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

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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

Metalimnion-thermocline

- Warmer epilimnion
- Colder hypolimnion
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.
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

*Unpublished data, subject to change, do not cite.*

*Slide courtesy of Ted Kennedy*
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Unpublished data, subject to change, do not cite.
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Unpublished data, subject to change, do not cite.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)

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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

USGS
Lake Powell Dissolved Oxygen (2000-2020)

Plot Courtesy of Robert Radtke
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
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)
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