Upper Klamath-Trinity River Spring-Run Chinook: Biology, Genetics and Recovery

A Concurrent Session at the 34th Annual Salmonid Restoration Conference held in Fortuna, CA from April 6-9, 2016.

Session Overview

- Session Coordinator:
  - Tom Hotaling, Salmon River Restoration Council

Klamath Basin Spring-run populations are currently at less than 10% of their historic level, and at least 7 runs in the Klamath Basin are now extinct. Previous NMFS status reviews of UKTR Chinook salmon lacked the genetic evidence to warrant a separate ESU for the Spring-Run. However, new technology has enabled greater insight into the genetic makeup of these fish. The question now is, how we move toward recovery of this run timing.

This session will feature presentations which provide an overview of Spring-Run Chinook biology, including new genetic information. Presentations will also address Spring-Run restoration efforts and the importance of Spring-Run Chinook for Native tribes of California. A panel discussion, focused on the next steps toward Klamath River Spring Chinook recovery will follow presentations.

Presentations

(Slide 4) Spring-Run Salmon Recovery in the Klamath-Trinity Basin
Joshua Strange, Ph.D., Stillwater Sciences

(Slide 60) Pacific Salmon Run Timing Reveals Critical Flaws in Current Methods for Conservation Unit Delineation
Michael Miller, PhD, UC Davis

Ishyâat, Spring Salmon
Josh Saxon, Karuk Tribal Council
*presentation not included

(Slide 88) Spring Chinook of the South Fork Trinity River
Joshua Smith, Watershed Research and Training Center

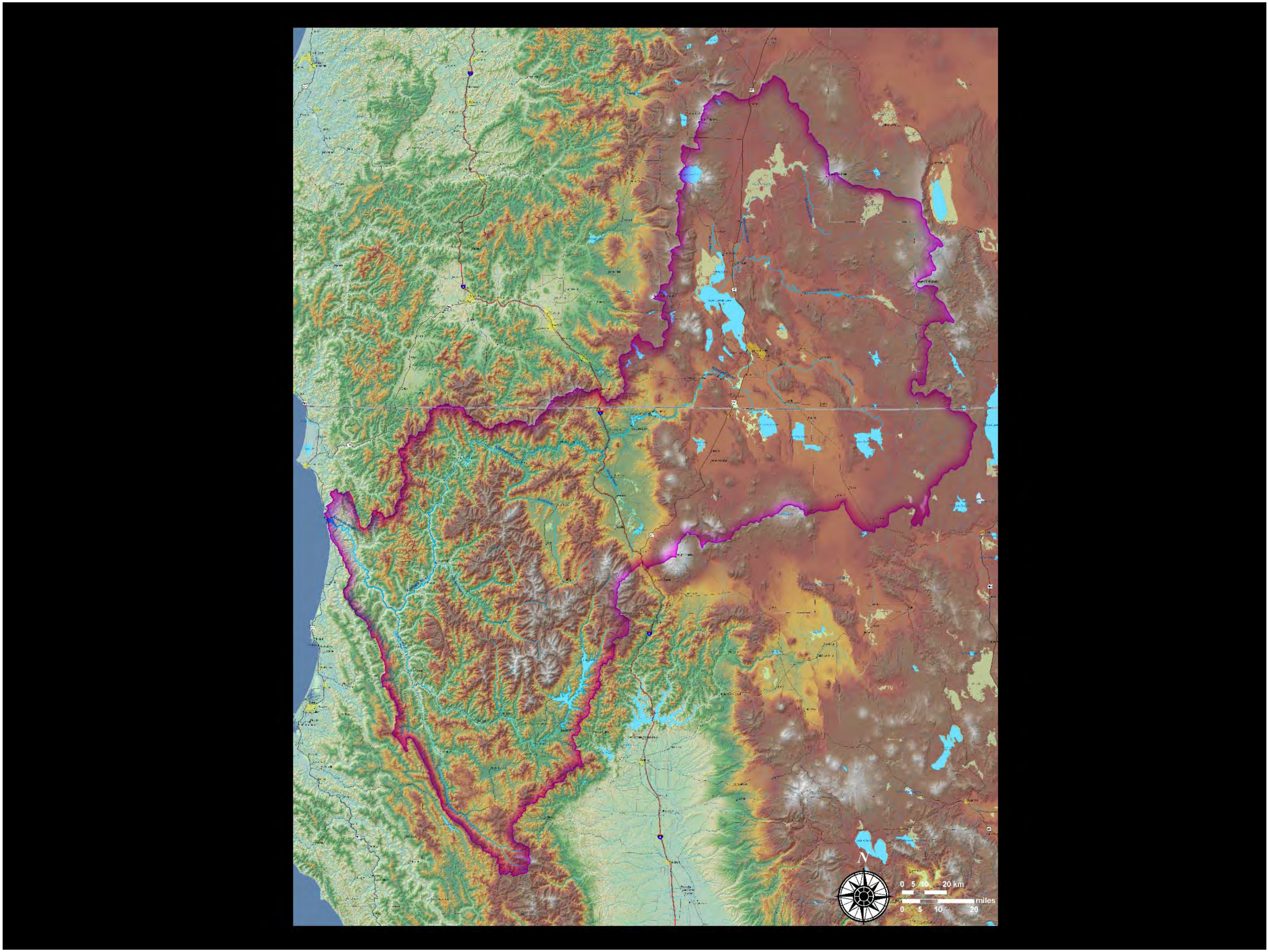
(Slide 130) Restoration of Wild Spring-Run Chinook on the South Fork Trinity River – A Call for Action
D.J. Bandrowski, Yurok Tribe

(Slide 167) Monitoring and Restoration Efforts for Salmon River Spring-Run Chinook and their Relevance to the Planned Reintroduction of Salmonids in the Upper Klamath Basin After Dam Removal
Nathaniel Pennington, Salmon River Restoration Council

Spring-run Salmon Recovery in the Klamath-Trinity Basin

Joshua Strange, PhD, Stillwater Sciences
Nat Pennington, Salmon River Restoration Council

34th Annual Salmonid Restoration Federation Conference


N
0 5 10 20 km
0 5 10 20 miles

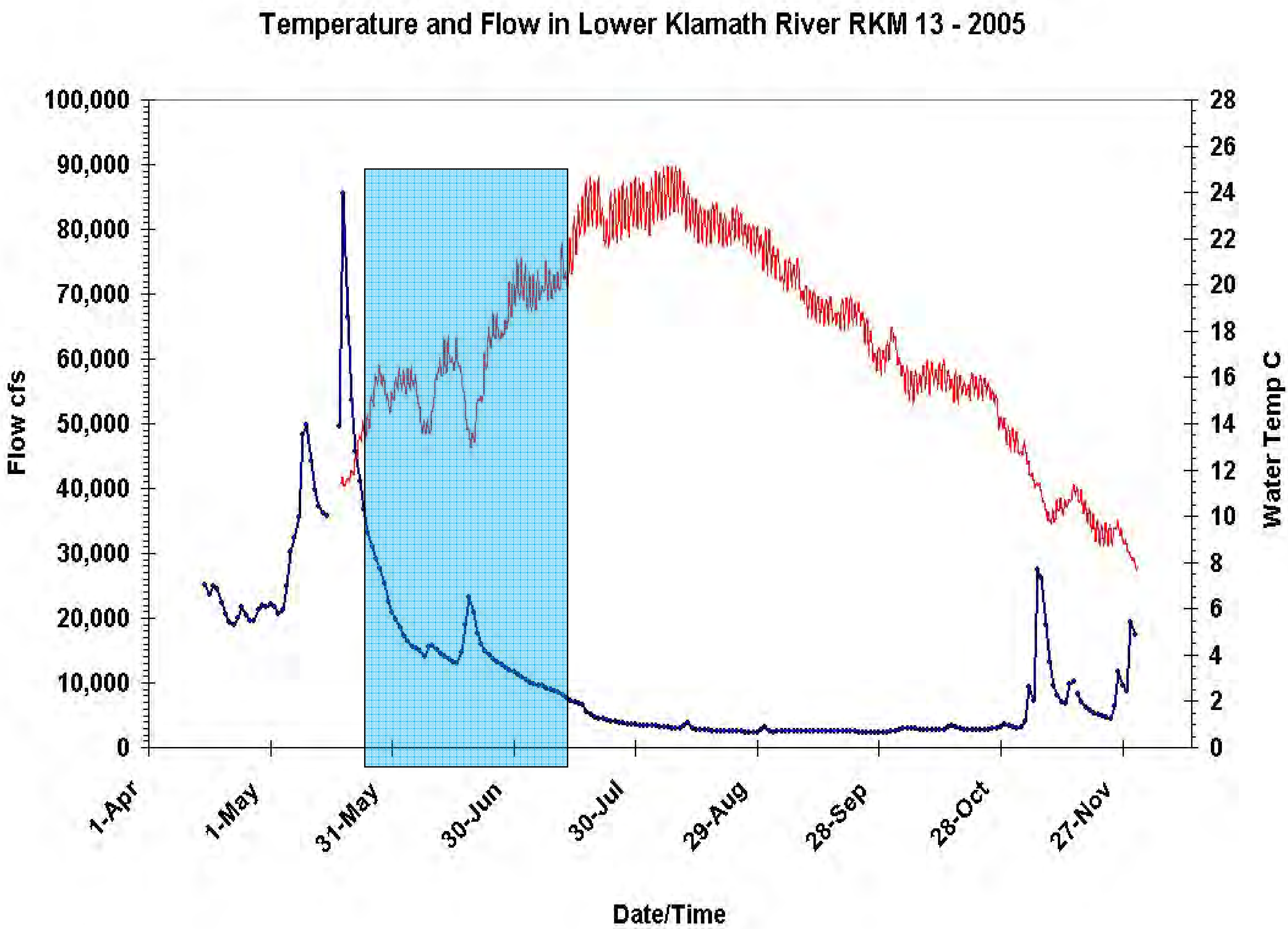
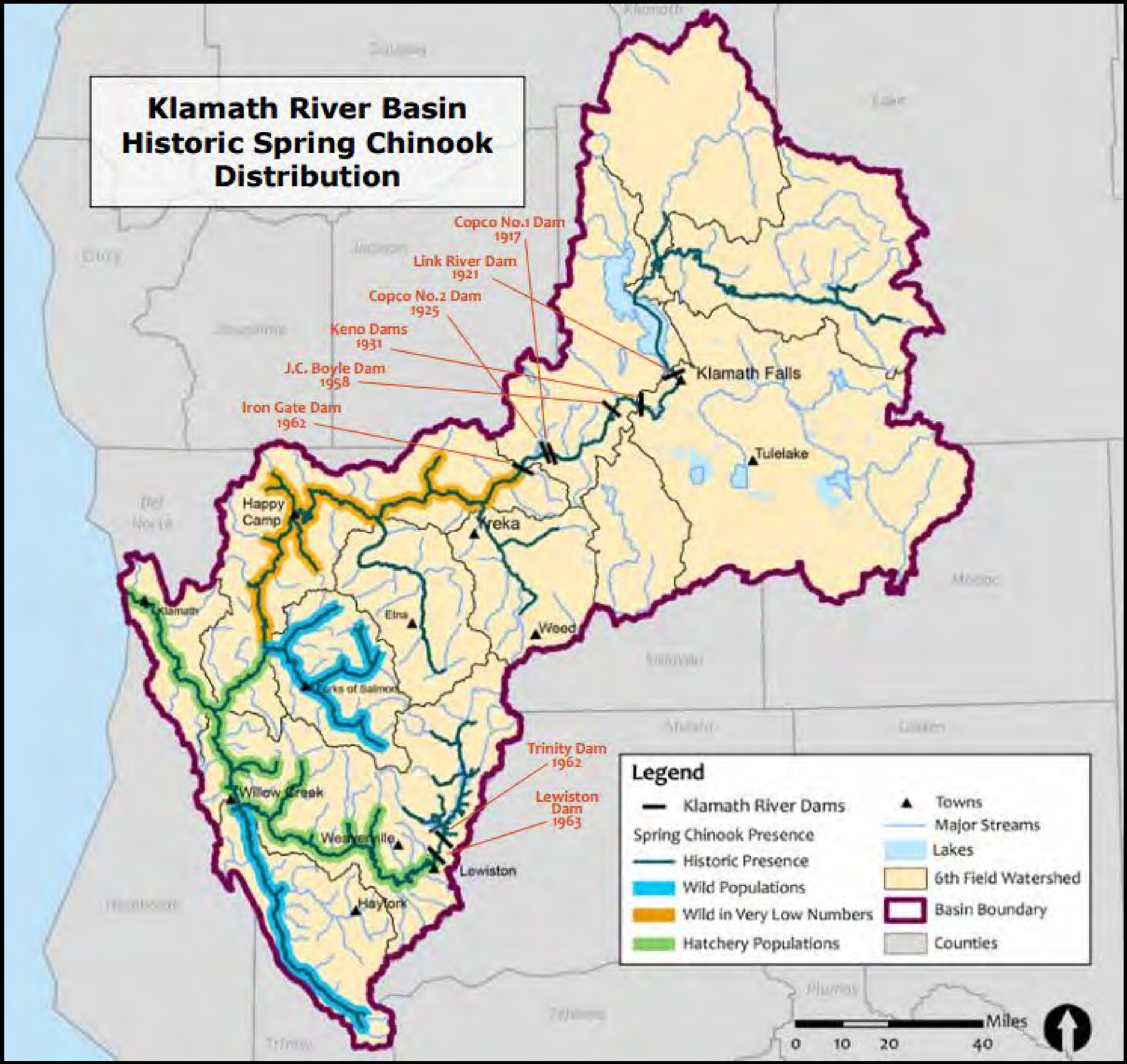

Temperature and Flow in Lower Klamath River RKM 13 - 2005
Flow cfs
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Water Temp C
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1-Apr
1-May
31-May
30-Jun
30-Jul
29-Aug
28-Sep
28-Oct
27-Nov
Date/Time

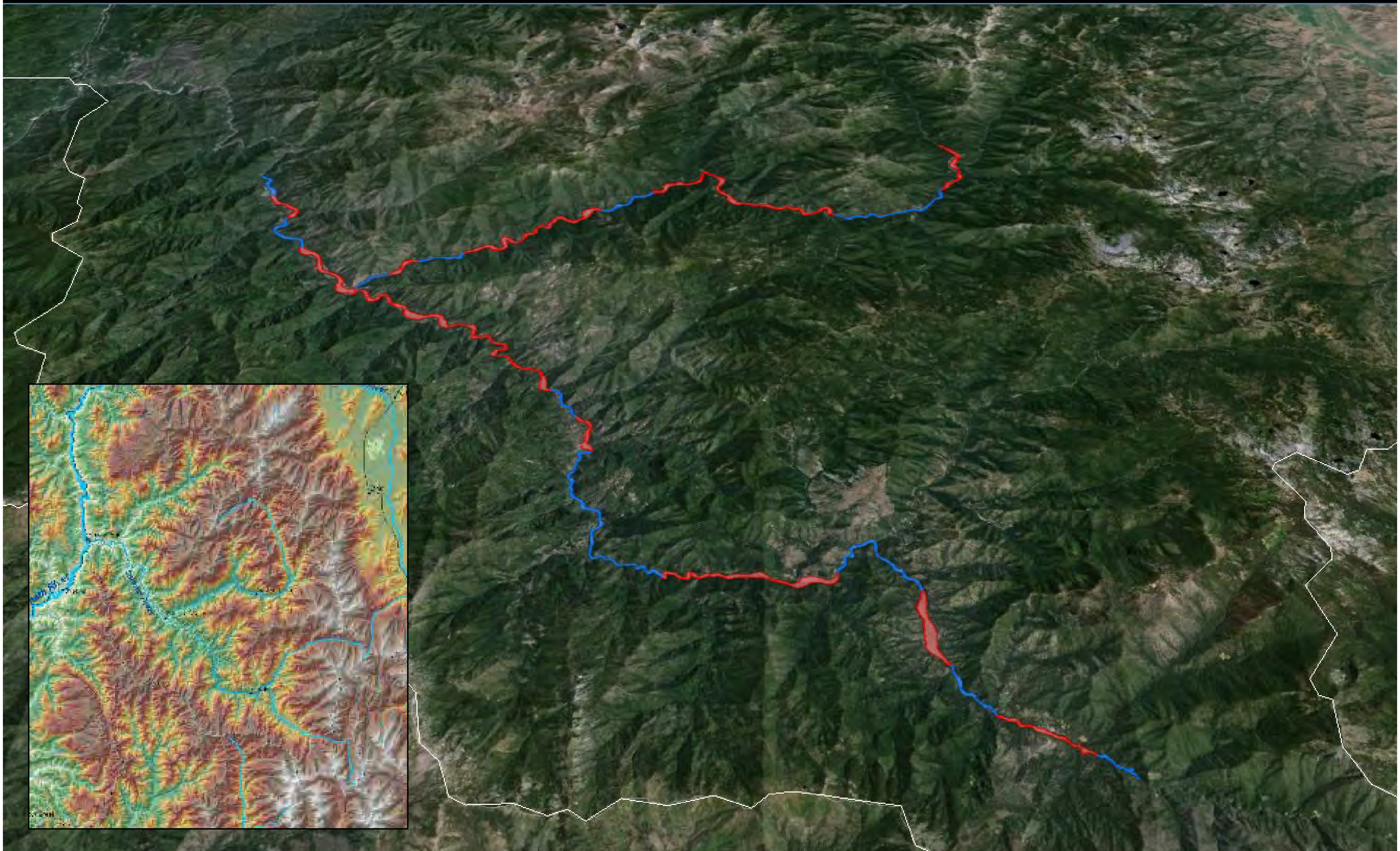

Photo: Jamie Holt

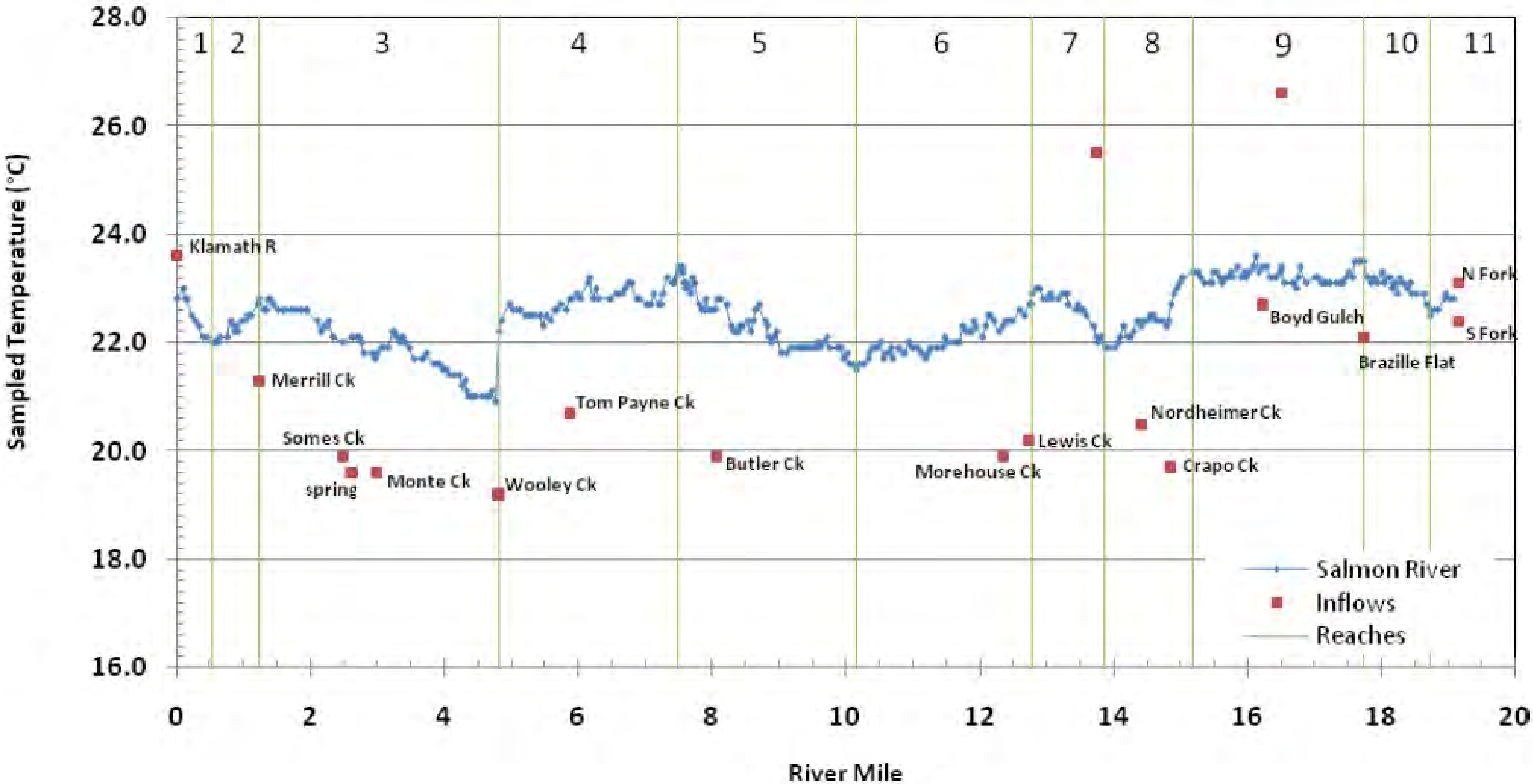

Klamath River Basin
Historic Spring Chinook
Distribution
Copco No.1 Dam
1917
Link River Dam
1921
Copco No.2 Dam
1925
Keno Dams
1931
J.C. Boyle Dam
1958
Iron Gate Dam
1962
Klamath Falls
Tulelake
Happy Camp
Yreka
Etna
Weed
Forks of Salmon
Trinity Dam
1962
Lewiston Dam
1963
Willow Creek
Weaverville
Lewiston
Hayfork
Legend
Klamath River Dams
Spring Chinook Presence
Historic Presence
Wild Populations
Wild in Very Low Numbers
Hatchery Populations
Towns
Major Streams
Lakes
6th Field Watershed
Basin Boundary
Counties
Miles
0 10 20 40

Problems and Risks

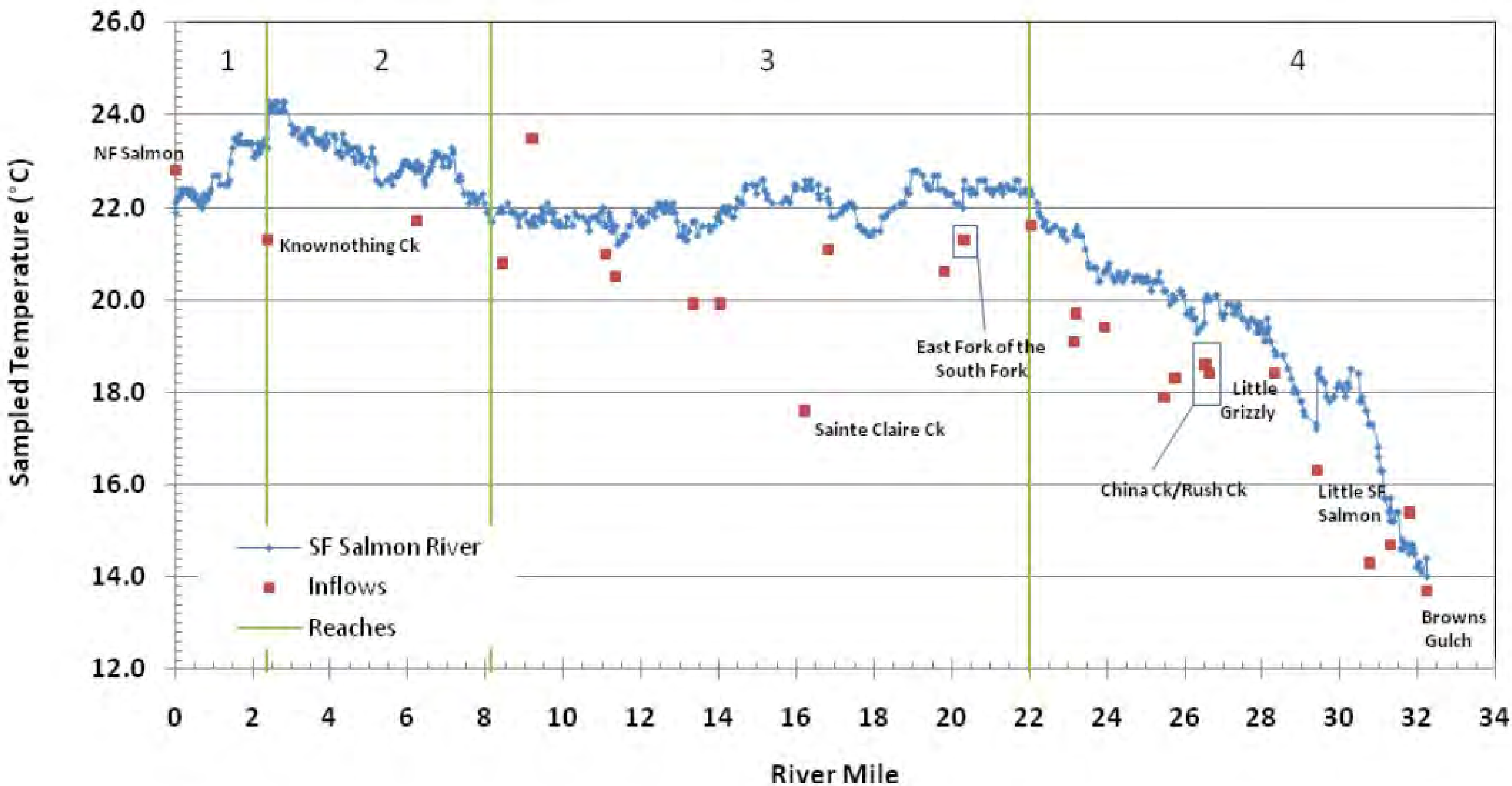
- Low abundance and depensation
- Limited spawning habitat
- Stream-type rearing
- Hybridization with fall-run
- Artificial selection
- Under-regulated harvest
- Constrained habitat
- Climate destabilization
- Elevated water temperatures
- Increased disease pathogens
- Limited spawning habitat

Salmon River





28.0
26.0
24.0
22.0
20.0
18.0
16.0
Sampled Temperature (°C)
1 2 3 4 5 6 7 8 9 10 11
Klamath R
Merrill Ck
Somes Ck
spring
Monte Ck
Wooley Ck
Tom Payne Ck
Butler Ck
Morehouse Ck
Lewis Ck
Nordheimer Ck
Crapo Ck
Boyd Gulch
Brazille Flat
N Fork
S Fork
Salmon River
Inflows
Reaches
0 2 4 6 8 10 12 14 16 18 20
River Mile


26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
Sampled Temperature (°C)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
River Mile
1
2
3
4
NF Salmon
Knownothing Ck
East Fork of the
South Fork
Sainte Claire Ck
Little
Grizzly
China Ck/Rush Ck
Little SF
Salmon
Browns
Gulch
SF Salmon River
Inflows
Reaches

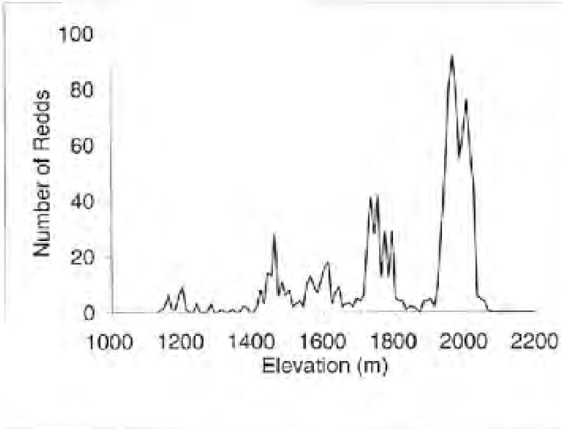
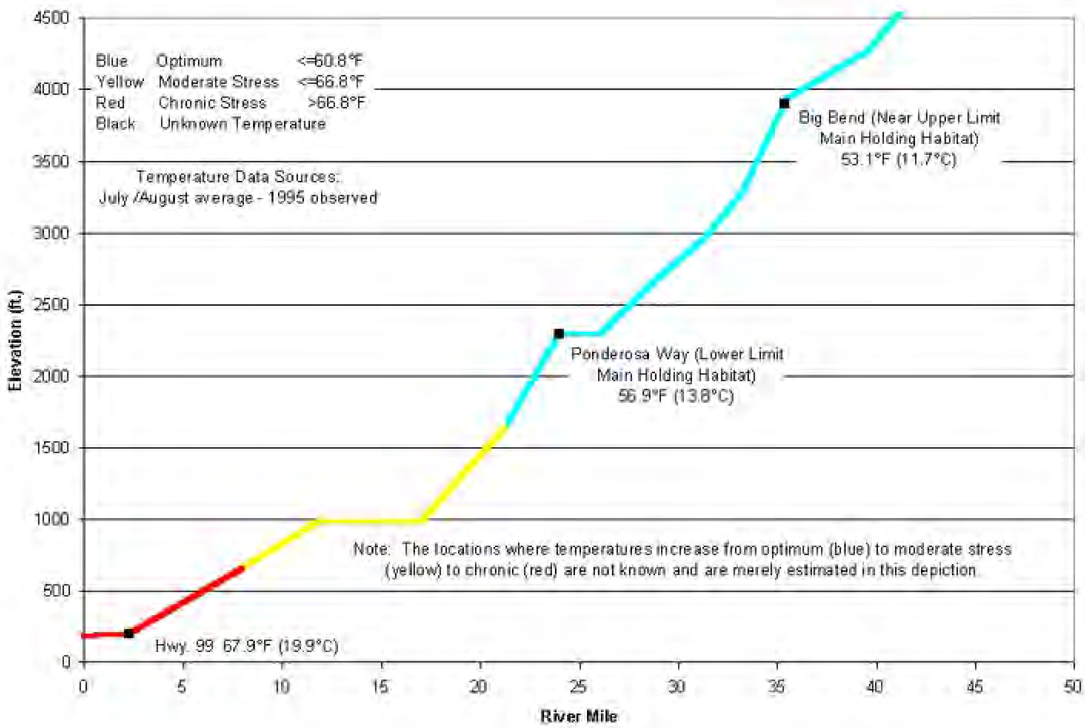


Figure 2—Elevation of 1,188 redds observed in the Middle Fork Salmon River, Idaho, 1995-1998.



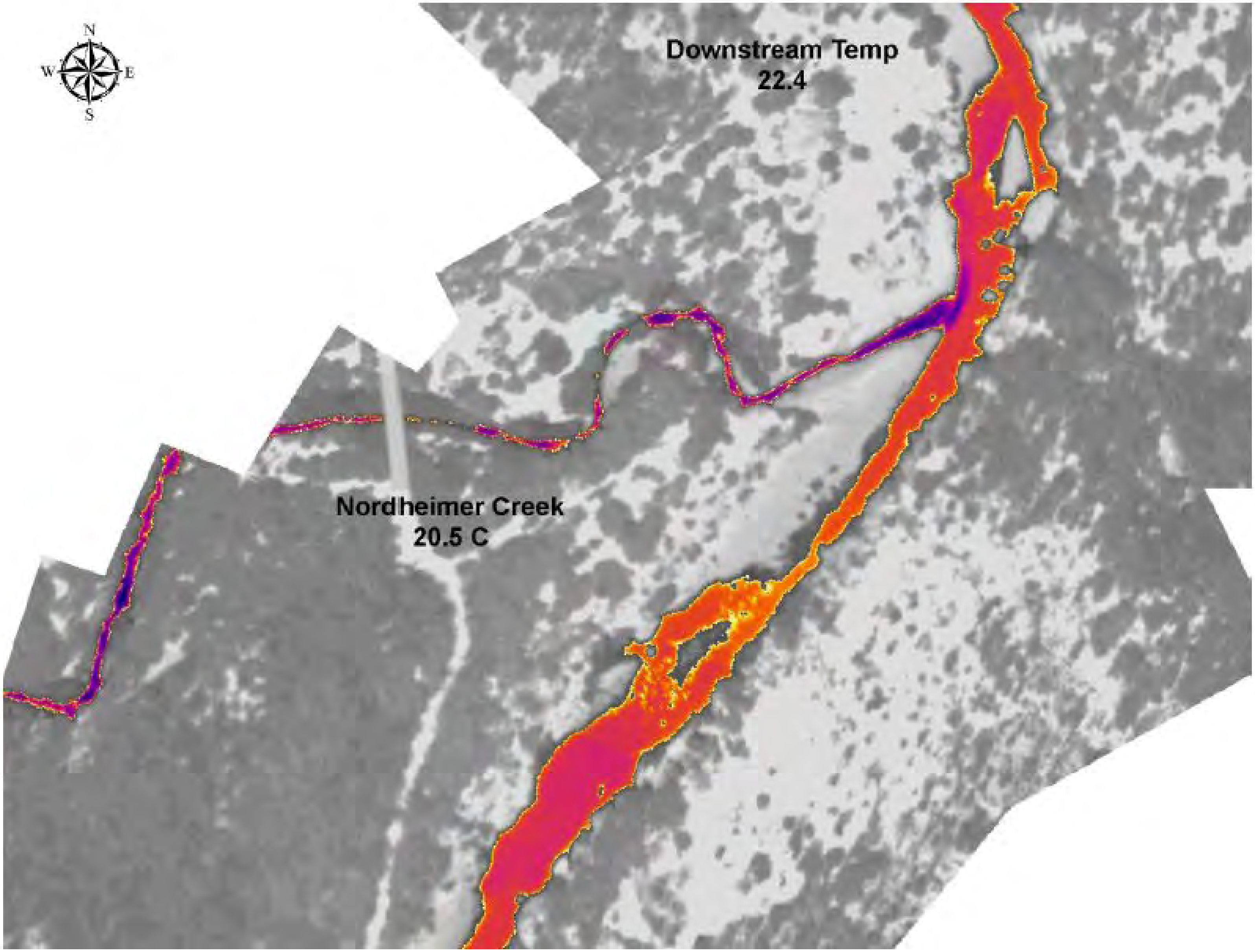
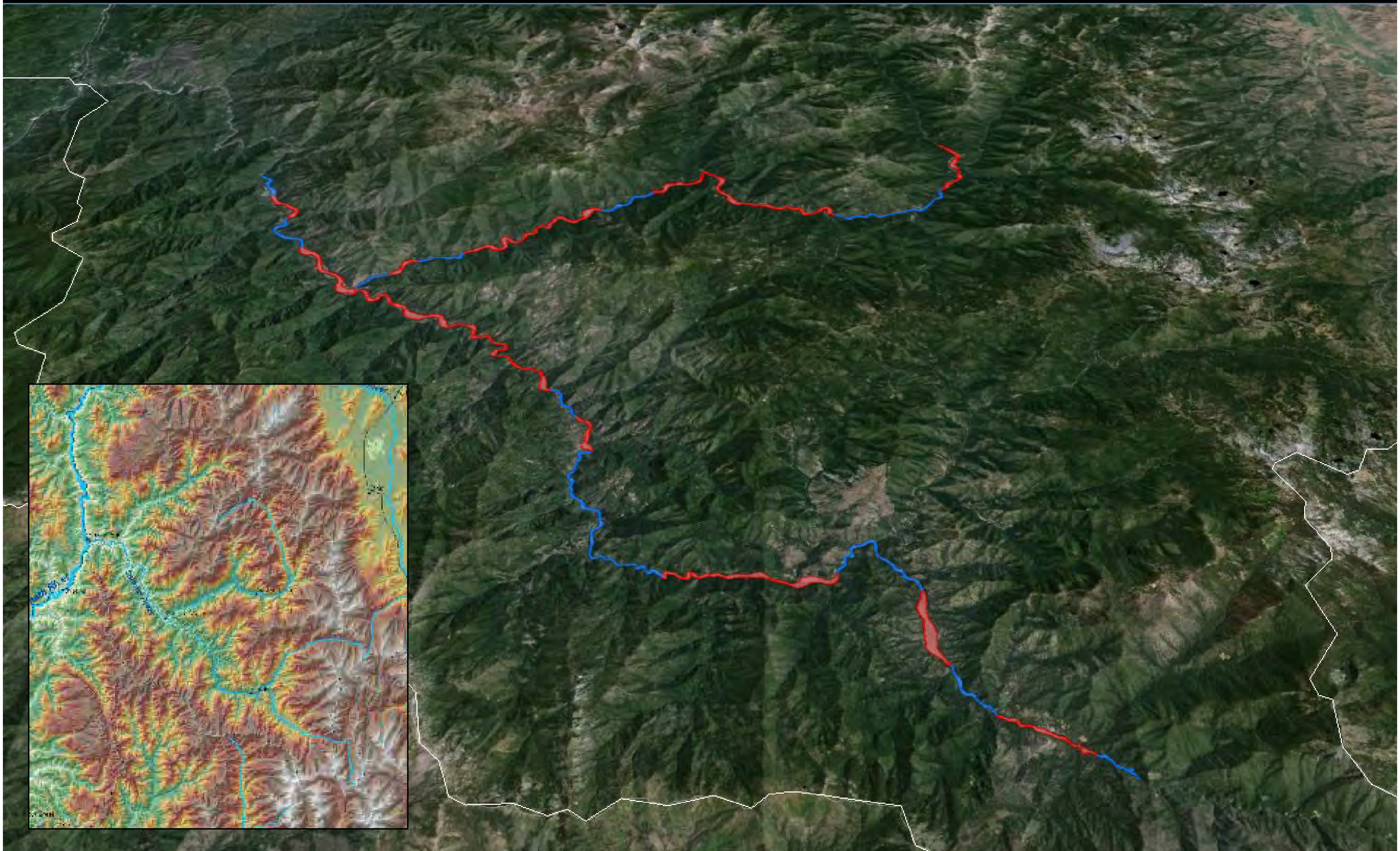
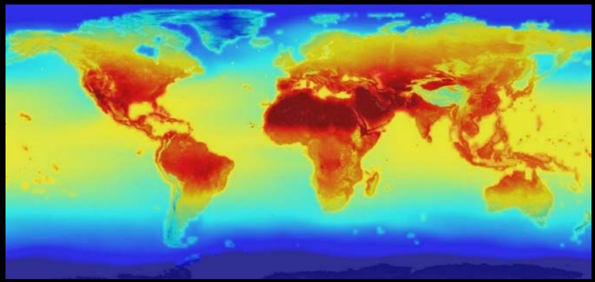
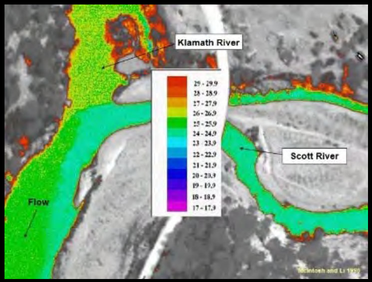

N
W
E
S
Downstream Temp
22.4
Nordheimer Creek
20.5 C

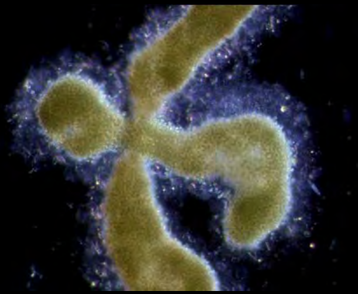

Photo: Josh Strange
Flavobactor columnare
“columnaris”

Salmon River

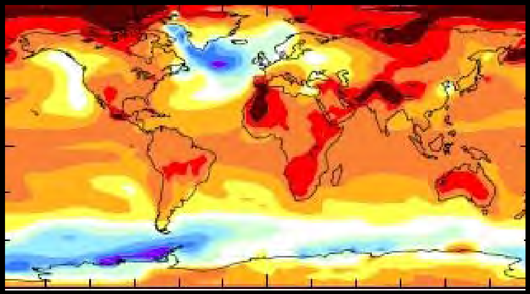


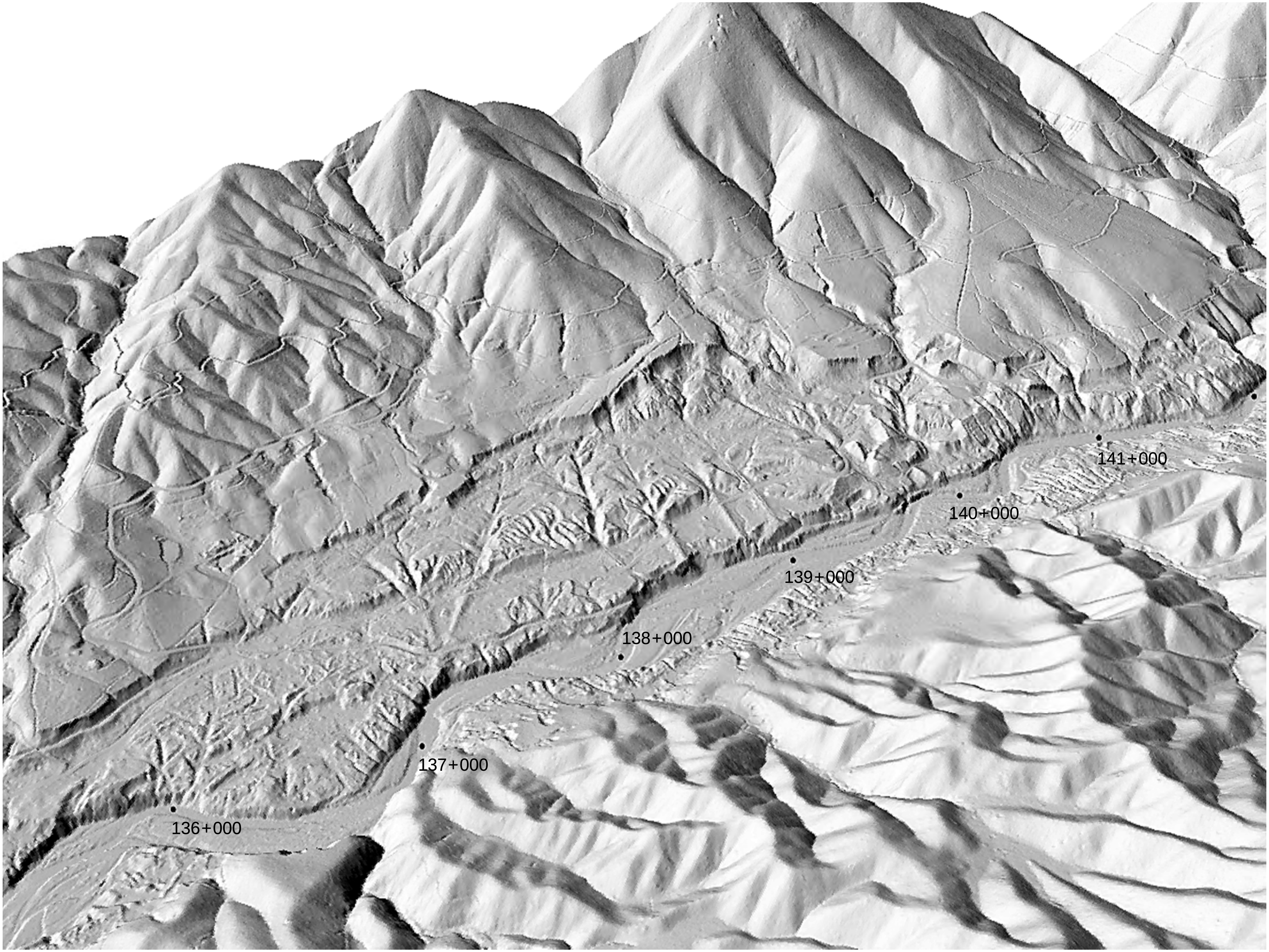



Klamath River
Scott River
Flow

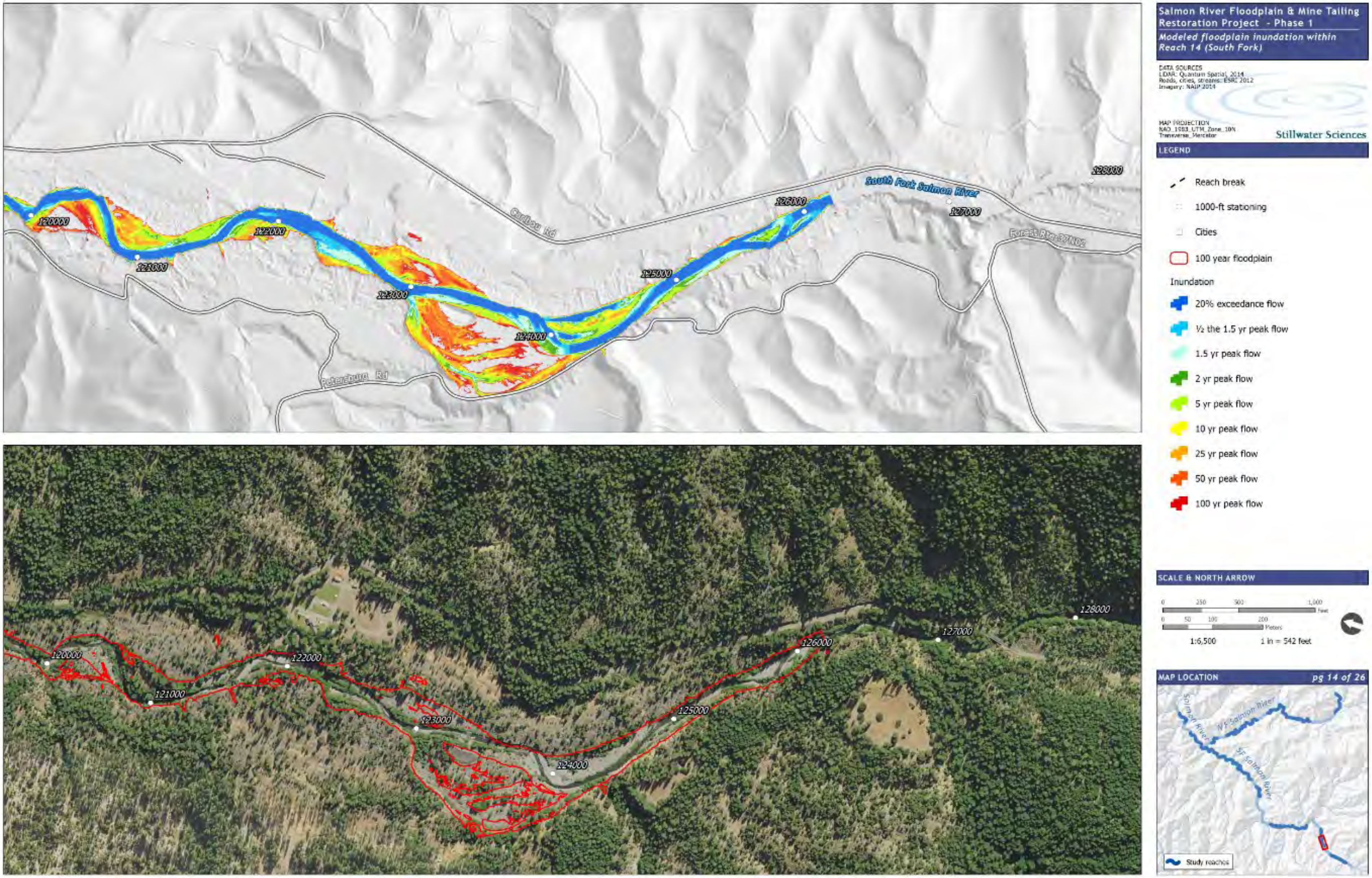



OCEAN ACIDIFICATION
Impacts on Sea Life
Corrodes Shellfish and Coral
Day 1
Day 45

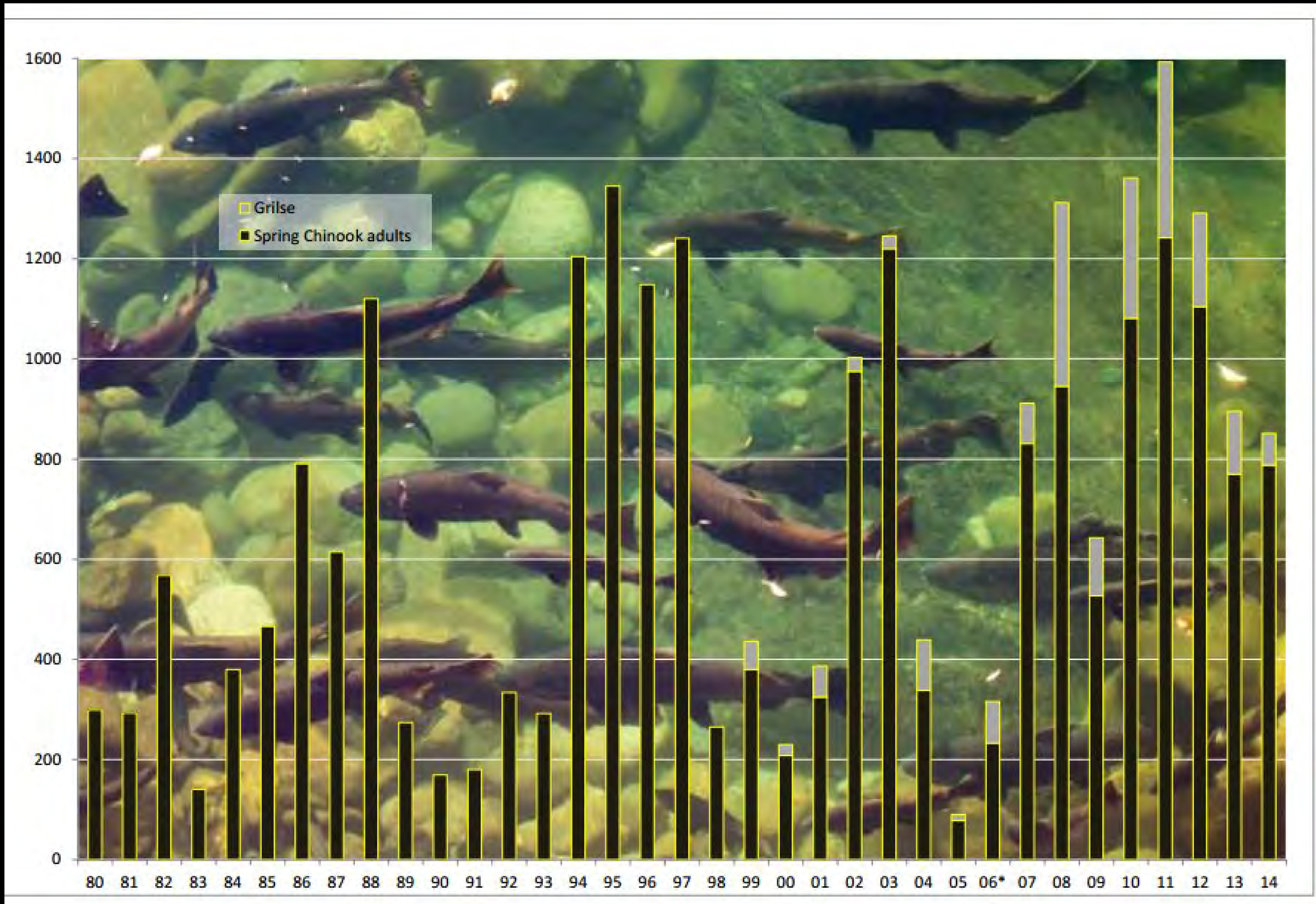




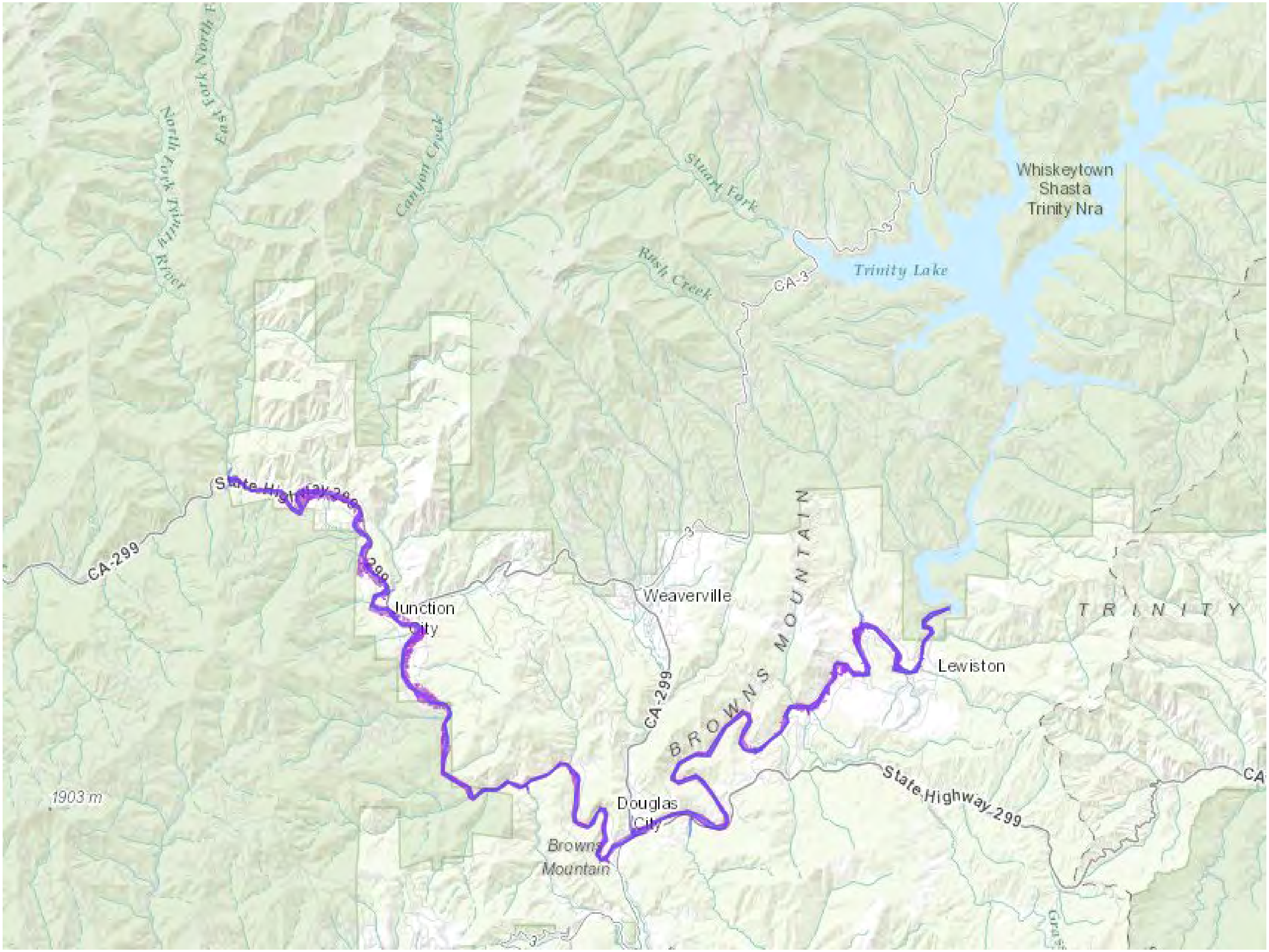
141+000
140+000
139+000
138+000
137+000
136+000



Salmon River Floodplain & Mine Tailing Restoration Project - Phase 1
Modeled floodplain inundation within Reach 14 (South Fork)
DATA SOURCES
LIDAR: Quantum Spatial, 2014
Roads, cities, streams: ESRI 2012
Imagery: NAIP 2014
MAP PROJECTION
NAD_1983_UTM_Zone_10N
Transverse_Mercator
Stillwater Sciences
LEGEND
Reach break
1000-ft stationing
Cities
100 year floodplain
Inundation
20% exceedance flow
½ the 1.5 yr peak flow
1.5 yr peak flow
2 yr peak flow
5 yr peak flow
10 yr peak flow
25 yr peak flow
50 yr peak flow
100 yr peak flow
SCALE & NORTH ARROW
0 250 500 1,000 Feet
0 50 100 200 Meters
1:6,500
1 in = 542 feet
MAP LOCATION
pg 14 of 26
NF Salmon River
SF Salmon River
Study reaches
South Fork Salmon River
Cecilville Rd
Petersburg Rd
Forest Rte 37N02
120000
121000
122000
123000
124000
125000
126000
127000
128000



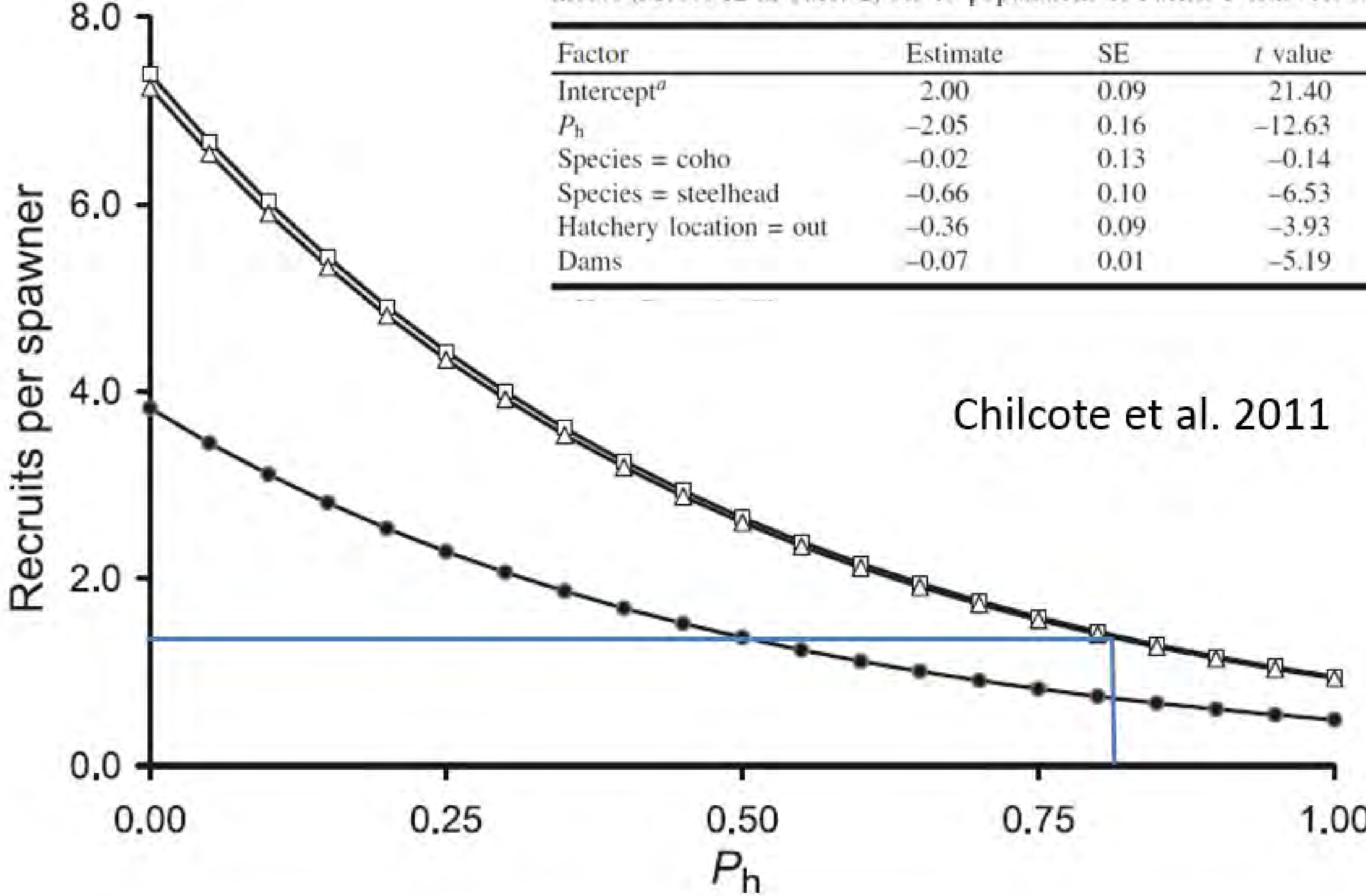
1600
1400
1200
1000
800
600
400
200
0
Grilse
Spring Chinook adults
80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06* 07 08 09 10 11 12 13 14



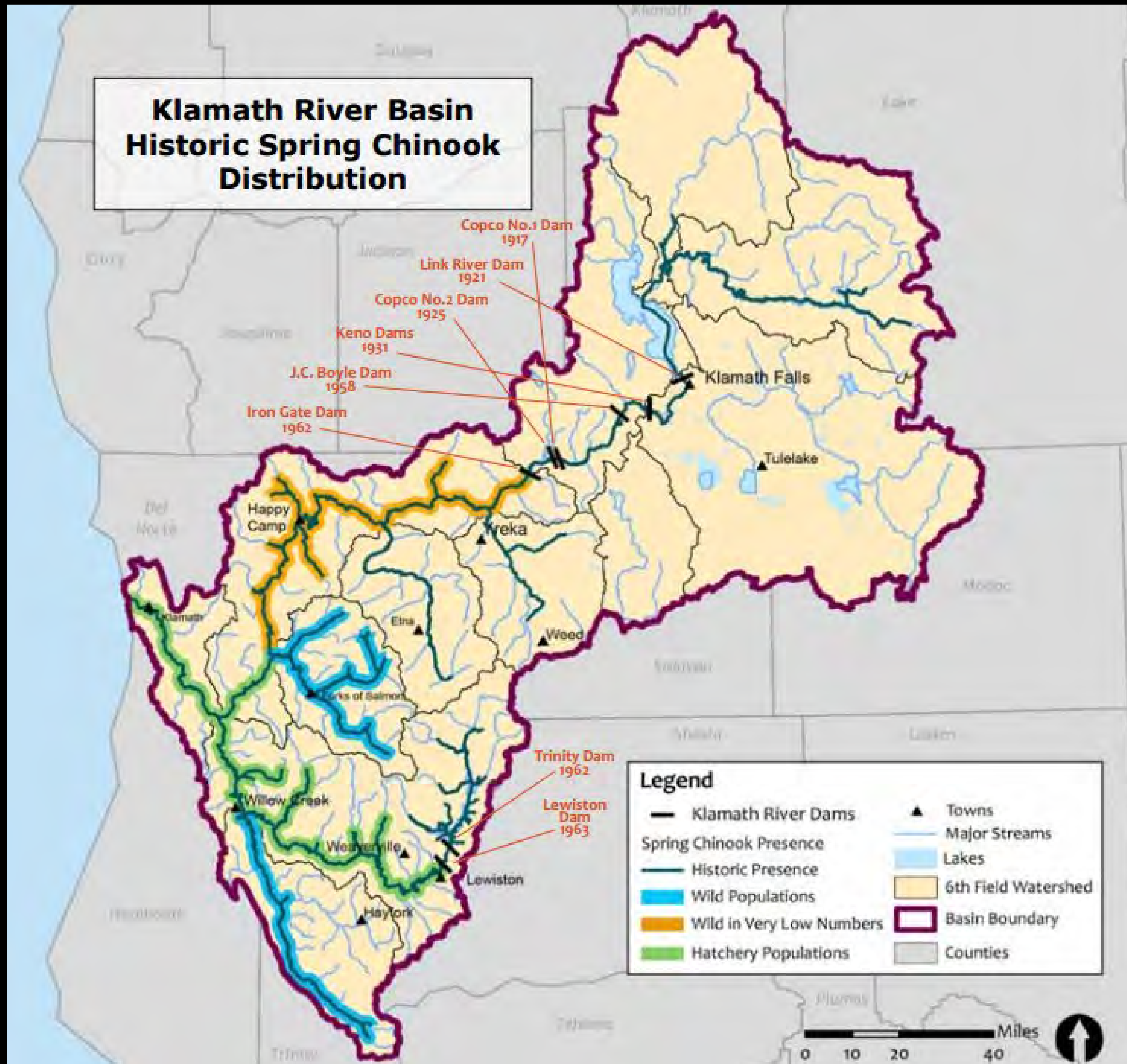
North Fork Trinity River
East Fork North F
Canyon Creek
Stuart Fork
Rush Creek
CA-3
Whiskeytown
Shasta
Trinity Nra
Trinity Lake
State Highway 299
CA-299
Junction
City
Weaverville
BROWNS MOUNTAIN
TRINITY
Lewiston
1903 m
Douglas
City
Browns
Mountain
State Highway 299

Table 3. Parameter estimates, SE, and significance of the factors in the best productivity model (Model 12 in Table 2) for 89 populations of Pacific Northwest salmon and steelhead.

Factor	Estimate	SE	t value	Pr. (>|t|)
Intercept[a]	2.00	0.09	21.40	<0.001
P_h	–2.05	0.16	–12.63	<0.001
Species = coho	–0.02	0.13	–0.14	0.892
Species = steelhead	–0.66	0.10	–6.53	<0.001
Hatchery location = out	–0.36	0.09	–3.93	<0.001
Dams	–0.07	0.01	–5.19	<0.001



Chilcote et al. 2011


Klamath River Basin Historic Spring Chinook Distribution
Copco No.1 Dam 1917
Link River Dam 1921
Copco No.2 Dam 1925
Keno Dams 1931
J.C. Boyle Dam 1958
Iron Gate Dam 1962
Trinity Dam 1962
Lewiston Dam 1963
Klamath Falls
Tulelake
Happy Camp
Yreka
Etna
Weed
Klamath
Forks of Salmon
Willow Creek
Weaverville
Lewiston
Hayfork
Legend
Klamath River Dams
Spring Chinook Presence
Historic Presence
Wild Populations
Wild in Very Low Numbers
Hatchery Populations
Towns
Major Streams
Lakes
6th Field Watershed
Basin Boundary
Counties
Miles
0 10 20 40

Solutions and Opportunities

Solutions and Opportunities

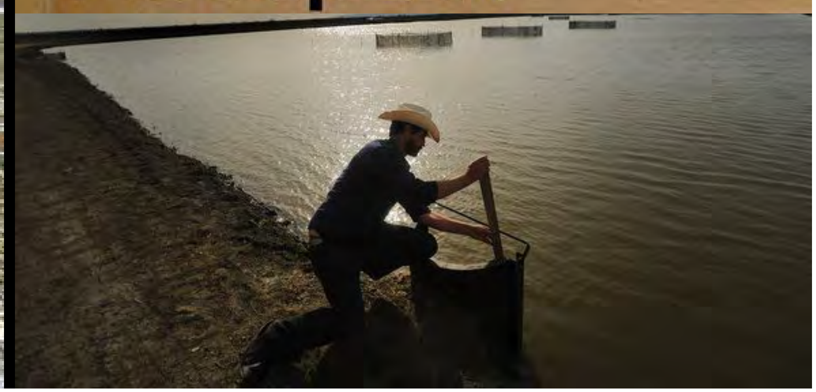
- **Implement Klamath dam removal agreement**

Photo: Thomas Dunklin

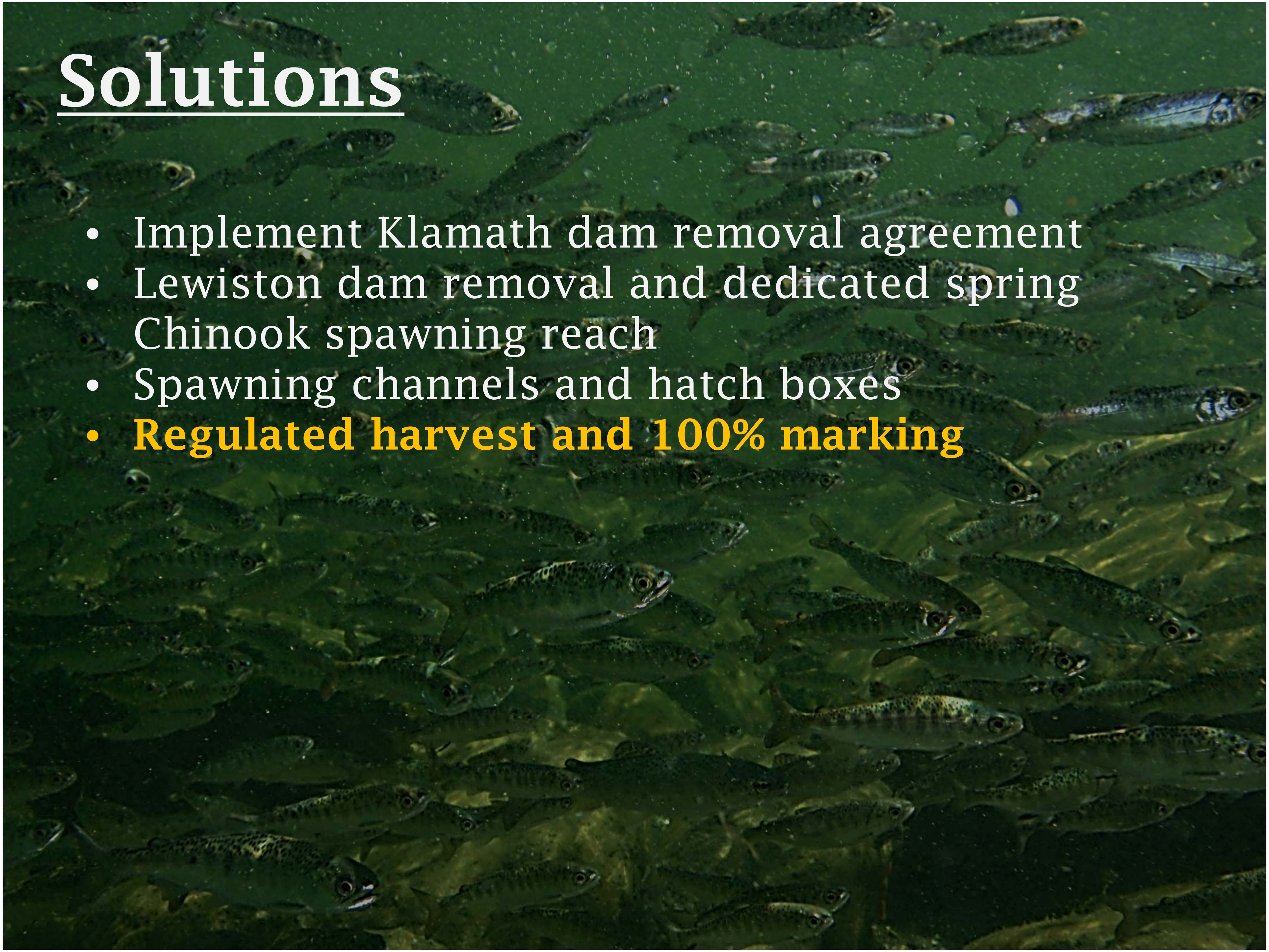
Solutions

- Implement Klamath dam removal agreement
- **Remove Lewiston dam and create dedicated spring Chinook spawning reach**


River
2
3
7
Floodplain

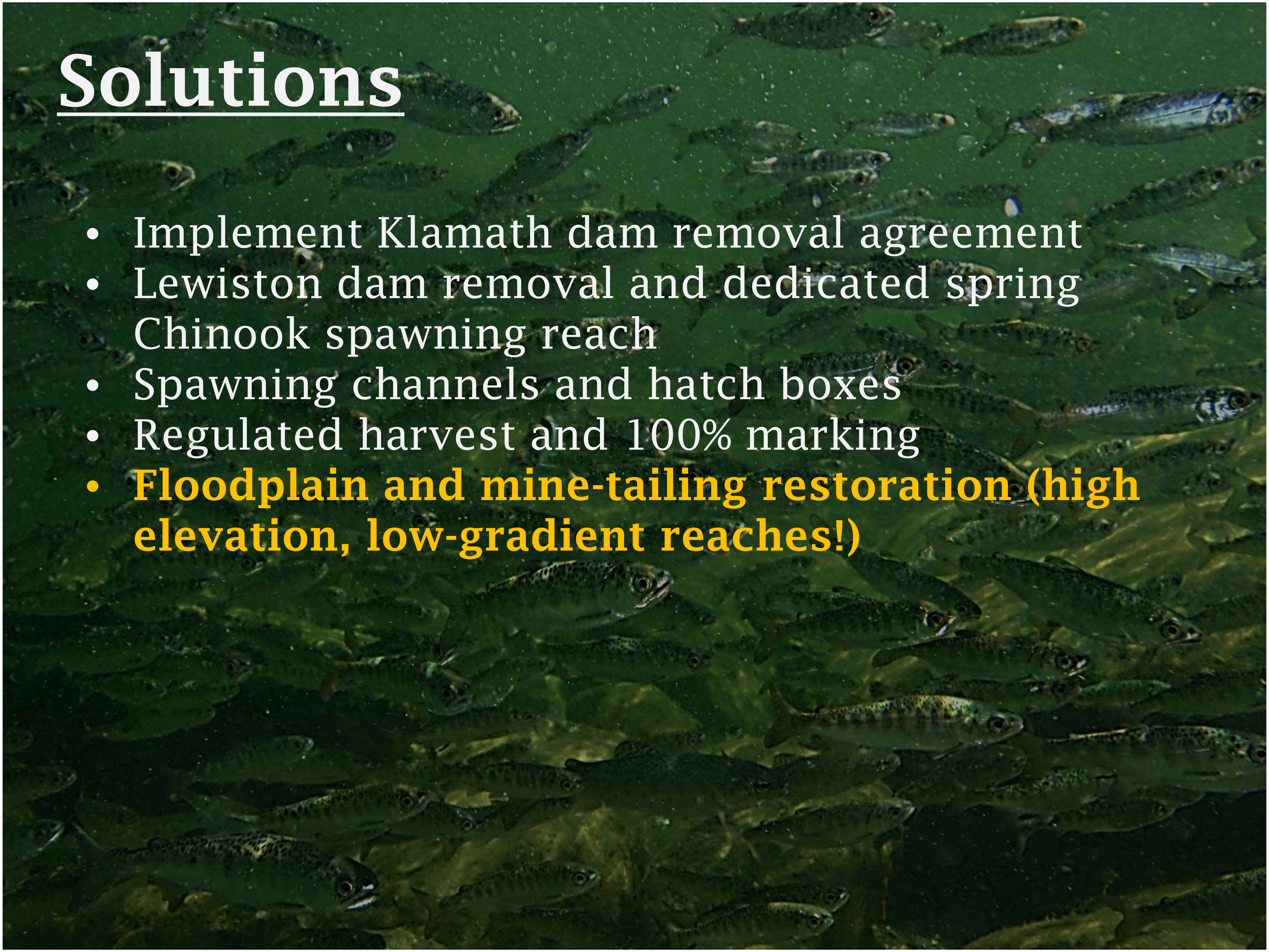



Solutions
• Implement Klamath dam removal agreement
• Lewiston dam removal and dedicated spring Chinook spawning reach
• Spawning channels and hatch boxes



Solutions

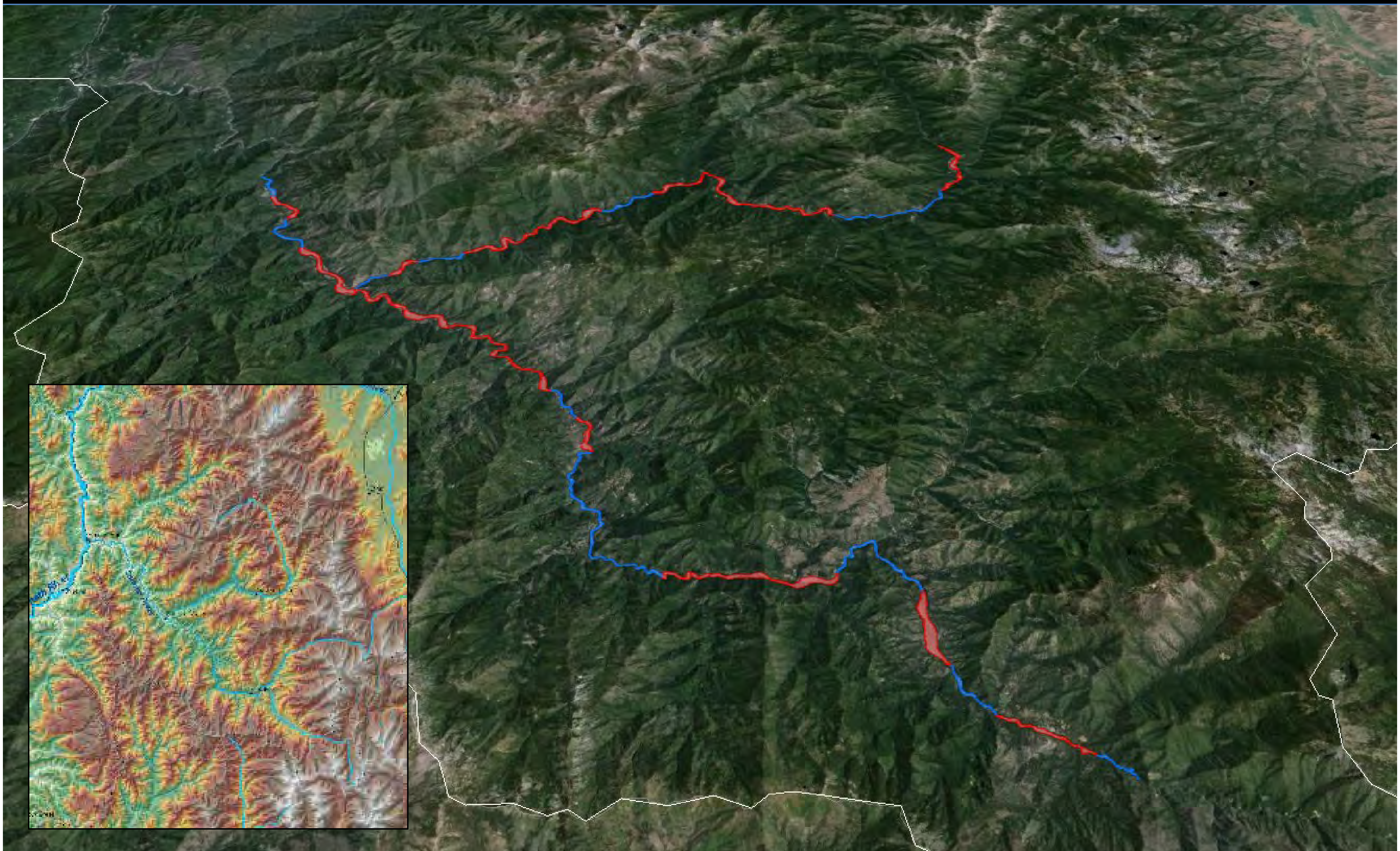
- Implement Klamath dam removal agreement
- Lewiston dam removal and dedicated spring Chinook spawning reach
- Spawning channels and hatch boxes
- **Regulated harvest and 100% marking**

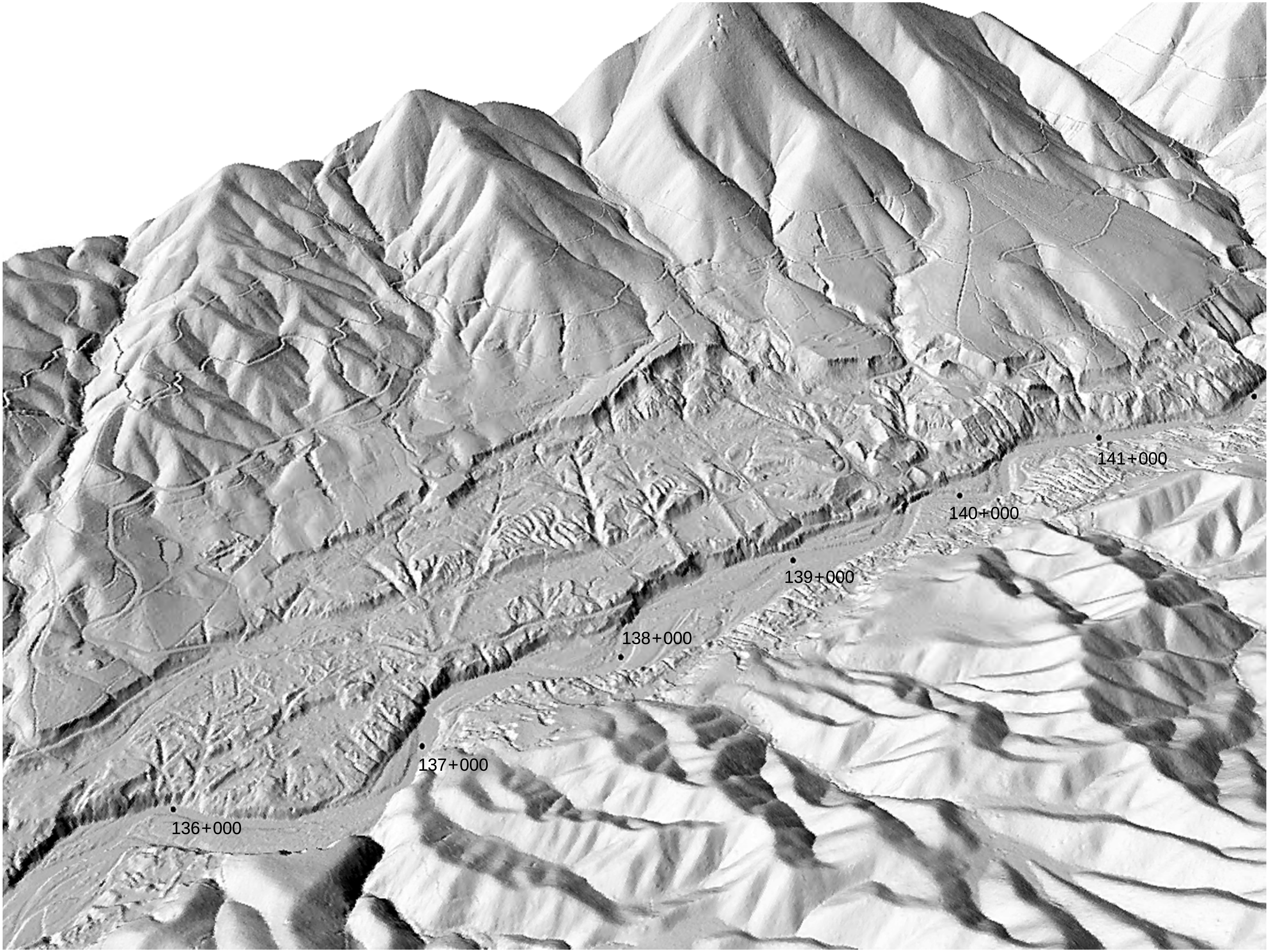


Solutions

- Implement Klamath dam removal agreement
- Lewiston dam removal and dedicated spring Chinook spawning reach
- Spawning channels and hatch boxes
- Regulated harvest and 100% marking
- **Floodplain and mine-tailing restoration (high elevation, low-gradient reaches!)**

Salmon River Floodplains




141+000
140+000
139+000
138+000
137+000
136+000

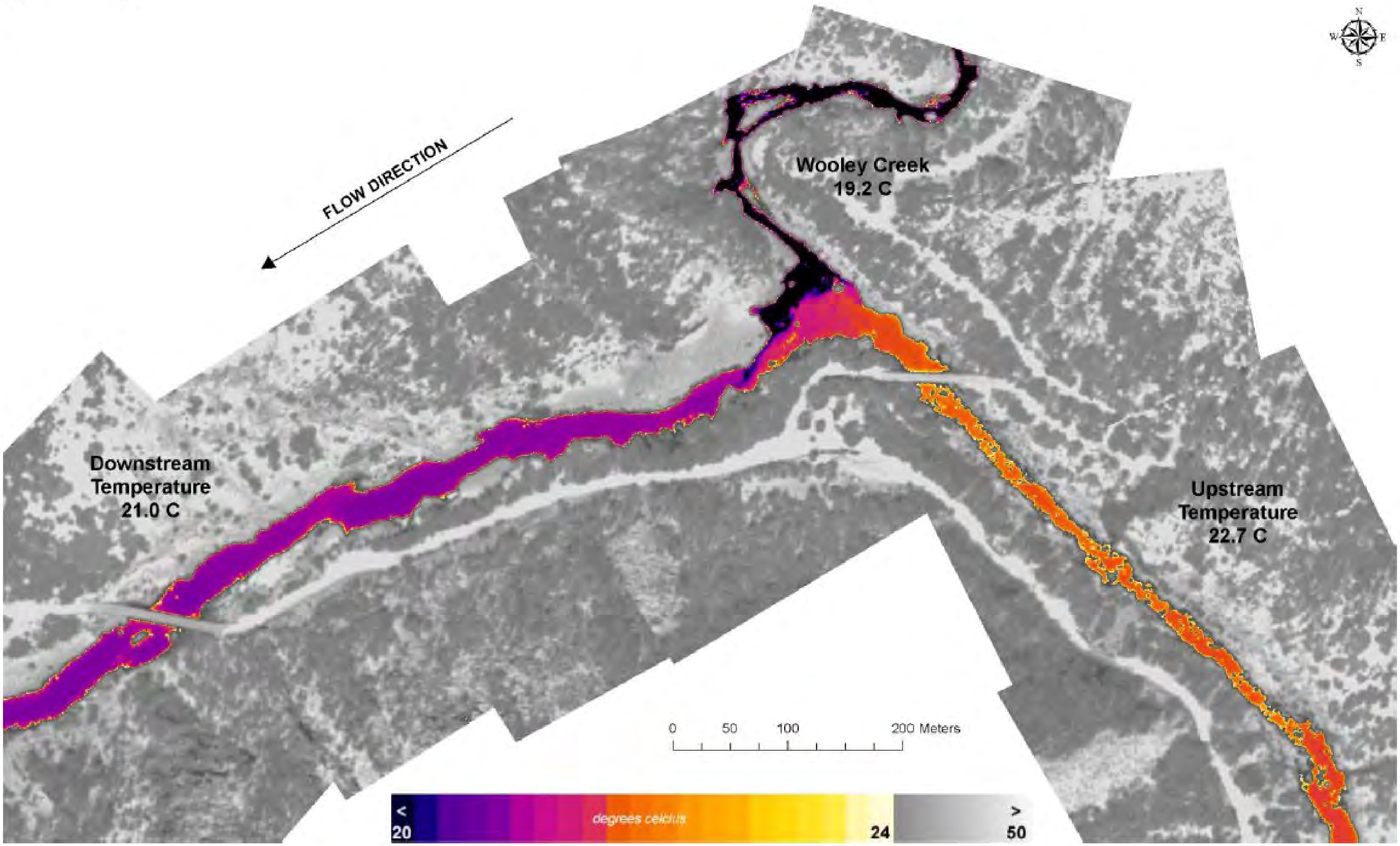

Cecilville Rd
Proposed Inundation
20% exceedence
1/2 bankfull
2 year
10 year
100 year

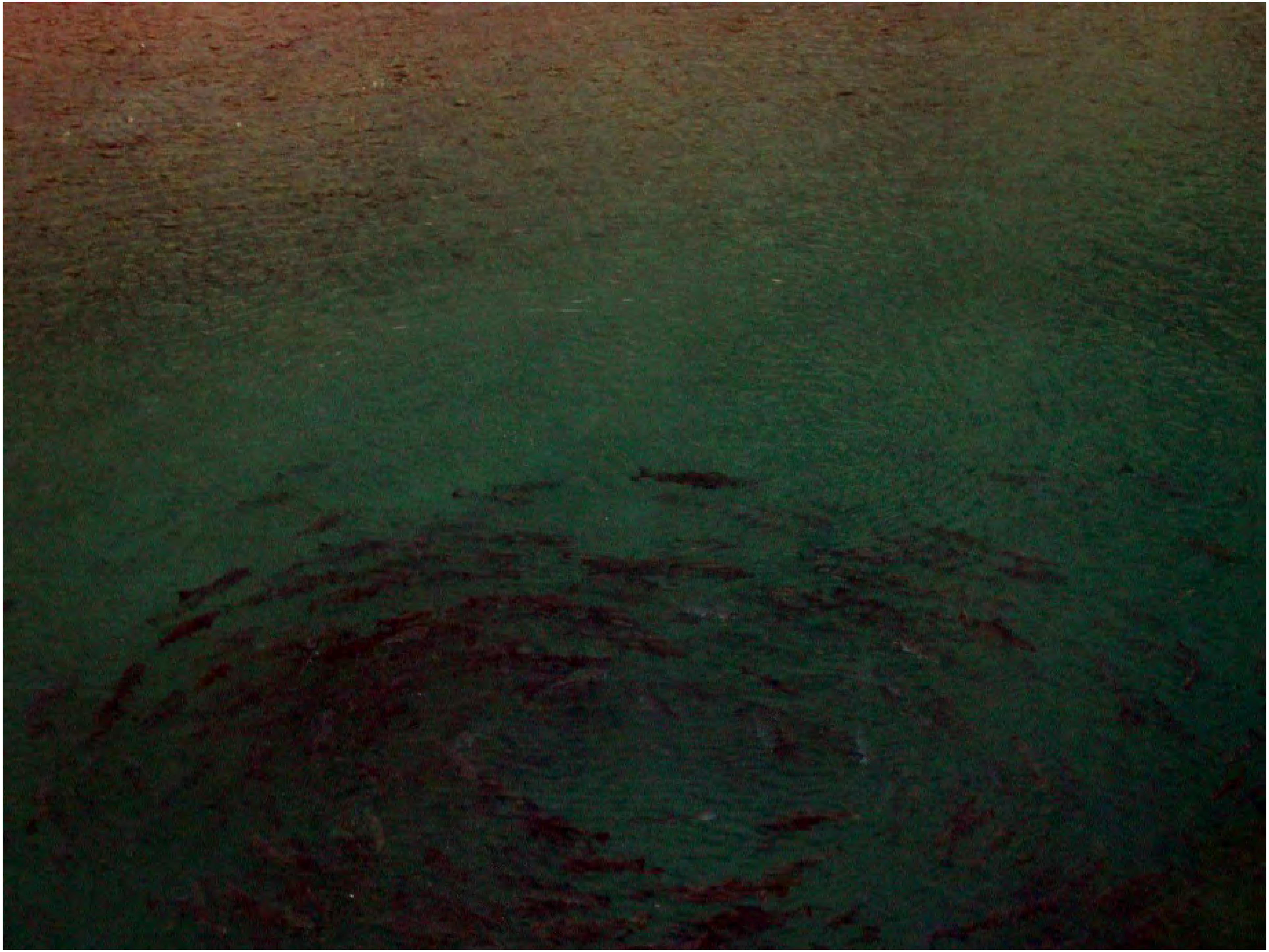

Cecilville Rd
Proposed Inundation
20% exceedence
1/2 bankfull
2 year
10 year
100 year

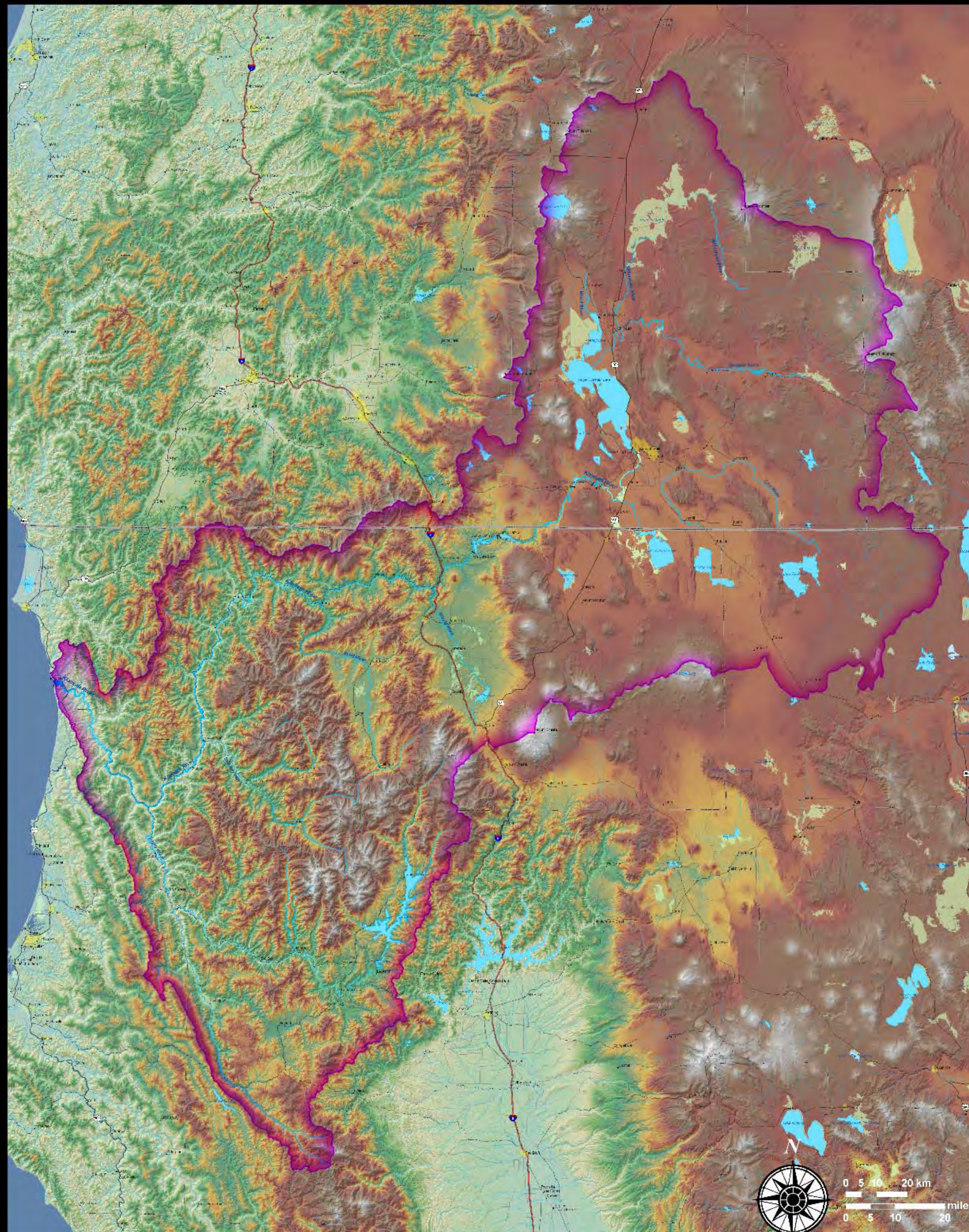
Salmon River as Refugia

Solutions

- Implement Klamath dam removal agreement
- Lewiston dam removal and dedicated spring Chinook spawning reach
- Spawning channels and hatch boxes
- Regulated harvest and 100% marking
- Floodplain and mine-tailing restoration (highest elevation low gradient reaches)
- **Protect and enhance cold water reaches and refuges (roadless areas, scour features, cover, thermal integrity)**


FLOW DIRECTION
Wooley Creek
19.2 C
Downstream
Temperature
21.0 C
Upstream
Temperature
22.7 C
0
50
100
200 Meters
<
20
degrees celcius
24
>
50
N
W
E
S




N
0 5 10 20 km
miles
0 5 10 20

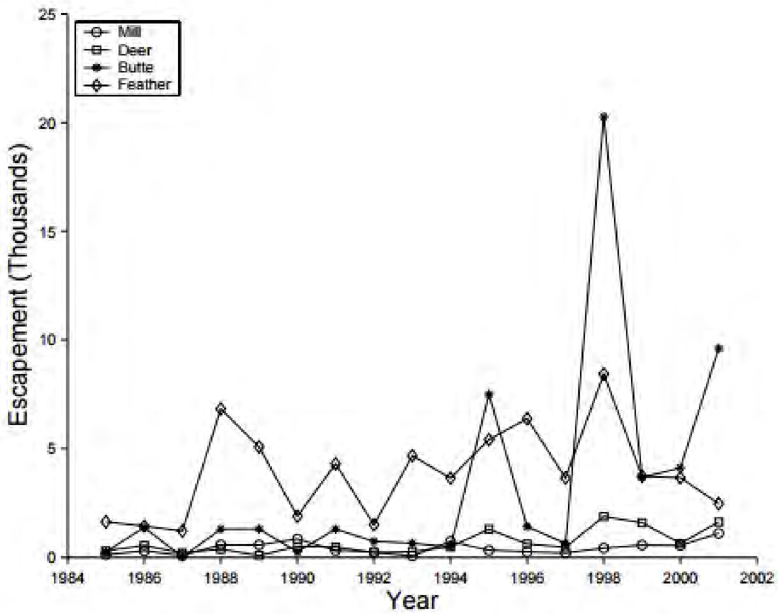


Figure 14. Estimated escapement of spring-run chinook in Mill, Deer, Butte creeks and the Feather River.

Table 3.
Spring-run Chinook Salmon Cohort Replacement Rate for Sacramento River Tributaries, 1998 - 2000.

Tributary	2000 Cohort Replacement Rate	1999 Cohort Replacement Rate	1998 Cohort Replacement Rate
Antelope Cr.	NA	40.0	22.0
Big Chico Cr.	13.5	13.5	1.8
Butte Creek	6.5	2.7	2.5
Mill Creek	2.7	1.3	2.2
Deer Creek	1.4	2.6	1.5
Cottonwood/Beegum Cr.	NA	59.7	17.7

[redacted]

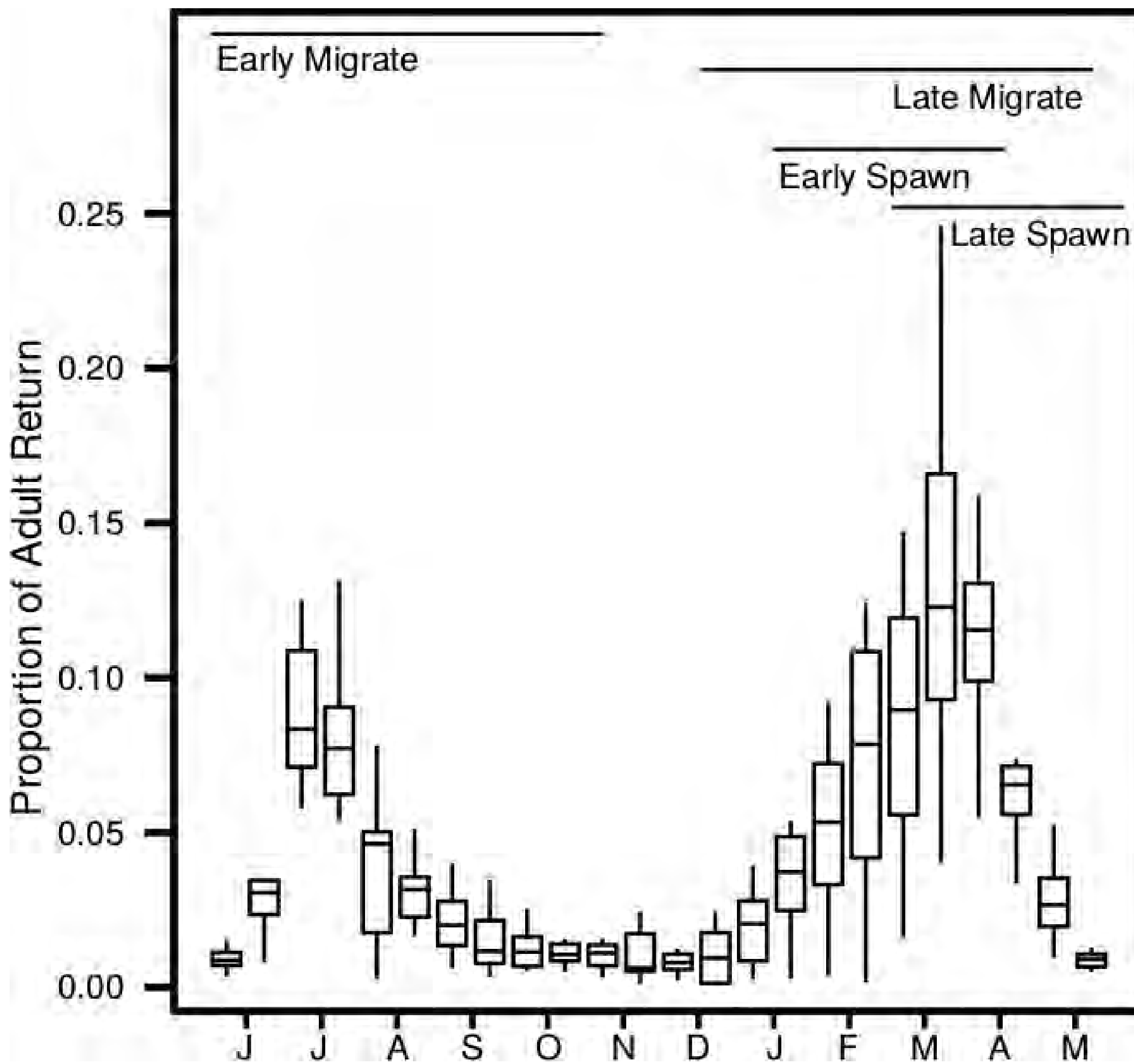
The evolutionary basis of premature migration in Pacific salmon highlights the utility of genomics for conservation unit delineation

Michael Miller

UCDAVIS
DEPARTMENT OF ANIMAL SCIENCE

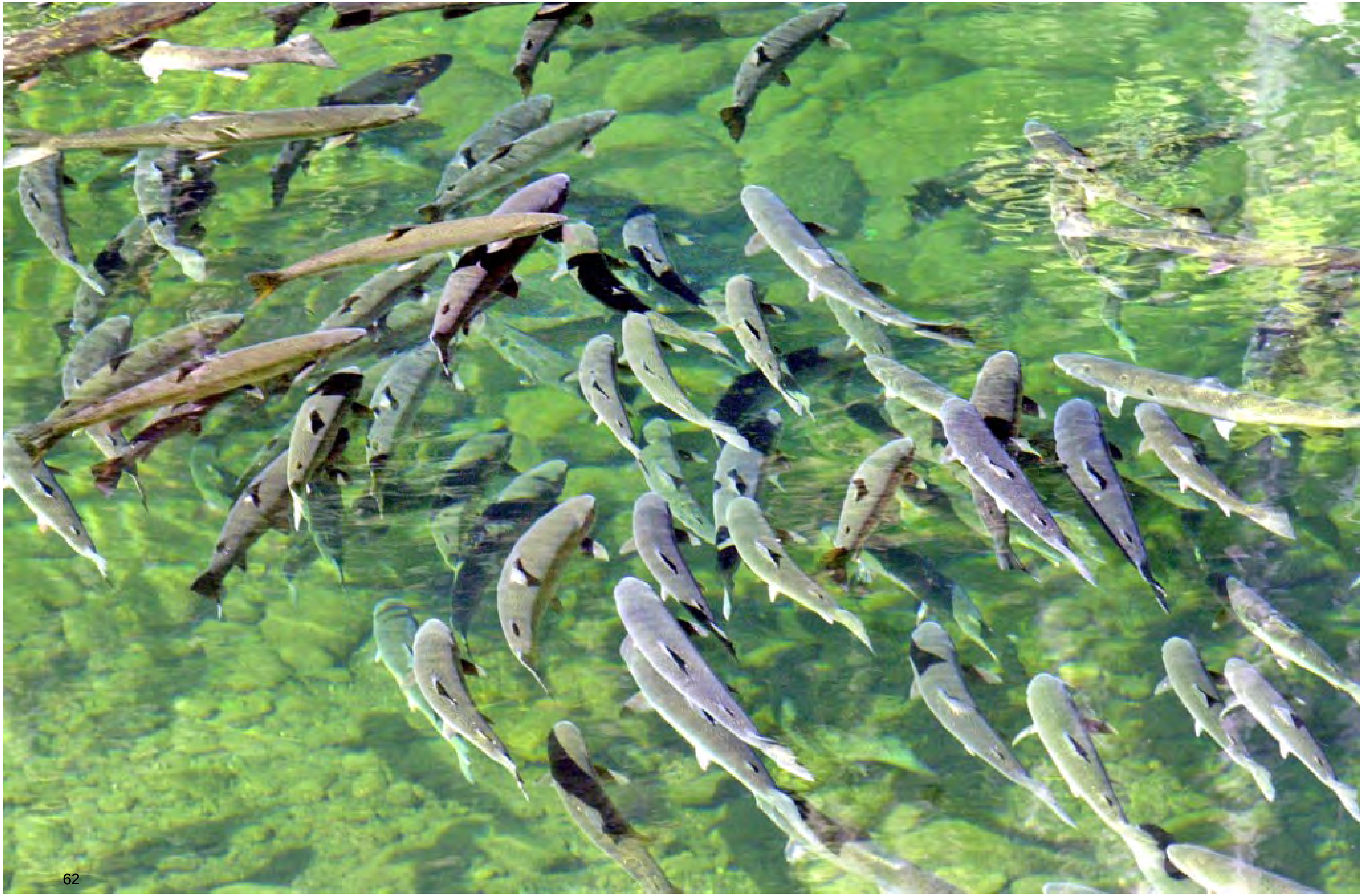
UCDAVIS
CENTER FOR WATERSHED SCIENCES

Early run Chinook and steelhead have evolved a unique life history that utilizes seasonal variation.

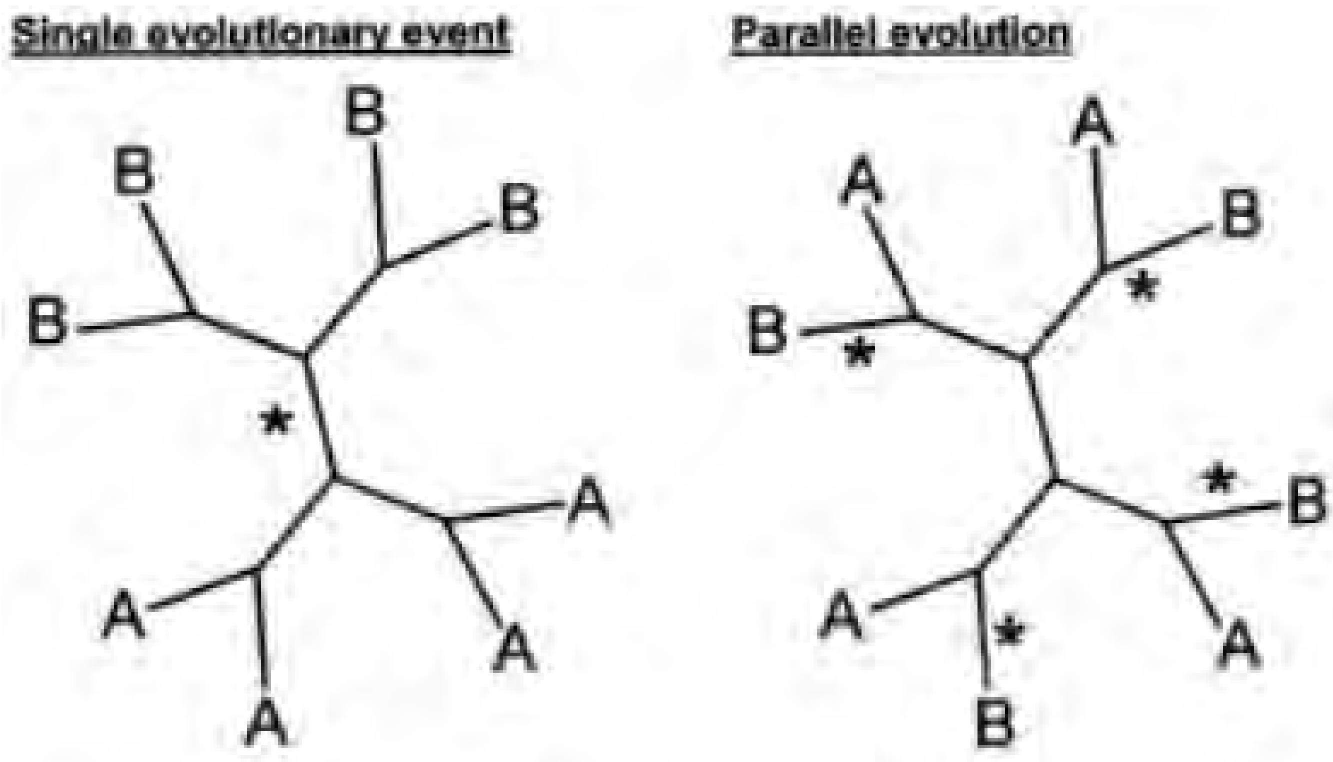


Prince *et al.* In preparation

The behavior and physiology of early run individuals is dramatically distinct from late run individuals.



Many studies have investigated the genetic and evolutionary basis early run timing.



A = Late Run
B = Early Run

Allendorf 1975
Chilcote *et al.* 1980
Thorgaard 1983
Nielsen *et al.* 1999
Waples *et al.* 2004
Kinziger *et al.* 2013
Arciniega *et al.* 2015

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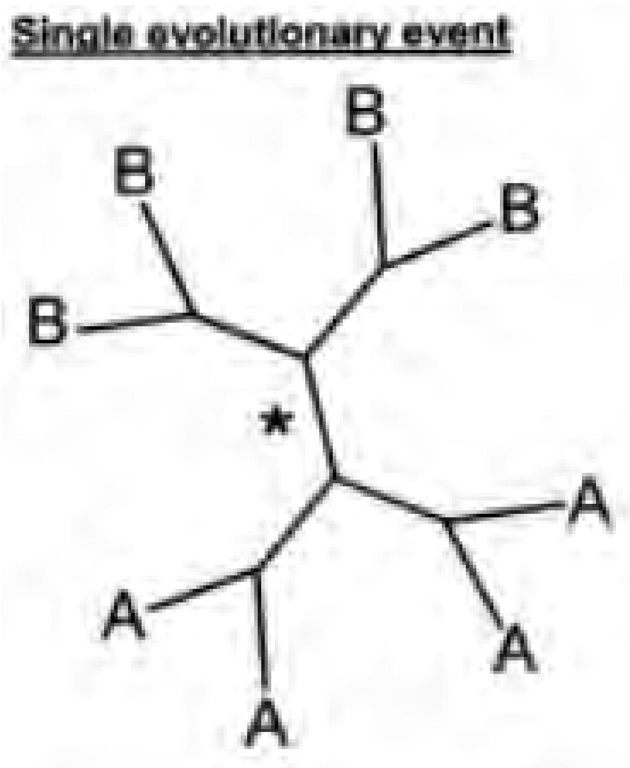

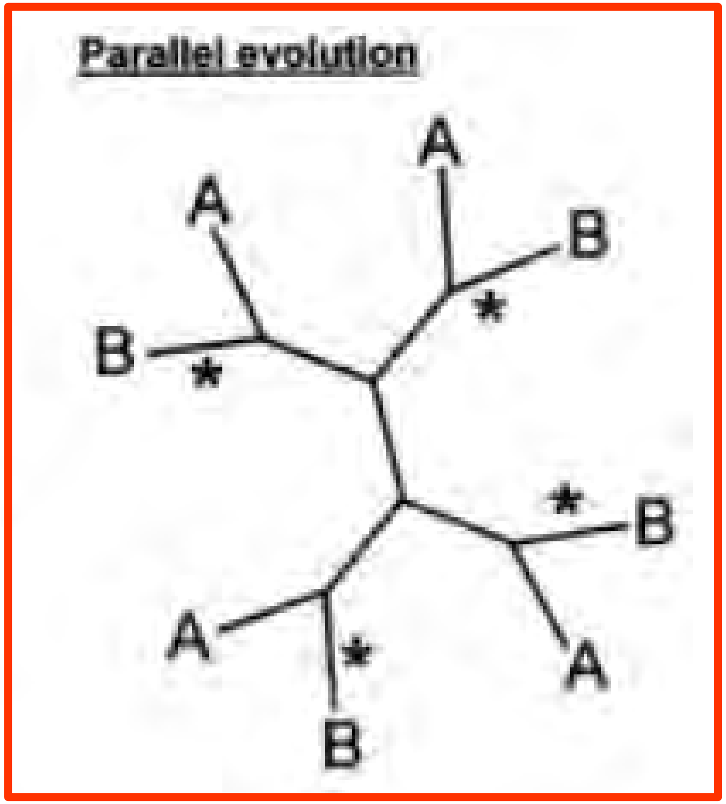

A = Late Run
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Allendorf 1975
Chilcote *et al.* 1980
Thorgaard 1983
Nielsen *et al.* 1999
Waples *et al.* 2004
Kinziger *et al.* 2013
Arciniega *et al.* 2015

All studies have supported a scenario of parallel evolution and evolutionary plasticity.

"Although the failure of most stock transfers indicates that local populations may be largely irreplaceable on human time frames, at least some patterns of Chinook salmon life-history diversity appear to be evolutionarily replaceable, perhaps over time frames of a century or so. The evidence for repeated parallel evolution of run timing in Chinook salmon indicates that such a process is likely, provided that habitats capable of supporting alternative life-history trajectories are present and sufficient, robust source populations are maintained."

Waples *et al.* 2004

These studies have had important policy implications as early run populations have declined dramatically.

January 27, 2011

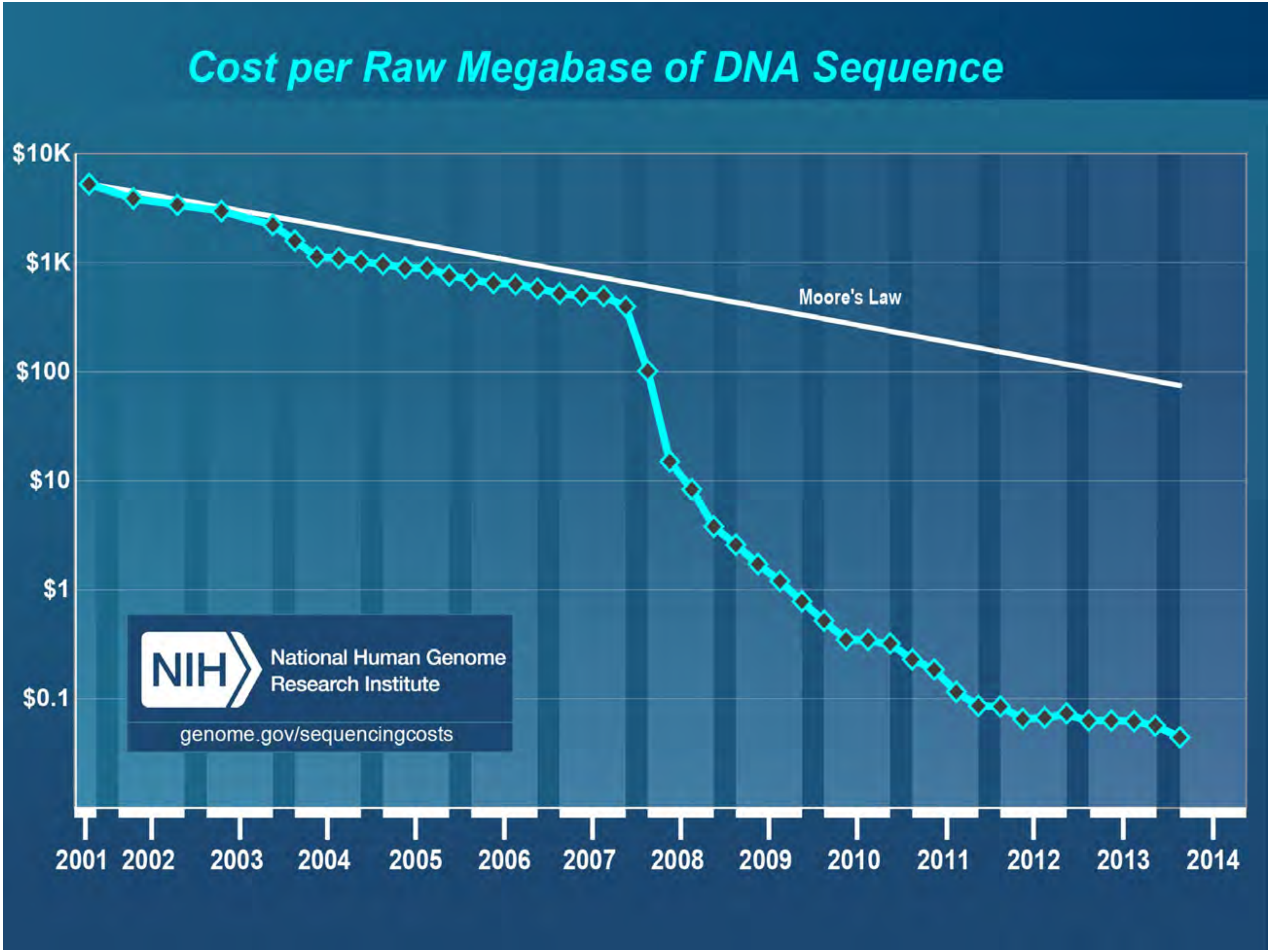
TO: Mr. Gary Locke
Secretary of Commerce
1401 Constitution Avenue, N.W.
Washington, DC 20230

Dear Secretary Locke:

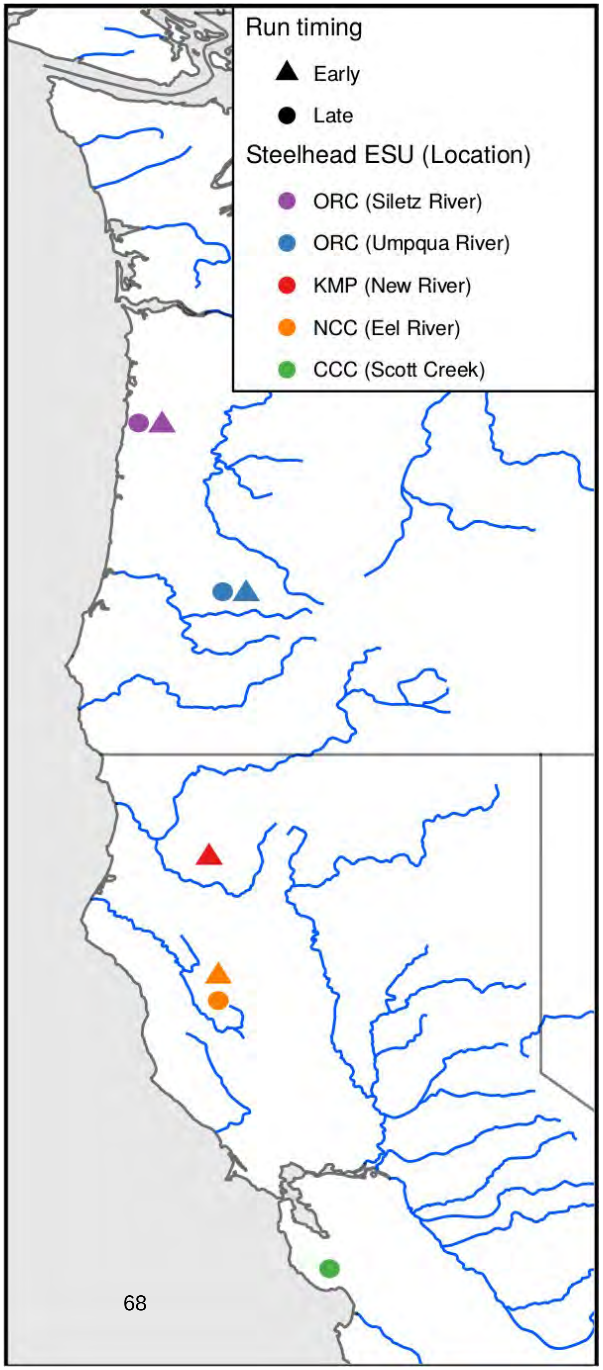
DECLINED

Petitioners Center for Biological Diversity (CBD), Oregon Wild, Environmental Protection Information Center (EPIC) and The Larch Company formally request that the National Marine Fisheries Service list Chinook salmon (*Oncorhynchus tshawytscha*) in the Upper Klamath Basin as a threatened or endangered species under the Endangered Species Act, 16 U.S.C. §§ 1531-1544, under one of the following three alternatives: 1) list spring run Chinook salmon as their own Evolutionary Significant Unit (ESU); 2) list spring run Chinook salmon as a distinct population segment; or 3) list the currently recognized Evolutionary Significant Unit containing both spring and fall run Chinook, based primarily on the severe loss of the spring run from the basin.

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



RAD data confirms that location determines overall genetic structure and agrees with current ESU designations.



Prince *et al.* In preparation

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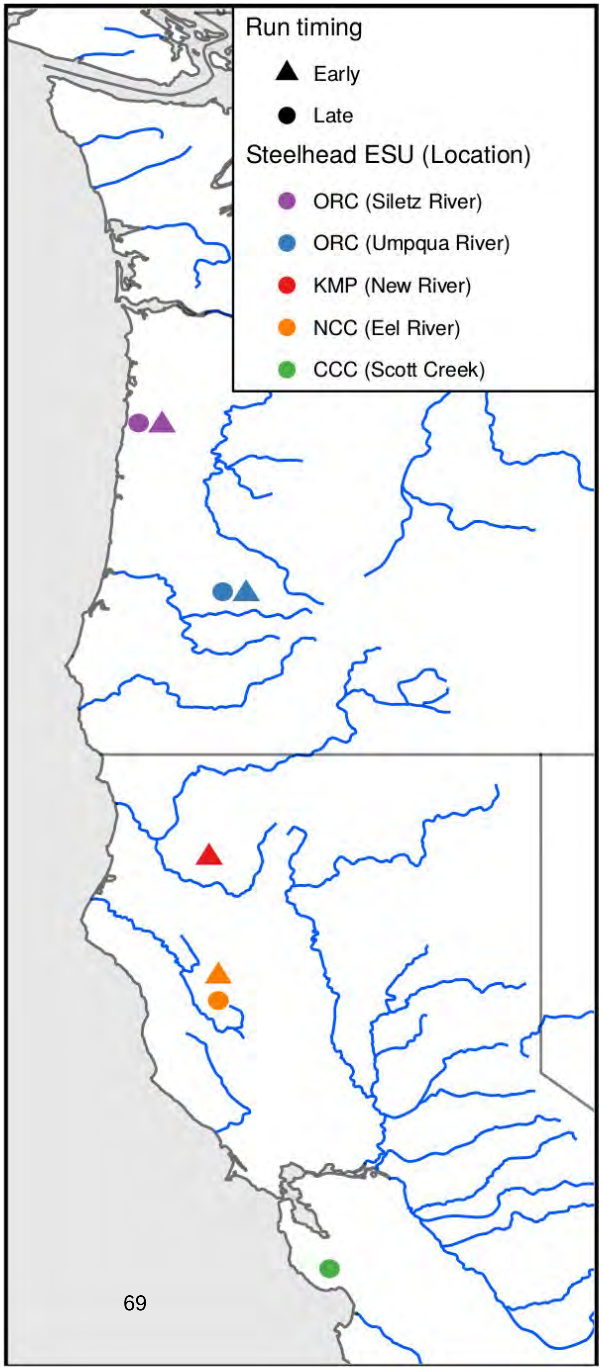

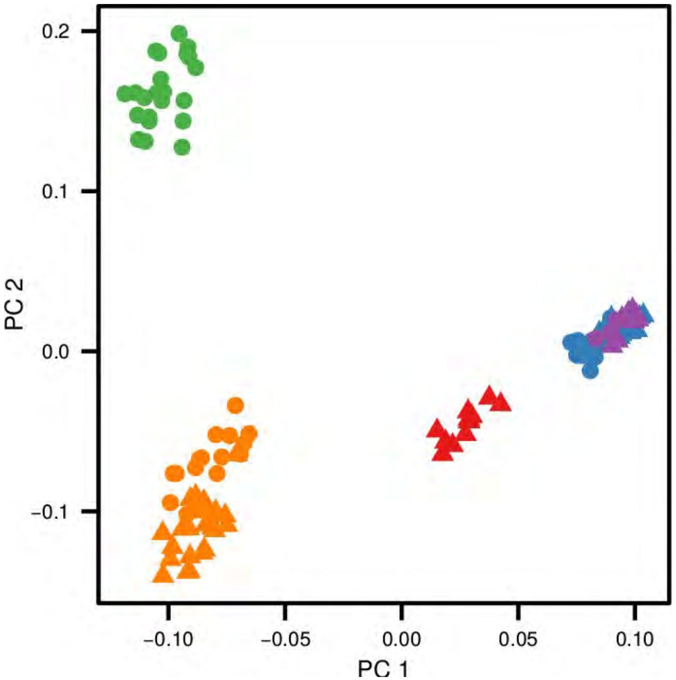

Prince *et al.* In preparation

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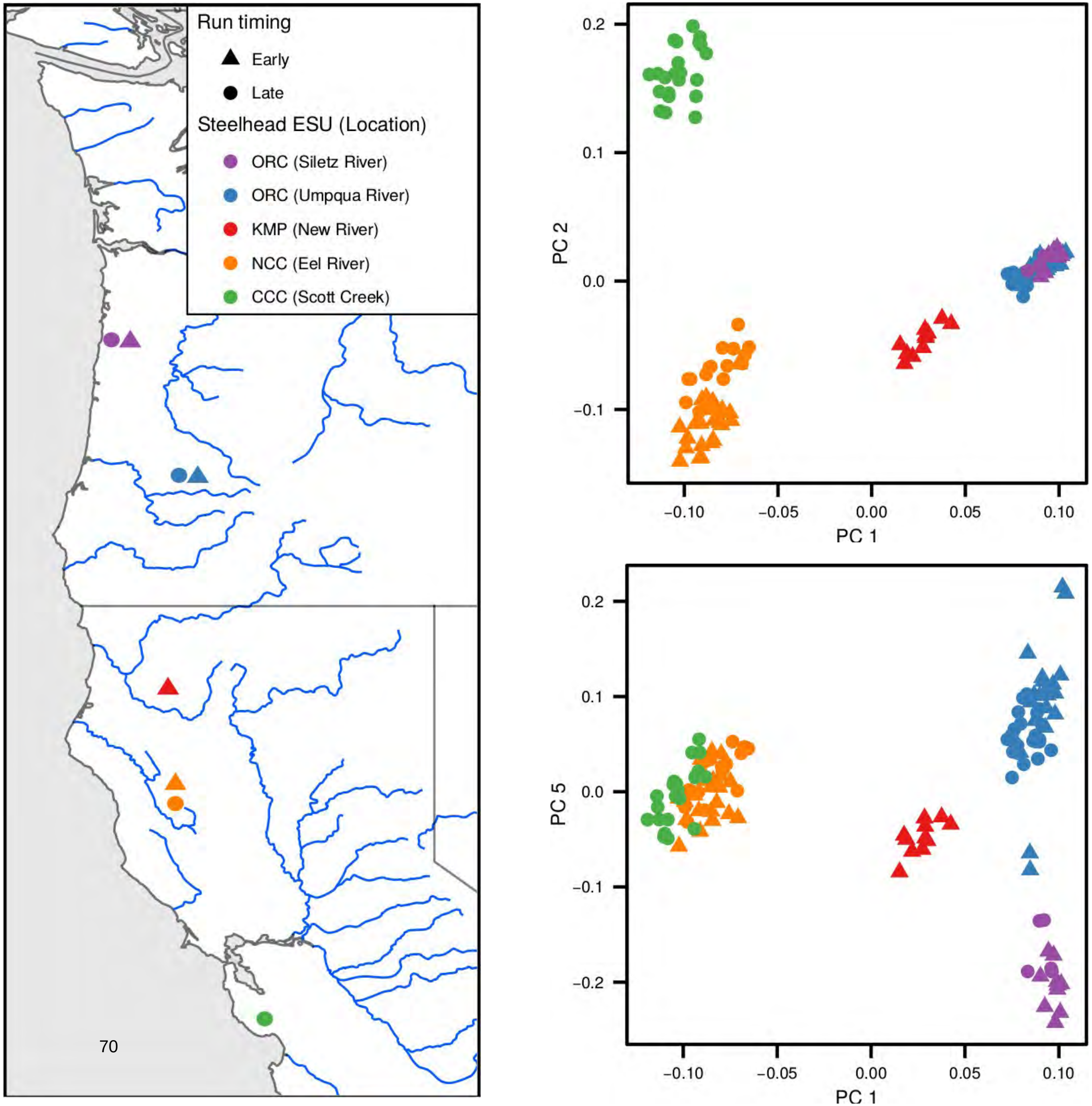
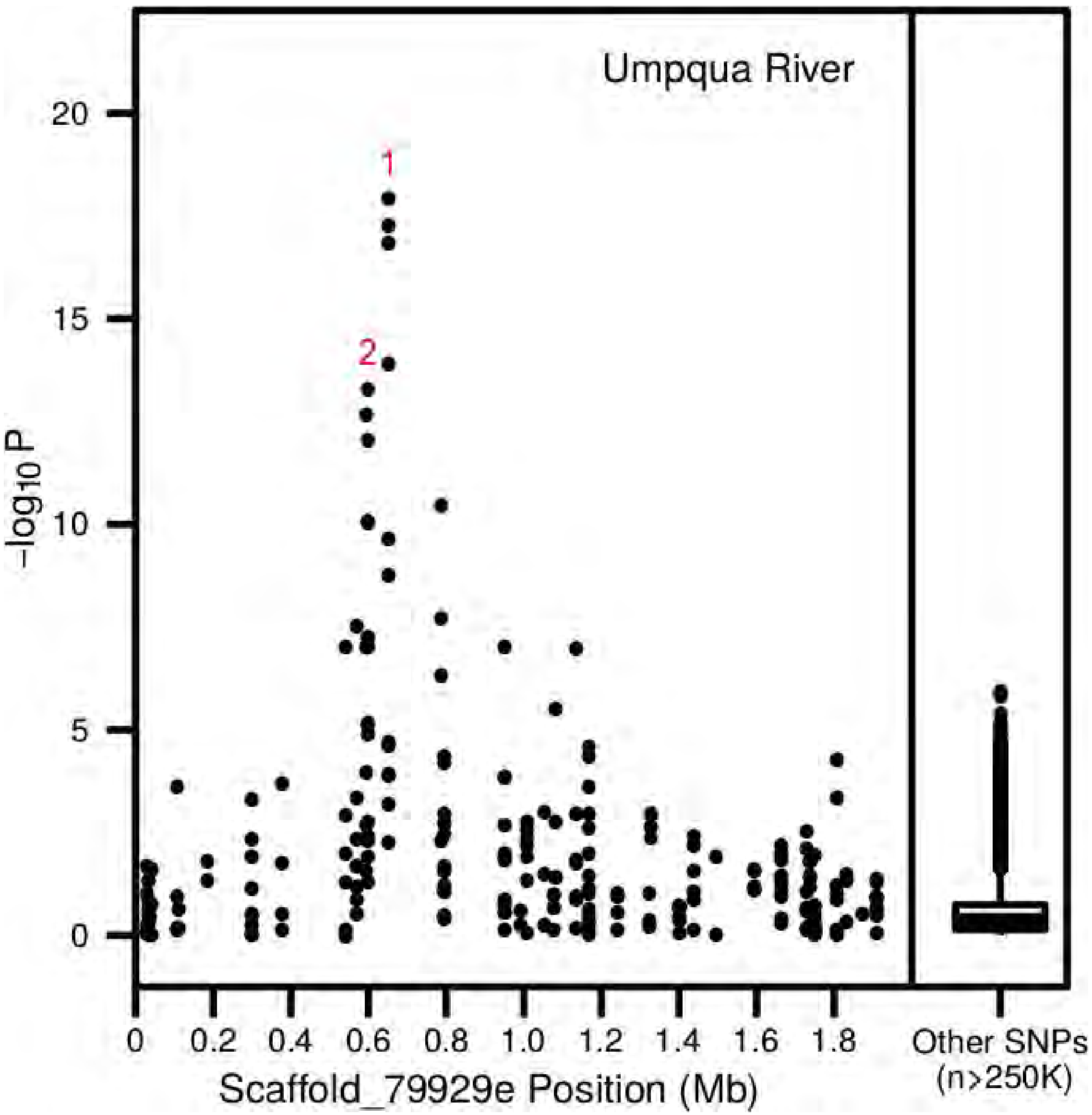


70

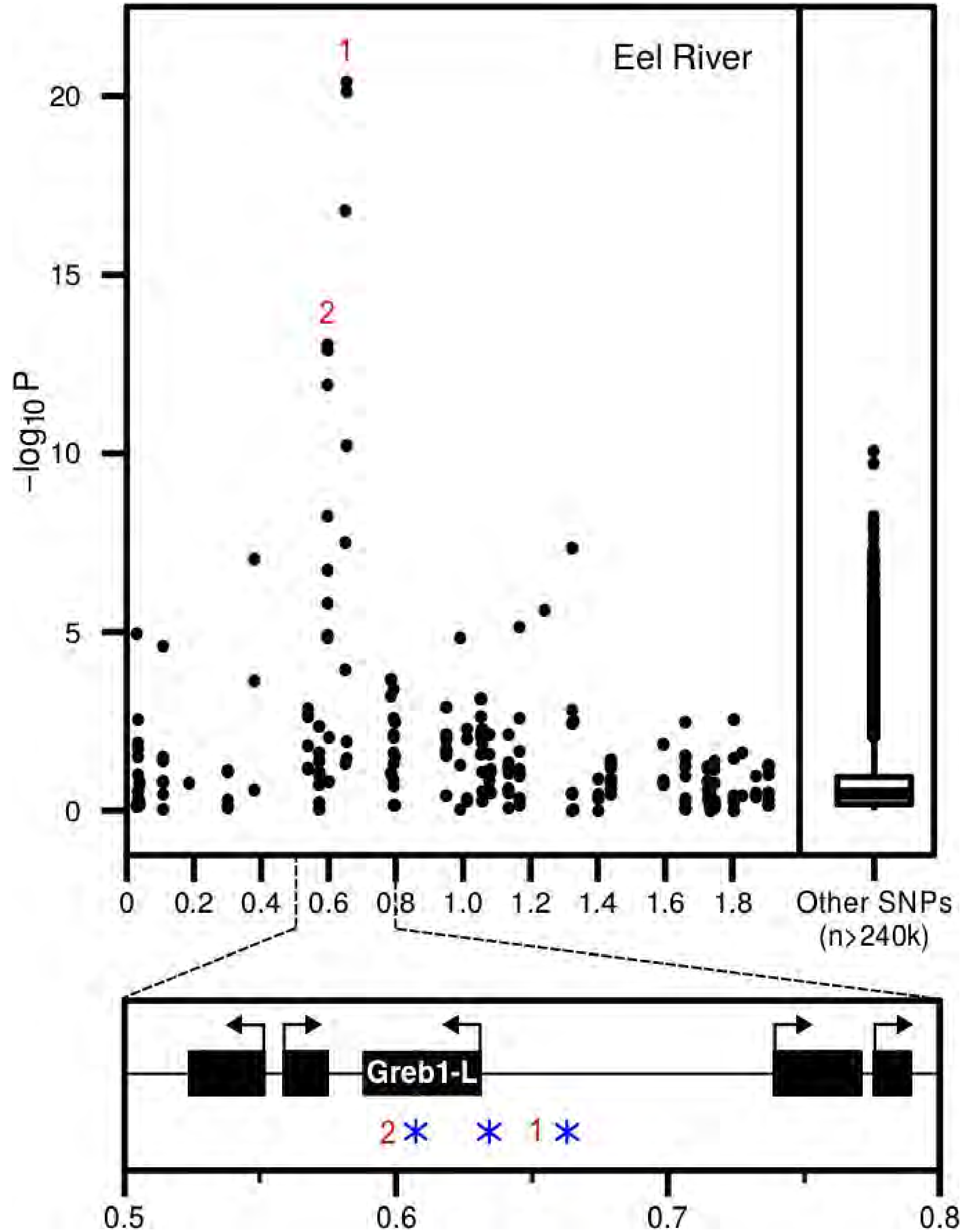
Prince *et al.* In preparation

A single genetic locus controls early run timing in North Umpqua steelhead.



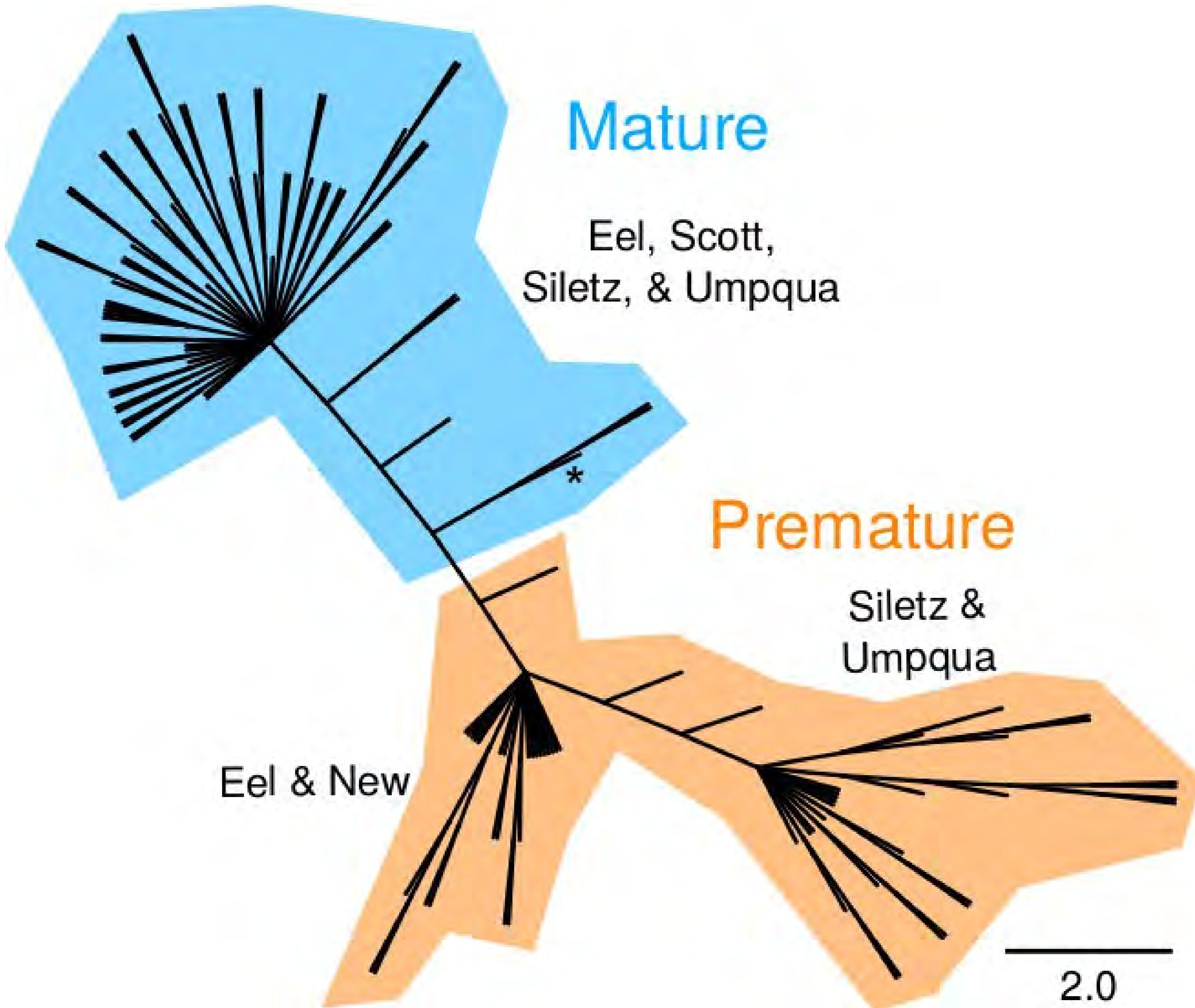
Prince *et al.* In preparation

The same genetic locus controls early run timing in Eel River steelhead.



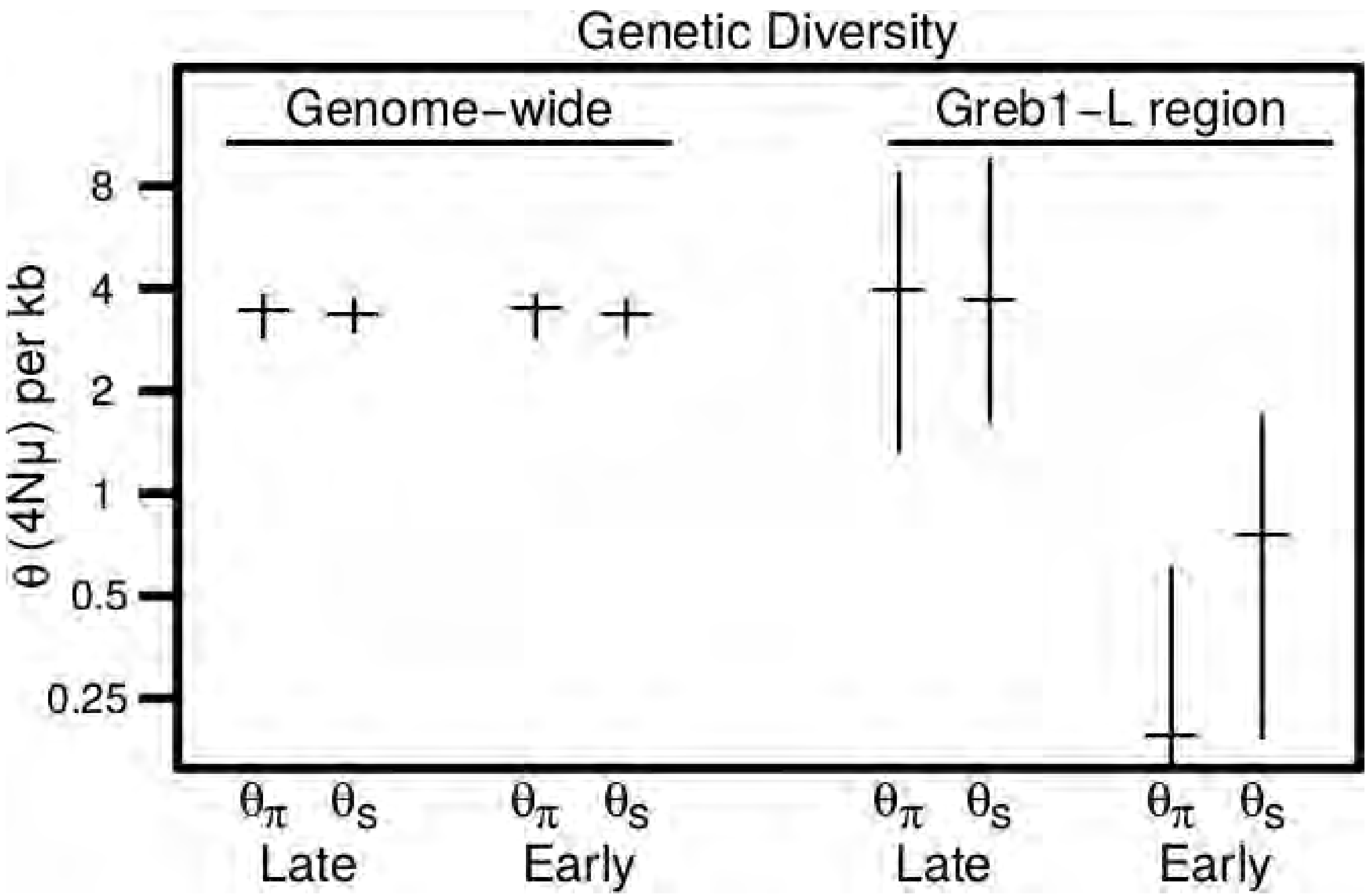
Prince *et al.* In preparation

A single ancient genetic evolutionary event is the ultimate source of all early run populations.



Prince *et al.* In preparation

Strong positive selection caused the early run allele to spread around the West Coast.



Prince *et al.* In preparation

Greb1-L is the master control gene for early run timing in steelhead.

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RESEARCH ARTICLE

Novel Genetic Loci Identified for the Pathophysiology of Childhood Obesity in the Hispanic Population

Anthony G. Comuzzie, Shelley A. Cole, Sandra L. Laston, V. Saroja Voruganti, Karin Haack, Richard A. Gibbs, Nancy F. Butte

Published: December 14, 2012 • DOI: 10.1371/journal.pone.0051954

ARTICLE

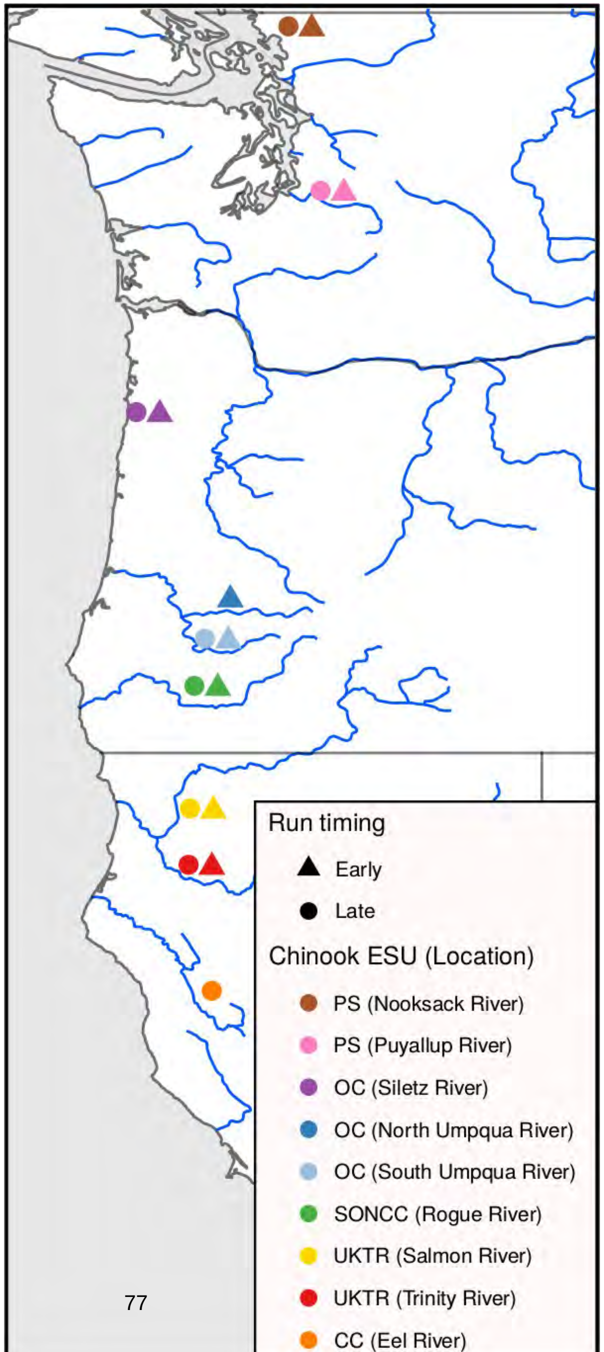
Replication study of *RAD54B* and *GREB1* polymorphisms and risk of PCOS in Han Chinese

Zhenyan Wang [a,b,1], Tao Li [a,c,d,e,1], Xiuye Xing [a,c,d,e,1], Xuan Gao [a,c,d,e], Xiuqing Zhang [a,c,d,e], Li You [a,c,d,e], Han Zhao [a,c,d,e], Jinlong Ma [a,c,d,e,*], Zi-Jiang Chen [a,c,d,e]

The hypothalamus contains key neuronal populations driving feeding behavior and energy expenditure.

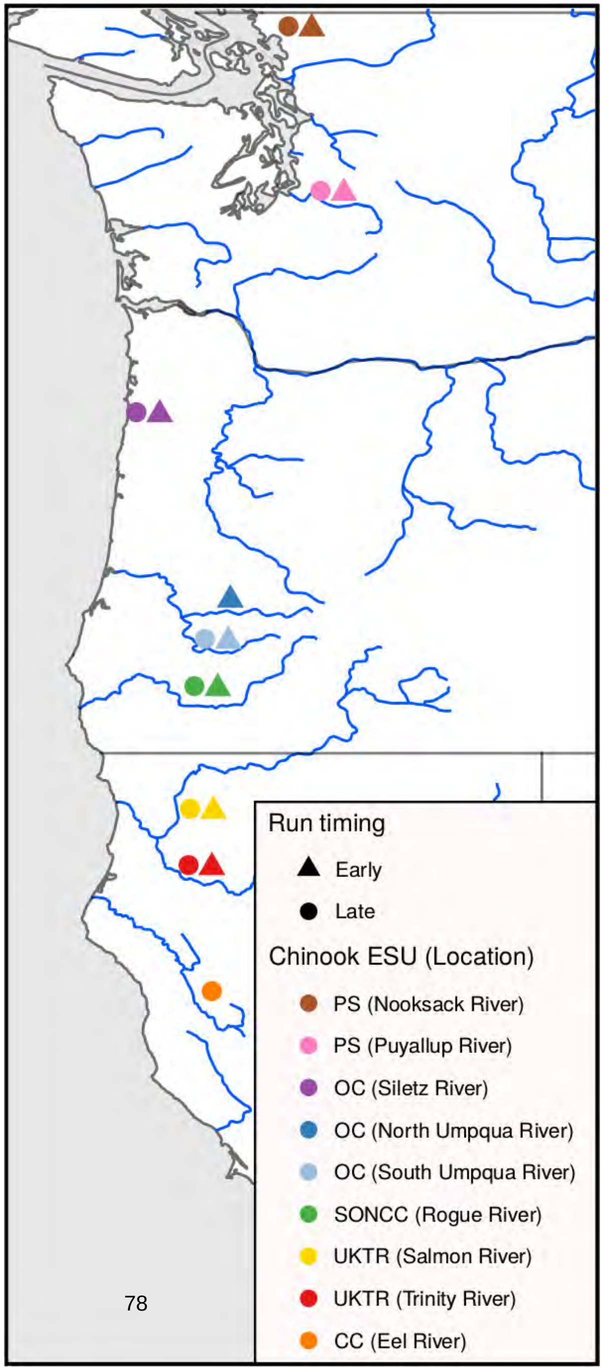
Greb1 expression in mice

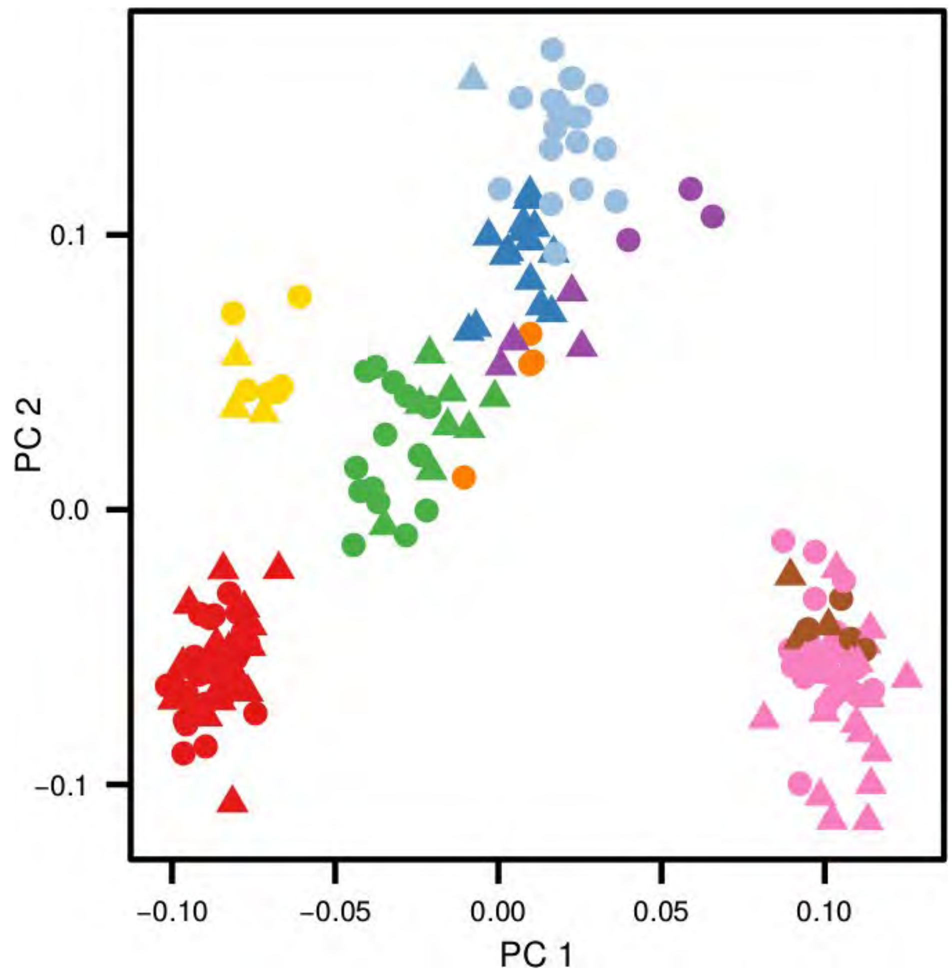
Chinook RAD data confirms that location determines overall genetic structure and agrees with current ESU designations.



Prince *et al.* In preparation

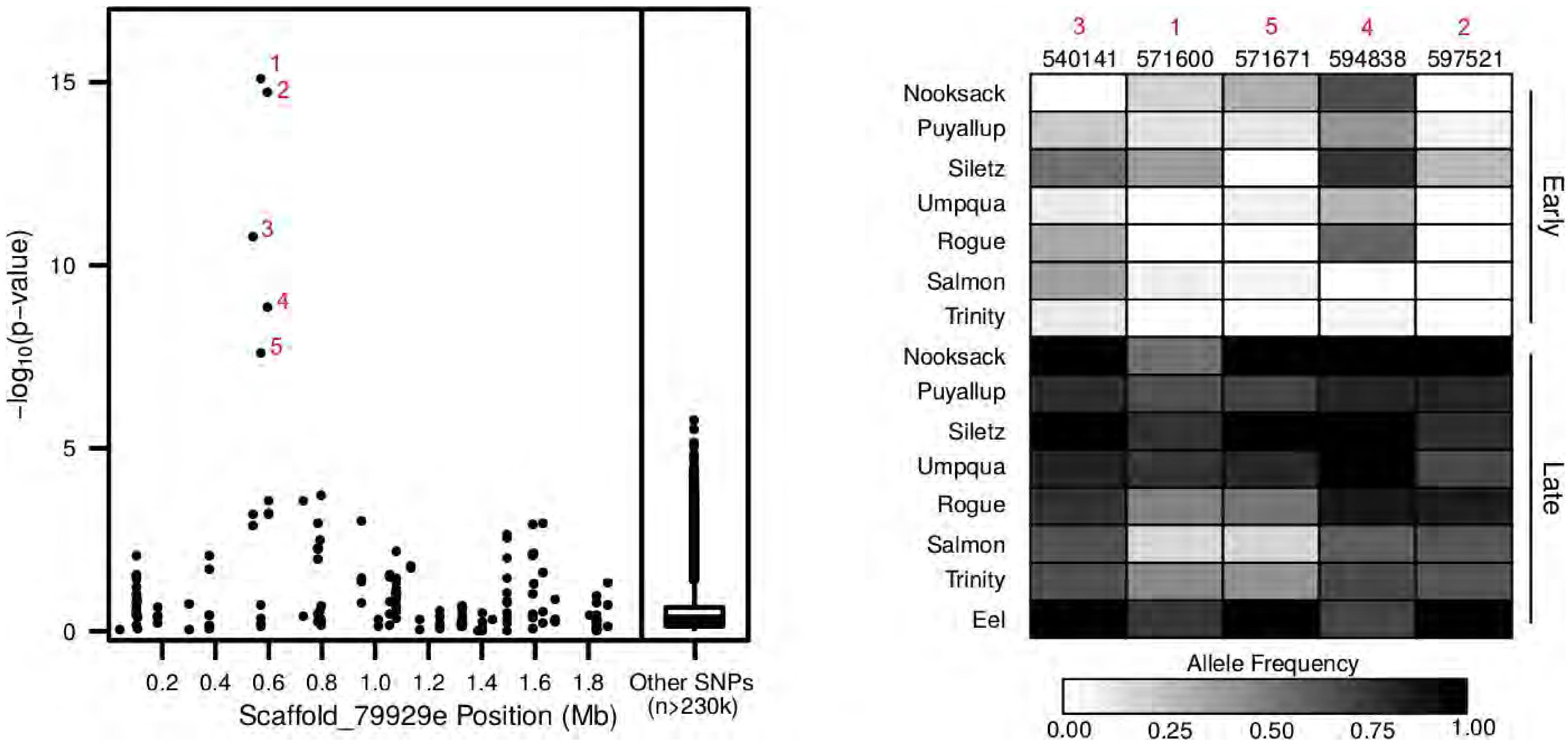
Chinook RAD data confirms that location determines overall genetic structure and agrees with current ESU designations.





Prince *et al.* In preparation

The same genetic and evolutionary mechanism controls early run timing in Chinook too.



Prince *et al.* In preparation

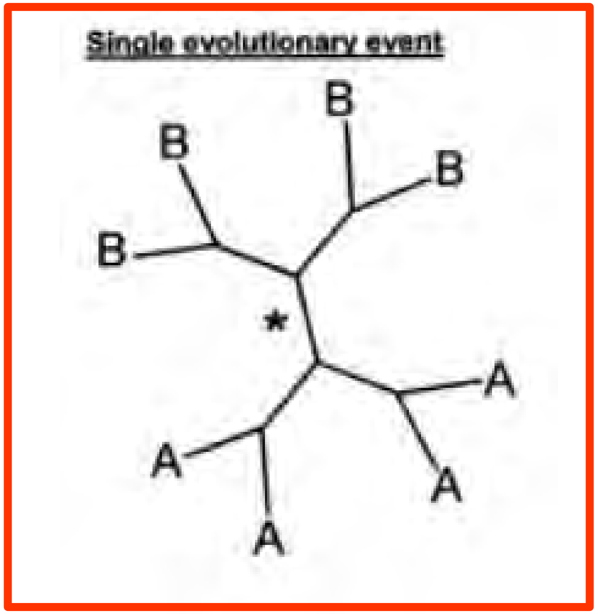
Previous genetic studies were correct with respect to phenotypic evolution but not genotypic evolution.

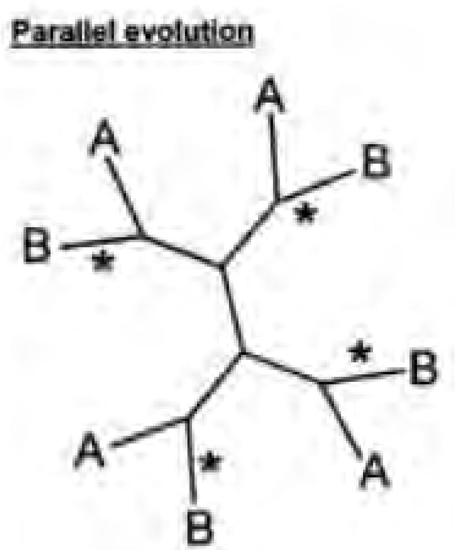
"Although the failure of most stock transfers indicates that local populations may be largely irreplaceable on human time frames, at least some patterns of Chinook salmon life-history diversity appear to be evolutionarily replaceable, perhaps over time frames of a century or so. The evidence for repeated parallel phenotypic evolution of run timing in Chinook salmon indicates that such a process is likely, provided that habitats capable of supporting alternative life-history trajectories are present and sufficient, robust source populations that contain the necessary, pre-existing genetic variation are maintained."

Waples *et al.* 2004*

The problem is that most source populations have been extirpated and none are robust.

Identifying the run-timing locus led to opposite conclusions about the evolutionary basis and conservation priority of run timing variation.





- Early run timing controlled by single locus
- Single ancient evolutionary event in each species
- New allele spread through positive selection and straying
- Can only evolve through limited genetic mechanisms
- Will not soon re-evolve if lost
- High conservation priority
- Genomics important tool for delineating conservation units


Dan Prince
Omar Ali
Hannah Lyman

Sean O'Rourke

Daniel J. Prince[1], Sean M. O'Rourke[1], Omar A. Ali[1], Martha Arciniega[2,3], Hannah S. Lyman[1], Ismail K. Saglam[1,4], Tasha Thompson[1], Anthony J. Clemento[2,3], Scott L. Harris[5], Thomas J. Hotaling[6], Holly A. Huchko[7], Laura S. Jackson[7], Marc A. Johnson[7], Andrew P. Kinziger[8], Adrian P. Spidle[9], J. Carlos Garza[2,3], Devon E. Pearse[2,3], Michael R. Miller[1,10]

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

"For spring-run and fall-run populations of Chinook salmon to be considered separate ESUs, as defined by Waples (1991) and later elaborated on by Waples (1995), these populations would need to be substantially reproductively isolated from other conspecific population units and they must represent an important component in the evolutionary legacy of the species. The concept of evolutionary legacy implies that there would need to be a monophyletic pattern of the evolutionary history of the two run-types within the UKTR. That is, spring-run Chinook salmon individuals and populations in the UKTR basin would need to be more similar to each other than to fall-run Chinook salmon individuals and populations within the UKTR basin (Waples et al. 2004) (Figure 1). " Williams et al. 2013

THE WATERSHED CENTER
HAYFORK, CALIFORNIA

Working towards healthy watersheds and healthy communities.

Joshua Smith

Watershed coordinator for the South Fork Trinity River

SPRING CHINOOK OF THE SOUTH FORK TRINITY RIVER

Photo: NOAA Fisheries

Please feel free to ask questions!

Chinook Salmon – *Oncorhynchus tshawytscha*

A Klamath River Tributary

Watershed	Miles^2
Klamath River Watershed (below Iron Gate)	1,543
Salmon River Watershed	744
Scott River Watershed	813
Shasta River Watershed	793
Main-stem Trinity River (Total)	2,036
Main-stem Trinity River (above dam)	718
Main-stem Trinity River (below dam)	1,318
South Fork Trinity River Watershed	929
North Fork Trinity River	152
The New River	233

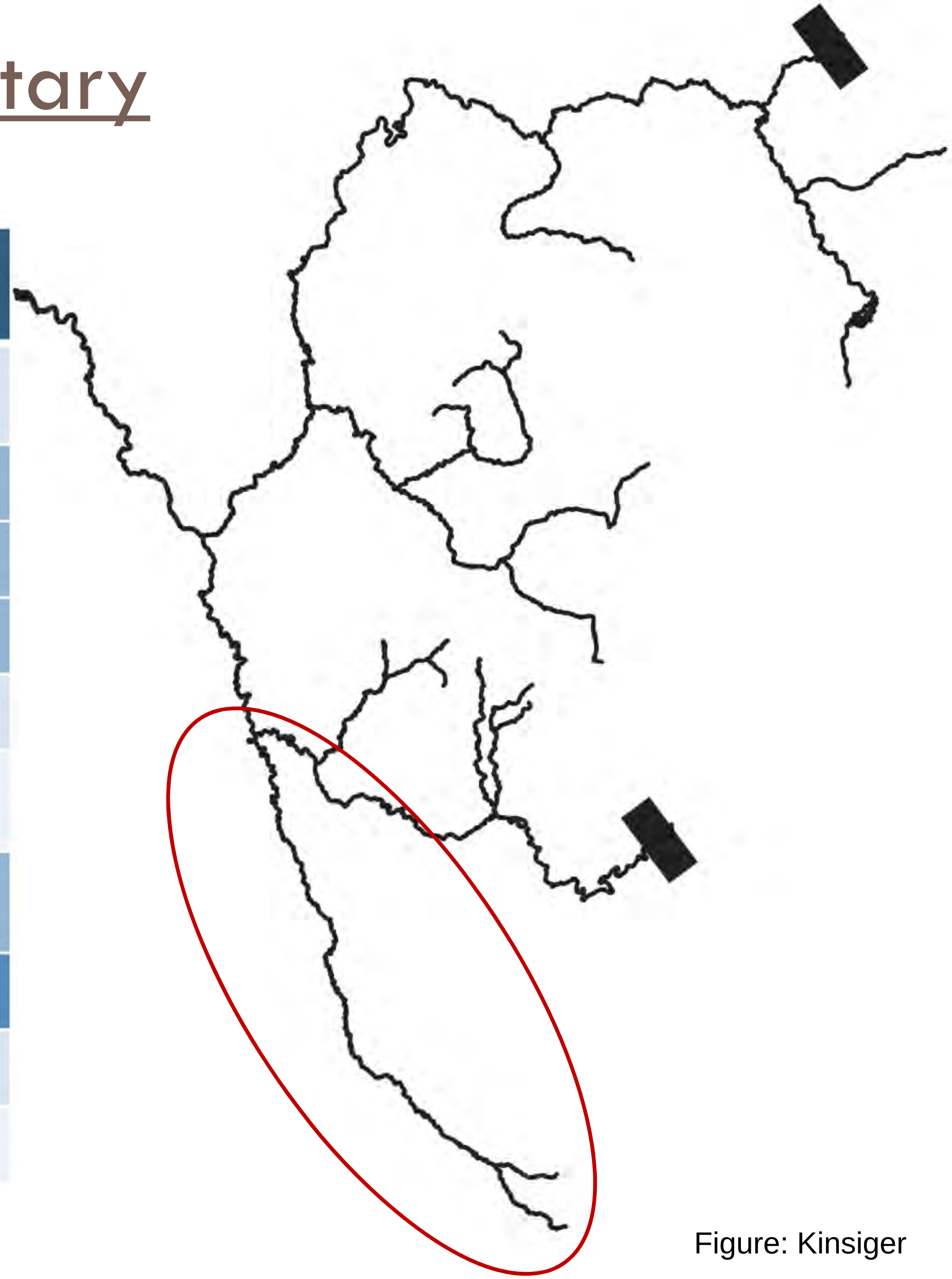
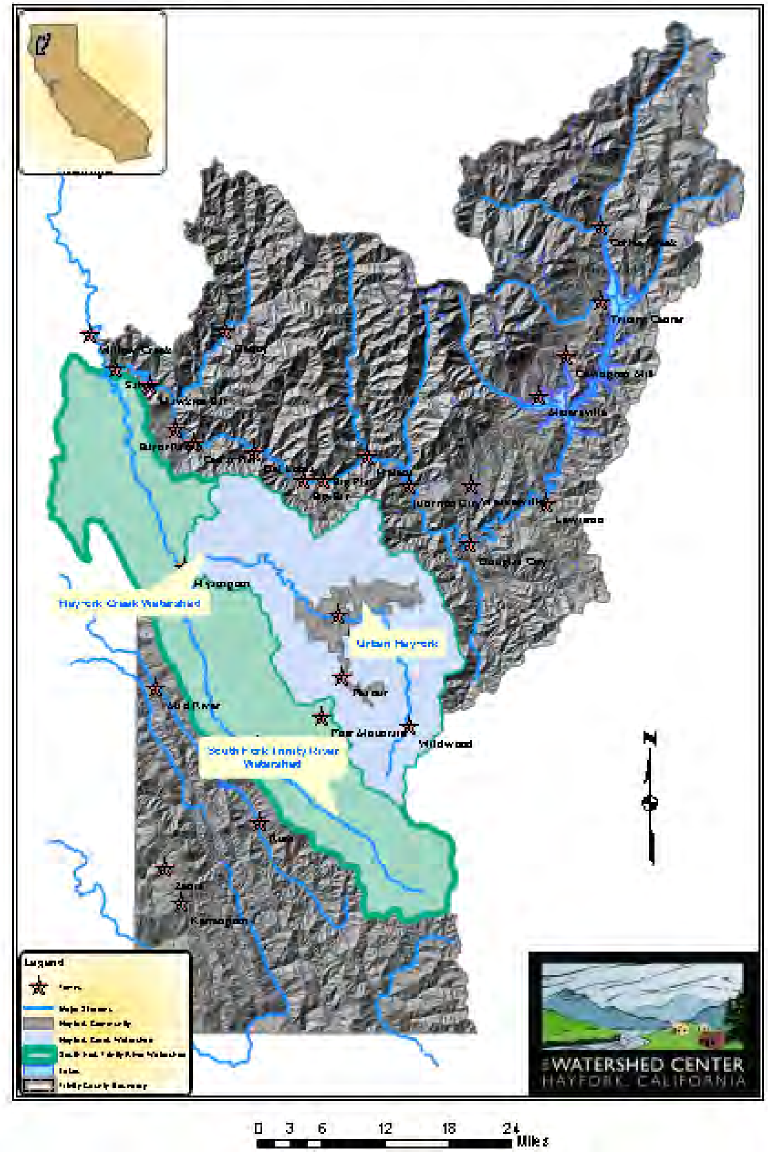


Figure: Kinsiger

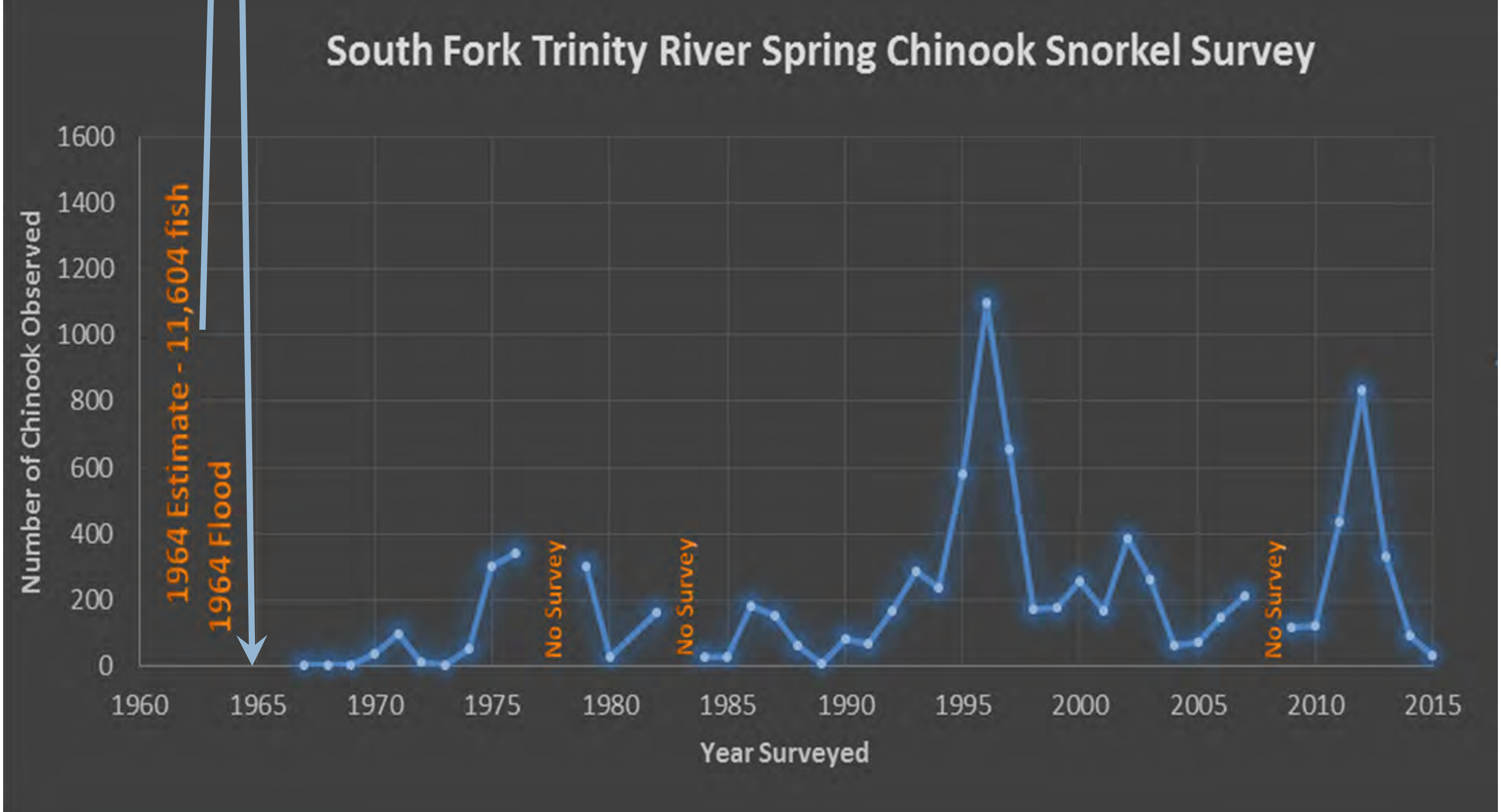
South Fork Trinity River (SFTR)

- Watershed Area:$1,000^2$ miles
- Mainstem is >90 miles long
- Largest undammed river remaining in California.
- Land protections: Wild and Scenic River, Roadless areas (18%), Wilderness areas (2%), and limited river access.
- Approximately 2,000 people in the entire watershed
- Historically robust spring Chinook population. 200+

South Fork Trinity River and Hayfork Creek Watersheds



POPULATION TRENDS



32 Chinook in 2015

SFTR: 1964 FLOOD IMPACTS

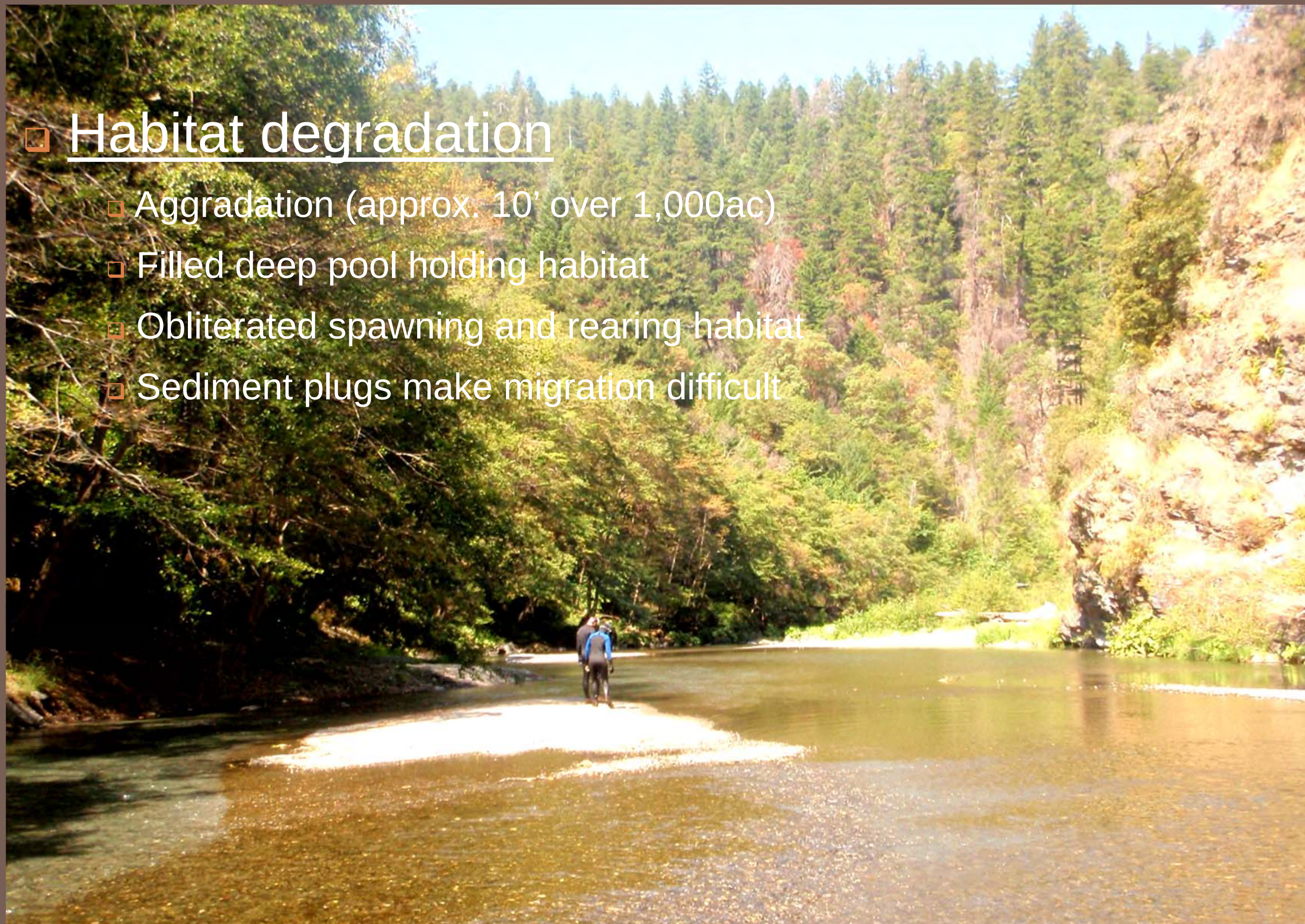
- 1964 flood
  - Freeze and heavy snow
  - Pineapple express
  - “1,000 year flood”
  - Bridges & homes lost
  - All this lead to…
- Mass wasting
  - Landslides up to 130 ac
  - Road failures
  - Sediment pollution

Photo: Big Slide 2003, Fitzgerald

- Sediment is still the primary factor limiting the SFTR spring chinook population

AFFECTS OF MASS WASTING

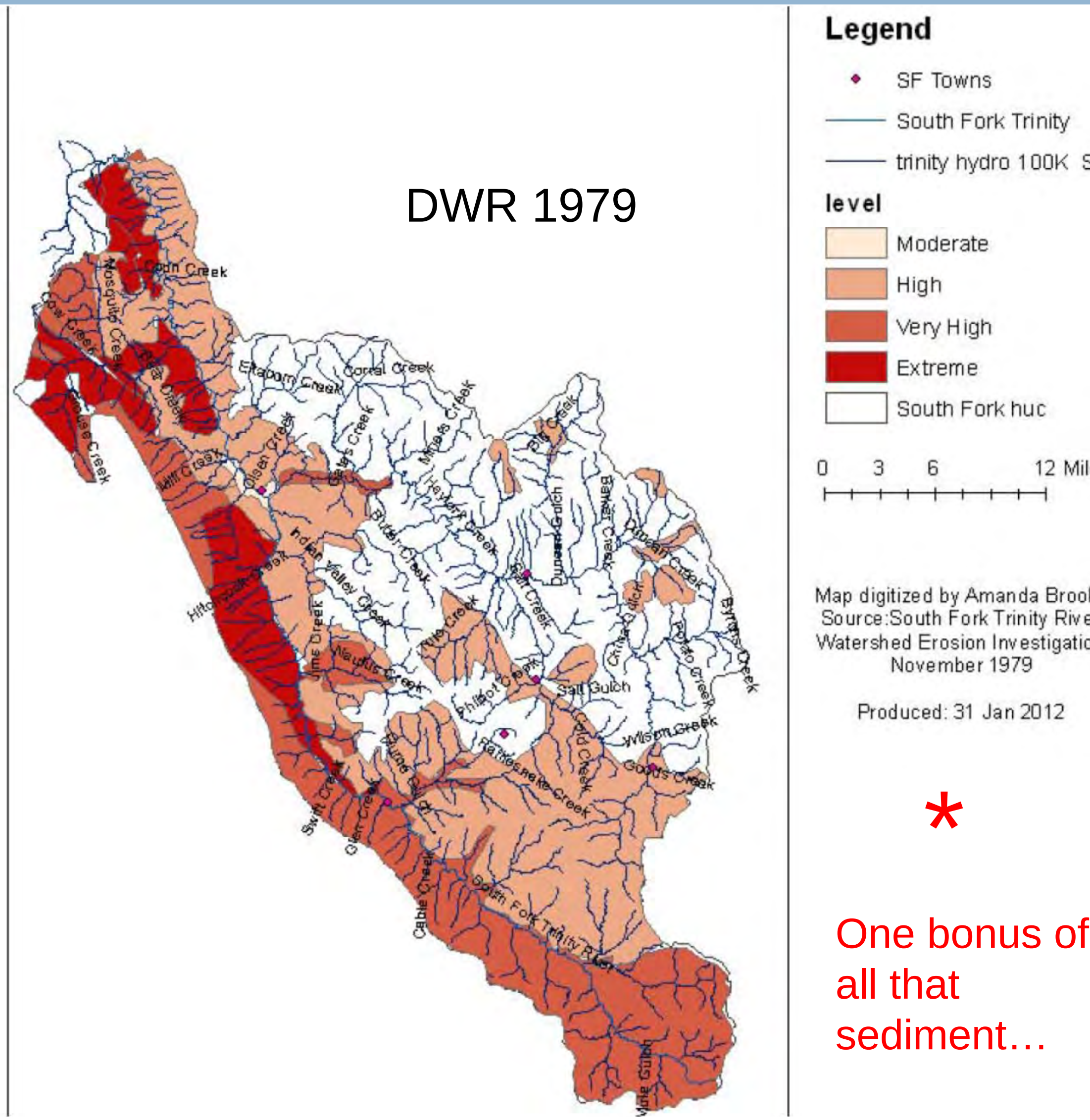
- Habitat degradation
  - Aggradation (approx. 10' over 1,000ac)
  - Filled deep pool holding habitat
  - Obliterated spawning and rearing habitat
  - Sediment plugs make migration difficult



Fine sediment

Sediment ≈ Factor of Geology

- <u>Contributing factors to sediment pollution</u>
  1. Geologic foundation,
  2. Poorly built roads,
  3. Poor harvest practices,
  4. Wildfires (high severity),
  - Floods
- <u>Underlying geologic belts</u>
  - <u>Central Metamorph</u> (423-443) *Sawyers Bar, Abrams*
  - <u>Western Paleozoic</u> (208-450) *Hayfork Cr, Rattlesnake Cr*
  - <u>Western Jurassic</u> (152-201) *Galice, Pickett Pk* (SF schist)
  - <u>Franciscan</u> coast ranges



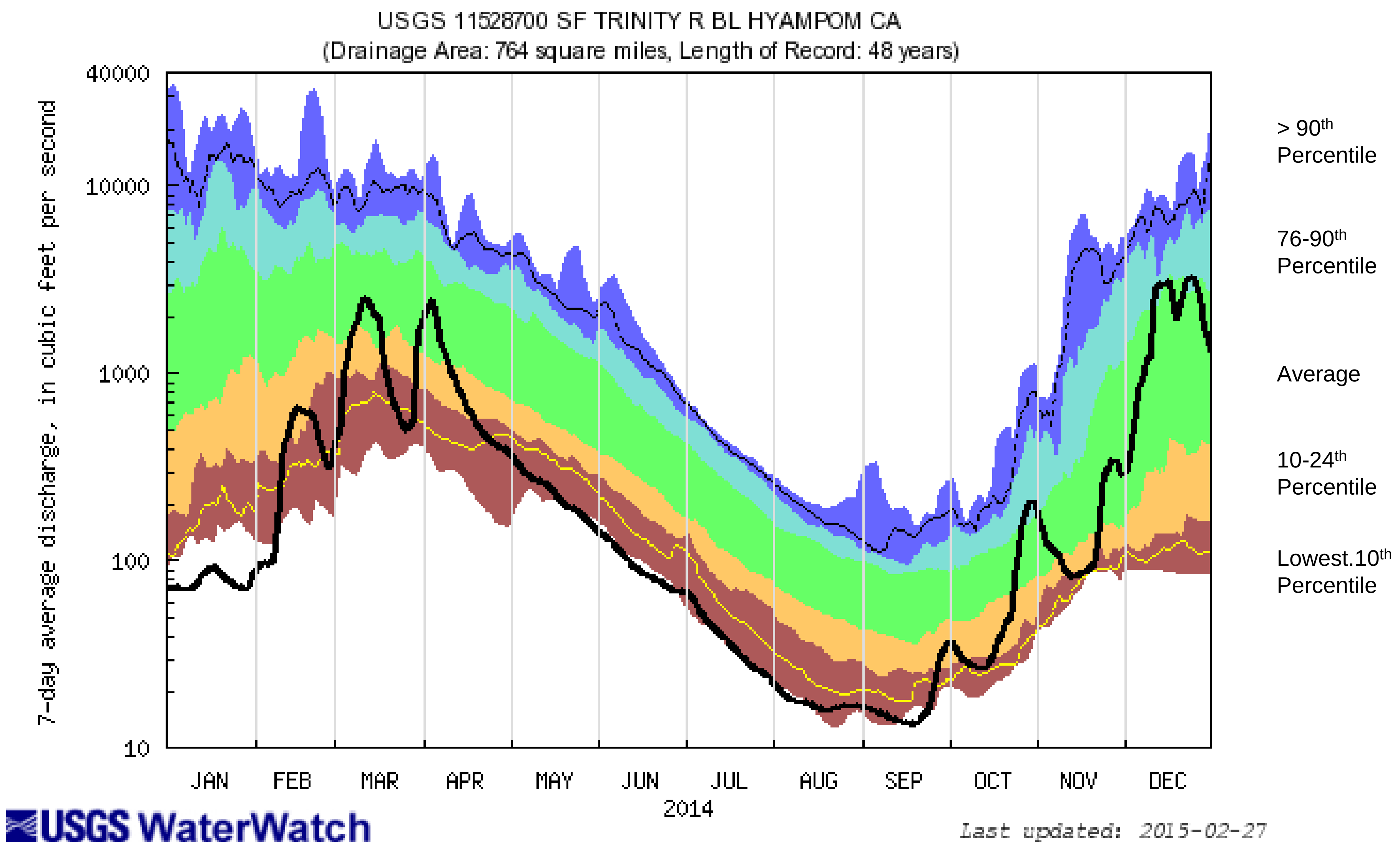
*
One bonus of all that sediment…

OTHER LIMITING FACTORS

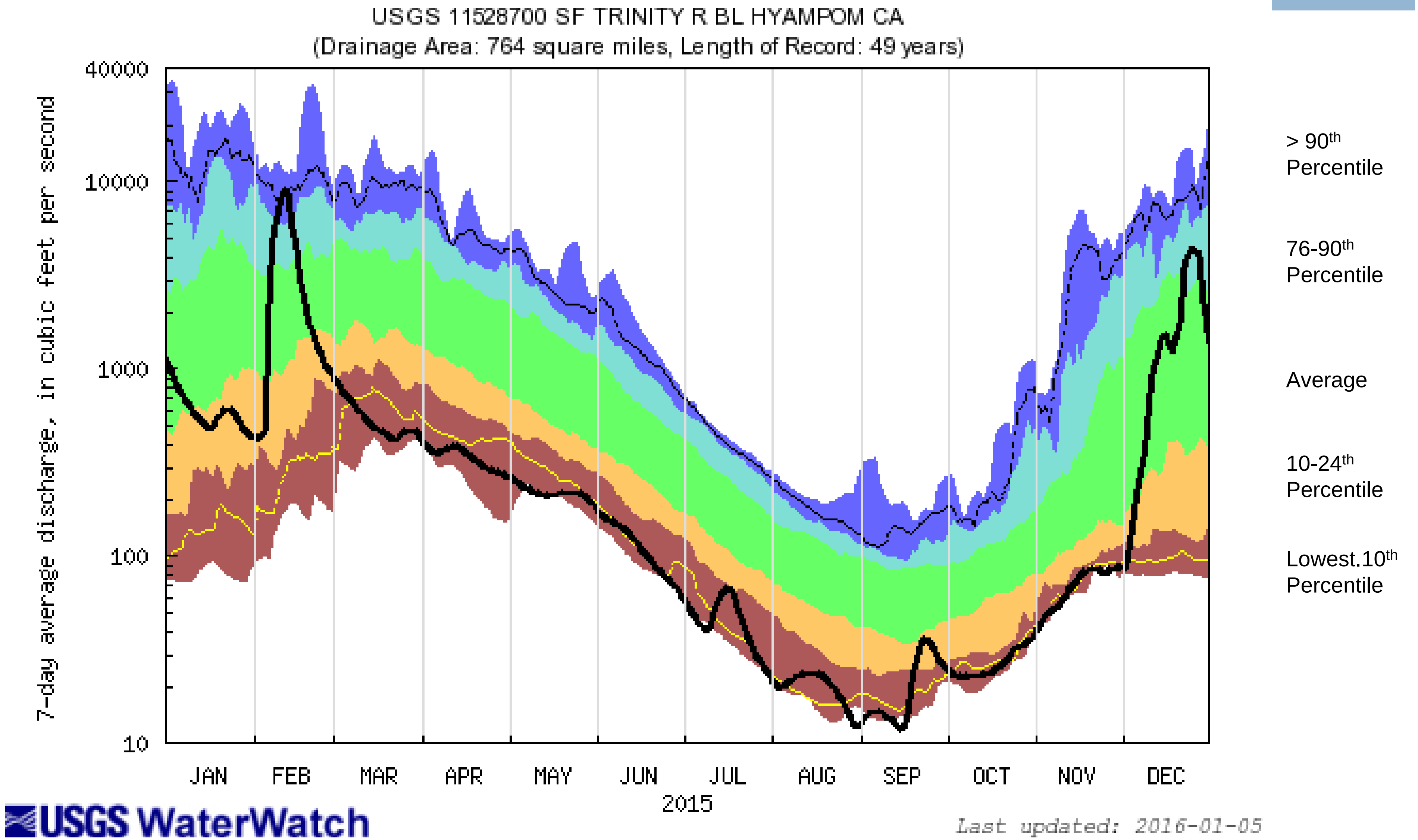
- **Harvest**
  - commercial
  - sport
  - tribal
  - poaching (200!)
- **Genetic structure**
  - hatchery influences
  - genetic bottleneck (inbreeding)
- **Water Quantity and Quality**
  - climatic
  - human impacts

Water Quantity

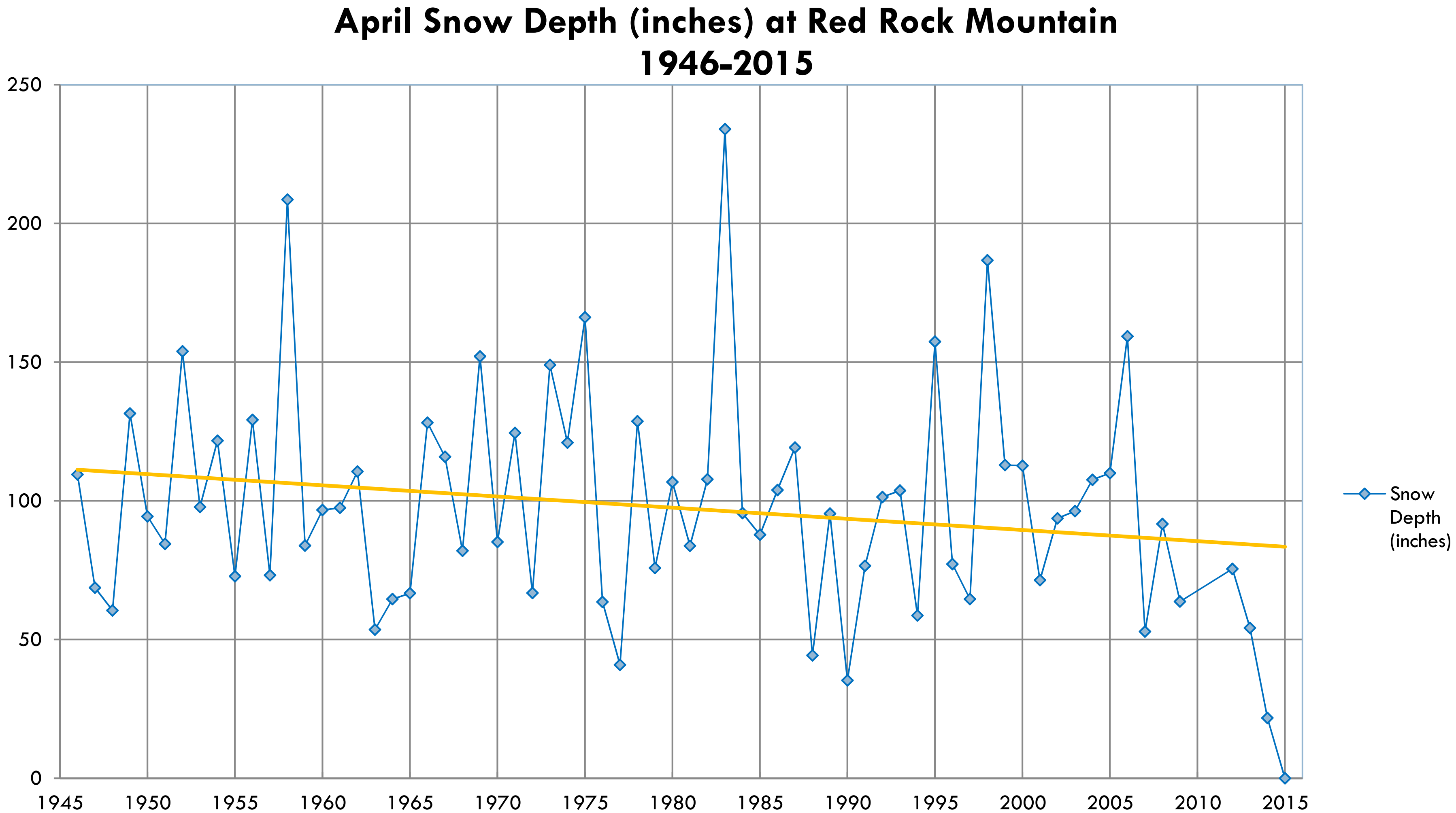
2014: The greatest drought on record.



2015: Continued...



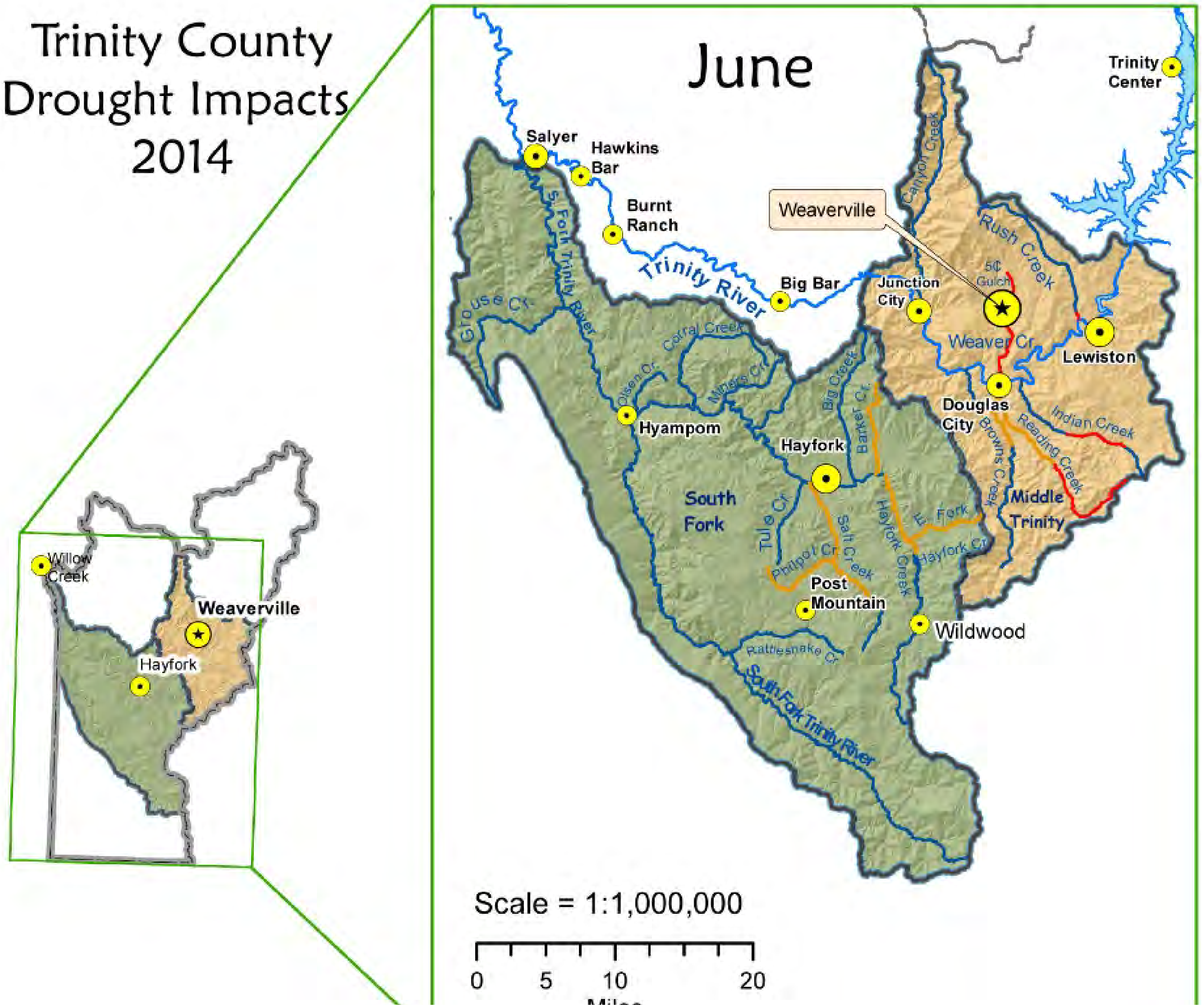
2015: Snowpack



* Crux: These are the snow salmon… what if there is no more snow on the mountains?

Local Conditions in 2014

Trinity County
Drought Impacts
2014



2014 Stream Conditions

Confirmed Subsurface

Historically Low (>1CFS)

Subsurface

Other Major Streams & Rivers

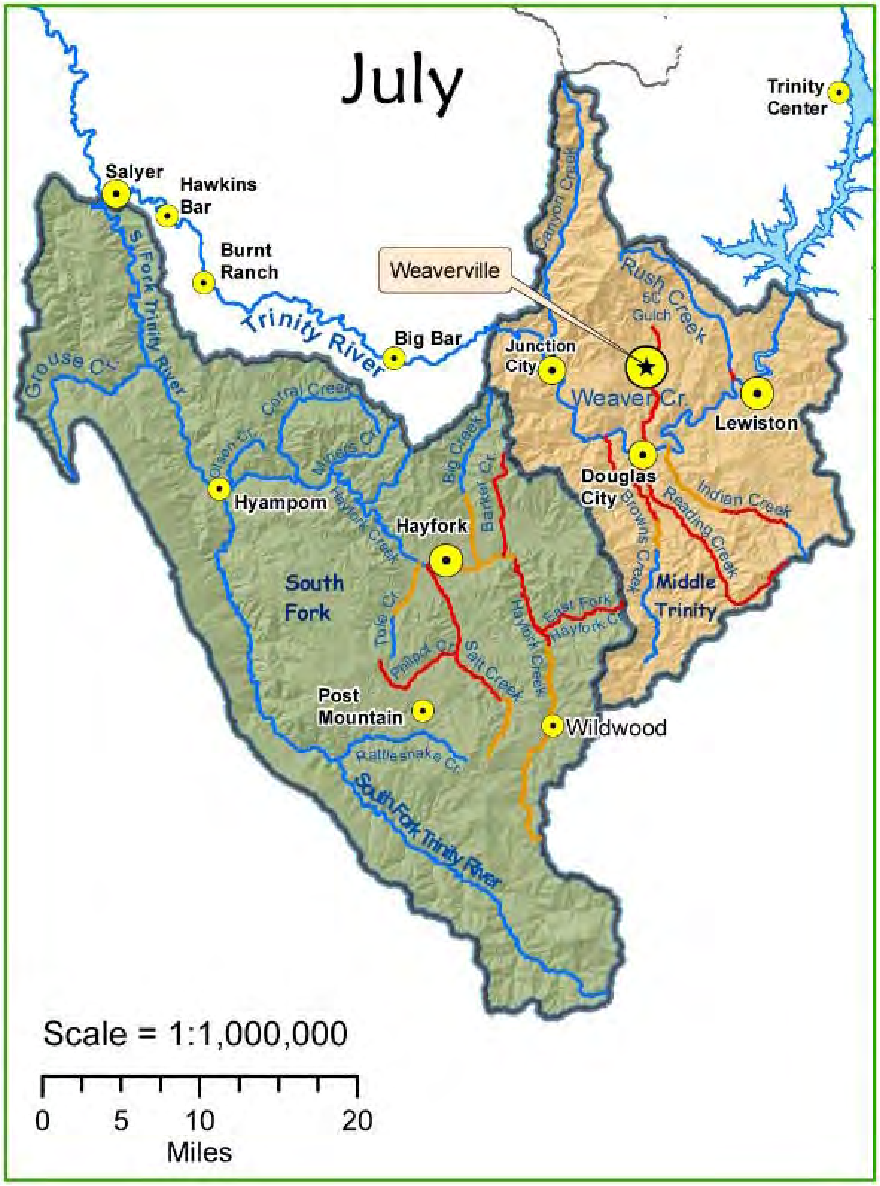
N

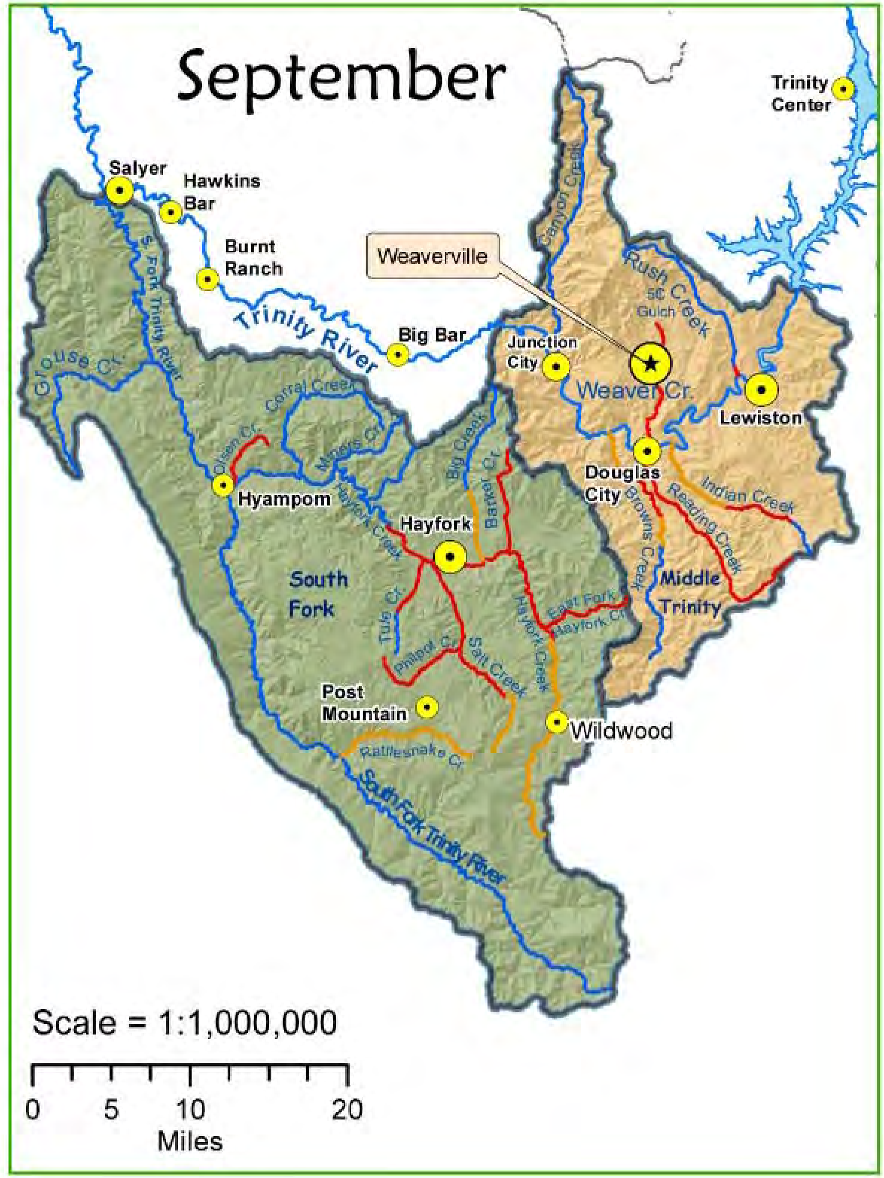
Trinity County Resource Conservation District

THE WATERSHED CENTER HAYFORK, CALIFORNIA

MB

Local Conditions in 2014





Water Quality

- High stream temps. > 70° F = barrier
- Increasing concentrations of pollutants and nutrients
- Increasing algae
- Decreasing dissolved oxygen

Potential for Recovery

- Sediment mitigation
  - USFS
  - Trinity County RCD
  - Improved BMP & THP
- Water quality
  - Public water & sewage
- Natural recovery & resilience
  - Sediment healing? Dresser
  - Forests heavily altered
  - Fire regime heavily altered
  - Beaver rebound

Slow Progression of Knowledge

- 1990's CRMP
  - Watershed Assessments
  - Detailed monitoring
  - Road and sediment work
- 2000's - ?
- 2010 – back 2 basics
  - Springer Limiting Factor Analysis – literature review
- 2014-2016

FRGP Watershed Assessment

  - Water Conservation
  - Stream Temperature Analysis
  - Fish Passage Assessment
  - Riparian Plan

WATERSHED CENTER PROGRAMS

- **Large Wood Projects**
  - Collaboration with Yurok Tribe
- **Wetland Enhancements**
  - USFWS, USFS
- **Education and Outreach:**
  - Poaching – Salmon Gathering
  - Water conservation workshops
  - Growing Green BMP education
  - Youth Programs: IVSC and HYC
- **Watershed Resilience:**
  - Beaver protection/enhancement
  - Upslope: prescribed fire, forest management, and FIRE USE.
  - Reclamation
  - Monitoring

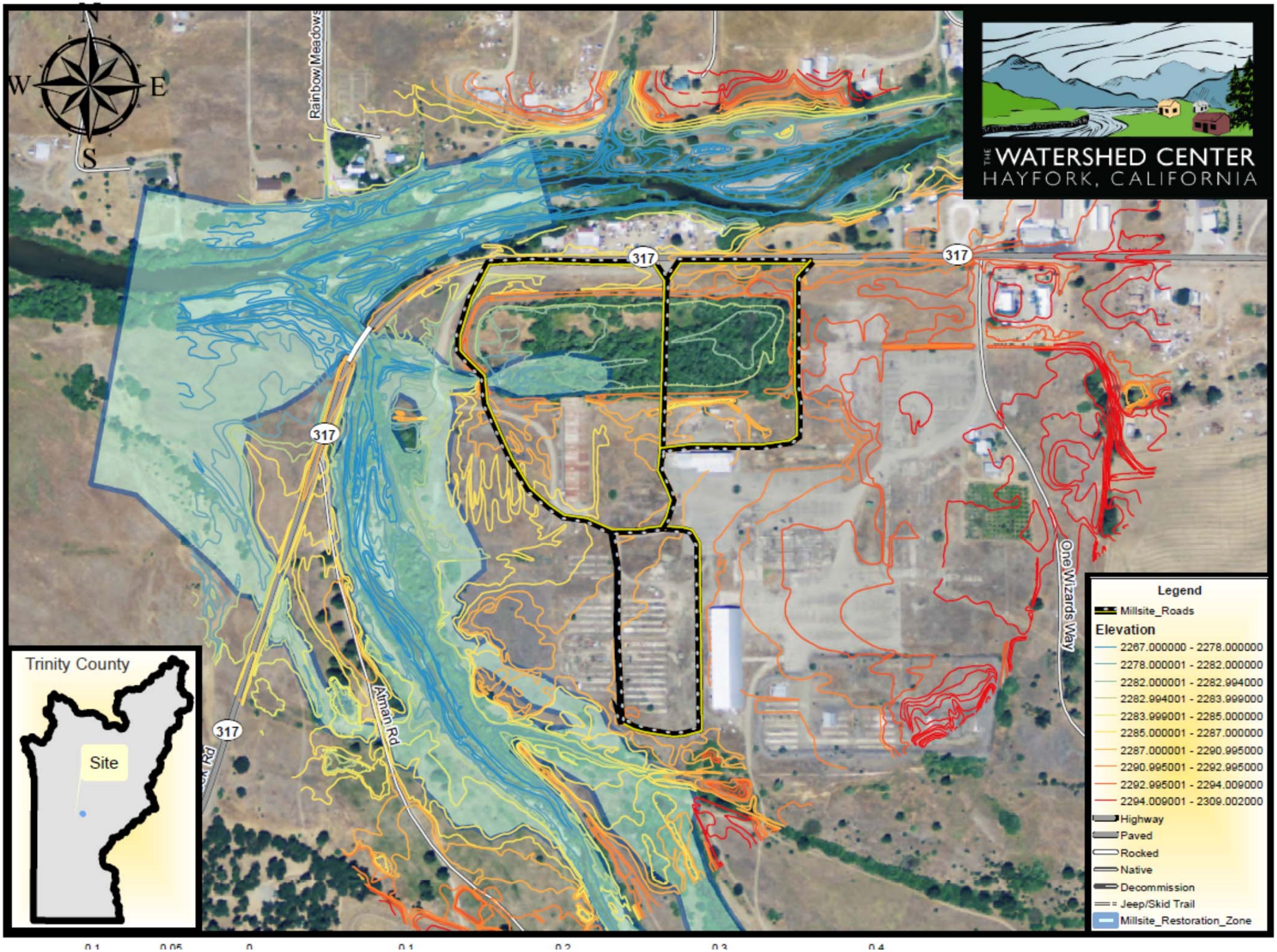
Illicit Grow-site Reclamation

PRESCRIBED FIRE

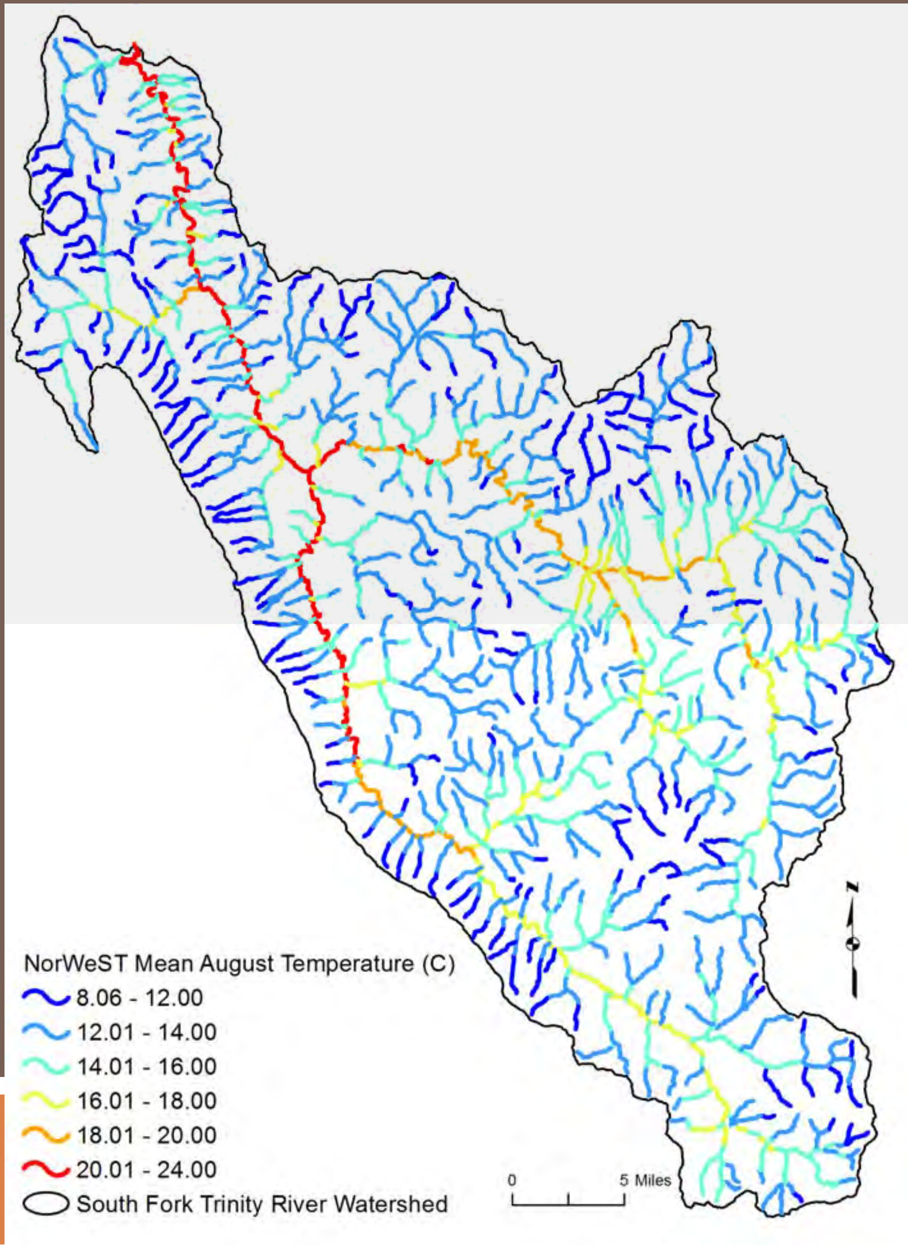
Beavers

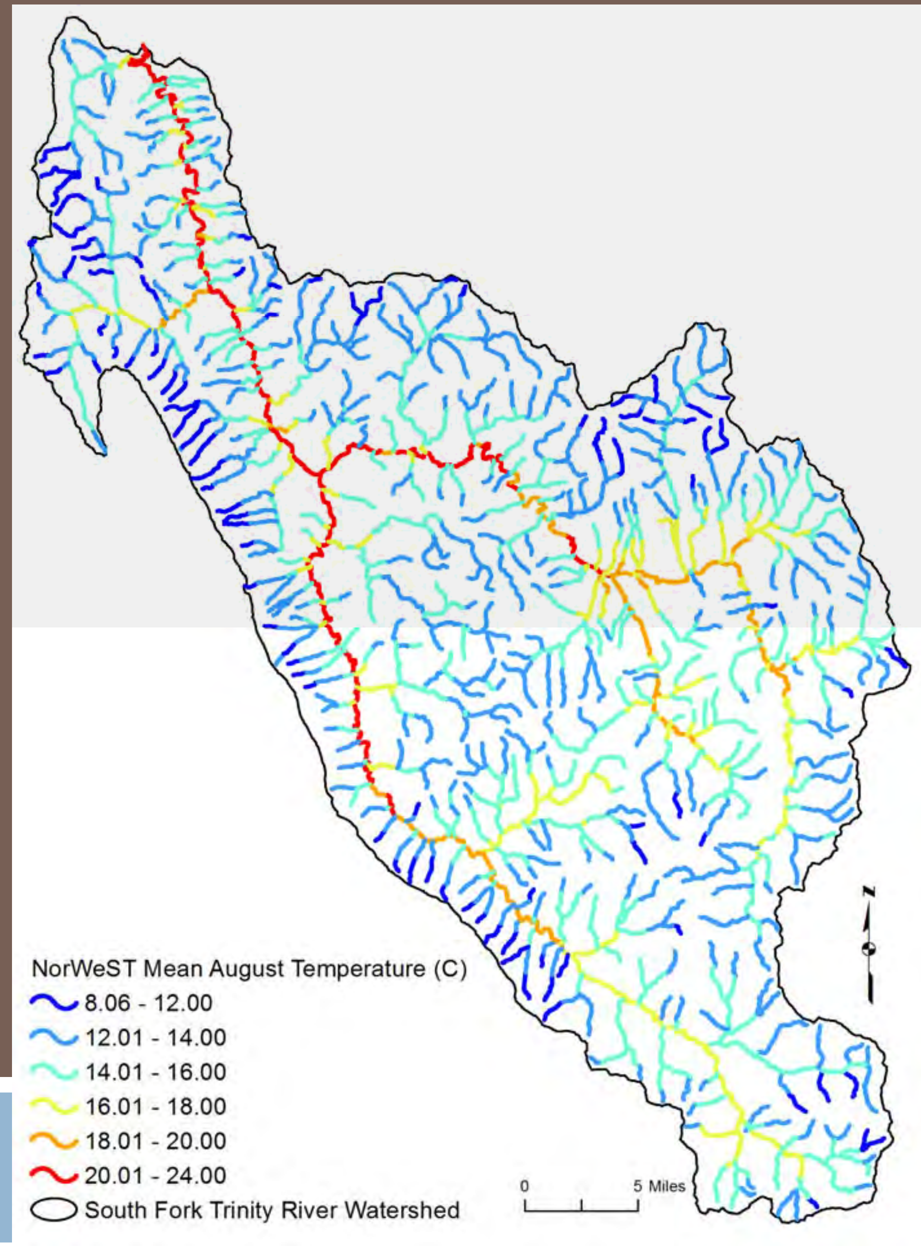
Wetland Enhancement:

Salt Creek Confl.: Channel Restoration



LARGE WOOD


NorWeST Mean August Temperature (C)
8.06 - 12.00
12.01 - 14.00
14.01 - 16.00
16.01 - 18.00
18.01 - 20.00
20.01 - 24.00
South Fork Trinity River Watershed
0
5 Miles
N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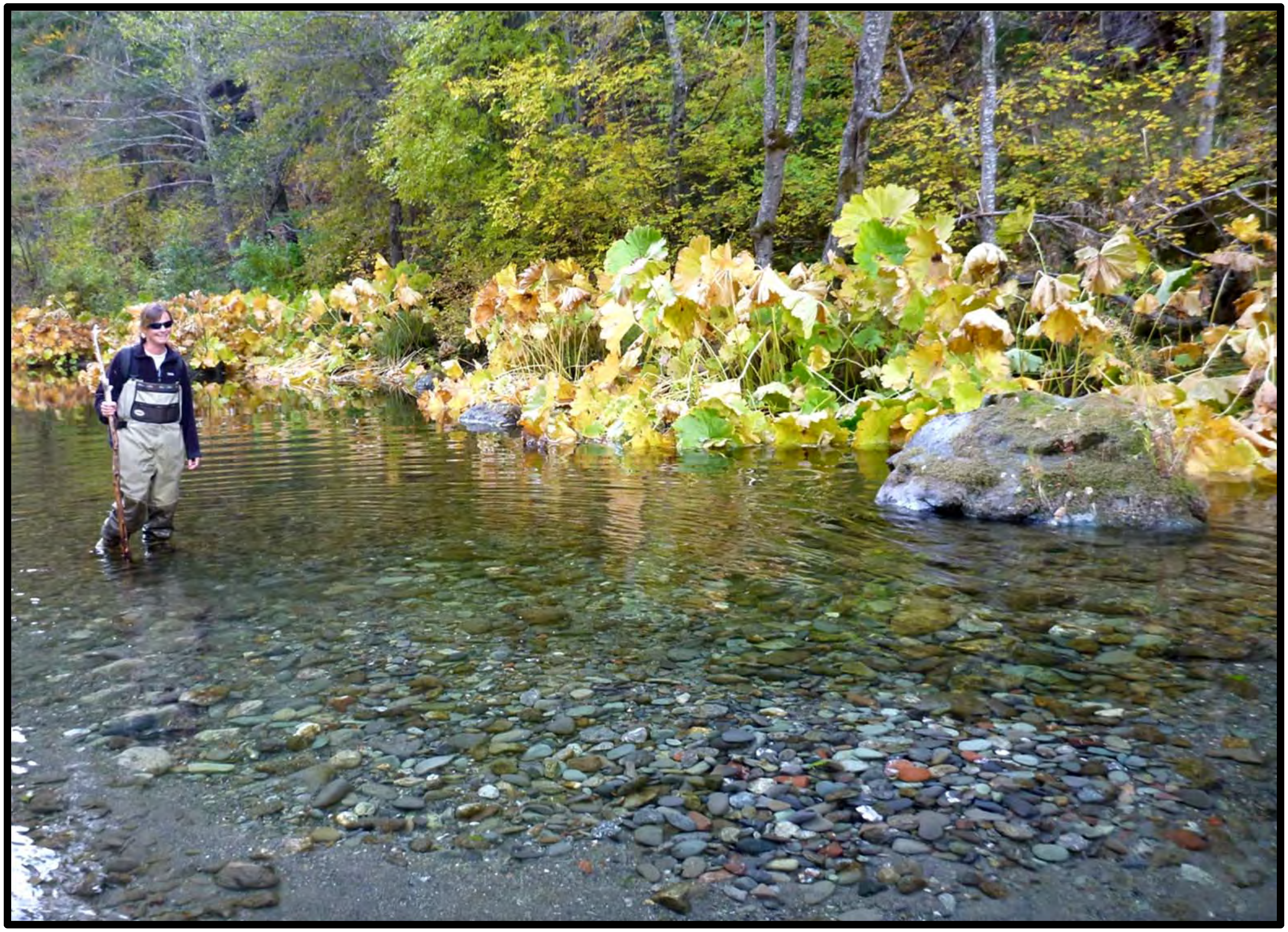
18.01 - 20.00
20.01 - 24.00
South Fork Trinity River Watershed
0
5 Miles
N


What can you do?
Become a steward!

Thank You!   Any questions?



Chinook redd near Smoky Creek

THE WATERSHED CENTER

HAYFORK, CALIFORNIA

South Fork Basin Stewards – You can help!

- Conserve water!
- Education – talk to your neighbors
- Noxious weed pulling volunteer days
- Salmonid surveys volunteer days
- Splash 4 Trash (creek cleanup days)
- Water quality monitoring
- Tree planting days
- Youth Camps and work programs
- Upslope fuels reduction & rx fire

Youth Education –
Indian Valley Summer Camp

- Watershed and natural resources education
- Service activities
- Nor El Muk Native American Education
- Fun! - Rafting and more
- Nutrition
- Music
- Art

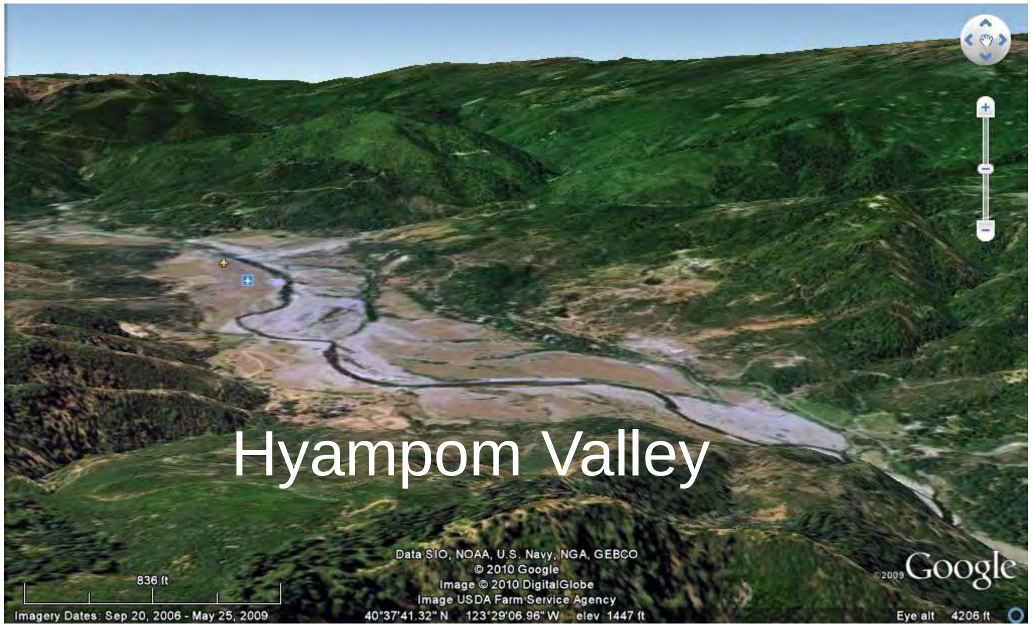
Youth Restoration Crew

- Stewardship values
- Trail Maintenance
- Noxious Weed Removal
- Senior projects
- Job shadowing

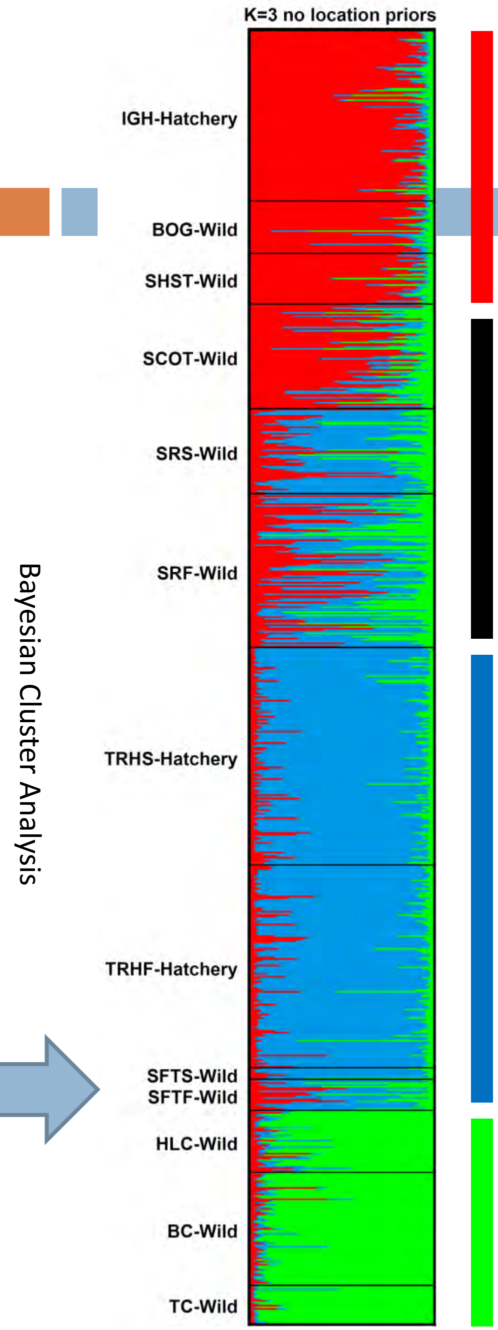


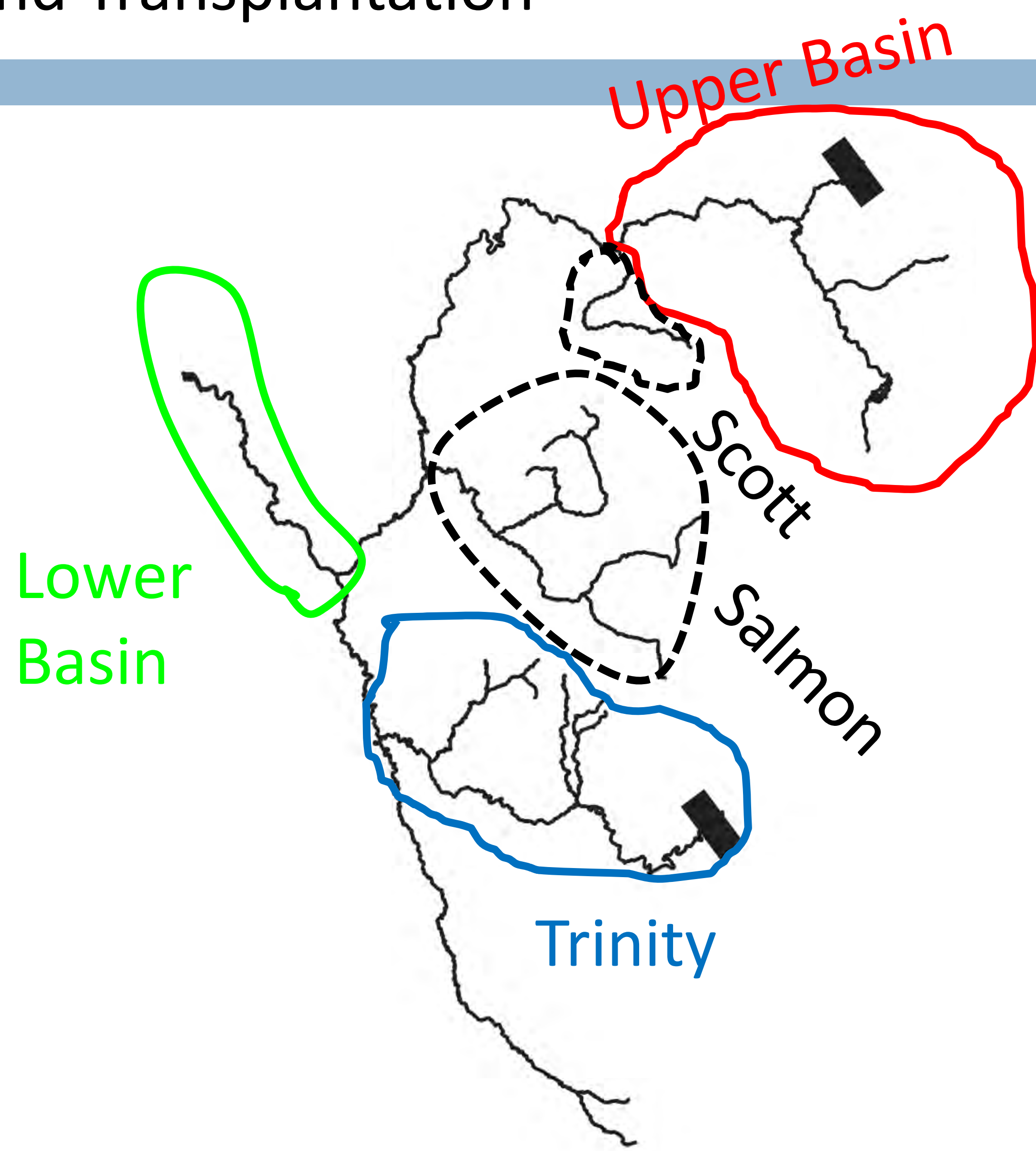

Genetics… maybe its in the genes

1. **We are working with geneticists to determine the genetic structure of the SFTR Chinook salmon. Structure seems to be based on:**
   - Geography
   - Influence of hatchery and transplantations
   - Spring/fall parallel evolution
   - However, it should be noted that
   - 7 SFTR samples have been
   - Analyzed & this is what NMFS's
   - listing is based on.

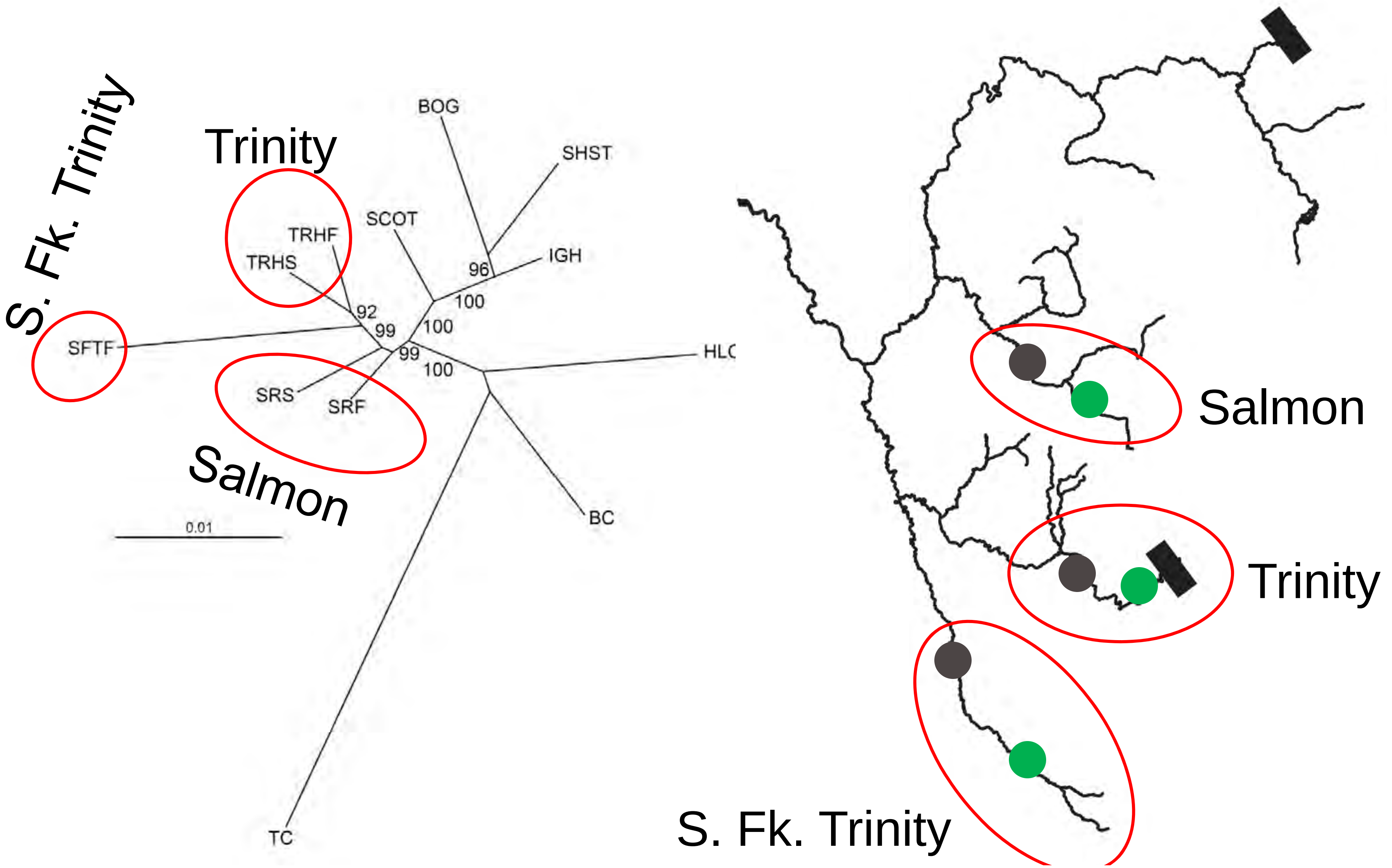


Genetic Structure: Geography, Hatcheries, and Transplantation





Spring and fall runs evolved independently via parallel evolution?



History of the Watershed Center

- Trinity County Ownership and Historical Land Use JS4
  - 1950's-1990's = Logging
- Impact of the Northwest Forest Plan = No more logging JS5
- Foundation of the Watershed Center in 1993
- Our Mission
  - "To promote healthy communities and sustainable forests through research, education, training, and economic development."
- Creating Land Stewards JS6

THE WATERSHED CENTER
HAYFORK, CALIFORNIA

Slide 36

JS4 Much of Trinity County is public land managed by the USFS.

Historical land management practices built a logging economy in Hayfork and the town was home to about 3,000 people at its peak.
Joshua Smith, 4/23/2010

JS6 By employing local workers in various aspects of resource management, we are simultaneously

improving the local economy,

engaging the community in knowledge of healthy ecosystems,

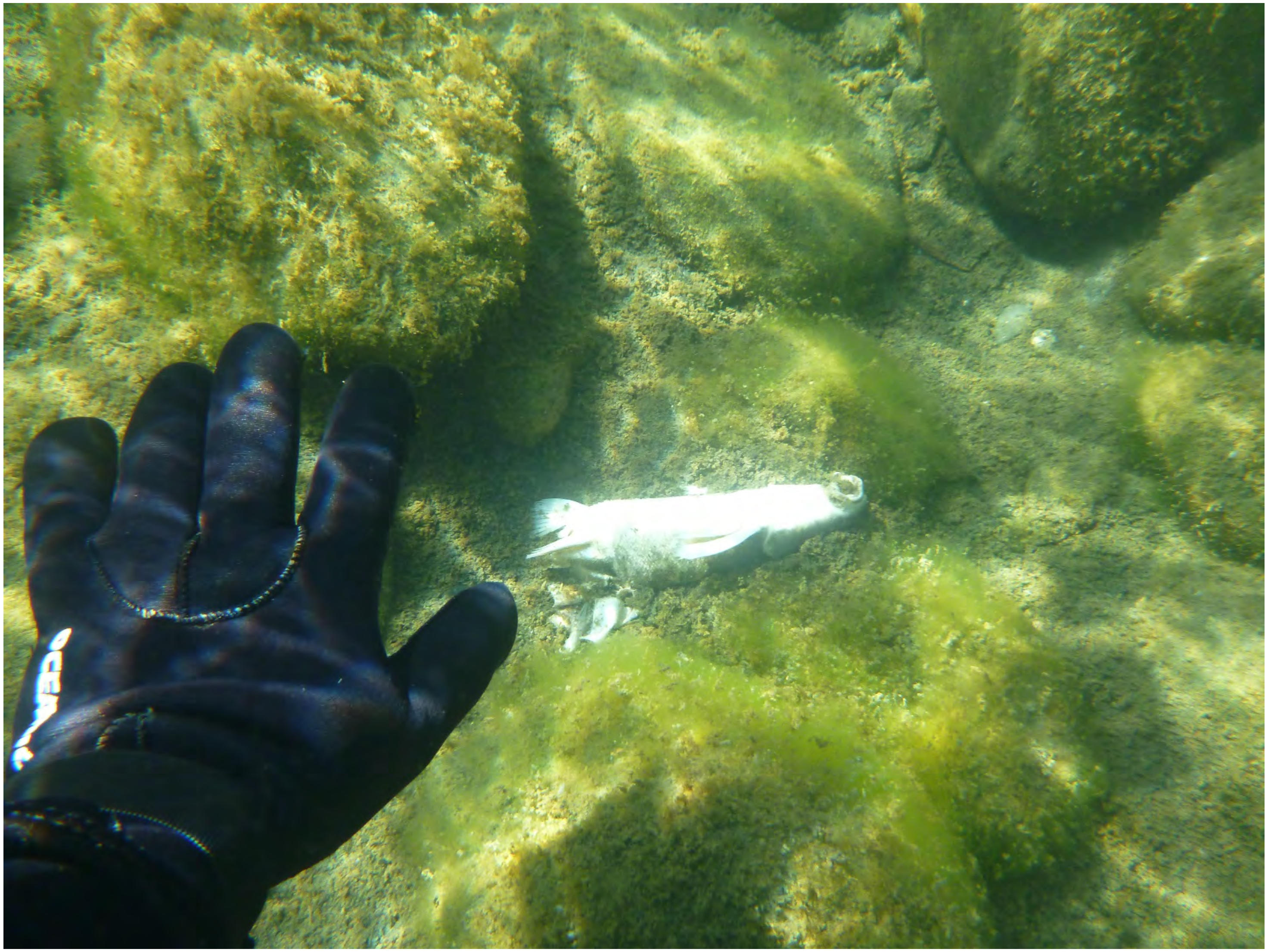
and growing the capacity of land stewardship within our community.
Joshua Smith, 4/23/2010

JS5 In the early 1990's forest management policy changed and the economy in Hayfork was drastically impacted; resulting in the loss of over 40% of the payroll in Hayfork.

Even now unemployment is around 29%, the third highest in California.
Joshua Smith, 4/26/2010

Our Current Programs

- Stewardship Contracting Implementation
- Environmental Planning, Modeling, and Monitoring
- Collaborative Regional and Community Planning
- Enterprise Development
- Rural Advocacy
- Research
- Prescribed Fire
- Youth and Education
- Watershed Restoration



THE WATERSHED CENTER
HAYFORK, CALIFORNIA

Restoration of Wild Spring-Run Chinook on The South Fork Trinity River – A Call for Action

Salmon Restoration Federation (SRF)
April 9, 2016

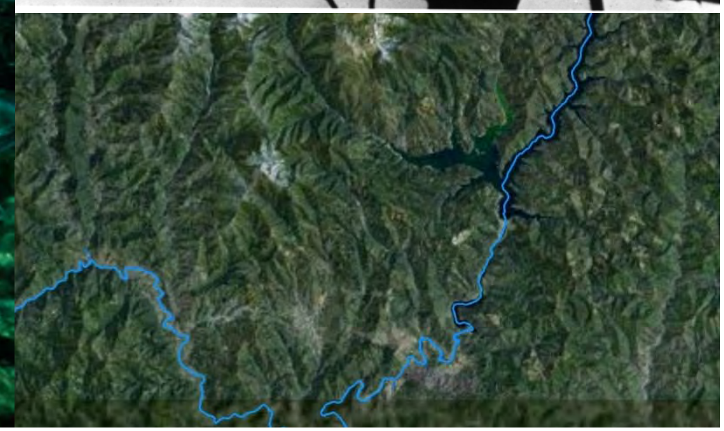
David (DJ) Bandrowski P.E.

Yurok Tribe – Fisheries Division

DISCUSSION TOPICS

- Setting The Stage – Historical Context and The Need for Restoration
- Complex Logistics – What are the Constraints and Challenges
- The Approach – Aggressive Techniques for In-River Restoration
- Pencil to Paper – Planning, Analysis, and Design Phase
- Learning by Doing – Physical and Biological Monitoring
- Future Vision – Embracing Uncertainty and Moving Forward


N
W
E
S
Yurok

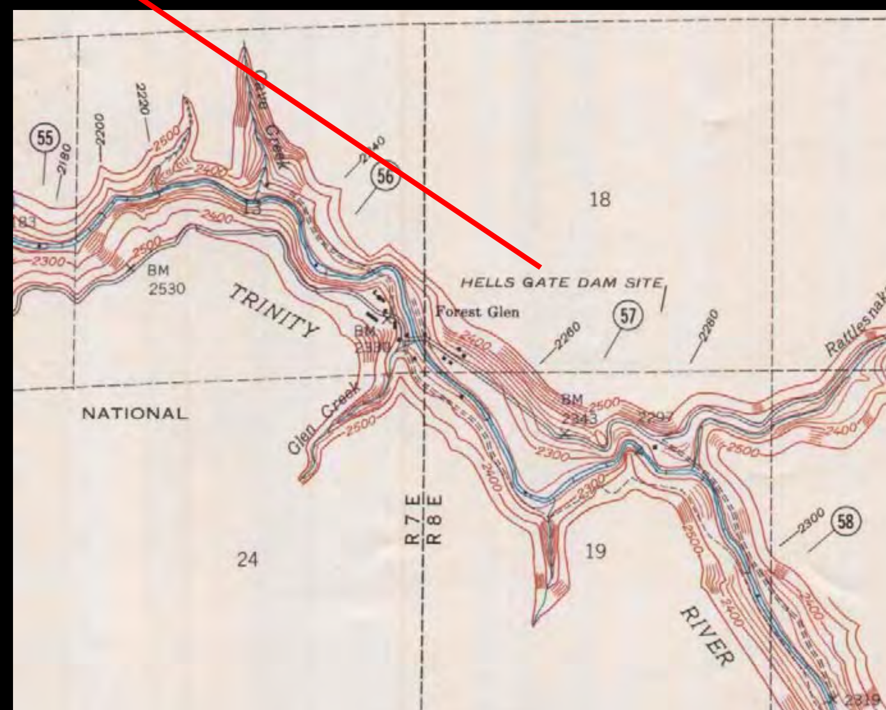


HISTORICAL CONTEXT - THE NEED FOR RESTORATION

PLAN AND PROFILE
SOUTH FORK TRINITY RIVER, MOUTH TO MILE 65.8
HAYFORK CREEK, MOUTH TO MOUTH OF EAST FORK, CALIFORNIA
DAM SITES

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Topography by R. W. Rumph and H. L. Pumphrey
Surveyed in 1948 and 1949



HISTORICAL CONTEXT - THE NEED FOR RESTORATION

Floods of December 1964 and January 1965 in the Far Western States

Part 1. Description

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1866-A

Prepared in cooperation with the States of California, Idaho, Nevada, Oregon, and Washington, and with other agencies

FIGURE 22.—Main Street, Klamath, Calif., after flood of December 23, 1964. Klamath River floodflows destroyed the town and damaged U.S. Highway 101 and the Douglas Memorial Bridge. Photograph by Eureka Newspapers, Inc.

The highest peak flow was 95,400 cubic feet per second (2,700 m^3/s) on January 20 in the 1964 Flood

HISTORICAL CONTEXT - THE NEED FOR RESTORATION

FIGURE 52.—Sediment, several feet deep, left by receding Trinity River floodwaters near Hoopa, Calif., December 1964. Photograph by George Porterfield, Water Resources Division, U.S. Geological Survey.

WATER RESOURCES RESEARCH, VOL. 18, NO. 6, PAGES 1643–1651, DECEMBER 1982

Effects of Aggradation and Degradation on Riffle-Pool Morphology in Natural Gravel Channels, Northwestern California

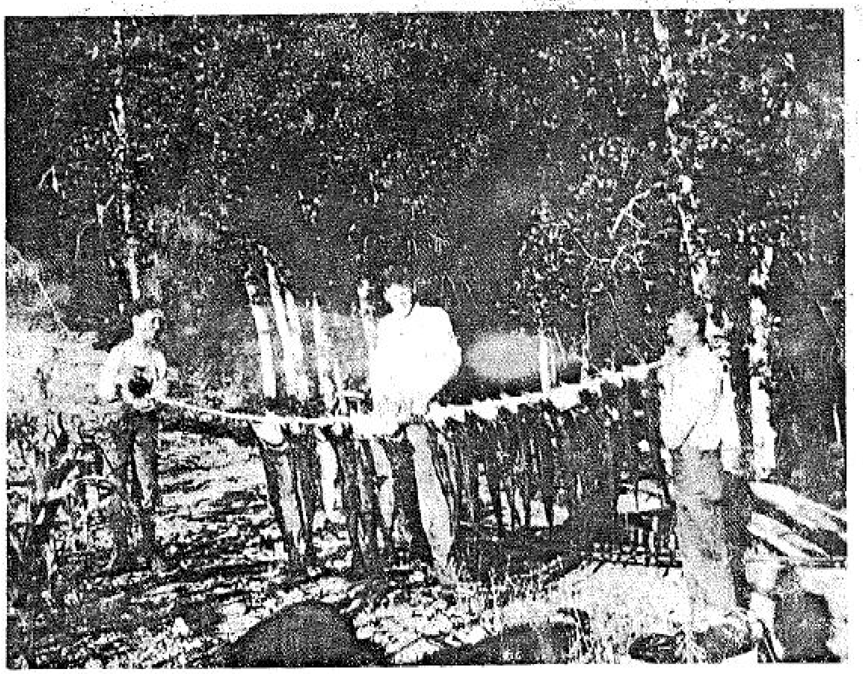
THOMAS E. LISLE

Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture Arcata, California 95521

After the flood of December 1964, 12 gaging sections in northern California widened as much as 100% and aggraded as much as 4 m, and then degraded to stable levels during a period of 5 years or more. As channels aggraded, bed material became finer, and low to moderate flow through gaging sections in pools became shallower, faster, and steeper. Comparisons of longitudinal profiles also show the diminishment of pools as well as a decrease in bar relief accompanying the excessive sediment load. As gaging sections degraded, hydraulic geometries recovered to a limited degree; full recovery probably depends on channel narrowing and further depletion of sediment supply. The hydraulic changes with aggradation indicate an increase in the effectiveness of moderate discharges (less than 1- to 2-year recurrence interval, annual flood series) to transport bed load and shape the bed. Bars become smaller, pools preferentially fill, and riffles armored with relatively small gravel tend to erode headward during falling stages and form a gentler gradient. Excess sediment can thus be more readily transported out of channels when additional contributions from watersheds are usuall slight.

HISTORICAL CONTEXT - THE NEED FOR RESTORATION

Action Plan for Restoration of the South Fork Trinity River Watershed and its Fisheries



prepared for

U.S. Bureau of Reclamation
and
The Trinity River Task Force

by

Pacific Watershed Associates
Arcata, California
February, 1994

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
NORTHERN DISTRICT

SOUTH FORK TRINITY RIVER SEDIMENT INVESTIGATION

Table 1 - Sediment Yield (in 1,000's of C.Y.)

Values are based on a 30 Year Study Period W.Y. 1961- W.Y. 1990	Engelund-Hansen Equation (TOTAL LOAD)			Meyer-Peter and Muller Equation (BEDLOAD)		
	Forest Glen	Hyampom	Salyer	Forest Glen	Hyampom	Salyer
Totals	5832	16093	76241	1935	5955	10765
Annual Average (30 years)	194	536	2541	65	199	359
Cumulative Drainage Areas (miles²)	208	764	898	208	764	898
Total Sediment Yield per mile²	28.0	21.1	84.9	9.3	7.8	12.0
Annual Average per mile²	0.93	0.70	2.83	0.31	0.26	0.40
Individual Basin Summary						
Individual Drainage Areas (miles²)	208	556	134	208	556	134
Total Sediment Yield per mile²	28.0	18.5	448.9	9.3	7.2	21.5
Annual Average per mile²	0.93	0.62	14.96	0.31	0.24	0.72

FEBRUARY 1992

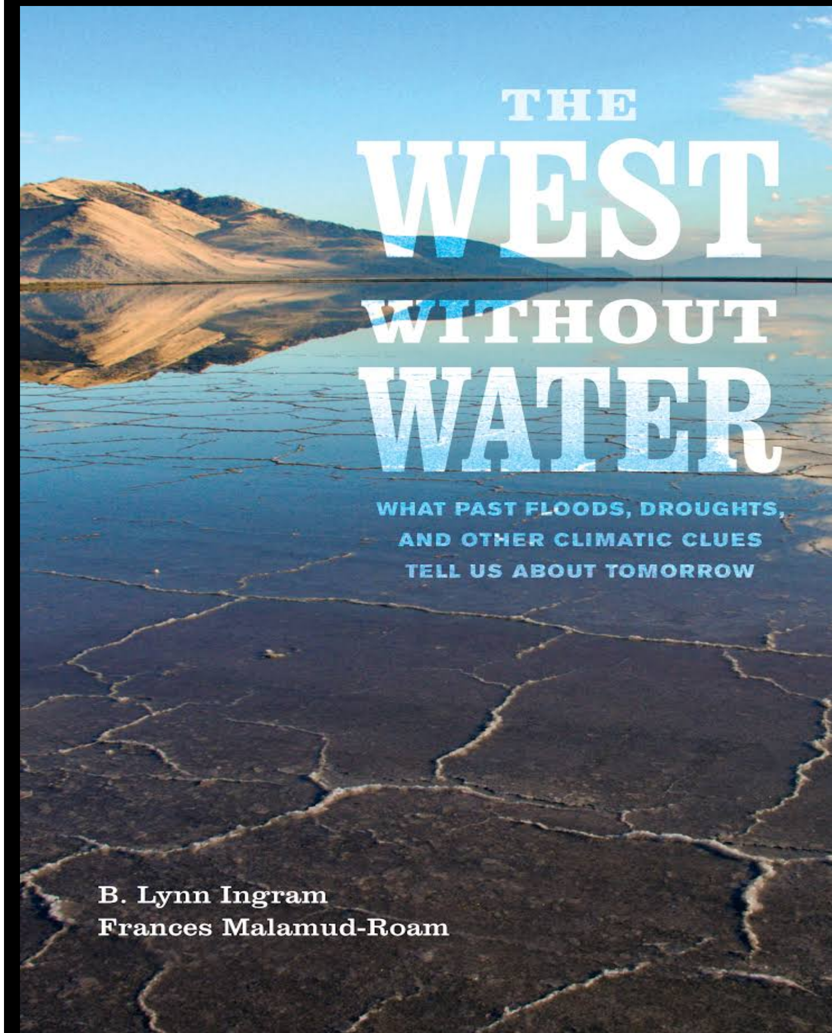
Douglas P. Wheeler
Secretary for Resources
The Resources Agency

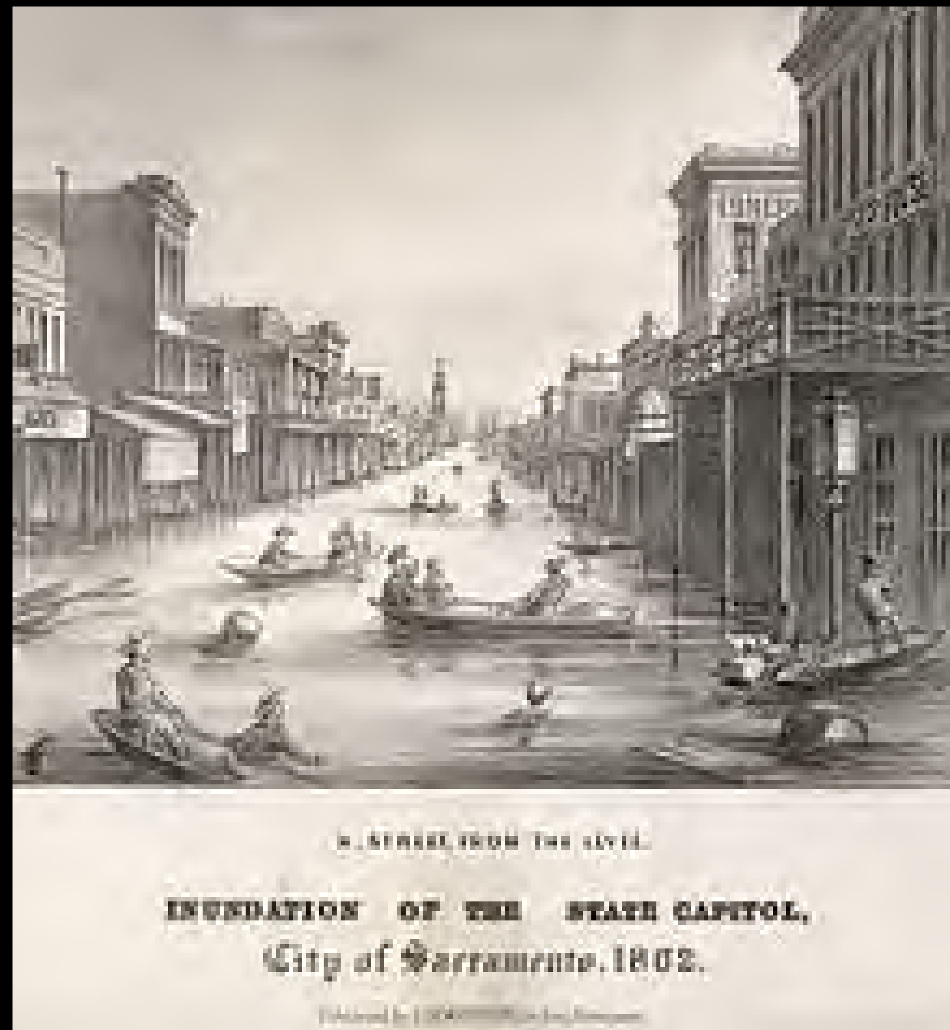
Pete Wilson
Governor
State of California

David N. Kennedy
Director
Department of Water Resources

HISTORICAL CONTEXT - THE NEED FOR RESTORATION

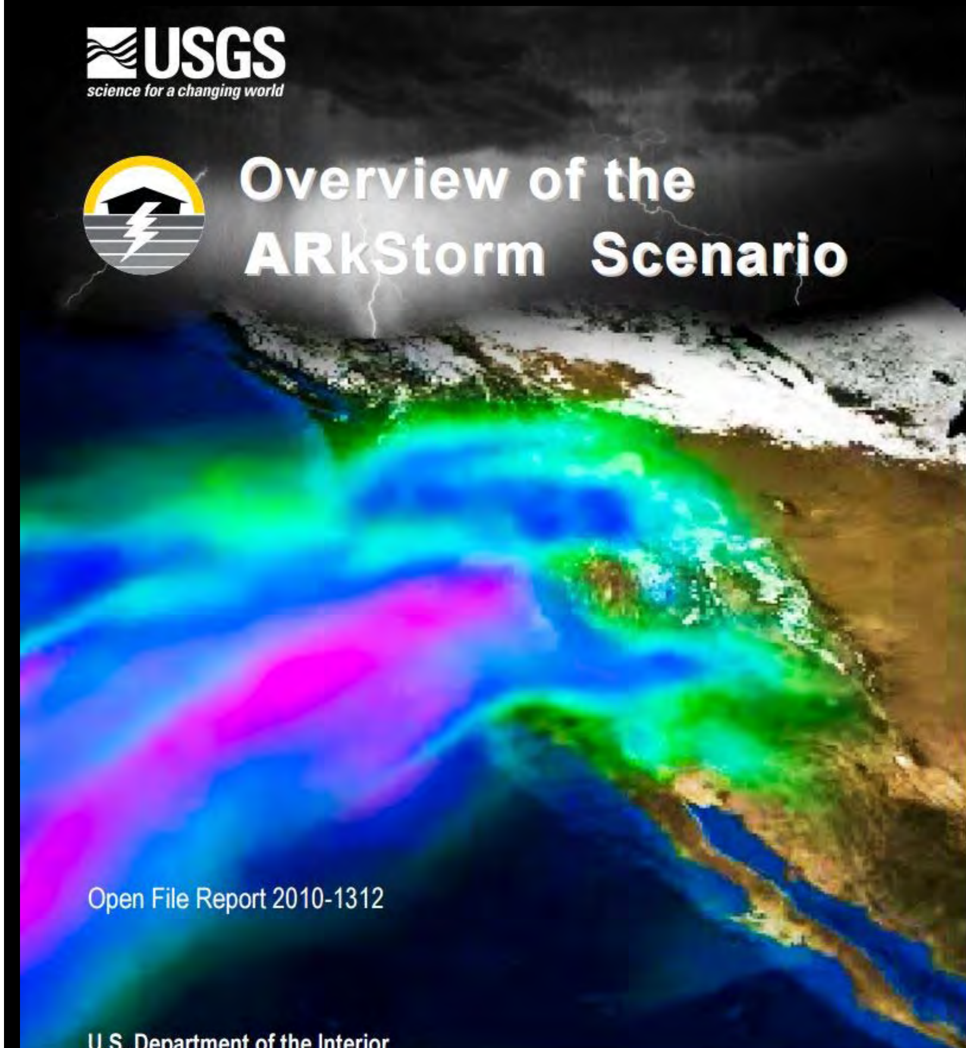
CLUES IN HISTORY – INFORMING US TODAY



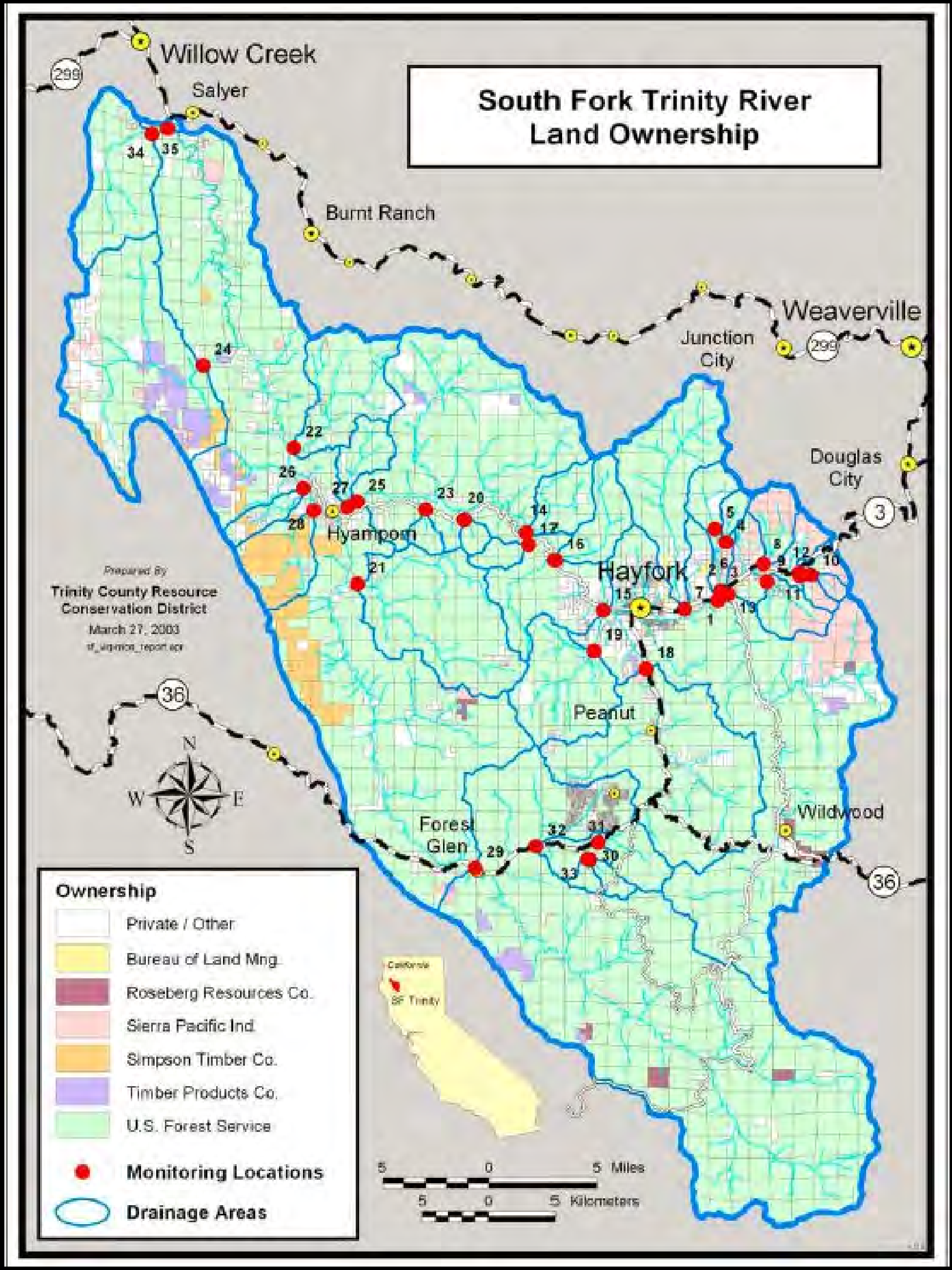


The Great Flood of 1862 was the largest flood in the recorded history of Oregon, Nevada, and California, occurring from December 1861 to January 1862. It was preceded by weeks of continuous rains (or snows in the very high elevations) that began in Oregon in November 1861 and continued into January 1862

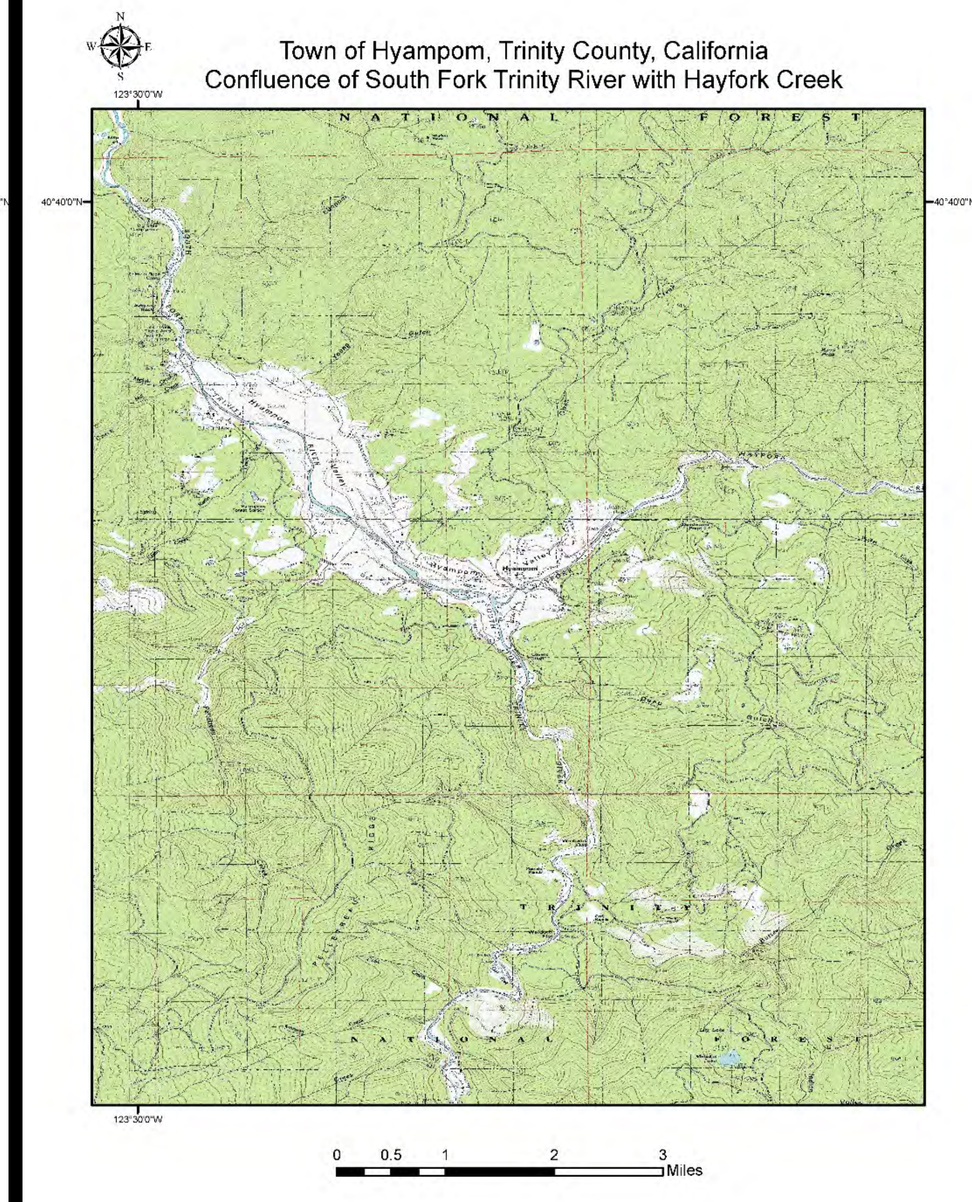
ARKSTORM – ATMOSPHERIC RIVER 1000 STORM



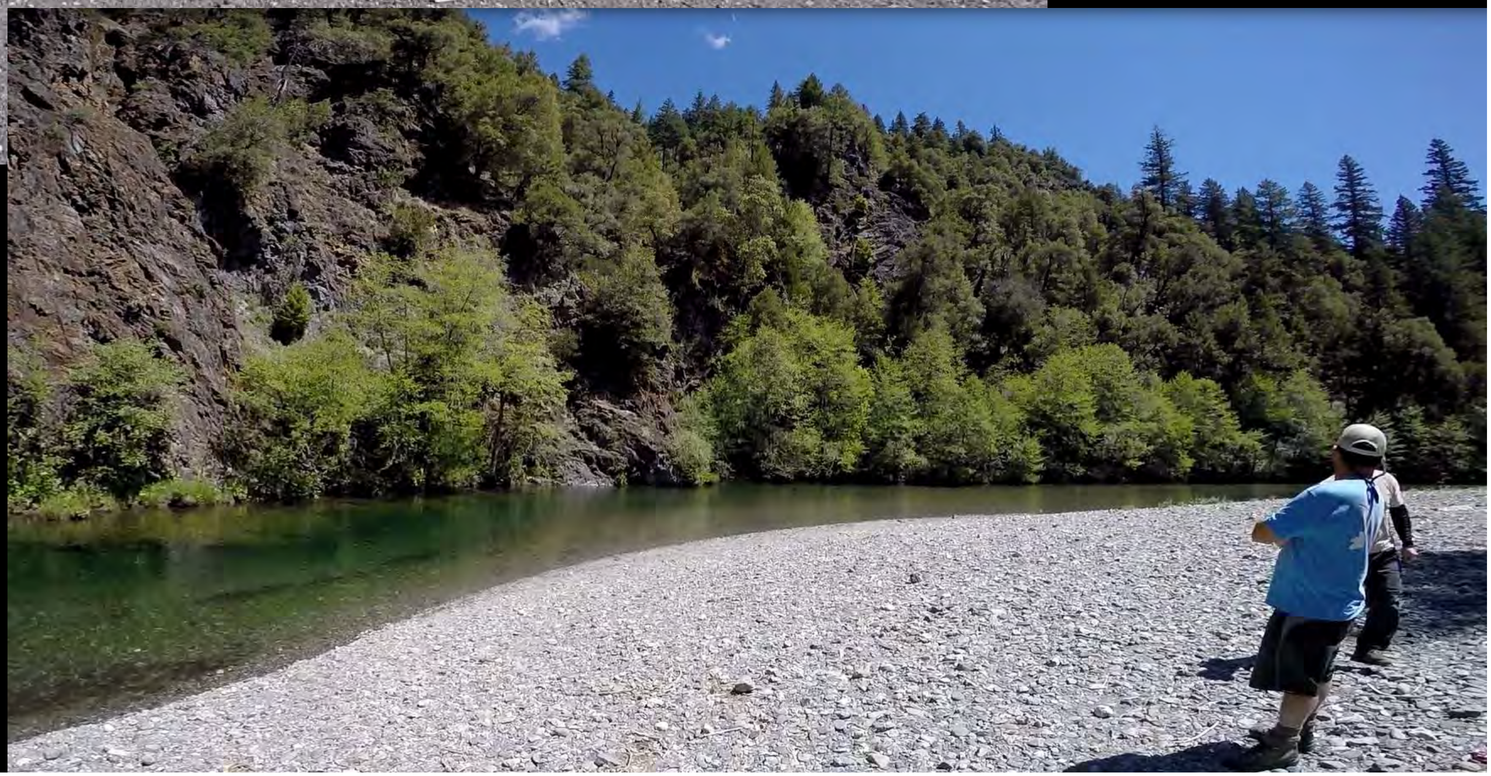
COMPLEX LOGISTICS – WHAT ARE THE CONSTRAINTS AND CHALLENGES



COMPLEX LOGISTICS – WHAT ARE THE CONSTRAINTS AND CHALLENGES



COMPLEX LOGISTICS – WHAT ARE THE CONSTRAINTS AND CHALLENGES



TRAIL AND ERROR – LEARNING BY DOING APPROACH

"If we worked on the assumption that what is accepted as true really is true, then there would be little hope for advance" - Orville Wright

"Isn't it astonishing that all these secrets have been preserved for so many years just so we could discover them!" - Orville Wright

The Wright brothers, Orville (August 19, 1871 – January 30, 1948) and Wilbur (April 16, 1867 – May 30, 1912), were two American brothers, inventors, and aviation pioneers who are credited with inventing and building the world's first successful airplane and making the first controlled, powered and sustained heavier-than-air human flight, on December 17, 1903.

The Approach - Aggressive Techniques for In-River Restoration

Tecta Creek – Tributary to the Klamath
Photos Courtesy of Rocco Fiori

THE APPROACH - AGGRESSIVE TECHNIQUES FOR IN-RIVER RESTORATION

Photos of Tucannon River, WA

THE APPROACH - AGGRESSIVE TECHNIQUES FOR IN-RIVER RESTORATION

Photos of The Klamath -Hunter Cr. And Trinity River

THE APPROACH - AGGRESSIVE TECHNIQUES FOR IN-RIVER RESTORATION

Photos of The Elwha River –
Post Dam Removal 2015

The Approach - Aggressive Techniques for In-River Restoration

Photos of Courtesy of Brian Bair, LLC
Near Welches OR (Sandy River, and Tributary to the Sandy)

NATIONAL LARGE WOOD MANUAL – DESIGN GUIDANCE

National Large Wood Manual

Assessment, Planning, Design, and Maintenance of Large Wood in Fluvial Ecosystems: Restoring Process, Function, and Structure

January 2016

U.S. Department of the Interior
Bureau of Reclamation

US Army Corps of Engineers®
Engineer Research and Development Center

Chapter 1. Large Wood Introduction

Chapter 2. Large Wood and the Fluvial Ecosystem Restoration Process

Chapter 3. Ecological and Biological Considerations

Chapter 4. Geomorphology and Hydrology Considerations

Chapter 5. Watershed-Scale and Long-Term Considerations

Chapter 6. Engineering Considerations

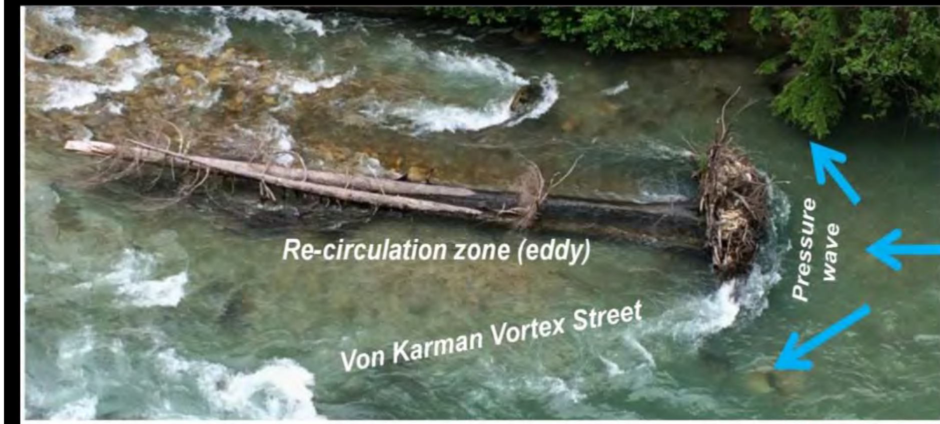
Chapter 7. Risk Considerations

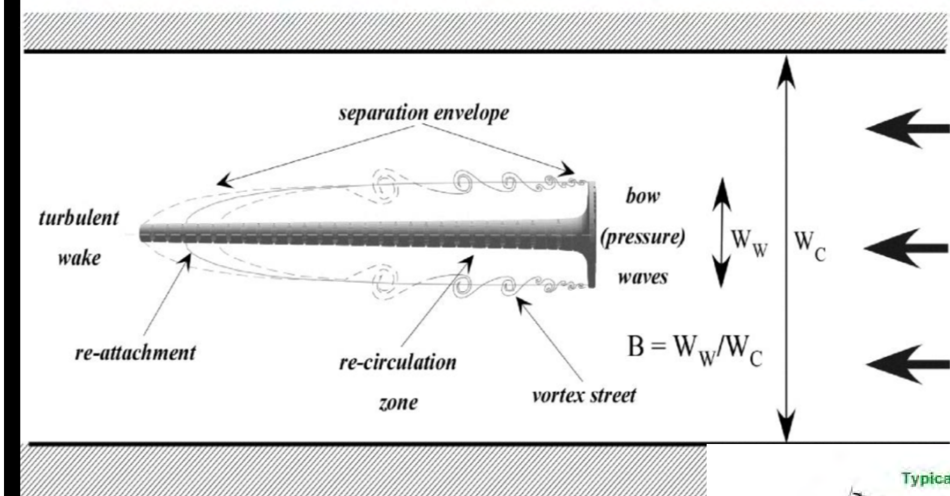
Chapter 8. Regulatory Compliance, Public Involvement, and Implementation

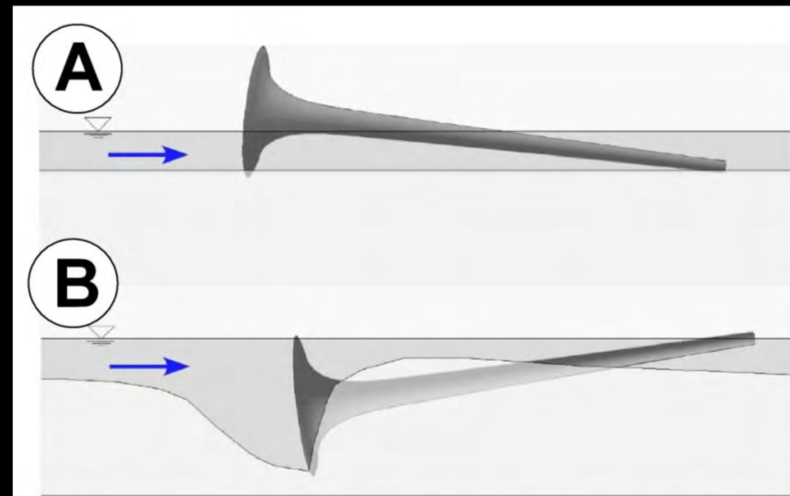
Chapter 9. Assessing Ecological Performance

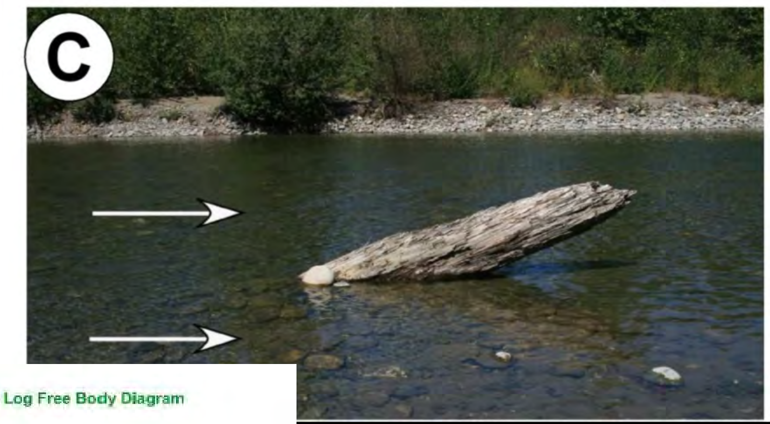
Chapter 10. Large Wood Bibliography

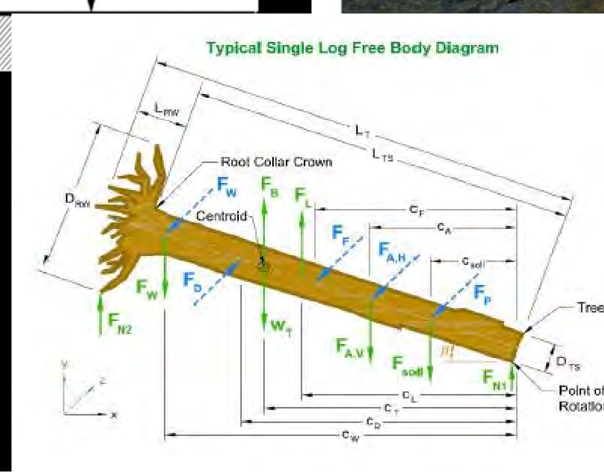
PENCIL TO PAPER – PLANNING, ANALYSIS, AND DESIGN PHASE



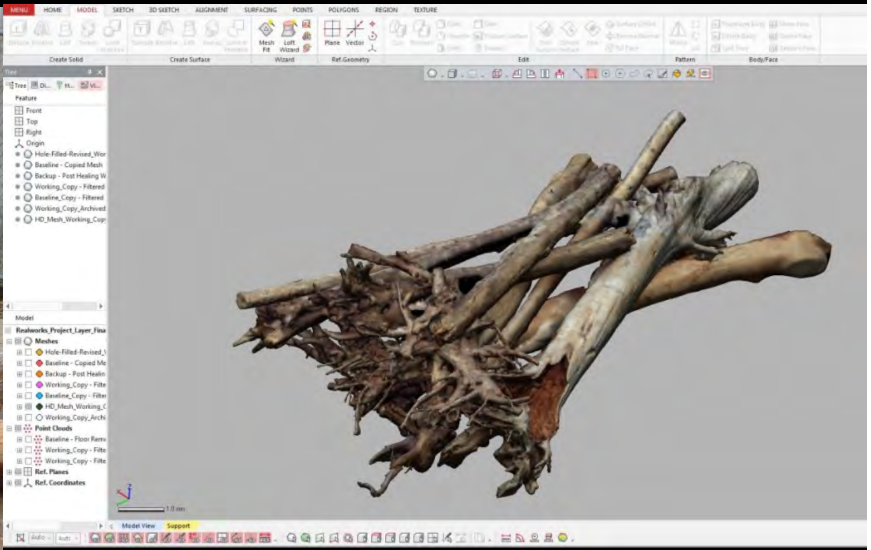








Modeling the Natural Environment - Replication Prototyping and Reverse Engineering Complex Geometries to Help Understand Natural Systems



Comparing Numerical Models to Laboratory Flume Based Evaluation

DESIGNING/BUILDING – FASTER – CHEAPER – BETTER
THINKING OUTSIDE THE BOX

"Failure is simply the opportunity to begin again, this time more intelligently."

"Obstacles are those frightful things you see when you take your eyes off your goal." - Henry Ford

Henry Ford (July 30, 1863 – April 7, 1947) was an American industrialist, the founder of the Ford Motor Company, and the sponsor of the development of the assembly line technique of mass production.

MODELING RIVERS USING STRUCTURE FOR MOTION (SFM)
JARVERNICK – GEOMORPHOLOGY 2014

Geomorphology xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

Modeling the topography of shallow braided rivers using Structure-from-Motion photogrammetry

L. Javernick [a,*], J. Brasington [b], B. Caruso [a]

[a] Department of Civil and Natural Resources Engineering, University of Canterbury, Private Bag 4800, Christchurch 8140, New Zealand
[b] School of Geography, Queen Mary, University of London, London E1 4NS, United Kingdom

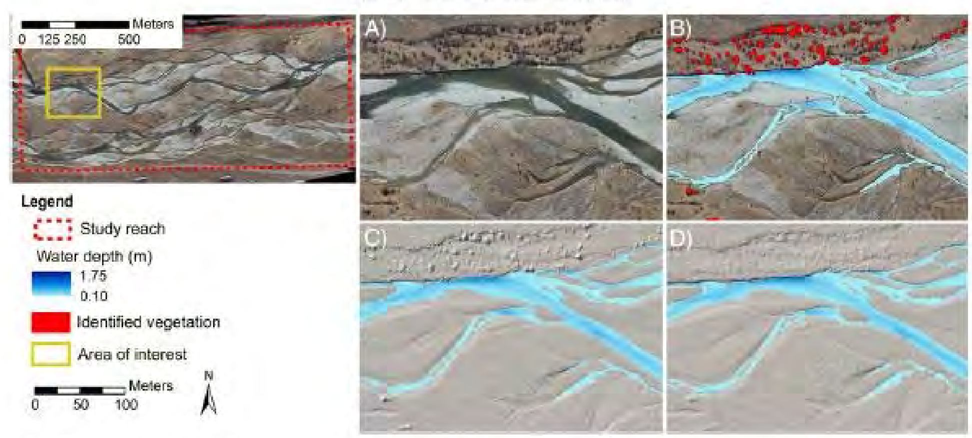
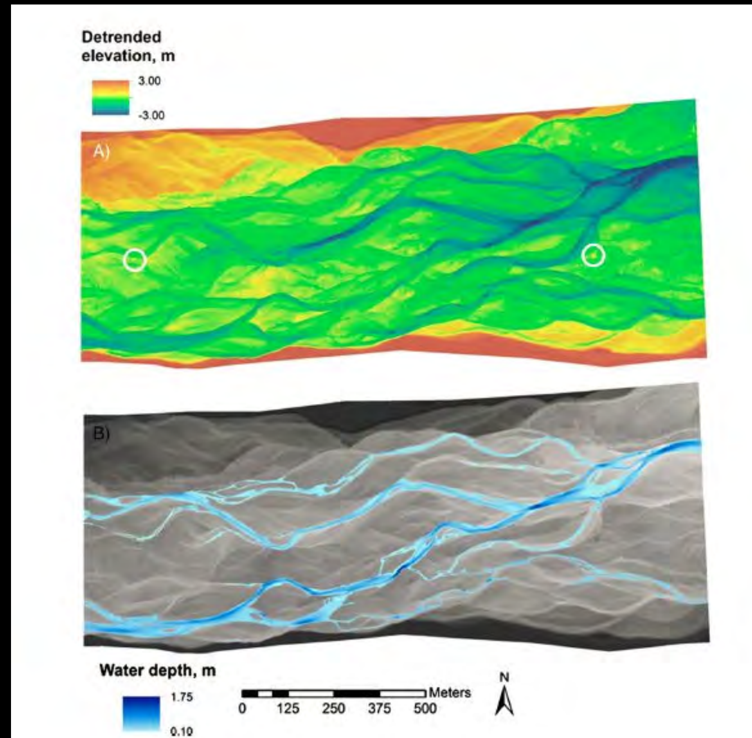


Fig. 6. ToPCAT vegetation noise reduction. A) example area, B) vegetation identified using ≥0.4 m threshold, C) topographic detail of SfM + ToPCAT raster, and D) topographic detail of SfM-Veg raster.



Pencil to Paper – Planning, Analysis, and Design Phase

1. Flight
    a. Airplane = Cessna
    b. Speed = 92 MPH (80 Knots)
    c. Elevation = 2500 feet
    d. Photos Interval = 1 second /175 feet along flight path
    e. 75% Overlap
    f. Total images = ~10,000 at Fine Resolution (15 MB)

Equipment:

2. Nikon D3200 24MP camera
    a. Lens, 35mm G DX
    b. Remote intervalometer, on/off control on the go
    c. Wifi connection for image review and refine settings
    d. 7" tablet for image review and navigation
    e. External power supply for camera (no image limit)
    f. 64GB memory card (capacity + 4000 images)

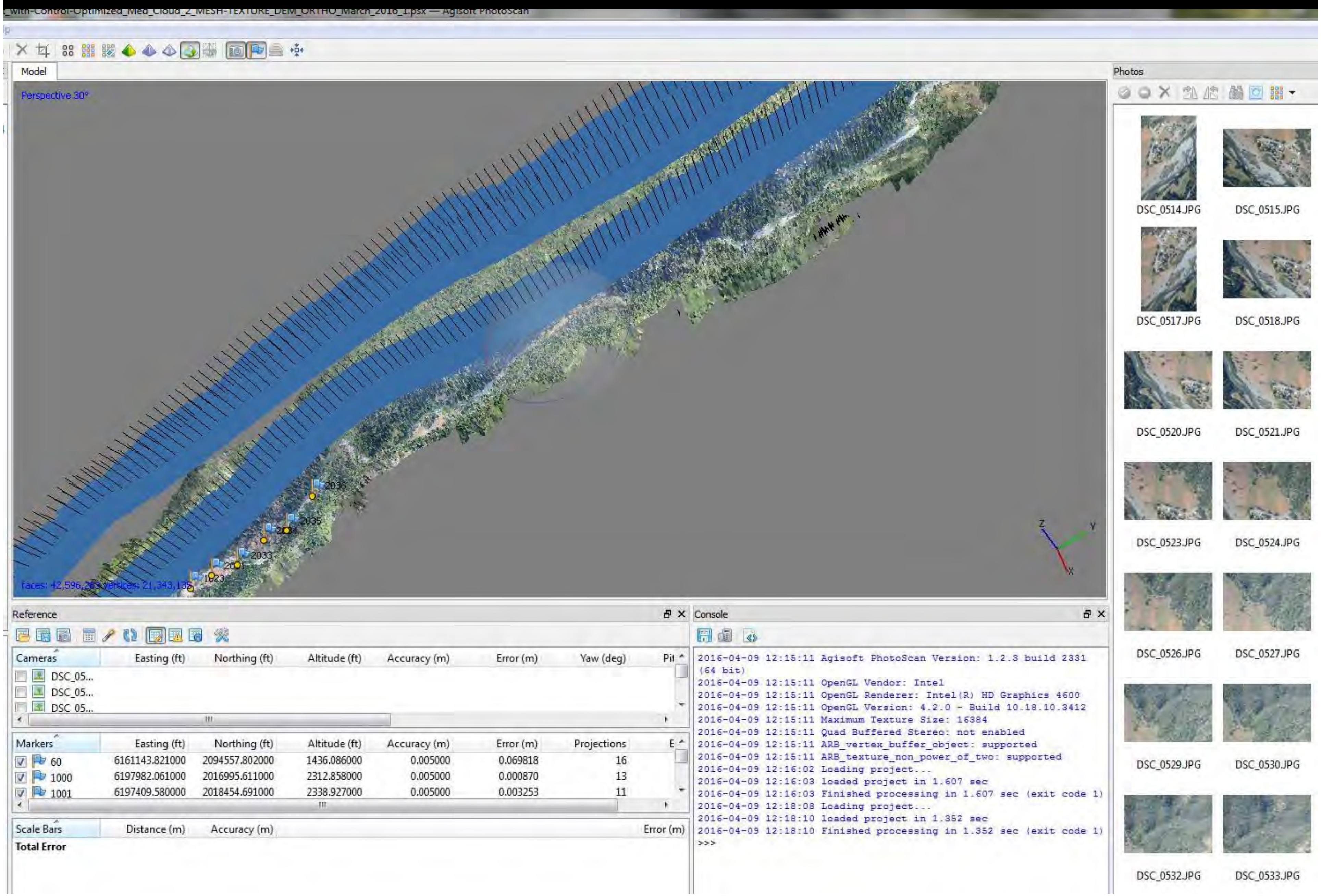
Settings:

1) Lenses:
    a) 2 stops down from wide open (for maximum sharpness at maximum light gathering)
        i) f 4 for the 35mm G DX
    b) No filters, no additional image distortion
2) Shutter speed:
    a) 1/1000 sec
    b) ISO (sensitivity) set to automatic

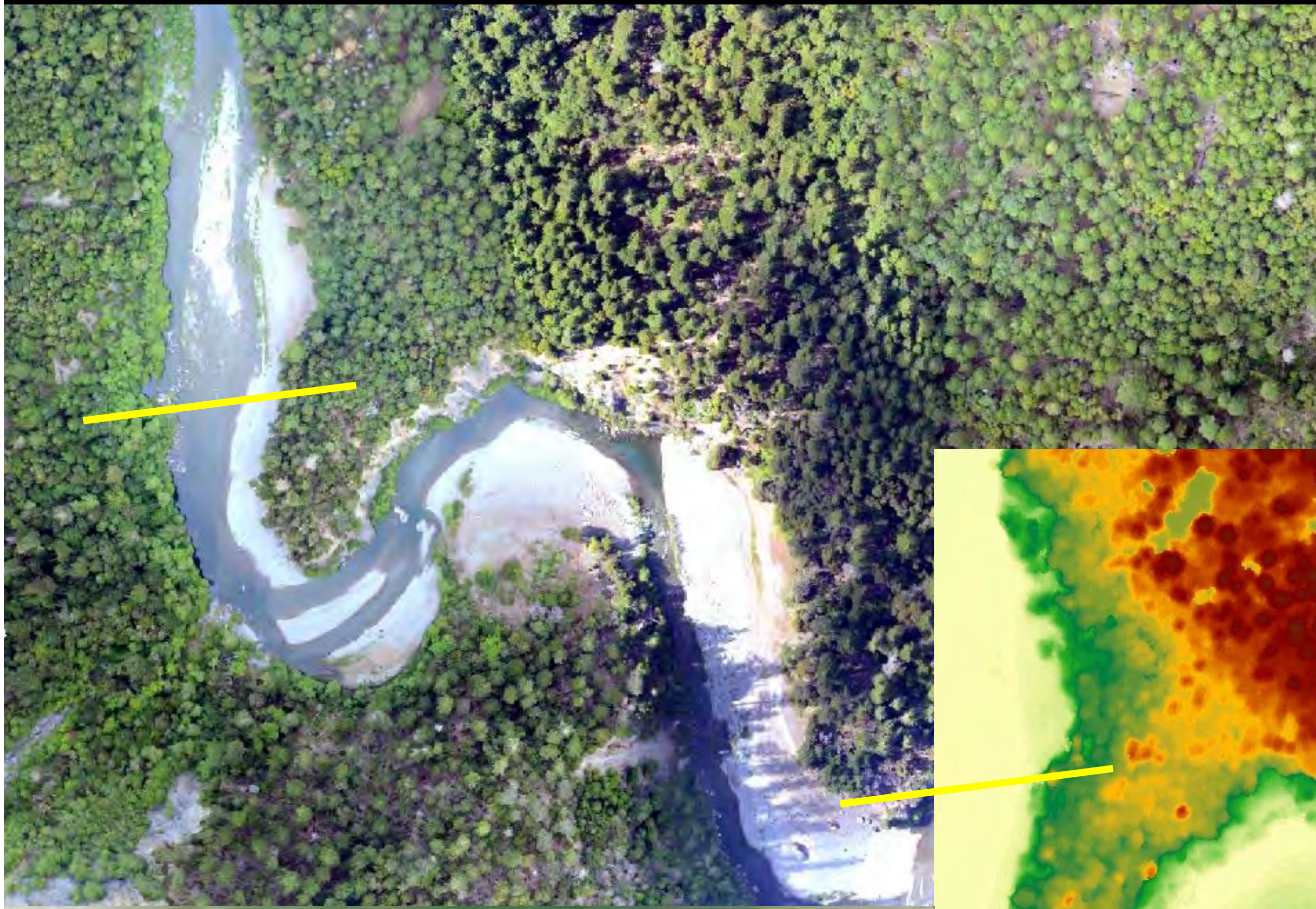
PENCIL TO PAPER – PLANNING, ANALYSIS, AND DESIGN PHASE

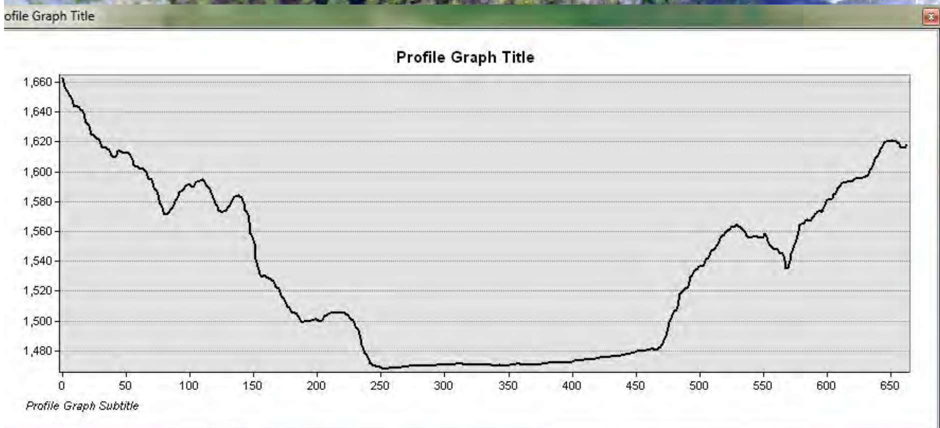
PENCIL TO PAPER – PLANNING, ANALYSIS, AND DESIGN PHASE

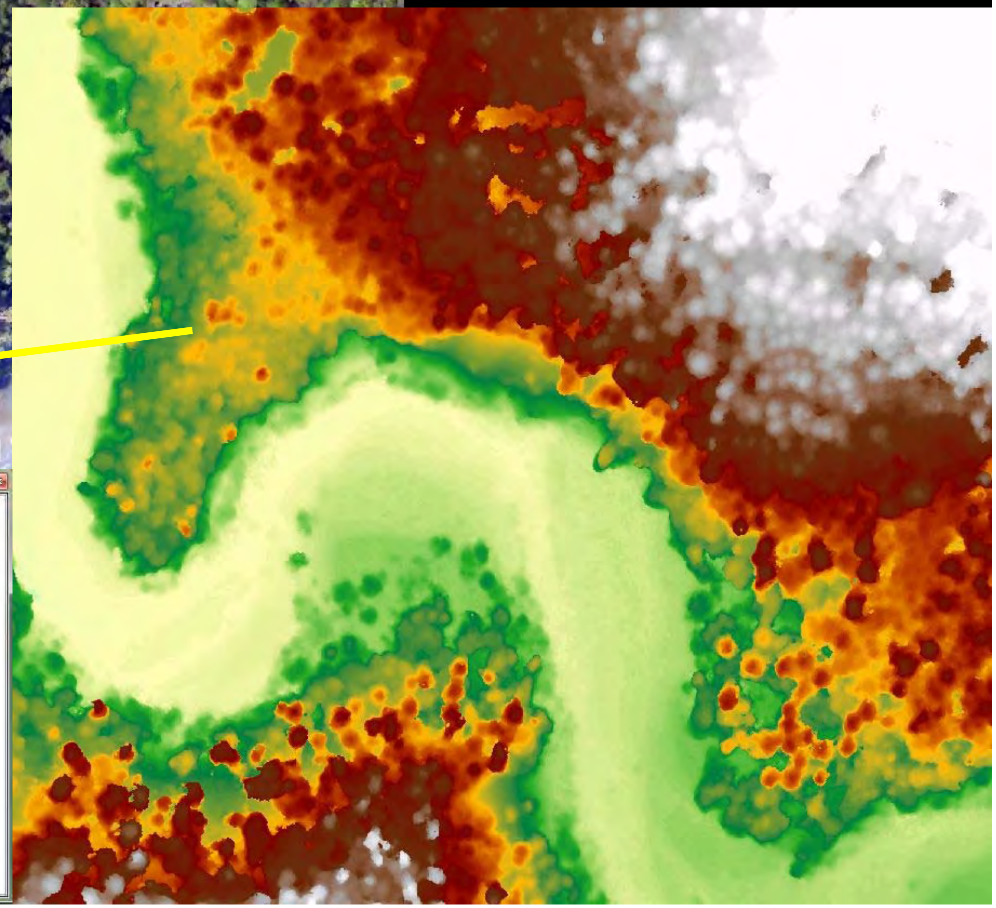
PENCIL TO PAPER – PLANNING, ANALYSIS, AND DESIGN PHASE

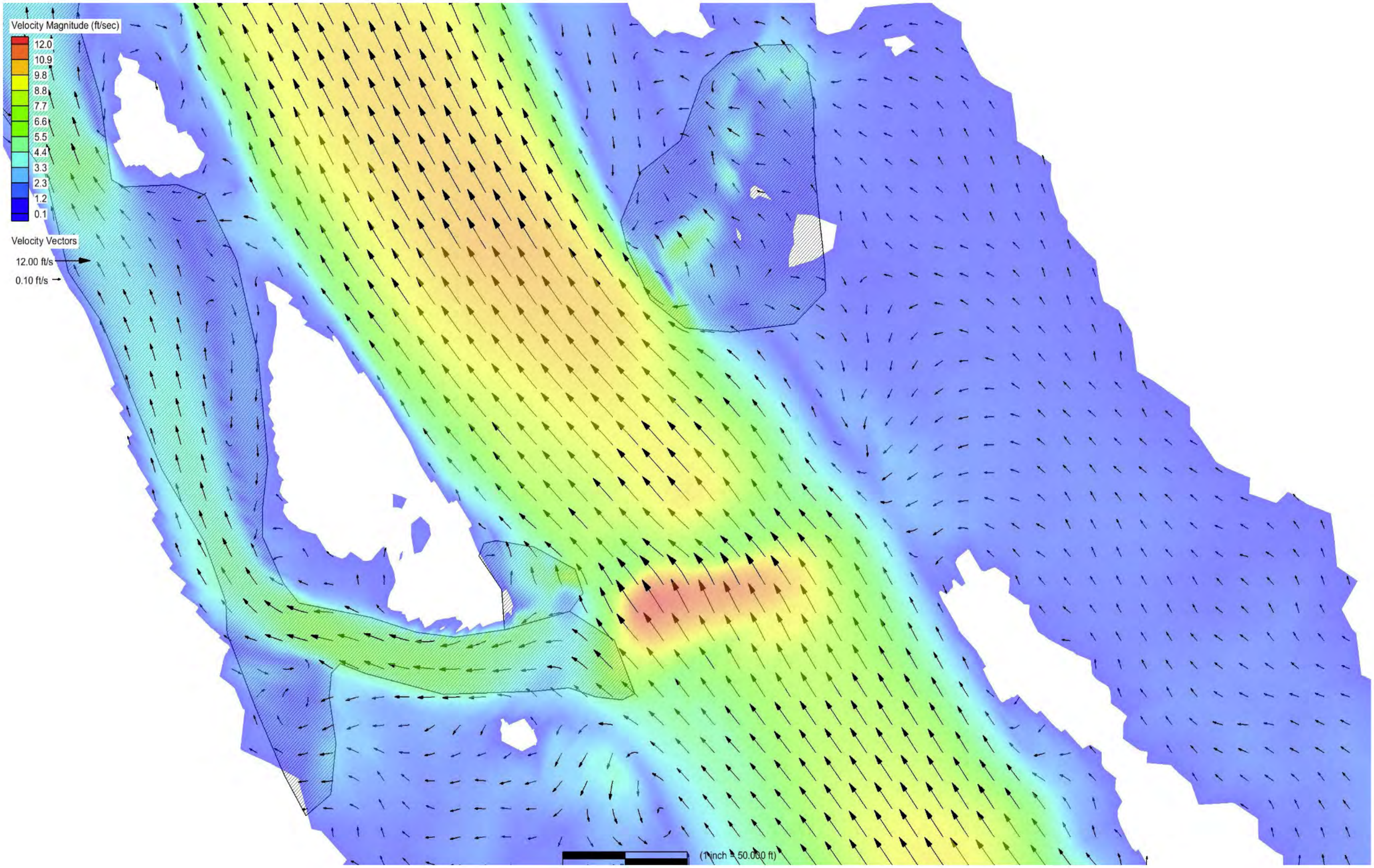


PENCIL TO PAPER – PLANNING, ANALYSIS, AND DESIGN PHASE

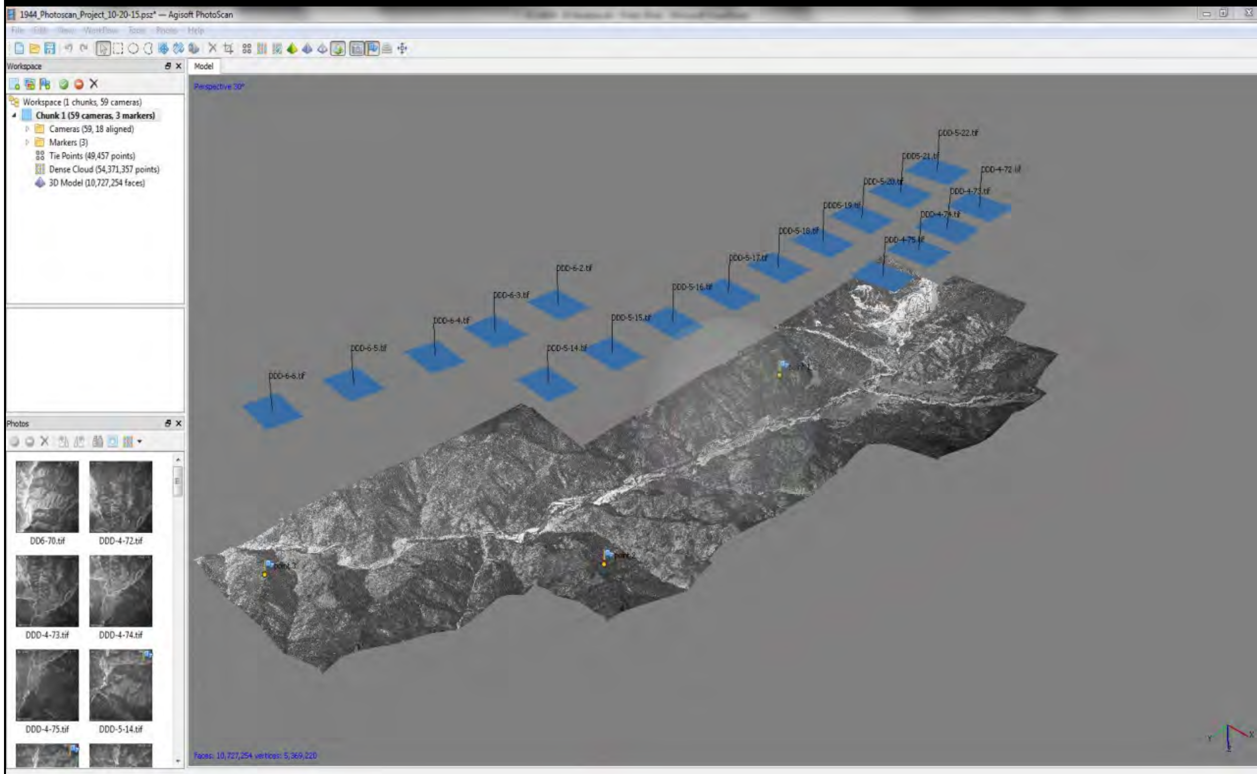


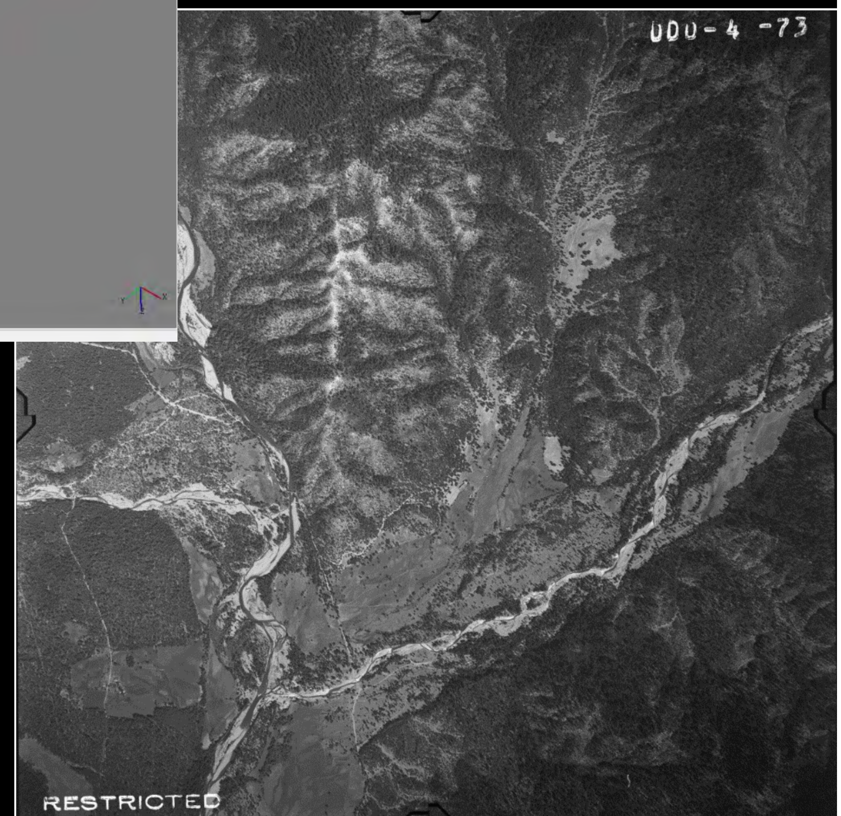




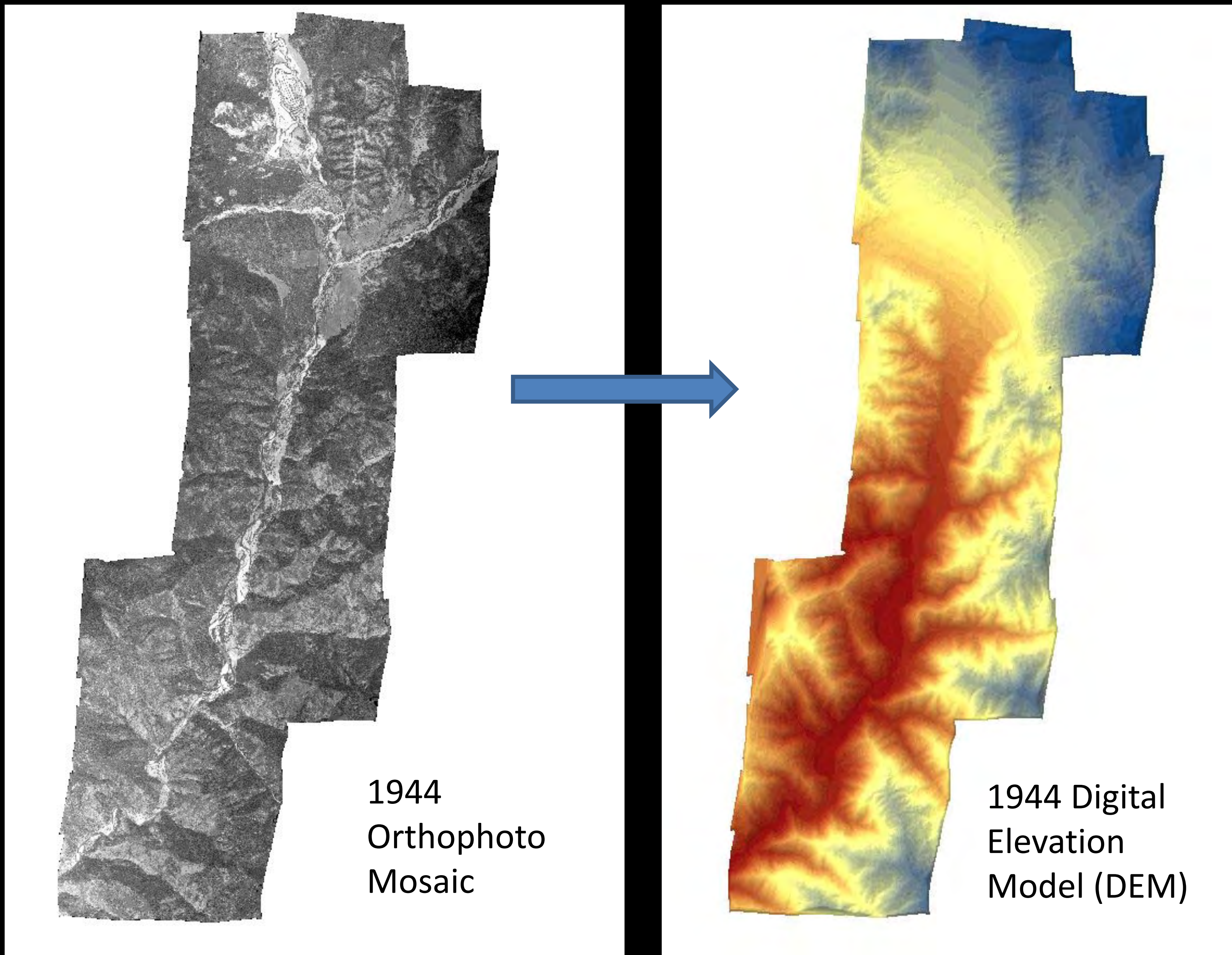

Velocity Magnitude (ft/sec)
12.0
10.9
9.8
8.8
7.7
6.6
5.5
4.4
3.3
2.3
1.2
0.1
Velocity Vectors
12.00 ft/s
0.10 ft/s
(1 inch = 50.000 ft)

Using Historical Aerial Imagery for Geomorphic Comparison

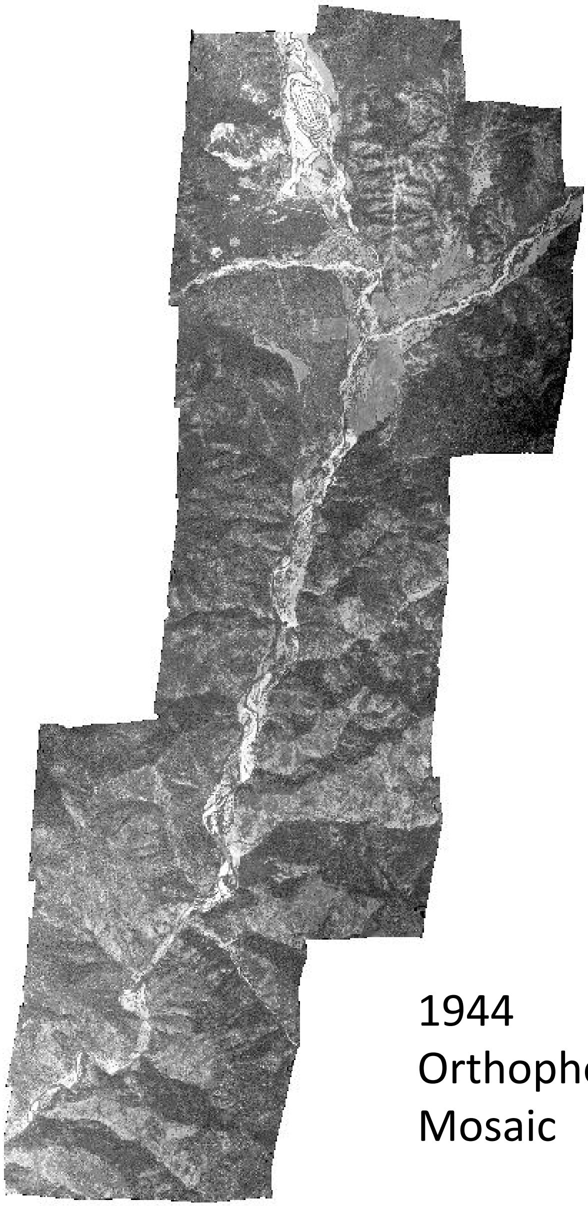




Harnessing SfM and Photogrammetry to Model the Past



Comparing the Past and Present – Evolution Modeling



1944
Orthophoto
Mosaic

PHYSICAL AND BIOLOGICAL MONITORING

Future Vision – Embracing Uncertainty and Moving Forward

Theodore Judah (March 4, 1826 – November 2, 1863) was an American railroad and civil engineer who was a central figure in the original promotion, establishment, and design of the first Transcontinental Railroad. He found investors for what became the Central Pacific Railroad (CPRR). As chief engineer, he performed much of the land survey work to determine the best route for the railroad over the Sierra Nevada mountains.

Future Vision – Embracing Uncertainty and Moving Forward

Tell me and I'll forget. Show me, and I may not remember. Involve me, and I'll understand.

- Native American Saying -

DJ Bandrowski P.E., Project Engineer
djbandrowski@yuroktribe.nsn.us
906-225-9137




Monitoring and Restoration Efforts for Salmon River Spring Run Chinook and Their Relevance to the Planned Reintroduction of Salmonids in the Upper Klamath Basin After Dam Removal

By: Nathaniel Pennington - Spring Chinook Specialist, Salmon River Restoration Council

SALMON RIVER RESTORATION COUNCIL(SRRC)

A 501 C 3 Non Profit

Since 1992 the SRRC mission has been to protect and restore the Salmon River ecosystem, highlighting the anadromous fisheries, through diversification of the local economic base by focusing on restoration, and promoting cooperation and communication between all of the stakeholders.

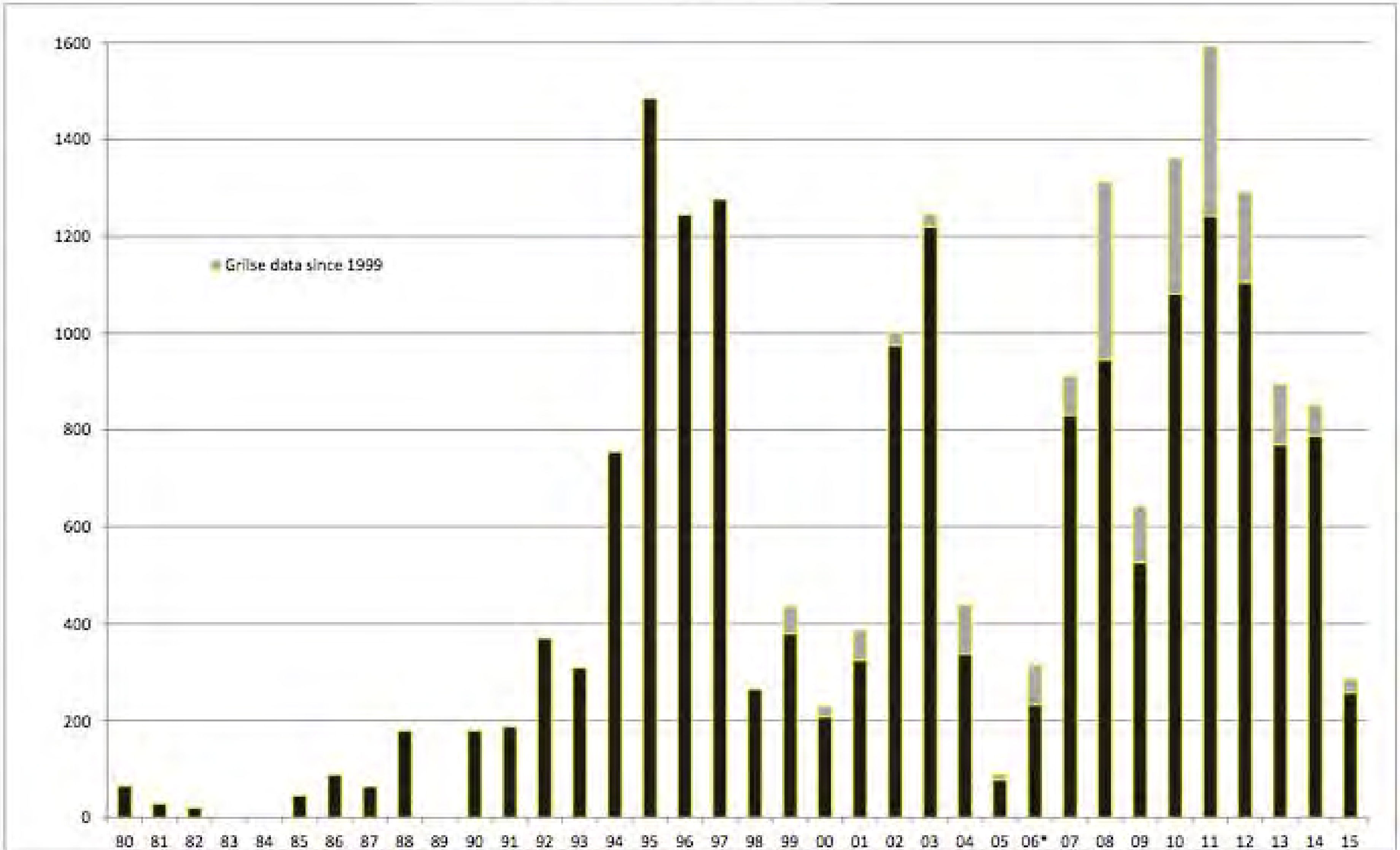
The SRRC has coordinated over 3 Million Dollars worth of restoration activities in the Salmon River, **almost half in community volunteer support**

Klamath Basin Spring Chinook Voluntary Recovery From the Headwaters to the Sea: Steps to Recovery of an Unprotected Stock, Once the Largest in the Basin, Now On the Brink of Extinction

Spring-run Chinook salmon were once the dominant run type in the Klamath/Trinity River Basin.

NMFS Status Review 1998

Salmon River Spring Chinook Population Totals 1980-2015



Grilse only counted separately since 1999

**2006 estimation due to inability to survey 35% of the river due to wildfires*

Salmon River Spring Chinook and Summer Steelhead Population Dive Surveys

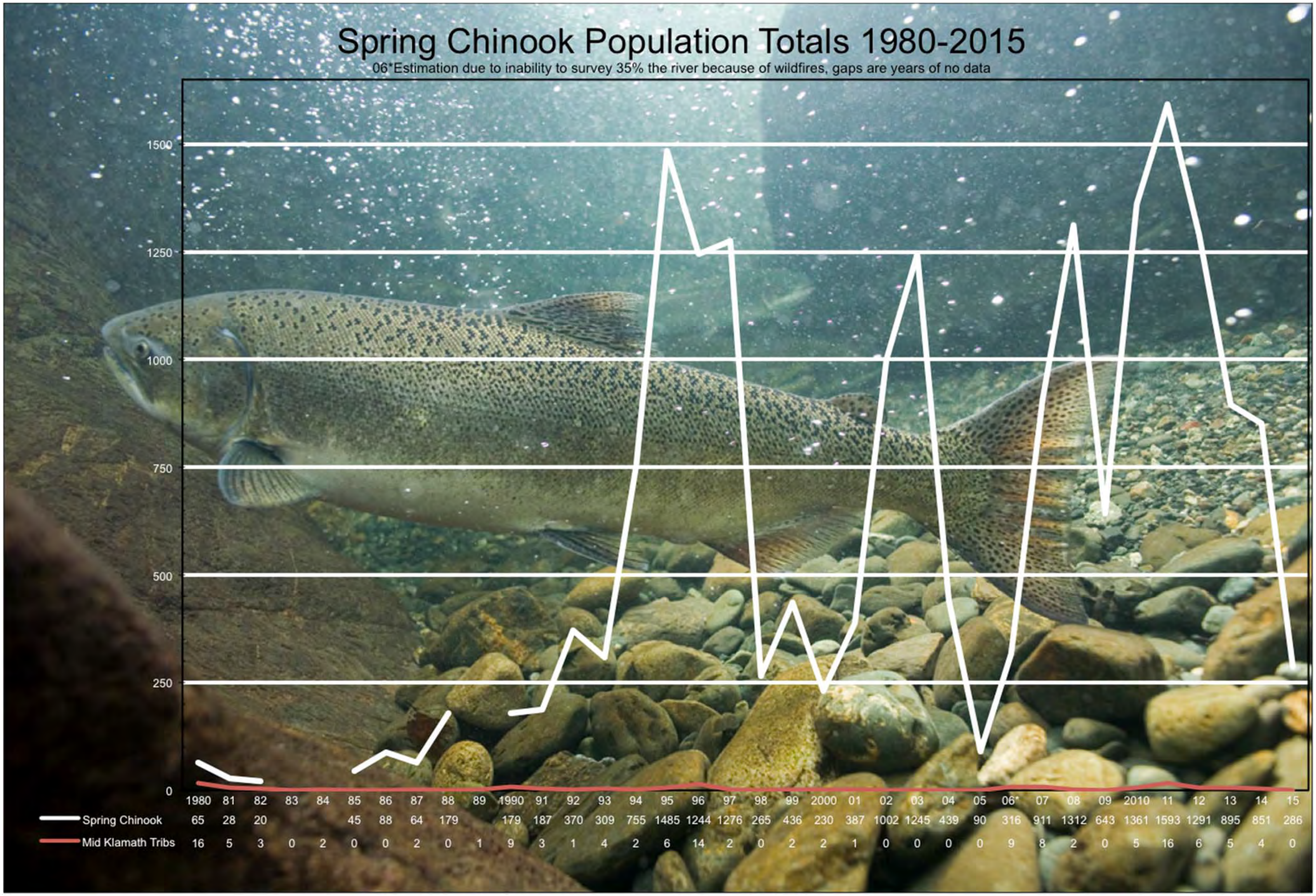
- SRRC has been lead coordinator with Co-Coordinator U.S.F.S. since 1995
- Karuk Tribe, Mid Klamath Watershed Council, Cal Dept of Fish &Wildlife, Yurok and Hoopa
- Average annual contribution of combined effort including many volunteers – $19,000
- $380,000 over the last twenty years
- Likely the most consistent data set in Pacific Northwest

Key Causative Factors of Decline

1) Water Quantity - Altered Hydrograph
2) Degraded Water Quality –
3) Degraded Riparian Habitat
4) Sedimentation - Lack of Holding Habitat,
5) Migration Barriers/Dams – Access to Habitat
6) Hatchery – **causing crowding, genetic transgression, natural life history deviation, competition, large artificial run gives appearance of run in good health**
7) Degraded Upslope Habitat
   - Altered Fire Regime
   - Unhealthy Forest-Poor Logging
   - Increased Sediment- Roads
8) Increase in Disease
9) Invasive Species
10) Lack of ESU Separation from Fall Run
11) Identify Wild & Hatchery Stock Biological Markers
12) Inadequate Harvest Management

SRRC fostered a community led effort to restore the Salmon River Spring Chinook

The Salmon River hosts the largest remnant population of the once predominant run in the Klamath Basin


Spring Chinook Population Totals 1980-2015
06*Estimation due to inability to survey 35% the river because of wildfires, gaps are years of no data
1500
1250
1000
750
500
250
0
1980 81 82 83 84 85 86 87 88 89 1990 91 92 93 94 95 96 97 98 99 2000 01 02 03 04 05 06* 07 08 09 2010 11 12 13 14 15
Spring Chinook 65 28 20 45 88 64 179 179 187 370 309 755 1485 1244 1276 265 436 230 387 1002 1245 439 90 316 911 1312 643 1361 1593 1291 895 851 286
Mid Klamath Tribs 16 5 3 0 2 0 0 2 0 1 9 3 1 4 2 6 14 2 0 2 2 1 0 0 0 0 9 8 2 0 5 16 6 5 4 0

Fish Will Need Your Help During This Extreme Drought!

For all of our sensitive runs of fish, water is critical - the cooler the better. Anything we can do individually and as a community to help leave as much water as possible in the streams they rely on for survival, and to maintain their ability to access cool water sources is crucial during a drought.

Salmon River Springers photo by David McLain

The Salmon River is in the midst of an extreme drought. Our watershed experienced historically low snowpack and below average rainfall this past winter. The river, streams and springs that both human and aquatic communities rely on are reaching perilously warm temperatures and low levels and may dry up completely as the summer progresses. Such conditions can altogether reduce the chances of survival for fish as warm water and low flows increase disease and mortality.

Salmon River's Unique Fishery

The Salmon River is home to wild runs of all of the native anadromous fish that occur in the Klamath River Watershed, including spring Chinook, fall Chinook, coho, steelhead, green sturgeon and Pacific lamprey. Several of these runs are rare or threatened and this river serves as an important refugia, where fish rely on the relatively cool, clean waters to survive.

The largest remaining wild run of spring Chinook in the Klamath watershed returns to the Salmon River each year. These once abundant fish migrate upstream from the ocean in the spring and reside in the river through the hot summer months, seeking refuge in deep pools and cool creek mouths to survive the warm summer water.

Coho salmon are the only fish species in the Salmon River listed under the endangered species act. Although rare here, at least a handful spawn each winter, and juveniles rear through the summer in the river and small creeks throughout the watershed. Unlike some of our other anadromous fish, coho often utilize small, low gradient creeks for spawning and rearing. This past winter had a strong spawning run, so there are many more juvenile coho than normal trying to survive this summer in the Salmon.

Fish Passage

If you have a creek on your property, even a small one, it is likely that fish will be trying to utilize it to stay alive this summer. Almost all of our creeks maintain cooler summer water temperatures than the river, which will exceed the lethal temperature threshold for fish during the heat of the summer by several degrees. The only way that fish can survive such temperatures is to escape for at least part of each day into cooler water. Things that you can do to help fish access this critical cool water include:

- **Make sure swimmers dams and water diversions do not block fish access into creeks, or upstream.**
- **If your creek mouth gets blocked off by rocks or sediment that prevent fish from getting through, spend some time moving rocks to create channels and step pools that allow fish access to the creek.**

Water Conservation & Efficiency

Most of us here on the Salmon River use water from springs, creeks or the river for our household and landscape needs. Making sure that you minimize any waste associated with your water use, so that you can leave as much as possible in the stream for the fish is very important. Examples of conservation and efficiency measures that you can take include:

- **Avoid unnecessary overflows from your water tanks. By installing float valves, automatic shut-off valves and/or overflow piping back to the source stream, countless gallons of water can be saved at relatively little cost.**
- **Return outflows from your micro-hydro system back to their source stream. Hydro systems use a tremendous amount of water, and by locating your hydro system near enough to the stream for water to return on its own, or by piping the water back to the stream, this water can provide your power while still supporting aquatic life.**
- **System leaks resulting from animal damage, joint leaks or dripping fixtures can also result in wasted water. Conducting system maintenance can reduce these impacts significantly.**
- **Water-efficient gardening and landscaping techniques can also greatly reduce water use. By watering at night, utilizing timers and other methods to avoid over watering, mulching and installing drip irrigation you can significantly reduce your water use. Simple water use efficiency techniques can reduce your water use by more than 50% and can be implemented for relatively low cost.**

Fish Friendly Water Storage

Although it is late this season to add water storage to your conservation actions, it is never too early to begin planning for next season. Water storage and forbearance is a water conservation method that requires a household to store enough water during the wet winter months in order to forbear pumping or diverting during the dry summer months when flows are at their lowest. Although it may not be feasible for every household, for those who can, it offers the greatest potential benefit to streamflows of any conservation activity.

The State Water Resources Control Board estimates that for the 3.5 months of summer, a water-efficient, two person household with an 800 square foot garden, requires 23,000 gallons of water storage.

Anyone who is interested in utilizing the storage and forbearance method, should contact us for more info on planning and implementing such a system.

SRRC's crews have been creating step pools to make the cold refugia creeks more accessible to juvenile fish during the summer's low water levels.

Contact us: Salmon River Restoration Council
PO Box 1089
Sawyers Bar, CA 96027
(530)462-4665 srrc@srrc.org

Funding for this product comes from: CA Department of Conservation, CA Department of Fish and Wildlife, US Fish and Wildlife Service, Firedoll Foundation, and Trees Foundation's Cereus Fund.
SRRC does not and shall not discriminate on the basis of race, color, religion, gender, gender expression, age, national origin, disability, marital status, sexual orientation, or military status, in any of its activities or operations.

SRRC Monitoring and Restoration Projects for Spring Chinook

- Population Dive Surveys
- Carcass and Redd Surveys initiated in 2001
- Downstream Migrant Trapping
- Genetic and Otolith Research
- Voluntary Recovery Group
- Limiting Factors Analysis
- Habitat Restoration / Off Channel Rearing
- Fish Passage Enhancement

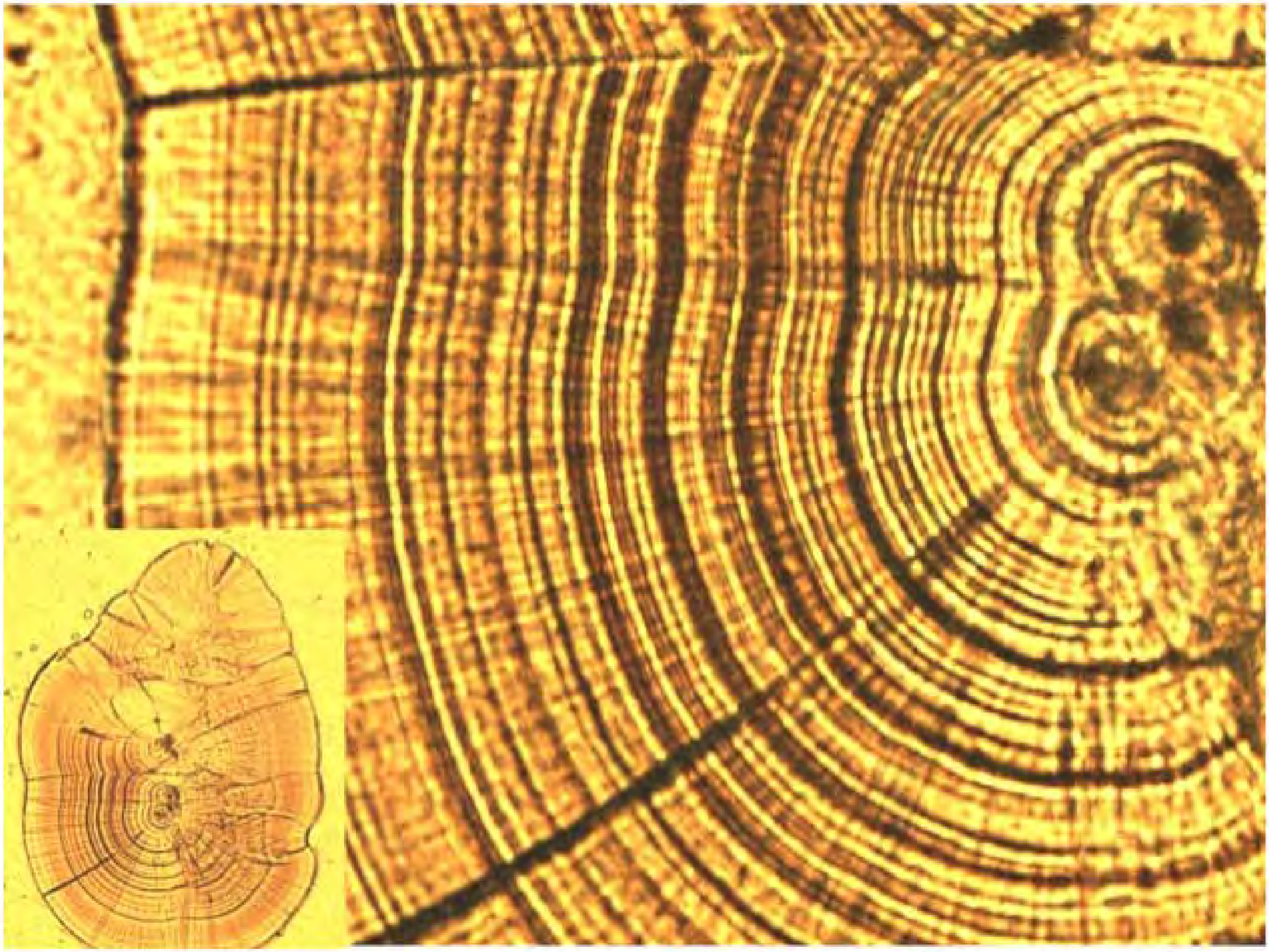
Plummer Creek Fish Passage Enhancement Project

Before

Plummer Creek Fish Passage Enhancement Project

After

Microstructural Natal Signature of Spring Chinook Salmon Otoliths from Salmon River Drainage



Jane C. Sartori

Highlights of Salmon River Spring Chinook Otolith Study

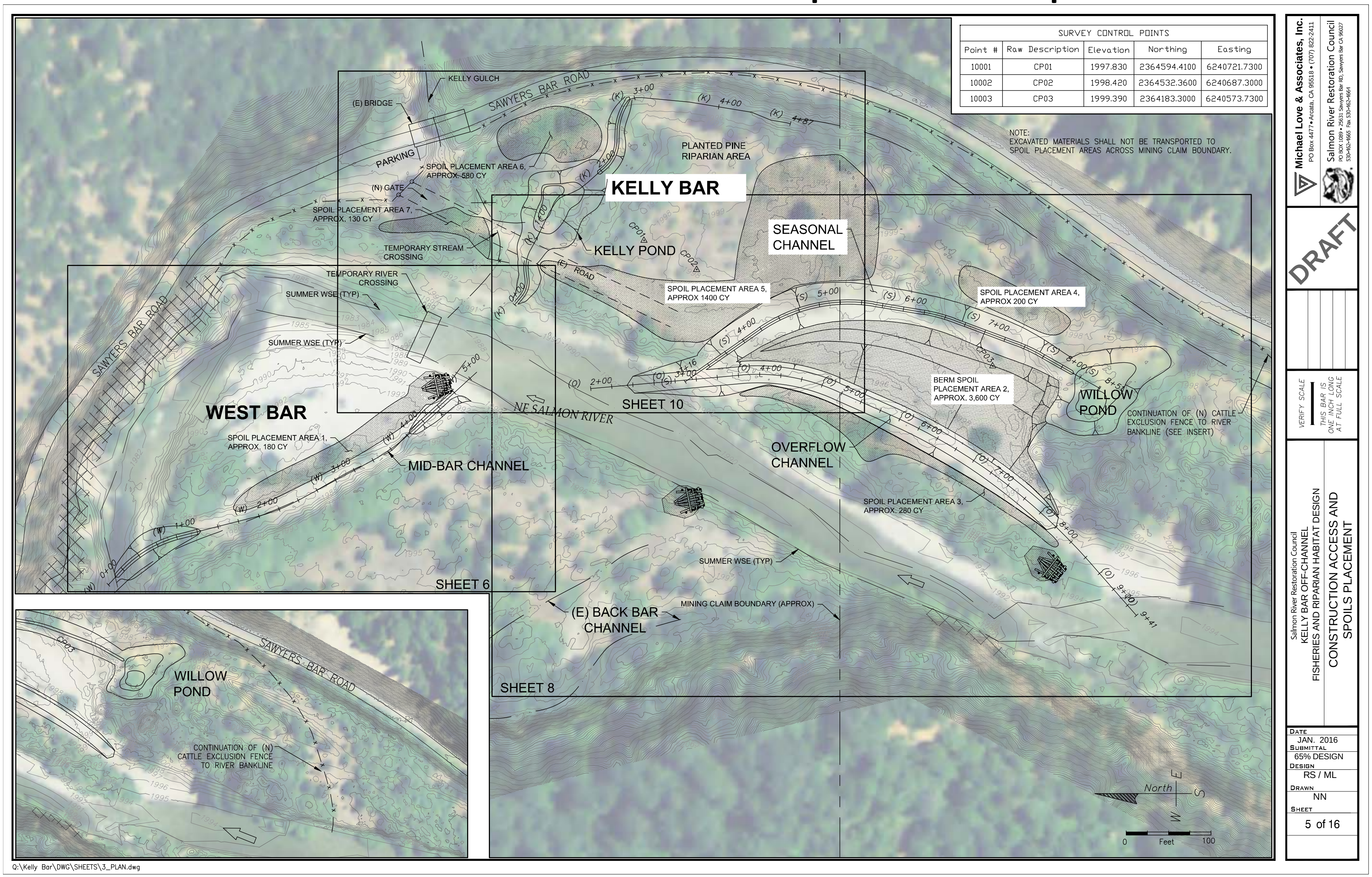
- Juveniles exhibit stream type vs. ocean type behavior residing in freshwater for longer durations compared to their ocean type relatives, the fall Chinook.

- 80% of juvenile otoliths sampled show an average of a 25 day residency in habitat that fostered increased daily growth rates.

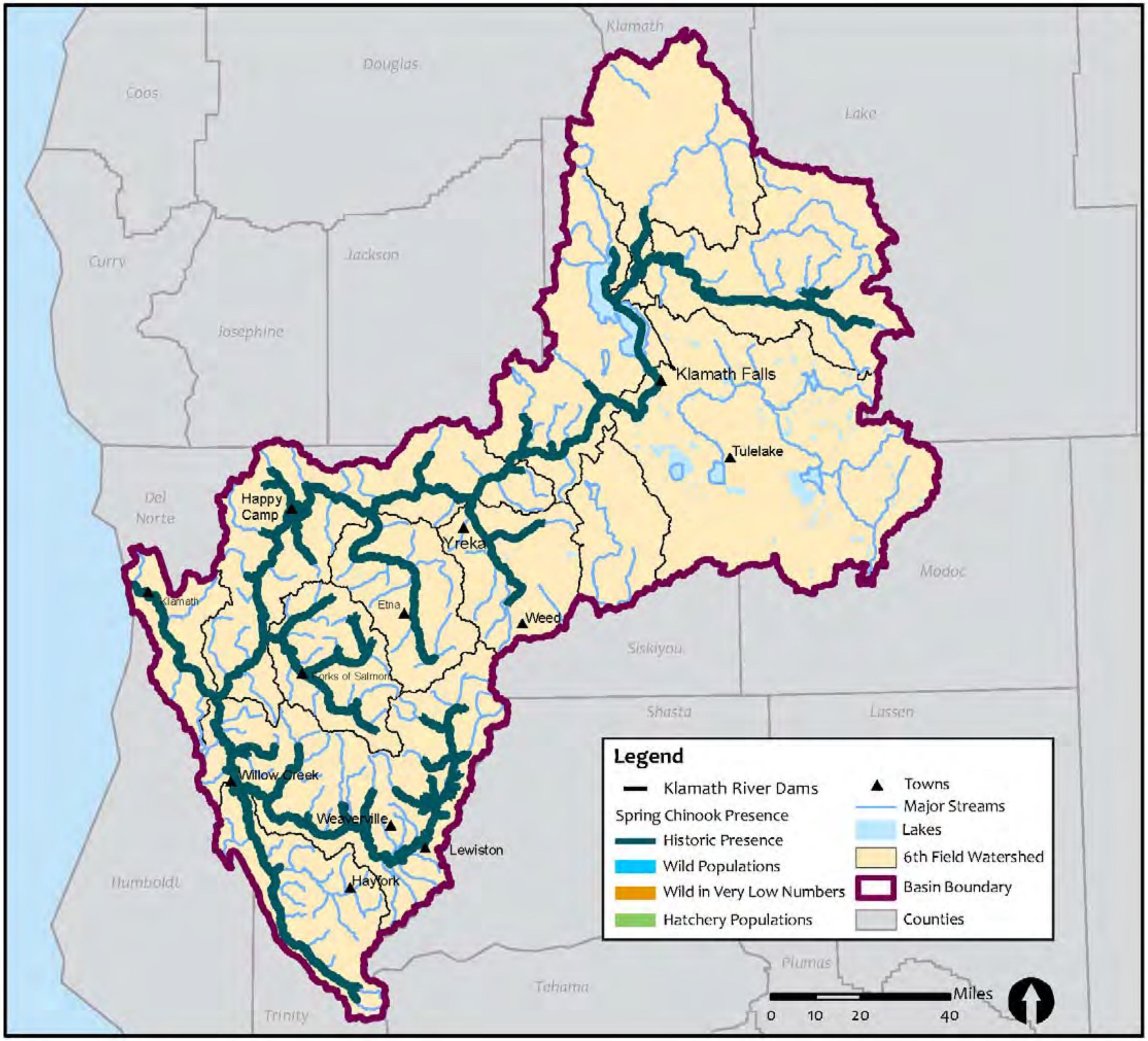
- Explanation for increased freshwater incremental width anomaly is a transition from an unfavorable freshwater habitat to a habitat which encompassed environmental variables more favorable to fish growth.

- Habitat variables such as optimum water temperatures, low population densities, and an abundance of prey would facilitate increased fish growth that would be represented by increased otolith incremental widths.

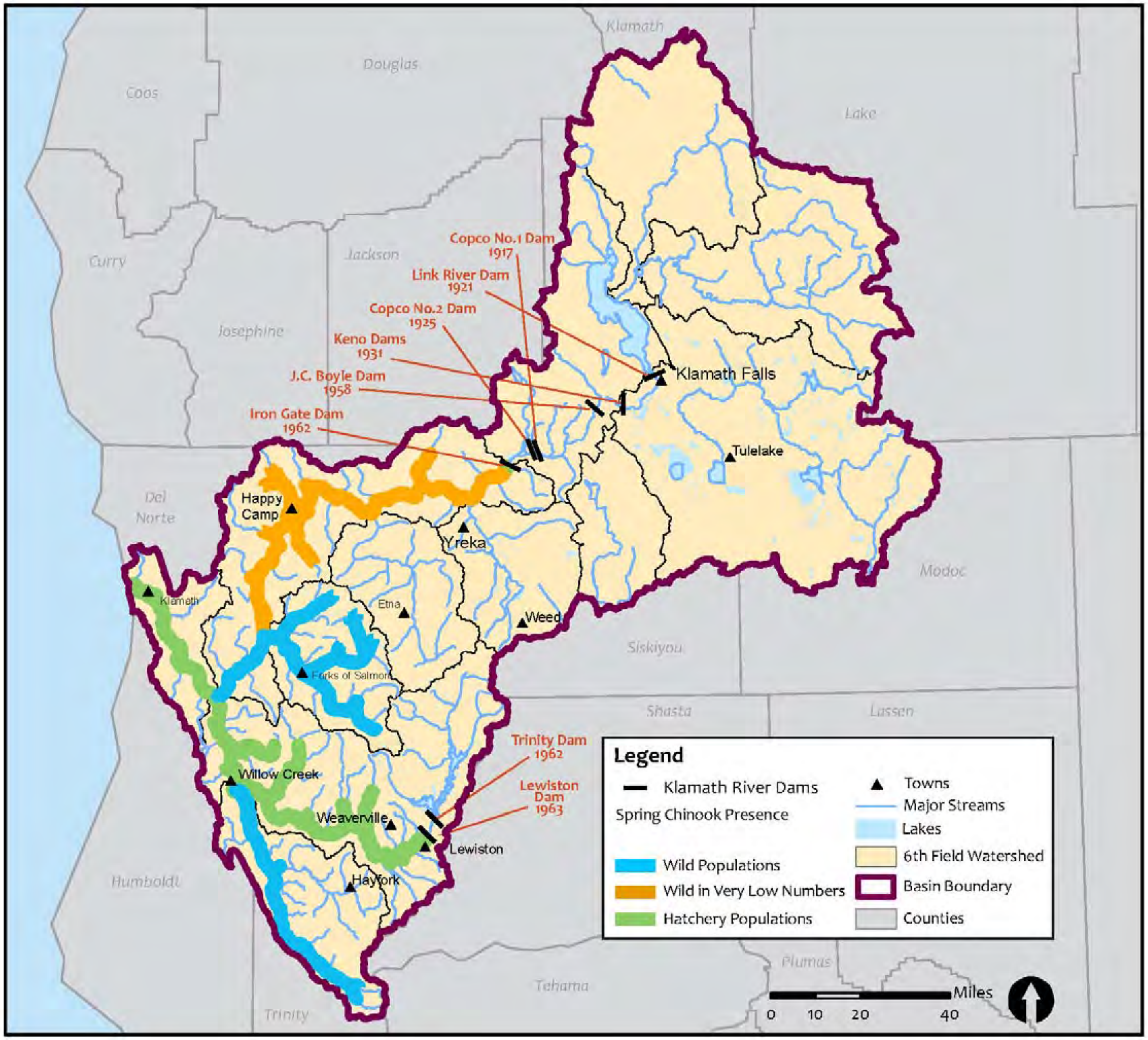
Off-channel Pond Development Proposal



Known Historic Presence of Upper Klamath Trinity Spring Run Chinook



Current Distribution of Upper Klamath Trinity River Spring Run Chinook



Klamath River Basin Spring Chinook Salmon Spawner Escapement, River Harvest and Run-Size

SPAWNER ESCAPEMENT

	2013			2014			2015		
Hatchery Spawners	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Trinity River Hatchery (TRH)	96	2,482	2,578	362	3,255	3,617	240	1,748	1,988
Natural Spawners									
Klamath River Basin									
Salmon River	125	770	895	63	788	851 0	28	258	286
Misc. Tribs.			0			0 0			0
Trinity River Basin						0			
Above JCW, excluding TRH	185	5,956	6,141	282	2,833	3,115 0	253	2,055	2,308
South Fork	36	295	331	8	83	91 0			0
Misc. Tribs.	57	167	224	27	105	132 0			0
Subtotals		7,188	7,591 0 0	380 0	3,809 0	4,189 0 0	281 0	2,313 0	2,594 0
Total Spawner Escapement	96	9,670	10,169	742	7,064	7,806	521	4,061	4,582

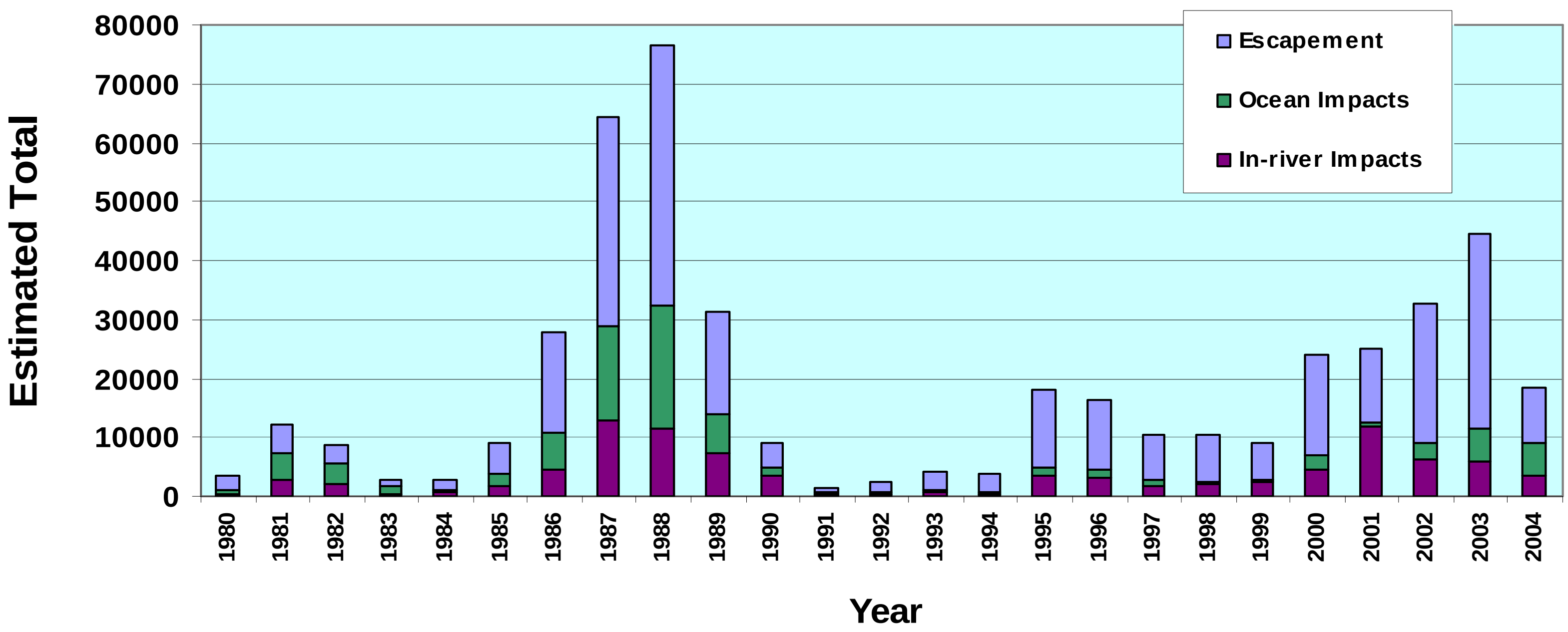
RIVER HARVEST

	2013			2014			2015		
Harvest	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Klamath River Basin									
Yurok Tribe	7	3,753	3,760	16	3,145	3,161			0
Angler	116	1,011	1,127	120	843	963	65	417	482
Trinity River Basin									
Hoopa Tribal Harvest	19	1,202	1,221	85	1,733	1,818	15	1,087	1,102
Angler	0	243	243	16	210	226	0	139	139
Total River Harvest	142	6,209	6,351	237	5,931	6,168	80	1,643	1,723

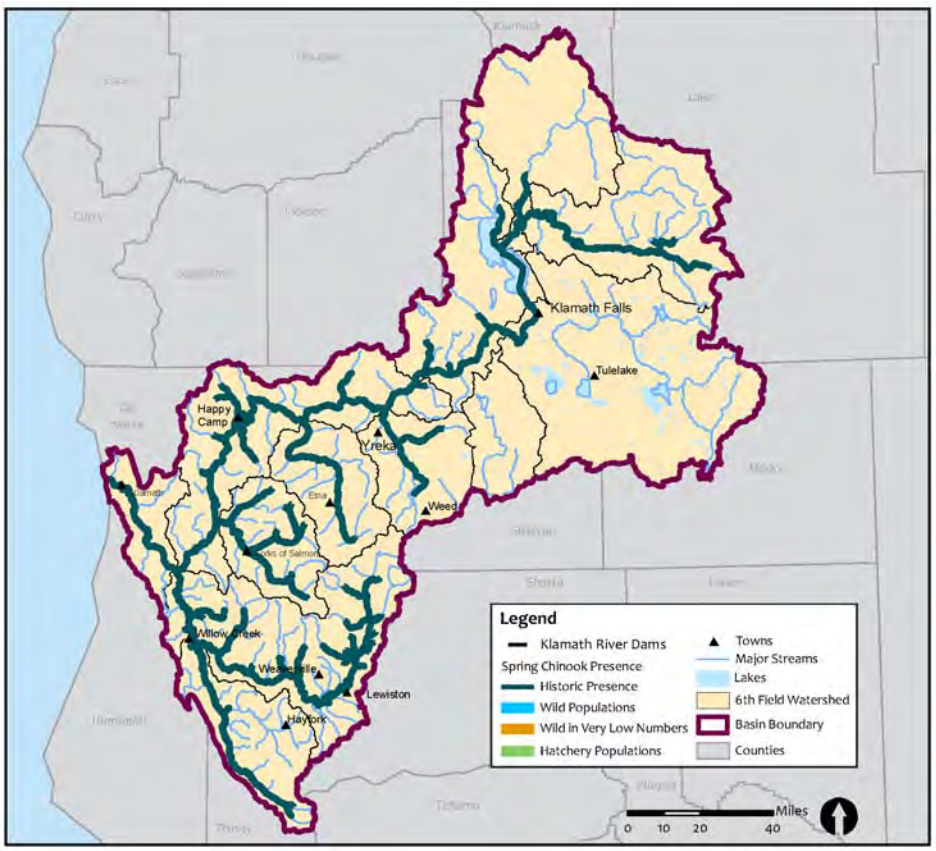
RUN-SIZE ESTIMATES

	2013			2014			2015		
	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Total Run-size Estimates	238	15,879	16,520	979	12,995	13,974	601	5,704	6,305

Escapement, Ocean and In-river Impacts on TRH Spring Chinook



Historical Presence of Spring Chinook in the Upper Klamath Basin

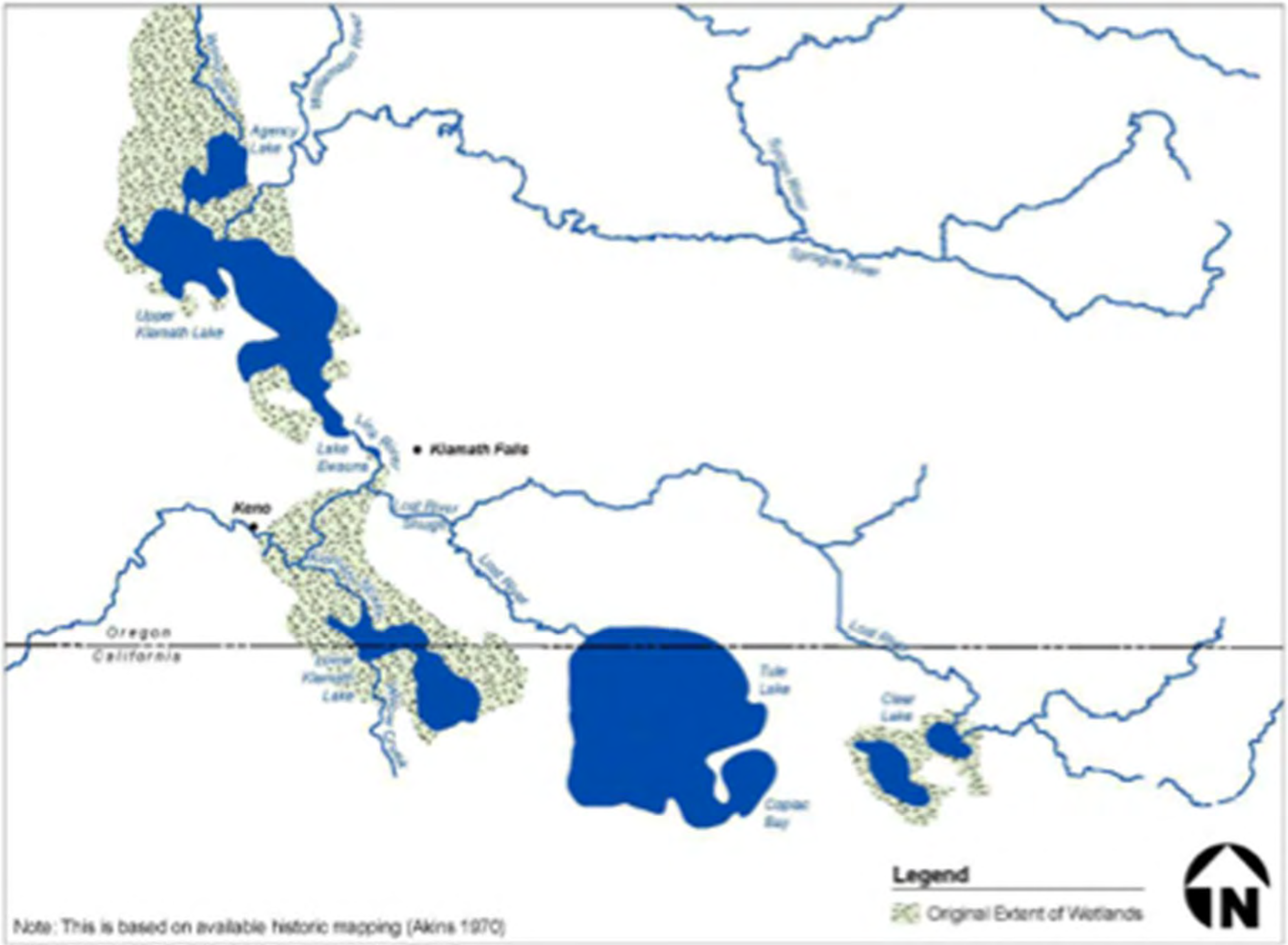


Numerous historical accounts and fisheries reports refer to the presence of salmon in the tributaries to Upper Klamath Lake, in particular, the Williamson and Sprague rivers.

- In excerpts from 50 interviews, conducted in the 1940s, members of the Klamath Tribe and older non-Indian settlers in the region provided accounts of numerous salmon fishing locations on the Sprague River, the Williamson River, Wood River, Upper Klamath Lake, and Spencer Creek.
- These accounts made a distinction between salmon and trout. In many instances the interviews in the document provided details on the weights of fish that indicated they could only be Chinook salmon.

- One of the earliest references in Lane and Lane Associates (1981) is to the explorer Fremont’s visit to the outlet of Upper Klamath Lake in May of 1846 and his observation of great numbers of salmon coming up the river to the lake. Most likely these would have been spring-run Chinook.

Historical Upper Klamath Basin Hydrology Before Dams, National Wildlife Refuges, and Reclamation's Klamath Project



- Chinook salmon utilized habitat in the Sprague River in the vicinity of Bly, Oregon, and further upstream. Fortune et al. (1966) reported that Chinook salmon spawned in the mainstem Sprague River; upstream on the South Fork of the Sprague above Bly to the headwaters; and on the North Fork of the Sprague as well.

- It should be noted that testimonies from Tribal members in Lane and Lane Associates (1981) were oriented toward harvest of adult salmon, which was restricted to within the reservation boundary, also located near Bly. Their report contained little information on the extent of anadromous salmonids in the Sprague River upstream of the reservation boundary.

- Successful fish passage through the high gradient Caldera reach for large-bodied, fall-run Chinook may have been problematic during certain years.

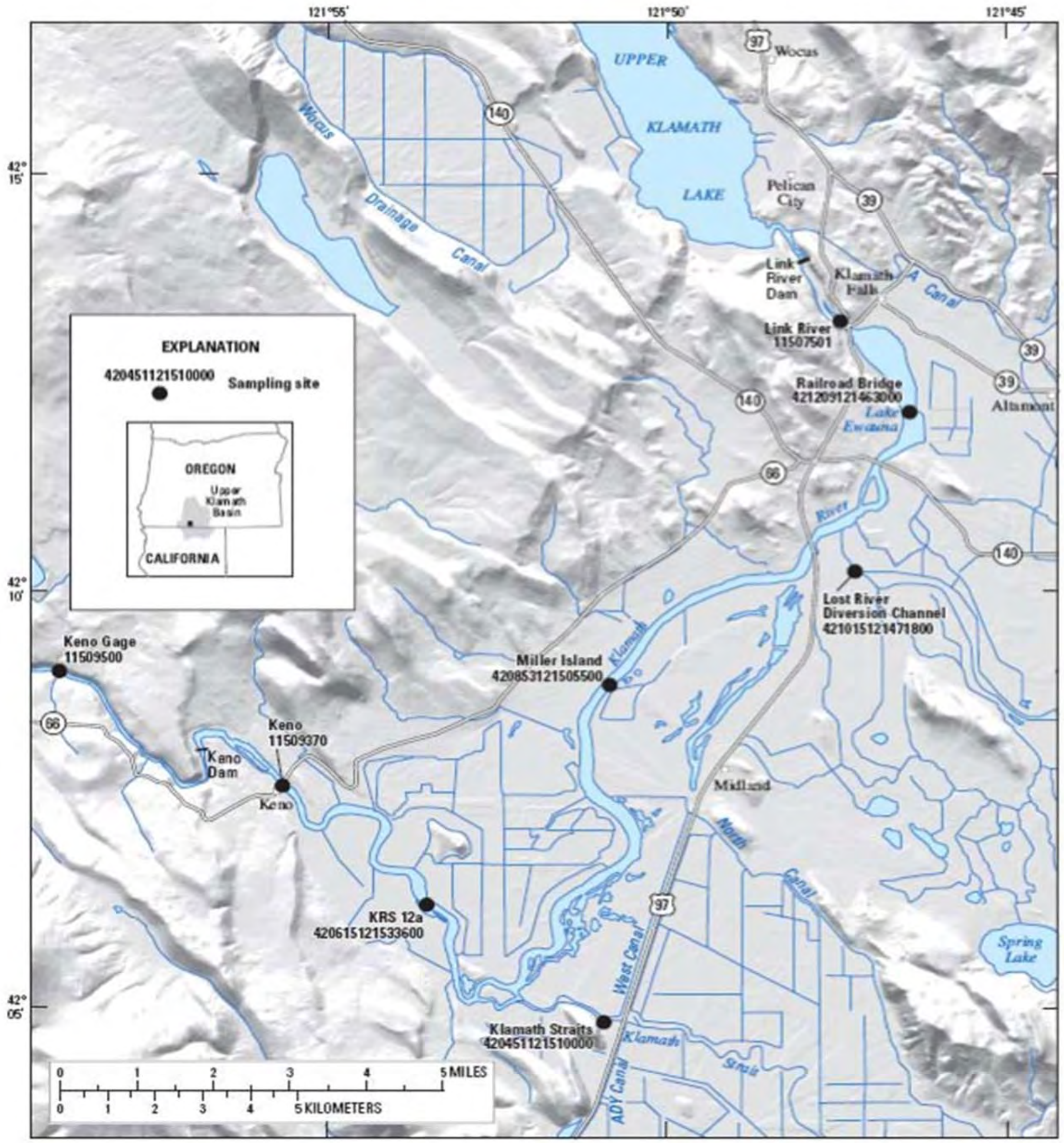
- This low water passage difficulty was noted a short distance upstream at Keno in the Klamath Falls Evening Herald (1908).

- Spring-run Chinook salmon, on the other hand, have a bi-modal run distribution. The spring-run Chinook encountered higher spring flows and would have been able to pass the Caldera reach.

The presence of both historic Tule and Lower Klamath Lake influenced flows in the Klamath River

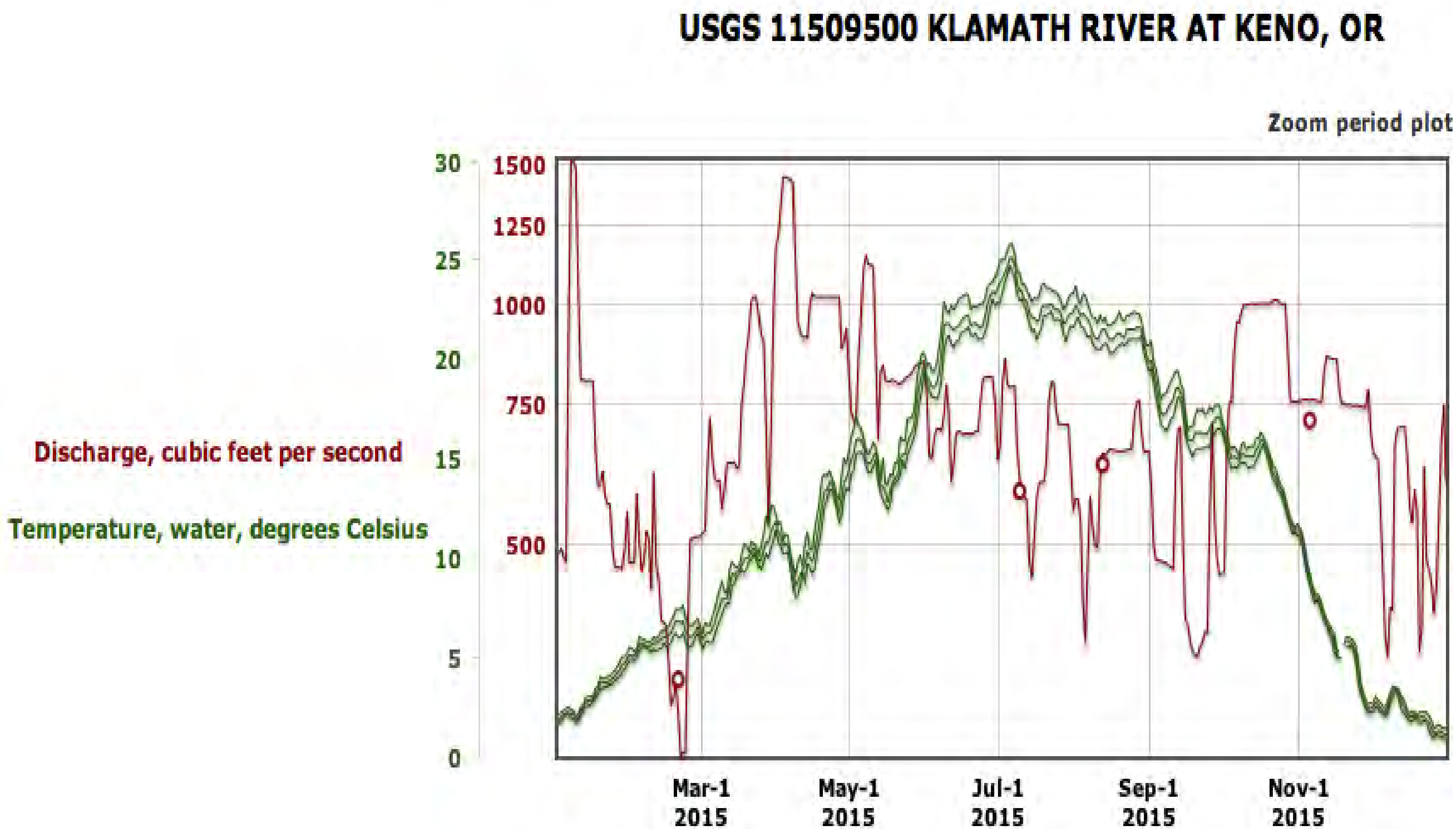
- Lower Klamath Lake (approximately 30,000 acres of open water and 55,000 surface acres of marsh) was connected to the Klamath River through the Klamath Straits.
- When the river began to rise in the spring during high water flow events, water overflowed into this lake and marsh at the Keno site and, as the river fell in the fall some of the water flowed back out of the lake (Weddell et al. Undated).
- Lower Klamath Lake provided some short term storage by reducing the total volume of water leaving the upper watershed as well as delaying the peak flow.

Map showing the Link River Dam to Keno Dam reach of the Klamath River, Oregon.



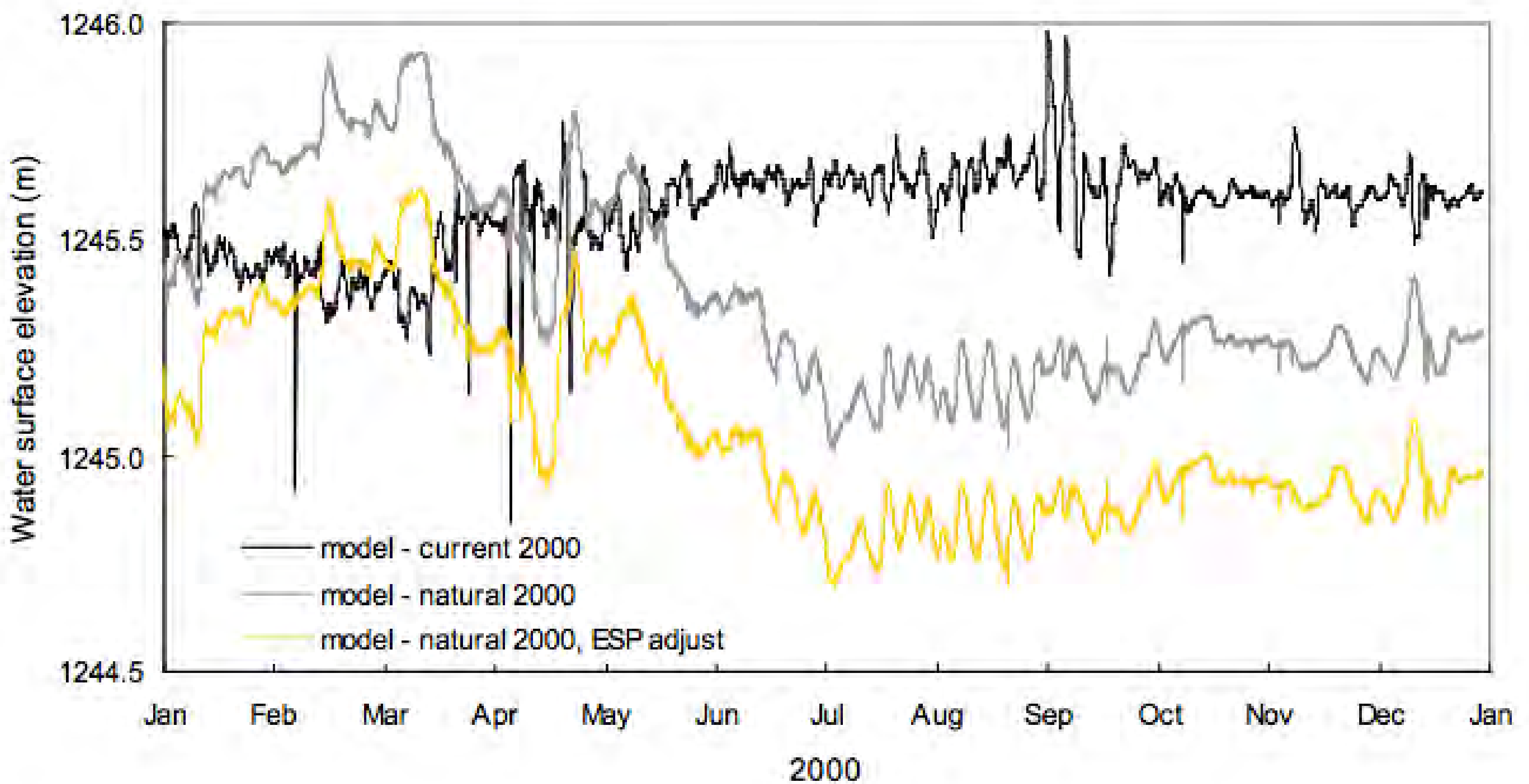
Keno Reservoir is an issue for salmonid migration

- Prior to the construction of Keno Dam in 1967, a shallow reef was present in the river where the dam was constructed. The reef was notched or removed when the dam was constructed.
- The recently signed KHSA and KPFA transfers Keno Dam to the Bureau of Reclamation.
- KPFA states Keno must remain in place and water levels must facilitate existing diversions.


USGS 11509500 KLAMATH RIVER AT KENO, OR
Zoom period plot
Discharge, cubic feet per second
Temperature, water, degrees Celsius
30
25
20
15
10
5
0
1500
1250
1000
750
500
Mar-1 2015
May-1 2015
Jul-1 2015
Sep-1 2015
Nov-1 2015

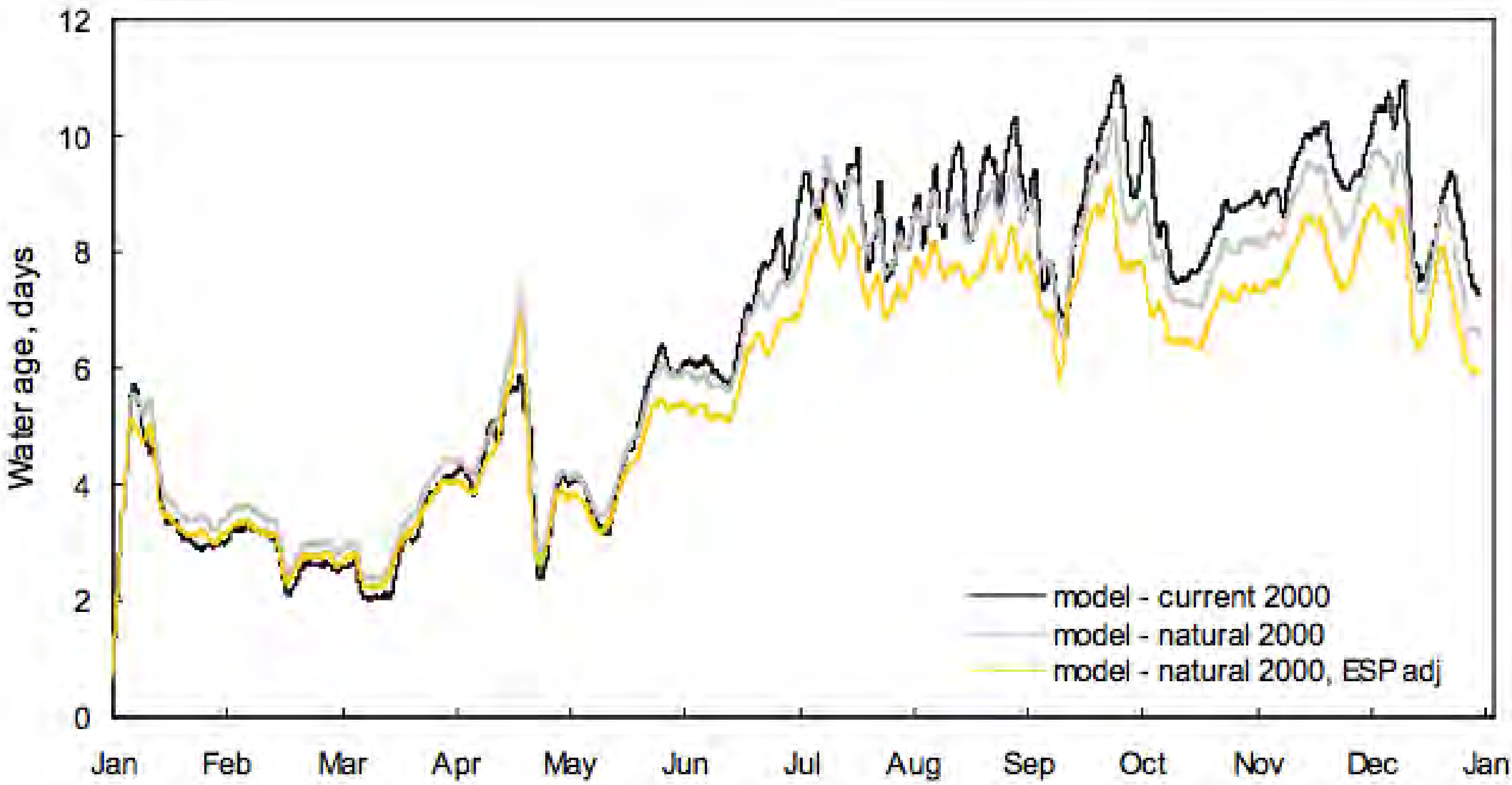
- The Klamath River meanders slowly for 20 miles from Lake Ewauna to Keno Dam, which was built "with the intent to produce power, but hydropower facilities were never developed." (PacifiCorp, 2002d).
- This reach has a very mild gradient and the 26 foot high dam results in a much slower travel rate for water, which creates conditions favorable to stream warming, increased biological activity and related water quality impairment (OWRD, 2004).

Graph showing water surface elevation at the location of Keno Dam from the current and natural conditions model scenarios in 2000. The natural conditions model was rerun with a lower Keno reef spillway elevation to produce the "ESP adjust"



- Water quality research shows high biological oxygen demand, low dissolved oxygen, high pH and high phosphorous and ammonia levels in the Keno reach.
- ODFW (1996) surveys found virtually no fish life in the Klamath River below Lake Ewauna, very low dissolved oxygen and a benthic community highly tolerant of pollution.
- Nutrient enrichment within Keno reservoir is boosted further by agricultural drainage from the Lost River Basin, via the Klamath Irrigation Project, entering the Klamath River through the Klamath Straits Drain (Resighini Rancheria, 2006) and when excess water is pumped from the Lost River in winter.

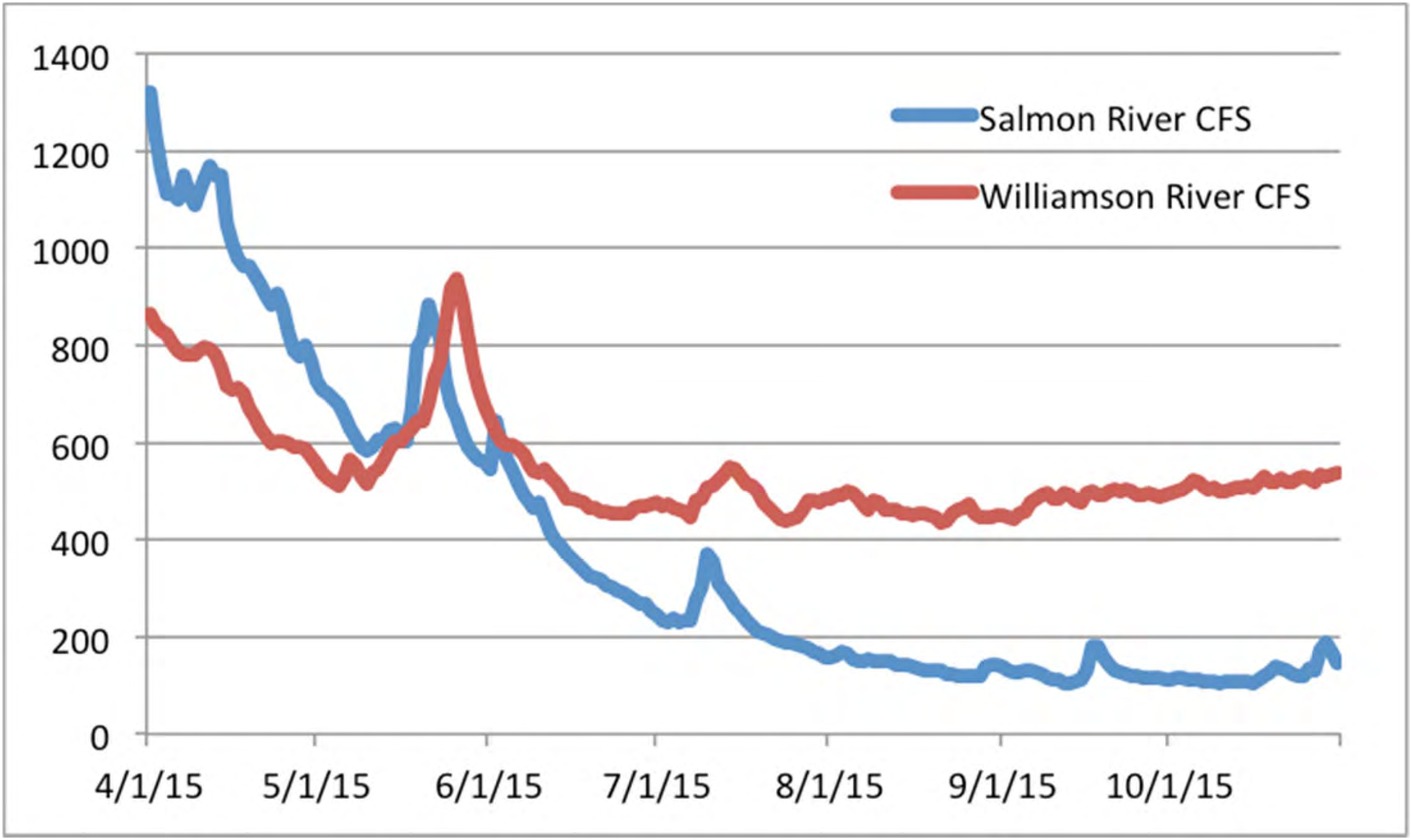
Graph showing average simulated residence time in the Lake Ewauna to Keno Dam model under current and natural conditions for the year 2000.



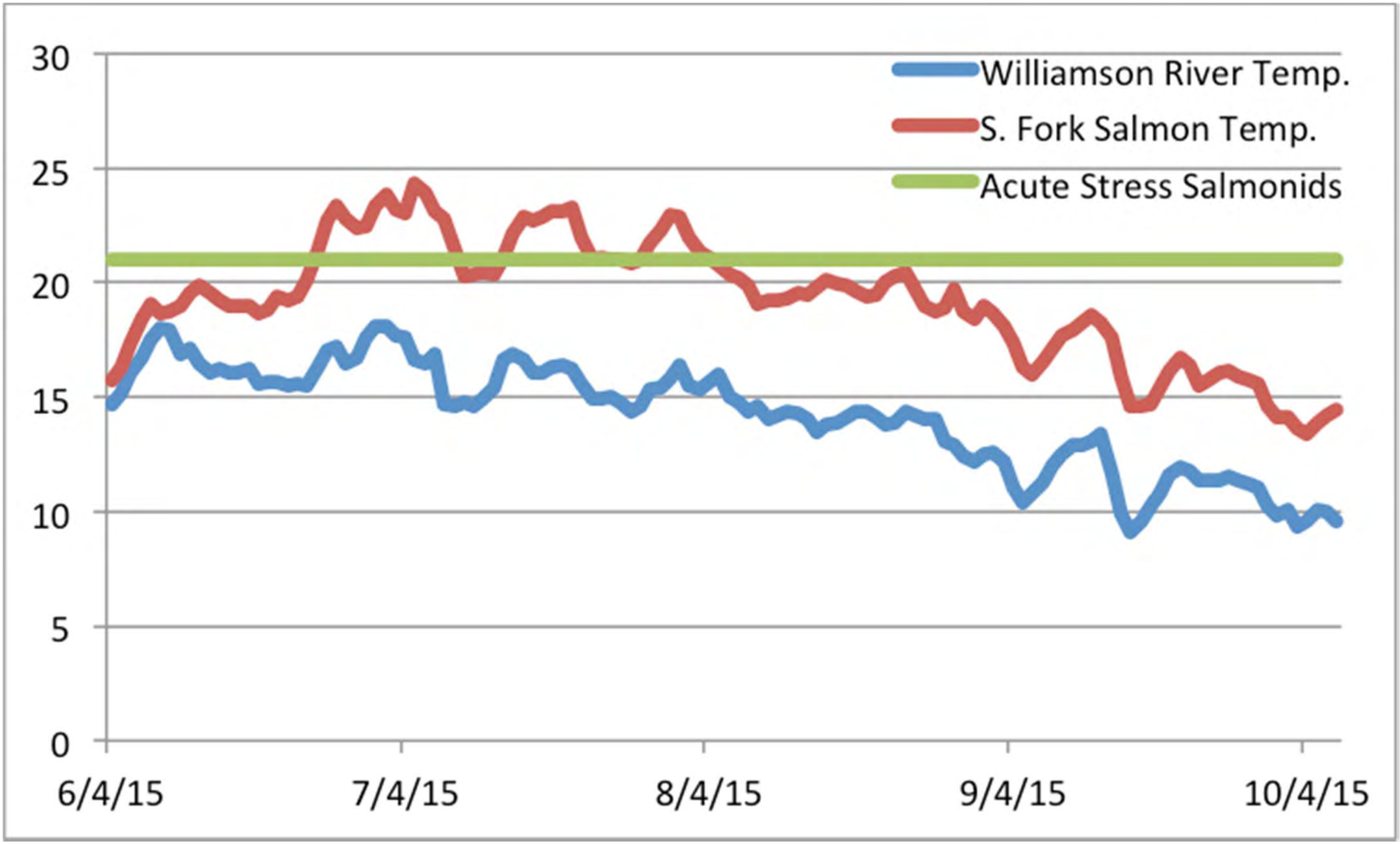
Cold Water Refugia in the footprint of the Klamath Hydroelectric Project

- The J.C. Boyle Bypass Reach is a 4.3-mile section of the Klamath River between the J.C. Boyle Dam and Powerhouse; it flows at a steep grade. At 0.5 miles downstream of the dam, flows are increased by groundwater entering the bypass reach. The average accretion due to groundwater inflow/spring inflow is 220 to 250 cfs and varies seasonally and from year to year (FERC 2007).
- Other cold water inputs such as Jenny and Shovel Creeks and numerous accretions are known to exist in the footprint of the hydro project.

Williamson River vs. Salmon River Flow During Adult Spring Run Migration, Holding and Spawning

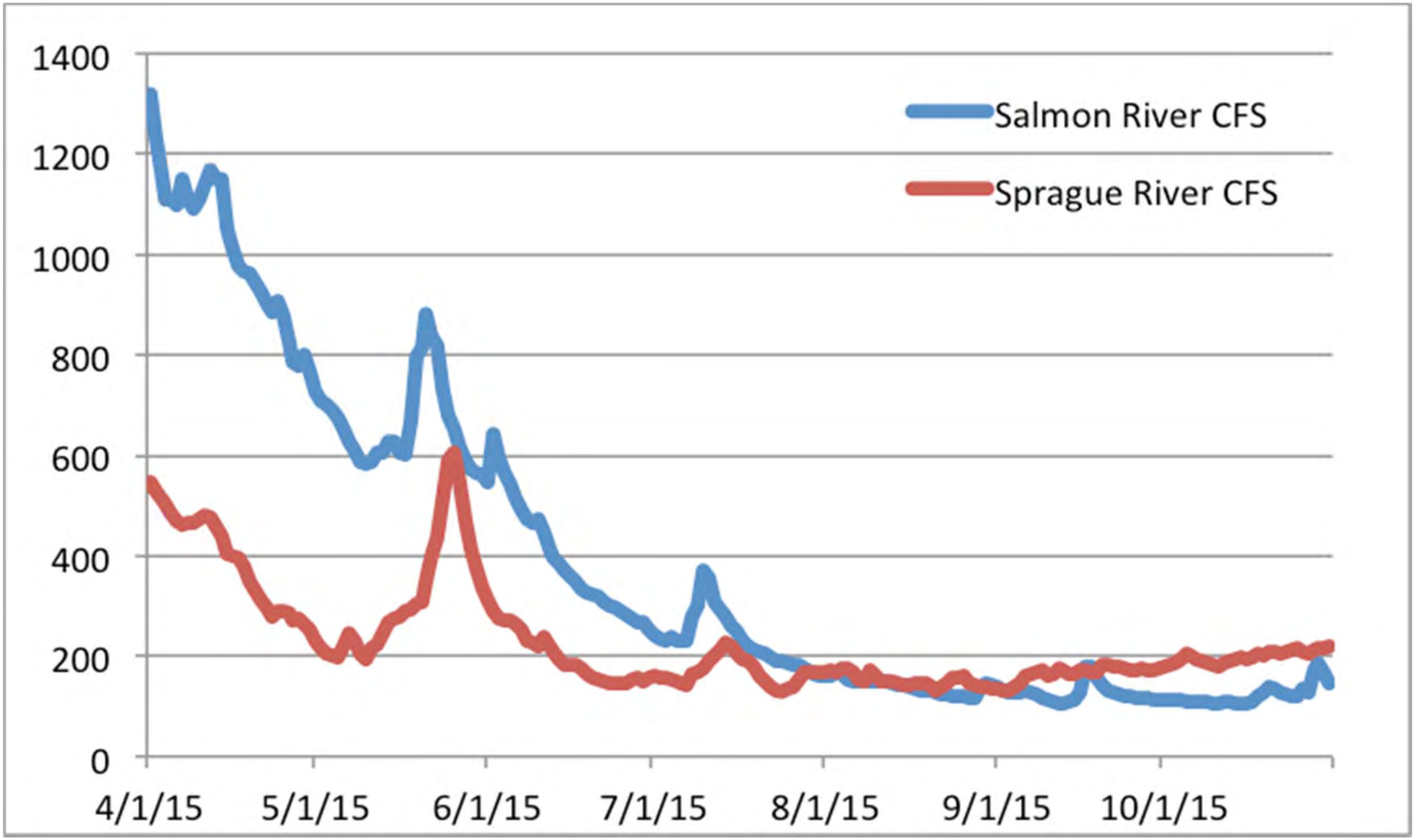


Williamson River vs. Salmon River Temperatures During Spring Chinook Holding Period

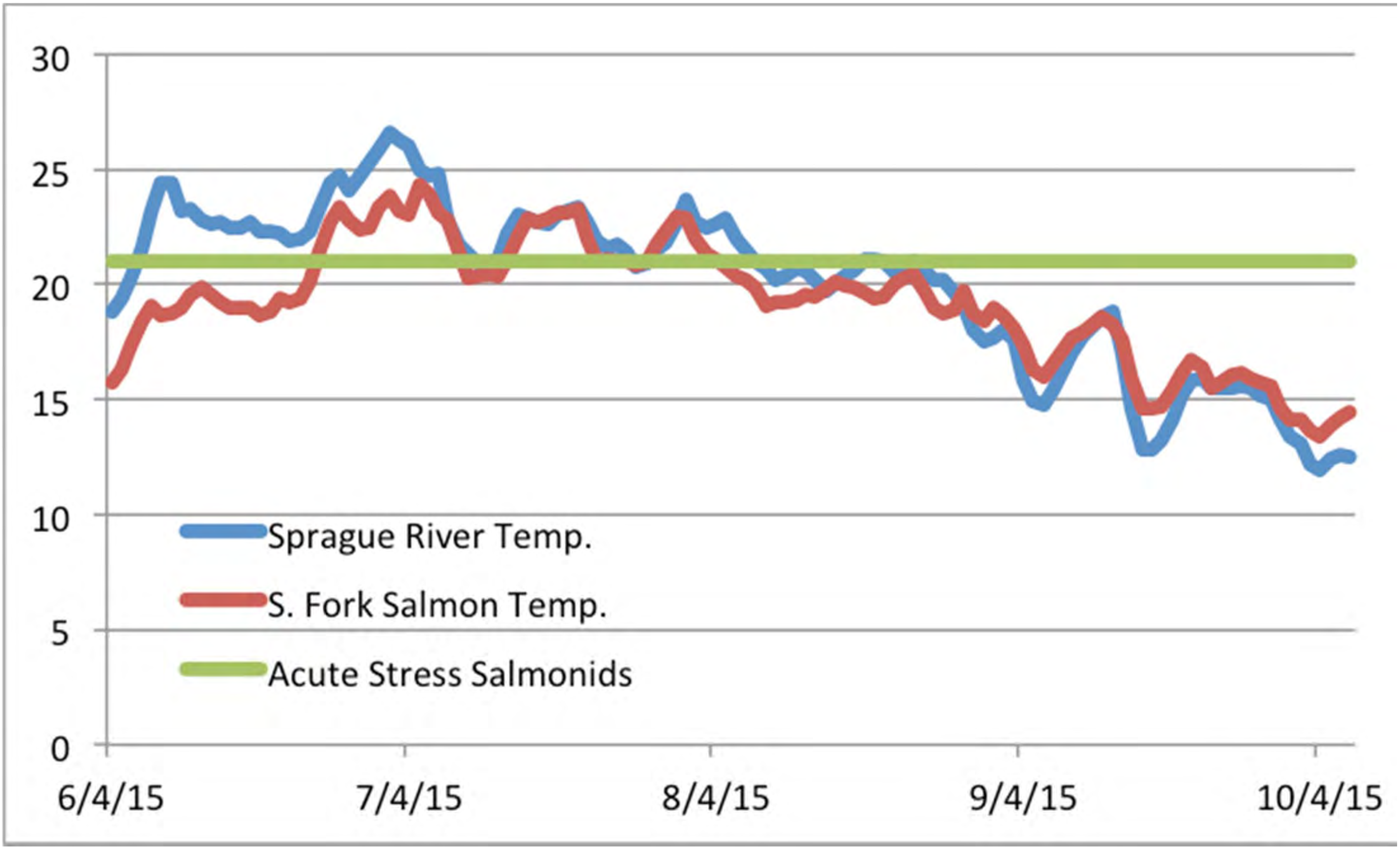


Williamson River above Sprague River Confluence

Sprague River vs. Salmon River Flow During Adult Spring Run Migration, Holding and Spawning

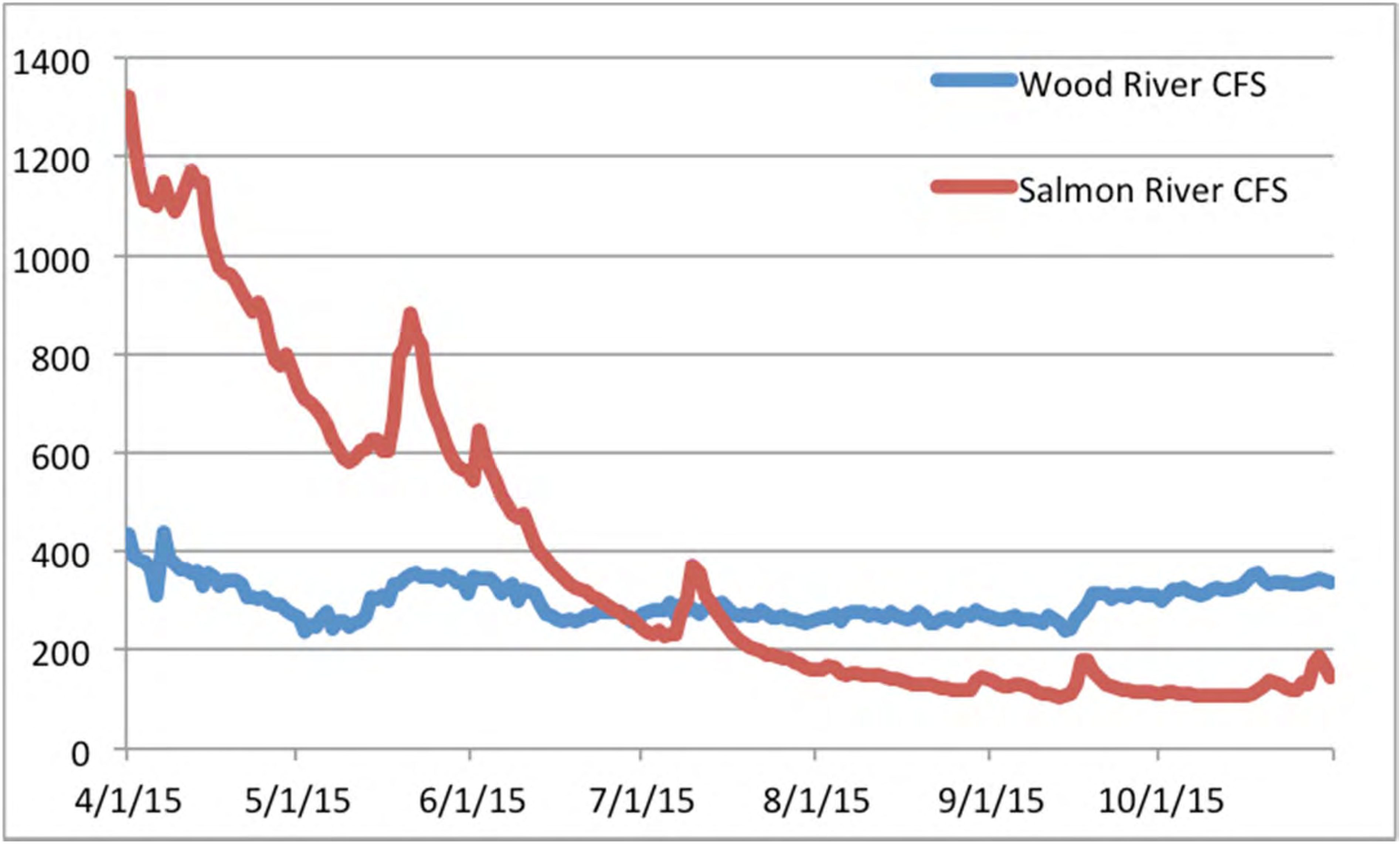


Sprague River vs. Salmon River Temperatures During Spring Chinook Holding Period

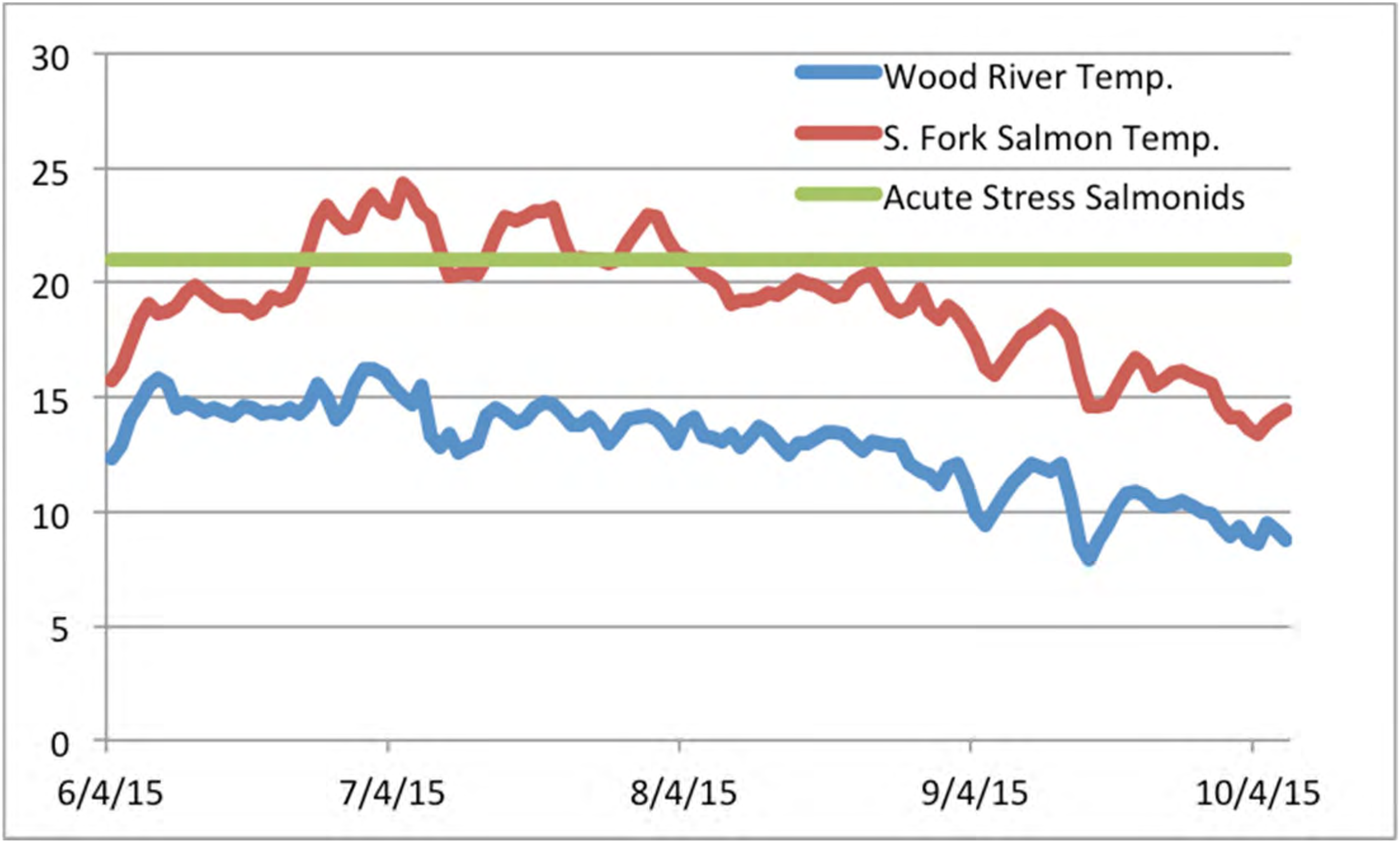


Sprague River near Bly, Oregon

Wood River vs. Salmon River Flow During Adult Spring Run Migration, Holding and Spawning



Wood River vs. Salmon River Temperatures During Spring Chinook Holding Period



Wood River near Upper Klamath Lake

Table 4. Climate change vulnerability (V_c) scores generated by four independent expert reviewers for native fishes of the lower Klamath River, California.

Taxon	Total V_c	V_c high	V_c low	Certainty score	V_c rating
Pacific lamprey	18.8 (17–22)	24.5 (24–26)	14.5 (14–16)	20.8 (19–22)	V_c2
Klamath River lamprey	17.8 (15–20)	21.5 (21–22)	14.5 (12–17)	12.0 (10–14)	V_c2−
Western brook lamprey	16.8 (15–18)	22.0 (21–23)	14.0 (13–15)	16.5 (12–19)	V_c1+
Northern green sturgeon	17.8 (16–20)	21.5 (20–24)	14.3 (13–15)	22.3 (19–24)	V_c2−
Klamath speckled dace	24.0 (23–25)	29.5 (27–31)	22.5 (21–23)	17.3 (14–20)	V_c3
Klamath smallscale sucker	26.8 (24–28)	30.8 (30–32)	14.3 (13–15)	22.3 (19–24)	V_c3+
Eulachon	18.8 (15–20)	24.3 (21–26)	16.0 (11–18)	20.8 (18–24)	V_c2−
Upper Klamath-Trinity fall Chinook salmon	17.3 (16–18)	21.8 (21–23)	14.3 (13–15)	24.5 (21–27)	V_c2−
Upper Klamath-Trinity spring Chinook salmon	14.8 (14–15)	19.3 (17–22)	13.8 (13–14)	25.5 (23–29)	V_c1
Southern Oregon Northern California coast fall Chinook salmon	17.5 (17–18)	20.5 (19–22)	14.3 (13–16)	24.8 (23–26)	V_c2
Southern Oregon Northern California coast coho salmon	15.0 (14–16)	18.3 (16–21)	13.8 (13–14)	27.3 (24–29)	V_c1
Pink salmon	17.3 (16–19)	21.5 (19–24)	14.8 (14–15)	20.5 (18–24)	V_c2−
Chum salmon	17.5 (17–18)	20.5 (19–23)	14.5 (13–15)	21.0 (17–24)	V_c2
Klamath Mountains Province winter steelhead	20.8 (18–24)	22.3 (18–25)	16.5 (15–19)	25.3 (23–27)	V_c2+
Klamath Mountains Province summer steelhead	13.0 (11–16)	17.0 (14–21)	11.5 (11–12)	24.5 (23–26)	V_c1
Coastal cutthroat trout	16.8 (16–18)	22.5 (20–24)	14.0 (13–15)	22.8 (20–24)	V_c1+
Lower Klamath marbled sculpin	20.3 (19–21)	24.8 (23–26)	17.0 (16–18)	16.3 (10–22)	V_c2
Coastal prickly sculpin	26.5 (26–28)	28.5 (27–30)	22.3 (18–25)	22.5 (16–28)	V_c3+
Coastrange sculpin	21.5 (20–23)	24.3 (22–26)	17.0 (12–20)	22.0 (20–24)	V_c2+
Coastal threespine stickleback	23.8 (22–26)	27.5 (26–29)	20.8 (18–22)	19.0 (15–25)	V_c3−

Notes: Data are presented as mean scores with ranges in parentheses. Mean total V_c scores translate into vulnerability categories as outlined in Table 2: V_c1 = critically vulnerable, V_c2 = highly vulnerable, V_c3 = less vulnerable, V_c4 = least vulnerable. A plus (+) or minus (−) sign following a V_c rating indicates that the total score generated by one or more reviewer resulted in the taxon being assigned to a higher (less vulnerable) or lower (more vulnerable) category, respectively. Scientific names of all species can be found in Table S1.

doi:10.1371/journal.pone.0063883.t004

Regional spring run Chinook populations and status

- Spring Chinook populations still thrive in many of the Klamath's sister rivers, but some, like the Klamath population, are barely hanging on by a thread. In Oregon, spring runs exist in the Tillamook, Nestucca, Siletz, Alsea, South Umpqua, North Umpqua, Rogue, Willamette, Columbia and Coquille Rivers. The Siuslaw and the Coos populations are presumed extinct.

- Many are designated as separate ESUs, listed as either threatened or endangered under the Endangered Species Act and are therefore afforded priority with respect to habitat accessibility and dam release flow regimes

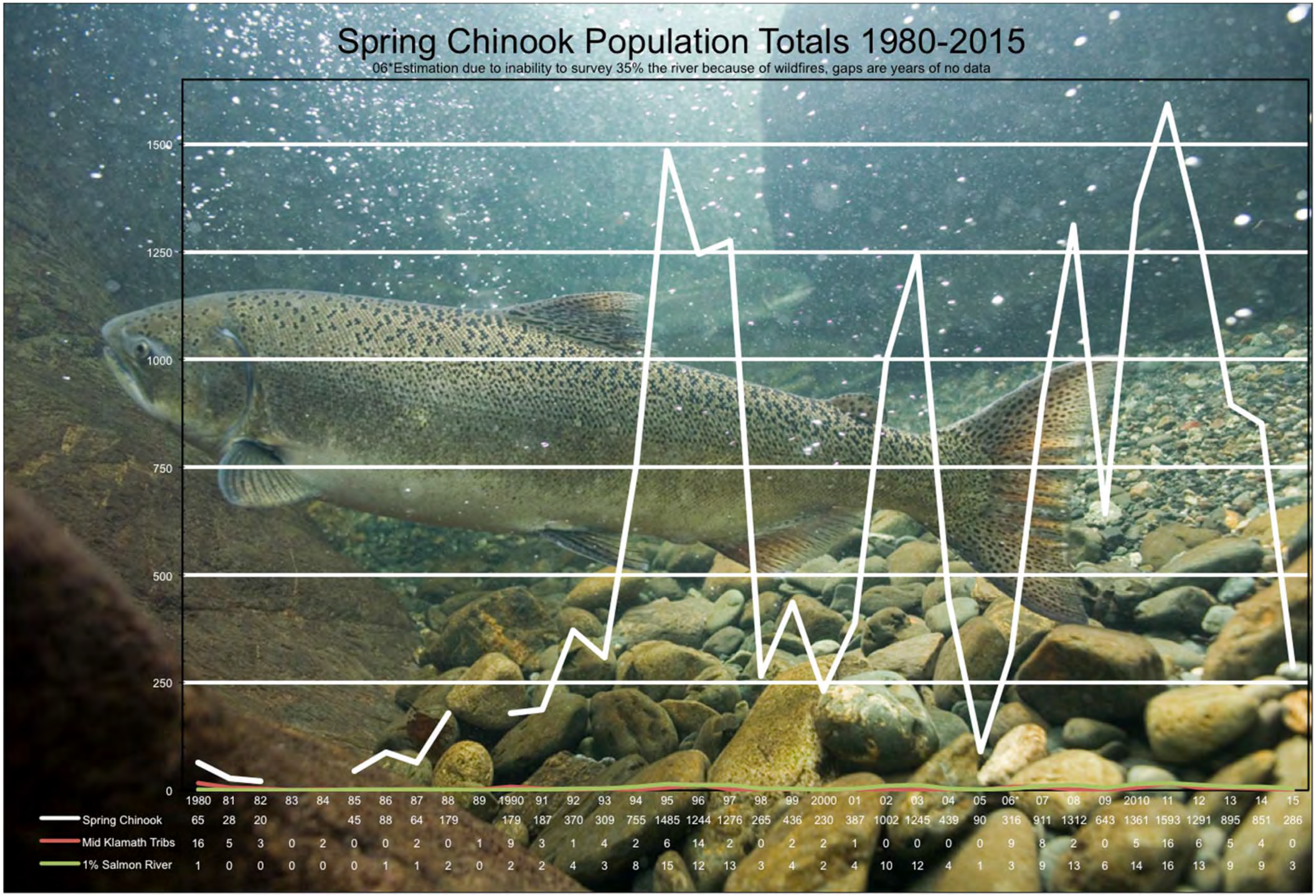
- These watershed's runs include: Central Valley Spring Run (threatened), Upper Willamette Spring Run, (threatened), Snake River Spring Run (threatened), Upper Columbia Spring Run (endangered), San Joaquin (experimental reintroduction).

Conclusions:

- To improve conditions in the Keno Reach strict regulation should be required for inputs of phosphorous and nitrogen from Upper Basin agriculture.
- A feasibility study should be initiated that looks into using hatch boxes to reintroduce wild spring Chinook into the Williamson River and other Upper Basin tributaries.
- The Salmon River spring Chinook represents the closest relative to the once predominant run in the Klamath Basin and is critical to restoration and repopulation. The Salmon River and S. Fork Trinity should be prioritized for restoration in the basin.
- Recent genetic research presents a strong case for managing Upper Klamath Trinity Spring Run Chinook as a distinct population segment (ESU).

Conclusions:

- The Salmon River spring Chinook run is unlikely to remain viable without a Upper Klamath Basin meta population.
- Archaeological Fish Remains (Portland State) should be cross referenced with Miller and Prince's findings to determine the heir to the Upper Klamath.
- Removal of the Klamath Hydroelectric Facilities will be less likely to achieve the goal of restored Chinook migration into Upper Klamath Lake without Spring Chinook.
- A 100 percent adipose fin clip mark of hatchery spring Chinook at TRH is critical to harvest management and reintroduction.


Spring Chinook Population Totals 1980-2015
06*Estimation due to inability to survey 35% the river because of wildfires, gaps are years of no data
1500
1250
1000
750
500
250
0
1980 81 82 83 84 85 86 87 88 89 1990 91 92 93 94 95 96 97 98 99 2000 01 02 03 04 05 06* 07 08 09 2010 11 12 13 14 15
Spring Chinook 65 28 20 45 88 64 179 179 187 370 309 755 1485 1244 1276 265 436 230 387 1002 1245 439 90 316 911 1312 643 1361 1593 1291 895 851 286
Mid Klamath Tribs 16 5 3 0 2 0 0 2 0 1 9 3 1 4 2 6 14 2 0 2 2 1 0 0 0 0 9 8 2 0 5 16 6 5 4 0
1% Salmon River 1 0 0 0 0 0 1 1 2 0 2 2 4 3 8 15 12 13 3 4 2 4 10 12 4 1 3 9 13 6 14 16 13 9 9 3