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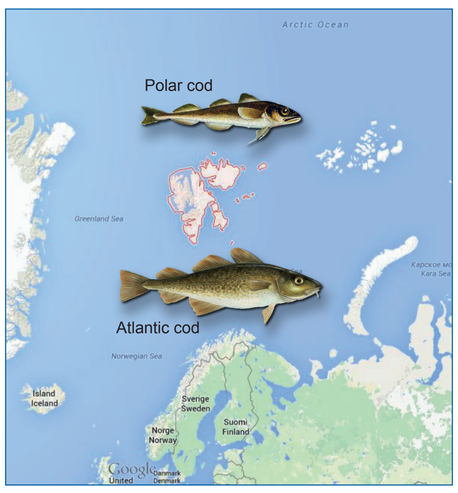
Heart metabolism of two gadoid fish species at their distribution boundary under elevated temperature and PCO_2

Introduction



Due to rising ocean temperature, Atlantic cod (*Gadus morhua*) have entered the waters around Svalbard, populated by the resident Polar cod (*Boreogadus saida*)[1].

Polar cod are cold stenotherm and the waters around Svalbard define their southern and warmest limit, while for Atlantic cod these waters represent the northern and coldest distribution limit.

Elevated PCO_2 in the ocean affects biological and physiological processes and influences the animals' thermal tolerance by decreasing the aerobic performance and narrowing the thermal range[2].

Cardiocirculatory capacity has a key role in defining the thermal tolerance of fish and heart failure is considered to set the limits of the thermal window[3].

Heart failure at elevated temperature may be caused by extrinsic factors like deficient oxygen supply or by intrinsic factors like mismatch in energy demand/supply.
Cardiac mitochondria provide 90% of requested energy (ATP), therefore the study of their function can help to understand a species' thermal tolerance[3].

Objectives

- Which is the role of heart mitochondria in shaping the thermal tolerance of these two fish species?
- Do high PCO_2 levels impact mitochondrial physiology and by this the thermal tolerance of the fish species?
- Can different physiology be related to environmental adaptations?

Acclimation

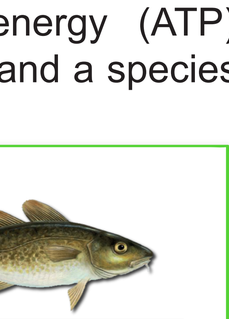
- 4 months
- 4 Temp.
- 2 PCO_2

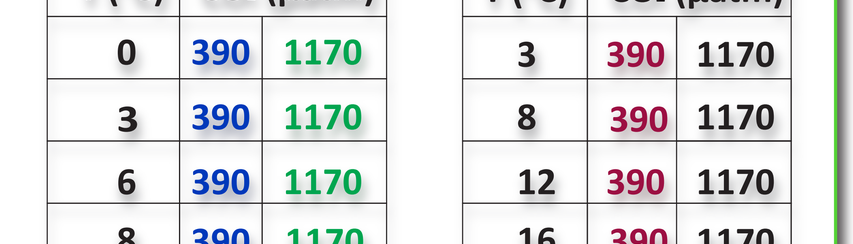
T (°C)	CO_2 (µatm)	
0	390	1170
3	390	1170
6	390	1170
8	390	1170

T (°C)	CO_2 (µatm)	
3	390	1170
8	390	1170
12	390	1170
16	390	1170

Method

- High Resolution Respirometry (O-2k)
- Permeabilized heart fibers
- Substrate-Inhibitor-Titration
- ➤ Maximum Oxidative Phosphorylation capacity
- ➤ Contribution of the single complexes to the Electron Transport System

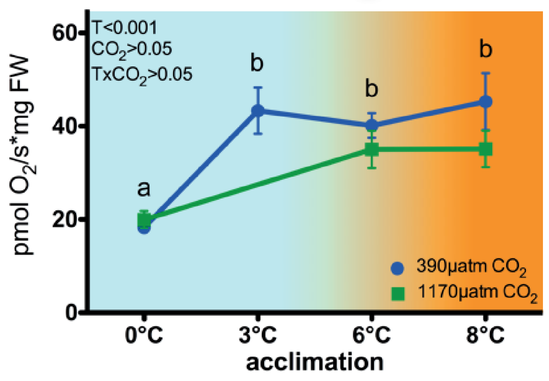




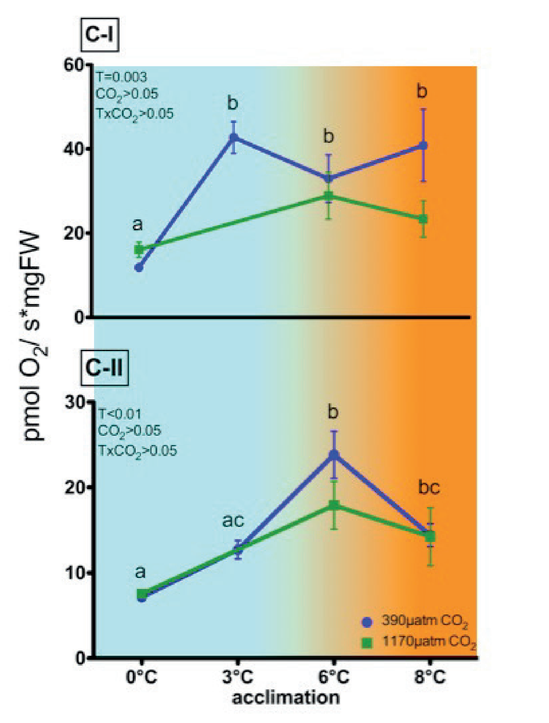
OXPHOS

Contribution of Complex I & II

Polar cod

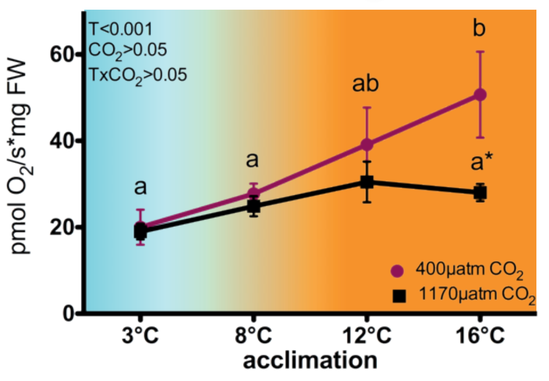


- No changes with temp.
- No changes with PCO_2



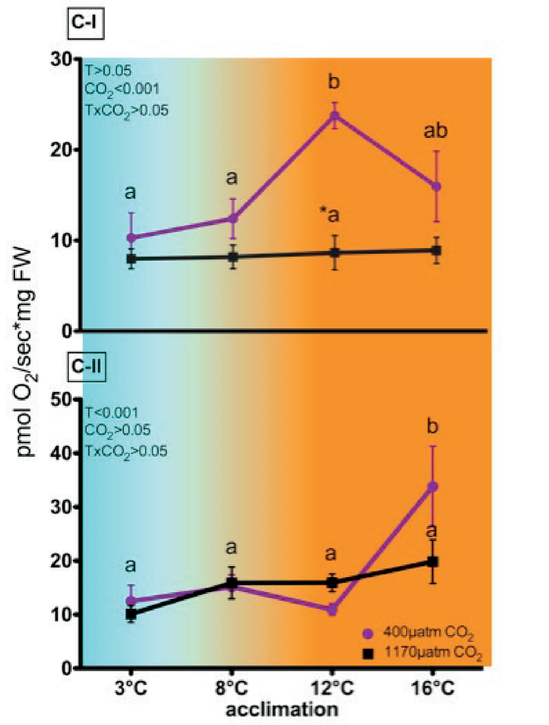
- No effects of high PCO_2 in both complexes
- Complex II capacity decreases at 8°C

Atlantic cod



* p<0.05

- Increasing with temp
- Decreased capacity at 16°C under high PCO_2 levels



- Complex I capacity is lower under high PCO_2
- Complex I capacity decreases at 16°C
- Complex II capacity increases at 16°C

Conclusions

- Cardiac mitochondria are affected by temperature close to the animals' upper thermal limits indicating a role in thermal tolerance
- Polar cod mitochondria are not sensitive to elevated PCO_2 In Atlantic cod, the lower OXPHOS under elevated PCO_2 suggests a narrowing of the thermal tolerance at the upper thermal limit
- The limited plasticity shown by Polar cod mitochondria is consistent with the adaptation to the cold and stable Arctic waters Atlantic cod are able to adjust their mitochondrial metabolism with rising temperature indicating higher thermal acclimation capacity

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References:
[1] Drinkwater 2009, Deep Sea Res. Part II: Topical Studies in Oceanogr. 56, 2087-2095
[2] Pörtner and Farrell 2008, Science 322, 690-692
[3] Pörtner and Knust 2007, Science 315, 95-97

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