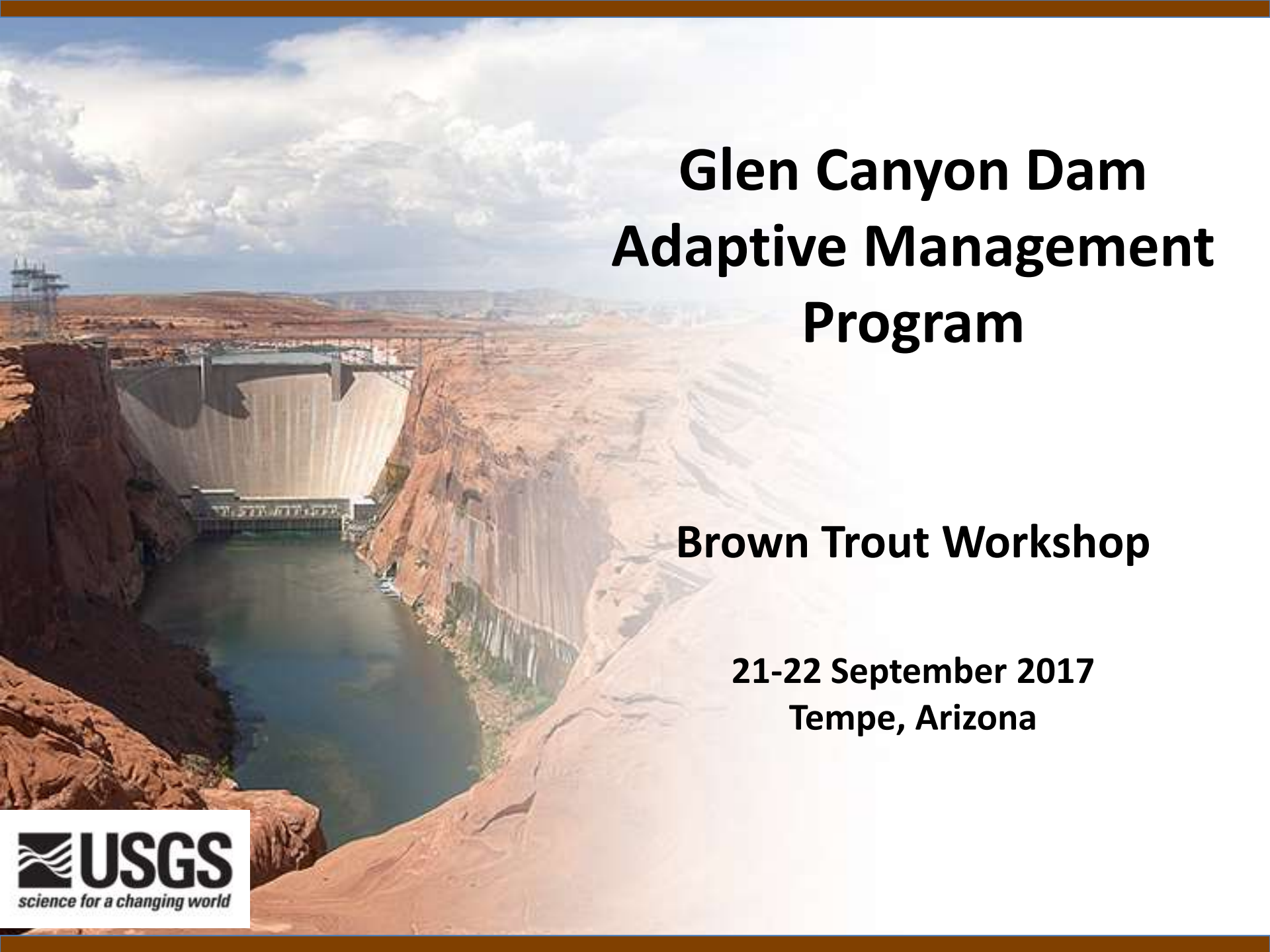

Glen Canyon Dam Adaptive Management Program

Brown Trout Workshop

21-22 September 2017
Tempe, Arizona

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Risks
(potential and current)

Charles B. Yackulic, USGS,
Kimberly Dibble, USGS; Michael Yard, USGS; David Ward,
USGS; and Josh Korman, ECOMETRIC.

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Outline

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

"Well he certainly does a very thorough risk analysis."

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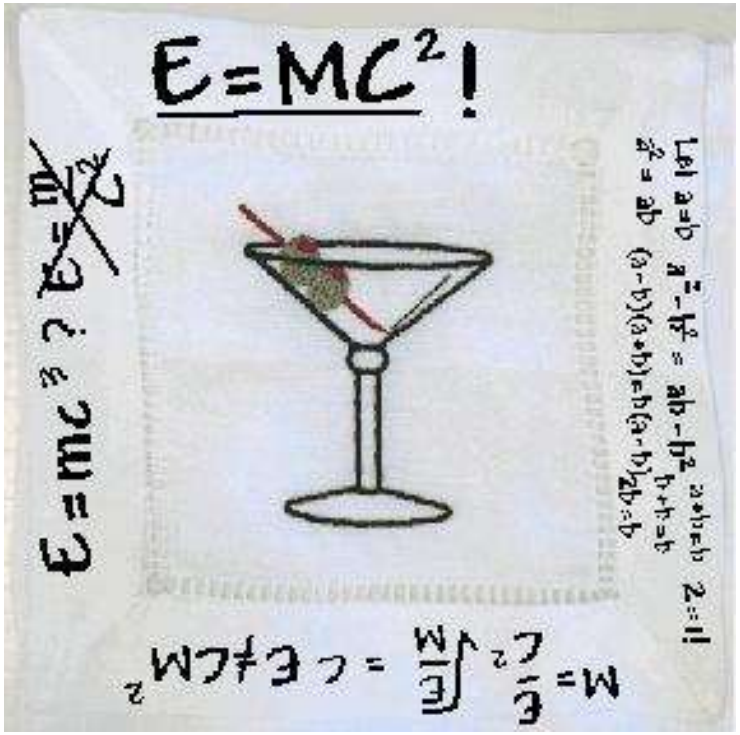
X-BOTEC analysis

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.



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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

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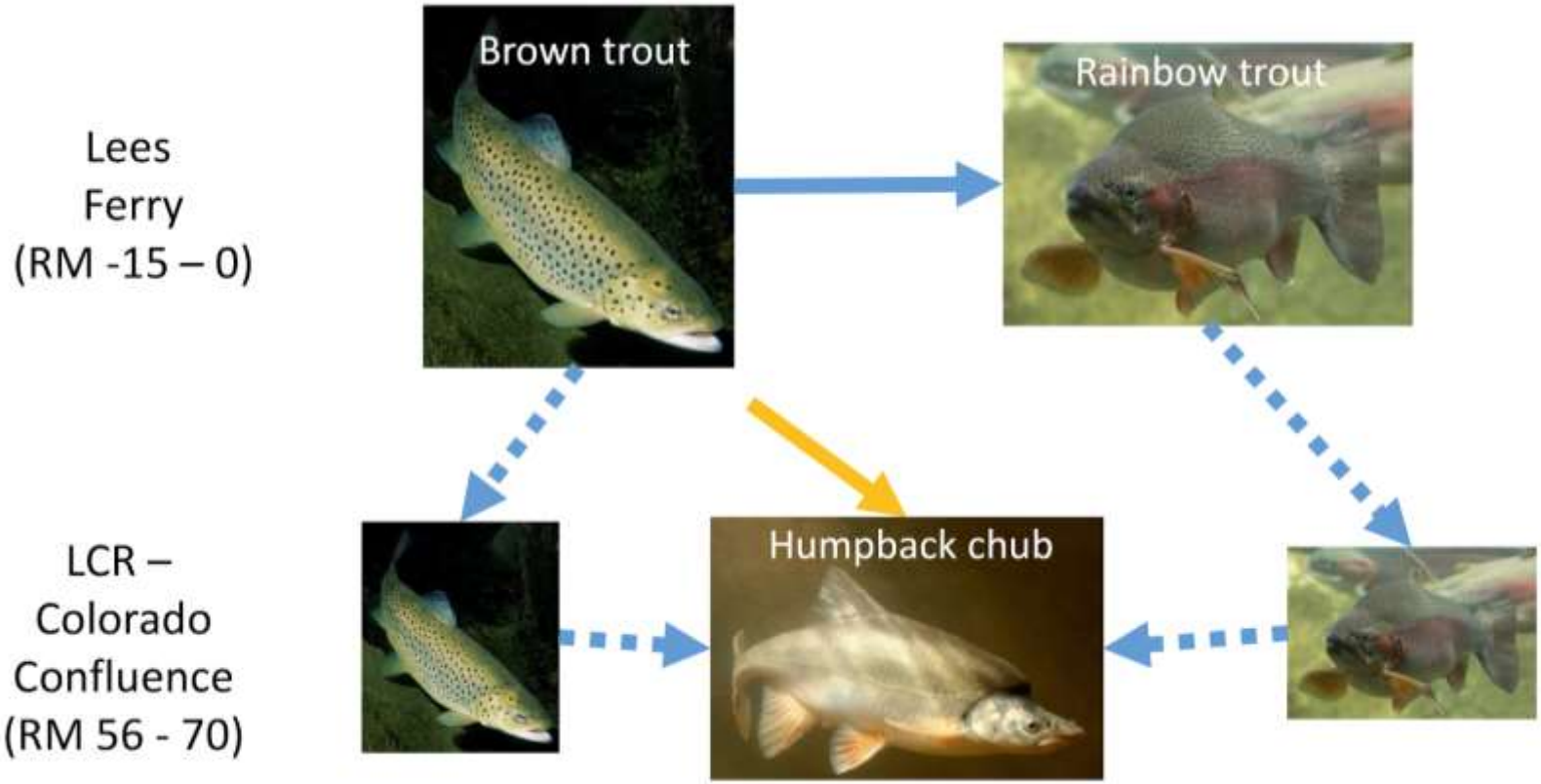
Break a big question into its parts
– easier to answer little questions
– reassess big questions at end



Outline

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

"...and by tomorrow, I'll need a list of specific unknown risks that we'll encounter with this project."

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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:** $r = RBT_{LF,\ potential} / BNT_{LF,\ potential}$
  3) **c :** $RBT_{LF,\ potential} = RBT_{no\ BNT} + c * BNT_{LF,\ potential}$

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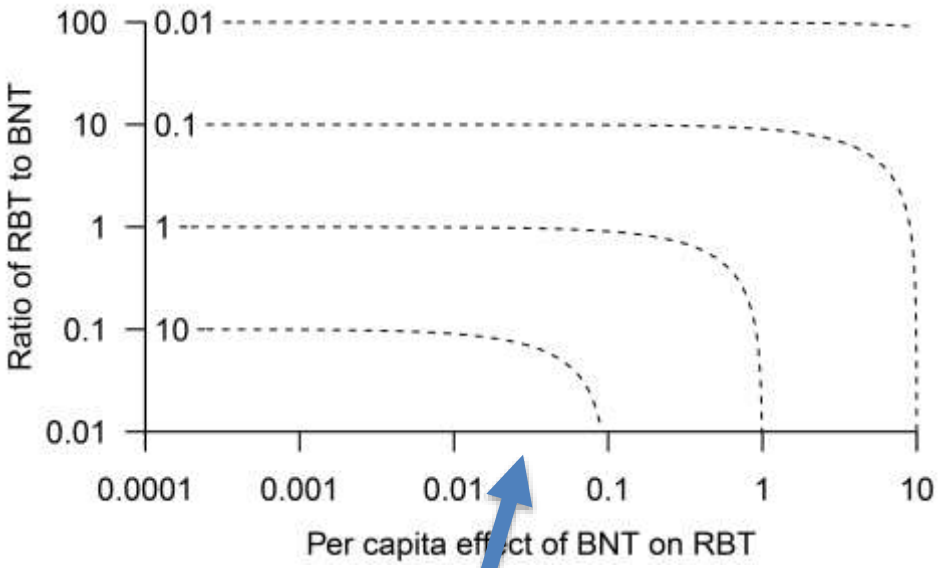
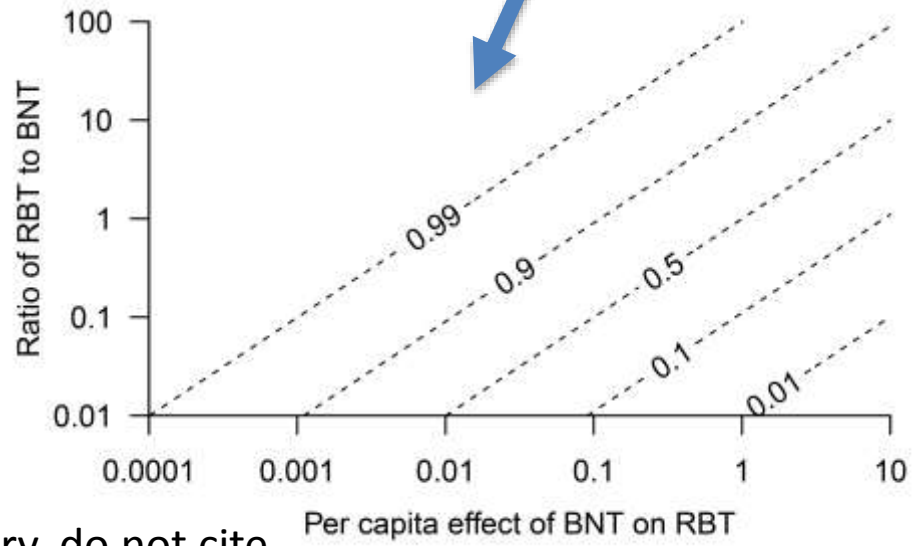
Dependency of population sizes on R and C





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Preliminary, do not cite.

Estimating R and C - Tailwater synthesis data

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

Ecological Applications, 25(8), 2015, pp. 2168–2179

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

KIMBERLY L. DIBBLE,[1,3] CHARLES B. YACKULIC,[1] THEODORE A. KENNEDY,[1] AND PHAEDRA BUDY[2]

[1]*U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona 86001 USA*
[2]*U.S. Geological Survey, Utah Cooperative Fish and Wildlife Research Unit, Department of Watershed Sciences and the Ecology Center, Utah State University, Logan, Utah 84322 USA*

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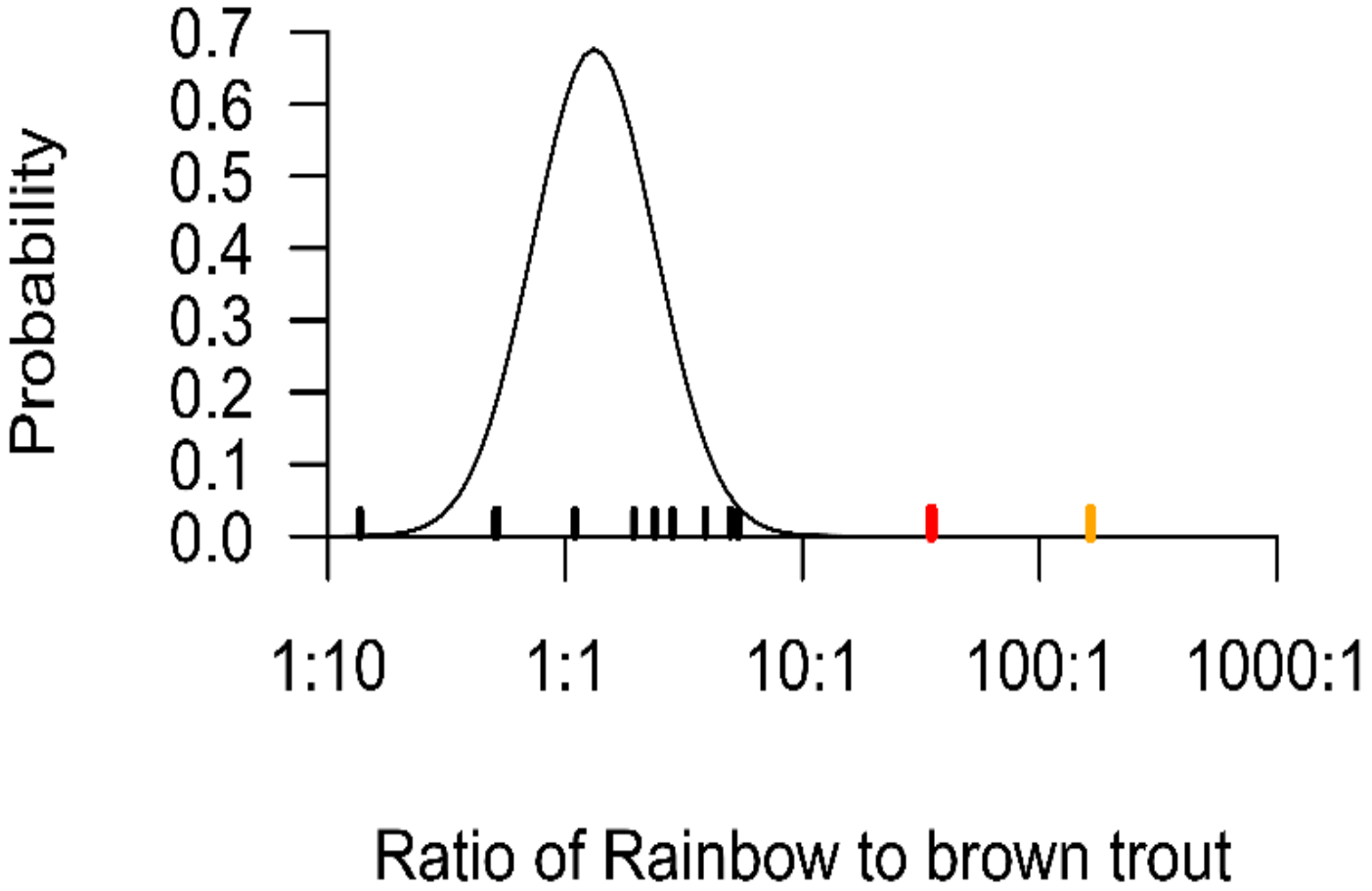

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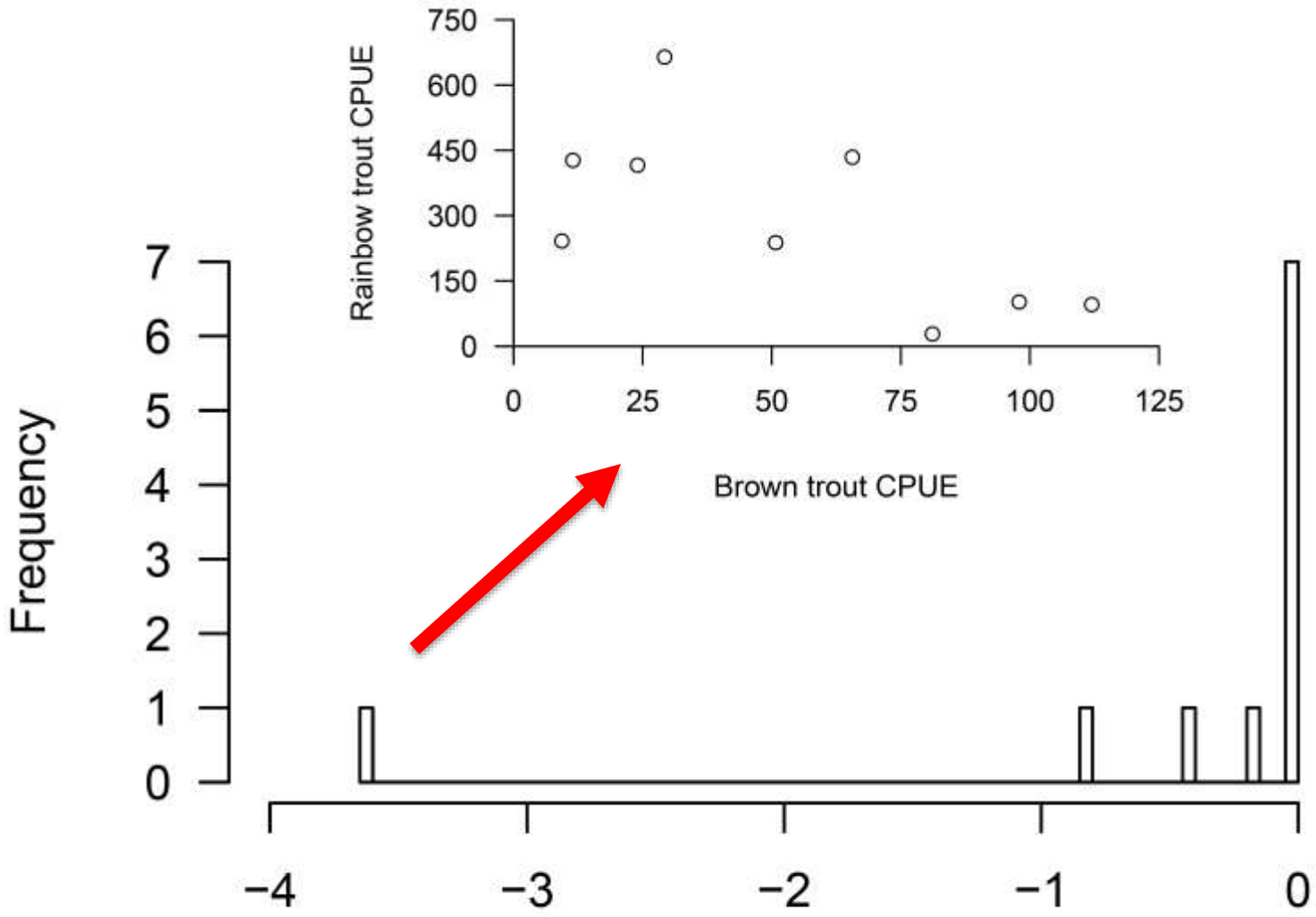

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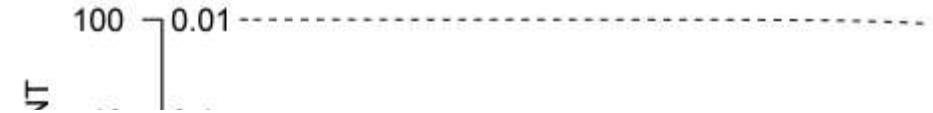
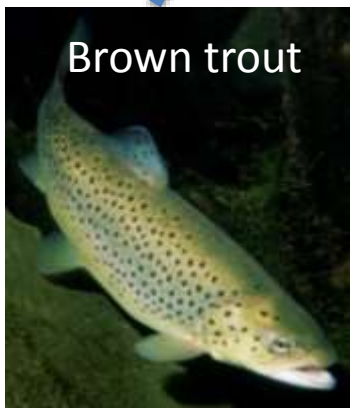
Preliminary, do not cite.

What is the risk to the rainbow trout fishery from brown trout?

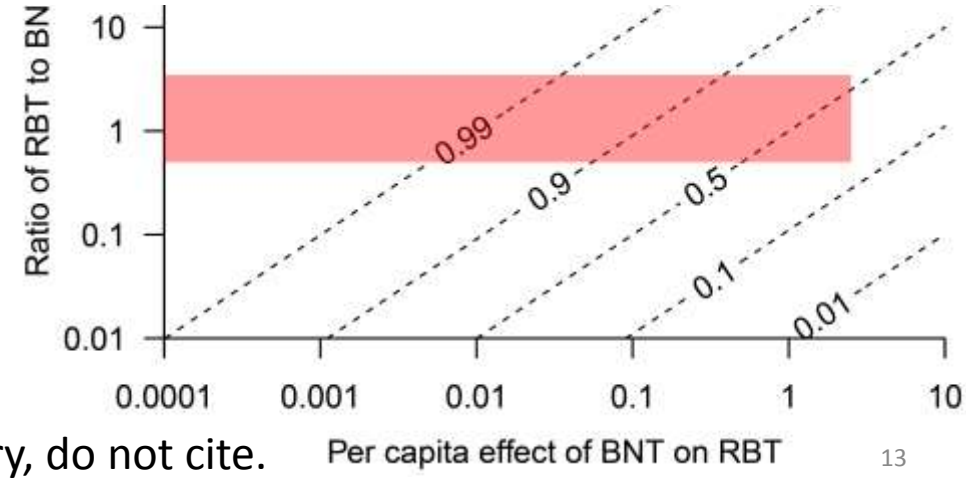


99K (80% CI: 50K – 100K)

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



63K
(80% CI: 27K – 138K)



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Outline

- Caveats
- Rainbow trout fishery
- **Humpback chub**
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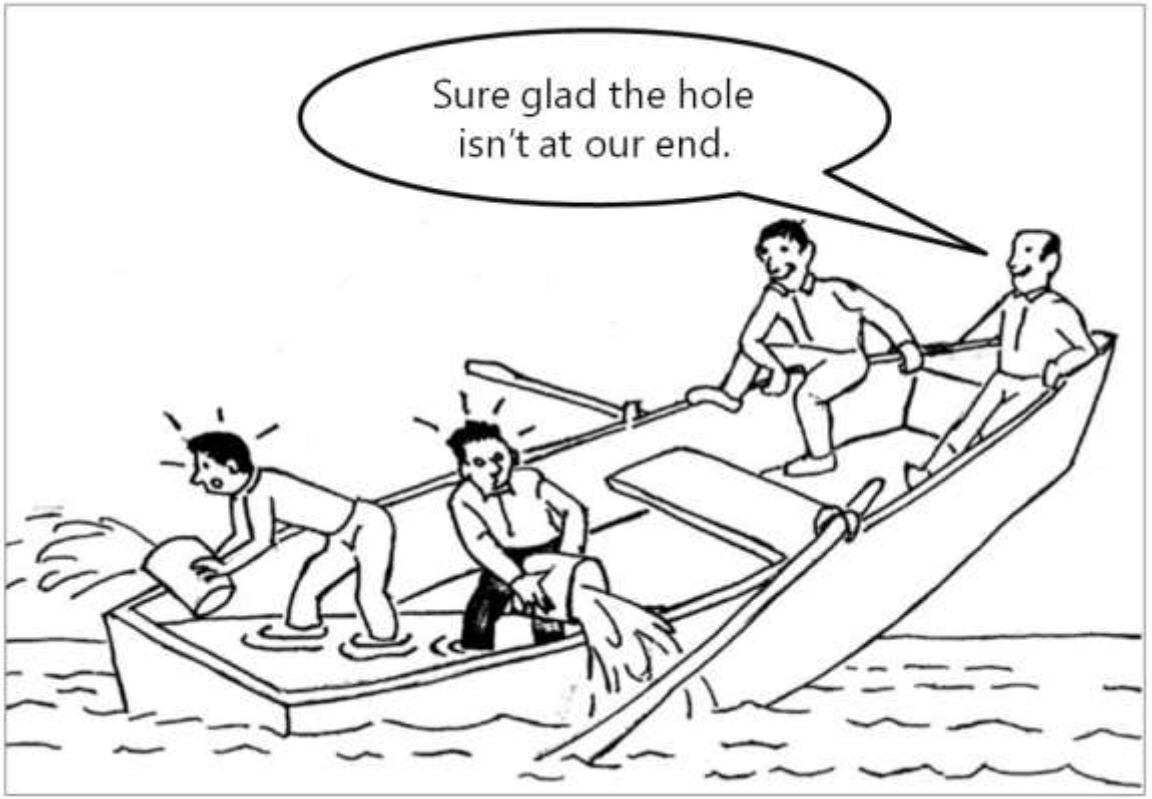

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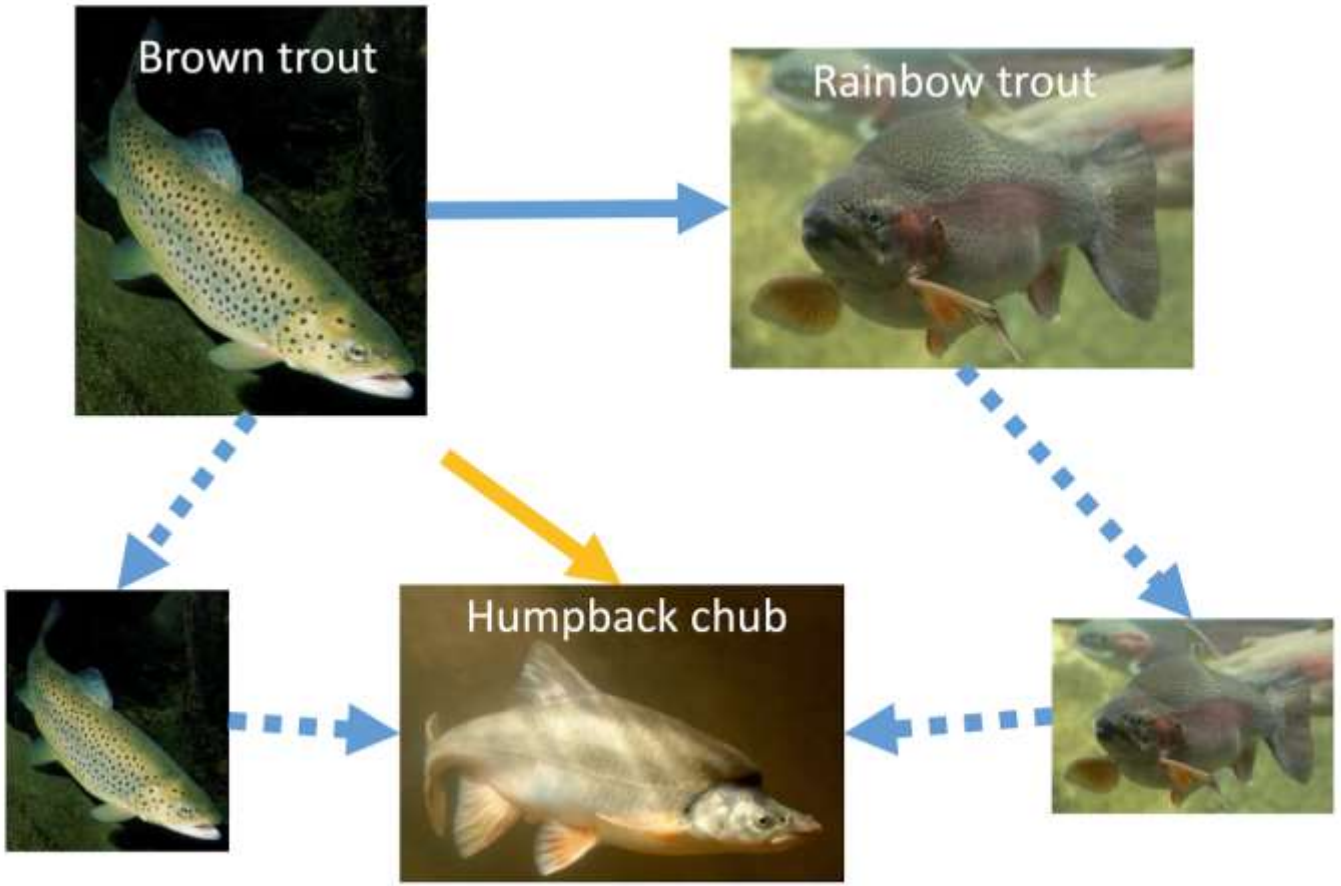
Lees Ferry (RM -15 – 0)

LCR – Colorado Confluence (RM 56 - 70)



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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.

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:
- (17+1)/(1+1) = 9 (17+3)/(1+3) = 5

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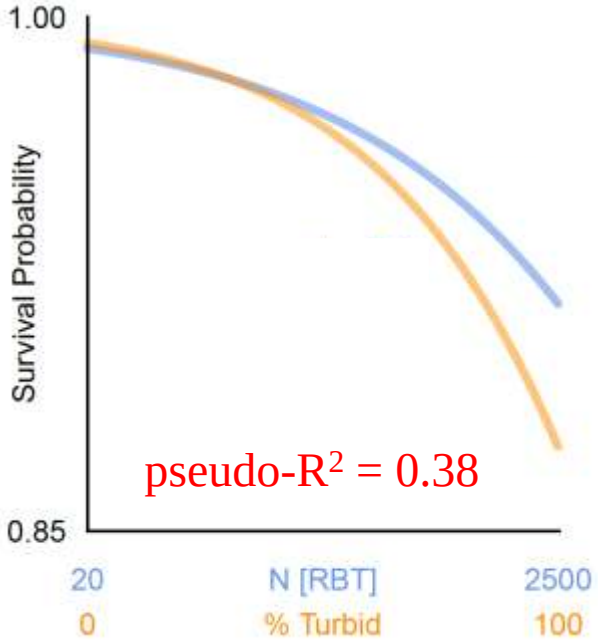
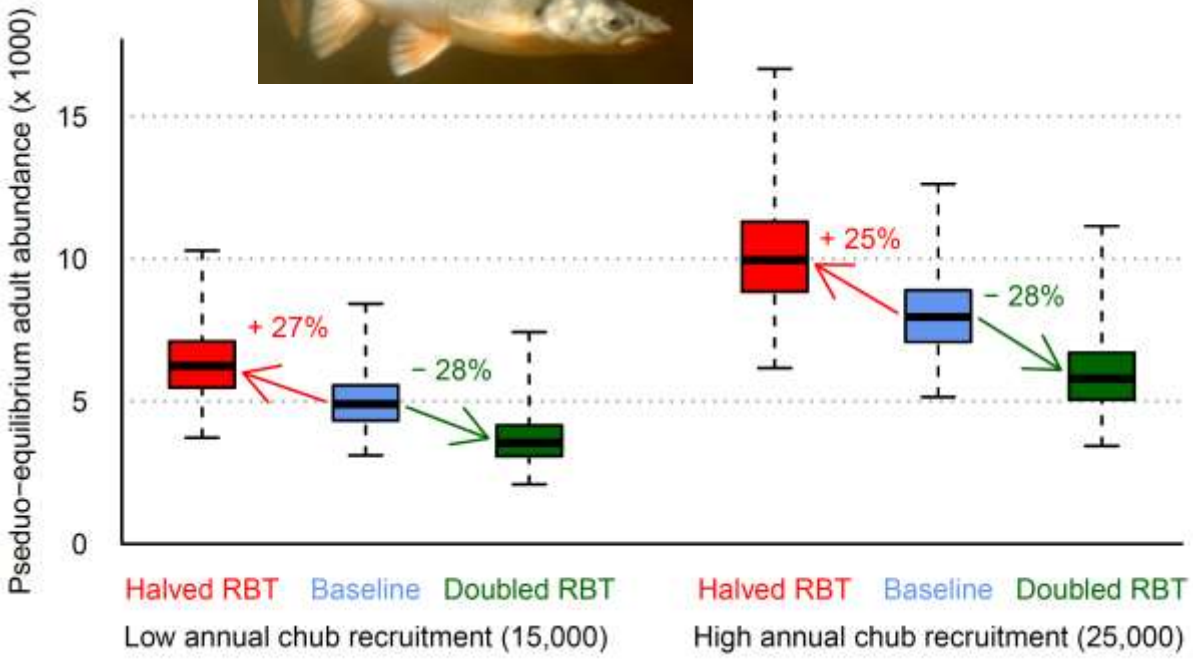
Effects of rainbow trout on juvenile humpback chub survival





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Preliminary, do not cite.

Effective RBT – rough guide to calculations

- 100,000 RBT in Lees Ferry
- 1,000 RBT near LCR

- 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

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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.

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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.

Outline

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"Wear a helmet."

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Break a big question into its parts
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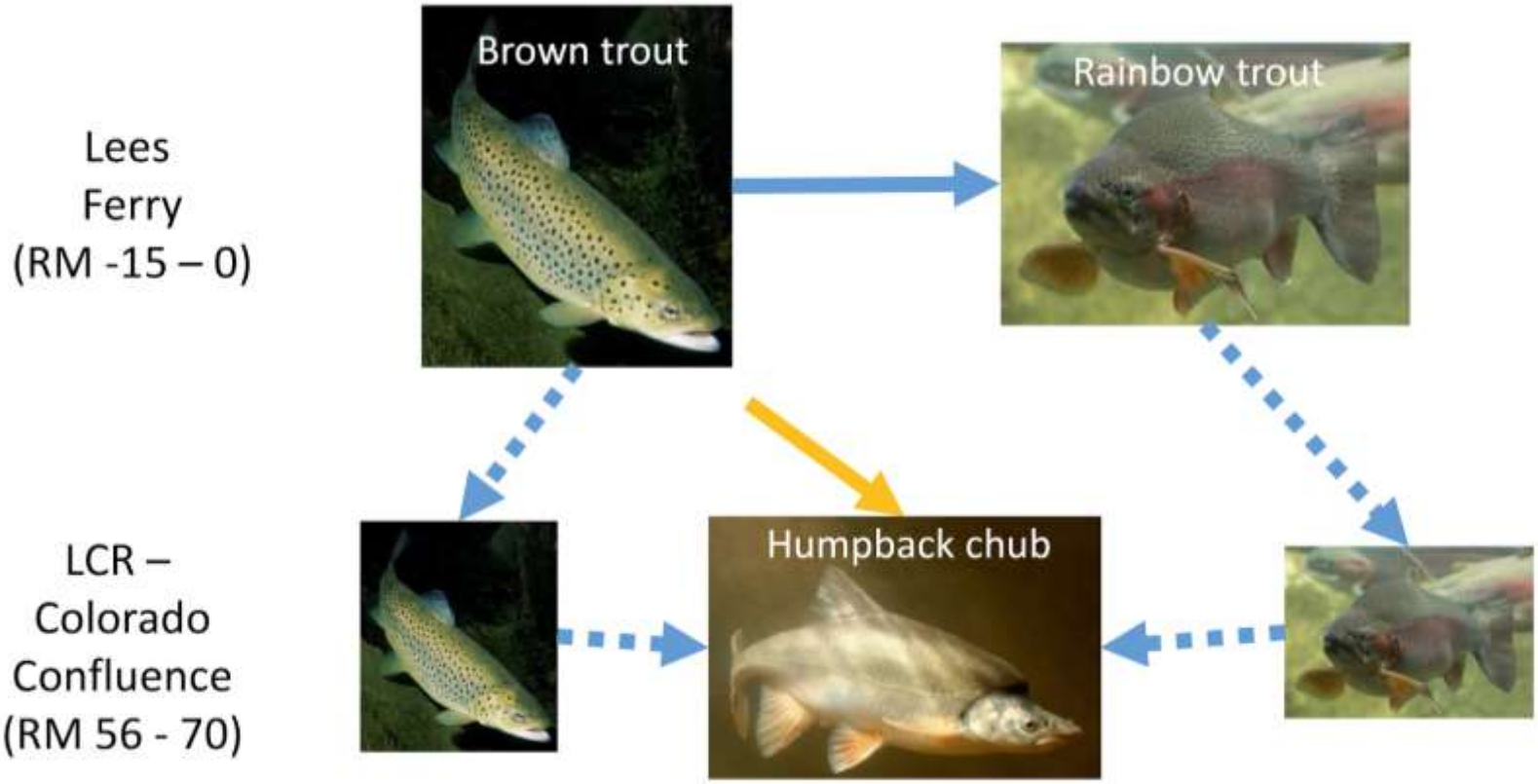

Essentially, all models are wrong, but some are useful.

All models are partial truths. Some are useful.

George Box*

*Not responsible for box and whisker plots.

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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.

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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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Preliminary, do not cite.

Outline

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"What if we don't change at all ...
and something magical just happens?"

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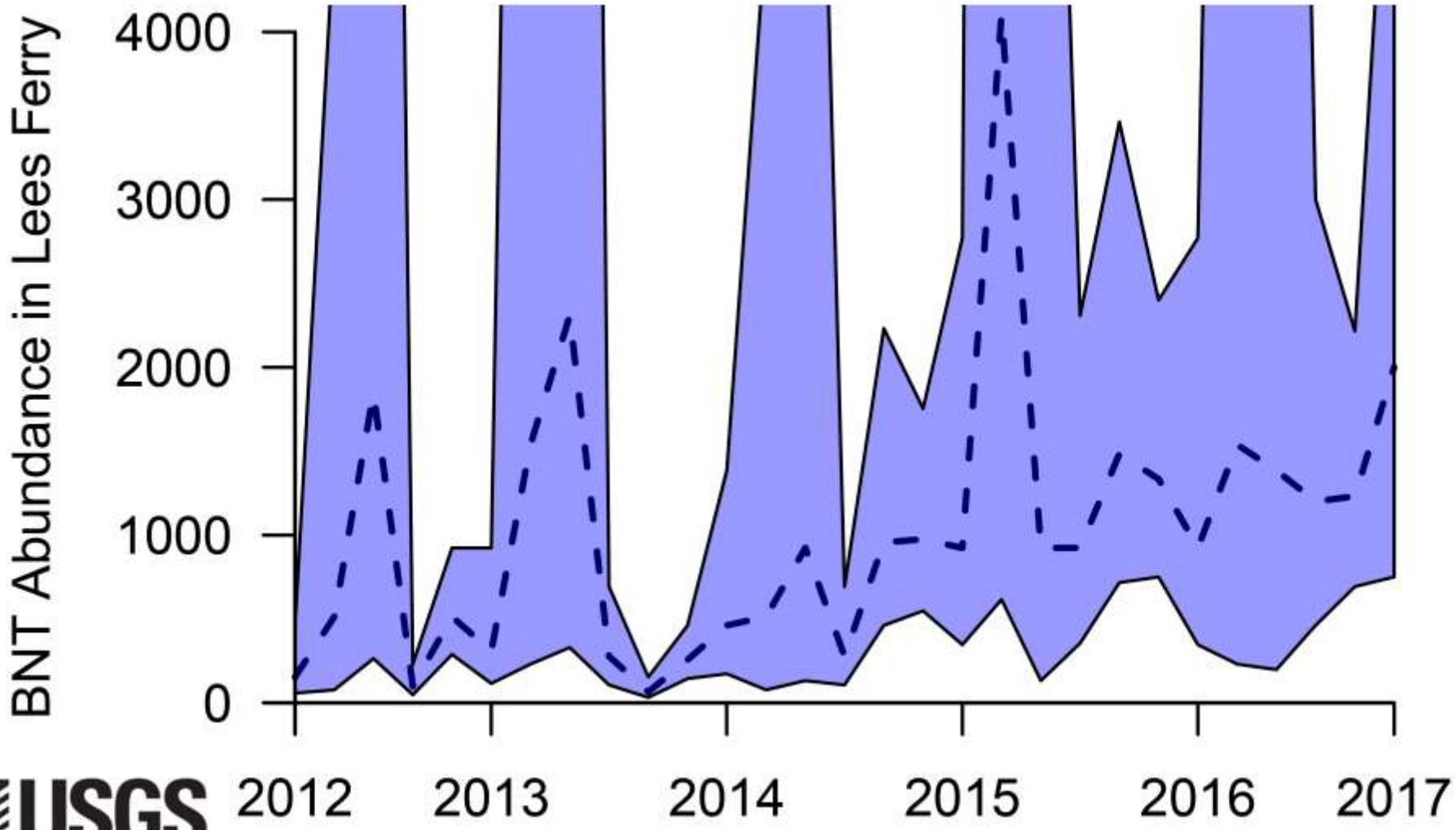
Adult brown trout (>350 mm) abundances are still low, but increasing…



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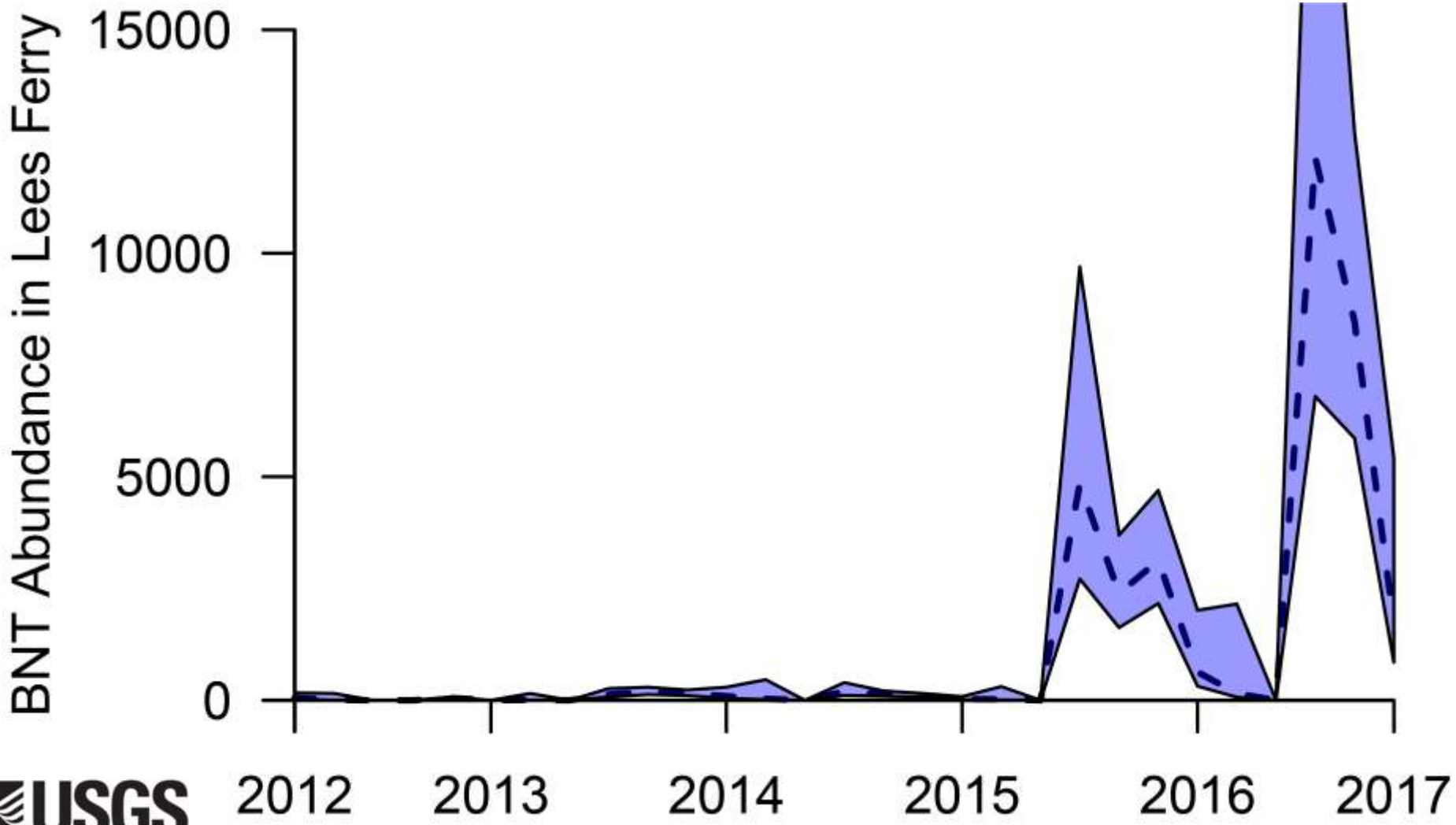
And young brown trout (<200 mm) have spiked in recent years



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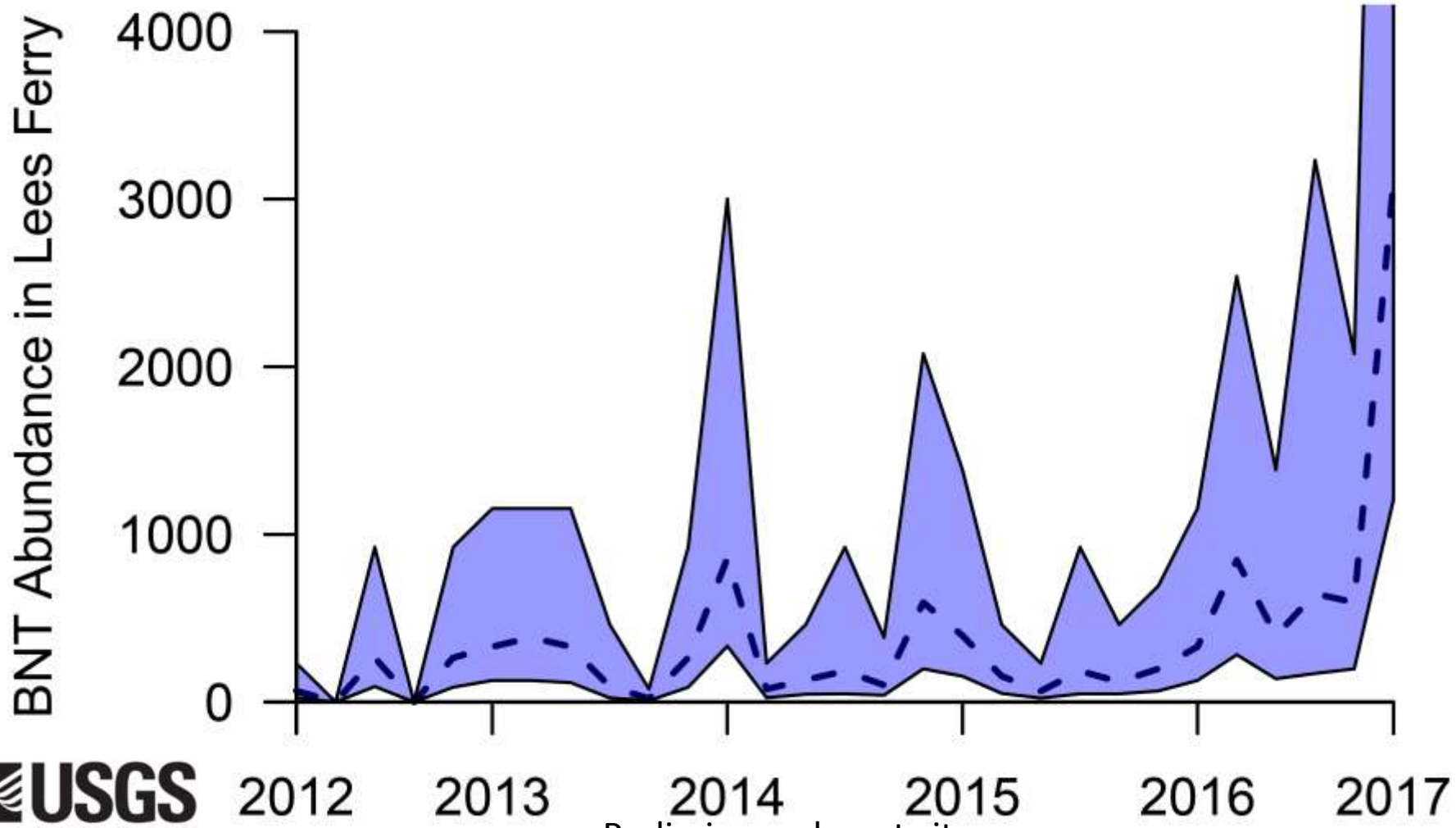
And sub-adult brown trout (200-350 mm) are upticking as well.



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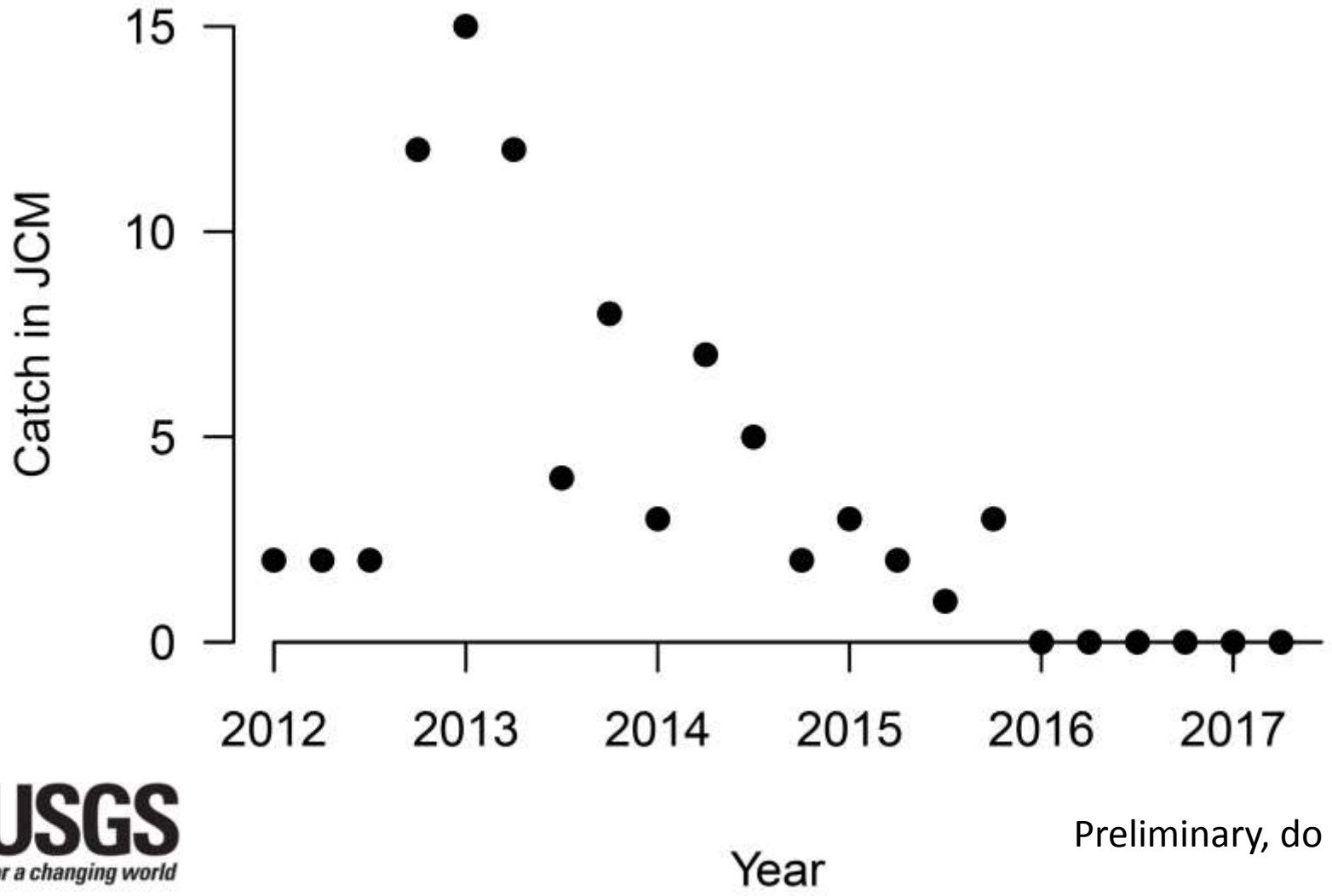
Preliminary, do not cite.

On the bright side, however, not many brown trout near the LCR.



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Outline

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We appreciate your back of the envelope calculation, Charles. Now put a stamp on the front and send it to somebody who cares.

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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.