Impacts of ocean acidification and warming stress on juvenile growth and metabolism in two populations of *Pecten maximus*

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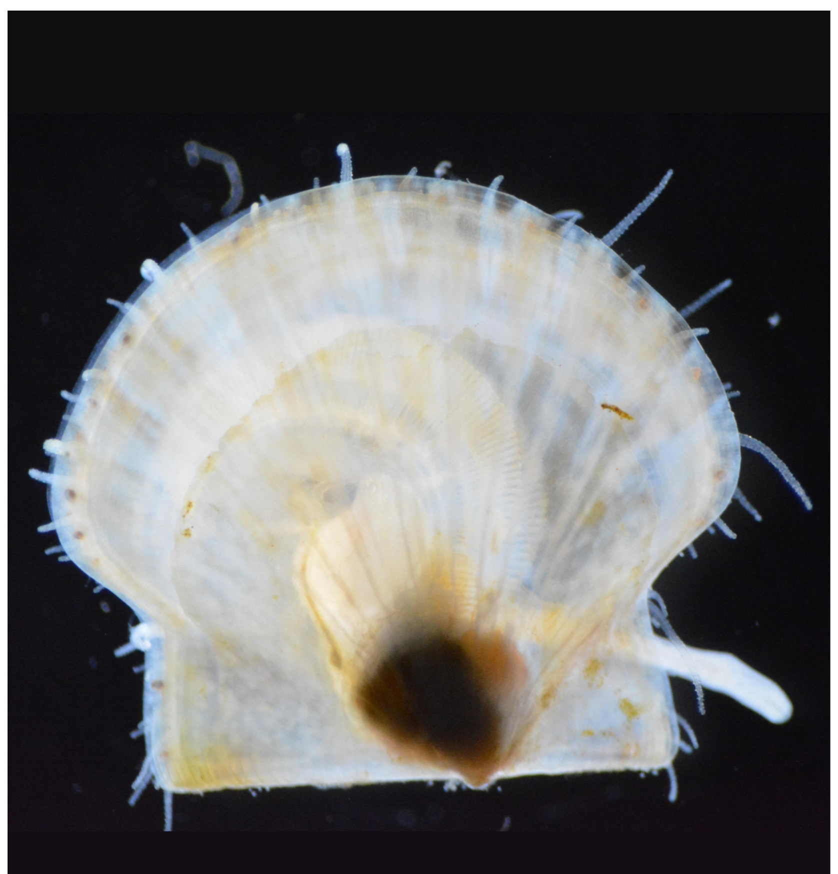

Fig. 1. Juvenile *P. maximus.*

How will climate change influence *P. maximus* growth?

Elevated atmospheric CO_2 is a major driver of global change in marine environments, causing sea surface temperatures to rise and acidification of marine environments (IPCC, 2013). We investigated how these climate stressors influenced juvenile growth of the great scallop *Pecten maximus* in two hatchery progenies from broodstock sampled from Bergen, Norway, and Brest, France.

The populations are genetically distinct (Morvezen *et al.*, 2016) but it is unclear whether differences arise from adaptive or neutral processes. Similarly, phenotypic differences observed in wild *P. maximus* (e.g. Chauvaud *et al.*, 2012; Artigaud *et al.*, 2014) may represent evolved differences, phenotypic plasticity or temperature-dependent differences in metabolism. Controlled laboratory experiments are required to distinguish these possibilities.

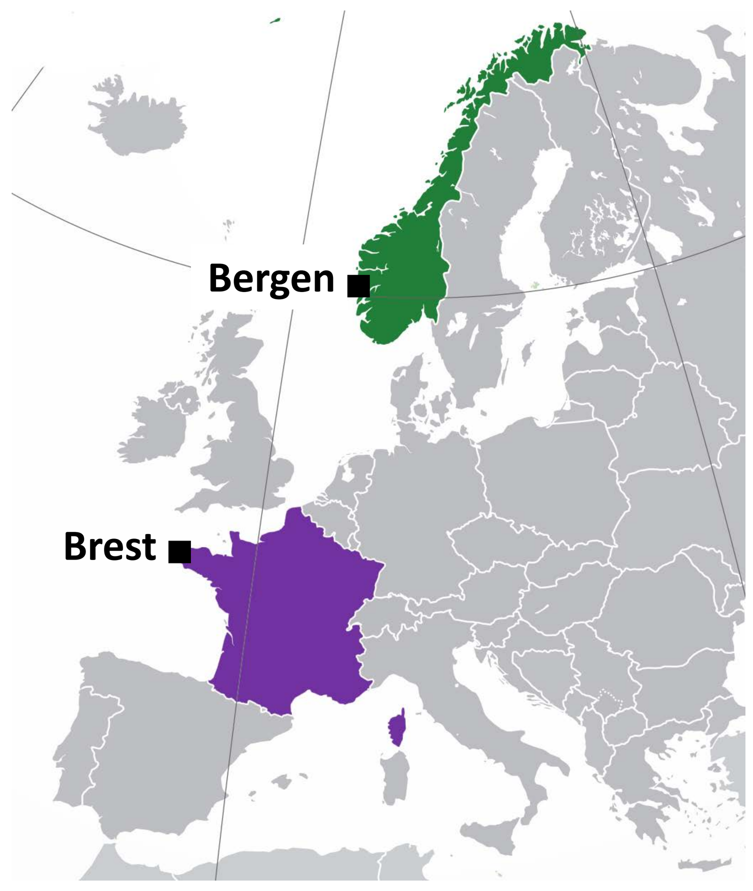

Fig. 2. Hatchery locations in France and Norway.

Disentangling genotype and environment

Spat (aged 3-6 months) were reared in controlled laboratory experiments for 5 weeks at 3 temperatures (13, 16 & 19°C) and at 2 pHs (8.0 & 7.7). For each population, approximately 500 spat were kept (spread across triplicated holding trays) in each condition.

Phenotypic measures (shell size and form, shell and body weight), eco-physiological measures (metabolic rate, filtration rate) and proteomic differences (global protein abundance via 2D gel electrophoresis) are currently being investigated.

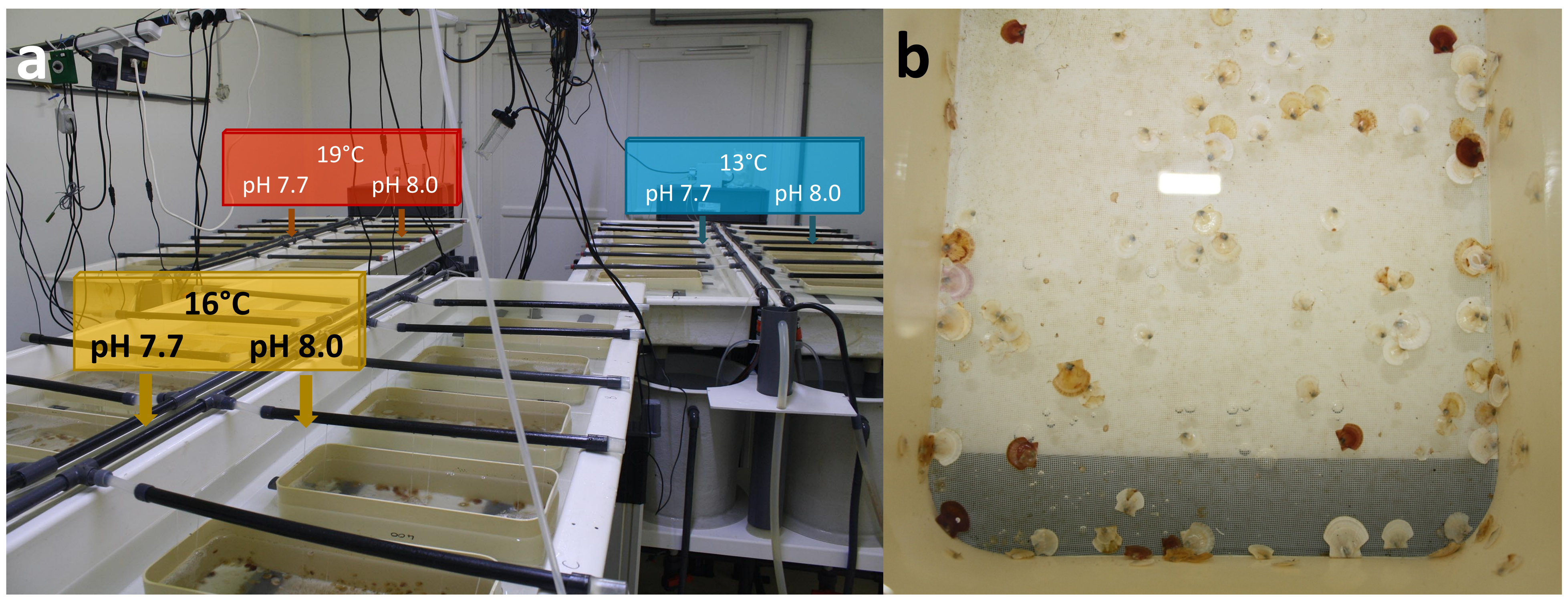

Fig. 3. a) Experimental installation at Ifremer facility, Plouzané where spat were reared and **b)** example of tray containing spat .

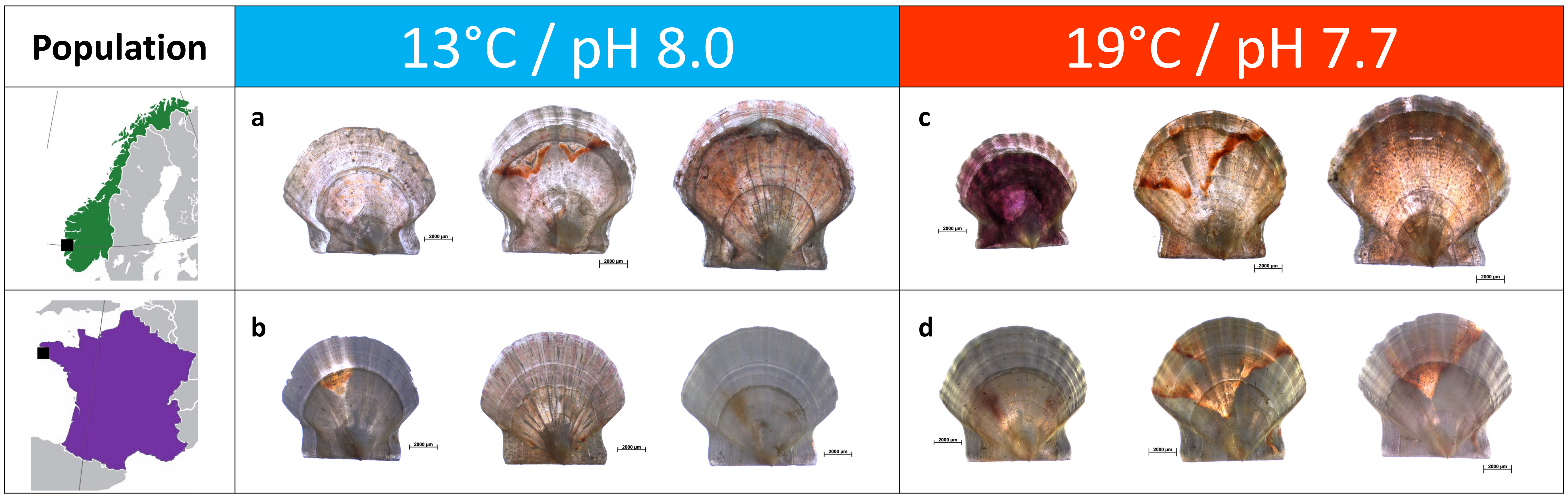

Fig. 4. Example images showing **a)** Norwegian and **b)** French *P. maximus* spat reared at 13°C / pH 8.0 , and **c)** Norwegian and **d)** French P. maximus spat reared at 19°C / pH 7.7. Growth estimated using final size (flat shell height) compared with size after transportation (transport and change in rearing environment caused clear break in shell margin). Photographs to scale.

Acknowledgements

We thank Thorolf Magnesen & Scalpro AS for providing Norwegian spat

Thanks to Florian Breton & the Tinduff Hatchery for providing French spat

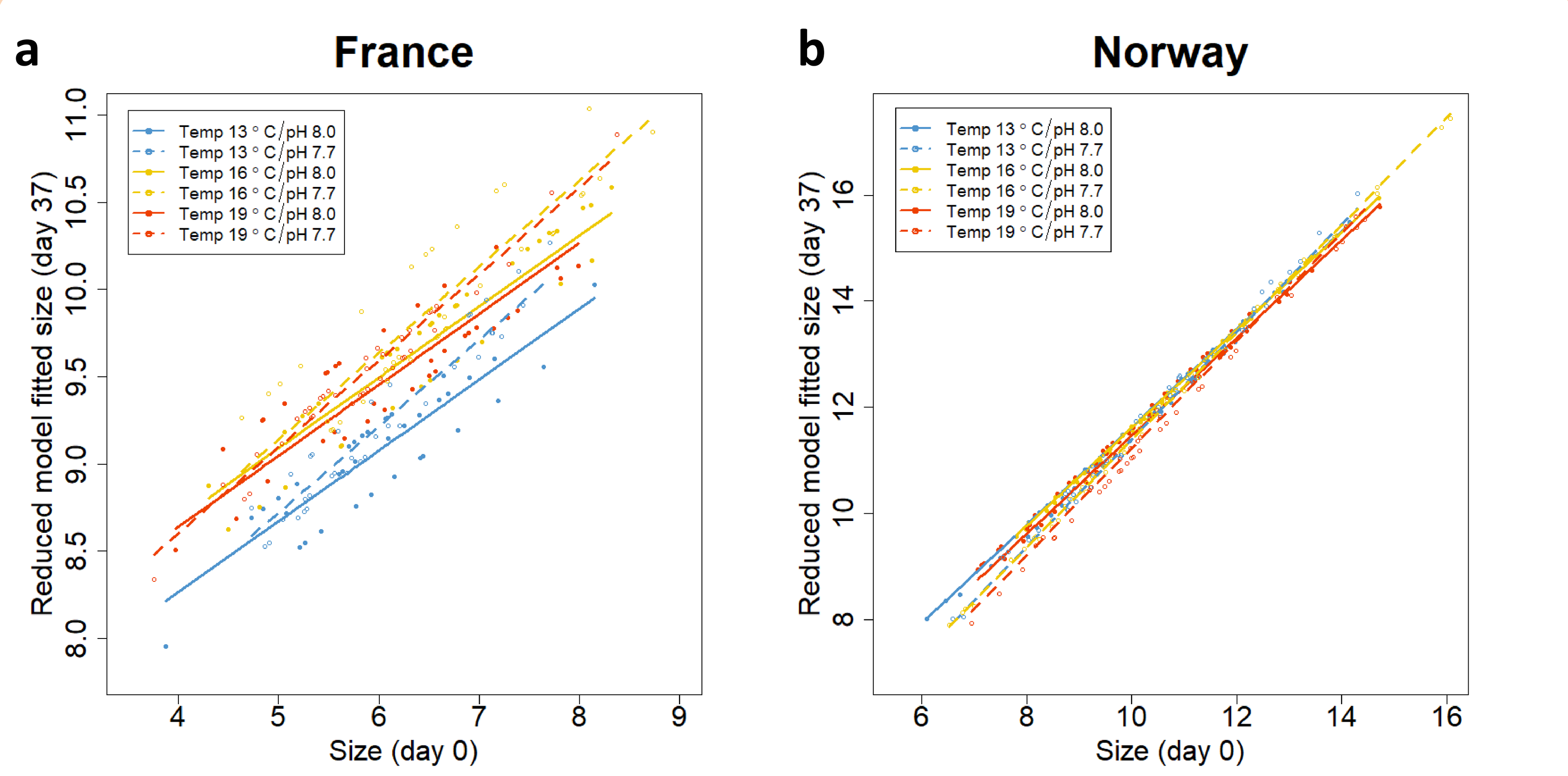

Fig. 5. Predicted (fitted) size (shell height) at day 37 plotted as a function of initial size at day 0 for **a)** French and **b)** Norwegian spat. Lines show regressions based on best fitting reduced linear mixed effects model (sig. effects in **bold**):

`Size_d37 ~` **`Size_d0`** `+ pH + Temp +` **`Pop`** `+` **`Size_d0:pH`** `+` **`Size_d0:Pop`** `+` **`pH:Pop`** `+` **`Temp:Pop`**

Results

Preliminary analysis of phenotypic results suggests that French animals grew more at higher temperatures and when pH was reduced (**Fig. 5**). Conversely, among spat from Norway, growth was less responsive to pH and temperature (although ↑ temp. and ↓ pH seems to reduce growth). However, body/shell weight ratio was reduced in low pH at 19°C for Norwegian spat (**Fig. 6**).

Perspectives

Integrating phenotypic, eco-physiological and proteomic results can improve our understanding of how populations differ, and might respond to future climate change.

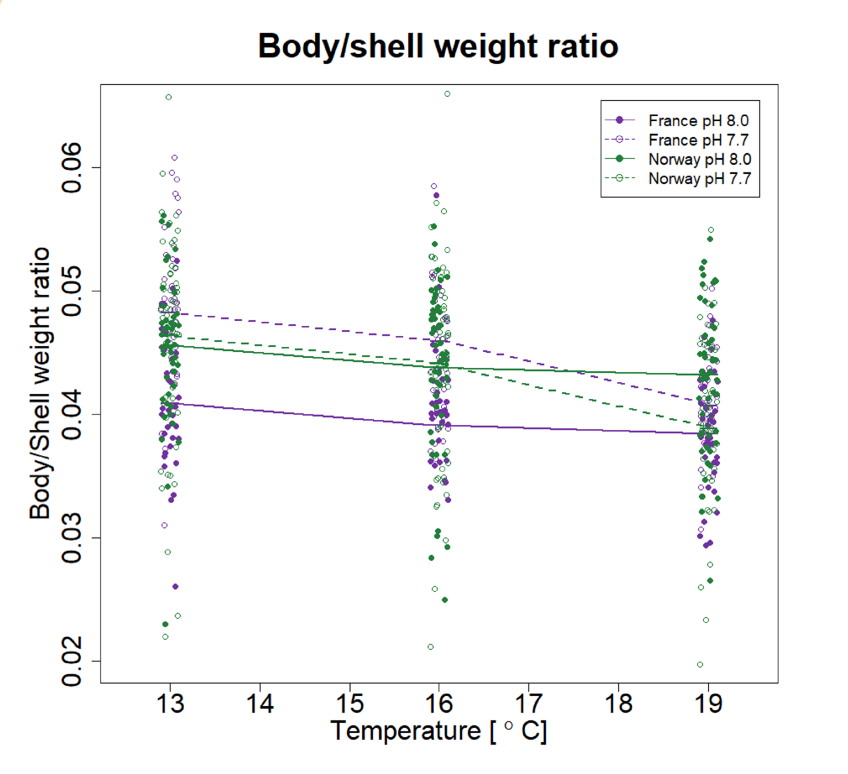

Fig. 6. Ratio of dry body/shell weight plotted across 3 temperatures. Circles are (jittered) data, lines join estimates based on best fitting reduced linear mixed effects model (sig. effects in **bold**):

`Ratio ~` **`pH`** `+` **`Temp`** `+` **`Pop`** `+` **`pH:Temp`** `+` **`pH:Pop`**

References: Artigaud, S. *et al*. (2014) Journal of Proteomics, **105**, 164–173; Chauvaud, L. *et al*. (2012) PLoS ONE, **7**, 6–15; IPCC (2013) Climate Change 2013: The Physical Science Basis, Cambridge, U.K.; Morvezen, R. *et al*. (2016) Conservation Genetics, **17**, 57–67.