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Fish as bioindicator: condition and health of ground fish species around Elephant Island, the South Shetland Island and at the tip of the Antarctic Peninsula

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3. FISH AS BIOINDICATOR: CONDITION AND HEALTH OF GROUND FISH SPECIES AROUND ELEPHANT ISLAND, THE SOUTH SHETLAND ISLANDS AND AT THE TIP OF THE ANTARCTIC PENINSULA

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Objectives

Increasing contamination with persistent bioaccumulating compounds is reported for the aquatic ecosystems of Antarctica. These substances mainly originating from distant sources are transported via the atmosphere at a global scale and are re-distributed in the aquatic environment by condensation and precipitation. These xenobiotics are accumulating in organisms (bioaccumulation), however, the effects on the various members of the food web are rarely investigated.

The Protocol on Environmental Protection to the Antarctic treaty emphasizes that the protection of the Antarctic environment is in the interest of mankind as a whole. Accordingly, the development and implementation of suitable procedures for environmental impact assessment in Antarctic areas affected by human settlement has to become a priority task.

To evaluate the health of the ecosystem it is one approach to study sensitive indicator species (= sentinel species). Sentinel species have been well established for various ecosystems. However, in Southern Ocean fishes, investigations on the suitability as sentinel species are still missing and a clear need for much more information on the response of polar marine species was addressed. Such species should be selected according to criteria of their role in the food web, their physiological capabilities to respond sensitively and to their prior exposure to chemicals. As a consequence, we focus on three ground fish species as they are representing different roles in the food web, e.g. the benthos feeding yellow notothenia (or bumphead notothenia *Gobionotothen gibberifrons)*, the fish feeder Scotia Sea icefish (or blackfin icefish, *Chaenocephalus aceratus)* and the krill feeding mackerel icefish (*Champsocephalus gunnari*).

As a consequence, this project aims at assessing the general potential of Antarctic groundfish species to cope with bioaccumulating organic toxicants and elucidate their potential as sentinel species. Therefore, we will study (1) if their physiological capability to accumulate and metabolise persistent organic pollutants is different from well-investigated sentinel species of boreal latitudes. With this, we attempt to raise first evidence whether one or more of the three Antarctic fish species are apt as sentinel species. (2) We will further study whether potential effects of preceding exposure to persistent bioaccumulating compounds affected health and selected biomarkers of these species. To raise these data, persistent organic pollutants will be measured in the fish muscle. Furthermore, endpoints will be studied such as condition factor, hepatosomatic index, spleenosomatic index, histopathology of liver and gill, as well as selected biomarkers.

Work at sea

Fish sampling will profit from the fishing program of the survey on the biology and ecology of Antarctic groundfish. This fishing will be conducted within the remit of CCAMLR and is thus due to specific research exemptions both under the Antarctic Treaty and CCAMLR. Accordingly, no additional fish has to be taken. From the provided three fish species, only male specimen of a specific maximum length (corresponding to age < 3 years) will be investigated to exclude sex differences, which are known to influence the bioaccumulation potency and the responsiveness of the biomarkers. At selected sampling sites, 20 fish fulfilling the mentioned criteria will be

sampled. Whole fish will be studied for biometric parameters. Muscle tissue will be dissected and preserved for further analysis of persistent organic pollutants (P. Schmid, EMPA). Liver, gill and muscle tissue will be sampled for biomarker analysis and PCR of selected enzymes of the detoxification metabolism

4. MOLECULAR BASIS OF CLIMATE SENSITIVITY IN ANTARCTIC FISH: MITOCHONDRIAL FUNCTIONING AND ITS IMPLICATION FOR IONIC AND OSMOTIC REGULATION

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Objectives

Increasing CO_2 in the atmosphere causes both, ocean warming and acidification. Due to its pervasive impact on all biological processes, temperature is a crucial abiotic factor limiting geographical distribution of marine ectothermal animals on large scales. Additional environmental factors like increasing PCO_2 and the concomitant drop in water pH are thought to narrow the thermal window, as they are believed to act on the same physiological mechanisms. Thermal adaptation and phenotypic plasticity, which define the thermal niche and the responses to fluctuating environmental factors, are ultimately set by the genetic interior of the organisms. Adaptations to the extreme cold appear to be evolved at the expense of high thermal sensitivity. Mitochondrial functioning and maintenance resemble a key functional trait, as it is directly related to the aerobic performance windows of animals. Example studies on mitochondria from Antarctic fish suggest that mitochondrial functioning underwent significant adaptations upon evolution to extreme cold. Our findings of elevated capacities of respiratory chain components and uncoupling proteins in Antarctic eelpouts upon warm acclimation suggest the use of acclimation pathways different from those in temperate fish. Furthermore, we identified a molecular network, responding sensitively to warming beyond the realized ecological niche and mediating large rearrangements in energy metabolism.

The allocation of energy through mitochondria limits the main energy demanding processes like protein and RNA synthesis and ion and pH regulation. The interrelation of ion regulation and energy demand becomes obvious in branchial mitochondrial-rich cells, where the main ion pump, the Na^+/K^+-ATPase, is concentrated, too. Tight regulation of this process with a strong impact on whole animal energy budget has been shown both in response to temperature and CO_2. Ocean acidification is compensated for by an efficient ion regulatory system. With respect to temperature effects, different strategies in the use of active and passive strategies of pH regulation are discussed for cold-adapted and temperate species. As hemoglobin-less icefishes are characterized by larger blood volume and flow due to limited oxygen transport capacity, consequences for the passive transepithelial transport of ions may be postulated.

Here, we aim to characterise the branchial energy budget and ion regulatory system in gills in relation to the allocation of energy by mitochondria upon relevant environmental factors in an array of different Antarctic fish groups, to distinguish common principles and specific climate sensitivities in the light of the ongoing climate change.

Work at sea

The current cruise will provide access to a large number of fresh tissue samples from all Antarctic fish groups, which provides an excellent basis for comparative tissue and cellular