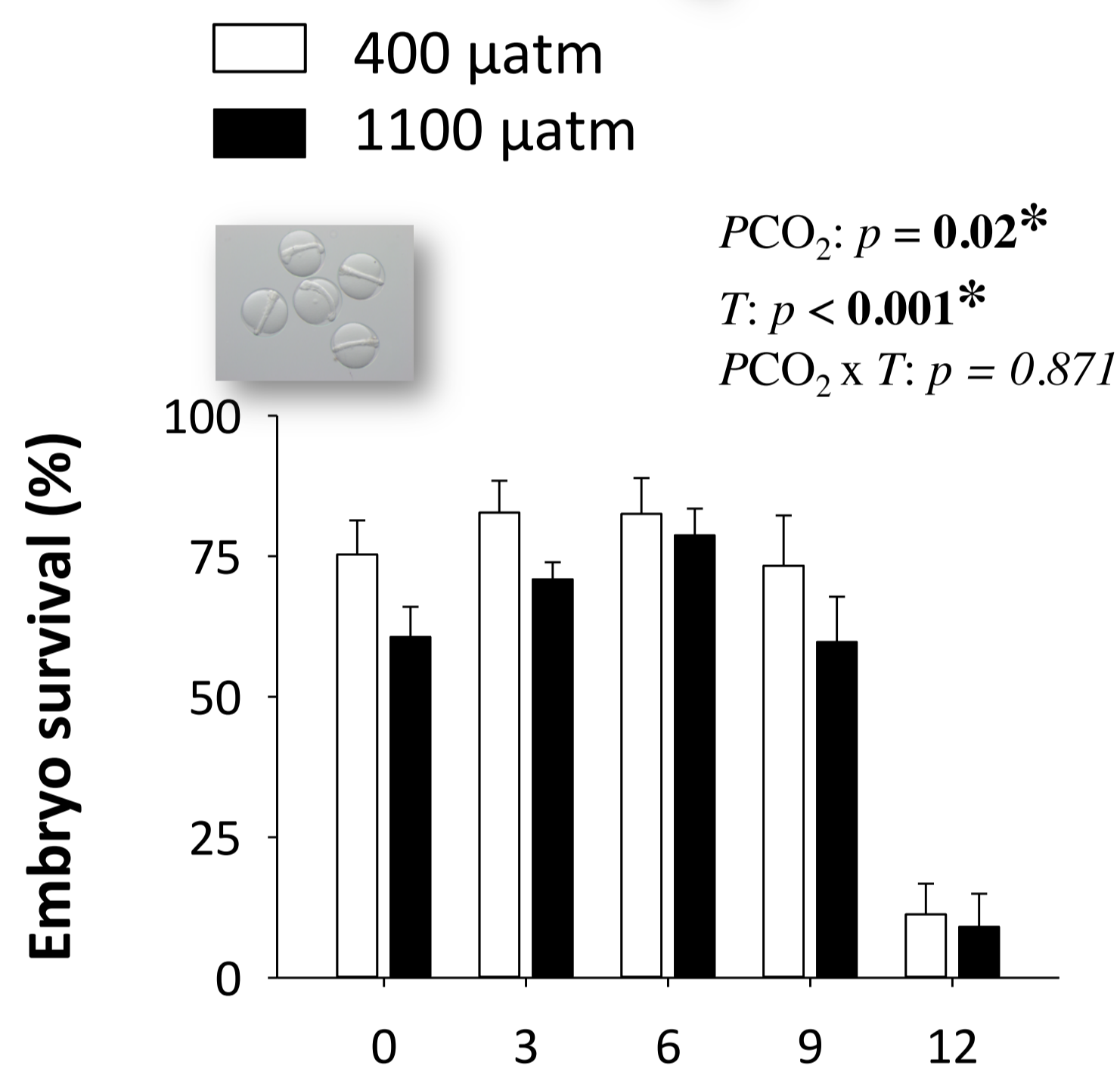


Climate sensitivity: Can we identify bottlenecks during early development and its effects on subsequent larval stages in crustaceans and fish?

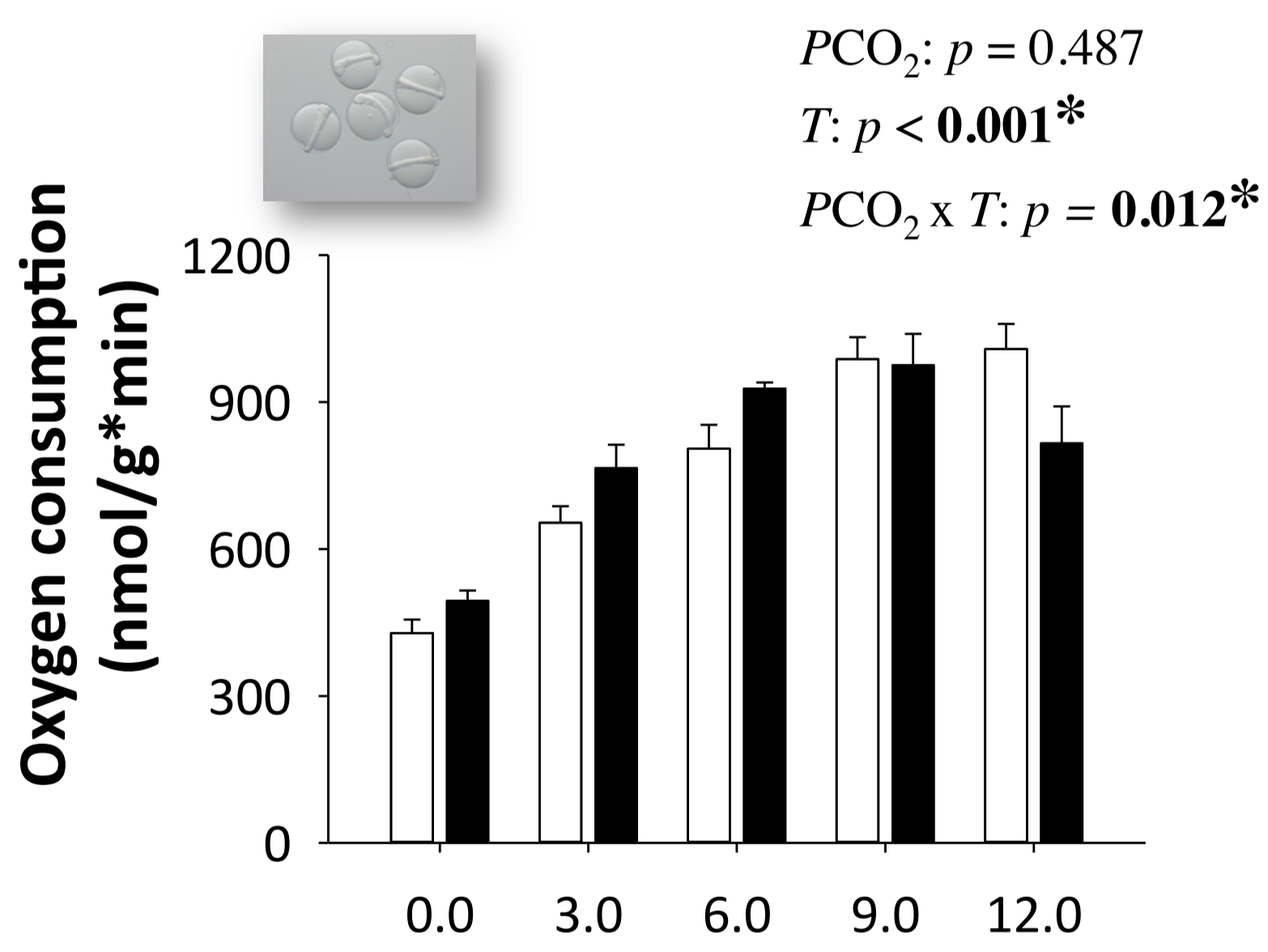
D. Storch, F. Dahlke, M. Schiffer, H.O. Pörtner
AWI Bremerhaven, Department of Integrative Ecophysiology, Germany

Ecosystem changes in response to climate change are largely driven by environmental temperature in combination with synergistic threats, such as ocean acidification (OA). Eggs and planktonic larvae, which are instrumental in shaping contemporary species distribution, are most vulnerable to such (geophysical, biochemical) changes. The understanding of how early life stages and transition phases from one to the next stage will respond to changes at a cellular and ecosystem level are crucial for predicting ocean warming and acidification (OWA) induced shifts in population dynamics and species distribution.

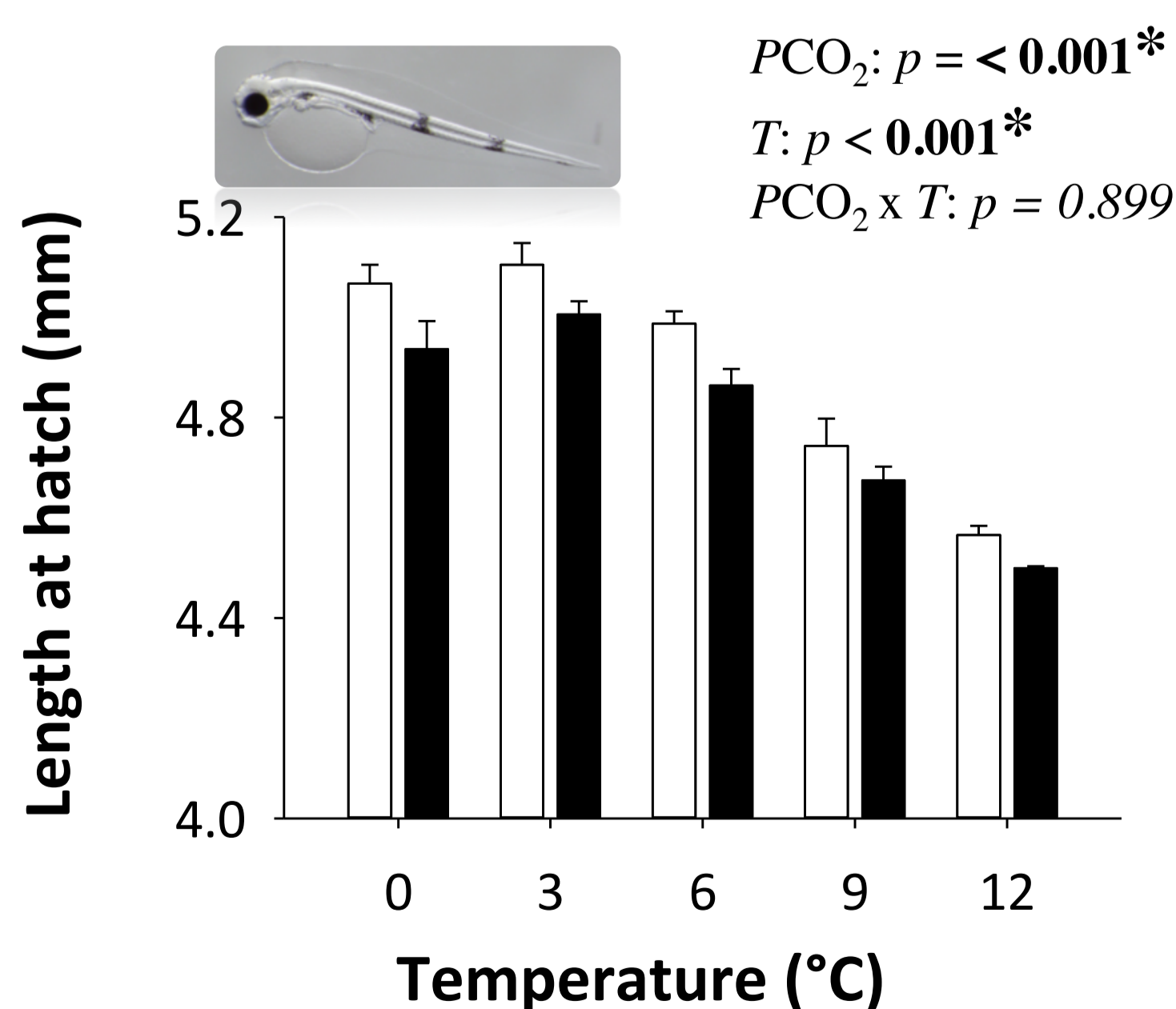
Fish



Gadus morhua: Mean (\pm SE, N = 6) embryo survival at different temperatures and PCO_2 . Each bar represents the proportion of hatching larvae from ≈ 500 eggs per female (N = 6)

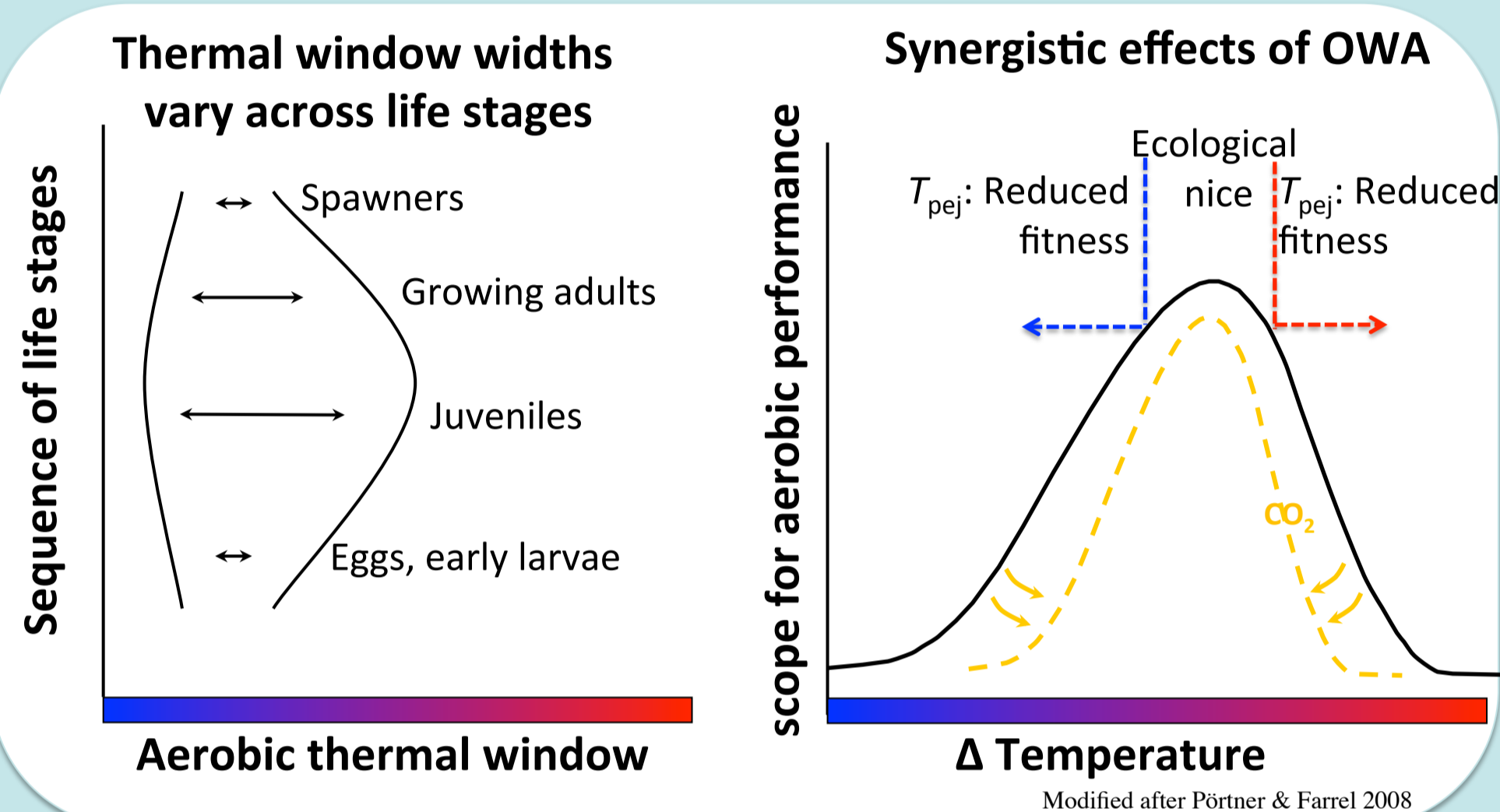


Gadus morhua: Mean (\pm SE, N = 6) oxygen consumption of developing embryos (stage IV) at different temperatures and PCO_2 .

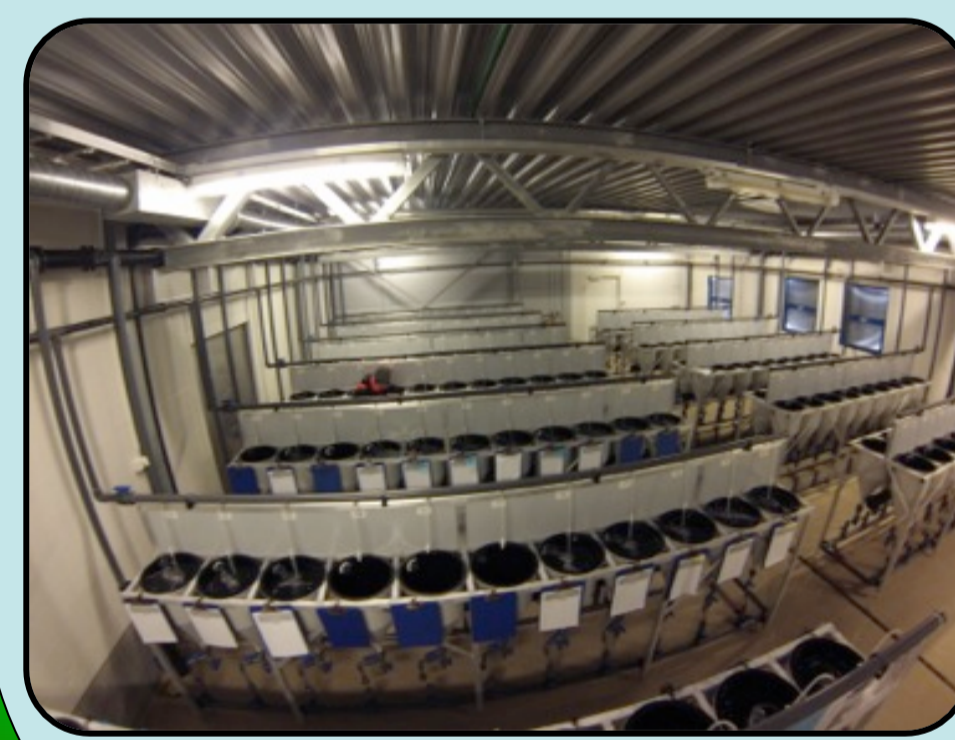


Gadus morhua: Mean (\pm SE, N = 6) standard length of hatching larvae at different temperatures and PCO_2 . Each bar represents ≈ 180 individuals (≈ 45 at 6°C)

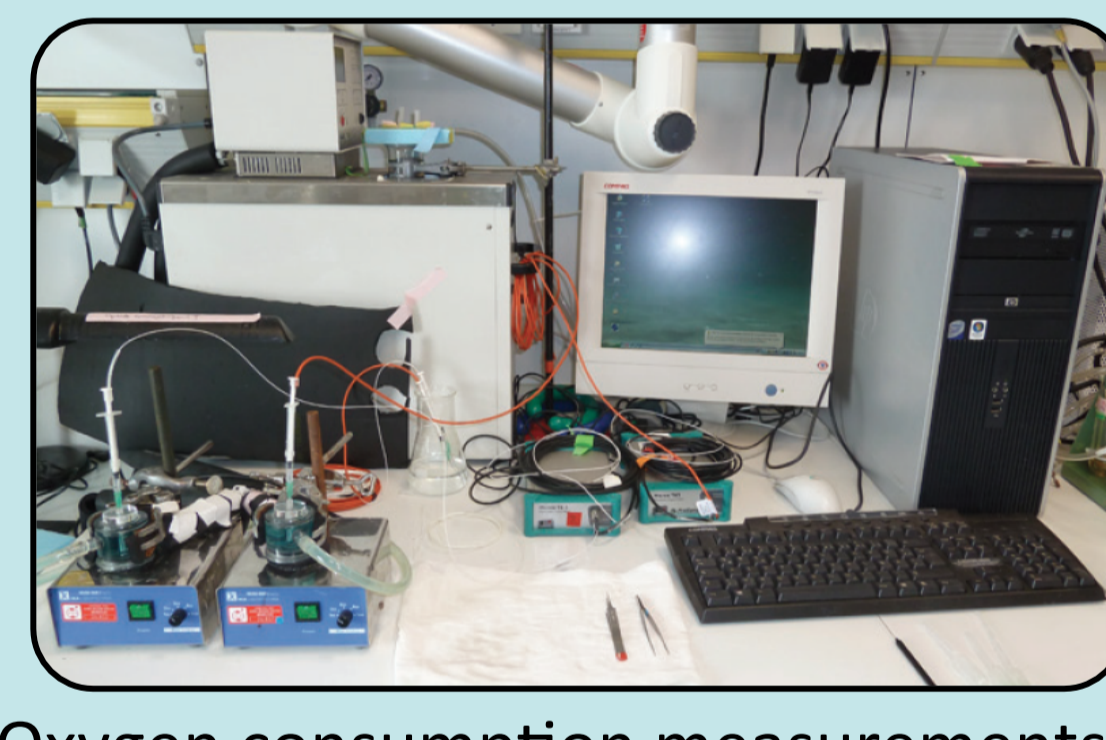
Objectives & Methods



- 1) There are differences in sensitivity to OWA between life stages.
- 2) Early life stages are most affected if transition phases such as "hatch" and "metamorphosis" are included in the incubation.



Fish egg Incubation Units



Oxygen consumption measurements

Results & Discussion

➤ Reduced embryo survival at increased oxygen consumption rates of embryos results in reduced body length of hatched larvae. Increased energy demand for ion regulation might decrease energy available for growth.

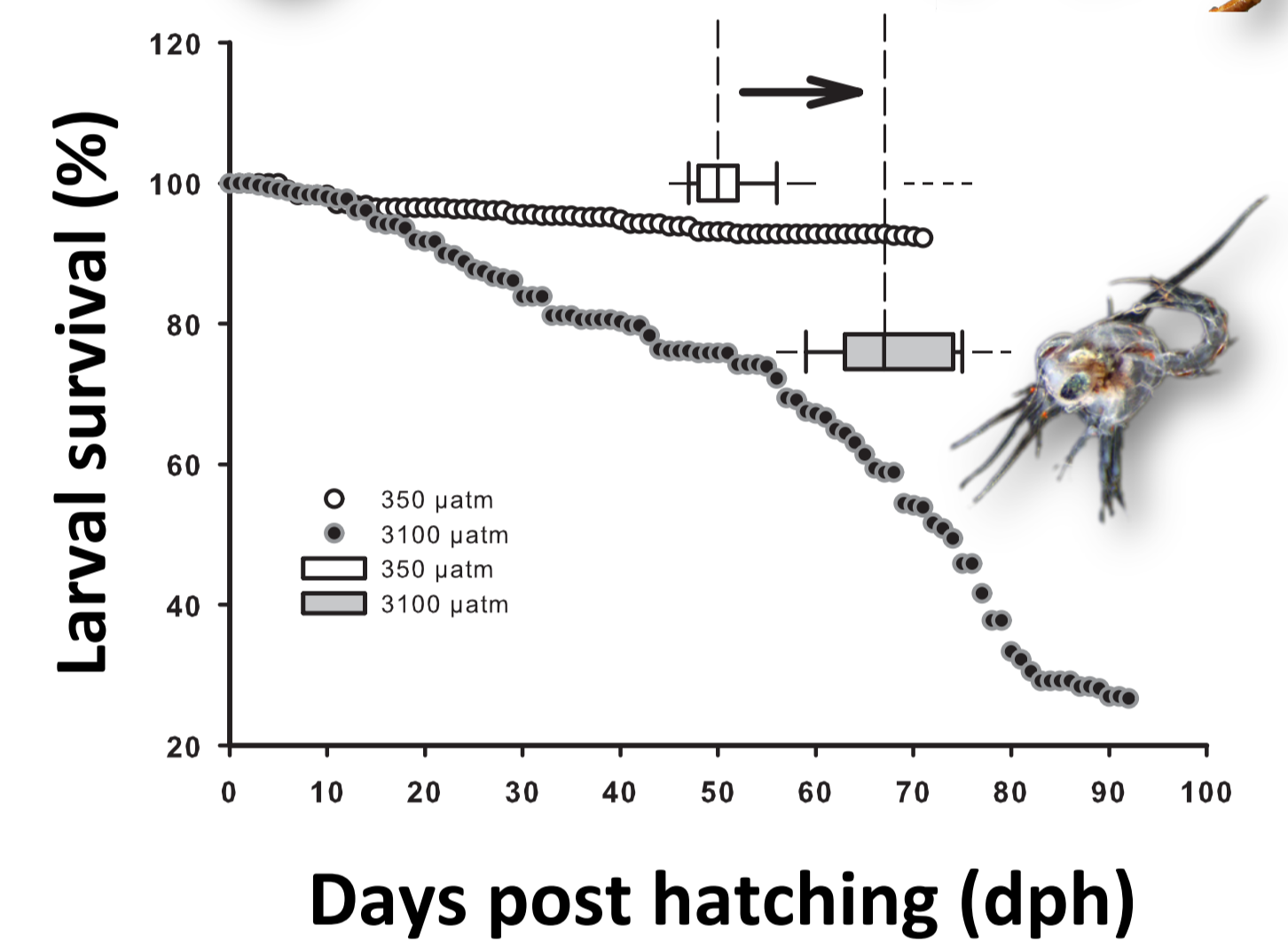
➤ Mortality of Zoea I was 60% higher and development 20 days delayed at high PCO_2 after two weeks of pre-exposure of ovigerous females and eggs.

➤ Reduced thermal tolerance was detected in Megalopa (including metamorphosis) compared to the Zoea stages. Thermal tolerance was further reduced under elevated PCO_2 .

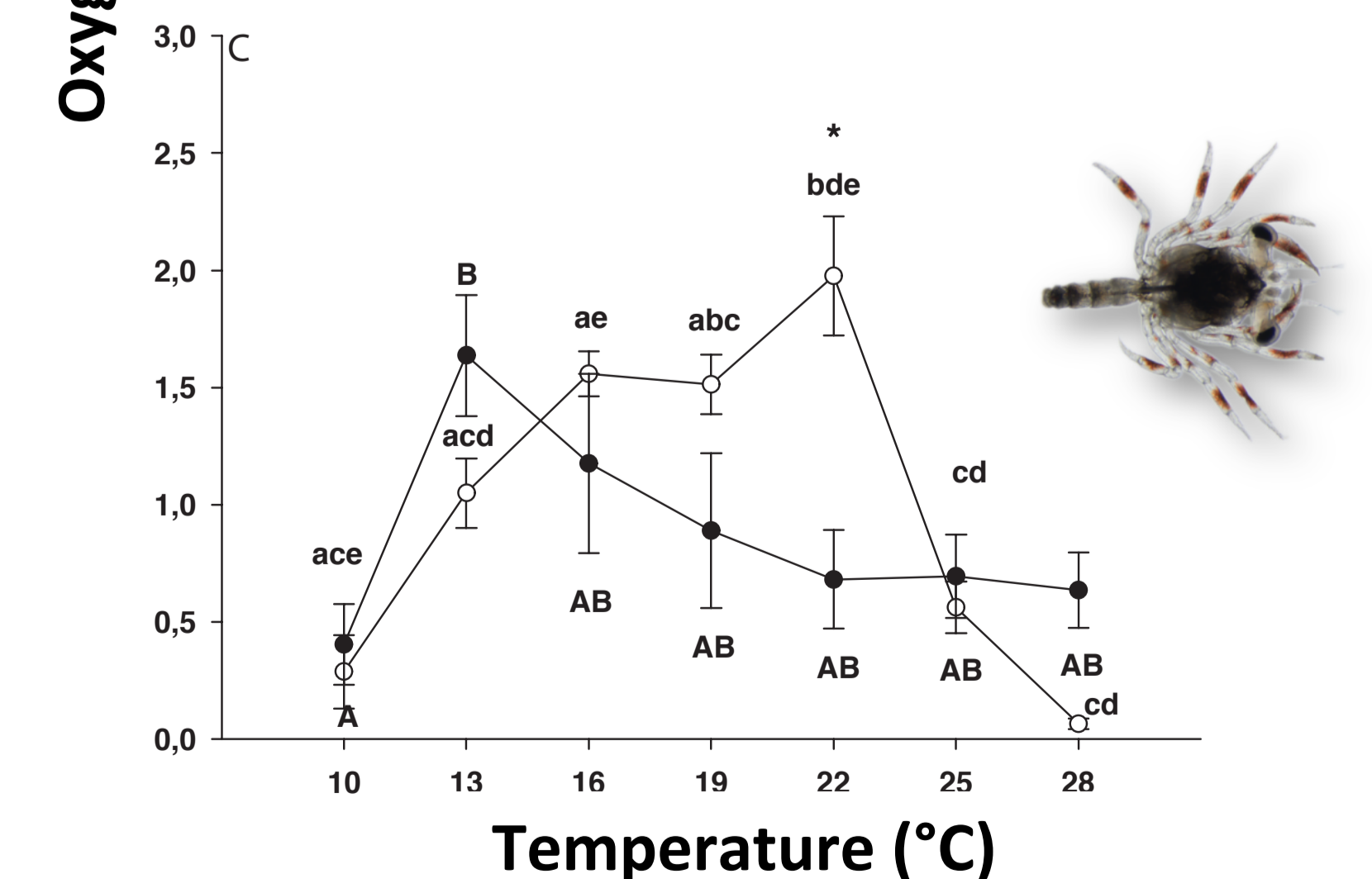
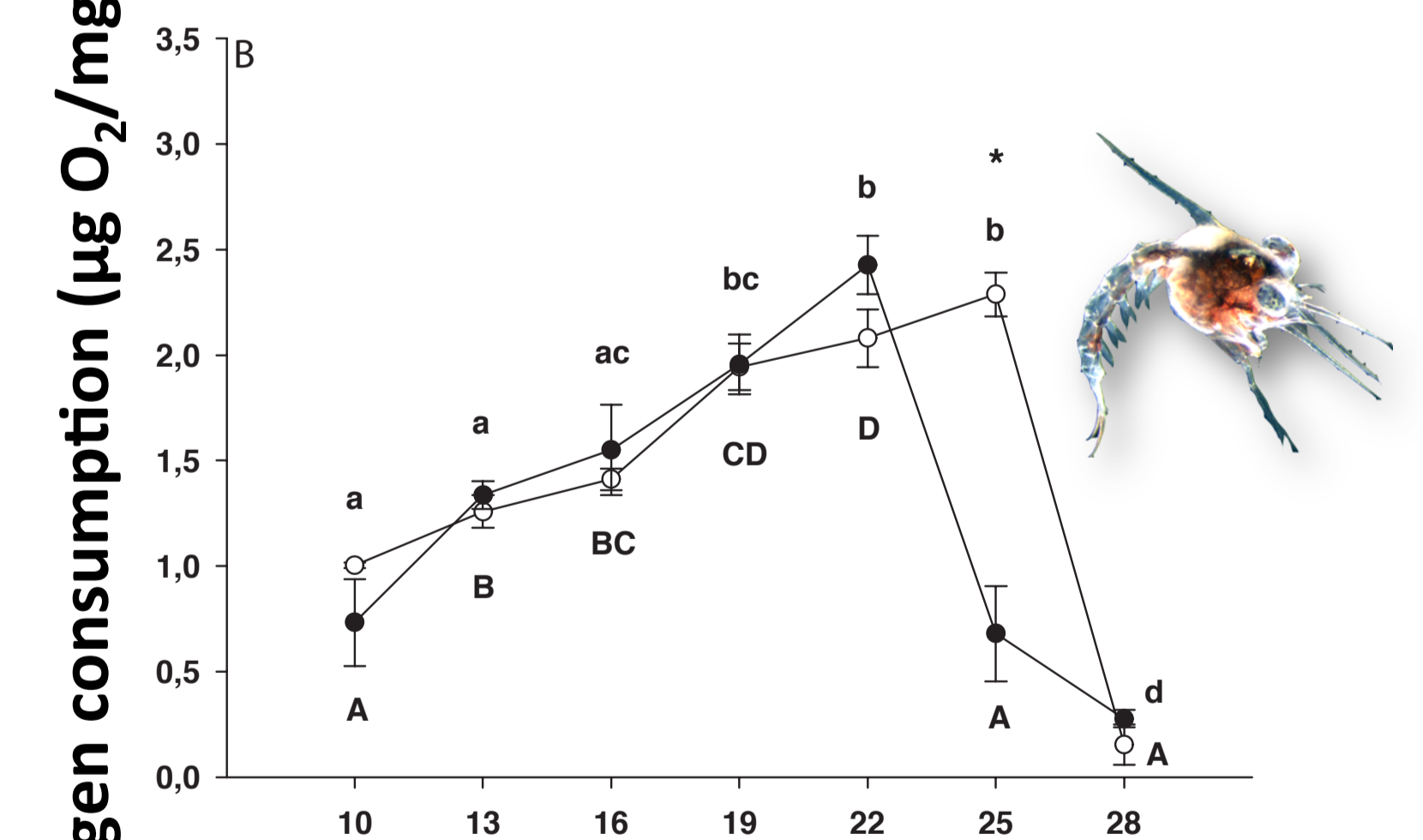
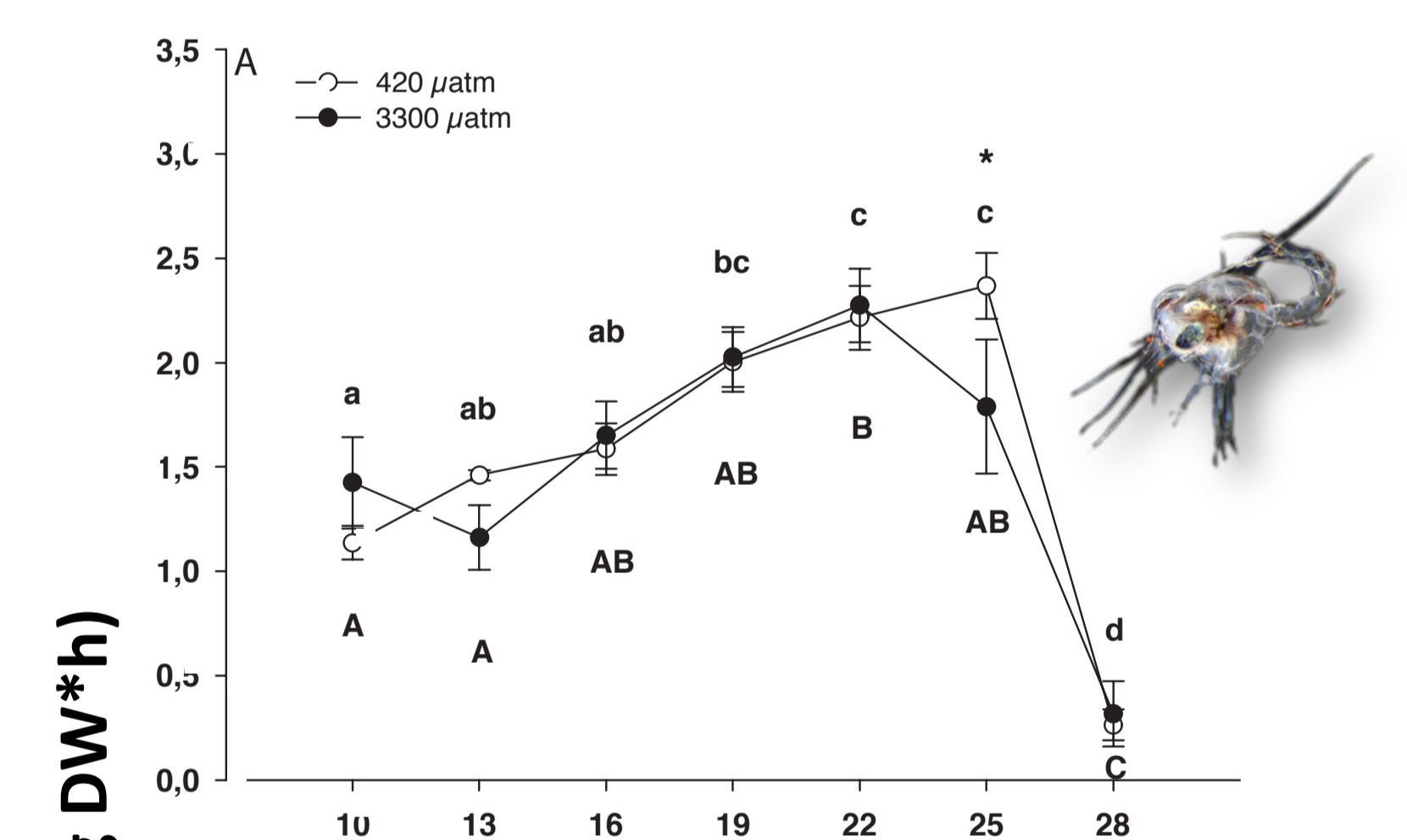
Conclusion

Transition phases such as "hatch" or "metamorphosis" during the incubation period increase sensitivities of subsequent life stages suggesting lowered physiological capacities to overcome OWA.

Crustaceans



Hyas araneus: Mortality and developmental time of Zoea I at 10°C and different PCO_2 after two weeks of the respective pre-exposure of ovigerous females and eggs.



Hyas araneus: Mean (\pm SE, N = 7) oxygen consumption rates of (A) Zoea I, (B) Zoea II and (C) Megalopa at various temperatures and PCO_2 .

References:

- Dahlke et al. submitted, Experimental ocean acidification and temperature shape survival, respiratory performance and growth during embryonic development of Atlantic cod *Gadus morhua*.
Schiffer et al. (2014), Temperature tolerance of different larval stages of the spider crab *Hyas araneus* exposed to elevated seawater PCO_2 . *Frontiers in Zoology* 2014, 11:87 doi:10.1186/s12983-014-0087-4
Schiffer et al. (2014b) Pre-hatching seawater PCO_2 affects development and survival of zoea stages of Arctic spider crab *Hyas araneus*. *Mar Ecol Prog Ser* 501: 127-139
Storch et al. (2011) Thermal tolerance of larval stages of the Chilean kelp crab *Taliepus dentatus*. *Mar Ecol Prog Ser* 429: 157-167