What Determines the Abundance of Rainbow Trout near the Little Colorado River Confluence?

Josh Korman
Ecometric Research

Michael Yard
GCMRC – USGS

Data and analytical contributions from:

Maria Dzul
Charles Yackulic
Michael Dodrill
Bridget Deemer
Theodore Kennedy

GCMRC-USGS

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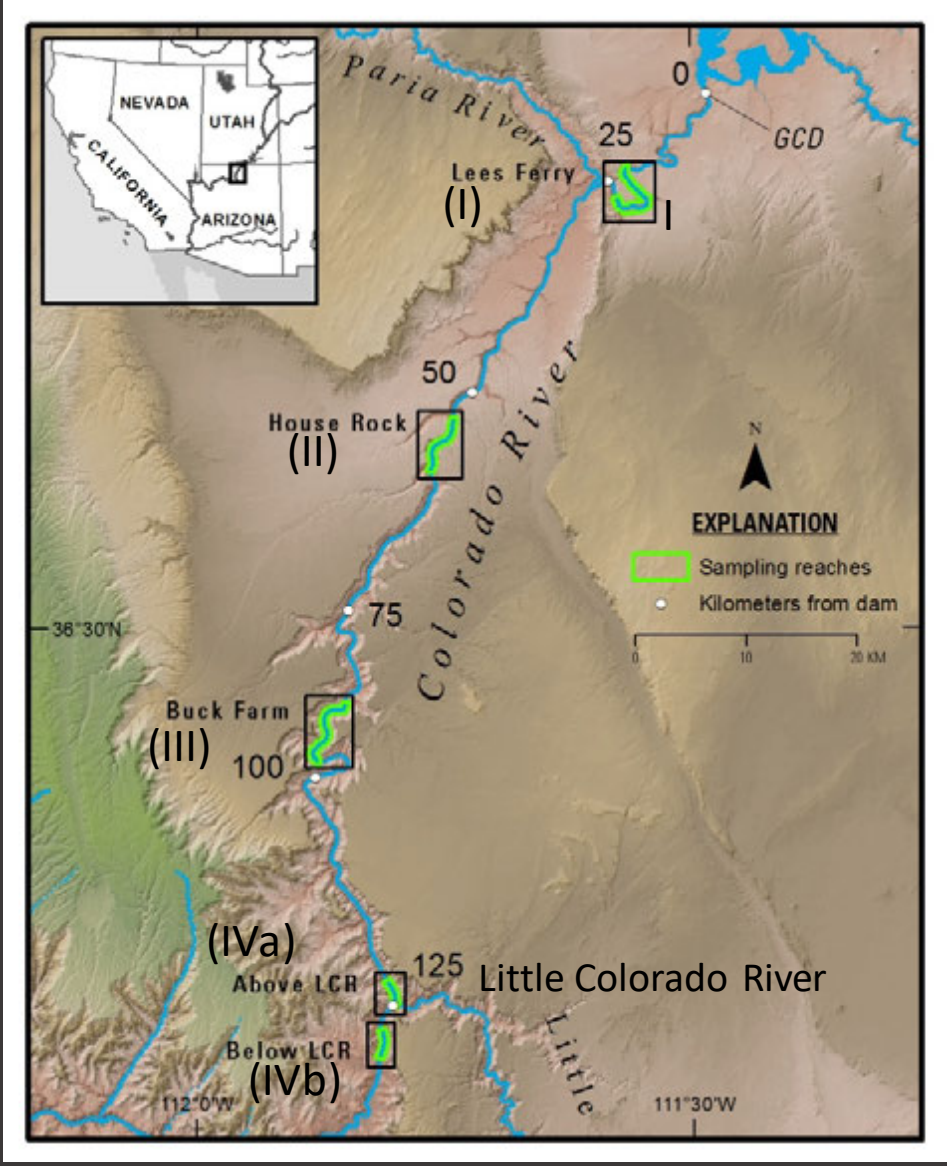
Sampling

- 5 reaches sampled quarterly, 2012-2016 (Natal Origins)
- Glen Canyon (reach I) and LCR inflow reach (IVb), 2017-2019 (TRGD, JCM)
- No sampling in Marble Canyon (II-IVa) after 2016 except for one night in reach II on July and September trips
- Mark-recapture used to estimate:
  - abundance
  - survival rate
  - recruitment (births and immigration)
  - growth rate
  - movement
- Drift measured in each reach on each trip, 2012-2016



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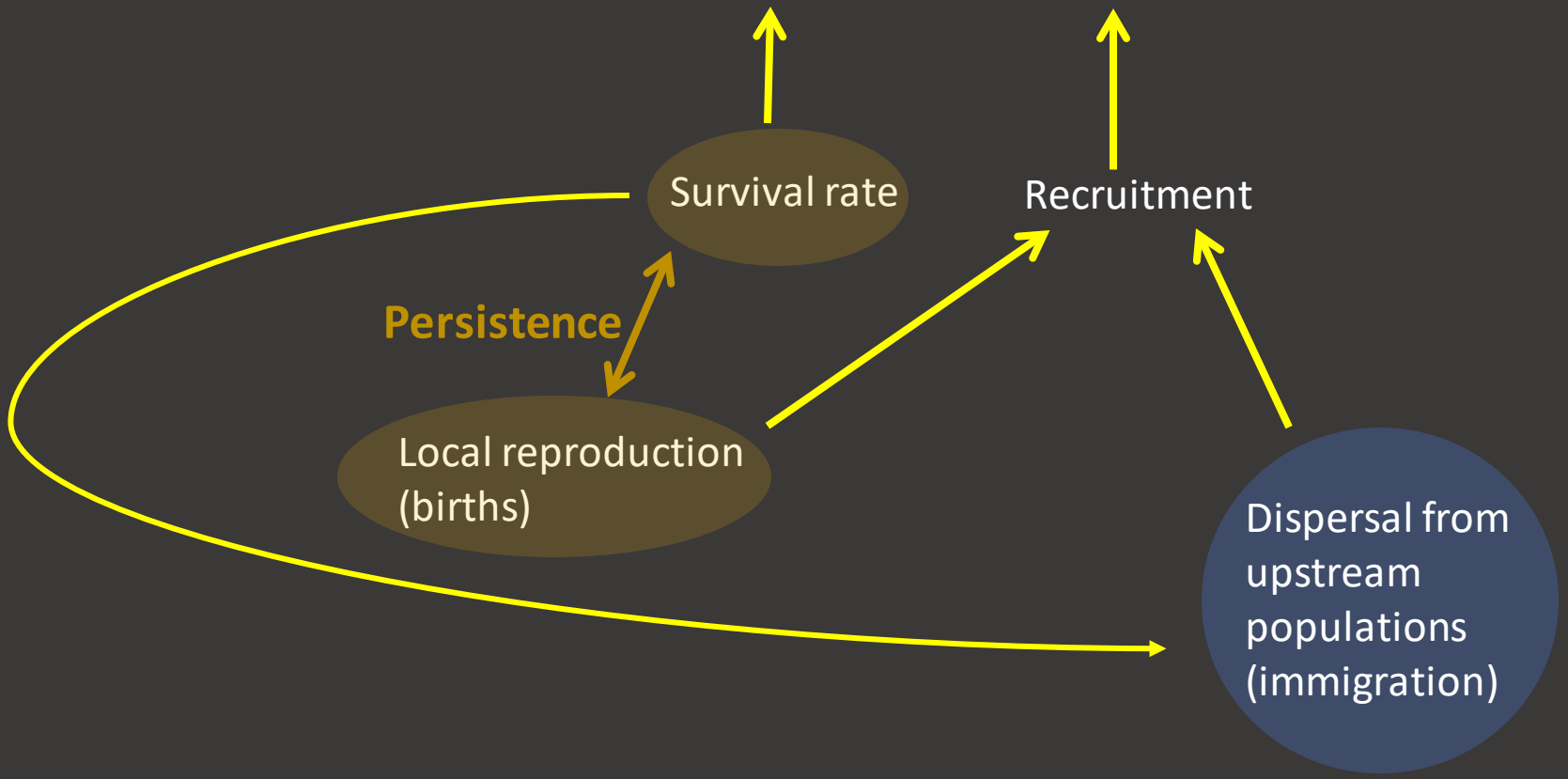
Trends in Abundance Depend on Survival and Recruitment

$$N_{2014} = N_{2013} * S_{2013} + R_{2013}$$



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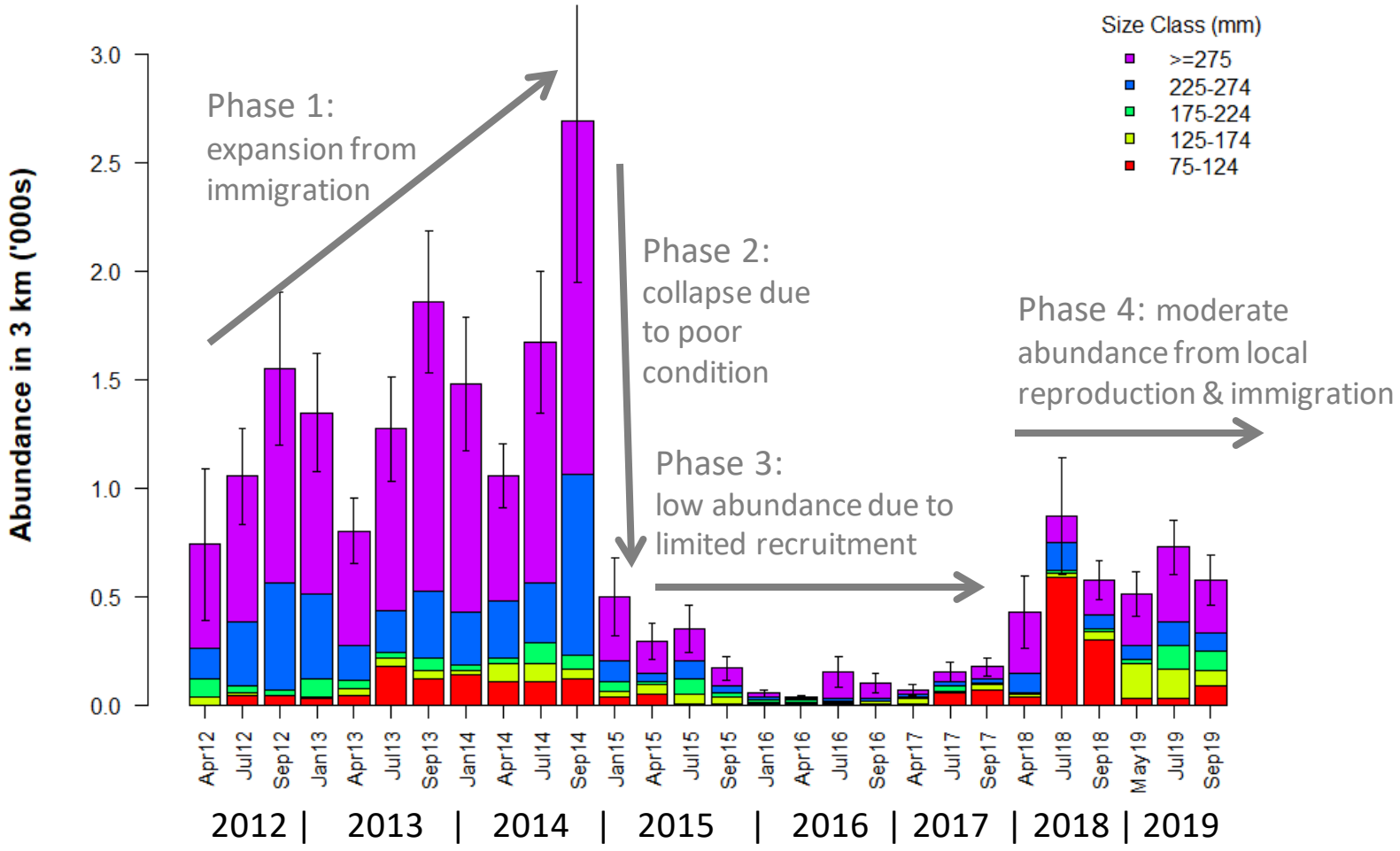
Trend in Rainbow Trout Abundance Downstream of the Little Colorado River (IVb, inflow reach)



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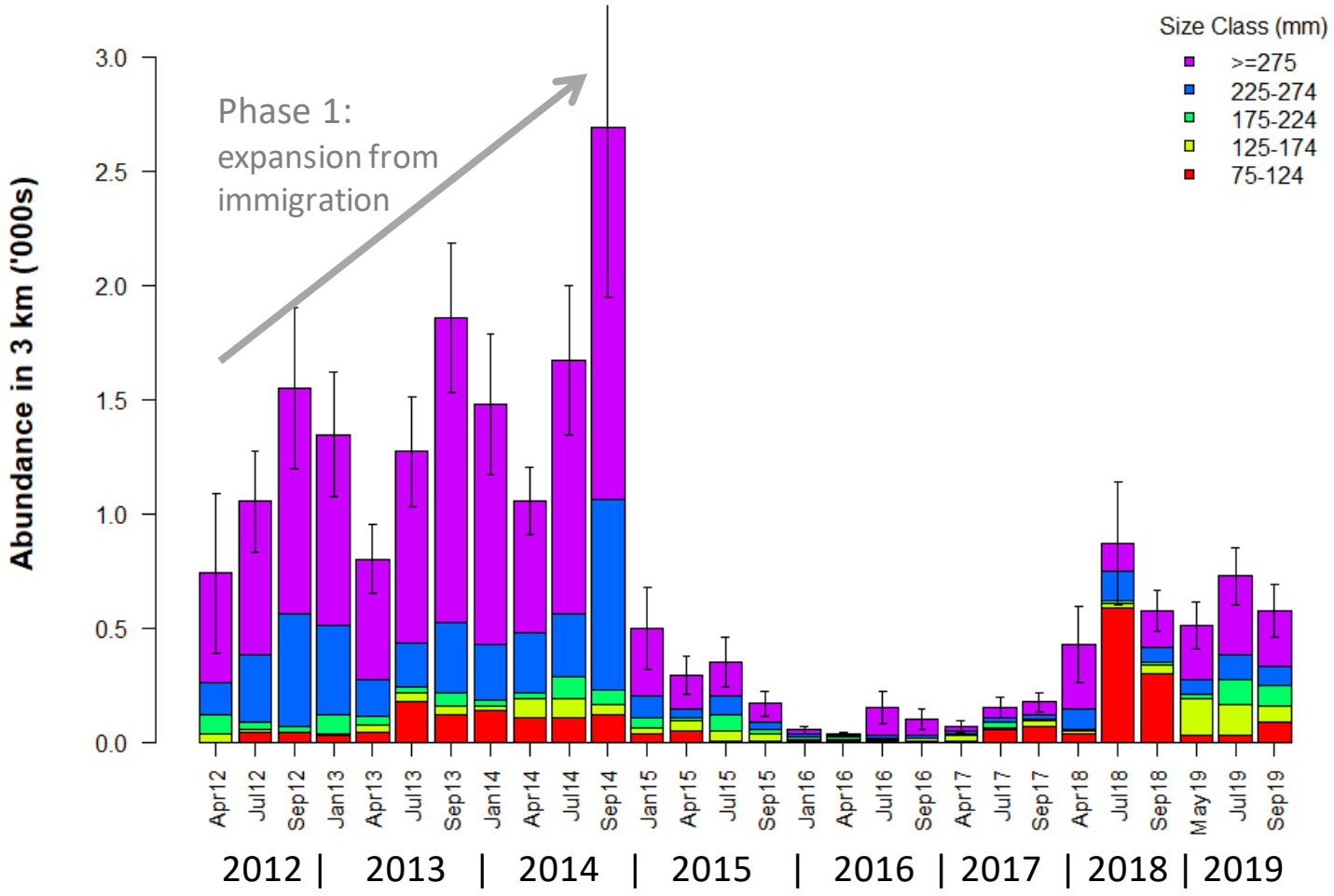
Phase 1: Expansion from Immigration



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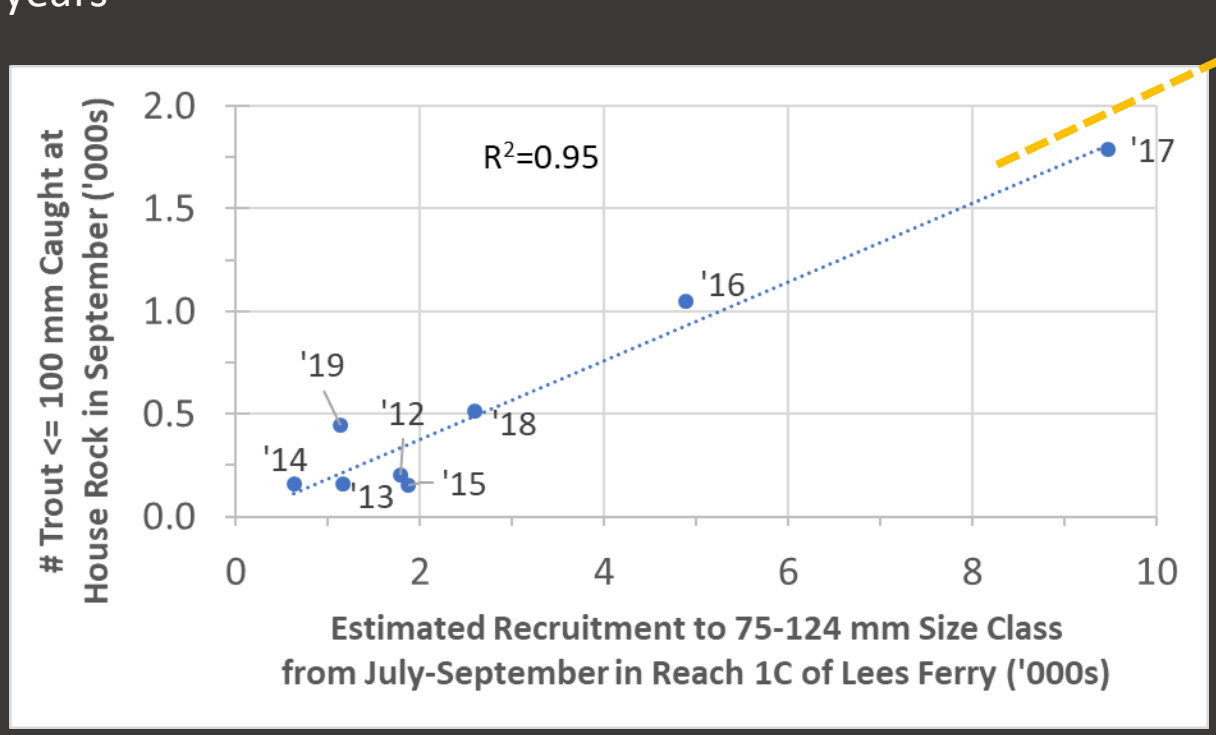
Phase 1: Expansion from Immigration

(dispersal from Lees Ferry to Marble Canyon, slide 1)

- Immigration of trout to LCR reaches is a two-step process:
  1) initial short-duration dispersal of young-of-year from Lees Ferry to upper-middle Marble Canyon in their first summer;
  2) Longer-duration downstream dispersal from Marble Canyon to the LCR in following years



- Higher recruitment in Lees Ferry leads to higher numbers of young rainbow trout dispersing downstream into Marble Canyon

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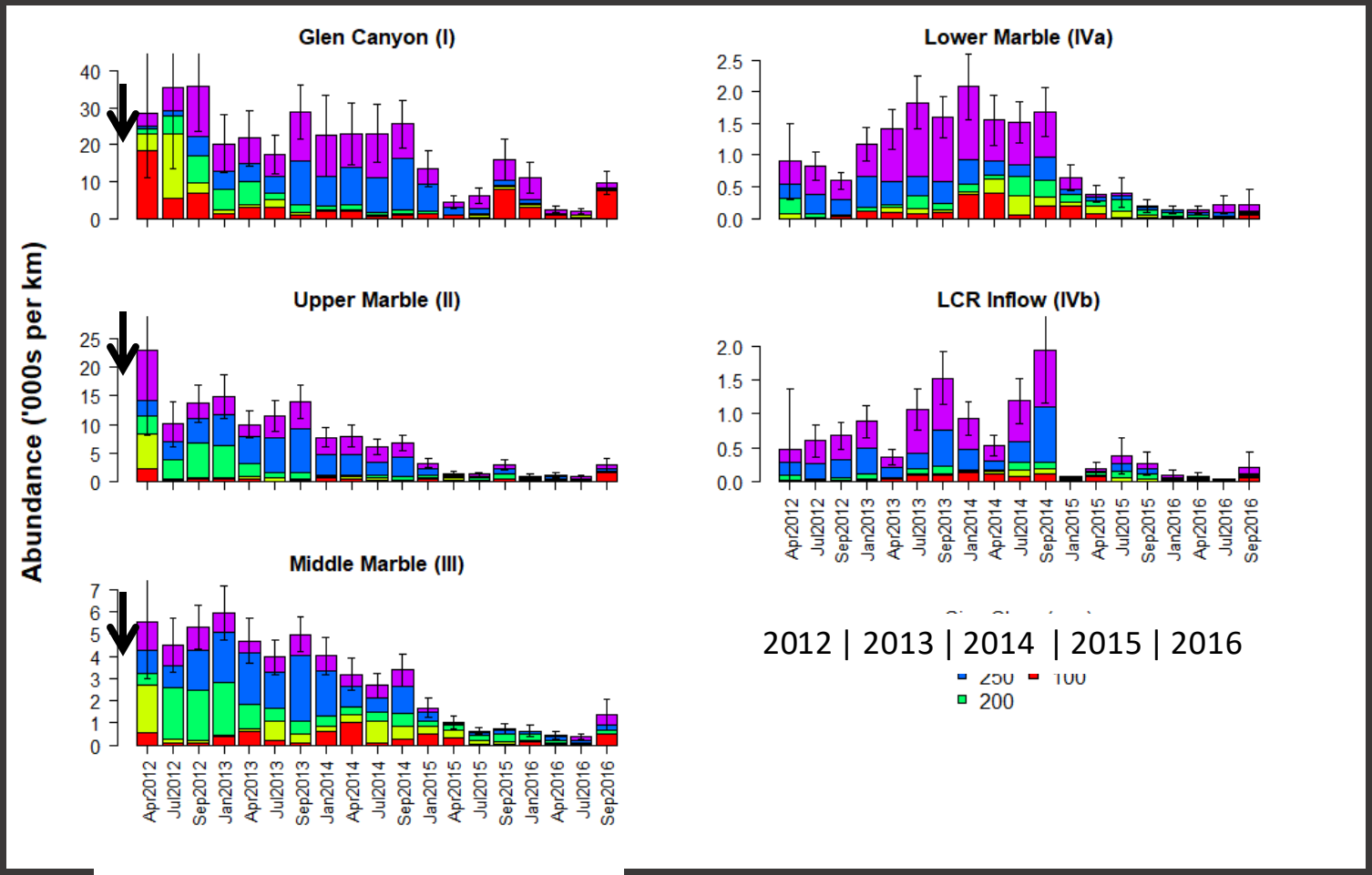
Phase 1: Expansion from Immigration

(dispersal from Lees Ferry to Marble Canyon, slide 2)



2012 | 2013 | 2014 | 2015 | 2016

- Large recruitment event in Lees Ferry in 2011 resulting from high inflows to Powell → equalization flows → high densities of small rainbow trout in Glen Canyon and upper half of Marble Canyon by April 2012 trip

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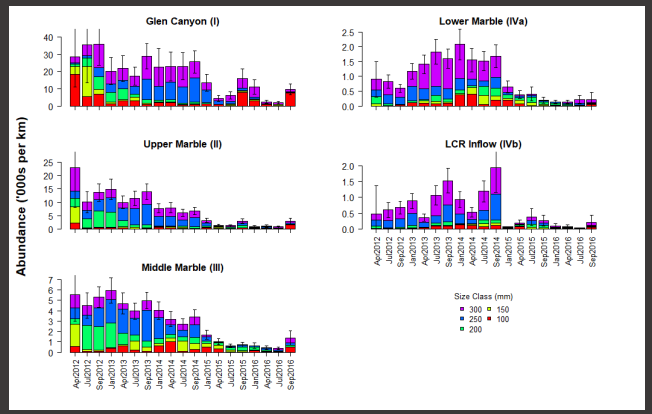
Phase 1: Expansion from Immigration

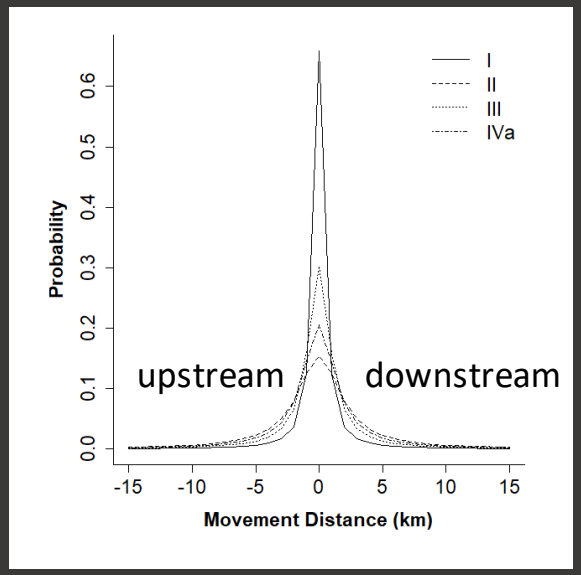
(dispersal from Marble Canyon to LCR)

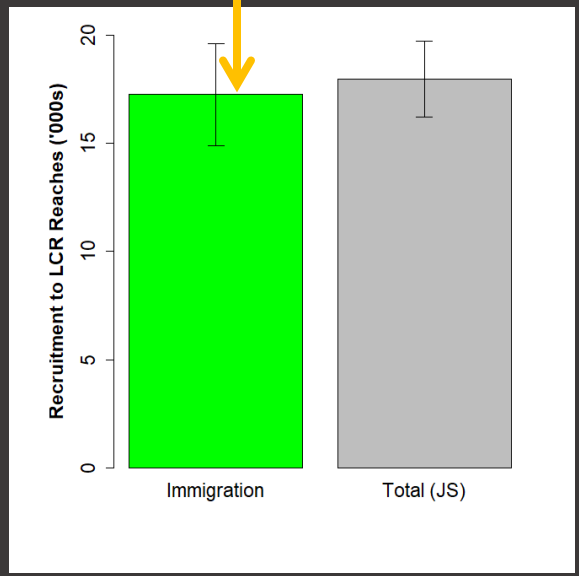
# of recaptures		Recovery Reach				
		I	II	III	IVa	IVb
Release Reach	I	3,133	12	1	0	2
	II	16	3,517	12	8	6
	III	1	15	3,162	10	8
	IVa	1	0	2	1,382	82
	IVb	1	0	1	13	560

A very small proportion of Glen and Marble Canyon populations moved downstream to the LCR between 2012 and 2014

Abundance * dispersal distribution = immigration to LCR reaches







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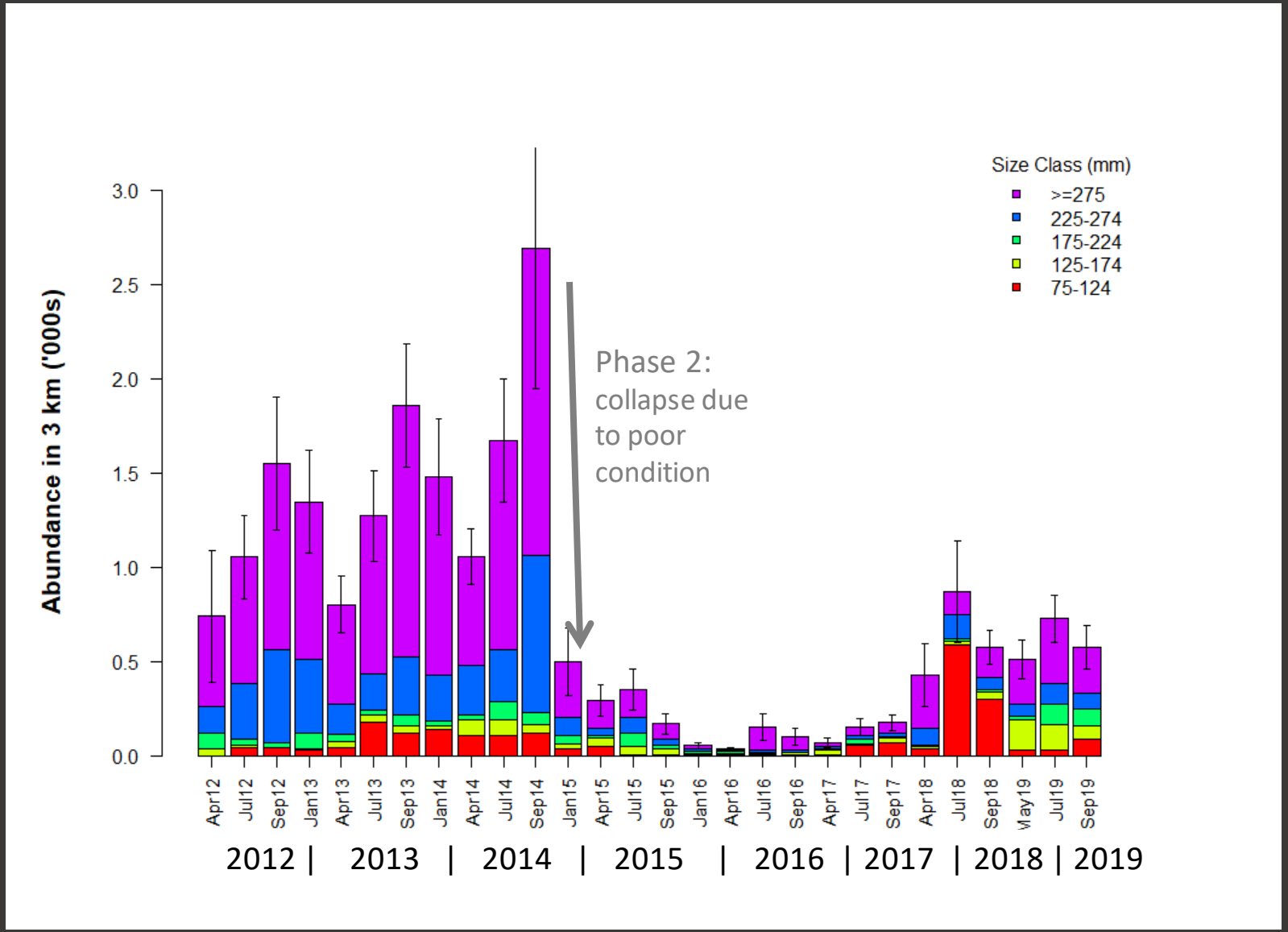
Phase 2: Collapse Due To Poor Condition



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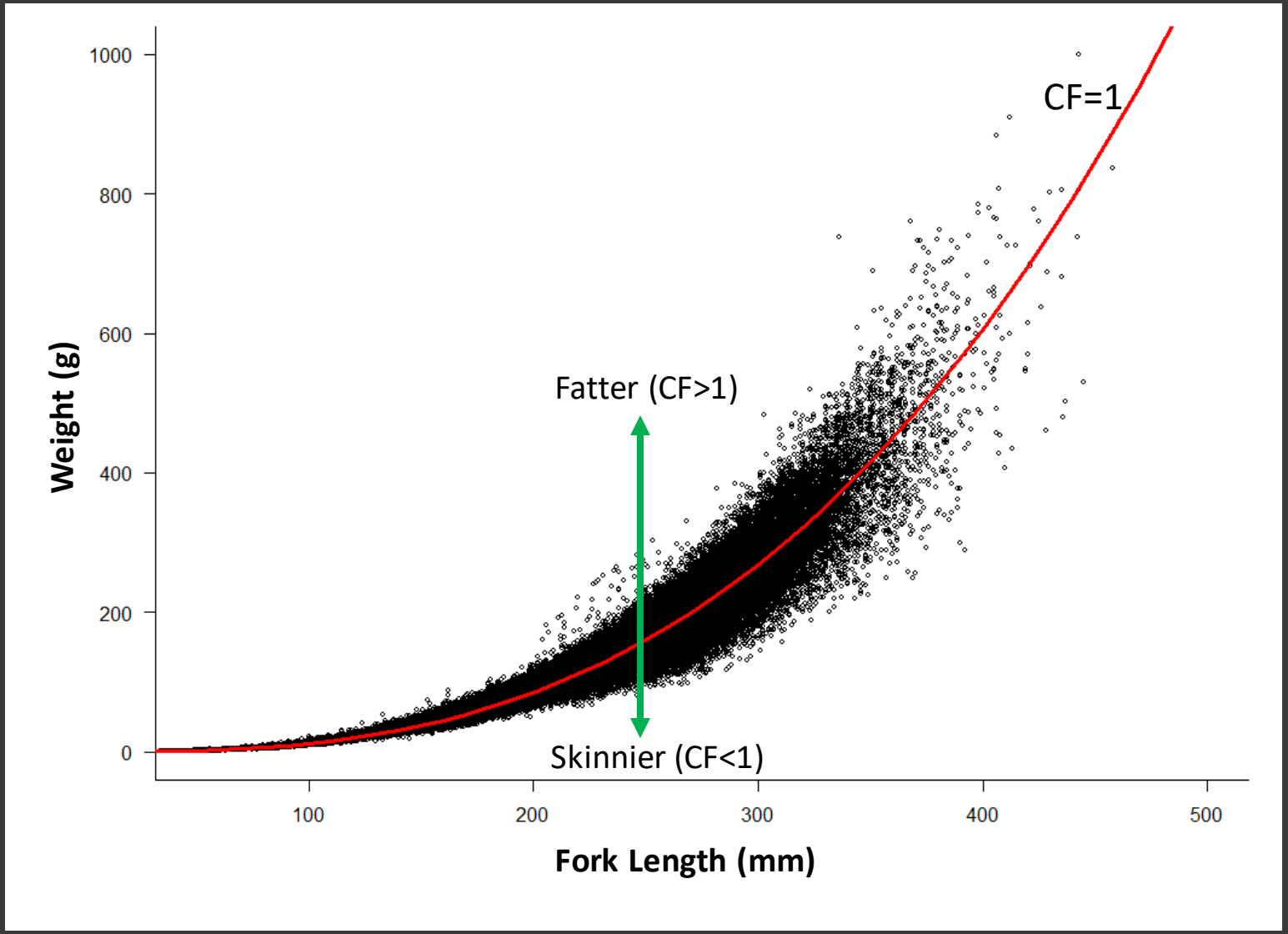
Phase 2: Collapse Due To Poor Condition

(what is condition factor (CF)?)



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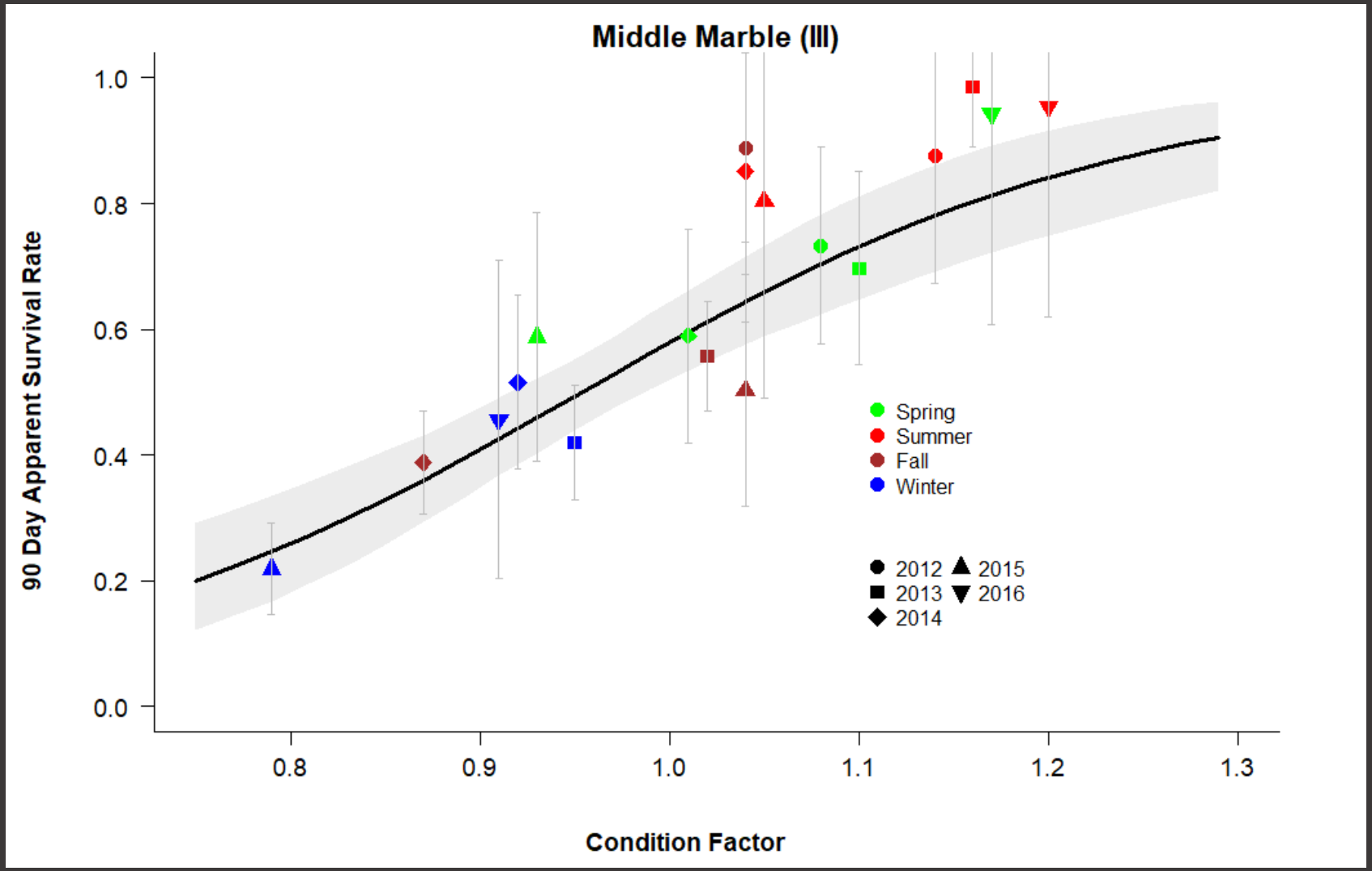
Phase 2: Collapse Due To Poor Condition

(condition factor influences survival rate, slide 1)



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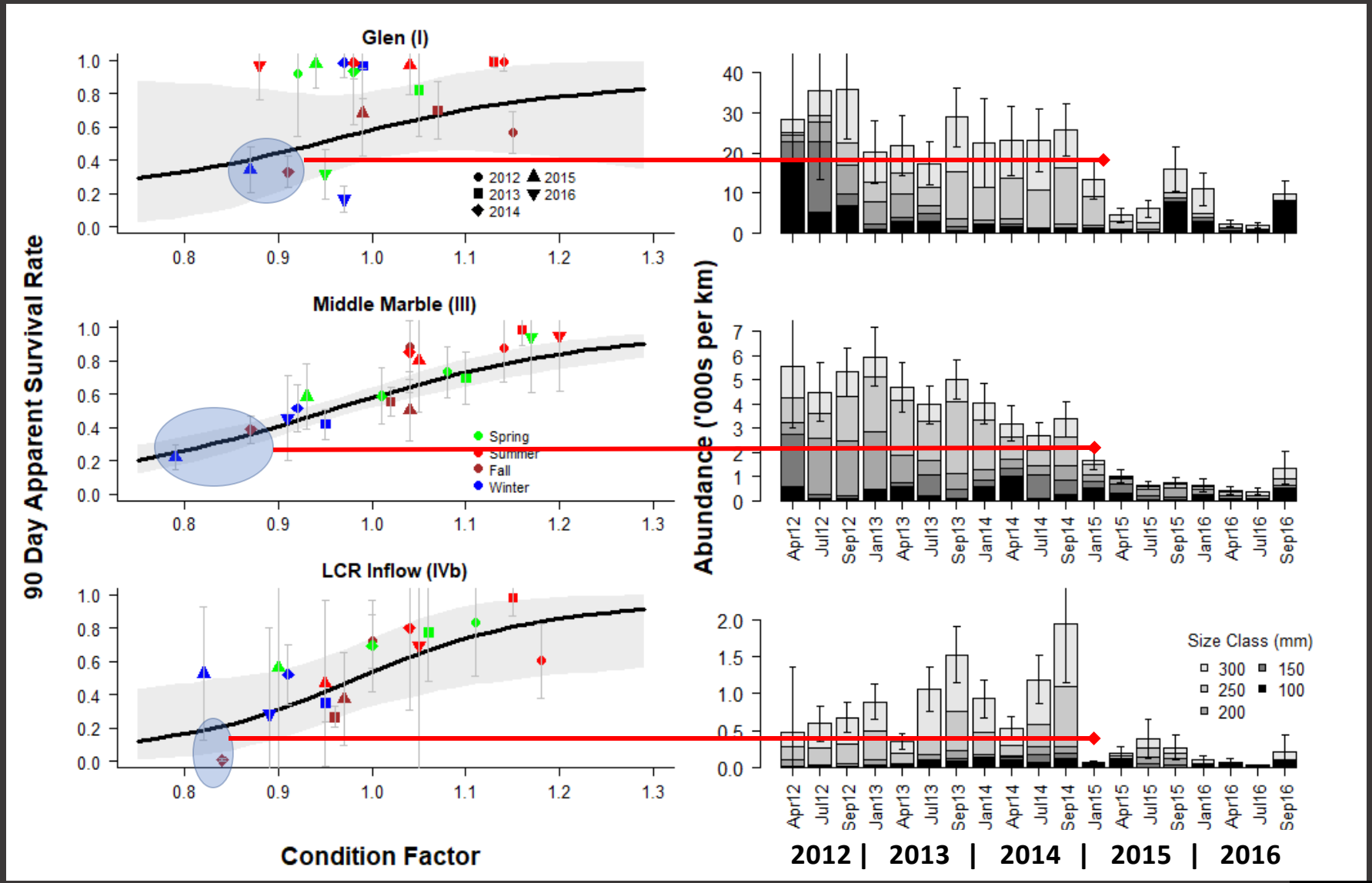
Phase 2: Collapse Due To Poor Condition

(condition factor influences survival rate, slide 2)



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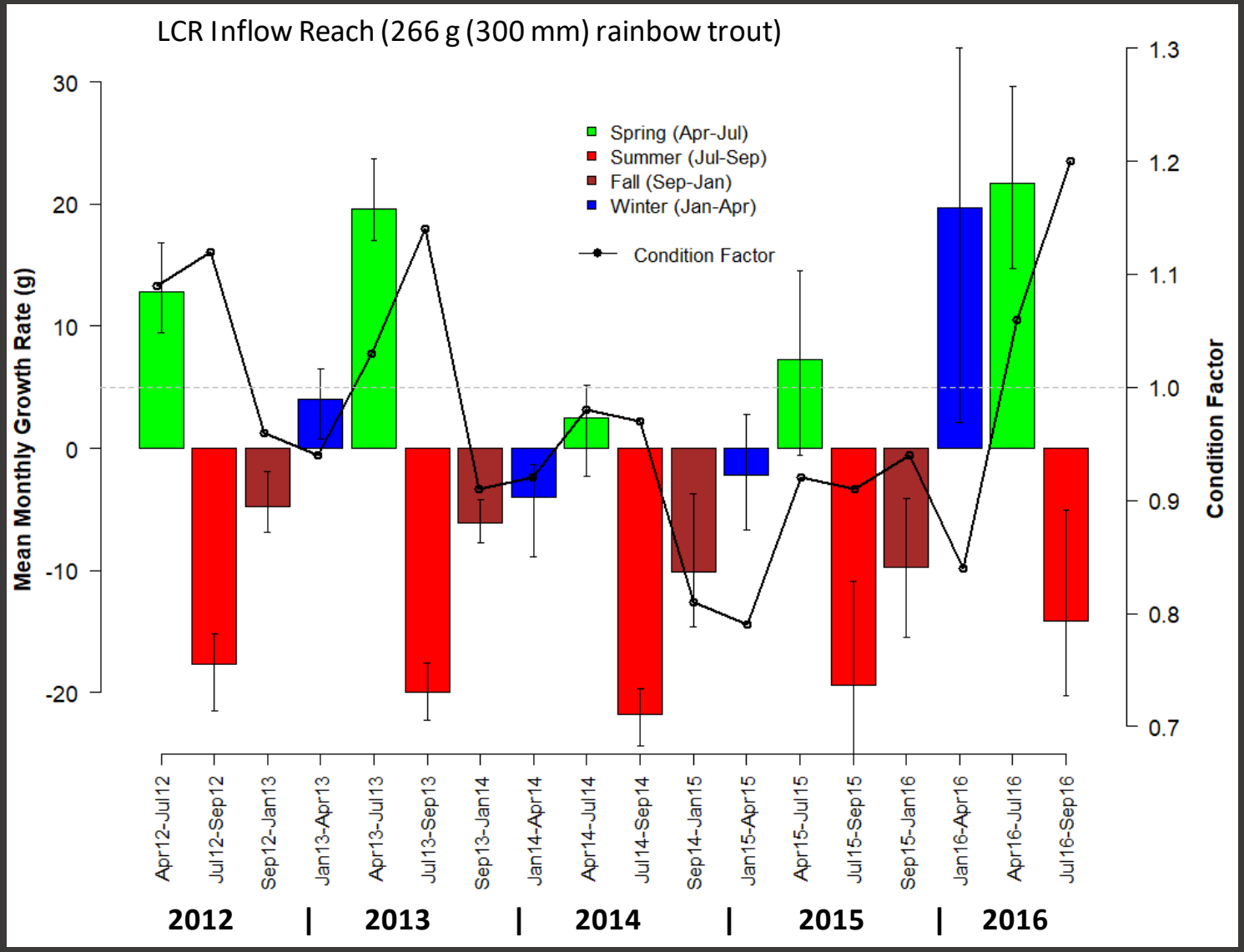
Phase 2: Collapse Due To Poor Condition

(variation in growth rate drives variation in condition)



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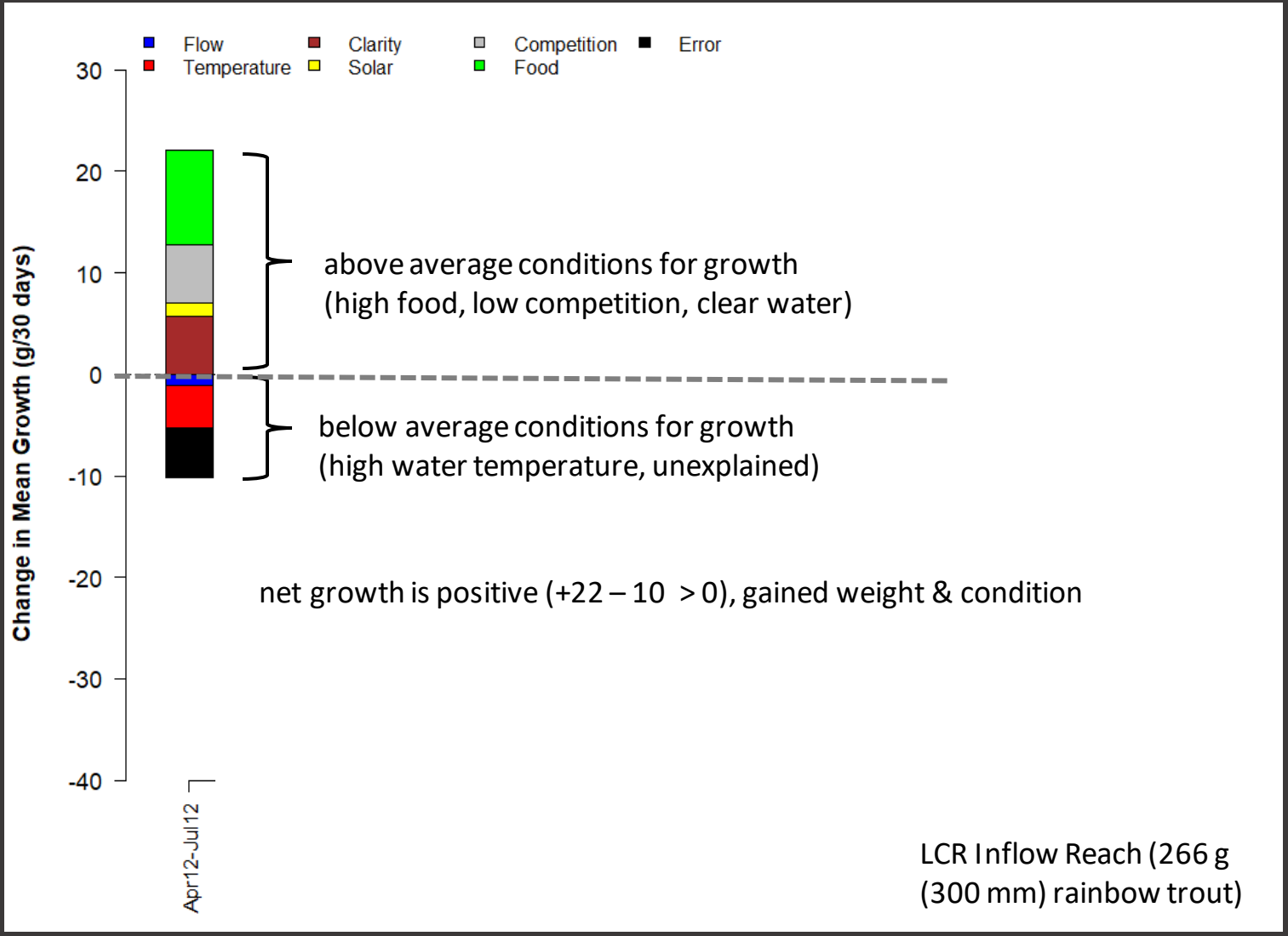
Phase 2: Collapse Due To Poor Condition

(cause of variation in growth at LCR, slide 1)



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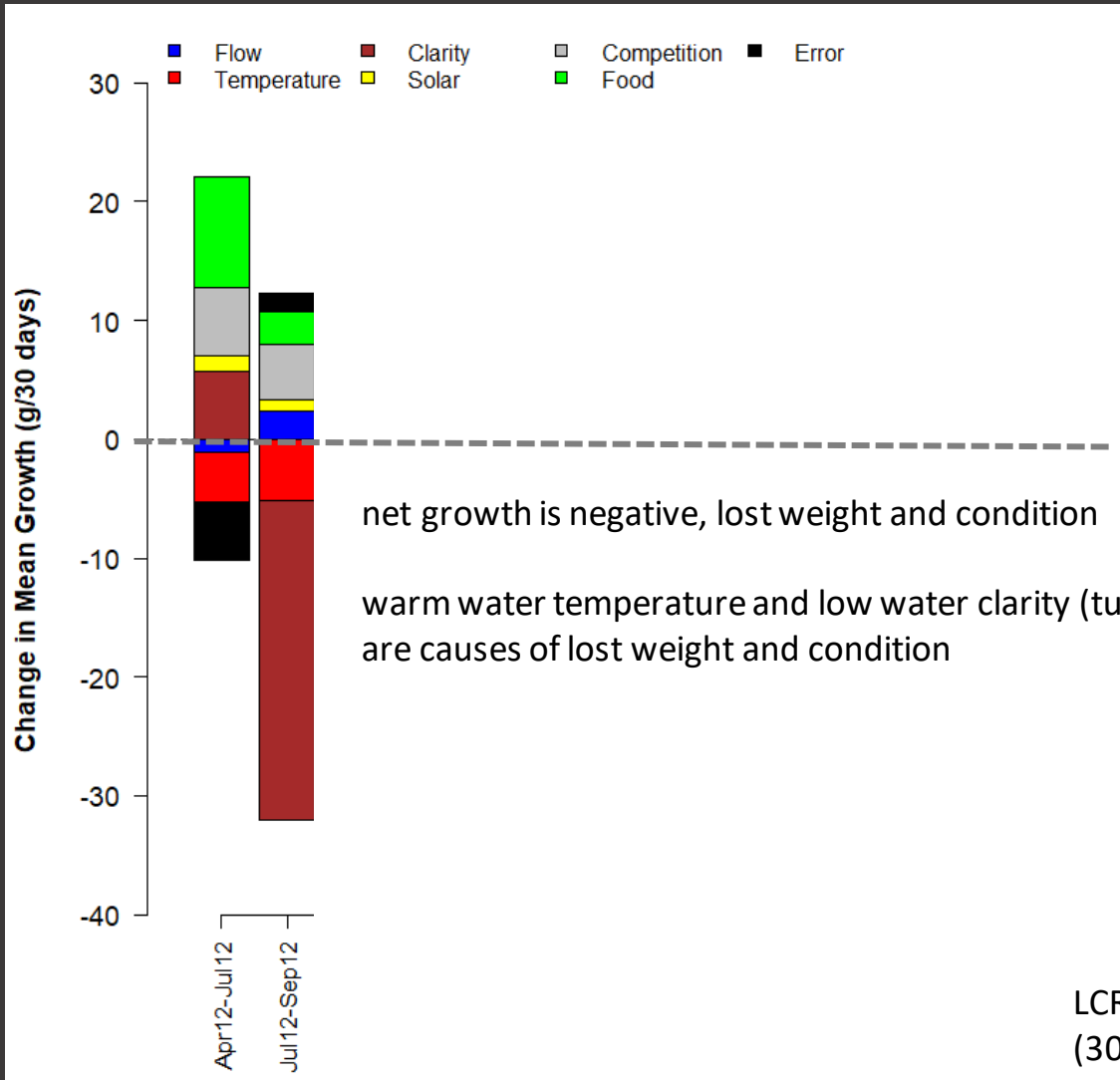
Phase 2: Collapse Due To Poor Condition

(cause of variation in growth at LCR, slide 2)



net growth is negative, lost weight and condition

warm water temperature and low water clarity (turbidity) are causes of lost weight and condition

LCR Inflow Reach (266 g (300 mm) rainbow trout)

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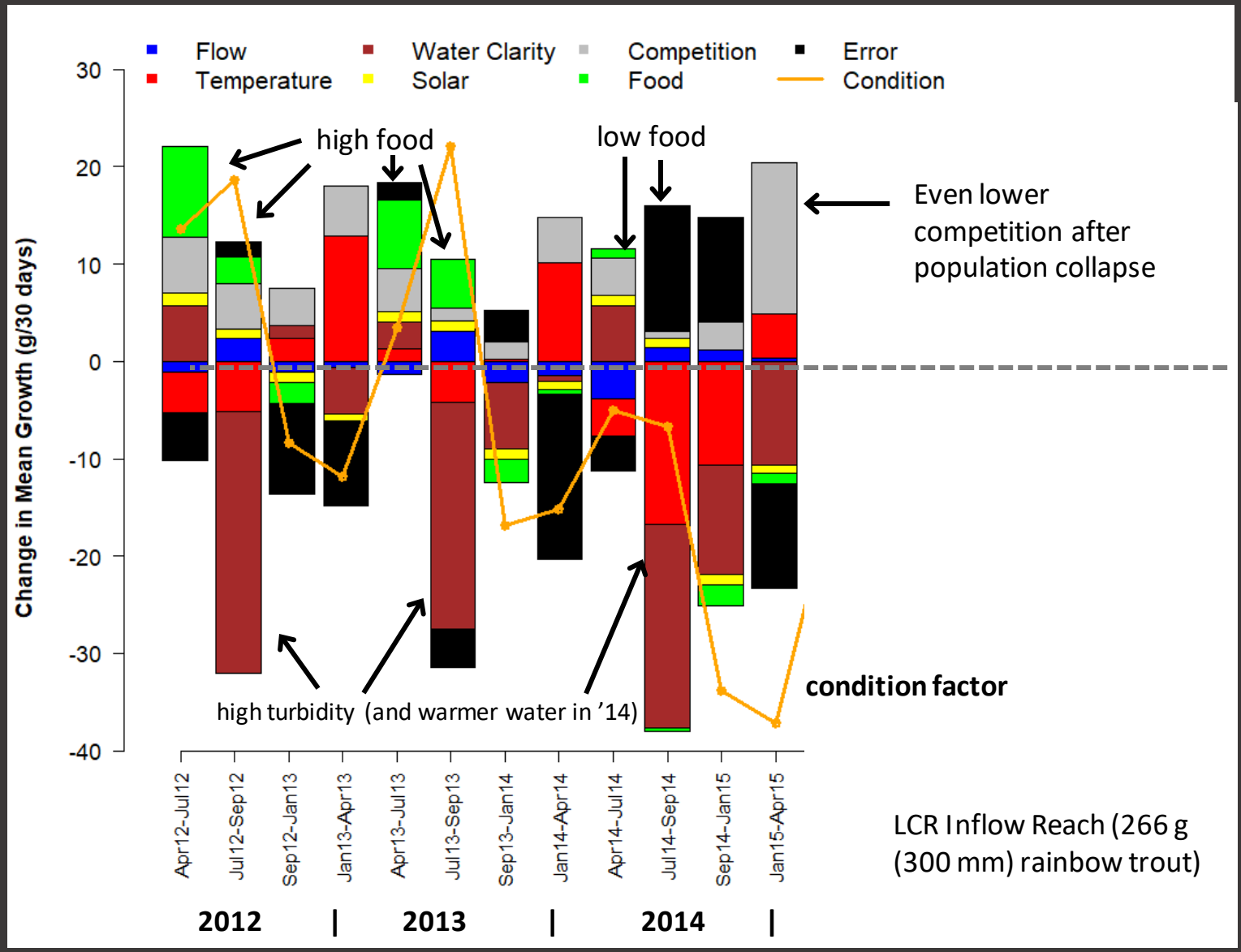
Phase 2: Collapse Due To Poor Condition

(2012-2014: a bumpy ride to the bottom)



LCR Inflow Reach (266 g (300 mm) rainbow trout)

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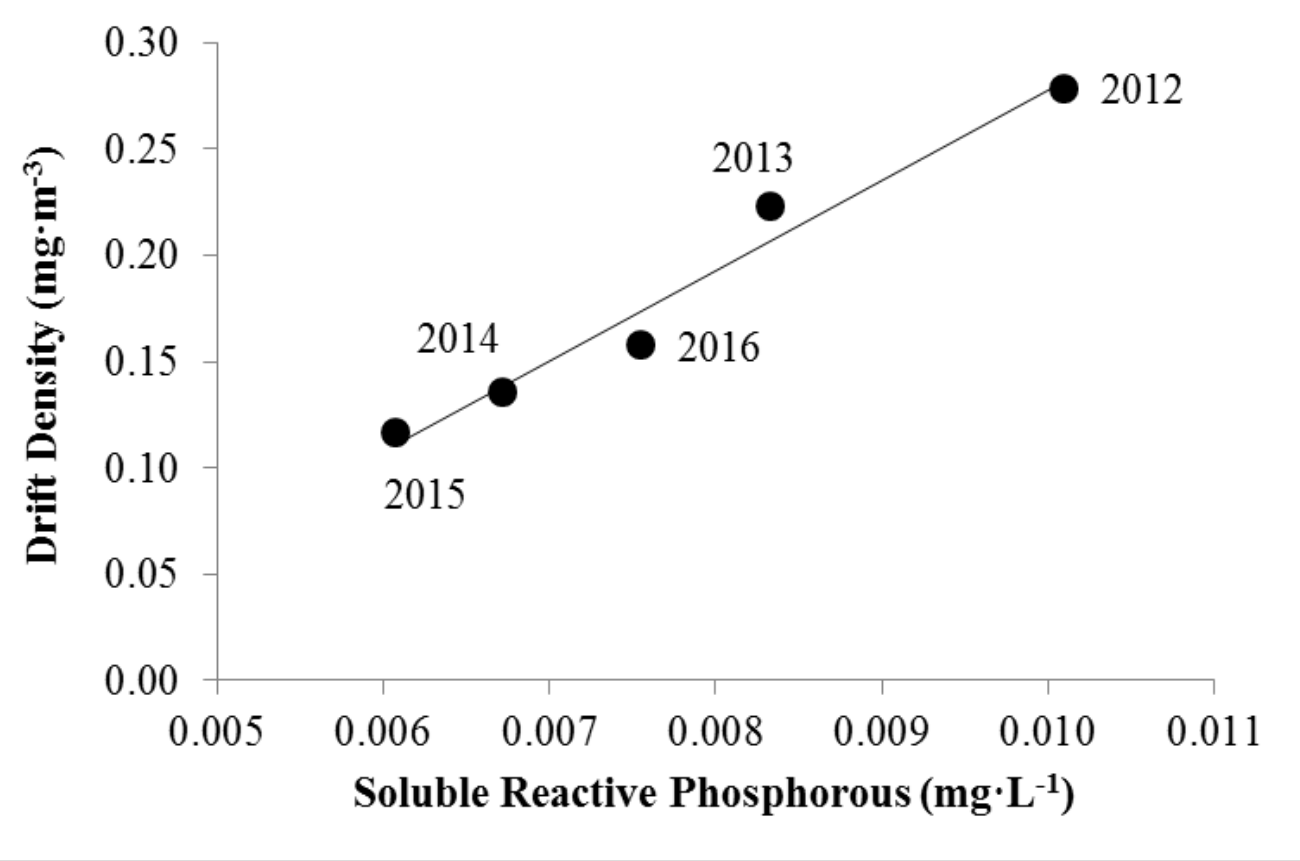
Phase 2: Collapse Due To Poor Condition

(potential explanation for food base changes 2012-2016)



Changes in food base between 2012-2016 likely driven by low concentrations of phosphorous in releases from Glen Canyon Dam

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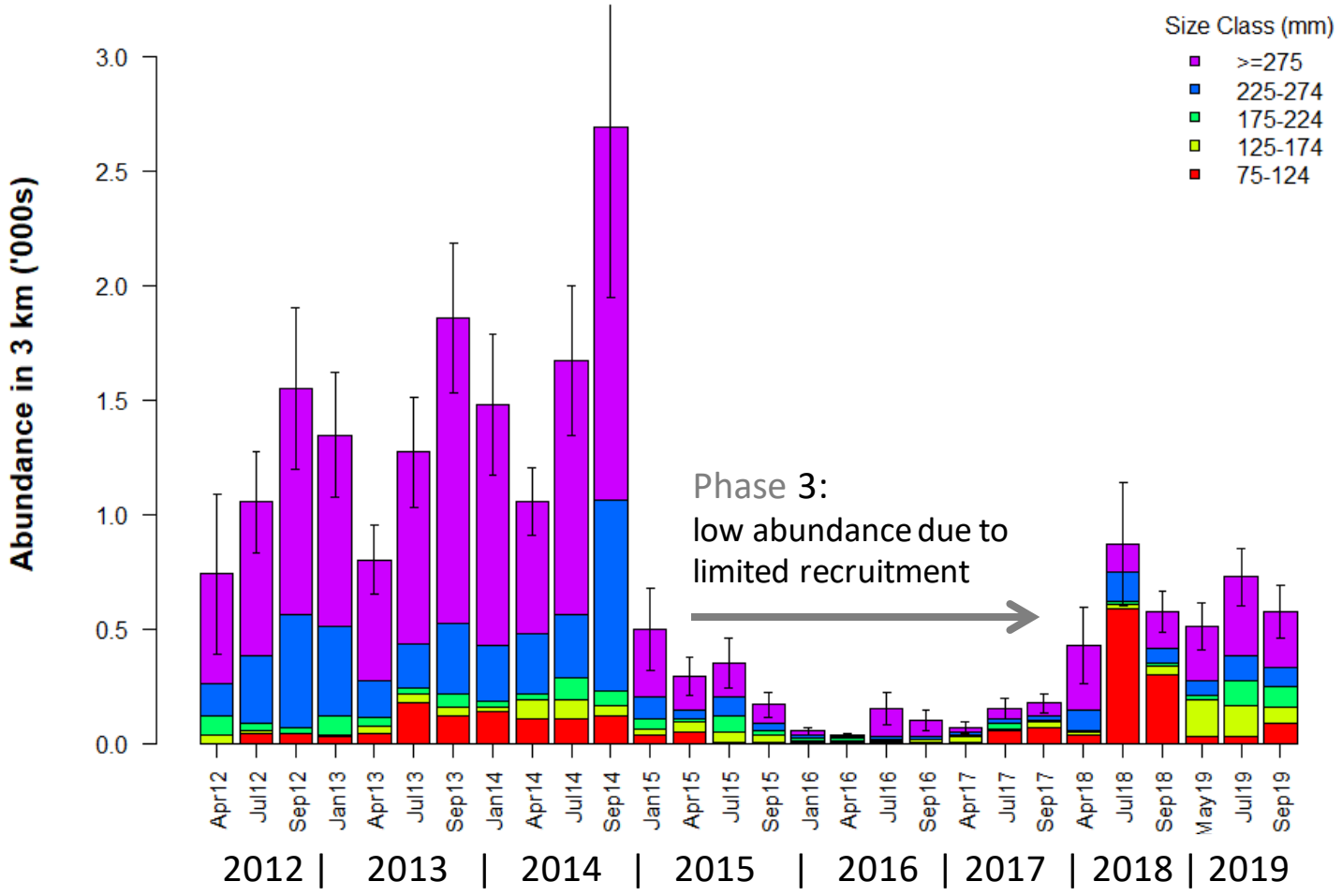
Trend in Rainbow Trout Abundance Downstream of the Little Colorado River (LCR)



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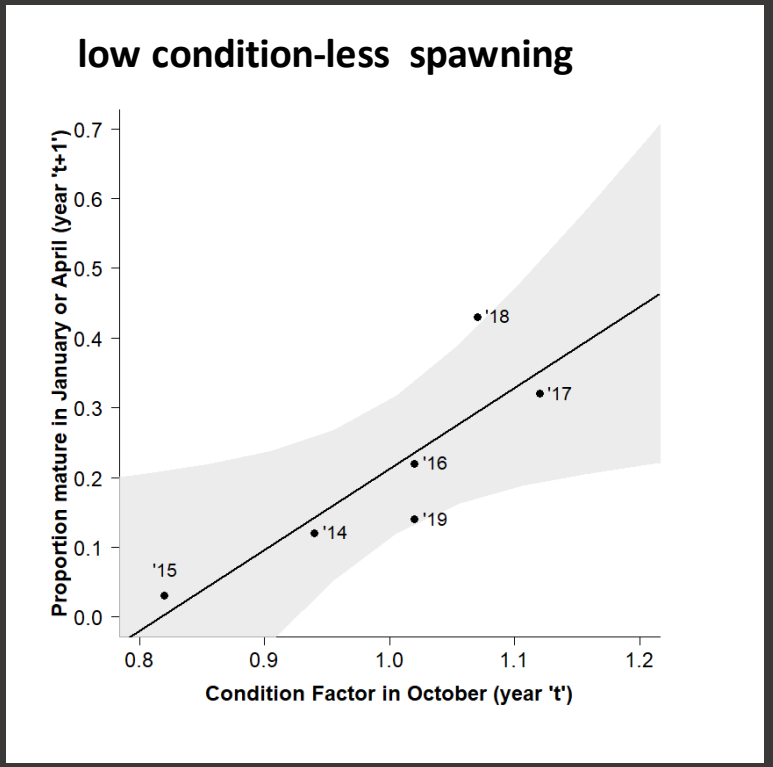
Phase 3: Low Abundance Due To Limited Recruitment

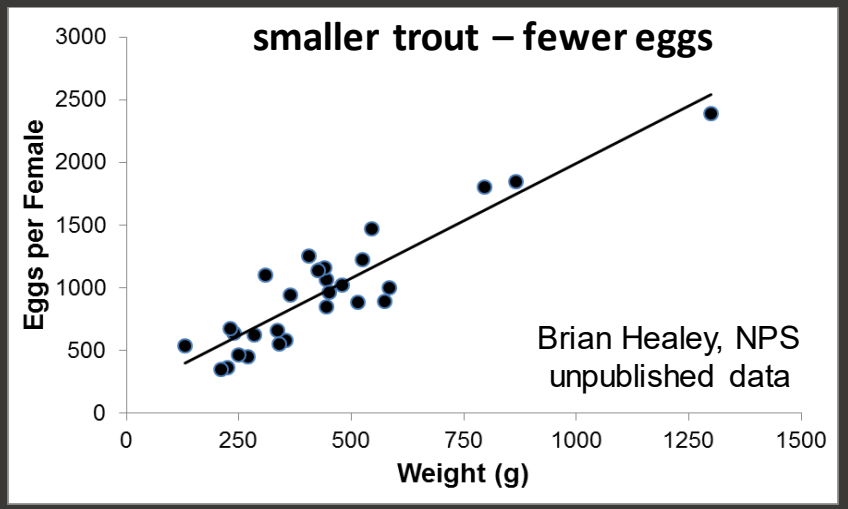
1. Low recruitment in Lees Ferry in 2015, limiting dispersal to Marble Canyon
2. Small trout populations in Marble Canyon after collapse, limiting immigration to LCR reach

immigration

3. Few potential spawners near LCR after collapse
4. Potential spawners in poor condition and smaller in 2015, leading to low rates of maturation and fecundity in 2016, and limiting recruitment in 2017

Local reproduction





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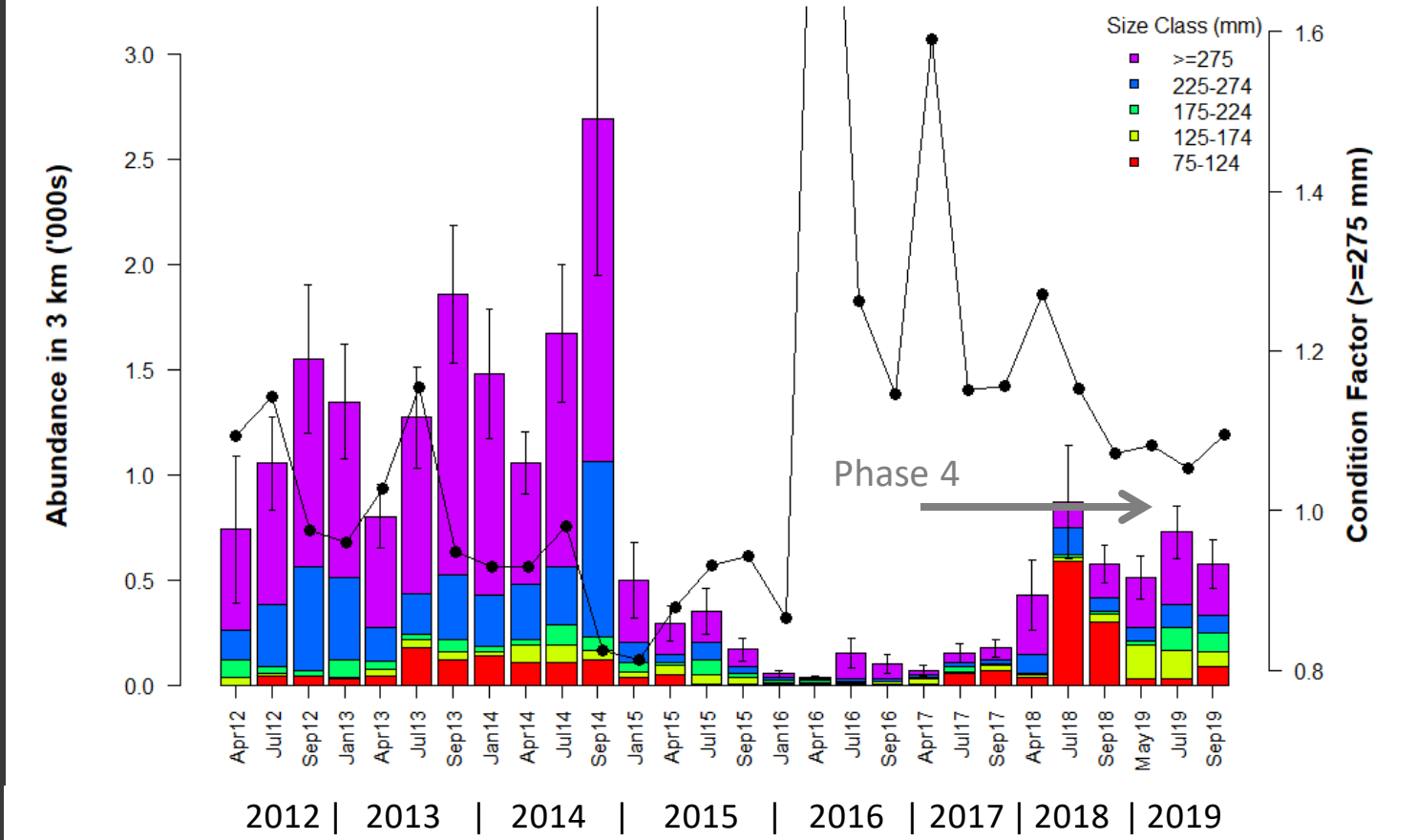
Phase 4: Moderate Abundance From Local Reproduction and Immigration

- **Good growth and condition starting in 2016 likely led to local reproduction**

- **Average size of rainbow trout <125 mm in July 2018 was 80 mm**
  - too small to have originated from Glen Canyon from large 2017 recruitment-dispersal event
  - too big and too far downstream to have originated from Glen Canyon form 2018 dispersal event
  - therefore likely from spawning in reach IVb or Marble Canyon in winter 2018



Preliminary data, do not cite

Conclusions

Factors controlling trout abundance at the LCR

- Dispersal of young rainbow trout from Lees Ferry to Marble Canyon
- Prey availability (food base)
- Water clarity (turbidity)
- Water temperature

Conditions in Lees Ferry (immigration)

Conditions in Marble Canyon & below LCR (persistence)

Trout Control Management Options

Trout Management Flows (limit immigration) *

Mechanical Removal near LCR (local reductions in immigration & persistence)

Turbidity Management - limit Fall HFEs (limit persistence) *

Do Nothing - (2007-2019)

No active trout control

Did we increase trout persistence in Marble Canyon through frequent fall HFE's?

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* = more study needed

Preliminary data, do not cite

Acknowledgements

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- Supporting data: Dave Topping, Nick Voichick
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