High reproductive success of Bonytail reared in off-channel habitats

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Bonytail (*Gila elegans*) background

- Was once prominent as one of Colorado's "big river" fishes
- Has experienced drastic declines
- Bonytail is endangered and considered functionally extinct in the wild.
- Broodstock was established in 1981 with less than 8 contributing individuals, low genetic diversity
- Hatcheries used for production

A Conservation Plan for Native Fishes of the Lower Colorado River

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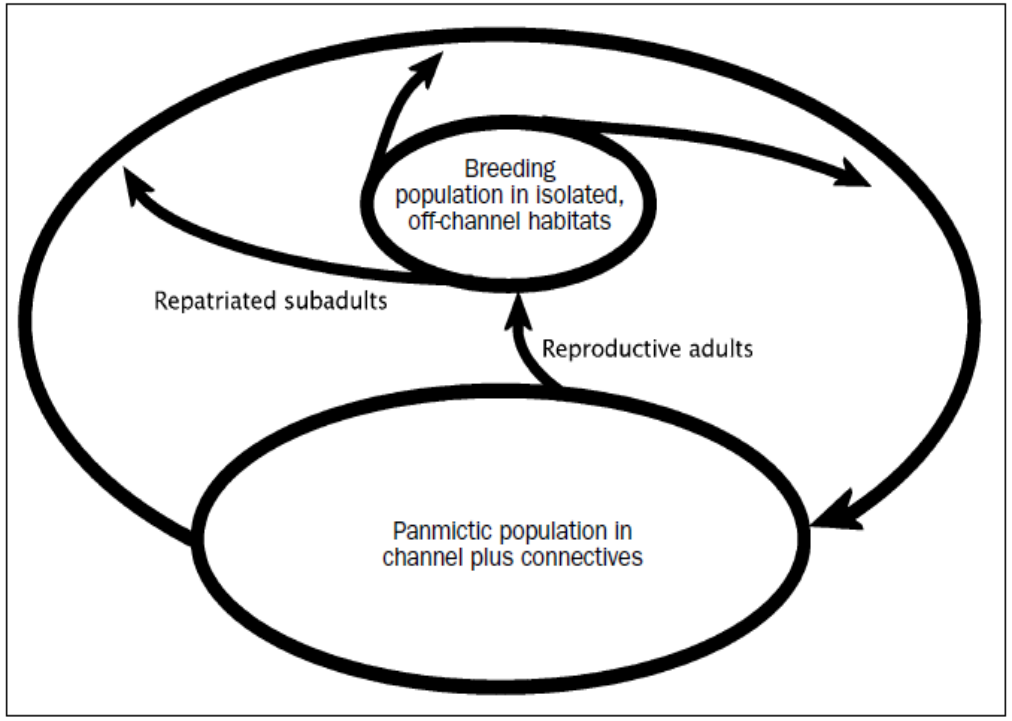
- Stock adult bonytail into off-channel ponds
- Able to mate naturally
- Absence of non-native species
- Subject to selection
- Still exposed to some predation



Variance in Reproductive Success

- Highly fecund species
- Aggregate broadcast spawners
  - All individuals have the opportunity to mate
  - Only few may be successful
  - Random mating?
- Increase risks of adverse genetic effects like inbreeding depression

Objectives

Use genetic data from bonytail broodstock and offspring produced in off-channel habitats to:

1. Quantify the contribution of adults to offspring production

2. Assess whether reproductive output is correlated with the number of breeding partners

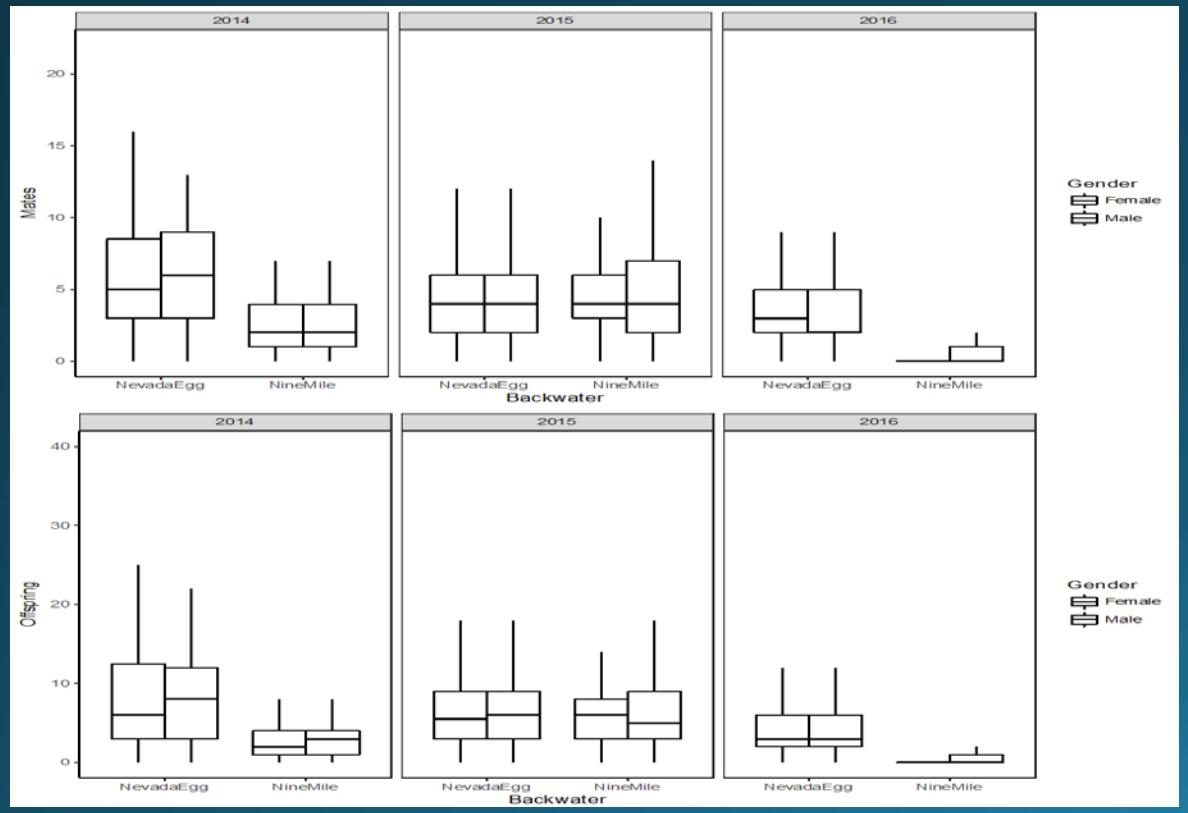
3. Identify the main source of variance (gender, pond, year) in reproductive success?

Mohave Backwaters-- Summary

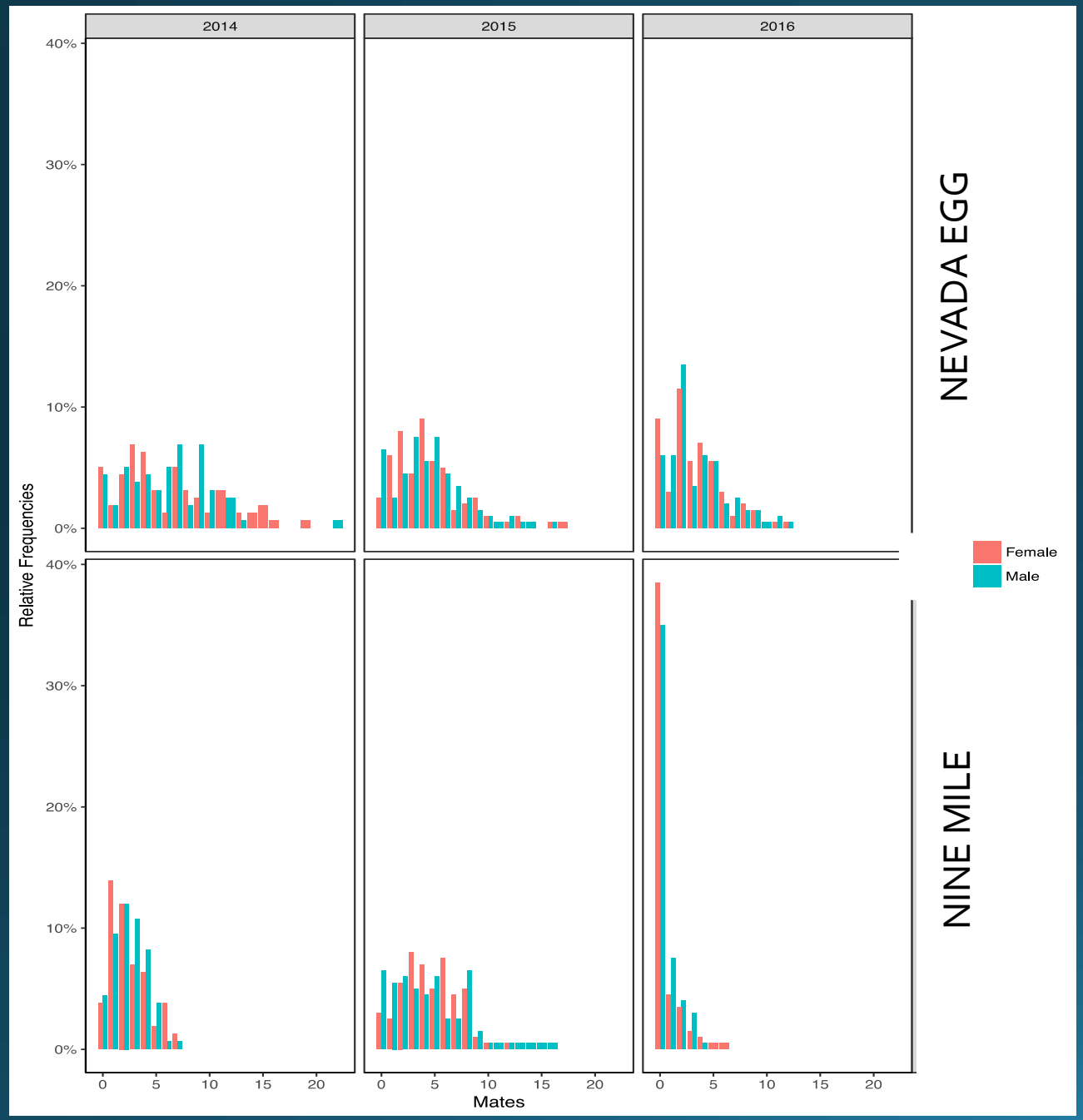
- 3 years (2014-2016) adult bonytail were stocked into North Nine Mile & Nevada Egg
- Genetic data from 18 microsatellites for 4130 adults & offspring

Contribution of adults to offspring production

- 82-94% adults contributed (except NM 2016)
- No difference between males and females
- Mean number of mates and offspring differed between 2014 and 2016
- GLM- variance in reproductive success explained by year-backwater NOT gender- environmental factors



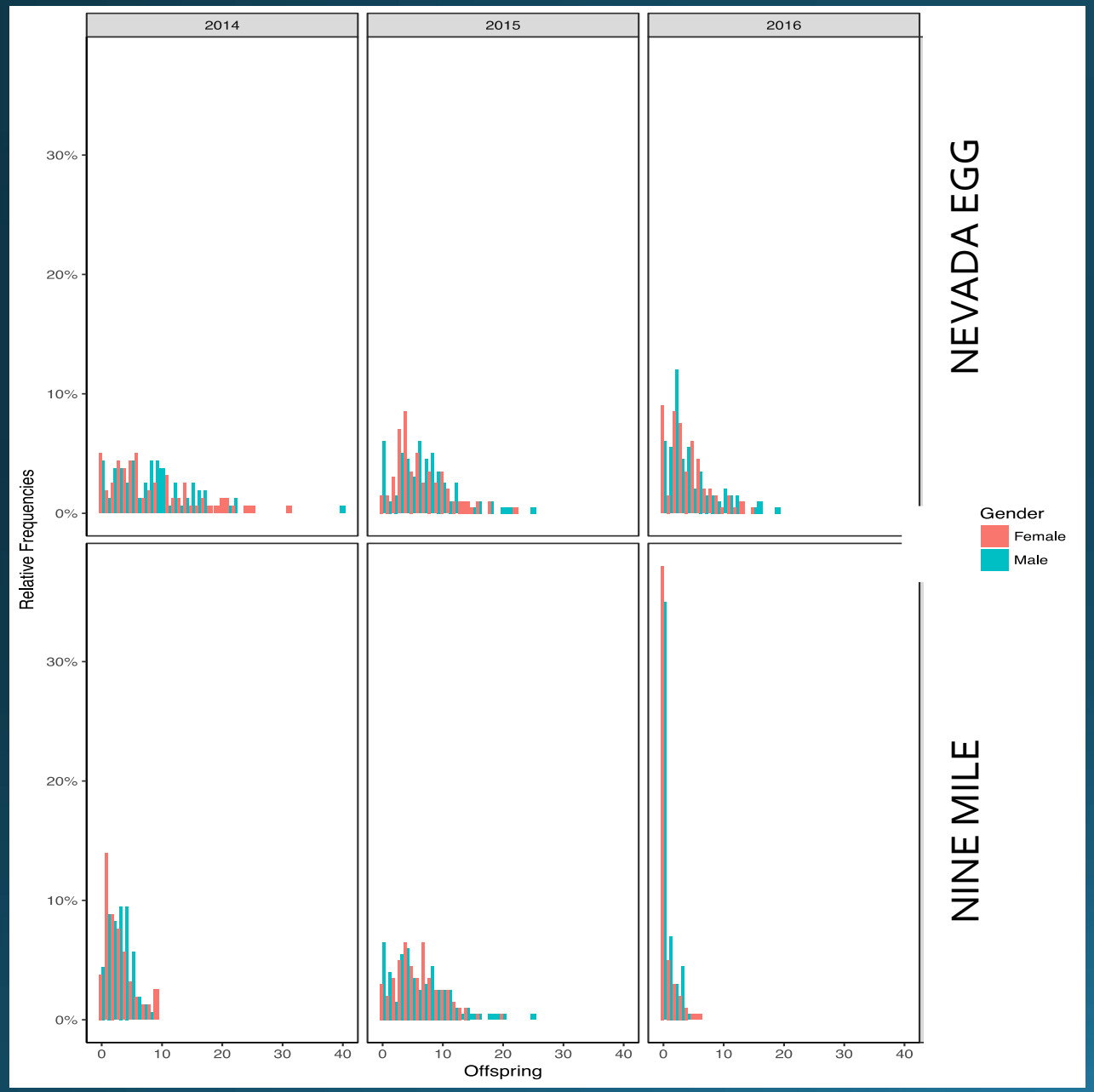
Gender	% Contributing
2014 Nevada Egg	
Male	0.938
Female	0.899
2014 Nine Mile	
Male	0.911
Female	0.913
2015 Nevada Egg	
Male	0.890
Female	0.940
2015 Nine Mile	
Male	0.870
Female	0.940
2016 Nevada Egg	
Male	0.88
Female	0.82
2016 Nine Mile	
Male	0.33
Female	0.27



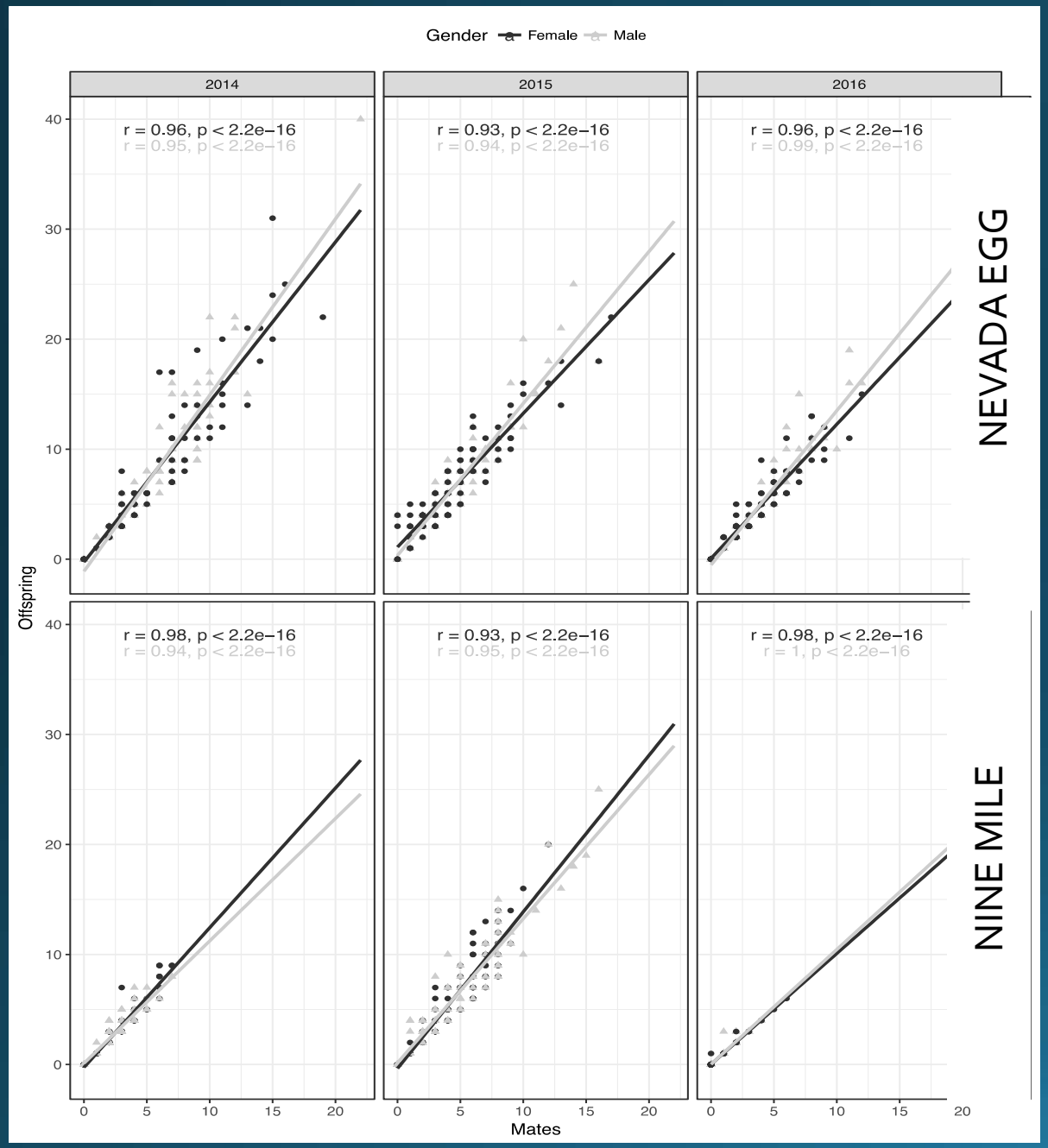
Majority of individuals have more than one mate (2014-2015)

NE- 80-90% individuals multiple mates

NM-70-80% individuals multiple mates



- Average number of offspring differed by backwater and year but not gender.
- Large variance in reproductive success among individuals in NE compared to NM in2014
- Smaller genetic effective size for NE 2014 compared to NM2014.



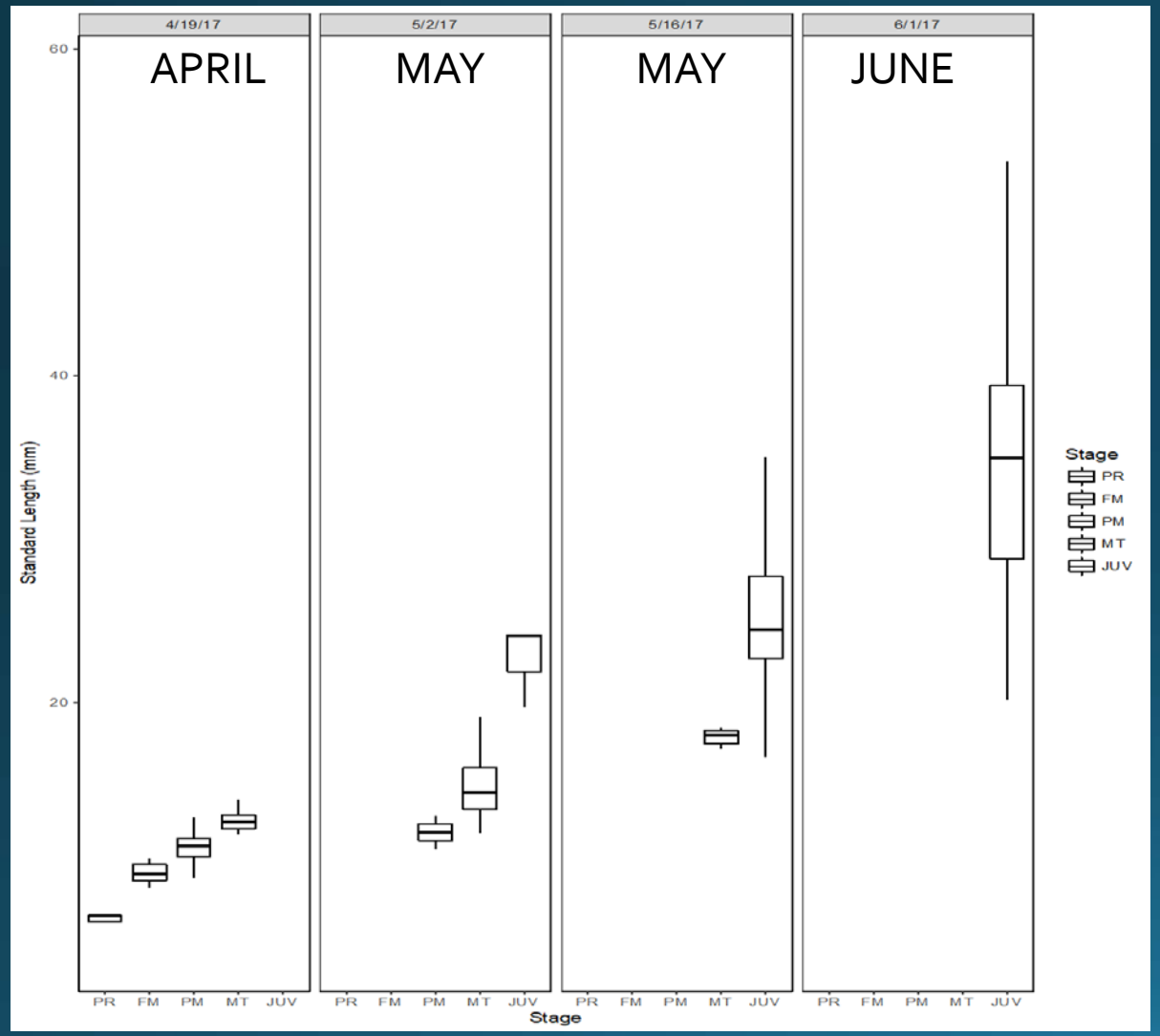
Number of offspring is highly correlated with the number of mates for both males and females

Imperial Ponds 2017

Imperial Ponds- 2017

- Three ponds (#2, 5, 6) stocked with 150 males and 150 female adult bonytail
- Date of stocking: March 21st 2017
- Sampled ~ every 2 weeks post stocking to monitor for reproduction- larvae first detected in mid April
- Conducted parentage analysis of individuals in **pond 2** using genetic data (300 adults & 551 larvae/juveniles)

Standard length of larvae by collection



The distribution of larval ontogenetic stages consistent with spawning occurring over a brief period of time.

PR- protolarvae FM- flexion meso larvae
PM- post flexion mesa larvae
MT- meta larvae JUV-juvenile

Genetic Diversity

Similar between ponds and parents & offspring

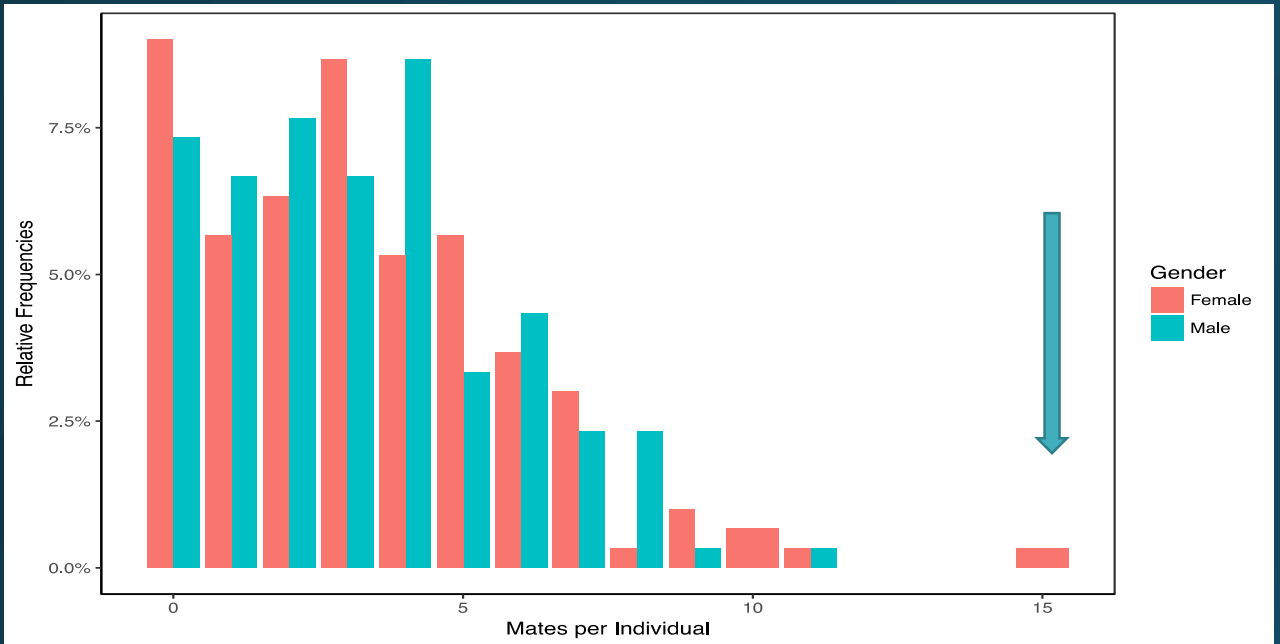
Pond	Sample	n	Gene diversity	Heterozygosity	Inbreeding coeff (F_{IS})	Allelic diversity
IP Pond 5	Adults	300	0.788	0.755	0.040	11.2
IP Pond 6	Adults	300	0.789	0.769	0.023	11.2
IP Pond 2	Adults	300	0.779	0.760	0.022	11.0
IP Pond 2	Progeny	552	0.778	0.732	0.056	10.7

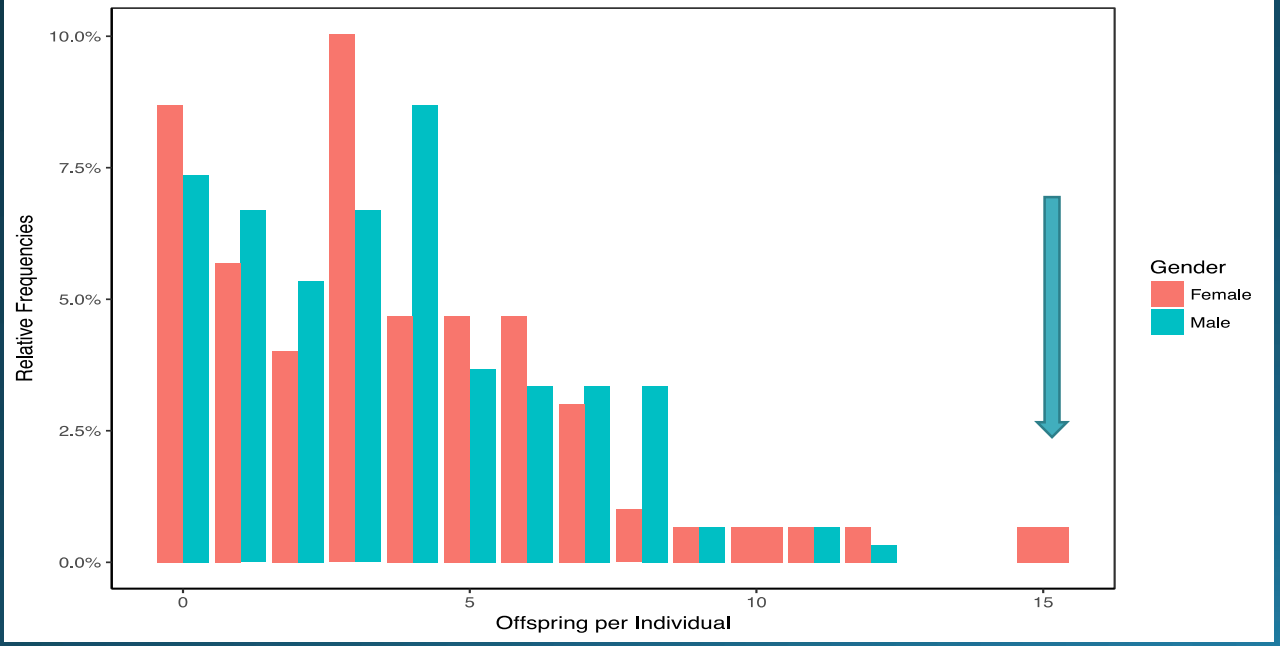
Reproductive Success

- Pond 2: more than 80% of individuals contributed offspring
- Average number of mates per individual: 3
- Average number of offspring per individual: 3

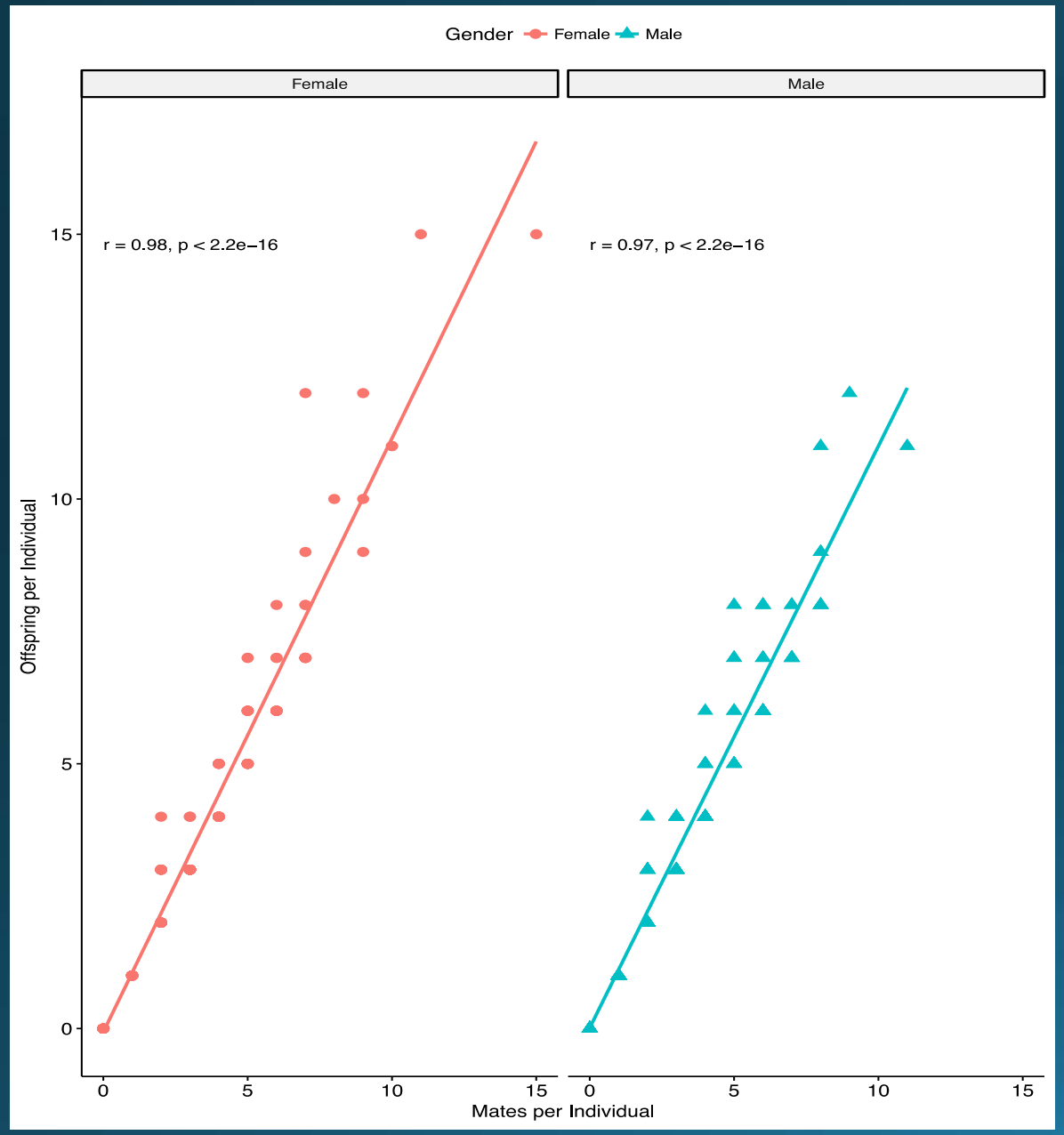
Pond 2	Males	Females
n	150	150
Contributing adults	85%	82%
Average # Mates	3.320	3.320
Variance ($k_{(Mates)}$)	6.649	7.253

Pond 2	Males	Females
n	150	150
Average # Offspring	3.553	3.613
Variance ($k_{(Offspring)}$)	7.376	9.594





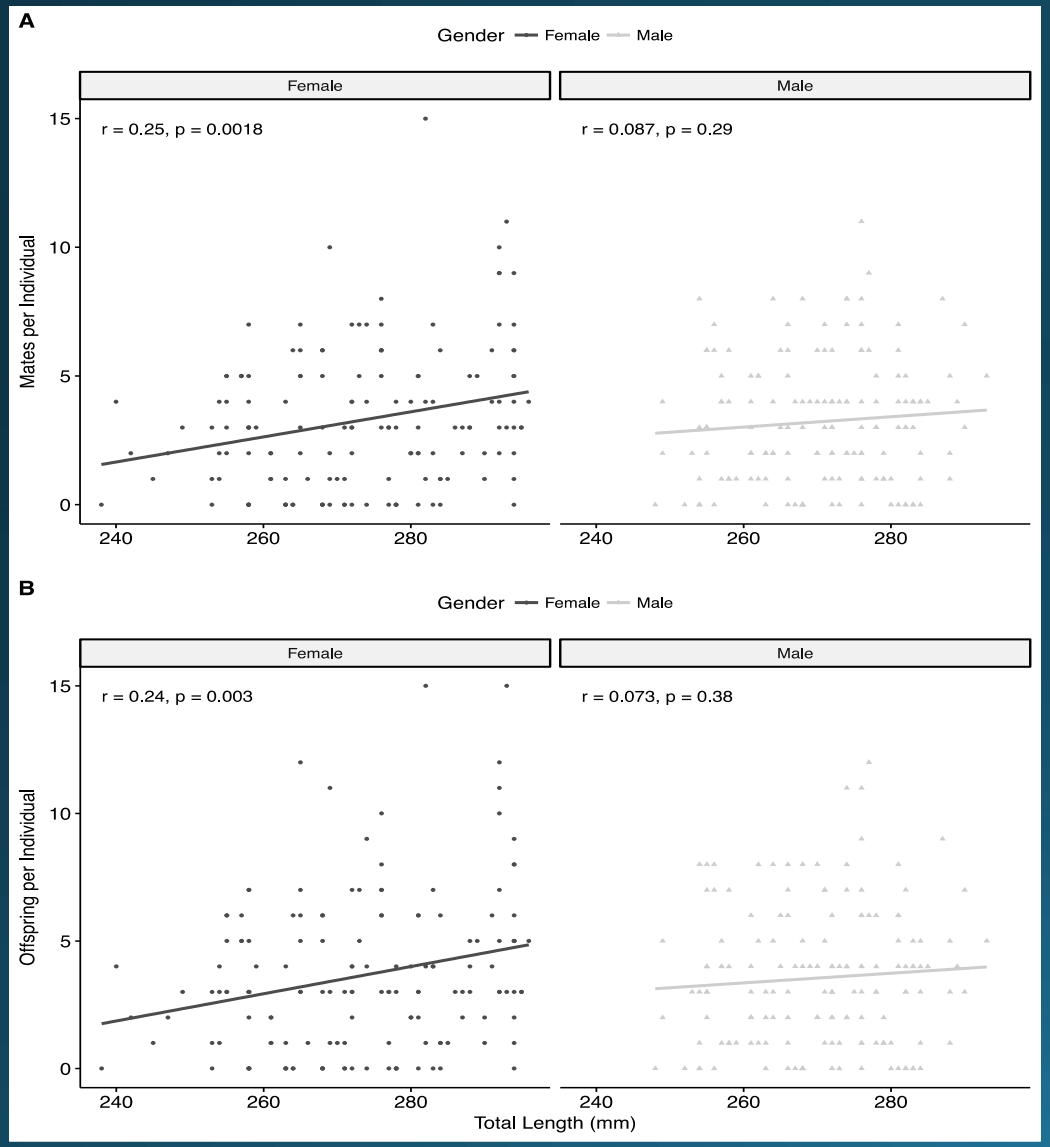
- Variance in reproductive success among individuals
- Majority of individuals have more than one mate and contributed multiple offspring.
- Average number of mates/offspring did not differ by gender



Imperial Ponds- 2017

More mates = more offspring

Standard Length and Reproductive Success



- Larger **females** had more mates and more offspring,
- **No** association between SL and mates/offspring for **males**

Imperial Ponds- 2017- Summary

- Reproduction in pond 2

- Genetic diversity similar between ponds and was maintained between parents and offspring

- Reproductive contribution of males and females was HIGH
- Males and females made equal contributions
- More mates=more offspring
- Larger females had more mates and offspring

Acknowledgements

- Jeff Lantow and staff for field collections
- Funding support of the LCMSCP
- Laboratory expertise (UNM): Alyssa Sanchez, Brian Fitzgerald, Charisa Bell
- David Camak (UNM)
- Expert curatorial services: Alexander Snyder (Museum of Southwestern Biology, Division of Fishes)
- Howard Brandenburg (ASIR) with larval stage identification
- Wade Wilson and William Knight (USFWS Southwestern Native ARCC)