8th Spring-run Chinook Symposium

July 26-28, 2016 in Chico, CA

Overview

- Sponsors:
  - PG&E
  - Northern California Water Association
  - Friends of Butte Creek
  - California Conservation Corps

The year's Symposium will highlight regional status reports on Spring-run Chinook populations, instream flow studies and fish passage assessments, water conservation and transactions, and how to translate research and genetics into implementation and recovery actions.

Field tours will include visits to the legendary spawning grounds in Upper Butte Creek and PG&E's hydroelectric retrofit projects; salmon and steelhead fish passage in Lower, Deer, Mill and Antelope Creek that have been prioritized for instream flow enhancement and fish passage projects; a Clear Creek Spring Chinook Restoration tour; and a tour of Lower Butte Creek Water Diversions.

Presentations

Orientation Presentations

(Slide 5) *The Evolutionary Basis of Premature Migration in Pacific Salmon Provides Insights into Conservation and Restoration,* Michael Miller, Ph.D., UC Davis

(Slide 40) *Closing the Loop: Floodplains and Full Life History Management of Spring-run Chinook,* Jacob Katz, Ph.D., Cal Trout

The Evolutionary Basis of Premature Migration in Pacific Salmon Provides Insights into Conservation and Restoration

Michael Miller

UC DAVIS
DEPARTMENT OF ANIMAL SCIENCE

UC DAVIS
CENTER FOR WATERSHED SCIENCES

1) Background

2) Genetic and evolutionary basis of premature migration

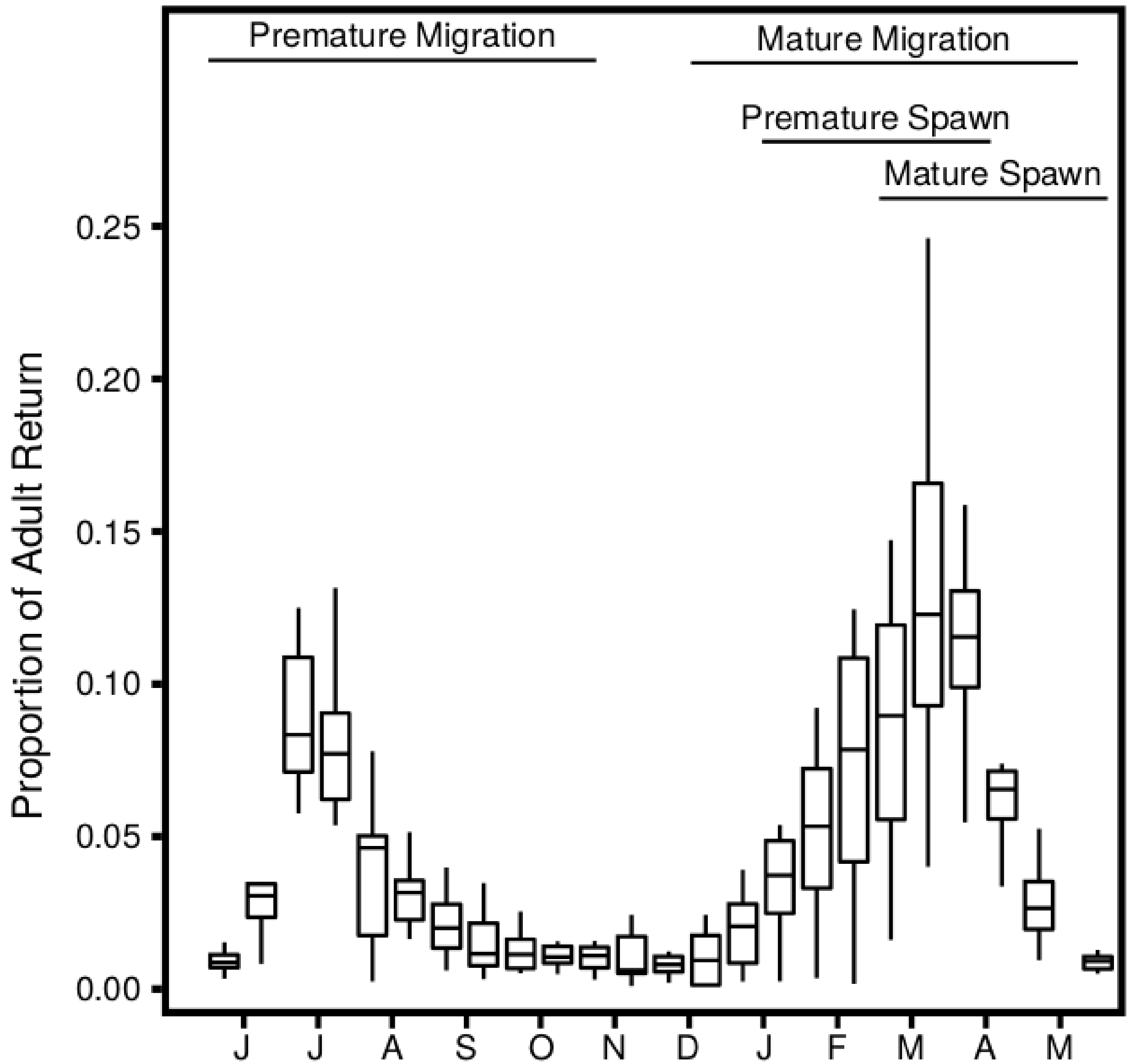
3) Implications for conservation and restoration

1) Background

2) Genetic and evolutionary basis of premature migration

3) Implications for conservation and restoration

Spring Chinook and summer steelhead have evolved a unique life history in response to seasonal variation.



Prince *et al.* bioRxiv

Premature migrating individuals have a dramatically different behavior and physiology.

*Store excess fat to uncouple migration and spawning behavior

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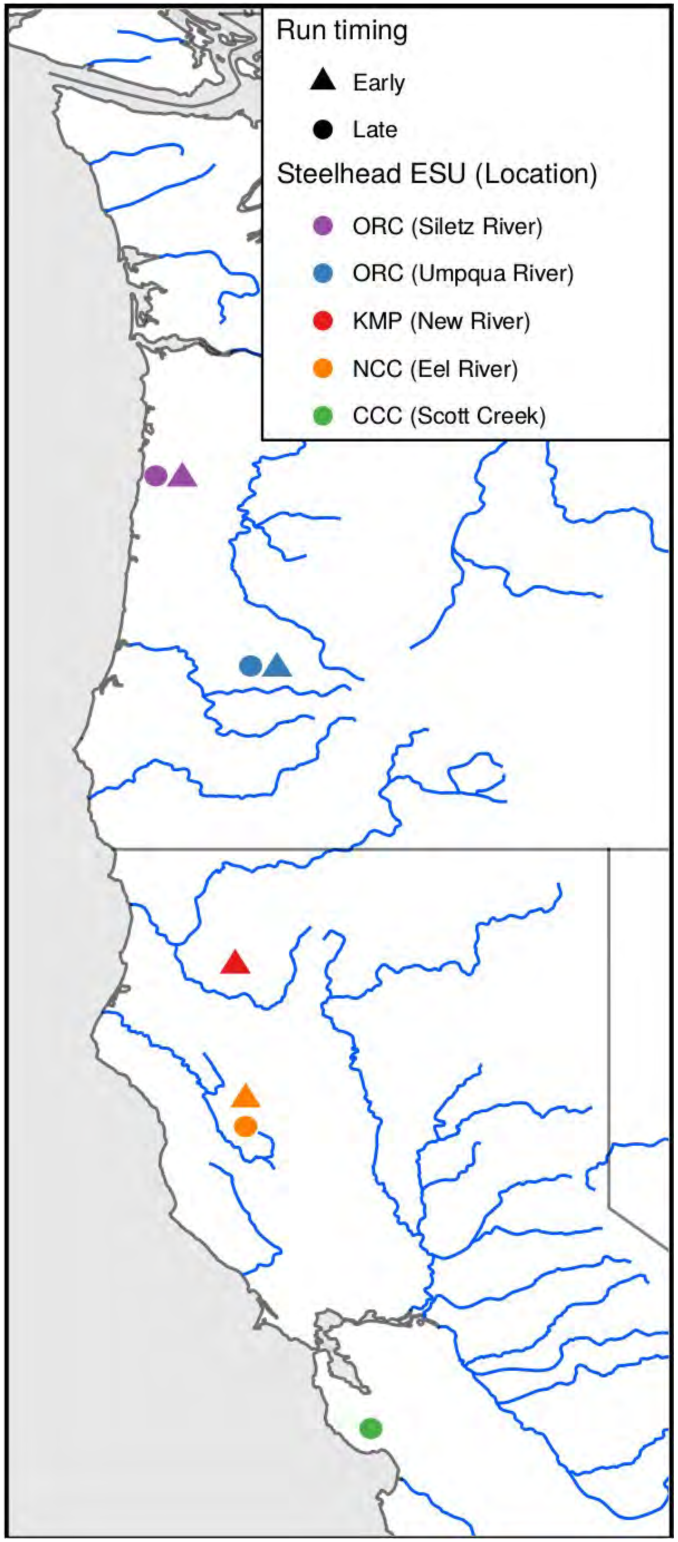
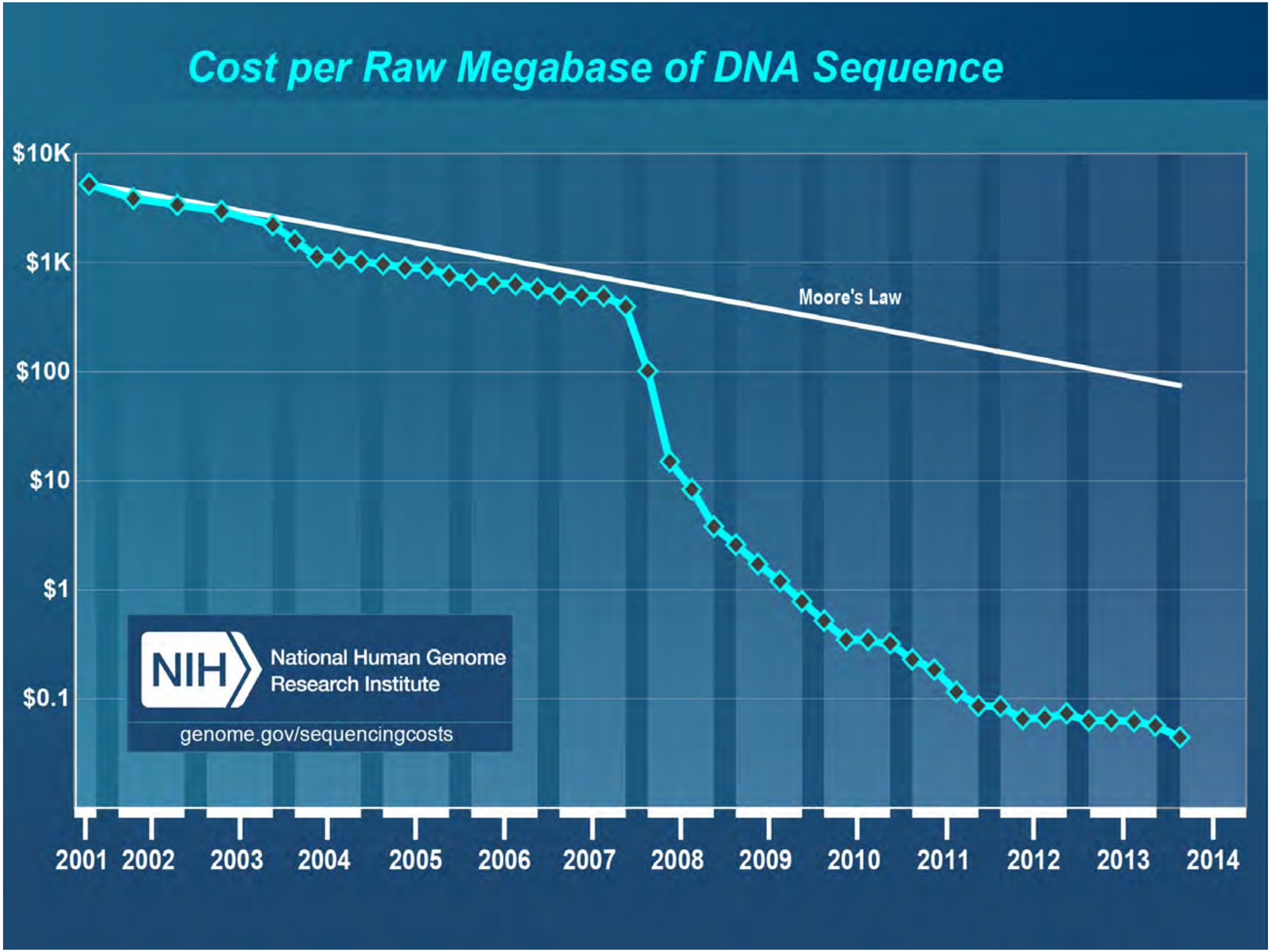
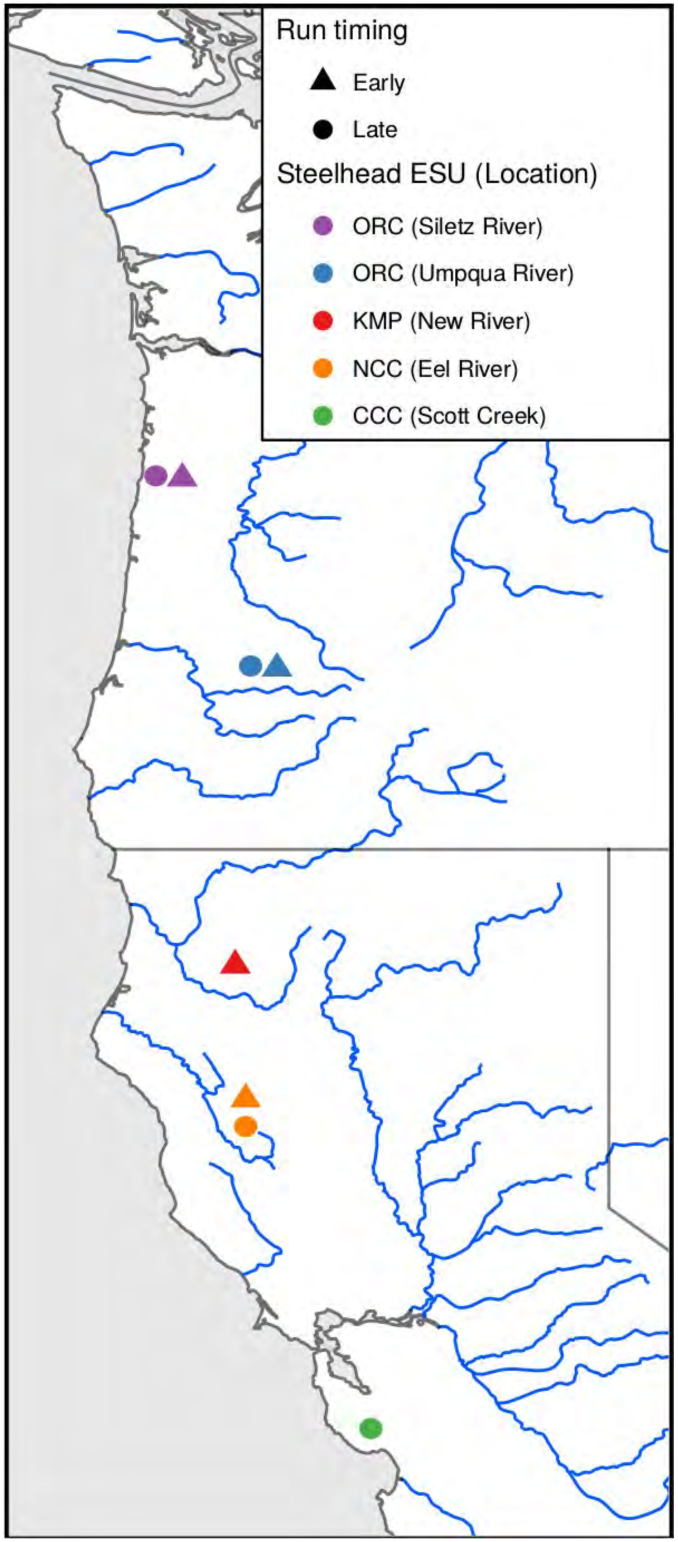
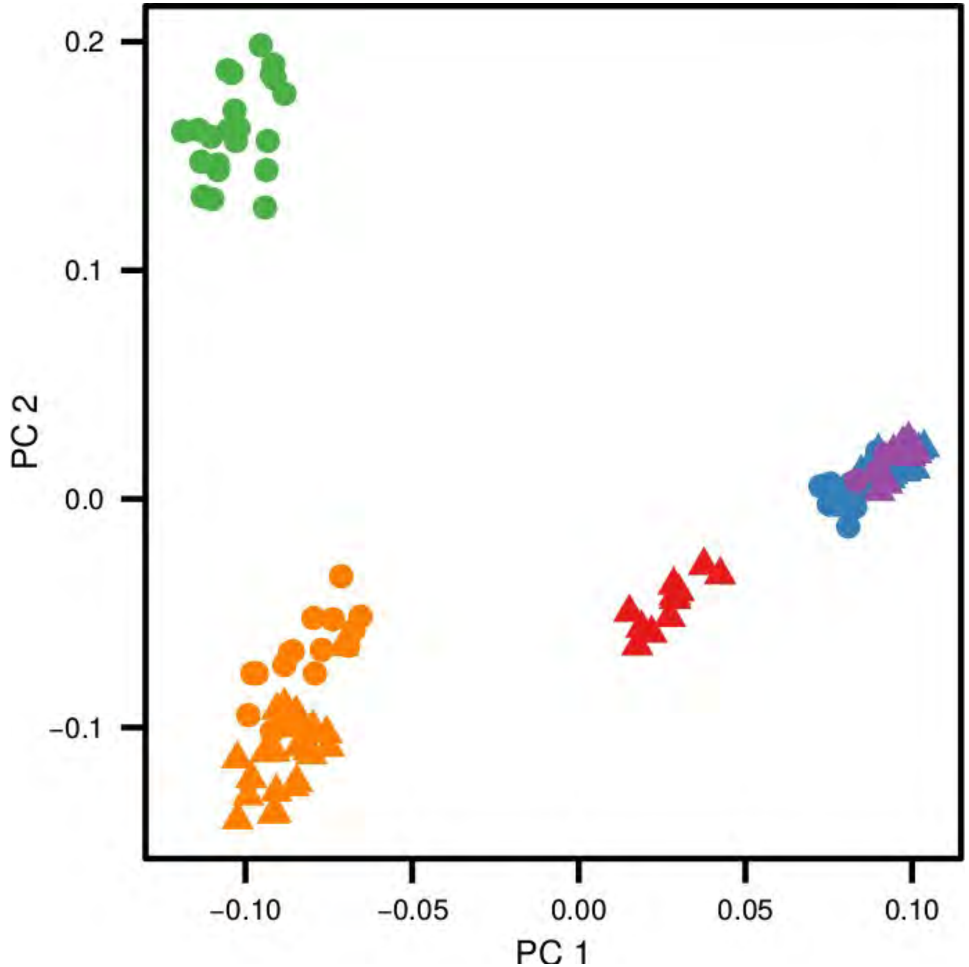

Run timing
Early
Late
Steelhead ESU (Location)
ORC (Siletz River)
ORC (Umpqua River)
KMP (New River)
NCC (Eel River)
CCC (Scott Creek)

Massively parallel sequencing technology makes high resolution genetic analysis fast and cheap.



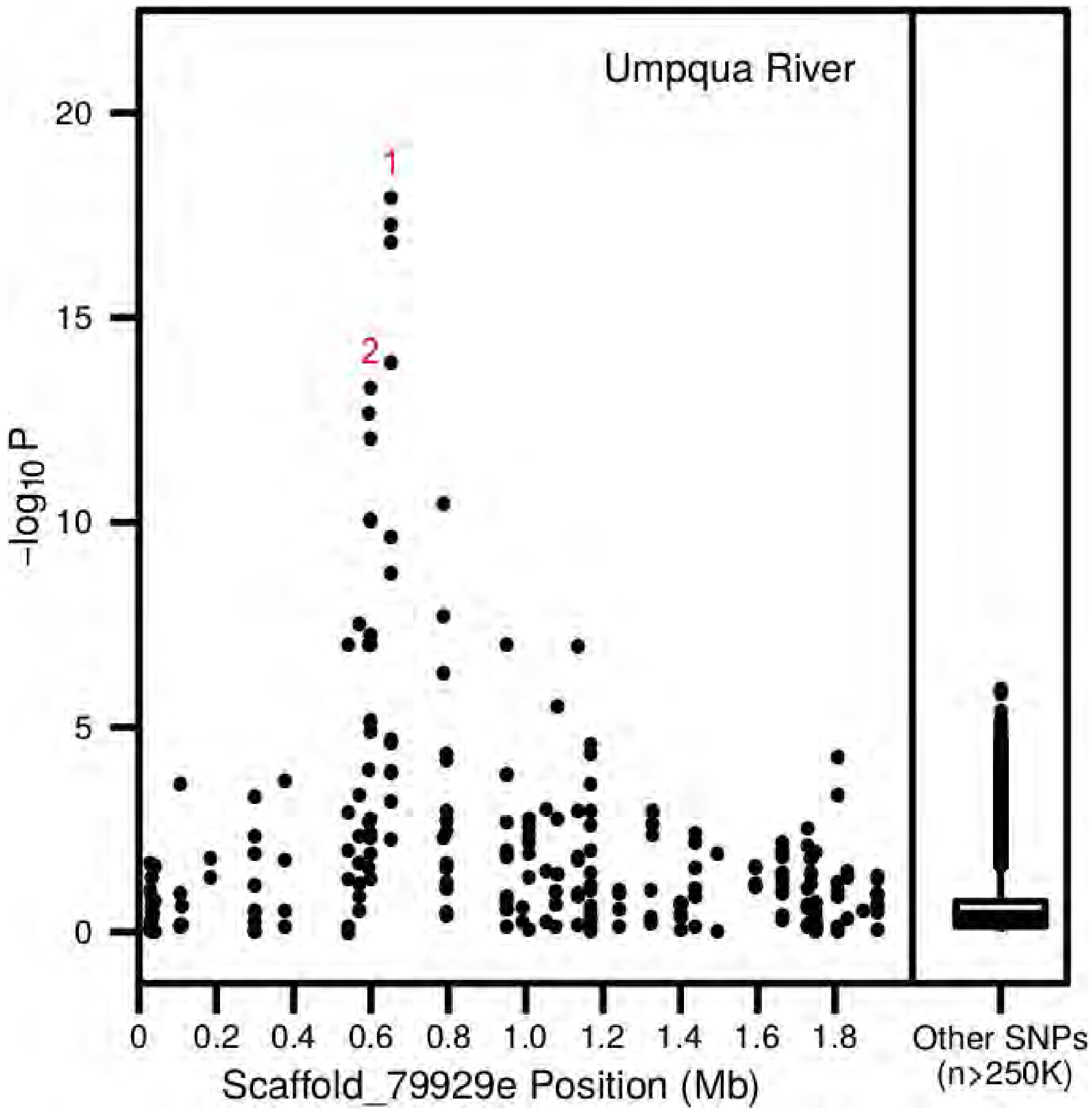
Overall genetic differentiation in steelhead relates to geography as opposed to migration category.





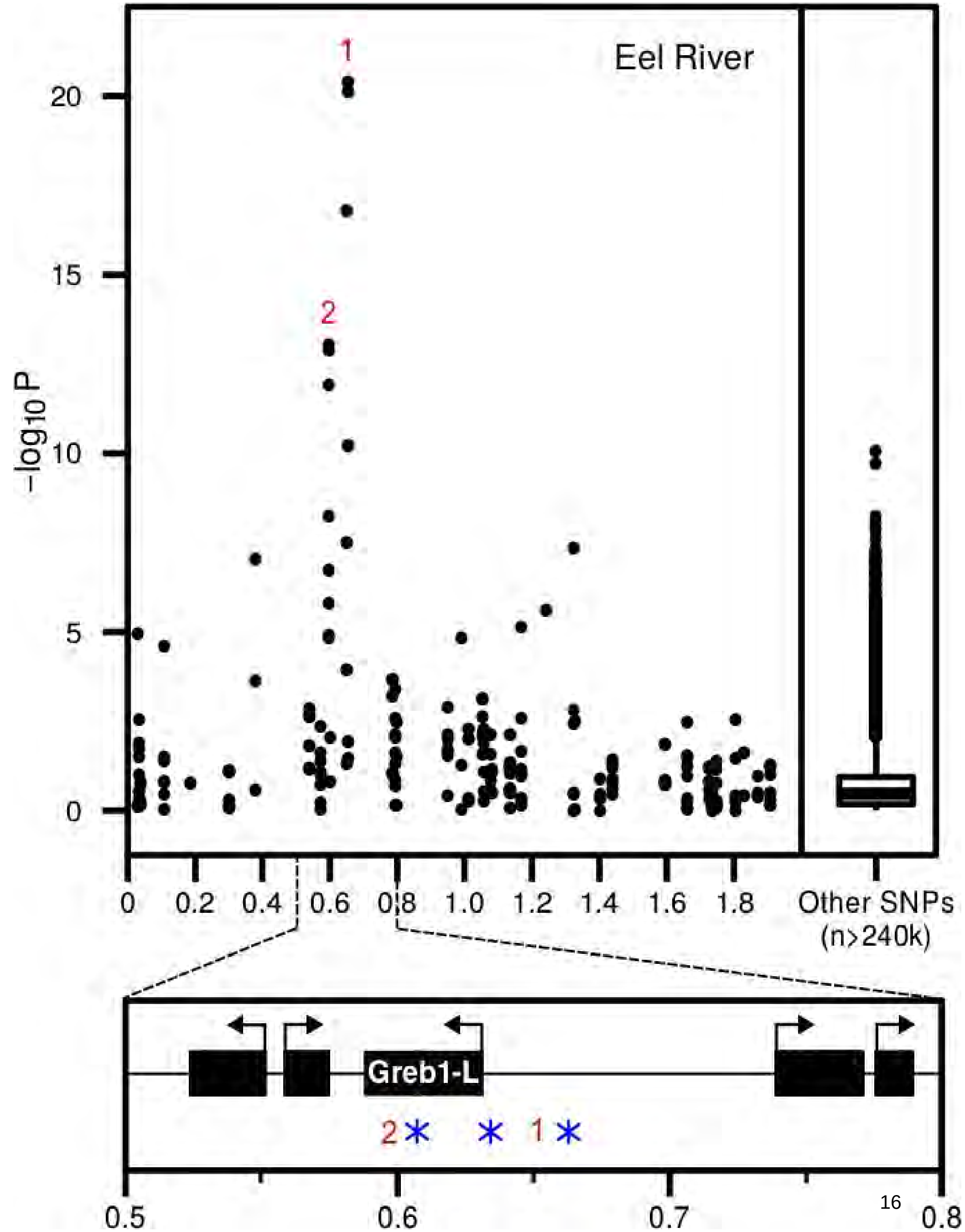
Prince *et al.* bioRxiv

A single genetic locus is associated with premature migration in North Umpqua steelhead.



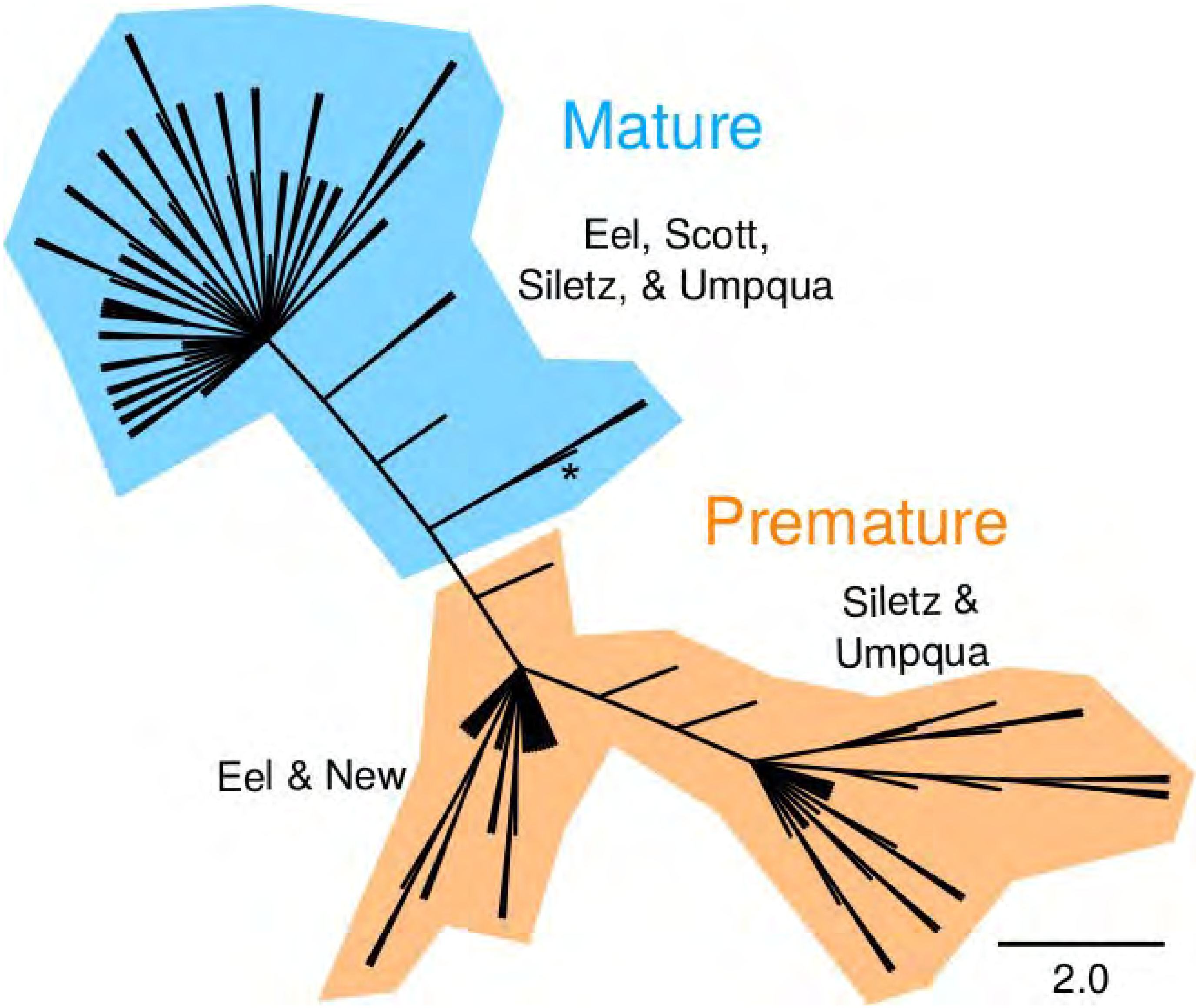
Prince *et al.* bioRxiv

The same locus associated with premature migration in Eel River steelhead.



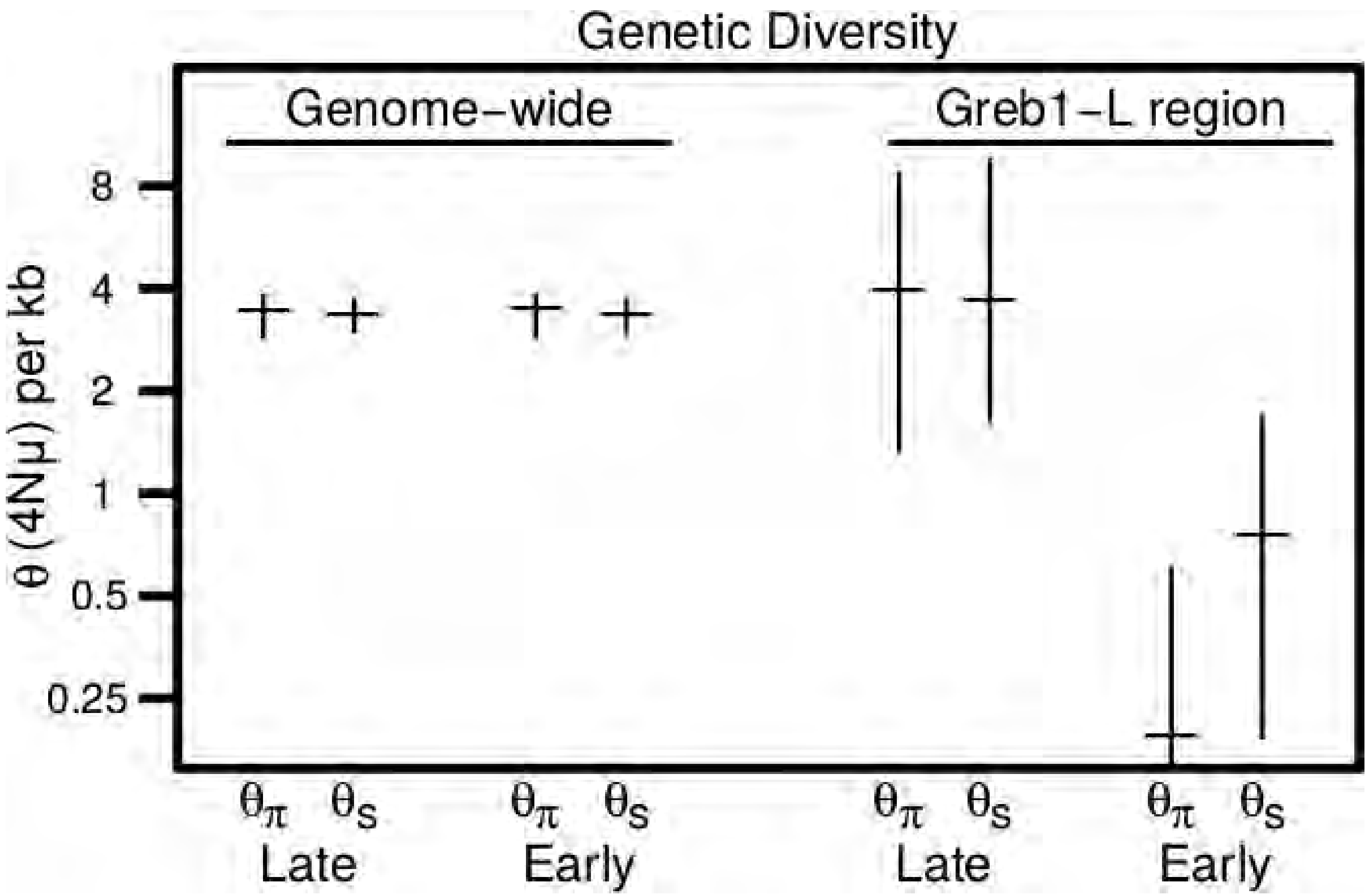
Prince *et al.* bioRxiv

A single ancient genetic evolutionary event is the ultimate source of all premature migrating alleles.



Prince *et al.* bioRxiv

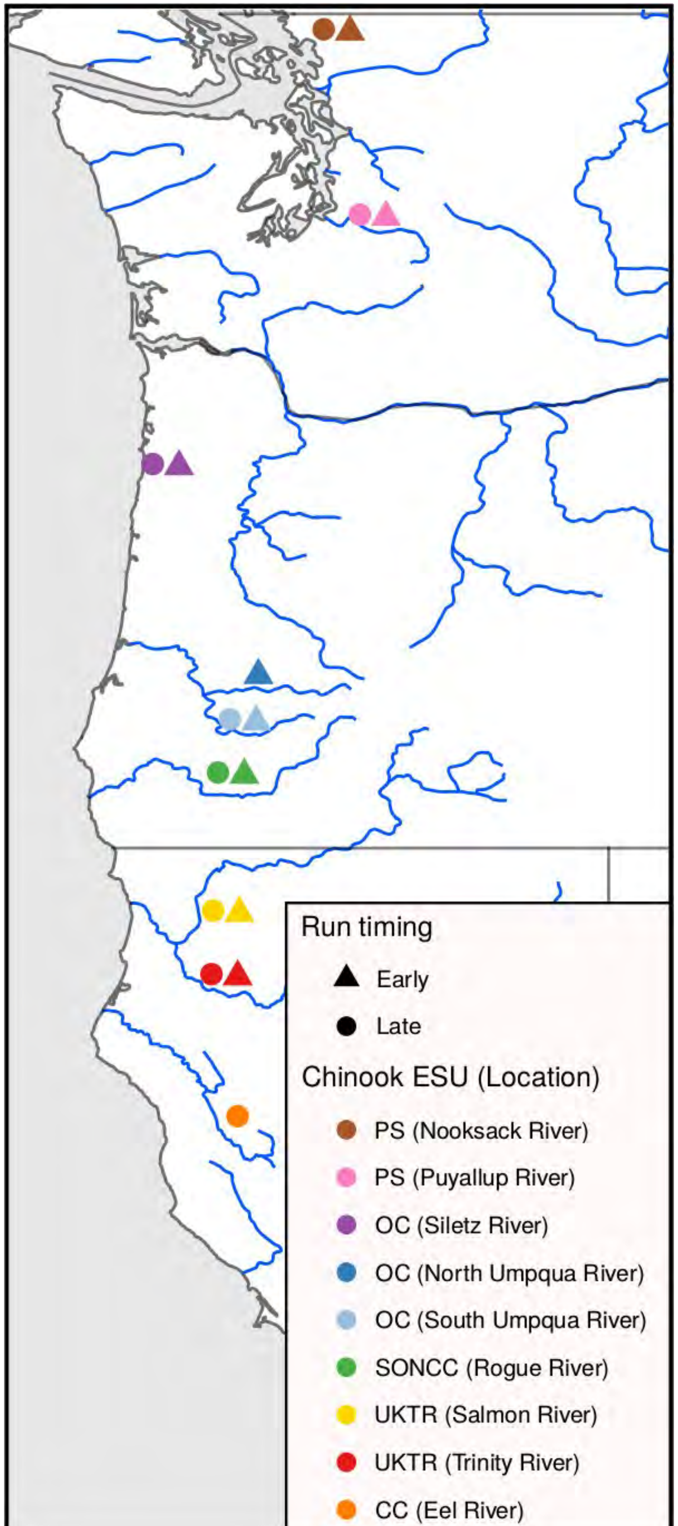
Strong positive selection caused premature migration to spread along the West Coast.

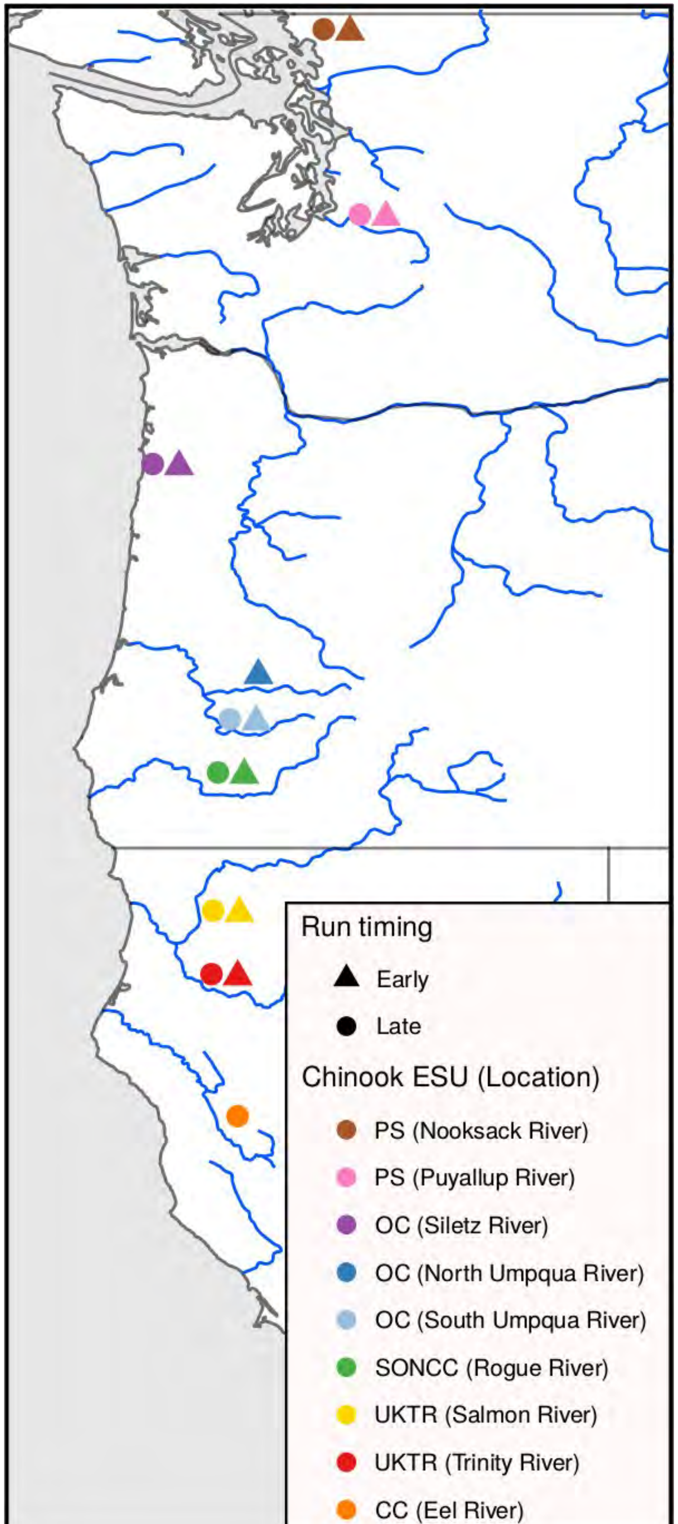


Prince *et al.* bioRxiv

Greb1L is expressed in AgRP neurons which modulate diverse behavior and metabolic processes.

Greb1L expression in mice


Run timing
Early
Late
Chinook ESU (Location)
PS (Nooksack River)
PS (Puyallup River)
OC (Siletz River)
OC (North Umpqua River)
OC (South Umpqua River)
SONCC (Rogue River)
UKTR (Salmon River)
UKTR (Trinity River)
CC (Eel River)



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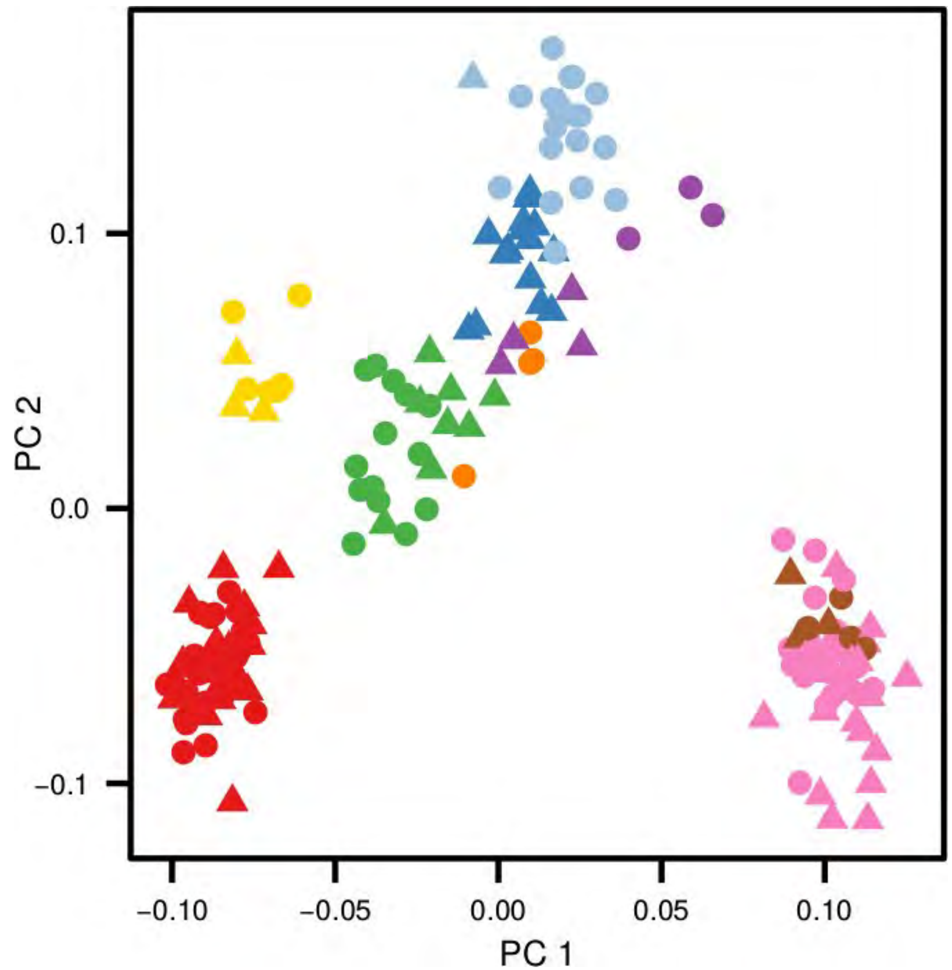
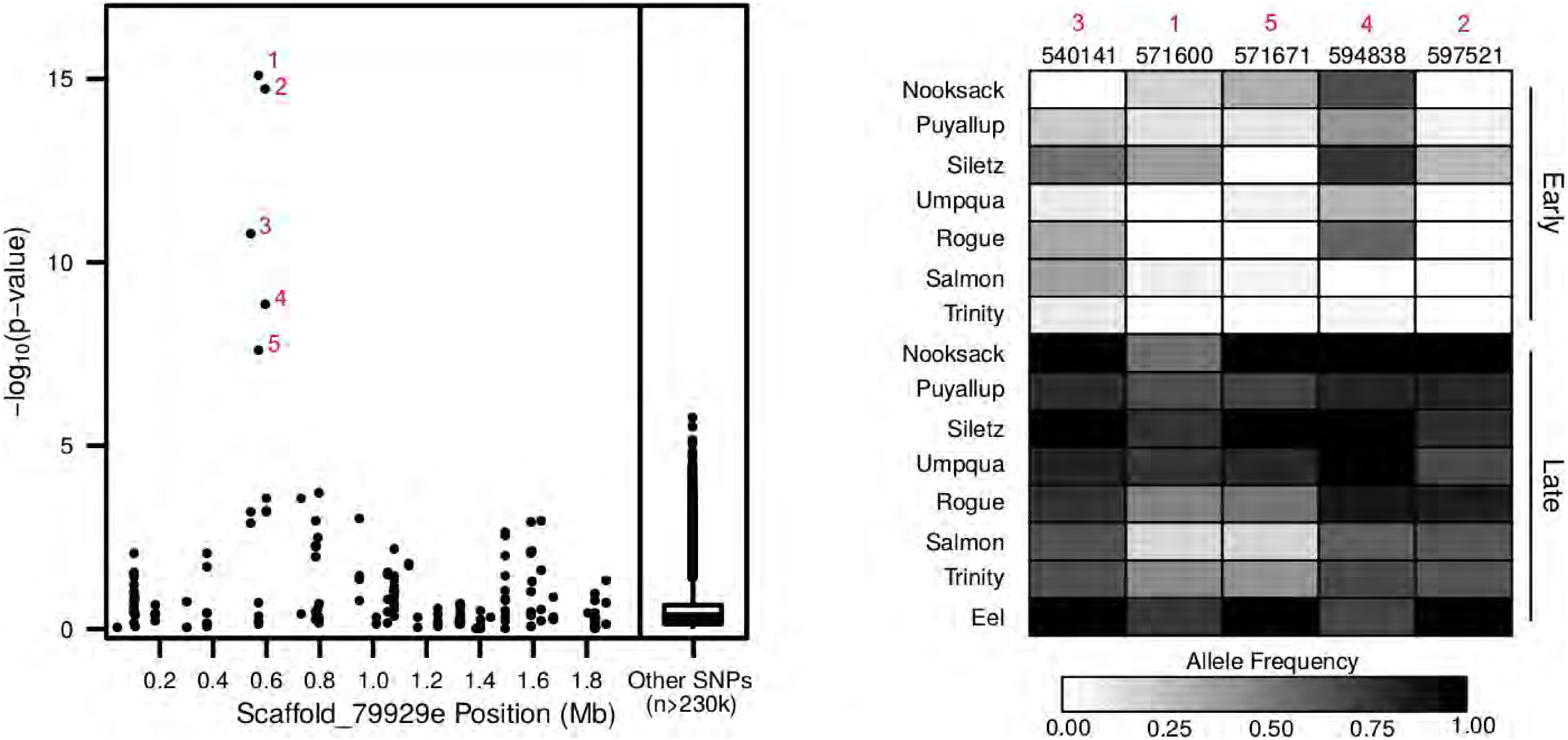


Prince *et al.* bioRxiv

Premature migrating Chinook evolved through the same genetic and evolutionary mechanism.



Prince *et al.* bioRxiv

1) Background

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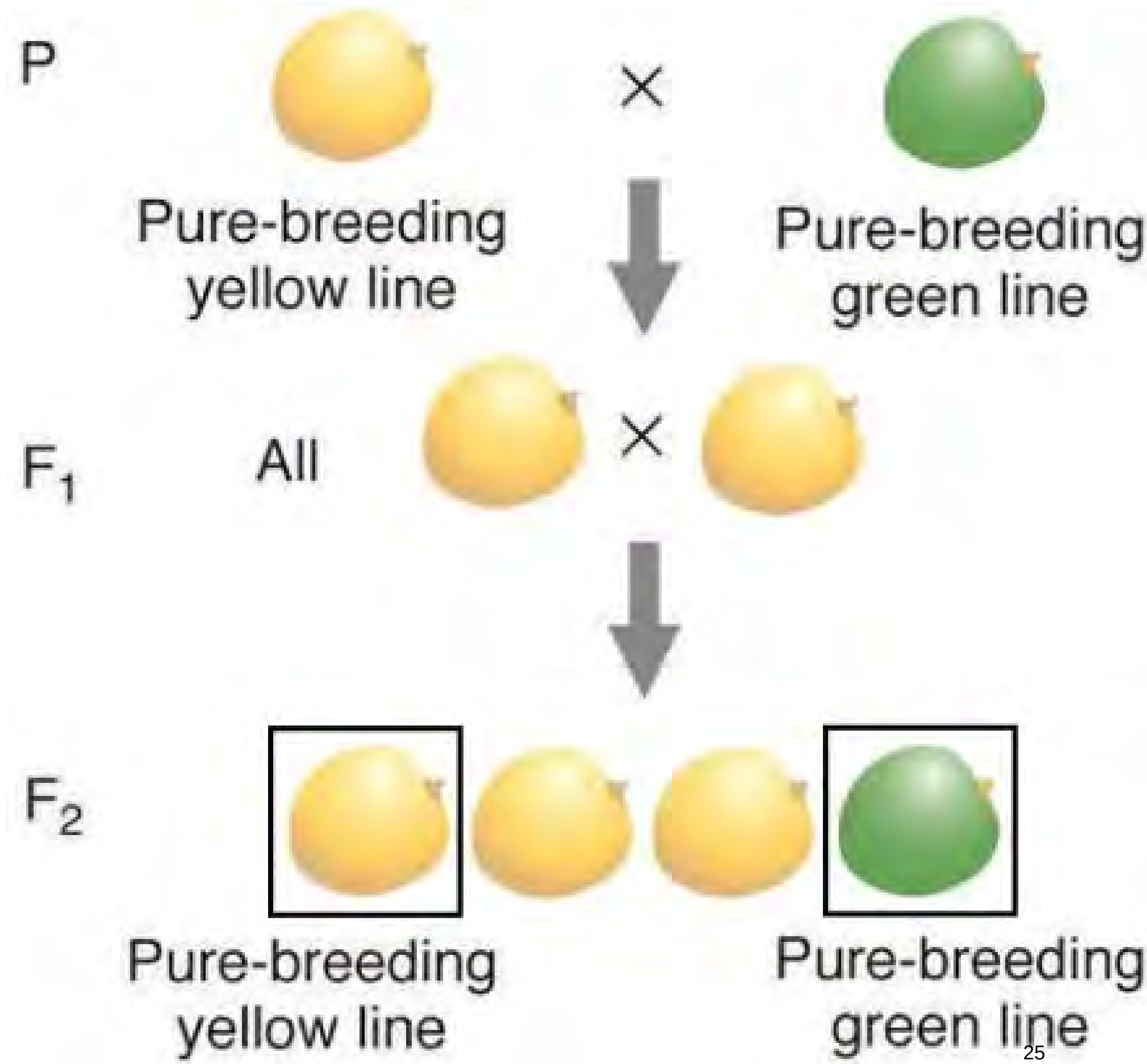
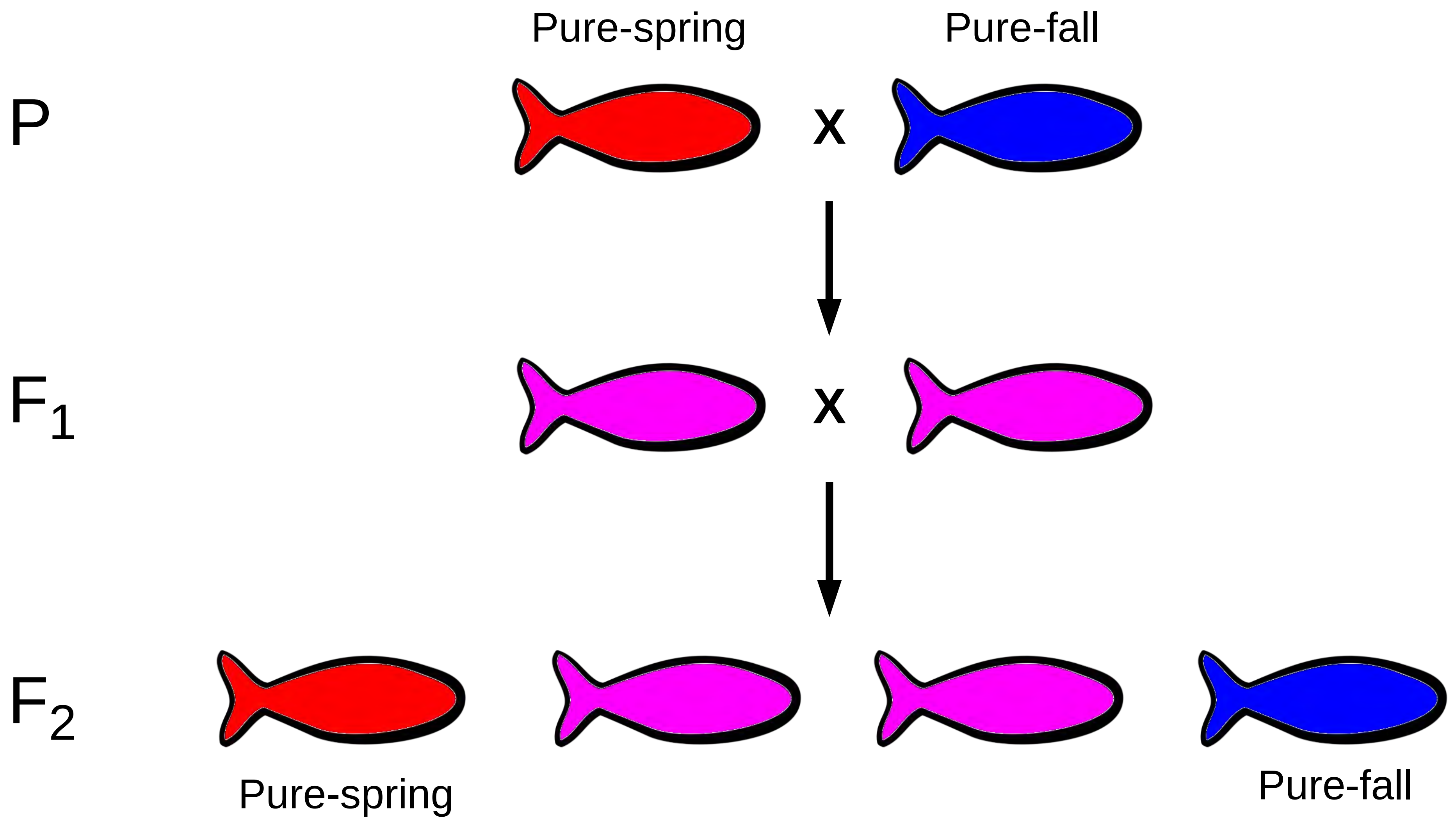
Hybridization between premature and mature migrating populations

Hybridization won't seriously compromise the genetic integrity of most premature and mature migrating populations.



Hybridization won't seriously compromise the genetic integrity of most premature and mature migrating populations.



*Hybridization occurs naturally in some conditions and can have genetic benefits

Do I worry about hybridization between premature and mature migrating populations?

Do I worry about hybridization between premature and mature migrating populations?

Absolutely - for ecological reasons …

Premature migrating individuals have reduced size and fecundity.

	Population	n	L (mm)	W (g)	I_G (%)
Spring Chinook	Clearwater	263	723 (3·3)	7930 (10)	15·5 (0·2)
	Raft	56	695 (6·9)	7230 (21)	19·2 (0·3)
	North Thompson	33	751 (6·3)	8630 (19)	20·1 (0·6)
	Finn Creek	119	710 (4·3)	7810 (15)	17·7 (0·3)
Fall Chinook	Quinsam	60	785 (7·5)	10 010 (32)	23·5 (0·6)
	Nitinat	60	770 (5·1)	9530 (27)	21·8 (0·4)
	Conuma	28	809 (7·9)	10 540 (33)	27·8 (1·0)
	Big Qualicum	70	716 (8·5)	6850 (28)	25·2 (0·6)
	Robertson	75	761 (6·9)	8620 (25)	24·9 (0·3)

*I_G = Gonosomatic index

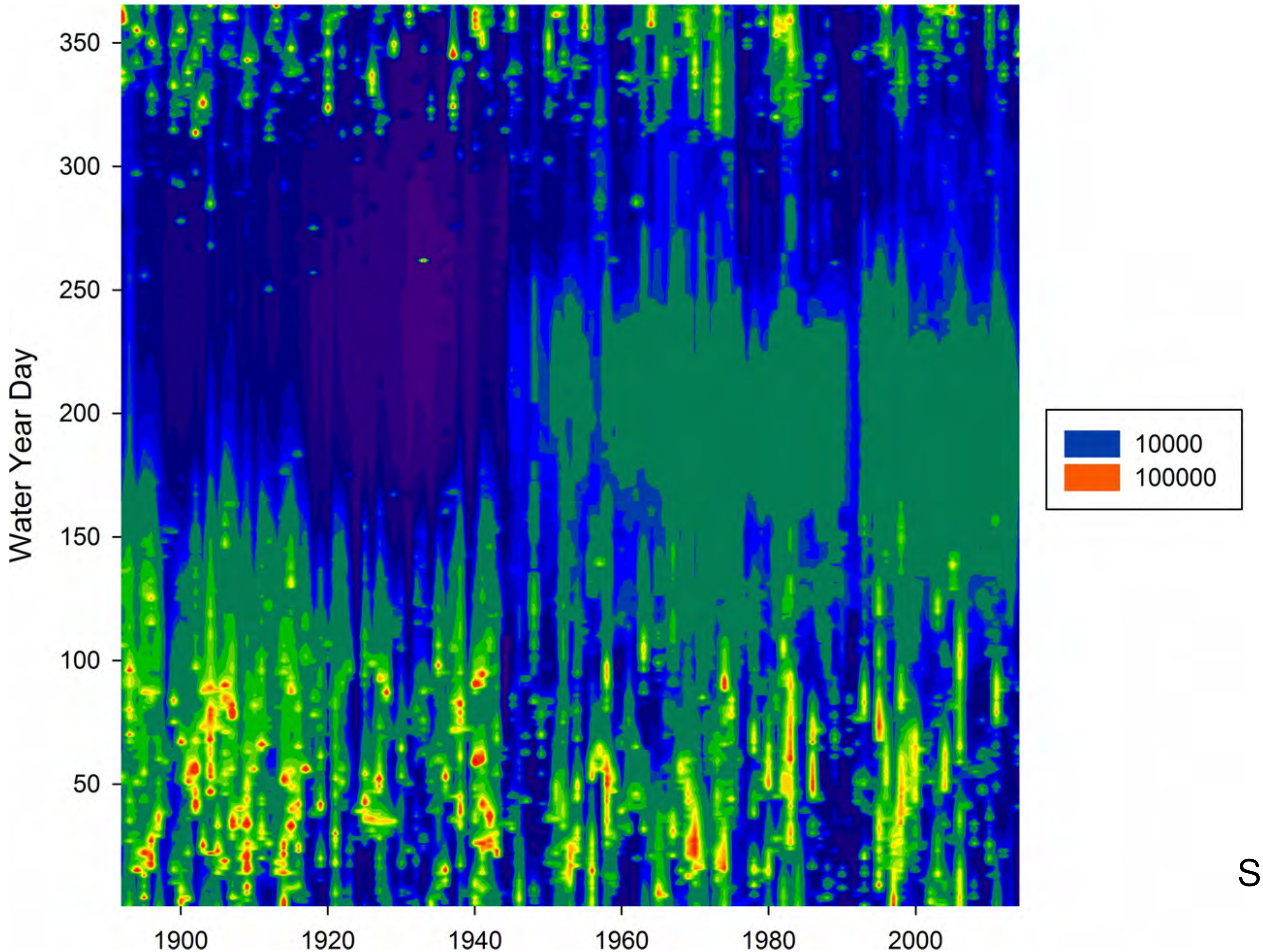
Healey 2001

Premature migrating individuals utilize temporal and spatial habitat that is difficult for mature migrating individuals to access under natural conditions.

> "If headwater streams are highly suitable for breeding and juvenile rearing but access is limited by some physical factor such as temperature or flow, such that adults could not ascend shortly before spawning, they may enter early, and pay an energetic cost in terms of egg size to account for the metabolic demand from a summer of fasting (Healey 2001). In addition to the energetic cost of fasting, the fish also lost foraging opportunities at sea, and thus are smaller than they would be, had they spent the extra months at sea and returned later."

Quinn *et al.* 2016

The advantage of premature migration has been lost in many locations due to artificial conditions.



Sacramento River
Carson Jeffres

Management actions could be taken to restore the advantage of premature migration.

1) Improve access to habitat which is not accessible to mature migrating individuals

2) Create more natural flow regimes – lower summer flows

3) Segregation weirs – not simply to prevent hybridization – must restore advantage of premature migration

Appropriate source populations for premature reintroduction

Previous work suggested premature migration evolved independently in many different locations and is evolutionarily plastic.

"These results suggest that the different times of return may have evolved independently in the different river systems."

Thorgaard 1983

"These results indicate that run-timing diversity has developed independently by a process of parallel evolution in many different coastal areas."

Waples *et al.* 2004

Previous work suggested premature migration evolved independently in many different locations and is evolutionarily plastic.

> "At least some patterns of Chinook salmon life-history diversity appear to be evolutionarily replaceable, perhaps over time frames of a century or so. The evidence for repeated parallel evolution of run timing in Chinook salmon indicates that such a process is likely … "

Waples *et al.* 2004

Premature migration cannot be expected to evolve from mature migrating source populations.

"Our results demonstrate that the evolution was not independent in each location but instead relied on pre-existing genetic variation, and thus, suggest that the widespread extirpation and decline of premature migrating populations has greatly diminished the potential restoration and expansion of premature migration across at least a substantial proportion of the range for both species."

Prince *et al.* bioRxiv

Source populations for premature reintroduction must contain the appropriate pre-existing genetic variation.

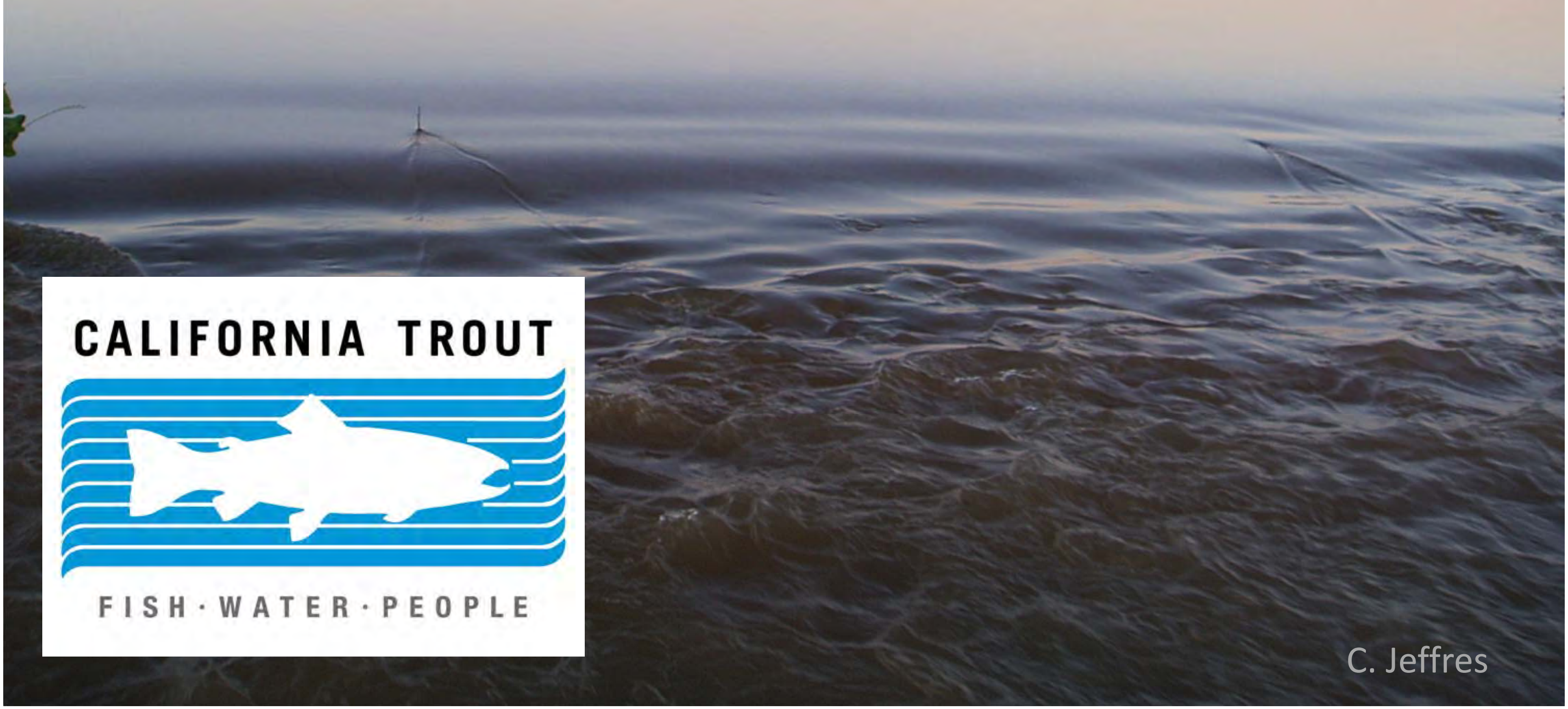
*Existing premature migrating populations must be a very high conservation priority

Daniel J. Prince[1], Sean M. O'Rourke[1], Tasha Thompson[1], Omar A. Ali[1], Martha Arciniega[2,3], Hannah S. Lyman[1], Ismail K. Saglam[1,4], Anthony J. Clemento[2,3], Thomas J. Hotaling[5], Andrew P. Kinziger[6], Adrian P. Spidle[7], J. Carlos Garza[2,3], Devon E. Pearse[2,3], Michael R. Miller[1,8]

[1]Department of Animal Science, University of California, Davis
[2]Fisheries Ecology Division, Southwest Fisheries Science Center, National Marine Fisheries Service
[3]Institute of Marine Sciences, University of California, Santa Cruz
[4]Ecological Sciences Research Laboratories, Department of Biology, Hacettepe University
[5]Salmon River Restoration Council
[6]Department of Fisheries Biology, Humboldt State University
[7]Northwest Indian Fisheries Commission
[8]Center for Watershed Sciences, University of California, Davis

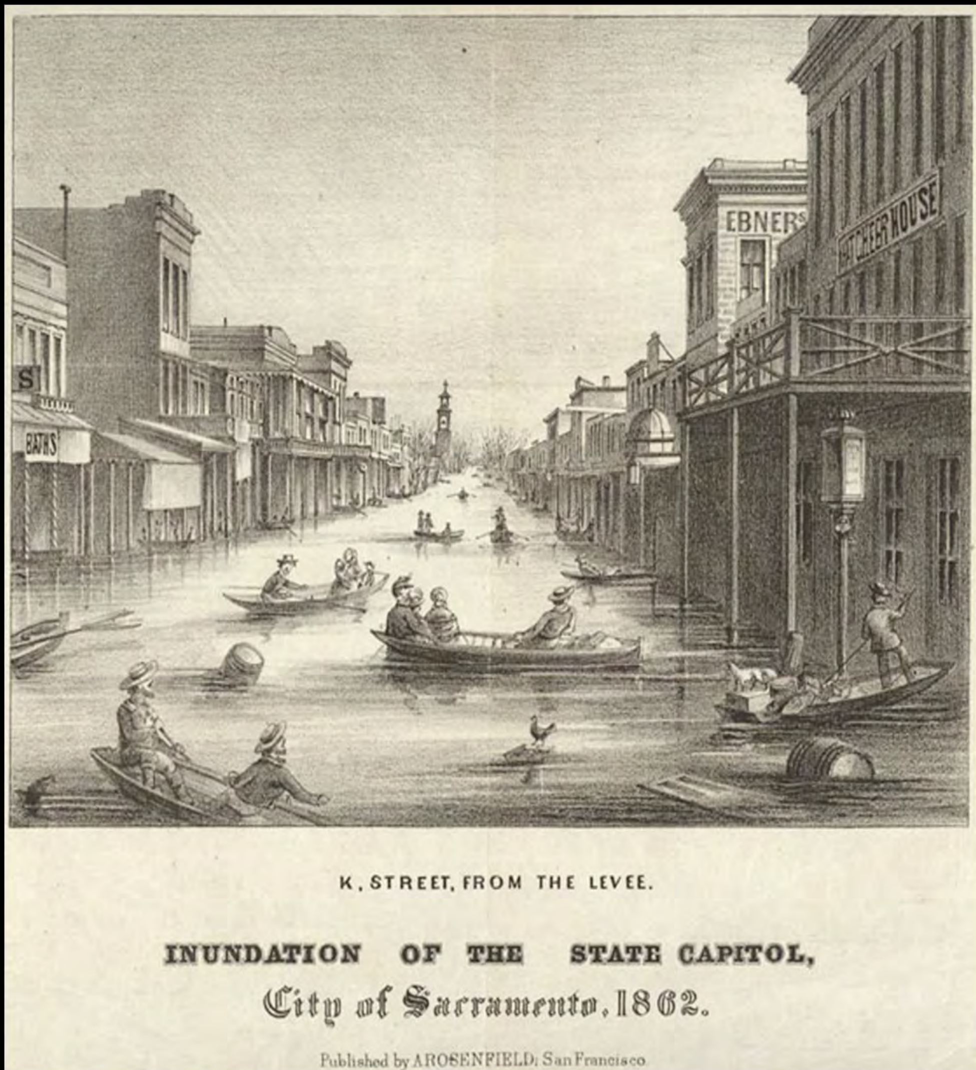
Closing the Loop:
Floodplains and Full Life History Management of Chinook Salmon

Jacob Katz – California Trout



C. Jeffres

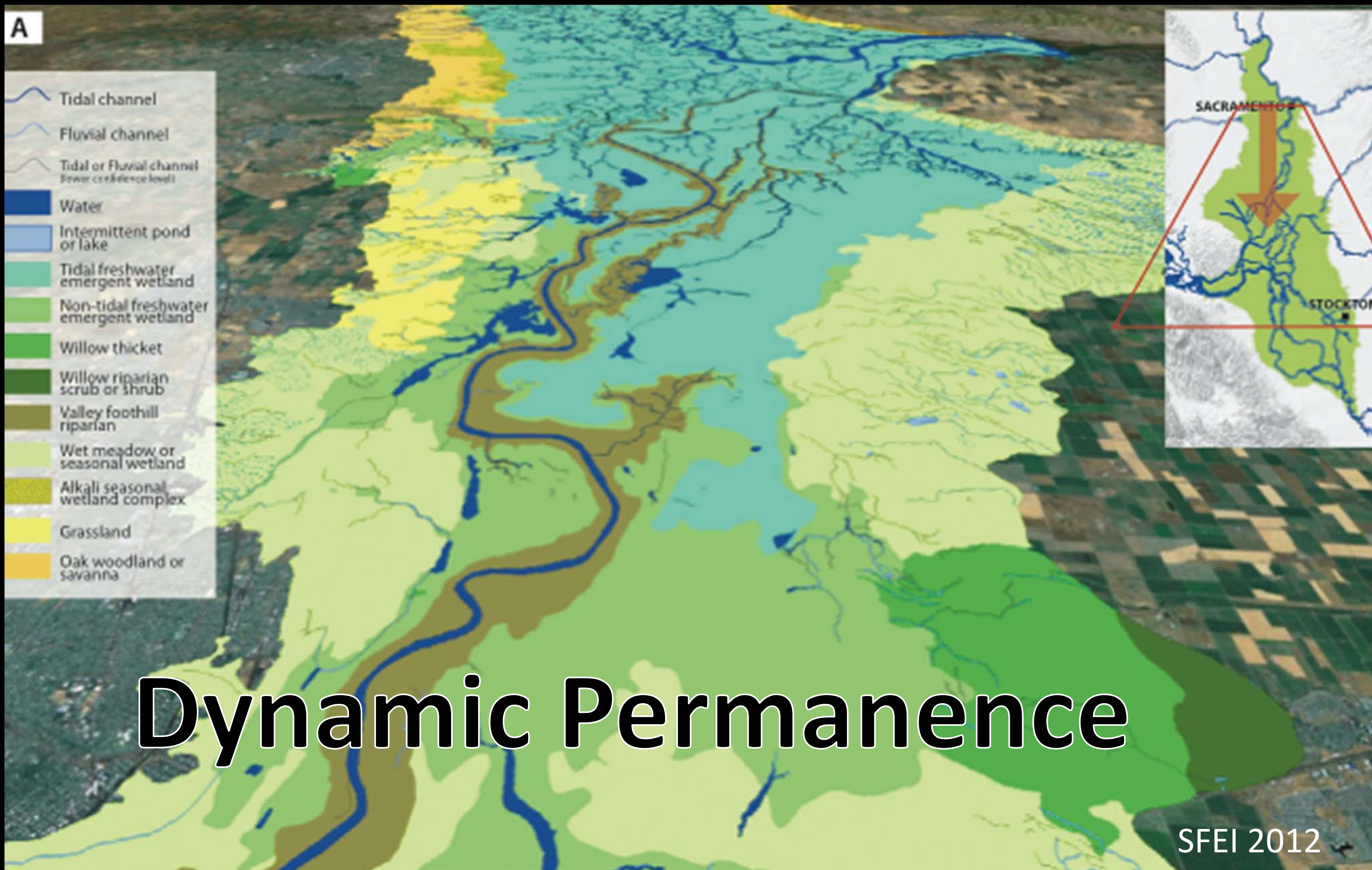
Inland Sea

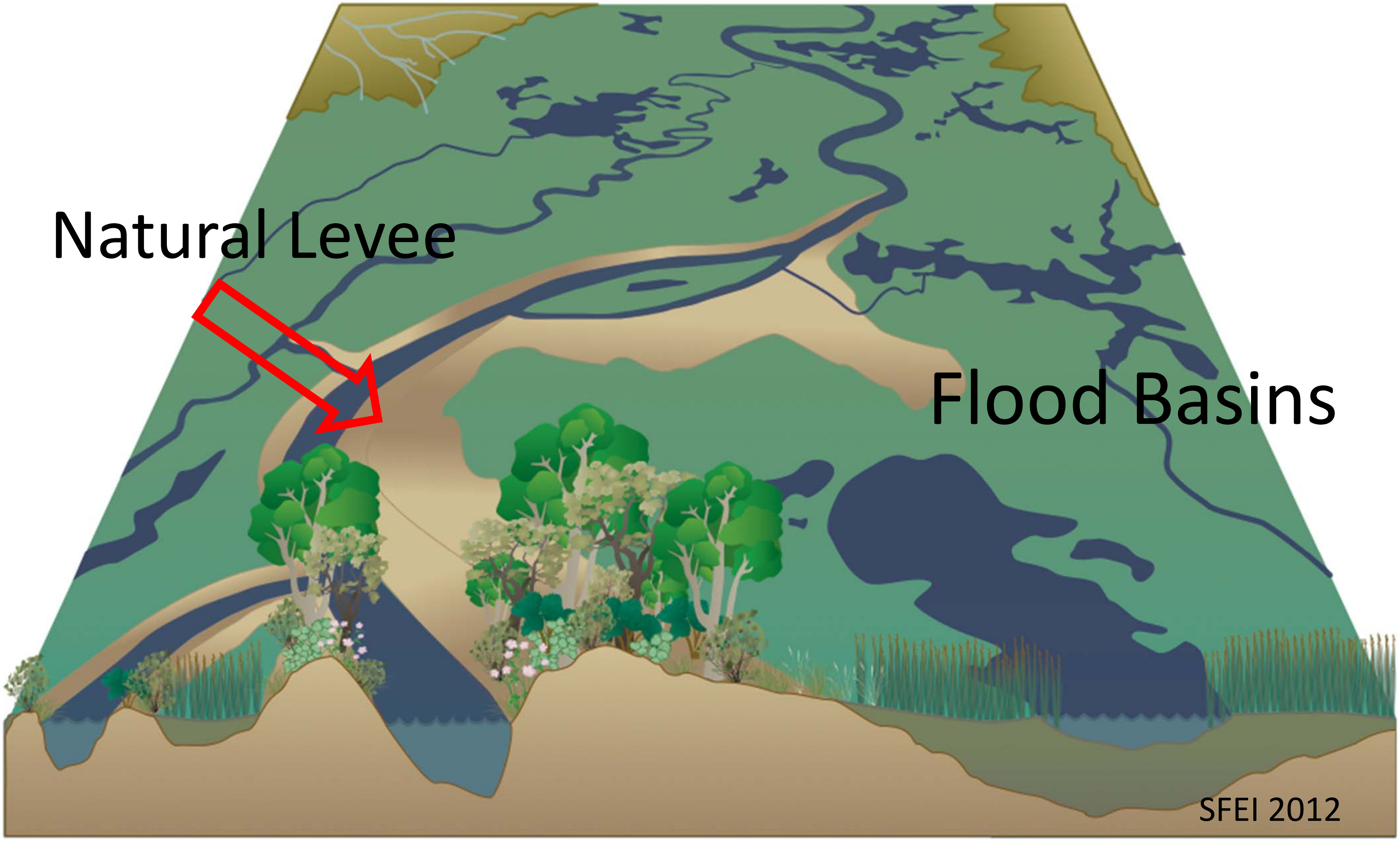


J street

Flood of 1862

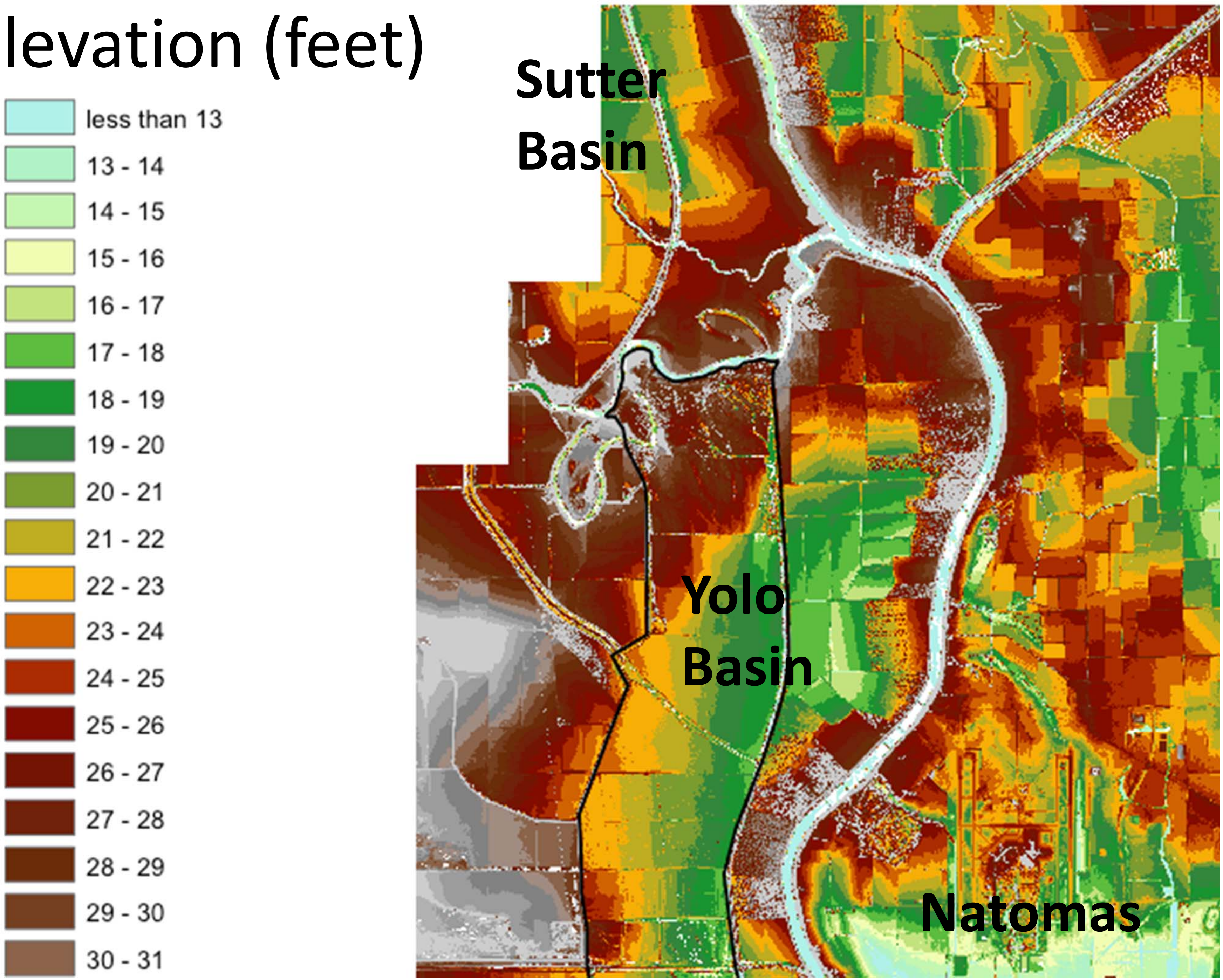
A Shifting Mosaic of Wetland Habitat Types



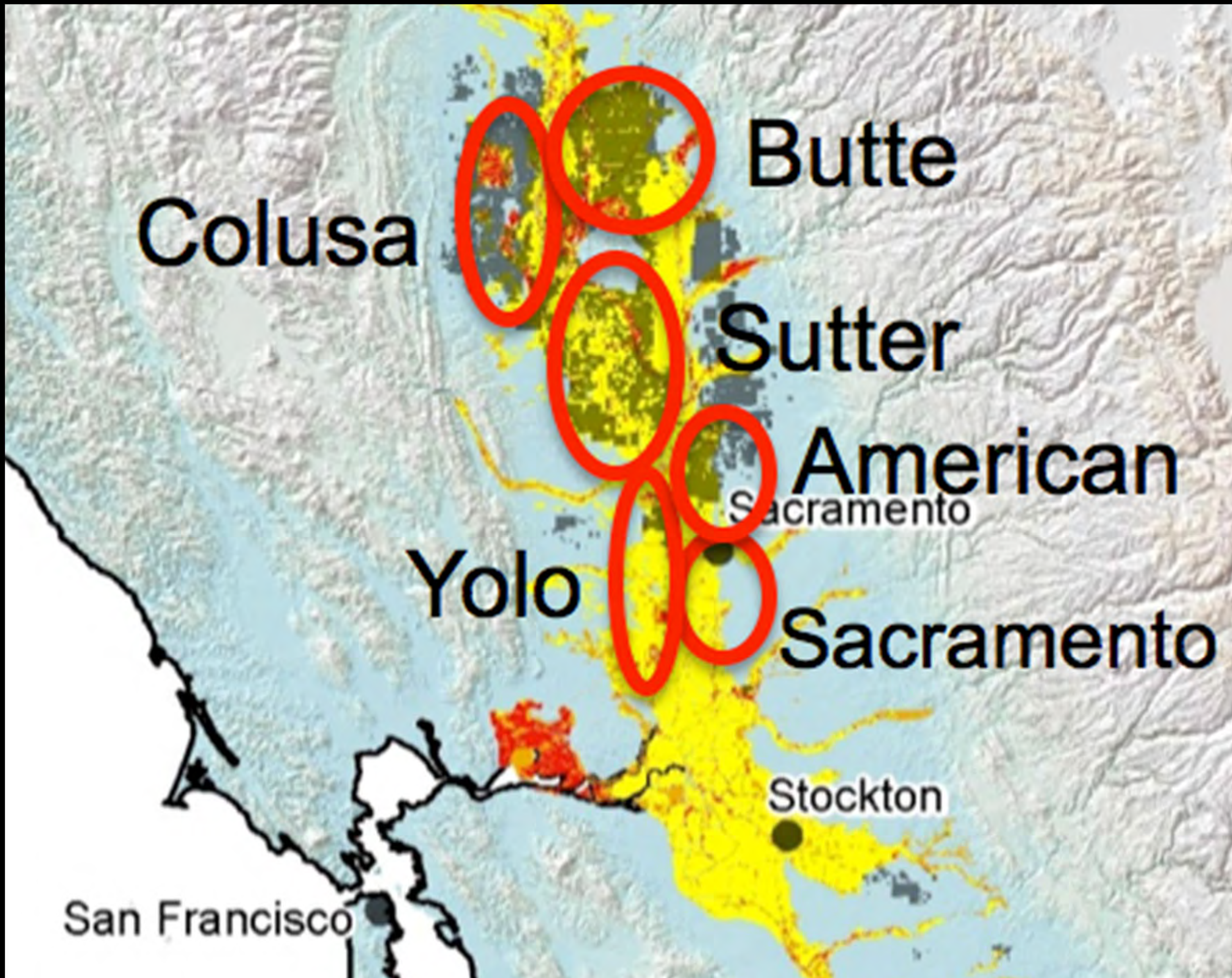


Fluvial Processes

Elevation (feet)



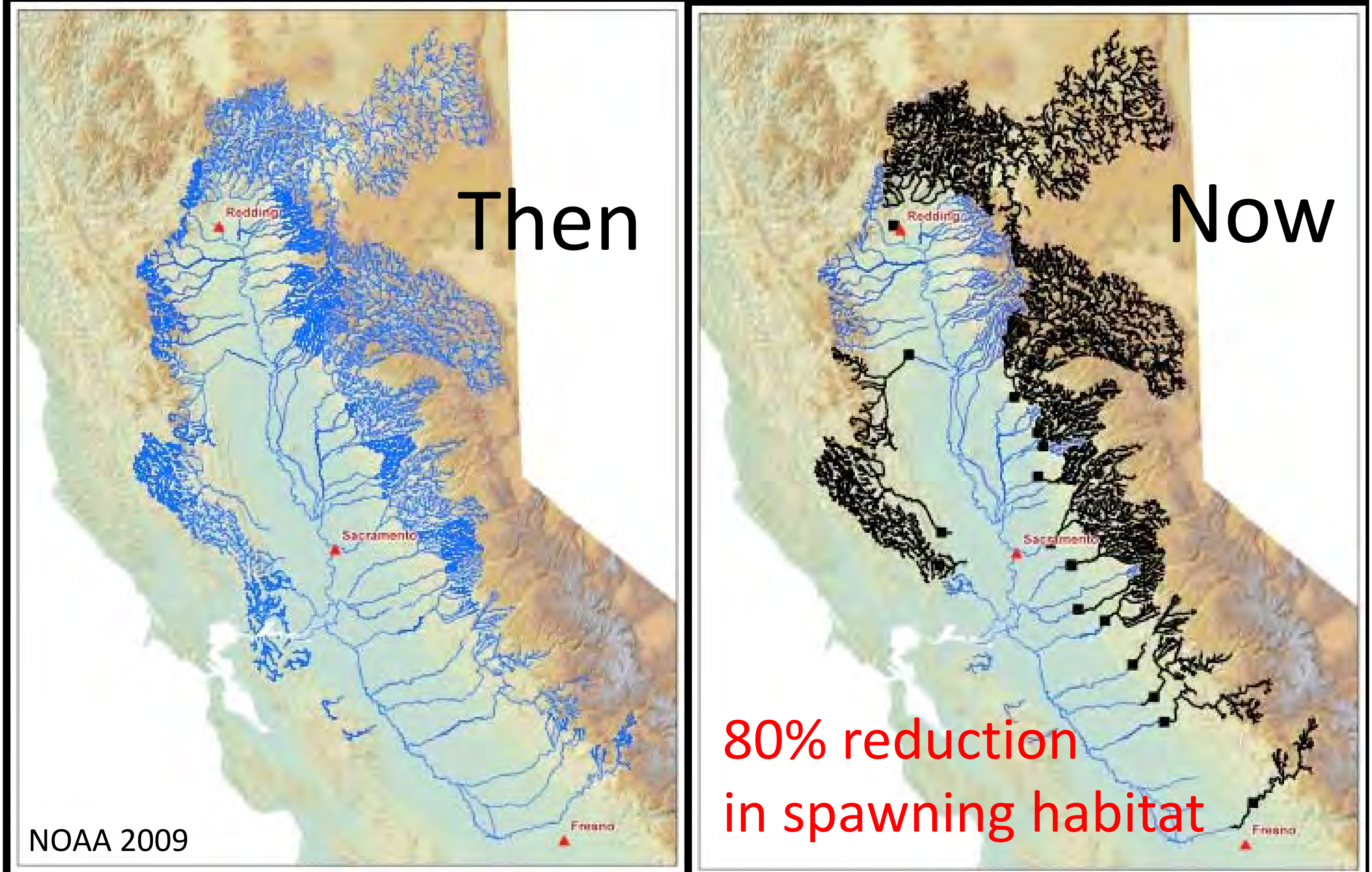
Sac Valley Flood Basins



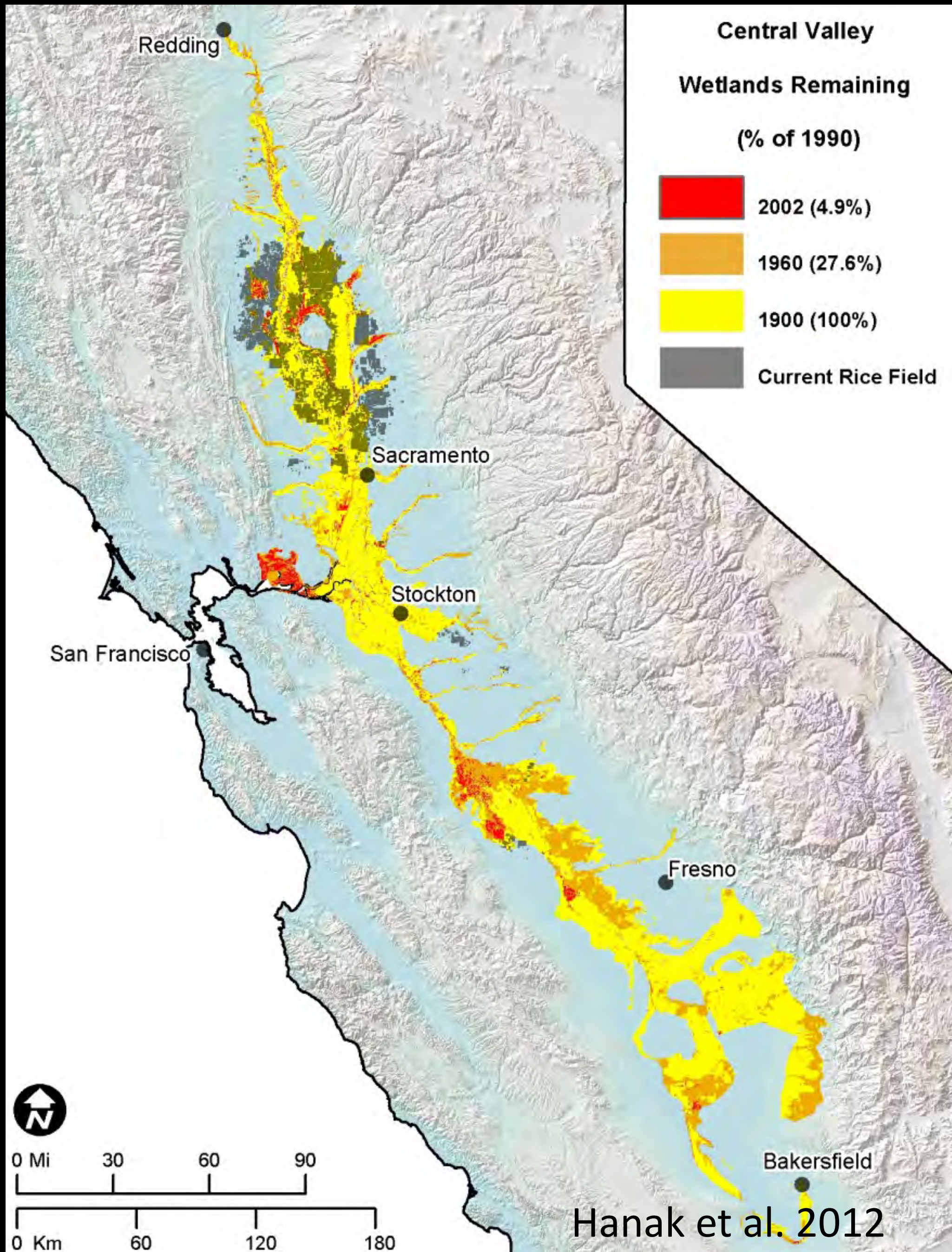
Every major river in California dammed-

At least once

Central Valley Water Infrastructure – Dams



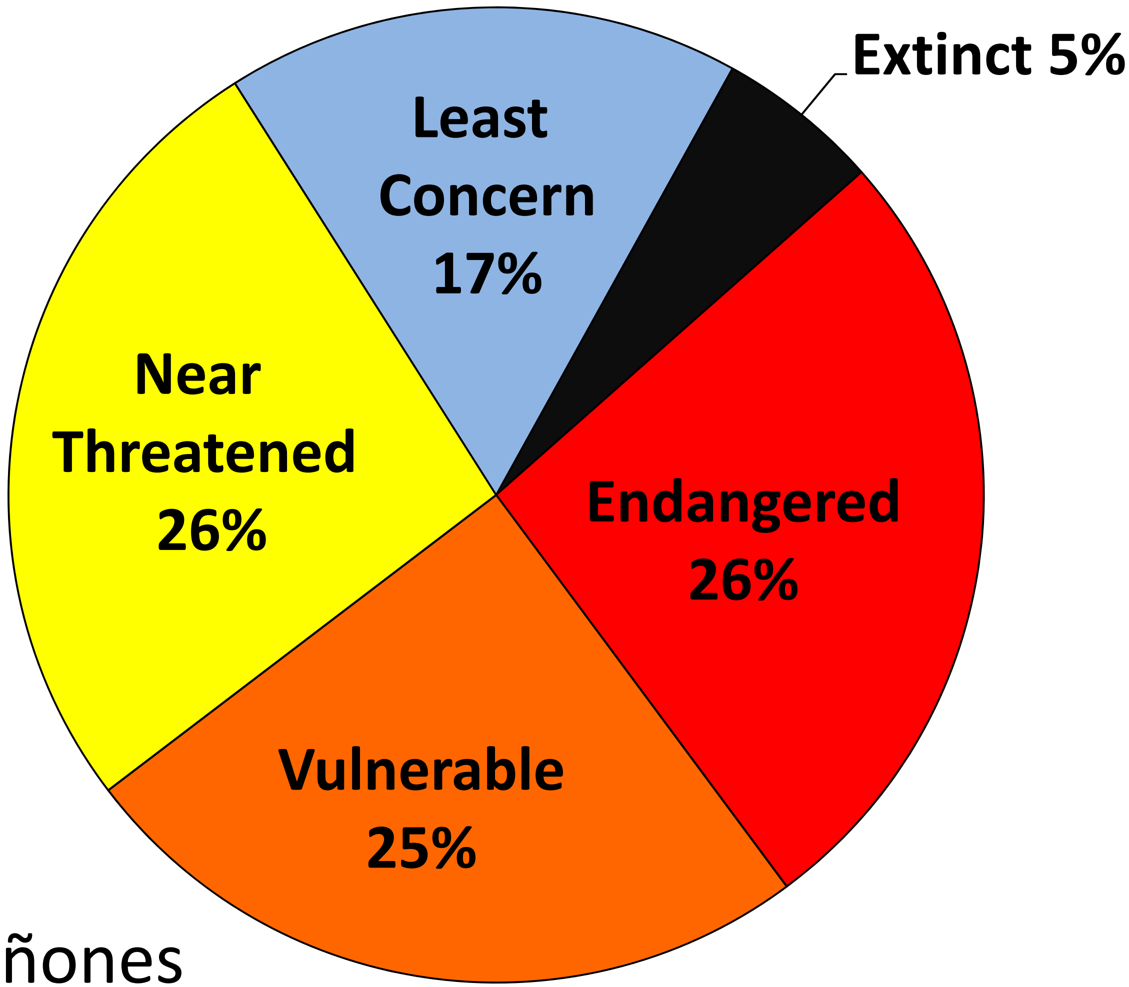
13,000 miles of levees



Central Valley Floodplain reduced by more than 95%

Rearing Habitat lost

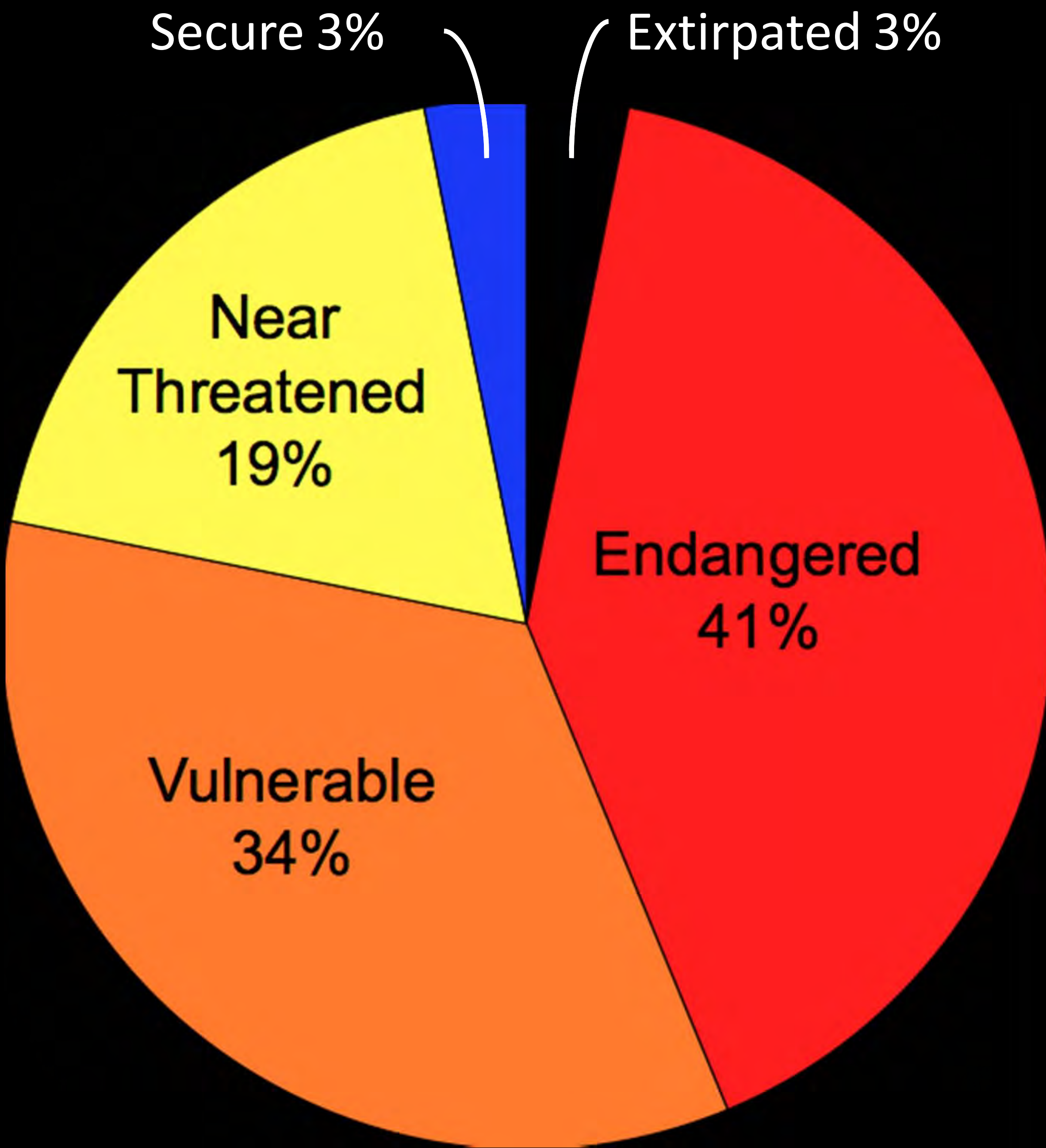
CA NATIVE FISHES



83% Extinct or in decline

Moyle, Katz & Quiñones
Biological Conservation,
Vol 144, issue 10, Oct. 2011

N=129



Impending extinction of CA salmonids

Vast Majority (94%) of California native salmonids in sharp decline

Katz et al. 2013
Env. Biology of Fishes 10

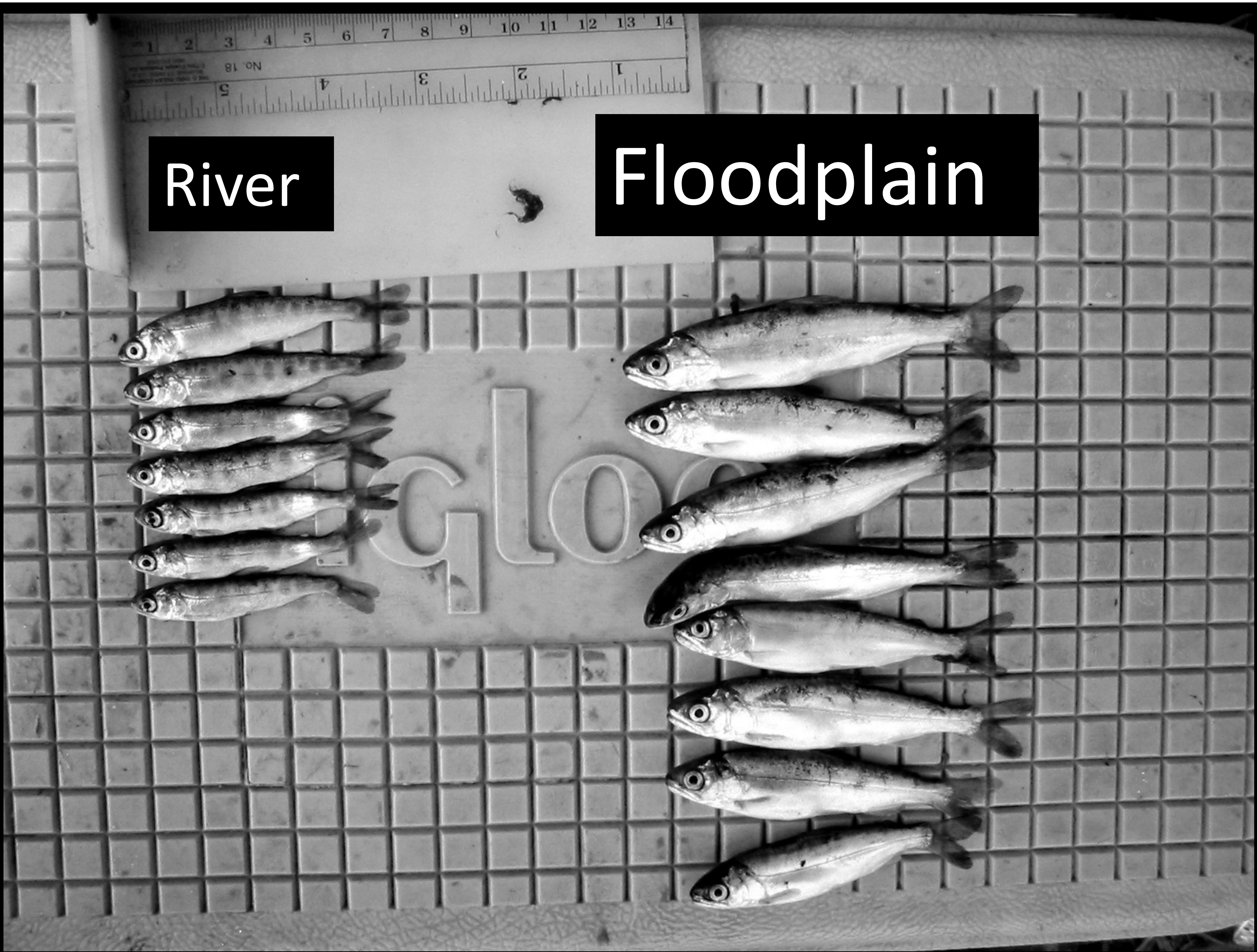
Central Valley Chinook

Of 4 runs

3 are endangered, the other is dominated by hatcheries

Cosumnes River 2008

No Dams = Floods with winter rain events = inundates floodplain



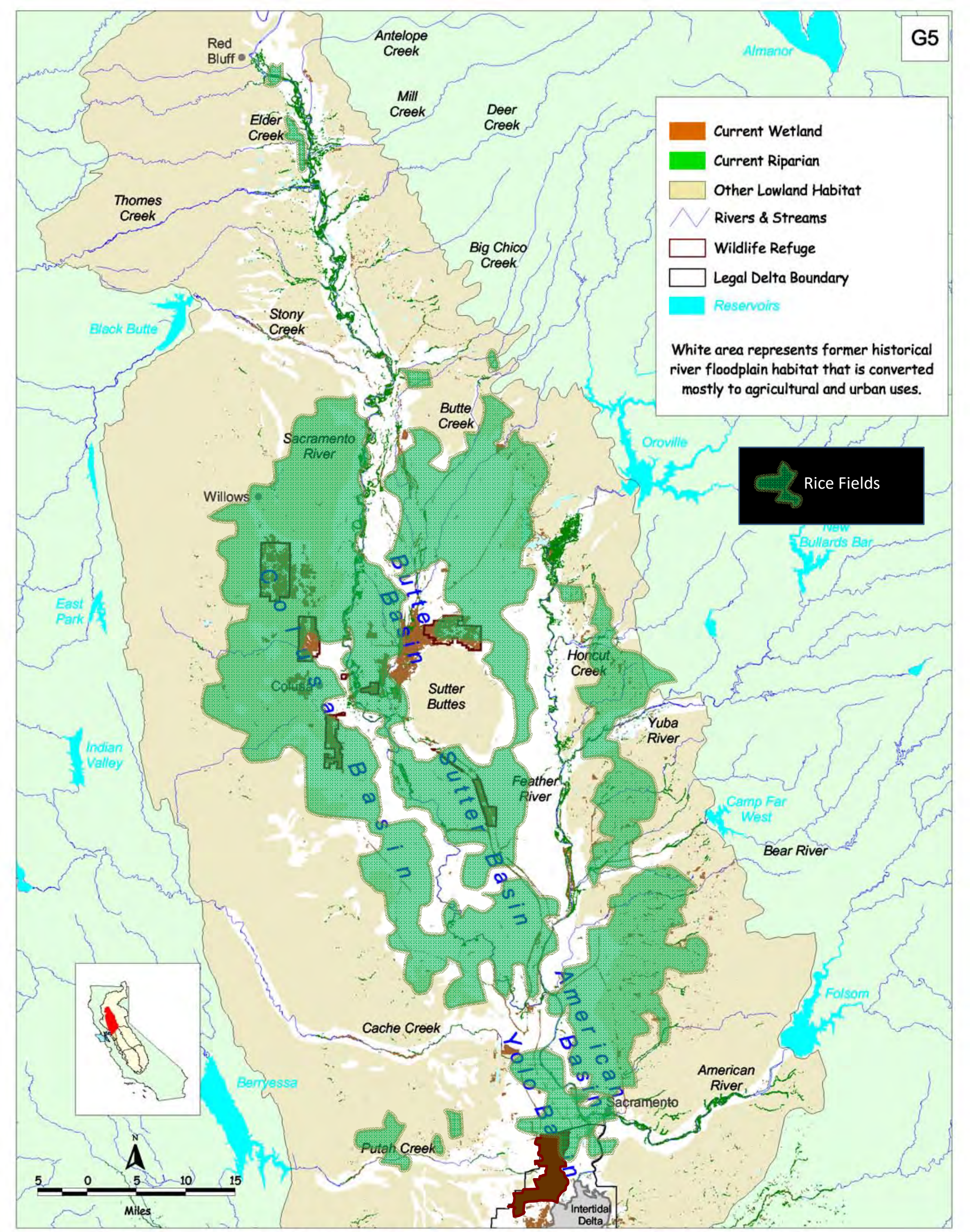
Jeffres et al. 2008

Historic:

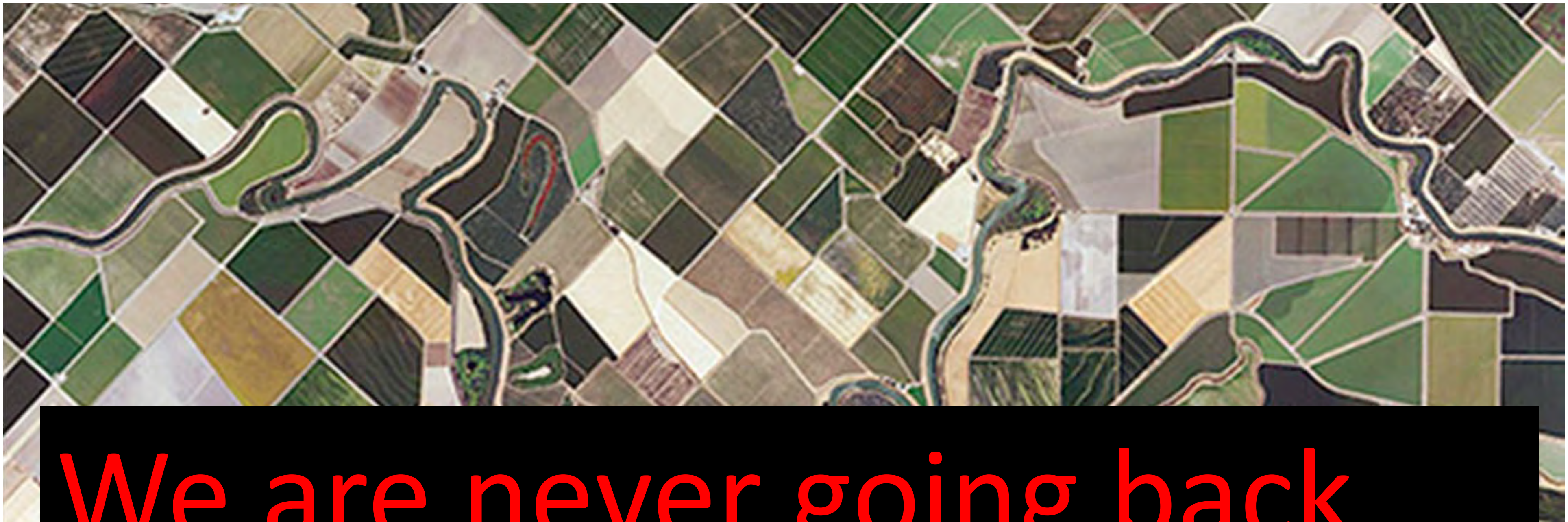
Fall run Chinook evolved rearing on floodplains

TODAY:

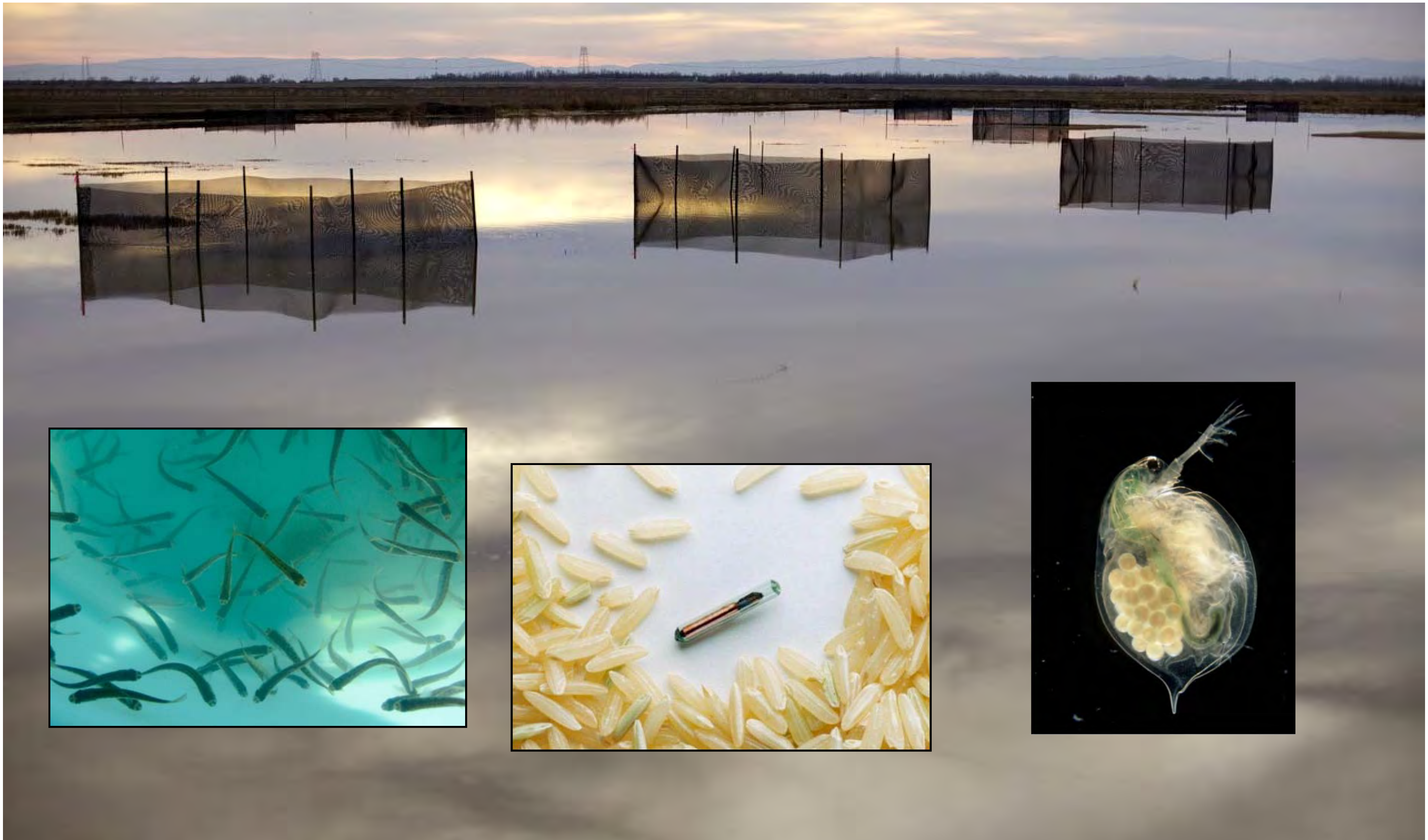
- 95% of floodplains lost
- drained and converted to rice.
- In California 550,000 acres of rice is farmed annually.
- Now, many of the rice fields are managed for migrating birds during winter months.



Sacramento Valley Current River Floodplain Ecosystem

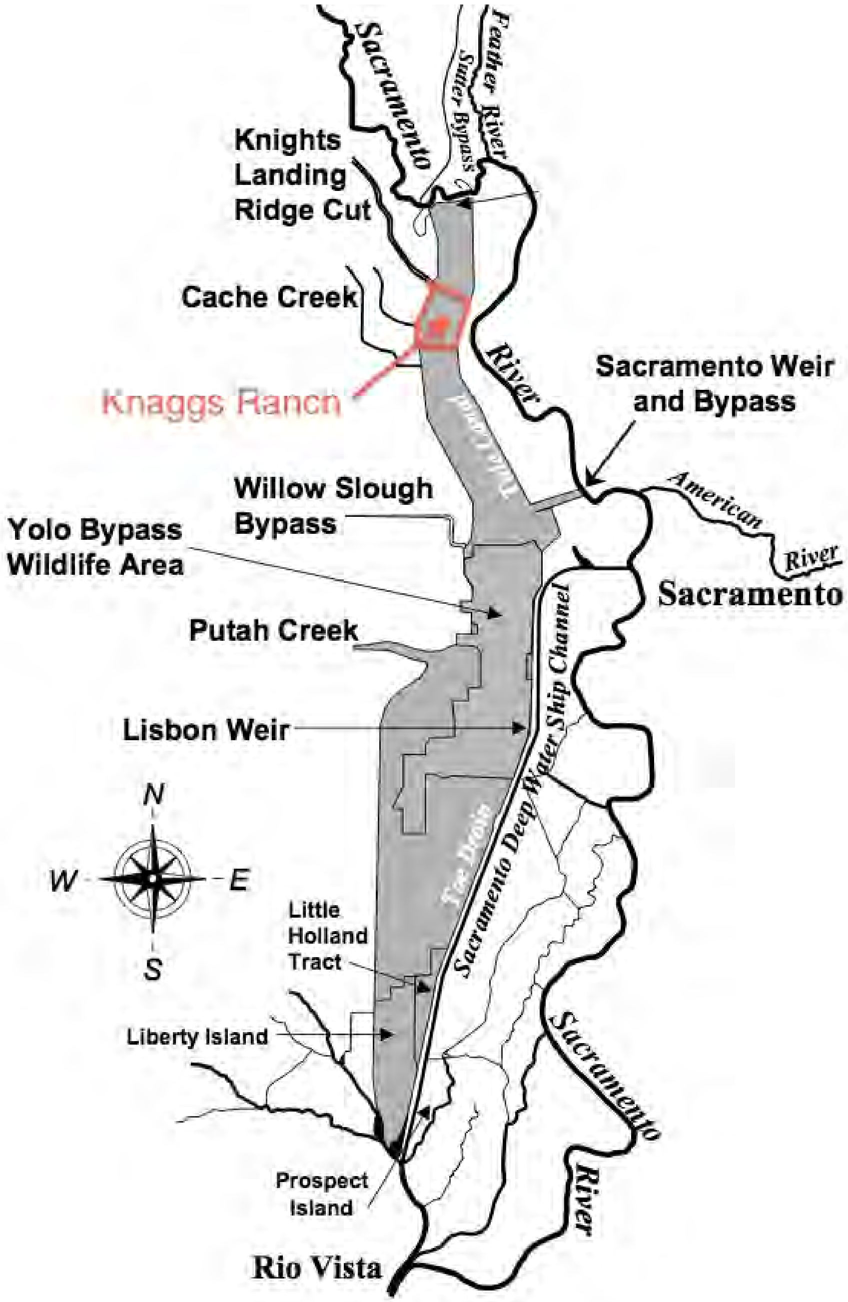


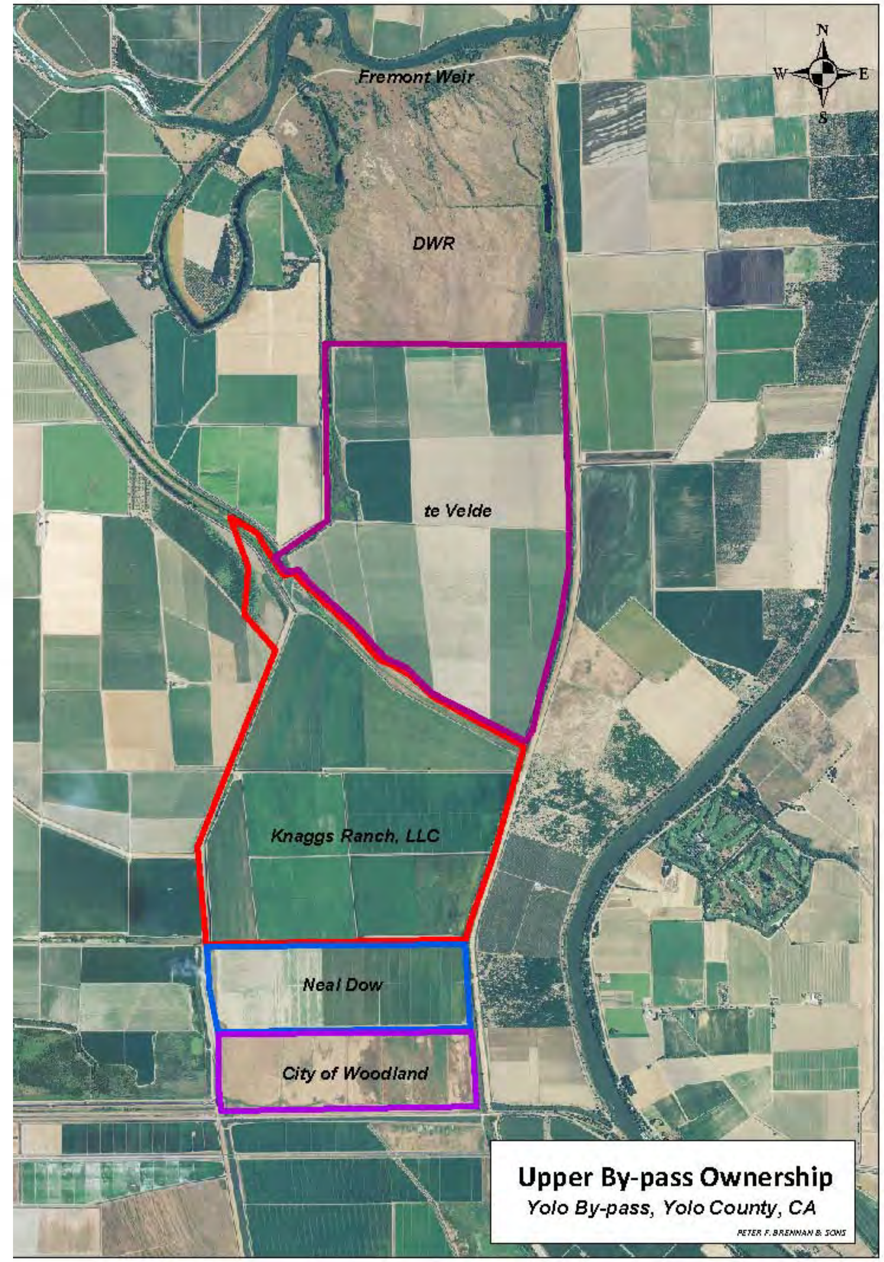
We are never going back



Mimicking natural floodplain processes
in post-harvest floodplain rice fields

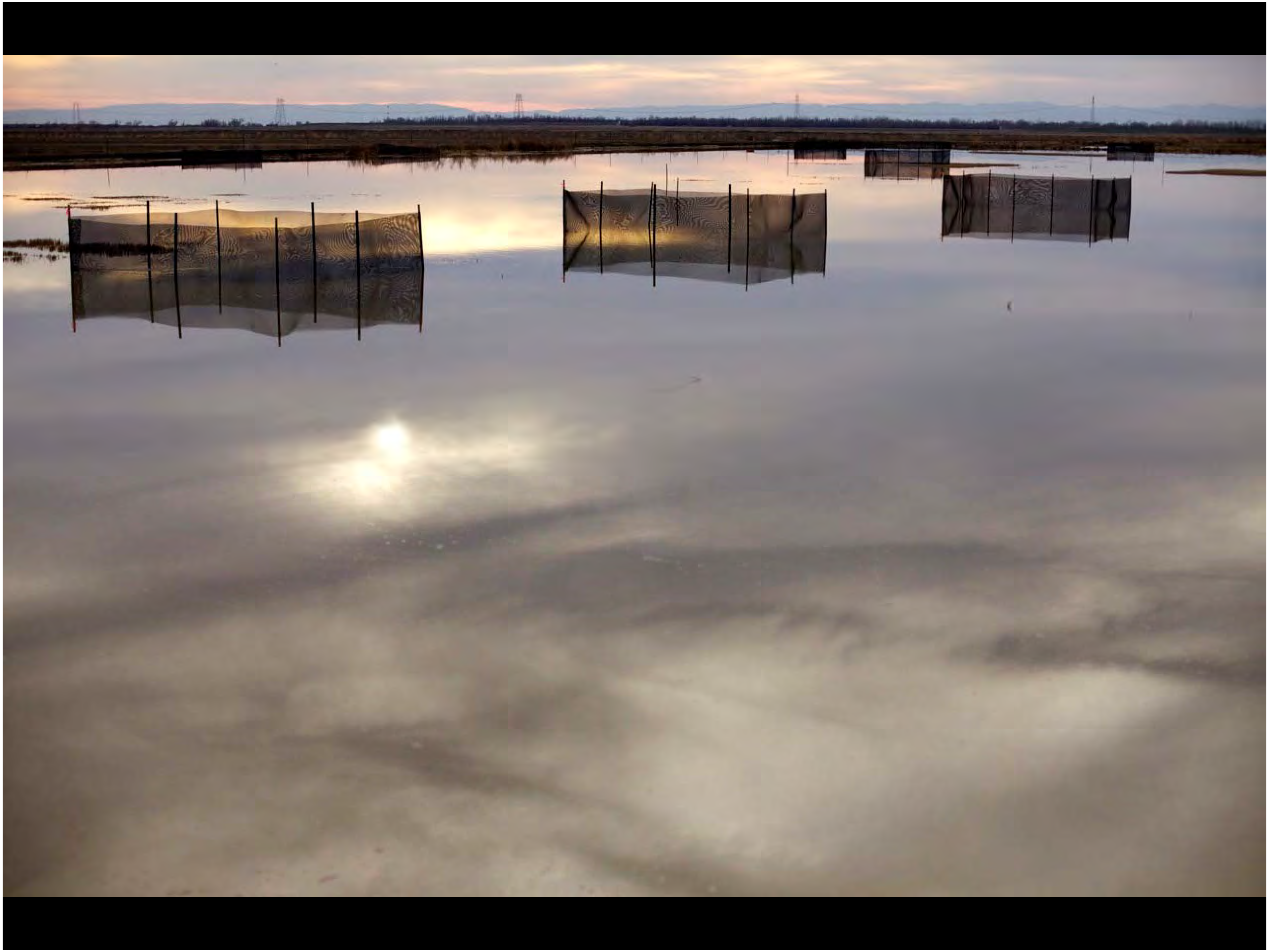
Knaggs Ranch on Yolo Bypass





Post Rice Harvest - November


Carson Jeffres

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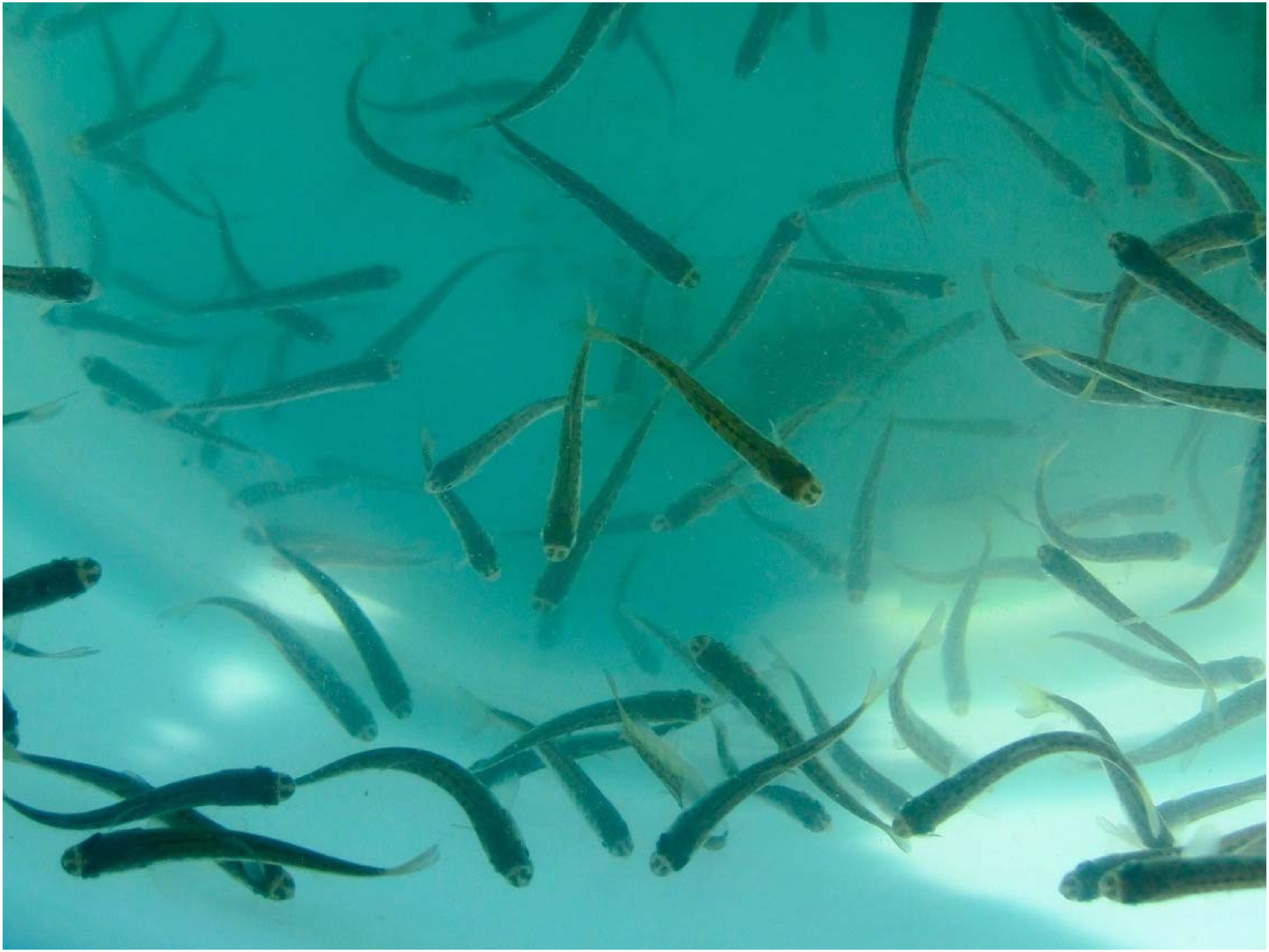
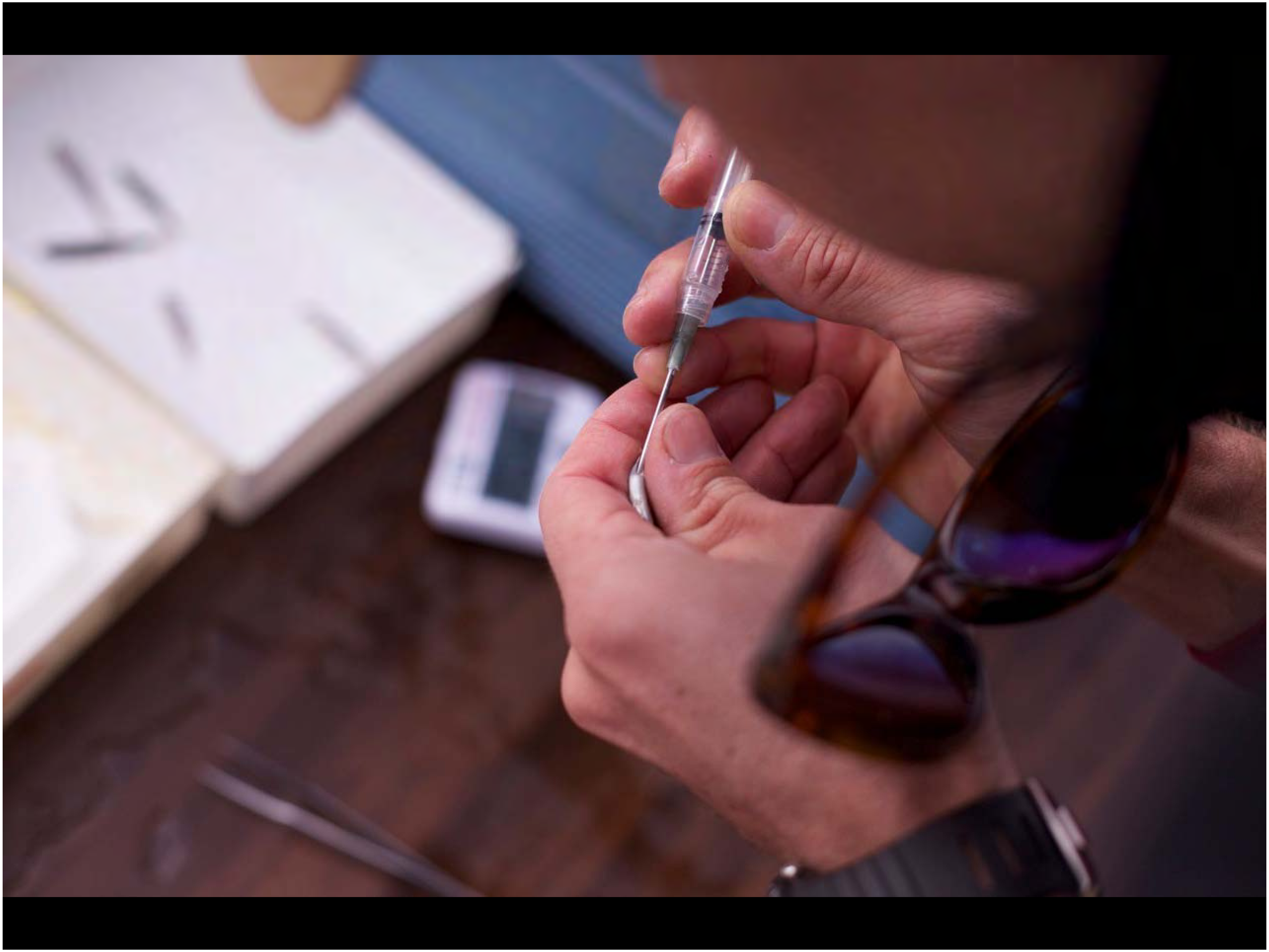


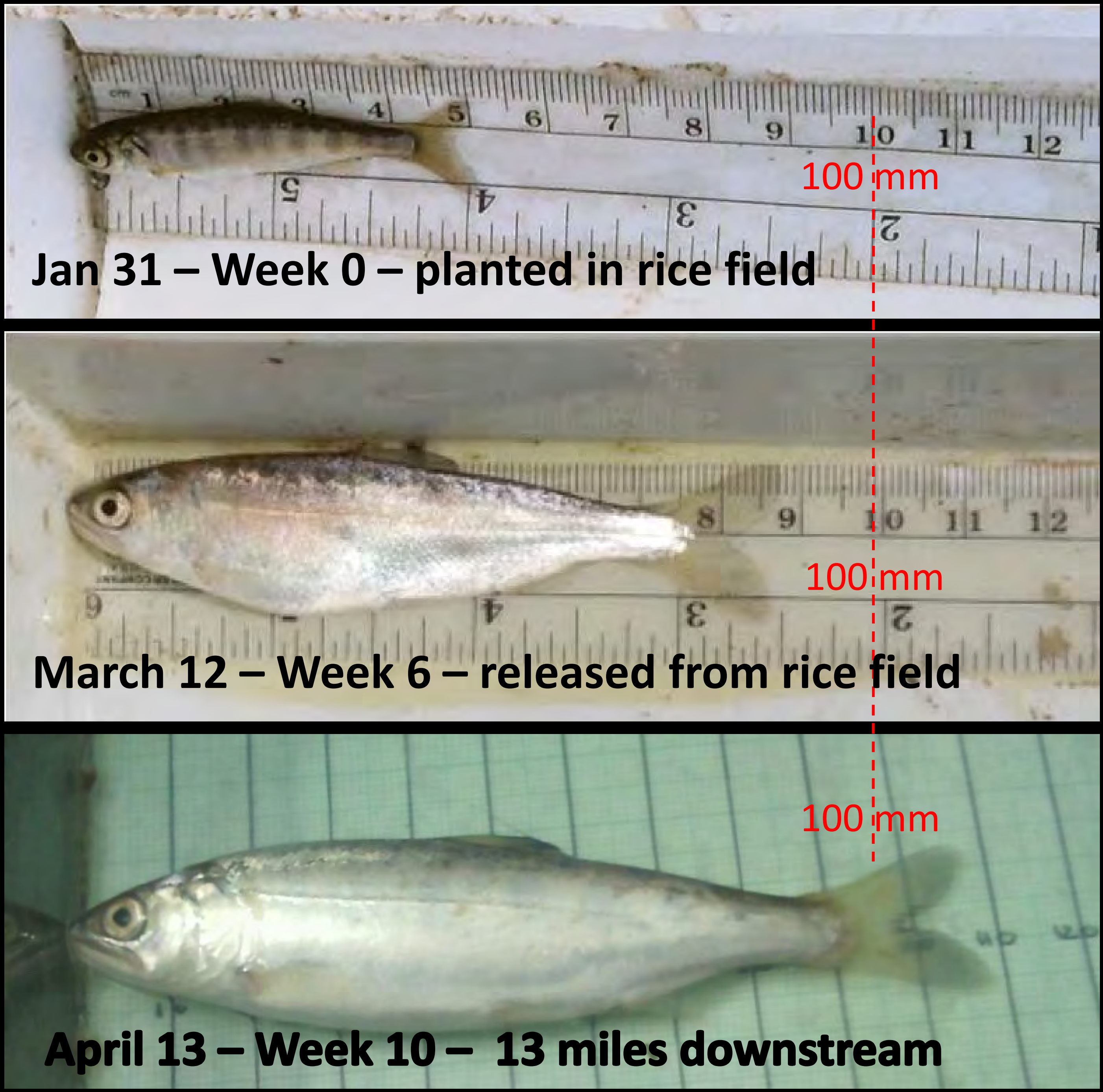
Passive integrated transponder (PIT tags)




Fish measured every 2 weeks

After 6 weeks field drained

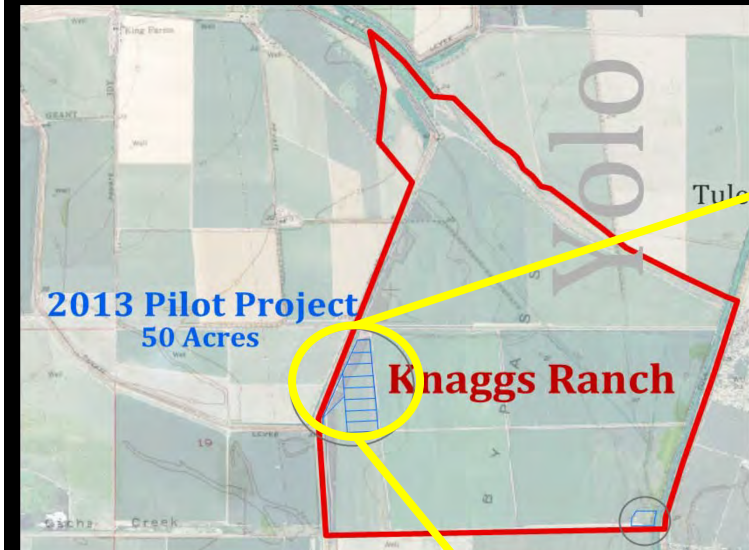
Fish measured and tags read


Jan 31 – Week 0 – planted in rice field
100 mm
March 12 – Week 6 – released from rice field
100 mm
April 13 – Week 10 – 13 miles downstream
100 mm

GROWTH




Nine 2-acre fields



2013: Farm Practices?

42,000 hatchery fish

Substrate type?

Fallow

Stubble

Stomped

Day 0 Day 38

2013

3/19

53 mm

1.5 g

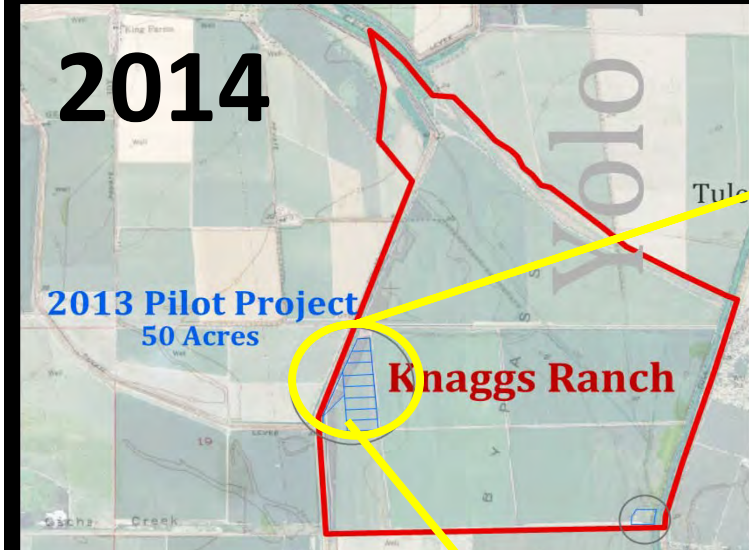
4/27

90 mm

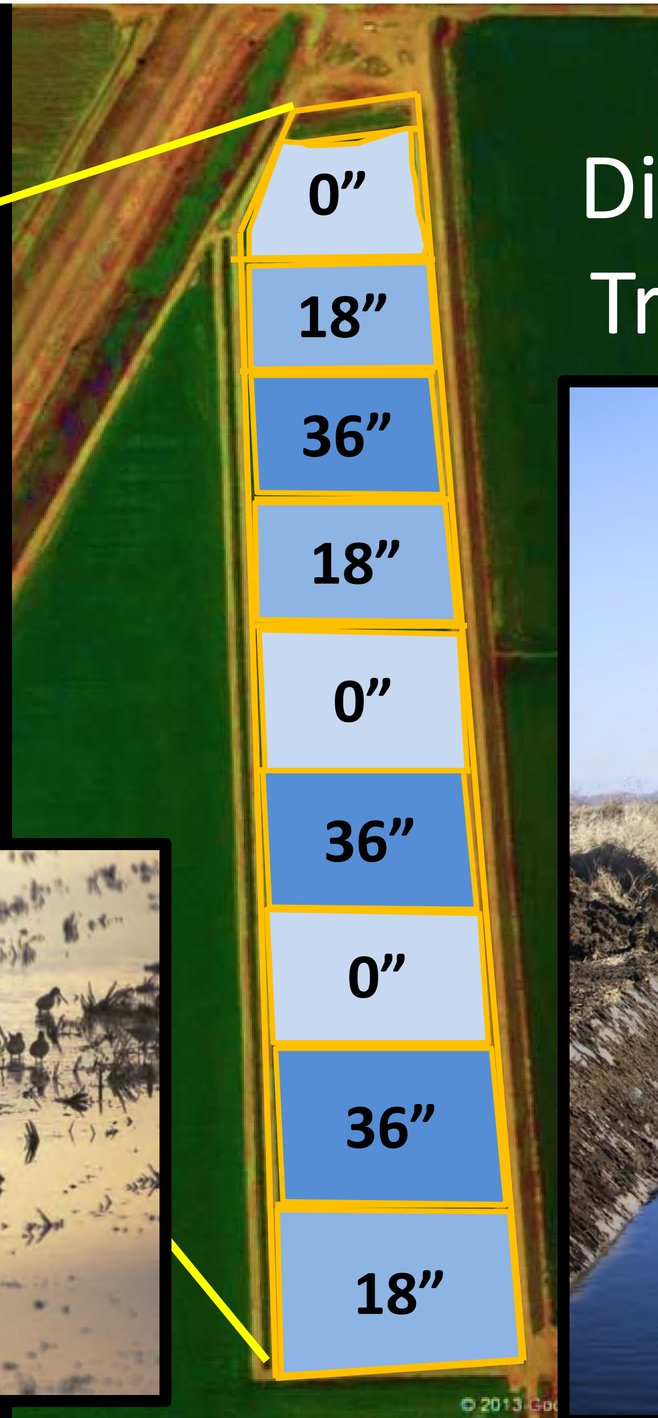
9.4 g

0.94 mm/d

0.18 g/d



45,000 hatchery fish,
400 Feather River “wild” fish



3 Ditch Depth Treatments

2014

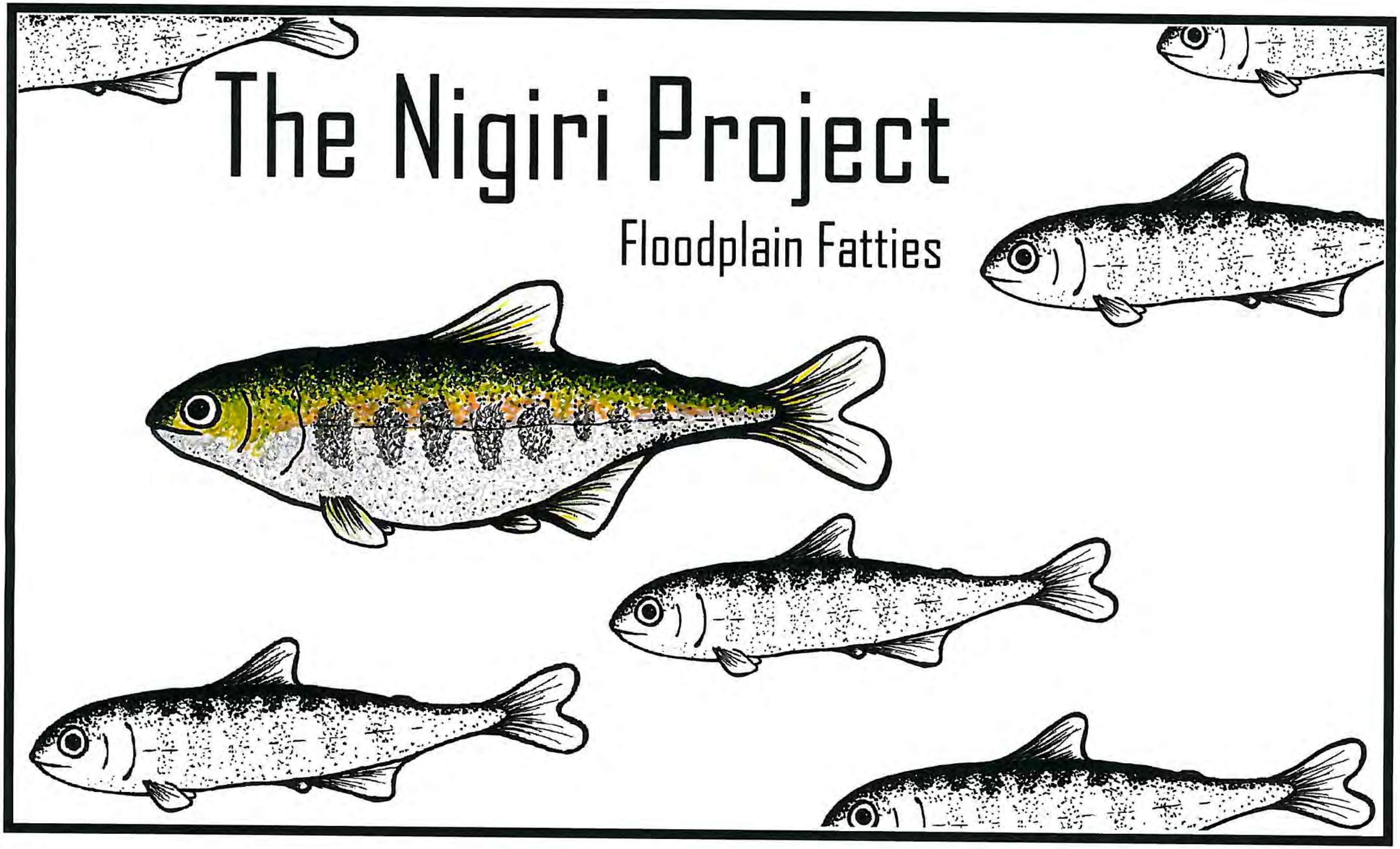
Similar Growth
(1 mm/day)

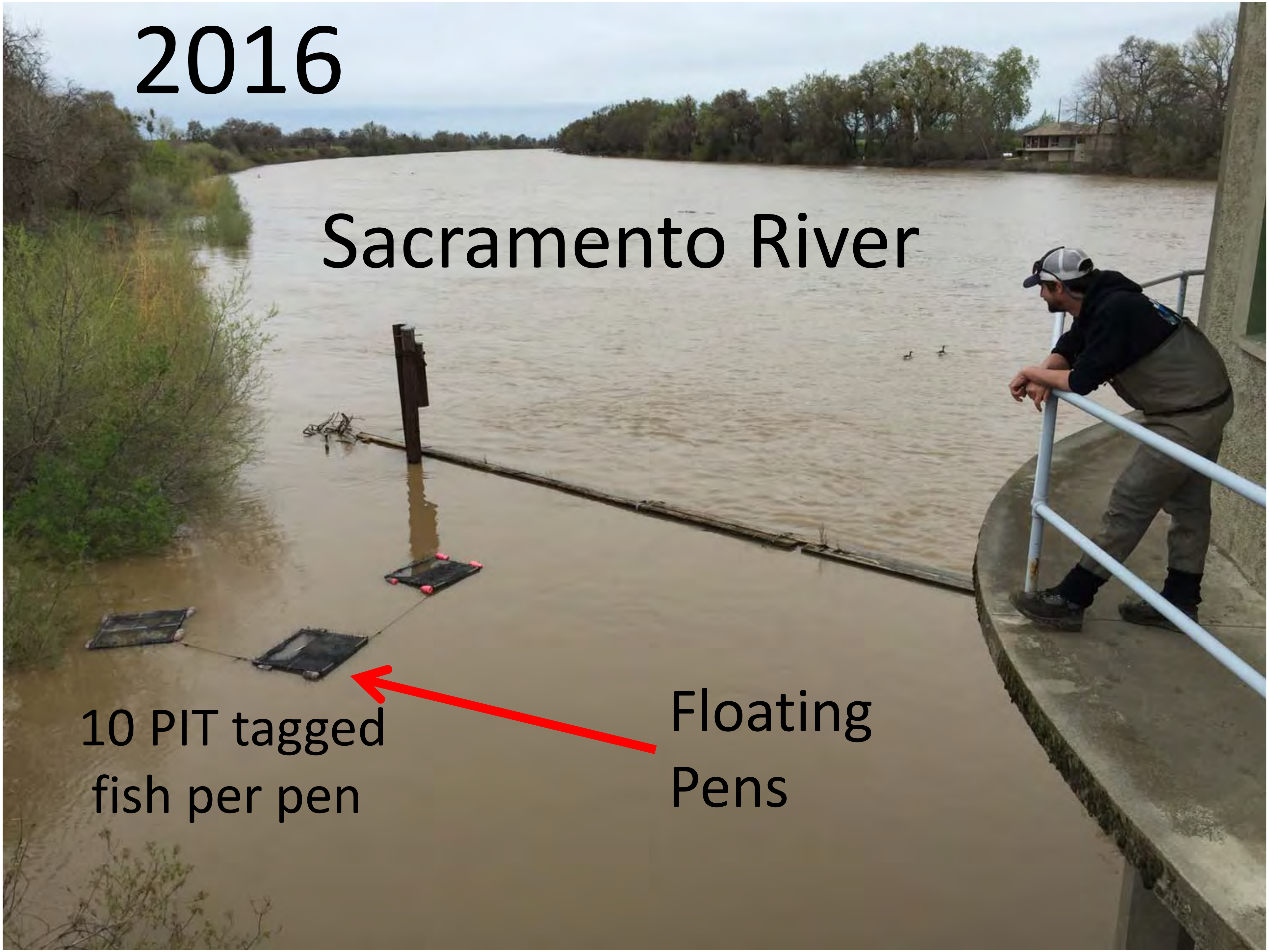
Better
Survival

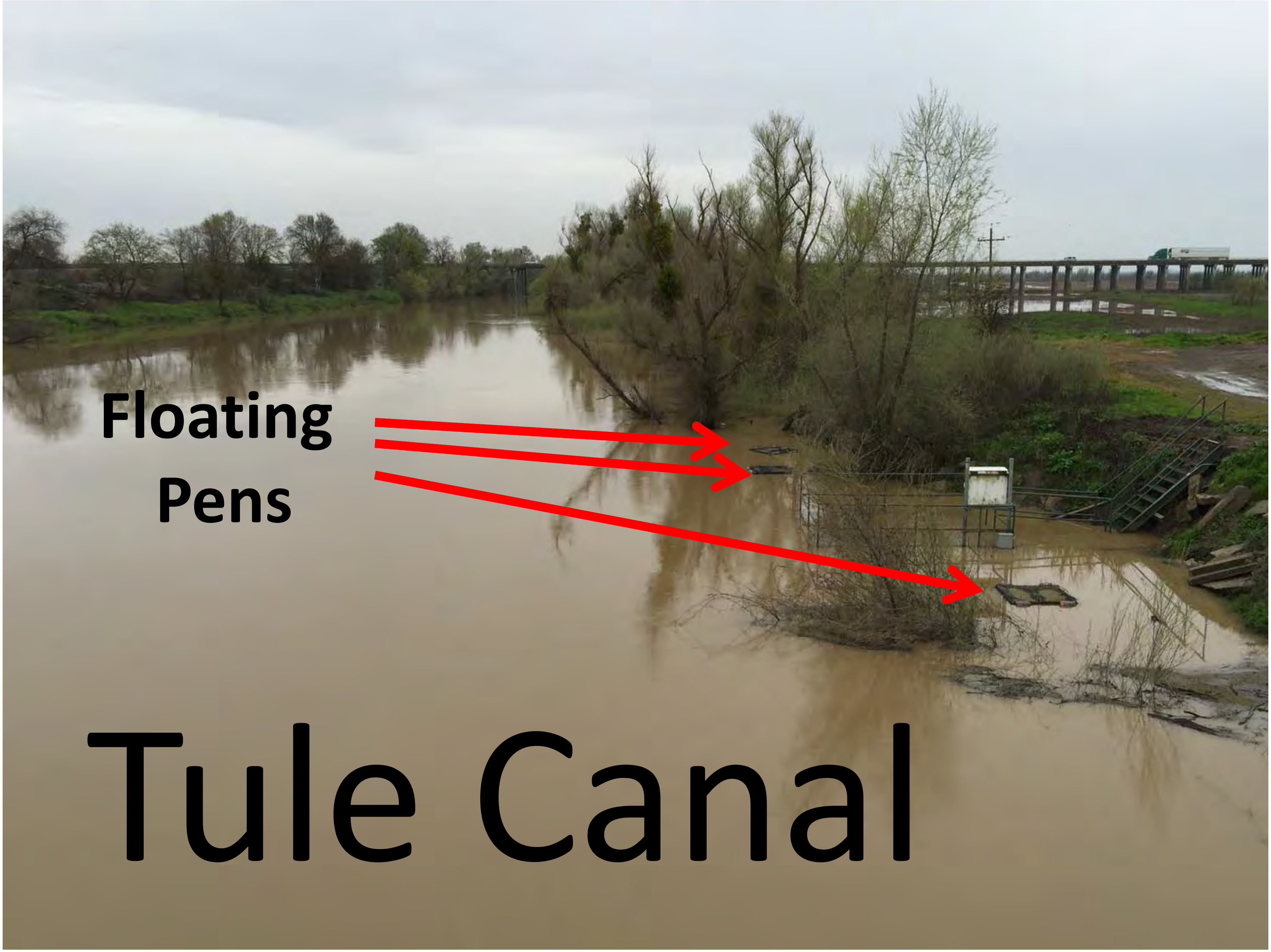
(Approx. 50%)

2015:
Fish at
Multiple Locations

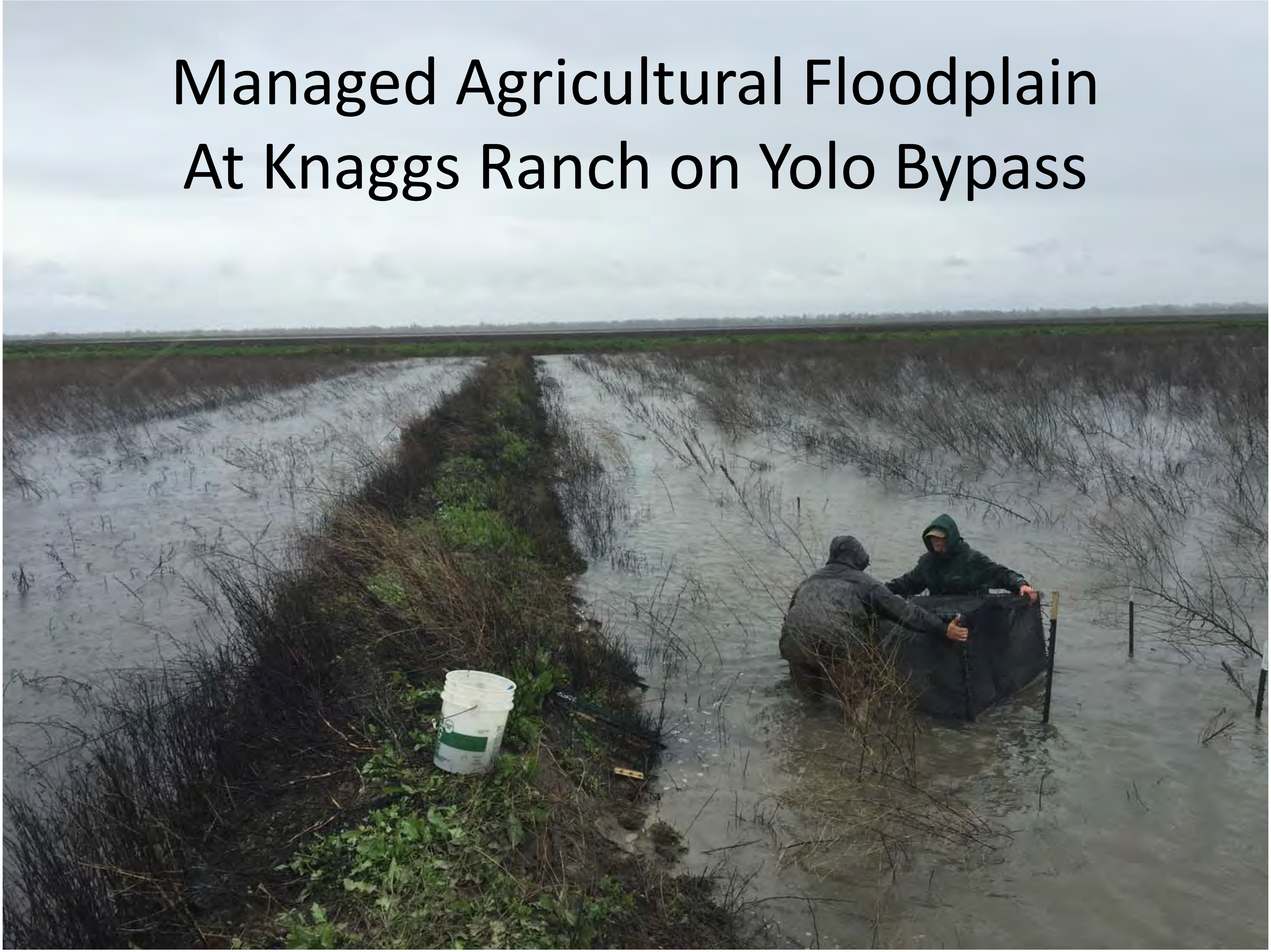
Similar results



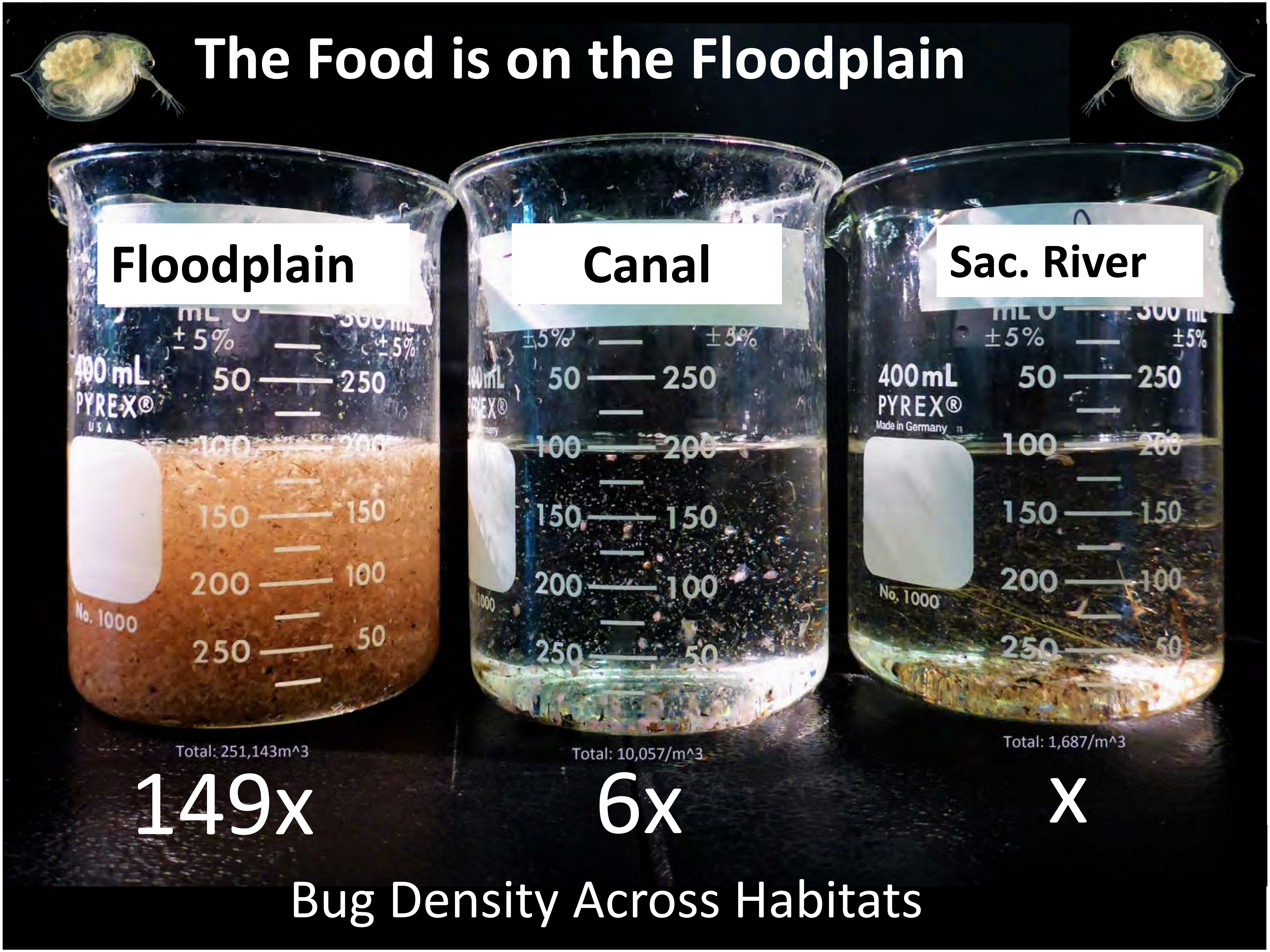

2016
Sacramento River
10 PIT tagged
fish per pen
Floating
Pens

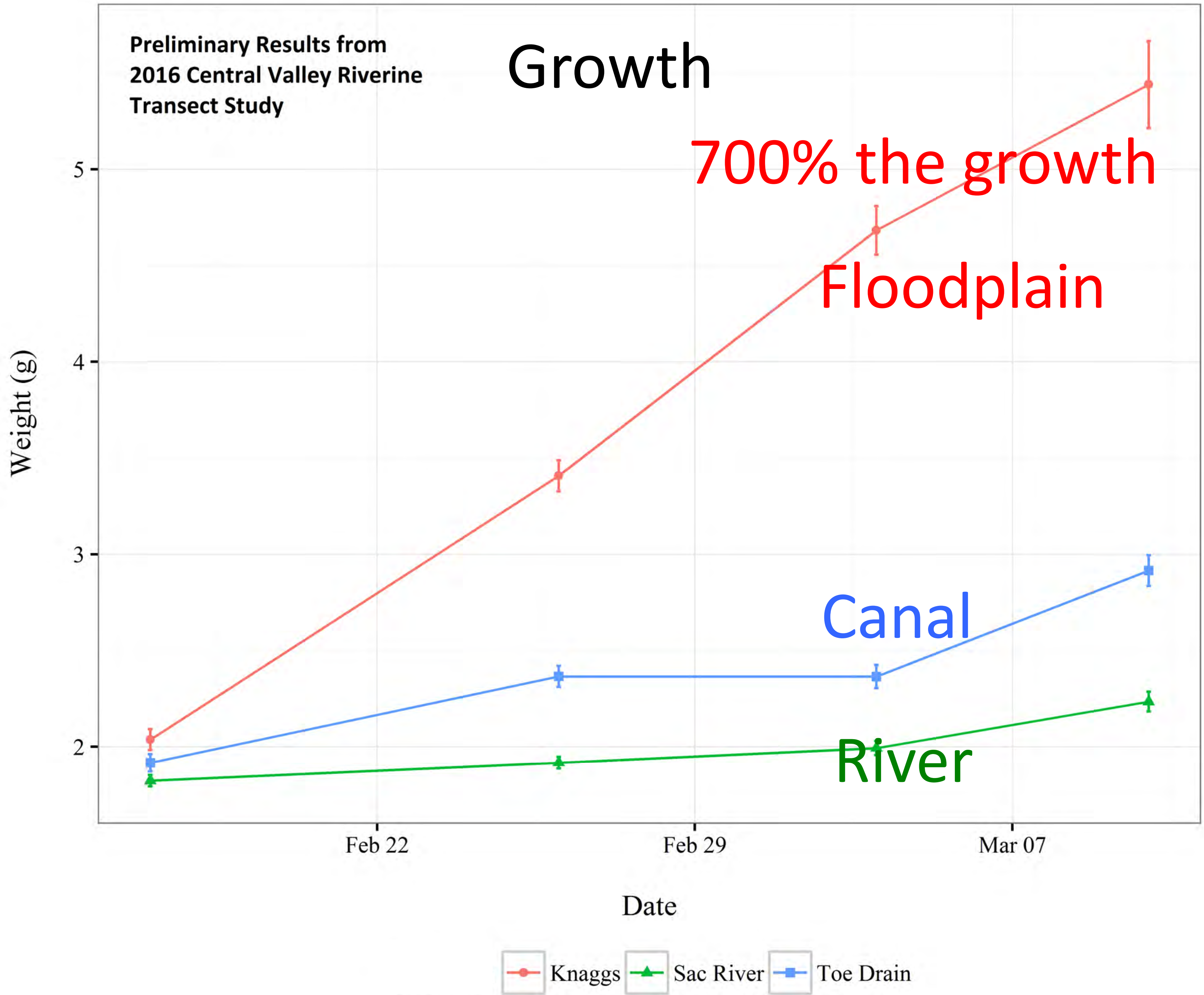

Floating
Pens
Tule Canal

Managed Agricultural Floodplain At Knaggs Ranch on Yolo Bypass

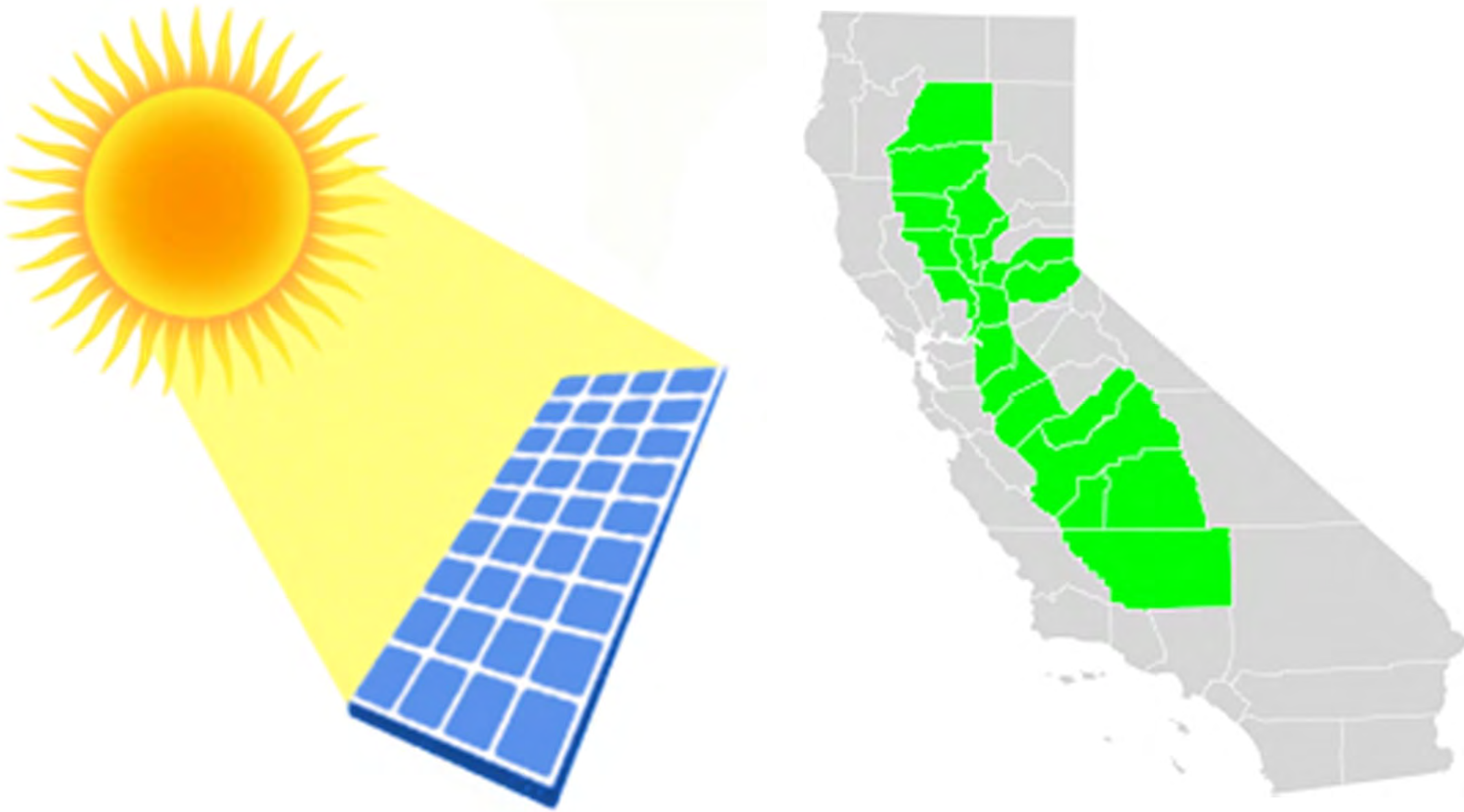



Floodplain
Canal
River
inch 1 2 3 4 5 6
These fish were the same size 3 weeks prior
Photo: J. Katz
3-11-2016


The Food is on the Floodplain
Floodplain
Canal
Sac. River
Total: 251,143m^3
Total: 10,057/m^3
Total: 1,687/m^3
149x
6x
x
Bug Density Across Habitats

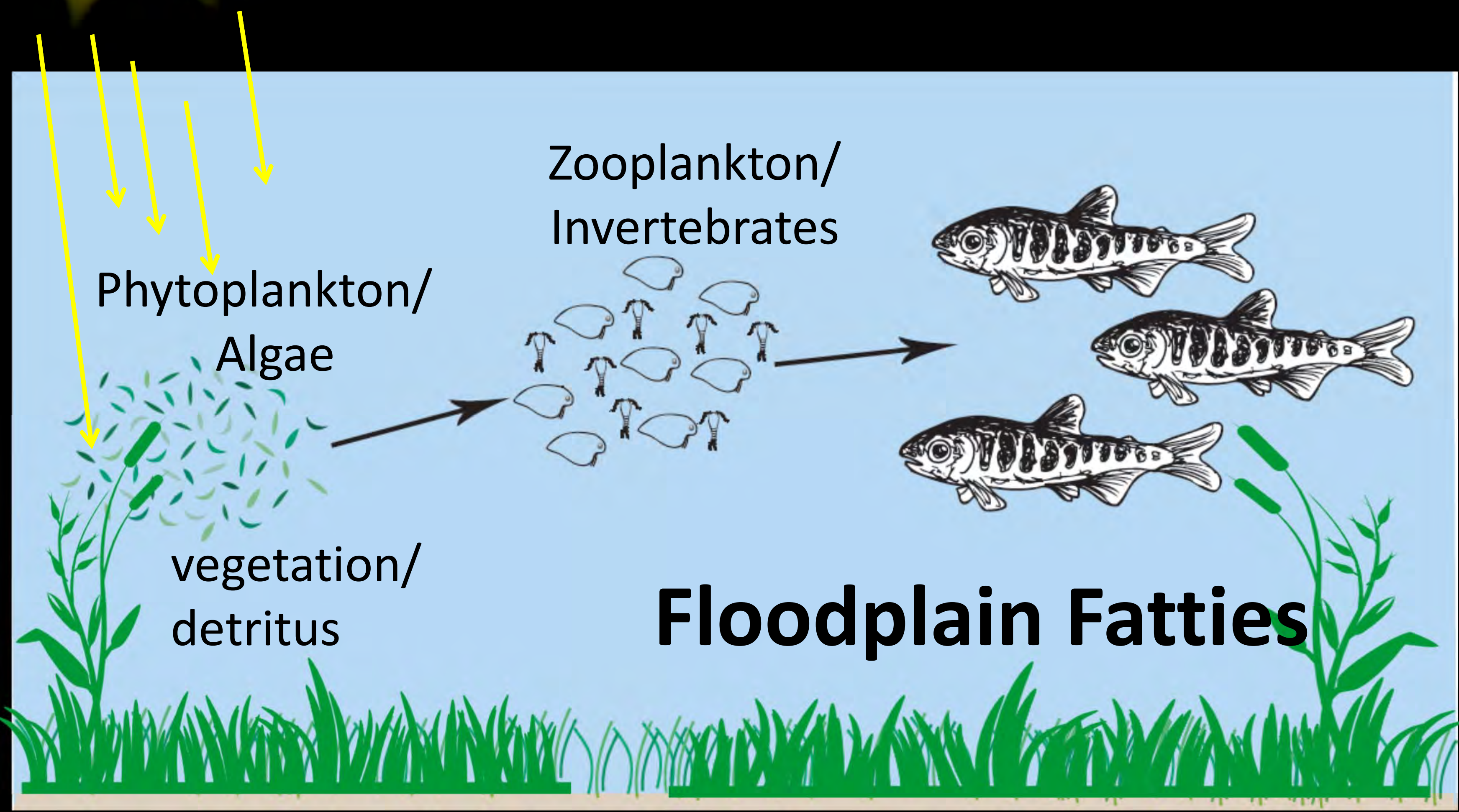

Preliminary Results from
2016 Central Valley Riverine
Transect Study
Growth
700% the growth
Floodplain
Canal
River
Weight (g)
5
4
3
2
Feb 22
Feb 29
Mar 07
Date
Knaggs
Sac River
Toe Drain

Floodplains are the solar collectors

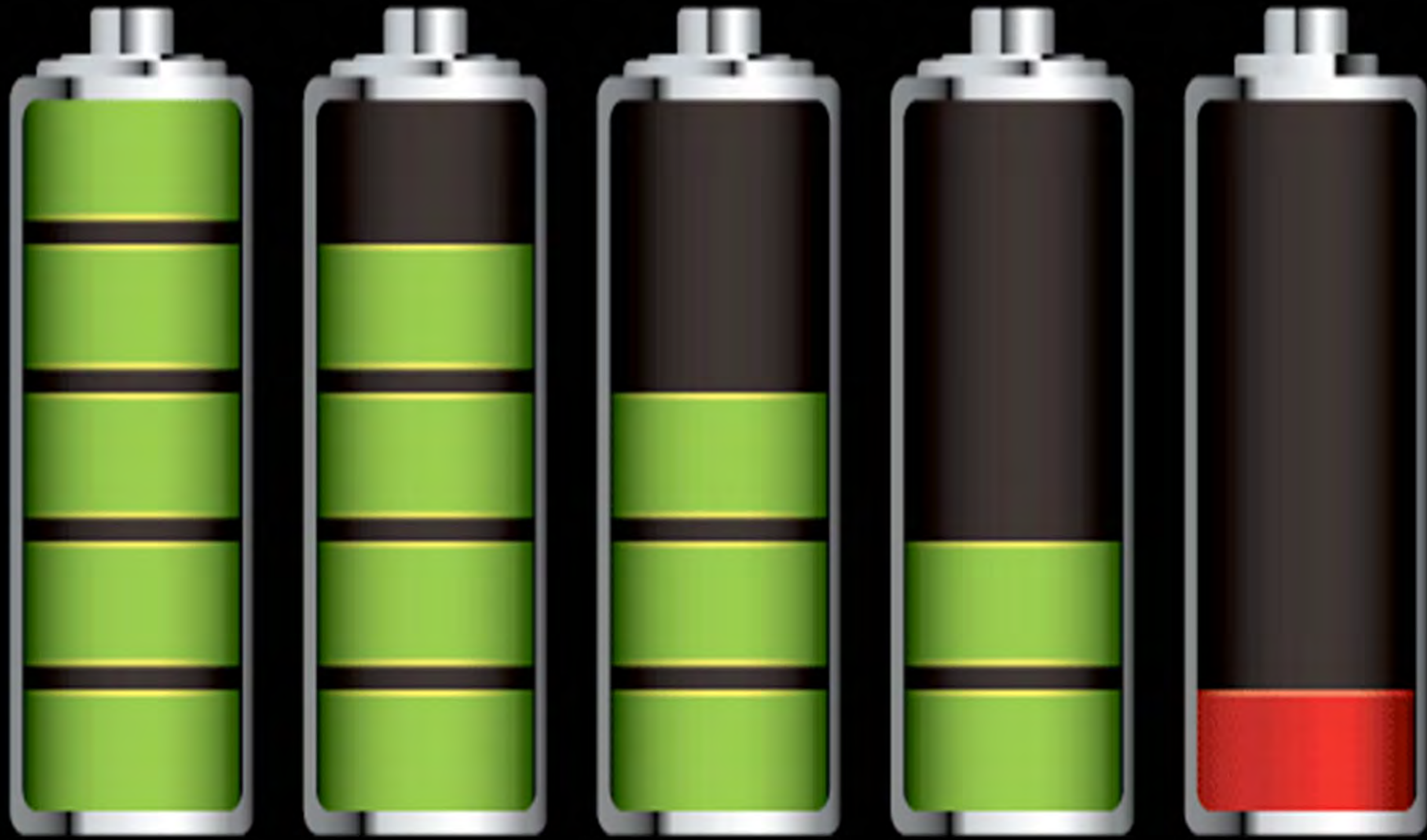


That power river food webs

Mimicking Hydrologic Process to Restore Ecological Function by Prolonging Floodplain Inundation



Extent of Seasonally Inundated Floodplain



Pre-development → Today

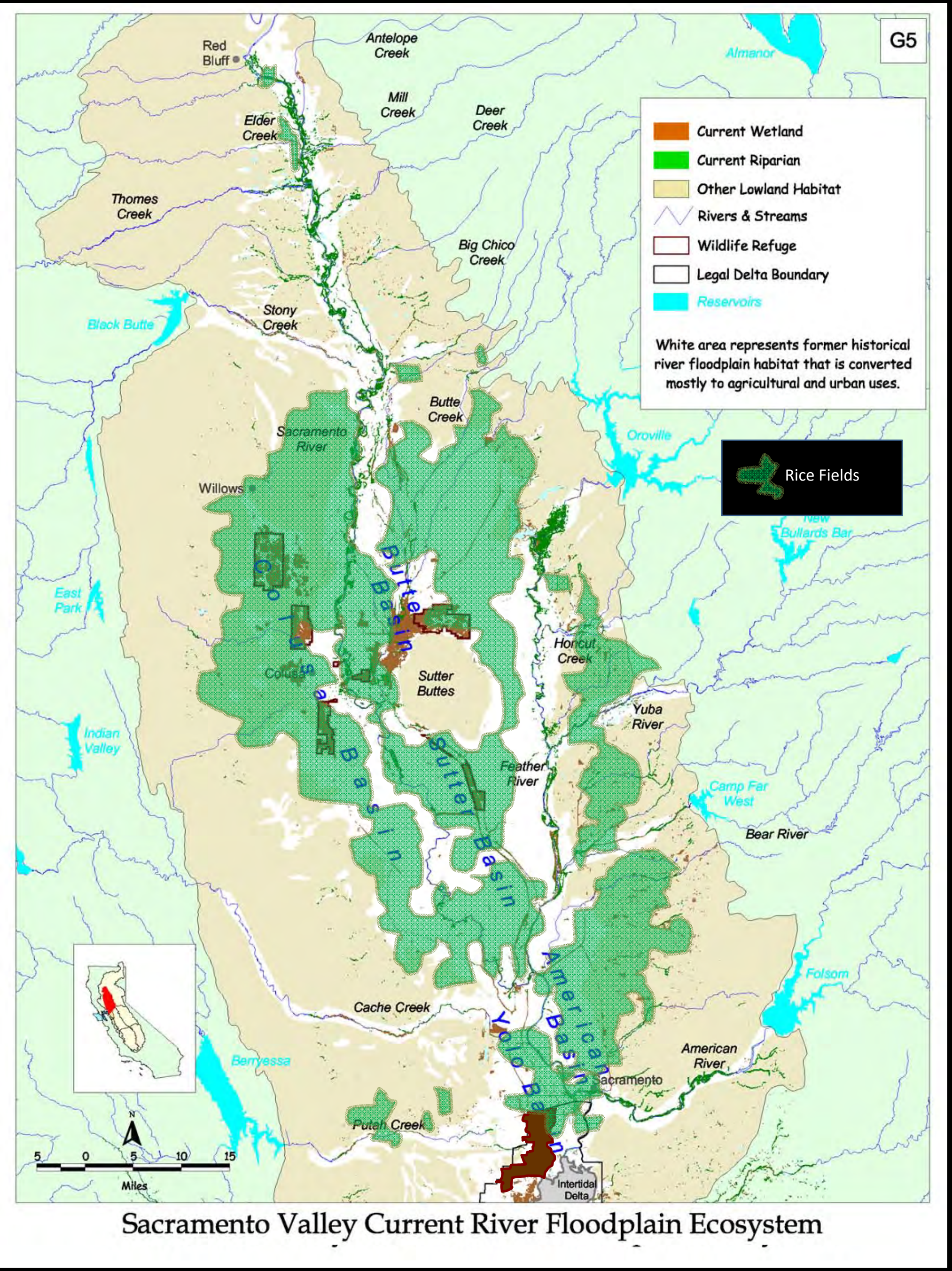
Ecosystem Running Out of Power!

95%

of loss of floodplains

=

Running on fumes

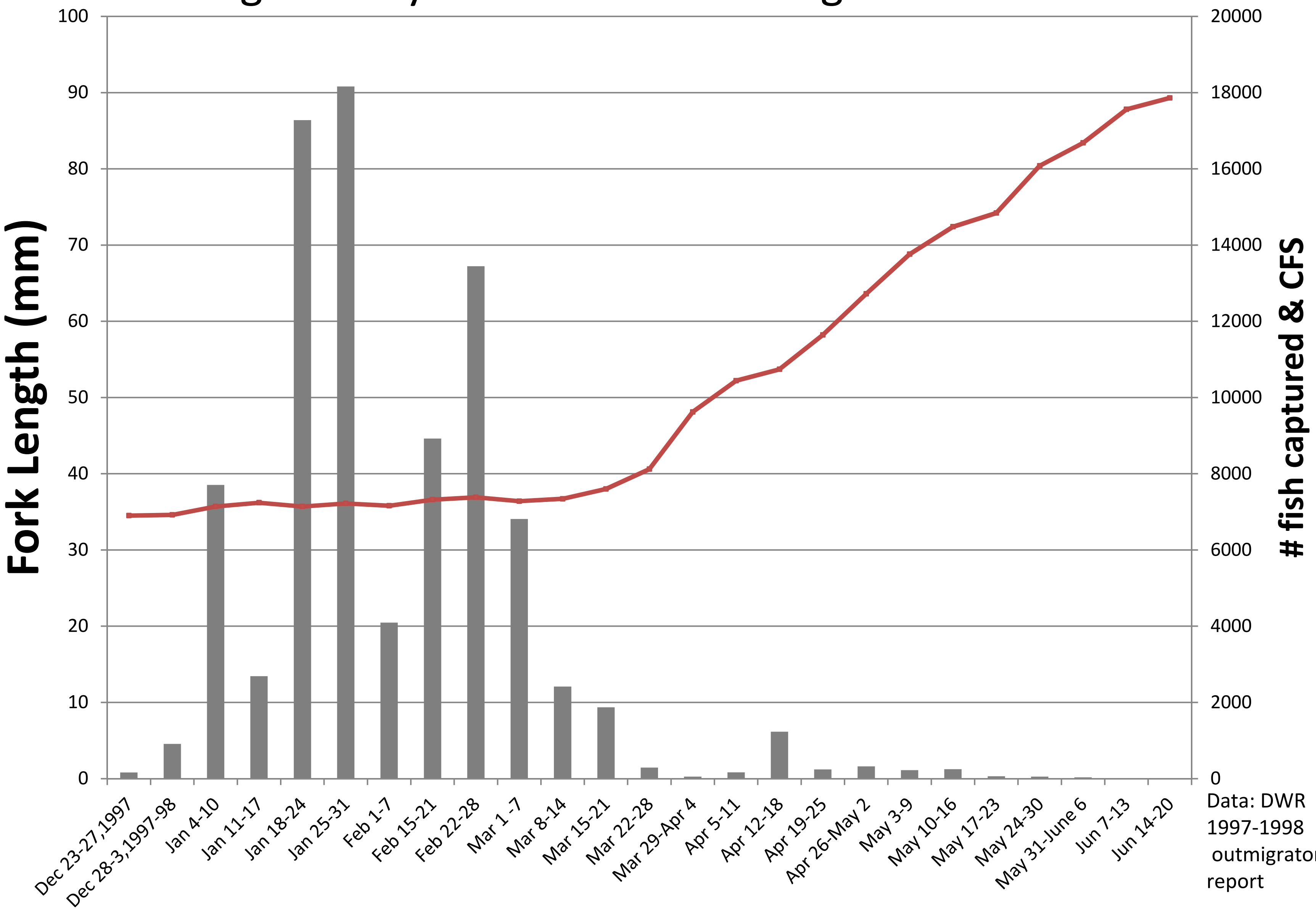



Slow it down
Spread it out
Sink it in
Grow ‘em up


Feather River 1997-1988

Estimated number of outmigrants **43,707,500**

99.8% emigrated by mid March. Average size ~**38mm**



Data: DWR 1997-1998 outmigraton report

Size at date?

DATA FROM TCFFOUT.WK1 REGRESSION
GROWTH CURVES FOR INDIVIDUAL RACES
(MM FL.)

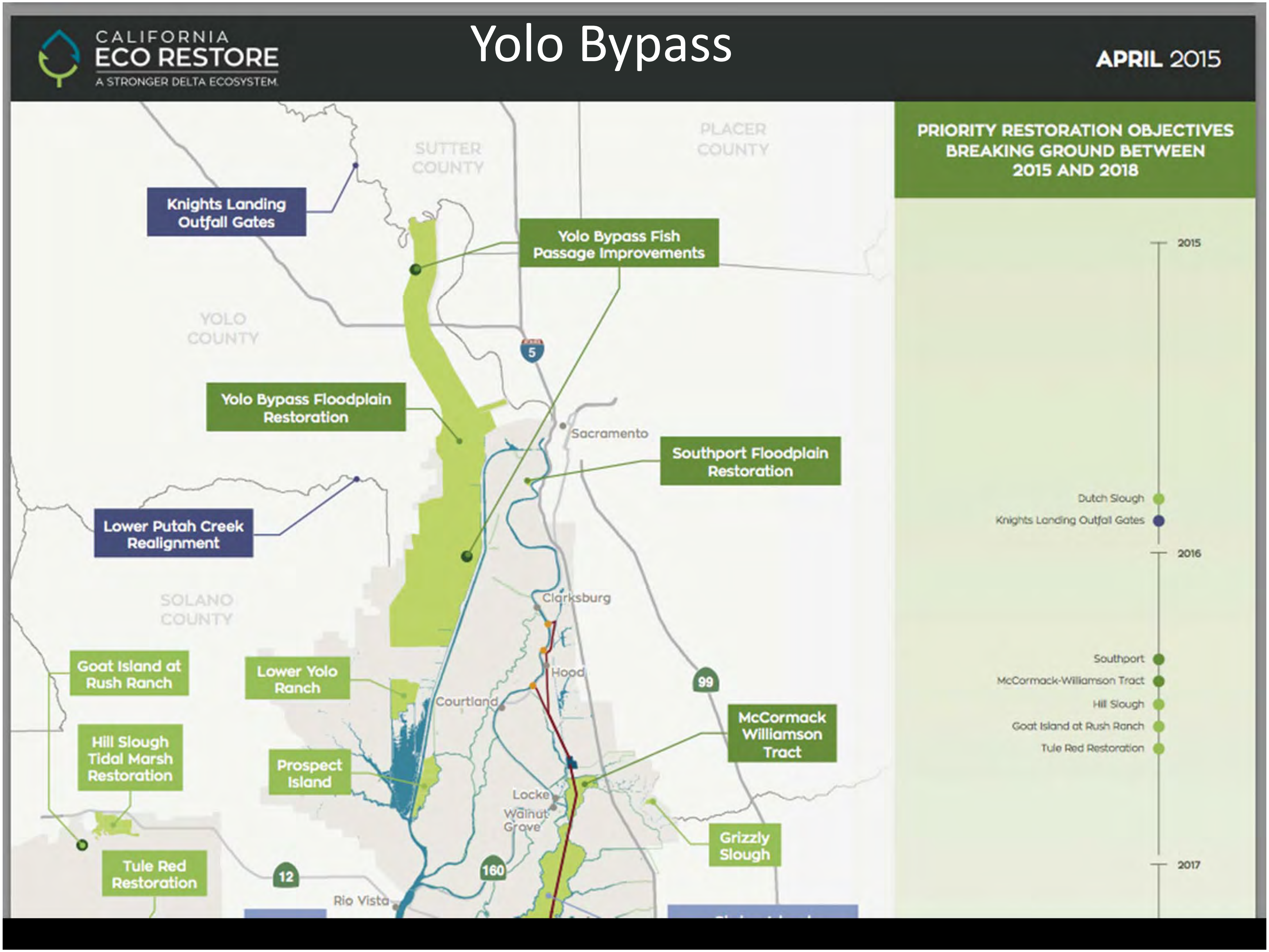
SPAWNING	FALL RUN			L.FALL RUN			WINTER RUN			SPRING RUN		
	EARLY	PEAK	LATE	EARLY	PEAK	LATE	EARLY	PEAK	LATE	EARLY	PEAK	LATE
TIME	OCT1		DEC31	JAN1		APR15	APR16		AUG15	AUG16		SEP30
EMERGE	DEC10		APR2	APR3		JUN27	JUN28		OCT18	OCT19		DEC9
DEC	34			166	122	89	89	65	45	45	41	34
mid month	37			181	136	99	99	73	49	49	45	37
JAN	41			200	150	110	110	80	54	54	49	41
	45			219	166	122	122	89	59	59	54	45
FEB	49	[illegible]		244	181	136	136	99	65	[illegible]	59	49
	54	[illegible]		270	200	150	150	110	73	[illegible]	65	54
MAR	59	41			219	166	166	122	80	80	73	59
	65	45			244	181	181	136	89	89	80	65
APR	73	49	34	34	270	200	200	150	99	99	89	73
	80	54	37	37		219	219	166	110	110	99	80
MAY	89	59	41	41		244	244	181	122	122	110	89
	99	65	45	45	34	270	270	200	136	136	122	99
JUN	110	73	49	49	37			219	150	150	136	110
	122	80	54	54	41			244	166	166	150	122
JUL	136	89	59	59	45	34	34	270	181	181	166	136
	150	99	65	65	49	37	37		200	200	181	150
AUG	166	110	73	73	54	41	41		219	219	200	166
	181	122	80	80	59	45	45	34	244	244	219	181
SEP	200	136	89	89	65	49	49	37	270	270	244	200
	219	150	99	99	73	54	54	41			270	219
OCT	244	166	110	110	80	59	59	45				244
	270	181	122	122	89	65	65	49	34	34		270
NOV		200	136	136	99	73	73	54	37	37	34	
		219	150	150	110	80	80	59	41	41	37	
DEC		244	166	166	122	89	89	65	45	45	41	34
		270	181	181	136	99	99	73	49	49	45	37

Sutter Floodplain Fatty photos:
NOAA’s Alex Huron, Jeremy Notch and Flora Cordoleani

Photo:NOAA's Alex Huron, Jeremy Notch and Flora Cordoleani

Fish Gotta Eat Too!

Yolo Bypass


CALIFORNIA
ECO RESTORE
A STRONGER DELTA ECOSYSTEM
APRIL 2015
PRIORITY RESTORATION OBJECTIVES BREAKING GROUND BETWEEN 2015 AND 2018
2015
Dutch Slough
Knights Landing Outfall Gates
2016
Southport
McCormack-Williamson Tract
Hill Slough
Goat Island at Rush Ranch
Tule Red Restoration
2017
SUTTER COUNTY
PLACER COUNTY
YOLO COUNTY
SOLANO COUNTY
Knights Landing Outfall Gates
Yolo Bypass Fish Passage Improvements
Yolo Bypass Floodplain Restoration
Sacramento
Southport Floodplain Restoration
Lower Putah Creek Realignment
Clarksburg
Hood
Courtland
Goat Island at Rush Ranch
Lower Yolo Ranch
Hill Slough Tidal Marsh Restoration
Prospect Island
McCormack Williamson Tract
Locke
Walnut Grove
Grizzly Slough
Tule Red Restoration
Rio Vista
5
99
12
160

A Cooperative Partnership

California Trout

The California Department of Water Resources

The UC Davis Center for Watershed Science

Cal Marsh and Farm Ventures, LLC

Knaggs Ranch & Conaway Ranch

The U.S. Bureau of Reclamation

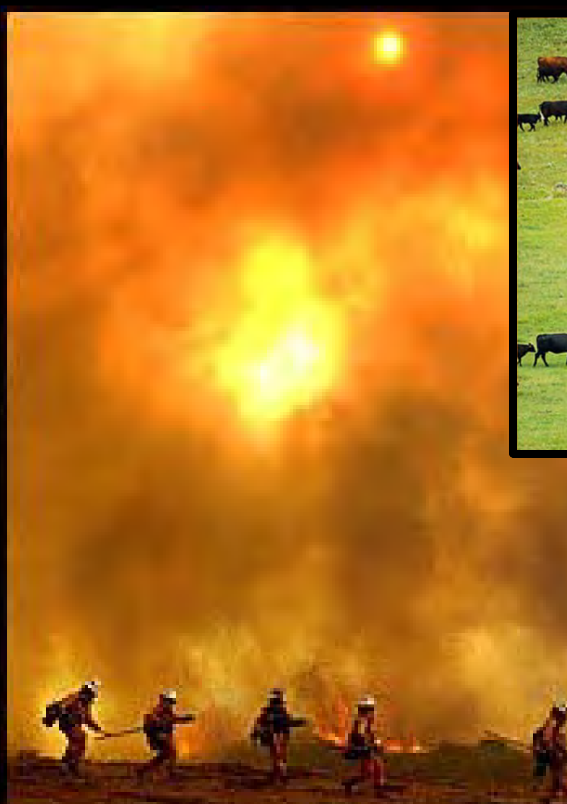
NOAA – Southwest Fisheries

Questions?

Carson Jeffres

Process-Based Reconciliation

Integrating a working knowledge of natural process, into management of natural resources



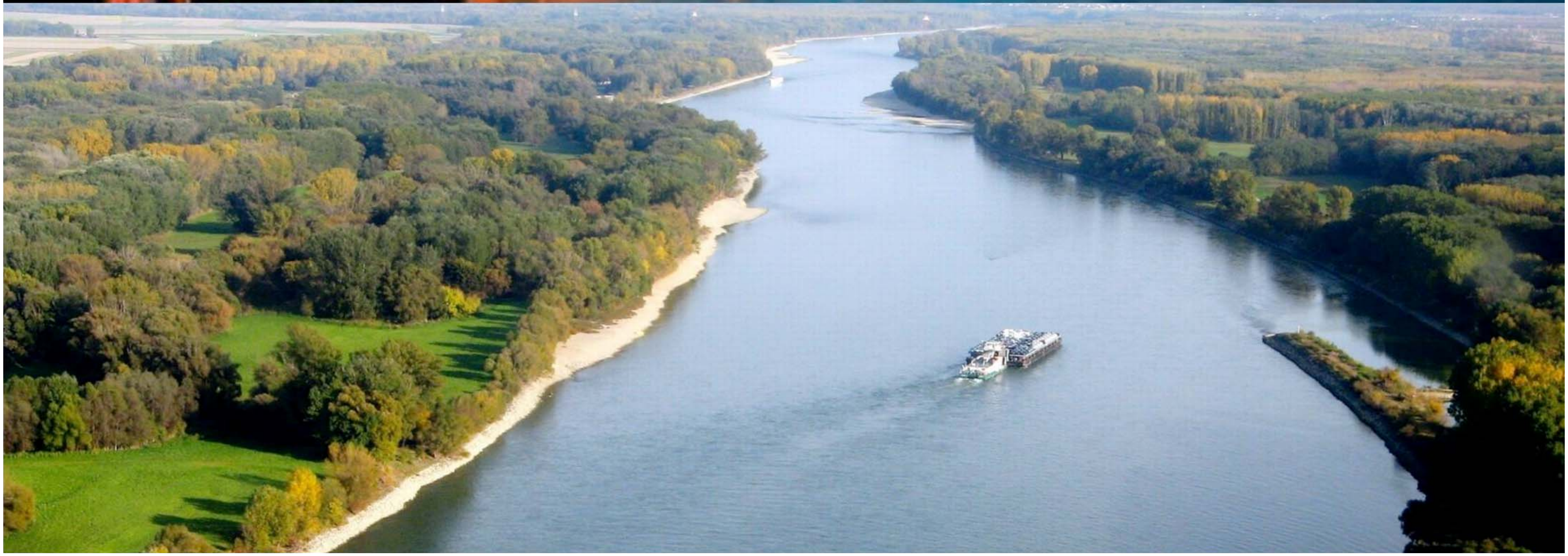

Thames


Mississippi


Seine


Thames


Danube




Smithsonian

Rice Can Help Save Salmon If Farms Are Allowed to Flood

The Nigiri Project aims to restore the beloved fish by cutting a notch in a California levee and letting some floodplains return to nature

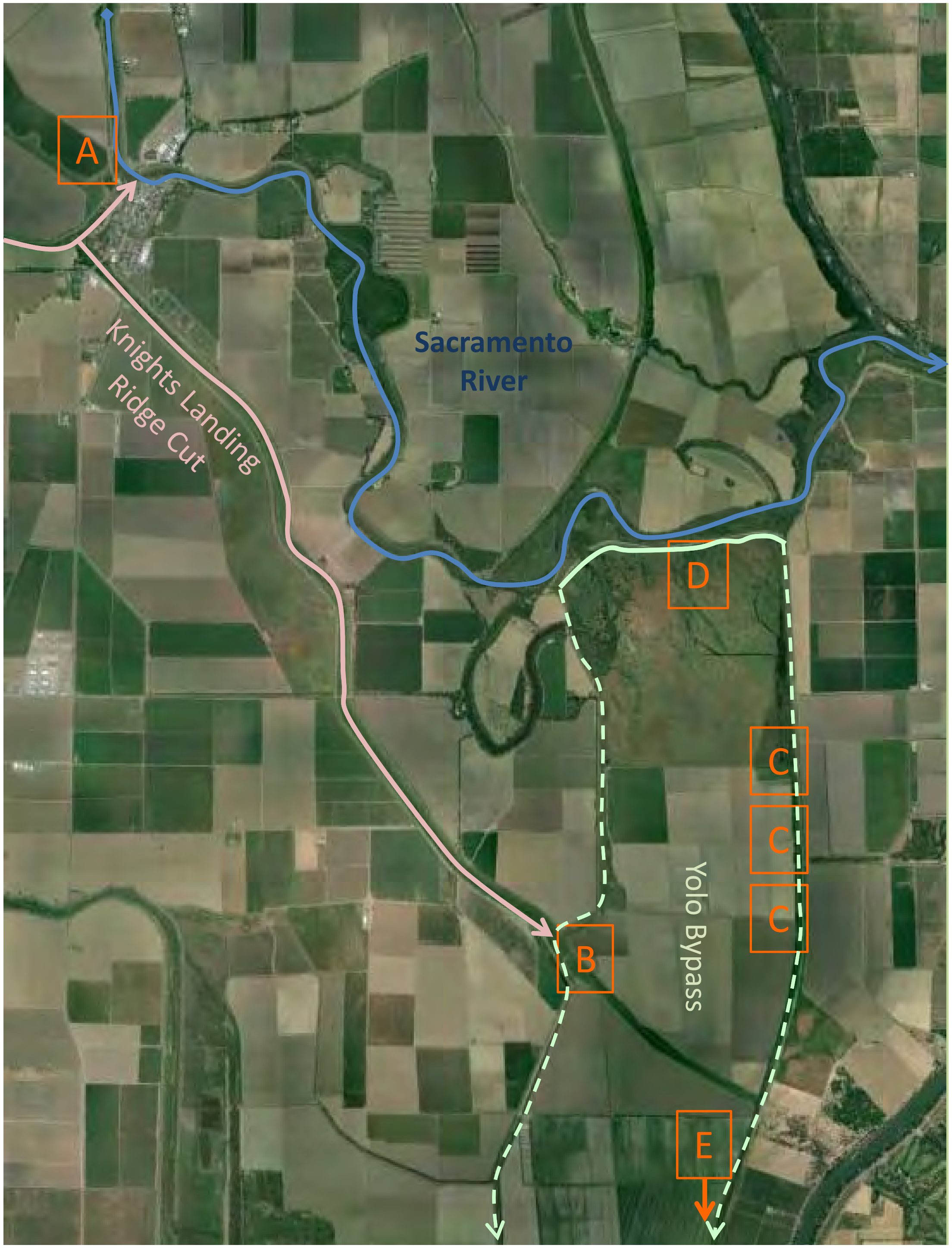
Jacob Katz stands atop a long, narrow wall of rock and gravel, gazing east over an expanse of off-season rice fields a few miles west of Sacramento. The sky is winter gray and the levee clay is damp and sticky after a brief morning shower.

CALIFORNIA TROUT

FISH · WATER · PEOPLE

"When some people look out here, they see a field of mud," says Katz, a fishery biologist with the conservation group California Trout. "I see the potential for a biological solar panel that can power our entire river system."

By Alastair Bland
March 23, 2015



Near-Term **EcoRestore** & 2009 Biological Opinion Fish Passage Projects

A	Knights Landing Outfall Gates	
B	Wallace Weir	2009 BiOp
C	Tule Ag. Crossings	2009 BiOp
D	Fish Ladder Modifications	2009 BiOp
E	Lisbon Weir	2009 BiOp

In advance of the Nov. 2015 completion of the voluntary Knights Landing Outfall Gates fish barrier, efforts are pivoting towards implementation of near-term fish passage projects per the 2009 BiOP. Wallace Weir will likely be pursued first (target groundbreaking in Summer 2016). Tule Ag. Crossings, Lisbon Weir, and Fremont Weir Fish Ladder modifications will be pursued simultaneously, with planned groundbreaking in 2017. Together, these efforts will effectively eliminate stranding in the Colusa Basin and significantly improve adult fish passage within the Bypass and across the Fremont Weir.

Time now to put the science into action and scale up

Use it to update obsolete water infrastructure built 100 years ago before anyone cared about fish

Working towards a mutually preferred alternative that creates greatest fish benefit, sustains ag and improves flood safety