C6.3
09:40 Wednesday 1st July 2009
Impacts of hypercapnia and temperature on physiological performance of marine invertebrates from the Baltic Sea

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Anthropogenic CO_2 emissions cause rising ocean pCO_2 and decreased ocean pH. This progressing ocean acidification has been shown to compromise physiological performance of many marine benthic organisms. In this study, Baltic blue mussel *Mytilus edulis* and common starfish *Asterias rubens* from Kiel Fjord were exposed to 6 different hypercapnic levels between 0.04 and 0.41 kPa pCO_2 for 1–2 weeks, respectively, at 12 °C. The experiments revealed extracellular acidosis in both species with no active accretion of HCO_3^-. Even at moderate pCO_2 levels (e.g. 0.08 kPa) pH_e was significant decreased. Although shell dissolution occurred in the highest pCO_2 treatment, no HCO_3^- or Ca^{2+} accumulation was observed in extracellular fluids. Gradients of pCO_2 between body fluids and ambient sea water were stable at lower pCO_2 levels and decreased at 0.41 kPa, which might indicate a metabolic depression. Ongoing metabolic rate and filtration rate determinations will resolve this issue. Calcification rates were only minorly impacted in the lower pCO_2 treatments and became negative at 0.41 kPa pCO_2. Field measurements conducted in Kiel Fjord revealed a large annual variability of surface pH and pCO_2. During winter and spring, surface pH averaged 8.1 but mean summer pH values were <7.8 and the highest measured pCO_2 value exceeded 0.2 kPa (ca 2000 µatm), thus even the maximum average pCO_2 values modelled for the surface ocean of the year 2300.

Experiments will be repeated at summer temperatures of 18–22 °C in June 2009 to clarify if thermal extremes increase the species' sensitivity towards hypercapnia.

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Synergistic effect of ocean acidification and elevated temperature on the physiological ecology of the intertidal crab *Porcellana platycheles*

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Ongoing global environmental changes pose an unprecedented threat to global biodiversity; in particular increasing environmental temperatures and decreasing ocean pH (Ocean Acidification or OA, as a result of increased seawater pCO_2^-). The extent to which these two drivers will act synergistically, reducing the thermal tolerance window of individual species, and so potentially affect their large-scale distribution, is only beginning to be understood. Here we present a formal test on the potential synergistic effect of elevated temperatures and hypercapnic sea water on the rate of O_2 uptake (as a proxy for metabolism), tolerance to heat, and the degree of exoskeleton calcification in the intertidal porcellanid crab *Porcellana platycheles*. Eighty individuals crabs were haphazardly assigned to one of four treatments, and kept for 40 days at either 15.0 °C (seasonal ambient) or 20.0 °C (+5 °C), and at either pH 8.0 (seasonal ambient) or 7.4. In *Porcellana platycheles* metabolic activity and tolerance to heat were positively affected by increasing temperature, whilst the degree of exoskeleton calcification was negatively affected. No effect of pH was detectable. It is therefore suggested that *P. platycheles* may not be affected by medium-term exposure to the predicted level of OA, but that acclimation to elevated temperatures may result in improved tolerance of high temperatures despite an increase in metabolic costs and a decrease of calcification. Our results are discussed within a broader ecological and evolutionary context, with particular emphasis on the idea that intertidal species may be to some extent exapted to hypercapnic exposure.

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Oxygen deficiency under elevated temperatures: a mechanism connecting the response of stream ectotherms to global warming?

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There are few demonstrated cases of causal links between global warming and changes in the species composition of communities, and the structure and functioning of ecosystems. Changes in growth, fecundity or the seasonal timing of biological events reduce a species' fitness and competitive ability, which may ultimately result in shifts in the species composition.

Oxygen deficiency may provide an example of a direct temperature-mediated causal link. Stream invertebrates display a range of adaptations related to respiration, and oxygen is considered a key factor structuring species assemblages. Furthermore, as water temperatures rise, aquatic ectotherms face the double problem of reduced oxygen concentrations and increased oxygen demand. Therefore, oxygen deficiency may be an important mechanism setting limits to thermal optima, thus explaining many of the effects of global warming. In marine ecosystems, a mismatch between oxygen demand and oxygen supply to tissues appears to be the first mechanism to restrict survival at thermal extremes.

Here we present evidence suggesting that climate-driven oxygen deficiency may occur in aquatic stream invertebrates. Not all species will be equally at risk, depending on their physiology (metabolic rate, thermal limits) and other traits (e.g. body size, type of respiration). Integrating information on a species' physiological and biological traits may yield a comprehensive mechanistic understanding of its thermal sensitivity.

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Thermal dependence of inducible defences in mosquito larvae

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Temperature profoundly influences the reaction rates and efficiency of all physiological systems. During predator–prey interactions we often expect temperature to directly influence the locomotor capabilities of both predator and prey, and thus alter the dynamics of the system. However, predation is seldom just a simple game of 'cat and mouse'. Prey can induce behavioural and morphological defenses that increase their