Manuscript

Larger but younger fish when growth compensates for higher mortality in heated ecosystem

Max Lindmark[a,b,1], Malin Karlsson[a], Anna Gårdmark[c]

[a] Swedish University of Agricultural Sciences, Department of Aquatic Resources, Institute of Coastal Research, Skolgatan 6, 742 42 Öregrund, Sweden

[b] Swedish University of Agricultural Sciences, Department of Aquatic Resources, Institute of Marine Research, Turistgatan 5, 453 30 Lysekil, Sweden

[c] Swedish University of Agricultural Sciences, Department of Aquatic Resources, Skolgatan 6, SE-742 42 Öregrund, Sweden

[1] Author to whom correspondence should be addressed. Current address:
Max Lindmark, Swedish University of Agricultural Sciences, Department of Aquatic Resources, Institute of Marine Research, Turistgatan 5, 453 30 Lysekil, Sweden, Tel.: +46(0)104784137, email: max.lindmark@slu.se

Dear Editor,
I am submitting the manuscript '*Larger but younger fish when growth compensates for higher mortality in heated ecosystem*' for consideration to be published as an article in *Nature Ecology & Evolution*.

Global warming is often predicted to lead to faster growth rates, but overall shrinking of ectotherm species (e.g., declines in mean body size due to declines in adult size-at-age). However, more informative than changes in average sizes is how the size spectrum of species changes. This is because key biological rates and ecological processes scale with size, and the value of these traits for the mean body size of a population is not the same as the mean population trait value, due to allometric scaling.

The size-spectrum of species is shaped by temperature-dependent biological and ecological processes such as body growth, mortality and recruitment. In this study, we use data from a unique, large-scale 23-year-long heating-experiment (~+8°C) of a coastal ecosystem (and a non-warmed reference area) to quantify how warming changed fish body growth and mortality, and how that has affected the size-spectrum. We quantify differences in key individual- and population level parameters, such as body growth, asymptotic size, mortality rates, and size-spectra between the heated and reference coastal area, using hierarchical Bayesian models.

Contrary to common predictions on the effects of warming on size-at-age and growth, we found that body size was larger for all ages and growth faster for all sizes in the heated area, compared to the reference area. These changes in growth and size were so large that, despite a higher mortality rate in the heated area, it still had a larger size-spectrum exponent (greater proportion of large fish).

Not only do these findings show that universal predictions about the shrinking of ectotherm organisms may be simplistic, they also reveal that in order to understand warming-induced changes in the size-structure of species, which affect ecological interactions and dynamics, it is critical to account for how climate change alters *both* mortality and growth rate, and these changes may depend on each other.

We are grateful for your consideration of our manuscript, and we look forward to hearing from you.

Sincerely,

Max Lindmark, on behalf of all co-authors
Swedish University of Agricultural Sciences, Department of Aquatic Resources, Institute of Marine Research, Turistgatan 5, Lysekil 453 30, Sweden, Tel.: +46(0)104784137, **email**: max.lindmark@slu.se