Thorsten Reusch PhD

*Science Advances* Editorial Team

*Science*

AAAS

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March 25th, 202

Dear Dr. Thorsten Reusch,

We are pleased to submit the manuscript “Message in a Bottle: Archived DNA Reveals Marine Heatwave-Associated Shifts in Fish Assemblages” for consideration as a manuscript at *Science Advances*. We reconstruct the fish fauna of the California Current Large Marine Ecosystem before, during, and after the 2014–2016 Pacific Marine Heatwave, integrating DNA amplicons from the ethanol of a 23-year longitudinal sample collection with microscopy-derived morphological identification through a novel joint model to provide a much higher-resolution picture of fish assemblages.

The novelty and importance of this paper stem as much from its methods as from its conclusions. First, our quantitative approach to combining morphological and molecular datasets allows us to leverage the taxonomic breadth and resolution of amplicon sequencing, combining these with the power of morphological counts to yield species-specific quantitative abundance estimates. This method is also broadly applicable to modern ecological datasets featuring environmental DNA, and answers a general methodological question by making metabarcoding data fully quantitative. Second, the archival element of the work opens the door to reconstructing marine assemblages from archived samples worldwide; the DNA stored in ethanol in museum jars around the world appears to be a deep well of contextual ecological information, and this paper vividly illustrates how to use such information to reconstruct near-term historical assemblages.

Consistent with expectations under warming, we find tropicalization of fish assemblages in favor of southern, mesopelagic species during elevated sea surface temperatures with declines in important temperate fisheries targets including Northern Pacific Hake (*Merluccius productus*) and Pacific Sardine (*Sardinops sagax*). We also identify novel diverse and abundant forage fish assemblages that are increasingly likely to comprise the ecological context for commercial species such as Northern Anchovy (*Engraulis mordax*). Furthermore, molecular data distinguish important cold-water indicator species and fisheries targets which lack species-specific morphological characteristics, revealing ecological dynamics otherwise hidden by shared larval morphology.

By reaching back in time to use the residual genetic information stored in ethanol-preserved samples, we offer a novel way to understand temporal shifts in entire marine communities in response to environmental fluctuations, specifically allowing us to establish requisite ecological baselines and better understand trophic ecology mechanisms that govern community dynamics. Archival collections worldwide could then be used for any number of ecological analyses in the context of a changing climate, both in terms of past shifts and to predict what may happen in the future.

The authors have no conflicts of interest to report. All data and code generated for this study will be made available in NCBI, Dryad, or GitHub. Thank you for considering this manuscript for publication in *Science Advances*.

Sincerely,

Zachary Gold, on behalf of all authors

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