Reproductive success of bonytail chub in isolated off-channel habitats.

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Bonytail chub (*Gila elegans*)

- Large (>50 cms TL), long lived (>40 yrs) cyprinid
- Former range: upper and lower Colorado basin from Wyoming to Mexico.
- Experienced the most abrupt decline of the Colorado's big river fishes.
- Endangered (US FWS 1978, 1980)
- Functionally extinct in the wild
  - no evidence of reproduction/recruitment

  In the wild.

- Captive population established in 1981
- 3-8 founders of the original captive stock (Hedrick et al. 1999)
- BTC—bred and reared in captivity for release
- Preserving remaining genetic diversity is critical
- Backwater program proposed by Minckley et al. 2003.

A Conservation Plan for Native Fishes of the Lower Colorado River

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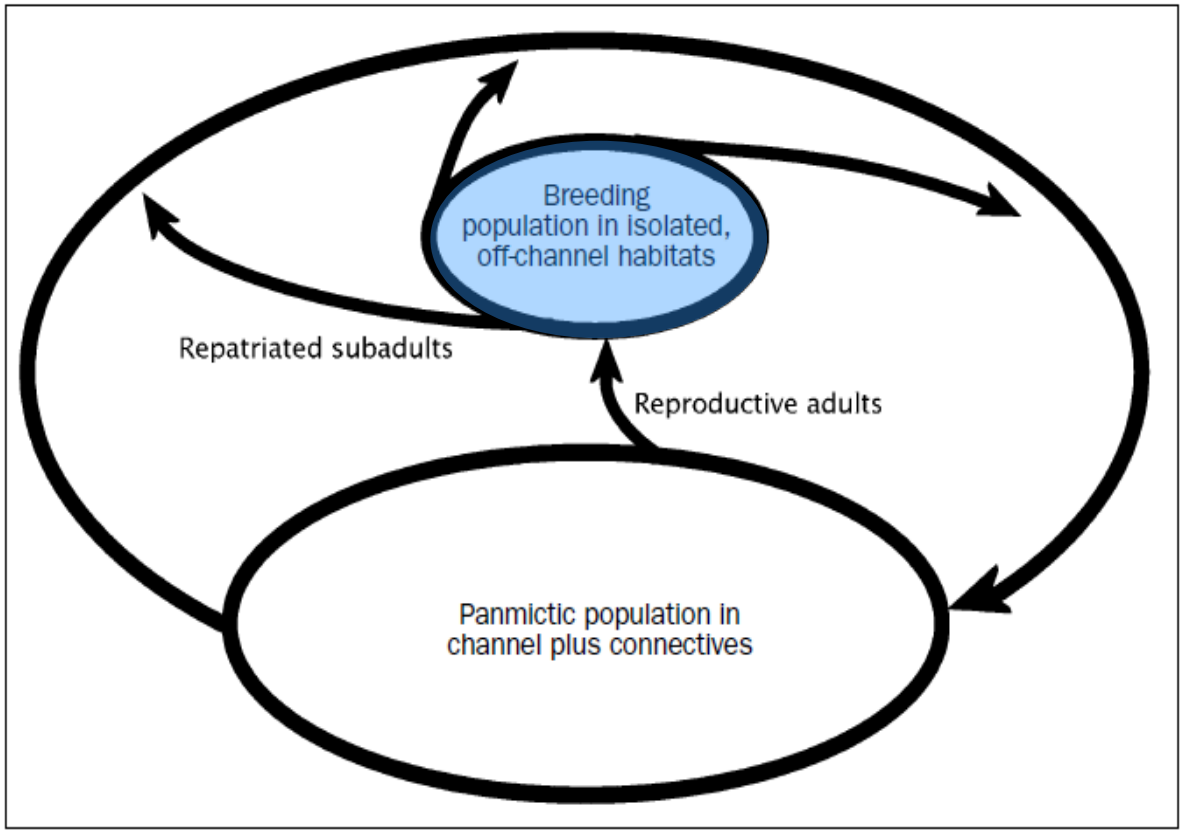


- Breed and progeny would grow in protected off-channel habitats
- Protected from some predation
- Selective pressures present
- Natural mating behaviors preserved

Variance in Reproductive Success

- Bonytail chub--- Highly fecund, eg. 2 yr old female ~1000-10,000 eggs (Hamman 1985)
- Aggregate spawner, deposit adhesive eggs
- Aggregate breeding- little or no monopolization of individuals or space, mechanism for large amounts of genetic mixing through multiple matings.
- BUT, some individuals may contribute disproportionately.
- Reduce genetic diversity and genetic effective population size.
- Increase risks of adverse genetic effects like inbreeding depression.

Objectives

- How may individuals make a reproductive contribution in backwaters stocked with BTC?
- Is genetic diversity preserved between parental and progeny generations?
- Do certain males/females contribute disproportionately?
- In variance in reproductive success similar between backwaters and males/females?

Methods

- Three isolated backwaters (North Nine Mile, Nevada Egg and Nevada larvae) on Lake Mohave were stocked with 79-80 males and females (Total 160 adults) in early May 2014.
- Prior to release, adults were sexed, fin clipped and pit tagged.
- BoR commenced monitoring the backwaters for signs of larvae 2 weeks post-stocking using lights and dip nets.
- Substantial evidence of reproduction was observed in North Nine Mile, Nevada Egg but only limited reproduction in Nevada larvae.
- DNA was isolated from stocked adults and larvae and YOY collected at multiple time points over the spring and summer.
- All fish were genotyped at 18 microsatellite loci.
- Genetic data used to infer parentage and sibship using the program Colony [Wang et al. 2009].

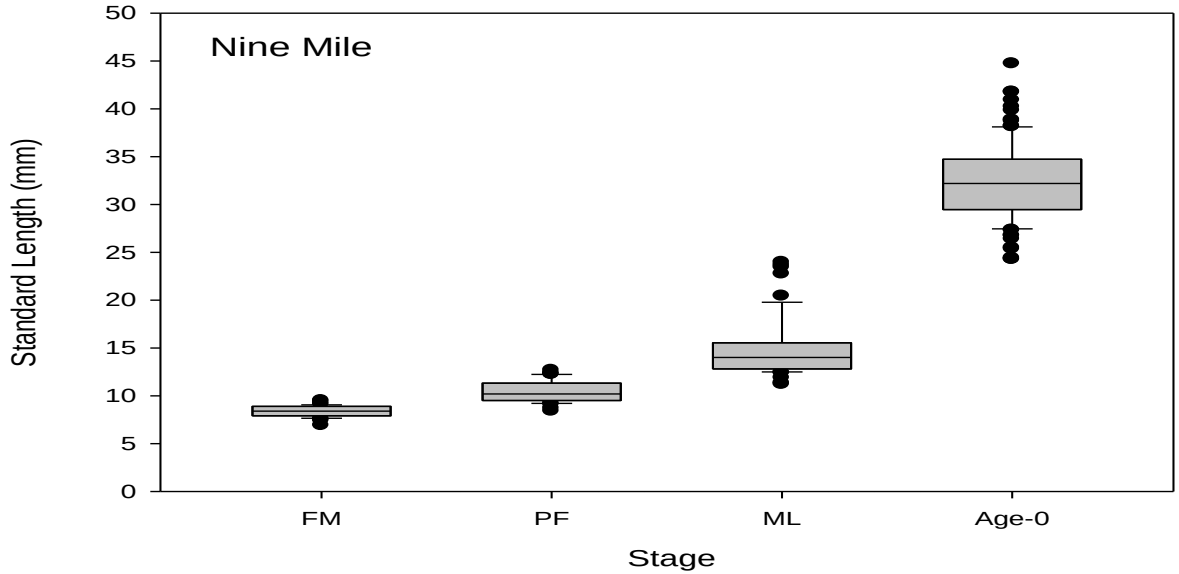
Mohave Backwaters

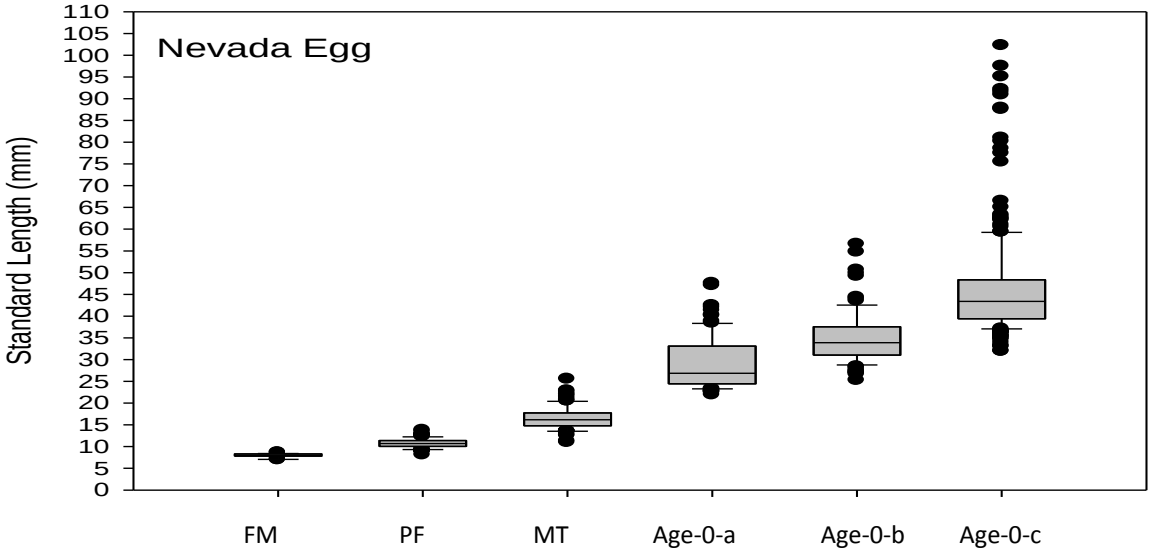
Backwater	Surface Area (ft^2)	Volume (ft^3)	Depth (ft)	Females	Males
North Nine Mile	27,414	113,341	6	80	79
Nevada Egg	NA	NA	8	80	80
Nevada Larvae*	16,206	88,980	9	80	81

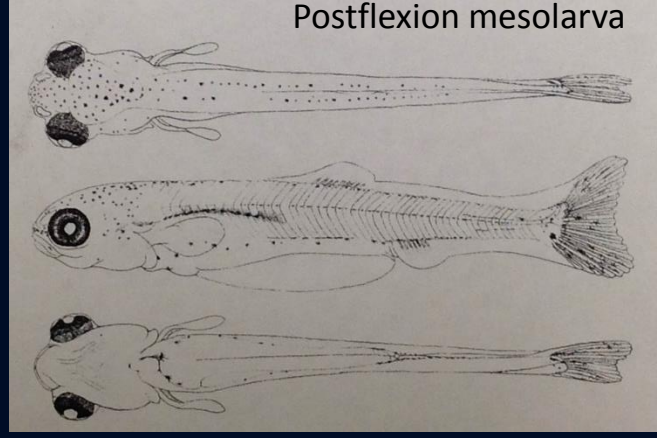
Nevada Larvae Backwater

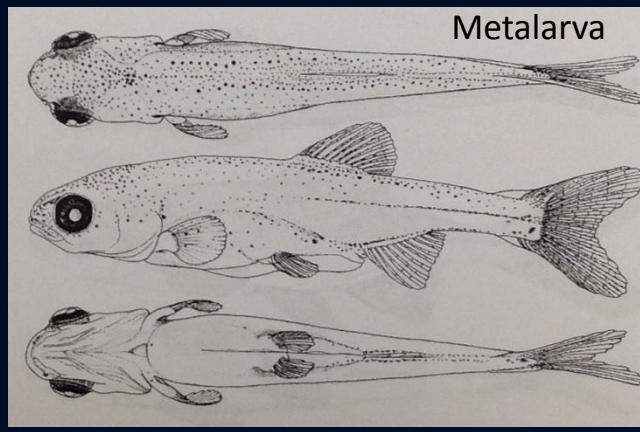
Nevada Egg Backwater

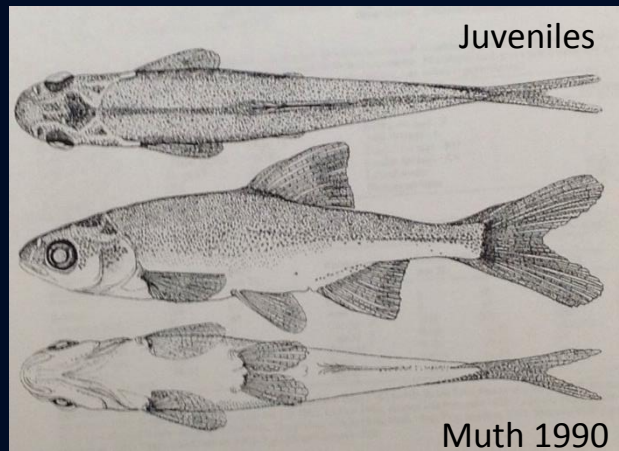
North Nine Mile Backwater







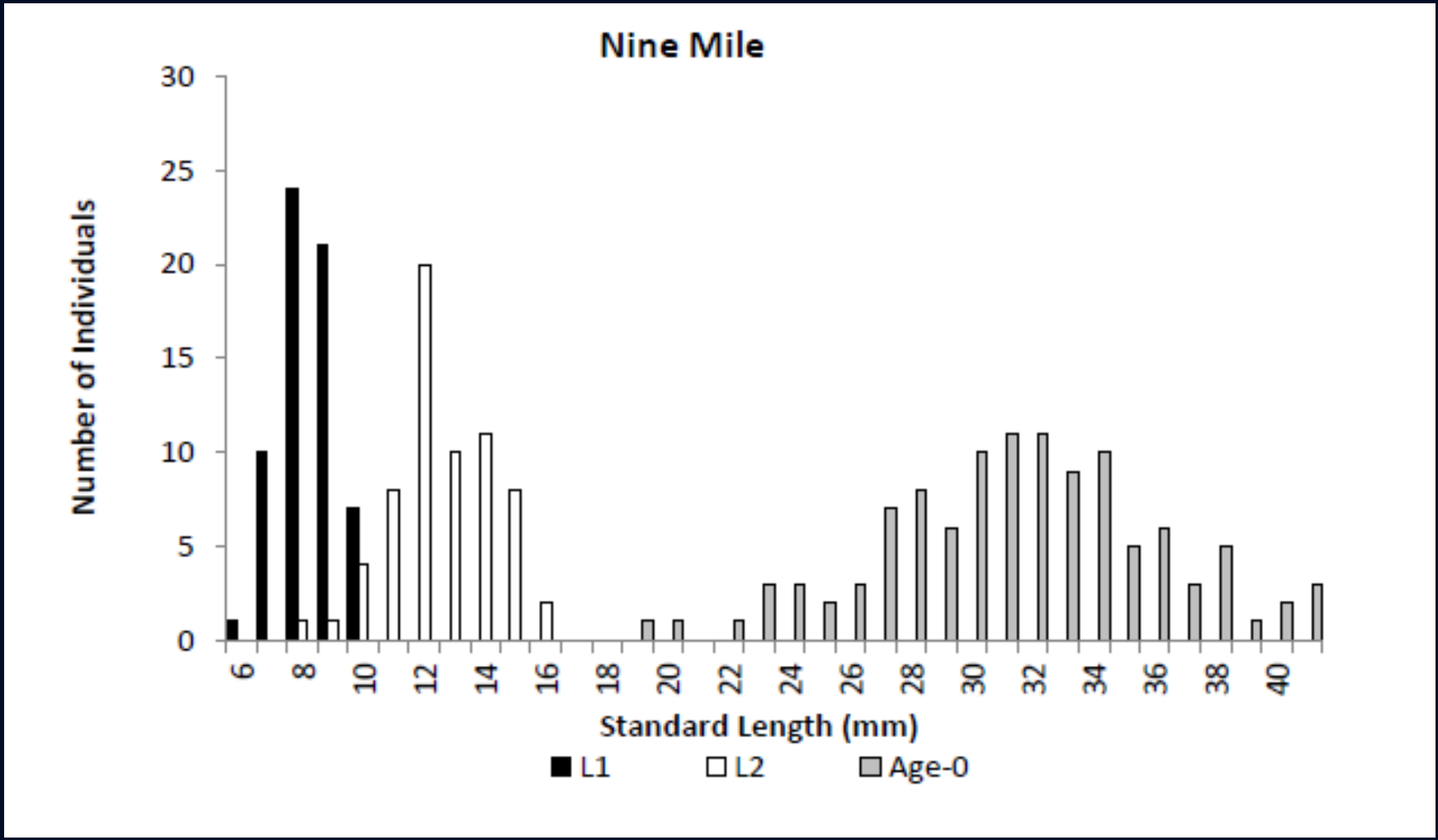




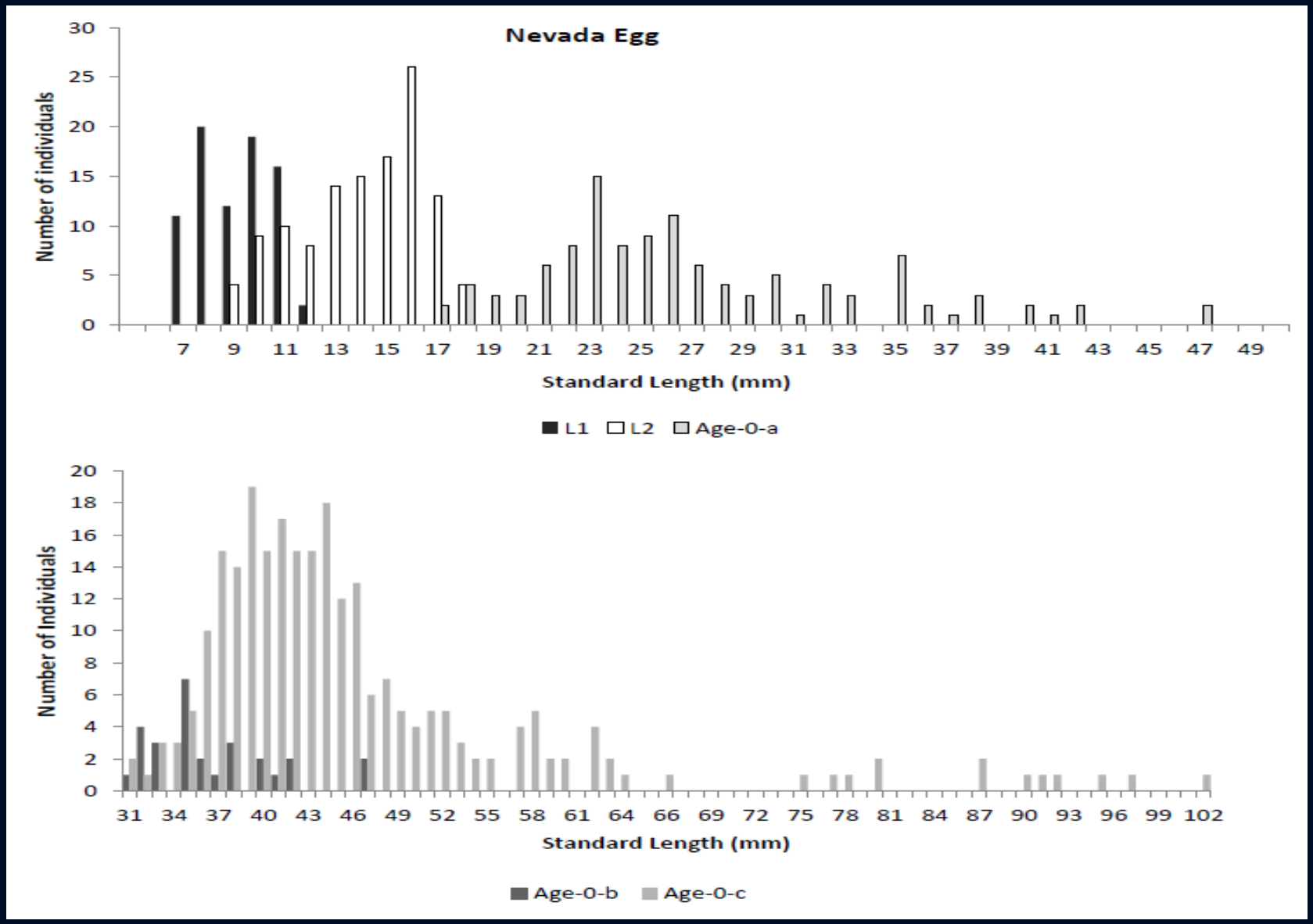
FM- Flexion meso-larvae (SL-8-9 mm)
PF- Post flexion meso-larvae (SL-9-11mm)
ML- Meta larvae (SL 11-22 mm)
Juveniles (22-44 mm SL)

Age-0 Collected 18th May (NM)
Age-0-a Collected 18th May (NE)
Age-0-b Collected 26th August (NE)
Age-0-c Collected late October (NE)

Length Frequency Histogram--Nine Mile



Length Frequency Histogram--Nevada Egg



Genetic Diversity

	Collection date	Sample	n	H_e	H_o	MNA	F_{IS}	$A_{R(n=59)}$
		Adults Stocked	159	0.790	0.743	11.22	0.060	10.130
Nevada Egg	5/9/2014	L1	80	0.781	0.756	10.11	0.031	9.862
	5/21/2014	L2	120	0.795	0.778	10.67	0.022	9.963
	5/18/2014	age-0	114	0.785	0.777	10.44	0.010	9.775
	8/26/2014	age-0	120	0.768	0.754	9.89	0.019	9.186
		Adults	158	0.793	0.774	11.44	0.025	10.434
Nine Mile	5/9/2014	L1	63	0.781	0.770	10.17	0.015	10.098
	5/21/2014	L2	65	0.797	0.782	10.22	0.019	10.136
	5/18/2014	age-0	111	0.788	0.738	10.39	0.064	9.947

	Number of Offspring	Unique Pairings	Reproductive contribution
North Nine Mile	239 (3 collections)	208	72 males (91%) 74 females (93%)
Nevada Egg	434 (4 collections)*	316	73 males (91%) 71 females (89%)

- Fifth collection was made from Nevada Egg and genetic analysis is underway.
- Fewer collections from Nine Mile due to late summer fish kill, eliminating all fish from the backwater.

			Offspring per sire (blue) and dam (pink)									
Nine Mile	Mates /Sire	Mates /Dam	L1	L1	L2	L2	age-01	age-01			Total Offspring /Sire	Total Offspring / Dam
Mean	2.49	2.65	0.73	0.78	0.75	0.80	1.34	1.34	--	--	2.82	2.91
SD	1.62	1.94	0.86	0.94	1.01	0.97	1.26	1.48	--	--	1.87	2.37
Max	7	7	5	3	4	4	5	7	--	--	8	9
Nevada Egg	Mates per Sire	Mates per Dam	L1	L1	L2	L2	age-0	age-0	age-0*	age-0*	Total Offspring per Sire	Total Offspring per Dam
Mean	4.09	4.10	0.97	1.04	1.41	1.48	1.43	1.38	1.61	1.48	5.34	5.30
SD	2.89	3.57	1.34	1.34	1.88	2.22	1.60	1.79	2.20	2.58	4.70	5.14
Max	14	15	7	6	9	10	7	8	11	13	25	22

- ✓ **Nine mile**: average ~2-3 mates per male/female, maximum- 7 mates per adult
- ✓ **Nevada Egg**: average ~4 mates per male/female, maximum- 14-15 offspring per adult

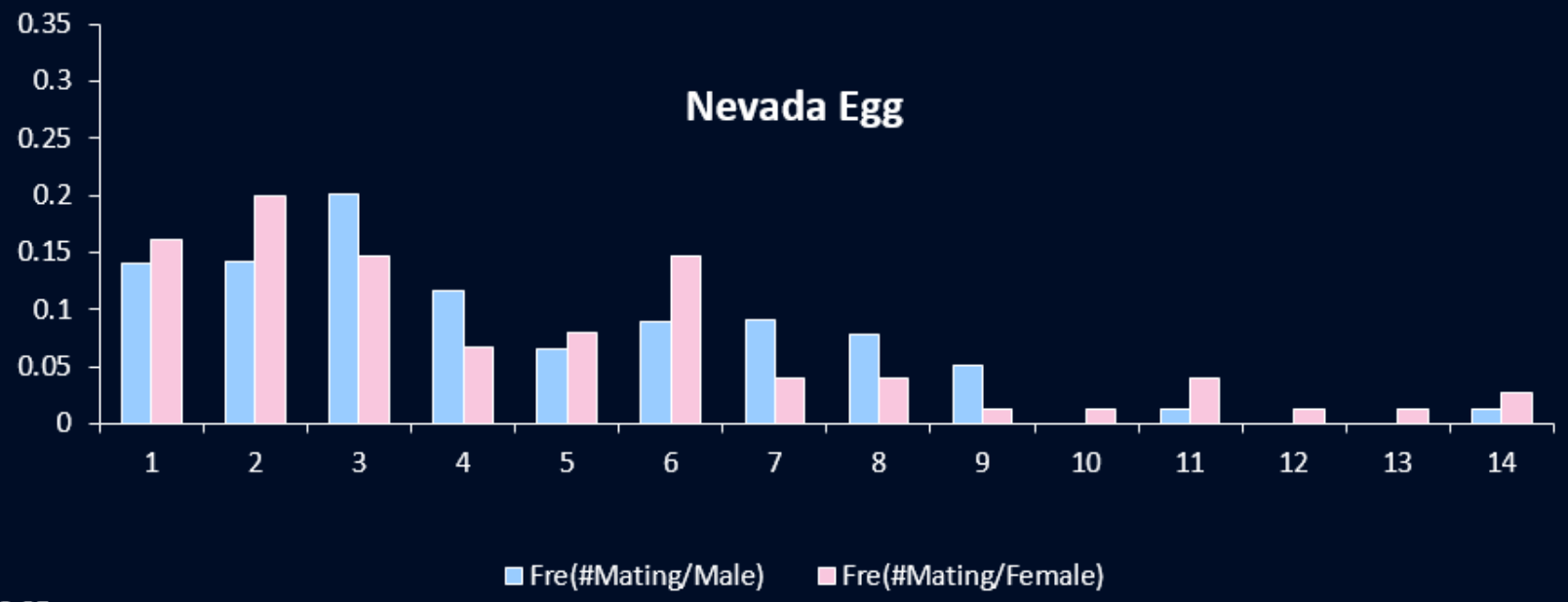
- ✓ **Nine mile**: average ~2-3 offspring per male/female, maximum- 8-9
- ✓ **Nevada Egg**: average ~5 offspring per male/female, maximum- 22-25 offspring per adult

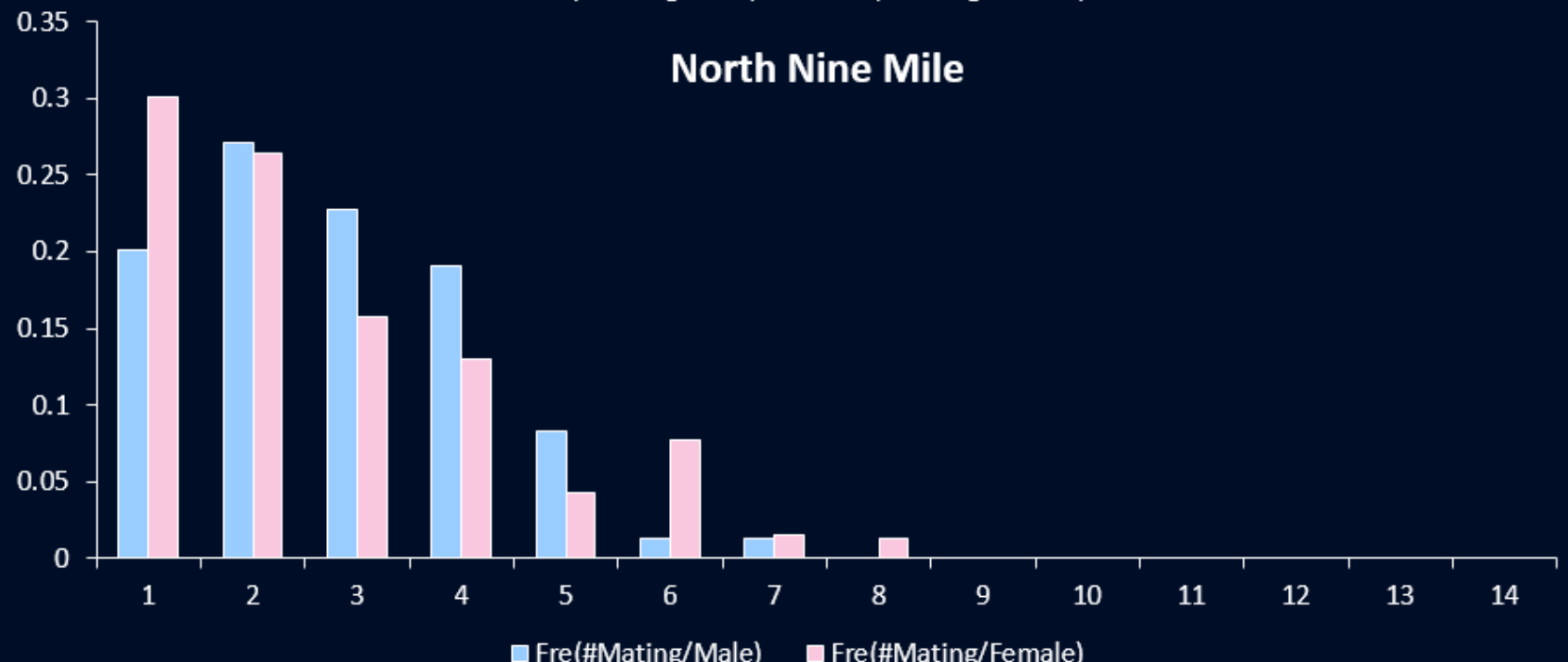
Effective Population Size

- Sibship method (based on molecular co-ancestry)
  - Nevada Egg $N_{e(sibship)}$=97 (95% CI 73-126)
  - Nine Mile $N_{e(sibship)}$=138 (95% CI 109-175)

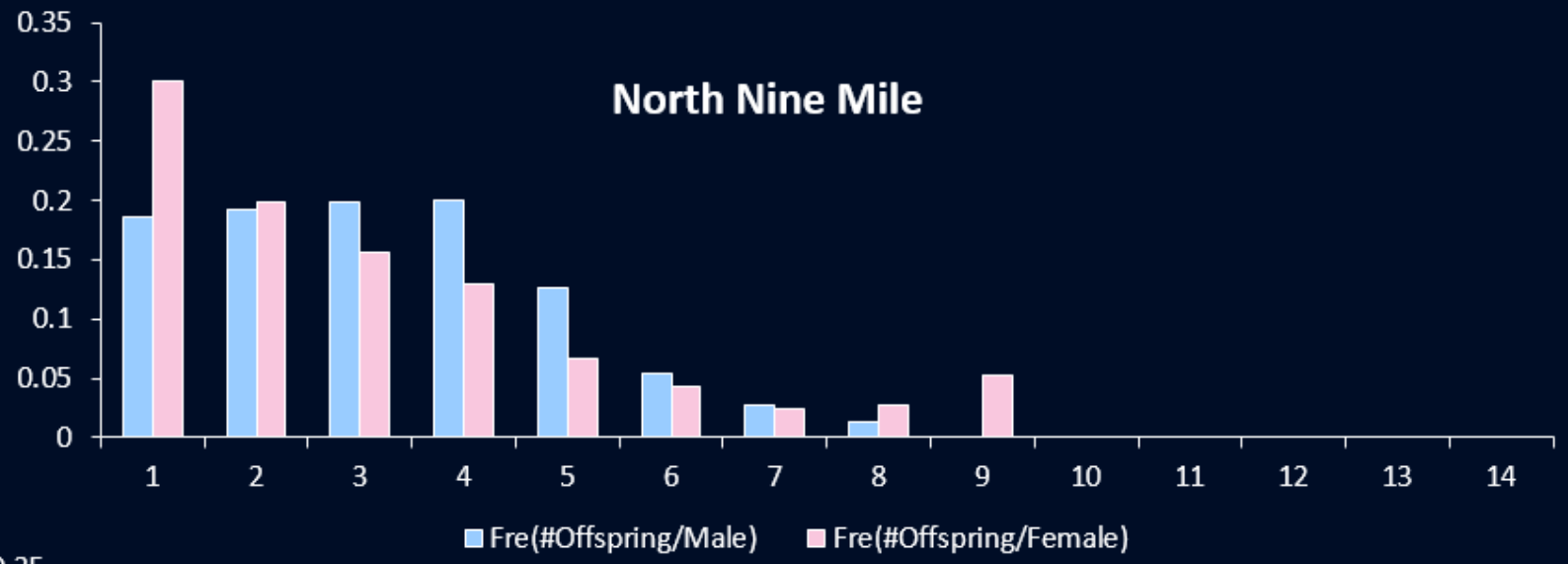
- Demographic estimates
  - Nevada Egg N_e=88
  - Nine Mile N_e=120

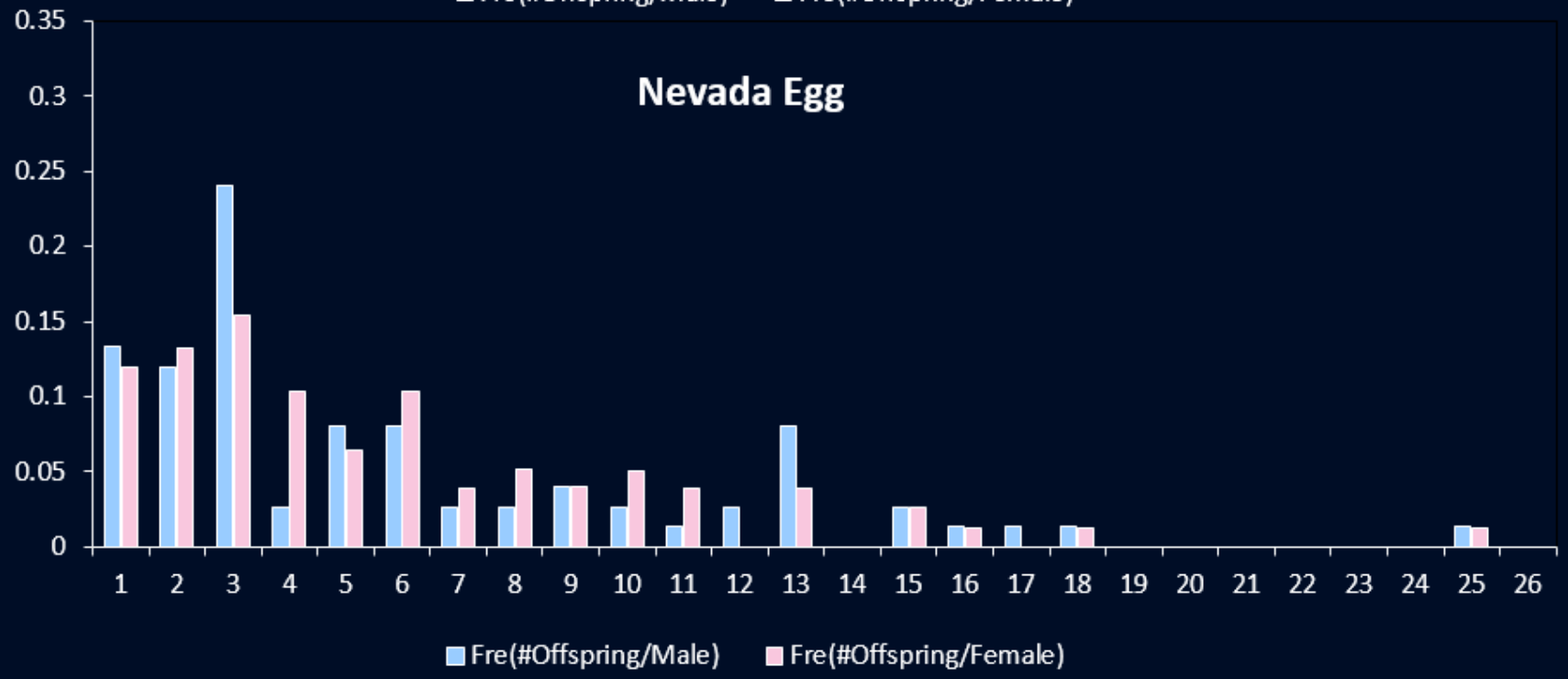
Frequency of matings per male/female





Frequency of Offspring per male/female





Conclusions

- How may individuals make a reproductive contribution in backwaters stocked with BTC?
  - ❖~89-93 % of individuals
- Is genetic diversity preserved between parental and progeny generations?
  - ❖There is a slight decline in diversity but not statistically significant, genetic effective size is lower in Nevada Egg, due to increased variance in reproductive success.

Conclusions

- Do certain males/females contribute disproportionately?
  - ❖ No, males and females make very similar contributions
- In variance in reproductive success similar between backwaters and males/females?
  - ❖ Variance in reproductive success differed by backwater (i.e habitat) but not between males and females (i.e. individuals)

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