Is Ocean Acidification Melting Sea Stars?

The Effect of Lowered pH and Wasting Disease on Nearshore Asteroid Health



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- First recorded June 2013
- Millions of sea stars have died



Affects Over 20 Species of Native Sea Star



Widespread from Alaska to Mexico

























The Pathogen: Sea Star-Associated Densovirus?



The Pathogen: Sea Star-Associated Densovirus?

But... densovirus has been around since 1942.











Stress Can Trigger Wasting Disease







Stress Can Trigger Wasting Disease

- Collected healthy
- Swollen within a day
- All died within two months



Stress Can Trigger Wasting Disease

- Asymptomatic sea stars can waste
- Stress of collection
- Environmental stressors?



Ocean Acidification

pH is predicted to fall by 0.3 to 0.5 units by the year 2100.

 CO_2 depletes carbonate for calcifying organisms.



http://www.pmel.noaa.gov/co2/file/Seawater+carbonate+chemistry

Calcium Carbonate Dissolution Rate Depends on Crystal Structure

Calcite (crustaceans), 1x Aragonite (corals and molluscs), 2x High-magnesium calcite (echinoderms), 30x

High-magnesium calcite echinoderm ossicle





Hypothesis

Ocean acidification amplifies wasting disease by forcing sea stars to redirect energy to skeletal maintenance at the expense of immune function.



Joanna Aizenberg and Gordon Hendler, Designing efficient microlens arrays: lessons from nature

Four Species



Mottled (n = 23)



$\frac{\text{Blood}}{(n=2)}$



Leather (n = 3)



Purple (n = 7)



Carbon dioxide

to acidify the water



Carbon dioxide

to acidify the water

Header tank

to dissolve and mix carbon dioxide

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Experimental tank

to mimic future ocean conditions



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Control tank

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Water testing

to monitor pH and quality





Tank Design

- Ambient pH: 7.8 to 8.0
- Lowered pH: 7.4 to 7.6
- CO₂ added (2 L/hr)
- O₂ added (to equalize dissolved oxygen)
- Baskets to identify individual sea stars



Disease Was Scored on Six-Point Scale



Score 2

- Lesions on 1 arm
- Lesions on central disc

Disease Was Scored on Six-Point Scale



Score 3

- 1 interface lesion
- Lesions on 2 arms
- Lesions on 1 arm & central disc

Score 4

- 2+ interface lesions
- Lesions on 3+ arms
- Lesions on 2 arms & central disc

Score 5

- 1+ arms detached
- Death



Statistical Analysis

We tested five cumulative link models and selected the best-fit model using AIC comparison.









Mean score

Leather (D. imbricata)









- Blood stars (*H. leviuscula*) remained asymptomatic
- Multiple color variants





MRI Shows Soft Tissue Changes



Asymptomatic

Diseased



Asymptomatic





Diseased



















Diseased: Amorphous Tissue

Anus



4

Mouth







Wasting Sea Stars Are Filled with Gonads



Wasting Sea Stars Are Filled with Gonads



Wasting Sea Stars Are Filled with Gonads

- Common stress response
- Energy redirected
- Other tissues decay



Discussion

- hypothesized that ocean acidification amplifies wasting disease by redirecting energy to skeletal maintenance at the expense of immune function
- found preliminary evidence to support in mottled and leather stars



Discussion

- found evidence that swelling, the first sign of wasting disease, is due to gonadal enlargement
- new hypothesis: sea stars infected with densovirus redirect energy to gonad production at the expense of tissue maintenance, resulting in lesions and arm autonomization



Future Directions

Physiological changes?

- coelomic fluid
- ossicle density

 Adaptive function of gonadal enlargement?
– spawning surveys



Oceans are Important

- supply 50% of oxygen we breathe
- absorb 25% of carbon dioxide we emit
- provide the primary source of protein for 3 billion people



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