Stress-induced mortality in large Atlantic salmon at high temperatures is associated with collapsing aerobic scopes

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Abstract

Climate change is projected to cause shrinking of fish sizes, and the underlying mechanism has been proposed to origin from oxygen limitations of the gills. This idea has been disputed as it does not seem to adhere to empirical data on respiratory limitations in fish at elevated temperatures. However, most experimental work is performed on smaller sized individuals (< 0.5 kg) and may not be representative of later life-stages. In this study, respirometry experiments were performed on larger sized Atlantic salmon weighing ≈4 kg following acclimation to seawater of 9 °C or 19 °C. At 9 °C oxygen uptake rates resembled earlier work on smaller size classes. However, at 19°C 81% died unexpectedly within 5.5 ± 0.6 hours of the trial while surviving fish struggled to recover a baseline oxygen uptake rate following initial stress exposure. Most noteworthy was that maximum oxygen uptake rates remained similar across temperature whereas in smaller Atlantic salmon maximum oxygen uptake rates continue to increase substantially until near-lethal temperatures. As resting oxygen consumption inevitably goes up with temperature, both absolute and factorial aerobic scopes became drastically reduced at 19°C in large Atlantic salmon, contrasting similar measurements on smaller fish. Hence, fish appeared unable to take up sufficient oxygen at 19°C to adequately cope with the imposed stress. While the precise cause of death was not discerned, it was likely not cardiac arrest as hearts were still beating when dissecting fish momentarily after dying. Regardless of whether these results were caused by gill-oxygen limitations or other factors, it highlights the need to include larger fish sizes in experimental work. This most certainly also include aquaculture research, as performance traits, environmental limitations, and welfare issues of near-harvest sized fish cannot be properly inferred from measurements on fish that are one or even two orders of magnitude smaller.