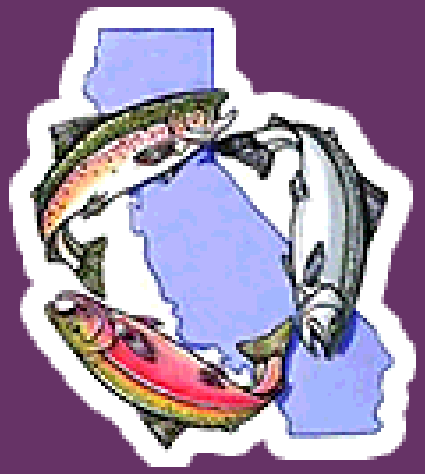


Overview of Klamath River Dam Removal and Salmon Reintroduction to the Upper Klamath Basin

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

Session Overview

- Session Coordinator:
  - Mike Belchik, Yurok Tribe

The decommissioning and removal of four dams on the Klamath River is on track to occur in 2020. As with recent dam removals, there are a range of expectations and a range of understanding of the process of removing the dams, monitoring the resources, and minimizing direct and indirect impacts on the natural resources and ecological processes in the watershed. This session will provide an update on the implementation of the dam removal and review the schedule of activities as well as plans for monitoring physical and biological aspects of the river. The purpose of this session is to provide a very up-to-date and concise overview of the process being implemented and the proposed schedule of activities.

Presentations

The Video Recording of the this Session is Located at
https://vimeo.com/album/5137447

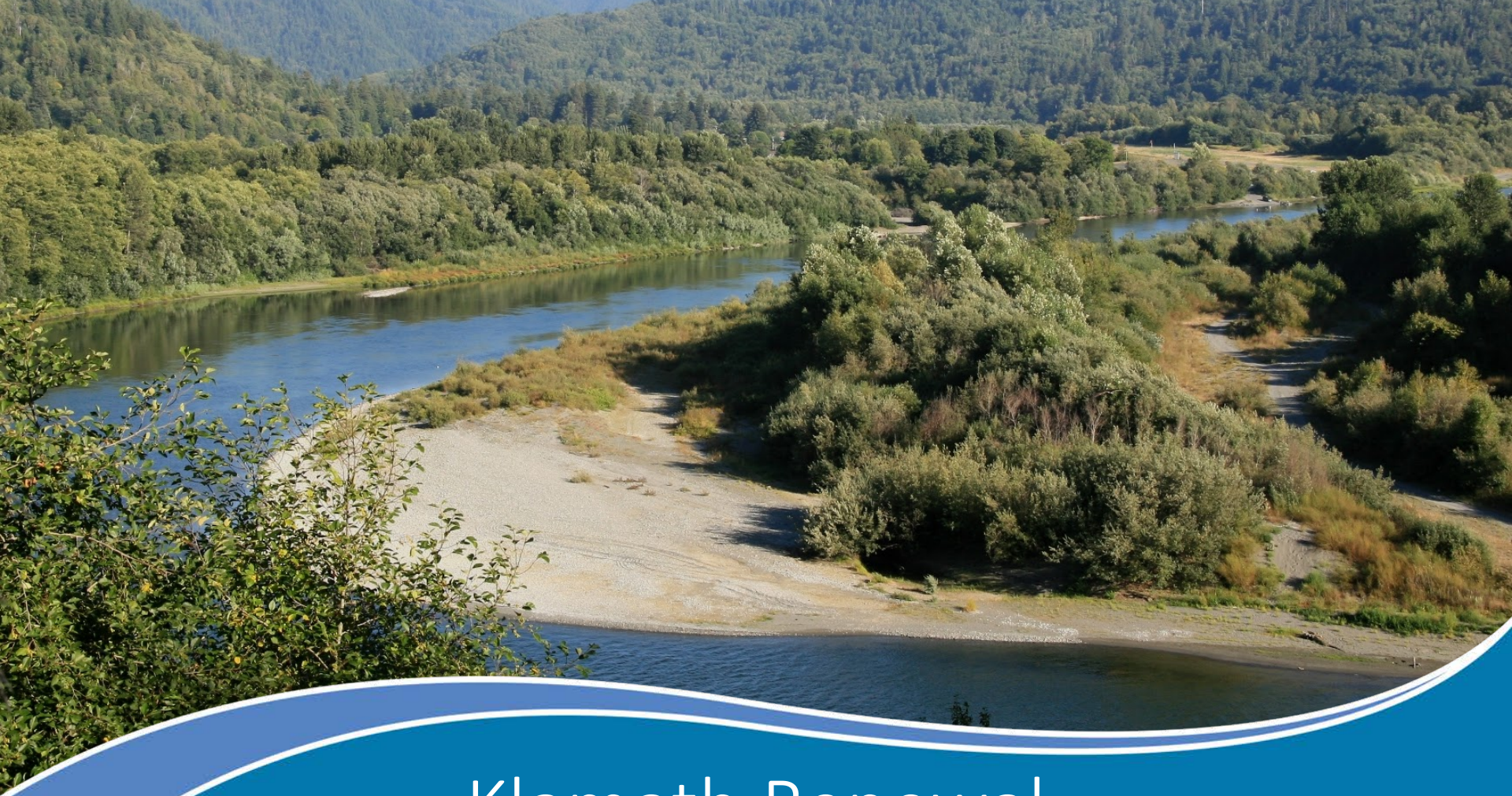
(Slide 4) Klamath River Dam Removal and the Klamath River Renewal Corporation (KRRC)
Mark Bransom, Executive Director, Klamath River Renewal Corporation

(Slide 41) Strategies for Repopulating the Upper and Middle Klamath River with Salmon and Steelhead Following Dam Removal
John Carlos Garza, PhD, NOAA, Southwest Fisheries Science Center

(Slide 69) The Persistence and Characteristics of Chinook Salmon Migrations to the Upper Klamath River Prior to Exclusion by Dams
John B. Hamilton, U.S. Fish and Wildlife Service

(Slide 136) Genetic Analyses of Contemporary and Ancient Samples Provide Insights into Restoring Upper Klamath Spring Chinook Tasha Q. Thompson, UC Davis

(Slide 167) An Update on the Reintroduction Implementation Plan of Anadromous Fishes into the Oregon Portion of the Upper Klamath Basin
Mark Hereford, Klamath Fisheries Reintroduction Planner, Oregon Department of Fish and Wildlife and Alex Gonyaw, Fisheries Biologist, Klamath Tribes



Klamath Renewal

Project Overview

Restoring the natural vitality of the Klamath River

KLAMATH
RIVER RENEWAL
CORPORATION

Overview

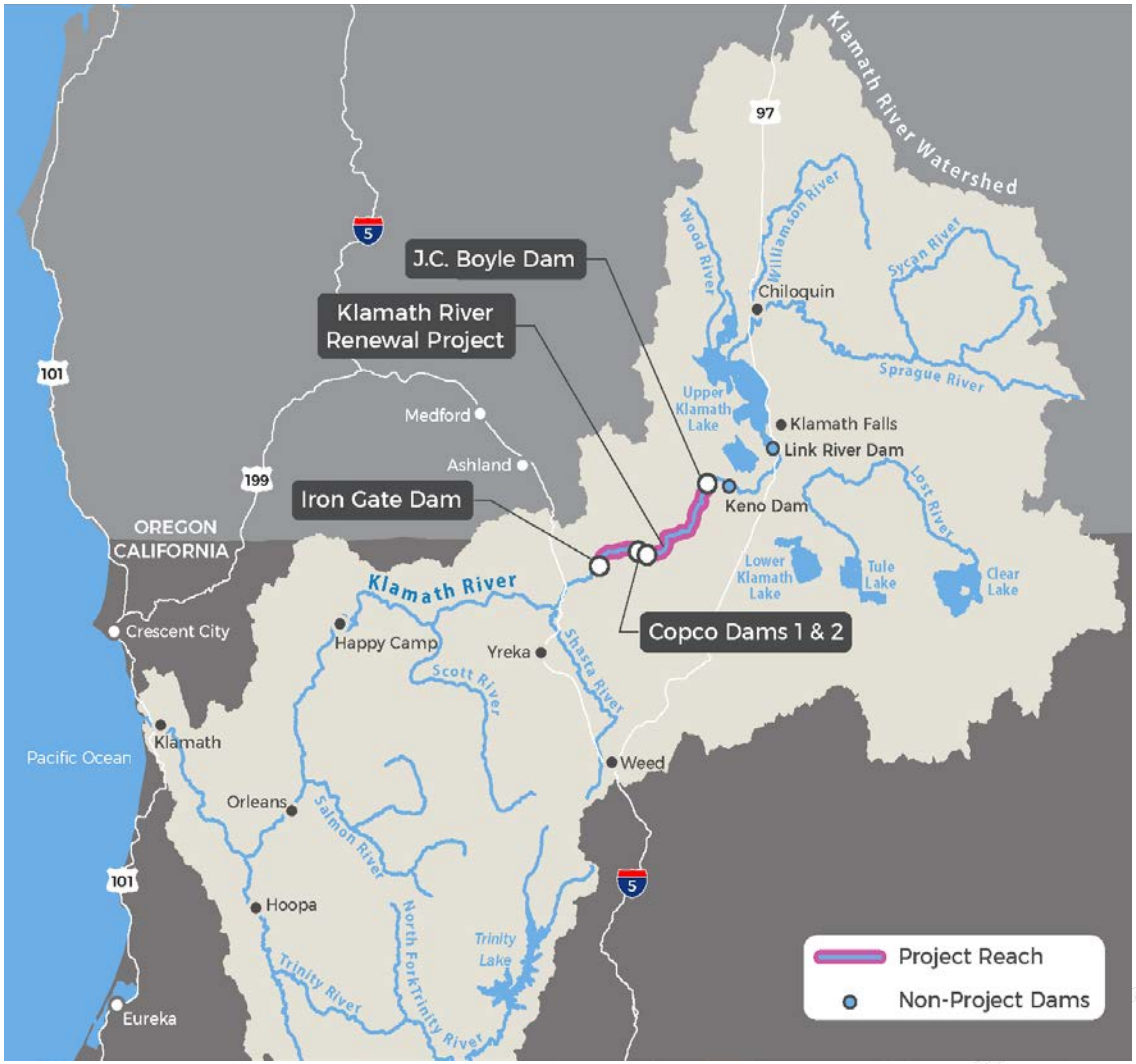
- Introduction
- Project Schedule
- Regulatory Process and Status
- Work Components Related to Aquatic Resources
  - Hatchery Modifications
  - Dam Modifications
  - Dam and Hydropower Facility Removal
  - Reservoir Recreation
  - Recreation Plan and Restoration

Klamath River Renewal Corporation

JC Boyle, OR

Copco No. 1 & 2, CA

Iron Gate, CA



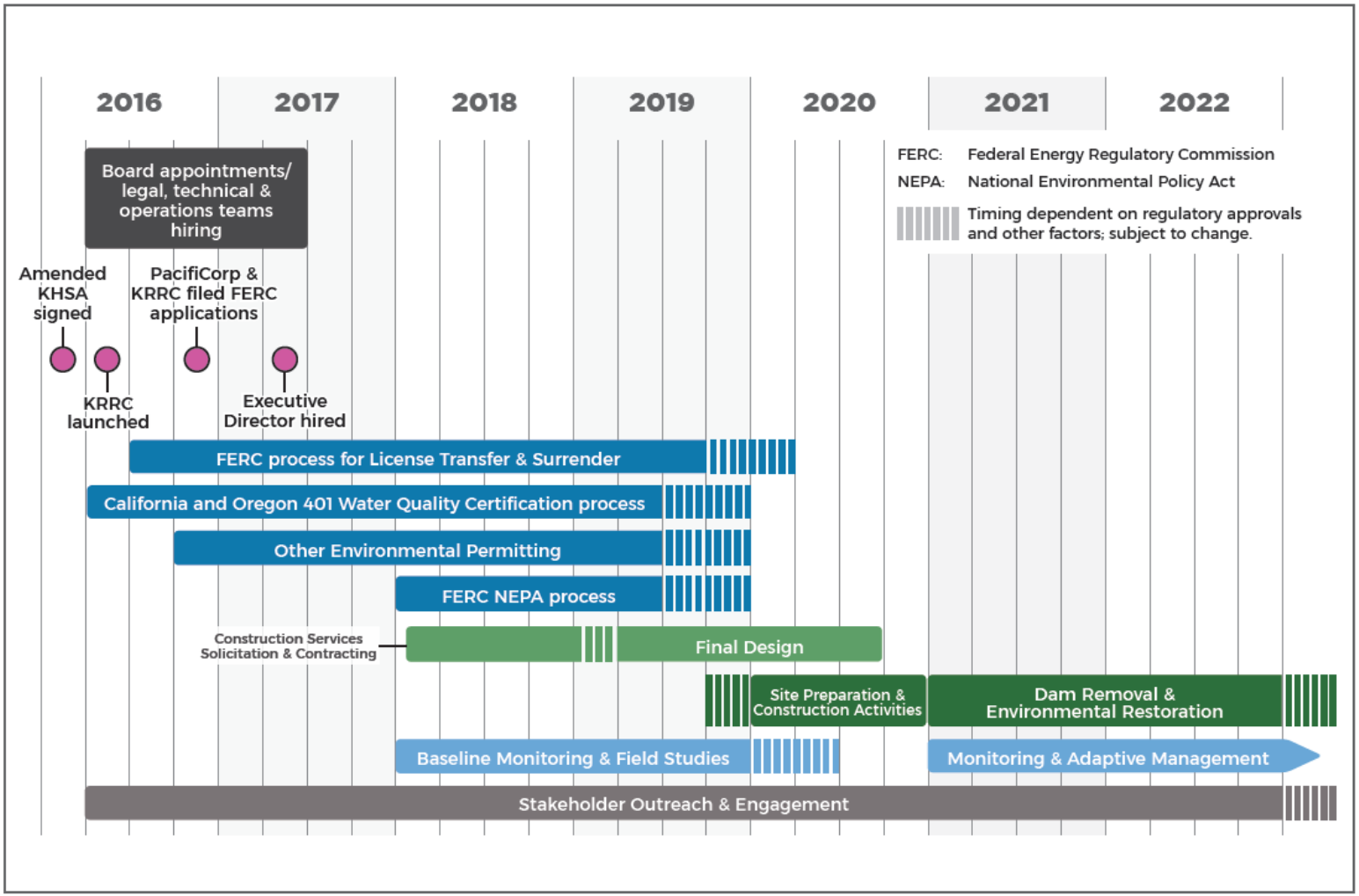
Klamath River Basin

KRRC is Fully Funded

- PacifiCorp Customer Funds via Public Utilities Commissions Funding Agreements
  - Oregon: $184 M
  - California: $16 M
- California Proposition 1 Bond Funds
  - Up to $250 million

Klamath River between JC Boyle Dam and Powerhouse

Current Thinking on Project Timeline



FERC License Applications

Transfer Application

- Filed by KRRC & PacifiCorp 9/2016
- Responses to info requests submitted 6/2017, 12/2017, 3/2018
- FERC Order split license and deferred decision on transfer, 3/2018
- Submitted Board of Consultants proposal to FERC, 3/2018
- Additional information responses due 7/2018
- Decision on transfer pending

Surrender Application

- Filed by KRRC 9/2016
- Response to info request 12/2017
- To file “Definite Plan” with FERC by 7/2018
- FERC has not initiated NEPA review.
- Decision on surrender pending

Water Quality Certification

- Submitted Water Quality Certification Applications 9/2016 with
  - CA State Water Resources Control Board (Water Board)
  - OR Department of Environmental Quality (ODEQ)
- Responses to info requests and updated info 6/2017, 9/2017, 1/2018
- Expect draft Water Quality Certification from States spring 2018

CA Environmental Quality Act (CEQA) Process

- Notice of Preparation (NOP) Scoping Meetings 1/2017
- Draft Environmental Impact Report (EIR) expected summer 2018
- Public comment period to follow
- Final EIR expected summer 2019

CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

Endangered Species Act (ESA) Consultation

- ESA Section 7 Consultation on Project Effects to ESA Species
- KRRC Technical Team leading Biological Assessment (BA) development
  - KRRC is in regular consultation with co-lead agencies
    - National Oceanic and Atmospheric Administration (NOAA) Fisheries
    - US Fish & Wildlife Service (USFWS)
  - BA expected in 2018
- NOAA and USFWS expected to issue a Biological Opinion (BO) on project effects and mitigation in 2019

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Tribal Consultations

Formal Consultations - AB 52

- CA Water Board leading the AB52 tribal consultation process
- Will identify:
  - Potential impacts to tribal cultural resources
  - Potential mitigation measures
- Part of the CEQA process
- Must be completed before the Water Board acts on KRRC's water quality certification application

Informal Consultation - Sec 106

- FERC designated KRRC and PacifiCorp as nonfederal representative
  - AECOM facilitating on their behalf
- Pursuant to Section 106 of the NHPA and Advisory Council regulations

FERC/Yurok Consultation

Regulatory Summary

More info, documents:
http://www.klamathrenewal.org/regulatory

Milestone	Status
KRRC applications to FERC and States	• Submitted September 2016
FERC Transfer Application	• March 15, 2018 order split license and deferred decision on transfer • Additional info requests due July 1, 2018 • Decision on transfer pending
FERC Surrender Application	• National Environmental Policy Act (NEPA): FERC has not yet initiated review • Decision on surrender pending
EIR under CEQA	• Draft EIR expected summer 2018
CA & OR Water Quality Certifications	• Drafts expected spring 2018
KRRC "Definite Plan" sent to FERC	• No later than July 1, 2018
ESA Consultations	• KRRC Biological Assessment (BA) expected 2018 • NOAA/USFWS Biological Opinion (BO) expected 2018/2019
Formal & informal tribal consultations	• State Board AB 52 consultation on-going • Sec 106 informal consultations on-going

KLAMATH RIVER RENEWAL CORPORATION

Primary Work Components/Categories

1. City of Yreka Intake and Pipeline Replacement
2. Temporary Construction Access Improvements
3. Permanent Road and Bridge Improvements
4. Downstream Flood Control Improvements
5. Hatchery Modifications
6. Dam Modifications
7. Dam and Hydropower Facility Removal
8. Reservoir Restoration
9. Recreation Plan and Restoration

KLAMATH RIVER RENEWAL CORPORATION

Primary Work Components/Categories

1. City of Yreka Intake and Pipeline Replacement
2. Temporary Construction Access Improvements
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5. **Hatchery Modifications**
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7. **Dam and Hydropower Facility Removal**
8. **Reservoir Restoration**
9. **Recreation Plan and Restoration**

KLAMATH RIVER RENEWAL CORPORATION

5. Hatchery Modifications

Iron Gate Hatchery

- Will continue operations for Chinook smolt
- Riparian water right on Bogus Creek will be registered
- Bogus Creek water diversion will be evaluated under CEQA and in consultation with NMFS and CDFW
- Water supply modifications would occur on the current hatchery footprint

Fall Creek Hatchery

- Will reopen for Coho and Chinook yearling production
- New circular tanks in the current hatchery footprint
- New settling pond and discharge point for Fall Creek is being evaluated

KLAMATH RIVER RENEWAL CORPORATION

6. Dam Modification

Modify dam infrastructure to allow for full reservoir drawdown

- Removal of sediment
- Demolition of existing gates
- Installation of new gates at Iron Gate and Copco No. 1 diversion tunnels

KLAMATH RIVER RENEWAL CORPORATION

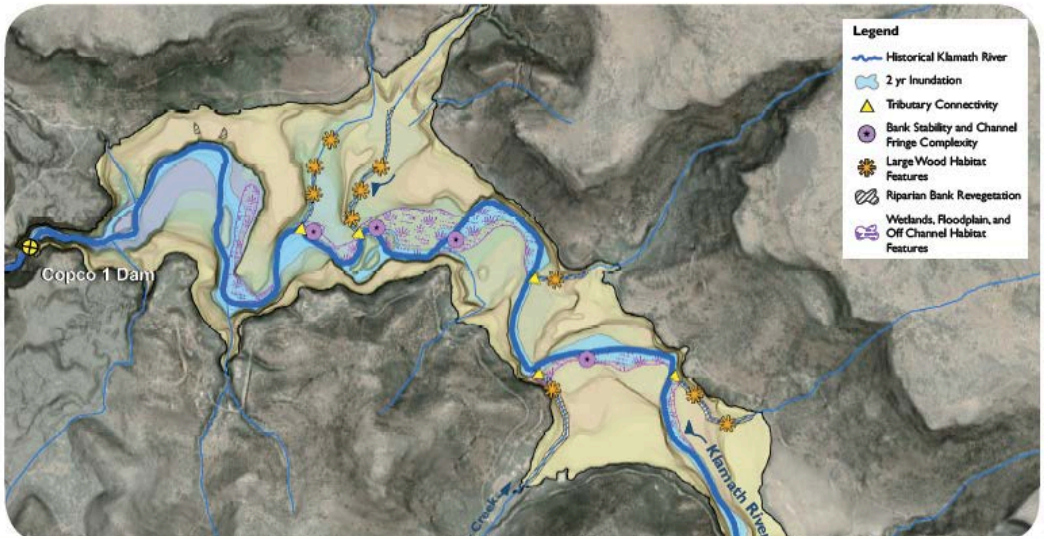
7. Dam and Hydropower Facility Removal

- Controlled release using modified infrastructure (January 1 start)
- Drawdown to tunnel inverts by March 15
- Full dam and hydropower facility removal

KLAMATH RIVER RENEWAL CORPORATION

8. Reservoir Stabilization

- Stabilize remaining accumulated reservoir sediments (as appropriate)
- Fully restore reservoir areas to native habitats
- Monitoring and adaptive management



KLAMATH RIVER RENEWAL CORPORATION

9. Recreation Plan and Restoration

- New and enhanced recreation facilities to mitigate for impact to year-round Hell's Corner rafting corridor
- Developing Recreation Plan through stakeholder process
- Plan may include additional boating and fishing access and other new recreation features
- Will restore reservoir recreation areas to native habitats

KLAMATH RIVER RENEWAL CORPORATION

Thank you!

Mark Bransom, Executive Director
Mark@KlamathRenewal.org

KLAMATH RIVER RENEWAL CORPORATION

Additional Slides

Staff and Contractors Hired

Mark Bransom	*[Search Ongoing]*	Dave Meurer	Araxi Polony
Executive Director	CFO/COO	Community Liaison	Admin Assistant

AECOM

Technical representative

WATER AND POWER LAW GROUP PC

General counsel

CEA California Environmental Associates

Day-to-day contracted staff

PERKINSCOIE
COUNSEL TO GREAT COMPANIES

FERC counsel

Willis Towers Watson

Risk management advisors

Hawkins DELAFIELD & WOOD LLP

Construction and corporate counsel

Launched in July 2016

- Board appointed by settlement signatories
- Governance protocols and board policies adopted
- Hired staff and contractors
- Established initial risk management program
- Role is to decommission dams; not authorized to evaluate dam removal alternatives

KLAMATH RIVER RENEWAL CORPORATION

Financial management and controls

- Policies
  - Comprehensive internal accounting system
  - Financial controls system
  - Conflict of interest
  - Etc.
- Board-adopted budgets through 6/18
- Independent audit for FY 16-17
- Reports to funders

Technical Studies

- “Definite Plan” no later than July 2018
- Field studies & technical assessments
- Risk management – insurance and liability protections

Procurement Process For Construction Services

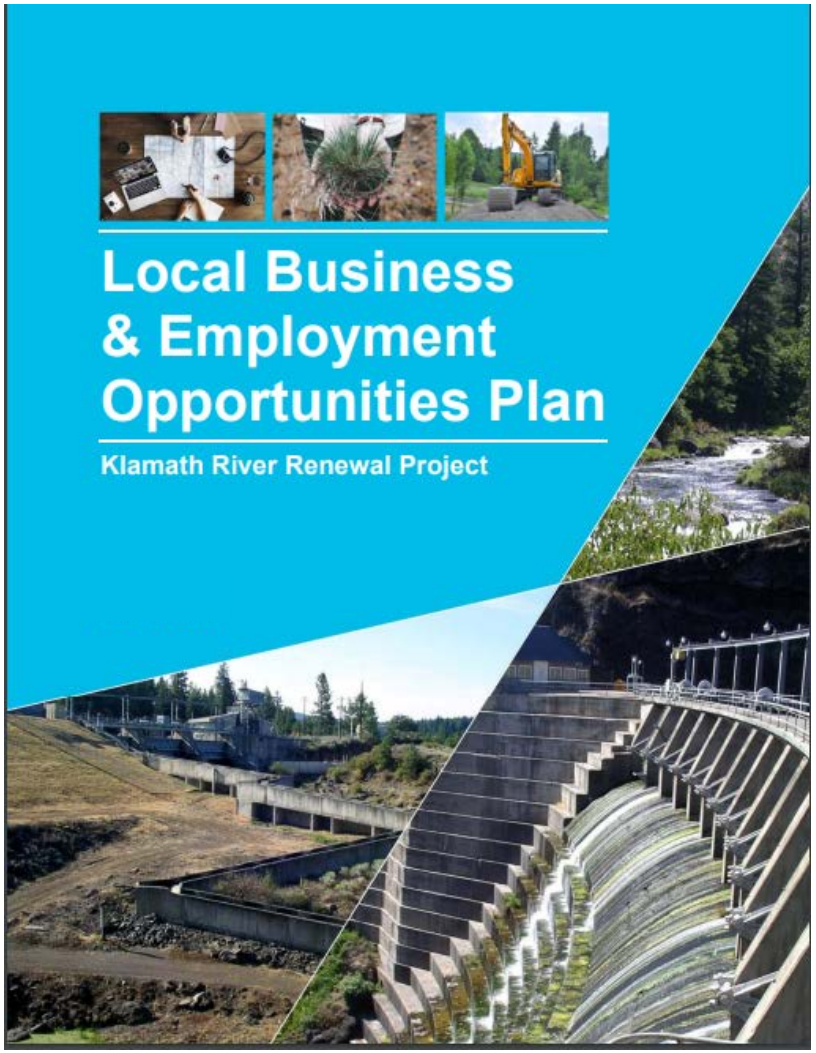
- Evaluate work packaging & construction delivery methods
- Initiating procurement process Spring 2018
  - Seed collection & plant propagation
  - Pre-construction services

Communications & Outreach

- Elected officials
- Tribal nations
- Economic development
- Landowners
- Recreation
- Agriculture
- Commercial fishing
- Environmental
- General public

Local Jobs

- KRRC prioritizes local hiring and contracting
- Partners with economic development agencies, local chambers of commerce, and local community colleges
- Supports these groups to
  - Hold job fairs
  - ID job training programs
  - Post job opportunities



Why River Renewal?

- The Klamath River's fisheries and water quality have been in decline for decades
- Local communities began developing collaborative solutions:
  - KRRC is leading decommissioning, a crucial first step to restore health of the river and its communities
  - Communities will continue to take other steps toward a shared, sustainable future for the Klamath Basin

Photo Credit: Karuk

History of Dam Removal Discussions

- 2006: PacifiCorp's license for hydro project expires
- 2010: Parties agree to KBRA and KHSA
- 2015: KBRA expires due to congressional inaction
- 2016: Parties sign amended KHSA and KRRC forms
- Present: KRRC is implementing amended KHSA and is pursuing dam decommissioning

KLAMATH RIVER RENEWAL CORPORATION

Amended Klamath Hydroelectric Settlement Agreement, 2016

- Approved by 23 parties
- Transfers four dams to KRRC
- License transfer & surrender is subject to FERC
- Requires no congressional funding or approval

KLAMATH RIVER RENEWAL CORPORATION

KRRC Board Members

- California
  - Lester Snow, Vice President
  - Michael Barr
  - Leon Szeptycki
  - Ricardo Cano
  - (Vacant)
- Oregon
  - Michael Carrier, President
  - Jim Root, Treasurer
  - Gov. Theodore Kulongoski
  - Krystyna Wolniakowski
- Karuk Tribe
  - Wendy “Poppy” George
- Yurok Tribe
  - Scott Williams
- Klamath Tribes
  - (Vacant, if they sign the Amended KHSA)
- NGOs
  - Laura Rose Day
  - Thomas Jensen
  - Michael Gerel

KLAMATH RIVER RENEWAL CORPORATION

Signatories of the Amended KHSA

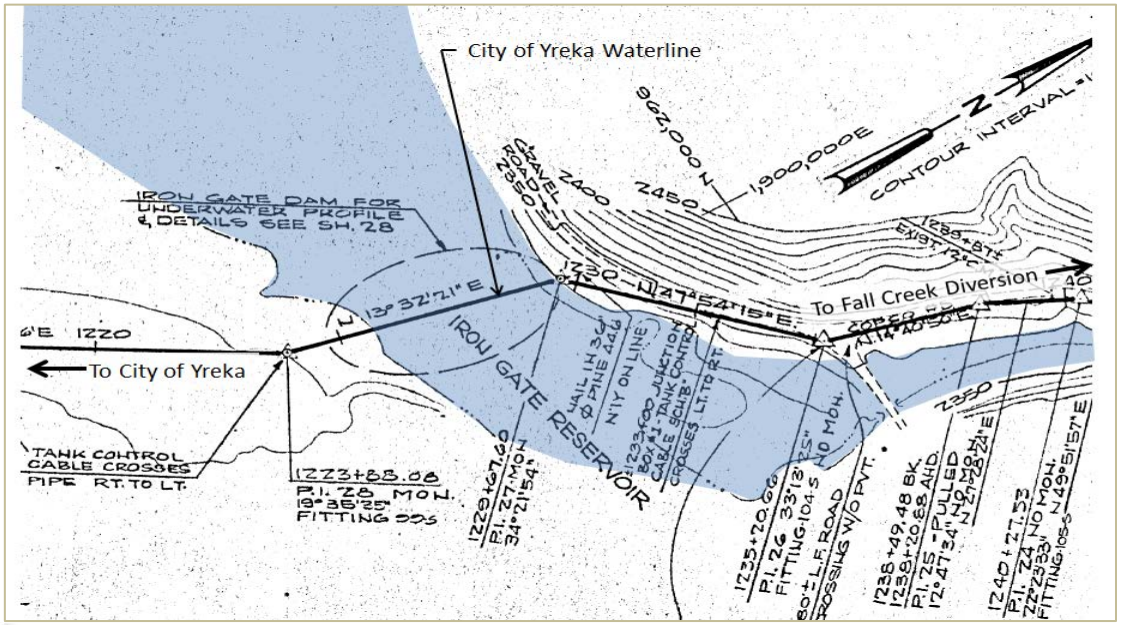
As of December 31, 2016

1. Department of the Interior
2. NOAA Fisheries
3. PacifiCorp
4. California Governor
5. Oregon Governor
6. California Fish and Wildlife
7. California Natural Resources Agency
8. Oregon Department of Environmental Quality
9. Oregon Department of Fish and Wildlife Department
10. Oregon Department of Water Resources
11. Yurok Tribe
12. Karuk Tribe
13. Humboldt County
14. American Rivers
15. California Trout
16. Pacific Coast Federation of Fishermen's Associations
17. Institute for Fisheries Resources
18. Federation of Fly Fishers
19. Trout Unlimited
20. Sustainable Northwest
21. Klamath River Renewal Corporation
22. Salmon River Restoration Council
23. Upper Klamath Water Users Association

KLAMATH RIVER RENEWAL CORPORATION

Primary Work Components/Categories

1. City of Yreka Intake and Pipeline Replacement
   - Relocate 24-inch water supply pipeline at upstream end of Iron Gate Reservoir (currently considering 4 options)
   - Potentially install new fish screens at existing diversion facility
   - Must be completed prior to reservoir drawdown and dam removal



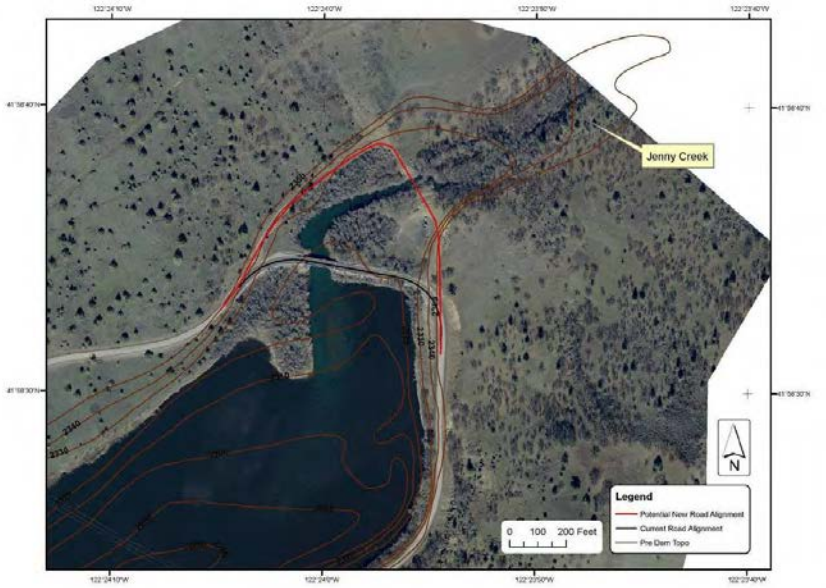
Primary Work Components/Categories

2. Temporary Construction Access Improvements
   - Numerous temporary construction access improvements associated with the project to allow for sufficient mobilization and construction related traffic
   - May include local road widening, development of turn-outs, road surface improvement, bridge improvement, etc.
   - Must be completed prior to related construction activity

KLAMATH RIVER RENEWAL CORPORATION

Primary Work Components/Categories

3. Permanent Road and Bridge Improvements
   - Improve several roads and bridges to mitigate impact from dam removal
   - Bridges at Daggett Road and Lakeview Road and on Copco Road at Dry Creek, Fall Creek, Camp Creek, and Jenny Creek
   - Culvert replacement at Scotch Creek

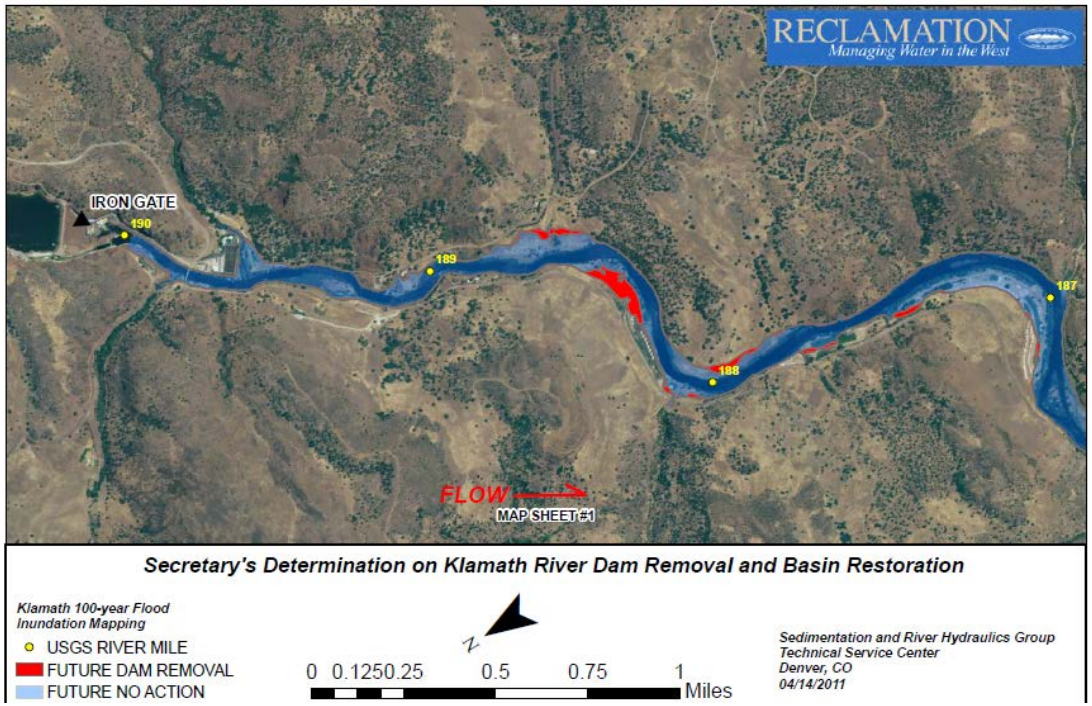


KLAMATH RIVER RENEWAL CORPORATION

Primary Work Components/Categories

4. Downstream Flood Control Improvements

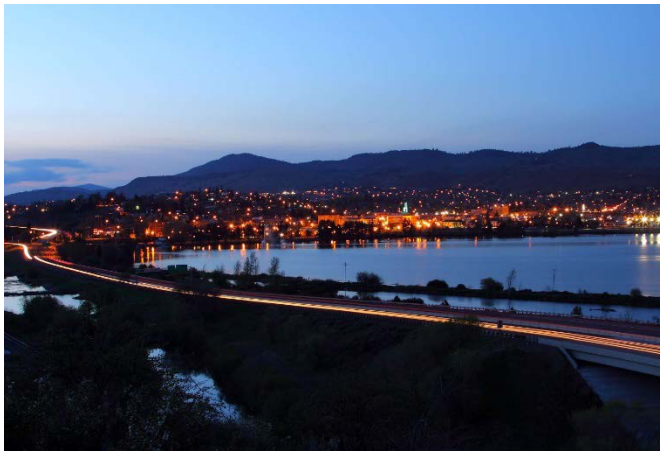
- Increased risk of flooding in 18-mile reach downstream of Iron Gate Dam to Humbug Creek
- Install flood control improvements to mitigate increased flood risk to up to 45 structures



KLAMATH RIVER RENEWAL CORPORATION

Dam Removal Benefits

- **Electricity:** lower cost for customers than upgrading dams due to agreement protections
- **Water quality:** improved temperature, oxygen, acidity, algae
- **Fish health:** improved habitat, less disease
- **Recreation**: expanded fishing opportunities, especially for steelhead
- **Agriculture**: does not impact ag diversions; Link and Keno dams stay in place
- **Jobs:** will create a few hundred direct jobs and over a thousand indirect jobs in the short term; longer term will benefit recreation and commercial fishing industries



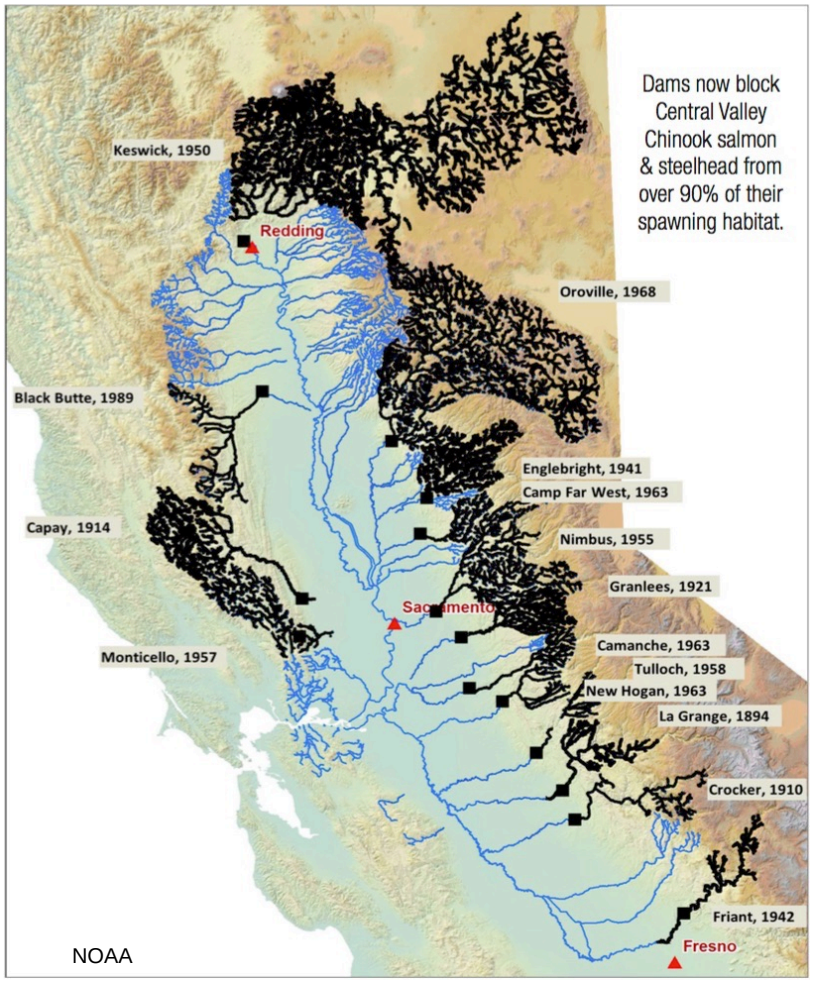
Strategies for Repopulating the Upper and Middle Klamath River with Salmon and Steelhead Following Dam Removal

John Carlos Garza
Southwest Fisheries Science Center
National Marine Fisheries Service
and
University of California, Santa Cruz

NOAA Fisheries
National Marine Fisheries Service

Why Repopulation?

- Much of American West is arid, but huge agricultural production and urbanization.
- Massive water development, with dams on almost every major river. Water operations degrade much of remaining habitat.
- Construction of dams and water diversions has eliminated ~90% of spawning habitat for ESA salmonids in the Central Valley.
- In other places, combinations of water projects, forestry practices and other habitat modifications have led to extirpations.



Why Reintroductions?

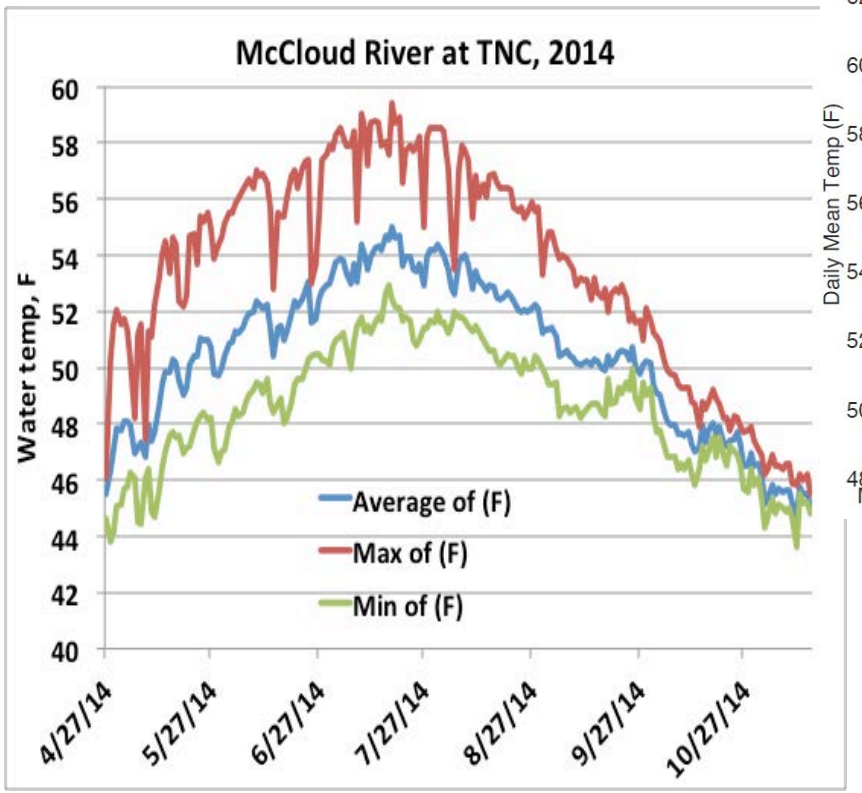
•Huge investments in habitat restoration have been made, and some of these dams are coming out. Yeah!

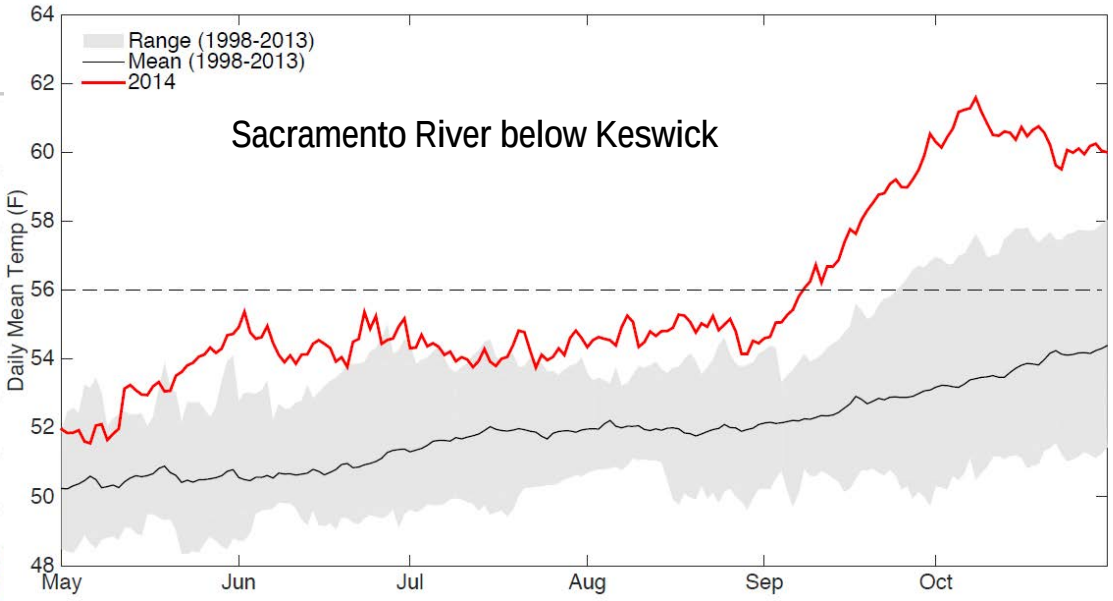
Why Reintroductions?

- Others are not. Sigh.

Why Reintroductions?

Temperature refugia





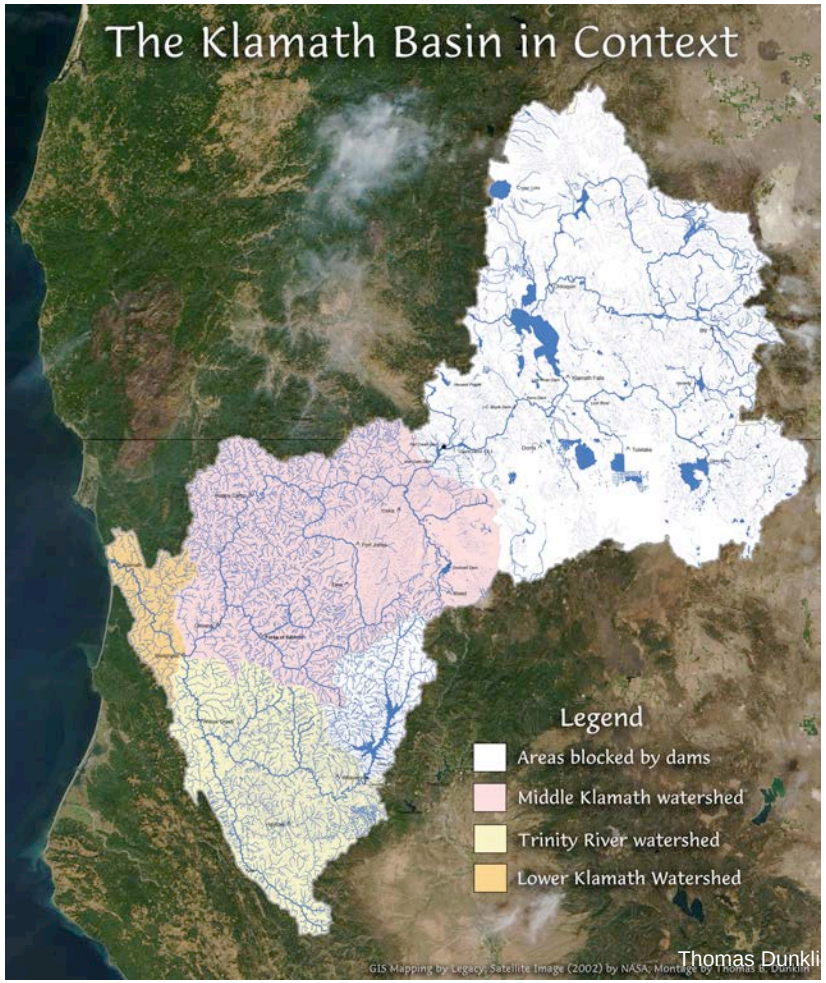
Climate Change will likely mean many more such temperature crises.

Salmonid Reintroduction Projects Underway or Actively Planning

- San Joaquin River- Spring-run Chinook Salmon
- North Yuba River- Spring-run Chinook Salmon
- McCloud/Upper Sacramento- Winter-run & Spring-run Chinook Salmon
- Battle Creek- Winter-run Chinook Salmon
- Upper Klamath- Spring-run & Fall-run Chinook Salmon, Coho Salmon, steelhead

Klamath Dam Removal

- Four dams owned by PacifiCorp are slated for removal in 2020
- Consequence of fish passage prescription at FERC relicensing a decade ago
- Largest dam removal and river restoration project in the history of the world
- Over 250 river miles of andromous fish habitat will become (mostly) accessible
- Three types of salmon, coho, fall Chinook, spring Chinook will have access, as will steelhead and lamprey.



Evaluation of potential donor stocks

- Usually can not predict stock-specific response to newly available habitat
- Should encompass the genetic & phenotypic diversity of the donor stock(s)
- Ensure broodstock mining doesn't demographically threaten donor stocks
- Initial phases should involve relatively "low value" fish: show me the river
- Different goals for hatchery support in different phases of reintroduction
- Can be conflicting considerations for different species
- New genetic tools can help identify appropriate donor stocks: Omy 5, GREB1L marker based evaluation

Strategies for Reintroduction

- Passive recolonization: requires relatively abundant source population in proximity to newly available habitat. Source population must have appropriate values of life history traits.

- Ex-situ (i.e., hatchery) production with juvenile releases
    - Traditional approach: not very successful

- Assisted migration: juveniles or adults
    - Move juveniles from natal habitat to newly available habitat
    - Capture migrating adults, or use captively raised adults, and move them directly to spawning habitat at maturation.

Upper Klamath/Trinity Coho Salmon

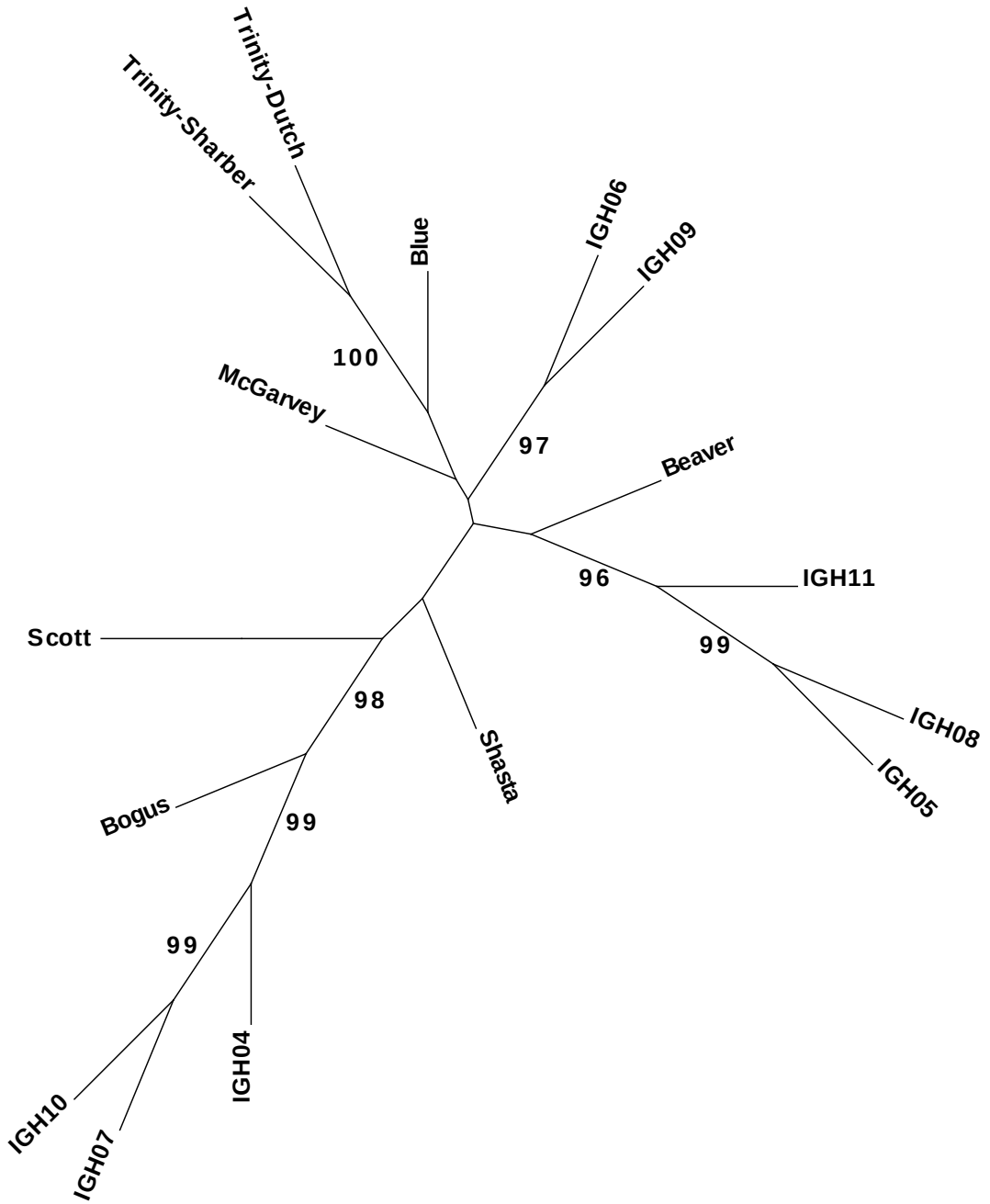
- Most challenging and most likely to need ex-situ (i.e., hatchery) intervention

- Abundance extremely low in the Middle Klamath: not enough fish to go around

Spawn Year	Total no. returns Shasta	Total no. returns Iron Gate
W2010/2011	44	513
W2011/2012	62	553
W2012/2013	115	601
W2013/2014	134	1350
W2014/2015	46	395
W2015/2016	45	72
W2016/2017	52	86
W2017/2018	41	116

Detailed Analysis of Klamath Basin Coho Salmon Population Structure

Round Two
3037 salmon
16 microsatellites
93 SNPs



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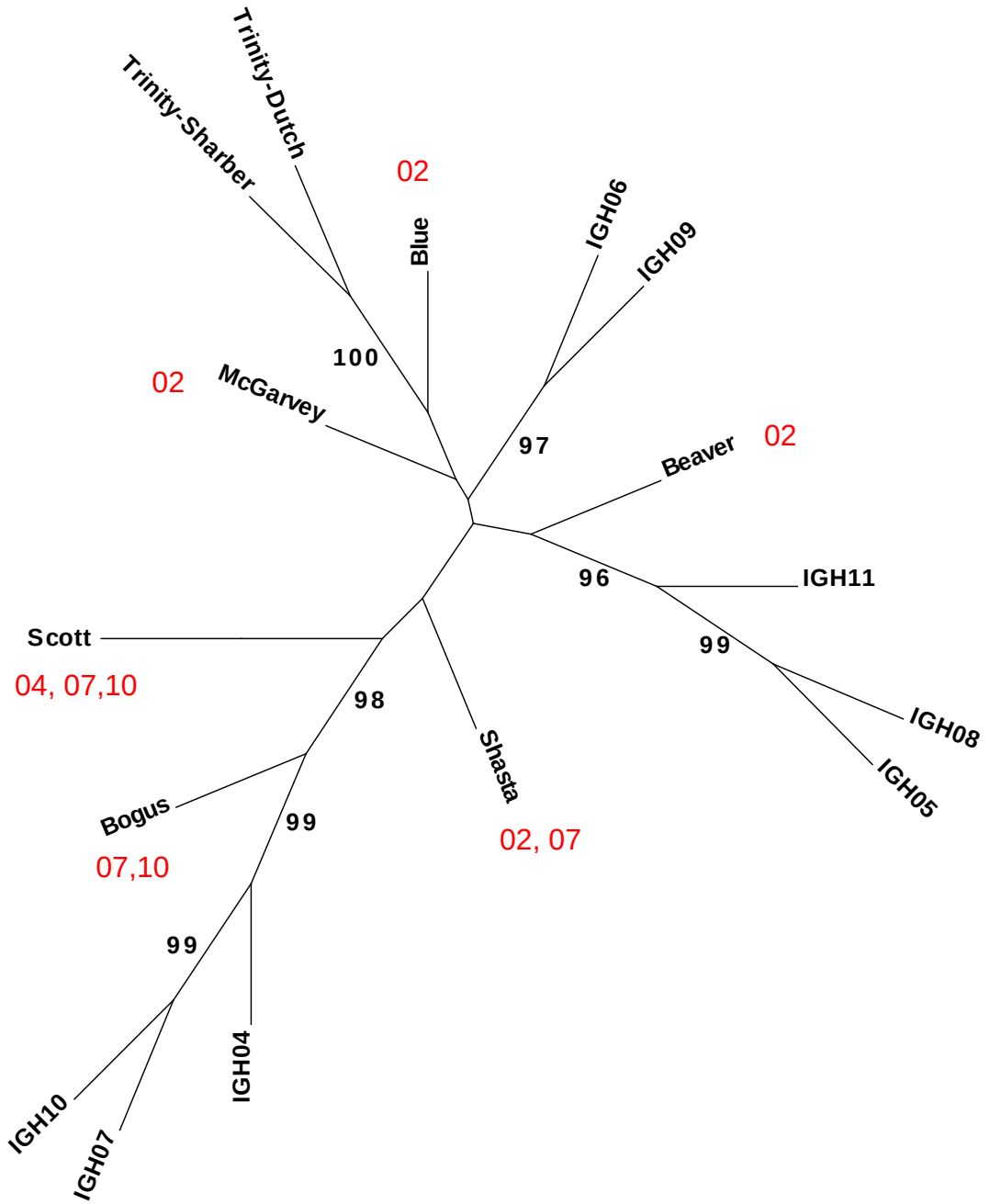
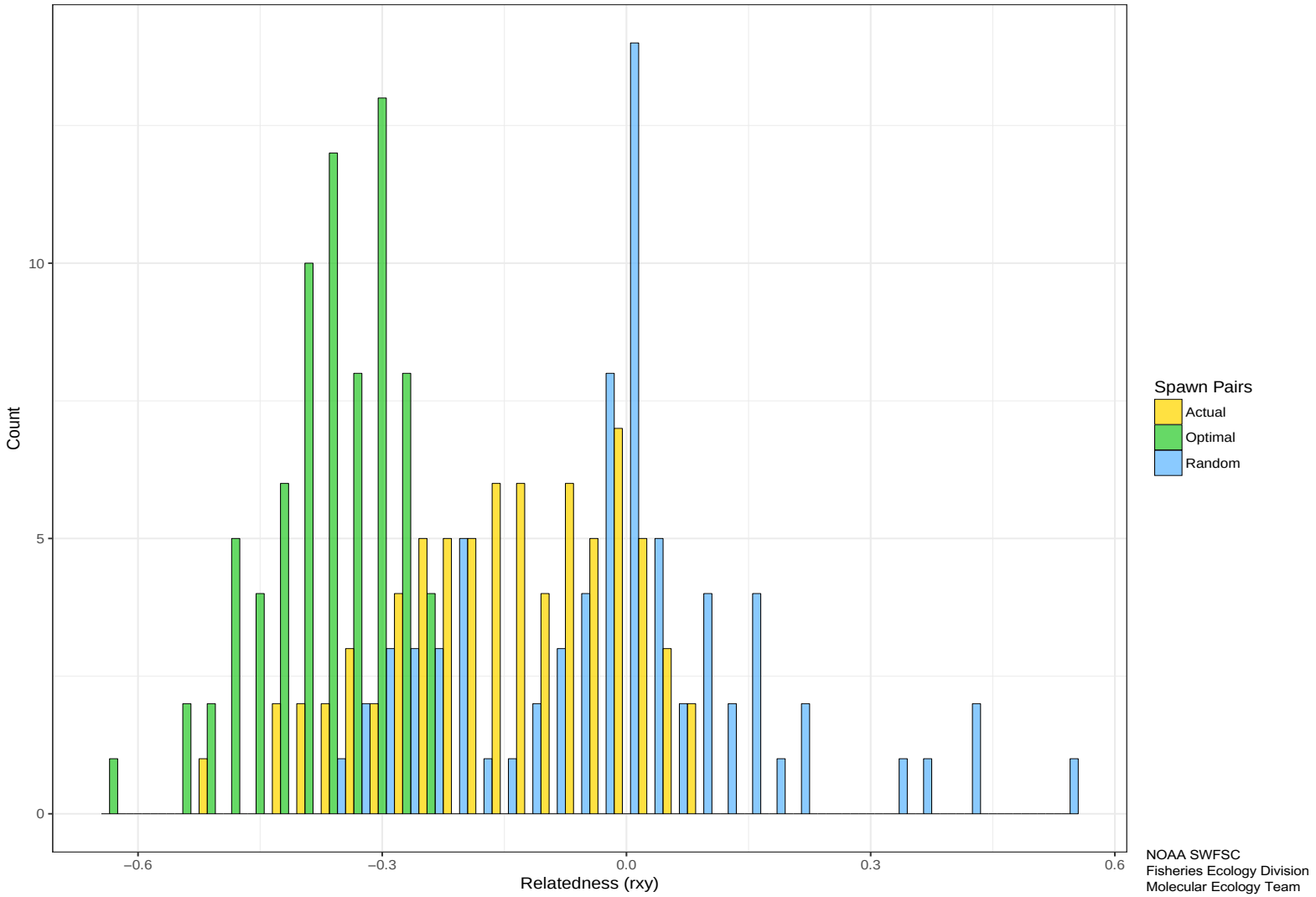


Iron Gate Hatchery coho salmon broodstock, 2017/2018 spawn season:
relatedness distributions of actual, optimal and random spawn pairs (39 females, 75 crosses)



NOAA SWFSC
Fisheries Ecology Division
Molecular Ecology Team

Upper Klamath Steelhead

Not a reintroduction but a supplementation project with potential integration of steelhead with current resident and redband trout populations.

California Hatchery Scientific Review Group Report

3. Issues of Greatest Importance for Management of California's Salmon and Steelhead Hatcheries

3.11 Several Steelhead Programs Have Seriously Underperformed

Several steelhead programs reviewed by the California HSRG were observed to be underperforming or potentially detrimental to native steelhead populations…….. Several steelhead programs experience very low adult return rates and appear to use resident fish as broodstock. At **Iron Gate** and Mokelumne River hatcheries, adult return rates are so low in comparison to historical returns, that the California HSRG recommends managers review the existing programs and develop alternative…. strategies so as to meet program goals and objectives……. The California HSRG believes that the recommendations for steelhead hatchery programs in this report should be assigned a high priority for implementation, and that continuing improvements in monitoring freshwater returns, including creel surveys, also have high priority.

Upper Klamath Steelhead

Not a reintroduction but a supplementation project with potential integration of steelhead with current resident and redband trout populations.

Questions to ponder

-Where will the fish come from?

Population structure considerations

-What will the fish do?

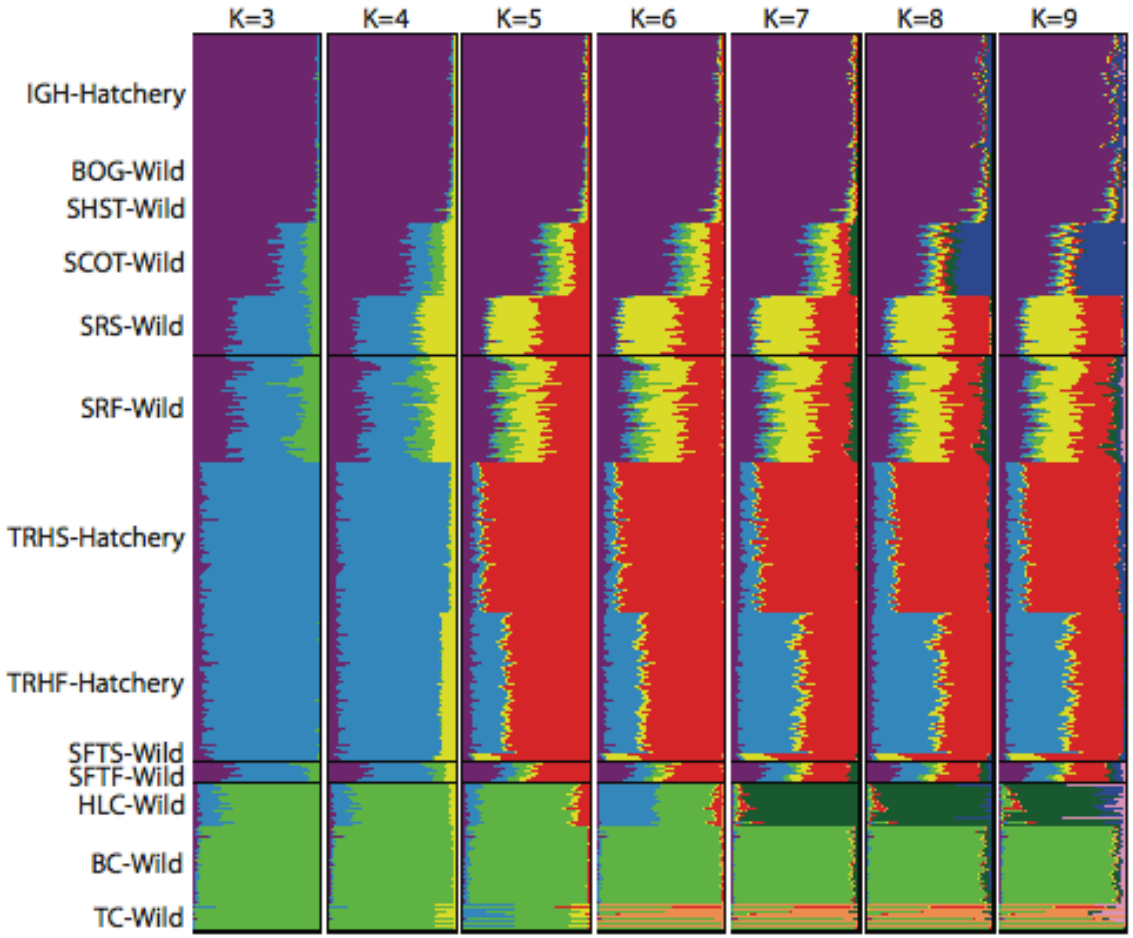
Life history heritability & outcomes of hybridization.

-Who are the fish?

Trapping opportunities and family relationships.

Upper Klamath/Trinity Chinook Salmon

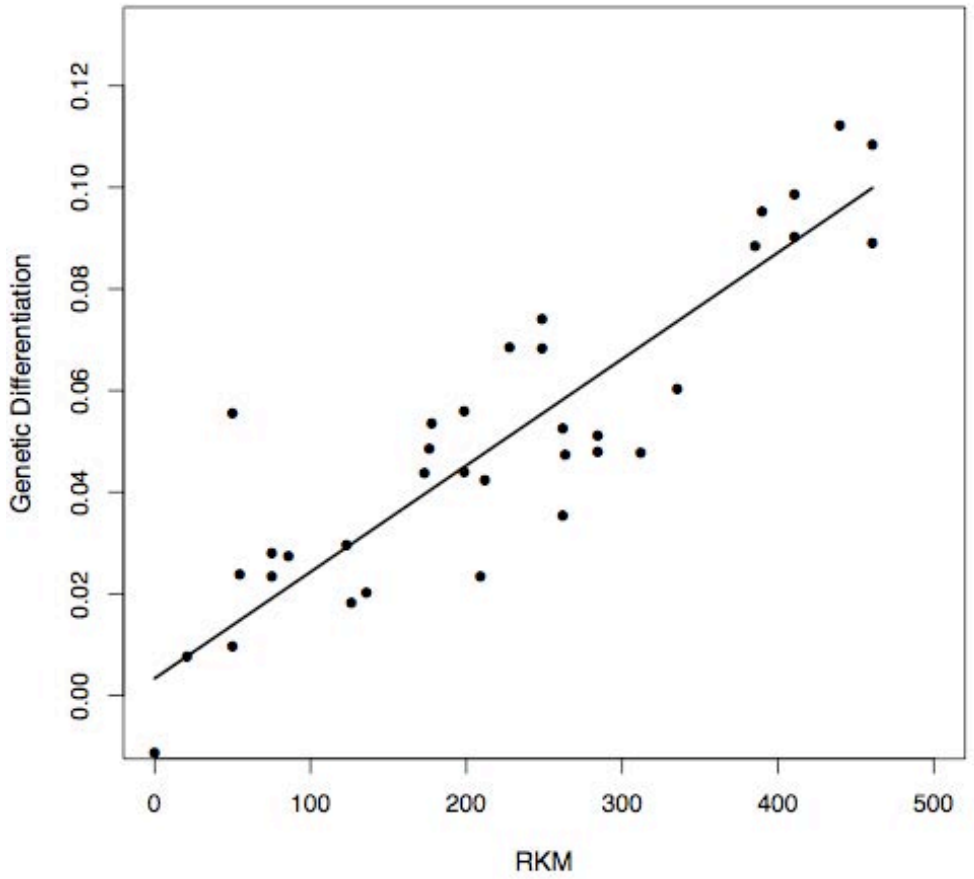
Model-based clustering analysis-*structure*



Kinziger, Hellmair, Hankin, Garza 2013, TAFS

Upper Klamath/Trinity Chinook Salmon
Isolation by Distance

Strong correlation between genetic and geographic distance
R^2=0.80
Intercept ≈ 0



Kinziger, Hellmair, Hankin, Garza 2013, TAFS

Upper Klamath/Trinity Chinook Salmon

GREB1L: Genomic marker for ecotype discrimination in Chinook salmon and steelhead

	Mature/ Mature	Mature/ Premature	Premature/ Premature
Trinity-Spring		0.02	0.98
Trinity-Fall	0.64	0.30	0.07

Upper Klamath/Trinity Chinook Salmon

GREB1L: Genomic region associated with ecotype discrimination in Chinook salmon and steelhead

	Mature/ Mature	Mature/ Premature	Premature/ Premature
Trinity-Spring		0.02	0.98
Trinity-Fall	0.64	0.30	0.07
Klamath-UpperMain	0.51	0.44	0.05
Eel-UpperMain	0.96	0.04	
Feather-Spring		0.06	0.94

Strategies for Reintroduction

- Passive recolonization: requires relatively abundant source population in proximity to newly available habitat. Source population must have appropriate values of life history traits.

- Ex-situ (i.e., hatchery) production with juvenile releases
    - Traditional approach: not very successful

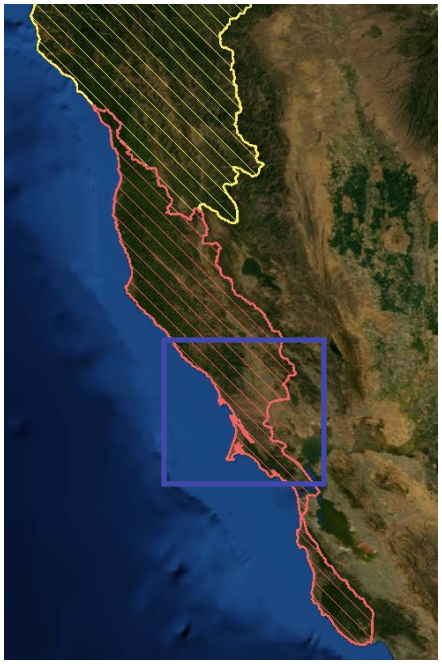
- Assisted migration: juveniles or adults
    - Move juveniles from natal habitat to newly available habitat
    - Capture migrating adults, or use captively raised adults, and move them directly to spawning habitat at maturation.

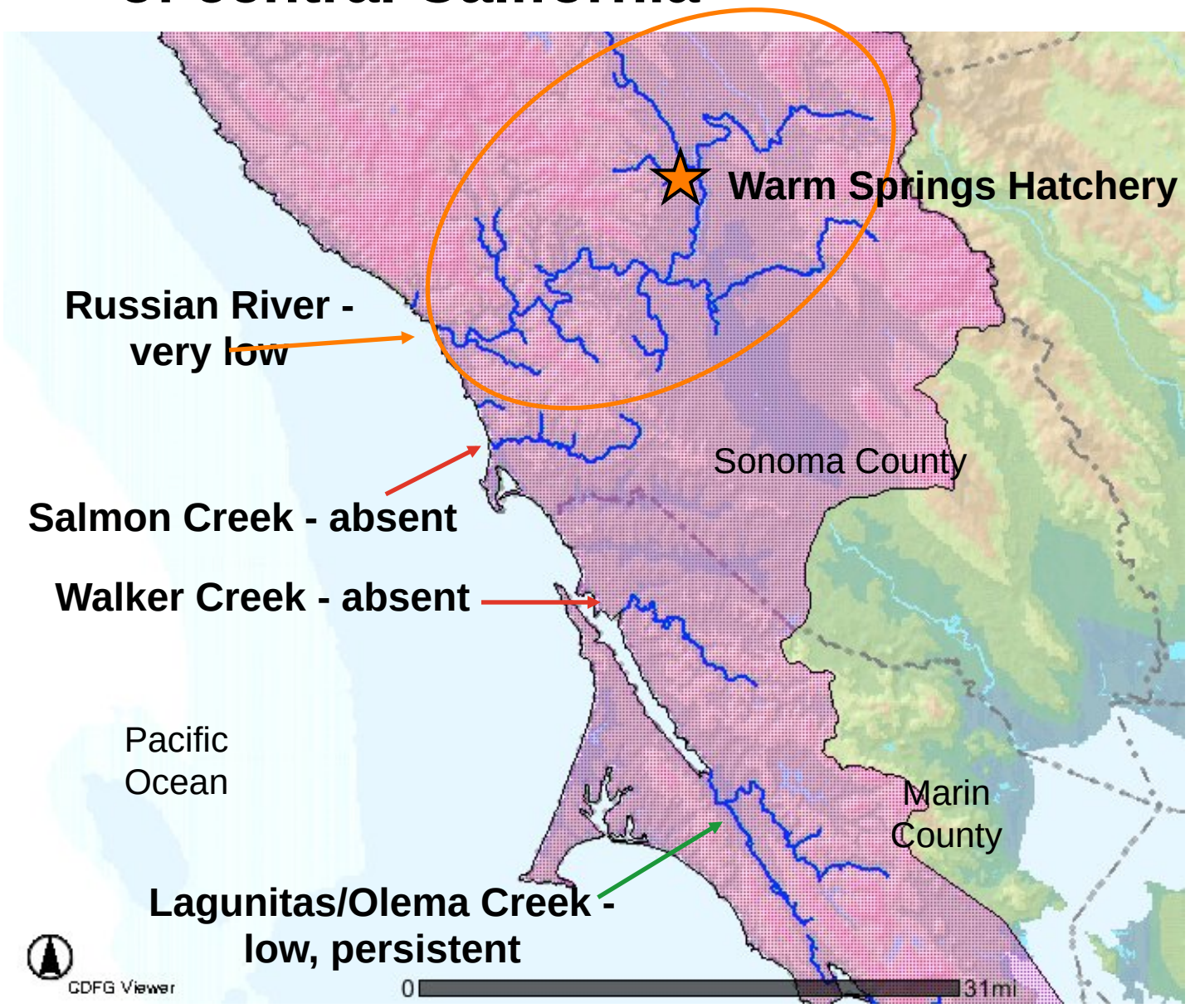
Adult Release Strategy

- Directly connects spawners with habitat
- Jumpstarts natural selection: immediately have natural origin fish
- Imprinting is complete
- Potential downside?: Not all released adults appear to be reproduce successfully. But that is probably a good thing.
- Extensive proof of concept with coho salmon. Now in use with Spring-run Chinook salmon.

Coho salmon populations in coastal watersheds of central California

Central California Coast Coho Salmon ESU

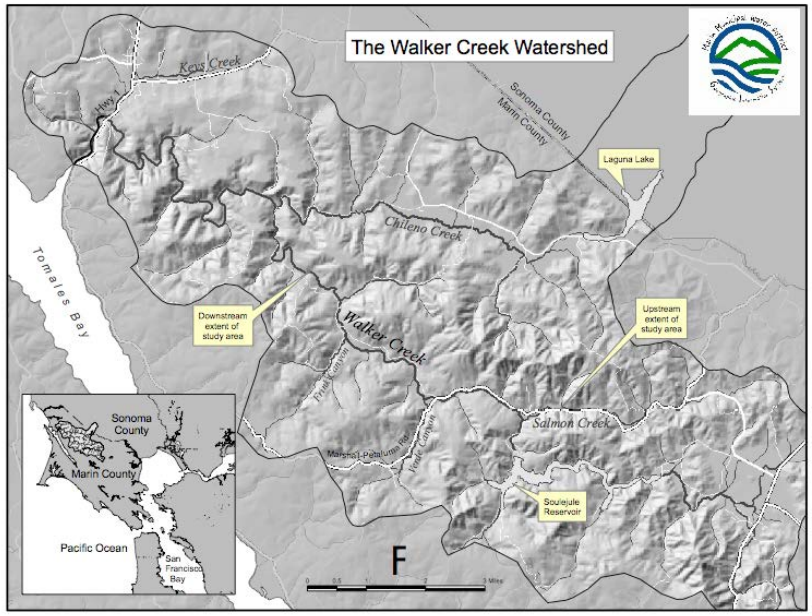




Release of captively-raised maturing adult coho salmon as a novel strategy for restoration and recovery-Walker Ck

Released into Walker Creek:

•December 2003, 2004, 2005 and 2007 - adult captive broodstock from Olema & Blueline Creeks (n=264 total)



•8 young-of-year (YOY) of BY03 -- 7 of these, sampled in one location, are offspring of hatchery-reared adults released in December 2003

•2 YOY and 2 jacks of BY04 -- 3 of these are offspring of at least one Olema Creek parent released in December 2004

•17 YOY of BY06 assign strongly to Olema Creek but parents unknown -- offspring of adults entering naturally to spawn

Release of captively-raised maturing adult coho salmon as a novel strategy for restoration and recovery-Salmon Ck

•Salmon Ck.- no coho salmon since ~1980

•Adults from Lagunitas Creek (N=152) and from the Russian River (N=158) released in December 2008

•Juveniles confirmed and sampled in two creeks, Fay Creek (N=105) and Finley Creek (N=105) in July 2009.

•Genotyped with 18 microsatellites. Data analyzed with NewHybrids. Sibship reconstruction with Almudevar & Field (1999).

Origin of coho salmon in Salmon Creek

No. of individuals

	Russian x Russian	Lagunitas x Lagunitas	Hybrid
Fay Ck	8	35	62
Finley Ck	0	14	90

No. of Matings

	Russian x Russian	Lagunitas x Lagunitas	Hybrid
Fay Ck	1	2	5 or 6
Finley Ck	0	1	2

NewHybrids posterior probabilities had mean of 0.99 to assigned genealogical class.

Genetic Management of Reintroduction

- Intensive monitoring and evaluation with intergenerational genetic tagging to evaluate whether fitness differences are stock-specific
- Individuals considered for reintroduction assessed with genetic techniques for relationship inference and stock identification
- Supplementation strategies that involve captive breeding must use genetic broodstock management: breeding directed by relatedness
- Adaptive management backed by **strong monitoring, evaluation and oversight** will be needed to determine success.

Acknowledgments

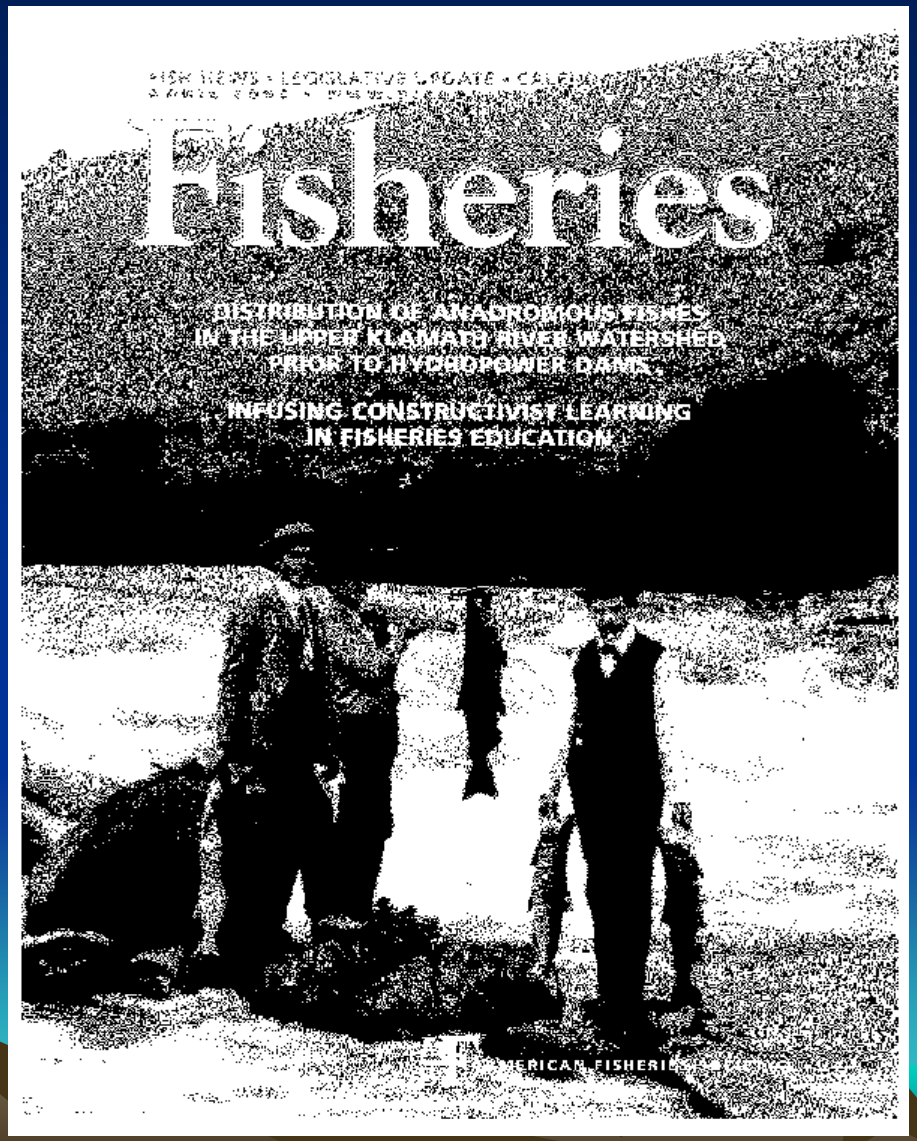
- Eric Anderson
- Anthony Clemento
- Cassie Columbus
- Libby Gilbert-Horvath
- Devon Pearse
- Neil Thompson
- Jon Ambrose
- Scott Harris
- Domenic Guidice
- Andrew Kinziger
- Manfred Kittel
- Morgan Knechtle

Presentation for Salmonid Restoration Federation

4/13/18

John Hamilton
(Retired)

Background – April 2005



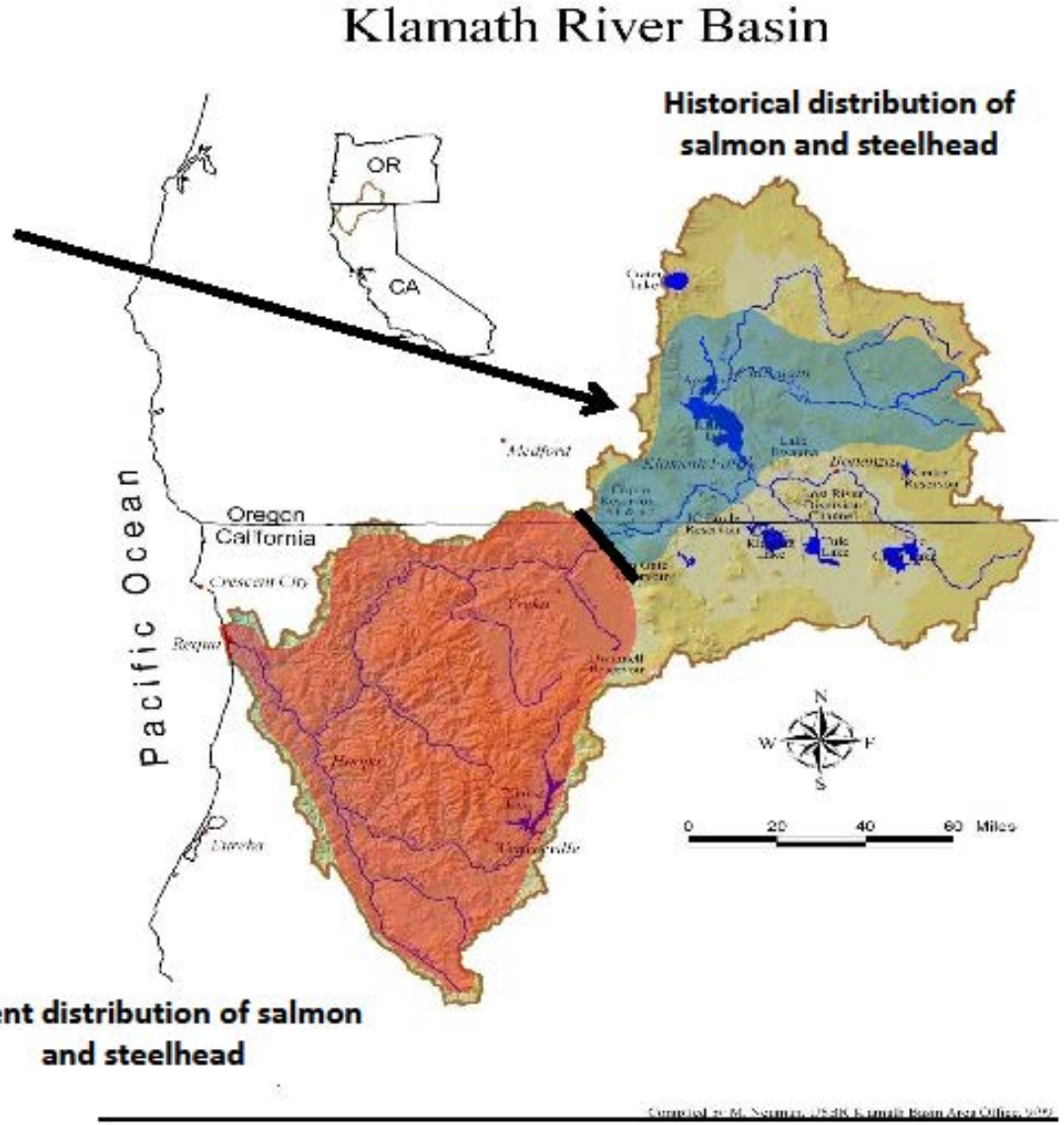
Background Klamath FERC 2005/2006

- March 2006 Klamath Hydro License Expired and Preliminary Fishway Prescriptions signed
- Nearly identical DOI and DOC Prescripts
- April 2006 – material facts challenged & alternative proposed
- August 2006 – Trial Type Hearing (TTH)
-

Administrative Law Judge TTH Finding (Sept. 2006):

- Chinook salmon (both spring and fall-run) were abundant in the tributaries of Upper Klamath Lake, including Jenny, Fall, and Shovel Creeks, as well as the Wood, Sprague, and Williamson rivers. (*NMFS/FWS-Issue 2A)*

Provides Salmon and Steelhead access to at least 420 miles of historical habitat.



Present distribution of salmon and steelhead

Since 2005/2006 FERC Relicensing

- Additional Accounts of Chinook Salmon Brought to Our Attention
- Some of New Info Conflicted the Record Before FERC on Chinook Salmon in Upper Klamath
- The FERC Record Needed to be Updated

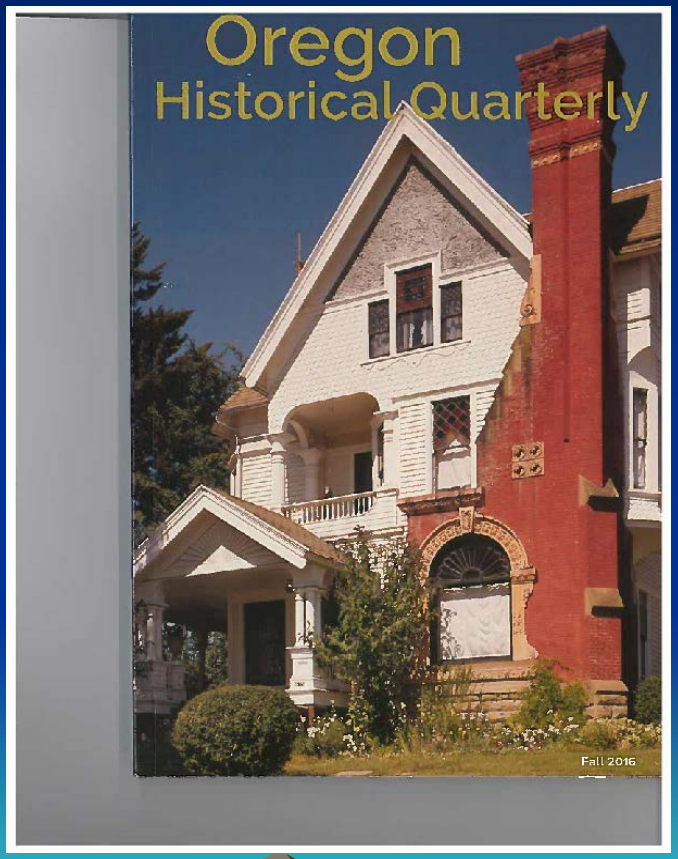
New Sources since 2005/2006: Digitized Historical Newspaper Collections

- California State Library – California Digital Newspaper Collection
- University of Oregon Library – Historic Oregon Newspaper Collection

Accounts of Salmon Upstream From IGD Since 2005/2006

Reach	2005 Publication	Accounts Since 2005
Upstream from IGD	17	**>100**
Link River and Upstream (Klamath Upper Basin)	12	**70*** ***We also found 5 stating that salmon migrated past IGD location but not to the Upper Basin**

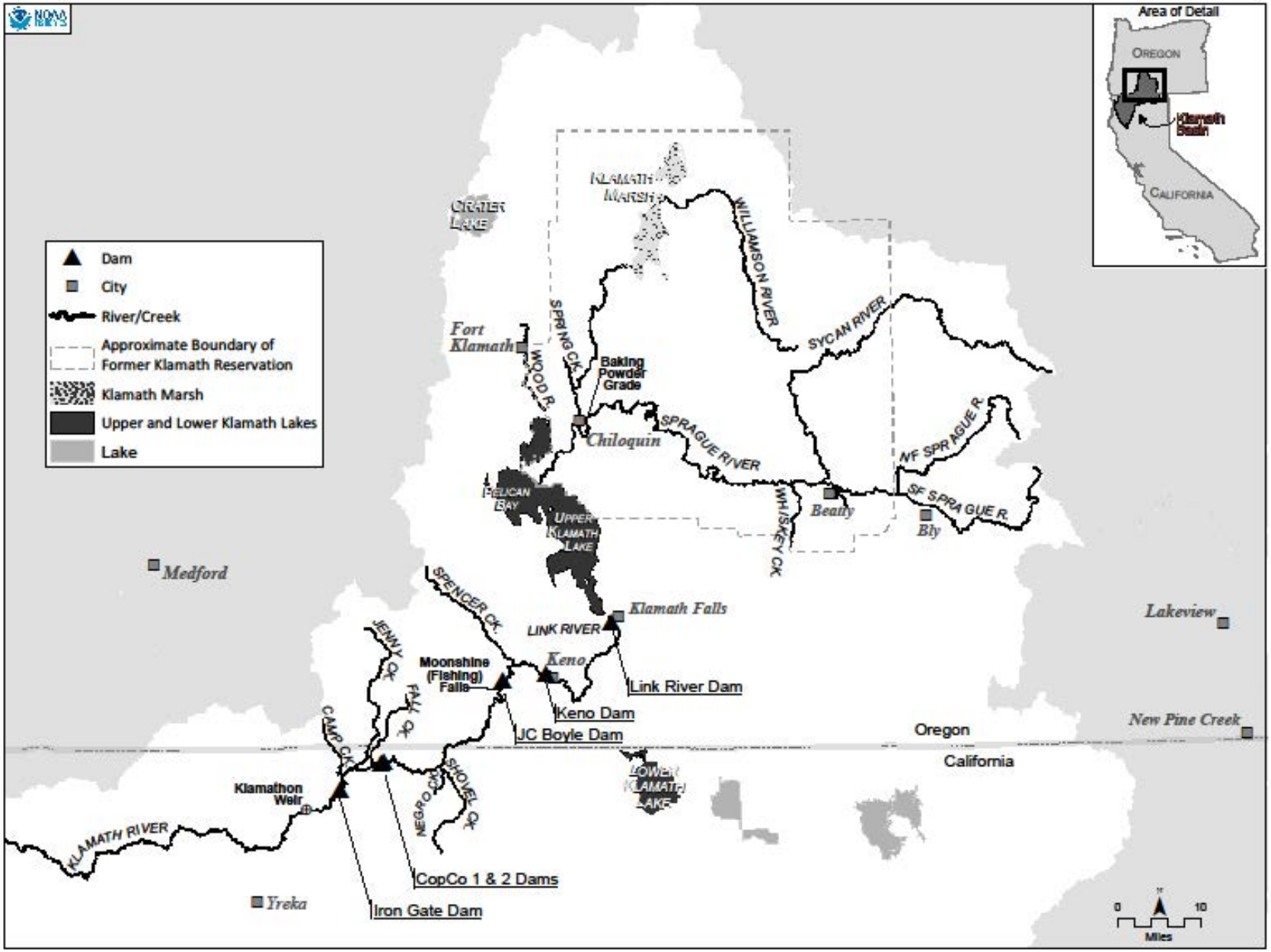
Fall 2016 Issue



The Persistence and Characteristics of Chinook Salmon Migrations to the Upper Klamath River Prior to Exclusion by Dams

John Hamilton, Yreka FWS
Dennis Rondorf, USGS
William Tinniswood, ODFW
Ryan Leary, Klamath Tribe
Tim Mayer, FWS
Charleen Gavette, NMFS
Lynne Casal, USGS

- Additional Accounts Now Means a Better Understanding of Historical Chinook Salmon Runs Upstream from IGD


Area of Detail
Oregon
Klamath Basin
California
Dam
City
River/Creek
Approximate Boundary of Former Klamath Reservation
Klamath Marsh
Upper and Lower Klamath Lakes
Lake
Crater Lake
Klamath Marsh
Williamson River
Sycan River
Fort Klamath
Spring Ck
Wood R.
Baking Powder Grade
Chiloquin
Sprague River
NF Sprague R.
SF Sprague R.
Beatty
Bly
Whiskey Ck
Pelican Bay
Upper Klamath Lake
Medford
Spencer Ck
Klamath Falls
Link River
Lakeview
Jenny Ck
Moonshine (Fishing) Falls
Keno
Link River Dam
Keno Dam
JC Boyle Dam
Fall Ck
Camp Ck
Oregon
California
New Pine Creek
Lower Klamath Lake
Klamathon Weir
Shovel Ck
Negro Ck
Klamath River
CopCo 1 & 2 Dams
Iron Gate Dam
Yreka
0
10
Miles

1889 Klamathon CA, Migration Blockage

- Timber Company constructed a Mill Dam without any Fish Ladder
- Many salmon trying to pass upstream were illegally trapped and sold

Blockage of Salmon Migration to Oregon Made this a Regional issue:

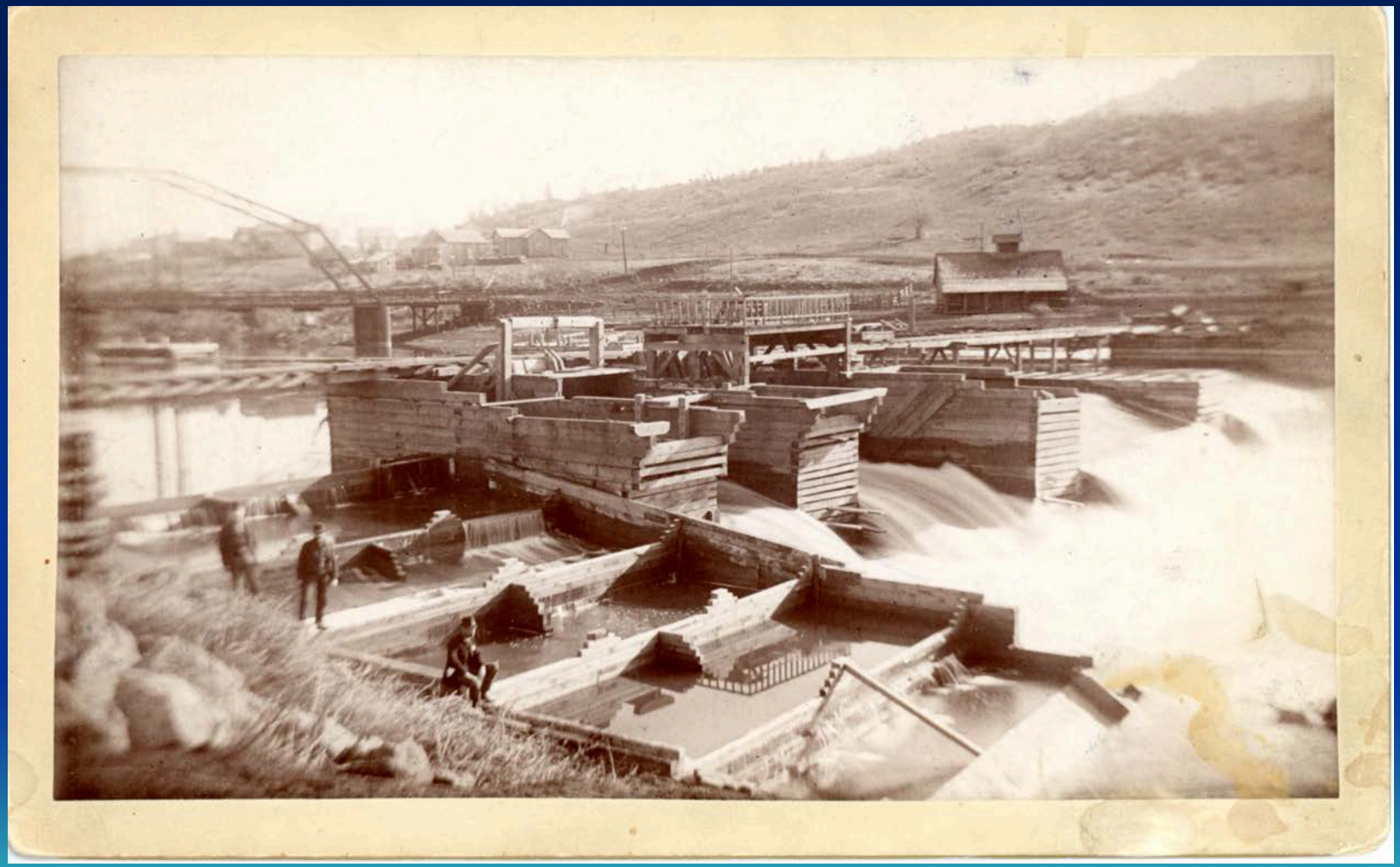
- Oregon Governor Penroyer insisted that "*measures be taken to stop the lawless acts and to have a fishway constructed that will allow the millions of salmon to pass up this important river, as this is the season they must go up to spawn*" (Sacramento Daily Union, September 25,1889)

Resolution of 1889 Klamathon Migration Blockage

CA Governor appointed a Siskiyou County Fish Commissioner & instructed the Sheriff to lend every assistance possible; fishing violators were arrested

The Company Responded by Constructing First Klamath River Fish Ladder

Late 1889 - Company Constructed Fish Ladder



What do Anecdotal Accounts Suggest about Abundance of Historical Runs of Chinook Salmon Upstream from IGD?

Historical Abundance Upstream from IGD

Year	Accounts: Non Occurrence	Accounts: Not Abundant	Accounts: Abundant
Pre-1910	NA	3	>41
Post -1910	**?**	**?**	**?**

Examples - Anecdotal Accounts of Abundance Range from Thousands to Millions

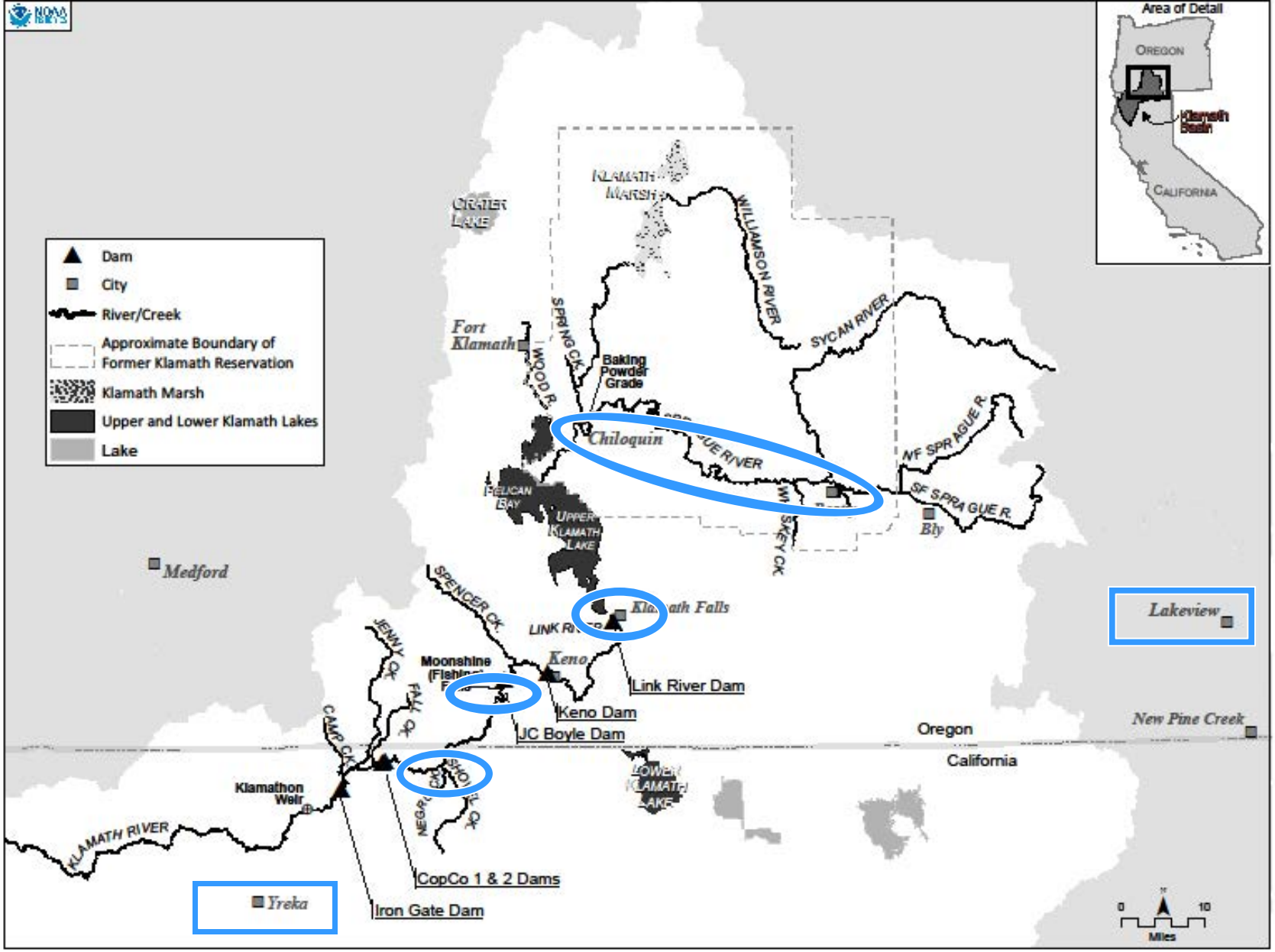
- *"..thousands of salmon are beating their lives out in an attempt to scale the falls* [Moonshine Falls]. *A fish ladder could be built …"* Portland *Sunday Oregonian* April 10, 1910

- *"…There are millions of the fish [salmon] below the falls near Keno…."* Klamath *Evening Herald*, September 24, 1908

Accounts of Upper Klamath River Harvest and Fishing Locations

Small Scale Commercial Harvest

- Four Locations
  - Shovel Creek, CA
  - Moonshine Falls, OR
  - Link River, OR
  - Sprague River, OR


Area of Detail
Oregon
Klamath Basin
California
Dam
City
River/Creek
Approximate Boundary of Former Klamath Reservation
Klamath Marsh
Upper and Lower Klamath Lakes
Lake
Crater Lake
Klamath Marsh
Williamson River
Sycan River
Fort Klamath
Spring Ck.
Wood R.
Baking Powder Grade
Chiloquin
NF Sprague R.
SF Sprague R.
Bly
Pelican Bay
Upper Klamath Lake
Wickey Ck.
Medford
Spencer Ck.
Link River
Klamath Falls
Lakeview
Jenny Ck.
Moonshine
Keno
Link River Dam
Keno Dam
JC Boyle Dam
Fall Ck.
Camp Ck.
Oregon
California
New Pine Creek
Lower Klamath Lake
Klamathon Weir
Klamath River
Negro Ck.
Shovel Ck.
CopCo 1 & 2 Dams
Iron Gate Dam
Yreka
0
10
Miles

Moonshine Falls: 1910

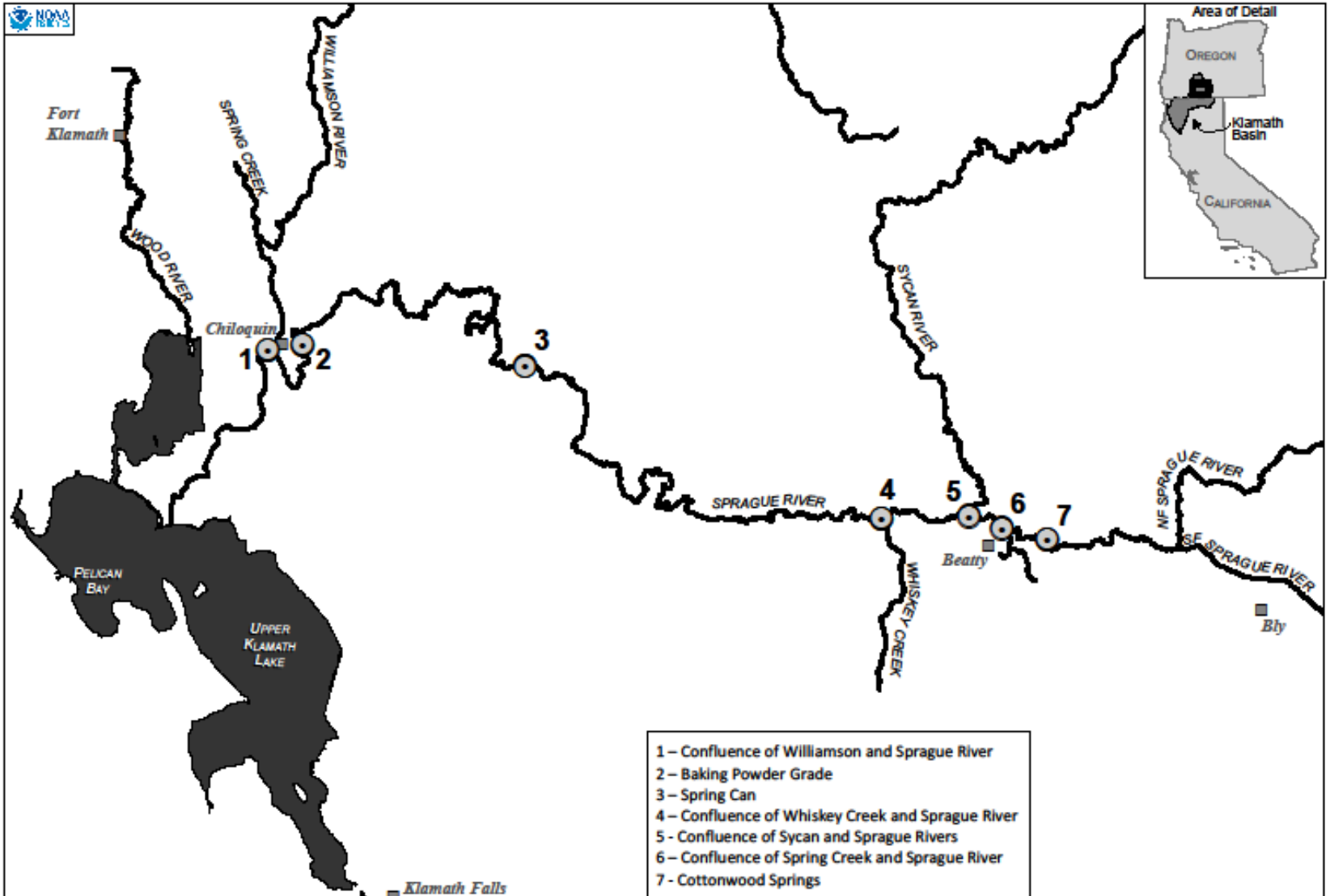
Salmon Fishing, Link River: (about 1907)

Gentlemen display their catch while salmon fishing on the rapids of Link River, 1891.

Sprague River: 1904

INDIANS AT HOME, KLAMATH RESERVATION, OREGON

“Indian Salmon Fishing Holes on the Sprague River” (Courtright 1941)



Recreational Fishing

Recreational Salmon Fishing: 1910, Klamath County

- "*Thousands of salmon enter the Klamath River [in Oregon] …The Klamath County Rod and Gun Club desires a special provision lifting the protection from salmon to permit Klamath people to get at least some benefit from the large salmon runs here during the Fall and Spring months. Now no one is allowed to fish other than with hook and line, and as salmon will not bite a hook this law gives people here absolutely no benefit from the millions of salmon in these waters*." Portland Morning *Oregonian*, December 10, 1910

Game Fishes of the World by C.F. Holder (1913) – salmon caught in Williamson River

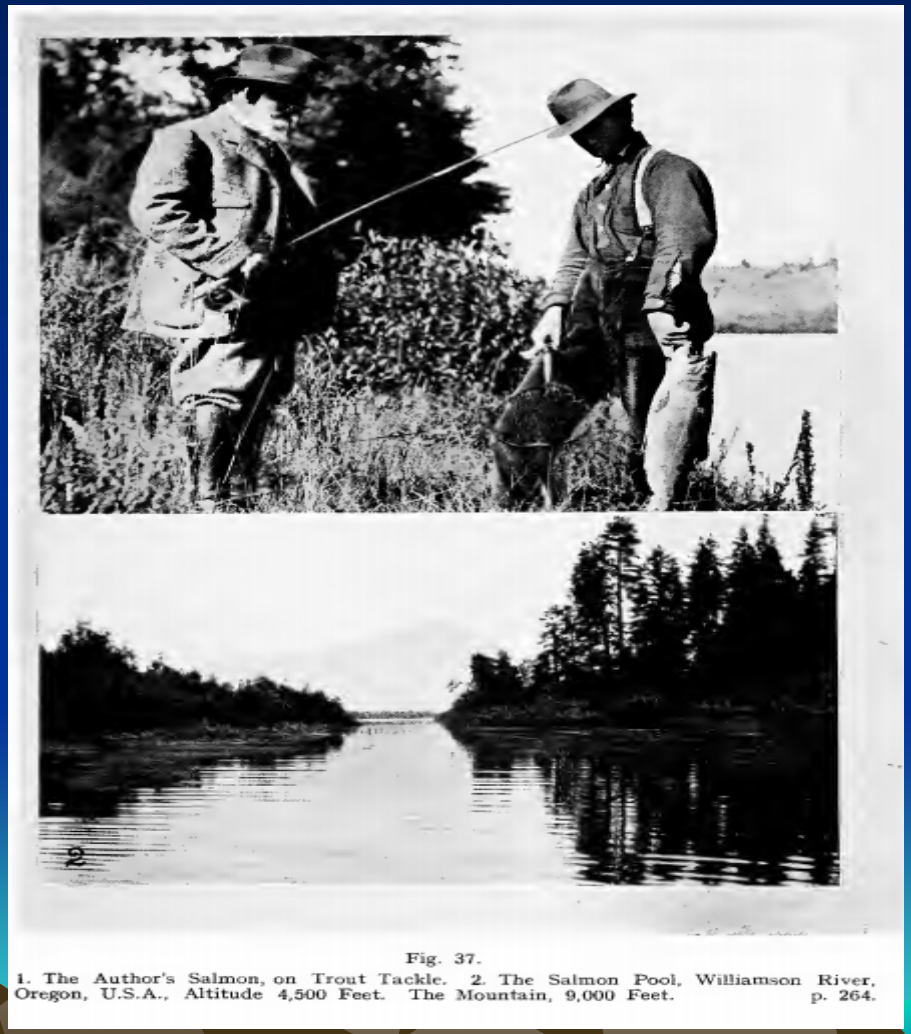
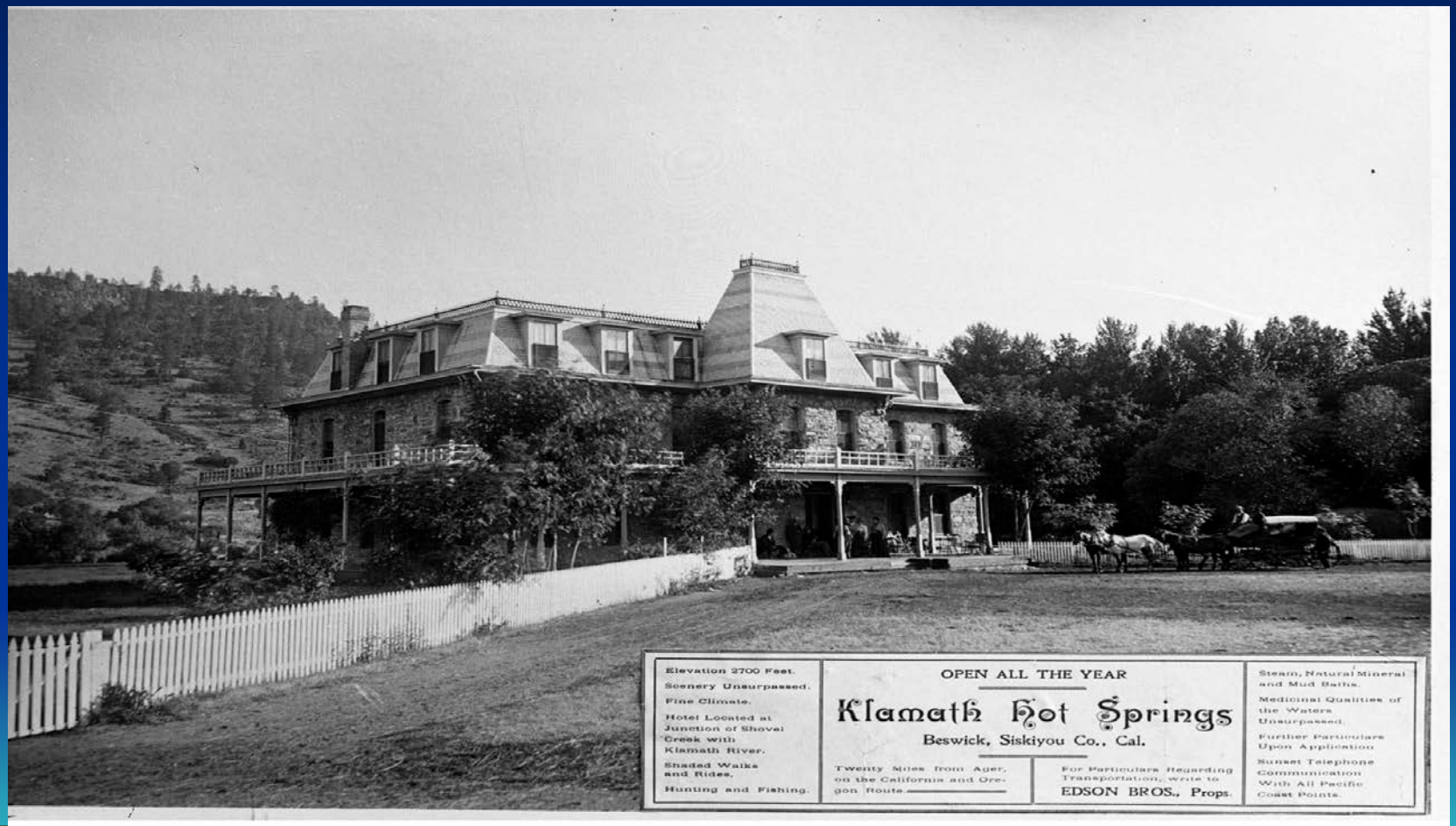


Fig. 37.

1. The Author's Salmon, on Trout Tackle. 2. The Salmon Pool, Williamson River, Oregon, U.S.A., Altitude 4,500 Feet. The Mountain, 9,000 Feet. p. 264.

Klamath Hot Springs Resort/Shovel Creek CA1900's

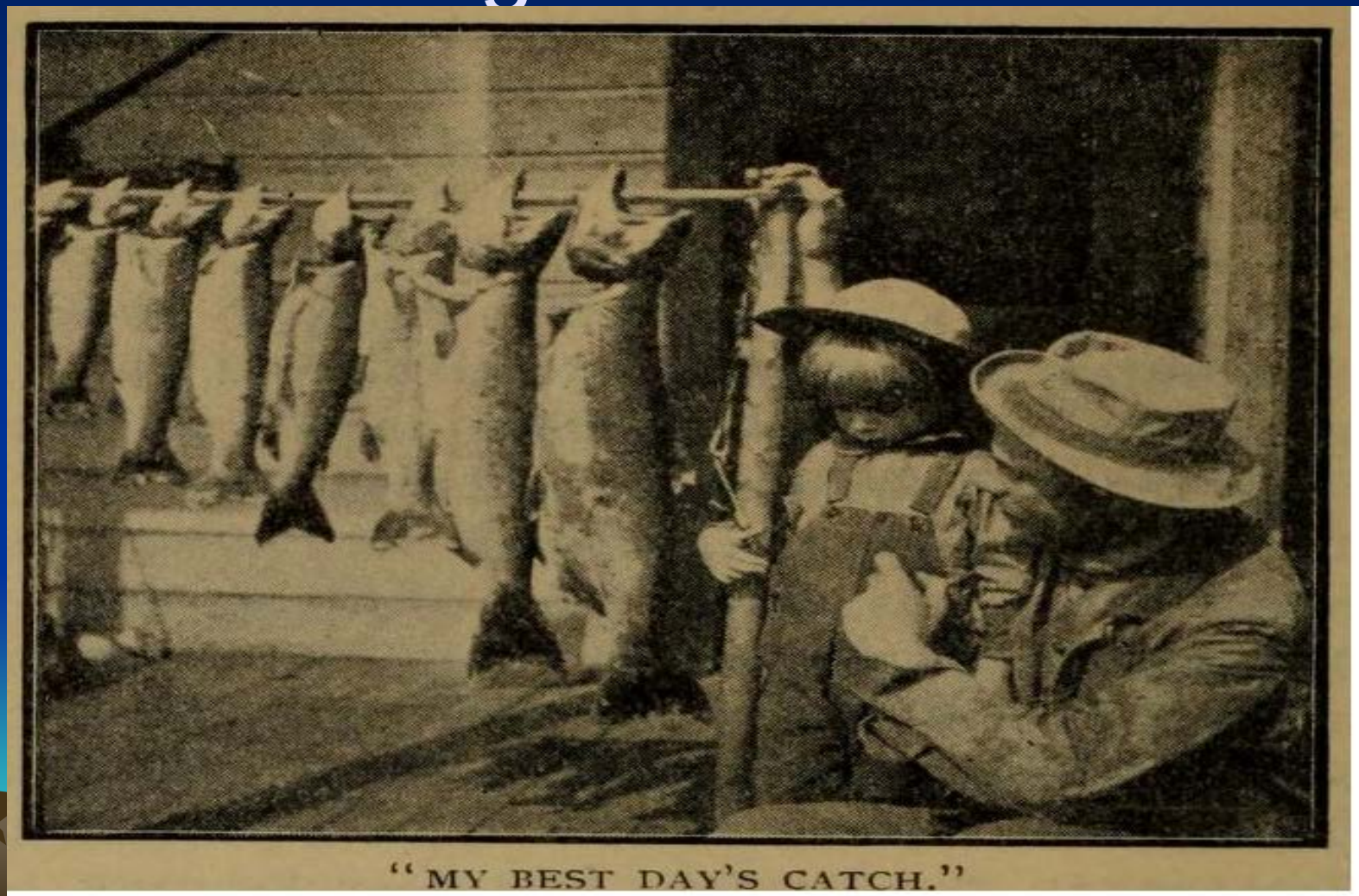


0016.1966.066.0032 M BALDWIN Klamath Hot Springs Hotel

Ogle66-0558

Klamath Hot Springs/Shovel Creek Peter Britt Photo 1885

Klamath Hot Springs Resort Article in Western Field Magazine1902



"MY BEST DAY'S CATCH."

When did Migrations Cease and Why?

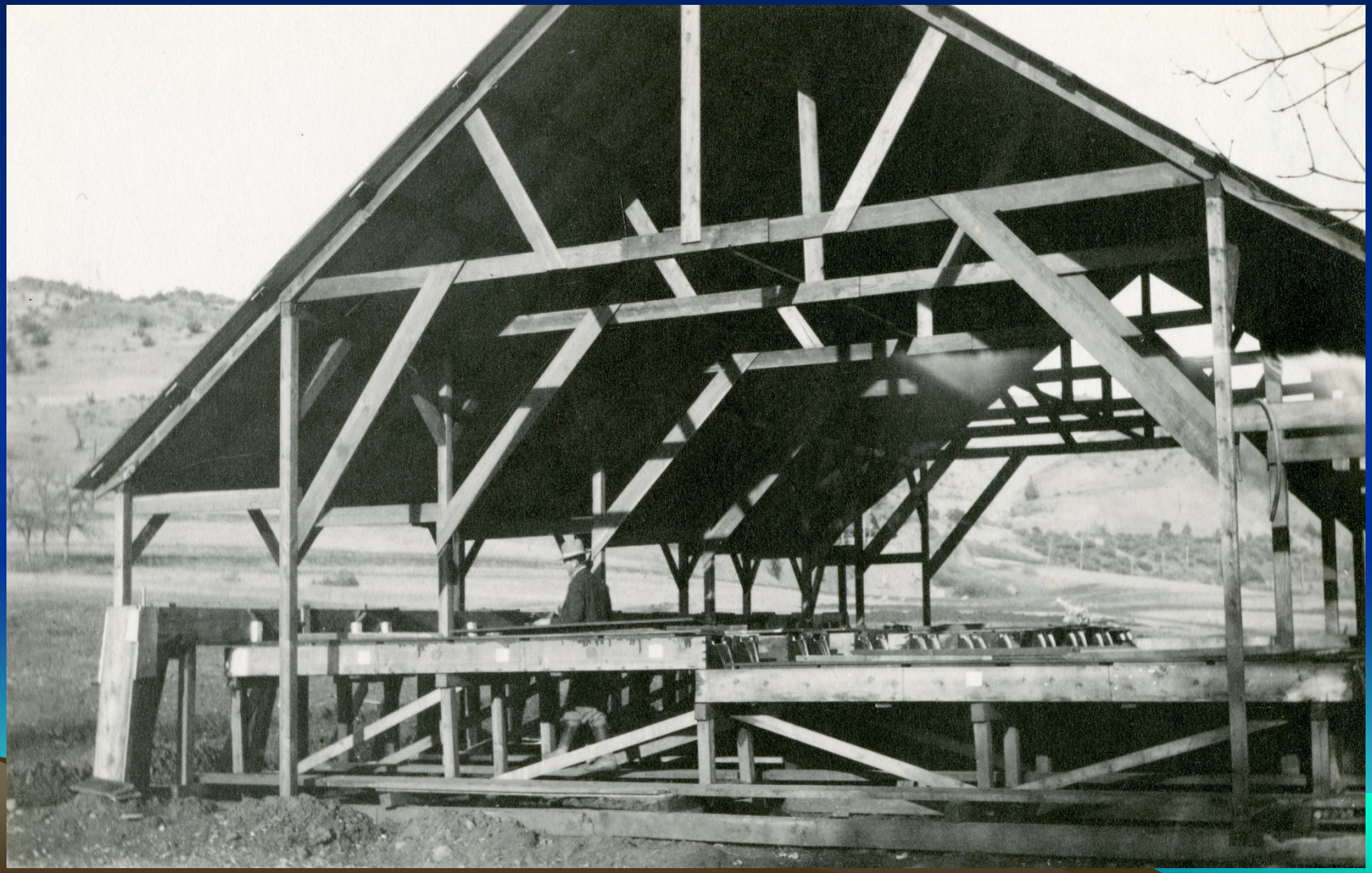
- Three Perspectives:
  - A. Historical Record
  - B. Fish Passage Hydraulics
  - C. BOF (1916) report summarizing their weir operation

Remember Klamathon?

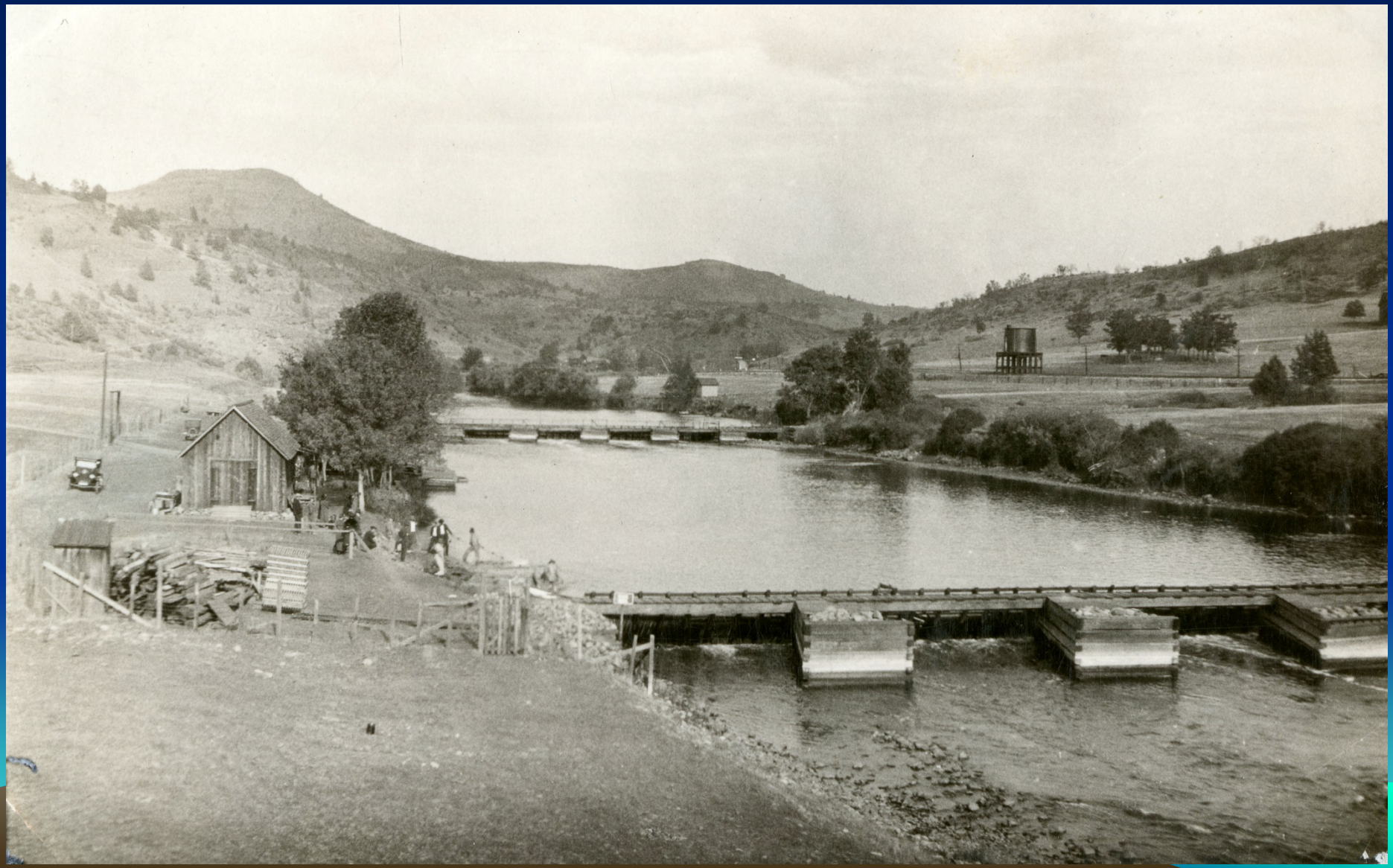
- Now Important for a second reason

- 1910 - in anticipation of Copco 1 Dam, U.S. Bureau of Commercial Fisheries (BOF) constructed a weir and began egg take at Klamathon - Referred to as Klamathon Racks

U.S. Bureau of Fisheries Hatchery, Klamathon (about 1910)



Klamathon Racks, CDFG



Klamathon Racks Salmon Capture

1913 Awareness of Migration Blockage - Klamath Falls *Evening Herald*

<u>Front Page Headlines</u>:

- *"Inspect the Klamath Dam - Officials will Investigate Salmon Shortage"* - October 28, 1913.
- *"Indians Oppose Salmon Racks at Hatcheries* [Klamathon Weir] *- Future Supply in Serious Danger"* - November 3, 1913.
- *"May Ask U.S. to See that River is Kept Clear: Is Shutting off Indians Salmon Supply"* October 23, 1914.

Conclusion of Investigation of Migration Blockage

- "*NO SALMON BELOW DAM: Hatchery* [BOF Klamathon Weir] *responsible for salmon shortage felt here" C.M. Ramsby and A.J. Sprague* - Klamath *Evening Herald,* October 30, 1914.

Did the BOF Weir Really Block Migration??

Year	Accounts: Non Occurrence	Accounts: Not Abundant	Accounts: Abundant
Pre-1910	NA	3	>41
Post -1910	Most Accounts: Klamathon weir stopped salmon	Most Accounts: Klamathon weir stopped salmon	**>6 accounts upstream from Klamathon after 1910**

Examples - Post 1910 Accounts of Abundance Upstream from Klamathon

- 1911: *"..one of the Klamath Indians, last week came over from the Reservation [to Lakeview, Oregon] bringing with him a large load of salmon which were caught in the Sprague River. It is needless to say that he found a ready sale for the fish."* Lakeview, OR Lake County *Examiner* (October 19)

- 1912: *"Salmon are running in fine style in the Klamath and Link Rivers .....None have been taken with hook and line as yet, although a number of fishermen have been whipping Link River for them."* Portland *Morning Oregonian* (September 9)

U.S. Bureau of Commercial Fisheries Report (1916) on Klamathon Weir Operation:

- *"The racks are put in place in September and removed in December of each year."*

- *'All the spring-run salmon are permitted to run upstream beyond the station. The racks are not in place until after the run is passed by and in the upper part of the river."*

So, if Migrations did not stop in 1910, when did they cease?

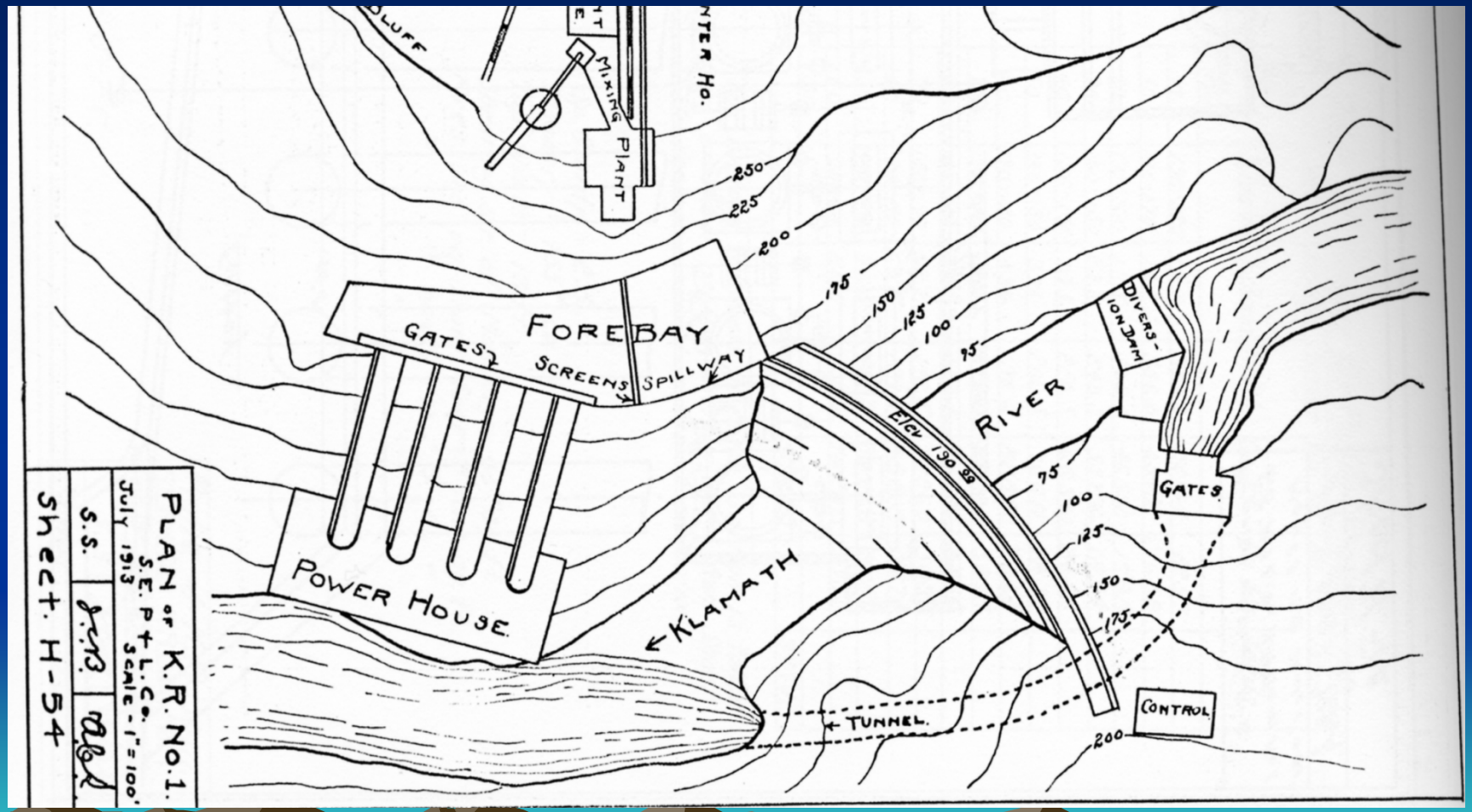
Lane and Lane Associates (1981)

- To resolve the issue of when runs ceased:

  "..the skills needed to unravel the mystery are those of fishway experts."

Fish Passage Hydraulic Calculations

Copco 1 Diversion Tunnel Plan: 1910



Copco 1 Diversion Tunnel

Copco 1 Diversion Tunnel 1911

Copco 1 Diversion Tunnel Headgates October 12,1912

First water turned through Copco No. 1 diversion tunnel. October 12, 1912.

Copco 1 Diversion Tunnel Flow Velocity

- Diversion Tunnel = 108 m long, 4.9 x 5.5 m xsection
- Slope 2.0%; Manning's n = 0.05
- Minimum average daily flow = 42.5 m3/sec
- Velocity thru tunnel = 3.3 m/sec
- Chinook salmon max swimming distance @ 3.3 m/sec flow = 51 m vs 108 m long tunnel

Migrations of salmon to the Upper Klamath River ceased about October 12, 1912

Summary

- The 2016 OHQ Publication supported previous conclusions that Chinook salmon historically migrated upstream of Link River and into tributaries of Upper Klamath Lake

- New information confirms the importance of runs to early settlers and Indians. We found accounts of robust in-river Tribal and recreational fisheries upstream from IGD

-

Summary (Cont.)

- Reports of abundant runs far outnumbered reports of non abundance

- We identified four general fishing areas that included small scale commercial harvest of Chinook, with harvest continuing in the upstream-most local at least through 1911

Summary (Cont.)

- Despite other threats and accounts to the contrary, salmon migrations persisted in the Klamath Upper Basin through the fall of 1912, when they were blocked by early construction of Copco 1 Dam

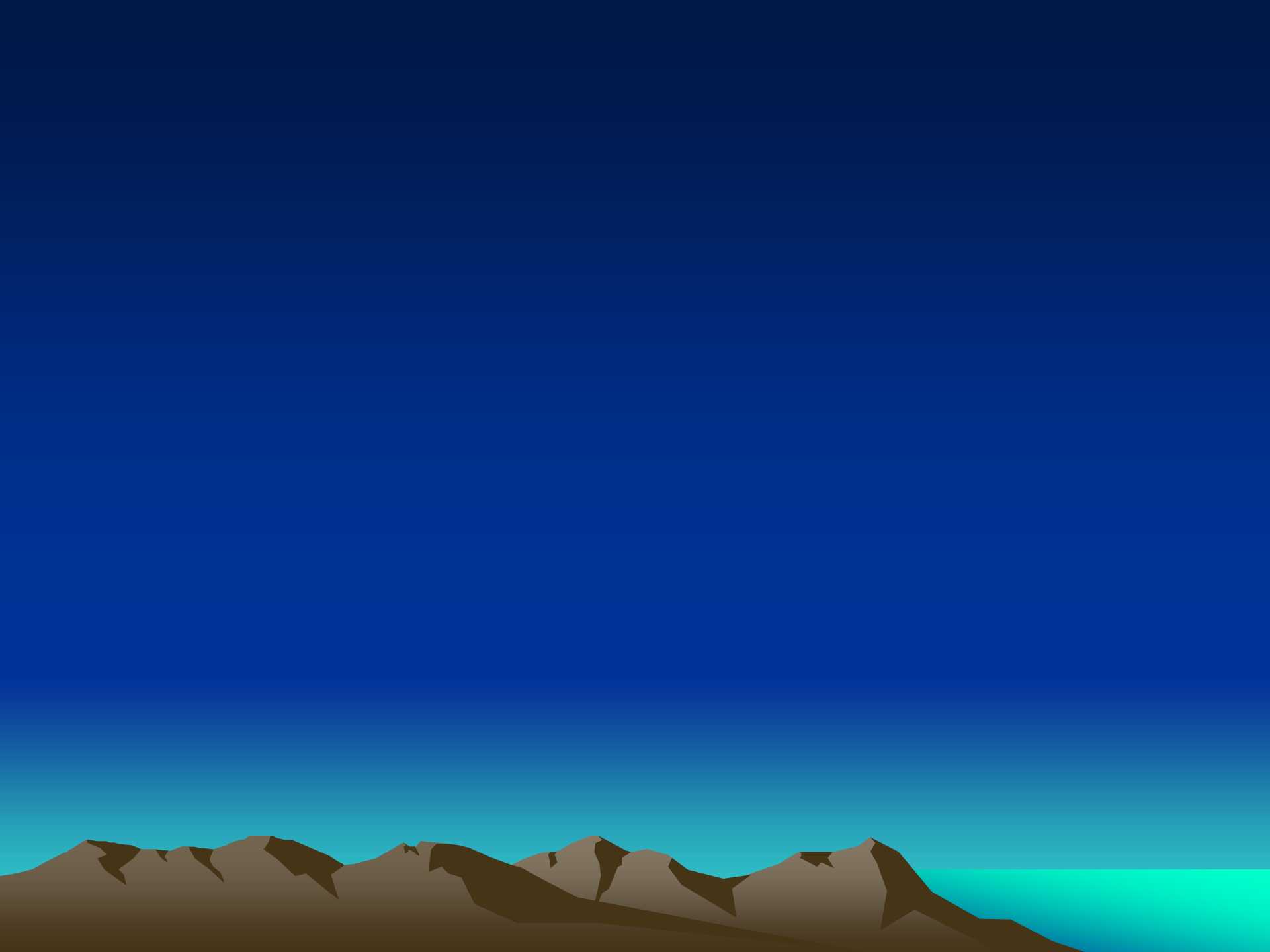
- As managers of the Klamath River consider monitoring, restoration, and reintroduction of Chinook salmon runs, they will likely look to the historical record for guidance. The 2016 summary will provide a background for planning

Link to 2016 Article

- http://ohs.org/research-and-library/oregon-historical-quarterly/upload/Hamilton_Chinook-Salmon-Migrations_OHQ_117_3_Fall-2016_Spread.pdf

QUESTIONS?


9-1 25# Salmon caught by Indian who lived just
Upstream from Little River Bridge



Settlement Agreements

- Driven by:
  - 2006 Trial Type Hearing Outcome and ALJ Findings
  - The need for 401 Water Quality Certification
    - –Administered by CA and OR

Settlement Agreements- 2010 - KHSA

Klamath Hydroelectric Settlement Agreement to Remove Lower 4 Dams **IF**:

- Affirmative Secretarial Determination
- DRE Accept Removal Liability
- Dam Removal Paid for thru Utility Surcharge

Settlement Agreements - 2010 KBRA

Klamath Basin Restoration Agreement:

- Reliable supply of water to On Project Irrigators
- Project Irrigators would not object to dam removal
- Funding for Fishery Restoration
- Water to Klamath Refuge

Current Settlement Status

- KBRA – Parties Pulled out at the end of 2015
- KHSA – Modified in April 2016. Agreement to remove lower 4 dams maintained.
  - Klamath River Renewal Corporation became dam removal entity
    - Removal Funds Made Available to KRRC
    - Accepted Liability

Decision Now Before FERC

- PacifiCorp and KRRC have submitted Application for the Lower 4 Klamath Dams to:
  - Transfer the License from PacifiCorp to KRRC
  - Decommission Dams

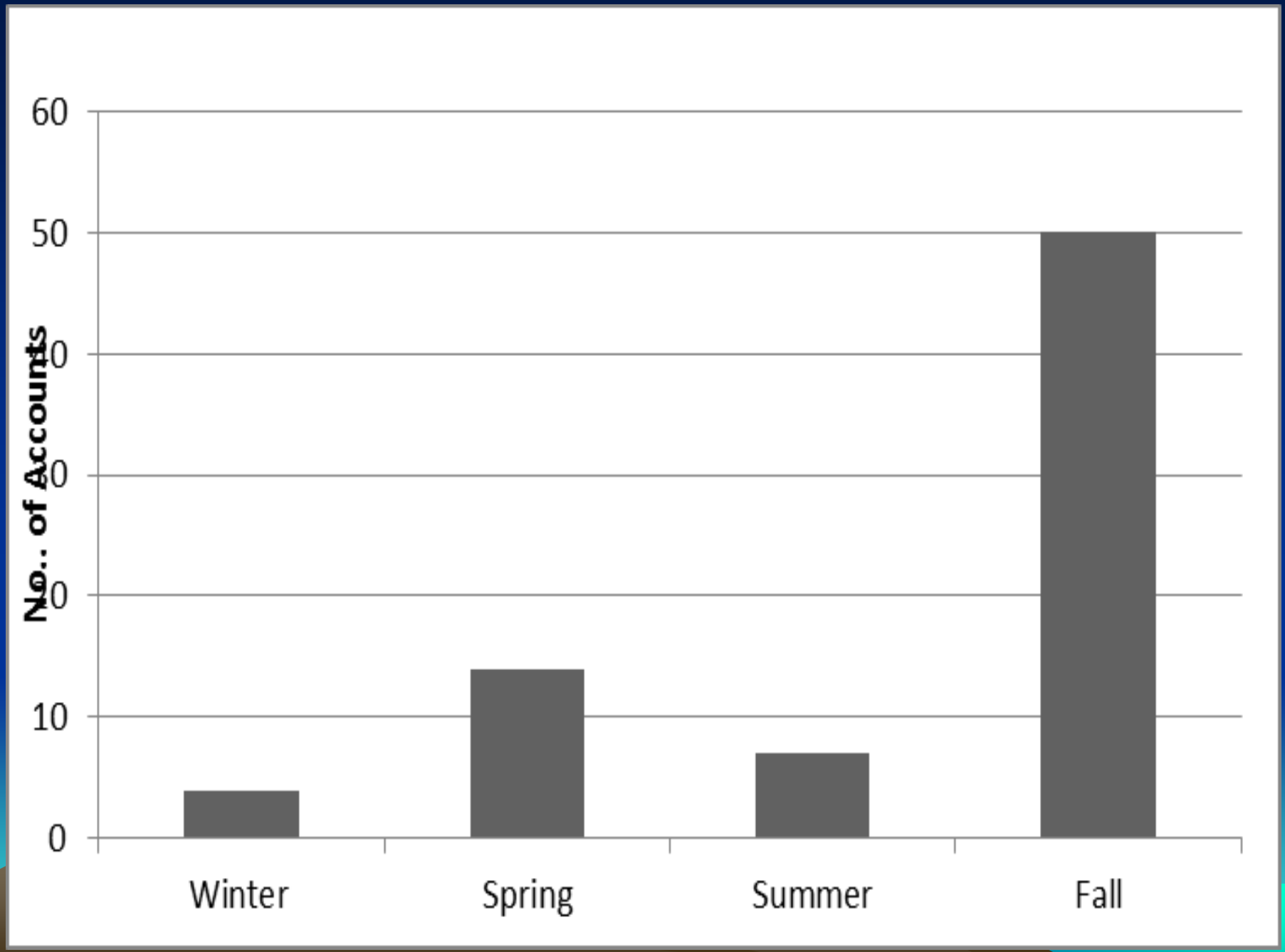
QUESTIONS?

USDI Bureau Land Management et. al. 1995

Chinook Salmon caught at the confluence of Spencer Creek and the Klamath River prior to 1917 by Charles A. Sprague - Governor of Oregon from 1939 to 1943 (photo courtesy of the Anderson family photo collection).

Fishing for steelhead on Spencer Creek, Charles Sprague (R) and Lest Anderson (L) around 1900 (photo courtesy of the Anderson family photo collection).

A day of huckleberry picking at Buck Lake around 1905 (photo courtesy of the Anderson family photo collection).


60
50
40
30
20
10
0
No.. of Accounts
Winter
Spring
Summer
Fall

- “…the presence of all body parts at project sites is consistent with local procurement. The most probable explanation for the presence of salmonid remains in Upper Klamath Basin archaeological sites is that they were caught in local rivers and streams.” Butler et al. (2010), page 47

Genetic analyses of contemporary and ancient samples provide insights into restoring upper Klamath spring Chinook

Tasha Thompson

Outline

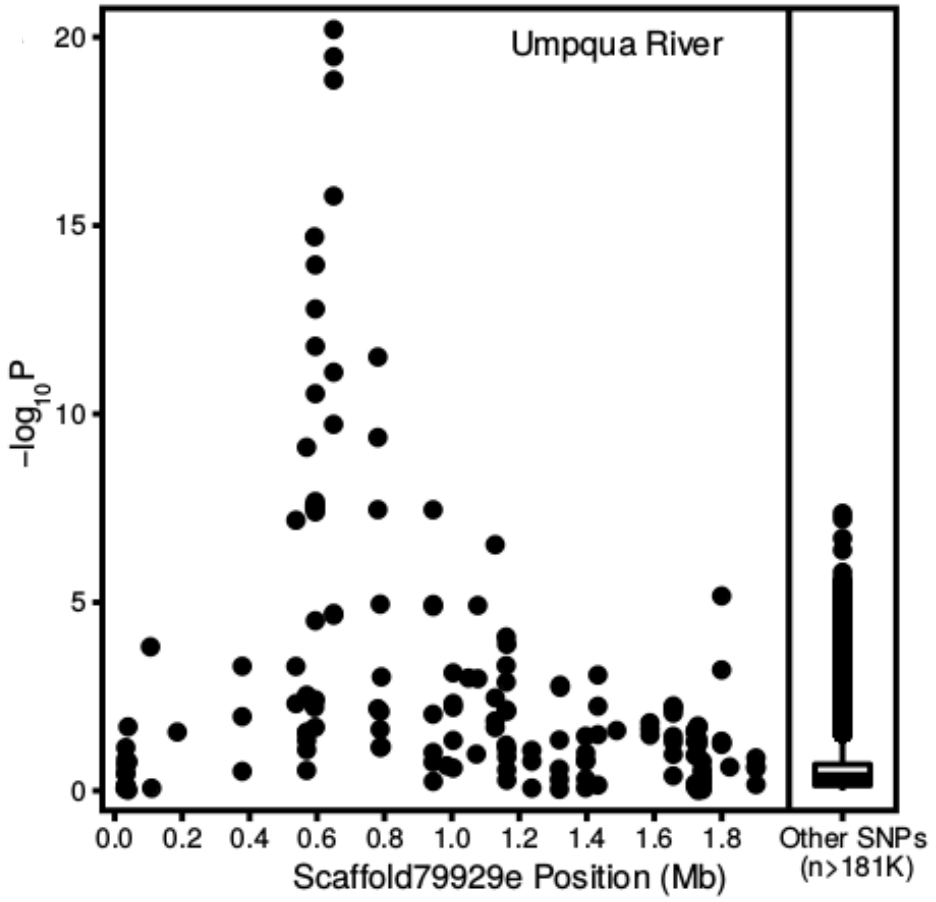
- *GREB1L* marker discovery and validation

- Analysis of Rogue River Chinook to understand migration time of heterozygotes

- Applications for restoring spring Chinook in the upper Klamath

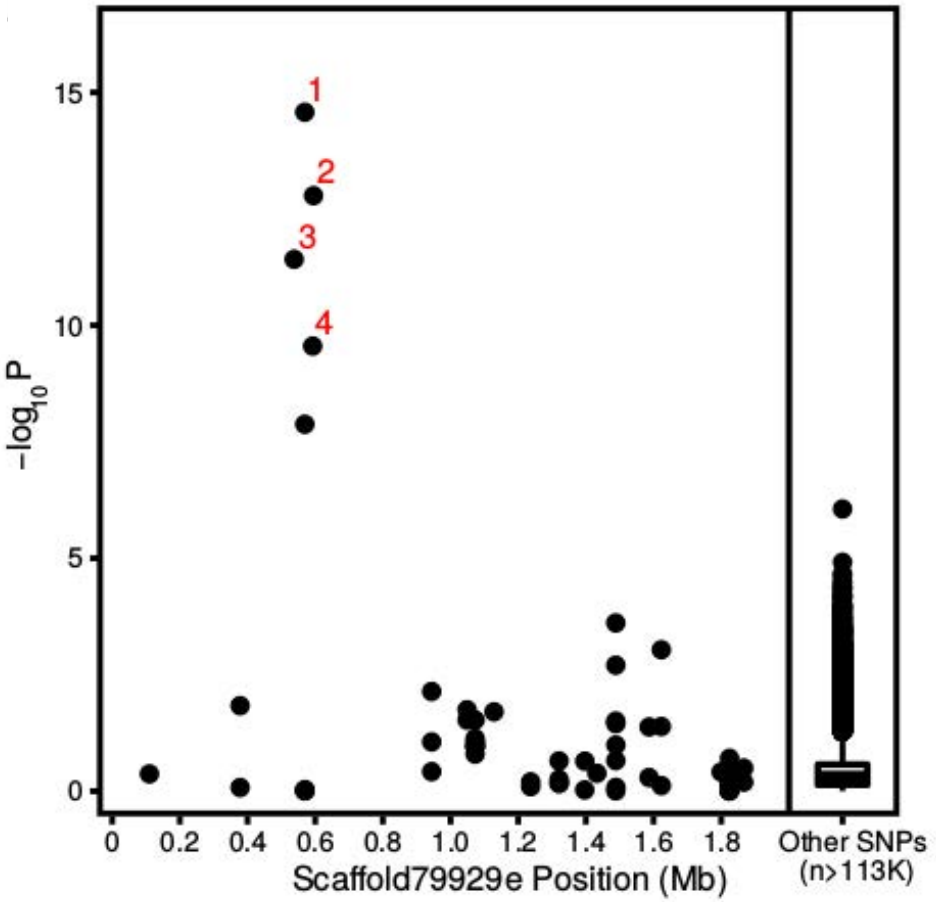
Previous study identified strong association of *GREB1L* region with premature vs. mature migration in steelhead and Chinook

Steelhead



GREB1L region

Chinook



GREB1L region

Prince *et al.* 2017

Premature:
Spring Chinook/
Summer steelhead

PP=homozygous premature

PM=heterozygous

MM=homozygous mature

Mature:
Fall Chinook/
Winter steelhead

Steelhead

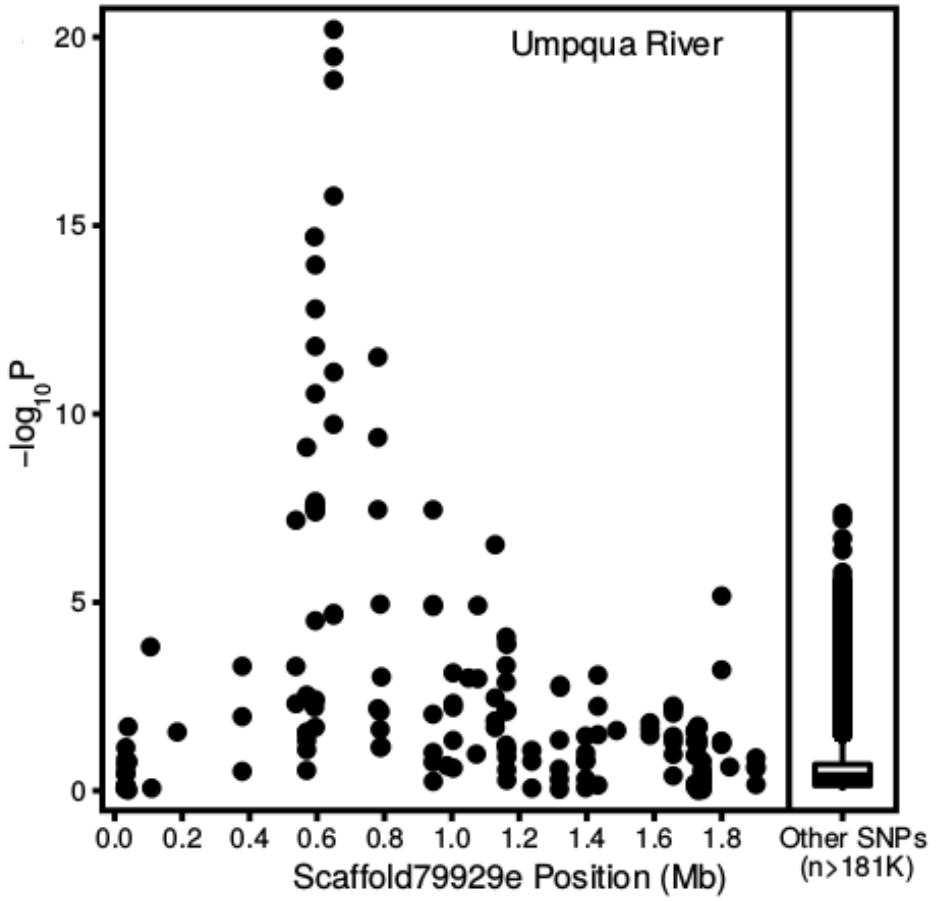
Location	Predicted phenotype	Top Prince et al. SNP
Eel River	Summer-run	PP
Eel River	Summer-run	PP
Eel River	Summer-run	PP
Eel River	Summer-run	PP
Eel River	Summer-run	PP
Eel River	Summer-run	PP
Eel River	Summer-run	PP
New River	Summer-run	PP
New River	Summer-run	PP
New River	Summer-run	PP
New River	Summer-run	PP
New River	Summer-run	PP
Siletz River	Summer-run	PP
Siletz River	Summer-run	PP
Siletz River	Summer-run	PP
Siletz River	Summer-run	PP
Umpqua River	Summer-run	PP
Umpqua River	Summer-run	PP
Umpqua River	Summer-run	PP
Umpqua River	Summer-run	PP
Umpqua River	Summer-run	PP
Eel River	Winter-run	MM
Eel River	Winter-run	MM
Eel River	Winter-run	MM
Eel River	Winter-run	MM
Eel River	Winter-run	MM
Scott Creek	Winter-run	MM
Scott Creek	Winter-run	MM
Scott Creek	Winter-run	MM
Scott Creek	Winter-run	MM
Scott Creek	Winter-run	MM
Scott Creek	Winter-run	MM
Scott Creek	Winter-run	MM
Siletz River	Winter-run	MM
Siletz River	Winter-run	PM
Umpqua River	Winter-run	MM
Umpqua River	Winter-run	MM
Umpqua River	Winter-run	MM
Umpqua River	Winter-run	MM
Umpqua River	Winter-run	MM
Umpqua River	Winter-run	MM
Umpqua River	Winter-run	PM
Umpqua River	Winter-run	MM
Umpqua River	Winter-run	MM
Umpqua River	Winter-run	MM
Umpqua River	Winter-run	MM

Chinook

Location	Predicted phenotype	Top Prince et al. SNP
Nooksack River	Spring-run	PP
Nooksack River	Spring-run	PP
Nooksack River	Spring-run	PM
North Umpqua River	Spring-run	PP
North Umpqua River	Spring-run	PP
North Umpqua River	Spring-run	PP
North Umpqua River	Spring-run	PP
Puyallup River	Spring-run	PP
Puyallup River	Spring-run	PP
Puyallup River	Spring-run	PP
Puyallup River	Spring-run	PP
Puyallup River	Spring-run	PP
Rogue River	Spring-run	PP
Rogue River	Spring-run	PP
Rogue River	Spring-run	PP
Rogue River	Spring-run	PP
Salmon River	Spring-run	PP
Trinity River	Spring-run	PP
Trinity River	Spring-run	PP
Trinity River	Spring-run	PP
Trinity River	Spring-run	PP
Nooksack River	Fall-run	PM
Nooksack River	Fall-run	PM
Nooksack River	Fall-run	MM
Puyallup River	Fall-run	MM
Puyallup River	Fall-run	MM
Puyallup River	Fall-run	PM
Puyallup River	Fall-run	MM
Puyallup River	Fall-run	PM
Rogue River	Fall-run	PP
Rogue River	Fall-run	MM
Rogue River	Fall-run	PM
Rogue River	Fall-run	PM
Salmon River	Fall-run	PP
Siletz River	Fall-run	MM
Siletz River	Fall-run	MM
Siletz River	Fall-run	PM
Siletz River	Fall-run	MM
South Umpqua River	Fall-run	MM
South Umpqua River	Fall-run	PM
South Umpqua River	Fall-run	MM
Trinity River	Fall-run	PP
Trinity River	Fall-run	PM
Trinity River	Fall-run	PP
Trinity River	Fall-run	PP
Trinity River	Fall-run	PM

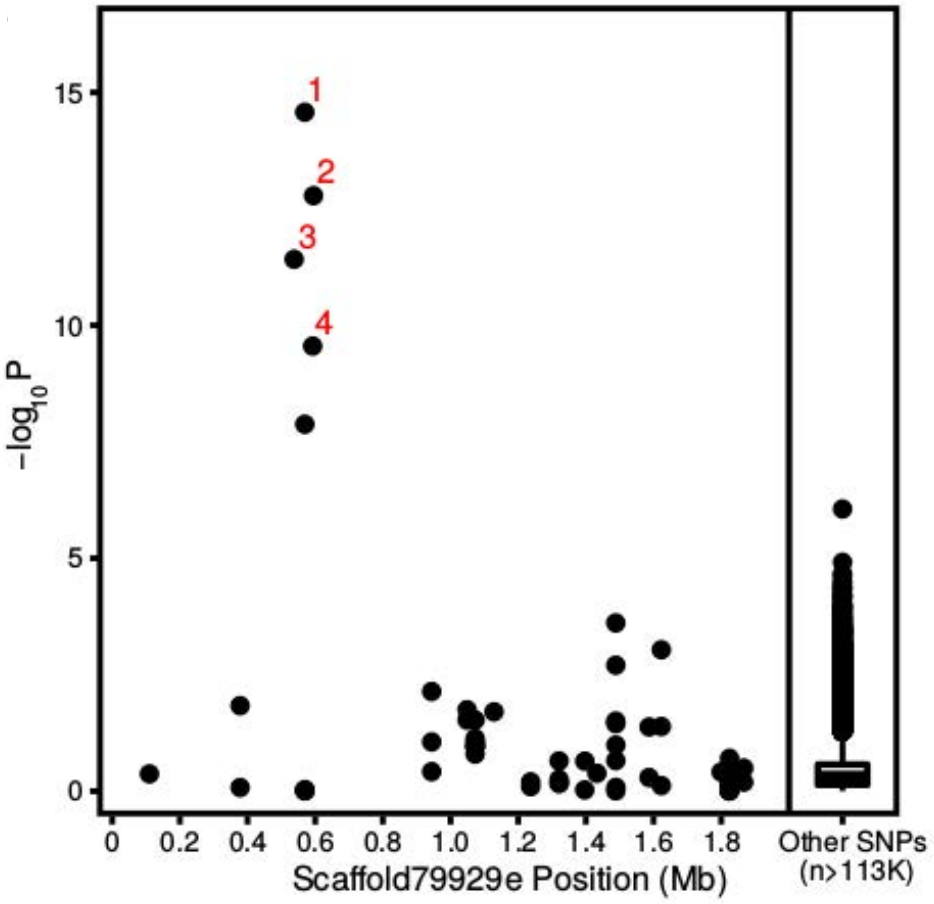
Chinook analysis was lower resolution and had missing data in region with highest association in steelhead

Steelhead



GREB1L region

Chinook

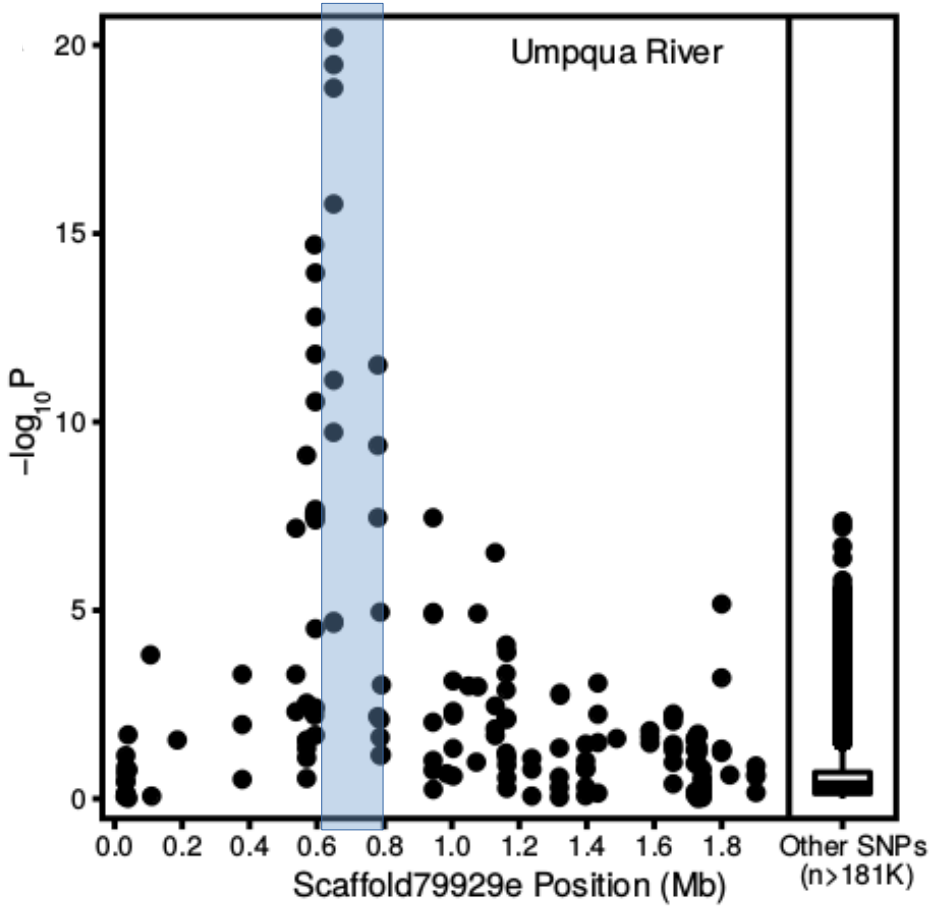


GREB1L region

Prince *et al.* 2017

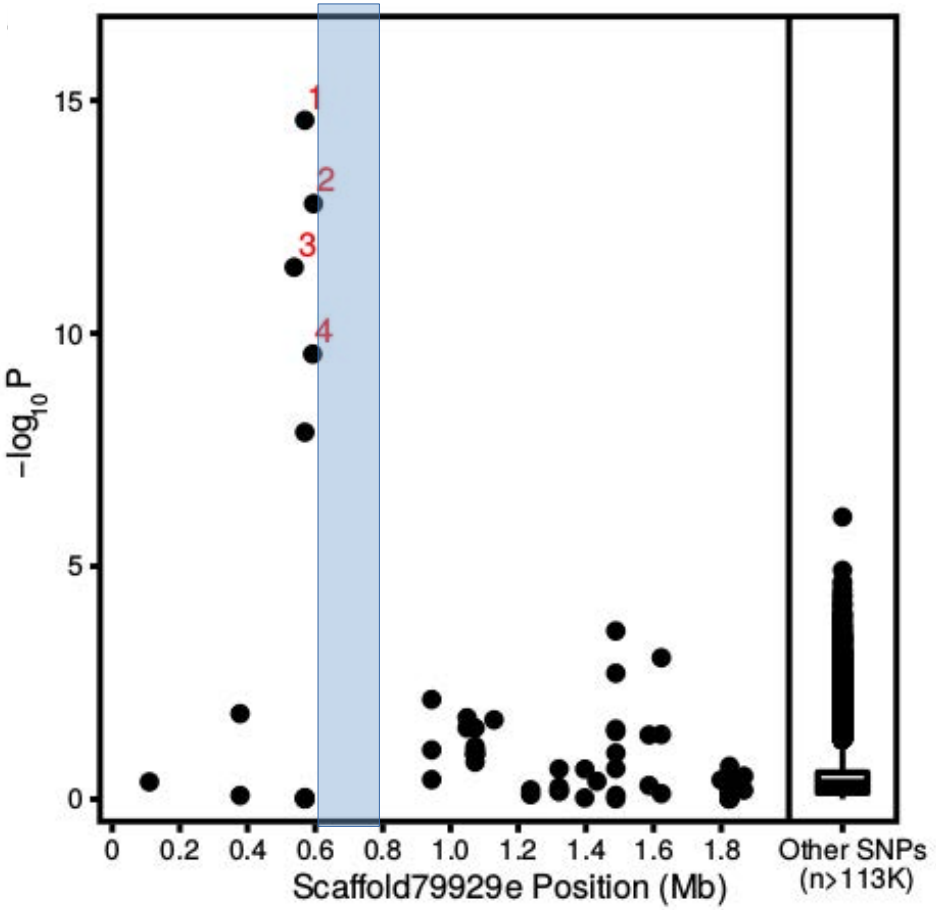
Chinook analysis was lower resolution and had missing data in region with highest association in steelhead

Steelhead



GREB1L region

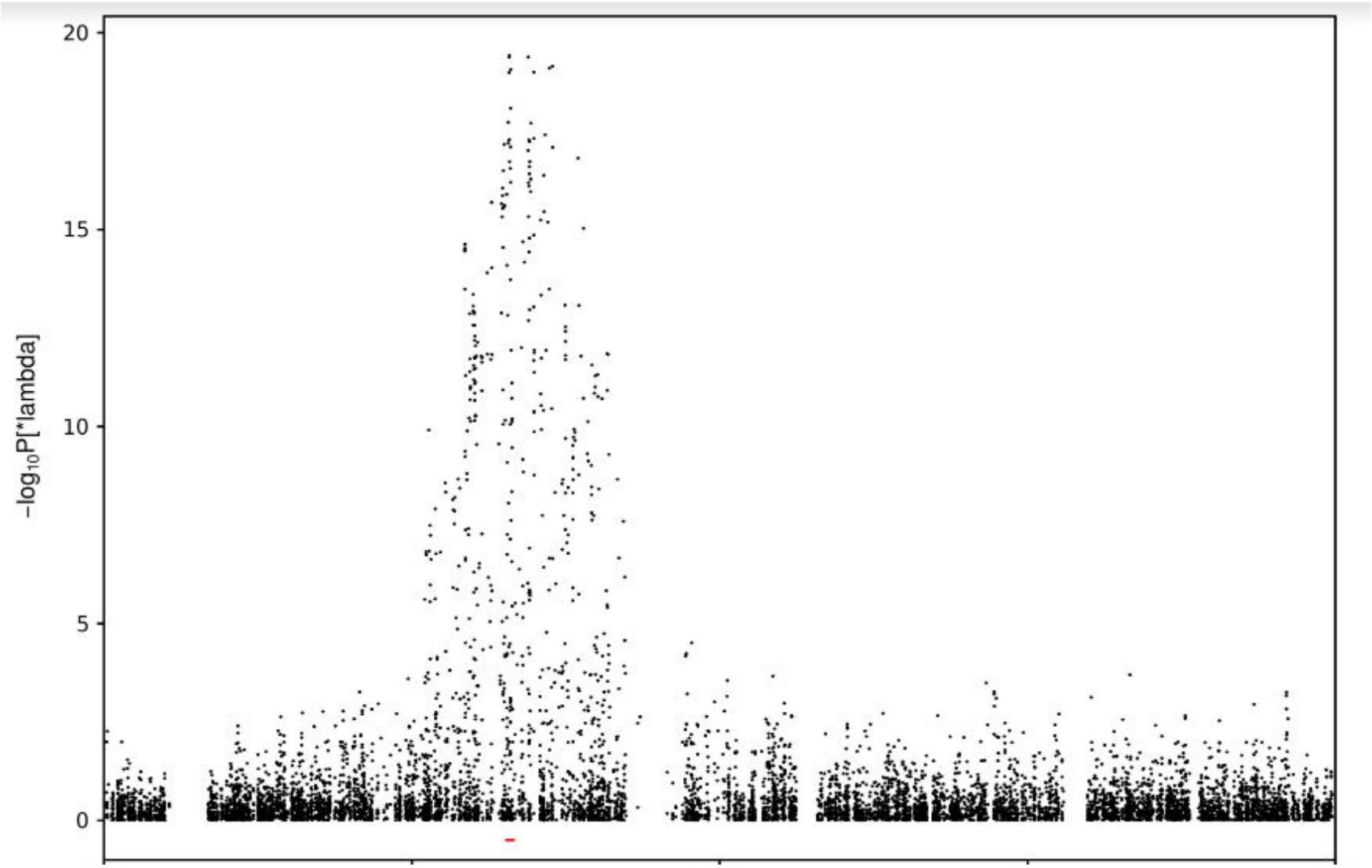
Chinook



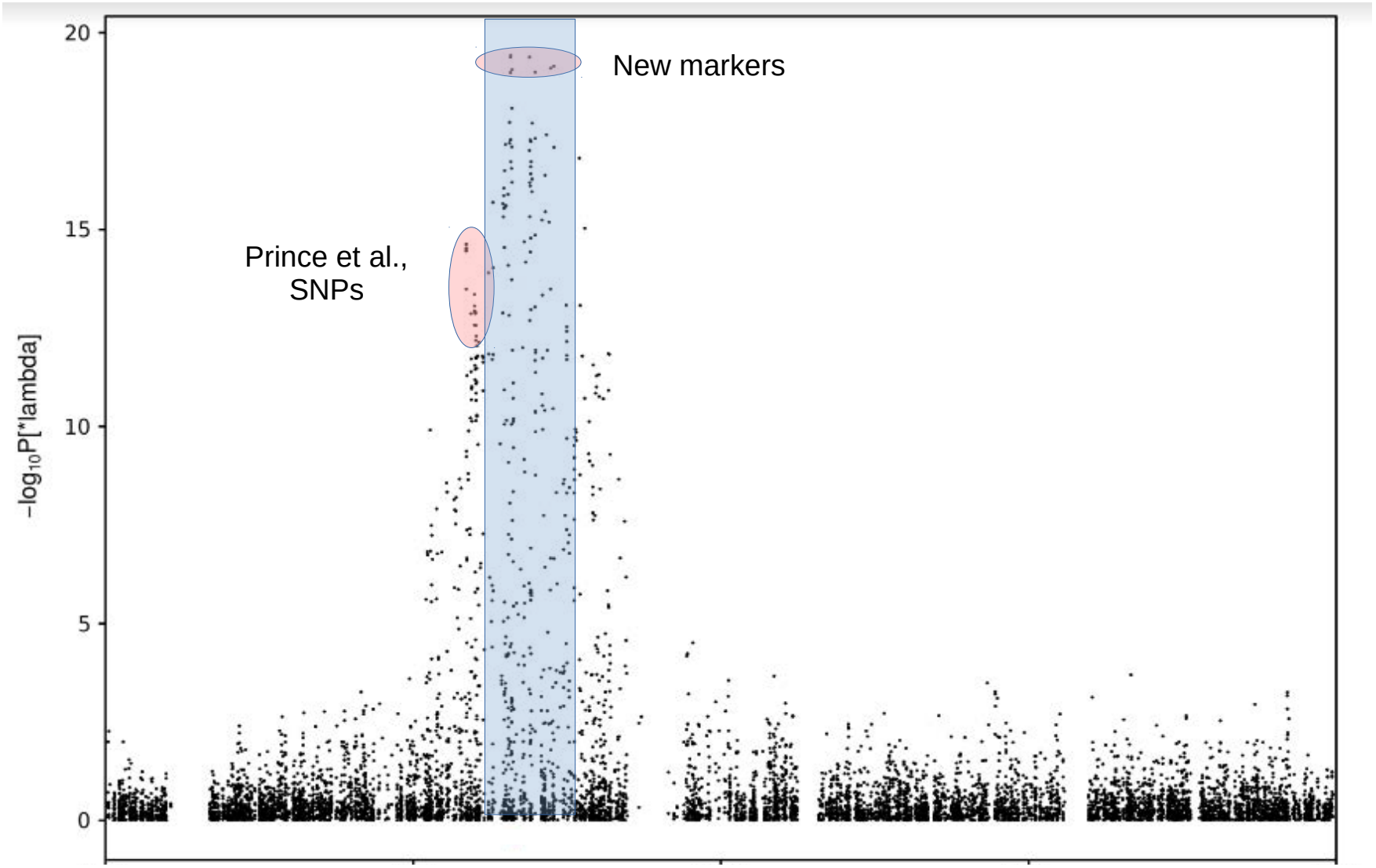
GREB1L region

Prince *et al.* 2017

Higher-resolution analysis of *GREB1L* region in Chinook revealed SNPs with stronger associations



Higher-resolution analysis of *GREB1L* region in Chinook revealed SNPs with stronger associations



Chinook

Spring-run

PP=homozygous premature

PM=heterozygous

MM=homozygous mature

Fall-run

Location	Predicted phenotype	Top Prince et al. SNP
Nooksack River	Spring-run	PP
Nooksack River	Spring-run	PP
Nooksack River	Spring-run	PM
North Umpqua River	Spring-run	PP
North Umpqua River	Spring-run	PP
North Umpqua River	Spring-run	PP
North Umpqua River	Spring-run	PP
Puyallup River	Spring-run	PP
Puyallup River	Spring-run	PP
Puyallup River	Spring-run	PP
Puyallup River	Spring-run	PP
Puyallup River	Spring-run	PP
Rogue River	Spring-run	PP
Rogue River	Spring-run	PP
Rogue River	Spring-run	PP
Rogue River	Spring-run	PP
Salmon River	Spring-run	PP
Trinity River	Spring-run	PP
Trinity River	Spring-run	PP
Trinity River	Spring-run	PP
Trinity River	Spring-run	PP
Nooksack River	Fall-run	PM
Nooksack River	Fall-run	PM
Nooksack River	Fall-run	MM
Puyallup River	Fall-run	MM
Puyallup River	Fall-run	MM
Puyallup River	Fall-run	PM
Puyallup River	Fall-run	MM
Puyallup River	Fall-run	PM
Rogue River	Fall-run	PP
Rogue River	Fall-run	MM
Rogue River	Fall-run	PM
Rogue River	Fall-run	PM
Salmon River	Fall-run	PP
Siletz River	Fall-run	MM
Siletz River	Fall-run	MM
Siletz River	Fall-run	PM
Siletz River	Fall-run	MM
South Umpqua River	Fall-run	MM
South Umpqua River	Fall-run	PM
South Umpqua River	Fall-run	MM
Trinity River	Fall-run	PP
Trinity River	Fall-run	PM
Trinity River	Fall-run	PP
Trinity River	Fall-run	PP
Trinity River	Fall-run	PM

Chinook

Spring-run

PP=homozygous premature

PM=heterozygous

MM=homozygous mature

Fall-run

Location	Predicted phenotype	Top Prince et al. SNP	New SNP 1	New SNP 2
Nooksack River	Spring-run	PP	PP	PP
Nooksack River	Spring-run	PP	PP	PP
Nooksack River	Spring-run	PM	PM	PM
North Umpqua River	Spring-run	PP	PP	PP
North Umpqua River	Spring-run	PP	PP	PP
North Umpqua River	Spring-run	PP	PP	PP
North Umpqua River	Spring-run	PP	PP	PP
Puyallup River	Spring-run	PP	PP	PP
Puyallup River	Spring-run	PP	PP	PP
Puyallup River	Spring-run	PP	PP	PP
Puyallup River	Spring-run	PP	PP	PP
Puyallup River	Spring-run	PP	PP	PP
Rogue River	Spring-run	PP	PP	PP
Rogue River	Spring-run	PP	PP	PP
Rogue River	Spring-run	PP	PP	PP
Rogue River	Spring-run	PP	PP	PP
Salmon River	Spring-run	PP	PP	PP
Trinity River	Spring-run	PP	PP	PP
Trinity River	Spring-run	PP	PP	PP
Trinity River	Spring-run	PP	PP	PP
Trinity River	Spring-run	PP	PP	PP
Nooksack River	Fall-run	PM	MM	MM
Nooksack River	Fall-run	PM	MM	MM
Nooksack River	Fall-run	MM	MM	MM
Puyallup River	Fall-run	MM	MM	MM
Puyallup River	Fall-run	MM	MM	MM
Puyallup River	Fall-run	PM	PM	PM
Puyallup River	Fall-run	MM	MM	MM
Puyallup River	Fall-run	PM	MM	MM
Rogue River	Fall-run	PP	MM	MM
Rogue River	Fall-run	MM	MM	MM
Rogue River	Fall-run	PM	MM	MM
Rogue River	Fall-run	PM	MM	MM
Salmon River	Fall-run	PP	MM	MM
Siletz River	Fall-run	MM	MM	MM
Siletz River	Fall-run	MM	MM	MM
Siletz River	Fall-run	PM	MM	MM
Siletz River	Fall-run	MM	MM	MM
South Umpqua River	Fall-run	MM	MM	MM
South Umpqua River	Fall-run	PM	MM	MM
South Umpqua River	Fall-run	MM	MM	MM
Trinity River	Fall-run	PP	MM	MM
Trinity River	Fall-run	PM	MM	MM
Trinity River	Fall-run	PP	MM	MM
Trinity River	Fall-run	PP	MM	MM
Trinity River	Fall-run	PM	MM	MM

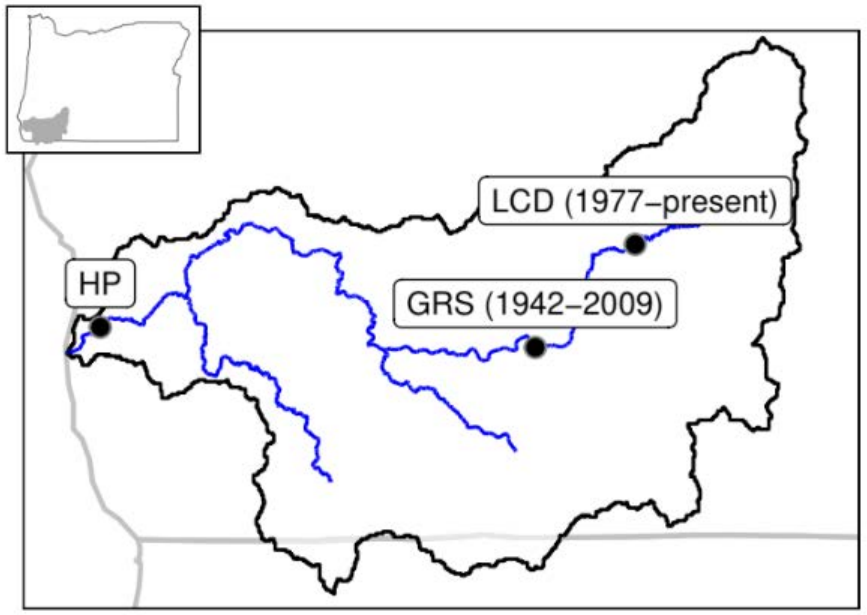
Outline

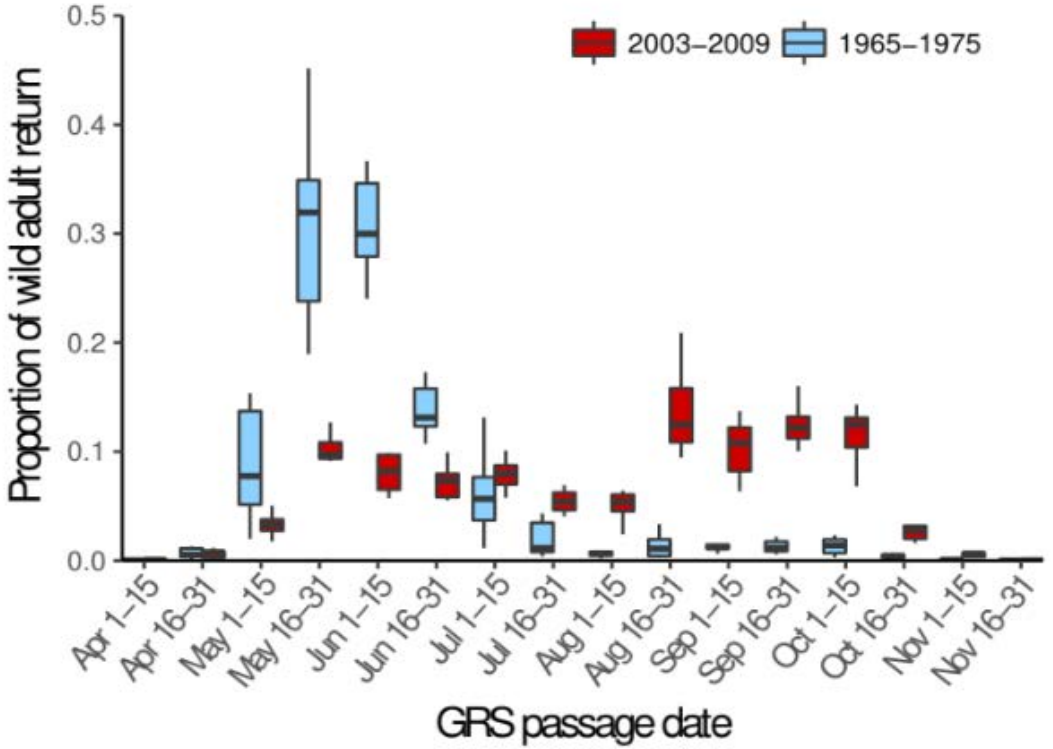
- *GREB1L* marker discover and validation

- Analysis of Rogue River Chinook to understand migration time of heterozygotes

- Applications for restoring spring Chinook in the upper Klamath

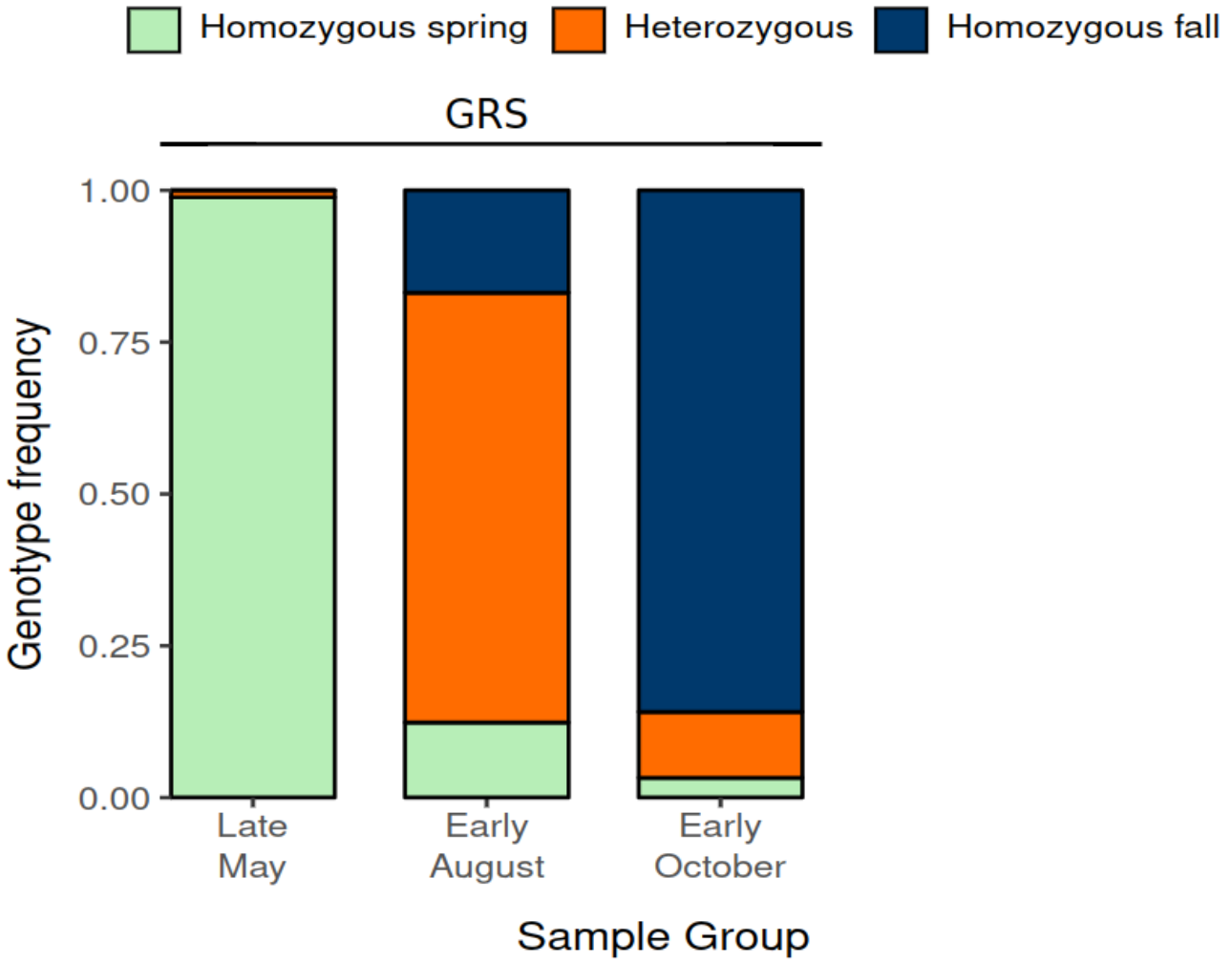
Rogue River, OR Chinook experienced a major shift in adult migration time after construction of Lost Creek Dam in 1977





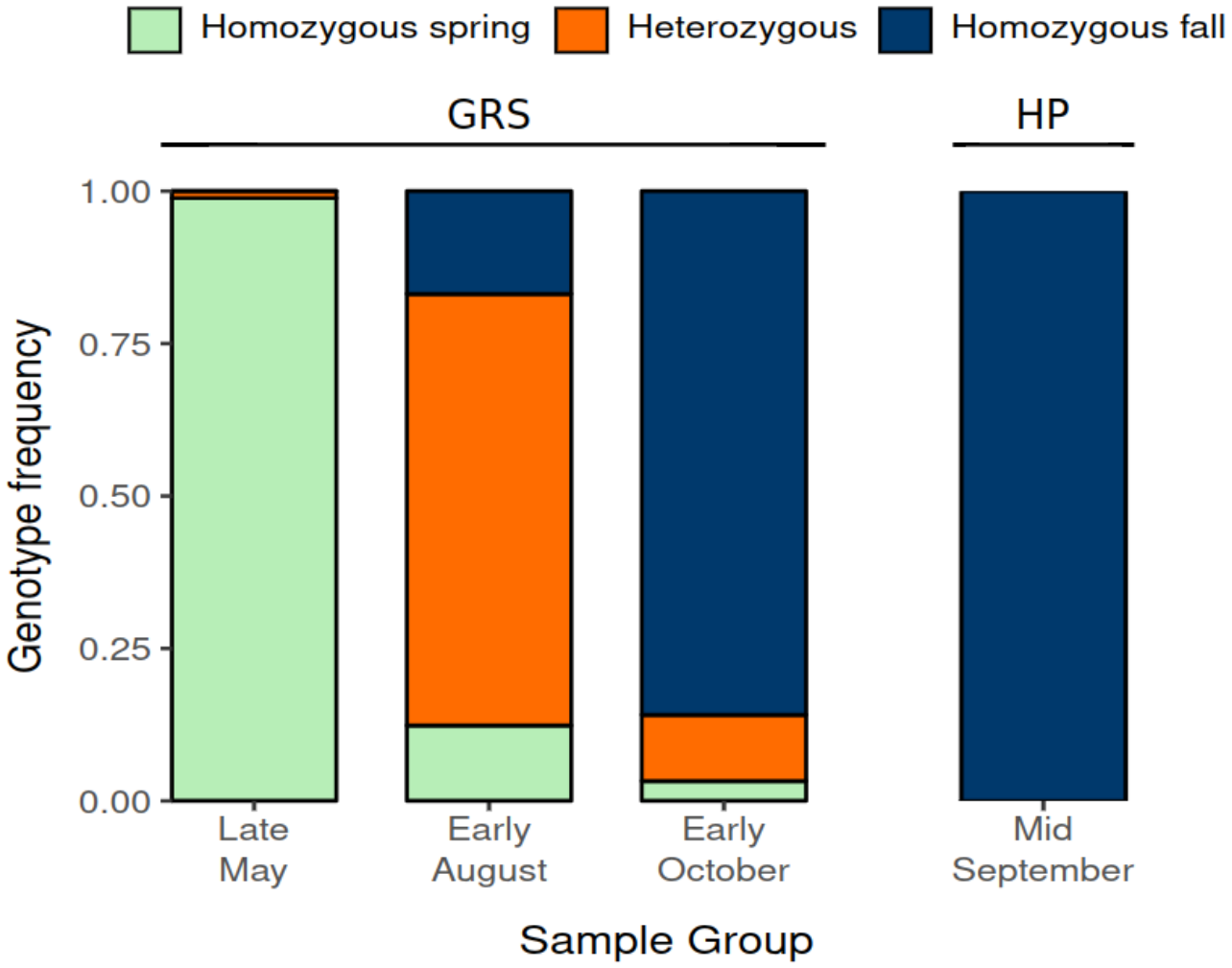
Thompson et al., *in prep*

Genotyping Rogue River Chinook that passed GRS during three time windows reveals heterozygotes have an intermediate phenotype



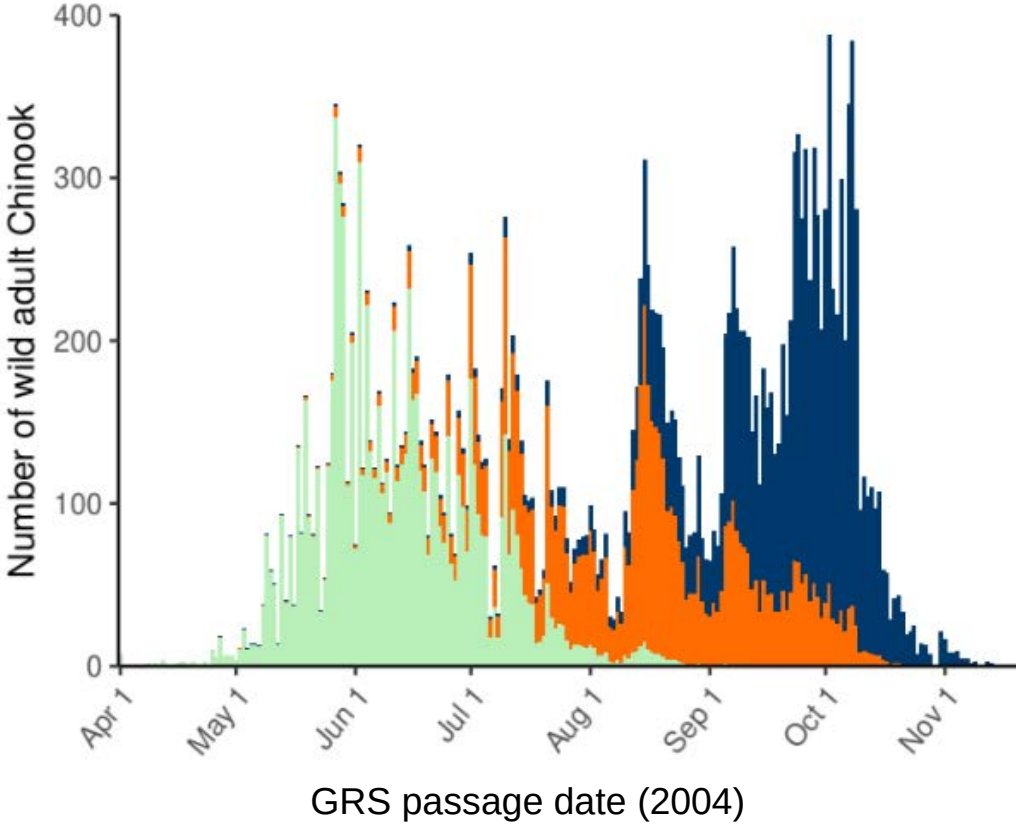
Thompson et al., *in prep*

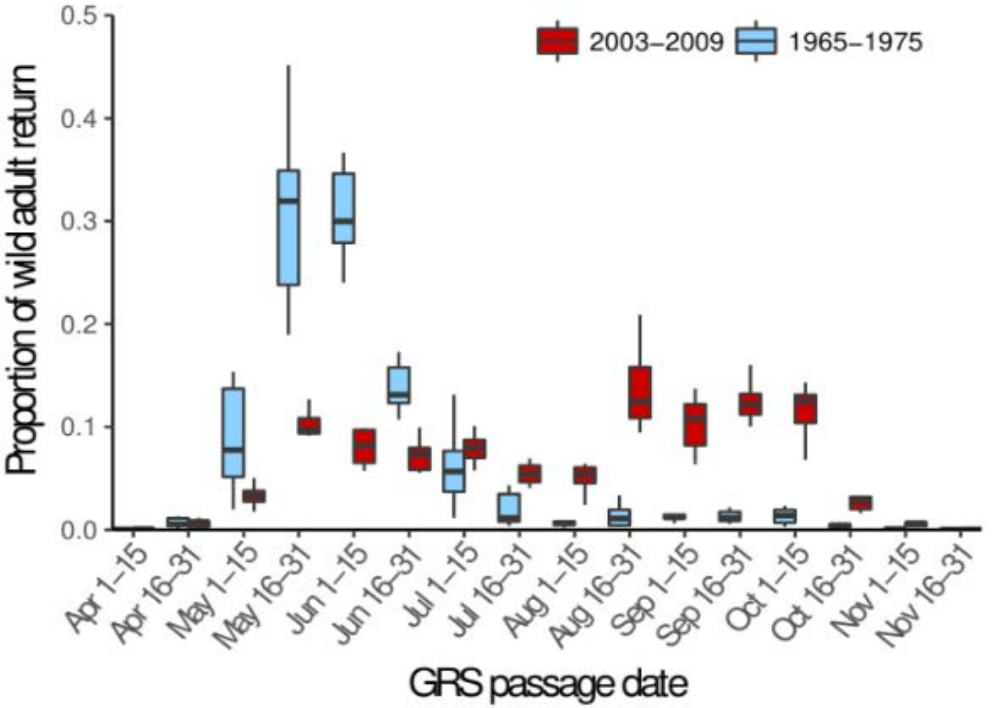
Mid-September HP results suggest homozygous-spring and heterozygous fish from GRS early-October had entered freshwater earlier in the year



Thompson et al., *in prep*

GRS genotyping results allowed us to estimate spring-run allele frequencies prior to LCD and in 2004

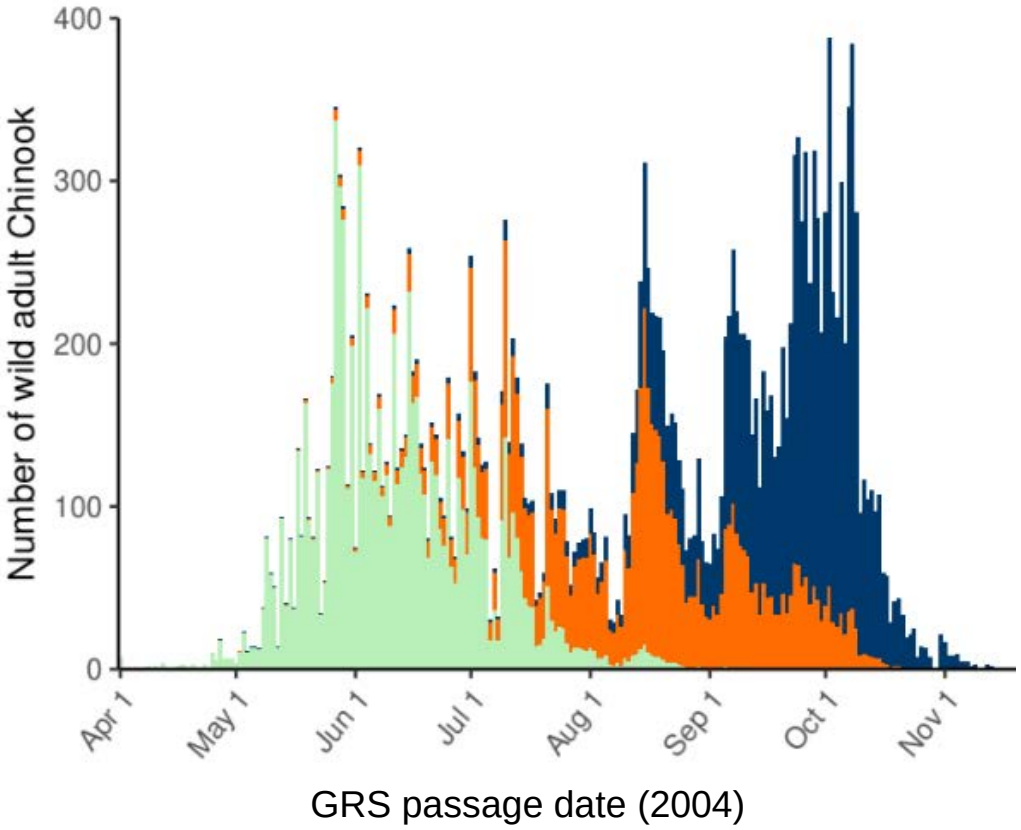




Homozygous spring | Heterozygous | Homozygous fall

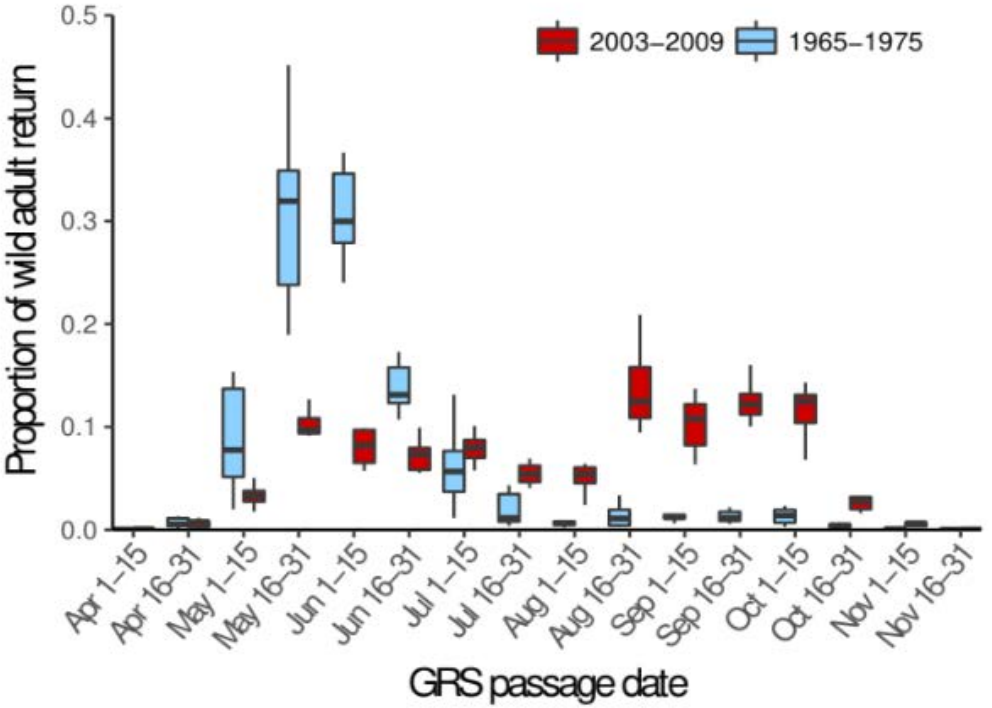
Thompson et al., *in prep*

GRS genotyping results allowed us to estimate spring-run allele frequencies prior to LCD and in 2004



2004 spring allele frequency estimate: **0.49**

Pre-LCD spring allele frequency estimate: **0.90**

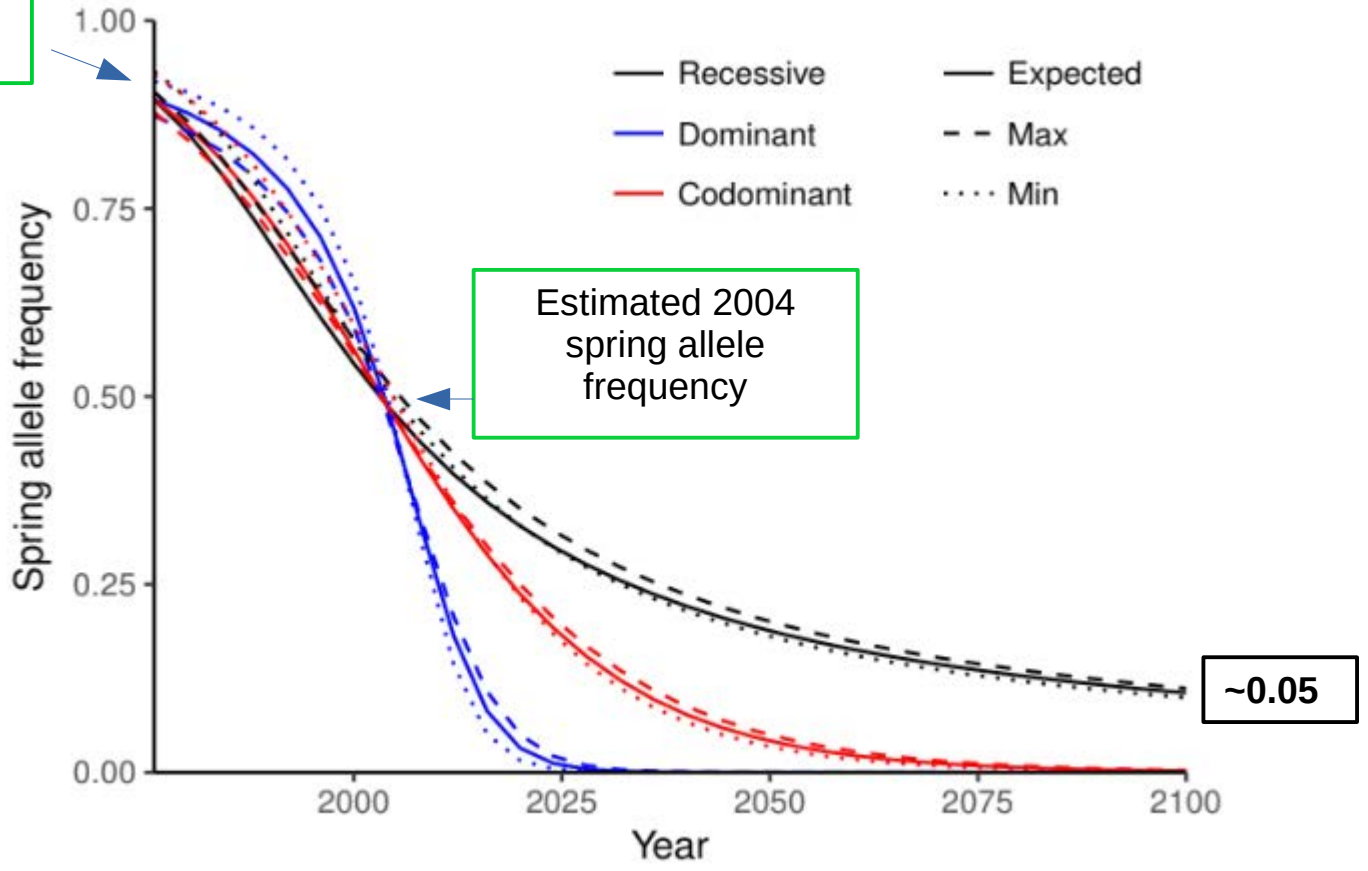


Homozygous spring | Heterozygous | Homozygous fall

Thompson et al., *in prep*

Selection modeling demonstrates negatively-selected alleles can be rapidly lost unless completely recessive with respect to fitness

Estimated pre-dam spring allele frequency



Estimated 2004 spring allele frequency

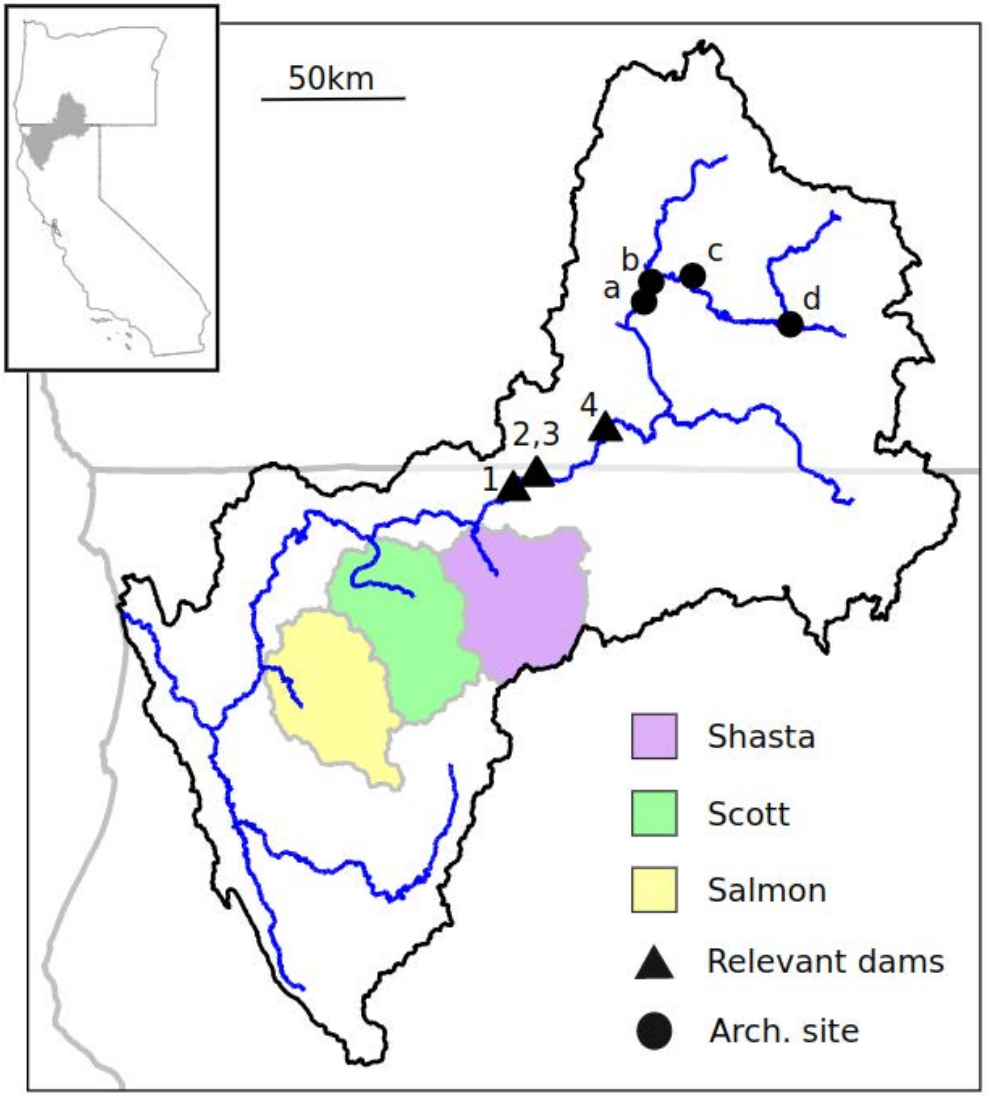
~0.05

Thompson et al., *in prep*

Outline

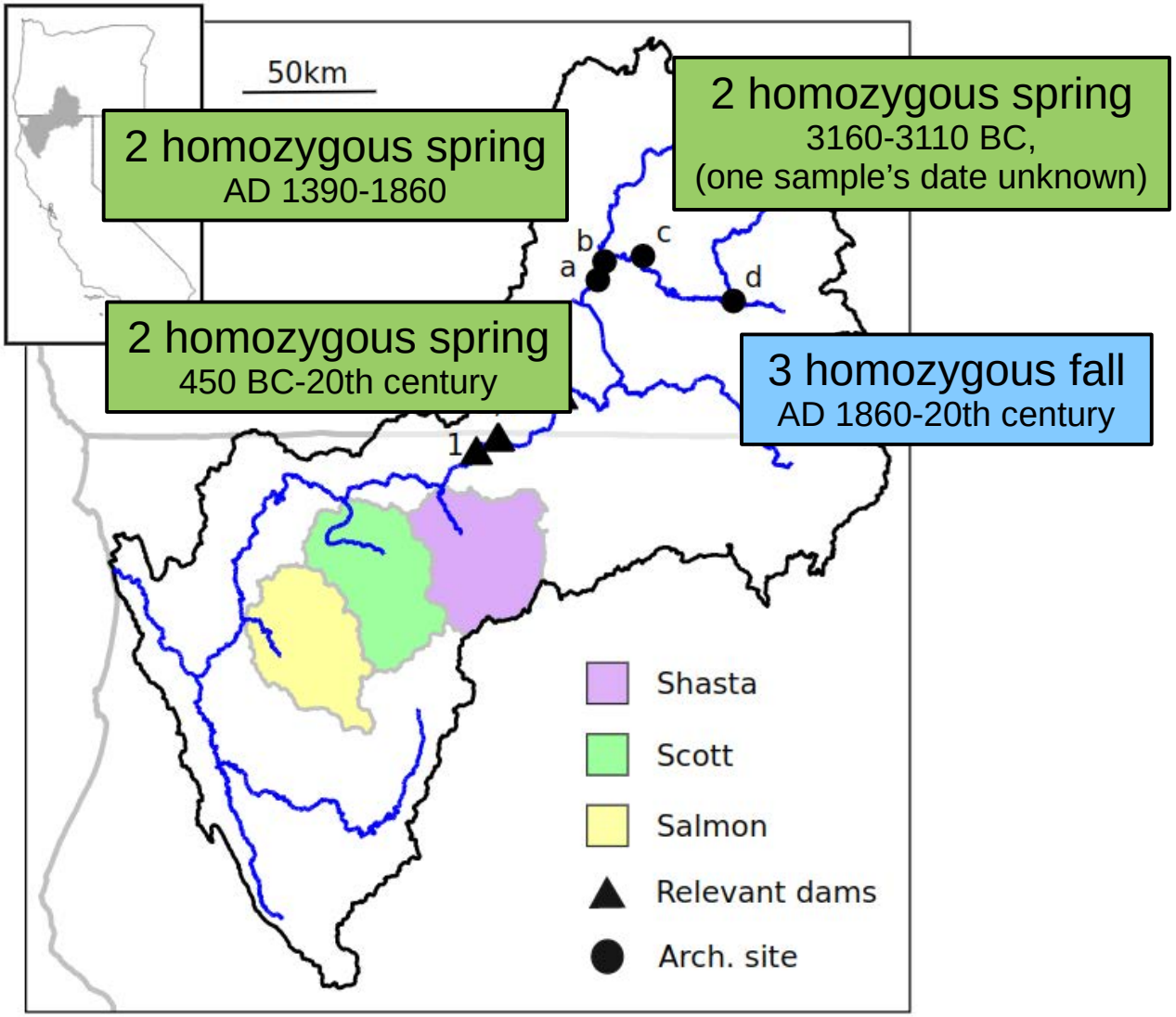
- *GREB1L* marker discover and validation
- Analysis of Rogue River Chinook to understand migration time of heterozygotes
- Applications for restoring spring Chinook in the upper Klamath

Analysis of ancient Chinook samples identifies both spring and fall alleles from archaeological sites above Klamath dams



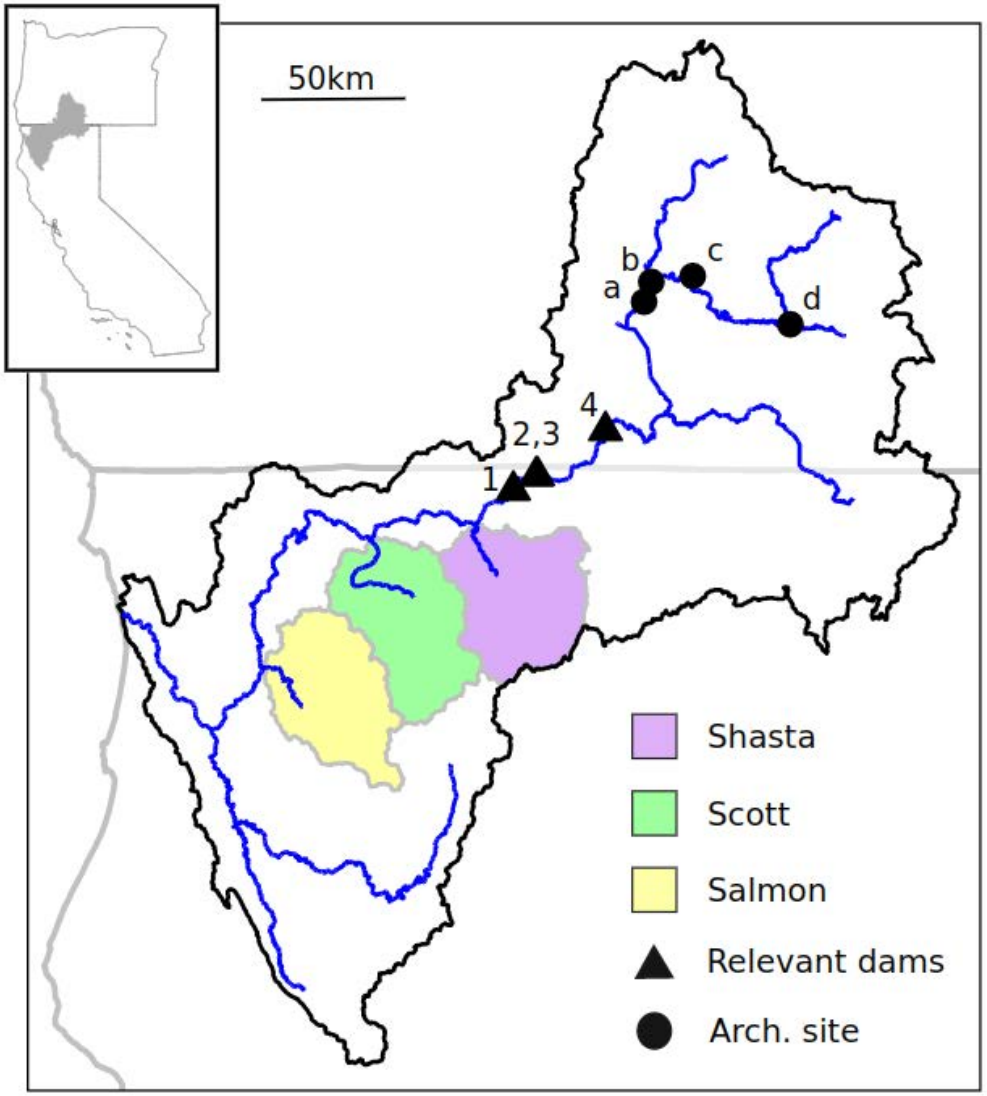
Thompson et al., *in prep*

Analysis of ancient Chinook samples identifies both spring and fall alleles from archaeological sites above Klamath dams



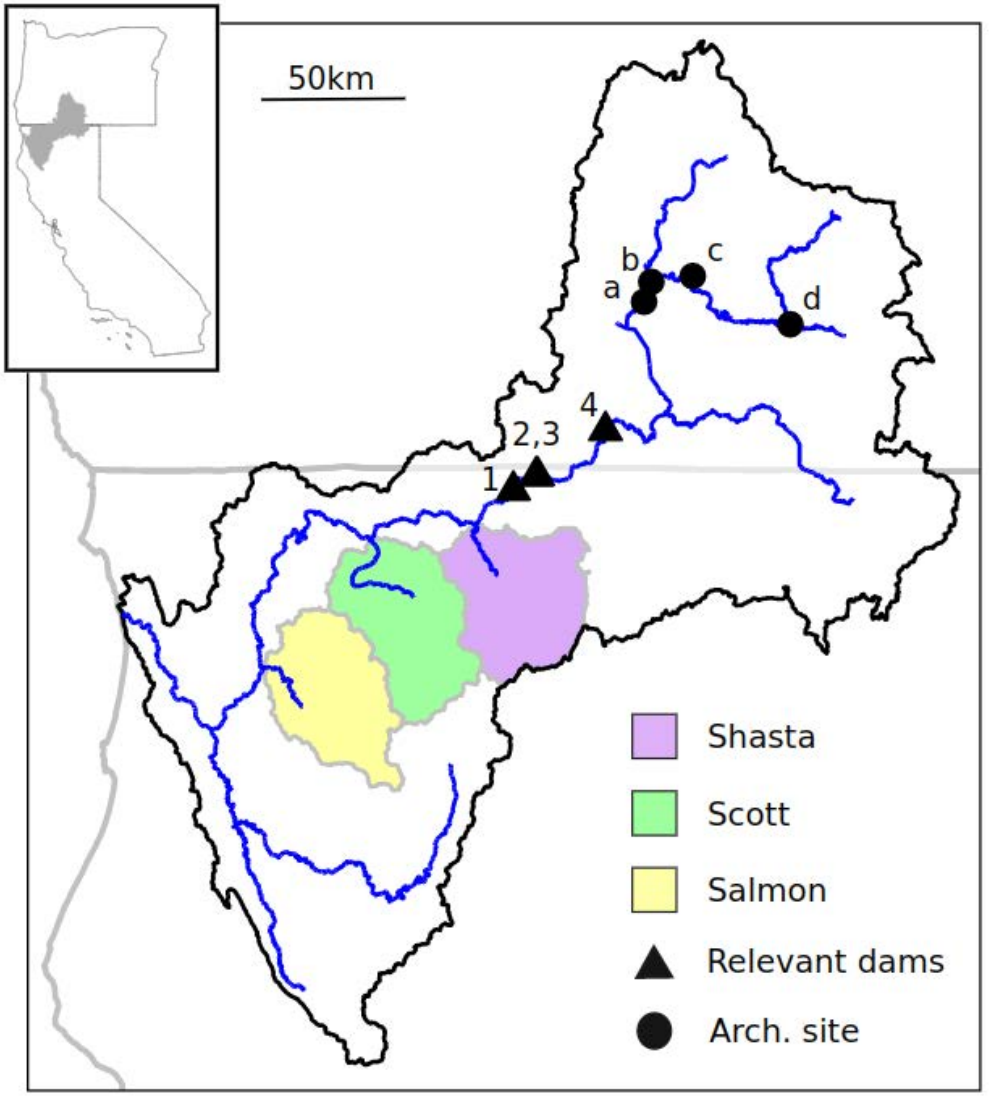
Thompson et al., *in prep*

Where are spring alleles for restoring upper Klamath spring Chinook going to come from?



Thompson et al., *in prep*

Can heterozygotes serve as a reservoir of spring alleles to restore spring Chinook after dam removal?



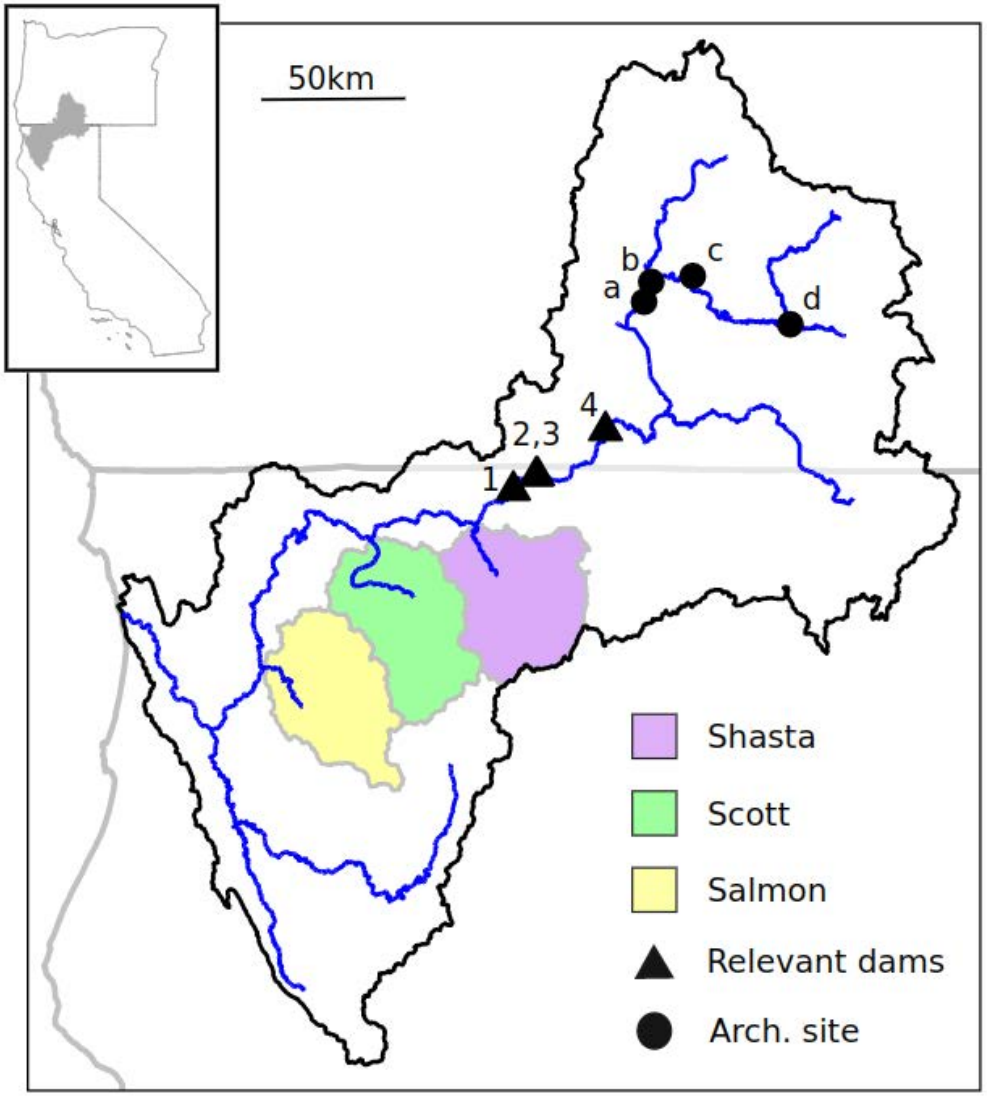
Shasta: spring Chinook extirpated in 1930's

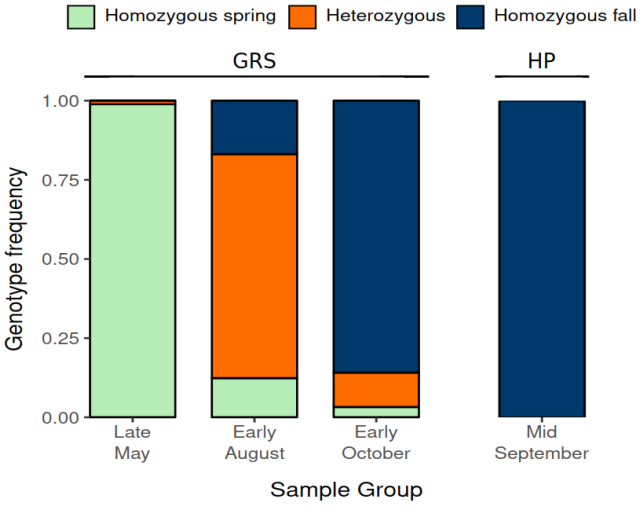
Scott: spring Chinook extirpated in 1970's

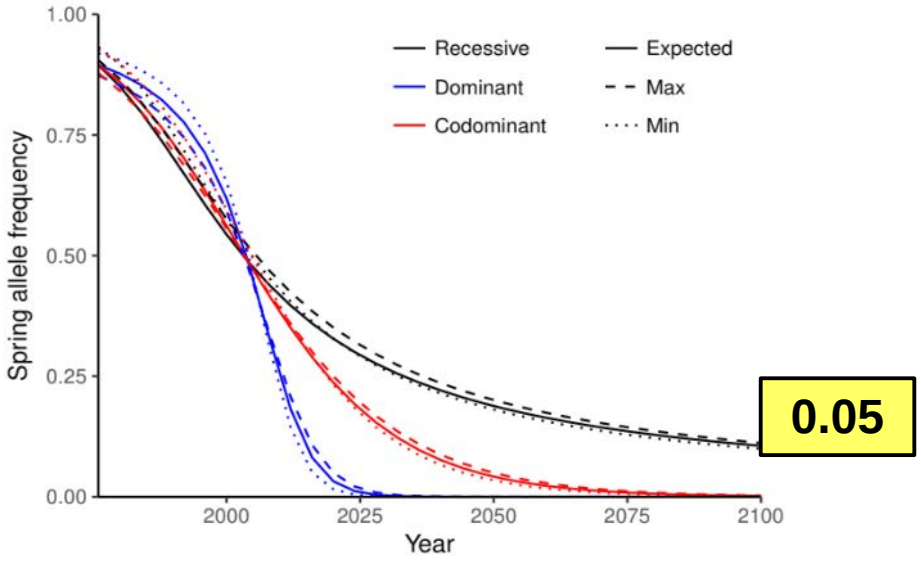
Salmon: spring Chinook still present

Thompson et al., *in prep*

The intermediate migration phenotype suggests heterozygotes may not be a sustainable reservoir for spring alleles



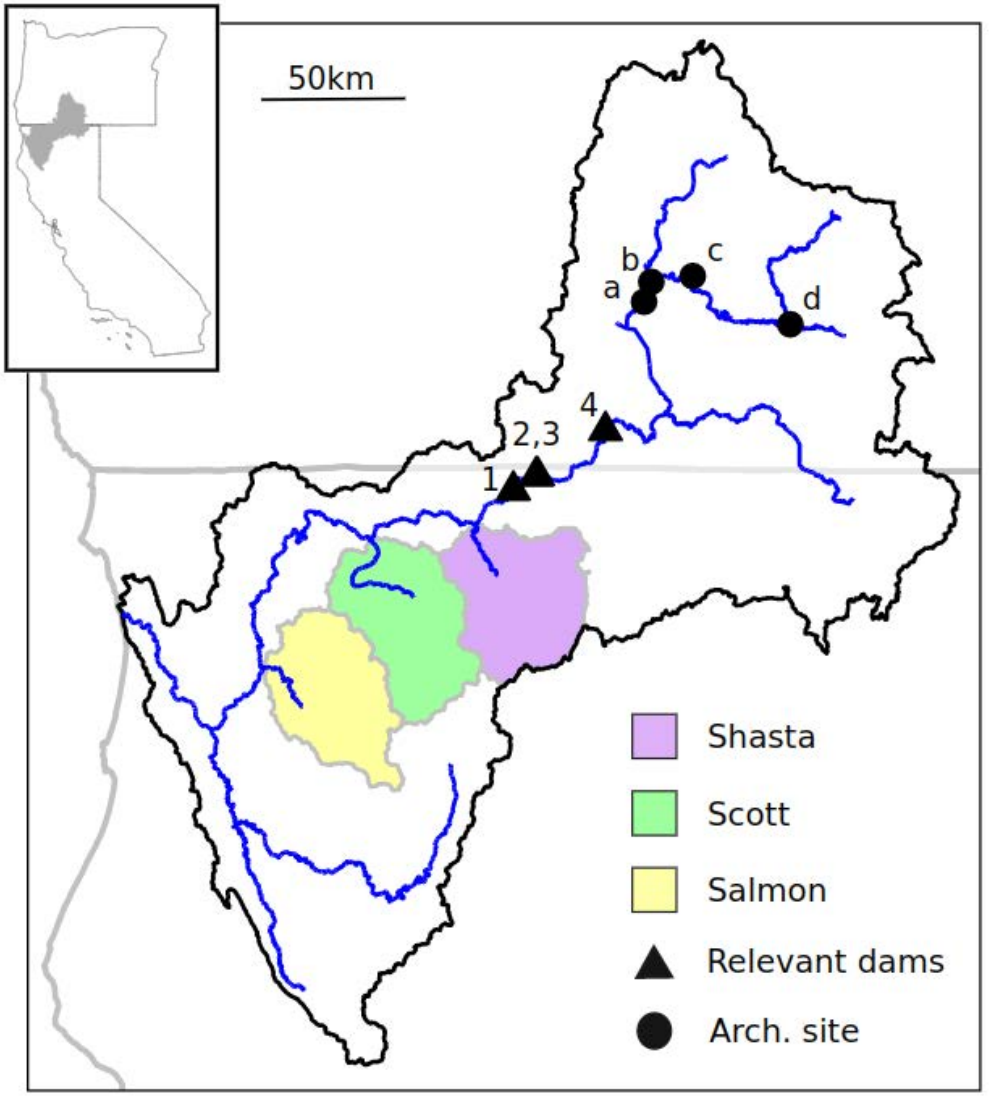




0.05

Thompson et al., *in prep*

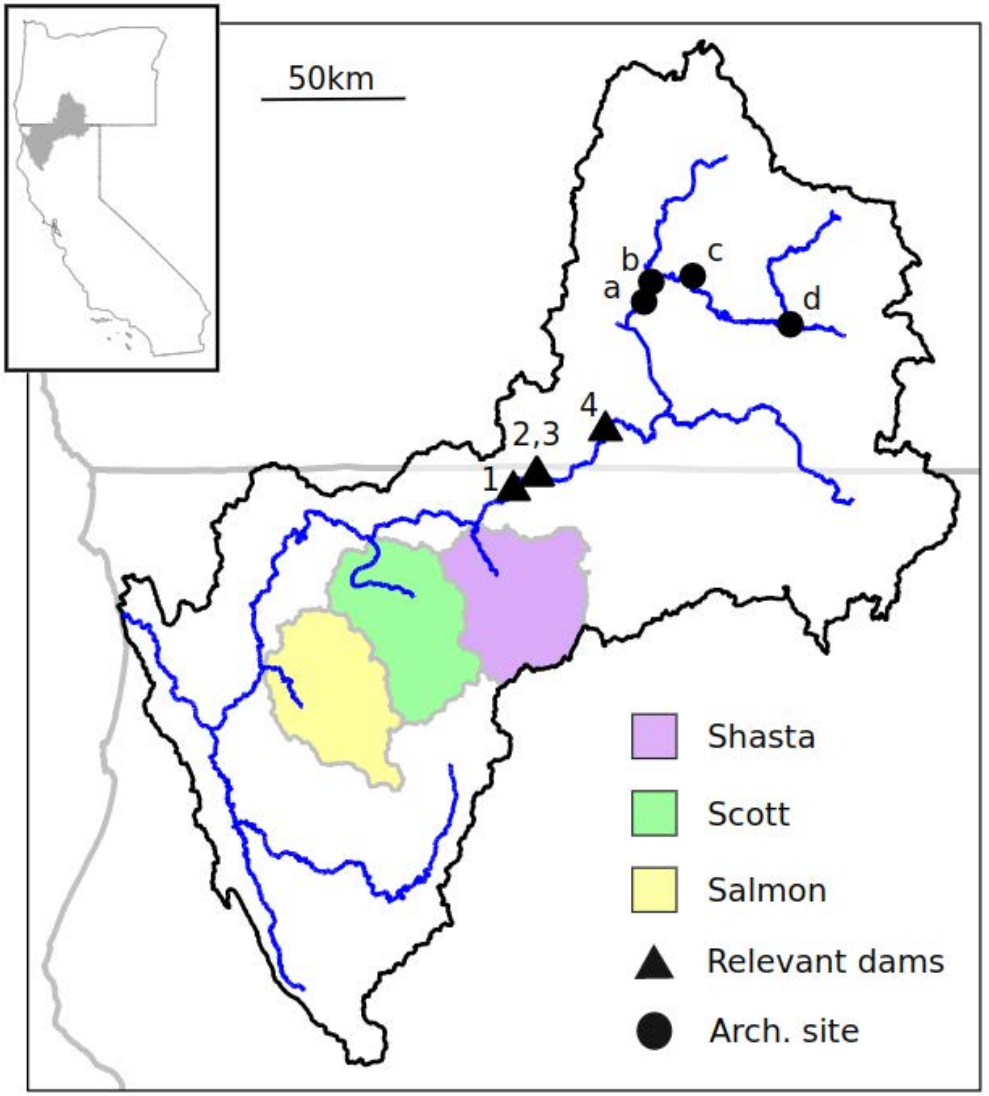
Genotyping smolt samples across juvenile outmigration period reveals spring allele frequencies in the Salmon, Shasta, and Scott



Location	Date spring Chinook last observed	Number of samples	Spring-run allele frequency
Salmon	present	116	**0.20**
Shasta	1930's	440	
Scott	1970's	432	

Thompson et al., *in prep*

Spring alleles have not been maintained in the Shasta or Scott at frequencies that could be used to restore upper Klamath spring Chinook



Location	Date spring Chinook last observed	Number of samples	Spring-run allele frequency
Salmon	2017	116	0.20
Shasta	1930's	440	**0.002 (~20 hets/year)**
Scott	1970's	432	**0.002 (~20 hets/year)**

Thompson et al., *in prep*

Summary and conclusions

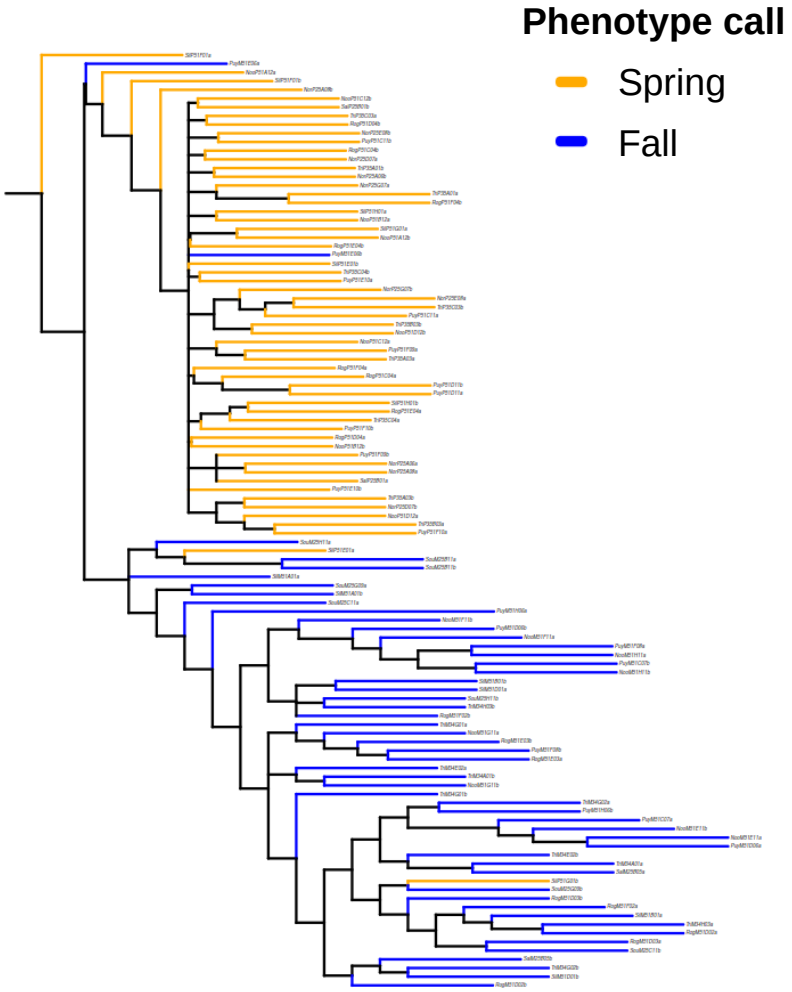
- Higher-resolution analysis of *GREB1L* led to discovery of new markers for migration type
- Validation of markers indicates they appear to be diagnostic for spring vs. fall migration type
- *GREB1L* heterozygotes have an intermediate migration phenotype
- Both spring and fall Chinook were found in ancient samples from above Klamath dams
- Spring alleles are not being maintained in the Shasta and Scott Rivers

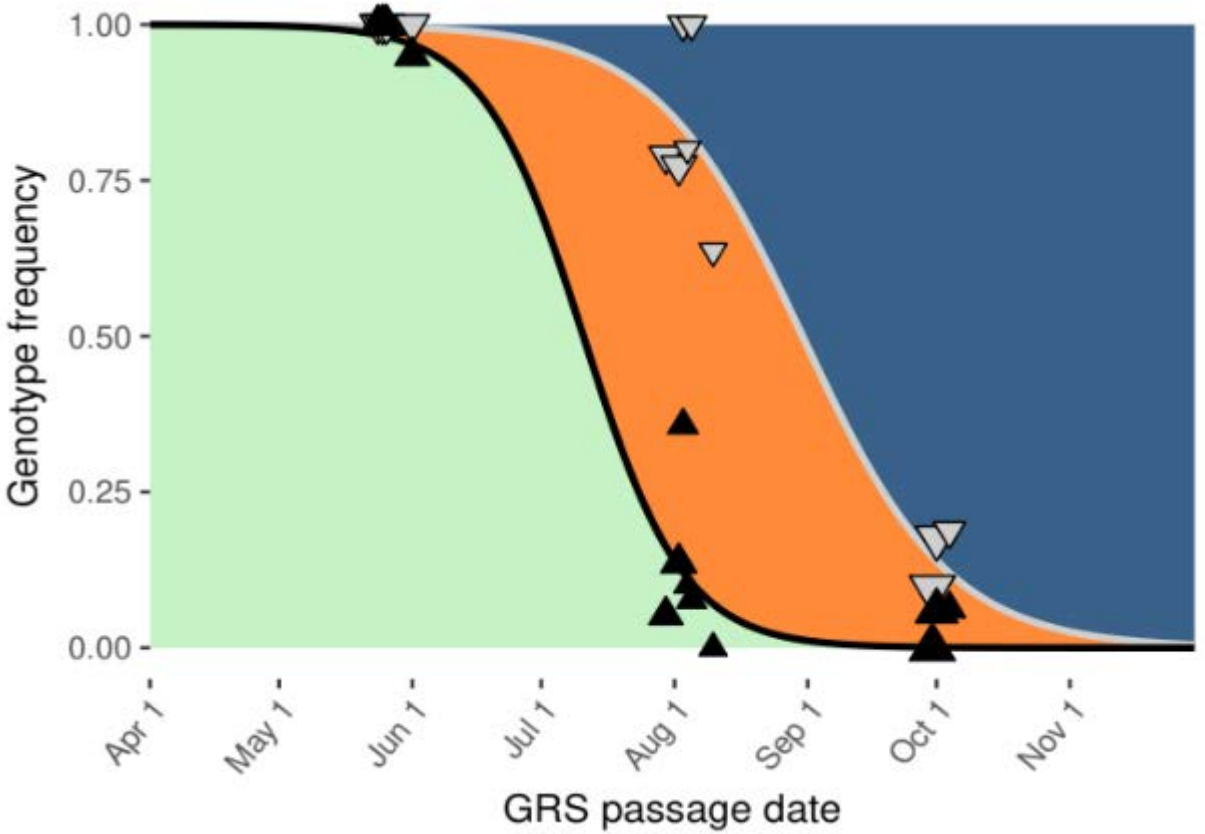
Acknowledgments

- Renee M. Bellinger
- Sean M. O'Rourke
- Daniel J. Prince
- Michelle Pepping
- Alexander E. Stevenson
- Antonia T. Rodrigues
- Matthew R. Sloat
- Camilla F. Speller
- Dongya Y. Yang
- Virginia L. Butler
- Michael A. Banks
- Michael R. Miller

- **Many, many more!!!**

Evolutionary analysis of coastal Chinook reveals monophyletic origin for spring-run alleles

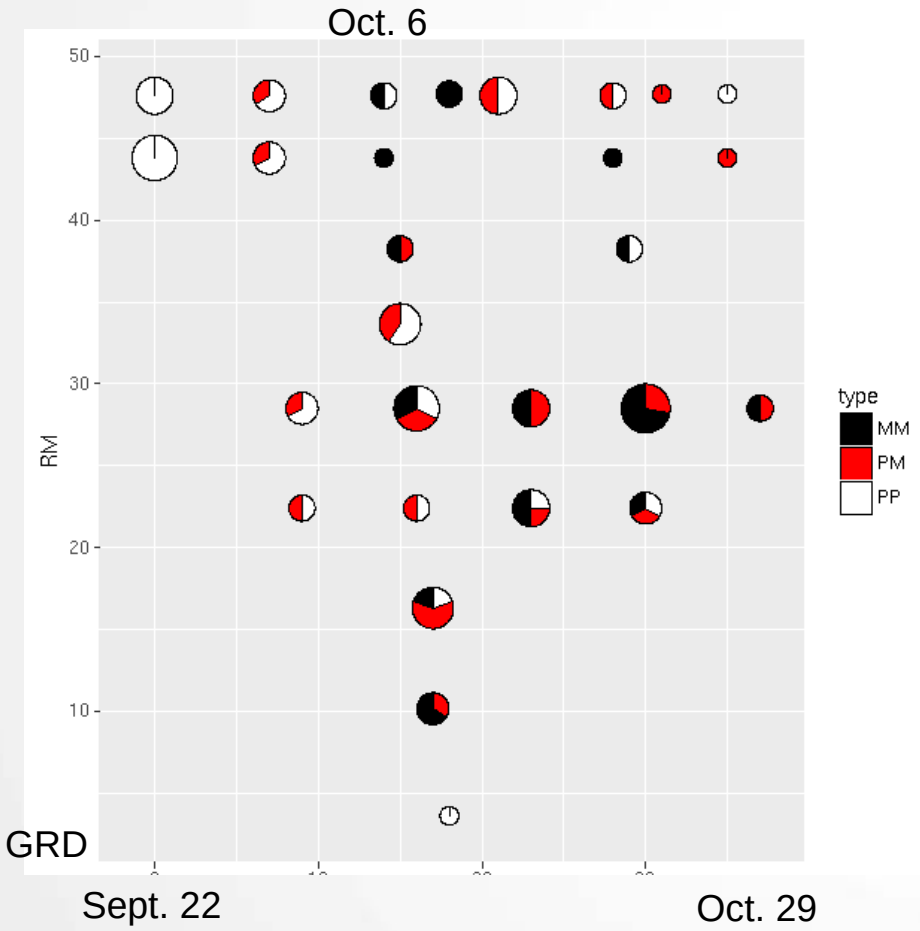



1.00
0.75
0.50
0.25
0.00
Genotype frequency
Apr 1
May 1
Jun 1
Jul 1
Aug 1
Sep 1
Oct 1
Nov 1
GRS passage date

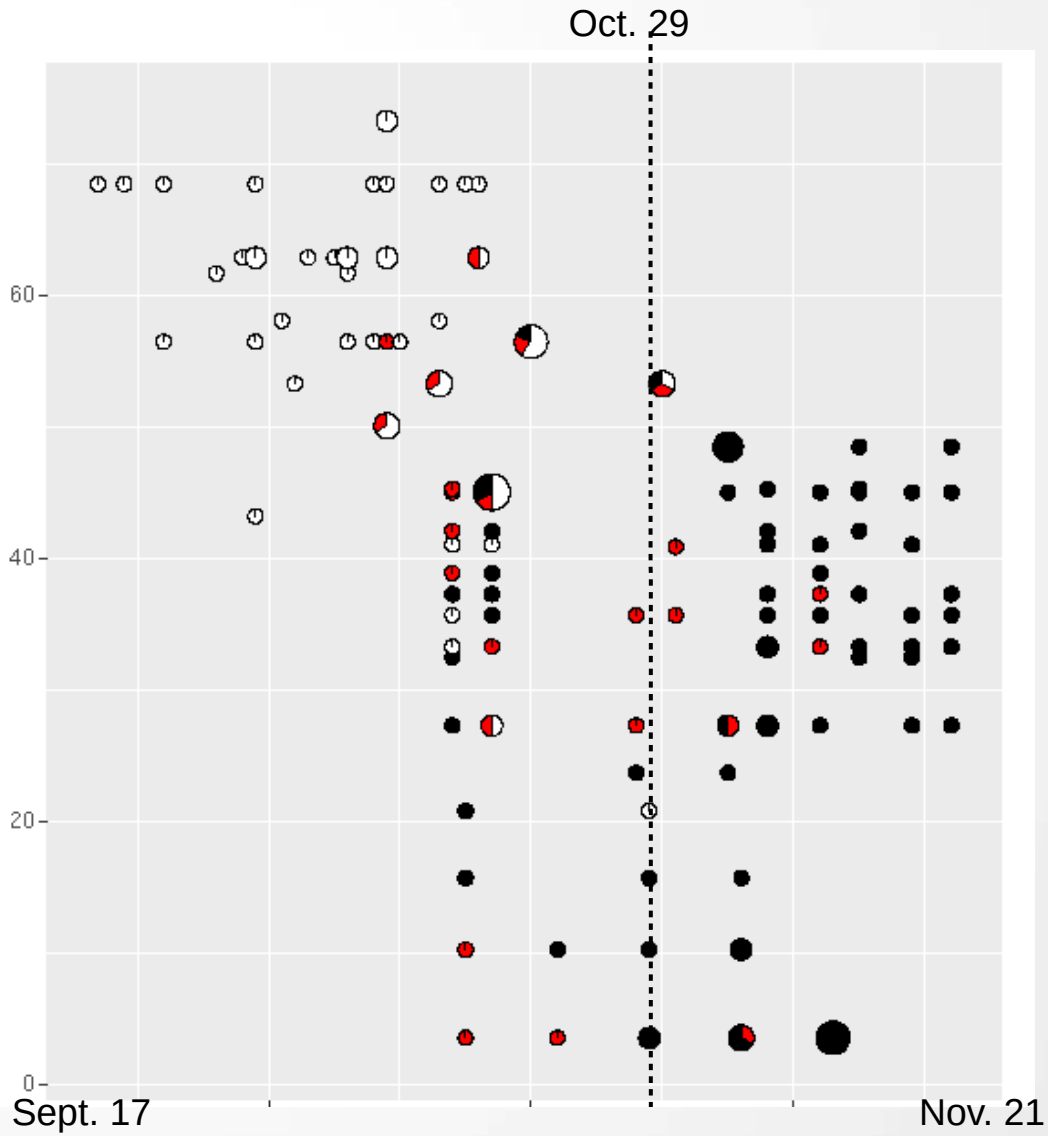
South Fork Trinity						
Sandy Bar Weir	5/15/1992	SS		Sandy Bar Weir	10/14/1993	FF
Sandy Bar Weir	5/21/1992	SS		Sandy Bar Weir	10/15/1993	FF
Sandy Bar Weir	5/25/1992	SS		Sandy Bar Weir	10/15/1993	FF
Sandy Bar Weir	6/12/1993	SS		Sandy Bar Weir	10/15/1993	FF
Sandy Bar Weir	6/21/1993	SS		Sandy Bar Weir	10/15/1993	FF
Sandy Bar Weir	6/25/1993	SS		Sandy Bar Weir	10/24/1993	FF
Forest Glen	6/25/1993	SS		Sandy Bar Weir	10/25/1993	FF
Sandy Bar Weir	6/26/1993	SS		Sandy Bar Weir	10/25/1993	FF
Sandy Bar Weir	6/28/1993	SS		Sandy Bar Weir	10/28/1993	FF
Sandy Bar Weir	6/29/1993	SS		Sandy Bar Weir	10/29/1993	FF
Sandy Bar Weir	6/29/1993	SS		Sandy Bar Weir	10/29/1993	FF
Forest Glen	6/30/1993	SS		Sandy Bar Weir	10/29/1993	FF
Forest Glen	7/2/1993	SS		Sandy Bar Weir	10/29/1993	FF
Sandy Bar Weir	7/3/1993	SS		Sandy Bar Weir	10/29/1993	FF
Sandy Bar Weir	7/6/1993	SS		Sandy Bar Weir	10/30/1993	FF
Sandy Bar Weir	7/7/1993	SS		Sandy Bar Weir	11/2/1993	FF
Sandy Bar Weir	7/8/1993	SS		Sandy Bar Weir	11/3/1993	FF
Sandy Bar Weir	7/8/1993	SS		Sandy Bar Weir	11/3/1993	FF
Sandy Bar Weir	7/13/1993	SS		Sandy Bar Weir	11/3/1993	FF
Sandy Bar Weir	7/16/1993	SS		Sandy Bar Weir	11/3/1993	FF
Sandy Bar Weir	7/20/1993	SS		Sandy Bar Weir	11/3/1993	FF
Sandy Bar Weir	7/23/1993	SS		Sandy Bar Weir	11/11/1993	FF
Sandy Bar Weir	7/23/1993	SS		Sandy Bar Weir	11/12/1993	FF
Sandy Bar Weir	7/24/1993	SS		Sandy Bar Weir	11/12/1993	FF
Sandy Bar Weir	7/24/1993	SS		Sandy Bar Weir	11/12/1993	FF
Sandy Bar Weir	7/24/1993	SS		Sandy Bar Weir	11/14/1993	FF
Sandy Bar Weir	7/24/1993	SS		Sandy Bar Weir	11/14/1993	FF
Sandy Bar Weir	7/24/1993	SS		Sandy Bar Weir	11/15/1993	FF
Sandy Bar Weir	7/31/1993	SF		Sandy Bar Weir	11/15/1993	FF

Rogue and Salmon River carcass survey genotyping results

Rogue River



Salmon River



DRAFT IMPLEMENTATION PLAN FOR REINTRODUCING ANADROMOUS FISHES INTO THE OREGON PORTION OF THE UPPER KLAMATH BASIN

An Update

Mark Hereford and Ted Wise

Oregon Department of Fish and Wildlife

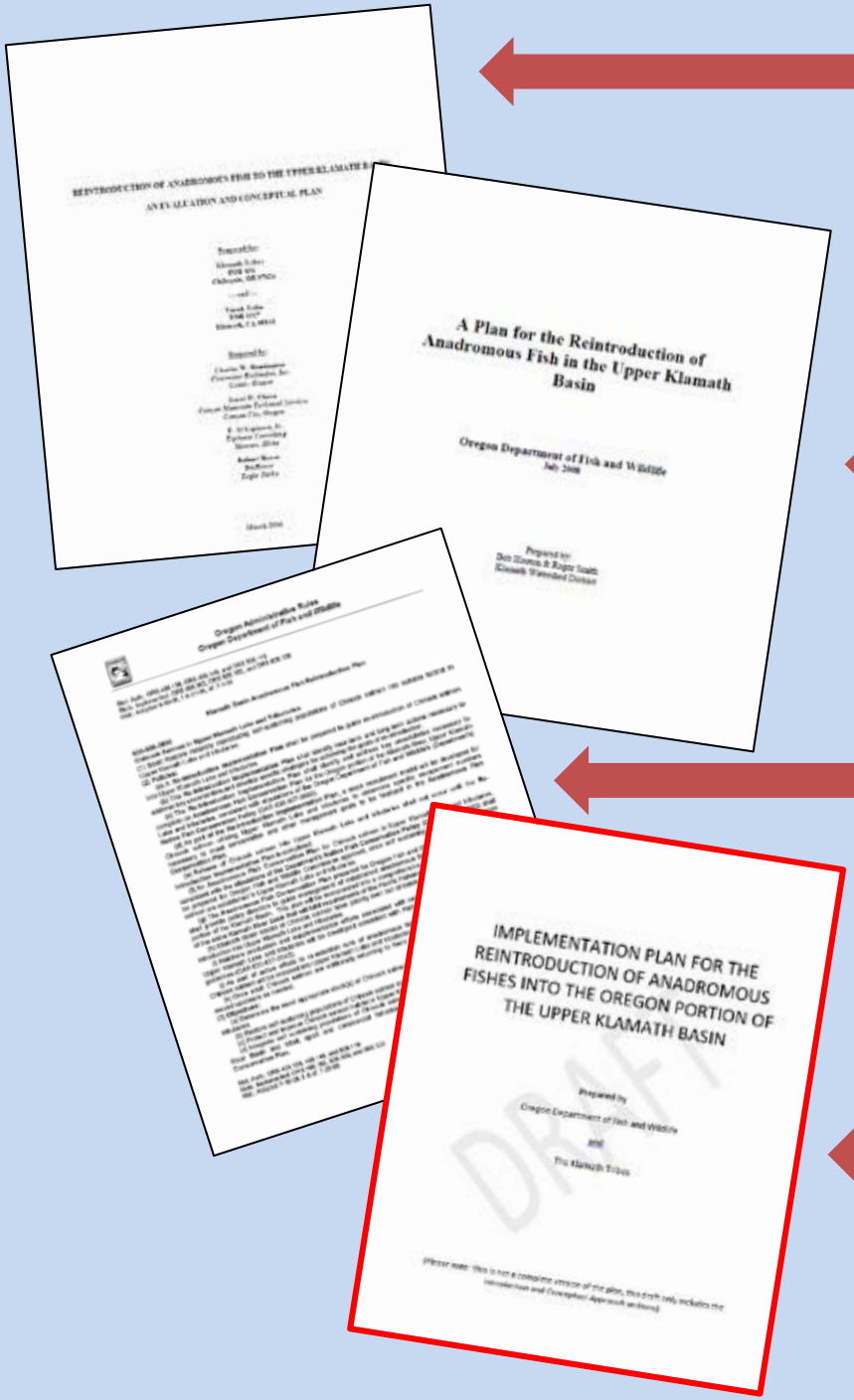
Alex Gonyaw

Klamath Tribes

Chuck Huntington

CBI

Photo courtesy of the Klamath County Historical Society

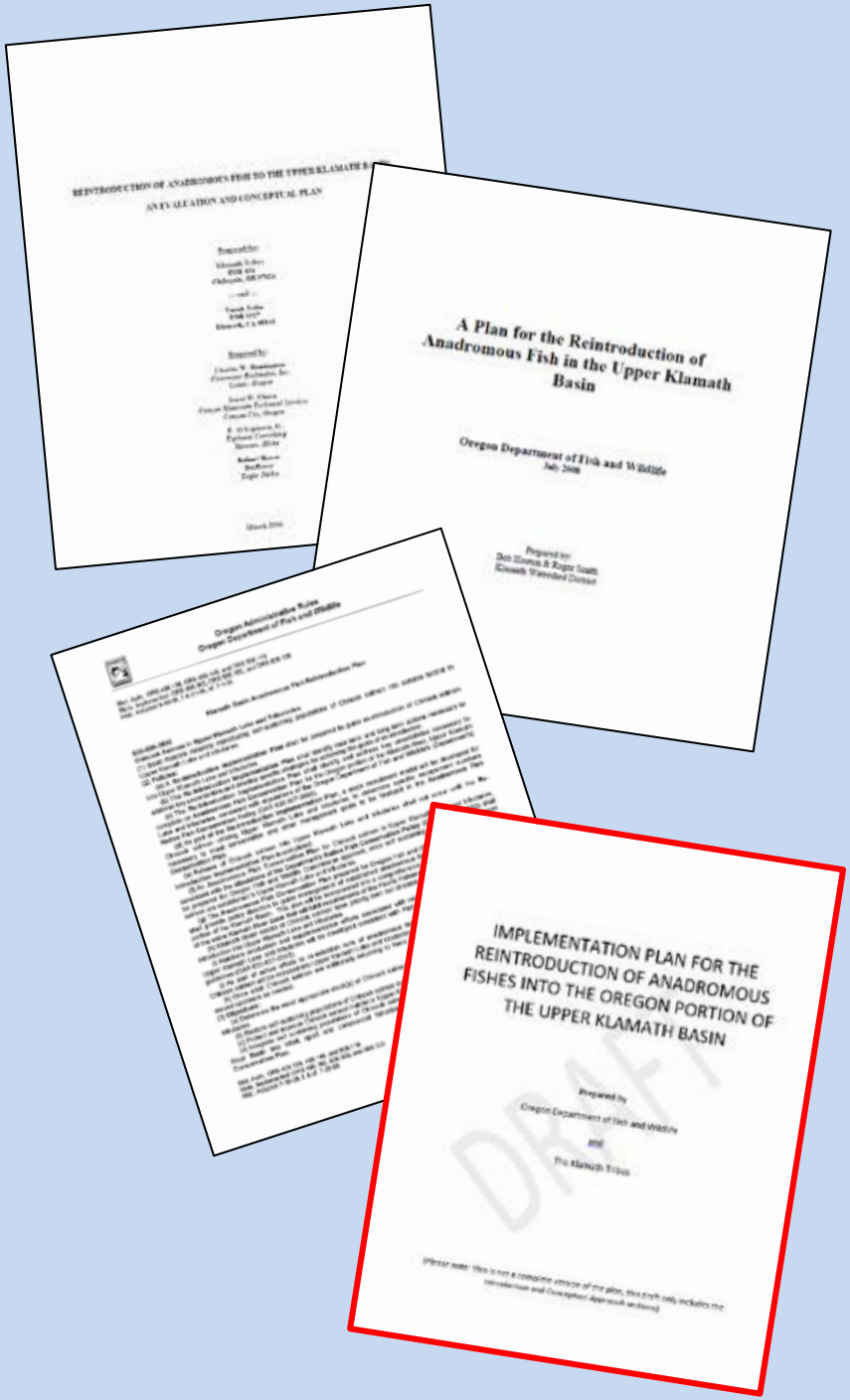


Evaluation and Conceptual Plan

Reintroduction Plan

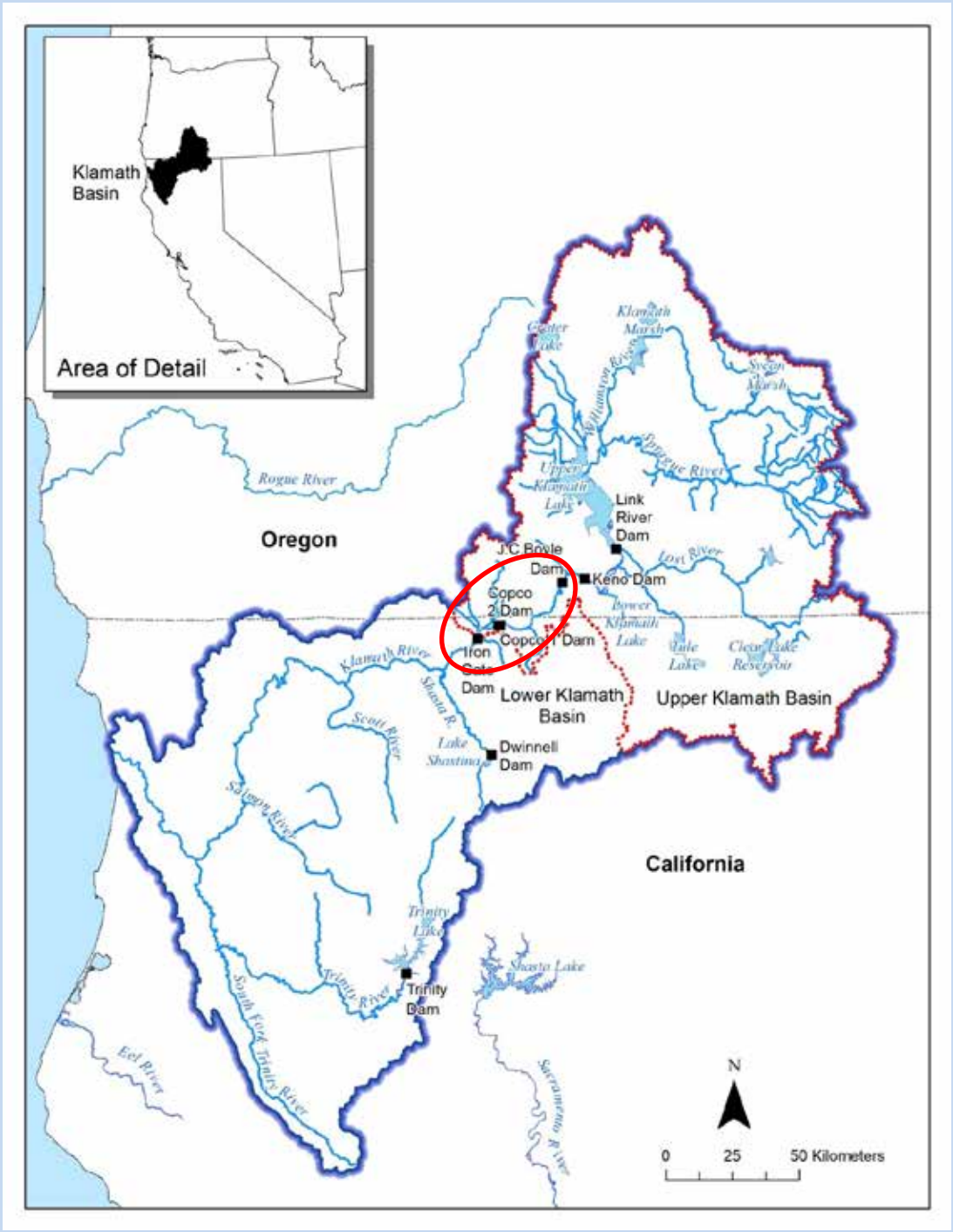
Policy

Implementation Plan
(this document)



An update on the progress toward completion of the <u>Implementation Plan</u>

- Completed initial drafts of *Introduction* and *Conceptual Approach* sections
- Currently working on the *Strategy for Monitoring recolonization of Anadromous Fishes* section
- Continue working on *Strategy for Active Reintroduction of Spring-Run Chinook Salmon* section
- Complete initial DRAFT of document by the end of 2018



Copco 1 Dam – construction completed 1918 – Klamath River mile 202

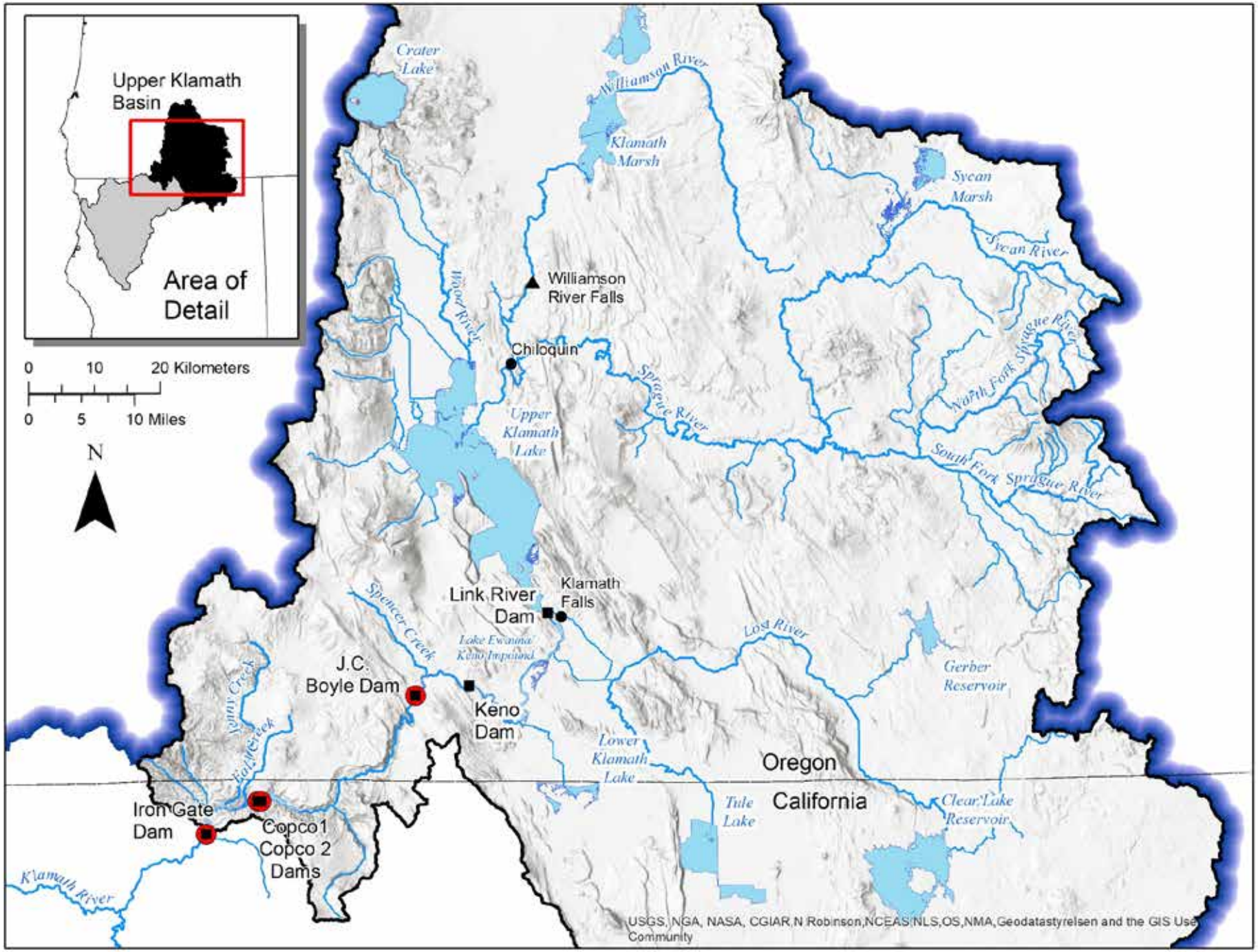
- Migration blocked due to construction in 1912

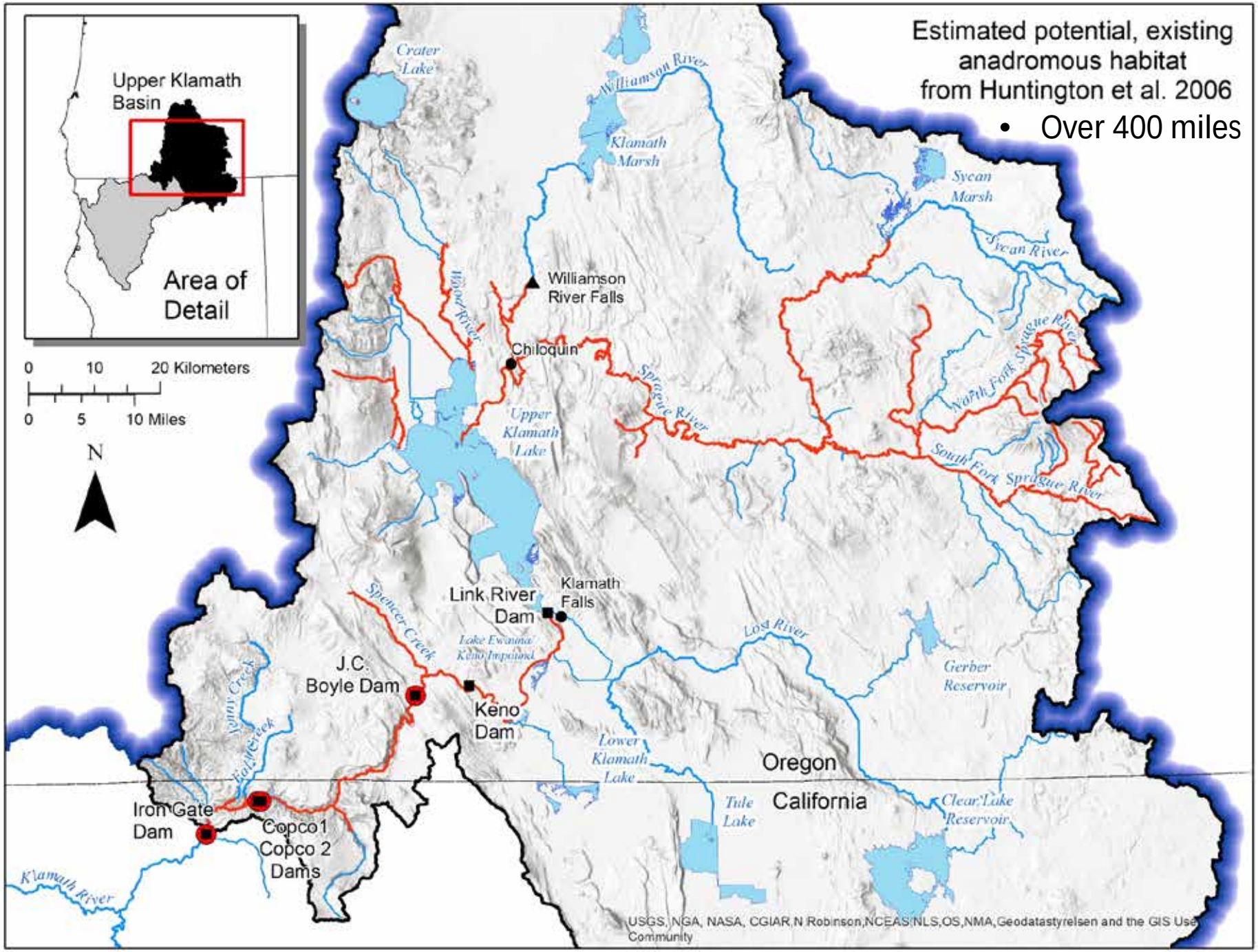
Subsequent mainstem dam construction

- **Copco 2 Dam** – 1925 rm 201.5
- **J.C. Boyle Dam** – 1958 rm 228
- **Iron Gate Dam** – 1962 rm 194
  - Current limit to anadromy

Other dams

- **Link River Dam** – 1927 rm 257.5
  - Fish ladder built in 2006
- **Keno Dam** – 1966 rm 236
  - Fish ladder, needs some modifications to allow passage for all species and life-stages of anadromous fishes


Upper Klamath Basin
Area of Detail
0 10 20 Kilometers
0 5 10 Miles
N
Crater Lake
Williamson River
Klamath Marsh
Sycan Marsh
Sycan River
Wood River
Williamson River Falls
Chiloquin
Sprague River
North Fork Sprague River
South Fork Sprague River
Upper Klamath Lake
Link River Dam
Klamath Falls
Spencer Creek
Lake Ewauna
Keno Impound
Lost River
Gerber Reservoir
J.C. Boyle Dam
Keno Dam
Keno Creek
Fall Creek
Lower Klamath Lake
Oregon
California
Tule Lake
Clear Lake Reservoir
Iron Gate Dam
Copco 1
Copco 2
Dams
Klamath River
USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen and the GIS User Community


Estimated potential, existing anadromous habitat from Huntington et al. 2006
• Over 400 miles
Upper Klamath Basin
Area of Detail
0 10 20 Kilometers
0 5 10 Miles
N
Crater Lake
Williamson River
Klamath Marsh
Sycan Marsh
Sycan River
Wood River
Williamson River Falls
Chiloquin
Upper Klamath Lake
Sprague River
North Fork Sprague River
South Fork Sprague River
Link River Dam
Klamath Falls
Spencer Creek
Lake Ewauna/ Keno Impound
J.C. Boyle Dam
Keno Dam
Lost River
Gerber Reservoir
Lower Klamath Lake
Oregon
California
Tule Lake
Clear Lake Reservoir
Iron Gate Dam
Copco 1
Copco 2
Dams
Klamath River
USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen and the GIS User Community

Oregon's Reintroduction Implementation Plan will:

- ***Follow Oregon State policy*** adopted in 2008 focused on reintroduction of anadromous fishes in the Oregon portion of the Upper Klamath Basin
  - **Goal:** Restore naturally reproducing, self-sustaining populations of anadromous fishes into suitable habitat in the Oregon portion of the Klamath Basin

"A Reintroduction Implementation Plan shall….

- ***Guide*** active reintroduction of Chinook Salmon into tributaries **above Upper Klamath Lake**
- Only use ***pathogen free eggs*** or ***juvenile*** Chinook Salmon as part of active efforts to re-establish populations
- ***Identify*** key uncertainties and considerations
- Identify facilities and evaluation activities ***to monitor natural recolonization of anadromous fishes (Chinook, Coho, steelhead, Pacific Lamprey)*** into the Oregon portion of Klamath Basin
  - Describe criteria to determine **if active intervention is needed** if natural recolonization is not occurring

Oregon's Reintroduction Implementation Plan will:

- Emphasize natural recolonization where feasible, in an effort to ***reestablish viable, self-sustaining runs of naturally spawning fish*** and to minimize risks.
- Recognize that fully effective use of many habitats that have been altered and/or unoccupied by anadromous fishes for over 100 years will not be immediate.

- ***Outline a structured and adaptive approach to active reintroduction.*** Where there is to be active intervention, the plan will identify how the approach will:
  - match stock selections and fish releases to the conditions the fish will encounter (migration, spawning, incubation, rearing)
  - assure that release strategies will allow natural selective pressures to shape new fish runs
  - monitor the fish, learn, and adapt

Reintroduction Approaches

Volitional Recolonization

Fall-run Chinook Salmon, Coho Salmon, Steelhead Trout, and Pacific Lamprey = <u>Source populations immediately below Iron Gate Dam</u>

- Monitor the rate, extent, diversity, and strength of recolonization after Iron Gate and the other mainstem Klamath dams no longer block passage.
- Identify, evaluate, and address impediments to fish performance.
- Assess ecological interactions and risks.
- Consider the possibility of active interventions (if deemed appropriate).
    - **after 3 fish generations**
        - Fall-run Chinook Salmon = 12 years
        - Coho Salmon = 9 years
        - Steelhead Trout = 15 years
        - Pacific Lamprey = 15 years

Reintroduction Approaches
Active Reintroduction

Spring-run Chinook Salmon = <u>No source population immediately below Iron Gate Dam</u>

<u>Phase 1</u>. Experimental Active Reintroduction

- Stock selection(s) from available candidates
- Hypothesis driven studies (release methods and locations, ecological goodness-of-fit trials, potential impediments to success).

<u>Phase 2</u>. Active Reintroduction

- A scaled-up application of what was learned in Phase 1
- Monitoring, evaluation, and adjustment(s)

Only pathogen free eggs or juvenile Chinook Salmon can be released into Upper Klamath Lake and tributaries

Any use of a hatchery for reintroduction efforts will be defined as a **conservation hatchery - operates to increase the number of naturally produced fish without negatively impacting naturally producing populations, once goals are met hatchery program will be discontinued.**

Whether reintroduction is passive or active…

- The goal is to restore **viable, self-sustaining, naturally-producing** populations of anadromous fishes into suitable habitat in the Oregon portion of the Klamath Basin that benefit the natural and human communities of the Klamath Basin and beyond.

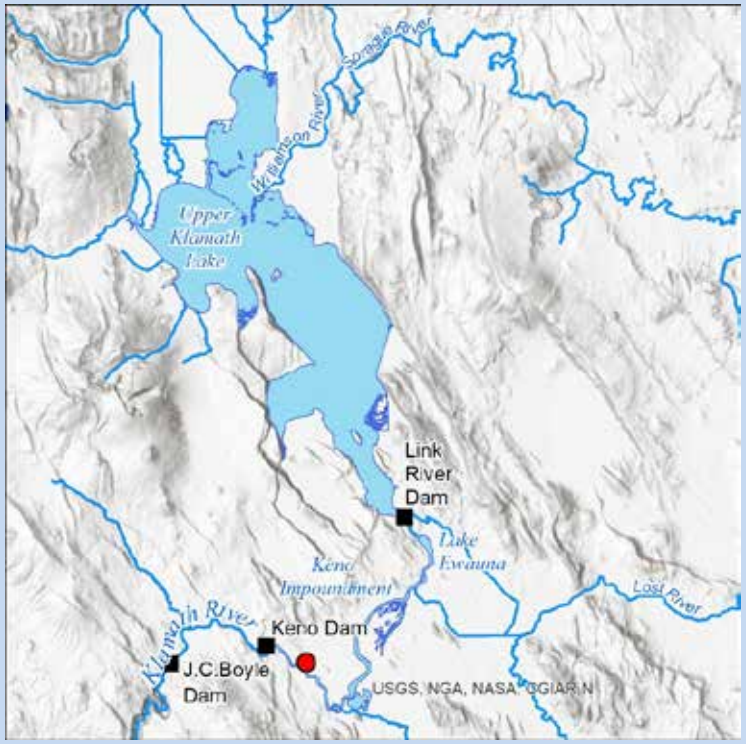
- Progress toward meeting this goal will be monitored, with a focus on multiple indicators:

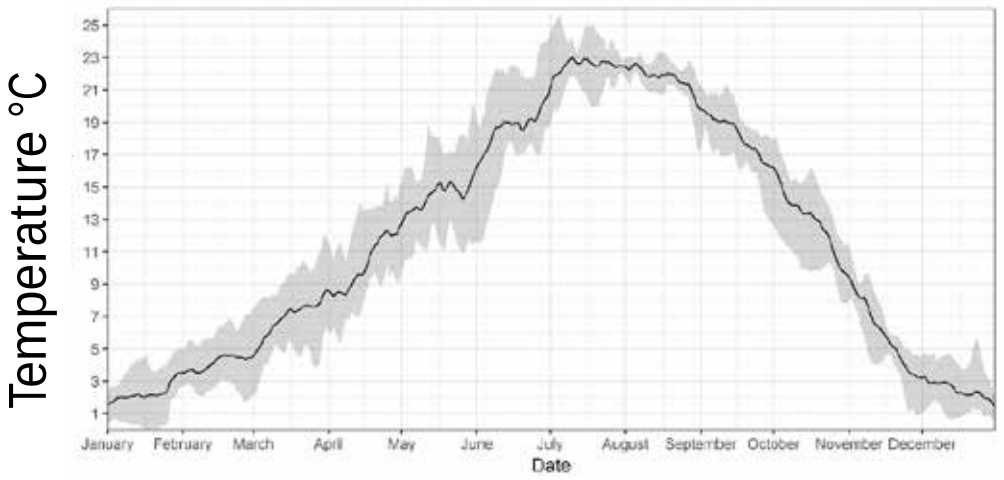
    - **Spatial distribution** – spatial extent in which spawning occurs
    - **Abundance** – number of spawners in populations
    - **Productivity** – number of juveniles per adult female
    - **Genetic diversity** – allelic richness and diversity
    - **Life history diversity** – multiple life histories expressed by adults and juveniles

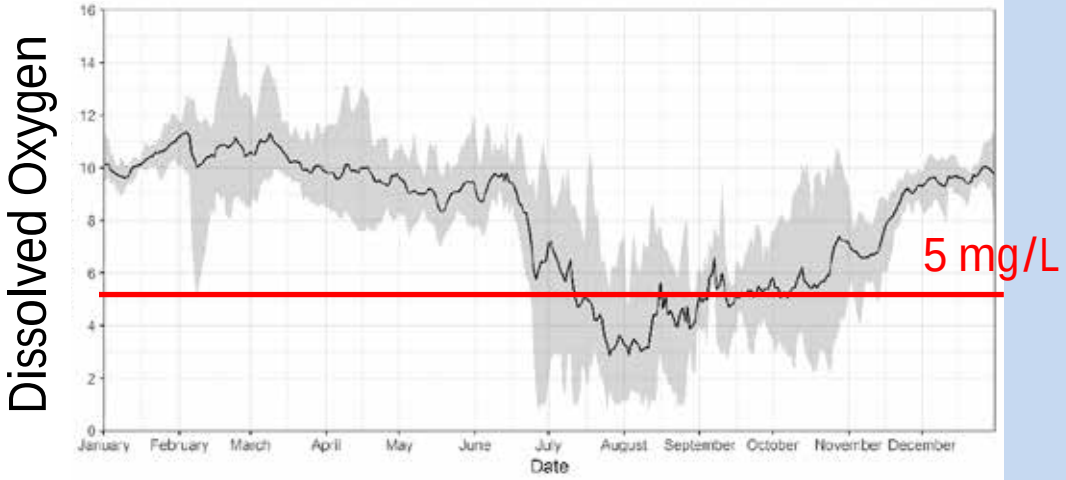
Use of Upper Klamath Lake/Lake Ewauna/Keno Impoundment

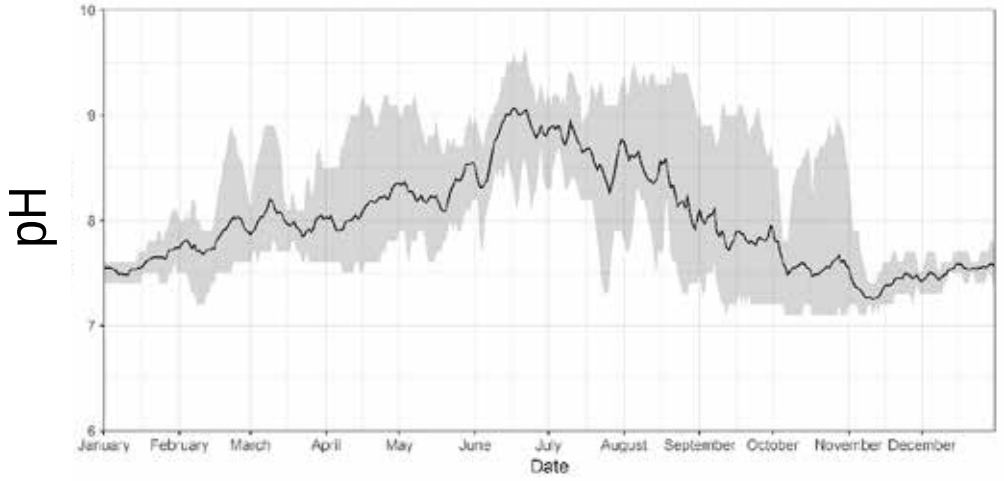
Water Quality

- **Keno Impoundment**
- Mean daily measurement averaged from 2010 – 2015 = **Black Line**
- Minimum and Maximum daily means from 2010 – 2015 = **Grey ribbon**





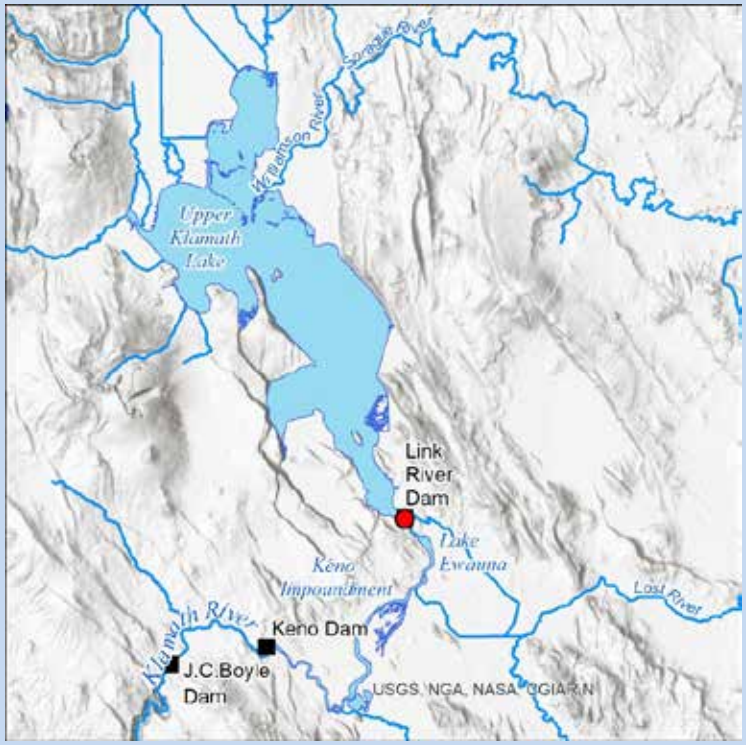


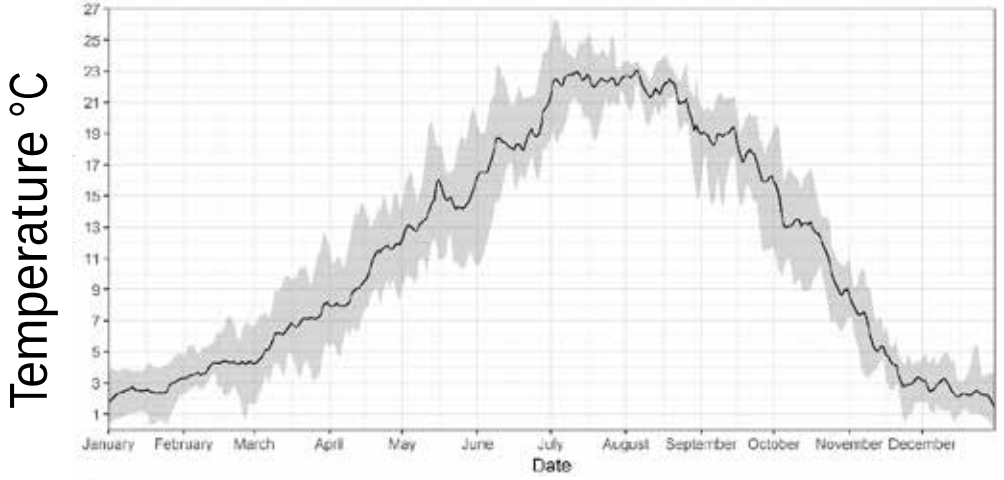


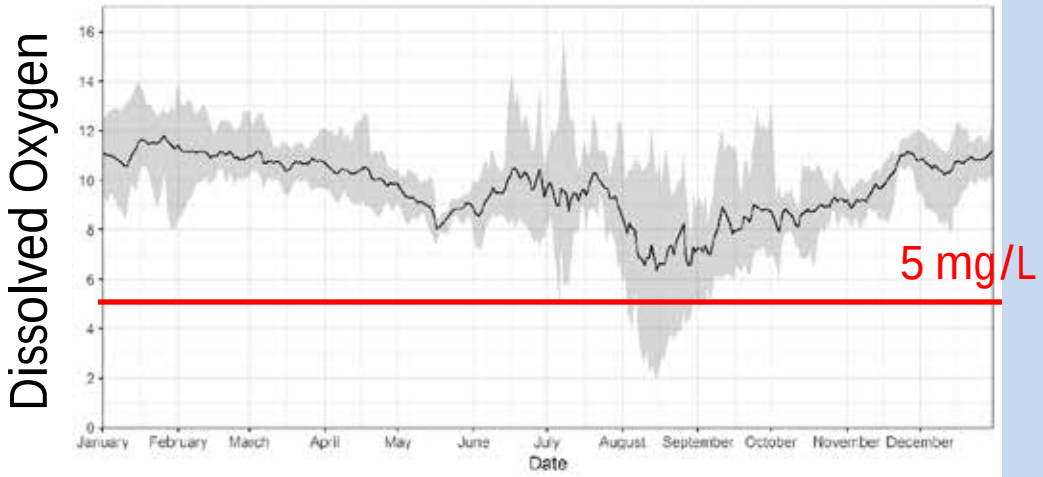
Use of Upper Klamath Lake/Lake Ewauna/Keno Impoundment

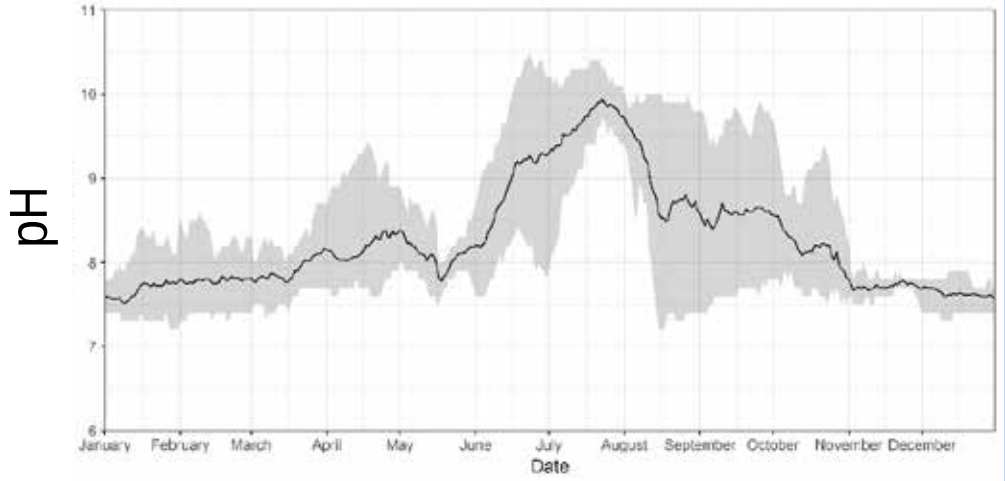
Water Quality

- **Upper Klamath Lake at Link River Dam**
- Mean daily measurement averaged from 2010 – 2015 = **Black Line**
- Minimum and Maximum daily means from 2010 – 2015 = **Grey ribbon**









Use of Upper Klamath Lake/Lake Ewauna/Keno Impoundment

Navigation through Upper Klamath Lake

- 18 miles from Link River Dam to mouth of Williamson River – straight line

- 28 miles to mouth of Wood River

PC: Mark Hereford, ODFW

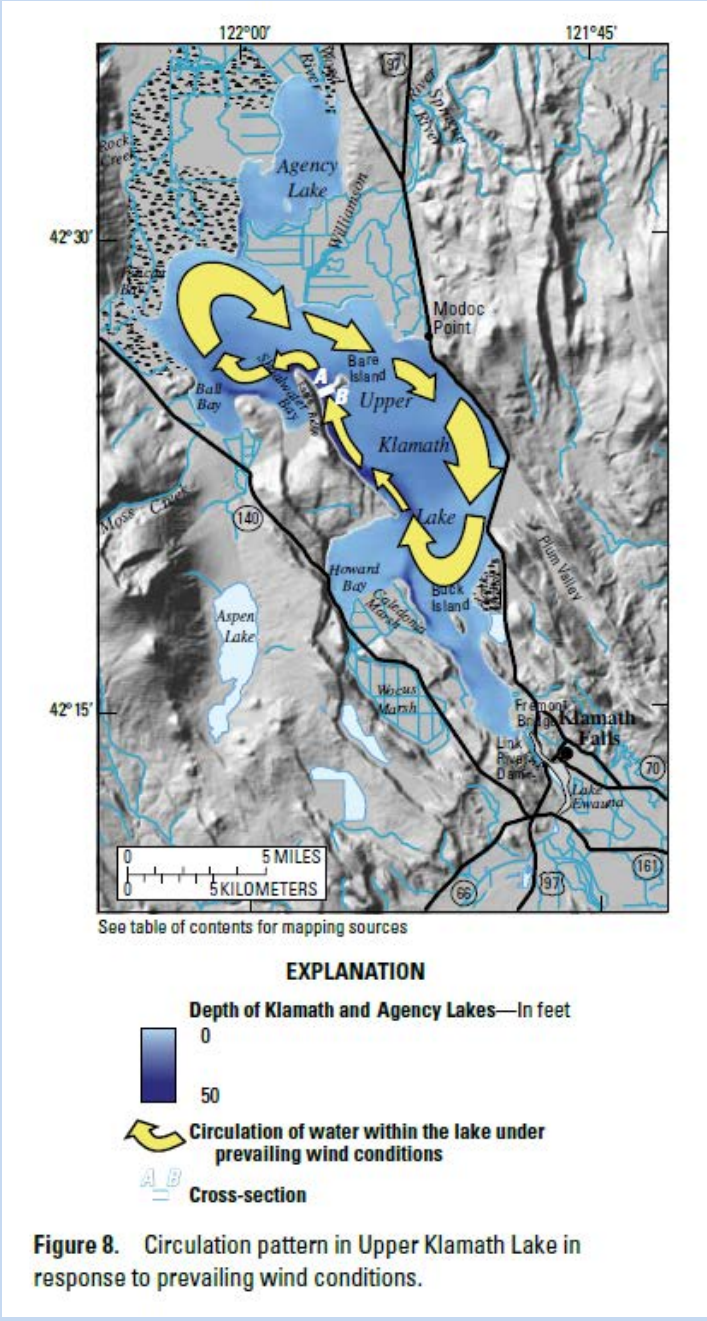
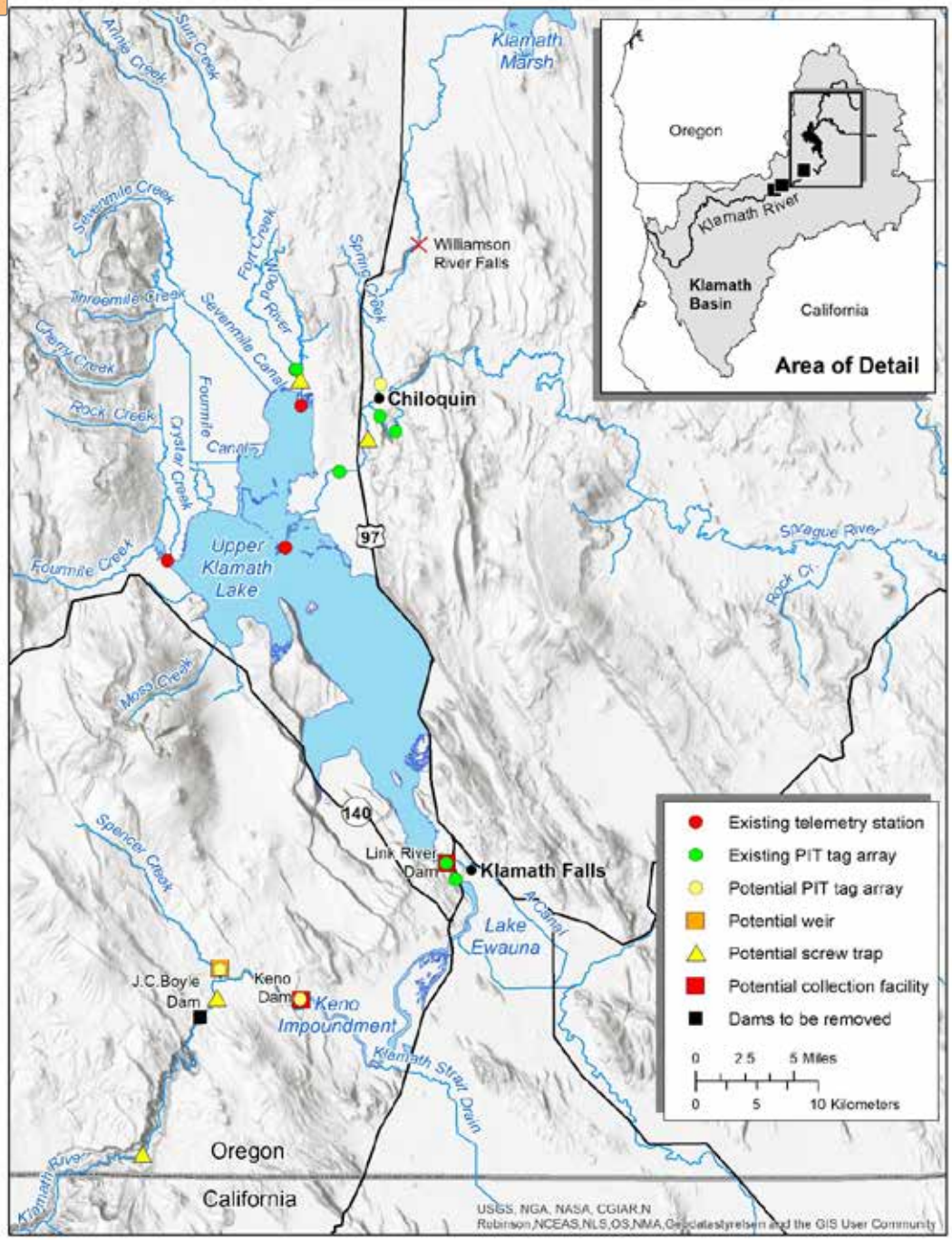


Figure 8. Circulation pattern in Upper Klamath Lake in response to prevailing wind conditions.

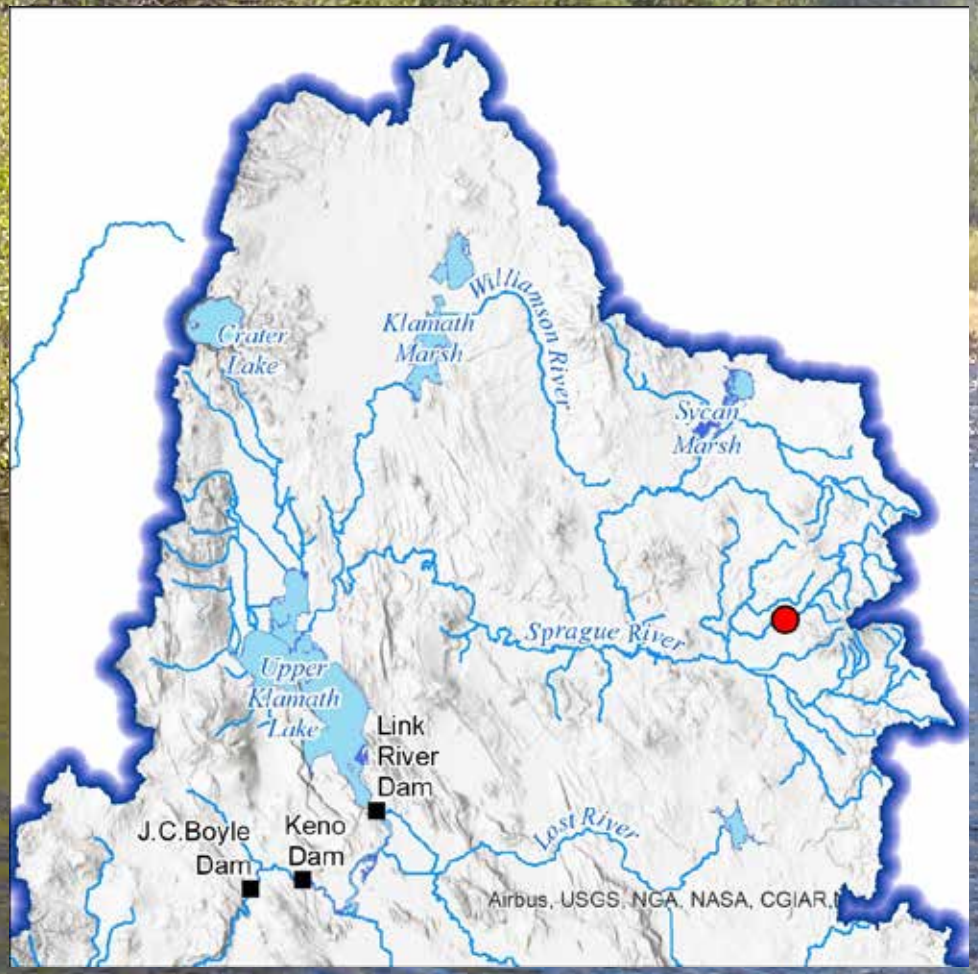
USGS – Wood et al. 2006



Strategy for Monitoring Recolonization

- Visual surveys (carcass) from Keno Dam through Klamath River Canyon
- Video/capture weir on Spencer Creek (tributary to Klamath River)
- Collection facility at Keno Dam
- PIT tag arrays
- Juvenile downstream traps
- Telemetry
- eDNA

There are hundreds of miles of streams above Iron Gate and Upper Klamath Lake (UKL). Some are in good condition....



North Fork Sprague River, OR

PC: Chuck Huntington

Fort Creek, OR

PC: Chuck Huntington

Others are in not-so-good condition....

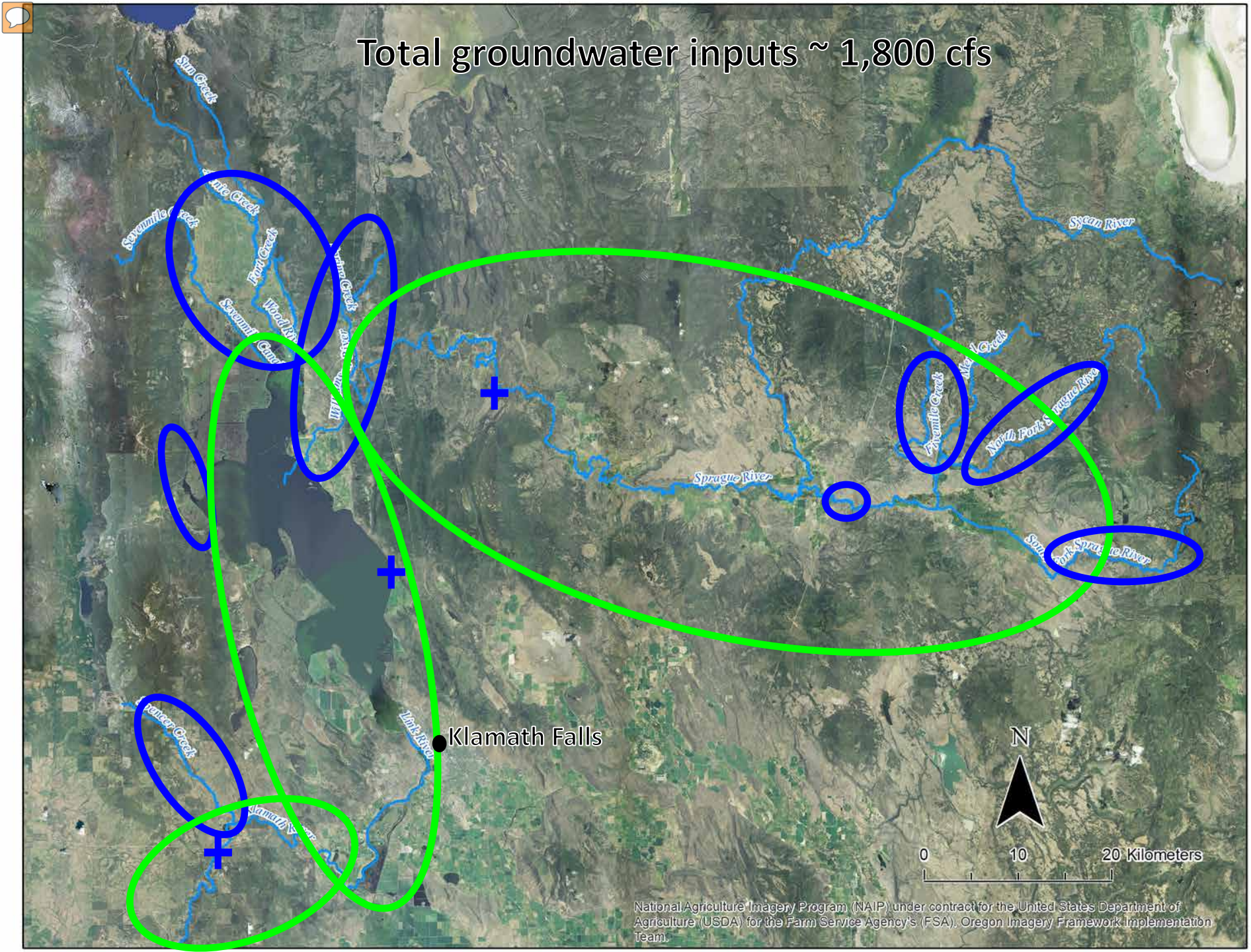
Sprague River, OR

PC: Chuck Huntington

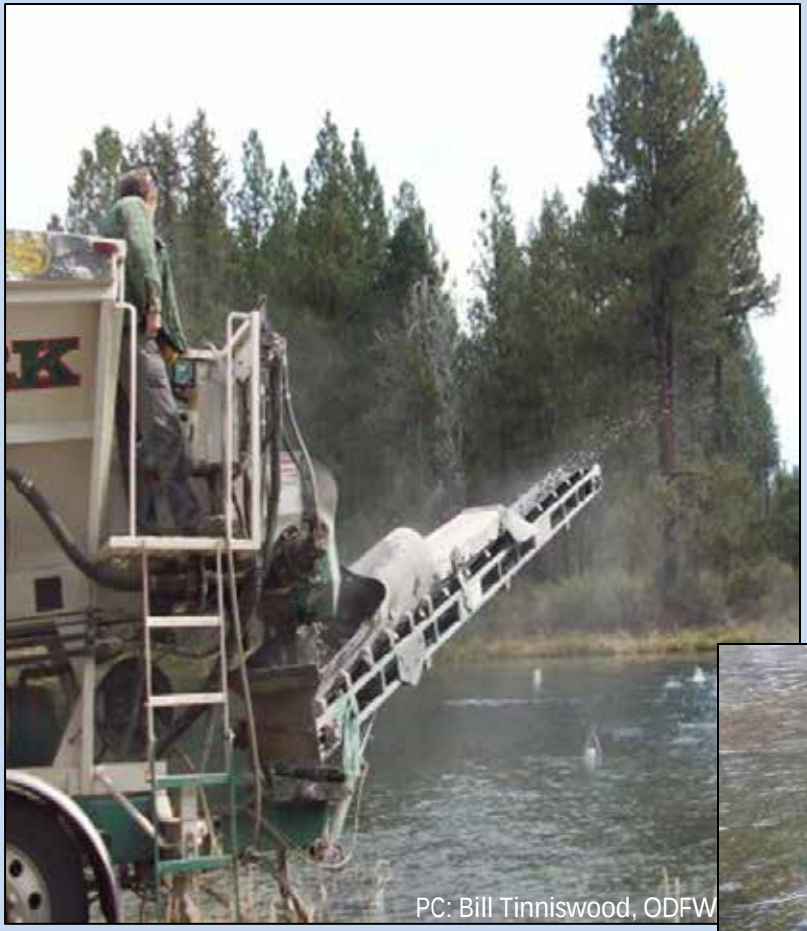
Some streams have been altered to the point that it is hard on first inspection to imagine their historical importance to anadromous fish….

Whiskey Creek, OR

PC: Chuck Huntington


Total groundwater inputs ~ 1,800 cfs
Sun Creek
Fort Creek
Wood River
Sycan River
Fivemile Creek
North Fork Sprague River
Sprague River
South Fork Sprague River
Spencer Creek
Lost River
Klamath Falls
N
0
10
20 Kilometers
National Agriculture Imagery Program (NAIP) under contract for the United States Department of Agriculture (USDA) for the Farm Service Agency's (FSA). Oregon Imagery Framework Implementation Team.

Recent Salmon-specific Restoration Project


PC: Bill Tinniswood, ODFW

Gravel augmentation in Williamson River and Spring Creek

- Gravel size targeted for adfluvial Redband Trout has been placed since the 1970's

- Fall of 2017 first gravel size targeted for Chinook Salmon
  - 110 cubic yards
  - Usage by Redband Trout seen in March 2018


PC: Bill Tinniswood, ODFW


Questions?
PC: Mark Hereford, ODFW

Groundwater (spring) discharges in the Upper Klamath Basin are an asset that will affect habitat suitability and fish life-histories

River System	Section	Groundwater Flow (CFS)
Lower Williamson River and Tributaries	River Mile 16.5-22.2	350
Wood River and Tributaries	Crooked Creek confluence (RM 2) to headwaters	490
Sevenmile Creek and Tributaries	Crane Creek confluence to headwaters	90
Sprague River	South Fork Sprague (RM 10.2) to Sprague River (RM 20.1)	202
Upper Klamath Lake	Springs in Upper Klamath Lake including Malone, Crystal, Sucker, and Barclay	350
Klamath River	Keno Dam (RM 231.5) to Powerhouse (RM 219)	285
Klamath River and Fall Creek	Powerhouse to Iron Gate Dam	128
Total		**1,895**

Source: USGS (2007); Tinniswood (2010 and 2011)

Spring Creek ~ 300 cfs

Temp 5 – 6 °C (42 – 43 F)

PC: Bill Tinniswood, ODFW