Glen Canyon Dam
Adaptive Management Program

Brown Trout Workshop

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Tempe, Arizona
Risks
(potential and current)

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Outline

- **Caveats**
- Rainbow trout fishery
- Humpback chub
- Reassess
- Context
- Conclusions

“Well he certainly does a very thorough risk analysis.”
X-BOTEC analysis  eXtended Back Of The Envelope Calculation

- A simple approach that ignores some details (that may or may not be important).
- Spur discussion
- (potentially) Identify knowledge gaps
- Identify IF/what additional analyses are needed.
- Avoid the weeds.
Details ignored
(we’ll come back to these)

- Dynamics/non-linearities
- Other drivers (e.g., temperature)
- Early life stages – for rainbow and brown trout,
  - Anglers mainly care about adults.
  - Adults primarily eat juvenile humpback chub.
- Heterogeneity in capture probability
Break a big question into its parts
– easier to answer little questions
– reassess big questions at end
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"...and by tomorrow, I'll need a list of specific unknown risks that we'll encounter with this project."
What is the risk to the rainbow trout fishery from brown trout?

- How large might the adult brown trout population in Lees Ferry become ($BNT_{LF, potential}$)?

- How much smaller would the adult rainbow trout population become as a result ($RBT_{LF, potential}$)?

- We can answer these questions if we know three things:
  
  1) $RBT_{no BNT}$
  2) $r: \quad r = \frac{RBT_{LF, potential}}{BNT_{LF, potential}}$
  3) $c: \quad RBT_{LF, potential} = RBT_{no BNT} + c \times BNT_{LF, potential}$
Dependency of population sizes on R and C
Estimating R and C - Tailwater synthesis data

- Adult catch per unit effort data
- Focused on mixed tailwaters

Flow management and fish density regulate salmonid recruitment and adult size in tailwaters across western North America

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Ratio of Rainbow to brown trout

Preliminary, do not cite.
What is the risk to the rainbow trout fishery from brown trout?

Most likely, there is a minimal to moderate impact to rainbow trout fishery from brown trout.

99K (80% CI: 50K – 100K)

63K (80% CI: 27K – 138K)

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Brown trout

Lees Ferry (RM -15 – 0)

LCR – Colorado Confluence (RM 56 - 70)

Rainbow trout

Humpback chub

USGS
Science for a changing world
Brown trout movement

• Movement >20 km observed during NO
  – Rainbow trout : 143 / 16,472 (0.009)
  – Brown trout : 5 / 194 (0.026)

• Based on rainbow trout movement should have expected 0.5 brown trout on mux antennae in the LCR...we’ve seen one.

• No clue when it comes to little brown trout.

• Assumed brown trout move anywhere from half as much to twice as much as rainbow trout.

• On average, trout abundances in JCM reach are ~1% of total adult population in Lees Ferry. If 100,000 adult RBT in Lees Ferry, expect around 1,000 RBT in JCM.

Preliminary, do not cite.
Brown trout effects on humpback chub

• Yard et al. 2011 estimated brown trout were ~17x as piscivorous as rainbow trout.

• But are rainbow trout effects primarily from piscivory? Rainbow trout compete for space and food with humpback chub. Difficult to disentangle under field conditions.

• Consider a range: competition and predation equal to competition three times as important as predation:
  
  $\frac{17+1}{1+1} = 9 \quad \frac{17+3}{1+3} = 5$
Effects of rainbow trout on juvenile humpback chub survival

Pseudo-$R^2 = 0.38$

Preliminary, do not cite.
Effective RBT – rough guide to calculations

- 100,000 RBT in Lees Ferry
- 1,000 RBT near LCR
- 4,150 effective RBT

- 30,000 BNT in Lees Ferry
- 450 BNT near LCR (assuming movement rate 1.5x RBT)
- 3,150 effective RBT (assuming 7x as effective as RBT)
- 4,150 effective RBT

Preliminary, do not cite.
Humpback chub

• Assume average of 19,000 juveniles produced each year by early July.

• Use survival, growth and movement (and associated uncertainty) from Yackulic et al. (2014) for all location- and size classes except juveniles in Colorado River.

• Incorporate uncertainty in brown trout abundance in Lees Ferry, movement, and effects of both rainbow and brown trout on juvenile humpback chub survival.

• Predict equilibrium abundance based on effective RBT calculation.
Risk to humpback chub

Take home: Large brown trout populations likely represent a substantial risk to humpback chub.

- With just rainbow trout, this approach predicts 0% chance of average chub abundance lower than 7,000 (probably a little too optimistic).

- With brown trout and rainbow trout, 54% chance of exceeding this threshold.

- With just brown trout, 44% chance.

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Break a big question into its parts
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Essentially, all models are wrong, but some are useful.

All models are partial truths. Some are useful.

*Not responsible for box and whisker plots.
Do rainbow trout risk numbers feel right?

- Some systems have heavily skewed ratios one way or the other. If analysis is off, I would guess we end up more rainbow trout skewed.

- Analysis for effects of brown trout on rainbow trout does not have much statistical power. Overriding biological effects (e.g., Holter) or capture probability effects could mask negative effects.

- Take home: Numbers seem plausible, maybe brown trout estimates are high.
Does chub analysis seem right?

- May be underestimating relative movement of brown trout and effect of brown trout – so may be underestimating potential effects of establishment of brown trout population in Lees Ferry.

- On other hand, brown trout population in Lees Ferry may be estimated too high.

- Overall, results make sense (to me).
Details ignored
(I came back to these!)

• Dynamics/non-linearities – least concern.

• Other drivers (e.g., temperature, food, nutrients?) – biggest concern.

• Early life stages – for rainbow and brown trout, moderate concern.
  – Anglers mainly care about adults.
  – Adults primarily eat juvenile humpback chub.

• Heterogeneity in capture probability – less of concern.

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“What if we don’t change at all ... and something magical just happens?”
Adult brown trout (>350 mm) abundances are still low, but increasing...
And young brown trout (<200 mm) have spiked in recent years.
And sub-adult brown trout (200-350 mm) are upticking as well.
On the bright side, however, not many brown trout near the LCR.
We appreciate your back of the envelope calculation, Charles. Now put a stamp on the front and send it to somebody who cares.
Conclusions

• Both present and future risk to rainbow trout fishery from brown trout is likely minimal to moderate.

• Immediate risk to humpback chub is minimal, but future risk is likely substantially greater than risk posed by rainbow trout.

• Big changes in environmental conditions (e.g., temperature, food) are likely to affect all three species in different ways and is the most important factor ignored in these analyses.