



Effects of Low Dissolved Oxygen and High Temperature on the Trout Fishery

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Glen Canyon Dam Adaptive Management Program

Adaptive Management Workgroup Meeting

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Photo Credit. David Herasimtschuk, ©Freshwaters Illustrated



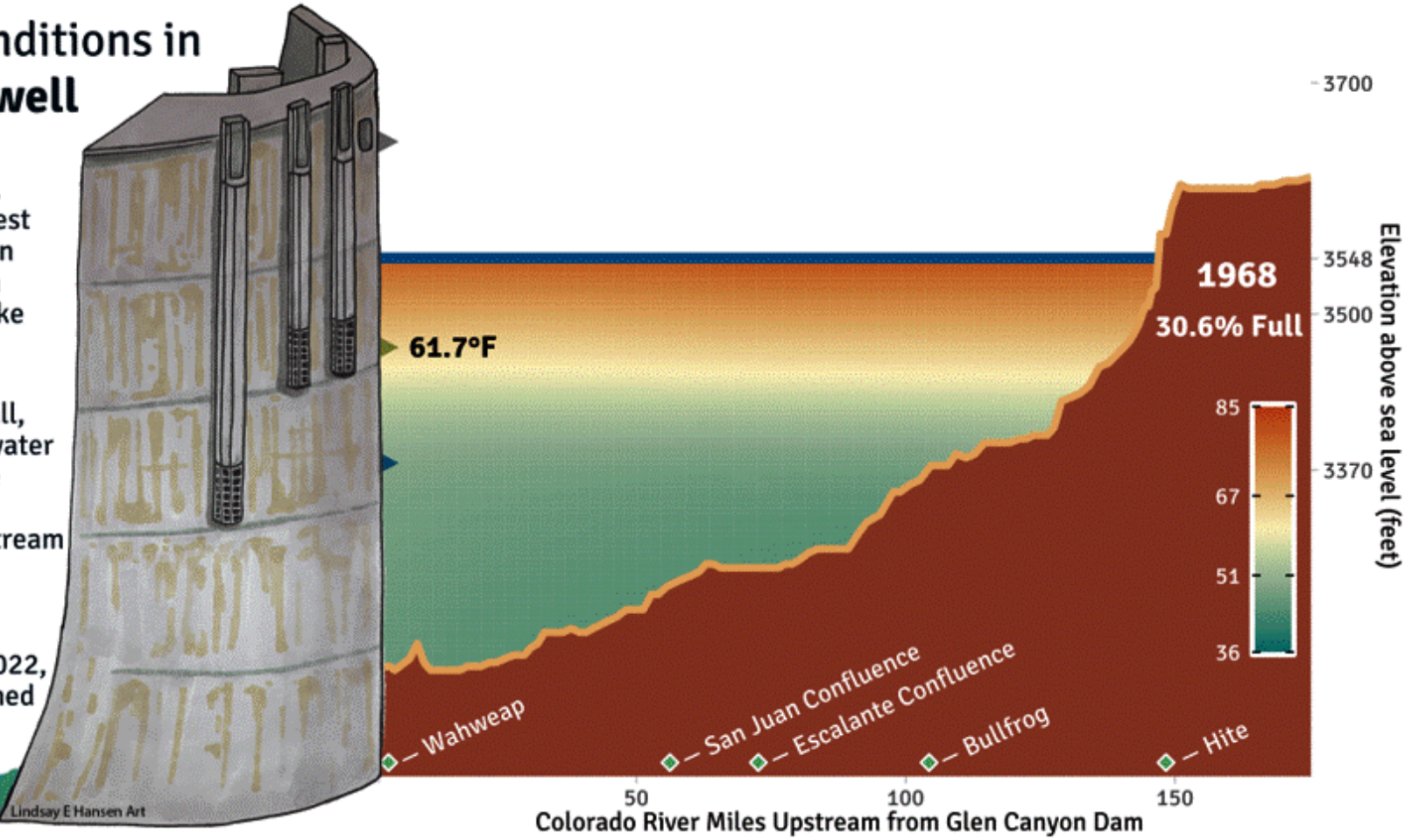
We are drawing increasingly from the reservoir surface waters

Summer Conditions in Lake Powell

In the late summer, there are the greatest differences between surface and bottom temperatures in Lake Powell.

When lake levels fall, the warm surface water moves closer to the power intakes that move water downstream to the Colorado River.

In the summer of 2022, temperatures reached their warmest in 50 years.

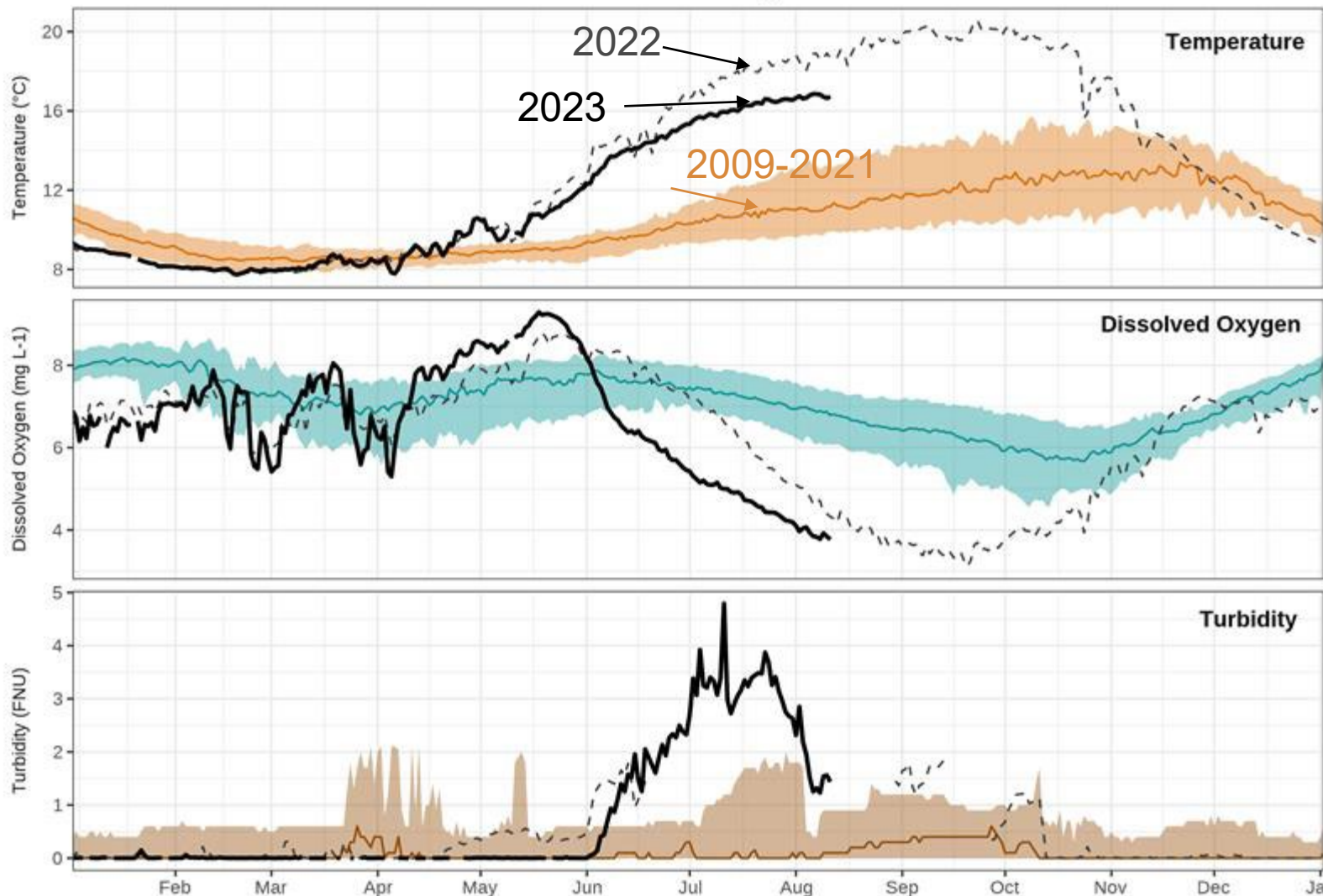


Data from the the Lake Powell Water Quality Database (doi.org/10.5066/P9ZIKVYW)
Chart by C.M. Andrews and B.R. Deemer



Preliminary Information- Subject to Revision. Not for Citation or Distribution

Water Quality Conditions Immediately Below Glen Canyon Dam

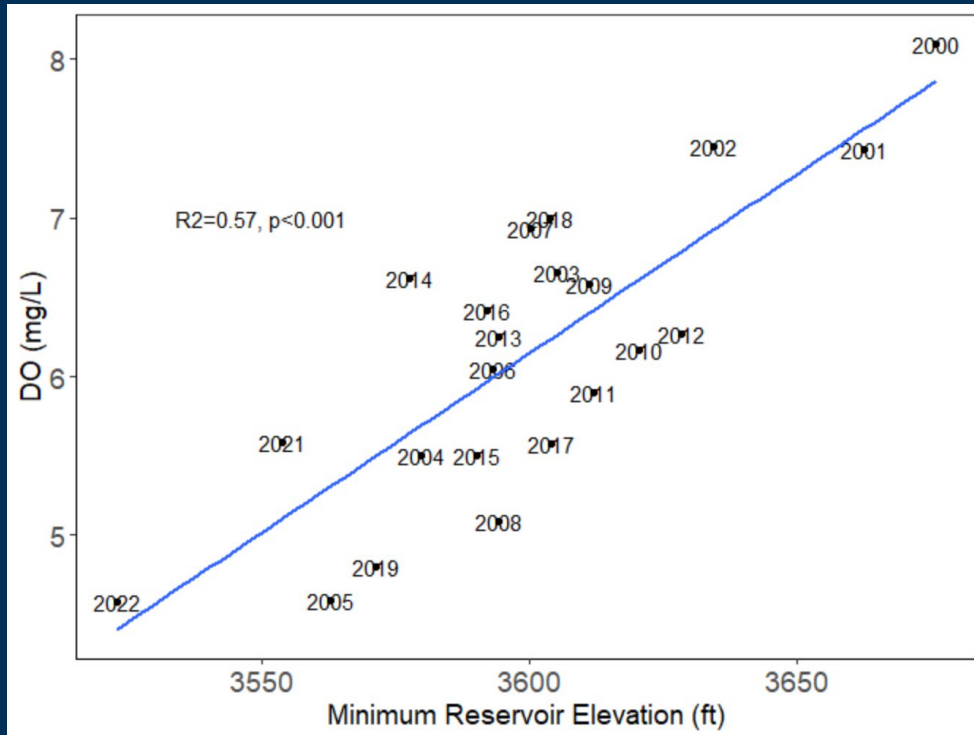


The colored lines and shaded regions depict daily trends from 2009 to 2021 as the 10th, 50th, and 90th quantiles. The thick blank line represents this years data and the dashed line, 2022. Data collected after 06/01/2023 is provisional.



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Deltaic Sediment Remobilization: low DO events



- Spring inflows in May and June mobilize deltaic sediment
- Lake-wide low dissolved oxygen events will be increasingly common when lake elevation is below ~3620 feet

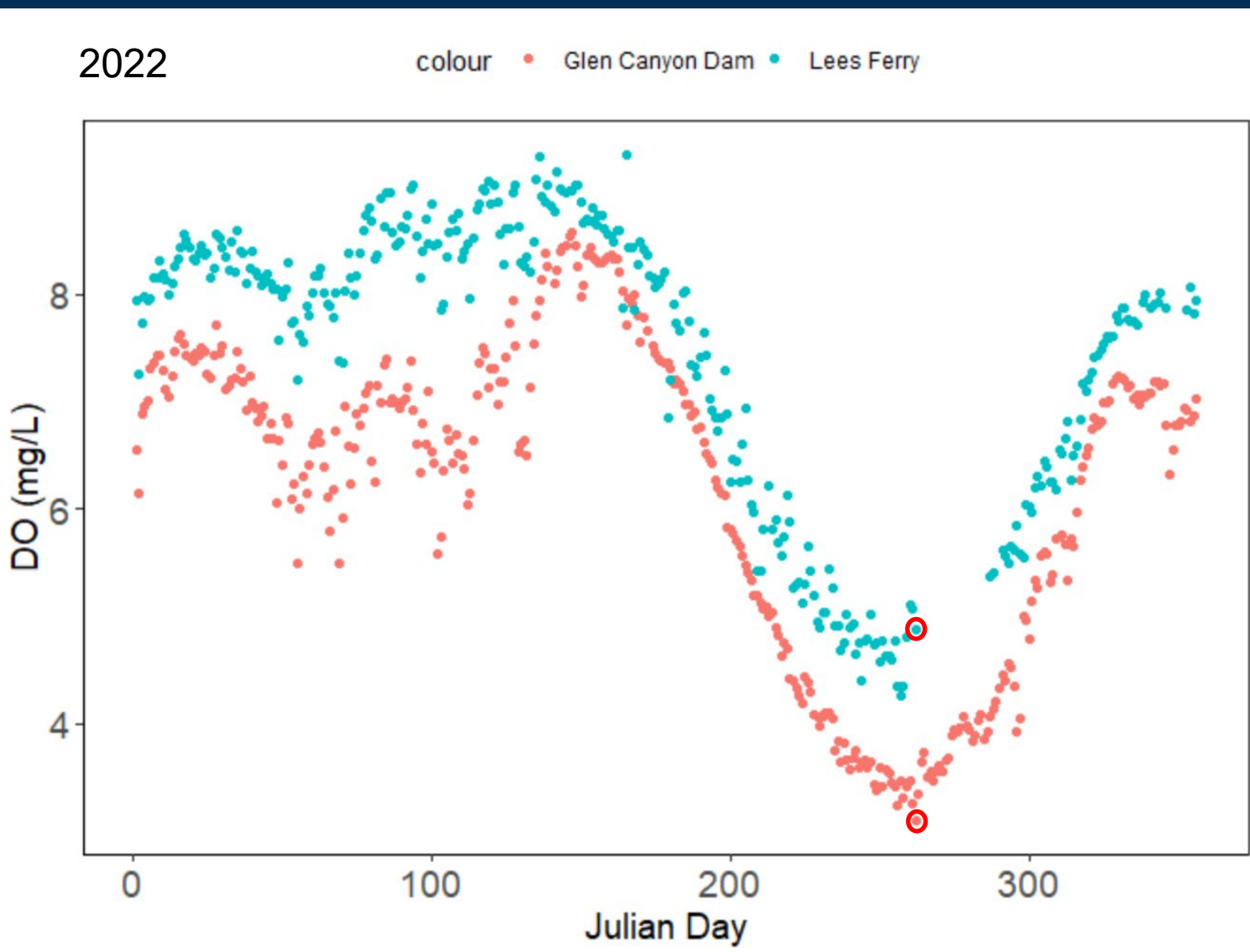
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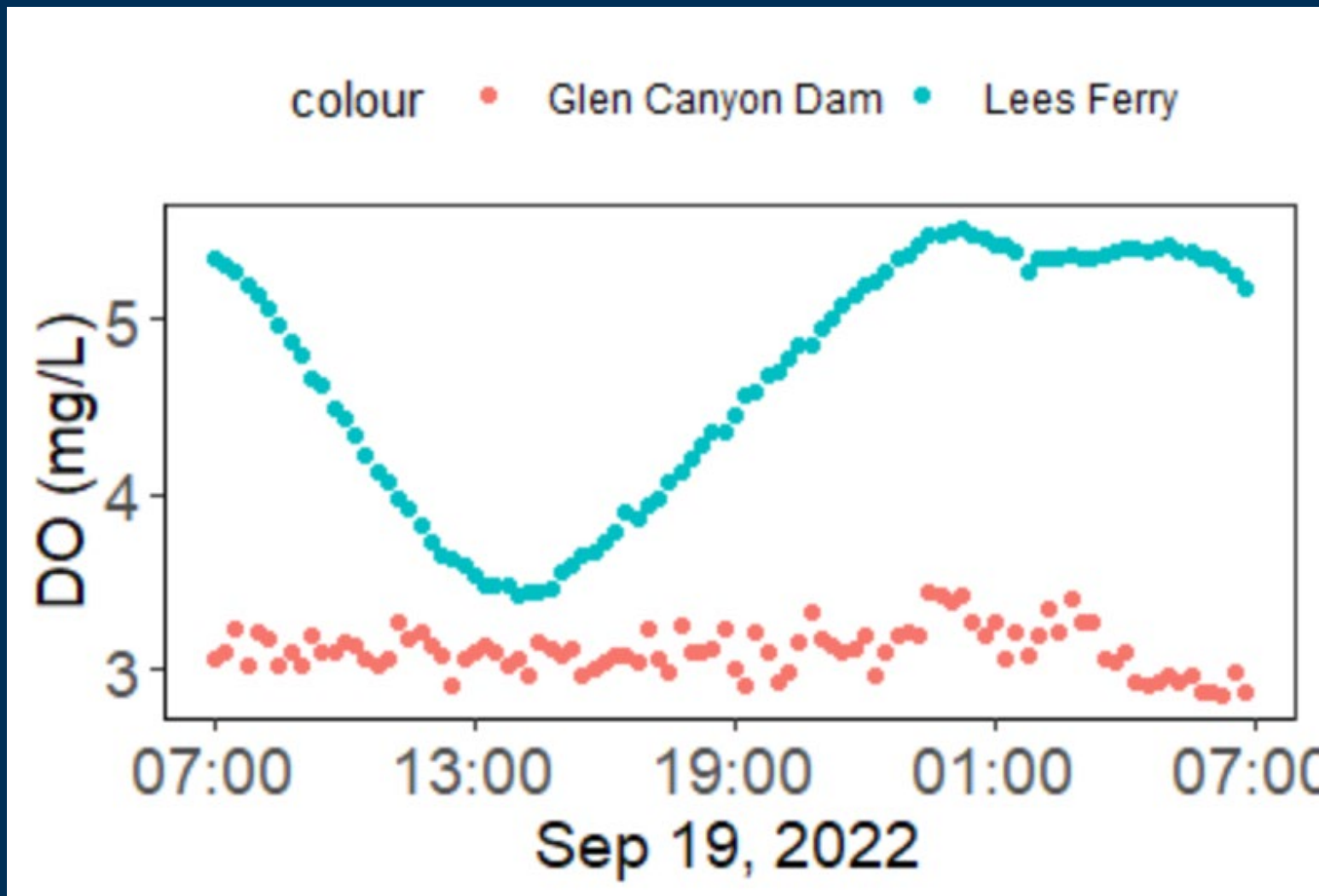
View from Highway 95 Near Hite Marina March 2002 (left) and March 2003 (right). Photos by John Dohrenwend

Low Dissolved Oxygen Will Have Largest Impact on Trout Near Dam

Daily average DO ~1 mg/L higher at Lees Ferry than at Dam



DO Departure Largest During Day



What does this mean for the Glen Canyon Tailwater?

Distributions	<i>n</i>	<i>Sp</i>	Median toxicity value
Lotic invertebrates	27	17	2.40
Lentic invertebrates	8	4	2.06
Lotic and lentic invertebrates	48	31	1.53
All acute invertebrates	83	52	1.99
Post-1986 invertebrates	8	6	0.93
Pre-1986 invertebrates	75	47	2.20
Chronic invertebrate LC ₅₀	5	5	4.5
Warm water fish EC ₁₀	5	4	5.00
Cold water fish EC ₁₀	16	7	5.20
Warm water fish EC ₅₀	5	4	1.38
Cold water fish EC ₅₀	16	7	2.26
Warm and cold water fish LC ₅₀	13	9	1.59
EPT taxa	62	38	2.66
None EPT taxa	21	14	0.96
All fish and invertebrate LC ₅₀	96	61	1.82

Red box shows where we are already below published literature median toxicity values

LC50- concentration that is lethal to 50% of test population w/ 96 hr. acute exposure

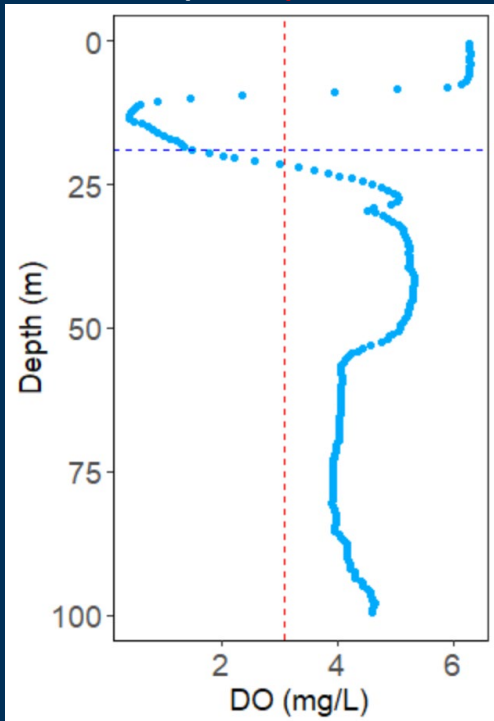
EC10- concentration that has a 10% effect on growth or reproductive effect w/ 96+ hours chronic exposure

What can be done?

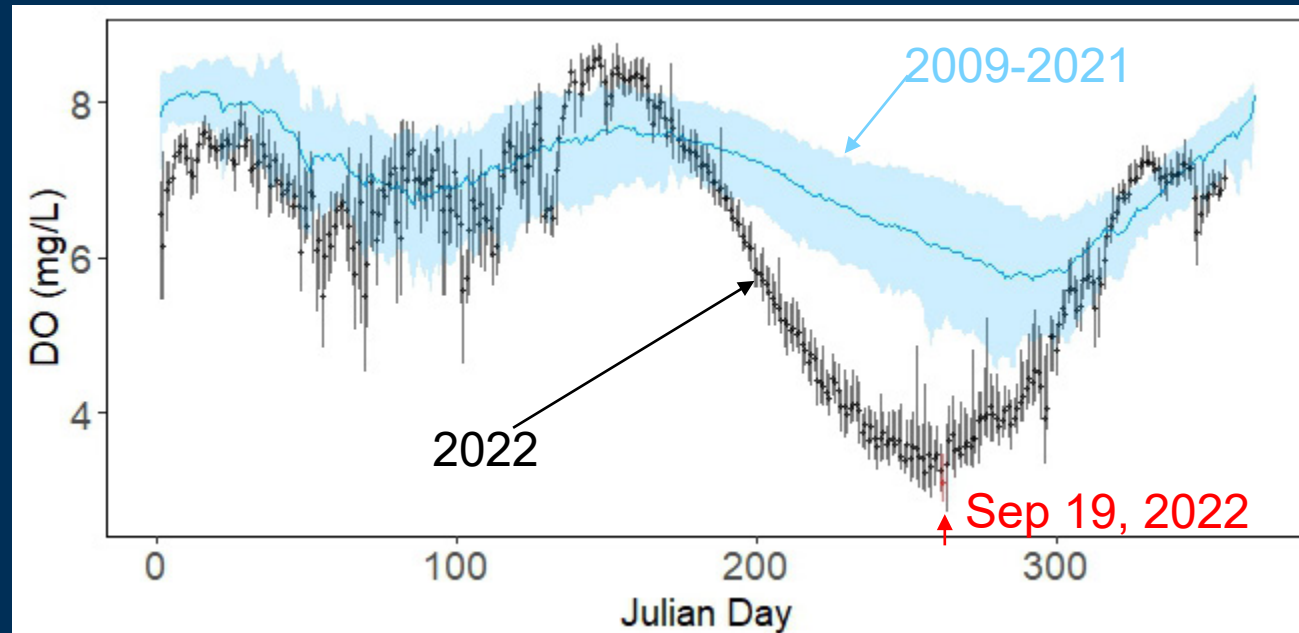
- An unknown source of oxygen mixed ~1 mg/L into fall 2022 releases
- Could air be drawn in below turbines to increase mixing?



Wahweap, Sep 19, 2022

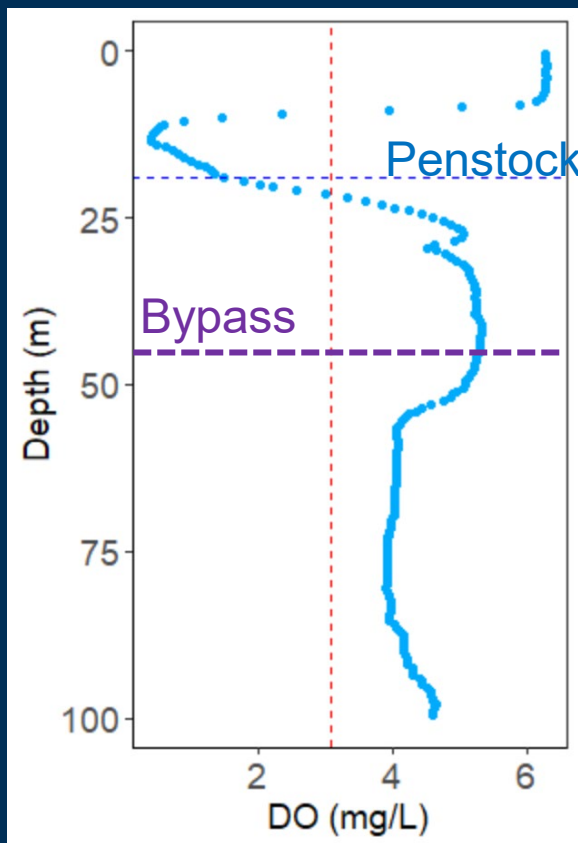


Below Glen Canyon Dam



What can be done?

Wahweap Profile from 9/19/22



Bypass would elevate dissolved oxygen by:

1. drawing from deeper down where oxygen concentrations are higher
2. physically aerating the water as it is released

Effects of the 2008 High-Flow Experiment on Water Quality in Lake Powell and Glen Canyon Dam Releases, Utah-Arizona



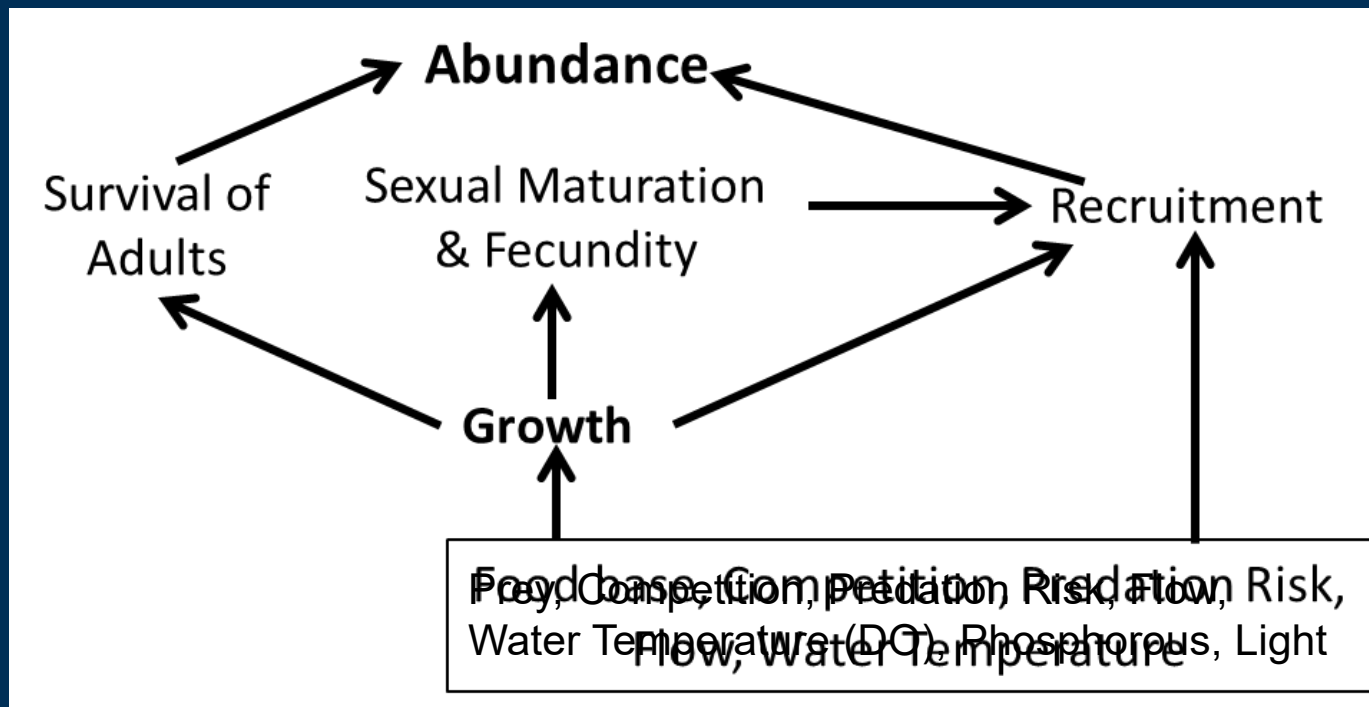
Open-File Report 2010-1159



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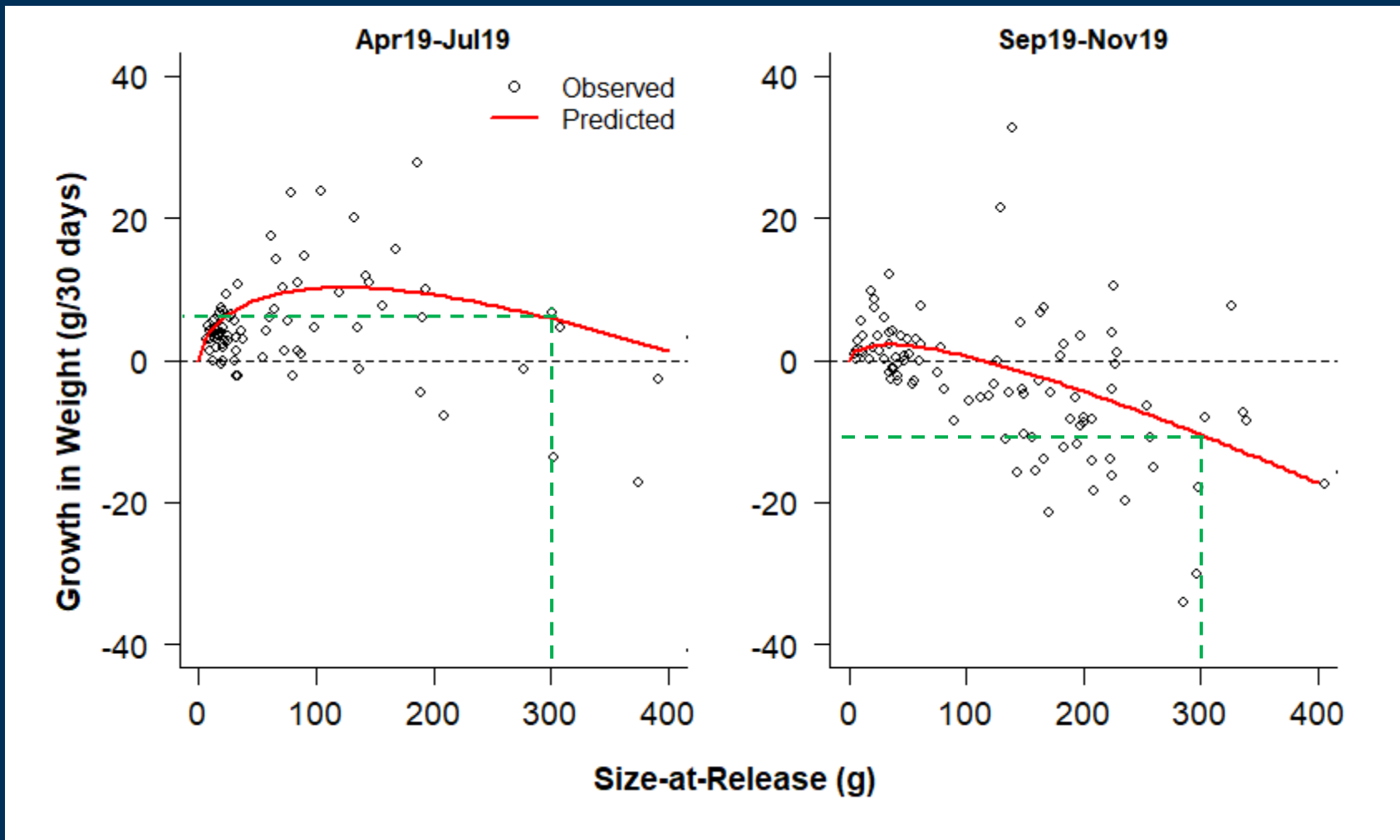
Chronic Effects of Temperature and Dissolved Oxygen on Growth of Rainbow Trout

Growth is an important determinant of abundance through effects on survival, maturation, and recruitment (it also effects the size of fish caught in the fishery)



Korman et al. 2021. Changes in prey, turbidity, and competition reduce somatic growth and cause the collapse of a fish population. *Ecological Monographs*.

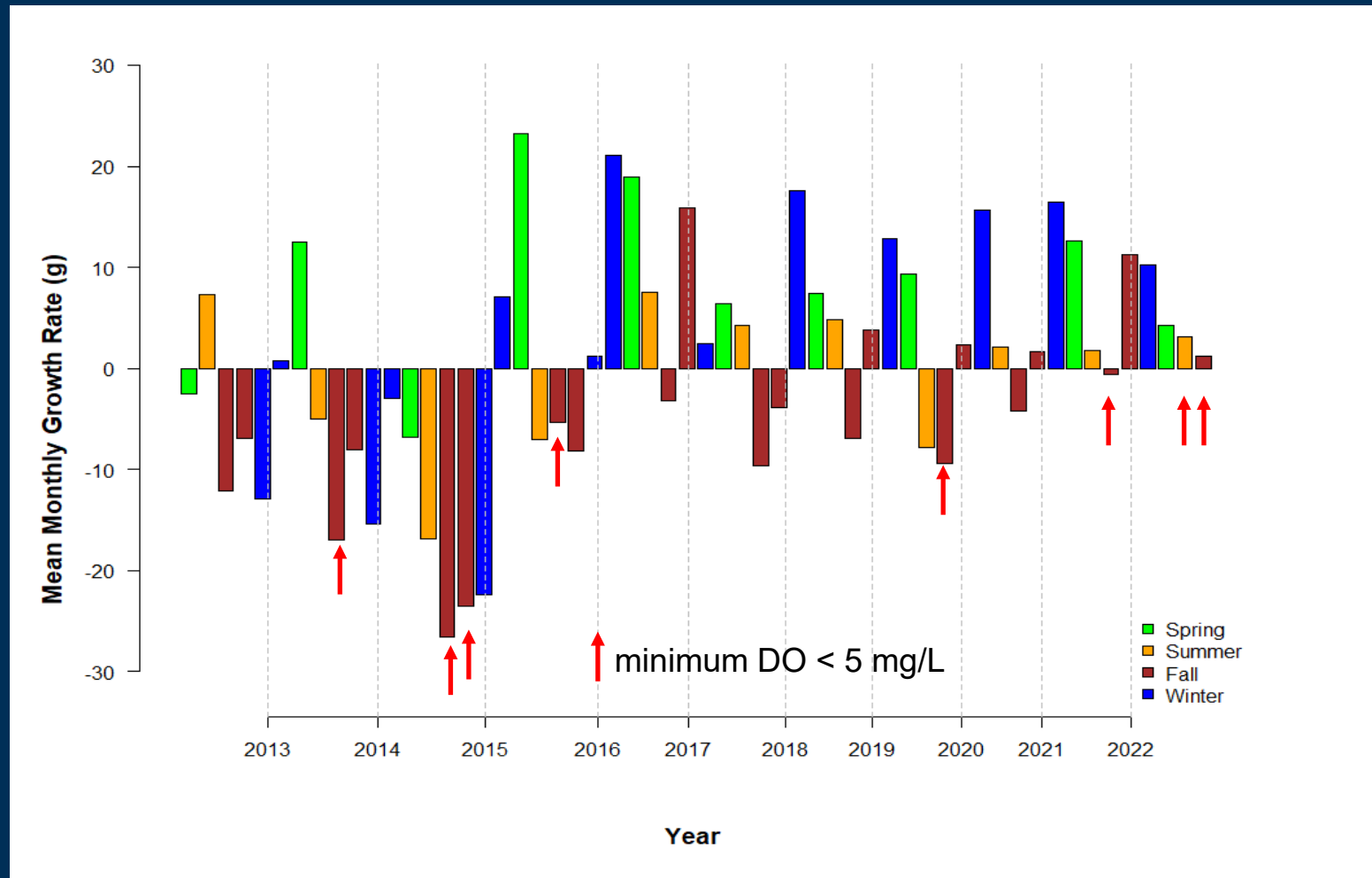
Mark-Recapture (TRGD* program) Provides Direct Observations of Growth in Length and Weight



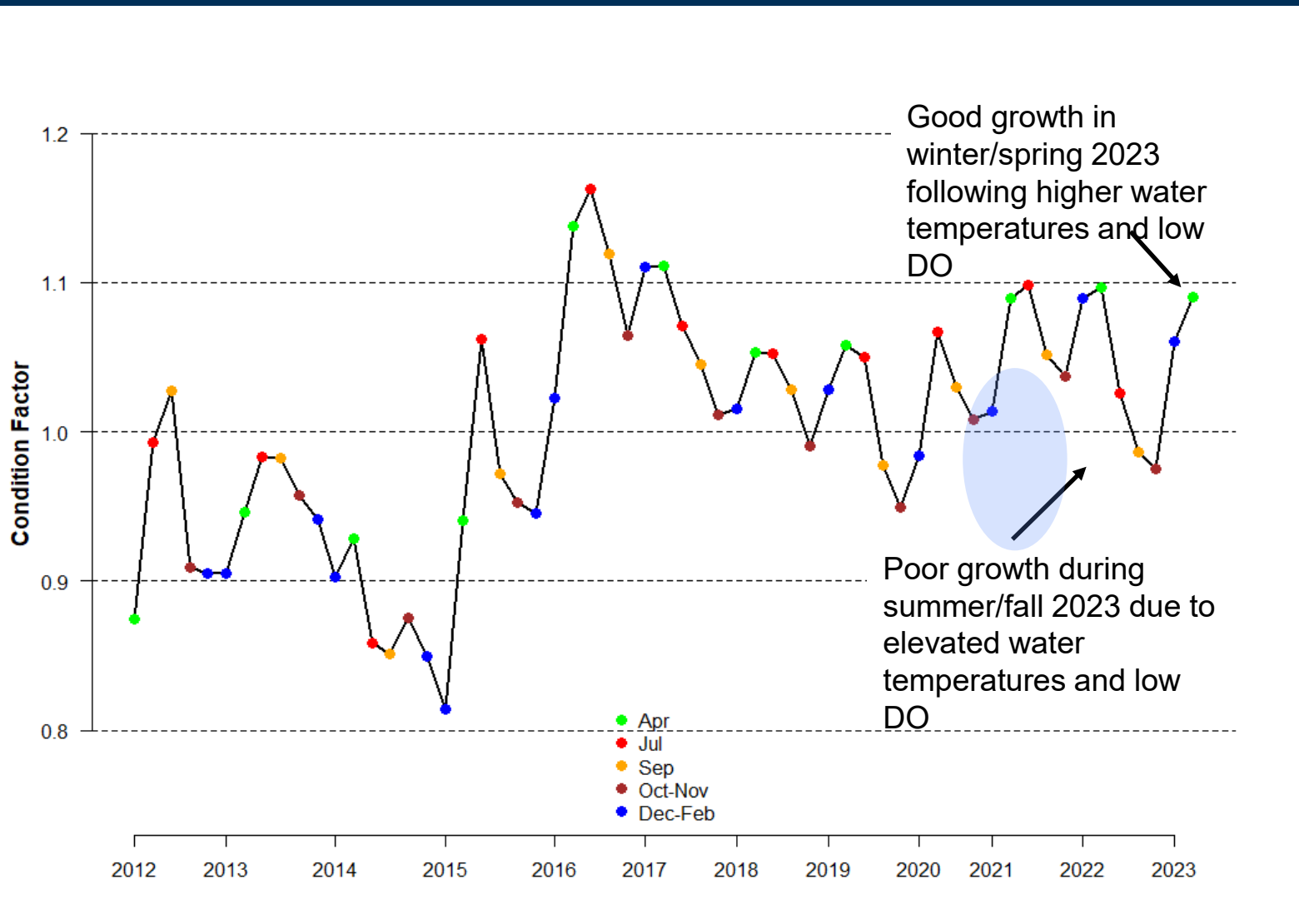
*TRGD= Trout Recruitment and Growth Dynamics

Considerable Seasonal and Interannual Variation in Growth

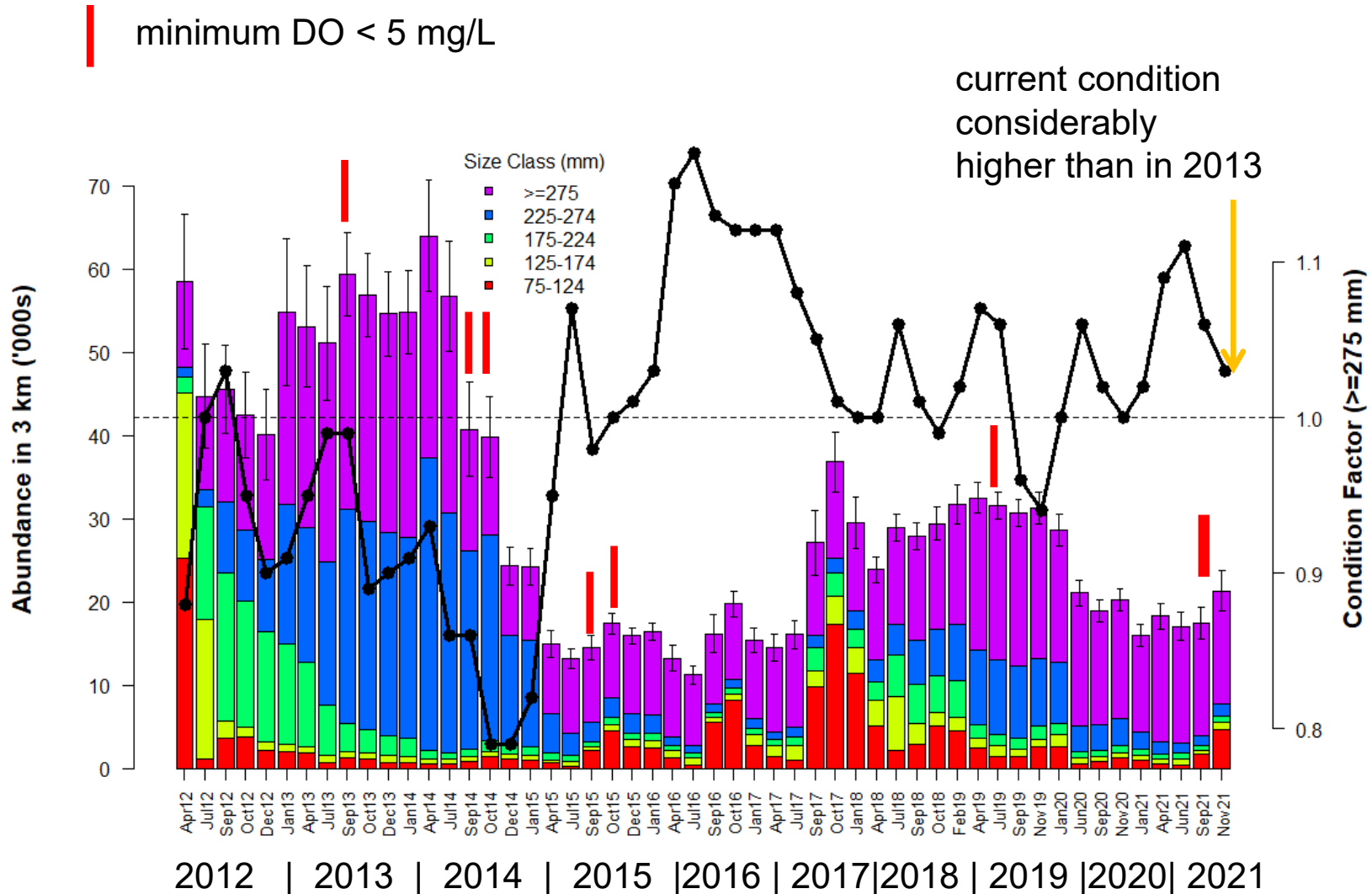
Model needed to separate Temperature/DO and other effects



Condition Factor of Rainbow Trout



Current Rainbow Population is Dominated by Larger Fish that are More Sensitive to Temperature Increases, but their Condition is Good



Summary

- **Multiple factors determine growth rates and resulting condition factor trends: Competition, prey availability, temperature/DO**
- **Condition of fish prior to entering high temp/low DO period an important determinant of die-off potential**
- **Current Rainbow Trout population has low abundance and dominated by larger/older fish which are in relatively good condition**
- **Population is currently in good shape to weather chronic temperature / DO impacts on growth**
 - **Condition factor is high, densities are low**
- **Population is in poor shape to weather an acute DO mortality event**
 - **Owing to limited recruitment (new births) since 2018, current population is dominated by older/larger fish which are more sensitive to high water temperatures and low dissolved oxygen**
 - **Few young and small fish, with lower temperature/DO sensitivity, are present to grow into larger size classes that support the fishery**
 - **Recovery of catch rates in fishery from 2014 collapse took 4-5 years**
 - **Previous recoveries from population collapses in 2006 and 2014 occurred during periods when brown trout abundance was much lower**