OCEAN BIOGEOGRAPHY

Climate change 'heard' in the ocean depths

Our global oceans are already experiencing the effects of a changing climate, including marine heatwaves, species redistributions and increased human–wildlife conflict. Now, researchers use acoustic surveys to project risk for one of the least understood and most abundant habitats on Earth, the ocean's mesopelagic zone.

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The mesopelagic zone between 200 m and 1,000 m deep contains the greatest animal biomass in our oceans, including many species that never see the light of day[1]. Owing in part to the difficulties associated with observing these organisms, the extent to which climate change reaches the ocean's deep mesopelagic layer largely remains a mystery. Now, writing in *Nature Climate Change*, Ariza et al.[2] report how they use a suite of acoustic surveys coupled with statistical modelling approaches to project high losses of mesopelagic organisms in low- and mid-latitude oceans under future climate scenarios.

Mesopelagic communities remain largely untouched by human activities and consist of many species, including fish, shrimp and squid (Fig. 1). Many of these organisms undertake the greatest migration on Earth[3], rising hundreds of metres every day as the Sun sets to feed on surface organisms and returning to deep waters as the Sun rises to avoid being eaten themselves. While we know relatively little about the deep oceans, recent discoveries have highlighted that they hold a high abundance and biodiversity of animal life and play a key role in marine food webs[1]. In many oceanic deserts, where surface waters are largely devoid of life, mesopelagic organisms are nonetheless abundant. Highly migratory marine predators such as birds, marine mammals and fish rely on these mesopelagic resources to survive[4], making them a critical part of oceanic ecosystems. However, the difficulty in sampling these deep water habitats has limited our ability to assess potential climate change impacts.

Ariza et al. address these difficulties by compiling more than 20 years of acoustic data, in which sound is used to measure the abundance and distribution of these organisms. The researchers implement a clustering algorithm to describe common patterns in mesopelagic biomass across multiple ocean ecosystems. They compare these clusters, termed echobiomes, across multiple climate change scenarios to get a range of likely outcomes for the mesopelagic community through to the end of the century. Unfortunately, across almost all of the climate scenarios, the low- and mid-latitude oceans are predicted to lose faunal biomass while the high-latitude oceans face an influx of warm water species. The predictions by Ariza et al. demonstrate a risk to mesopelagic species that could cascade to migratory predators that depend on them for food, which, in turn, could adversely affect fisheries. The researchers provide hope that if we can keep global warming below 2 °C, we could minimize mesopelagic declines to under 10%.

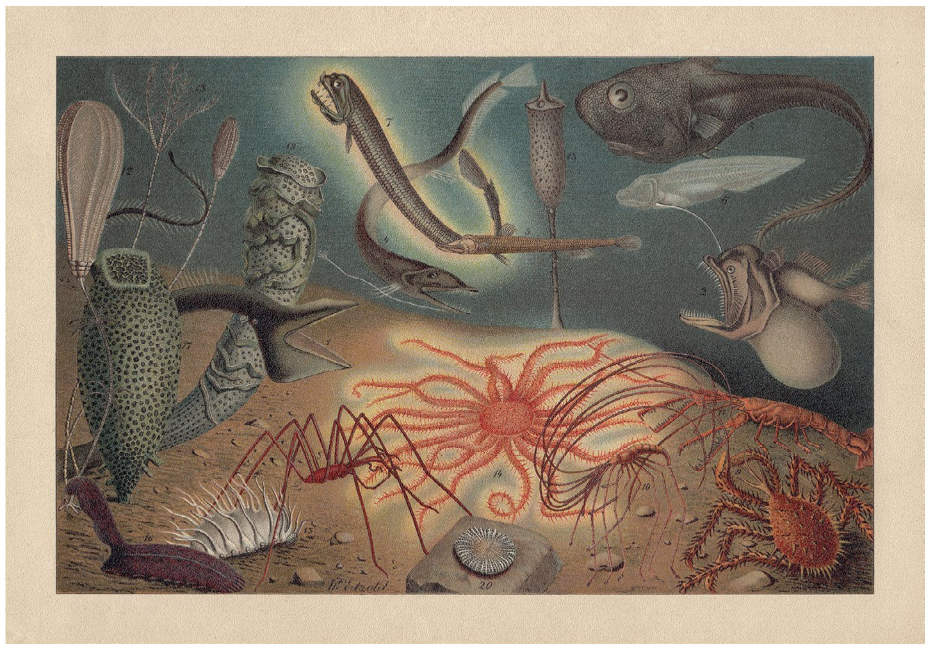

Fig. 1 | Organisms of the mesopelagic. The organisms that make up the mesopelagic zone are relatively understudied. They include fish (those above the bottom here) and siphonophores (Cnidarians, not shown), which both dominate the acoustically defined echobiomes. Credit: ZU_09/DigitalVision Vectors/Getty

While the global picture shows an overall decline in mesopelagic biomass, the researchers also detail regional variability. Mesopelagic biomass was predicted to deepen by up to 100 m, particularly as new species redistribute as waters warm. Modelled chlorophyll *a* was the most variable predictor in the mesopelagic models, which also drove the greatest variability in mesopelagic patterns. Physiologically, temperature increases could benefit mesopelagic organisms, but Ariza et al. posit that a concurrent decline in chlorophyll *a* would negate these effects. The simplicity of the researchers' correlative modelling approach aligns well with previous estimates of mesopelagic biomass changes based on more complex ecosystem modelling approaches[5]. However, the echobiomes can only provide a broad picture of mesopelagic communities, and thus individual species may have varied responses to climate change.

The researchers' latest study excelled at illuminating the mesopelagic prey community, yet gaps remain in our understanding of climate change impacts. Previous studies on climate shifts have focused on oceanographic provinces[6], fished species[7] and top predators[8]. We rely on observational data and experiments to provide much of the information on how ecosystems are most likely to respond to changing climate. Models have been invaluable in extending our assessment of which species or ecosystems are most likely to be impacted in the future and to predict climate-driven redistributions of species worldwide[7,9]. Purves et al.[10] argued that we should model all life on Earth, and Hobday et al.[11] proposed that models could inform multi-scale management approaches. Ecological modelling can also look for patterns across multiple models; understanding the range of scenarios across ecological models is important to inform robust, precautionary and ecosystem-based management approaches.

To leverage the output of ecological forecasts and projections, we can use output from models to prioritize management towards places and species most at risk. This can include using real-time models to close areas to fishing when sensitive species are present[12], using climate projections to triage species most vulnerable to climate change[11], or using projections when evaluating trade-offs in the use of marine resources to ensure that present-day scenarios persist in the future. Inference from multiple models, including mass-balance, mechanistic and statistical, will help assess uncertainty and provide a best estimate of future conditions. Laboratory experiments can inform thresholds of ecological response, and collecting new data remains important to validate existing models such as the ones presented here[2]. Finally, we should work towards modelling all life on Earth, even in a hypothetical framework, to test the influence of individual traits, ecological interactions and observed adaptation as climate change continues to bring the realm of ecological modelling up to the speed to that of atmospheric and oceanographic modelling. Models are only part of the solution though, as we need to continue to combine them with novel tools such as fisheries acoustics to shine a light on the least-known parts of our oceans[2]. ❐

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Competing interests

The author declares no competing interests.