Changes on a coral reef at a thermal vent along a pH gradient – community characteristics of corals and molluscs

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Pulau Weh, Indonesia

- Last volcanic activity in the island occurred in Pleistocene, which forms the hydrothermal vent at the Lhok Pria Laot Bay in Pulau Weh.
• Sampling transects:
  – parallel and perpendicular to the shore were established

• Parameters measured includes:
  – pH of seawater
  – live coral coverage
  – coral genus composition

• pH of seawater was measured during:
  – wet (October 2012) and dry season (May 2013)
October 2012
Wet Season

May 2013
Dry Season
Dry season (May 2013)
Range of pH: 6.89 – 7.89

Wet season (Oct 2012)
Range of pH: 6.99 – 8.01
Location of sampling points along the pH gradient
Station A  
P: 7.21

Station B  
P: 7.31

Station C  
P: 7.50

Station D  
P: 7.83
Association between average live coral cover and pH

Average of area coverage of live coral (m²)

pH

R² = 0.9189
Percentage of live coral cover at Lhok Pria Laot Bay, Pulau Weh

Station

Increasing distance away from the hydrothermal vent

<table>
<thead>
<tr>
<th>Station</th>
<th>pH</th>
<th>Coral Rubble</th>
<th>Macroalgae</th>
<th>Sand</th>
<th>Dead Coral</th>
<th>Live Coral</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>7.31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>7.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>7.83</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Changes in coral genus along the pH gradient

Increasing distance away from the main vent
Association between number of coral genera and pH in the Straits of Malacca
Permanent monitoring sites for coral health and ocean acidification
Shell characteristics
### Shell Characteristics

**PARAMETERS MEASURED**

- Morfology description
- X-ray diffraction
  *(for crystalline phases)*
- X-ray Flourescne spectroscopy analysis
  *(for chemical composition)*
- Scanning electron microscope

<table>
<thead>
<tr>
<th>Site</th>
<th>Control</th>
<th>Thermal Vent (200m from source)</th>
<th>Thermal Vent (300m from source)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean pH</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.30</td>
<td>8.08</td>
<td>7.77</td>
</tr>
<tr>
<td><strong>Mean salinity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30.3 ppt</td>
<td>34.5 ppt</td>
<td>33.4 ppt</td>
</tr>
<tr>
<td><strong>Salinity range</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>28 - 32 ppt</td>
<td>33 - 35 ppt</td>
<td>32 - 35 ppt</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>31-35 ppt</td>
</tr>
</tbody>
</table>
Shell Morphology

Control

Thermal Vent (300m from source)

Thermal Vent (200m from source)

Thermal Vent (100m from source)

Thermal Vent (source)
The analysis of crystal structure using XRD shows that the main peak appeared at 2 theta were from 29°C to 31°C.

The main peaks in all samples from different areas correspond to a limestone peak or known as Calcium carbonate, CaCO₃.
The finding demonstrates that oyster shells from different study locations were made up of calcium (92-93%).

<table>
<thead>
<tr>
<th>Compound</th>
<th>Control</th>
<th>200m from source</th>
<th>300m from source</th>
<th>Thermal vent (source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO</td>
<td>92.24</td>
<td>93.38</td>
<td>92.01</td>
<td>92.28</td>
</tr>
<tr>
<td>LOI</td>
<td>4.22</td>
<td>4.42</td>
<td>5.82</td>
<td>5.28</td>
</tr>
<tr>
<td>MgO</td>
<td>0.51</td>
<td>0.52</td>
<td>0.52</td>
<td>0.52</td>
</tr>
<tr>
<td>SO₃</td>
<td>0.52</td>
<td>0.87</td>
<td>0.79</td>
<td>0.66</td>
</tr>
</tbody>
</table>
### SCANNING ELECTRON MICROSCOPY SHOWING THE MICROSTRUCTURE OF THE OYSTER SHELLS

<table>
<thead>
<tr>
<th>Pulau Weh, Indonesia</th>
<th>Site</th>
<th>Control</th>
<th>Thermal Vent (200m from source)</th>
<th>Thermal Vent (300m from source)</th>
<th>Thermal Vent (source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEM of oyster shells</td>
<td></td>
<td><img src="image1" alt="SEM Image" /></td>
<td><img src="image2" alt="SEM Image" /></td>
<td><img src="image3" alt="SEM Image" /></td>
<td><img src="image4" alt="SEM Image" /></td>
</tr>
<tr>
<td>Mean pH</td>
<td>8.30</td>
<td>8.08</td>
<td>7.77</td>
<td>7.14</td>
<td></td>
</tr>
</tbody>
</table>
Synergistic stressors

- Low pH (Ocean Acidification)
- High temperature
- Low salinity

Can they survive in the tropics?
FOOD SECURITY

CHANGE
GLOBAL CLIMATE CHANGE
Already happening today...

- Between 2005 and 2012, Thailand, Malaysia and Vietnam’s shellfish industries suffered disastrous production losses.
- Some experienced 100% mortality of bivalve culture especially mussel culture.
- Is ocean acidification the “culprit”?
Hatchery-Produced Oyster Seeds

Site with normal pH

Site with lower pH

PARAMETERS MEASURED

- Survival
- Growth
- Feasibility to reproduce

Crassostrea iredalei

Crassostrea belcheri
<table>
<thead>
<tr>
<th>Site</th>
<th>Normal pH</th>
<th>Lower pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean pH</td>
<td>8.30</td>
<td>7.29</td>
</tr>
<tr>
<td>Mean salinity</td>
<td>30.3 ppt</td>
<td>20.5ppt</td>
</tr>
<tr>
<td>SURVIVAL (%)</td>
<td>CI</td>
<td>CI</td>
</tr>
<tr>
<td></td>
<td>CB</td>
<td>CB</td>
</tr>
<tr>
<td>Shell thickness</td>
<td>Thick</td>
<td>Thin</td>
</tr>
<tr>
<td>GROWTH</td>
<td>CI / CB</td>
<td>Faster</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Slower</td>
</tr>
<tr>
<td>REPRODUCTION</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>FECUNDITY</td>
<td>CI / CB</td>
<td>✔</td>
</tr>
</tbody>
</table>

Both *Crassostrea belcheri* and *Crassostrea iredalei* are able to tolerate acidic environment.

Oysters at Site B showed higher survival, but no significant differences compared to Site A.
Note: Survival at pediveliger stage
Larval settlement of broodstock from Site with lower pH showed no significant differences between pH from 7.6 to 8.0.

Settlement would not be affected by different pH levels if the optimum salinity is given during the settlement stage.

No settlement experiment was conducted at these pH levels because of high mortality during the larval stage.
Increased CO$_2$ and ocean acidification

### Biophysical effects

Effects on calciferous animals eg. molluscs, crustaceans, corals, echinoderms and some phytoplankton

### “Complicated Responses”

- *Acclimation*?
- *Adaptation*?

Depending on:

- Species
- Populations
- Different life stages
- etc.
Special Thanks to:

• Local organizing committee
• IOC/WESTPAC
• Mr. Wenxi Zhu
• Phuket Marine Biological Station