POPULATION DYNAMICS

Zebrafish help model the effects of fishing pressure in a warming world

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The basic and preclinical biomedical communities are no strangers to the zebrafish. Decades of work have gone into making *Danio rerio* a valuable, tractable model organism that can be kept relatively easily in the lab environment and used to study myriad facets of development, health, and disease that are of potential translational relevance to humans. That relevance also extends beyond trying to help keep us healthy. Zebrafish might also help keep us fed.

According to the Food and Agriculture Organization of the United Nations, around a billion people worldwide depend on fish as their main source of protein, and it supplements the diets of many more. Sustainably managing fisheries is therefore of major cultural and economic importance. Much work in the field has focused on studying the impacts of fishing itself on fish populations, says Henry Wootton, a researcher who recently completed his PhD at the University of Melbourne; however, the research and fishing communities have been becoming increasingly aware of the potentially deleterious impacts of ever warming waters.

Those effects may compound each other. "In the real world, fisheries are susceptible to multiple stressor at the same time," Wootton says. "If our understanding is built on single stressors only, then we might be missing the context of the interaction." Long-lived, large-bodied fish aren't exactly easy to keep in the lab for long periods of time in order to ask big questions, however. So Wootton, his PI in Melbourne John Morrongiello, and Asta Audzijonyte from the University of Tasmania across the Bass Strait looked for a model to simplify and speed things up.

With thanks to all those in the zebrafish community who worked out the husbandry requirements over the years, the lab brought in zebrafish. Lots of zebrafish. After a small trial to determine some details, they set up 18 populations of 250 individuals – enough to avoid genetic bottlenecks without mucking up the tanks too much. They then followed their zebrafish for six consecutive generations while manipulating thermal and harvesting regimes between the different populations over time. Fish were maintained within their natural comfort zone, around 26 °C, or at 30 °C, the upper temperature they are likely to experience in the wild. The team also subjected the populations to one of three size-selective harvesting methods. The results, published in *The Proceedings of the National Academies of Sciences*, suggest synergist effects of the two sources of stress.

Credit: piola666 / E+ / Getty

Most notably, says Wootton, they saw a drastic decline in recruitment among those populations experiencing elevated temperatures. Recruitment, defined in this study as the proportion of tanks reaching the 250 individual carrying capacity by week seven, is the transition of young fish to the reproductive adults needed to produce the next generation. Even a 10% decline would have been significant, Wootton says, but in some populations it was much as half – a worrisome trend for long-term sustainability. One population ended up failing to reproduce entirely.

That effect on recruitment took a little while to manifest, however – four generations passed before the drop, suggesting that shorter-term studies might be missing some details. "A lot of those studies [in which] we might think things are ok might be underestimating the long-term impacts," Wootton says.

Fishing pressure also influenced how drastically the populations in hot water declined. The greatest decreases occurred in tanks in which the lab harvested the largest fish – which tend to be females and thus a limit of the potential size of the next generation — whereas only selecting for smaller individuals left a more favorable sex ratio and helped maintain recruitment between generations.

As when its used in biomedicine, the zebrafish model is just that: a model. Wild fish populations experience considerably more complex environmental conditions and harvesting pressures. The conclusions that can be drawn from zebrafish studies can however help shape future research questions and inform fisheries management practices. For example, says Wootton, leaving the largest fish out there be – these are the individuals with the greatest reproductive potential, as that capacity is non-linear in most fish – could be a relatively easy way to help buffer against the impacts of warming.

The current study was focused on early life stages, which are thought to be more susceptible to the effects of warming than more resilient adults. Future publications will look more closely at older zebrafish – in particular, how big they're actually getting. "We think that warming *and* fishing is selecting for smaller body sizes, and that's going to have a large impact on the profitability of a lot of fisheries," says Wootton, as bigger fish mean more protein and thus more value for the fisheries.

Using zebrafish made this work possible, says Wootton, and the model organism will likely continue playing growing roles in fisheries research. "You can ask these really complex but super relevant questions," he says. "Ecologists and fisheries biologists are really realizing the utility there – I think these sort of studies will really explode."

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