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Effects of elevated temperature and pCO_2 on Arctic and Mediterranean Thecosome pteropods

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Thecosome pteropods (shelled pelagic molluscs) can play a key role in the food web of various marine ecosystems. They can be an important food source for zooplankton or higher predators such as fishes, whales and birds, particularly in high latitude regions. Since they maintain an external calcareous shell made of aragonite, a relatively soluble form of calcium carbonate ($CaCO_3$), they are suspected to be highly sensitive to changes in seawater carbonate chemistry. Several physiological parameters such as calcification, respiration, excretion, gut clearance and larval development were measured on Arctic (*Limacina helicina*) and Mediterranean (*Creseis acicula*, *Cavolinia inflexa)* pteropods maintained under laboratory conditions mimicking predicted future ocean conditions. The gut clearance rate is unaffected by a decrease in pH down to pH_T $\sim$7.6. In *L. helicina*, the respiration rate is unaffected by pH at 0˚C (control temperature) but increases significantly at lower pH at 4˚C. In contrast, respiration is not affected by pH in *C. acicula*. These experiments demonstrate that all three species exhibit a strong reduction in gross calcification as a function of decreasing aragonite saturation state. Empirical relationships between gross $CaCO_3$ precipitation and the aragonite saturation state were combined with model projections of future aragonite saturation stateand with data on the vertical migration of pteropods in order to estimate the effect of ocean acidification on *in situ* calcification. Results suggest that under the IPCC SRES A2 scenario, Arctic pteropods will not be able to precipitate any $CaCO_3$ by the end of the century. But even if they would be able to precipitate $CaCO_3$ in slightly undersaturated conditions, it is unlikely that they could maintain a positive net balance between gross $CaCO_3$ precipitation and dissolution. This is inferred from measured rates of dissolution in *C. acicula* and observations showing that larvae of *C. inflexa* are unable to make shells in seawater that is undersaturated with respect to aragonite. Our results justify the concern about the future of shelled pteropods in the high-latitude oceans.