Spatial and Temporal Patterns in Rainbow Trout Redds and Fry in the Lee's Ferry Reach of the Colorado River: Preliminary Evaluation of the Jan-Mar ’03 Fluctuating Flow Experiment

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Objectives

- **Measure timing and hypsometry of redd deposition** to estimate potential egg and alevin mortality resulting from Jan-Mar.' 03 fluctuating flows.

- **Quantify spawning habitat preference** (depth, velocity, substrate) to predict spawning location as a function of discharge in Lee's Ferry and potential for spawning in the mainstem in Grand Canyon.

- **Estimate timing of fry emergence and mortality** to design more effective flow experiments and evaluate future operational impacts.

Methodology

- Surveyed redds every month from Feb. – May to determine redd hypsometry

- Redd surveys were conducted at four sites to get exact elevations. A rapid assessment protocol was used to provide rougher estimates of elevation for redds over the entire Lee's Ferry reach.

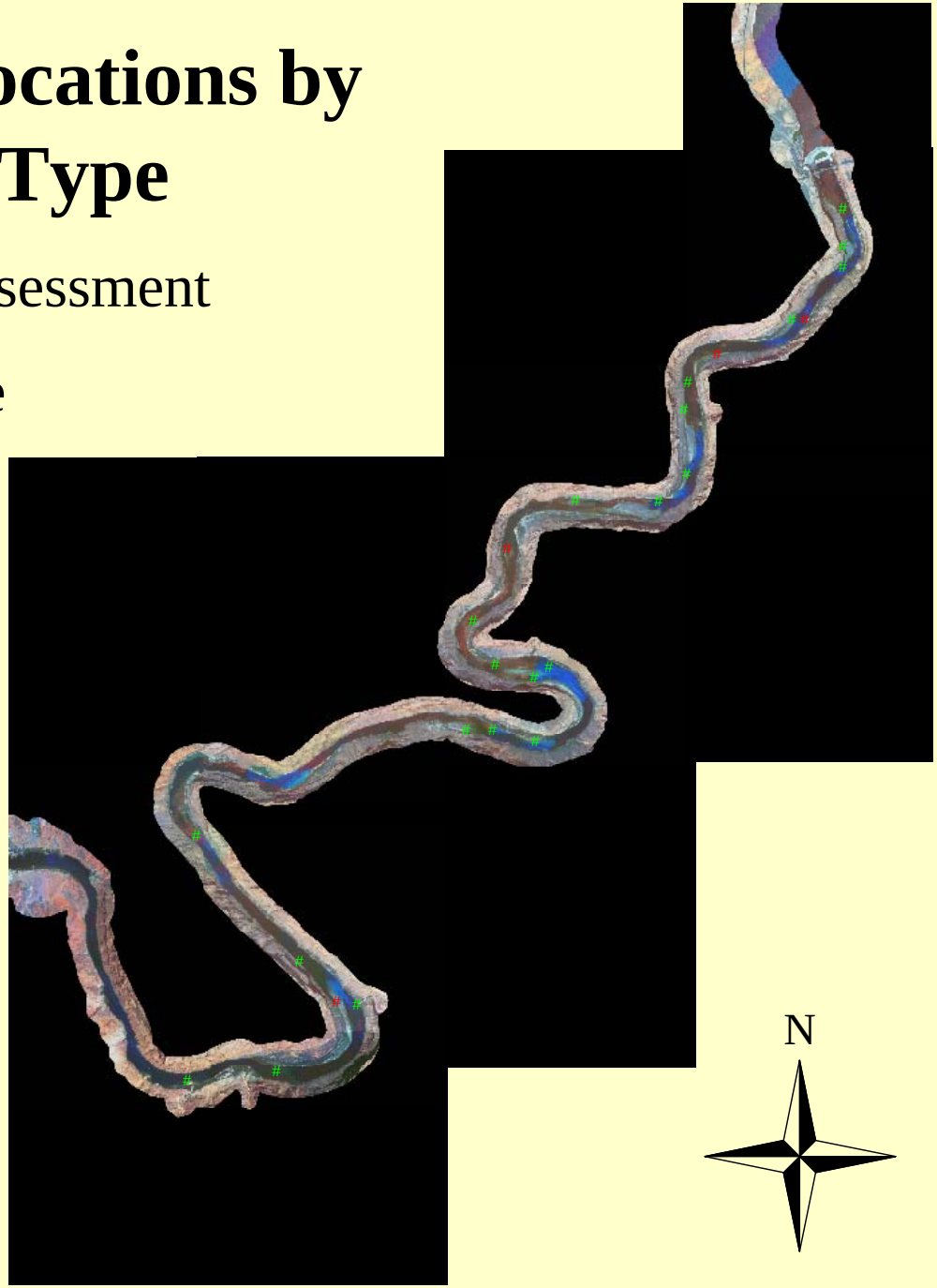
- Measured habitat characteristics (depth, velocity, particle size) at redds and non-redd locations to determine habitat preference at a range of discharges (what determines spawning location?).

- Monthly fry sampling at at 20-25 index sites and ageing (daily otolith rings) of 250 fish to estimate timing of emergence, growth, mortality, and recruitment.

Redd Locations by Sample Type

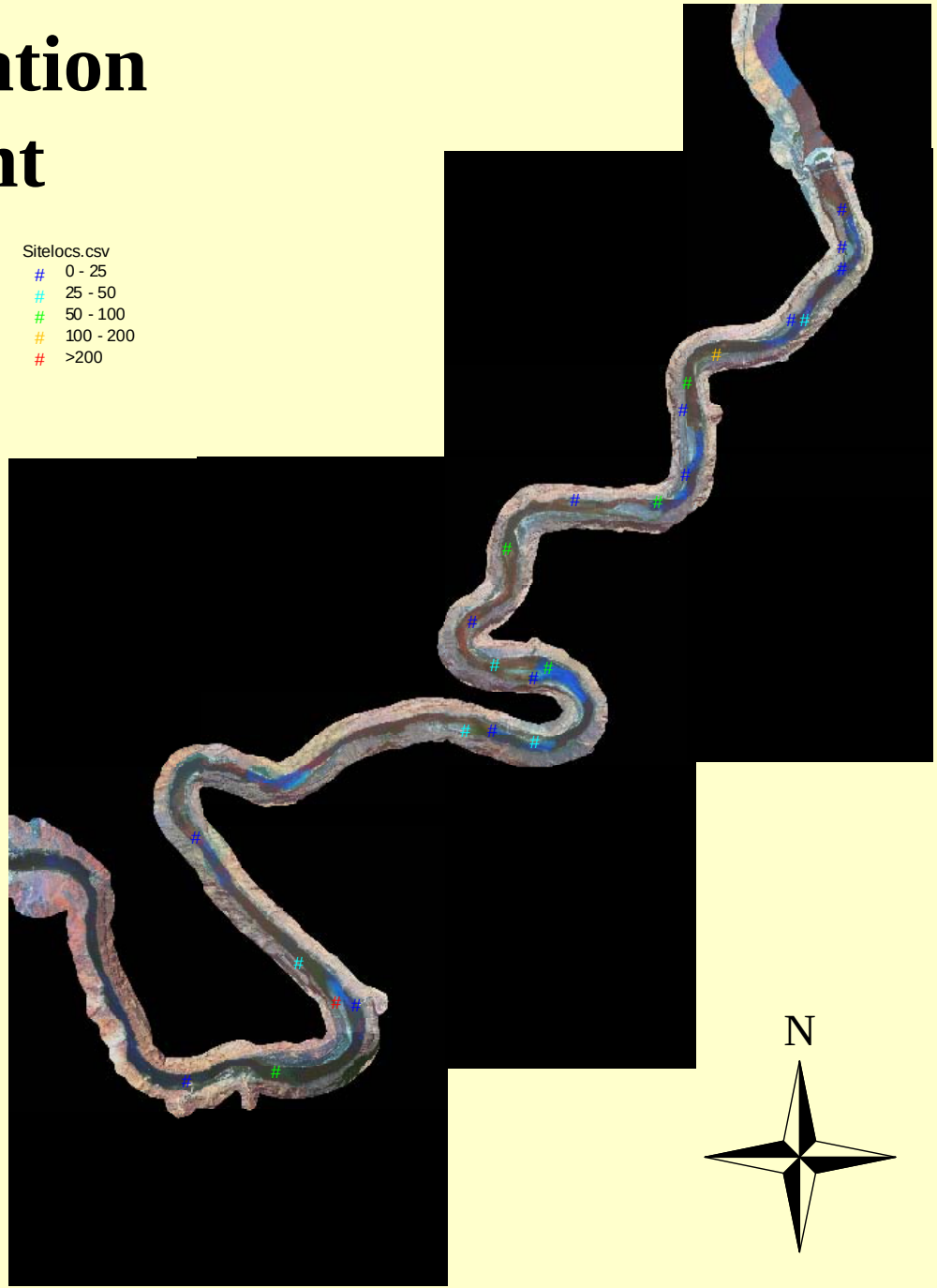
Rapid assessment

Intensive

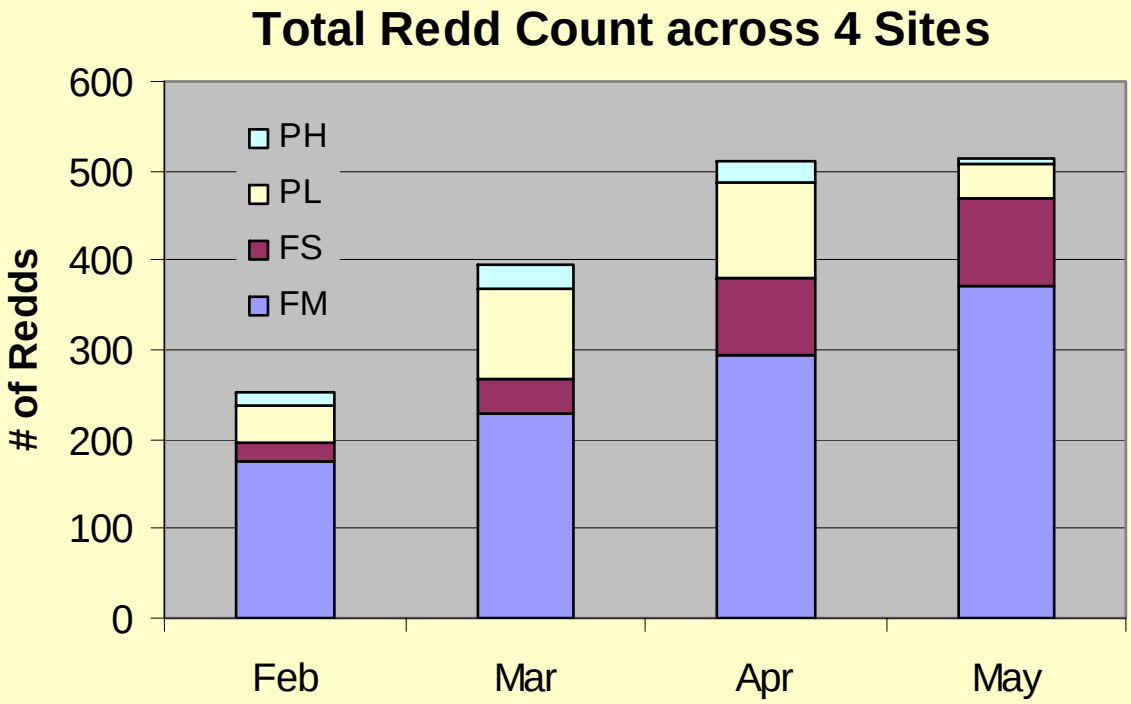


Redd Location
Peak Count

- 0-25
- 25-50
- 50-100
- 100-200
- >200



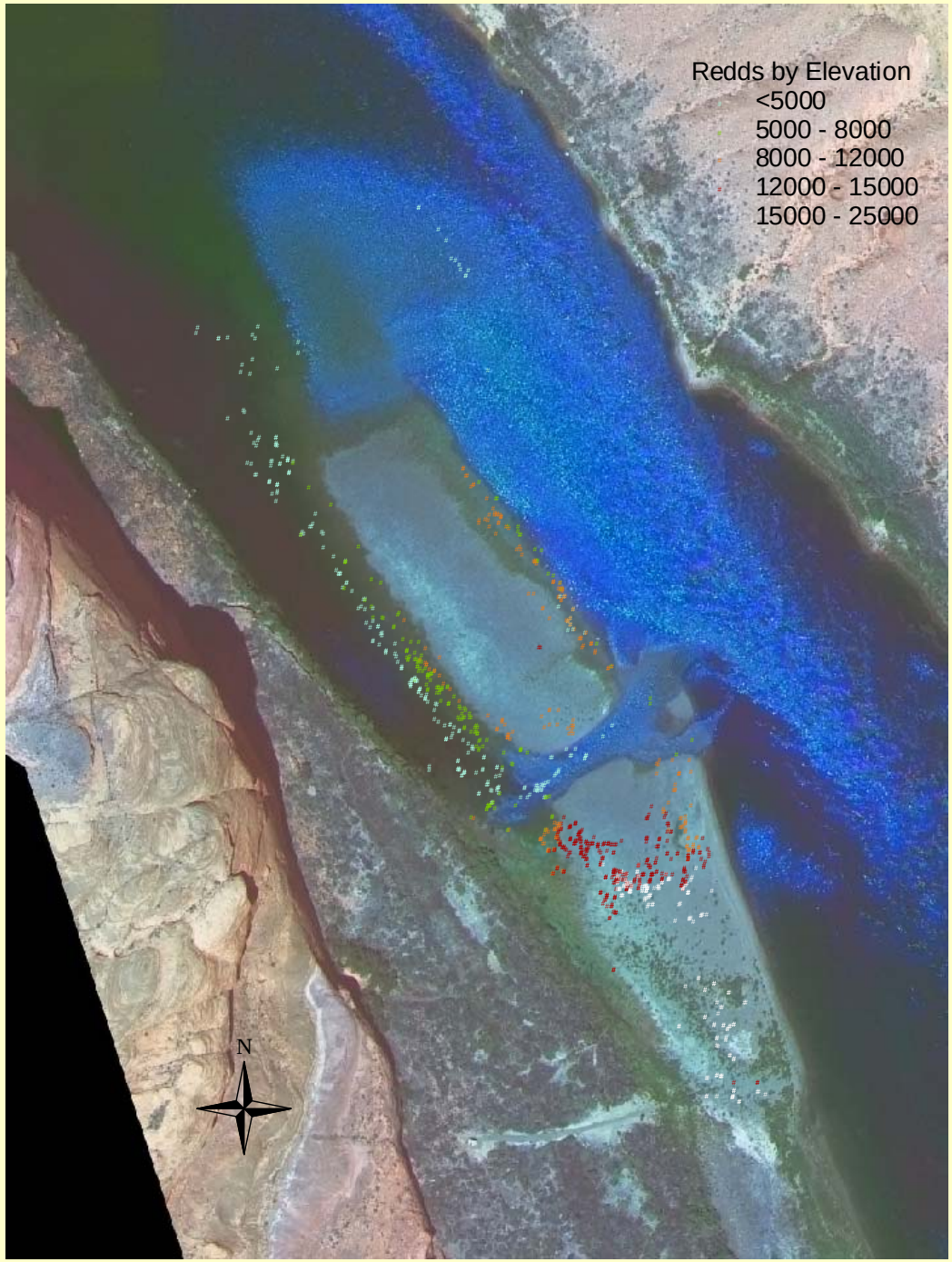
Timing and Distribution of Redds at Intensive Sites



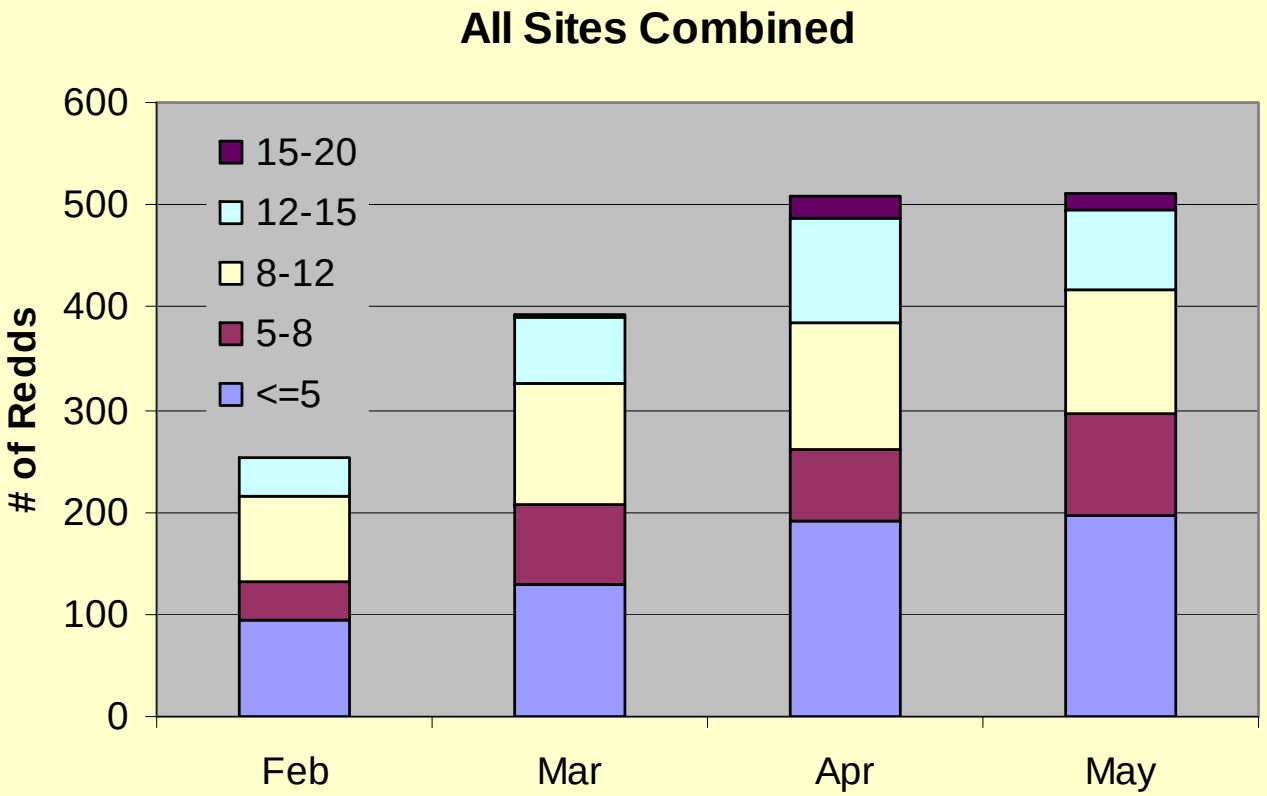
- FM site made up 65% of total redds counted across 4 intensive sites
- Majority of spawning completed by mid-April
- Late spawn becomes progressively more difficult to assess due to:
  - redd superimposition
  - redd survey life

Redd Hypsometry @ Four Mile Bar

- <5 kcfs
- 5 – 8 kcfs
- 8 – 12 kcfs
- 12 – 15 kcfs
- 15 – 20 kcfs

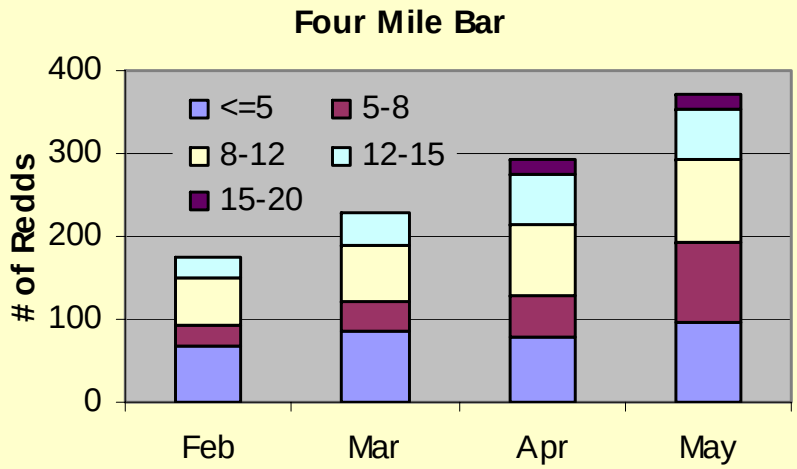


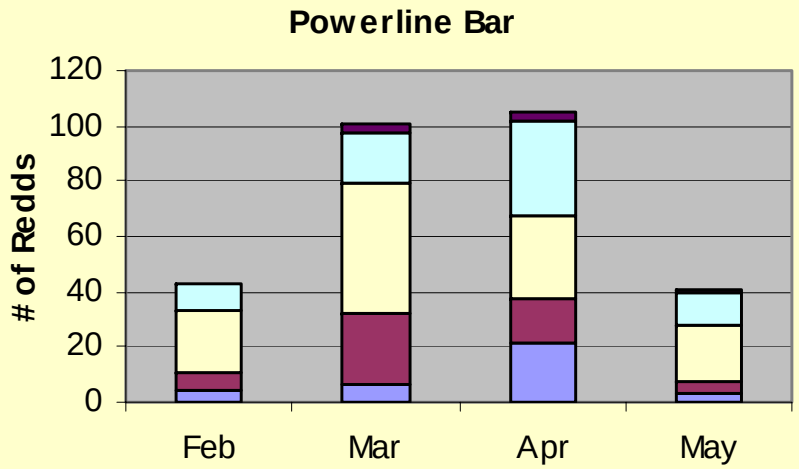
Redd Hypsometry at Intensive Sites

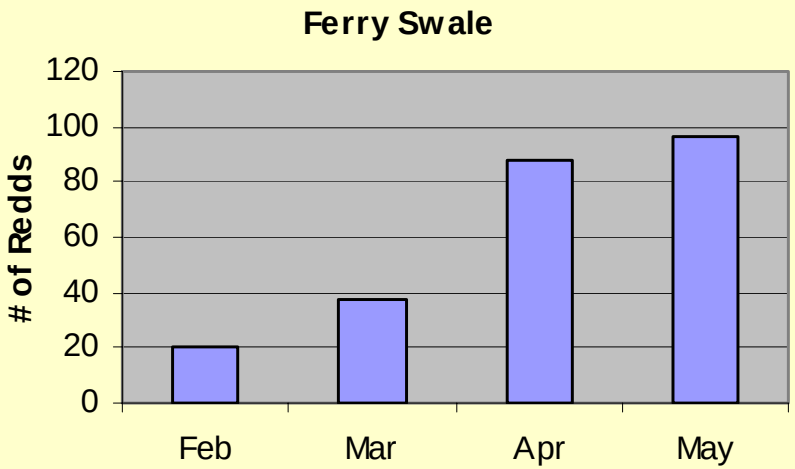


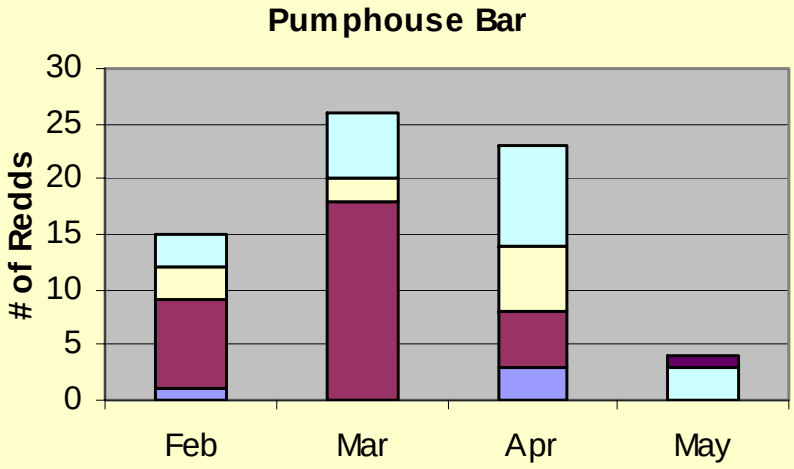
- 35% of redds were above 12 kcfs
- 55% of redds were above 8 kcfs

Redd Hypsometry at Individual Sites

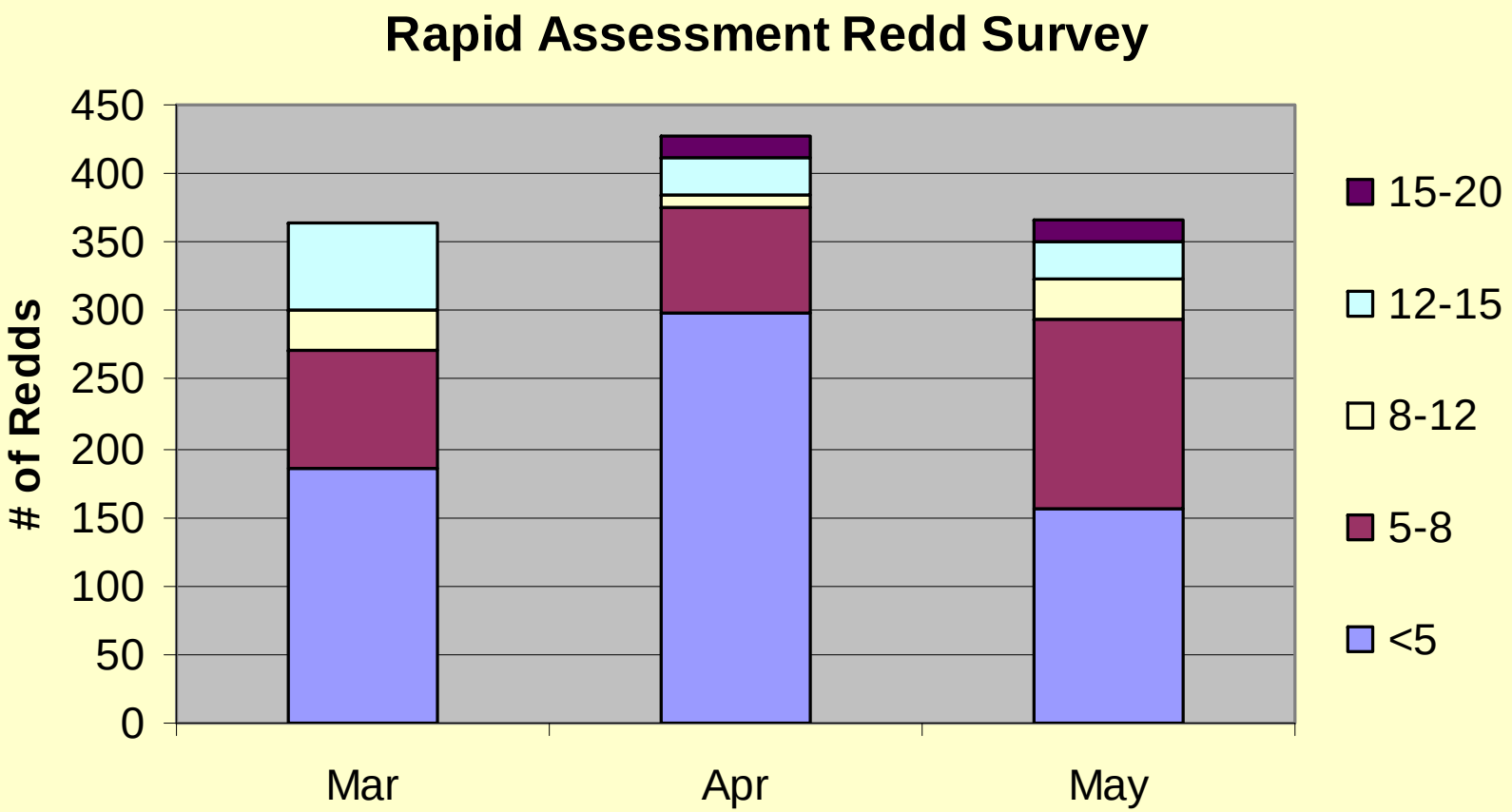








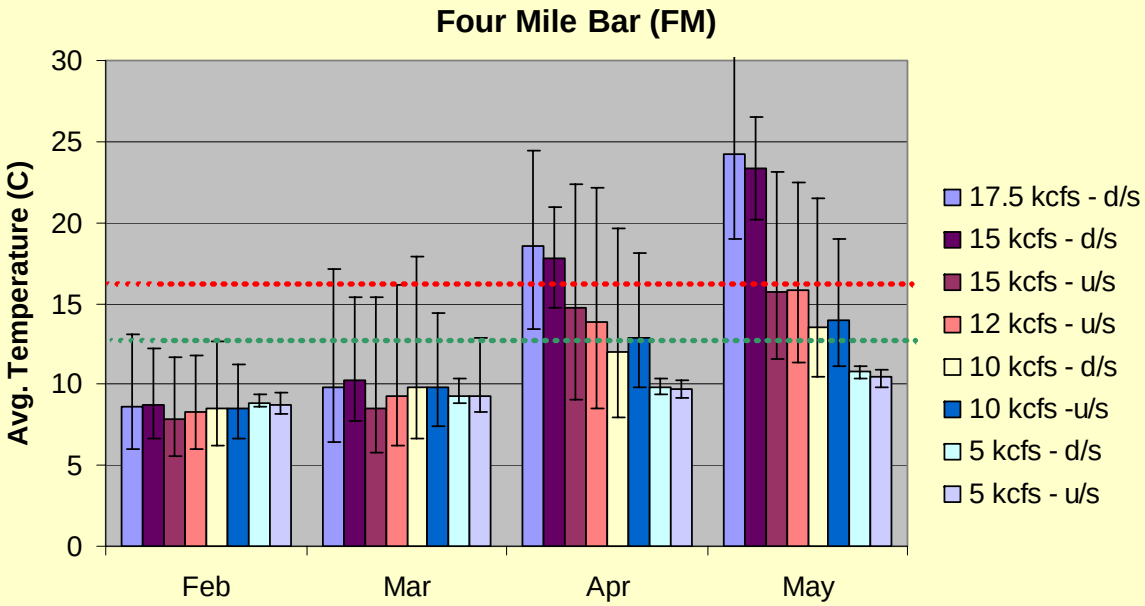
Rapid Assessment Redd Survey

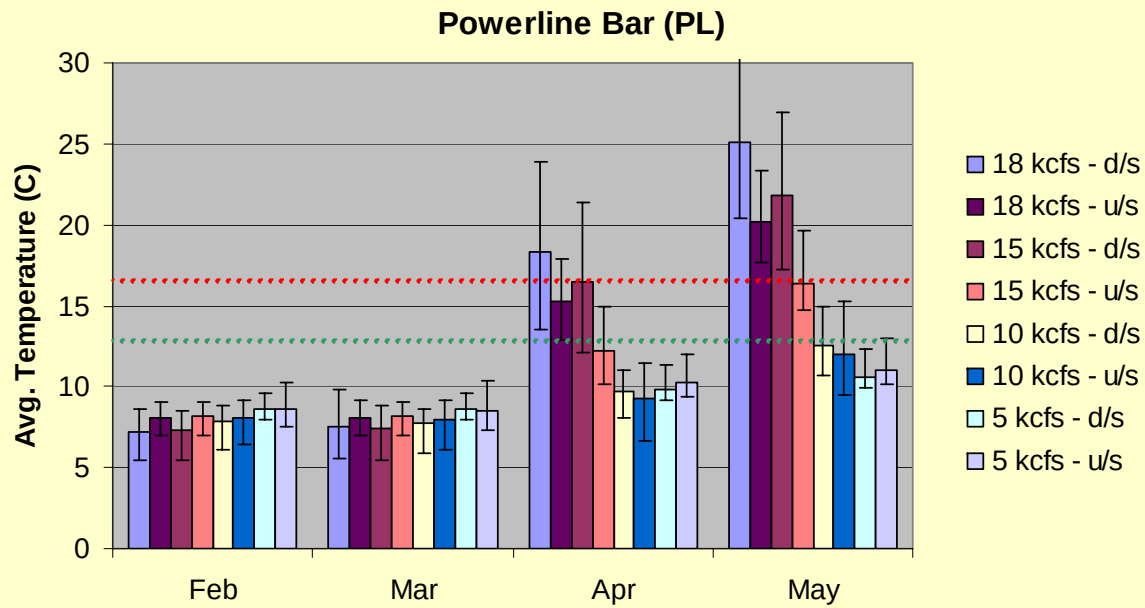


RAT: 10% of redds > 12 kcfs, 15% > 8 kcfs

Intensive: 35% of redds > 12 kcfs, 55% > 8 kcfs

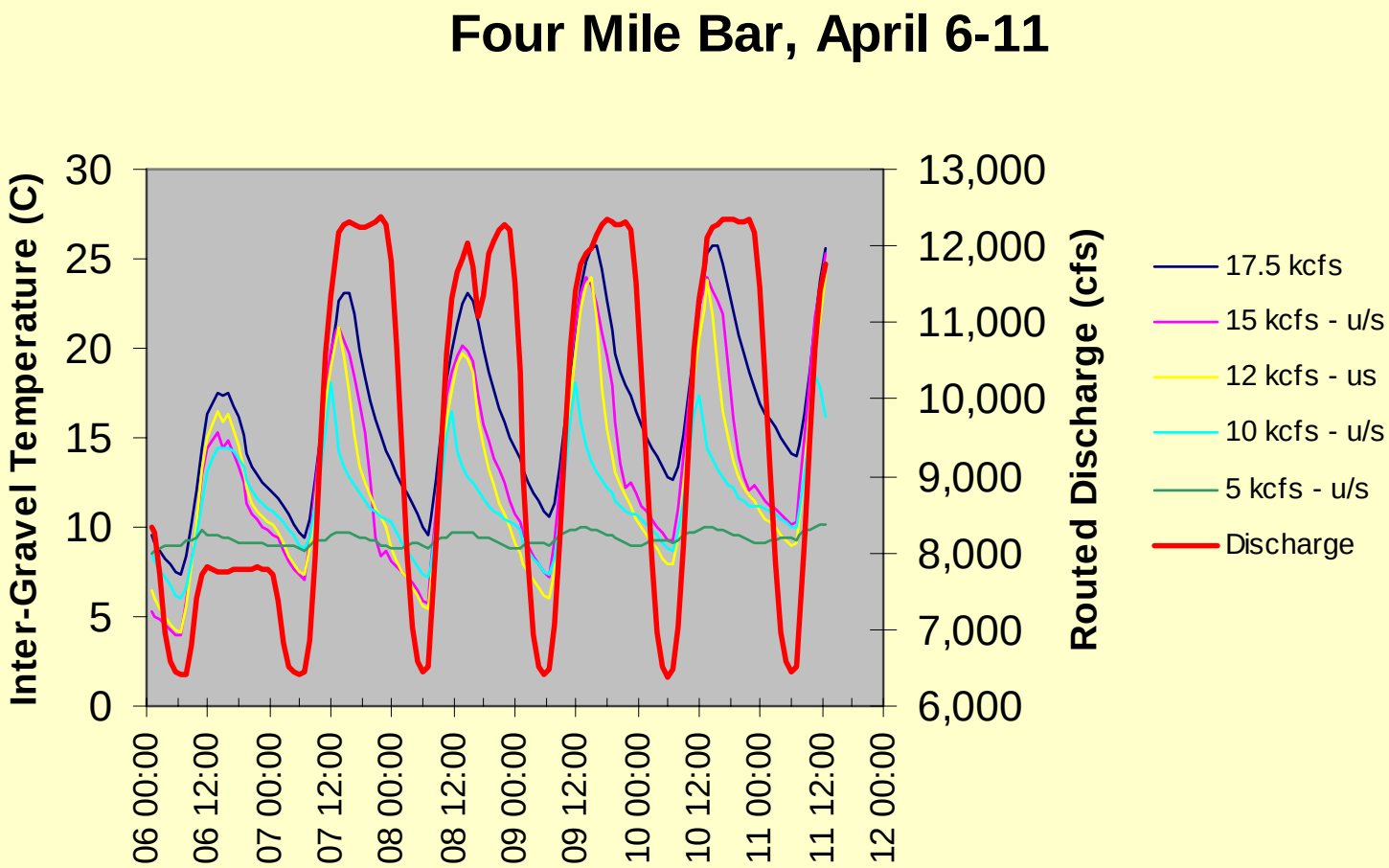
Gravel Temperatures





- At FM, temperature is at or near lethal temperatures for egg incubation in Mar. at 10 kcfs and higher.
- At PL, the 10 kcfs stage has acceptable temperatures in Apr. (more shade and inundation occurs earlier in the day).
- Sunday daytime low flows likely cause temperature-related mortality at FM under normal operations.

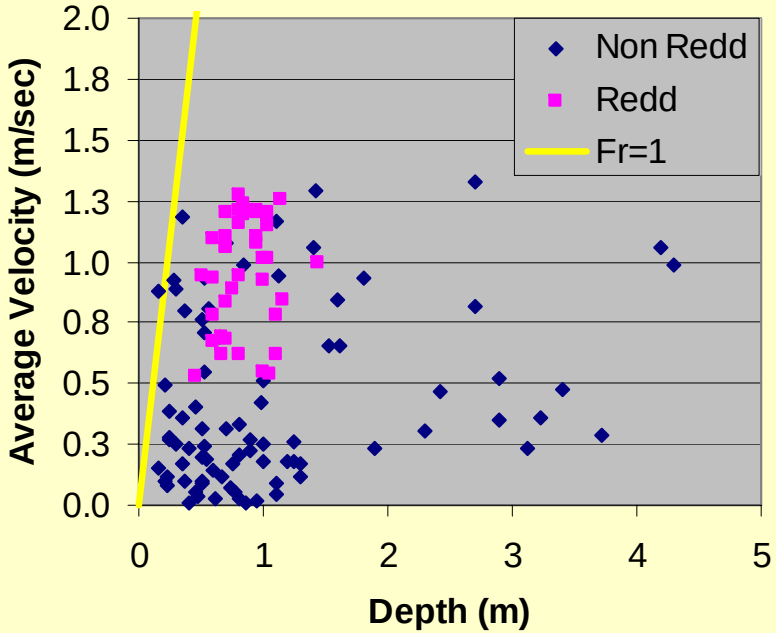
Temperature Dynamics at Four-Mile Bar



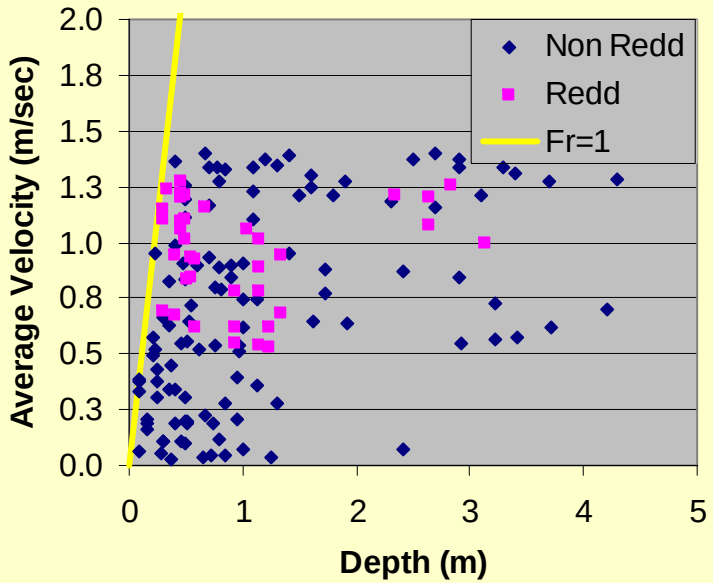
Conclusions on Effects of 2003 Experiment on Egg and Alevin Mortality

- Higher fluctuating flows (5-20 kcfs) from Jan – Mar were effective in increasing spawning elevations and resulted in redd stranding at elevations > ca. 12 kcfs.
- High temperatures very likely resulted in additional mortality at the 8-12 kcfs stage at Four-Mile Bar.
- At intensive sites, mortality of Jan-Mar egg was a minimum of 35% (>12 kcfs) to a maximum of 55% (>8 kcfs).
- At rapid assessment sites loss was ca. 10-15%
- Overall loss for fry still in gravel by Apr. 1 ranged from 25% to 35%.
- Difficult to assess the overall loss (e.g. include post Apr. 1 deposition) due to unknown degree of redd superimposition and redd survey life.

Spawning Habitat Preference



Ferry Swale – 5 kcfs



Four Mile Bar – 20 kcfs

	FM @ 20 kcfs (n=228/200)								
		Velocity							
		0.25	0.5	0.75	1	1.25	1.5	1.75	2
Depth	0.5	0.1	***1.8***	***2.1***	0.9				
	1	0.3	***2.3***	***1.7***	0.3	0.3	0.0		
	1.5	***3.1***	***2.1***	***2.3***	***1.2***	***2.6***			
	2	0.0	0.2	0.2	0.3	0.1			
	2.5	0.0	0.0	0.0	0.0				
	3	0.0	0.0						
	FS @ 5 kcfs (n=39/93)								
		Velocity							
		0.25	0.5	0.75	1	1.25	1.5	1.75	2
Depth	0.5	0.0	0.3		0.0	0.0		0.0	
	1	0.1	***3.2***	***15.9***	***3.6***	0.0			
	1.5	0.6	***7.2***	***3.6***	***2.4***				
	2	0.0	0.0	0.0	0.0				
	2.5		0.0						
	3	0.0				0.0			
	PL @ 20 kcfs (n=111/130)								
		Velocity							
		0.25	0.5	0.75	1	1.25	1.5	1.75	2
Depth	0.5	0.1	0.9						
	1	0.1	***2.0***	0.7	0.0				
	1.5	***4.1***	***5.2***	***6.2***	0.3	0.0			
	2	0.0	0.3		0.6	0.0			
	2.5	0.0	0.3	0.6					
	3	0.0	0.6	0.2					

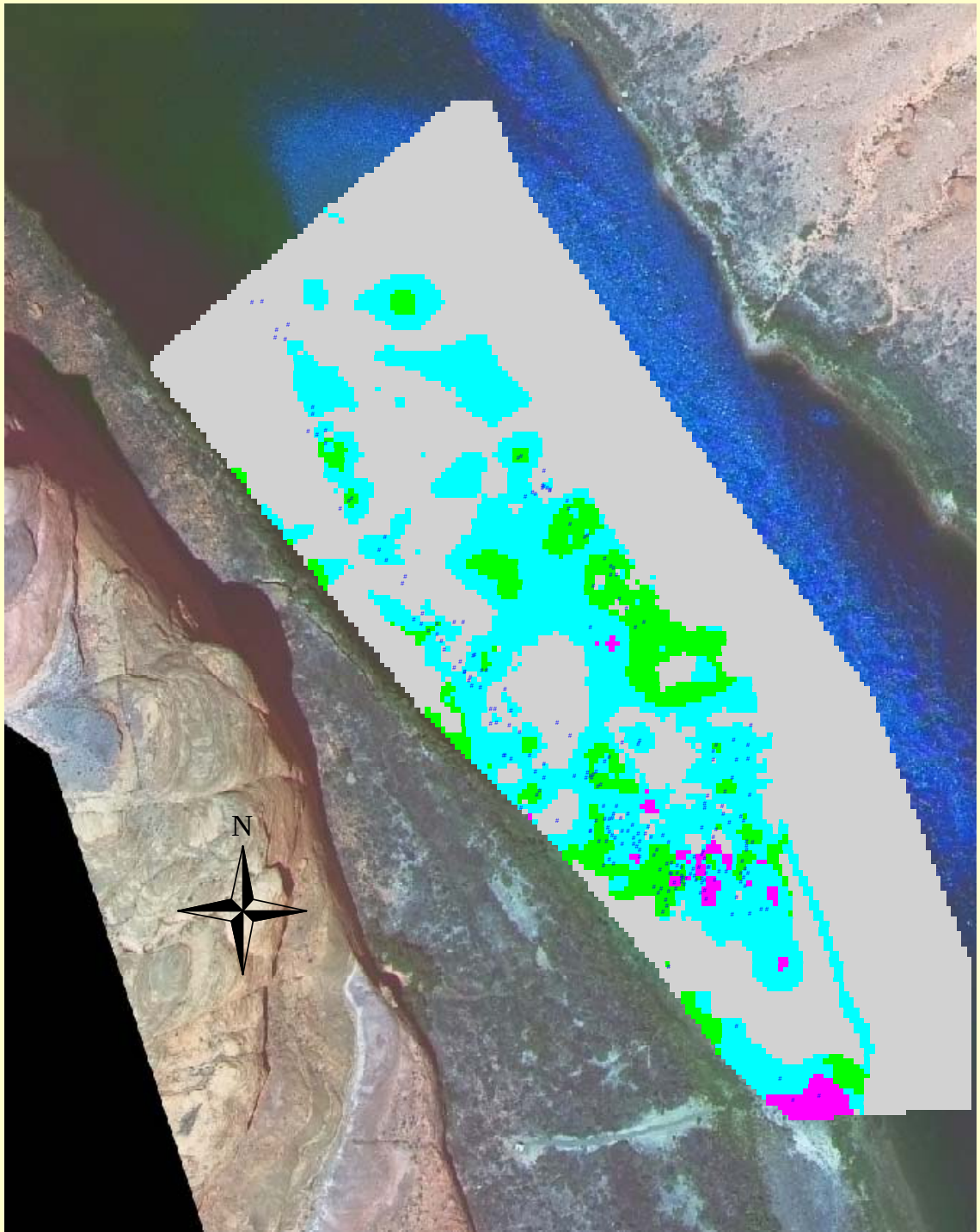
Spawning Habitat Selectivity

Predicted Spawning Habitat Preference At Four Mile Bar (20 kcfs)

Selectivity

- <1
- 1-2
- 2-4
- 4-6

- Redds in Mar.

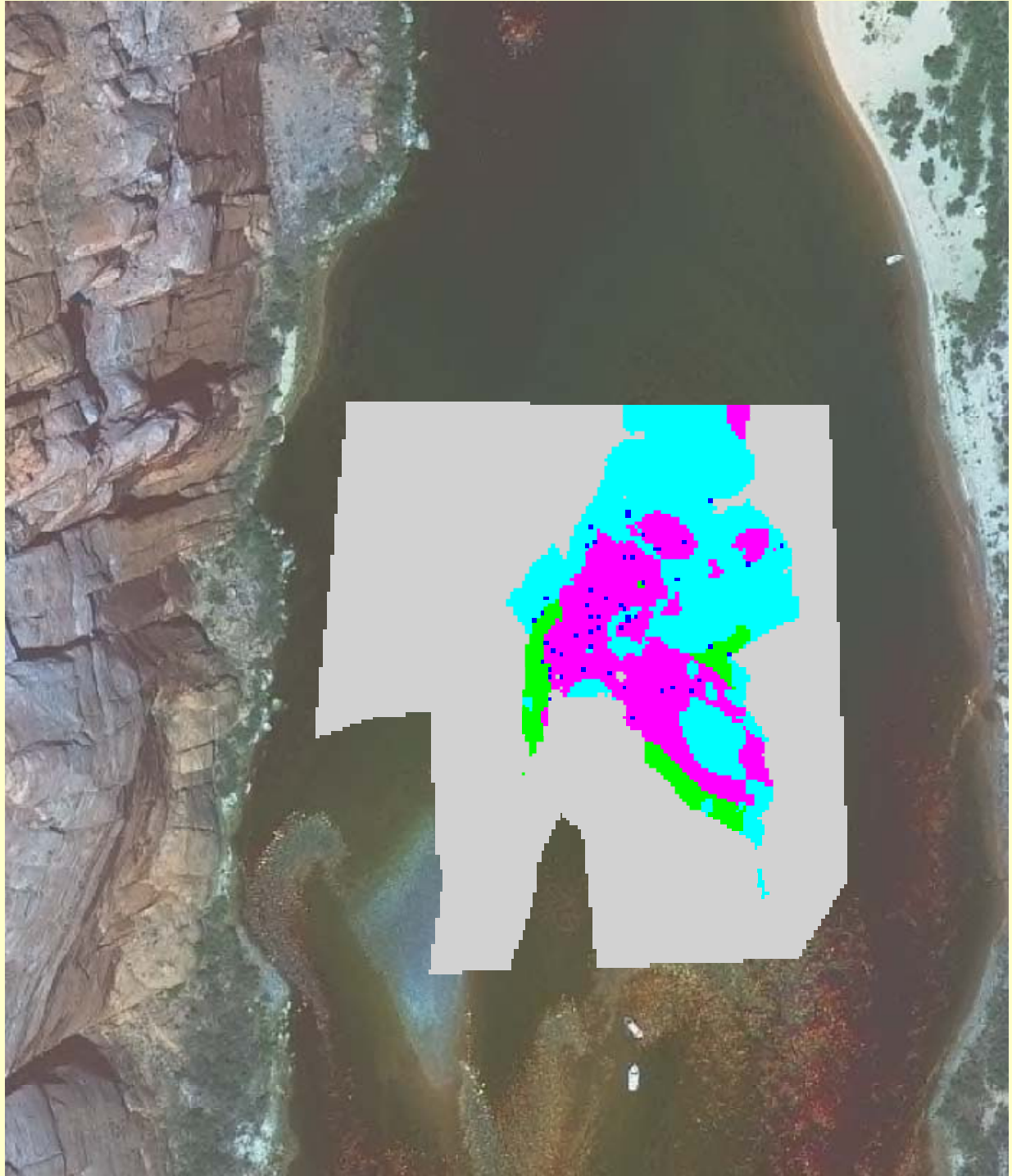


Predicted Spawning Habitat Preference At Ferry Swale (5 kcfs)

Selectivity

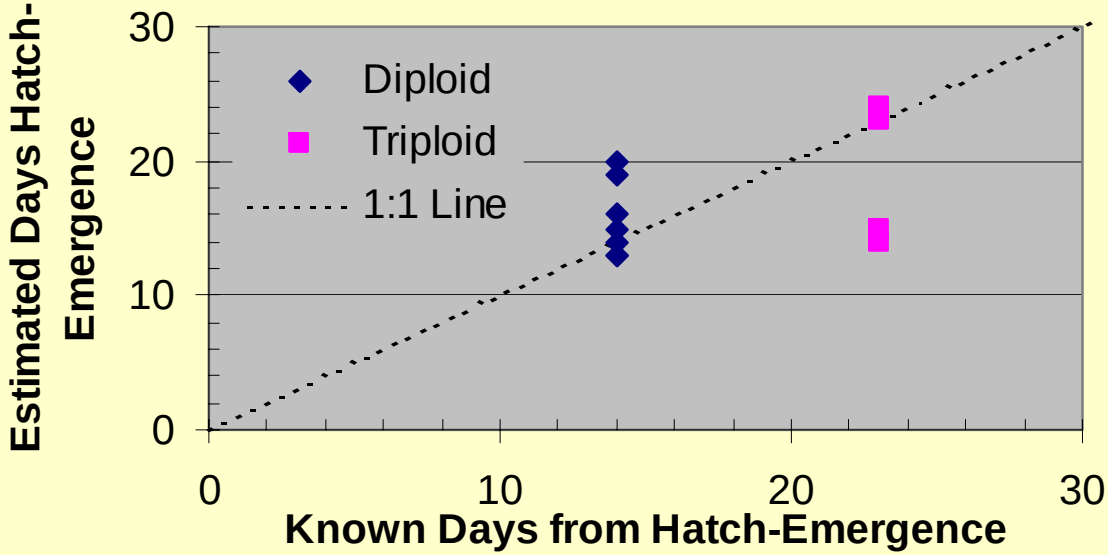
- <1
- 1-2
- 2-4
- 4-6

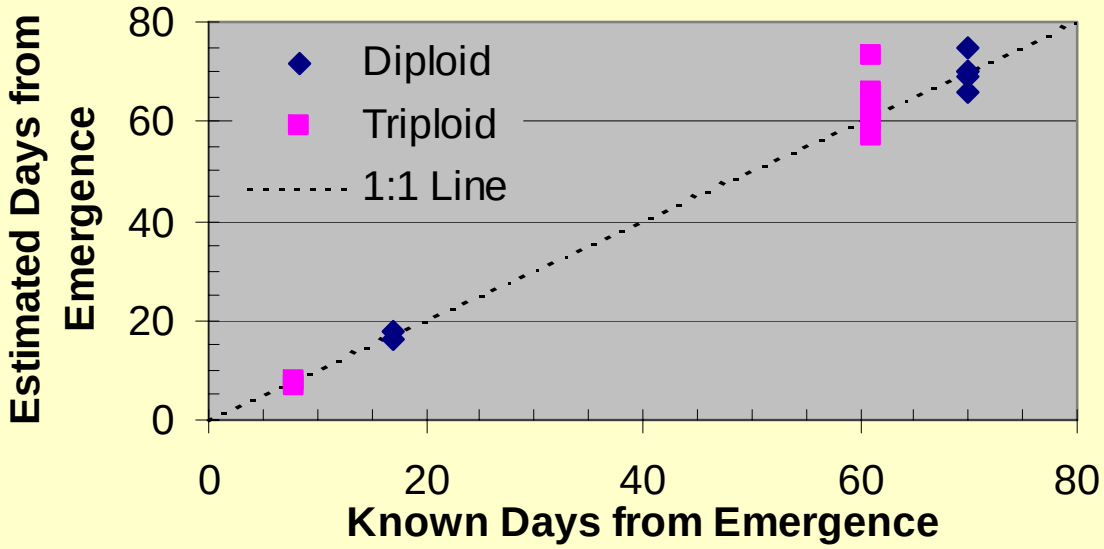
Redds in Mar.



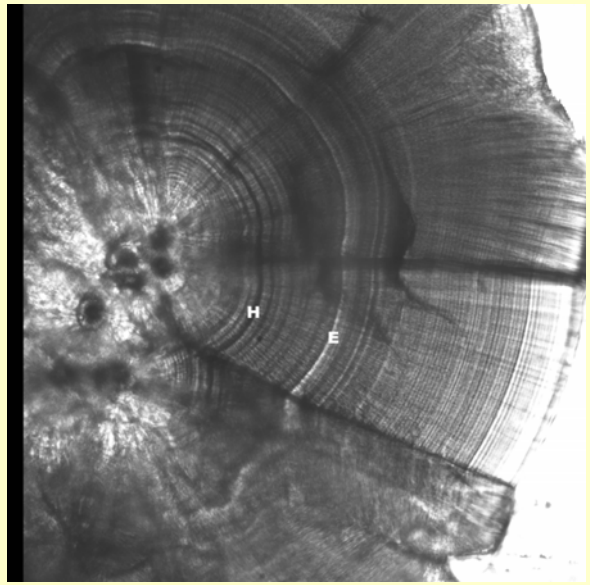
Methods for Estimating Timing of Emergence and Fry Morality

- Monthly catch-per-effort sampling by backpack electrofishing in fry habitat at minimum flow.
- Age a subset of fish from otoliths to develop length-age key and accurately estimate time of hatch and emergence.
- Translate length-frequency of catch (by month) into age-frequency.
- Use model to compute in-season estimates of apparent mortality and recruitment.
- Examine relationships between operations and mortality and growth patterns.

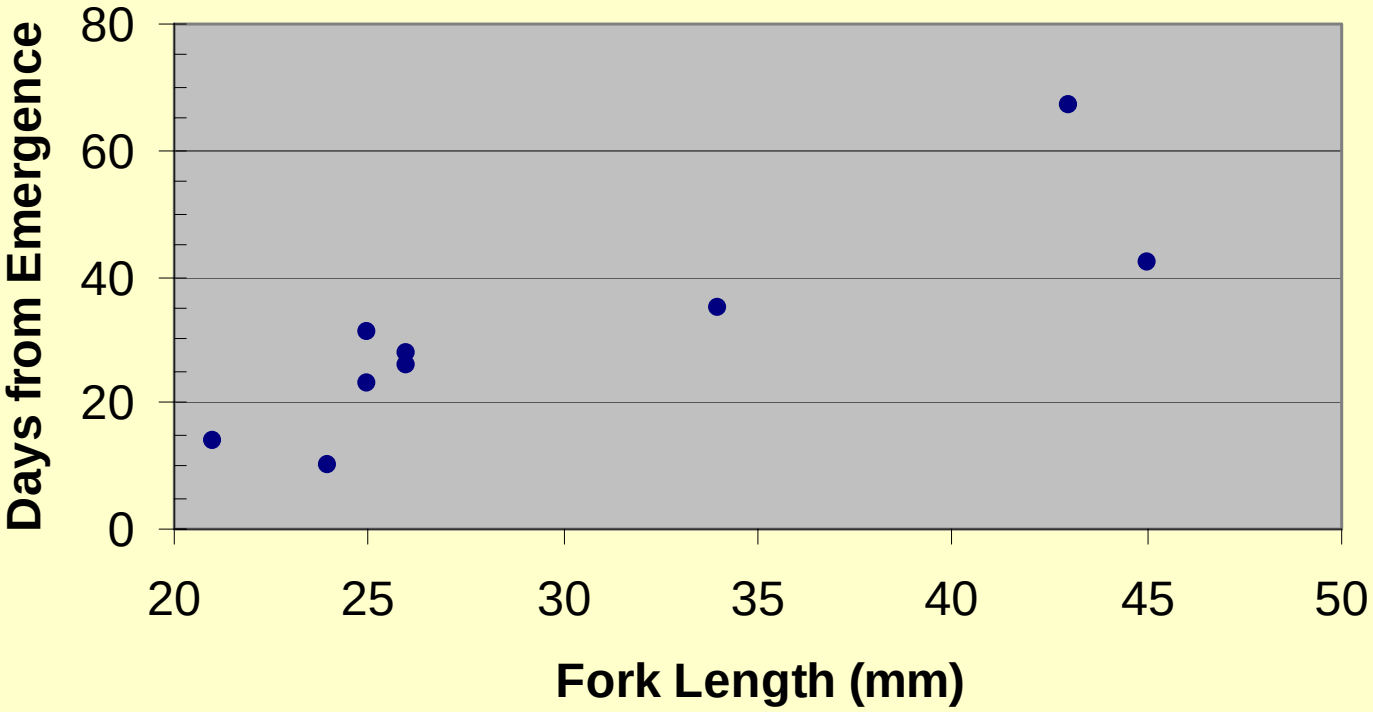




Validation of days from hatch-emergence and emergence to date of sampling using hatchery fish



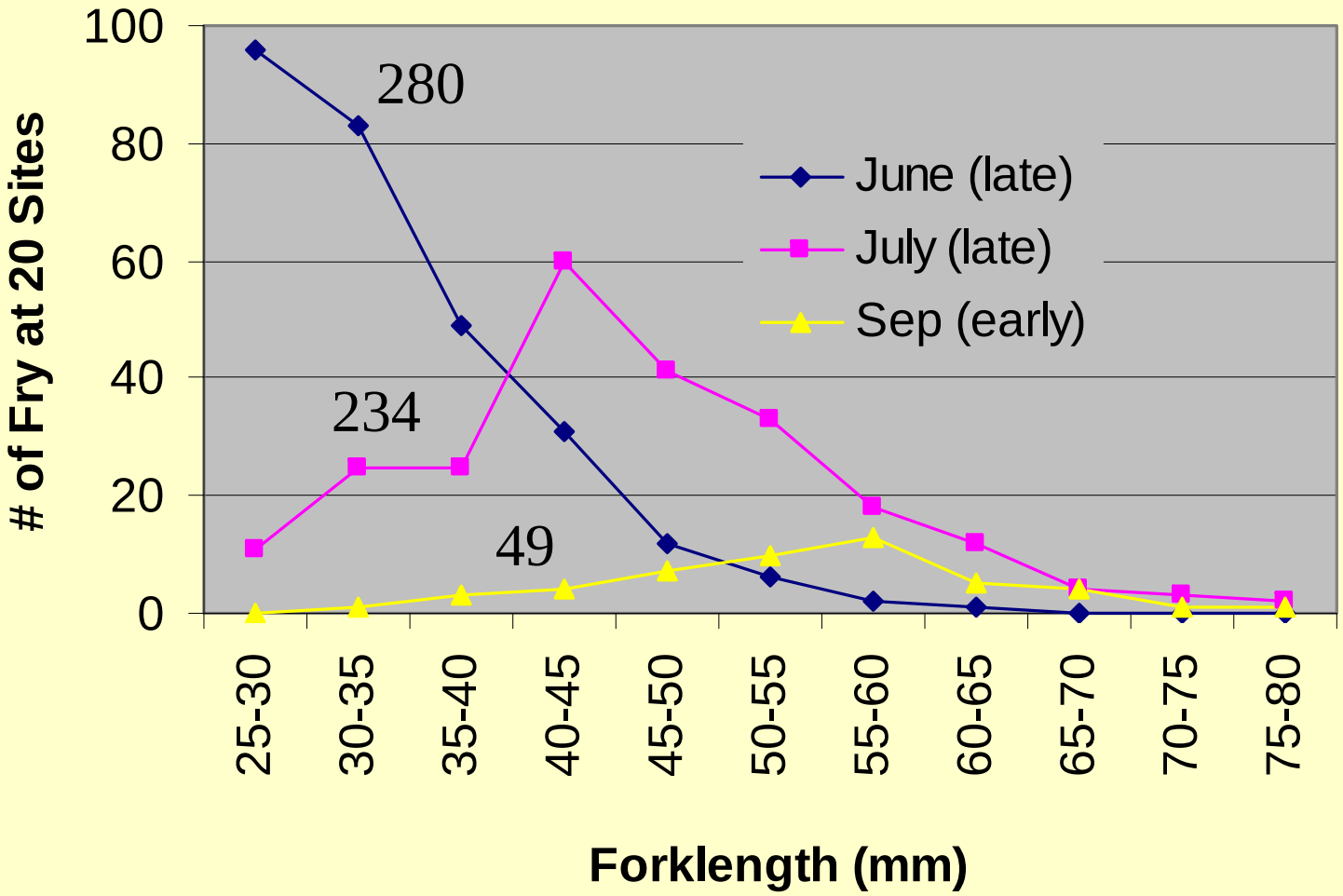
Fry Ageing in ’03 for Lee’s Ferry



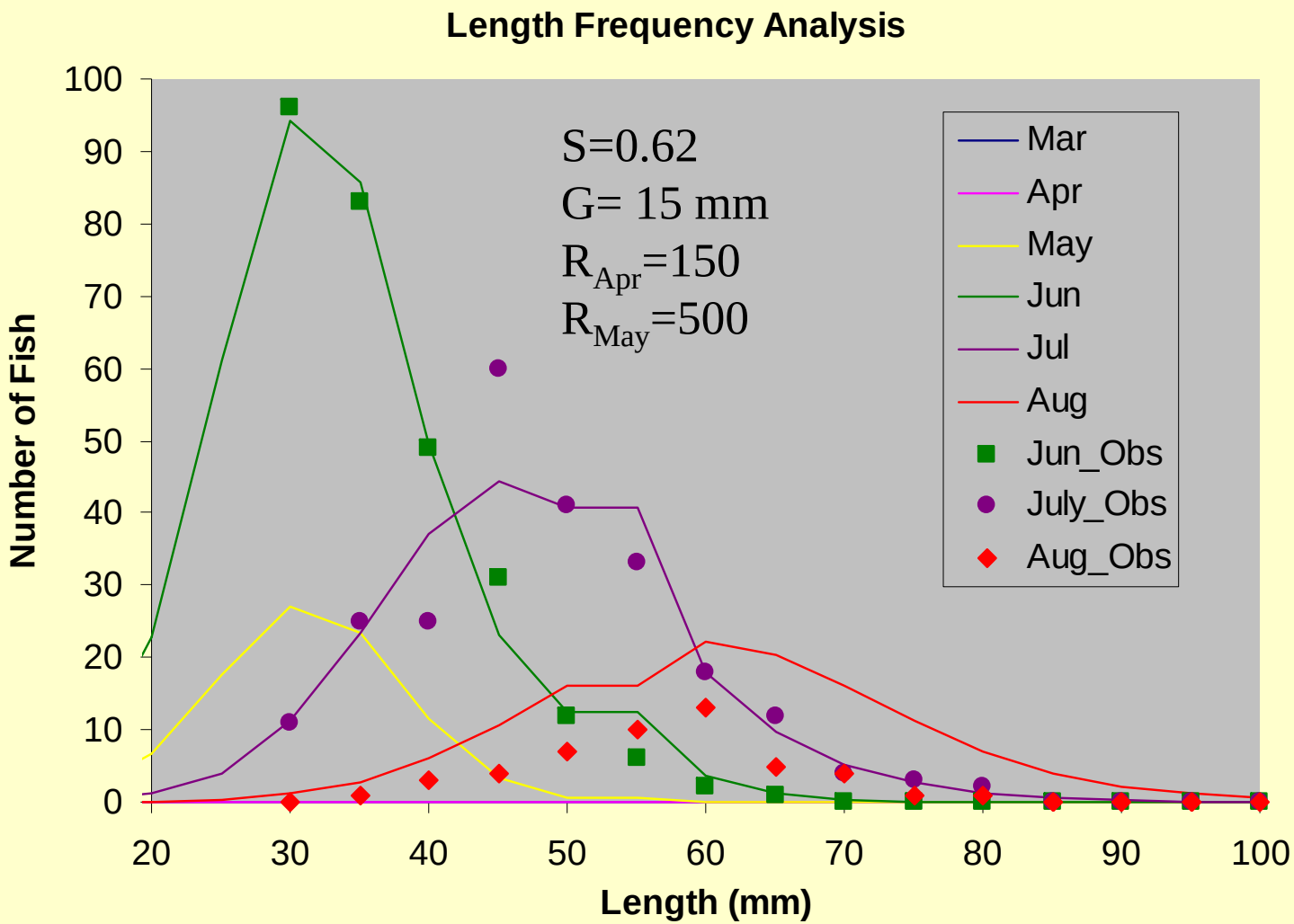
Sample size for length-age key (N=281)

	Apr	May	Jun	Jul	Sep	Oct
#	14	43	59	56	61	48

RBT Length-Frequency ‘03



Predicted and Observed



Initial Observations from Fry Sampling

- For the most part, fry distribution limited to stage of minimum flow.
- Youngest fry most common in cobble bar habitats, older fry shift to deeper-water habitats (talus slopes, debris fans).
- Fluctuating flow experiment was over well before any fry had emerged.
- Virtually no fry found in shallow habitats (cobble bars/vegetated shorelines) in early Sept. sample, which was preceded by large change in minimum flow (12 → 5 kcfs). Significant mortality event?
- Periodic short changes in minimum flow over summer (12→5 kcfs) may be most effective way to reduce fry recruitment without inflicting major impacts on food base and adult trout growth. Assess via in-season length-frequency analysis.