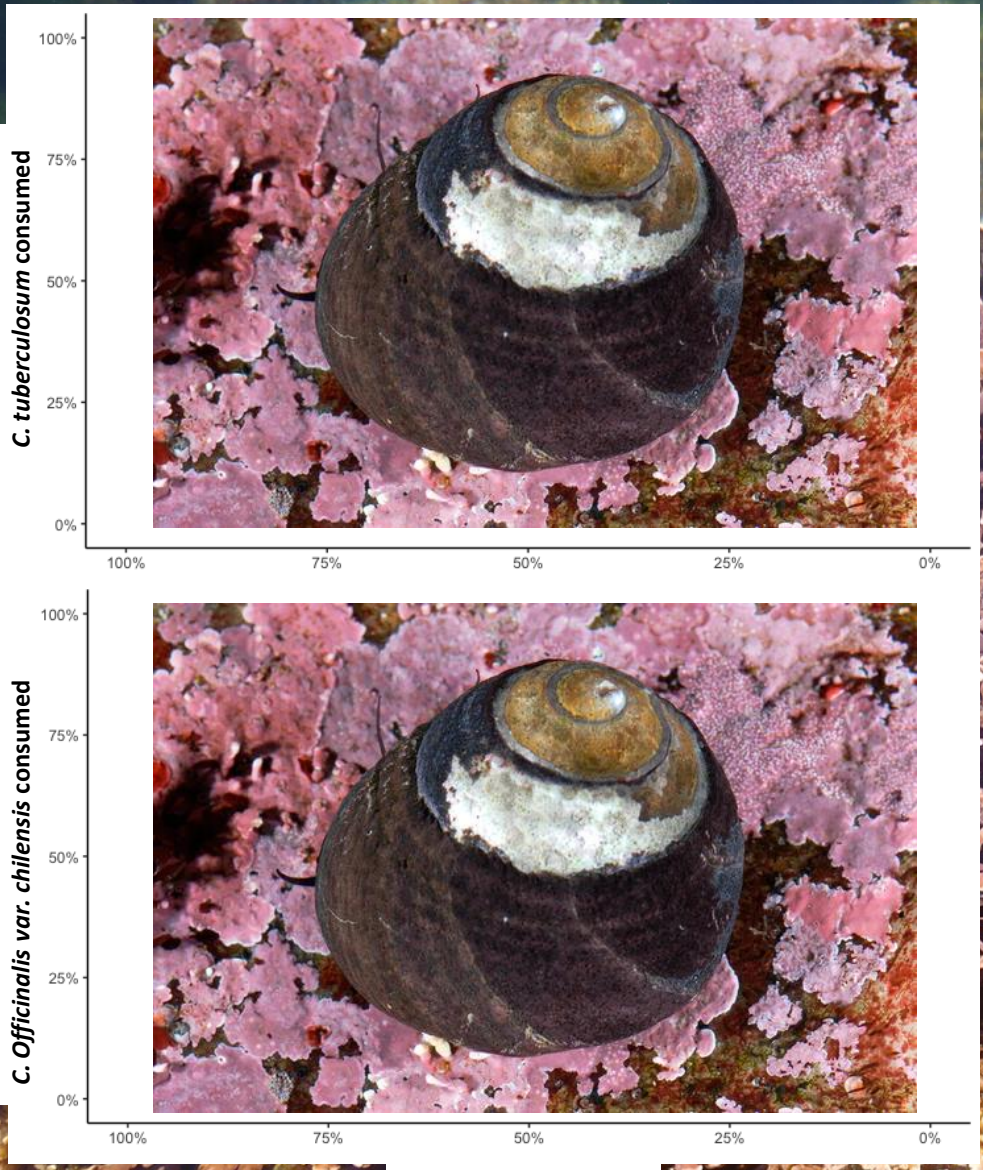
Repeated experiment with turban snails (*Tegula funebralis*)

Mollusc grazers



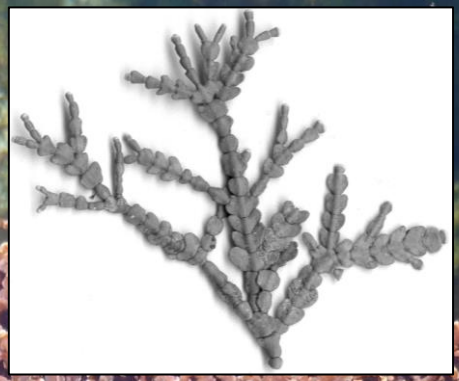
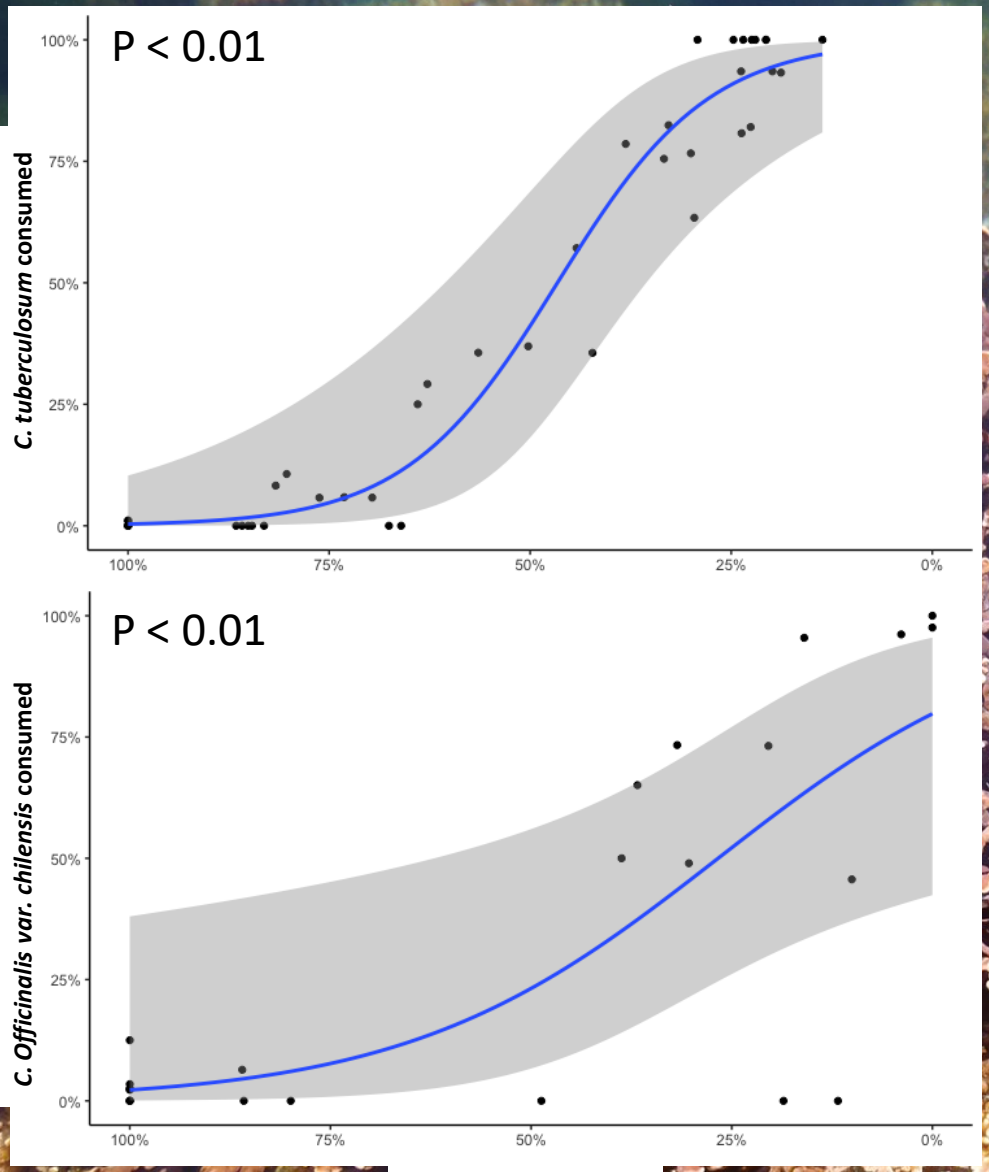


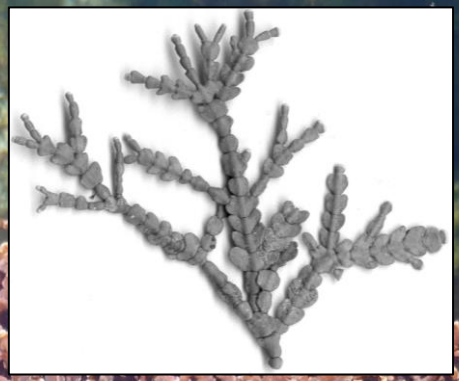
Photo: Totalaquatics.com

Emma Simonok & Mikayla Holloway
Directed Studies, Bamfield MSC 2022

Loss of $CaCO_3$ increased snail grazing on both species

Mollusc grazers





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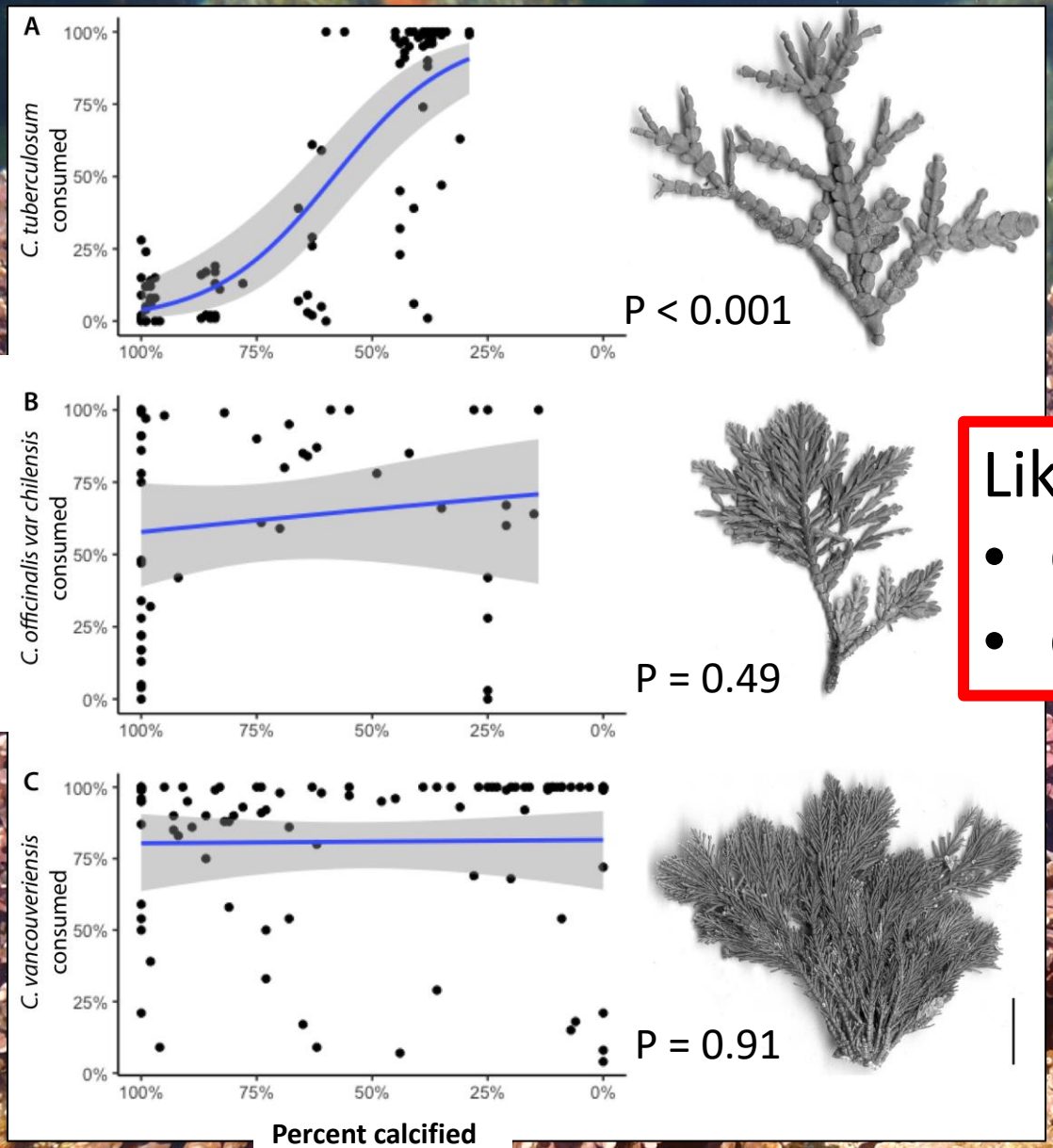
Directed Studies, Bamfield MSC 2022

Calcification does not universally decrease palatability



Likely need to consider

- **Coralline morphology**
- **Grazer type**

Martone et al. 2021, *JEMBE*

Coralline algae resist herbivores … thanks to calcification?

~~Calcification makes~~ *Not necessarily* ~~ore difficult to eat~~

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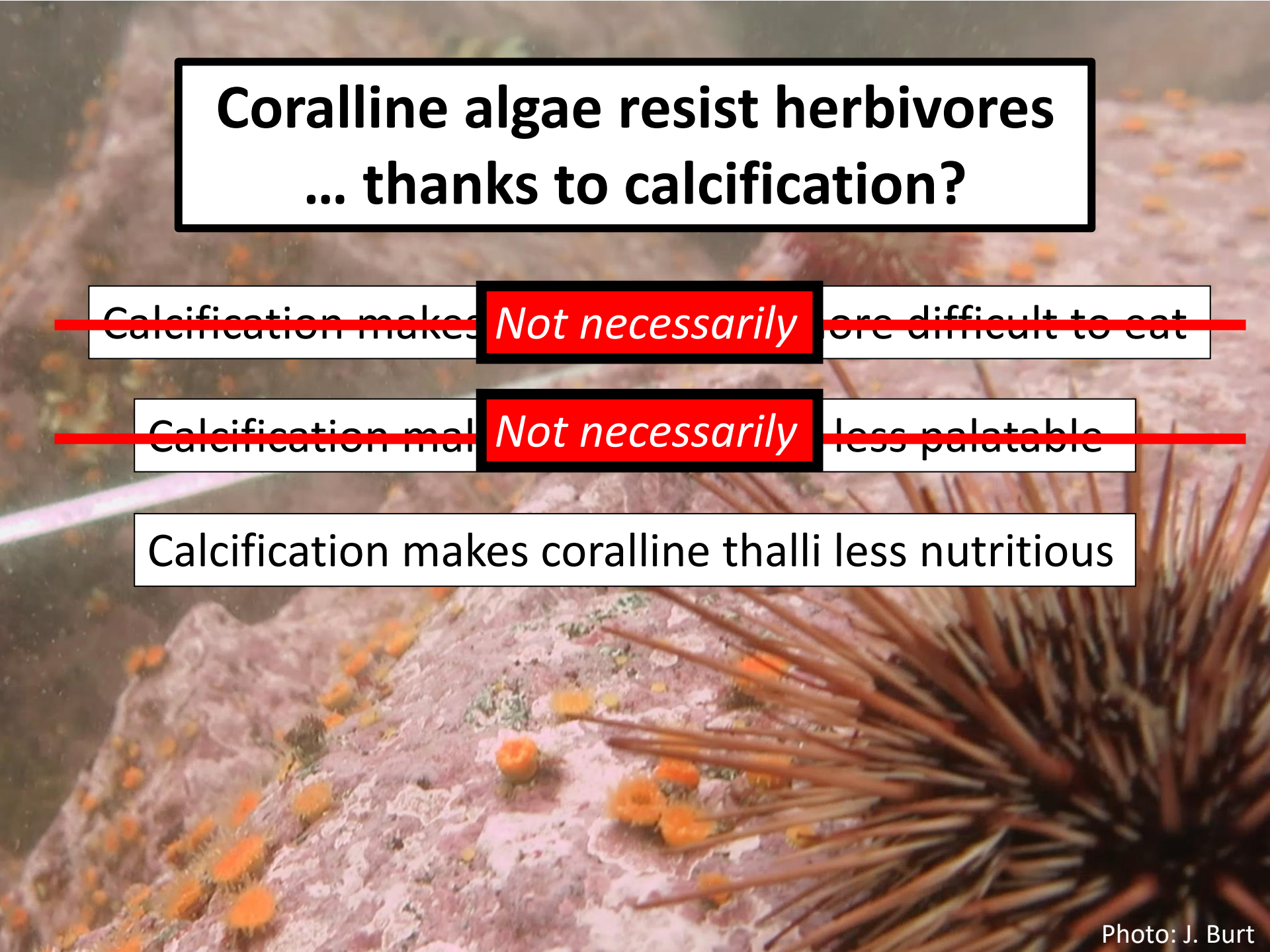

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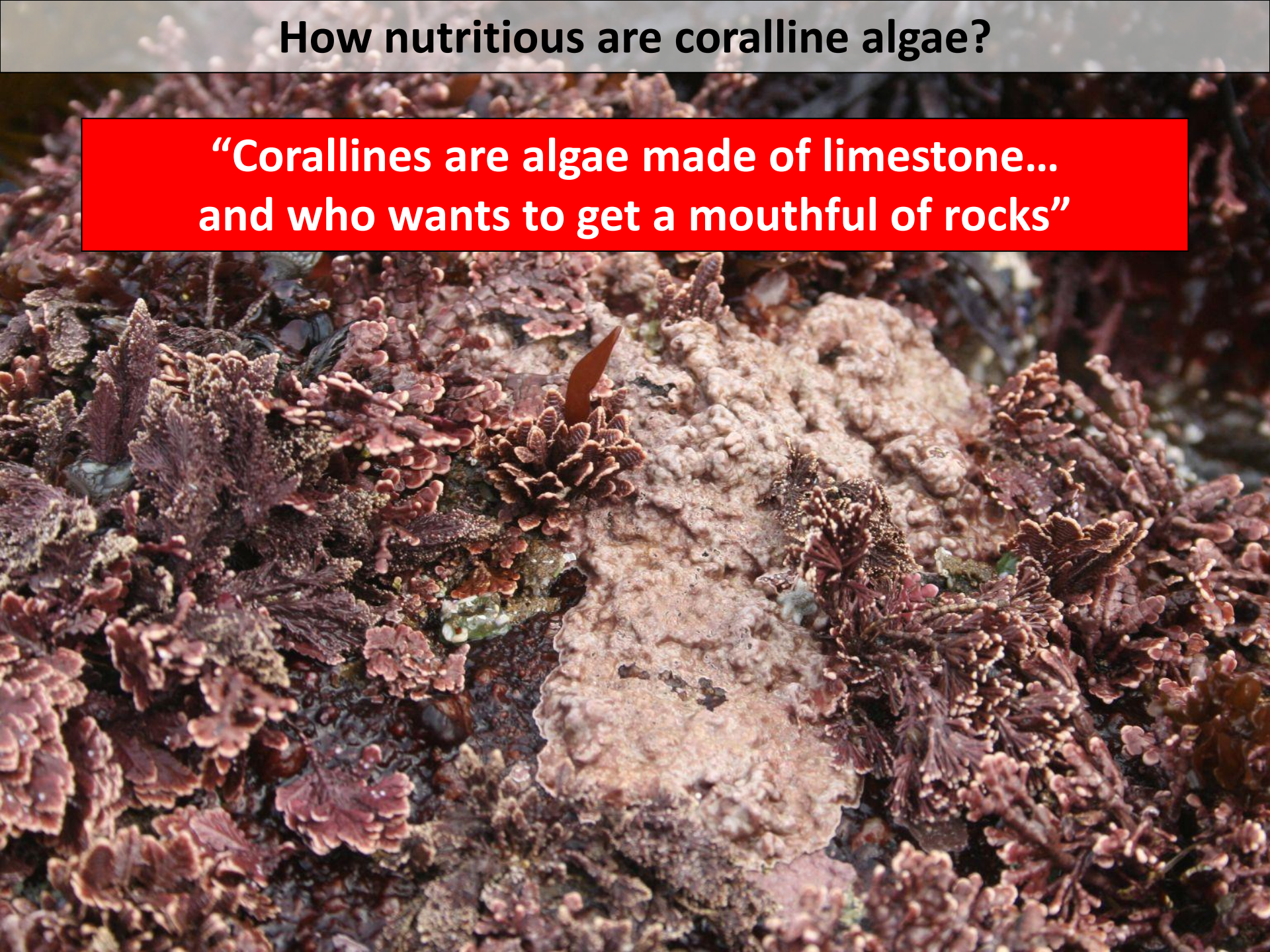
How nutritious are coralline algae?



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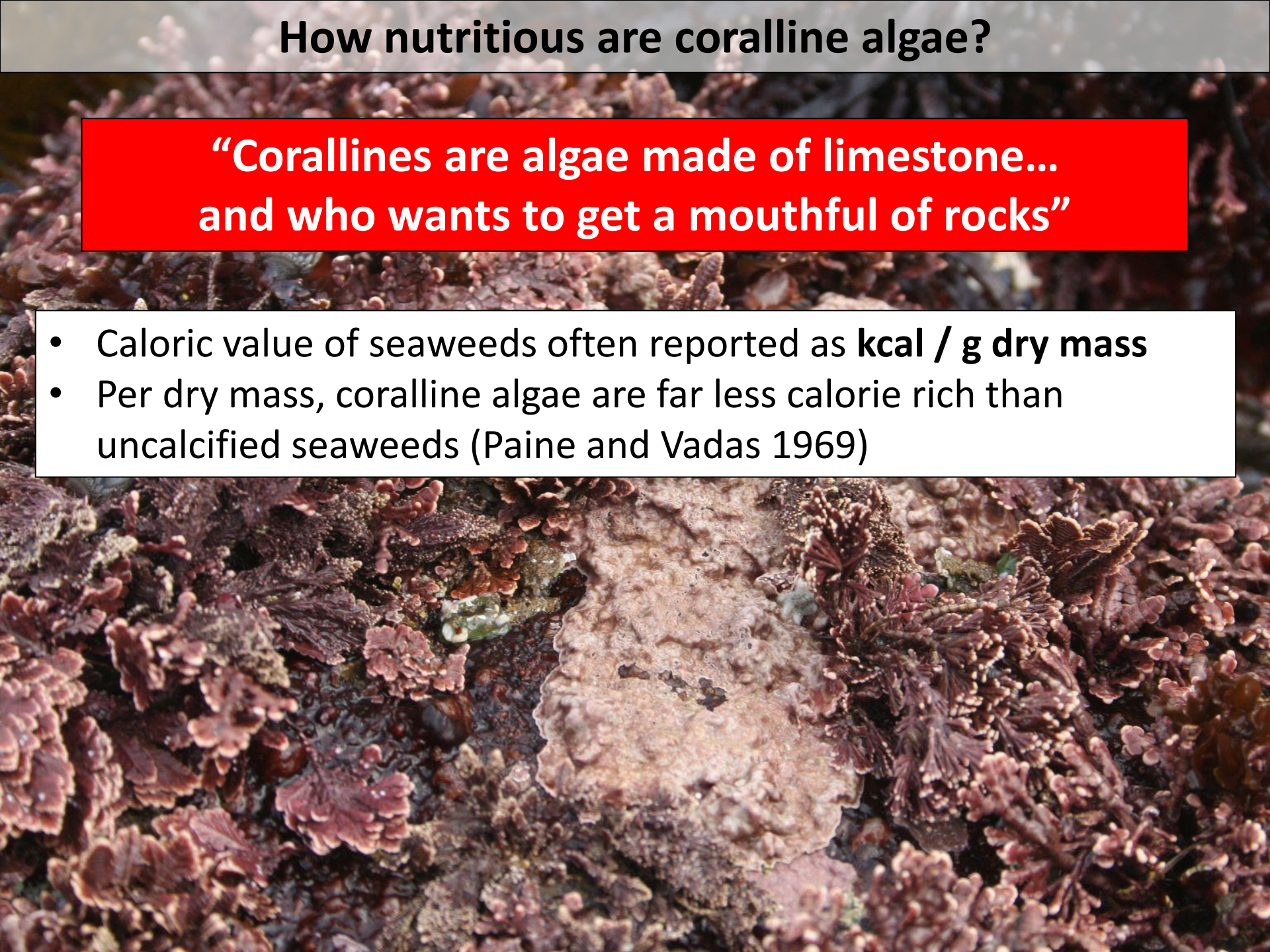

**"Corallines are algae made of limestone…
and who wants to get a mouthful of rocks"**

- Caloric value of seaweeds often reported as **kcal / g dry mass**
- Per dry mass, coralline algae are far less calorie rich than uncalcified seaweeds (Paine and Vadas 1969)

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- We measured the **volume** and **caloric value** of calcified and uncalcified seaweeds to determine the caloric value of "mouthfuls" of seaweed

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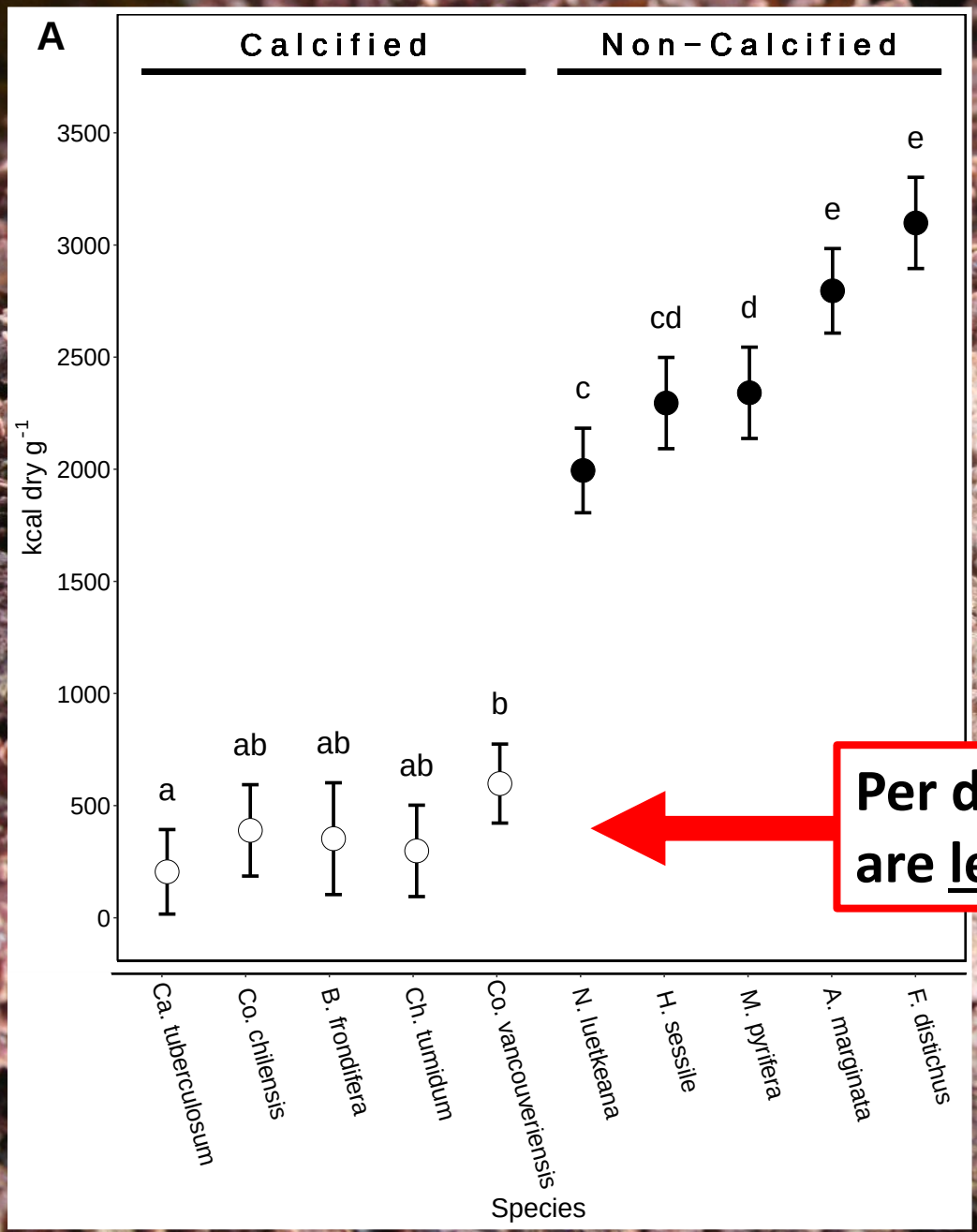

Per dry mass, corallines are <u>less</u> calorie rich

Haberman & Martone, *in review MEPS*

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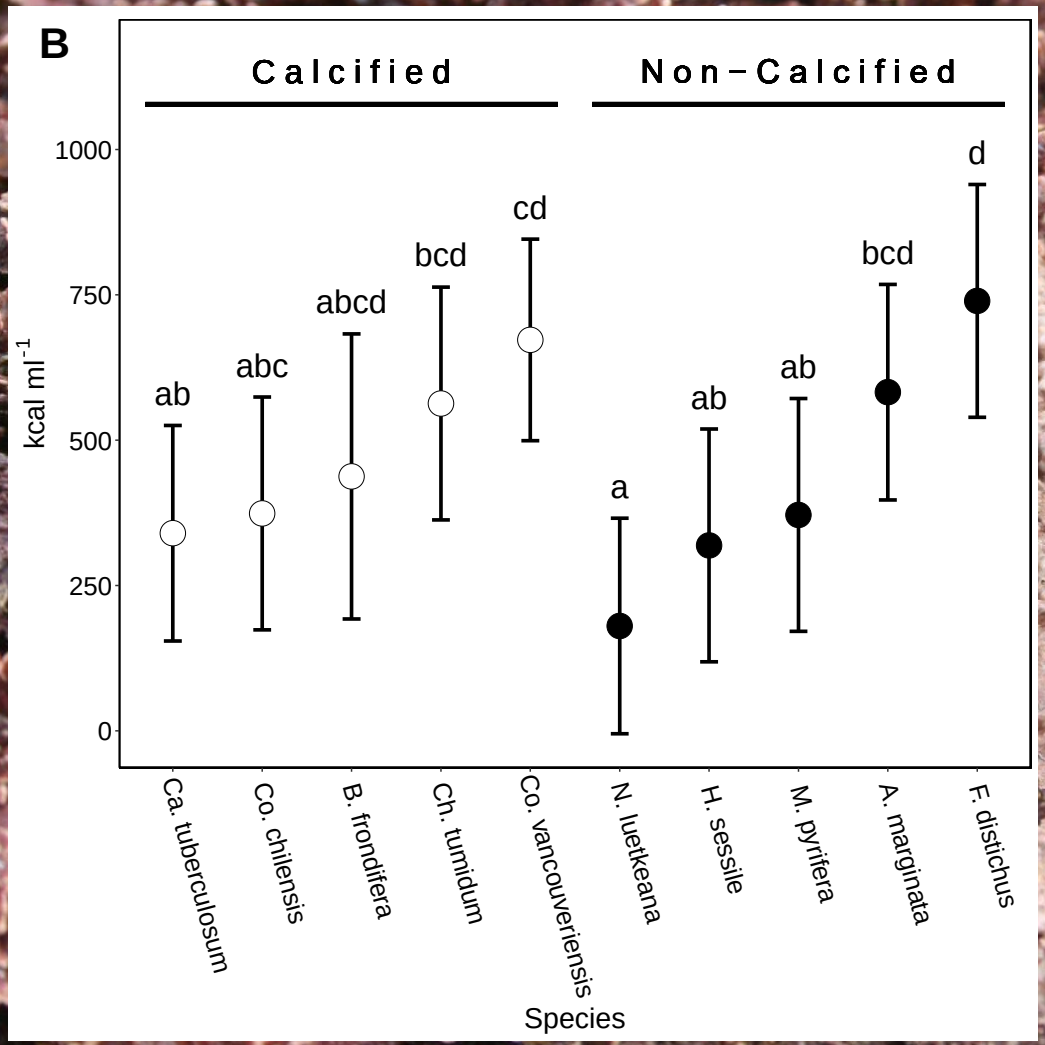

Per volume ("mouthful"), caloric value of corallines isn't different from uncalcified seaweeds

Haberman & Martone, *in review MEPS*

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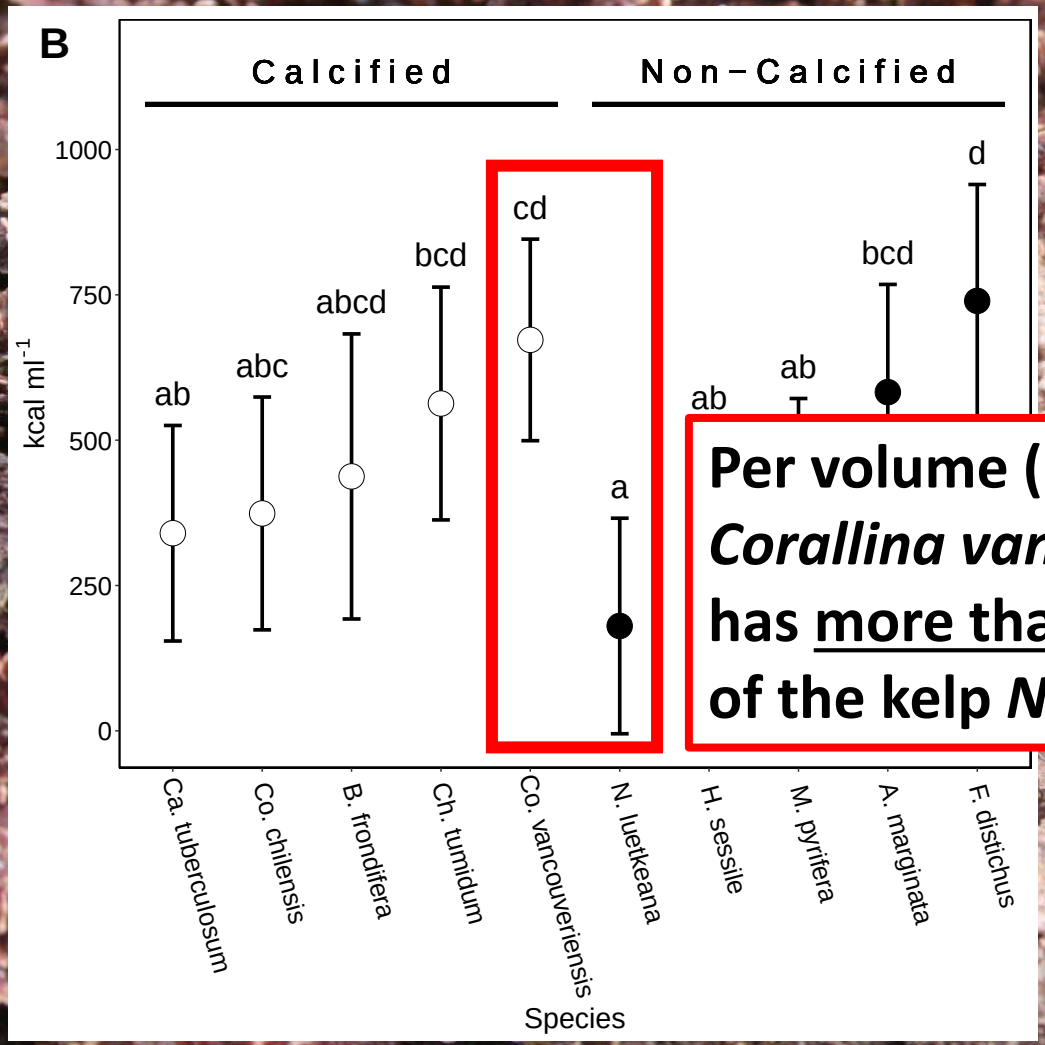

Per volume ("mouthful"), *Corallina vancouveriensis* has more than double the calories of the kelp *Nereocystis luetkeana*

Haberman & Martone, *in review MEPS*

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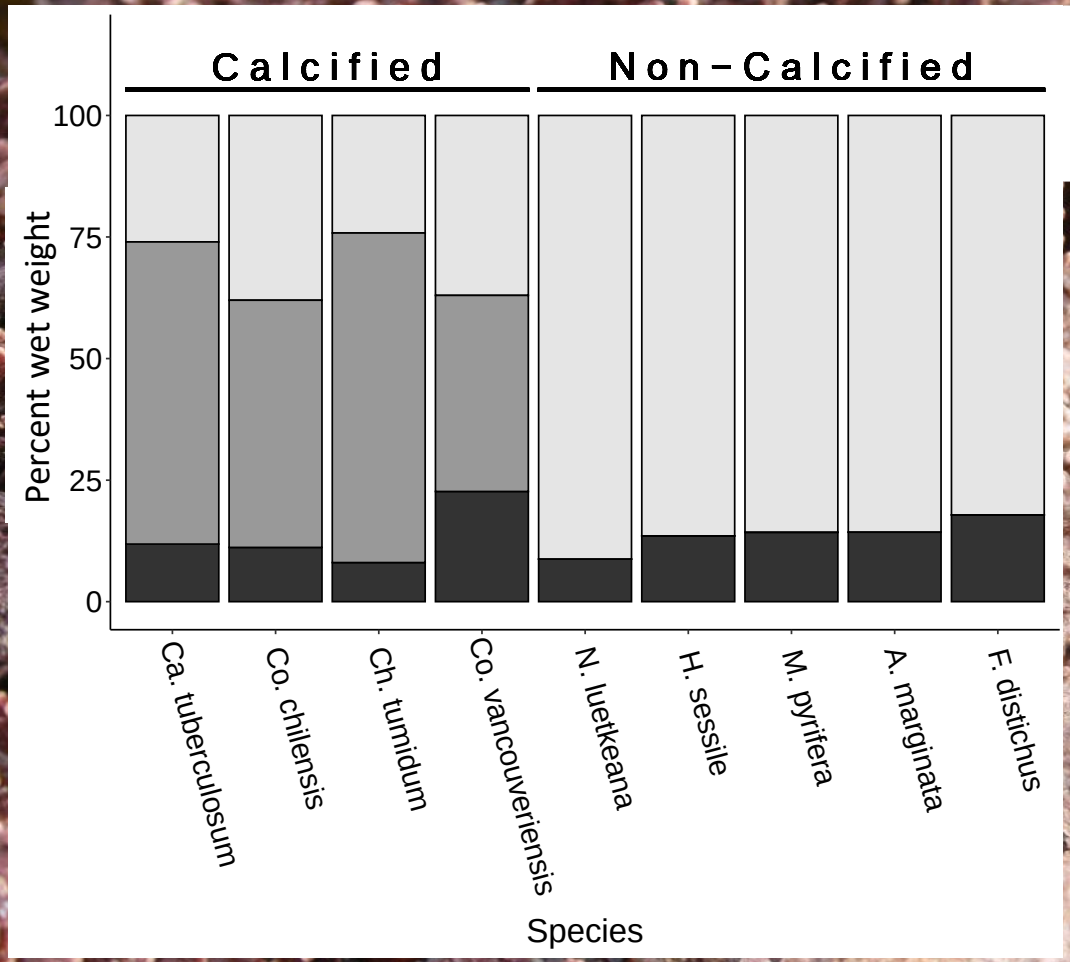

Calcified and uncalcified seaweeds contain similar amount of algal tissue

Corallines are mostly CaCO3… but fleshy seaweeds are mostly water

Haberman & Martone, *in review MEPS*

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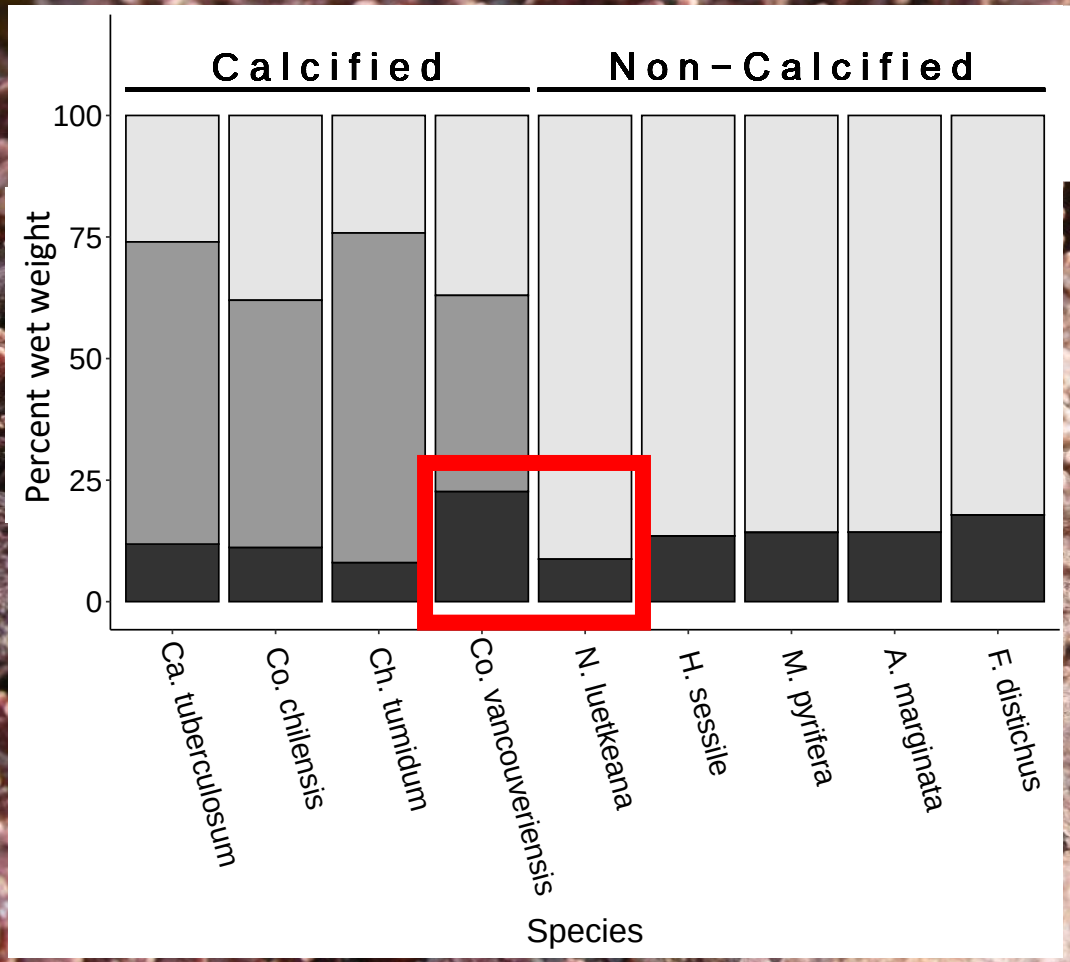

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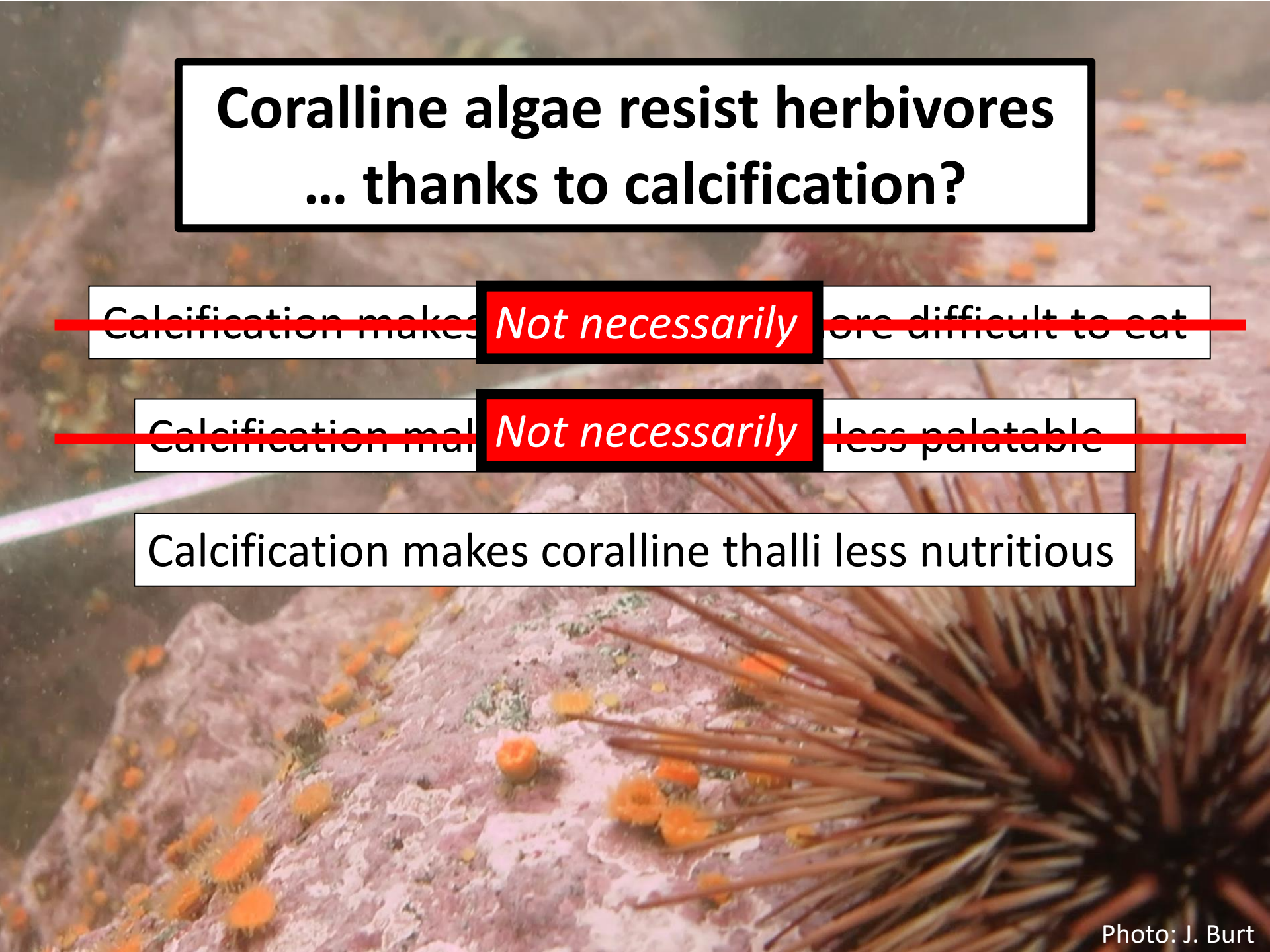

Photo: J. Burt

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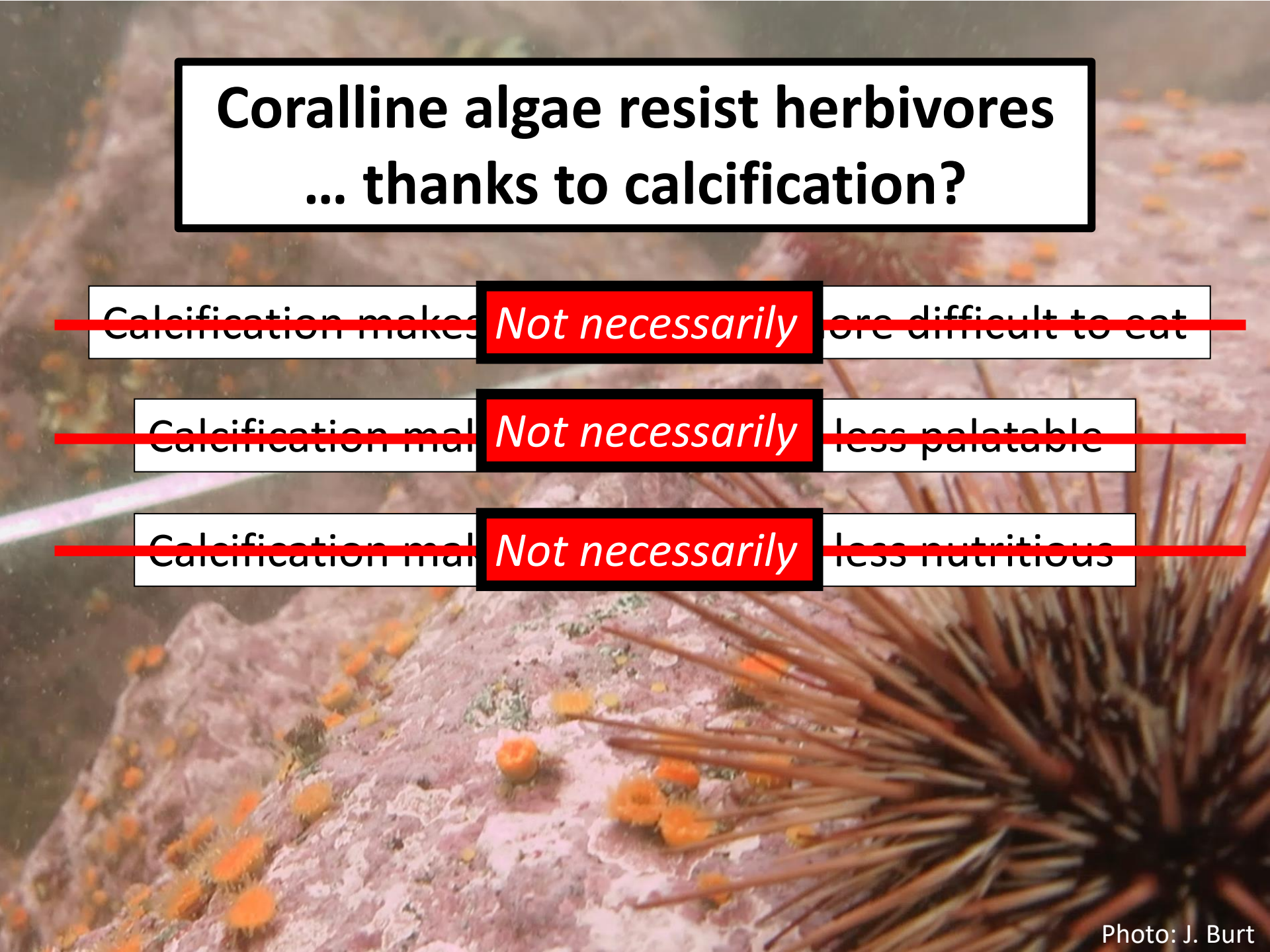


Photo: J. Burt

Coralline algae resist herbivores … thanks to calcification?

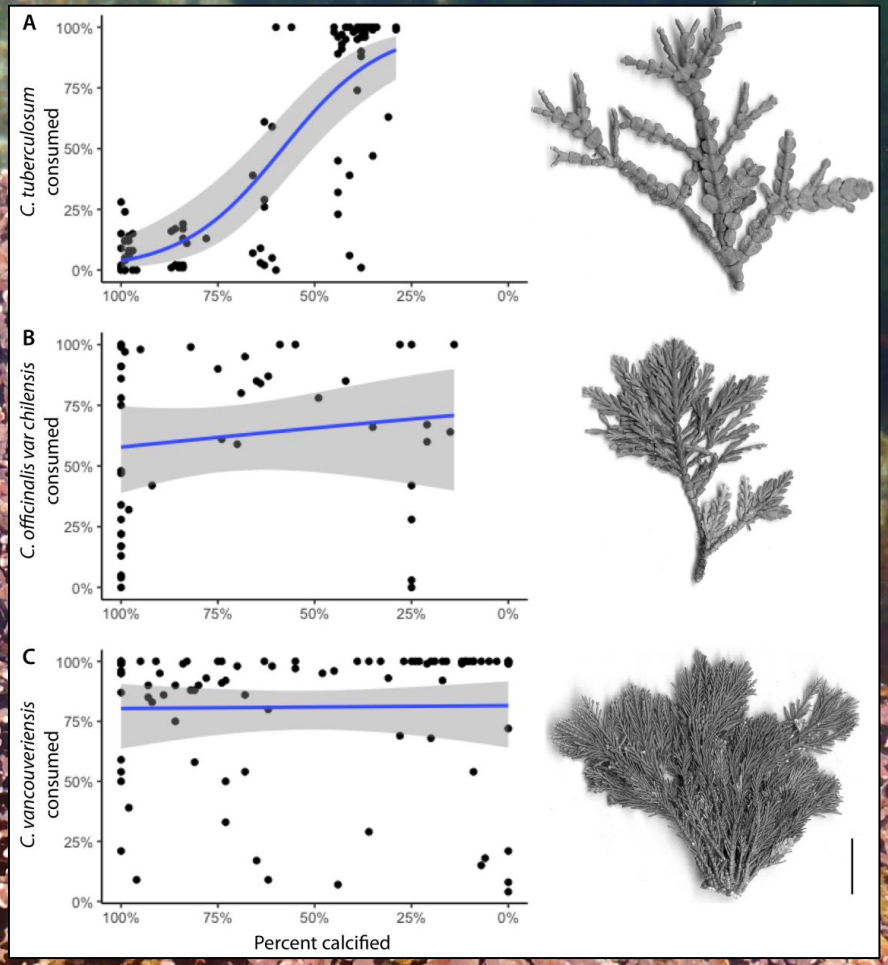
Other ideas:

- Calcification may disrupt digestion
- Secondary metabolites might be the real culprit, perhaps exacerbated by calcification (Hay et al. 1994)
- Choice experiments also needed

Photo: J. Burt

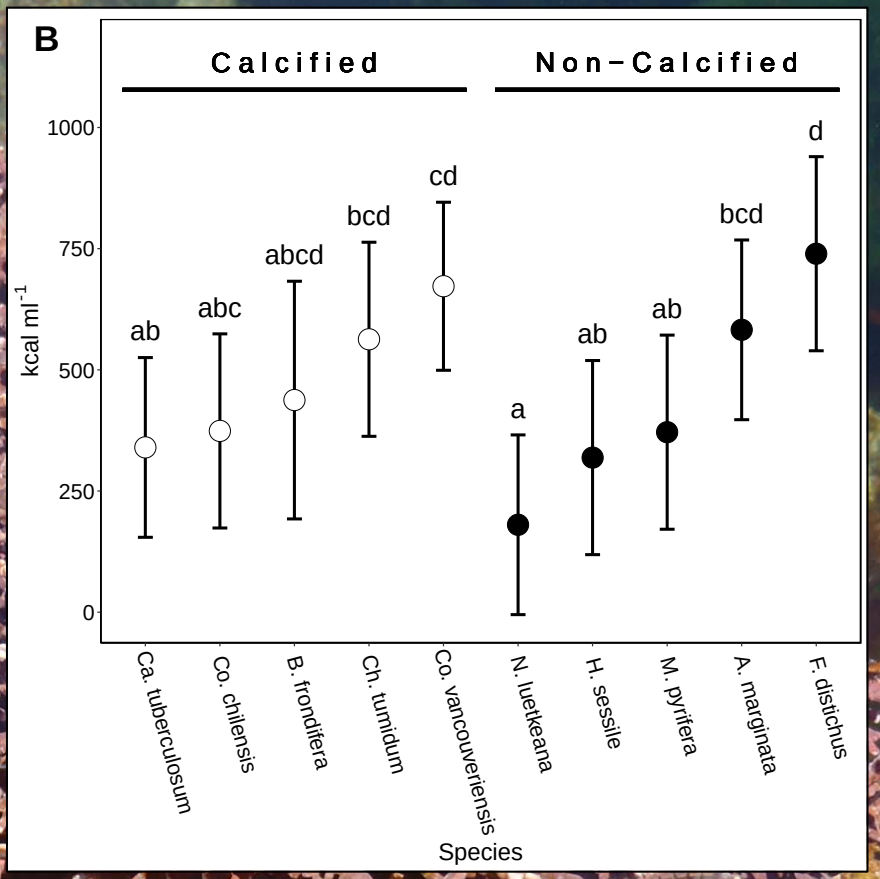
Conclusions

- Calcification does <u>not</u> universally protect articulated coralline algae from herbivory
- Calcification benefits may depend upon morphology and grazer type



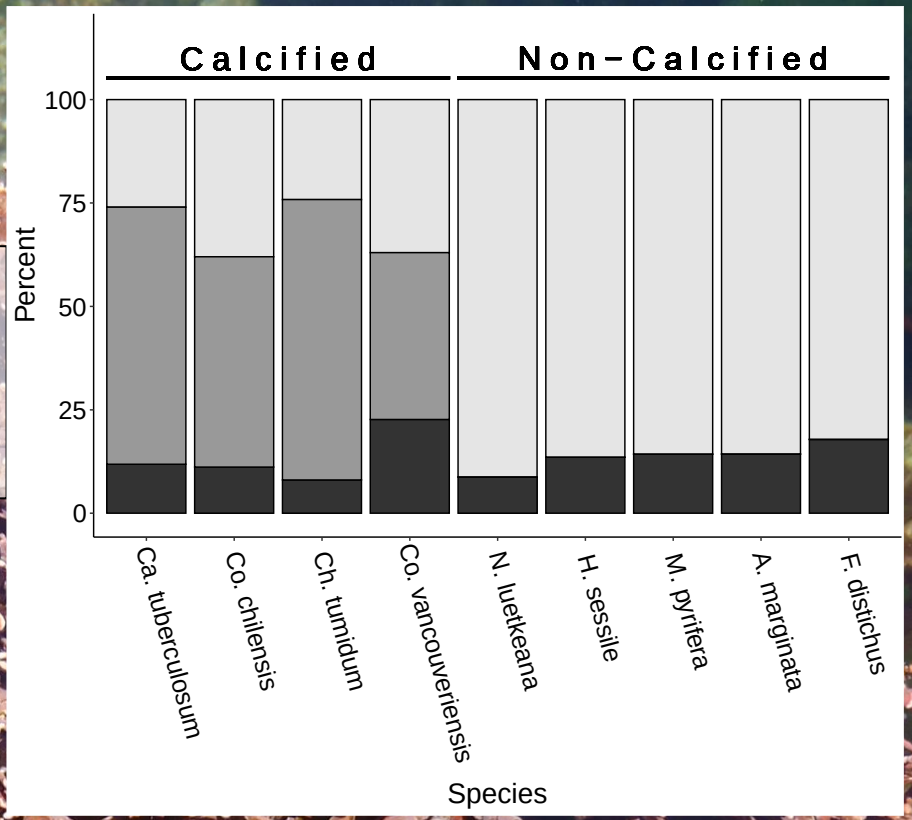
Conclusions

- **Per volume (“mouthful”), the caloric value of coralline algae and uncalcified seaweeds is <u>not different</u>**



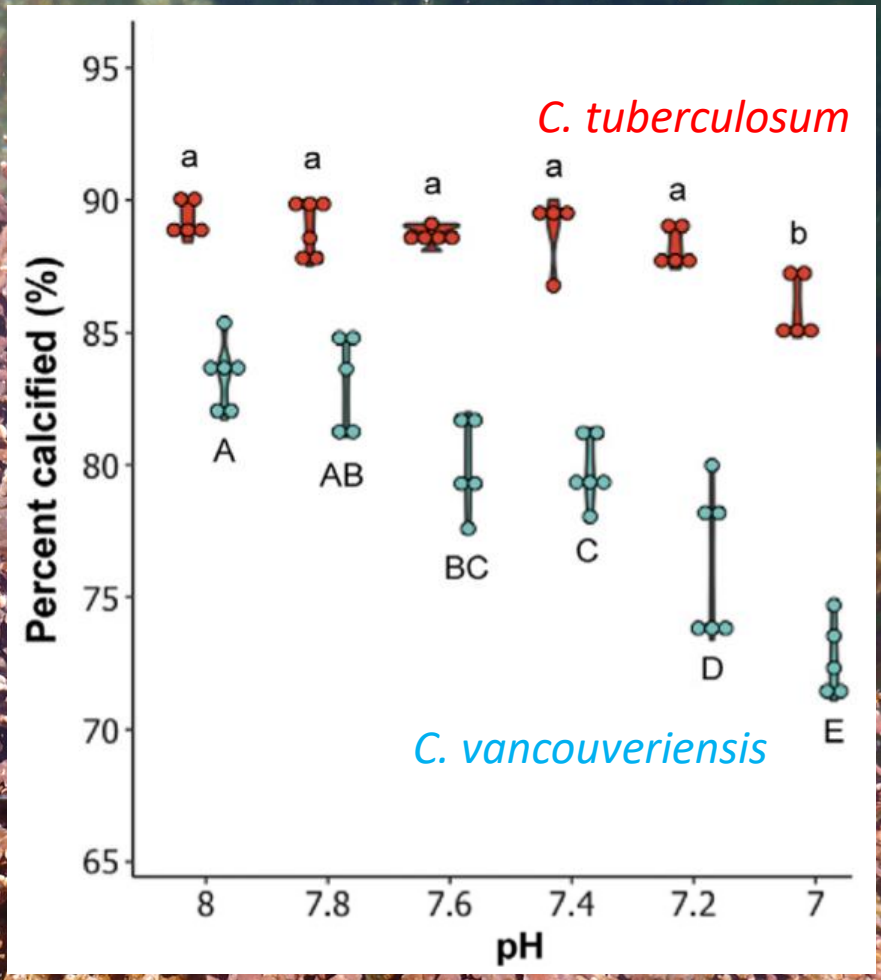
Conclusions

- **Organic fraction of coralline algae and uncalcified seaweeds is generally <u>not different</u>**



Conclusions

- Decline in calcification due to ocean acidification <u>may not</u> have a big impact on herbivory
- Basic paradigms about coralline ecology deserve further scrutiny
- More research is needed



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