University of
Western Sydney

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

THE EFFECTS OF OCEAN ACIDIFICATION AND TEMPERATURE ON OYSTERS AND THE POTENTIAL OF SELECTIVE BREEDING TO AMELIORATE CLIMATE CHANGE

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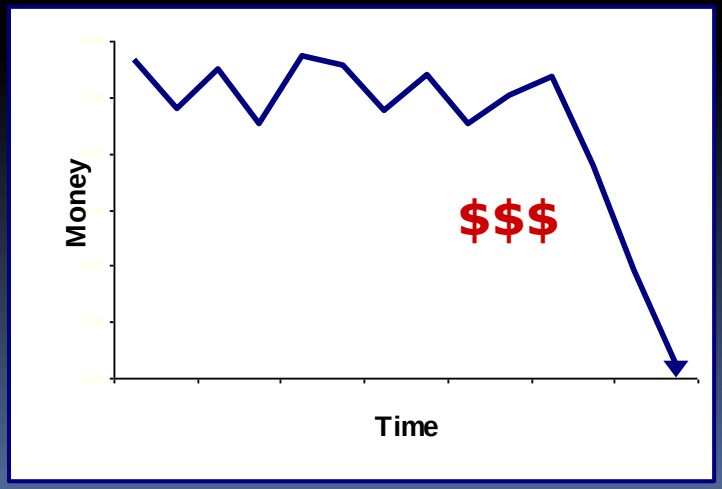
Australia

BACKGROUND

- **Climate change** is expected to have impacts on marine organisms and ecosystems

'Economic consequences'

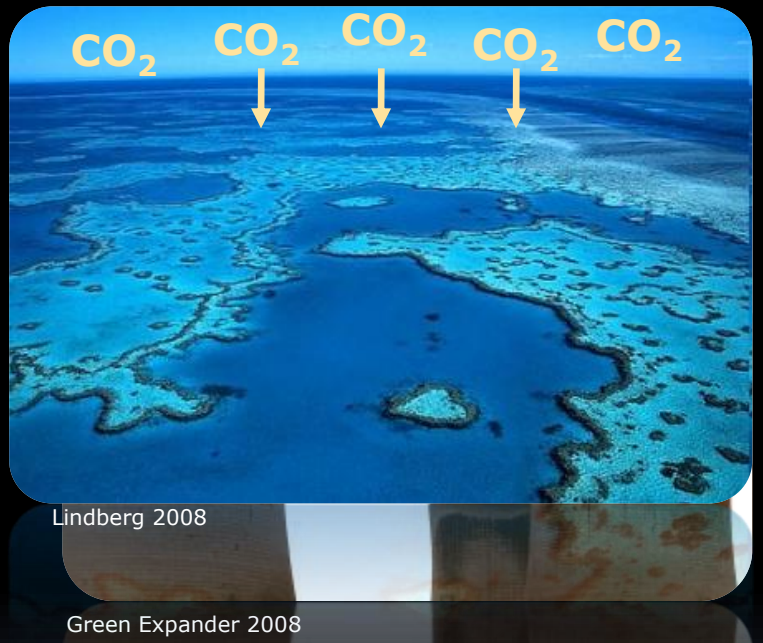


BACKGROUND

Elevations in atmospheric CO_2:

- Temperature of oceans rising
- Changing ocean chemistry

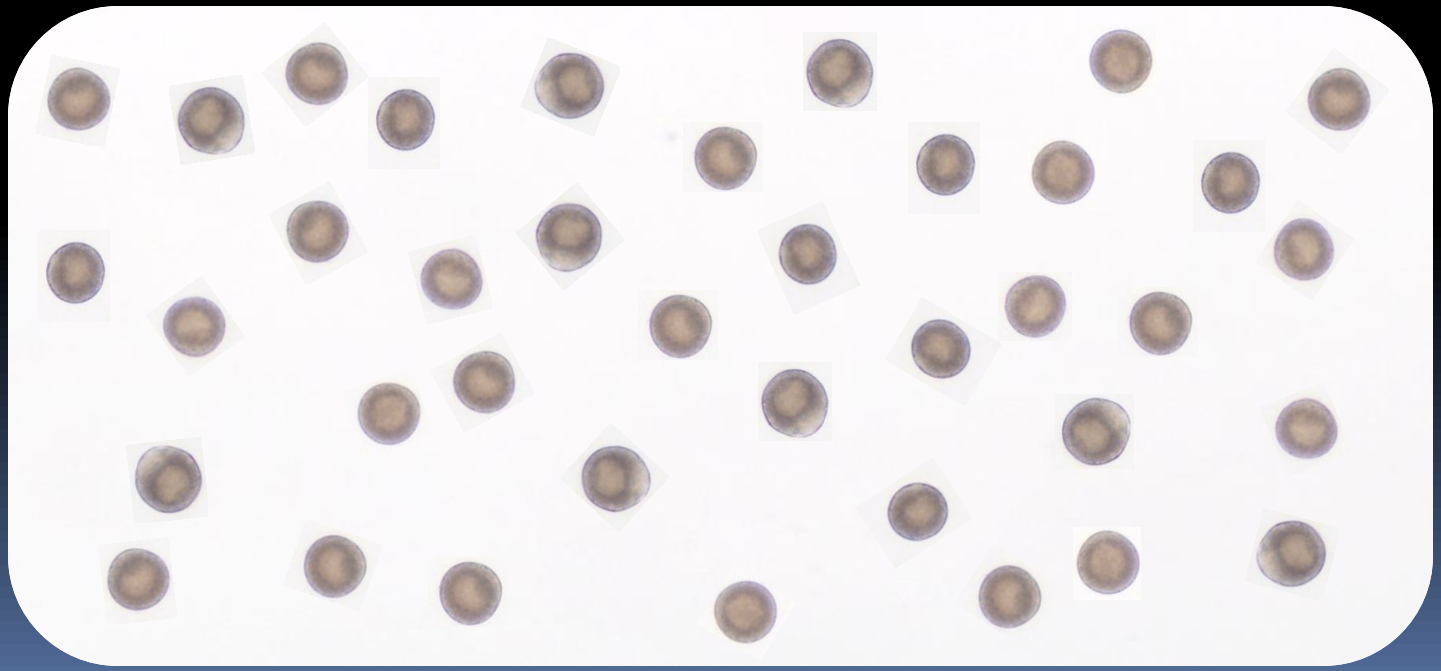
Dissolves into the Ocean



'Ocean acidification'

IF OCEANS ACIDIFY AND WARM

- Broadcast spawners such as molluscs, which release their gametes into the water column, may be affected from the beginning of their development



PREVIOUS STUDIES: EGGS AND LARVAE

Few studies:

- ↓ Fertilisation (Kurihara *et al*. 2004; 2007, Havenhand *et al*. 2008)
- ↓ Size (Kurihara *et al*. 2004; 2007)
- ↑ Abnormality (Kurihara *et al*. 2004; 2007)
- ↑ Mortality (Yamada and Ikeda 2004)

Wim van Egmond 1995

Synergistic impacts:

- Two Studies... (Parker *et al*. 2009; Byrne *et al*. 2009)

Doyle ABC News 2008

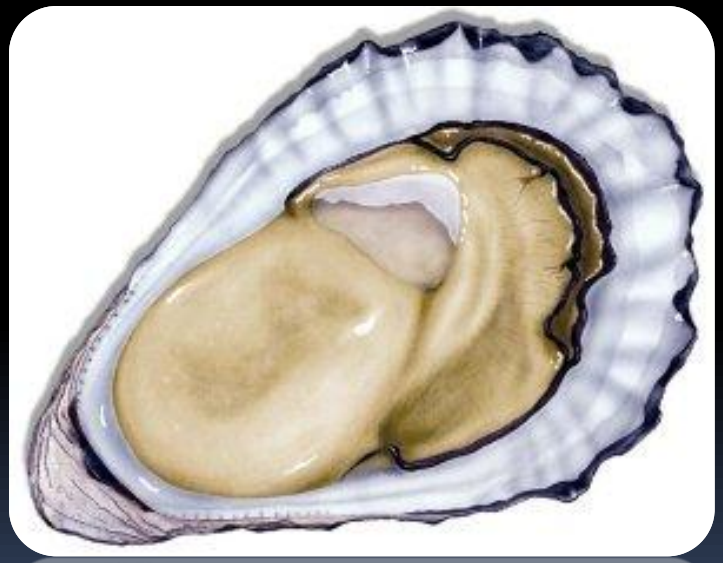
AIM – PART 1

To determine and compare the **synergistic impacts** of ocean acidification and temperature on **embryos** and **larvae** of two ecologically and economically important **oysters**

OYSTERS

Sydney rock oyster

Saccostrea glomerata



Fisheries 2006

Pacific oyster

Crassostrea gigas

John McCabe 2005

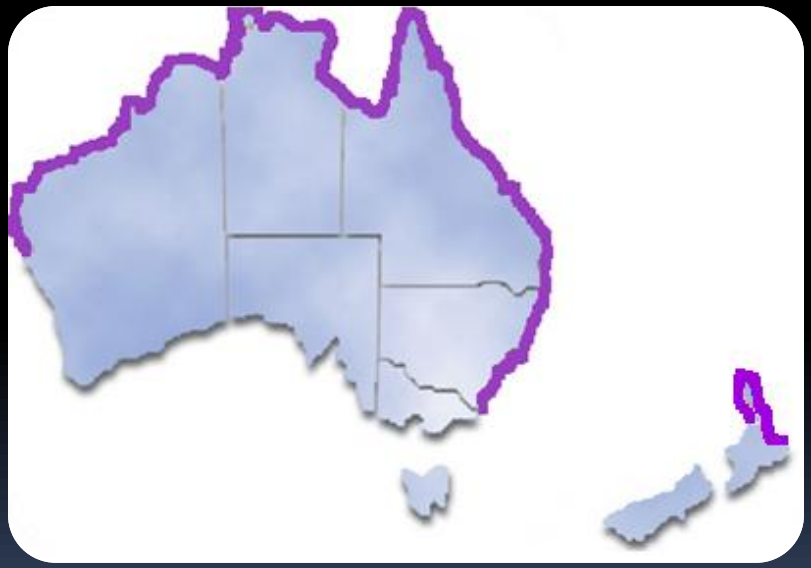
OYSTERS

Sydney rock oyster

Saccostrea glomerata

Pacific oyster

Crassostrea gigas



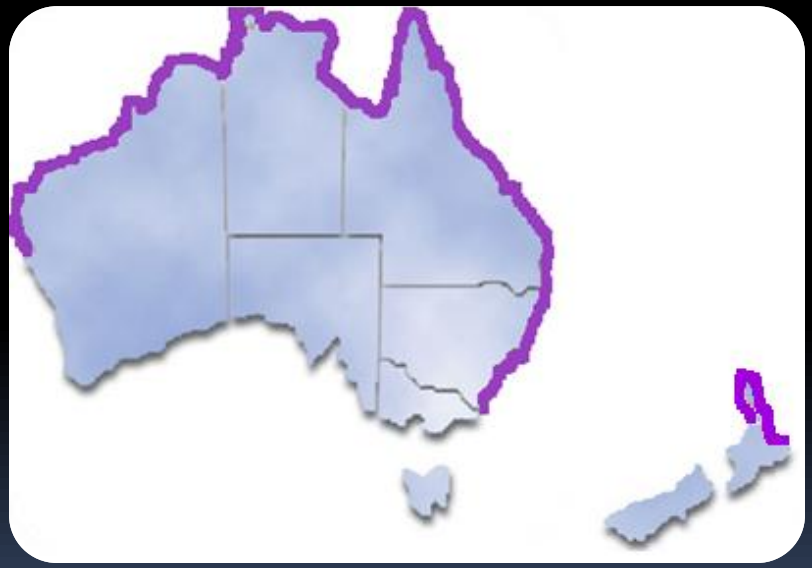
Flox 2008

Australia & New Zealand

OYSTERS

Sydney rock oyster

Saccostrea glomerata

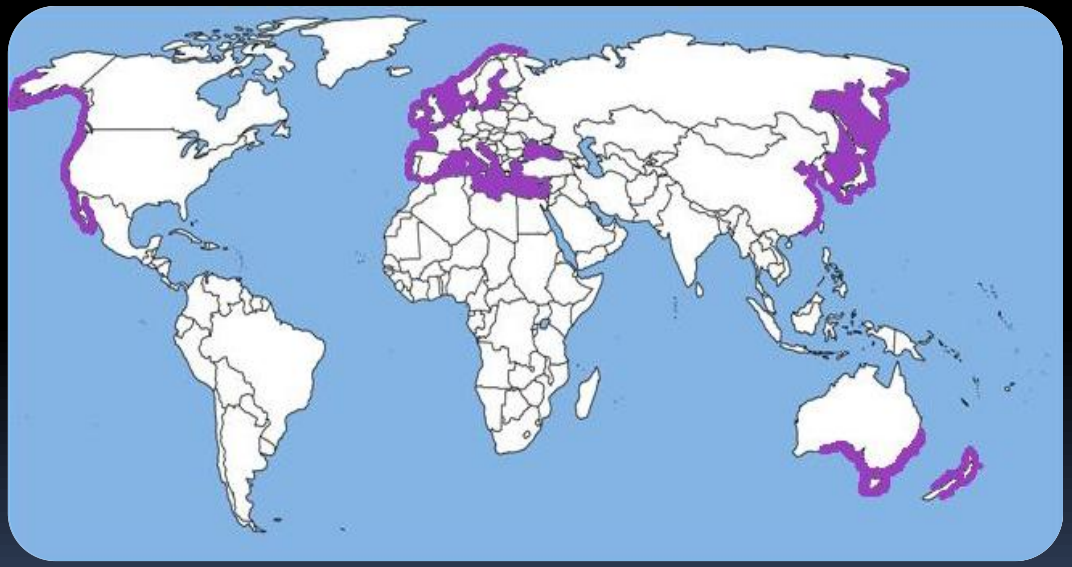


Flox 2008

Australia & New Zealand

Pacific oyster

Crassostrea gigas



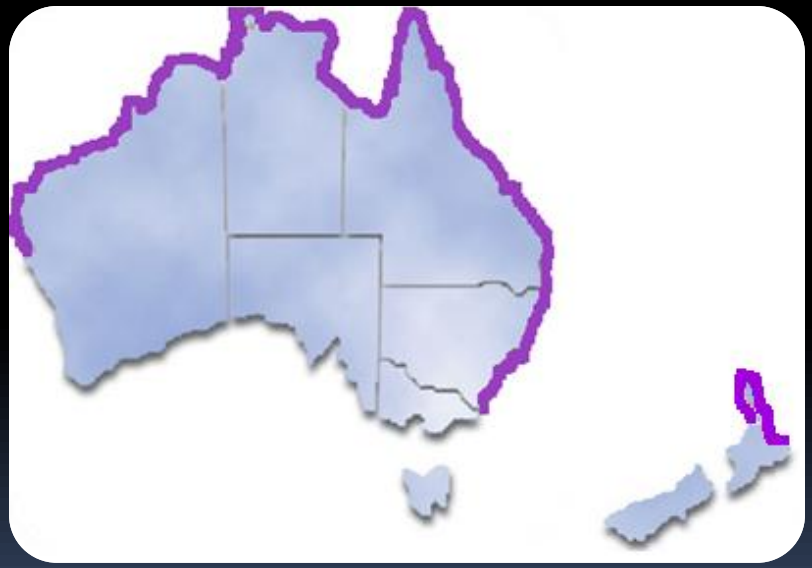
Wikimedia 2007

World wide distribution

OYSTERS

Sydney rock oyster

Saccostrea glomerata



Flox 2008

Australia & New Zealand

Pacific oyster

Crassostrea gigas

Flox 2008

Introduced 1940’s

OYSTERS

Sydney rock oyster
Saccostrea glomerata

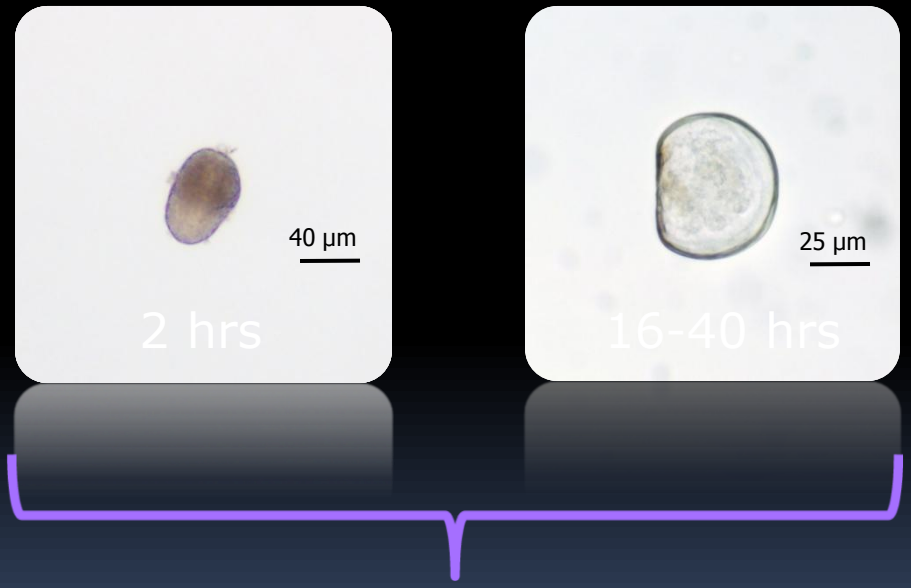
Pacific oyster
Crassostrea gigas

Tucker 2007

TEST STAGES – PART 1

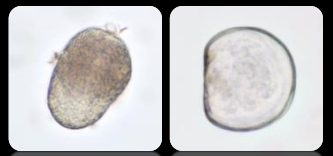
Two stages of development:

Fertilisation D-veliger



Suspended in water column

EXPERIMENTAL DESIGN



Fisheries 2006

John McCabe 2005

Gametes collected induced spawning

Eggs **Sperm**

Transferred into pCO_2 and temperature treatments

18 °C 22 °C 26 °C 30 °C

50 eggs/ ml; 7 x 10^5 sperm/ml

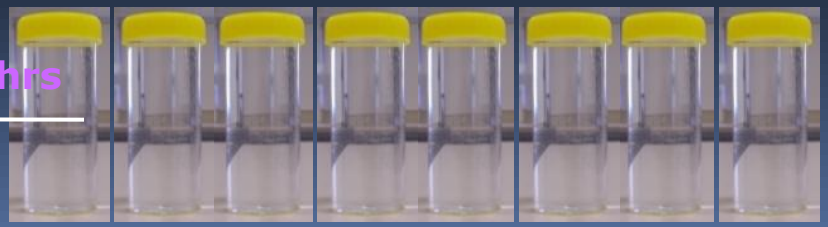
375 ppm 600 ppm 750 ppm 1000 ppm

10 mL subsample

% fertilisation

n = 3

2 hrs



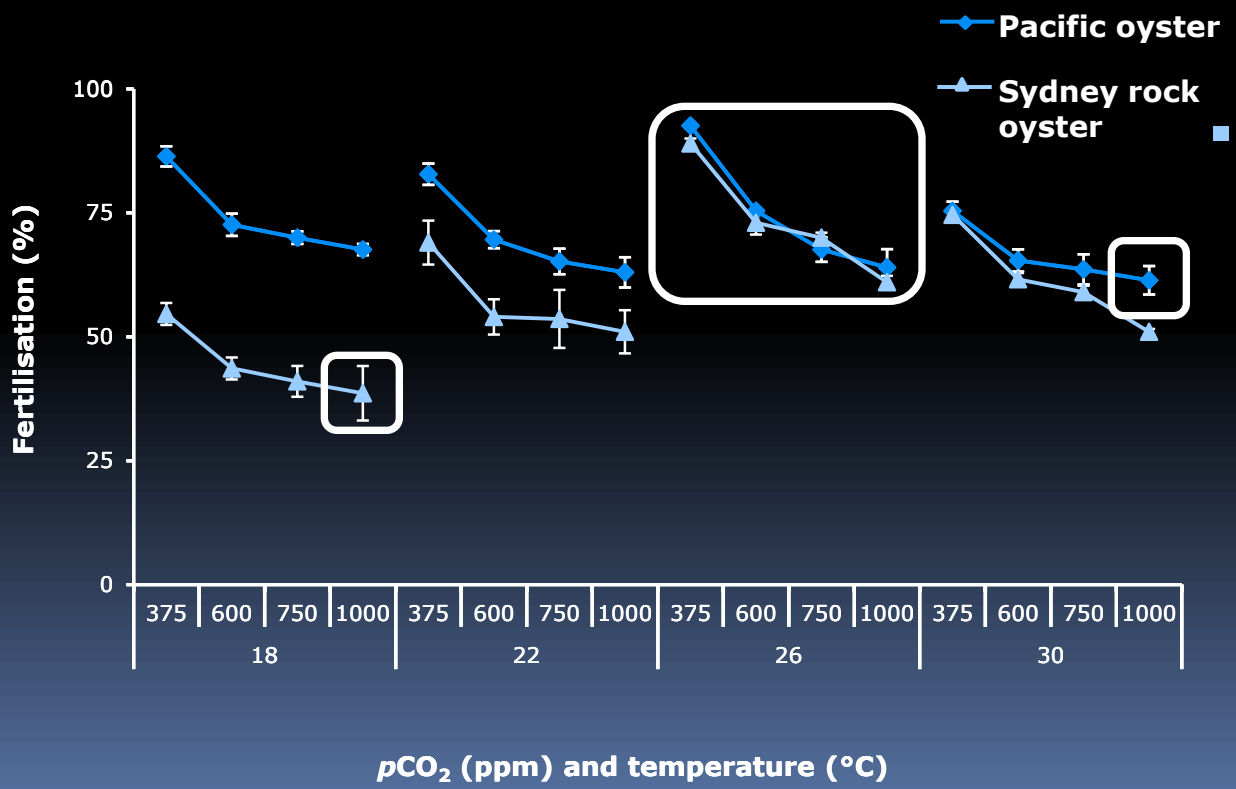
D-veliger

Shell length

48 hours

FERTILISATION: RESULTS

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



- Fertilisation greatest at
  26 °C for both species
  18 °C at 1000 ppm for SRO
  50 % reduction

  30 °C at 1000 ppm for PO
  31 % reduction

D-VELIGER RESULTS

Decrease in normality

Figure 1.

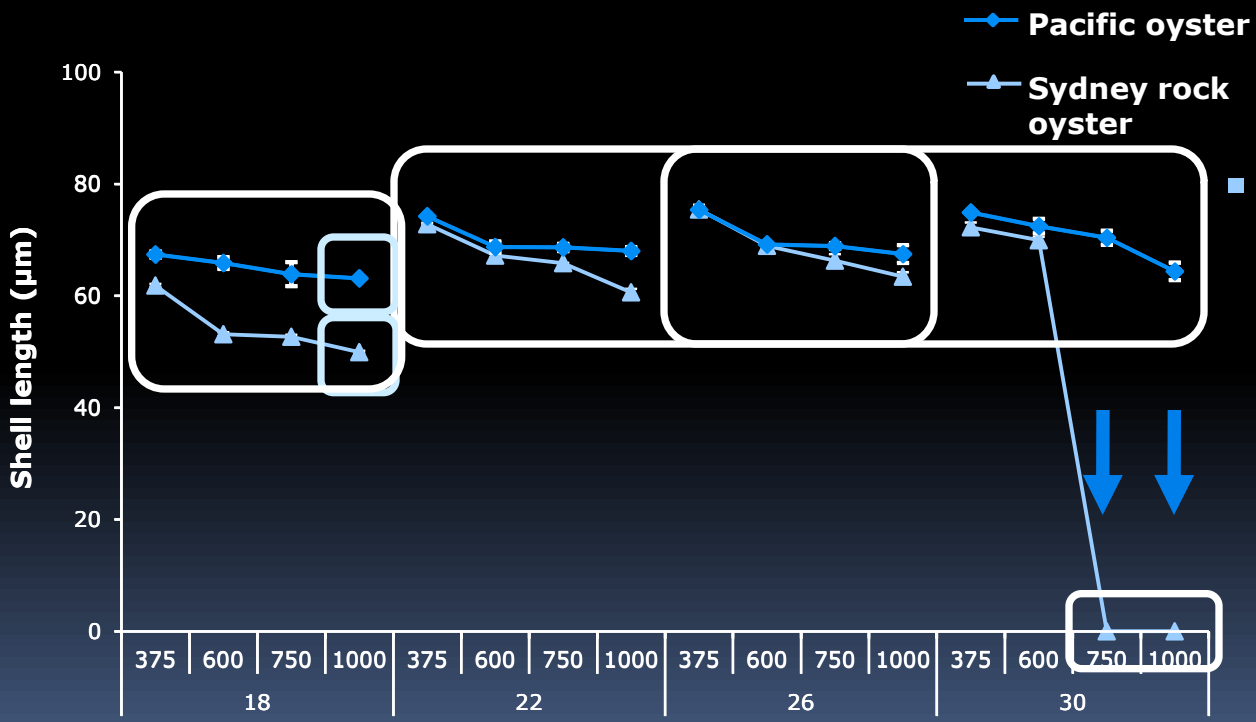
Ambient 375 ppm

Figure 2.

Elevated 1000 ppm

SHELL LENGTH OF D-VELIGERS

Shell length decreased with increased pCO_2
(pCO_2 x temperature $P <$ ** SRO; * PO)

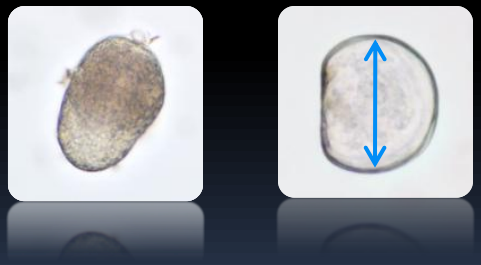


- Shell length decreased at:
  30 °C at 750 – 1000 ppm
  18 °C at 1000 ppm
- For species:
  33 % reduction SRO
  22, 26 & 30 °C for PO
  12 % reduction for PO

Lethal effects

SUMMARY – PART 1

Ocean acidification and temperature had a significant impact on the embryonic and larval stages of the Sydney rock and Pacific oyster



PART 2

Do genetic differences in oysters have the potential to ameliorate these impacts???

SELECTIVE BREEDING

- Selective breeding programs used in major aquaculture industries for many years
- SRO selectively bred for fast growth as well as resistance to disease
- This study used two selectively bred lines and a control line:

Georges River – 6 generations fast growth
QX resistant

Quibray Bay – 6 generations fast growth
Winter mortality resistant

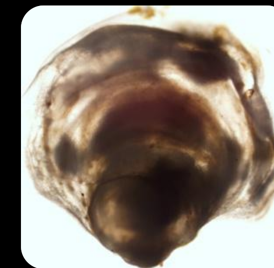
Control – No selection

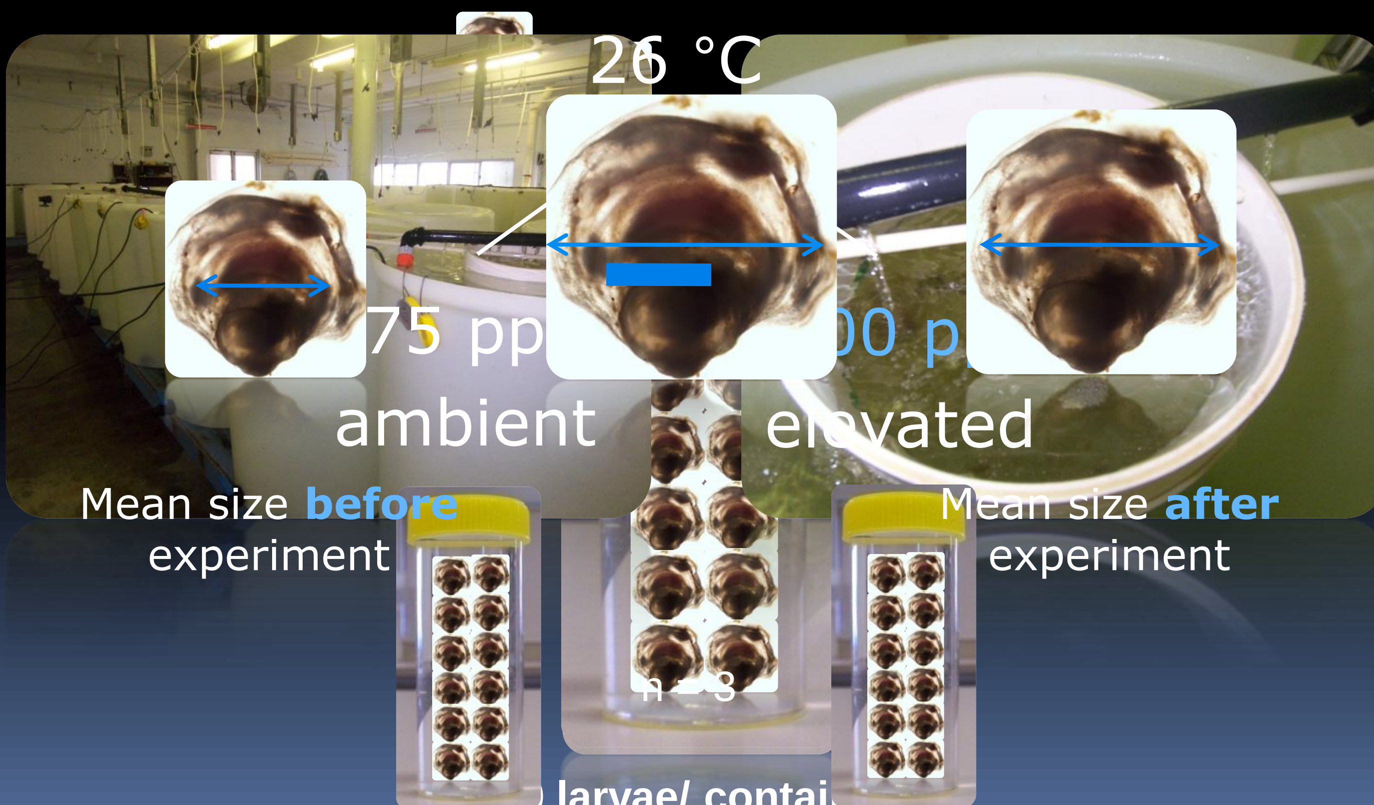
TEST STAGE – PART 2

Spat

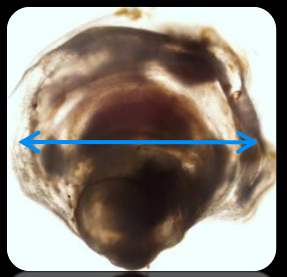
Newly metamorphosed

EXPERIMENTAL DESIGN SELECTED LINES

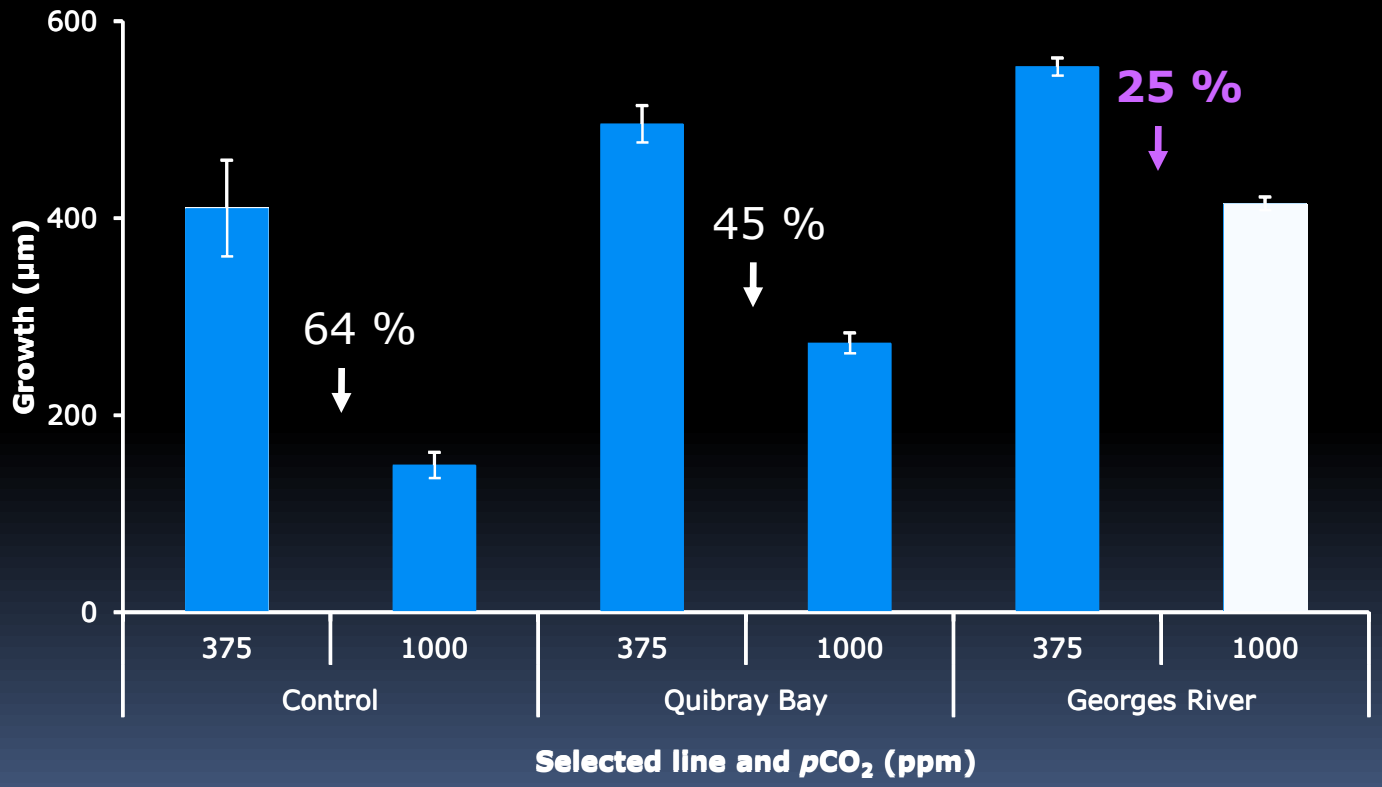




SELECTED LINES

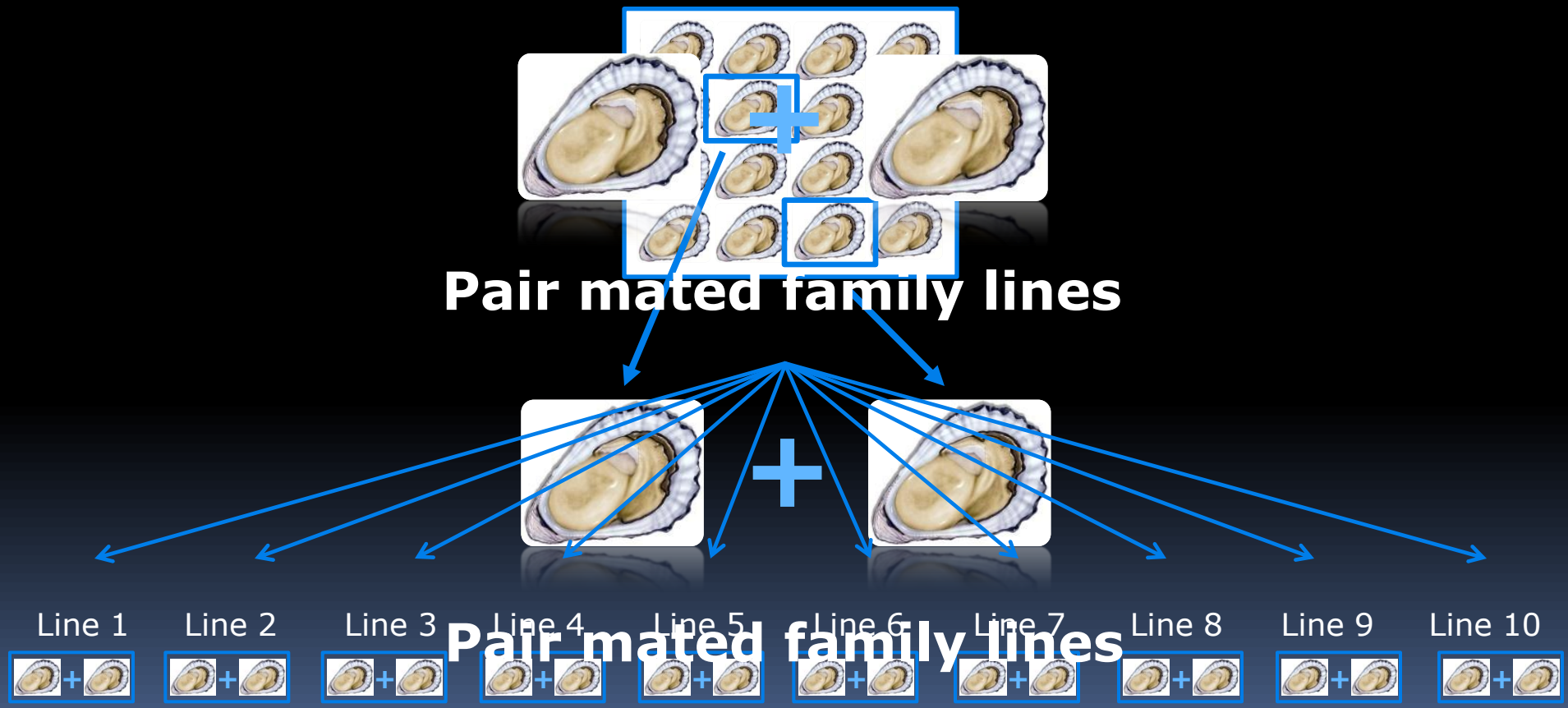


Georges River oysters at ambient pCO_2 (Ran ***)

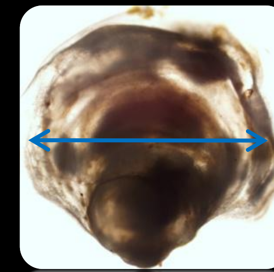


PAIR MATED LINES

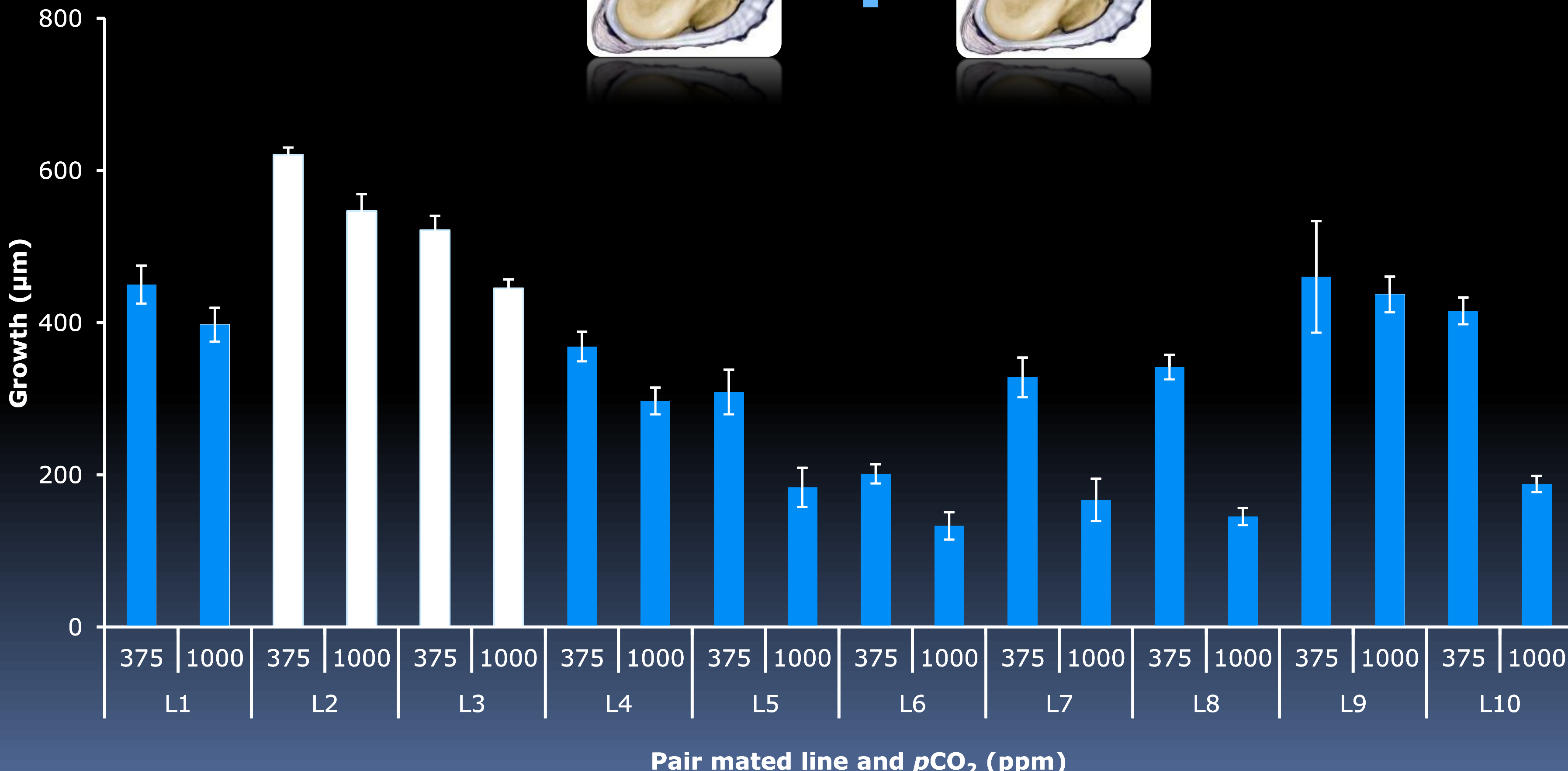
Georges River selected line



PAIR MATED LINES



Growth decre… Except 1 … NO … significant difference (P < ***)



SUMMARY – PART 2

Selectively bred > Control Oysters

Oysters may have an adaptive capacity to ocean acidification stress

PART 3

Identifying the underlying mechanisms responsible…

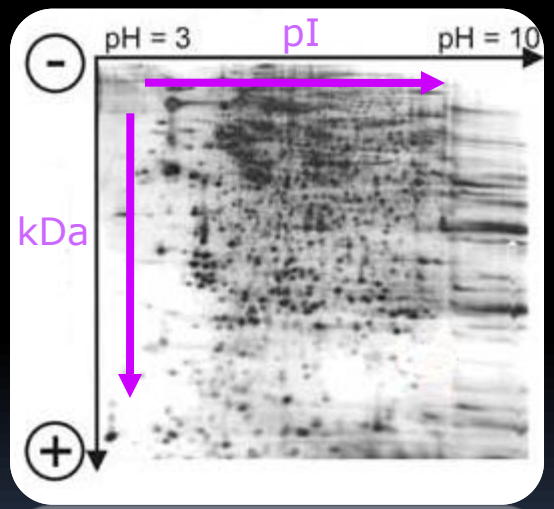
PROTEOMICS

2 Dimensional – Gel Electrophoresis

- powerful protein separating technique which separates proteins based on charge and size

Charge

Size



Šeda *et al*., 2006

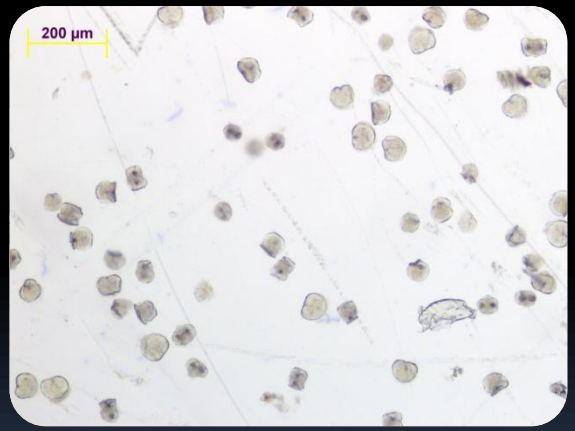
- used to compare proteins in different samples

(Görg *et al*. 2000)

2D – GEL ELECTROPHORESIS

Two dimensional electrophoresis (2DE) detect differences in:

1. 'control' and 'CO_2 stressed' oyster embryos



2. 'wild type' vs. 'selectively bred'

Differences in protein expression can be "on" vs. "off"…. 2D – GEL RESULTS

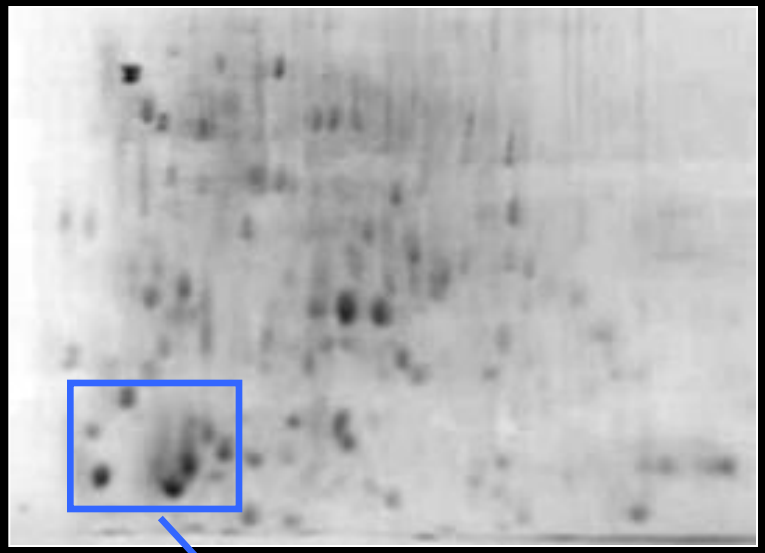


Fig 1. ambient 375 ppm

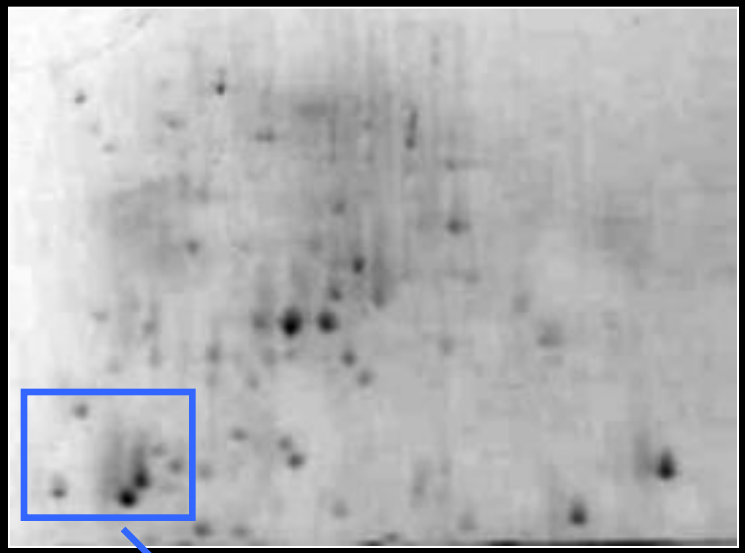
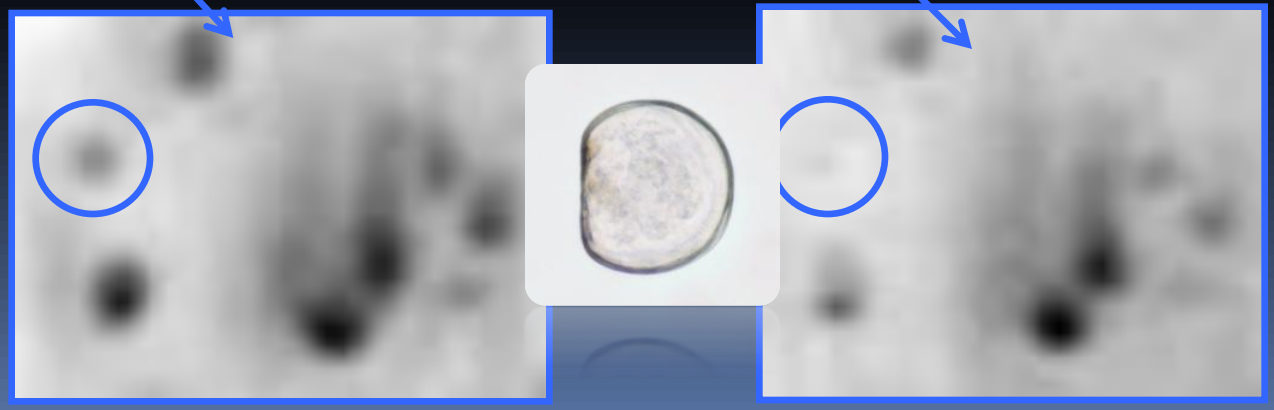
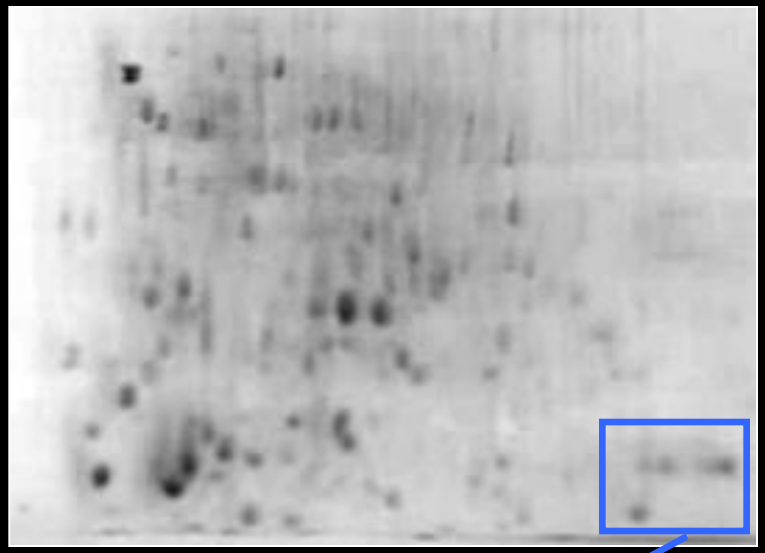


Fig 2. elevated 1000 ppm



…or differences in relative protein concentration



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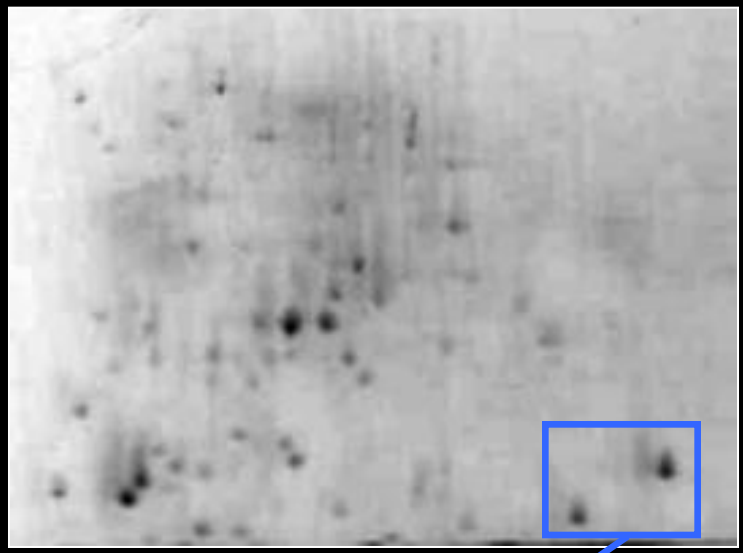
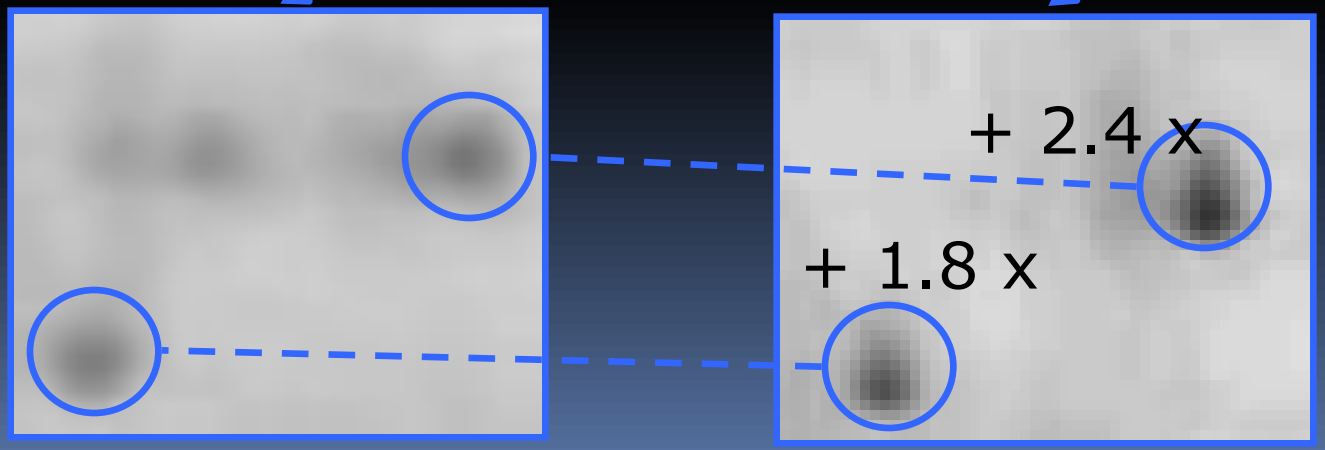


Fig 2. elevated 1000 ppm



SIGNIFICANCE

- Acute studies have shown that oysters are particularly vulnerable to ocean acidification and temperature
- Some oysters show an adaptive response of to climate change
- If we can isolate the genes and/ or proteins involved in this adaptive response, then we may be able to ‘climate proof’ oyster industries

Flox 2008

THANK YOU

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