

## **How do seals swim? Swimming behavior constrained by biomechanical and ecological factors**

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How to manipulate the manner of swimming is a fundamental issue for breath-hold marine divers because swimming behavior is closely related to both energy gain (foraging) and expenditure (stroking). To test whether and how they achieve cost-efficient swimming, we investigated the swimming and foraging behavior of repetitive deep divers, female northern elephant seals. We attached two types of accelerometer-based data loggers on the backs and the mandibles of 7 seals and monitored stroke rate, swim speed, pitch angle and foraging depth. The results showed that, first, seals changed ascent stroke rate and descent swim speed in response to their own body density (i.e. buoyancy). Second, seals changed their swimming behavior in response to their foraging depth: swim faster (i.e. stroke more) at steeper pitch angle when forage at shallower depth. This depth-dependent behavior accord with the prediction of diving models by Thompson et al. (1993) that maximize the time spent at bottom phase. We suggest that free-ranging female northern elephant seals manipulate the manner of swimming by both biomechanical and ecological factors simultaneously to handle inevitable cost-benefit trade-off of deep water foraging.