



October 26, 2023

Dear Editorial Board,

Animal migrations are one of Earth's most amazing wildlife spectacles, but migratory species are susceptible to a wide range of threats. Within the marine environment, baleen whales (Mysticeti) display some of the longest migrations, but we do not know how they 1) manage the energetic burden of this extreme behavior or 2) what impact different locomotor strategies may have on an individual's energy economy and ability to cope with future environmental change. Our study seeks to fill these knowledge gaps with estimates of the energetic cost of migration as well as how migratory variables and changing foraging conditions throughout the year might impact the annual energetic calculus for an individual. *Current Biology* has published numerous key works on animal migration and thus we feel our manuscript would be an ideal fit for this journal and represent a significant advancement in the literature^{1,2,3,4,5,6,7}.

The advent of attachable bio-logging tags in the 1990s has led to an explosion of information on the movements and behavior of marine species that would be difficult or impossible to study otherwise⁸. The field of energetics – the intake and cost of life – has seen a particularly large push in the last few years^{9,10}. Unfortunately, a majority of these studies have focused almost exclusively on a single time-scale of movement, using either high-resolution multi-sensor biologgers to study fine-scale behaviors^{11,12,13,14,15} or low-resolution GPS to study broader-scale movements such as migrations^{16,17,18}. This has led to deep understanding of individual behaviors, but an incomplete picture of the broader fitness implications for individuals, populations, and species. Understanding how species will react to changing oceans requires more holistic analyses that incorporate a range of data collected at varying scales.

Fortunately, baleen whales have been extensively tagged with both high- and low-resolution devices, making this the ideal time for a multi-scale approach to energetic analyses. Using high-resolution data, we now have accurate and detailed measures of the fine-scale energetic economy of foraging^{11,19} as well as the mechanics and cost of swimming^{20,21}. From lower-resolution datasets, we have migratory distances and durations^{18,22,23}. Here, my coauthors and I submit **Baleen Whale Migration Speeds Optimize Year-round Energetic Budgets** for consideration as a report in *Current Biology*. In this study, we used high-resolution tag data to estimate the energetic economics of a complete foraging season in higher resolution than ever before. We then used a combination of detailed high-resolution and long-duration low-resolution tag data to estimate how variables such as body size, migration duration, and migratory swimming speed impact the annual energetics of an individual. Through this integration of datasets, we were able to estimate a range of optimal migratory speeds between 1-2 m s⁻¹, suggesting that swimming too quickly leads to an increased cost of transport, but swimming too slowly results in a late arrival to the foraging ground and subsequently missed foraging opportunity. In addition, we found a novel tradeoff between migratory distance and speed, with longer-distance migrations corresponding with higher optimal migratory speeds. To validate our modeled results, we compared our optimal speed range against satellite tag

data from migrating baleen whales and found a similar relationship with increasing migratory distance leading to faster migratory swimming speeds. For fast “pace-of-life” species such as baleen whales that are thought to be highly susceptible to disturbance²⁴, our results can act as baselines and inform management models determining the impacts of environmental shifts on individual and population fitness.

To review this manuscript, we suggest the following referees based on their expertise in behavioral energetics, cost of transport, and the ecology and conservation of migratory species:

Dr. Enrico Pirotta

Dr. Terrie Williams

Dr. Anders Hedenström

Dr. Elizabeth McHuron

Dr. Åke Lindström

Dr. Leena Riekkola

Sincerely,

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