THE EFFECT OF OCEAN ACIDIFICATION AND TEMPERATURE ON THE FERTILISATION AND DEVELOPMENT OF THE OYSTER *Saccostrea glomerata* (GOULD 1850)

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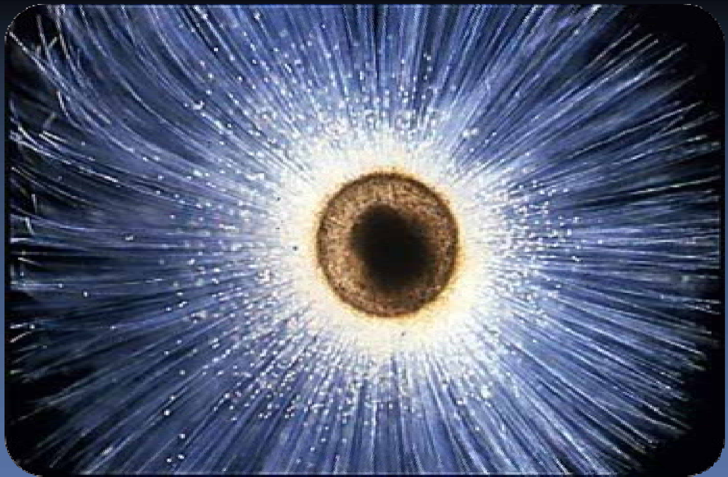
PREVIOUS STUDIES: ADULTS

Reduced calcification in:

- Coccolithophores (80%)
  (Riebesell *et al*. 2000)
- Corals (25-30% - some 54%)
  (Langdon *et al*. 2000; Leclercq *et al*. 2000)
- Foraminifera
  (Bijma *et al*. 1999)
- Pteropods
  (Orr *et al*. 2005)
- Bivalves (10-25%)
  (Gazeau *et al*. 2007)

Peeters 2007

Science Magazine 2004



Spero 2002

PREVIOUS STUDIES: EGGS AND LARVAE

- Reduced fertilisation of copepod eggs > 1000 ppm
  (Kurihara *et al*. 2004)

Wim van Egmond 1995

- High mortality of marine zooplankton passing through CO_2 rich plumes
  (Yamada and Ikeda 2004)

Doyle ABC News 2008

PREVIOUS STUDIES: SYNERGISTIC EFFECTS ON ADULTS

- Only one study has measured the synergistic effects of ocean acidification and temperature

- Reynaud *et al*. 2003:

- no reduction in calcification of scleractinian coral, *Stylophora pistillata* at elevated CO_2

- 50% reduction in calcification synergistic effect of CO_2 and temperature

Stylophora pistillata

AcquaPortal 2008

AIM

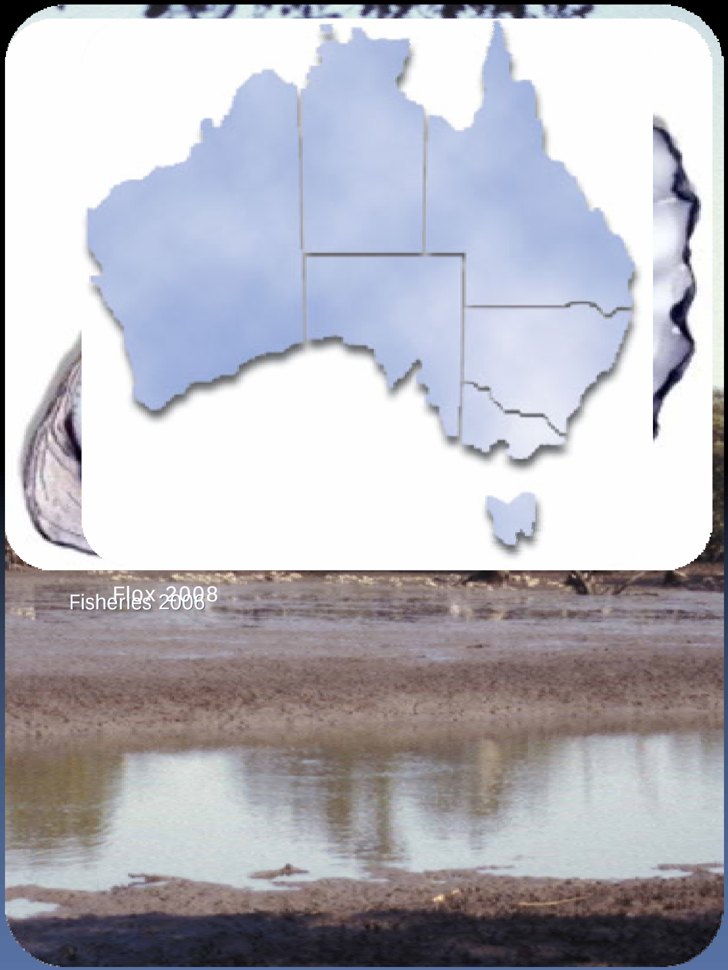
To determine the **synergistic effects** of ocean acidification and temperature on the **eggs and larvae** of an ecologically and economically important **oyster** in Australian estuaries

OYSTER

Sydney rock oyster

Saccostrea glomerata

- Ecologically and economically one of the most significant organisms in Australian estuaries
- Vital in food web and water quality
- 21.4 million € (32.8 million USD) per annum
- 95% of shell composed $CaCO_3$ (aragonite and calcite)



Tucker 2003

Saccostrea glomerata

Four stages of development:

Fertilisation D-veliger Umbonant Pediveliger

Time (days)

0 ⟷ 18-22

D-VELIGERS

Saccostrea glomerata

Four stages of development:

Fertilisation D-veliger Umbonant Pediveliger

0 Time (days) 18-22

HYPOTHESES

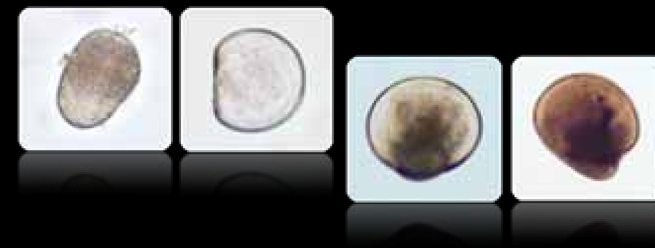
AIMS OF STUDY

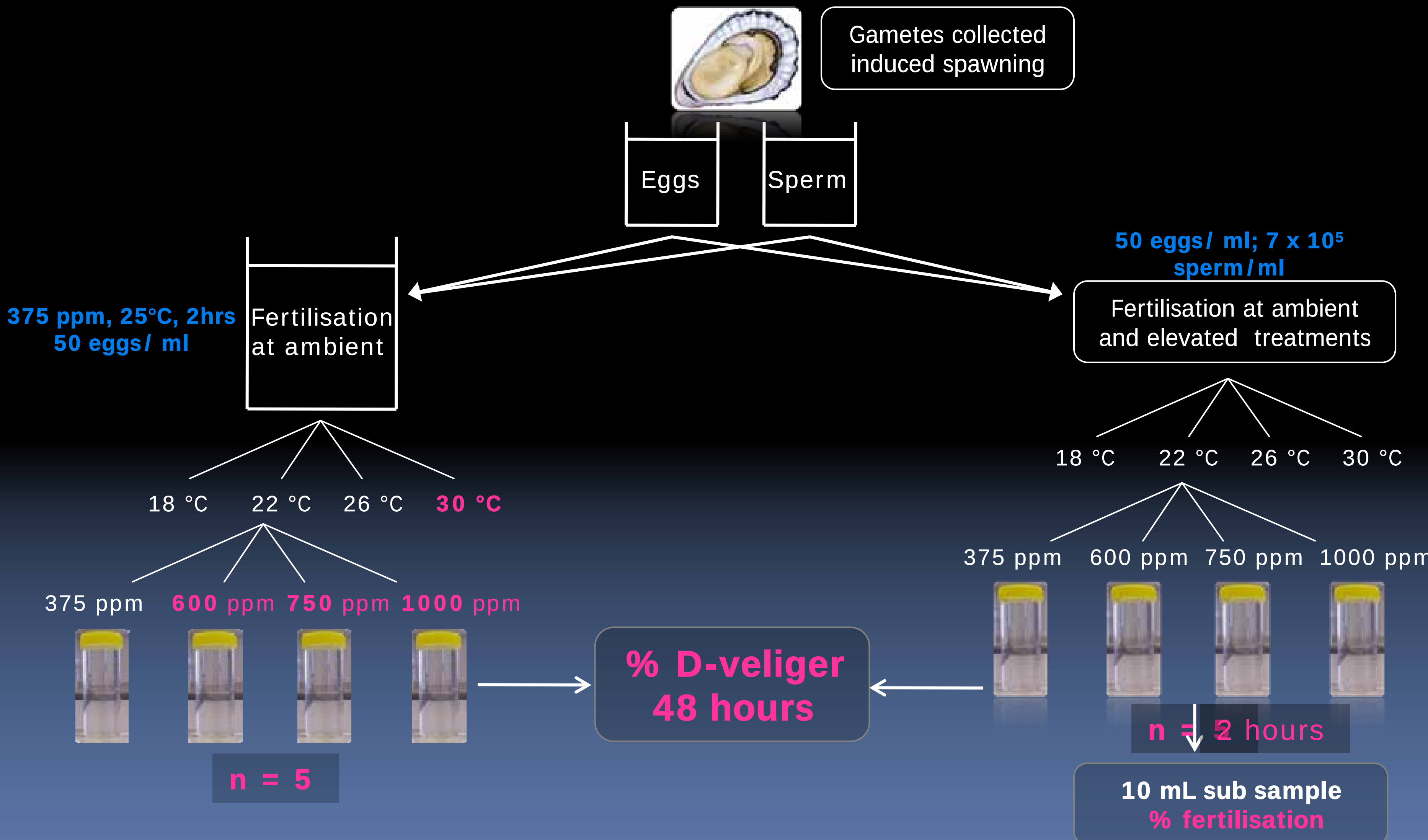
To determine the synergistic effect of ocean acidification and temperature on:

There will be:

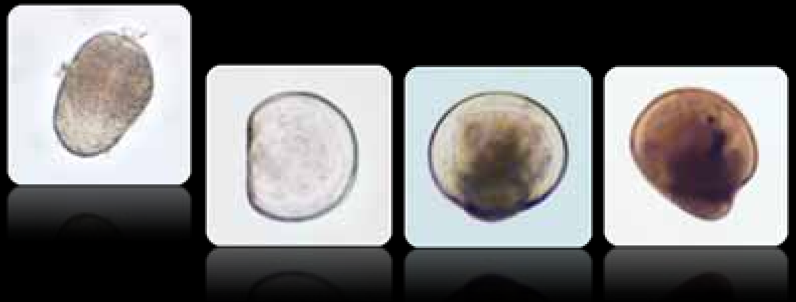
- ↓ fertilisation of *Saccostrea glomerata* gametes
- ↓ development, growth and ↑ abnormality of D-veliger larvae
- ↓ growth of umbonant and pediveliger larvae

FERTILISATION AND D-VELIGER: METHODS

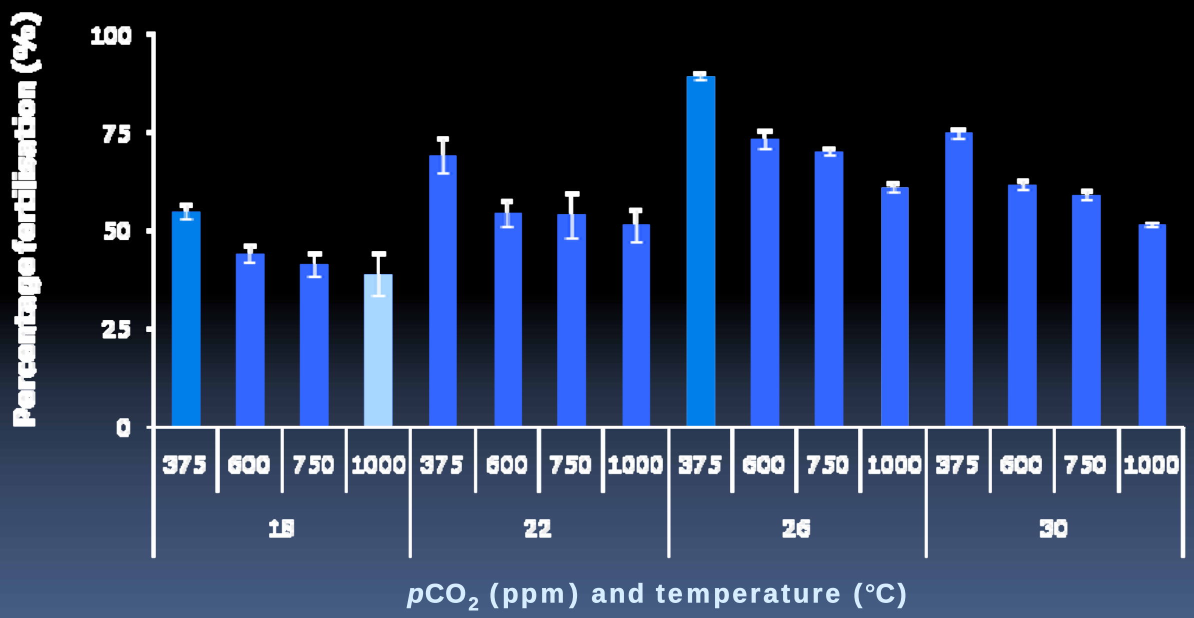




FERTILISATION: RESULTS



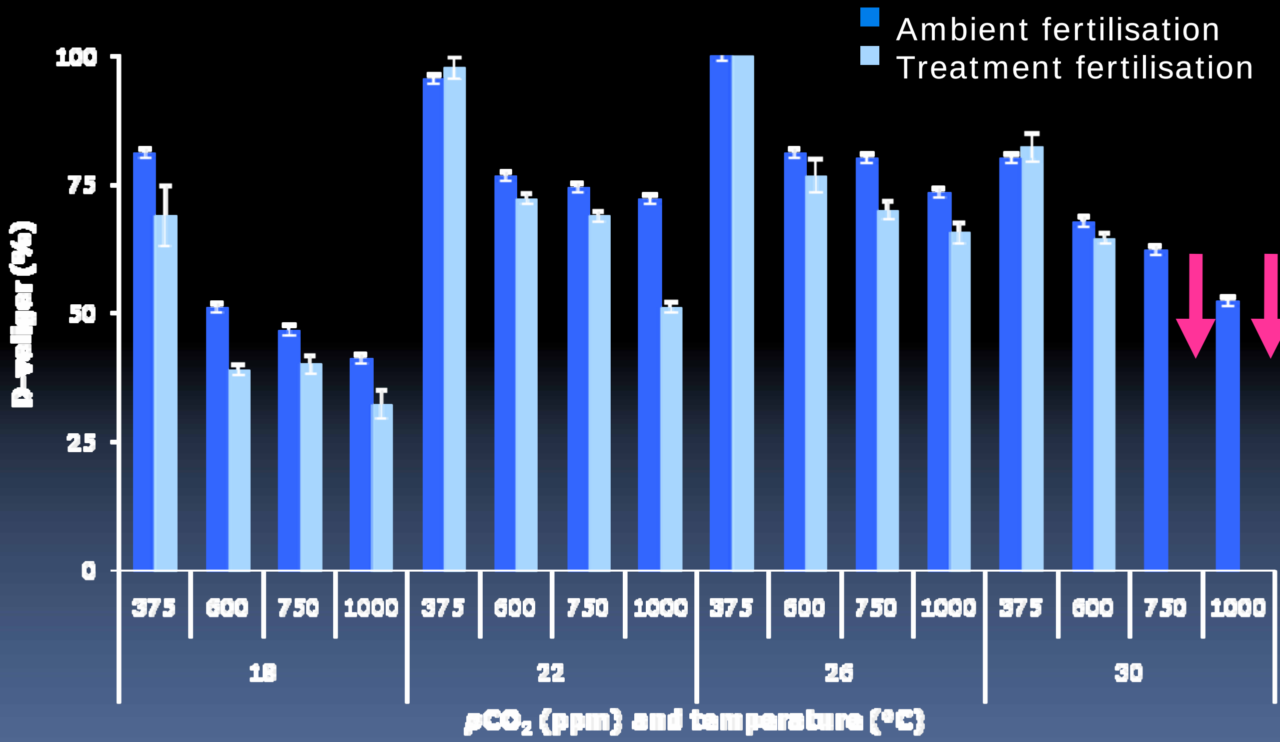
Fertilisation decreased with increased pCO_2
(pCO_2 and temperature P < ***)



- 27 % reduction at elevated pCO_2 optimal temp (26 °C)
- Further 25 % reduction at elevated pCO_2 suboptimal temp (18 °C)

% DEVELOPMENT OF D-VELIGER

Development decreased with increased pCO_2
(pCO_2 x temperature P < ***)



- 27% reduction at elevated pCO_2 optimal temp (26 °C)
- Development at 750-1000 ppm and 30 °C after treatment fertilisation
- Development reduced by 17 ± 6 % in treatment vs. ambient fertilisation
- 40% reduction at elevated pCO_2 suboptimal temp (18 °C)

% ABNORMALITY OF D-VELIGER

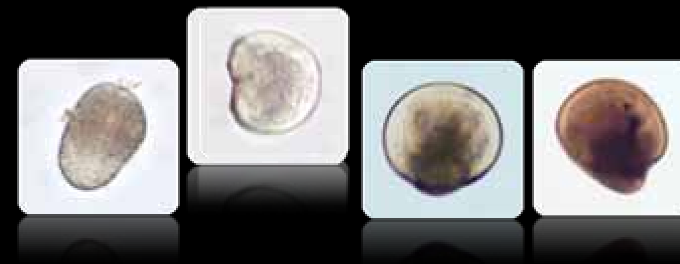
Figure 1.

Ambient 375 ppm

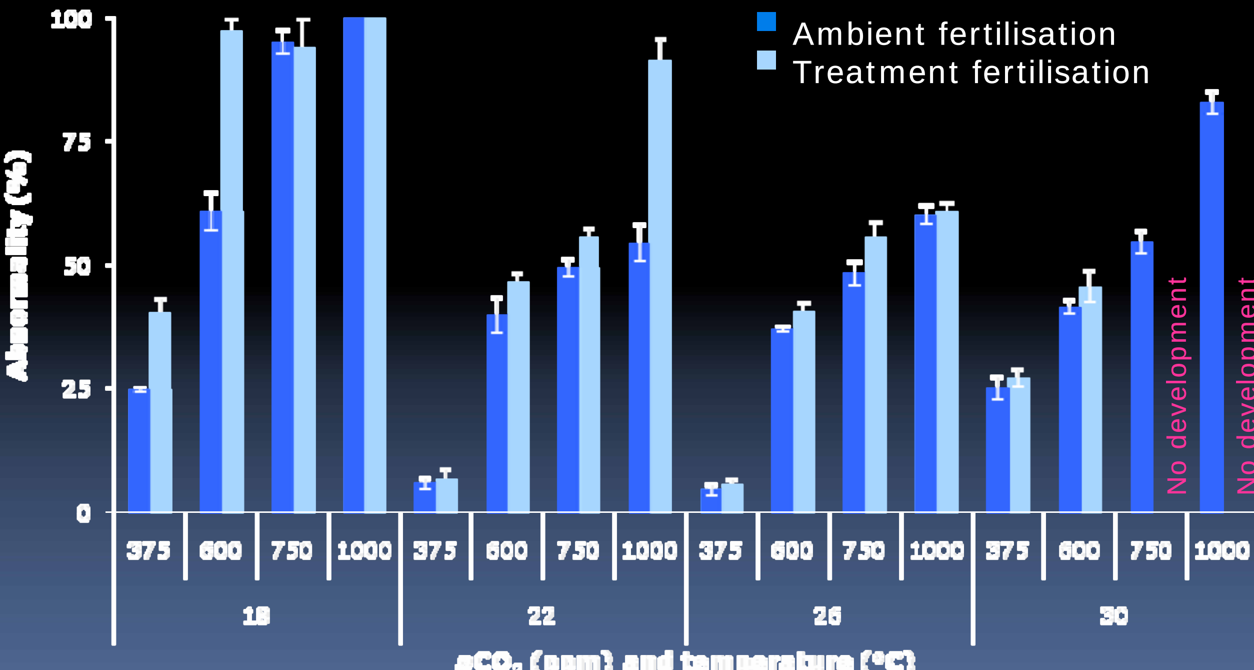
Figure 2.

Elevated 1000 ppm

% ABNORMALITY OF D-VELIGER



Abnormality increased with increased pCO_2
(pCO_2 x temperature P < ***)



- Abnormality increased 10 ± 4 % in treatment vs. ambient fertilisation
- 53% increase at elevated pCO_2 optimal temp (26 °C)
- Abnormality highest at 18 °C and elevated pCO_2 (1000 ppm)
- 75% increase at elevated pCO_2 suboptimal temp (18 °C)
- 100% abnormality

SHELL LENGTH OF D-VELIGER

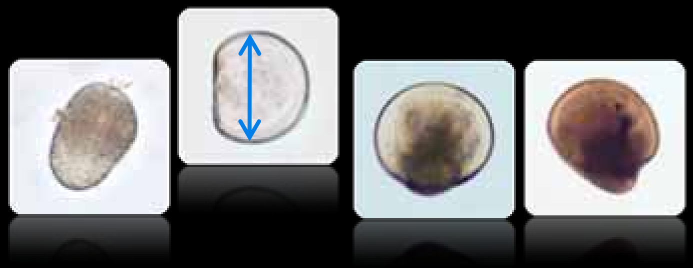
Figure 1.

Ambient 375 ppm

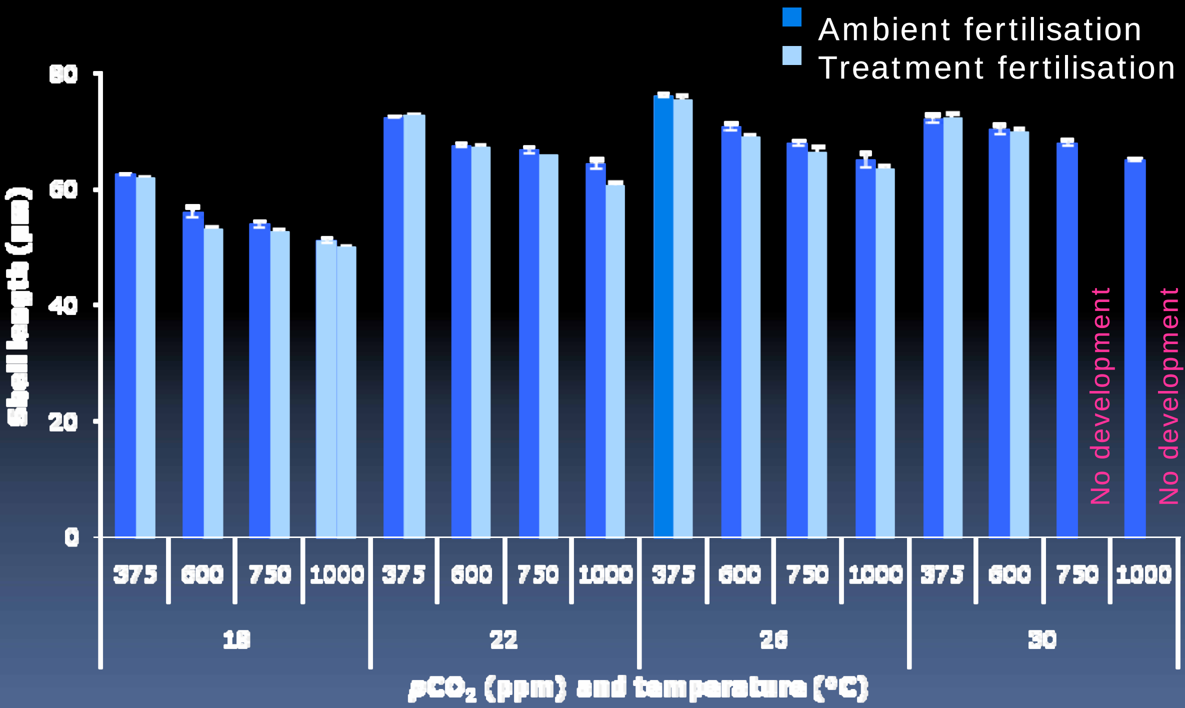
Figure 2.

Elevated 1000 ppm

SHELL LENGTH OF D-VELIGER



Shell length decreased with increased pCO_2
(pCO_2 x temperature P < **)

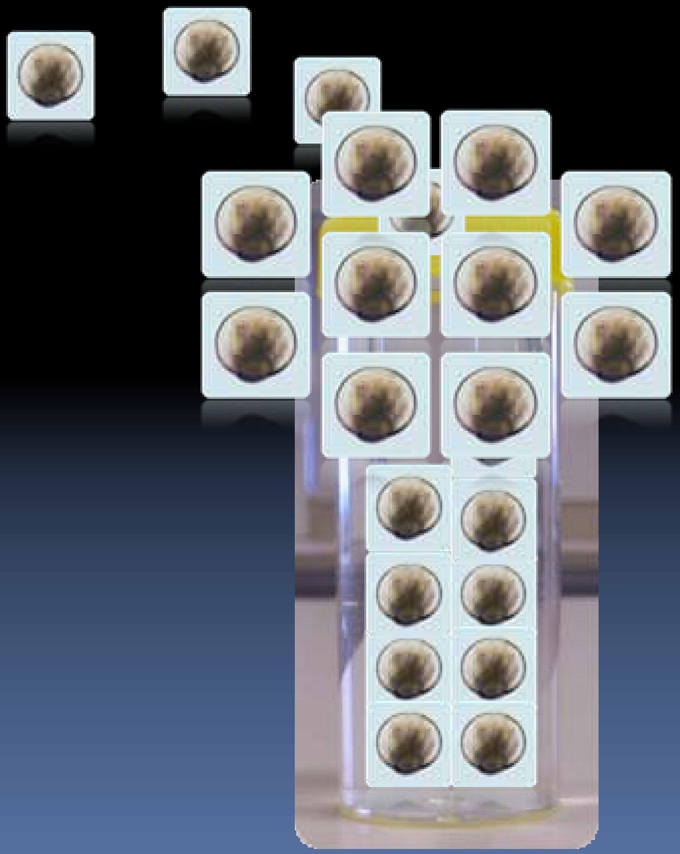


- Shell length greatest at 375 ppm and 26 °C (76 ± 0.30 µm)
- Shell length 1.51 ± 0.34 µm smaller in treatment vs. ambient fertilisation
- Shell length smallest at 1000 ppm and 18 °C (51 ± 0.40 µm)

UMBONANT: METHODS

Larvae were selected at the beginning of the umbonant stage (90 µm)

Transferred in seawater at their pCO_2 and temperature treatments (2.5 larvae/mL)



EXPERIMENTAL DESIGN

Four temperature treatments

18 °C

22 °C

26 °C

30 °C

Natural spawning temperatures

Elevated temperature

Four pCO_2 treatments

n = 5

375 ppm

Control
Current ambient

600 ppm

750 ppm

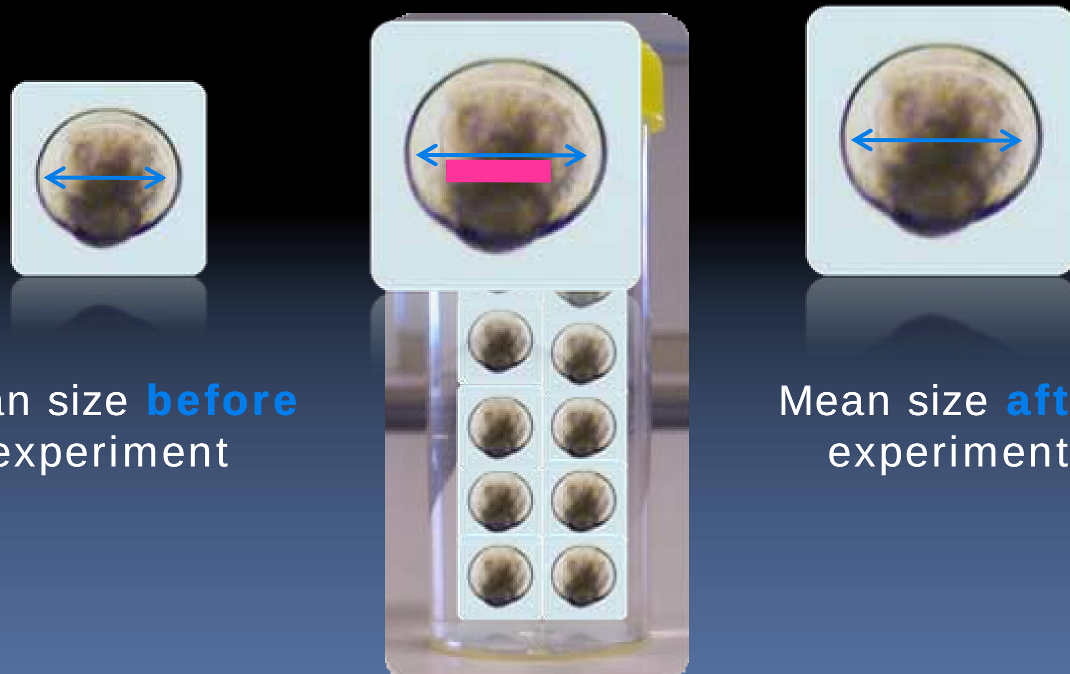
Elevated pCO_2 treatments

1000 ppm

UMBONANT: METHODS

Feed known daily algal diet of *Chaetoceros muelleri*, *Pavlova lutheri* and *Tahitian Isochrysis*

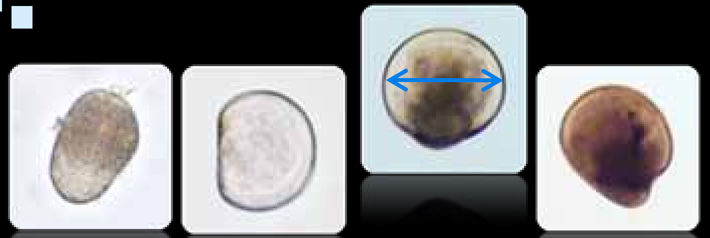
Shell length measured after 4 days (i.e. rapid instantaneous growth)



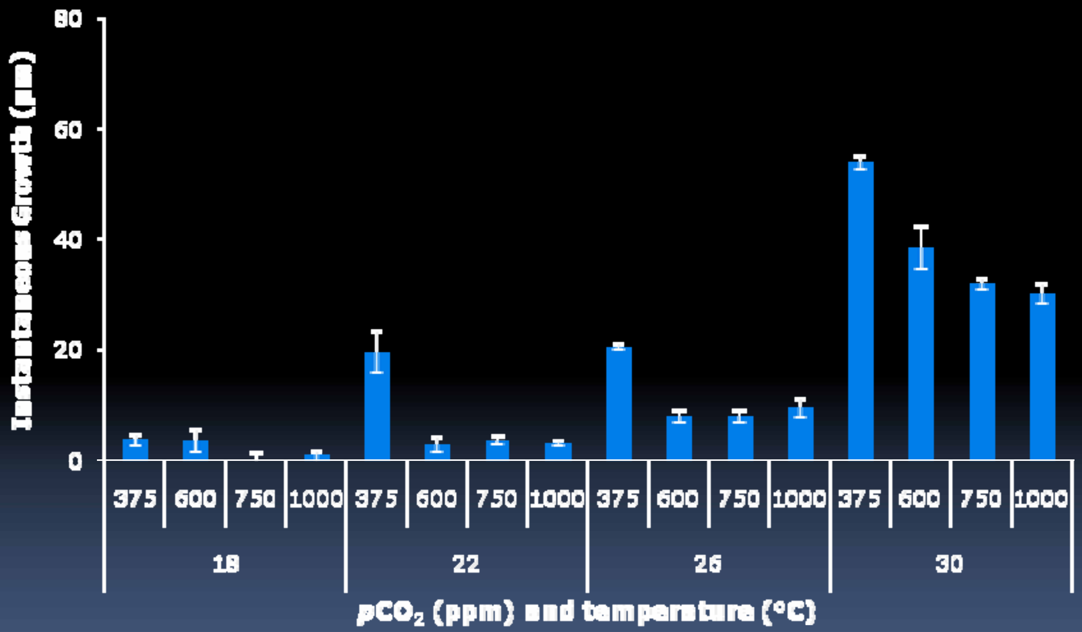
Mean size **before** experiment

Mean size **after** experiment

UMBONANT RESULTS: SHELL LENGTH

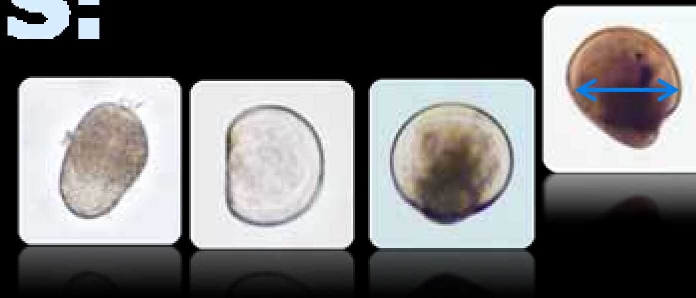


Growth decreased with increased pCO_2 (pCO_2 x temperature P < ***)

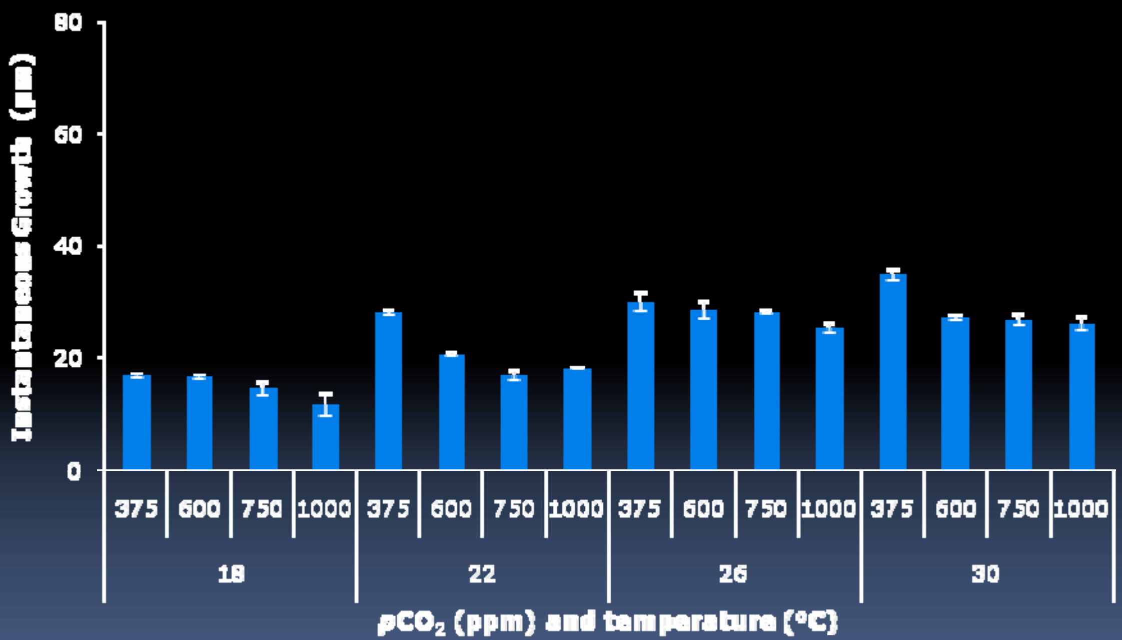


- Growth best at 30 °C
- Growth severely reduced at lower temperatures and elevated pCO_2

PEDIVELIGER RESULTS: SHELL LENGTH



Growth decreased with increased pCO_2 (P < ***)



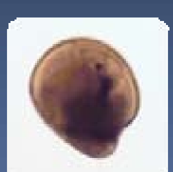
- Growth greatest at 26 – 30 °C
- Better growth at elevated pCO_2 than umbonant stage

SUMMARY OF RESULTS

Fertilisation ↓ with increased pCO_2
Optimal temperature: 26 °C
Suboptimal temperature: 18 °C

Development & growth ↓ and abnormality ↑ with increased pCO_2
Optimal temperature: 26 °C
Suboptimal temperature: 18 °C (ambient fertilisation)
30 °C (treatment fertilisation – lethal effects)

Growth ↓ with increased pCO_2
Optimal temperature: 30 °C
Suboptimal temperature: 18 °C

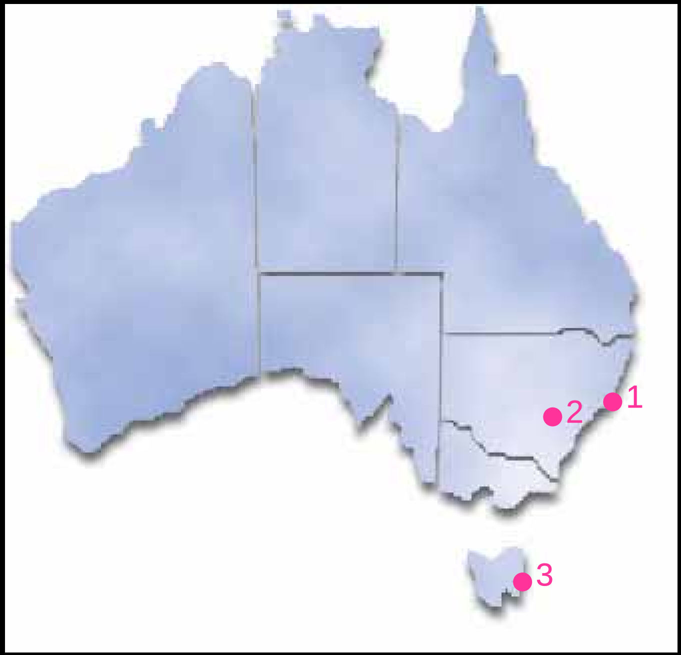


Growth ↓ with increased pCO_2
Optimal temperature: 26 - 30 °C
Suboptimal temperature: 18 °C

CONCLUDING STATEMENTS

- Ocean acidification and temperature had a significant effect on the fertilisation and embryonic development of *S. glomerata*.
- Sub-lethal and lethal effects , depending on the stage of development and length of exposure.
- Other bivalves in our estuaries may be similarly affected.

- *S. glomerata* has been selectively bred within Australia for fast growth and disease resistance.
- My current research is to determine whether these lines may be resistant to ocean acidification and temperature.



Flox 2008

THANK YOU

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