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Orientation, Coastal Monitoring, and Limiting Factors

Morning Session at the 3rd Steelhead Summit held in Ventura, California on December 3, 2018.

Presentations

Orientation

The Origins of Life History Variation in Oncorhynchus mykiss, John Carlos Garza, PhD, Southwest Fisheries Science Center, NOAA Fisheries

Implementing Risk Mitigation Strategies to Protect Vulnerable Native O. mykiss Populations in Southern California, Sandra Jacobson, PhD, CalTrout

Coastal Monitoring and Limiting Factors for Steelhead: Status, Challenges, and Opportunities Presentations and Panel Discussion

The Current Status of Southern California Steelhead Monitoring, Kyle Evans, CDFW

Abundance and Distribution of Steelhead in the Santa Monica Bay, Rosi Dagit, Santa Monica Mountains RCD

Steelhead Monitoring in the Santa Ynez Watershed, Tim Robinson, Cachuma Operations and Maintenance Board

The Origins of Life History Variation in *Oncorhynchus mykiss*

Photo credit: Morgan Bond

John Carlos Garza

Fisheries Ecology Division
NOAA Southwest Fisheries Science Center
and
University of California, Santa Cruz

NOAA Fisheries
National Marine Fisheries Service

Acknowledgments

- Eric Anderson
- Anthony Clemento
- Cassie Columbus
- Neil Thompson
- Devon Pearse
- Mac Campbell
- Scott Harris
- Kerry Reid

Ecotypic Differentiation in Salmonids

- Many varieties
  - Lake beach &river spawning sockeye salmon
  - Spring-run & Fall-run Chinook salmon
  - Resident rainbow trout & anadromous steelhead
  - Summer-run & Winter-run steelhead.

Life History Variation in *O. mykiss*

- Migration related traits
  - The big one: residency & anadromy
  - Summer-run & Winter-run steelhead
  - Variation in spawn timing within ecotype
  - Variation in age at maturity.

Big Creek Falls

- *O. Mykiss* introduced above Big Creek Falls *c.* 1910

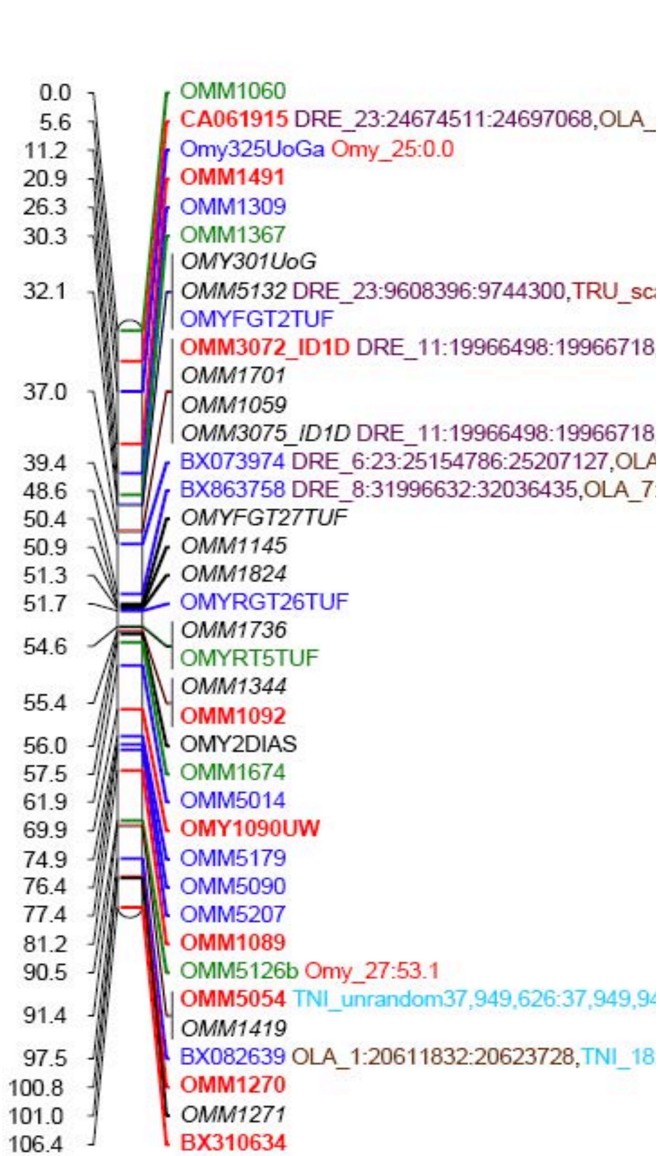
- Genetic analysis supports within-basin origin of the above-falls population
  (Pearse et al. 2009)

- 1.8% emigration rate over the falls, based on PIT tag data.
  (Hayes et al. 2012)

>> Strong, continuing selection on above-falls fish to not move downstream.

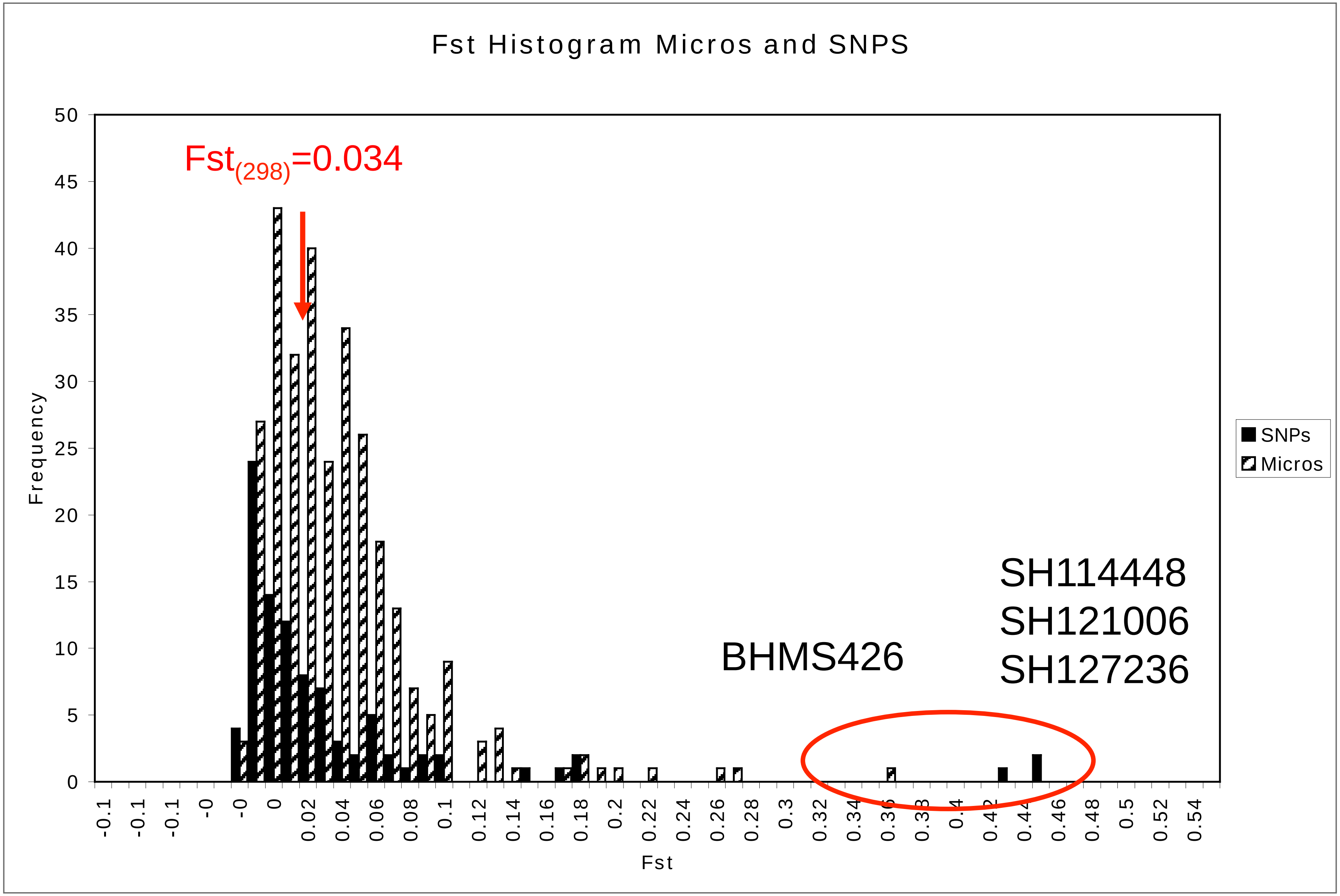

Photos: Corey Phillis

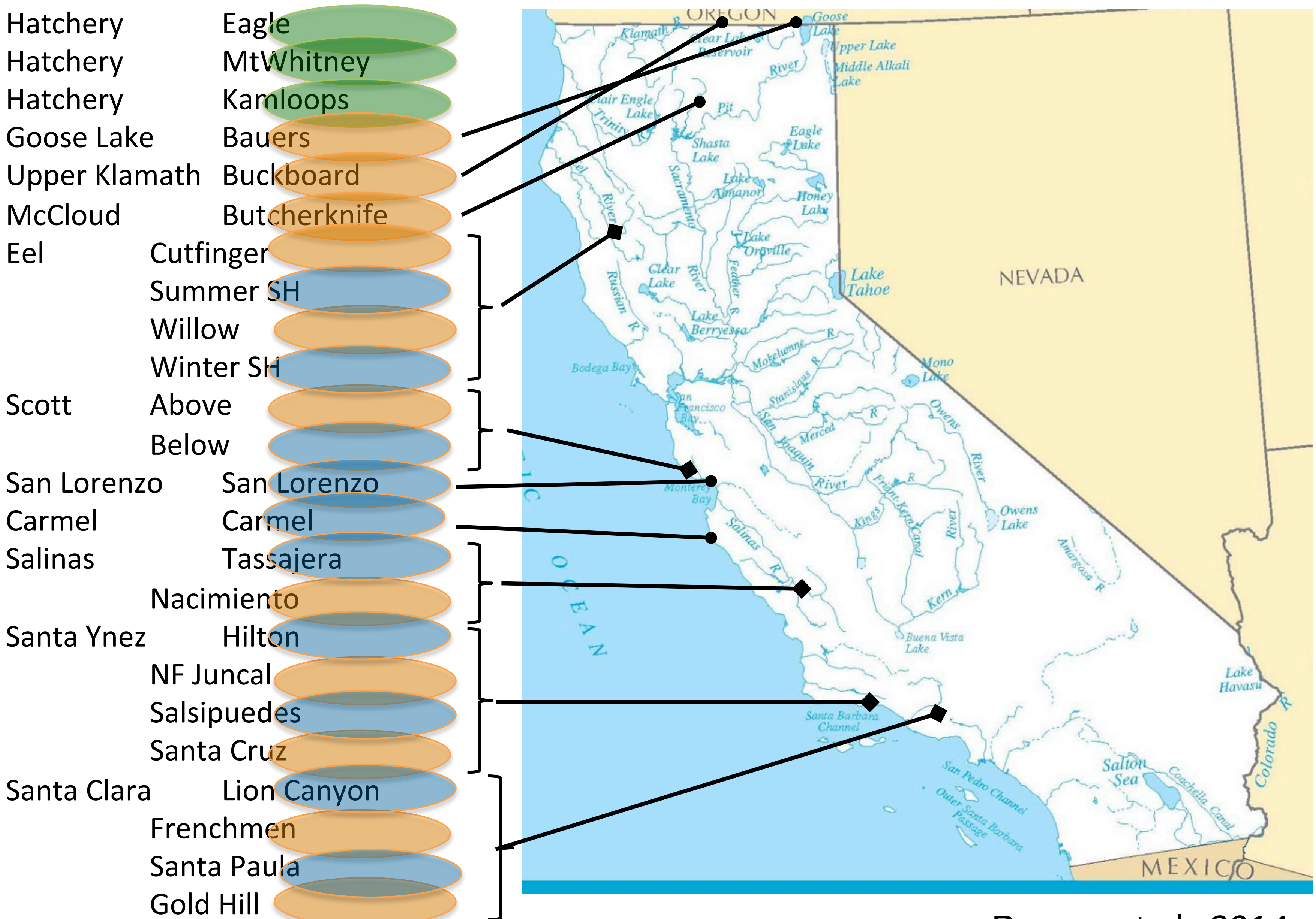
Early genome Screen leads to discovery of strong association Martinez et al. 2011



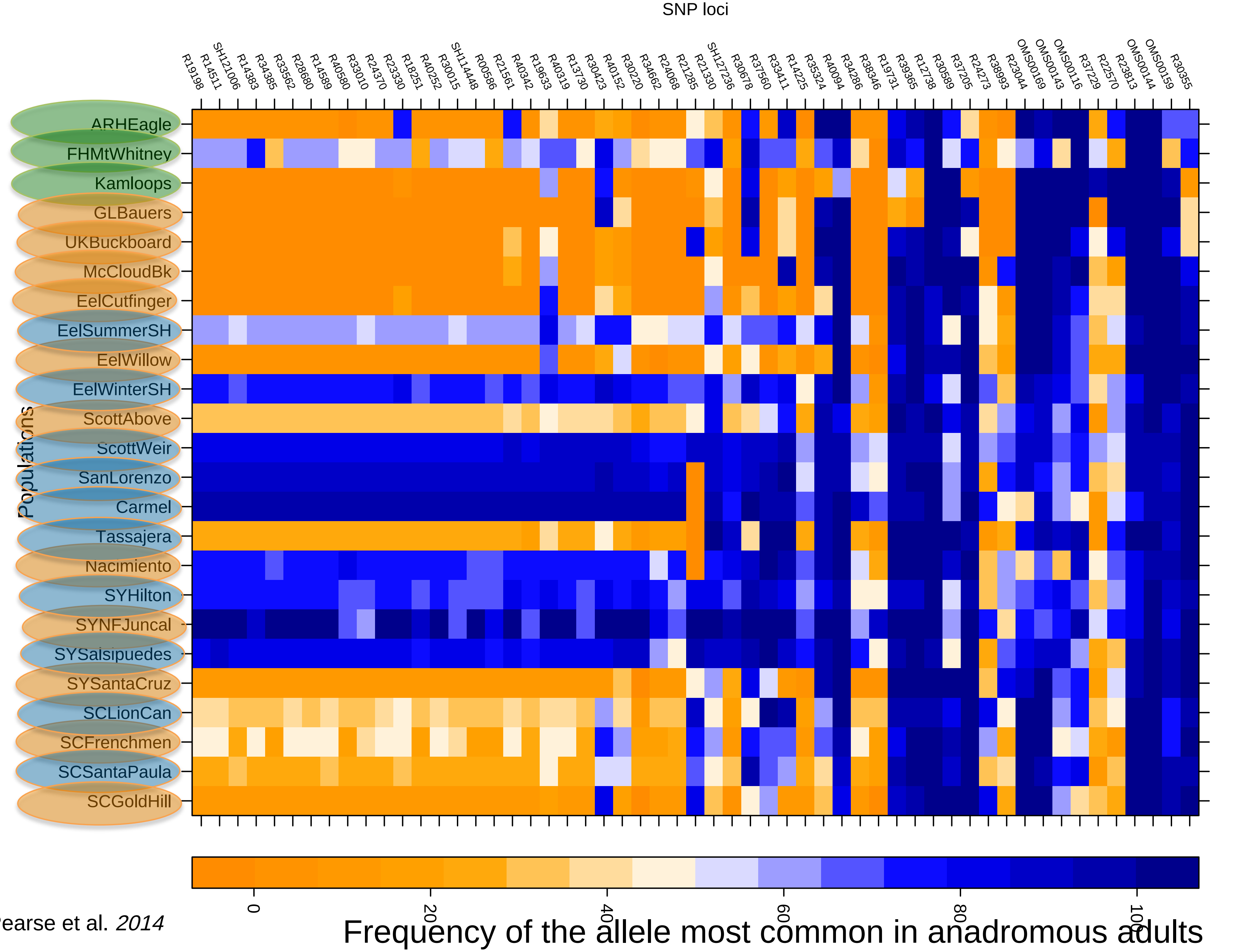
- 24 individuals each from above and below Big Creek falls.
- 298 microsatellite loci genotyped
- Three of 96 un-mapped SNP loci also associated (Abadía-Cardoso et al. 2011)
- Subsequent map of 400 loci distributed over all 29 linkage groups with ~10 cM coverage of the genome showed this was chromosome Omy5.

Early genome Screen leads to discovery of strong association
Martinez et al. 2011





Pearse et al. *2014*



Pearse et al. *2014*

Genomic basis of **individual** life-history dynamics:

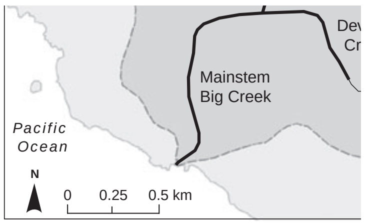


Fig. 1. Map of the study area in the Big Creek watershed on the Big Sur

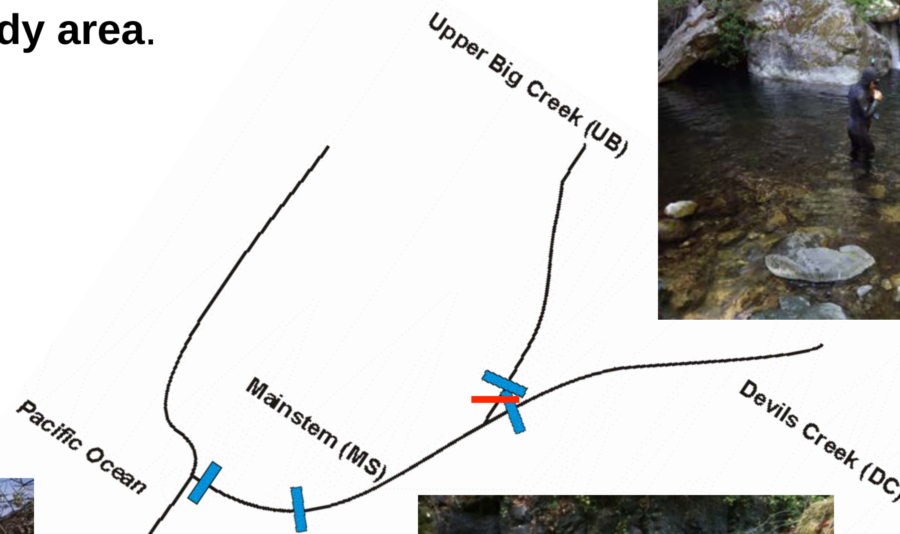
294

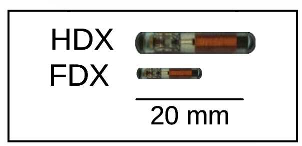
UC SANTA CRUZ

- **Juvenile** capture-recapture sampling using PIT tags
  - Fall and Spring since fall 2005; Intensive genetic sampling since 2009.
  - Re-sampling and monitoring 2010-2015.

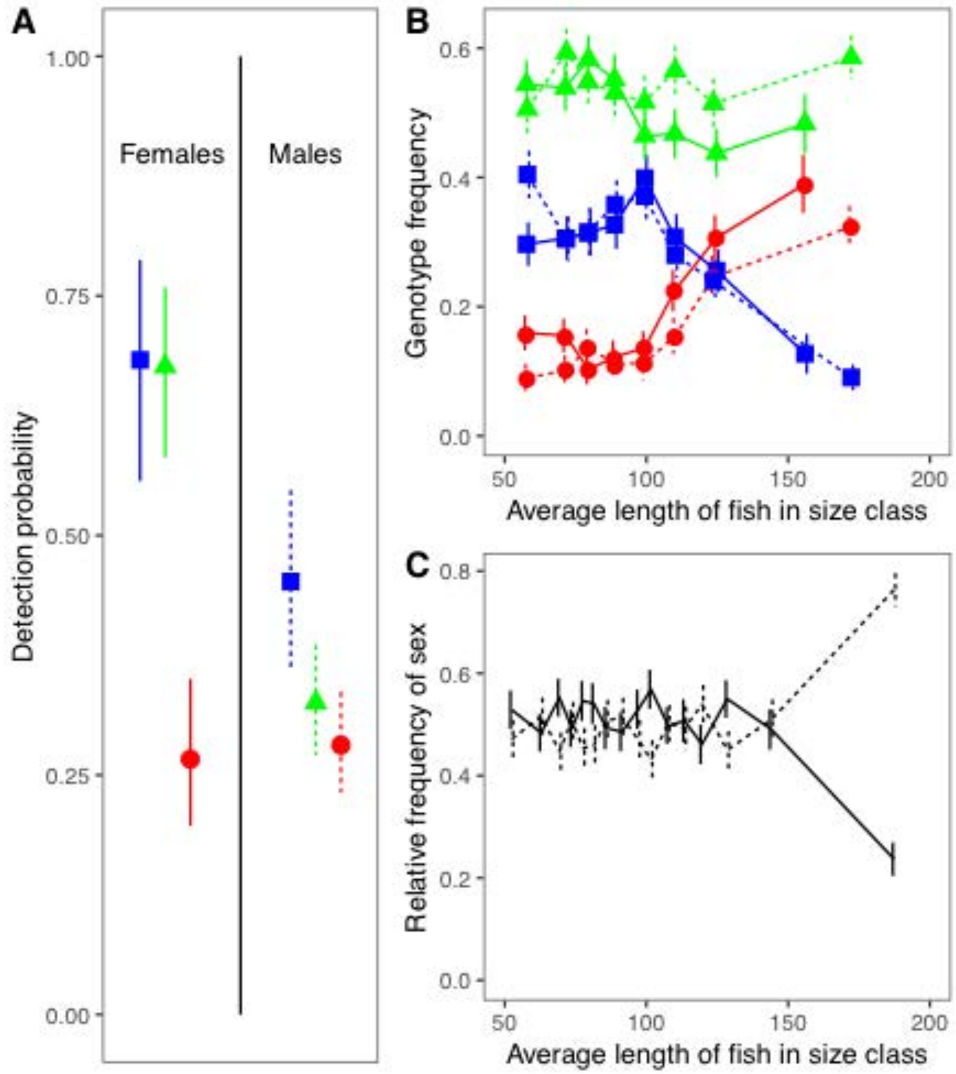
- Track fish **with PIT tag antennas**
  - Within basin and to and from ocean
  - **No barriers in study area**.

- Genetic analysis for
  - -Population genetics,
  - -Family structure
  - -**Sex**
  - -**Omy5**.





Highly skewed sex ratio in post-smolt population

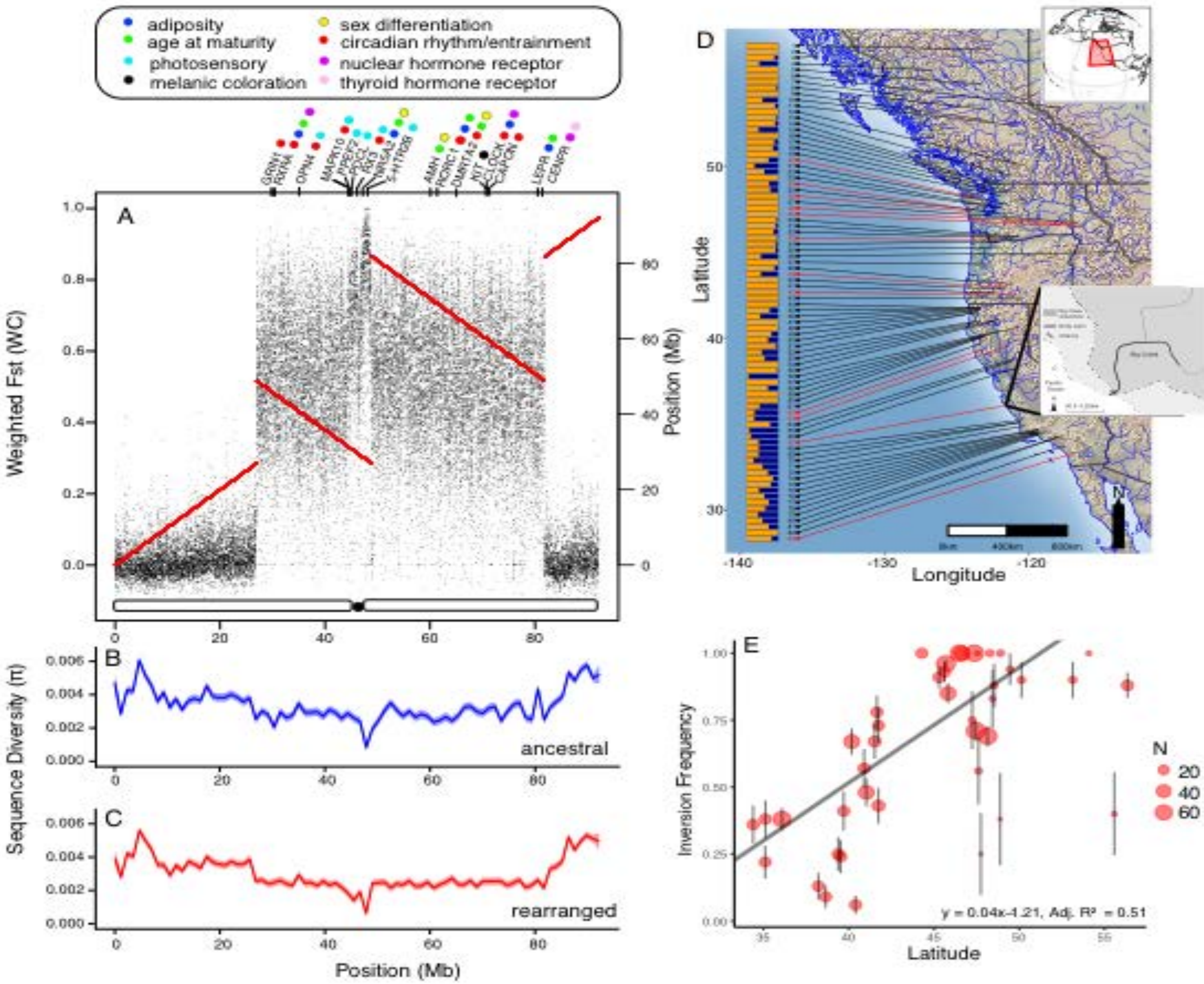


Ecotypic Differentiation in Salmonids
Early vs. Late Migration

- Most salmon and steelhead enter freshwater sexually and spawn shortly thereafter: fall-run Chinook salmon and winter steelhead
- In California, Oregon & Washington there are multiple populations of Chinook salmon and steelhead that enter freshwater sexually immature, hold in deep, cold pools mid-river for 4-6 months, before maturing and moving higher up with the first significant flows.
- Allows exploitation of often-inaccessible upstream spawning and rearing habitat (and most susceptible to loss due to dams or water diversions).

Whole genome sequencing reveals origin of association at Omy5

Chromosome Omy 5 is dominated by two large tandem inversions



Ecotypic Differentiation in Salmonids

Three Types of Klamath Steelhead

Table 4. Timing of spring, fall and winter race adult steelhead migration into the Klamath River as cited by four different reports.

Steelhead Race	KRSIC (1993)	CDFG (1987b)	USFWS (1984a)	USFWS (1979)
Spring/Summer	May - July	March -June	May - June	April - June
Fall	August - October	July - October	October - November	August - November
Winter	November - February	November - March	December - January	November - February

Ecotypic Differentiation in Salmonids

SCIENCE ADVANCES | RESEARCH ARTICLE

EVOLUTIONARY GENETICS

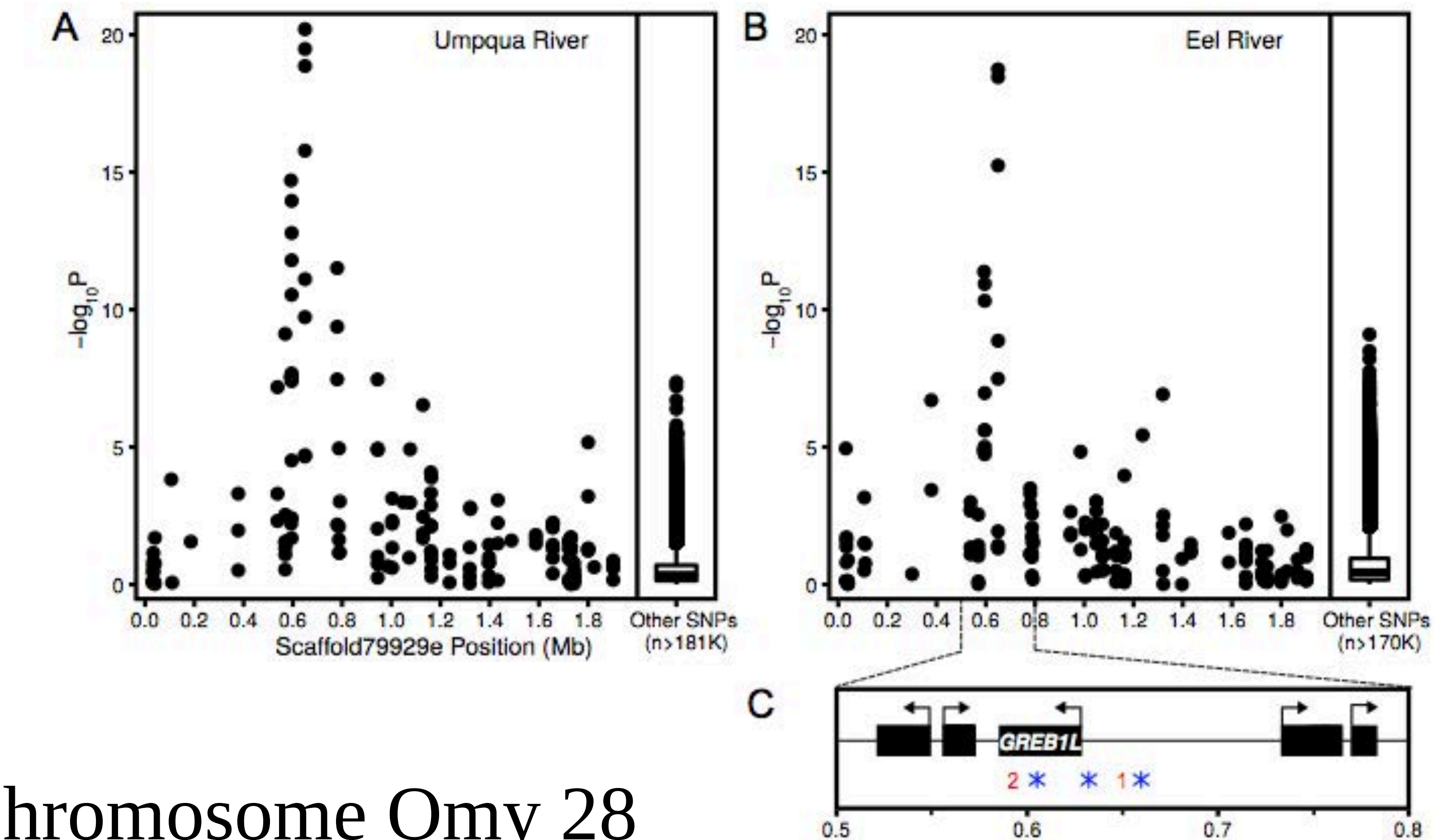
The evolutionary basis of premature migration in Pacific salmon highlights the utility of genomics for informing conservation

Daniel J. Prince,[1,2] Sean M. O'Rourke,[1]* Tasha Q. Thompson,[1]* Omar A. Ali,[1] Hannah S. Lyman,[1] Ismail K. Saglam,[1,3] Thomas J. Hotaling,[4] Adrian P. Spidle,[5] Michael R. Miller[1,2]†

The delineation of conservation units (CUs) is a challenging issue that has profound implications for minimizing the loss of biodiversity and ecosystem services. CU delineation typically seeks to prioritize evolutionary significance, and genetic methods play a pivotal role in the delineation process by quantifying overall differentiation between populations. Although CUs that primarily reflect overall genetic differentiation do protect adaptive differences between distant populations, they do not necessarily protect adaptive variation within highly connected populations. Advances in genomic methodology facilitate the characterization of adaptive genetic variation, but the potential utility of this information for CU delineation is unclear. We use genomic methods to investigate the evolutionary basis of premature migration in Pacific salmon, a complex behavioral and physiological phenotype that exists within highly connected populations and has experienced severe declines. Strikingly, we find that premature migration is associated with the same single locus across multiple populations in each of two different species. Patterns of variation at this locus suggest that the premature migration alleles arose from a single evolutionary event within each species and were subsequently spread to distant populations through straying and positive selection. Our results reveal that complex adaptive variation can depend on rare mutational events at a single locus, demonstrate that CUs reflecting overall genetic differentiation can fail to protect evolutionarily significant variation that has substantial ecological and societal benefits, and suggest that a supplemental framework for protecting specific adaptive variation will sometimes be necessary to prevent the loss of significant biodiversity and ecosystem services.

Steelhead-Mature vs. Premature Migration

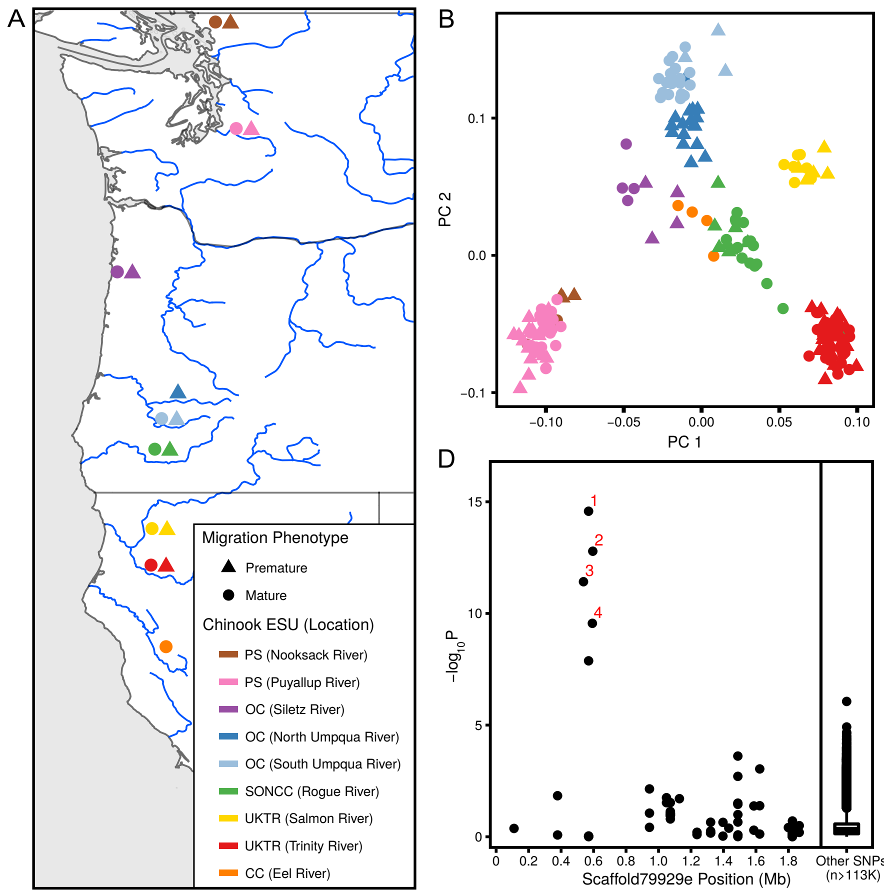
RADSeq Genome Scan-170K SNPs called



Chromosome Omy 28

Chinook Salmon-Mature vs. Premature Migration

RADSeq Genome Scan-113K SNPs called



The same gene region!!!

Ecotypic Differentiation in Salmonids

Title

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

Authors and Affiliations

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

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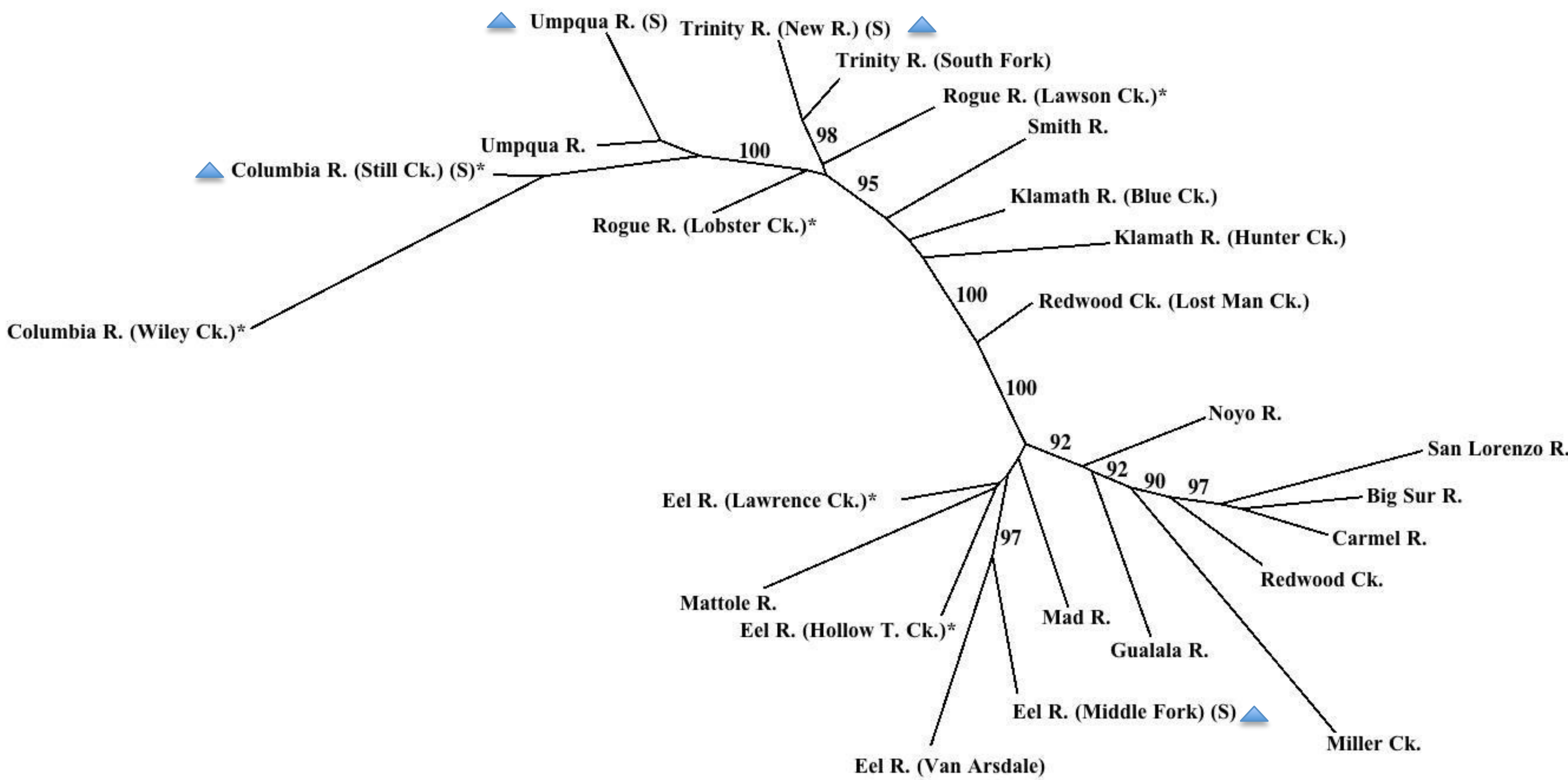
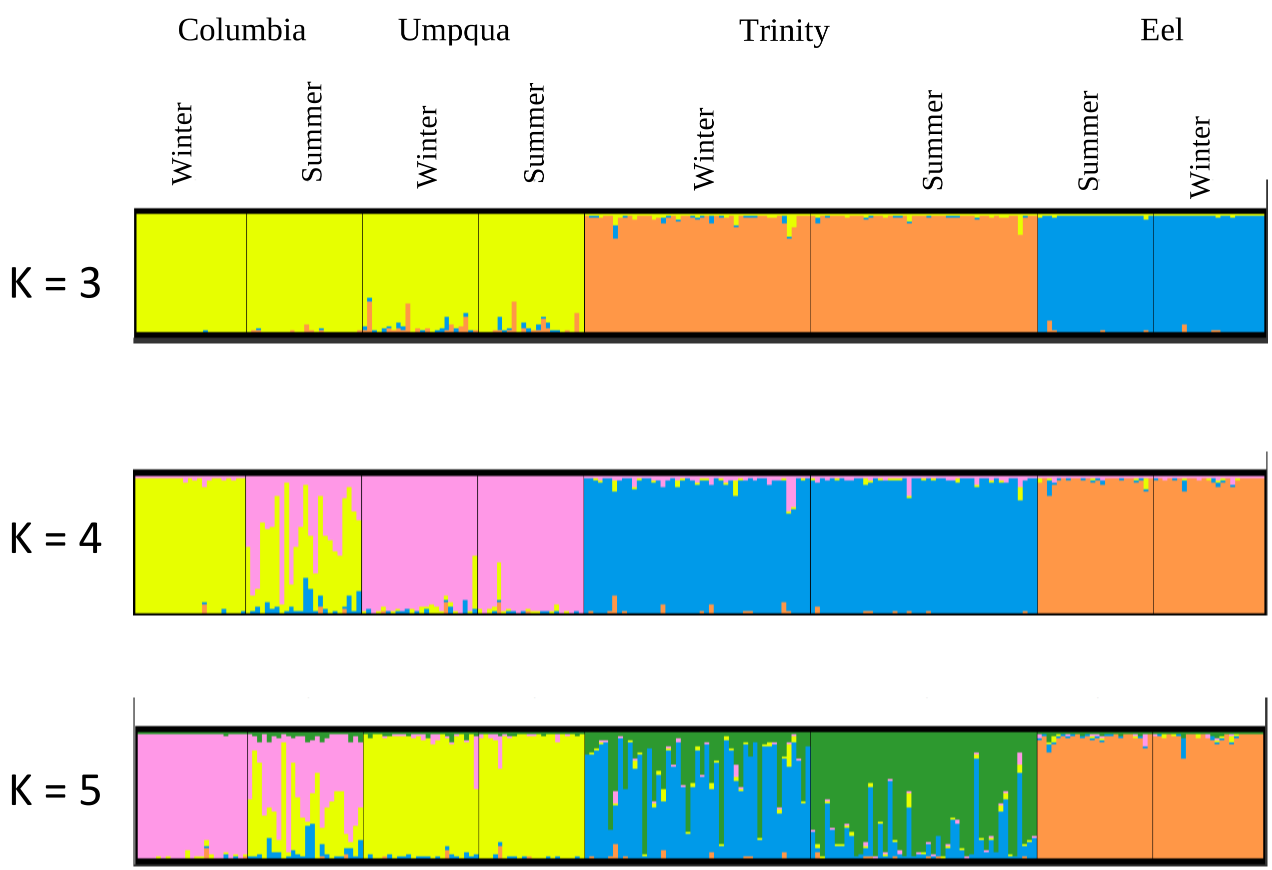
Phylogeography of Steelhead



Chord/Neighbor Joining Tree
Bootstrap Consensus -1000 reps

Arciniega et al. 2015-Conservation Genetics

Phylogeography of Steelhead



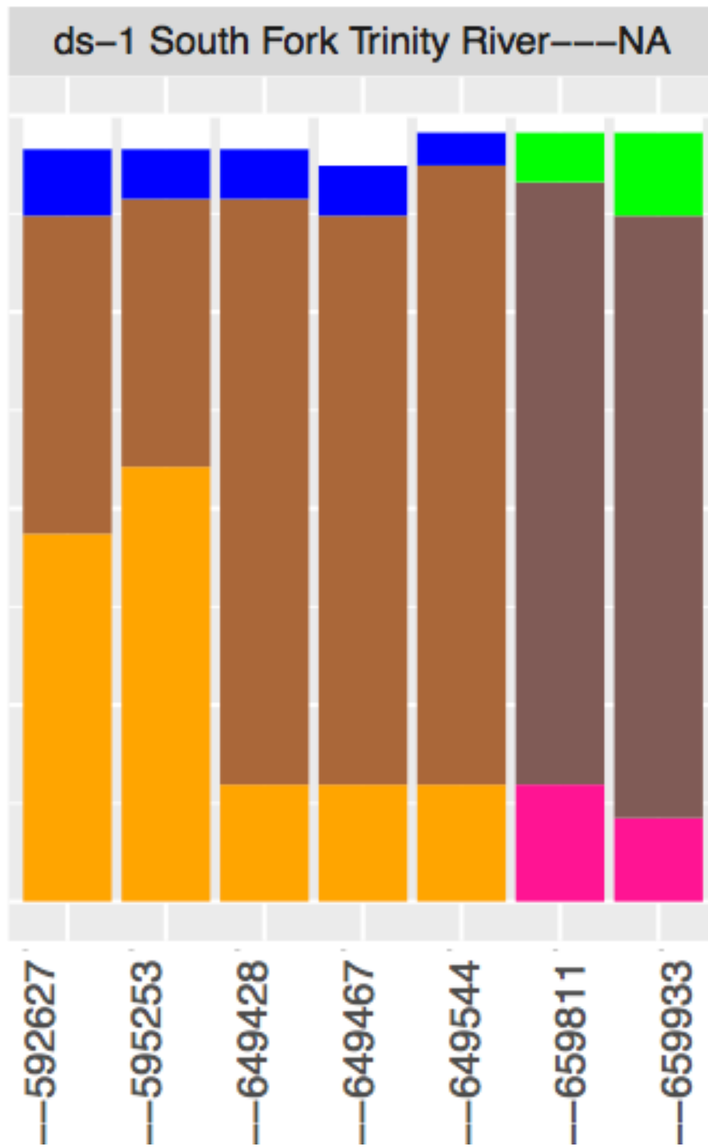
Model-based clustering-Structure
No location prior.

Arciniega et al. 2015-Conservation Genetics

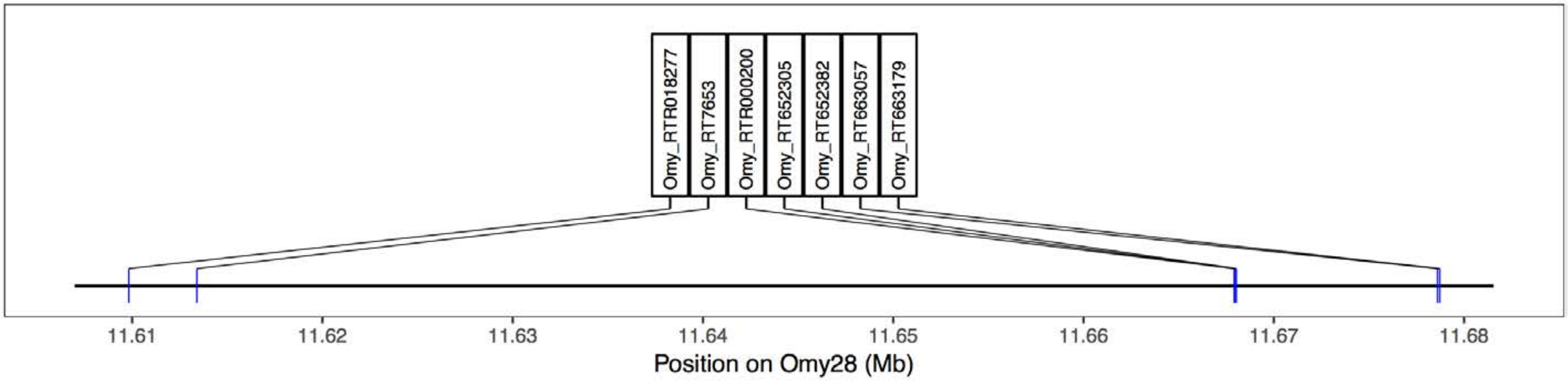
Problems with Prince et al.

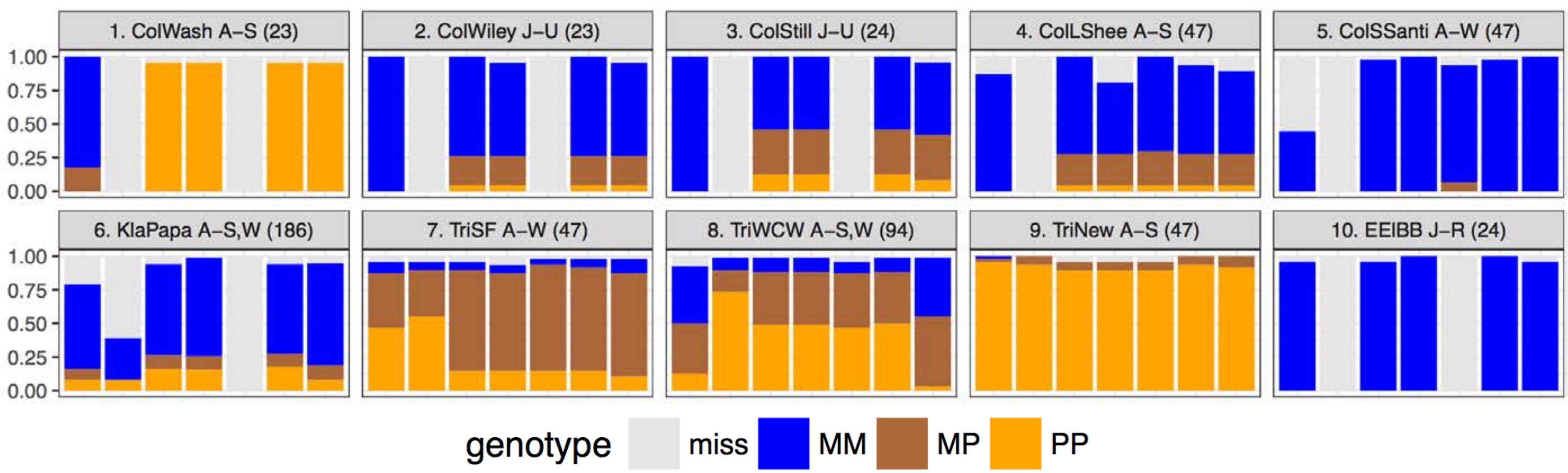
- Interpretation
  – "Mature populations are not an important source or conduit of genetic variants associated with early phenotypes"
    - Translation: heterozygotes are rare, selectively inferior and transient
  – Study design not appropriate for determining distribution of heterozygotes
  – They threw out a population with abundant heterozygotes: South Fork Trinity steelhead.

South Fork Trinity steelhead



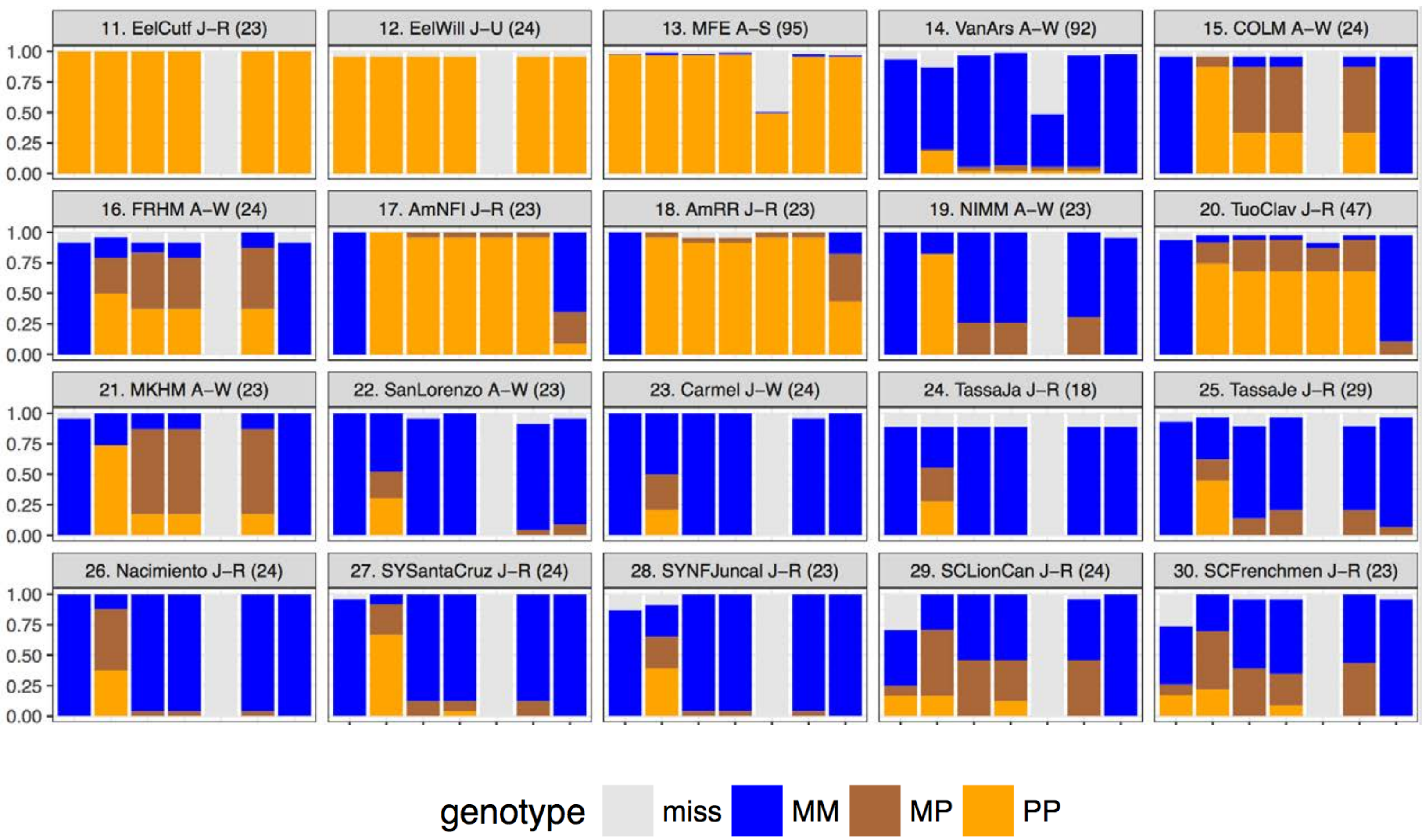
Steelhead GREB1L/ROCK1 region





Frequencies of RoSA genotypes

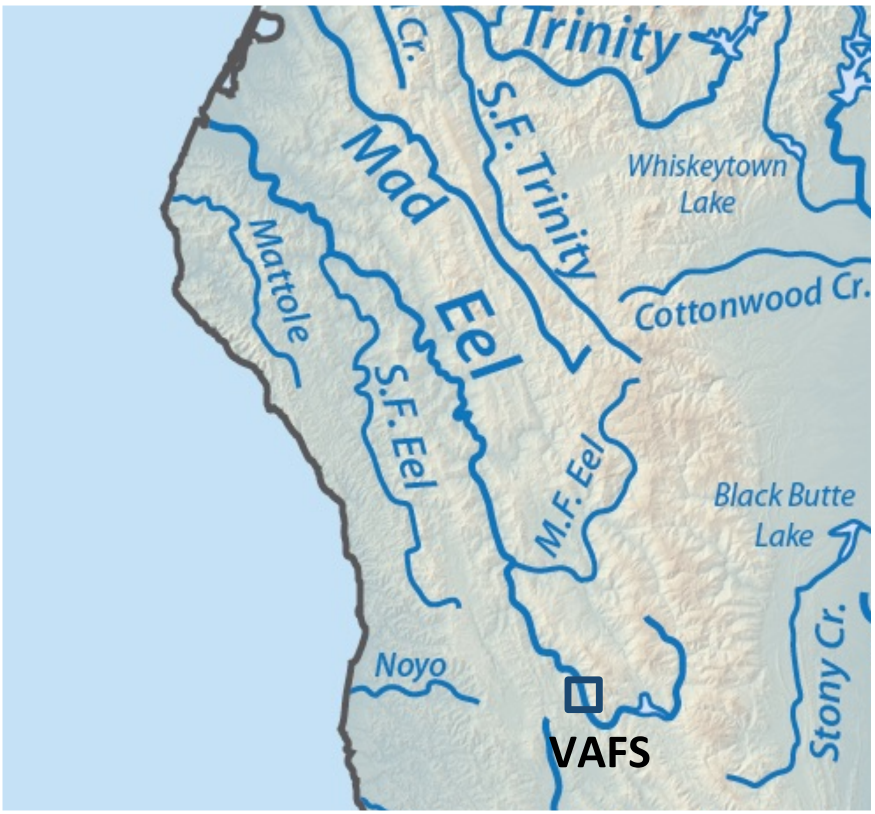
Steelhead GREB1L/ROCK1 region

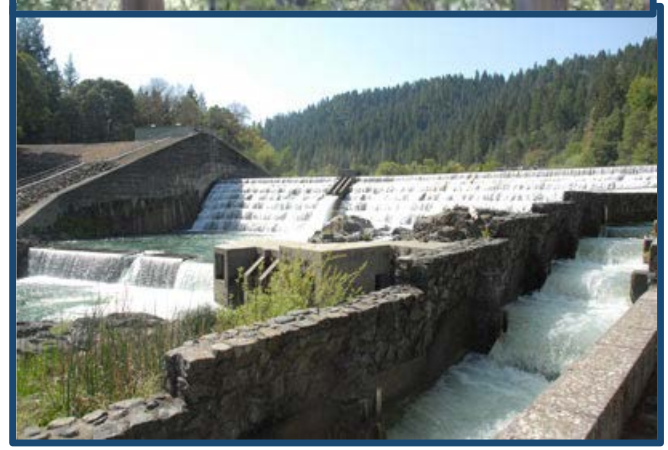


Frequencies of RoSA genotypes

Eel River Steelhead

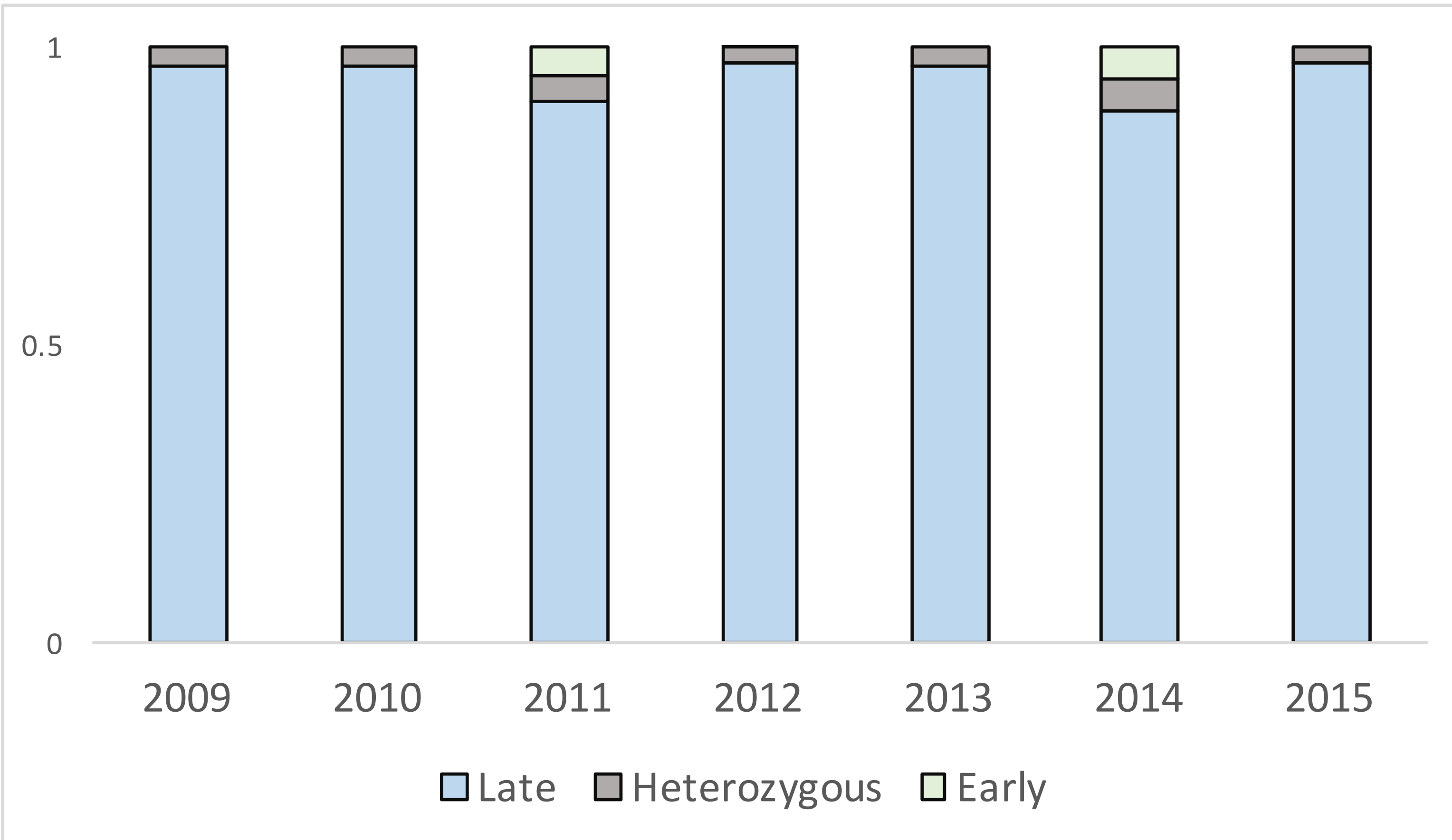
Complete sampling of adult returns over dam
from 2009-2017 for pedigree analysis





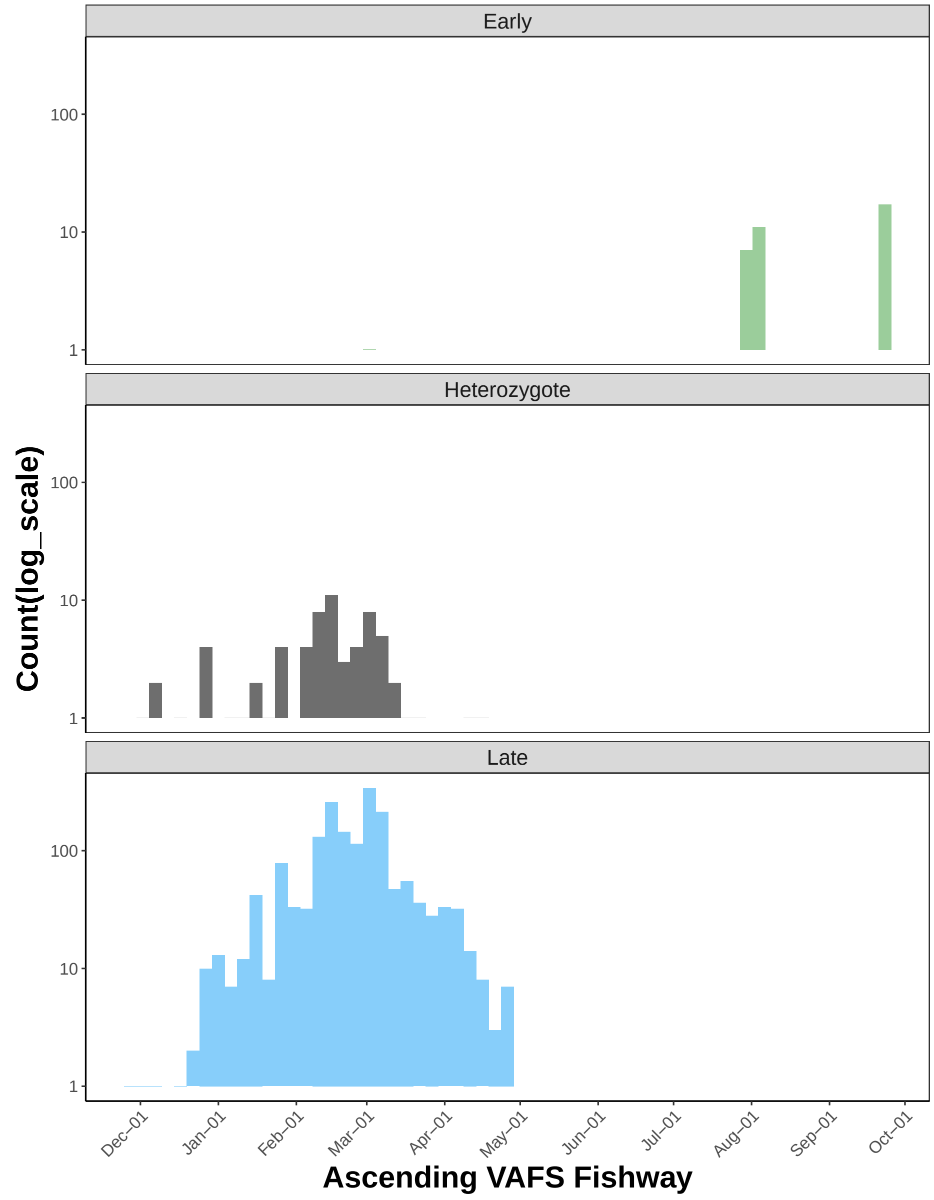
Eel River Steelhead

Frequencies of RoSA genotypes



Eel River Steelhead

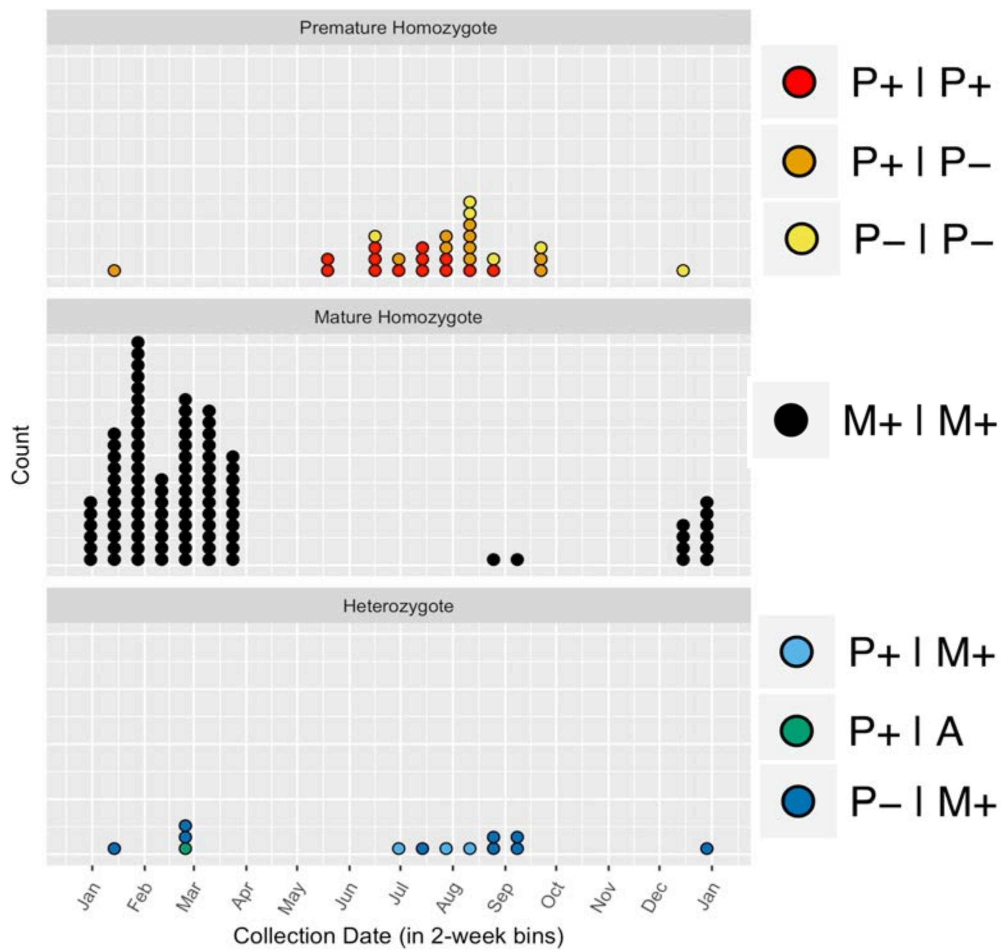
Return dates by RoSA genotype
N=1,922



Eel River Steelhead
Not an evolutionary dead-end

- In 2011 and 2014, homozygotes for the Early alleles (associated with summer-run steelhead) entered the fishway in August/September, months before other fish.
- One of these Early homozygotes and 12 heterozygotes produced offspring (23) that returned in subsequent years
- Of these parents carrying at least one copy of the Early allele, eight produced more than one offspring and these progeny were either heterozygotes or Late homozygotes

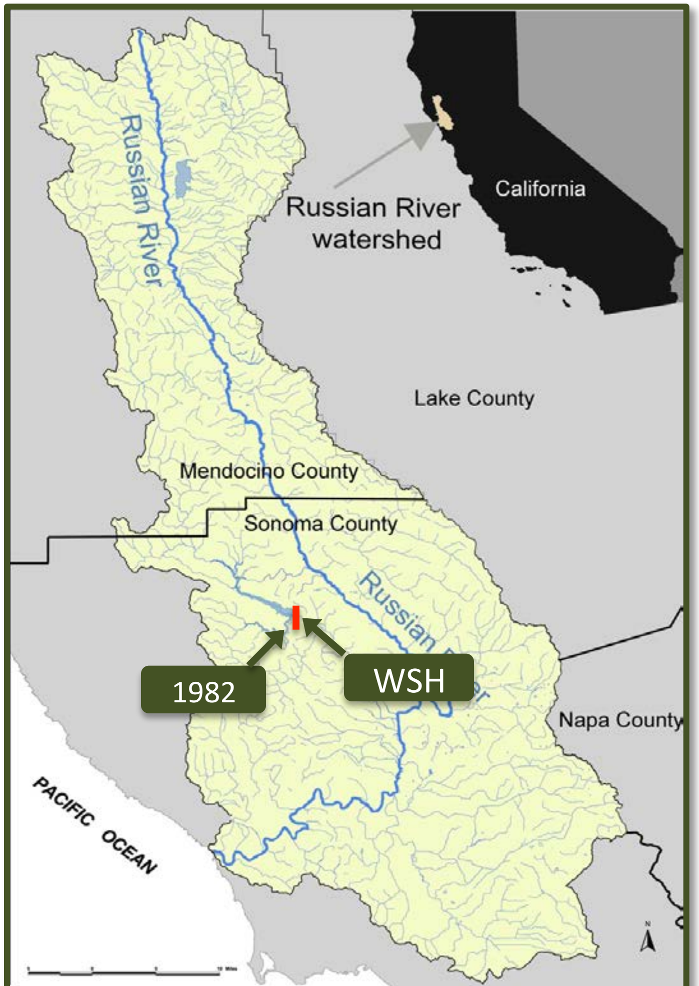
Klamath River Steelhead



Reanalysis of samples from Papa et al. (2007). J. Applied, Ichthy.

Yurok Tribal Fisheries Program samples 2000-2002 (Jan – Sept) from the estuary and lower Klamath River

Intergenerational genetic tagging in steelhead



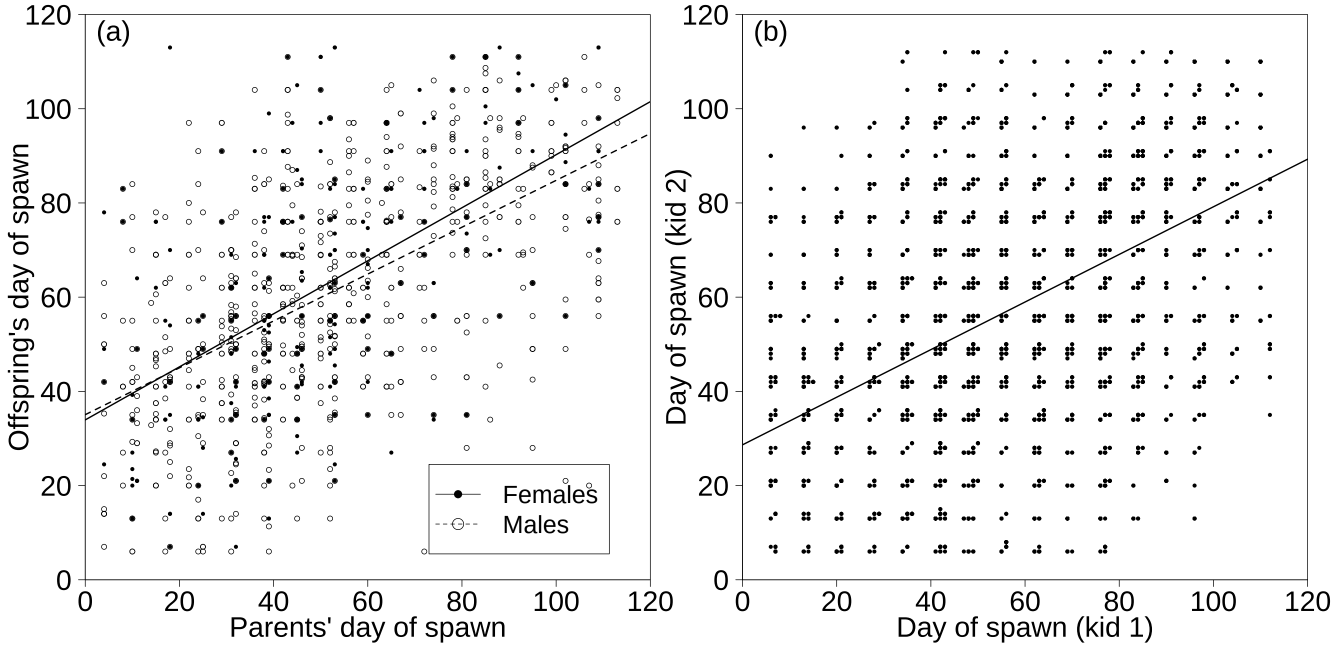
Russian River, California

WSH - Warm Springs Hatchery

Samples: 3,517 returning adults

Data: 95 SNP loci, 1 sex ID assay

Intergenerational genetic tagging in steelhead
Heritability of run timing



Statistics-Males	
R^2	0.321
Heritability H^2	0.497

Statistics-Females	
R^2	0.320
Heritability H^2	0.563

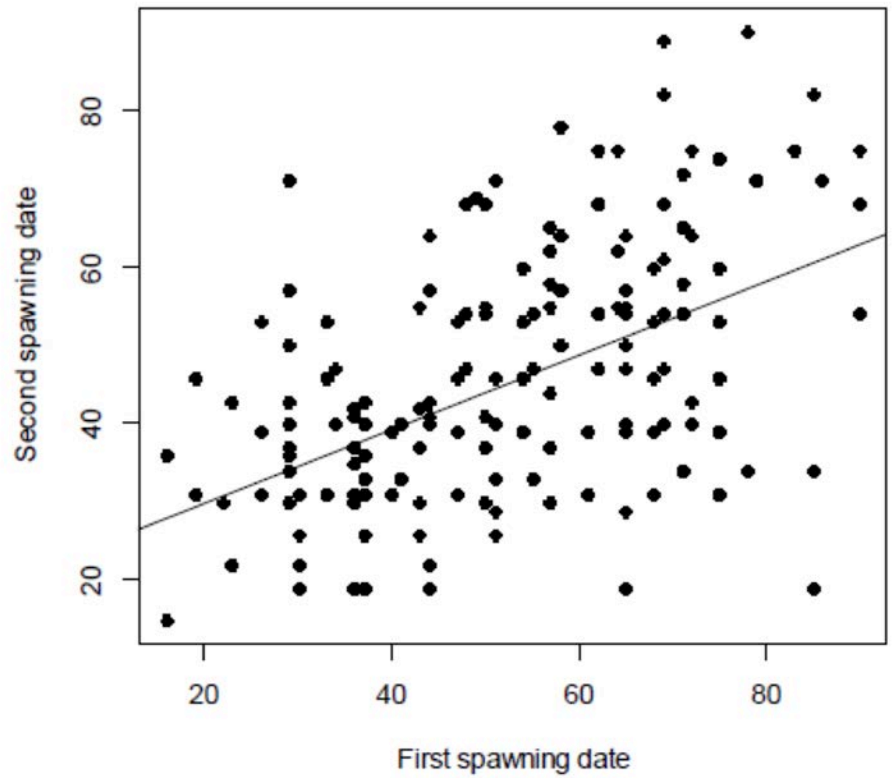
Abadía-Cardoso, Anderson, Pearse, Garza 2013 Molecular Ecology

Intergenerational genetic tagging in steelhead

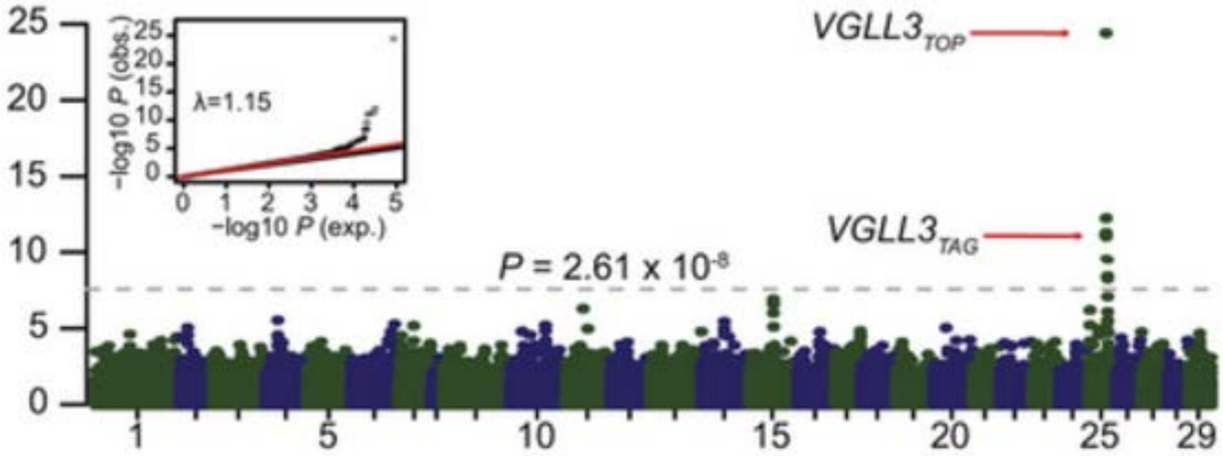
Iteroparity and repeat spawning

Matching samples analysis

Correlation between 1st and 2nd spawn dates for iteroparous fish
R^2=0.31

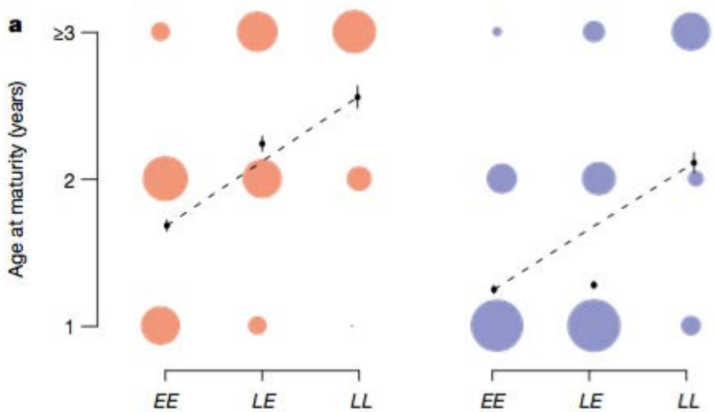


Age-of-Maturity in Atlantic Salmon: VGLL3 gene



208,704
← SNPs

Barson et al. 2015



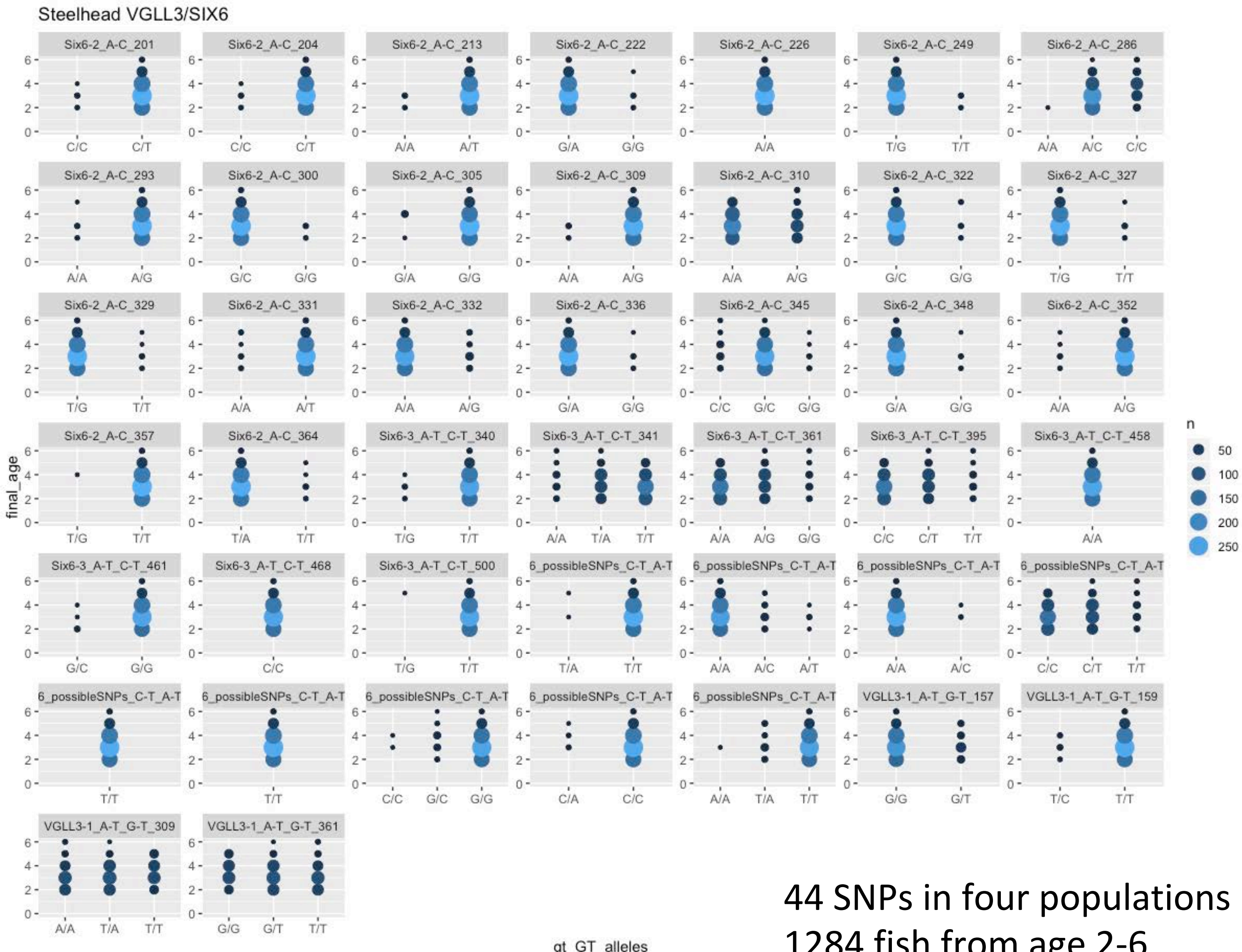
EE, EL, LL
2yo, het, 3yo

>Sex-dependent dominance reversal.

>Explains 39% of variance.

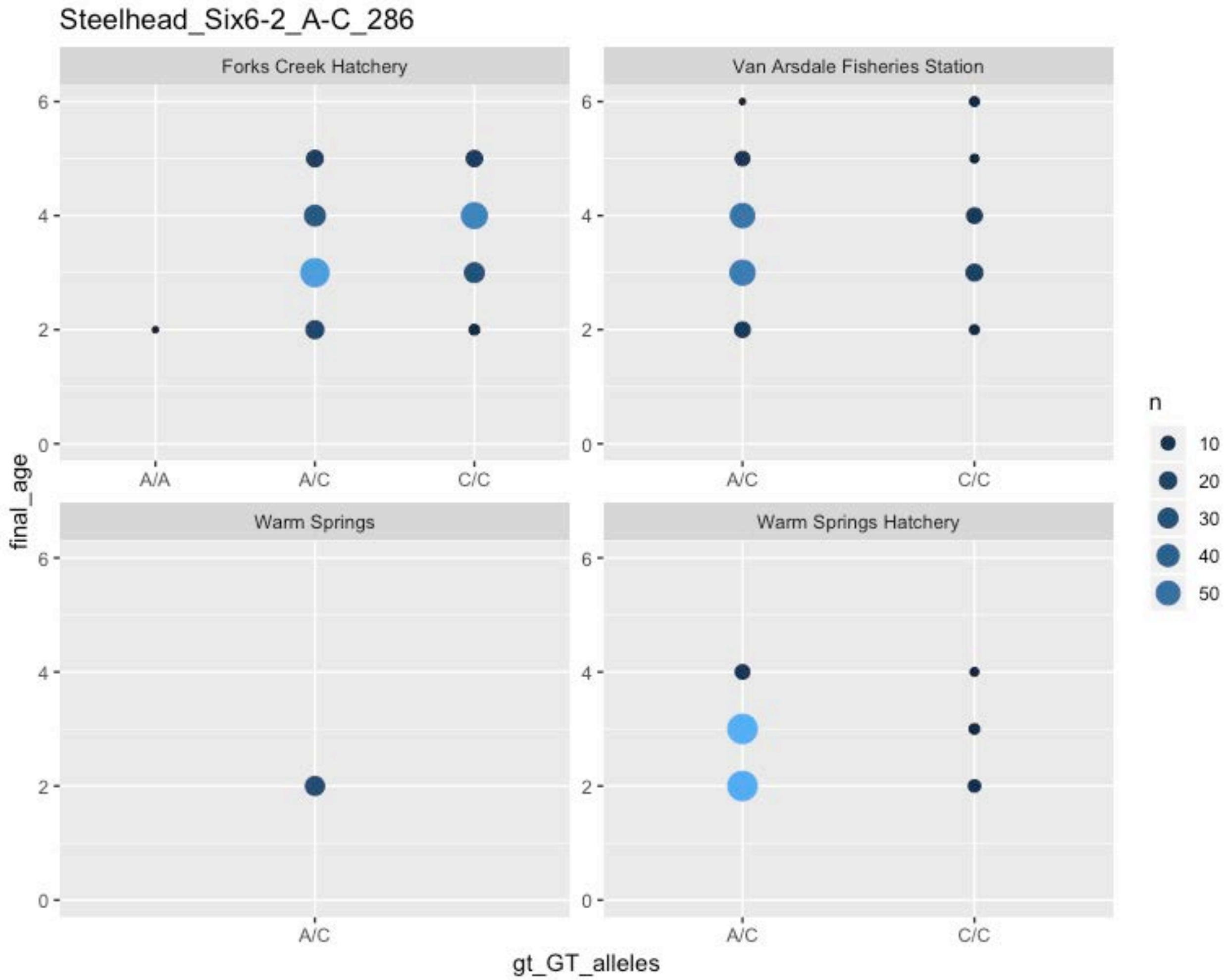
>VGLL3 is associated with lipid storage and age of puberty in humans.

Age-of-Maturity in Steelhead: VGLL3 and SIX6 genes



44 SNPs in four populations in CA, WA
1284 fish from age 2-6.

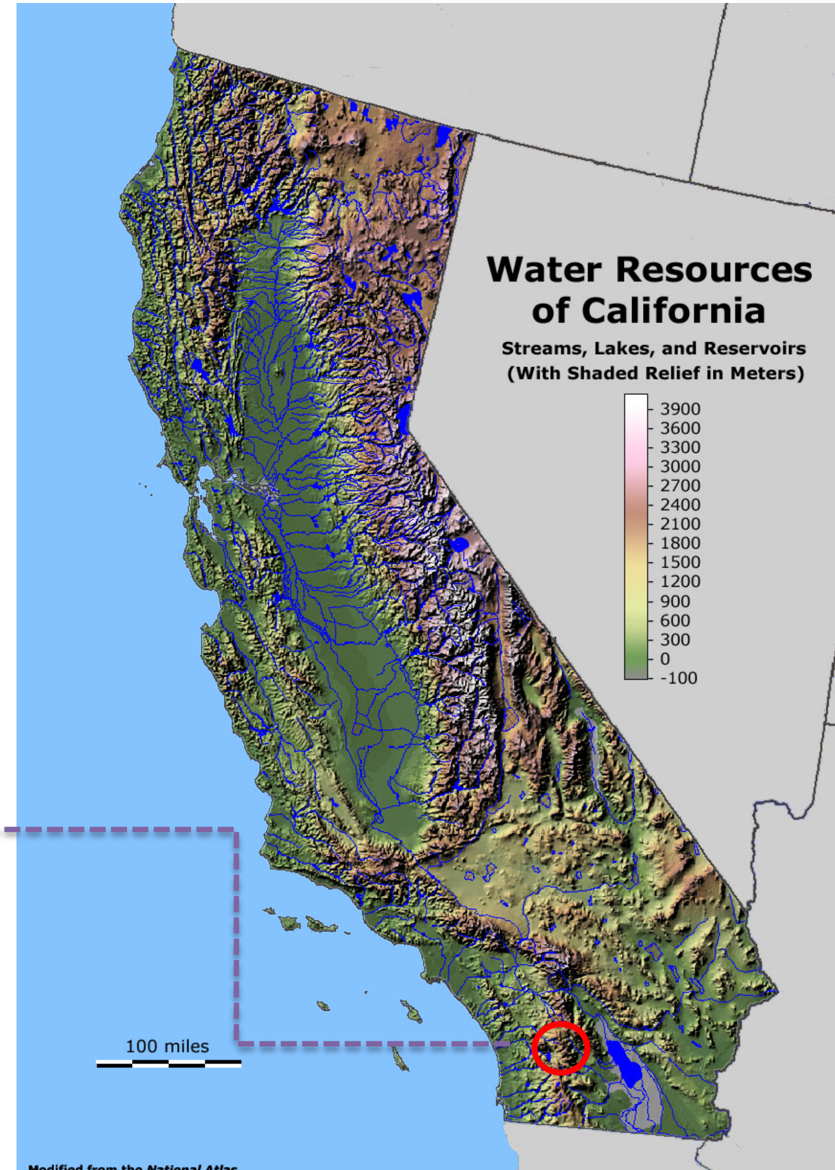
Age-of-Maturity in Steelhead: VGLL3 and SIX6 genes



44 SNPs in four populations in CA, WA
1284 fish from age 2-6.


Thank you!

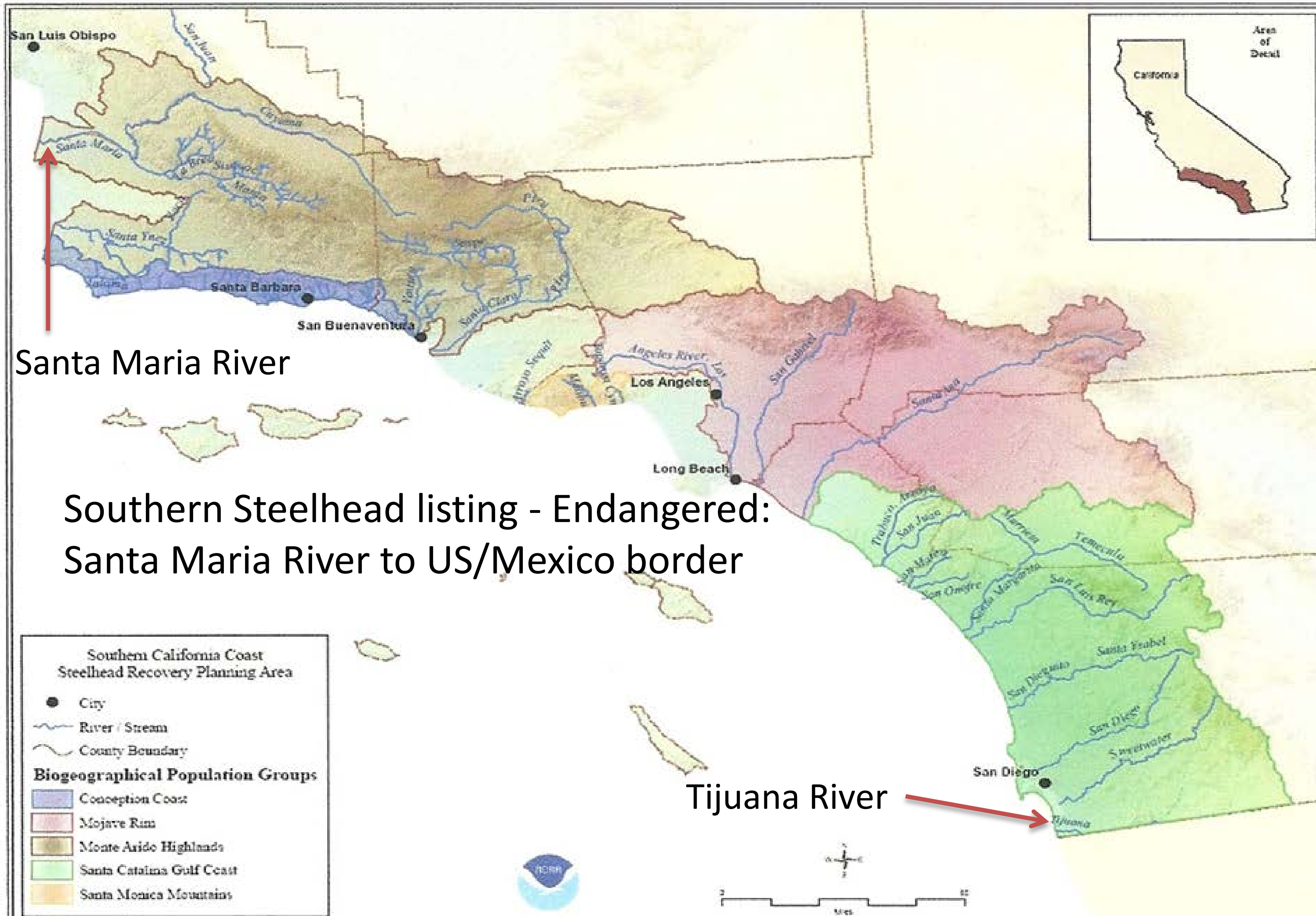
Implementing Risk Mitigation Strategies to Protect Vulnerable Native *O. mykiss* Populations in Southern California



Sandra Jacobson, Ph.D.
CalTrout
Director, South Coast Region

Steelhead Summit 12-3-2018

Southern California Steelhead – Distinct Population Segment

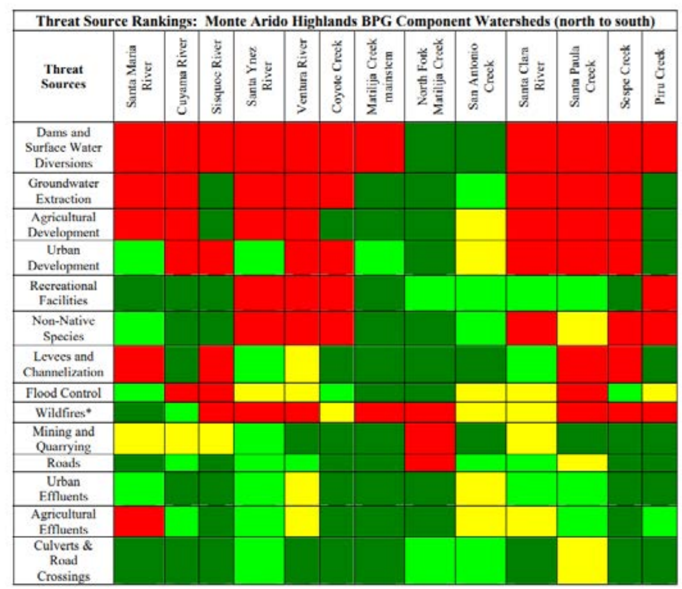


Adapted from NMFS Southern California Steelhead Recovery Plan (2012): BPG North to South: Monte Arido Highlands, Conception Coast, Mojave Rim, Santa Monica Mtns, Santa Catalina Gulf Coast

NMSF (2012) Southern Steelhead Recovery Plan Objectives

- **Prevent steelhead extinction** by protecting existing populations and their habitats.
- **Maintain current distribution** of steelhead and restore distribution to previously occupied areas
- **Increase abundance** of steelhead to viable population levels, including the expression of all life history forms and strategies.
- **Conserve existing genetic diversity** and provide opportunities for mixing genetic material between and within meta-populations.

Federal Recovery Plan: Roadmap
-Scientific basis of recovery criteria
-Identifies and ranks threats to recovery and prioritizes actions



Key: Red = Very High threat; Yellow = High threat; Light green = Medium threat; Dark green = Low threat
Threat cell colors represent threat rating from Conservation Planning (CAP) Workbooks.

*Wildfires were not identified during the CAP Workbook analyses as one of the top five threats in several of these watersheds, but recent fires in coastal watersheds indicates that future wild fires could result in significant habitats impacts.

Risk Mitigation Strategies Linked to Recovery Threats

1. **Mitigate for cumulative effects** that lead to extinction:
   O. mykiss biological research, strengthen anadromous and resident populations, habitat enhancement and access via barrier removal, non-native removal, in-stream flows and water quality, monitoring
      Monitoring and Abundance: Evans, Dagit/Larson, Robinson
2. **Mitigate for sudden extirpation** from environmental events
      Adapting to Drought, Fires, Floods: Capelli, Klose, Lindsay, Smith
3. **Advance policy and legislative backing** – legal recourse to meet water/habitat needs and secure funding for implementing recovery actions.
      Instream Flow Needs and Balancing Fish, Water and People: Meneghin, Clifford, Hirsh

Case Study – San Juan Creek Watershed, Orange County

1. Cumulative effects: restore anadromous and resident populations

-barrier removal - coastal and headwaters

-recent fire impact drives need for proactive planning for relocation refugia

2. Sudden Extirpation: increase genetic and geographic diversity

Possible risk mitigation strategies

-rescued trout relocation √

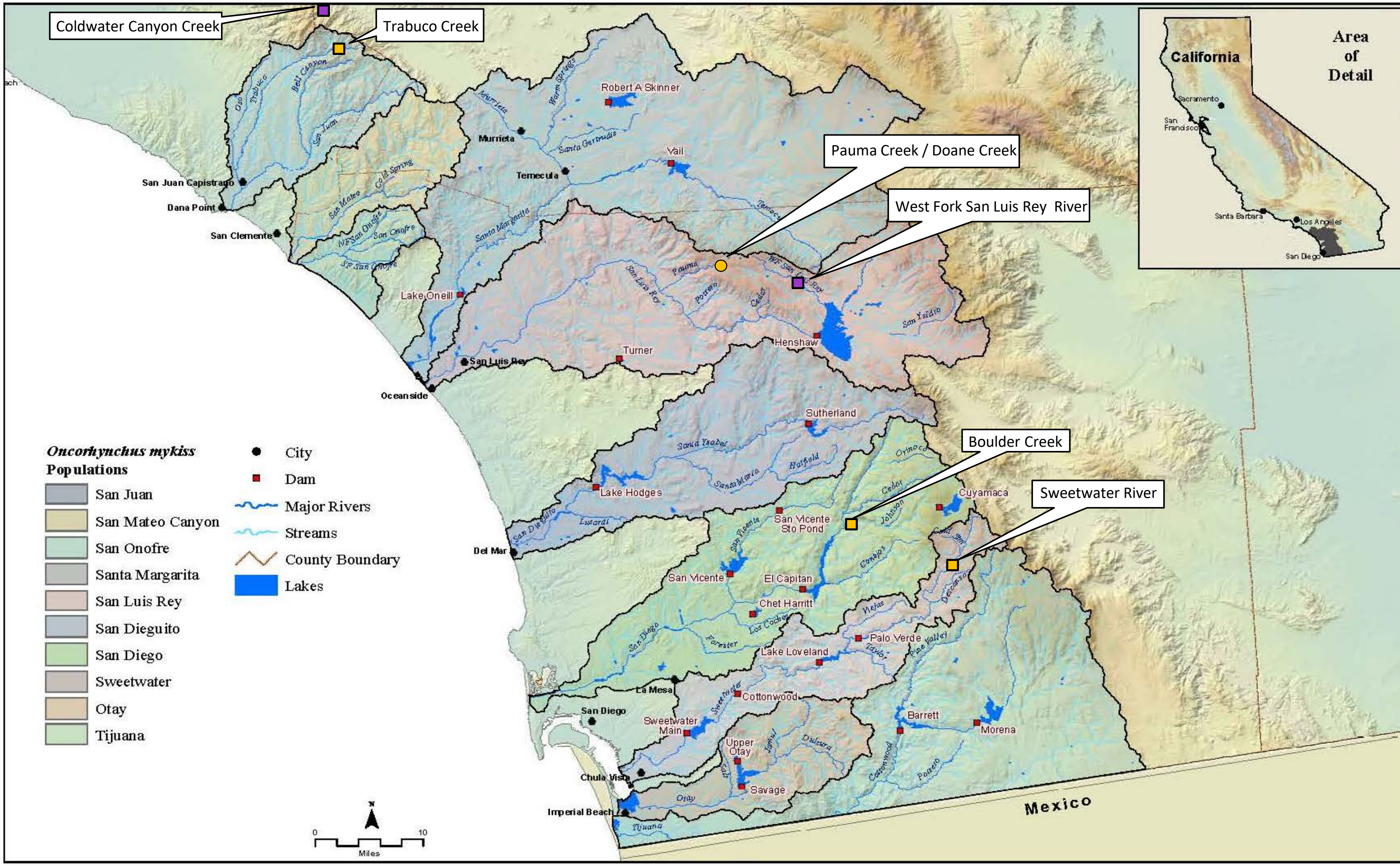
-embryonic translocation

-conservation hatchery

3. Policy: multi-benefit projects

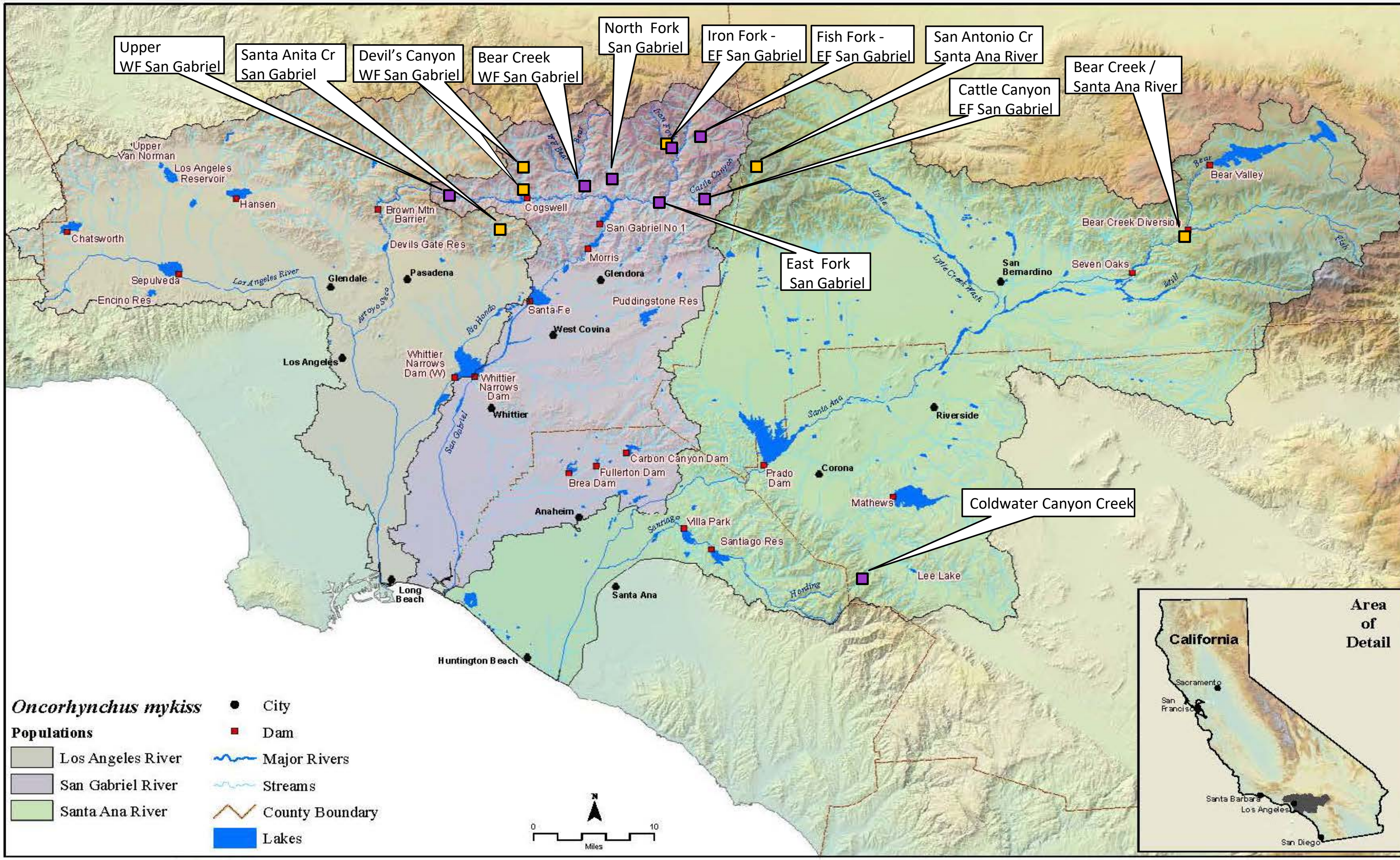
work with OC Flood Control District and water districts to balance needs of steelhead with public needs of water reliability, flood management

Southern Section So Cal Study–Santa Catalina Gulf Coast BPG



So Cal Population Genetics Study Jacobson et al (20140), Abadia-Cardoso et al (2016).
Tissue Collection (CDFW w/ Golden State Flycasters/Trout Unlimited-SD: Marshall/Dalrymple and others);
Genetic analysis-SW Fisheries Science Center (NOAA – Garza Group).

Middle Section So Cal Study– Mojave Rim BPG



So Cal Population Genetics Study Jacobson et al (20140), Abadia-Cardoso et al (2016).
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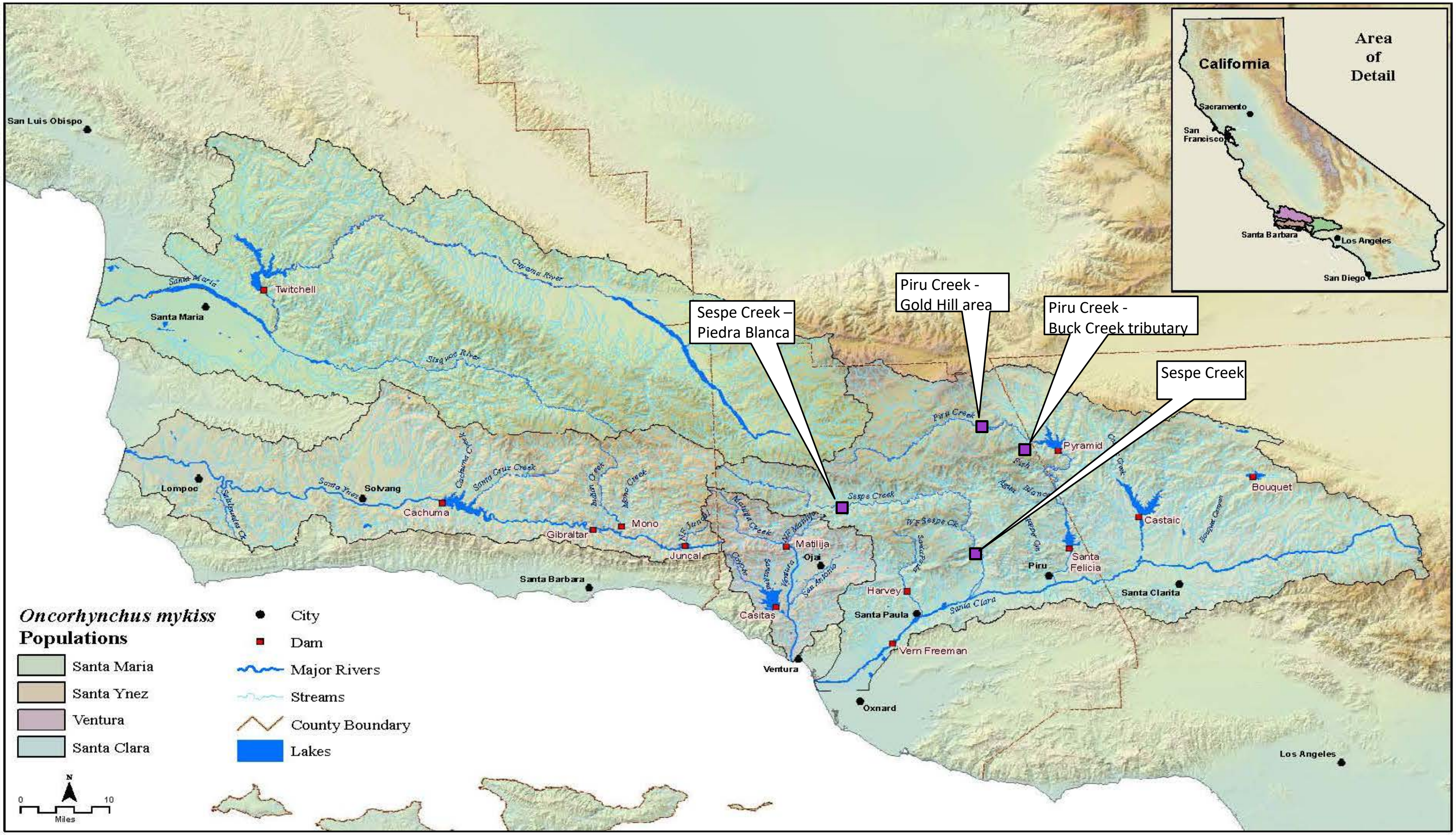
Northern Section So Cal Study– Mojave Rim BPG



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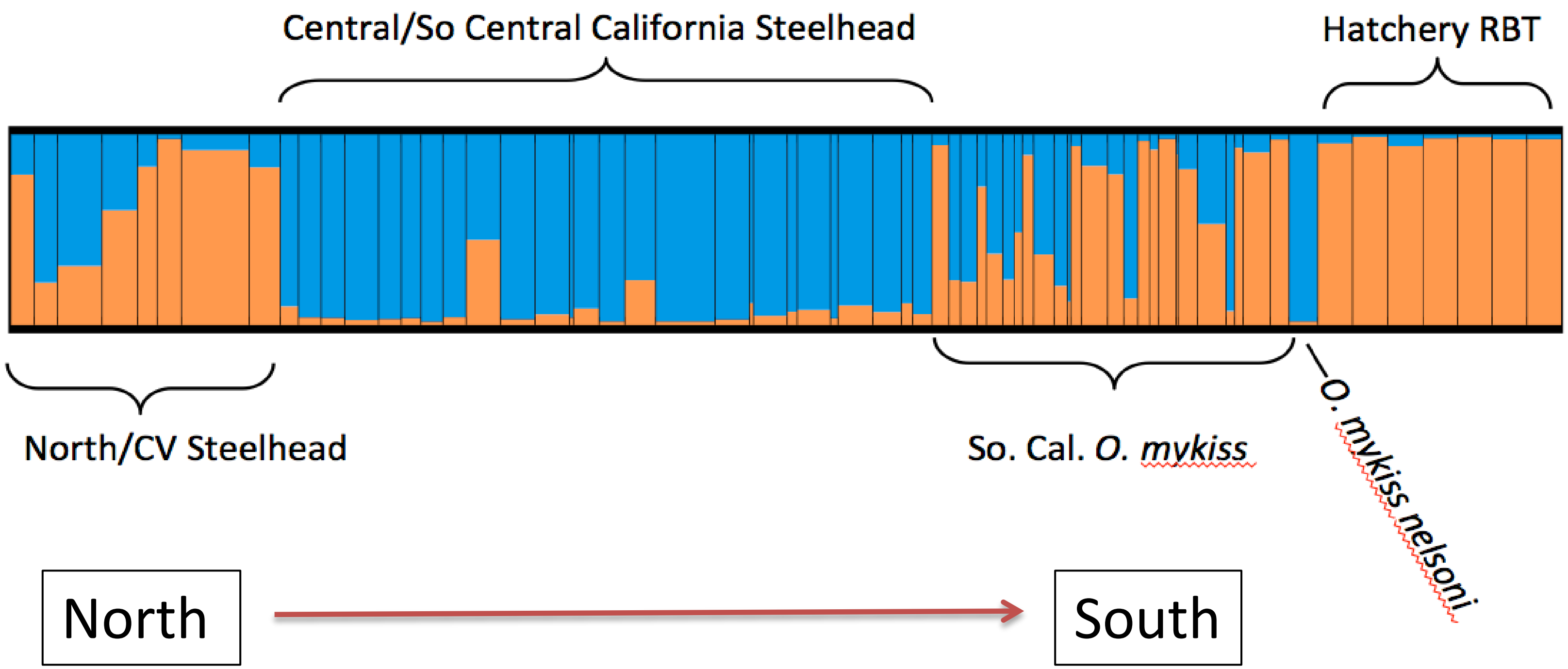
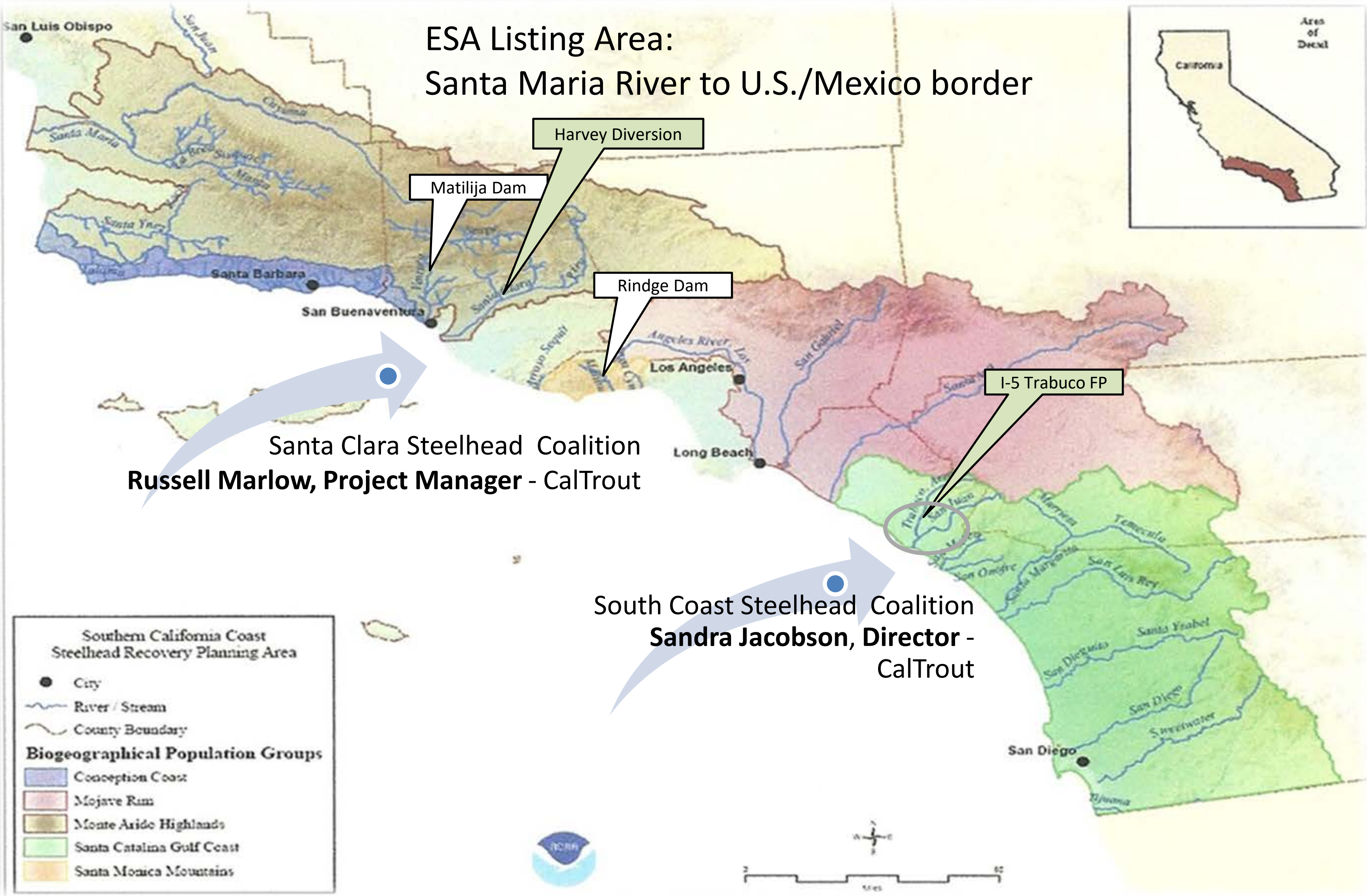
Hatchery Introgression in Southern O. mykiss populations



Fractional ancestry Analysis *O. mykiss* (Garza lab)
Orange = derived primarily from hatchery rainbow trout lineages
Blue = blue represent ancestry of coastal steelhead lineage, while Intermediate values are populations with some introgression and shared ancestry from both lineages.

Southern California Steelhead – ESA Listing Area



Adapted from NMFS Southern California Steelhead Recovery Plan (2012). Coalition Funded by CDFW.

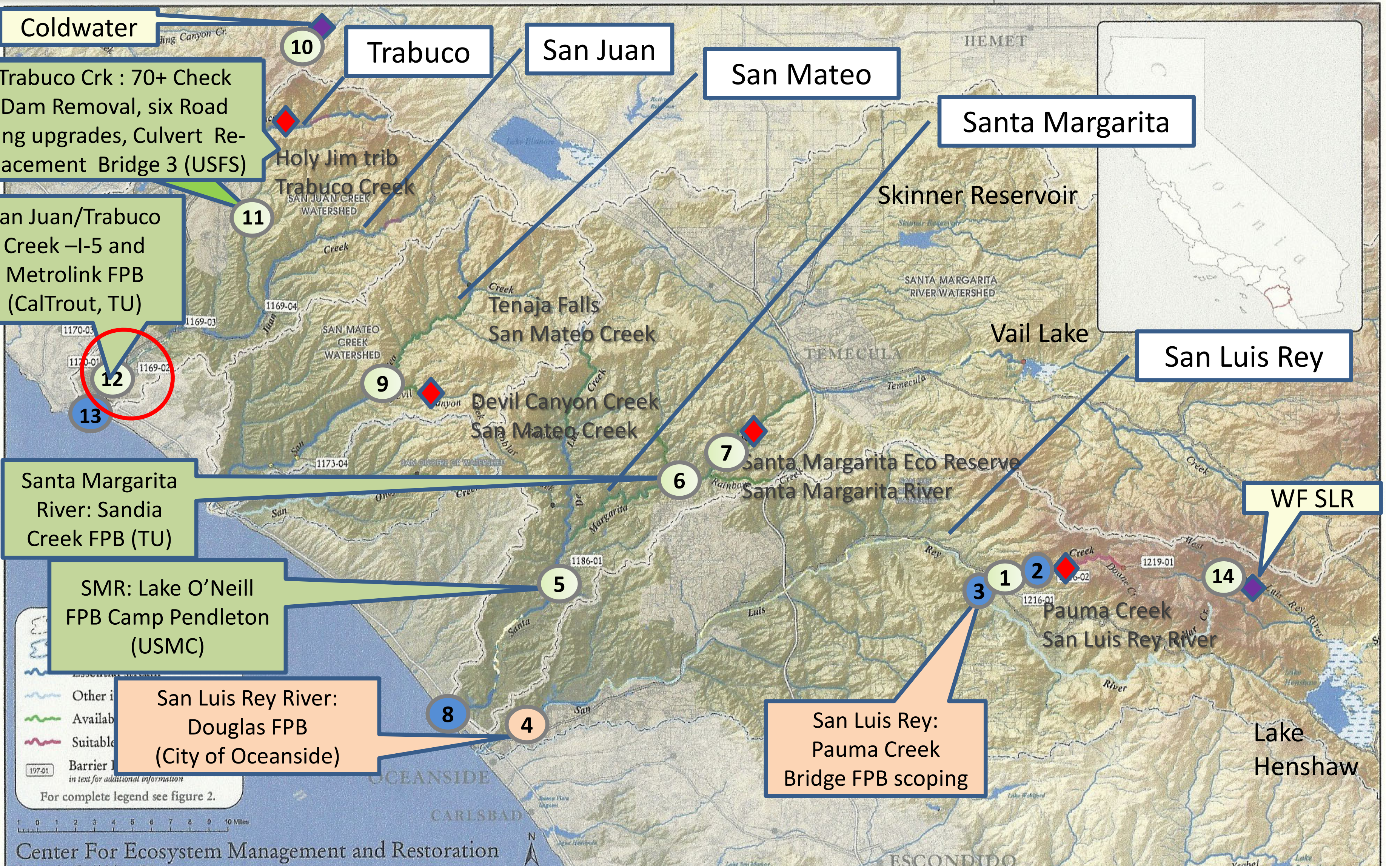
Conservation Goals – South Coast Coalition

- **CONNECT:** establish two connected steelhead populations in focal watersheds in ten years (2025)
    Coastal steelhead populations that are connected to ocean and to each other in focal watersheds

- **CREATE**: establish more unconnected native rainbow trout populations from two to eight for risk mitigation/diversity
    Expand native trout populations into high quality refuge sites; may be within same watershed or neighboring one; may be occupied or unoccupied.

- Remove fish passage barriers
- Improve habitat upstream
- Water conservation / water quality
- Preserve native trout populations

Project Implementation for Steelhead Recovery

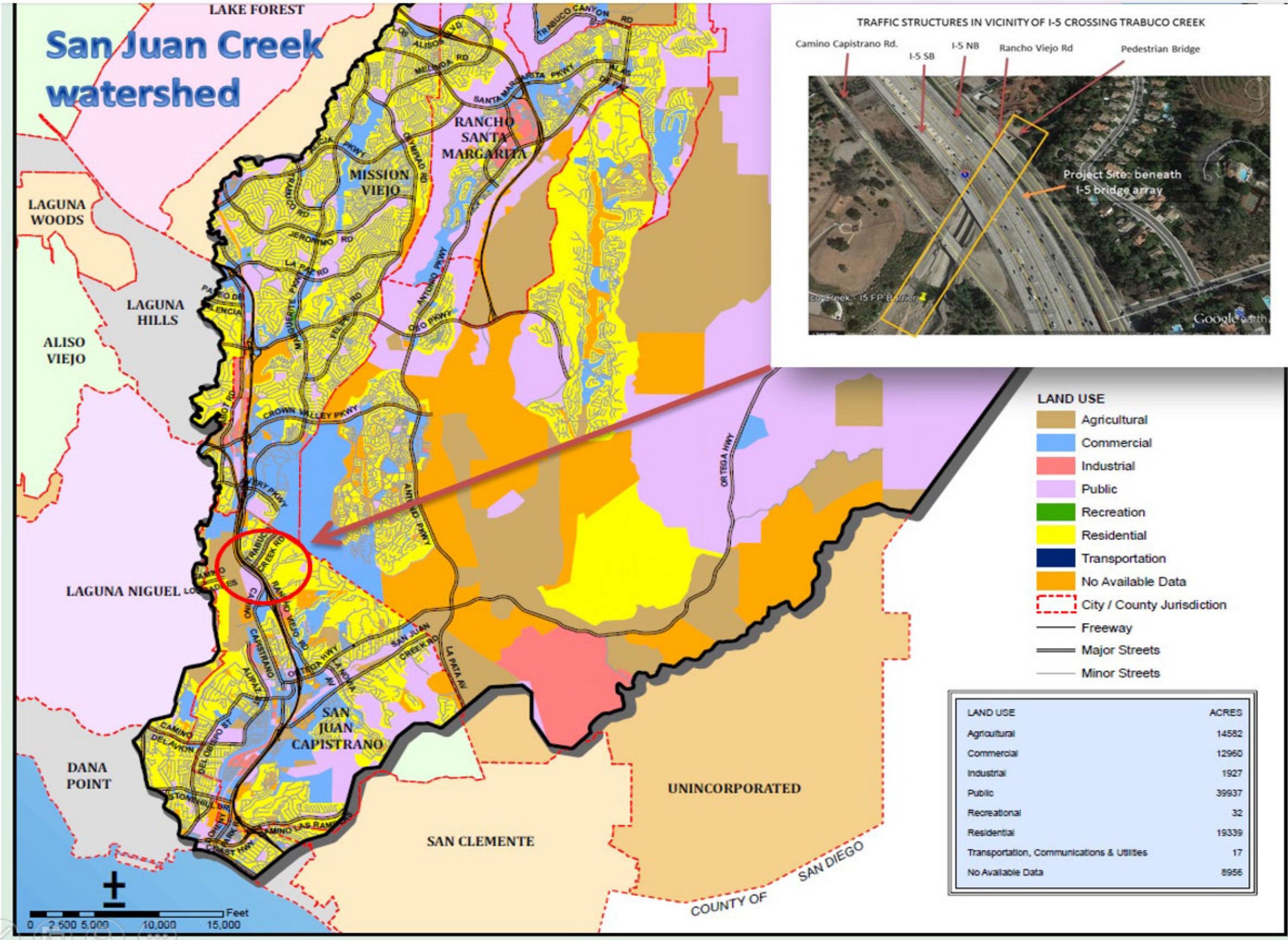


Base map from CEMAR, annotated to illustrate NMFS high priority steelhead recovery rivers and Coalition projects.

- Target habitat for new anadromous populations
- Native rainbow trout populations of steelhead lineage
- Fish Passage Barriers (square symbols, FPB)
- Projects Underway
- In Development

I5-Trabuco Fish Passage – Orange County

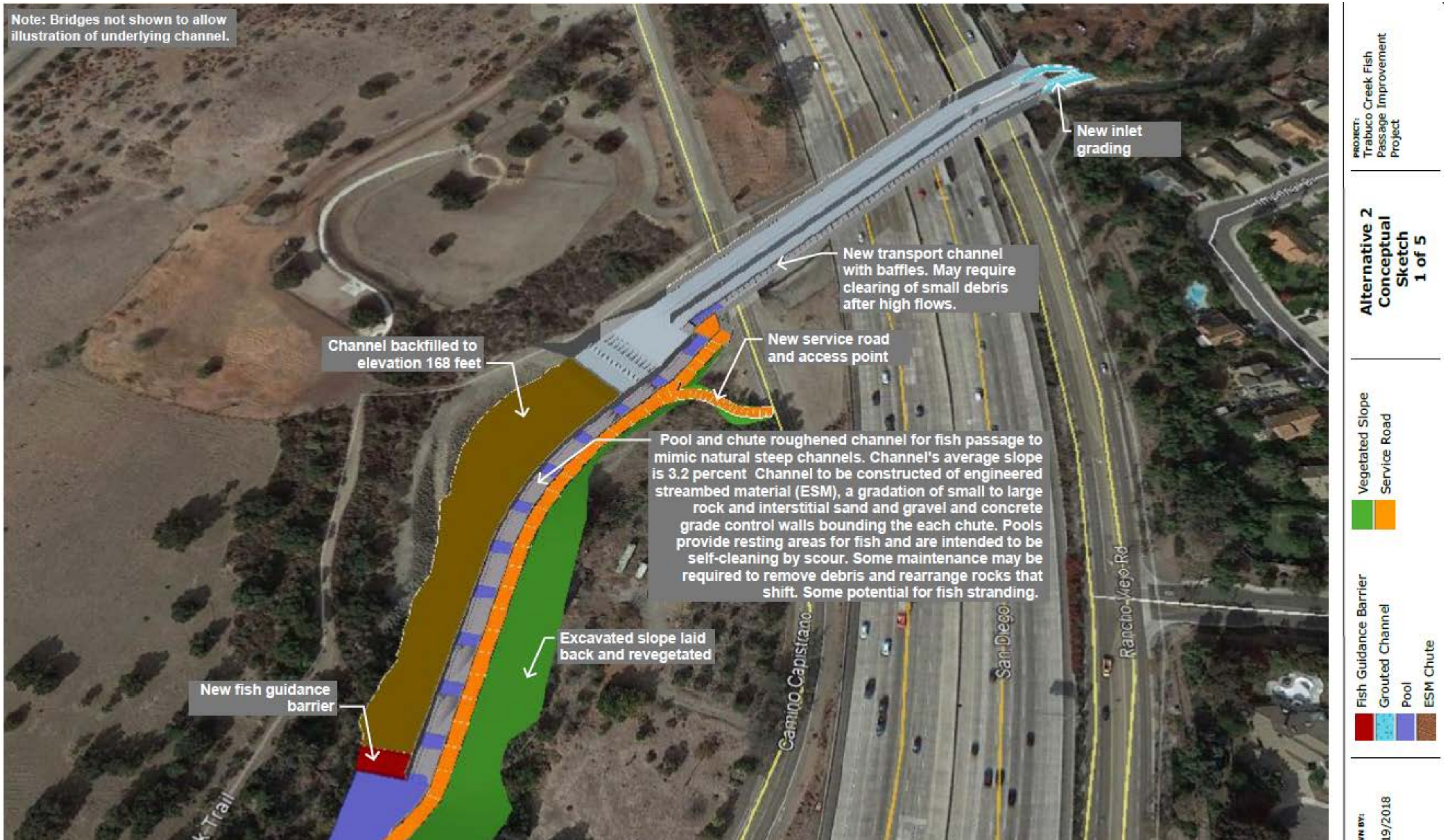
Project Area Map - lower Trabuco Creek I-5 fish passage barrier in San Juan Creek watershed, Orange County California



I-5 Fish Passage – Orange County

I-5 Bridge Array Fish Passage Barrier funded for 65% design level. CalTrout project lead. Funding from CDFW (Prop 1), NFWF, WCB. CalTrout project lead, TU partner. Engineering team: NHC, Love & Assoc, SAGE, Stillwater.

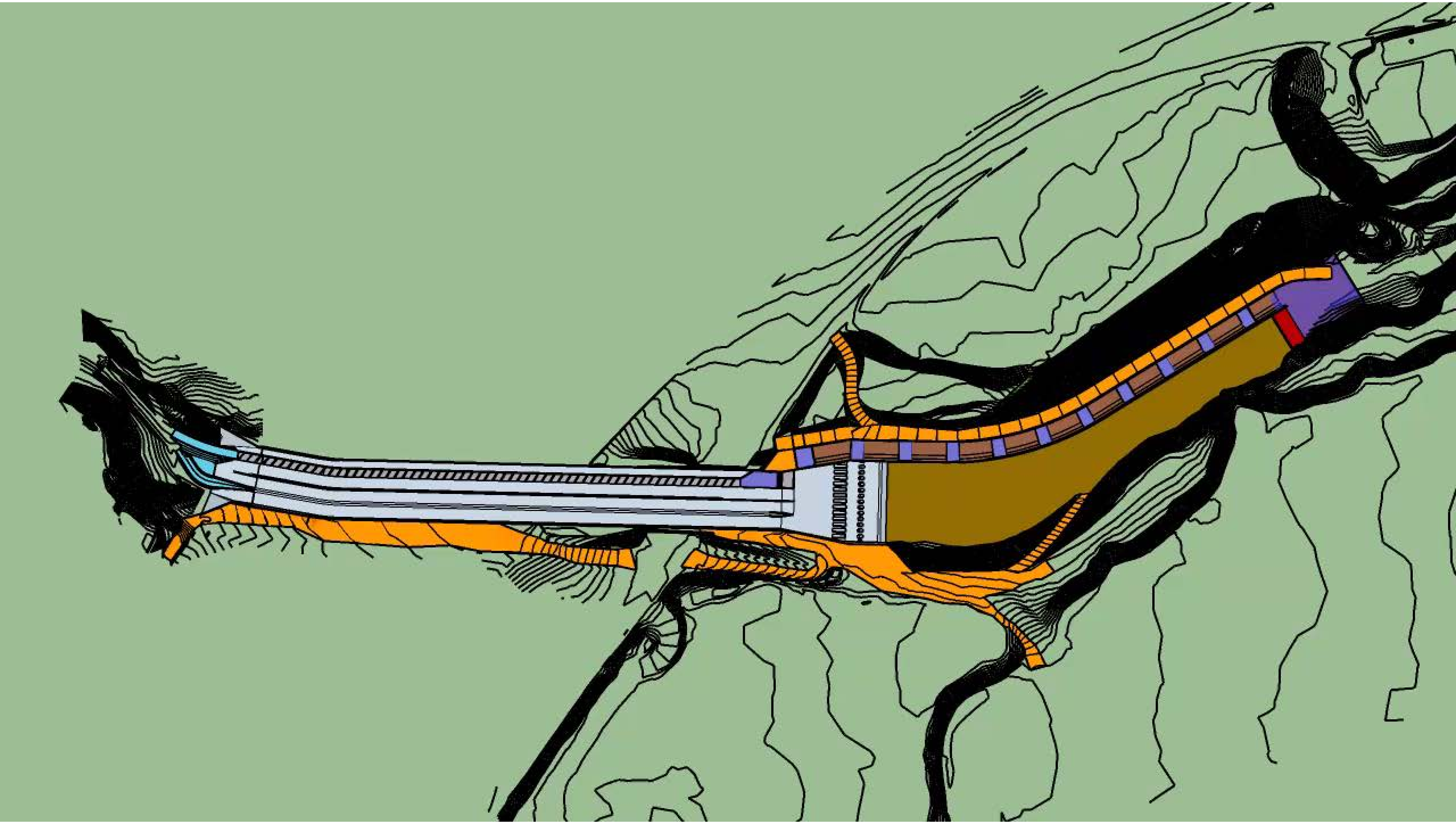
I-5 Fish Passage – Alternative 2 (East Bank)



Perspective view of 3D model with aerial background, flow from top to bottom.

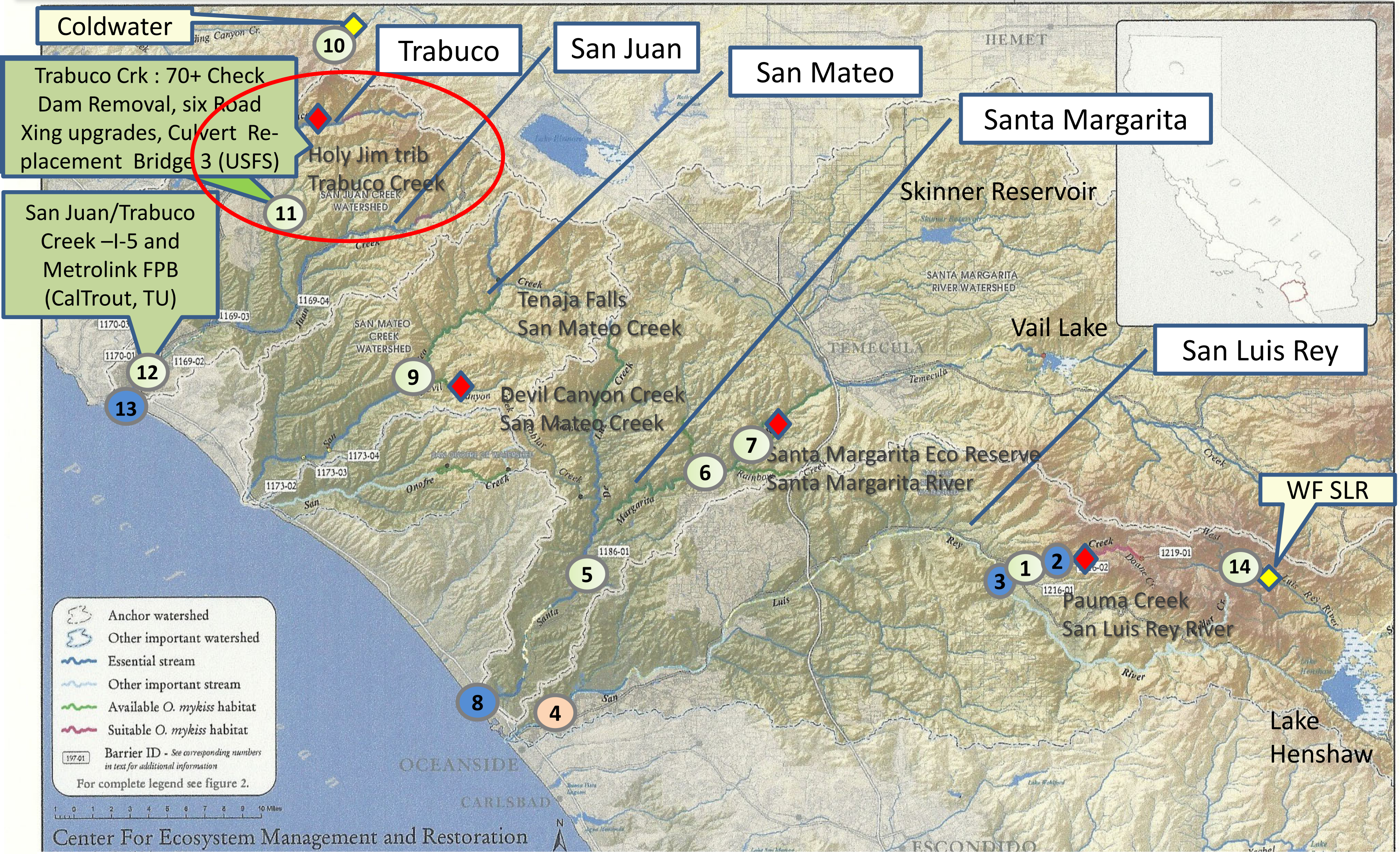
3D rendering by Michael Love & Assoc (Travis James, Mike Love) and NHC (Ed Wallace) I-5 Trabuco fish passage project design team.

I-5 Fish Passage – Alternative 2 (East Bank)



3D/video by Michael Love & Assoc (Travis James, Mike Love)

San Juan Creek – upper barrier removal



Base map from CEMAR, annotated to illustrate NMFS high priority steelhead recovery rivers and Coalition projects.

◆ Target habitat for new anadromous populations ◆ Native rainbow trout populations of steelhead lineage

■ Fish Passage Barriers (square symbols, FPB) ● Projects Underway ● In Development

Headwaters Fish Passage Barrier Removal

>70 check dams to be removed in upper San Juan Creek /Trabuco Creek

Led by Cleveland National Forest (**53 out now**)

The downstream I-5 and Metrolink projects leverage concurrent coast to headwaters fish passage restoration projects in the watershed, allowing access to 15 miles of habitat in an ecosystem level approach that promotes resiliency in coastal areas.

Case Study – San Juan Creek Watershed, Orange County

1. Cumulative effects: restore anadromous and resident populations

-barrier removal - coastal and headwaters

-recent fire impact drives need for proactive planning for relocation refugia

2. Sudden Extirpation: increase genetic and geographic diversity

Possible risk mitigation strategies

-rescued trout relocation √

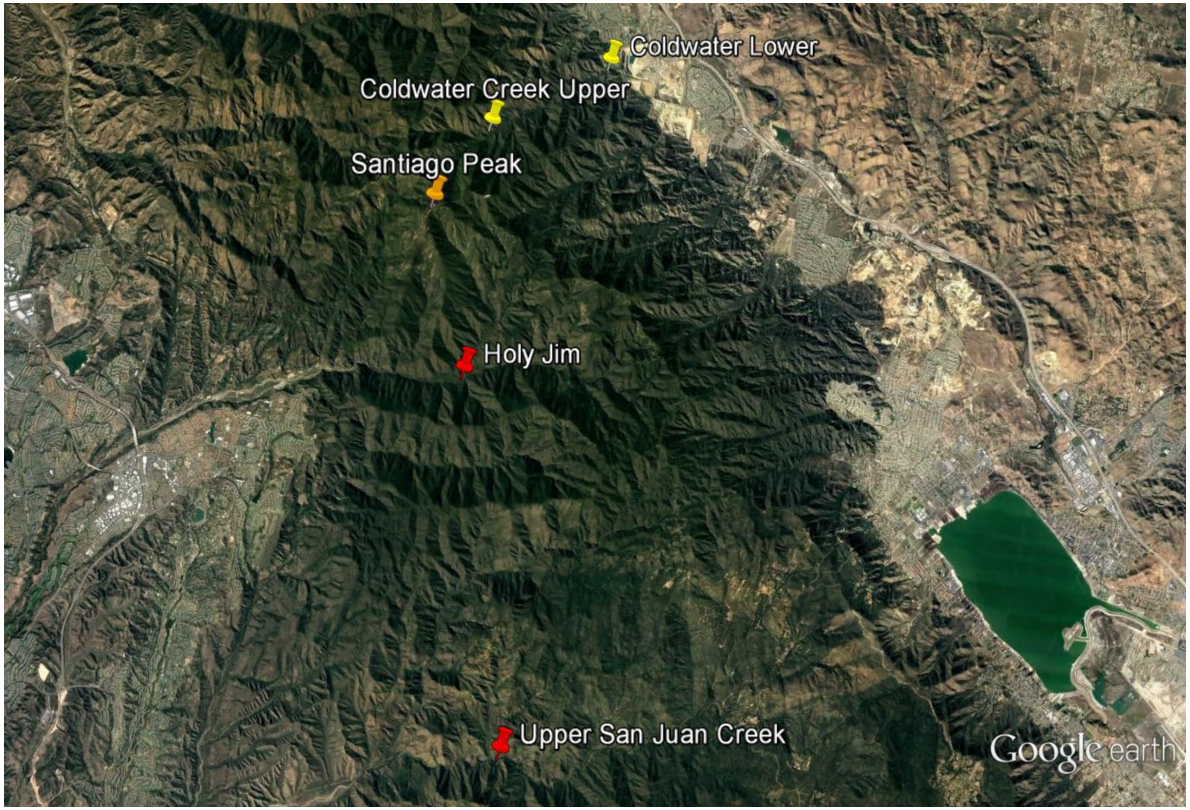
-embryonic translocation

-conservation hatchery

3. Policy: multi-benefit projects

work with OC Flood Control District and water districts to balance needs of steelhead with public needs of water reliability, flood management

Coldwater Canyon Creek Holy Fire Information



Holy Fire (August 2018)

22,986 acres burned

Start: 8/6/2018

Location: Trabuco Canyon

Burned up through Santiago Peak, then down front range canyons near Corona, including Coldwater Canyon

Coldwater Canyon: One of two known native rainbow trout populations of steelhead lineage remaining in this part of Southern California

Native Trout: Coldwater Canyon Creek (RCRCD) and WF San Luis Rey (CDFW)

West Fork San Luis Rey River – Native Trout
San Luis Rey watershed
Bullhead removal successful.

Coldwater Canyon Creek – Native Trout
Santa Ana River watershed - RCRCD
Excessive vegetation removed by CCC crews.

Holy Fire Aug 2018 – Coldwater Canyon impact

Photo:
Julie Donnell,
U.S. Forest Service

Part of BAER Team post-fire assessment

CDFW, Riverside-Corona RCD, U.S. Forest Service, Fire crews – rescued >200 trout from burned Coldwater Canyon – trout are in interim safe holding location; next steps for long-term management = relocation to refugia.

Refugia Characteristics – CDFW / PSMFC

Refugia characteristics (excerpt from Downie and Kajtaniak (CDFW, PSMFC) San Luis Rey Watershed Assessment Report 2010 Introduction:

"Establishment and maintenance of salmonid refugia areas containing high quality habitat and sustaining fish populations are activities vital to the conservation of our anadromous salmonid resources (Moyle and Yoshiyama 1992; Li et al. 1995; Reeves et al. 1995). Protecting these areas will prevent the loss of the remaining high quality salmon habitat and salmonid populations. Therefore, a refugia investigation project should focus on identifying areas found to have high salmonid productivity and diversity."

Refugia support vital activities – spawning and rearing.
Anadromous salmonids exist in dynamic environments.
Conservation of patchy populations requires conservation of several suitable habitat patches and maintaining passage corridors between them."

Refugia habitat elements include the following:

- Areas that provide shelter or protection during times of danger or distress;
- Locations and areas of high quality habitat that support populations limited to fragments of their former geographic range, and;
- A center from which dispersion may take place to re-colonize areas after a watershed and/or sub-watershed level disturbance event and readjustment.

Refugia List – Relocation Ready

Relocation plan for rescued trout

-List of where move fish now

-takes 3+ years to re-establish habitat from rescued location

-move from hatchery asap

-opportunity to use as broodstock?

List of prioritized refugia

Field Work – recon for vacant habitat

-habitat characteristics:

water, flow regimes, canopy, gravels

-trout presence? Best if vacant

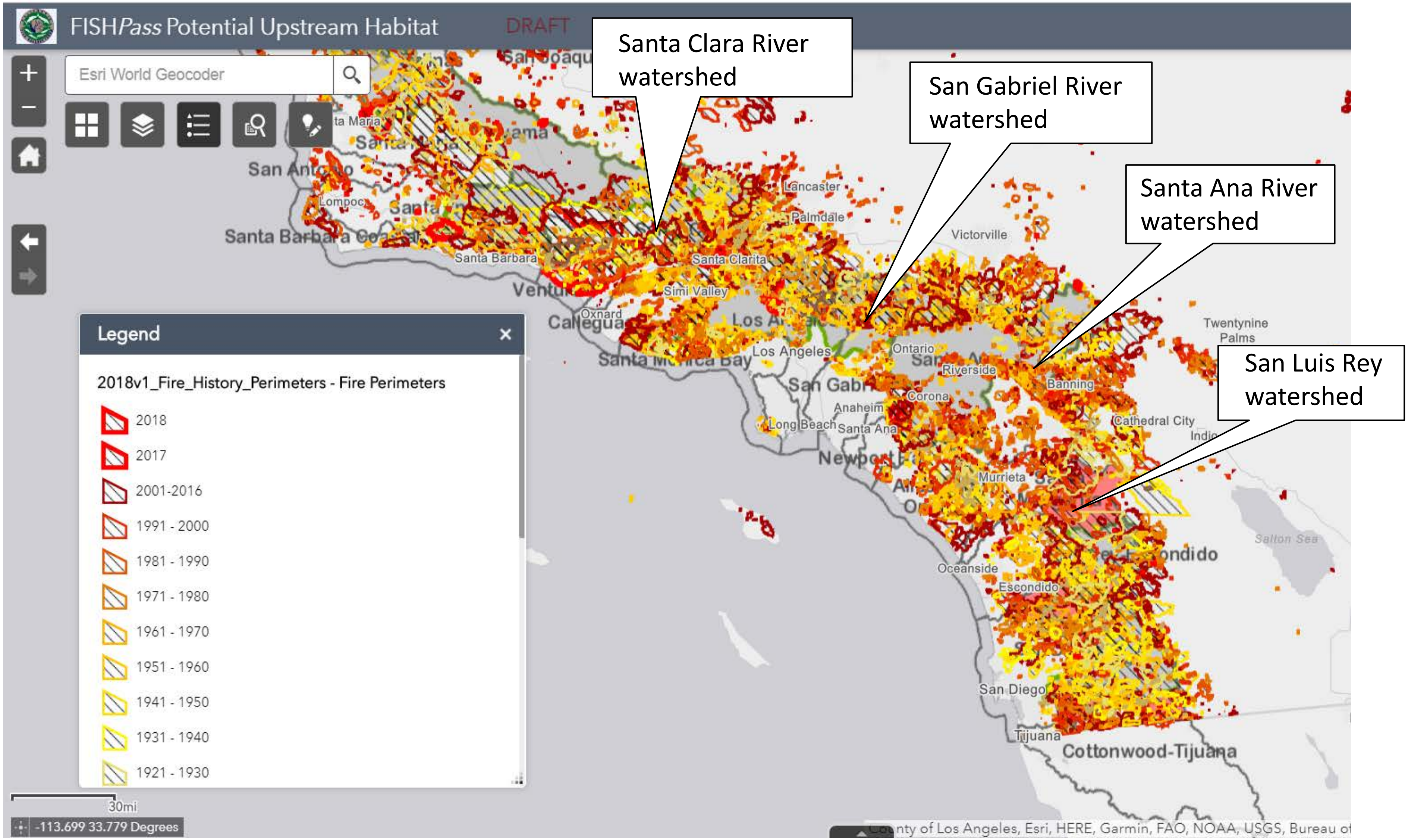
-data for 2+ years for water temp, level, macroinverts

-accessible to relocate and check?

-springs present for consistent water temp?

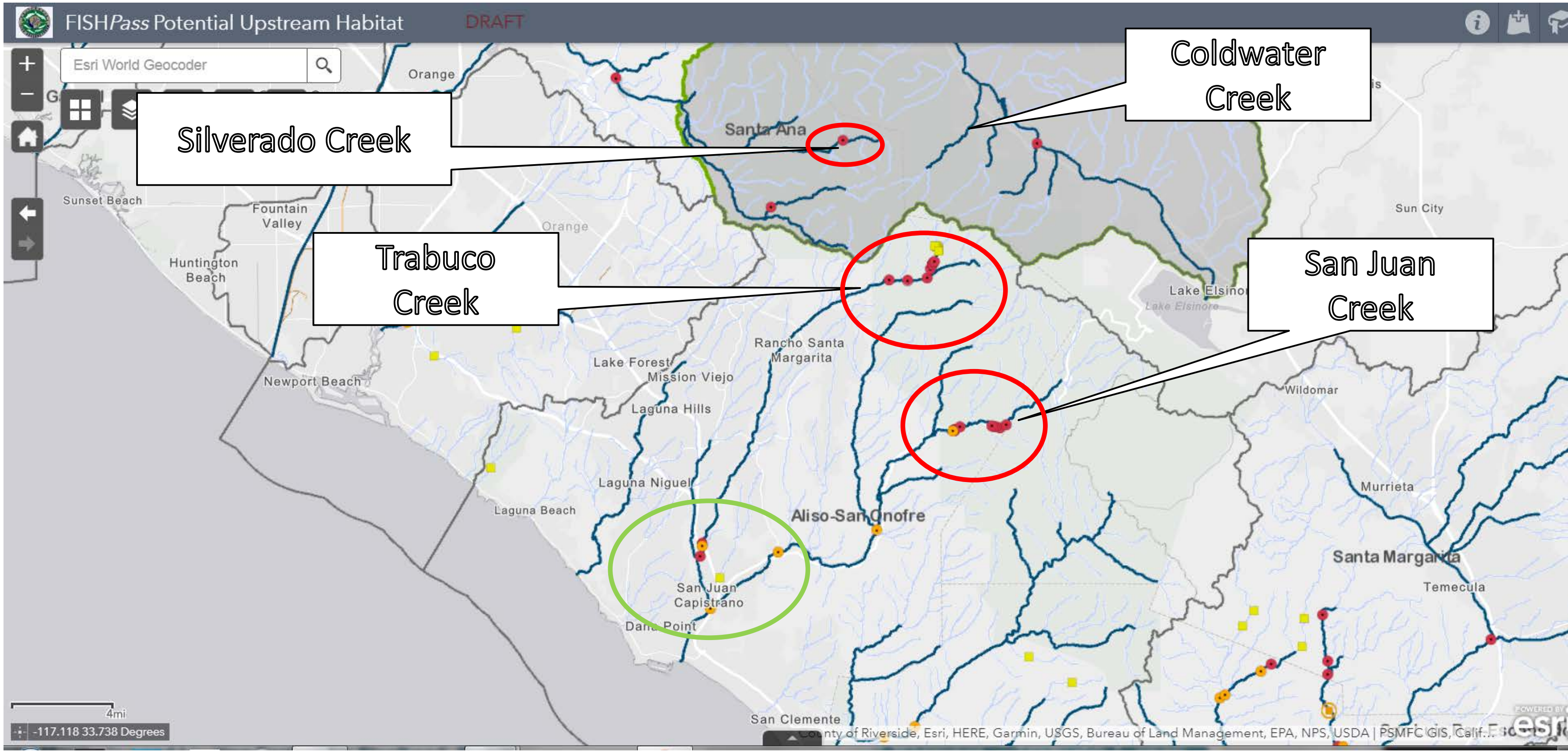
-fire history maps – when last burned?

Refugia List – Relocation Ready



High resolution analysis of fire history and predictions from fire professionals on changing frequency, together with habitat and wildlife conditions for refugia – prioritized list.

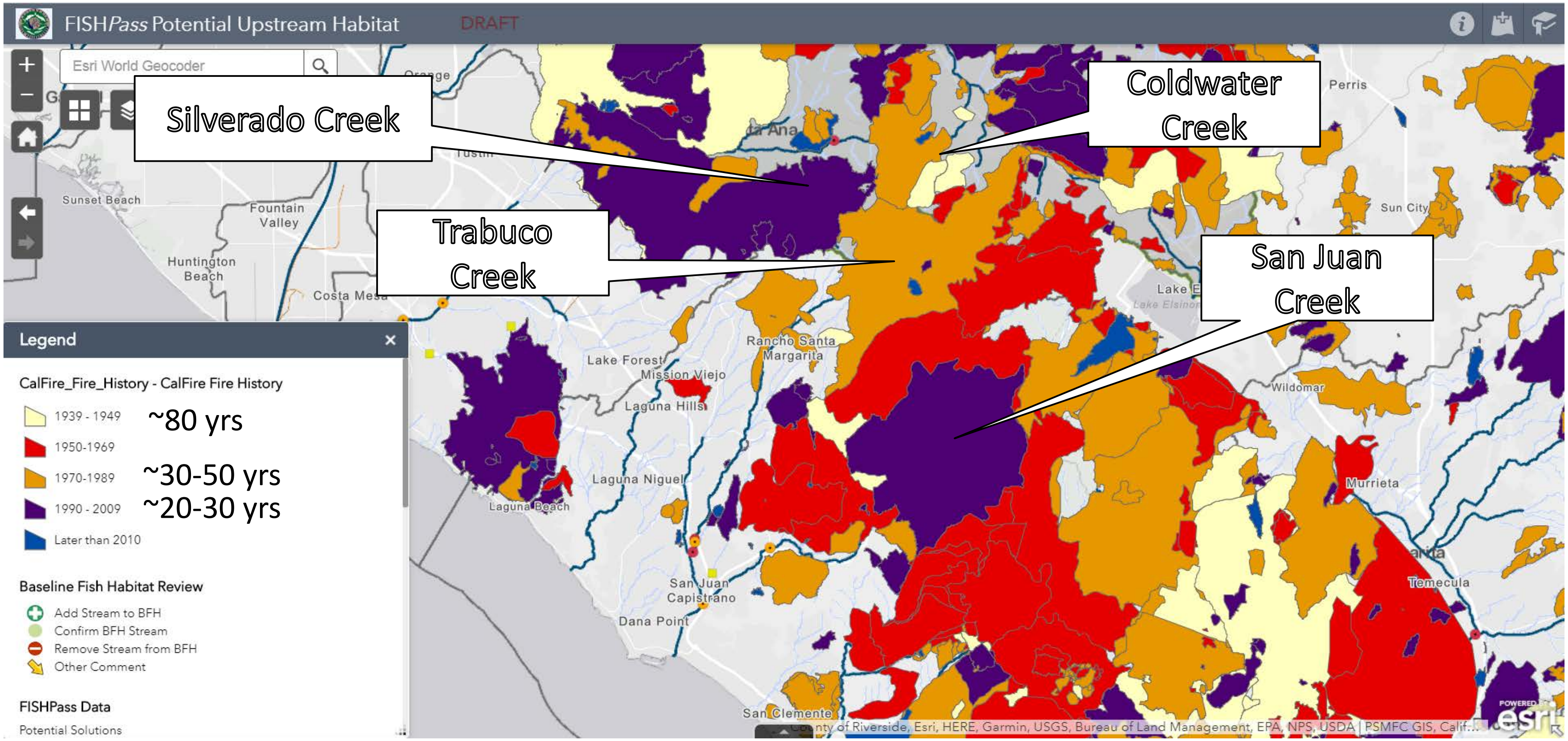
San Juan / Trabuco Watershed – barrier savvy



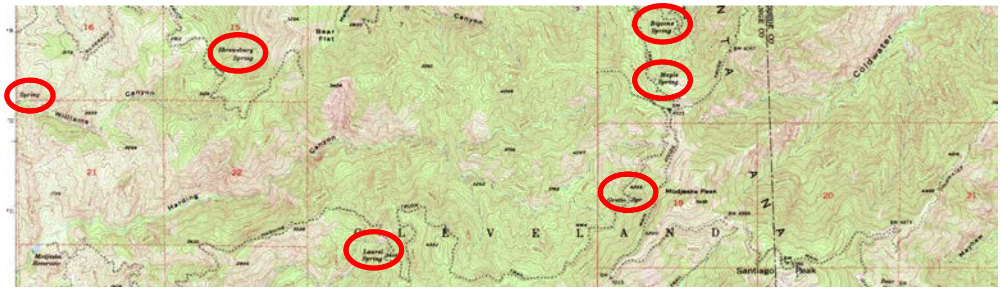
California Fish Passage Forum - FISHPass Layer for Statewide Barrier Removal Prioritization Tool
Brett Holycross (PSMFC) lead with Anne Elston (CDFW) and Cal Passage Assessment Database

Focus for developing tool was on anadromy – (green circle) removing barriers proximal to ocean
But in So Cal – advantages of removing barriers upstream of dams and natural barriers – (red circle)
fish can move in response to environmental issues such as drought and fire.

San Juan / Trabuco Watershed – fire history



Where do natural springs co-locate?



Harding/Coldwater Canyon area

Case Study – San Juan Creek Watershed, Orange County

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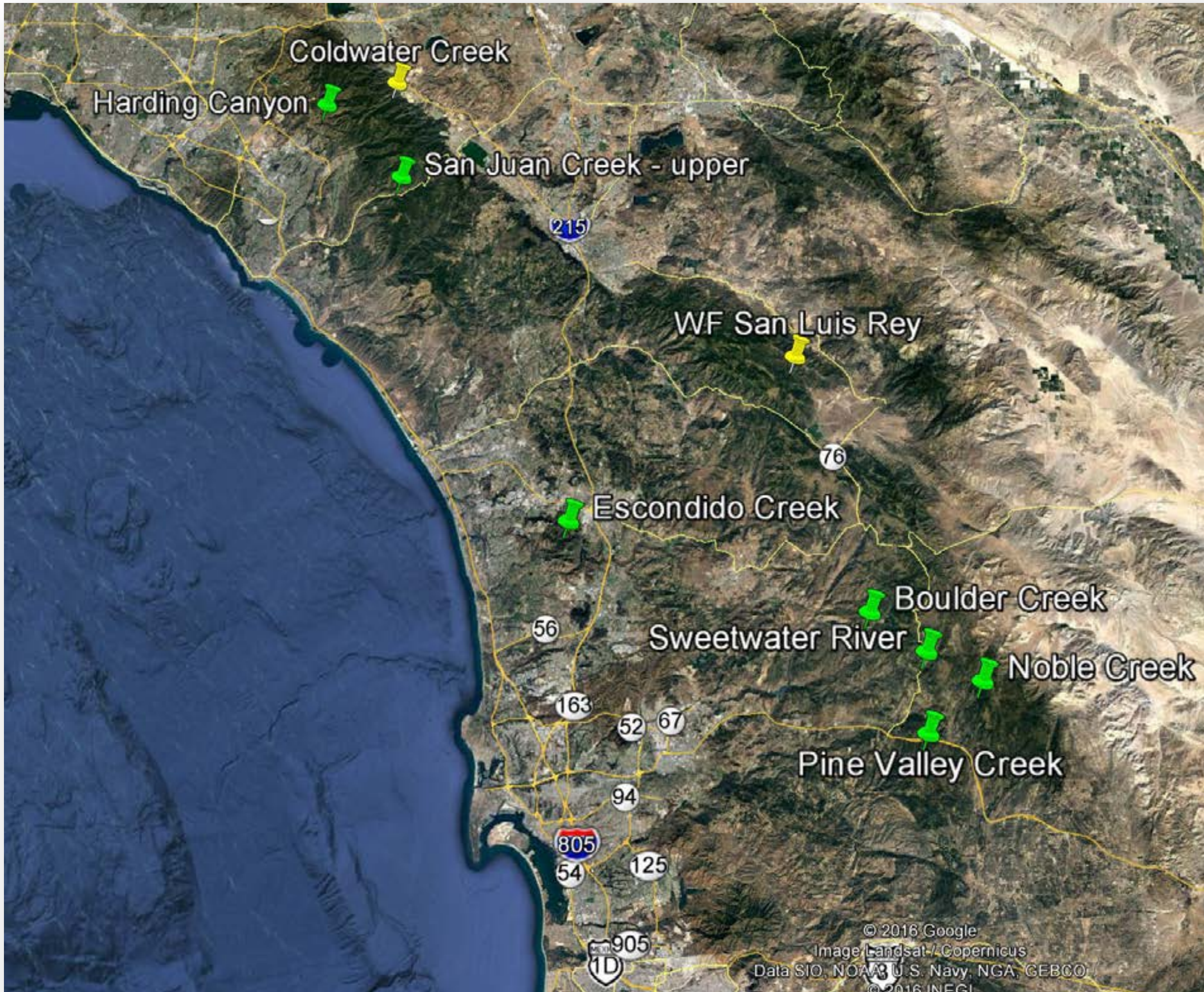
Fires and Drought: Drivers of Immediate Need to Increase Genetic and Geographic Diversity



Use guidelines from NMFS Recovery Plan and State Plans to develop approach for Native Rainbow Trout Sub-population Expansion. Yellow tacks = existing; Green tacks = proposed

Characterize Habitat

Optimize Habitat

Implement Plan

Native Rainbow Trout Subpopulation Expansion

- Native Trout Sub-population Expansion Plan (SE Plan)
  -provides a step-wise methodology for expanding native resident rainbow trout sub-populations for ecological risk mitigation (fires)
  -draft reviewed by state and federal agency managers

- Translocation of native rainbow trout embryos into suitable habitat
  -increase geographic diversity
  -increase genetic diversity (breeding matrix).
  -not a conservation hatchery; not artificial propagation.
  -can start implementation immediately using Coldwater broodstock rescued from Holy Fire;

- Strategy follows Andrews et al (2016)
  -successful in Cherry Creek, tributary to Madison River in Montana
  "Performance of Juvenile Cutthroat Trout Translocated as Embryos from Five Populations into a Common Habitat".

- Use this approach in parallel with efforts to re-establish anadromous populations to support long-term viability of endangered steelhead

Embryonic Translocation Methodology

Spawn adults from native rainbow trout donor populations
(enclosure confined temporarily; ~10 adults to minimize impact)

↓

Collect milt/blastomeres for cryopreservation

Take parental fin clips for genetic analysis

Perform *in vitro* fertilization; incubate in facility to eyed stage

↓

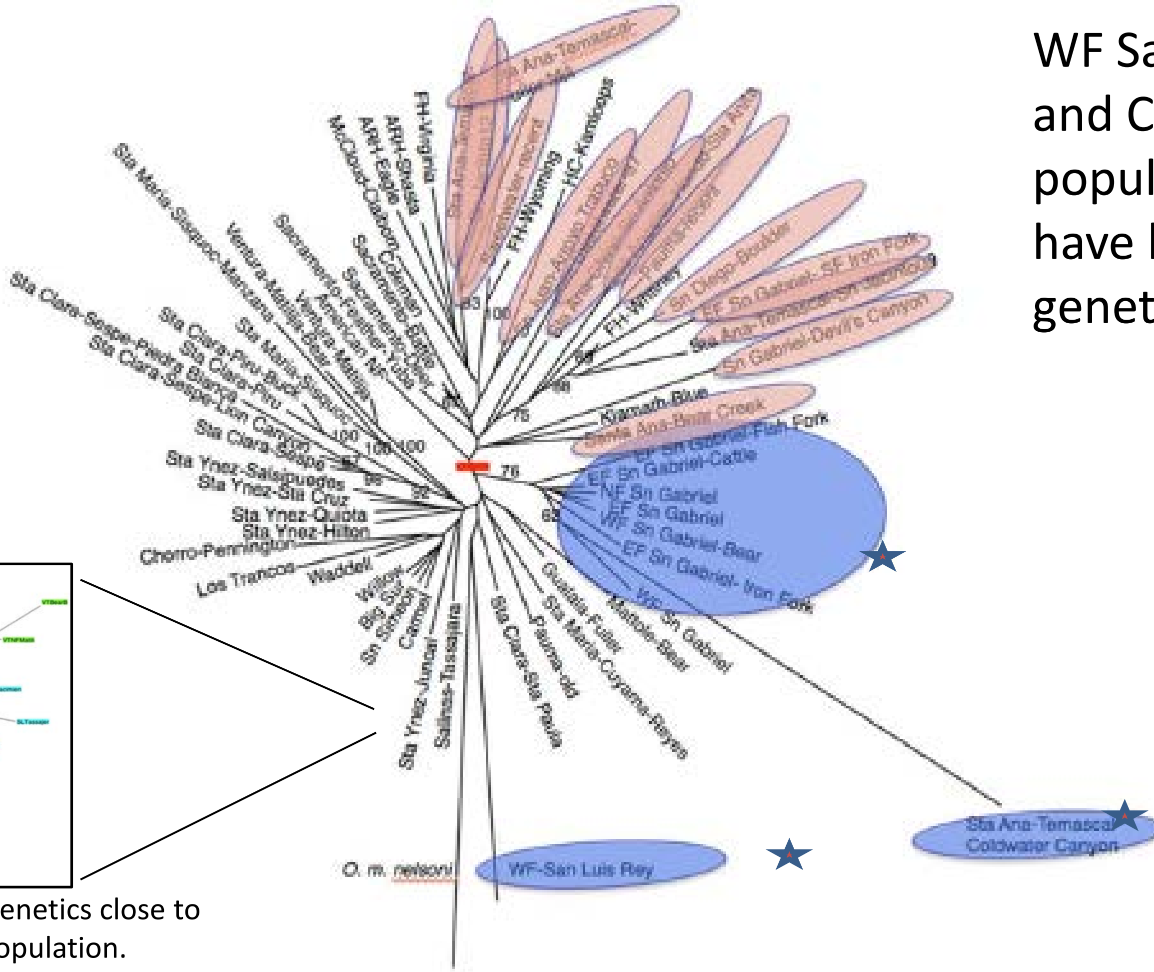
Transfer embryos to Remote Site Incubators (RSI) at 3 sites in target habitat
Incubate until fry hatch then release

↓

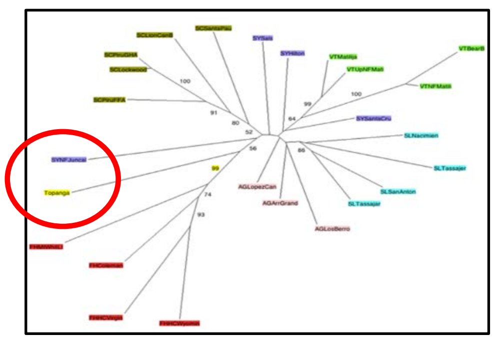
Perform juvenile sampling at 1 year and 2+ years to quantify success

-abundance: population survey
-diversity: genetic analysis
-productivity: redd count, size distribution
-morphology: body weight, fork length, lipid content
-location: distance from release site, PIT tag analysis

Increase Genetic Diversity



WF San Luis Rey and Coldwater populations have lowest genetic diversity



Topanga (yellow) population genetics close to Santa Ynez – Juncal (Purple) population. From Krug et al (2014), Dagit et al (2016).

Neighbor Joining Dendrogram from Southern California *O. mykiss* population genetics study (Abadia-Cardoso et al 2016; Jacobson et al 2014). Those that cluster with hatchery rainbow trout strains are shown in pink, while those closer to coastal O. mykiss populations are blue.

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Conservation Hatchery – NFMS Recovery Plan

Definition: A program that conserves and propagates steelhead taken from the wild for conservation purposes, and returns the progeny to their native habitats to mature and reproduce naturally. Use Plan to articulate purpose of native trout propagation facility and predicted outcomes. Evaluate genetic models to support population persistence.

Native Trout Propagation Facility uses:

Preserve local populations faced with immediate extirpation from catastrophic events such as wildfire, flood, landslide, drought

Preserve remaining genotypic and phenotypic characteristics

Reduce short-term risk of extinction

Reintroduce populations into restored watersheds

Conduct research on southern California stock relevant to species conservation

Scientific and Management considerations:

Conditions necessitating rescue and re-establishment

Methods used for rescue or reestablishment

Protocols for evaluating effectiveness of trout propagation facility functions

Ability of population to increase abundance, growth rate, spatial dispersal and genetic diversity

Address needs for starting operation: biological significance of population, genetic diversity, population viability, population loss upon dispersal

Conservation Hatchery – NFMS Recovery Plan cont.

<u>Native Trout Propagation Facility needs:</u>
Hatchery and genetic management plan
Objectives consistent with Federal Recovery Plan
Adaptive management structure
Monitoring component to evaluate the short- and long-term goals of program
Change management directives
Plan for closing down

<u>Native Trout Propagation Facility research program support:</u>
Fish culture problems arising within the program
Fish response to habitat, environmental challenges, pathogens, etc.
Factors that reduce fitness and reproductive success of hatchery fish
Behavioral changes of facility reared fish released into their natal waters
Contain strategy for terminating the propagation facility

NMFS DPS Goals

Distinct Population Segment-wide Goals

- Preserve over-all species diversity (genetic, phenotypic, life-history)

- Protect species from extinction due to catastrophic disturbance (wildfires, flooding, droughts)

NMFS DPS Viability Factors

Distinct Population Segment-wide Viability

Landscape Strategy

- Minimum number viable in each biogeographic region
- Occupy watersheds with drought refugia
- Minimum geographic separation (wildland fire analysis)
- Exhibit life history diversity

< 5% extinction risk in 1000 years

Research and Monitoring

Priority Topics

- Expression of life-history forms
- Dispersal between watersheds
- Role of intermittent streams
- Role of lagoons/estuaries

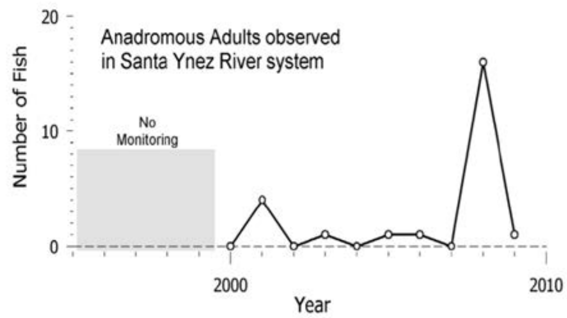


Figure 10. Adult steelhead observed in the Santa Ynez River System. Numbers are incomplete counts, unadjusted for observation probabilities/errors (Williams *et al.* 2011).

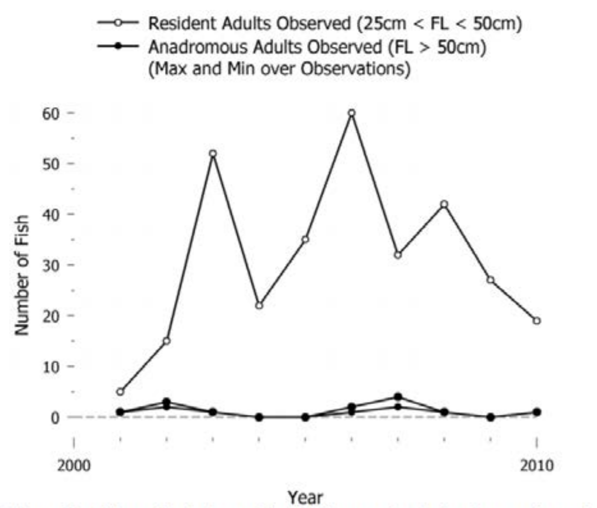
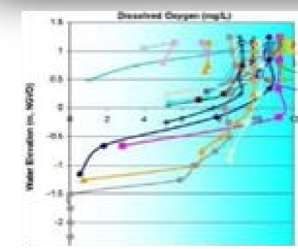
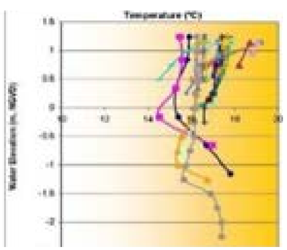


Figure 16. Adult steelhead observed in the Topanga Creek. Numbers are incomplete counts, unadjusted for observation probabilities/errors (Williams *et al.* 2011).

So Cal Estuary Study – Salmonid Biology and Abundance





Estuary study goal: scientific synthesis of estuary water quality data

- water temp
- dissolved oxygen
- salinity; and how this relates to Southern California steelhead physiological tolerances, occupancy and estuary usage.

Funding from Orange County Community Foundation – Warne Family Fund for Endangered Species gratefully acknowledged to CalTrout.

Contact Information

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FISH · WATER · PEOPLE

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Director, South Coast Region
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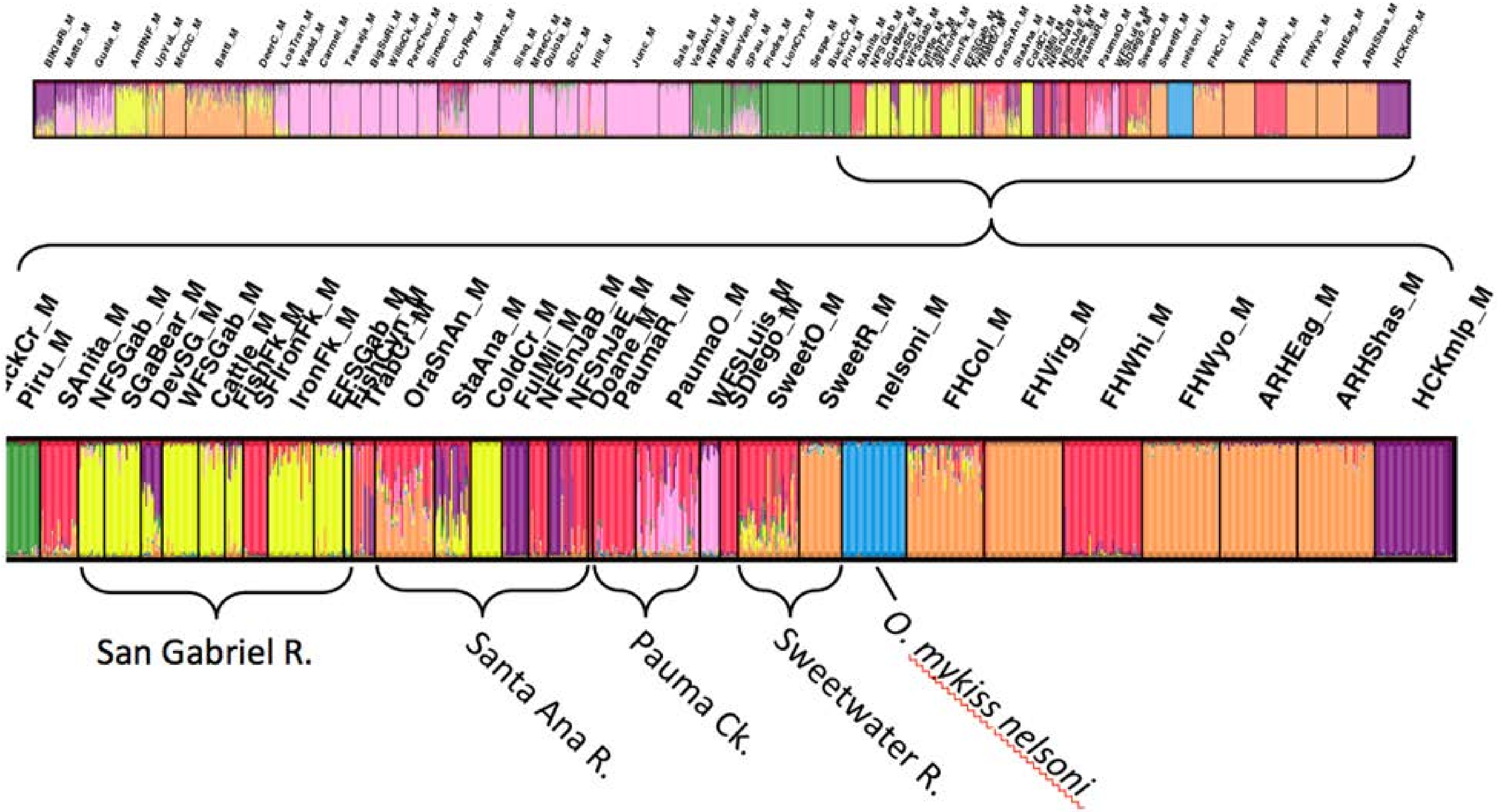
Populations of Native Steelhead Lineage Remain in South



Individual Q-values (fractional ancestry) estimated by the program STRUCTURE for K=7 genetic clusters (Garza lab)

Hatchery rainbow trout ancestry divided into purple, orange, and red genetic clusters; native southern California *O. mykiss* ancestry: yellow and pink.

Increase Genetic Diversity

Allelic Diversity Comparison

Table 4. Genetic diversity-Southern California rainbow trout populations (Abadia-Cardoso et al 2016).

Population ID	N	H_O	H_E	Ar	P(0.95)	P(0.99)	r^2
Sta Maria-Cuyama-Reyes	47	0.41	0.41	4.08	0.94	0.99	1.000
Sta Maria-Sisquoc-Manzana	47	0.36	0.34	3.30	0.79	0.88	0.585
Sta Maria-Sisquoc	47	0.37	0.37	3.76	0.91	0.96	0.790
Montecito	5	0.37	0.32	–	–	–	–
Sta Ynez-Quiota	35	0.40	0.39	3.77	0.91	0.98	0.887
Sta Ynez-Sta Cruz	35	0.38	0.38	4.08	0.88	0.93	0.999
Sta Ynez-Hilton	42	0.40	0.40	3.93	0.90	0.98	0.379
Sta Ynez-Juncal	81	0.38	0.37	3.53	0.81	0.95	0.990
*Sta Ynez-Salsipuedes	47	0.36	0.38	3.79	0.90	0.95	0.999
Ventura-Matilija	46	0.38	0.37	3.70	0.86	0.96	0.732
Ventura-Matilija-Bear	14	0.37	0.35	3.47	0.79	0.86	0.882
Sta Clara-Sta Paula	45	0.41	0.42	4.34	0.93	0.97	1.000
Sta Clara-Piru	26	0.34	0.35	3.82	0.83	0.94	0.999
Sta Clara-Piru-Buck	16	0.36	0.37	3.61	0.88	0.93	0.997
Sta Clara-Sespe	39	0.36	0.37	4.13	0.90	0.98	0.999
Sta Clara-Sespe-Piedra Blanca	10	0.32	0.33	3.35	0.89	0.89	0.999
Sta Clara-Sespe-Lion Canyon	47	0.36	0.36	3.95	0.88	0.98	0.909
Los Angeles-Hondo-Sta Anita	23	0.25	0.33	2.83	0.79	0.90	0.890
NF Sn Gabriel	16	0.37	0.39	4.18	0.91	0.97	0.802
WF Sn Gabriel-Bear	22	0.38	0.38	4.06	0.89	0.98	0.832
WF Sn Gabriel-Devil's Canyon	13	0.33	0.31	2.65	0.69	0.71	–
WF Sn Gabriel	22	0.32	0.34	3.32	0.80	0.90	1.000
*EF Sn Gabriel-Cattle	16	0.38	0.40	4.19	0.93	0.96	0.999
EF Sn Gabriel-Fish Fork	11	0.40	0.40	3.89	0.82	0.88	0.998
EF Sn Gabriel-SFIron Fork	15	0.37	0.35	2.91	0.80	0.82	0.000
EF Sn Gabriel-Iron Fork	28	0.37	0.37	3.52	0.91	0.97	0.350
EF Sn Gabriel	18	0.38	0.39	4.13	0.90	0.98	0.724
Sn Gabriel-Fish Canyon	5	0.36	0.35	–	–	–	0.999
Sta Ana-Chino-Sn Antonio	36	0.39	0.40	3.84	0.89	0.93	0.052
Sta Ana-Bear	22	0.38	0.40	4.57	0.83	0.94	0.645
*Sta Ana-Temescal-Coldwater Cyn	19	0.13	0.12	1.76	0.30	0.32	0.485
Sta Ana-Temescal-Fuller Mill	16	0.34	0.27	2.50	0.57	0.71	–
Sta Ana-Temescal-Sn Jacinto09	12	0.36	0.35	3.01	0.78	0.84	0.996
Sta Ana-Temescal-Sn Jacinto12	24	0.31	0.34	3.04	0.85	0.90	0.428
Sn Juan-Arroyo Trabuco	14	0.39	0.41	4.12	0.94	0.98	0.532
Sn Luis Rey-Doane	3	0.28	0.27	–	–	–	0.999
PaumaO (old 1997)	39	0.38	0.38	3.92	0.87	0.97	0.813
PaumaR (recent 2009–2011)	26	0.31	0.32	2.93	0.78	0.82	0.828
*WF San Luis Rey	12	0.26	0.26	2.53	0.59	0.66	0.999
Sn Diego-Boulder	11	0.37	0.34	3.09	0.80	0.83	0.353
Sweetwater (old 1997)	26	0.36	0.37	3.58	0.86	0.94	0.229
Sweetwater (recent 2010/2013)	37	0.38	0.37	3.69	0.83	0.92	0.409
O. m. nelsoni	39	0.16	0.19	2.27	0.43	0.55	0.999

Obs Ar: 4.15 (EF-SG) good vs 1.76 (Coldwater) and 2.53 (WF SLR) low

Sample Breeding Matrix from SE Plan

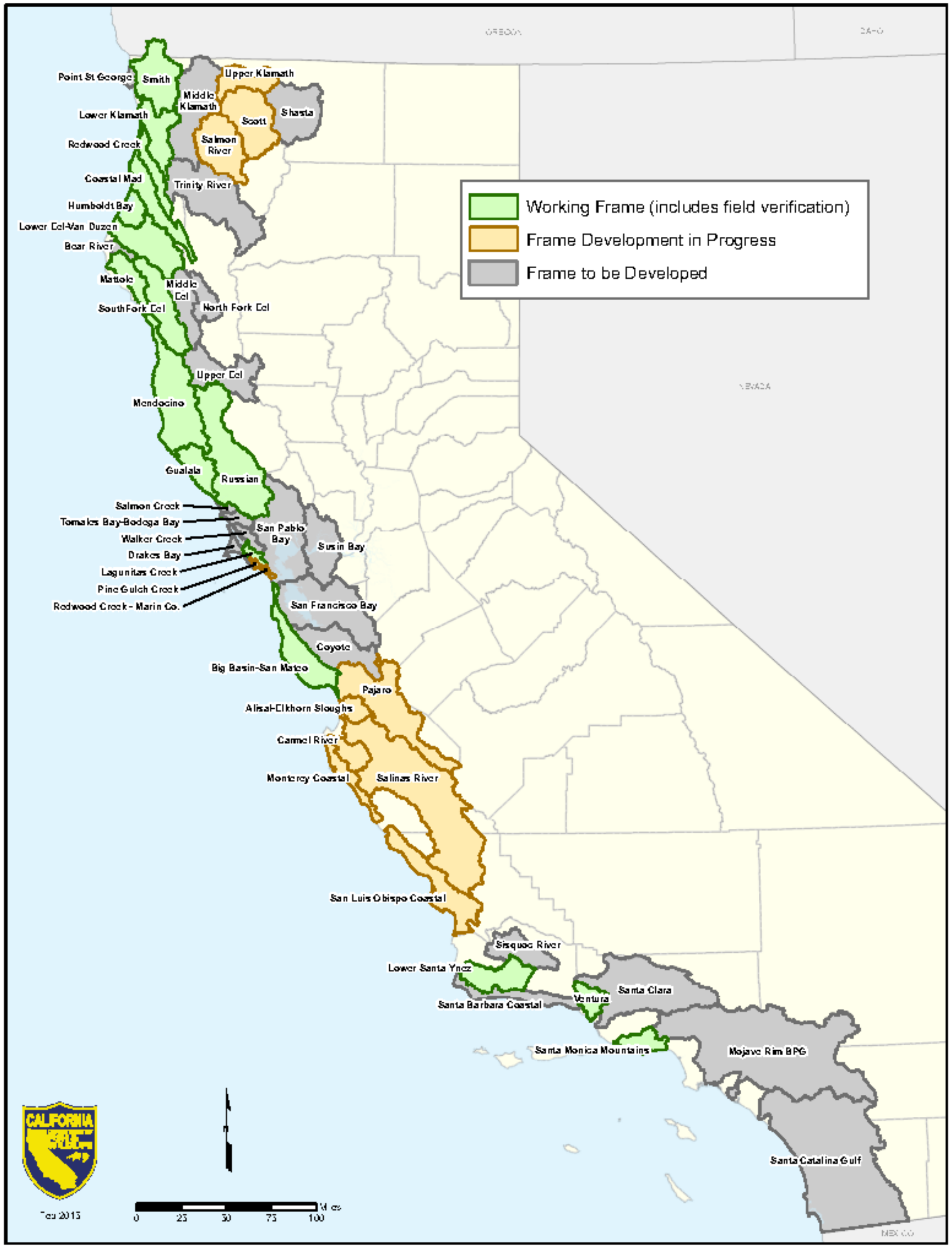
		Female parental line			
		Coldwater Canyon (CW)	WF San Luis Rey (WF)	EF San Gabriel - Cattle Canyon (SG) + derivs	Topanga Creek or Carmel River
Male parental line	Coldwater Canyon	Year 1 control: CW ♀ x CW ♂	Year 1 and 2 : WF ♀ x CW ♂	Year 4 SG ♀ x CWxWF F1 ♂	Year 4 TC ♀ x CWxWF F1 ♂
	WF San Luis Rey	Year 1 and 2: CW ♀ x WF ♂	Year 1 Control: WF ♀ x WF ♂	Yr 5: CWxSG F1 ♀ x CWxWF F1 ♂	Yr 5: CWxTC F1 ♀ x CWxWF F1 ♂
	EF San Gabriel – Cattle Cyn	Year 3: CW ♀ x SG ♂	Year 3: WF ♀ x SG ♂	Yr 6: CWxWFxSG F1 ♀ x SG ♂	Yr 6: CWxWFxTC F1 ♀ x SG ♂
	Topanga Creek or Carmel River	Year 3: CW ♀ x TC ♂	Year 3: WF ♀ x TC ♂	Yr 6: CWxWFxSG F1 ♀ x TC ♂	Yr 6: CWxWFxTC F1 ♀ x TC ♂

Legend: ♀ = Female parent; ♂ = Male parent. CW = Coldwater Canyon Creek; WF = West Fork San Luis Rey; SG = EF San Gabriel River; TC = Topanga Creek; CR = Carmel River. F1 = first generation offspring.

Current Status of Southern California Steelhead Monitoring

CALIFORNIA
DEPARTMENT OF
FISH &
WILDLIFE

Kyle Evans



OREGON
IDAHO
NEVADA
Working Frame (includes field verification)
Frame Development in Progress
Frame to be Developed
Point St George
Smith
Upper Klamath
Middle Klamath
Shasta
Lower Klamath
Scott
Redwood Creek
Salmon River
Coastal Mad
Trinity River
Humboldt Bay
Lower Eel-Van Duzen
Bear River
Mattole
Middle Eel
South Fork Eel
North Fork Eel
Upper Eel
Mendocino
Gualala
Russian
Salmon Creek
Tomales Bay-Bodega Bay
Walker Creek
Drakes Bay
Lagunitas Creek
Pine Gulch Creek
Redwood Creek - Marin Co.
San Pablo Bay
Suisun Bay
San Francisco Bay
Coyote
Big Basin-San Mateo
Pajaro
Alisal-Elkhorn Sloughs
Carmel River
Monterey Coastal
Salinas River
San Luis Obispo Coastal
Sisquoc River
Lower Santa Ynez
Santa Clara
Ventura
Santa Barbara Coastal
Santa Monica Mountains
Mojave Rim BPG
Santa Catalina Gulf
MEXICO
0 25 50 75 100 Miles

Ventura River
Santa Barbara
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South-Central DPS
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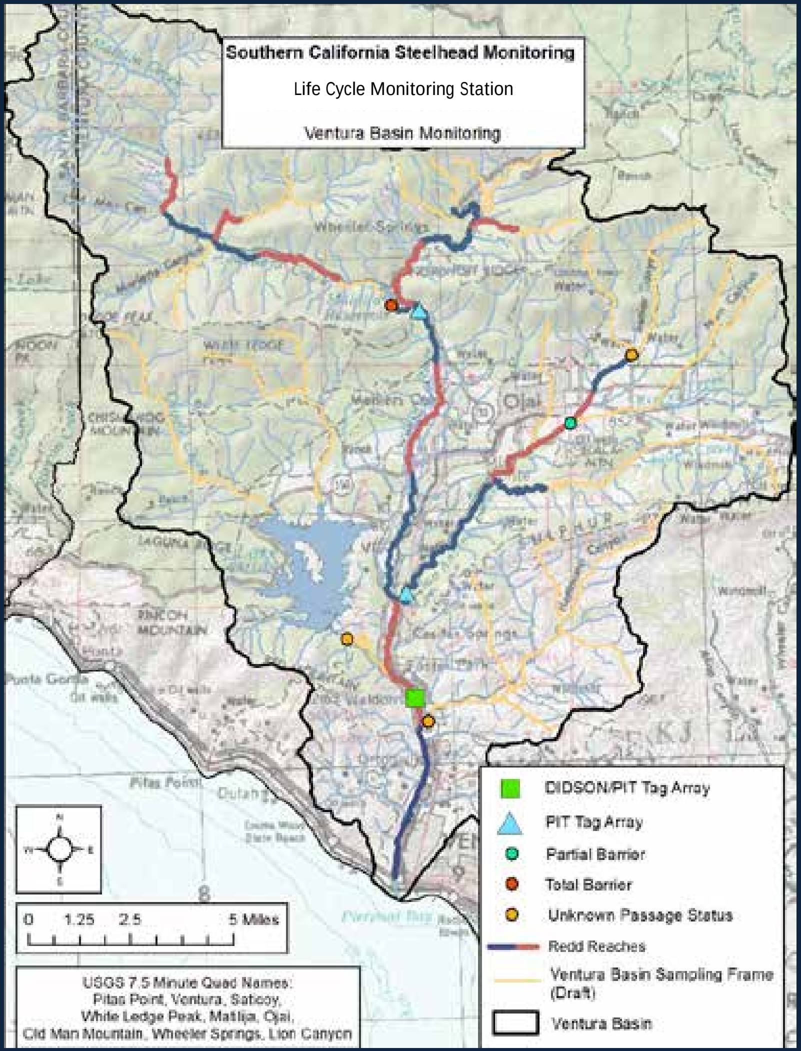
Viable Salmonid Population (VSP)

- Abundance
- Productivity
- Spatial Structure
- Diversity

Life Cycle Monitoring Station (LCM)

Ventura River

- DIDSON
- Redd Surveys
- PIT Tagging
- E-fish Calibrated Snorkel Surveys



Dual Frequency Identification Sonar

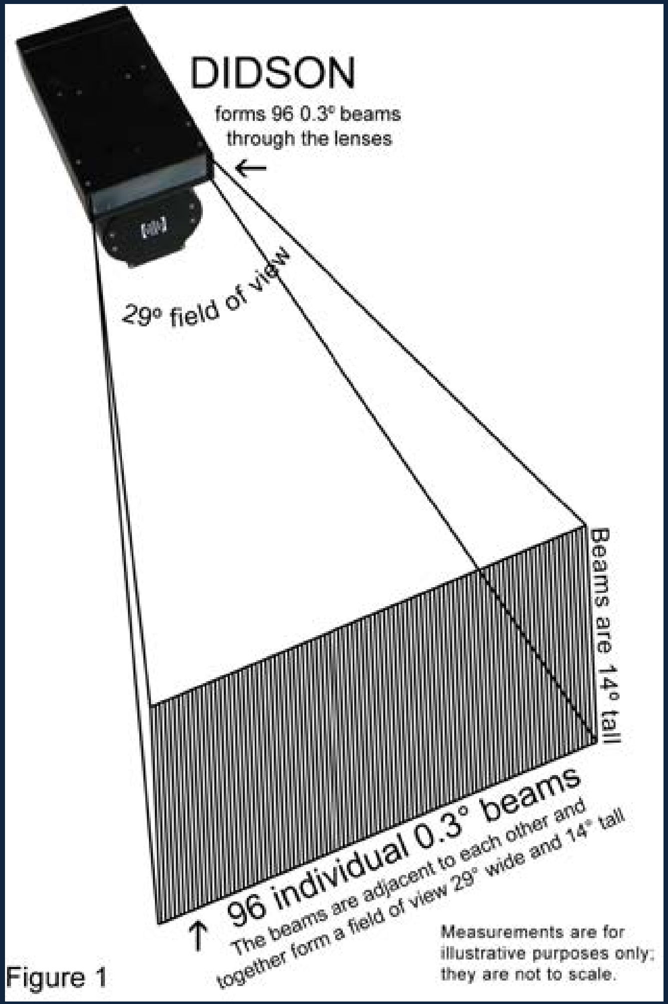
Adaptive Resolution Imaging Sonar

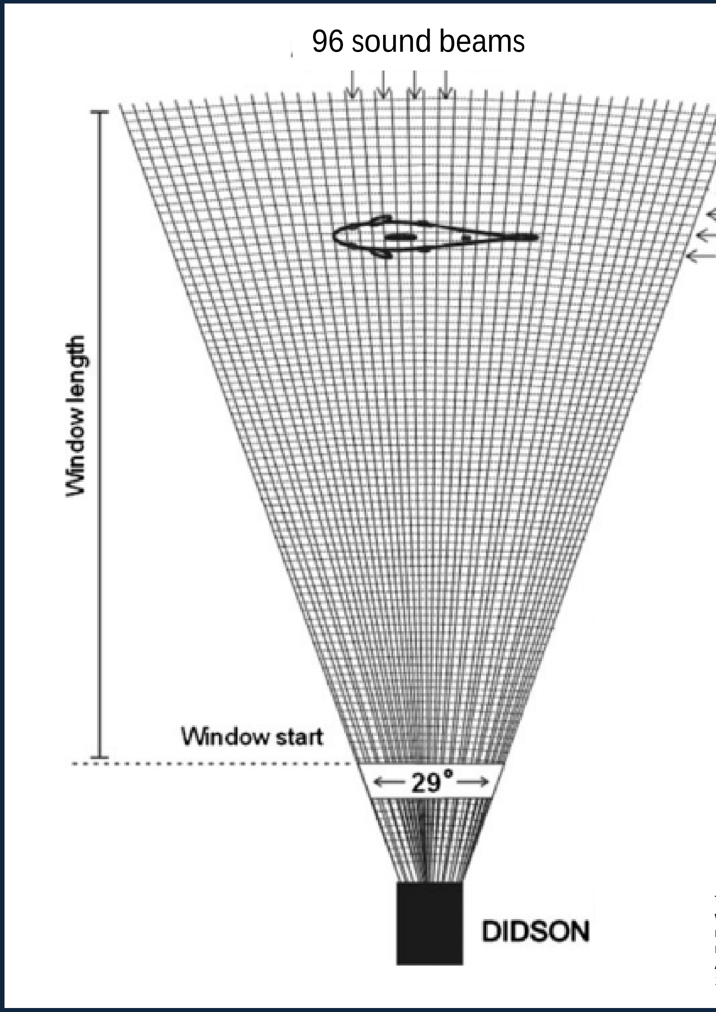
DIDSON

ARIS

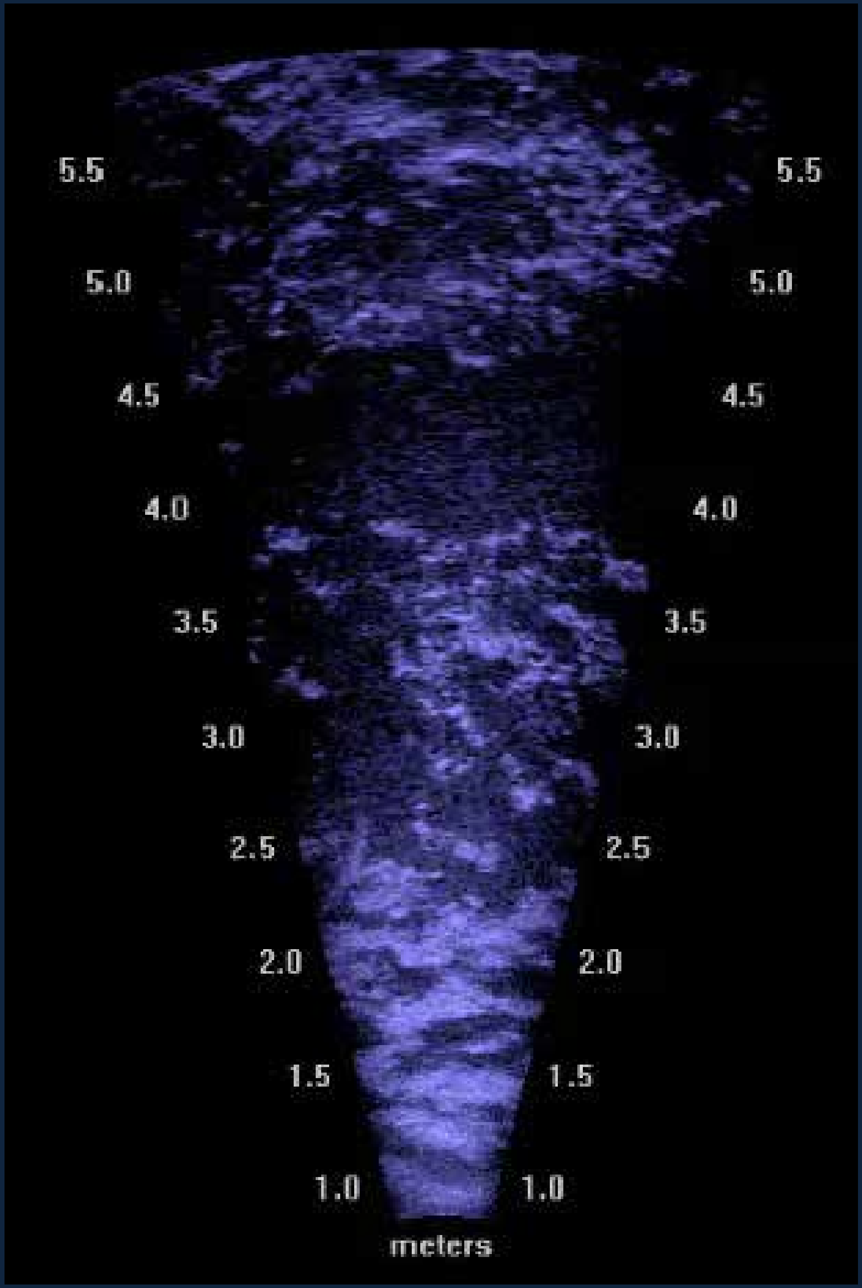
DIDSON and ARIS Sonar

- Near video quality images using pulses of high frequency sound





The use of acoustic cameras in shallow waters: new hydroacoustic tools for monitoring migratory fish population. A review of DIDSON technology. F. Martignac, A. Daroux, et. Al. Fish and Fisheries. 2015, 16, 486-510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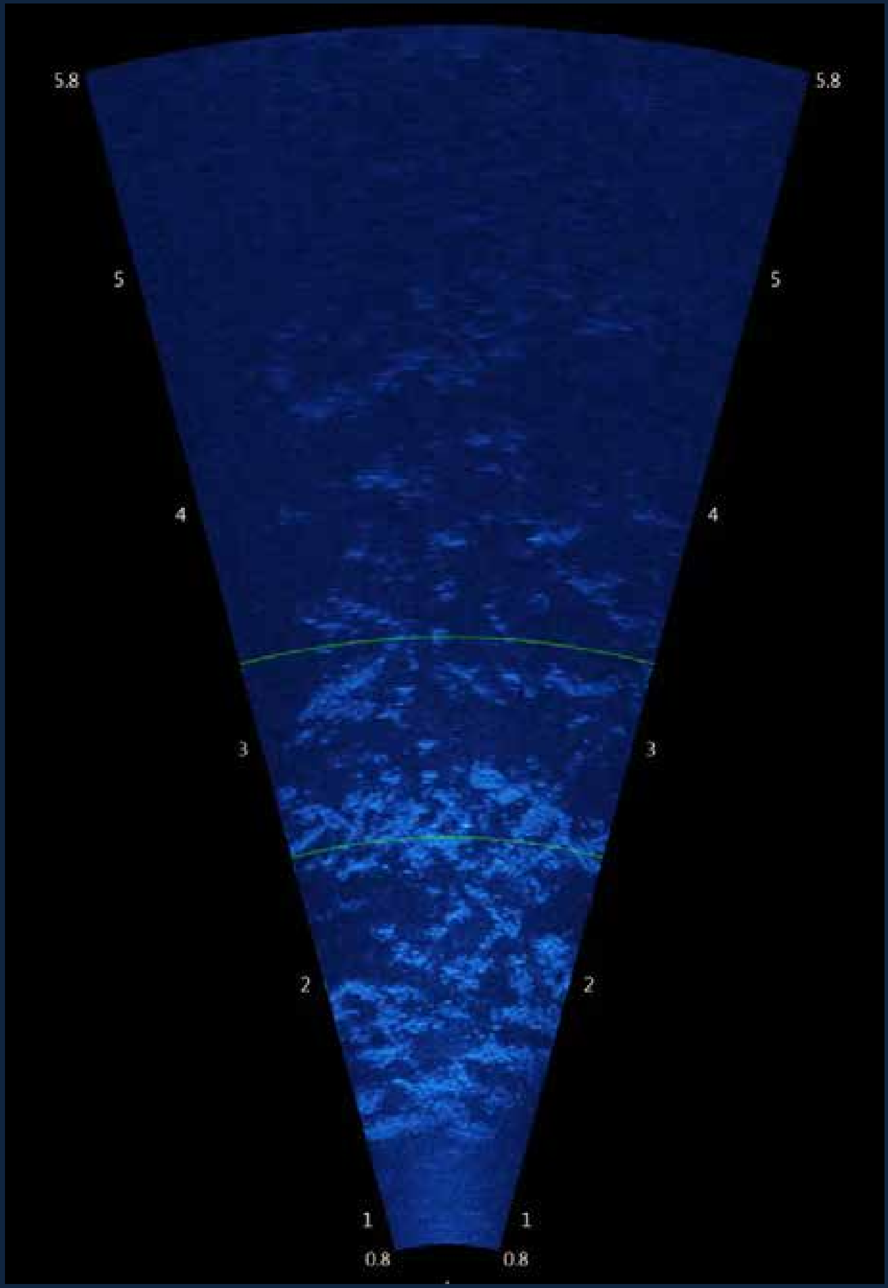
3.0
2.5
2.5
2.0
2.0
1.5
1.5
1.0
1.0
meters

DIDSON


5.8
5.8
5
5
4
4
3
3
2
2
1
1
0.8
0.8

ARIS

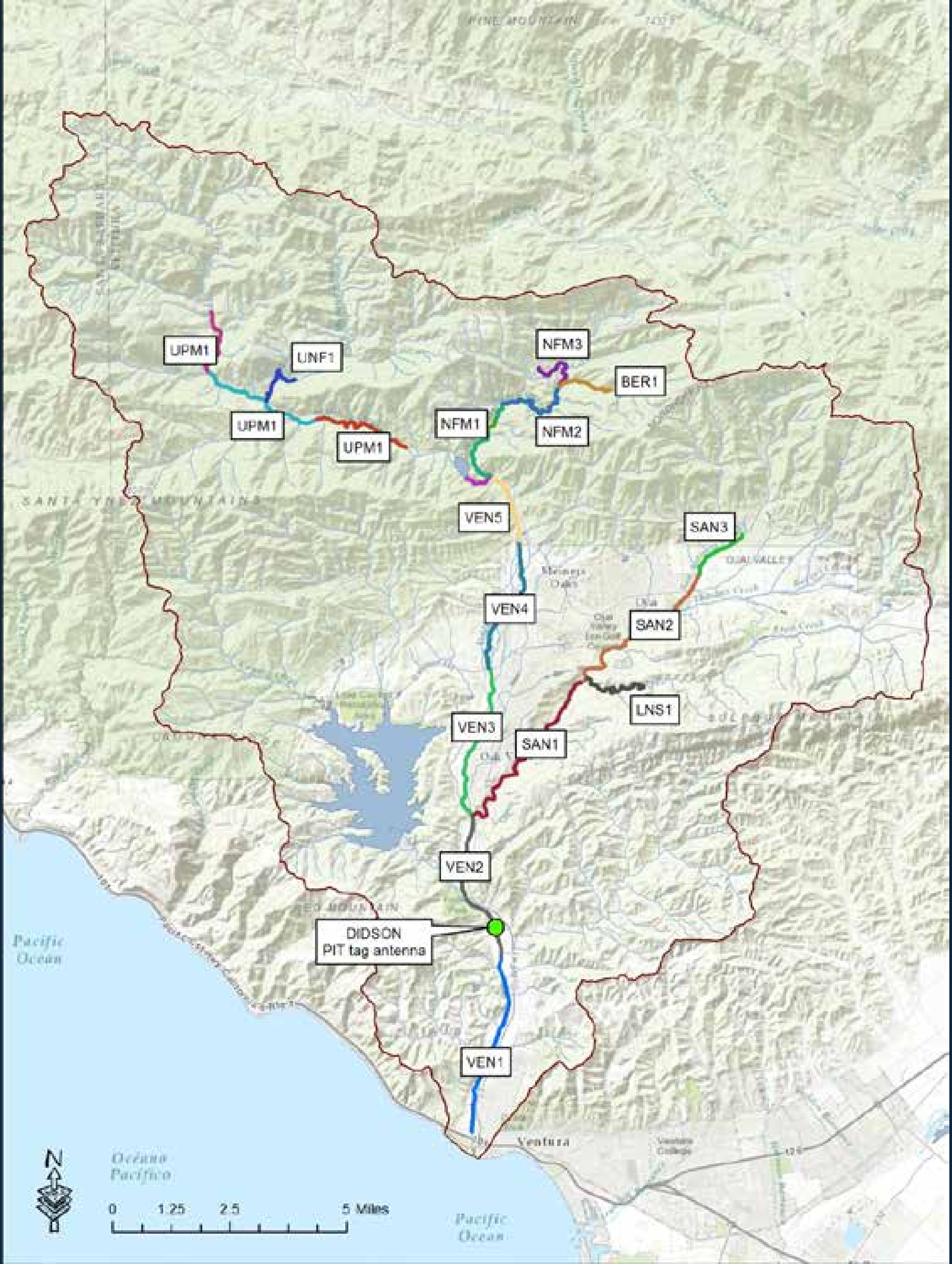
DIDON and ARIS sonar cameras

- Passive monitoring
- Able to see through turbid water
- Does not require a light source

Species Identification


Made in U.S.A. by Wildco® 800-799-8301 • 71

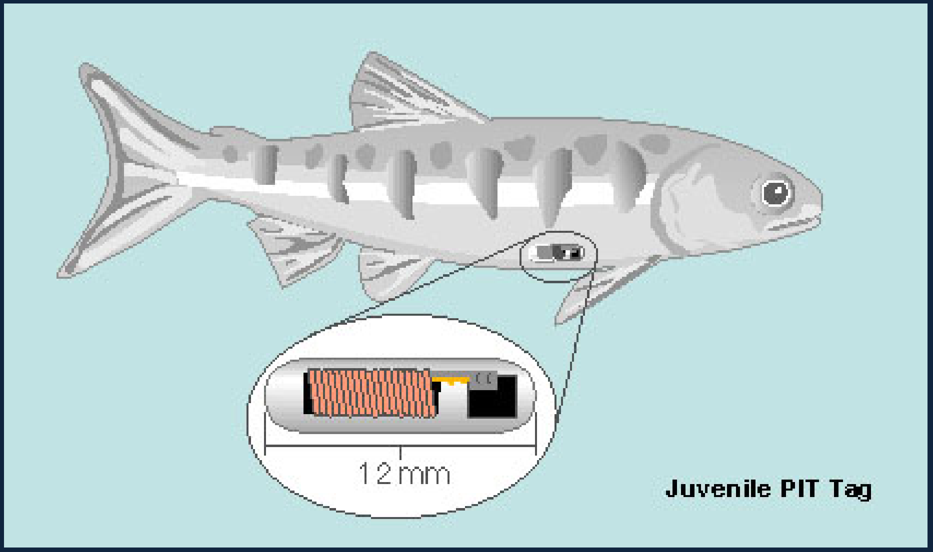
Redd Surveys



UPM1
UNF1
UPM1
UPM1
NFM3
BER1
NFM1
NFM2
VEN5
SAN3
VEN4
SAN2
LNS1
VEN3
SAN1
VEN2
DIDSON
PIT tag antenna
VEN1
Pacific Ocean
Ventura
0 1.25 2.5 5 Miles
N

PIT Tagging and E-fishing Calibrated Snorkel Surveys

- TJAMM – Tagging Juveniles and Monitoring Migrants



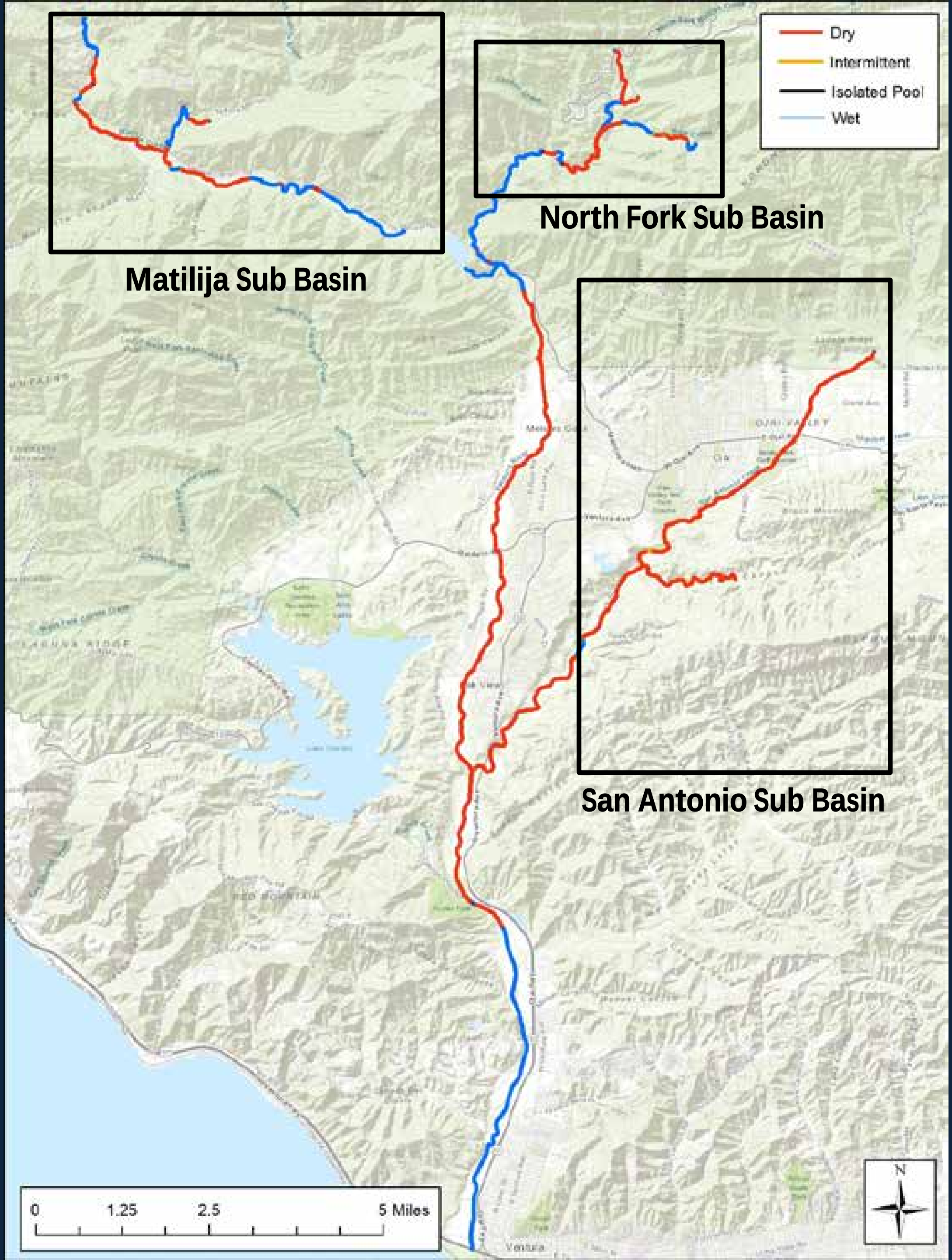

CDFW

Measured Water Conductivity (mS/cm)
1.076
1.023
Hilton Creek
Santa Ynez River
1.165
Arroyo Hondo Creek
1.232
Maria Ygnacio Creek
1.106
Montecito Creek
1.054
San Ysidro Creek
1.032
Gobernador Creek
Upper North Fork Matilija
1.058
1.19
Matilija Creek
North Fork Matilija Creek
1.175
1.945
San Antonio Creek
Ventura River
Santa Paula Creek
Sisar Creek
0.81
Santa Clara River
Topanga Creek
1.694
0 5 10 20 Miles
N
Source: ESRI; CDFW; PSMFC; RCDSMM

Drought Refugia

Drought refugia as percent of surveyed reach wet between 2015-2018

	# Surveys	Survey Miles	% Wet
Ventura River	102	16.62	37.33
San Antonio Sub-Basin			
San Antonio Creek	82	9.75	2.97
Lion Creek	23	1.90	0.00
North Fork Sub-Basin			
North Fork Matilija Creek	62	6.19	56.81
Bear Creek	31	1.73	47.86
Matilija Sub-Basin			
Upper Matilija Creek	57	7.48	49.15
Upper North Fork Matilja Creek	30	1.29	69.97


Dry
Intermittent
Isolated Pool
Wet
Matilija Sub Basin
North Fork Sub Basin
San Antonio Sub Basin
0
1.25
2.5
5 Miles
N
Ventura

Kyle Evans
California Department of Fish & Wildlife

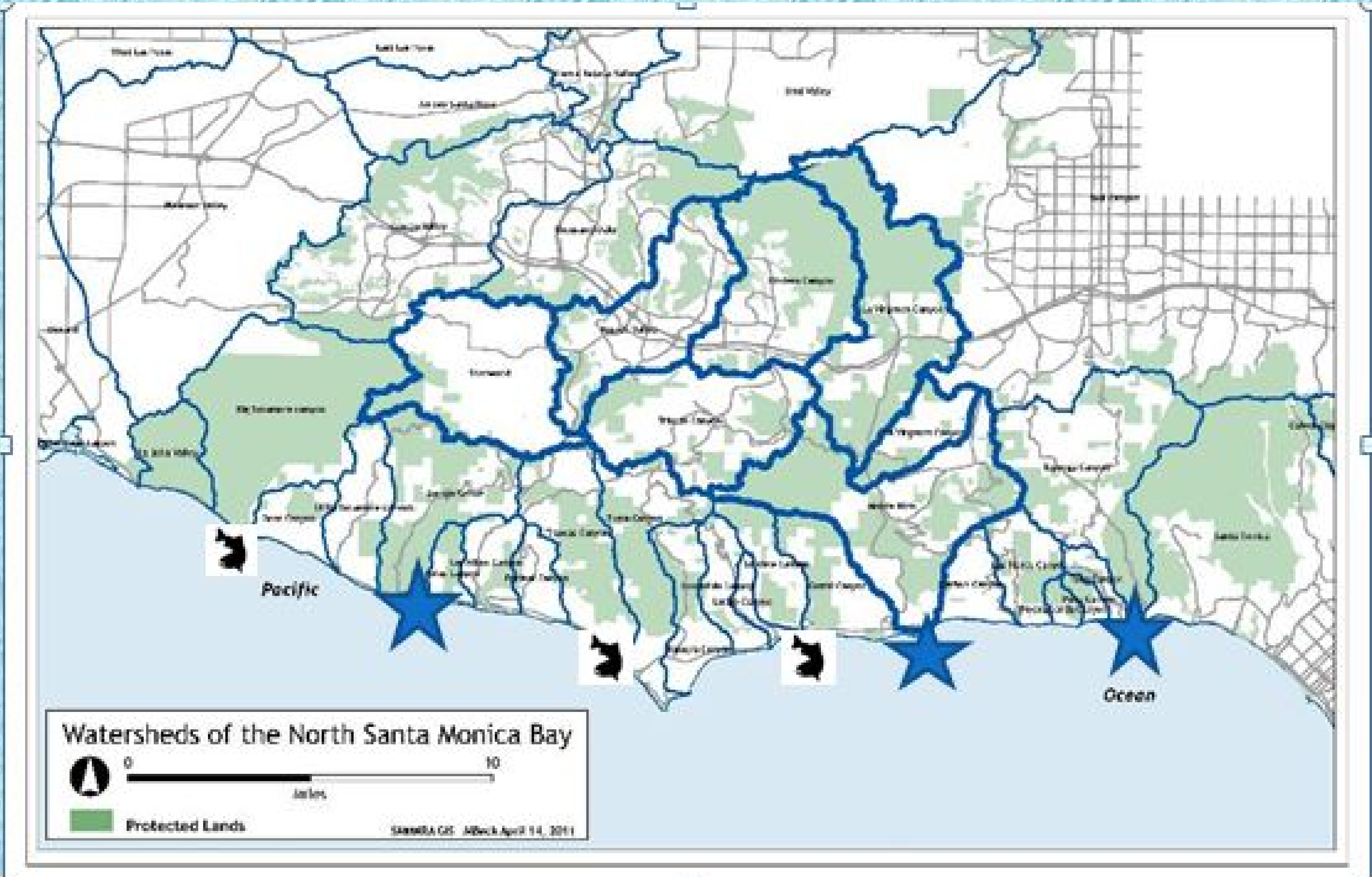
Abundance and Distribution of Steelhead in the Santa Monica Bay

Presented by
Rosi Dagit,
Senior Conservation Biologist
Steelhead Summit 2018

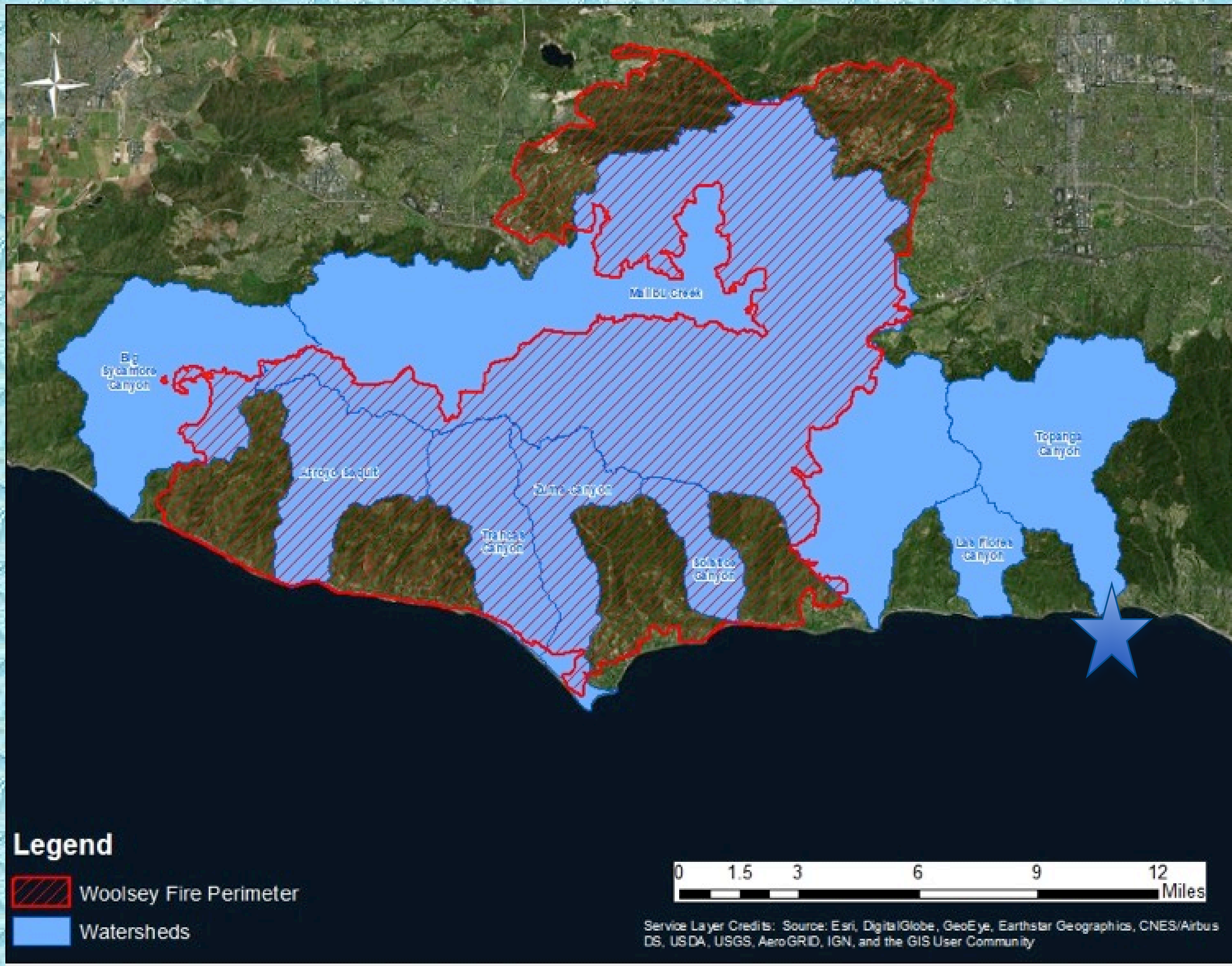
Thanks to.....

- Fisheries Restoration Grant Program Funding
- CDFW staff
- CA Department of Parks and Recreation (access)
- Los Angeles County Department of Beaches and Harbors (access)
- National Marine Fisheries Service (permits)
- RCDSMM Stream Team members
- Santa Monica Mountains National Recreation Area (access)
- US Fish and Wildlife Service (permits)

Current and Past Distribution in the Santa Monica Bay



2018 Distribution in the Santa Monica Bay



Methods Used 2001-2018

Snorkel Surveys (with and without water!)

Redd

School of juveniles

Big Sycamore Creek

Watershed area:
21 square miles

Number of days connected to ocean and passable:
2012- 0
2013- 0   Spring Fire May 2013
2014-0
2015- 0
2016-0
2017- 30
2018 - 0

Big Sycamore Lagoon

Imagery Date: 08/26/2012

OTHER OPPORTUNITIES FOR RESTORATION BIG SYCAMORE LAGOON

Big Sycamore mouth closed October 2016

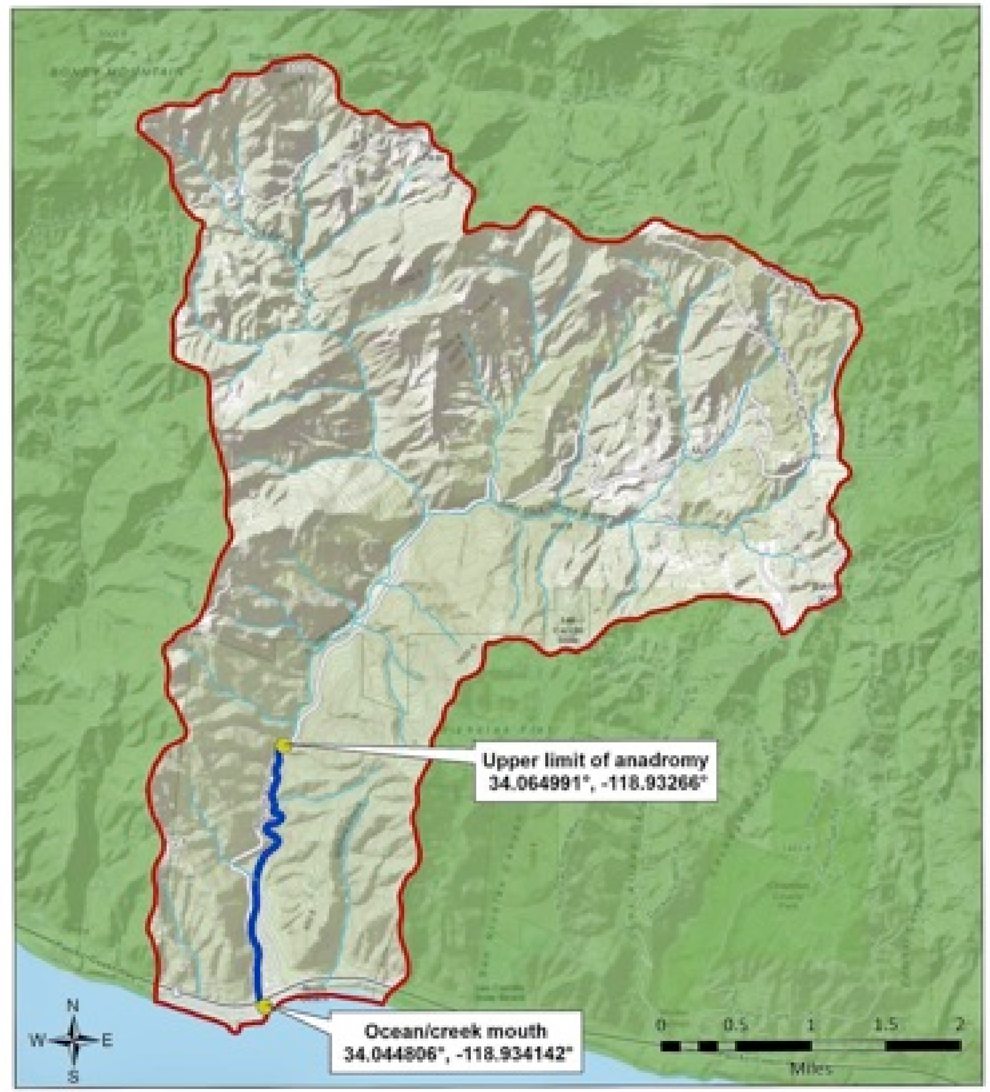
Big Sycamore connected 1.23.17

Arroyo Sequit Creek Leo Carrillo State Beach

Watershed area:
12 square miles

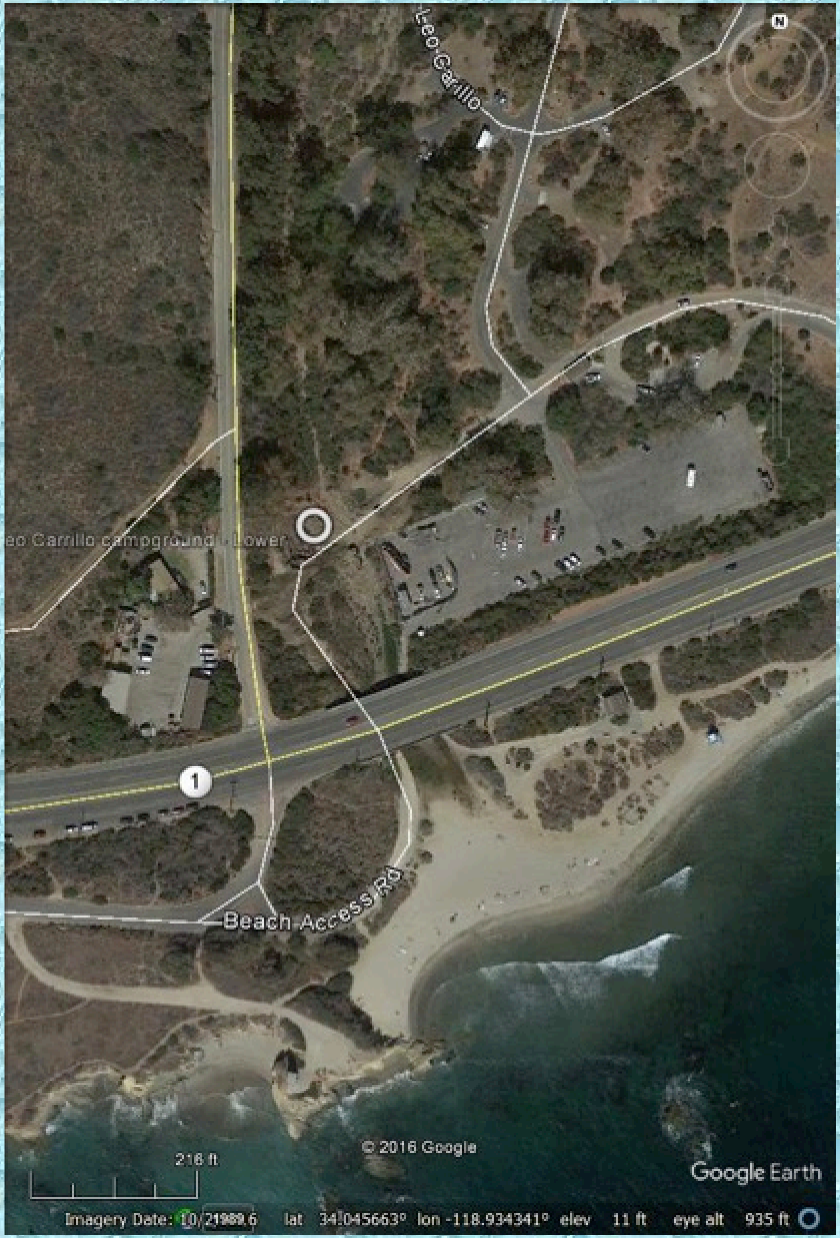
Number of days connected to ocean:

2012- 0
2013- 0
2014- 0
2015- 0
2016- 0
2017- 51
2018 - 0



Arroyo Sequit Watershed Map

Arroyo Sequit Lagoon



Imagery date: October 2017

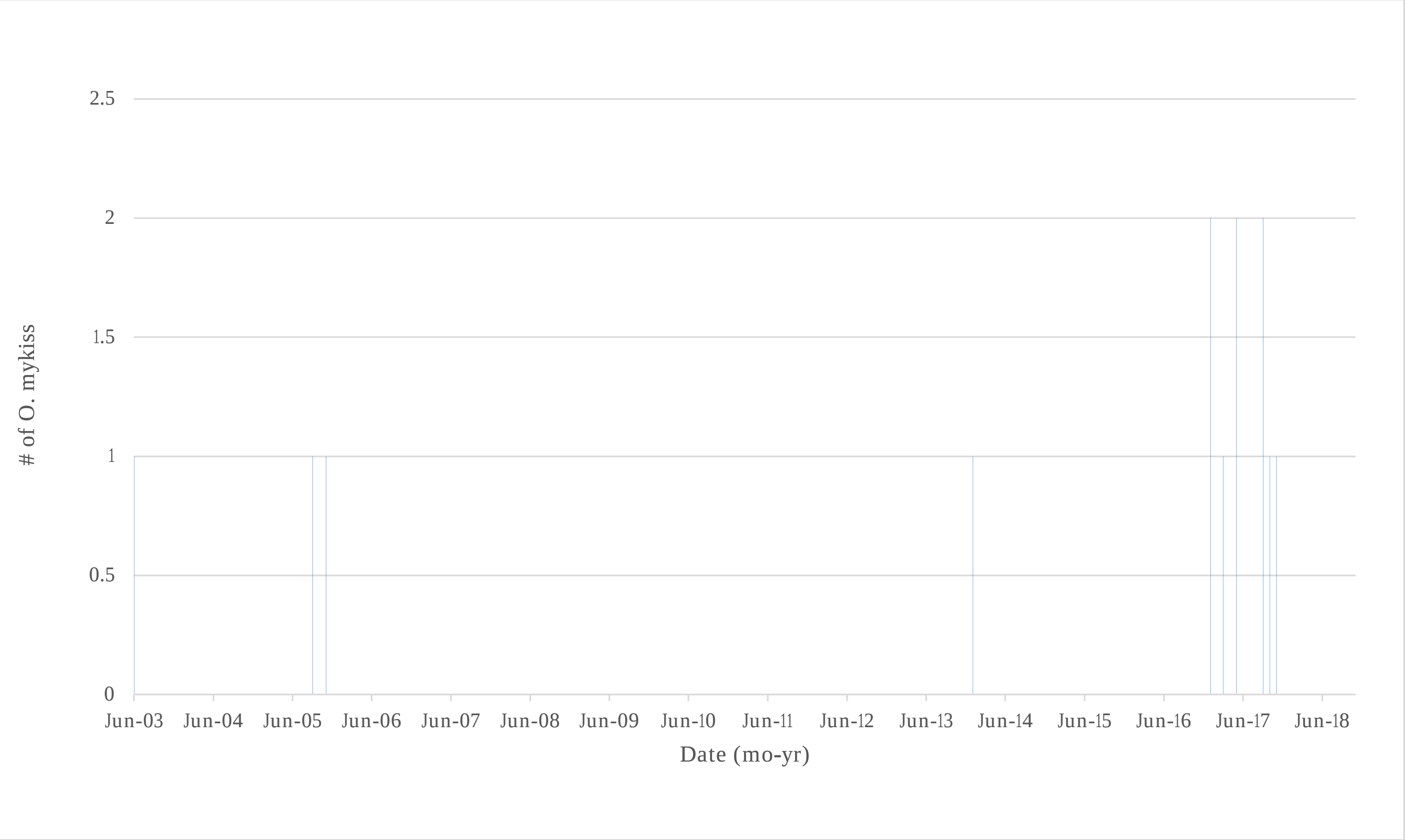
Arroyo Sequit Lagoon mouth closed Nov 2012

Arroyo Sequit Lagoon mouth connected 1.23.17

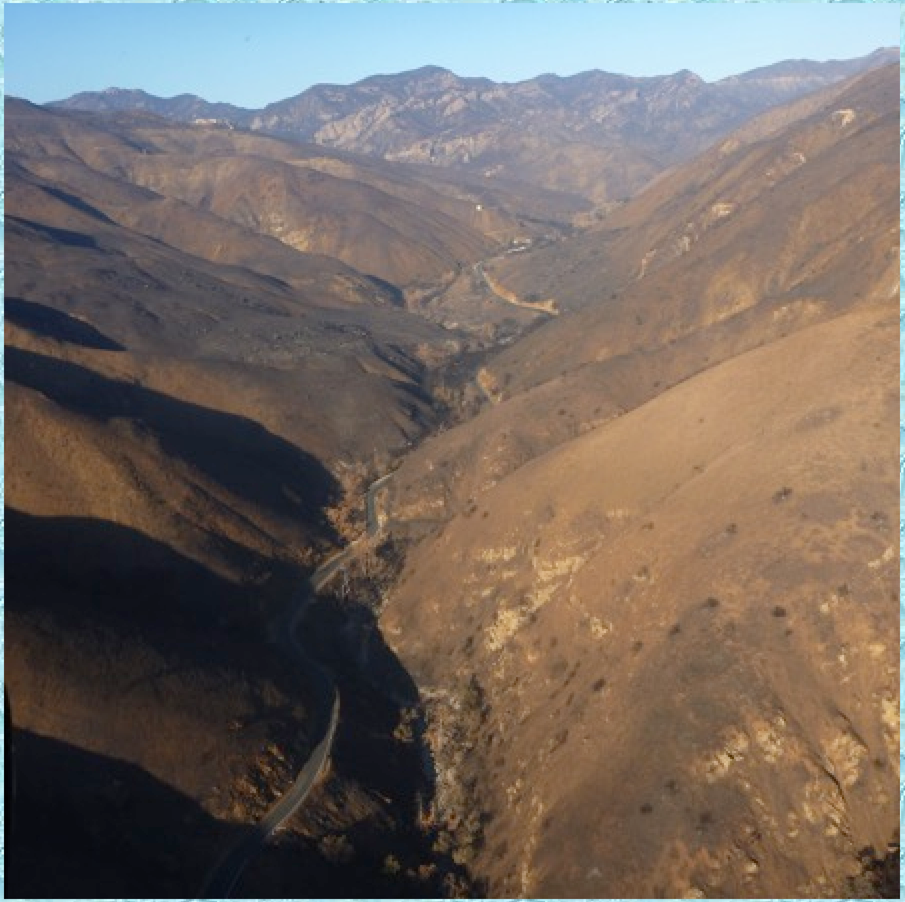
Arroyo Sequit lower bridge Jan 2017

Arroyo Sequit steelhead 1.30.17

Abundance of *O. mykiss* 2005-2018



Arroyo Sequit post Woolsey Fire 11.27.18



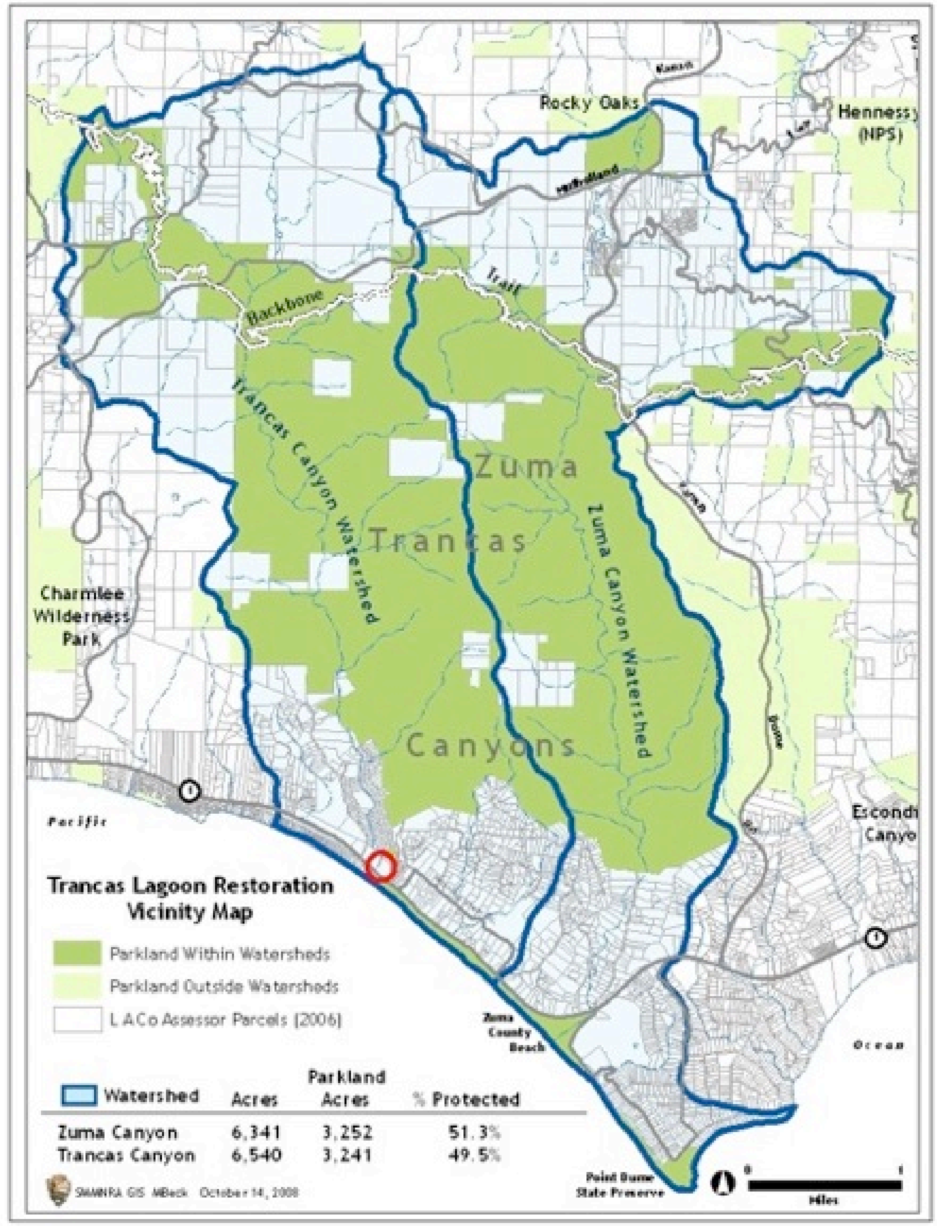
Arroyo Sequit post Woolsey Fire 11.25.18

Trancas Creek

Watershed area:
10.2 square miles

Number of days connected to ocean:

2012- 0
2013- 0
2014- 0
2015- <5
2016- 0
2017- 61
2018- 0



Trancas Lagoon

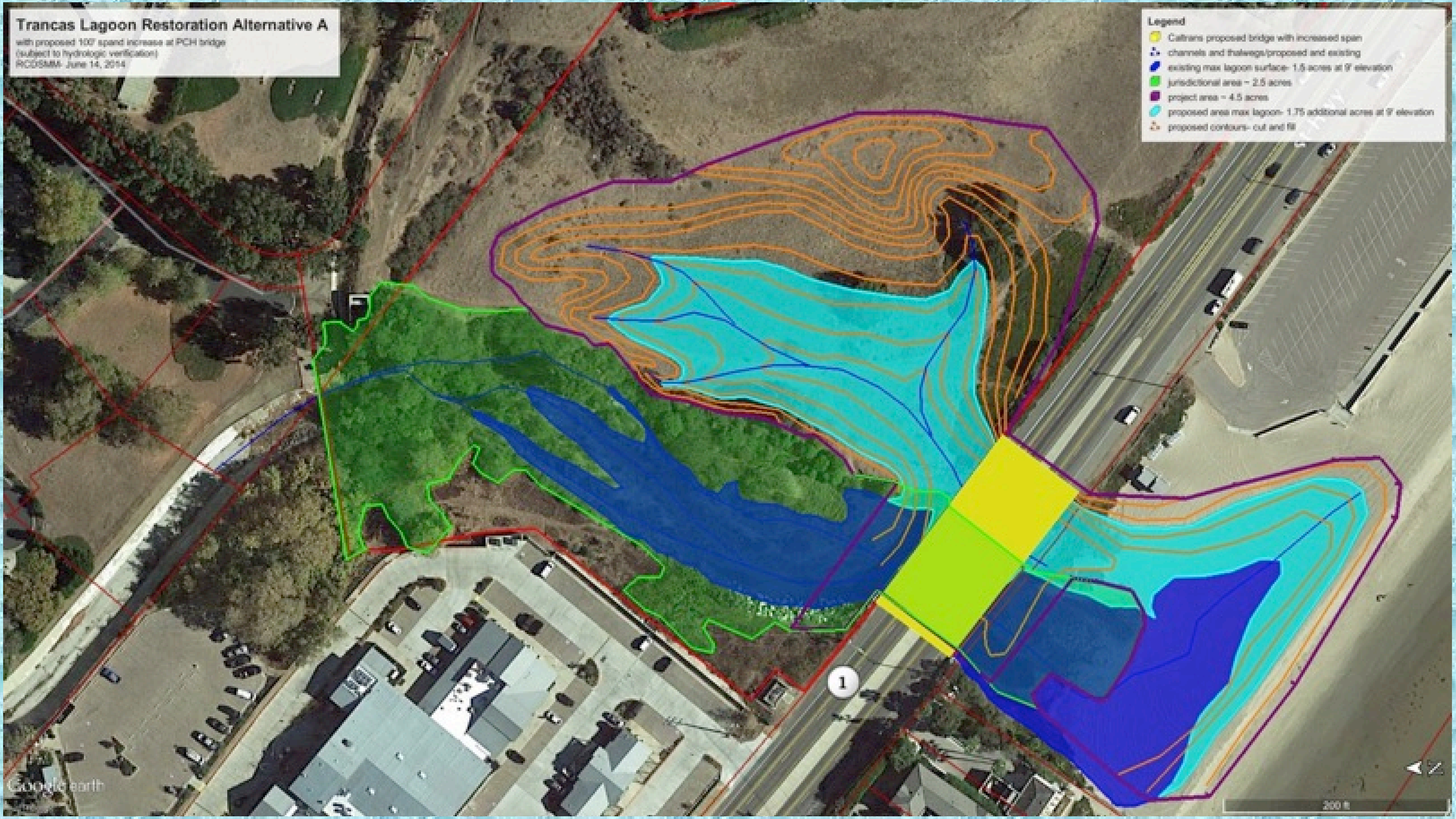
Imagery Date: 11/07/13

Trancas Lagoon closed August 2016

Trancas Lagoon connected 1.27.17

Trancas Lagoon 3.14.17

Trancas Lagoon potential restoration



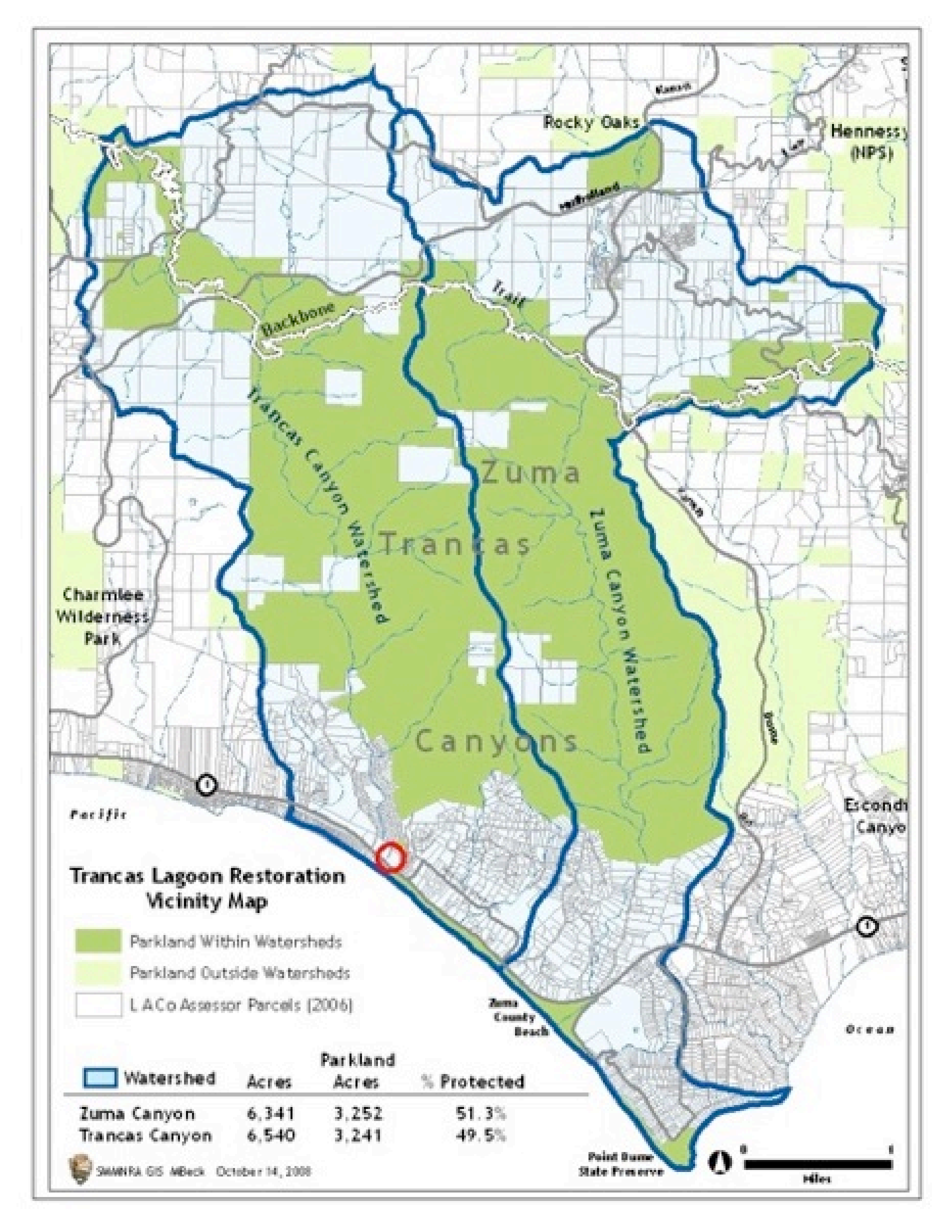
Trancas Lagoon area post Woolsey Fire 11.22.18

Zuma Creek

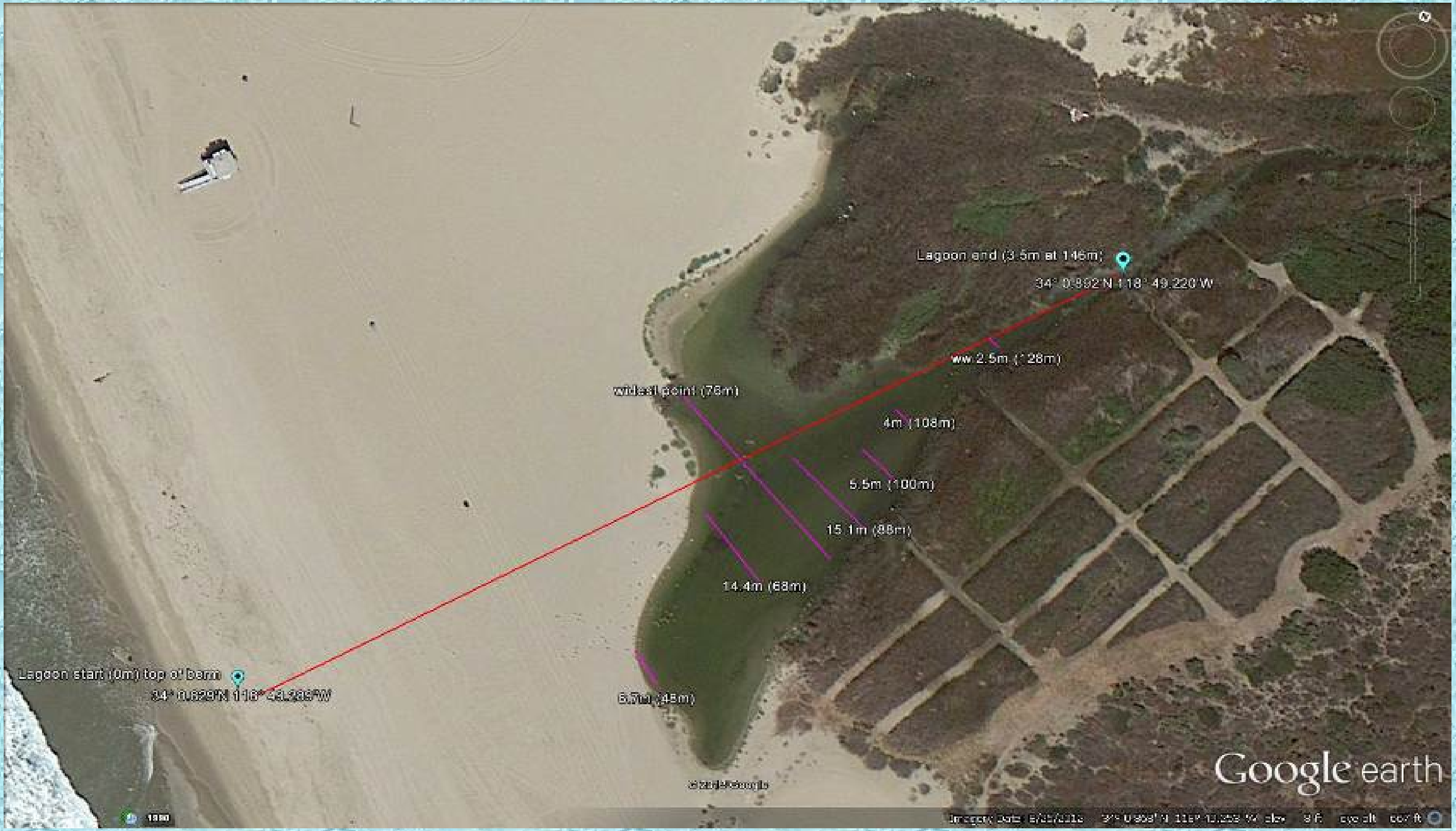
Watershed area:
10 square miles

Number of days connected to ocean:

2012- 0
2013- 0
2014- 0
2015- 0
2016- 0
2017- 39
2018- 0



Zuma Lagoon



Imagery Date: 08/26/2012

Zuma Lagoon closed October 2016

Zuma Lagoon connected 1.23.17

Zuma Lagoon post Woolsey Fire 11.25.18

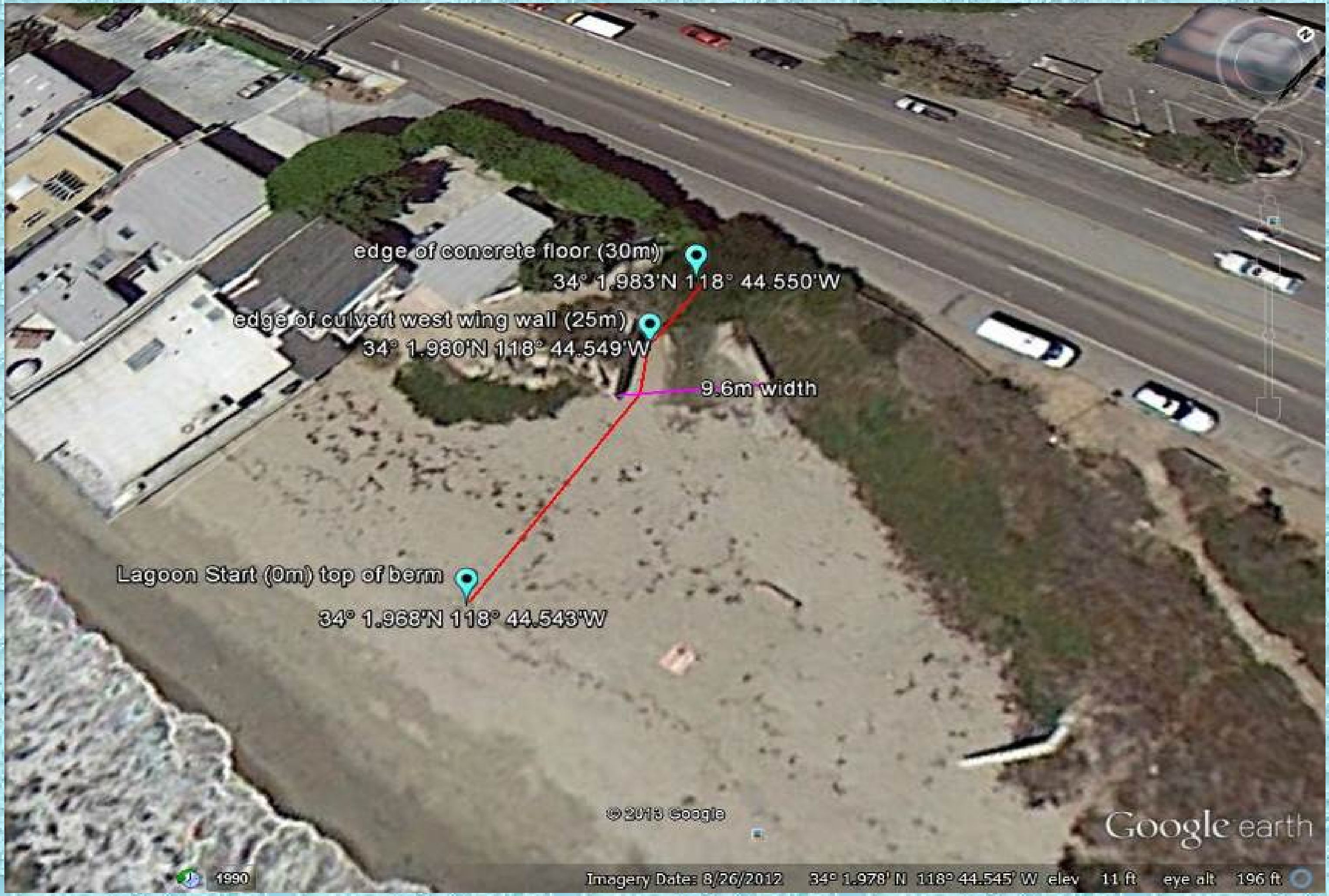
Solstice Creek

Watershed area:
12 square miles

Number of days connected to ocean:

2012- 0
2013- 0
2014-0
2015- <10
2016- 0
2017- 5
2018- 0

Solstice Lagoon



Imagery date: 08/26/2012

Solstice Creek mouth closed July 2014

Solstice Creek mouth connected 1.23.17

Solstice Creek PCH culvert 1.23.17

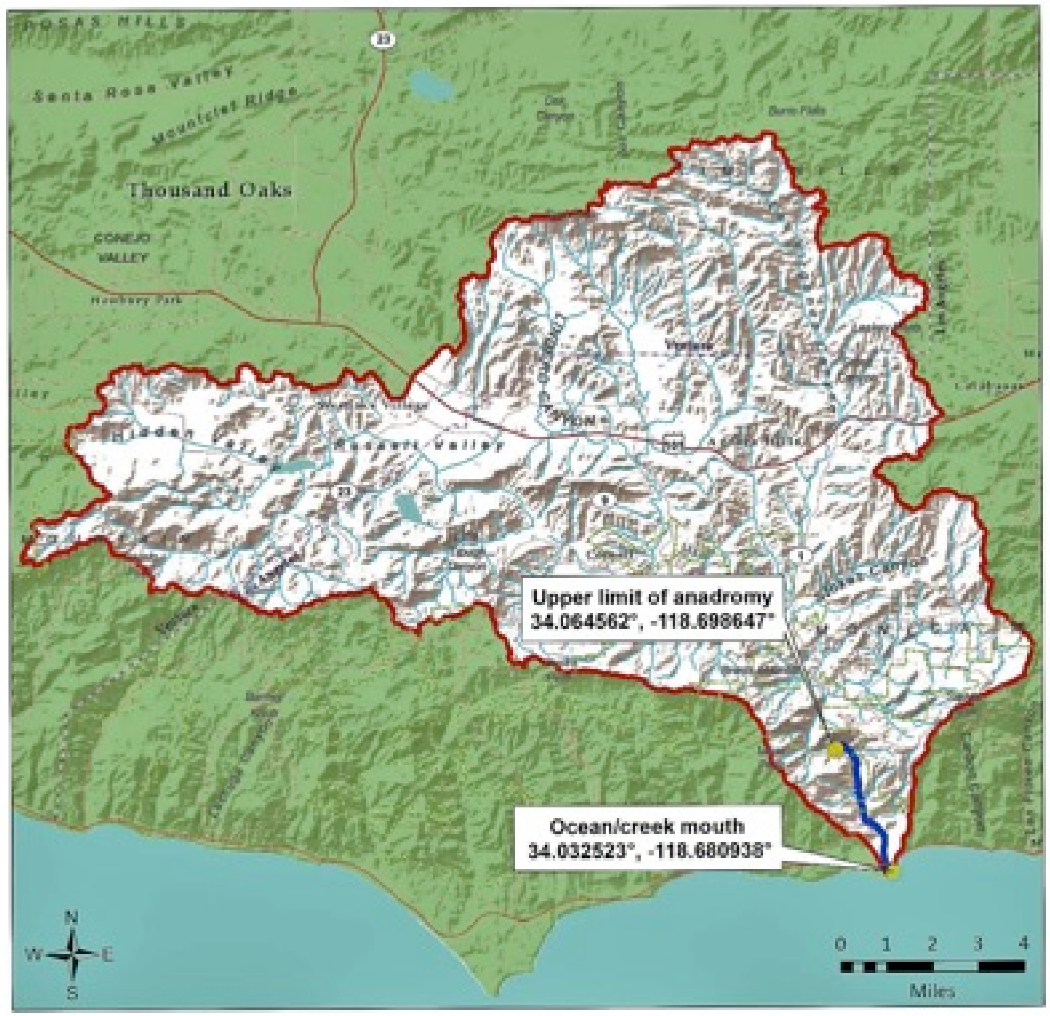
Solstice Creek post Woolsey Fire 11.27.18

Malibu Creek

Watershed area:
109 square miles

Number of days connected to ocean:

2012- 200
2013- 200
2014- 200
2015- 200
2016- 200
2017 – 200
2018 - ~180
(breach 11.22.18)



Malibu Creek Watershed Map

Malibu lagoon restoration 2012

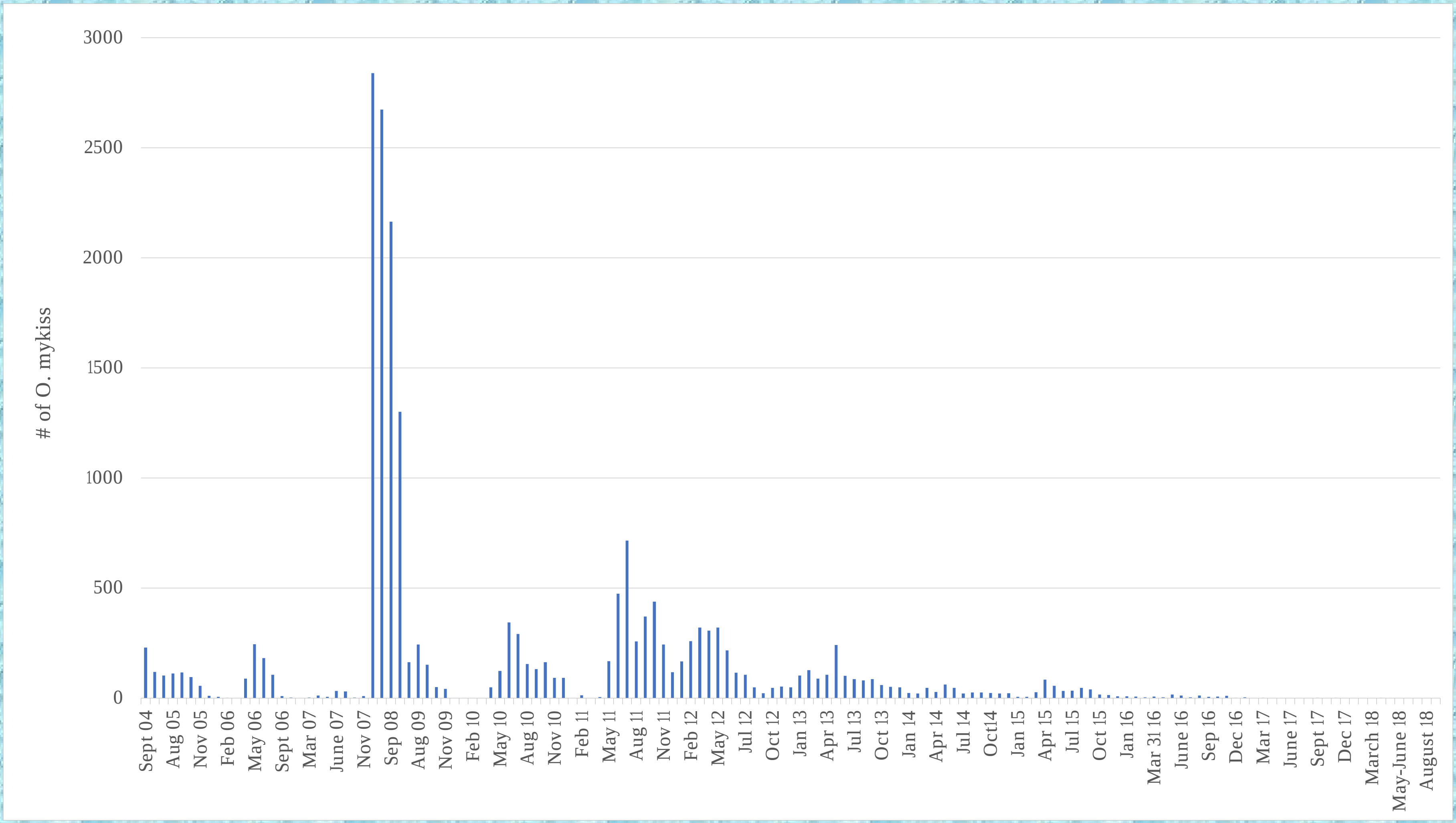
May 2014
first steelhead sighting in Malibu Lagoon!

Malibu Creek lagoon closed September 2016

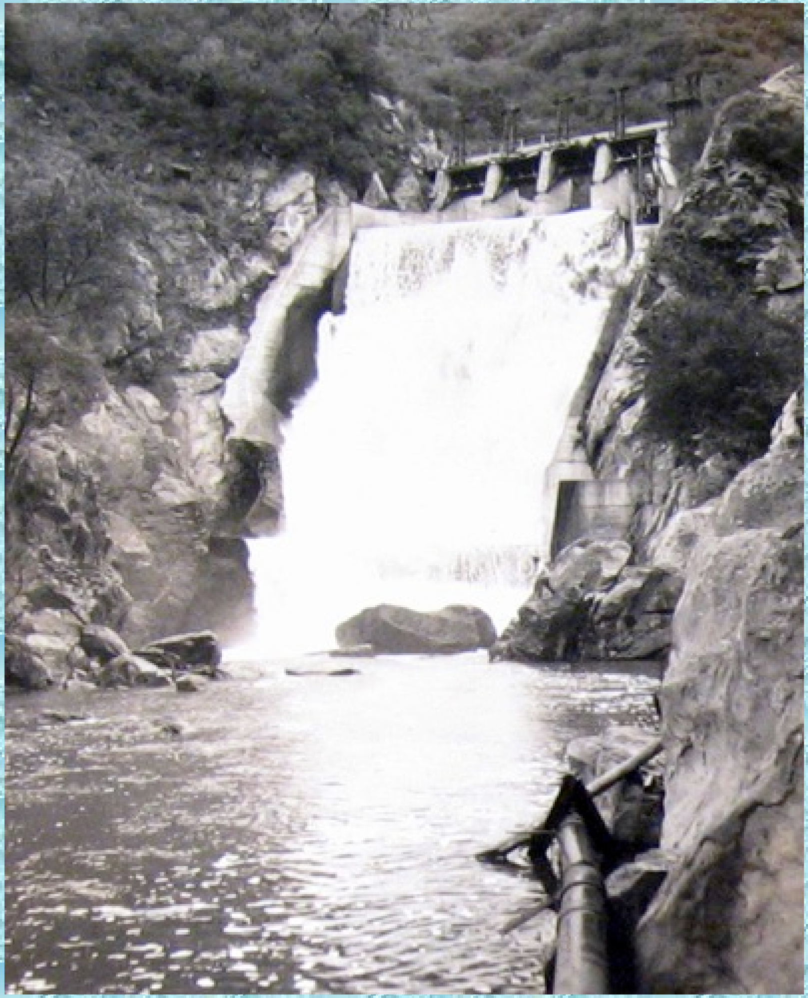
Malibu Creek lagoon connected Nov 2016

Only Steelhead in Malibu died March 2017

Abundance of *O. mykiss* 2005-2018



Rindge Dam upper limit

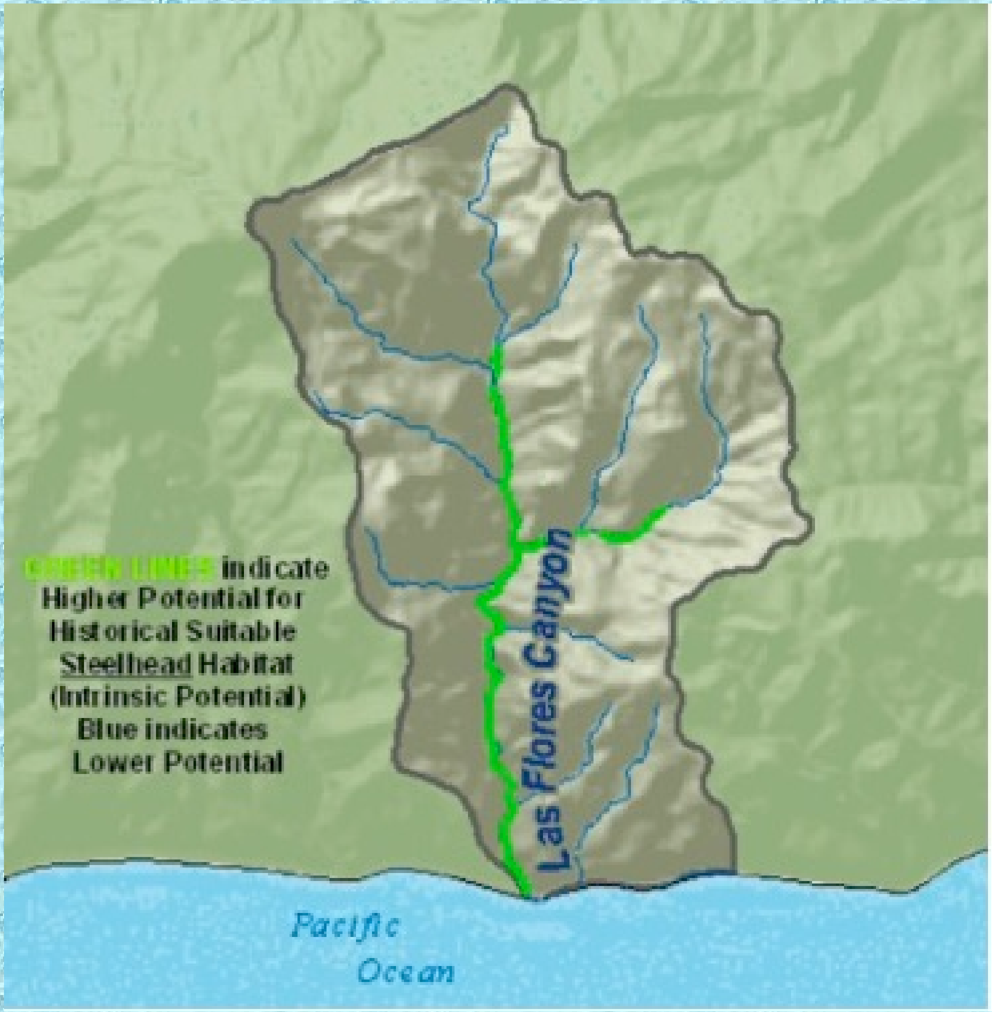


Malibu Creek post Woolsey Fire 11.28.18

Las Flores Creek

Watershed area:
4.5 square miles

Number of days connected to ocean:
2012- 0
2013- 0
2014- 4
2015- <10
2016- 0
2017- 44
2018 - 0



Las Flores Lagoon

Imagery Date: 08/26/2012

Las Flores Lagoon closed October 2016

Las Flores connected 1.23.17

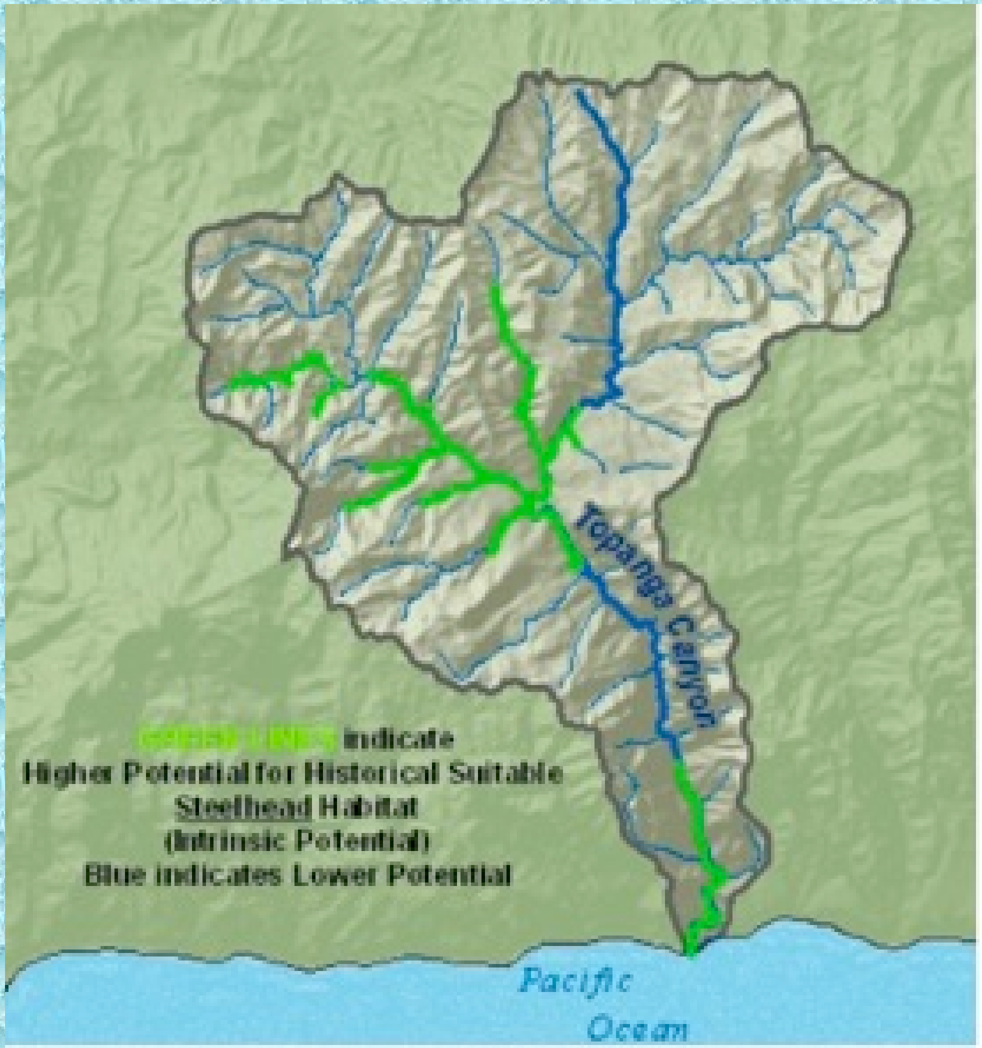
Las Flores Creek wall Jan 2018

Topanga Creek

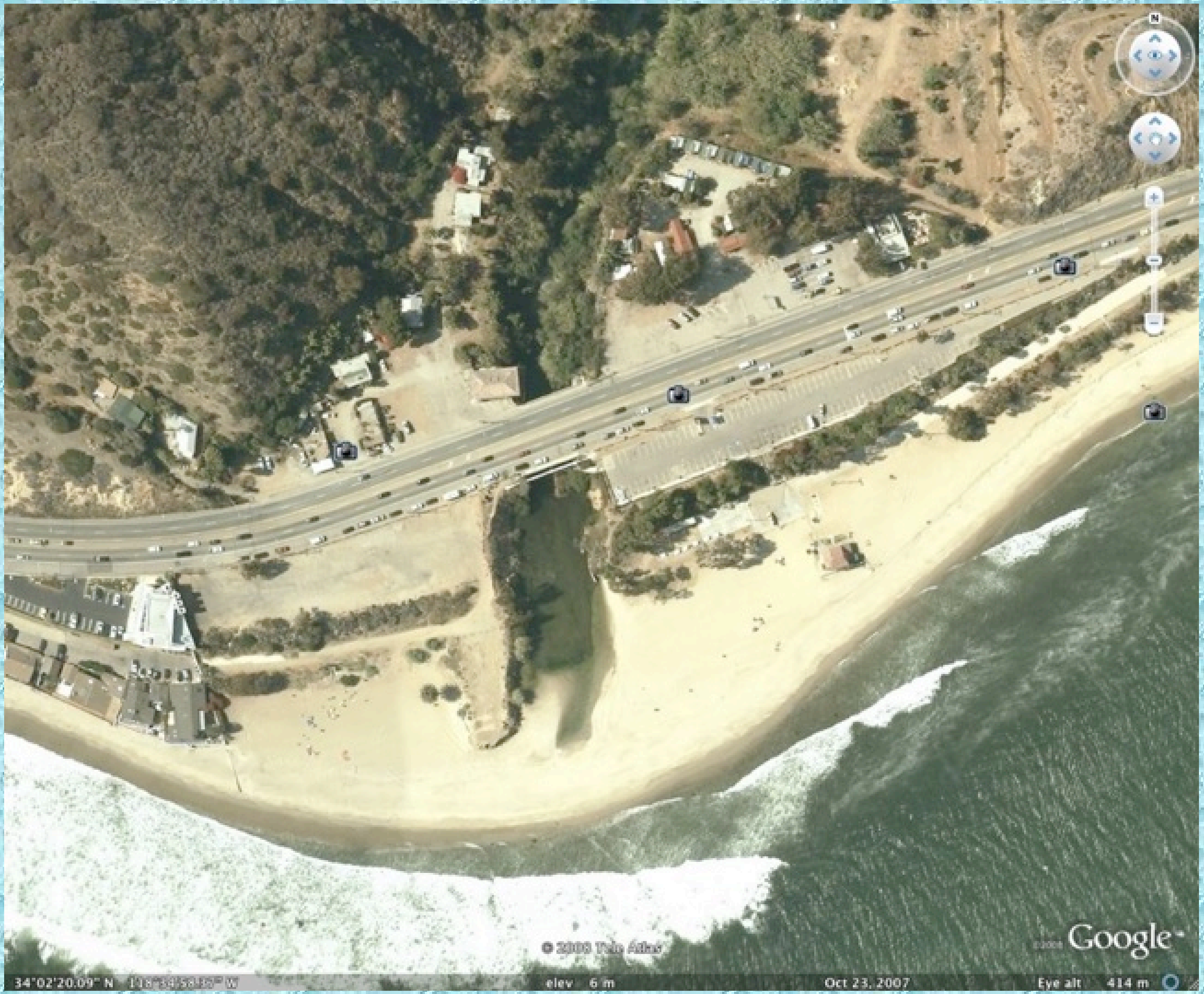
Watershed area:
18 square miles

Number of days connected to ocean:

2012-
2013- 0
2014- 4
2015- <10
2016- 1
2017- 36
2018 - 15



Topanga Lagoon

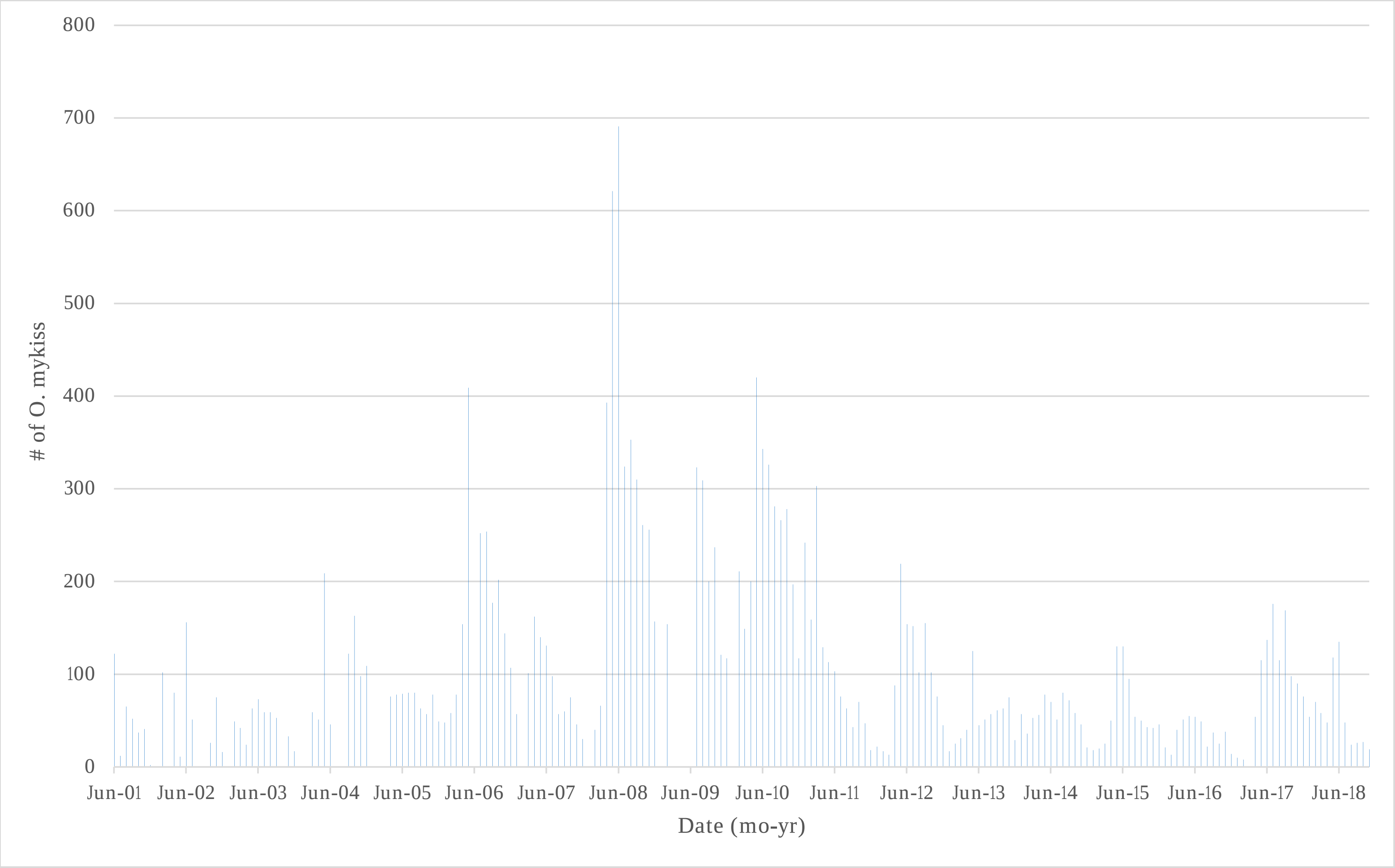


Imagery date: October 2007

Topanga Creek mouth closed October 2016

Topanga Creek mouth connected 1.27.17

Abundance of *O. mykiss* 2001-2018



Topanga Lifecycle Monitoring Station

Mark-recapture- over 900 tagged

Instream antenna

DIDSON Camera

Weir Trap

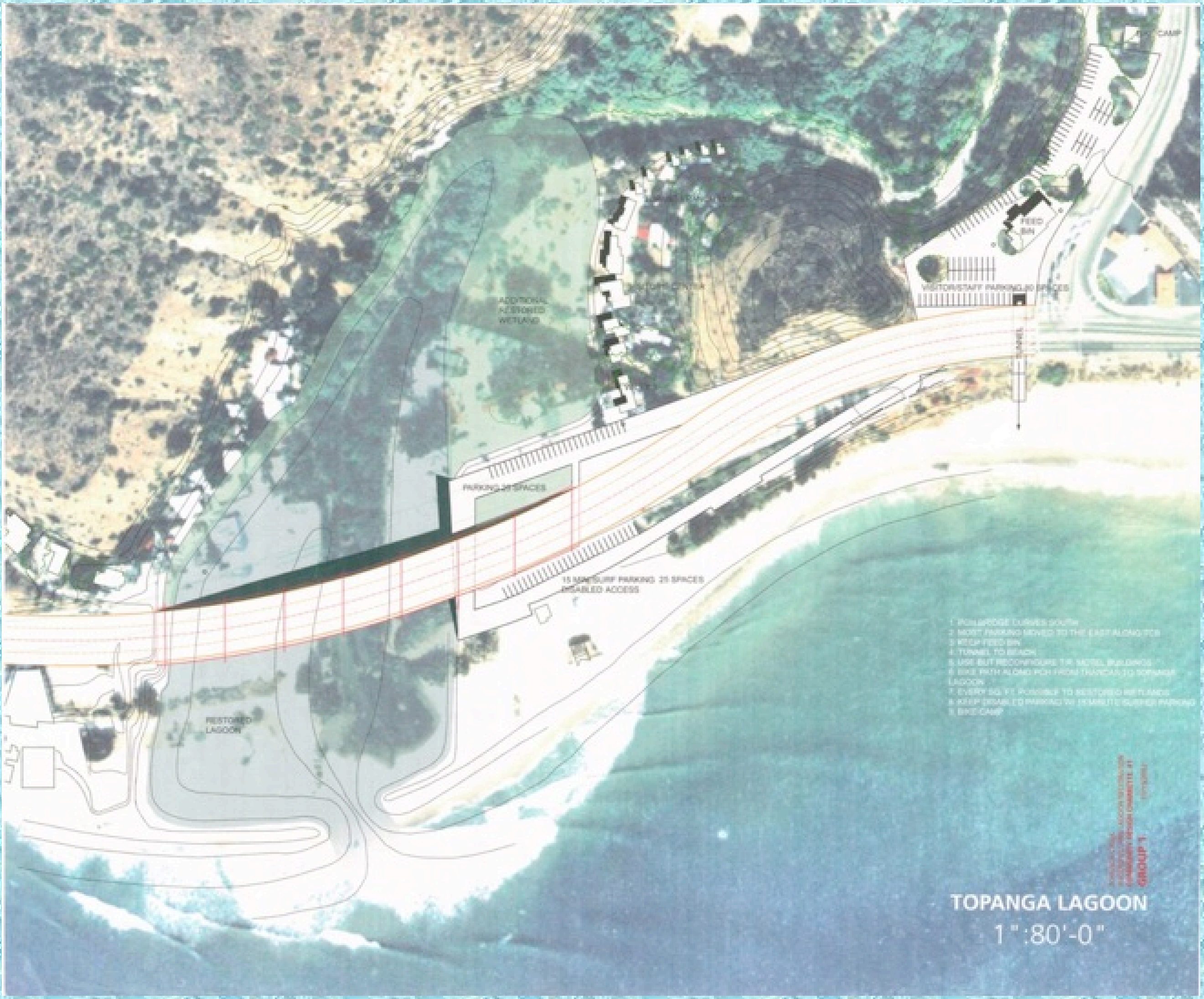
Topanga Lagoon 1910's

Courtesy of Randy Young collection

Restoring Topanga lagoon

Photo from 1930 courtesy of Santa Monica Public Library

Restoring Topanga lagoon- the future?

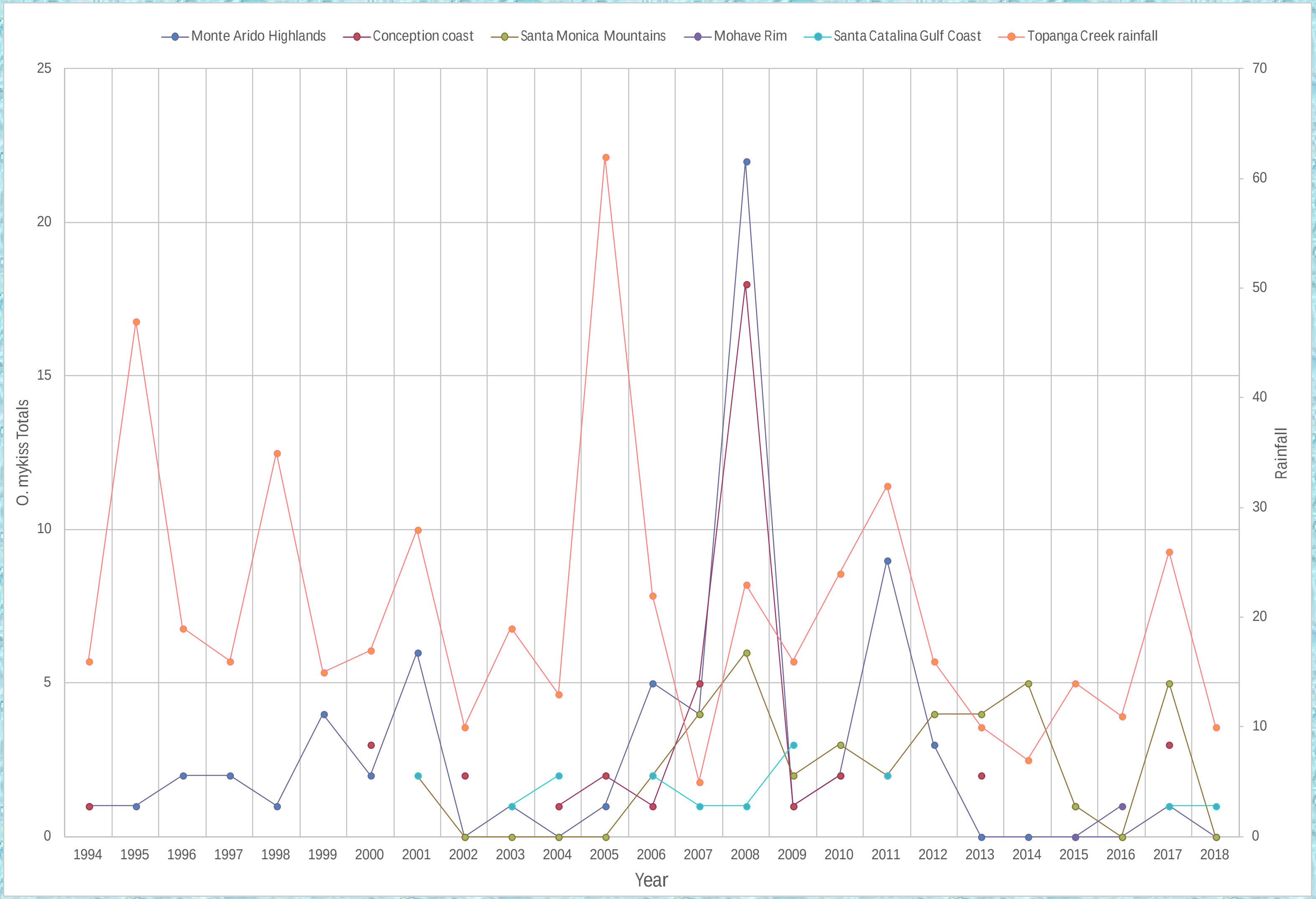


Occurrences of Anadromous Steelhead Trout

Summary of Occurrences 1994-2018

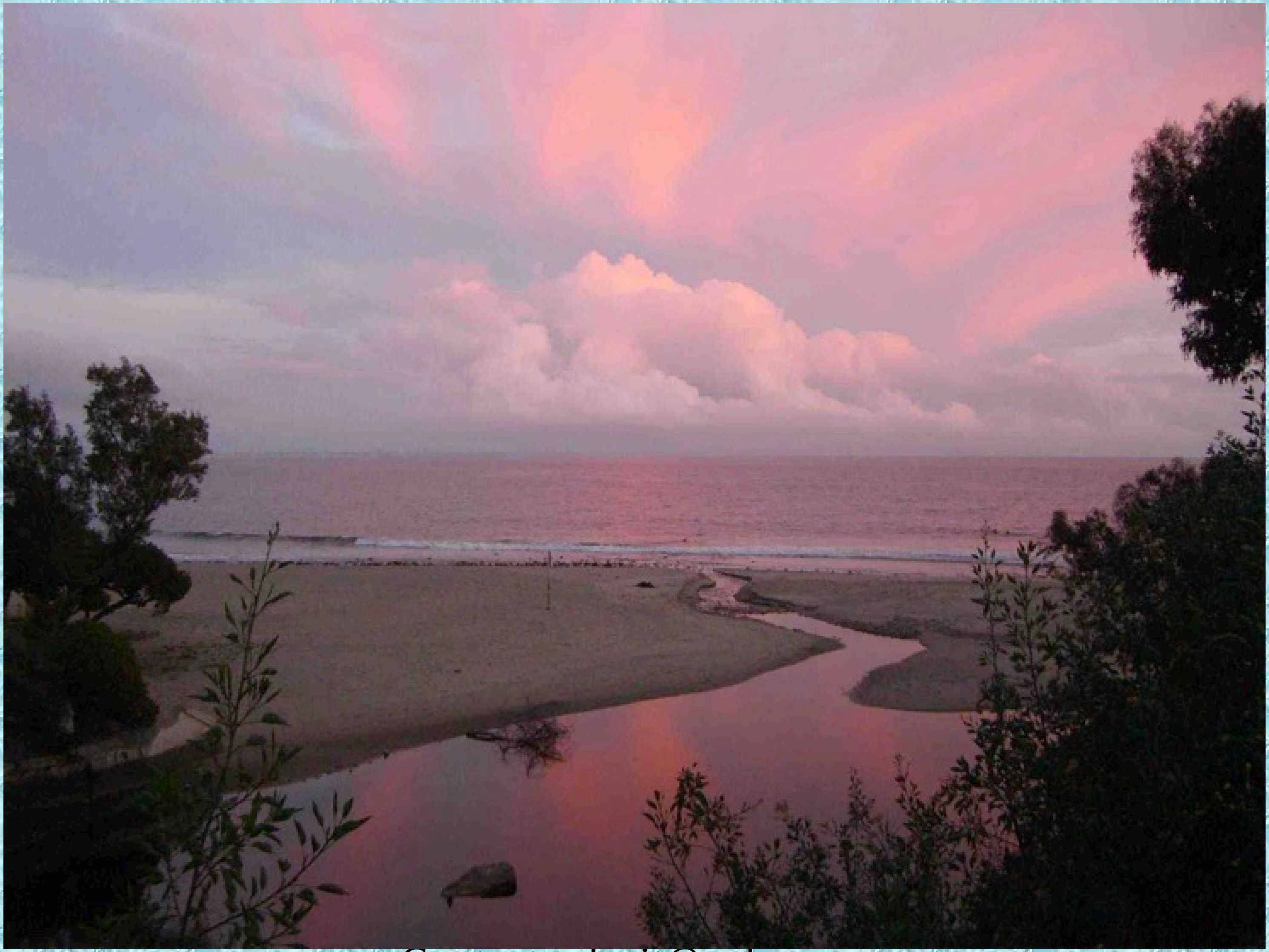
BPG:	Location	DPS CORE Ranking	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Monte Arido Highlands	Santa Ynez River	1		0	0	2	1	3	0	4	0	1	0	1	1	0	16	1	1	9	0	0	0	0	0	0	0	40
	Robles Diversion	1													4	0	6	0	1	0	0	0	0	0	0	0	0	11
	Ventura River	1														4						0	0	0	0	0	0	4
	San Antonio Creek	1																				0	0	0	0	1	0	1
	Santa Clara Freeman Diversion	1	1	1	2	0	0	1	2	2	0	0	0	0	0	0	2	2	0	0	3	0	0	0	0	0	0	16
Conception Coast	Arroyo Hondo	3																								2		2
	Goleta Slough Maria Ygnacio Creek	1							1								1	1								1		4
	Goleta Slough Atascadero Creek	1																	2			2						4
	Goleta Slough San Pedro Creek	1		1													1											2
	Mission Creek	1							2		2		1	2	1	5	13							1				27
	Carpinteria Creek	1															3											3
Santa Monica Mountains	Conejo Creek	Not listed																				1						1
	Big Sycamore Creek	3																				0	0	0	0	0	0	0
	Arroyo Sequit Creek	2												0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
	Las Flores Creek																					0	0	0	0	0	0	0
	Solstice Creek	3																				0	0	0	0	0	0	0
	Malibu Creek	1												0	1	2	4	1	2	2	3	3	5	1	0	1	0	25
	Topanga Creek	1								2	0	0	0	0	1	2	2	1	1	0	1	0	0	0	0	2	0	12
	Trancas Creek	Not listed																					0	0	0	0	0	0
	Zuma Creek	Not listed																					0	0	0	0	0	0
Mohave Rim	Ballona Creek	Not listed														2												2
	Los Angeles River	3																						0				0
	San Gabriel River	1																							1			1
	Santa Ana River	2																										0
Santa Catalina Gulf Coast	San Juan Creek	1												2		1	1				1					0	1	6
	San Mateo Creek	1								2		1														1	0	4
	Santa Margarita River	1																3								0	0	3
	San Luis Rey River	1														1										0	0	1
	Los Penasquitos Creek	Not listed																			1							1
	TOTAL DPS		1	2	2	2	1	4	5	10	2	2	1	5	8	17	49	9	7	11	9	6	5	2	1	10	1	172

Trends



Monte Arido Highlands
Conception coast
Santa Monica Mountains
Mohave Rim
Santa Catalina Gulf Coast
Topanga Creek rainfall
O. mykiss Totals
Rainfall
Year
0
5
10
15
20
25
0
10
20
30
40
50
60
70
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018

Questions?



Contact: rdagit@rcdsmm.org

3rd Steelhead Summit

December 3-5, 2018

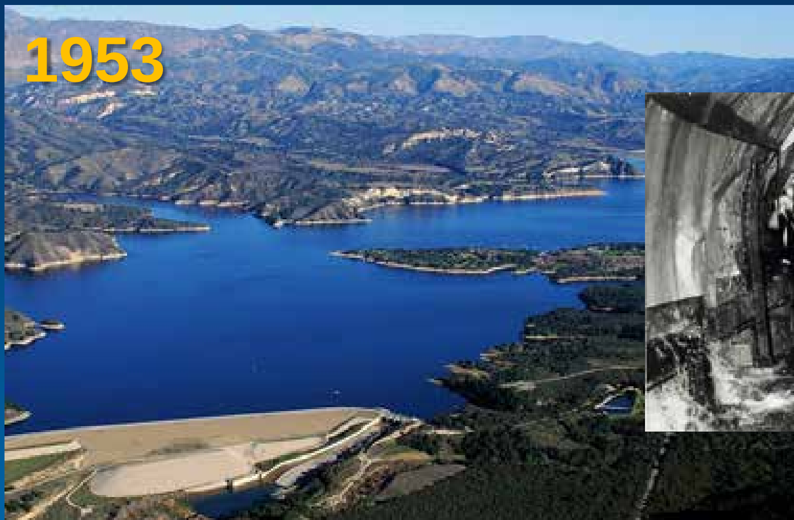
Ventura, CA

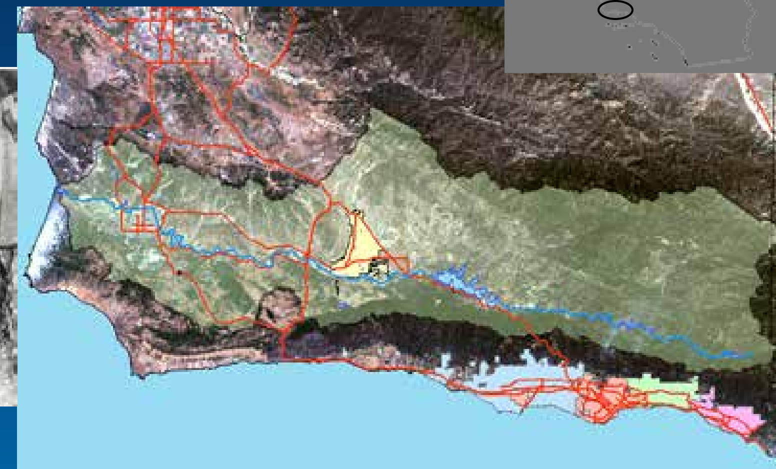
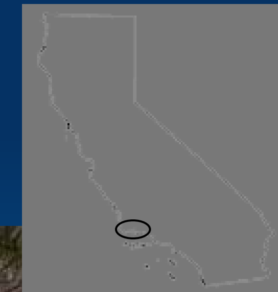
Steelhead Monitoring in the Santa Ynez River Watershed

Timothy H. Robinson

Cachuma Project Water Agencies

The Cachuma Project - USBR
History and Fisheries Compliance



1993 Beginning of the Fisheries Program at COMB

1997 Listing

1999 Biological Assessment (BA) for Cachuma Project Operations

2000 Cachuma Project Biological Opinion (BO) – Proposed Actions & RPMs

2000 LSYR Fish Management Plan (FMP)

2004 EIR/EIS for BO and FMP LSYR Fish Management Plan

2005 Requested reconsultation -> BA –> draft BO -> final BO?

2012 Southern California Steelhead Recovery Plan (Monte Arido Highlands BGP)

Monitoring / Reporting

- Trapping (January – May)
- Redd Surveys (February – May)
- Snorkel Surveys (Spring, Summer and Fall)
- Invasive species monitoring (ongoing)
- Beaver Dam Surveys (December)
- Stream/River Discharge (year round)
- Water Quality (dry season, April – November, year round)
- Habitat Quality (as needed or yearly)
- Restoration Projects (pending grant funding)
- Adaptive management

Migrant Trapping - Locations
(Photograph, measure, scale + tissue samples, and release)

2F.1+S/L

4+F

Tissue Analyses: NMFS – COMB 2014 Matches

218 mm growth in 23 months

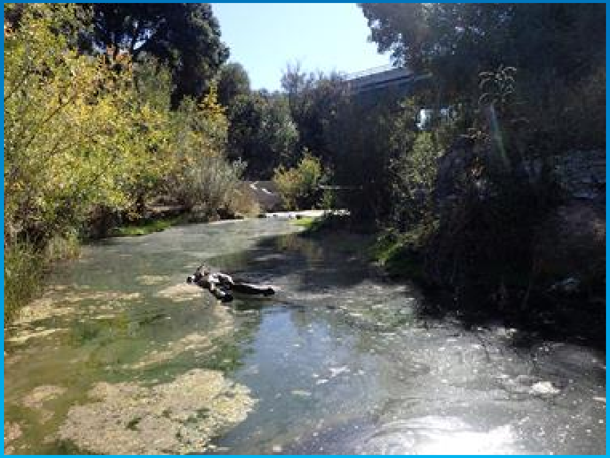
291 mm growth in 25 months

Fish-ID	Collection_Date	Sex	Length (mm)	Fish-ID	Collection_Date	Sex	Length (mm)	Score
HD-117	3/18/2012	?	160	HU_13	2/27/2014	M	378	100%
HU-01	2/1/2012	?	99	HU_23	3/3/2014	F	390	100%

DIDSON (CDFW) – Trapping (COMB)
Salsipuedes Creek

Snorkel Surveys (Spring, Summer and Fall)




Non-Native Aquatic Species

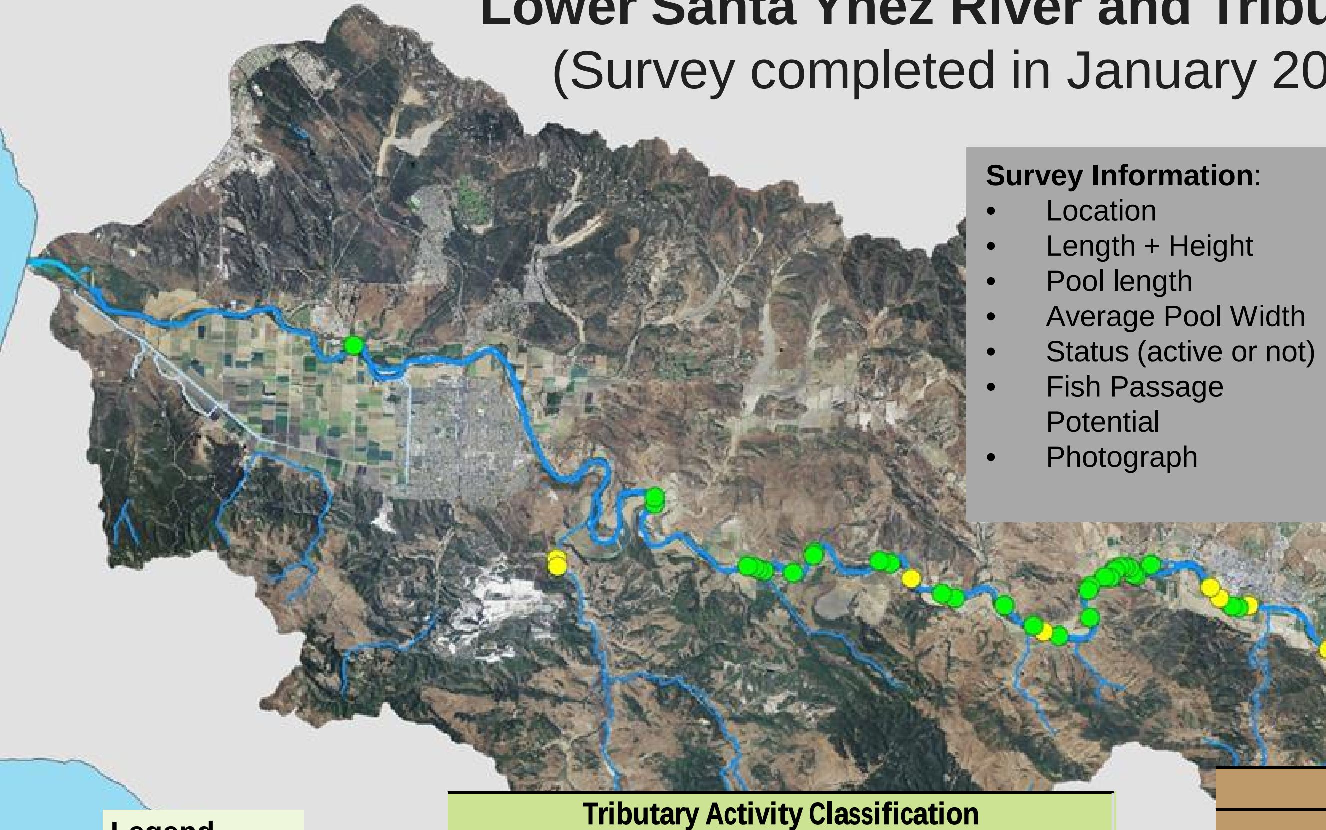
Centrarchids: Largemouth Bass (*Micropterus salmoides*),Green Sunfish, Red-eared Sunfish, Bluegill (*Lepomis sp.)*

Long Pool LMB Gut Analysis: 4 of 15 (6/6/14)

Non-Native Fish Removal
LSYR Stilling Basin

WY2018 Beaver Dam Survey
Lower Santa Ynez River and Tributaries
(Survey completed in January 2018)

Survey Information:
- Location
- Length + Height
- Pool length
- Average Pool Width
- Status (active or not)
- Fish Passage Potential
- Photograph



Tributary Activity Classification				
	Active	Non-Act	No Data	Σ
WY2010	25	0	0	25
WY2011	2	0	3	5
WY2012	-	-	14	14
WY2013	-	-	35	35
WY2014	-	-	36	36
WY2015	6	15	0	21
WY2016	1	7	0	8
WY2017	0	8	0	8
WY2018	0	2	0	2

Mainstem Activity Classification				
	Active	Non-Act	No Data	Σ
WY2010	128	0	0	128
WY2011	10	1	71	82
WY2012	9	0	67	76
WY2013	-	-	132	132
WY2014	-	-	121	121
WY2015	21	87	0	108
WY2016	16	29	0	45
WY2017*	14	52	0	66
WY2018	37	10	0	47

* Additional reaches surveyed from previous year.

~ 50 miles
~ 2 weeks
~ December

Stream Discharge
USGS (Q and WQ)

Stream Discharge
COMB (continuous and spot)

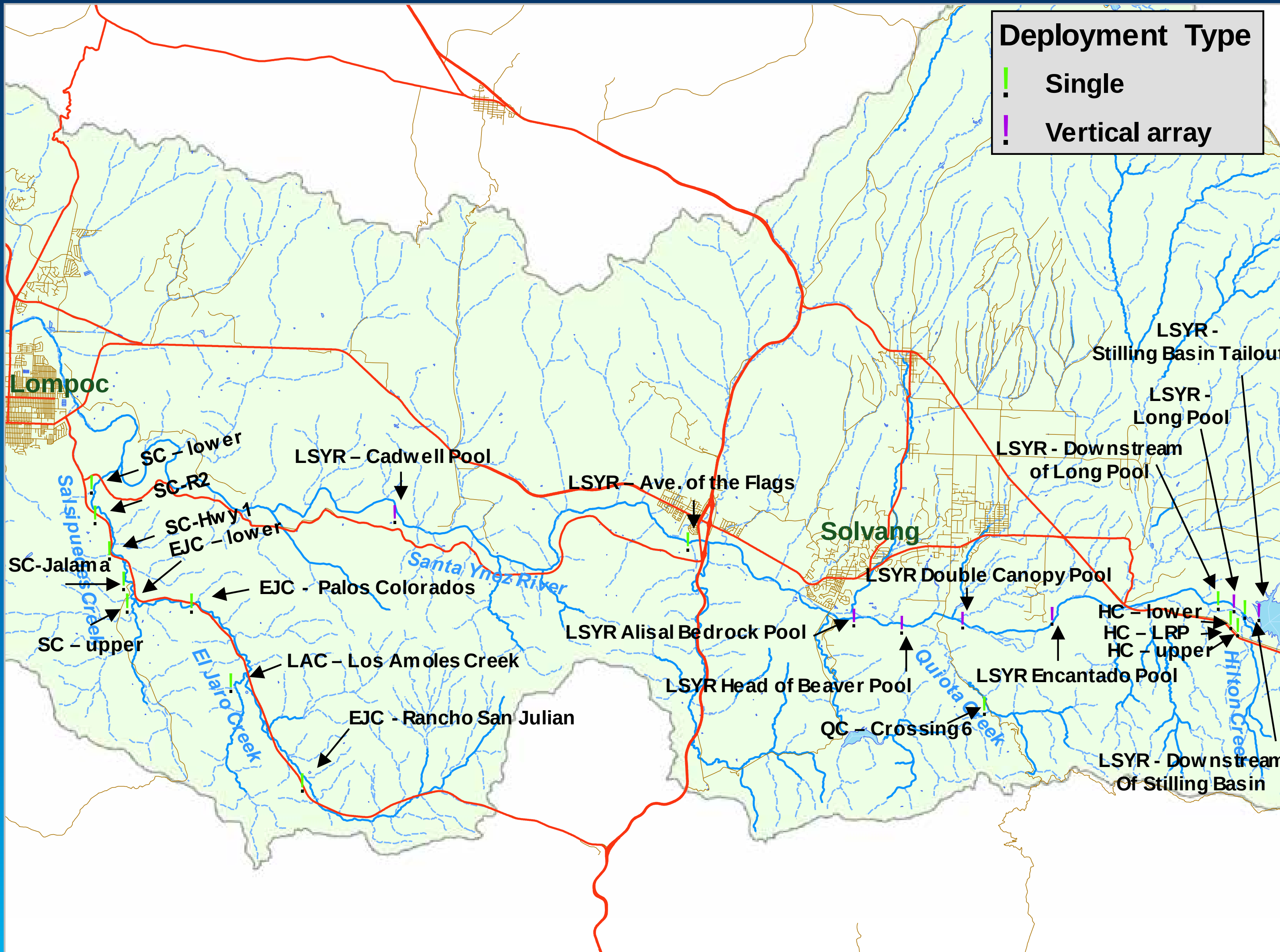
Flow Meter (Q)
SonTek Flow Tracker 2

Pressure Transducer (Z and T)
Solinst Levelogger and Barologger

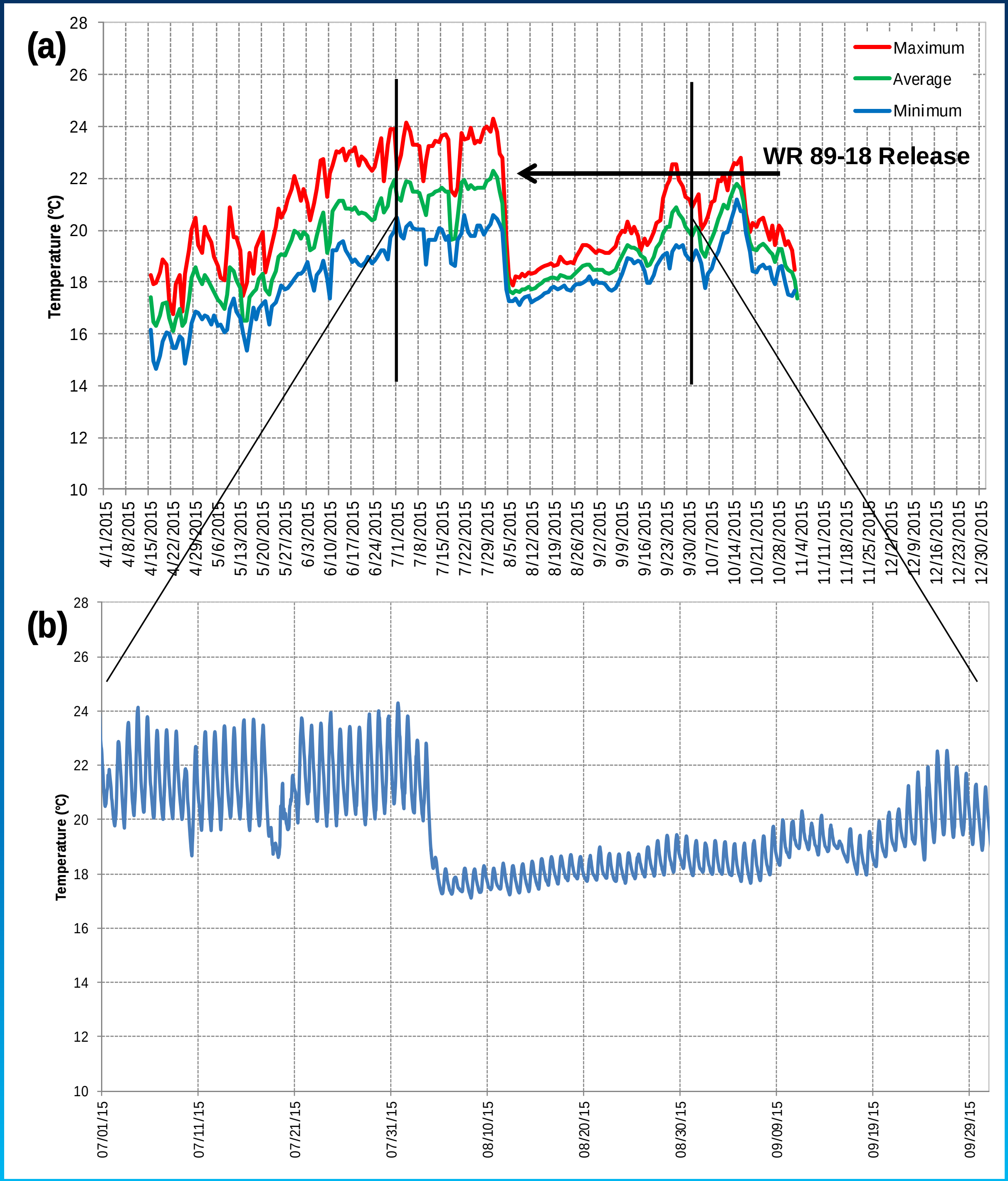
Water Quality Monitoring

- onset HOBO Water Temp Pro v2 (Thermograph)
- onset HOBO U26 Dissolved Oxygen Logger
- YSI Multi-Parameter Sonde (6920 V2, 650 MDS and cable)

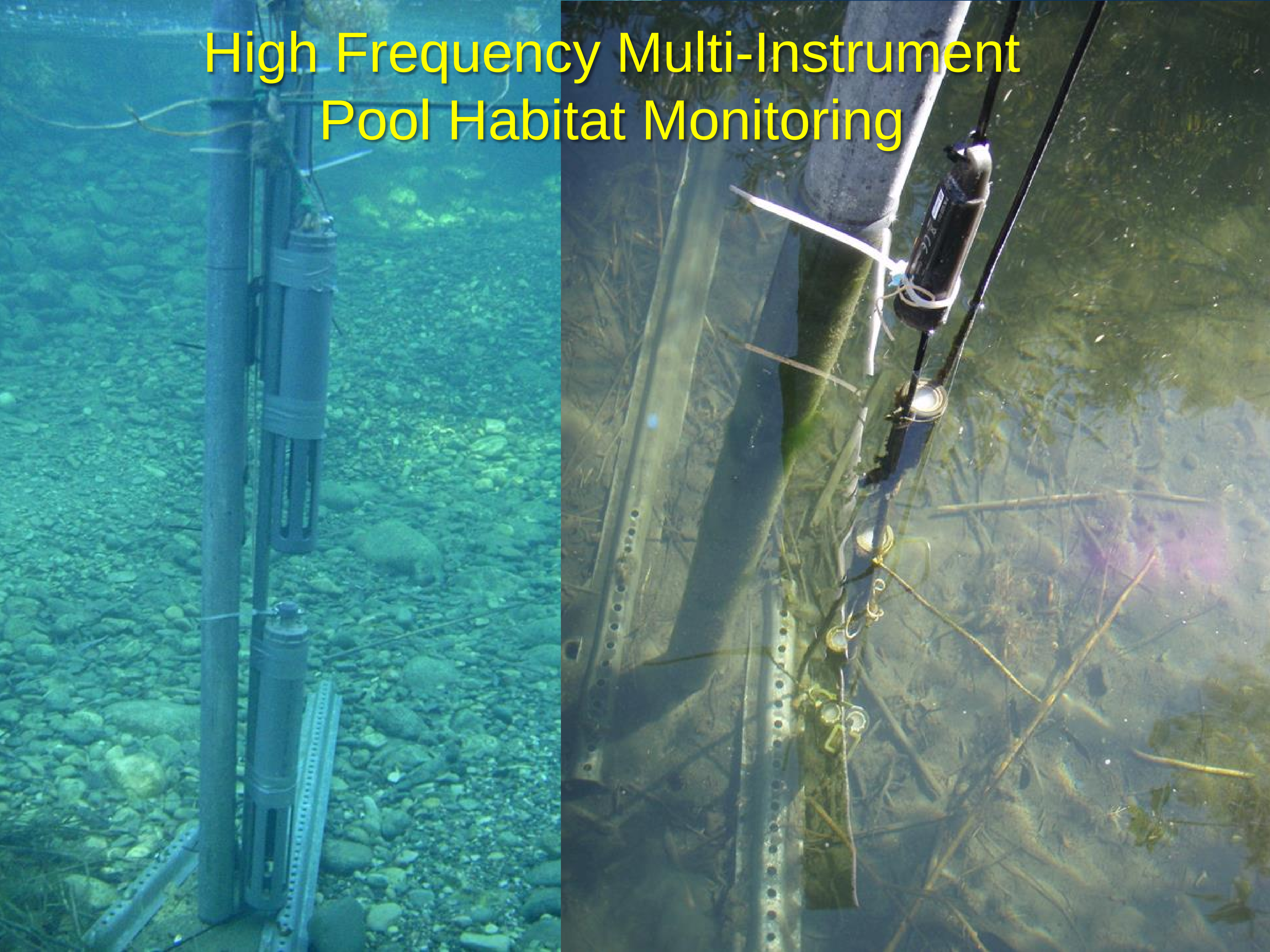
WQ Monitoring Locations & Types



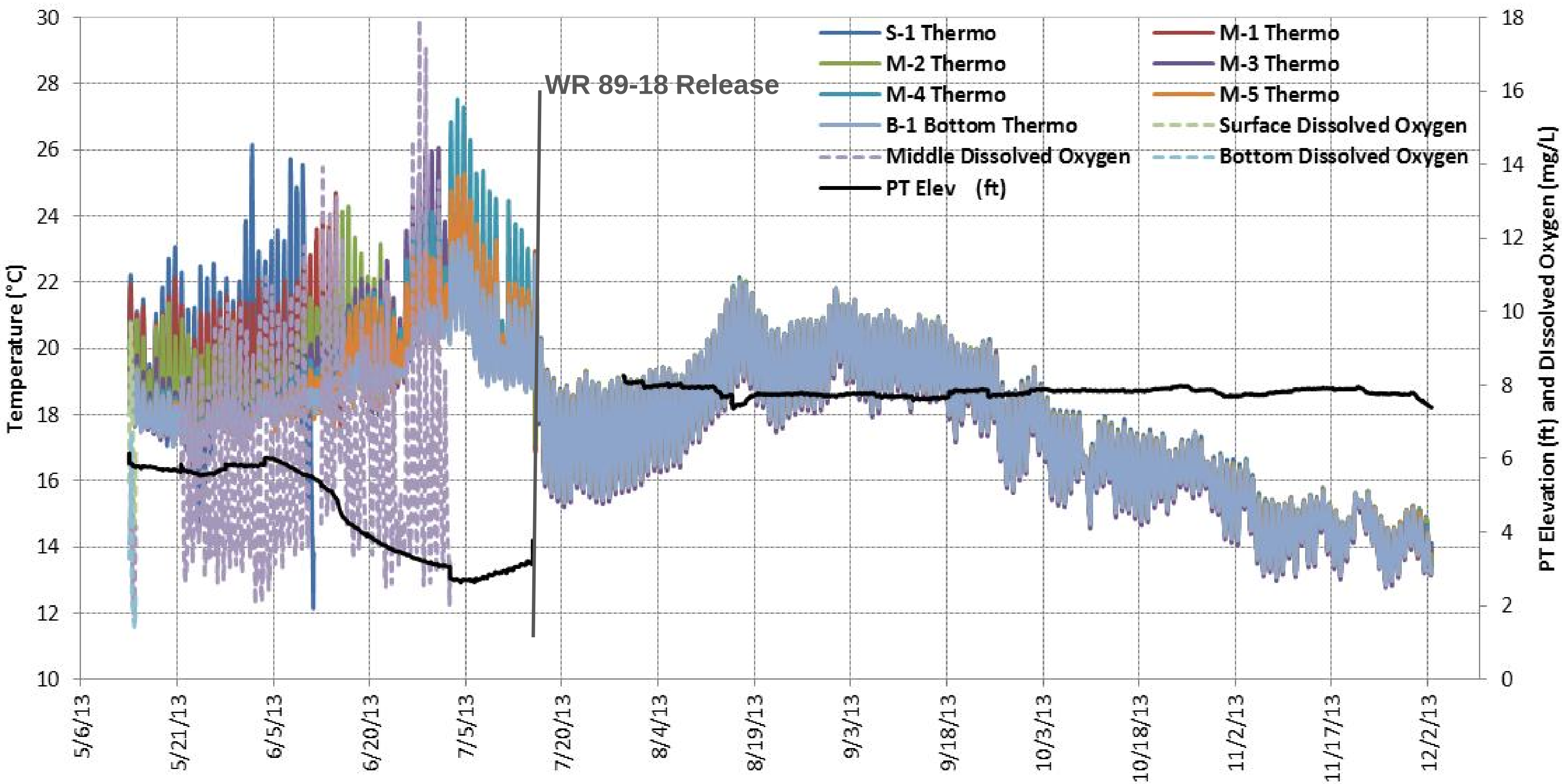
Santa Ynez River - Long Pool (LSYR-0.51, surface)



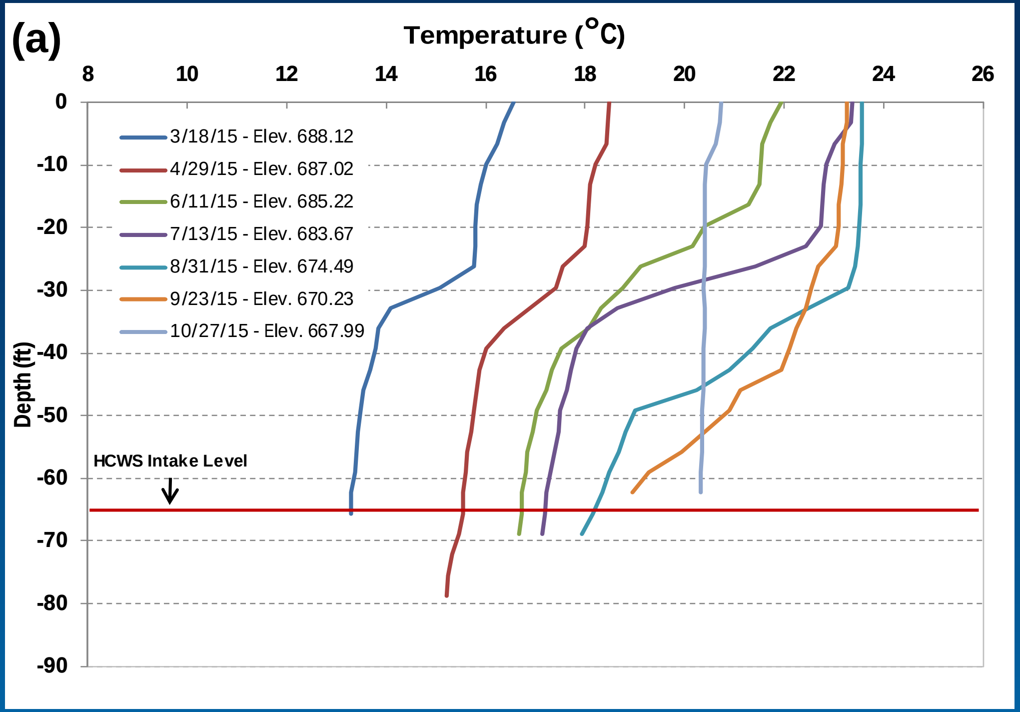
High Frequency Multi-Instrument Pool Habitat Monitoring

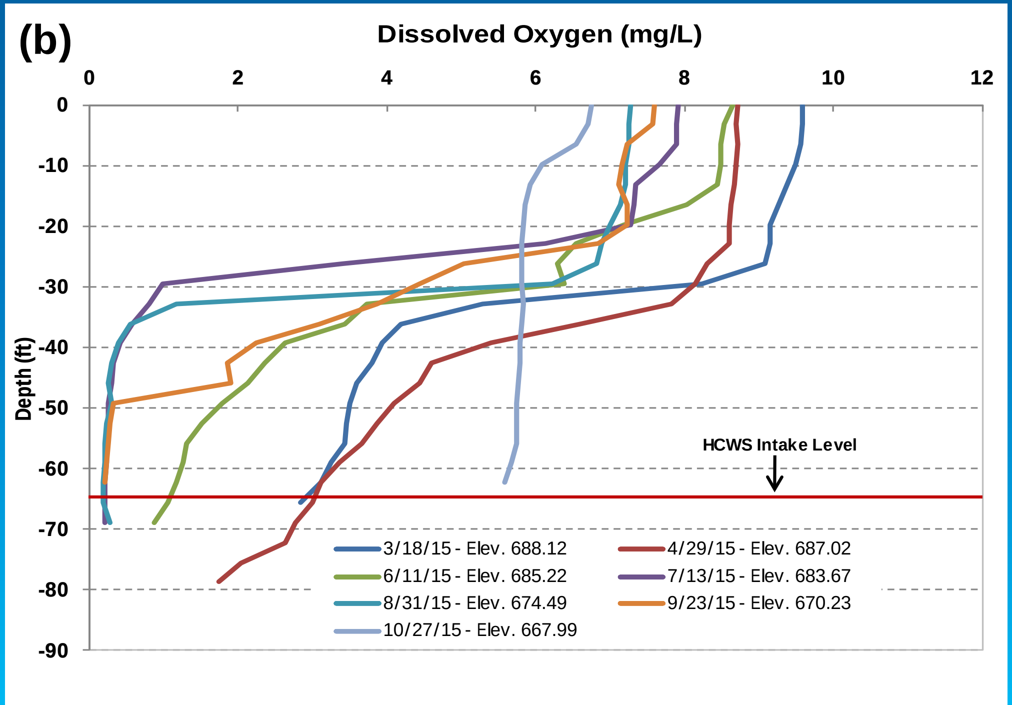


Encantado Pool (LSYR-4.95)

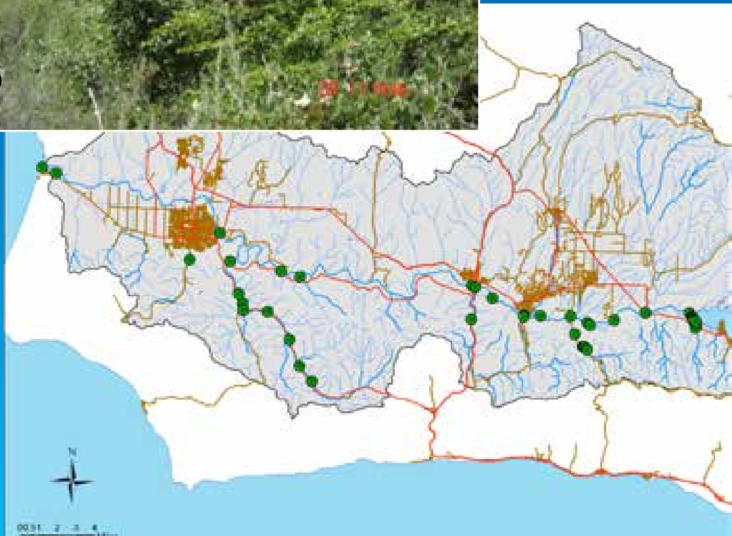


Lake Cachuma WQ Profiles





Habitat Quality – Photo Point Documentation



Monitoring at Restoration Projects

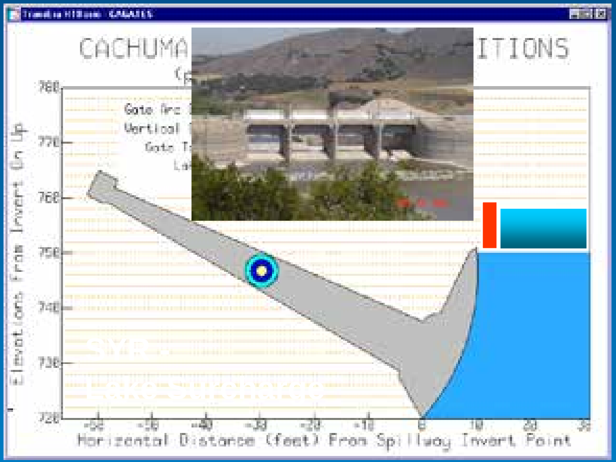
El Jaro Creek – Bank Stabilization

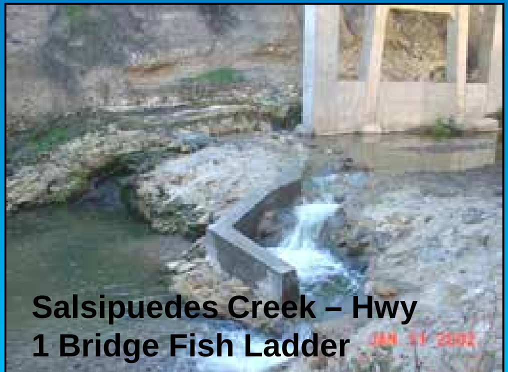
El Jaro Creek – Culvert Replacement

El Jaro Creek – Cross Creek Ranch

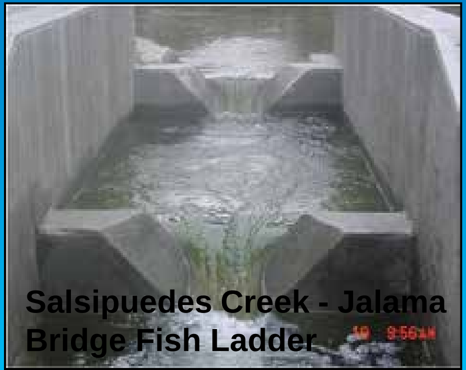
Hilton Creek – Cascade/ Chute Passage

Project	Drainage	Timeline
Hilton Creek Watering System	Hilton	2000
Hwy 1 Bridge Fish Ladder	Salsipuedes	2002
Streambank and Side Channel Restoration	El Jaro	2003
Jalama Bridge Fish Ladder	Salsipuedes	2004
Bradbury Dam Flashboard Installation (Surcharge)	Santa Ynez River	2004
Cascade Chute	Hilton	2005
Crossing 6 60-ft Bottomless Arched Culvert	Quiota	2008
San Julian Ranch Fish Ladder	El Jaro	2008
Cross Creek Ranch Fish Passage Improvement	El Jaro	2009
Crossing 2 60-ft Bottomless Arched Culvert	Quiota	2011
Crossing 7 60-ft Bottomless Arched Culvert	Quiota	2012
Crossing 1 60-ft Bottomless Arched Culvert	Quiota	2013
Crossing 3 53-ft Bottomless Arched Culvert	Quiota	2015
Crossing 0A 55-ft Bottomless Arched Culvert	Quiota	2015
Crossing 4 54-ft Bottomless Arched Culvert	Quiota	2016
Crossing 5 58-ft Bottomless Arched Culvert	Quiota	2018
Crossing 9 60-ft Bottomless Arched Culvert	Quiota	2018





Salsipuedes Creek – Hwy 1 Bridge Fish Ladder

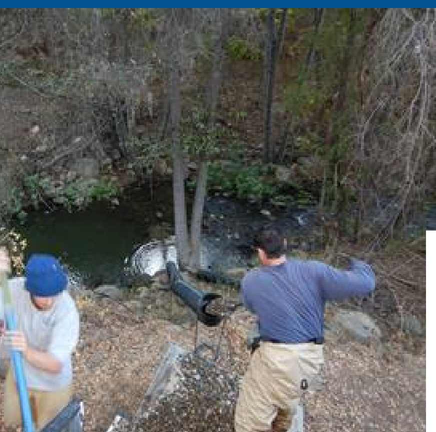


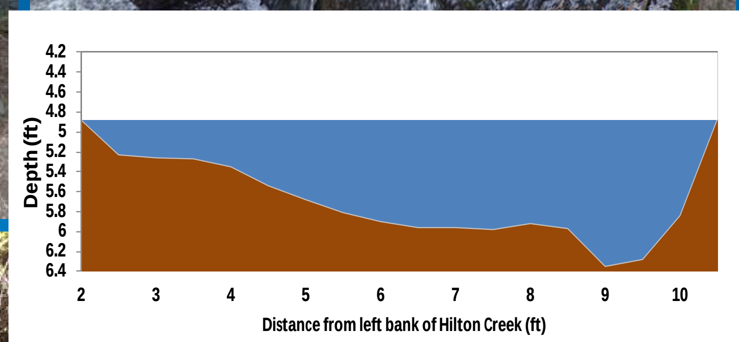
Salsipuedes Creek - Jalama Bridge Fish Ladder

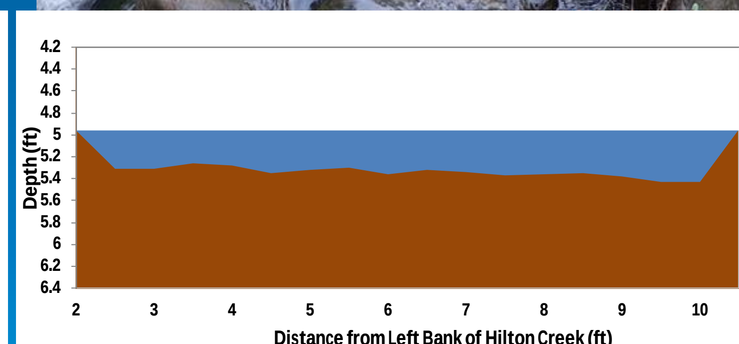
El Jaro Creek – San Julian Ranch Fish Ladder

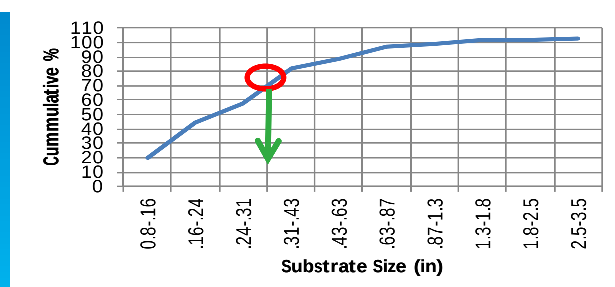
Quiota Creek - Crossing 6

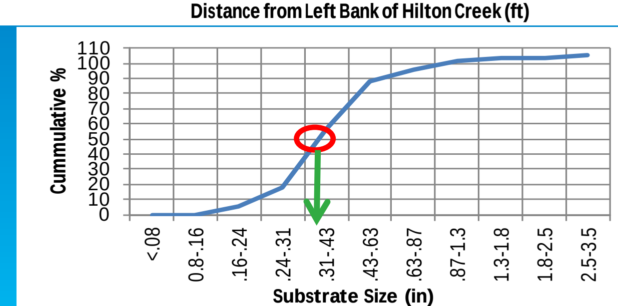
Hilton Creek Gravel Augmentation



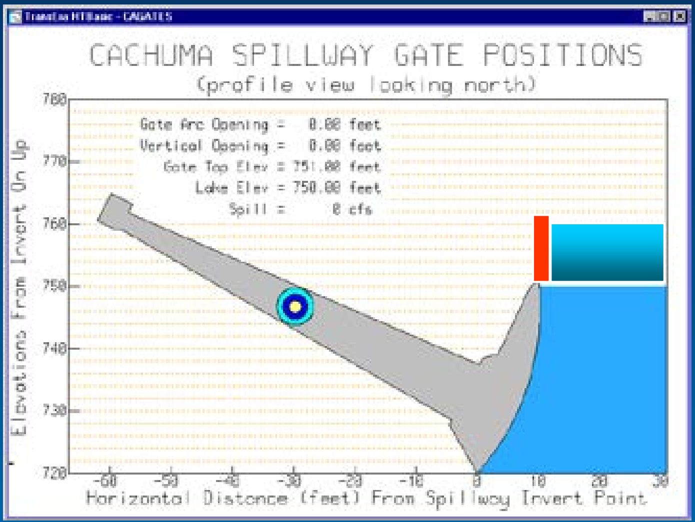


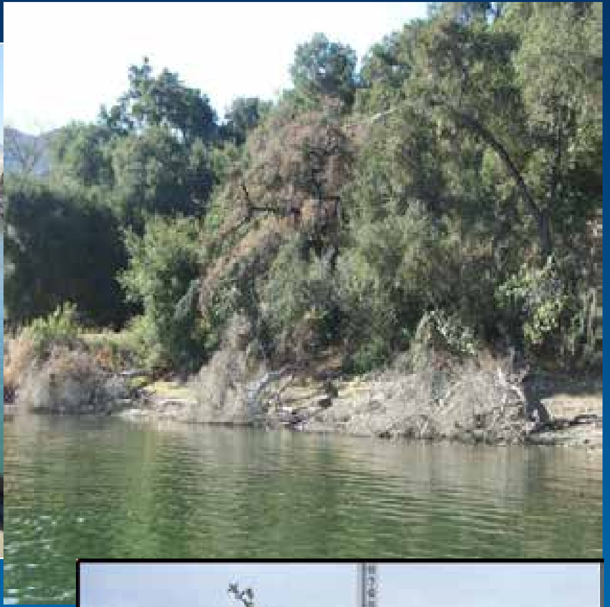






Lake Cachuma Oak Tree Restoration





Conclusions

- We are busy
- The extent of out monitoring effort and success of our recovery efforts are limited
- Drought and wildfires continue to be a significant driver in the *O. mykiss* population within the Santa Ynez River watershed
- We continue to collaborate closely with USBR, NMFS, CDFW and USFWS
- The new BO for the Cachuma Project will give us more coverage and tools to work with over a wider geographic area
- Pacific Lamprey monitoring (Damon Goodman and Stewart Reid)

Questions

Thanks for your attention!


Salsipuedes Creek Upstream
701 mm = 27.6 Inches
February 5th, 2008
*Largest Steelhead Ever Captured On Project

Hilton Creek Upstream
659 mm = 26.0 Inches
February 7th, 2008
***First Confirmed Steelhead In Hilton Creek (Near Bradbury Dam)**