OCEAN ACIDIFICATION
What consequences for larvae, juveniles and adult abalone \textit{H. tuberculata}?

Sabine Roussel, Sophie Martin, Sylvain Huchette, Rob Day, Philippe Dubois, Aicha Badou, Stéphanie Bordenave
According to the most pessimistic predictions (SSP5-8.5 scenario, IPCC), surface ocean pH should decrease up to 0.4 unit by 2100.

**OCEAN ACIDIFICATION : A MAJOR GLOBAL STRESSOR**

- Reduced pH
- Changes in carbonate chemistry
  - calcium carbonate saturation state ($\Omega$)

*Global ocean surface pH* (IPCC, 2021, 6th assessment report)
OCEAN ACIDIFICATION affects organisms producing calcium carbonate shells, tests or skeletons, such as molluscs, corals and echinoderms, to different extents (Hendriks et al., 2010; Hofmann et al., 2010; Wittmann and Pörtner, 2013; Cyronak et al., 2016).

MOLLUSCS are VULNERABLE

CaCO₃ shell
Limited acid-base regulation

(Fabry, 2008; Gazeau et al., 2013; Kroeker et al., 2013; Parker et al., 2013)

(From Kroeker et al., 2013)
OBJECTIVE

Investigate the effects of ocean acidification (OA) on different stages of the European abalone *H. tuberculata* with an interdisciplinary approach.
EXPERIMENTAL SET-UP

Present-day pHₜ (8.0 – 8.1)
Reduced pHₜ (7.6 – 7.7)

CO₂ bubbling in head tanks (no pseudo-replicate)
**Summary**: effects of ocean acidification on the different life stages of *H. tuberculata*

<table>
<thead>
<tr>
<th></th>
<th>Eggs</th>
<th>Larvae</th>
<th>Post-larvae</th>
<th>Juveniles &lt; 6mo</th>
<th>Juveniles &gt; 12 mo</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Survival</strong></td>
<td></td>
<td>[Red]</td>
<td>[Red]</td>
<td>[Blue]</td>
<td>[Blue]</td>
<td>[Blue]</td>
</tr>
<tr>
<td><strong>Reproduction</strong></td>
<td></td>
<td></td>
<td></td>
<td>[Blue]</td>
<td>[Blue]</td>
<td>[Blue]</td>
</tr>
<tr>
<td><strong>Growth</strong></td>
<td>[Red]</td>
<td></td>
<td></td>
<td>[Red]</td>
<td>[Orange]</td>
<td>[Red]</td>
</tr>
<tr>
<td><strong>Settlement</strong></td>
<td>[Blue]</td>
<td></td>
<td></td>
<td>[Blue]</td>
<td>[Blue]</td>
<td>[Blue]</td>
</tr>
<tr>
<td><strong>Behaviour</strong></td>
<td></td>
<td></td>
<td></td>
<td>[Blue]</td>
<td>[Blue]</td>
<td>[Blue]</td>
</tr>
<tr>
<td><strong>Haemolymph pH</strong></td>
<td></td>
<td>[Red]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Metabolism</strong></td>
<td>[Blue]</td>
<td></td>
<td></td>
<td>[Blue]</td>
<td>[Blue]</td>
<td>[Blue]</td>
</tr>
<tr>
<td><strong>Calcification</strong></td>
<td>[Red]</td>
<td></td>
<td></td>
<td>[Red]</td>
<td>[Orange]</td>
<td>[Red]</td>
</tr>
</tbody>
</table>

- **Strong negative effect**
- **Limited negative effect**
- **Non significant difference**
- **Untested effect**
Reduced growth in length and less gonad investment

(Avignon et al., 2020)
SHELL MICROSTRUCTURE: periostracum

Objective

- Ambient pH (8.0)
- Reduced pH (7.7)

Results and discussion

- Scanning electron microscopy

Conclusion

(© S. Bordenave, 2020)
**SHELL MICROSTRUCTURE: nacre**

**Introduction**

**Objective**

**M&M**

**Results and discussion**

**Conclusion**

**Scanning electron microscopy**

- Regular stacks of aragonite platelets
- Disorganized and pitting corrosion

**pH 8.0**

**pH 7.7**

(Avignon et al., 2020)
**LARVAL GROWTH**

- Reduced growth in length

- Ambient pH (8.0)

- Reduced pH (7.7)

(Auzoux-Bordenave et al., 2022)

⇒ Reduced growth in length
LARVAL MORPHOLOGY AT 48hpf

Introduction

Objective

M&M

Results and discussion

Conclusion

Larval body contracted

Residual or absent shell

ambient pH (8.0)

reduced pH (7.7)

© S. Bordenave

(Auzoux-Bordenave et al., 2022)
OA : reduction of **growth** and impairment of **calcification**, at every stage of *H. tuberculata* life cycle

OA : increased **mortality** and **abnormalities of larvae**

No effect on other functions such as metabolism and behaviour

**Global change** = acidification AND **warming**
*(but also pollution, decrease in oxygen, stronger waves in coastal area ...)*

**Additive, synergetic, or antagonist effects ?**
A team work:

In collab with:

Stéphanie Bordenave  Aicha Badou
Sophie Martin

Sabine Roussel
Sylvain Huchette

Philippe Dubois
Rob Day
MANY THANKS TO ...

Solène AVIGNON
Manon COHELEACH
Carole DI POI
Fanny GAILLARD
Javid KAVOUSI
Christophe LAMBERT
Apolline LEDOUX
Nelly LE GOIC
Saloua M’ZOUDI
Loic MALET
Nicolas RICHARD
Marc SUQUET
Arianna SERVILI