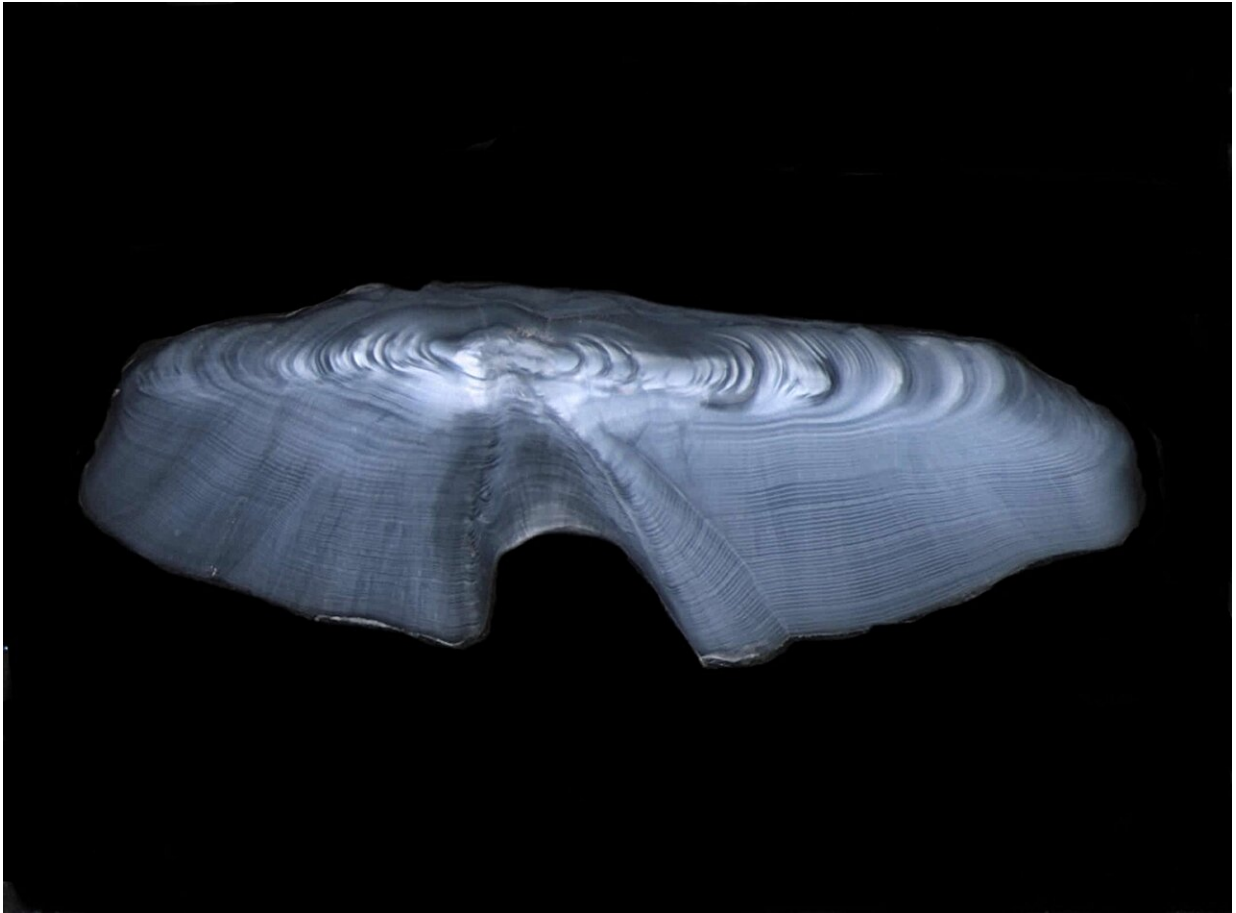


Q&A: Growth rings in fish give clues about fluctuations in climate over decades

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Cross-sectional view of a splitnose rockfish (*Sebastes diploproa*) otolith collected off the coast of California. Credit: Bryan Black

A giant tree in your backyard can reveal stories about Earth's past

climate. The concentric rings in the trunk, besides indicating the age of the tree, also shed light on the corresponding weather conditions during each year of the tree's life.

But [growth rings](#) are not exclusive to trees. Similar rings found in the tiny ear bones of [fish](#) provide clues about the effects of climate change on both land and sea.

Bryan Black, an associate professor of dendrochronology at the University of Arizona Laboratory of Tree-Ring Research, has been applying the tree-ring dating techniques to so-called "fish rings" to understand how environmental variability is affecting fish growth and productivity over decades.

In this Q&A, Black discusses the techniques he uses to study growth increments in the ear bones, or otoliths, of fish; the correlation between otoliths and climate change; and how the fish-ring dating technique is comparable to tree-ring dating.

How did you develop an interest for studying fish growth rings?

Black: It was by chance that I came to know this area of research exists. After finishing my Ph.D. with a specialization in Appalachian Forest ecology, I came across an advertisement from Oregon State University's Hatfield Marine Science Center, looking for someone to do growth increment analysis in fish. I had no idea that fish lived a long time and formed rings. But I was intrigued by this idea. As a tree-ring scientist, I thought I could incorporate the techniques I'd used to analyze growth increments in trees to address problems in the marine systems, analogous to issues that we address in terrestrial systems.

How do growth rings in trees compare to growth rings in fish when it comes to understanding climate change?

I could step back to the founding of the Laboratory of Tree-Ring Research. A.E. Douglass, the lab's founder, invented the technique of "crossdating." As climate varies from year to year, it induces synchronous growth patterns among all the trees of a given species and location. For example, in the Southwest, where rainfall strongly affects growth, trees form a wide ring during wet years and a narrow ring in dry years. As climate varies from year to year, it leads to the formation of a time-specific synchronous barcode of growth among trees.

Crossdating is the process of matching those growth barcodes. It ensures that the calendar year of every ring is correctly identified, as sometimes trees don't form a ring the whole way around their circumference. If you sample the tree at a place where it didn't form a ring, you wouldn't know if you just did simple ring counts. But by sampling a whole bunch of trees and comparing the growth patterns, you'd immediately know if the ring was missed.

The foundational idea behind bringing tree-ring techniques to the marine system is understanding if we can crossdate these fish to build chronologies going back multiple decades; integrate chronologies across different fish species; and compare chronologies with environmental data like ocean temperature and salinity to tell us how fish respond to climate variability in the world's oceans.

With these fish otoliths, we have a shortcut to develop exactly dated, well-replicated histories of fish growth in marine systems and study how it relates to variability in climate. It can also help disentangle the effects of humans on [marine systems](#).

Is there a species of fish you prefer to study, and how do you go about collecting samples?

One of the main things to prove the concept was to choose a [fish species](#) that doesn't have a big range and does not migrate. It also needed to be a species where the growth increments are annual. Just like trees, you want fish living in an environment where there's some seasonal variability, like a cold and a warm season, which will induce differences in the otoliths' growth that would show up as an annual banding pattern. We did have several candidates and selected a species of rockfish from the North Pacific that tends to have a compact home area. This species of rockfish, the splitnose rockfish, is also known to live a long time and form increments that are annual and clearly visible.

Many species of rockfish, all of which are from a diverse genus of fish named *Sebastes*, are economically important and support valuable fisheries. So, the National Oceanic and Atmospheric Administration is charged with management of rockfish species, which are periodically surveyed for their biological parameters. The pea-sized otoliths floating in the fish's head are collected, and the age of each fish is estimated.

We have collections of rockfish otoliths along the western U.S. coast that go back to the 1970s and had been used for simple ring counts to estimate age of these fish. I could use those otoliths to extract the next level of information in the increment widths for crossdating and developing growth chronologies. In fact, there are millions of these archived otoliths from a wide range of species around the country that are ready for this purpose.

What else do you hope to learn about the otoliths in the future?

I've been working with fish chronologies for 20 years now. There is a network of fish chronologies across Europe, Australia, the U.S. and Canada, by which we can study what the chronologies have in common, what they tell us about broad-scale climate drivers. We can even compare fish chronologies from the ocean to tree-ring chronologies on land to show how broad-scale atmospheric patterns simultaneously affect marine and terrestrial environments.

Right now, we are also working with collaborators in Australia on trans-Pacific comparisons of chronologies to learn how climate, especially marine heat waves, affects growth of fish, and to compare responses of fish populations that are heavily exploited by fisheries against those that have not been heavily exploited. We hope to learn more about how fish populations are responding to extreme [climate](#) events and histories of heavy fishing.

Provided by University of Arizona

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