The significance of respiration frequency and timing in the energetics of killer whales (*Orcinus orca*)

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ABSTRACT
Breathing rate has been used as indicator of cetacean metabolic rates to evaluate their role in food webs, though it does not account for breath-by-breath variation in gas exchange. Our aim was to investigate the potential influence of including respiratory timing (in addition to rate) and oxygen uptake dynamics on in-situ cetacean energetic studies. Kinematic data from 19 wild North-Atlantic diverse sized herring-feeding killer whales (*Orcinus orca*) were recorded with high-resolution tags (DTAGs) to reveal individual breathing events. Three-axis accelerometer and flow noise data were used to derive stroking rate and speed as metrics of underwater activity level. An oxygen exchange model, including an oxygen uptake curve as key feature, was established to estimate oxygen extraction dynamically per individual breath, based upon modelled oxygen store at the time of each breath. Correlations between predicted oxygen uptake and stroking activity over 15 min periods were relatively weak when using constant uptake per breath (r^2 < 0.5 for 15 individuals). Including fluctuating oxygen uptake per breath significantly improved the correlation between modelled oxygen uptake and activity level (r^2 > 0.9 for 17 individuals). Hence, taking into account respiration timing, in addition to rate, is crucial in making accurate cetacean energetic estimations.