





National Oceanography Centre Natural Environment Research council

The effects of ocean acidification and temperature on the physiology and burrowing behaviour of two infaunal invertebrates

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www.benthic-acidification.org www.oceanacidification.org.uk











Impacts of ocean acidification



Surface ocean temperatures

↑ ~ 0.6 - 0.76°C over past 100 years

↑ up to 7°C over next 100 years



Kroeker et al. (2010) Ecol. Lett







Experimental design

- Soft-sediment invertebrate species
 - *Amphiura filiformis* (n = 4 ind. core⁻¹)
 - *Cerastoderma edule* (n = 4 ind. core⁻¹)
 - *Nereis virens* (n = 3 ind. core⁻¹)
- Atmospheric CO₂ (ppm): 380 (pH ~ 8.1), 750 (pH ~ 7.9), 1000 (pH ~ 7.7)
- **Temperature**: ambient, ambient + 4°C
- **Regime**: seasonal vs. constant
- Time: 0, 3, 6, 12, 18 months





N. virens



C. edule





A. filiformis









Aquarium chillers to maintain seawater temperature ± 1°C set temperature

Air – CO₂ gas mixing system to control seawater pH

CO ₂	CO ₂	
(target, ppm)	(actual ppm)	pH_{NBS}
380	403.83 ± 21.36	8.101 ± 0.175
750	758.78 ± 57.48	7.910 ± 0.155
1000	1021.26 ± 65.39	7.779 ± 0.069
Salinity: 33.07 ± 0.89		



Bioturbation and bioirrigation

Sediment reworking (bioturbation)

- fluorescent pink luminophore tracers
- Imaging of the sediment profile (day 0 and day 6)
- quantification using image analysis (ImageJ) (f-SPI) and a process based simulation model (Schiffers *et al.* 2012)

Burrow flushing (bioirrigation)

- Sodium bromide added to overlying water to increase Br⁻ concentration to approx. 10mM
- Incubate cores for up to 8 hours (water samples after 0, 2, 4, 8 hrs)







Results 1: Bioturbation after 12 months

exposure



Temperature pCO₂

×





Results 2: Bioirrigation over time





Results 2: Bioirrigation over time



- Weak CO_2 effects
- \rightarrow patterns reflect seasonal changes in temperature
- Warmer temperature increases bioirrigation: Temperature regime

1



Results 3: Resting metabolic rate after 12 months exposure



- No effect of CO₂, except under constant temperature regime
- Reduction in metabolic rate at higher temperature & 750 ppm

- No effect of CO₂
- Higher metabolic rate at higher temperature



Conclusions so far....

• Responses are **species specific**, **BUT** there are generic trends:

• Effects of ocean acidification on activity and behaviour are weak after 12 months exposure

• Some evidence that acclimation may be taking place, offsetting the effects of OA

• Responses are largely driven by temperature BUT these effects depend on the absolute temperature AND seasonal timing of that temperature