



Metalimnion low dissolved oxygen events in Lake Powell and their transport downstream of Glen Canyon Dam

Bridget Deemer

TWG Meeting 24 June

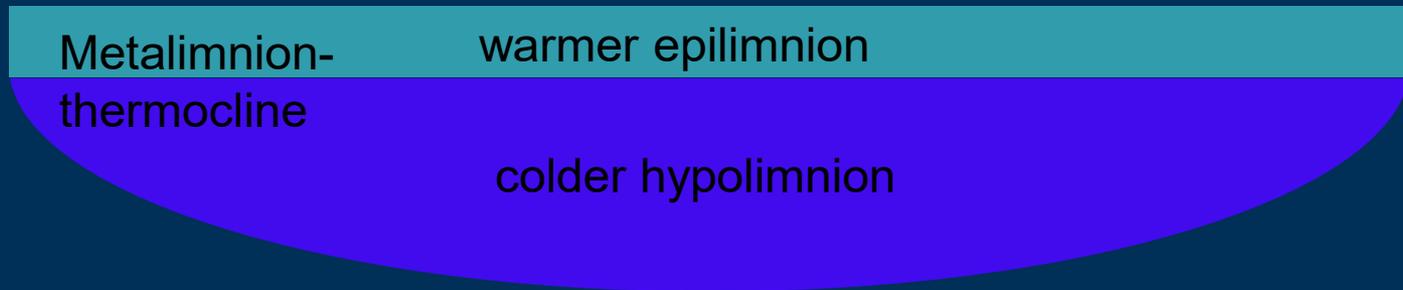
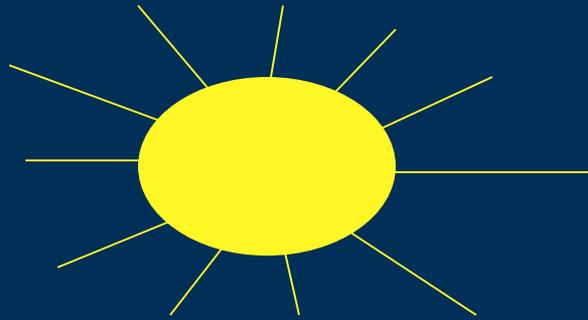
2020

Grand Canyon Monitoring and Research Center
Southwest Biological Science Center
U.S. Department of the Interior
U.S. Geological Survey

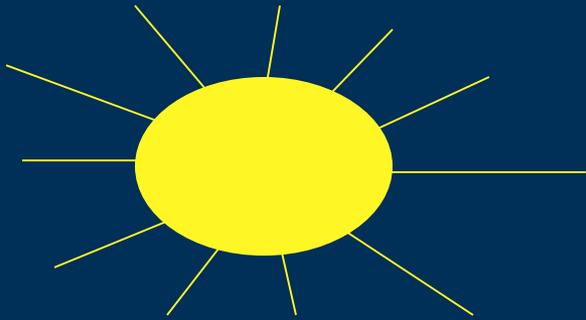
Outline

- Background
- Low DO Events in Lake Powell
- Current Predictive Capacity
- Ongoing Work

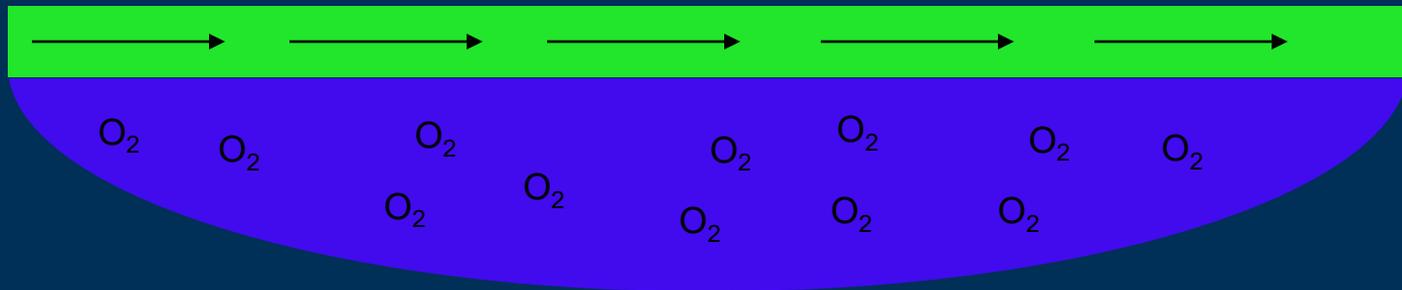
Factors controlling dissolved oxygen in lake and reservoir bottom waters



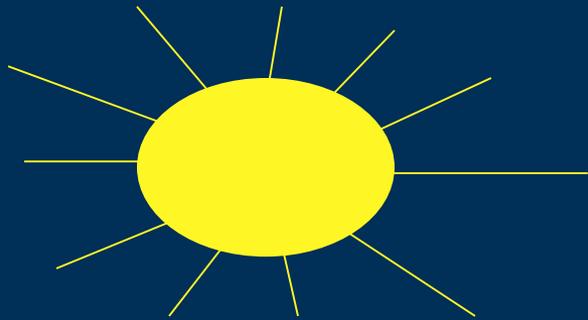
Factors controlling dissolved oxygen in lake and reservoir bottom waters, cont.



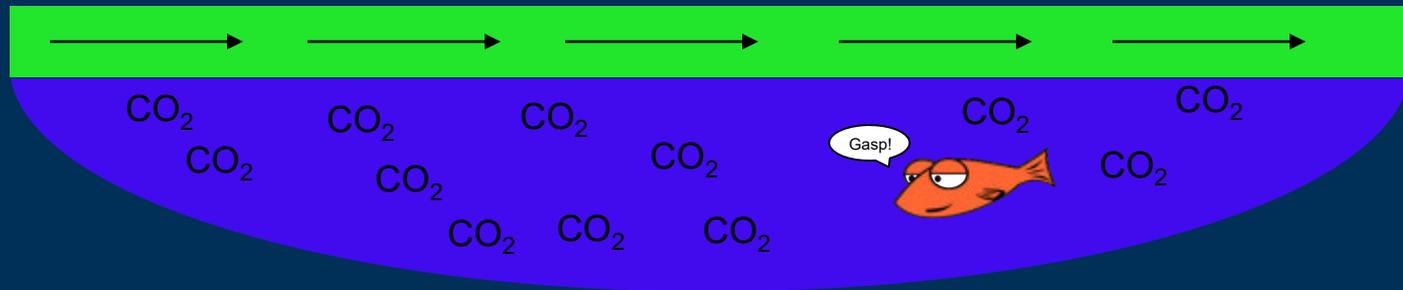
Nutrient loading from inlet water supports primary production



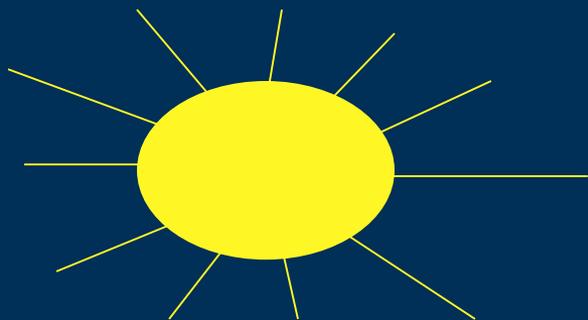
Factors controlling dissolved oxygen in lake and reservoir bottom waters, , cont. 2



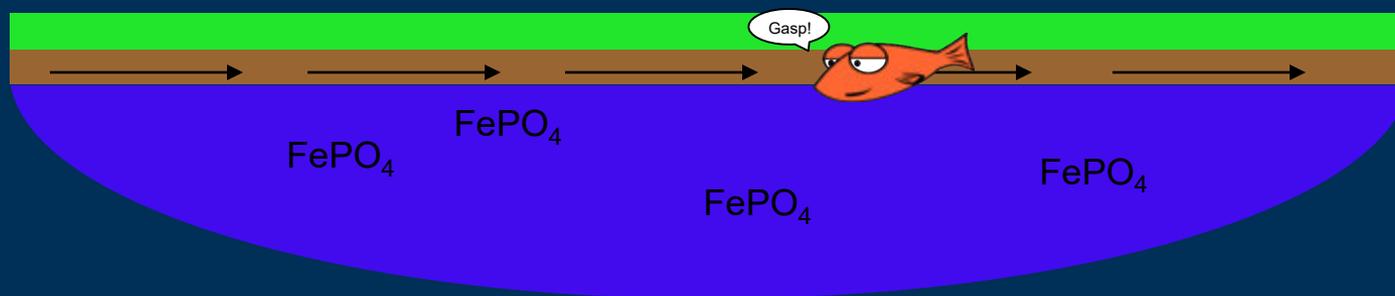
Heterotrophic respiration of decaying organic matter creates anoxic conditions in the hypolimnion



Factors controlling dissolved oxygen in lake and reservoir bottom waters, , cont. 3

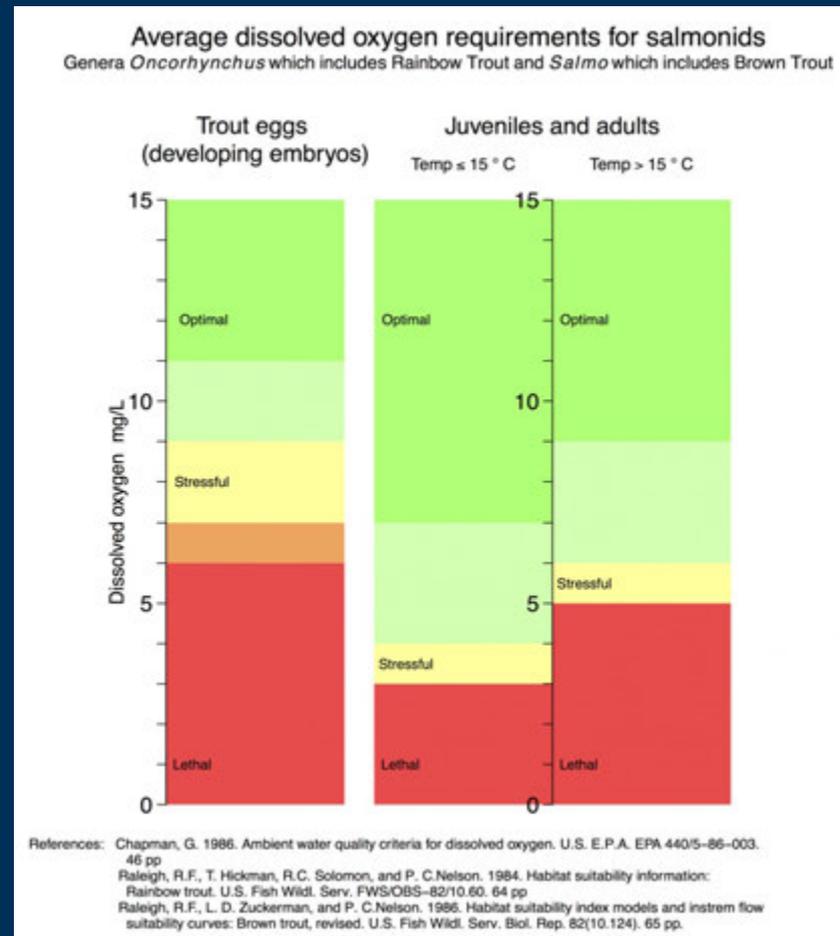


Chemical oxygen demand can consume dissolved oxygen as suspended sediments undergo oxidation

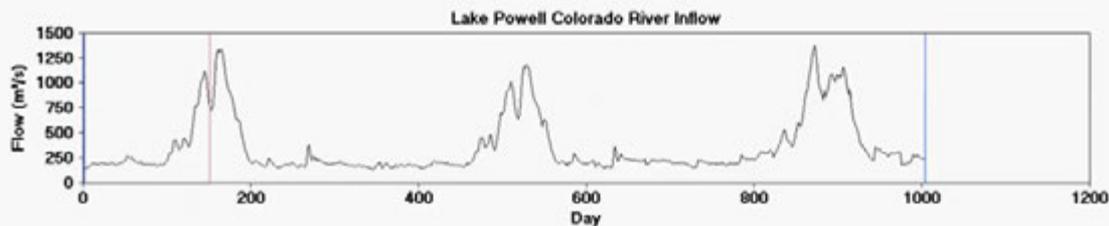
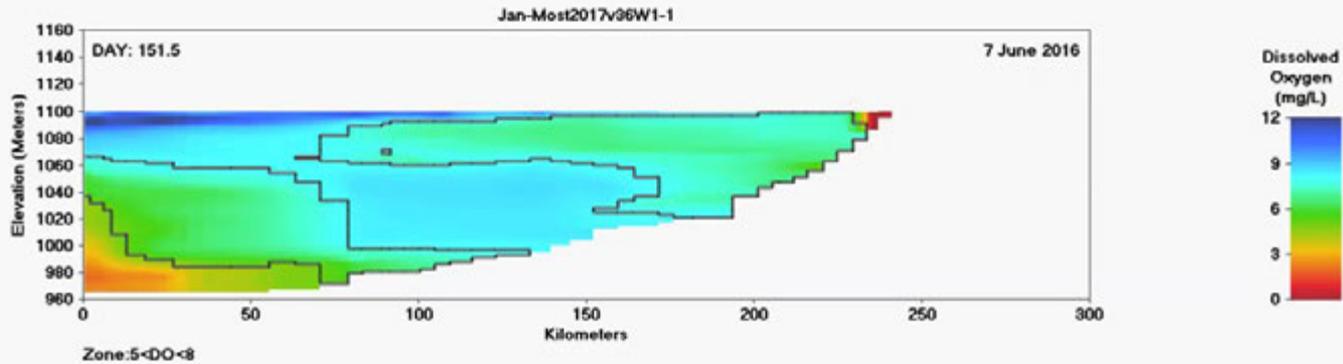


Dissolved oxygen and trout

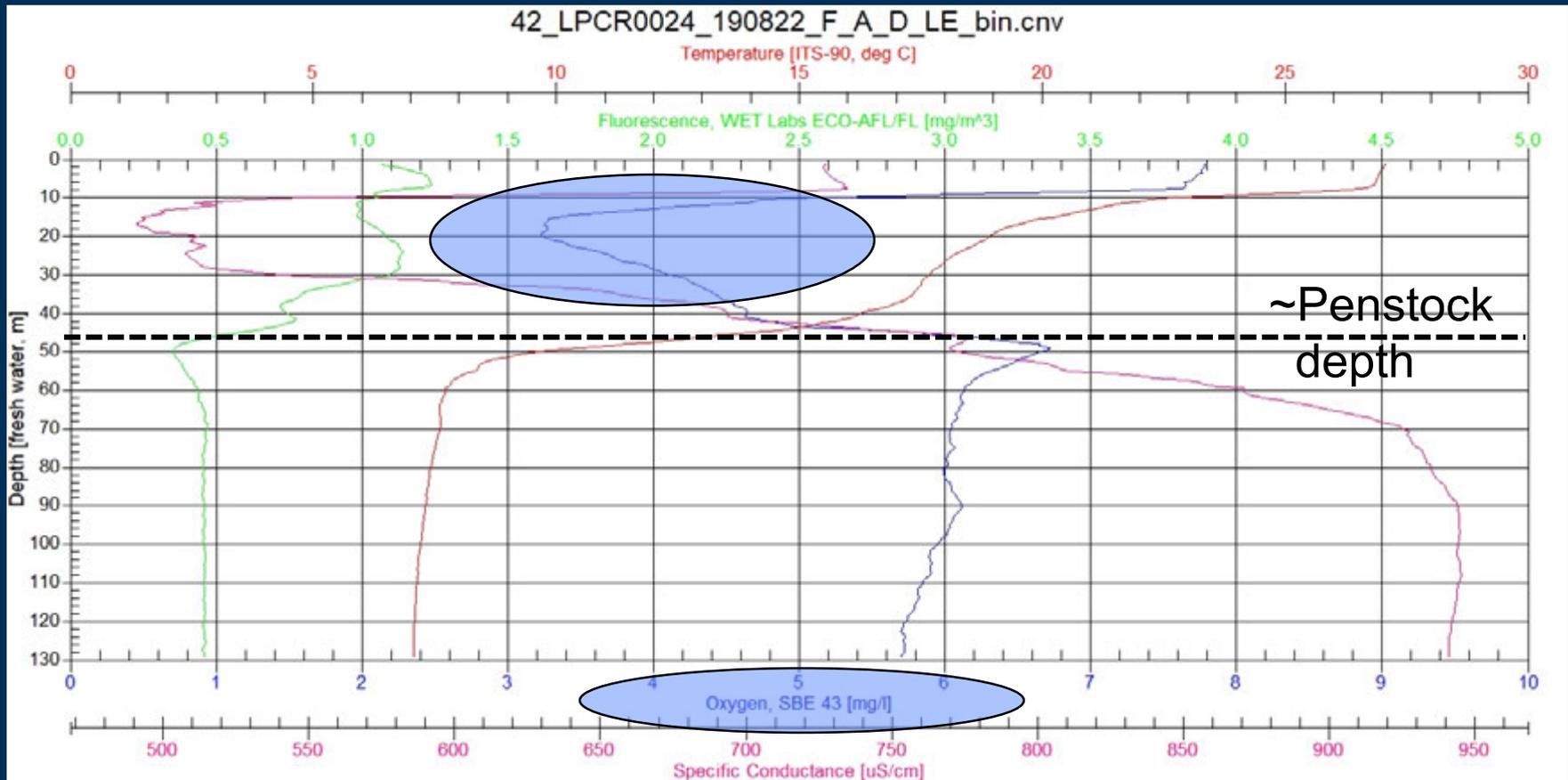
- Temps <15C
 - DO can be lethal if <3 mg/L
- Temps >15C
 - DO can be lethal if <5 mg/L



Advection carries low DO from zones of high production/sediment to Glen Canyon Dam



Lake Powell—August 22, 2019

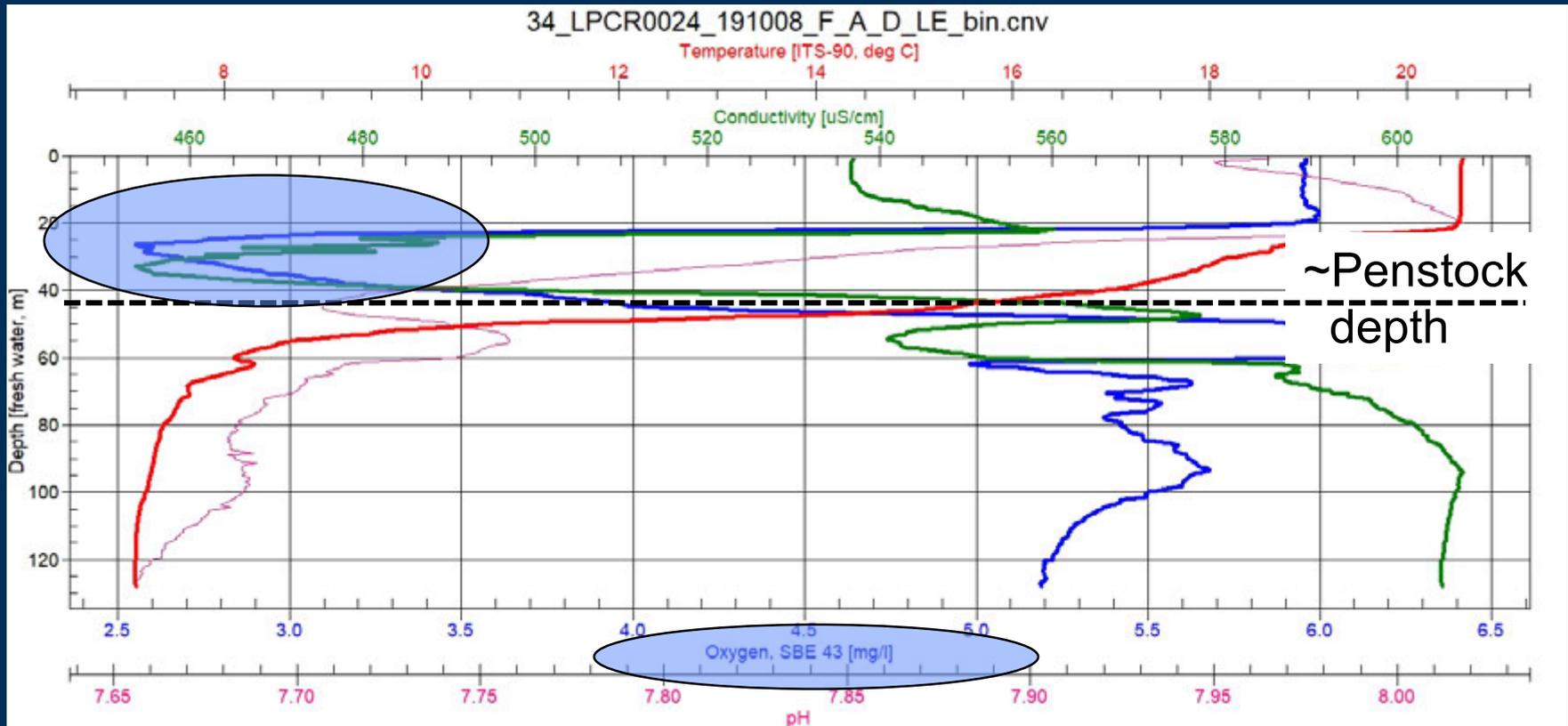


Pocket of low dissolved oxygen water above penstocks (minimum DO = 3.2 mg/L)



Unpublished data, subject to change, do not cite.

Lake Powell—October 8, 2019



Unpublished data, subject to change, do not cite.

Pocket of low dissolved oxygen water above penstocks (minimum DO = 2.6 mg/L)

Events typically occur in fall and are improved by mixing

As of 11 Oct 2019

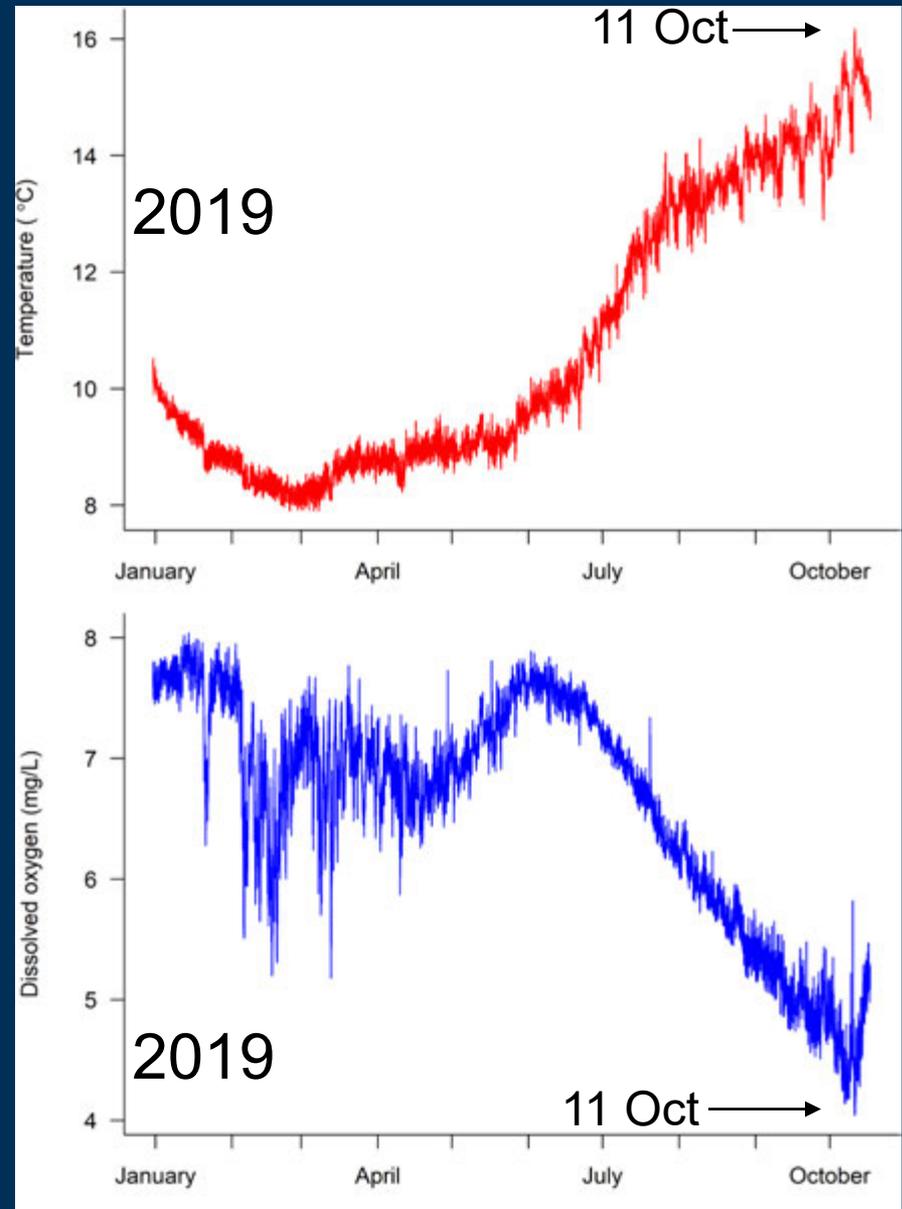
Lake was mixing

- Temperatures falling
- Oxygen rising

Graph showing temperature and dissolved oxygen for Colorado River below Glen Canyon Dam



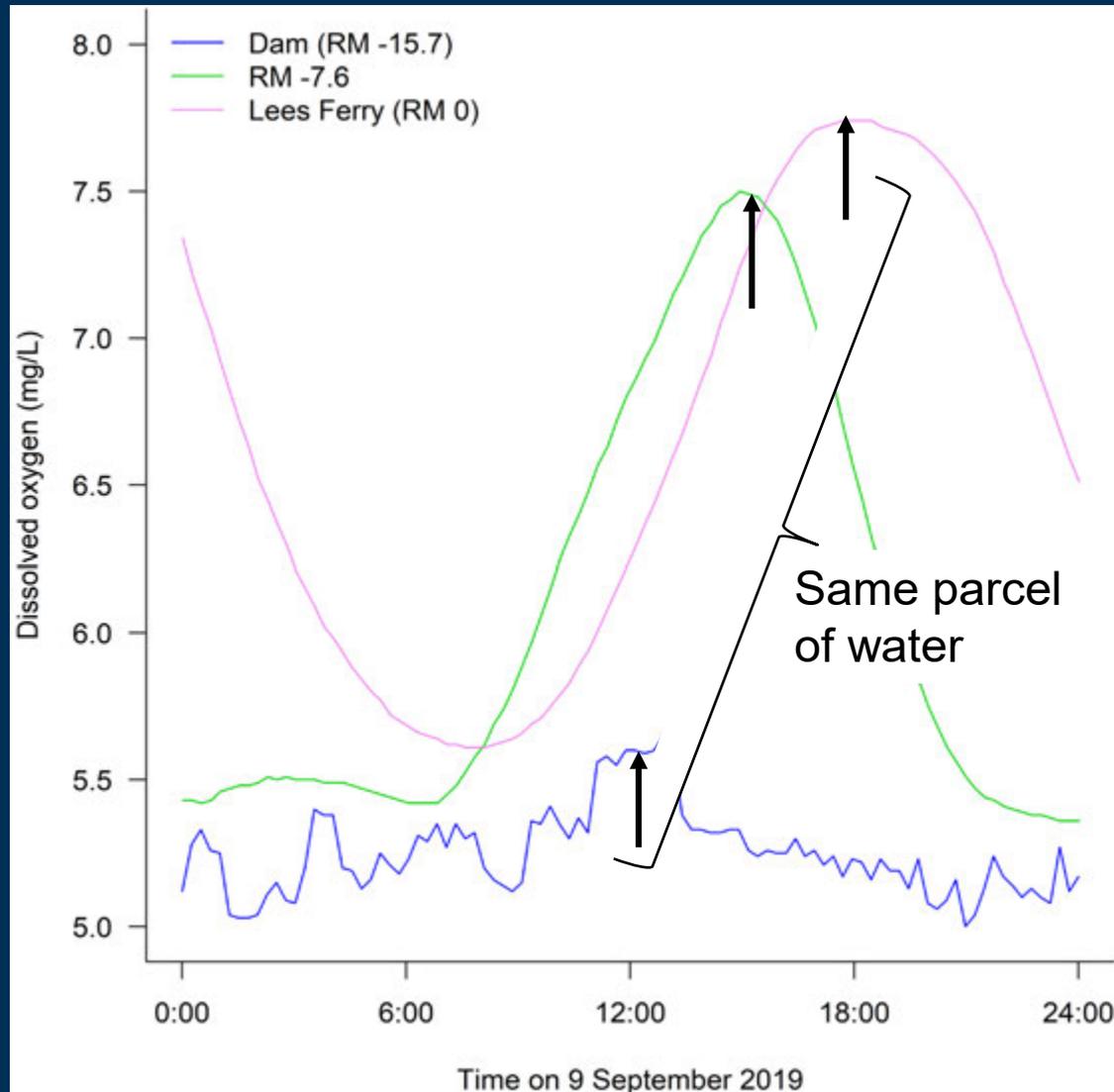
Unpublished data, subject to change, do not cite.



Slide modified from Ted Kennedy

Dissolved oxygen increases downstream

- Increase in maximum DO mostly owing to algae
- Rule of thumb: Air-water gas exchange increases DO in Lees Ferry by ~ 0.04 mg/mile (Hall et al. 2012)



Unpublished data, subject to change, do not cite.

Slide modified from Ted Kennedy

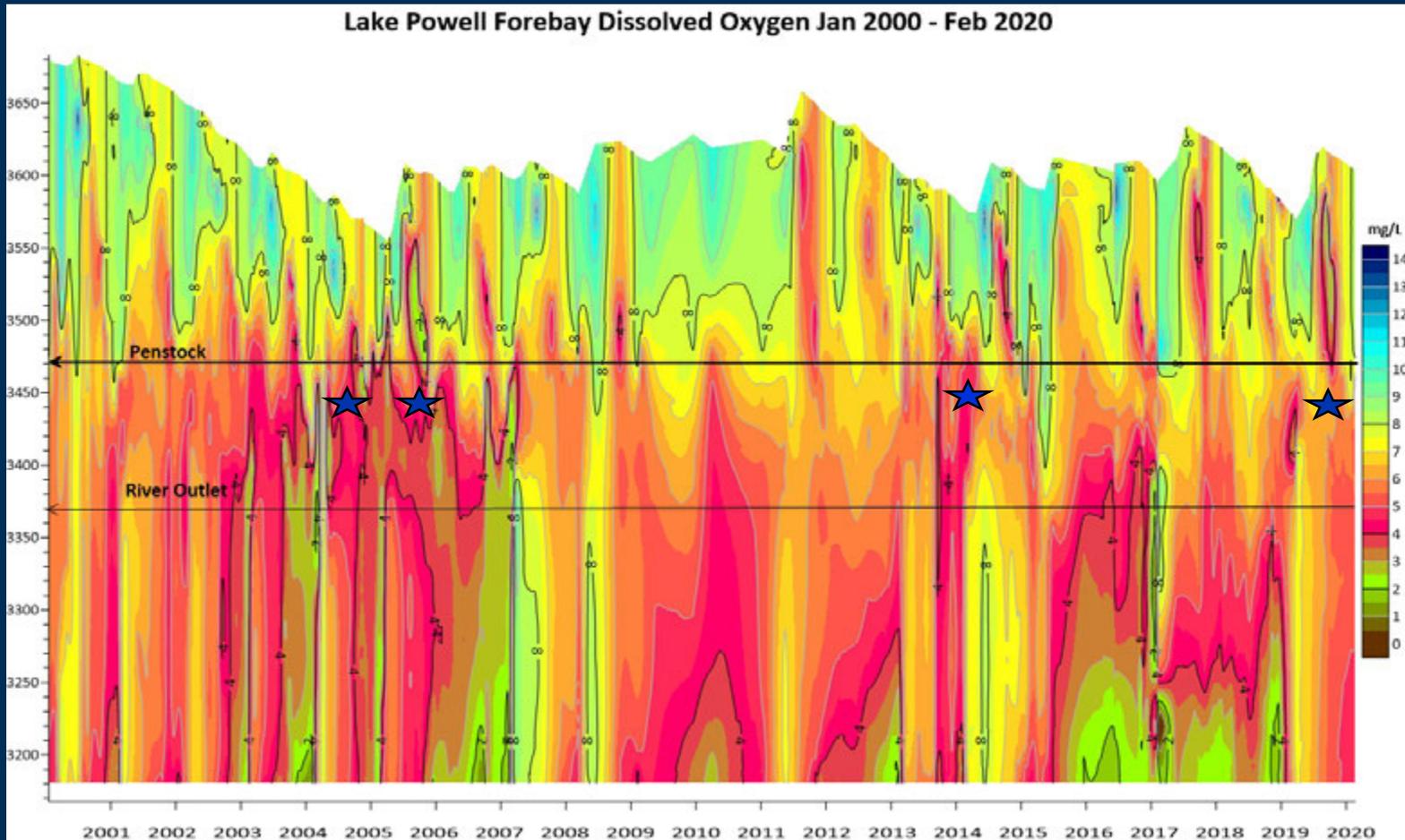
Summary of Low DO Affecting Downstream River in GCD System

- Several instances where low dissolved oxygen water reached the reservoir outflow causing concern for the GCD reach
 - 2003
 - 2005
 - 2014
 - 2019

Water Quality Knowledge Assessment

- Team: Bridget Deemer, Peggy Roefer, Todd Tietjen, Robert Radtke, Charles Yackulic
- Status and Trends:
 - **SIGNIFICANT CONCERN**, UNKNOWN TREND: GCD outflow temperature and dissolved oxygen in support of Rainbow Trout
 - **GOOD CONDITION**, INCREASING TREND: GCD outflow temperature in support of Humpback Chub
 - **SIGNIFICANT CONCERN**, UNKNOWN TREND: GCD outflow phosphorus concentrations in support of ecosystem productivity

Lake Powell Dissolved Oxygen (2000-2020)



Current Predictive Capacity

- DO module for CE-QUAL-W2 can predict low DO events, but does not always predict the concentrations at penstock height accurately
- We know these events are most likely to occur when the reservoir is low and we have a high inflow year
- Quarterly whole-lake trips and monthly trips to Lake Powell give us an idea of when a low DO event may be likely to reach the penstock depth

Sonde Directly Below Dam

- Data from 2015 forward available on the GCMRC Data Portal
- Nick Voichick is working to QA/QC back years

The screenshot shows the USGS data portal interface for the Glen Canyon Dam near Page, AZ. The page features a navigation menu on the left, a main content area with a 'Parameter Availability' section, a 'Date Range' selection tool, and a 'Location' map. The 'Parameter Availability' section lists four categories: Water Temperature, Specific Conductance, Dissolved Oxygen, and Turbidity, each with a list of available data ranges and units. The 'Date Range' section includes input fields for 'Start' and 'End' dates, both set to 2020-05-08 and 2020-06-08 respectively, and buttons for 'Build Graph' and 'Download'. The 'Location' section shows a photograph of the dam and a map with a red pin indicating the sonde location. The 'Additional Information' section at the bottom right provides details about the data source and a link to find data in NWS.

USGS
science for a changing world

Grand Canyon Monitoring and Research Center

Glen Canyon Dam near Page, AZ 09379901

Home > Discharge, Sediment and Water Quality > Grand Canyon Stations > 09379901

Parameter Availability

- Water Temperature**
 - degrees celsius (°C)
 - 1988-06-10 to 2020-06-08
- Specific Conductance**
 - microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C)
 - 2014-11-06 to 2020-06-08
- Dissolved Oxygen**
 - milligrams per liter (mg/L)
 - 2015-07-01 to 2020-06-08
- Turbidity**
 - formazin nephelometric units (FNU)
 - 2015-10-07 to 2020-06-08

Date Range

Start: 2020-05-08

End: 2020-06-08

Build Graph Download

Location

Data

To visualize data in a graph, please select parameters from the left as well as a date range from above.

Additional Information

Data provided by:

- USGS** Grand Canyon Monitoring and Research Center
- Find data for this site in NWS

Current Progress in Realtime Sonde Connectivity

- Sonde at Lees Ferry currently transmitting data to Amazon Web Services
- Goal is to have data transmitting from the sonde directly below GCD soon
 - Tim Andrews has sent an enclosure to BOR and is working with a duplicate to setup design
 - BOR will be upgrading electrical outlet and installing the enclosure that Tim sent
 - Final step will be attaching cellular antennae (1 or 2 site visits from USGS)

Dashboard / Account: gs-chs-sbse-iot (USGS)
Mile 0 YSI Water Quality Sensor
Dashboards

Current Water Turbidity [FNU]

Live Data

1.8
turbid

Current Dissolved Oxygen [mg\L]

Live Data

8.00
odo

Current Water Temperature [deg C]

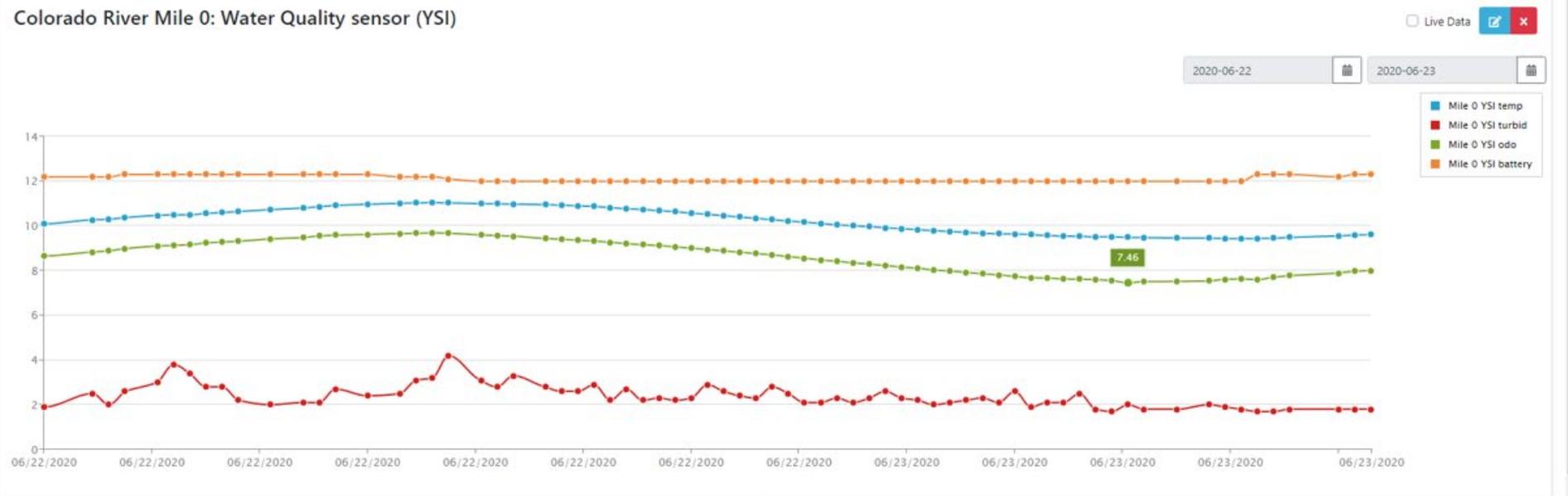
Live Data

9.61
temp

Current Specific Conductance [uS/cm]

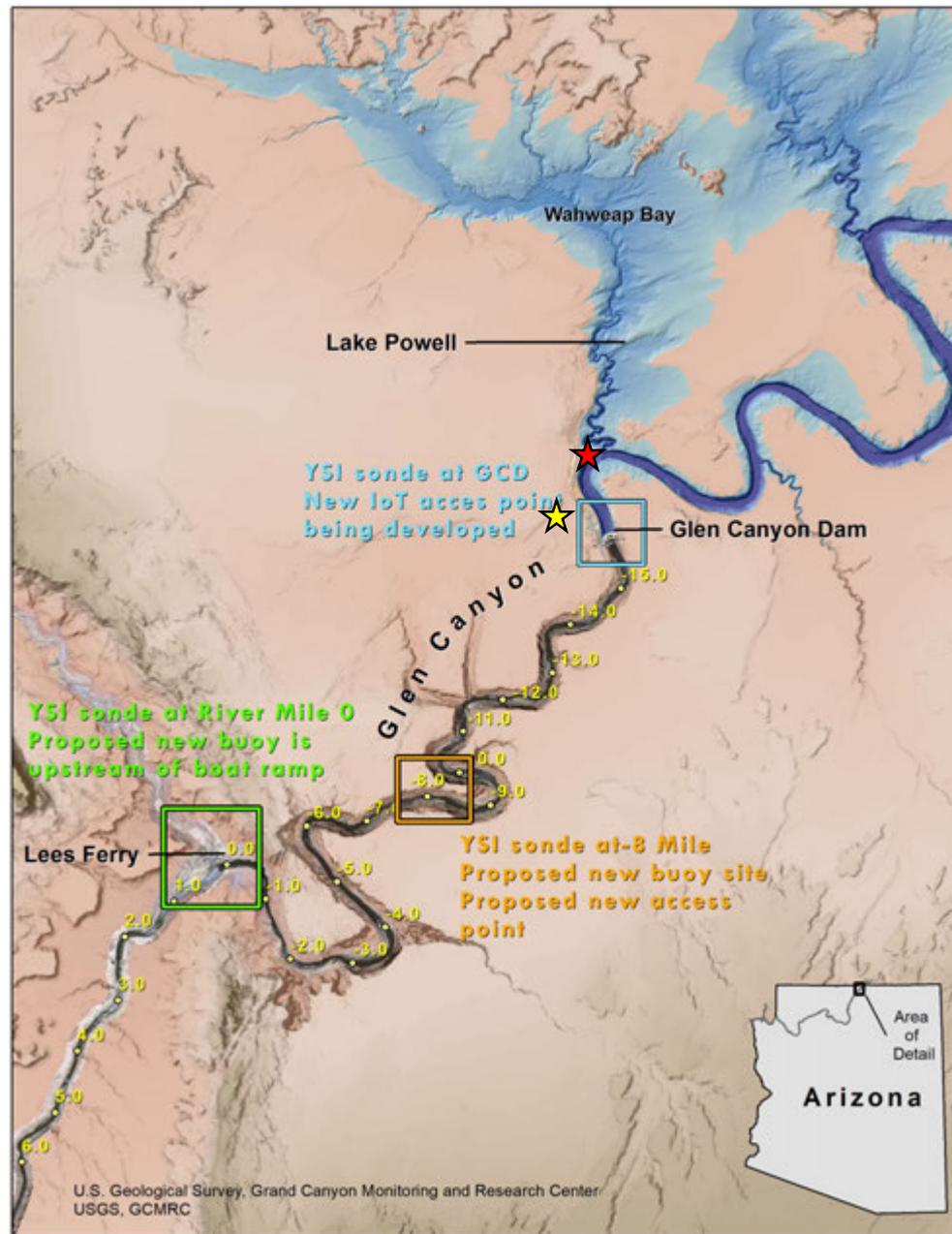
Live Data

686
spcond



Proposal in for USGS/NPS Water Quality Partnership Grant Program

- Modernizing water quality monitoring of the Colorado River in Glen Canyon, AZ
- Proposal would fund connectivity at 2 buoyed sites
- Technical Assistance Proposal
 - 1-2 year follow up potentially, up to \$150,000



Map Courtesy of Tom Gushue