November 22, 2021

Dr. Kathryn Cottingham

Editor-in-Chief, *Ecology*

Ecological Society of America

Dear Dr. Cottingham and Editorial Board Members,

Please find our attached manuscript entitled “Delayed trophic response of a marine predator to ocean condition and prey availability during the past century,” which we are submitting to Ecology as an Article.

A major theme in ecology is identifying how food web structure and predator populations are regulated by their environment (bottom-up control; sensu Estes et al. 1998). Simultaneously, there is also great interest in understanding how predators have responded to climatic changes in the past in order to anticipate future responses. Elucidating predator responses to ecological and environmental change over climate-relevant time scales is therefore critical for both our basic understanding of ecological systems and developing approaches for managing ecosystems in a changing world.

In this manuscript, we present compound-specific nitrogen stable isotope of amino acids data from 153 museum specimens spanning a century (1928 – 2014), which allows us to analyze how the trophic ecology of harbor seals in Washington state has responded to major changes in prey (i.e., endangered Chinook salmon) and ocean condition (i.e., sea surface temperature). As such, we present a study that unrivaled both its application of state-of-the-art isotope data and the temporal extent under consideration.

Key results from this paper include:

1. The nearshore marine predator we examined (harbor seals) showed delayed trophic response (quantified as trophic level) to ocean conditions and prey availability on multiple temporal scales, as different perturbations propagate through the food web at different rates. This result highlights importance of considering dynamic multiscale interactions of predators to their environment when seeking to understand predator responses to environmental change, as multiple ecological factors are often changing simultaneously and predator response occurs at multiple temporal scales.
2. Our novel parameterization of the trophic position equation applied in this analysis (multi-amino acid, multi-trophic enrichment factors, weighted beta, tissue turnover time) improved trophic position estimates, which tend to be underestimated relative to ecologically realistic values across CSIA studies.
3. Spatially distinct management strategies that are reevaluated in the context of changing ecological conditions will likely be important for managing harbor seal prey given their dynamic foraging strategies.

We believe this work is appropriate for Ecology because:

1. The regulation of food web structure by resources (bottom-up control) and the presence of top predators (top-down control) is fundamental for understanding food web responses to environmental, ecological, and anthropogenic change. How marine predators respond to multiple types of bottom-up drivers (i.e., ocean condition, prey availability), and the different temporal scales over which they respond, is crucial for understanding community stability and resistance to change.
2. Our result of delayed trophic responses to environmental change over the past century for a top level consumer would be otherwise unidentifiable if it were not for the extensive time series data. This result is likely transferable to other high tropic level terrestrial and marine consumers, and can therefore inform future research.
3. CSIA is a rapidly growing technique in the field of ecology, particularly for retrospective analyses examining food web forcing. Applications of CSIA require careful consideration of physiological and ecological processes (i.e., variability of trophic enrichment factors, primary production pathways, tissue turnover times, and ecological delays), which we carefully consider beyond what has been previously offered.

Finally, we believe this work justifies the extra lengths afforded an Article because the research is detailed both with respect to the data acquisition and how the CSIA data are transformed into estimated trophic position. We do not know of a similarly thorough consideration of this type of data. Furthermore, we provide a statistical framework for retrospective analyses that considers both physiological and ecological dynamics of a given system. Therefore, we see this work as relevant to ecologist from a wide range of subdisciplines, including but not limited to, marine and food web ecologist, historical ecologists, and stable isotope ecologists.

This manuscript has been approved for submission by all authors and is not being considered for publication elsewhere. Please address correspondence to me at: University of Washington, School of Aquatic and Fishery Sciences, Seattle, WA 98195. Email: mfeddern@uw.edu; Phone: (603) 651-6802.

Please contact me with any questions.

Sincerely,

Megan Feddern