



Text for cod and otolith figure – for promoting Breitburg et al. Ocean Deoxygenation article (to appear January 5) – by Karin Limburg, SUNY College of Environmental Science and Forestry

### Tracking lifetime exposure to hypoxia in a fish’s head.

New findings show that a fish’s exposure to low oxygen can be “recorded” in tiny bones called otoliths (literally, “ear-stones”). Otoliths, which aid in hearing and balance, are made of calcium carbonate, but grow similarly to tree rings. Recently it was shown that the otolith’s trace element manganese (Mn), relative to the major component calcium (Ca), tracks a fish’s exposure to hypoxia (1, 2). This is because Mn becomes available when oxygen levels drop into the hypoxic range, and Mn is then taken up by the fish and incorporated into the otoliths.

The figure illustrates a cod from the Baltic Sea (left panel, top), where summertime hypoxia has become severe. The otolith (middle panel, top) has poor definition of visible seasonal banding, but has very clear seasonal changes in Mn/Ca ratios (right panel, top). The lower panels compare a Gulf of Maine cod that did not experience hypoxia, and has much lower levels of Mn/Ca (right panel, bottom). The otolith has much more distinct seasonal banding (middle panel, bottom).

The red arrows indicate winter time minima. Each fish was estimated to be 5 years old when caught. The black arrows on the otolith photos show the tracks of a laser that was used to sample the otoliths for the chemical analyses.

Note that the fish photographs are illustrations only. However, the relative “skinniness” of Baltic Sea cod vs. the other cod is characteristic of Baltic cod nowadays, and hypoxia has been found to be the major cause (3). Poor growth of the otoliths is another result, such that Baltic cod ages are very difficult to determine now.

With this micro-chemical method of tracking lifetime exposure to hypoxia, scientists can begin to understand individual exposure histories, and study how hypoxia exposure correlates to important variables such as fish growth rate and condition.

## Literature Cited.

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