Metabolic responses of two species of brachyuran crustaceans to ocean acidification & reduced salinity

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Project overview

Preliminary results are presented from a project examining the combined effects of elevated seawater pCO_2 & reduced salinity, in 2 temperate species of brachyuran crustaceans with differing abilities to compensate for environmental change. *Carcinus maenas* (Fig.2) is a weak osmoregulator & is highly tolerant of environmental change, such as the conditions expected during climate change (Fig.1). *Cancer pagurus* is a sublittoral crab, an osmoconformer & is relatively poor at compensating for change. The costs & consequences of physiological adjustments in crustaceans over the longer term (months to years) to relevant changes in seawater pCO_2 levels & other co-varying environmental factors are currently unknown. This project therefore aims to: characterise the physiological capacities for change in the 2 species (compensator vs non-compensator); examine the associated metabolic costs over time; & establish whether these costly changes compromise individual fitness & performance by affecting other energy demanding processes, such as acid/base balance and osmoregulation.

Fig.1: IPCC predicted seawater treatments & key to Fig. 2.

Seawater + control CO_2 (**SW + CCO_2;** control) 33 psu; pH 8.0	**Seawater + High CO_2** (**SW + HCO_2**) 33 psu; pH 7.6	**Dilute seawater + High CO_2** (**DW + HCO_2**) 25 psu; pH 7.7	**Dilute seawater + control CO_2** (**DW + CCO_2**) 25 psu; pH 8.1

Fig. 2: Species & their responses to the treatments over 6 -12 months (key in Fig.1).

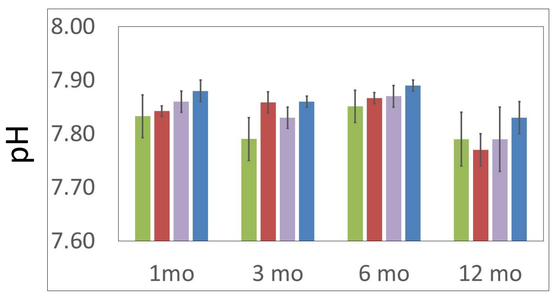
Extracellular pH →

Extracellular $[HCO_3^-]$ →

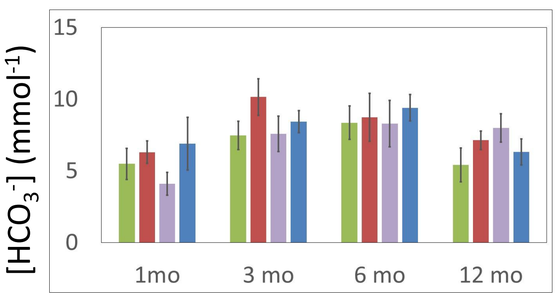
Osmoregulation →

Metabolic rate →

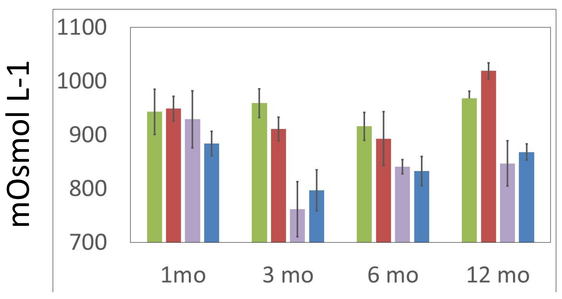
Carcinus maenas (n~504)
Hyper-osmoregulator
Compensation



Haemolymph pH was different across time:
1 & 6mo > 12mo
(P = 0.003)

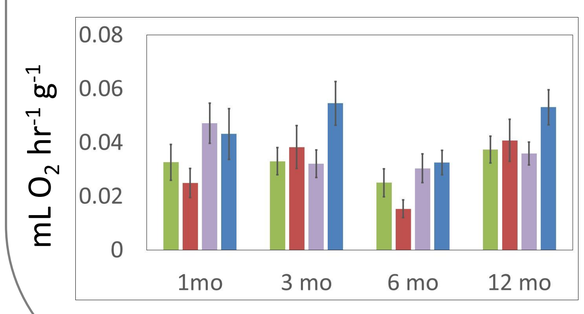


Haemolymph HCO_3^- was different across time:
1 mo < 3 & 6mo
(P = 0.005)



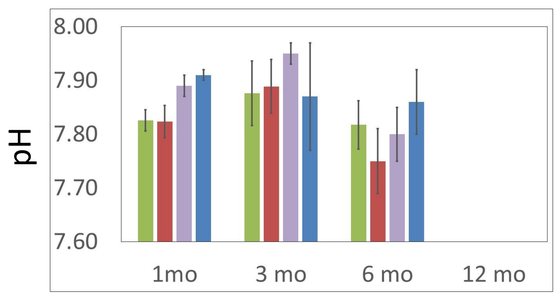
X-axis = surrounding dilute seawater (DW) osmolality

Haemolymph osmolality was different across salinity:
SW > DW (P < 0.001)
& across time:
3 mo < 6mo (P = 0.006)
DW: 1mo > 3 mo
(P=0.039)

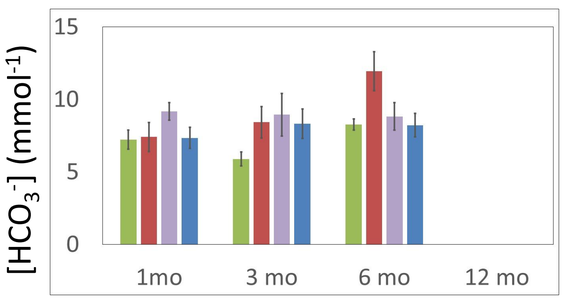


Oxygen uptake rate was different across salinity
SW < DW (P = 0.002)
& time:
6 mo < 12 mo
(P = 0.003)

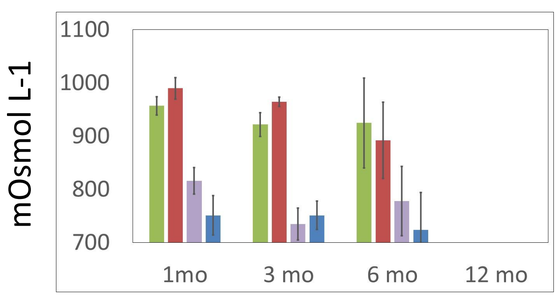
Cancer pagurus (n~478)
Osmo-conformer
Partial compensation



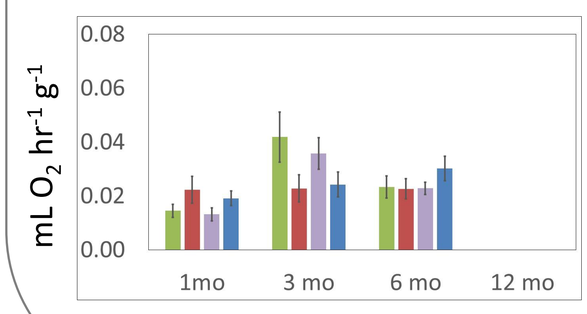
Haemolymph pH was different across time:
3 mo > 6 mo
(P = 0.031)



Haemolymph HCO_3^- was different across $[CO_2]$:
CCO_2 < HCO_2 (P = 0.004)
& across salinity & time:
SW: 1 mo < 3 & 6mo
(P = 0.005)



Haemolymph osmolality was different across salinity:
SW > DW (P < 0.001)
& across time:
1 mo > 6mo (P = 0.026)



Oxygen uptake rate was different across time:
1 mo < 3 mo
(P < 0.001)

Discussion

- Exposure to **low salinity or High-CO_2 had different effects** on the **2 crab species**, but both showed variations in physiological parameters over time.
- In the species with the ability to compensate for change (***Carcinus maenas***), haemolymph **acid-base status was unaffected**. Haemolymph pH was generally low after 12 months, likely due to passive changes associated with water temperature increase. When in low salinity *Carcinus* was able to maintain its haemolymph osmolality at around 150 mOsmol L^{-1} higher than surrounding diluted seawater. **Rates of oxygen uptake were higher in low salinity likely reflecting the increased cost of osmoregulation.**
- In the species with a limited ability to compensate for change (***Cancer pagurus***), **haemolymph $[HCO_3^-]$ levels increased in high-CO_2 & ambient salinity** ($SW+HCO_2$) but were otherwise unaffected by CO_2 & salinity. **Osmoregulation was more of a problem for *C. pagurus* compared to *C. maenas*.** Under low salinity, *C. pagurus* maintained haemolymph osmolality at only 30-80 mOsmol L^{-1} higher than surrounding diluted seawater. Rates of oxygen uptake in *C. pagurus* were generally lower than those in *C. maenas* & were unchanged by salinity.

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