

#### A4.14 THERMAL PHENOTYPIC PLASTICITY IN PHYSIOLOGICAL 'CEILINGS' BUT NOT 'FLOORS' IN ESTUARINE CROCODILES (*CROCODYLUS POROSUS*)

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Reductions in ectotherm aerobic capacity are predicted to occur with climate change but thermal acclimatisation is set to play a pivotal protective role. Resting cardiorespiratory functions (physiological floors) are typically thermally phenotypically plastic whilst maximum capacities (physiological ceilings) are generally fixed in fishes, lending to the 'plastic floors and concrete ceilings' hypothesis. The applicability of this hypothesis to semi-aquatic ectotherms remains untested. Moreover, it is unknown how performance constrained by 'physiological floors' (e.g. predator avoidance diving) fits within theoretical frameworks of aerobic capacity. We assessed the thermal sensitivity and plasticity of standard oxygen uptake ( $VO_{2STANDARD}$ ), maximum oxygen uptake ( $VO_{2MAX}$ ), absolute aerobic scope ( $AAS = VO_{2MAX} - VO_{2STANDARD}$ ) and diving performance (min submerged) in juvenile estuarine crocodiles (*Crocodylus porosus*) acclimated temperatures emulating climate warming scenarios for six months (i.e. current summer water temperatures, 28°C and 'high' climate warming, 34°C). Standard rates of oxygen uptake did not differ between thermal acclimation treatments, but  $VO_{2MAX}$  was phenotypically plastic. Thermal thresholds marking decrements in diving performance did not align with reductions in AAS. Together, these findings oppose the 'plastic floors and concrete ceilings' hypothesis and also suggest assessing the vulnerability of diving ectotherms based solely on aerobic scope measurements underestimates susceptibility to elevated temperatures.

#### A4.15 LUNG FUNCTION IN MARINE MAMMALS: A POTENTIAL PARADIGM SHIFT IN OUR UNDERSTANDING HOW MARINE MAMMALS MANAGE GAS DURING DIVING

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In 1940 Per Scholander postulated his hypothesis that lung compression and alveolar collapse reduces gas exchange, uptake of  $N_2$  and thereby the risk of gas emboli. However, studies of beached and bycaught cetaceans and sea turtles imply that air breathing marine vertebrates may, under unusual circumstances, develop gas emboli that result in gas emboli and decompression sickness symptoms. Combining published results from marine mammals and turtles we propose that marine vertebrates may have developed alternative mechanisms to manage gas exchange in the lung. Specialized lung

architecture and volitional control of autonomic cardiac responses in the cetacean result in two pulmonary regions with distinctly different levels of alveolar ventilation and perfusion. By varying the level of ventilation-perfusion matching the lung is able to selectively exchange different gases, thereby exchanging  $O_2$  and  $CO_2$  while minimizing  $N_2$  exchange. Stressful situations could alter the ventilation-perfusion match, causing increased  $N_2$  exchange and risk for gas emboli. Our new hypothesis provides an explanation how marine vertebrates usually avoid the diving related problems observed in human divers, and how failure of this adaptation may result in diving related trauma.

#### A4.16 BREATHING PATTERNS INDICATE EXERCISE MODULATED DIVING COSTS AND RESPONSE TO EXPERIMENTAL SOUND EXPOSURES IN LONG-FINNED PILOT WHALES

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Air-breathing marine predators that target sub-surface prey have to balance the energetic benefit of foraging against the time, energetic and physiological costs of diving to depth. Here we use on-animal data loggers to assess whether such trade-offs can be revealed by the breathing rates (BR) and timing of breaths in long-finned pilot whales (*Globicephala melas*), immediately following foraging dives in particular where respiratory behaviour can be expected to be more conserved. Breath times and fluke strokes were detected using on board sensors (pressure, 3-axis acceleration) attached to animals using suction cups. The number and timing of breaths were quantified in non-linear models that incorporated serial correlation and individual as a random effect. We found that pilot whales increased their BR 5-10 min before, and immediately following, dives that exceeded 31 m depth. While pre-dive BRs did not vary with dive duration, the initial post-dive BR was linearly correlated with duration of >2 min dives, with BR then declining exponentially. Apparent diving costs (breaths  $min^{-1}$  diving) were 1.74 (SE 0.19) for medium-sized animals, and the highest for small animals and animals associated with calves. Every fluke stroke was estimated to cost 0.06 breaths, which amounted to 60-70% average contribution of locomotion to the apparent diving costs. Breathing behaviour changed from the expected pattern during 1-2 kHz sonar exposures. We discuss the potential roles of  $O_2/CO_2$ , muscle gas stores and stress, and highlight the need for physiological measurements by combining our results with published per-breath  $O_2$  consumption to proxy field metabolic rates and per-stroke energy costs.