The effects of CO$_2$-induced ocean acidification on the survival and development of early larval stage Antarctic krill (Euphausia superba Dana)

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Krill Lifecycle

Source: Nicol, 2006
Developmental ascent

- Nauplius I \( \sim 8 \) days
- Nauplius II \( \sim 13 \) days
- Metanauplius \( \sim 20 \) days
- Calyptopis I \( \sim 30 \) days
Specific Aims

• Investigate the effects of elevated $pCO_2$ on:
  • 1. Survival in the early larval stages
  • 2. Successful development to calyptopis I
  • 3. Swimming capability and activity level
Experimental set-up
Mortality rate

Mean (+/- S.E.) mortality rate per jar (day⁻¹)

$pCO_2$ (µatm)

- 380
- 700
- 950
- 2000
Developmental stages

- The proportion of surviving larvae in each jar which had reached the metanauplius or calyptopis I stage at the time of sampling.
Proportion of calyptopis I

![Graph showing the proportion of calyptopis across different $pCO_2$ values (µatm)].

- Mean ± S.E. (% calyptopis per jar day⁻¹)

<table>
<thead>
<tr>
<th>$pCO_2$ (µatm)</th>
<th>Mean ± S.E.</th>
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<tbody>
<tr>
<td>380</td>
<td>2.0% ± 0.1%</td>
</tr>
<tr>
<td>700</td>
<td>1.8% ± 0.1%</td>
</tr>
<tr>
<td>950</td>
<td>1.6% ± 0.1%</td>
</tr>
<tr>
<td>2000</td>
<td>1.4% ± 0.1%</td>
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Active swimmers

![Bar chart showing the mean (+/− S.E.) total proportion of swimming larvae per jar at different pCO₂ (μatm) levels: 380, 700, 950, and 2000. The chart indicates a decrease in swimming larvae proportion with increasing pCO₂.]
Developmental ascent

• Combining these results revealed:
• The proportion of calyptopis I larvae which could actively swim in the water column.
• These individuals represented larvae which could complete the developmental ascent.
• Providing a relative measure of changes to recruitment potential under elevated $p\text{CO}_2$. 
Developmental ascent

![Graph showing mean (+/- S.E.) proportion of swimming calyptopis larvae per jar across different $pCO_2$ conditions.]

- **Control**
- **700**
- **950**
- **2000**

$pCO_2$ (μatm)
CO₂ increase at depth

Weddell Sea

(Source: Kawaguchi et al. 2010)
Tipping point

- At what level of $p\text{CO}_2$ will we begin to see the negative effects on:
  - Embryonic development
  - Larval development
  - Maturation cycle
  - Krill population size
  - The Antarctic ecosystem
Conclusion

• Elevated $pCO_2$ has the potential to negatively affect larval survival, development, swimming ability and subsequent recruitment to the adult population.

• The experiment needs further replication to confirm the results.
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