Alfred Wegener Institute for Polar and Marine Research

Physiological measures of climate dependent organismal performance investigated in populations of the lugworm *Arenicola marina* in a latitudinal cline

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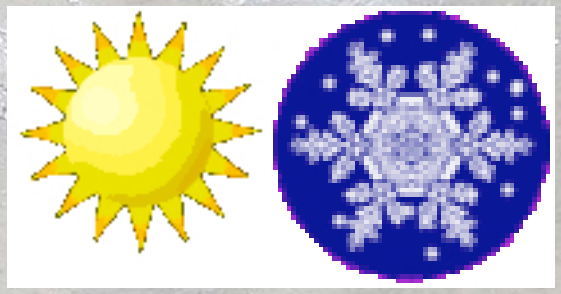
WESTFÄLISCHE WILHELMS-UNIVERSITÄT MÜNSTER

Latitudinal adaptation and Seasonal acclimatisation



- How does it work?
- Is adaptation to climate change possible?

Oxygen limited thermal tolerance

Tp: pejus temperatures, optimum range thresholds

oxygen supply limit => decreasing blood oxygenation

Tc: critical temperatures, metabolism turns anaerobic

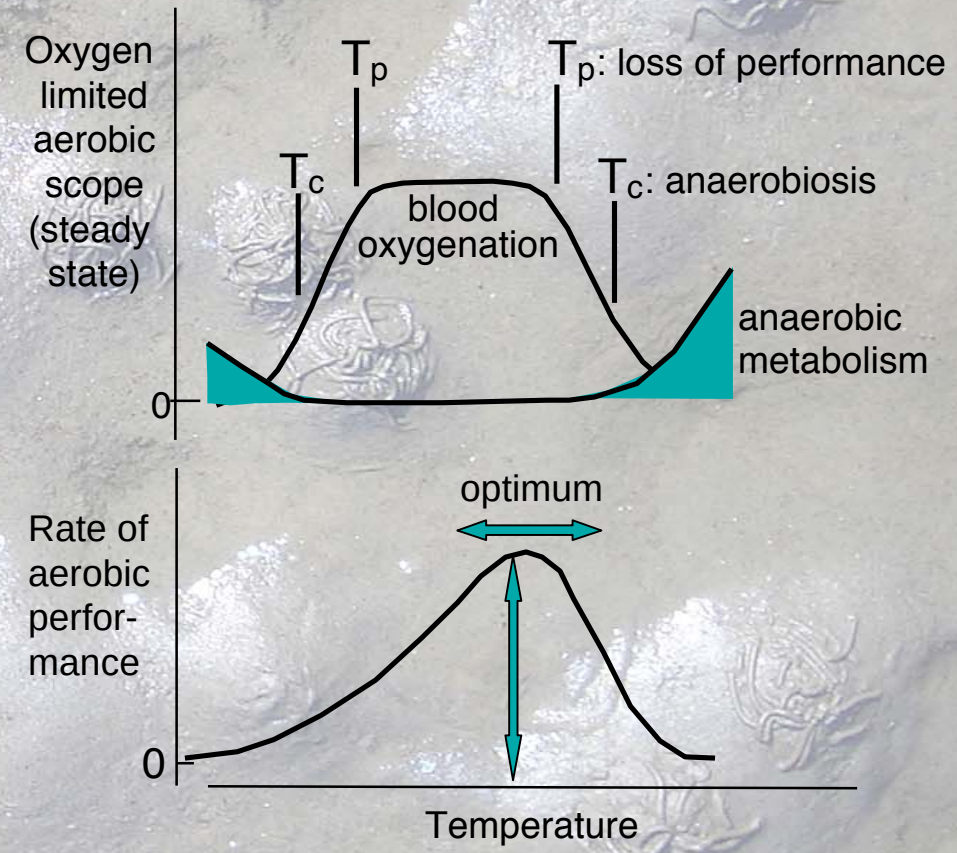
survival time limited unless acclimatisation occurs

As seen in fishes, long-term warming beyond pejus temperatures
(Pörtner and Knust, Science 2007)

=> reduced performance (growth, reproduction, muscle exercise,...)

=> ecological consequences:

- decreased abundance
- local extinction
- shift in distribution



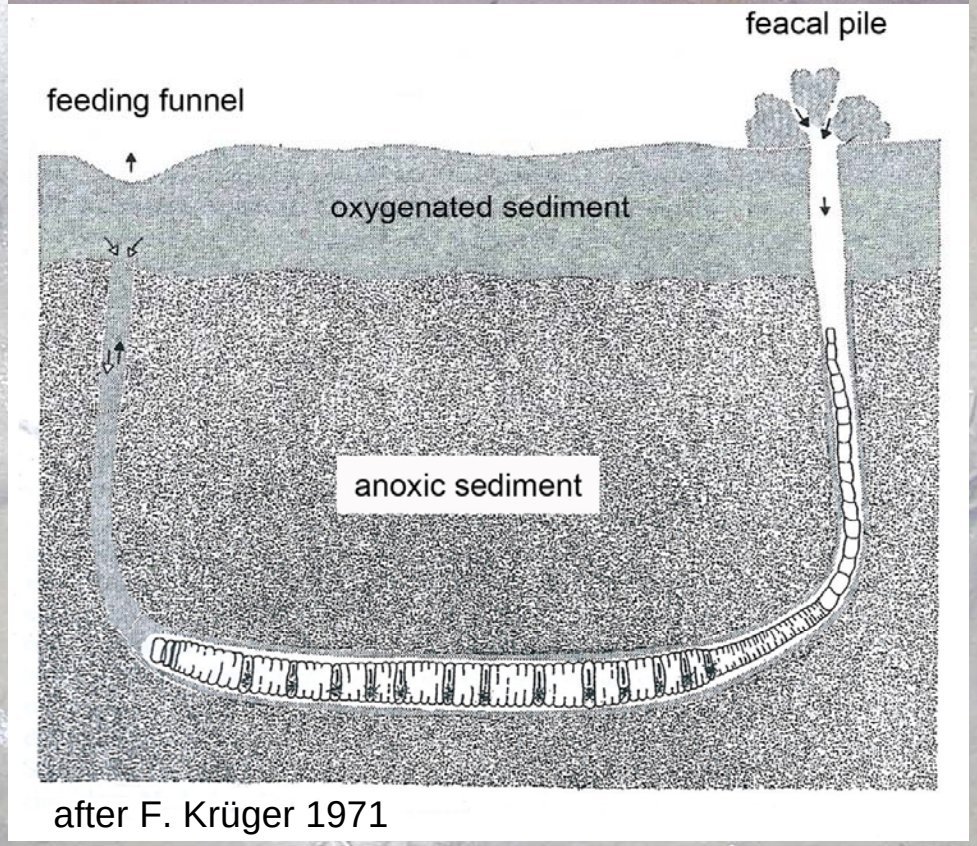
After: Pörtner et al. 2004

Performance curve: oxygen supply budget above basic metabolism

Model organism

The lugworm *Arenicola marina* beside it's burrow

Longitudinal section of the burrow



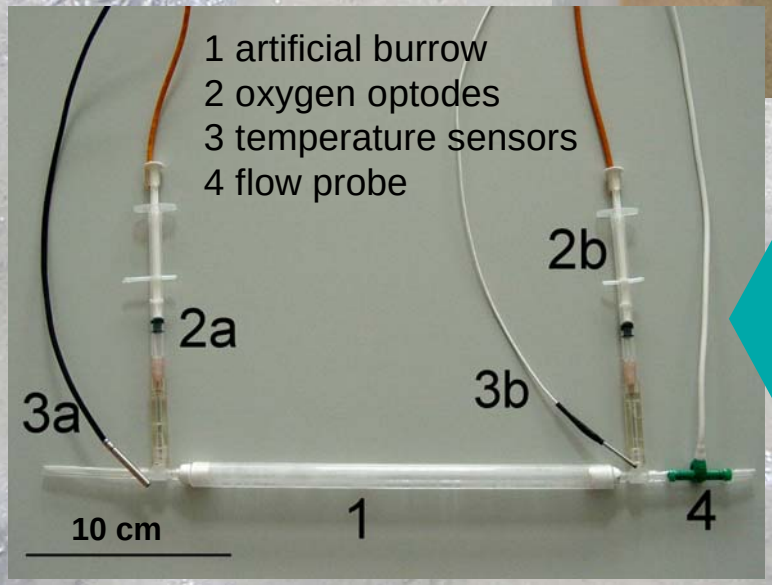
after F. Krüger 1971

Populations

Methods

Muscle exercise: quantification of digging activity

Haemoglobin properties: Seasonal changes of P_{50} (oxygen partial pressure when haemoglobin is half saturated)

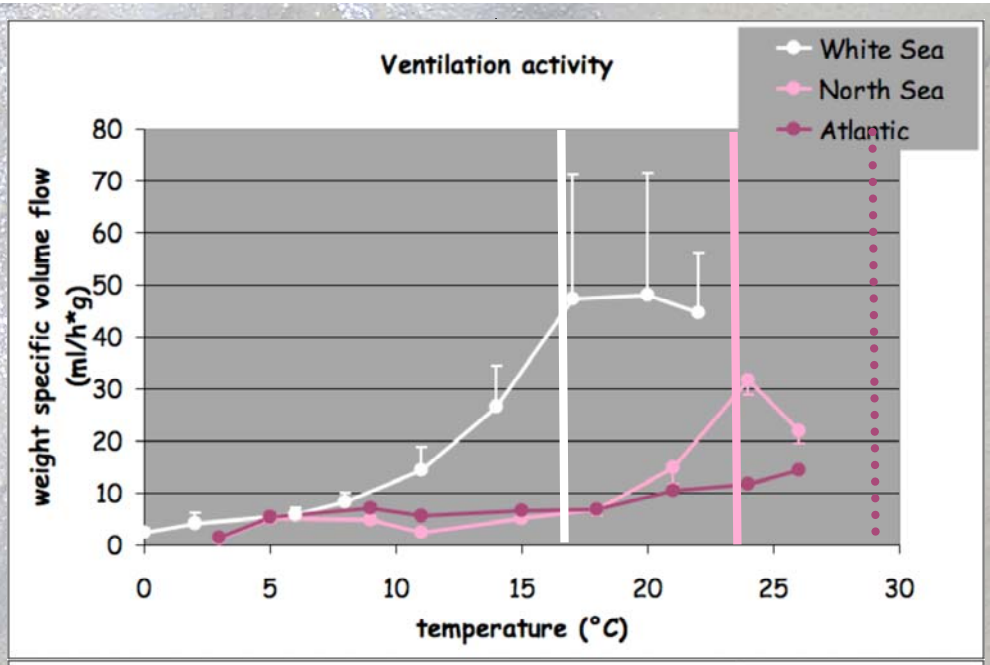


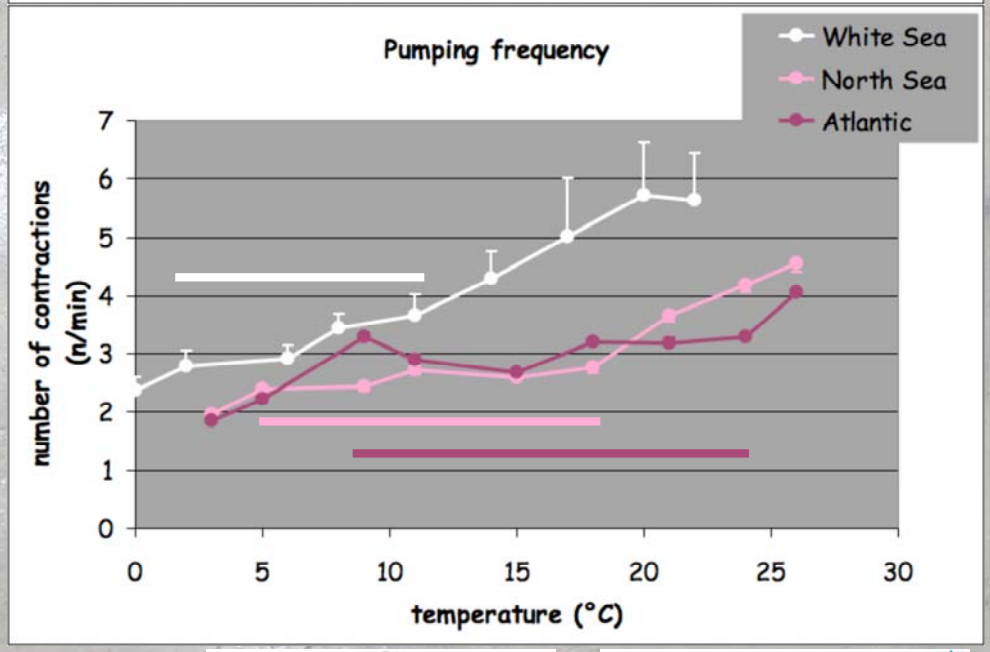
Ventilation and respiration: recording of pumping activity, volume flow and oxygen consumption

Results: Latitudinal adaptation

Comparison of summer animals in a latitudinal cline:

- upper critical temperature
- optimum range

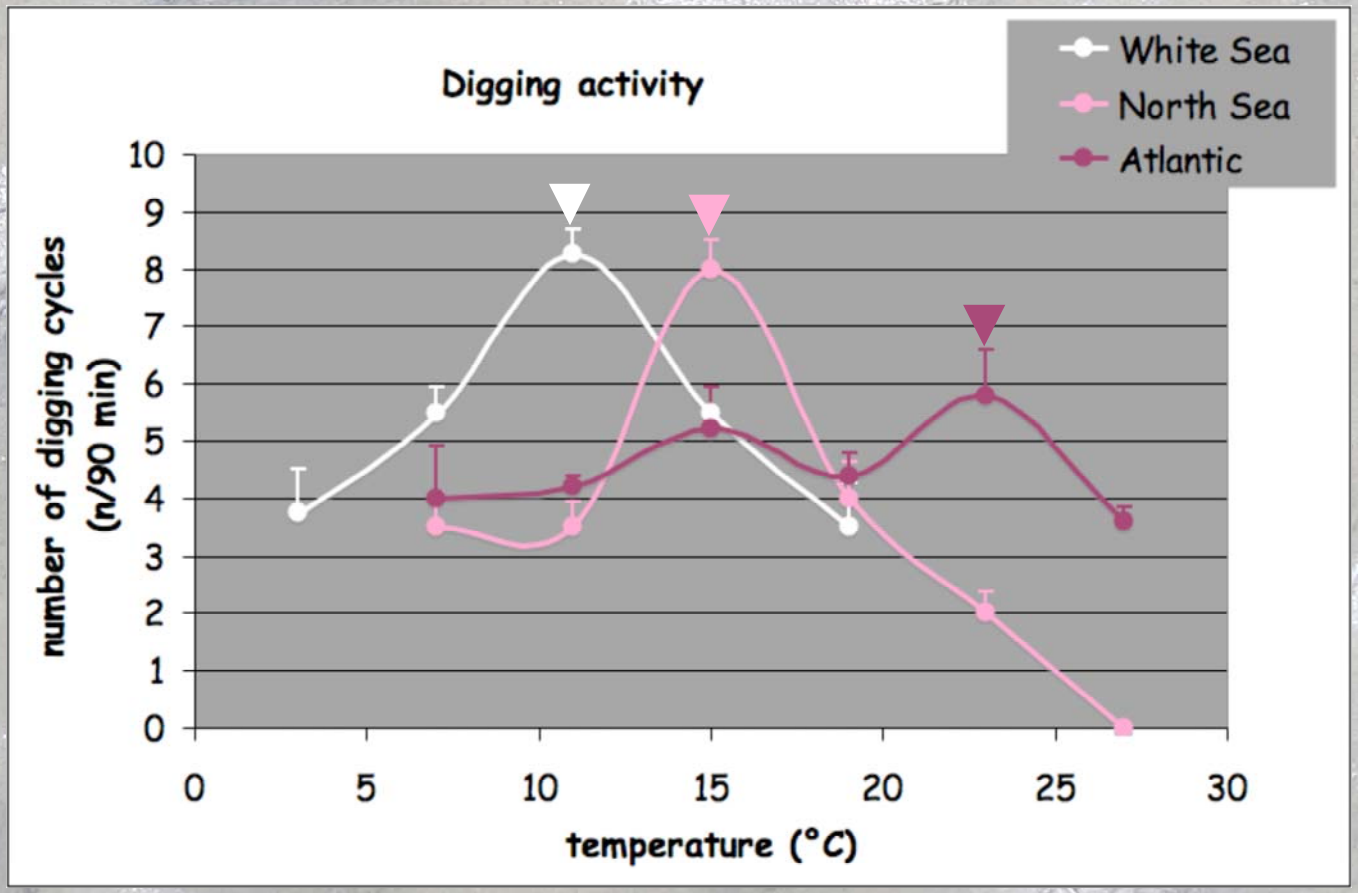




Results: Latitudinal adaptation

Comparison of summer animals in a latitudinal cline:

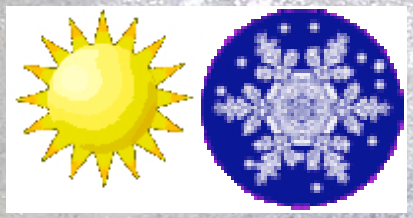
location of exercise performance optimum



White Sea: 11°C

North Sea: 15°C

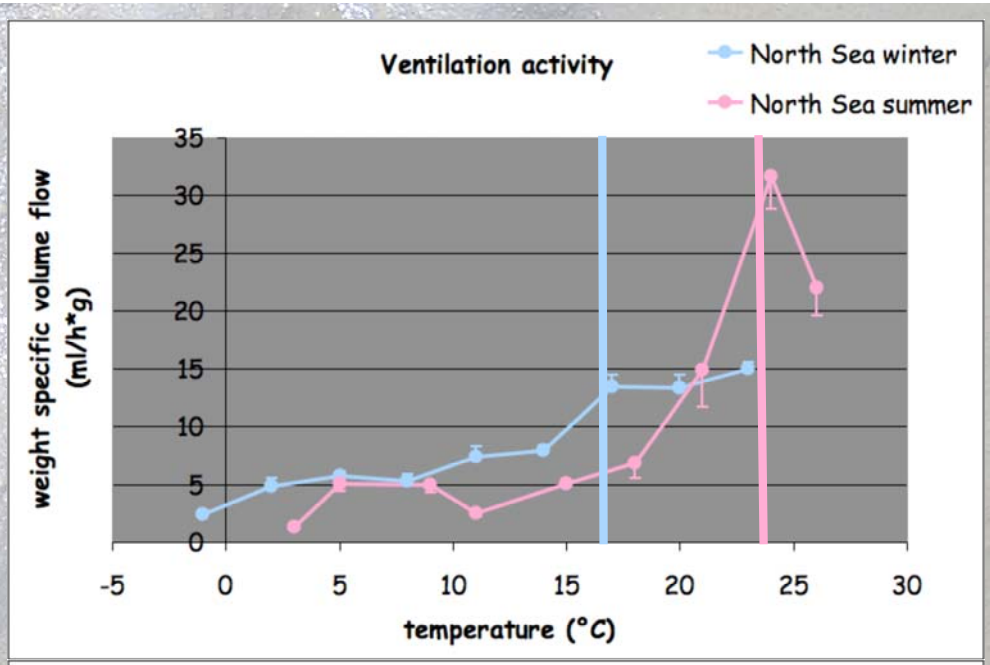
Atlantic: 23°C

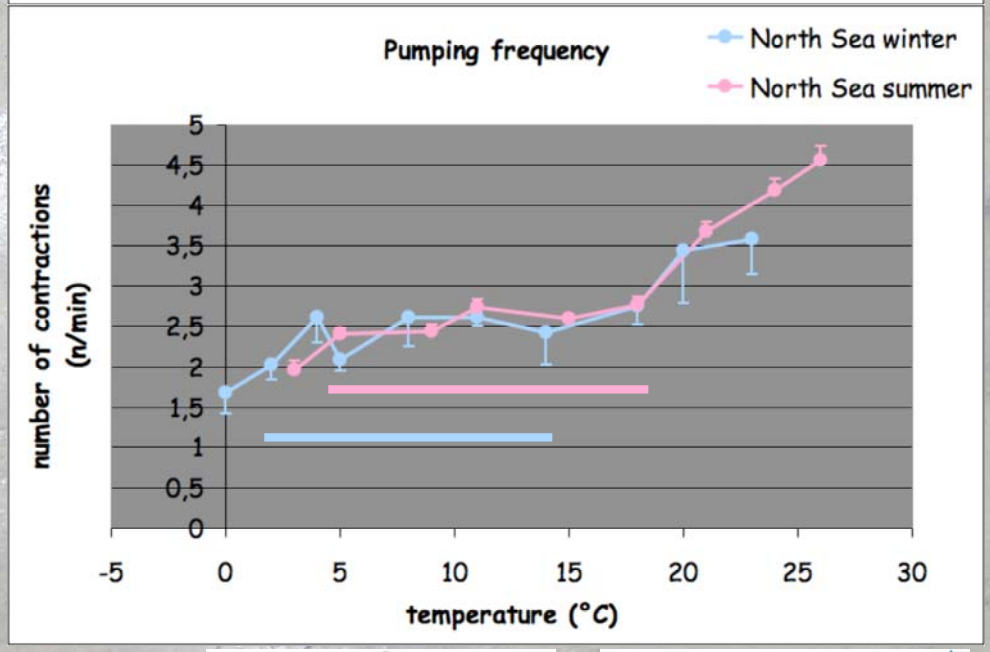


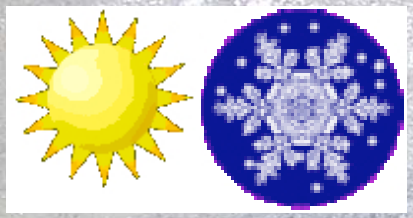
Results: Seasonal acclimatisation

Comparison of **North Sea** animals in summer and winter:

- upper critical temperature
- optimum range



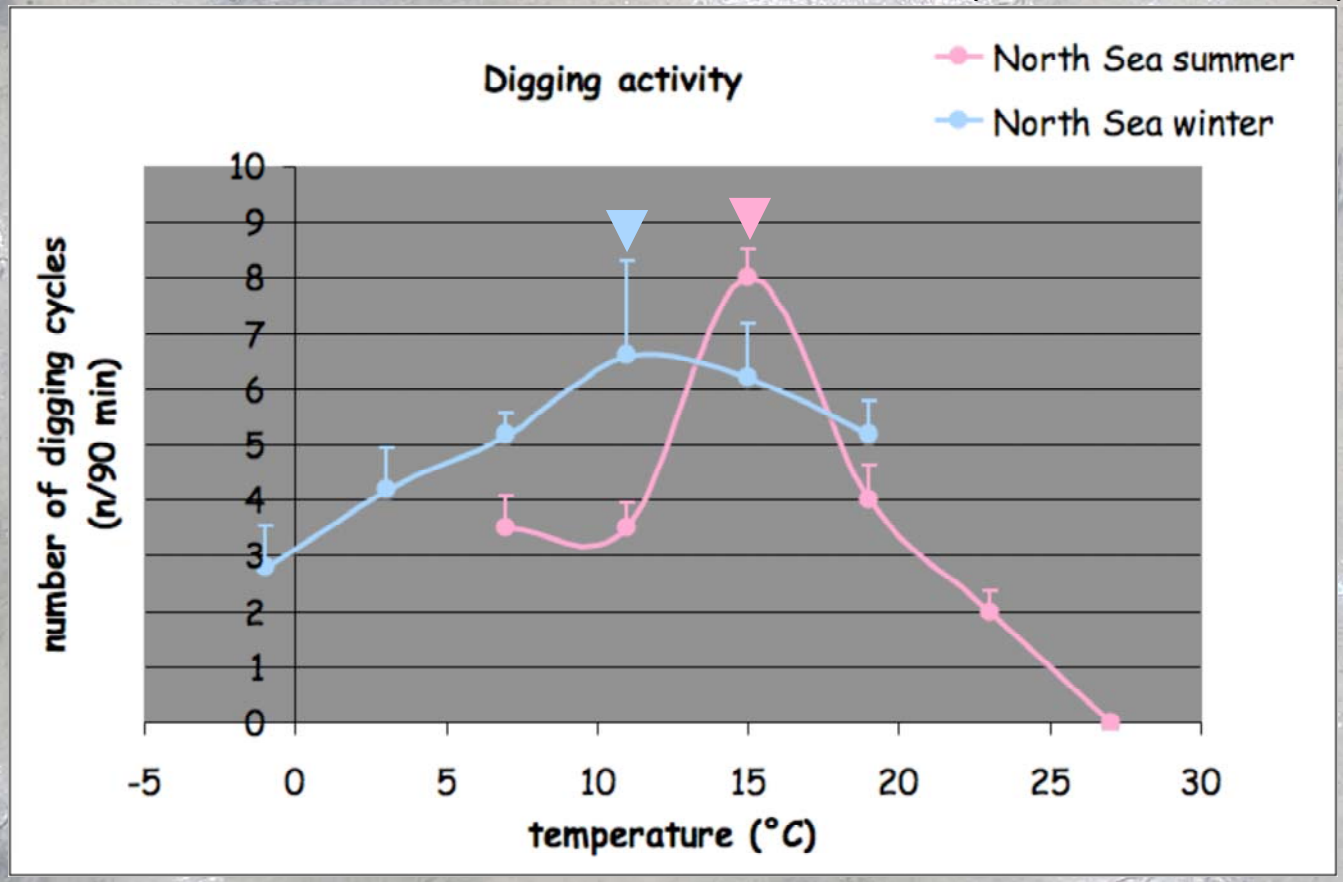




Results: Seasonal acclimatisation

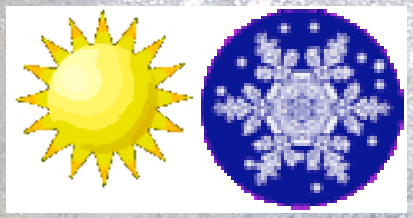
Comparison of **North Sea** animals in summer and winter:

location of exercise performance optimum



Summer: 15°C

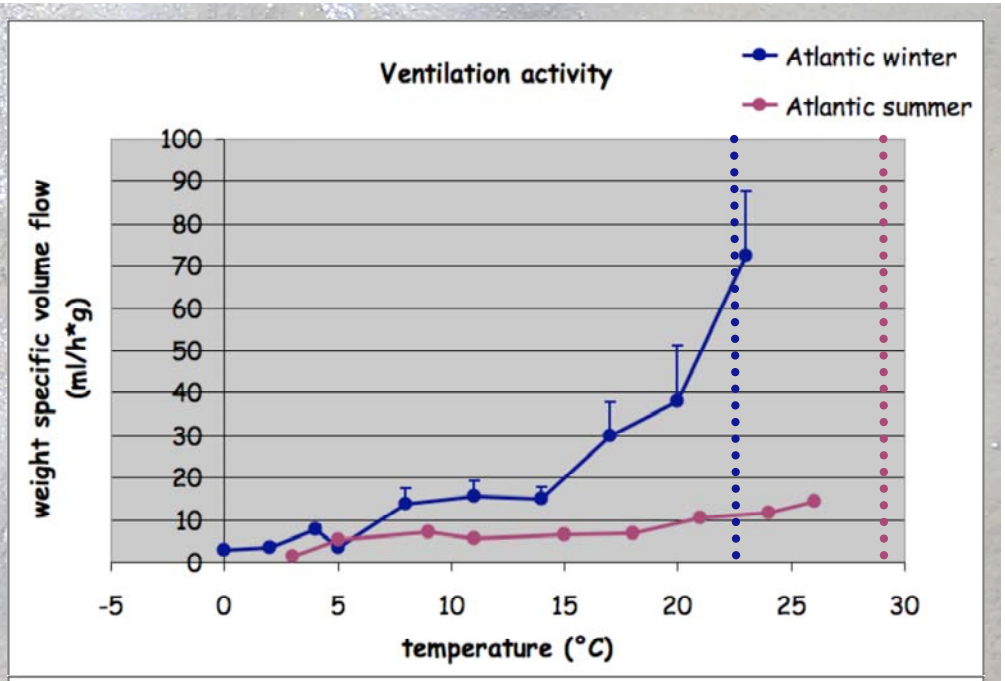
Winter: 11°C

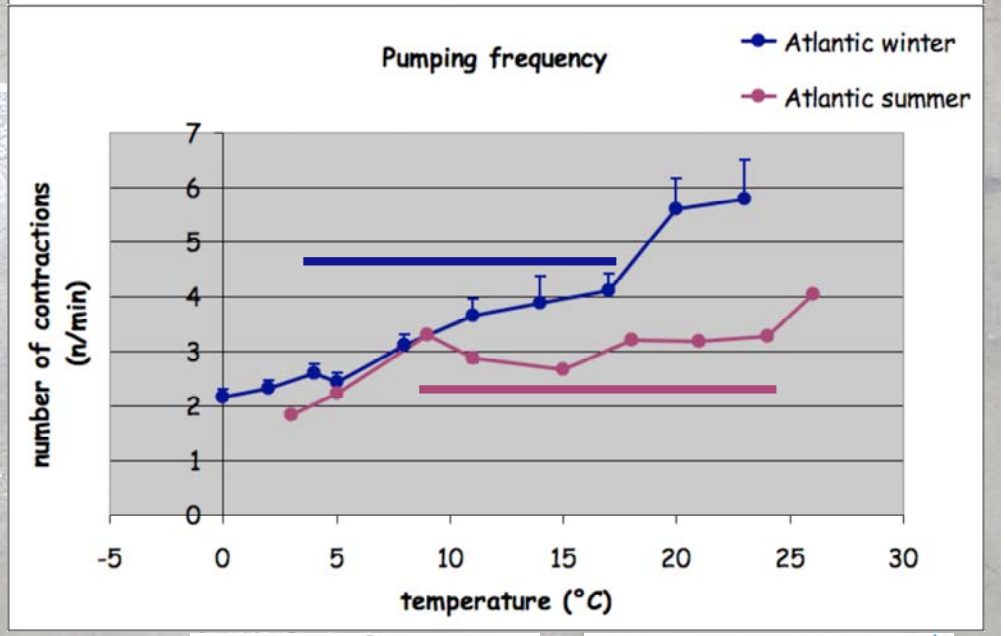


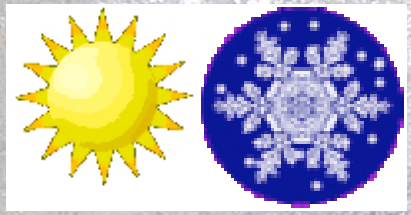
Results: Seasonal acclimatisation

Comparison of **Atlantic** animals in summer and winter:

- upper critical temperature
- optimum range



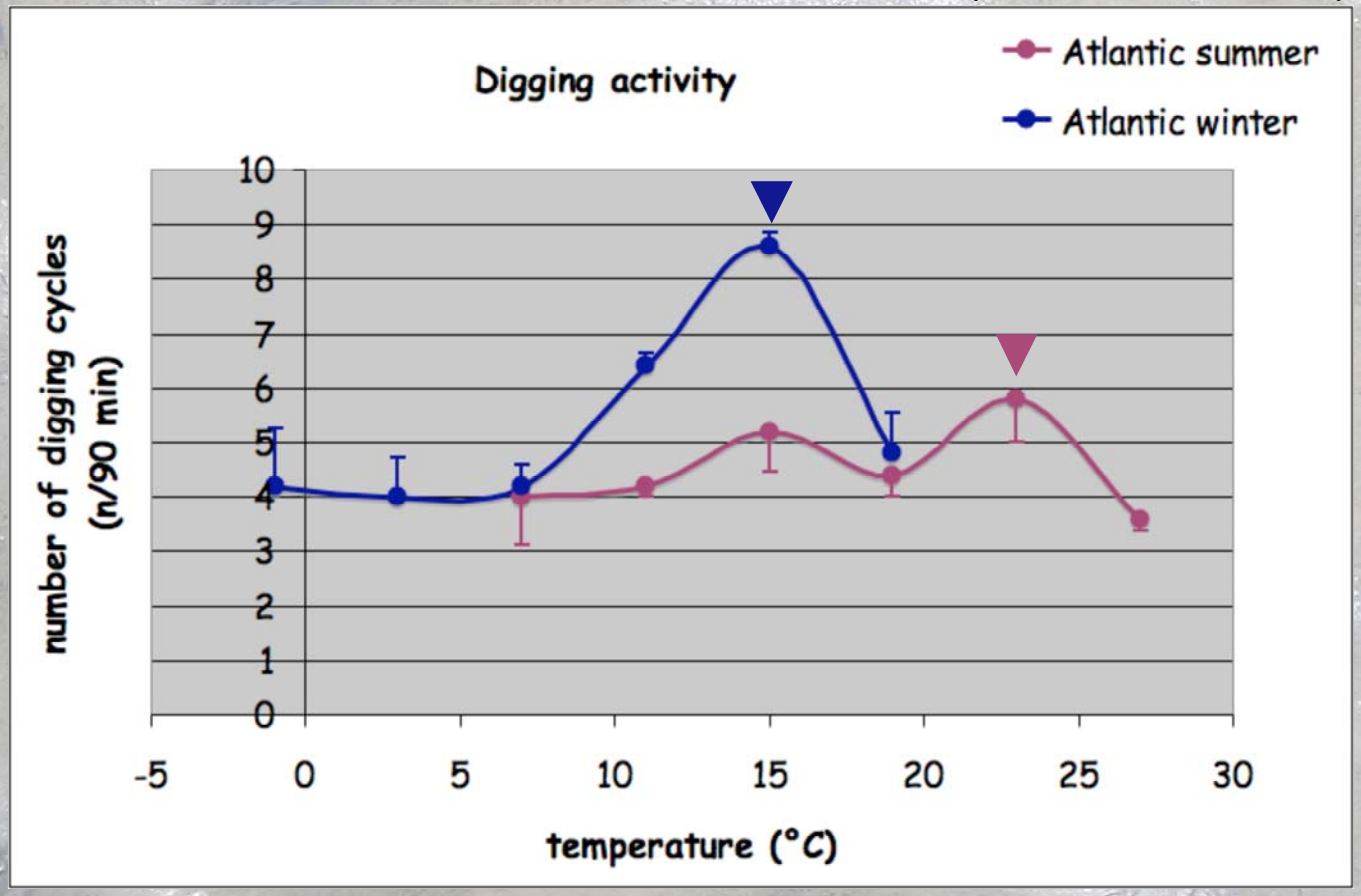




Results: Seasonal acclimatisation

Comparison of **Atlantic** animals in summer and winter:

location of exercise performance optimum



Summer: 23°C

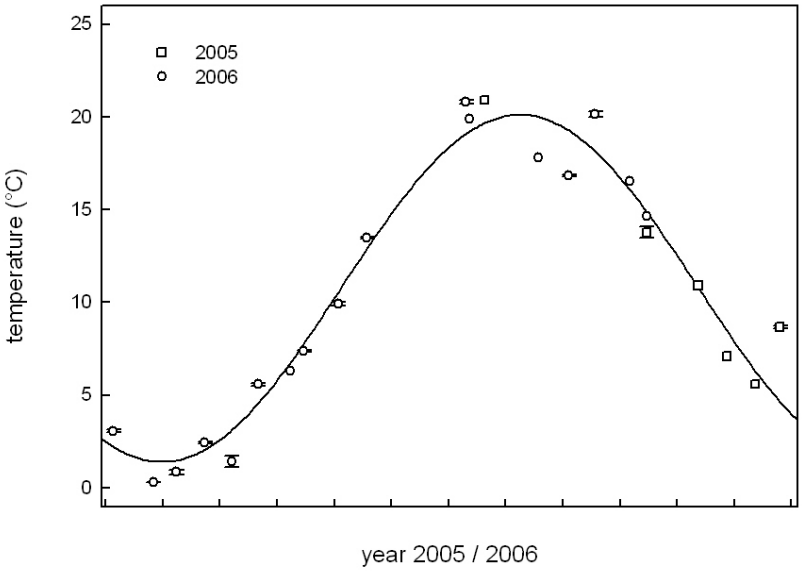
Winter: 15°C

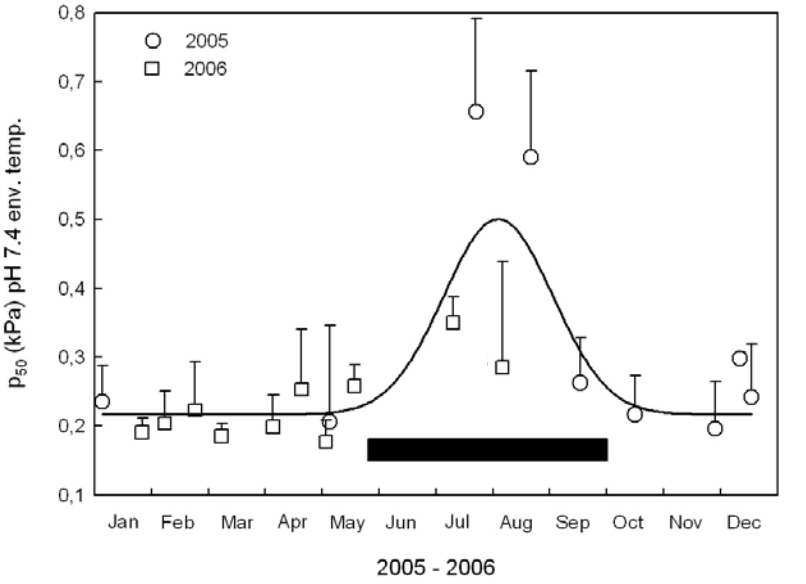
Results: Seasonal acclimatisation

Seasonal comparison of **North Sea** animals:

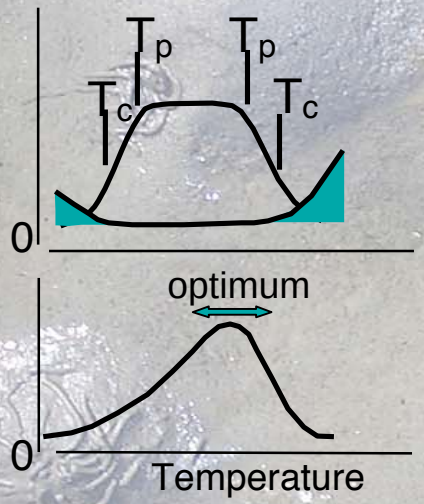
-Temperature in 20 cm depth

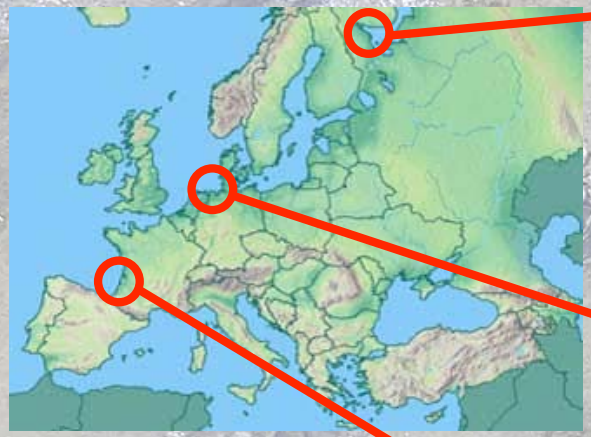
- **Haemoglobin properties**: Seasonal changes of P_{50} (oxygen partial pressure when haemoglobin is half saturated)
- increased P_{50} in summer
- => facilitated oxygen release to tissues during reproductive phase (June-September)
- effects on thermal tolerance and performance

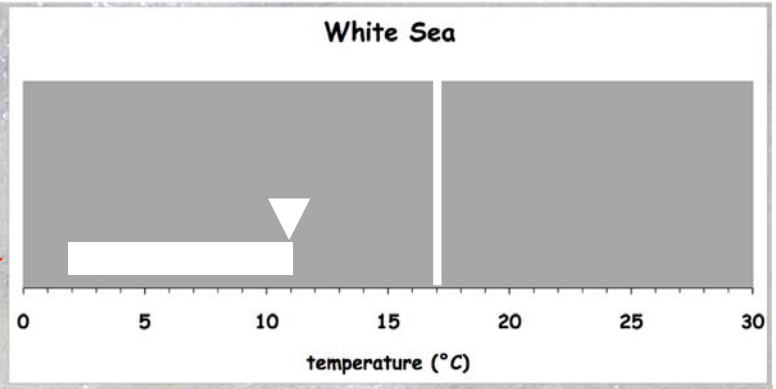


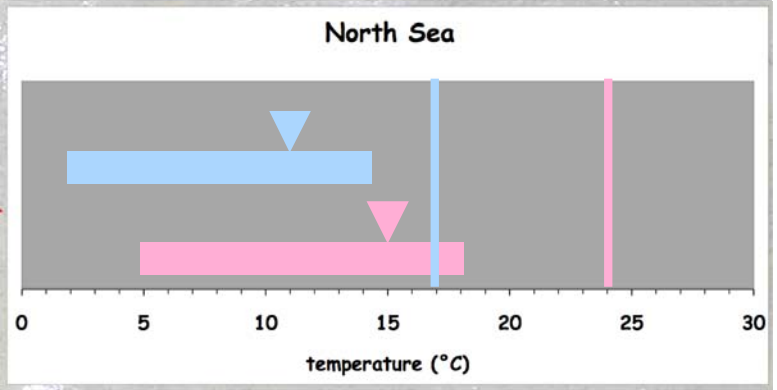


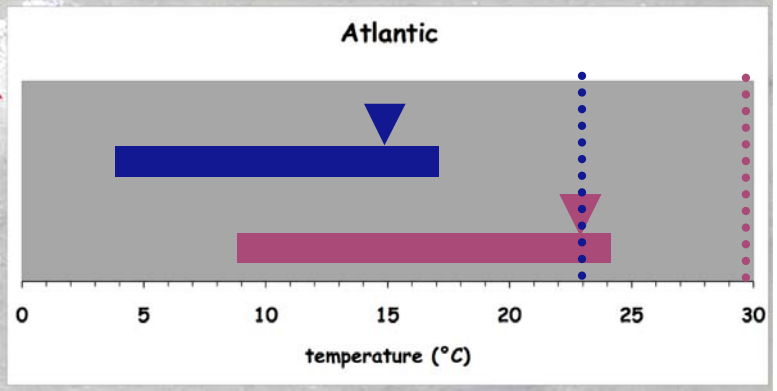
Summary











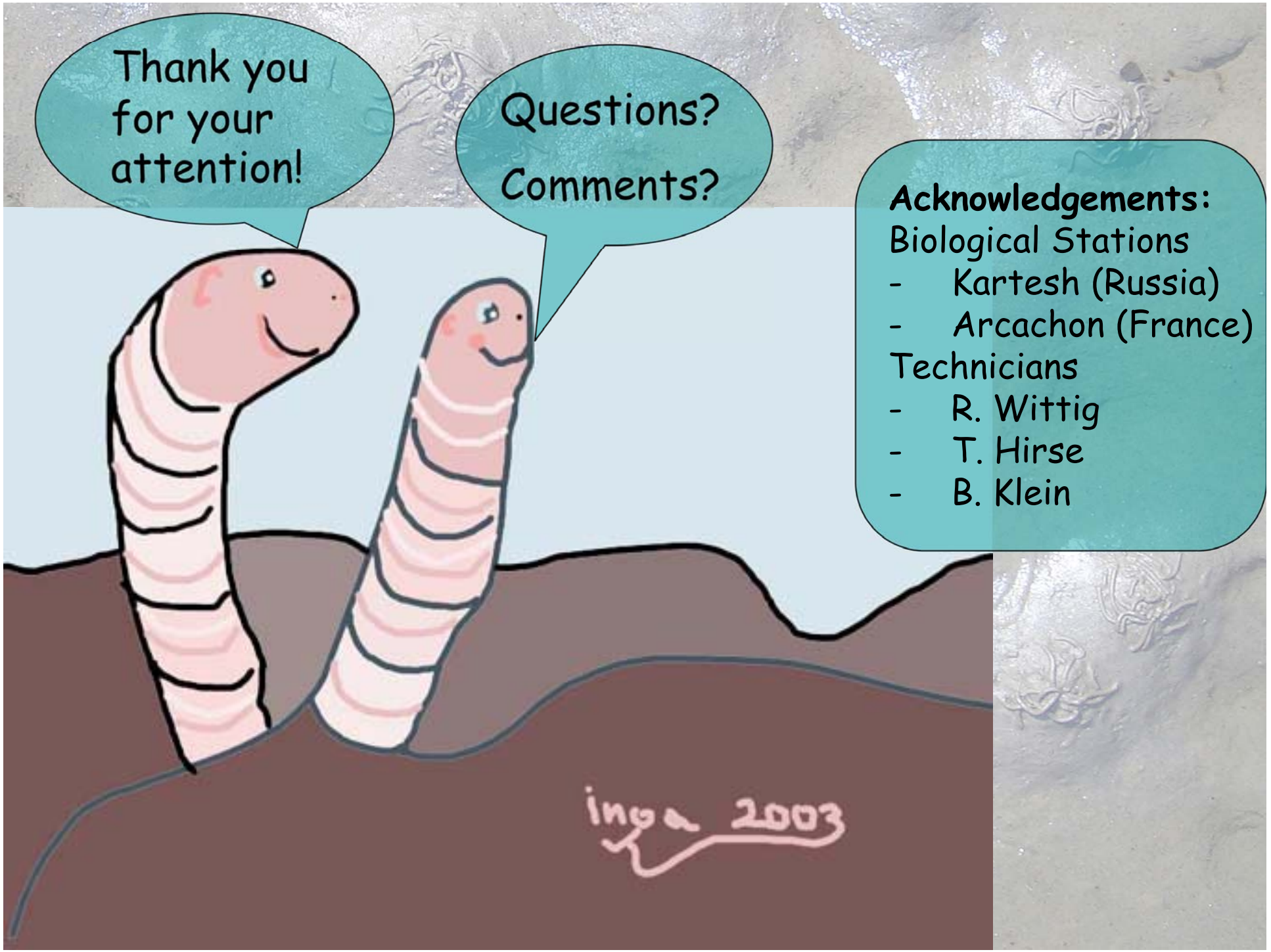
Thermal tolerance windows:

- seasonal shifts and changing width
- latitudinal specialisation

Conclusions

Climate change:

- Our results show capacities to regain balance in oxygen demand and supply with changing temperature.
- Global warming: application of the same mechanisms: short-term acclimatisation and long-term adaptation
- Summer animals: Have they reached their acclimatisation limits? => adaptation over a larger timescale is necessary
- Southernmost populations: Have they reached their adaptation limits?


Thank you for your attention!
Questions?
Comments?
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