+

Effectiveness Monitoring of Instream Restoration Projects - Lessons Learned and Where Do We Go From Here

A Workshop at the 36th Annual Salmonid Restoration Conference held in Fortuna, California from April 11 – 14, 2018.

Workshop Overview

- Session Coordinator:
  - Bob Pagliuco, NOAA Restoration Center
  - Ross Taylor, Ross Taylor and Associates

Restoration Project types and techniques are constantly evolving as we learn more about fish and habitat response to various types of restoration. Physical and biological monitoring at an individual project and larger watershed scale is essential to understanding these relationships. The purpose of this workshop is to explore various restoration project effectiveness monitoring approaches and learn how project and watershed level physical and biological data are helping us evaluate these projects. In addition, this workshop will have a group discussion that explores existing monitoring data and provides input on what data would be most useful to collect in the future to advance restoration effectiveness science. Presentations in this session will focus on restoration effectiveness monitoring efforts for salmon and steelhead restoration projects and be prepared to explore ideas on where we need more effectiveness monitoring data to advance restoration science.

+

Presentations

(Slide 5) The Pudding Creek BACI Experiment: A Paired Watershed Approach to Effectiveness Monitoring
Elizabeth Mackey, Trout Unlimited

(Slide 32) A Study of Aquatic Habitat and Fish Behavioral Response to Enhanced Flows in a Russian River Tributary
Gabe Rossi, UC Berkeley

(Slide 86) Tools and Methods to Monitor the Effectiveness of the Dry Creek Habitat Enhancement Project, Russian River Basin
Neil Lassettre, Sonoma County Water Agency

(Slide 123) Differing Responses of Natal and Non-natal Juvenile Coho Salmon to Restoration Actions in McGarvey Creek, a Tributary to the Lower Klamath River
Jimmy Faukner, Yurok Tribal Fisheries Program

(Slide 151) Using Science to Guide Coho Restoration In the Middle Klamath River: If You Build it, They Will Come
Toz Soto, Karuk Tribal Fisheries Program

(Slide 210) Monitoring the Physical and Biological Effects of Beaver Dam Analogues in the Klamath River Basin
Michael Pollock, PhD, NOAA Fisheries

Presentations

(Slide 239) Annual, Seasonal, and Diurnal Variation in Fish Use of Constructed Slough Habitat in the Mattole River Estuary
Nathan Queener, Mattole Salmon Group

(Slide 270) The Old Man and the SEE: Lessons Learned From 15 Years of Monitoring Coho Salmon Life History and Habitat Restoration Projects in the Stream-Estuary Ecotone
Michael Wallace, CA Department of Fish and Wildlife

(Slide 324) Effectiveness Monitoring of Fish Passage Projects in CA
Leah Mahan, NOAA Restoration Center, and Ross Taylor, Ross Taylor and Associates

(Slide 352) Temporal Patterns and Environmental Correlates of Young-of-the-Year Coho Salmon Movement Into Non-Natal Seasonal Habitats
Seth Ricker, California Department of Fish and Wildlife

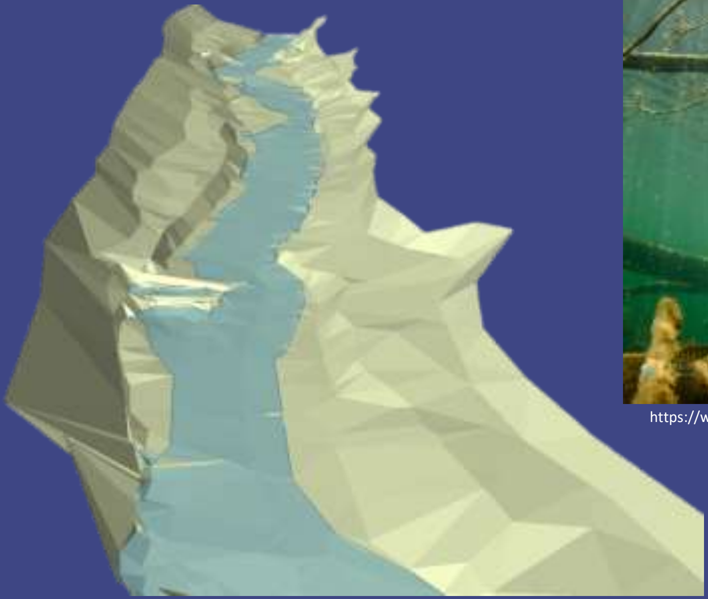
(Slide 374) Group Discussion Topics

The Pudding Creek BACI Experiment: A Paired Watershed Approach to Effectiveness Monitoring

Elizabeth Mackey
North Coast Coho Project Manager
Trout Unlimited
Fort Bragg, CA

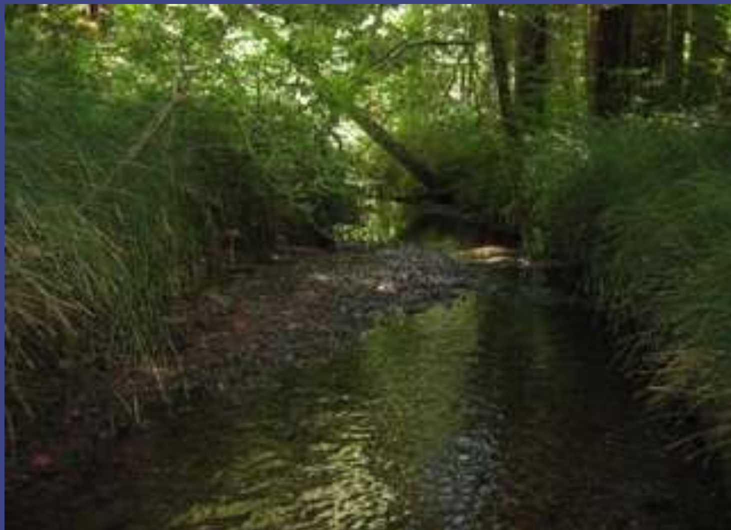
April 11, 2018


Photo Courtesy of Blencowe Watershed Management




https://www.mendocinolandtrust.org/care/salmon-recovery/a-better-home-for-salmon/

Effectiveness Monitoring



Restoration Photos Courtesy of Blencowe Watershed Management

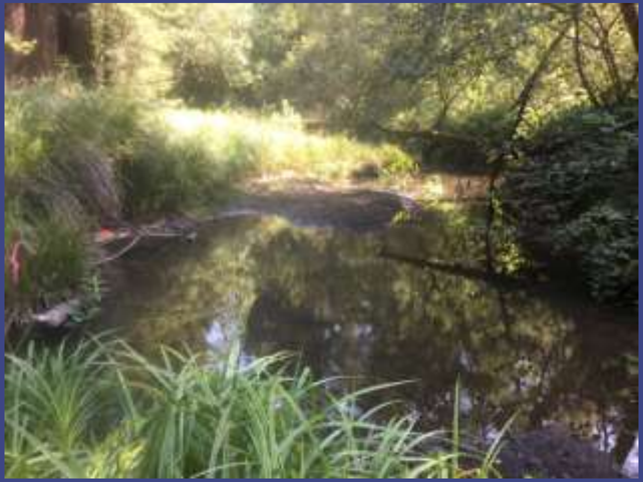
www.fishwatch.gov

Pudding Creek and Caspar Creek

Pudding Creek

- Drains watershed ~17.4 mi²
- Average BFW 20 ft
- Average gradient ~1.8%
- Supports runs of Coho Salmon and steelhead

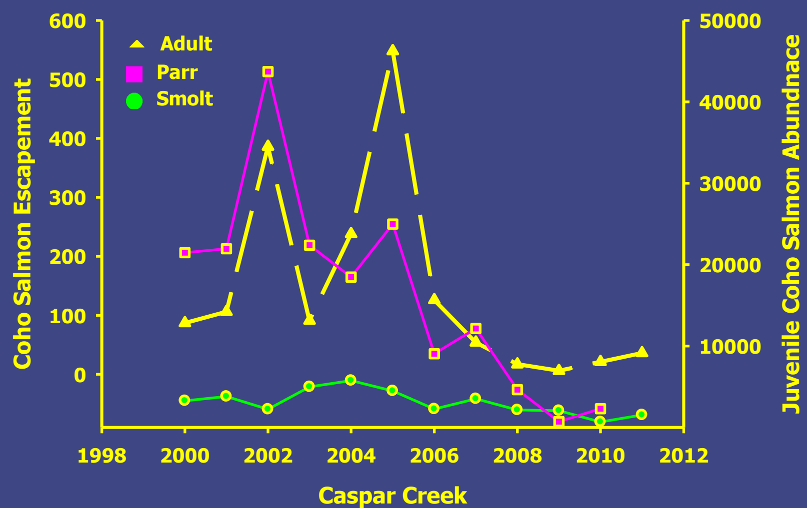
Caspar Creek

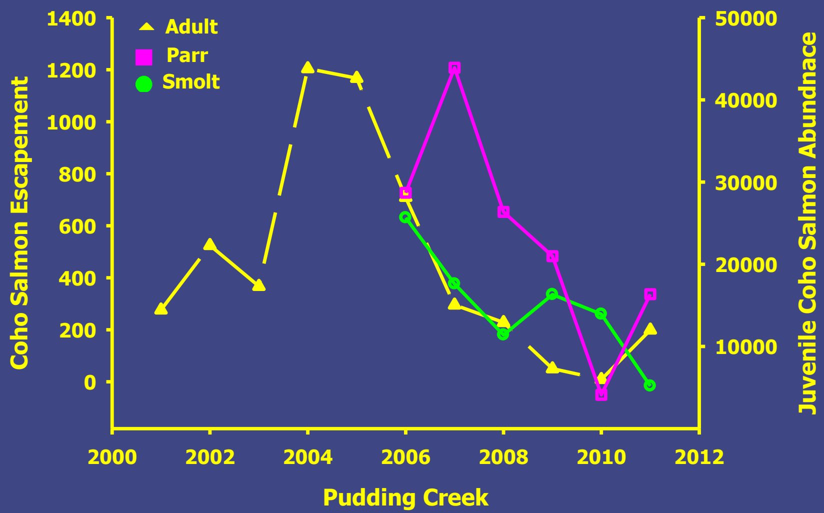


- Drains watershed ~14.0 mi²
- Average BFW 20 ft
- Average gradient ~1.5%
- Supports runs of Coho Salmon and steelhead

Pudding Creek and Caspar Creek

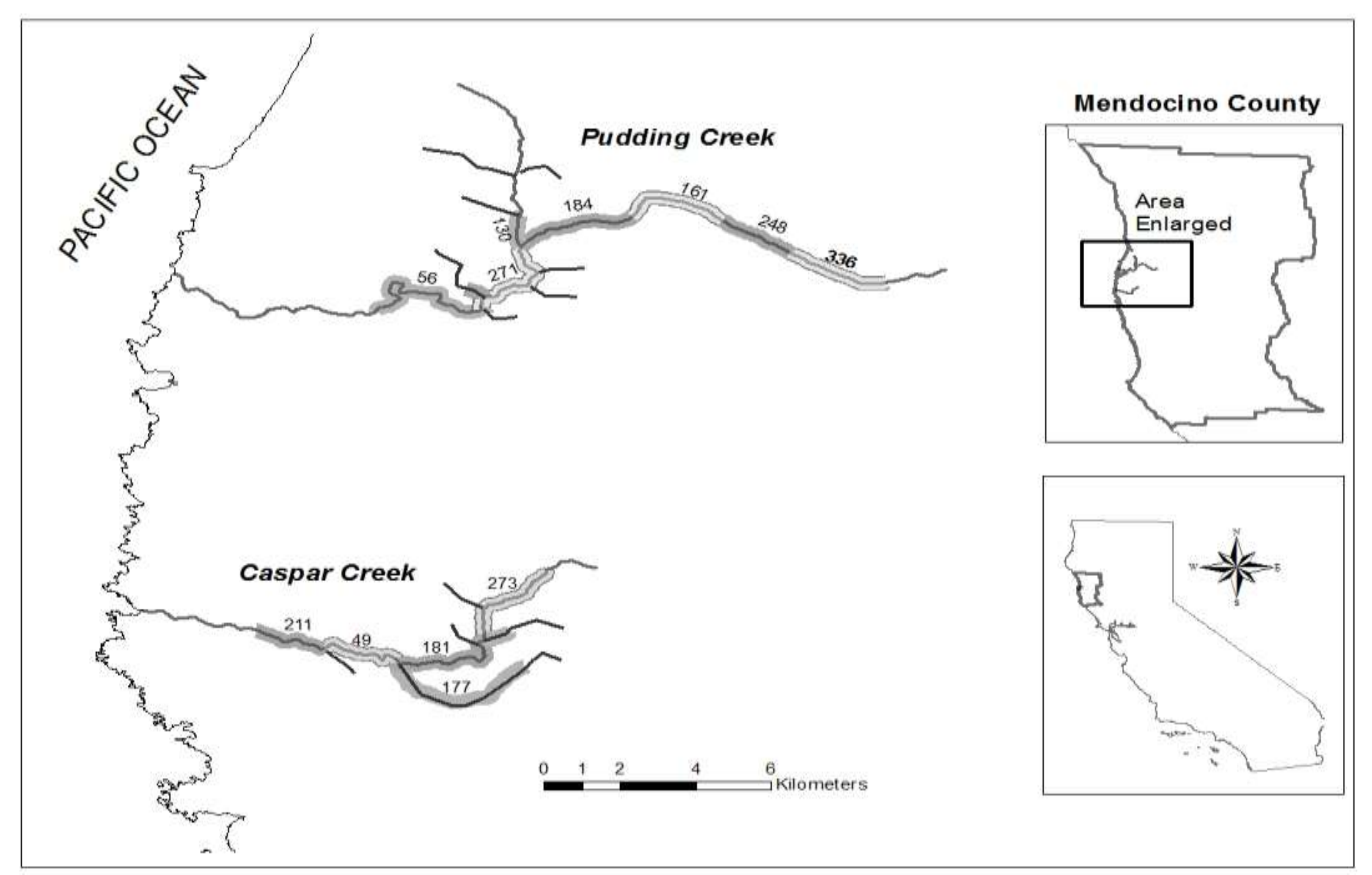
Both Life Cycle Monitoring Streams since early 2000s



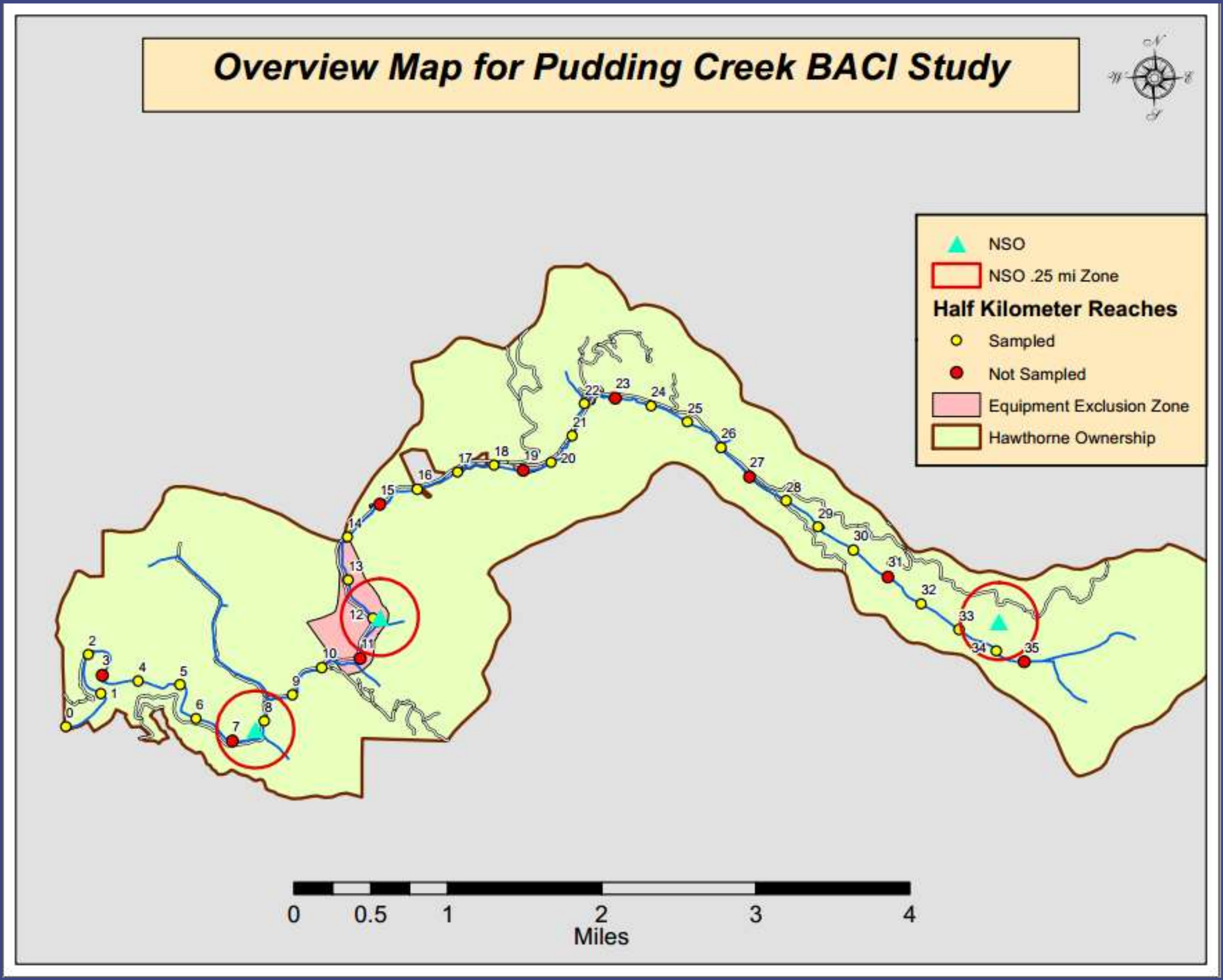


Experimental Design

- Before-After-Control-Impact
  - Repeated measures design, 3 years pre-/ 3 years post-treatment monitoring
- Treat 80% (8.5 mi) of mainstem Pudding Creek



Experimental Design



Large Wood Treatment

- Completed during summer/fall 2015
- Accelerated recruitment approach
- 438 individual wood pieces
- 236 unique structure sites

Expected Results

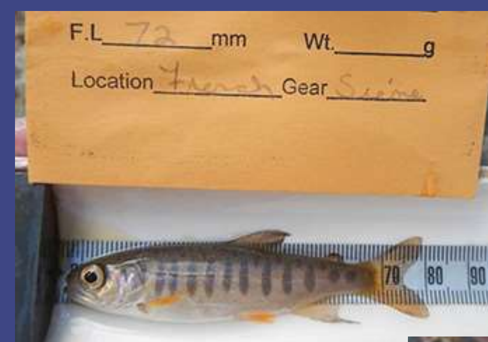
We anticipate an increase in the following metrics in Pudding Creek relative to Caspar Creek post-treatment:

Physical Habitat

- Increased habitat complexity
- Increase in area, volume, and frequency of slow water habitats
- Improved gravel quality, cover elements, etc.


Biological Variables

- Increase in over-summer growth
- Increase in over-winter survival
- Increase in smolt-per-spawner



Monitoring Methods

Physical Habitat

CHaMP

Columbia Habitat Monitoring Program Protocol

Topographic Data

Auxiliary Habitat Data

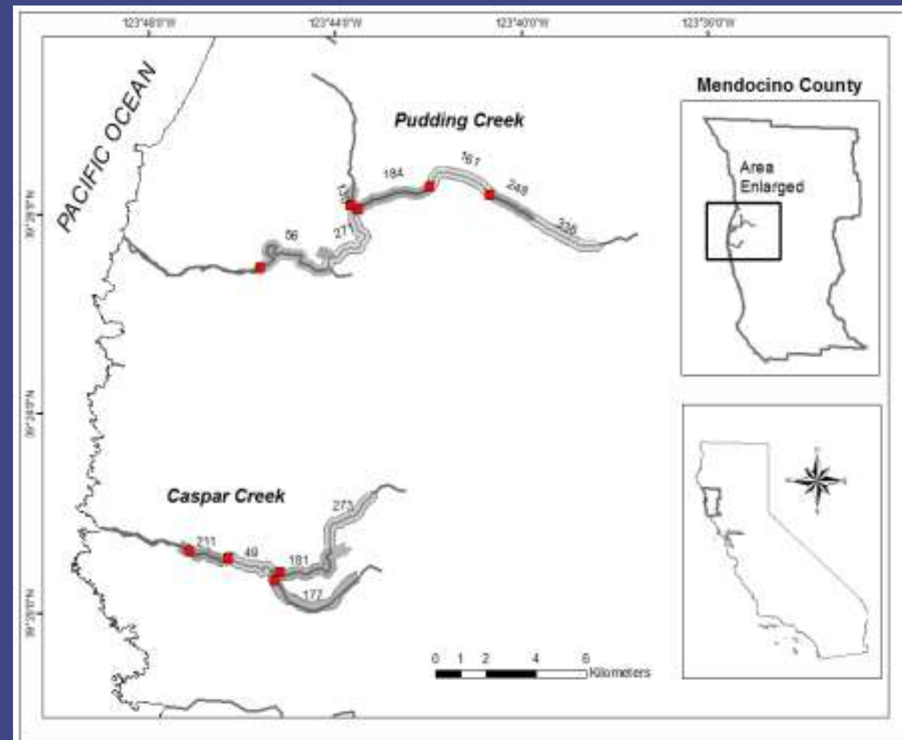
"The goal of CHaMP is to generate and implement a standard set of fish habitat monitoring (status and trend) methods in up to 26 watersheds across the Columbia River Basin."

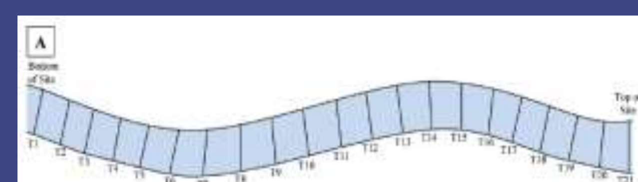
Monitoring Methods

Physical Habitat

CHaMP

- Rapid but rigorous surveys at summer base flow
- Site lengths range from 120-600m
- 5 sites on Pudding Creek, 4 sites on Caspar Creek





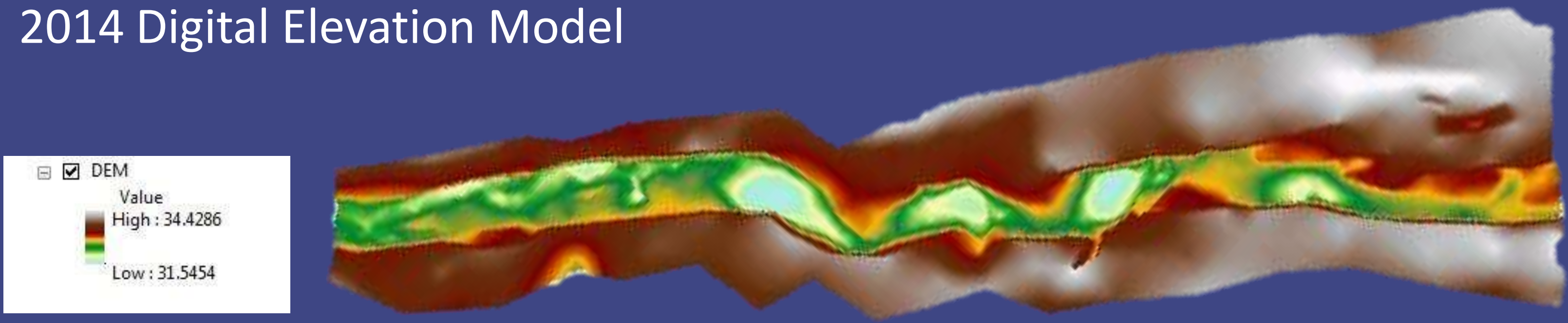
Monitoring Methods

Physical Habitat

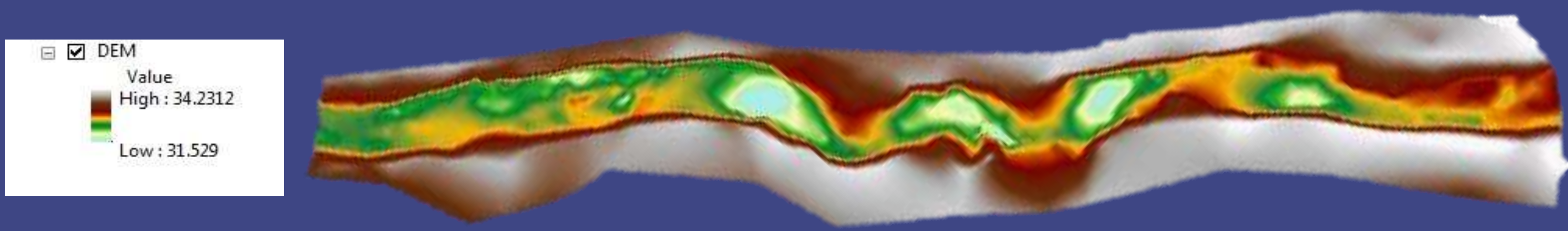
CHaMP

Geomorphic Change Detection

2014 Digital Elevation Model



2013 Digital Elevation Model

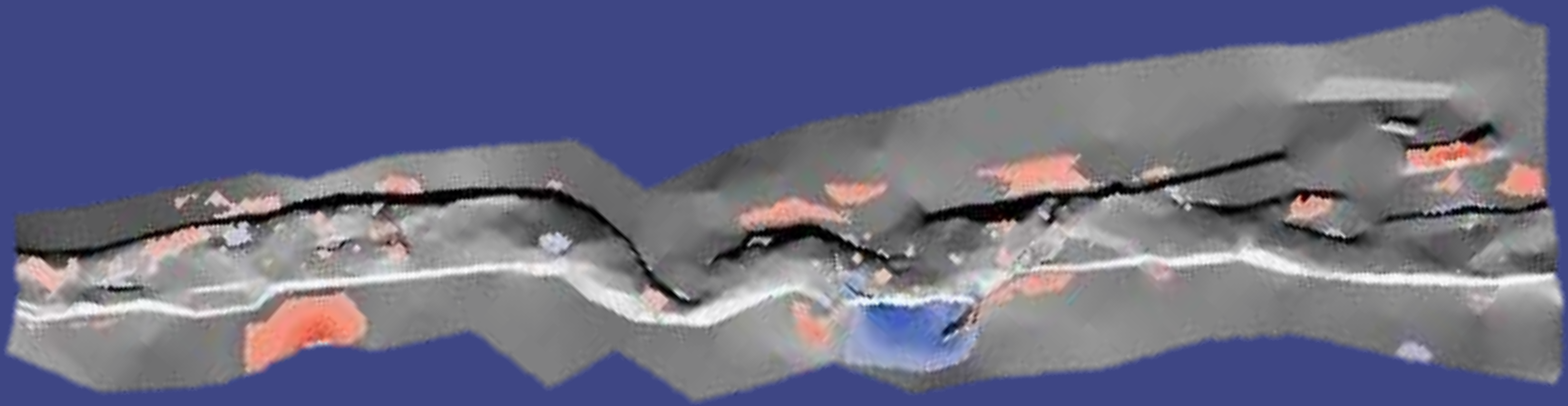


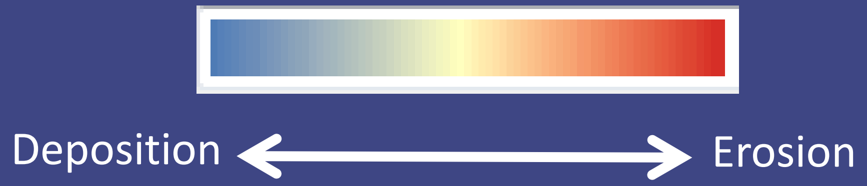
Monitoring Methods

Physical Habitat

CHaMP

Geomorphic Change Detection





Monitoring Methods

Physical Habitat

Summer and Winter Habitat Census

- Rapid assessments of all anadromous habitat
- SUMMER - Entire length of stream habitat is delineated into habitat unit types (e.g. scour pool, riffle, non-turbulent fast water etc.) and habitat attributes are measured or estimated.
  - Example attributes are large woody debris counts, ocular substrate estimates and fish cover estimates

- WINTER - During high flow in winter the entire length of anadromous fish habitat is delineated to get the ratio of fast to slow water

- Methods are adapted from the CHaMP protocol



Monitoring Methods

Biological Monitoring

Life Cycle Monitoring

- Adult Monitoring
  - Spawning Ground Surveys
  - Adult Mark/Recapture

- Downstream Outmigrant Trapping
  - All individuals PIT tagged
  - Measured FL, weighed



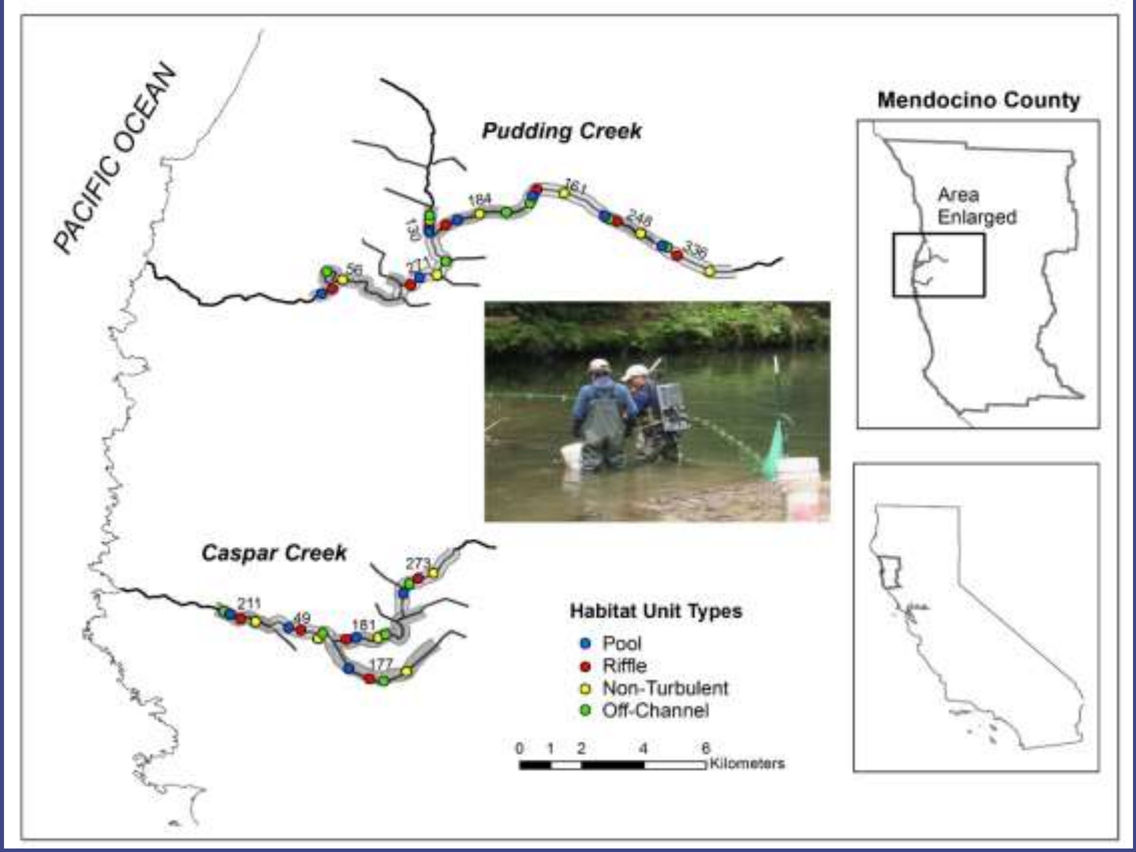



Monitoring Methods

Biological Monitoring

Summer and Fall Electrofishing Surveys

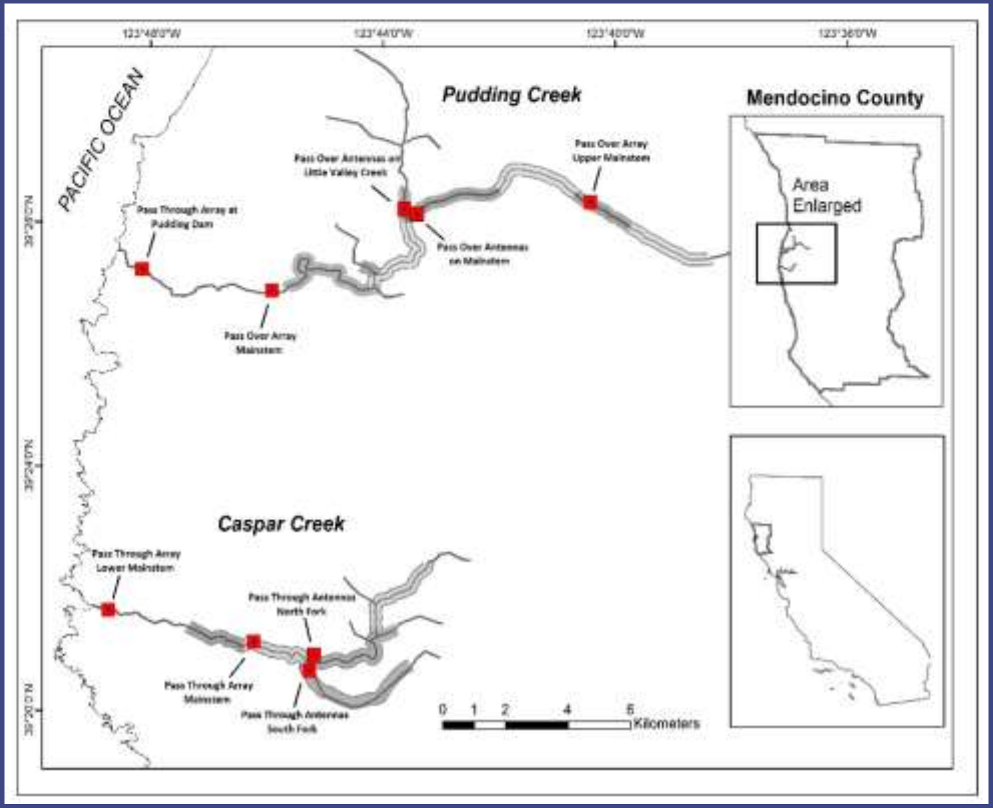
- Subset of habitat units delineated during summer habitat census randomly selected for sampling
- 3-pass depletion surveys
- Individuals marked with maxillary clips and PIT tags
- Return in fall to sample selected units again
- Data used to generate over-summer survival estimates



Monitoring Methods

Biological Monitoring

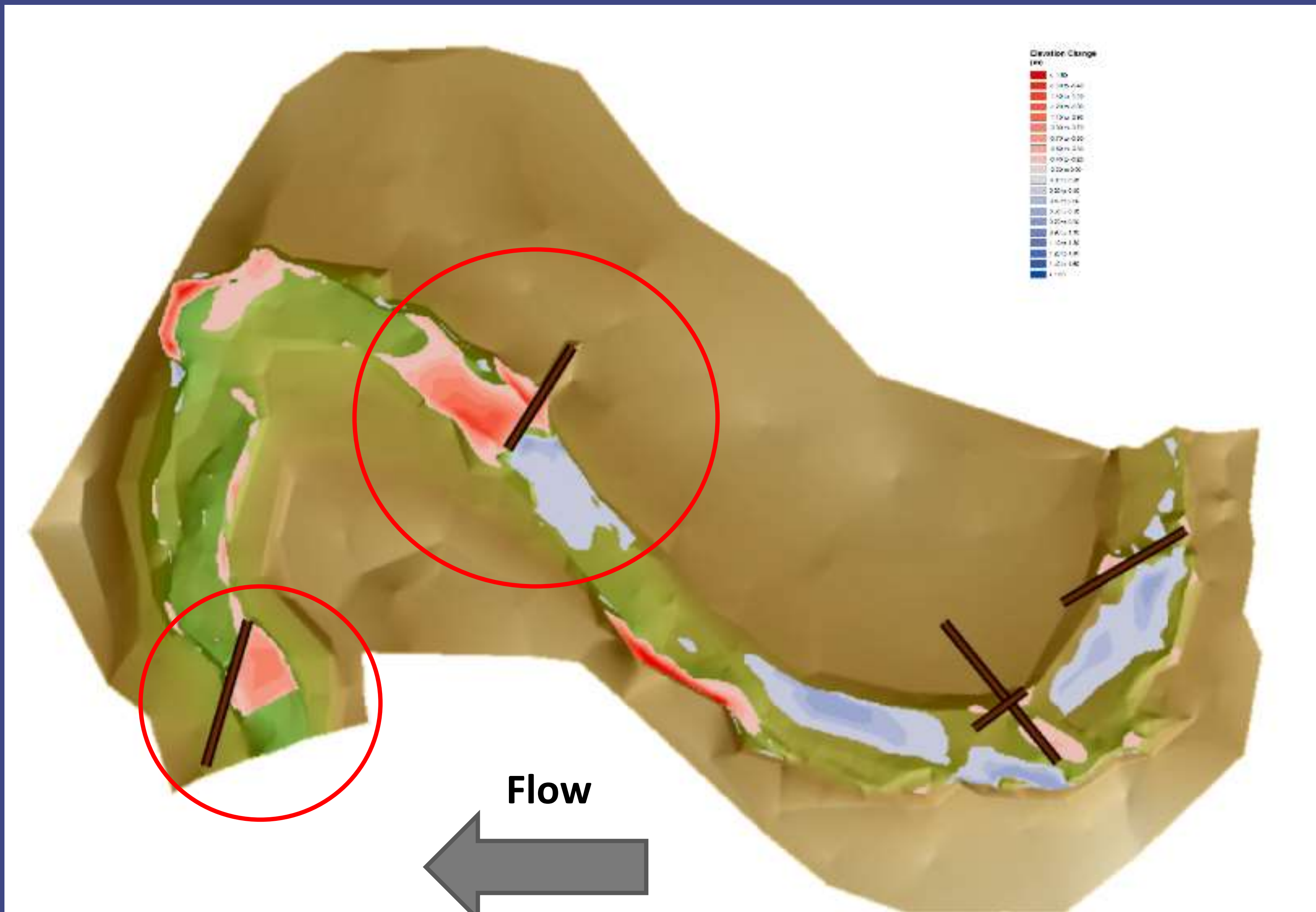
PIT Tag Antenna Arrays

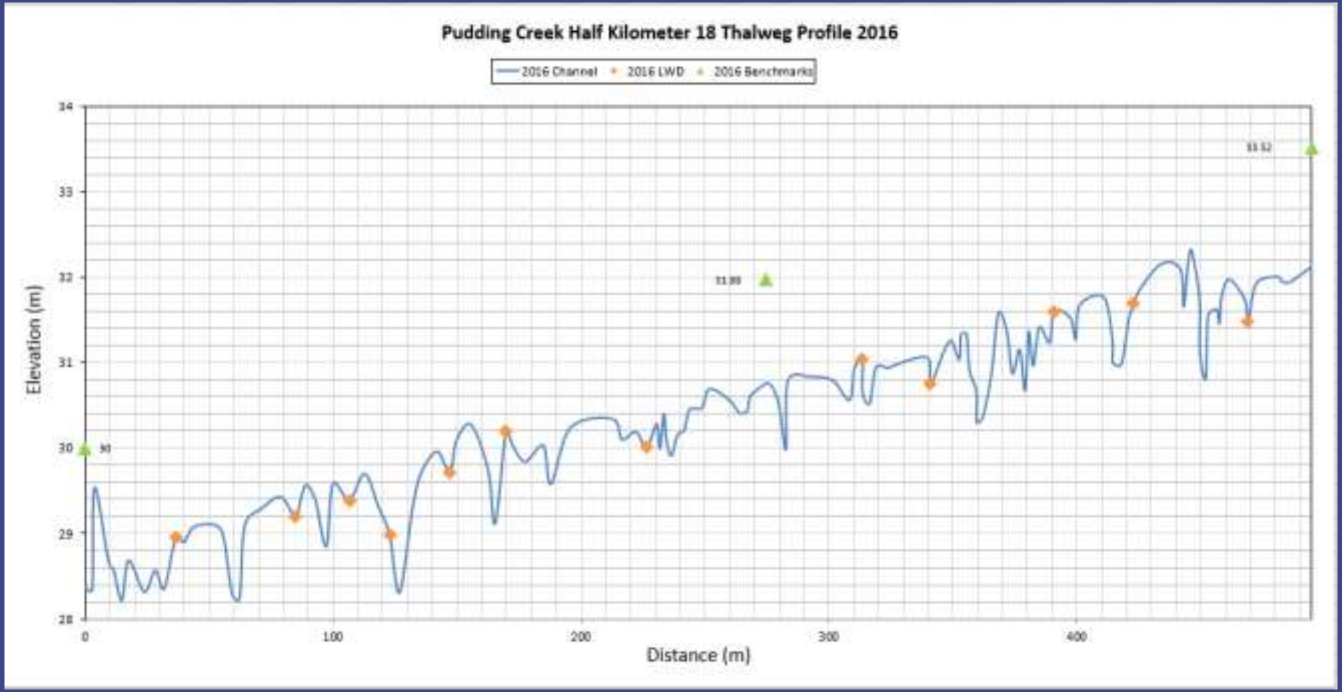


Results To Date

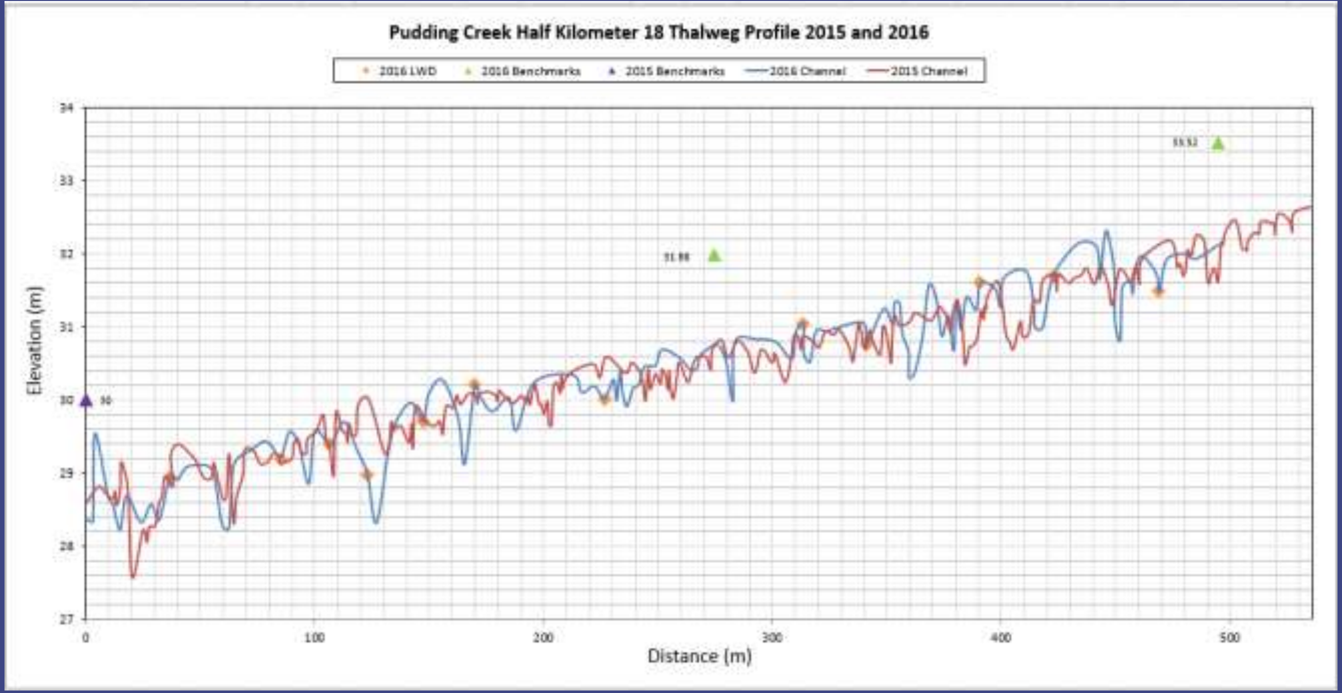
Physical Habitat Monitoring

GCD Pre-Treatment 2015 – Post-Treatment 2016





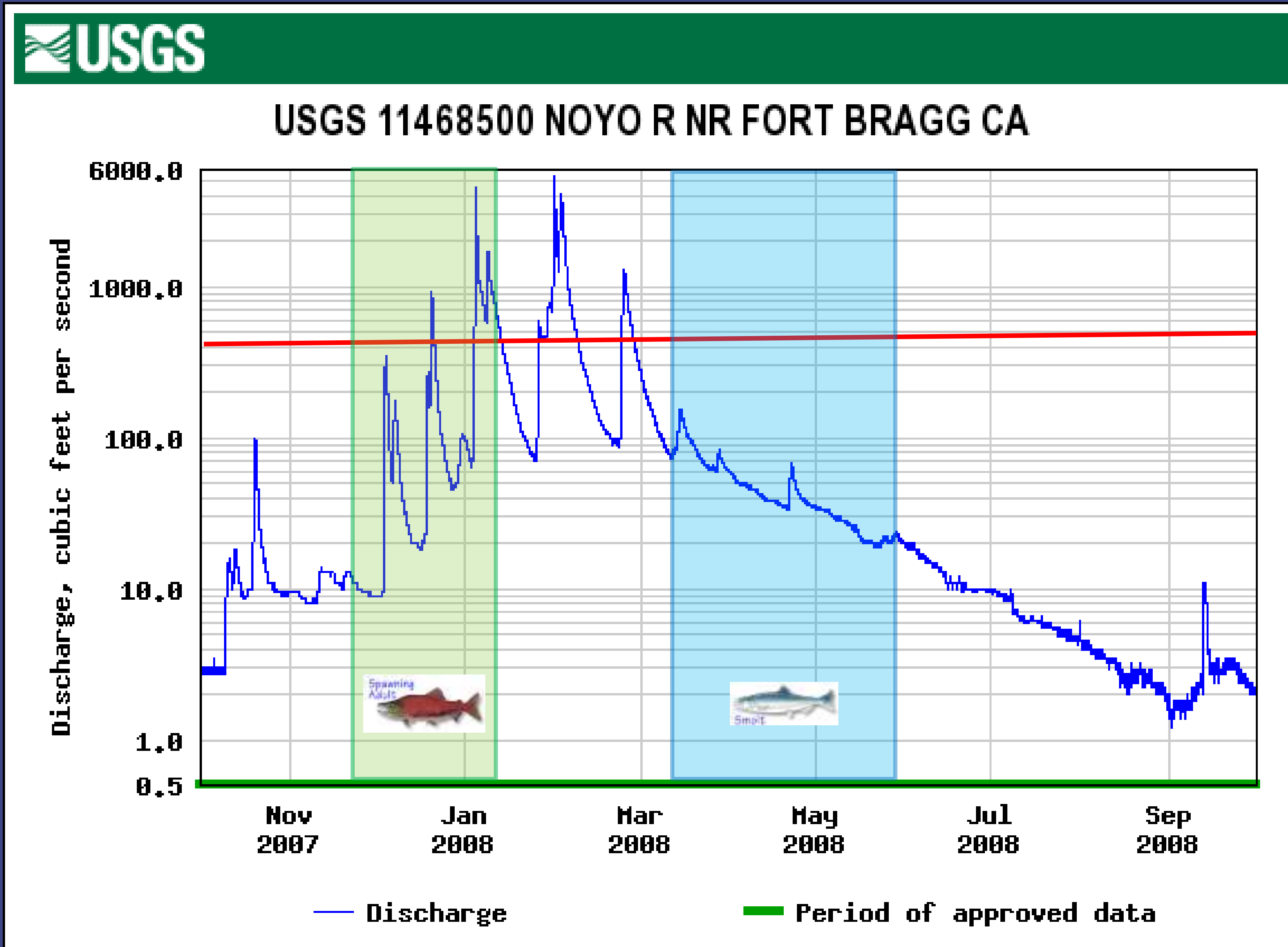
Pudding Creek Half Kilometer 18 Thalweg Profile 2016
2016 Channel
2016 LWD
2016 Benchmarks
Elevation (m)
Distance (m)



Pudding Creek Half Kilometer 18 Thalweg Profile 2015 and 2016
2016 LWD
2016 Benchmarks
2015 Benchmarks
2016 Channel
2015 Channel
Elevation (m)
Distance (m)

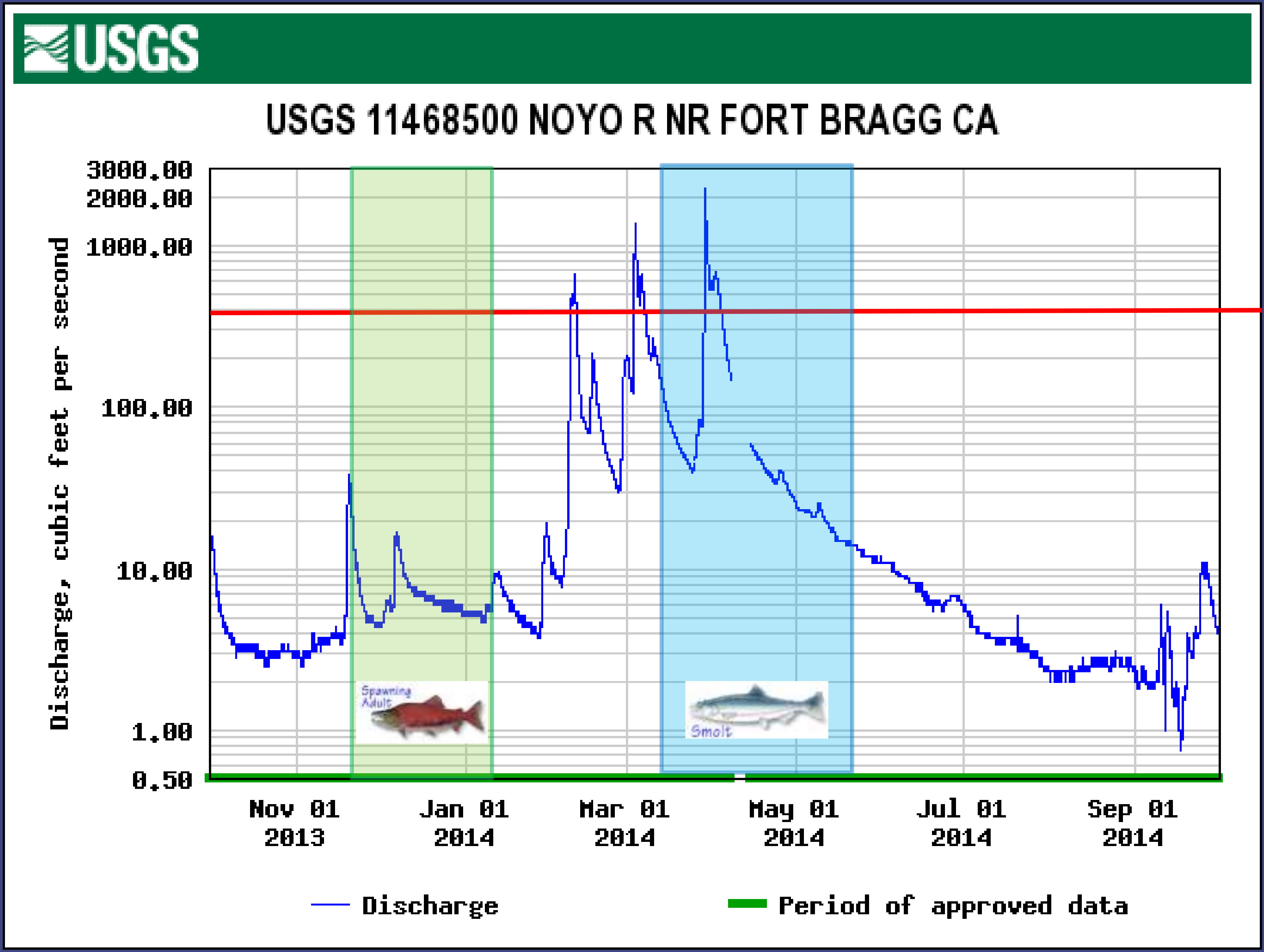
Results To Date

Drought Years



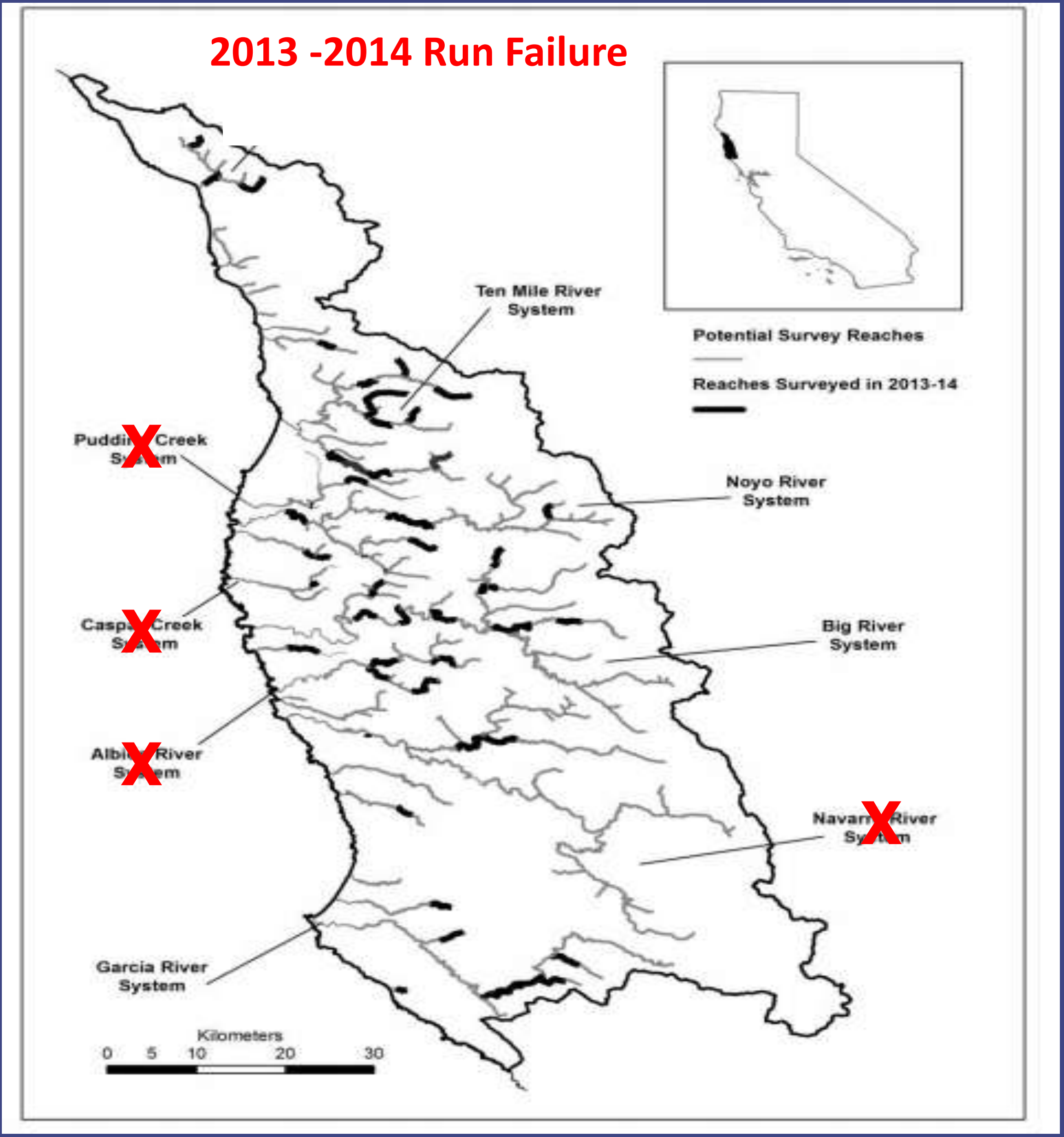
Results To Date

Drought Years



Results To Date

Drought Years



Results To Date

Biological Monitoring

Juvenile Abundance Estimates

Table 5: Summer and fall abundance estimates or Coho Salmon (top) and steelhead (bottom) from electrofishing surveys on Pudding and Caspar creeks from 2013-2016.

	Pudding Creek						Caspar Creek					
	Summer Coho Parr Abundance			Fall Coho Parr Abundance			Summer Coho Parr Abundance			Fall Coho Parr Abundance		
Sampling Year	Low 95% CI	Point Estimate	High 95% CI	Low 95% CI	Point Estimate	High 95% CI	Low 95% CI	Point Estimate	High 95% CI	Low 95% CI	Point Estimate	High 95% CI
2013	57,452	82,306	107,160	43,301	61,353	79,405	2,638	6,306	9,975	960	4,392	7,825
2014[1]	5,661	9,432	13,204	3,565	6,154	8,742	0	0	0	0	0	0
2015[2]	30,686	53,875	77,066	8,349	30,836	53,323	8,249	15,658	23,067	4,127	9,297	14,467
2016	10,660	18,396	26,131	8,561	14,841	21,121	6,226	11,251	16,276	4,176	11,338	18,500

[1] Complete spawning run failure in winter 2013-14, parr in Pudding Creek were likely 2 year old fish

[2] Drought conditions likely caused low over summer survival rates

Results To Date

Drought Years

Life History Strategies

IN DRAFT - Lost and Found: A Year Class Lost to Drought Reveals "Hidden" Life History Diversity in Central California Coastal Coho Salmon

Sean P. Gallagher[1], Emily D. Lang[2], Shaun A. Thompson[1], David W. Ulrich[3], David W. Wright[4], Wendy E. Holloway[5], and Stephanie M. Carlson[6]

1 California State Department of Fish and Game, 32330 North Harbor Drive, Fort Bragg, CA, 95437, USA

2 Lyme Redwood Forest Company, LLC, PO Box 1228, Fort Bragg, CA, 95437, USA

3 Mendocino Redwood Company, LLC, PO Box 996, Ukiah, CA, 95482, USA

4 The Nature Conservancy, 201 Mission St. 4th Floor, San Francisco, CA 94105, USA, (707) 357-4933

5 Pacific States Marine Fisheries Commission, 32330 North Harbor Drive, Fort Bragg, CA, 95437, USA

6 University of California, Department of Environmental Science, Policy & Management, 130 Mulford Hall #3114, Berkeley, CA 94720-3114

Results To Date

Drought Years

Physical Habitat Monitoring

- Dry channel segments
- Significant decrease in wetted channel habitat areas and volumes
- Lack of winter habitat conditions

Summary

- Experiment is ongoing
  - Data collection will continue through 2019
  - Final analysis and manuscript will be completed by 2021
- Power of paired watershed approach
  - A whole watershed approach to large wood restoration may be necessary to produce measurable changes in fish abundance
  - Aids in detecting inter-annual stochastic events within regional salmonid populations (e.g. marine survival, drought conditions)
- Importance of monitoring of longer time-scales
- Experiment first of this kind in California

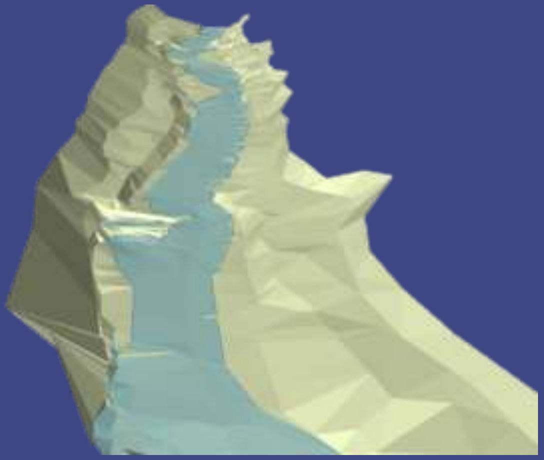
Acknowledgements

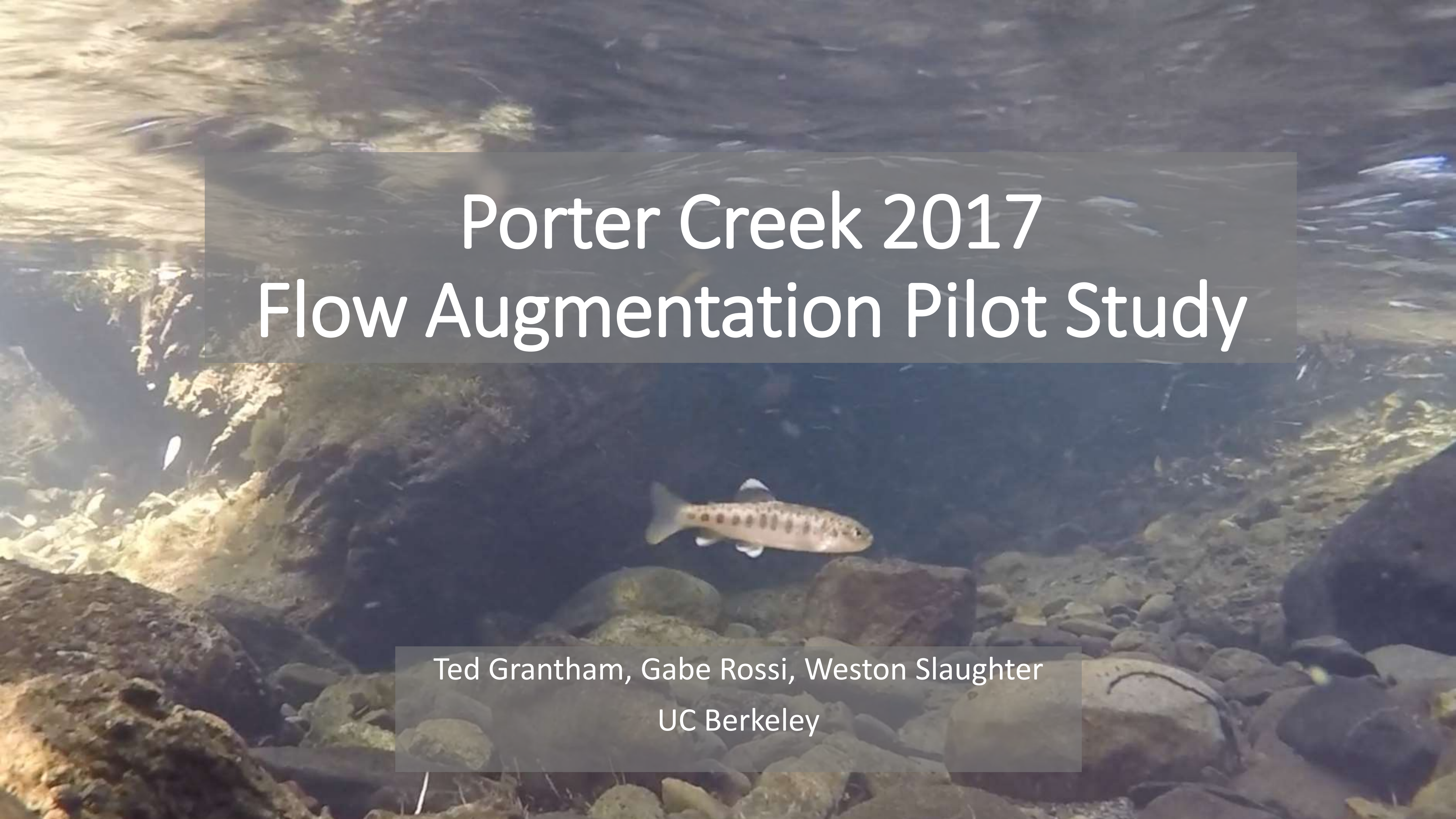
- Special thanks to CDFW FRGP for funding this effort
- Thanks to Sean Gallagher, Wendy Holloway, Dave Wright, Emily Lang and Chris Blencowe for management and implementation of this project

- Special thanks to Chris Jordan, Carol Volk, Meagan Polino, Boyd and Nick Bouwes, Steve Bennett, and the rest of the CHaMP development team

- Thanks to field biologists and technicians Greg McClary, Andy McClary, Natalie Okun, JJ Brunner, Sean Studer, Matt Bogaard, Rick Helgerson, and many ***many*** others for their tireless hours and work on this project.

Questions?



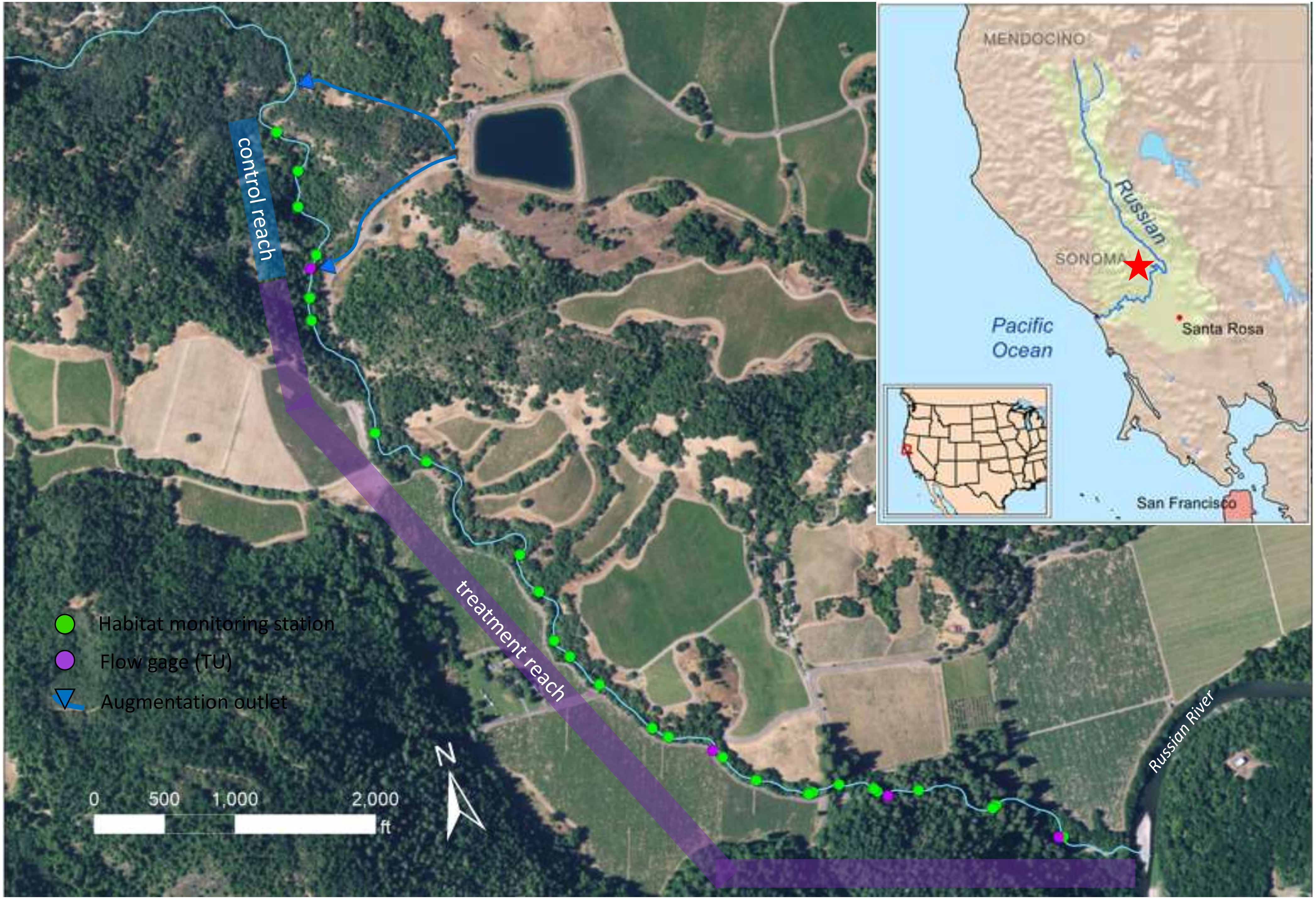


Porter Creek 2017 Flow Augmentation Pilot Study

Ted Grantham, Gabe Rossi, Weston Slaughter

UC Berkeley

Study Reach



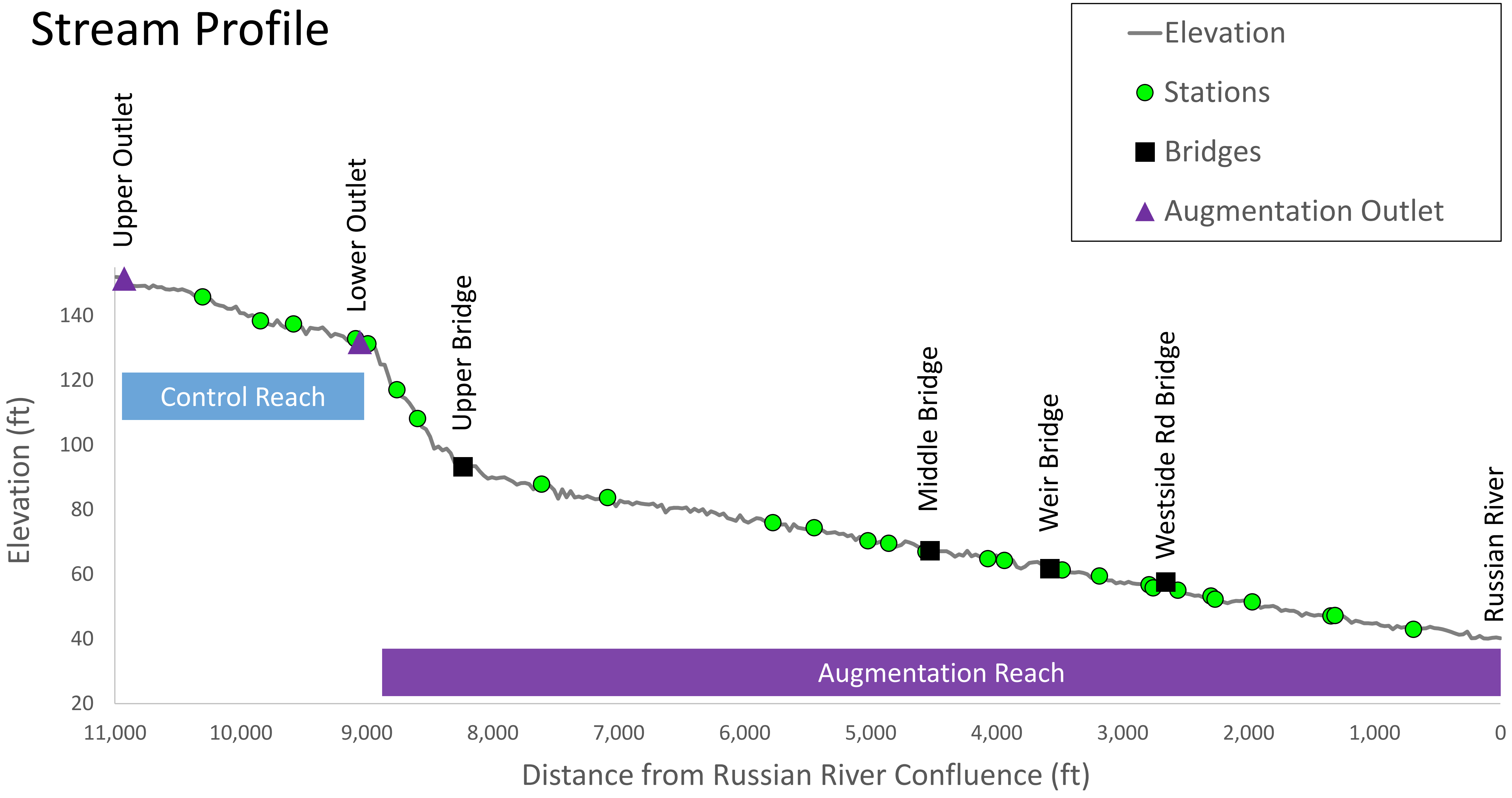
MENDOCINO
Russian
SONOMA
Pacific Ocean
Santa Rosa
San Francisco
control reach
treatment reach
Russian River
Habitat monitoring station
Flow gage (TU)
Augmentation outlet
0
500
1,000
2,000
ft
N

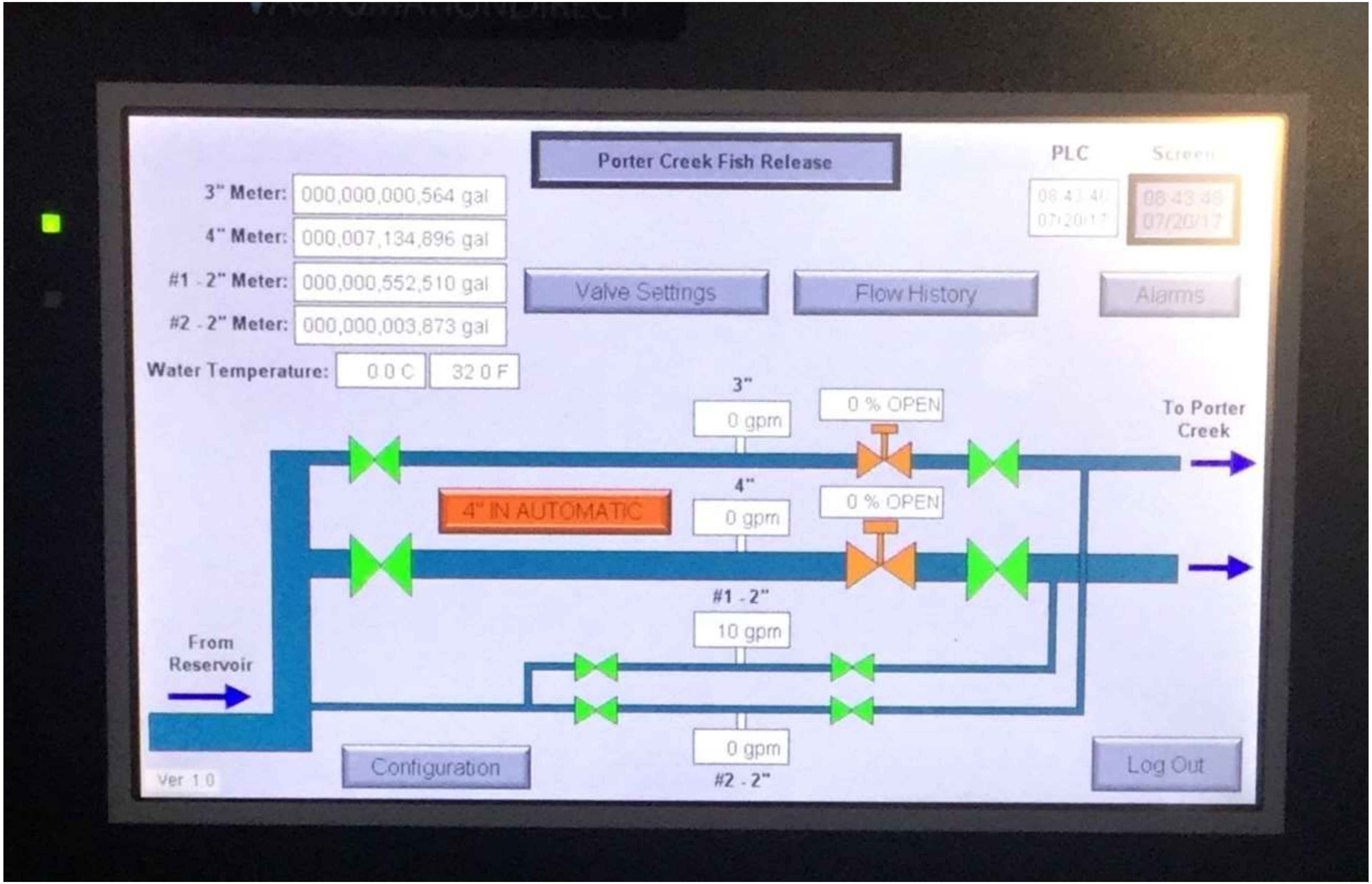
U.C. Berkeley 2017 Pilot Study

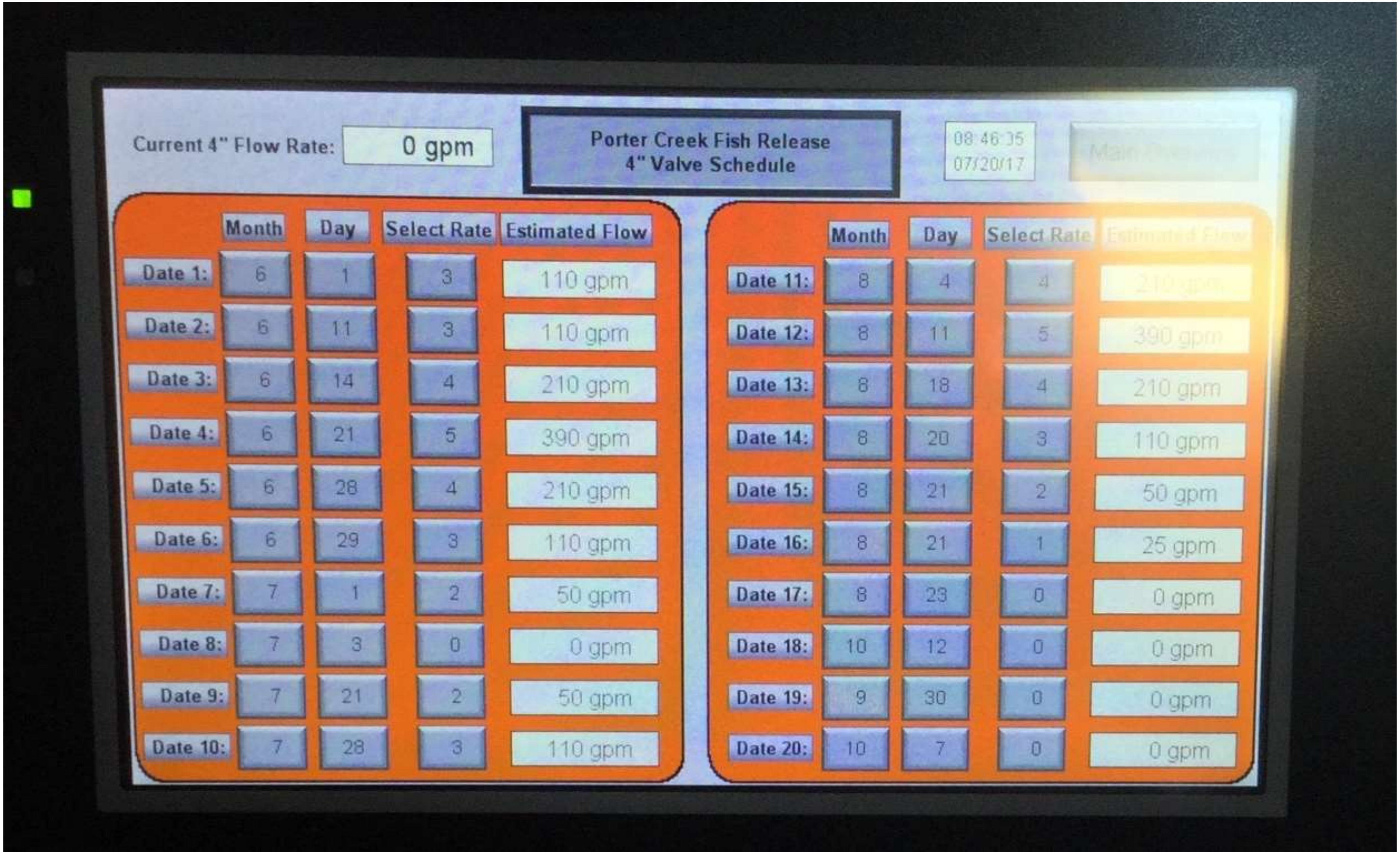
What are the effects of flow augmentation on physical habitat, stream connectivity, and water quality and salmonid foraging behavior?

Porter Creek at Russian River, May 18, 2017

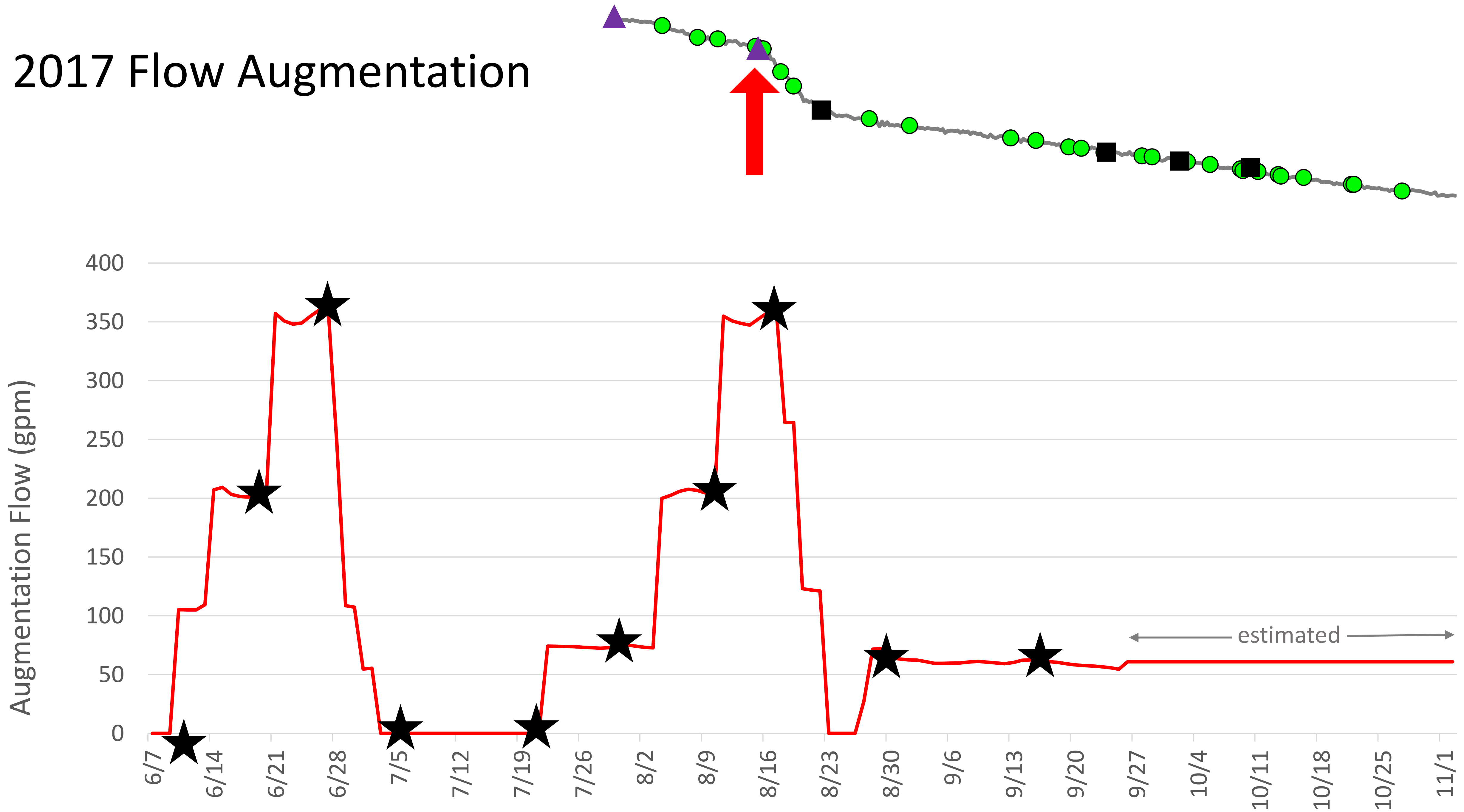
Stream Profile



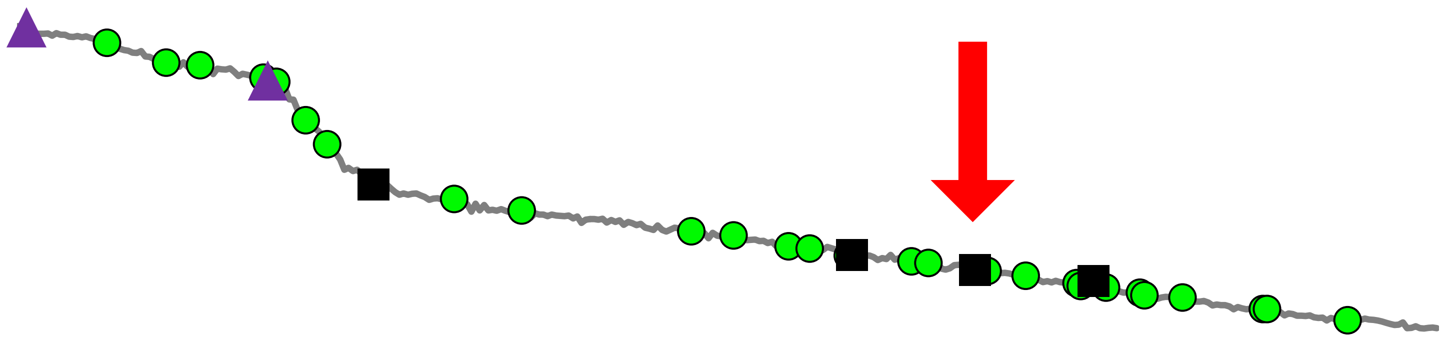

Porter Creek Fish Release
PLC
Screen
3" Meter: 000,000,000,564 gal
4" Meter: 000,007,134,896 gal
#1 - 2" Meter: 000,000,552,510 gal
#2 - 2" Meter: 000,000,003,873 gal
Water Temperature: 0.0 C 32.0 F
Valve Settings
Flow History
Alarms
3"
0 gpm
0 % OPEN
To Porter Creek
4"
4" IN AUTOMATIC
0 gpm
0 % OPEN
#1 - 2"
10 gpm
From Reservoir
0 gpm
#2 - 2"
Configuration
Log Out
Ver 1.0

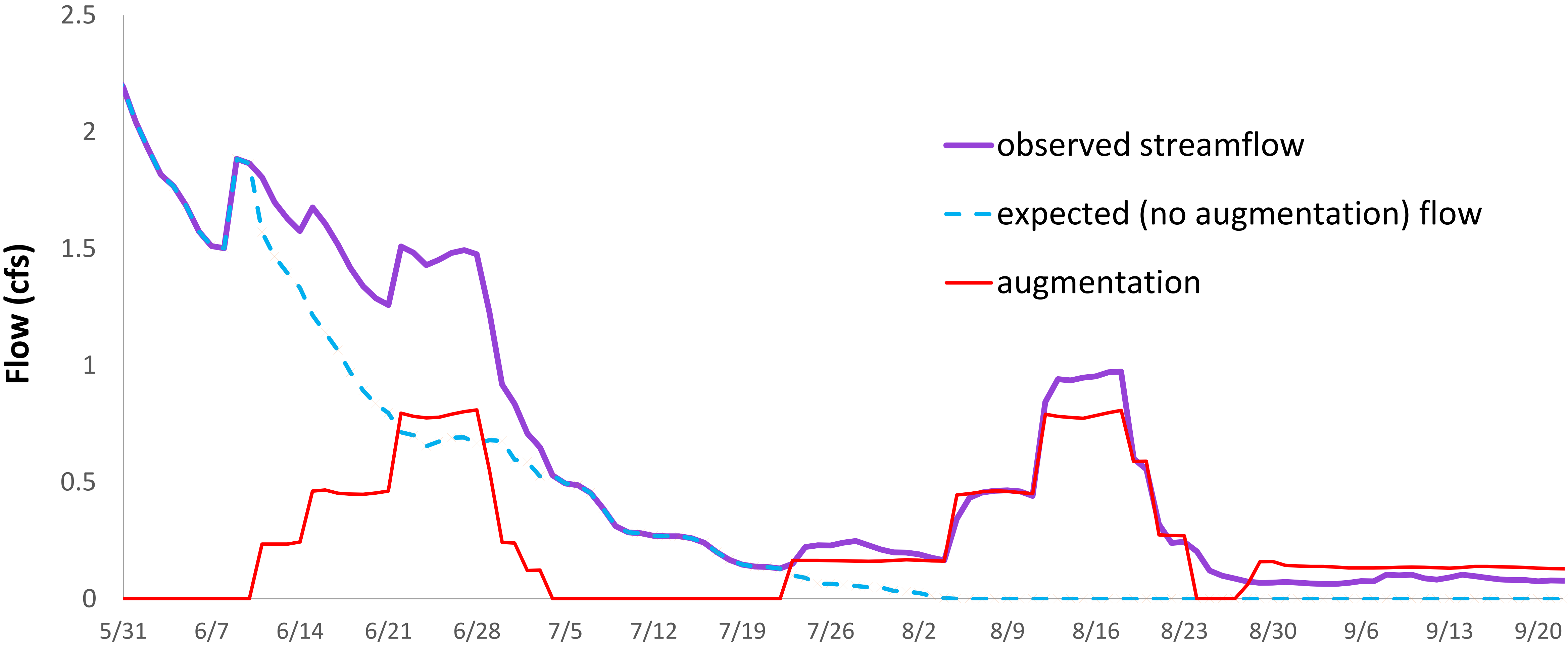

Current 4" Flow Rate: 0 gpm
Porter Creek Fish Release
4" Valve Schedule
08:46:35
07/20/17
Month Day Select Rate Estimated Flow
Date 1: 6 1 3 110 gpm
Date 2: 6 11 3 110 gpm
Date 3: 6 14 4 210 gpm
Date 4: 6 21 5 390 gpm
Date 5: 6 28 4 210 gpm
Date 6: 6 29 3 110 gpm
Date 7: 7 1 2 50 gpm
Date 8: 7 3 0 0 gpm
Date 9: 7 21 2 50 gpm
Date 10: 7 28 3 110 gpm
Month Day Select Rate
Date 11: 8 4 4
Date 12: 8 11 5 390 gpm
Date 13: 8 18 4 210 gpm
Date 14: 8 20 3 110 gpm
Date 15: 8 21 2 50 gpm
Date 16: 8 21 1 25 gpm
Date 17: 8 23 0 0 gpm
Date 18: 10 12 0 0 gpm
Date 19: 9 30 0 0 gpm
Date 20: 10 7 0 0 gpm

2017 Flow Augmentation

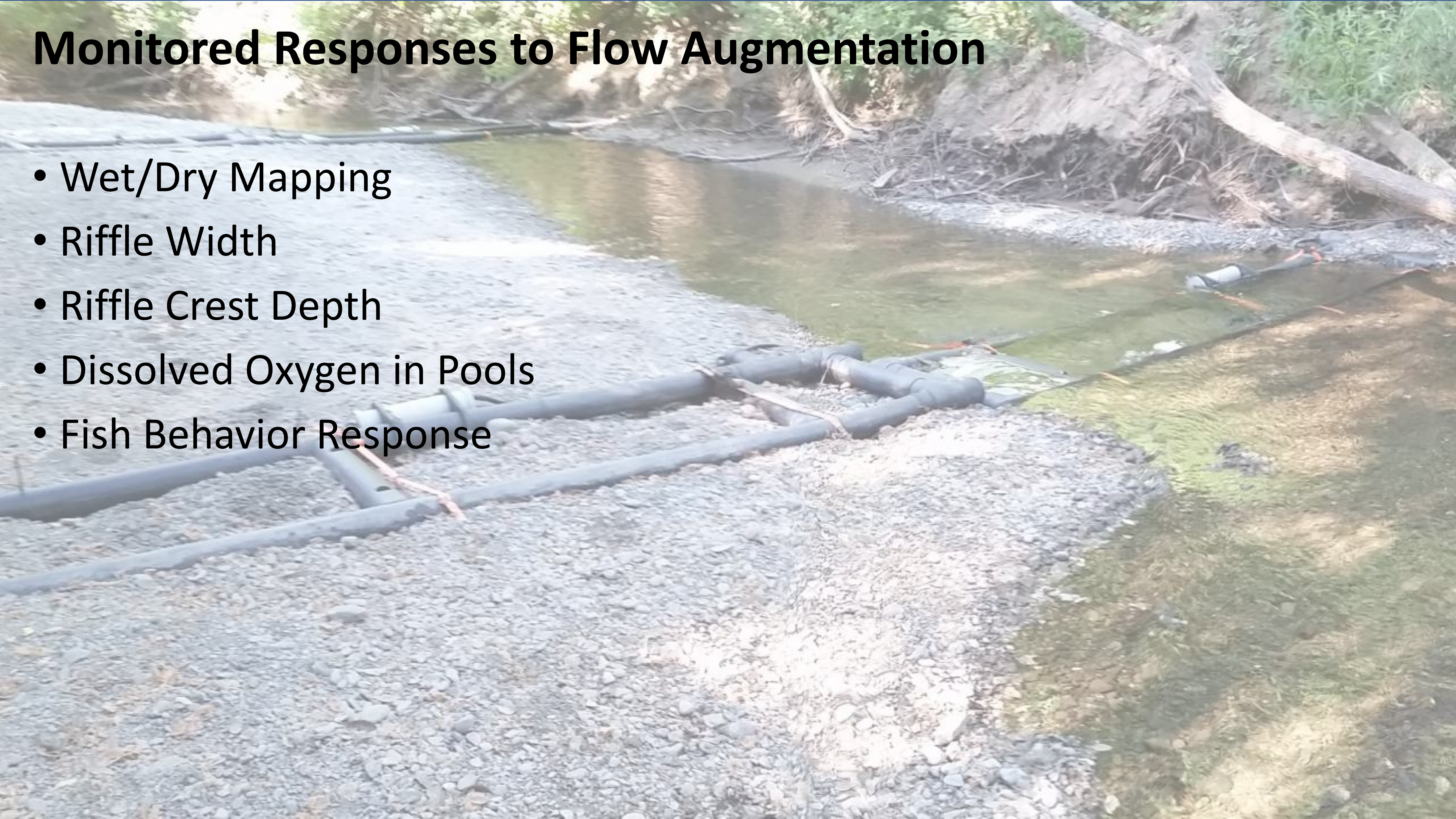


Measured Flow Response at Weir Bridge (P03)



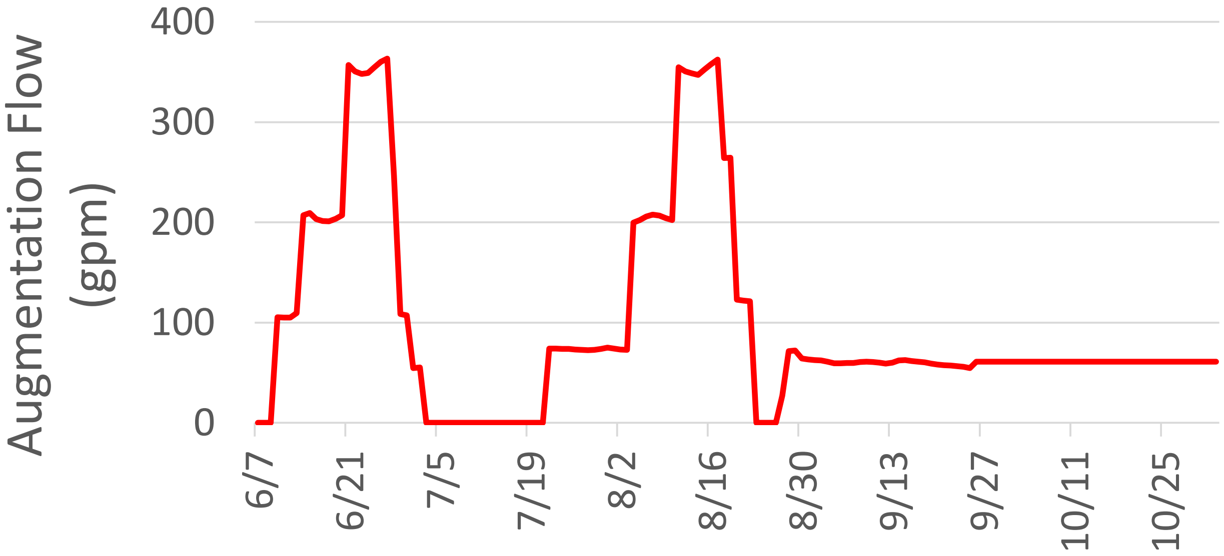


Monitored Responses to Flow Augmentation

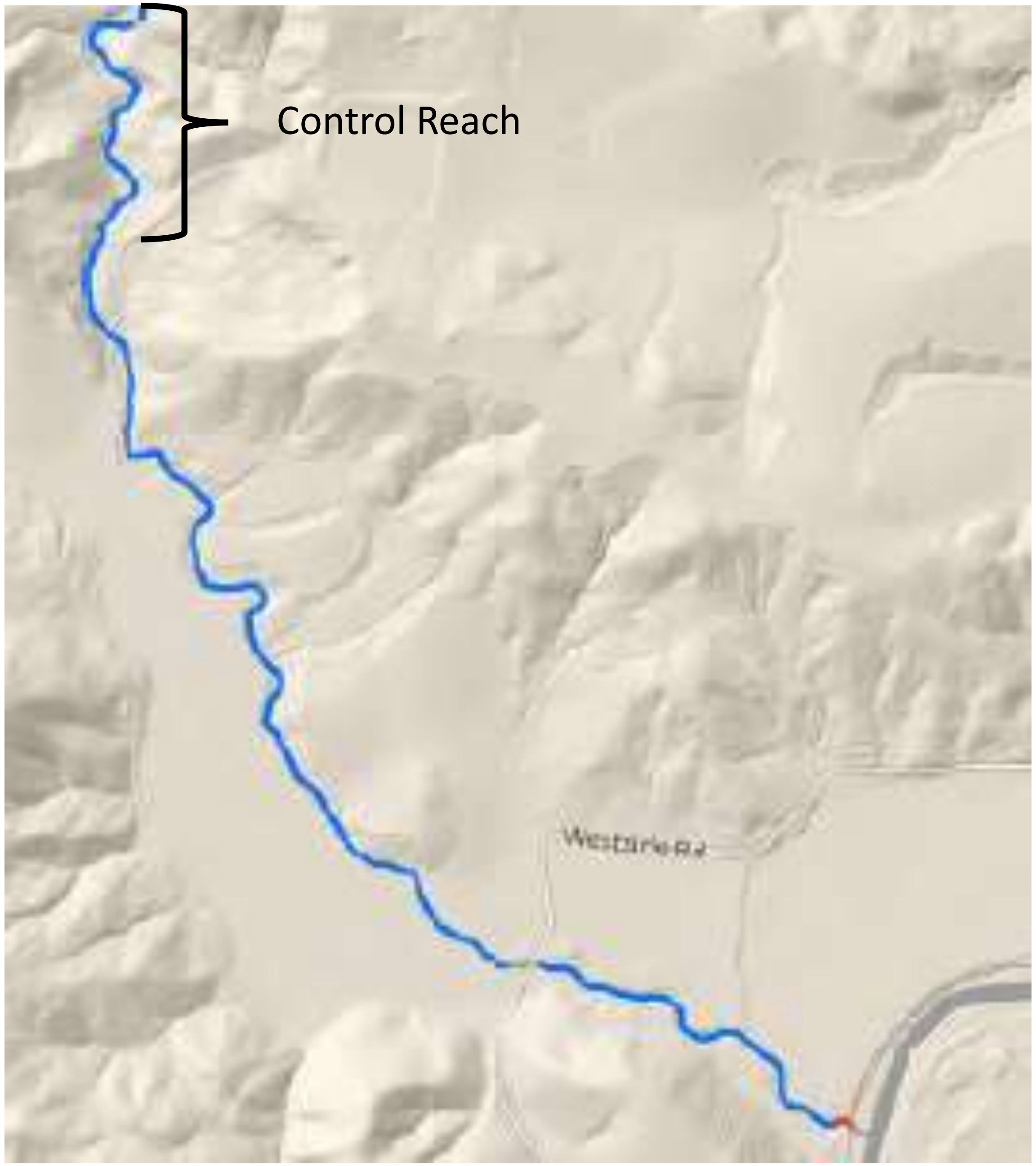


- Wet/Dry Mapping
- Riffle Width
- Riffle Crest Depth
- Dissolved Oxygen in Pools
- Fish Behavior Response

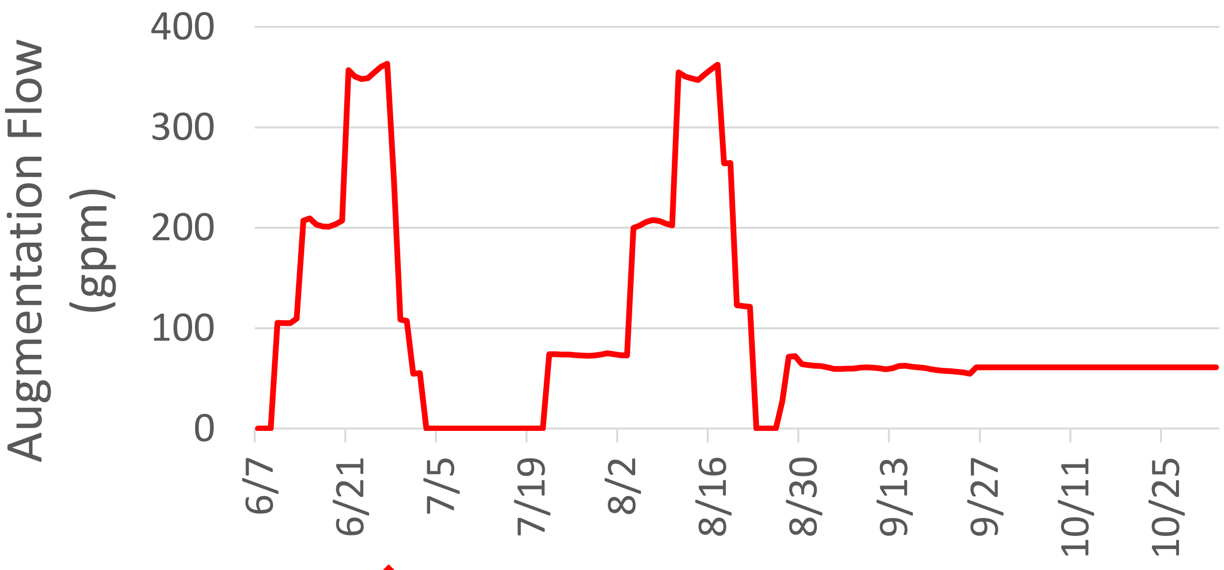
Wetted Channel Response



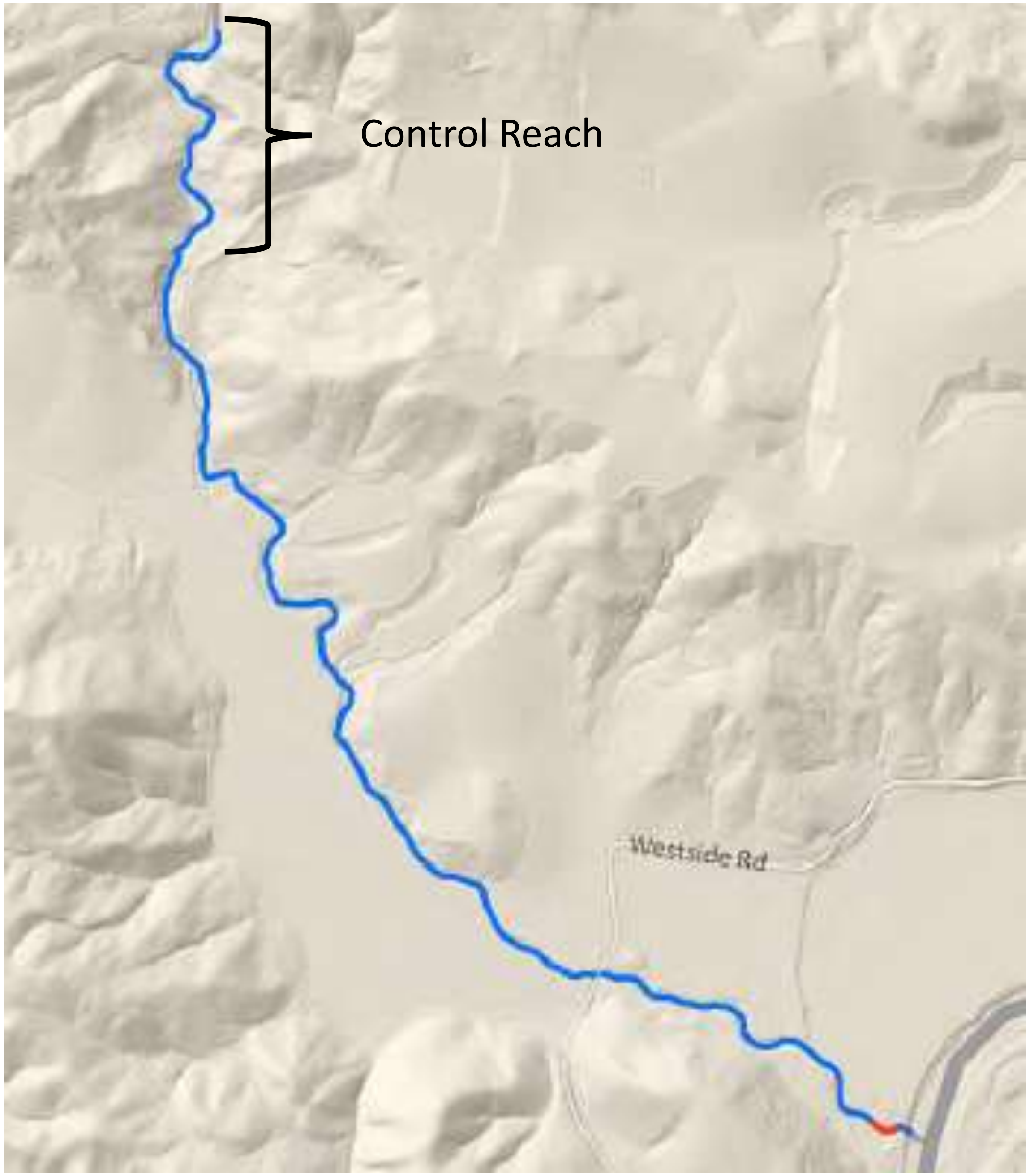
June 9



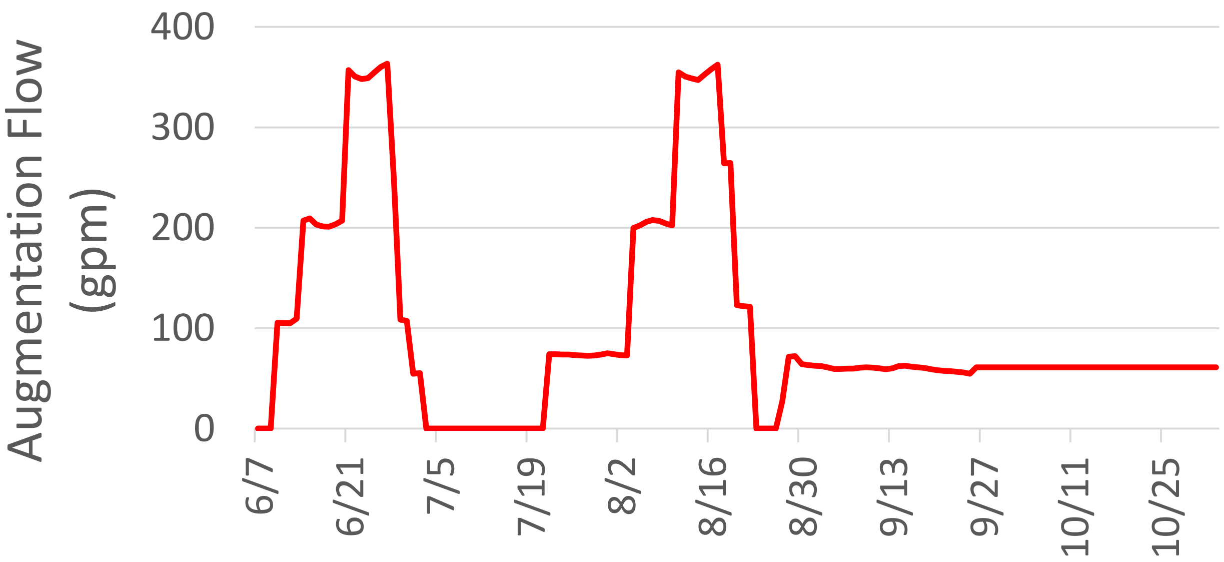
Wetted Channel Response



June 26

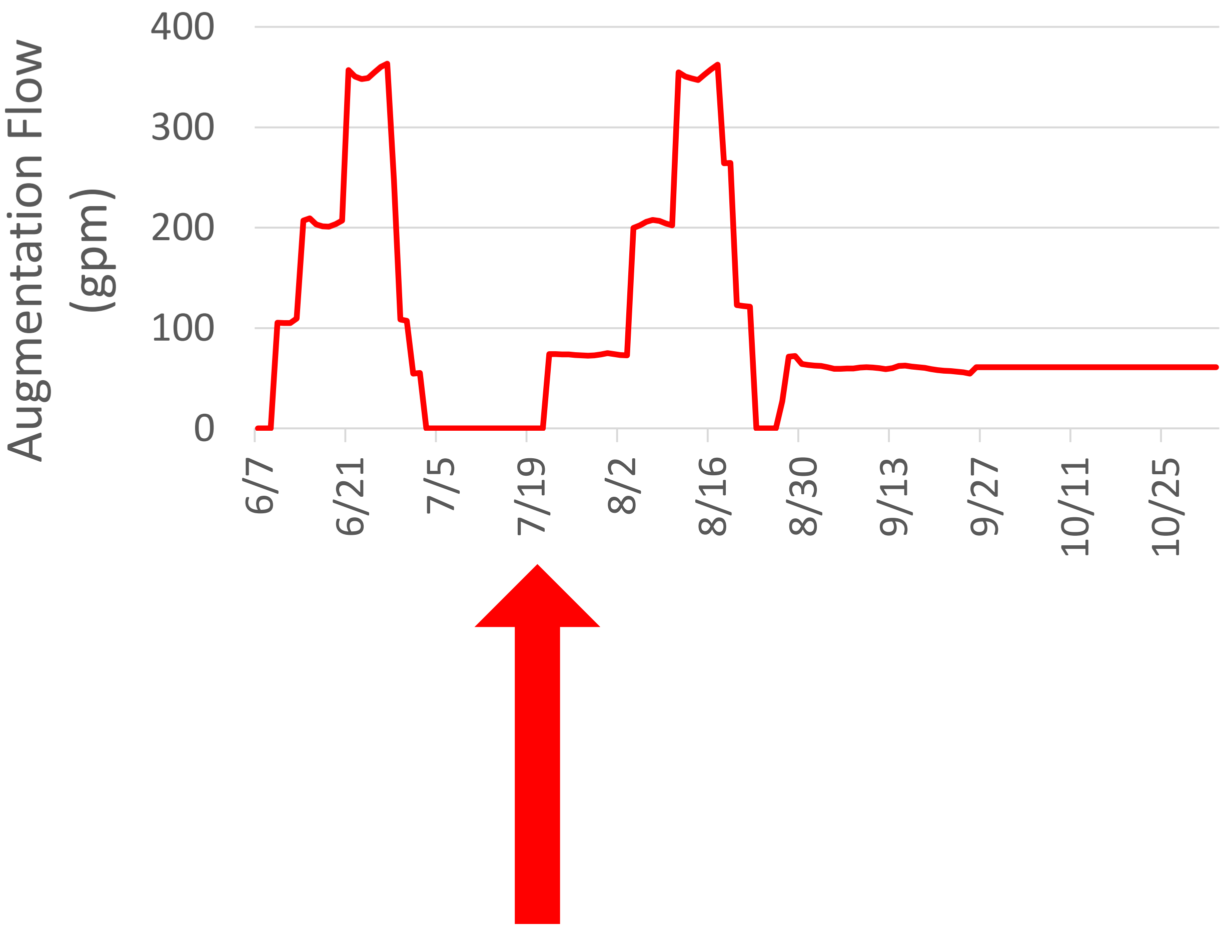


Wetted Channel Response

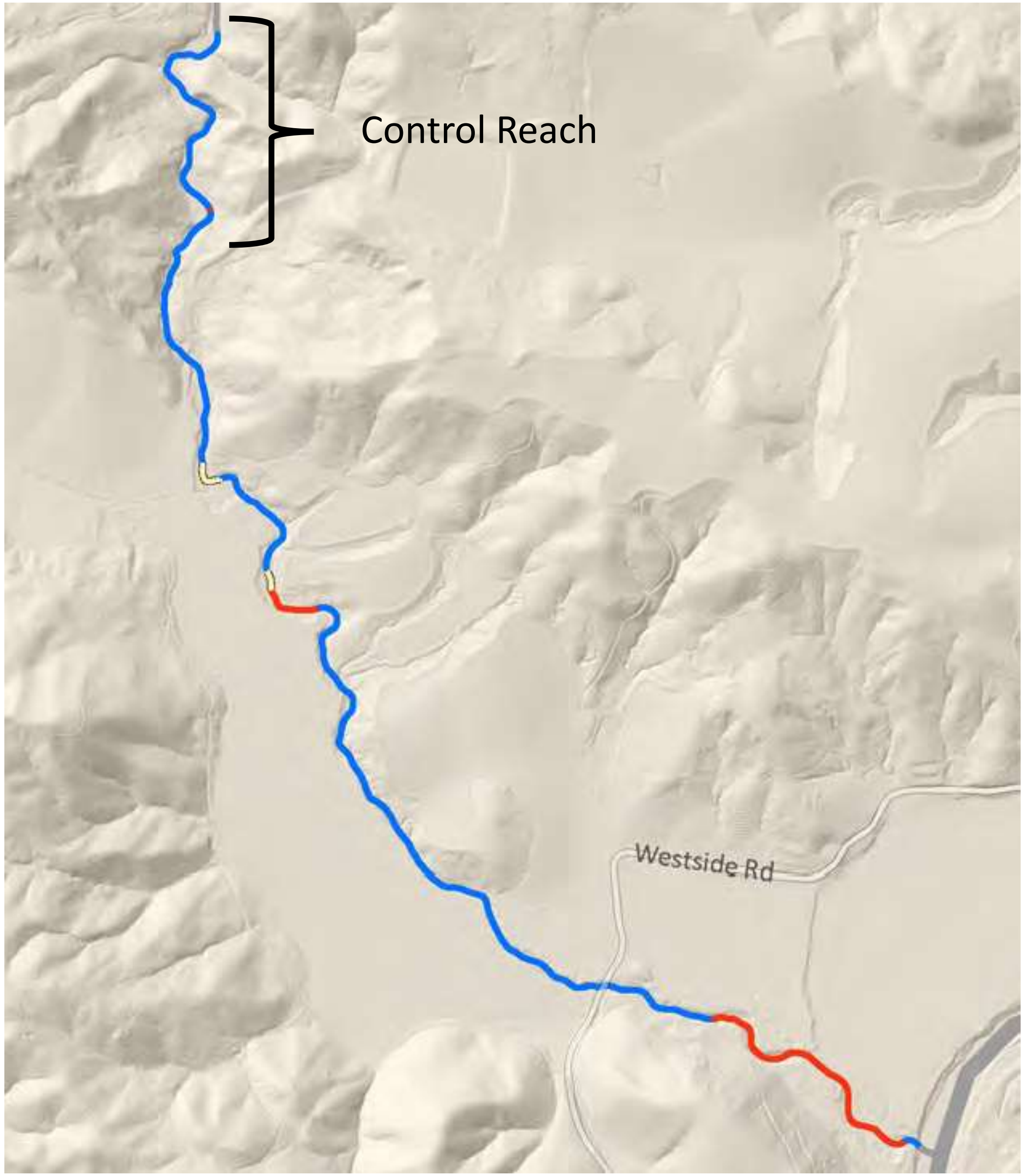


July 5

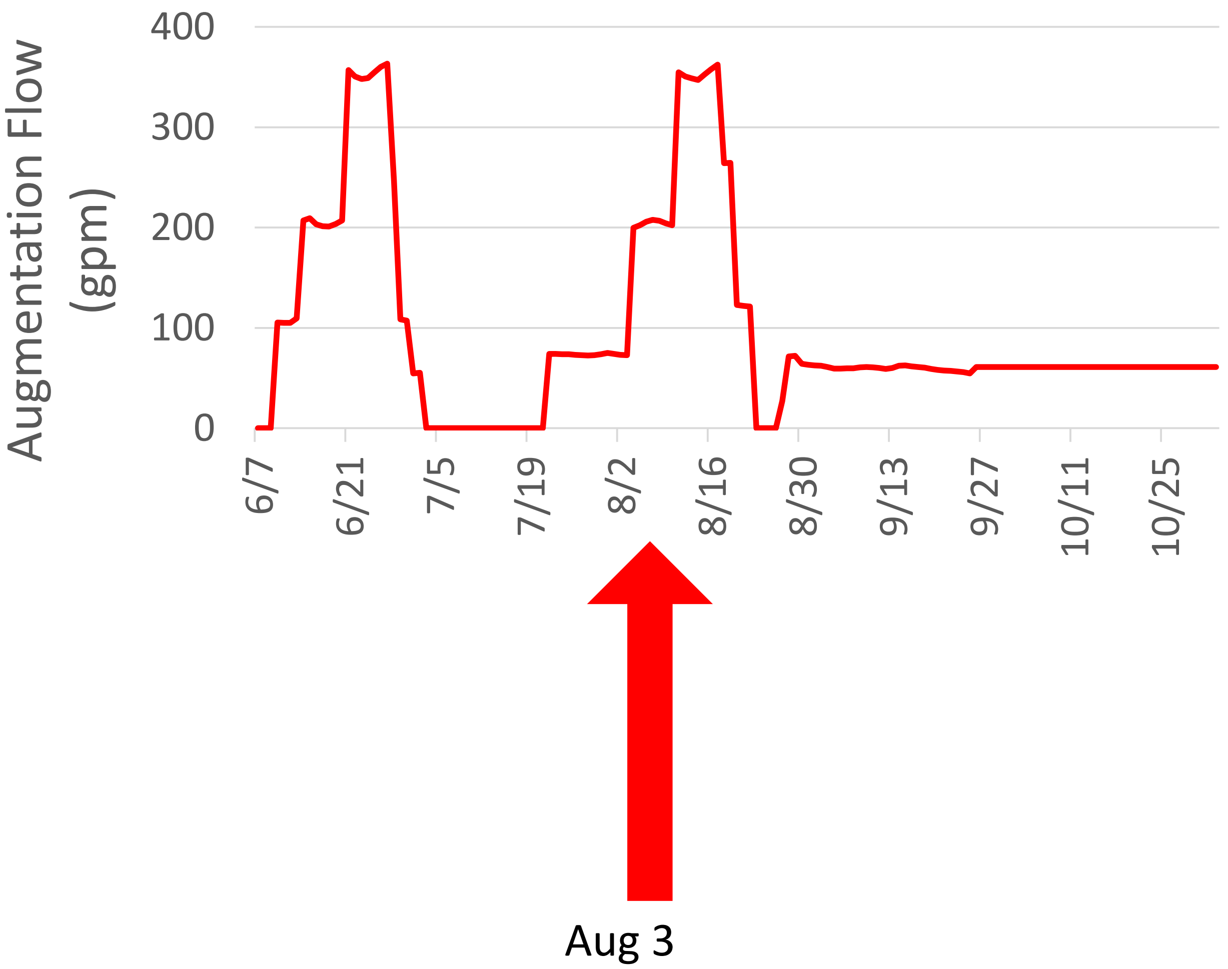
Wetted Channel Response

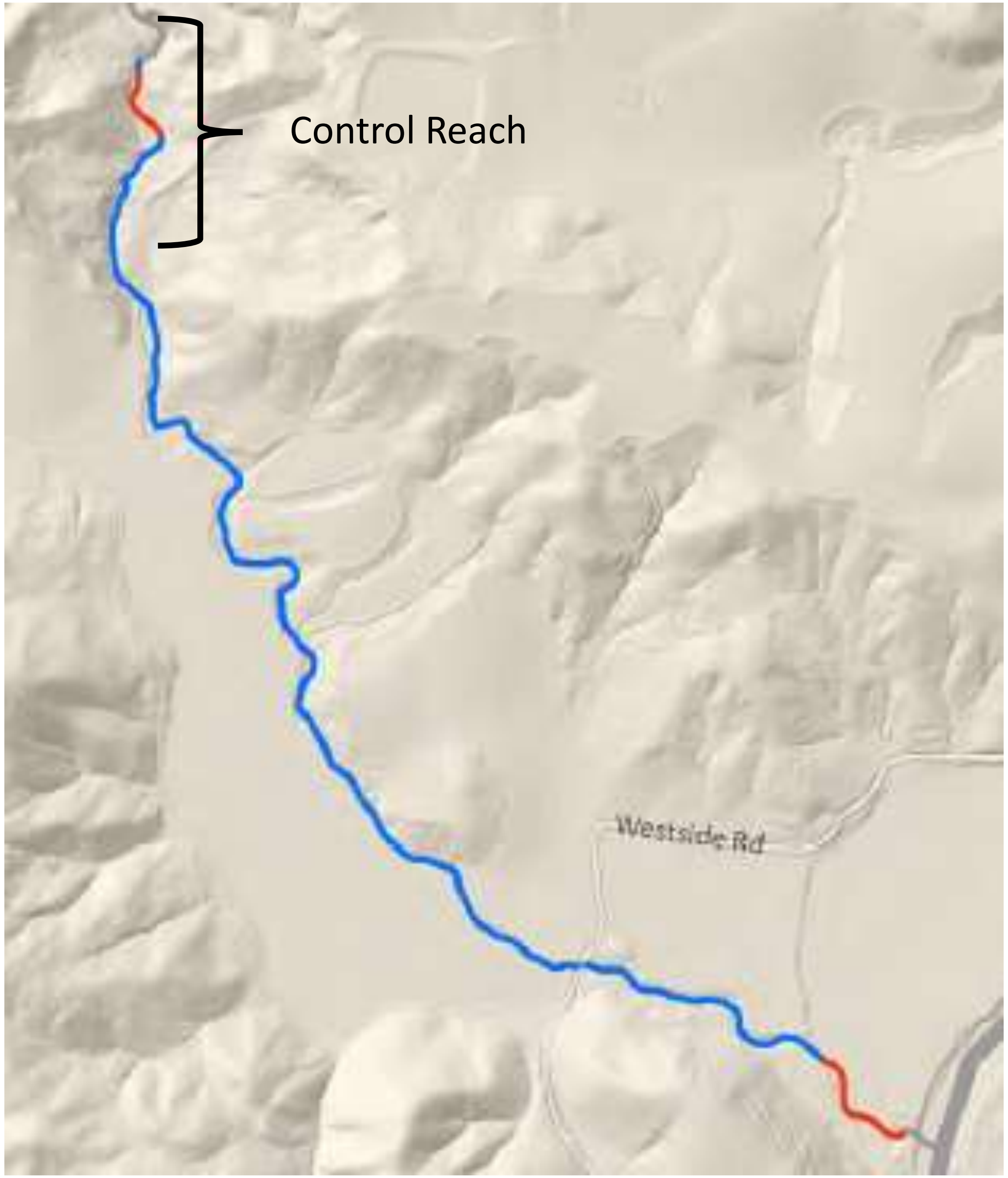


July 19

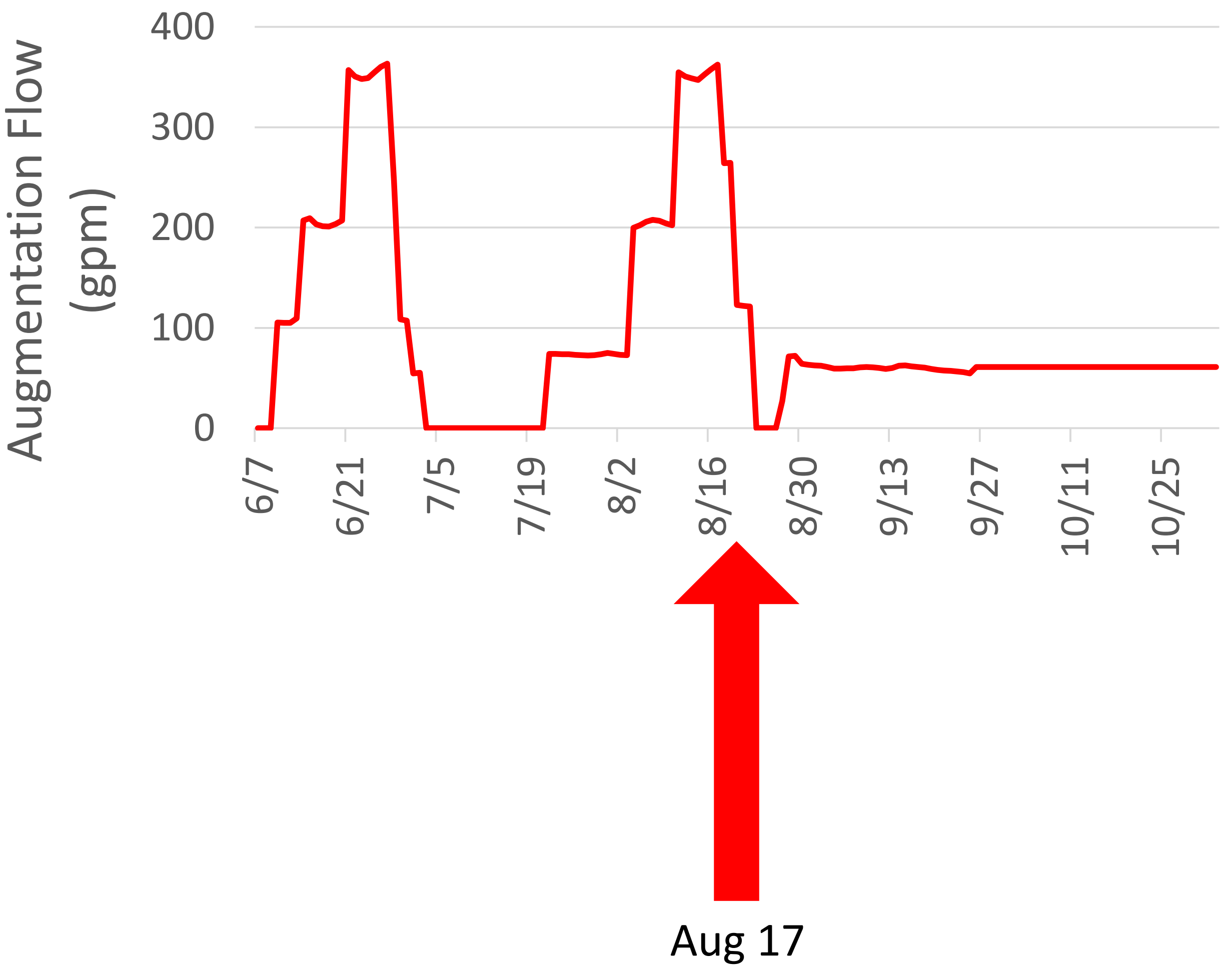


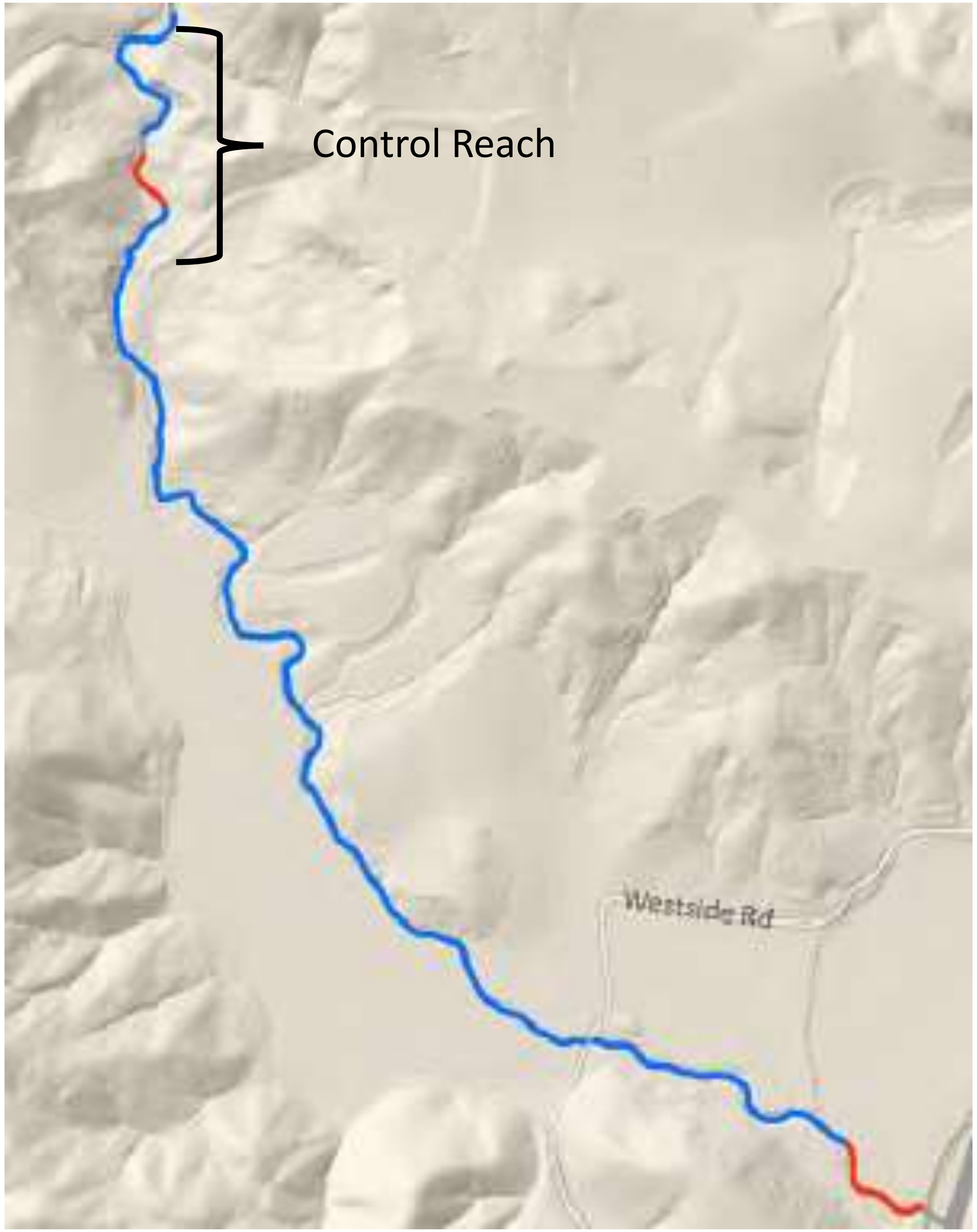
Wetted Channel Response



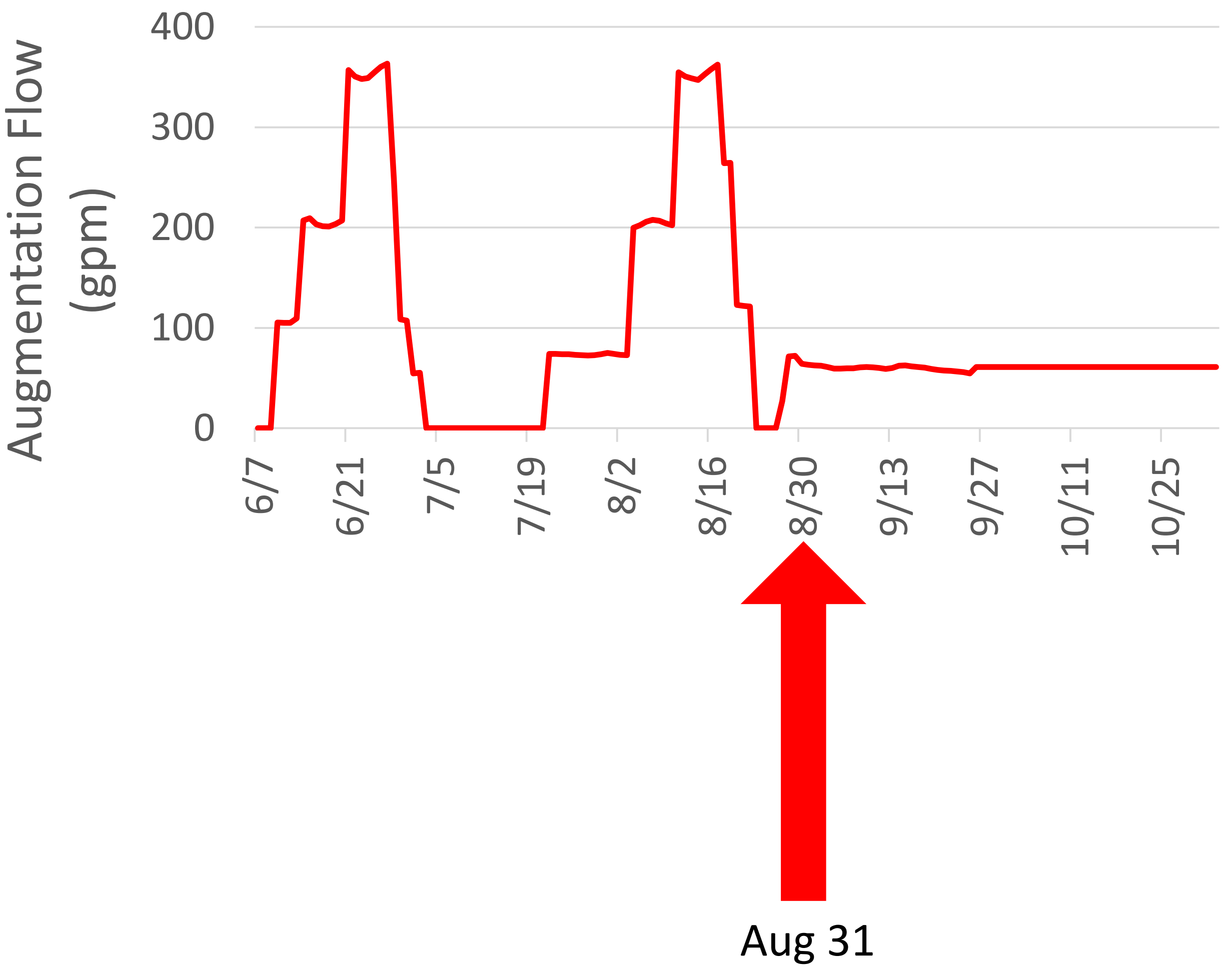


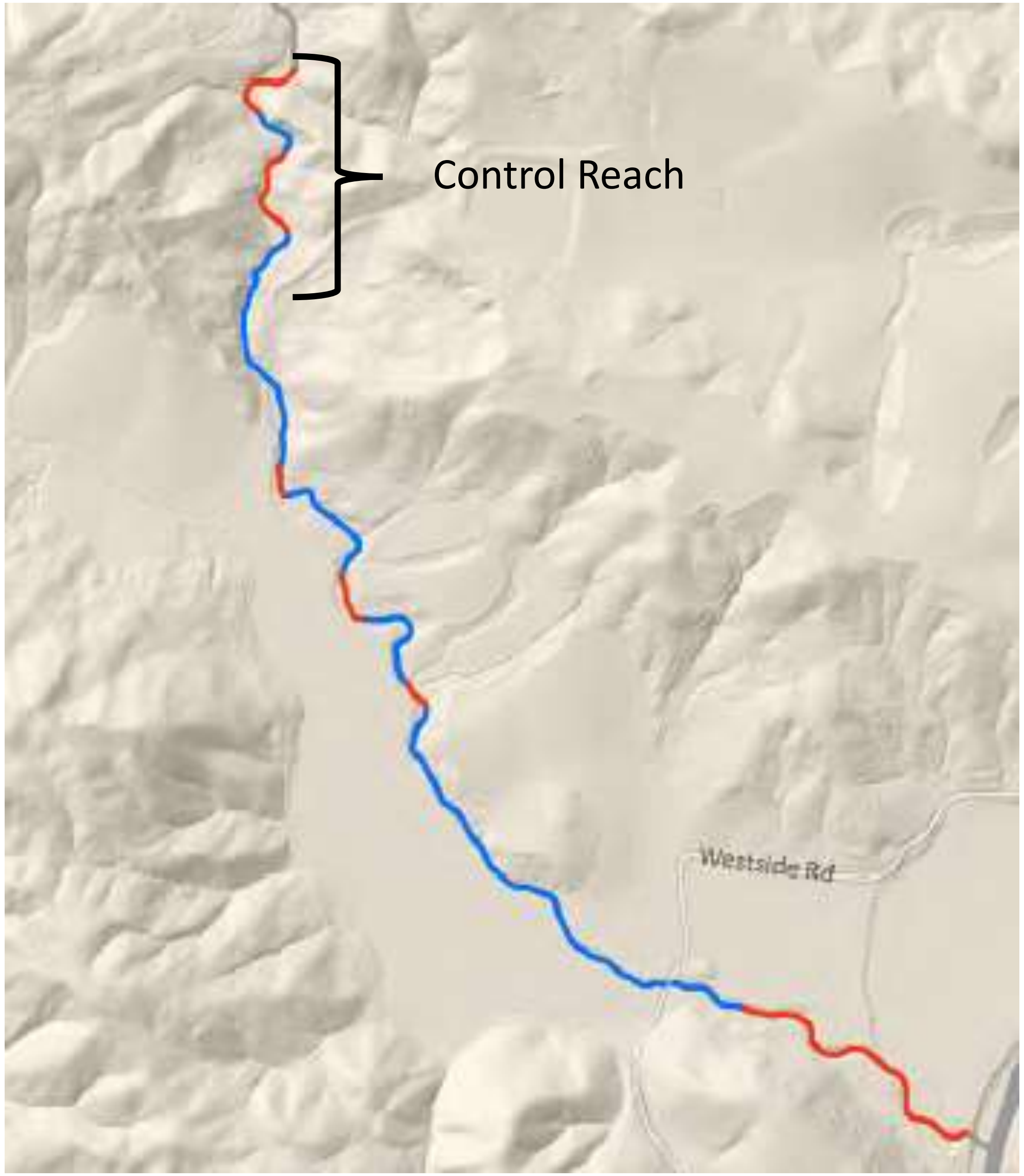
Wetted Channel Response



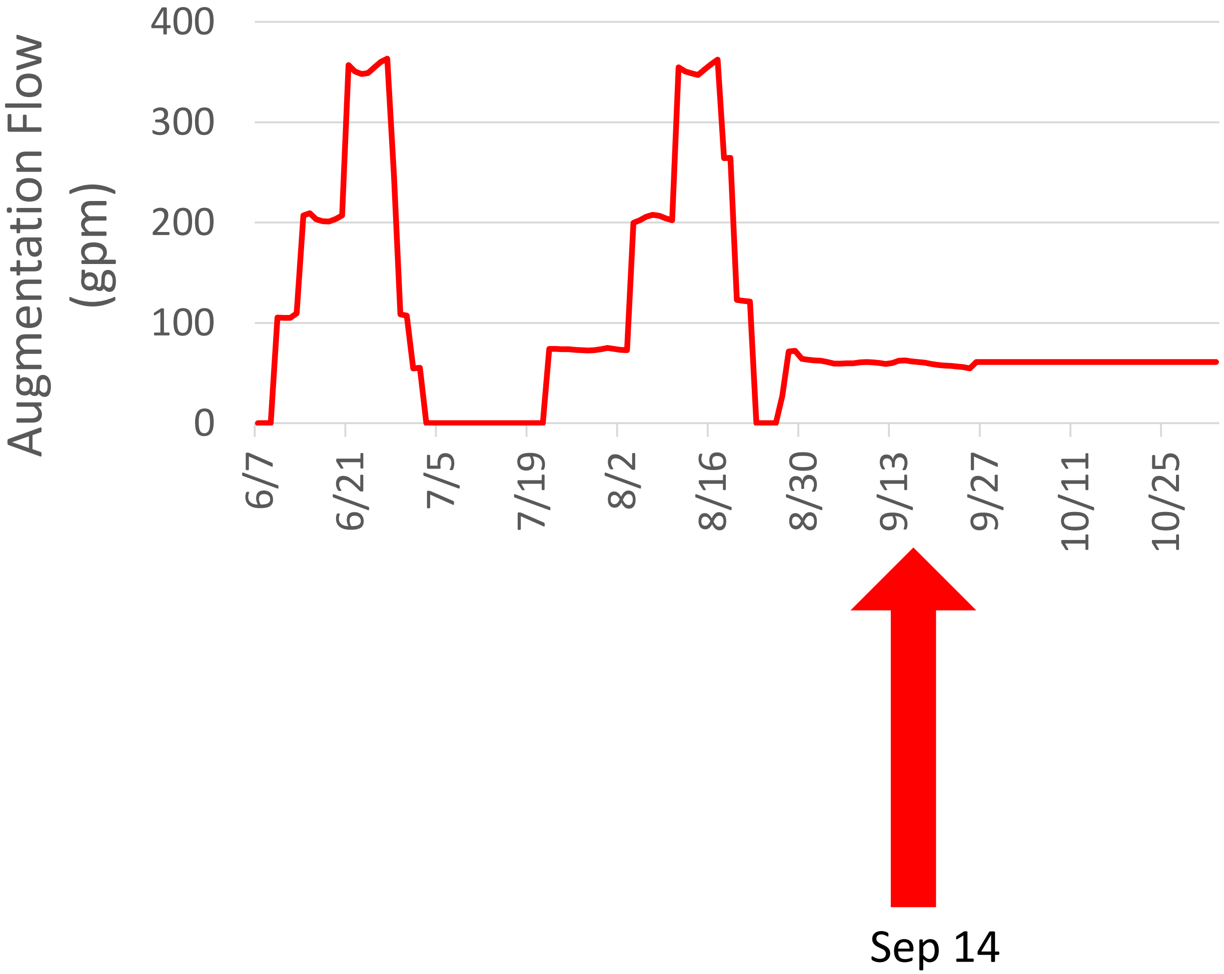


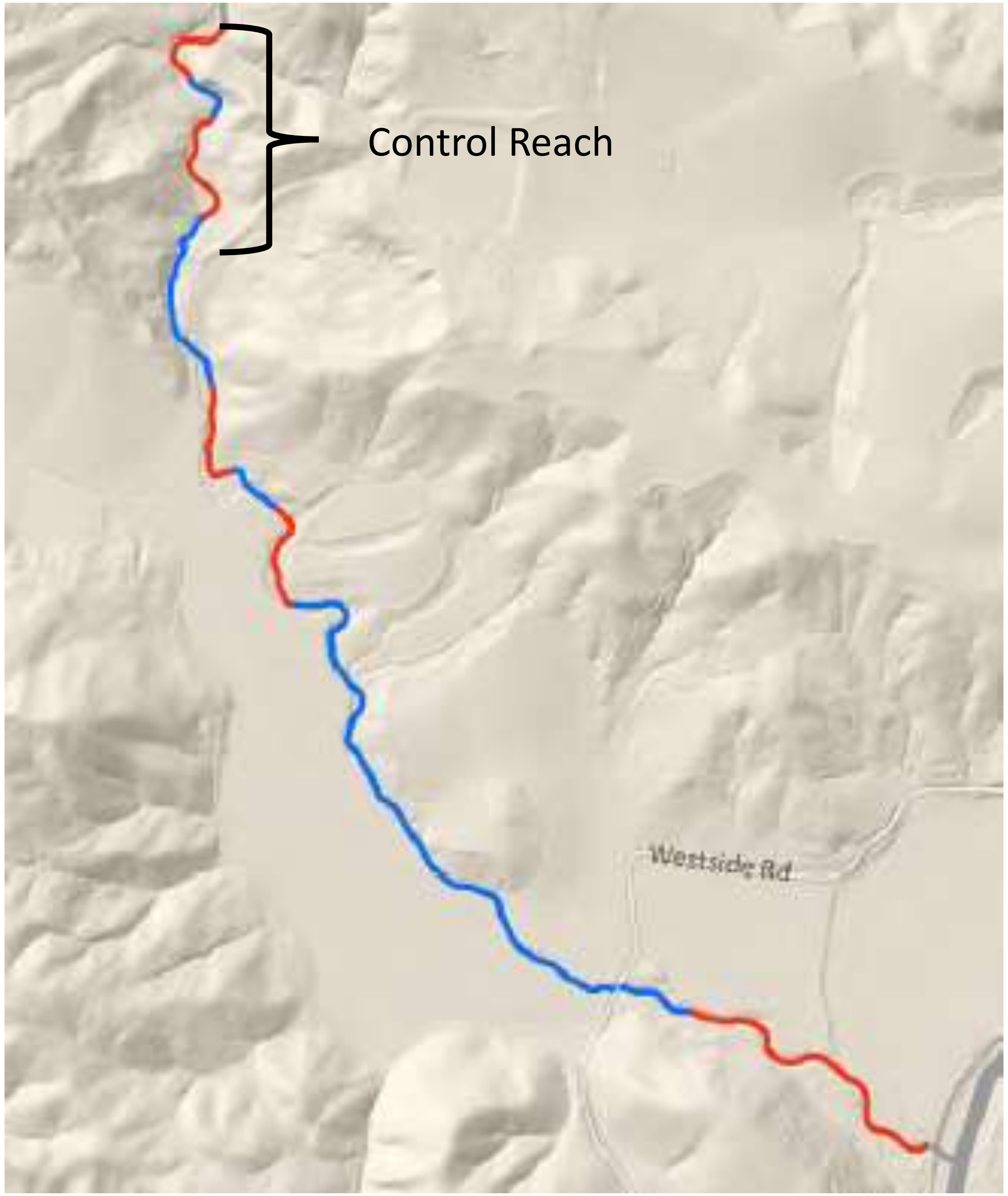
Wetted Channel Response



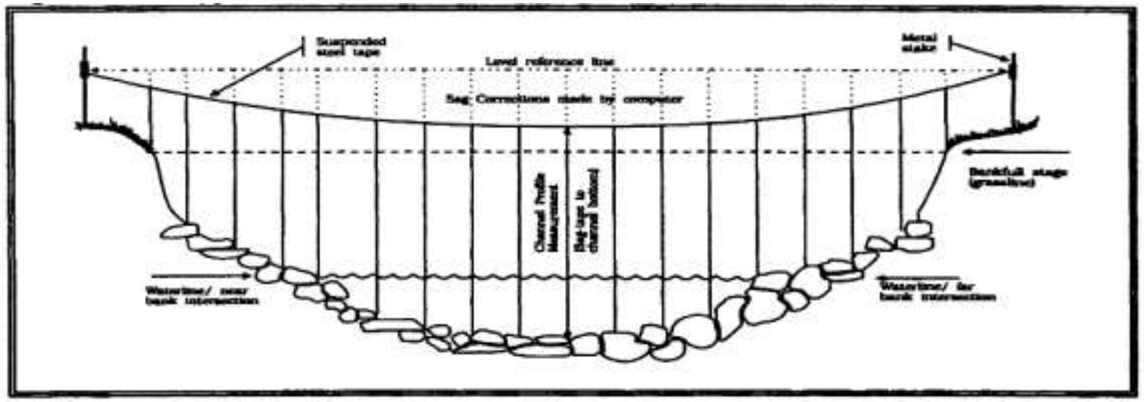


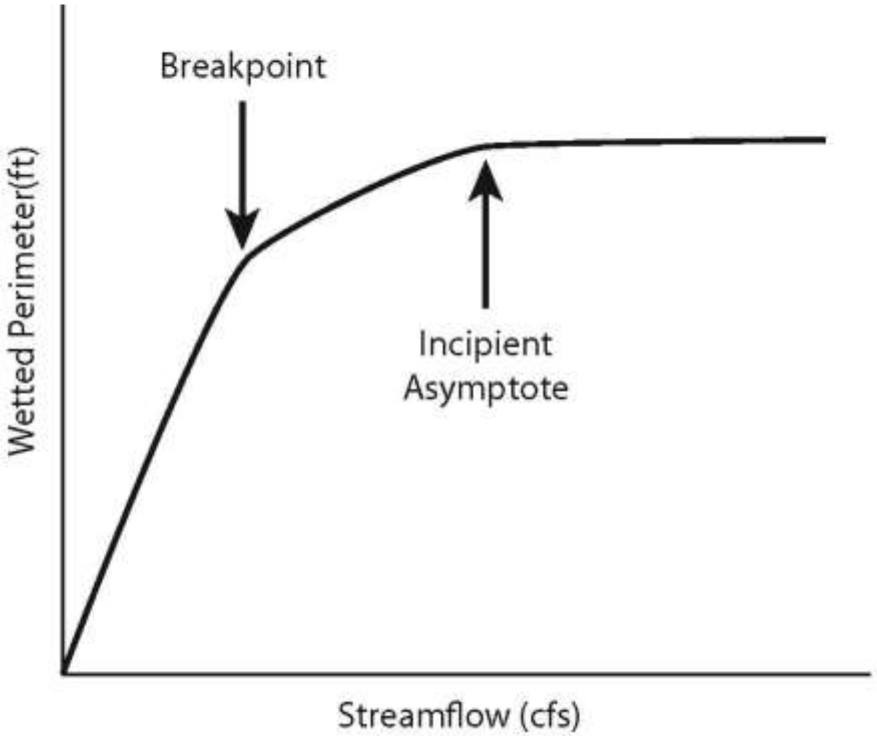
Wetted Channel Response

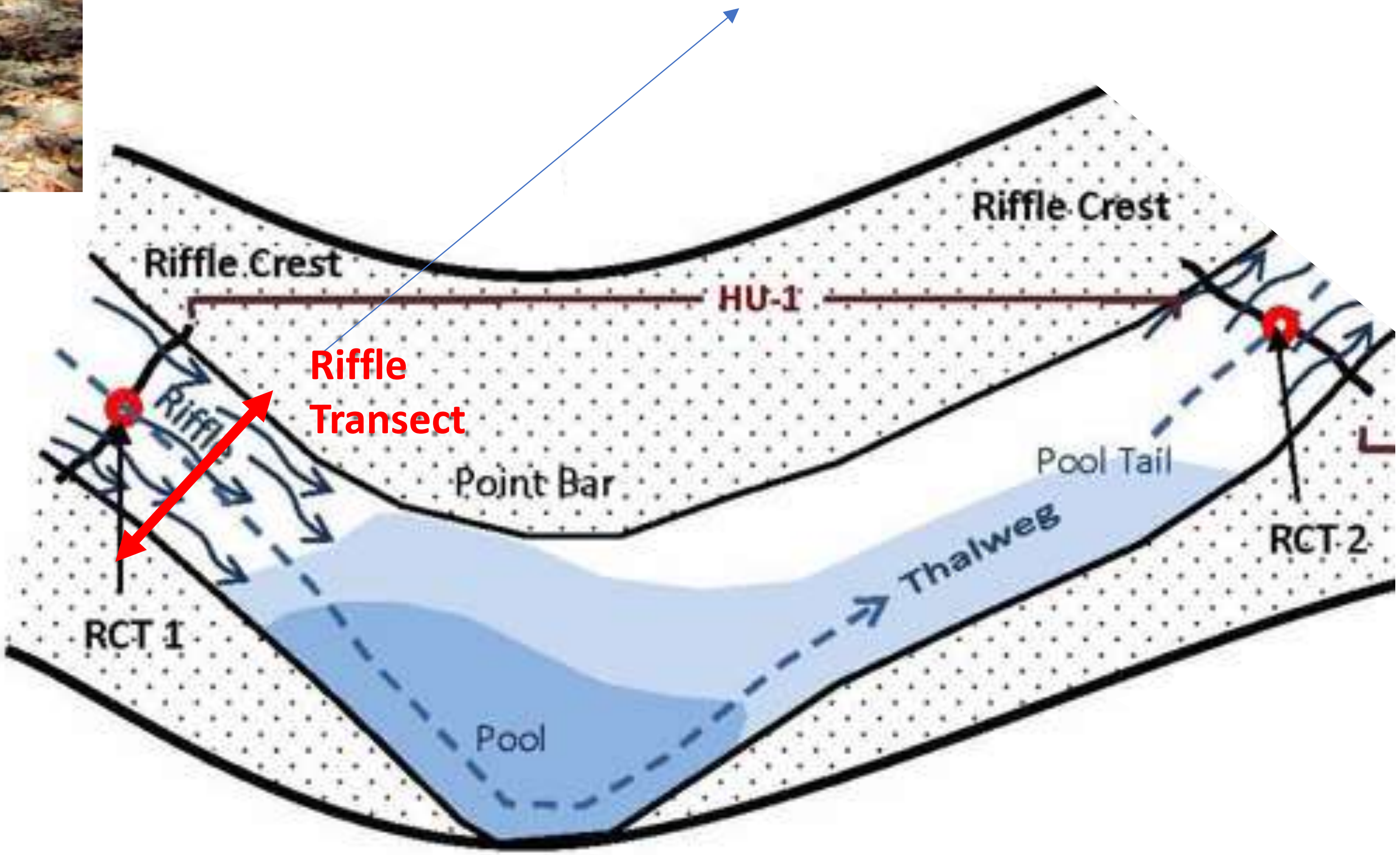


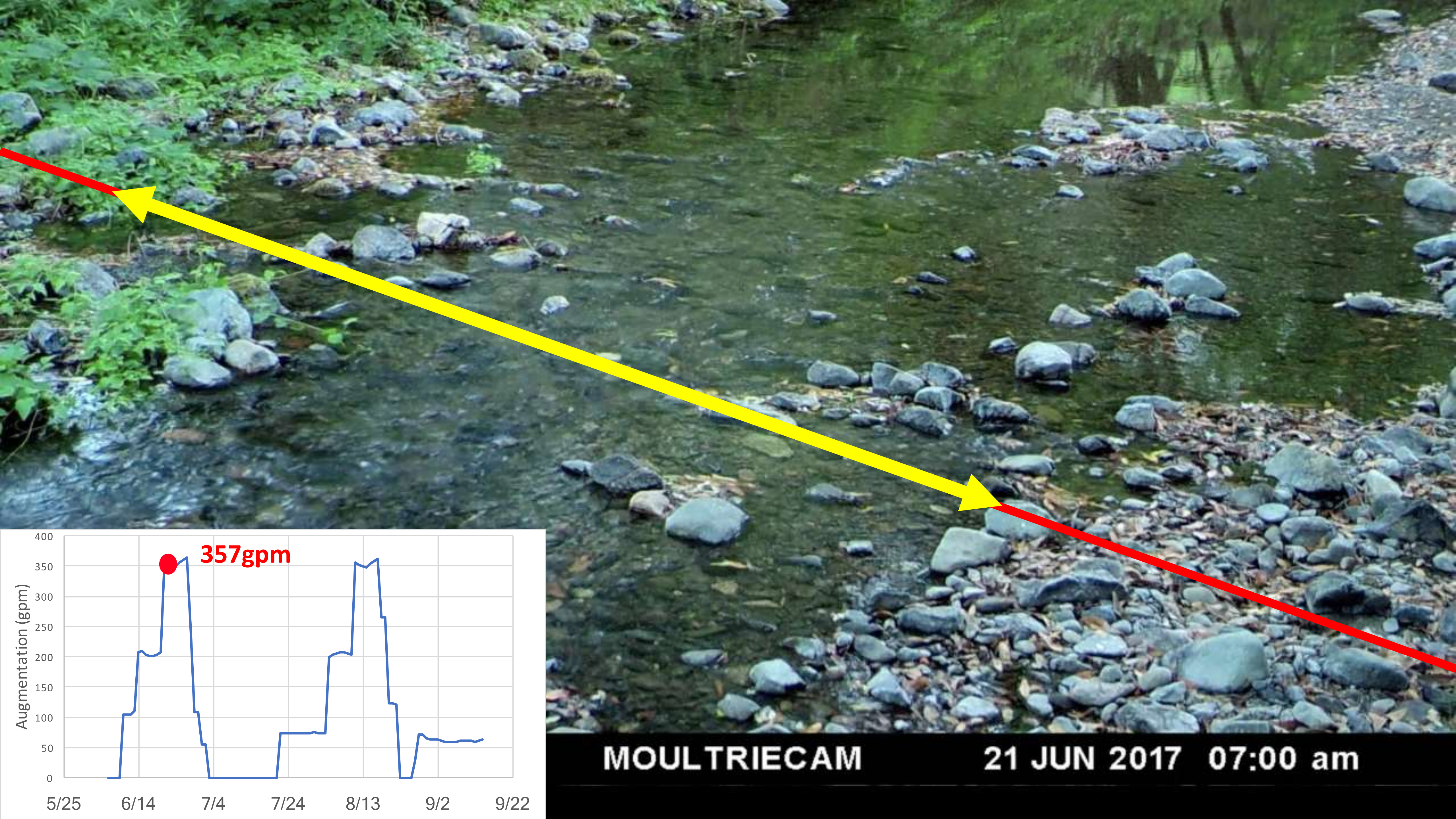


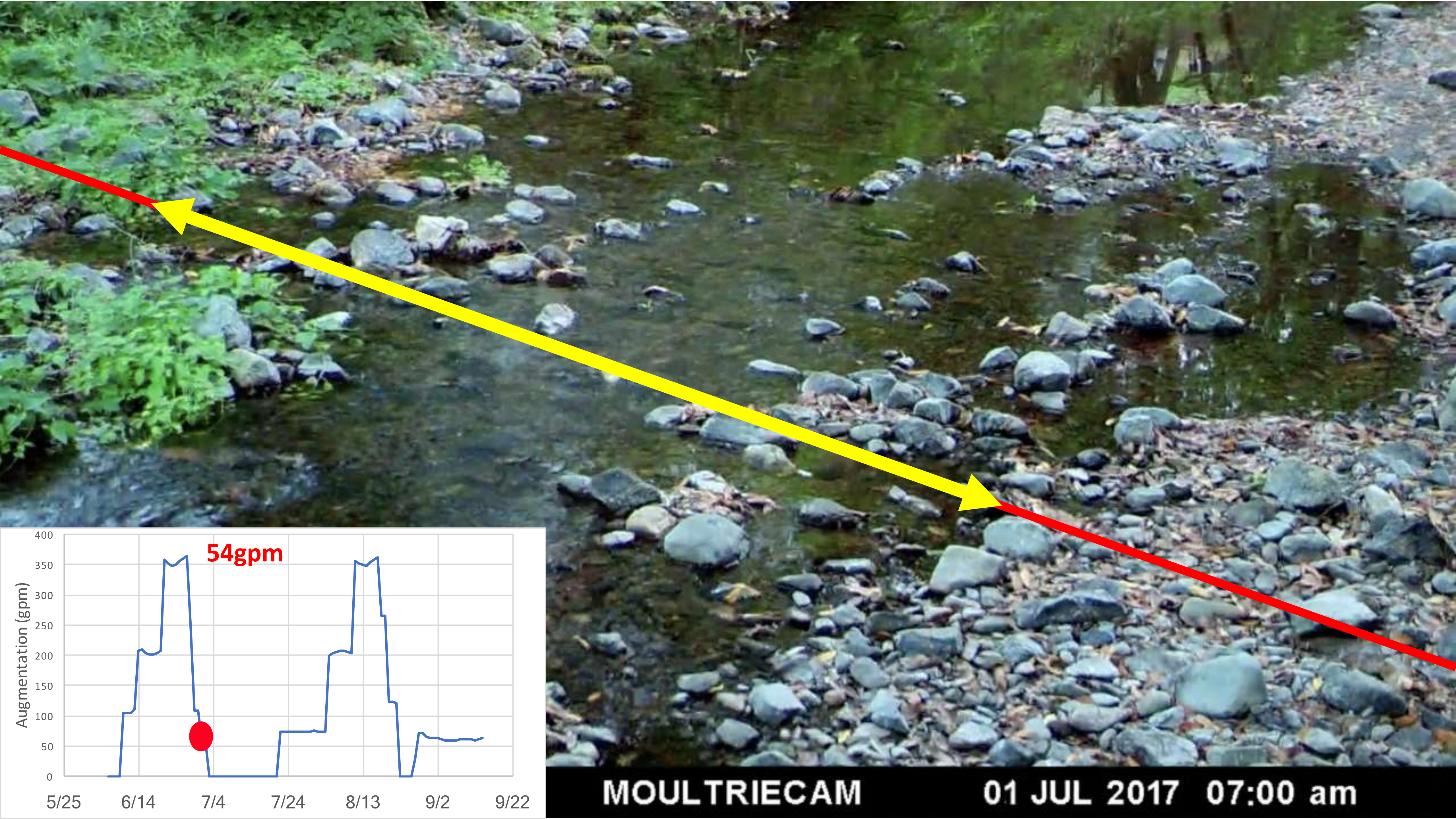
Riffle widths and depths

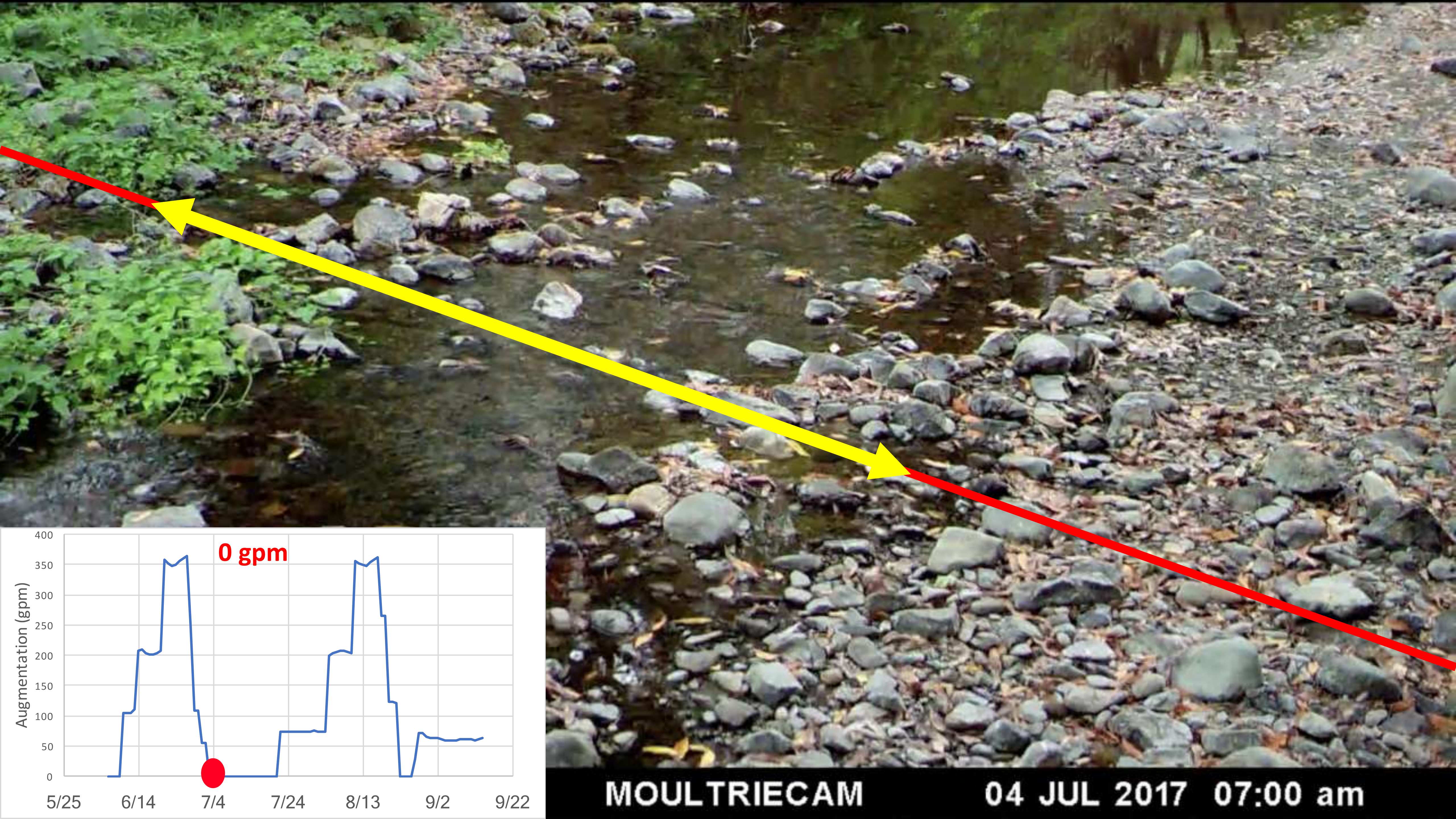




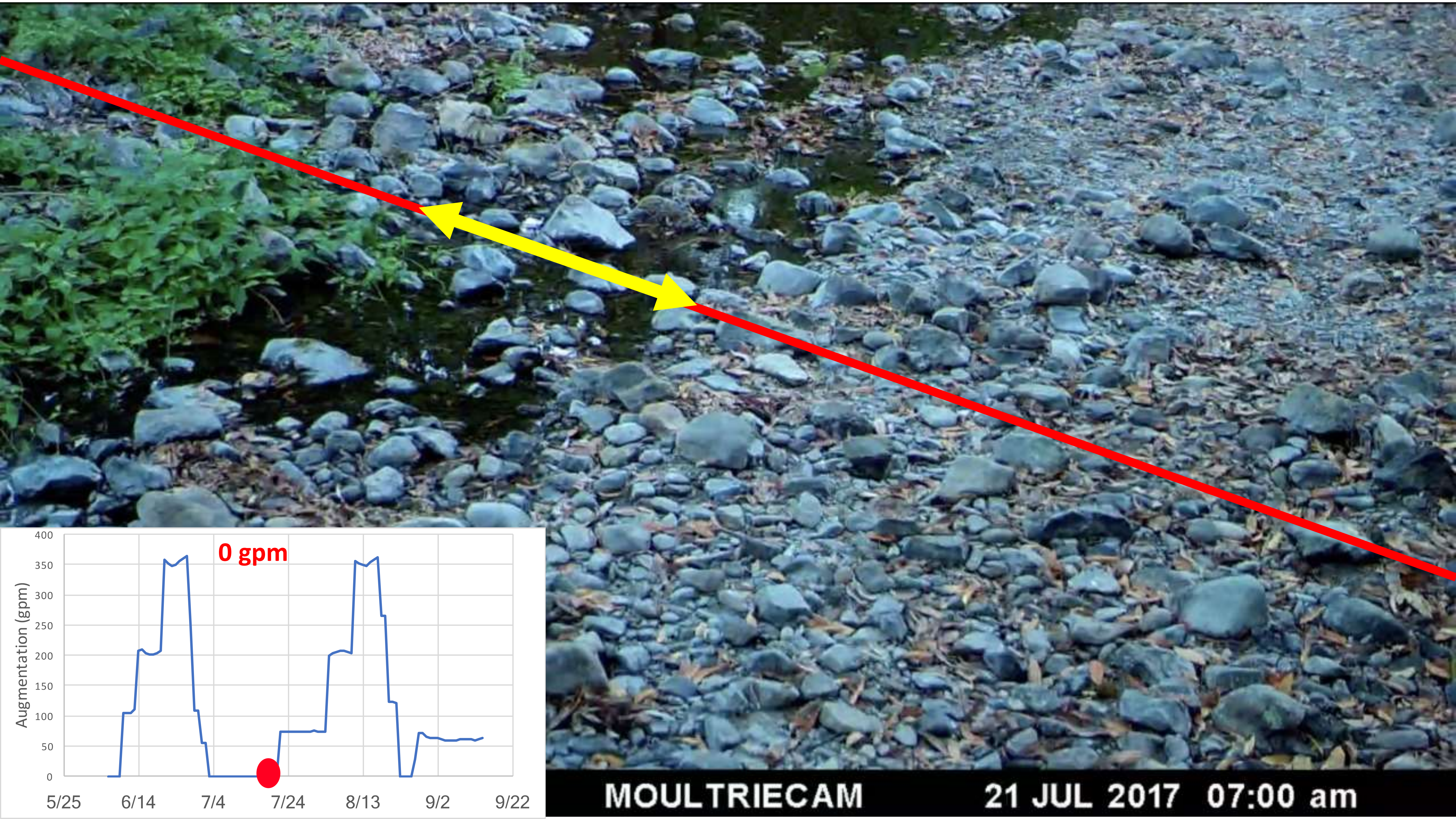


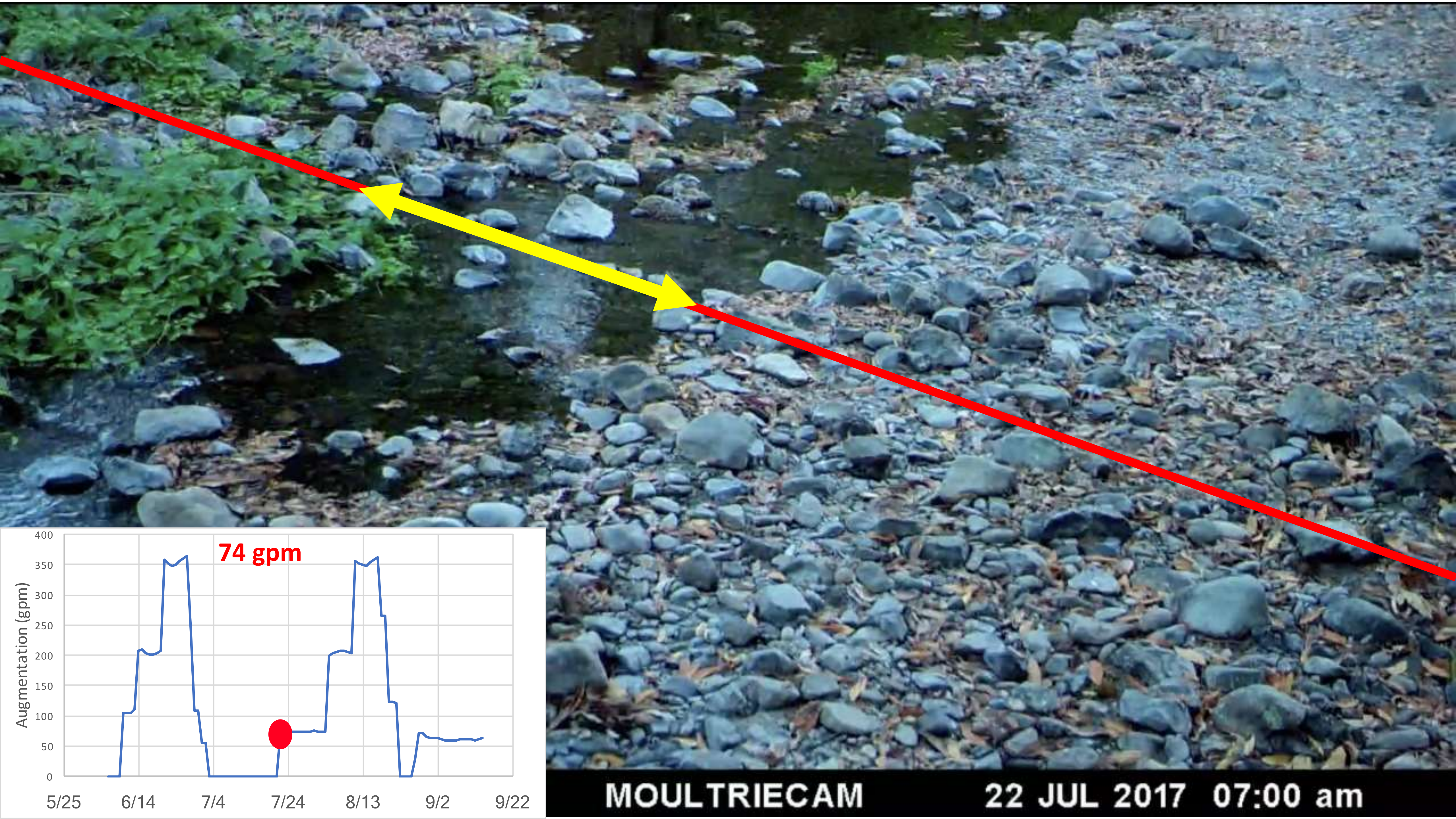

MOULTRIECAM
21 JUN 2017 07:00 am
357gpm
Augmentation (gpm)
400
350
300
250
200
150
100
50
0
5/25
6/14
7/4
7/24
8/13
9/2
9/22

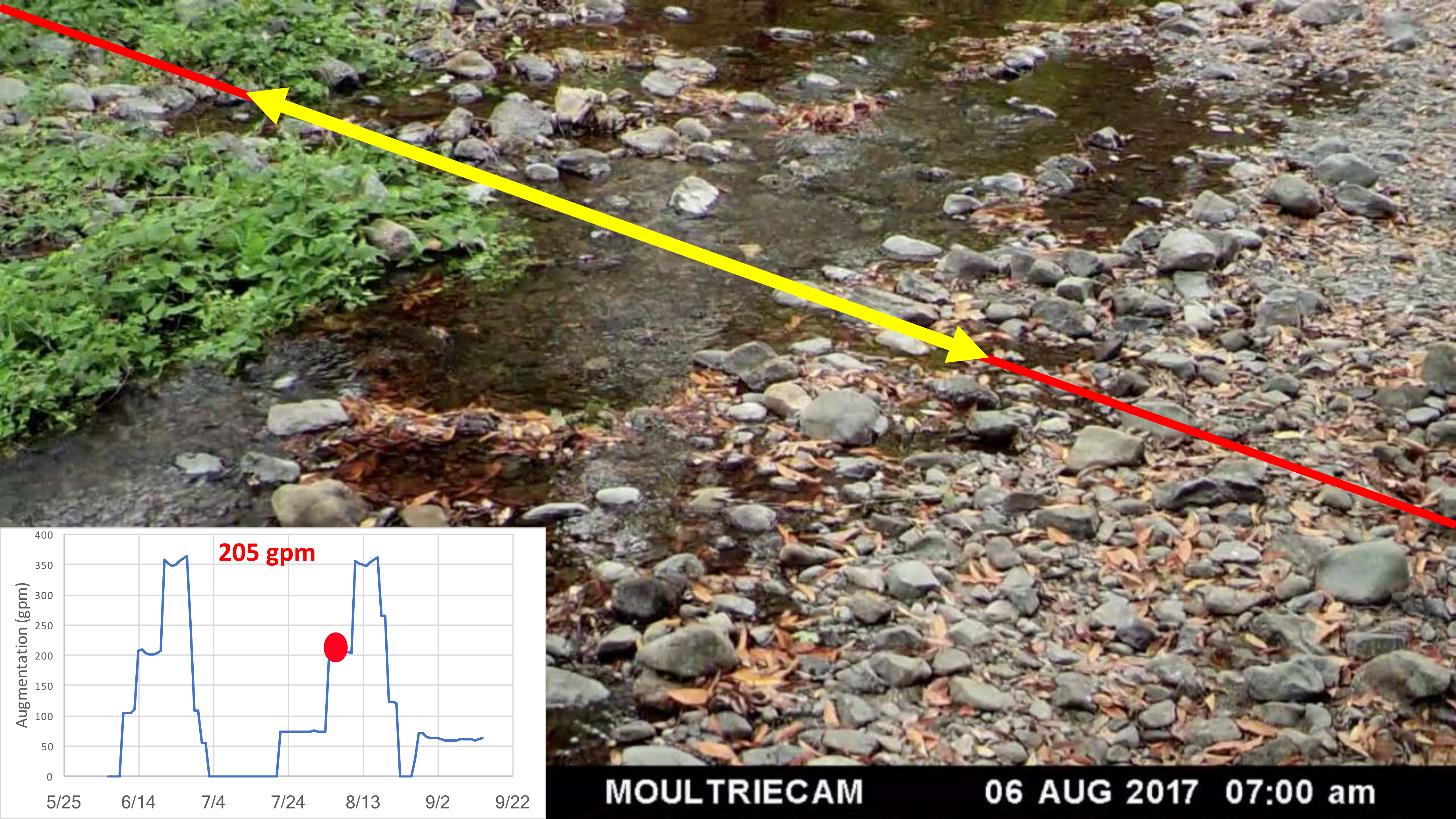

54gpm
Augmentation (gpm)
400
350
300
250
200
150
100
50
0
5/25
6/14
7/4
7/24
8/13
9/2
9/22
MOULTRIECAM
01 JUL 2017 07:00 am

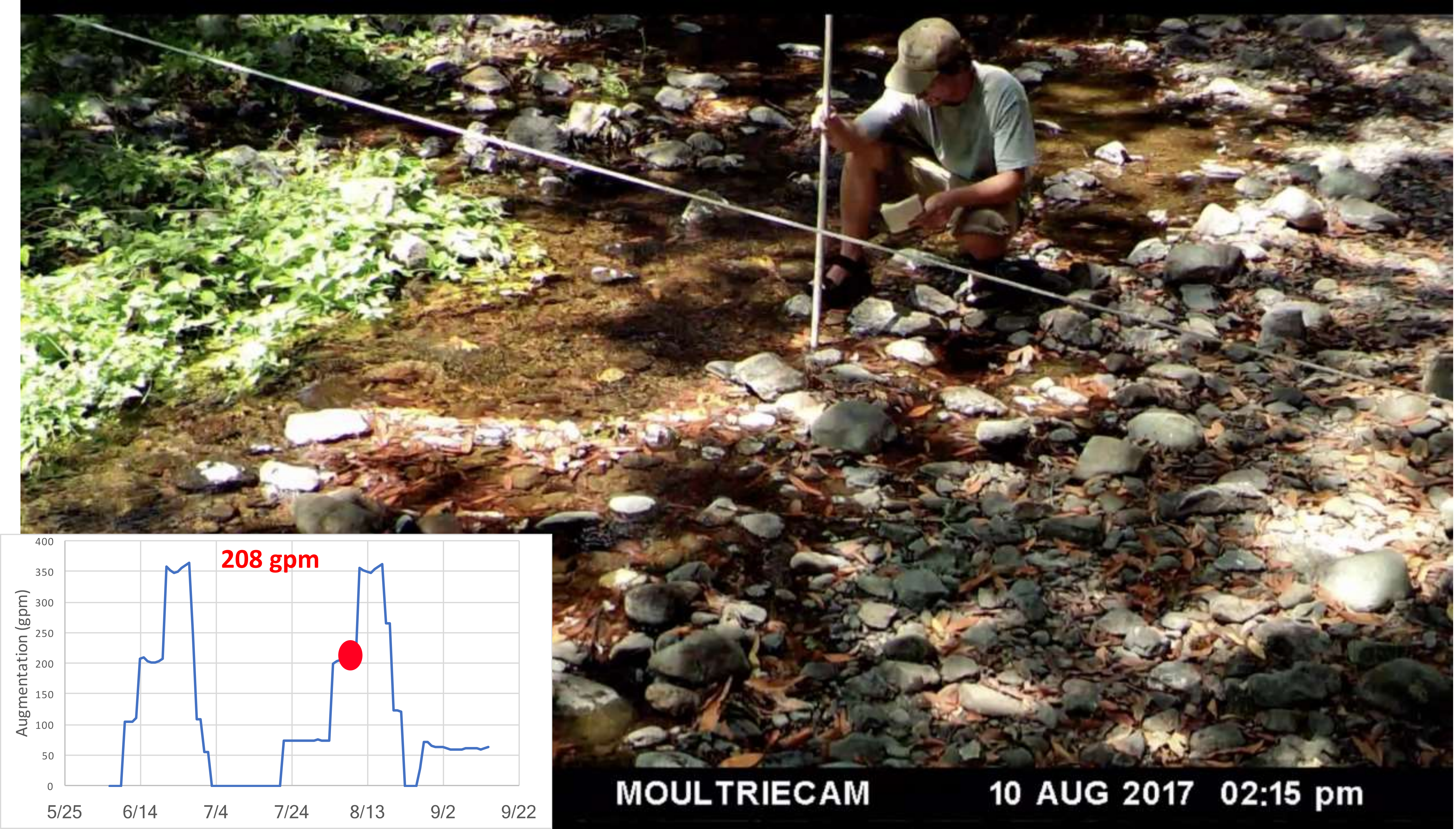


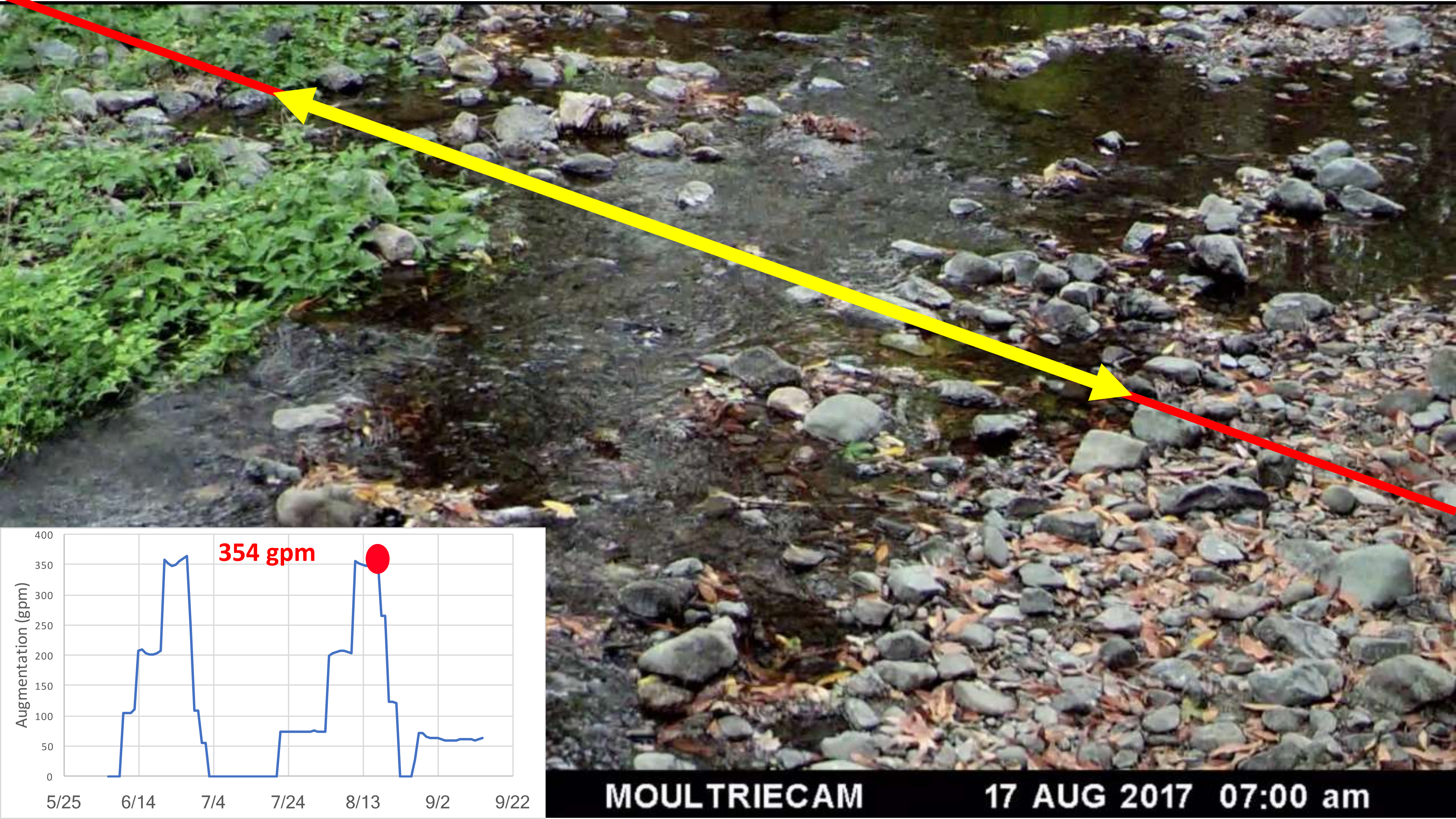
0 gpm
Augmentation (gpm)
400
350
300
250
200
150
100
50
0
5/25
6/14
7/4
7/24
8/13
9/2
9/22
MOULTRIECAM
04 JUL 2017 07:00 am

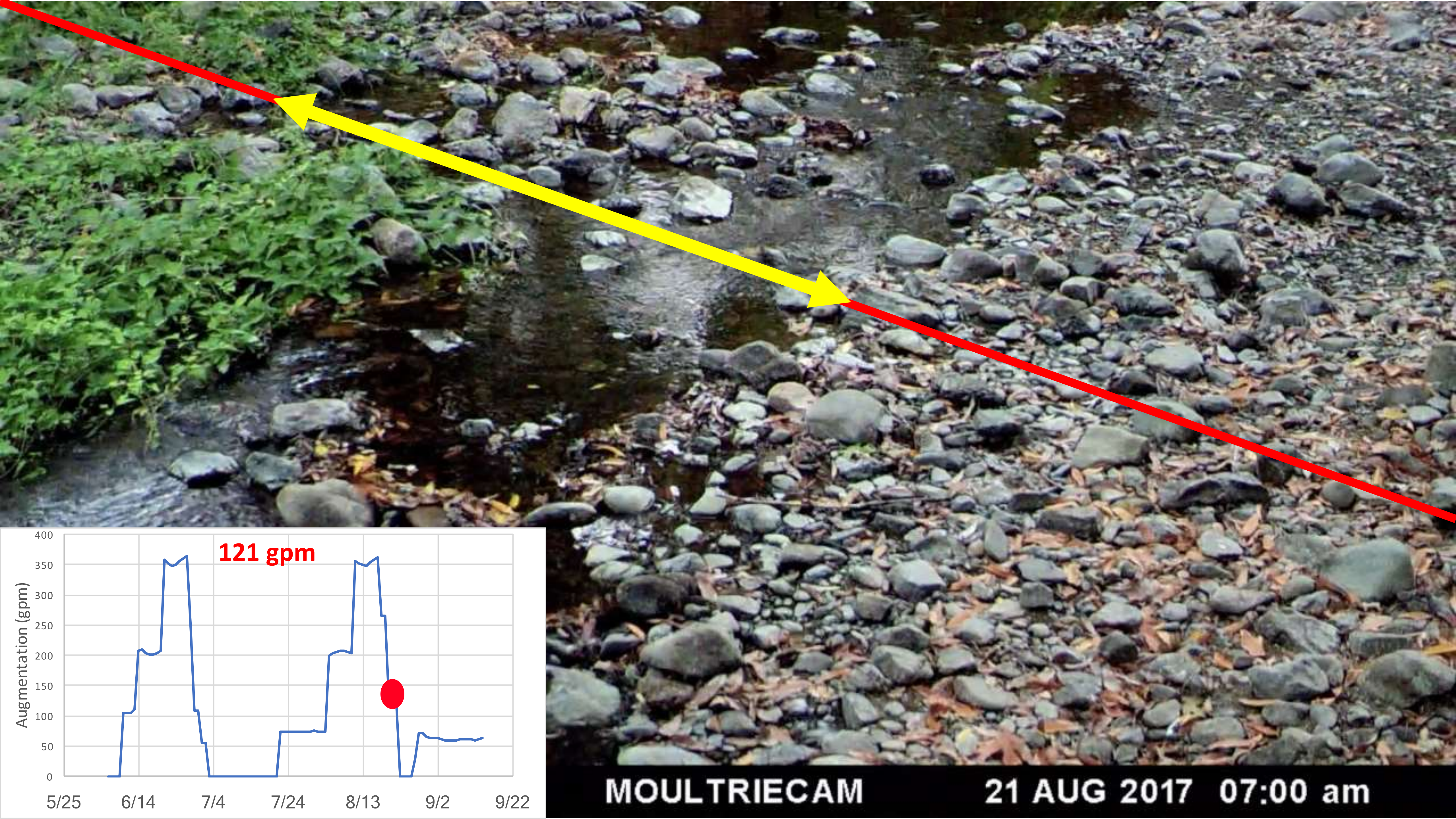

0 gpm
Augmentation (gpm)
400
350
300
250
200
150
100
50
0
5/25
6/14
7/4
7/24
8/13
9/2
9/22
MOULTRIECAM
21 JUL 2017 07:00 am

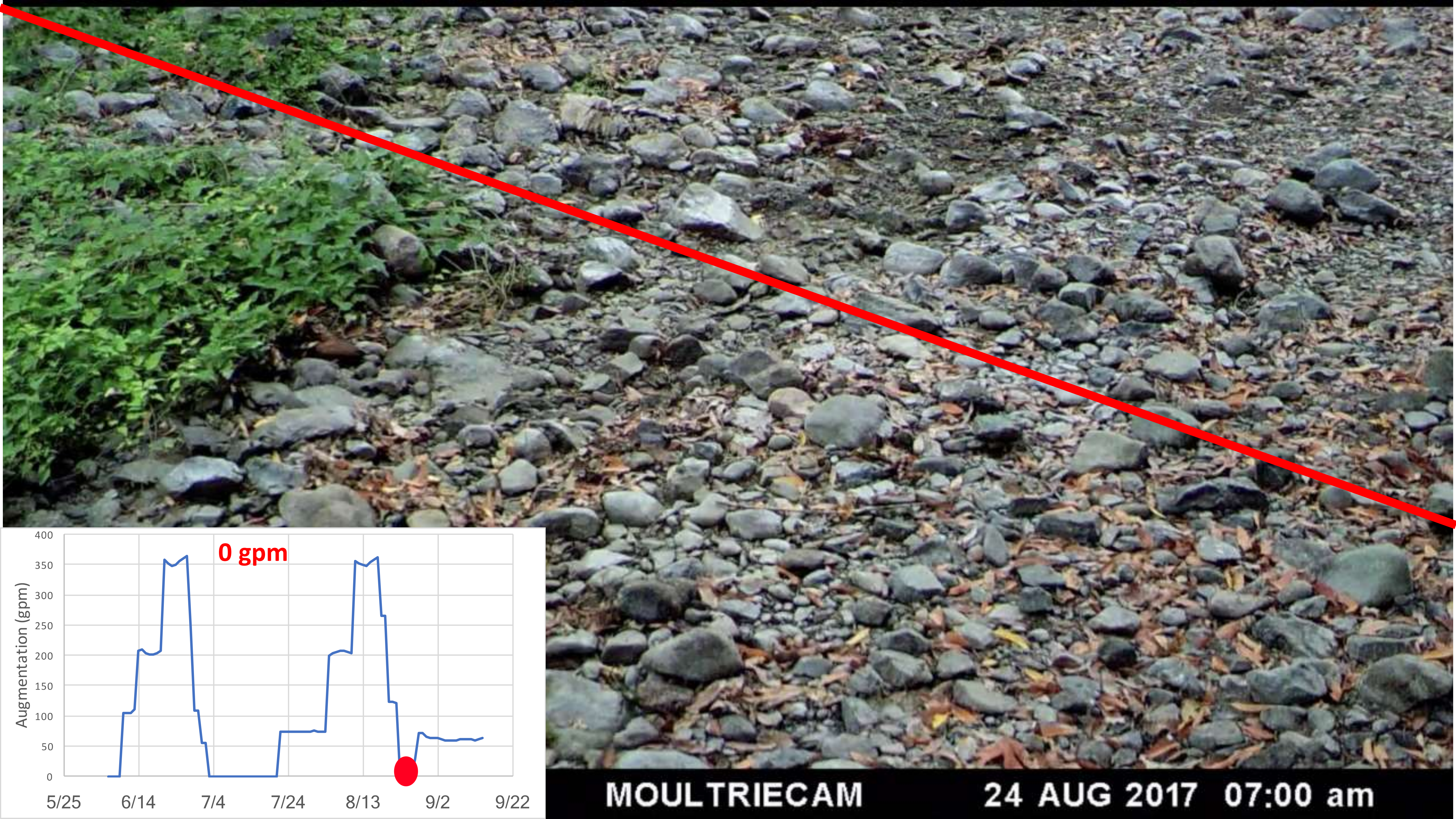

74 gpm
Augmentation (gpm)
400
350
300
250
200
150
100
50
0
5/25
6/14
7/4
7/24
8/13
9/2
9/22
MOULTRIECAM
22 JUL 2017 07:00 am

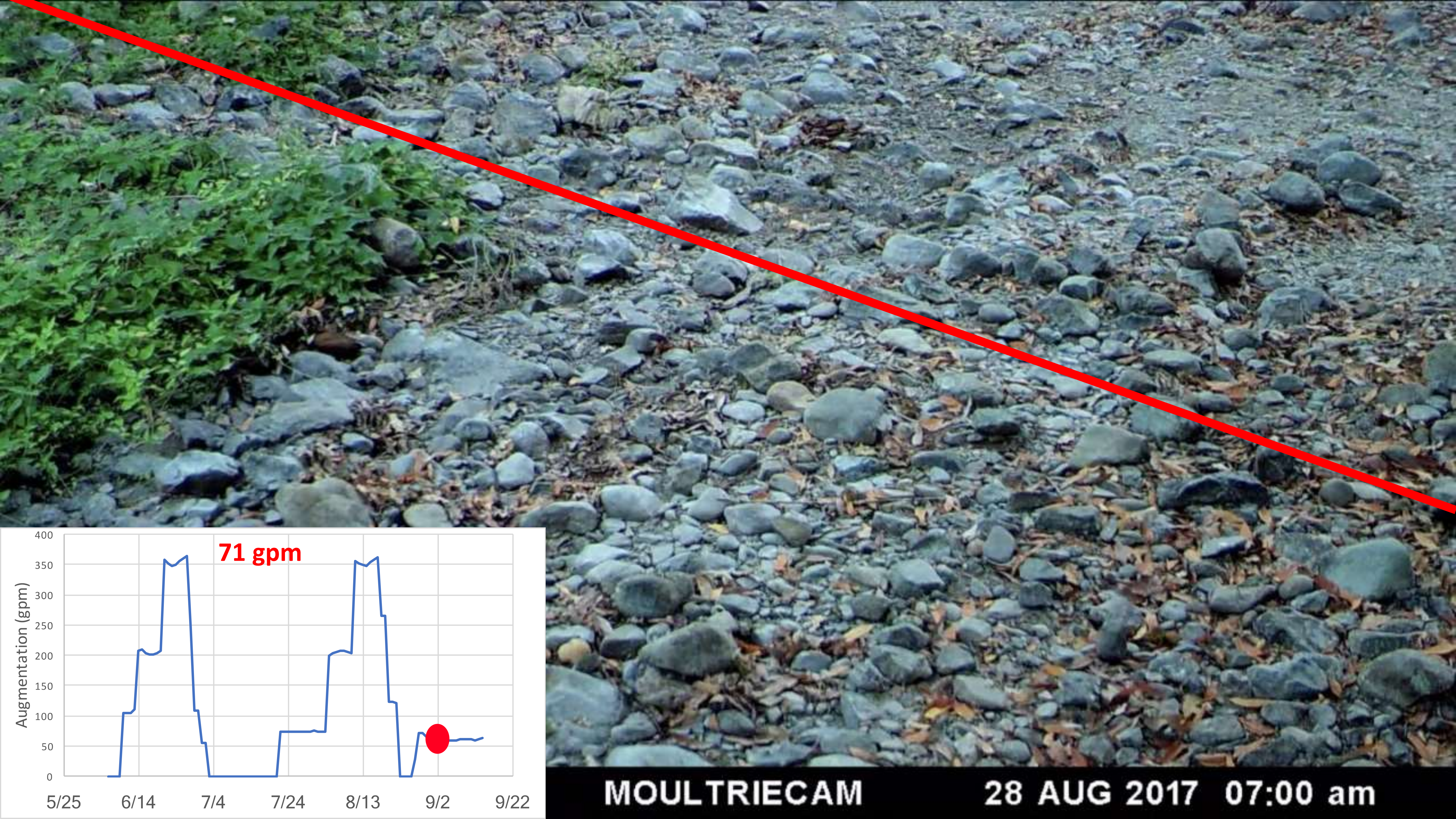

205 gpm
Augmentation (gpm)
400
350
300
250
200
150
100
50
0
5/25
6/14
7/4
7/24
8/13
9/2
9/22
MOULTRIECAM
06 AUG 2017 07:00 am

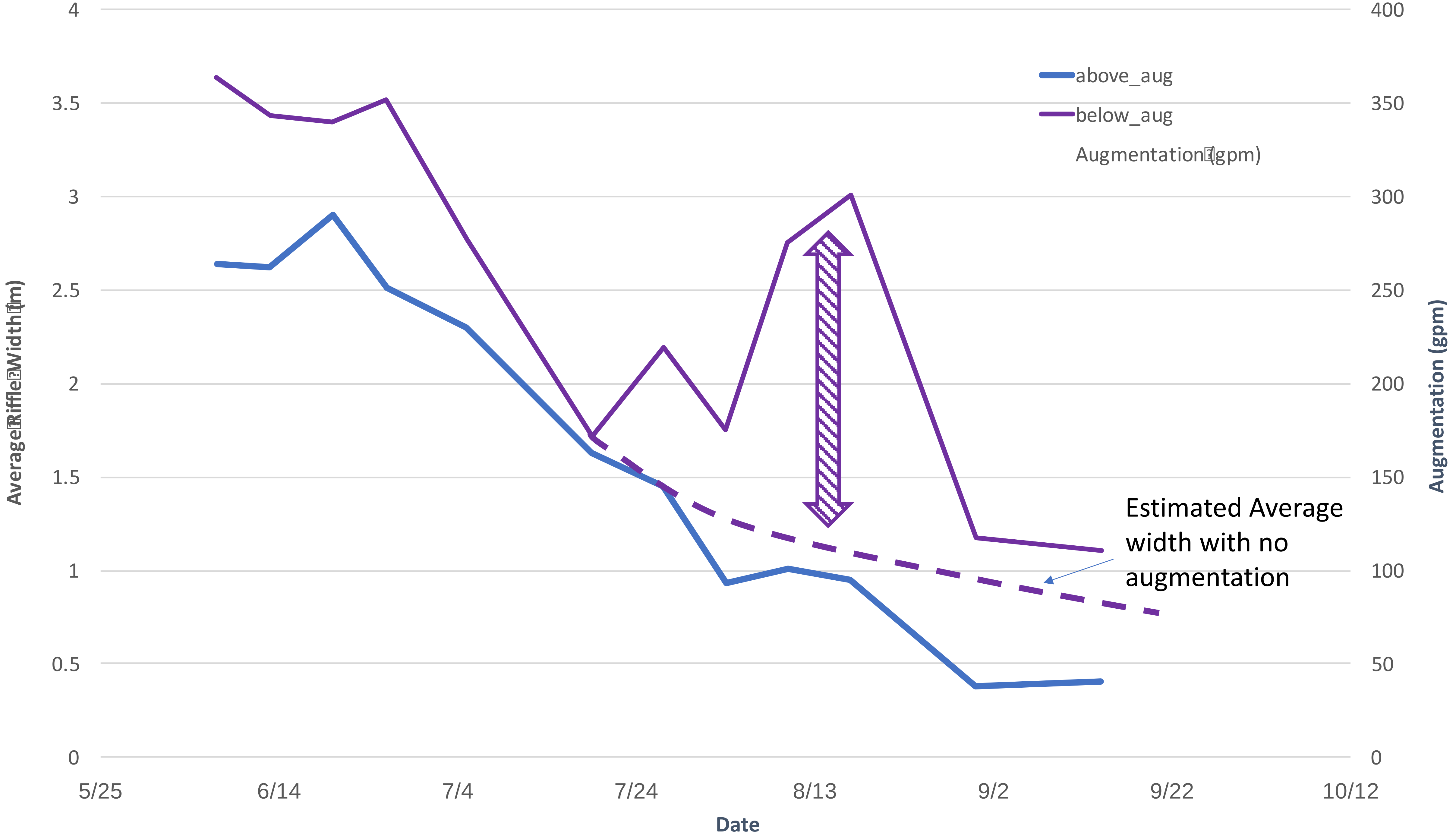

208 gpm
Augmentation (gpm)
400
350
300
250
200
150
100
50
0
5/25
6/14
7/4
7/24
8/13
9/2
9/22
MOULTRIECAM
10 AUG 2017 02:15 pm


354 gpm
Augmentation (gpm)
400
350
300
250
200
150
100
50
0
5/25
6/14
7/4
7/24
8/13
9/2
9/22
MOULTRIECAM
17 AUG 2017 07:00 am

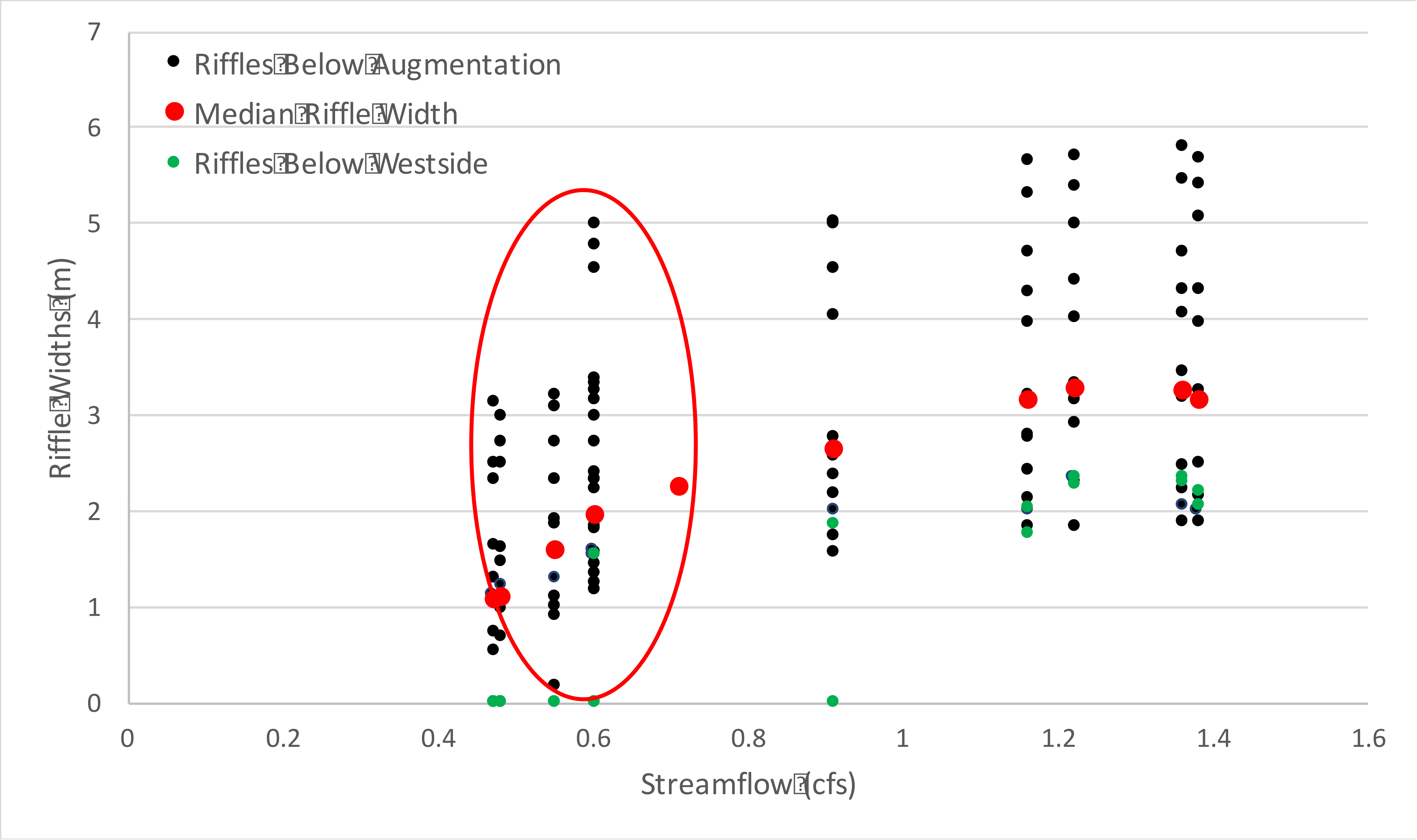

121 gpm
Augmentation (gpm)
400
350
300
250
200
150
100
50
0
5/25
6/14
7/4
7/24
8/13
9/2
9/22
MOULTRIECAM
21 AUG 2017 07:00 am


0 gpm
Augmentation (gpm)
400
350
300
250
200
150
100
50
0
5/25
6/14
7/4
7/24
8/13
9/2
9/22
MOULTRIECAM
24 AUG 2017 07:00 am

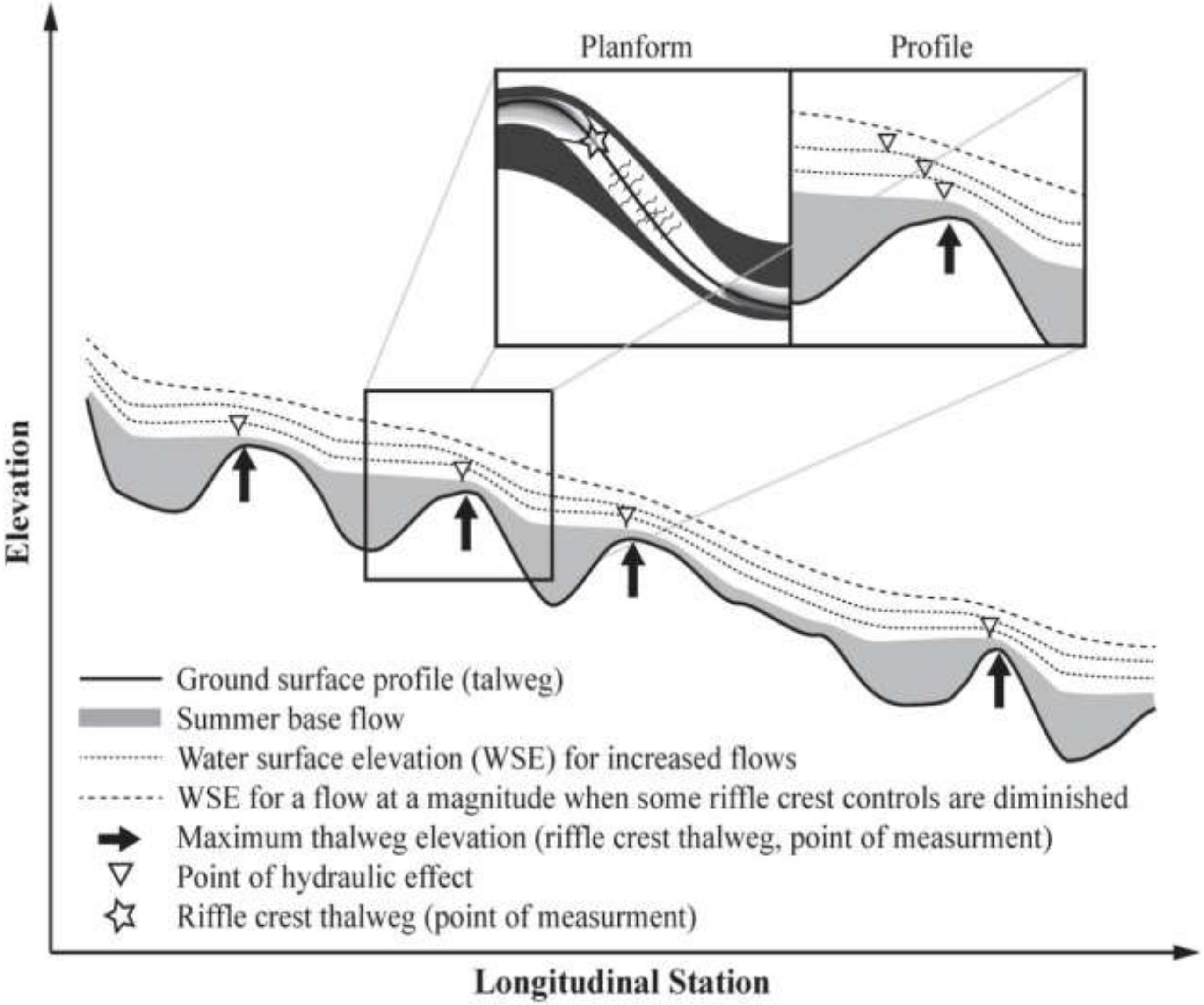

71 gpm
Augmentation (gpm)
400
350
300
250
200
150
100
50
0
5/25
6/14
7/4
7/24
8/13
9/2
9/22
MOULTRIECAM
28 AUG 2017 07:00 am

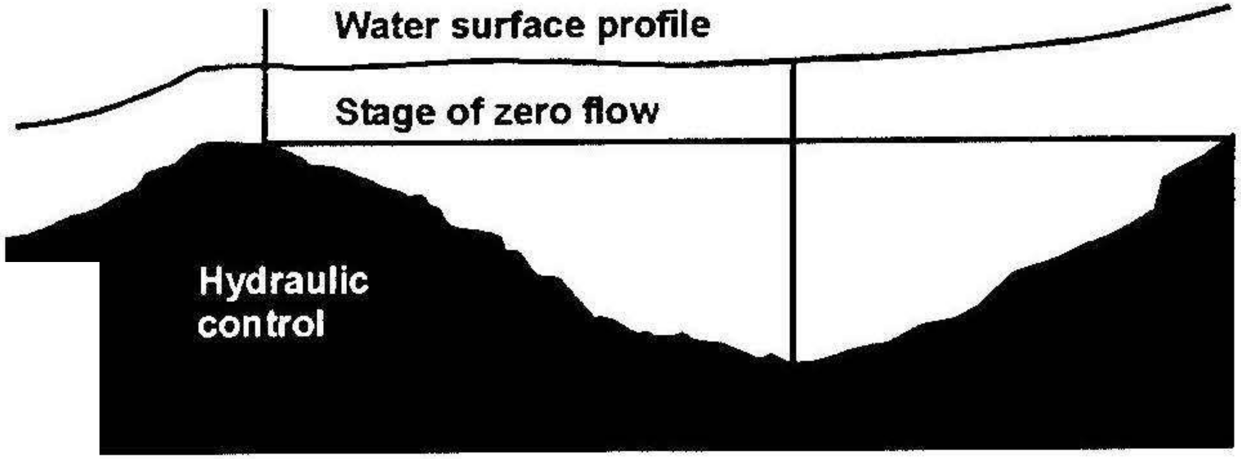


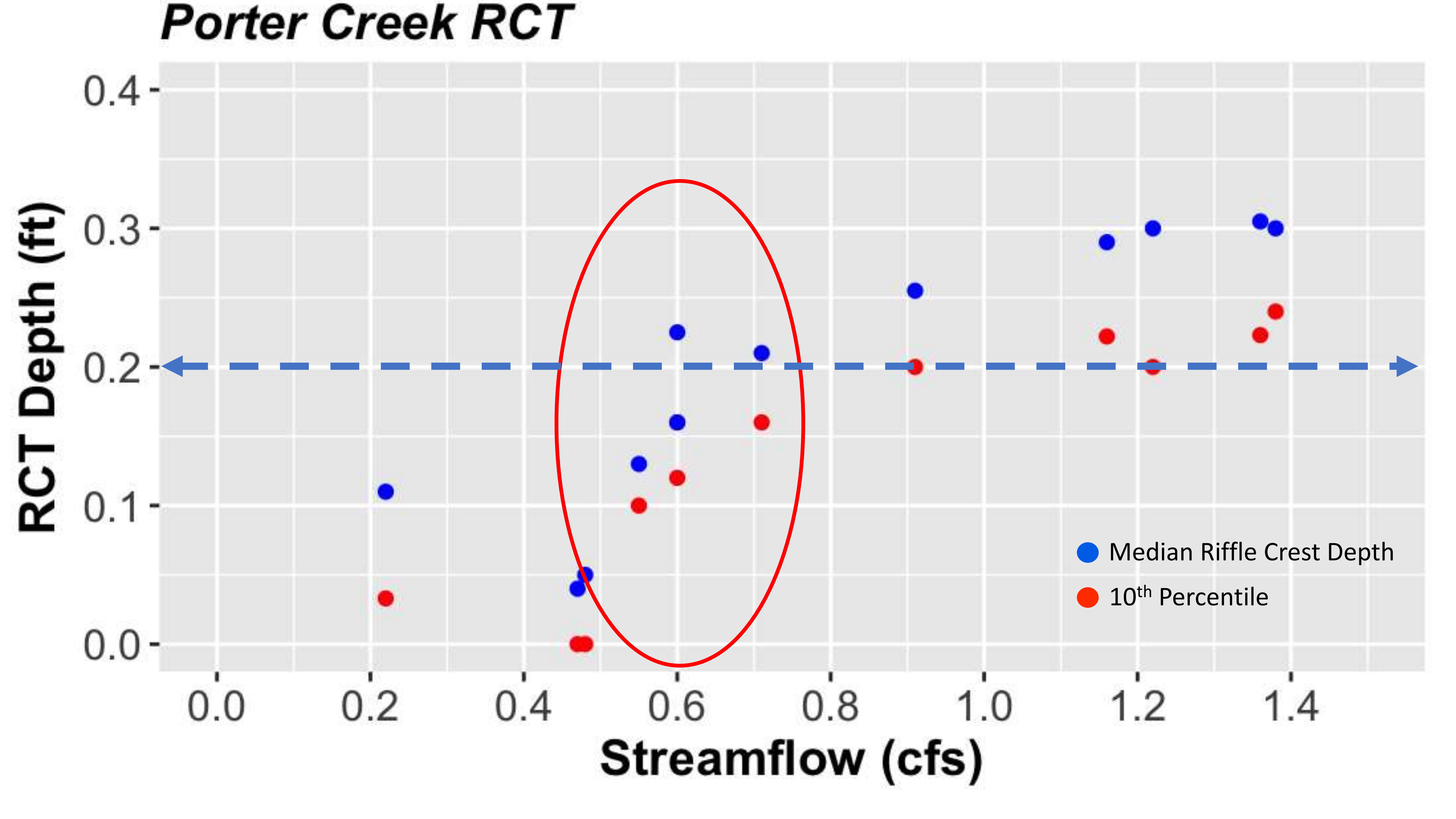
above_aug
below_aug
Augmentation (gpm)
Estimated Average width with no augmentation
Average Riffle Width (m)
Augmentation (gpm)
Date
4
3.5
3
2.5
2
1.5
1
0.5
0
400
350
300
250
200
150
100
50
0
5/25
6/14
7/4
7/24
8/13
9/2
9/22
10/12

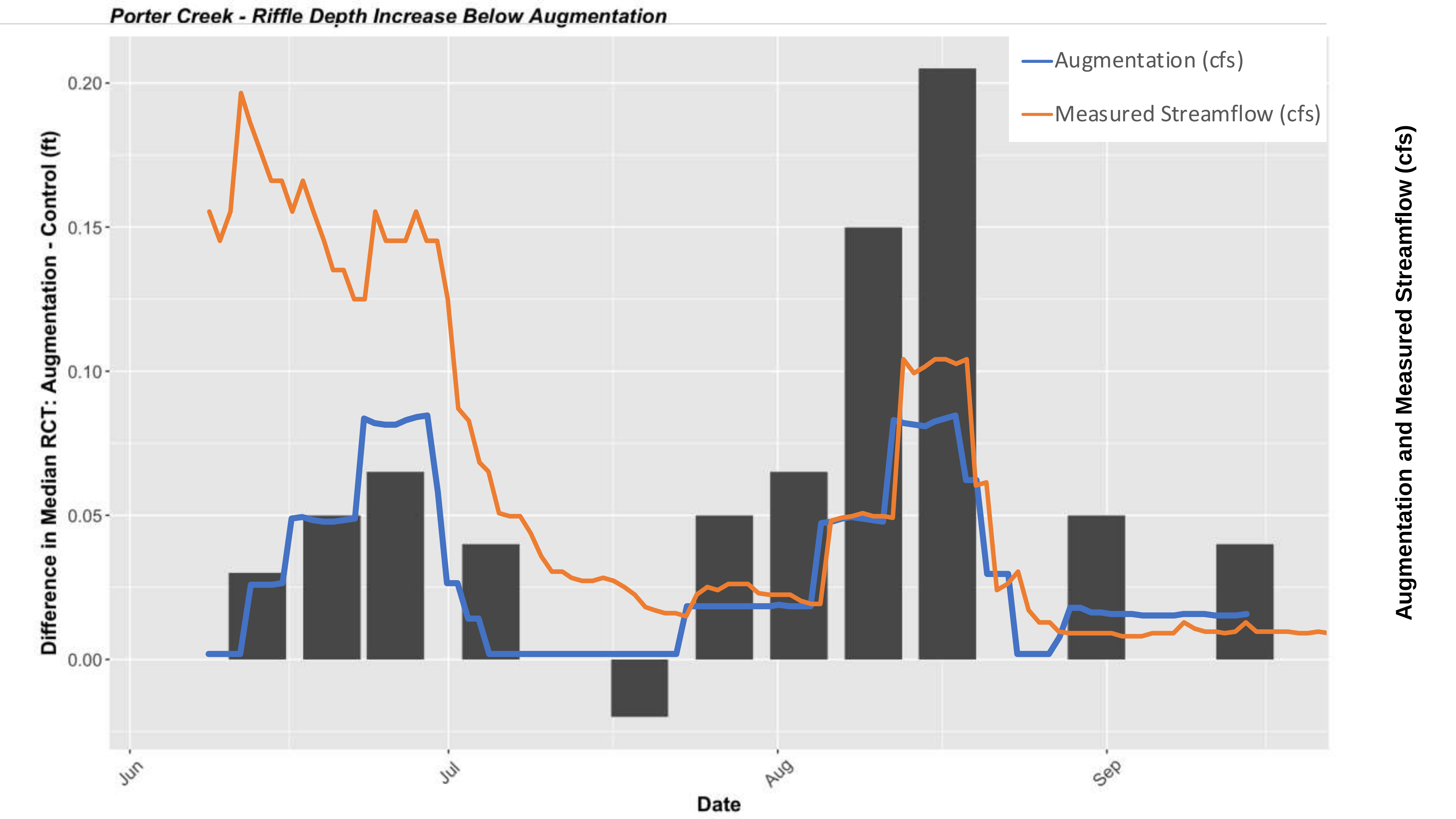

Riffles Below Augmentation
Median Riffle Width
Riffles Below Westside
Riffle Widths (m)
Streamflow (cfs)
0
1
2
3
4
5
6
7
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6

Riffle Thalweg Depths

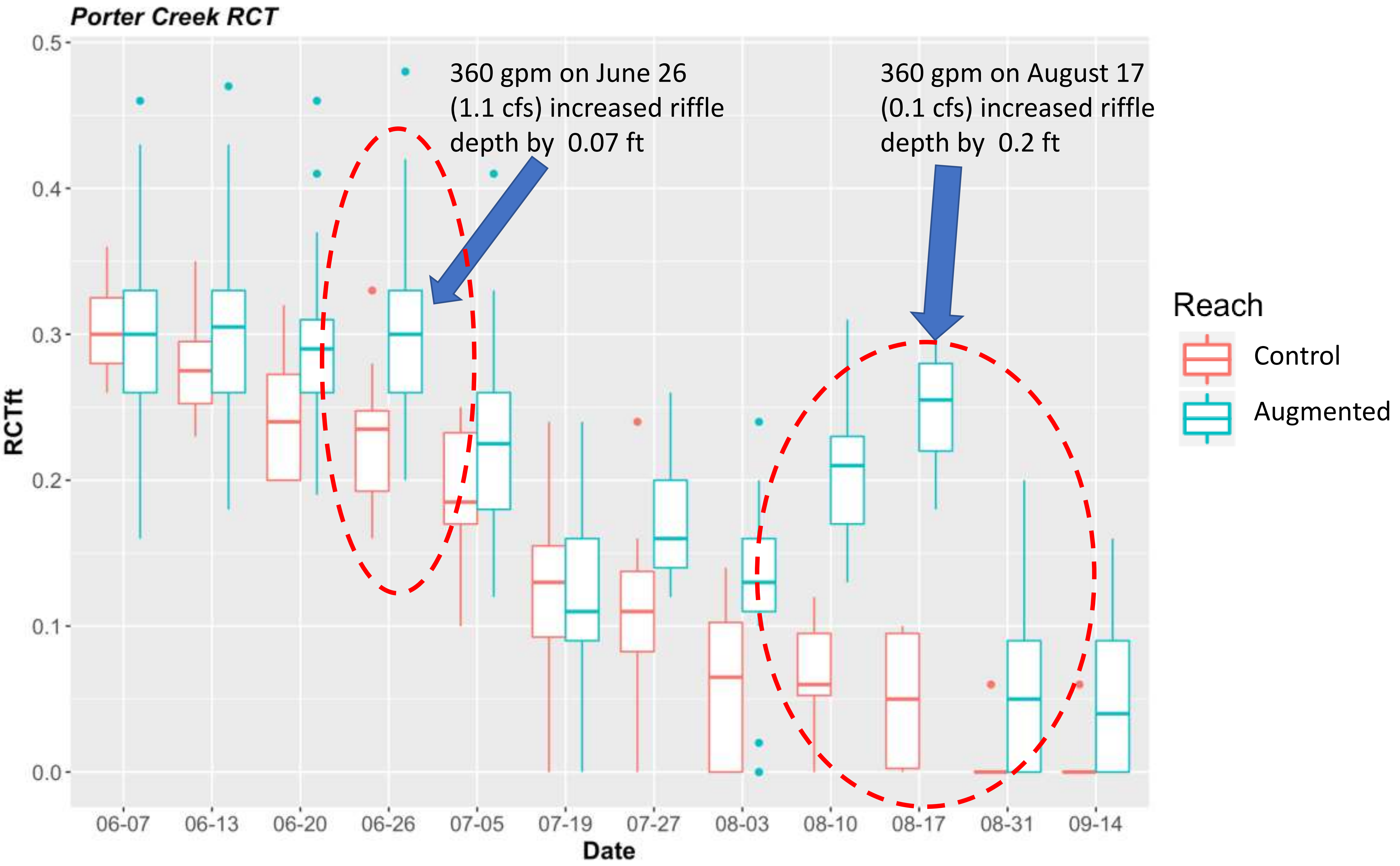





Porter Creek RCT
RCT Depth (ft)
0.0
0.1
0.2
0.3
0.4
Streamflow (cfs)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Median Riffle Crest Depth
10th Percentile



Porter Creek - Riffle Depth Increase Below Augmentation
Augmentation (cfs)
Measured Streamflow (cfs)
Difference in Median RCT: Augmentation - Control (ft)
Augmentation and Measured Streamflow (cfs)
0.20
0.15
0.10
0.05
0.00
Jun
Jul
Aug
Sep
Date


Porter Creek RCT
360 gpm on June 26
(1.1 cfs) increased riffle
depth by 0.07 ft
360 gpm on August 17
(0.1 cfs) increased riffle
depth by 0.2 ft
RCTft
0.5
0.4
0.3
0.2
0.1
0.0
06-07
06-13
06-20
06-26
07-05
07-19
07-27
08-03
08-10
08-17
08-31
09-14
Date
Reach
Control
Augmented

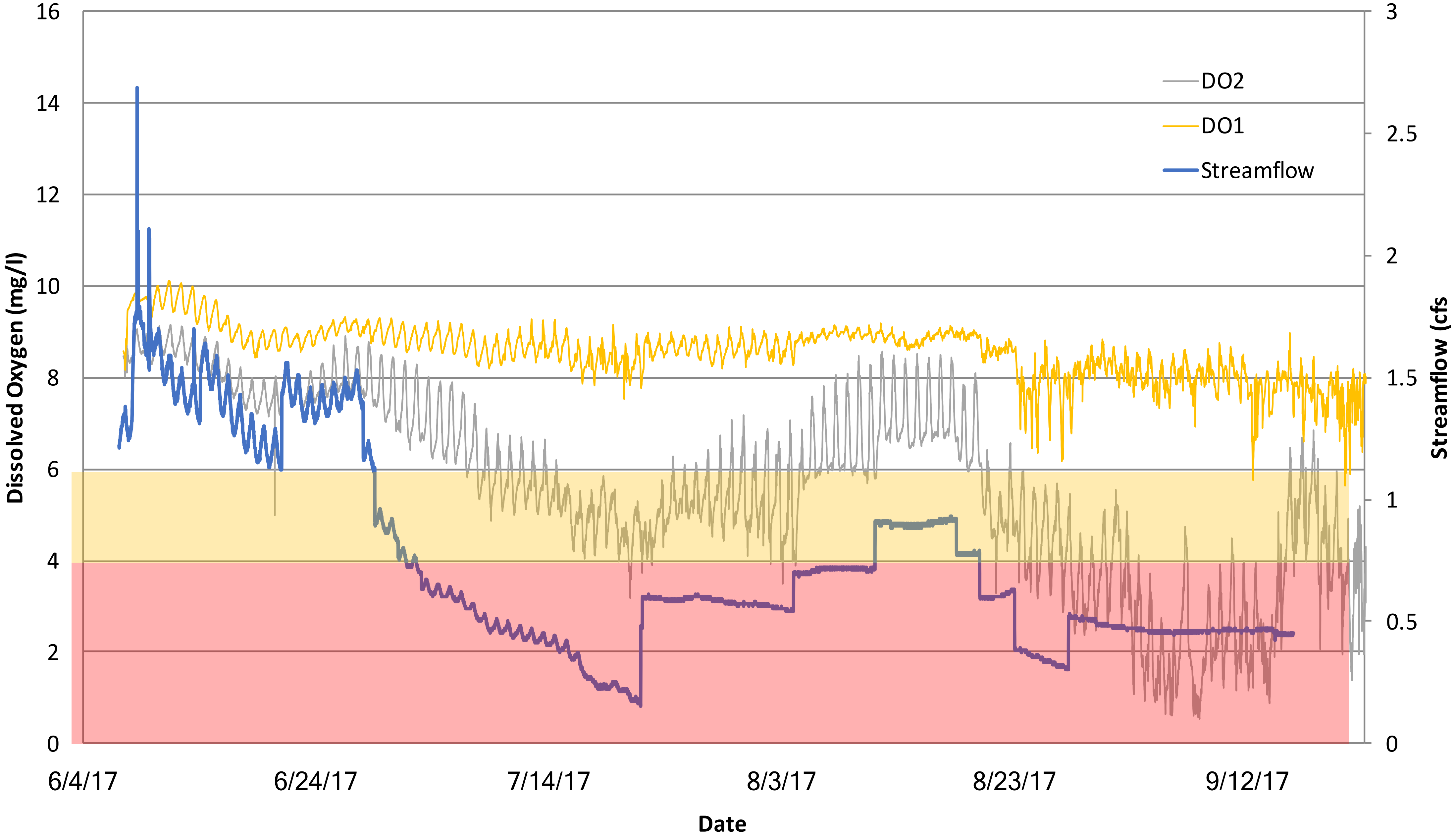
Pools

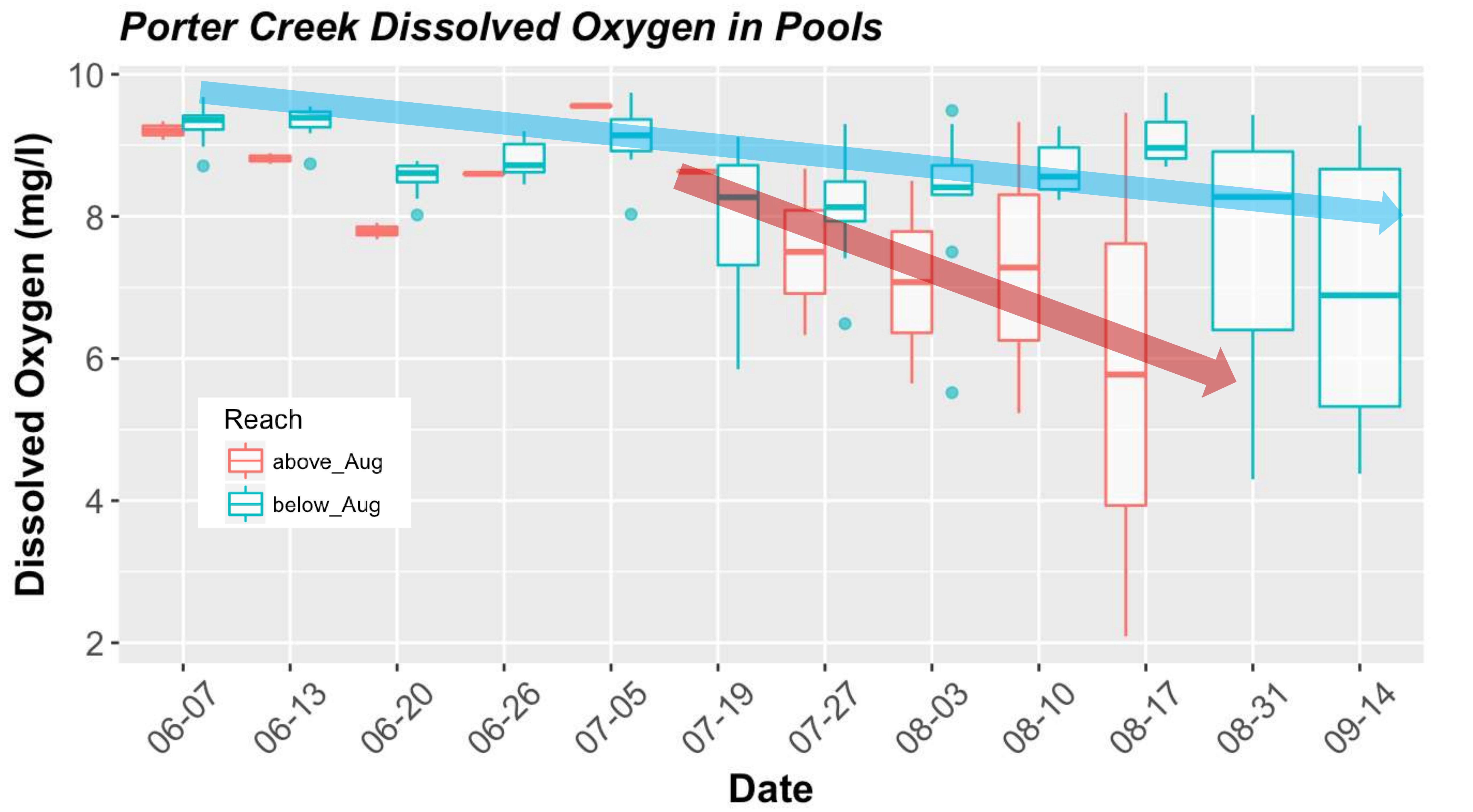

June 7th (late July at 370 gpm was similar

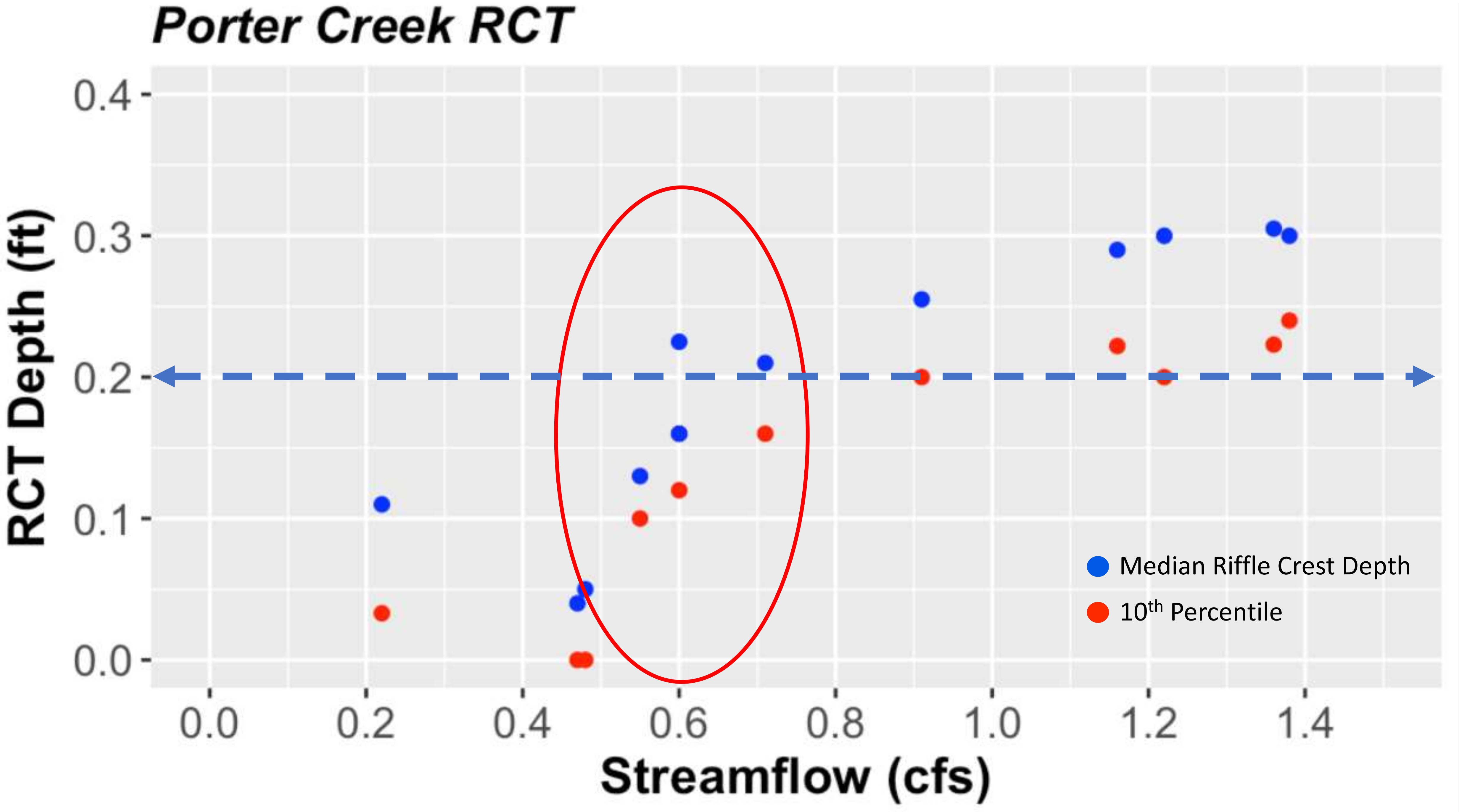

July 20th (No
augmentation


Mid August

Dissolved Oxygen

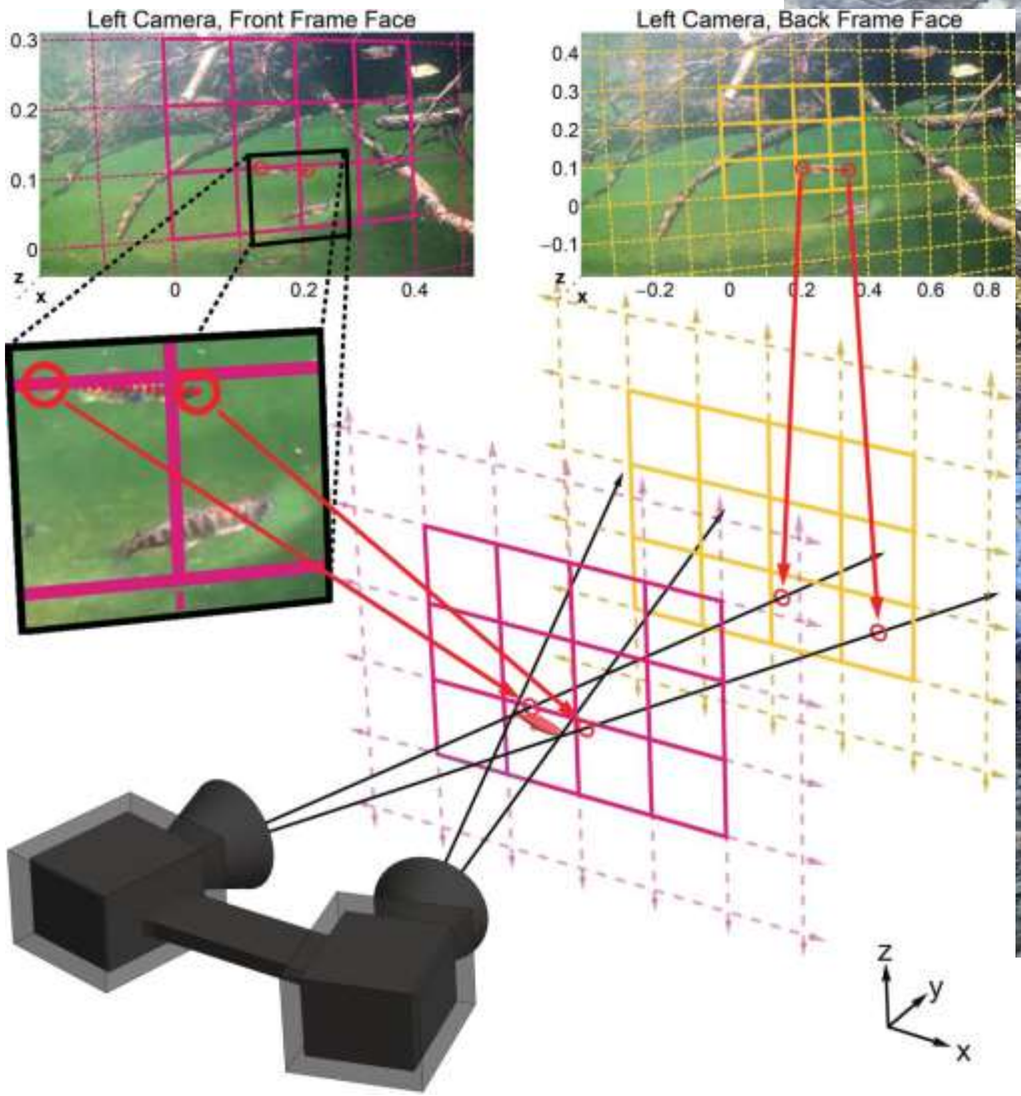



Porter Creek Dissolved Oxygen in Pools
Dissolved Oxygen (mg/l)
10
8
6
4
2
Reach
above_Aug
below_Aug
06-07
06-13
06-20
06-26
07-05
07-19
07-27
08-03
08-10
08-17
08-31
09-14
Date

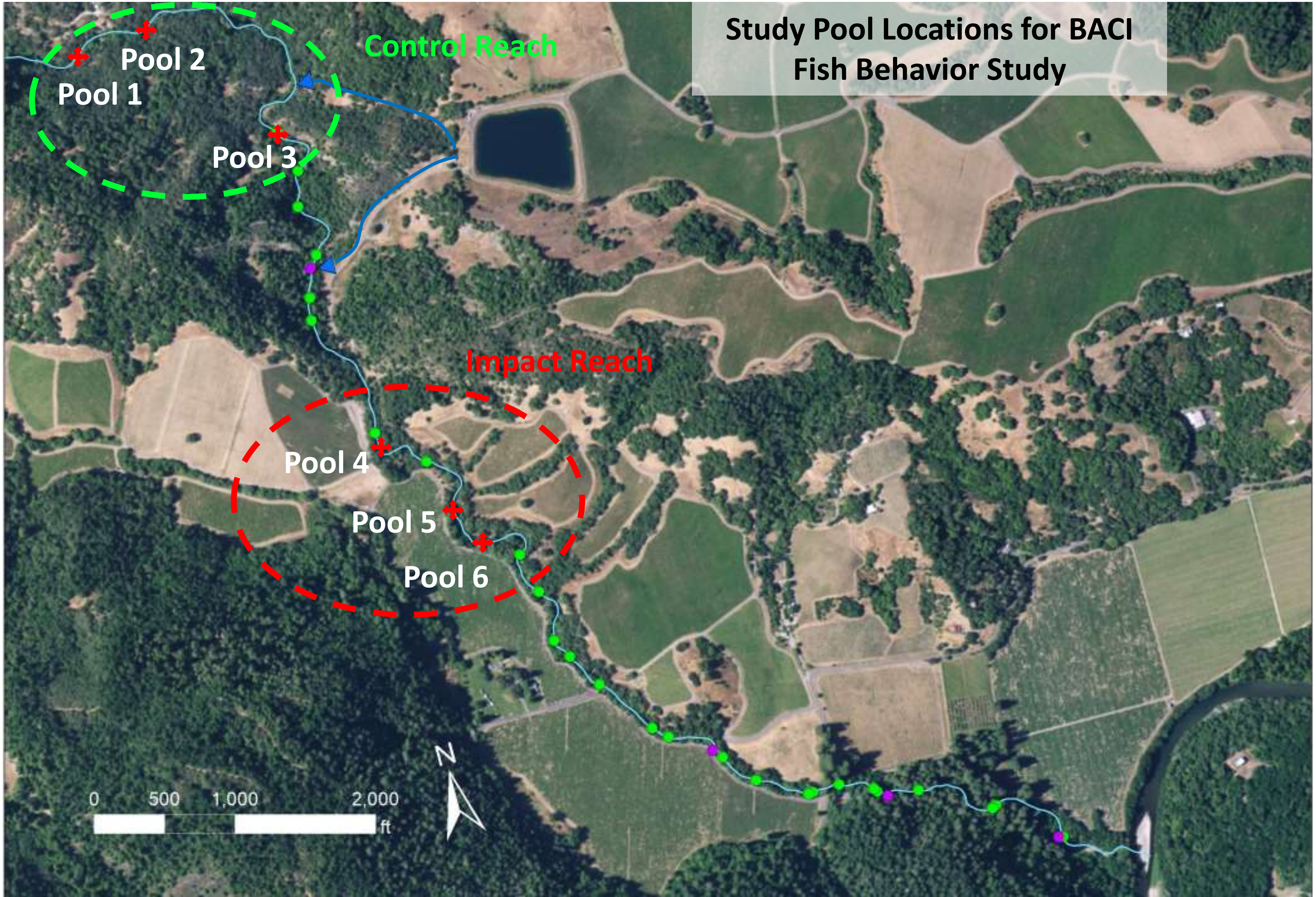

Porter Creek RCT
RCT Depth (ft)
0.4
0.3
0.2
0.1
0.0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Streamflow (cfs)
Median Riffle Crest Depth
10th Percentile

Fish Behavior Study

VidSync
Neuswanger 2016



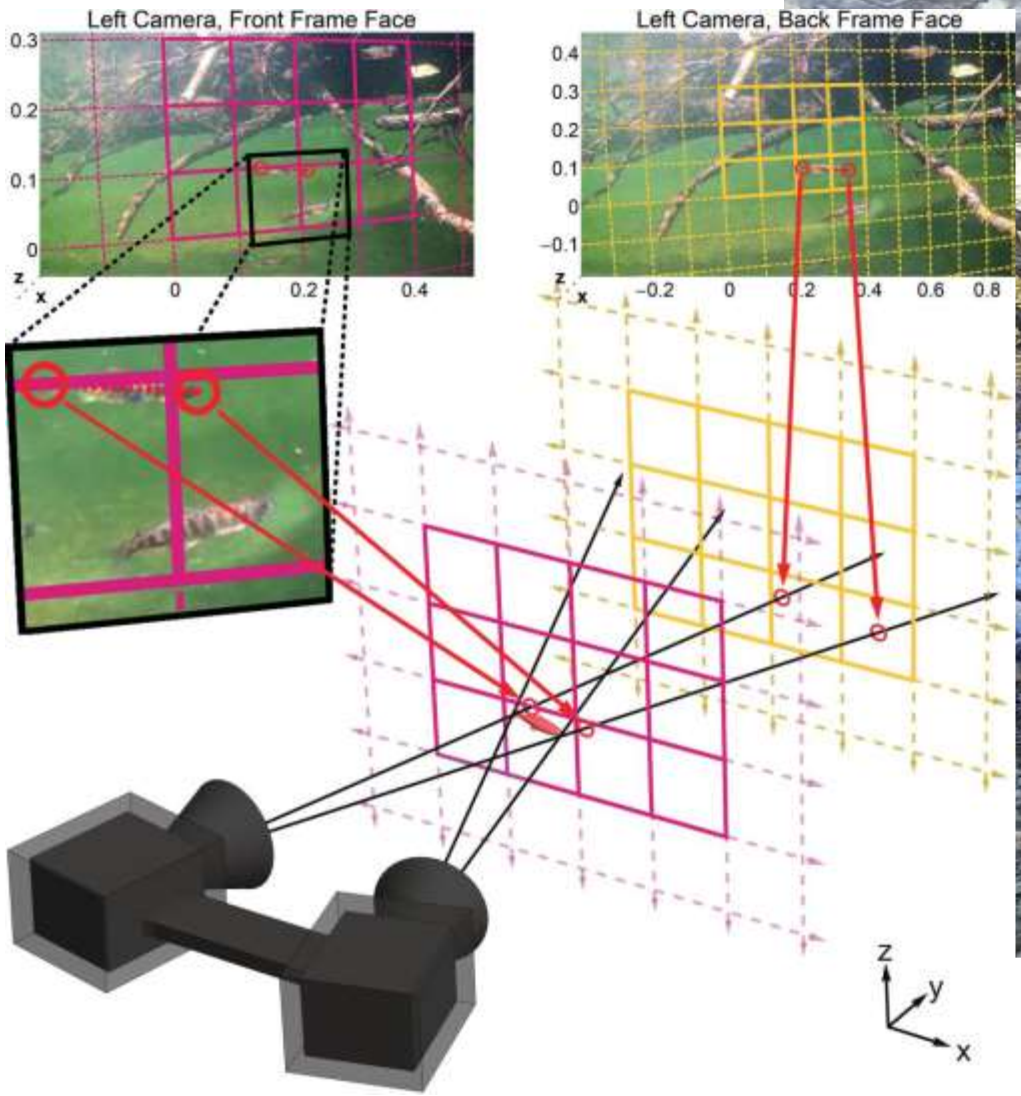
Stereo-video framework to quantify size frequency, and behavioral response of salmonids (diagram from Neuswanger (2017)).



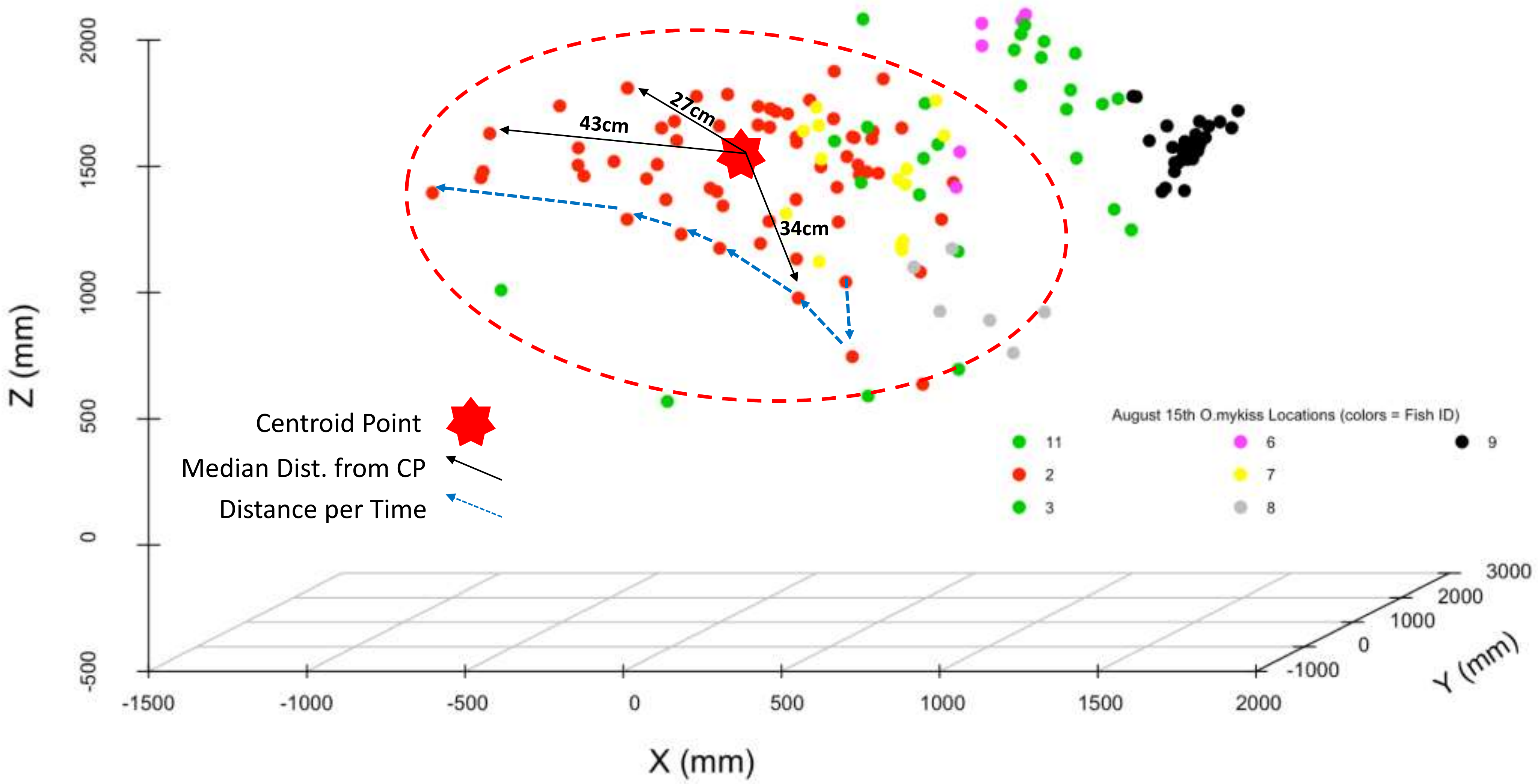
Study Pool Locations for BACI
Fish Behavior Study
Control Reach
Pool 1
Pool 2
Pool 3
Impact Reach
Pool 4
Pool 5
Pool 6
N
0
500
1,000
2,000
ft

Fish Behavior Study

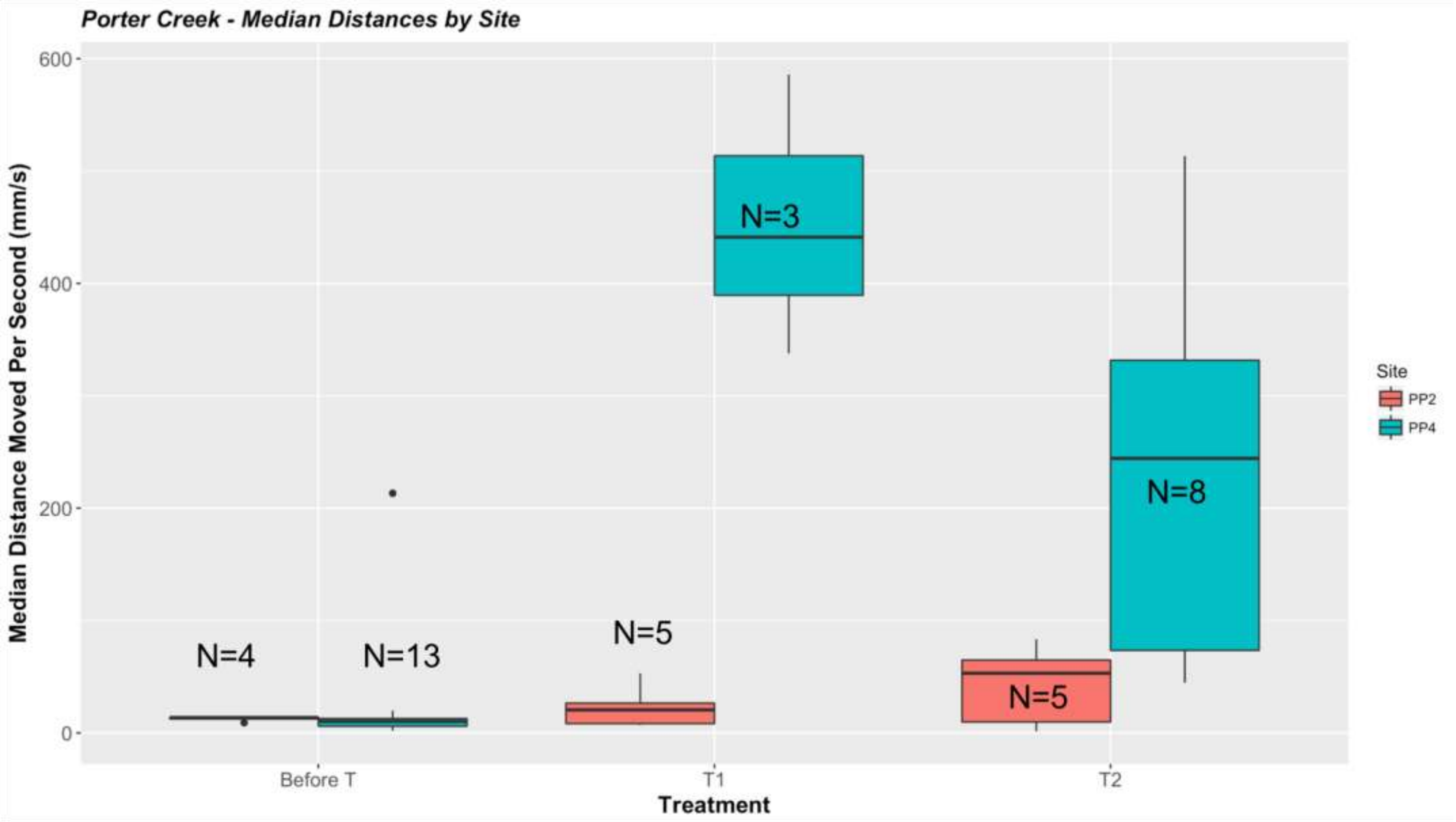
VidSync
Neuswanger 2016



Stereo-video framework to quantify size frequency, and behavioral response of salmonids (diagram from Neuswanger (2017)).



Z (mm)
X (mm)
Y (mm)
43cm
27cm
34cm
Centroid Point
Median Dist. from CP
Distance per Time
August 15th O.mykiss Locations (colors = Fish ID)
11
2
3
6
7
8
9

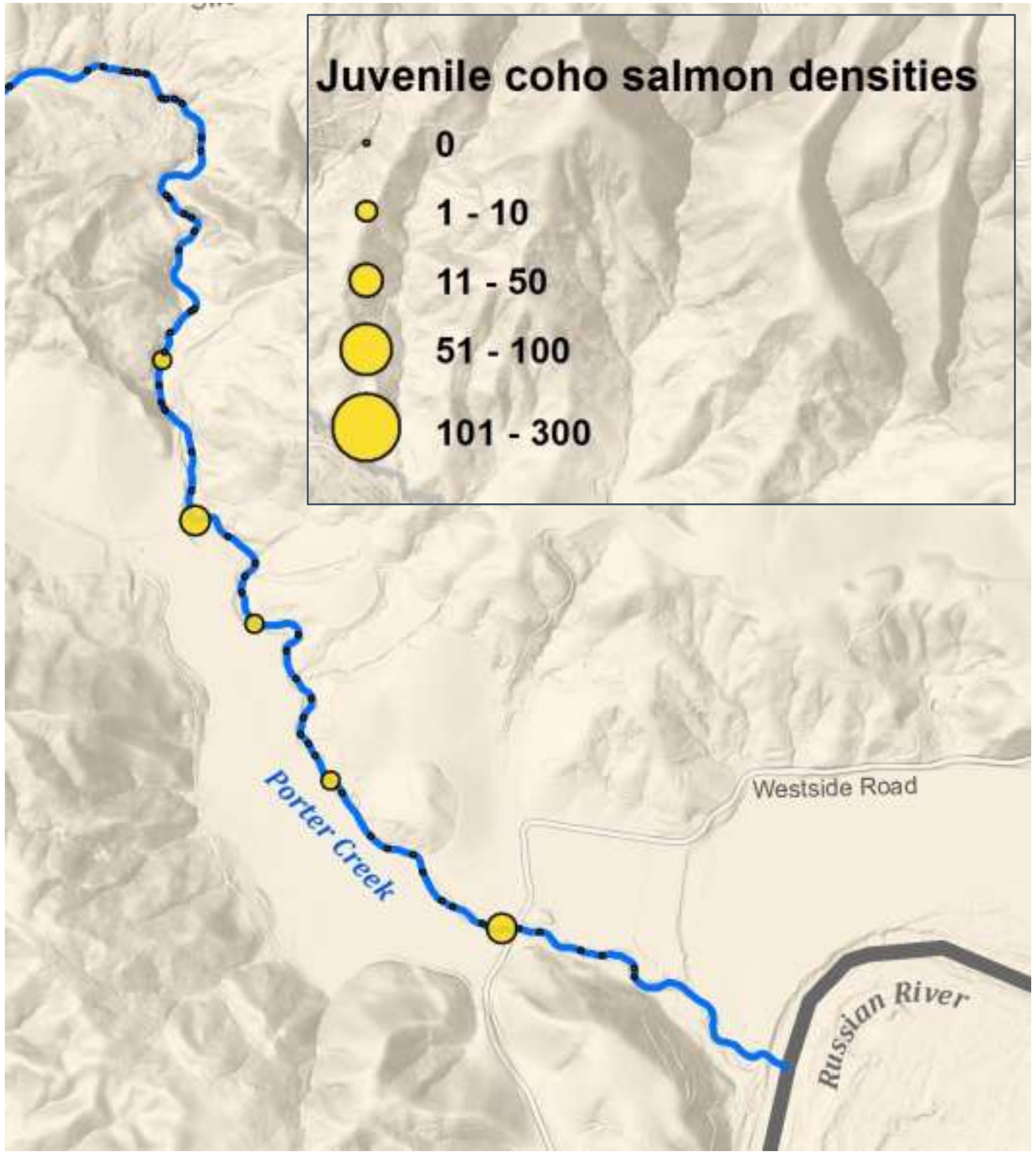


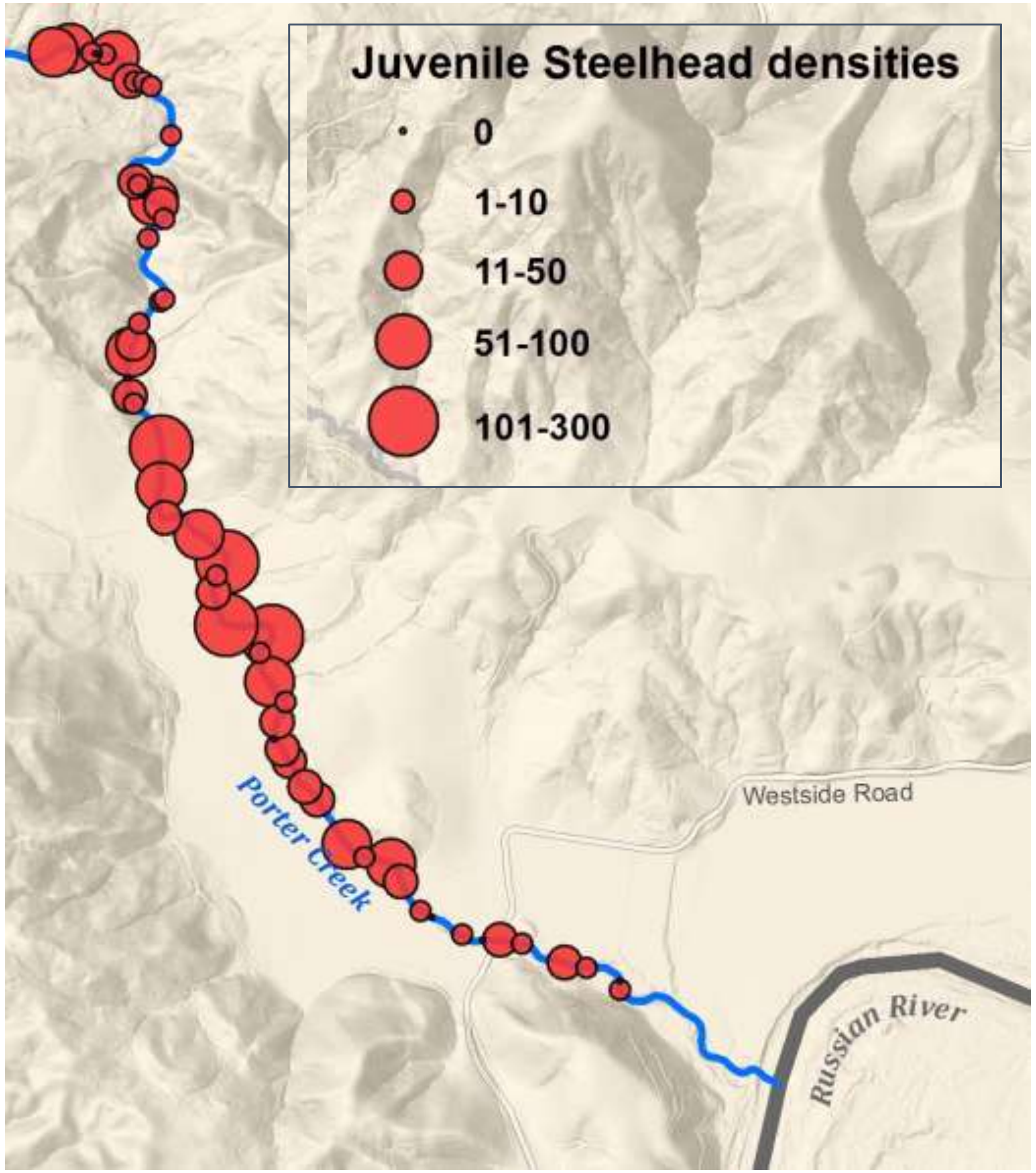
Date July 20th
Flow ~ 0.21 cfs
Augmentation = 0gpm

Date July 26/27th
T1 Flow~ 0.6 cfs
Unimpaired Flow ~ 0.2cfs
Augmentation = 110gpm

Date August 16th
T2 Flow~ 0.89 cfs
Unimpaired Flow ~ 0.1cfs
Augmentation = 390gpm

Fish Occupancy in Augmentation Reach (July 17)





Results Summary

Flow augmentation increased the length and duration of stream connectivity and had a strong effect on biologically relevant physical habitat parameters

Flow augmentation did not have a strong effect on water quality parameters in the early dry season, when natural flows were high, but significantly increased DO and decreased temperatures in the late season

There appears to be an important threshold between connectivity and DO at RCT depths ~ 0.2 ft

Fish behavior (particularly movement) seemed to change markedly after augmentation (as compared to the control reach) in analyzed pools. However implications of this movement needs to be assessed.

Flow augmentation maintained flow in fish-bearing reaches and kept salmon alive!

Habitat responses to flow augmentation could differ in dry years - it may not be possible maintain suitable conditions in the augmentation reach in all years, particularly below the Westside Road bridge

Several Unanswered Questions…

How can flow augmentation assist smolt outmigration?

How will the physical responses to flow augmentation differ in a dry year? In dry years, is there risk of attracting fish to reaches that we can’t keep wet?

How do fish respond to the changes in physical habitat (movement, feeding behavior and health)?

How can we most effectively determine when and how much flow augmentation is needed in an operations context?

Acknowledgements

E&J Gallo

CA Sea Grant

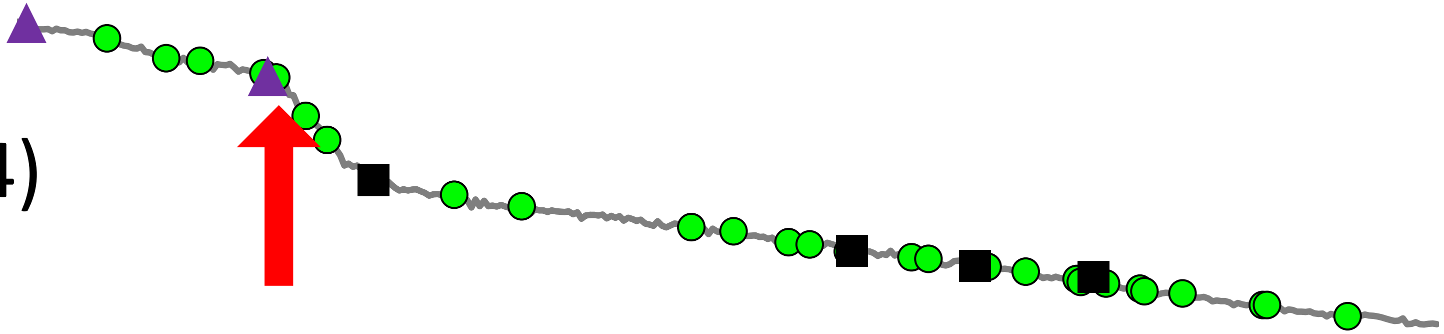
Russian River Coho Broodstock Program

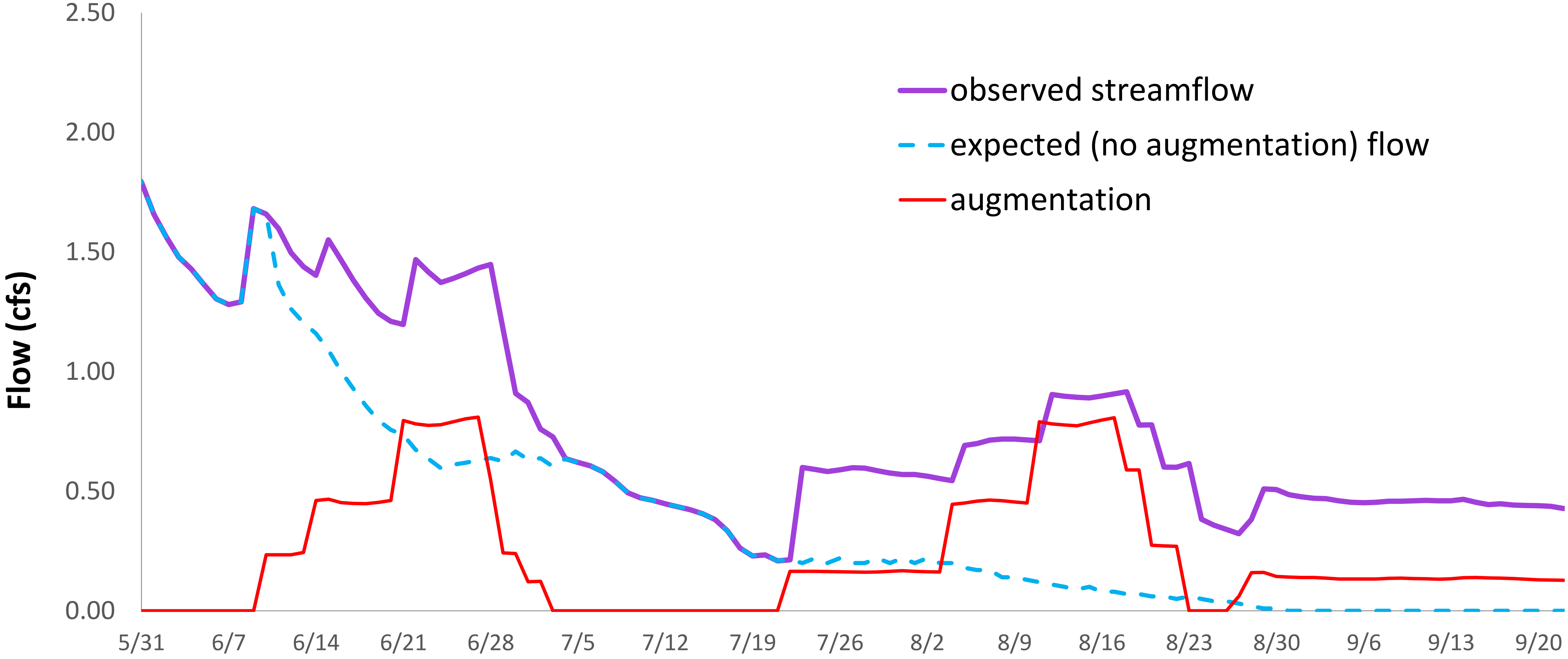
USGS via ANR

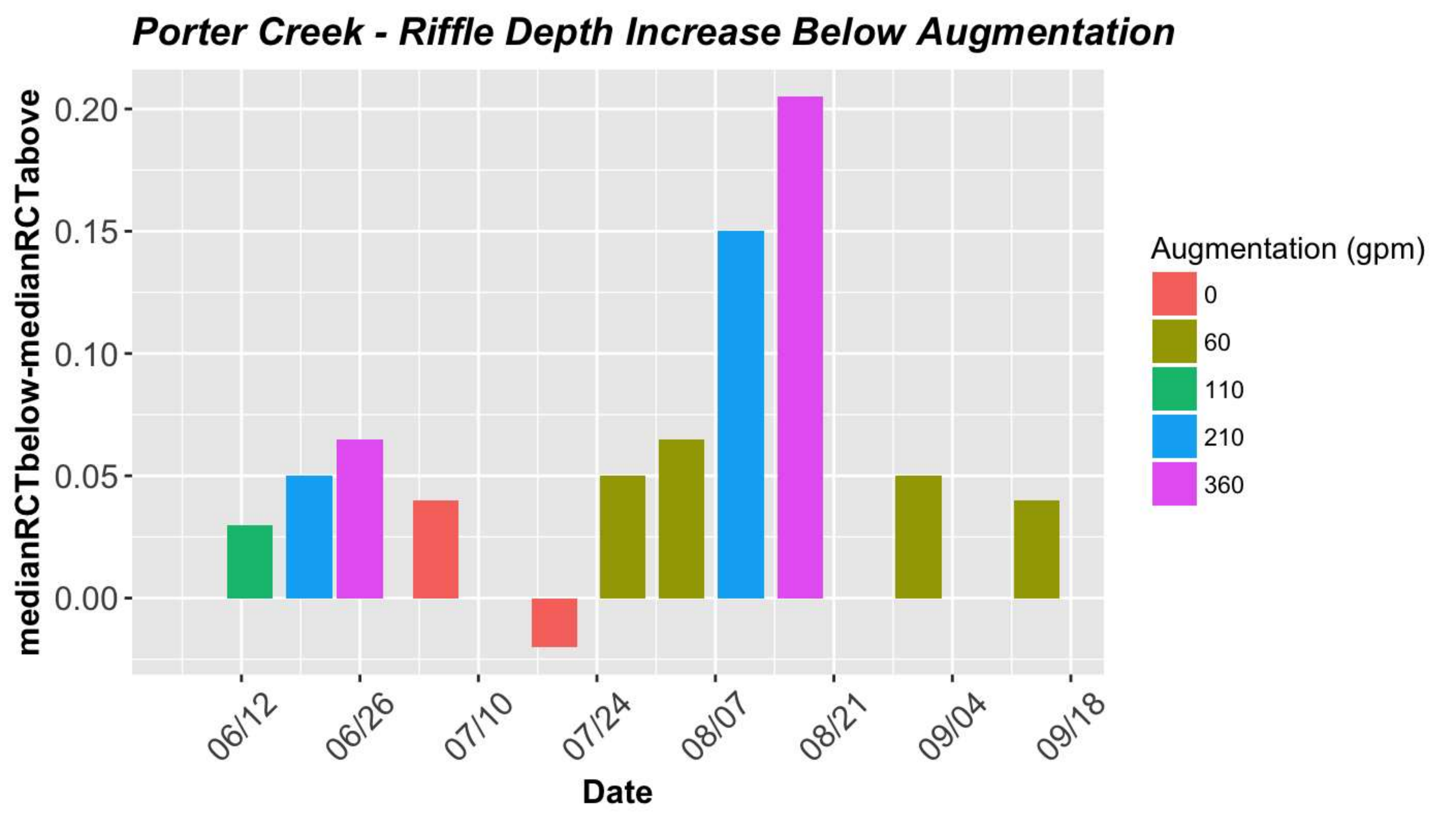
Trout Unlimited

Sonoma RCD

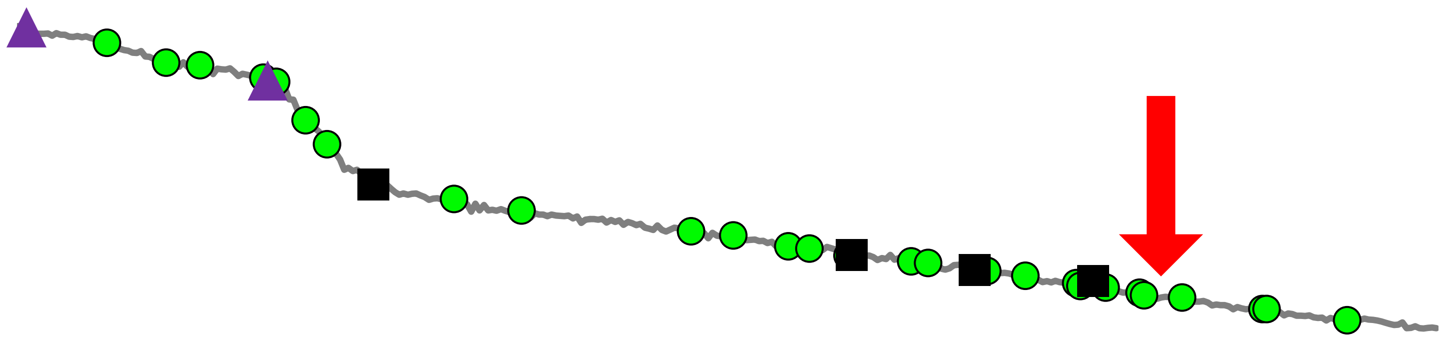
Measured Flow Response at Augmentation Outlet (P04)

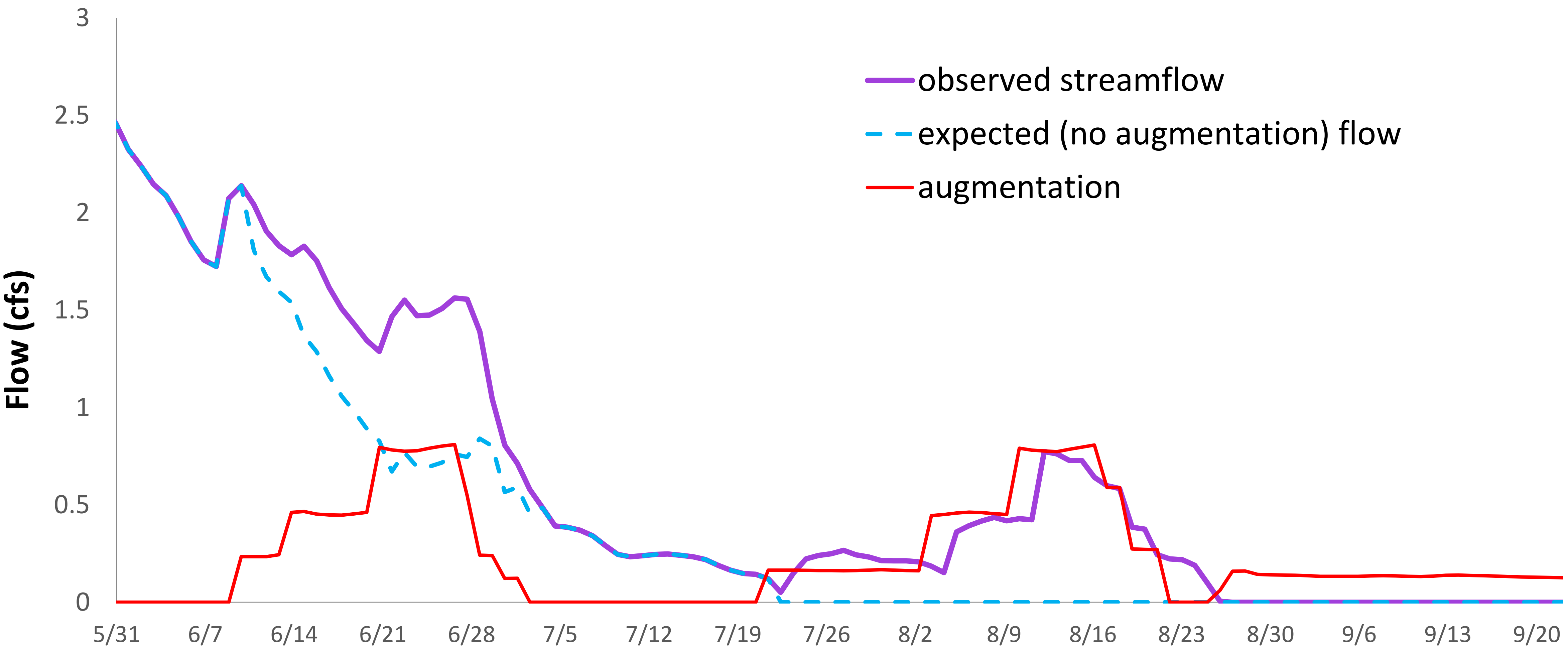




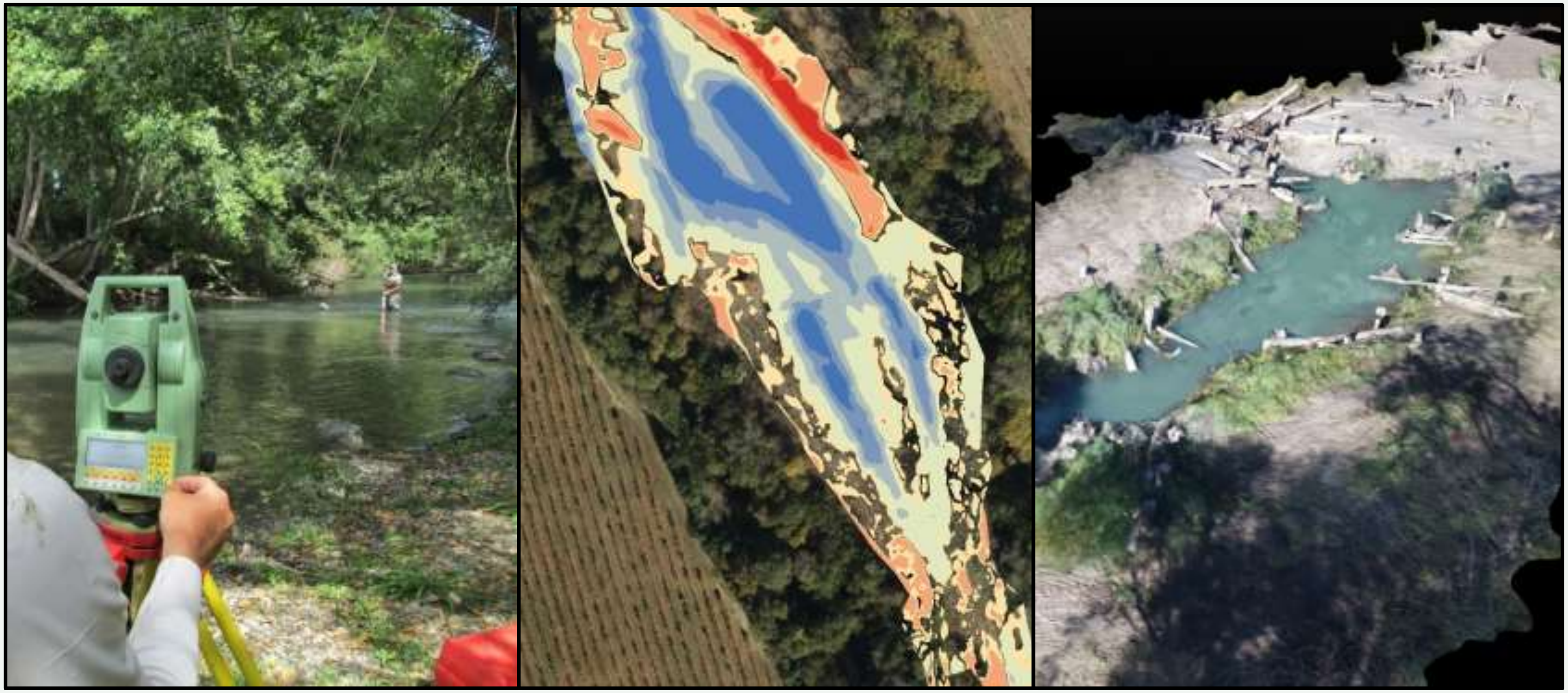

Porter Creek - Riffle Depth Increase Below Augmentation
medianRCTbelow-medianRCTabove
0.20
0.15
0.10
0.05
0.00
06/12
06/26
07/10
07/24
08/07
08/21
09/04
09/18
Date
Augmentation (gpm)
0
60
110
210
360

Measured Flow Response in Lower Reach (P02)





Tools and Methods to Monitor Effectiveness of the Dry Creek Habitat Enhancement Project, Russian River Basin



Neil Lassettre, PhD (neil.lassettre@scwa.ca.gov)

David Manning, Mark Goin, Celeste Melosh, Eric McDermott

Sonoma County Water Agency, 404 Aviation Boulevard, Santa Rosa CA, 95403

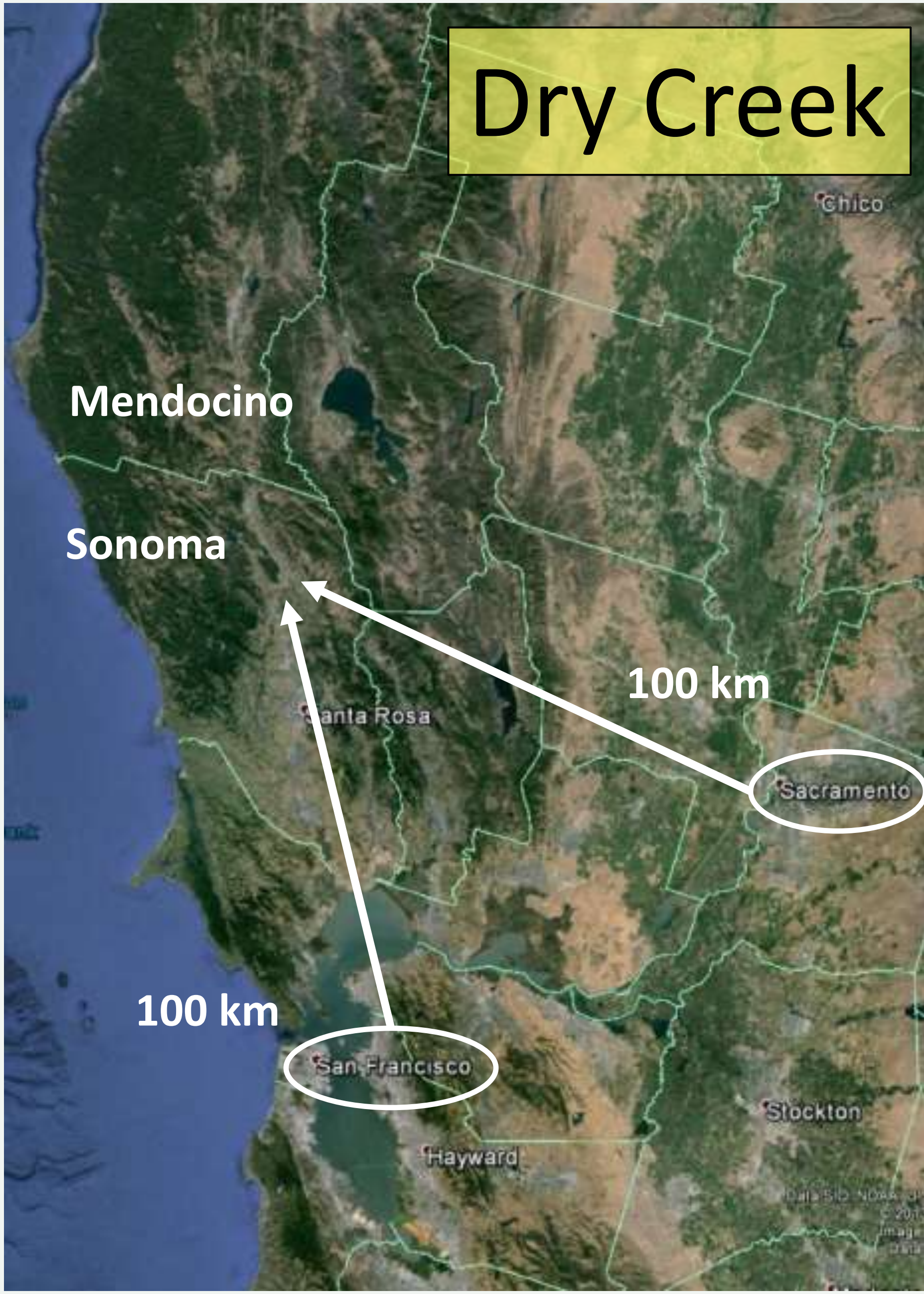
SONOMA COUNTY WATER AGENCY

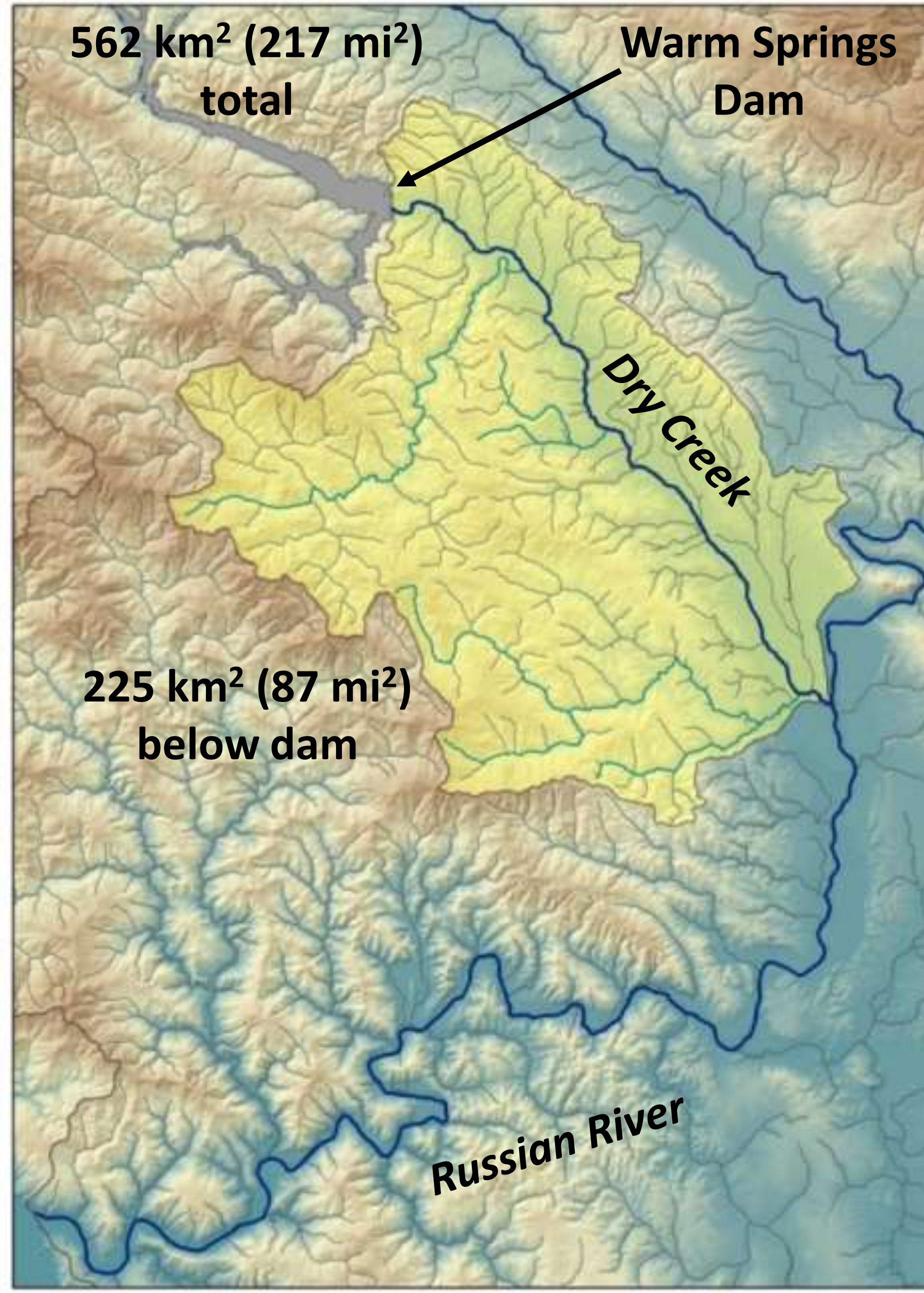
Salmonid Restoration Federation, Fortuna CA, April 12, 2018

Dry Creek Habitat Enhancement Project

- Enhance coho and steelhead juvenile habitat along six miles
- Design and implement projects to meet performance measures
- Monitor projects to assess performance
- Monitoring plan, project phasing allows management to adapt
- Project performance will guide future actions

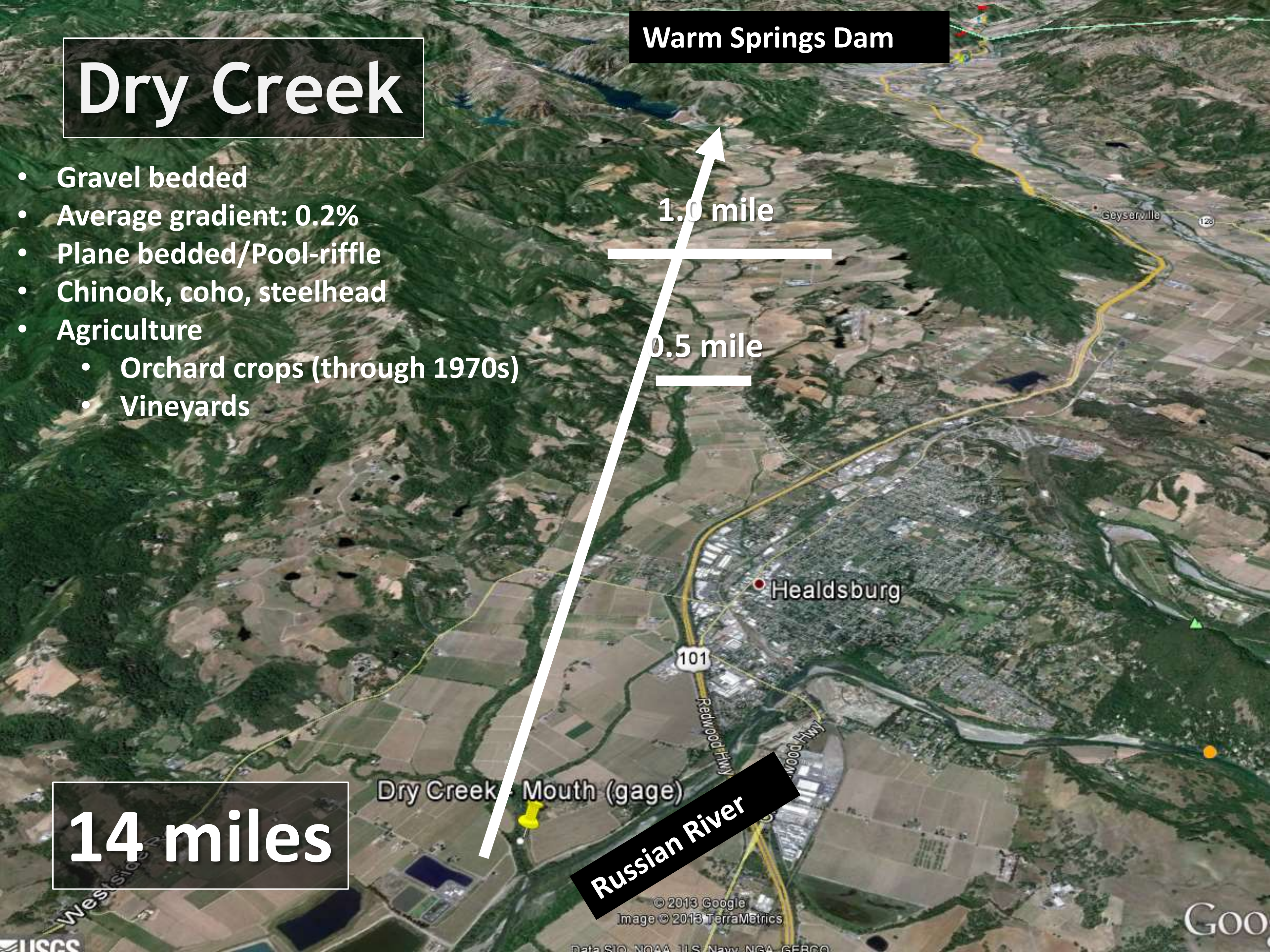
Dry Creek


Mendocino
Sonoma
100 km
Santa Rosa
Sacramento
100 km
San Francisco
Stockton
Hayward
Chico

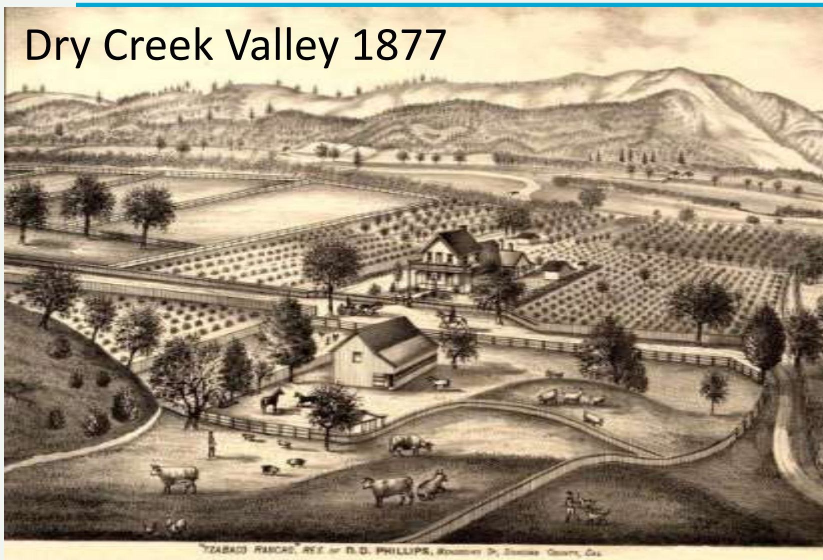

562 km² (217 mi²)
total
Warm Springs
Dam
Dry Creek
225 km² (87 mi²)
below dam
Russian River

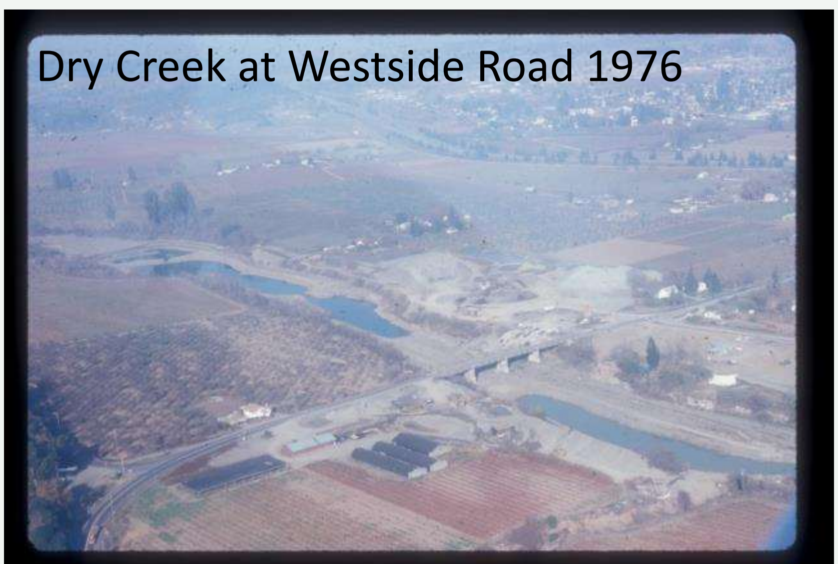
Dry Creek

- Gravel bedded
- Average gradient: 0.2%
- Plane bedded/Pool-riffle
- Chinook, coho, steelhead
- Agriculture
    - Orchard crops (through 1970s)
    - Vineyards



Dry Creek has evolved over the past 150 years


Dry Creek Valley 1877


Dry Creek at Westside Road 1976

1850 to 1900

- 40% of forest cleared
- Converted to grazing
- Changed runoff and sediment delivery
- Aggradation of streambed

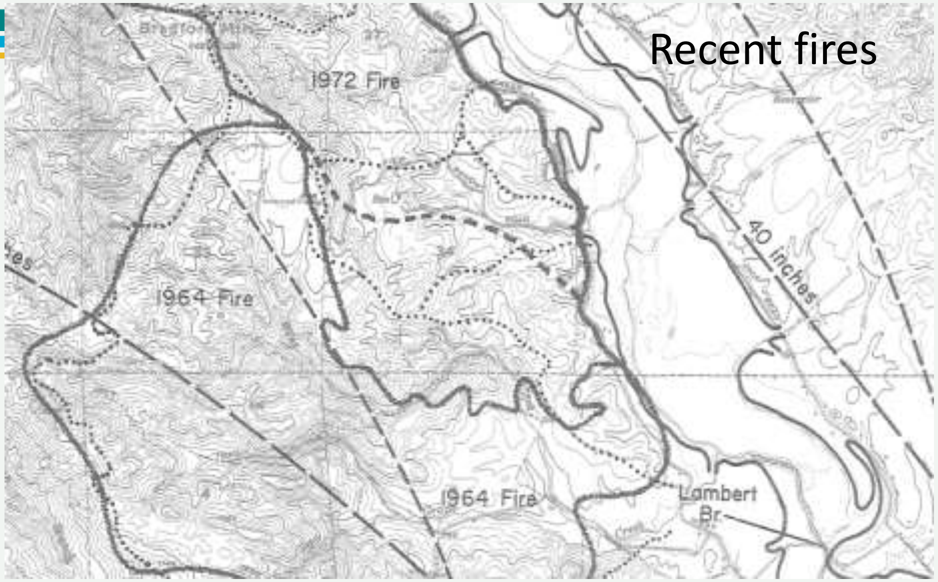
1900-1970

- Gravel mining in Russian River
- Escalated in 1950s and 1960s in Dry Creek
- Channel incision, lowered base level
- Channel instability
- Bank erosion

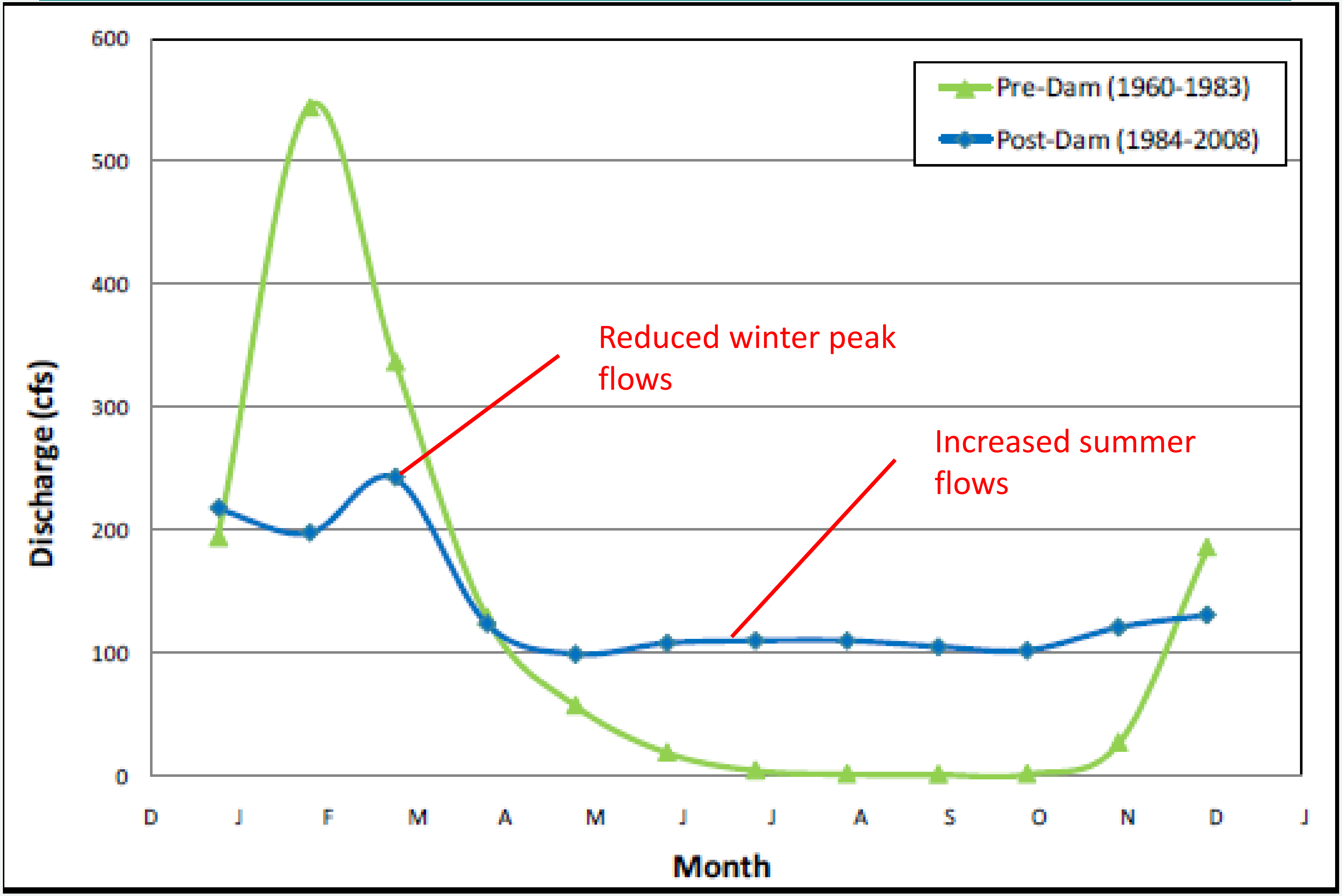
Dry Creek has evolved over the past 150 years

1970s to Present

- Fires
- Flooding
- Warm Springs Dam completed 1983



Dam altered hydrology and summer flows



From Lambert Bridge then and now

1970

- Higher peak flows
- Lower summer flows
- Limited vegetation encroachment

2010

- Constant summer flows
- Good riparian growth conditions
- Vegetation encroachment

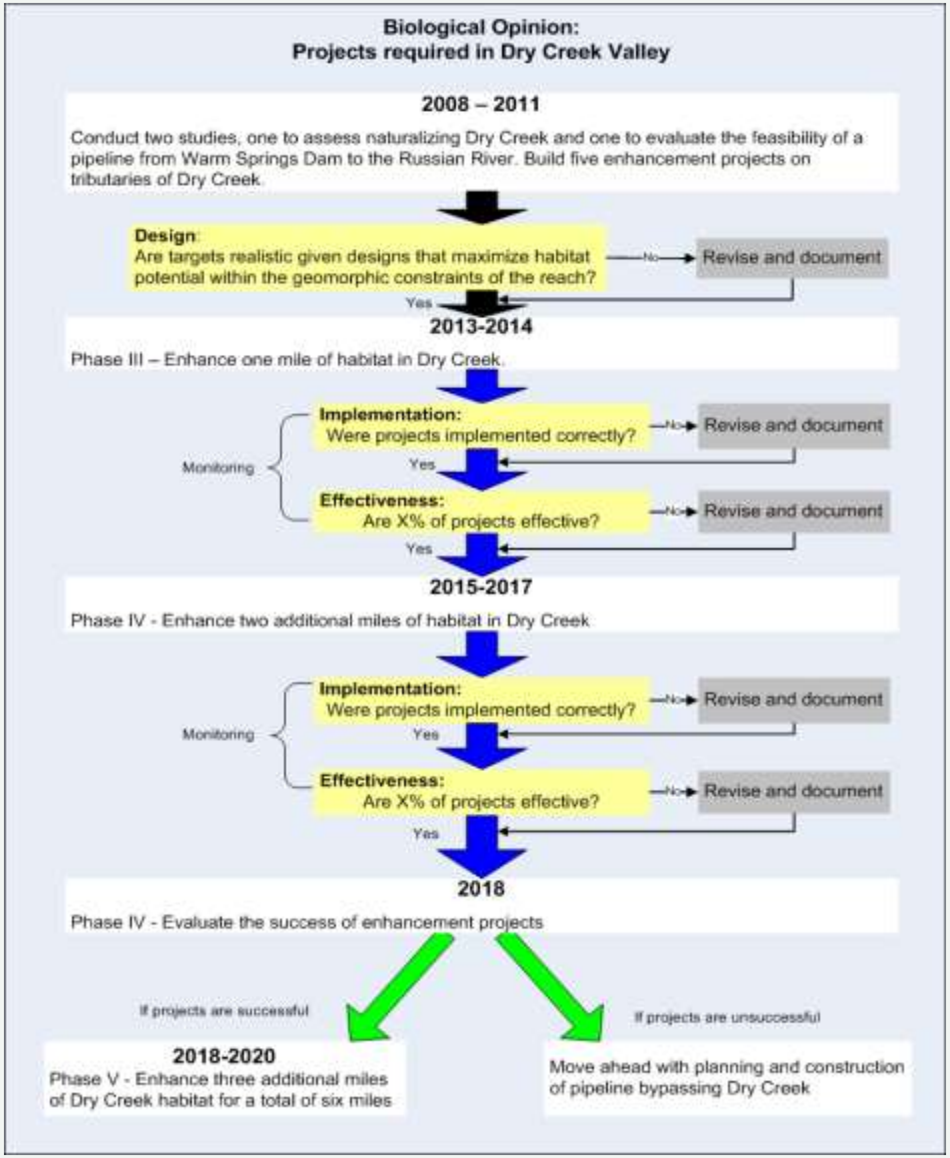
Russian River Biological Opinion

Russian River Project:

- Likely to jeopardize recovery of **coho salmon** and steelhead (not Chinook)
- RPA has 23 actions for SCWA and US Army Corps to modify operations
- Identified need to improve **rearing habitat** in Dry Creek and Russian River
- 15 Year timeline (2008 to 2023)
- If don't improve habitat then must build a **pipeline**

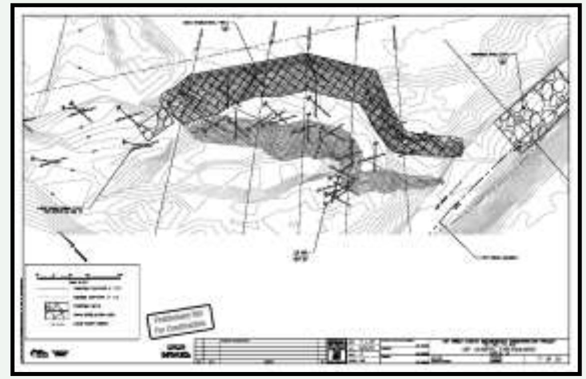
Timeline

- **2008 - 2018:** Design, construct & monitor 3 miles of habitat enhancements in Dry Creek
- **2018:** Decide whether enhancements are sufficiently effective to warrant construction of another 3 miles of habitat (6 miles total)



3 Types of Monitoring

- **Implementation (as built)**– Constructed per approved design?



- **Effectiveness (habitat)** – Are desired habitat conditions being created?

- **Validation (biological response)** – Are fish benefiting?

Assess against performance measures

Type of Performance Measure	Performance Measure	Life Stage	Biologic Function	Spatial Scale	Habitat Type	Evaluation Method	Near-Optimal Ranges		
							Spring Flow[1]	Summer Flow[2]	Winter Flow[3]
Primary	Velocity (ft/sec)	fry	Rearing	Feature/ Site	margins	Quantitative & Qualitative	0-0.5 ft/s	n/a	n/a
	Depth (ft)	fry	Rearing	Feature/ Site	margins	Quantitative & Qualitative	0.5-2.0 ft	n/a	n/a
	Velocity (ft/sec)	Summer/winter parr	Rearing	Feature/ Site	Pools, off-channel	Quantitative & Qualitative	0-0.5 ft/s	0-0.5 ft/s	0-0.5ft/s
	Depth (ft)	Summer/winter parr	Rearing	Feature/ Site	Pools, off-channel	Quantitative & Qualitative	2-4 ft	2-4 ft	2-4 ft
	Shelter value	Juvenile	Rearing	Feature/ Site	Pools, margins, off-channel	Quantitative & Qualitative	≥80	≥80	≥80
	Pool:Riffle ratio	Juvenile	Rearing	Project reach	Pools, riffles	Quantitative & Qualitative	n/a	1:2 to 2:1	n/a
Secondary	Temperature (°C)	Juvenile	Rearing	Site	Off-channel	Quantitative	n/a	8-16°C	n/a
	Dissolved oxygen (mg/l)	Juvenile	Rearing	Site	Off-channel	Quantitative	n/a	6-10 mg/l	n/a
	Canopy (%)	Juvenile	Rearing	Site	Off-channel	Quantitative	80 %		
	Quiet water (< 0.5 ft/s) (%)	Juvenile	Rearing	Enhancement reach	Pools, off-channel/backwaters in winter refuge areas	Quantitative & Qualitative	n/a	n/a	≥ 25%
	Off-channel access (off-ramps) (ft/sec)	Juvenile	Rearing	Project reach	Off-channel/backwaters	Quantitative & Qualitative	Approx. 1.5 – 1.8 cm/s (Ucrit); Approx. 3.3 ft/s (burst speed)		
	Connectivity of habitats	Juvenile	Rearing	Project reach	Pools, riffles, margins, off-channel	Qualitative & GIS & Inter-Fluve modeling	Undefined		
	Substrate particle size (in.)	Adult	Spawning	Feature/ Site	Riffles	Quantitative & Qualitative	n/a	n/a	0.25-2.5 in.
	Depth (ft)	Adult	Spawning	Feature/ Site	Riffles	Quantitative & Qualitative	n/a	n/a	0.5-1.6 ft

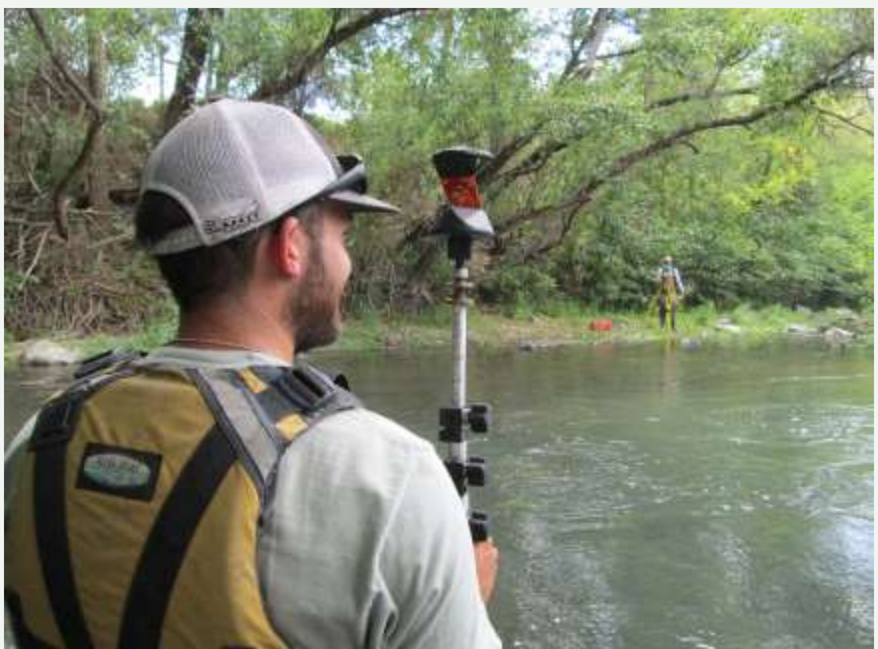
[1] Target coho life stage during spring is newly-emerged feeding fry which use shallower depths than would be preferred later in the summer and winter when fish would be larger. Target spring flow (discharge within the enhancement reach) is 200 cfs (approximately double the summer "base" flow).
[2] Target summer flow is 105 cfs
[3] Target winter flow is 1000 cfs

Effectiveness Monitoring: Goals

1. Adaptive Management Plan
   - Compare to 1° and 2° performance metrics
   - Inform feature and site ratings

2. Future phases
   - Test assumptions
   - Inform future feature and site designs

3. Physical response
   - Observe change over time
   - Additional learning opportunity

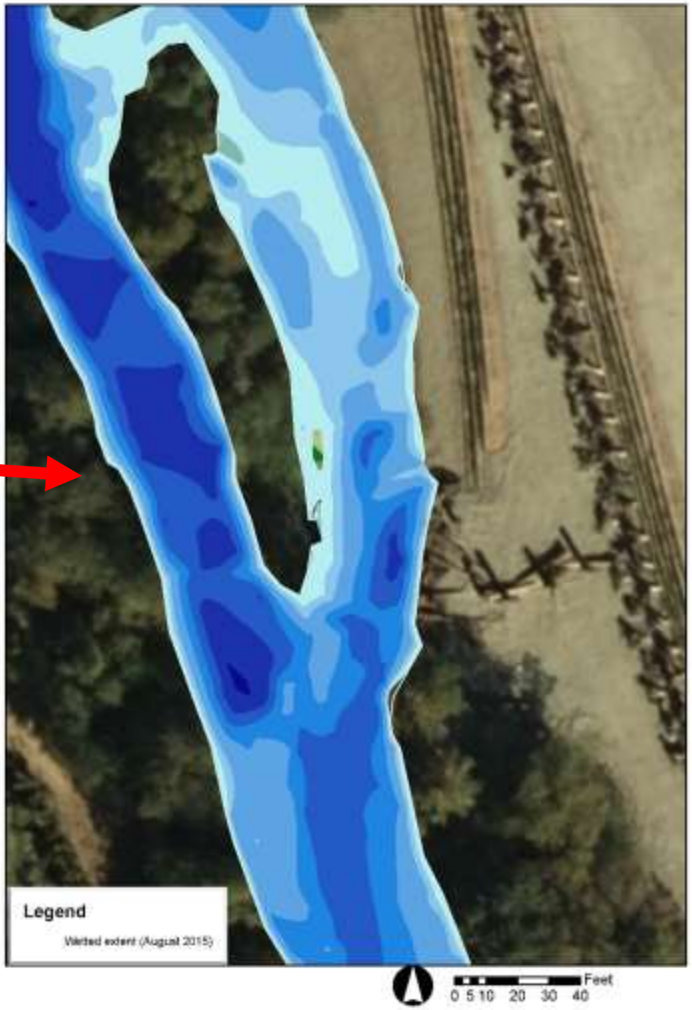



LA
Times

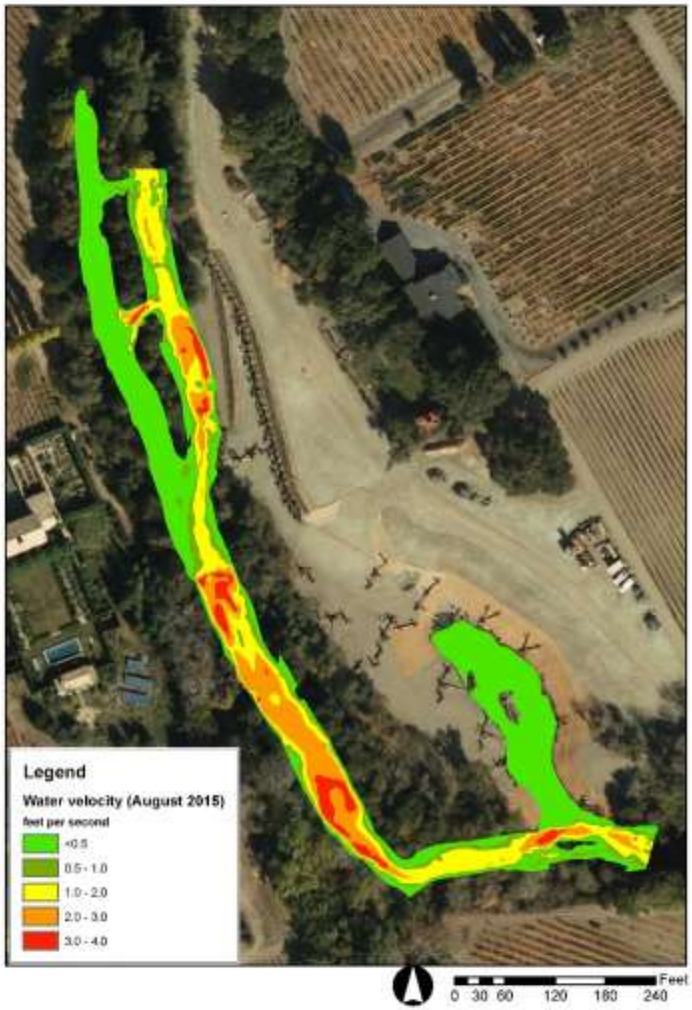
Elevation, depth, velocity

Within GIS: Triangulated Irregular Network (TIN)

Digital Elevation Model (DEM): water depth



DEMs of depth and velocity



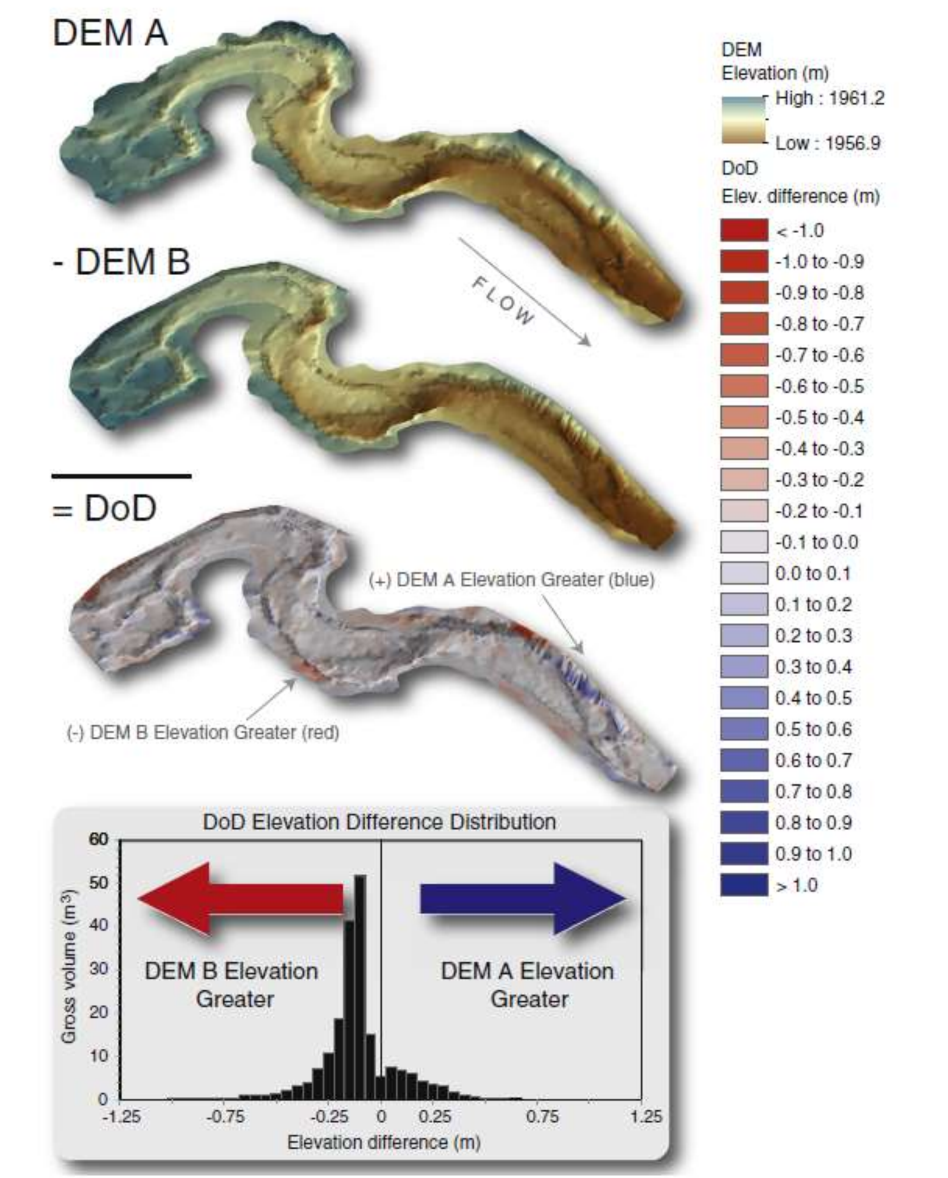
Determine optimal depth and velocity

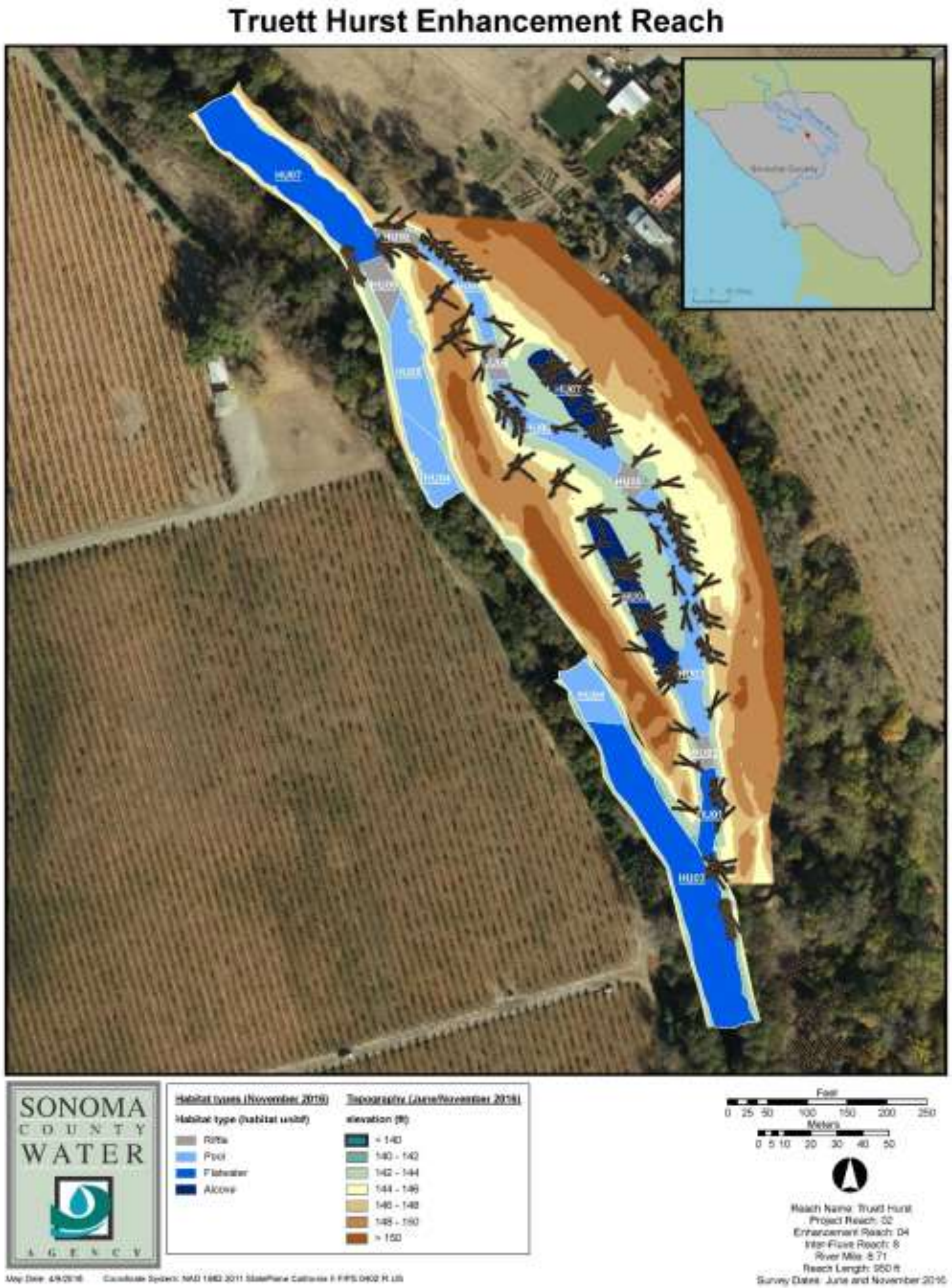
Calculate area of optimal habitat + suitable shelter

Geomorphic Change Detection (GCD)

- Detect change before and after two events
- Identify and quantify scour and fill
- Repeat topographic surveys
- Compare changes between surveys (DEMs)

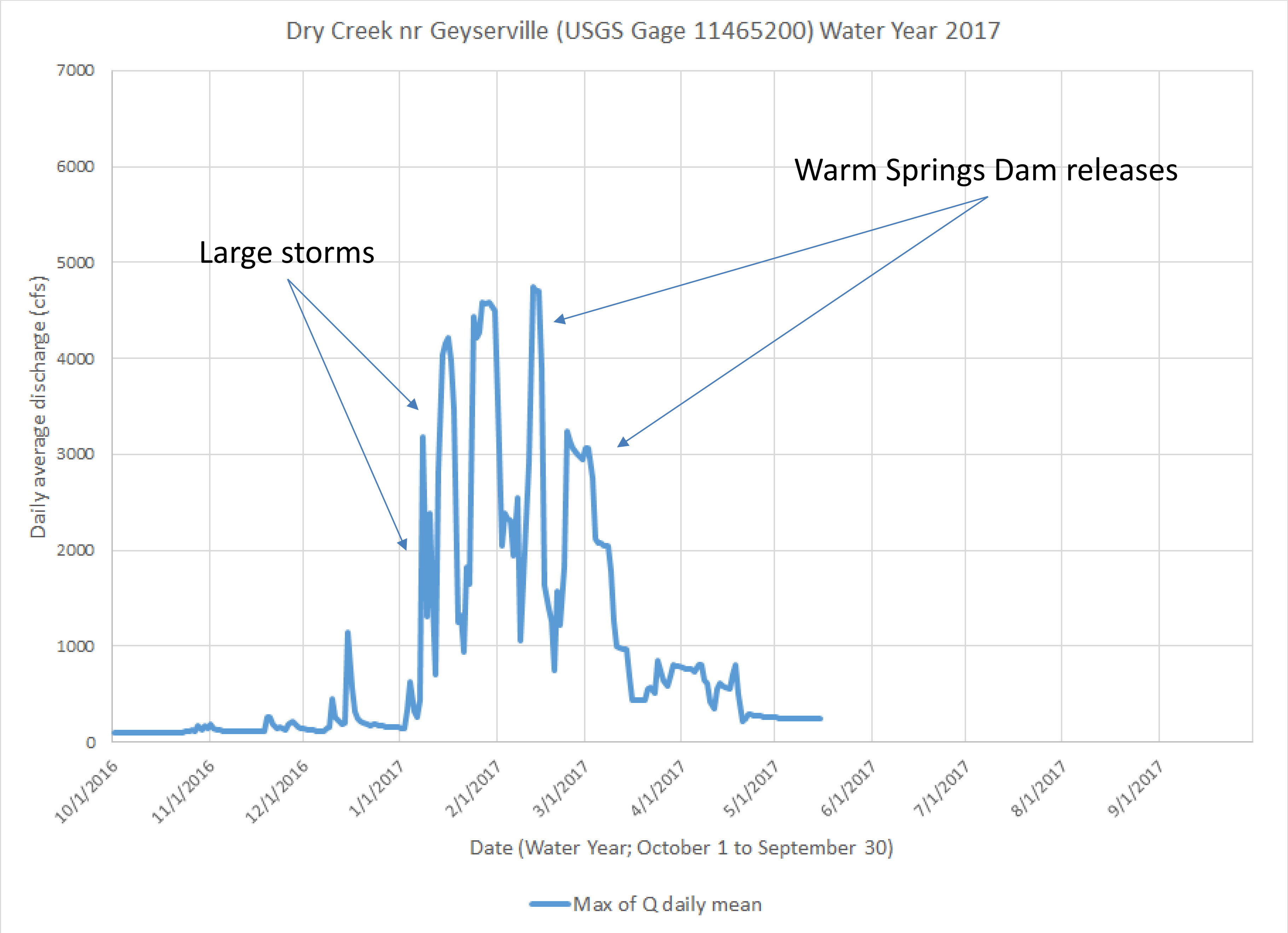
Geomorphic Change Detection (GCD)





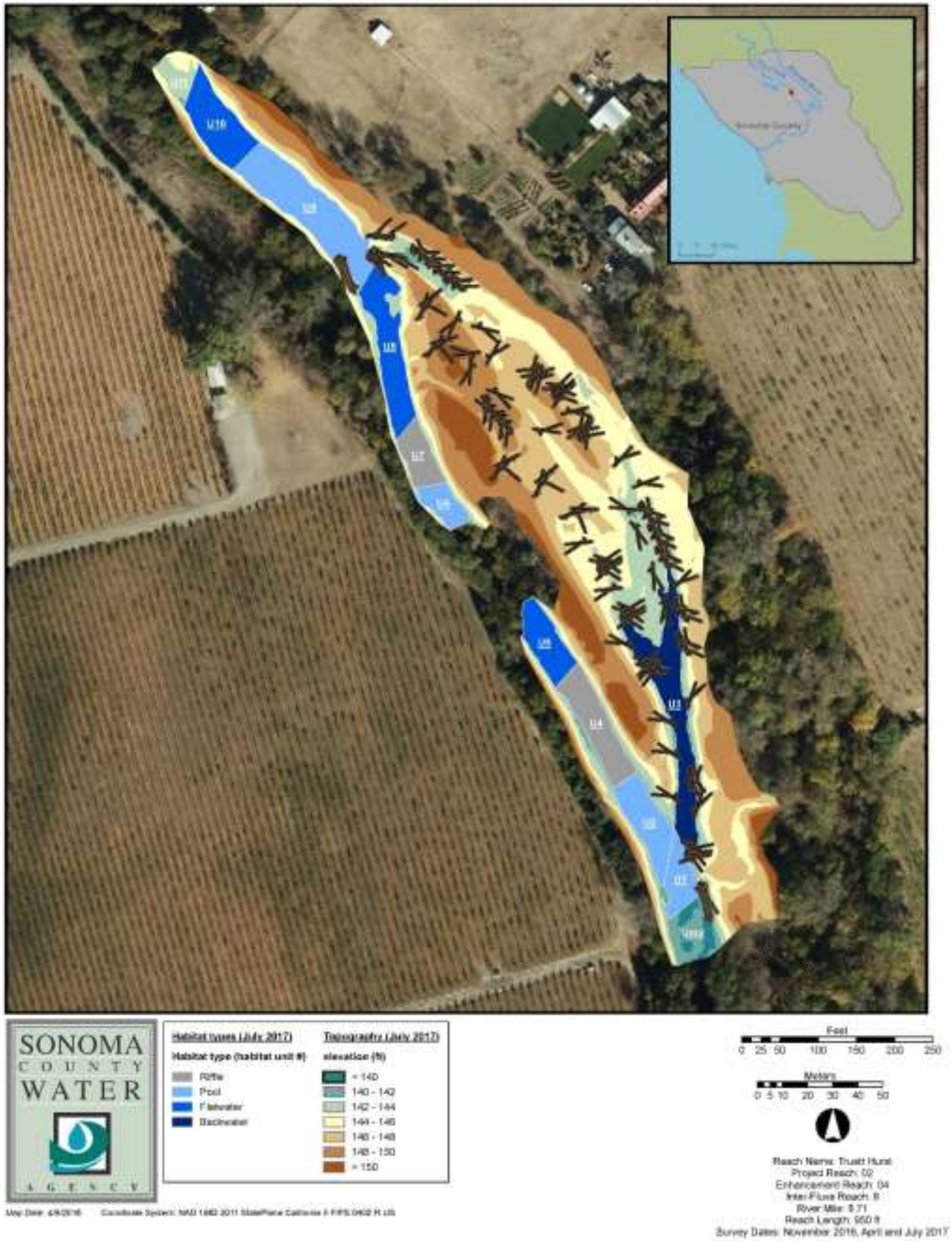
November 2016

- Phase II of Dry Creek Habitat Enhancement
- Construct side channel with alcoves
- Boulder fields and riffles to control grade
- LWD jams



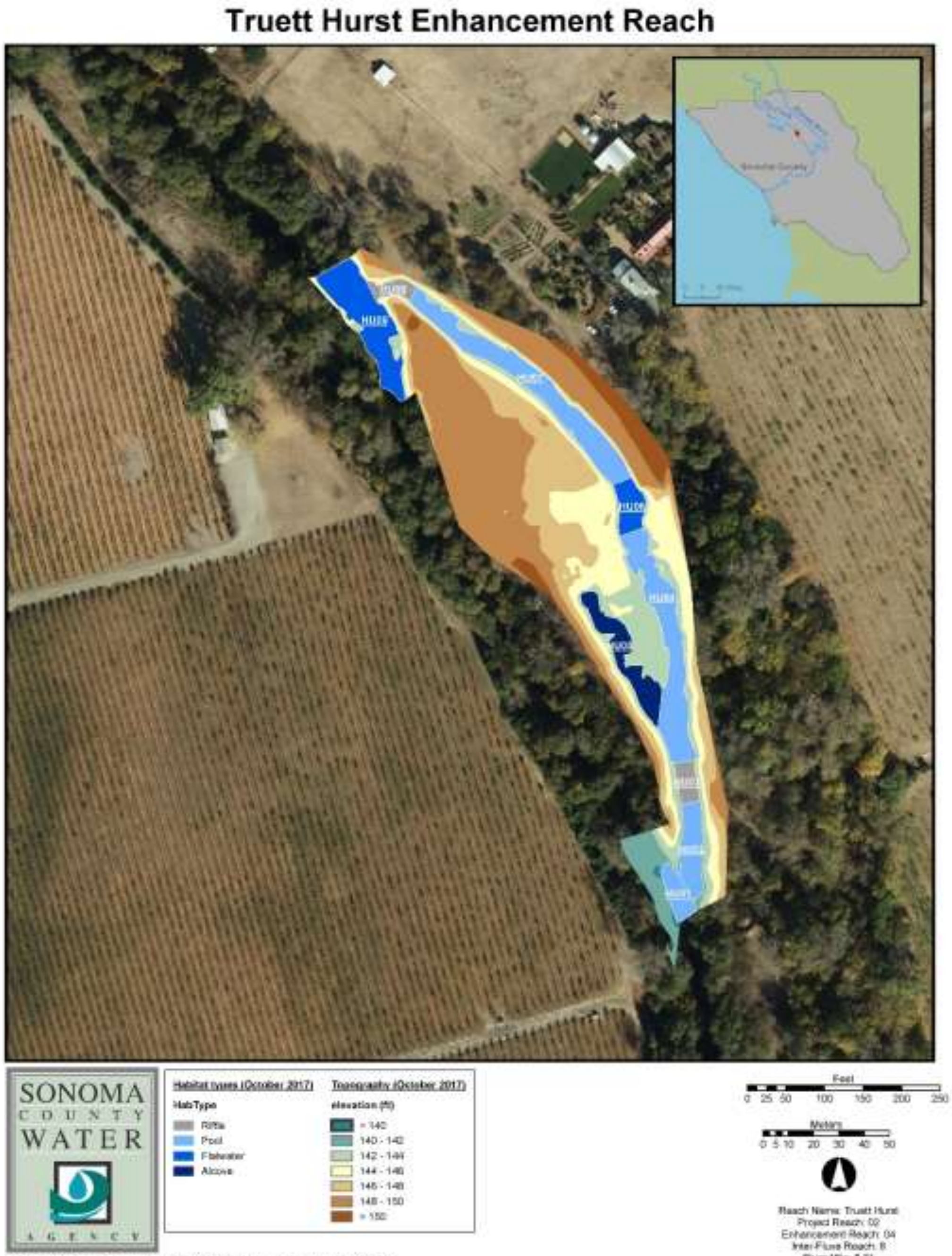
Dry Creek nr Geyserville (USGS Gage 11465200) Water Year 2017
Warm Springs Dam releases
Large storms
Daily average discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
10/1/2016
11/1/2016
12/1/2016
1/1/2017
2/1/2017
3/1/2017
4/1/2017
5/1/2017
6/1/2017
7/1/2017
8/1/2017
9/1/2017
Date (Water Year; October 1 to September 30)
Max of Q daily mean

Truett Hurst Enhancement Reach



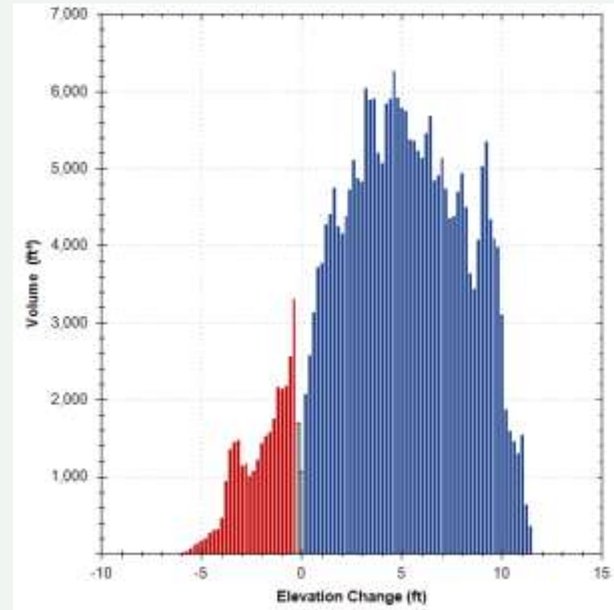
July 2017

- Substantial changes from November 2016 to July 2017
- Side channel disconnected
- Deposition within alcoves
- LWD buried



SONOMA COUNTY WATER AGENCY

2016 to 2017



- Total erosion: 32,000 ft^3
- Total deposition 245,000 ft^3
- Difference: + 213,000 ft^3

- Modified design in October 2017
- Follow flow path
- Eliminate alcove

SONOMA COUNTY WATER AGENCY

New method to collect topographic data

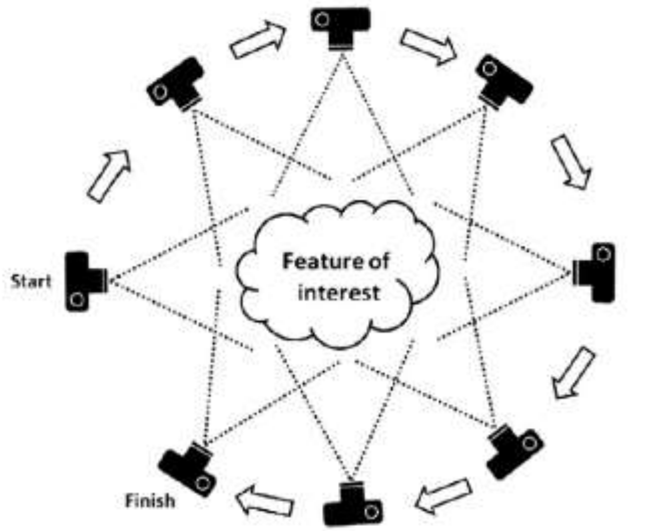


Fig. 1. Structure-from-Motion (SfM). Instead of a single stereo pair, the SfM technique requires multiple, overlapping photographs as input to feature extraction and 3-D reconstruction algorithms.

- Same idea as stereoscopic air photos, use parallax, the apparent displacement of an object as seen from two different points
- But, resolve structure from multiple (>2) overlapping images taken while moving around an object
- Modern computing algorithms and digital cameras enable detailed structure from multiple camera views and angles
- High resolution topo data from ground or air photos (as taken from drones)
- Structure from Motion

Carlson/Lonestar Enhancement Reach


- Total station
- 2 weeks field
- 1 week office


- Structure from motion (w/ Drone)
- 1.0 day field
- 2.0 day office

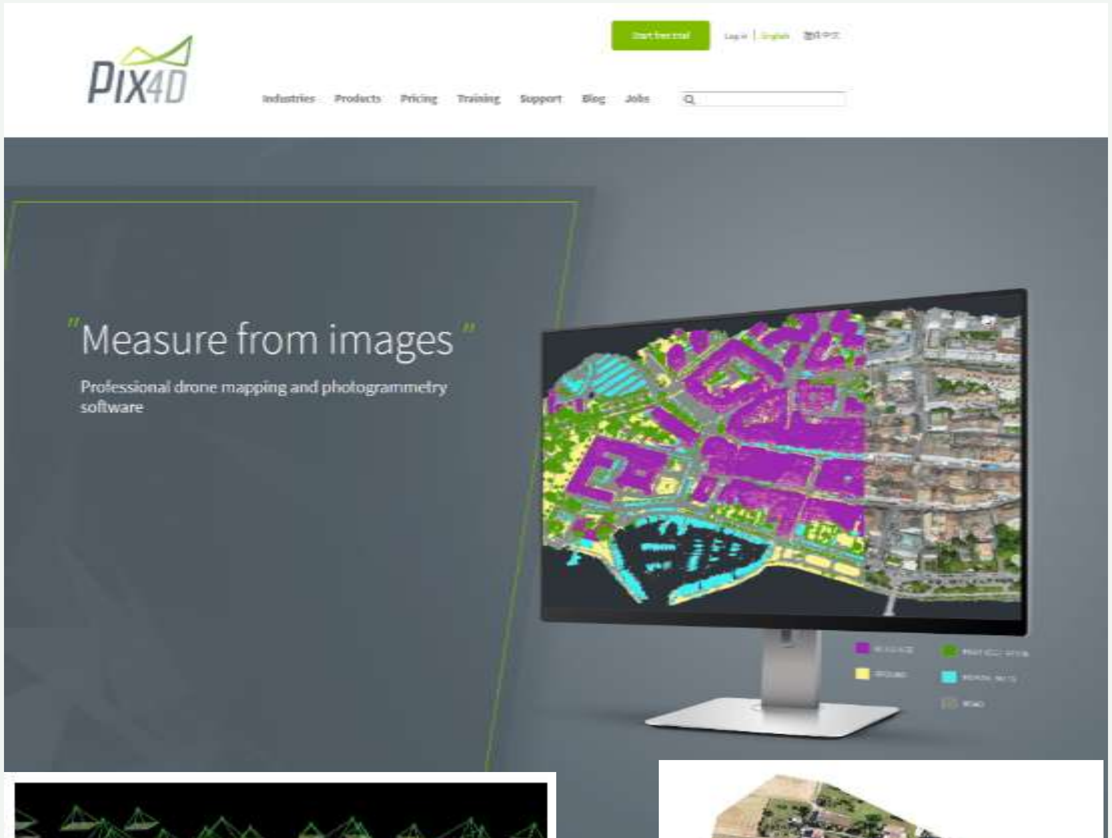
Carlson/Lonestar Enhancement Reach

Aerial images

Seamless mosaic

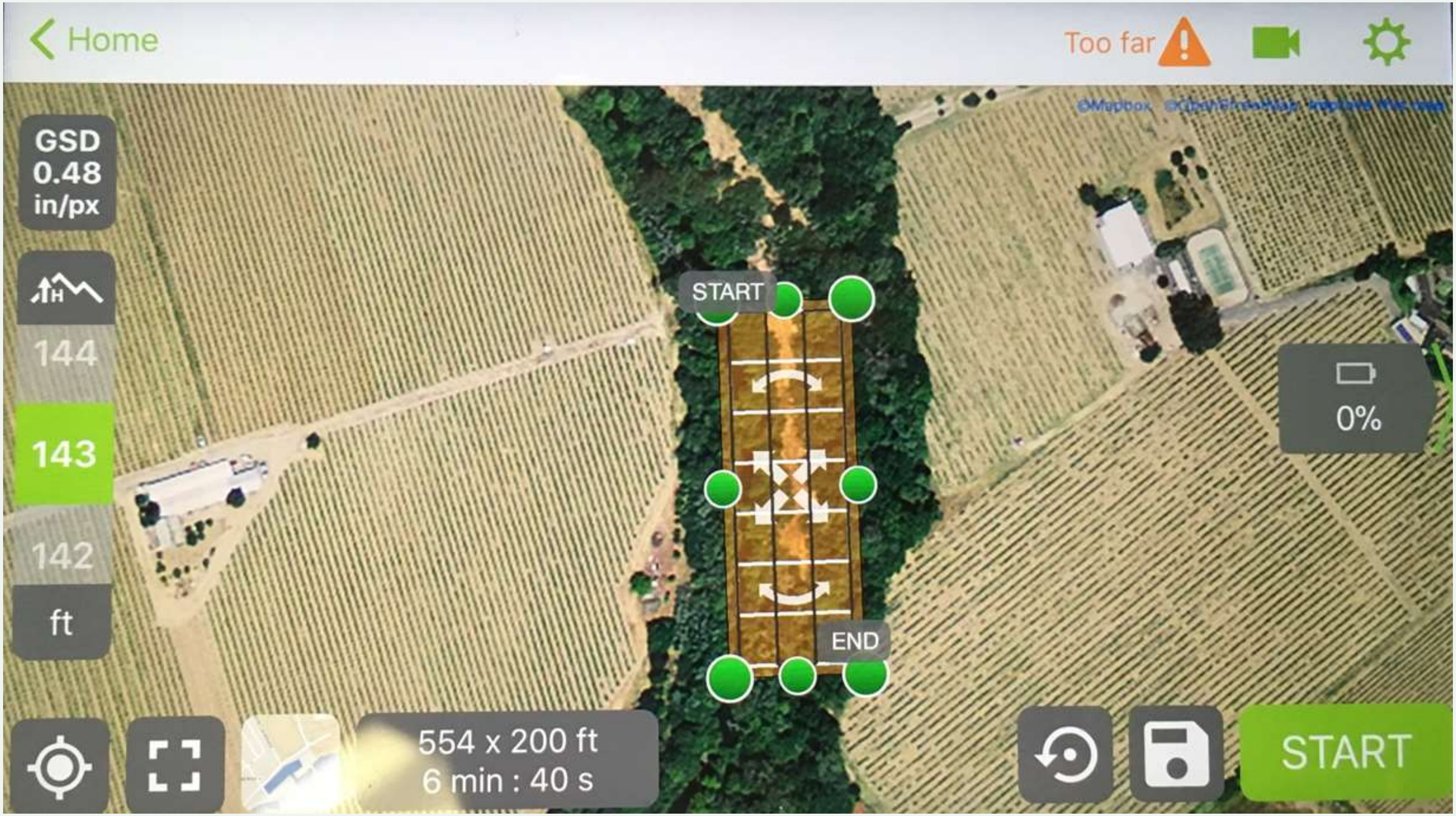
3-D structure

Use Pix4D software

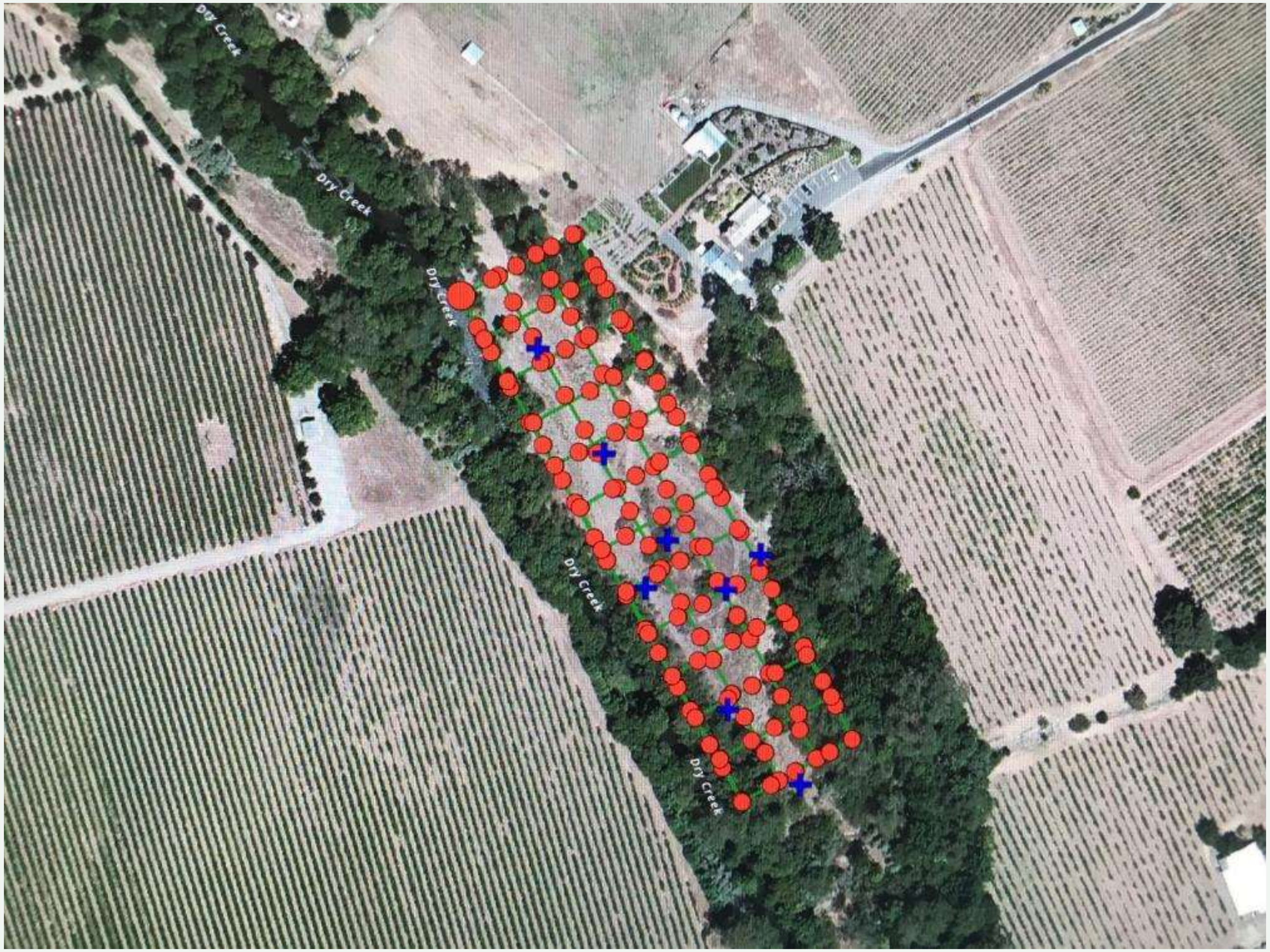


- Pix4D mapper
  - Utilizes 2D images
  - Produces 3D reconstructions and 2D mosaics
- Cloud version
  - Upload photos
  - Process remotely
  - Access online; Downloadable files
- Desktop Version
  - More options
  - Works with cloud version
  - Need computing power

Works with app to guide flight



Programmed flight path

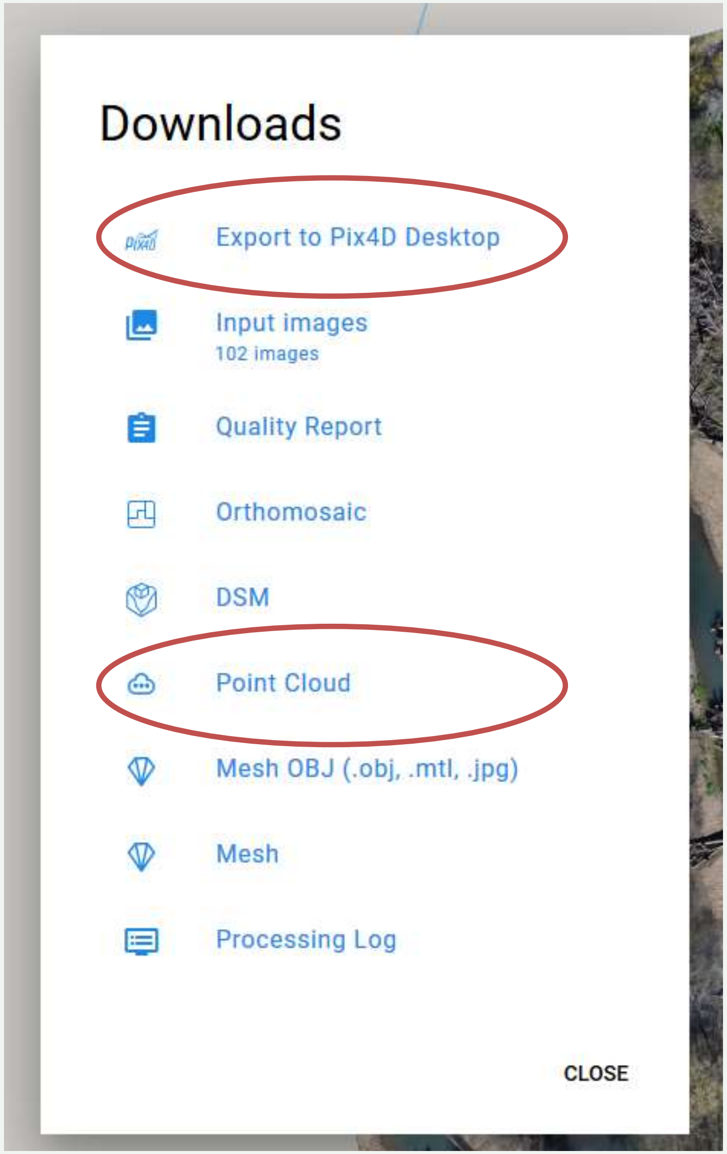


Green = Flight Path

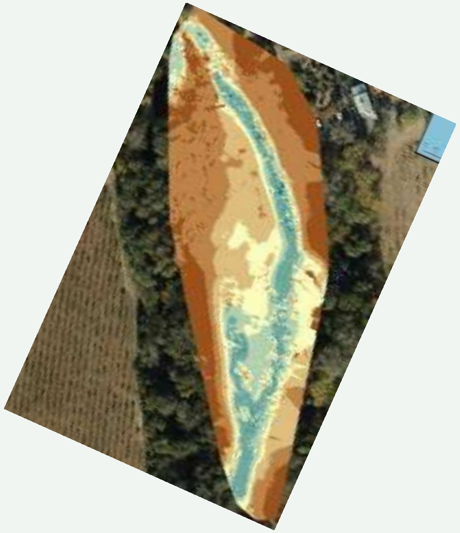
Red = Photo Locations

Blue = Ground Control Points (GCP's)

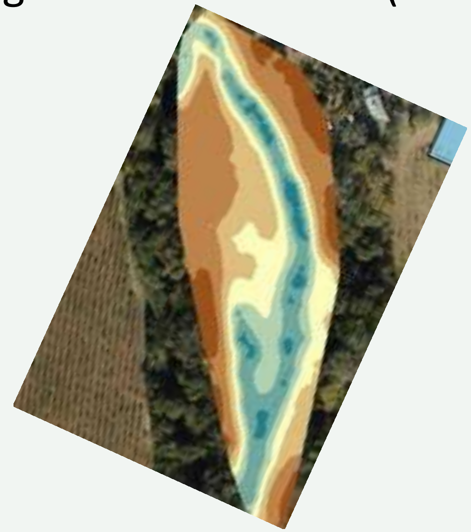
Downloadable products



Orthomosaic

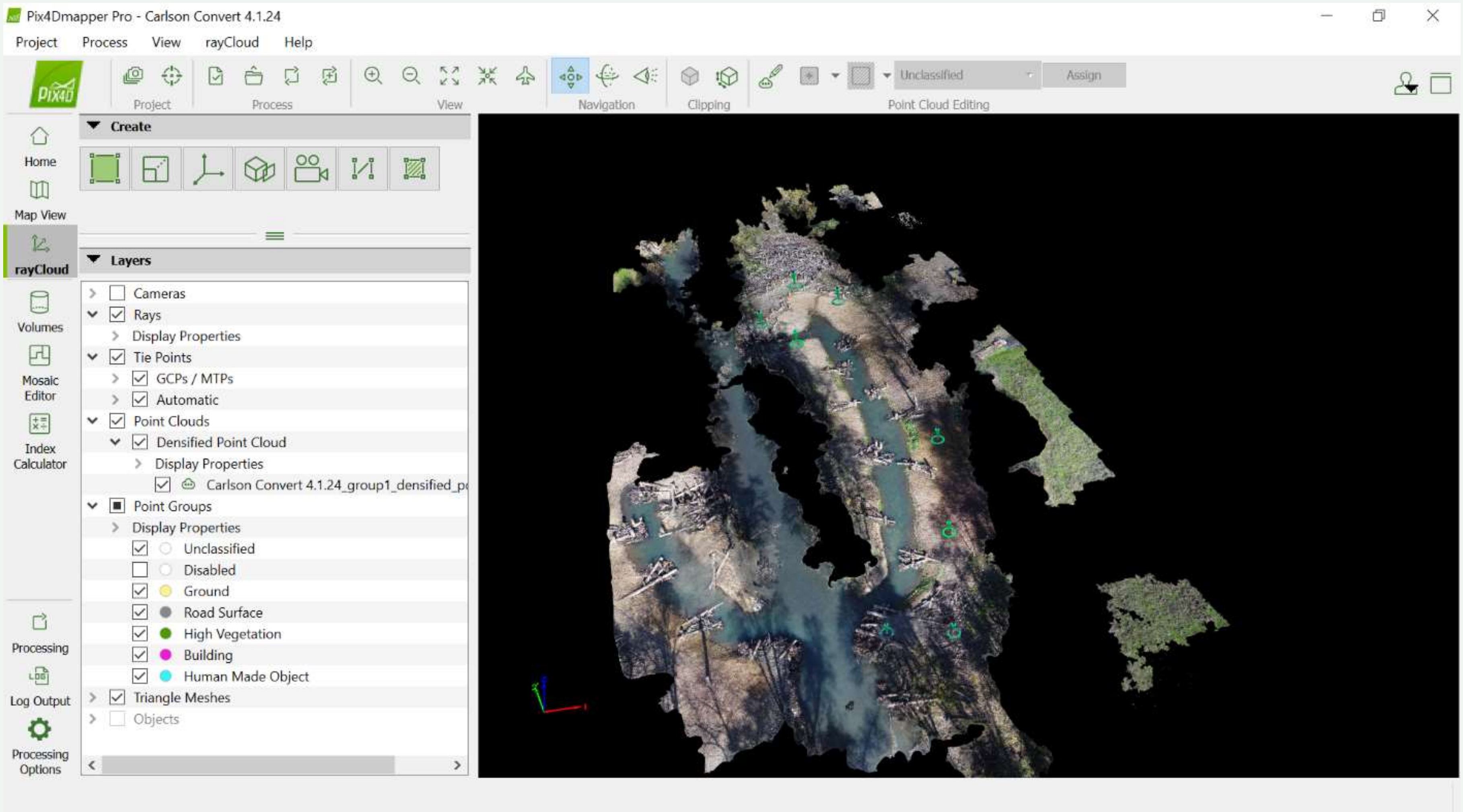


Digital surface model (DSM)

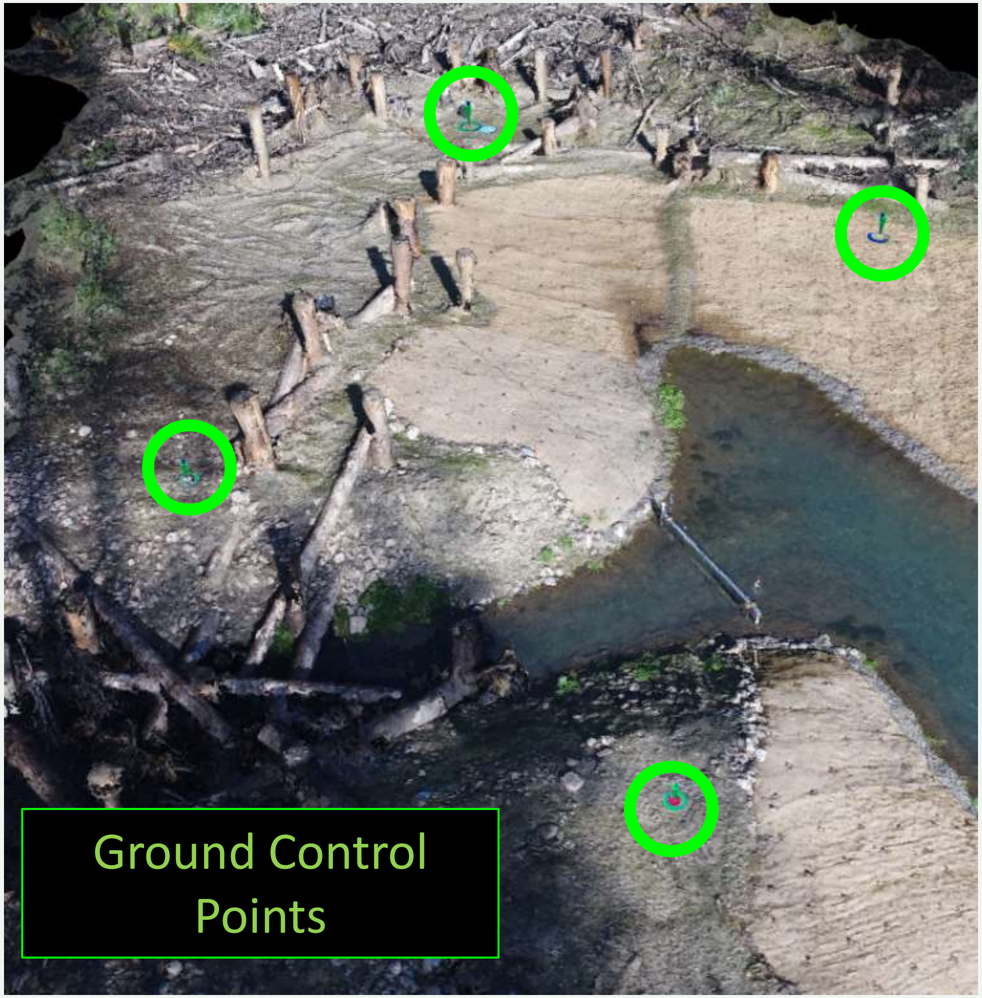


Digital terrain model (DTM)

Desktop version: customization and editing



Integration of ground control points



TS and sUAS

GCD
+/- 0.5 ft

sUAS

Tools and Methods: Conclusions

- Evolving for Dry Creek Habitat Enhancement Project
- Quantify habitat area created and sustained
- Inform past and future designs and maintenance
- Learn about next phase of Dry Creek geomorphology
- Improve efficiency of data collection
- Still collect high quality data for this and other projects

Differing Responses of Natal and Non-natal Juvenile Coho Salmon to Restoration Actions in McGarvey Creek, a Tributary to the Lower Klamath River.

Jimmy Faukner, Yurok Tribe Fisheries Department

Nicholas Som, U.S. Fish and Wildlife Service, Arcata Field Office

Toz Soto, Karuk Tribe Natural Resources Department



ACKNOWLEDGEMENTS

Yurok Tribe Fisheries Department

Scott Silloway, Nick Folkins, Dwayne Davis,
Sarah Beesley, and Andrew Antonetti

Fiori GeoSciences

Rocco Fiori

Karuk Tribe Natural Resources Department

Alex Corum and Emillo Tripp

California Cooperative Fish and Wildlife Research Unit

Christopher Manhard

USGS, Columbia River Research Station

Russell Perry

Bureau of Reclamation

Funding source for Coho Ecology Project

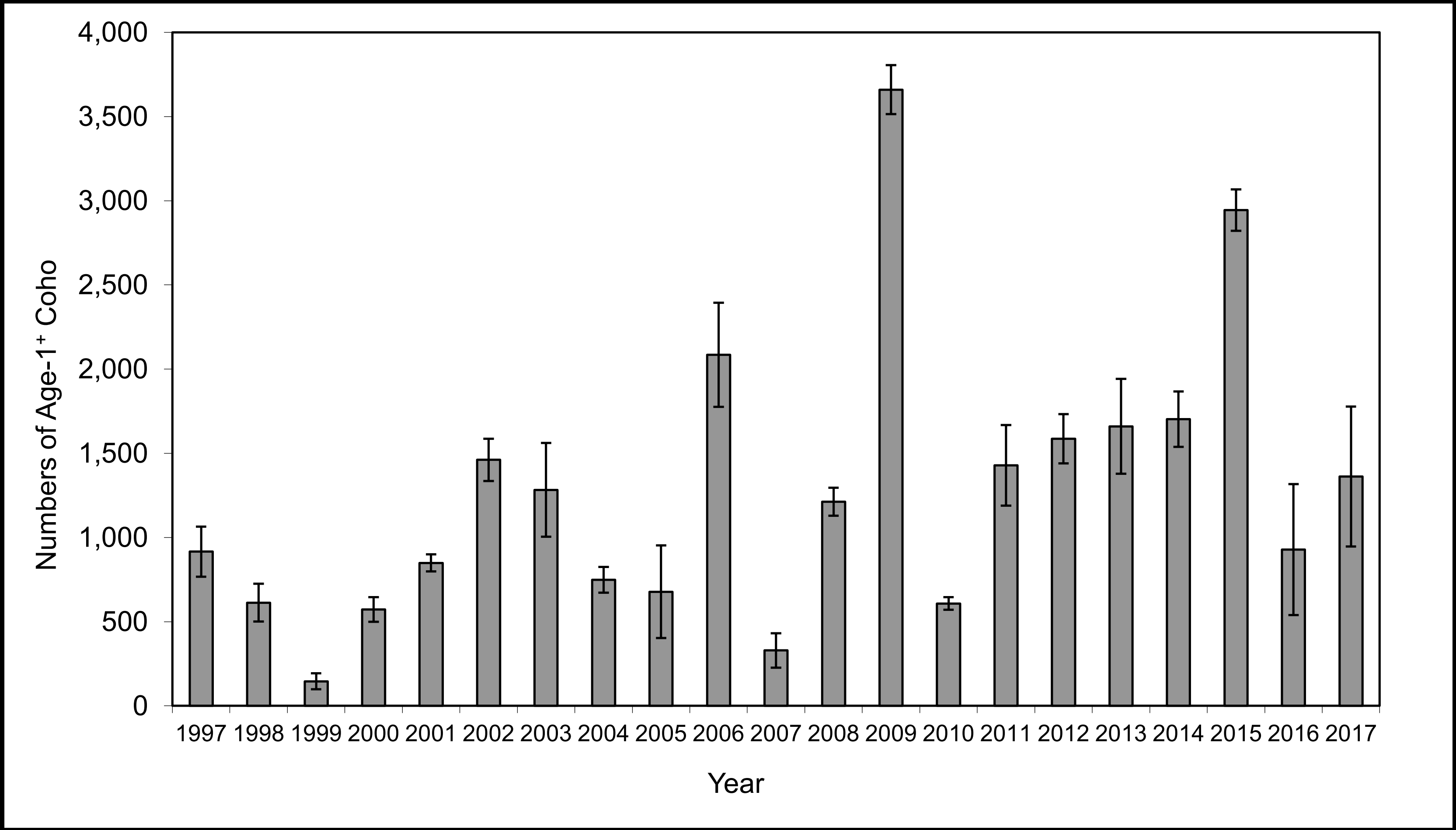
STUDY AREA

- Small coastal stream near the estuary
- Watershed area = 23 km^2
- Annual flow range = 0-400 cfs
- Primary land use is timber harvest
- Supports a small natal population of Coho

  < 30 adults often much lower
- Supports non-natal Coho arrive in the fall/winter
- Sections of the lower creek typically go dry summer/fall


Untitled Map
Legend
McGarvey Creek
McGarvey Creek
169
101
Google Earth
1 mi

SPRING OUTMIGRATION ESTIMATES



STUDY SITES

Lower Reach

Three alcoves, 1 side channel, and over 30 CWJs

Site	Construction Date	Area (m^2)
Alcove I	Summer 2010	809
Alcove II	Summer 2012	405
Alcove III	Summer 2013	567
Side Channel I	Summer 2014	971

Alcove I

Alcove II

Alcove III

Side Channel I

SUMMER POPULATION ESTIMATES

Year	Site	Pop Est	95% CI
2015	Alcove I	0	–
	Alcove II	0	–
	Alcove III[a]	64	59–69
	Side Channel I	158	140–176
2016	Alcove I[a]	–	–
	Alcove II	60	52–68
	Alcove III	72	65–79
	Side Channel I	170	151–189
2017	Alcove I	0	0
	Alcove II	25	24-26
	Alcove III[a]	–	–
	Side Channel I	74	62–86

[a] Insufficient recaptures to generate estimates

WINTER POPULATION ESTIMATES

Year	Site	Pop Est	95% CI
2015	Alcove I	30	26−34
	Alcove II	41	29−53
	Alcove III	12	29−43
	Side Channel I	162	140−184
2016	Alcove I	103	94−122
	Alcove II	28	21−35
	Alcove III	31	28−34
	Side Channel I	128	125−131
2018	Alcove I	81	81
	Alcove II	24	21−27
	Alcove III	31	24−38
	Side Channel I	225	105−345

SIDE CHANNEL I AS GOOD OR BETTER THAN ALCOVES I–III

- Habitat complexity?
- Density produces similar results
- Other side channel

  ~ Alcoves II and III

SURVIVAL

- Not “Apparent” survival accounts for early emigrants
- Not calculated in MARK
- Model developed by Nick Som, Chris Manhard, and Russ Perry
- Manhard et al. (2018)

  “Analytical methods for estimating freshwater productivity, overwinter survival, and migration patterns of Klamath River Coho Salmon”
- Interested in the model?

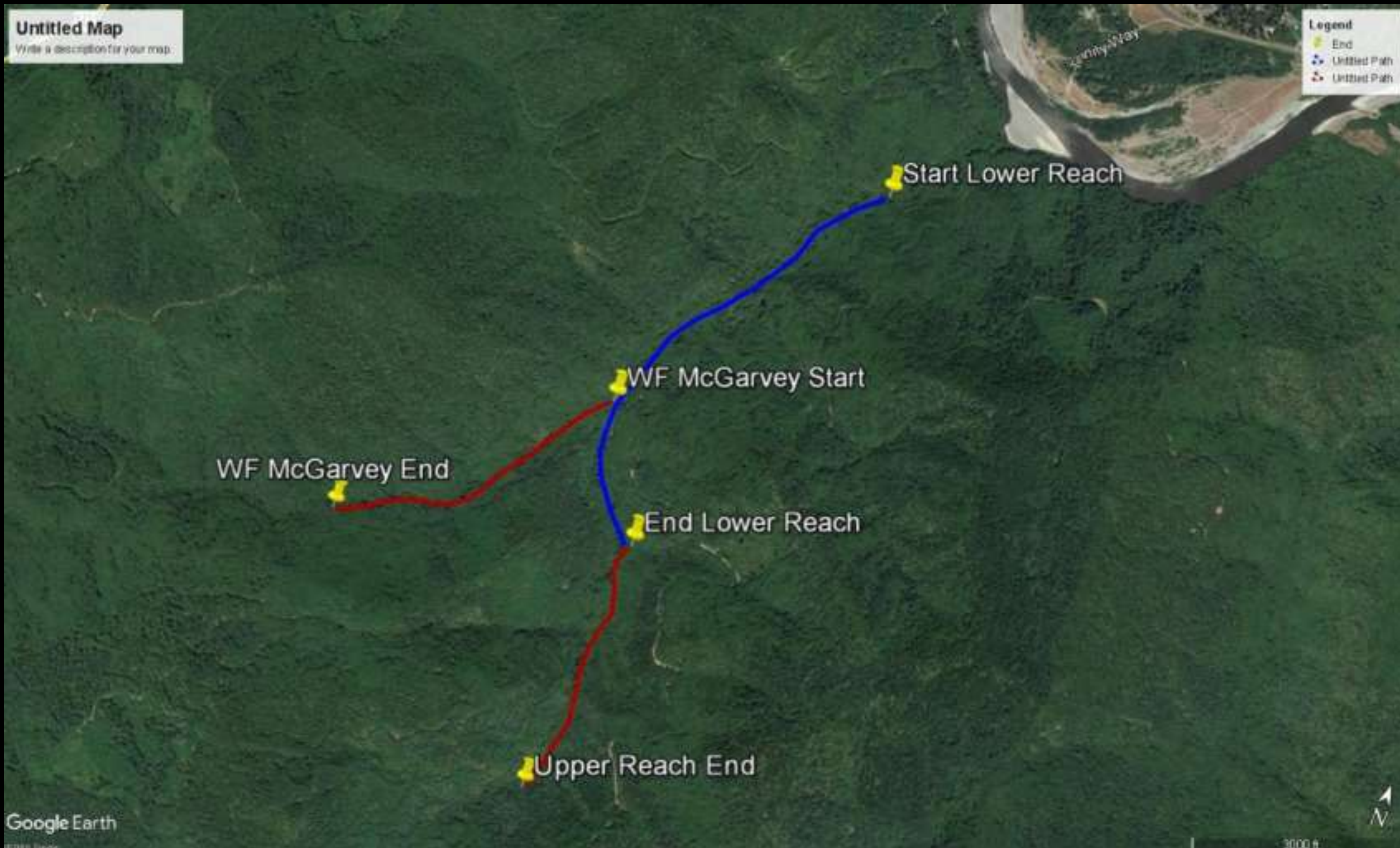
  Nick Som

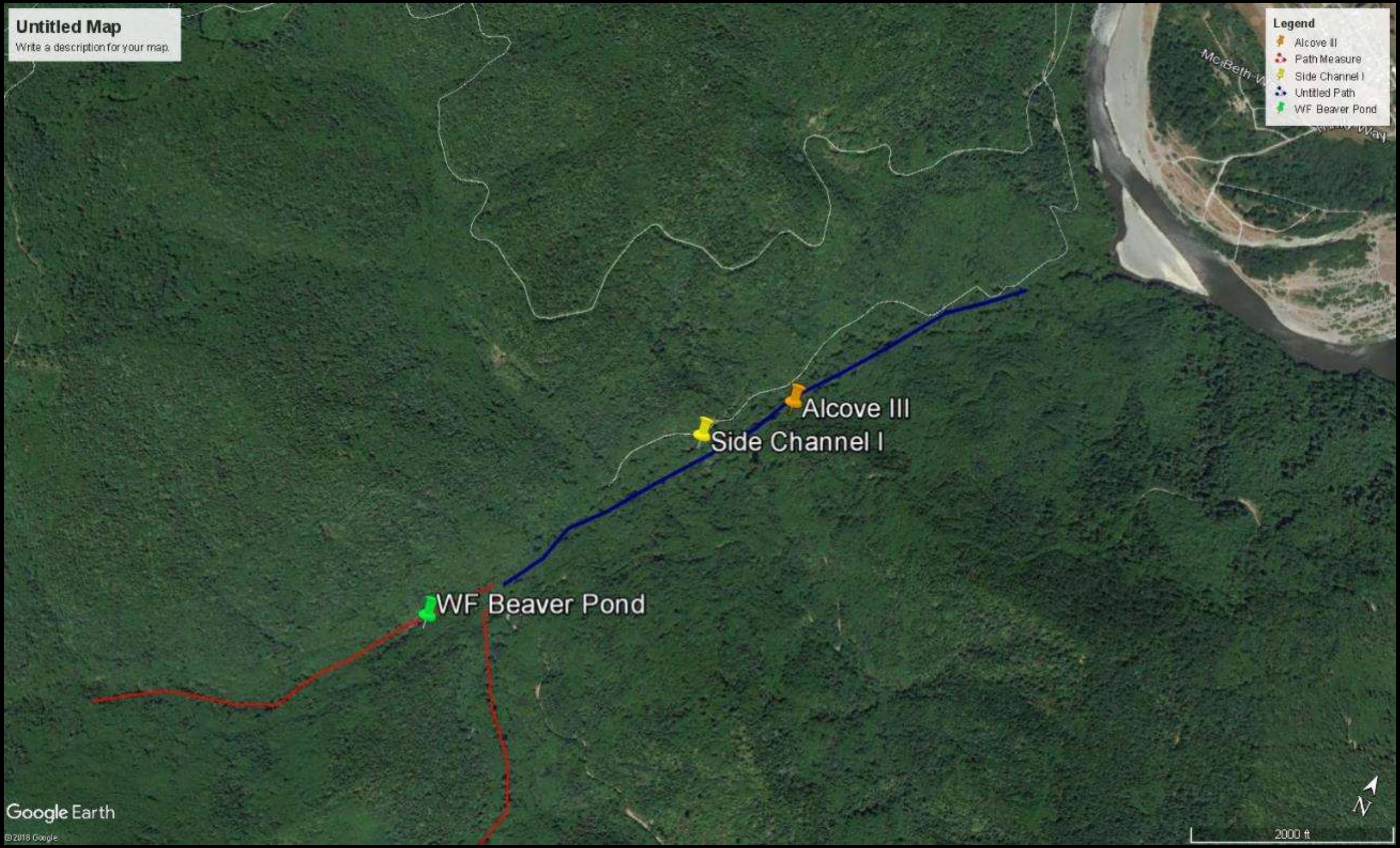
LOWER AND UPPER REACHES

- Lower Reach – Alcoves I−III and Side Channel I

  Prone to channel drying
- Upper Reach − upper mainstem and WF McGarvey

  Not prone to channel drying


Untitled Map
Write a description for your map
Legend
End
Untitled Path
Untitled Path
Start Lower Reach
WF McGarvey Start
WF McGarvey End
End Lower Reach
Upper Reach End
Google Earth
3000 ft

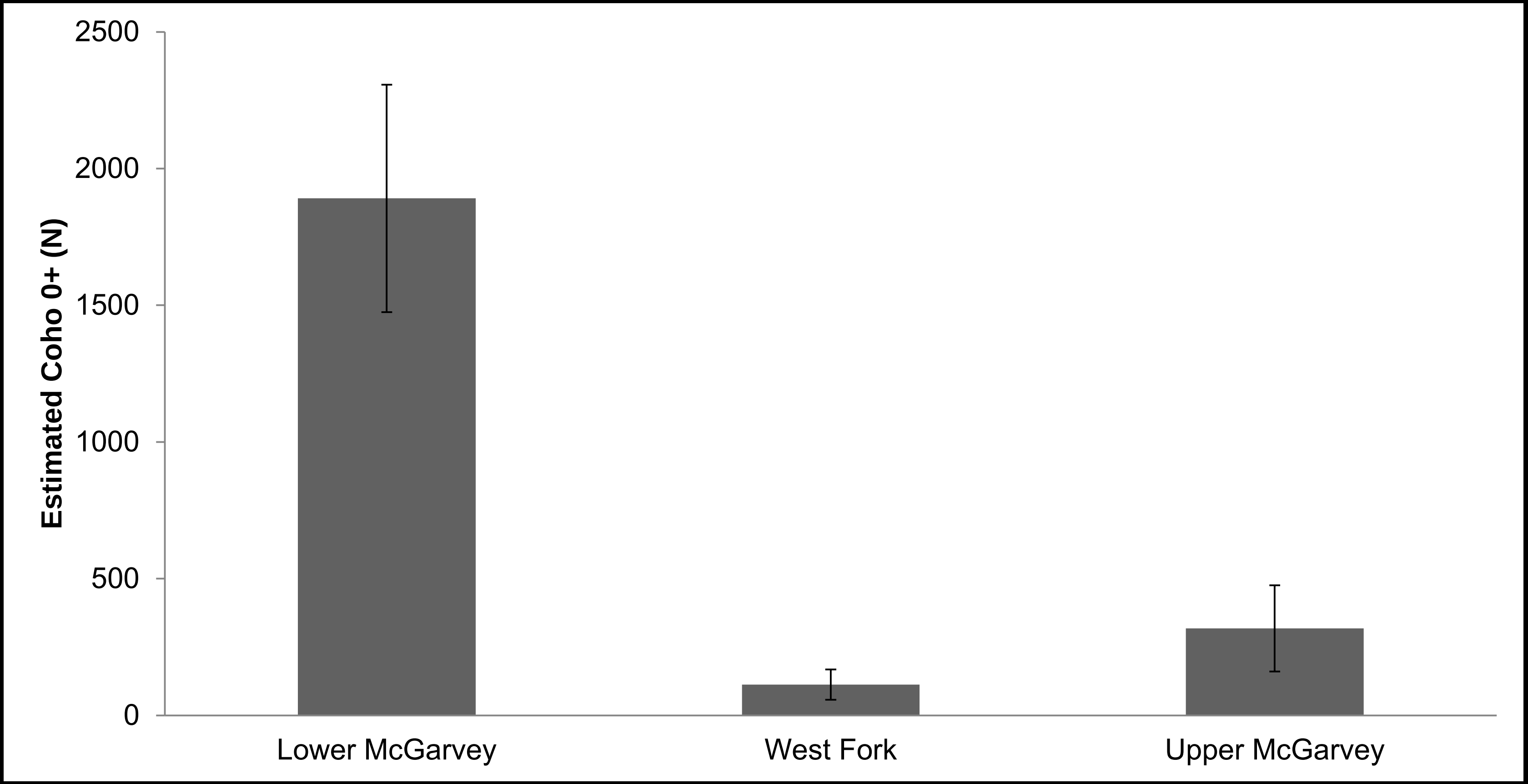


Untitled Map
Write a description for your map.
Legend
Alcove III
Path Measure
Side Channel I
Untitled Path
WF Beaver Pond
Alcove III
Side Channel I
WF Beaver Pond
Google Earth
2000 ft

Survival: Feb 1st to June 30th

Tagging Year	Reach	Tagged (*N*)	Survival	95% CI
2012	Upper	110	0.43	0.33−0.54
	Lower	271	0.54	0.48−0.61
2013	Upper	205	0.41	0.34−0.48
	Lower	163	0.38	0.30−0.46
2014	Upper	131	0.42	0.30−0.58
	Lower	177	0.53	0.42−0.67
	Rescue	212	0.40	0.32−0.51
2015	Upper	83	0.62	0.48−0.84
	Lower	82	−	−
	Rescue	95	−	−
2016	Upper	104	0.63	0.45−0.90
	Lower	351	−	−

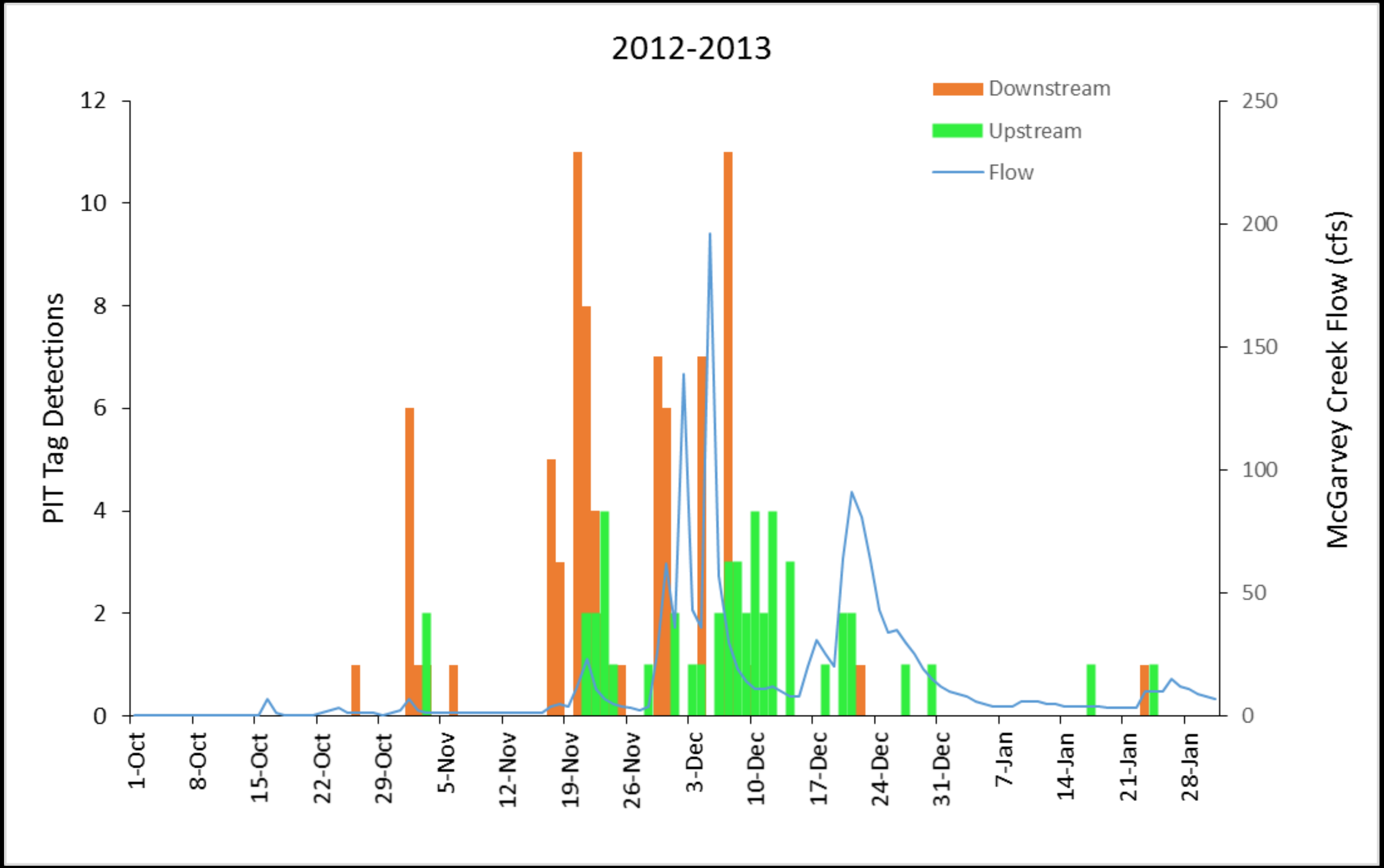
Summer Abundance Estimate for McGarvey Creek 2012



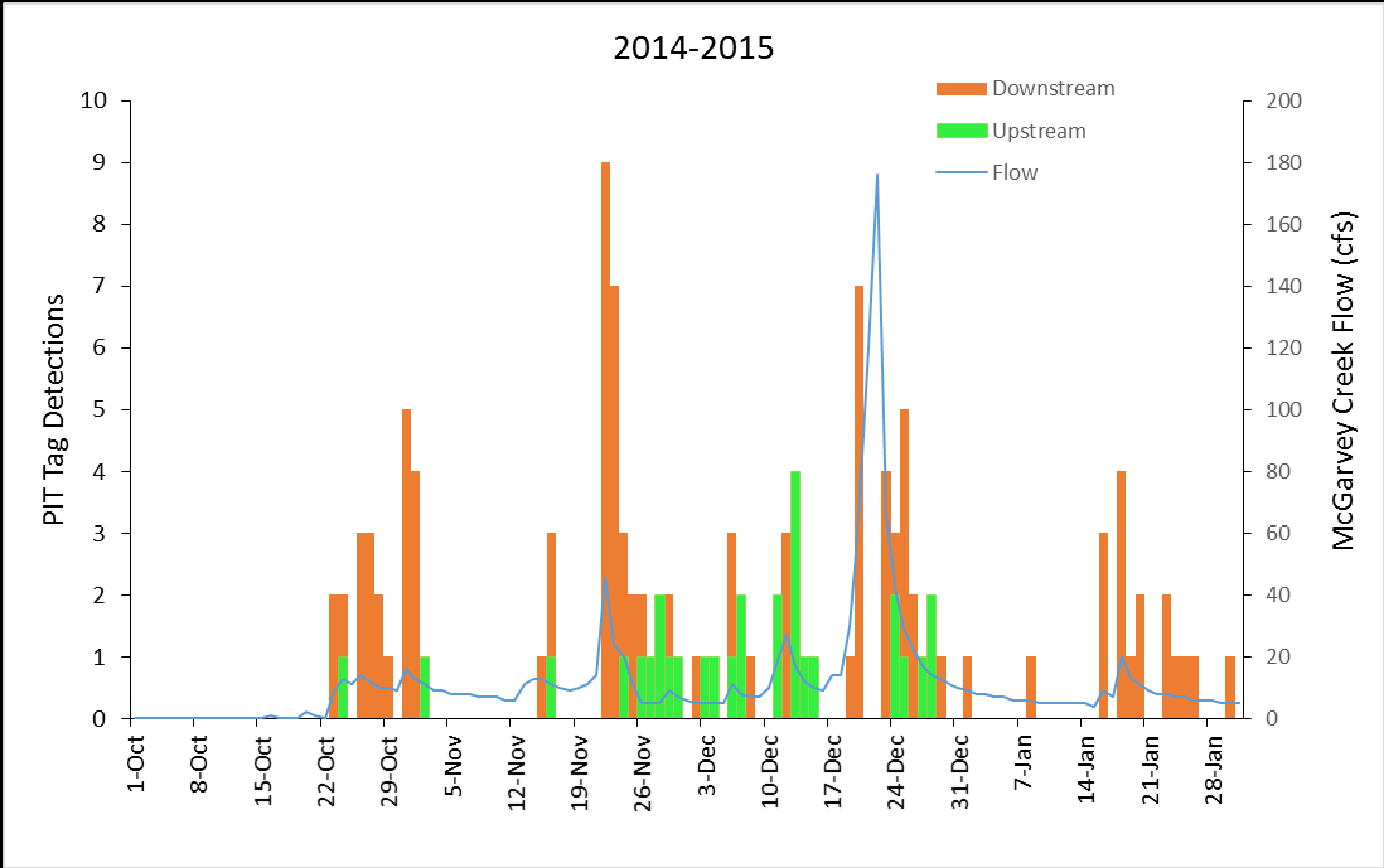
Winter Emigration: Oct 1st−Jan 31st

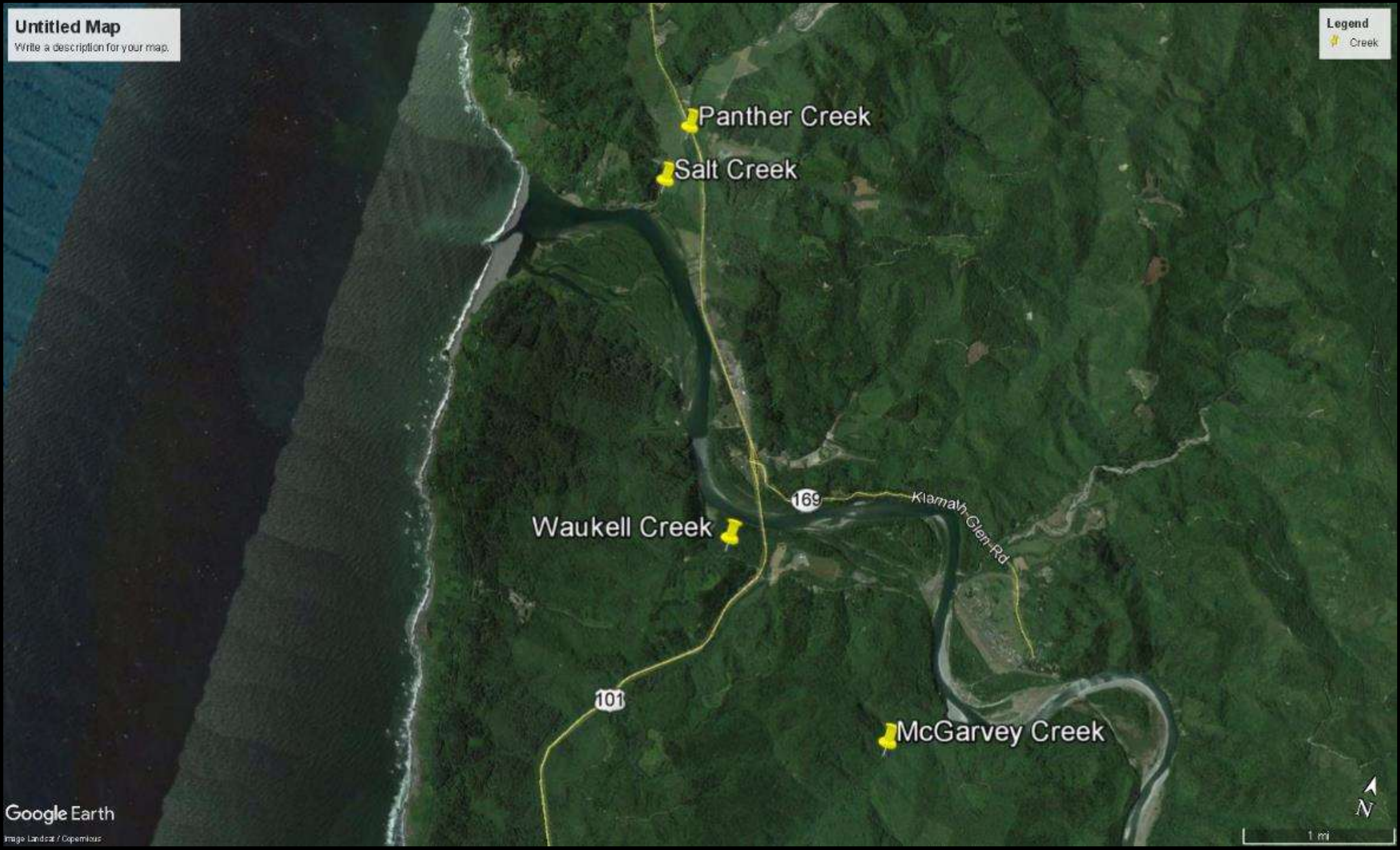
Tagging Year	Reach	Tagged (*N*)	Winter Emigration Rate	95% CI
2012	Upper	110	0.16	0.09−0.25
	Lower	271	0.35	0.32−0.41
2013	Upper	205	0.07	0.04−0.11
	Lower	163	0.14	0.09−0.20
2014	Upper	131	0.07	0.02−0.16
	Lower	177	0.40	0.31−0.44
	Rescue	212	0.23	0.16−0.33
2015	Upper	83	0.23	0.11−0.46
	Lower	82	−	−
	Rescue	95	−	−
2016	Upper	104	0.50	0.34−0.73
	Lower	351	−	−

NON-NATAL USE



NON-NATAL USE





Untitled Map
Write a description for your map.
Legend
Creek
Panther Creek
Salt Creek
Waukell Creek
McGarvey Creek
169
Klamath-Glen-Rd
101
Google Earth
Image Landsat / Copernicus
N
1 mi

NON-NATAL DETECTIONS

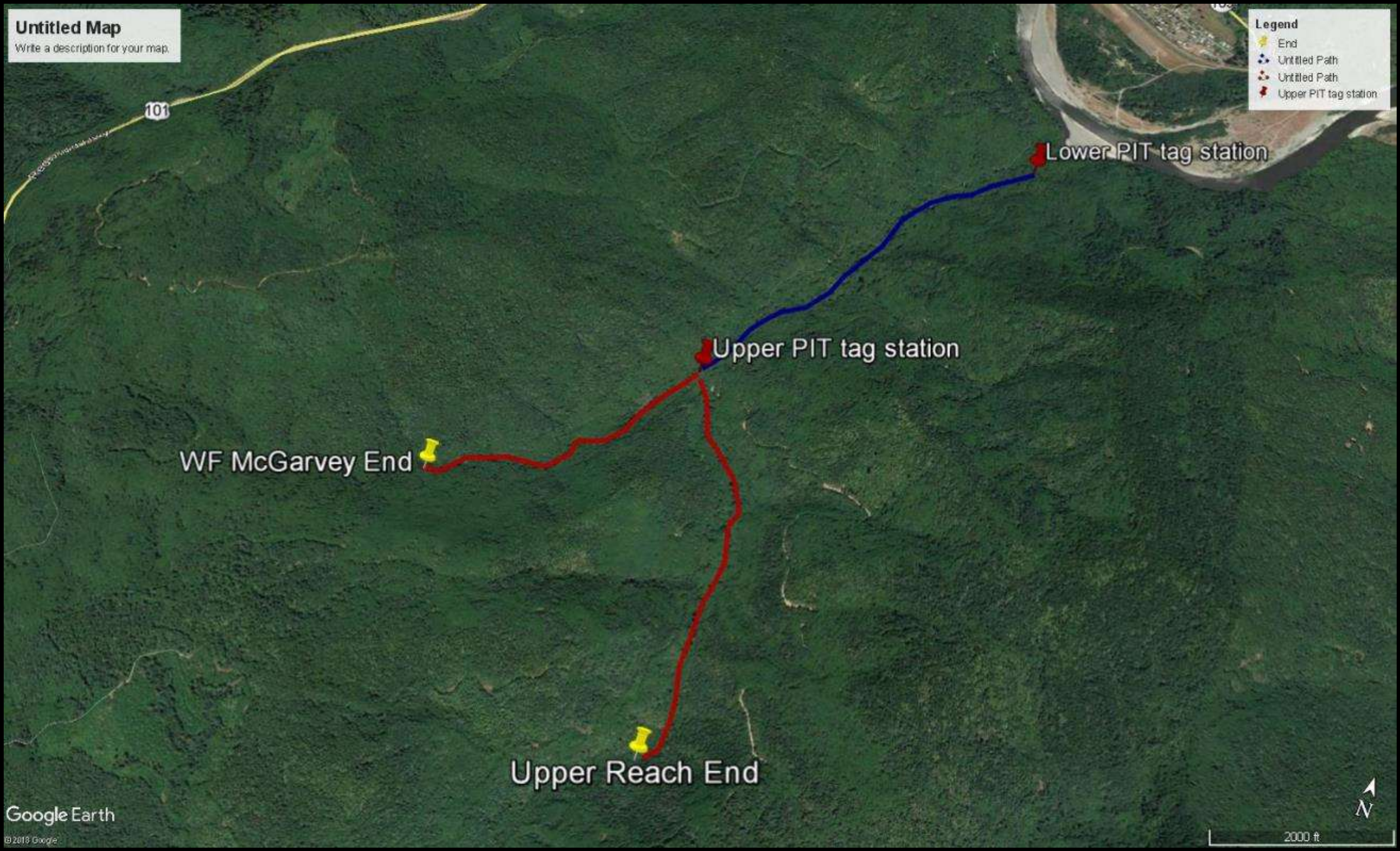
Mid-Klamath Tagging		McGarvey	Waukell	Panther	Salt	Total
Year	*N*	*n*	*n*	*n*	*n*	*n*
2012	4776	11	72	20	19	126
2013	3758	53	83	47	59	246
2014	2680	3	11	1	3	20
2015	2803	29	61	16	3	110
2016	2346	11	19	3	16	49
2017	2291	69	77	46	33	247

SPRING OUTMIGRATION POPULATION ESTIMATES

Year	Site	Pop. Est.	95% CI
2012	Waukell Creek	7,851	6,969 - 8,733
	McGarvey Creek	1,586	1,300 - 1,872
2013	Waukell Creek	2,275	1,683 - 2,867
	McGarvey Creek	1,728	1,156 - 2,300
2014	Waukell Creek	767	624 - 910
	McGarvey Creek	1,703	1,380 - 2,026
2015	Waukell Creek	10,659	9,409 - 11,909
	McGarvey Creek	2,944	2,703 - 3,185
2016	Waukell Creek	4,795	3,880 - 5,710
	McGarvey Creek	929	165 - 1,693
2017	Waukell Creek	9,432	7,801 - 11,063
	McGarvey Creek	1,362	547 - 2,177

NON-NATAL SURVIVAL
MCGARVEY vs WAUKELL

Tagging Year	Site	Tagged (*N*)	Survival	95% CI
2012	McGarvey	59	0.64	0.49−0.81
	Waukell	178	0.15	0.10−0.21
2013	McGarvey	143	0.64	0.54−0.75
	Waukell	175	0.15	0.10−0.22
2014	McGarvey	129	0.53	0.38−0.75
	Waukell	853	0.32	0.29−0.35
2015	McGarvey	−	−	−
	Waukell	94	0.43	0.34−0.53
2016	McGarvey	69	0.52	0.38−0.71
	Waukell	67	0.47	0.34−0.50


Untitled Map
Write a description for your map.
Legend
End
Untitled Path
Untitled Path
Upper PIT tag station
101
Lower PIT tag station
Upper PIT tag station
WF McGarvey End
Upper Reach End
Google Earth
N
2000 ft

NON-NATAL DETECTIONS BY REACH

Year	Lower	Upper
2012-2013	47	6
2013-2014	11	1
2014-2015	22	5
2015-2016	10	2
2016-2017	35	34

NON-NATAL DETECTIONS AT FEATURES

	Detections			
Year	Alcove II	Side Channel I	Total	Proportion
2012-2013	10	–	53	0.19
2013-2014	1	–	3	0.33
2014-2015	3	4	29	0.24
2015-2016	3	4	11	0.64
2016-2017	13	26	69	0.57

DISCUSSION

- Was over-winter survival a problem in McGarvey Creek?
- Off-channel habitat has not reduced early emigration
- Over-summer survival is more likely a limiting factor
- Non-natal survival substantially higher than natal survival could also implicate channel drying as a limiting factor and not over-winter survival
- Non-natal survival as good or better than Waukell Creek

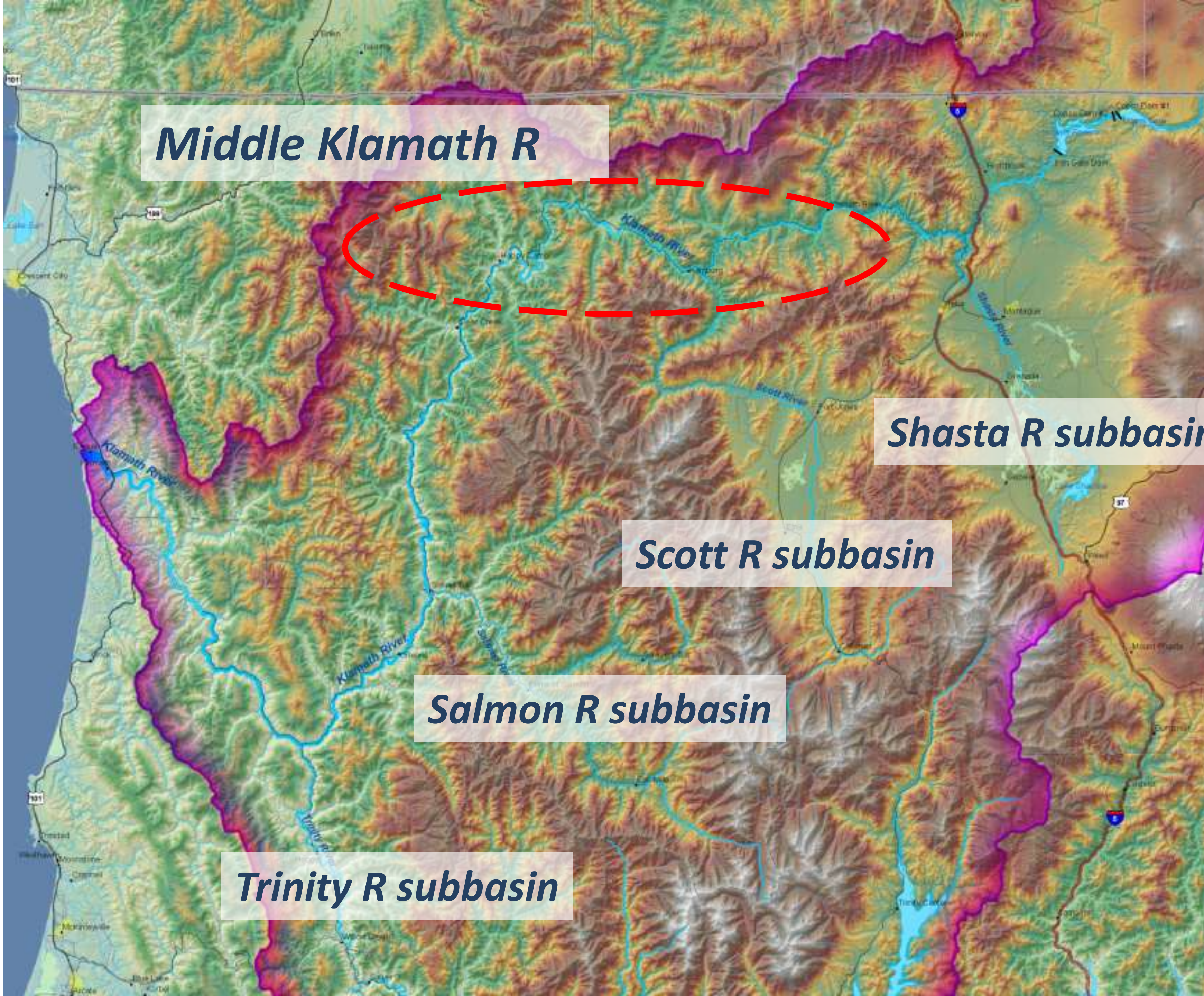
Predation a likely factor in Waukell Creek

WHERE DO WE GO FROM HERE?

- BDAs in the Lower reach – summer 2018
- Fish relocation during dry years
- Restoration in lower portions of watersheds may provide benefits for non-natal fish
- Spread risk

USING SCIENCE TO GUIDE COHO RESTORATION IN THE MID KLAMATH: IF YOU WOULD BUILD IT THEY WILL COME:

Authors:
Toz Soto, James Peterson, Sophie Price, Charles Wickman, Will Harling


Middle Klamath R
Shasta R subbasin
Scott R subbasin
Salmon R subbasin
Trinity R subbasin
Klamath River
Klamath River
Klamath River
Scott River

Legacy of Degraded Floodplains and Off Channel Habitat Loss

Downstream View Flood Levee

Upstream View of Flood Levee

PROBLEM: Humans and Coho are competing for the same space found on floodplains and stream valleys.

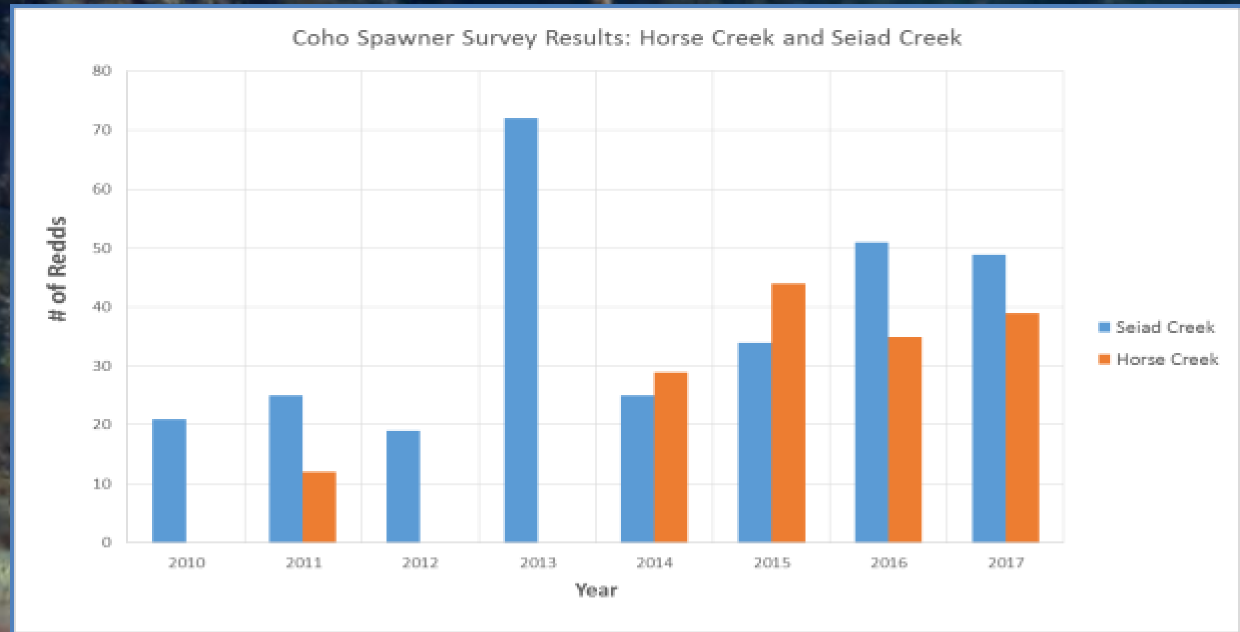
DREDGING THE KLAMATH RIVER AT HUMBUG CREEK - 1941


Klamath River at Humbug Creek - Today

Klamath River Coho Ecology Study

Karuk Tribe and Yurok Tribe collaborative effort since 2007

- Diverse Coho life history patterns-non-natal stream rearing is common
- Seasonal movements of age 0+ juveniles- early summer and late fall
- Long migrations of age 0+ juveniles to find suitable habitats
- Winter rearing habitat in the Mid Klamath is mostly low quality and in short supply
- Restoration goals should focus on habitat quality and consider constructed off channel habitats to improve survival.



Middle Klamath Adult Coho Population

- ESA listed species since 1997
- The adult spawning population is less than 200 fish annually
- Most spawning occurs in just a few tributaries- Horse Creek and Seiad Creek

Common Coho life history theme:

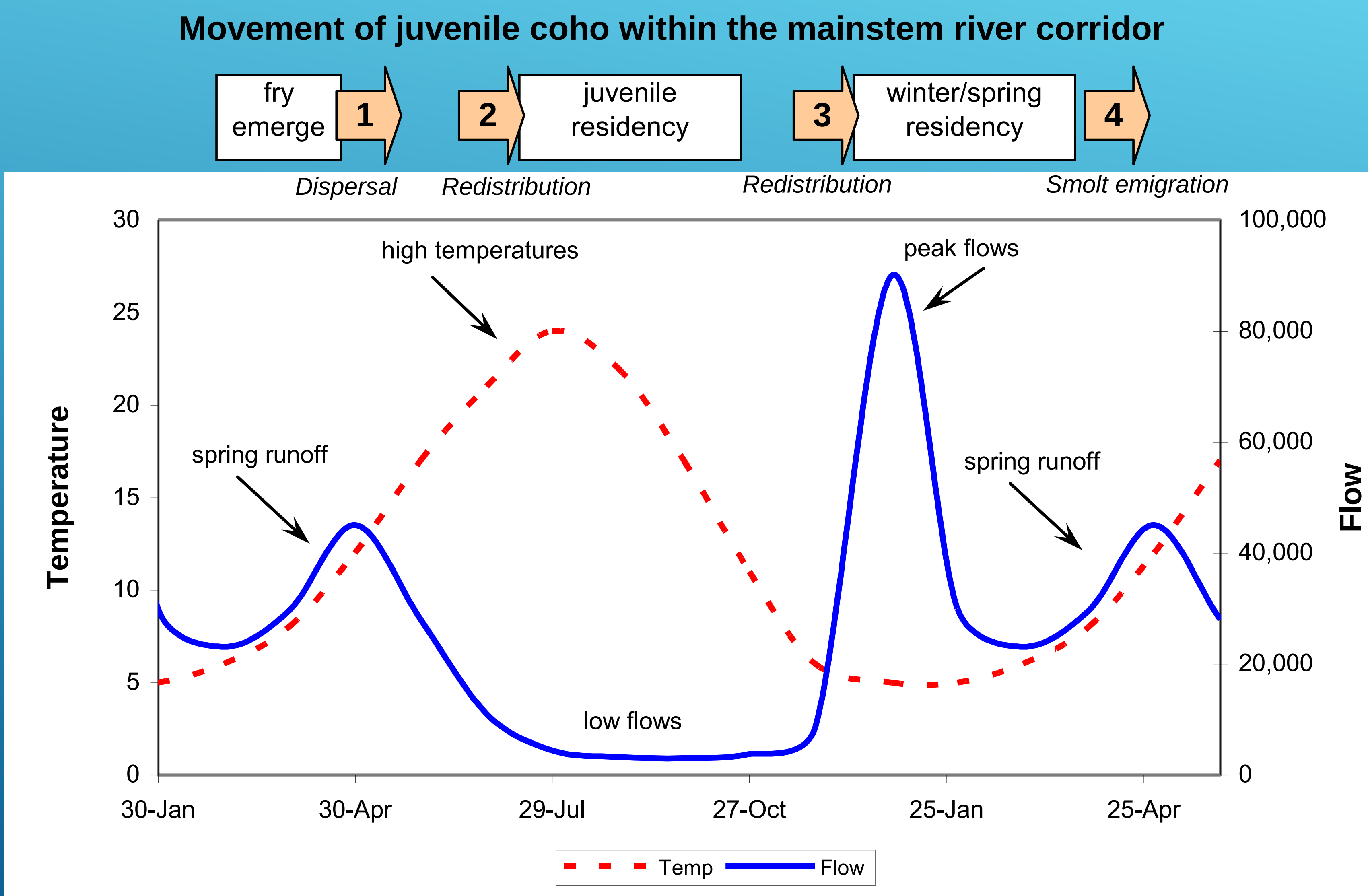
Life in the slow lane!

- Slow water velocities with suitable water temperatures

JUVENILE COHO LIFE HISTORY PATTERNS

- Early Summer Movements
- Late Fall Movements

Another theme: Seasonal redistributions



Simple Hypothesis: *If we build what Klamath River juvenile Coho are looking for will they use it?*

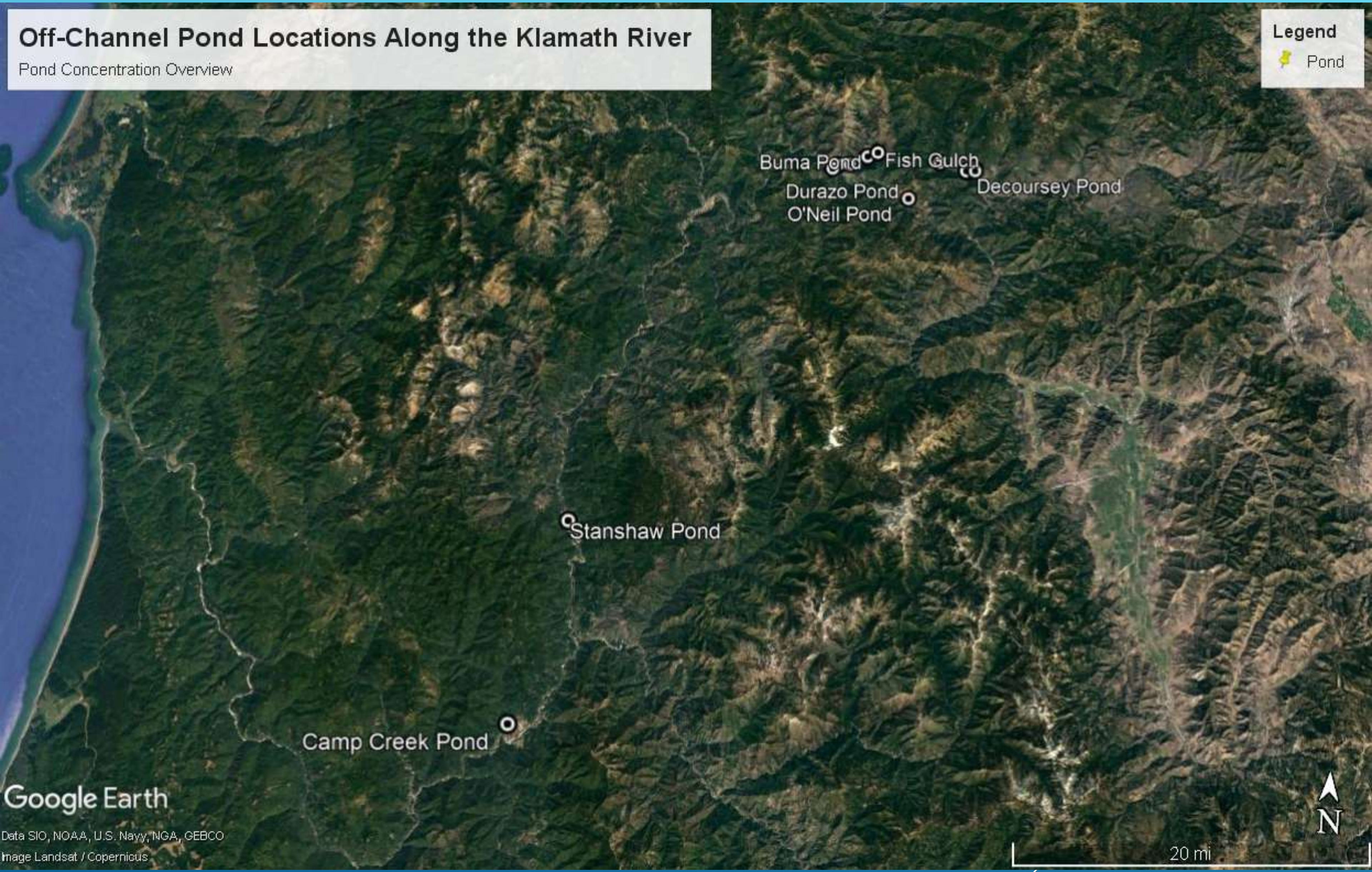
Habitat Projects-They range from simple off-channel ponds to complex floodplain restoration projects.

3-5 years

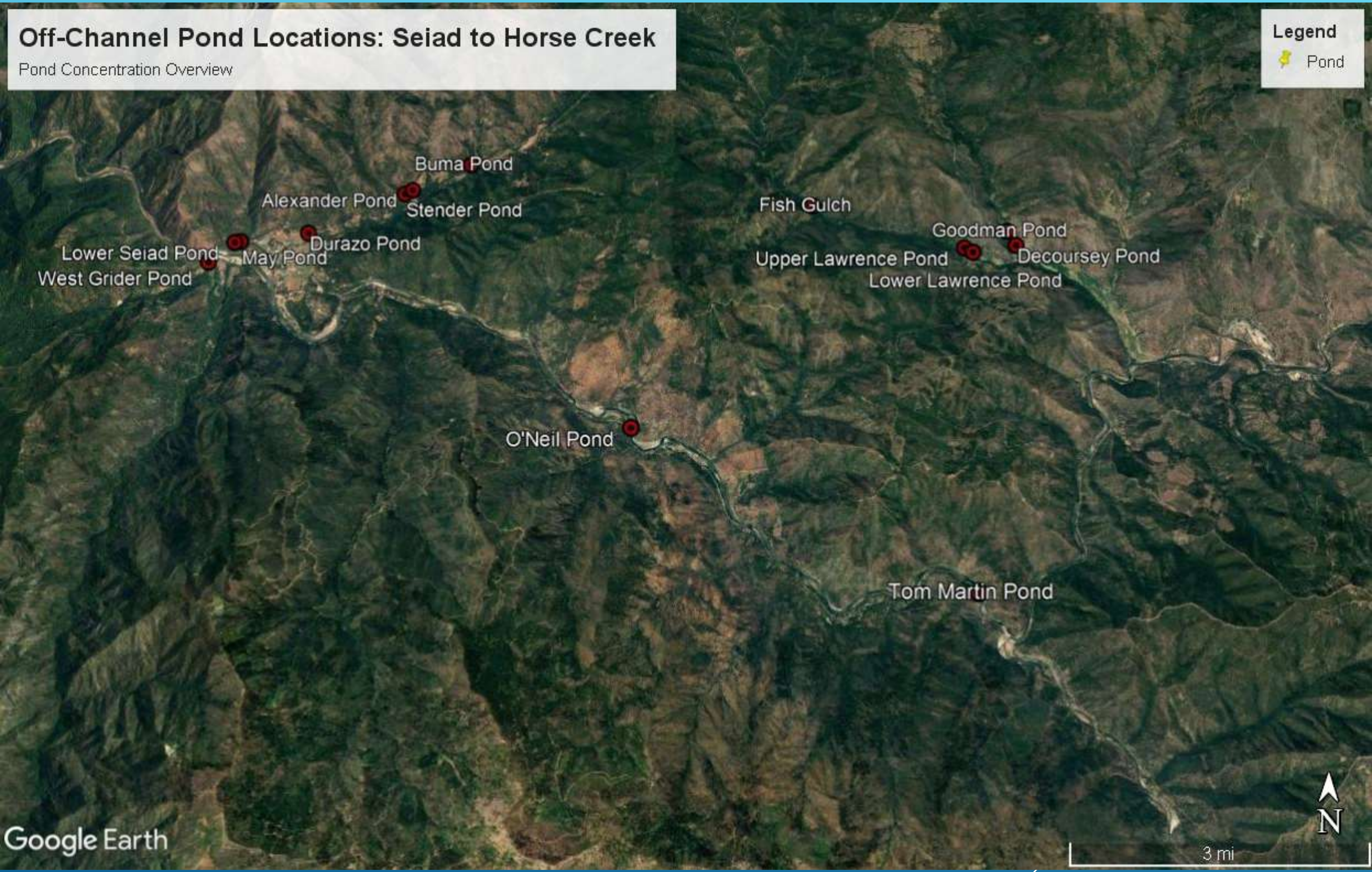
- Off-Channel Floodplain Ponds-15 built sites since 2010

5-10 years

- Seiad Creek Floodplain Restoration Project- 2008-2017



Off-Channel Pond Locations Along the Klamath River
Pond Concentration Overview
Legend
Pond
Buma Pond
Fish Gulch
Decoursey Pond
Durazo Pond
O'Neil Pond
Stanshaw Pond
Camp Creek Pond
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
N
20 mi

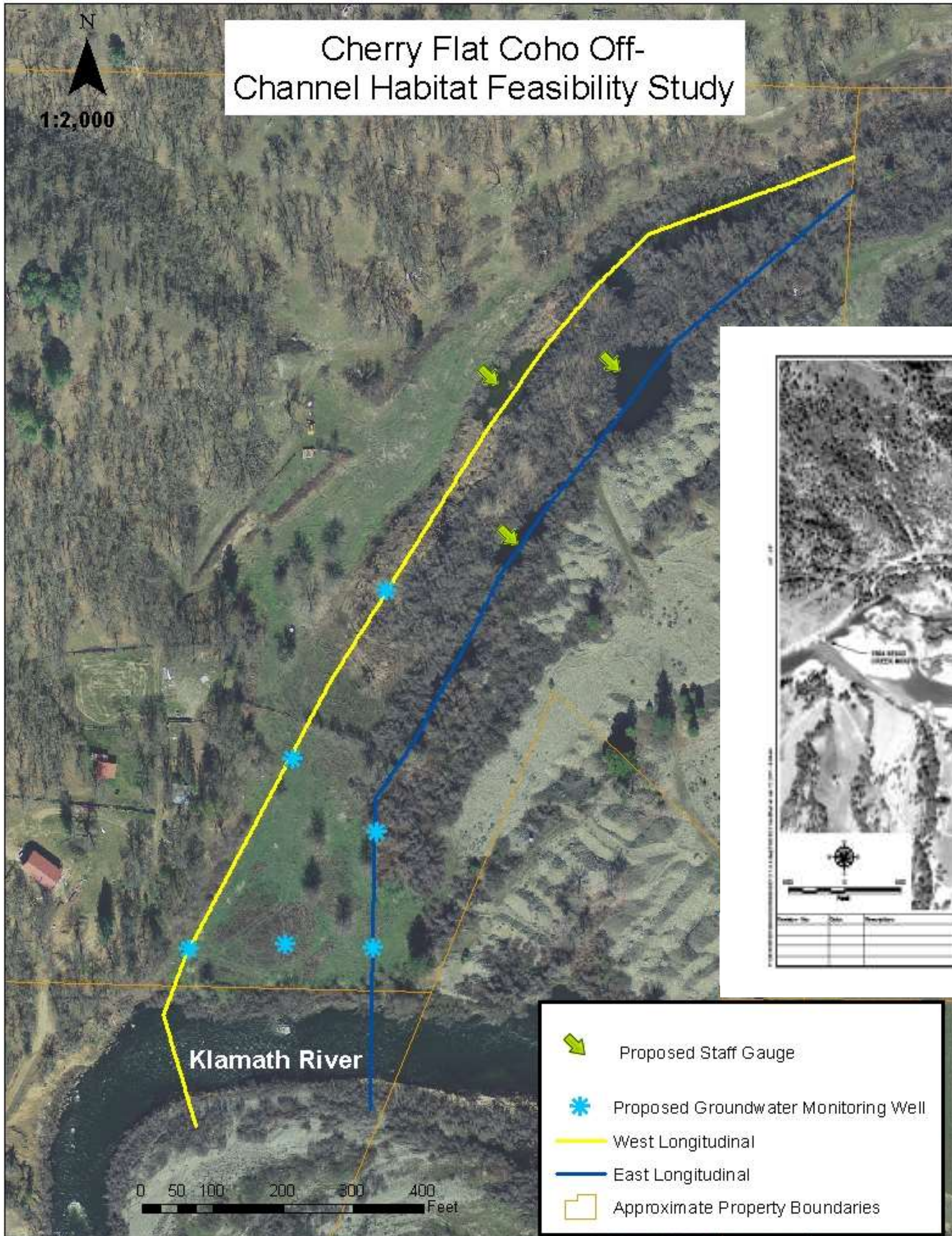


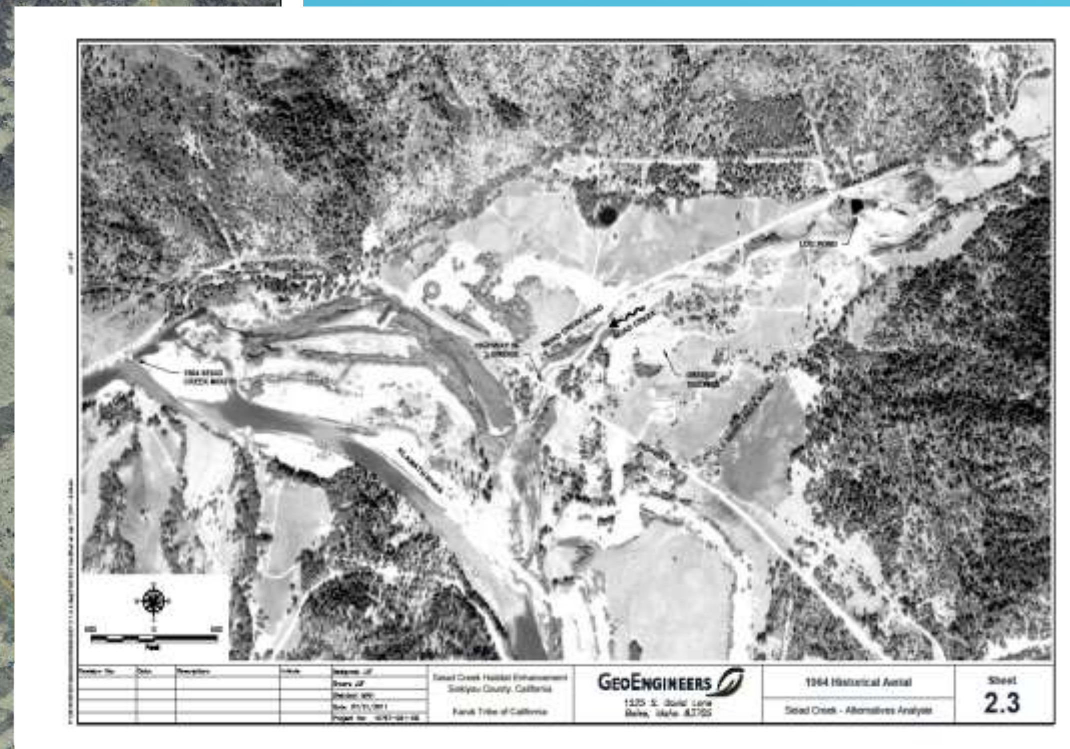
Off-Channel Pond Locations: Seiad to Horse Creek
Pond Concentration Overview
Legend
Pond
Buma Pond
Alexander Pond
Stender Pond
Durazo Pond
Lower Seiad Pond
May Pond
West Grider Pond
Fish Gulch
Goodman Pond
Upper Lawrence Pond
Decoursey Pond
Lower Lawrence Pond
O'Neil Pond
Tom Martin Pond
Google Earth
N
3 mi

BASIC QUESTIONS DURING PROJECT SITE SELECTION

- What's the landownership and can we get landowner cooperation?
- Where is the source of fish? Natal or non-natal fish?
- Fish movement patterns?
- Groundwater elevations? How do groundwater elevations compare to surface water elevation?
- Is groundwater perched above surface water?
- Season temperature?
- What is the terrain like?
- What are historical air photos telling us? What's flood history?

USING CURRENT AND HISTORICAL ARIAL IMAGINING TO SEARCH FOR SITES





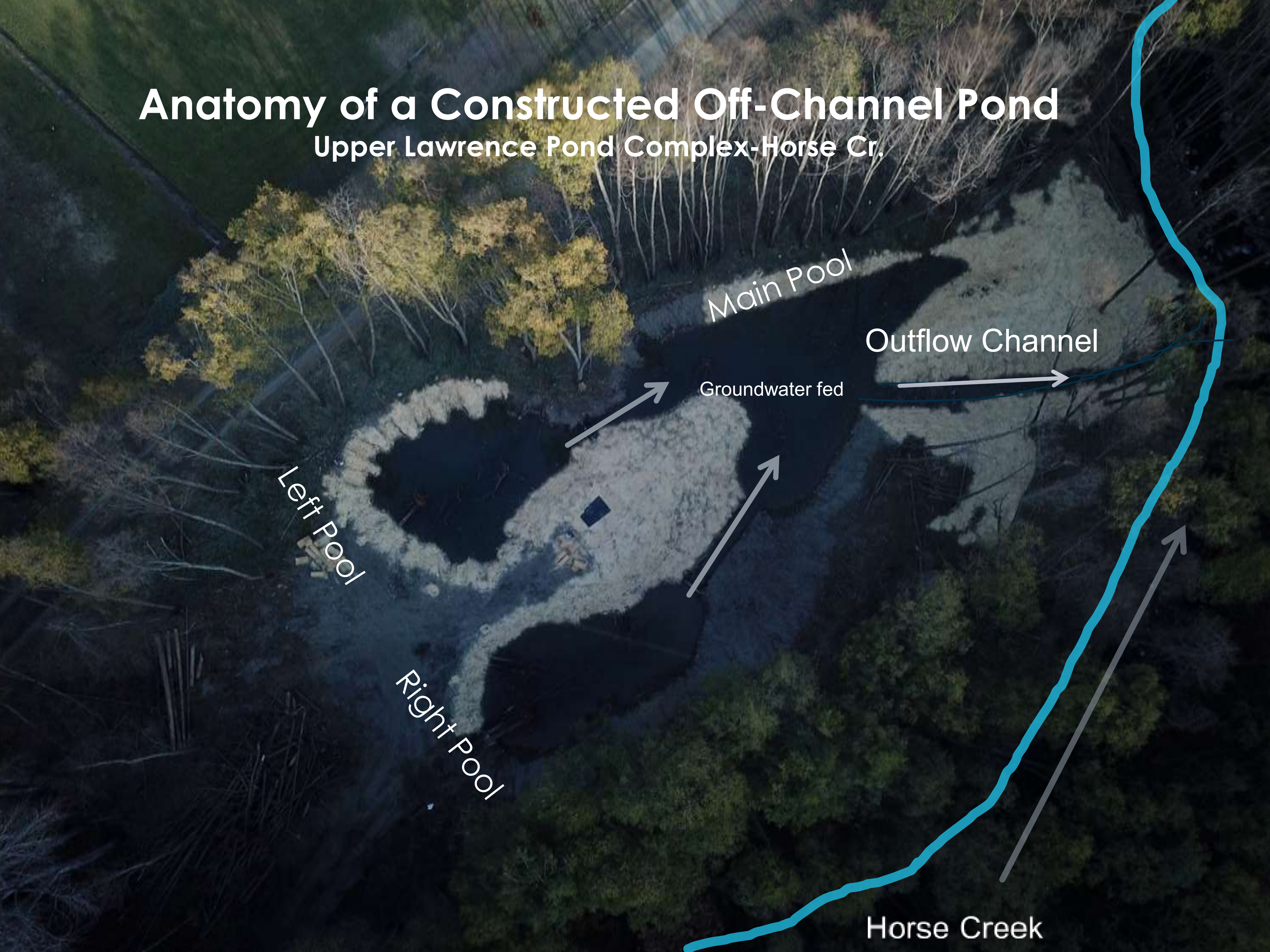
INSTALLING GROUNDWATER MONITORING WELLS WITHIN PROJECT SITE

GROUNDWATER ELEVATION MONITORING

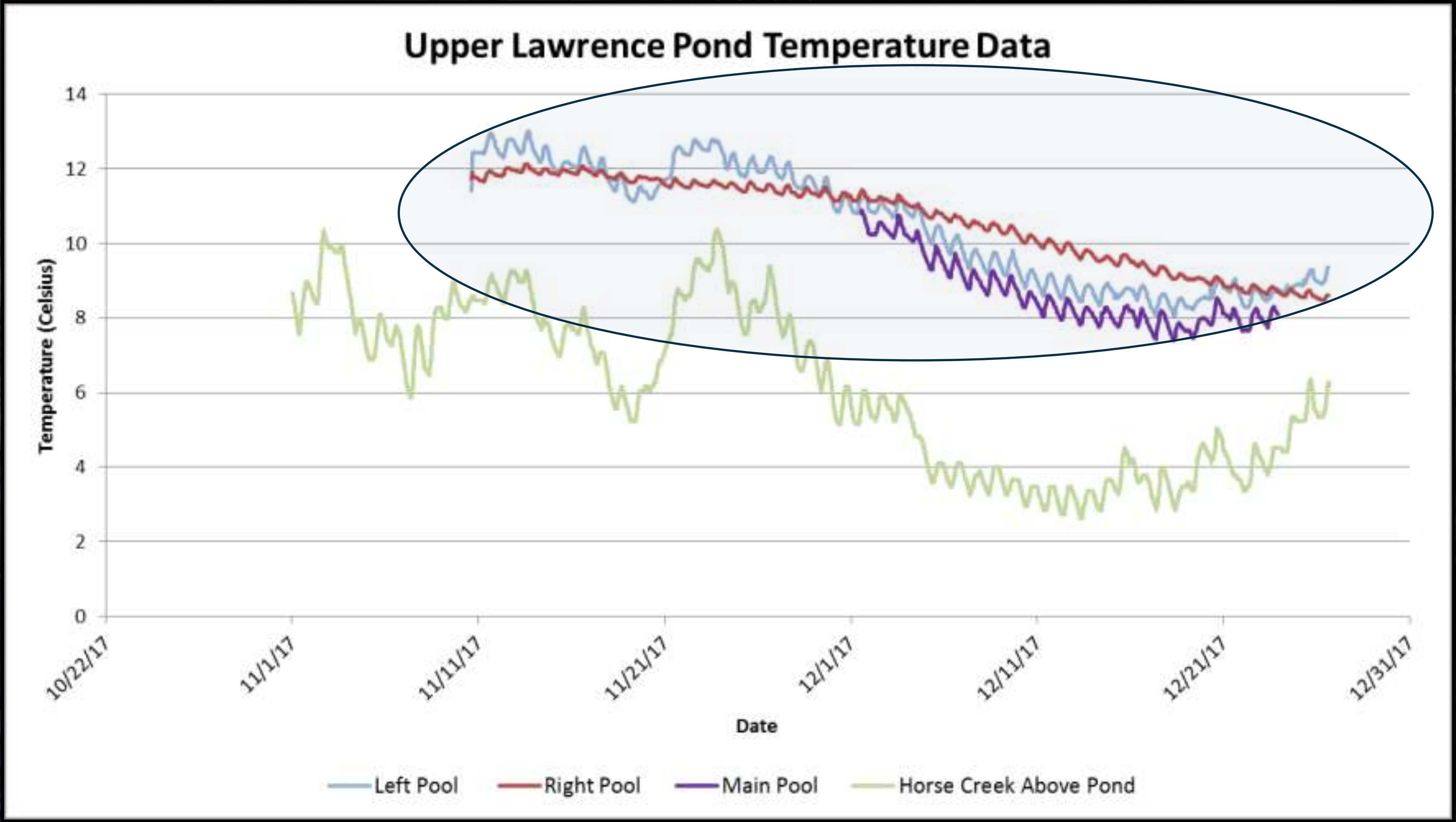
Groundwater Elevation Data

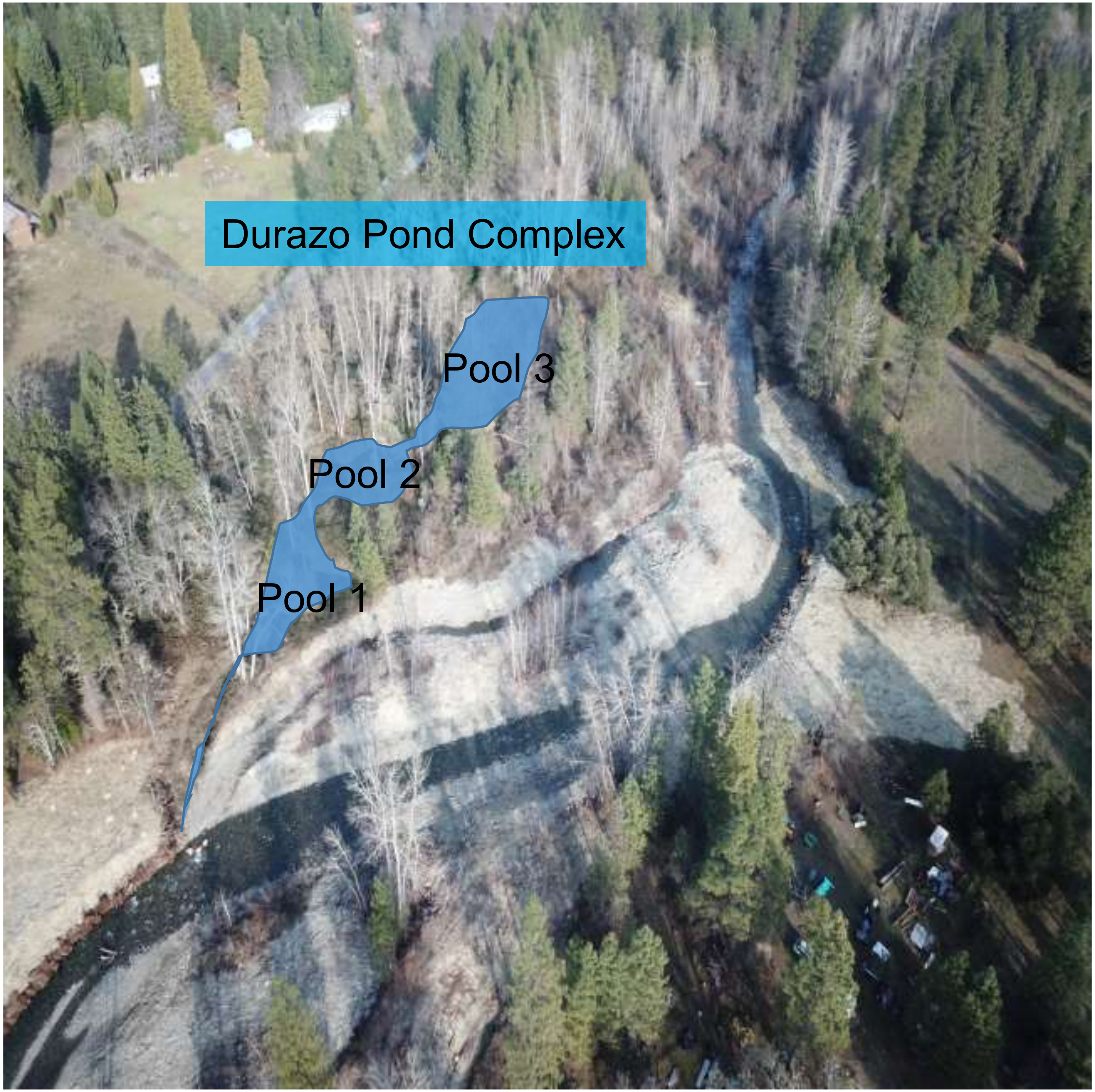
Topographic Surveys- Detailed Cross Sectional and Longitudinal Surveys of Project Sites


UPPER LAWRENCE POND COMPLEX- FALL 2017

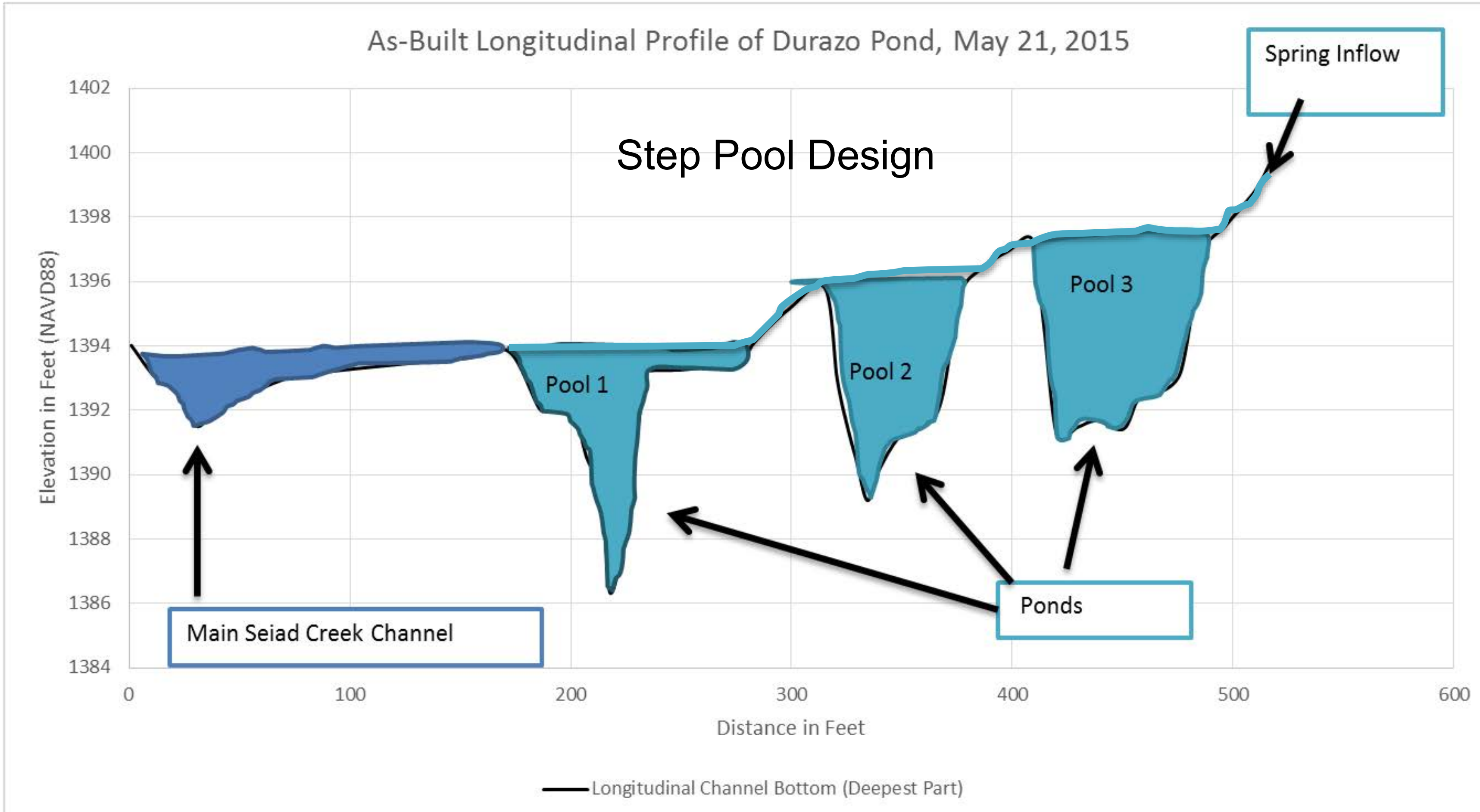

Anatomy of a Constructed Off-Channel Pond
Upper Lawrence Pond Complex-Horse Cr.
Main Pool
Outflow Channel
Groundwater fed
Left Pool
Right Pool
Horse Creek

WARMER WINTER TEMPERATURES INDICATE STRONG GROUND WATER INPUT




Durazo Pond Complex
Pool 3
Pool 2
Pool 1

Durazo Pond Complex




We take lots site photos

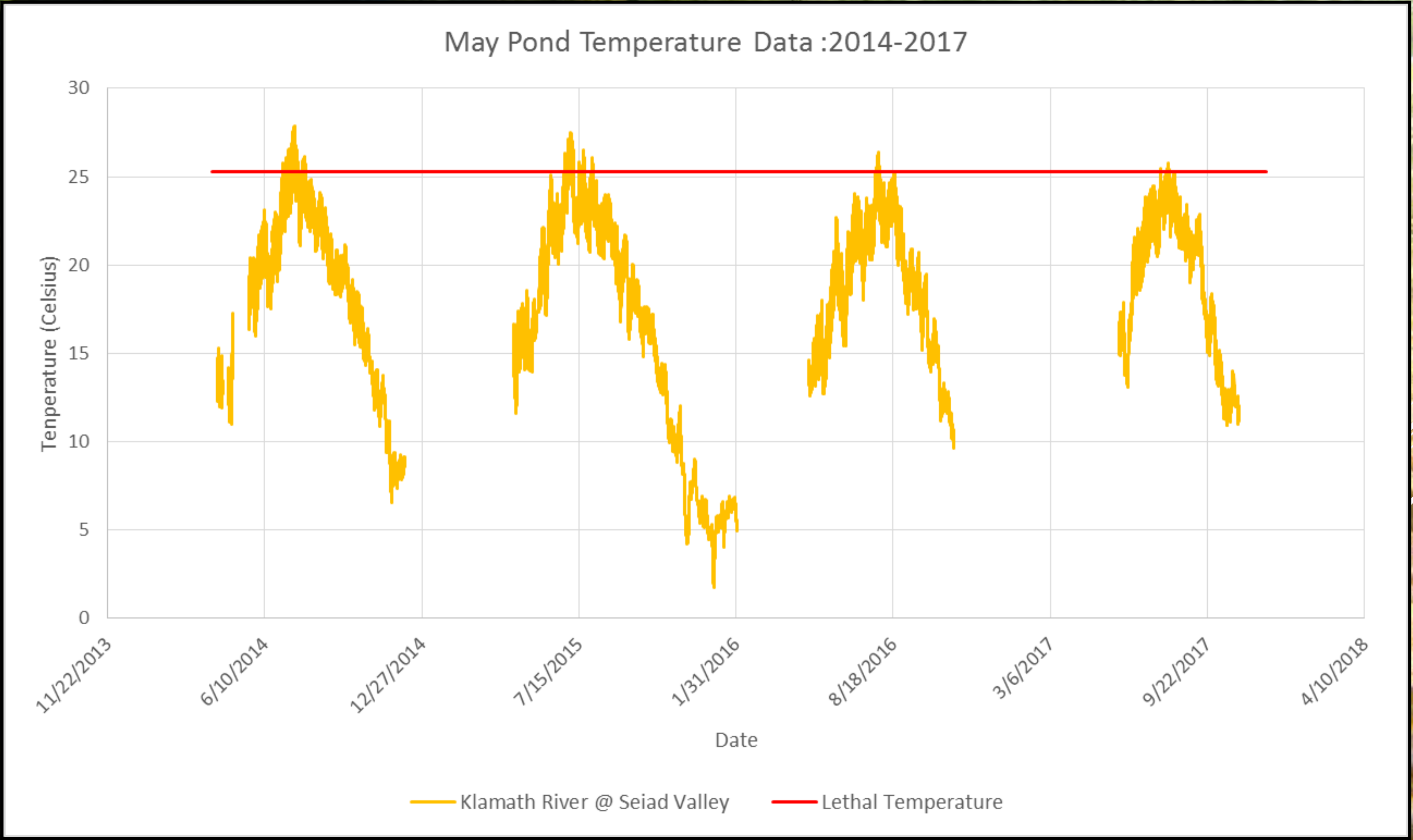
PROJECT MONITORING

- Water Quality (temperature, dissolved oxygen)
- Water elevations (surface water elevation, groundwater elevation)
- Population estimates
- Fish movement patterns (PIT tag arrays)
- Habitat Connectivity/Fish passage conditions
- Coho performance (growth, residency and survival)
- Vegetation recruitment (riparian density, aquatic vegetation)
- Invasive species presence/absence
- Site bathometry (pool depth)

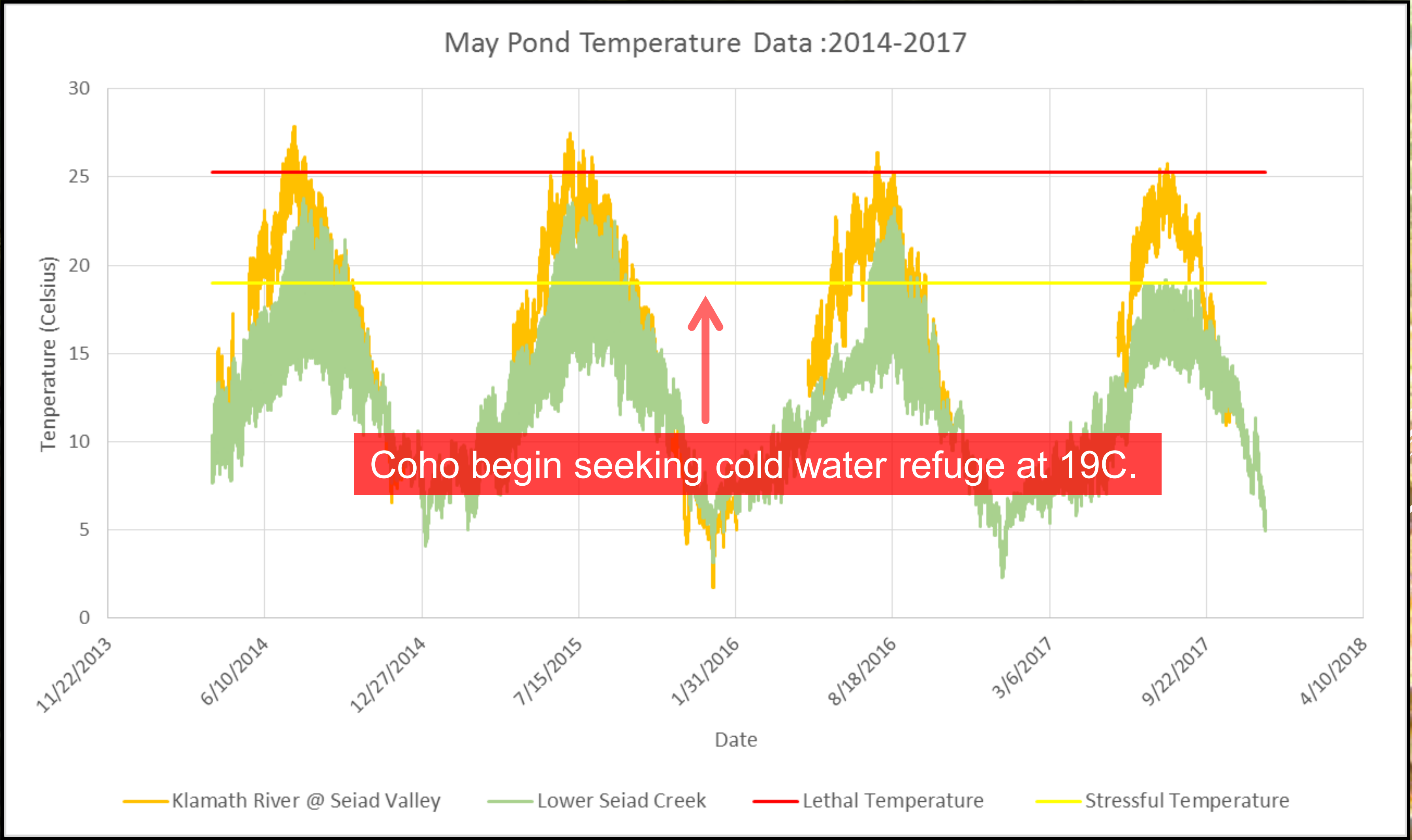
MONITORING RESULTS: WHAT IS THE WATER TELLING US?

WATER MONITORING

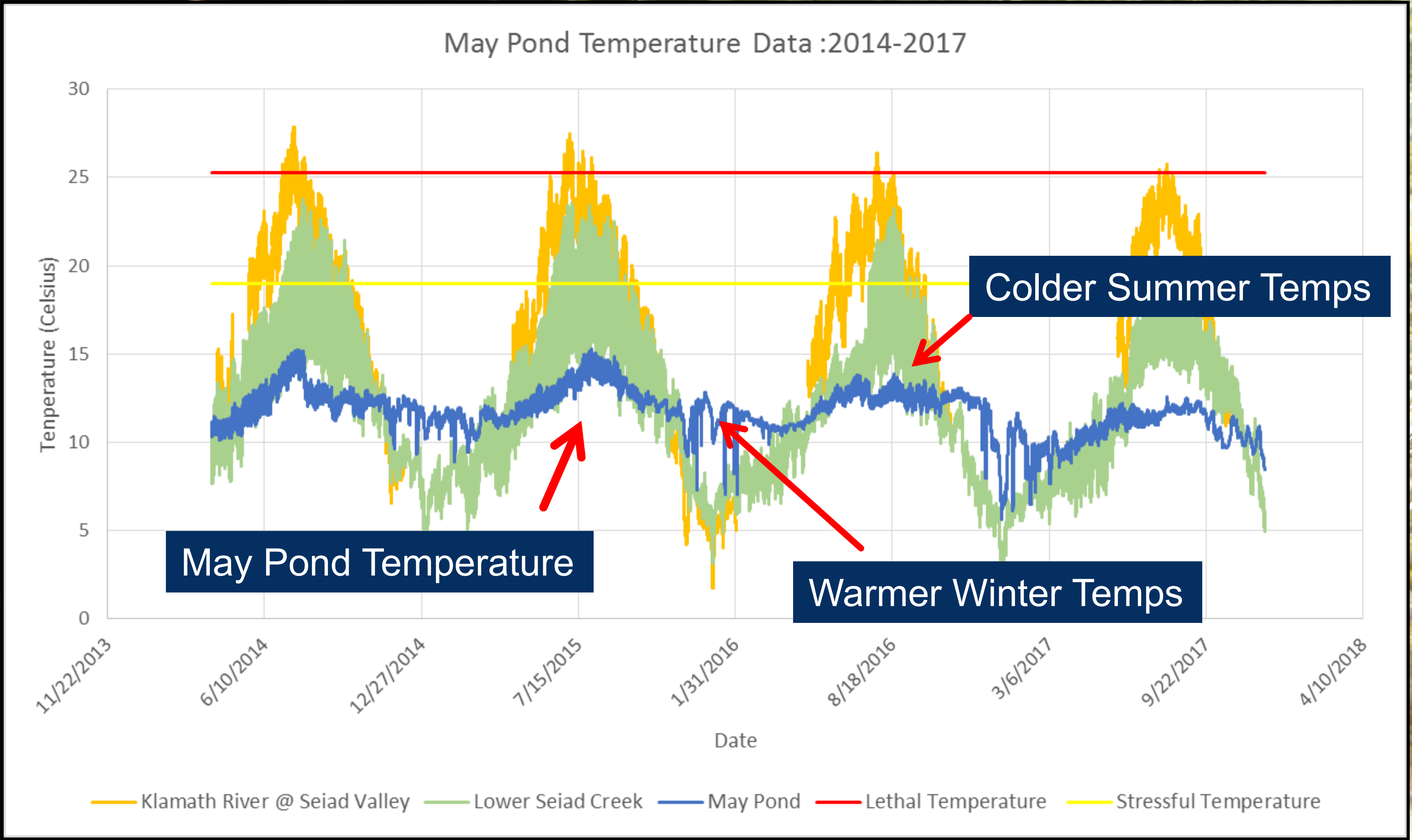
Mainstem Klamath Summer Temperatures



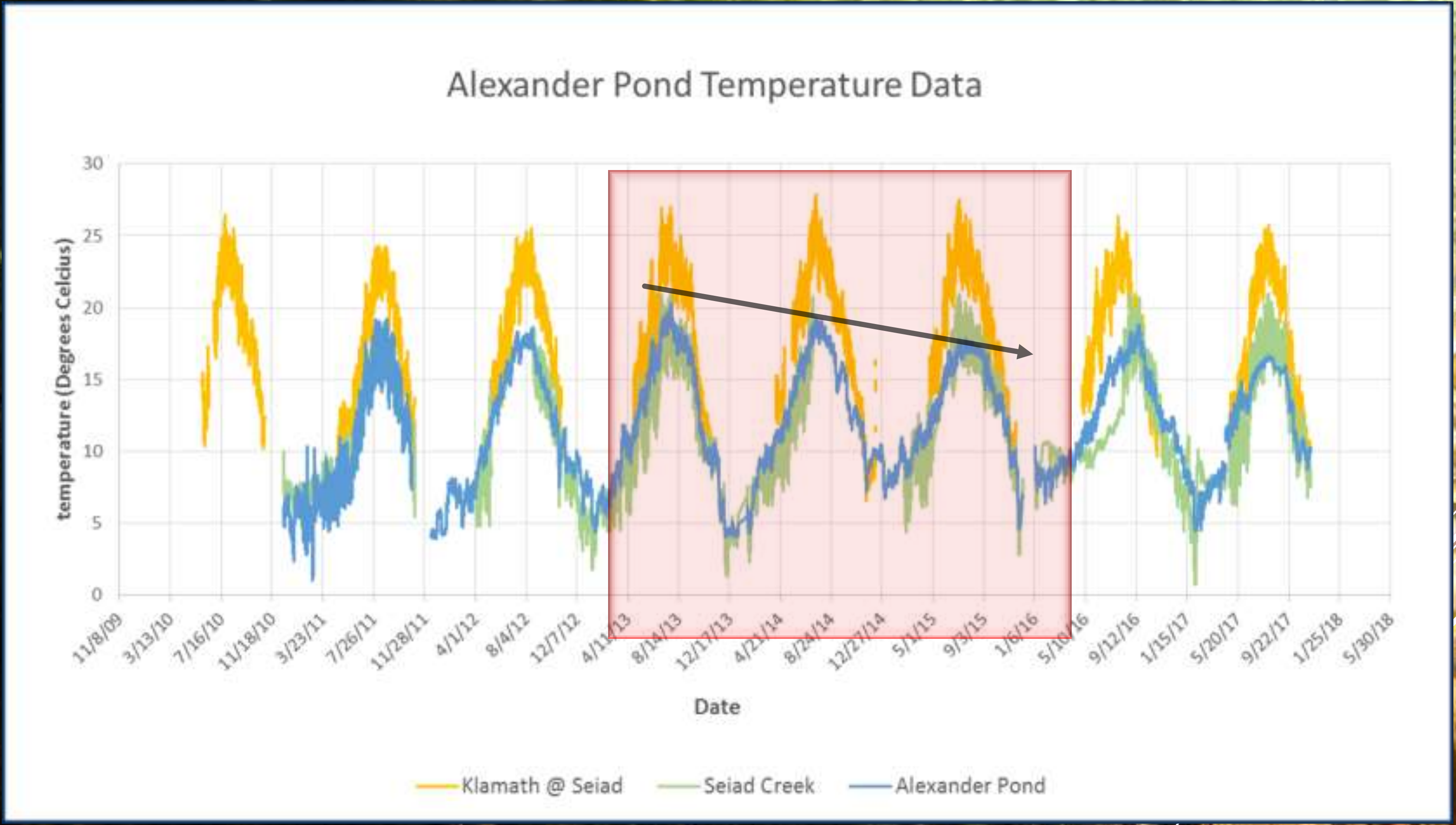
Lower Seiad Creek & Mainstem Klamath Summer Temperature

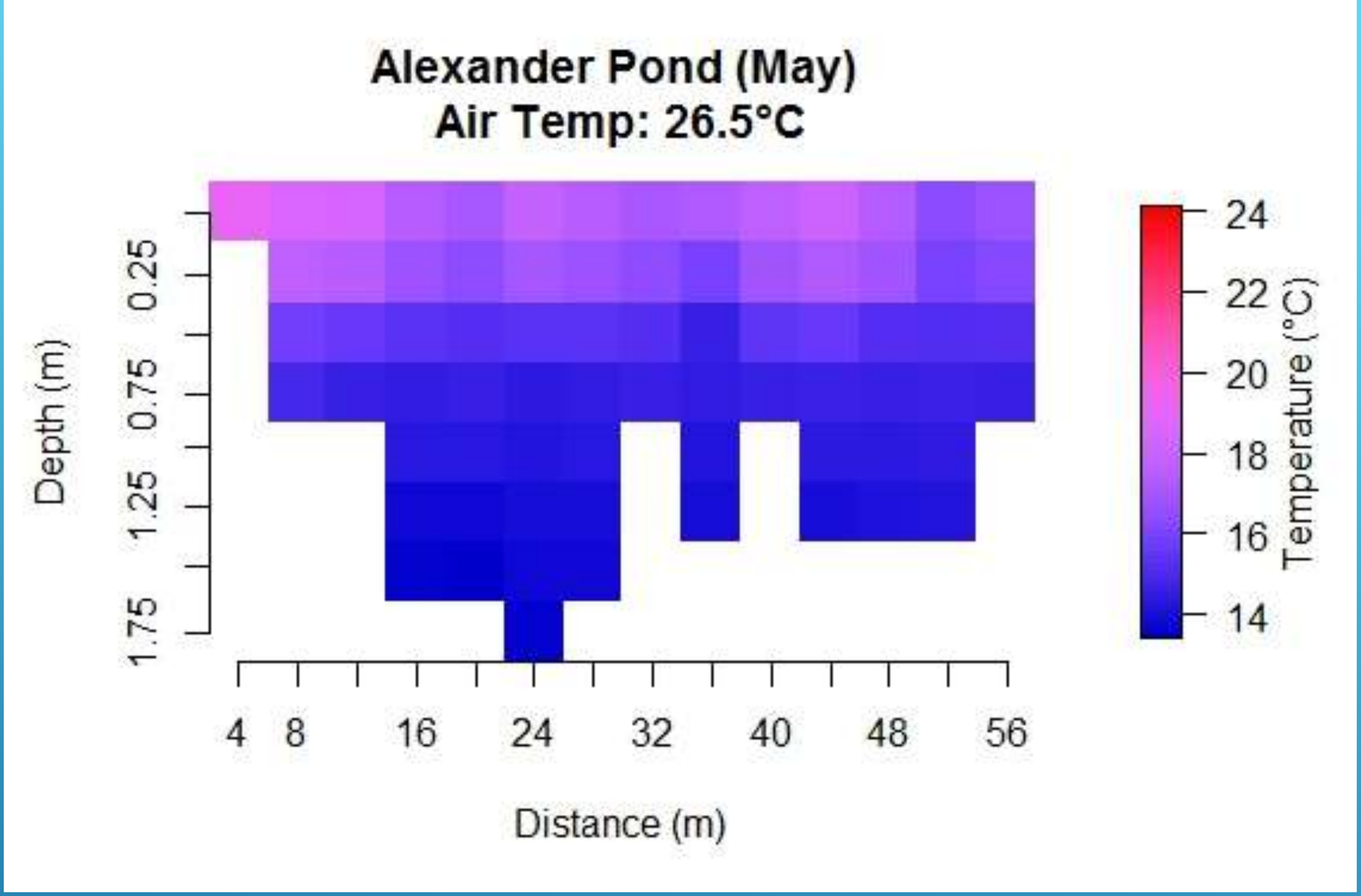


Klamath River vs Seiad Creek vs May Pond



SEVERE DROUGHT CONDITIONS 2014-2015

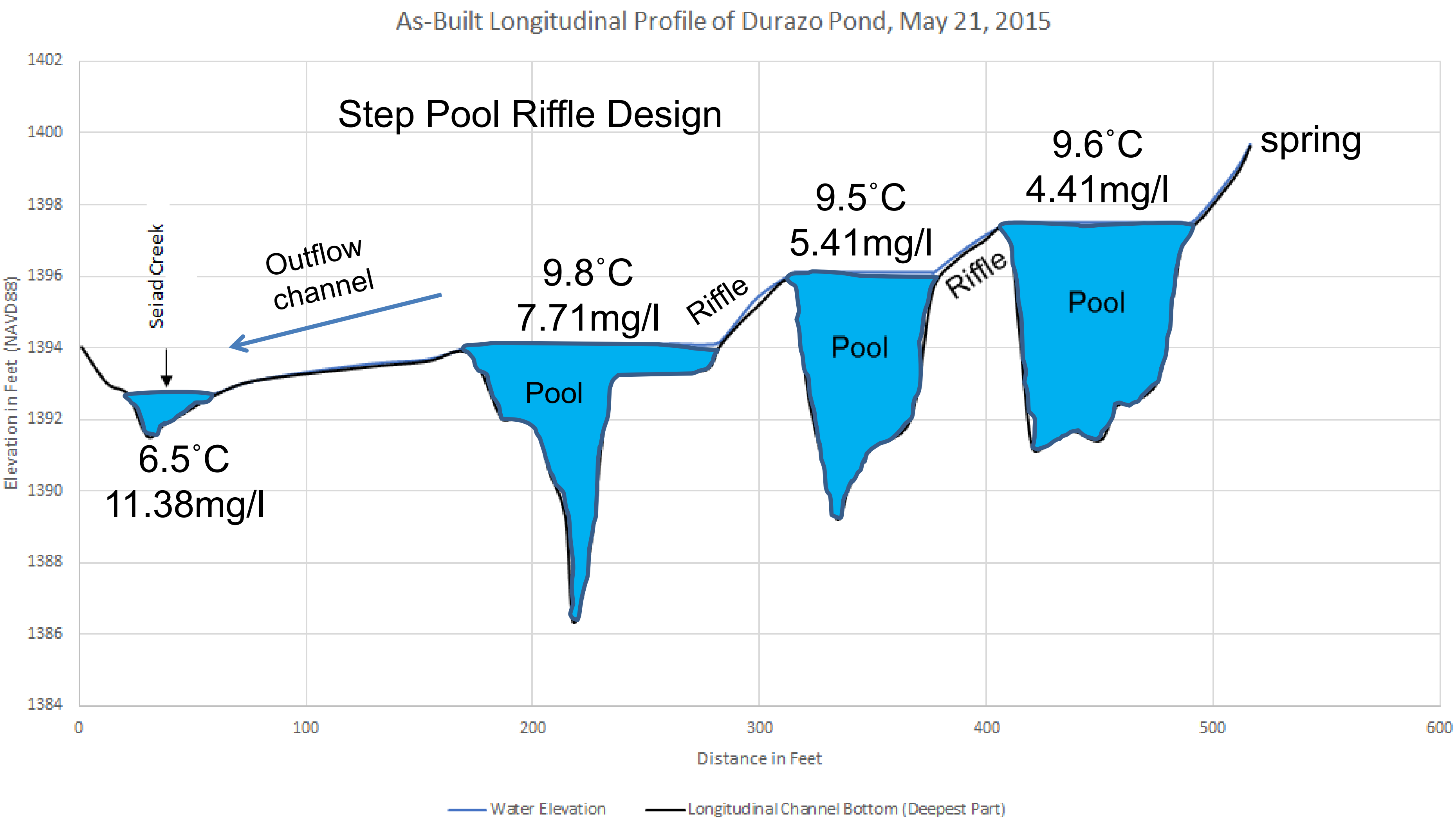


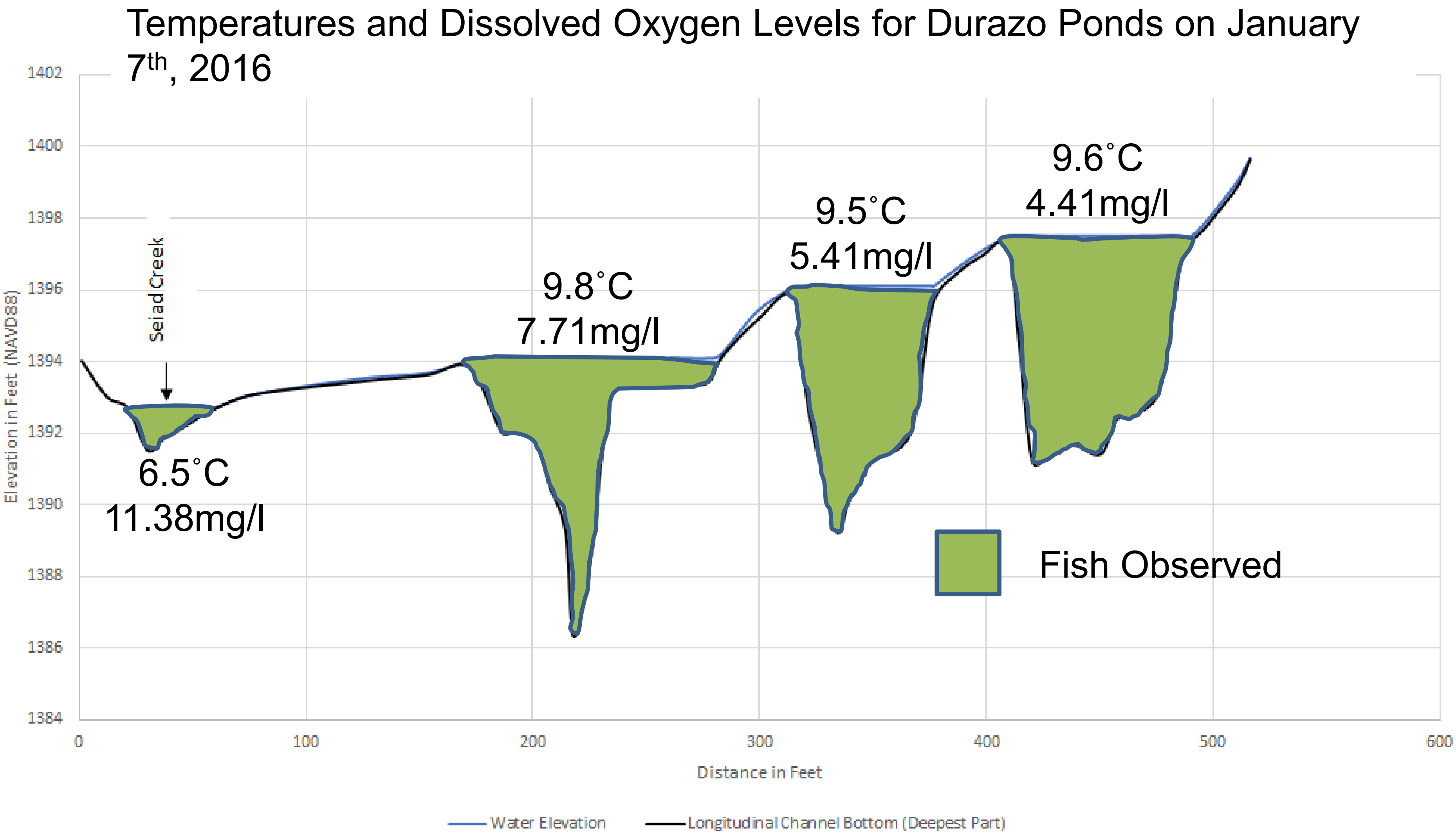


POND TEMPERATURE AND DEPTH PROFILE

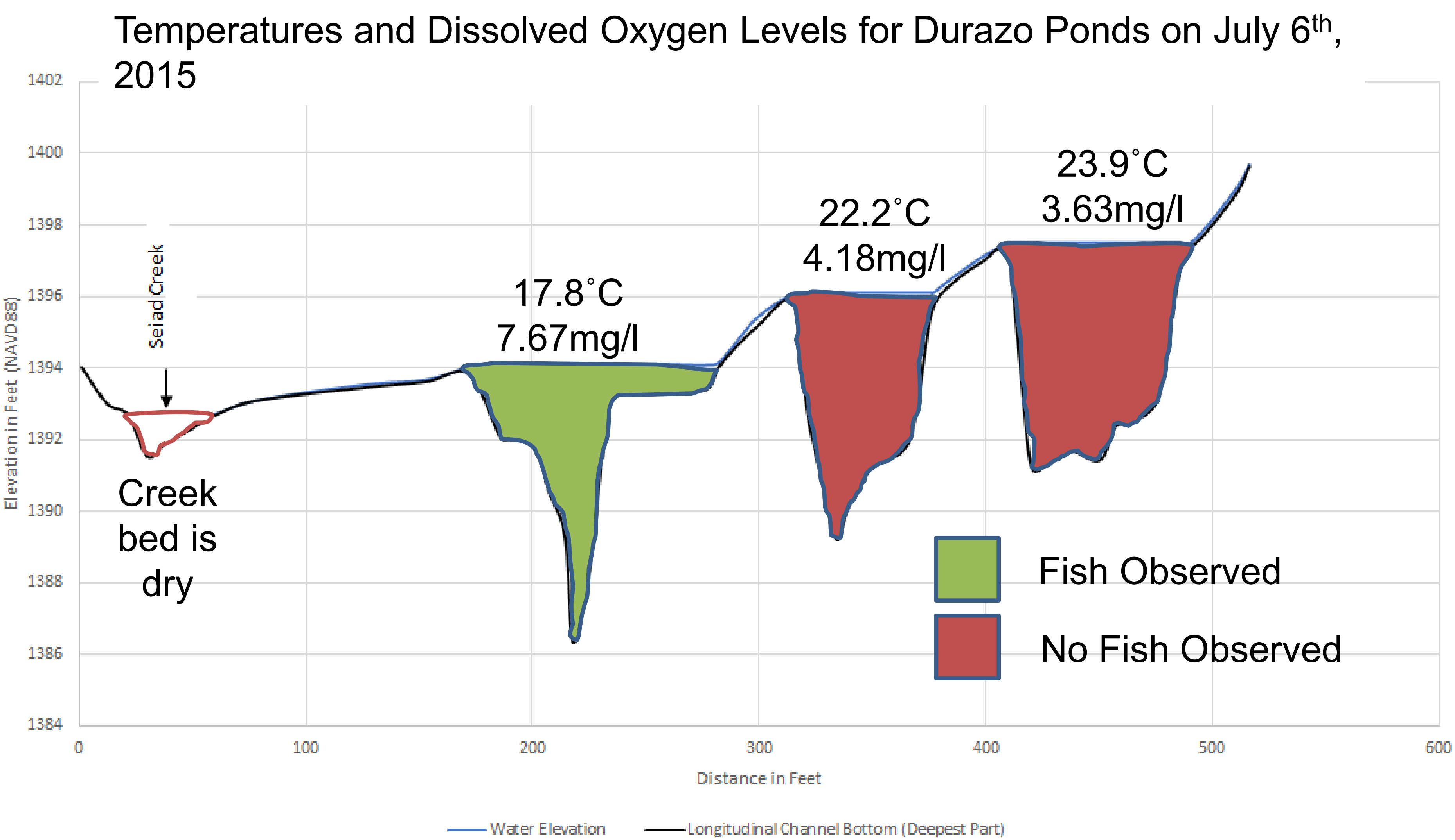
Data: Michelle Krall

Temperatures and Dissolved Oxygen Levels During Winter





Temperatures and Dissolved Oxygen Levels for Durazo Ponds on January 7th, 2016
1402
1400
1398
1396
1394
1392
1390
1388
1386
1384
Elevation in Feet (NAVD88)
Seiad Creek
6.5˚C
11.38mg/l
9.8˚C
7.71mg/l
9.5˚C
5.41mg/l
9.6˚C
4.41mg/l
Fish Observed
0
100
200
300
400
500
600
Distance in Feet
Water Elevation
Longitudinal Channel Bottom (Deepest Part)



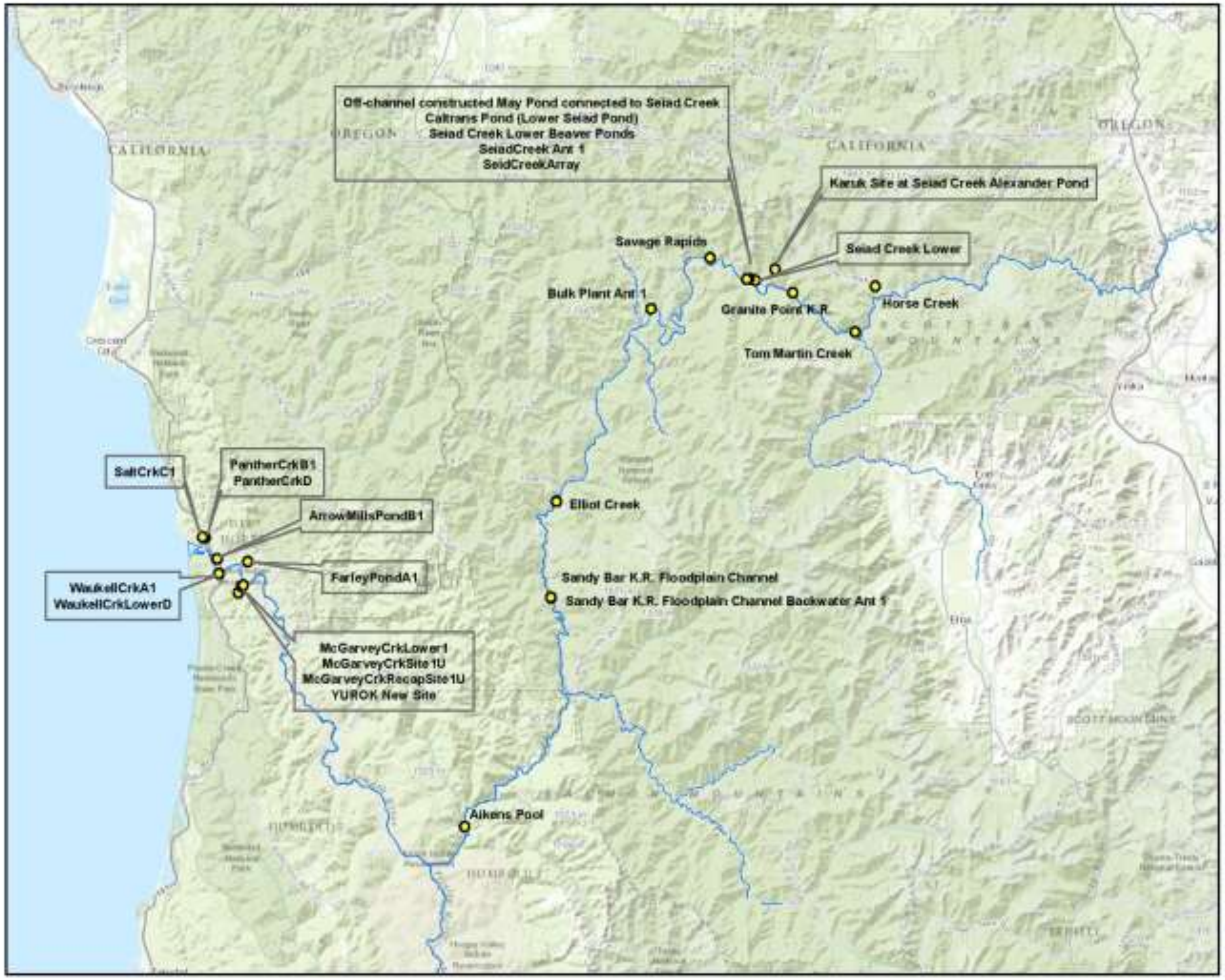
Temperatures and Dissolved Oxygen Levels for Durazo Ponds on July 6th, 2015
Elevation in Feet (NAVD88)
1402
1400
1398
1396
1394
1392
1390
1388
1386
1384
Seiad Creek
Creek bed is dry
17.8˚C
7.67mg/l
22.2˚C
4.18mg/l
23.9˚C
3.63mg/l
Fish Observed
No Fish Observed
0
100
200
300
400
500
600
Distance in Feet
Water Elevation
Longitudinal Channel Bottom (Deepest Part)

MONITORING RESULTS: WHAT ARE THE FISH TELLING US?

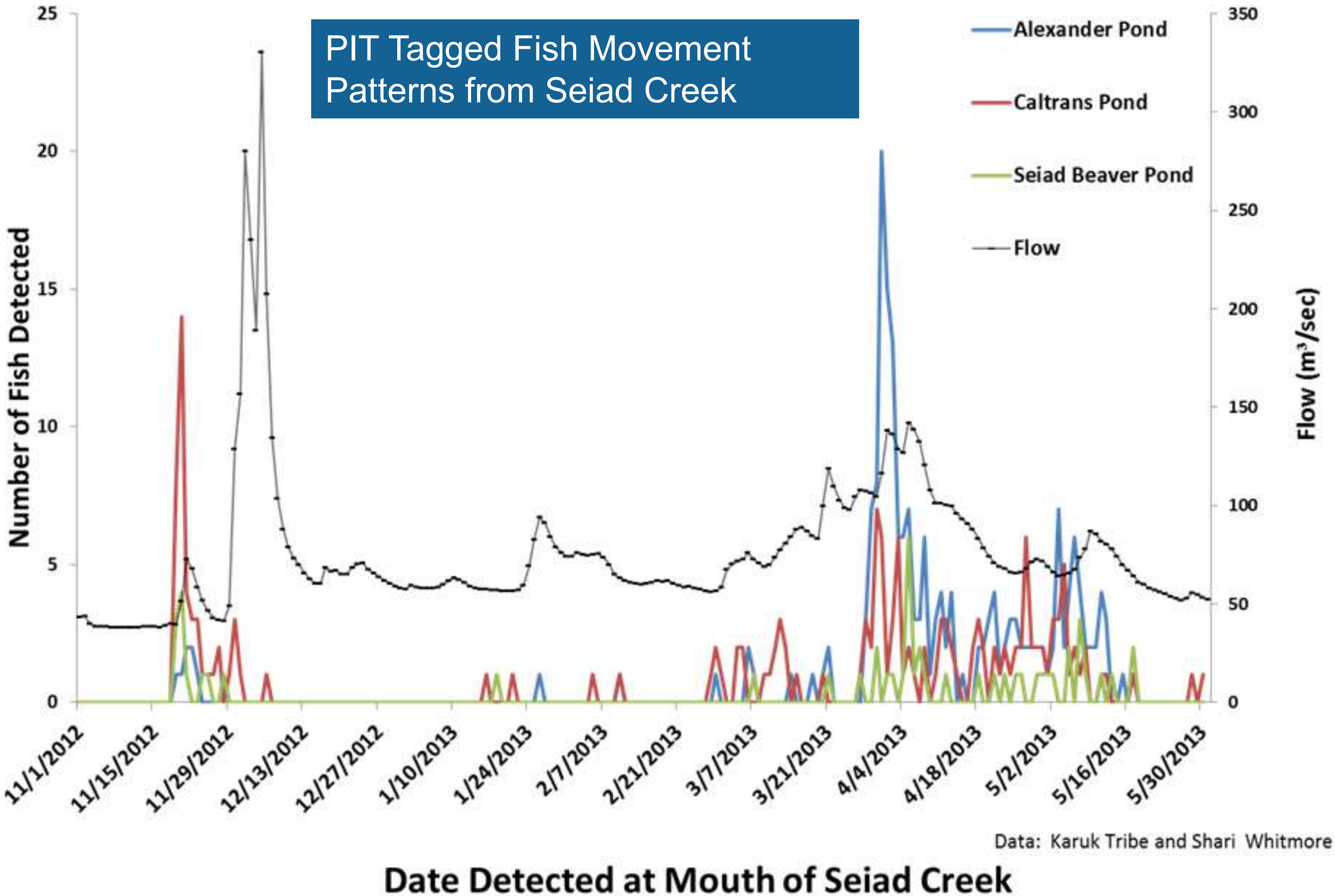
JUVENILE COHO MOVEMENT

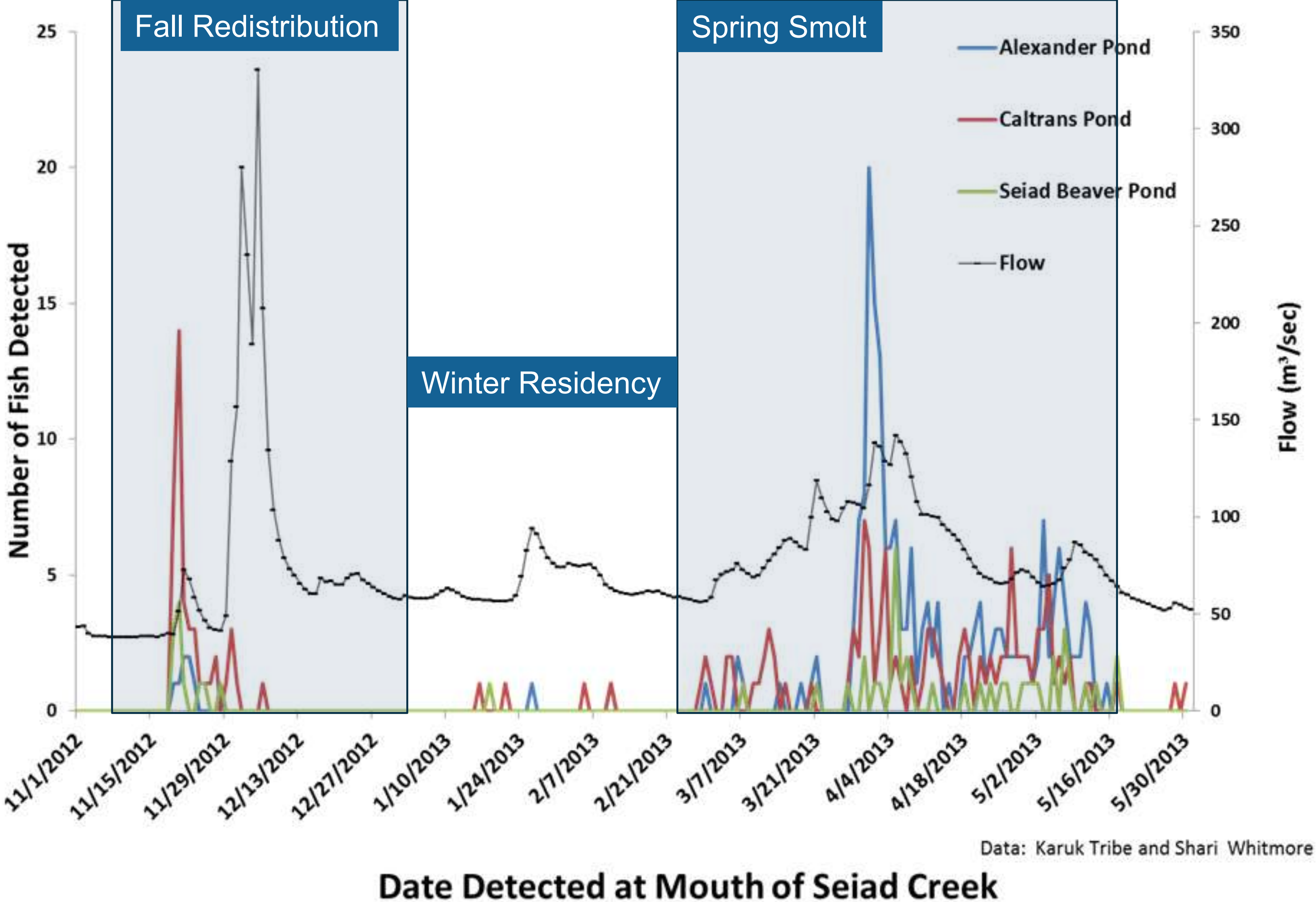
REMOTE PIT TAG DETECTION SYSTEMS

MOVEMENT OF PIT TAGGED FISH IS BASIN WIDE

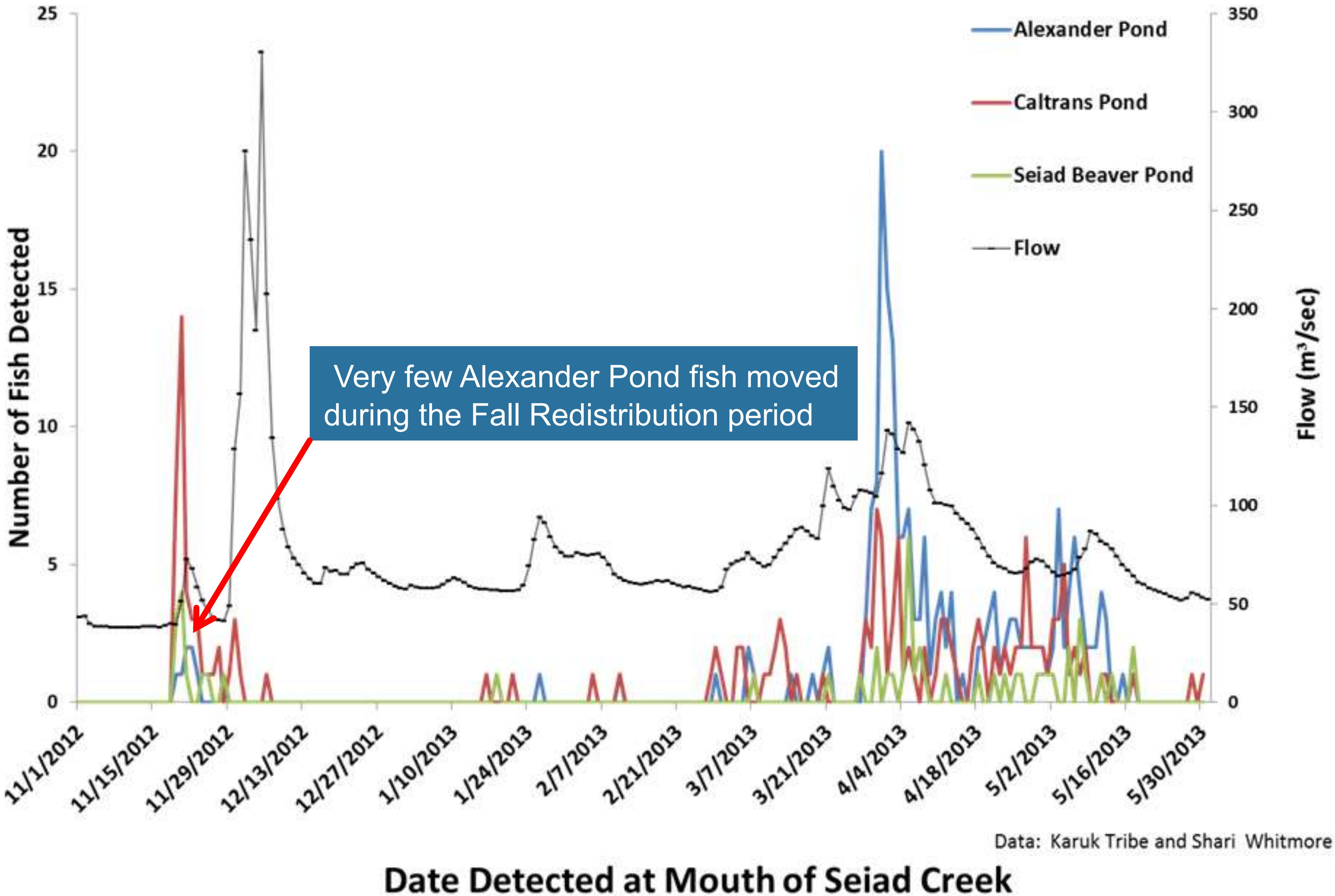


PIT Tagged Fish Movement Patterns from Seiad Creek



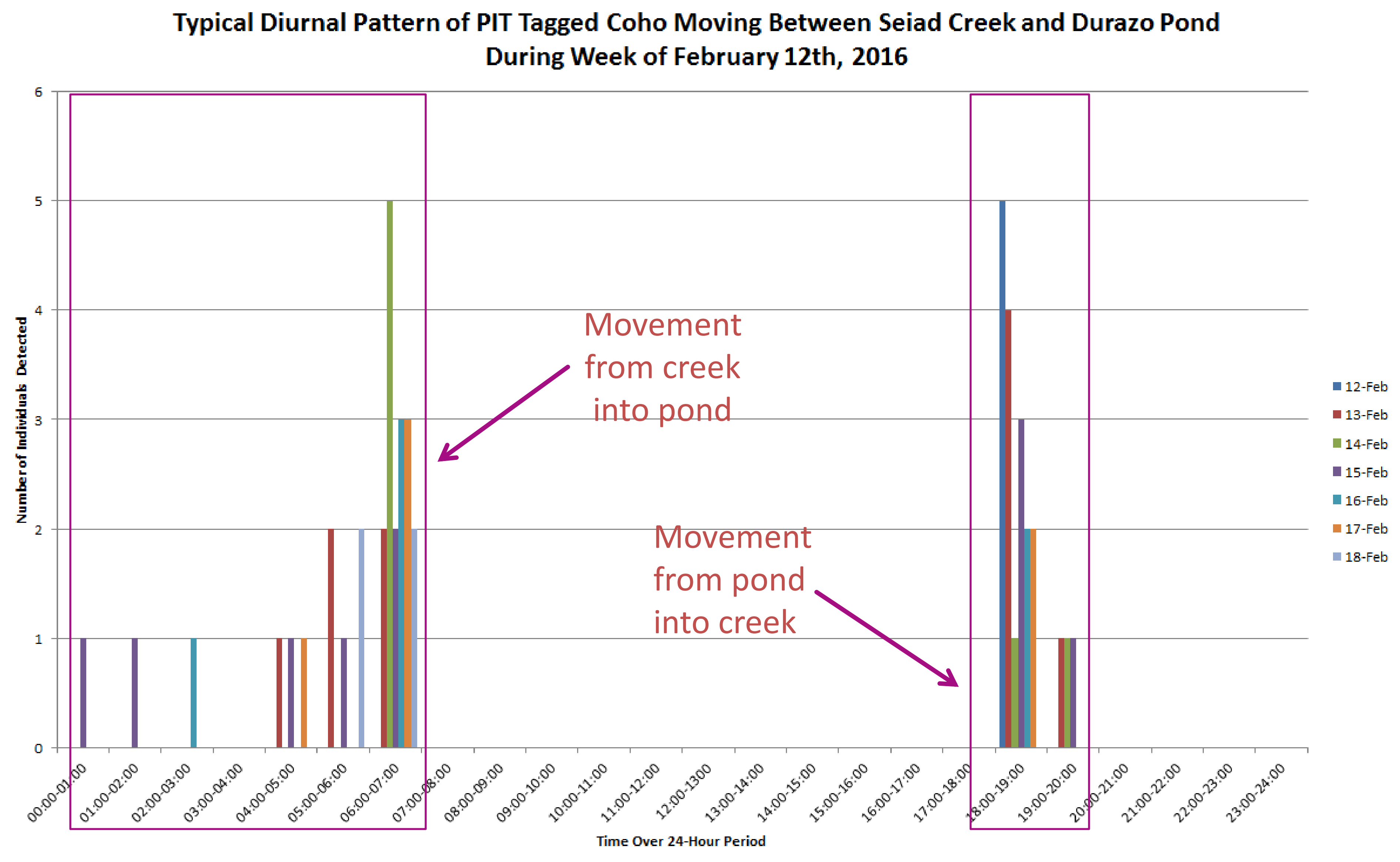


Fall Redistribution
Winter Residency
Spring Smolt
Alexander Pond
Caltrans Pond
Seiad Beaver Pond
Flow
Number of Fish Detected
Flow (m³/sec)
25
20
15
10
5
0
350
300
250
200
150
100
50
0
11/1/2012
11/15/2012
11/29/2012
12/13/2012
12/27/2012
1/10/2013
1/24/2013
2/7/2013
2/21/2013
3/7/2013
3/21/2013
4/4/2013
4/18/2013
5/2/2013
5/16/2013
5/30/2013
Data: Karuk Tribe and Shari Whitmore
Date Detected at Mouth of Seiad Creek



Very few Alexander Pond fish moved during the Fall Redistribution period
Alexander Pond
Caltrans Pond
Seiad Beaver Pond
Flow
Number of Fish Detected
Flow (m³/sec)
Date Detected at Mouth of Seiad Creek
Data: Karuk Tribe and Shari Whitmore
0
5
10
15
20
25
50
100
150
200
250
300
350
11/1/2012
11/15/2012
11/29/2012
12/13/2012
12/27/2012
1/10/2013
1/24/2013
2/7/2013
2/21/2013
3/7/2013
3/21/2013
4/4/2013
4/18/2013
5/2/2013
5/16/2013
5/30/2013

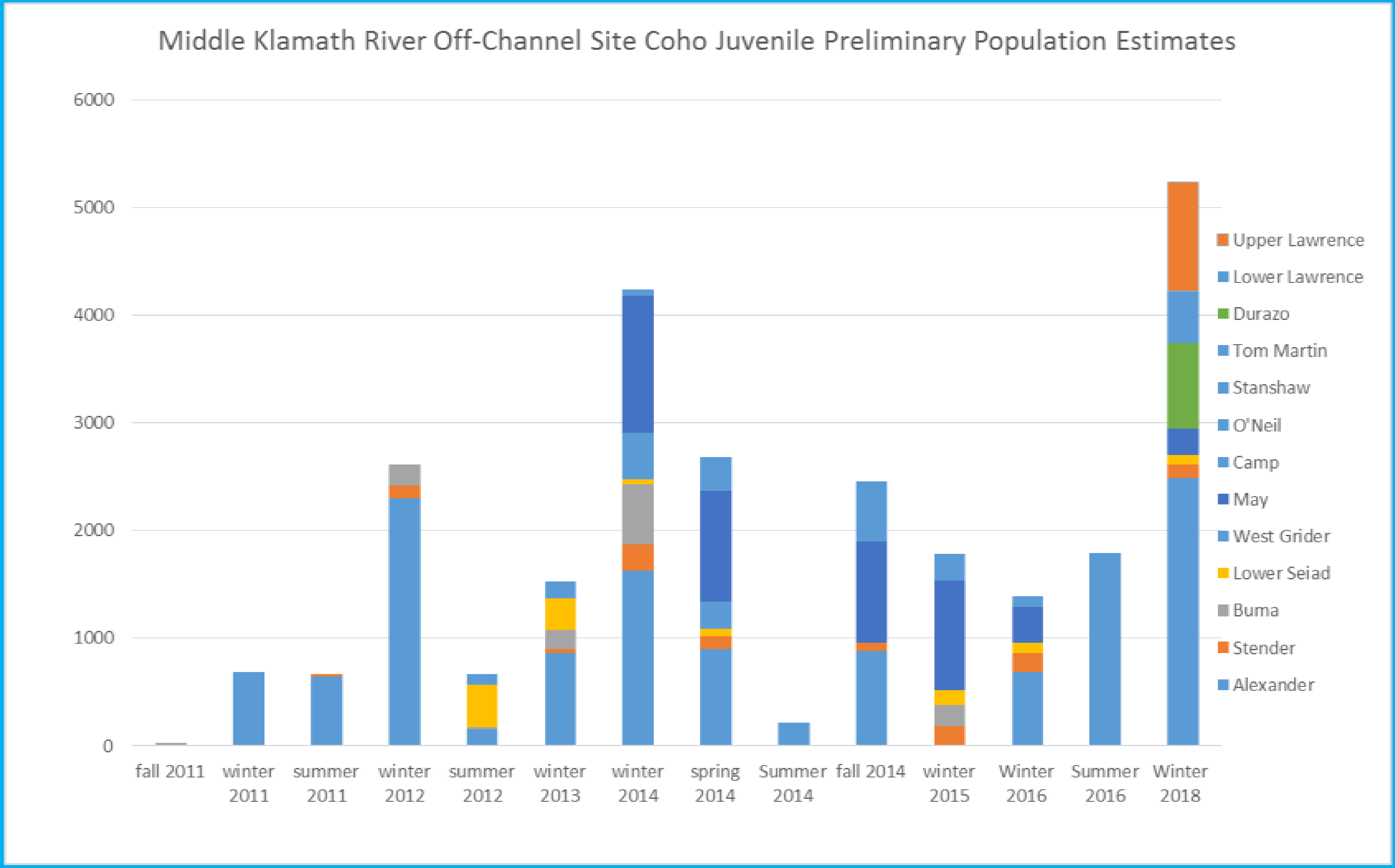
Diurnal Movement



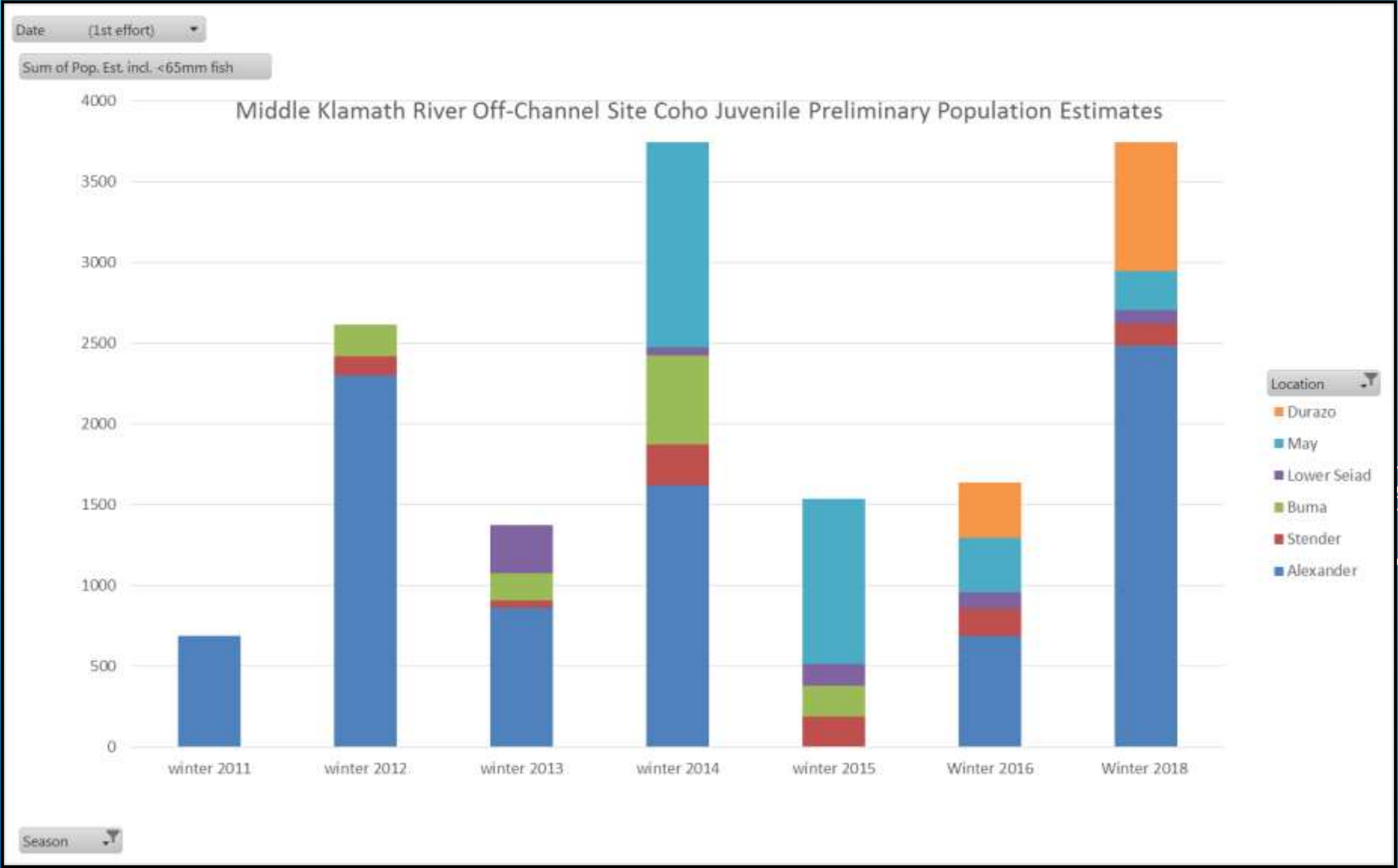
MONITORING RESULTS: WHAT ARE THE FISH TELLING US?

POPULATION ESTIMATES

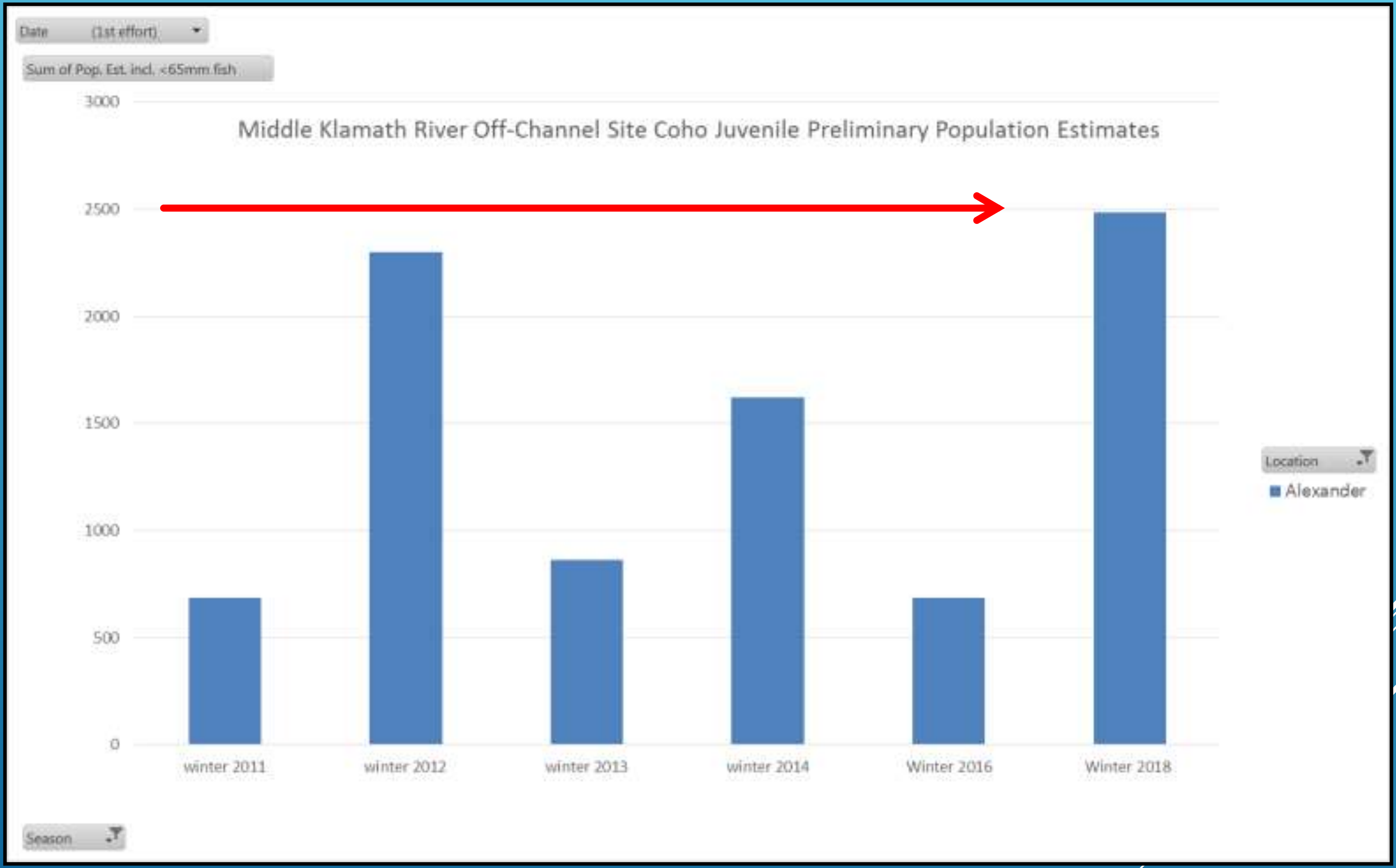
Seasonal Rearing Population Estimates



Seiad Creek Sites-Winter Rearing Population Estimates -2011-2018

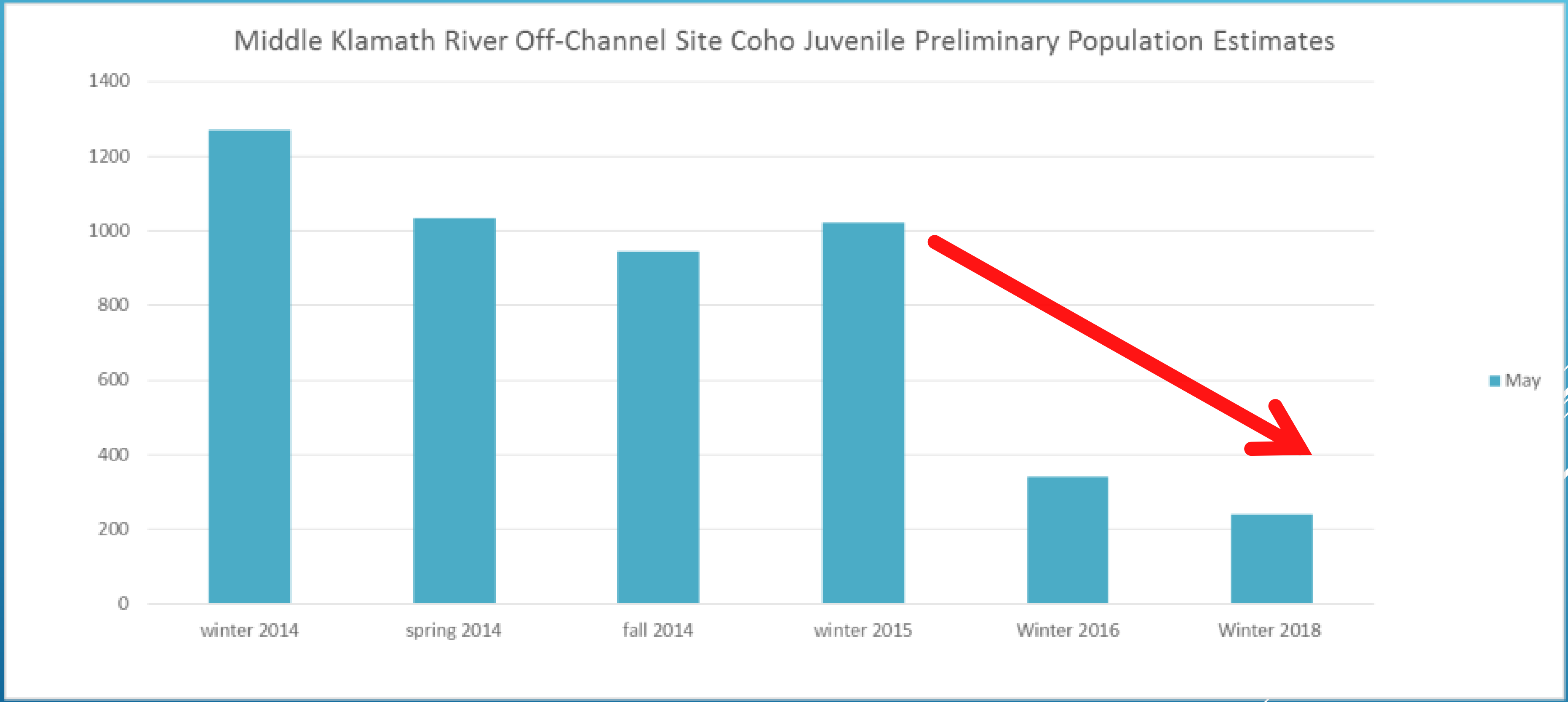


Alexander Pond Winter Rearing Estimates 2011-2018

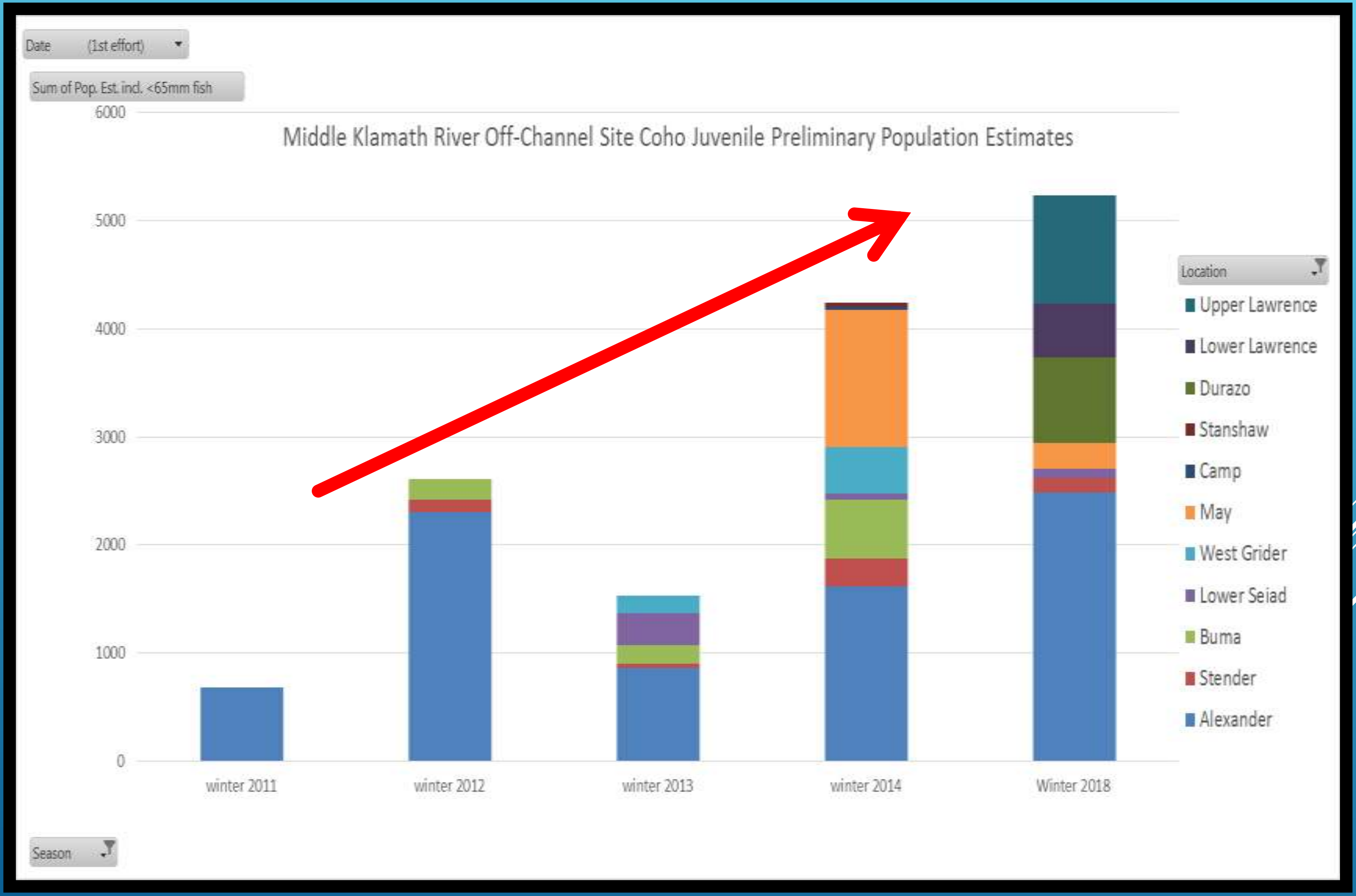


May Pond Population Estimates 2014-2018

Fish accessibility is suspected as cause for the decline?



MORE SITES=MORE FISH



Conclusions

- If you build habitat fish are looking for they will use it.
- Both summer and winter utilization.
- Summer utilization is high at sites with groundwater cooling influence.
- Population size is likely a function of the fishes ability to find the site.
- Winter warming effects at sites with strong groundwater influence.
- Sites can function during drought cycles.
- Pre and post project monitoring is important for understanding project effectiveness

Acknowledgement's

- Karuk Fisheries Program
  - Ken Brink
  - Sophie Price
  - Mike Polmateer
  - Alex Corum
- Middle Klamath Watershed Council
  - Charles Wickman
  - Mitzi Wickman
  - Will Harling
  - Jimmy Peterson
- Humboldt State Grade Students
  - Michelle Krall
  - Shari Whitmore

- Consultants
  - Rocco Fiori
  - Larry Lestelle

- Funding Provided by the Nation Fish and Wildlife Foundation and US Bureau of Reclamation

QUESTIONS

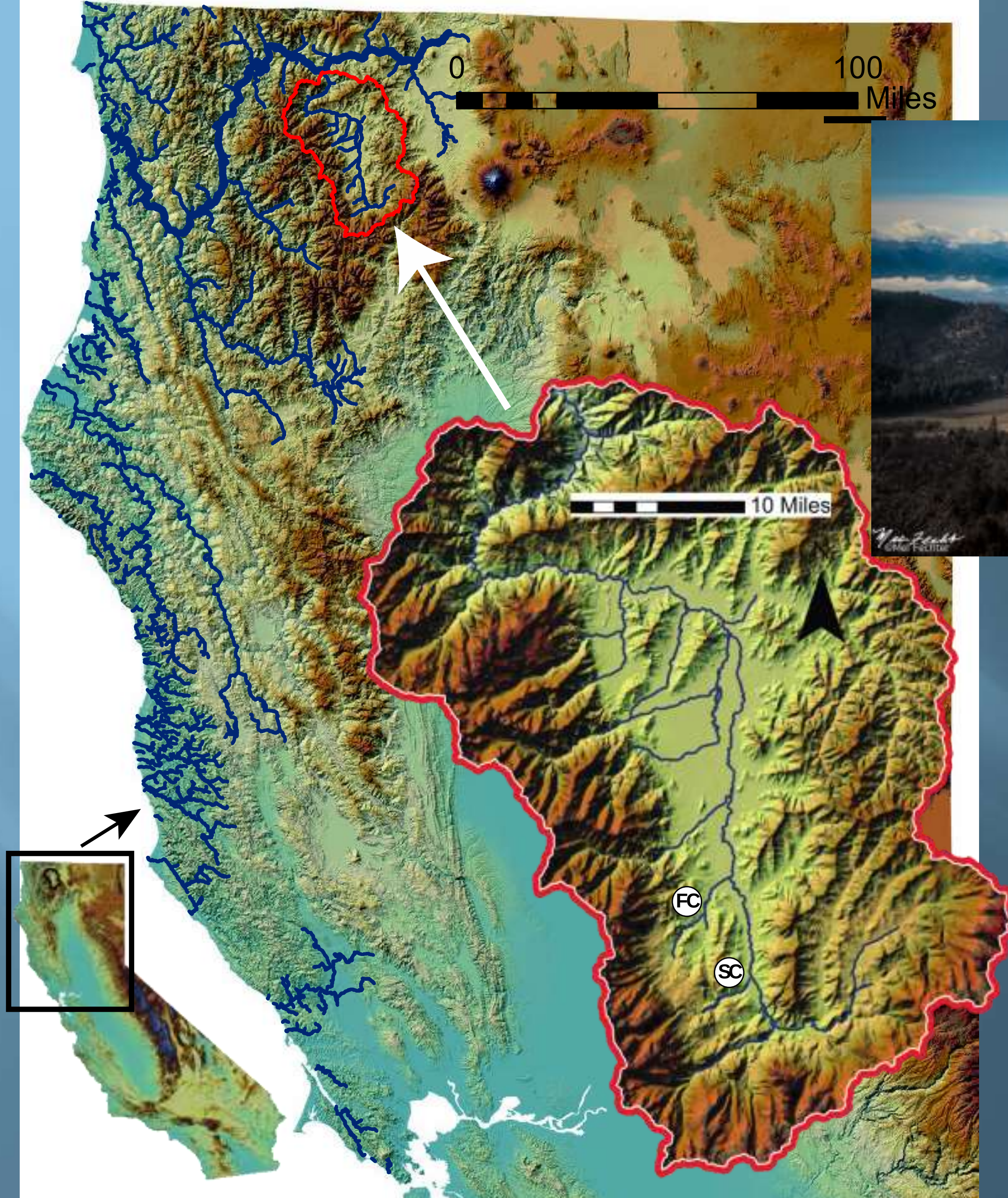
Monitoring the Physical and Biological Effects of Beaver Dam Analogues in the Klamath River Basin

Michael M. Pollock[1], Shari Witmore[2], Erich Yokel[3], Betsy Stapleton[3], Charnna Gilmore[3]

1 NOAA Fisheries - Northwest Fisheries Science Center, Seattle

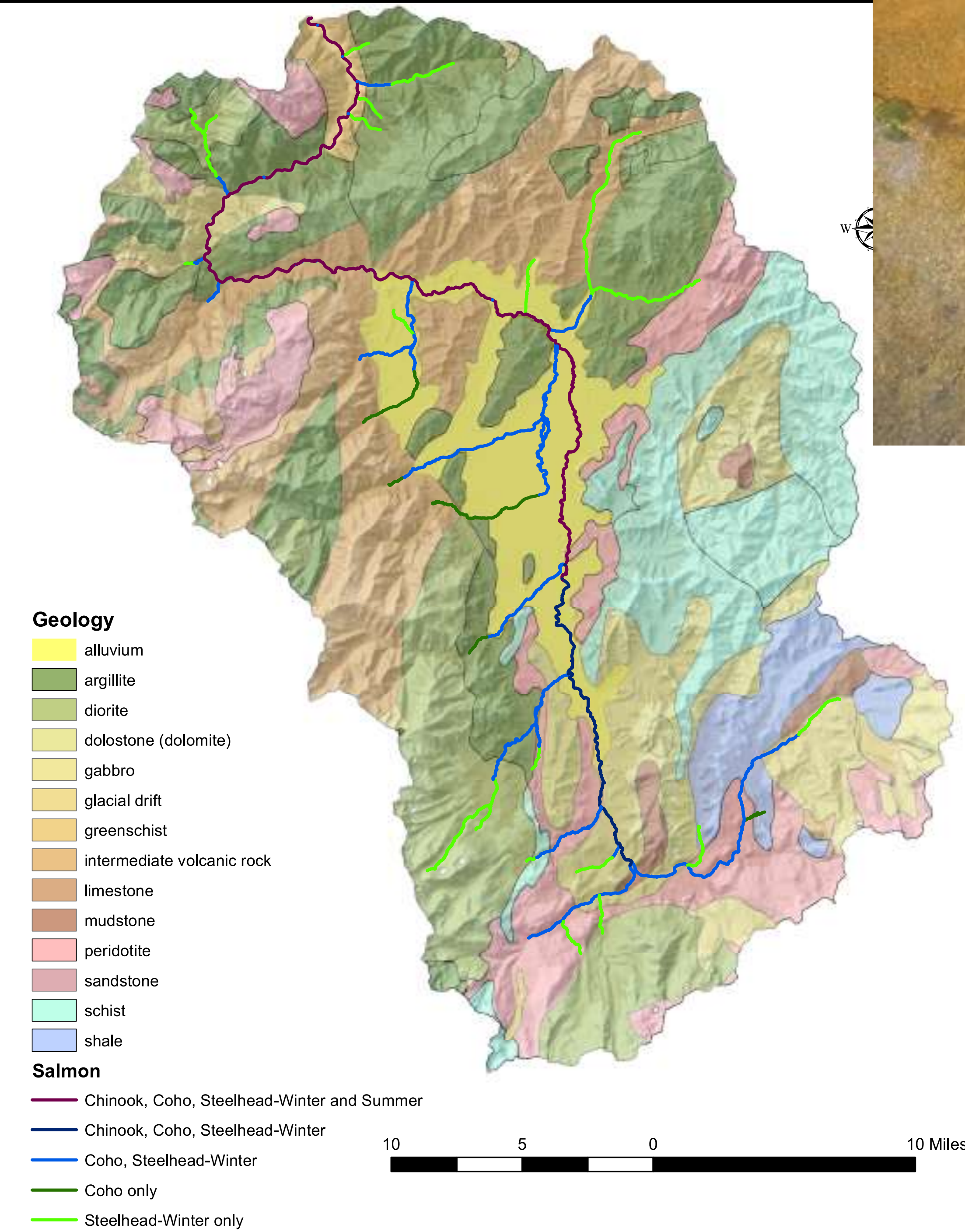
2 NOAA Fisheries - Klamath Branch, Arcata

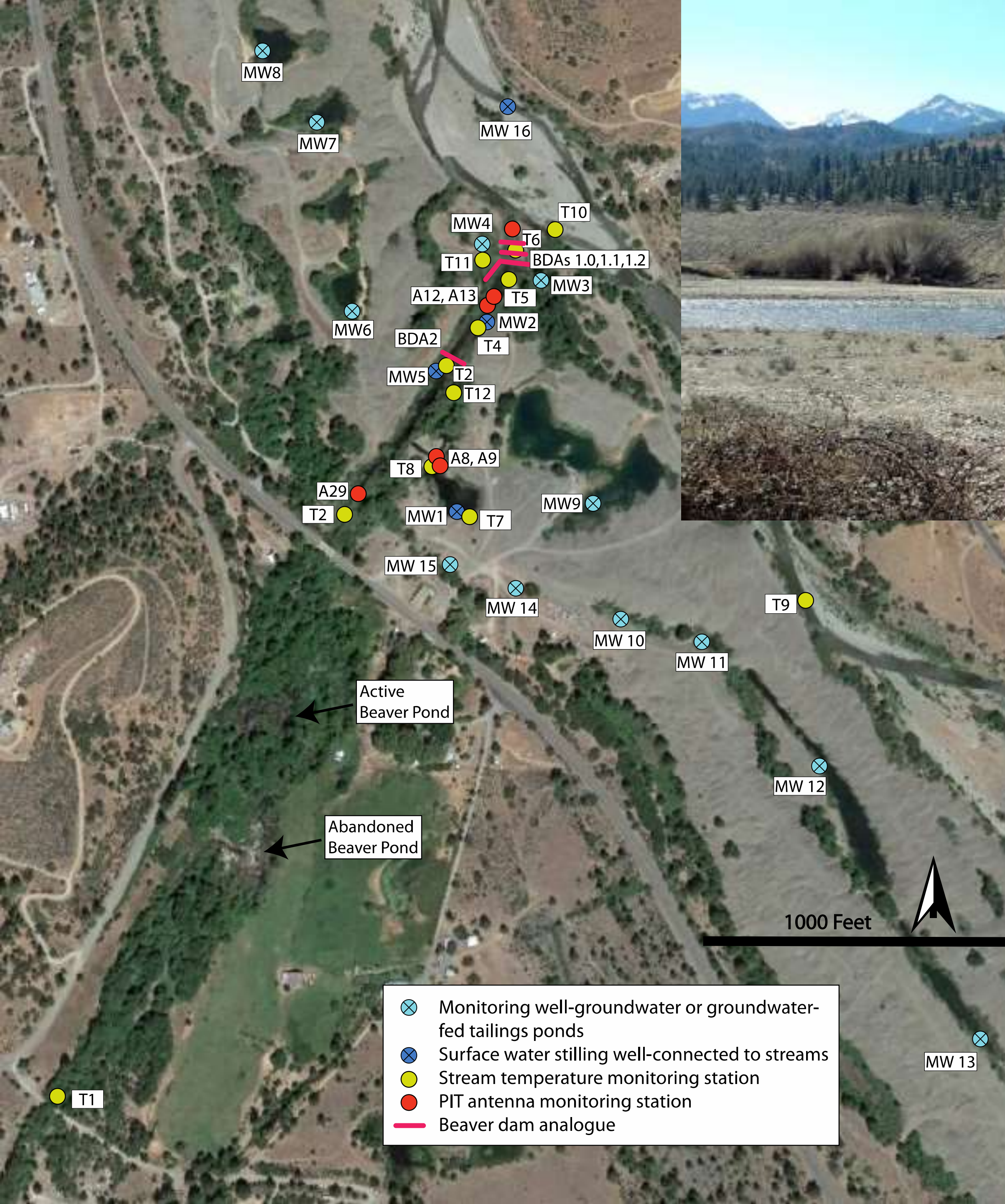
3 Scott River Watershed Council, Etna



Location of the Scott River Watershed, a Klamath River tributary, in the context of coho salmon habitat (blue lines) in California

Geologic Map of the Scott River Watershed





Scott River mine tailings near Sugar Creek (above)

Sugar Creek monitoring network overview (left)

Beaver Dam Analogues

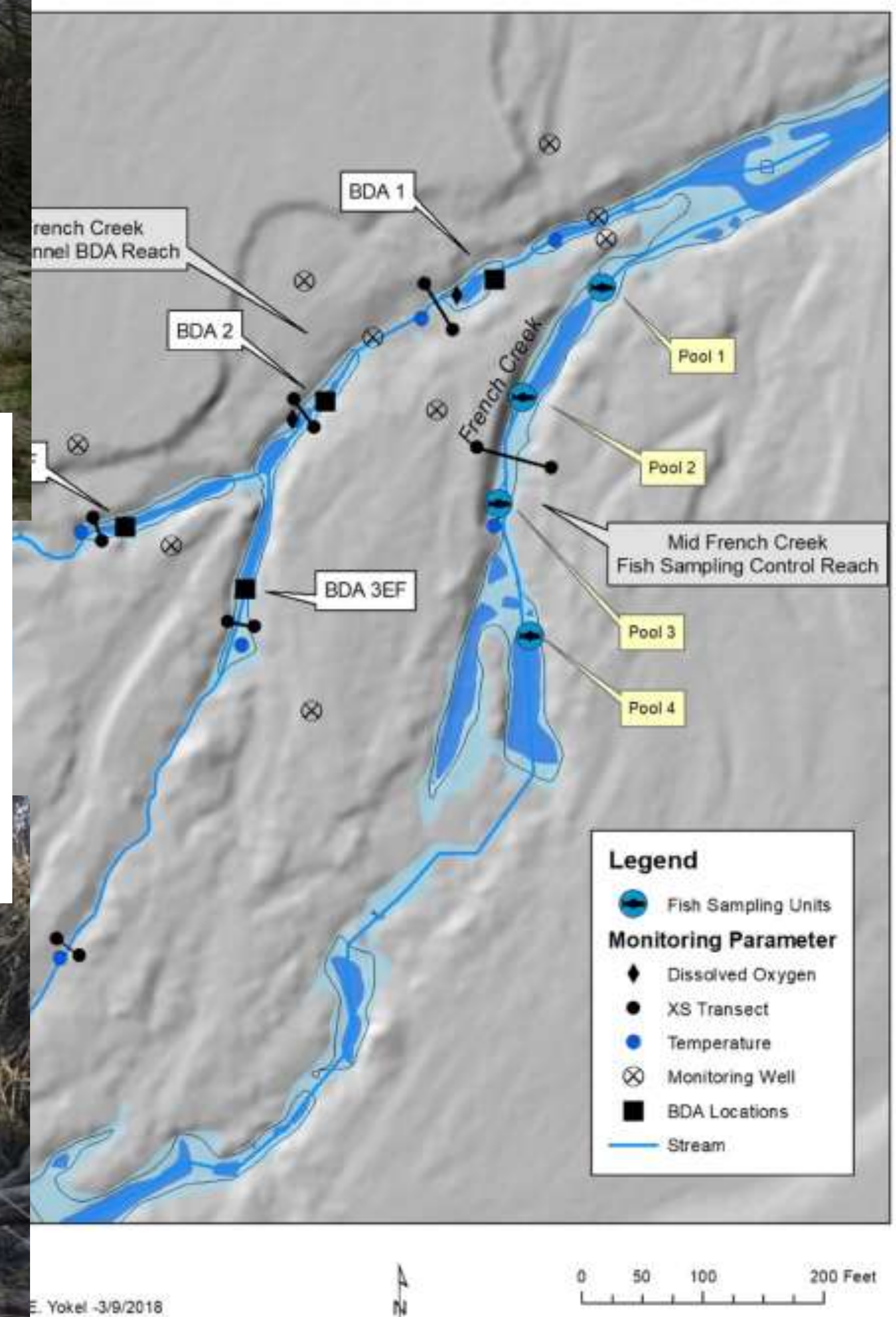
Sugar Creek-Beaver Dam Analogue Pond 1 Pre-Treatment v. Post Treatment

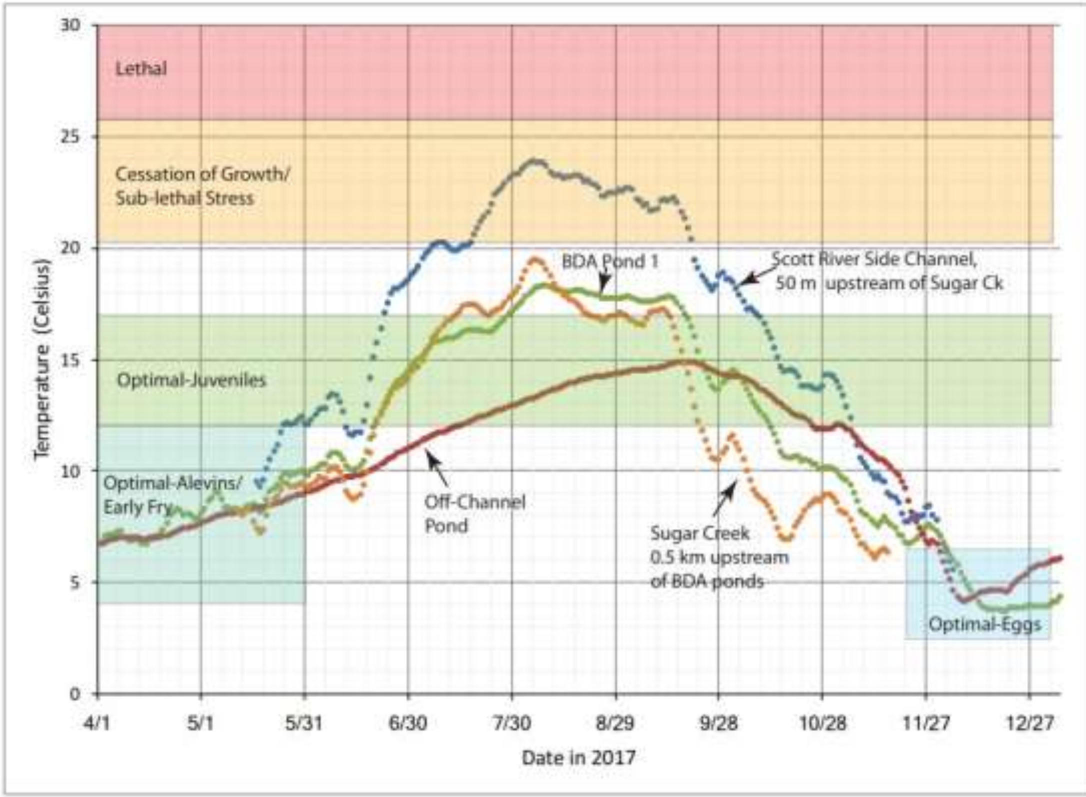
Sugar Creek Restoration Site Overview

French Creek mainstem in winter (above)

French Creek control site and restoration site overview (right)

French Creek side channel in winter (below)



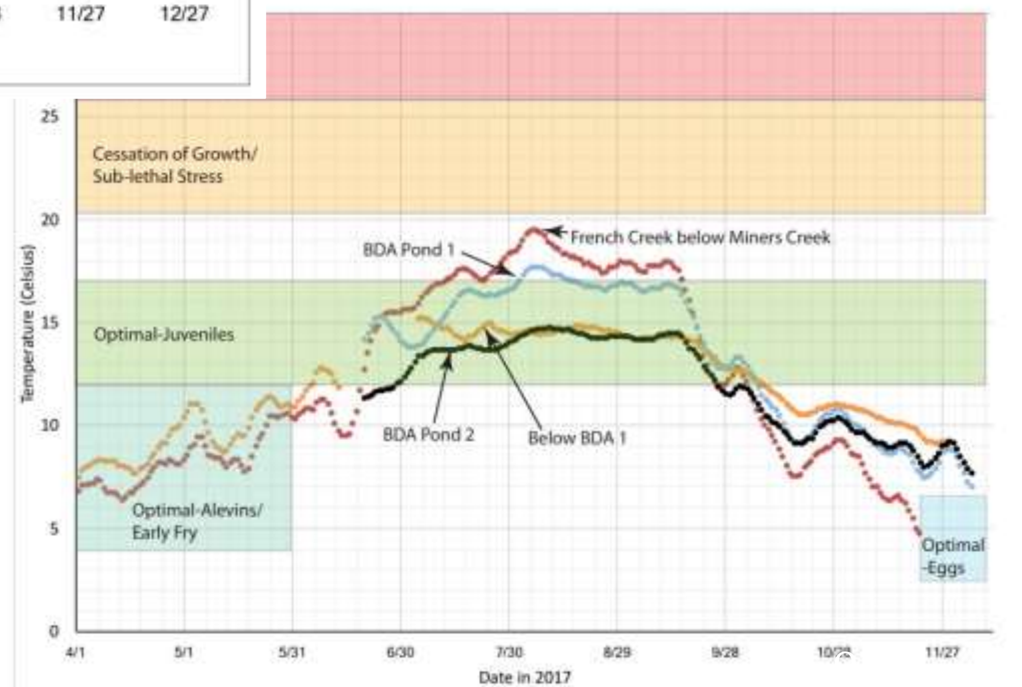


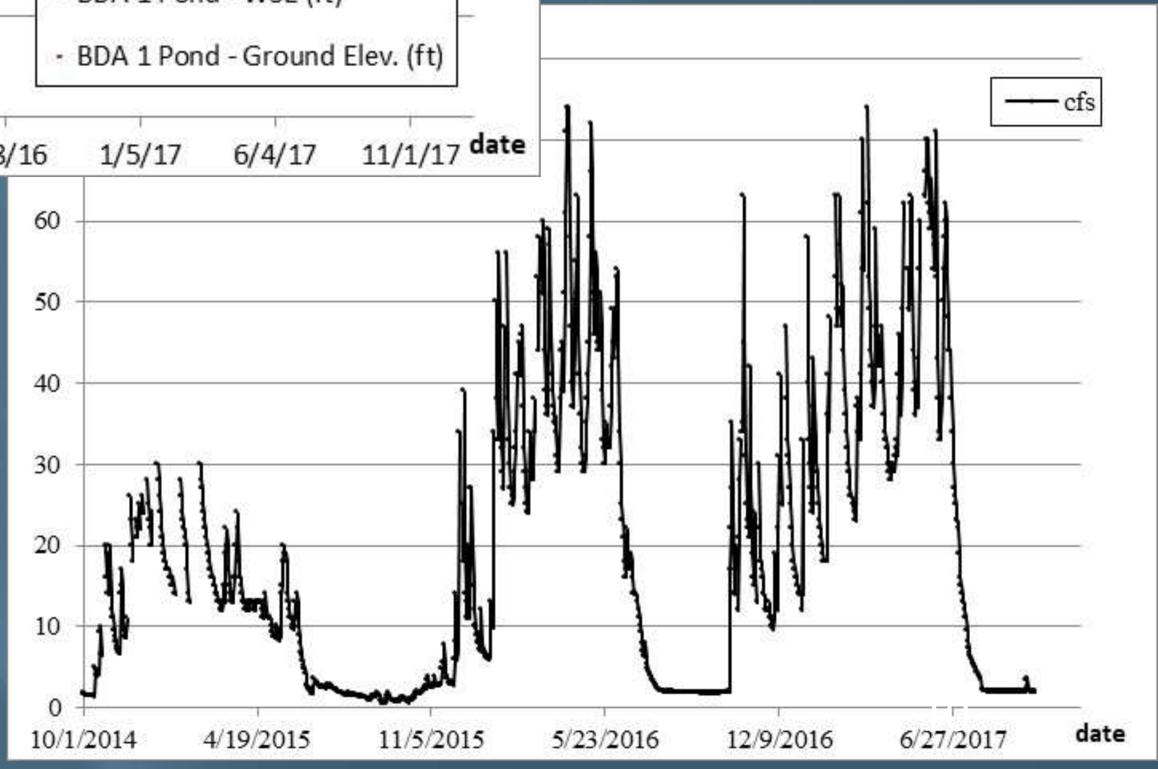
Moving weekly maximum temperature (MWMT) (°C). Thermal optimum and stressful ranges for coho salmon life stages based on Richter and Kolmes (2005).

Surface Water Temperatures, April-December, 2017

Sugar Creek (above)

French Creek (right)





Water Surface Elevation at Sugar Creek BDA Pond 1, 2014-2017 (above)

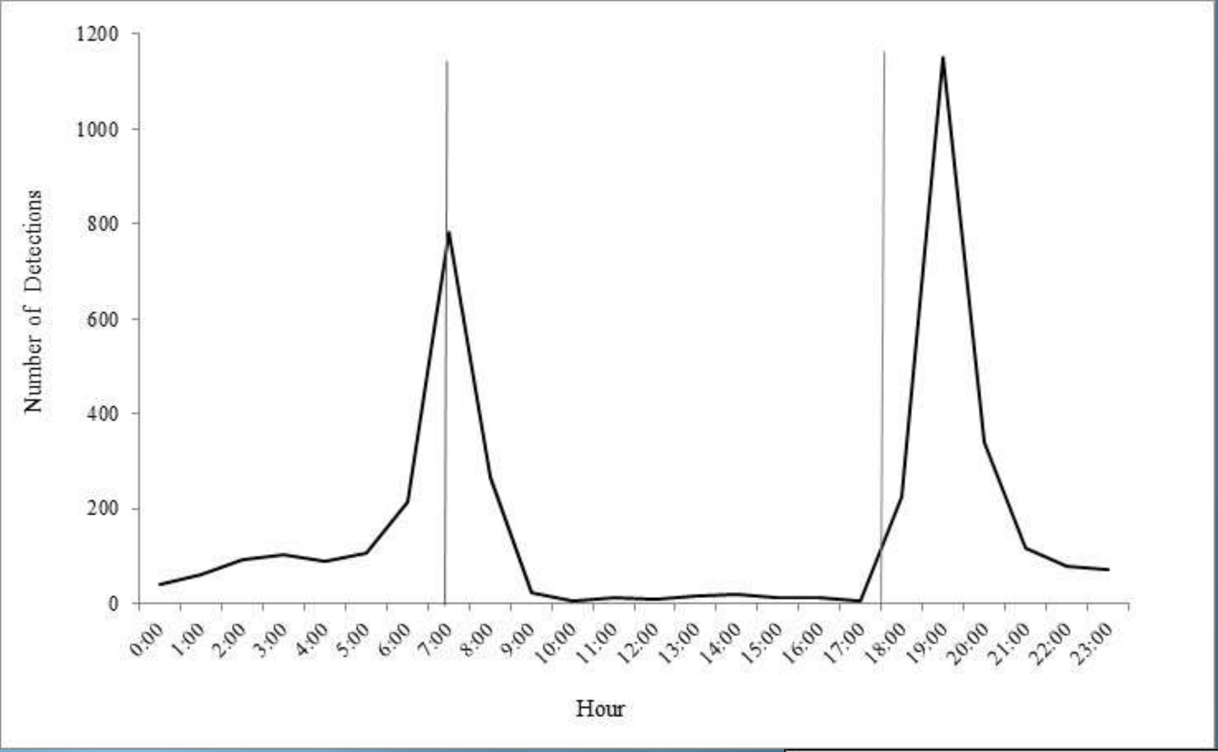
Sugar Creek Hydrograph, 2014-2017 (right)

Water Surface Elevation at Sugar Creek BDA Pond 1, 2017 (above)

A breach in Sugar Creek BDA 1 in 2017 (right)

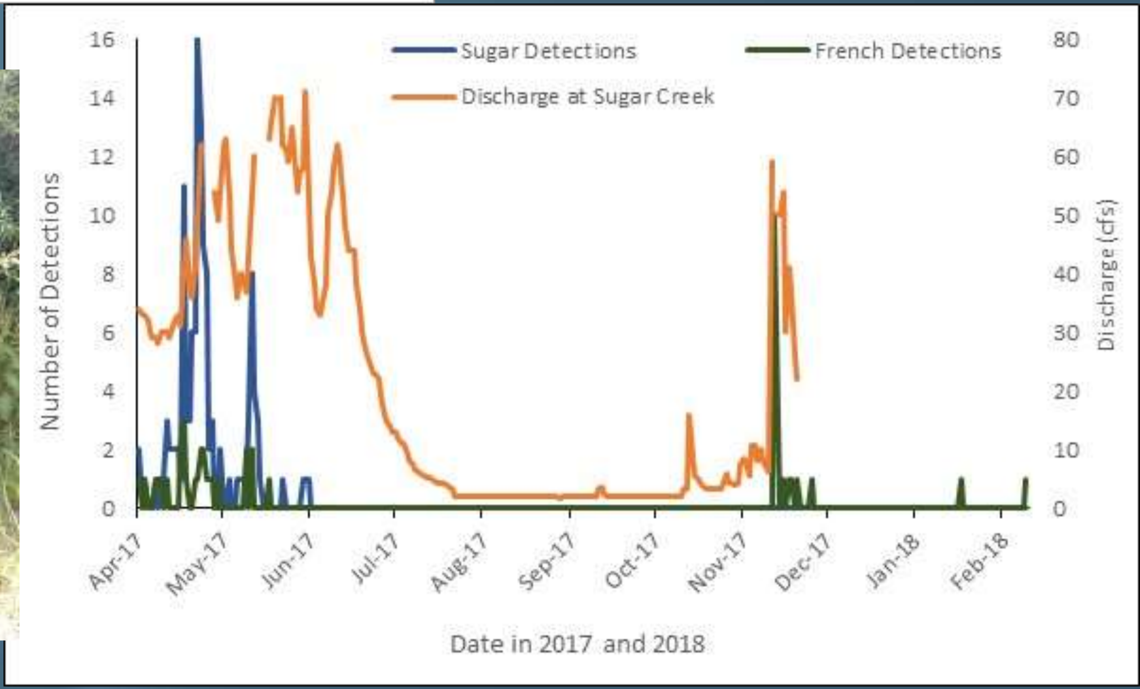
Changes is Water Surface Elevations in Response to BDA 1 repair that raised BDA Pond 1 0.9 ft.

Water surface elevations increased 0.5 ft 3000 ft upstream, and 0.1 ft 1000 ft downstream

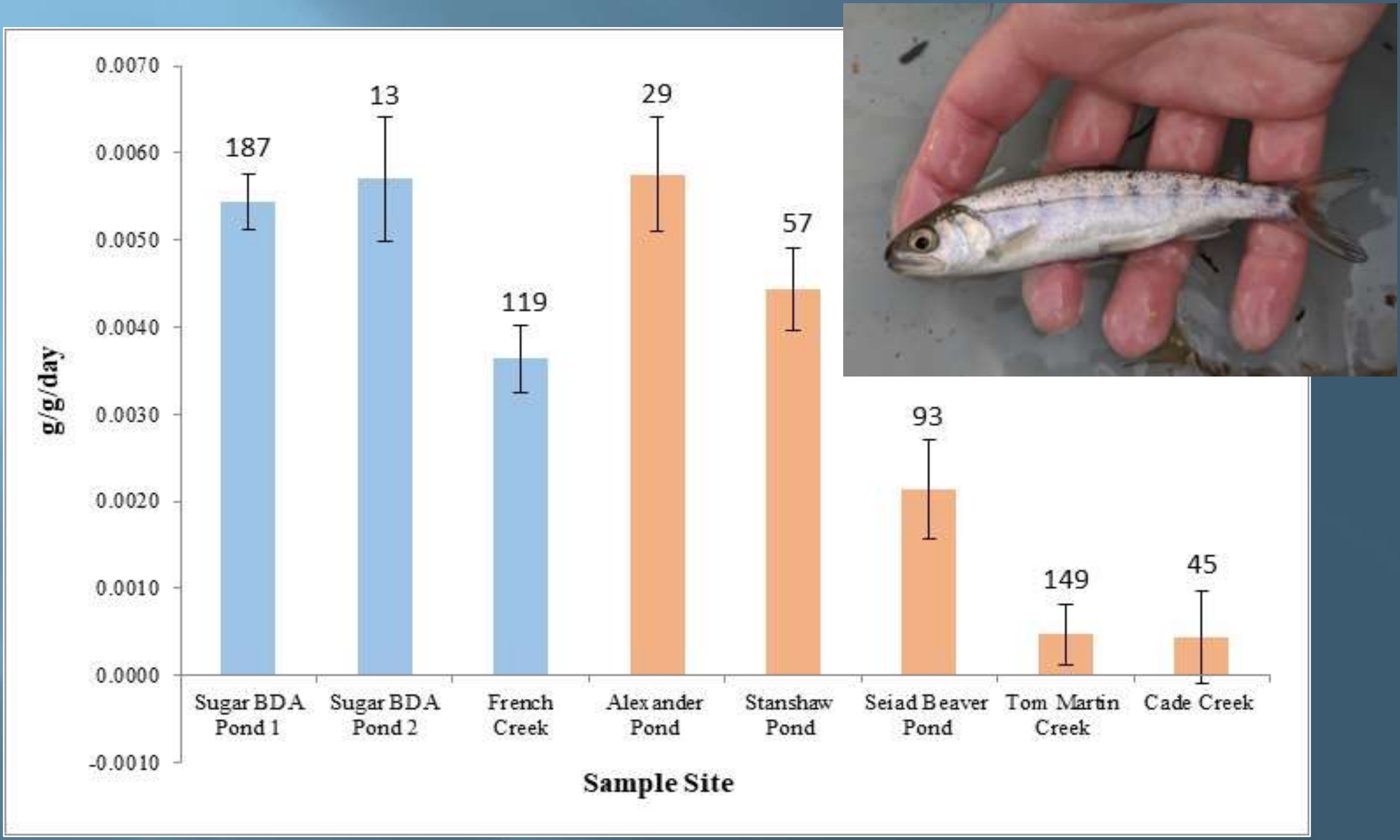


Diurnal movement of coho to and from the off-channel pond (left)

Seasonal movement of coho in relation to flow (below)



Growth rate of juvenile coho salmon at restoration site (Sugar Ck) and control site (French Ck) in relative to growth rates in other ponds and tributaries in the Klamath River basin.



Juvenile Coho Habitat Capacity Estimates for Sugar Creek Restoration Complex

2017 Conditions

Site	Area (m^2)	pp	pp/m^2	pp/m	L (m)	Area (%)	pp (%)
BDAP1	2572	2570	1.0	22.2	115.7	28%	34%
BDAP2	3276	2867	0.9	13.0	220.2	36%	38%
SCB-Marsh	879	1143	1.3	15.4	74.0	10%	15%
SCA	353	165	0.5	1.7	167.0	4%	2%
OCP	2049	748	0.4	5.7	131.0	22%	10%
Total-All	9129	7493	0.8	10.6	707.9	100%	100%
Ttl-BDAPs	6727	6579	1.0	16.1	409.9	74%	88%

2016 Conditions

Site	Area (m^2)	pp	pp/m^2	pp/m	L (m)	Area (%)	pp (%)
BDAP1	2261	1732	0.8	16.0	108.1	26.7%	27.4%
BDAP2	3162	2947	0.9	14.0	210.9	37.3%	46.6%
SCB-Marsh	645	735	1.1	8.6	74.0	7.6%	11.6%
SCA	353	165	0.5	1.7	167.0	4.2%	2.6%
OCP	2049	748	0.4	5.7	131.0	24.2%	11.8%
Total-All	8471	6327	0.7	9.2	691.0	100.0%	100.0%
Ttl-BDAPs	6068	5414	0.9	13.8	393.0	72%	86%

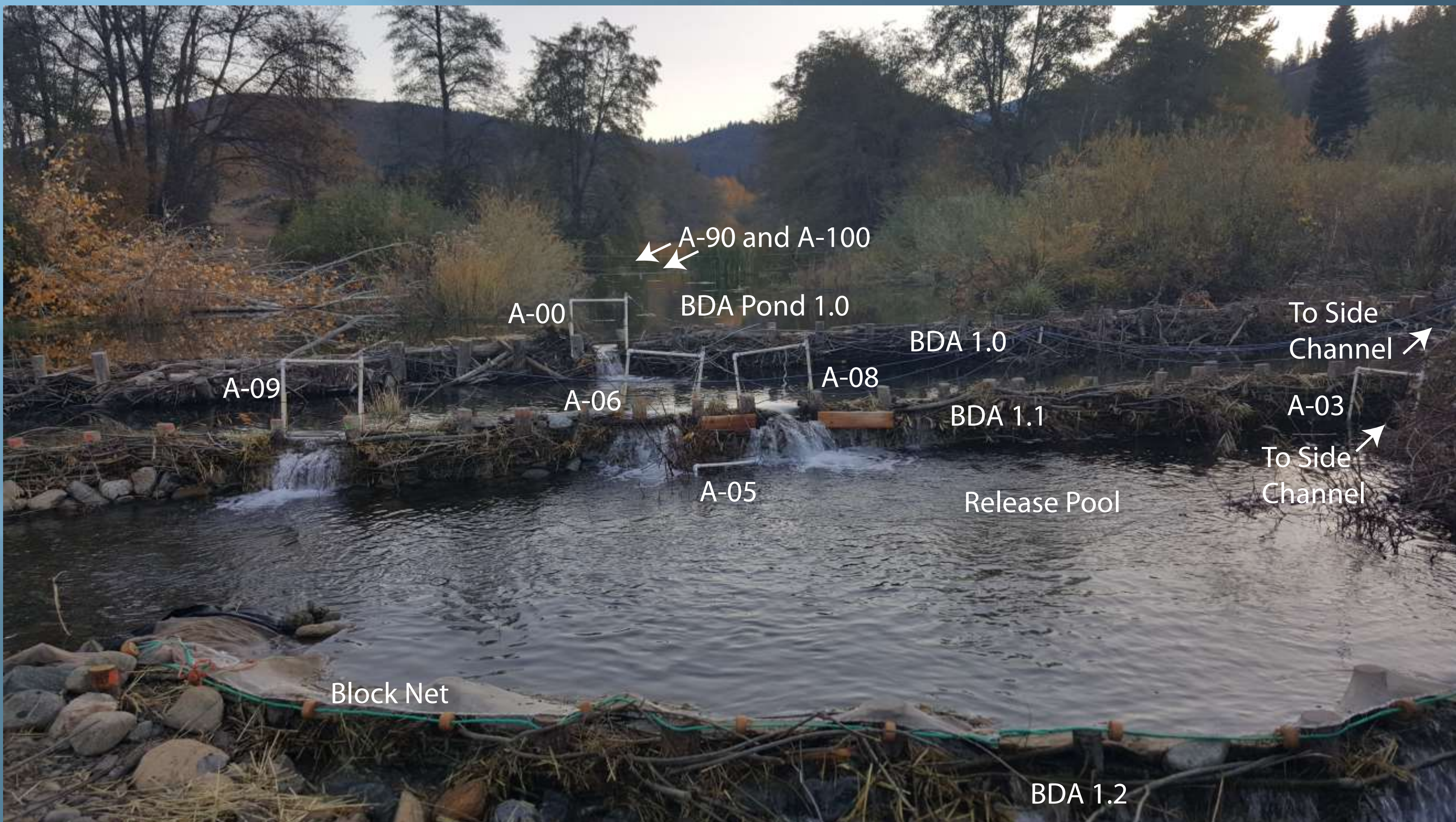
Pre-project Conditions

Site	Area (m^2)	pp	pp/m^2	pp/m	L (m)	Area (%)	pp (%)
Mainstem	533	350	0.7	1.0	355.0	100%	100%

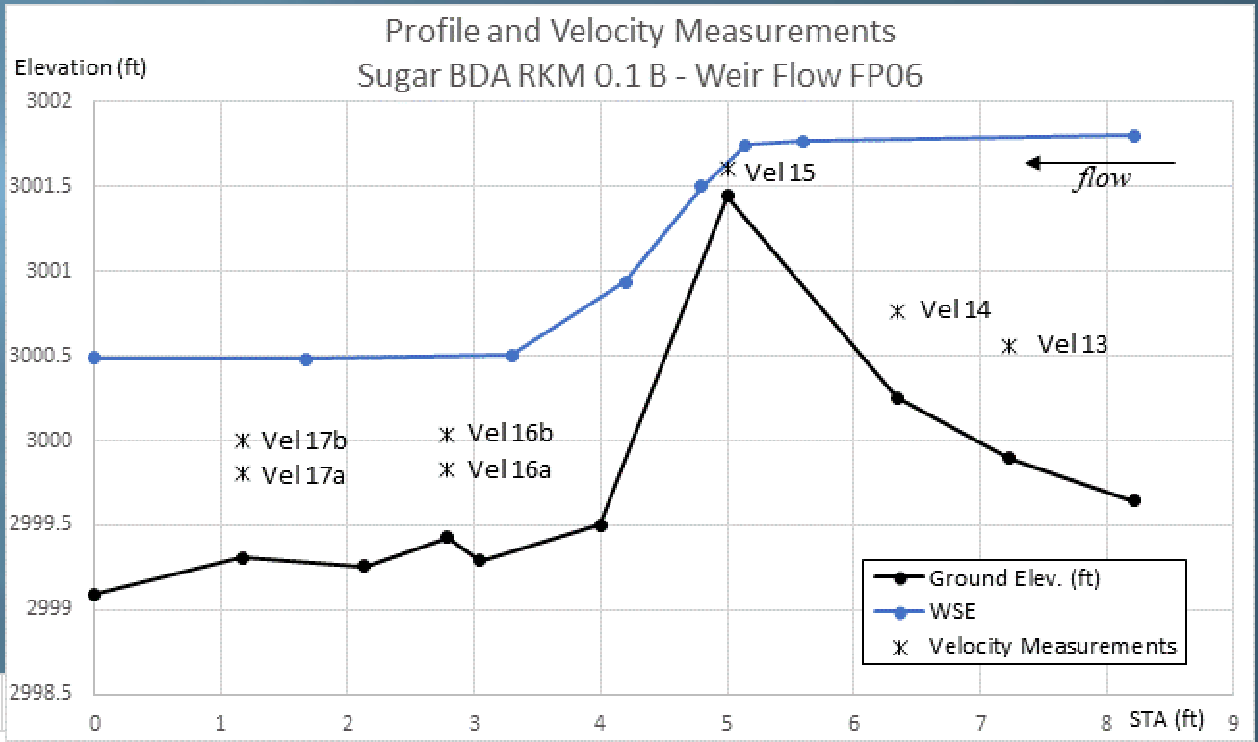
Juvenile Coho Salmon Habitat Capacity v. Population Estimates in Treatment and Control Reaches

Metric	Sugar Ck	French Ck
Pop. Estimate	2698	218
Capacity Estimate	7493	355
% Utilization	36%	61%
Area	9129	973
HC/m2	0.79	0.42
Fish/m2 (early fall)	0.29	0.22

Fish Passage Across Beaver Dam Analogues- an experimental study



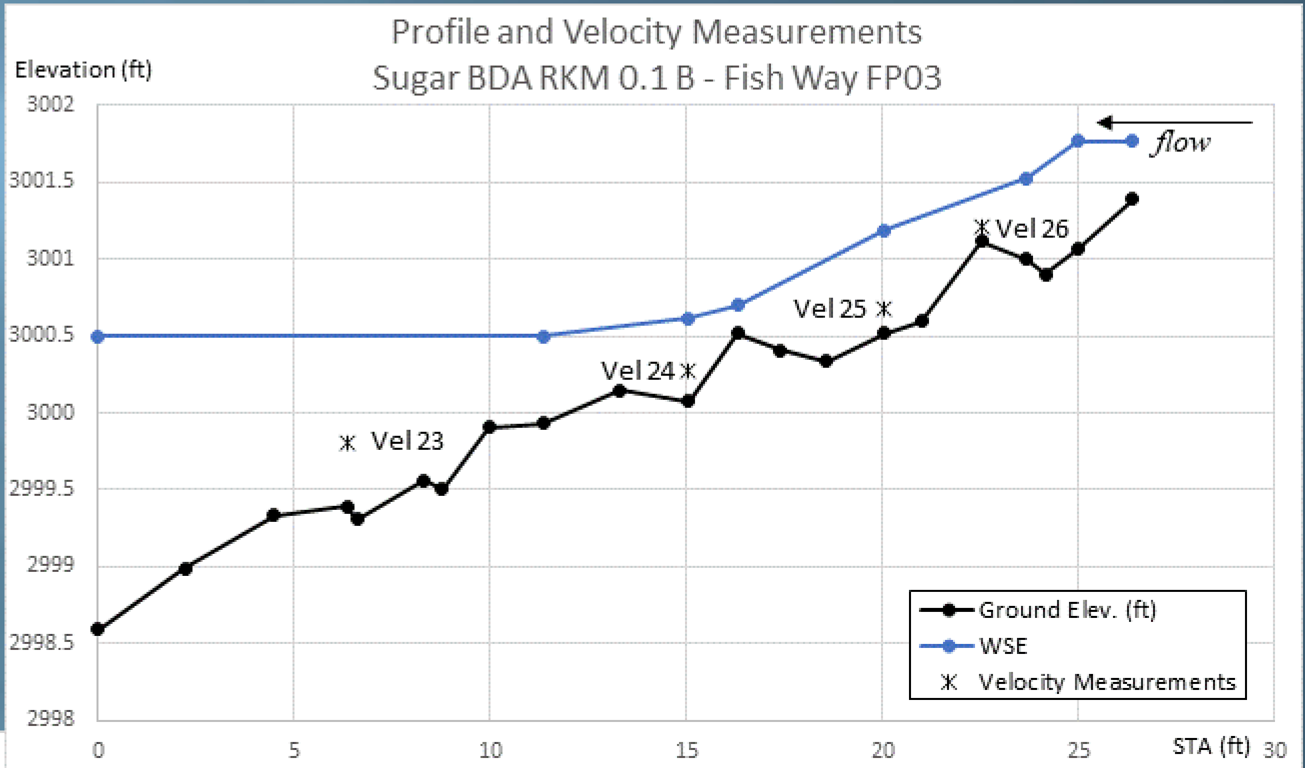
Velocity and Depth Profile at FP08, the Jump Route With the Most Detections



BDA B - Weir Flow - FP08

Site	Depth (ft)		Velocity (ft/s)		
	Water Column	V meas.	V_x	V_y	Velocity
Vel 18	1.9	0.8	0.15	-0.15	0.2
Vel 19	1.25	0.5	0.32	-0.19	0.4
Vel 20	0.4	0.2	2.42	-1.04	2.6
Vel 21a	1.9	0.8	-0.27	0.24	0.4
Vel 21b	1.9	1.2	0.95	0.1	1.0
Vel 22a	1.7	0.7	0.26	0.22	0.3
Vel 22b	1.7	1	0.58	0.15	0.6

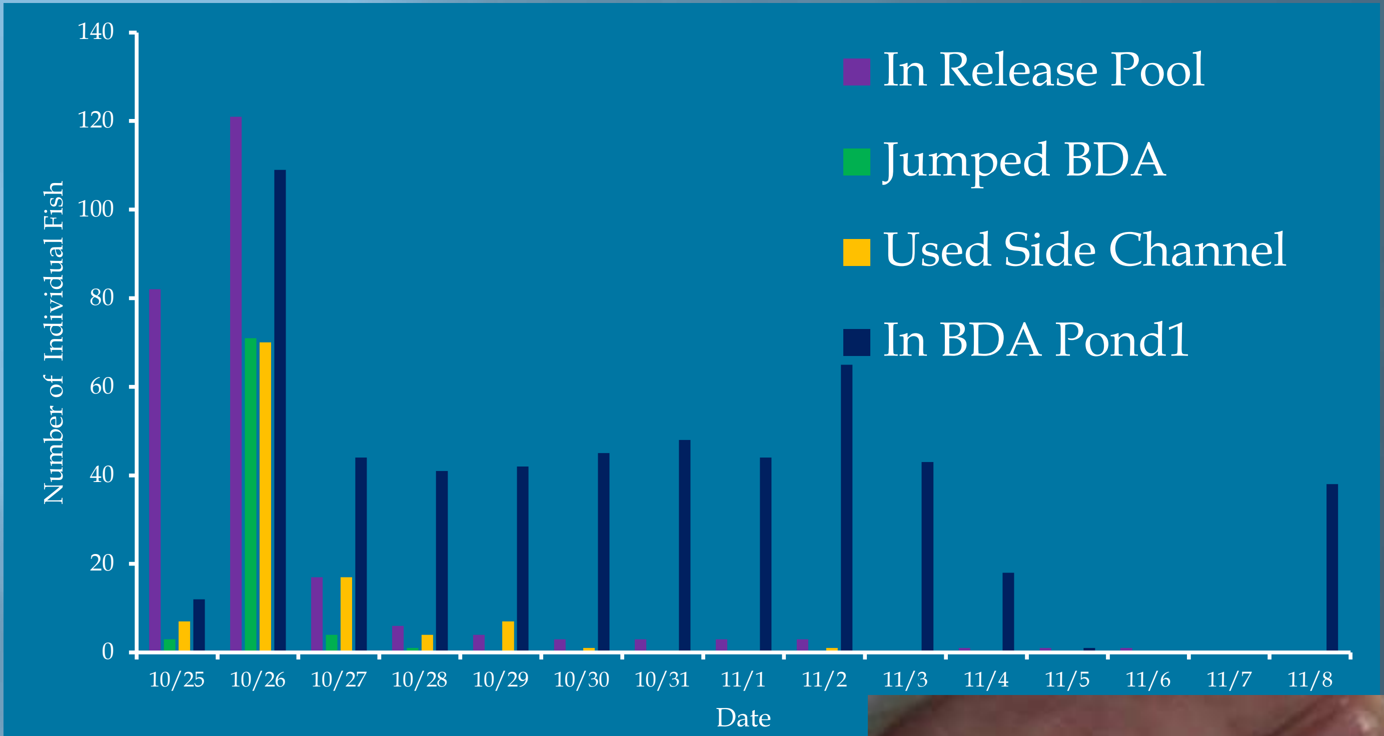
Velocity and Depth Profile at FP03, the Side Passage Route With the Most Detections



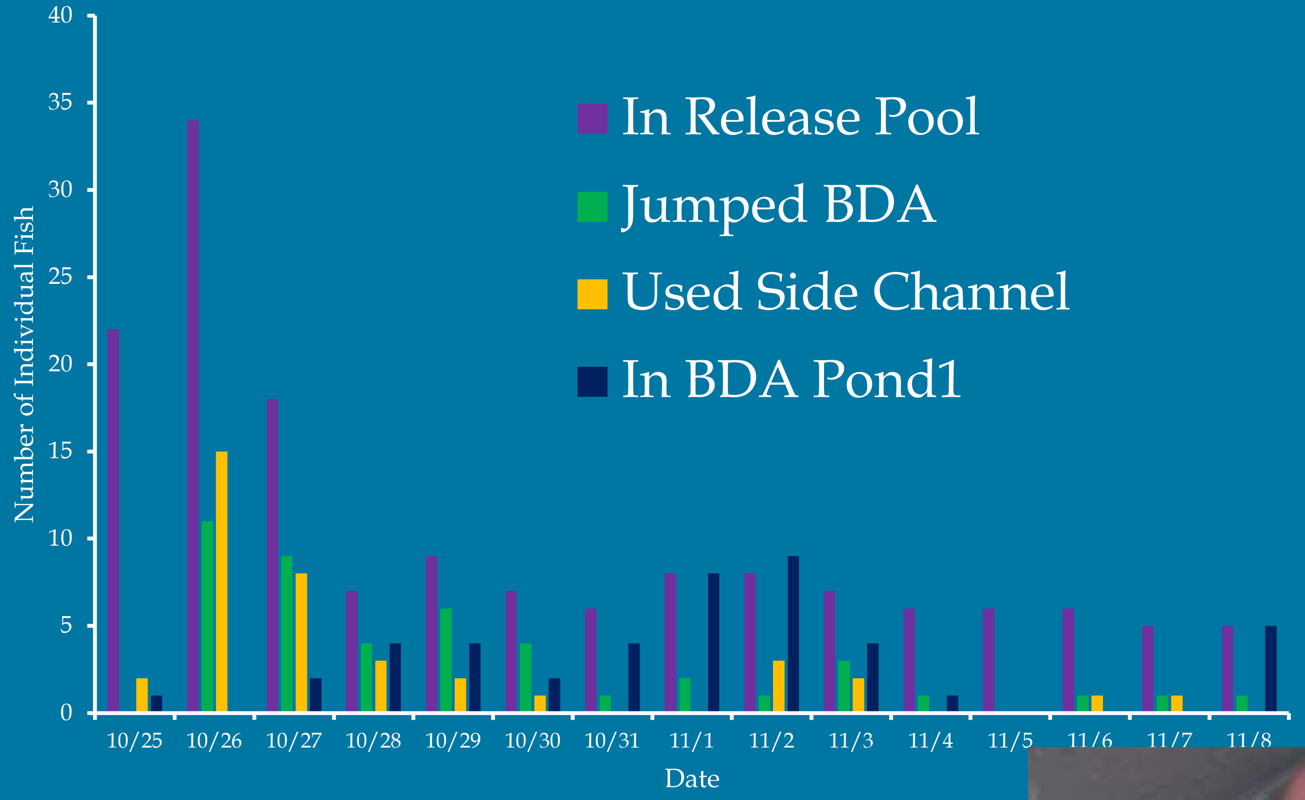
BDA B - Fish Way - FP03

	Depth (ft)		Velocity (ft/s)		
Site	**Water Column**	**V meas.**	V_x	V_y	**Velocity**
Vel 23	1.05	0.4	0.12	0.06	0.1
Vel 24	0.5	0.2	0.14	0.03	0.1
Vel 25	0.4	0.2	0.2	0.08	0.2
Vel 26	0.25	0.1	0.32	0.06	0.3

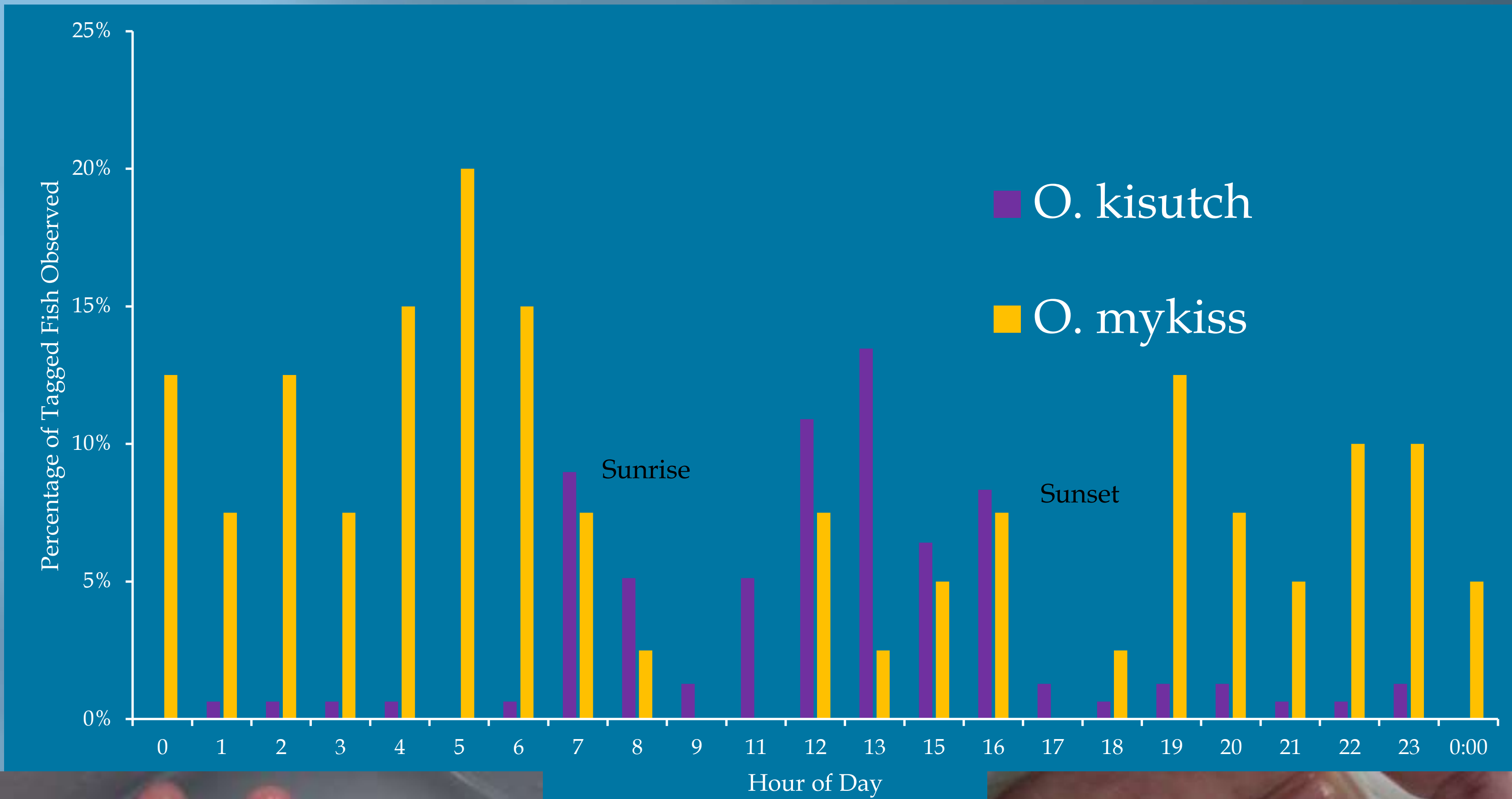
Juvenile Coho Salmon Detections for Two Weeks After 156 Were Released in Pool Below BDA 1.1



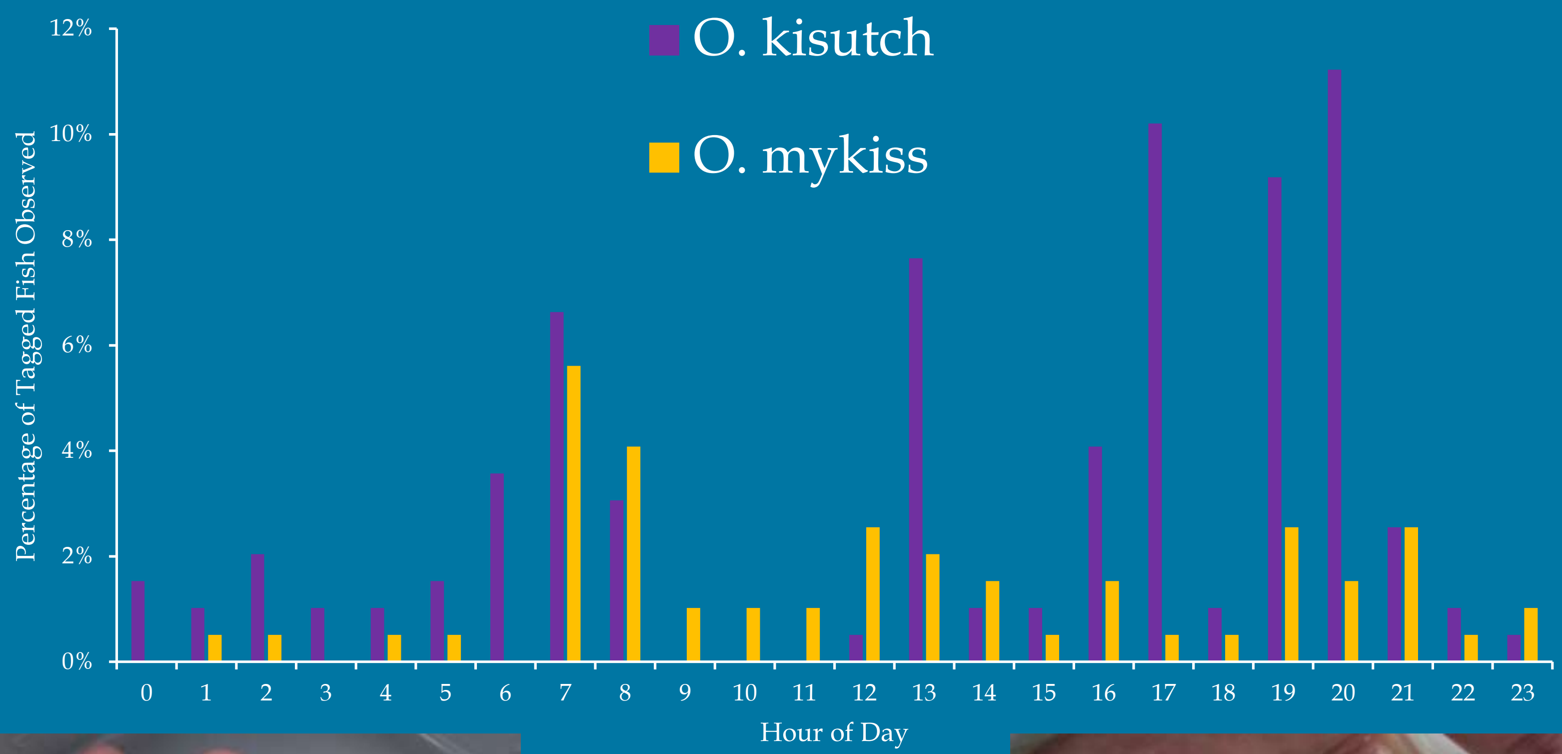
Juvenile Steelhead Trout Detections for 2 Weeks After 40 Were Released in Pool Below BDA 1.1



Timing of Juvenile Salmonids Jumping Over BDAs

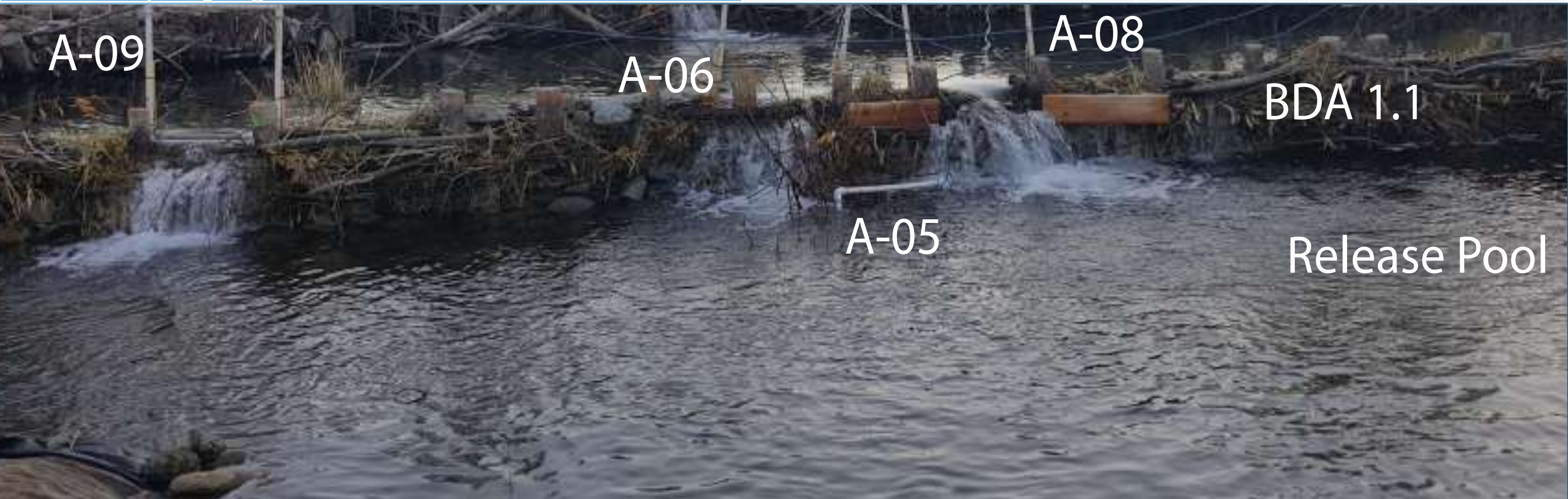


Timing of Juvenile Coho Salmon and Steelhead Trout Swimming Around BDAs



Summary of Fish Passage Over or Around BDAs

Metric	Coho N	Coho (%)		Stlhd N	Stlhd (%)		Total N	Total-Percent
Released	156	100%		40	100%		196	100%
Detected after release	156	100%		40	100%		196	100%
Detected in release pool	143	92%		39	98%		182	93%
Detected upstream of release pool (BDA1.1)	152	97%		32	80%		184	94%
Detected upstream of BDA 1.0	139	89%		20	50%		159	81%
Detected moving downstream	0	0%		0	0%		0	0%
BDA Passage Routes								
Detected using a side channel to cross a BDA	93	60%		25	63%		118	60%
Detected jumping over a BDA	77	49%		17	43%		94	48%



Conclusions

- The habitat rearing capacity for juvenile coho salmon increased by 8% to a total of 7,493 relative to 2016, and an overall 20-fold increase in habitat capacity since the restoration project began.
- The total area of wetted habitat increased by 11% from 2016, to a total of 9,129 m^2 (2.3 acres). This does not include riparian areas.
- The volume of aquatic habitat in the BDA ponds increased by about 40%.
- Stream temperatures continued to improve and generally stayed within or close to the range optimal for coho salmon.
- Groundwater monitoring suggests that for every 30 cm of height that the BDAs are raised, groundwater levels rise 15 cm or more, as far as 0.9 kilometer up valley. There were also less dramatic increases observed as much as 350 m down valley. A conservative estimate suggests that the lower BDA in Sugar Creek increased water storage capacity by about 37,000 m^3 (about 30 acre-feet). It is likely that the area of groundwater influenced by the BDAs extends beyond the limits of our groundwater monitoring network.
- Juvenile coho population estimates decreased by about 25%. This may be due to the severe flooding the previous winter that may have destroyed salmon redds.

Conclusions

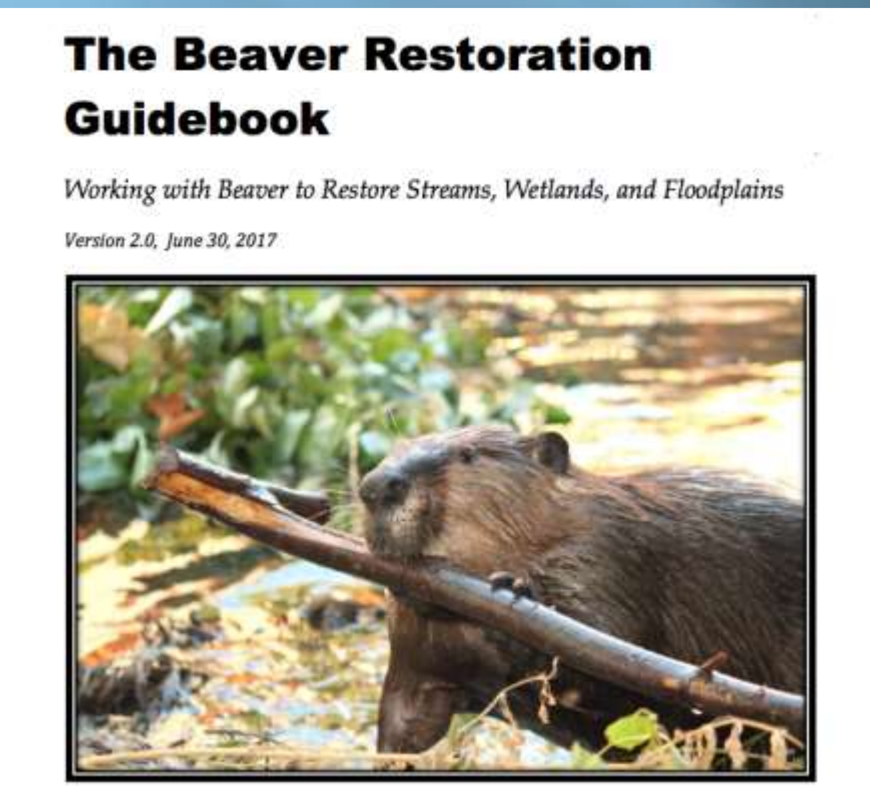
- Juvenile coho populations were at about 36% of capacity, while at the French Creek control site, the population was at about 61% of capacity.
- Preliminary results indicate that relatively few coho (7%) outmigrated from French Creek in the spring of 2017, while a much higher percentage (40%) of tagged coho in Sugar Creek outmigrated.
- An experiment was conducted to test the passability of BDAs by placing PIT-tagged juvenile coho and steelhead downstream of two BDAs. A series of PIT antennas on and upstream of the BDAs detected 97% of the coho upstream of one BDA and detected 89% of the coho upstream of both BDAs.
- Most of the coho moved upstream within 36 hours of being released.
- The juvenile salmonids had a choice of either swimming around the BDAs up a steep, roughened riffle, or jumping over them (jump heights of 40 cm and 30 cm). There was a slight preference for swimming around rather than jumping over for both species, but 49% of the coho jumped over at least one of the BDAs and the majority that jumped, jumped over the 40 cm high BDA.

Acknowledgements

Bob Pagliuco, *NOAA Restoration Center*; Serena Doose, Ryan Fogerty, Shari Hagwood, Dave Johnson & Rebecca Reeves, *US Fish and Wildlife Service Partners Program*; Anne Butterfield & Colleen Walters, *National Fish and Wildlife Foundation;* Demian Ebert, *PacifiCorp;* Annie Yates & the Board of Directors, *Bella Vista Foundation*; Eli Scott, Jake Shannon & Jonathan Warmerdam of the *North Coast Regional Water Quality Control Board;* Curt Babcock, Jennifer Bull, Mike Harris, Mary Olswang, Janae Scruggs, Mark Smelser, *California Department of Fish and Wildlife*; Joey Howard, PE., *Cascade Stream Solutions*; Kenneth Brink, Mike Polmateer, Toz Soto & Clayton Tuttle, *Karuk Tribe*; Sarah Rockwell, Jeff & Jaime Stephens, *Klamath Bird Observatory*; *Scott Valley Landowners* Samual Betzen, Mike Kalpin, Jerry Lewis, Bill & Jeffy Marx, Michael & Betsy Stapleton, Becky Schenone, the Farmers Ditch Company, the Tobias Ranch & the Whipple Ranch*;* Brian Cluer & Don Flickinger, *NOAA Fisheries*; Bill & Patty Parry *of North Rivers Construction*; Rocco Fiori, *Fiori Geosciences*; Darren Ward, Professor, *Humboldt State University*; Lindsay Magranet, *Siskiyou Resource Conservation District*; Sarah Beesley, *Yurok Tribe*, Will Harling, *Mid Klamath Watershed Council* and Michael & Lynn Thamer, *Community Members*.

Resources

Scott River Beaver Dam Analogue Coho Salmon Habitat Restoration Program 2017 Monitoring Report



The Beaver Restoration Guidebook

Working with Beaver to Restore Streams, Wetlands, and Floodplains

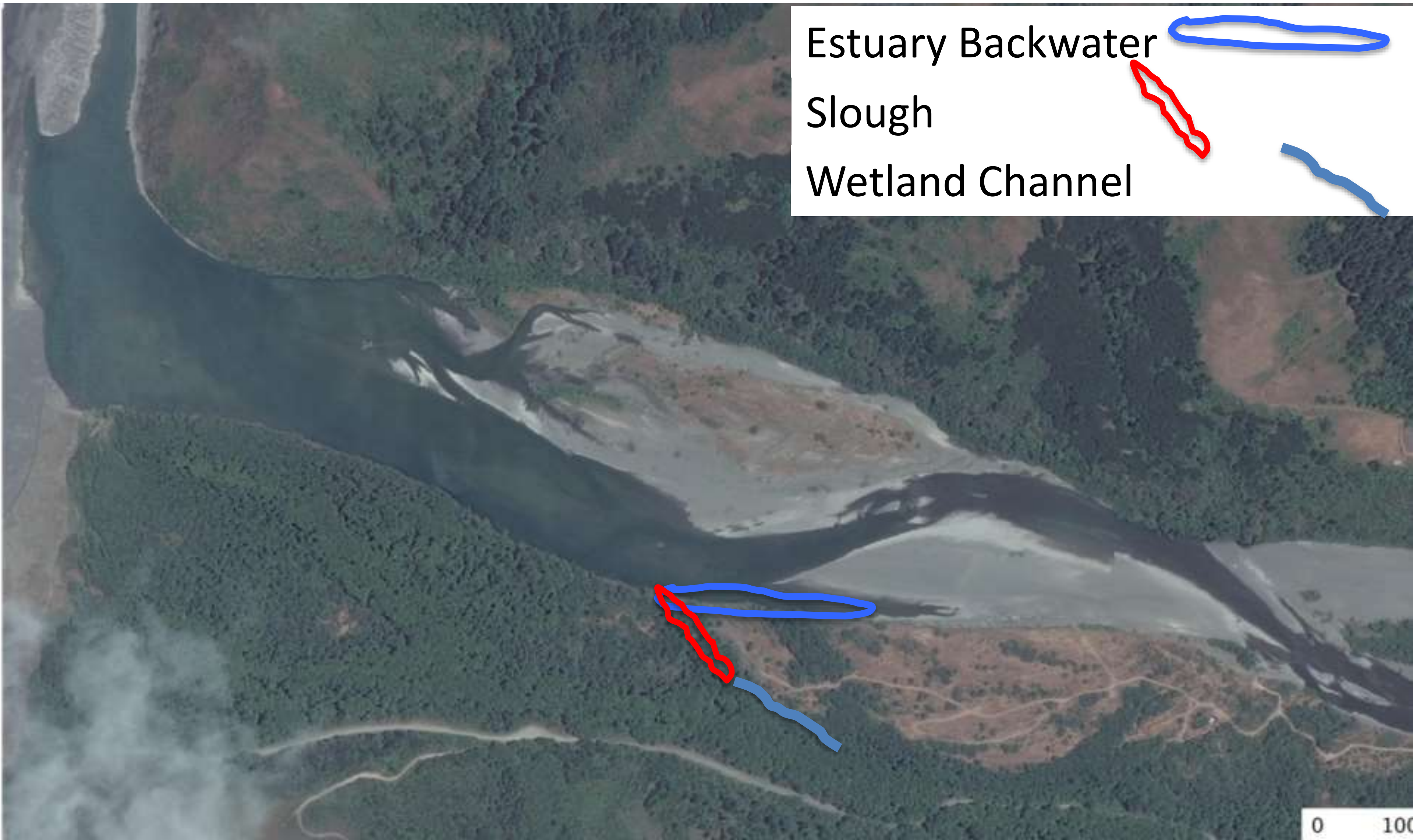
Version 2.0, June 30, 2017

Annual, seasonal, and diurnal variation in fish use of constructed slough habitat in the Mattole River estuary

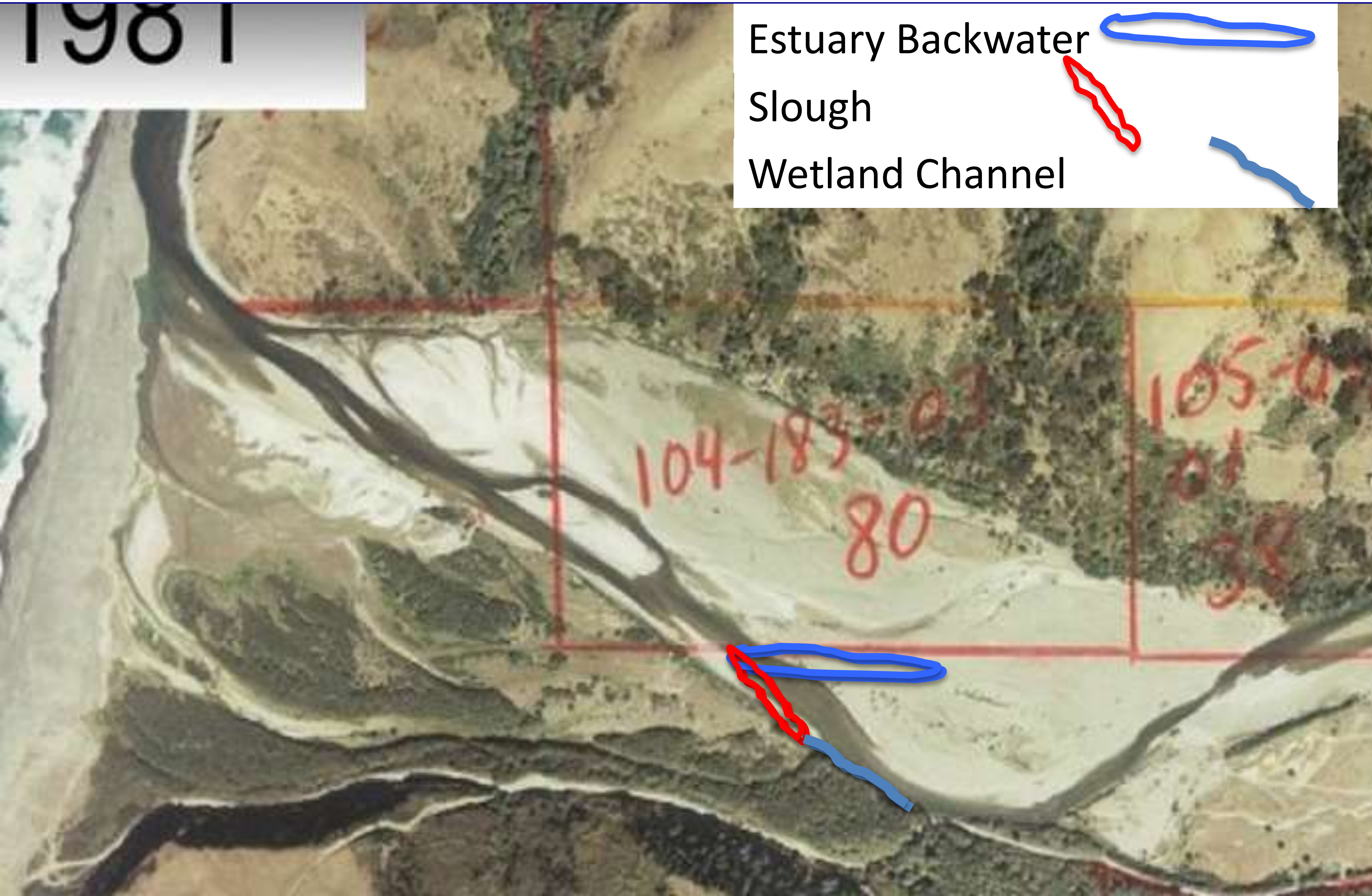
Nathan Queener

Mattole Salmon Group

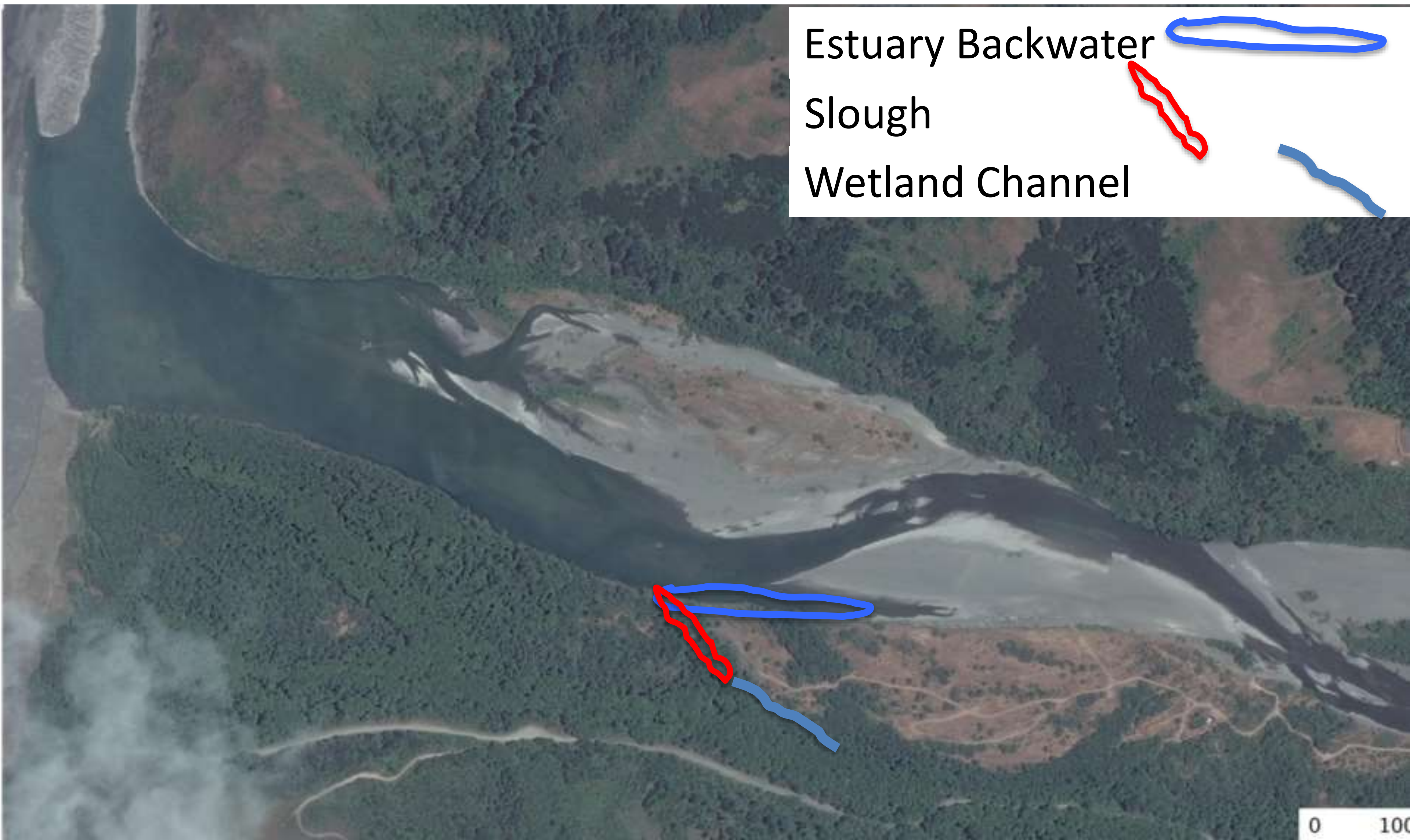
Mattole Lagoon in June 2016 with 2014-2017 Survey Units



Mattole Estuary in 1981 with 2014-2017 Survey Units



Mattole Lagoon in June 2016 with 2014-2017 Survey Units



Methods

- Single-pass snorkeling
- Habitat units with defined boundaries
- Multiple “control” units
- Span range of seasons
- Consistent personnel

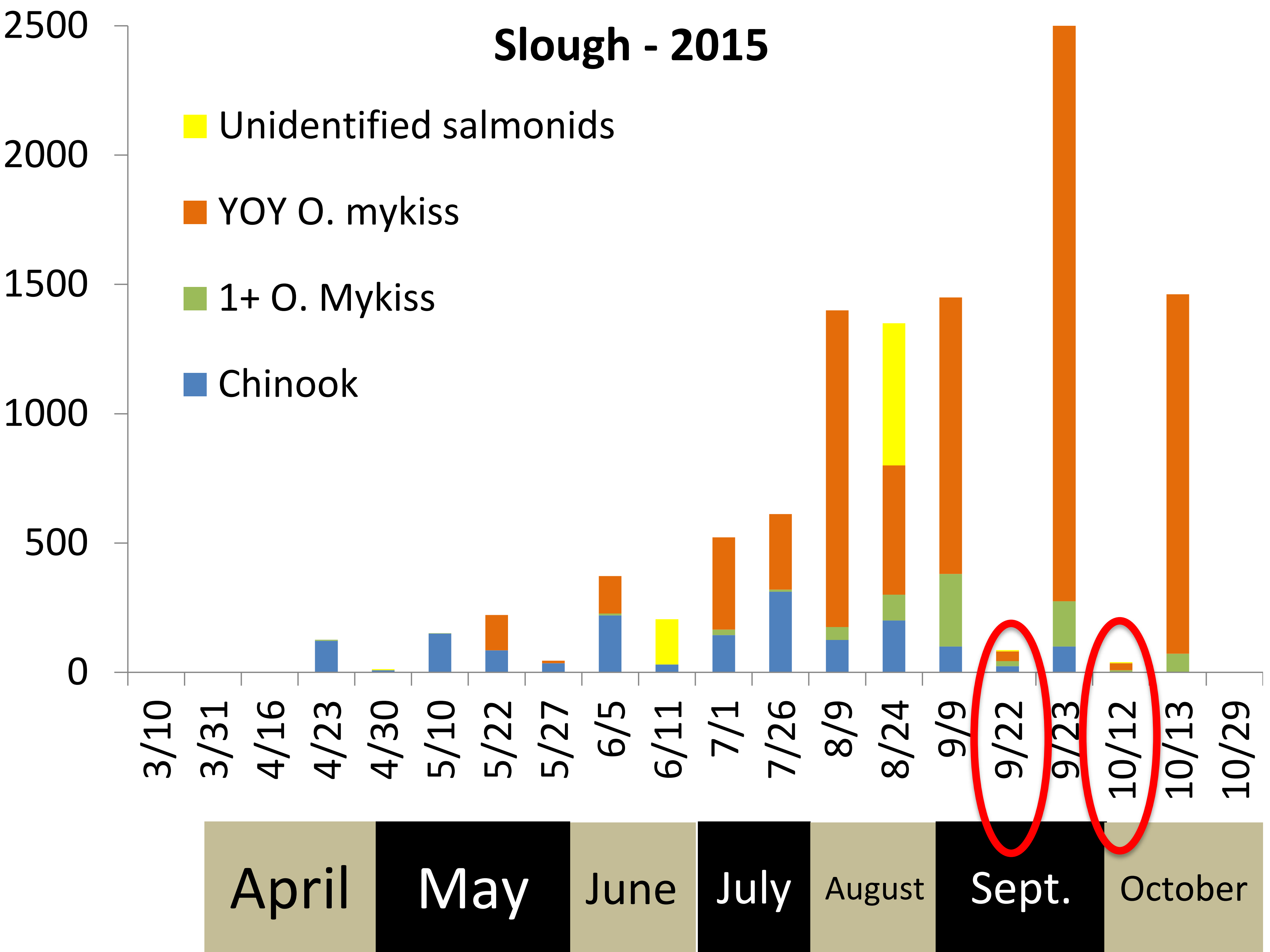

"Slough"
December 10, 2014


"Slough"
December 13, 2014

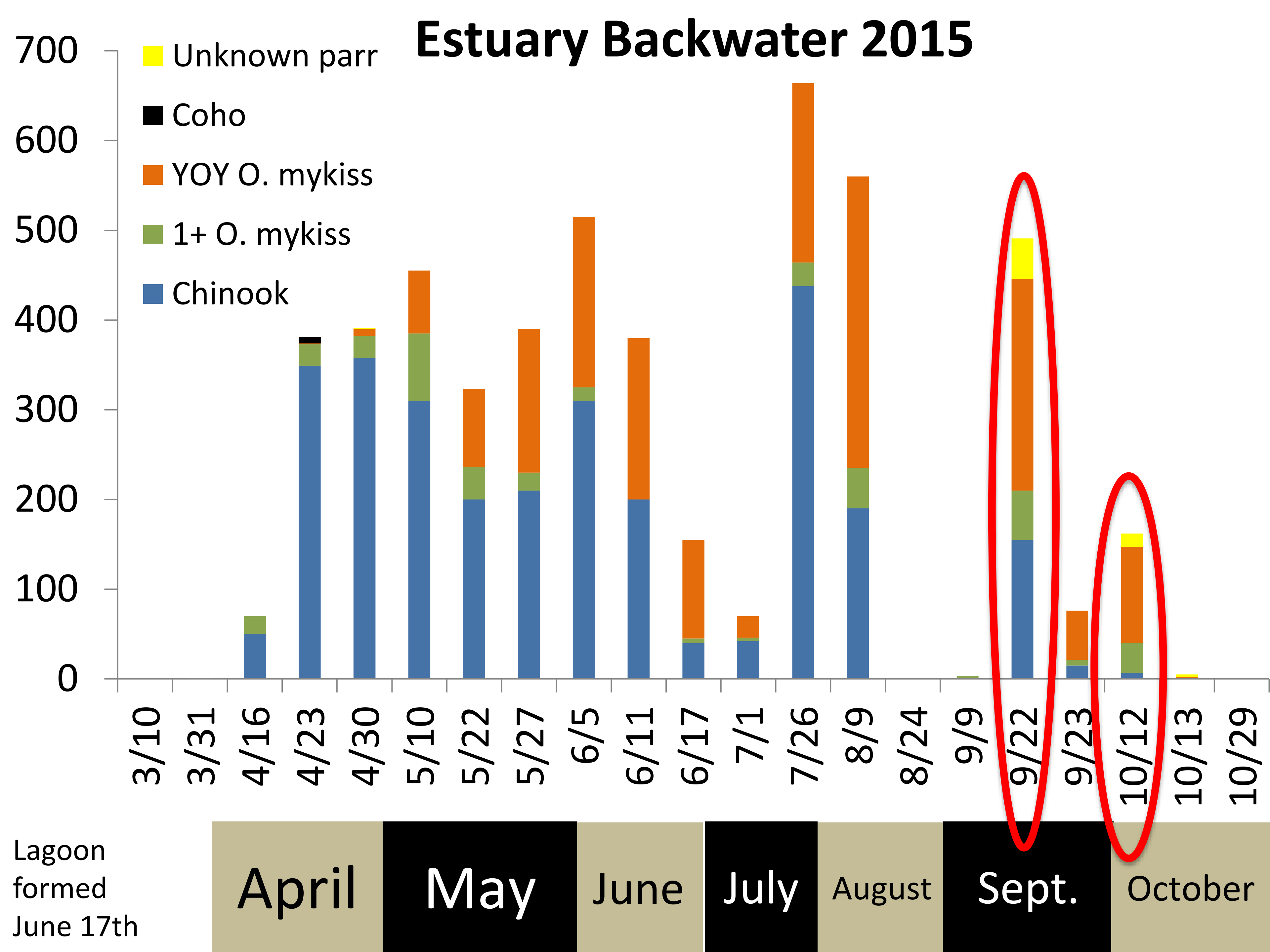
“Slough”

“Estuary Backwater”

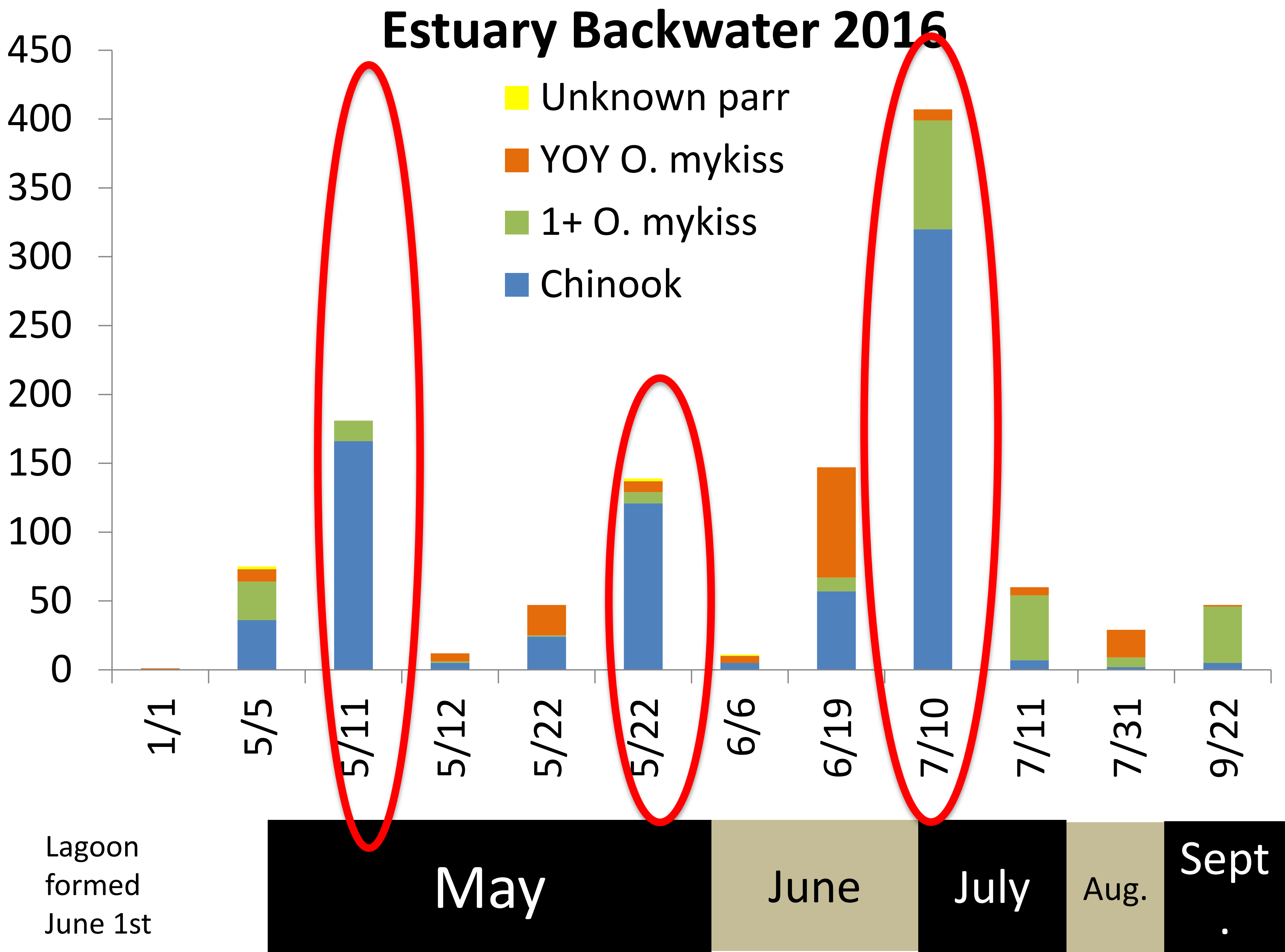
“Wetland Channel” – upstream of slough



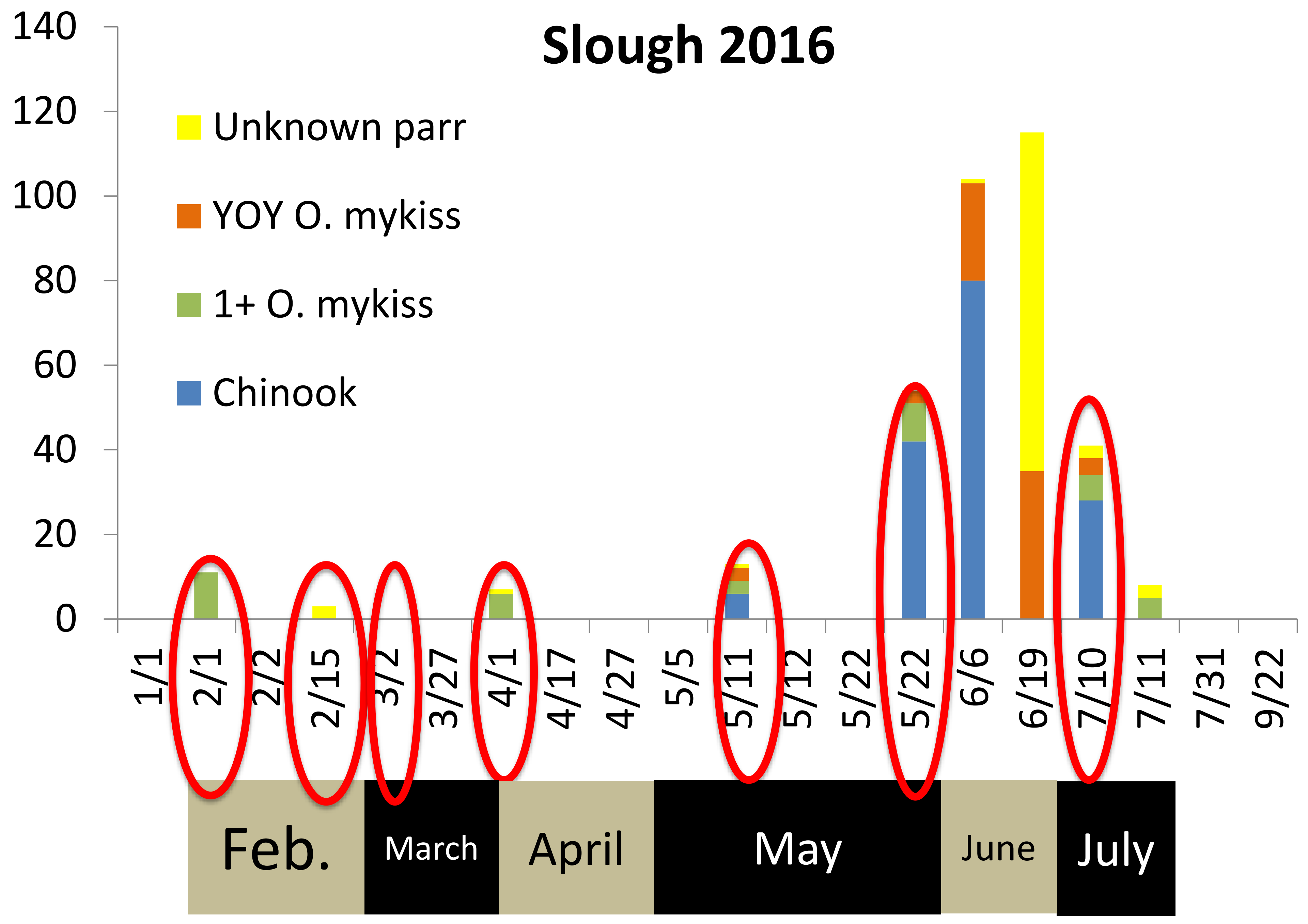
Slough - 2015
Unidentified salmonids
YOY O. mykiss
1+ O. Mykiss
Chinook
2500
2000
1500
1000
500
0
3/10
3/31
4/16
4/23
4/30
5/10
5/22
5/27
6/5
6/11
7/1
7/26
8/9
8/24
9/9
9/22
9/23
10/12
10/13
10/29
April
May
June
July
August
Sept.
October



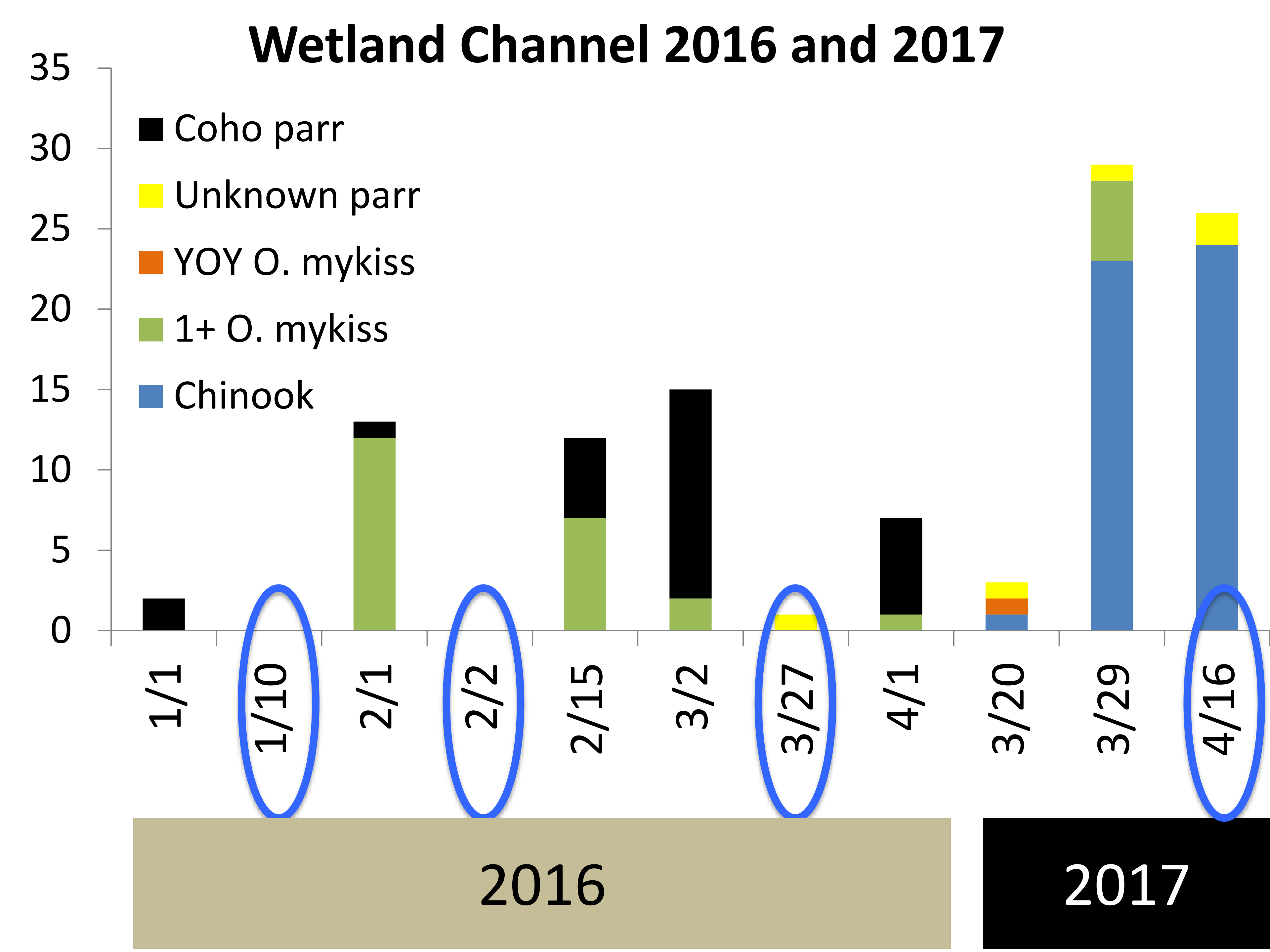
Estuary Backwater 2015
700
600
500
400
300
200
100
0
Unknown parr
Coho
YOY O. mykiss
1+ O. mykiss
Chinook
3/10
3/31
4/16
4/23
4/30
5/10
5/22
5/27
6/5
6/11
6/17
7/1
7/26
8/9
8/24
9/9
9/22
9/23
10/12
10/13
10/29
Lagoon formed June 17th
April
May
June
July
August
Sept.
October



Estuary Backwater 2016
450
400
350
300
250
200
150
100
50
0
Unknown parr
YOY O. mykiss
1+ O. mykiss
Chinook
1/1
5/5
5/11
5/12
5/22
5/22
6/6
6/19
7/10
7/11
7/31
9/22
Lagoon formed June 1st
May
June
July
Aug.
Sept.



Slough 2016
140
120
100
80
60
40
20
0
Unknown parr
YOY O. mykiss
1+ O. mykiss
Chinook
1/1
2/1
2/2
2/15
3/2
3/27
4/1
4/17
4/27
5/5
5/11
5/12
5/22
5/22
6/6
6/19
7/10
7/11
7/31
9/22
Feb.
March
April
May
June
July


Wetland Channel 2016 and 2017
35
30
25
20
15
10
5
0
Coho parr
Unknown parr
YOY O. mykiss
1+ O. mykiss
Chinook
1/1
1/10
2/1
2/2
2/15
3/2
3/27
4/1
3/20
3/29
4/16
2016
2017

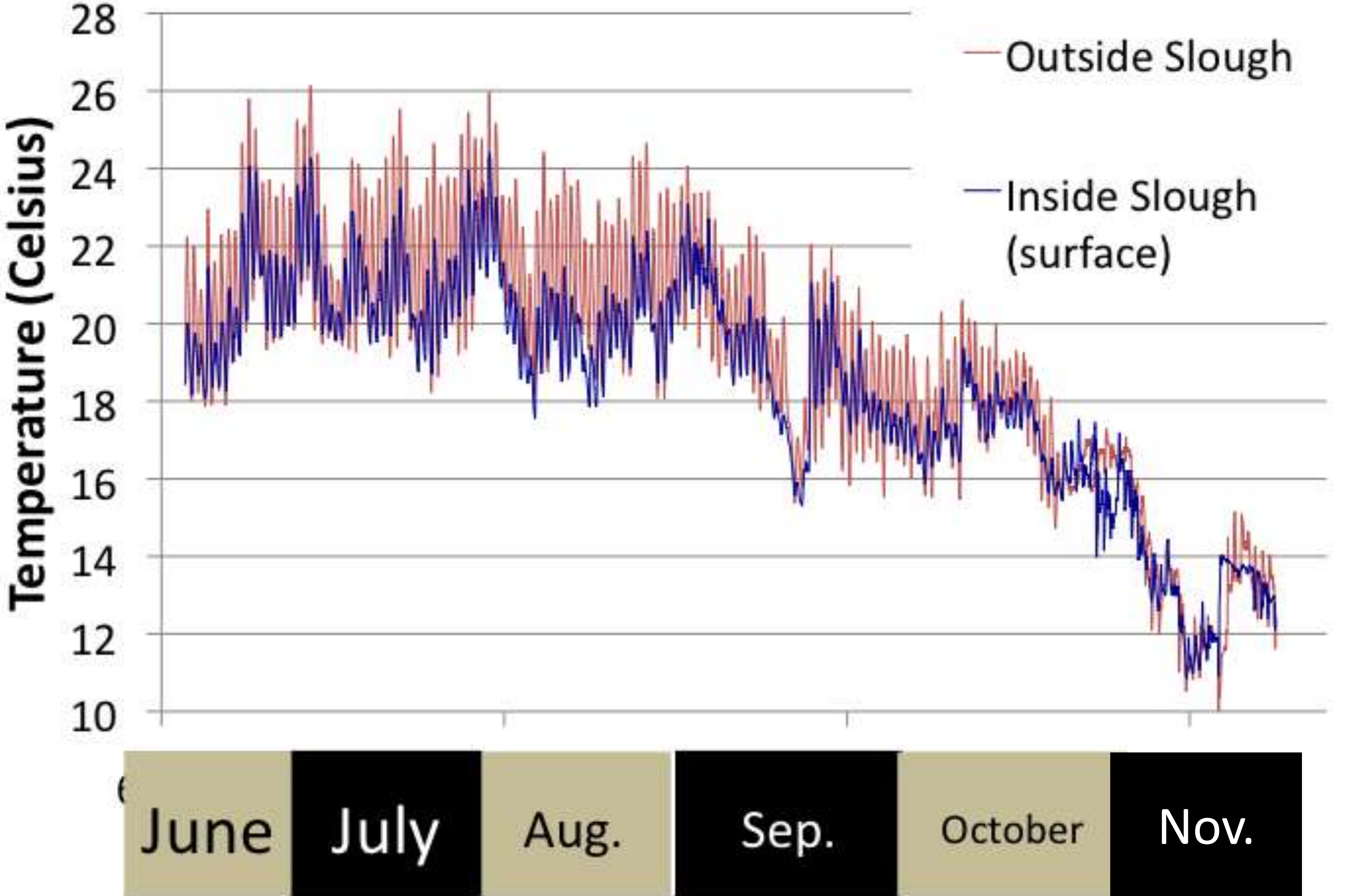


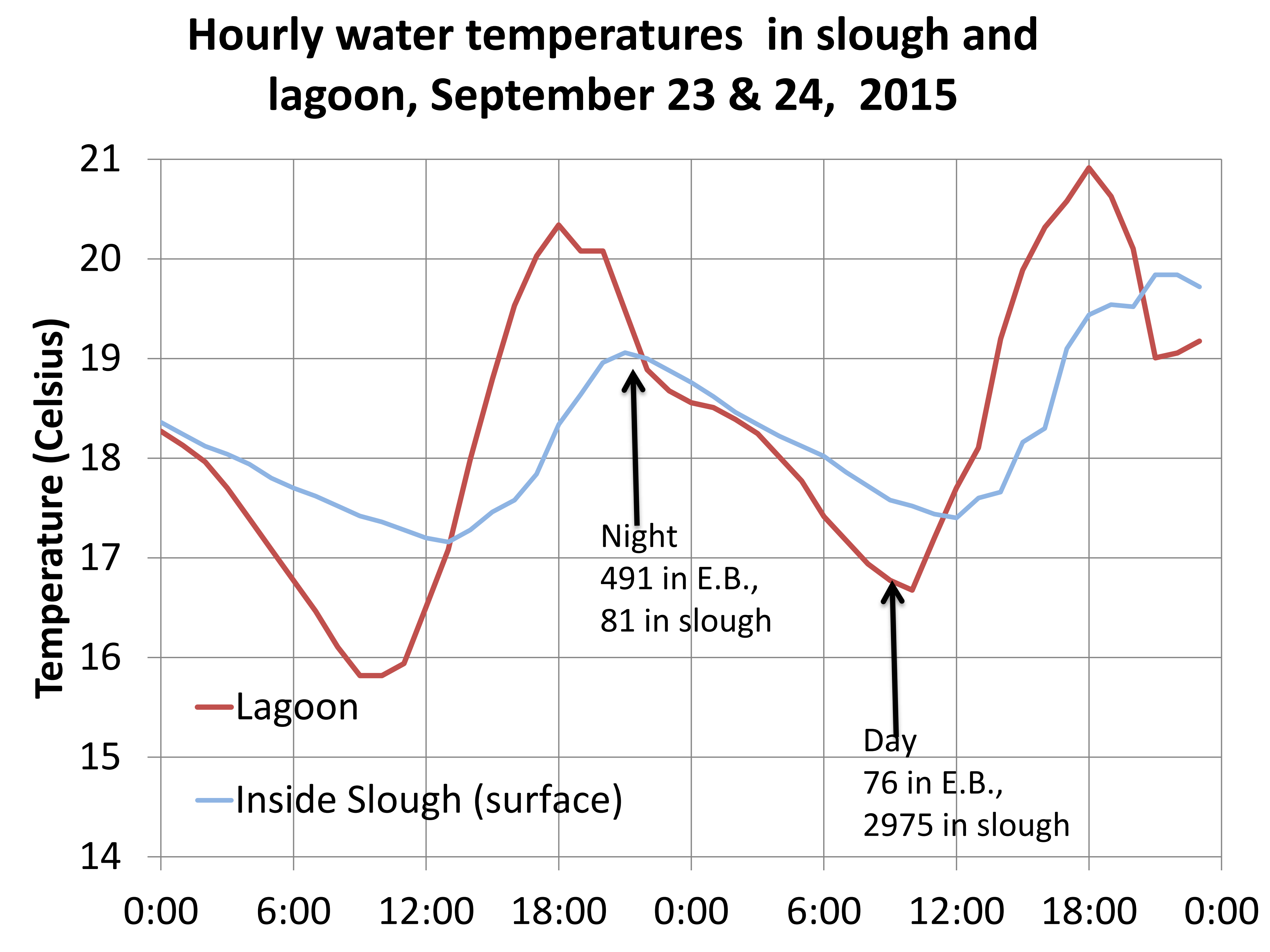
- Diurnal variation – fish disperse after dark, exhibit less cryptic behavior
- Diurnal variation - Fall of 2015, mass movement between slough and lagoon
- Seasonal variation – cryptic daytime behavior in winter/spring
- Seasonal variation – few fish in slough prior to ~May?
- Seasonal variation - sudden decrease in late summer/fall?
- Annual variation - Greatest number of fish seen in slough and estuary backwater in 2015, much fewer in 2016 and 2014, especially in slough
- Annual variation – coho in wetland channel in 2016, Chinook in 2017

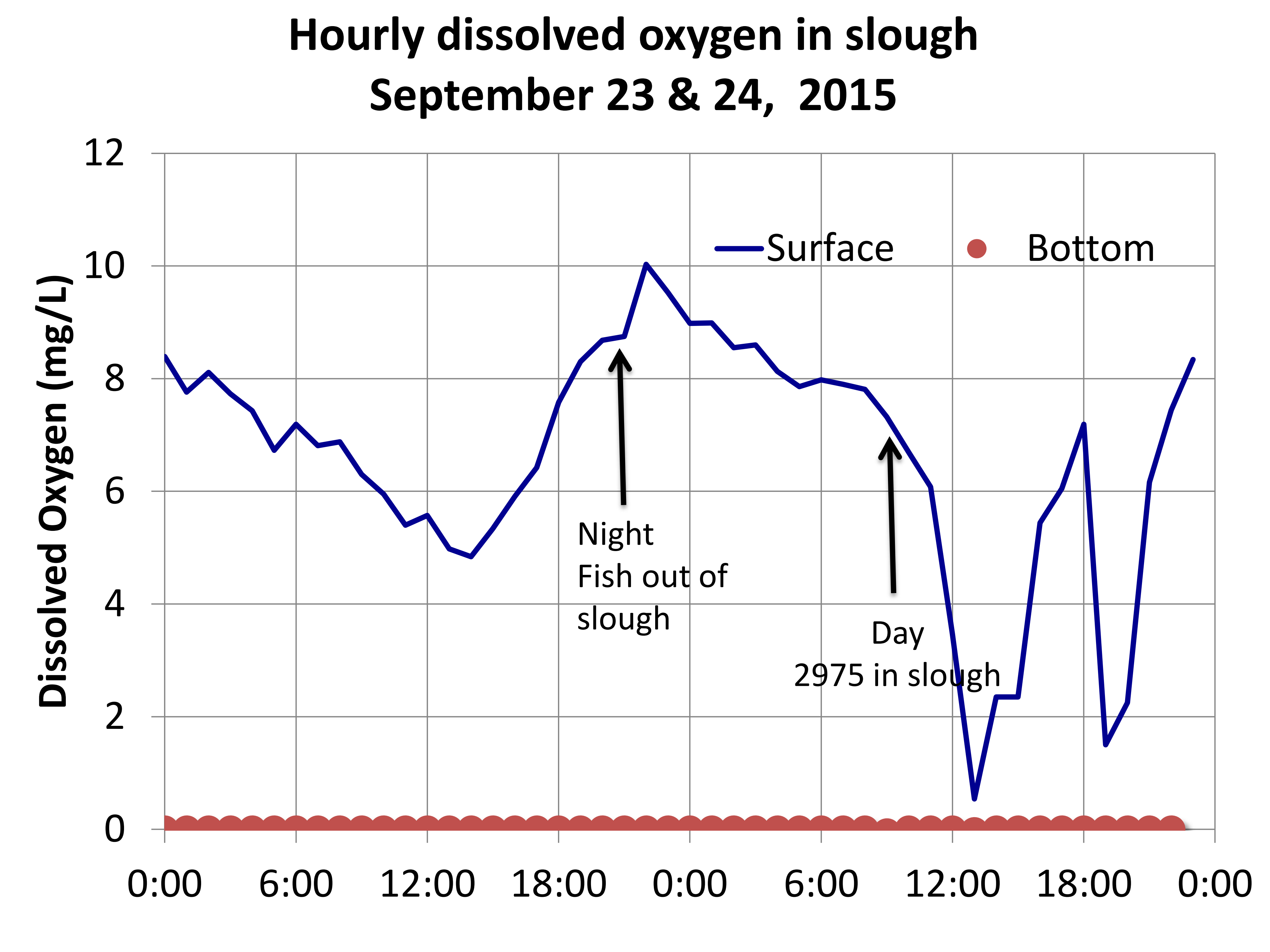
Potential explanations for observed variation in species abundance

- Water Quality
- Food
- Risk/predation
- Alternate habitat availability
- Fish abundance and proximity
- Detection probability

Hourly water temperatures in slough and lagoon/estuary, 2015




Hourly water temperatures in slough and lagoon, September 23 & 24, 2015
Temperature (Celsius)
21
20
19
18
17
16
15
14
0:00
6:00
12:00
18:00
0:00
6:00
12:00
18:00
0:00
Night
491 in E.B.,
81 in slough
Day
76 in E.B.,
2975 in slough
Lagoon
Inside Slough (surface)



Hourly dissolved oxygen in slough
September 23 & 24, 2015
Dissolved Oxygen (mg/L)
12
10
8
6
4
2
0
0:00
6:00
12:00
18:00
0:00
6:00
12:00
18:00
0:00
Surface
Bottom
Night
Fish out of
slough
Day
2975 in slough

Food?

Not becoming food?

September 10, 2015 – north bank of Mattole lagoon in dense Tule (*Scirpus sp.)*

Habitat expands and contracts - November 15, 2015, shortly before lagoon breach

- Climatic variability affects suitability of monitored habitat, and suitability of other habitats
- Climatic variability affects timing of fish movement and migration

Conclusions

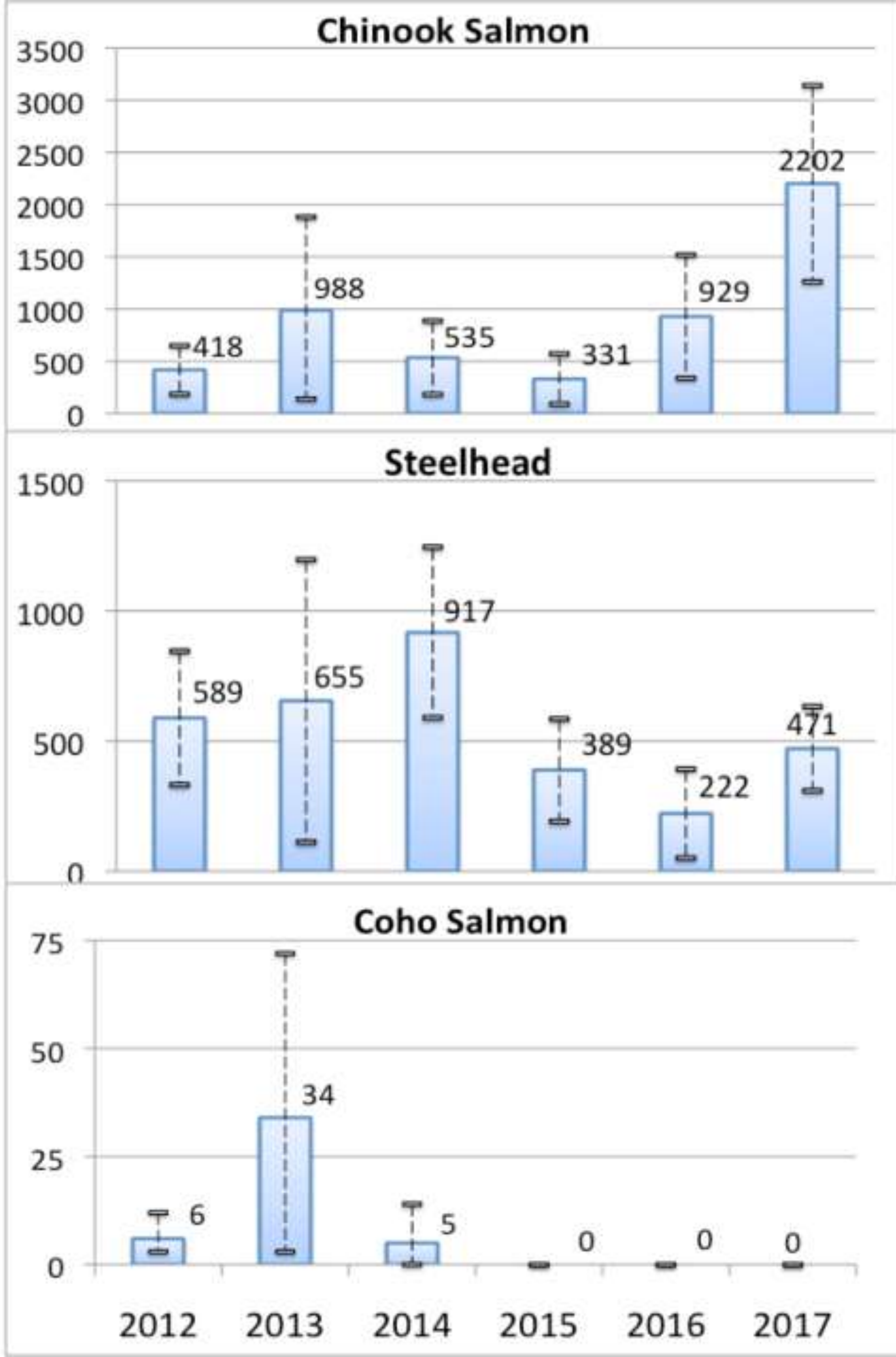
- Should a single habitat project be expected to serve multiple needs?

- Fish move around!
- “Control” sites add context
- Importance of multi-year monitoring
- Consider cryptic behavior
- Mask & snorkel – inexpensive and flexible approach to gathering rich data in clear water conditions, with limitations

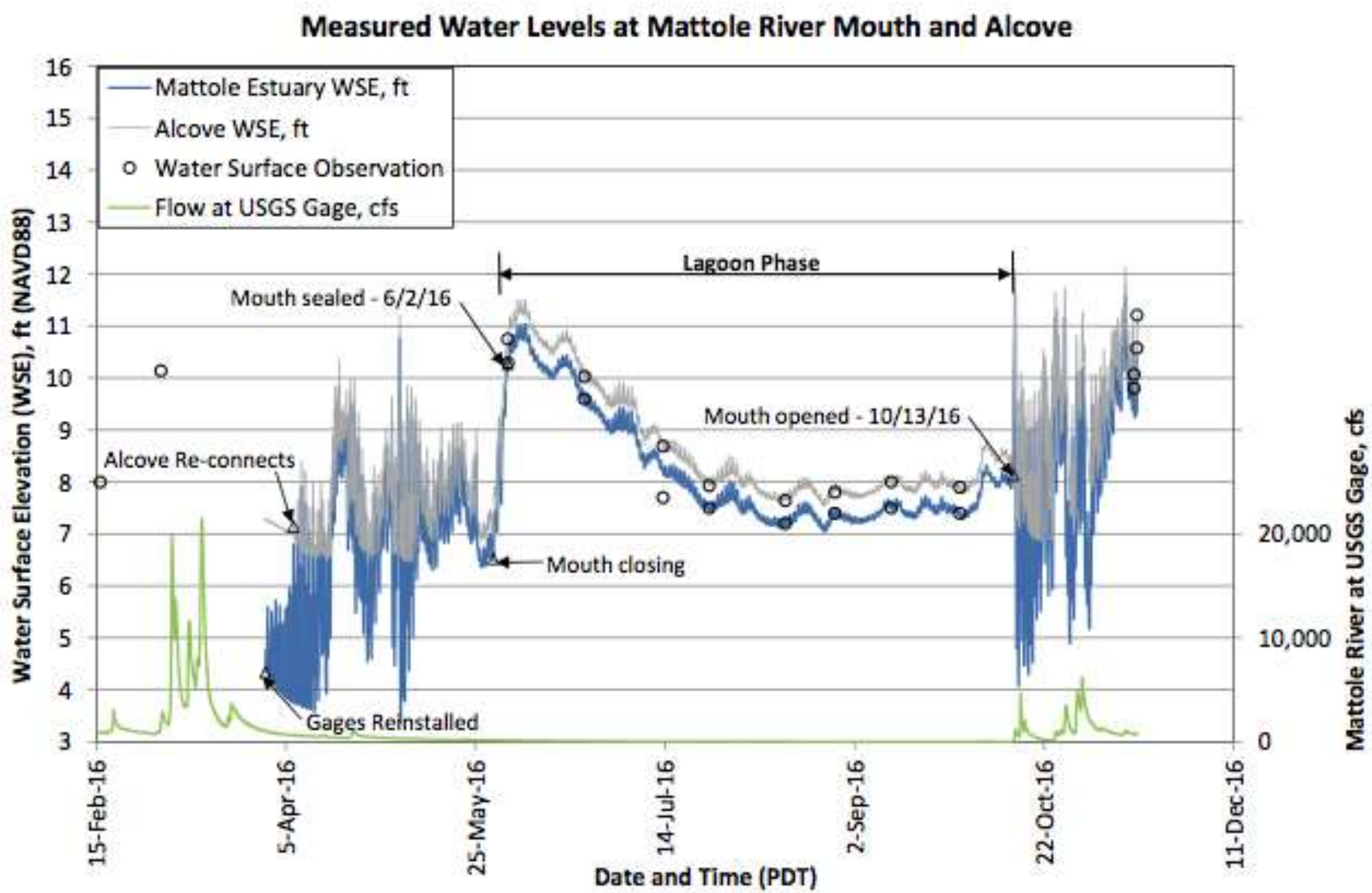
Thanks to:

- Bella Vista Foundation and the Arcata office of the Bureau of Land Management for funding monitoring work
- Sam Flanagan and Zane Ruddy at Arcata BLM
- Tony Llanos and Mike Love of Mike Love & Associates
- Field staff: Michelle Dow, Kate Cenci, Joe Sykes, Kris Schultz

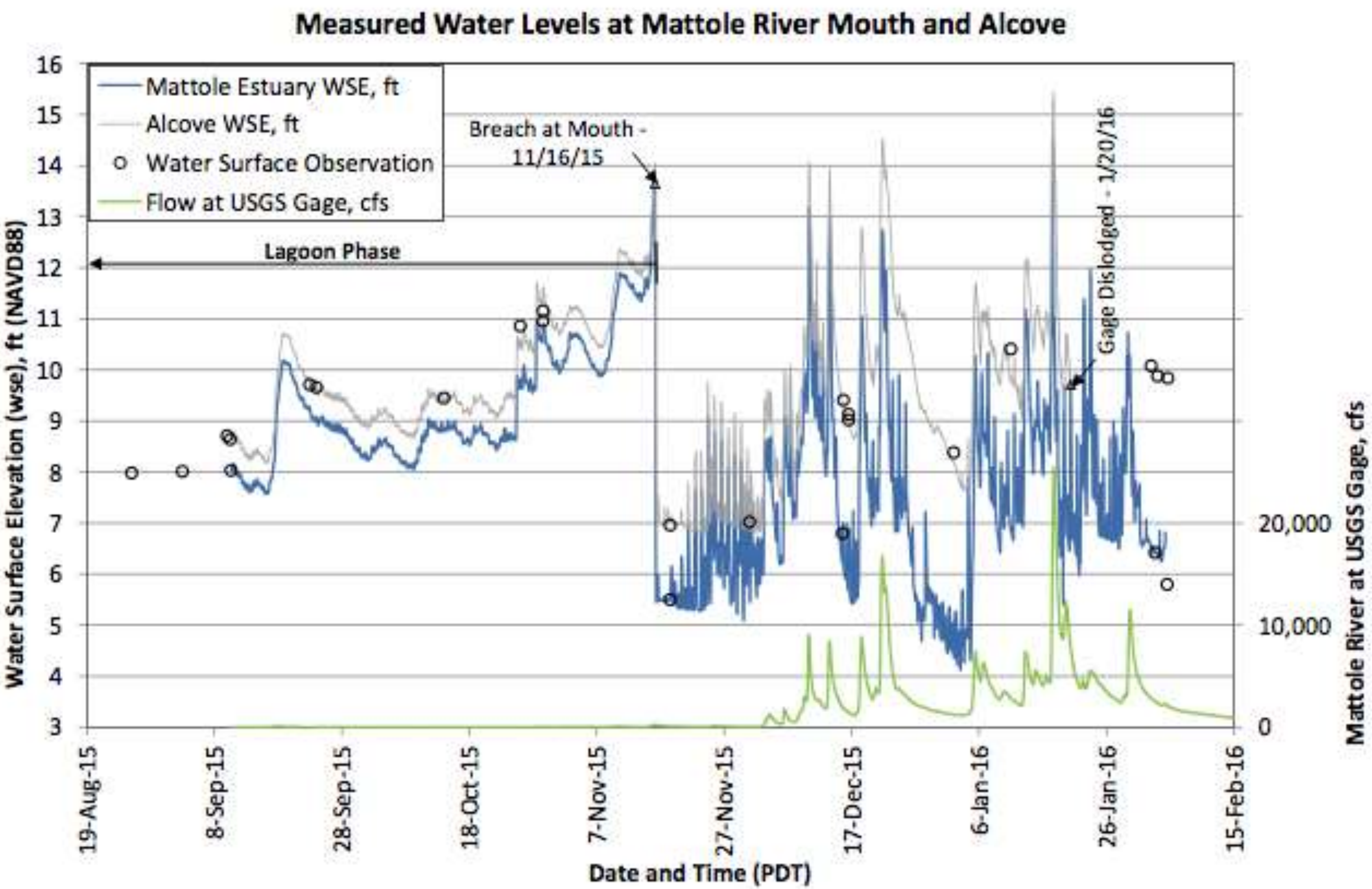

Photo by Michael Evenson



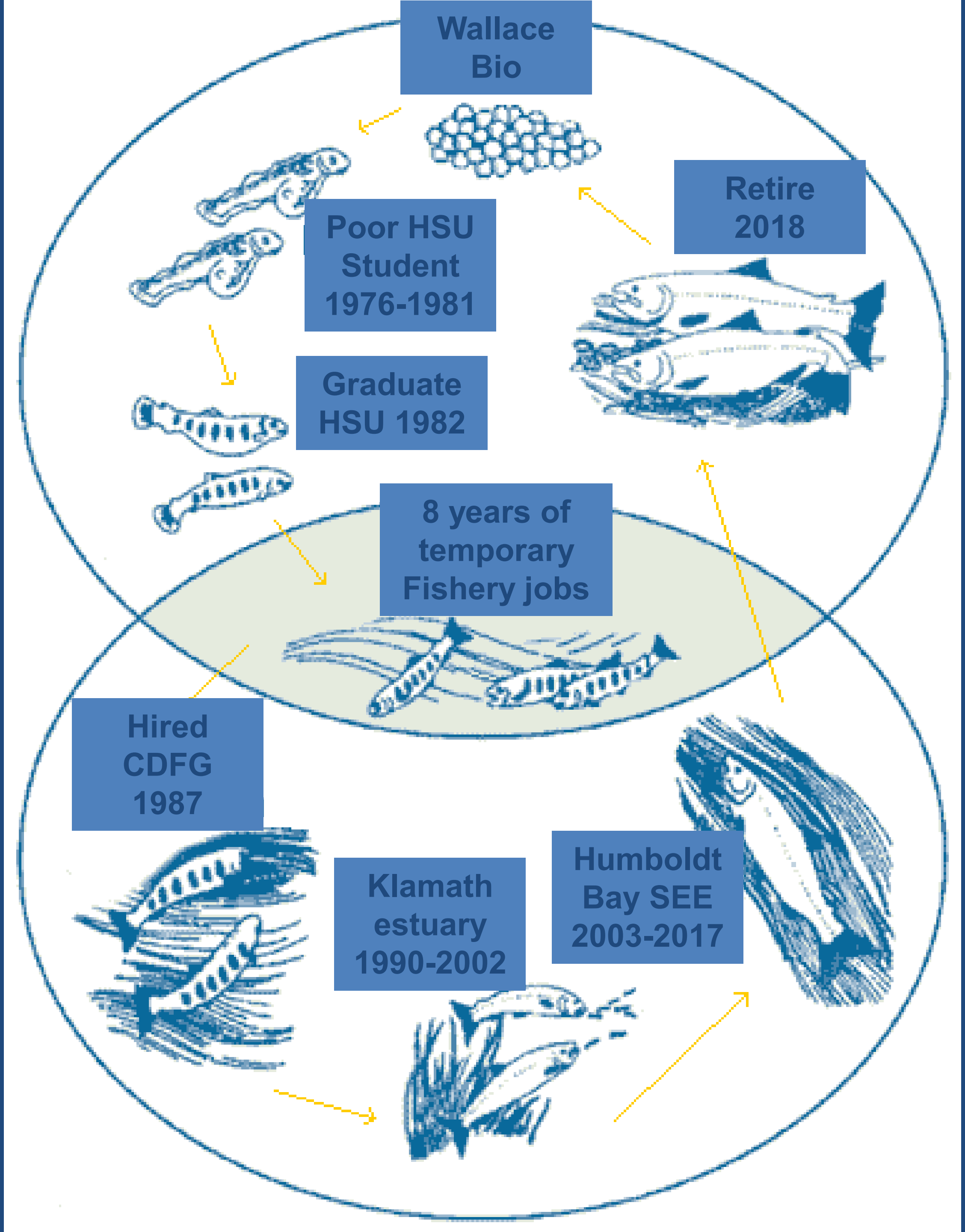
Chinook Salmon
3500
3000
2500
2000
1500
1000
500
0
418
988
535
331
929
2202
Steelhead
1500
1000
500
0
589
655
917
389
222
471
Coho Salmon
75
50
25
0
6
34
5
0
0
0
2012
2013
2014
2015
2016
2017



Measured Water Levels at Mattole River Mouth and Alcove
Mattole Estuary WSE, ft
Alcove WSE, ft
Water Surface Observation
Flow at USGS Gage, cfs
Lagoon Phase
Mouth sealed - 6/2/16
Mouth opened - 10/13/16
Alcove Re-connects
Mouth closing
Gages Reinstalled
Water Surface Elevation (WSE), ft (NAVD88)
Mattole River at USGS Gage, cfs
Date and Time (PDT)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
20,000
10,000
0
15-Feb-16
5-Apr-16
25-May-16
14-Jul-16
2-Sep-16
22-Oct-16
11-Dec-16

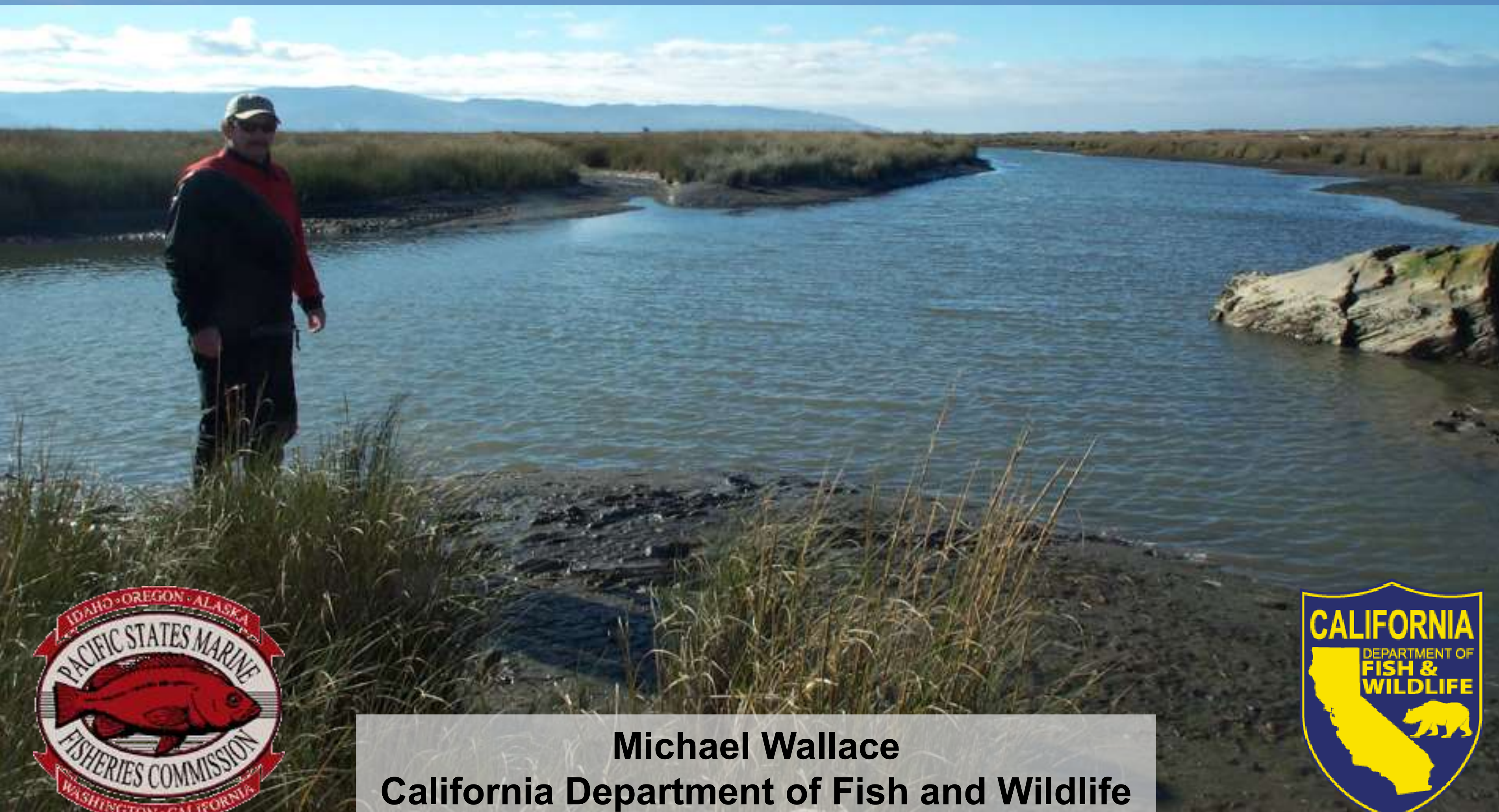


Measured Water Levels at Mattole River Mouth and Alcove
Mattole Estuary WSE, ft
Alcove WSE, ft
Water Surface Observation
Flow at USGS Gage, cfs
Breach at Mouth - 11/16/15
Gage Dislodged - 1/20/16
Lagoon Phase
Water Surface Elevation (wse), ft (NAVD88)
Mattole River at USGS Gage, cfs
Date and Time (PDT)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
20,000
10,000
0
19-Aug-15
8-Sep-15
28-Sep-15
18-Oct-15
7-Nov-15
27-Nov-15
17-Dec-15
6-Jan-16
26-Jan-16
15-Feb-16


Wallace Bio
Poor HSU Student 1976-1981
Graduate HSU 1982
8 years of temporary Fishery jobs
Hired CDFG 1987
Klamath estuary 1990-2002
Humboldt Bay SEE 2003-2017
Retire 2018

The Old Man and the SEE:

Lessons Learned From 15 Years of Coho Salmon Life History and Habitat Restoration Monitoring in the Stream-Estuary Ecotone



Michael Wallace
California Department of Fish and Wildlife

Presentation Outline

- Evolution in recognizing Coho use of stream-estuary ecotone (SEE)
- Coho life history strategies and habitat needs in the SEE
- SEE habitat restoration project monitoring
- SEE habitat restoration project suggestions
- Three general recommendations

What took so long?

The Recent Past

Groot and Margolis (1991). Pacific Salmon Life Histories
No mention of estuary residence by Coho Salmon

"Project captured very few sub-yearling coho in the estuary, so it appears that very few use the estuary for rearing."

Wallace (2003). Juvenile Salmonid Emigration From the Klamath River Basin

"Coho Salmon fry found in estuaries have generally been regarded as surplus to the carrying capacity of the stream and assumed to perish at sea."

Quinn (2005). Behavior & Ecology of Pacific Salmon & Trout

Present Day

Miller, B.A. and S. Sadro. 2003. Residence time and seasonal movements of juvenile coho salmon in the ecotone and lower estuary of Winchester Creek, South Slough, Oregon. Transactions of the American Fisheries Society 132(3): 546-559.

Koski, K.V. 2009. The fate of coho salmon nomads: the story of an estuarine-rearing strategy promoting resilience. Ecology and Society 14 (1): 4.

Jones, K.K., T.J. Cornwell, D.L. Bottom, L.A. Campbell, and S. Stein. 2014. The contribution of estuary-resident life histories to the return of adult *Oncorhynchus kisutch*. Journal of fish biology 85(1): 52-80.

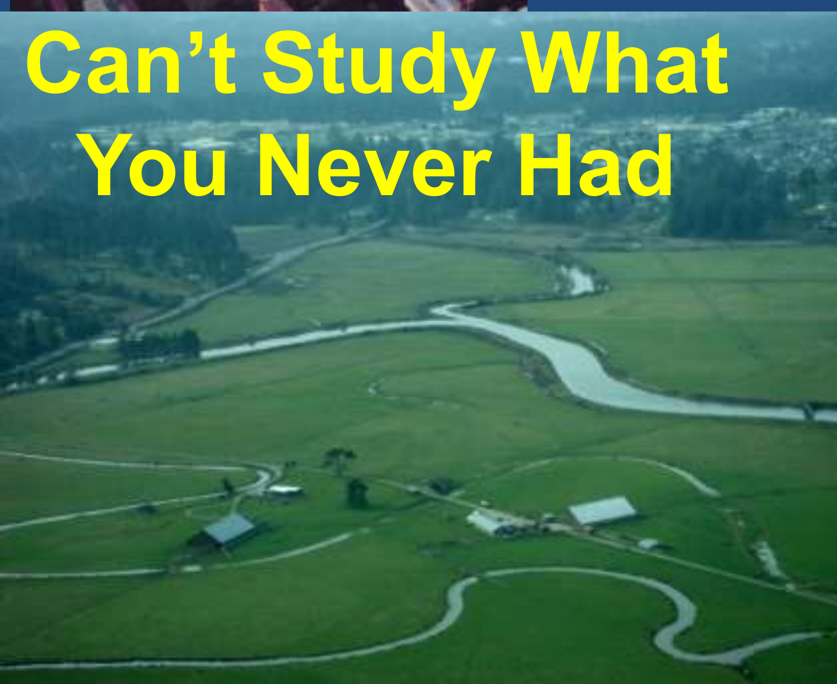
Wallace, M., S. Ricker, J. Garwood, A. Frimodig, and S. Allen. 2015. Importance of the stream-estuary ecotone to juvenile coho salmon (*Oncorhynchus kisutch*) in Humboldt Bay, California. California Fish and Game 101(4): 241-266; 2015.

Stream-Estuary Ecotone Importance to Coho Salmon

- Prolonged residence
- Used by multiple life stages
- Good growth/survival
- Substantial portion of population uses habitat
- Provides habitat during stressful periods

Why did we miss the importance of estuaries to Coho Salmon?

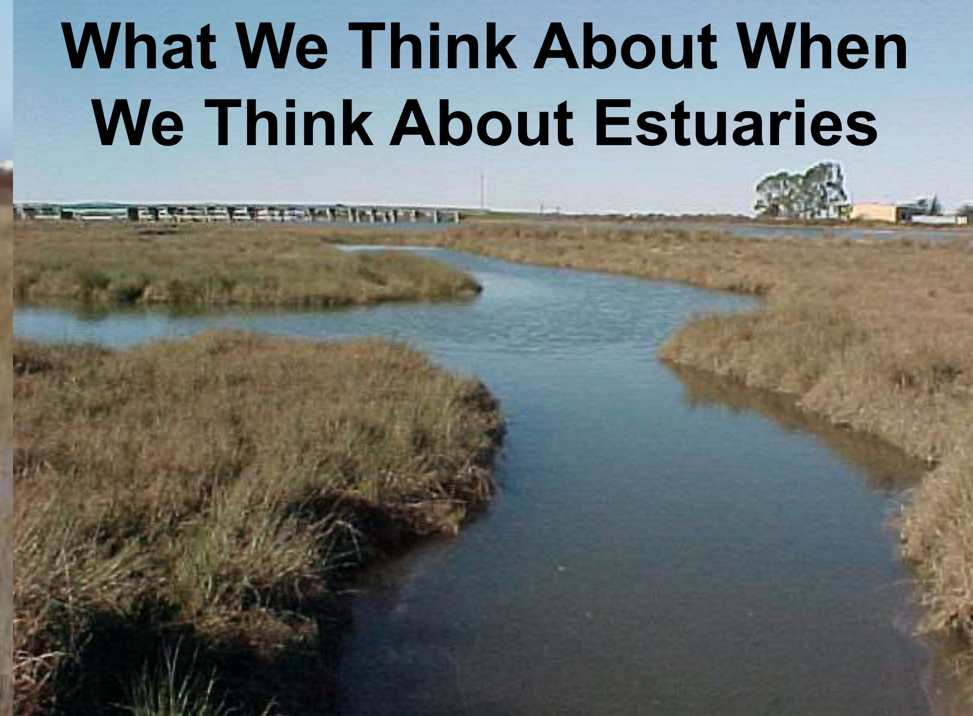
Can’t Study What You Never Had



Hard to Sample

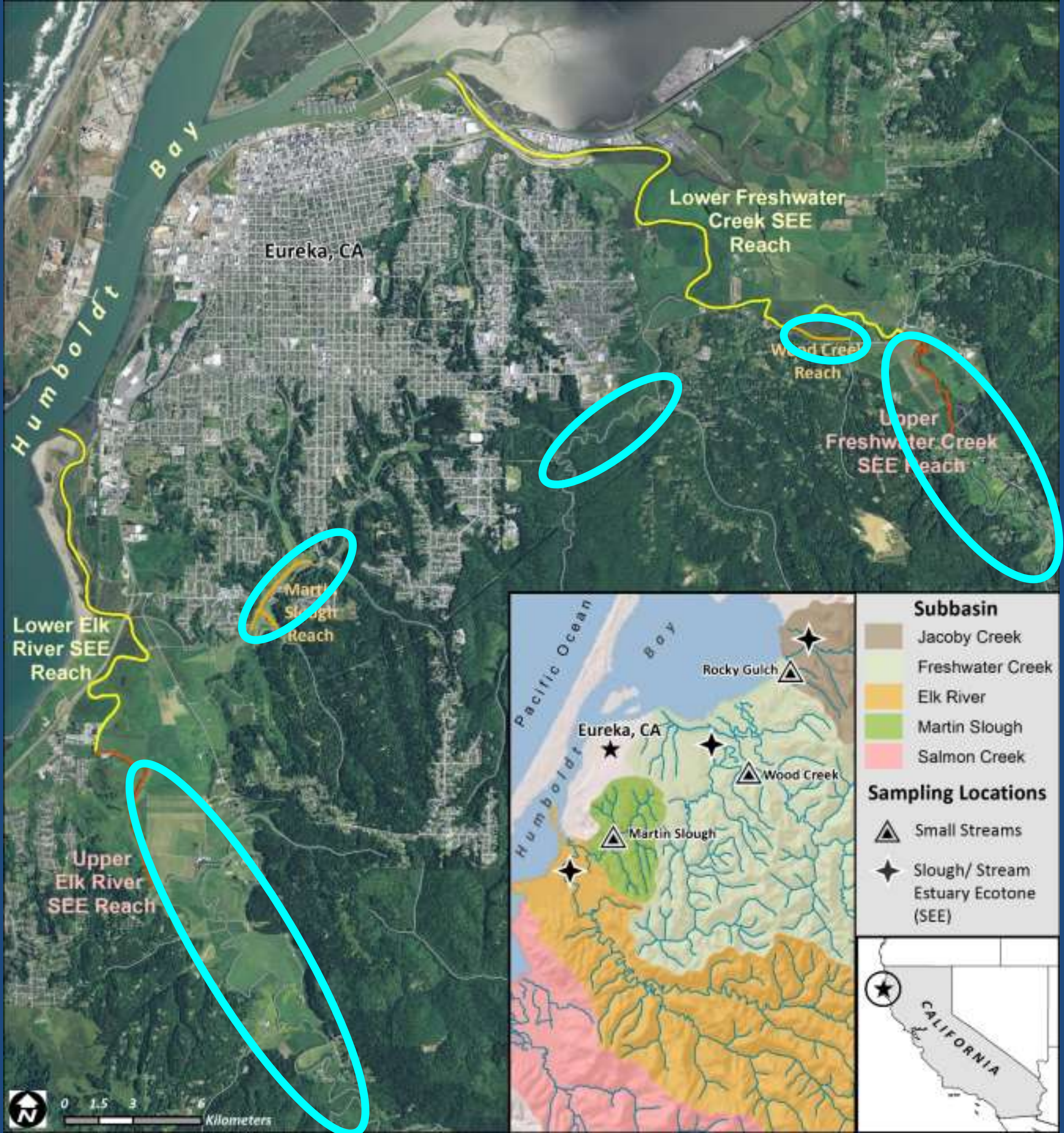
Traditional Techniques Ineffective

What We Think About When We Think About Estuaries



Looking for Coho in all the Wrong Places



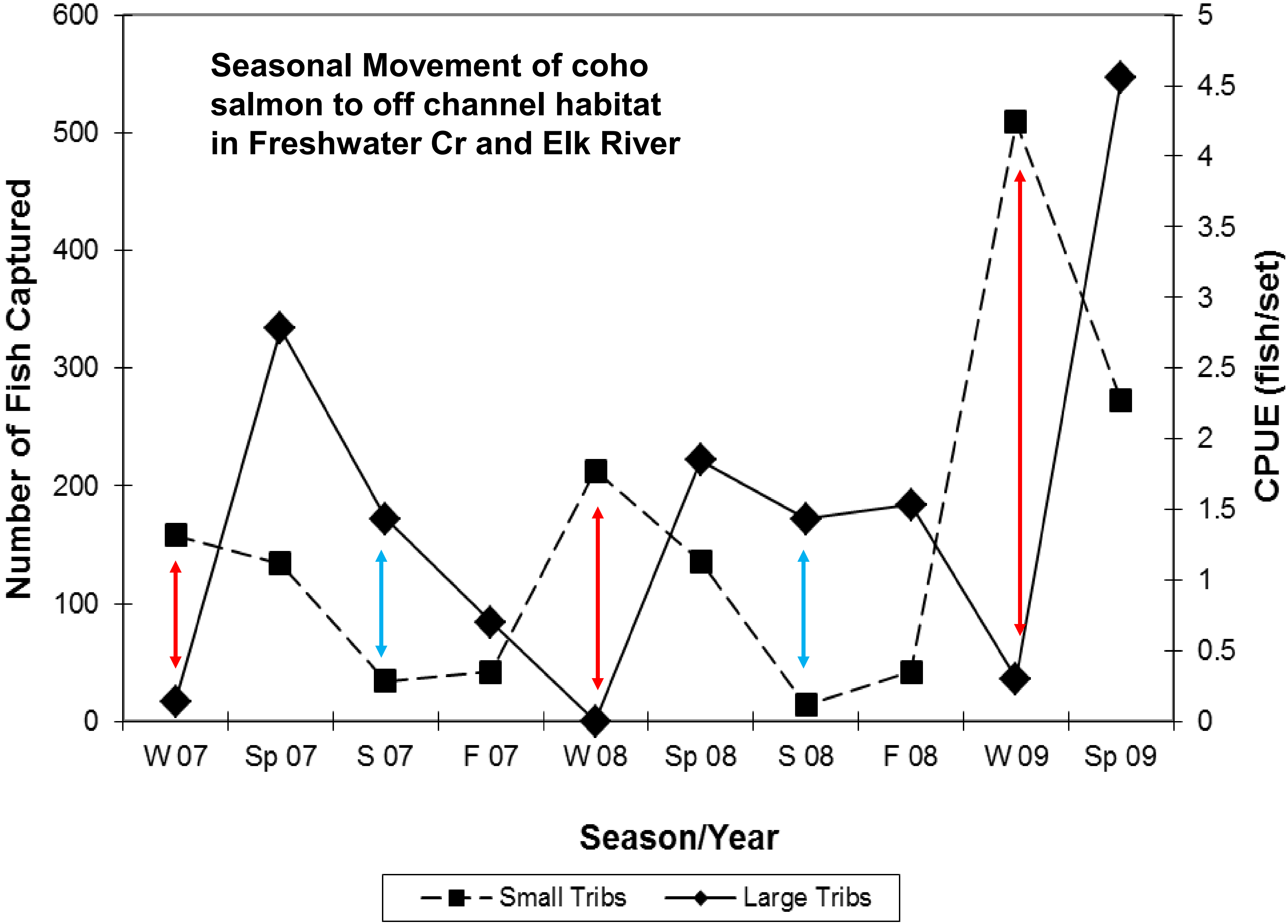
Humboldt Bay
Eureka, CA
Lower Freshwater Creek SEE Reach
Wood Creek Reach
Upper Freshwater Creek SEE Reach
Martin Slough Reach
Lower Elk River SEE Reach
Upper Elk River SEE Reach
0 1.5 3 6 Kilometers
Pacific Ocean
Bay
Humboldt
Rocky Gulch
Eureka, CA
Wood Creek
Martin Slough
Subbasin
Jacoby Creek
Freshwater Creek
Elk River
Martin Slough
Salmon Creek
Sampling Locations
Small Streams
Slough/ Stream Estuary Ecotone (SEE)
CALIFORNIA

Location More Important Than Land Use?


#10 TEE
RIDING CARTS

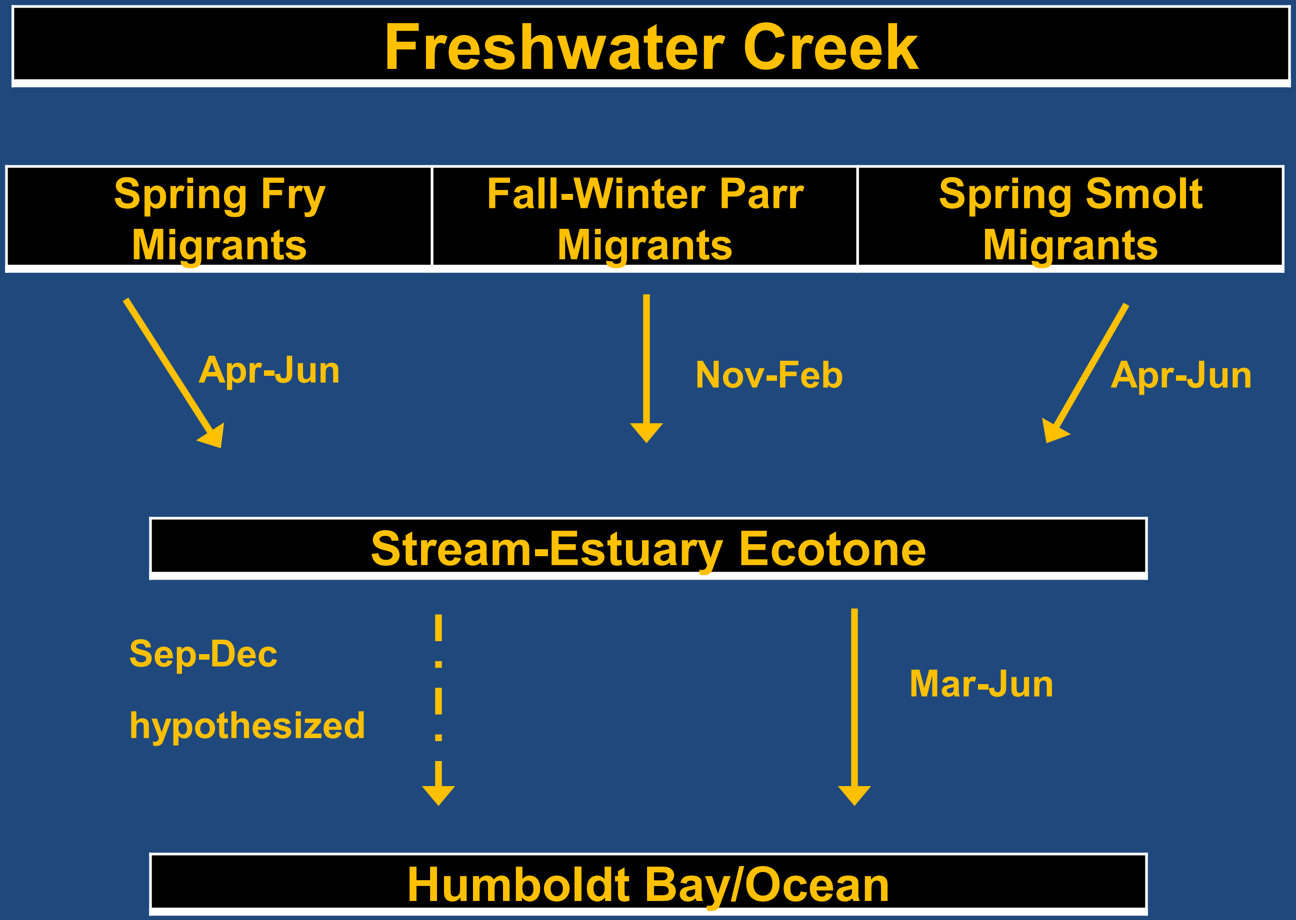
Looking for Coho in All the Wrong Seasons

Coho Salmon Life History and Habitat Requirements



Seasonal Movement of coho salmon to off channel habitat in Freshwater Cr and Elk River
Number of Fish Captured
CPUE (fish/set)
600
500
400
300
200
100
0
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
W 07
Sp 07
S 07
F 07
W 08
Sp 08
S 08
F 08
W 09
Sp 09
Season/Year
Small Tribs
Large Tribs

Basic Coho Salmon Life Histories



Needed Habitat Conditions for Coho

- Cool water <18°C
- Fresh water for sub-yearling; can be brackish for yearling-plus
- Dissolved Oxygen >3.5 mg/l
- Water depth >1.5 feet
- Low current velocity
- Need access/connection

Estuarine Habitat Restoration









Effectiveness Monitoring

Determines if actions had desired effects on watershed, physical processes, or habitat (i.e. did pool area increase?)

Roni (2005)

Do we have the right data to make correct conclusions?


South Slough, Coos Bay Oregon


South Slough, Coos Bay Oregon





Before


After

Which one is better?


Lower Jacoby Cr Pond


Upper Jacoby Cr Pond

Number of Juvenile Salmonids Captured in Jacoby Cr Ponds and Stream

Season	Upper Pond		Lower Pond		Jacoby Cr	
	CO	SH	CO	SH	CO	SH
Jan-Nov 2015	n/a	n/a	0	0	19	16
December 2015	0	0	0	0	high flow	high flow
Jan-Mar 2016	248 (63)	14 (2)	6	0	0	2
Jan-Mar 2017	215 (18)	21 (2)	1	1	0	0
Total	463 (81)	35 (4)	(7)	(1)	19	18

Numbers in parentheses are amount captured in minnow traps

Date	Site	Water Temp (°C)	Cond (uS/cm)	DO mg/l
January '16	Lower Pond Upper Pond	11.8 11.1	114.4 92.2	8.47 9.14
February '16	Lower Pond Upper Pond	12.2 10.8	131.9 97.3	8.52 7.90
March '16	Lower Pond Upper Pond	11.5 9.7	105.3 80.3	6.06 8.14
April '16	Lower Pond Upper Pond	13.7 14.6	122.4 112.6	3.87 7.06
May '16	Lower Pond Upper Pond	14.1 15.3	111.6 143.6	**2.62** 7.21
June '16	Lower Pond Upper Pond	16.4 18.5	119.5 200.7	**2.10** 5.32
January '17	Lower Pond Upper Pond	7.5 7.0	102.9 91.0	**3.10** 8.63
February 17	Lower Pond Upper Pond	9.5 8.4	62.5 71.1	5.52 9.16
March '17	Lower Pond Upper Pond	9.8 10.9	102.9 83.8	**2.04** 8.45
April '17	Lower Pond Upper Pond	12.3 11.1	118.3 85.0	3.86 8.12
May '17	Lower Pond Upper Pond	12.9 10.6	109.3 84.2	**3.32** 8.14
June '17	Lower Pond Upper Pond	11.6 11.9	80.0 94.6	**3.06** 7.11

Room To Move

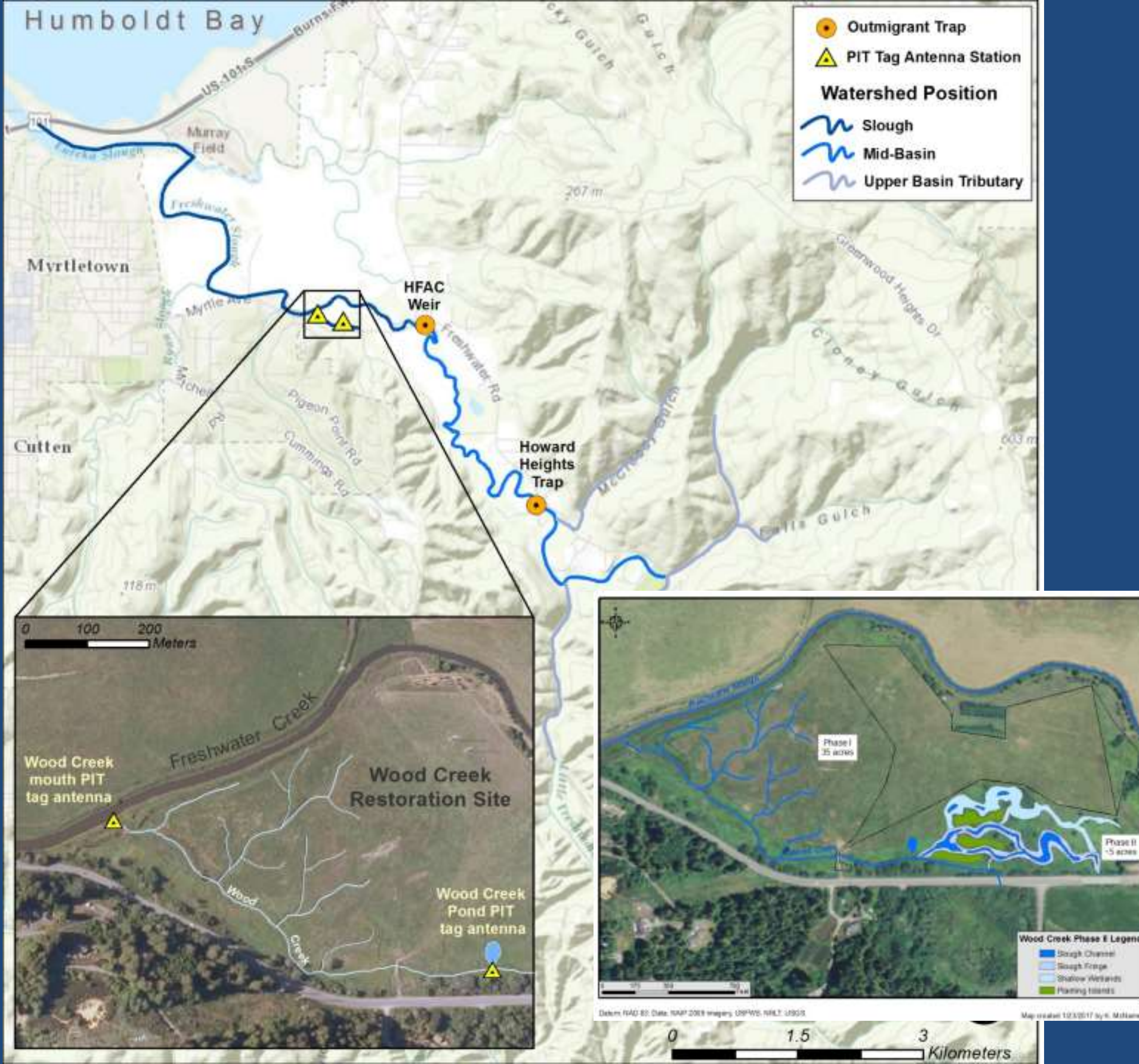
SEE Habitat is Ephemeral

Nothing Stays the Same

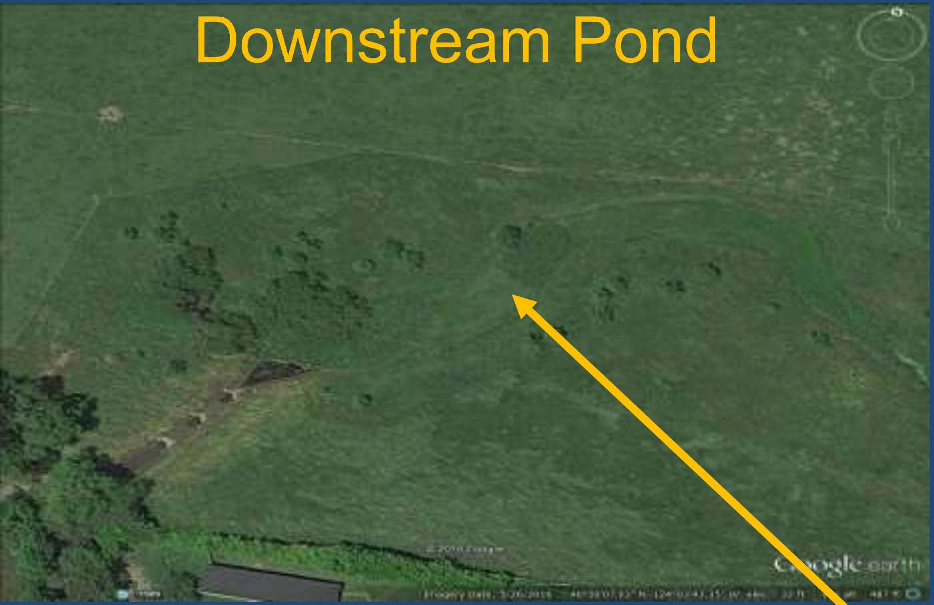
Spread Out!

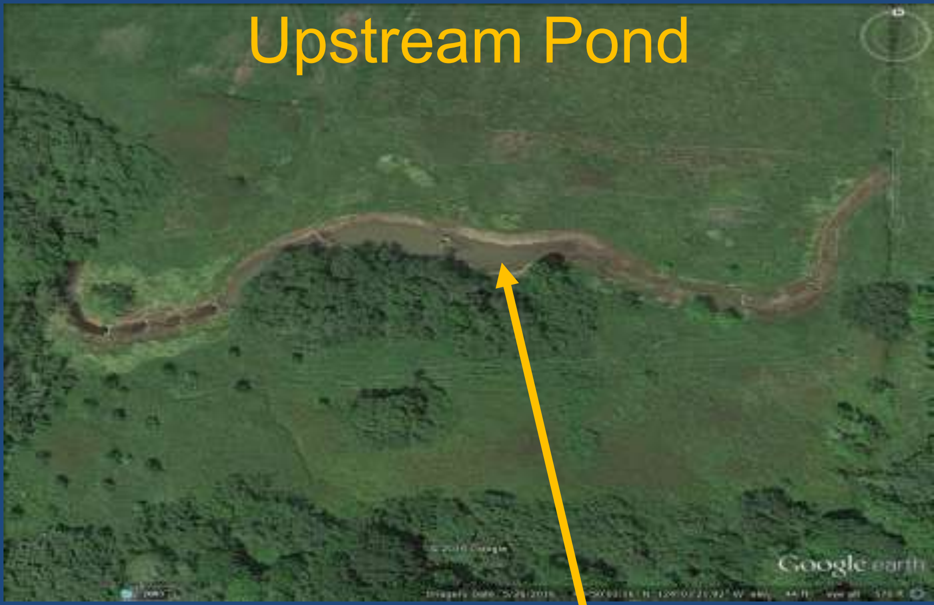
Project Envy

Is it big enough?



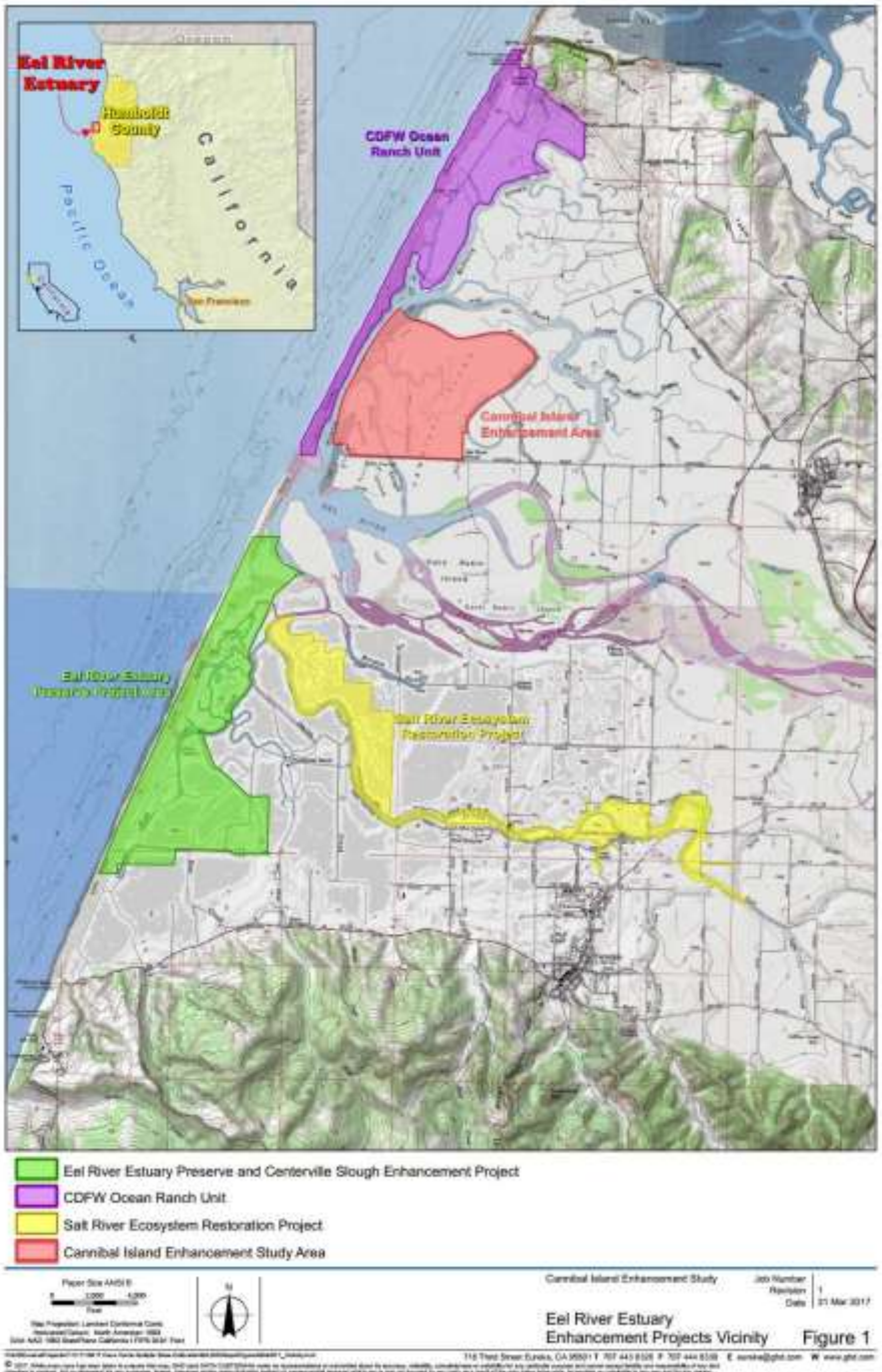
Humboldt Bay
US-101-S
Murray Field
Eureka Slough
Freshwater Slough
Myrtletown
Myrtle Ave
Cutten
HFAC Weir
Freshwater Rd
Pigeon Point Rd
Cummings Rd
Howard Heights Trap
Greenwood Heights Dr
Cloney Gulch
Falls Gulch
267 m
118 m
Outmigrant Trap
PIT Tag Antenna Station
Watershed Position
Slough
Mid-Basin
Upper Basin Tributary
0 100 200 Meters
Freshwater Creek
Wood Creek mouth PIT tag antenna
Wood Creek Restoration Site
Wood Creek
Wood Creek Pond PIT tag antenna
Phase I 35 acres
Phase II ~5 acres
Wood Creek Phase II Legend
0 1.5 3 Kilometers





Jacoby Creek Off-Channel Ponds

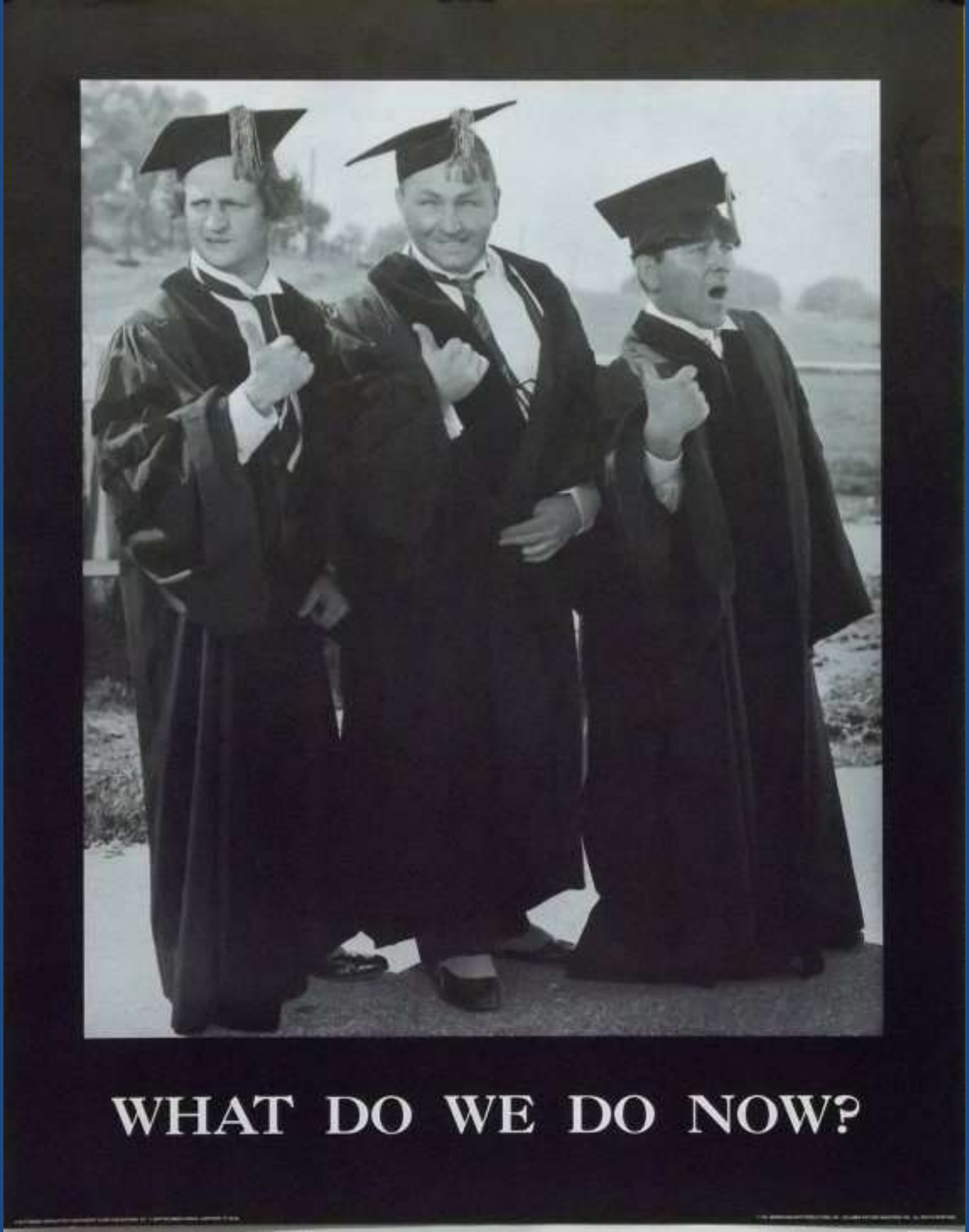
Jacoby Creek Estuary



Roni et al 2011- "*Our study demonstrates that considerable restoration is needed to produce measurable changes in fish abundance on a watershed scale*"

(At least 20% of watershed to detect 25% increase in population)

Connect the Dots


WHAT DO WE DO NOW?

Estuaries: The Poor Step-Child of Salmonid Management

Include Estuary/SEE Habitat in:

- CDFW Habitat Restoration Manual
- CMP Sampling Protocols
- CMP Habitat Protocols

Permitting to Allow Maintenance

SEE Habitat is Ephemeral

Ephemeral doesn't have to mean forever (in fact it doesn't mean that at all)

Ephemeral in a fixed location won't work

Self maintaining off channel projects unlikely in the SEE

New direction or ideas are needed to permit off channel habitat projects.

Centralized Coordinated Monitoring

- Consistent monitoring techniques
- Trained experienced field crews
- Can ask specific questions or target specific or new restoration techniques
- Potential savings in monitoring cost which would result in more money spent on actual restoration work or less expensive projects

Restoration Project Monitoring

- McDaniel Slough/Janes Creek
- Gannon Slough
- Jacoby Creek Marsh
- Jacoby Creek Off-Channel Ponds
- Rocky Gulch
- Fay Slough/Cochrane Creek
- Wood Creek
- Martin Slough
- Salmon Creek Estuary
- McNulty Slough (Eel River Estuary)
- Additional life history monitoring in Freshwater Creek, Ryan Creek, Elk River and Hookton sloughs

Who is qualified to do monitoring?

State/Federal/Local Agencies

Tribal Fisheries Departments

Non Profit Natural Resource Organizations

Private Consultants

Contact Regulating Agencies if you think this is a good idea


Photo by Thomas Dunklin

Questions?

Fish Passage Effectiveness Monitoring

Ross Taylor and Associates (RTA)

Leah Mahan, NOAA Restoration Center

Ross Taylor, RTA

Ross' work has as made a HUGE difference in advancing fish passage in California

Fisheries Biological Monitoring

Physical Monitoring of Barrier Removals

Barrier Assessment Protocols

Prioritization Frameworks

Barrier Assessments

Thorough and Thoughtful approach

Leah Mahan, NOAA Restoration Center

Contract Administration

Grant Administration

Physical Monitoring of Barrier Removals

Regional and Programmatic Prioritization

Dam Removal Planning and Monitoring

Development of Program Monitoring Plans

NOAA Restoration Center Fish Passage ~2009

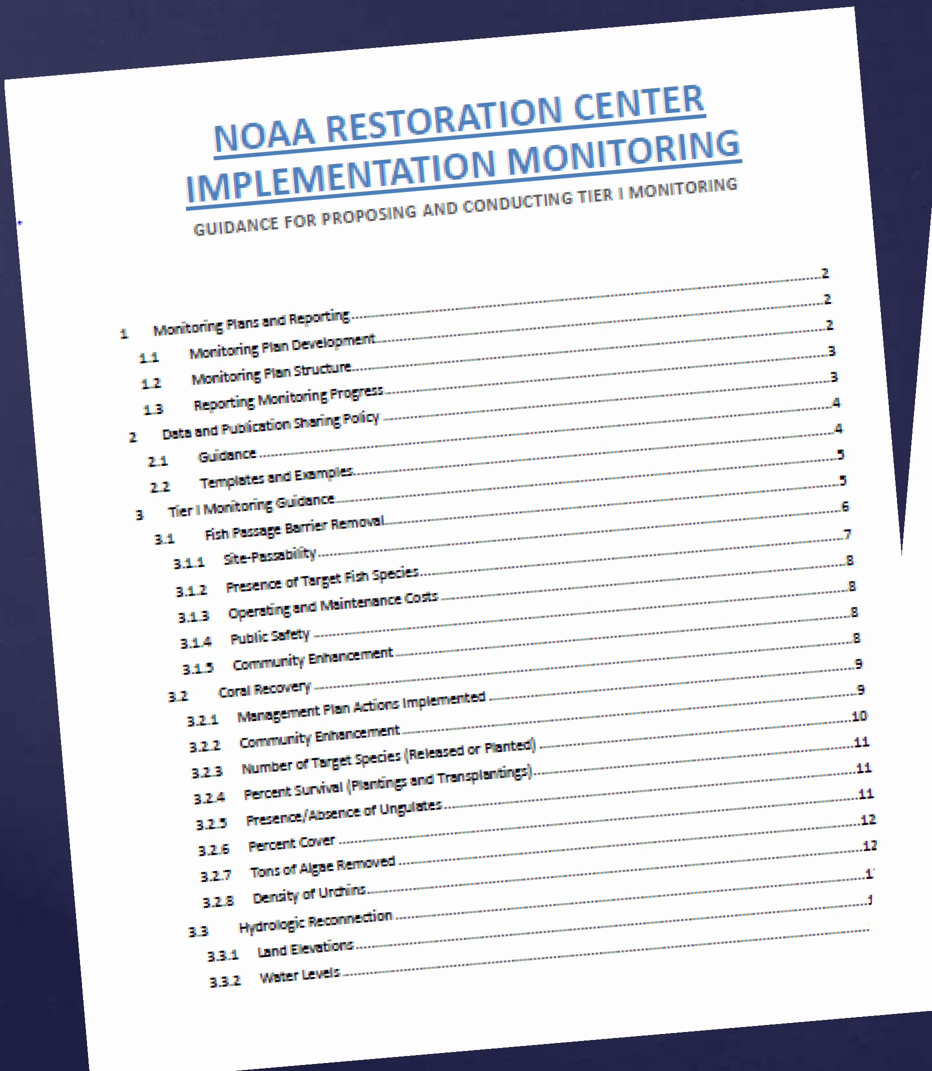
NOAA Program Managers and Congress:

"Are these restoration projects making more fish?"

"Is our program moving the needle on recovery?"

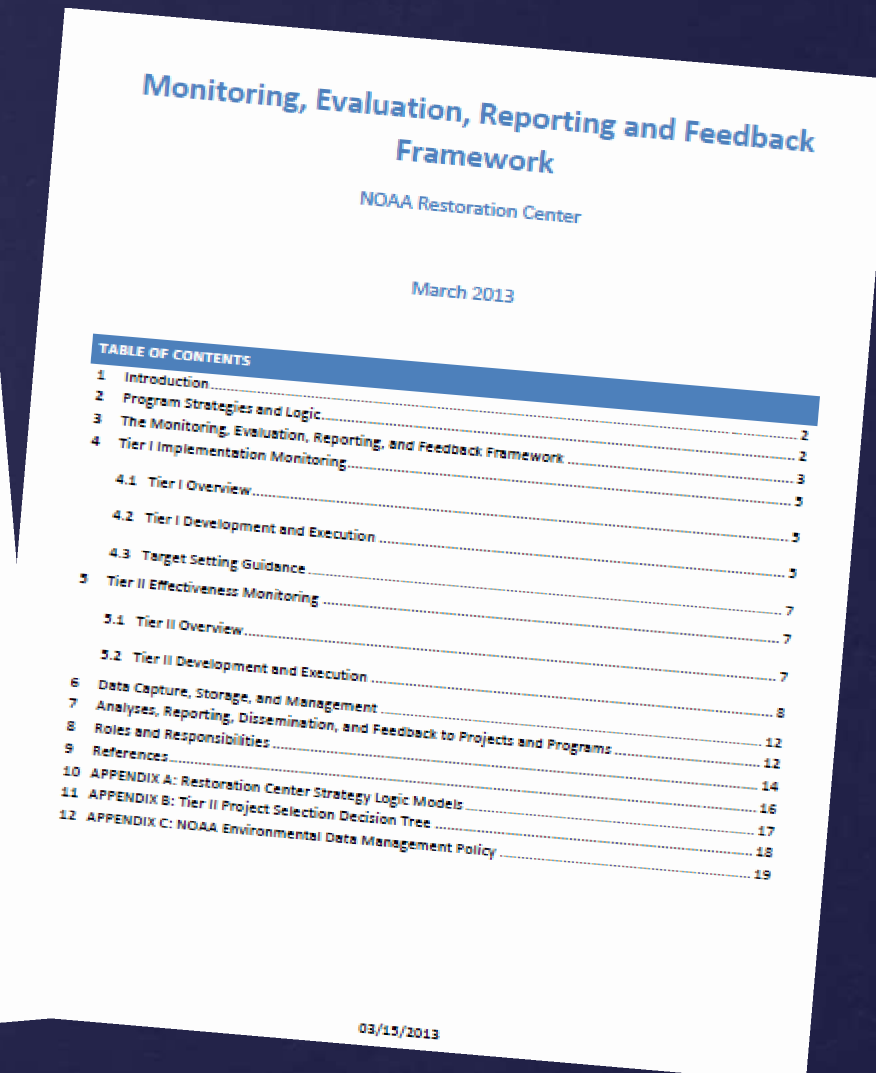
"How much more money will it take?"

Development of NOAA Restoration Center Fish Passage Monitoring Strategy



NOAA RESTORATION CENTER IMPLEMENTATION MONITORING

GUIDANCE FOR PROPOSING AND CONDUCTING TIER I MONITORING



Monitoring, Evaluation, Reporting and Feedback Framework

NOAA Restoration Center

March 2013

TABLE OF CONTENTS

RC Fish Passage Strategy Implementation Monitoring

- Are the design and as-built jump heights consistent with regional fish passage guidelines?
- Is the target species upstream of the project site before and/or after implementation?
- Do site maintenance costs change as a result of the project?
- Does community safety change as a result of the project?
- Are there recreational or civic changes as a result of the project?

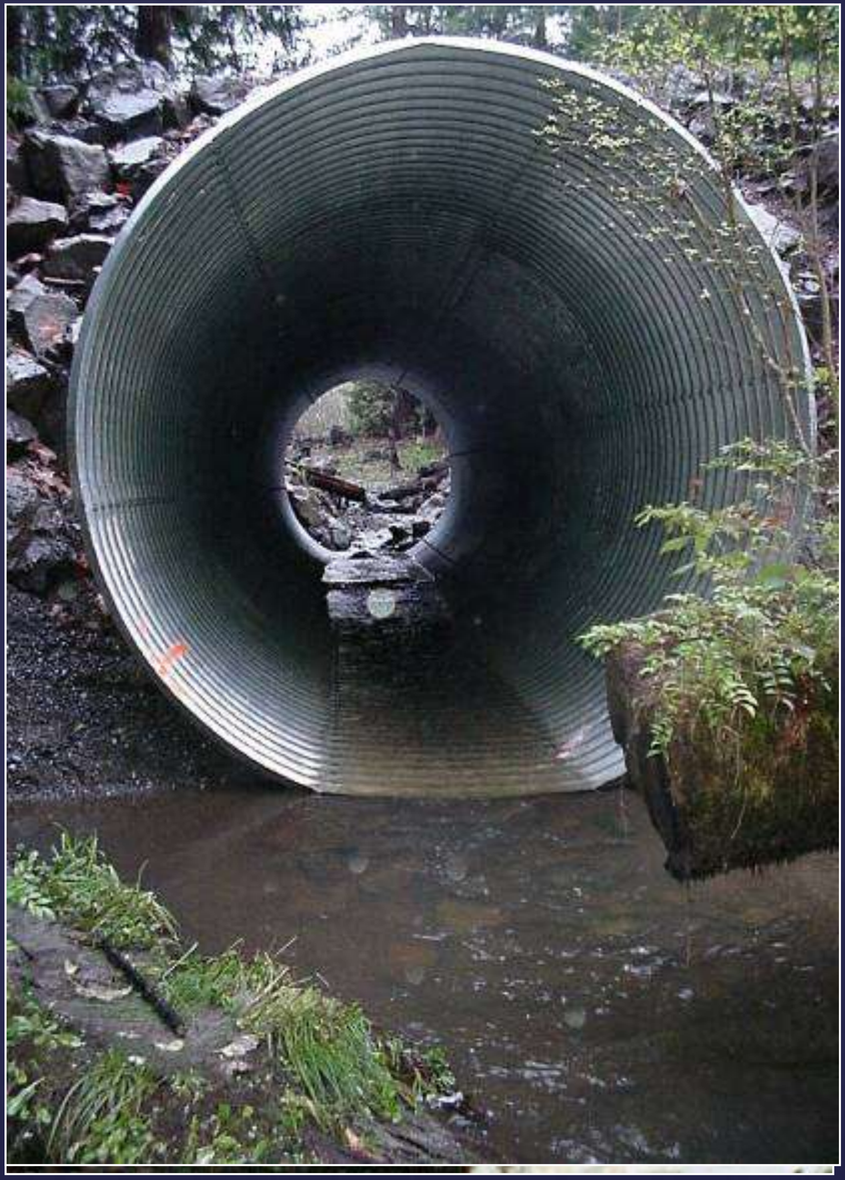
RC Fish Passage Monitoring Physical and Biological Effectiveness

- Are there temporal or spatial changes in abundance and/or distribution of the target species after implementation of the project?
  - Spawner/redd surveys
  - Juvenile surveys
- Are there physical changes in channel characteristics after the project (slope, width, sediment characteristics)?
  - Long profile
  - Channel cross sections
  - Pebble counts/sediment characterization
- Is there a change in habitat value as a result of the project?

Application of RC Monitoring Strategy

- Glenbrook Gulch Dam Removal Project
  - First RTA/NOAA joint effort
  - A chance to test RC strategy
- Monitoring a handful of sites across Northern CA
- Focus on total barriers
- Implementation based on funding limitations and project construction delays
- Resulting suite of case studies and data

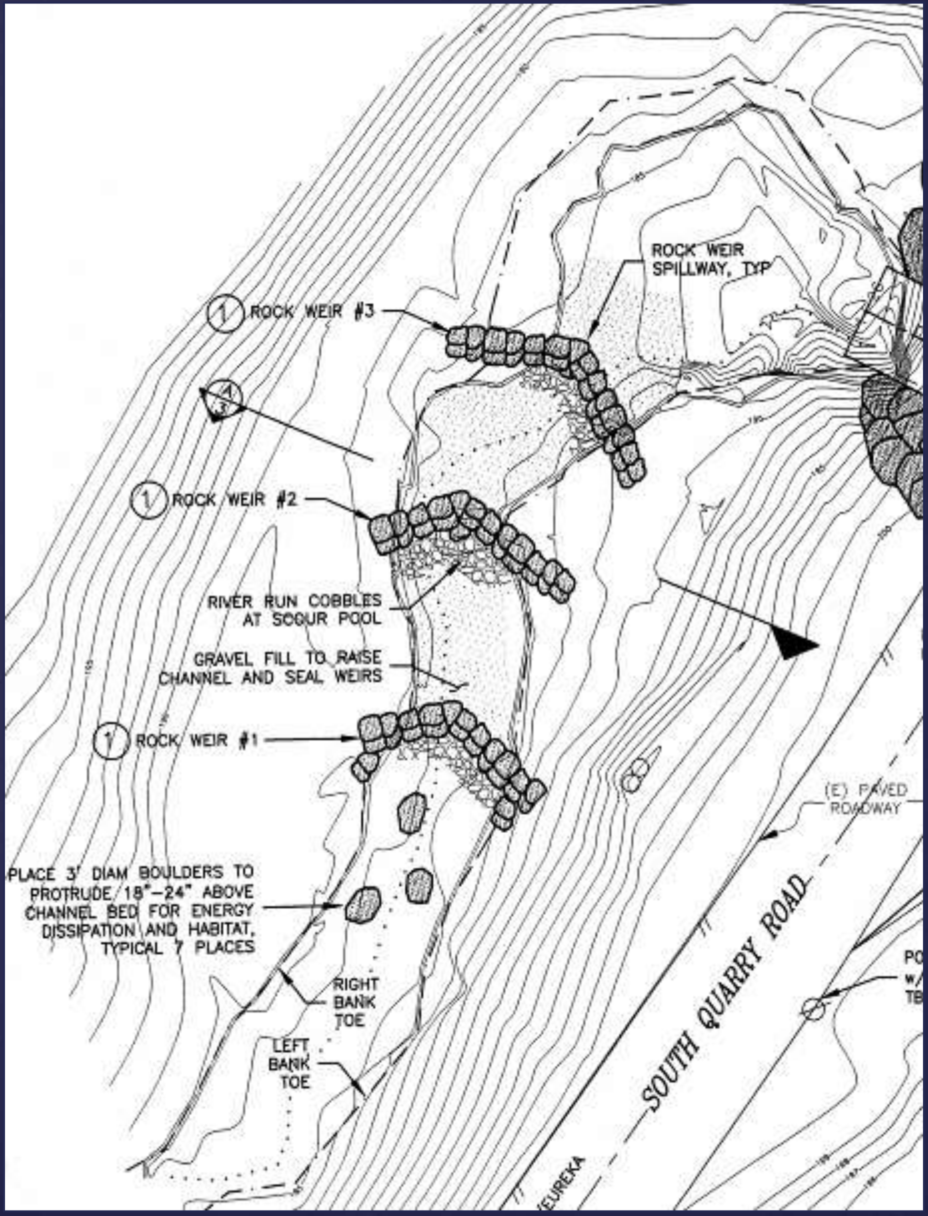
Morrison Gulch – Case Study of Design versus As-built



Morrison Gulch – Design Features

- Hydraulic design option.
- Slope through culvert = 0.0%.
- Six boulder weirs – 3 upstream, 3 downstream.
- Elevation of downstream weir relative to culvert outlet = 0.5 feet higher.
- Design concept – install culvert, then construct grade-control weirs.
- Nine-inch (0.75-ft) drops over each weir.
- Pass the 100-year flow.

Morrison Gulch – Design Features

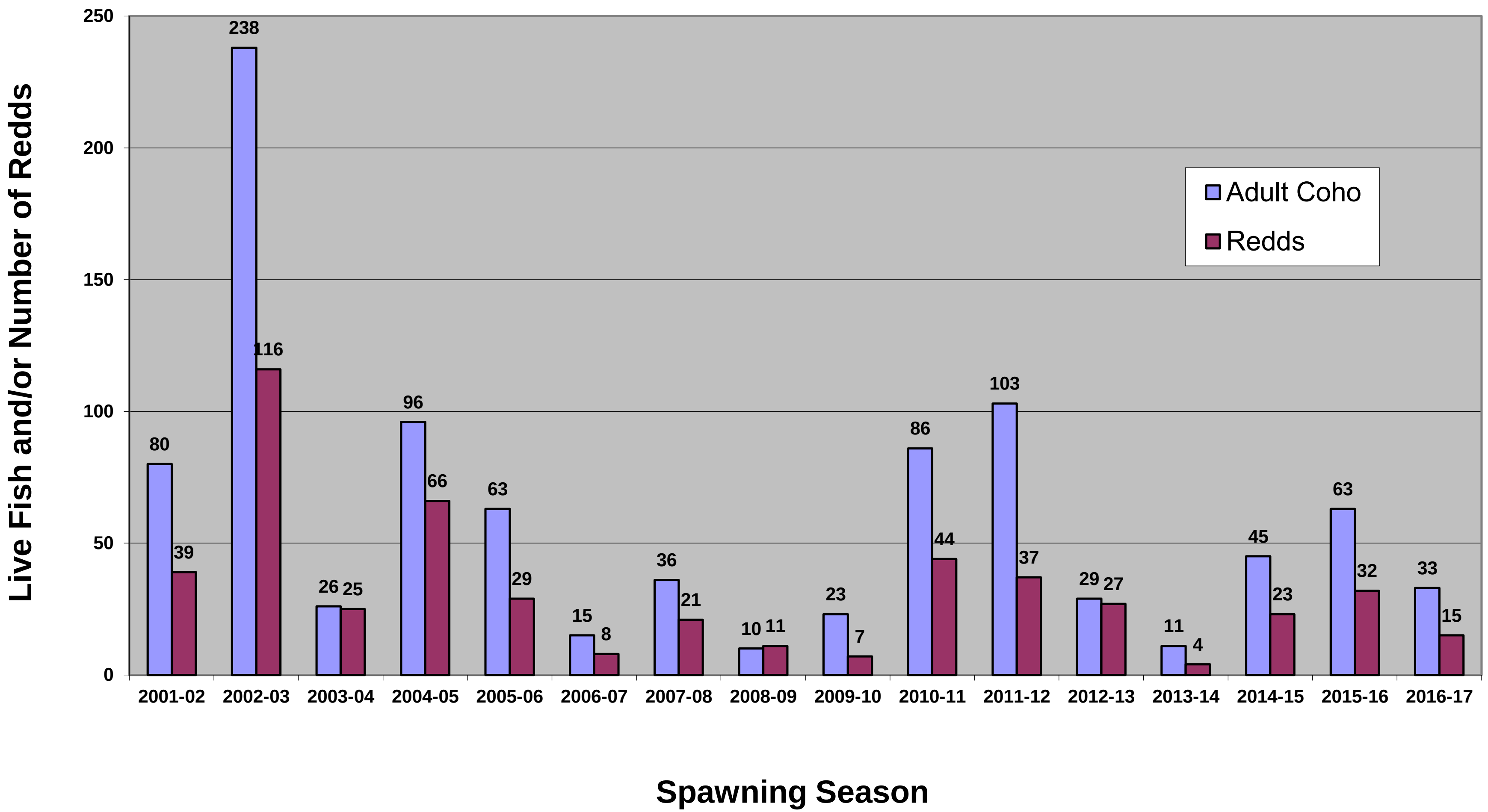


Morrison Gulch – As-Built Features

- Slope through culvert = 1.17%.
- Elevation of downstream weir relative to culvert outlet = set at same elevation.
- Grade-control weirs were constructed first - then culvert was installed.

Quantitative Monitoring – Passage Evaluation

- Utilized re-survey data and new culvert specification.
- Assessed with FishXing.
- Adult passage = 90% - insufficient depth.
- Resident/2+ passage = 30% - excessive velocity.
- 1+/y-o-y passage = 0% - excessive velocity.
- Visual observations y-o-y upstream of culvert, failing to pass grade-control weirs.



Live Fish and/or Number of Redds
250
200
150
100
50
0
238
116
80
39
26 25
96
66
63
29
15
8
36
21
10 11
23
7
86
44
103
37
29 27
11
4
45
23
63
32
33
15
Adult Coho
Redds
2001-02
2002-03
2003-04
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
2013-14
2014-15
2015-16
2016-17
Spawning Season


PHOTO: THOMAS DUNKLIN


PHOTO: THOMAS DUNKLIN

Morrison Gulch – Stability and Longevity

- Resurveyed downstream weirs and culvert inlet and outlet on May 5, 2017.
- Slope through culvert = 1.31% (>0.14%).
- Elevation of 1st downstream weir relative to culvert outlet = 0.21 feet higher.
- Elevation between 1st and 2nd weirs = 0.78 feet.
- Elevation between 2nd and 3rd weirs = 0.79 feet.

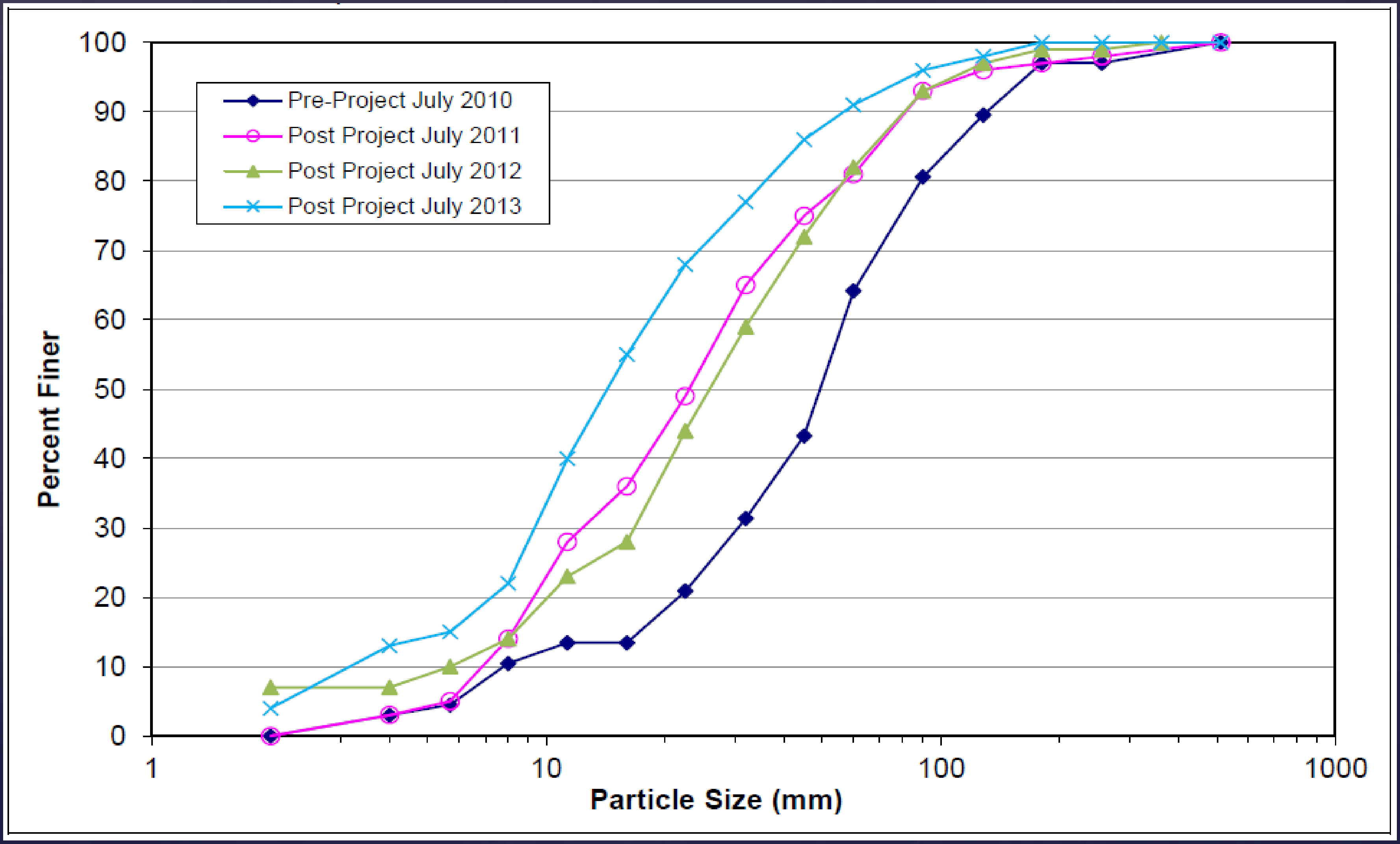
Glenbrook Gulch – Dam Removal Case Study

Glenbrook Gulch – Project Objectives

- Primary objective – remove dam and open up 4,000 feet of habitat.
- Secondary objective – restore downstream spawning habitat. Improve rearing habitat.
- Solutions - no removal of sediment stored behind the dam. Installation of 23 log and boulder structures to capture mobilized sediment and increase habitat complexity.
- Monitoring – photo points and pebble counts (pre and post, above and below dam site).

Glenbrook Gulch – Pebble Counts

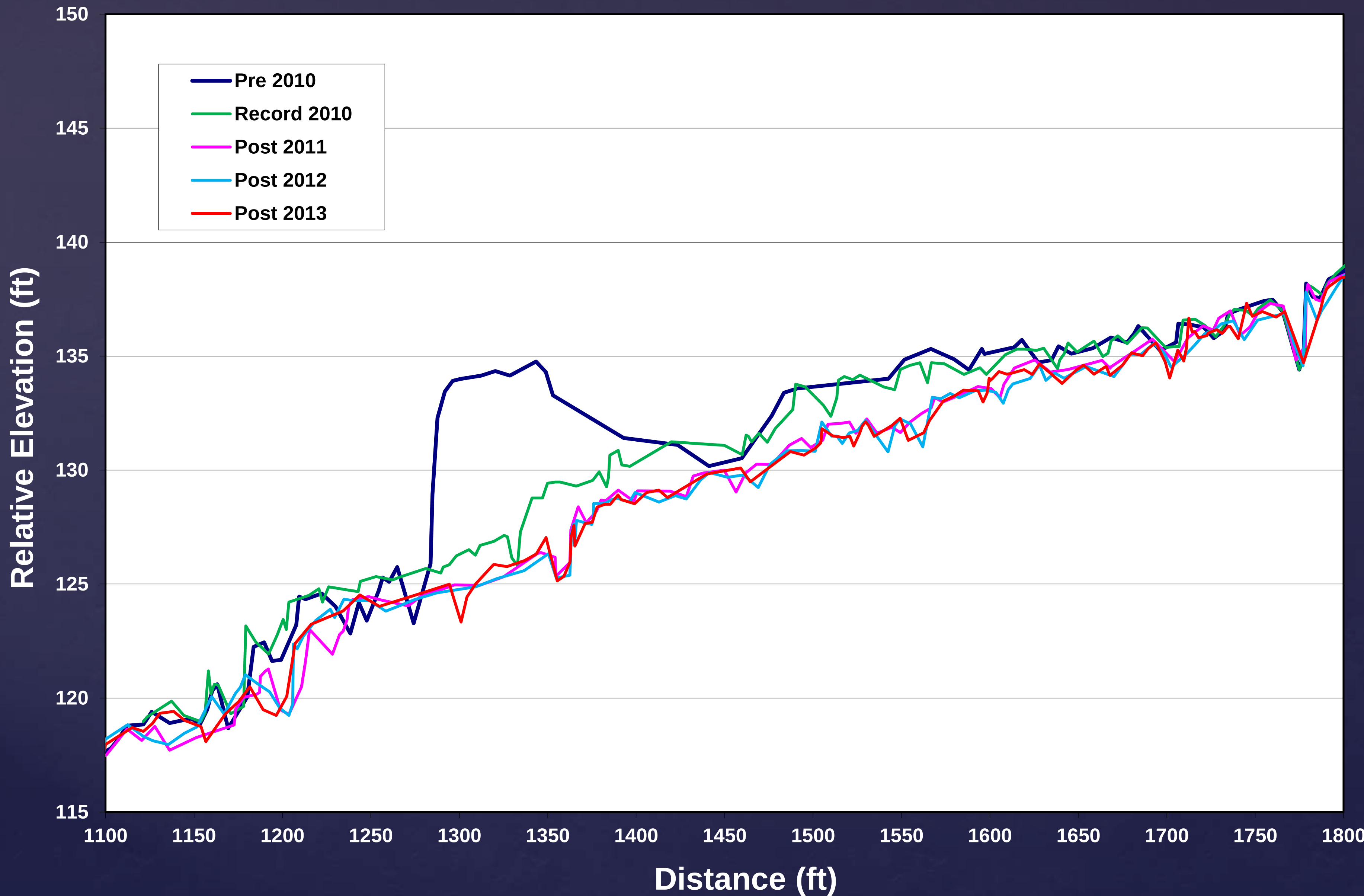
Transect #2 – Pre and Post Particle Size Distribution



Glenbrook Gulch – Spawning Habitat

Below Dam – two winters post-removal

Glenbrook Gulch – Channel Adjustments



Glenbrook Gulch – Biological Response

- No fish above dam pre-project.
- Movement of juvenile STHD above dam, first 3 post-project summers.
- Non-natal juvenile Coho below dam during 1st post-project survey.
- Spawner surveys – adult Coho entered system during 3rd post-project winter.
- Second cohort of adult Coho observed during 4th winter.

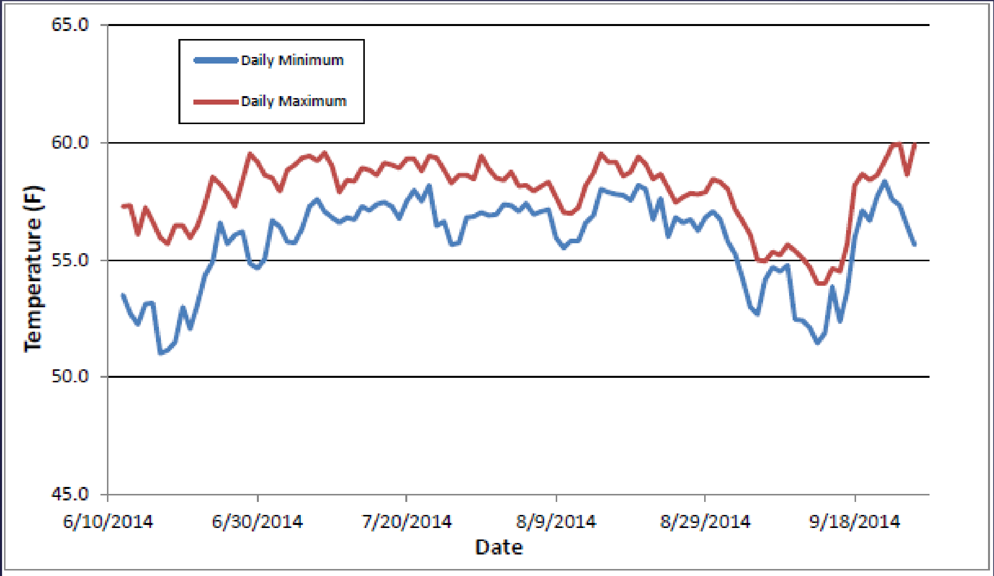
RC Strategy Next Steps- Monitoring Feedback Loop

- 2018-2019 Restoration Center Fish Passage Monitoring Plan
  - Summarize lessons learned
  - Identify data gaps
  - Develop structure for feedback loop
- Using monitoring in future:
  - Planning/prioritization
  - Implementation
  - Monitoring

Use of Monitoring Data for Prioritization

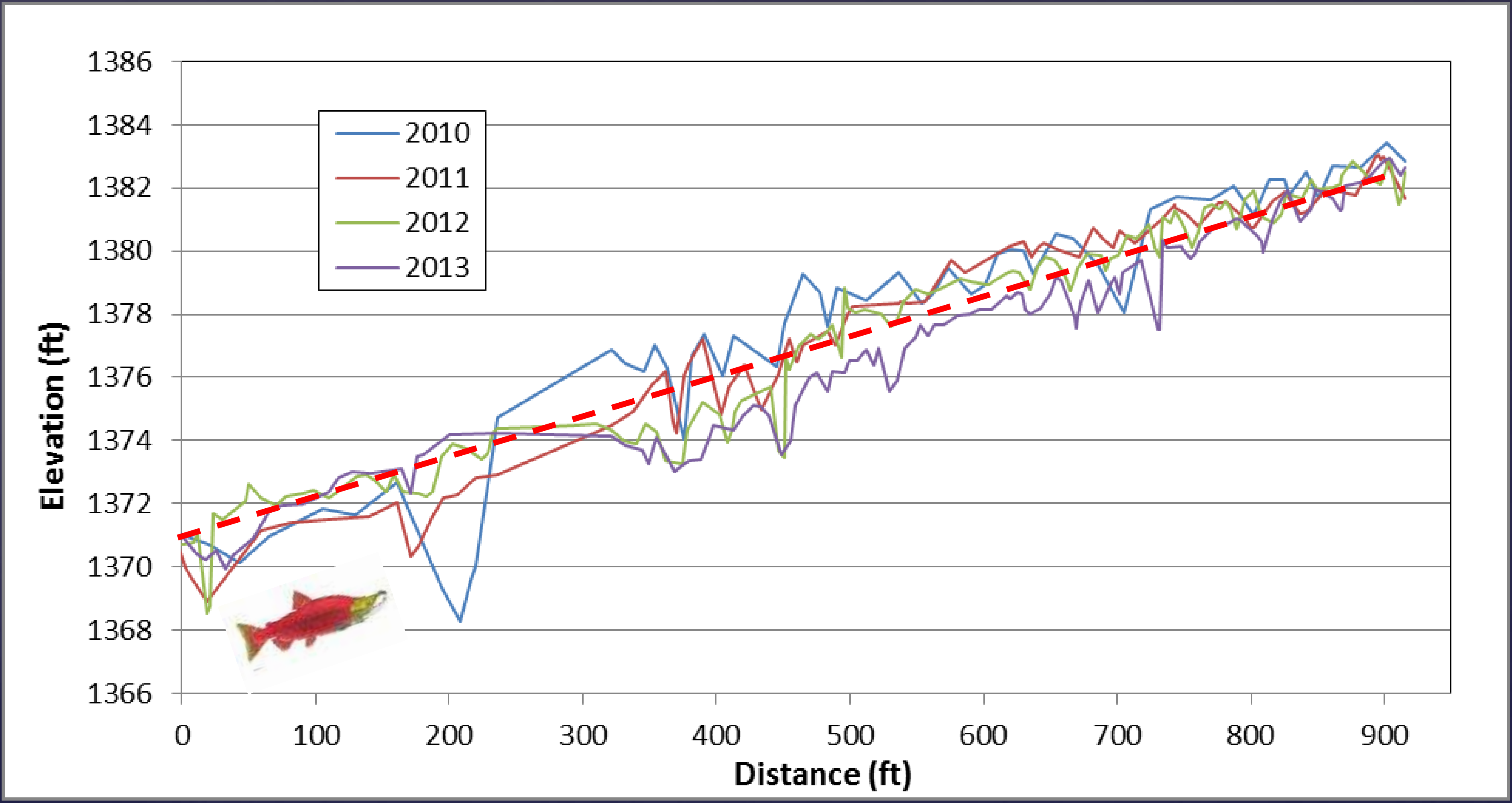
Essex Gulch, Mad R.

- 2.3 miles blocked
- Expensive and complex
- Initially priority #11 in Caltrans District 1
- Habitat Surveys with data gaps



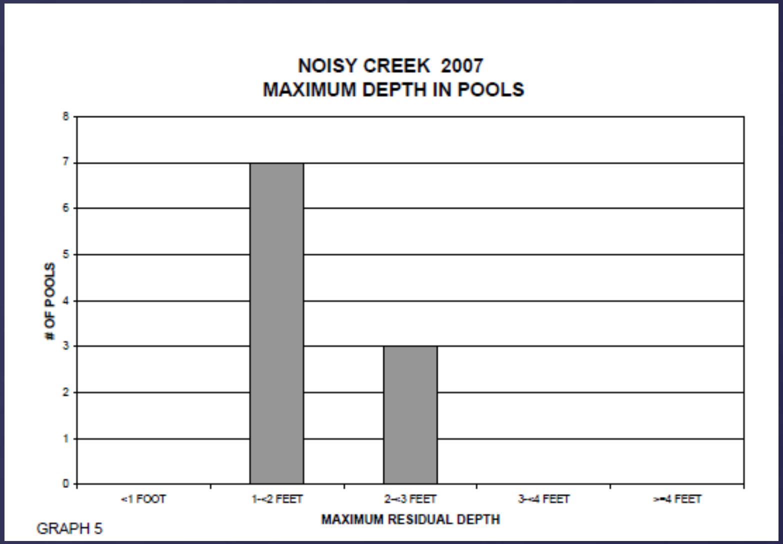
- Suitable temperature
- Perennial flow
- Potential for 170 coho adults
- 31% of Recovery target
- Depensation threshold 138
- Project re-prioritized #2

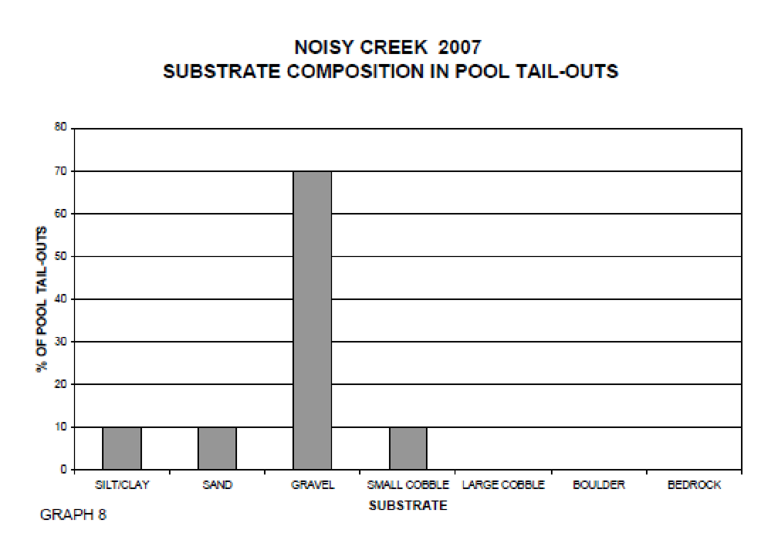
Use of monitoring data to guide Implementation

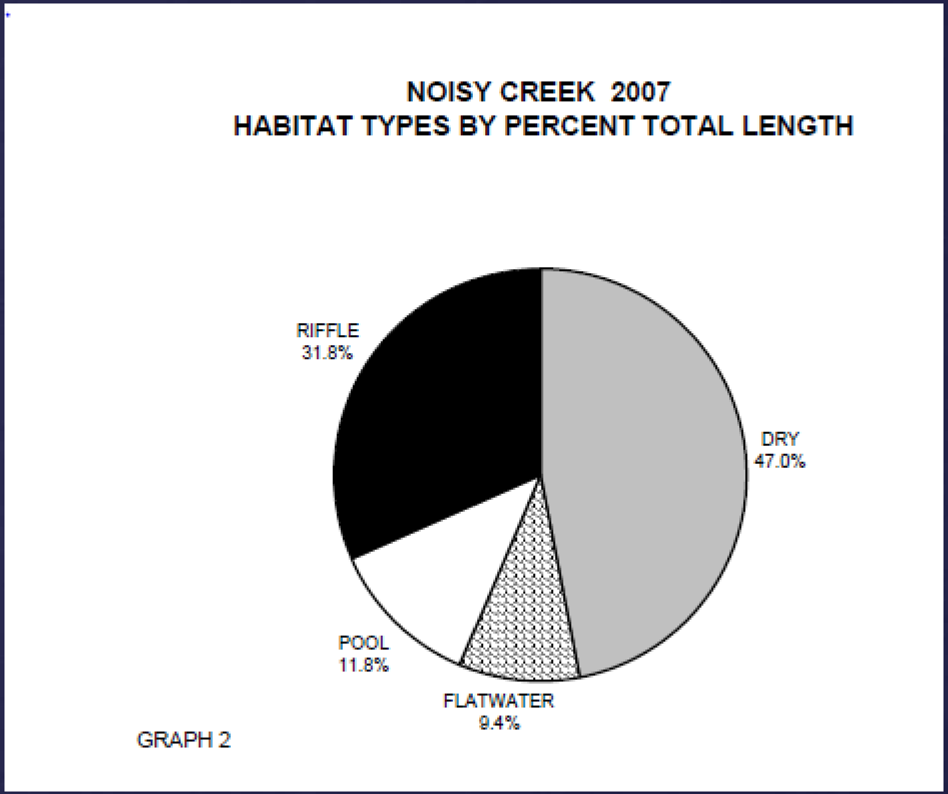


Ryan Creek long profile 2010-2013, Ross Taylor and Associates

Focusing Future Monitoring to Fill Data Gaps- Habitat







Future Fish Passage Monitoring Opportunities

- Monitor project expectations and actual (Essex)
- Monitor habitat changes resulting from treatment types/combinations
- Use monitoring to maximize site and project potential
- Future monitoring opportunities:
  - Jack of Hearts Dam Removal (small)
  - Woodman Creek RR Barrier removal (med)
  - Klamath Dam Removals (large)

Fish Passage Monitoring Collaboration

- Invitation to all- collect and share physical and biological monitoring data, and lessons learned

- Leah Mahan, NOAA Restoration Center, leah.mahan@noaa.gov
- Ross Taylor, Ross Taylor and Associates, rossntaylor@sbcglobal.net

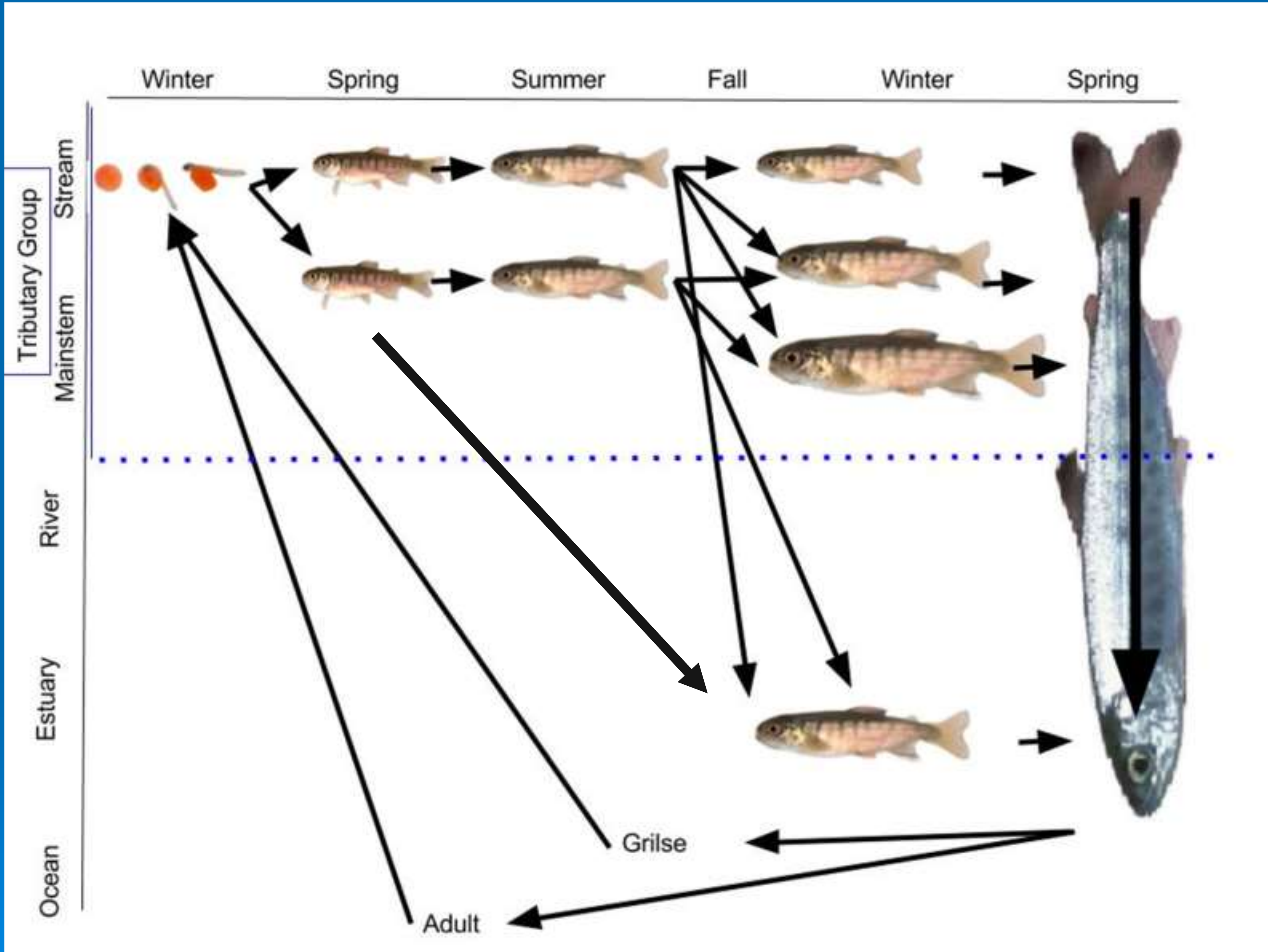
- Additional case studies and data will help us better understand this picture

Temporal Patterns and Environmental Correlates of Young-of-the-Year Coho Salmon Movement into Non-natal Seasonal Habitats

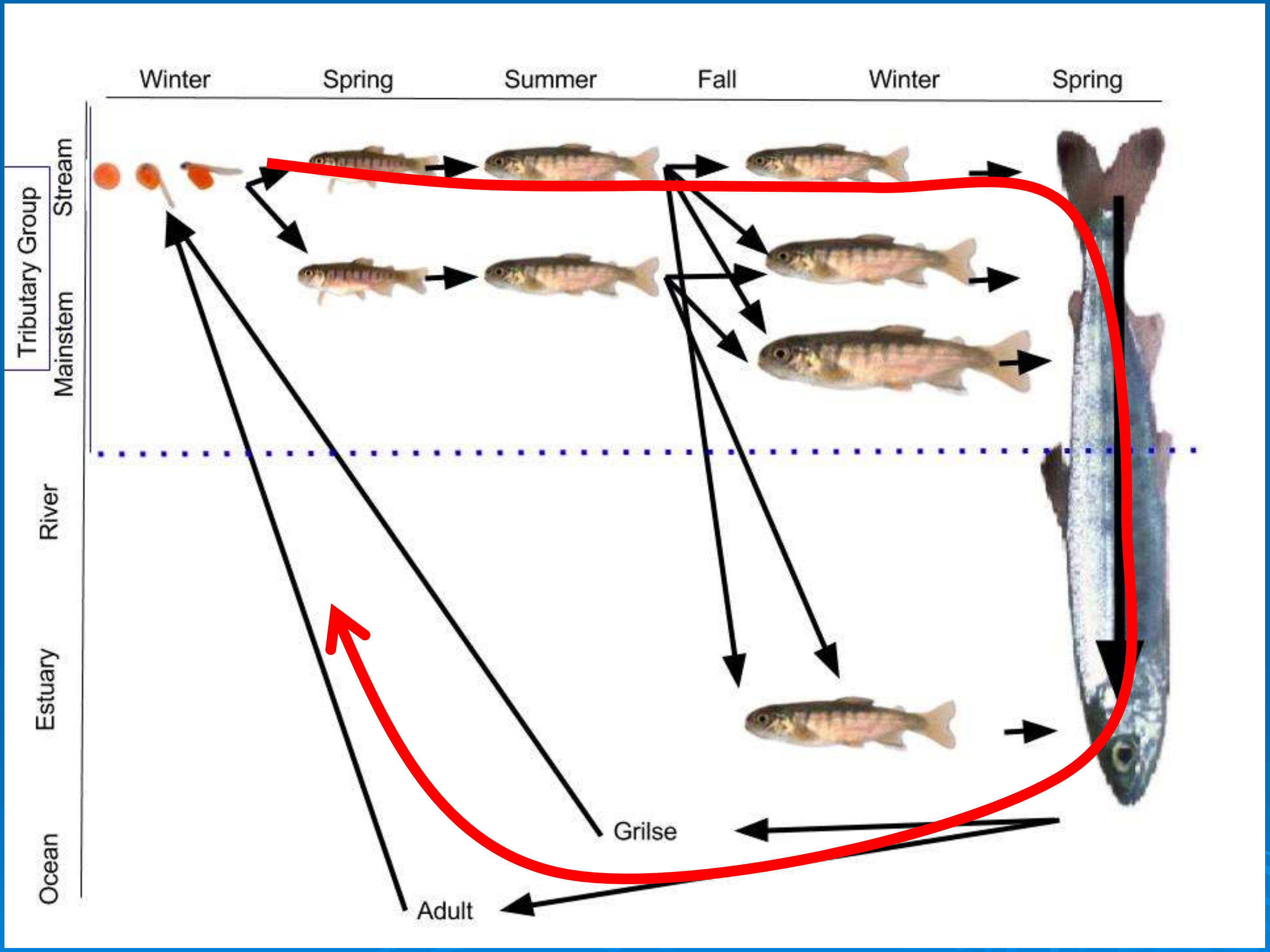
seth.ricker@wildlife.ca.gov

Acknowledgements:

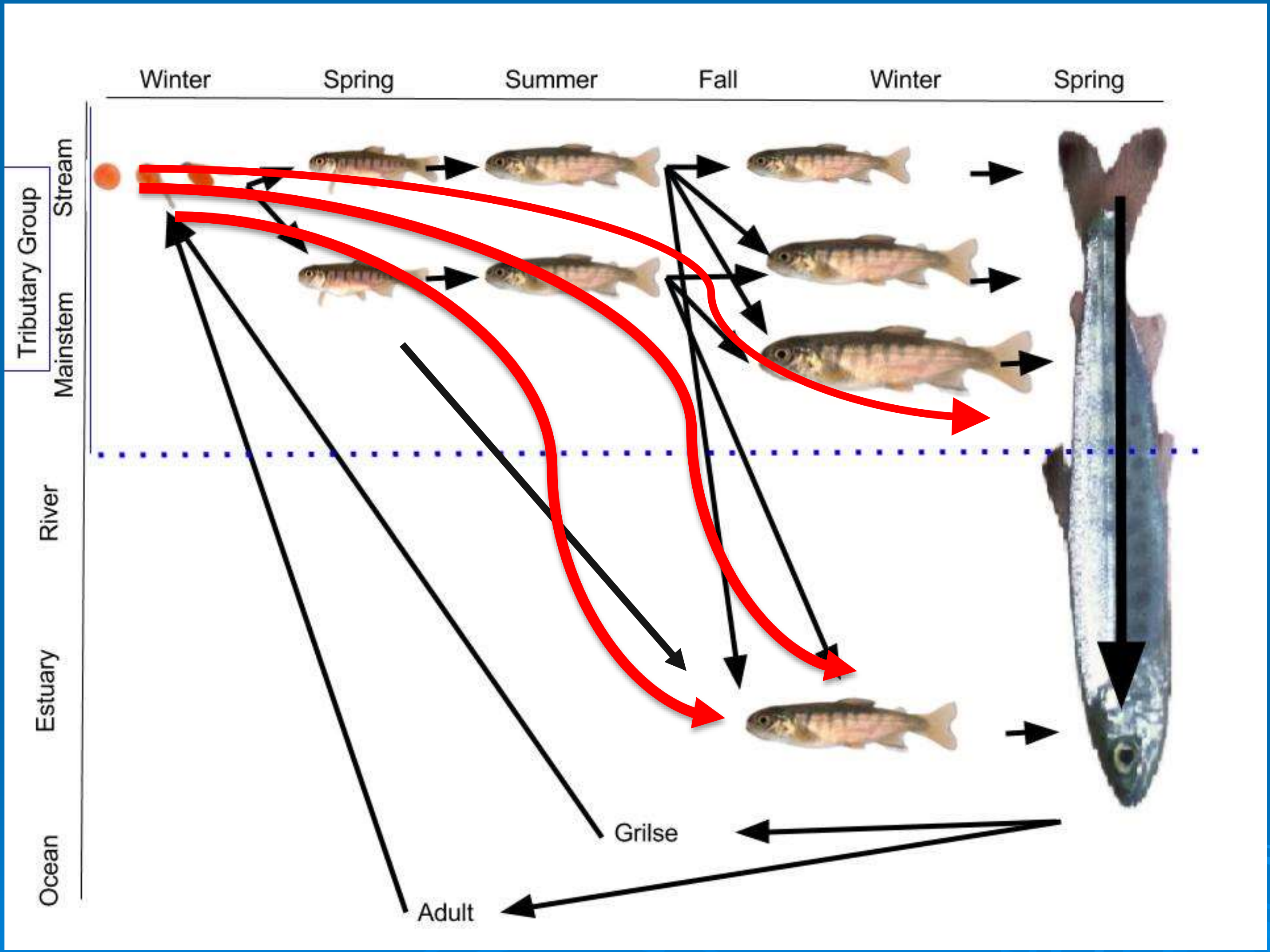
- Mike Wallace, Justin Garwood, CDFW
- Colin Anderson, Terry Roeloffs, Darren Ward, Jennifer Rebenack, Gabe Scheer Humboldt State University
- Humboldt Redwood Company
- Green Diamond Rescource Company
- Many devoted Pacific States Marine Fisheries Commission, CDFW, and Humboldt State University Sponsored Programs, and Watershed Stewards Program fisheries technicians
- Major Funding: CDFW Fisheries Restoration Grants Program



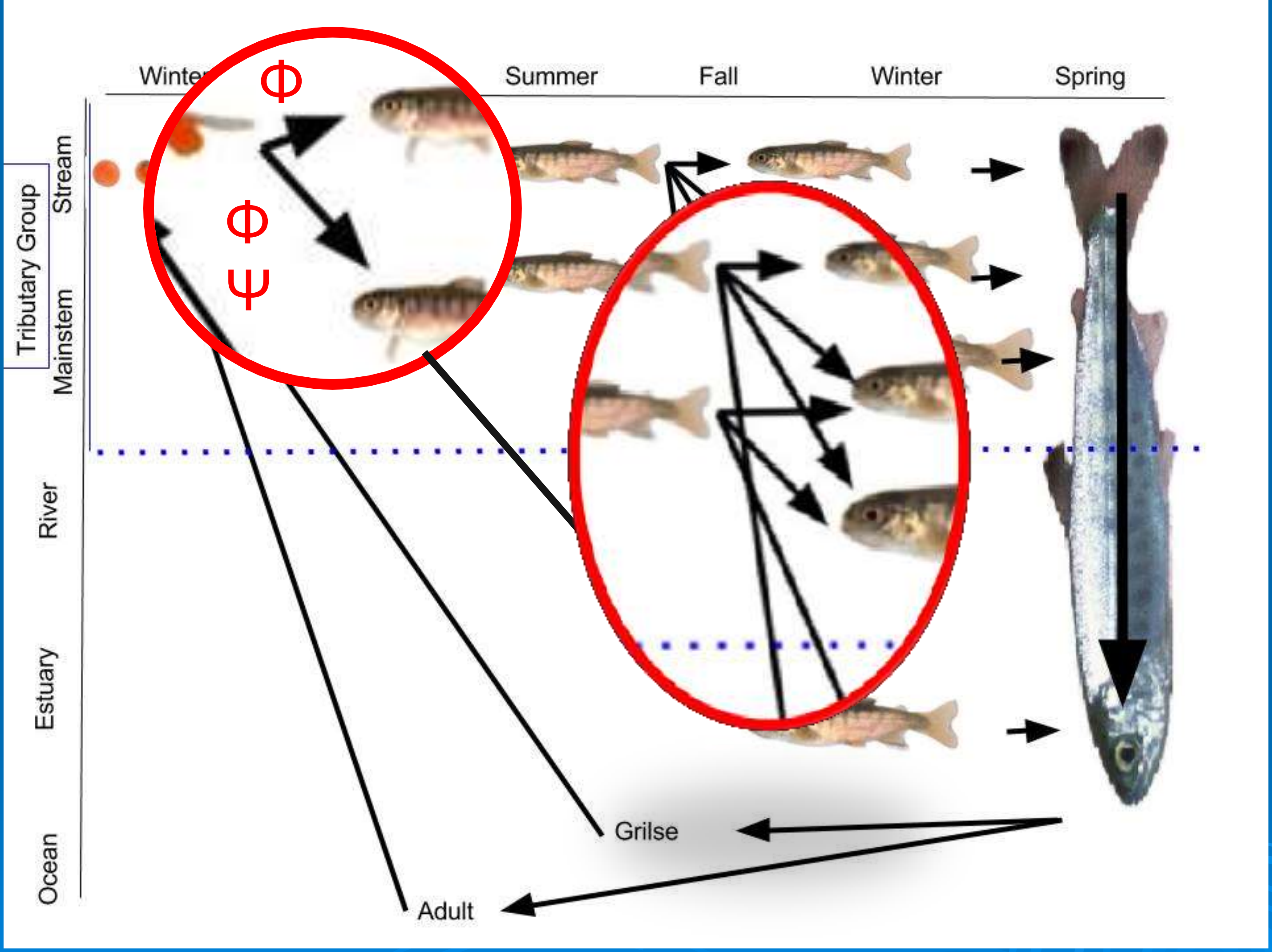
Winter
Spring
Summer
Fall
Winter
Spring
Tributary Group
Stream
Mainstem
River
Estuary
Ocean
Grilse
Adult



Winter
Spring
Summer
Fall
Winter
Spring
Tributary Group
Stream
Mainstem
River
Estuary
Ocean
Grilse
Adult

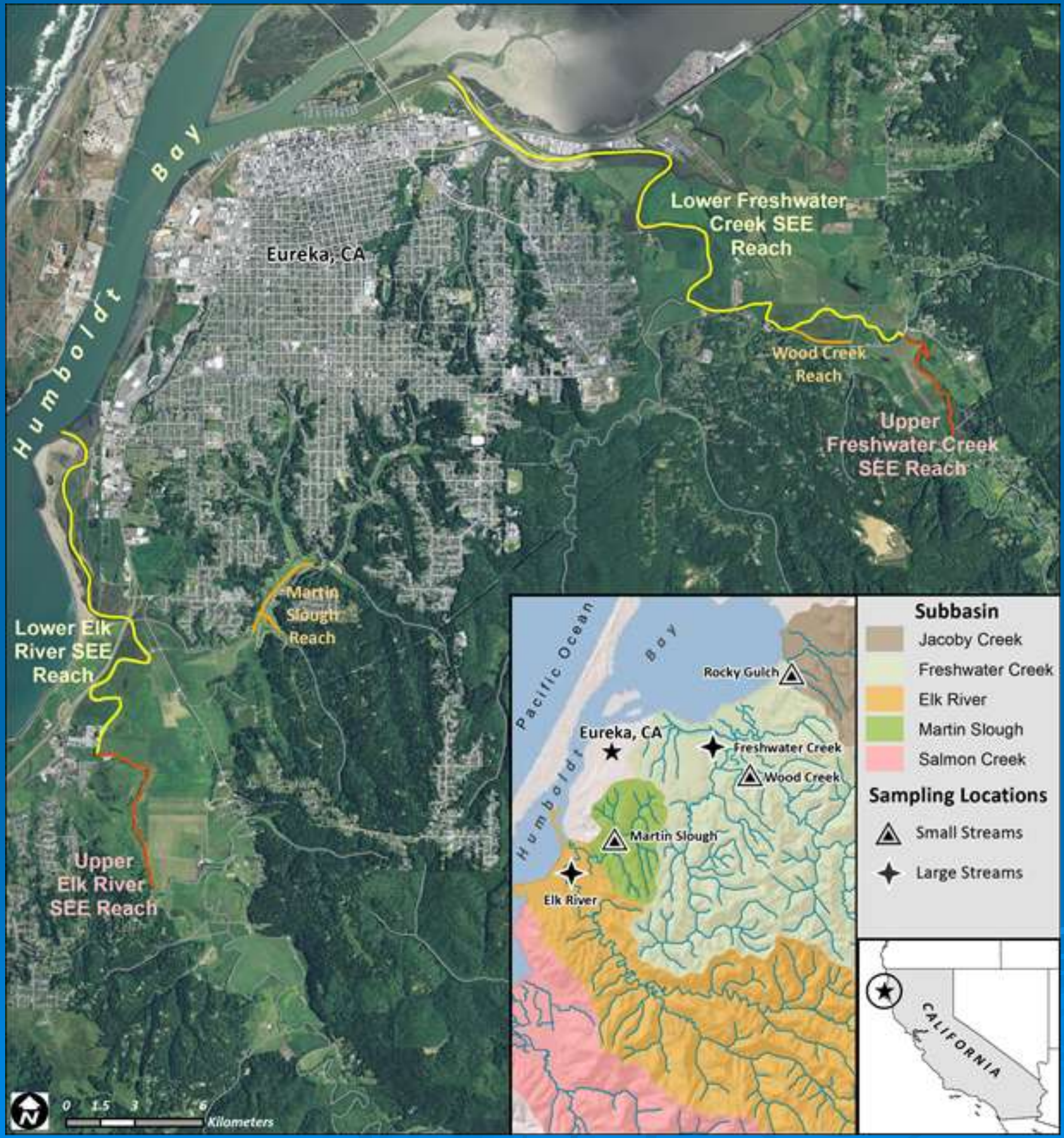


Winter
Spring
Summer
Fall
Winter
Spring
Tributary Group
Stream
Mainstem
River
Estuary
Ocean
Grilse
Adult



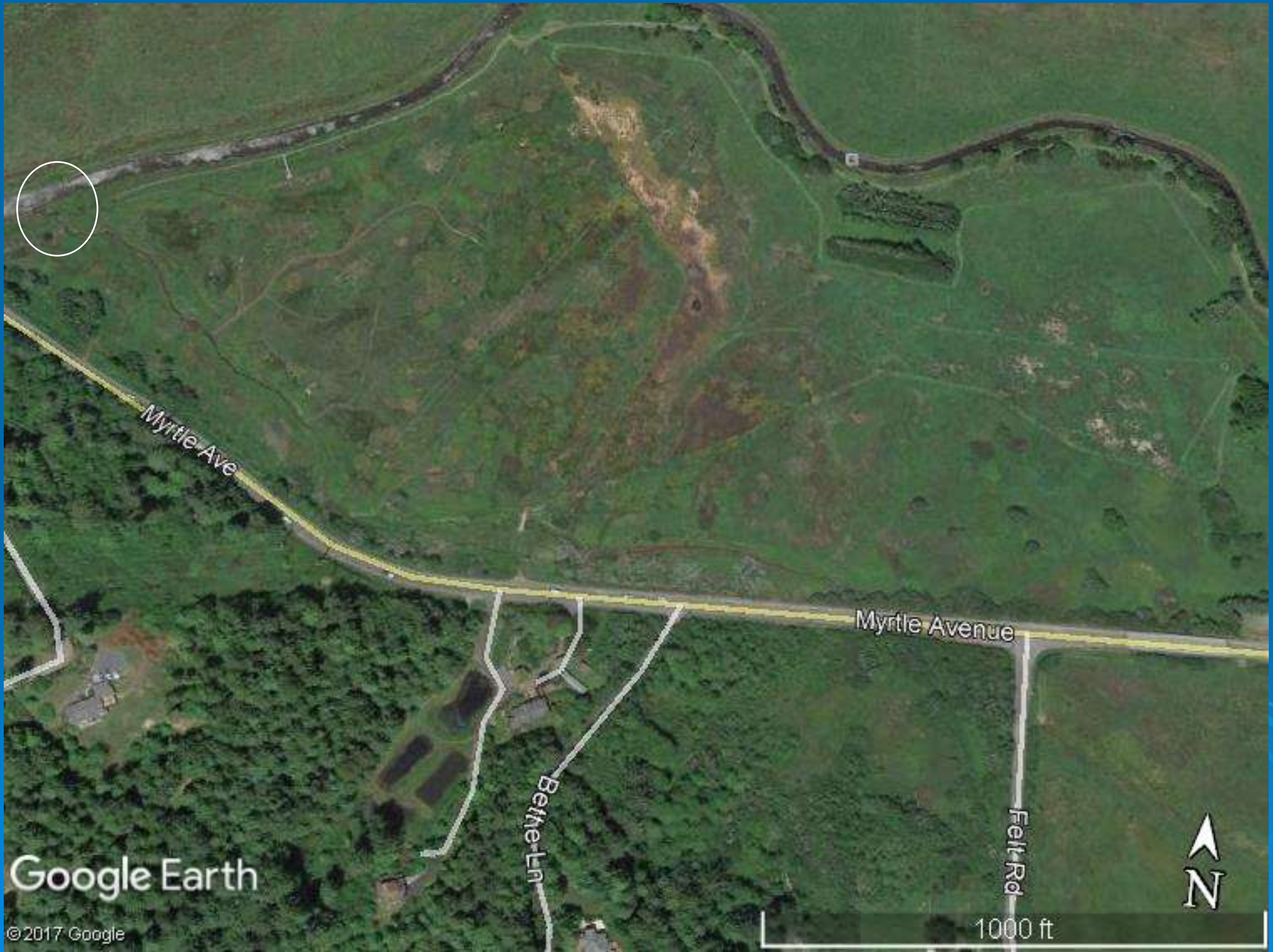
Winter
Summer
Fall
Winter
Spring
Tributary Group
Stream
Mainstem
River
Estuary
Ocean
Φ
Φ
Ψ
Grilse
Adult

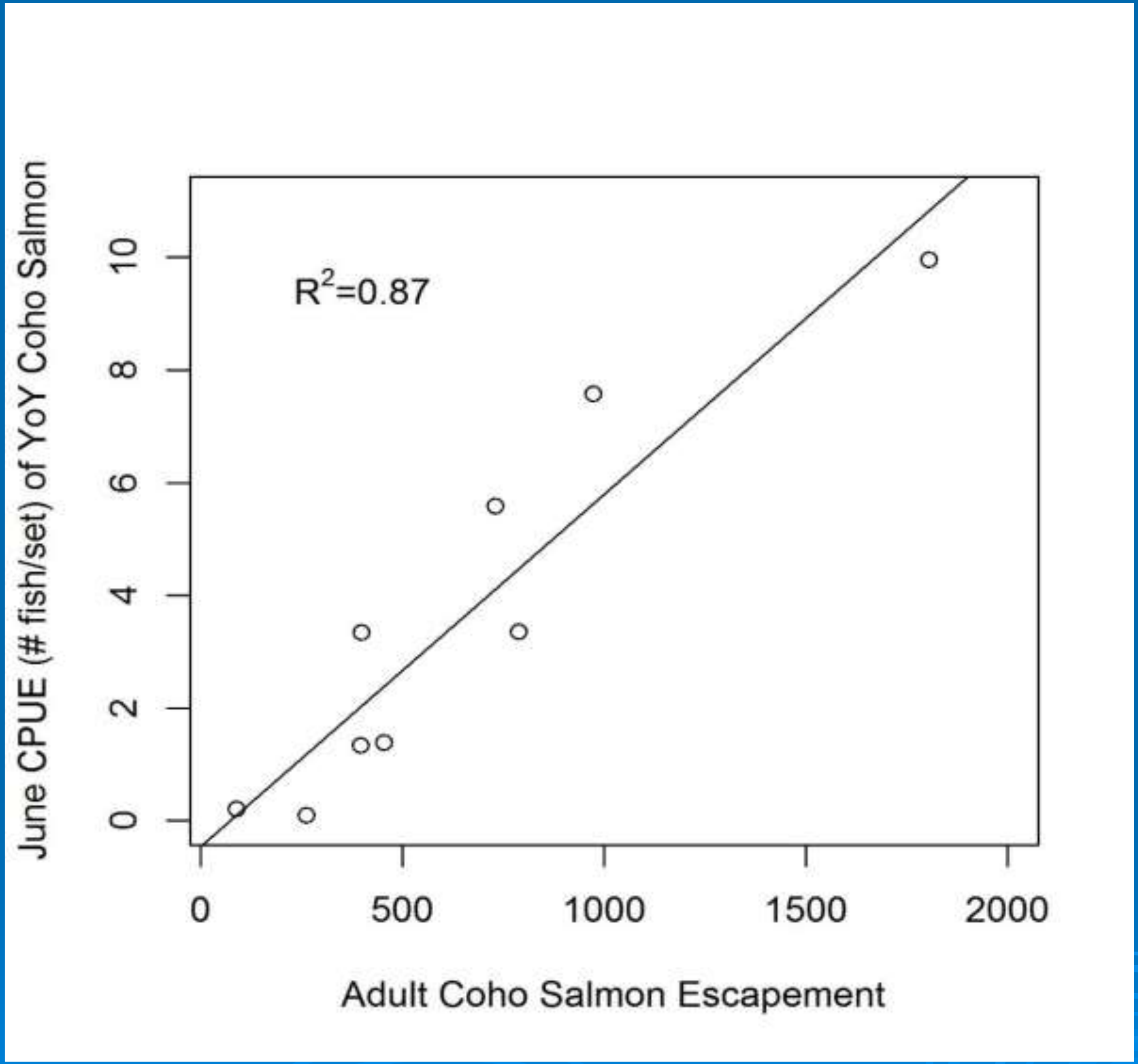

10mm
20
30
40
50
60



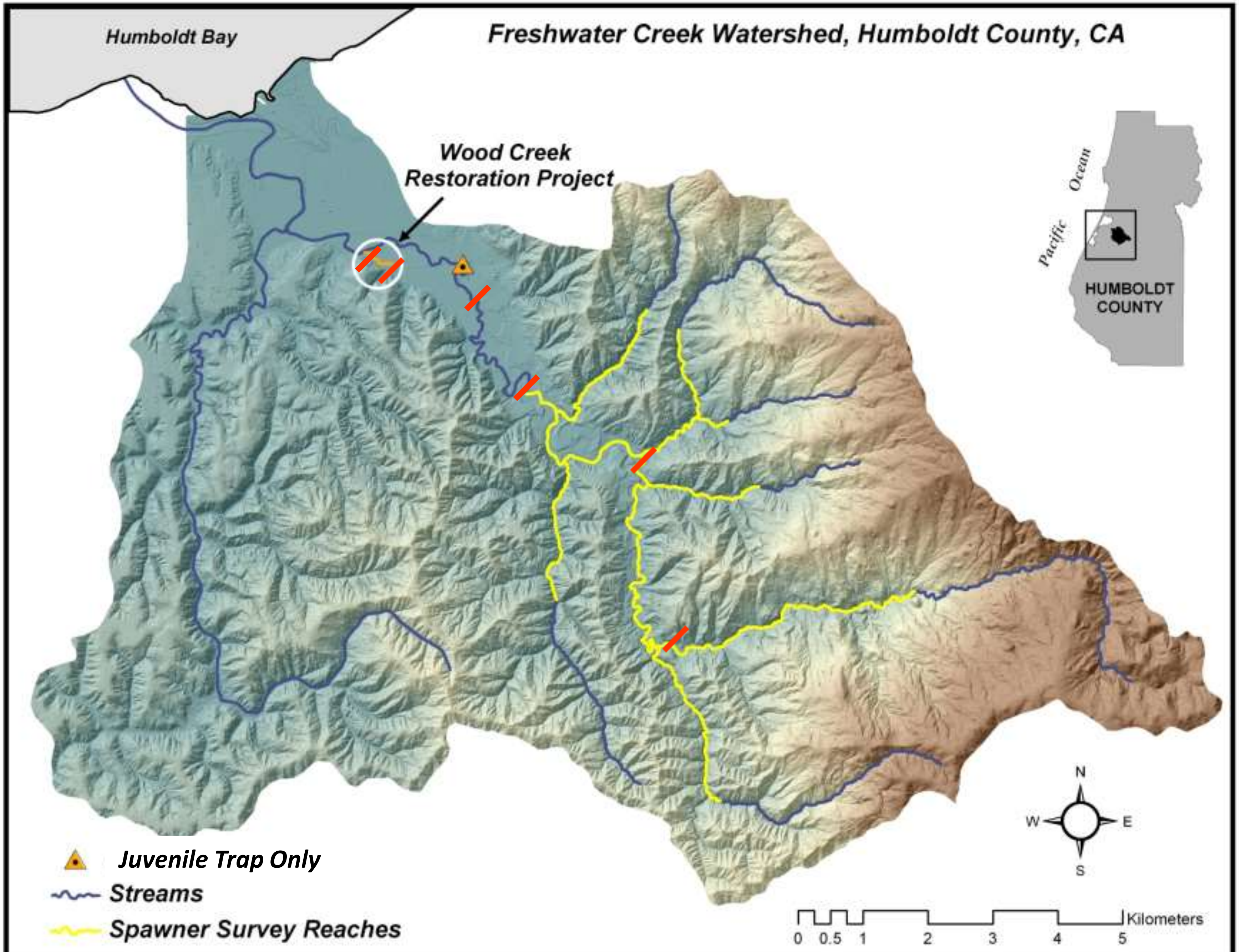
Humboldt Bay
Eureka, CA
Lower Freshwater Creek SEE Reach
Wood Creek Reach
Upper Freshwater Creek SEE Reach
Martin Slough Reach
Lower Elk River SEE Reach
Upper Elk River SEE Reach
0 1.5 3 6
Kilometers
Pacific Ocean
Bay
Humboldt
Rocky Gulch
Eureka, CA
Freshwater Creek
Wood Creek
Martin Slough
Elk River
Subbasin
Jacoby Creek
Freshwater Creek
Elk River
Martin Slough
Salmon Creek
Sampling Locations
Small Streams
Large Streams
CALIFORNIA

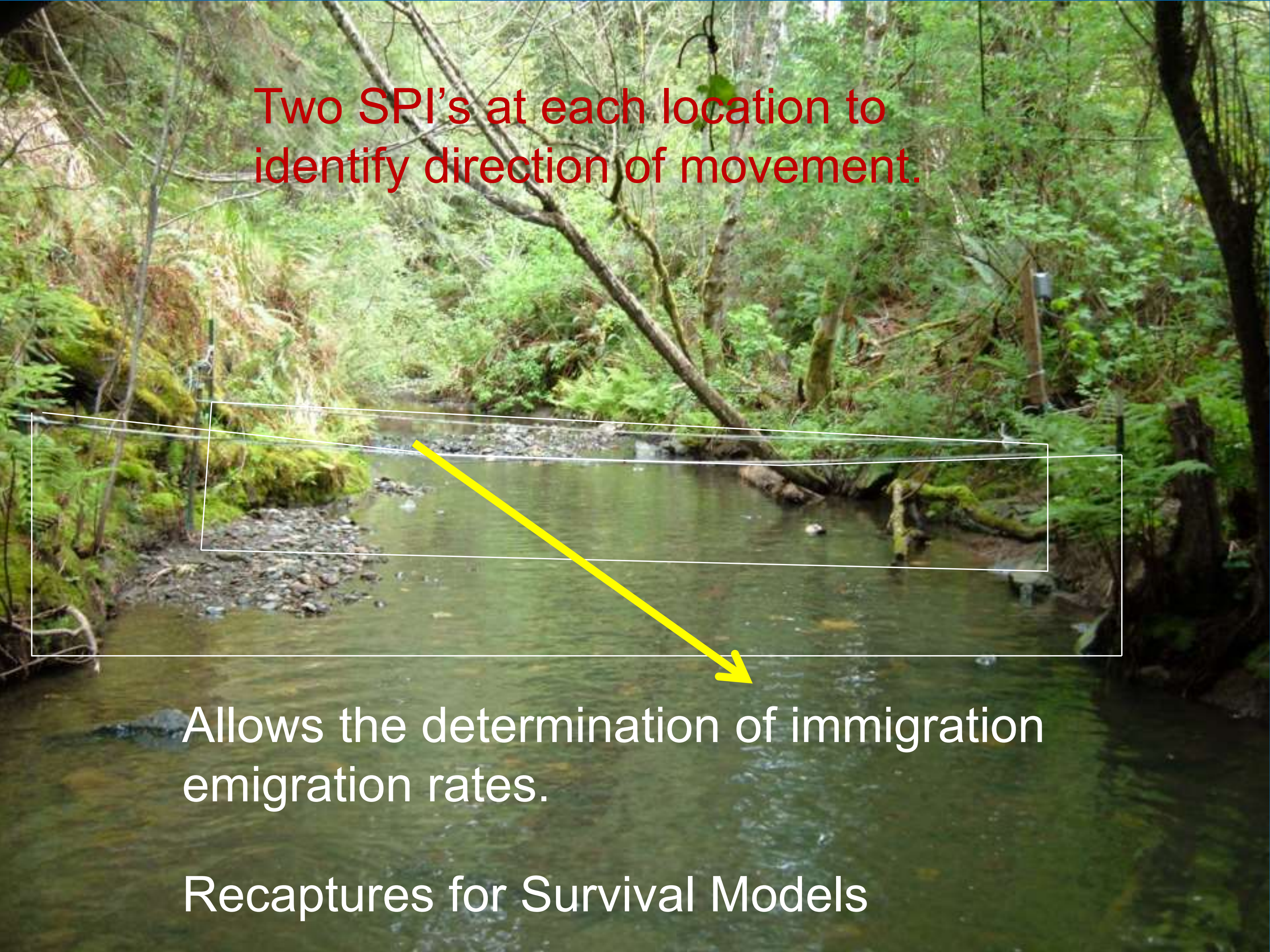
Wood Creek

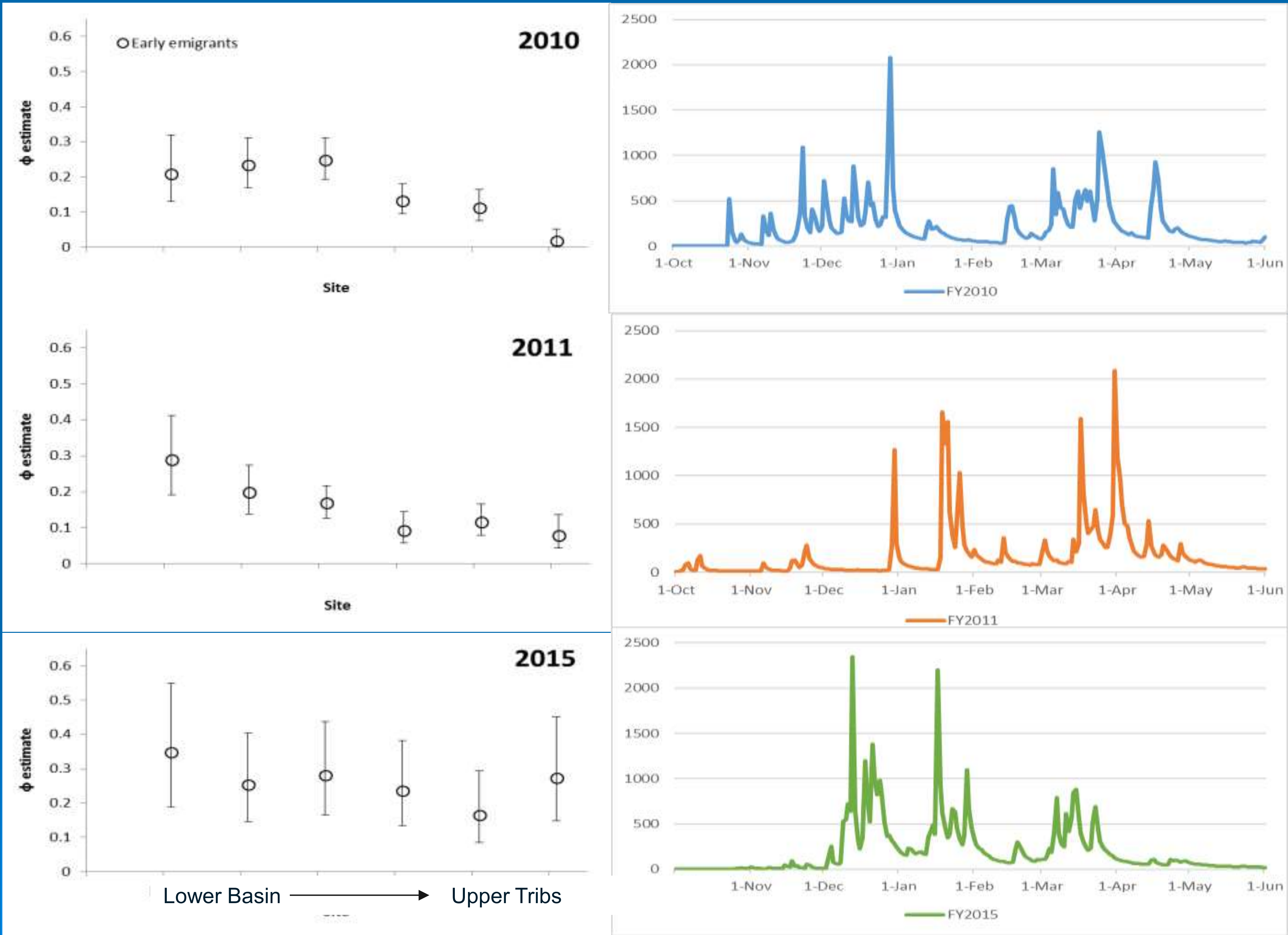

Myrtle Ave
Myrtle Avenue
Belfite Ln
Felt Rd
Google Earth
©2017 Google
1000 ft
N



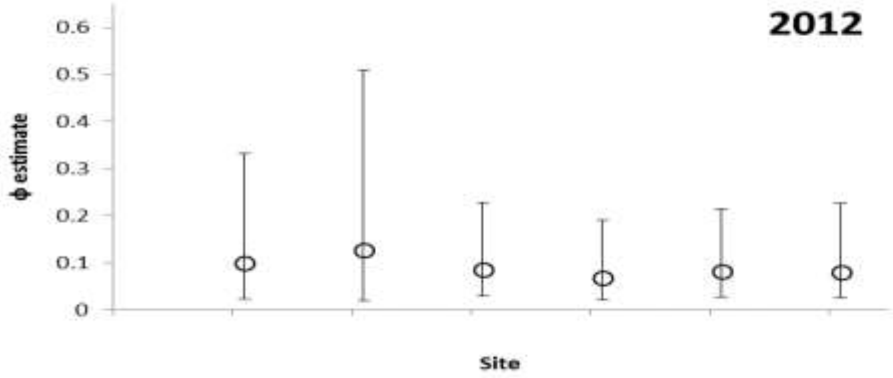
June CPUE (# fish/set) of YoY Coho Salmon
0
2
4
6
8
10
R²=0.87
0
500
1000
1500
2000
Adult Coho Salmon Escapement

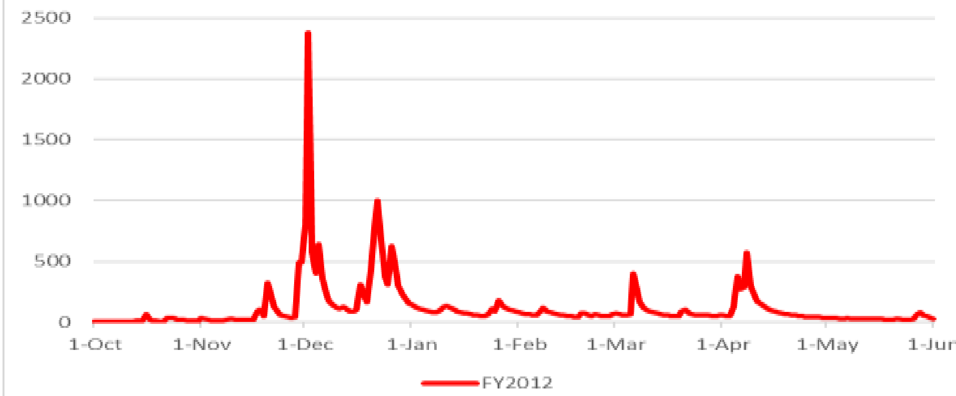

Freshwater Creek Watershed, Humboldt County, CA
Humboldt Bay
Wood Creek
Restoration Project
Pacific Ocean
HUMBOLDT COUNTY
Juvenile Trap Only
Streams
Spawner Survey Reaches
N
W
E
S
0 0.5 1 2 3 4 5 Kilometers

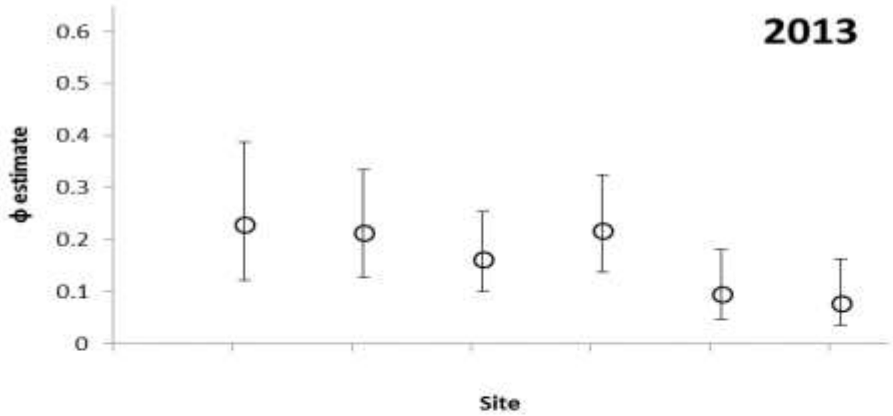

Two SPI's at each location to identify direction of movement.
Allows the determination of immigration emigration rates.
Recaptures for Survival Models

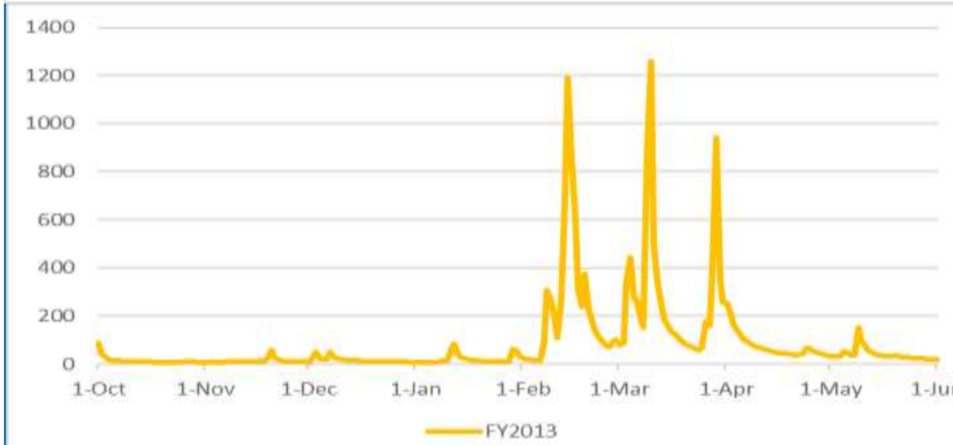


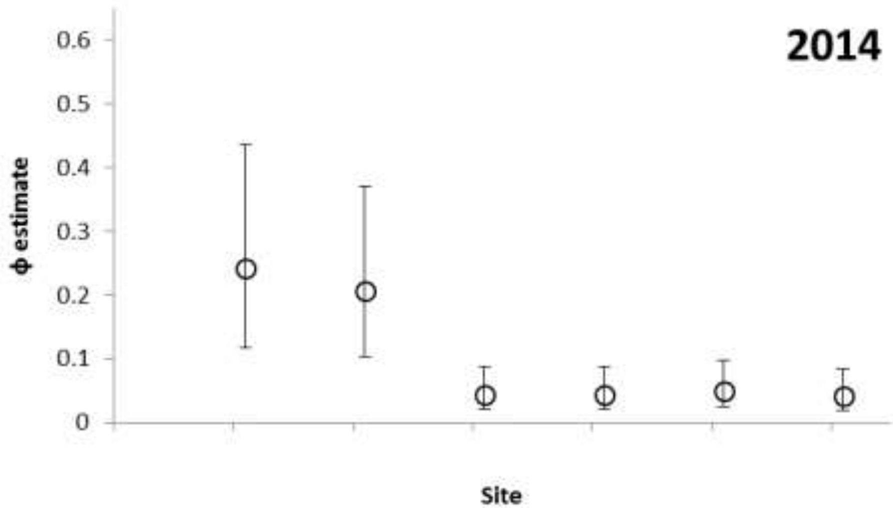
2010
Early emigrants
ϕ estimate
Site
FY2010
2011
ϕ estimate
Site
FY2011
2015
ϕ estimate
FY2015
Lower Basin
Upper Tribs
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun

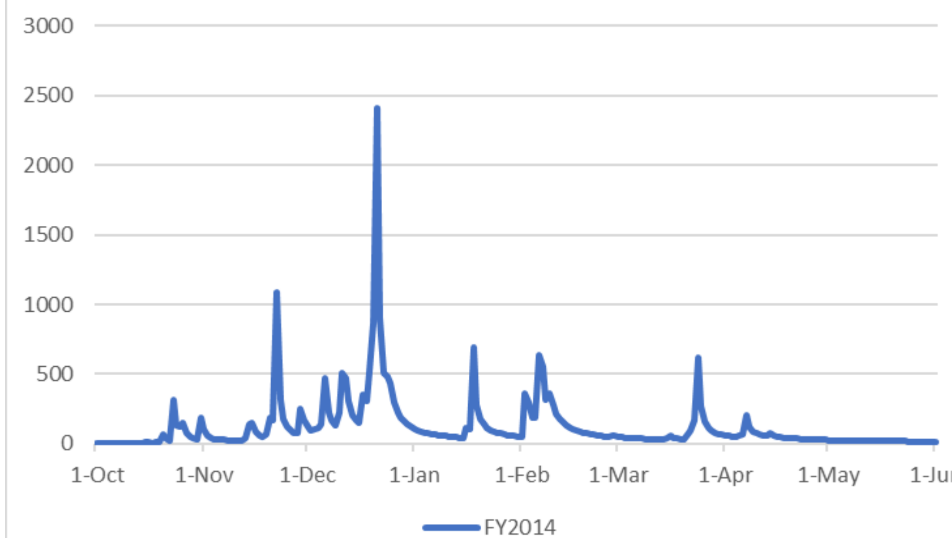

2012
φ estimate
0.6
0.5
0.4
0.3
0.2
0.1
0
Site

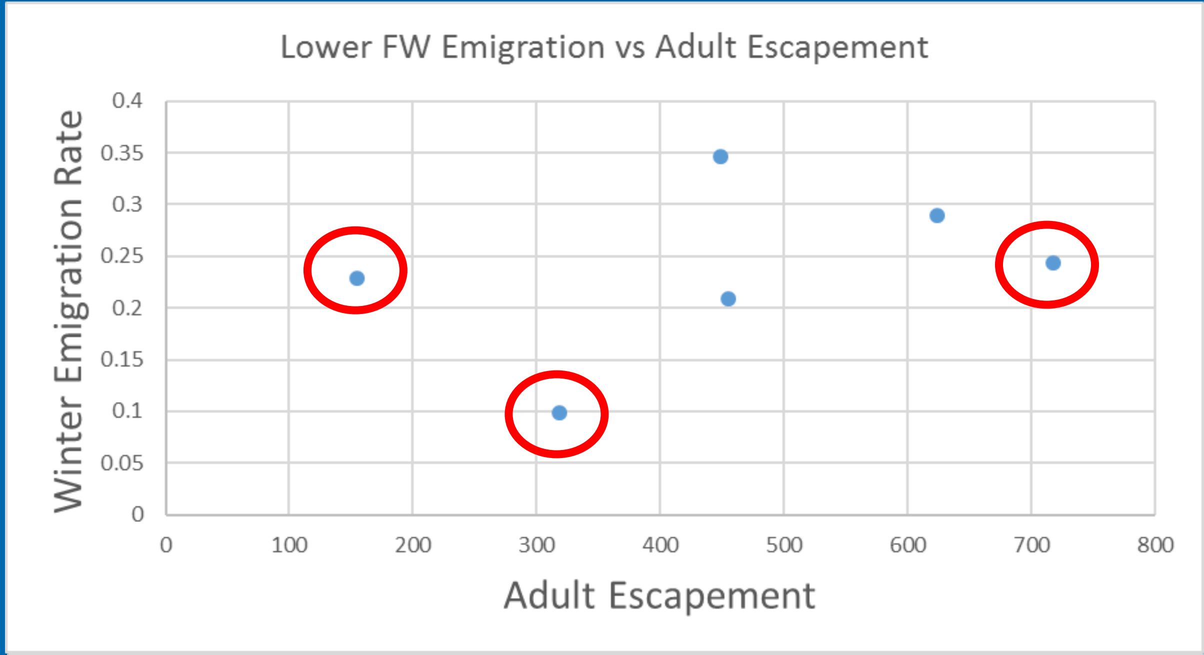

2500
2000
1500
1000
500
0
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
FY2012


2013
φ estimate
0.6
0.5
0.4
0.3
0.2
0.1
0
Site

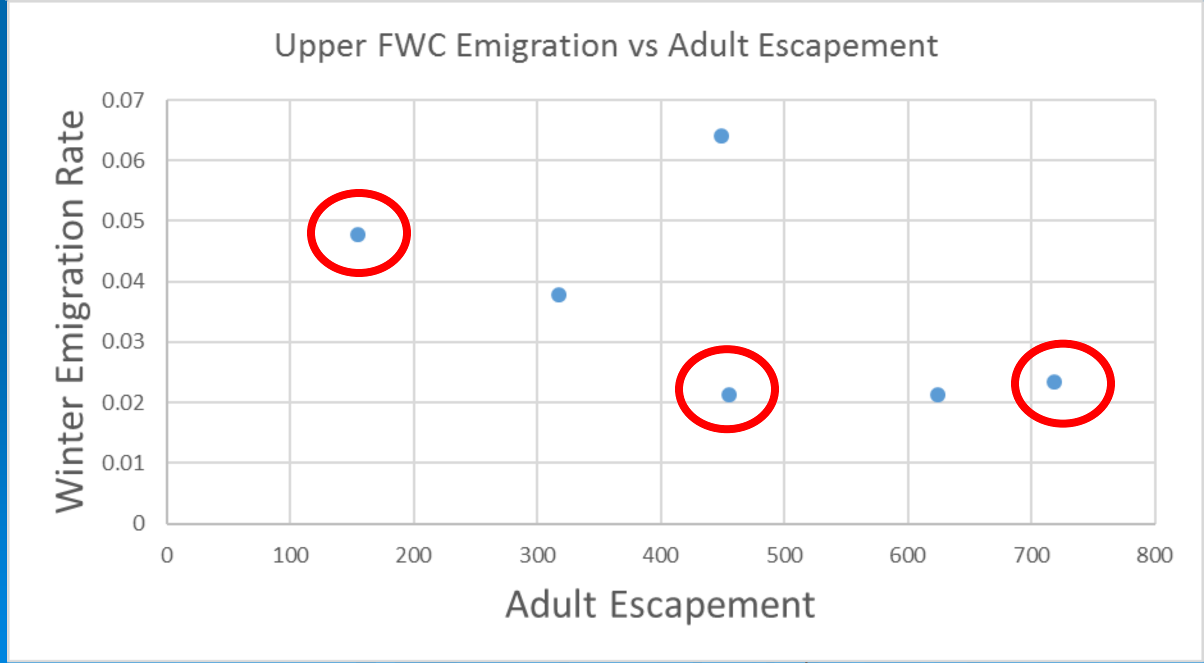

1400
1200
1000
800
600
400
200
0
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
FY2013


2014
φ estimate
0.6
0.5
0.4
0.3
0.2
0.1
0
Site

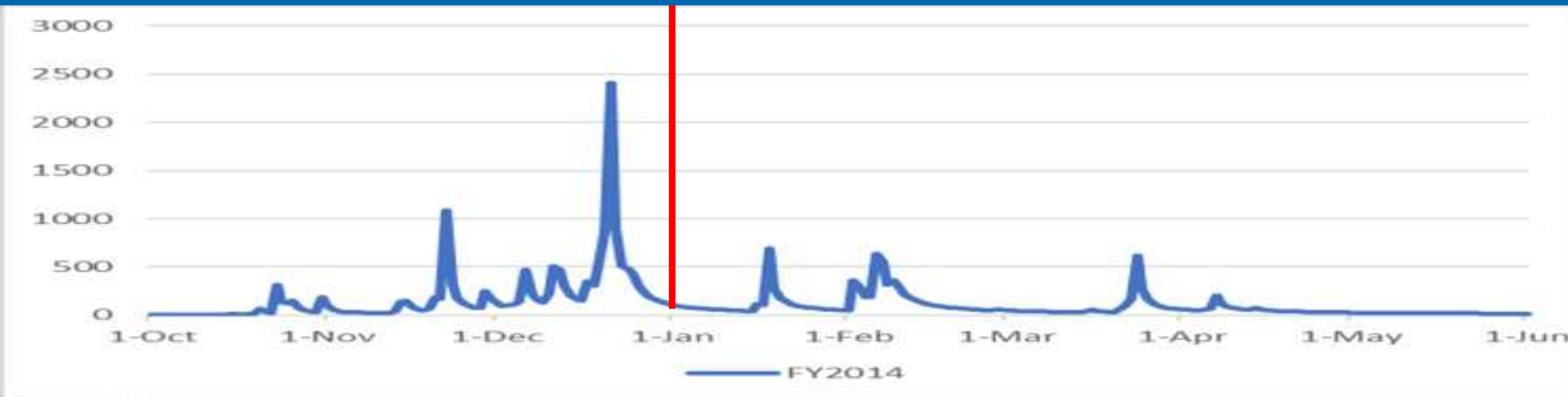

3000
2500
2000
1500
1000
500
0
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
FY2014

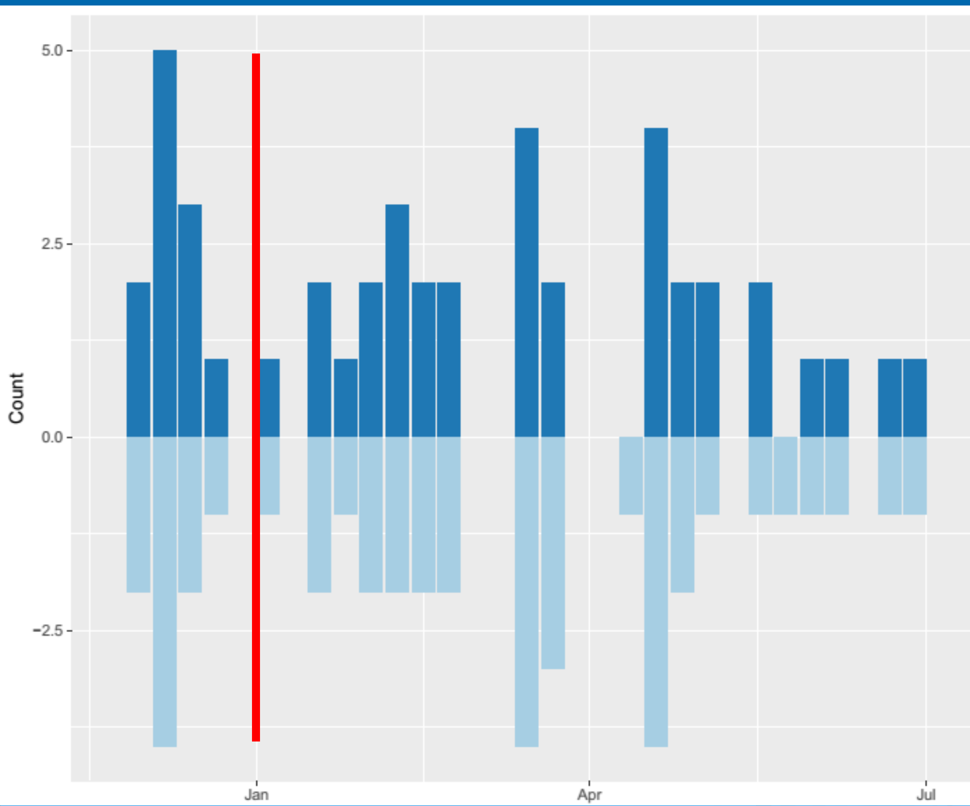


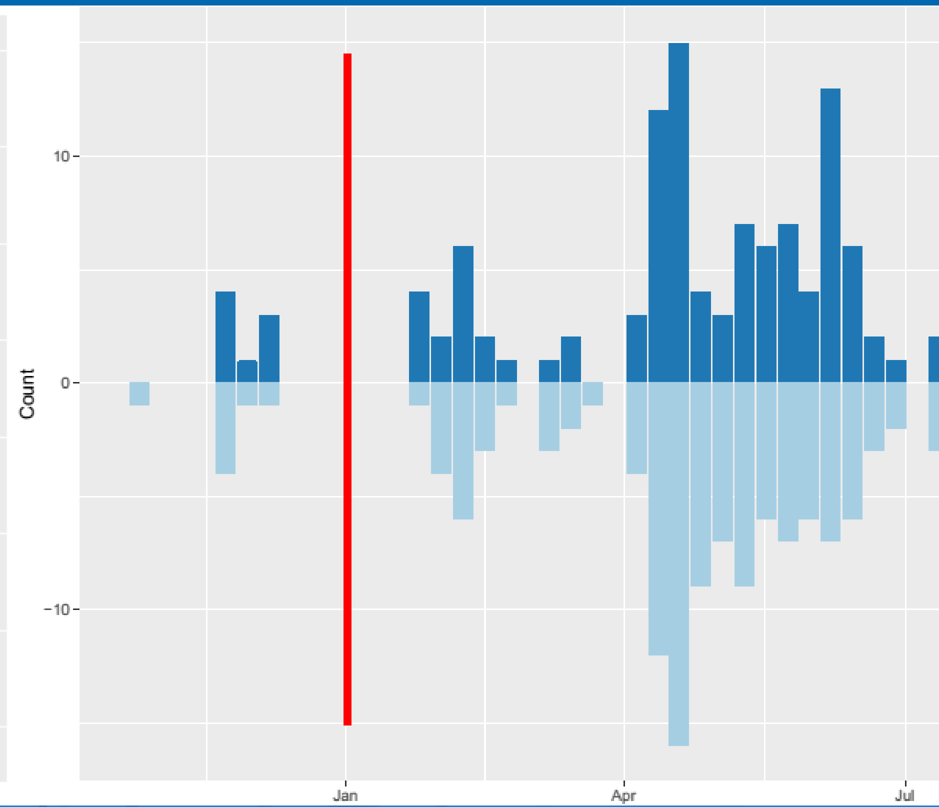
Lower FW Emigration vs Adult Escapement
Winter Emigration Rate
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
100
200
300
400
500
600
700
800
Adult Escapement

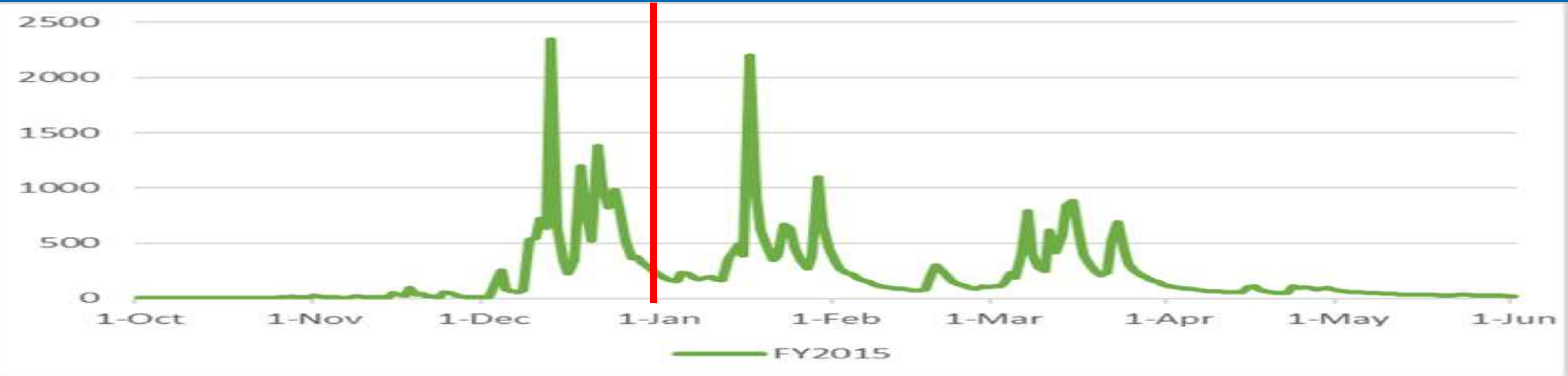


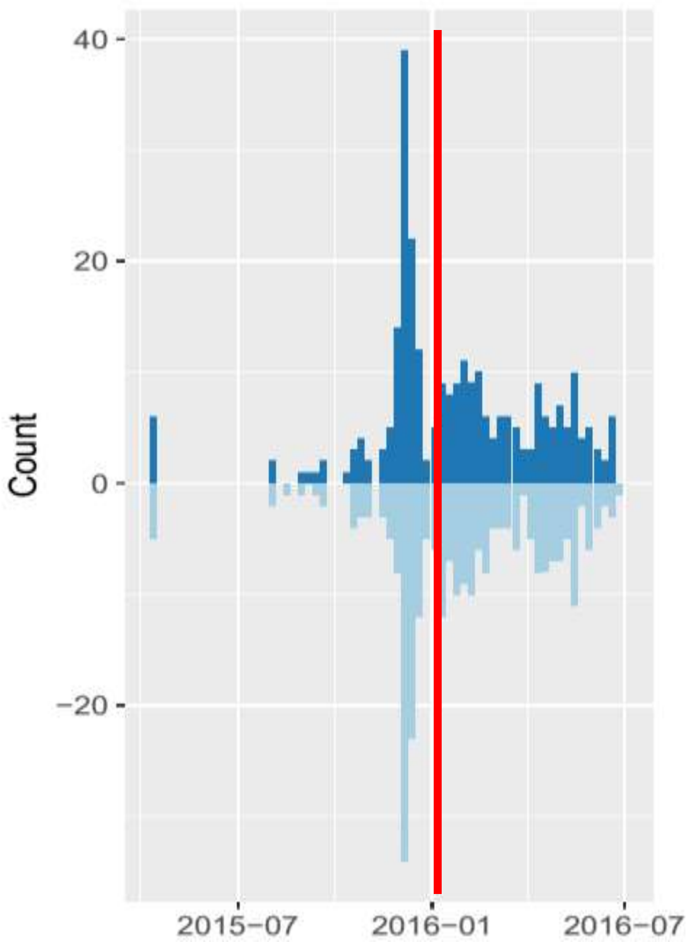
Upper FWC Emigration vs Adult Escapement
Winter Emigration Rate
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
100
200
300
400
500
600
700
800
Adult Escapement

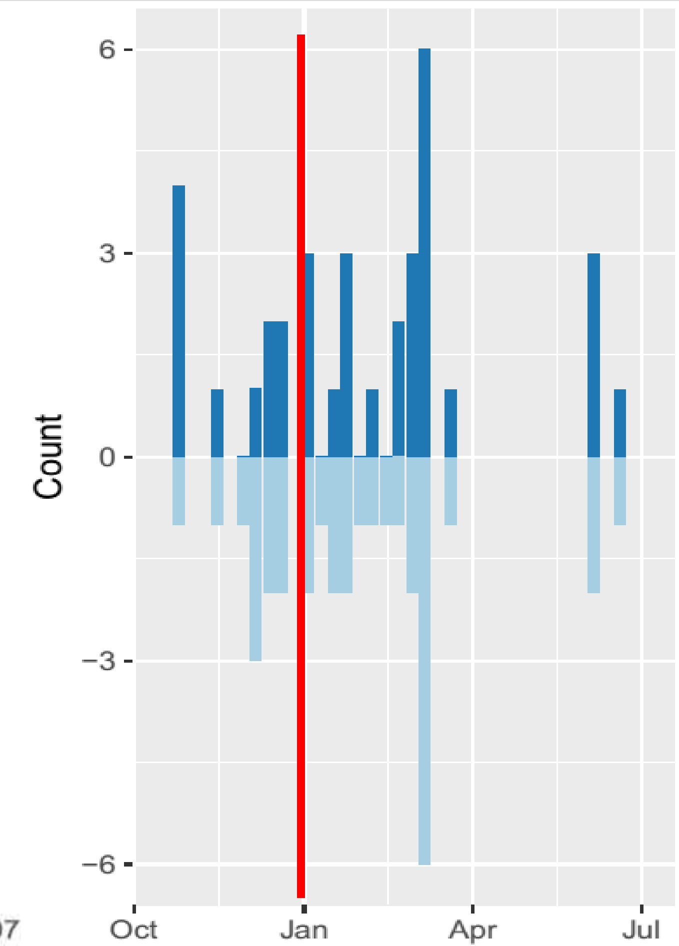

3000
2500
2000
1500
1000
500
0
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
FY2014


5.0
2.5
0.0
-2.5
Count
Jan
Apr
Jul


10
0
-10
Count
Jan
Apr
Jul

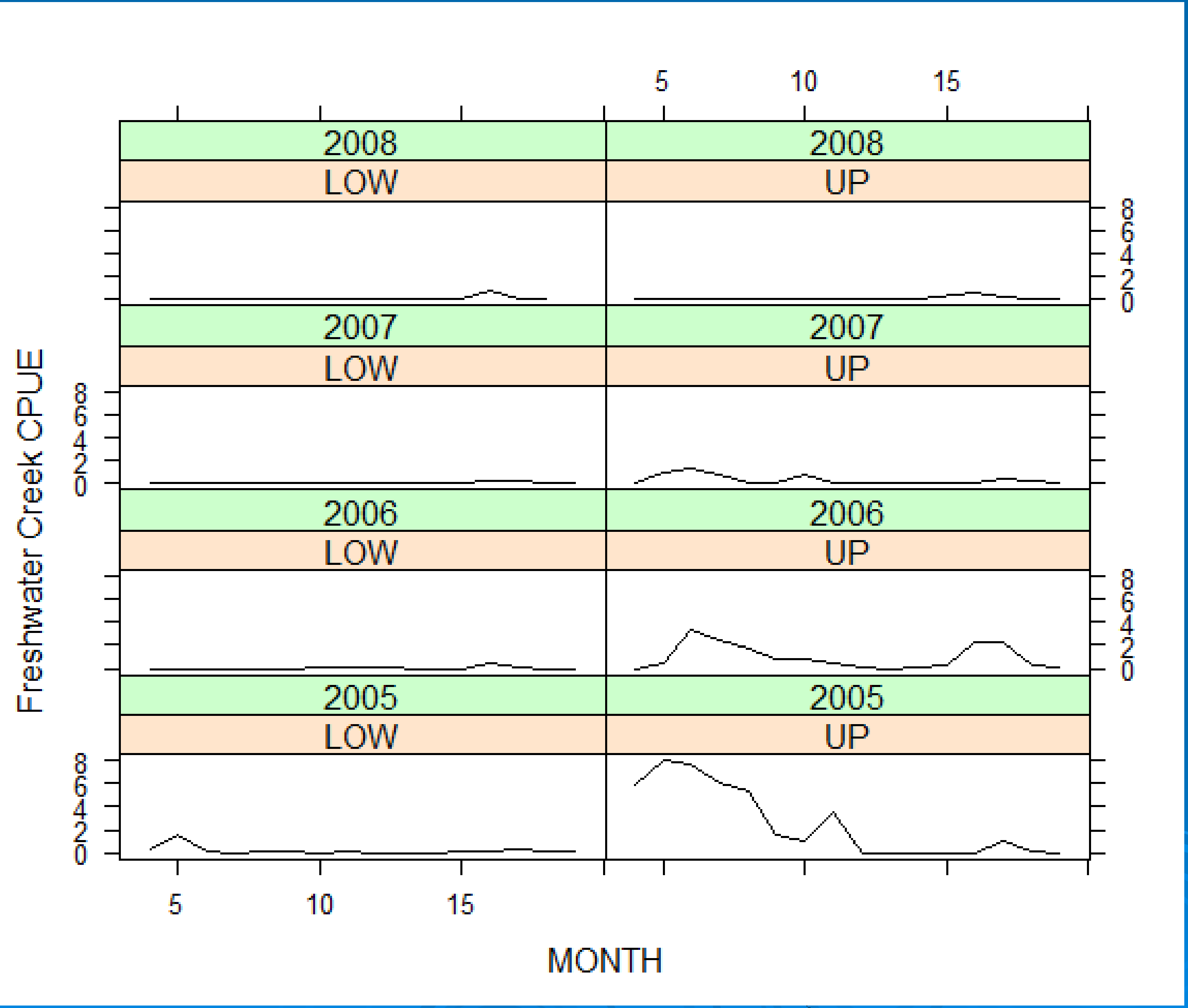

2500
2000
1500
1000
500
0
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
FY2015


40
20
0
−20
Count
2015−07
2016−01
2016−07


6
3
0
−3
−6
Count
Oct
Jan
Apr
Jul

- Coho in coastal California systems appear to transition to non-natal habitat during spring and fall

- Movement to non-natal habitats is variable
  - Annual Rate
  - Timing
    - Demographic
    - Environmental



2008
LOW
2008
UP
2007
LOW
2007
UP
2006
LOW
2006
UP
2005
LOW
2005
UP
Freshwater Creek CPUE
MONTH
0 2 4 6 8
5 10 15

How should we monitor?

- What do we measure?
- Where and when do we measure it?
- How do we interpret seasonal catch data?
- What sampling designs are appropriate?

+ Group Discussion Topics

Data Gaps

- What project types are we lacking in effectiveness monitoring information?
- Stream flow improvements, summer flow conditions in areas such as the Russian River. Other areas - Lower Klamath. Would increases in winter survival offset losses in summer survival? Methods for monitoring streamflow and water quality. Residence time of water in pools.
- Instream wood projects. CDFW FRGP about 10% of projects are monitored.
- Unable to get a sediment reduction presentation for this workshop. French Creek/Scott River studies by Sari Summerstrom. Lower Elk River sediment studies, long profiles. Compare modern erosion rates with historic rates for Elk River TMDL. Gualala long-term sediment studies in conjunction with road decommissioning. Green Diamond HCP has sediment and channel monitoring components.
- Other monitoring tools – PIT tags and drones in today's presentations. No discussion of using Dydson counts for adult escapement. Northern CA include Redwood Creek and Smith River. Overlap of species timing is a potential issue.
- Engineered log jams, fish counts are difficult and potentially unsafe. Other means to make counts?
- How do we collect pre project biological and physical data on projects prior to getting funded for the implementation and design?
- How do quantify effectiveness? Continue life cycle monitoring in watersheds. Start with a detailed diagnosis of the ecosystem, develop hypotheses prior to project type selection. Appropriate time frames for monitoring. Project longevity. Cost-benefit analyses. Short-term fixes until the natural processes are restored, but in many cases natural processes may be unrestorable.
- Water quality (D.O.) with juvenile salmonids thriving in levels lower than published studies. Is there a need for pulling values together from other studies or focus more work with this topic?

+ Group Discussion Topics

Priority and Geographic Needs

- Project types that are priority? Southern Ca, fish passage is a priority, lots of blockages in lower river channels.
- Funding for project implementation, SLO. Sacramento, status and trends, spring-run Chinook.
- New techniques and methodologies….see previous list. Dry Creek drone surveys for channel restoration, subscription-based software analysis. Still requires total station for surveying wetted channel bottom. Drones have other limitations and requirements that may restrict their utility.
- PIT tag arrays construction and operation methods/trainings. E-DNA technology for presence and distribution, and for diet analysis. Genetic markers for M-R methods.
- Standard methods are important for comparison, but new techniques are critical to explore other habitats and potential life history strategies. Also new analysis of older data sets. Unimpaired hydrograph analysis as an example.
- Synthesize what data we do have – funding limitation? Honest assessment of past restoration, did it work?
- Adequate staffing and trained personnel……well thought out study designs and competent staff to properly implement the studies.
- Geographic needs (North Coast, SF Bay Area, Central Valley, Central Coast, South Coast).

+ Group Discussion Topics

Funding and Synergistic Opportunities

- Funding - CDFW FRGP, Prop 1, NMFS, Coastal Conservancy, Fish Passage Forum, Others?
- Synergistic Opportunities – Coupling effectiveness monitoring with CMP watersheds, Other opportunities?
- Wallace presentation – combine efforts within a geographic scope, as such as Humboldt Bay. Look for other opportunities already ongoing to piggyback onto.
- FRGP requires a level of monitoring tied to funded projects. Cost benefit to pooling $ to fund fewer people to monitor a larger group of projects?
- How can pre-project monitoring get funded? How can effectiveness be assessed with limited or no pre-project data? Challenges of funding timing with both project implementation and monitoring.
- Establish a stable funding source dedicated to project monitoring. CMP monitoring as part of the grants program? Statewide costs of CMPs?
- Obvious there's not enough money for monitoring, let alone restoration. Look beyond state and federal sources. Look to urban areas for funds. Lottery sales?
- Proximity to colleges and universities to assist with monitoring? Adequate training? Time available?
- Need better ways to communicate the importance of monitoring to funders – or the results of previous efforts to fund future efforts. Share both successes and failures. FishXing case studies do share project fails and limitations.
- Apply results and conclusions of extensive studies (as such BACI) to other areas and monitoring.
- CDFW to support and provide training for their staff and provide trainings opportunities to others.