Eye lens chemistry of fishes in the Baltic Sea collected 2019-2021 for Project Breathless

Website: https://www.bco-dmo.org/dataset/967934
Data Type: Other Field Results
Version: 1
Version Date: 2025-07-11

Project
» Collaborative Research: Shifting the Hypoxia Paradigm – New Directions to Explore the Spread and Impacts of Ocean/Great Lakes Deoxygenation (HypoxiDigm / Project Breathless)

Contributors	Affiliation	Role
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Coverage

Location: Baltic Sea at several locations, and North Atlantic around Iceland
Spatial Extent: **N**:60.68278 **E**:18.83864 **S**:55.18133 **W**:13.27433
Temporal Extent: 2019-10-02 - 2021-10-20

Dataset Description

This dataset is part of Project Breathless, which brings together an interdisciplinary team of ecologists, economists and communication scholars to increase understanding of the impact of low oxygen dead zones in lakes and oceans. The project team focuses on how low oxygen conditions influence fish, their habitats and the food webs that support them, as well as ecosystem services, including fisheries production.

This dataset is one of three examining Baltic fishes using data collected during routine surveys for monitoring the status of fish stocks:

- Dataset 967907 (Baltic fishes stable isotopes and mercury) summarizes capture data as well as basic biological information; it also includes all stable isotopic ratio and total mercury data collected from muscle

tissue (not from every fish).
- Dataset 967925 (this dataset of Baltic fishes otolith chemistry) contains all of the Baltic Sea fish otolith chemistry data; it also includes data from 14 Icelandic cod otoliths that were used as an out-group for part of the study
- **Dataset 967934 (this dataset of Baltic fishes eye lens chemistry)** contains all of the eye lens chemistry data.

(See Related Datasets section below for links)

Methods & Sampling

Fish were collected during routine surveys performed for monitoring the status of fish stocks, either by national fishery management agencies (Department of Aquatic Resources, Swedish University of Agricultural Sciences, Icelandic Marine and Freshwater Research Institute) or international collaborative effort (Baltic International Trawl Survey). Fish were caught by trawl or by gillnet sets, then frozen for later processing.

In the lab, fish were measured for length and weighed. Sex and spawning stage were determined where possible. Otoliths and eye lenses were removed, cleaned, and stored until workup. Samples of dorsal muscle tissue were collected for mercury and stable isotope analysis and were dried to constant weight (see Related Datasets section below).

Otoliths and eye lenses were embedded in clean epoxy (Struers EpoFix), then sectioned to expose the core and polished. Trace elemental concentrations were quantified using a Teledyne-Cetac (formerly Photon) Analyte Excite 193-nm excimer laser ablation (LA) unit coupled to a Thermo Scientific iCAP TQ inductively coupled plasma mass spectrometer (ICP-MS). For both otoliths and eye lenses, a laser ablation transect was made across the polished sections from one edge to the other; the ablated material was swept via a helium carrier gas into an argon plasma, which ionized the material that was subsequently counted by a mass spectrometer in single-quadrupole mode. Transects were typically made with a 100-micron circular spot size, driven at a rate of 5-8 micron/second, fluence between 1.2 and 1.8 J/cm2, and a laser repetition rate of 10 Hz. Materials-appropriate standards were run periodically during each analysis day to calibrate and correct for instrument drift. Data files containing counts per second of each trace element were produced; each transect analysis had its own data file, but they have been concatenated here for archiving.

(For otolith chemistry, total mercury analyses, and stable isotopic ratio analyses, see the Related Datasets section below.)

Data Processing Description

Otolith and eye lens trace elemental data were processed in Excel files. Calibrations made over the course of the day were fit to plots of the calibrants as a function of time to produce drift corrections. Processing of the raw data included removal of spurious spikes (> 1 SD) and subsequent interpolation. Raw data were then calibrated and drift-corrected simultaneously, to produce data as parts per million.

Problem Description

Not all analytes were collected on every single fish. There were too many fish collected to allow for all of them to be assayed.

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Related Publications

Limburg, K. E., Heimbrand, Y., & Kuliński, K. (2023). Marked recent declines in boron in Baltic Sea cod otoliths – a bellwether of incipient acidification in a vast hypoxic system? Biogeosciences, 20(23), 4751–4760. https://doi.org/10.5194/bg-20-4751-2023
Results

Limburg, K. E., Heimbrand, Y., Hüssy, K., Blass, M., Thomas, J. B., Mäkinen, K., & Næraa, T. (2025). The forgotten element: Why do we ignore calcium in otolith studies? Fisheries Research, 283, 107297. https://doi.org/10.1016/j.fishres.2025.107297
Results

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Related Datasets

IsRelatedTo

Limburg, K., Heimbrand, Y., Razavi, R., Miraly, H. (2025) **Otolith chemistry of fishes in the Baltic Sea collected 2019-2021 for Project Breathless.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-07-11 http://lod.bco-dmo.org/id/dataset/967925 [view at BCO-DMO]

Limburg, K., Heimbrand, Y., Razavi, R., Miraly, H. (2025) **Stable isotope analyses, mercury measurements, and capture data from Baltic fishes collected 2019-2021 for Project Breathless.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-07-11 http://lod.bco-dmo.org/id/dataset/967907 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
Fish_ID	Unique identifier for the sample	unitless
FishID_synonym	Unique identifier synonym	unitless
Fish_ID_capture_iso_Hg	Unique identifier for the sample (from isotopes dataset)	unitless
Species	Scientific name of the fish species	unitless
Water_Body	Water body of sampling (Baltic or North Atlantic)	unitless
ICES_subdivision	Geographical area; the statistical subdivision given by the International Council for the Exploration of the Seas (ICES)	unitless
Site_Name	Site name	unitless
Latitude	Latitude of sampling site	decimal degrees
Longitude	Longitude of sampling site	decimal degrees
Nominal_Status	Indicates oxygen conditions of the water at the sampling site (Hypoxic or Normoxic)	unitless

Capture_Year	Year of capture	unitless
Date_Collected	Date of collection	unitless
Date_Analyzed	Date the chemical analyses were performed	unitless
Distance_from_core	Distance from the core; Lenses were analyzed from one edge, through the core, and out to the edge on another axix that was undamaged (lenses are fragile). The core is used as the reference and is denoted as 0.	micrometers (um)
Li	Lithium concentration	parts per million (ppm)
B	Boron concentration	parts per million (ppm)
Na	Sodium concentration	parts per million (ppm)
Mg	Magnesium concentration	parts per million (ppm)
P	Phosphorus concentration	parts per million (ppm)
S32	Sulfur concentration calculated on mass 32	parts per million (ppm)
S34	Sulfur concentration calculated on mass 34	parts per million (ppm)
Ca	Calcium concentration	parts per million (ppm)
Mn	Manganese concentration	parts per million (ppm)
Cu	Copper concentration	parts per million (ppm)
Zn	Zinc concentration	parts per million (ppm)
Se	Selenium concentration	parts per million (ppm)
Br	Bromine concentration	parts per million (ppm)
Rb	Rubidium concentration	parts per million (ppm)

Sr	Strontium concentration	parts per million (ppm)
I	Iodine concentration	parts per million (ppm)
Ba	Barium concentration	parts per million (ppm)
Hg200	Mercury concentration calculated on mass 200	parts per million (ppm)
Hg202	Mercury concentration calculated on mass 202	parts per million (ppm)
Pb	Lead concentration	parts per million (ppm)

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Instruments

Dataset-specific Instrument Name	Teledyne-Cetac (formerly Photon) Analyte Excite 193-nm excimer laser ablation (LA) unit coupled to a Thermo Scientific iCAP TQ inductively coupled plasma mass spectrometer (ICP-MS).
Generic Instrument Name	Laser Ablation Inductively Coupled Plasma Mass Spectrometer
Dataset-specific Description	Trace elements were analyzed with a Teledyne-Cetac (formerly Photon) Analyte Excite 193-nm excimer laser ablation (LA) unit coupled to a Thermo Scientific iCAP TQ inductively coupled plasma mass spectrometer (ICP-MS).
Generic Instrument Description	Laser ablation-inductively coupled plasma-mass spectrometer (LA-ICP-MS) is an instrument that utilizes a laser to vaporize a small amount of solid material for elemental analysis. The process begins with the laser vaporizing a portion of the sample, which is then carried into a plasma where it is atomized and ionized. The resulting ions are analyzed in a mass spectrometer, producing a mass spectrum that reveals the relative abundances of different elements.

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Project Information

Collaborative Research: Shifting the Hypoxia Paradigm – New Directions to Explore the Spread and Impacts of Ocean/Great Lakes Deoxygenation (HypoxiDigm / Project Breathless)

Coverage: Central Baltic Sea; Lake Erie; and Lavaca Bay, Texas

NSF Award Abstract:
Ocean oxygen loss (deoxygenation) is increasing due to climate warming. This warming, together with nutrient loading, is causing many marine and freshwater systems to experience increasing episodes of hypoxia (low oxygen) of greater duration and intensity. Impacts on fish and fisheries have been difficult to quantify; direct observation has been challenged by a lack of long-term exposure indicators. This team has successfully refined the use of fish chemical biomarkers in fish otoliths (earstones) to directly assess lifetime hypoxia

exposure in fishes. This project will those findings to look for additional biomarkers and models, to expand our understanding of how hypoxia affects fish and their food webs, contaminant transfers, and ecosystem services including economic impacts. The project includes a unique way of training students in science communication, posing the question: What forms of media and "messaging strategies" about deoxygenation are most effective at raising public awareness and understanding? Students are developing entries for PlanetForward's Storyfest, which is a contest to tell compelling stories to foster environmental understanding and solutions. Students from historically underrepresented, economically disadvantaged backgrounds are particularly sought out to participate. The investigators will engage with regional, national, and international management agencies and other relevant stakeholder groups to share information.

This project encompasses a novel, linked set of interdisciplinary studies of food webs, and ecosystem services assessment. The thematic questions explored in this project are: 1. How does hypoxia alter habitat use for fishes? 2. How does hypoxia-altered habitat use and habitat productivity change food webs? 3. How does hypoxia affect/enhance trophic transfer of methylmercury? 4. How do hypoxia-induced changes in food webs affect aquatic ecosystem services? The set of linked studies will employ chemical analyses of otoliths and eye lenses, combined with chemical analyses of muscle tissues (Questions 1 and 3), physiologically-structured food web modeling informed by monitoring time-series (Questions 2 and 4), and a scoping workshop to address ecosystem services (Question 4). The investigators are using a "trans-basin" comparative approach to system-specific responses, studying fishes in Lake Erie, the Baltic Sea, and a Gulf of Mexico estuary. They study three species from each system that represent different degrees of benthic reliance, to discern differential responses to the increasingly hypoxic environment. This research provides novel insight about variable biotic responses to oxygen loss and the impacts on ecosystem functioning.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1923965

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