Changes in foraging depth trigger diurnal cycles of swim speed in northern elephant seals

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Foraging theory predicts that breath-hold divers maximize the time spent foraging at depth in relation to both post-surface time and transit time to and from foraging depths. To achieve this, diving animals can change swim speed during transit to adjust the time and energy costs of swimming during transit. Previous studies showed that swim speeds of free-ranging divers vary largely with changes in their buoyancy (body density), but little is known about how swim speeds vary with the depths of foraging, despite the strong influence of foraging depth on transit distance and time. Here, to investigate the effect of foraging depths on swim speeds of free-ranging divers, we used long-term accelerometry techniques that quantify swim speed and stroking frequency together with foraging depth in eight free-ranging female northern elephant seals (Mirounga angustirostris) over their months-long oceanic migrations. Seals demonstrated both significant changes in buoyancy and variability in foraging depths while feeding on mesopelagic prey. As negatively buoyant seals gradually increased their fat stores and buoyancy while foraging at sea over months, swim speed decreased in the buoyancy-aided direction (descending), but did not change in the buoyancy-hindered direction (ascending), with an associated change in stroking frequency. Additionally, seals changed swimming behaviour in response to diurnal, short-term changes in foraging depth; seals swam faster by stroking more frequently when they foraged in shallower depths in response to the diel vertical migration of mesopelagic prey (ranging from 200-800 m in depth). This diurnal cycle in swim speed appeared to reflect the swimming strategy that maximizes the proportion of time spent foraging at depth, in agreement with the optimality model for breath-hold divers developed by Thompson et al. (1993). These results suggest that both long-term changes in buoyancy and short-term changes in foraging depth shape the swimming behaviour of ocean-migrating elephant seals.