Climate change impacts ('ocean acidification' and temperature) on the metabolic scope and activity of nektonic organisms: *a crustacean example*

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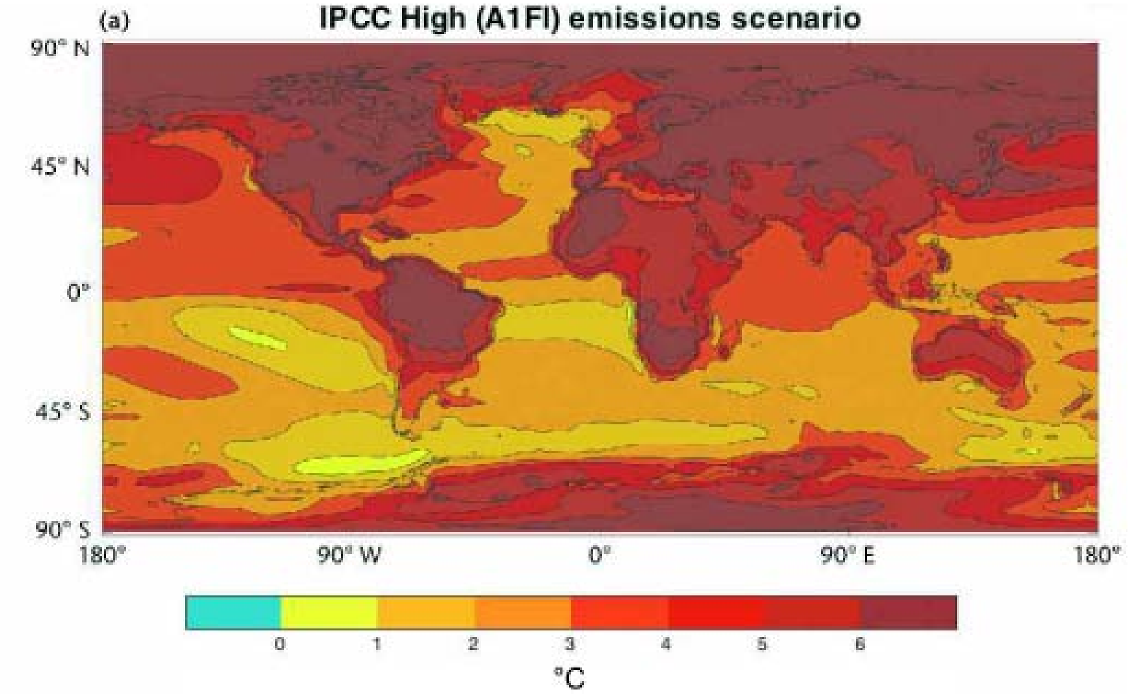
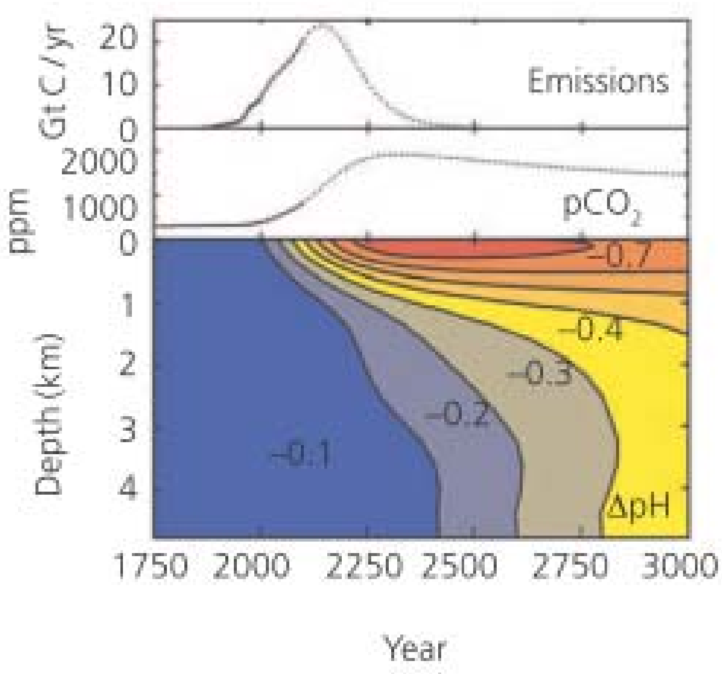
Physical drivers of climate change

Climate warming:
projected to rise by 2 - 4.5 °C

Ocean acidification:
1900 ppm CO_2 by yr 2300
(pH ~ 7.4)



Hadley Centre for Climate Prediction and Research



Caldeira & Wickett (2003)

Rationale

"..likely that changes in sea-water chemistry would affect the internal physiological functioning of marine organisms"

Prof. John Raven

<u>Ionic and osmotic regulation:</u>
The maintenance in a body fluid of concentrations of ions (ionic) and total particle concentration (osmotic) differing to that of the external medium

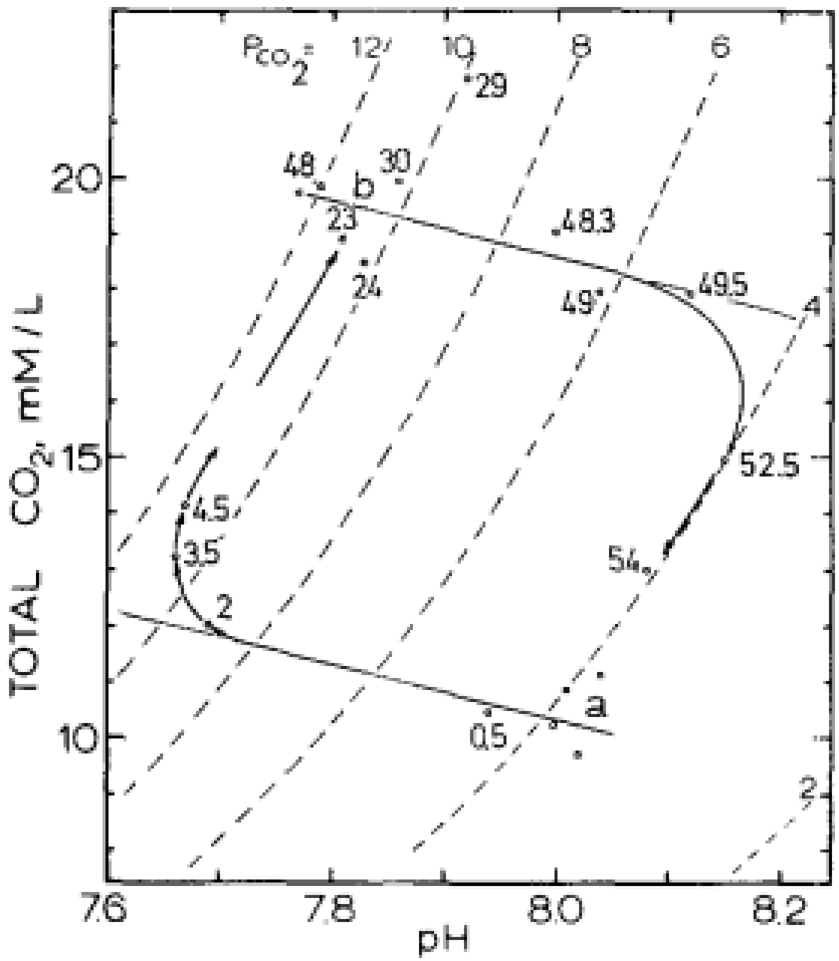
(Robertson 1949, 1960)

<u>Acid-base balance:</u>
Tight control of pH is required for proper physiological functioning

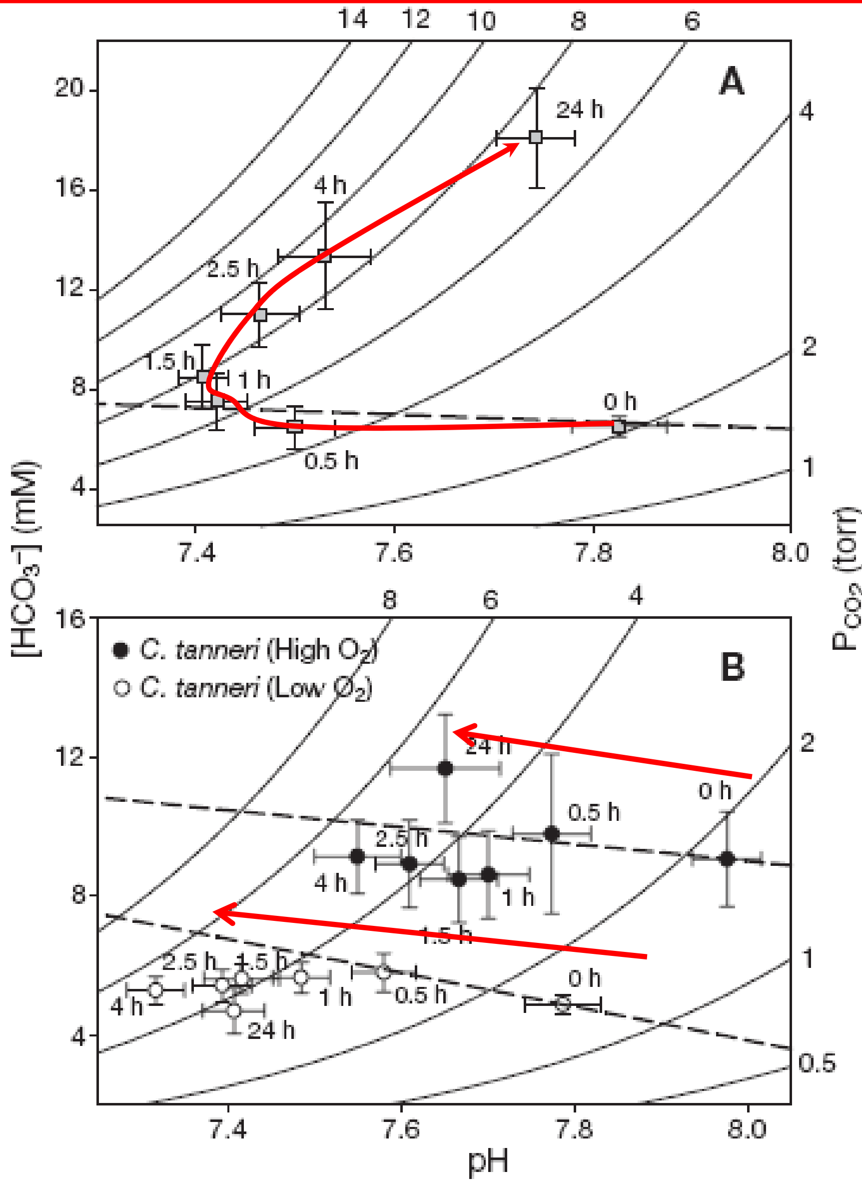
(Seibel & Walsh 2003)

Short-term effects: acid-base changes

Exposure to 1 % CO_2



Cameron (1978)



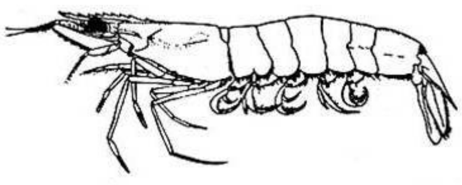
Pane & Barry (2007)

Goals of OA research

Diagnostic:

Mechanisms

- *Changes in internal functioning ?*

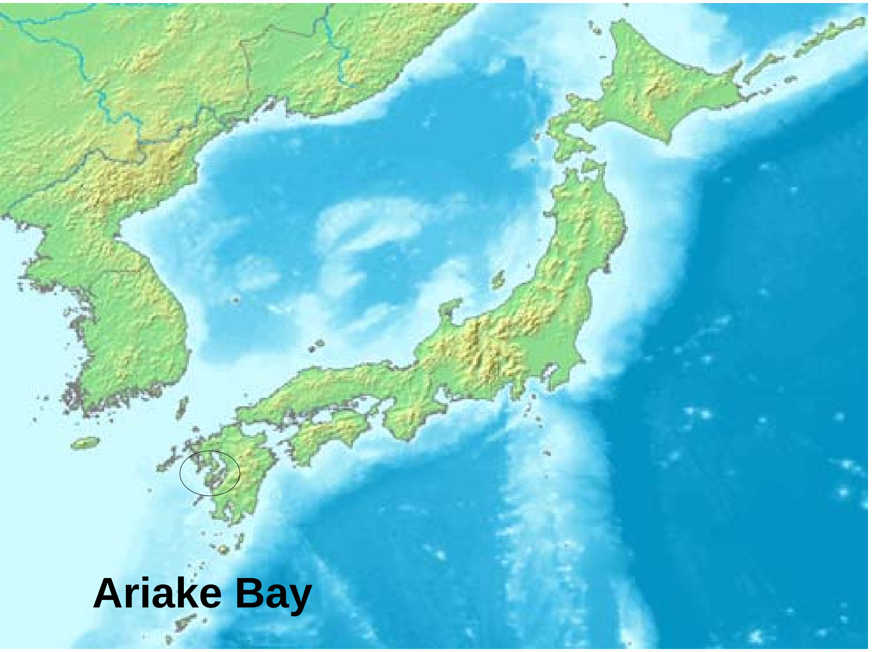


Prognostic:

Physiological and ecological consequences

- *Growth rates ?*
- *Behaviour ?*

Importance of Penaeids

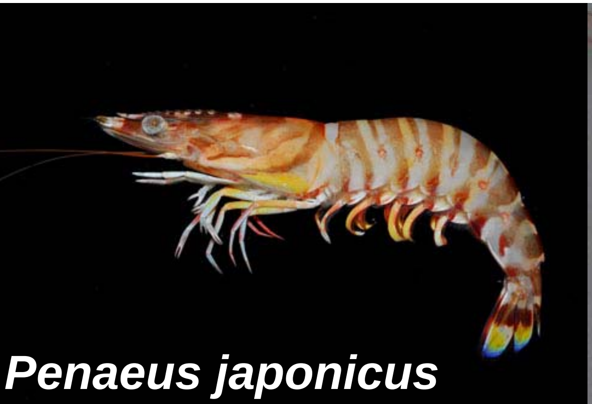


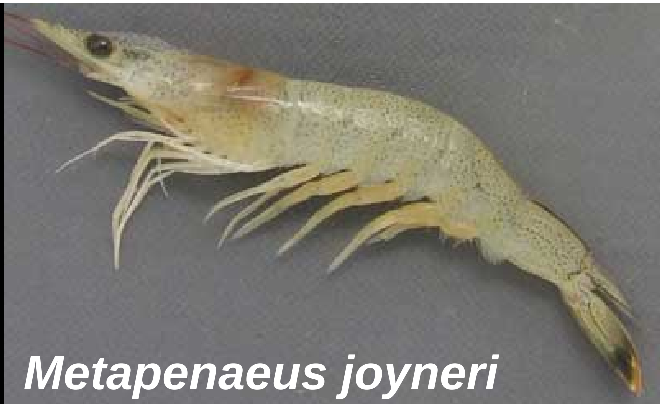
Fish as food: per capita supply (average 2003-2005):

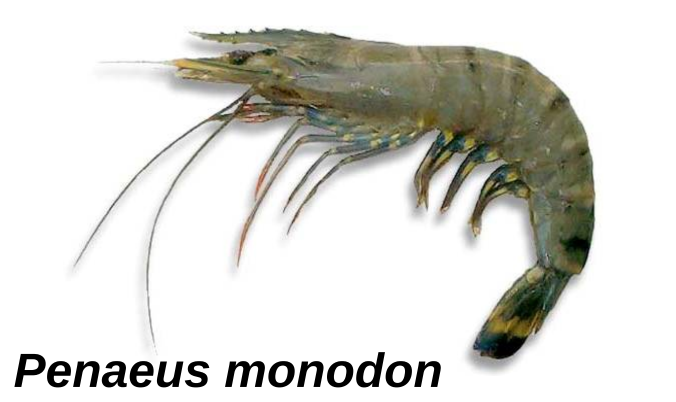
Japan = > 60 kg yr^{-1}
Western Europe = 5-10 kg yr^{-1}
UK = 2-5 kg yr^{-1}

Total catch = 3,416,533 (tonnes)
Penaeids (919,088) **i.e. 26% of total shrimp**

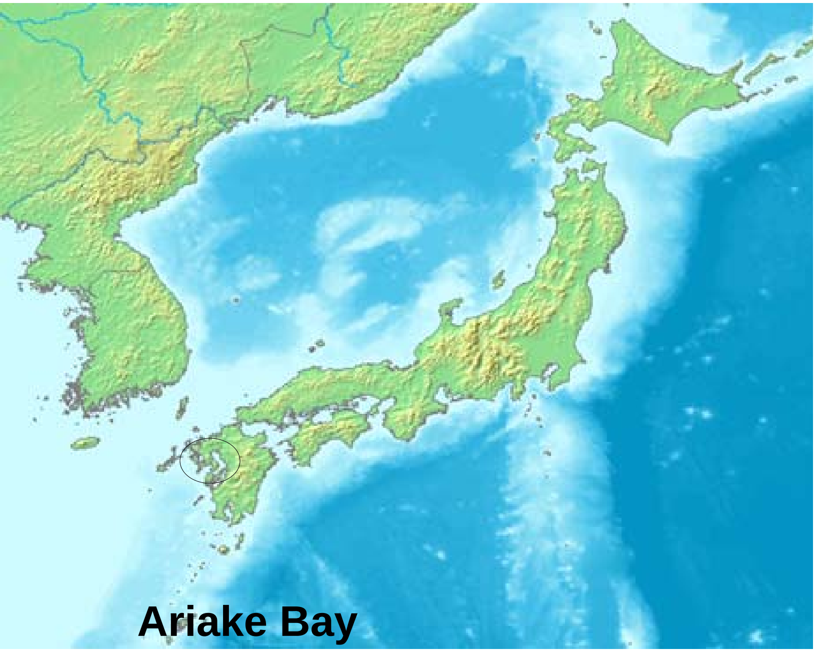
FAO. (2008)



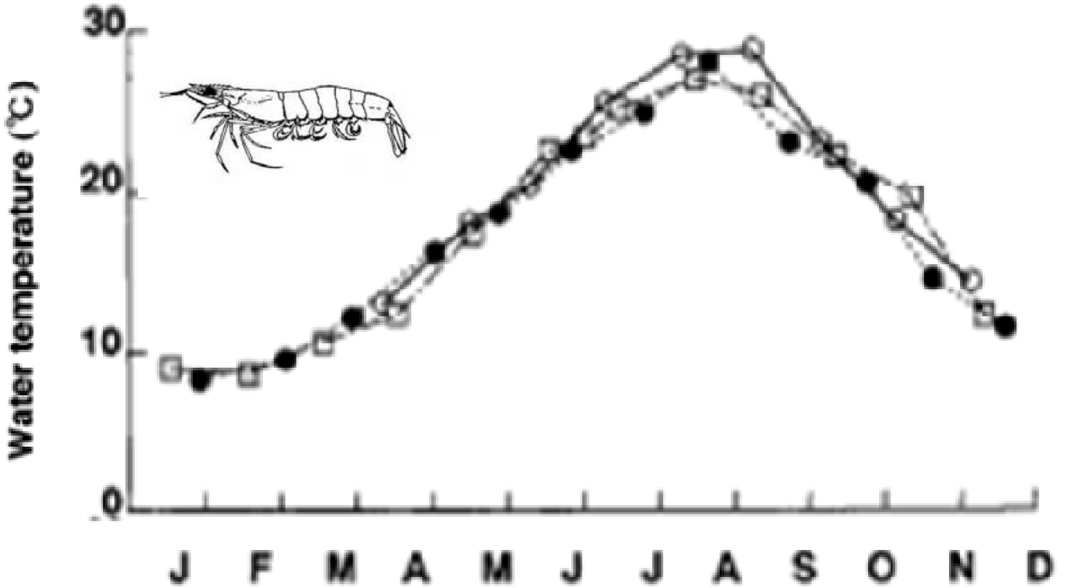




Metapenaeus joyneri



Minagawa et al. (1987). Mar. Biol. 136, 223-231.

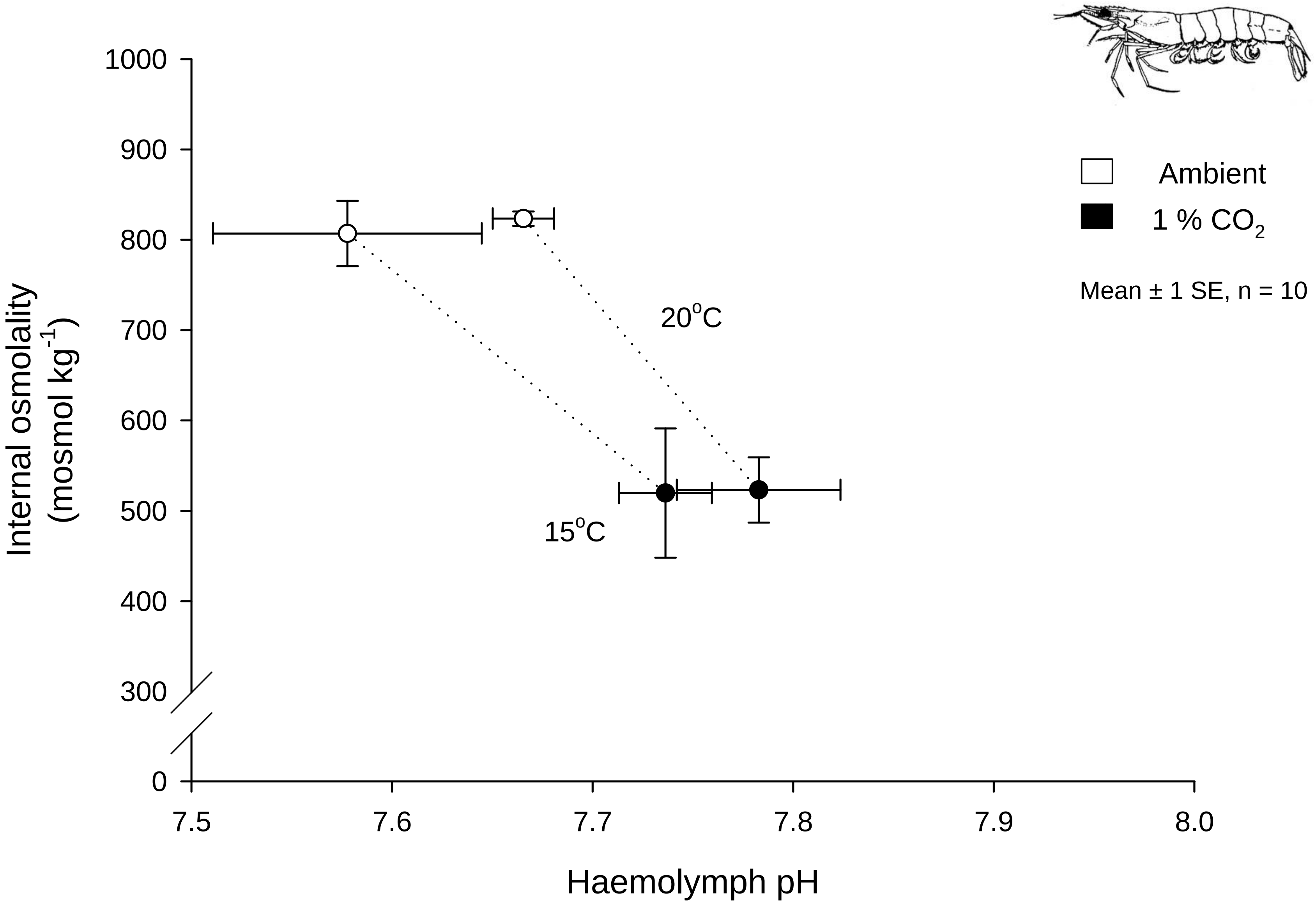


Thermal range: 8 - 28 °C

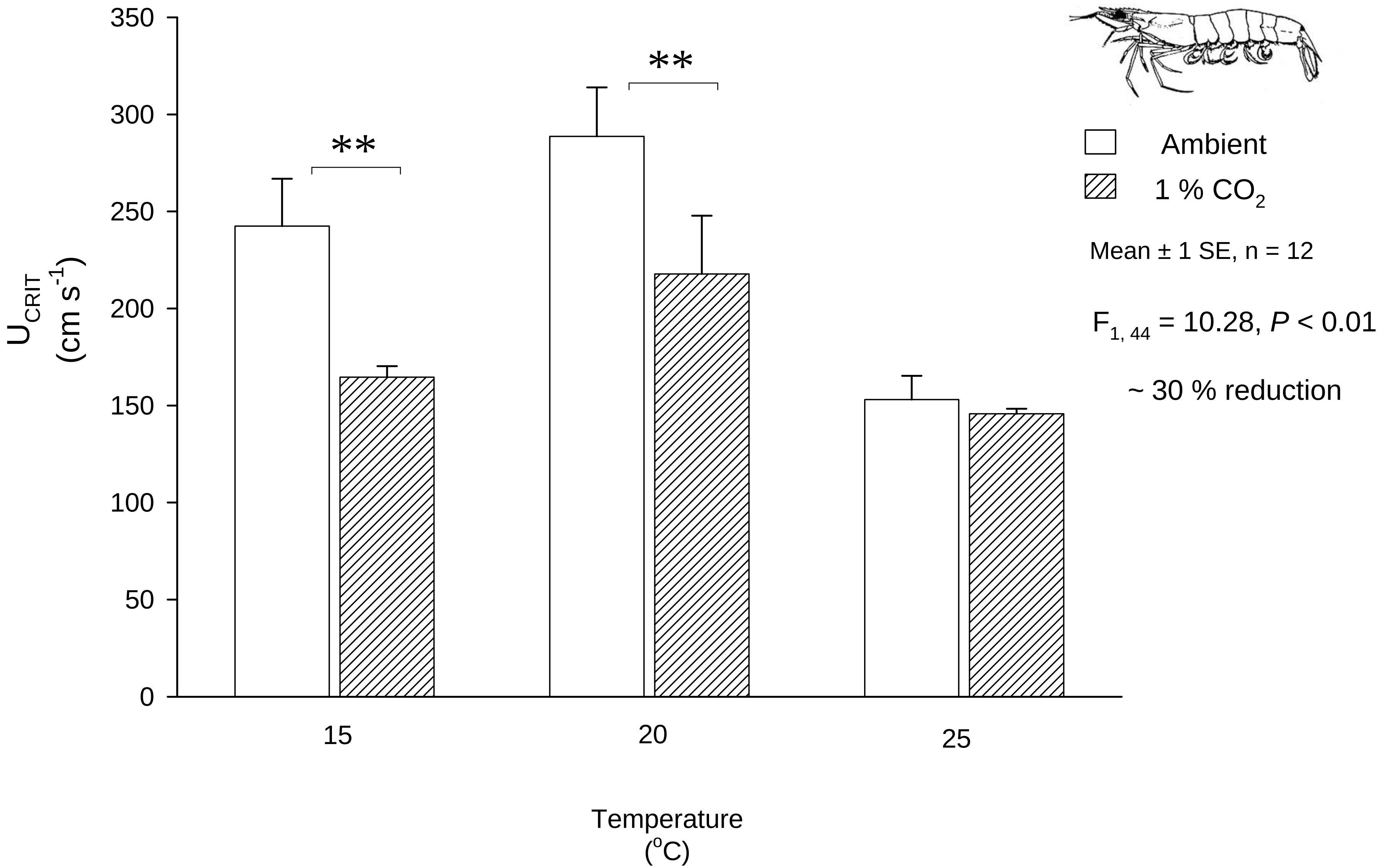
Distribution: Pacific region from Korea and Japan to southern China

Model natant group: occupying various ecosystems: (shallow-water coastal and open ocean).

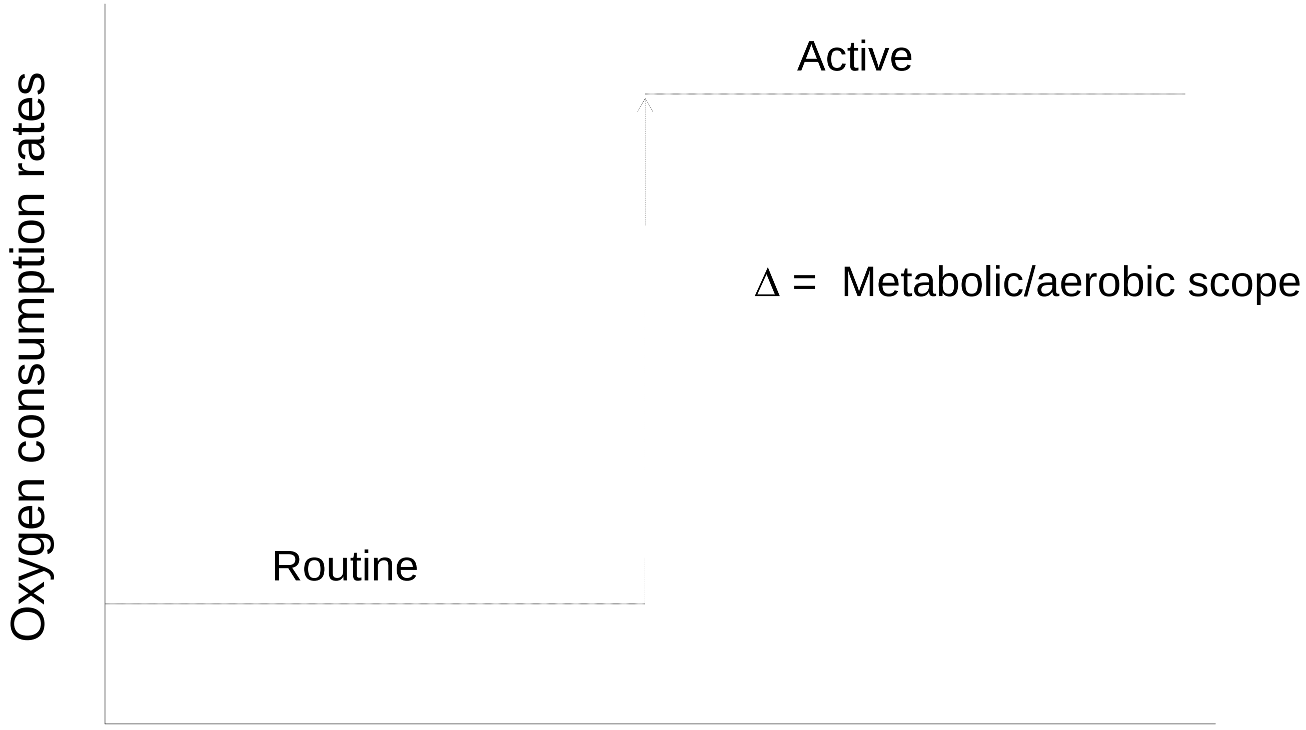
Haemolymph pH and internal osmolality



Critical swimming behaviour assessment (U_{crit})

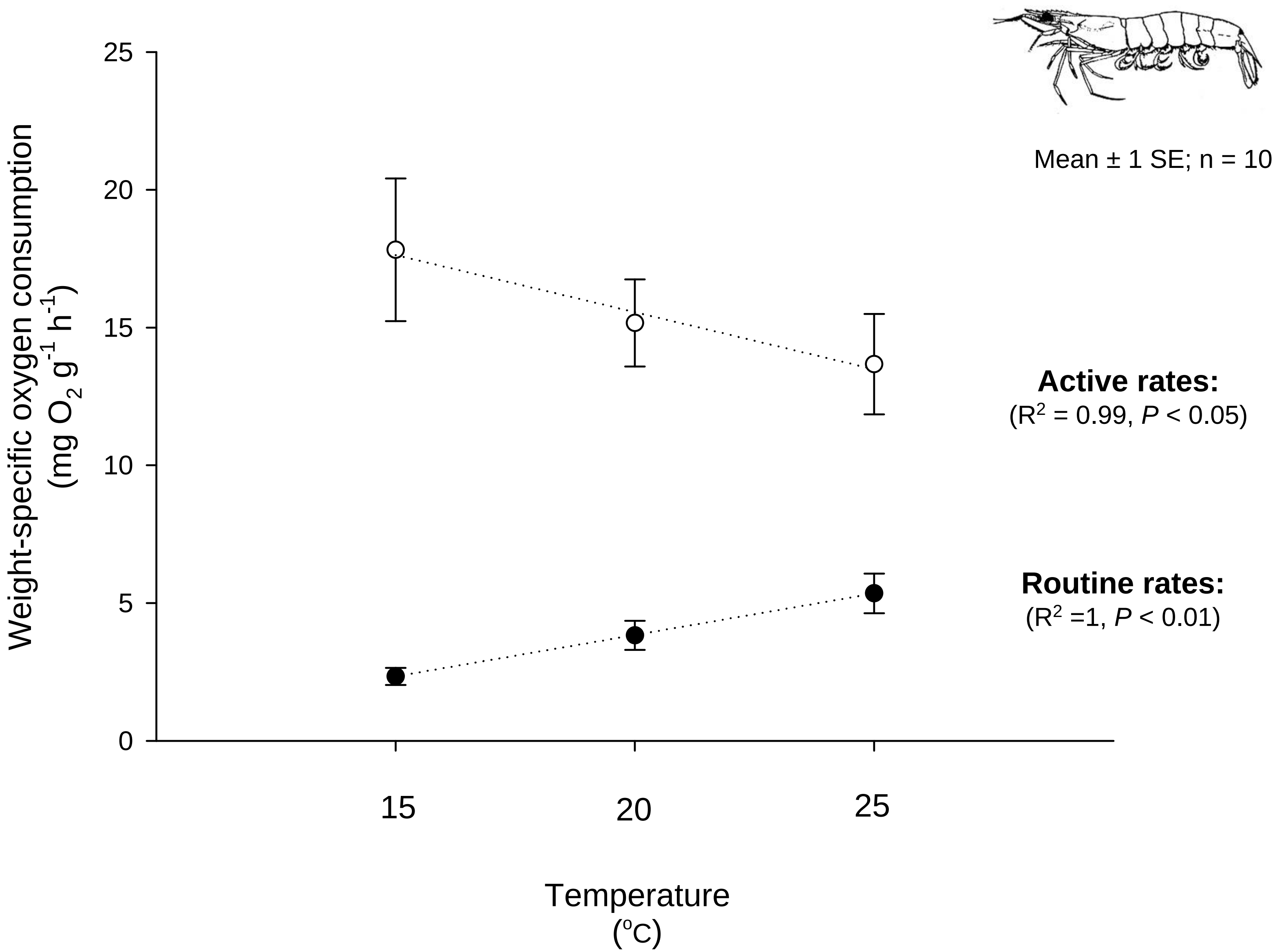


Oxygen consumption (Metabolic/aerobic scope)

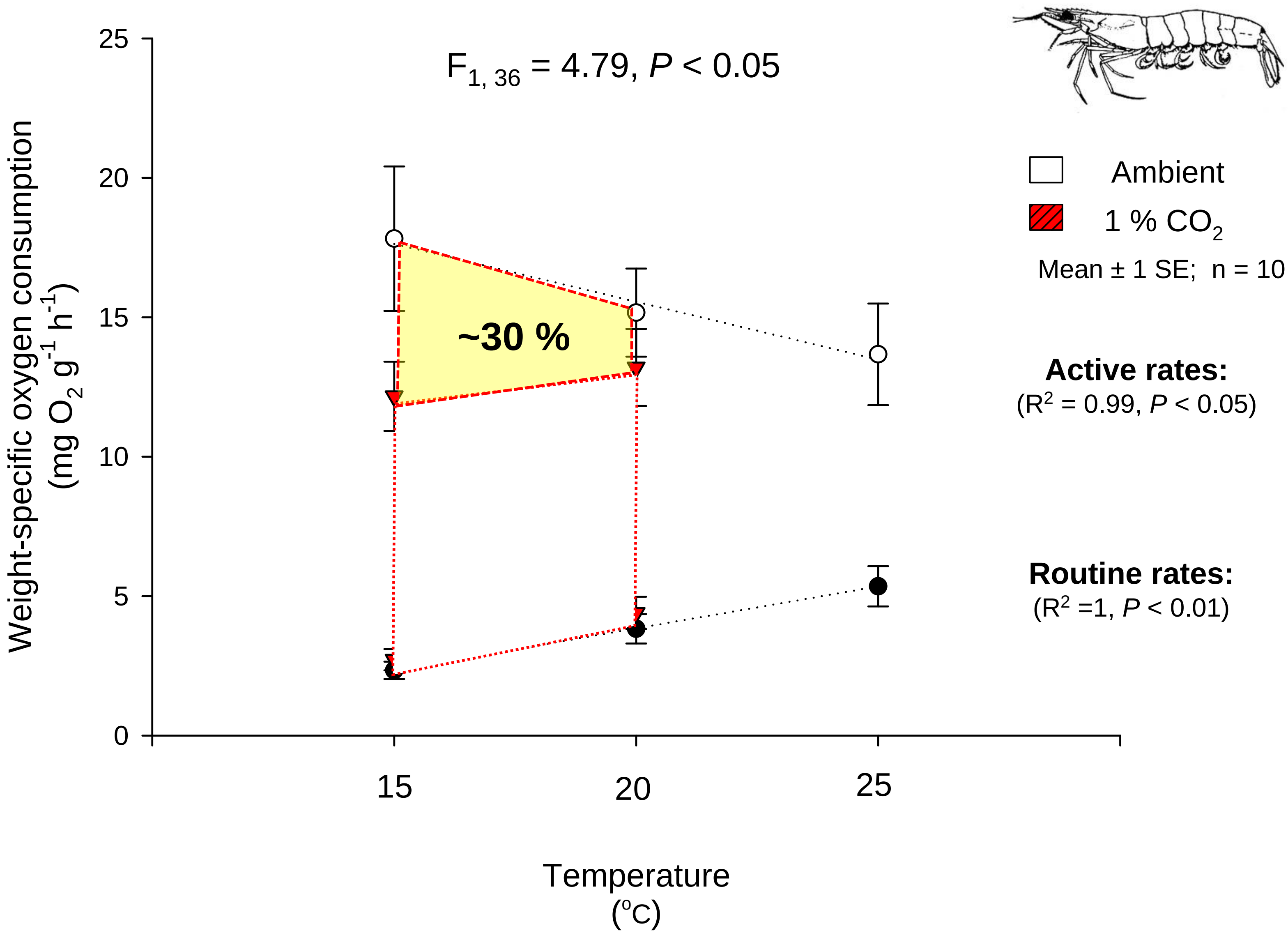


Metabolic scope (MS) = difference between active and routine;
"*an animal's capacity for aerobic metabolism beyond that required biological maintenance*" (Fry, 1947).

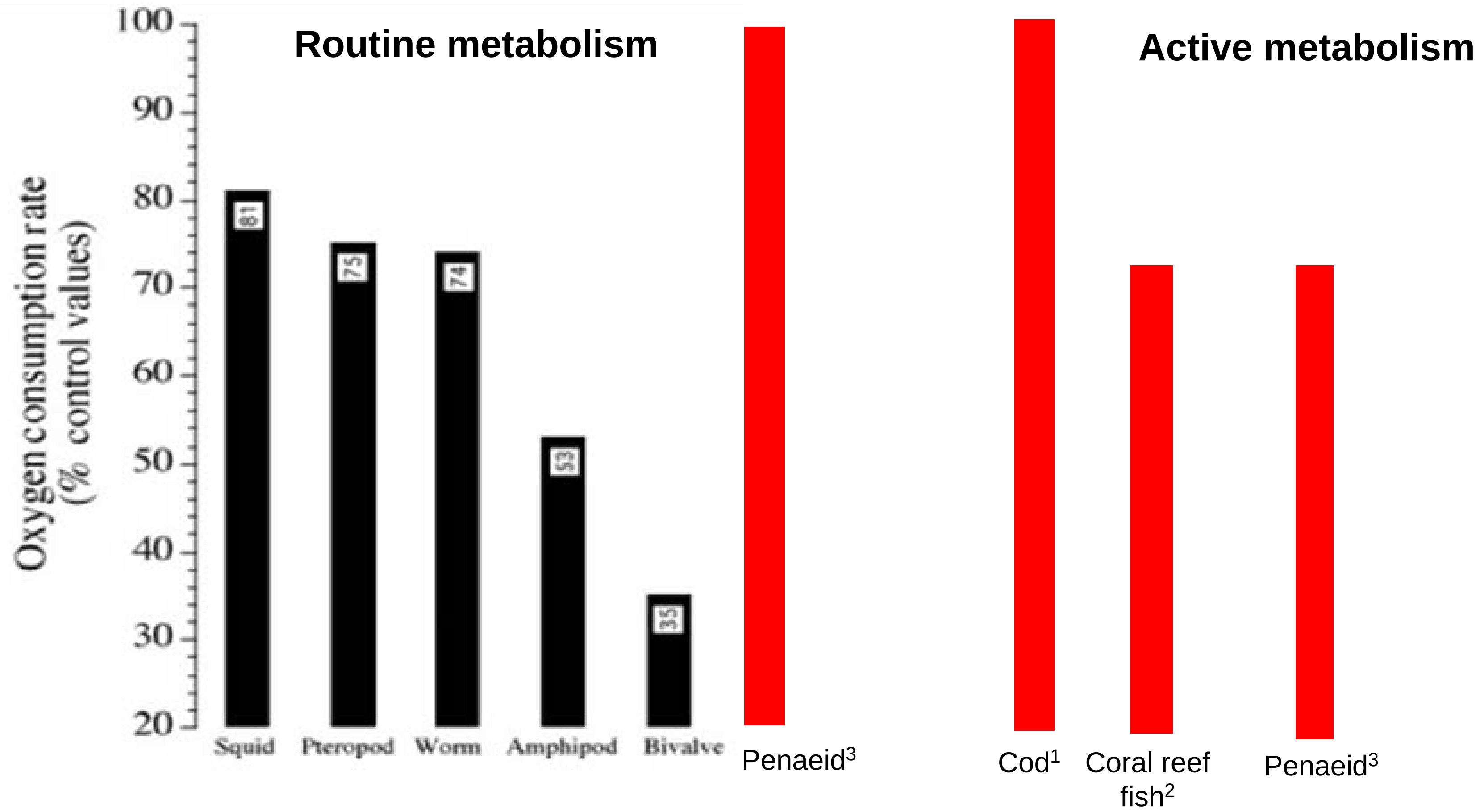
Metabolic/aerobic scope



Metabolic/aerobic scope



Oxygen consumption under elevated CO_2



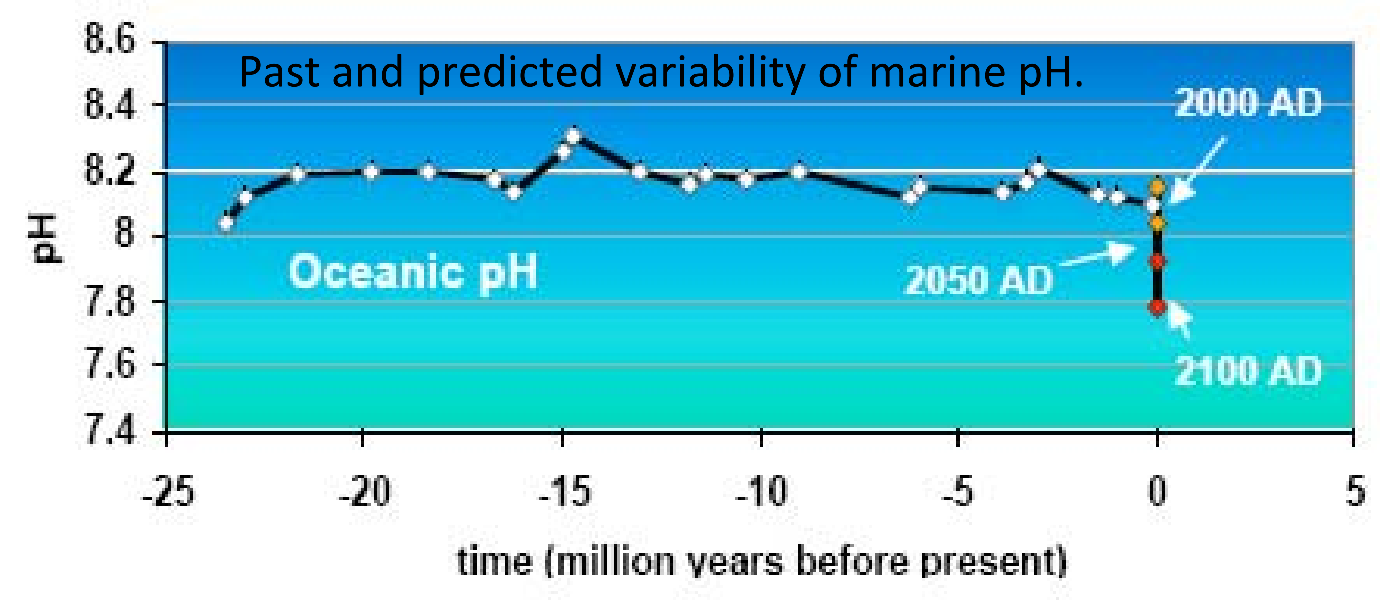
Reviewed in Fabry et al. (2008). ICES J. Mar. Sci.

1. Melzner et al. (2009). Aquat. Toxicol.
2. Munday et al. (2009). MEPS
3. This study

Moult Death Syndrome ?

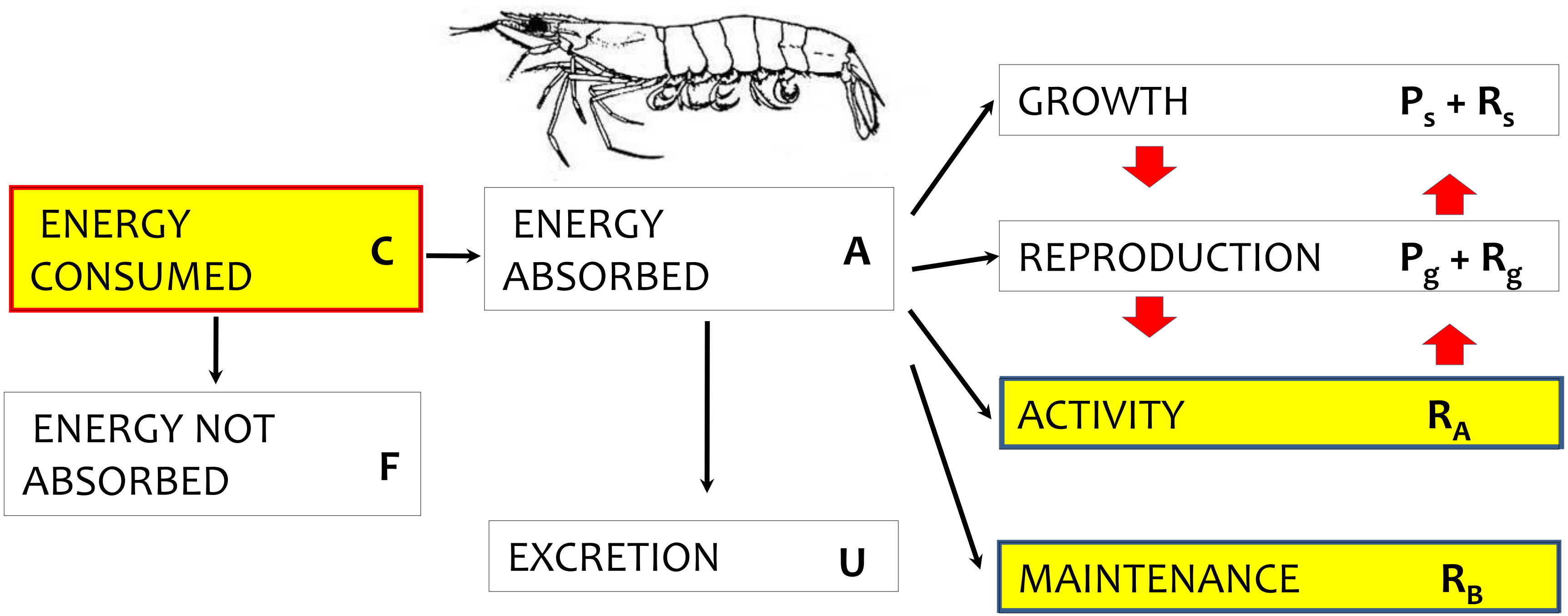
LONG TERM EFFECTS ?

Can organisms evolve on contemporary timescales (within a few decades) in response to environmental change ?



(Pearson and Palmer, 2000)

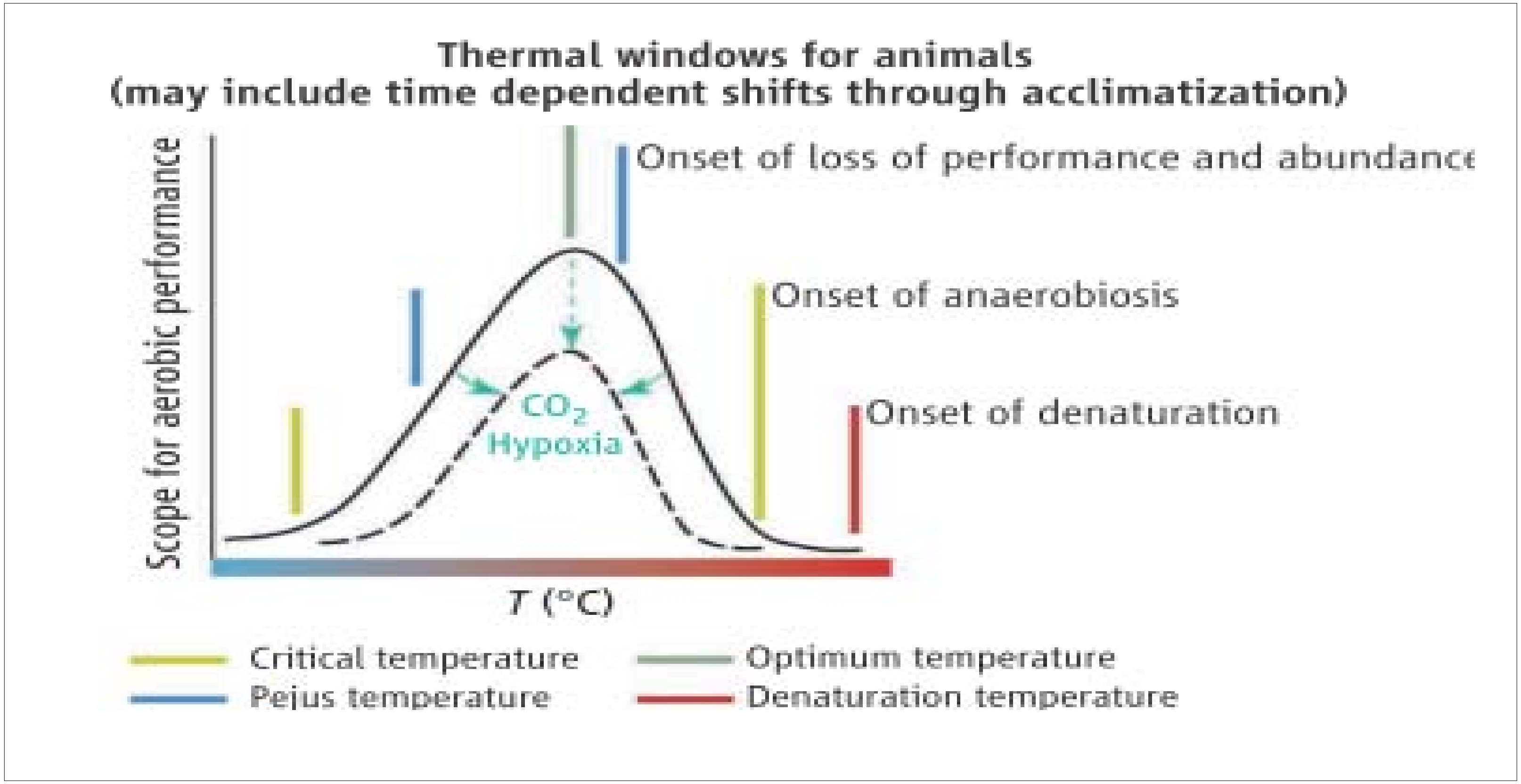
LONG-TERM EFFECTS ?



Activity e.g. swimming ability
Maintenance (osmoregulation & acid-base balance)

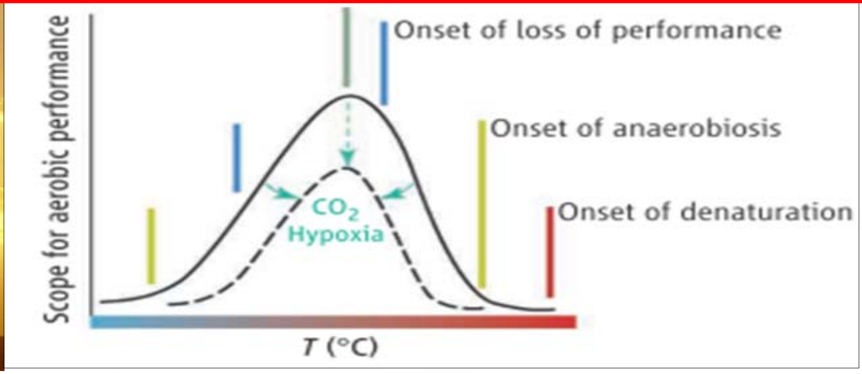
Clarke (1987). MEPS. 38, 89-99.

LONG-TERM EFFECTS ?



Pörtner & Farrell. (2008). Science. 322, 690-692

CONCLUSIONS

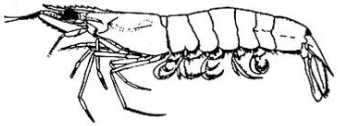


Effects of 1 % CO_2 exposure: **- allow for determination of mechanistic effects**
- relevant for CO_2 sequestrations leaks

<u>Short-term :</u>

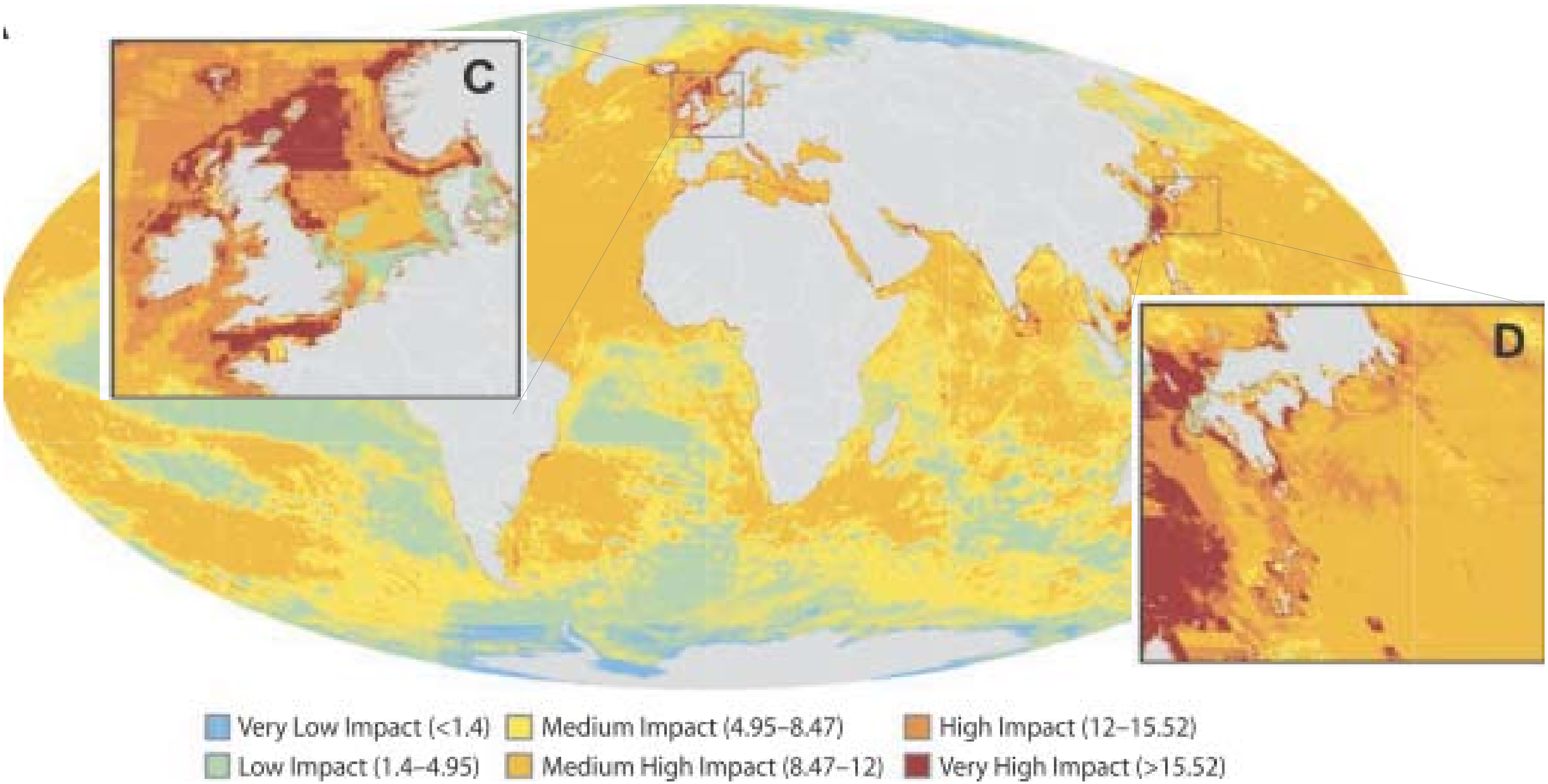
- *Change in internal physiological functioning (new steady state).*

<u>Long-term :</u>



- *Reduced swimming ability/aerobic scope: knock-on effects?*
- *Moult Death Syndrome? At risk during moulting process.*

Predicted ‘hotspots’ of anthropogenic impact



Halpern et al. (2008). Science. 319, 948-952

LONG TERM CONSEQUENCES ?

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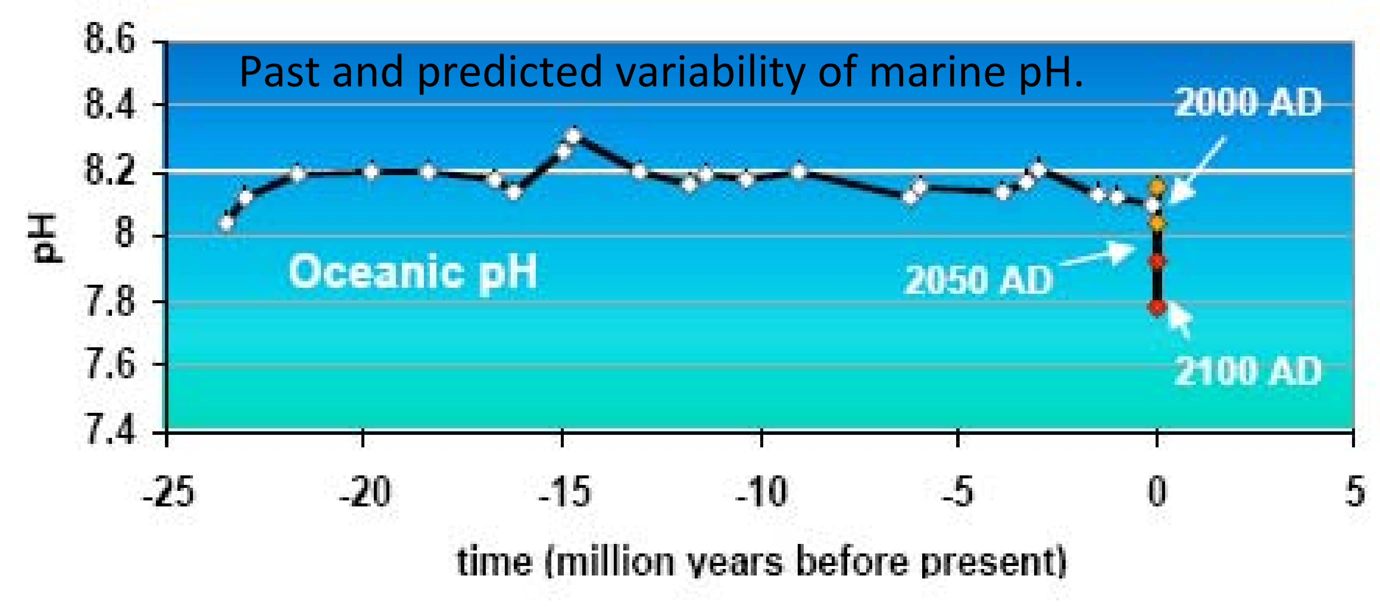

(Pearson and Palmer, 2000)