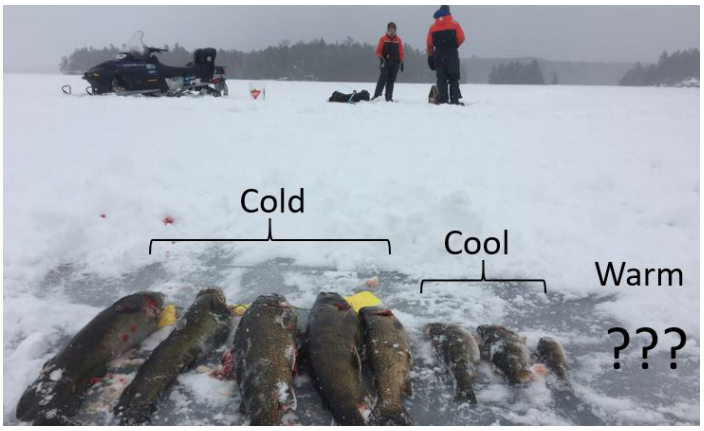
Winter shapes fish behavior and species interactions

For temperate fishes, winter is a dramatically different environment than all other seasons: temperatures decline to near freezing, light is reduced, and, in some systems, oxygen and prey density also decline. As any ice angler can attest, fishes respond differently to these winter conditions; some remain active, while others become inactive (see image). However, the ecological consequences of differential responses to winter in fish communities remain poorly studied.

Our paper demonstrates how fish habitat use and activity differ from summer to winter and vary among coexisting species. Specifically, using acoustic telemetry, we show that lake trout (*Salvelinus namaycush*) move nearshore into littoral habitats and remain active throughout the winter. In contrast, smallmouth bass (*Micropterus dolmieu*), a littoral warm-water species, move to slightly deeper water and dramatically reduce their activity rates, weakening the potential for interspecific competition in this species pair. Activity patterns for lake trout and burbot (*Lota lota*), two cold-water species, are also shown to diverge throughout the year.

We argue that winter could play a widespread role in promoting coexistence in freshwater fishes. Periods of low temperature, light, and oxygen provide rich opportunities for species to diverge, and these divergent responses to winter appear widespread both across and within thermal guilds. Alarmingly, competition models developed in our study suggest that shorter winters, already arising under a changing climate, threaten this seasonally mediated coexistence. Quantifying how diverse physiological and ecological responses to winter vary across species and populations and shape species interactions from small to large lakes remains a fruitful avenue for future research.



Fishes respond differently to winter conditions. Species that remain active during winter tend to belong to the cold- and cool-water thermal guilds. Species that reduce their activity, making them challenging to catch under the ice, tend to belong to the warm-water thermal guild. Photo: Bailey McMeans.

By Bailey McMeans, University of Toronto Mississauga

Filling data gaps: A project to measure winter oxygen and carbon dioxide levels in western Lake Erie

Lake Erie faces an onslaught of stressors including climate change, eutrophication, invasive species, and harmful algal blooms. Two dissolved gases, oxygen (O_2) and carbon dioxide (pCO_2), can act as tracers of the past (e.g., temperature, wind, metabolic history), influencers of the present (e.g., fisheries and harmful algal bloom impacts), and indicators of the future (e.g., improve modelling of lake processes and climate). Despite the importance of these gases, large data gaps exist throughout the year. Measurements of O_2 and pCO_2 are particularly limited in the winter, when ice cover and harsh conditions hinder sampling efforts.

To help remedy this, a team from Oberlin College headed to South Bass Island for the 2020 winter term. A pump off the dock at Stone Laboratory continuously supplied flow-through water for sonde measurements and discrete sampling of a suite of biogeochemical parameters including pH and alkalinity. In addition, we assessed the balance of photosynthesis and respiration of the water column using an Equilibrator Inlet Mass Spectrometer, which continuously measures the water's oxygen-argon ratio, or biologically driven oxygen signal.

During January, we derived pCO_2 values ranging from 380-525 μatm, with this lake region on average behaving as a source of CO_2 to the atmosphere at this time. As the season progressed, we observed a shift to net autotrophic conditions with daily variability tied to storm events and fleeting ice. Our study season was a particularly low ice year, so may be reflective of more common conditions in the future. Work is ongoing to amass winter O_2 and pCO_2 data from more locations and years and connect winter processes to spring and summer dynamics and blooms.



By Rachel Eveleth, Oberlin College, Oberlin, Ohio