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The ”iron gate” protecting carbon in lake sediment can be opened under low-oxygen conditions, with implications for global climate change

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BACKGROUND

- Organic materials (plants, animals, etc.) have two primary fates: they can either be buried in soils and sediment or emitted to the atmosphere as greenhouse gases
- One of the main factors that helps to trap carbon in soils and sediment is chemical bonding with minerals (iron, aluminum, etc.)[1]
- However, these associations may be sensitive to oxygen, releasing carbon for decomposition[2, 3]
- Better quantifying iron and carbon dynamics under varying oxygen conditions would help predict carbon cycling in the face of global change.

WHOLE-ECOSYSTEM OXYGENATION EXPERIMENTS HIGHLIGHT THE IMPACT OF OXYGEN ON IRON AND ORGANIC CARBON CLCYING

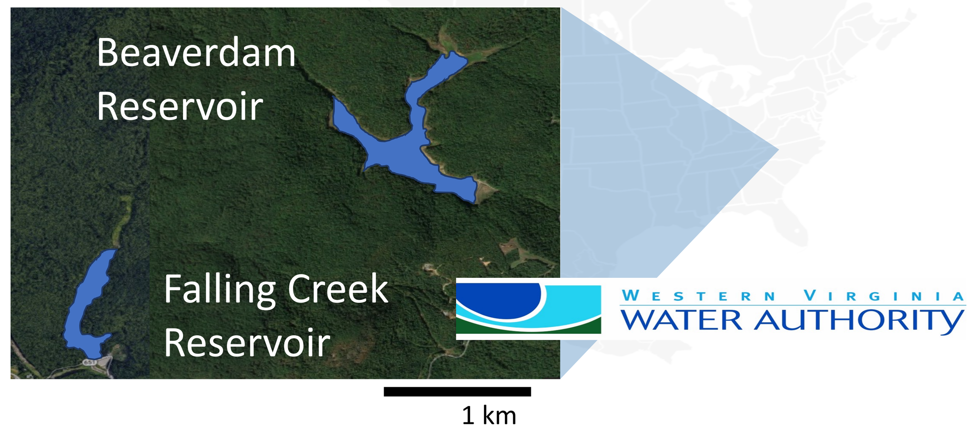
Reservoirs are important sites for carbon processing, burying more carbon than oceans each year. Here, we used whole-ecosystem experiments to test the sensitivity of Fe-OC to changing oxygen levels in two reservoirs:

Falling Creek Reservoir (FCR)

- Hypolimnetic oxygenation system has been operated since 2013, maintaining oxic conditions

Beaverdam Reservoir (BVR)

- Reference reservoir



Whole-ecosystem oxygenation experiments successfully increased oxygen concentrations in FCR, relative to BVR.

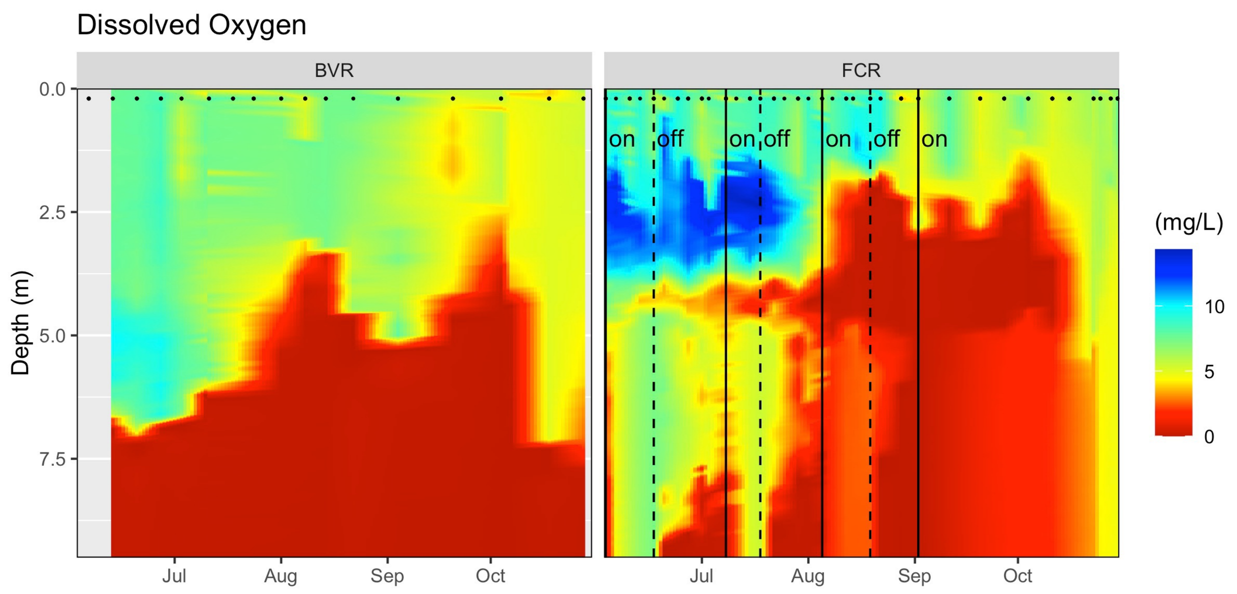


Figure 1: Heatmap of dissolved oxygen concentrations in BVR and FCR throughout the stratified period of 2019. Points indicate sampling dates. Lines indicate activation and deactivation of the oxygenation system in FCR.

Concentrations of iron and dissolved organic carbon were suppressed by oxygenation in FCR.

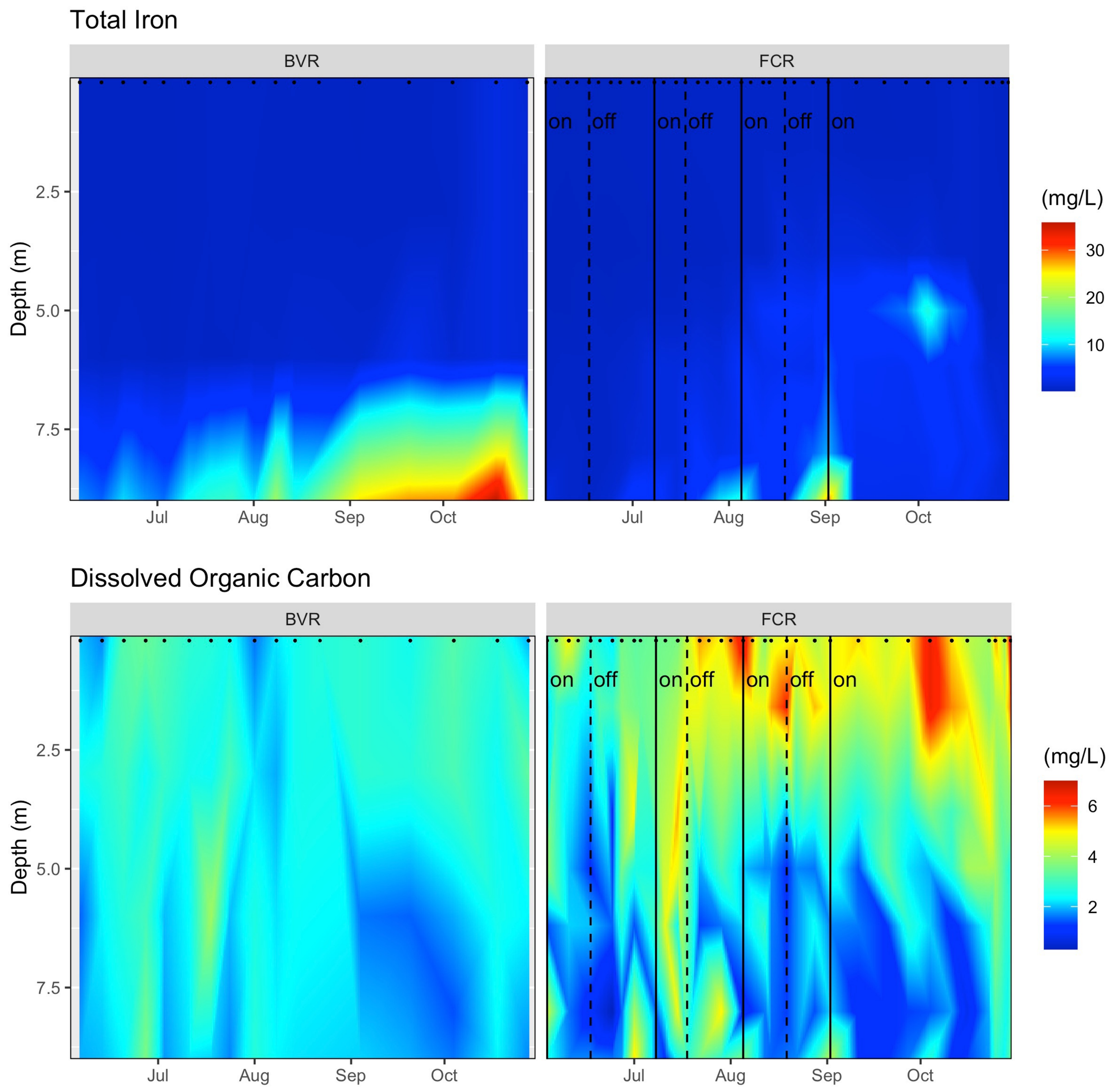


Figure 2: Heatmaps of total iron and dissolved organic carbon concentrations in BVR and FCR throughout the stratified period of 2019. Points indicate sampling dates. Lines indicate activation and deactivation of the oxygenation system in FCR.

Iron-bound organic carbon concentrations were higher than those previously reported for lakes[1, 3], and comparable to ocean sediments[1]. Concentrations differed between reservoirs and between oxygenation intervals in FCR (not pictured), indicating that low oxygen concentrations disrupt iron-based protection of carbon.

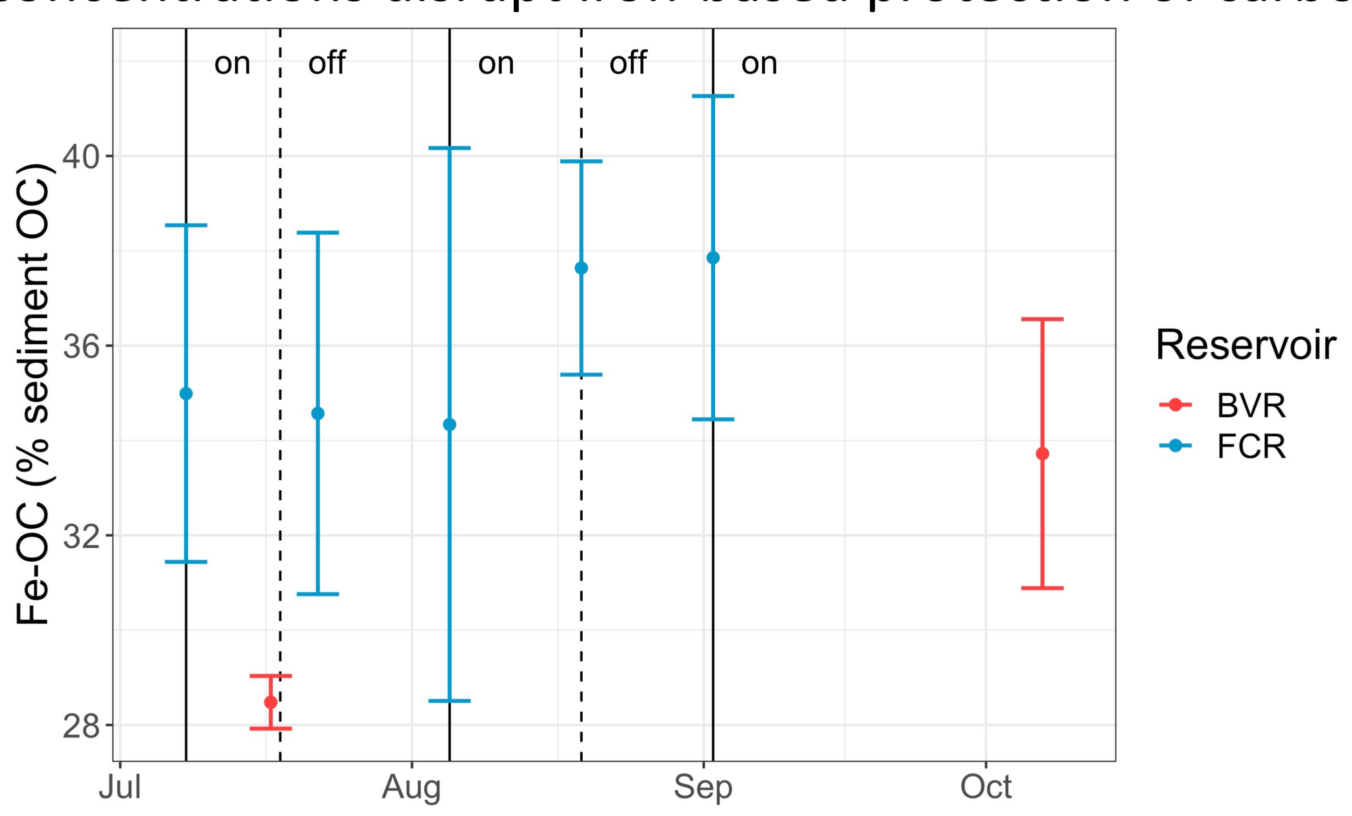


Figure 3: Iron-bound organic carbon (Fe-OC) as a percentage of the total sediment organic carbon in the top 1 cm of sediment from FCR and BVR during the stratified period of 2019. Dotted and dashed lines indicate activation and deactivation of the hypolimnetic oxygenation system in FCR, respectively.

MICROCOSM EXPERIMENT ISOLATES MECHANISM DRIVING SHORT-TERM CHANGES IN DISSOVED IRON AND ORGANIC CARBON

To more precisely understand the role of iron in carbon sequestration under variable oxygen conditions, we performed a controlled laboratory experiment using sediment and hypolimnetic water from FCR.

Both iron and carbon showed clear responses to oxygen treatments. However, the pattern of response varied between variables.

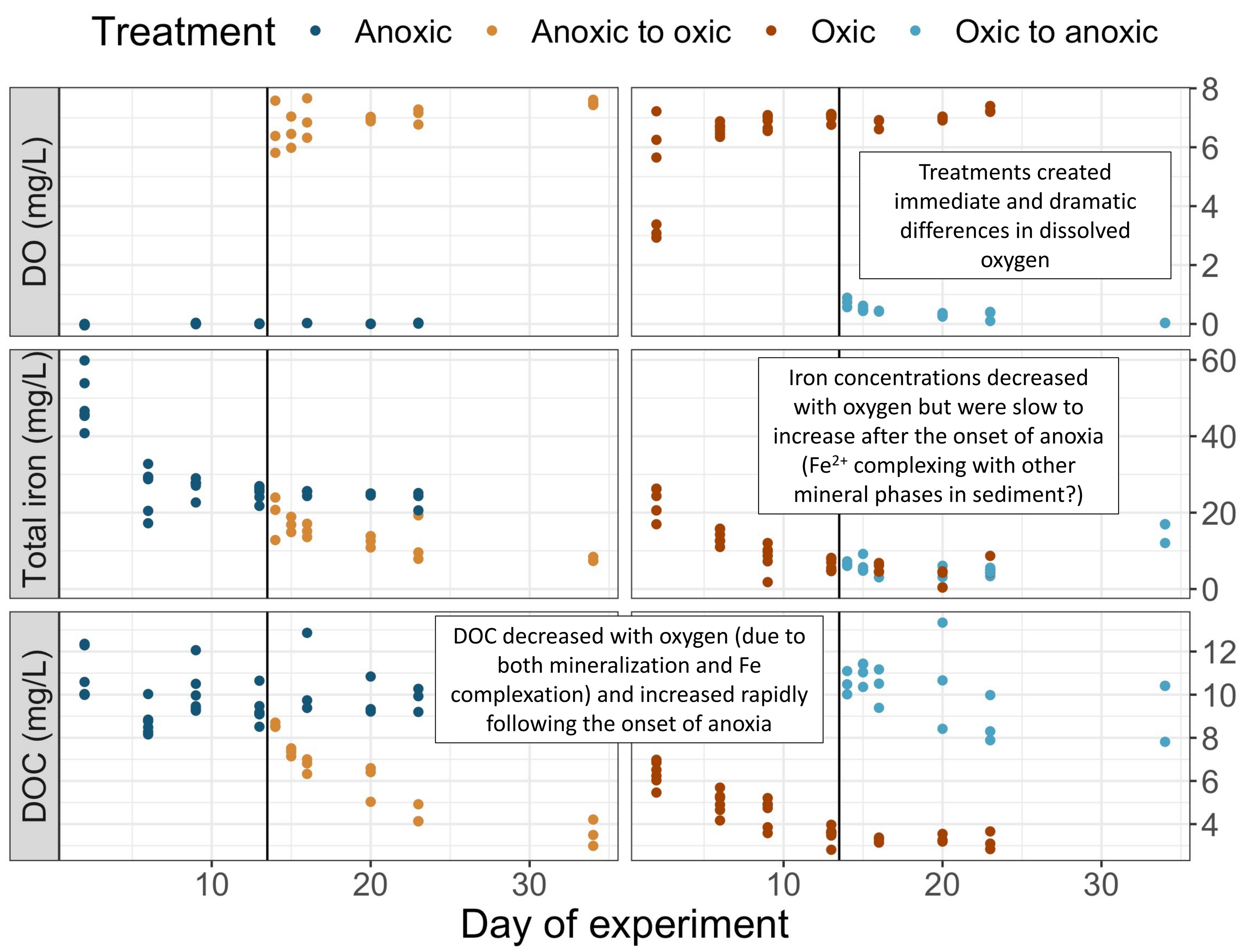


Figure 4: Dissolved oxygen (top), total iron (middle), and dissolved organic carbon (DOC; bottom) concentrations in each of four oxygen treatments. Vertical line indicates the date upon which the oxygen condition was changed for “Anoxic to oxic” and “Oxic to anoxic” treatments.

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