Drought decisions in a highly impacted California River

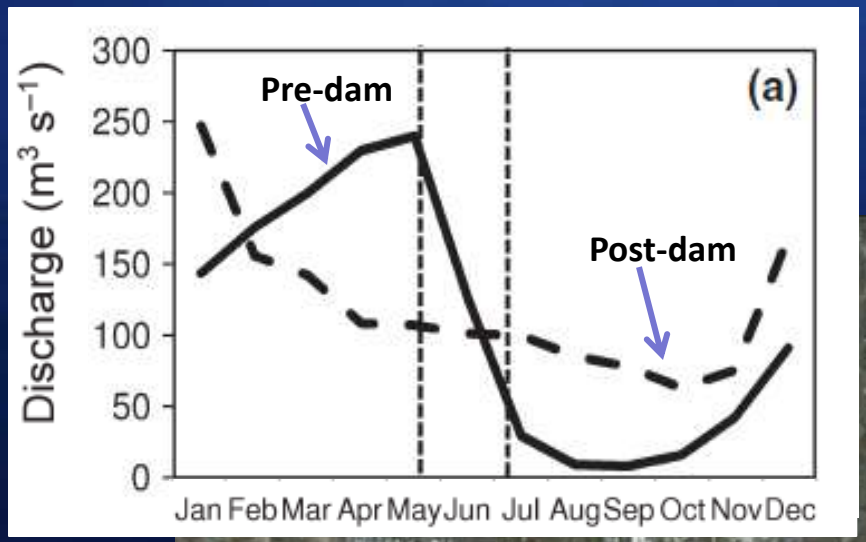
Using umbrella species to inform water management

Kirsten Sellheim, Steve Zeug, John Hannon, Tom Gohring, and Joseph Merz

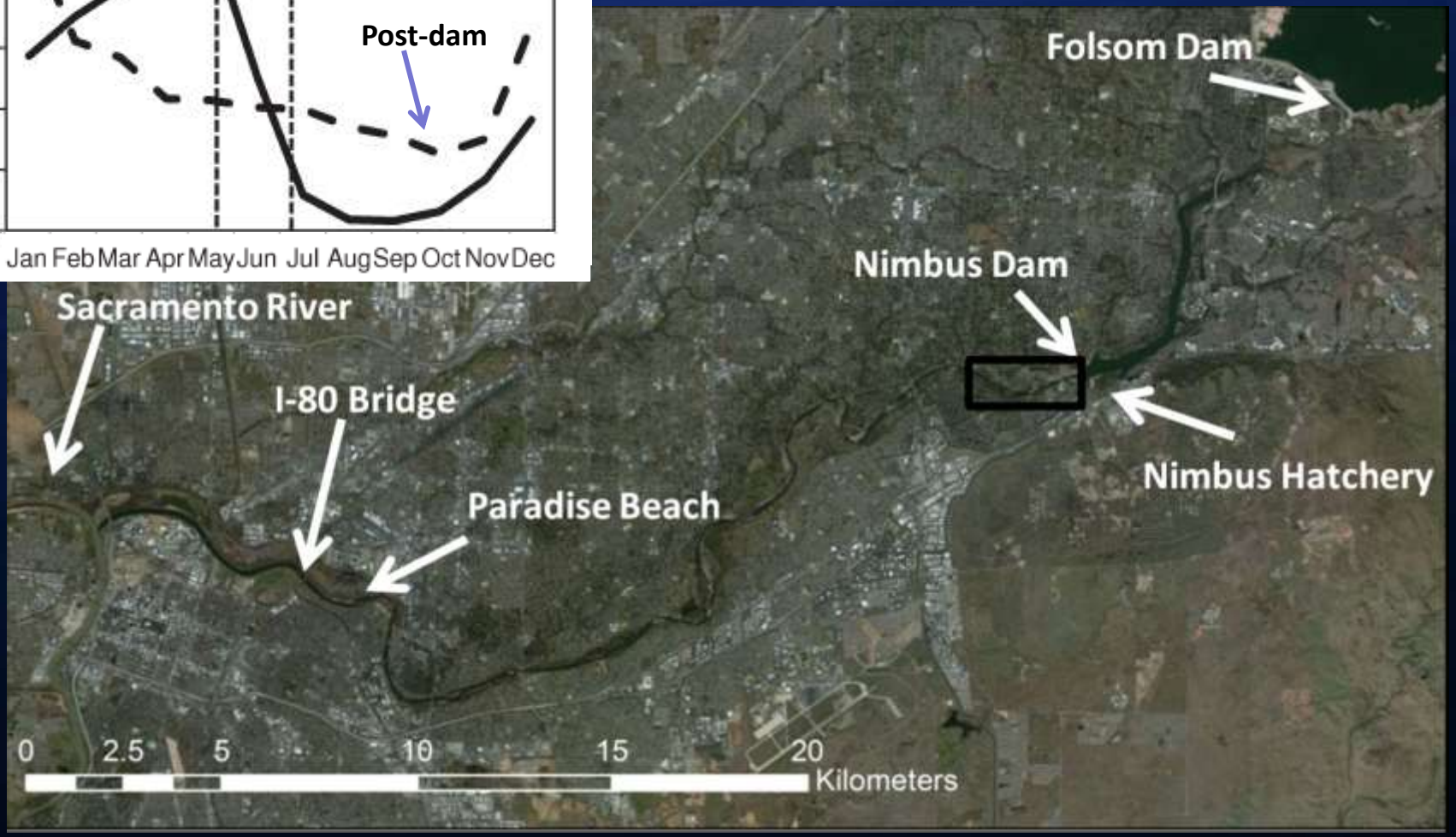
Overview

- LAR drought flows
- Acute and chronic effects of flow reduction
- Response to management actions
- What did we learn?

The Lower American River: A heavily impacted system

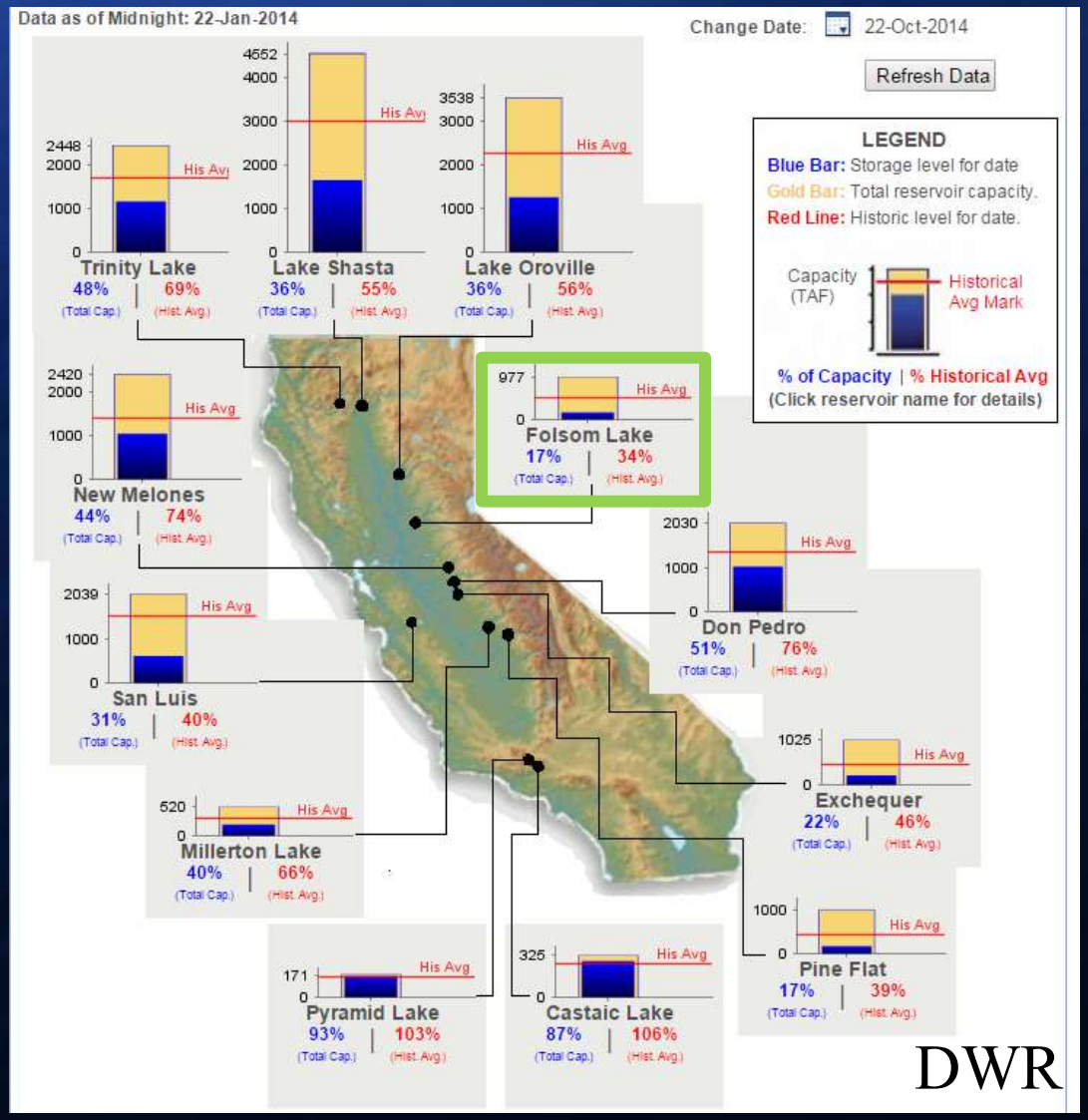


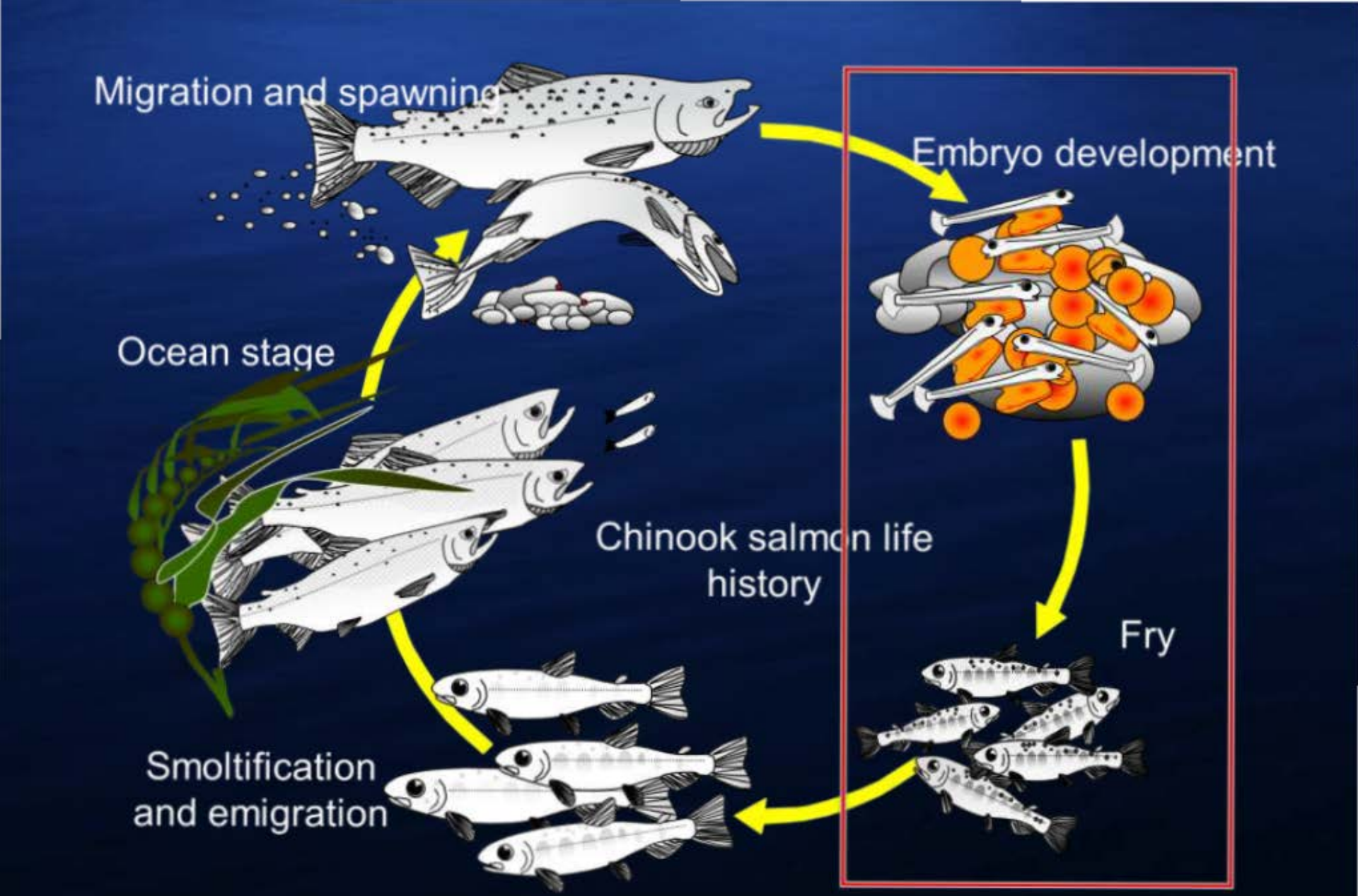
Zeug et al. 2011, Fish. Manag. Ecol.



The 2014 Drought

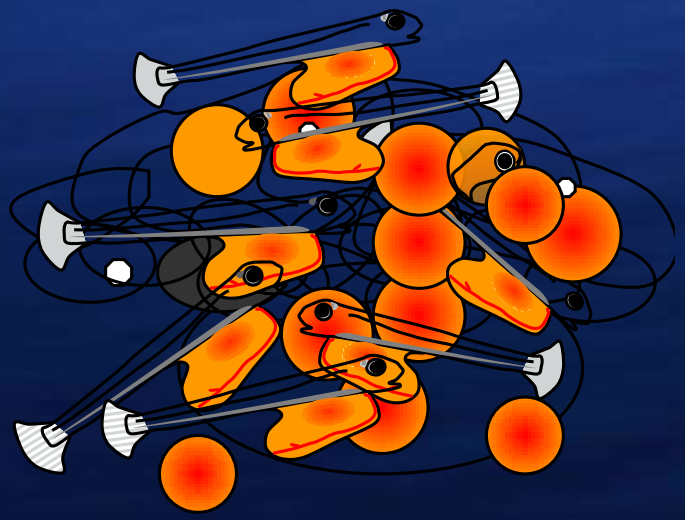
- Third largest in recorded CA history
- Storage in Folsom Reservoir reached an all-time low (17% capacity)
- Streamflow on LAR drastically reduced during key incubation period for Chinook salmon embryos




Migration and spawning
Embryo development
Ocean stage
Chinook salmon life history
Fry
Smoltification and emigration

J. Merz

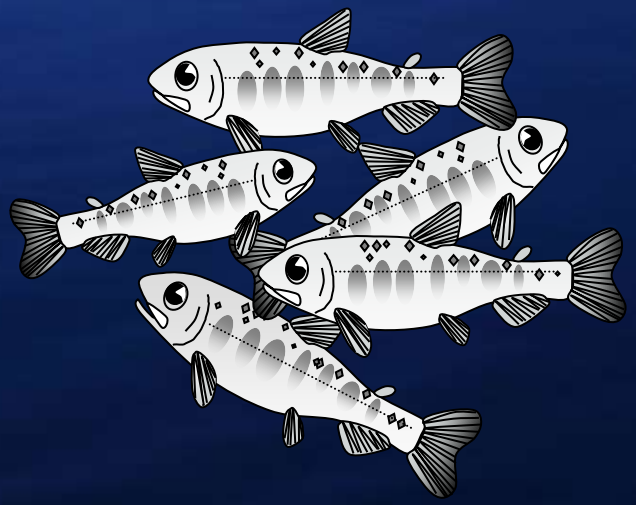
Eggs, embryos and alevin in gravel



Key impacts:

- No water
- Poor water quality
- Waste build-up
- Run out of yolk

Rearing fry



Key impacts:

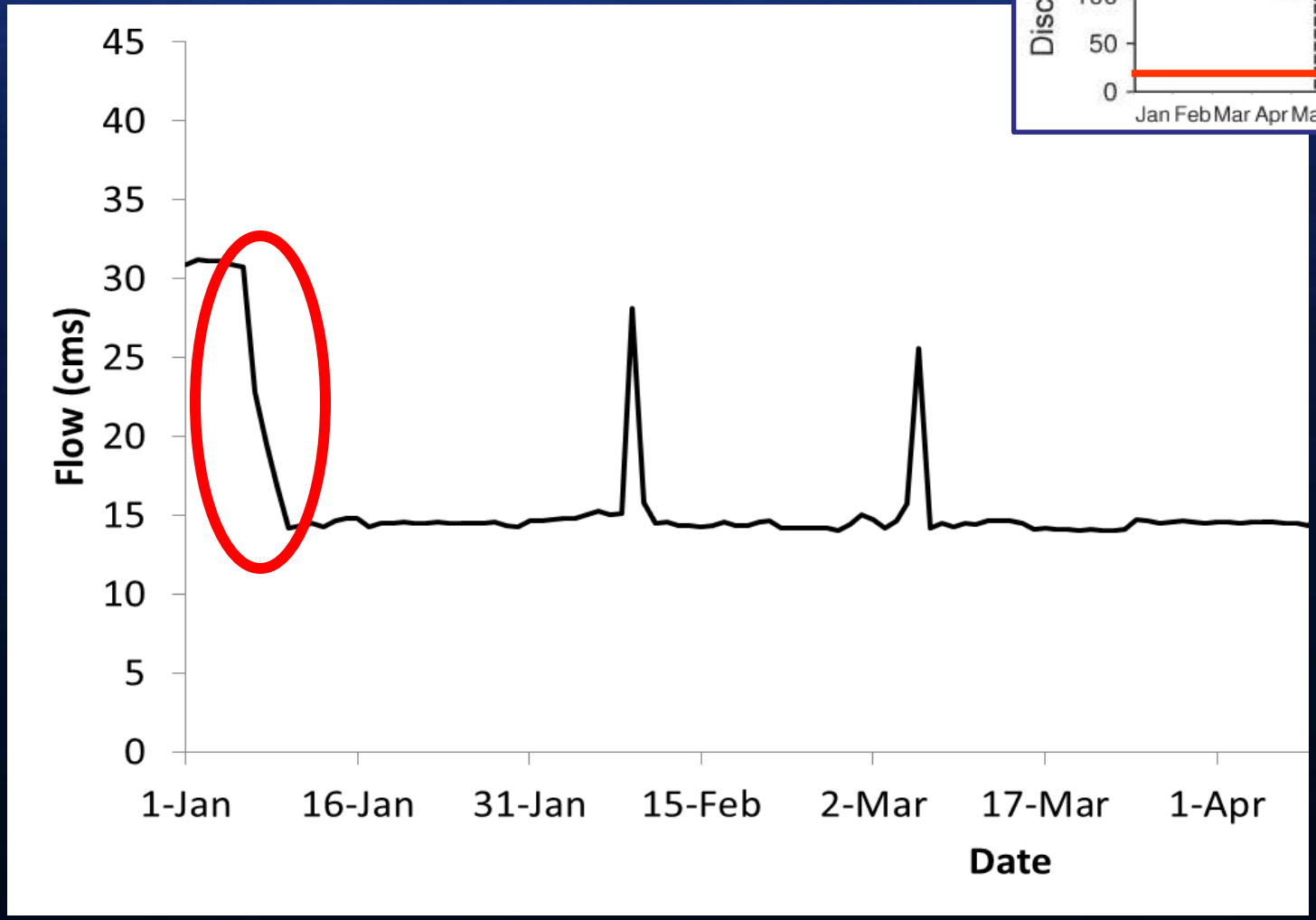
- Stranding
- Poor water quality
- Prey limitation
- Limited rearing habitat
- Predation

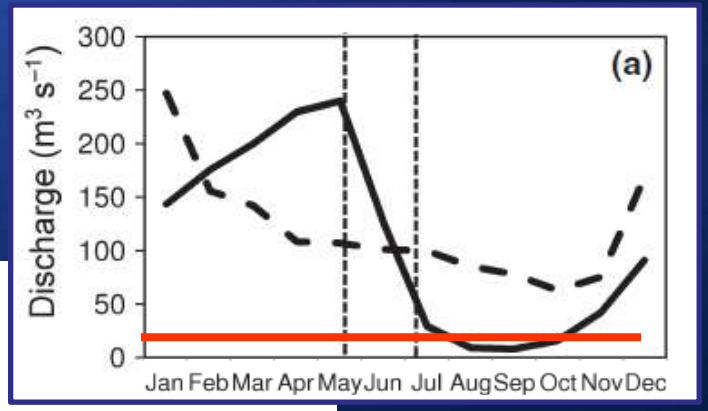
Research question: What was the impact of flow reduction on embryo survival?

Acute impacts: redd dewatering

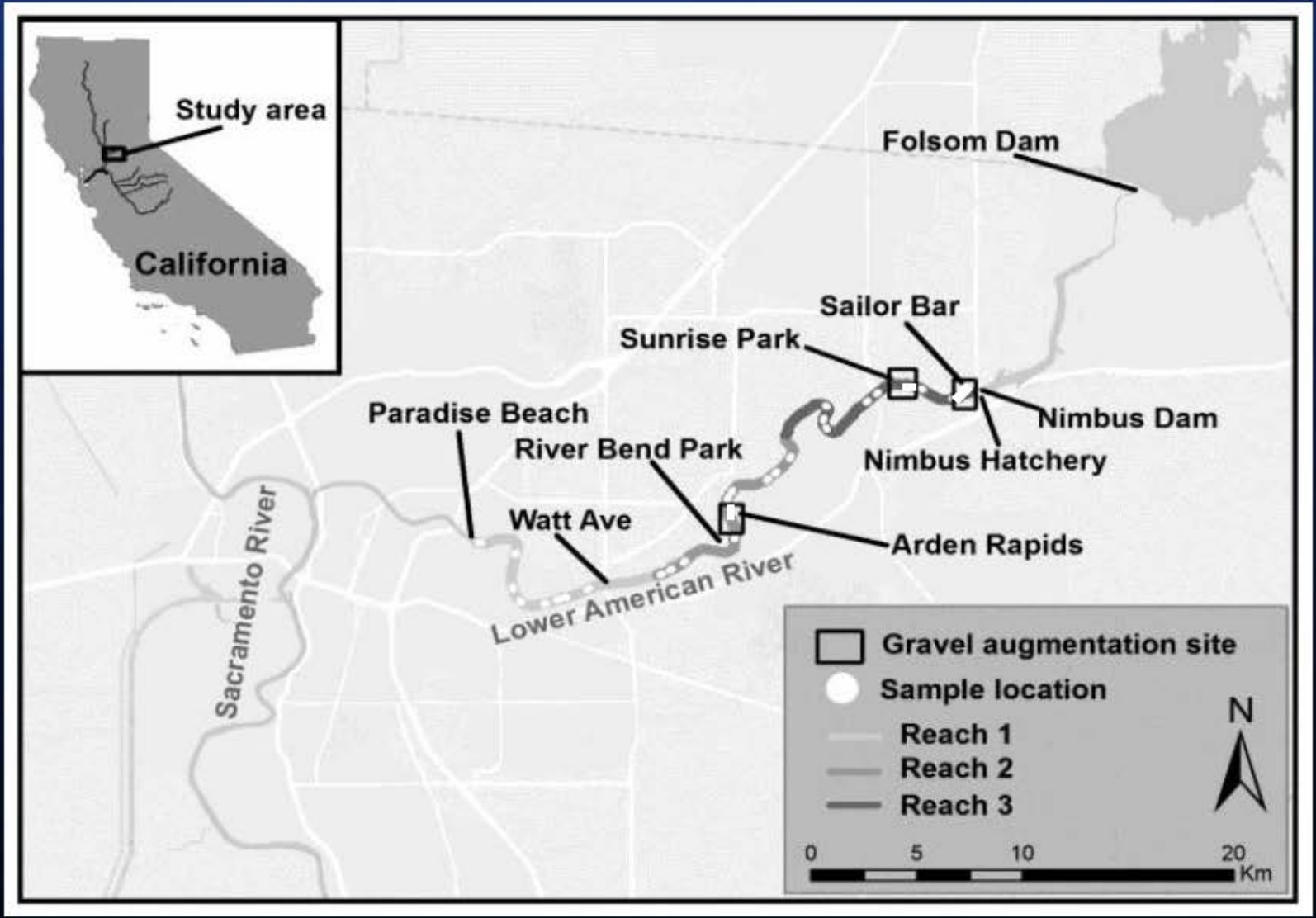
Chronic impacts: intergravel water quality

Flow reduction



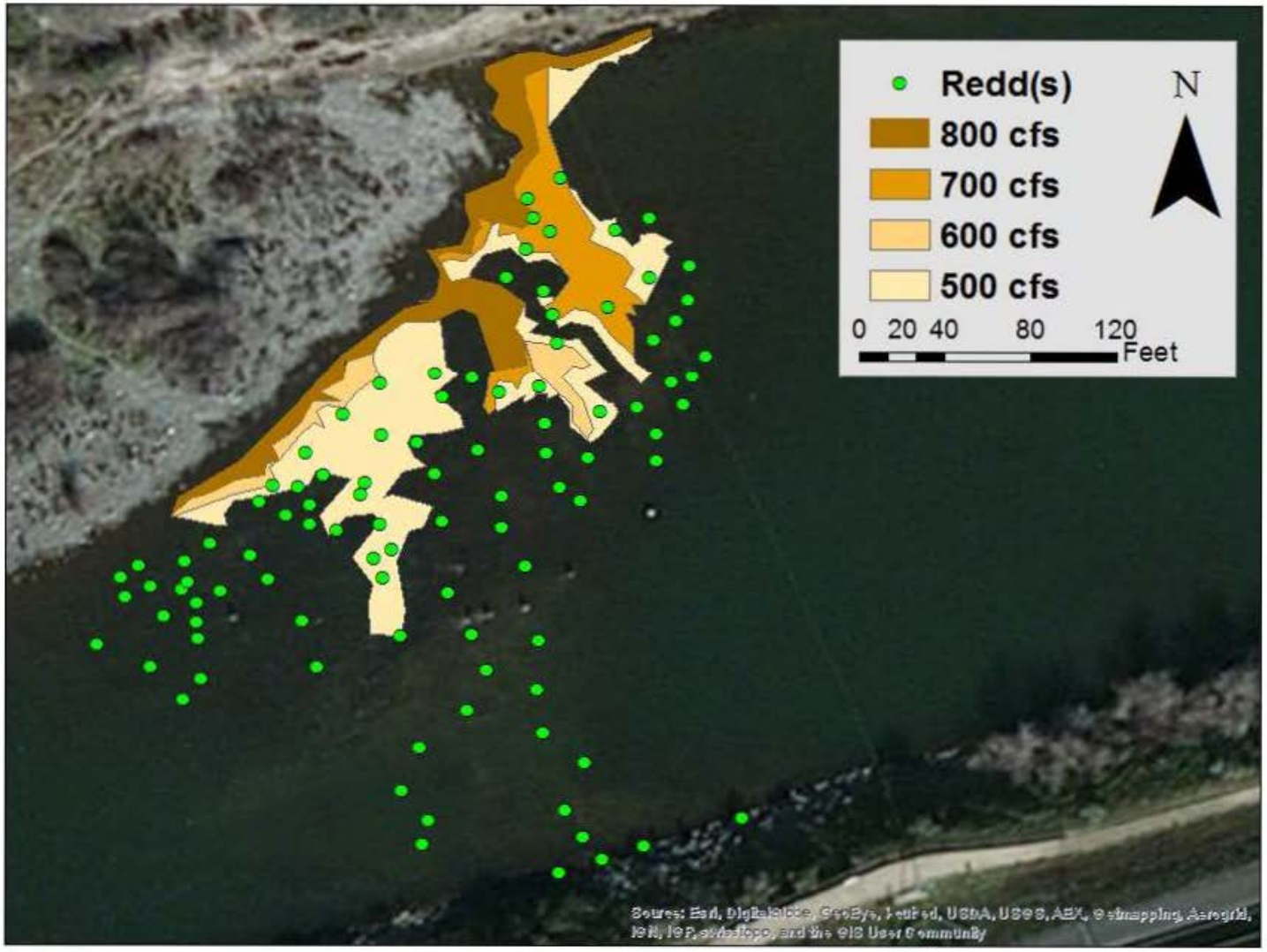


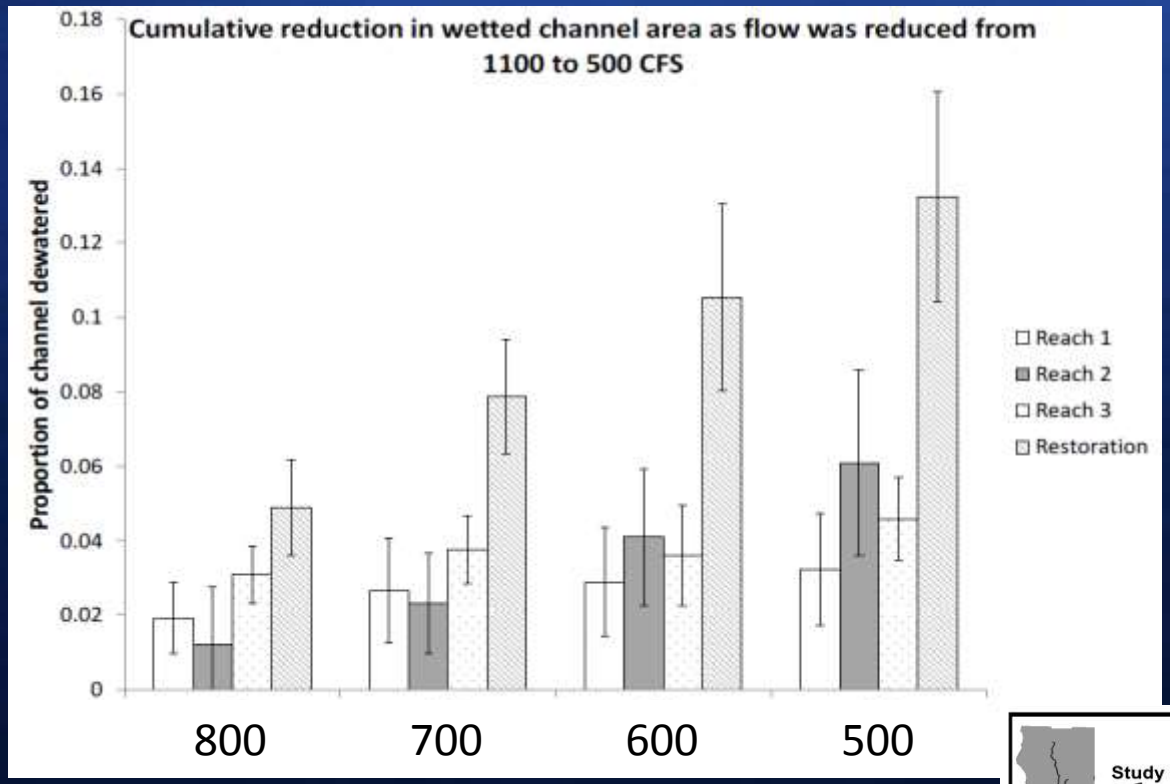
Study Reaches

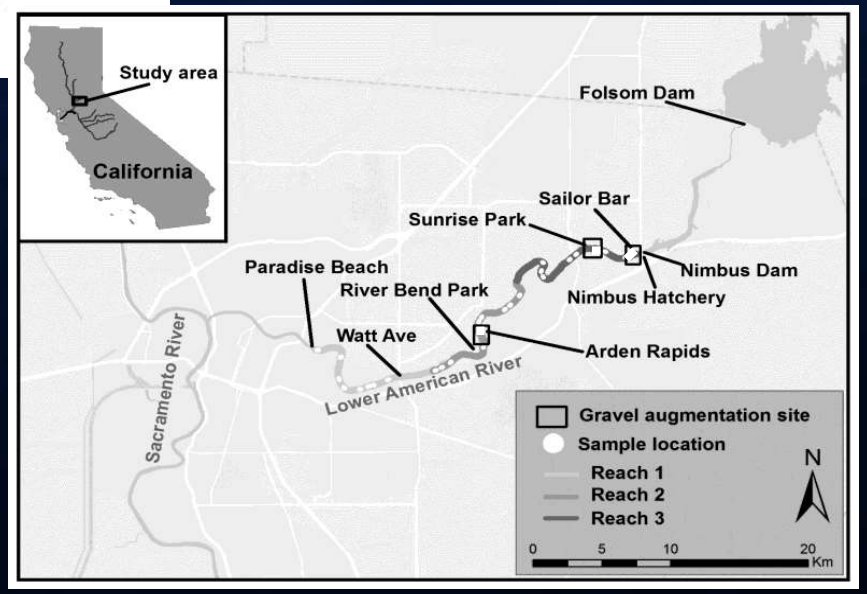


Sailor Bar Gravel Augmentation site

Dewatered area at incremental flow reductions







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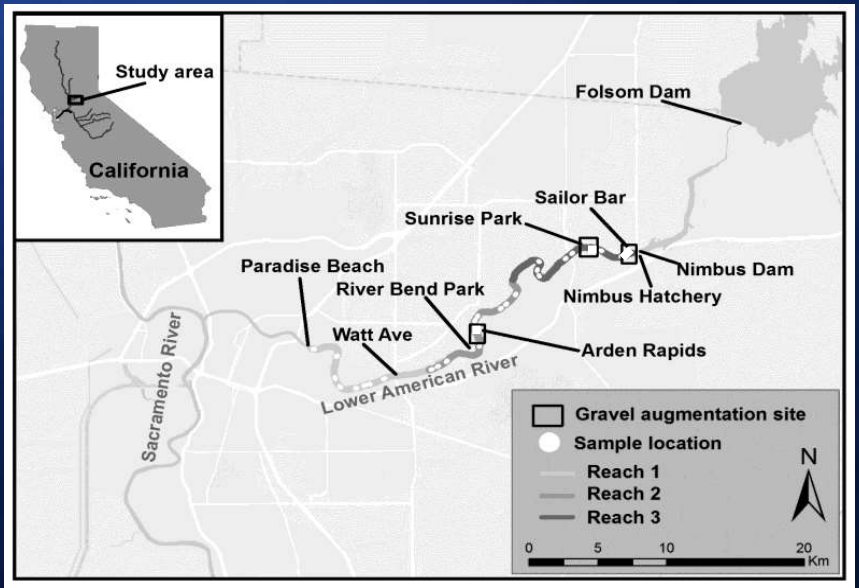
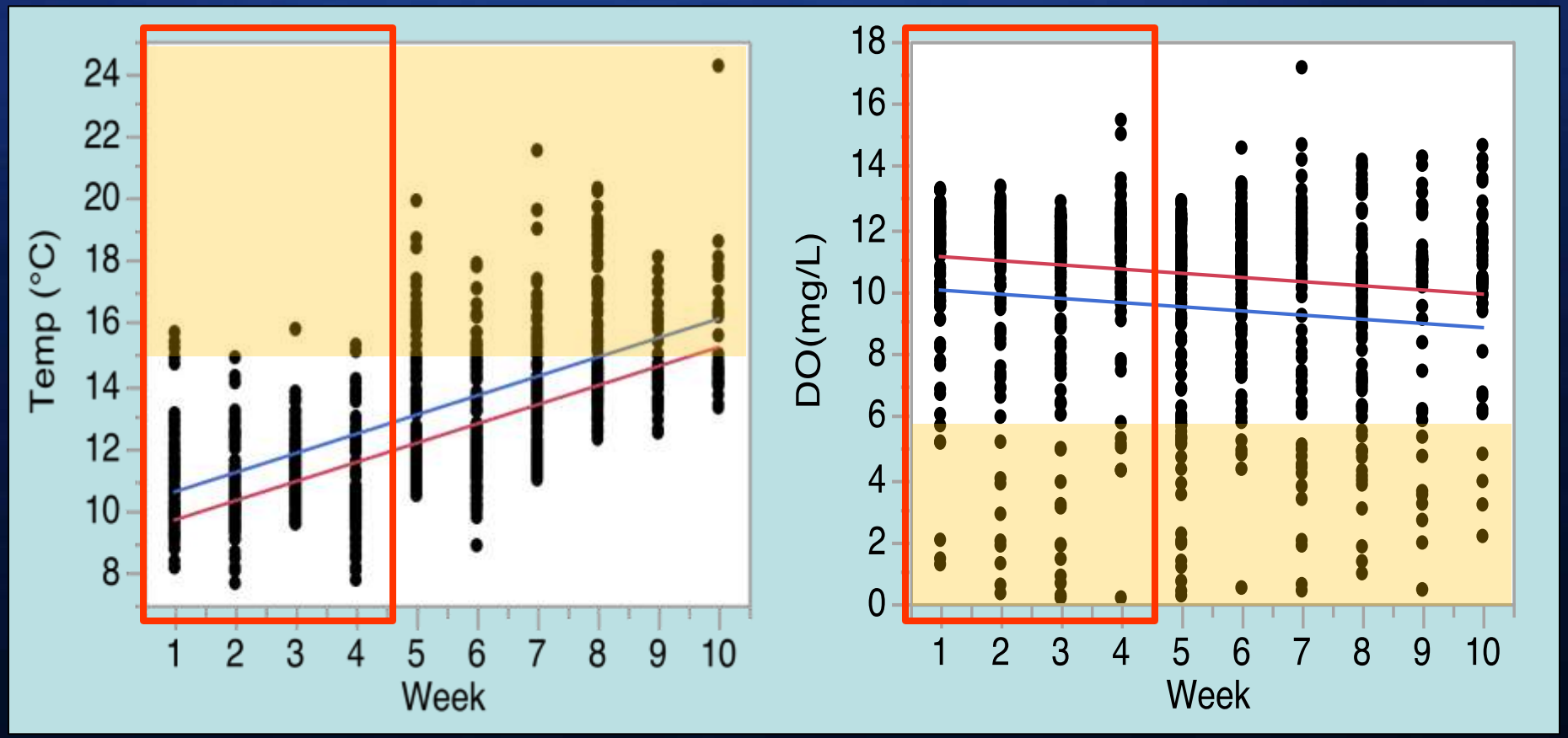


Streamflow (cfs)	Reach 1 (42 redds)		Reach 2 (438 redds)		Reach 3 (2360 redds)		Total LAR (2840 redds)	
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
800	0	NA	0	NA	1	0 - 6	1	0 - 6
700	0	NA	4	1 - 10	24	15 - 36	28	18 - 40
600	1	0 - 5	12	6 - 21	64	49 - 81	77	61 - 96
500	4	1-10	46	34 - 60	249	220-280	299	268 - 333

Weekly inter-gravel water quality sampling

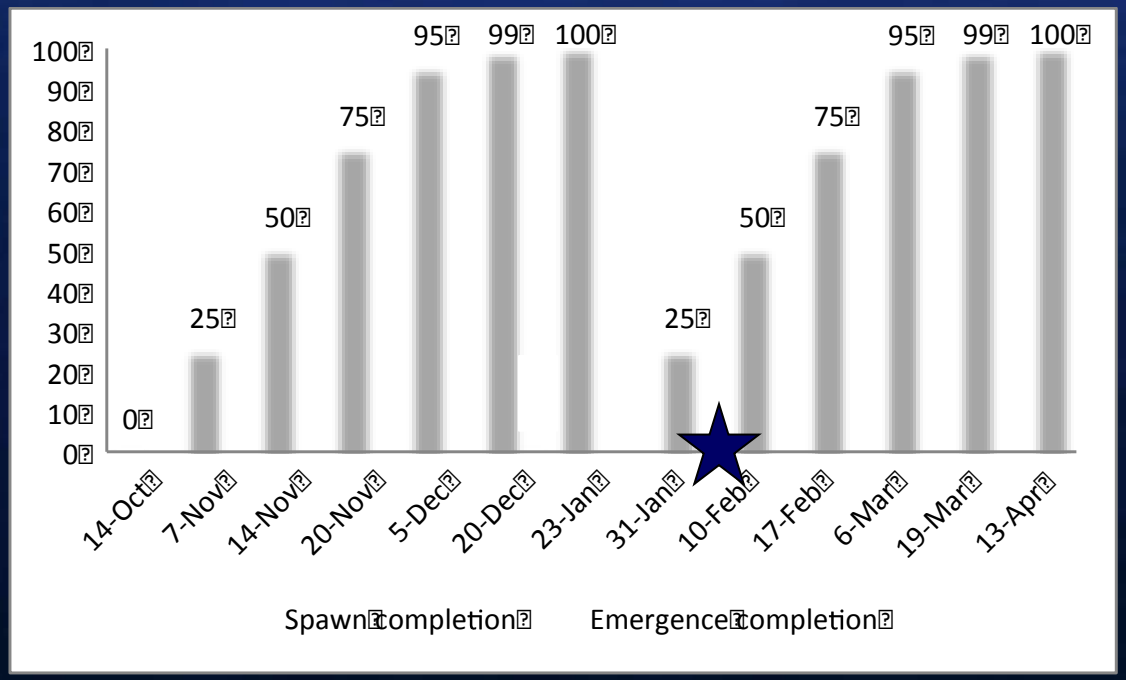
- Partially dewatered and main channel control sites
  - Temperature
  - Dissolved Oxygen
  - Turbidity
  - Permeability

Inter-gravel water quality



Orange boxes represent stressful conditions
Red lines represent control sites, blue lines represent dewatered redds

When to pulse flow?

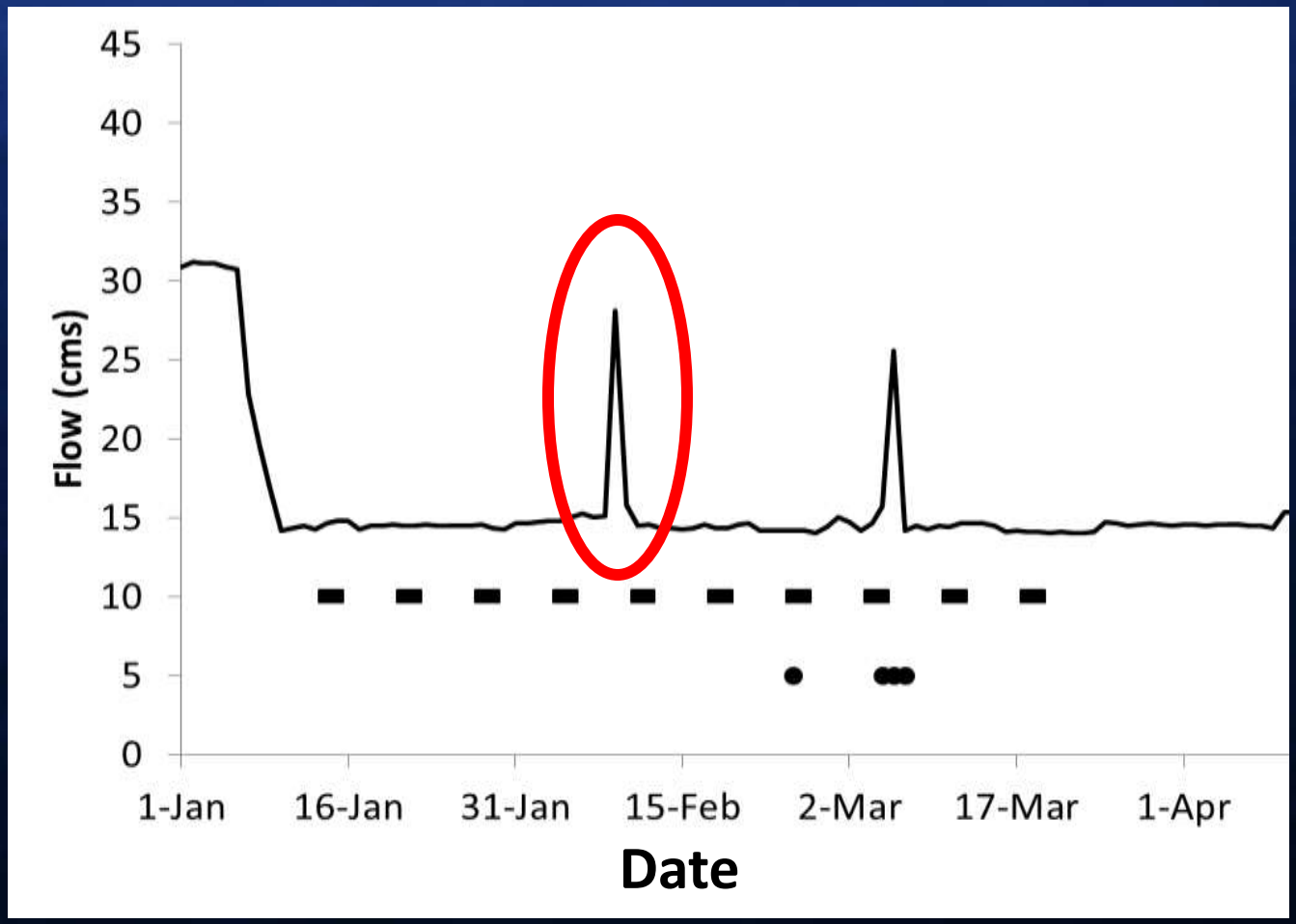


50% Emergence – Feb 5-15

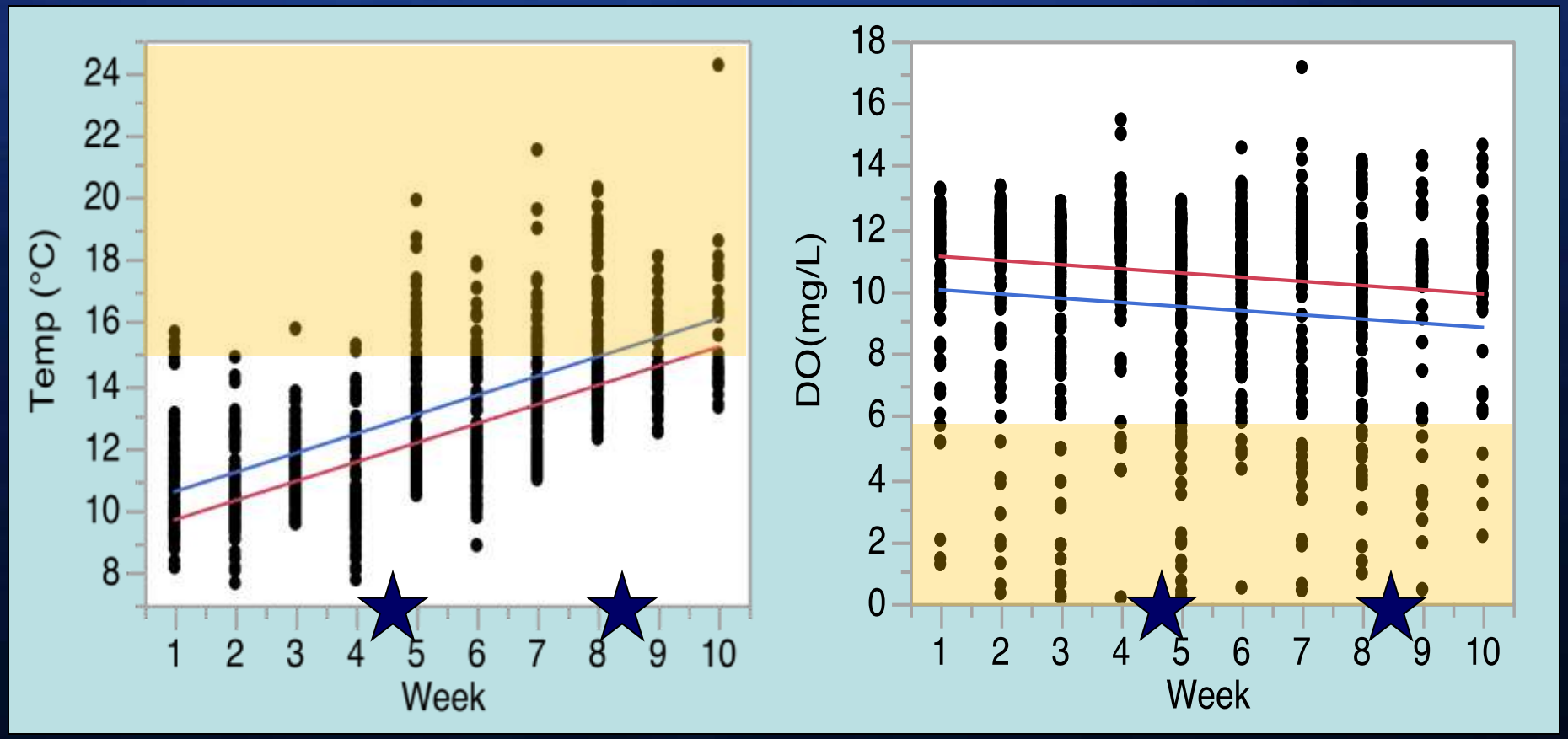
75% Emergence – Feb 13-22

99% Emergence – March 13-22

First flow pulse



Inter-gravel water quality

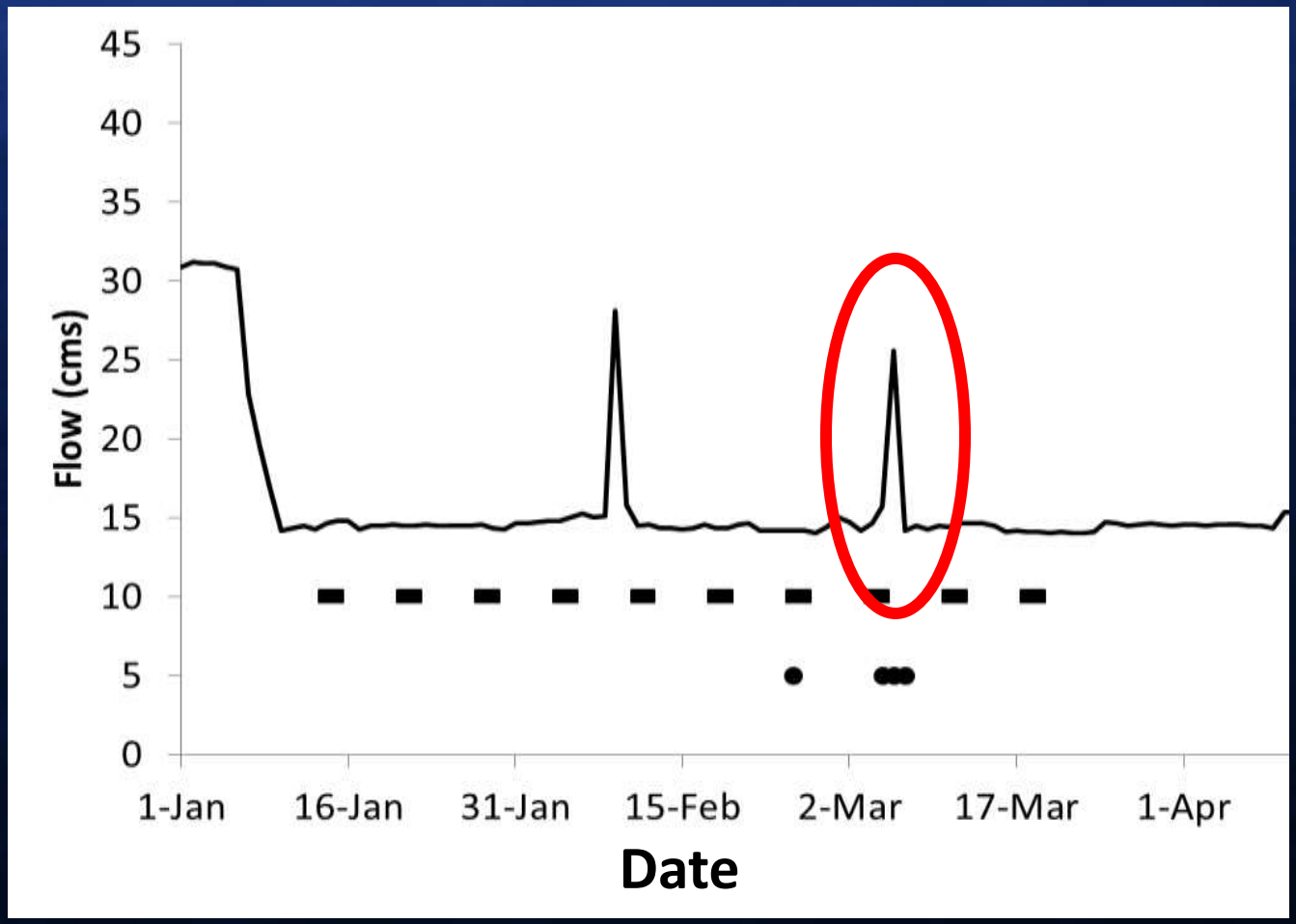


Orange boxes represent stressful conditions
Red lines represent control sites, blue lines represent dewatered redds
Stars are flow pulses

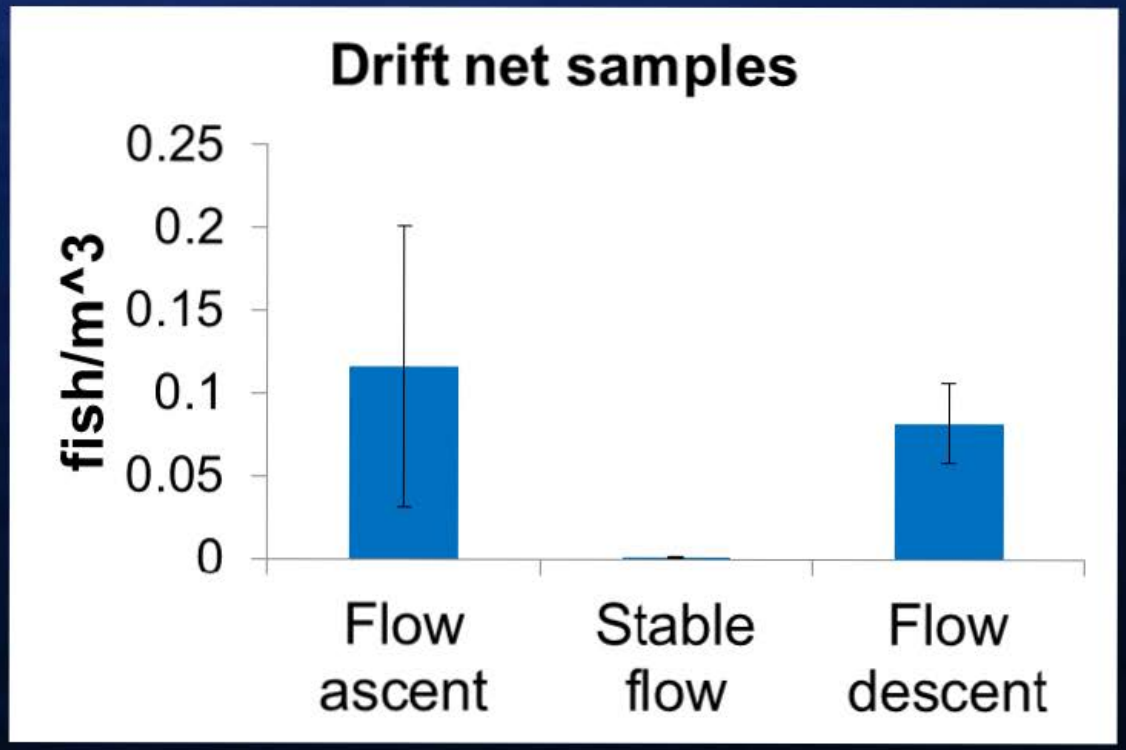
Second flow pulse

- Reconnect partially dewatered redds containing hatched alevin
- Reconnect stranded juveniles with the main channel

Second flow pulse

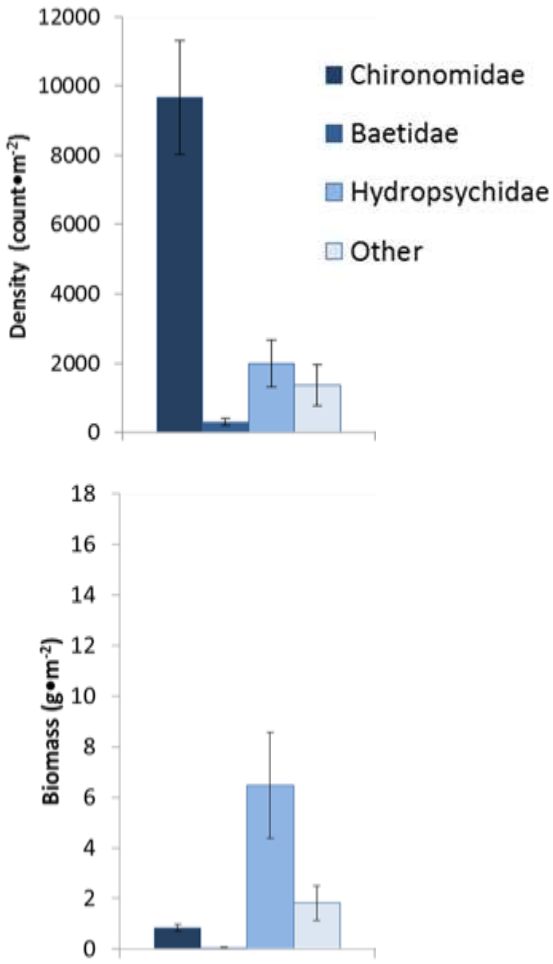


Drift net sampling

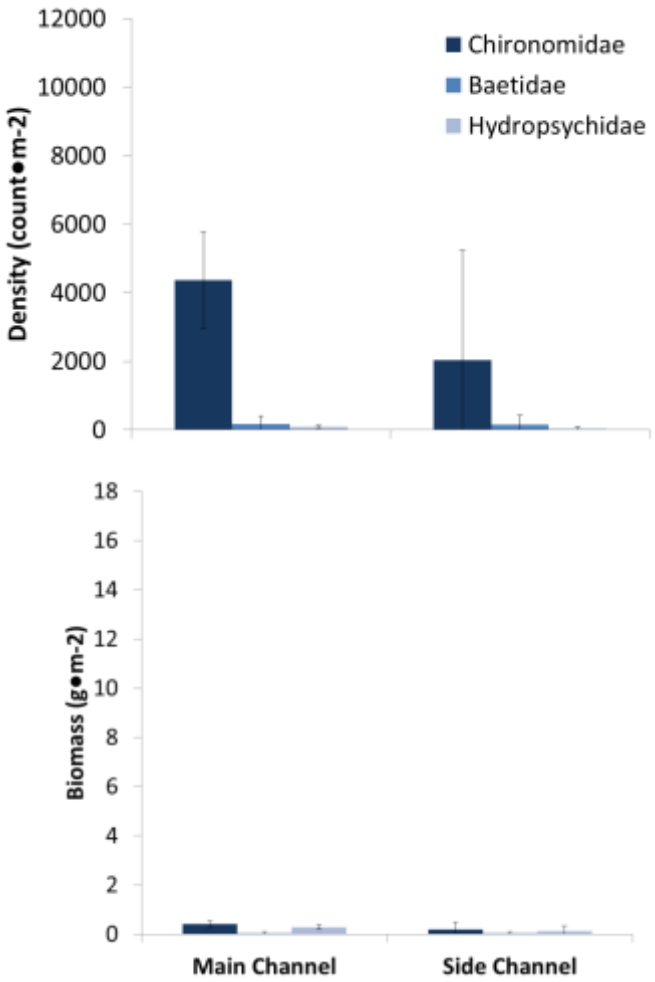


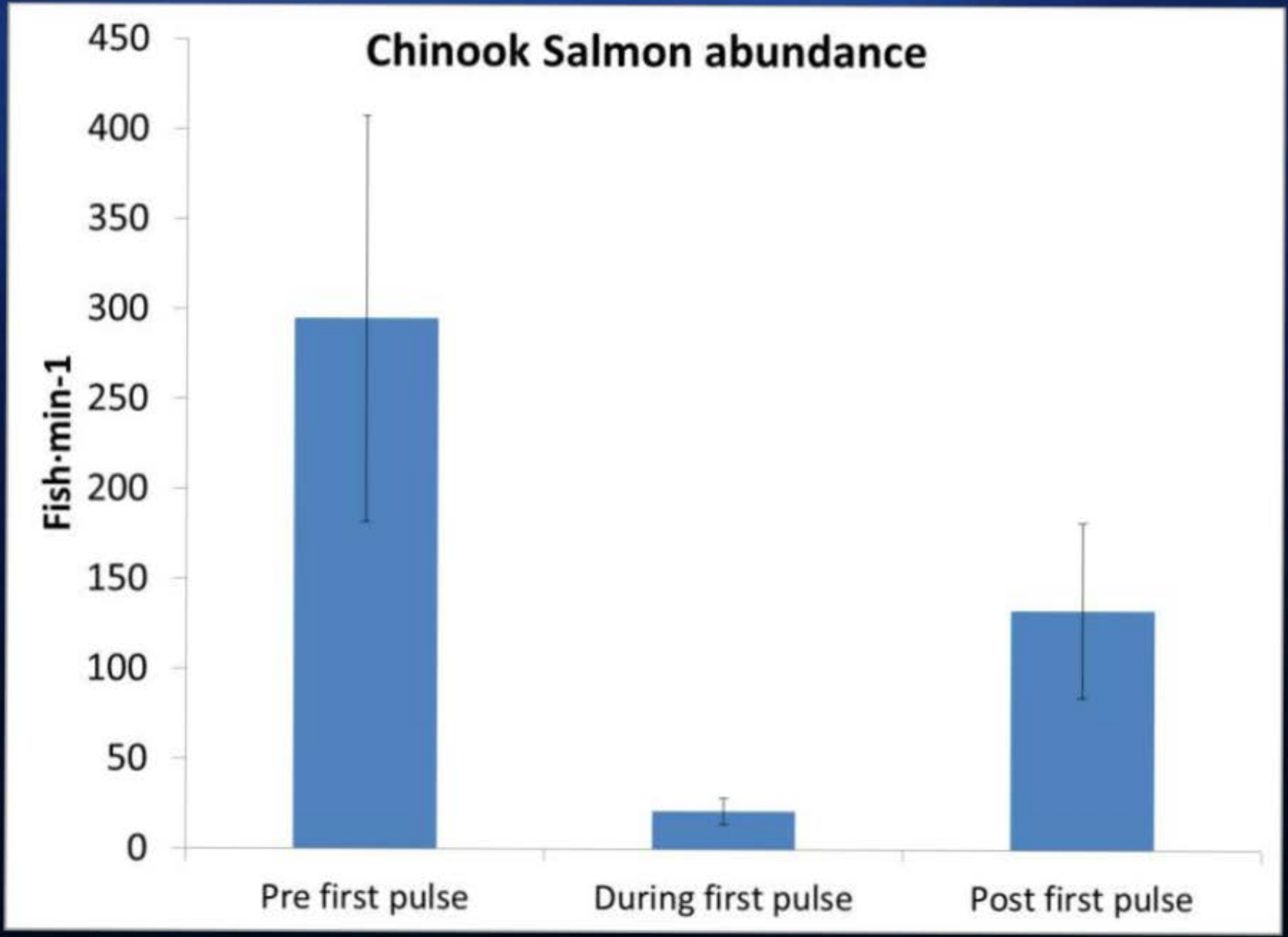
Benthic invertebrate prey

Normal flow conditions:

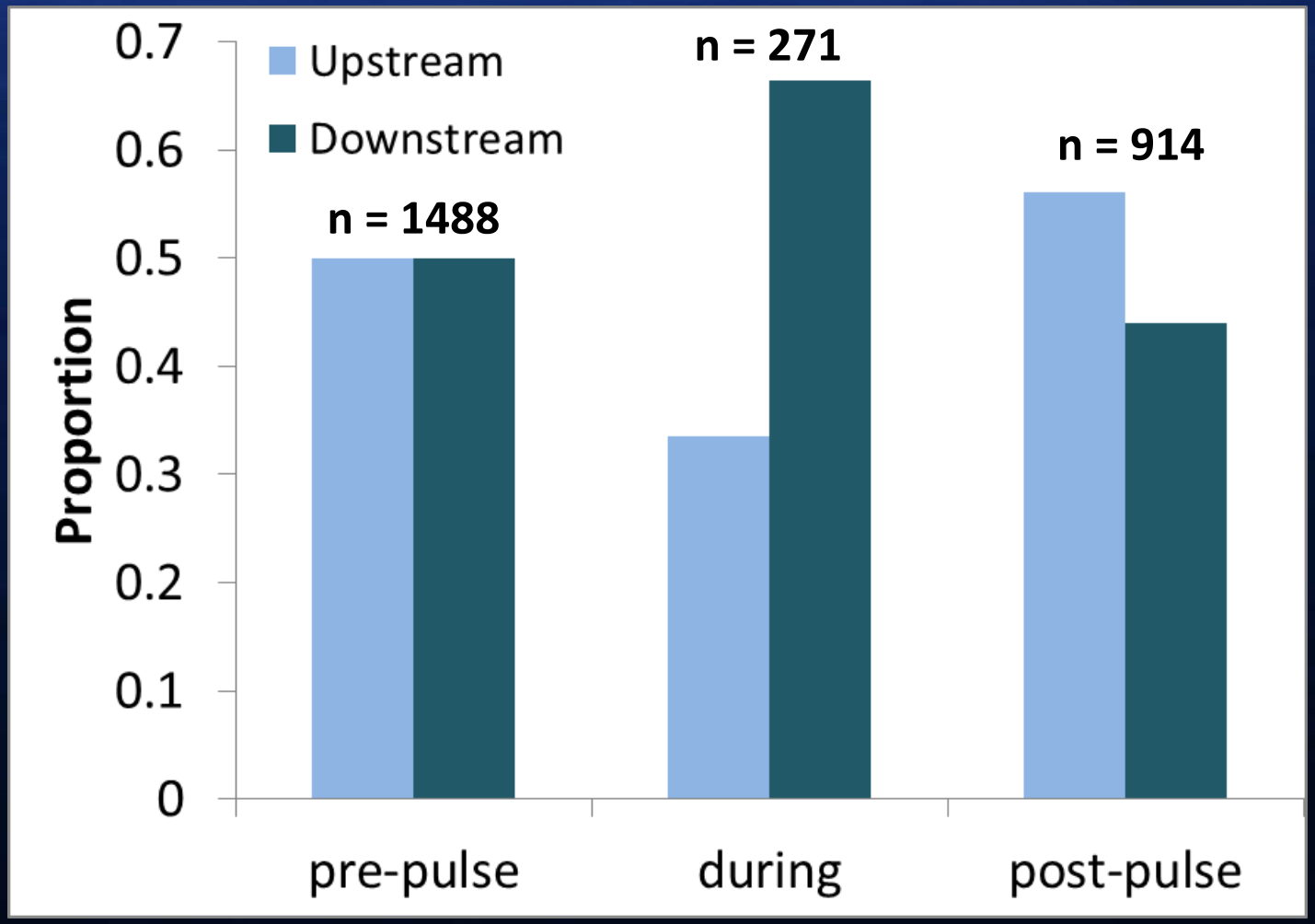


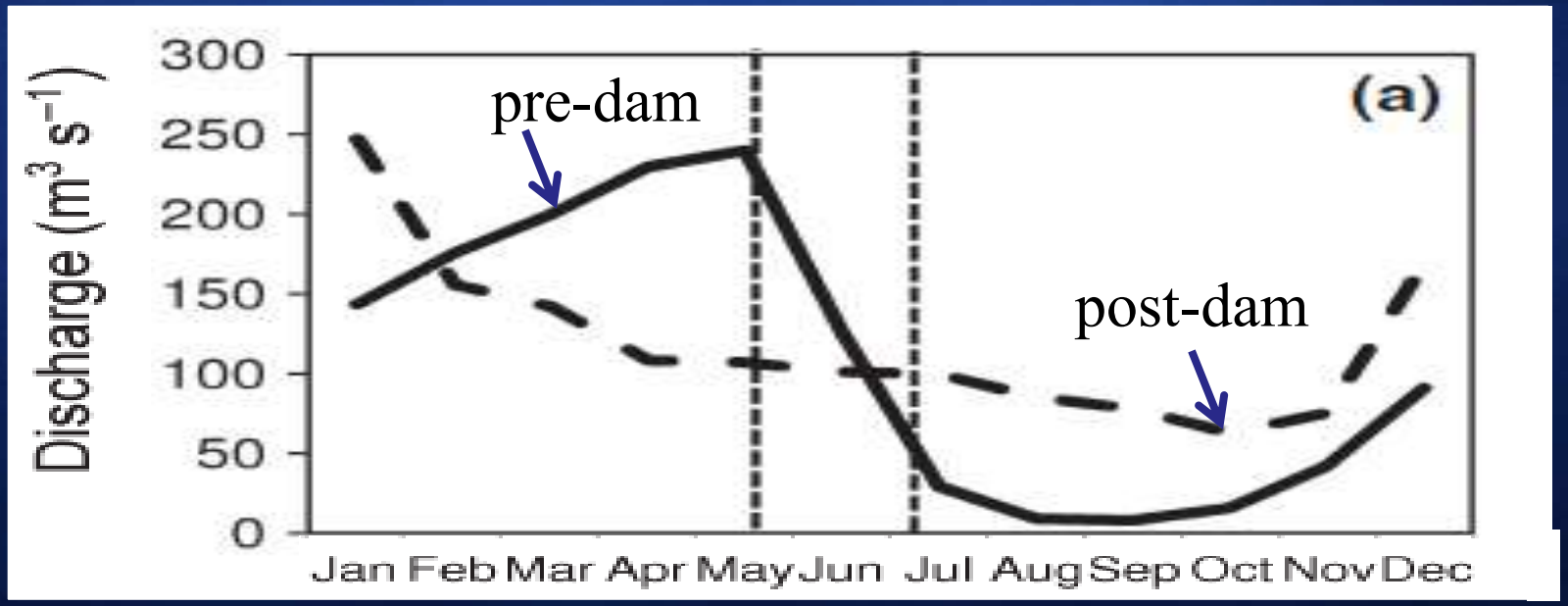
At 500 cfs:

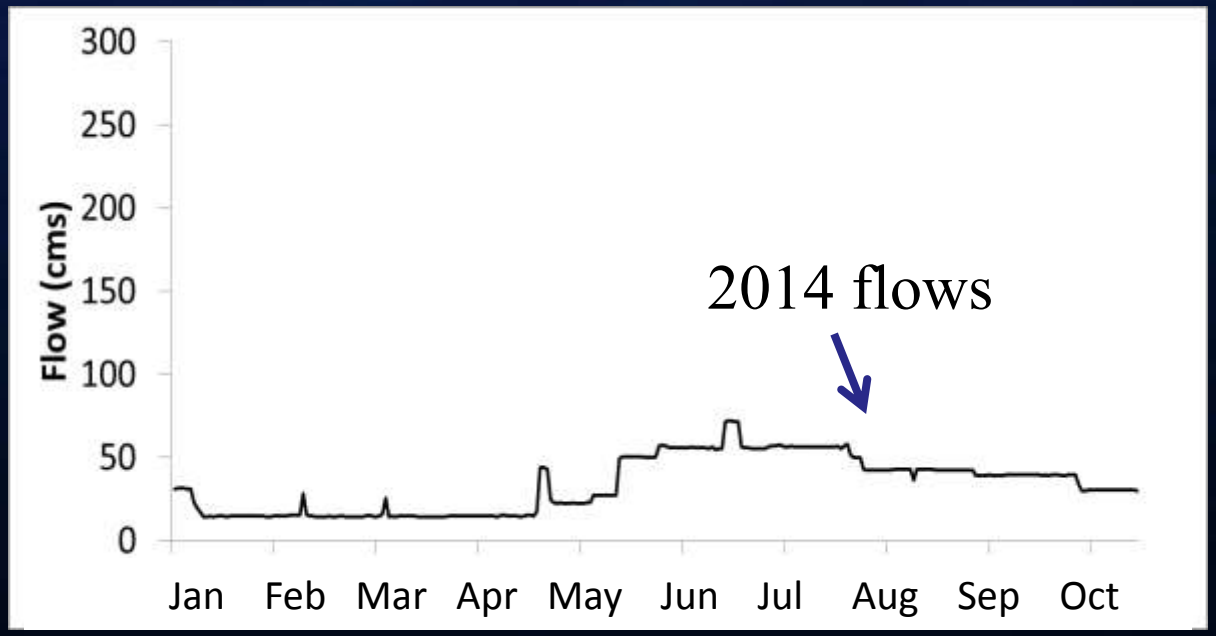



Chinook Salmon abundance
Fish·min-1
450
400
350
300
250
200
150
100
50
0
Pre first pulse
During first pulse
Post first pulse

Juvenile movement







From Zeug et al. 2011

Take-home points

- Redd dewatering most severe when flows drop below 600 cfs, with 11% of redds dewatered when flows reached 500 cfs
- More redds dewatered in restored reaches
- Intergravel water quality declines over time under low stream flows, both in main channel and partially dewatered redds
- Low flow conditions result in low-functioning rearing habitat, lower prey productivity, and stranding
- Flow pulses may be effective in moving fish out of stranding pools into the main channel, but short-term pulses are not expected to improve intergravel water quality

Acknowledgements

- Bureau of Reclamation
  - Jessica Andrieux, John Hannon
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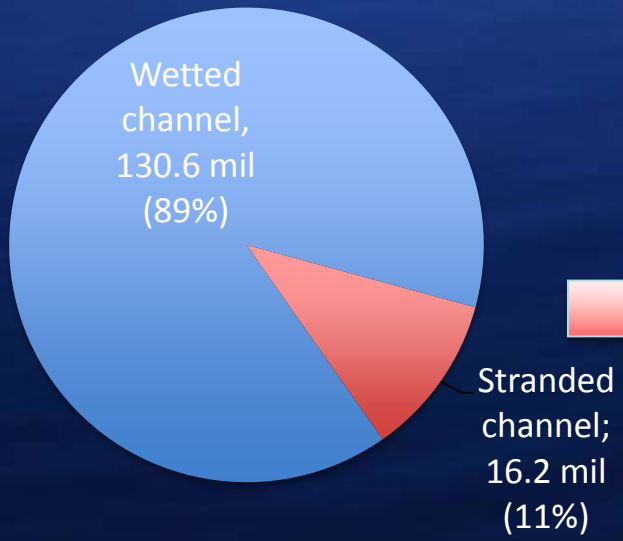
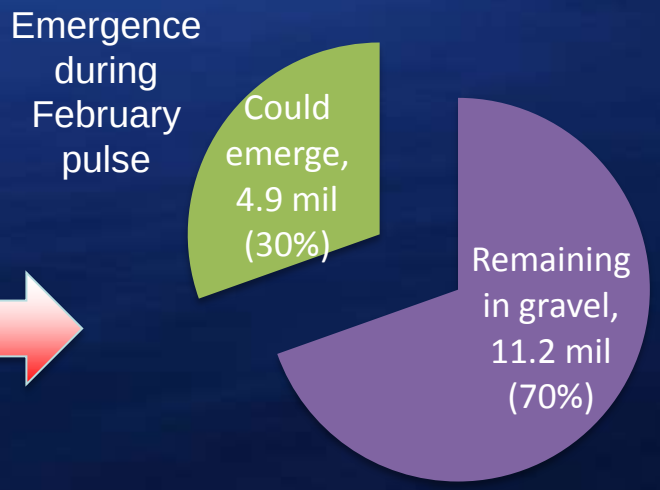
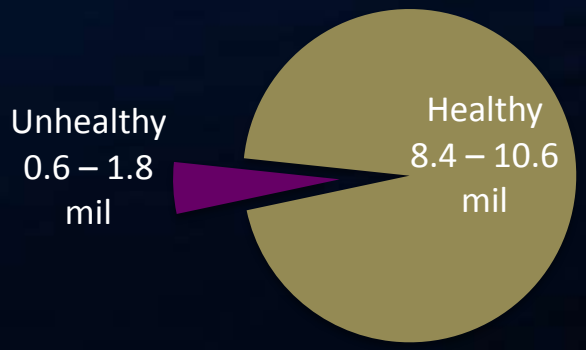
146.8 million Chinook salmon embryos available in 2013/14



16.2 million Originally Stranded



11.2 million remain stranded after February 7-9 pulse