Acoustic Telemetry – Salmon Migration and Survival Study, Sacramento River, Knights Landing to the Delta

Natalie McNair
U.S. Army Corps of Engineers, Sacramento District

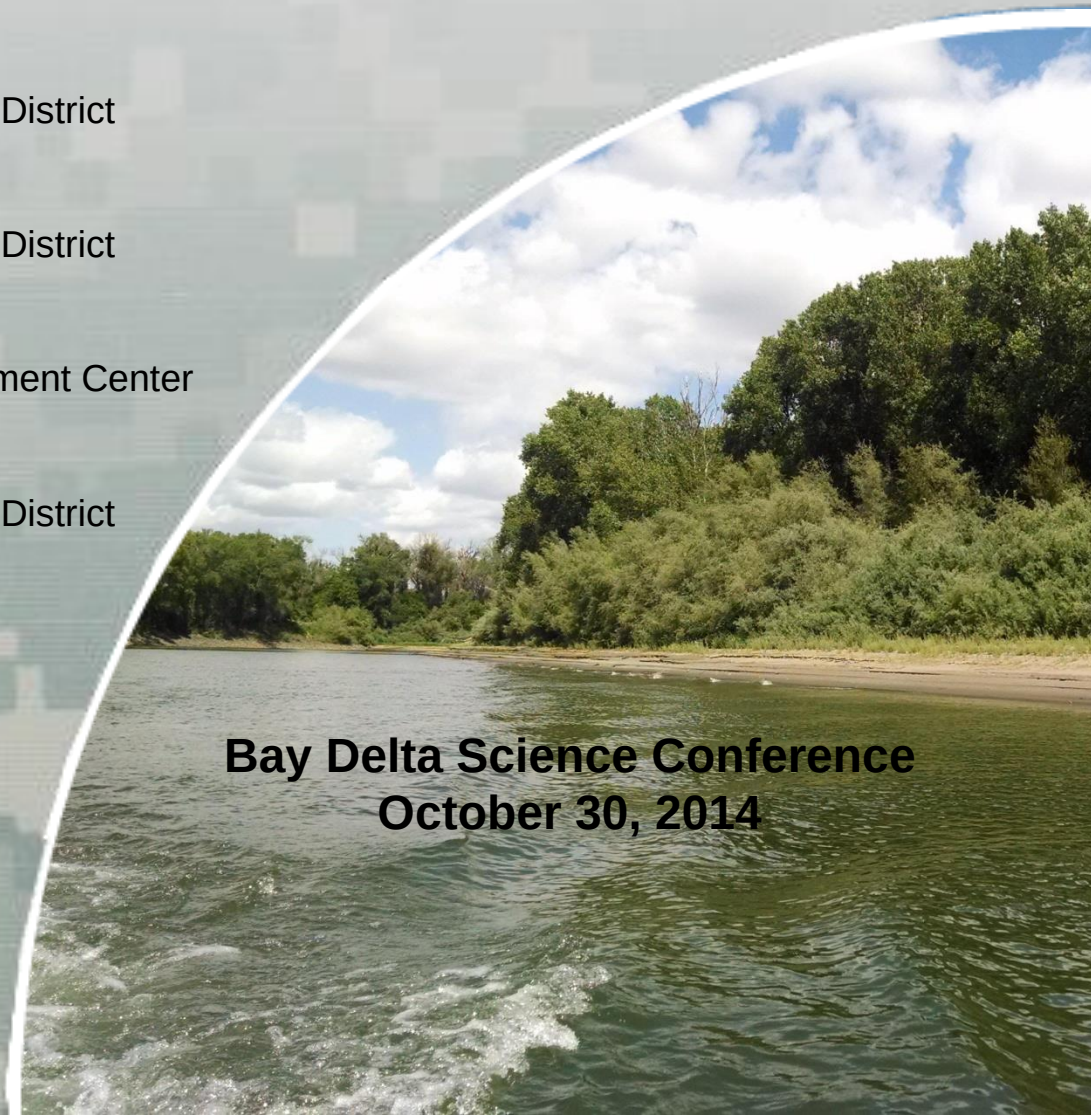
Brian Mulvey
U.S. Army Corps of Engineers, Sacramento District

David Smith
U.S. Army Engineer Research and Development Center

Michael Fong
U.S. Army Corps of Engineers, Sacramento District

Anna Smith
U.C. Davis

Gabriel Singer
U.C. Davis



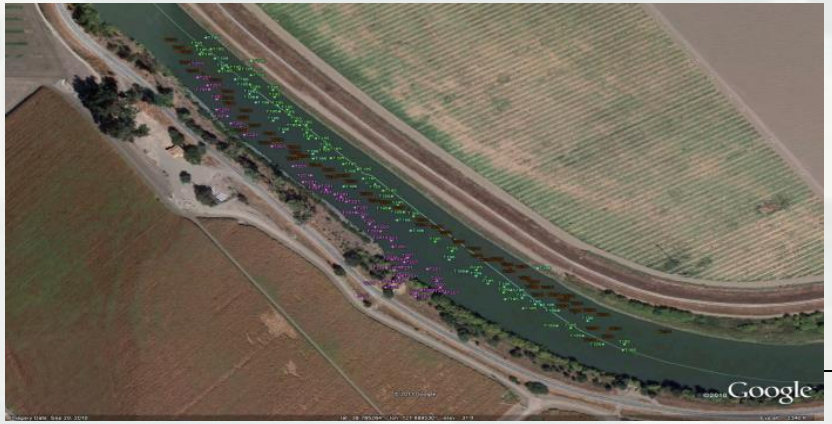
Bay Delta Science Conference
October 30, 2014

US Army Corps of Engineers
BUILDING STRONG®

Background

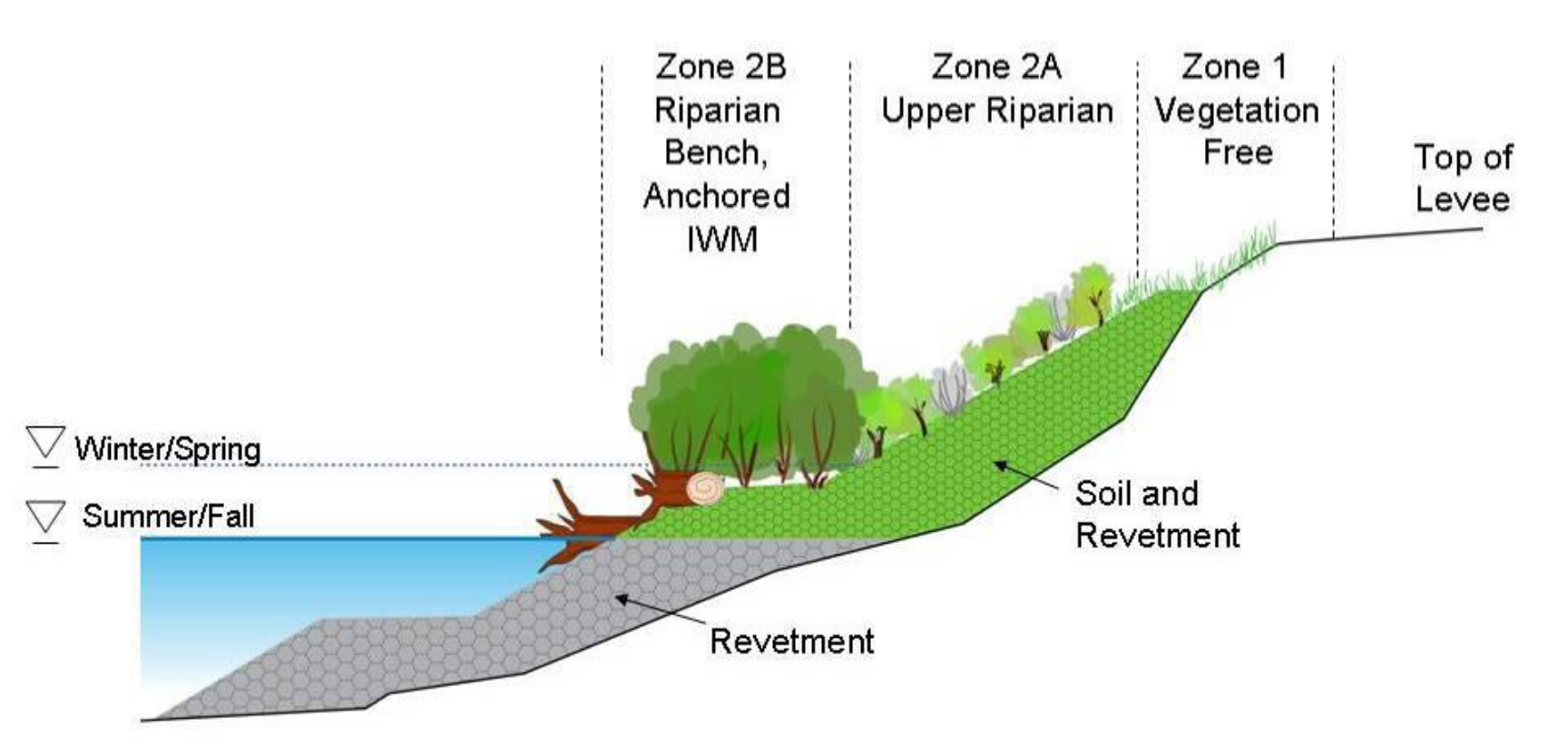
Project - Sacramento River Bank Protection Project

Problem - Repair Erosion While Restoring Fish Habitat



Tools - Modeling, E-Fishing, Monitoring and 2D Fish Tracking

Background


Zone 2B
Riparian
Bench,
Anchored
IWM
Zone 2A
Upper Riparian
Zone 1
Vegetation
Free
Top of
Levee
Winter/Spring
Summer/Fall
Soil and
Revetment
Revetment

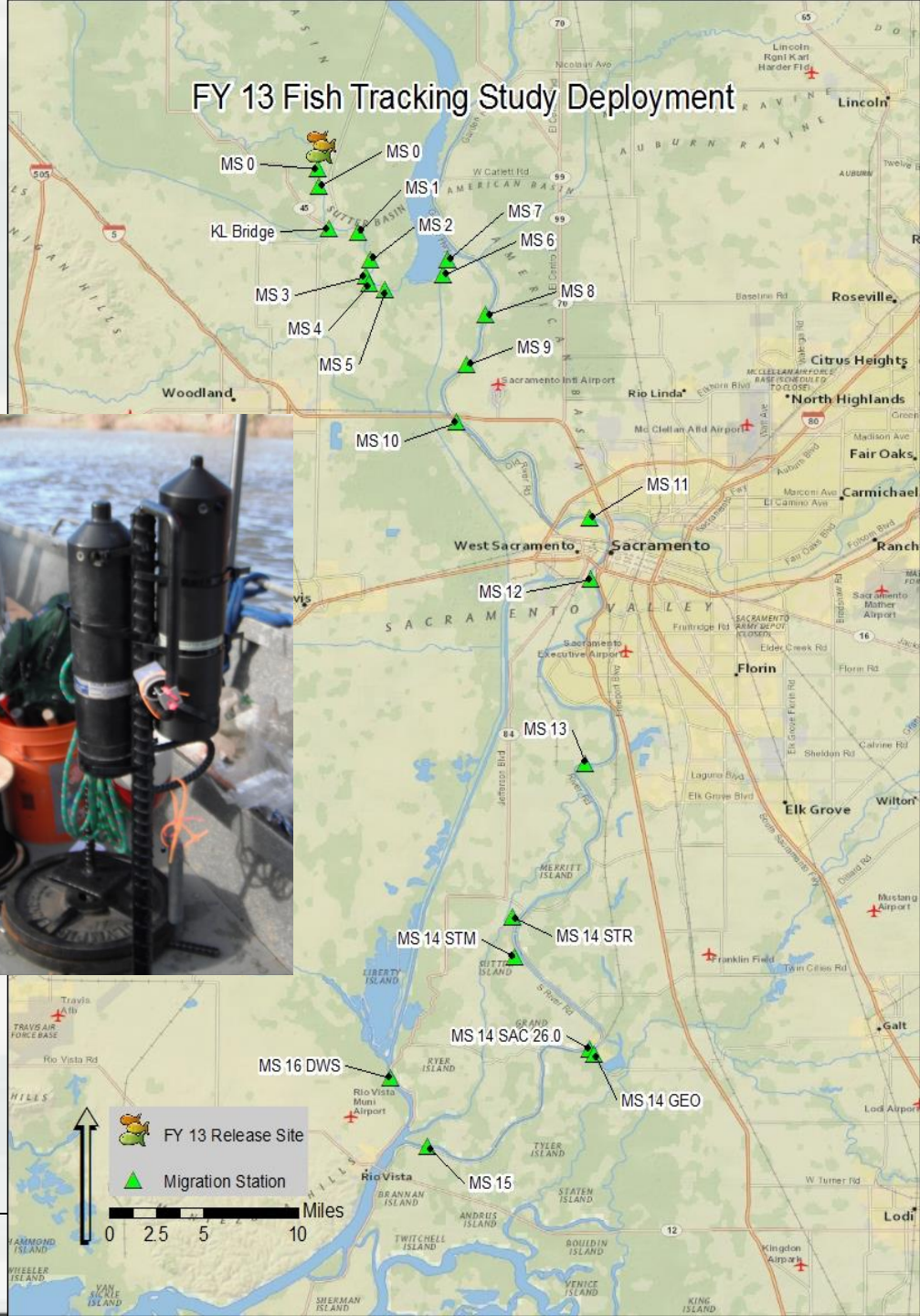
Tagging and Release

- Used V5 and V8 tags
- Total:
  - 148 STH
  - 615 LFC
- Analysis only completed on LFC

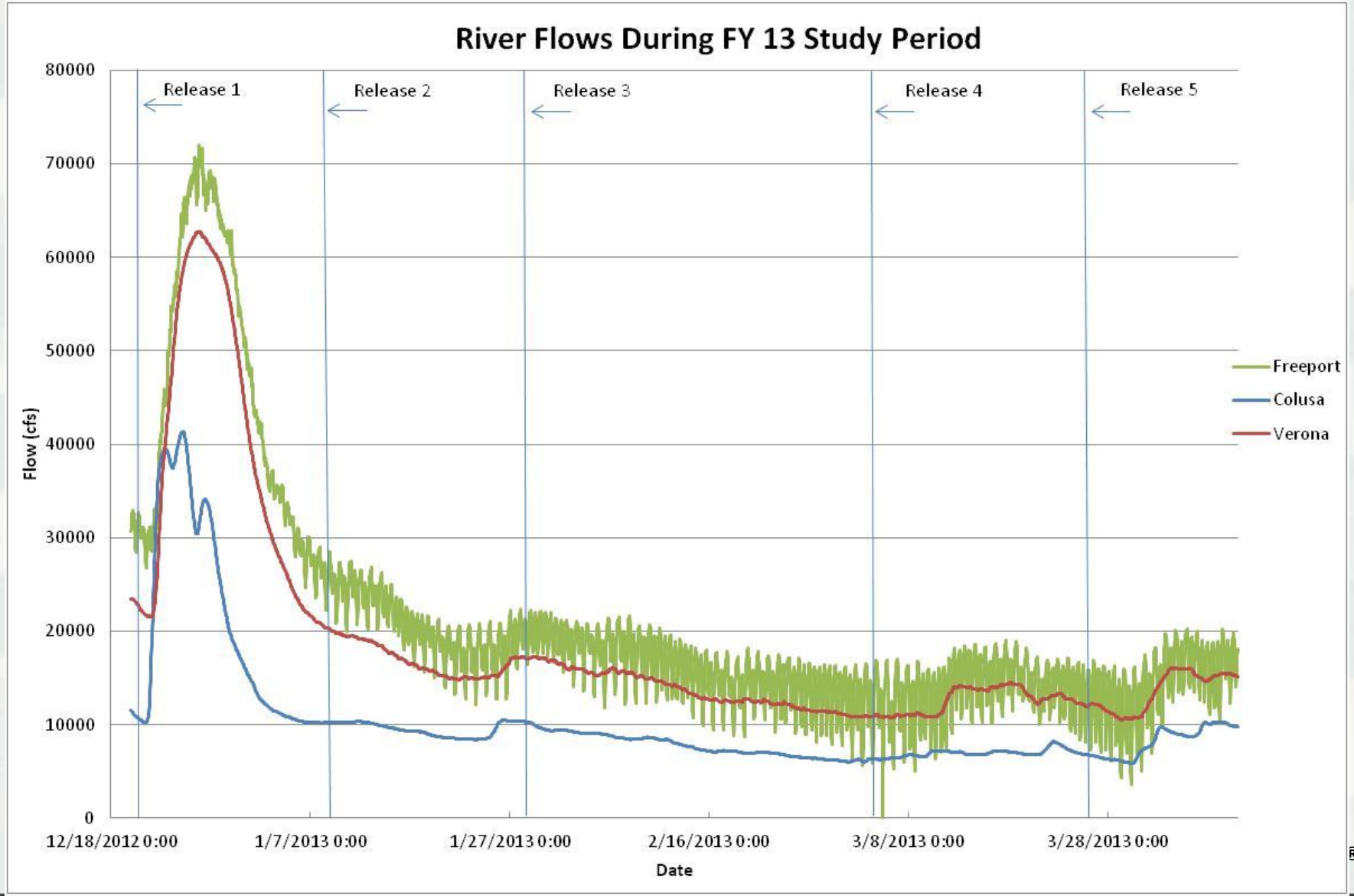
Group ID	Species	# Released	Date Released
1a	STH	25	12/19/2012
1b	LFC	95	12/20/2012
2a	STH	25	1/9/2013
2b	LFC	100	1/10/2013
3a	STH	25	1/29/2013
3b	LFC	100	1/30/2013
4a	STH	25	3/5/2013
4b	LFC	10	3/5/2013
4c	LFC	100	3/6/2013
5a	STH	78	3/26/2013
5b&c	LFC	210	3/27/2013

Array

- 18 acoustic gates (migration stations)
  - Knights Landing and Rio Vista
  - Sacramento River Mile 93 to 15
- Sixty-seven 180kHz and forty 69kHz receivers deployed



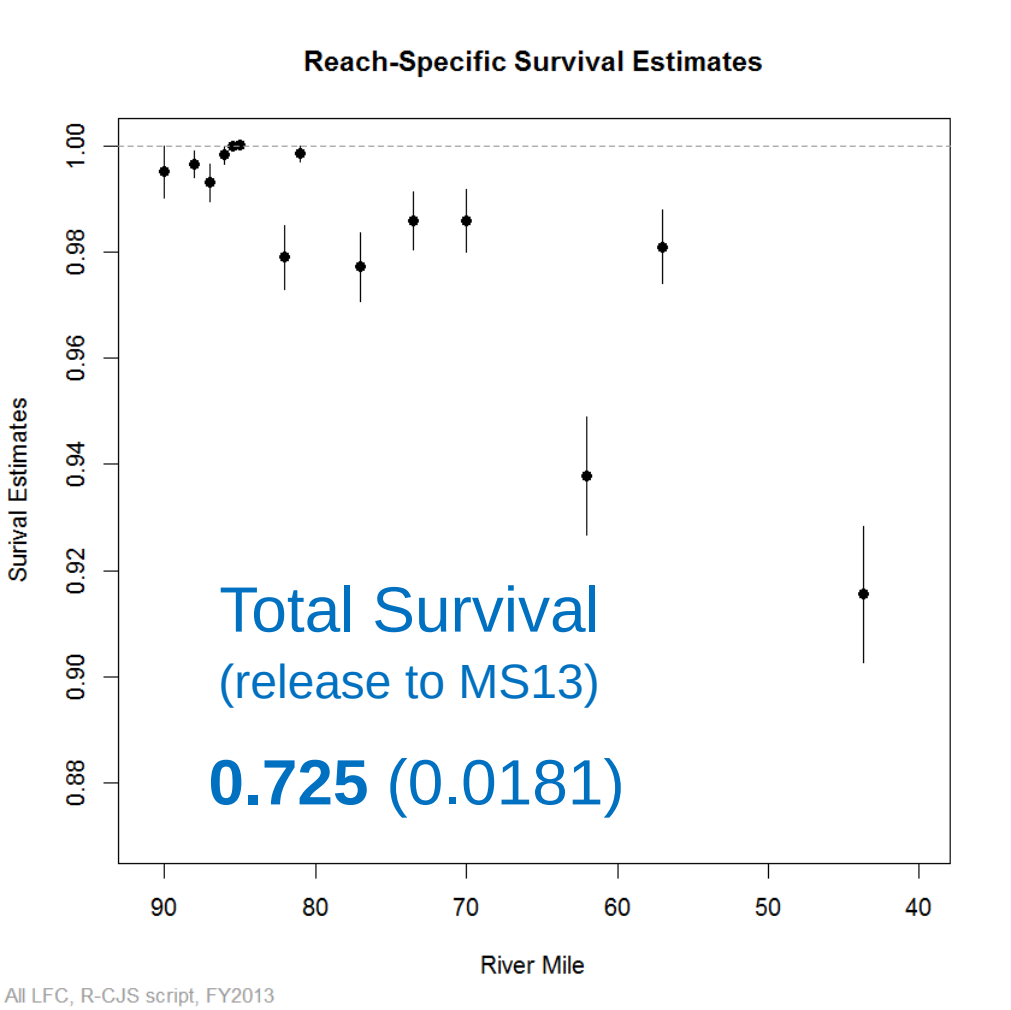
Sacramento River Flows



Analysis

- Survival analysis
  - Cormack-Jolly-Seber mark-recapture
- Migration speeds
- Ecological interactions
  - habitat
  - predation

Results: Survival



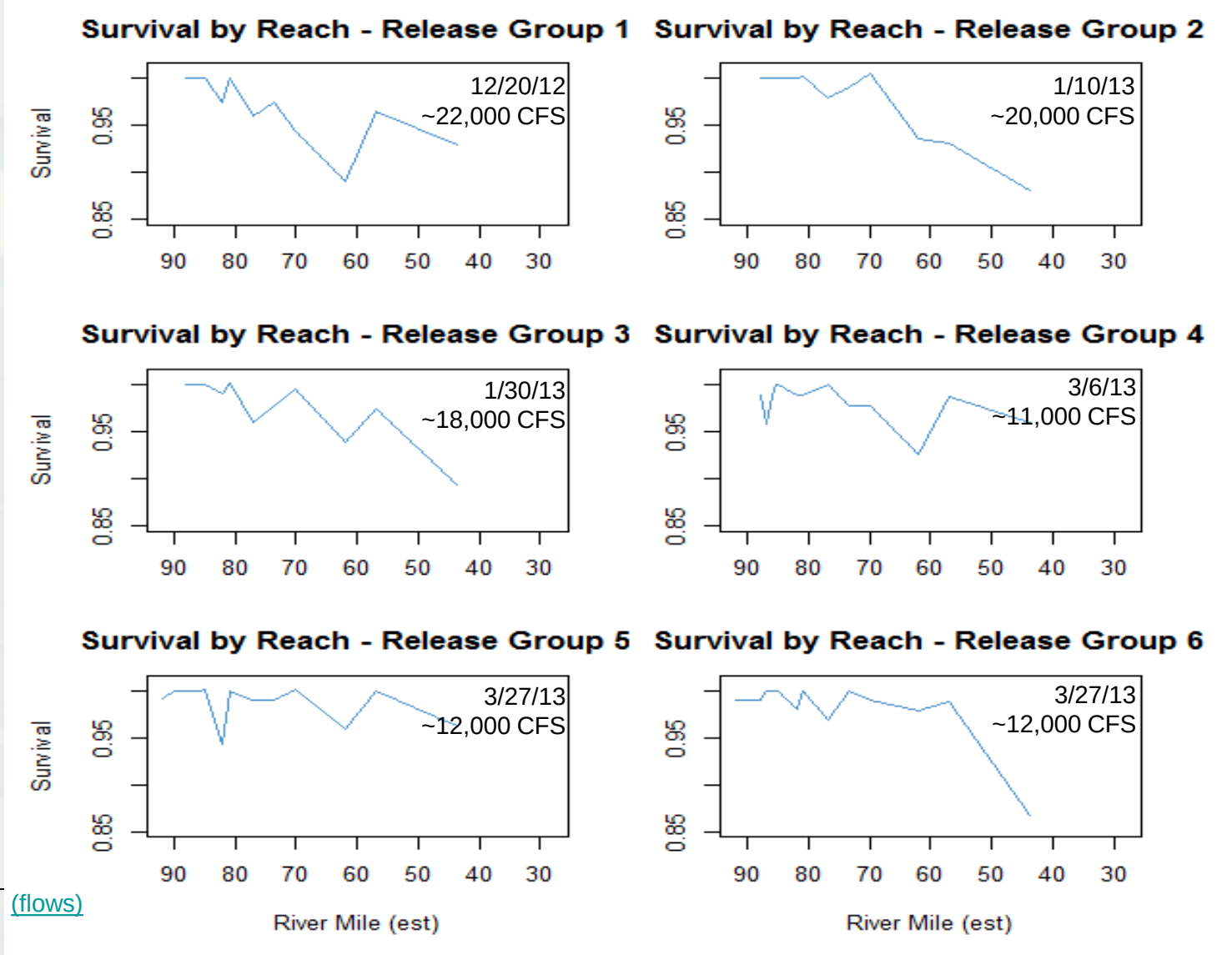
Station	estRM	ϕ	se(ϕ)
MS00	92	0.961	0.026
KLB	90	0.997	0.006
MS01	88	0.997	0.005
MS02	87	0.993	0.018
MS03	86	0.998	0.005
MS04	85.5	1.000	0.000
MS05	85	1.000	0.000
→ MS06	82	0.979	0.021
MS07	81	0.999	0.005
→ MS08	77	0.976	0.017
MS09	73.5	0.985	0.010
MS10	70	0.985	0.022
→ MS11	62	0.938	0.030
MS12	57	0.974	0.025
→ MS13	43.7	0.914	0.041

(map) (flows)

BUILDING STRONG®

* These means do not include data from release 4b (10 fish)

Results: Survival

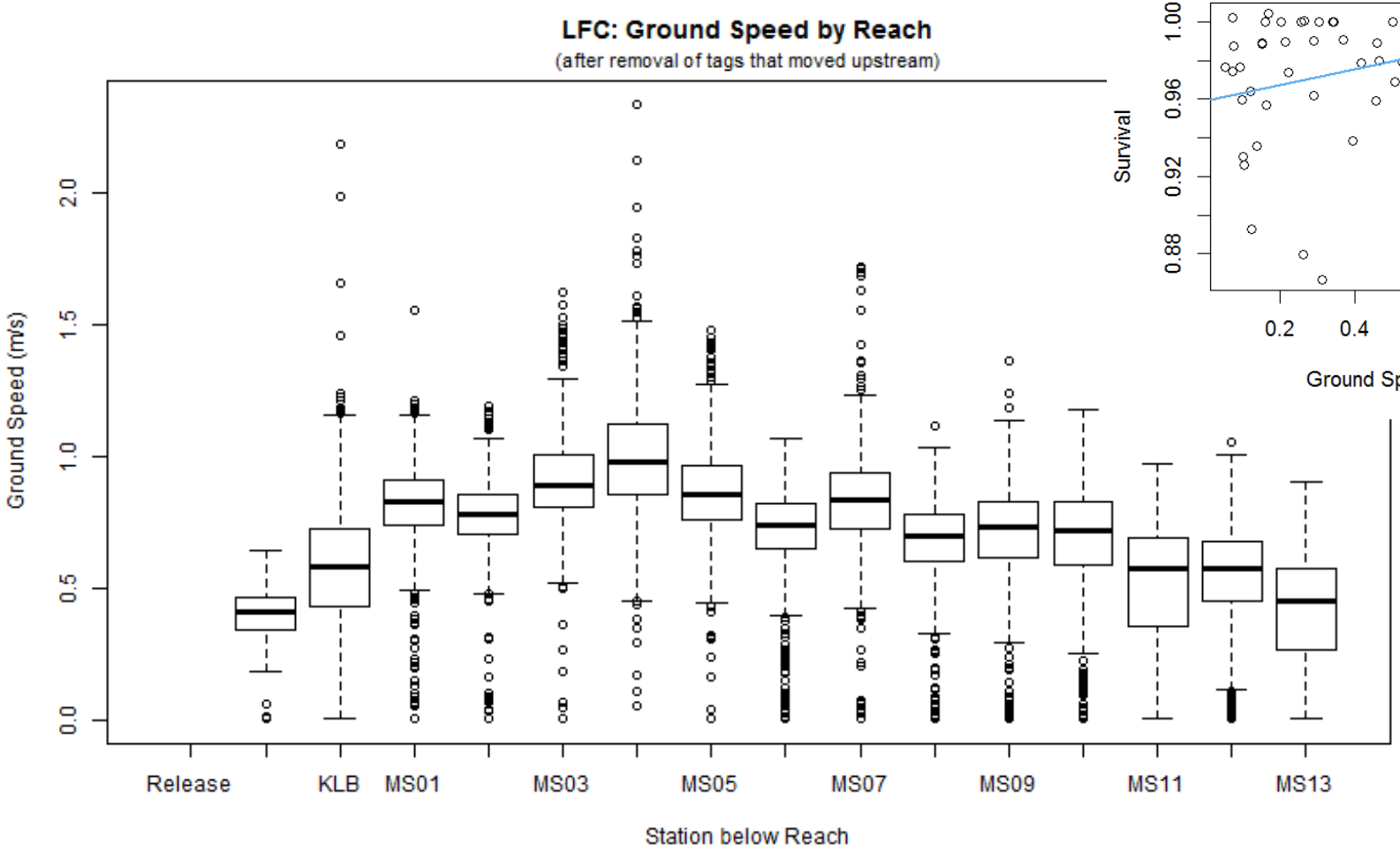


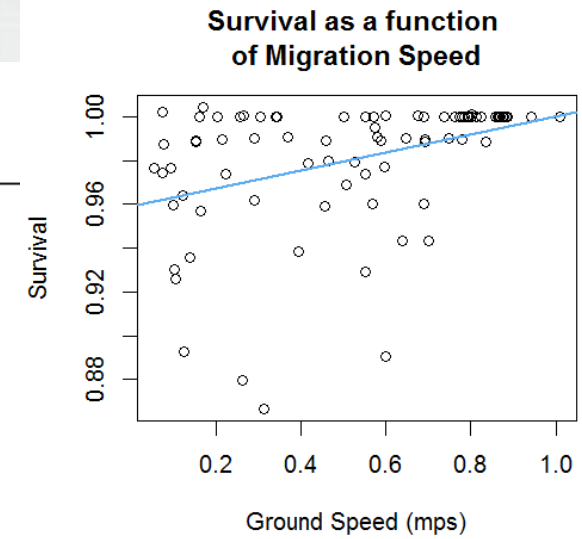
Station	estRM
MS00	92.0
KLB	90.0
MS01	88.0
MS02	87.0
MS03	86.0
MS04	85.5
MS05	85.0
MS06	82.0
MS07	81.0
MS08	77.0
MS09	73.5
MS10	70.0
MS11	62.0
MS12	57.0
MS13	43.7
>MS13	28.0

(map) (flows)

STRONG®

Results: Migration Speed



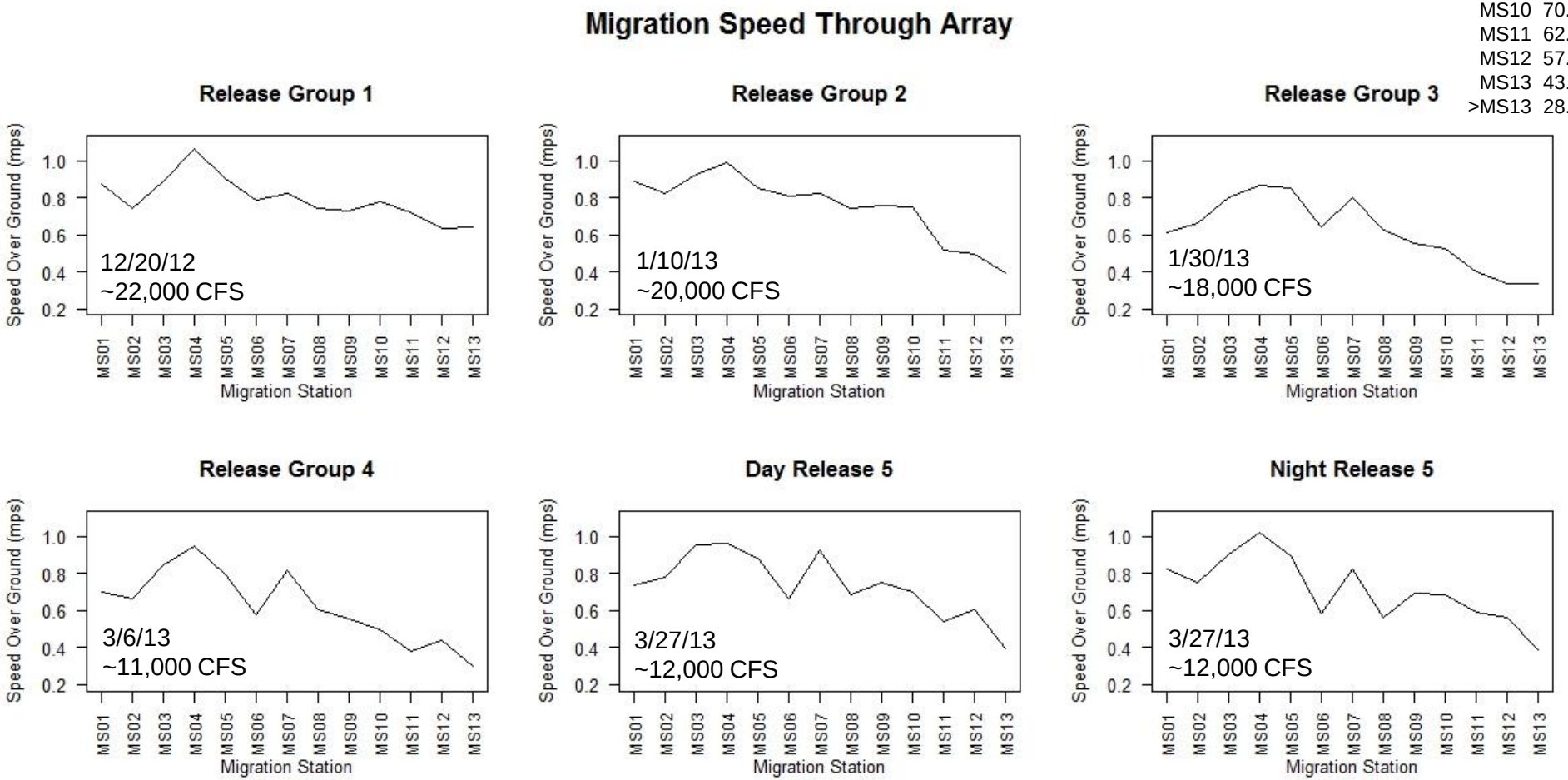


(map) (flows)

BUILDING STRONG®

Results: Migration Speed

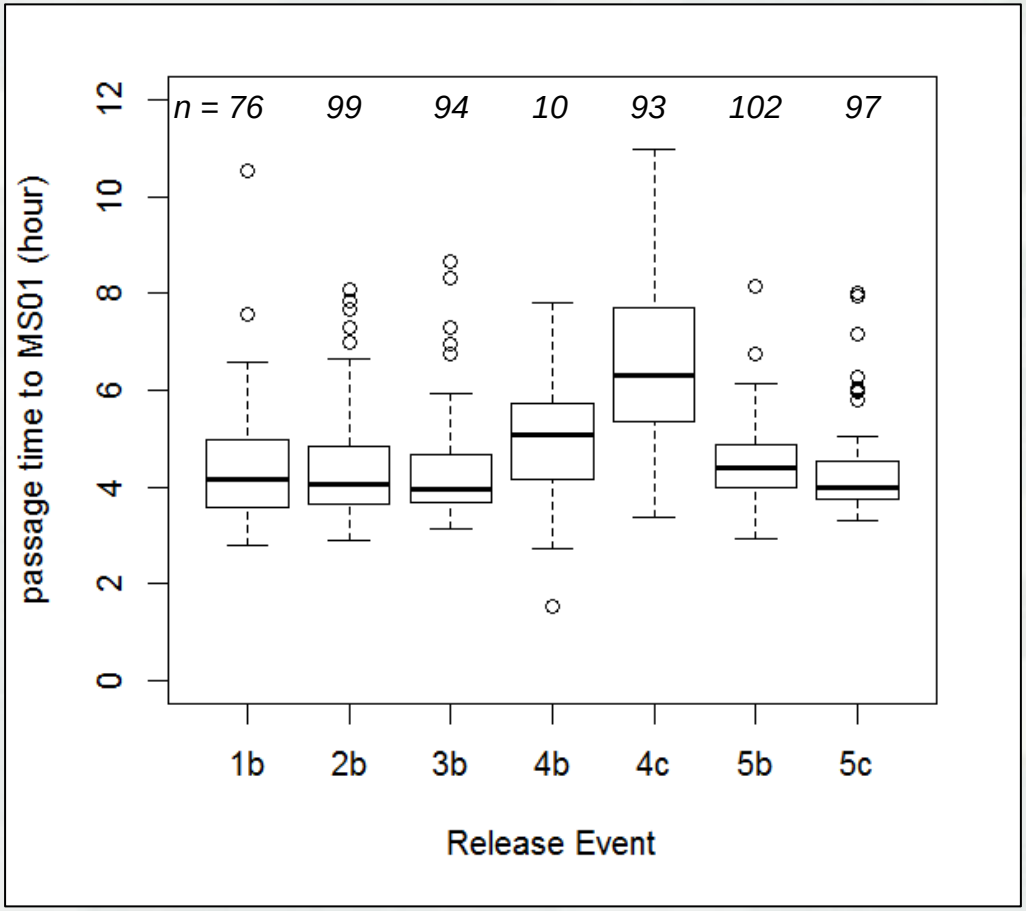
Station	estRM
MS00	92.0
KLB	90.0
MS01	88.0
MS02	87.0
MS03	86.0
MS04	85.5
MS05	85.0
MS06	82.0
MS07	81.0
MS08	77.0
MS09	73.5
MS10	70.0
MS11	62.0
MS12	57.0
MS13	43.7
>MS13	28.0



(map) (flows)

*Approximate flows at Verona

Results: Initial Movement

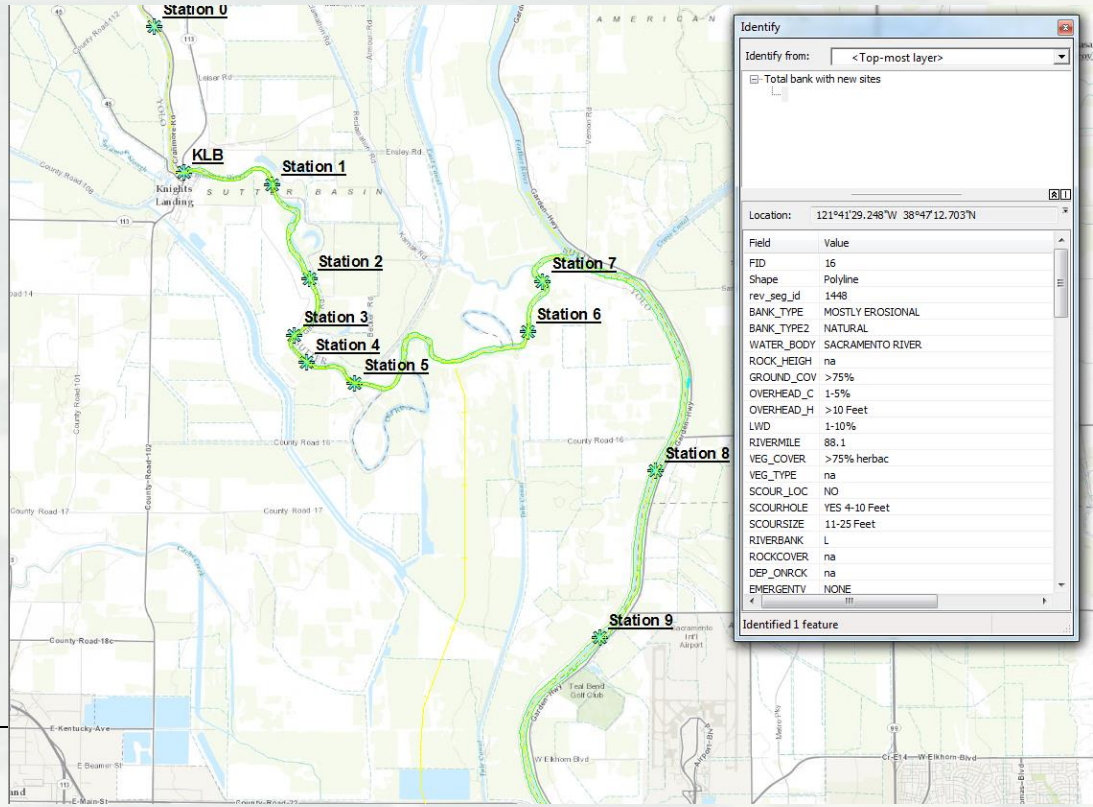


Release Event	Release Time	Arrival Time	Migration Speed
1b	12/20/2012 14:00	12/20/2012 18:22	0.19 mps
2b	1/10/2013 13:30	1/10/2013 17:28	0.20 mps
3b	1/30/2013 13:30	1/30/2013 17:45	0.19 mps
4b	3/5/2013 13:20	3/5/2013 18:24	---
4c	3/6/2013 13:25	3/6/2013 20:05	0.16 mps
5b	3/27/2013 14:30	3/27/2013 18:56	0.21 mps
5c	3/27/2013 23:20	3/28/2013 3:39	0.21 mps

Results: Bank Habitat

- USACE Revetment Database
  - ► Bank lengths were ranked and assigned categories
  - ► Shade = None, 1-5%, 6-25%, 26%-75%, >75%

- Transformed habitat characteristic data to an index for regression analysis



Results: Bank Habitat

- Linear Regressions
  - Average Speed= α*Environmental Index + β
- Multiple Linear Regressions
  - Average Speed$_i$=$\beta_ø$+β_1(River Mile)+β_2(Velocity)+ε_i
  - Average Speed$_i$=$\beta_ø$+β_1(River Mile)+β_2(Environmental Index)+ε_i
- Multiple Linear Regression (Final Model)
  - Average Speed$_i$=$\beta_ø$+β_1(SRA Index)+β_2(Veg Index)+ β_3(River Mile)+ β_4(Average Reach Velocity)+ β_5(Release Group)+ ε_i

Results: Bank Habitat

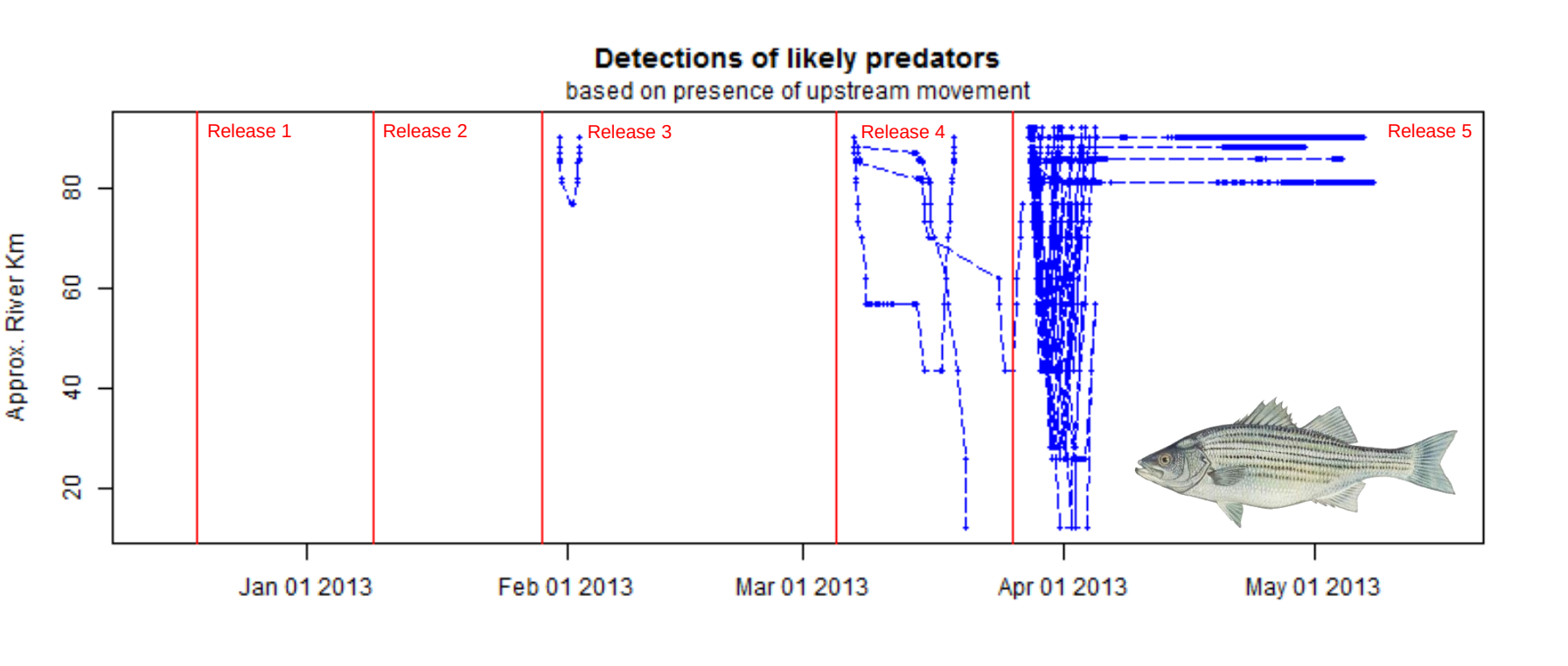
- River mile most significant with small effect size
- Vegetation had largest effect, slowing fish down
- Shade and velocity were also significant
- IWM was dropped from the final model due to colinearity with shade and insignificance in prior models

	Coefficient	Std. Error	t-Statistic	Probability		R^2	Adjusted R^2
SRA Index	0.1600	0.0576	2.78	0.0074	**		
Veg Index	-0.8181	0.1581	-5.18	3.18E-06	***		
Velocity	0.2245	0.0784	2.87	0.0059	**		
River Mile	0.0151	0.0013	12.02	2.00E-16	***		
Release 1	0.1929	0.1661	1.16	0.2506			
Release 2	0.1844	0.1574	1.17	0.2464			
Release 3	0.2248	0.1570	1.43	0.1579			
Release 4	0.1227	0.1530	0.80	0.4261			
Release 5	0.2203	0.1533	1.44	0.1561			
Release 5N	0.2047	0.1533	1.34	0.1870		0.9932	0.992

Discussion: Bank Habitat

- IWM results inconsistent with results from FishBio's side scan and e-fishing work
  - Hatchery vs. wild fish
  - Size and age differences
- Could be problem of scale
- Need better habitat dataset
  - In process

Results: Predation



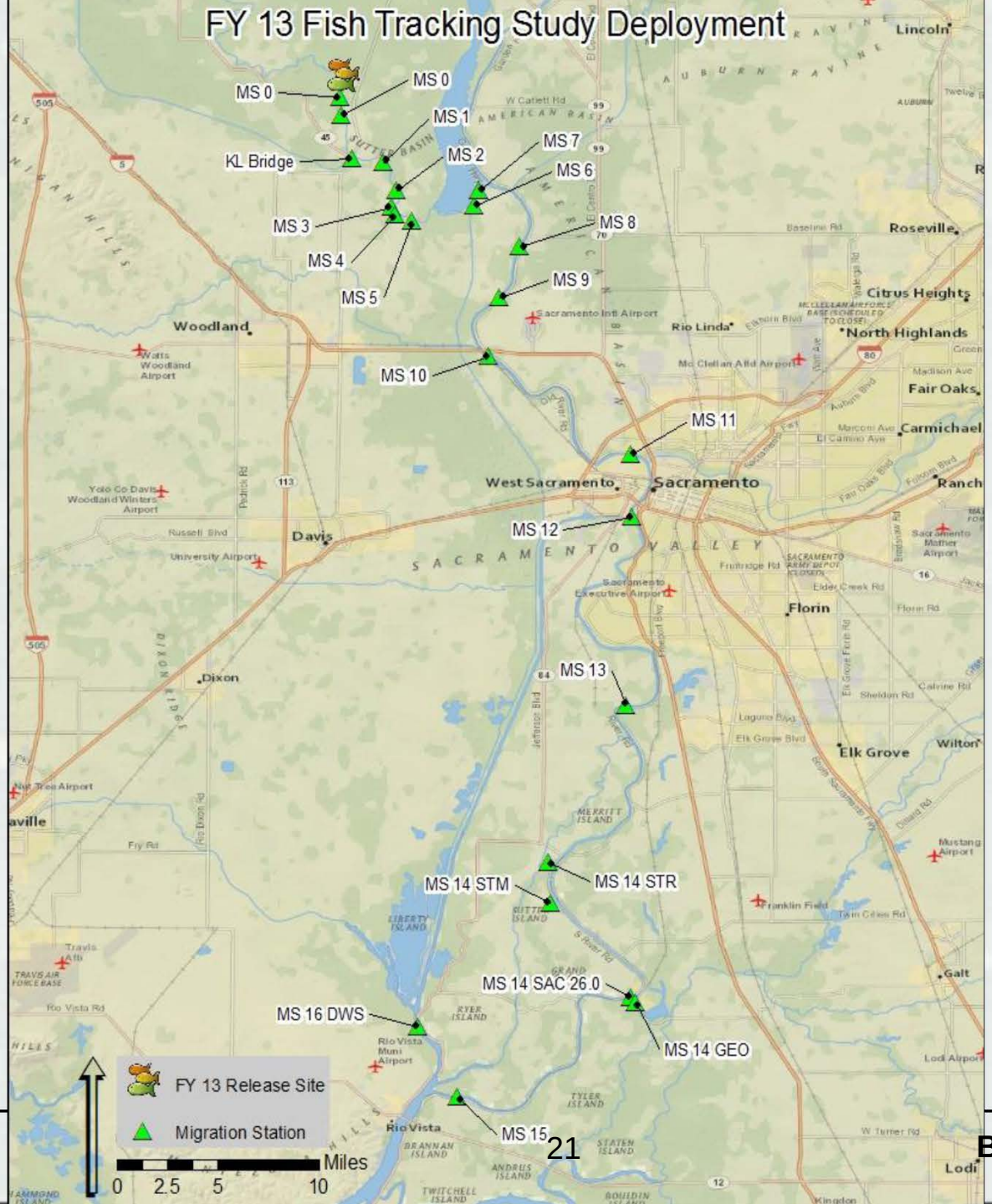
BUILDING STRONG®

Future Studies

- FY 14 – Repeated the study but with a few additional stations
  - Drought conditions
  - In process of analyzing data
- FY 15 – Plan to repeat study again but with additional 2D array at Clarksburg Bend (RM 43.7)

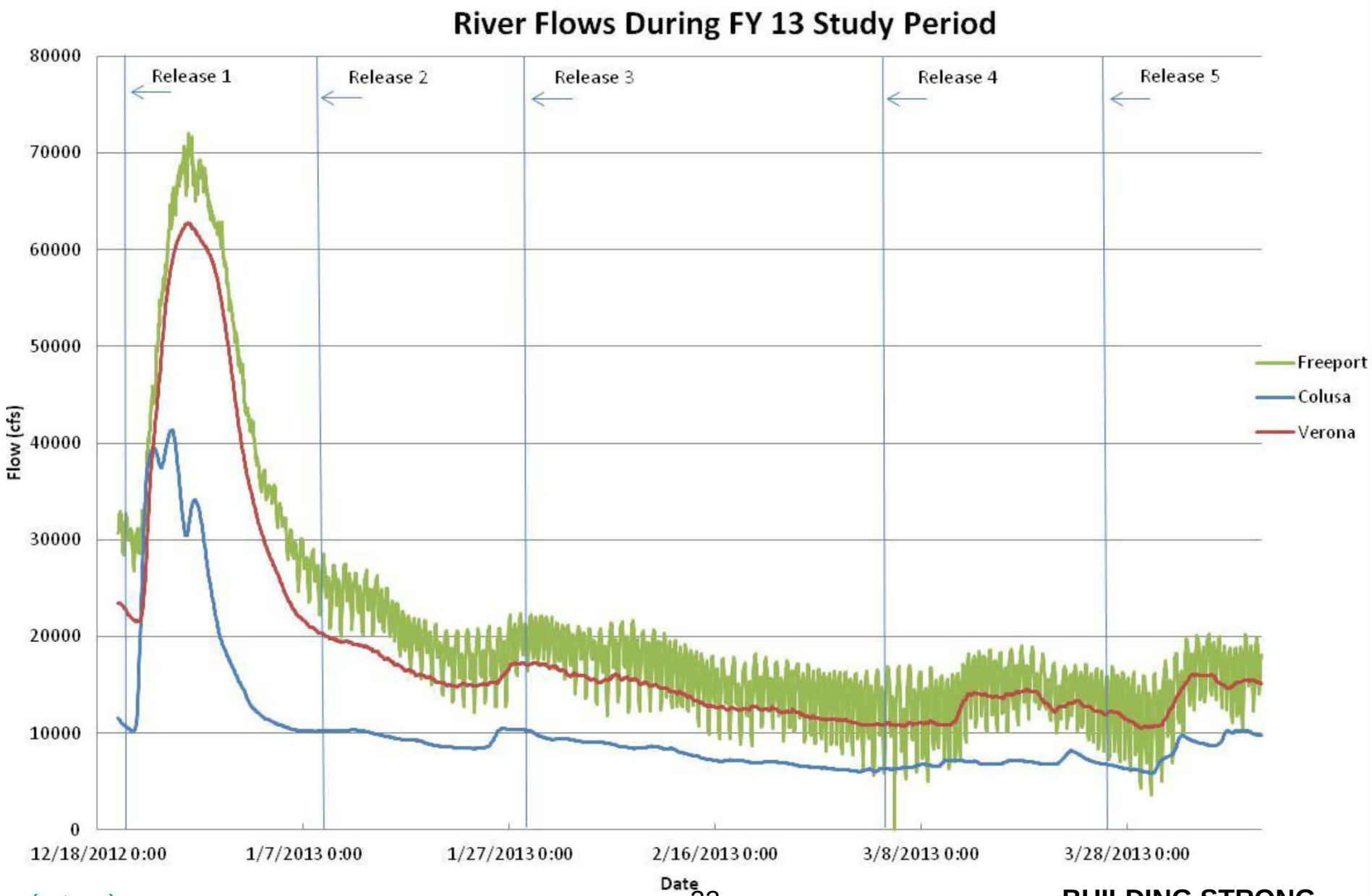
Thank You!

FY 13 Fish Tracking Study Deployment



(return)

BUILDING STRONG®



(return)

BUILDING STRONG®