Environmental DNA (eDNA) analysis of San Francisquito Creek (2023 & 2024 eDNA surveys)

Rick Lanman, MD
Institute for Historical Ecology

Institute for Historical Ecology Publications

California Fish and Game 98(2):129-132; 2012

Novel physical evidence that beaver historically were native to the Sierra Nevada

Charles D. James and Richard B. Lanman*

California Fish and Game 98(2):65-80; 2012

The historical range of beaver in the Sierra Nevada: a review of the evidence

Richard B. Lanman*, Heidi Perryman, Brock Dolman, and Charles D. James

California Fish and Game 99(4):193-221; 2013

The historical range of beaver (*Castor canadensis*) in coastal California: an updated review of the evidence

Christopher W. Lanman, Kate Lundquist, Heidi Perryman, J. Eli Asarian, Brock Dolman, Richard B. Lanman*, Michael M. Pollock

PLOS ONE

RESEARCH ARTICLE

Ancient DNA analysis of archaeological specimens extends Chinook salmon's known historic range to San Francisco Bay's tributaries and southernmost watershed

Richard B. Lanman[1,2]*, Linda Hylkema[3], Cristie M. Boone[4], Brian Allée[5], Roger O. Castillo[6], Stephanie A. Moreno[1], Mary Faith Flores[7], Upuli DeSilva[7], Brittany Bingham[7], Brian M. Kemp[7]

California Fish and Wildlife 107(2):89-98; 2021 www.doi.org/10.51492/cfwj.107.8

FULL RESEARCH ARTICLE

Western Message Petroglyphs indicate historic beaver presence in a San Francisco Bay Area watershed

LEIGH MARYMOR[1] AND RICHARD BURNHAM LANMAN[2,3]*

California Fish and Wildlife Scientific Journal

Quarterly scientific journal published by the California Department of Fish and Wildlife

October 11, 2022

Review of considerations for restoration of tule elk to the San Francisco Peninsula and northern Monterey Bay counties of California

REVIEW PAPER

RICHARD B. LANMAN[1,2], WILLIAM C. LEIKAM[2,3], MONICA V. ARELLANO[4], ALAN LEVENTHAL[4,5], VALENTIN LOPEZ[6], RYAN A. PHILLIPS[7], JULIE A. PHILLIPS[8], AND KRISTIN DENRYTER[9,10]

California Fish and Wildlife Scientific Journal

Quarterly scientific journal published by the California Department of Fish and Wildlife

October 11, 2022

Road and highway undercrossings as potential critical linkages for California's elk populations

RESEARCH NOTE

RICHARD B. LANMAN[1]*, JAMES KILBER[2], JEFF CANN[3], CARRINGTON HILSON[4], ERIN ZULLIGER[5], JOSHUA BUSH[6], FLOYD W. WECKERLY[7], AND THOMAS J. BATTER[8]

California Fish and Wildlife Scientific Journal

Quarterly scientific journal published by the California Department of Fish and Wildlife

December 29, 2023

Habitat suitability assessment for tule elk in the San Francisco Bay and Monterey Bay areas

FULL RESEARCH ARTICLE

Thomas Connor[1,2], Thomas J. Batter[2], Cristen O. Langer[3], Jeff Cann[4], Cynthia McColl[5], and Richard B. Lanman[5,6]*

PLOS ONE

September 18, 2024

RESEARCH ARTICLE

Novel evidence that elk were historically native to the Sierra Nevada, and recent range expansions into the region

Richard B. Lanman[1☯]*, Thomas J. Batter[2☯¤], Cody J. Mckee[3☯]

Our forthcoming publications are on California redwoods, gray wolves, then pronghorn.

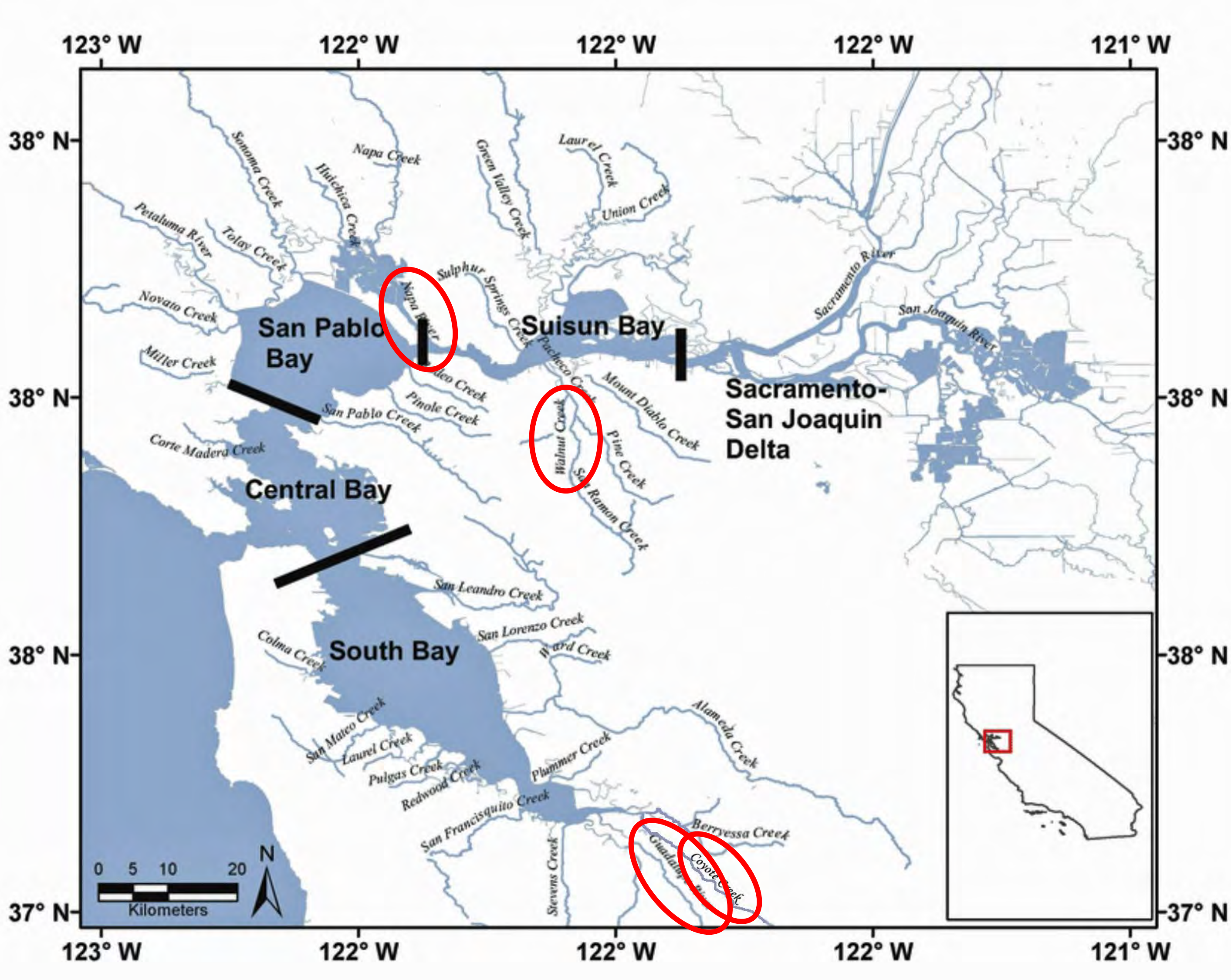
Acknowledgements

- Dr. Robert Leidy, San Francisco EPA-based fish biologist, who has surveyed every SF Bay stream, literally written the book on steelhead trout in our region, and who taught me to electrofish
- Roger Castillo, citizen scientist and discoverer of the Columbian mammoth “Lucy” fossil on the banks of the Guadalupe River, champion for our wildlife both aquatic and land-based, and who taught me the life history of salmonids
- Cheryl Dean and Scott Blankenship at Cramer Fish Sciences, who taught me how to collect eDNA samples and translate the results

Chinook Salmon Are Thriving in the Guadalupe River and Coyote Creek Watersheds in South San Francisco Bay

In mid-October 1996, Roger Castillo, founder of the Salmon and Steelhead Restoration Group, found a 43” Chinook salmon carcass in San Tomas Aquino Creek in Santa Clara, CA. This creek flows into the Guadalupe Slough and thence to south San Francisco Bay.

Four San Francisco Bay tributaries have enduring Chinook salmon runs



[1] Grimaldo (Brennan) et al. 2020 Forage Fish Larvae Distribution and Habitat Use During Contrasting Years of Low and High Freshwater Flow in the San Francisco Estuary. *San Francisco Estuary & Watershed Science*

Ancient DNA Sequencing of 58 Unspecified Salmonid Vertebrae from circa 1800 Mission Santa Clara Found Three as Chinook Salmon

Sample no. for aDNA[1]	Archaeological Feature[2]	Species ID by aDNA	Vertebra Size Estimate[3]
2.4	155	*O. mykiss*	3 mm
2.5	155	*O. mykiss*	3 mm
2.6	155	*O. mykiss*	2–3 mm
2.7	503	*O. mykiss*	1–2 mm
3.1	79	*O. mykiss*	1–2 mm
3.2	155	*O. mykiss*	2–3 mm
3.4	503	*O. tshawytscha*	> 10 mm
3.5	91	*O. mykiss*	4 mm
3.6	155	*O. tshawytscha*	> 10 mm
4.1	79	*O. mykiss*	2 mm
4.3	119	*O. mykiss*	2 mm
4.5	119	*O. mykiss*	3 mm
4.6	119	*O. mykiss*	1–2 mm
5.1	119	*O. mykiss*	2–3 mm
5.3	119	*O. mykiss*	2 mm
5.4	119	*O. mykiss*	2 mm
5.5	119	*O. mykiss*	2–3 mm
5.6	119	*O. mykiss*	1–2 mm
5.7	119	*O. mykiss*	2–3 mm
6.2	155	*O. mykiss*	2–3 mm
6.3	155	*O. mykiss*	2–3 mm
6.4	155	*O. mykiss*	2–3 mm
6.5	155	*O. mykiss*	2–3 mm
6.6	155	*O. mykiss*	2–3 mm
6.7	503	*O. mykiss*	2 mm
7.1	155	*O. mykiss*	2 mm
7.2	155	*O. mykiss*	3 mm
7.3	230	*O. mykiss*	1–2 mm
7.4	503	*O. tshawytscha*	Large
8.1	66	*O. mykiss*	2–3 mm
12.7	155	*O. mykiss*	2–3 mm
13.1	155	*O. mykiss*	2--3 mm
13.2	155	*O. mykiss*	2--3 mm
13.3	155	*O. mykiss*	2–3 mm
13.4	155	*O. mykiss*	3 mm
13.5	155	*O. mykiss*	2–3 mm

[1] 30 specimens did not produce aDNA results and are not included in this table.

[2] Feature 503 is from the St. Clare project; all other features are from the Franklin Block projects.

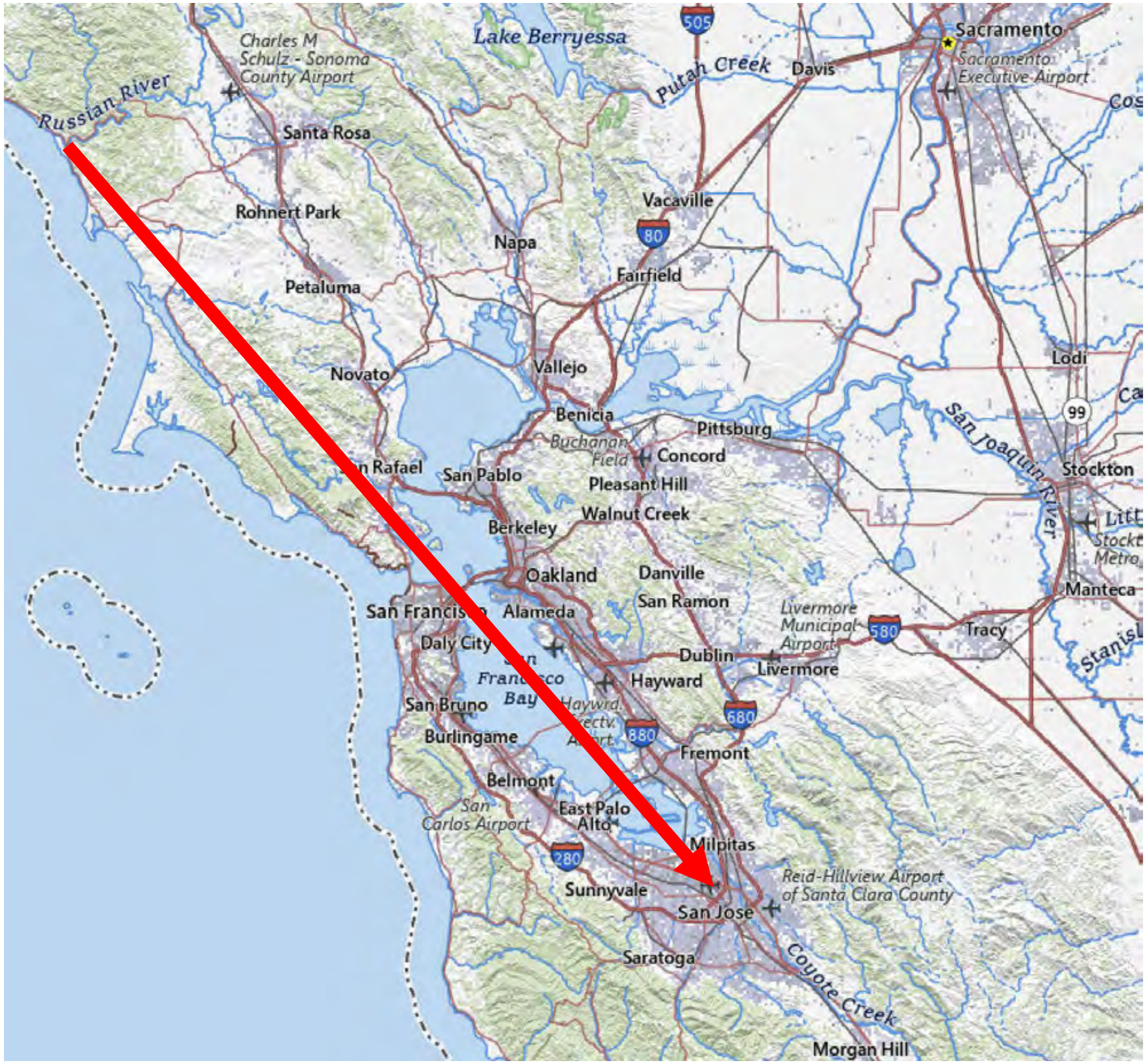
1. All others (n=55) were identified as rainbow/steelhead trout.

2. Further aDNA analysis found the three Chinook were three different individuals, consistent with one specimen coming from a different archaeological feature (155) than the other two (503).

3. Only Chinook and chum salmon vertebral diameters are typically larger than 10 mm, and the latter do not spawn south of central Oregon.

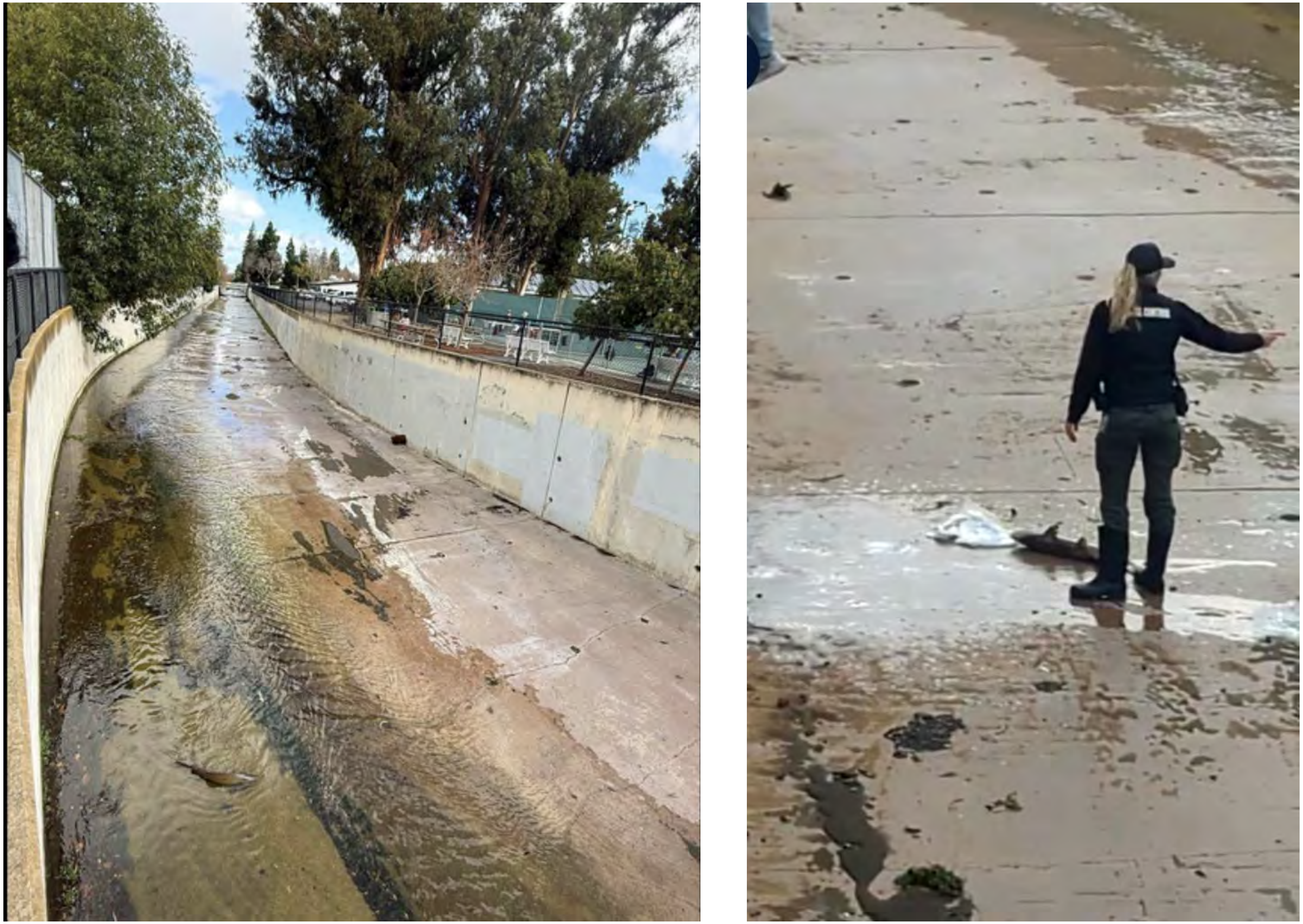
Lanman et al. 2021 Ancient DNA analysis of archaeological specimens extends Chinook salmon's known historic range to San Francisco Bay's tributaries and southernmost watershed. *PLoS One* https://doi.org/10.1371/journal.pone.0244470

Ancient DNA Evidence Moves the Historical Range of California Coastal Chinook Salmon 100 miles Further South



Lanman (Kemp) et al. 2021 Ancient DNA analysis of archaeological specimens eXtends Chinook salmon's known historic range to San Francisco Bay's tributaries and southernmost watershed. *PLoS One*

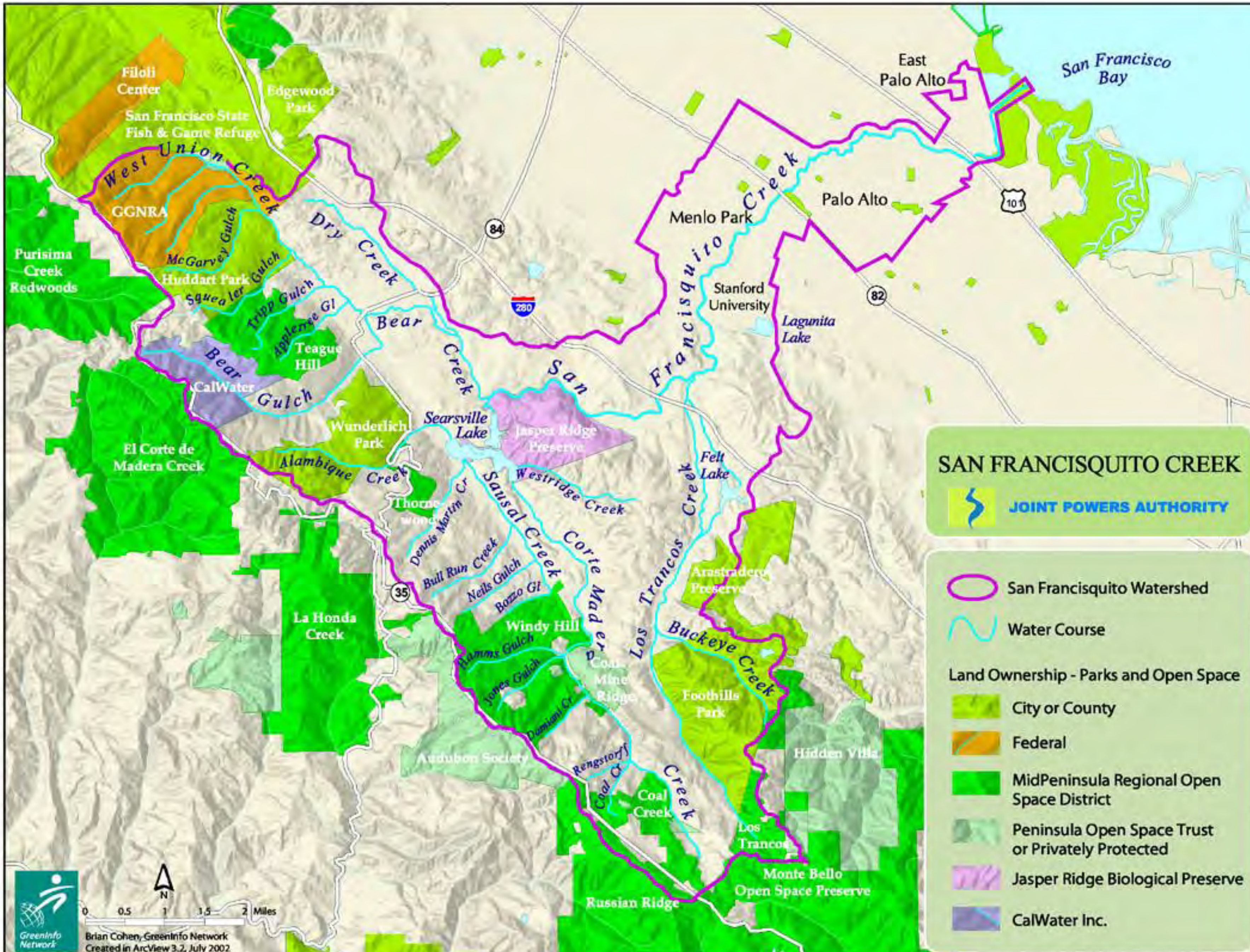
Concrete Flood Control Channels without Low Flow Inset Channels Are Salmon Kill Zones



Chinook salmon in Adobe Creek December 25, 2025 – stranded because of absence of low flow inset channel in concretized channel. Near Middlefield Road, Palo Alto. Photo courtesy Dr. Russell Kawahata.

San Francisquito Creek

- One of two large streams left in San Mateo County and Santa Clara County with a natural channel (lacks concrete channelization for flood control), thanks to it being the boundary between the two counties (the other is Coyote Creek in east San Jose)
- It is a large-ish watershed with drainage 45 square miles (120 km^2)
- The SFC mainstem runs 12.9 miles (20.8 km) from the confluence of Bear Creek and Corte Madera Creek to southwest San Francisco Bay
- Its major tributary is Corte Madera Creek, along with Los Trancos Creek (which continues the two Counties Boundary), and Bear Creek
- Bear Creek and Corte Madera Creek have a multitude (22) of sub-tributaries, owing to the San Andreas Fault
- Stanford University and the San Mateo Resource Conservation District deserve credit for removing most partial fish barriers
- One impassable barrier remains, Searsville Dam, completed in 1892



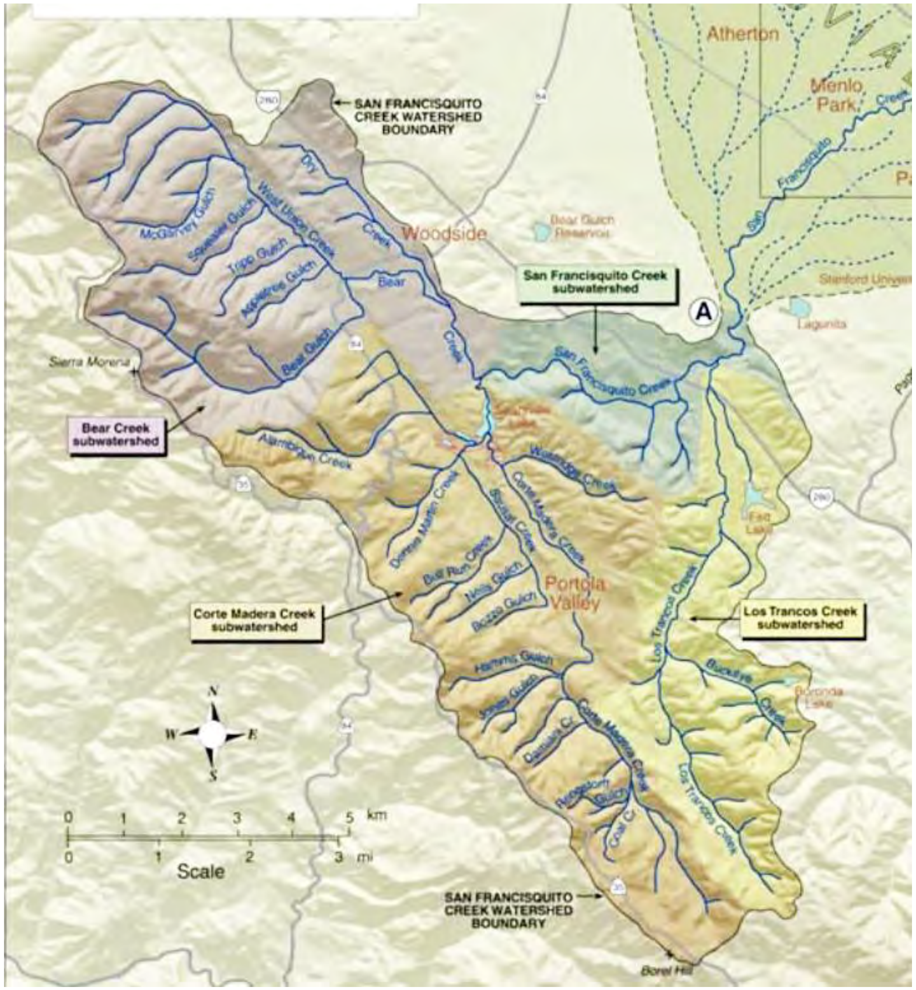
SAN FRANCISQUITO CREEK
JOINT POWERS AUTHORITY
San Francisquito Watershed
Water Course
Land Ownership - Parks and Open Space
City or County
Federal
MidPeninsula Regional Open Space District
Peninsula Open Space Trust or Privately Protected
Jasper Ridge Biological Preserve
CalWater Inc.
San Francisco Bay
East Palo Alto
Palo Alto
Menlo Park
Stanford University
Lagunita Lake
Filoli Center
Edgewood Park
San Francisco State Fish & Game Refuge
West Union Creek
GGNRA
Purisima Creek Redwoods
McGarvey Gulch
Huddart Park
Squealer Gulch
Tripp Gulch
Appletree Gl
Teague Hill
Dry Creek
Bear Creek
Bear Gulch
CalWater
San Francisquito Creek
Searsville Lake
Jasper Ridge Preserve
Wunderlich Park
El Corte de Madera Creek
Alambique Creek
Westridge Creek
Felt Lake
Thornewood
Dennis Martin Cr
Sausal Creek
Corte Madera Creek
Los Trancos Creek
Bull Run Creek
Neils Gulch
Bozzo Gl
Windy Hill
La Honda Creek
Arastradero Preserve
Buckeye Creek
Hamms Gulch
Jones Gulch
Coal Mine Ridge
Damiani Cr.
Foothills Park
Audubon Society
Hidden Villa
Rengstorff
Coal Cr
Coal Creek
Los Trancos
Monte Bello Open Space Preserve
Russian Ridge
84
280
82
101
35
N
0 0.5 1 1.5 2 Miles
GreenInfo Network
Brian Cohen, GreenInfo Network
Created in ArcView 3.2, July 2002

Chinook salmon in San Francisco Bay tributaries

- Today, Chinook salmon spawn in large numbers in the Guadalupe River, Coyote Creek, Napa River and Walnut Creek – streams with deeper, intertidal lower reaches.[1]
- Physical evidence of historical Chinook salmon presence includes zooarchaeological remains at Walnut Creek and Alameda Creek,[2,3] the collection of Chinook salmon eggs in San Leandro Creek in 1879 before it was dammed,[4] and a 2021 ancient DNA study of Mission Santa Clara salmonid remains identified Chinook presence circa 1800[1]
- Historical observer records in Guadalupe River, Alameda Creek and San Francisquito Creek differentiate salmon and trout and appear reliable.[1]
- Genetics studies find that most Chinook salmon in the Napa River and Guadalupe River are hatchery strays but also found some wild strays are from the Klamath River, Russian River and Columbia River.[1]

[1] Lanman (Kemp) et al. 2021 Ancient DNA analysis of archaeological specimens eXtends Chinook salmon's known historic range to San Francisco Bay's tributaries and southernmost watershed. *PLoS One*
[2] Gobalet et al 2004. Archaeological Perspectives on Native American Fisheries of California, with Emphasis on Steelhead and Salmon. *Trans Am Fish Soc. doi.10.1577/T02-084.1*
[3] Gobalet 2020 Fish Remains from Archaeological Site CA-ALA-565/H and a Summary of the Fishes in the Archaeological Record of the San Francisco Bay; in Protohistoric Village Organization and Territorial Maintenance: The Archaeology of Sı´i Tu´upentak (CA-ALA-565/H) in the San Francisco Bay Area. *Center for Archaeological Research at Davis, CARD Publication 20.* ISBN 978-1-7345255-1-9, pp. 230- 236, 448-458
[4] *Atkins, Charles G. 1879* On the distribution of schoodic salmon, in: Part V, Report of the Commissioner for 1877. *U.S. Commission of Fish and Fisheries, Government Printing Office.*

Historical Records of Salmon in San Francisquito Creek



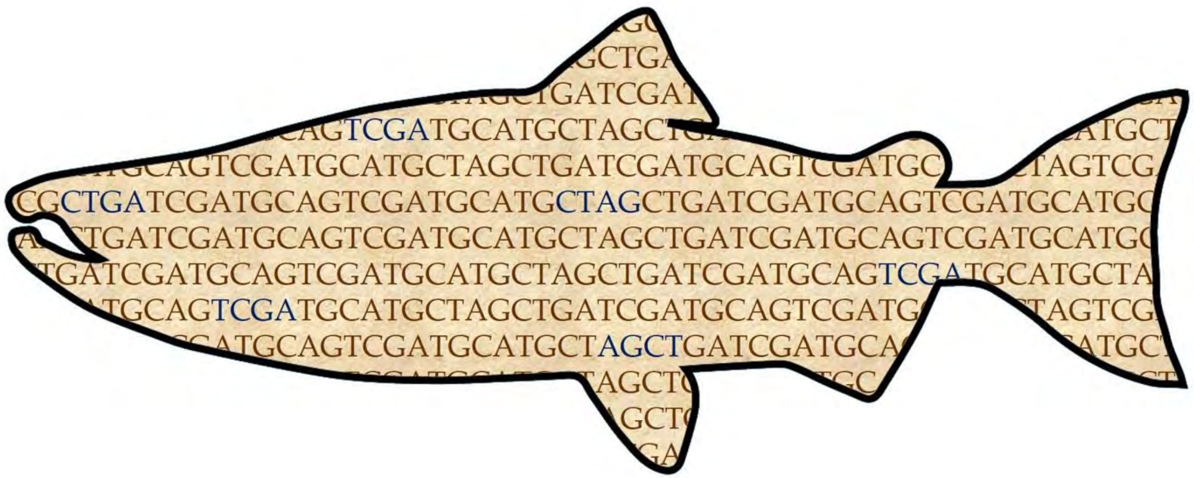
1. Dorothy Regnery's 1966 interview with Edgar H. Batchelder, who was 2 years old when his father became caretaker of Searsville Dam in 1897, "When the dam was 'wasting', or overflowing in the winter, **salmon** would swim upstream as far as the base of the dam. Using a pitchfork Mr. Batchelder would spear them to supplement the family's menu." His "favorite place to fish for trout was in the Dennis Martin Creek".[1]

2. A second source described catching "steelhead" and silver (coho) salmon in San Francisquito Creek and the Guadalupe River watershed in the 1930s and 1940s. He said that the Guadalupe River also had runs of **chinook salmon** that were very large in wet years."[2]

3. Dennis L. Bark, a senior fellow at Stanford's Hoover Institution, recalls playing on San Francisquito Creek around 1947: "**Salmon** swam up it, and in winter it was a dangerous place."[3]

[1] Regnery, Dorothy (1966). "E.H. Batchelder personal interviews". Dorothy F. Regnery papers (Interview). Vol. M0479, boX 6, folder 13. Department of Special Collections, Stanford University Libraries. p. 5.
[2] Watershed Assessment Subgroup, Santa Clara Basin Watershed Management Initiative (August 2003). Volume One Unabridged Watershed Characteristics Report, Chapter 7 "Natural Setting" (PDF) (Report). Santa Clara Valley Urban Runoff Pollution Prevention Program. p. 7-Xi.
[3] Dennis L. Bark (Fall 2010). "Growing Up on The Farm" (PDF). Sandstone & Tile: 18

Environmental DNA (eDNA) Metabarcoding Simultaneously Differentiates Hundreds of Fish Species (and Amphibians, Birds & Mammals!) from a Water Sample



- Primers are designed to capture eDNA fragments of a hypervariable 163–185-bp region within the 12S RNA gene of mitochondrial DNA (mtDNA) for nearly 1,000 different species.[1]
- The captured eDNA fragments are amplified then neXt-generation DNA sequencing (NGS) is used to analyze them.[1]
- The metabarcoding approach has good sensitivity and very high specificity for the fish (or other animal or plant) species – thus some species may not be detected but a detection is likely a true positive.[1]
- This approach has enabled a shift from single-species management to ecosystem-based fishery management.[2]

[1] Miya (Kawasaki) et al. 2015 MiFish, a set of universal PCR primers for metabarcoding environmental DNA from fishes: detection of more than 230 subtropical marine species. *Royal Society Open Science*. http://dX.doi.org/10.1098/rsos.150088
[2] Miya, Gotoh, Sado 2020 MiFish metabarcoding: a high-throughput approach for simultaneous detection of multiple fish species from environmental DNA and other samples. *Fisheries Science*. https://doi.org/10.1007/s12562-020-01461-X

Environmental DNA Offers Advantages over Electrofishing or Screw Traps to Assess the Fish Assemblage of a Stream

Feature	Traditional (Netting/Electrofishing)	eDNA Metabarcoding
Invasiveness	High (can stress or kill fish)	**None** (only water is taken)
Detection	Misses rare or "cryptic" species	**Highly sensitive** to rare species
Effort	Labor-intensive and slow	**Rapid** field collection
Safety	Requires wading/dangerous gear	**Safe** bank-side collection

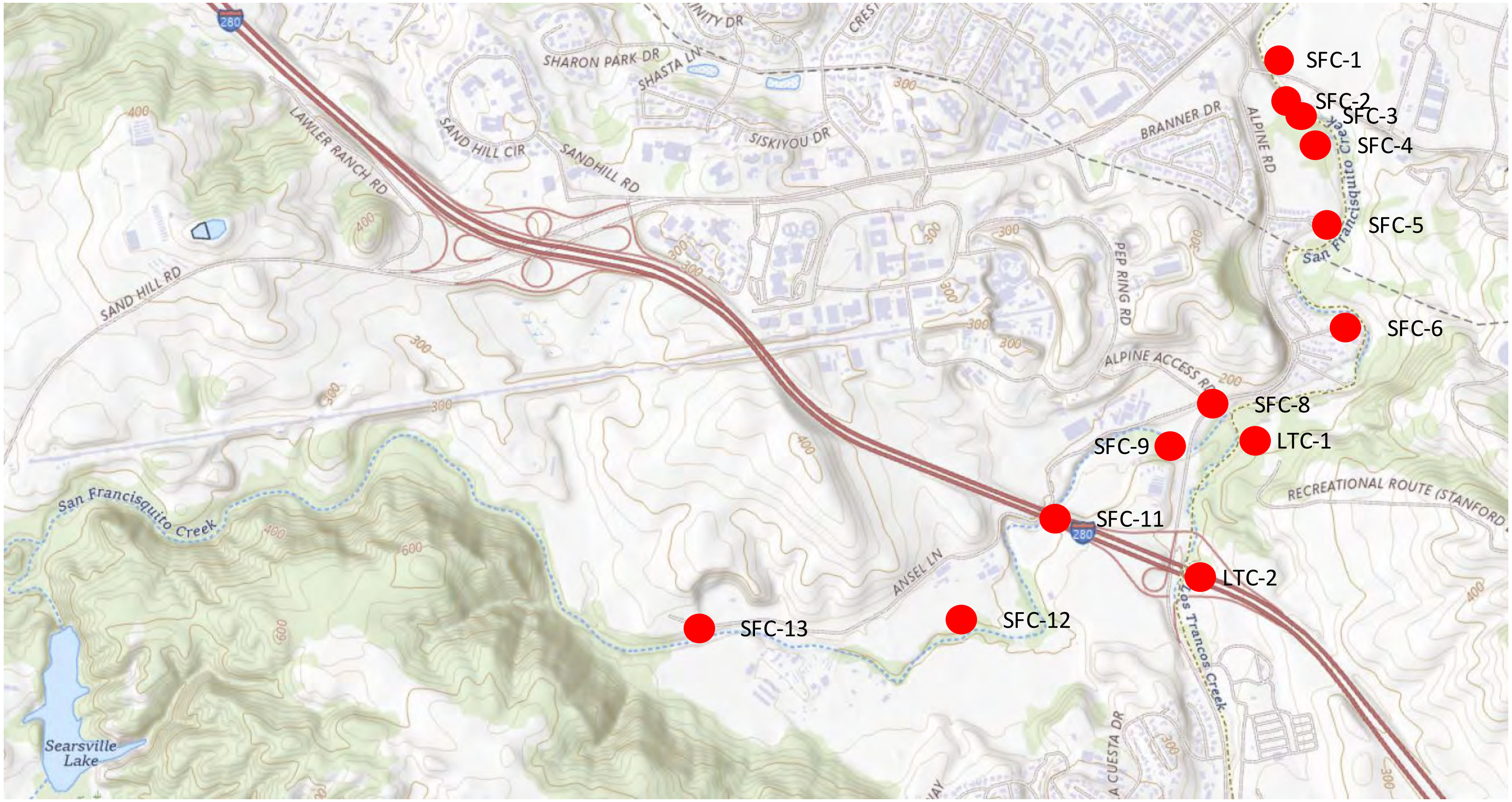
Miya, Gotoh, Sado 2020 MiFish metabarcoding: a high-throughput approach for simultaneous detection of multiple fish species from environmental DNA and other samples. *Fisheries Science* 86:939–970

eDNA Study Goals

- Establish a new baseline for the supratidal fish assemblage of SFC prior to Searsville Dam fenestration (limited to below the dam)
- Contrast eDNA sensitivity to two prior electrofishing surveys by Dr. Robert Leidy in 1981 and 1993–1999
- Contrast sensitivity of multiple spatial collection sites at a single timepoint vs. fewer (four) spatial collection sites at three timepoints 3 weeks apart
- Assess for successful spawning/rearing of threatened/listed anadromous fish – Central California Coast steelhead DPS, California Coastal Chinook salmon ESU, Pacific lamprey (CA status "vulnerable" S3) – therefore sample at peak juvenile abundance March-April
- Utilize eDNA broad metabarcoding to detect other threatened or potentially recolonizing species such as California red-legged frog or beaver

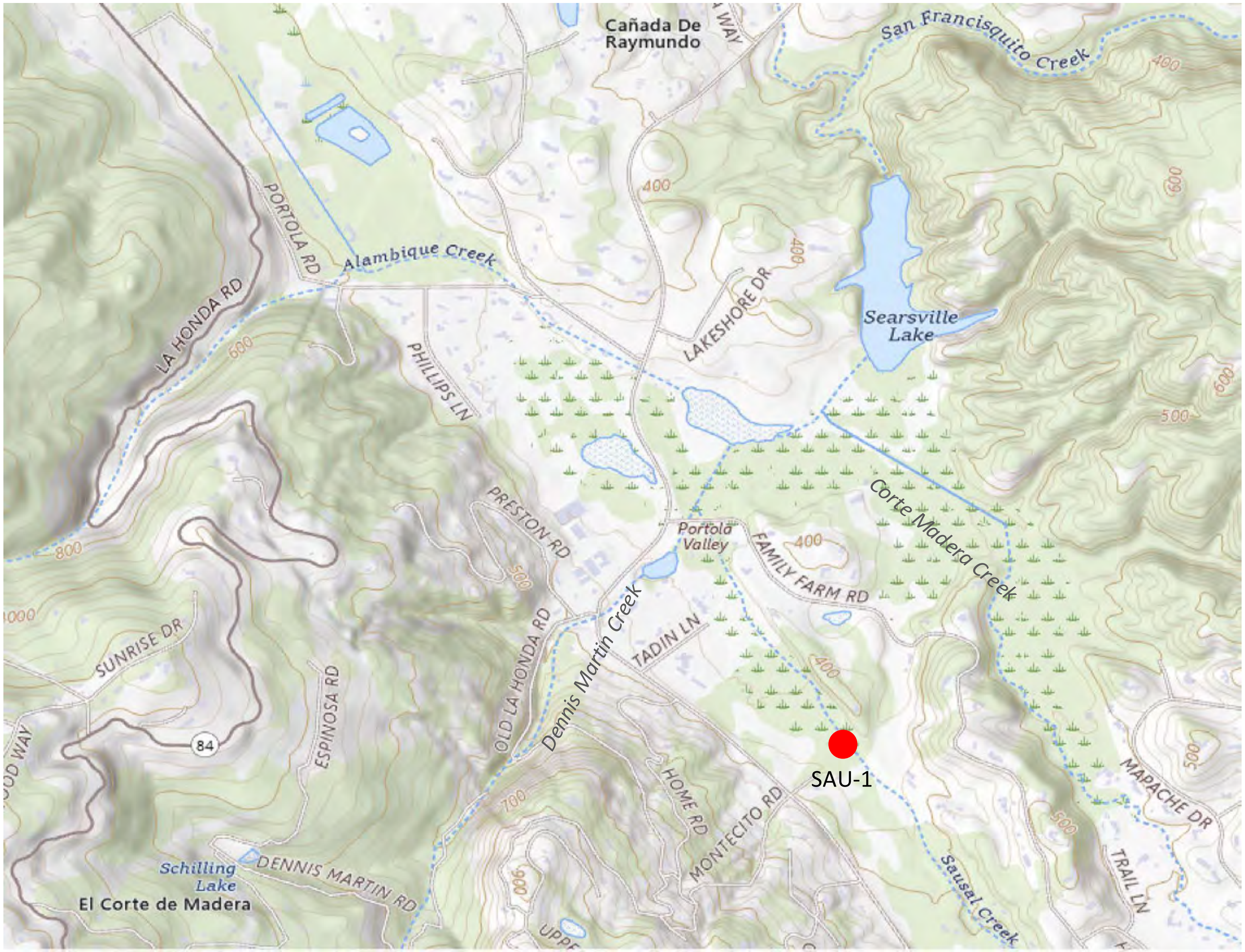
2023 eDNA at one timepoint (May 26) and 14 locations

SFC mainstem below Jasper Ridge Bio Preserve to Junipero Serra Blvd.

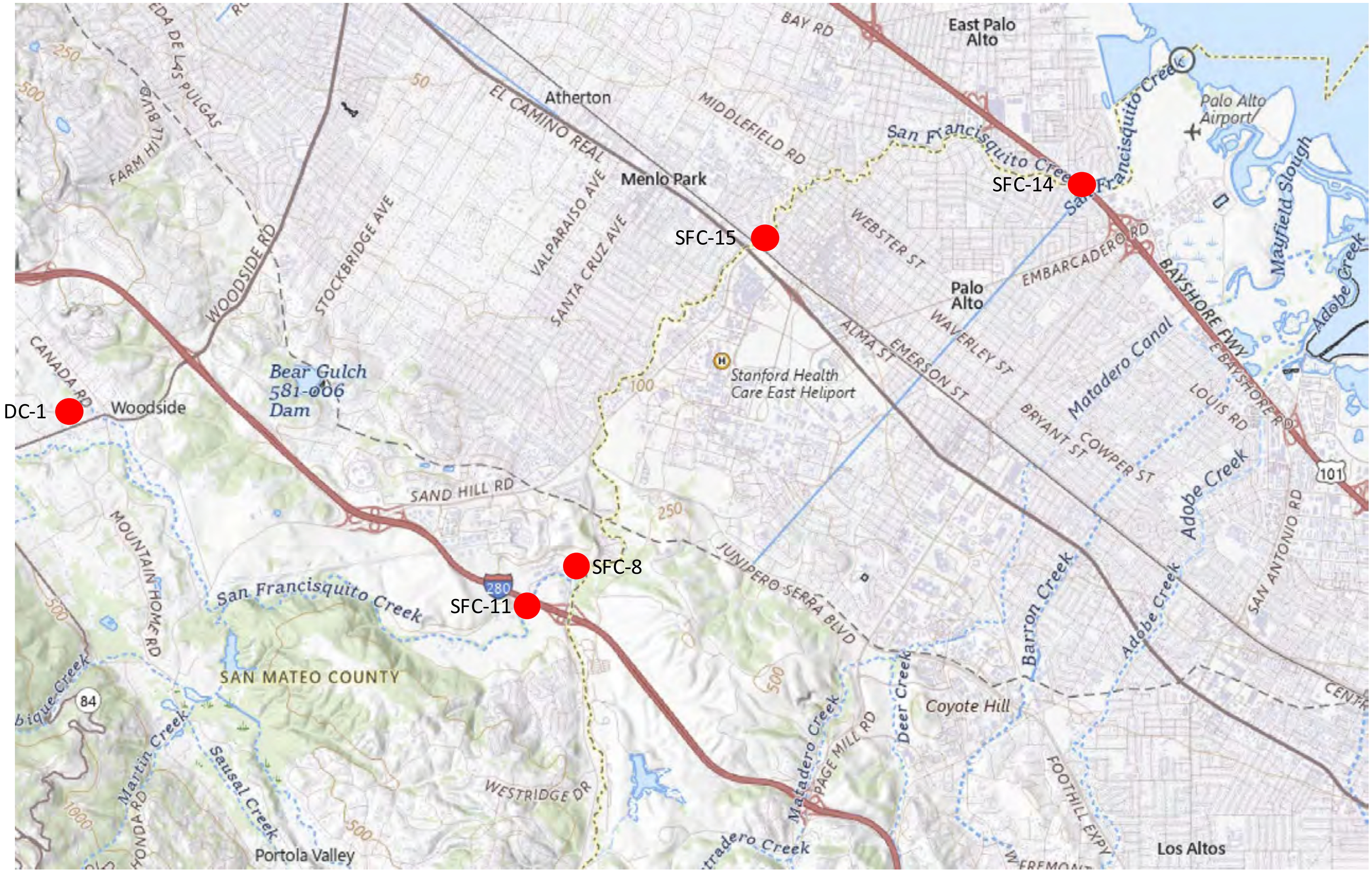


2023 eDNA at one timepoint (May 26) and 14 locations

One sample on Sausal Creek and Family Farm Road



2024 eDNA at 4 more widely spaced locations X 3 timepoints each (March 5, March 26, April 16) and (+ 1 sample at Dry Creek)



Environmental DNA (eDNA) analysis of San Francisquito Creek
(2023 & 2024 data)

RESULTS

Summary – 2023 and 2024 eDNA Surveys

1. Supratidal non-native fish species richness (8) greater than native fish species (7)
2. eDNA identified more total fish species (n=15, 7 native, 8 introduced) than 1990s prior electrofishing survey (n=13, 6 native, 7 introduced).
3. More fish species were identified in 2024 (n=12) with four more widely spaced collection sites sampled over three different time points than in 2023 (n=8) when 13 more closely spaced collection sites were sampled at a single time point, likely related in part to variation in winter-spring stream flows.
4. Although eDNA identified steelhead trout at a majority of sampling locations, there were no findings of Chinook salmon or Pacific lamprey.
5. eDNA identified native Sacramento blackfish which had not been previously reported.

Native fish species of the Supratidal San Francisquito Creek Mainstem = Seven* (1 new)
*2 Sculpins resolved only to *Cottus* genus by eDNA)

Native fish species	Native Range	Preferred Habitat	Earliest report	Leidy 1981[1]	Leidy 1993–1999[2]	eDNA 2023–2024
California roach (*Hesperoleucus symmetricus*)	California	Lotic shallow streams	1898	✓	✓	✓
Hitch (*Lavinia eXilicauda*)	California Central Valley and Central Coast	Lentic streams and rivers	-	-	-	(likely H. symmetricus)
Steelhead/rainbow trout (*Oncorhynchus mykiss*)	West Coast	Lotic, anadromous	1898	✓	✓	✓
Sacramento blackfish (*Orthodon microlepidotus*)	California Central Valley and Central Coast	Lotic and lentic, prefers slower flows, benthic	-	-	-	✓
Sacramento sucker (*Catostomus occidentalis*)	Central and Northern California/southern Oregon	Lotic streams, also lakes and brackish estuaries, benthic	1890	✓	✓	✓
Coastal riffle sculpin *(Cottus ohlone)*	Northern California Coastal Range	Lotic cool streams, benthic	1981	✓	✓	✓
Prickly sculpin (*Cottus asper*)	West Coast	Lotic	1898	-	✓	✓
Three-spined stickleback (*Gasterosteus aculeatus*)	Coastal holarctic	Lotic, anadromous	1898	✓	✓	✓
Sacramento pikeminnow (*Ptychocheilus grandis*)	Central and Northern California	Lotic	1898	-	-	-
Sacramento perch (*Archoplites interruptus*)	Central and Northern California	Lentic rivers and lakes	1860	-	-	-

[1] Leidy 1984 Distribution and Ecology of Stream Fishes in the San Francisco Bay Drainage (*Hilgardia*)
[2] Leidy 2007 Ecology, Assemblage Structure, Distribution, and Status of Fishes in Streams Tributary to the San Francisco Estuary, California (San Francisco Estuary Institute)

Non-native Fish species of the Supratidal San Francisquito Creek Mainstem = Eight (2 new, 1 not detected)

Non-native fish species	Native Range	Preferred Habitat	Earliest report	Leidy 1981[1]	Leidy 1993–1999[2]	eDNA 2023–2024
Black crappie (*PomoXis nigromaculatus*)	Eastern US	Lentic lakes, reservoirs	1981	-	✓	✓
Brown Bullhead (*Ameiurus nebulosus*)	Central US	Lentic lakes, ponds, slow-moving streams/river, benthic	1956	-	✓	✓
Bluegill (*Lepomis macrochirus*)	Eastern US	Lentic lakes, ponds	1978	-	✓	✓
Common carp (*Cyprinus carpio)*	Eurasia	Lentic eutrophic lakes, ponds, rivers, brackish estuaries		-	-	✓
Goldfish (*Carassius auratus*)	Asia	Lentic ponds	1974	-	-	✓
Green sunfish (*Lepomis cyanellus*)	Eastern US to Rocky Mountains	Lentic backwaters, lakes, ponds	1956	-	✓	✓
Rainwater killifish (*Lucania parva*)	Eastern US & MeXico	Lentic fresh- and brackish estuaries/coastal rivers	1977	✓	✓	✓
Western mosquitofish (*Gambusia affinis*)	Central US	Lentic, fresh- and saltwater	1981	✓	✓	-
Largemouth bass (*Micropterus nigricans*)	Eastern and Central US	Lentic rivers, lakes	1956	-	✓	✓
Tench (*Tinca tinca*)	Eurasia	Lentic fresh- and brackish water	1940	-	-	-
Atlantic salmon (Salmo salar)	North Atlantic and tributaries	Lotic, anadromous	1878	-	-	-
Japanese rice fish (*Oryzias latipes)*	East and Southeast Asia	Lotic, euryhaline, lakes, ponds, slow-moving streams	1930	-	-	-

[1] Leidy 1984 Distribution and Ecology of Stream Fishes in the San Francisco Bay Drainage (*Hilgardia*)
[2] Leidy 2007 Ecology, Assemblage Structure, Distribution, and Status of Fishes in Streams Tributary to the San Francisco Estuary, California (San Francisco Estuary Institute)

Searsville Dam Impacts on Salmonids

1. Dams are absolute barriers to anadromous fish passage. Searsville Dam blocks 20 miles of salmonid spawning and rearing habitat, including most of the Corte Madera Creek mainstem and its Alambique Creek, Dennis Martin Creek, and Sausal Creek tributaries.[1]

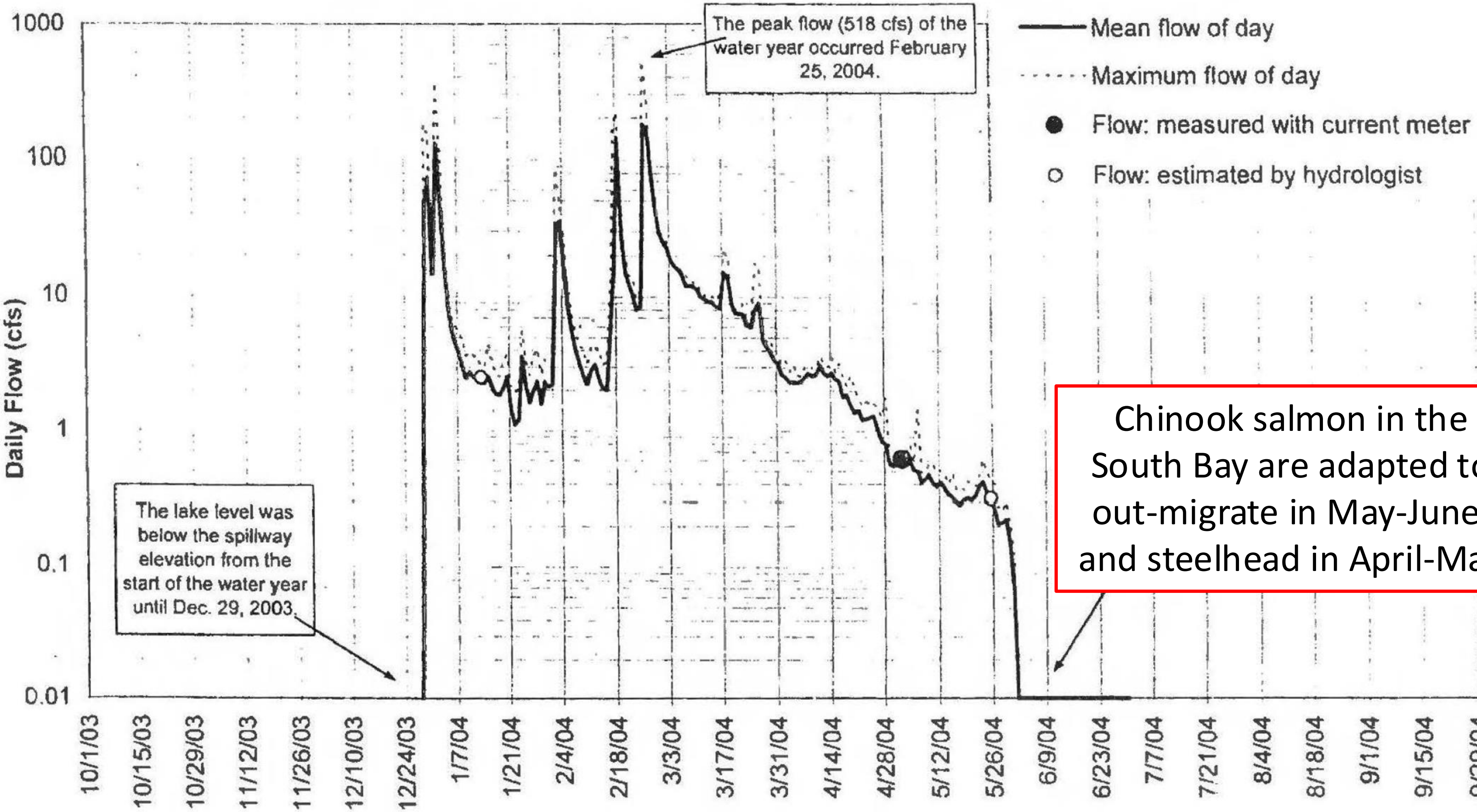
2. Reservoirs above dams gradually collect introduced non-native fish (and herp) species, some of which prey on juvenile salmonids (largemouth bass, bullfrogs) or salmonid eggs (carp, bluegill, sunfish).

3. Dams starve downstream spawning grounds of gravel substrate necessary for salmonid redds. Searsville Dam block gravel flows from Corte Madera Creek, and the Felt Lake Diversion Dam partially blocks gravel contributions from Los Trancos Creek, leaving Bear Creek as the only remaining major source of gravel to mainstem San Francisquito Creek

4. Searsville Dam shortens the hydroperiod downstream – reservoir filling in late fall/early winter delays downstream flows and the last winter rains fill the reservoir lowered by evaporation, again truncating downstream flows. Both result in stranded fish downstream.

[1] Stoecker 2014. Habitat Quality, Rainbow Trout Occurrence, and Steelhead Recovery Potential Upstream of Searsville Dam. Stoecker Ecological. Pp. 78.
[2] Hecht 2004. Daily flow hydrograph: Searsville Lake at Searsville Dam, water year 2004. Balance Hydrologics, Inc. Oakland, CA.

Searsville Dam Shortens the Downstream SFC Hydroperiod, Stranding Salmonids



Chinook salmon in the South Bay are adapted to out-migrate in May-June, and steelhead in April-May

Figure 1: Hecht 2004. Daily flow hydrograph: Searsville Lake at Searsville Dam, water year 2004. The peak flow for the water year occurred Feb. 25, 2004. Flow over the dam ends quickly in the late spring. Balance Hydrologics, Inc. Note: Y aXis is logarithmic.

eDNA 2023 Detailed Results – All 5/26/2023

8 Fish species (5 native, 3 introduced)

Identifier	Location	Bullhead	Goldfish	Green sunfish	Roach /Hitch	Steelhead trout	Sacramento Blackfish	Sacramento Sucker	3-Spined Stickleback	Pacific tree frog	California newt	Western toad	Mallard
LDCT - Control	-												
LTC1	Piers Lane Bridge				X	X				X			X
LTC2	I280 Bridge				X	X							X
SAU1	Farm Family Rd Bridge			X						X			X
SFC1	Junipero Serra Blvd			X	X	X		X	X				X
SFC2	below USGS Stream Gage Weir				X			X	X				X
SFC3	above USGS Stream Gage Weir				X								X
SFC4	Stanford Pump Station and weir		X		X	X		X	X	X			X
SFC5	Stowe Lane				X	X		X	X				X
SFC6	Bishop Lane/ Bishop Creek Ct			X	X			X	X	X			X
SFC8	Piers Lane Bridge		X	X	X	X	X	X	X	X	X	X	X
SFC9	Alpine Road Bridge			X	X	X		X	X				X
SFC11	I280 Bridge	X	X	X	X	X		X	X	X	X	X	X
SFC12	Webb Ranch Horse Bridge				X			X	X		X		X
SFC13	Top of Webb Ranch	X	X	X	X			X	X	X			

eDNA 2024 Detailed Results – 13 Fish Spp. (5 Native, 8 Introduced)

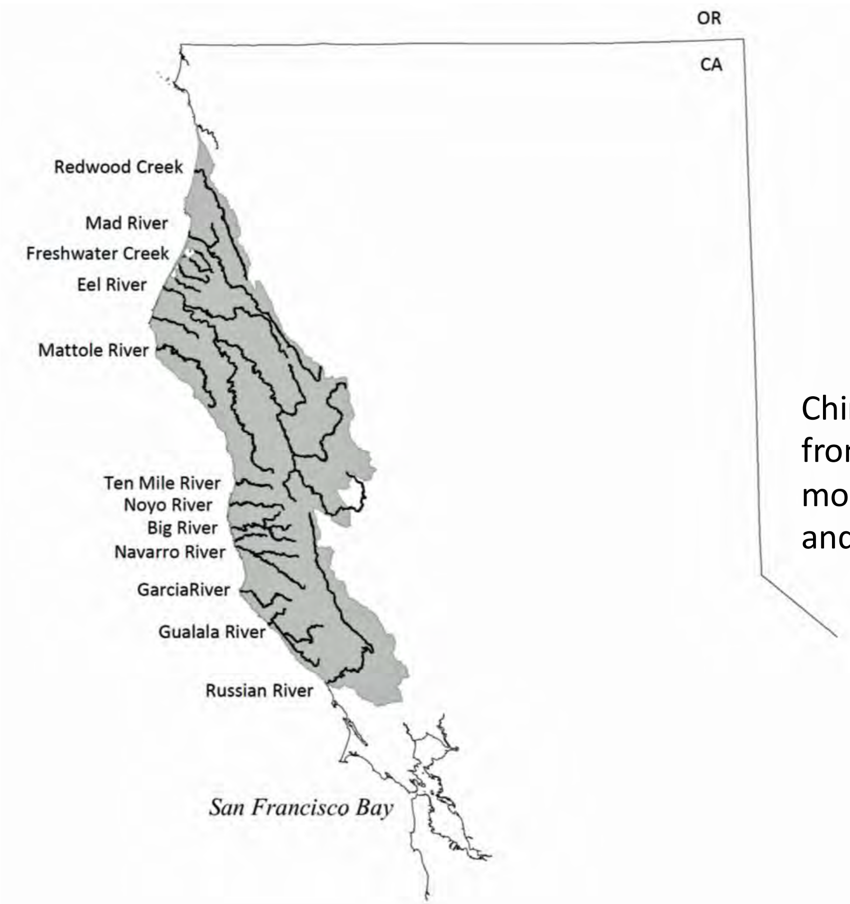
Identifier	Location	Black Crappie	Bullhead	Bluegill	Carp	Goldfish	Green sunfish	Largemouth bass	Rainwater killifish	Roach /Hitch	Steelhead trout	Sacramento Blackfish	Sacramento Sucker	Sculpin	3-Spined Stickleback	Bullfrog	Pacific tree frog	Salamander	Western fence lizard	Western toad	Hooded Merganser	Mallard
SFC14 3/5/24	Bayshore Rd, S. of Hwy 101									X	X		X	X	X							X
SFC15 3/5/24	El Palo Alto Park									X	X		X	X	X					X		X
SFC8 3/5/24	Piers Lane Bridge						X			X			X									
SFC11 3/5/24	I280 Bridge									X			X		X		X					
Control 3/5/24																						
SFC14 3/26/24	Bayshore Rd, S. of Hwy 101						X		X	X			X	X	X			X				X
SFC15 3/26/24	El Palo Alto Park		X			X	X			X	X	X	X	X	X			X				X
SFC8 3/26/24	Piers Lane Bridge		X				X			X	X	X	X		X		X	X			X	X
SFC11 3/26/24	I280 Bridge					X	X			X	X	X	X		X		X				X	X
Control 3/26/24																						
SFC14 4/16/24	Bayshore Rd, S. of Hwy 101		X	X	X	X		X		X	X	X	X	X	X		X					X
SFC15 4/16/24	El Palo Alto Park		X	X	X	X	X			X	X	X	X		X							X
SFC8 4/16/24	Piers Lane Bridge	X	X		X	X	X			X	X	X	X		X		X					X
SFC11 4/16/24	I280 Bridge	X	X	X	X	X	X			X	X	X	X		X	X	X					X
DC14 4/16/24	Dry Creek - Buck's									X	X						X		X			X
Control 4/16/24																						

Key Learnings & Next Steps

1. Wider spatial intervals with multiple timepoints appears a superior approach as winter flows and timing of spawning and hatching vary eDNA concentrations.
2. eDNA matched electrofishing surveys with low labor investment, and were inexpensive
3. An ecosystem-level assessment of the fish assemblage sets a baseline prior to Searsville Dam fenestration. Hopefully the native vs. non-native fish assemblage will change.
4. Sacramento blackfish have been "discovered" using eDNA in multiple other SF Bay tributaries as well.
5. Sacramento pikeminnow and Sacramento perch described historically, seem lost
6. Why were Chinook salmon not detected?
   a) eDNA may peak when spawners' carcasses decay vs. goal to detect juveniles and prove successful spawning/rearing – plan Dec-Jan-Feb sampling.
   b) Lack of larger gravel substrate may have led to poor/no success building redds.
   c) Nearby source populations only recently gaining a foothold – the 2025 Guadalupe River run was 600 strong.

SUPPLEMENTARY SLIDES

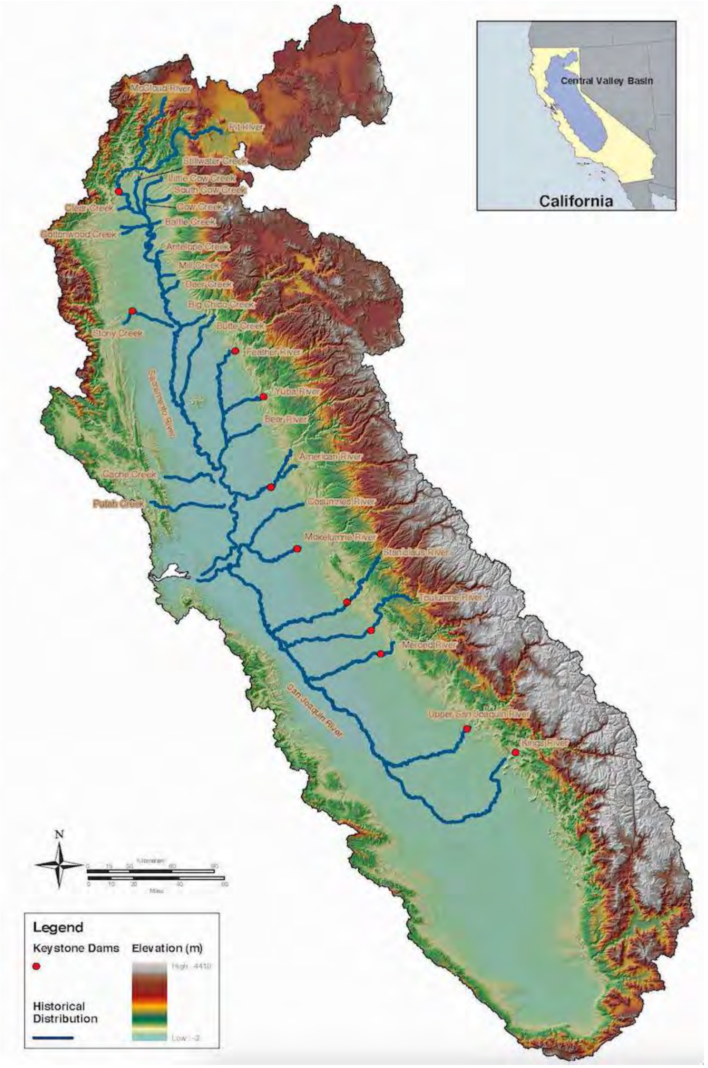
NOAA NMFS Map of the California Coastal Chinook Salmon ESU EXcludes San Francisco Bay Tributaries[1]



Chinook were considered eXtirpated and historically scarce from the Russian River until a 5-year underwater camera monitoring study in the early 2000's revealed an abundant and self-sustaining population.[2]

[1] Schick, RS, et al. 2005 Historical and Current Distribution of Pacific Salmonids in the Central Valley, CA. Santa Cruz, California: NOAA Fisheries, Southwest Fisheries Science Center Report No.: NOAA-TM-NMFS-SWFSC-369.
[2] Chase et al. 2007 Historical accounts, recent abundance, and current distribution of threatened Chinook salmon in the Russian River, California. *California Fish and Game Journal*.

NOAA NMFS Map for Fall-run Central Valley Chinook Also Excludes San Francisco Bay Tributaries



At least since the 1980's, the lower, perennial reaches of four San Francisco Bay tributary watersheds host Chinook salmon runs:

1. Walnut Creek in Suisun Bay
2. Napa River in the San Pablo Bay
3. Guadalupe River in the South Bay
4. Coyote Creek in the South Bay

O'Farrell, Michael, et al. 2015 California Coastal Chinook Salmon Fishery Management: Future Prospects. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-542. https://repository.library.noaa.gov/view/noaa/4924