2.2.1 Adaptive competence of Teleostei (C. Bock, E. Brodte, T. Hirse, R. Knust, N. Koschnick, F. Mark)

Objectives

One of the main abiotic factors determining the biogeography of poikilotherm fish is temperature. Latitudinal distribution of fish populations is thus mainly defined by their tolerance towards temperature. Eurythermal fish are able to cover a wide distribution spectrum while stenothermal fish are restricted to narrower areas. Temperature adaptability of polar teleostei differs between animals from High-Antarctica in comparison to fish from more sub-Antarctic locations. Apart from restrictions of the cardiovascular system, temperature adaptability of an organism might be defined on a rather low, e.g. cellular level by temperature induced shifts in the energy allocation to the metabolic processes of the cell.

In our studies we wanted to compare the temperature sensitivity of the cell's energy consuming processes like protein, RNA and ATP synthesis, as well as ion regulation between different fish species. Furthermore, the effect of temperature on protein synthesis and lipid metabolism will be investigated by incubation experiments on High-Antarctic fish. A specification on the ability of temperature adaptability of selected fish species will be done by molecular analysis of tissue samples.

Work at sea

Animals were collected with Agassiz- and bottom trawls and fish traps near Bouvet Island and from stations in Atka Bay, Austasen and Drescher-Inlet. Samples for molecular analysis of various tissues were taken from anaesthetized fish directly after catching and were deep-frozen in liquid nitrogen for further analysis at the AWI. Living specimens of Sub-Antarctic and High-Antarctic fish were collected in an aquarium container for several days before experimentation. For studies on cell energy metabolism, fish hepatocytes were isolated, counted and stored in a buffered salt solution at 0°C until further analysis. Oxygen consumption of liver cells was measured at different temperatures and after the addition of specific metabolic cell inhibitors to determine the amount of specific cell processes on the overall energy demand of the cells. In a second approach isolated liver cells were incubated with ^{13}C-labeled phenylalanine or acetate at different temperatures for the study of temperature dependent protein and lipid synthesis, respectively. Samples were taken 2, 4 and 6 hours after the addition of the tracers, washed and immediately frozen in liquid nitrogen. The incorporation of ^{13}C-isotopes will be measured in these samples with NMR spectroscopy for the determination of temperature dependent protein and lipid synthesis at the AWI.

Preliminary results

Table 1 summarizes the collected fish species and tissue samples taken for molecular analyses. ^{13}C-labeled incubation experiments were performed at 0°C, 3°C and 6°C on liver cells from the High-Antarctic fish *Trematomus pennellii* (Table 2).

First results of the hepatocyte experiments indicate that hepatocytes of sub-Antarctic fish clearly differ from High-Antarctic fish in terms of oxygen consumption, but at sufficient ambient oxygen concentrations the cellular energetic balance is being hold upright over a range between 0 - 15°C. Figure 1 presents the results of oxygen consumption measurements of hepatocytes of

the Sub-Antarctic fish *Lepidonotothen larseni* at different temperatures. The cellular preferential temperature appears to be located between 4 and 6°C, where oxygen uptake is lowest.
After the addition of metabolic inhibitors the amount of specific energy consuming processes in the cell could be determined. Figure 2 depicts the cellular energy budget over the range of temperatures.
Figure 3 shows cellular oxygen consumption of the High-Antarctic fish *Trematomus eulepidotus* hepatocytes, here, oxygen consumption is lowest at 0°C. The cellular energy budget (figure 4) presents a rather uniform picture, without any obvious effects of temperature.

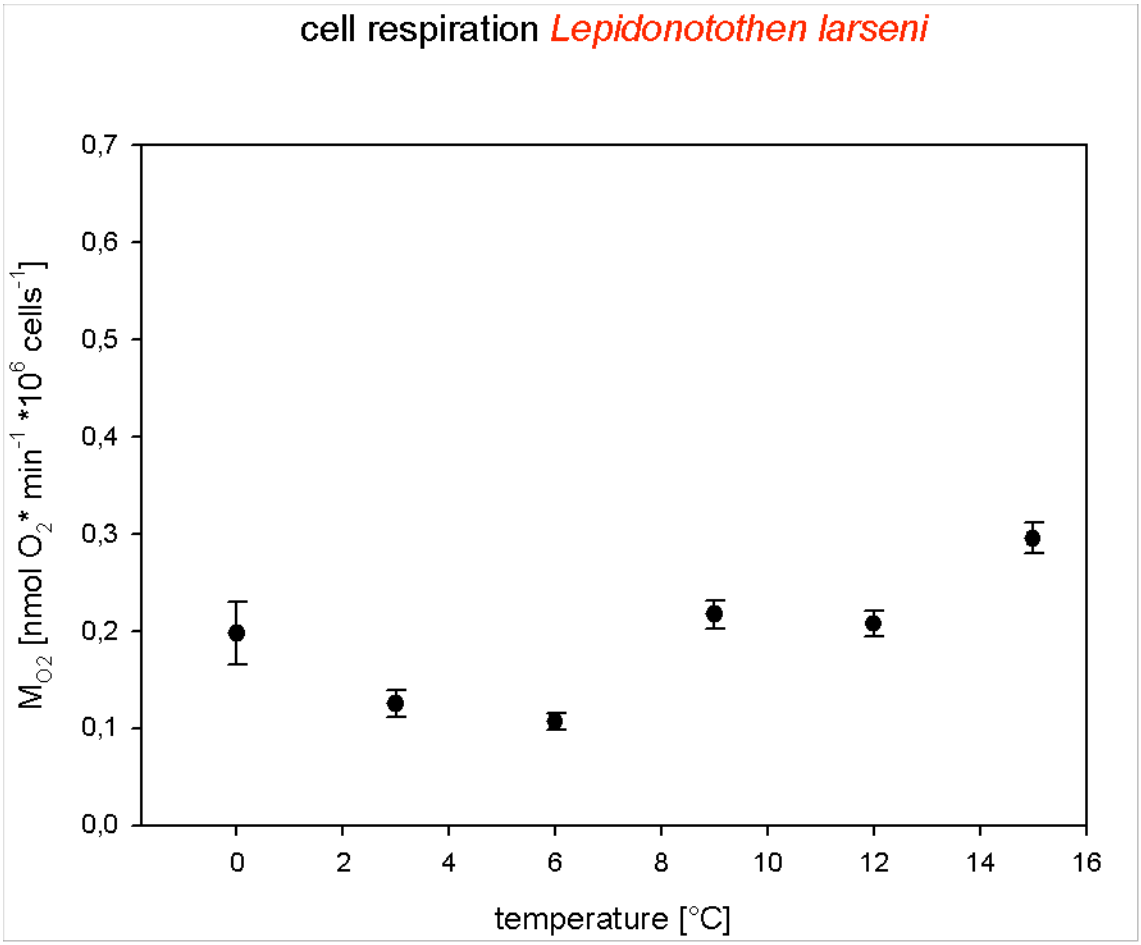

Fig. 1 Hepatocyte respiration of the Sub-Antarctic fish *Lepidonotothen larseni*

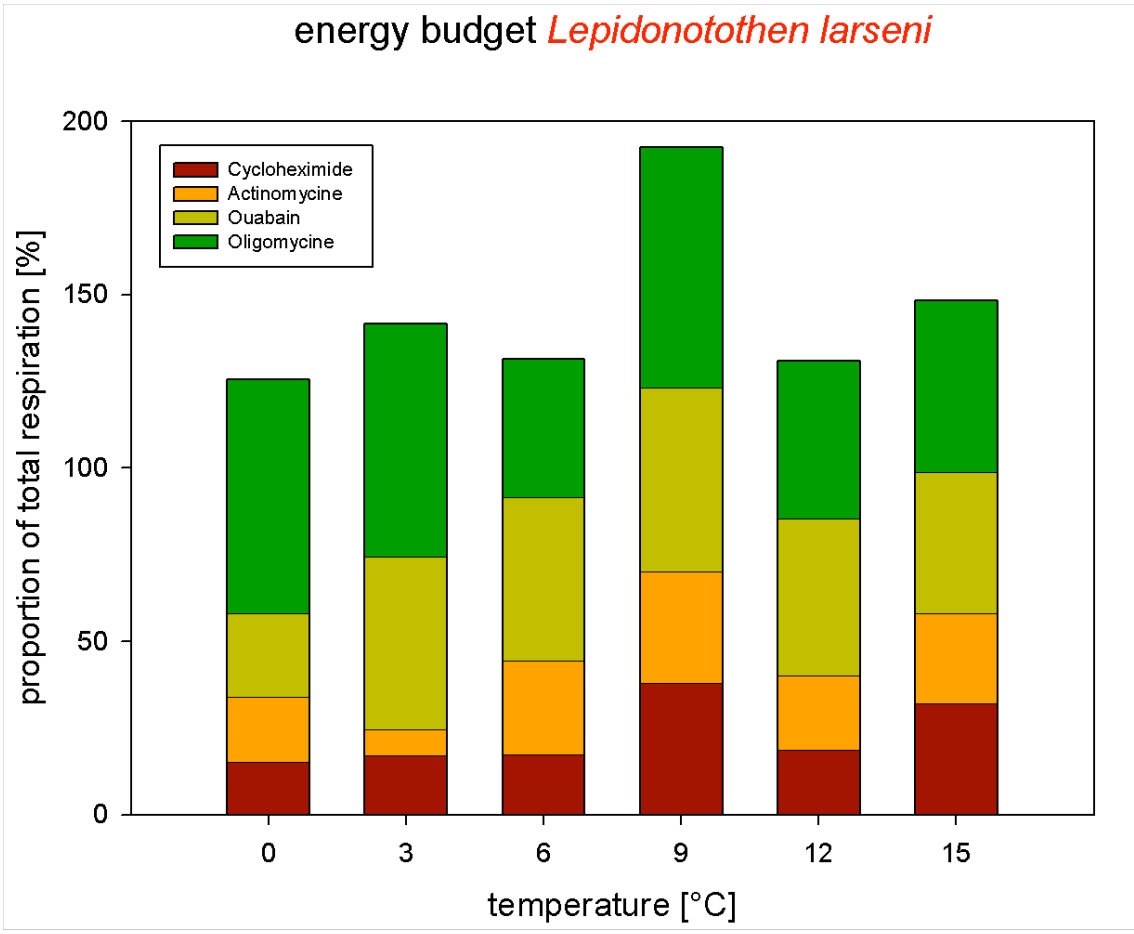

Fig. 2 Cellular energy budget of *Lepidonotothen larseni.*
Used inhibitors were mainly effective on protein synthesis (cycloheximide), RNA synthesis (actinomycine), Na^{+}-K^{+}-ATPase (ouabain) and ATP-Synthetase (oligomycine).

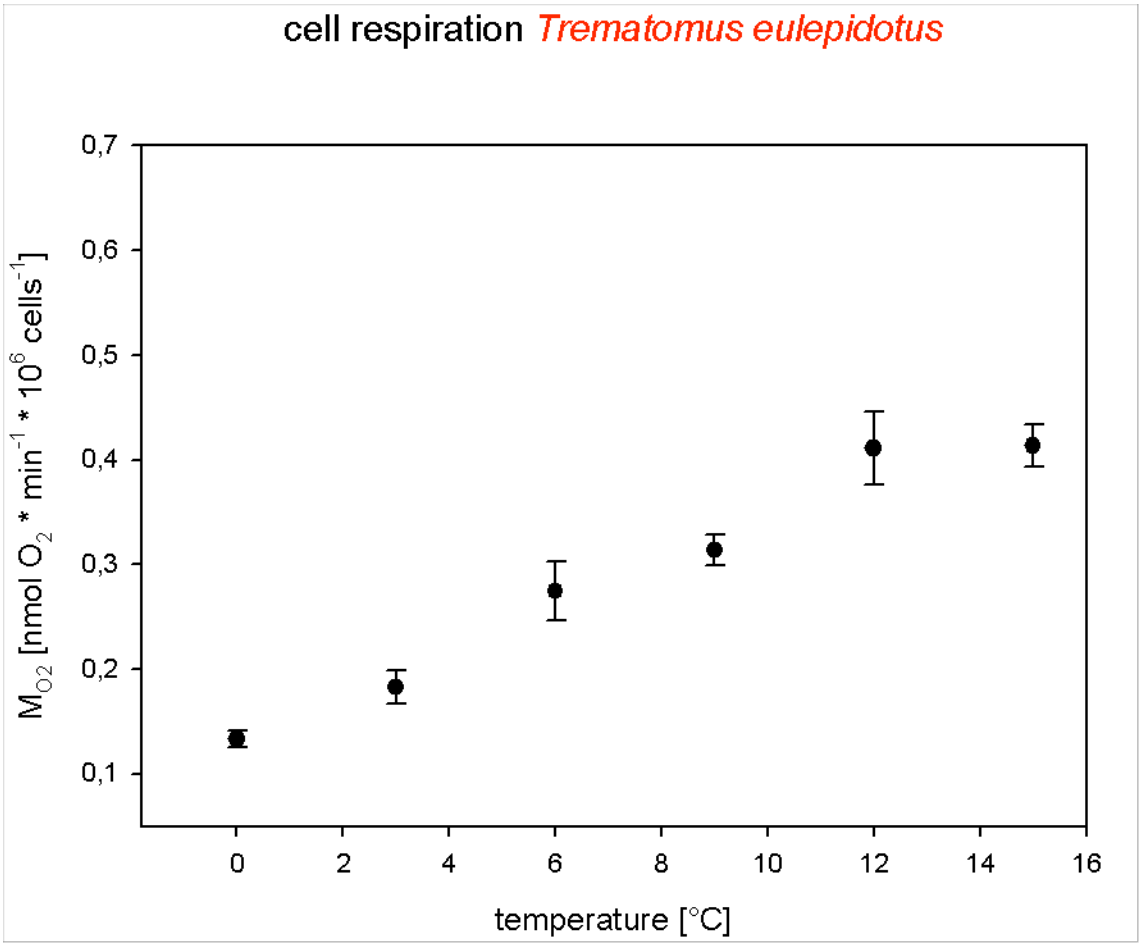

Fig. 3 Hepatocyte respiration of the High-Antarctic fish *Trematomus eulepidotus*.

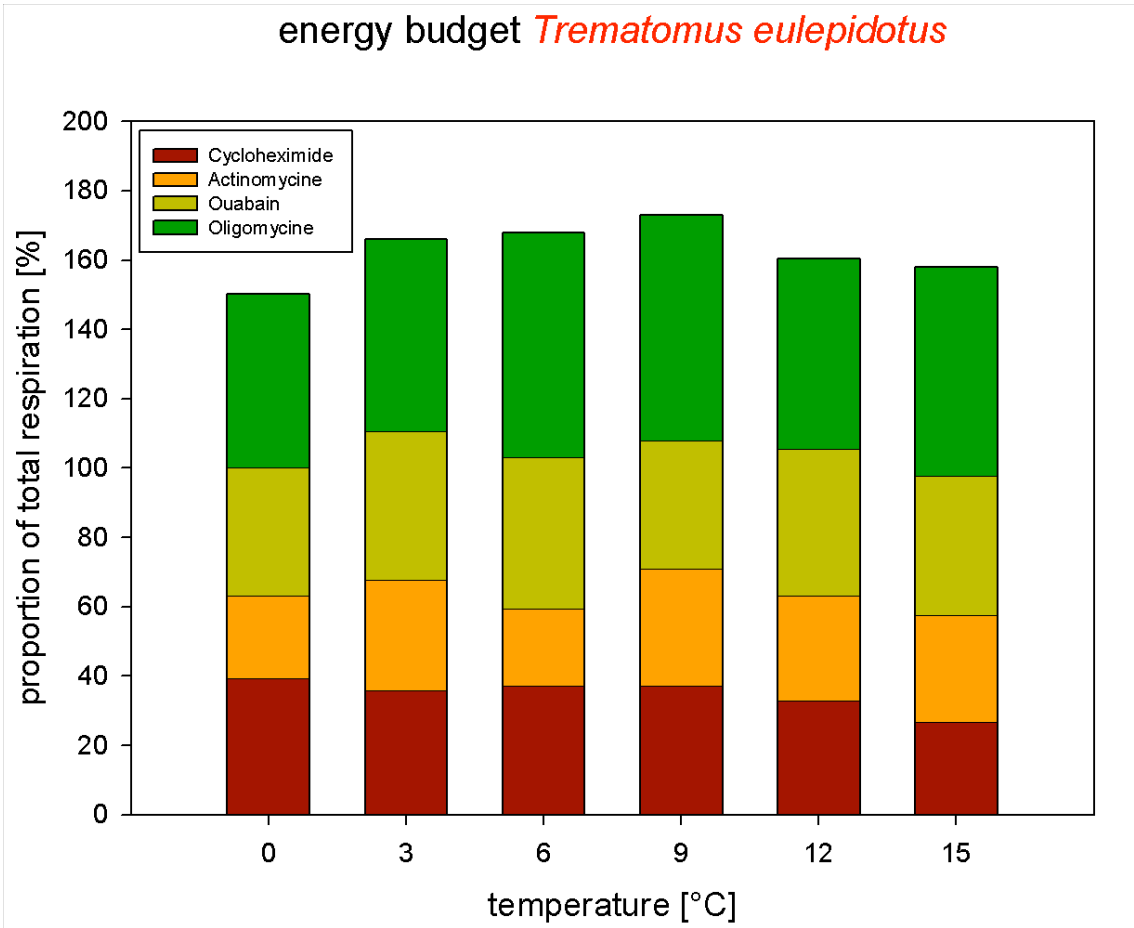

Fig. 4 Cellular energy budget of *Trematomus eulepidotus.*
Used inhibitors were mainly effective on protein synthesis (cycloheximide), RNA synthesis (actinomycine), Na^{+}-K^{+}-ATPase (ouabain) and ATP-Synthetase (oligomycine).

Tab. 1 Fish species of which tissue samples were taken for molecular analysis (muscle, blood, gills, liver, heart, spleen)

Main taxa	Species	Station	N° of individuals
Artedidraconidae	*Artedidraco orianae*	121, 276	5
Artedidraconidae	*Artedidraco shackeltoni*	39, 265	7
Artedidraconidae	*Dolloidraco longedorsalis*	283	5
Artedidraconidae	*Histiodraco velifer*	121	1
Bathydraconidae	*Cygnodraco mawsoni*	121, 247, 265, 276	6
Bathydraconidae	*Gymnodraco acuticeps*	39, 247	3
Channichthyidae	*Chaenodraco wilsoni*	259	1
Channichthyidae	*Chionodraco hamatus*	247, 336	2
Channichthyidae	*Chionodraco myersi*	259, 274, 280, 292	10
Channichthyidae	*Cryodraco antarcticus*	259, 292	3
Channichthyidae	*Pagetopsis macropherus*	39	1
Channichthyidae	*Pagetopsis maculatus*	259	1
Nototheniidae	*Pleuragramma antarcticum*	329	7
Nototheniidae	*Trematomus bernacchii*	245, 259	4
Nototheniidae	*Trematomus eulepidotus*	245, 253, 259, 265	5
Nototheniidae	*Trematomus hansoni*	39, 247, 248, 259	12
Nototheniidae	*Trematomus lepidorhinus*	248, 253, 259, 265	7
Nototheniidae	*Trematomus nicolai*	39, 245	3

Nototheniidae	*Trematomus pennellii*	121, 245, 259	10
Nototheniidae	*Trematomus scotti*	245, 265, 276	7
Zoarcidae	*Pachycara brachycephalum*	289	2

Tab. 2 Number of ^{13}C labeled experiments

species	incubation temperature	acetate	phenylalanine
Trematomus pennellii	0 °C	4	4
Trematomus pennellii	3 °C	4	3
Trematomus pennellii	6 °C	4	4