MARINE BIOLOGY WITH PLYMOUTH UNIVERSITY

Long-term physiological responses to elevated CO_2 and temperature in the sea urchin *Paracentrotus lividus*.

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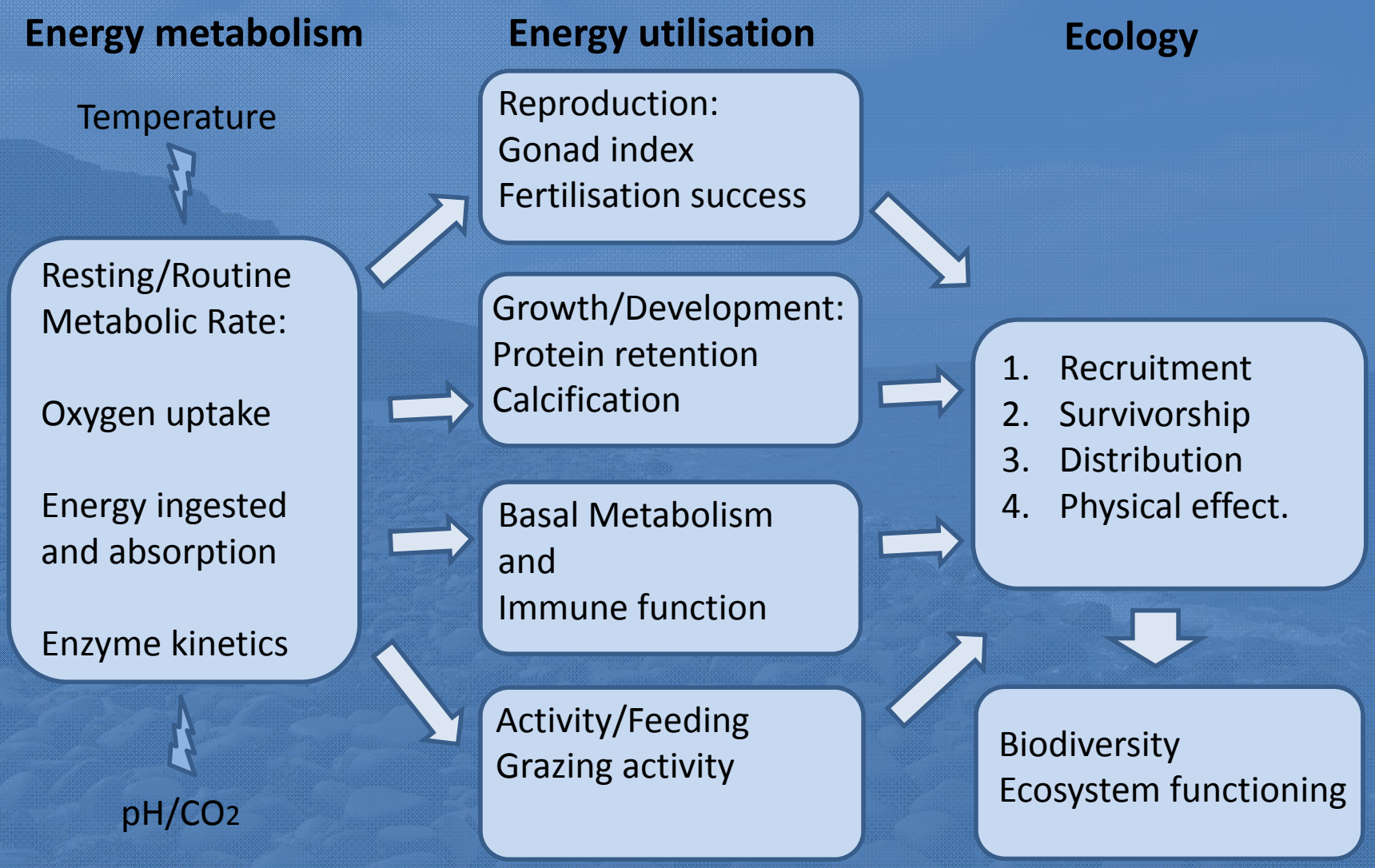
Introduction, energy metabolism, energy utilisation, long-term response, **Ecology**

Introduction, energy metabolism, energy utilisation, long-term response, ecology



Introduction, energy metabolism, energy utilisation, long-term response, ecology

- Ecologically important in coastal habitats worldwide
  (Lawrence, 1975; Harrold & Pearse, 1987; Dayton, 1992; Elner & Vadas, 1990; Estes & Duggins, 1995; Shears & Babcock 2002).

- *Paracentrotus lividus* "most significant invertebrate herbivore in the Mediterranean"
  (Boudouresque & Verlaque, 2001)

- Economically important
- Available in large numbers
- Reasonably easy to keep in the lab
- Large amount of coelomic fluid

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- 380 ppm, 750 ppm and 1000 ppm (ambient temp only)
- Ambient and +4 ˚C (9˚C and 13˚C for the first 3 months)
- 0, 3, 6 and 12 months

- Oxygen uptake
- Acid-base status
- Energy ingested and energy absorption

- **Growth**: growth rate
- **Reproduction**: gonad index and fertilisation success.
- **Immune function**: differential haemocyte counts and phagocytosis.
- **Activity/behaviour**: grazing activity and righting response

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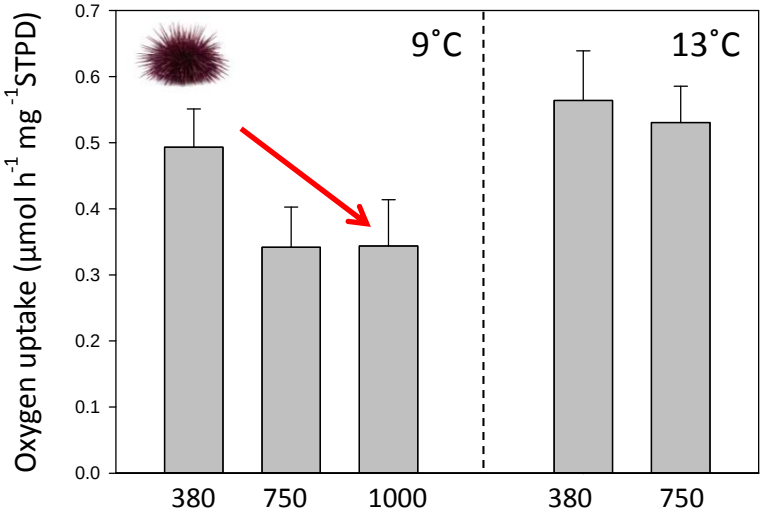
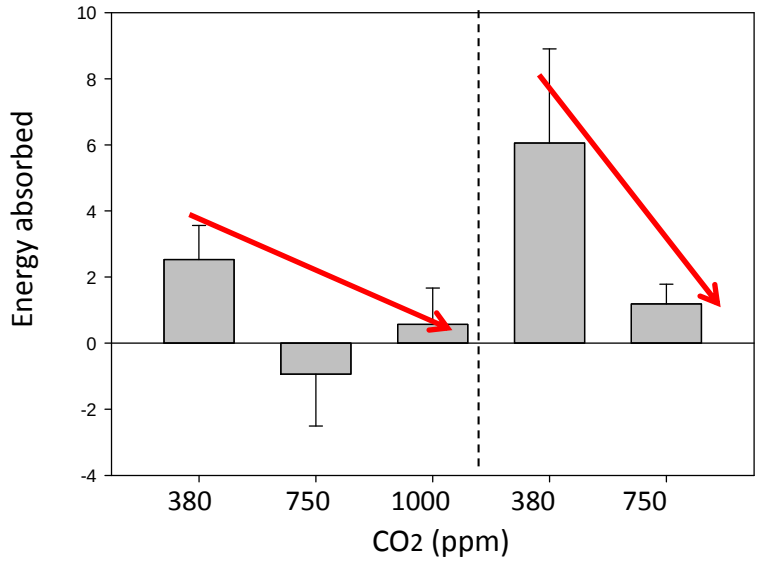




	df	*f*	*p* -value
pCO_2	2	3.97	0.025
Temp.	1	1.16	0.287
pCO_2 * Temp.	1	1.68	0.2

Significant decrease in MO2 with pCO2

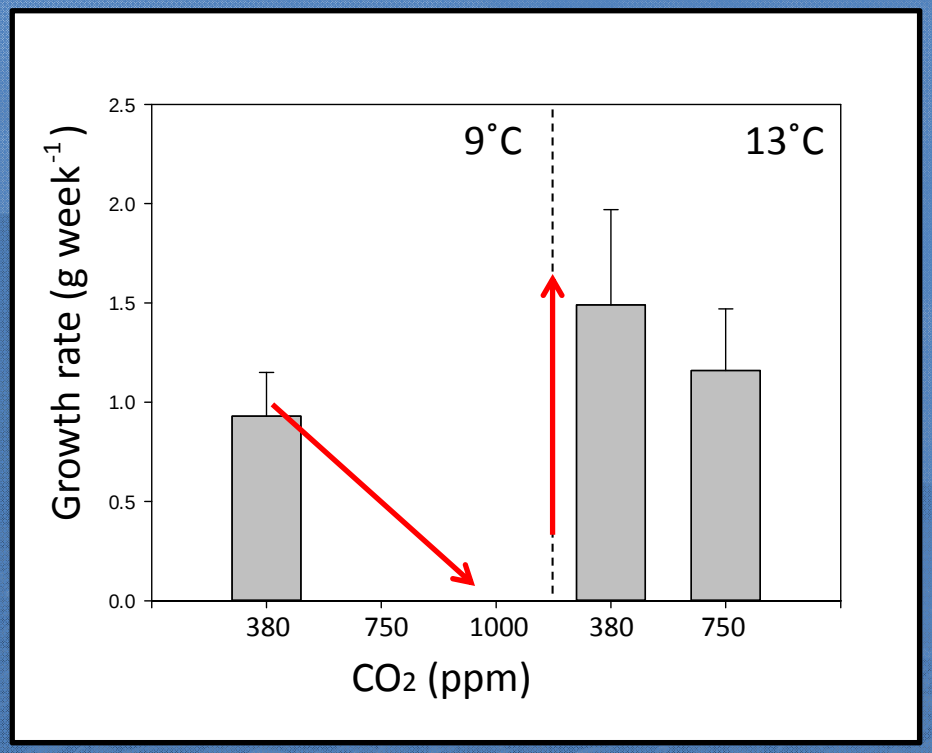
No significant variation in MO2 with temperature

Higher temperature appears to counteract the effect of higher pCO2.

	df	*f*	*p* -value
pCO_2	2	0.153	0.05
Temp.	1	0.138	0.097
pCO_2 * Temp.	1	0.78	0.676

Energy absorbed decreases with PCO2

No significant variation in energy absorbed with temperature



	df	*f*	*p* -value
Time	9	11.06	0
Time * pCO_2	18	1.84	0.027
Time * Temp.	9	3.26	0.001
Time * pCO_2 * Temp.	9	0.78	0.632

- Growth rate decreases with PCO2
- Growth rate increases with temperature

	df	*f*	r	*p* -value	Growth (g/week)
380 +4	5.00	9.65	0.71	0.036	1.49±0.48
750 +4	5.00	13.86	0.78	0.02	1.16±0.31
380.00	5.00	17.41	0.813	0.01	0.93±0.22
750.00	5.00	0.65	0.088	0.47	No sig growth
1000.00	5.00	17.4	0.13	0.5	No sig growth

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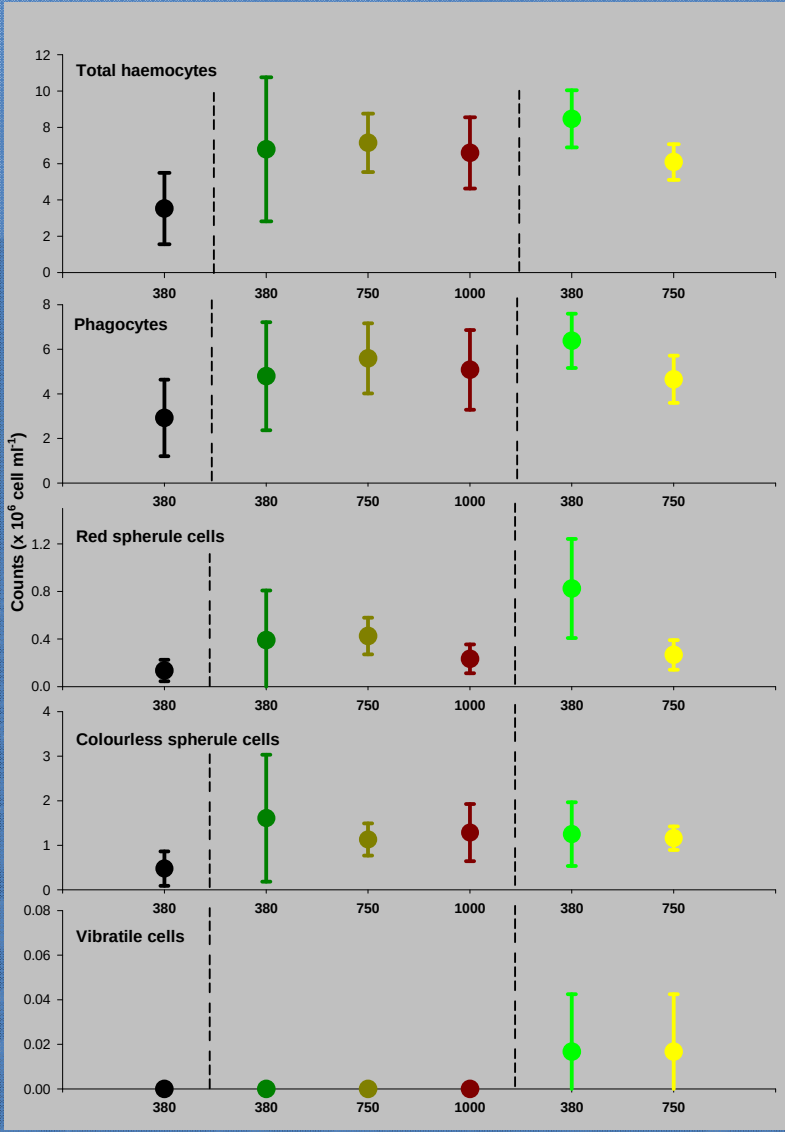
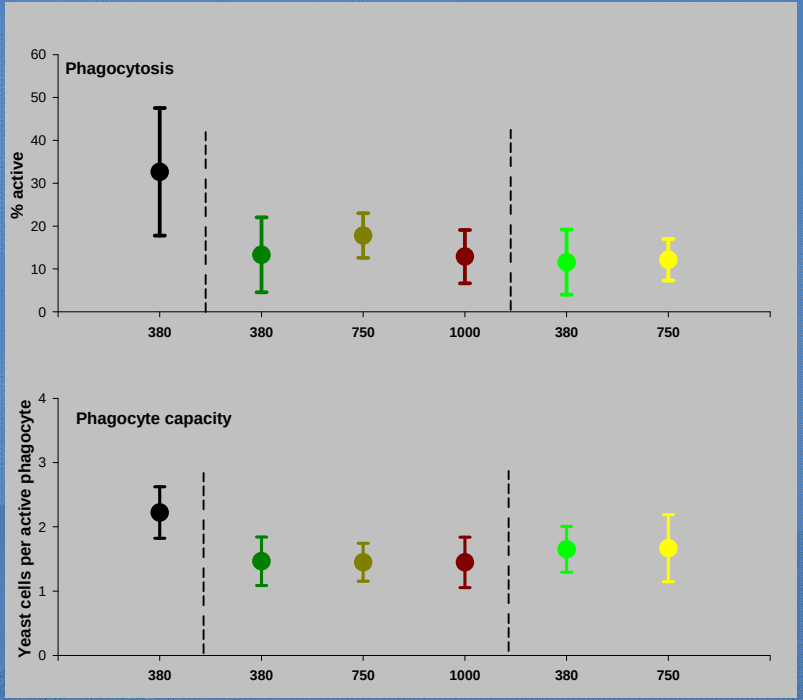
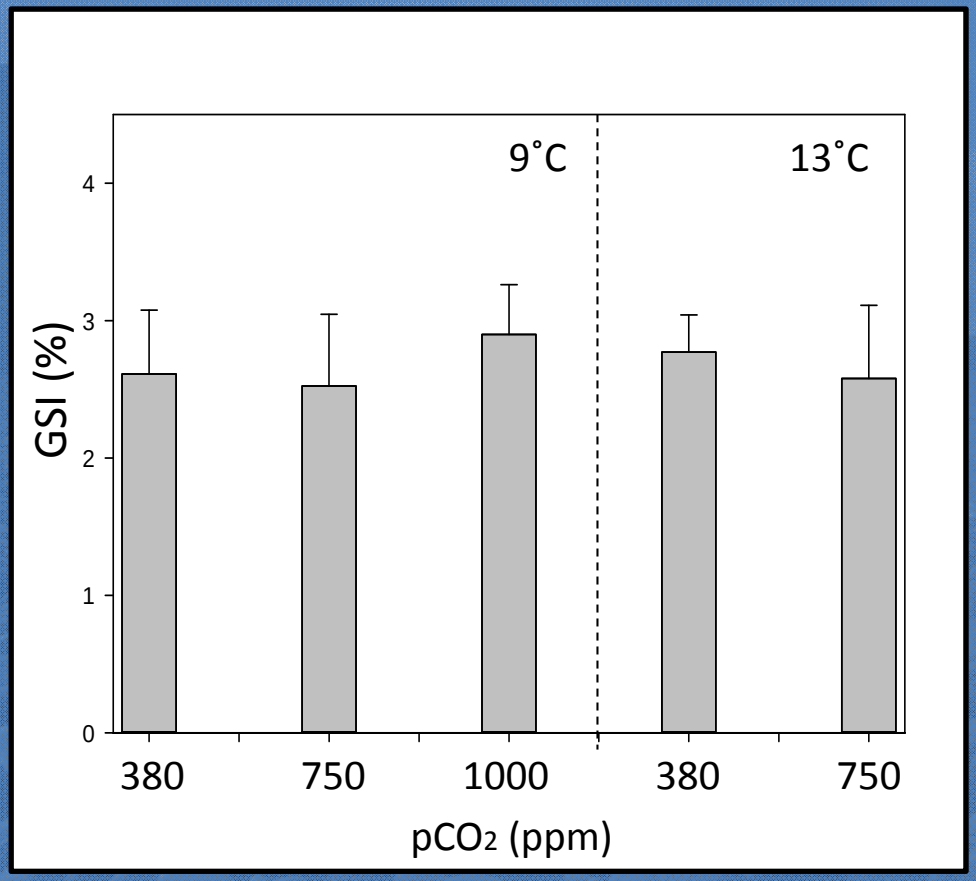




- NO significant pCO_2 or temperature effect

Gonad index (GSI) = (mass of the gonad / total mass) * 100



temperature

- No variation in GSI with PCO_2

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	pCO2	Temp
Metabolism	↓	=
Growth	↓	↑
Reproduction	=	=
Immune function	=	=

How may these responses and trade-offs vary over longer incubations.

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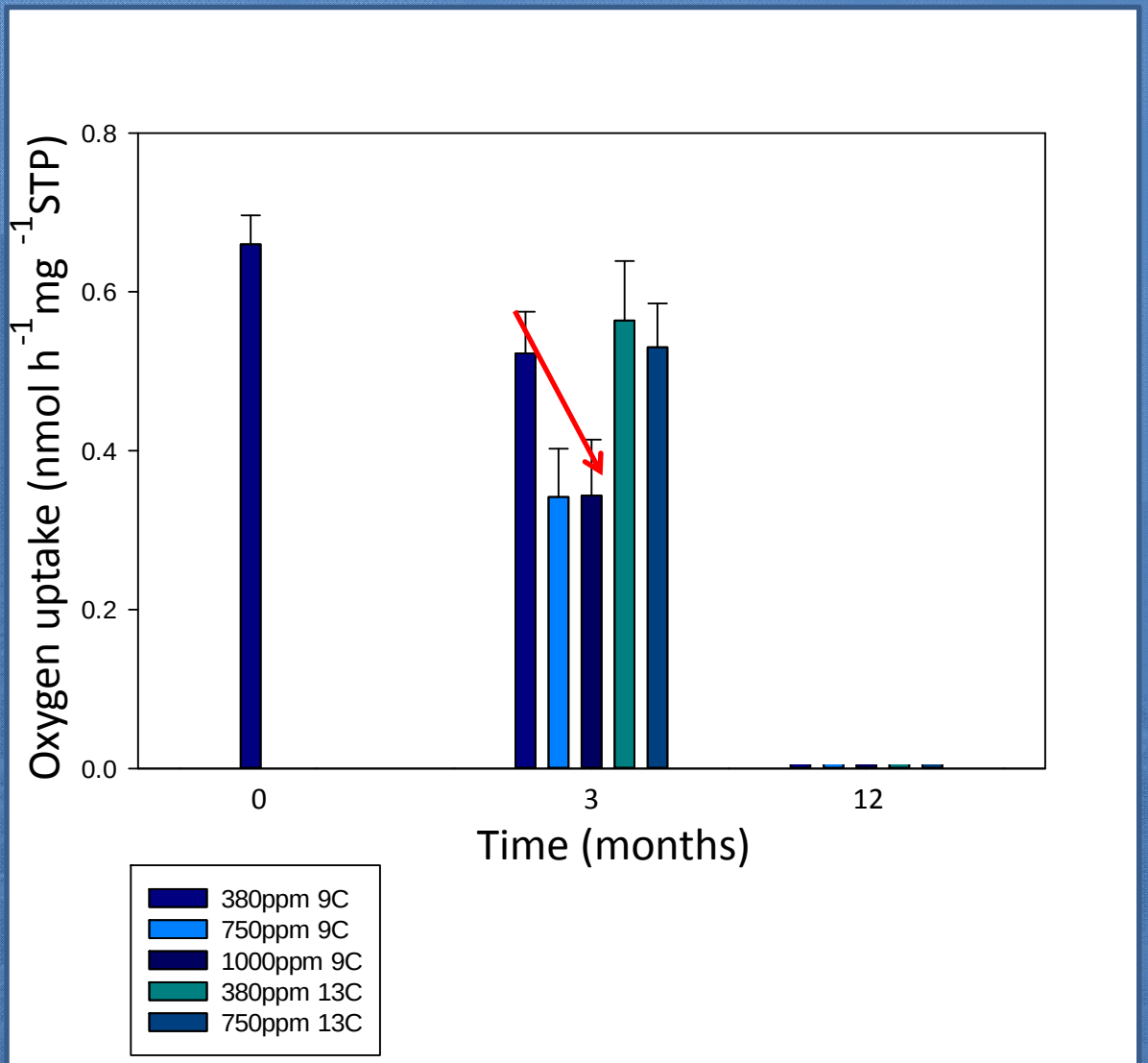
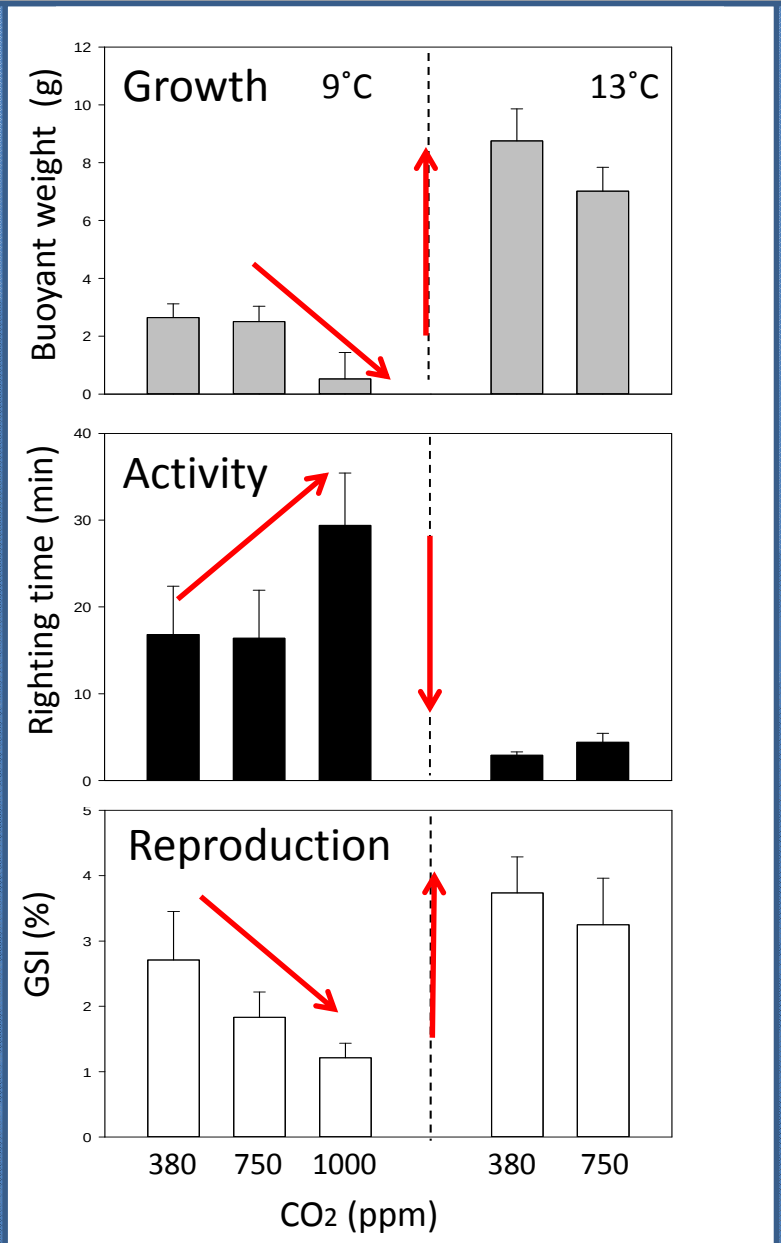


- **3 Months**
  MO_2 decreases with PCO_2
- **12 Months**
  MO_2 increases with PCO_2 and temperature



After 12 months:

buoyant weight decreases with PCO_2

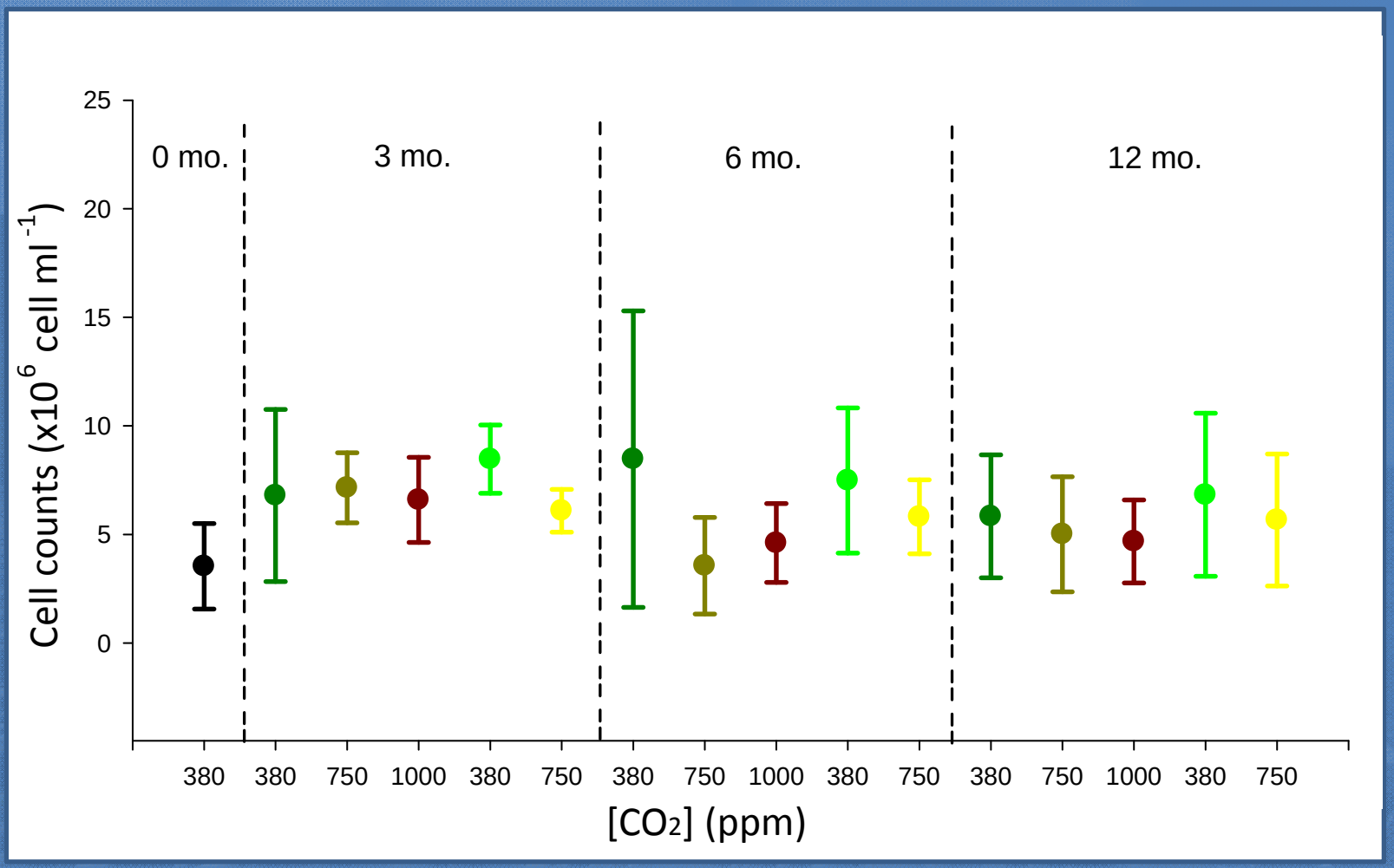
buoyant weight increases with temperature

Activity decreases with PCO_2

Activity increases with temperature

GSI decreases with PCO_2

GSI increases with temperature



- NO significant pCO_2 or temperature effect

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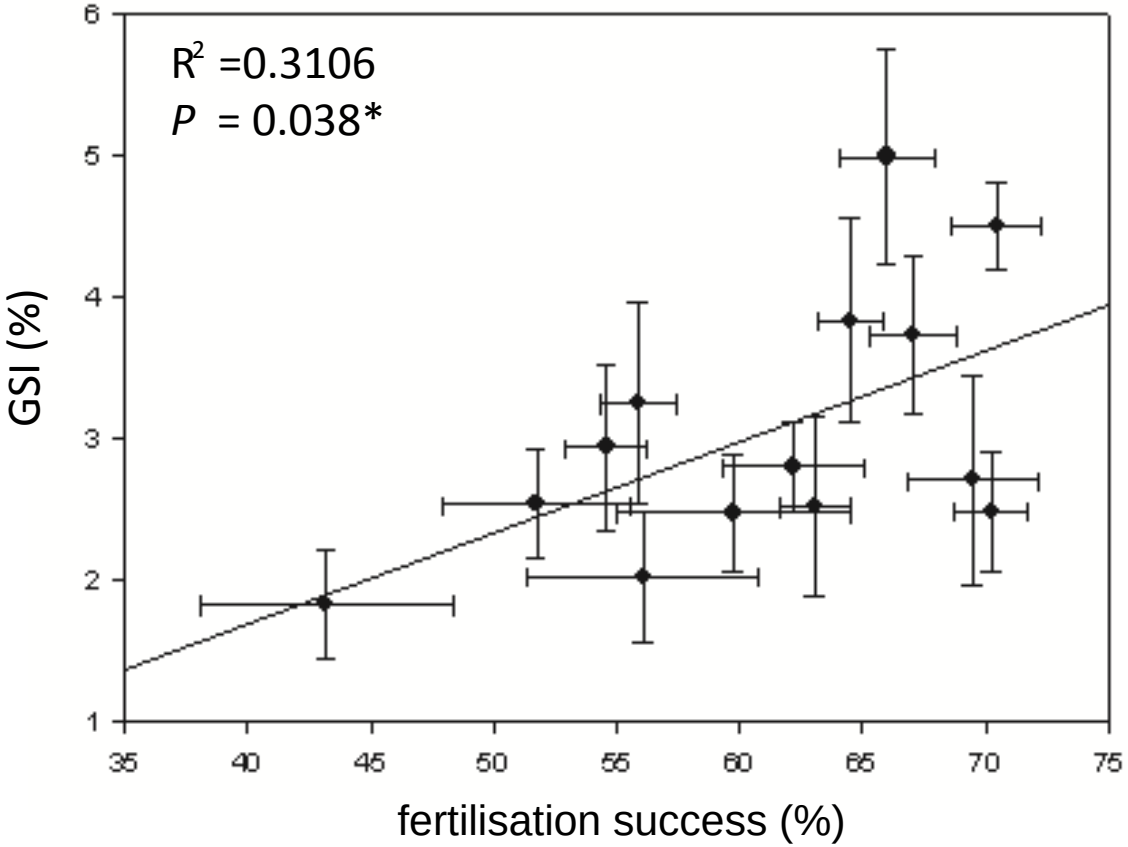
	3 months		12 months	
	pCO2	Temp	pCO2	Temp
Metabolism	↓	=	↑	↑
Growth	↓	=	↓	↑
Immune function	=	=	=	=
Reproduction	=	=	↓	↑
Activity			↓	↑

How may these trade-offs effect the ecology of species?



Significant relationship between GSI and fertilisation success.

Suggesting a relationship between parental investment and recruitment.

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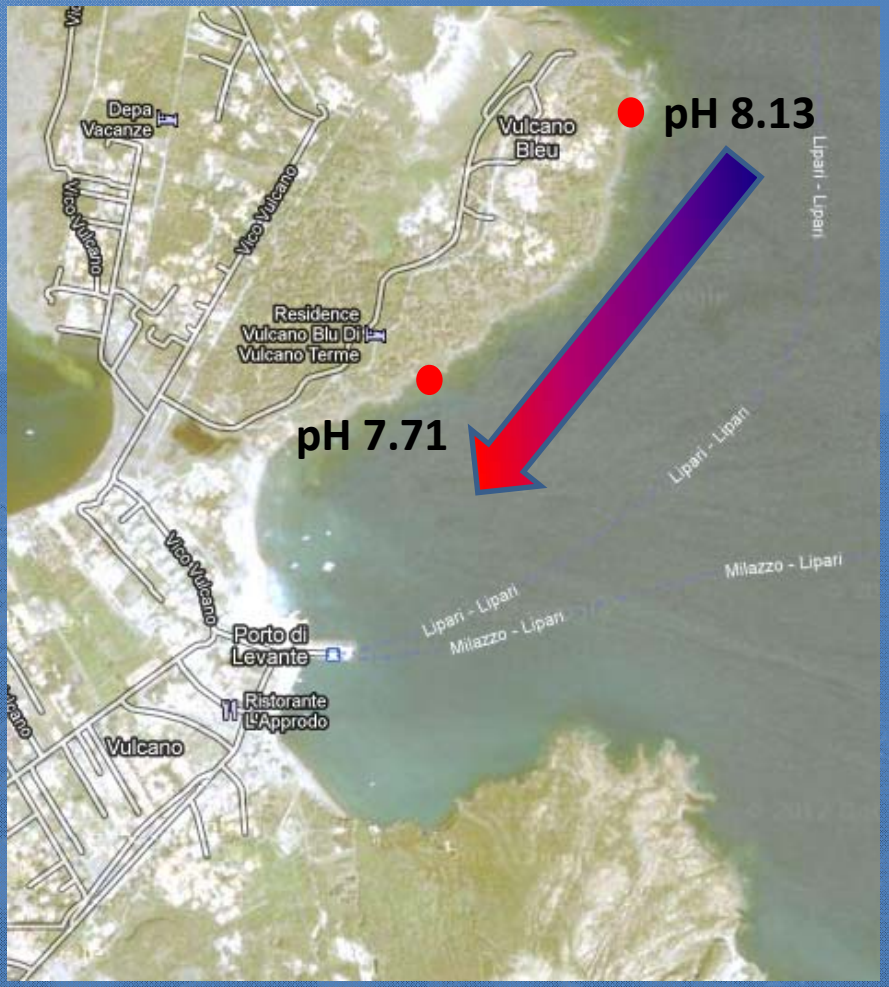

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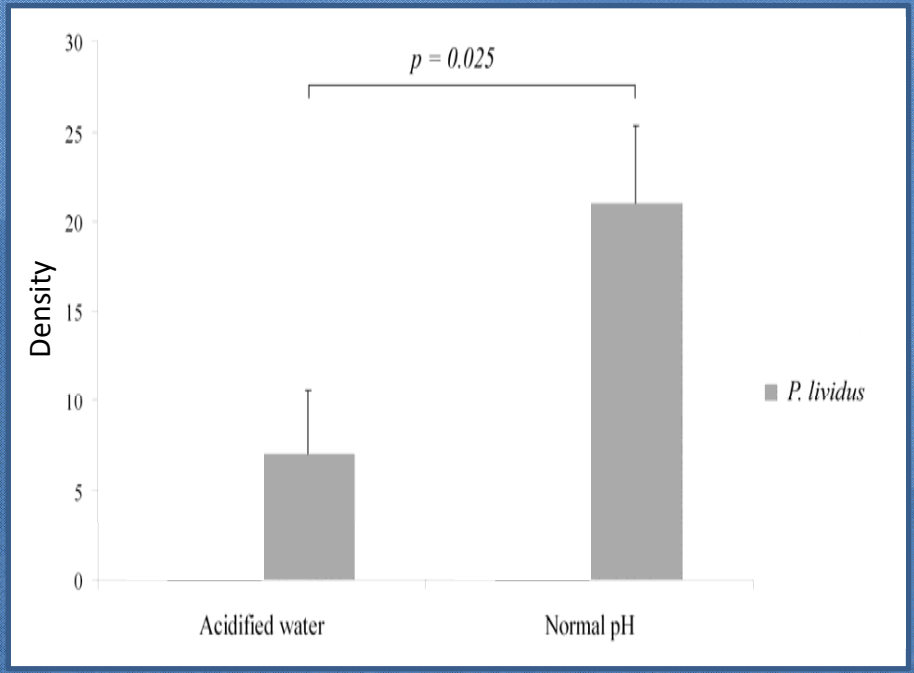


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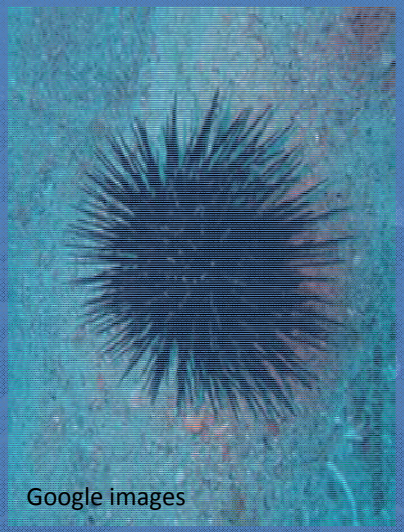
Paracentrotus lividus:

Non-calcareous algae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Arbacia lixula:

Calcareous algae

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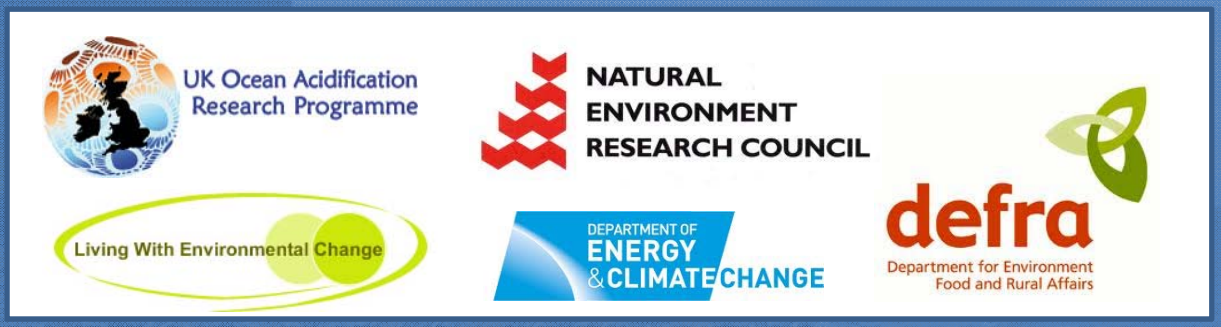
	3 months		12 months	
	pCO2	Temp	pCO2	Temp
Metabolism	↓	=	↑	↑
Growth	↓	↑	↓	↑
Immune function	=	=	=	=
Reproduction	=	=	↓	↑
Activity			↓	↑

- Over the 12 months there are changes in the metabolic response.
- This underlies changes in the trade-offs between energy demanding processes (e.g. growth, reproduction, basal metabolism).
- That may affect the recruitment and ecological distribution of species

People:

Data Collection: Chris Hauton, Helen Graham, Nichola Lacey, Ana Queiros
System Design: Helen Findlay
Mentors/Funding: Piero Calosi, John Spicer, Stephen Widdicombe, Nia Whiteley.

Project funding:



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