Updates on
1. Bright Angel Creek Trout Removal and
2. Brown Trout Movement Modeling Study

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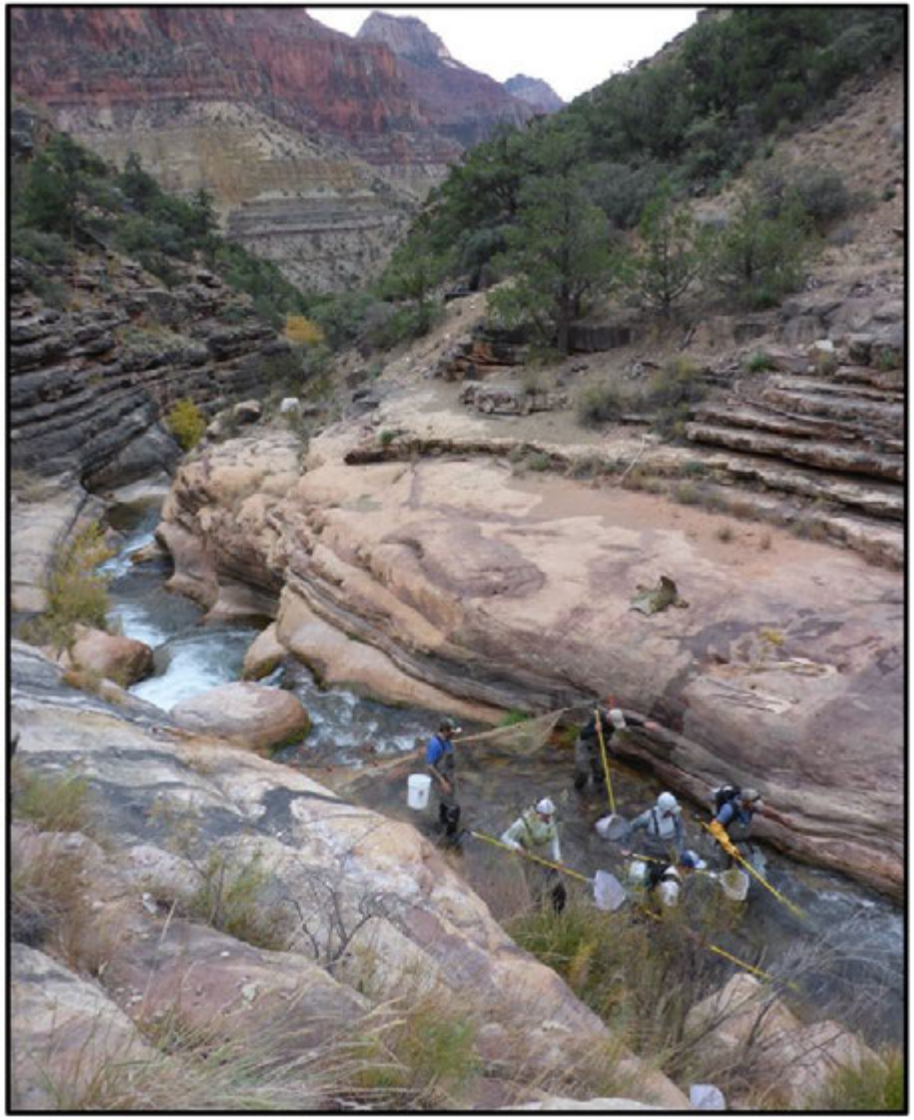
Collaborating agencies:

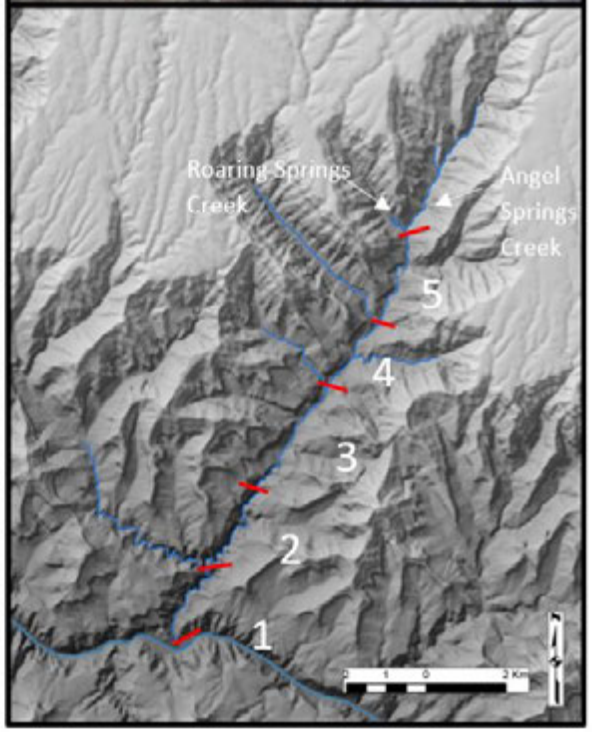
Funded by Reclamation, NPS, and GCC

Project title: Bright Angel Creek Trout Removal

- Project elements: Not included in AMP workplan; relates to project H objectives
- Project Objectives: Nonnative fish control
  - LTEMP goals addressed:
    - 3. Humpback Chub. Meet humpback chub recovery goals, including maintaining a self-sustaining population, spawning habitat, and aggregations in the Colorado River and its tributaries below Glen Canyon Dam.
    - 5. Other Native Fish. Maintain self-sustaining native fish species populations and their habitats in their natural ranges on the Colorado River and its tributaries.
    - 10. Nonnative Invasive Species. Minimize or reduce the presence and expansion of aquatic nonnative invasive species.
- Funding amount and source: FY2020 - $306,000 for brown trout control from Bureau of Reclamation, with other funding from NPS and Grand Canyon Conservancy
- Cooperators – see previous slide
- Products:
  - Annual reports to Reclamation
  - Manuscript *in prep.* on brown trout movement modeling with PIT-tag data

1. Bright Angel Creek trout removal update

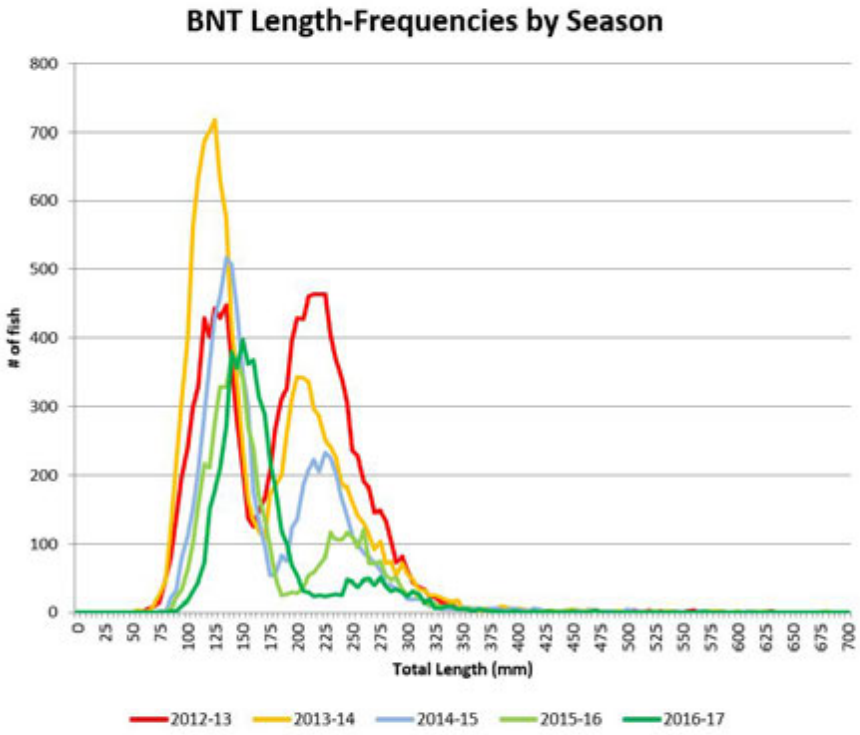


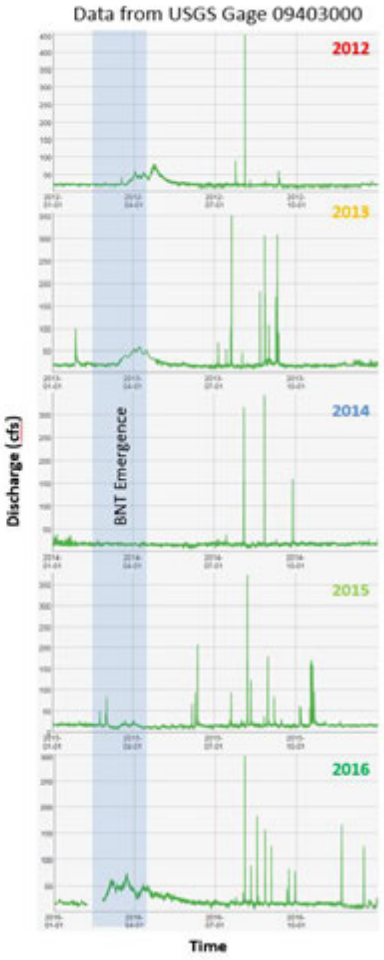


Beneficial use

Bright Angel Creek Trout Removal: first 5 seasons

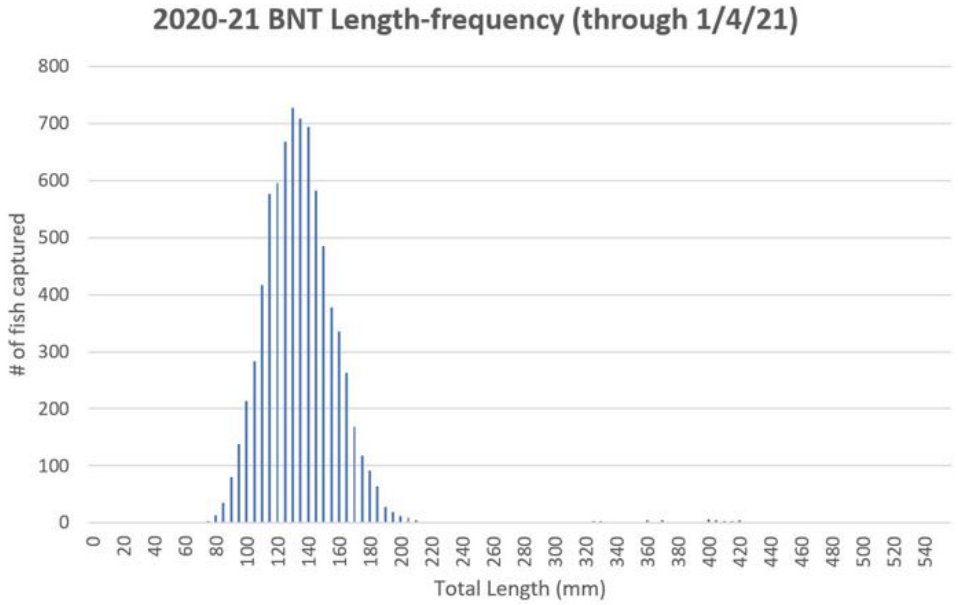
- Steady production of young-of-year cohorts (75-200 mm TL)
- Declines driven by reductions in larger size-classes, age-1 and older fish
- No high-magnitude spring runoff floods during BNT emergence period
- High-magnitude, short-duration monsoonal floods typical July-September

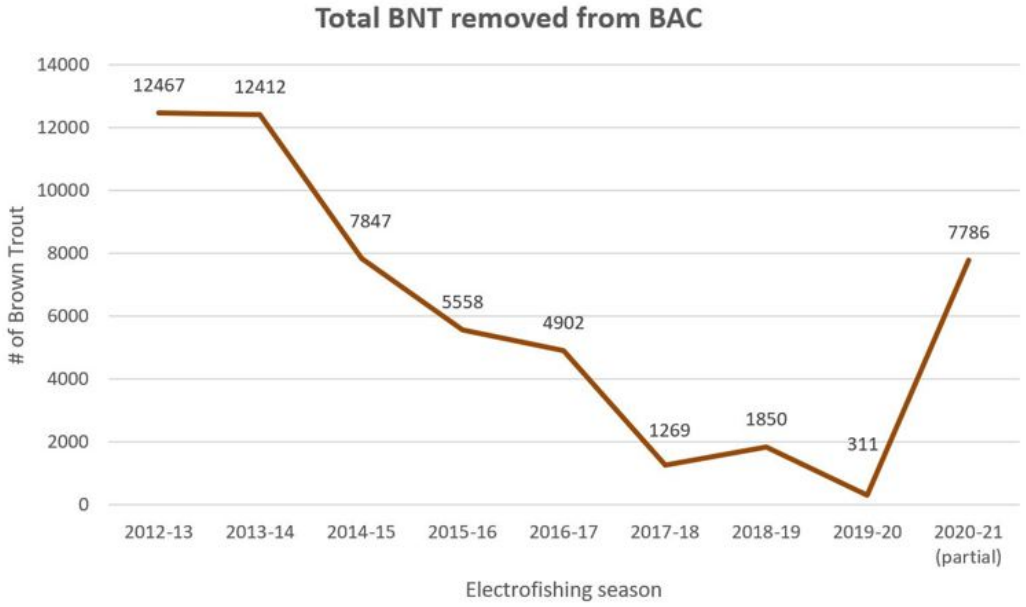




Brown Trout resurgence in BAC in 2020-21

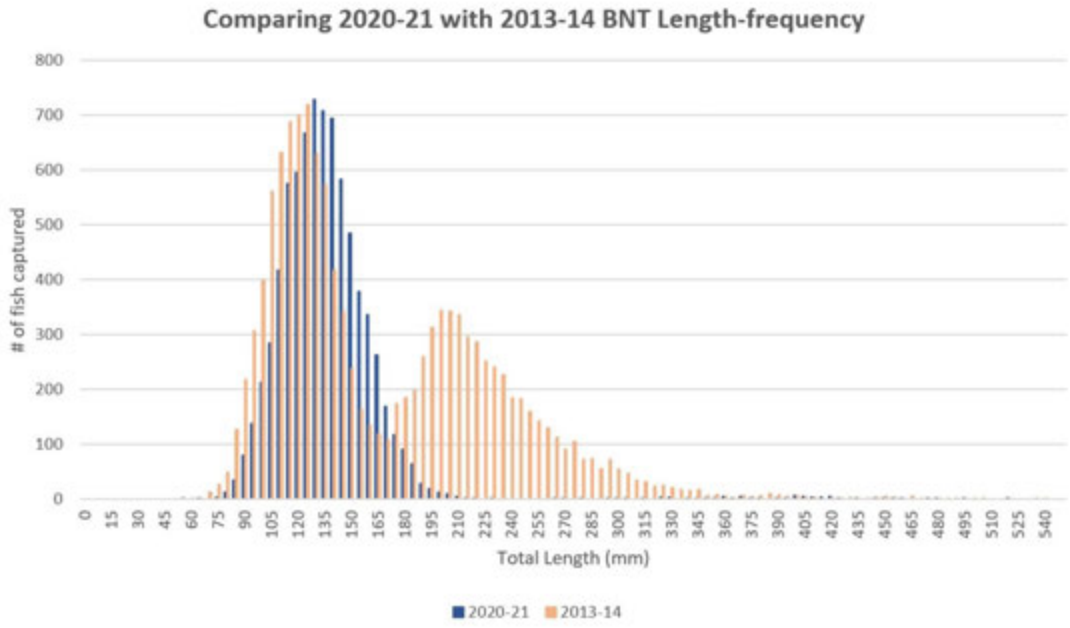
- Driven by large young-of-year cohort, with fish 80-200 mm TL
- Raw numbers rival early years of project
- Similar large year class of rainbow trout, n=2607





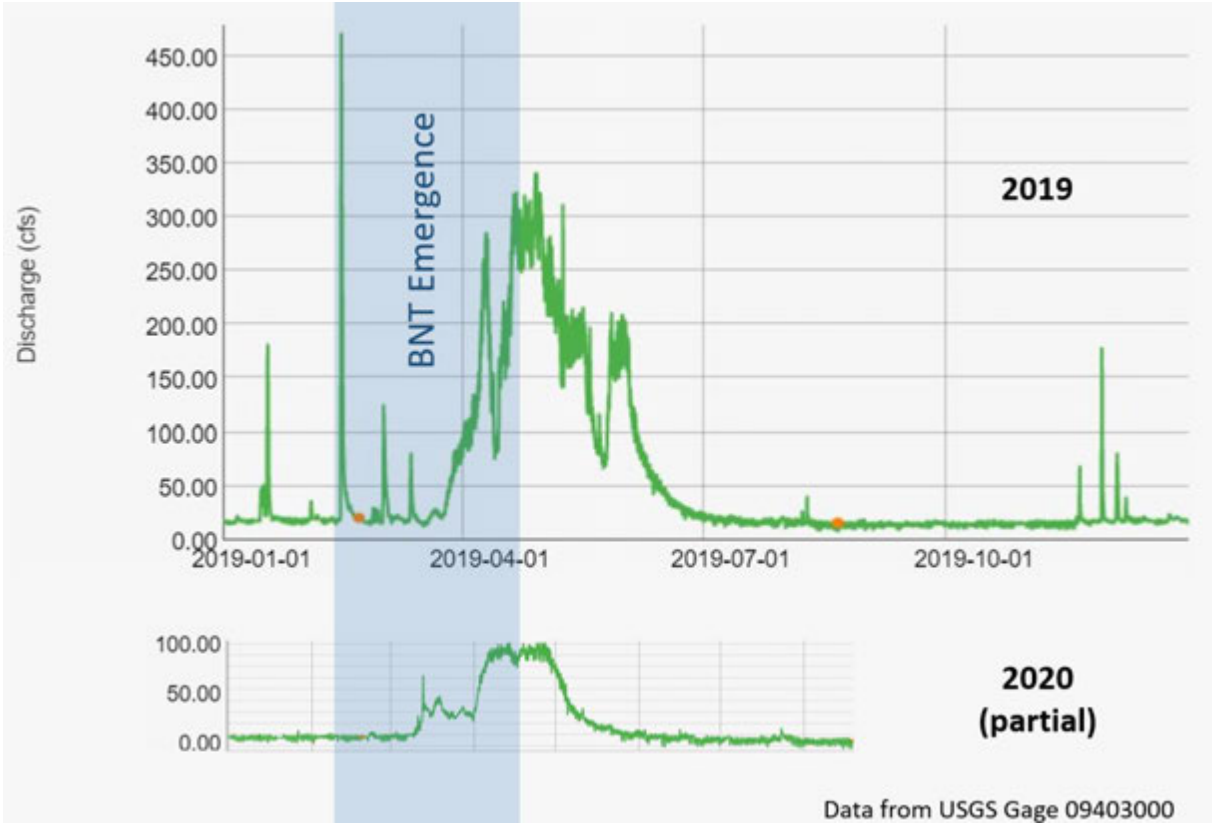
Strong YOY Brown Trout cohorts compared

- This season's length-frequency is reminiscent of 2013-14, minus the age-1 and older size-classes



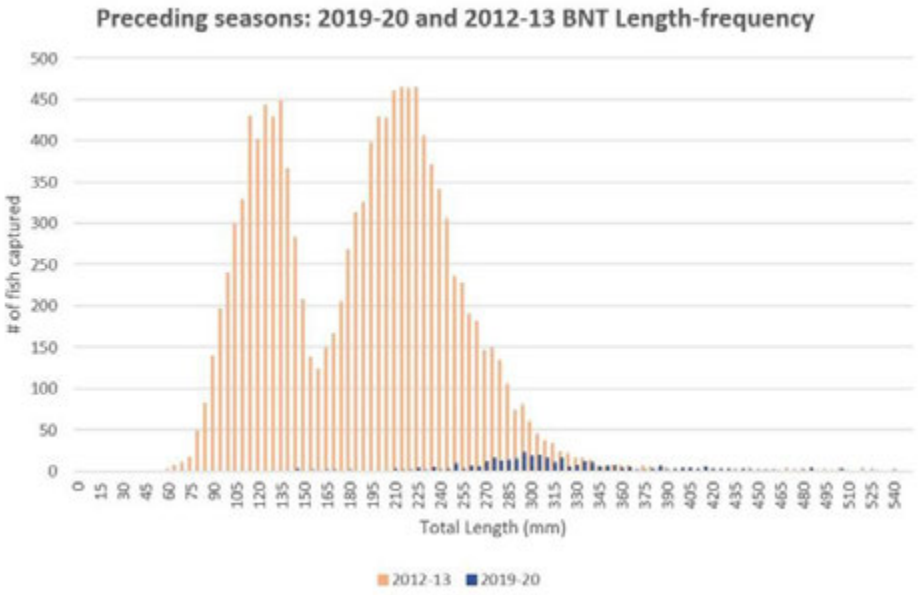
Bright Angel Creek hydrographs for 2019 and 2020

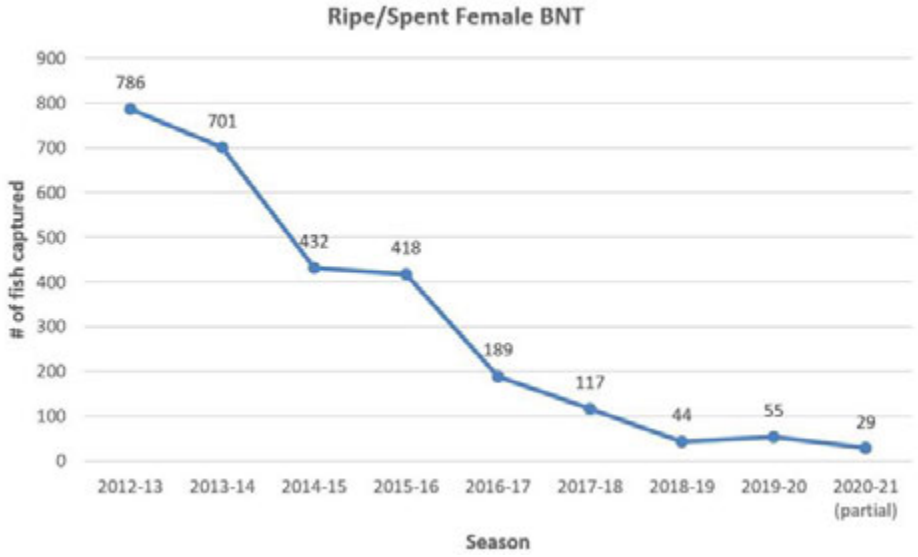
- High-magnitude early spring floods and a sustained high-magnitude runoff in 2019 may have disfavored newly emerged Brown Trout
- Lack of early spring floods and low-magnitude runoff in 2020 may have allowed for high survival of newly emerged trout



Reproductive potential in preceding seasons

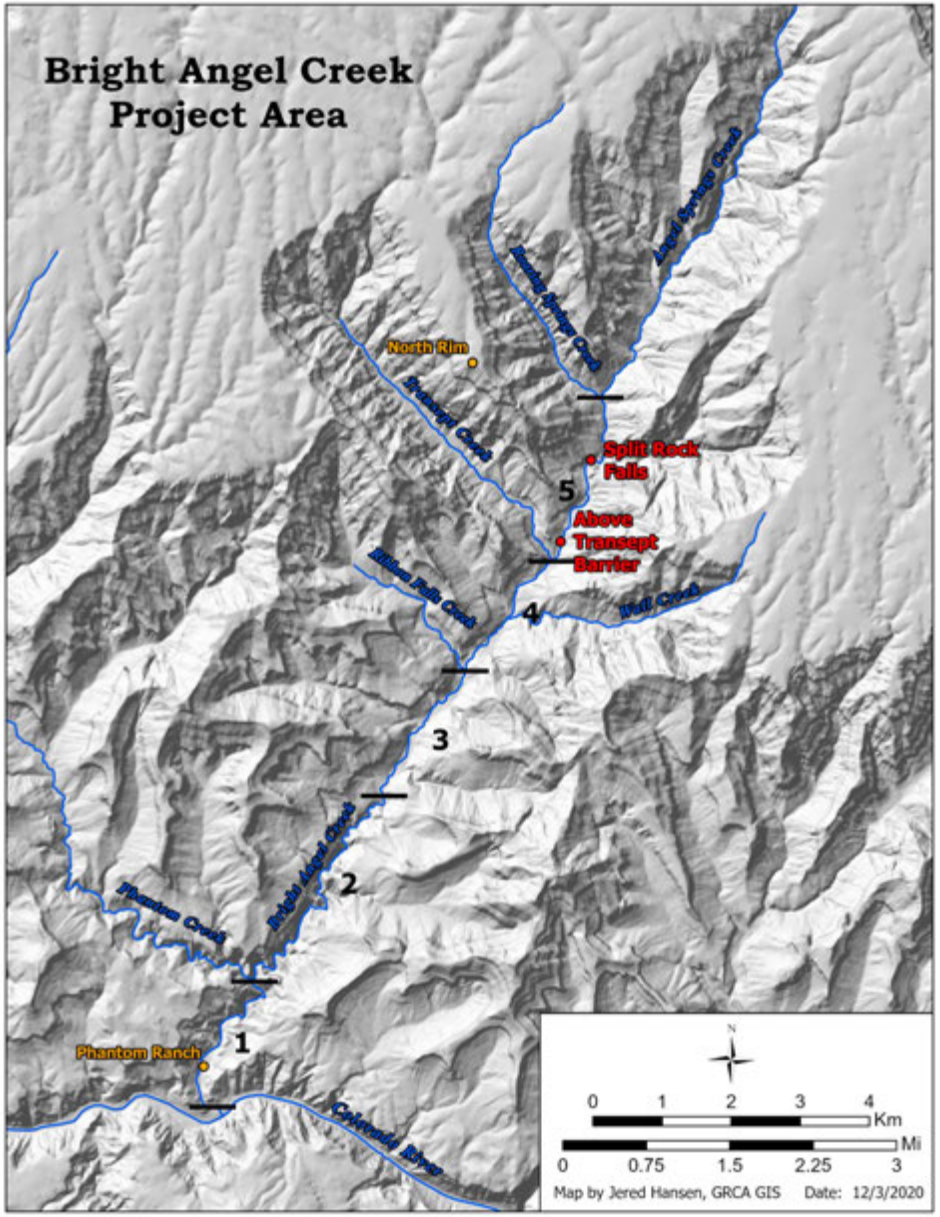
- Presently less common to see a ripe female Brown Trout <300 mm TL
- In early years of project, rare to see ripe female Brown Trout <200 mm TL; many ripe females from 200 mm TL and larger
- Interpretation: female Brown Trout in their second year are growing larger thanks to lower densities
- The size of the 2020 cohort demonstrates the reproductive potential of even a small number of spawning females





Stream Renovation: a future possibility

- Renovation of BAC upstream of Transept Barrier would eliminate trout production from more than 5 miles of creek
- Reach 5 includes deep, electrofishing invulnerable pools

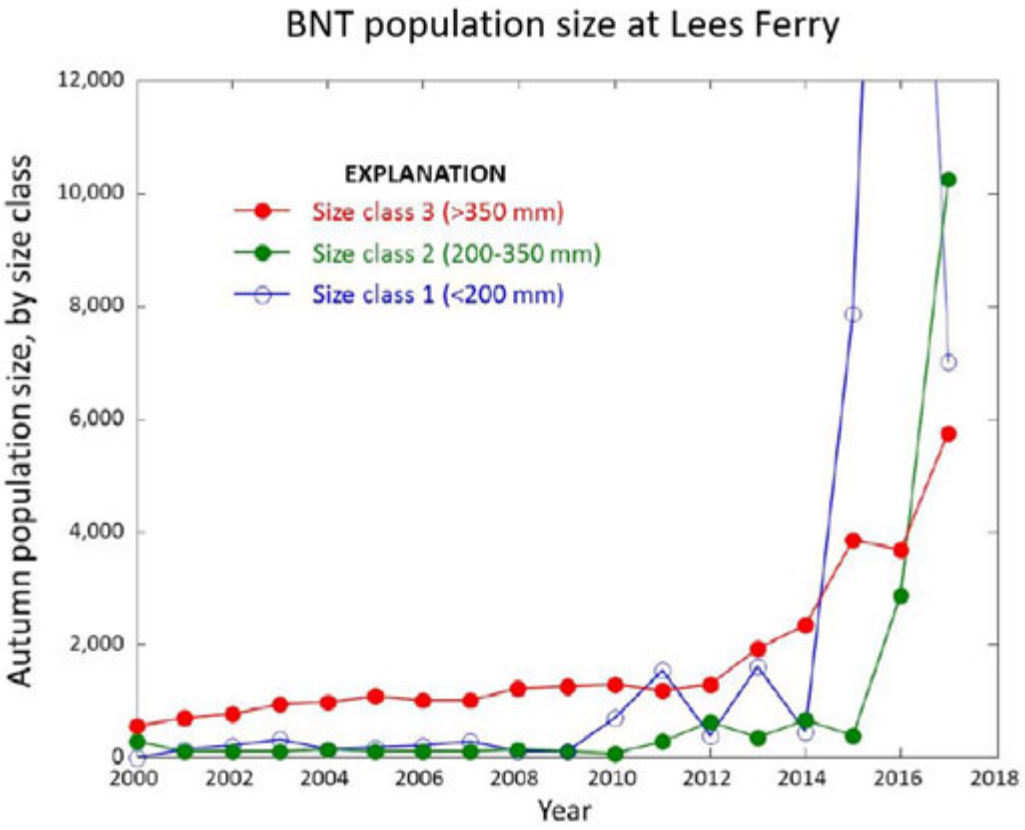


Potential barriers:
Split-Rock Falls (left) and Above Transept (right)

2. Brown Trout movement: PIT-tag data

Brown Trout whitepaper modeling of Lees Ferry increases

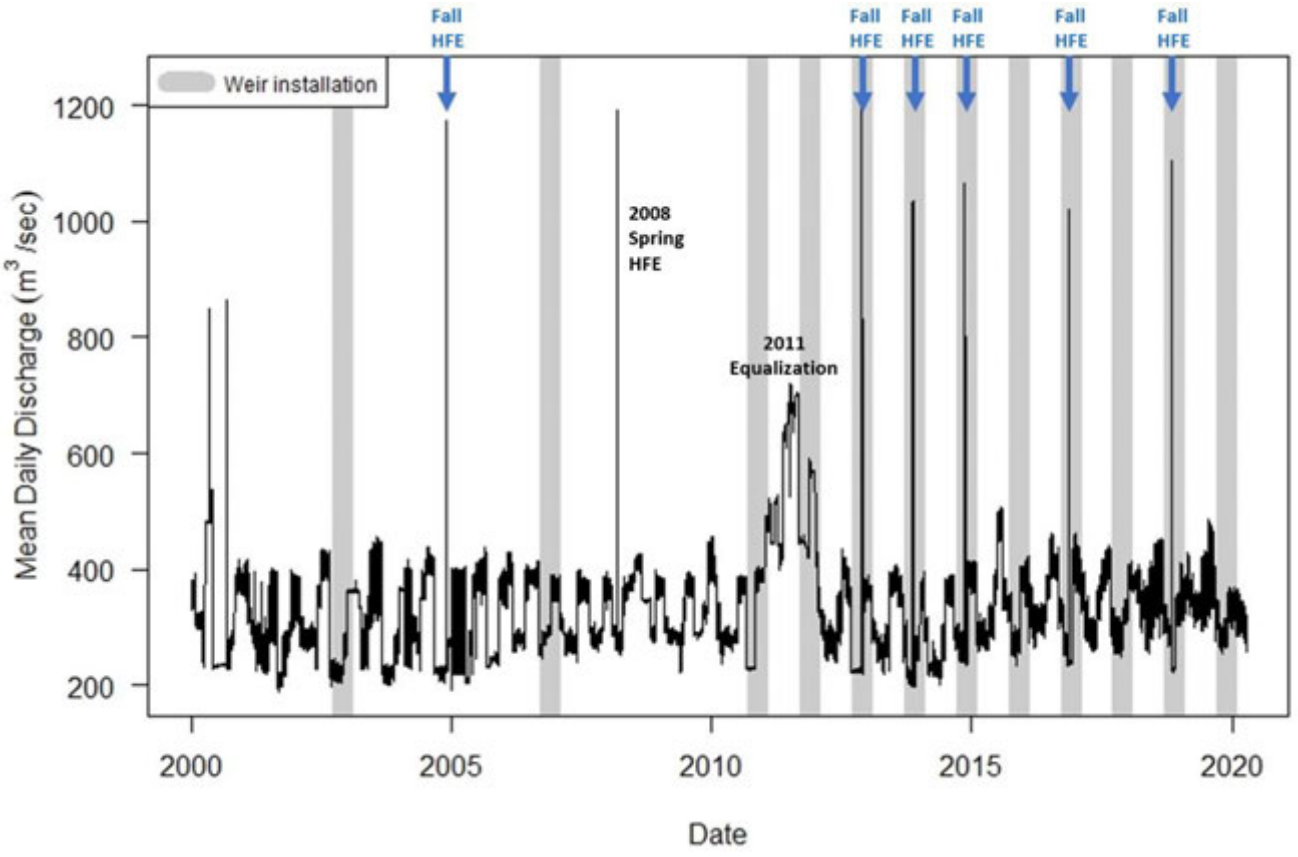
- Size-class distribution flipped
- Increased immigration beginning in fall 2014
- Increased reproduction in 2011, 2013, and from 2015 onward



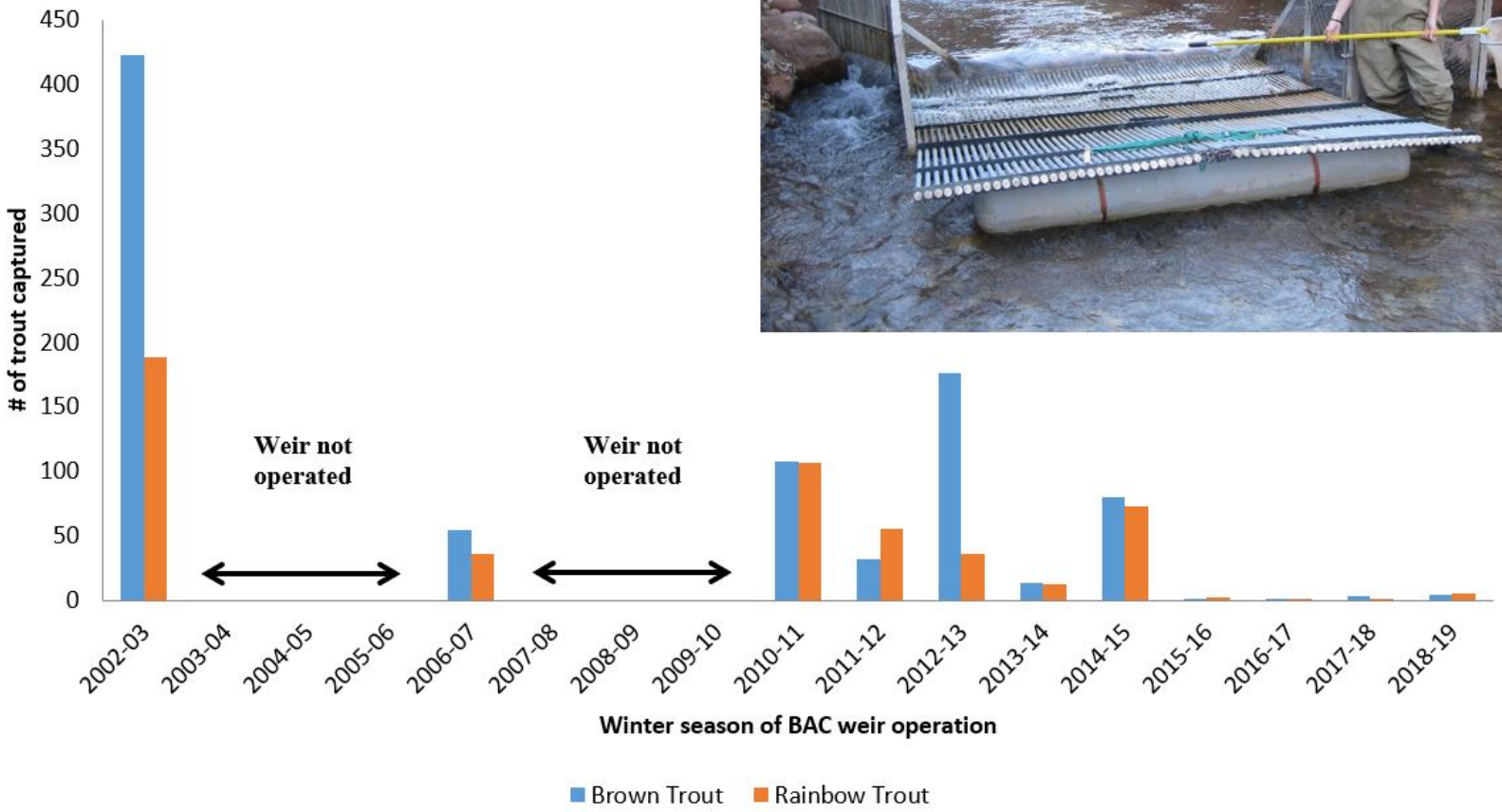
From Runge et al 2018

Colorado River at Lees Ferry Hydrograph (2000-2020)

- Fall HFEs: blue arrows (2004, 2012, 2013, 2014, 2016, 2018)
- BAC weir operation: gray bars
- Only 1 spring HFE: 2008
- Only 1 equalization flow: 2011
- Winter BAC weir operation constant, and fall HFEs common, during period of Lees Ferry BNT increase



BAC Weir Captures



Hypotheses for increased Brown Trout immigration into Lees Ferry (Runge et al. 2018)

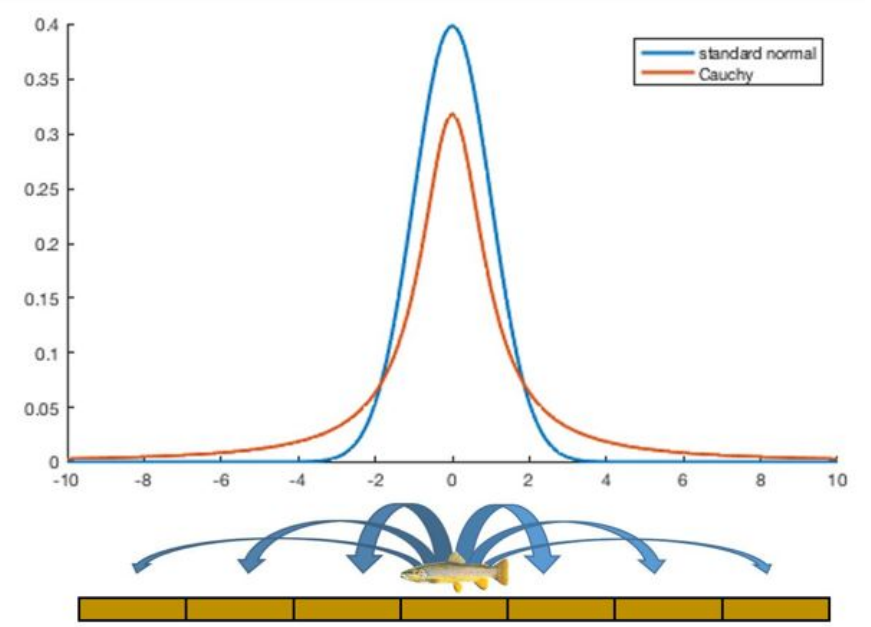
- Fall HFEs cue ripe and gravid fish to migrate. High variance in flow and temperature triggers migration to spawning areas (Ovidio et al. 1998)
- Bright Angel Creek rendered inaccessible by weir
- Compensatory reproduction in BAC following removals, with upstream movement of large cohort
- System-wide reduction in food resources induces upstream migration

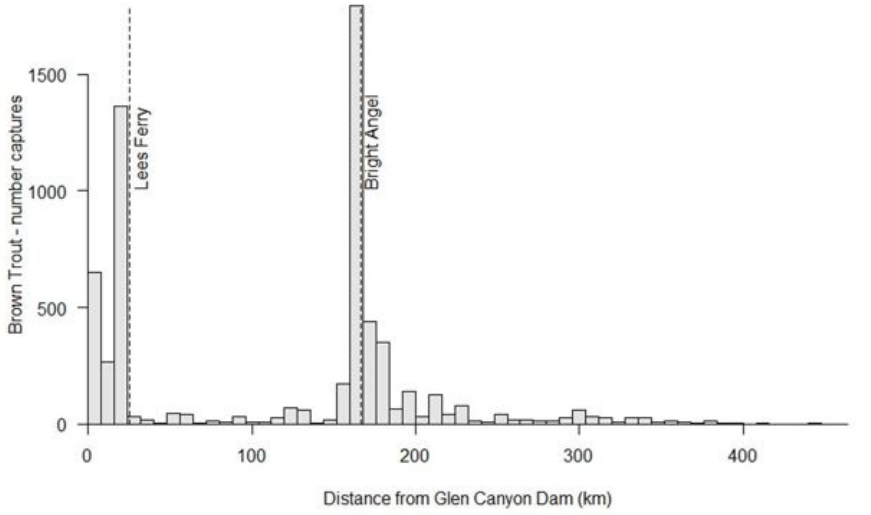
Modeling BNT movement with 20 yrs of PIT-tag recapture data

- Manuscript in preparation with Charles Yackulic and Brian Healy
- Data from GCDAMP sampling between 2000-2019: system-wide and Lees Ferry monitoring of large-bodied fishes (AZGFD), near-shore ecology study (GCMRC), population dynamics of Rainbow Trout (GCMRC), salmonid suppression near LCR confluence (GCMRC), and Bright Angel Creek salmonid suppression (NPS), among others
- 207 sampling events, 2000-2019
- Brown Trout <200 mm TL excluded to reduce heterogeneity in capture probability and survival
- 3747 Brown Trout tagged and released, 399 recaptured one or more times

Multistate mark-recapture model

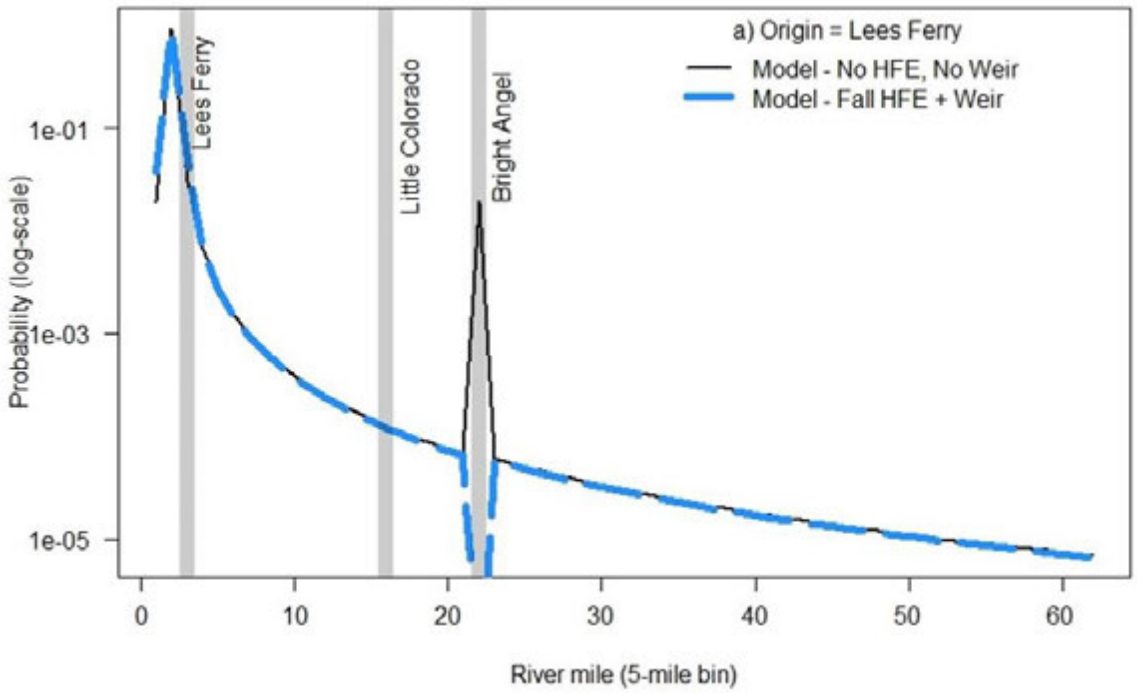
- Cauchy distribution for movement probability (top right)
- Grand Canyon divided into 61 five-mile blocks (Lees to Pearce), with block 62 representing Bright Angel Creek (captures mapped by location in bottom right)
- 4 season time-step: winter (Dec-Feb), spring (Mar-May), summer (June-Aug), fall (Sept-Nov)
- Dispersal function modified to test for directed movement, adding parameters for “homing” to Lees Ferry, into Bright Angel, and out of Bright Angel
- Time-varying covariates tested: BAC weir operation, fall HFEs, fall to winter transition when BNT typically spawn
- Three models with fall HFE covariate considered, testing influence on upriver change in direction of movement, change in scale of movemement, and increase in movement to Lees Ferry





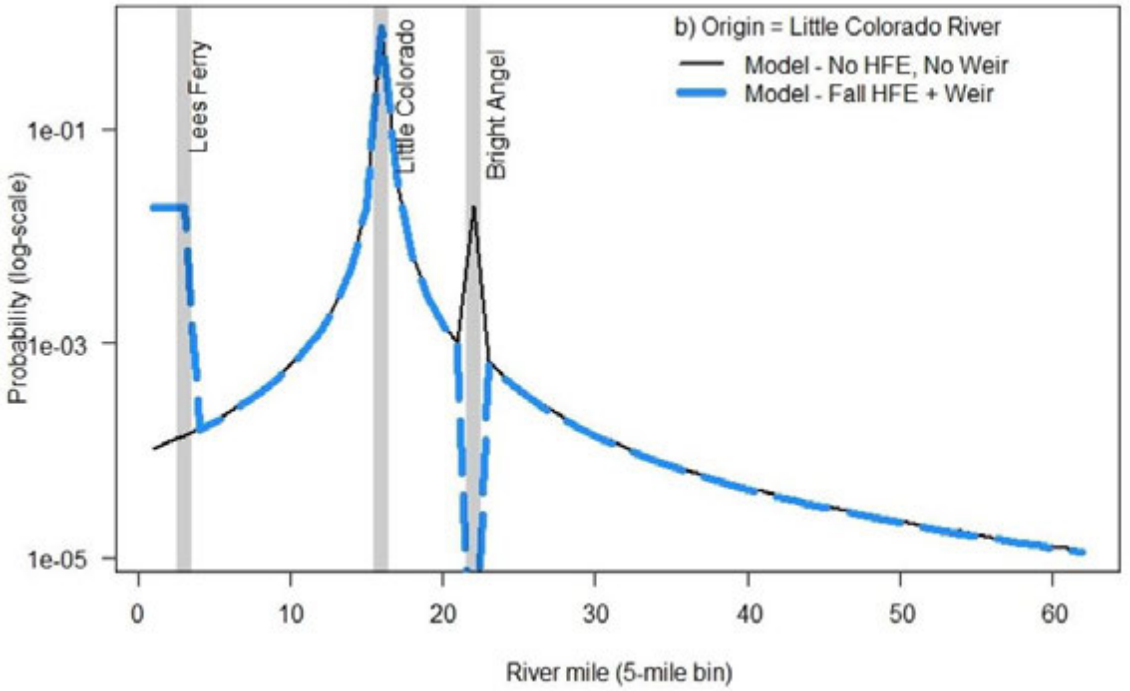
Best supported model with Lees Ferry origin

- Greater movement into Bright Angel Creek in absence of weir



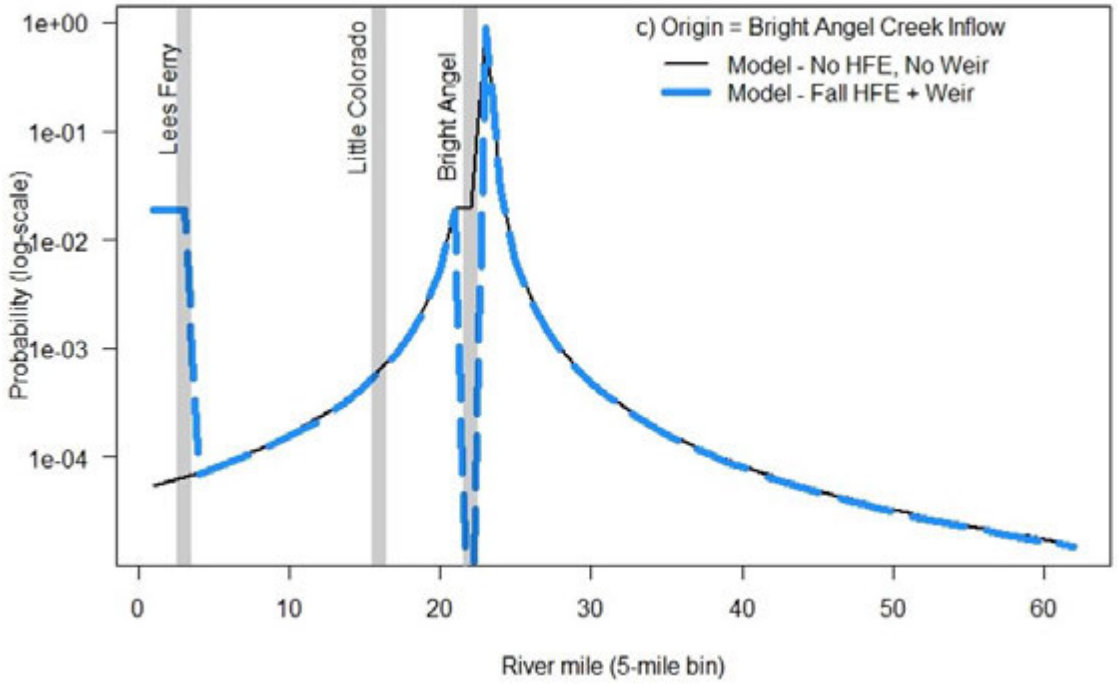
Best supported model with LCR origin

- Again, greater movement into Bright Angel Creek in absence of weir
- Increased immigration into Lees Ferry in years with fall HFEs and BAC weir operation



Best supported model with BAC inflow origin

- Increased immigration into Lees Ferry in years with fall HFEs and BAC weir operation



How to Interpret?

- Experimental fall floods increase rates of Brown Trout immigration into tailwater
- This modeling helps to slightly improve our understanding of factors driving Brown Trout ecology in Grand Canyon
- This modeling examined movement only; does not have bearing on increased reproduction and recruitment of Brown Trout in Lees Ferry
- There are numerous, sometimes competing, resource goals factoring in management decisions. Any increases in understanding of factors influencing Brown Trout may be helpful to managers in the context of changing conditions.