California Lamprey Considerations for People Restoring Streams Workshop and Field Tour

A Concurrent Session at the 40th Annual Salmonid Restoration Conference held in Fortuna, California from April 25–28, 2023

Session Coordinators:

- Katrina Nystrom, Salmonid Restoration Federation
- Marisa McGrew, Wiyot Tribe
- Abel Brumo, Stillwater Sciences

Most of the restoration and conservation activities that occur in Pacific coastal streams are intended to promote salmonid recovery but could also benefit native lampreys. This workshop will highlight the efforts of the Pacific Lamprey Conservation Initiative (PLCI) and its Restoration Subgroup to bring attention to these ecologically and culturally important species and leverage the expertise of individuals studying and working to restore them in California. The goals of the workshop are increasing awareness of native lamprey species, enabling stakeholders to identify different lamprey species in the field, and empowering participants with the knowledge and practical tools to incorporate lamprey needs and conservation practices into their restoration projects and in-water work activities.

The workshop will include a morning classroom session and an afternoon field tour. The classroom session will include presentations covering lamprey biology and systematics, cultural and ecological importance, and differences in life history and habitat requirements from salmonids. The afternoon field tour will visit local streams to observe lampreys and their habitats. The tour will include discussions of techniques for lamprey sampling and salvage, best management practices, and opportunities to integrate lamprey into salmonid-focused restoration projects.

Presentations

- Slide 4, **Fostering Enthusiasm and Partnerships to Advance Lamprey Conservation,** Josh Boyce, Ph.D., *USFWS,* and Co-Author; Alicia Marrs, *Pacific Lamprey Conservation Initiative*
- Slide 31, **A Bounty of Lampreys - BioDiversity in Lampreys**, Stewart Reid, *Western Fishes*
- Slide 63, **Seeking Sand: Habitat Constraints for Lampreys***,* Stewart Reid*, Western Fishes*
- Slide 91, **Reconnecting Pacific Lamprey with their Historical Habitats in California**, Damon Goodman, *CalTrout*
- Slide 109, **Pacific Lamprey: Anthropocene Sentinel for Pacific Northwest Water Quality**, Cynthia LeDoux-Bloom, *Department of Fisheries Biology, Cal Poly Humboldt*
- Slide 135, **Filter Feeding by Larval Pacific Lamprey for Reducing Escherichia Coli and Improving Water Quality**, Parker Kalan, *Tenera Environmental, Inc*
- Slide 165, **Central Valley Lamprey: An Overlooked Presence in High Use Watersheds**, Christina Parker, MNR, *California Department of Fish and Wildlife*

Fostering Enthusiasm and Partnerships for Lamprey Conservation

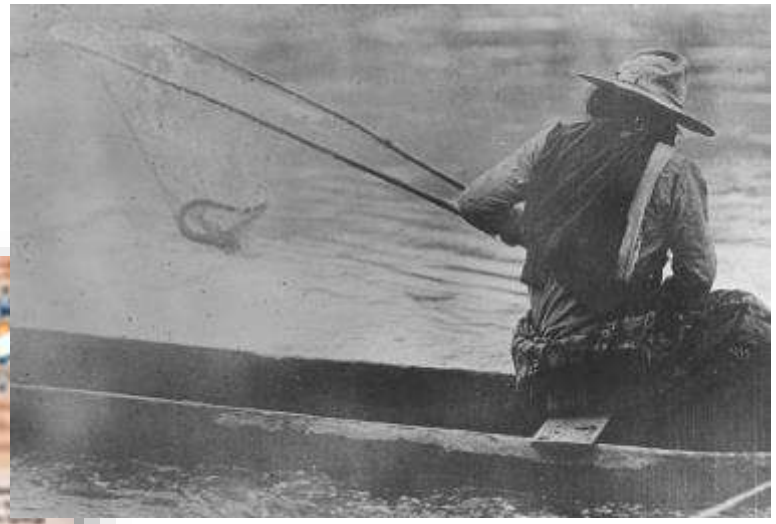
Josh Boyce, U.S. Fish & Wildlife Service
Alicia Marrs, National Wildlife Federation

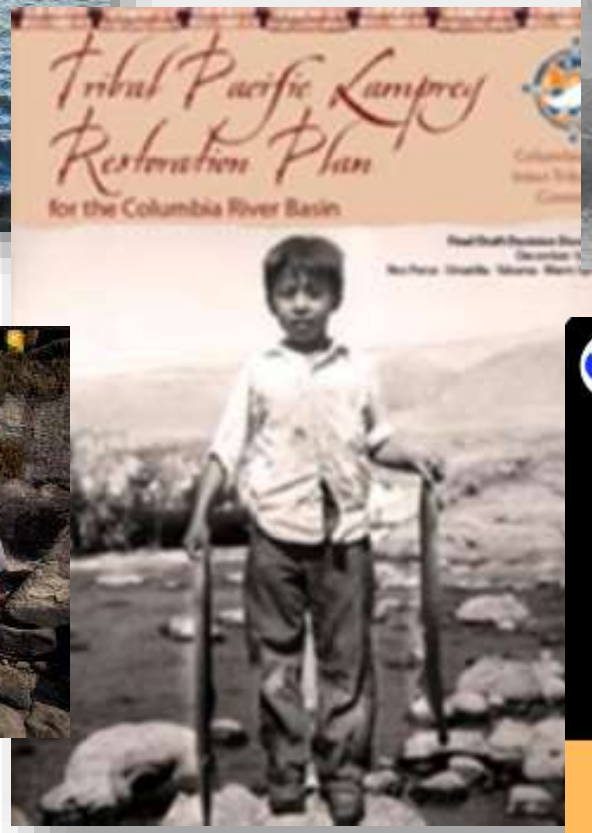
Salmonid Restoration Federation Annual Meeting, April 25-28, 2023
Fortuna, California


One of the oldest and fascinating animals on earth!
Often misunderstood
Culturally important
There is so much to do and learn!
Ecologically important
Experiencing significant declines
in population and distribution
NAIAD.org
Dave Herasimtschuk © Fl

Cultural Significance of Lamprey Provides Foundation for PLCI

- Traditional first food and medicinal use
- Continued harvests in the lower 48 and Alaska.
- Concern from tribes drove push for initial listing and creation of restoration plans.
- Tribes continue to be leaders in elevating the need and urgency for lamprey conservation.



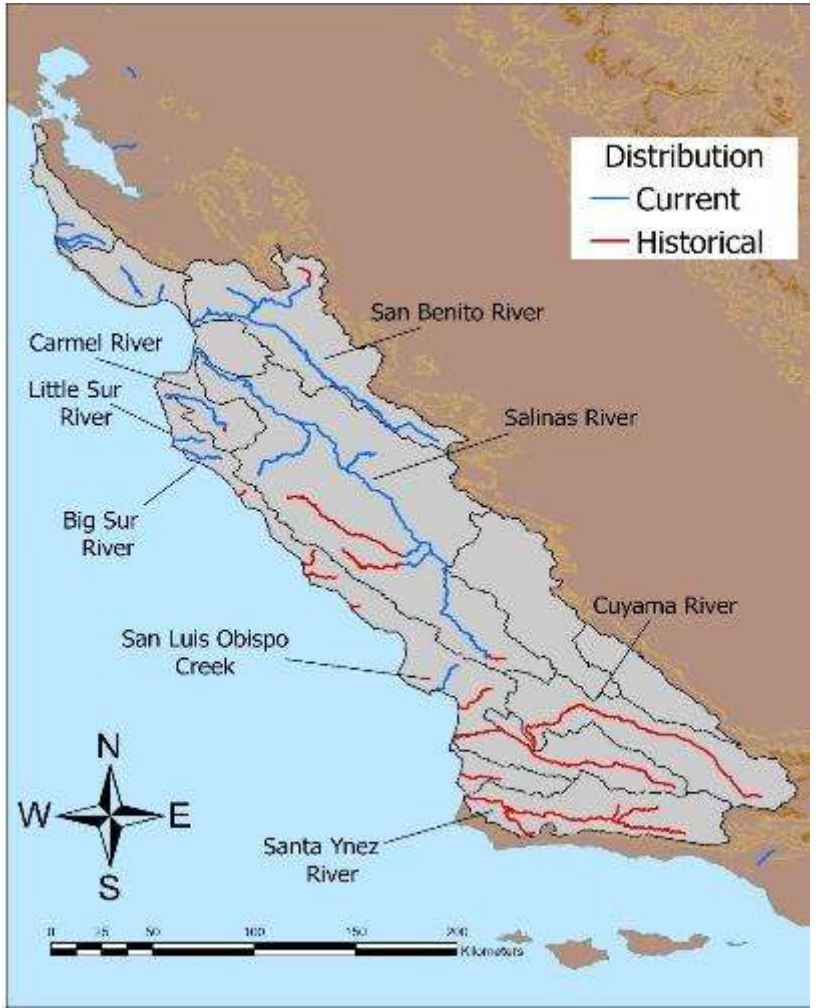


Limited information on role of lamprey for tribes south of the Eel River

Hoopa Tribe
Trinity River

Yurok Tribe
Klamath River

Carmel River Steelhead Association
Esselen Tribe:
Tom Little Bear Nason
Cari Werthel
Jana Nason



Pacific Lamprey Conservation Initiative

What is the Pacific Lamprey Conservation Initiative (PLCI) ?

PLCI is a collaboration of Native American tribes, federal, state, municipal and local agencies, and non-profits working together to conserve Pacific Lamprey.

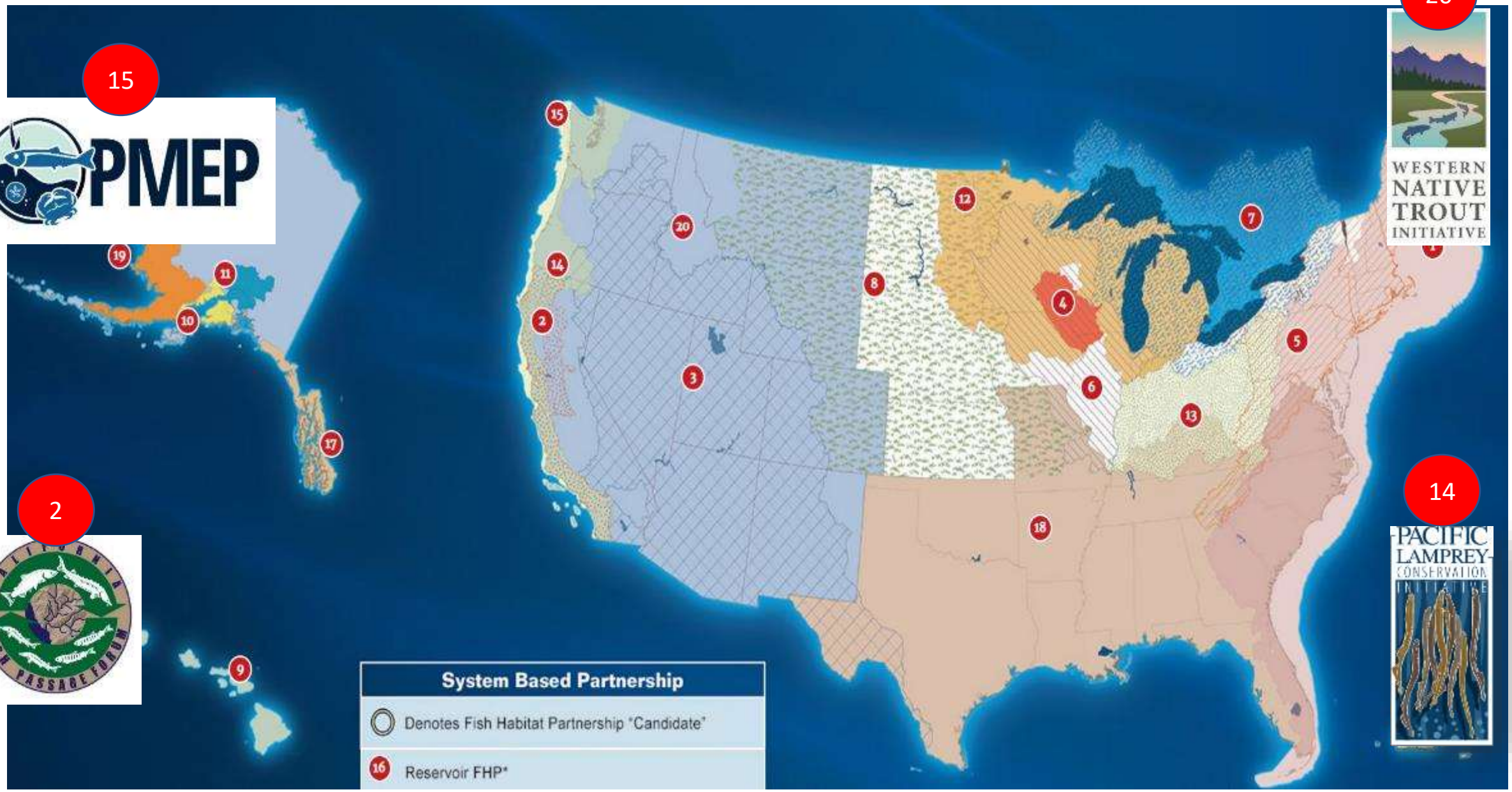
Mission

Achieve long-term persistence of Pacific Lamprey and their habitats and support their traditional tribal use throughout their historical range (AK, CA, ID, OR, WA).

PLCI by the Numbers

- > 170 partners
- 36 signatories to the Conservation Agreement
- 18 Regional Management Units
- 5 Western States
- 1 of 20 Fish Habitat Partnerships

National Fish Habitat Partnerships

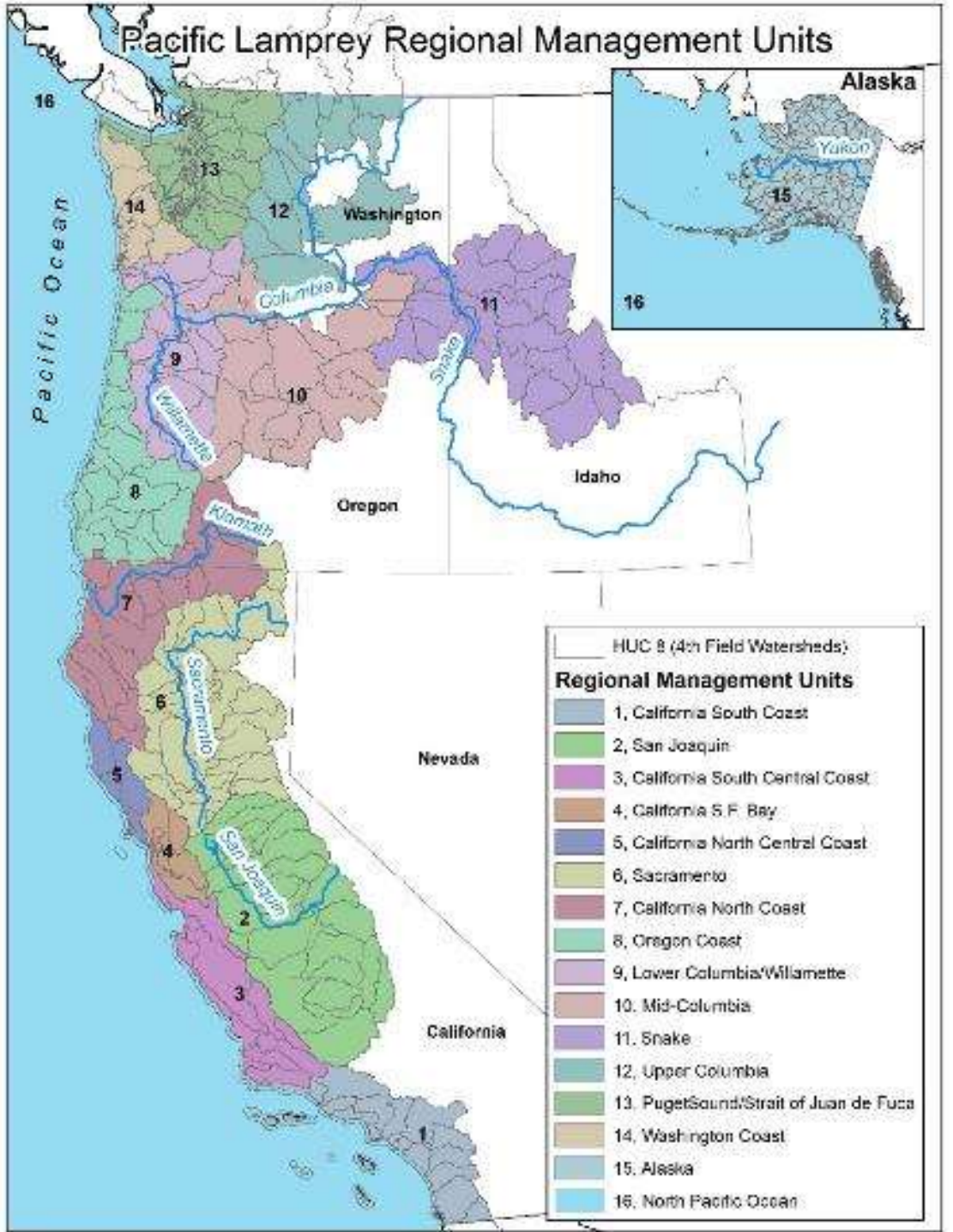


Three primary components of PLCI:

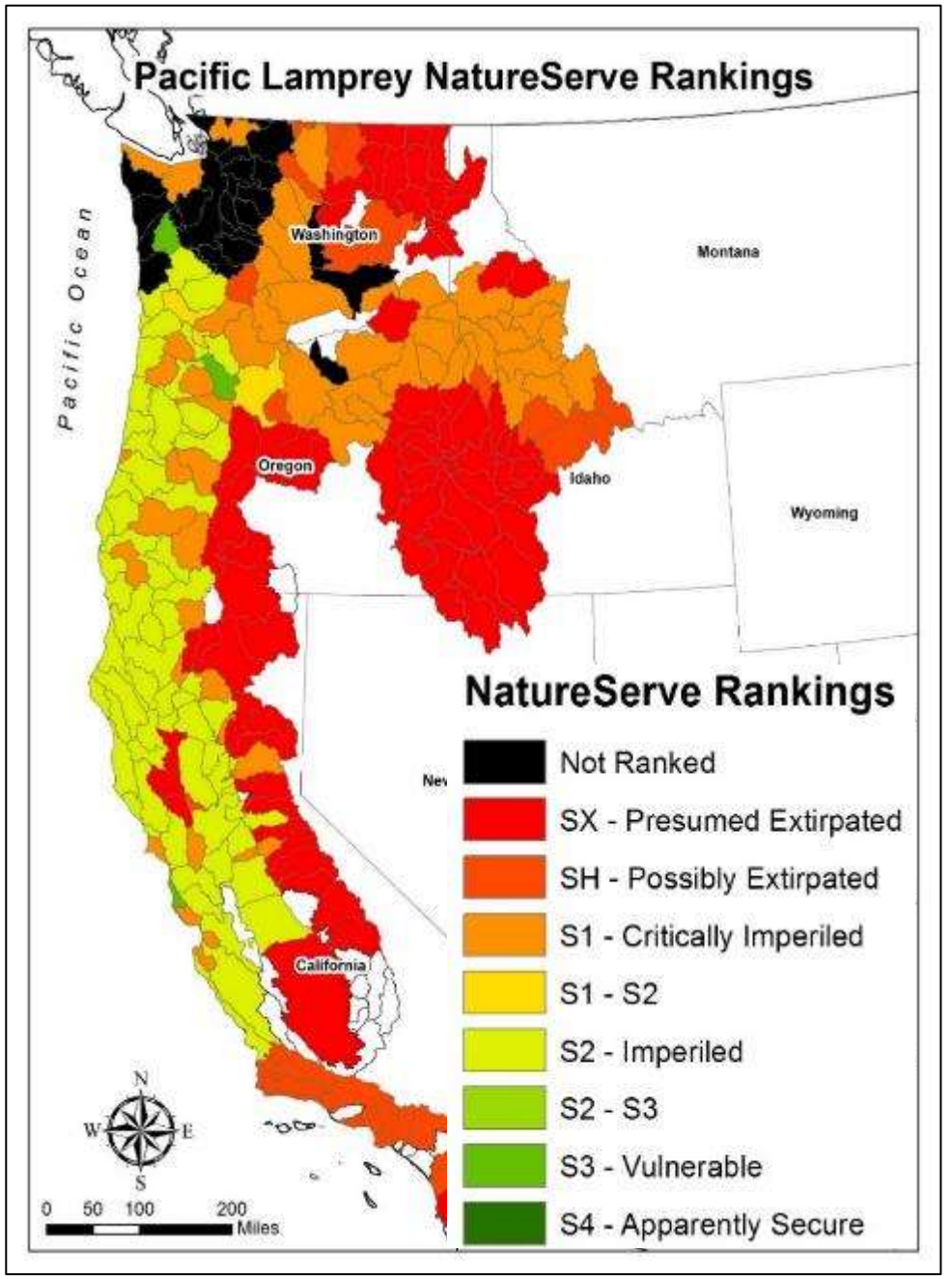
- **Assessment:**
  - habitat condition, demographics, distribution, and threats every 5 years
- **Regional Implementation Plans:**
  - 18 Regional Management Units (RMUs)
  - prioritize, and implement key conservation actions
- **Conservation Agreement:**
  First signed in 2012
  Voluntary commitment by partners

AND!

Lamprey Summit V:
December 13, 2022
Updated all three components



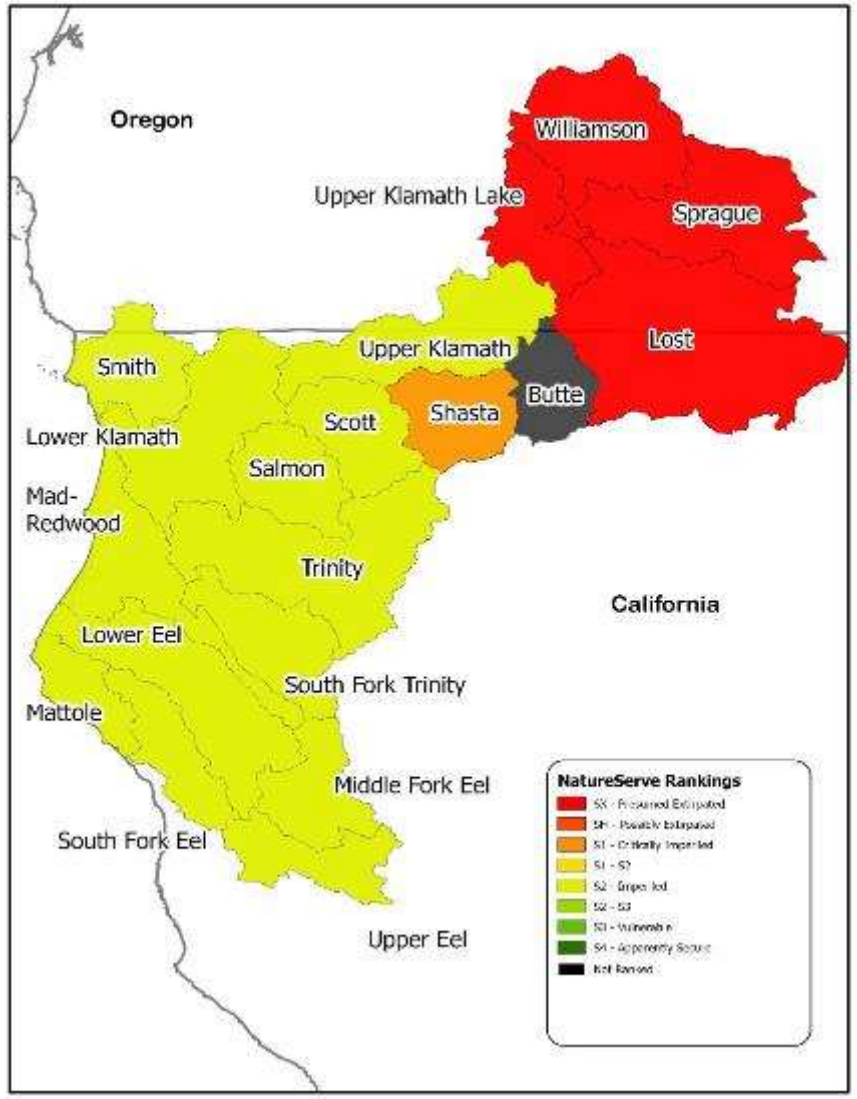
- **Assessments** have been conducted in 2011, 2017-2018, 2022
- Track **current knowledge** of Pacific Lamprey population demographics and threats
- Rankings created using diagnostic tool adapted from **NatureServe model**
- **Local knowledge is key** to informing the Assessment – annual **RMU calls an opportunity to provide feedback** and discuss major changes



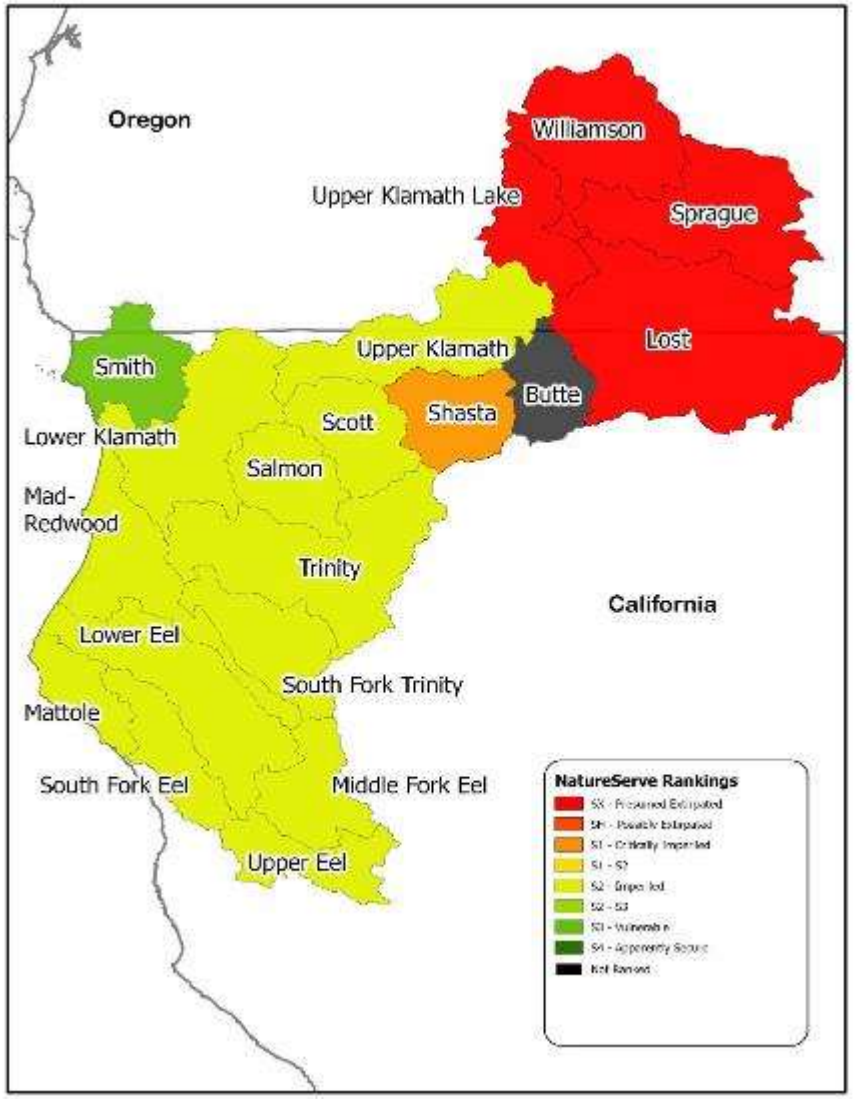
Pacific Lamprey Risk Assessment

Characterizes conservation risk of Pacific Lamprey across their range

2022 Pacific Lamprey Assessment: North Coast RMU



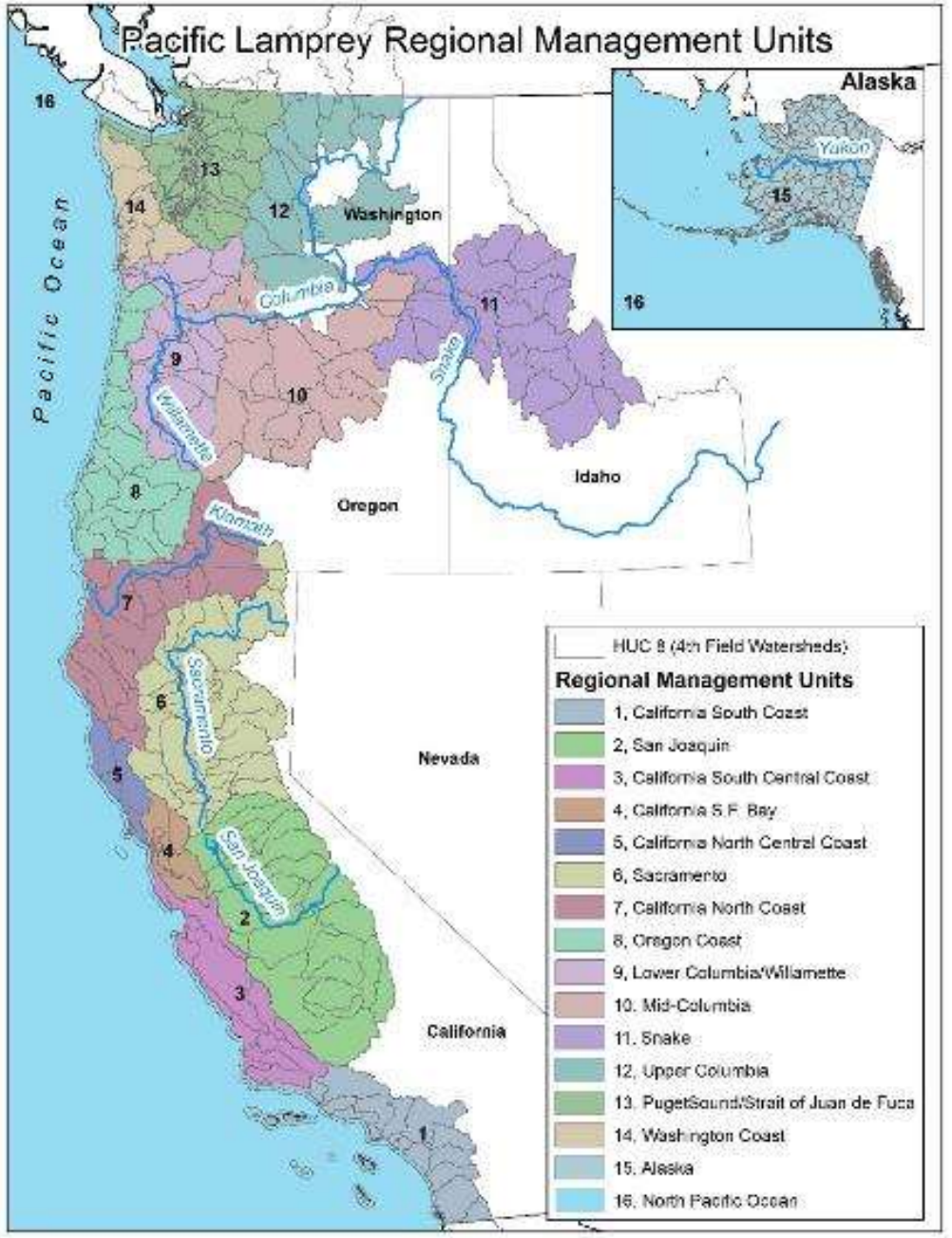
2017 Assessment



2022 Assessment

18 Regional Management Units

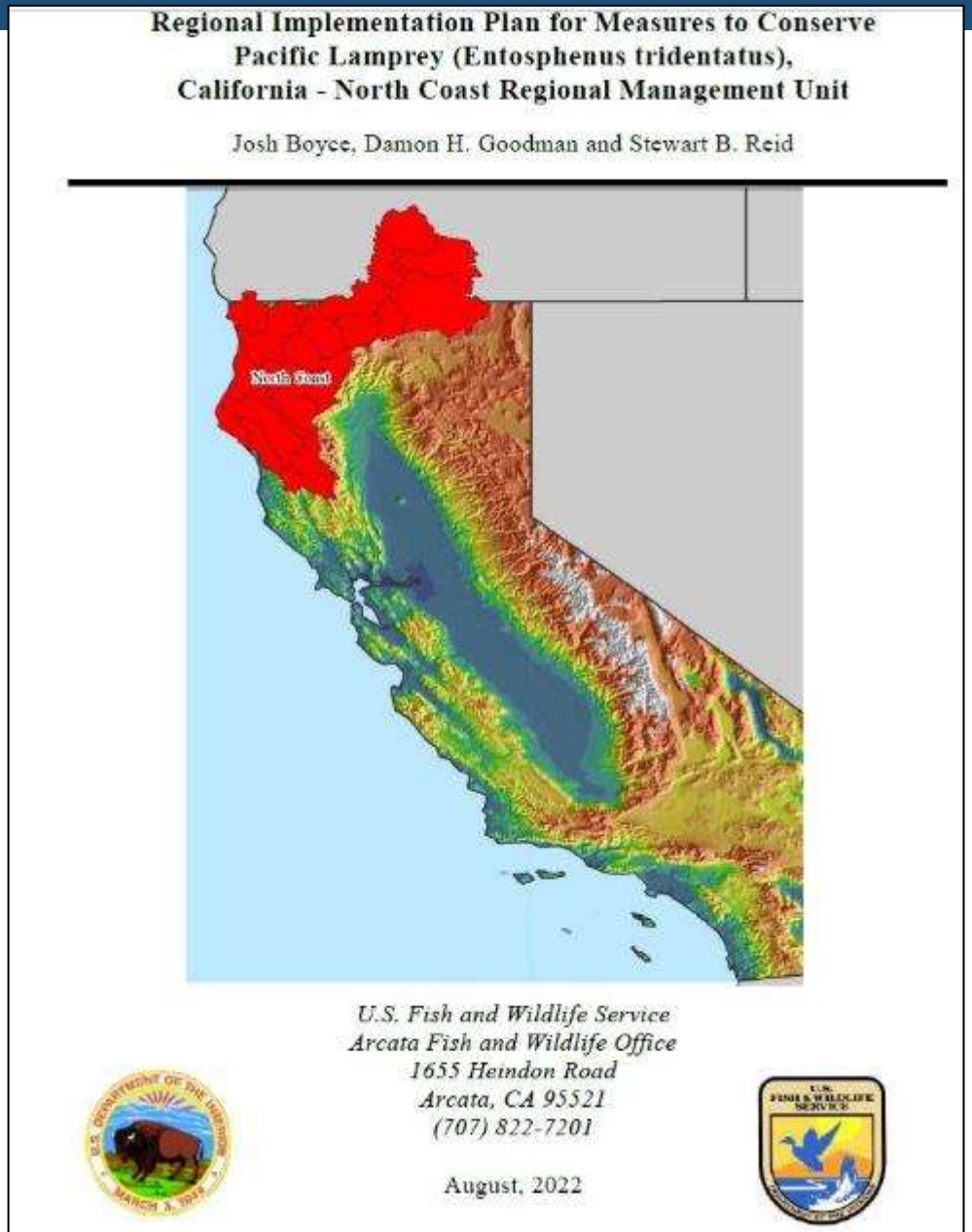
- Participation open to any biologists, restoration practitioners, researchers, managers, etc. (you?)
  - Targeting those with local knowledge/interest of rivers and threats to the RMU
- Annual Meetings
- Identify Risks and Restoration Actions
- Share Information and Resources
- Collaborate on Projects
- Produce Regional Implementation Plans (RIPs) – Available online

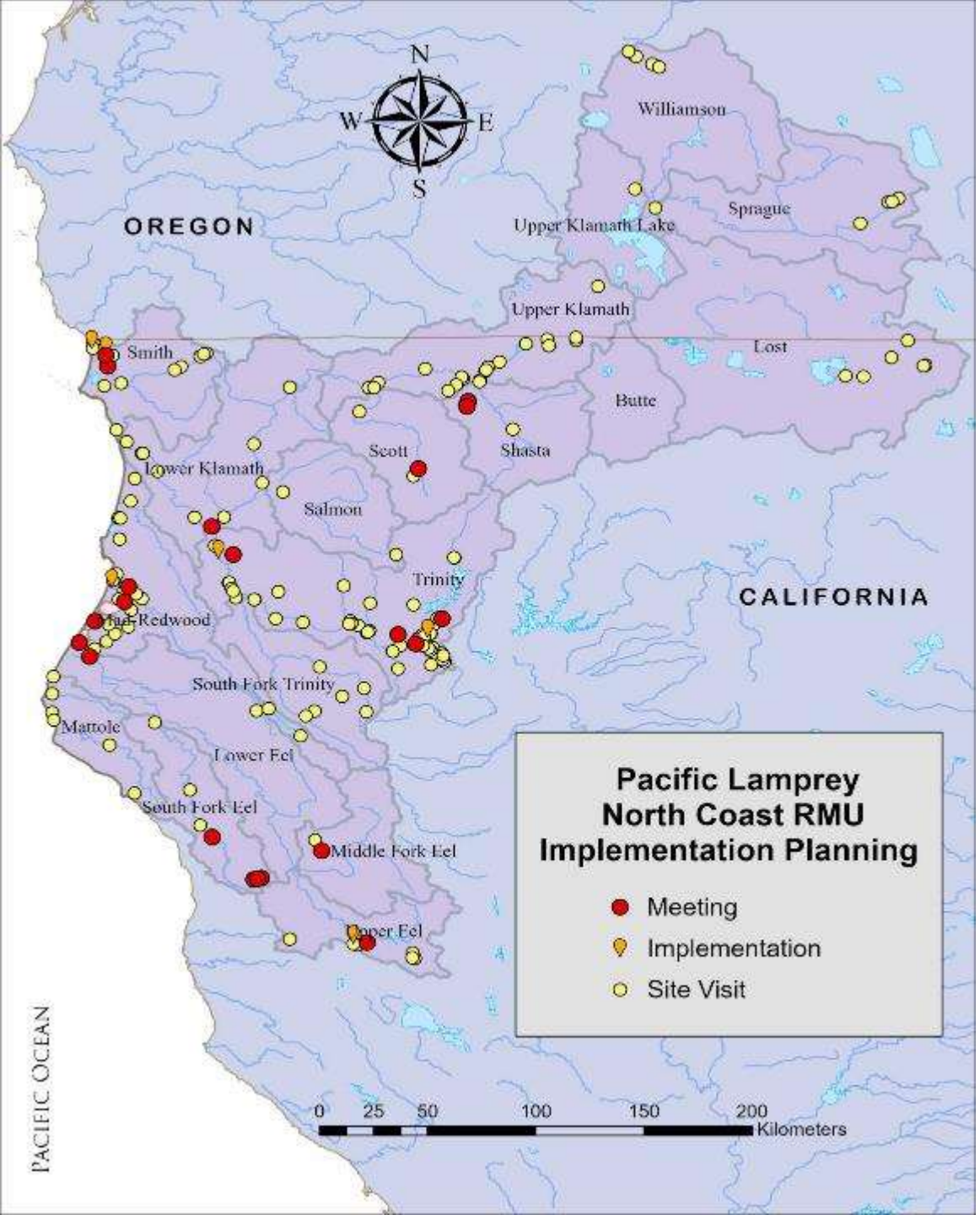


Learn more here: www.pacificlamprey.org/rmu

Regional Implementation Plans (RIPs)

- Adaptive management based on local insights
- Summarize Pacific Lamprey status, distributions, and threats
- Highlight completed and ongoing conservation measures (stakeholder meetings; site visits)
- Identify high priority projects that address key threats
- Help inform project proposals for PLCI funding





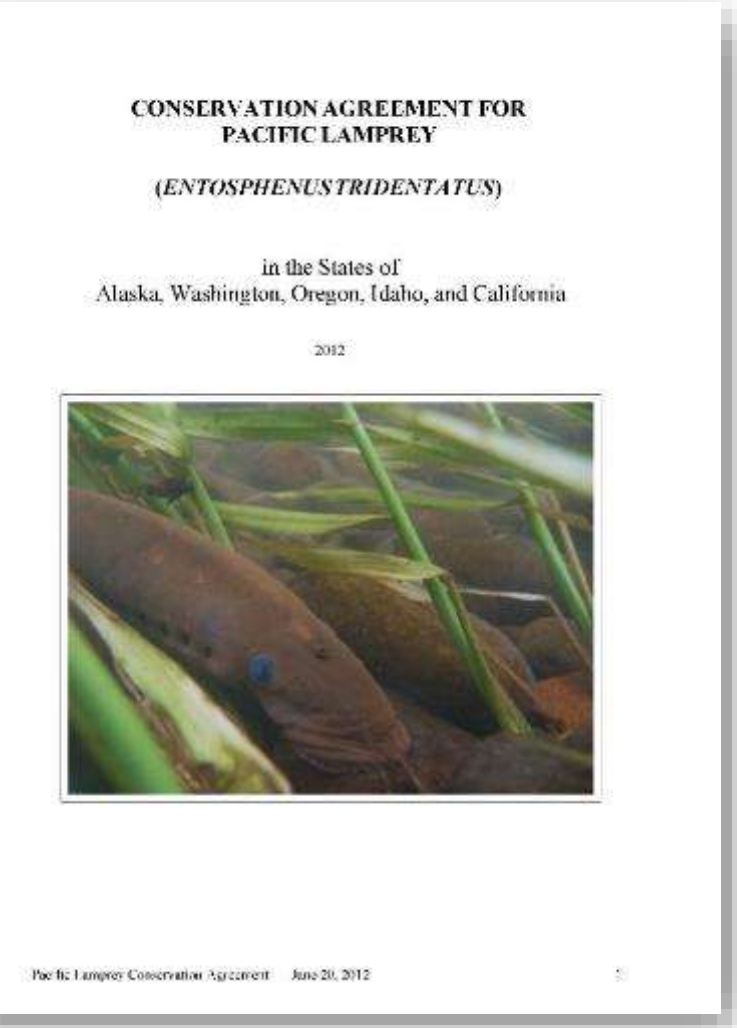
Key Priorities:

monitoring (all life stages)
- *distribution*
- rotary screw traps
- Wiyot tribe

research
- flow management and migration
- thermal/DO tolerances of adults (mortalities)

restoration
- Klamath River “dead zone” above Scott River confluence

passage
- upper Klamath
- Eel River


CONSERVATION AGREEMENT FOR
PACIFIC LAMPREY

(*ENTOSPHENUS TRIDENTATUS*)

in the States of
Alaska, Washington, Oregon, Idaho, and California

2012

Pacific Lamprey Conservation Agreement June 20, 2012

- Conservation Agreement is revisited every 5 years
- 2022 is the first time it is being updated
  - No changes made in 2017 – only added signatories
- 2022 Conservation Agreement reflects a comprehensive review by PLCI's Conservation Team to capture current status and progress made by PLCI and partners in support of lamprey conservation since 2012
- Opportunity for new partners

2022 Update to Conservation Agreement

Original Conservation Agreement Partners

Yakama Nation
Umatilla Tribes
Warm Springs Tribes
Cow Creek Band of Umpqua Tribe
Grand Ronde Tribes
Siletz Tribes
Blue Lake Rancheria Tribe
Mechoopda Tribe
Wiyot Tribe
Yurok Tribe
Coos, Lower Umpqua Siuslaw Tribes
California Dept of Fish and Wildlife
Oregon Dept of Fish and Wildlife
Idaho Dept of Fish and Game
Washington Dept of Fish and Wildlife
Alaska Dept of Fish and Game
Portland Metro
Oregon Zoo

City of Portland Environmental Services
Portland General Electric
Bonneville Power Administration
U.S. Army Corps of Engineers
U.S. Bureau of Indian Affairs
U.S. Bureau of Land Management – CA, ID & OR
U.S. Bureau of Reclamation
US Fish and Wildlife Service – Regions 1, 7 & 8
U.S. Forest Service – Regions 1, 4, 5 & 6
National Marine Fisheries Service
Pacific States Marine Fish Commission
Lower Columbia River Estuary Partnership
Columbia Land Trust
Salmon Creek Watershed Council
California Dept of Water Resources
U.S. Environmental Protection Agency – Region 10
Grant County PUD
Chelan County PUD

Road to Lamprey Summit V

Lamprey Summit I (2004)
Petition to List

Lamprey Summit II (2008)
Workshop to lay the groundwork to est. PLCI

Lamprey Summit III (2012)
First Conservation Agreement signed (photo right)

Lamprey Summit IV (2017)
Recommitment to Conservation Agreement & Revised Assessment

Lamprey Summit V (2022)
Revised Conservation Agreement
Revised Assessment
Revised Regional Implementation Plans

PLCI Facilitates Lamprey Project Funding

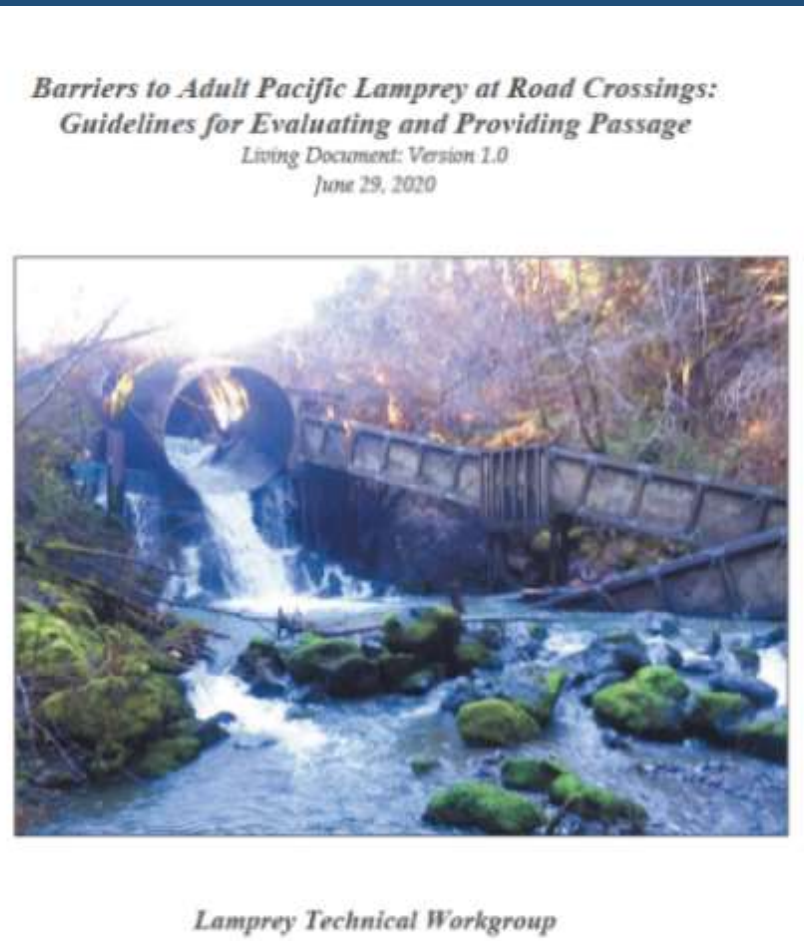
- **New in 2022!**
  - Two separate Requests for Proposals (RFPs)
- **Bonneville Power Administration**
  - RFP announced Aug 2022
  - Funding available for projects in the Columbia River Basin
- **National Fish Habitat Partnership**
  - RFP announced Fall 2022
  - Funding available for projects in any RMU
- **Other potential opportunities**
  - Bi-partisan Infrastructure Legislation (BIL)

Lamprey Technical Workgroup

- Lamprey Technical Workgroup (LTWG) is the **technical advisory committee** of PLCI
- Nearly **175 members**
- **13 subgroups** providing specialized expertise
- Facilitates sharing of information and techniques throughout lamprey research and conservation community with **Lamprey Information Exchanges**
  - Pivoted to a webinar series in 2021 and 2022
  - Hoping for in-person **December, 2023**
- Participation open to all lamprey enthusiasts
  - Contact the LTWG Chair, Christina Wang (USFWS)
    - christina_wang@fws.gov

Lamprey Technical Workgroup Subgroups

- Adult Passage
- Juvenile Entrainment, Dredging, and Dewatering Investigations (JEDDI)
- Genetics and eDNA
- Ocean
- Contaminants
- Other Lamprey Species-Anadromous and Resident (SOLAR)
- Tagging
- Engineering Criteria/BMGs
- Restoration
- Outreach
- Lamprey Aquaculture Partnership NEW!
- Barriers to Tidal Connectivity NEW!
- Abundance Goals NEW!



www.pacificlamprey.org/ltwg

Recent Publications

Recent LTWG Publications

- *Best Management Guidelines for Native Lampreys During In-water Work* (LTWG)
- ***Comparison of Pacific Lamprey and Pacific Salmon Life Histories, Habitat and Ecology*** (LTWG)

Other Recent Publications

- *Microhabitat use by pre-spawning Pacific lamprey Entosphenus tridentatus in a large, regulated river differs by year, river segment, and availability* (Clemens and Schreck 2021)
- *Dispelling misperceptions of native lampreys (Entosphenus and Lampetra spp.) in the Pacific northwest (USA)* (Clemens and Wang 2021)

**More lamprey publications can be found on the PLCI Data Clearinghouse:

https://www.sciencebase.gov/catalog/item/53ad8d9de4b0729c15418232

Comparison of Pacific Lamprey and Pacific Salmon Life Histories, Habitat and Ecology

Living Document, Original Version 1.0

March 8, 2023

Lamprey Technical Workgroup

Living document

- lamprey restoration is new
- anticipate changes

Life history/habitat comparisons

Ecosystem interactions and considerations for restoration

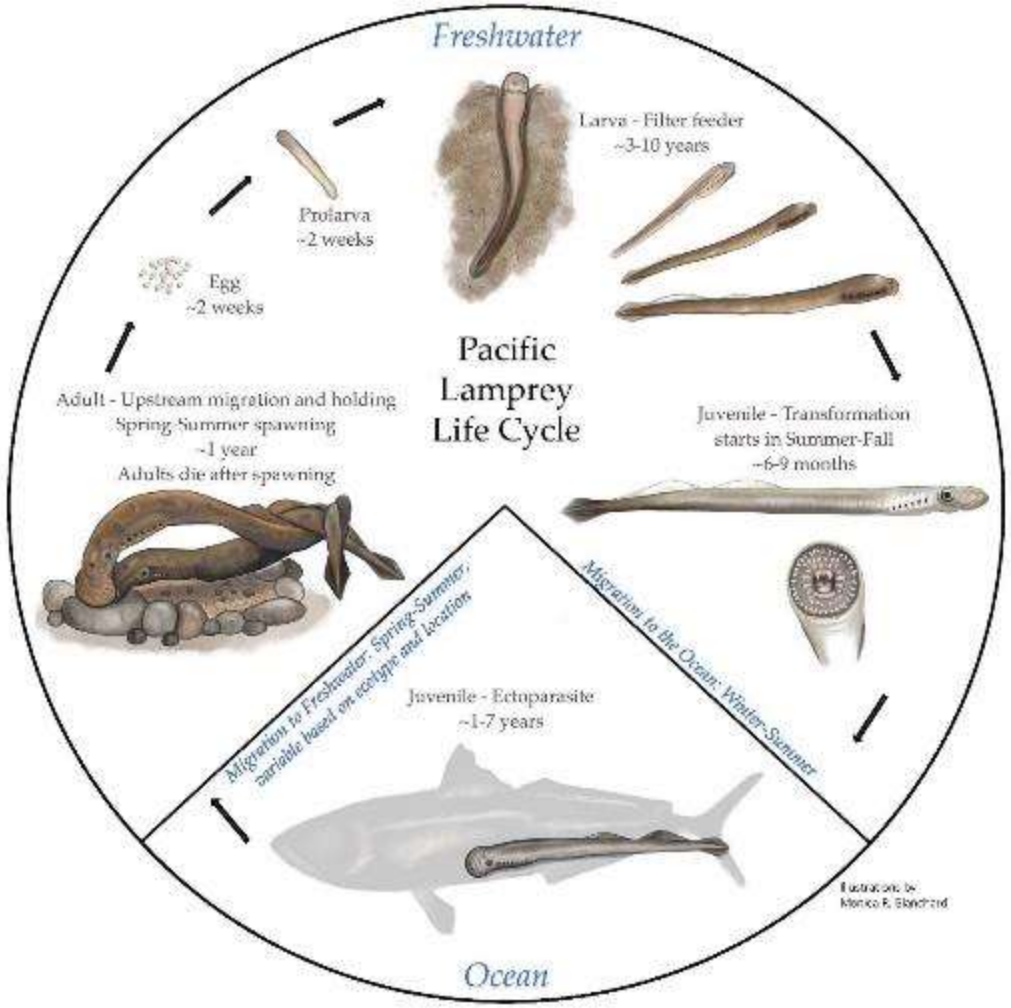
Limiting factors and threats

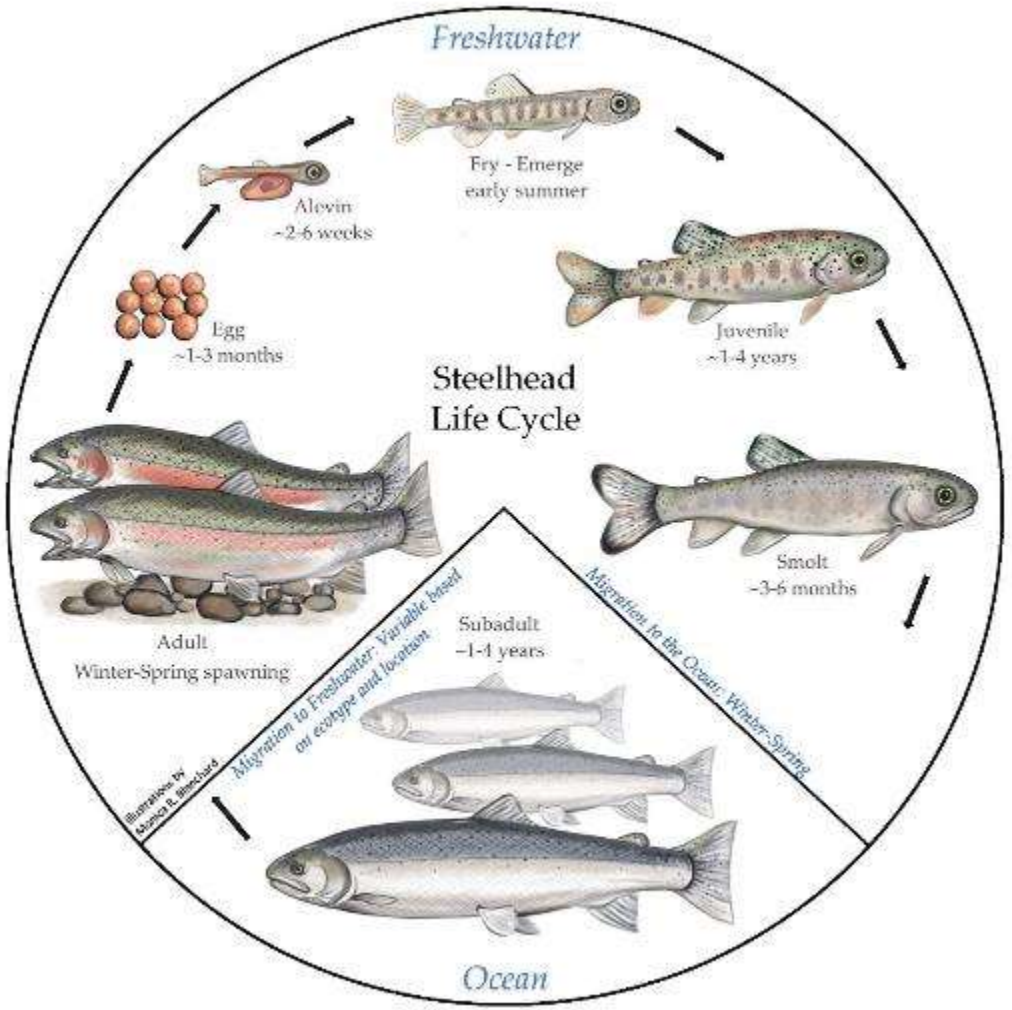
Informational

- NOT a guide for restoration of either species

Lamprey Technical Workgroup. 2023. Comparison of Pacific Lamprey and Pacific Salmon Life Histories, Habitat and Ecology, March 8, 2023. Available: https://www.pacificlamprey.org/ltwg/.

Pacific Lamprey and Salmon Express Similar Life Cycles

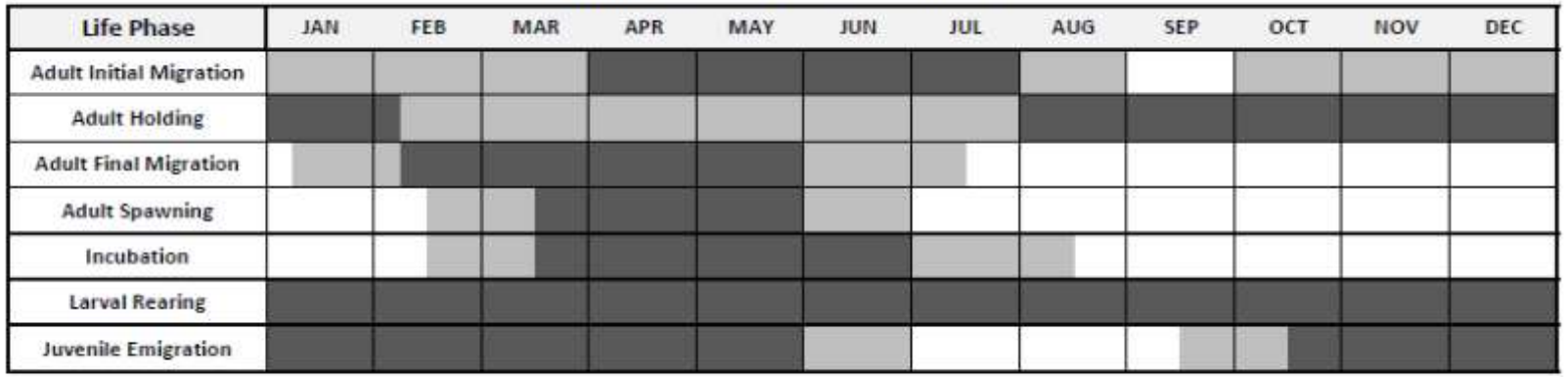




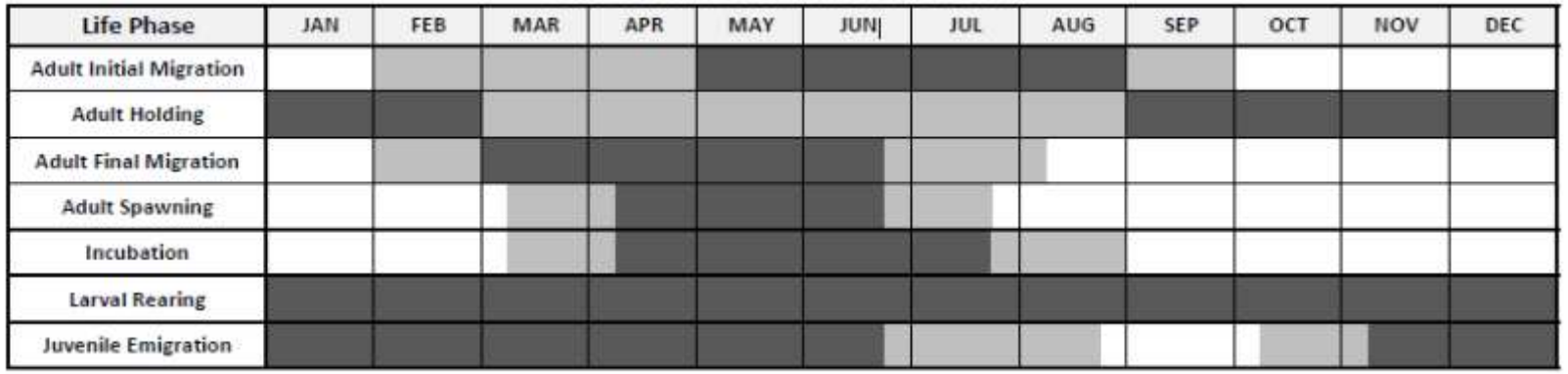
Lamprey Technical Workgroup. 2023. Comparison of Pacific Lamprey and Pacific Salmon Life Histories, Habitat and Ecology, March 8, 2023. Available: https://www.pacificlamprey.org/ltwg/.

General timing* of Pacific Lamprey life stages in fresh water

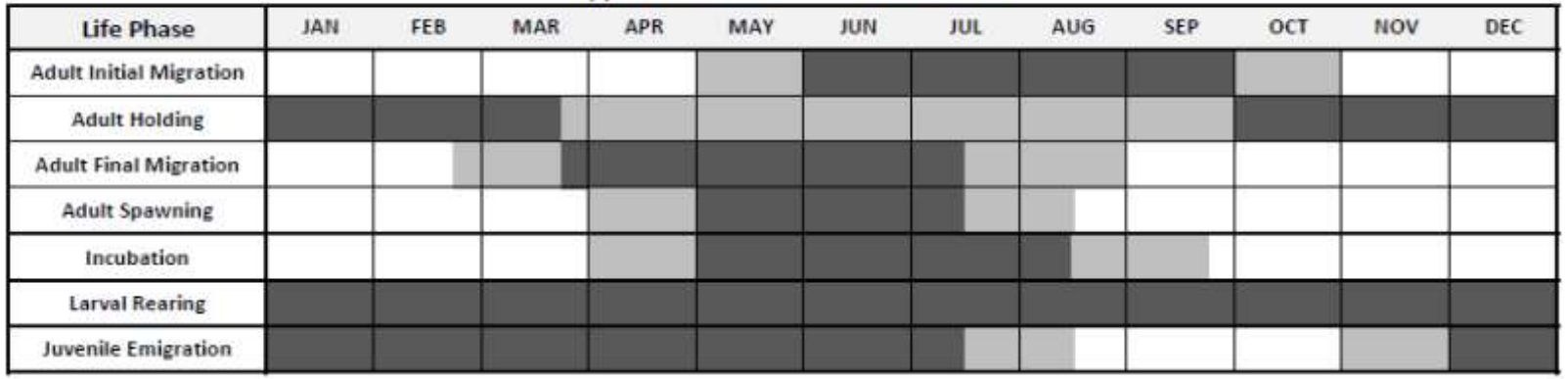
Pacific Northwest Coastal River Basins



Lower Columbia & Willamette River Basins



Upper Columbia & Snake River Basins



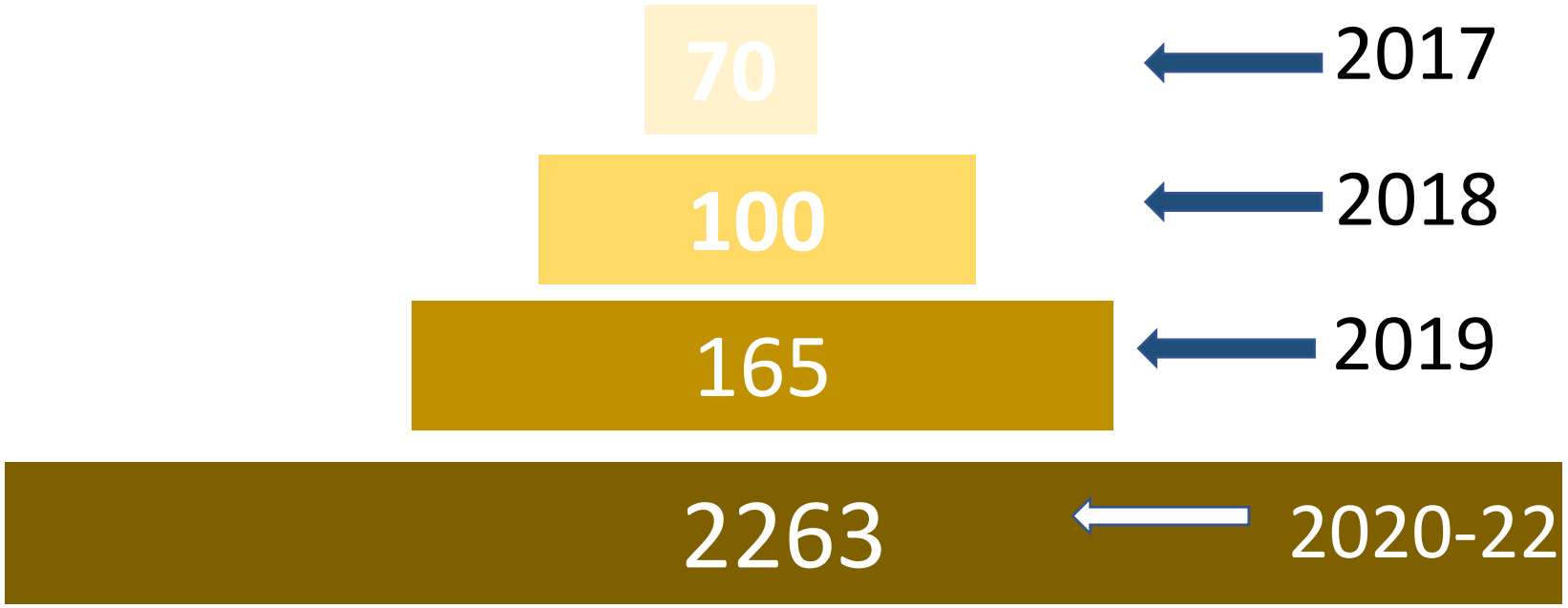
Habitat Comparisons and Abilities to Overcome Select Threats

Habitat Parameter	Pacific Lamprey	Steelhead	Chinook Salmon	Coho Salmon
Adult migration and holding				
Substrate	Boulder/bedrock associated with pools and riffles	Pools; riffles	Pools; riffles	Pools; riffles
Spawning				
Substrate	Cobble; gravel; sand	Cobble; gravel	Cobble; gravel	Cobble; gravel
Velocity (m/s; fps)	<0.9 (3)[a]	<0.9 (3)[b]	<1.2 (4)[b]	<0.6 (2)[b]
Habitat Unit	Pool tail-outs; riffles; glides	Pool tail-outs; riffles	Pool tail-outs; riffles	Pool tail-outs; riffles
Incubation				
Substrate (mm)	27-89[a]	6-102[b]	13-102[b]	13-102[b]
Velocity (m/s; fps)	0.2-1.0 (0.6-3.3)[a]	>0.6 (2.0)[c]	0.3-0.9 (1.0-3.0)[d]	>0.4 (1.4)[c]
Rearing				
Substrate	Silt/sand/organic	Cobble; gravel	Cobble; gravel	Cobble; gravel
Velocity (m/s; fps)	Larvae: 0.073 (0.24)[g]	Fry: <0.5 (1.5)[e]; Juvenile: <1.0 (3.25)	Fry: <0.5 (1.5)[e]; Juvenile: <0.6 (2.0)	<0.2 (0.7)[f]
Habitat Unit	Pools	Pools, riffles, glides	Pools and glides	Pools
Outmigration				
Water column position	Near bottom	Near surface	Near surface	Near surface

Threat	Fish Response	Pacific Lamprey	Steelhead	Chinook Salmon	Coho Salmon
Vertical Barrier[a]	Vertical Jumping Ability (m; ft)	0	<3.3 (10.9)	<2.4 (7.8)	<2.2 (7.2)
Velocity Barrier[1, 2]	Sustained Speed (m/s; fps)	<0.9 (3).0	<1.2 (4.6)	<1.1 (3.4)	<1.1 (3.4)
	Burst Speed (m/s; fps)	<2.5 (8.2)	<8.1 (26.5)	<5.9 (22.4)	<6.6 (21.5)

Annual Lamprey Information Exchanges

- **Goal:** share information and techniques
- Pivoted to virtual format in 2020



Increased Awareness & Engagement

Recap: Ways to get involved in PLCI

- **Explore PLCI's new website!**
  - www.pacificlamprey.org

- **Consider applying to fund a project through PLCI's two funding opportunities**
  - Late summer 2023 – BPA RFP
  - Late fall/ Early winter 2023 – NFHP RFP

- **Participate in Lamprey Information Exchanges**
  - **Dates TBD**

Learn more and stay in the loop

New Website!

www.pacificlamprey.org

Sign up for the PLCI listserv

At the bottom of every page on
www.pacificlamprey.org

Thank You

Josh Boyce
USFWS and Lead of CA RMUs
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Alicia Marrs
Director of Western Water
National Wildlife Federation

Christina Wang
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Kelly Coates
PLCI Conservation Team - Tribal Co-Chair
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Benjamin Clemens
PLCI Conservation Team - State/Federal Co-Chair
ben.clemens@oregonstate.edu

A BOUNTY OF LAMPREYS

BioDiversity

in

Lampreys

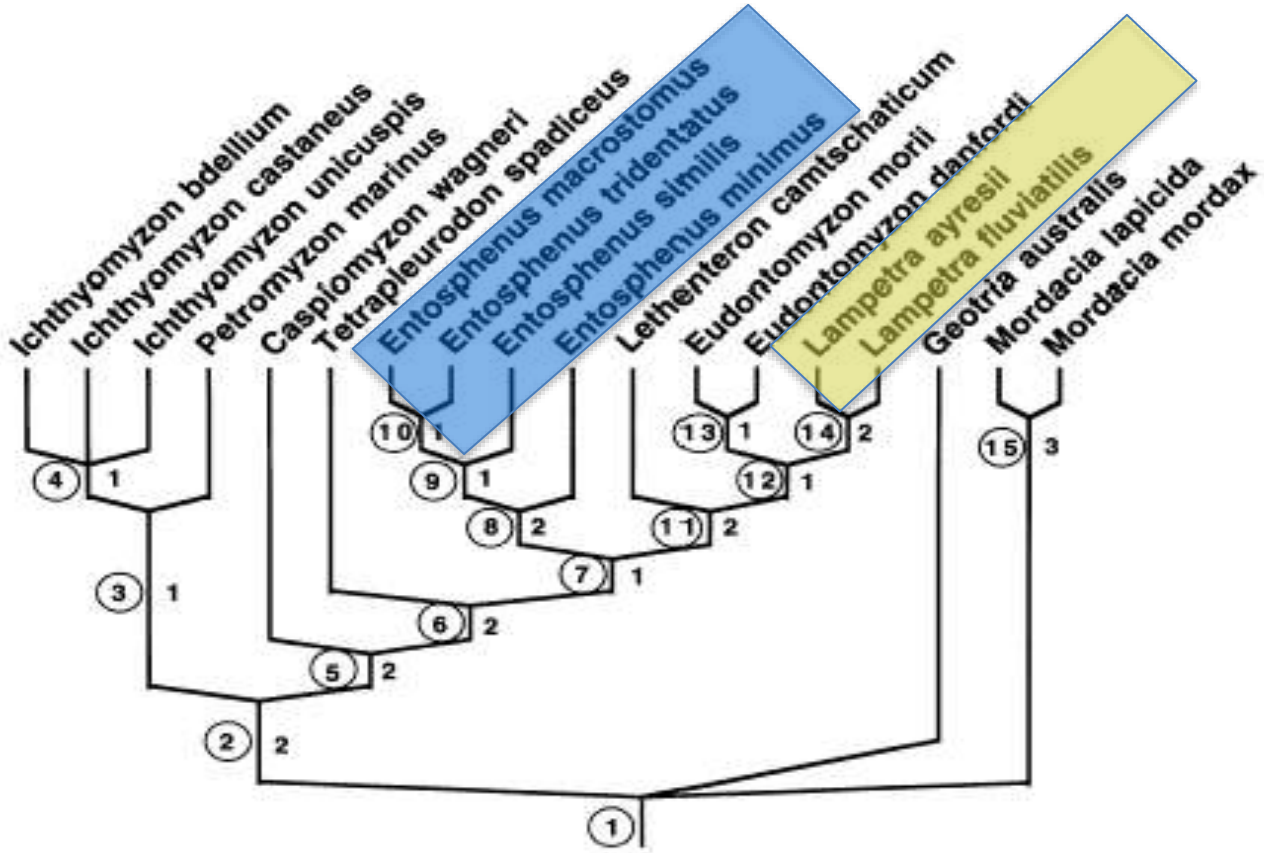
Worldwide
ca. 45 species

Western
North America
ca. 14+ species

- **Lethenteron (2)**
- **Lampetra (4)**
- **Entosphenus (6)**
- **Tetrapleurodon (2)**

Taxonomy

Entosphenus vs. *Lampetra*



Gill et al. 2003. Phylogeny of living and parasitic lampreys (Petromyzontiformes) based on morphological data. Copeia:687-703.

Systematic and Ecological Diversity in *Entosphenus*

Entosphenus

Anadromous:

Pacific Lamprey	***Entosphenus tridentatus***	**[widespread]**

Resident Predatory:

Vancouver	***Entosphenus macrostomus***	**[Vancouver Is.]**
Miller Lake	***Entosphenus minimus***	**[Klamath]**
Klamath River	***Entosphenus similis***	**[Klamath]**
"Klamath Lake"	***Entosphenus* sp.**	**[Klamath]**
"Goose Lake"	***Entosphenus* sp.**	**[Goose]**

Resident non-Predatory:

Pit Brook	***Entosphenus lethophagus***	**[Pit R. / Goose]**
Klamath Brook	***Entosphenus* cf. *lethophagus***	**[Klamath]**
Modoc Brook	***Entosphenus folletti***	**[Klamath]**

Pacific Lamprey, *Entosphenus tridentatus*

The only anadromous lamprey in the genus *Entosphenus*

Pacific Lamprey Distribution (Western North America)

Alaska to Baja California

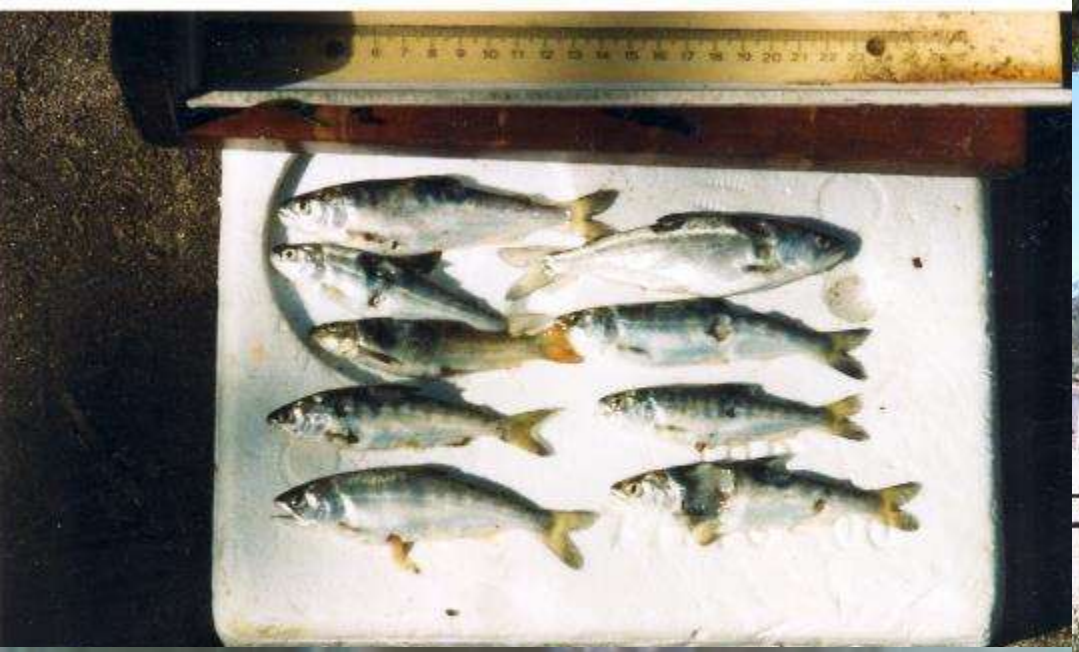
Klamath Marsh, in the upper Williamson River sub-basin, trib. to Upper Klamath Lake

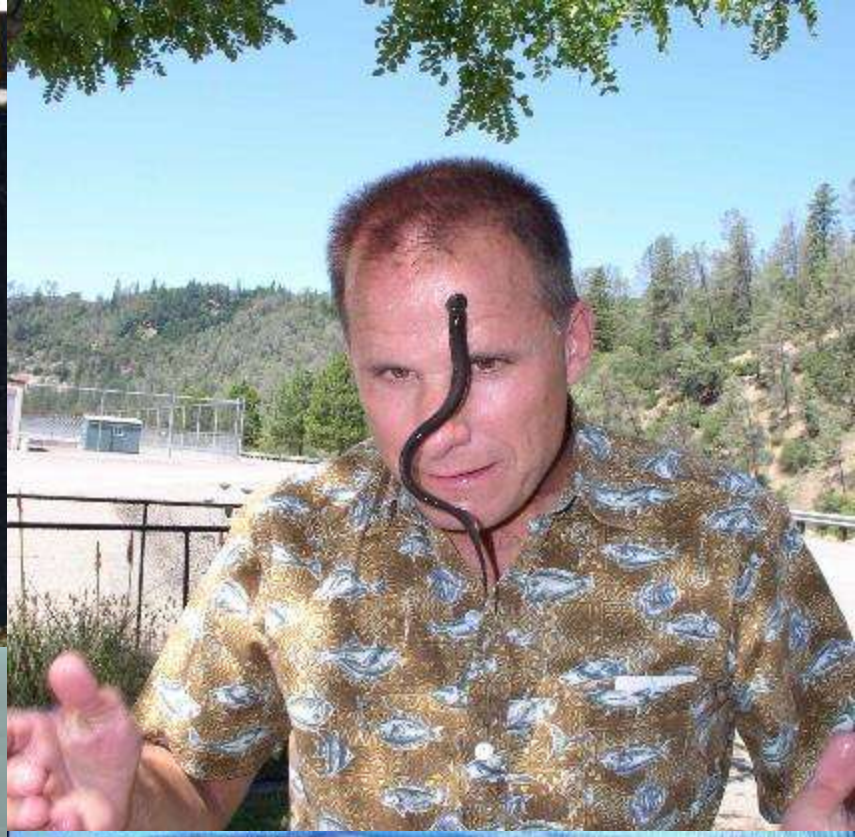
Miller Lake, elev. 5630’

Miller Lake Lamprey, *Entosphenus minimus*

Miller Creek

Klamath River Lamprey, *Entosphenus similis*

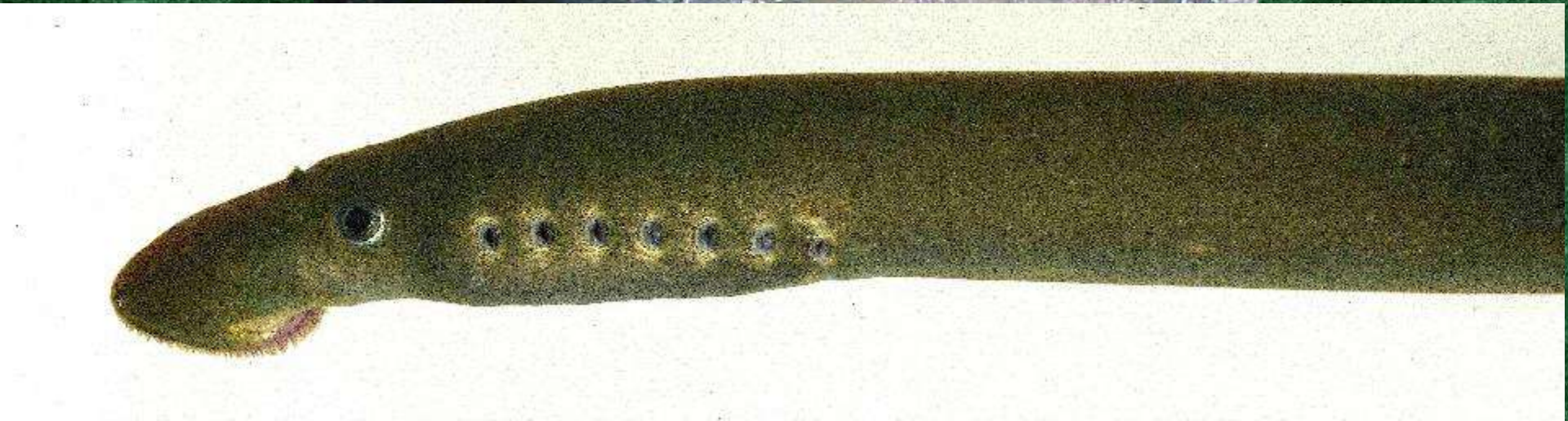




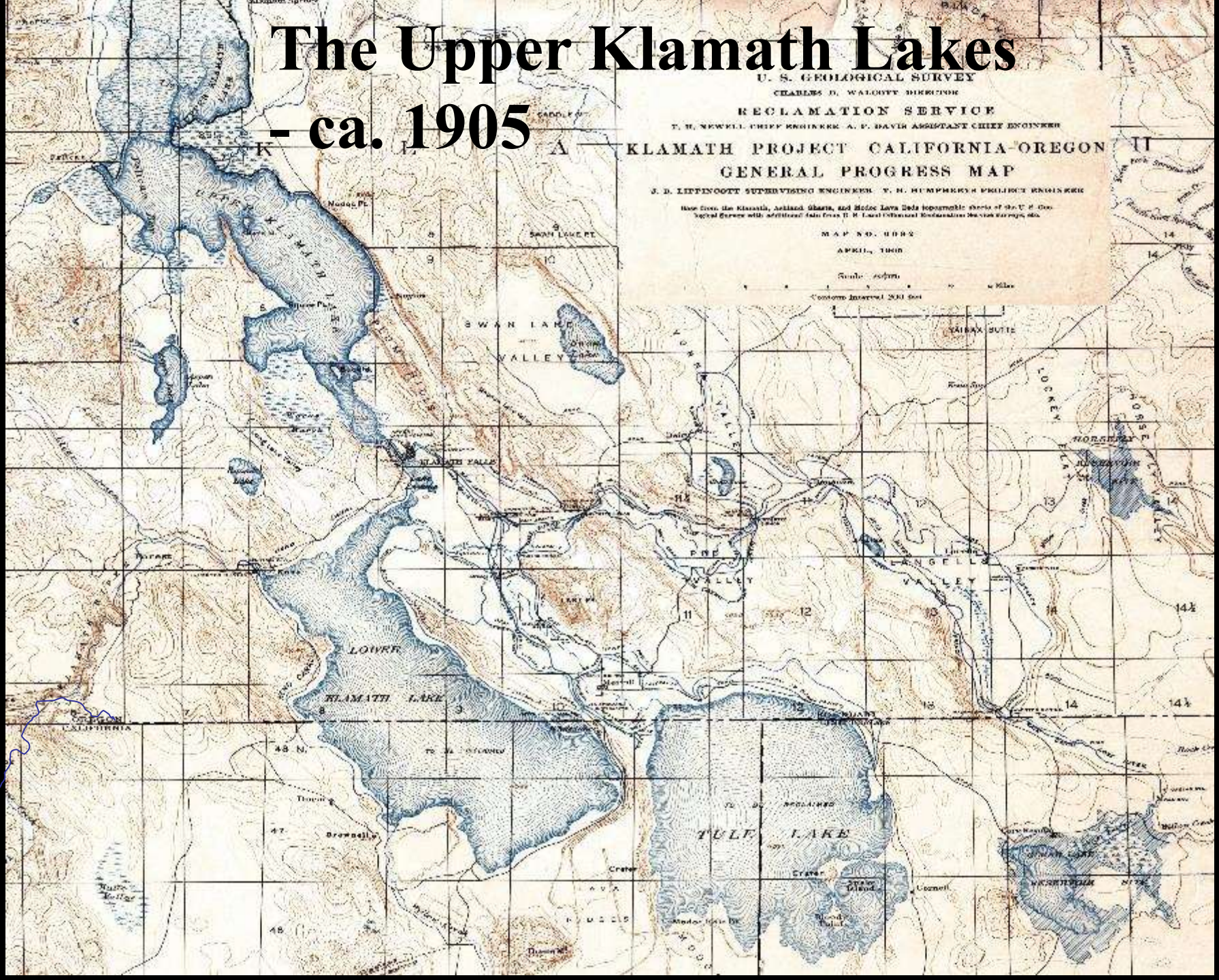
Klamath River Lamprey feed on a wide range of species and are the principal lamprey on adult salmon.

Photo: Mark Hampton, CDFG Klamath River Project

"Klamath Lake" Lamprey, *Entosphenus* sp.



The Upper Klamath Lakes - ca. 1905



“Klamath Lake” Lamprey, *Entosphenus* sp., wound on Shortnose Sucker, *Chasmistes brevirostris* (BRD-2003).

"Goose Lake" Lamprey
Entosphenus sp.

Photos - Bill Tinniswood, ODFW

Photo - Google Earth

Vancouver Lamprey
Entosphenus macrostomus

Beamish 1982

- Vancouver Island endemic
- Freshwater resident in lakes
- Predatory

Pacific Lamprey “Praecox”
(Hood Canal/N. Olympics)

Hamma Hamma Ck., Mike Hayes

East Twin Ck., Larry Ward

20-30 cm TL

“Brook lampreys” is a general term and occur in both *Entosphenus* and *Lampetra*

“Brook lampreys” don’t feed as adults …

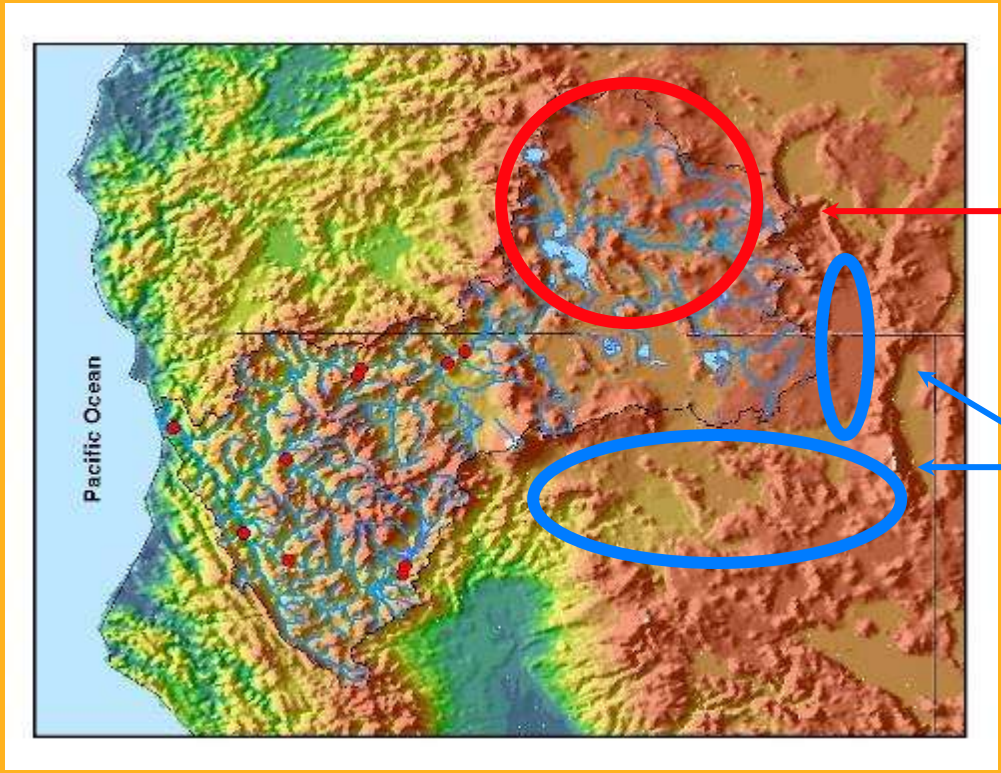
“Brook lampreys” is a general term and occur in both *Entosphenus* and *Lampetra*

“Brook lampreys” don’t feed as adults …

They shrink, spawn and die

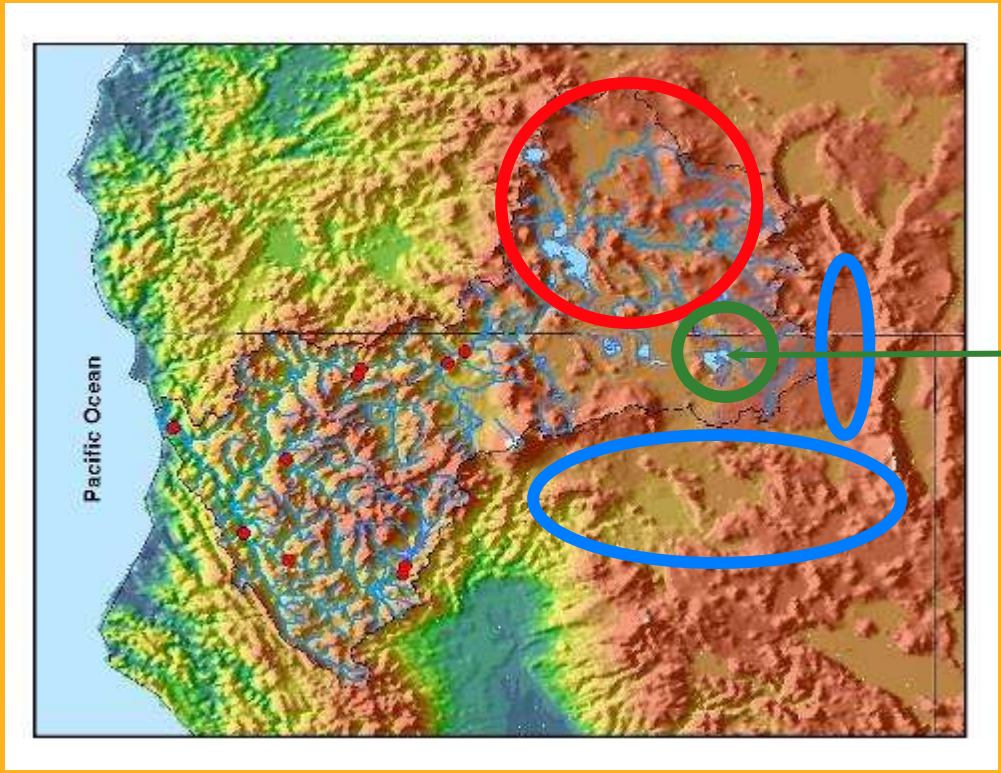
Entosphenus lethophagus

Pit-Klamath Brook Lamprey



Entosphenus folletti

Modoc Brook Lamprey



"There are currently four mostly widely-distributed species of Lampetra on the west coast"

- River Lamprey, *Lampetra ayresii*

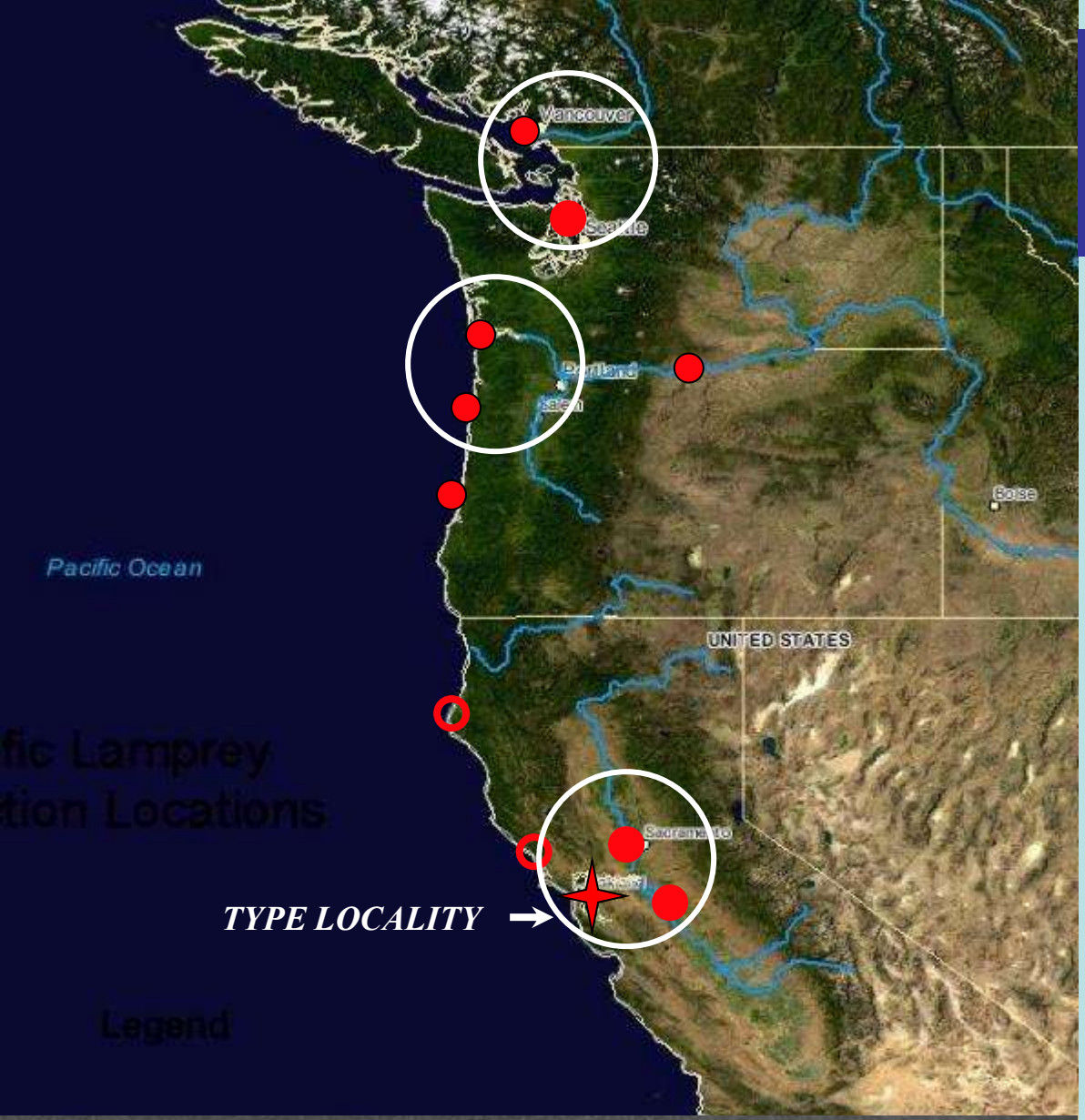
- Western Brook Lamprey, *L. richardsoni*

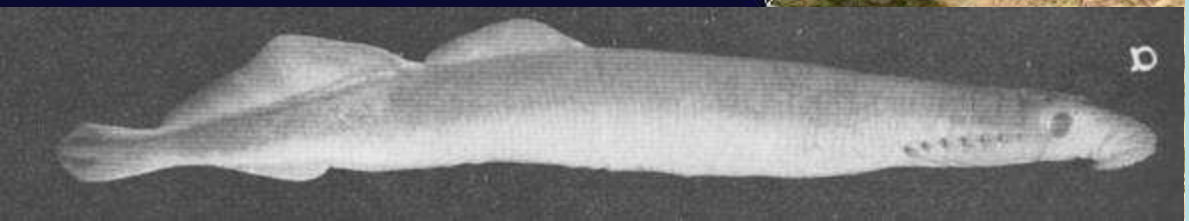
- Pacific Brook Lamprey, *L. pacifica*

- Kern Brook Lamprey, *L. hubbsi*

(Conventional Wisdom)

River Lamprey
Lampetra ayresii



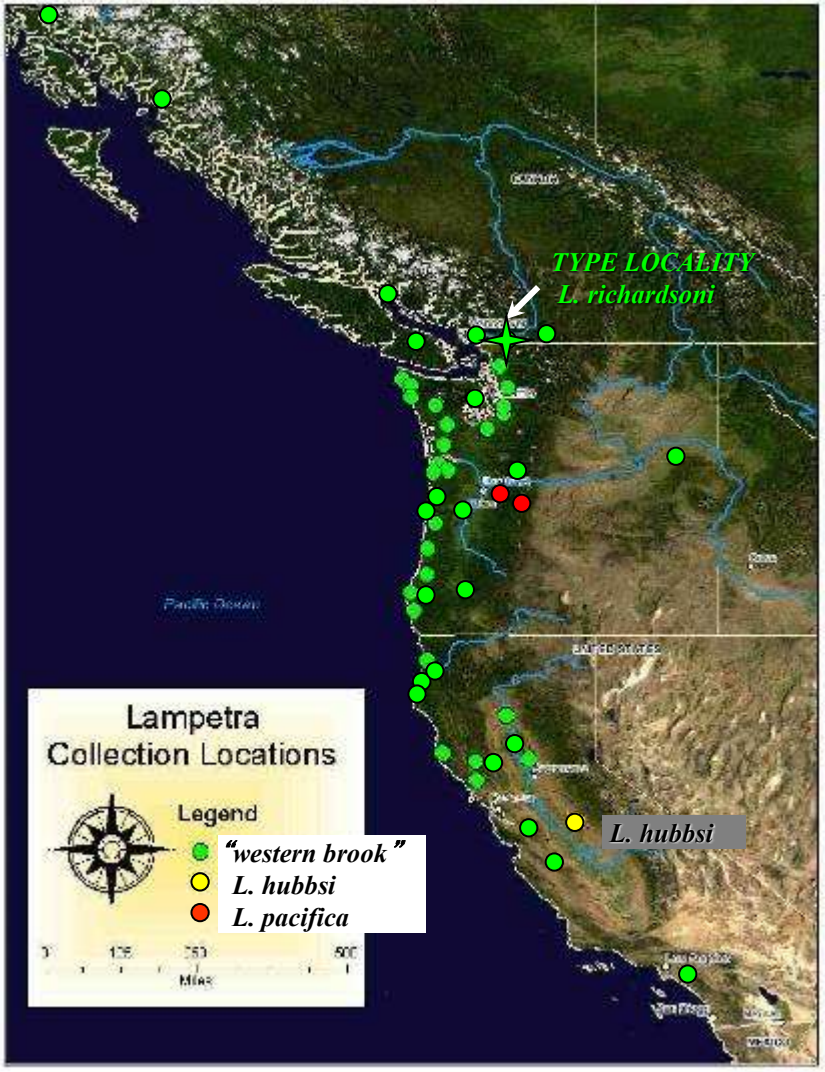


- *associated with large rivers*
- *estuarine*
- *short marine phase*
- *not predatory in freshwater*
- *relatively small (ca. 30 cm)*

Joe Tomelleri

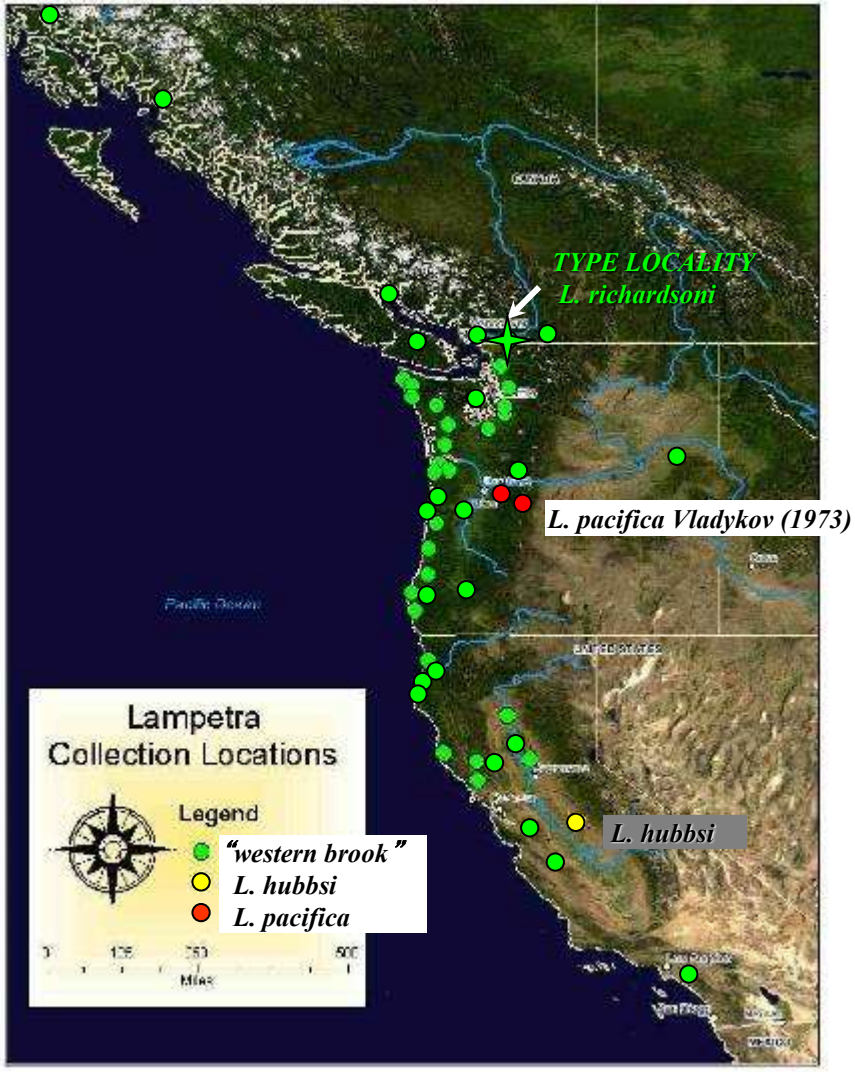
Western Brook Lamprey
cf. *Lampetra richardsoni*

A distribution of convenience

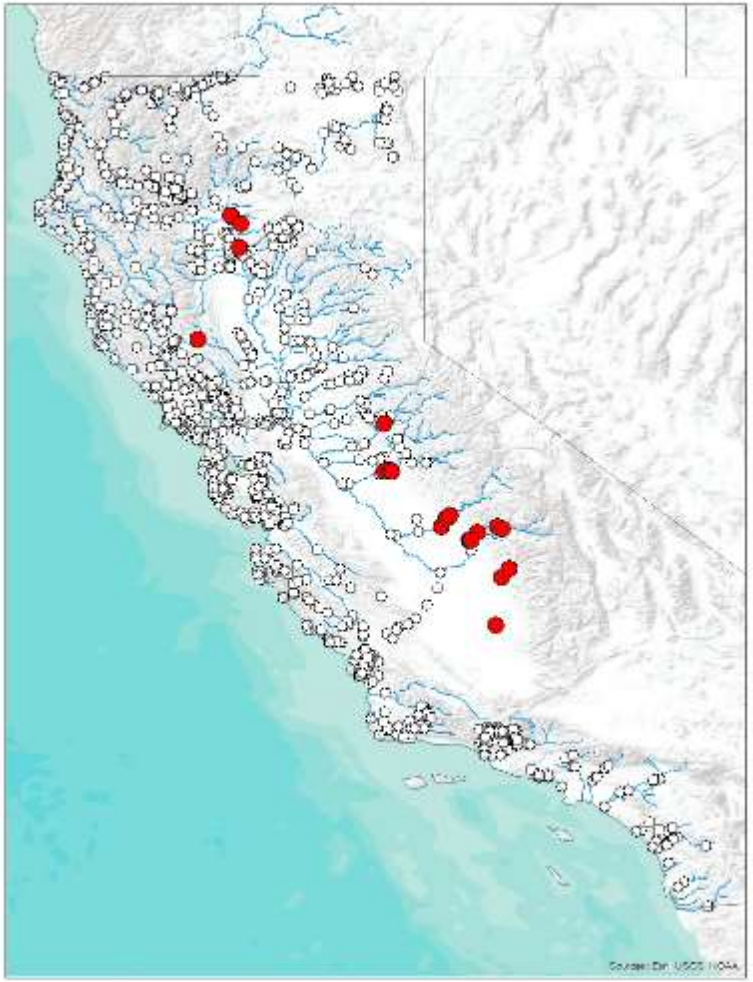


Pacific Brook Lamprey
Lampetra pacifica
Vladykov 1973

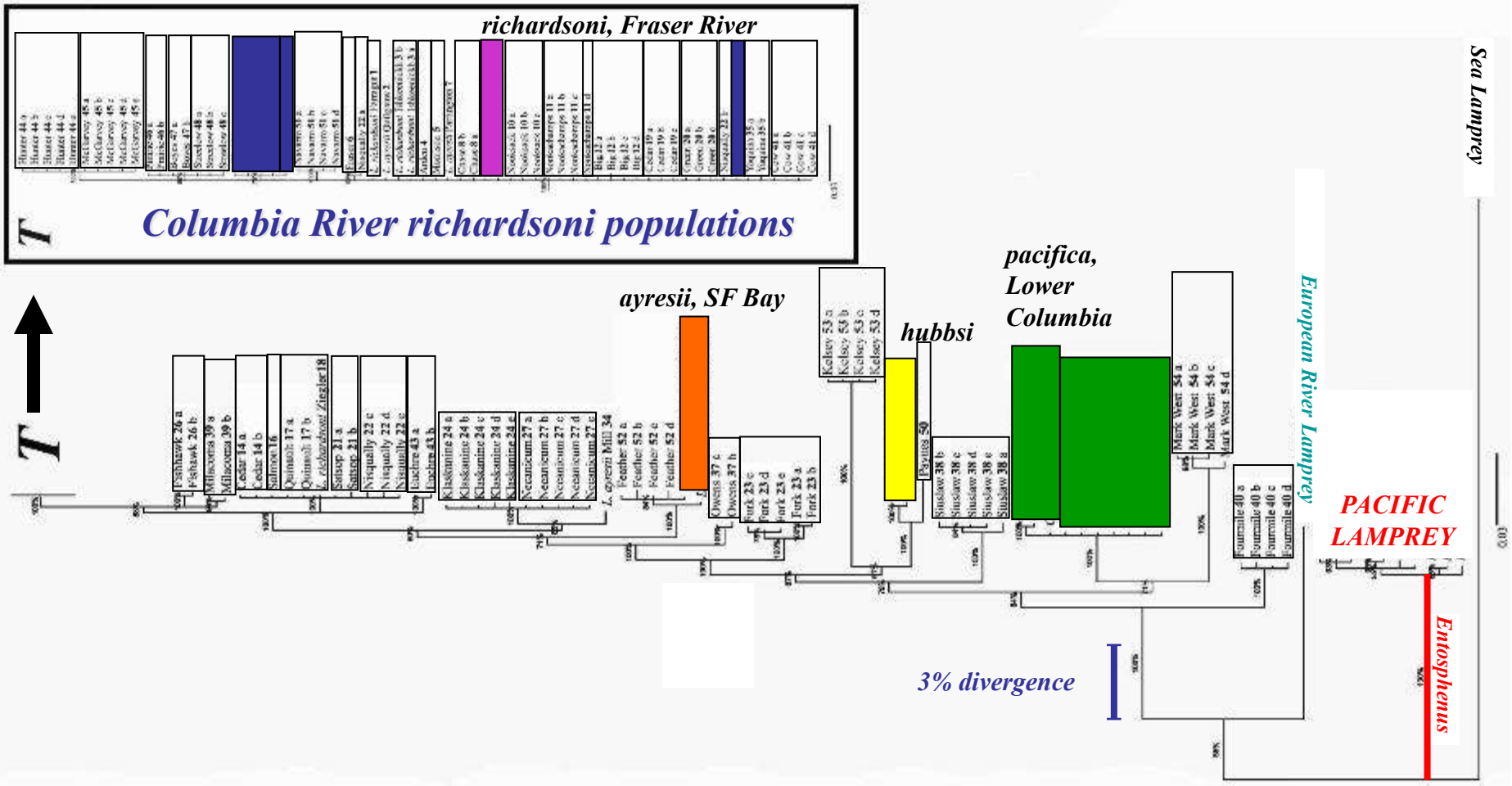
- lower myomere counts
- in past, synonymized w/ L. richardsoni
- Reid et al. (2015) established validity



Kern Brook Lamprey
Lampetra hubbsi



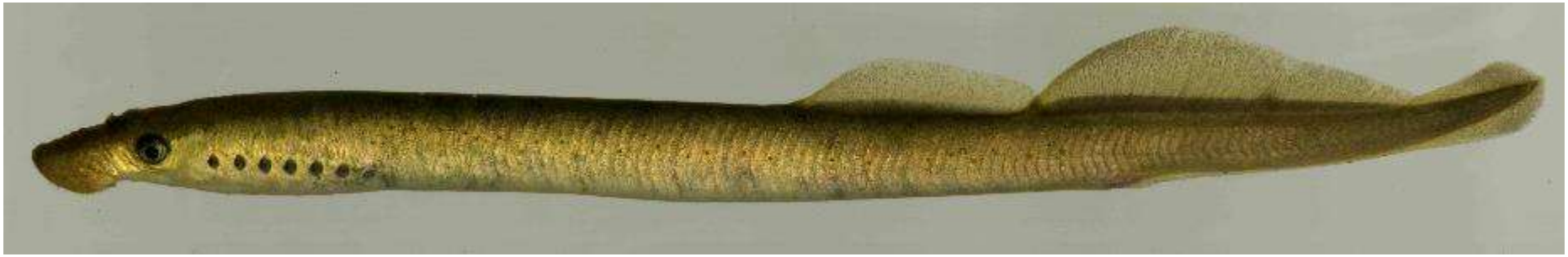
Sacramento / San Joaquin Valley



Genetic diversity in Western *Lampetra*

Lampetra MtDNA ***Complete CytB (1191 bp) : Boguski, Reid, Goodman and Docker – 2012***

***Lampetra richardsoni* - Quinault, WA**
(Olympic Peninsula)



Lampetra richardsoni – Coquille River, OR

Lampetra pacifica - Clackamas River, OR
(Columbia)

***Lampetra* sp. - Clear Lake, CA**

Lampetra sp. - Cache Creek [Sacramento]

Lampetra sp.
Mynot Creek, CA
(Klamath)

CONCLUSION:

"Don't take your identification of western lampreys for granted"

(Conventional Wisdom 2023)

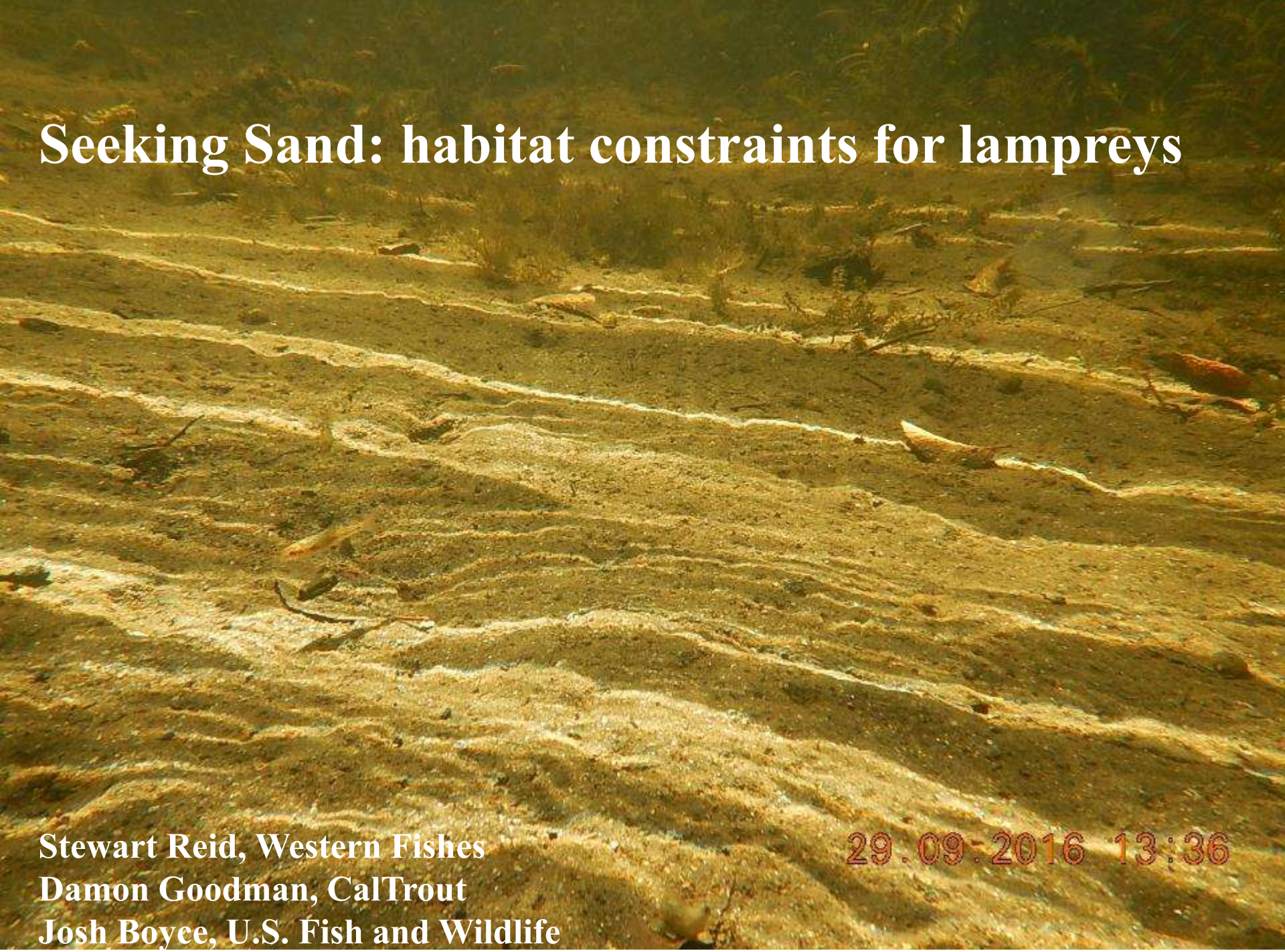
The Western Lamprey Program

A Collaborative Effort to Explore the Diversity, Biology and Conservation of Western Lampreys

LAMPREY HOTLINE

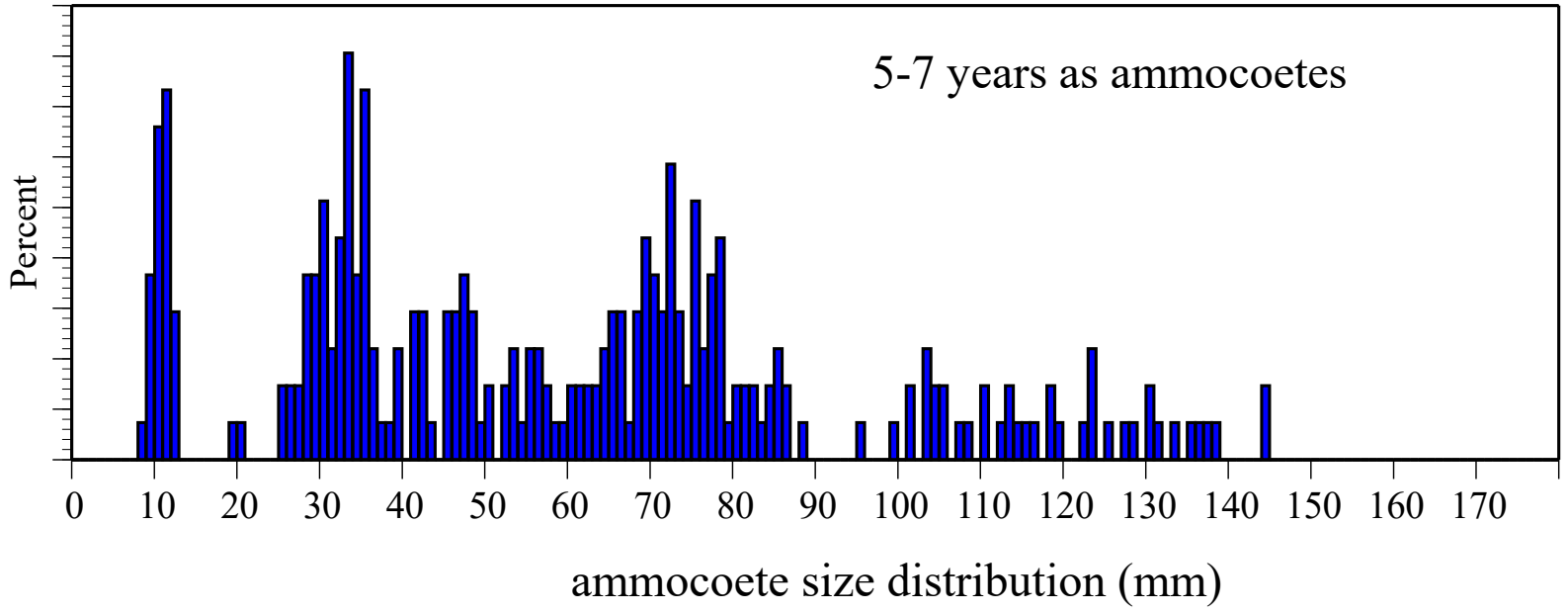
(541) 890-1669

Seeking Sand: habitat constraints for lampreys



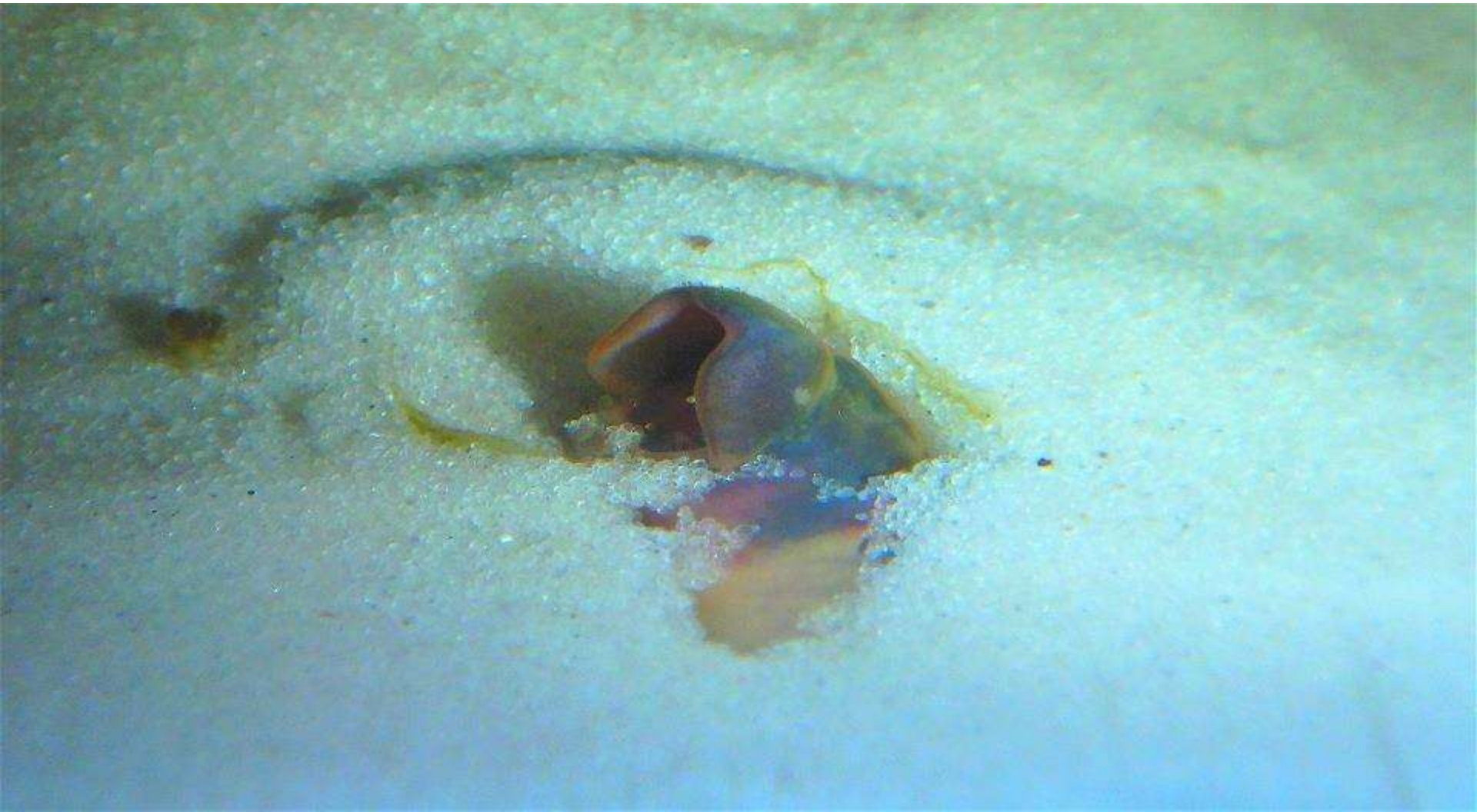
Stewart Reid, Western Fishes
Damon Goodman, CalTrout
Josh Boyce, U.S. Fish and Wildlife

Swim-up larva = Ammocoete - ca. 10mm



Larval Lampreys - Ammocoetes
Substrate dwellers / Filter feeders

Filter the water column
Clearing algae and micro-organics




Mix the stream substrate, like earthworms

Abundant in streams – often major component of fish biomass

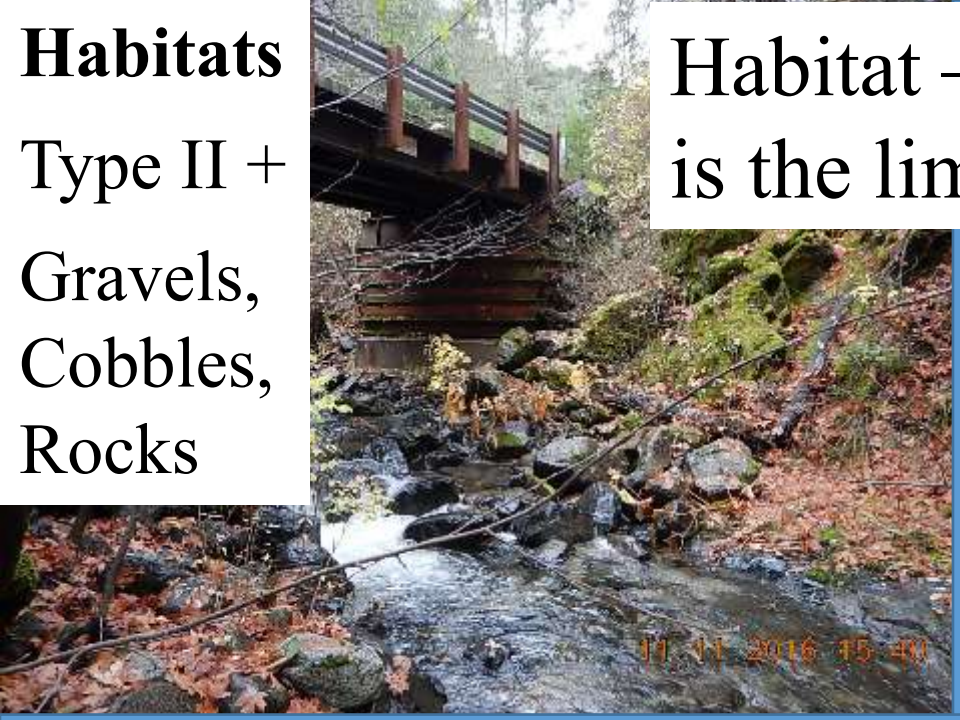
Where are the ammocoetes?

Habitats

Type II +

Gravels, Cobbles, Rocks

Habitat – availability of fines is the limiting factor.



Habitat

Type I

Silt, sands

Habitat Use by Ammocoetes Hamilton Ponds Grass Valley Ck (Trinity Basin CA)

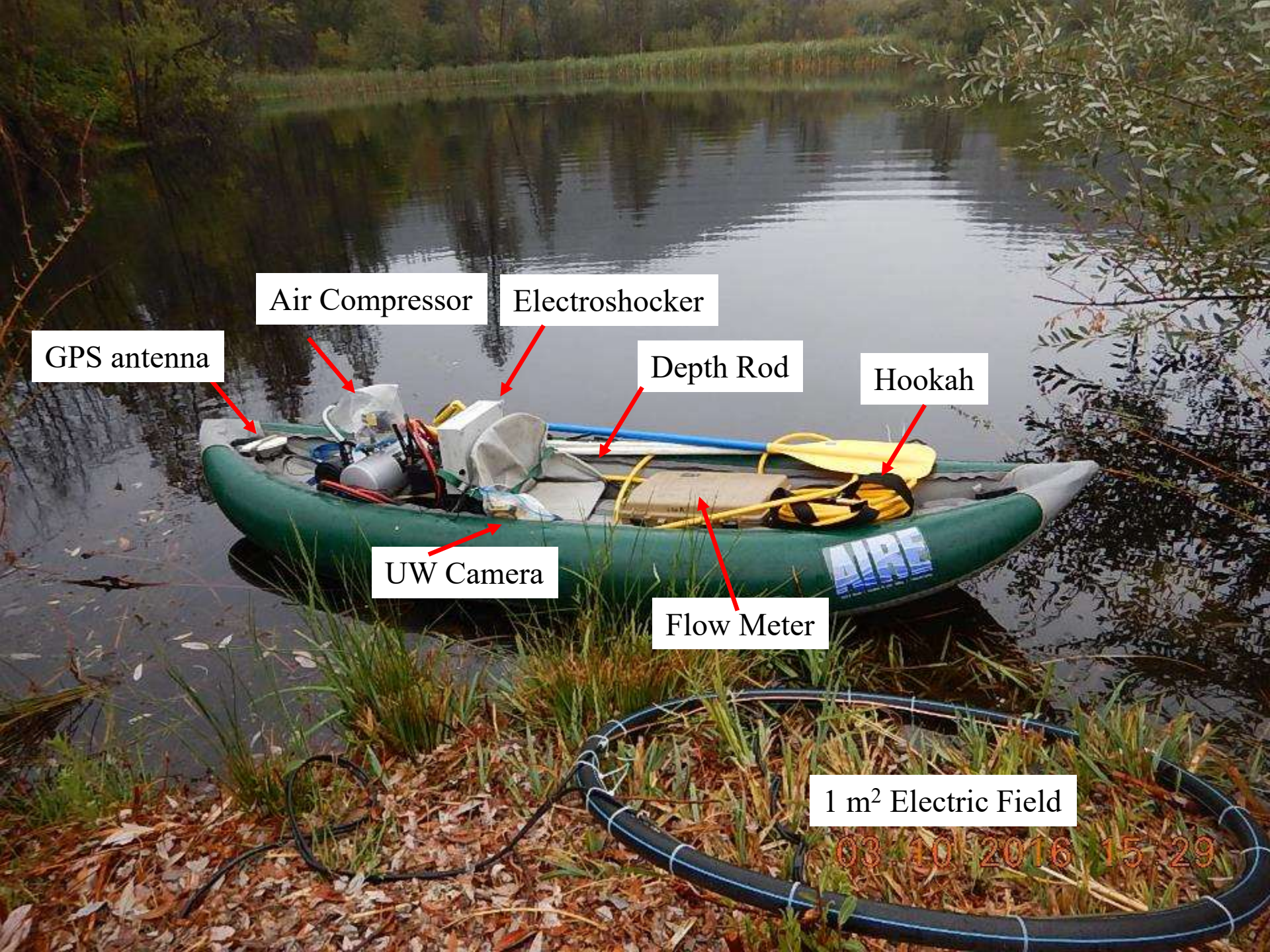
Stewart Reid – Western Fishes
Damon Goodman – CalTrout

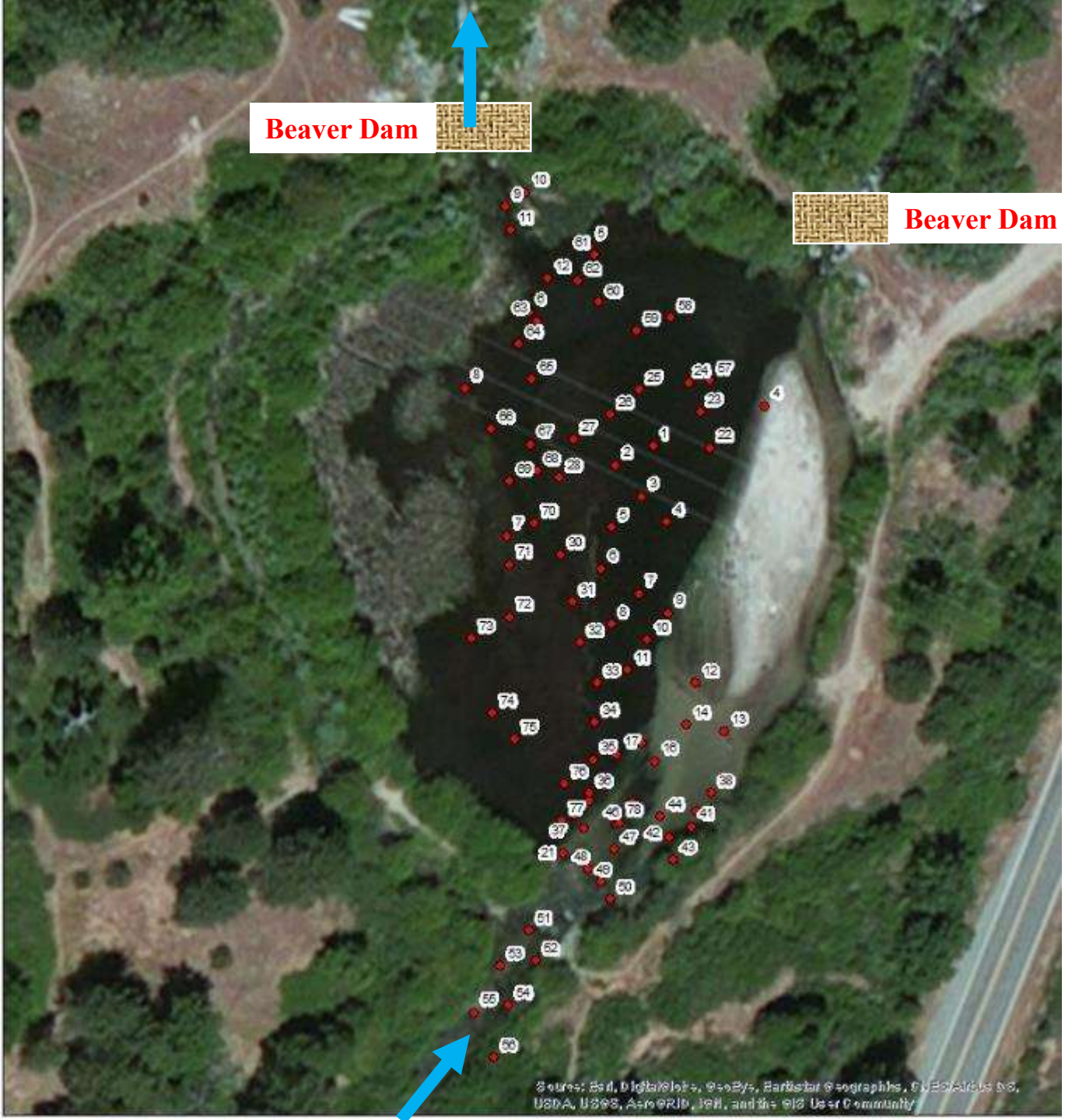
The goals of the project were to:

1) **Distribution**: determine the distribution of and relative abundance of larval lampreys (ammocoetes) in the Ponds,

2) **Habitat**: evaluate habitat use by ammocoetes in the Ponds,

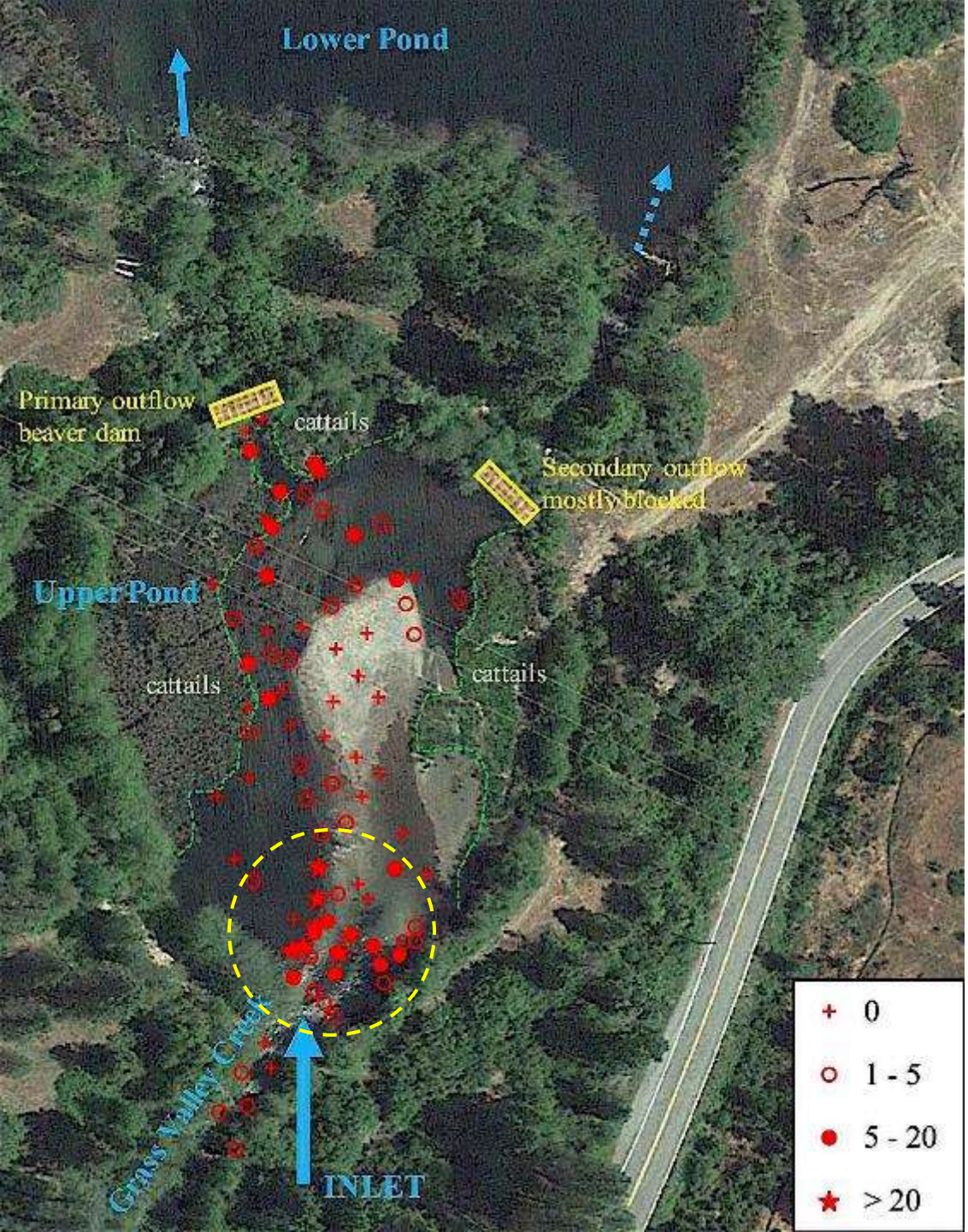
3) **Management**: develop management suggestions to minimize impacts on lamprey during management operations (e.g. sediment removal).


Air Compressor
Electroshocker
GPS antenna
Depth Rod
Hookah
UW Camera
Flow Meter
1 m² Electric Field
03 10 2016 15:29



Hamilton Pond
Grass Valley Creek
Trinity Basin,
Northern California

Ammocoete
Habitat Surveys
2016



Distribution of ammocoetes in 2016

Sample sites (1 m^2; n=90)
Ammocoete abundance (#/m^2)

Sampling 28 Sept - 4 Oct 2016

Sand bar was submerged due to beaver dam activity about two weeks before sampling.

Habitat Variables

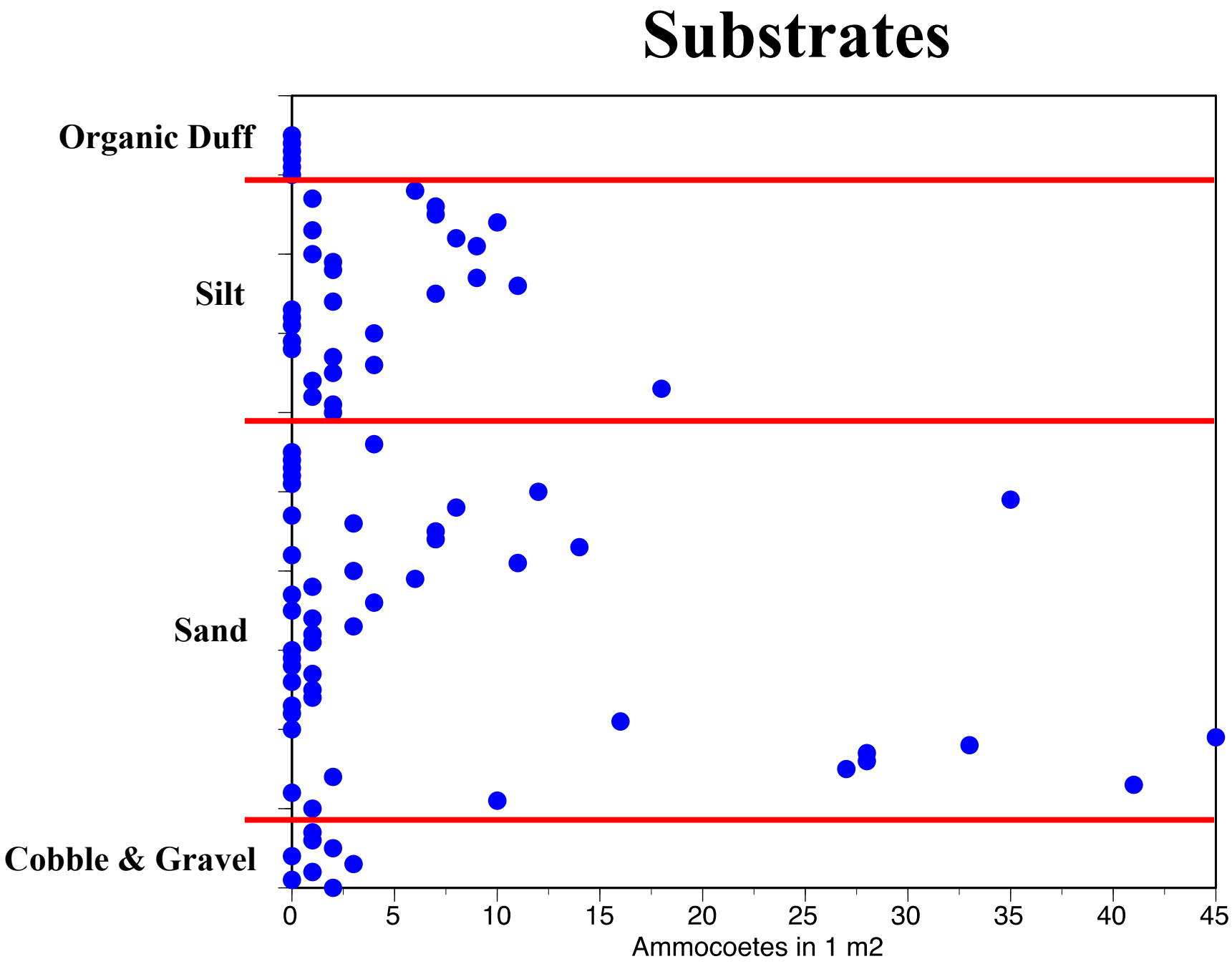
1) Depth
2) Current
2) Substrate
3) Vegetative cover
4) Organic cover
5) Sediment Out-gassing

Gravels and cobbles

Sand

Silt

Organic Duff


Substrates
Organic Duff
Silt
Sand
Cobble & Gravel
0
5
10
15
20
25
30
35
40
45
Ammocoetes in 1 m2

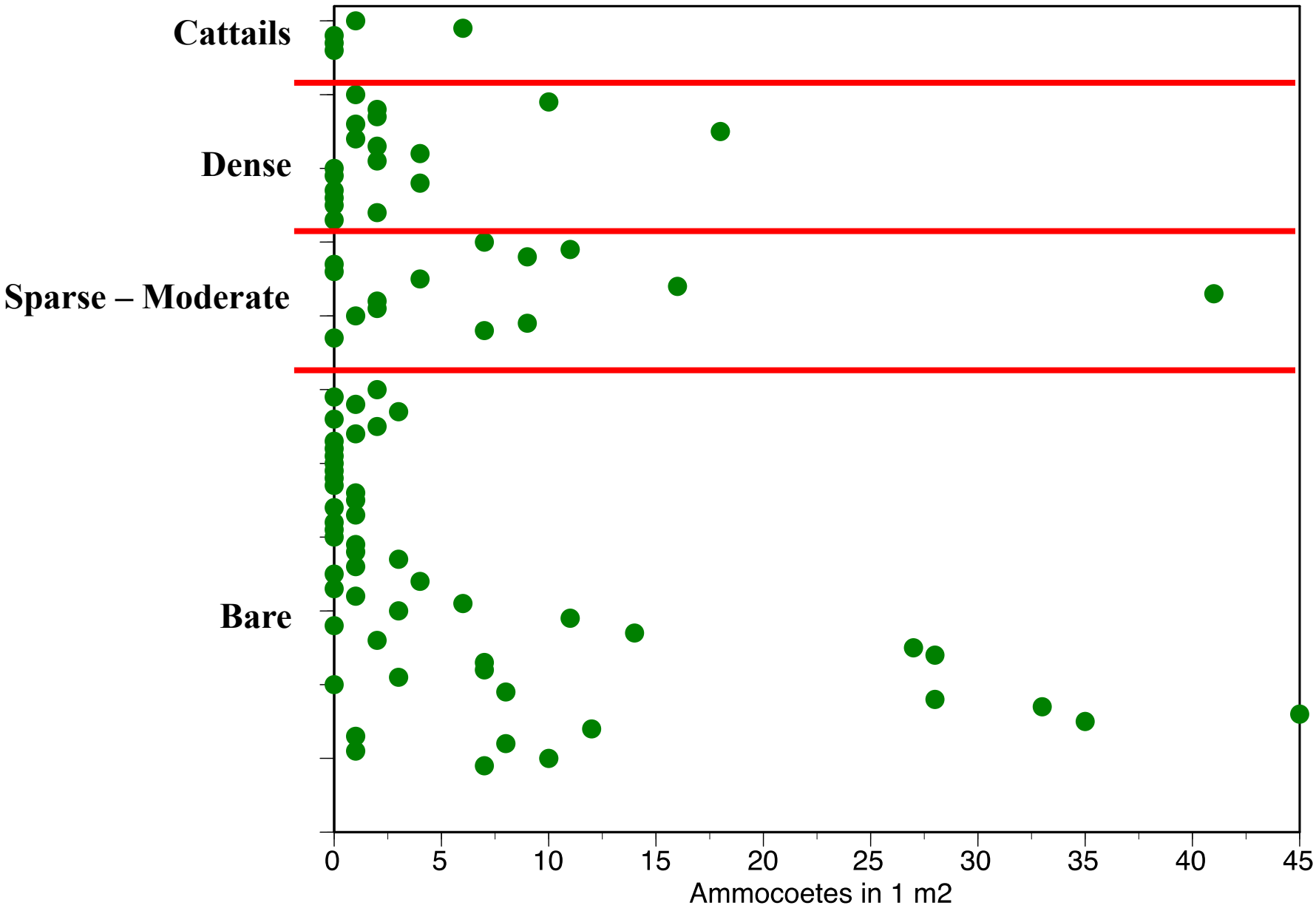
Bare – no vegetation

Sparse to moderate

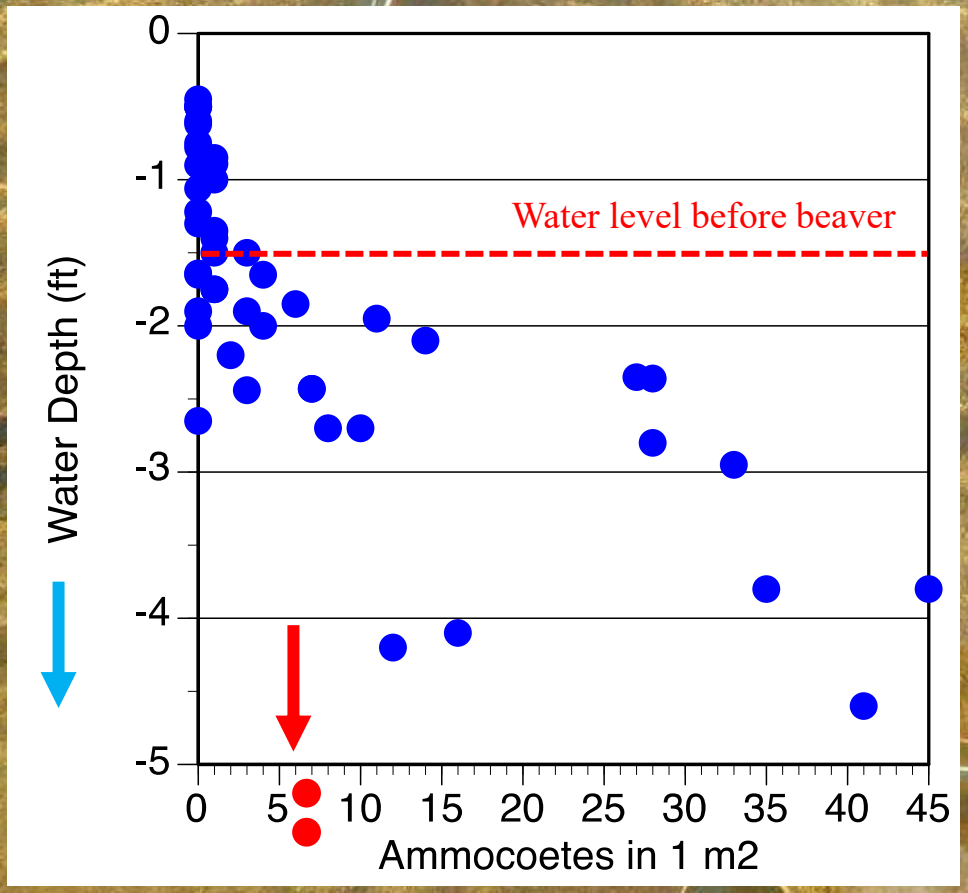
Dense vegetation

Cattails

Vegetation

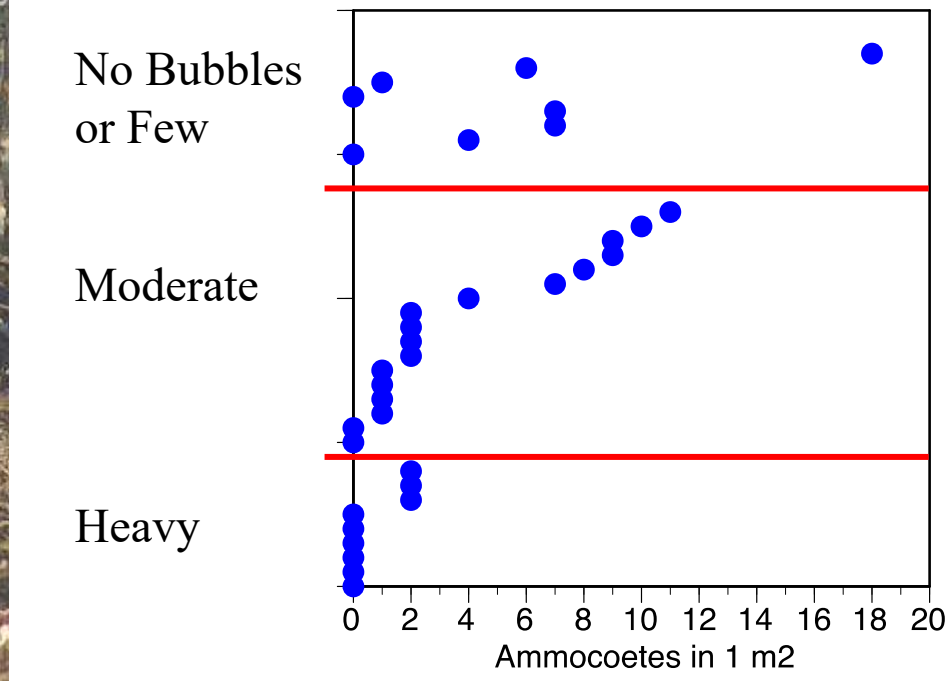

Cattails
Dense
Sparse – Moderate
Bare
0
5
10
15
20
25
30
35
40
45
Ammocoetes in 1 m2

DEPTH



28.09.2016 11:55

Sediment Gases, in deep silt or organic substrates



<u>Considerations relative to habitat use and behavior of lamprey ammocoetes</u>:

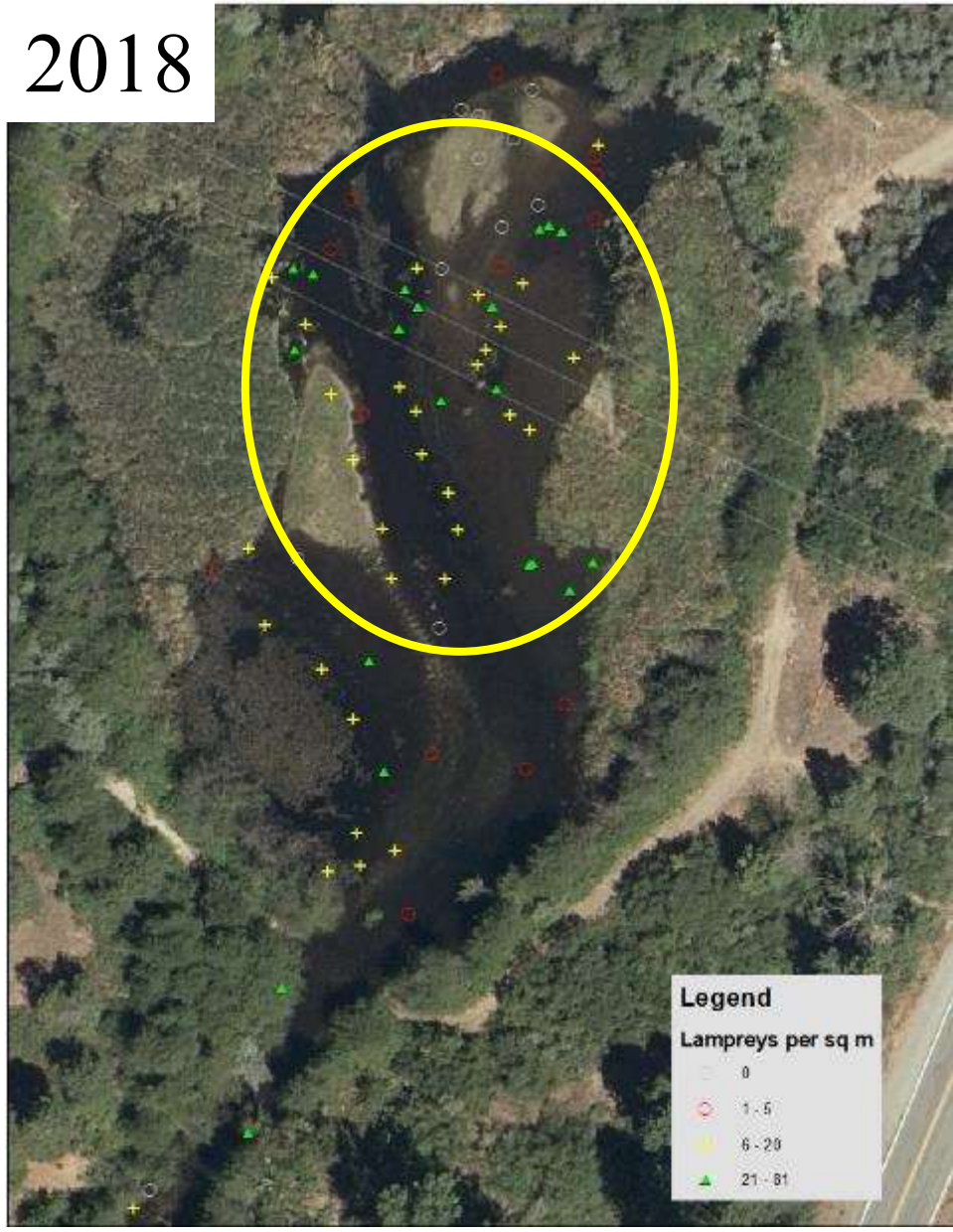
- Ammocoetes of up to seven year-classes (10-180 mm TL) are present year-round in the pond and will be impacted by any instream activities, particularly sediment removal.

- Preferred habitat is open sands and silts at all depths.

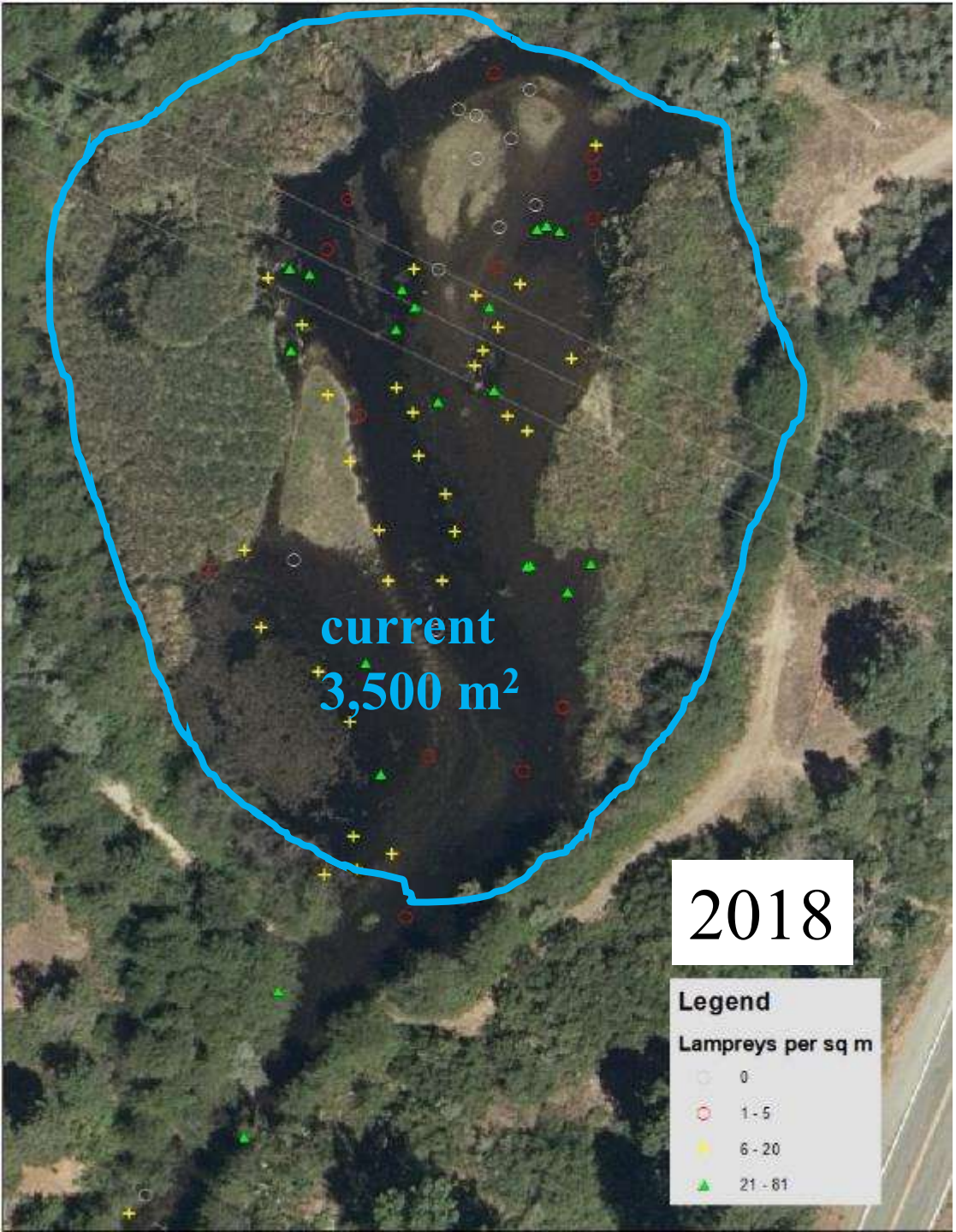
- Higher densities occur in areas of low velocities associated with some flow.

- Highest densities occurred within about 80 ft of inlet and outlet.
    - dependent on flow patterns.

- Dense vegetation and slack water with organic ooze or rotting vegetation are avoided.



Survey Distribution and Density of Ammocoetes



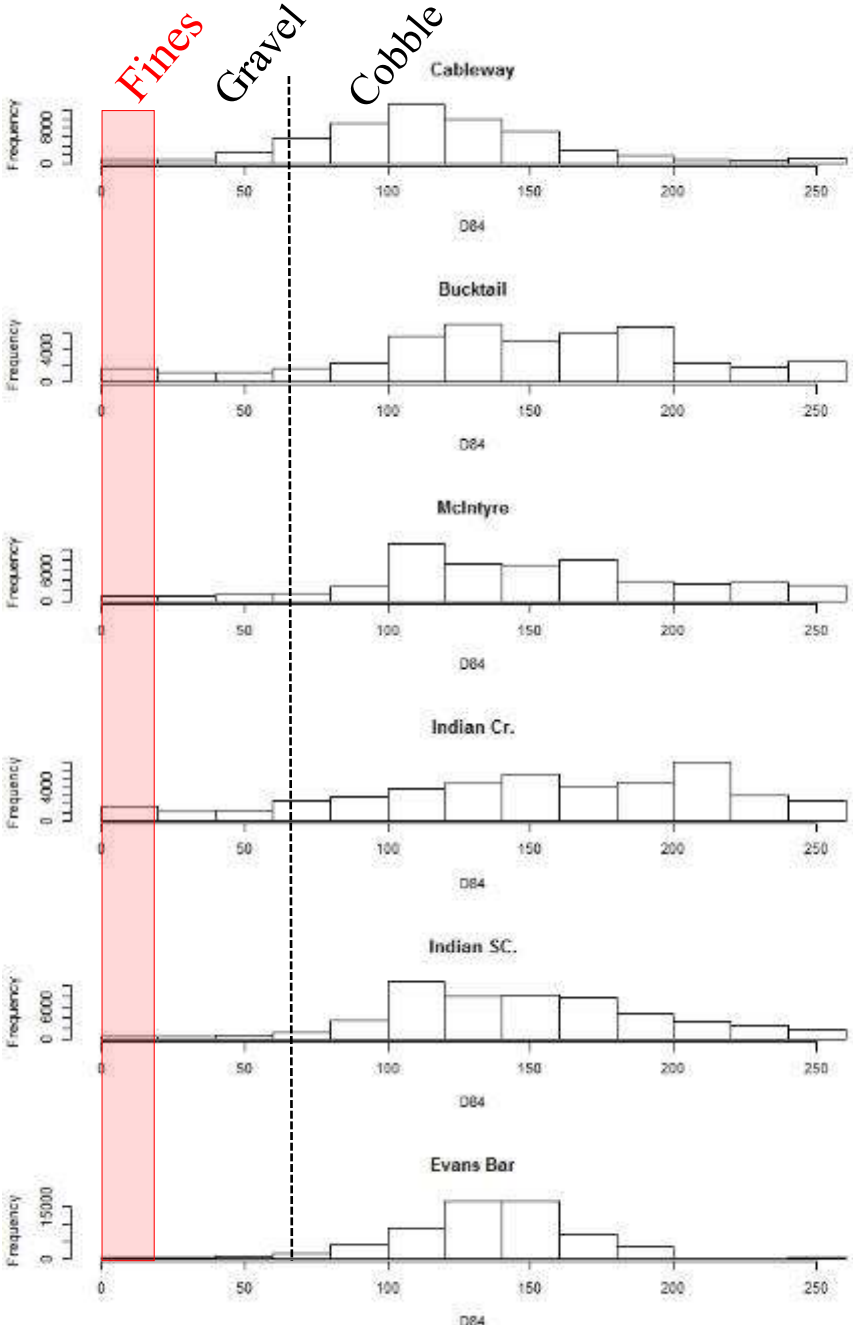
Avg. density 2018 = 17 ammocoetes per m^2

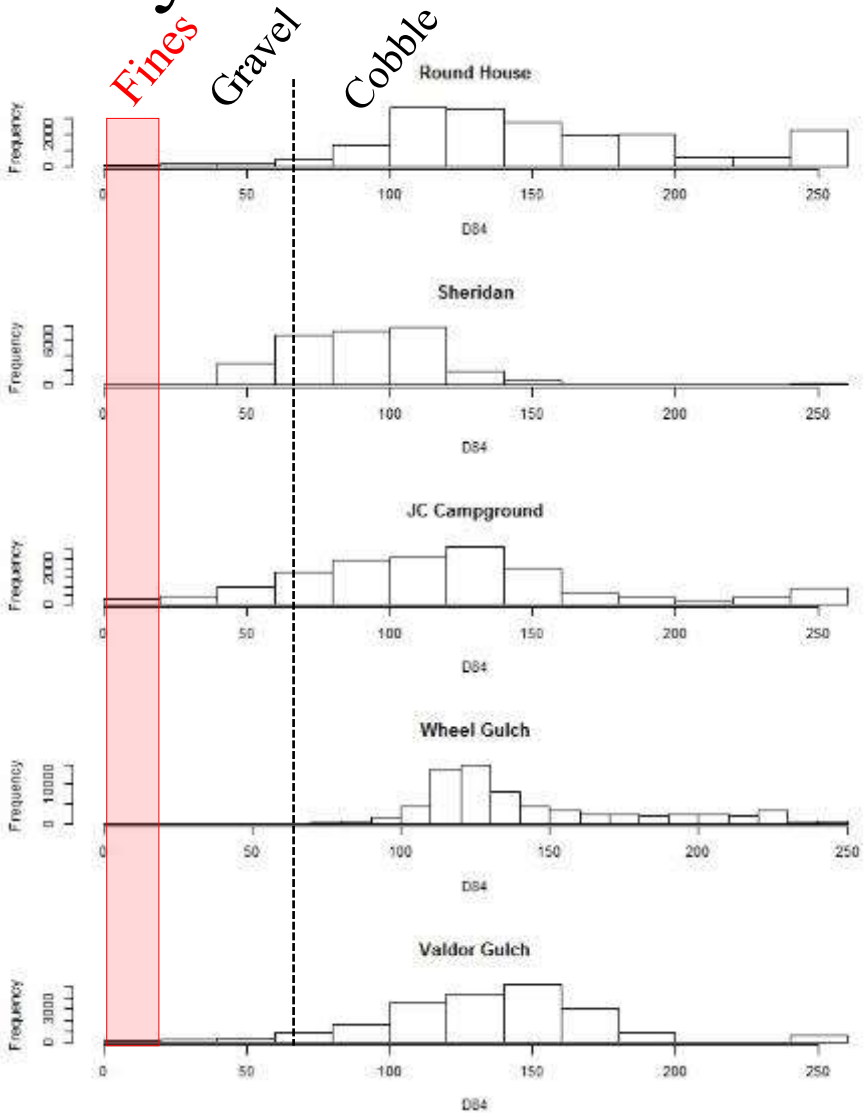
Population est. = 3,500 * 17

= **59,500 ammocoetes**

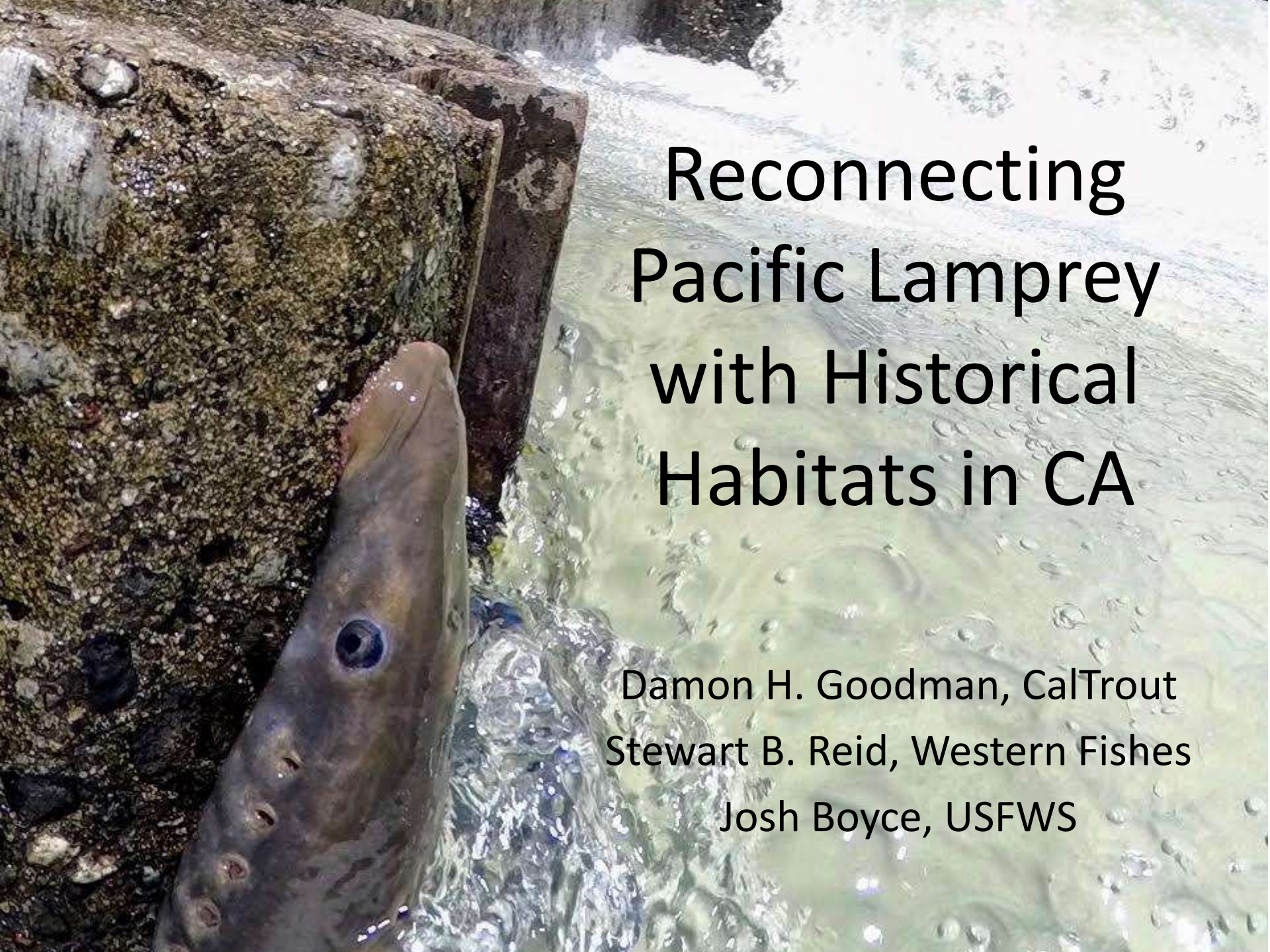
age 1-7 yrs
excludes YOY

Substrate Distribution -Trinity Restoration Reach





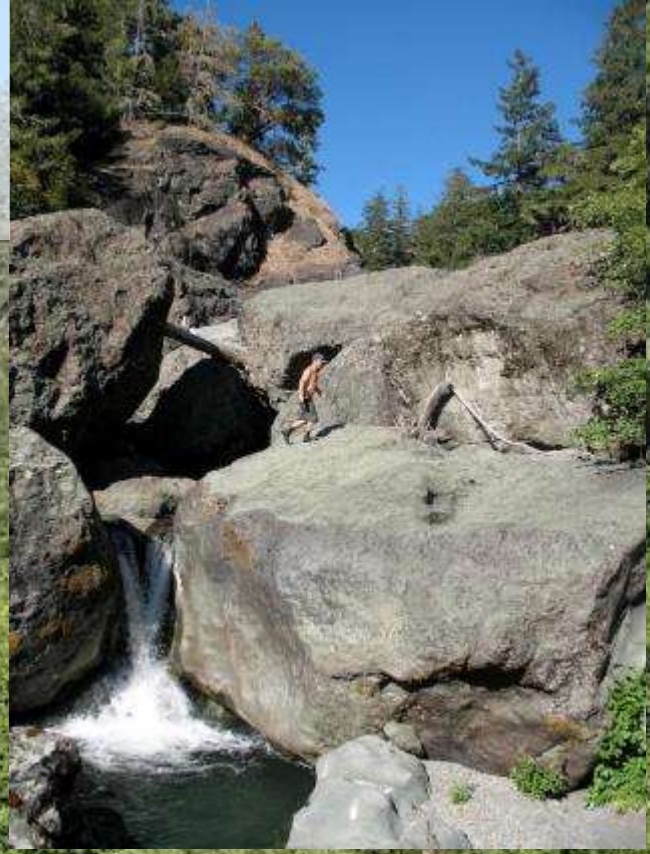

Sand …
29.09.2016 13:36



Reconnecting Pacific Lamprey with Historical Habitats in CA

Damon H. Goodman, CalTrout
Stewart B. Reid, Western Fishes
Josh Boyce, USFWS

Nature's Obstacles
A Template for Evolution



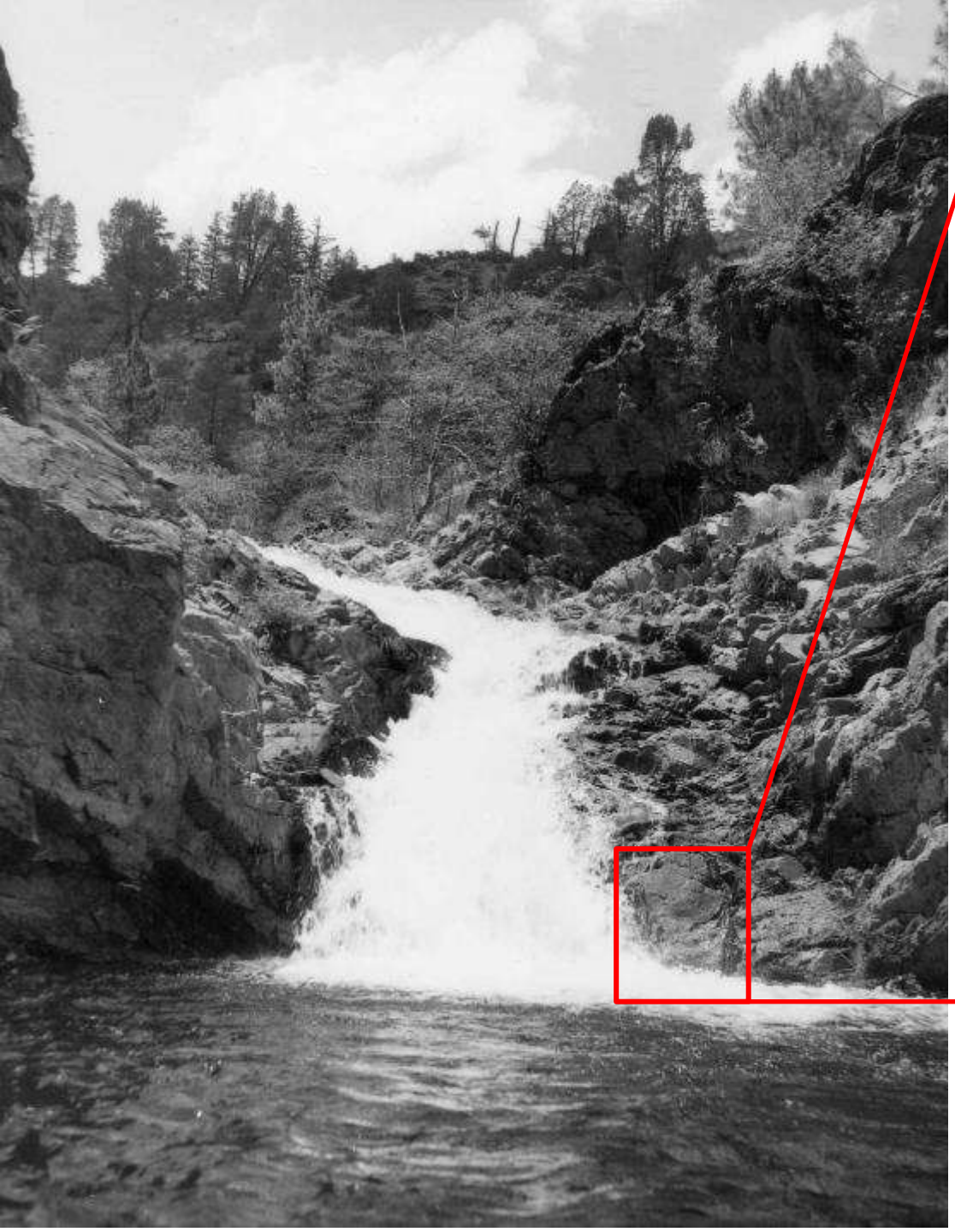
Van Duzen River, Eel River Drainage

Historical Extent of Steelhead Distribution

Pacific Lampreys developed an alternate (May we say SUPERIOR) approach to ascending obstacles

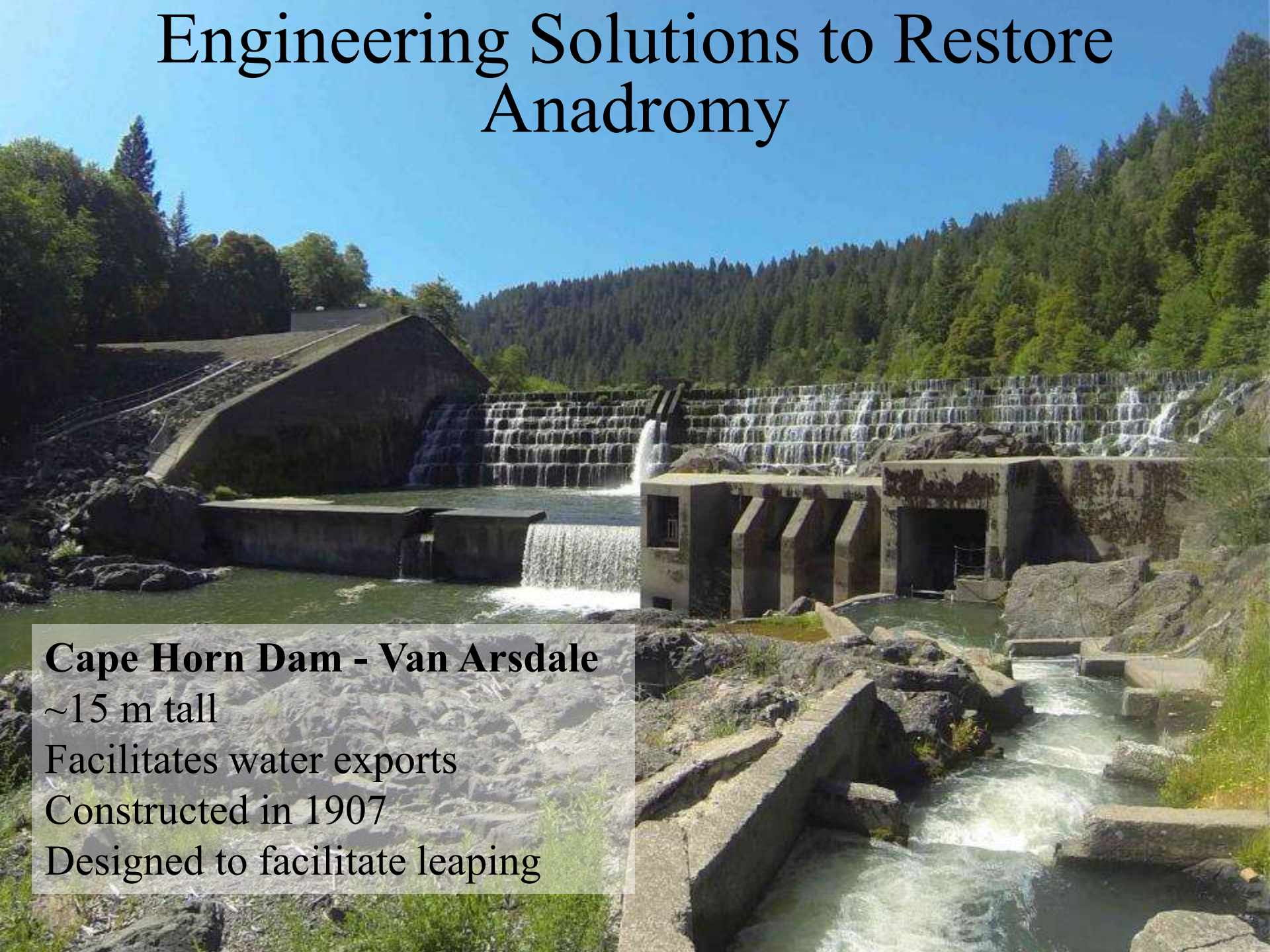
Hayfork Falls – trib. Trinity River
July 1963

Historical Extent of Steelhead Distribution



Hayfork Falls – trib. Trinity River
July 1963

Engineering Solutions to Restore Anadromy



Cape Horn Dam - Van Arsdale
~15 m tall
Facilitates water exports
Constructed in 1907
Designed to facilitate leaping

Target Species

Salmonid monitoring since 1922

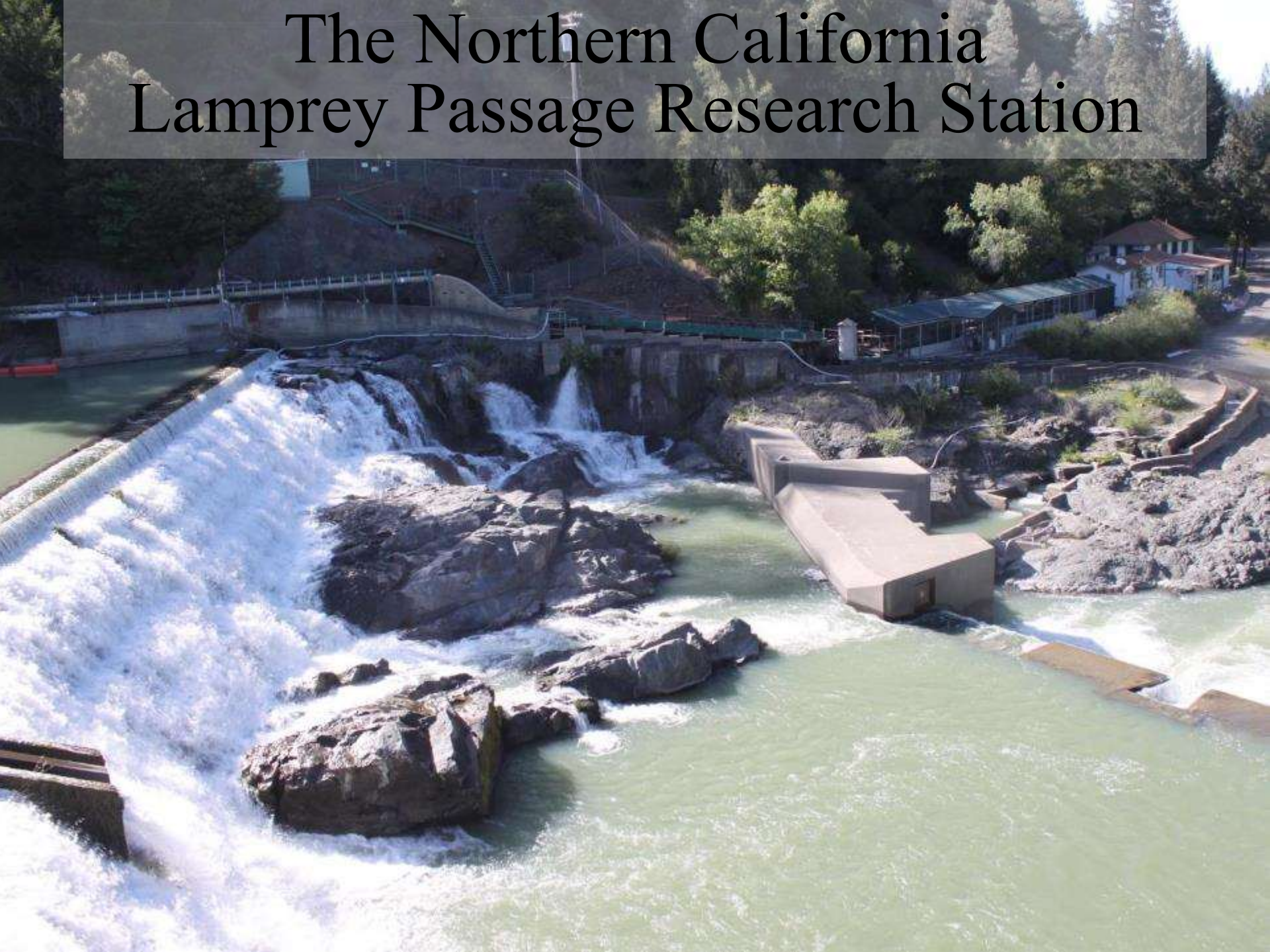
The Problem….

Unexpected Situations……

Unexpected Problems….

And More Problems……

The Northern California Lamprey Passage Research Station

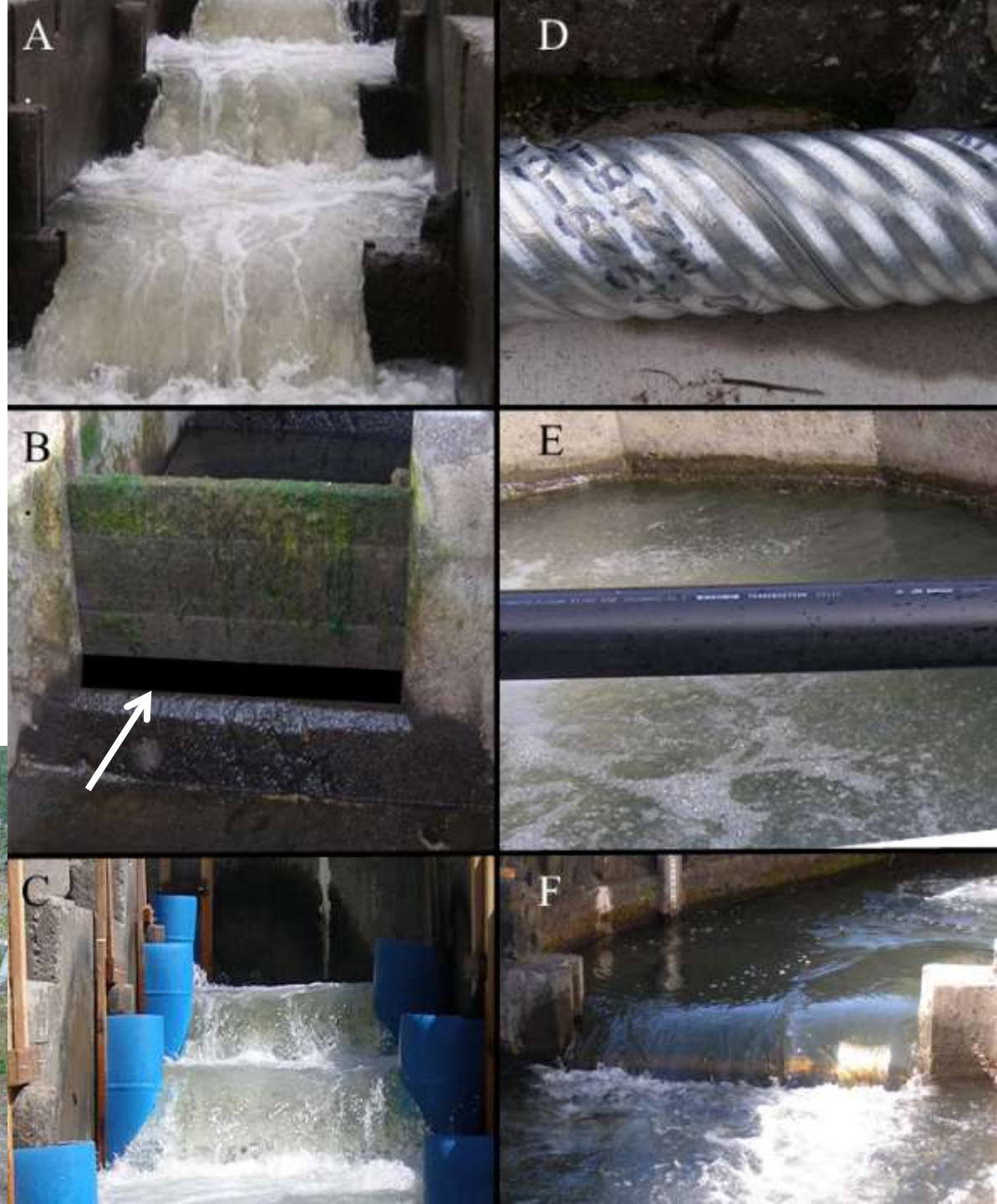


Assessment Framework

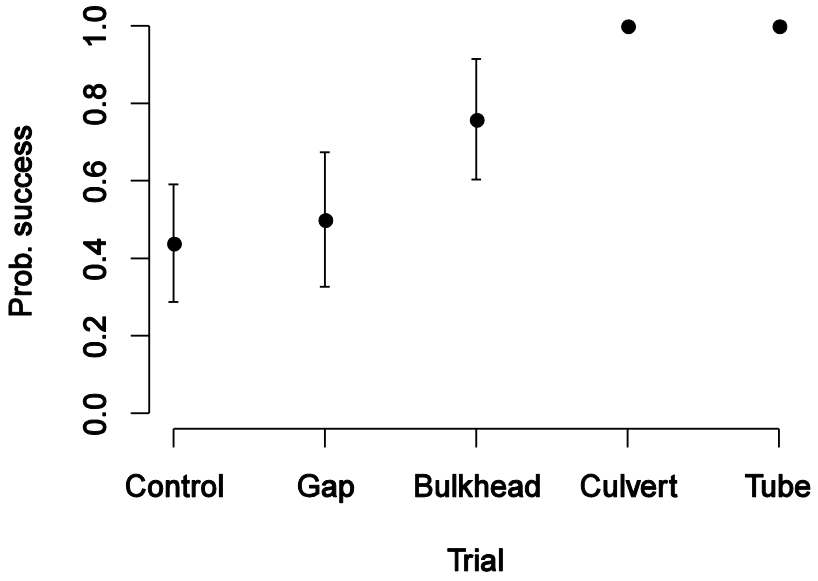
- Challenged lampreys with 5 modifications
  - 10 m section (4 weirs)
  - 10% gradient

- Nighttime observations
- Established PIT arrays

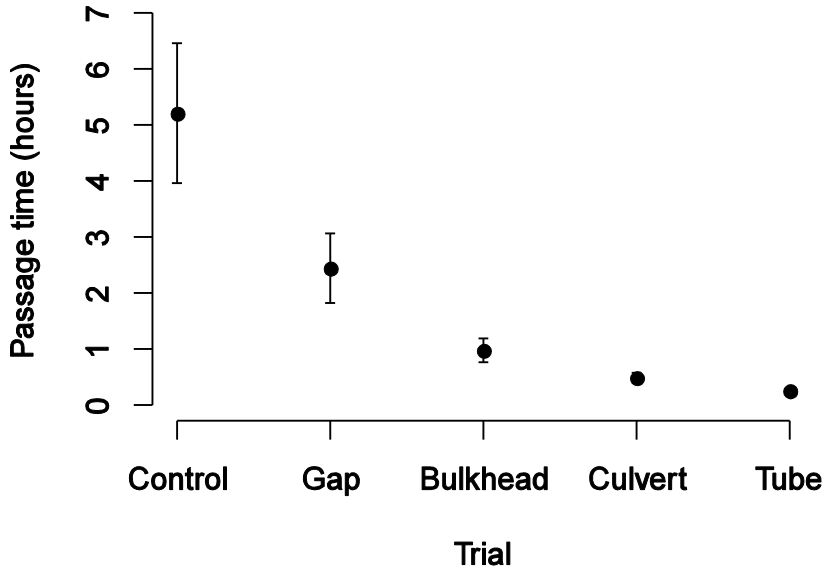
- Evaluated
  - Behavior
  - Passage success (overnight)
  - Passage time



Probability of Success



Passage Time



Contents lists available at ScienceDirect
Ecological Engineering
journal homepage: www.elsevier.com/locate/ecoleng

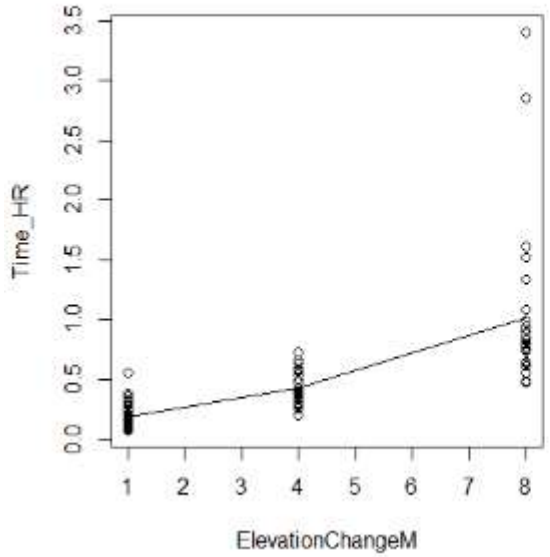
Research Paper

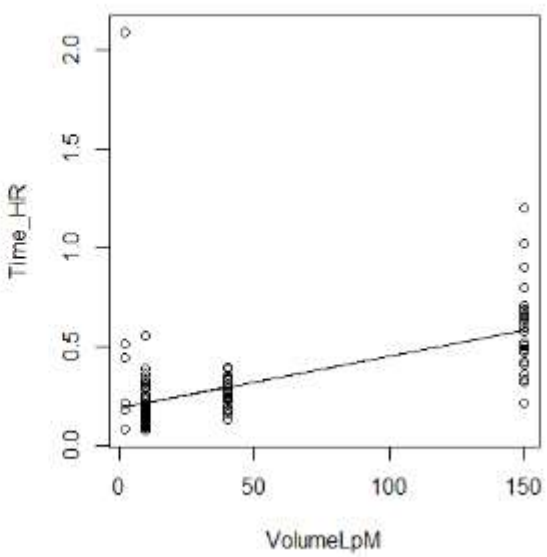
Climbing above the competition: Innovative approaches and recommendations for improving Pacific Lamprey passage at fishways

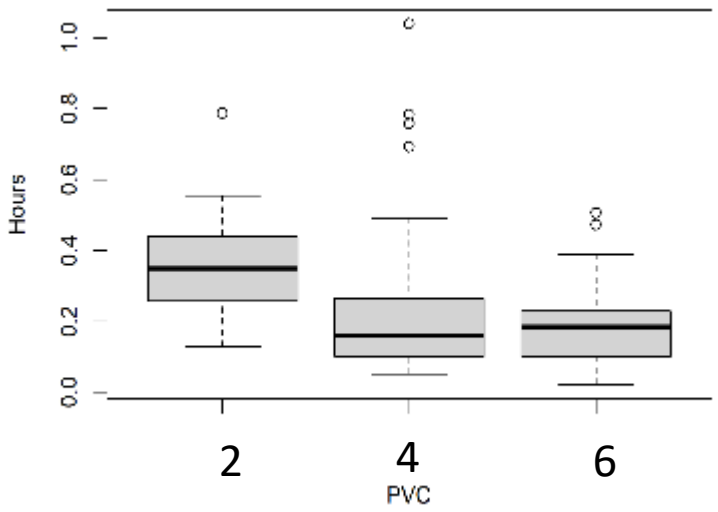
Damon H. Goodman[a,*], Stewart B. Reid[b]

GLM
Error bars indicate 95% CI
No effect of lamprey length

Refining the Design Process

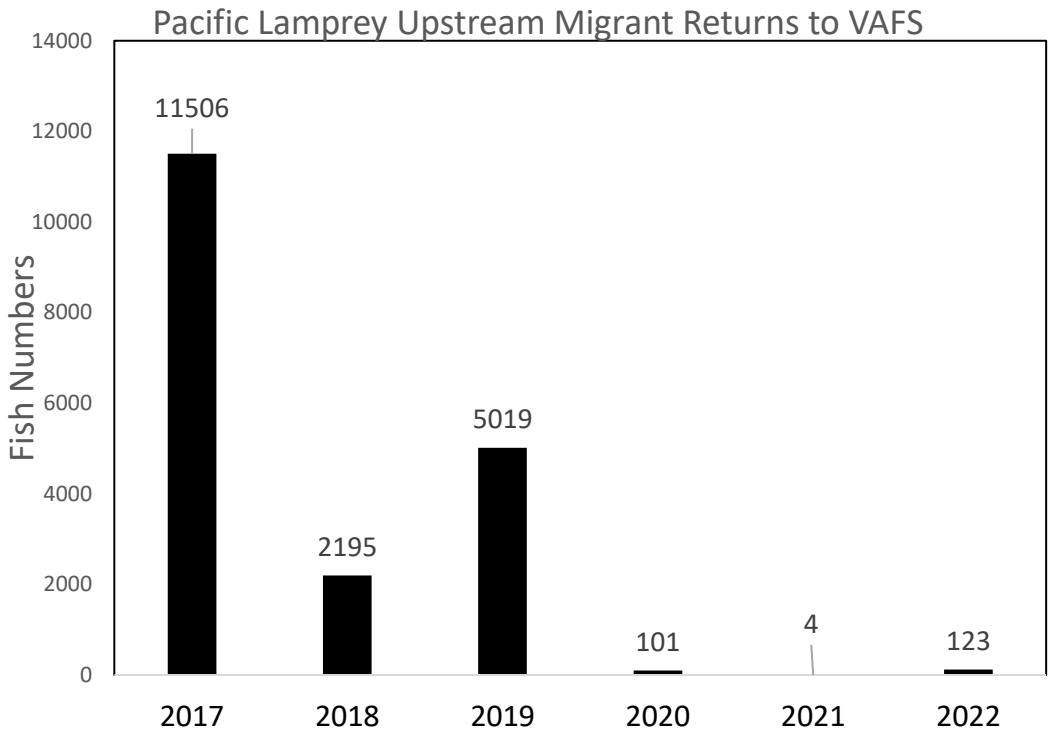


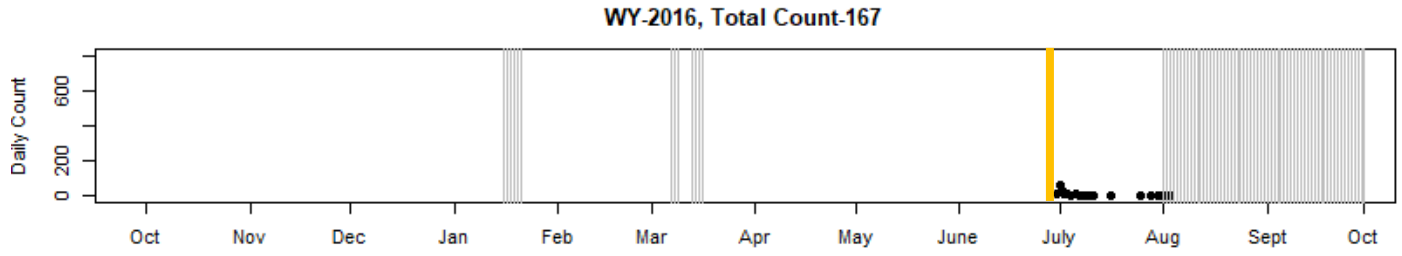


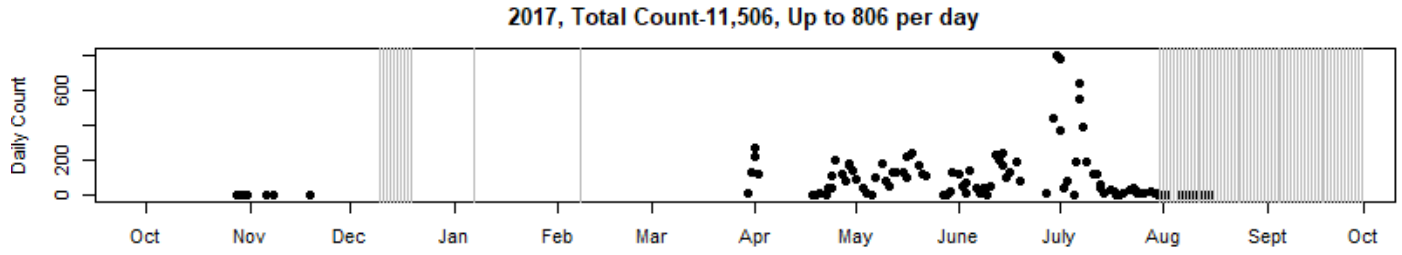


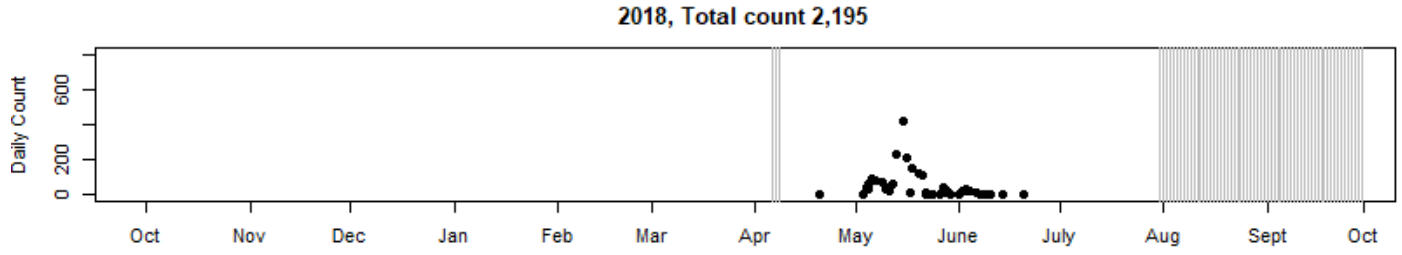
So Now What????

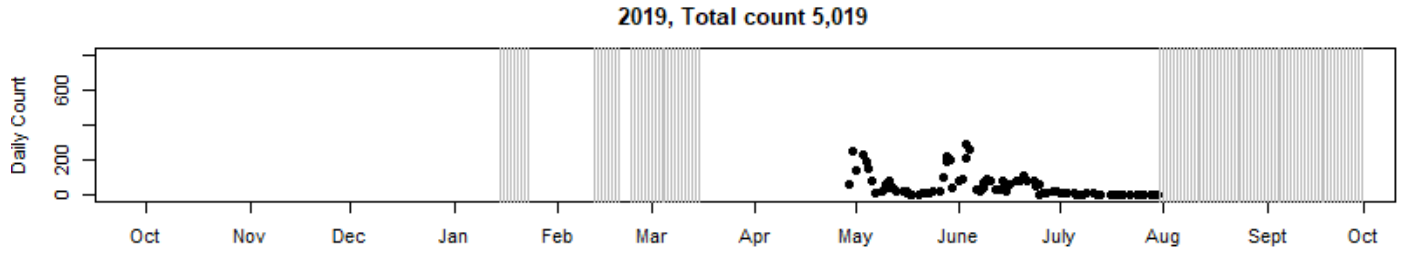
>11,000 passed in the first year
Up to 800 per day

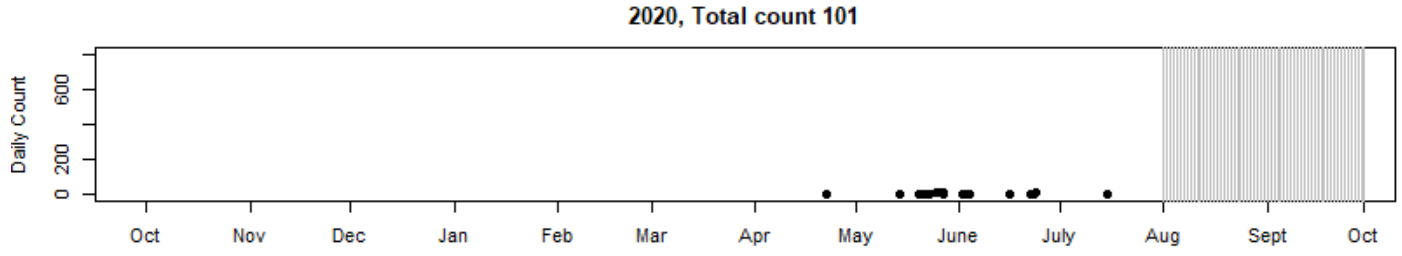

Pacific Lamprey Upstream Migrant Returns to VAFS
Fish Numbers
14000
12000
10000
8000
6000
4000
2000
0
11506
2195
5019
101
4
123
2017
2018
2019
2020
2021
2022











Data need :
Flow & Temperature

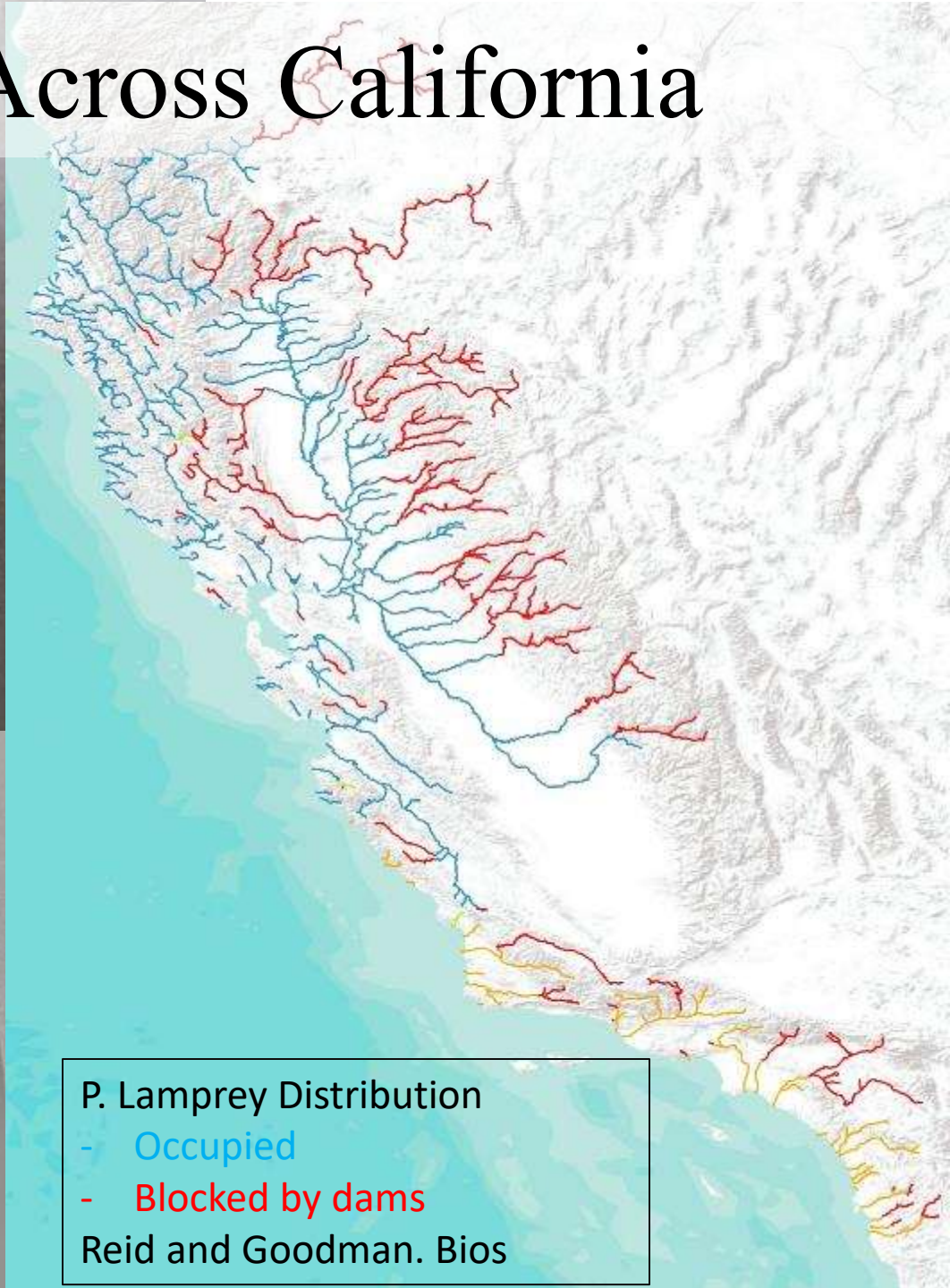
Lamprey count assumptions

1. Fishway closure ~ tube closure
2. Consistent dates for fall maint. Exact dates are a data need.

Applicable Across California

One tool for turning
Red lines to blue

-Noyo River
-Eel River
-Russian River
-San Luis Obispo River
-Santa Clara River
-Smith River
-Carmel River (in prep)



P. Lamprey Distribution
- Occupied
- Blocked by dams

Reid and Goodman. Bios

Pacific Lamprey: Anthropocene Sentinel for Pacific Northwest Water Quality

Salmonid Restoration Federation - 2023
Lamprey Workshop

Cal Poly Humboldt.

Cynthia Le Doux-Bloom, PhD |

26 April 2023

Unique Circumstances = Unique Opportunities

Overarching Goals: Describe Projects 1 and 2 and link how their findings provide the foundation for future projects

The Reality… Project 1

- Inherited NFWF funds to investigate juvenile coho health in relationship to the Trinity River health (<2018)…
- Reconning sites to place caged coho for the funded study with Paul Petros.
- Located lots of sites with larval (Clemons 2019) lamprey present
- Discovered funding window would expire before Hoopa could get permits
- Larval lamprey used for MeHg studies (Bettaso & Goodman 2008 and others)
- Could lamprey health be used as surrogate for coho health? Tribal Health? He et al. 2012

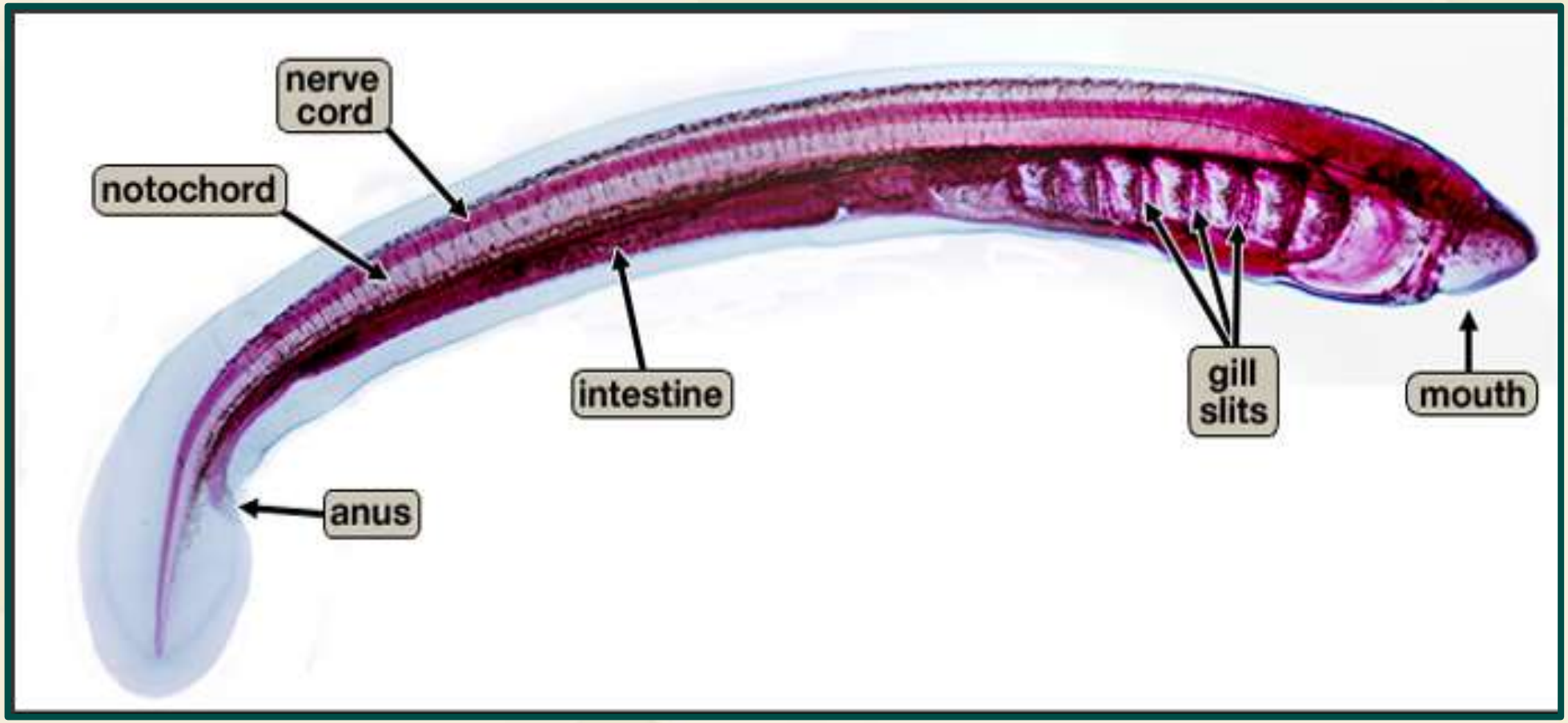
Cal Poly Humboldt.

Larval Pacific Lamprey Basics

- Life cycle begins as filter-feeding larvae in riverine habitat (Clemons 2019)
- Larvae filter food via their pharynx with 7 visceral pouches into the GIT
- Muscular velum generates flow of water that is respiratory and feeding
- Pouches open directly to water and the gills facilitate feeding and respiration
- Larvae show tolerance to rapid warming and freezing conditions (Moser et al., 2018)
- Larvae consume little oxygen and are tolerant of stagnant or hypoxic water (Moser et al., 2019)
- Larvae are largely sedentary (Lampman et al. 2021) = defensible biological indicator and a sentinel for water quality

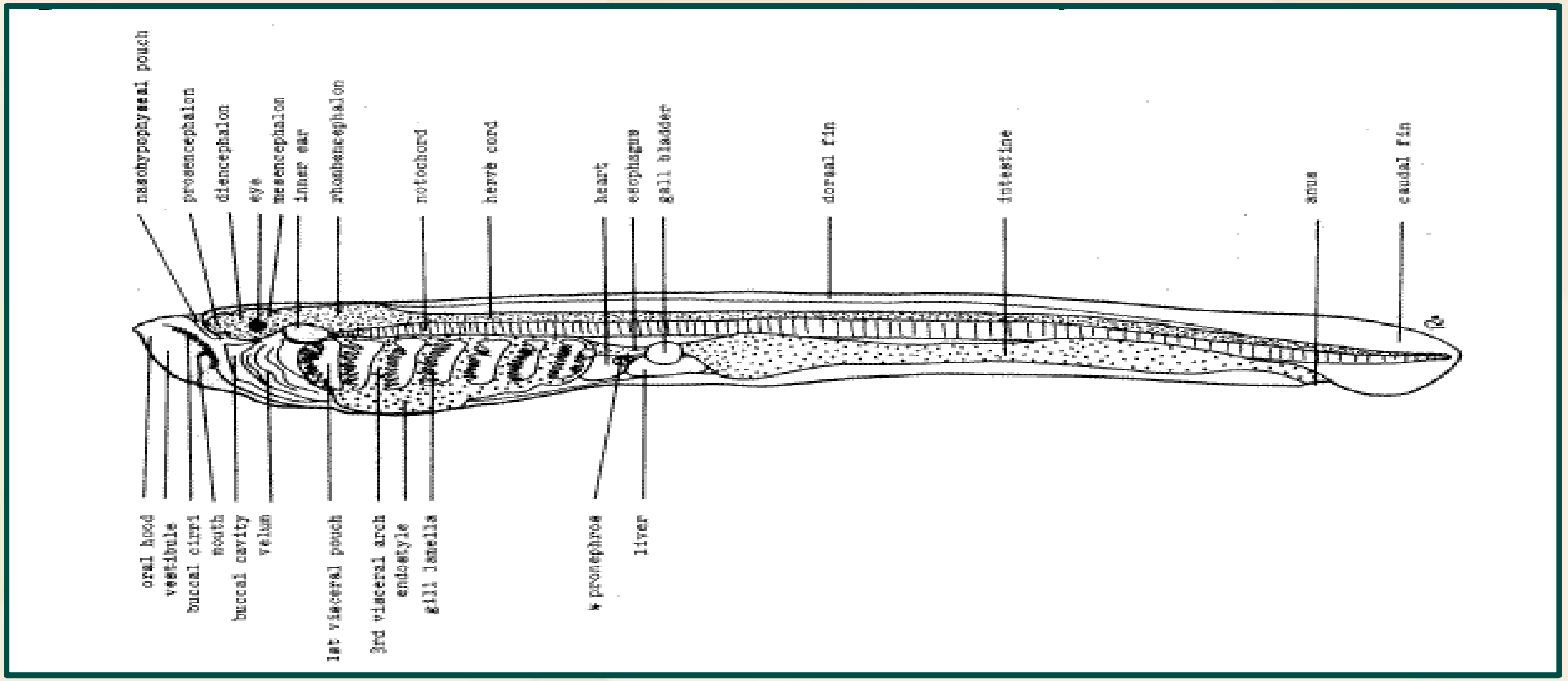
Cal Poly Humboldt.

Basic Larvae Physiology

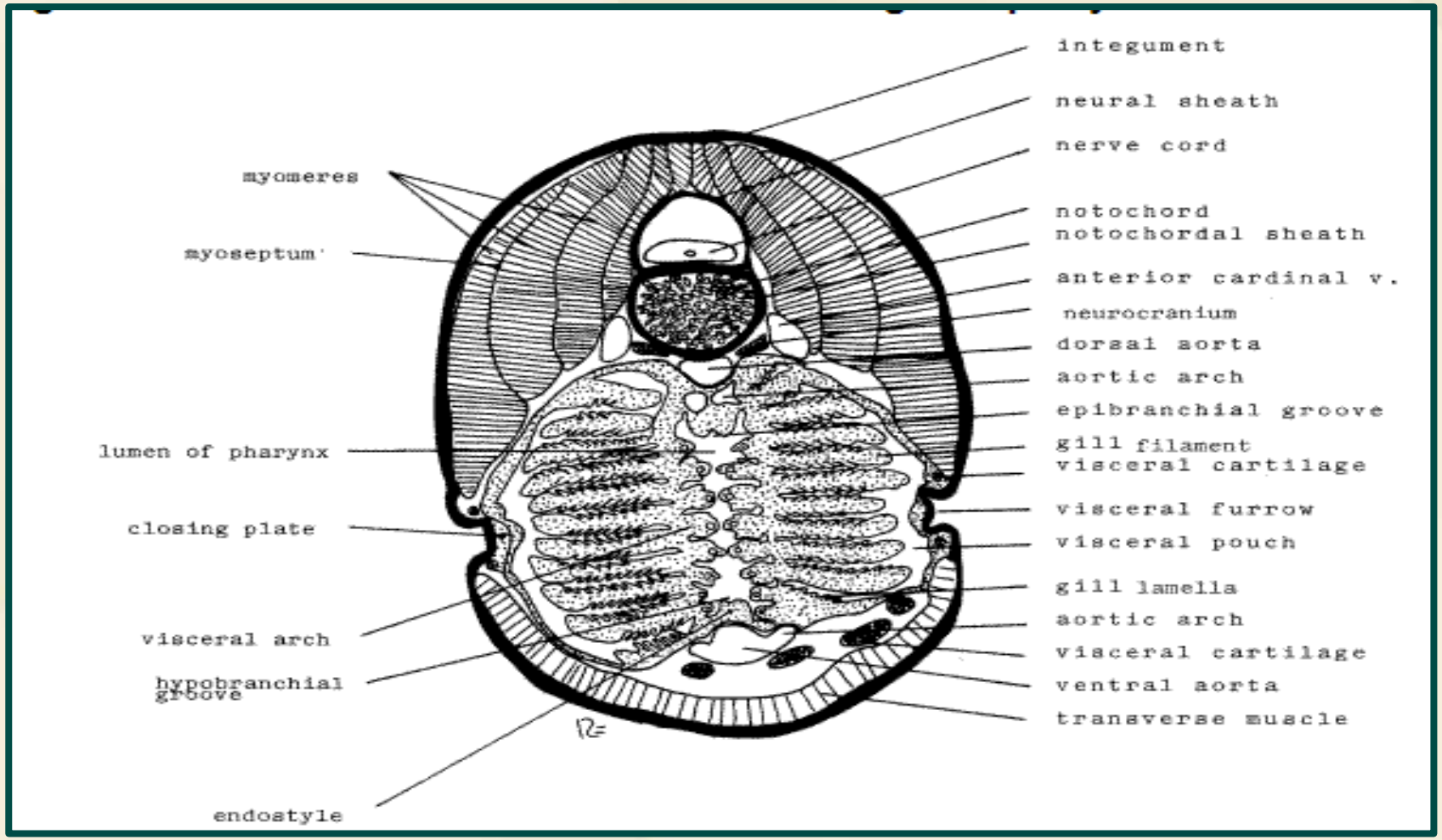


Cal Poly Humboldt.

Detailed Larvae Physiology



Pharyngeal Cross Section



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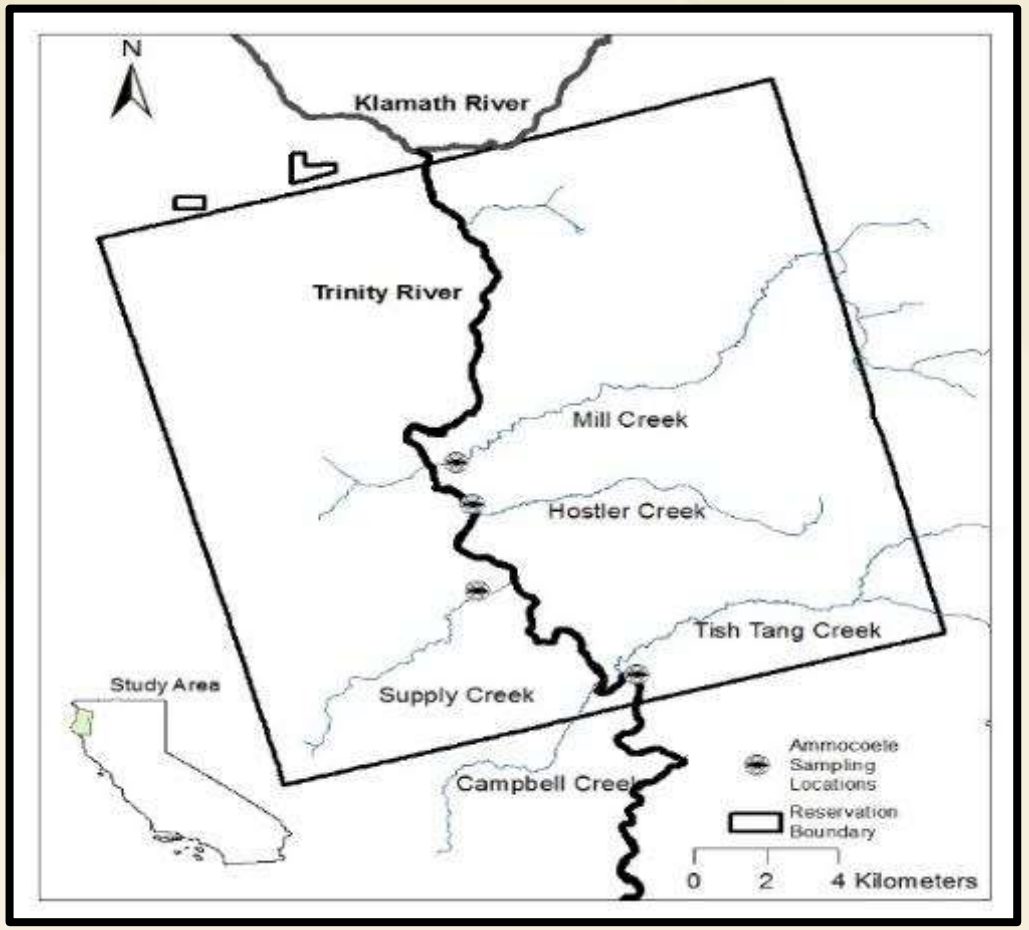
Study Site & Sample Sites – Hoopa Rez



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Research Goals & Objectives: Project 1

- Approved to use some of the NFWF funds to collect larval lamprey
- No funding to test for contaminants, Hg / MeHg

1. Create a team who would run the histological samples for FREE
2. Determine if larvae detect contaminants
3. Adults being consumed by Klamath Tribes contain toxic Hg/MeHg levels? (He et al. 2012




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Team 2018 (Project 1) - Proof of Concept

Can a prehistoric larval lamprey be used as a Surrogate of Ecosystem Health in the Anthropocene?

Justin Alvarez, Hoopa Tribal Fisheries
2018 -2022 FIELD WORK

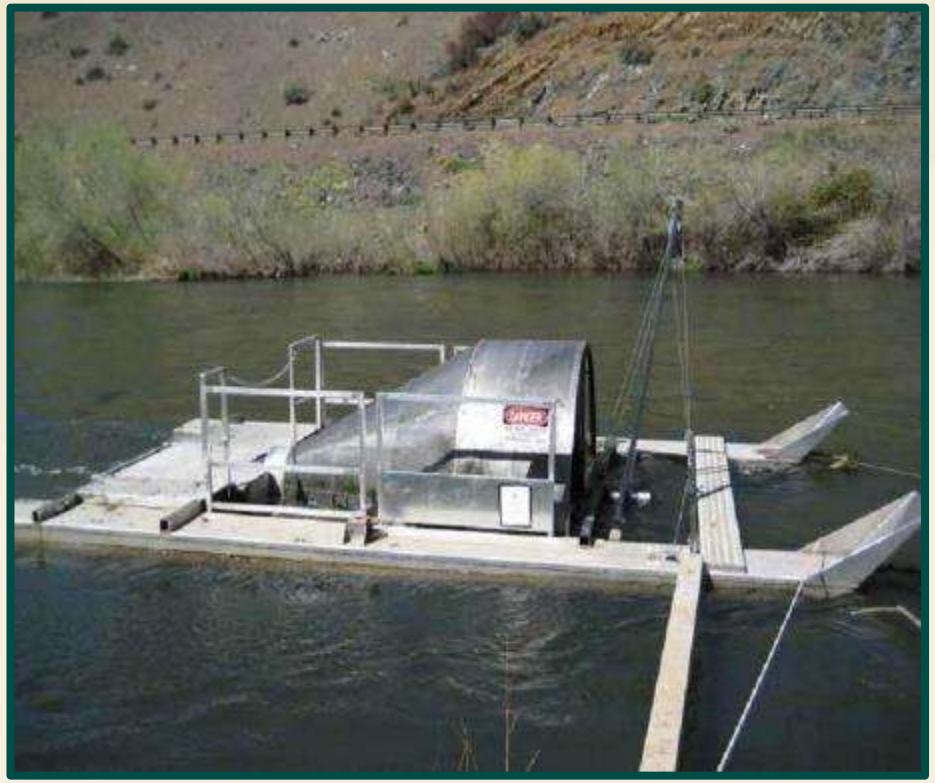
Dr. Michelle Hladik, UGSS
2018 -2022 CONTAMINANTS

Dr. Collin Eagles-Smith, USGS
2018 -2022 Hg/ MeHg

Methods & Materials

Adults Creel

DMT



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Methods & Materials SCP + IACUC*

Larvae

125V, 3:1 Burst Rate
Slow Pulse (tickle charge) 4.0,
Duty Cycle 26.5%

Fast Pulse (Stun Charge) 30,
Duty Cycle 24.9%

FedExed USGS Sampled + Dry Ice

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Pesticide Analyses

- Approximately 0.2 g of tissue was dried and homogenized with sodium sulfate.
- The samples were extracted with dichloromethane and acetone using an accelerated solvent extractor at 1500 psi and 100°C.
- Matrix removal was achieved with a solid phase extraction (Z-sep+ for tissue; carbon/alumina for sediment).
- Quantitation was done using both gas and liquid chromatography-tandem mass spectrometry.
- Tested for 150 analytes.

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Mercury Analyses

- Each sample was freeze-dried and homogenized to a fine powder using a porcelain mortar and pestle.

- Total Hg was determined via cold-vapor atomic absorption following EPA method 7473 (U.S. Environmental Protection Agency, 2000) on a Nippon MA-3000 mercury analyzer.

- For MeHg, 2-10 mg of dried homogenate was digested in 3-4ml 30% nitric acid at 60◦C overnight (~15 hours), ethylated with 1% sodium tetraethylborate, then analyzed via cold-vapor atomic fluorescence spectrometry on a MERX-M (Brooks Rand Instruments, Seattle, Washington, USA) automated methylmercury analyzer.

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Results Project 1

- MeHg was detected in all Klamath River adults and most Trinity River adults, but only the Trinity River adults exceeded the safe consumption rates of 3 meals/week. A meal is less than the size of a hot dog.
- MeHg was detected in
- Larval and adult lamprey were positive for contaminants
- Bifenthrin (pyrethroid insecticide) was detected in Trinity River adults and larvae and Mill Creek larvae. No contaminants were detected in Supply Creek larvae.
- Pendimethalin (herbicide) was detected in Trinity River adults
- DDT and its metabolites were present in all Trinity River adults. – not surprising!

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Table 1. Numbers of MeHg, Bifenthrin, Pendimethalin, DDD, DDE, and DDT in µg/kg of adult and juvenile tissue samples by location in the Klamath Basin in 2018. Larvae from Supply Creek had only MeHg detections (n=17/17; 0.16 – 0.34).

Site	Method	MeHg µg/g	Bifenthrin	Pendimethalin	DDD	DDE	DDT
Klamath (3) Adult	Creel	3 0.06-0.10	0	0	0	0	0
Trinity (12) Adult	DMT	12 0.2 -1.18 H	5 4.5-7.7	5 2.2-6.4	12 2.7-37.5	12 2.7-37.5	12 3.0-46.3
Trinity(22)	E-Fish	22 0.18 -0.45	6 0.0-4.0	0	0	0	0
Mill (11)	E-Fish	11 0.24 -0.56	6 0.5-3.5	0	0	0	0

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Findings and Next Questions

1. Create a team who would run the histological samples for FREE - Done
2. Determine if larvae indicate contaminants - Done
3. Do adult lamprey being consumed by Klamath Tribes contain Hg and MeHg? – YES

- Are we *really* testing larval Pacific Lamprey?
- Do the contaminants differ between seasonal flows? Years?
- Can larval lamprey be used for Regional Water Quality Monitoring?
- Could this monitoring detect changes due to climate change?

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Research Goals & Objectives: Project 2

1. Assess tribal drinking water on the Hoopa Valley Indian Reservation for contaminates using larval Pacific lamprey tissue. BOR Funded
2. Assess potential environmental impacts on Tribal Health?
3. Add a team member who would run the genetic samples for FREE to show what lamprey species were being tested.

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Team 2020 – 2022 (Project 2)

Can larval Pacific Lamprey Surrogate of Ecosystem Health in the Anthropocene?

Justin Alvarez, Hoopa Tribal Fisheries
2018 -2022 FIELD WORK

Dr. Michelle Hladik, UGSS
2018 -2022 CONTAMINANTS

Dr. Collin Eagles-Smith, USGS
2018 -2022 Hg/ MeHg

Dr. John Hess, Columbia River Intertribal Fish Com
2020 – 2022 GENETICS

Methods and Materials

- Same collection methods as Project 1, but limited to larvae only
- Focus on Trinity River and tributaries that supply drinking water to the Hoopa Tribe.
- **Genetic Analyses (new):** CRITFC conducted the species ID at no cost to this project. Read Dr. Jon Hess's papers.

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Results Project 2

- MeHg was detected in all Klamath River adults and most Trinity River adults, but only the Trinity River adults exceeded the safe consumption rates of 3 meals/week. A meal is less than the size of a hot dog. A lamprey meal is usually bigger than a hotdog.
- MeHg was detected in
- Larval and adult lamprey were positive for contaminants
- Bifenthrin (pyrethroid insecticide) was detected in Trinity River adults and larvae and Mill Creek larvae. No contaminants were detected in Supply Creek larvae.
- Pendimethalin (herbicide) was detected in Trinity River adults
- DDT and its metabolites were present in all Trinity River adults. – not surprising!
- With a 99.9% probability, the larvae were Pacific Lamprey!!!

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Table 1. Detected concentrations in larval Pacific lamprey tissue collected on select streams on the Hoopa Valley Indian Reservation in the Fall 2020 and Spring 2021. Mass (g); Pesticides concentration (ng/g wet wt); Hg concentration (ppm wet wt); H (highest value recorded)

Date	Stream	Bifenthrin	Permethrin	p,p'DDE	MeHg	THg	%MeHg
Fall20	Trinity	4.1 H	8.2	0.48	0.24	0.28	86
			7.6	0.74 H	0.29	0.28	103
		2.9	14.8		0.15	0.19	76
	Campbell		44.5		0.32	0.34	95
		0.9	53.4		0.29	0.29	99
			55.5 H		0.27	0.29	93
	Mill				0.16	0.16	105
	Supply	0.5			0.24	0.24	102
Spr21	Trinity			0.73	0.31	0.37	86
				0.48	0.35	0.34	101
		1.7	3.1		0.29	0.32	91
	Campbell				0.51 H	0.45	114
					0.30	0.32	93
		0.9			0.38	0.41	91
	Mill				0.37	0.41	90
				0.51	0.41	0.46 H	90
				0.45	0.41	0.49 H	90
	Supply				0.37	0.45	81
					0.32	0.28	112

Conclusions

MeHg was present in 100% of the larvae across both projects in all years.

MeHg levels detected in adults exceeded safe human consumption levels.

Bifenthrin was present in lamprey tissues across both projects in all years.

Permethrin was present in 2020 and 2021.

Both Bifenthrin and Permethrin are extremely toxic to fishes.

Pendimethalin was present in 2018. It is highly toxic to fishes.

DDT levels were variable across projects and years.

Results indicate further monitoring is warranted using larval Pacific Lamprey.

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Findings and Next Questions

1. Assess tribal drinking water on the Hoopa Valley Indian Reservation for contaminates using larval Pacific lamprey tissue. DONE
2. Assess potential environmental impacts on Tribal Health? POSSIBLE
3. Add a team member who would run the genetic samples for FREE to show what lamprey species were being tested. DONE

How do we expand the larval Pacific Lamprey contaminants study to its entire range? Starting with the Copper River (AK), Elwa River, Columbia Basin, Eel, Sacramento rivers…

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Funded and Projected Funding

- Project 1: 2018 Pilot Study - Hoopa Fisheries & USGS (in-kind)
  Proof of Concept(s): Lamprey and Contaminants - Surrogate
- Project 2: 2020 Study – Hoopa Tribal Environmental Protection Agency with the U.S. Bureau of Reclamation Native American Affairs: Technical Assistance to Tribes for Hoopa Tribal Drinking Water Quality
- Project 3: FY2023 Study – Columbia River Intertribal Fish Commission with the Pacific Lamprey Conservation Initiative (PCBs and MeHg) Not funded
- Under Development: PNW and AK Regional partnership with proposals to National Fish Habitat Partnership and others

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Thank You & Questions

Collaboration is KEY to successful scientific endeavors!

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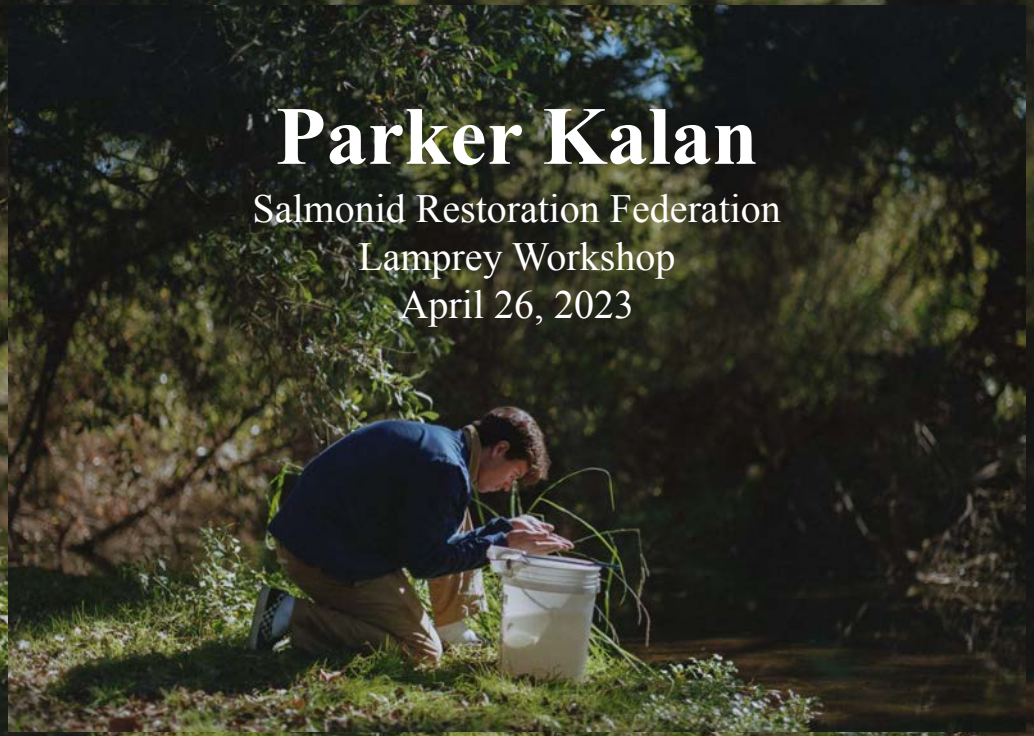
Ecological Function of Pacific Lamprey (*Entosphenus Tridentatus*) ammocoetes in the San Luis Obispo Creek Watershed



Parker Kalan

Salmonid Restoration Federation

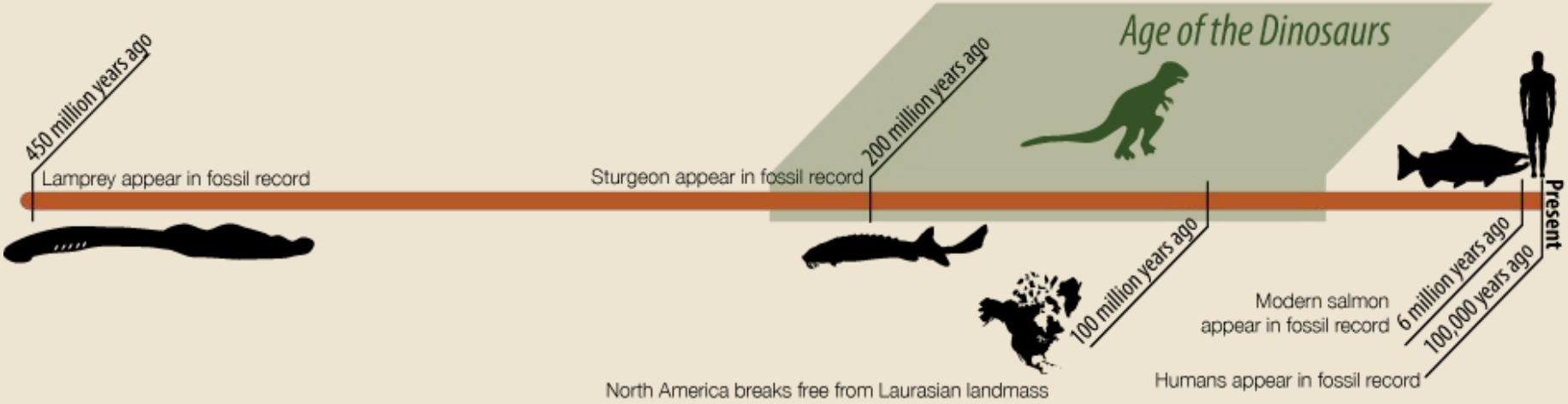
Lamprey Workshop
April 26, 2023

Pacific lamprey

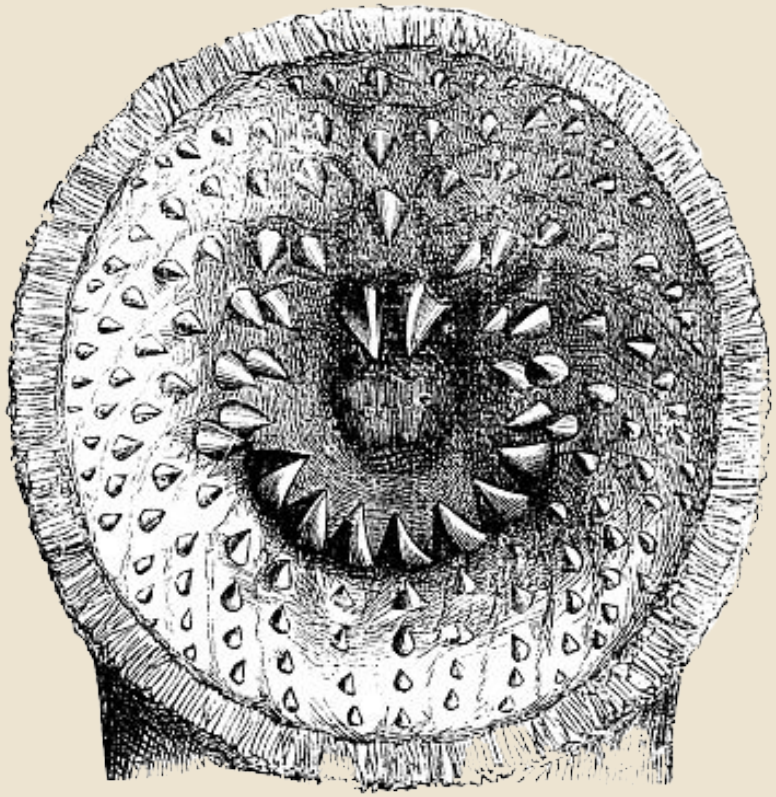
Entosphenus tridentatus

Order: Petromyziformes

Family: Petromyzontidae



Credit: Columbia River Inter-Tribal Fish Comission

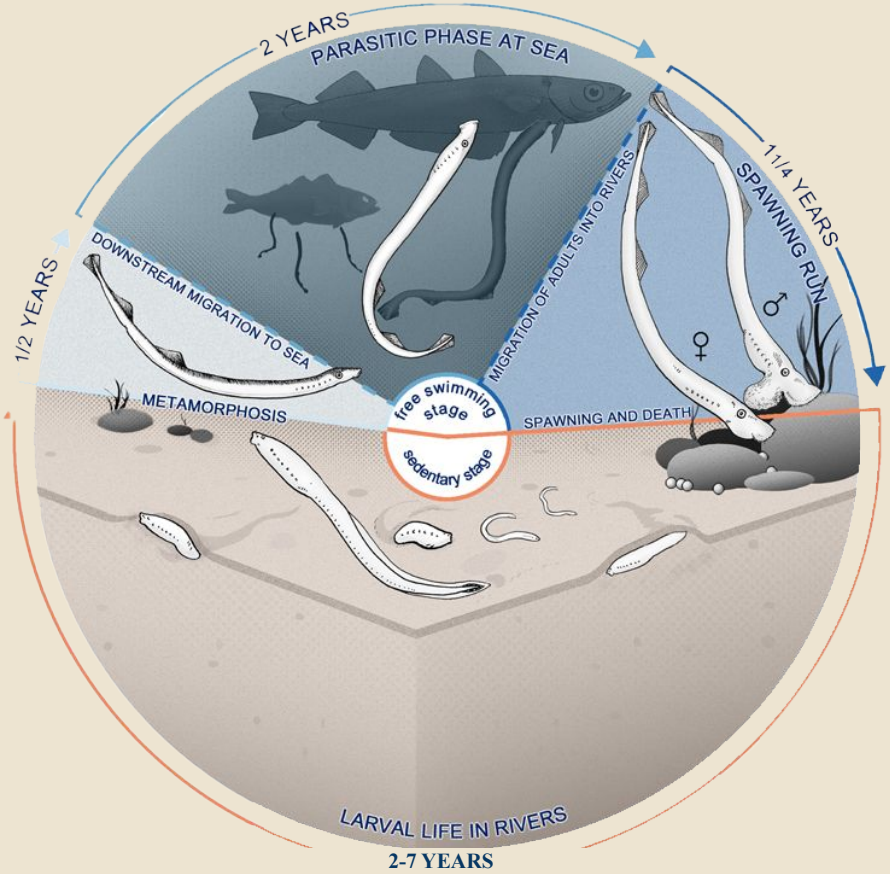


Parasites?

Image Credits: US Fish and Wildlife Service

Life History

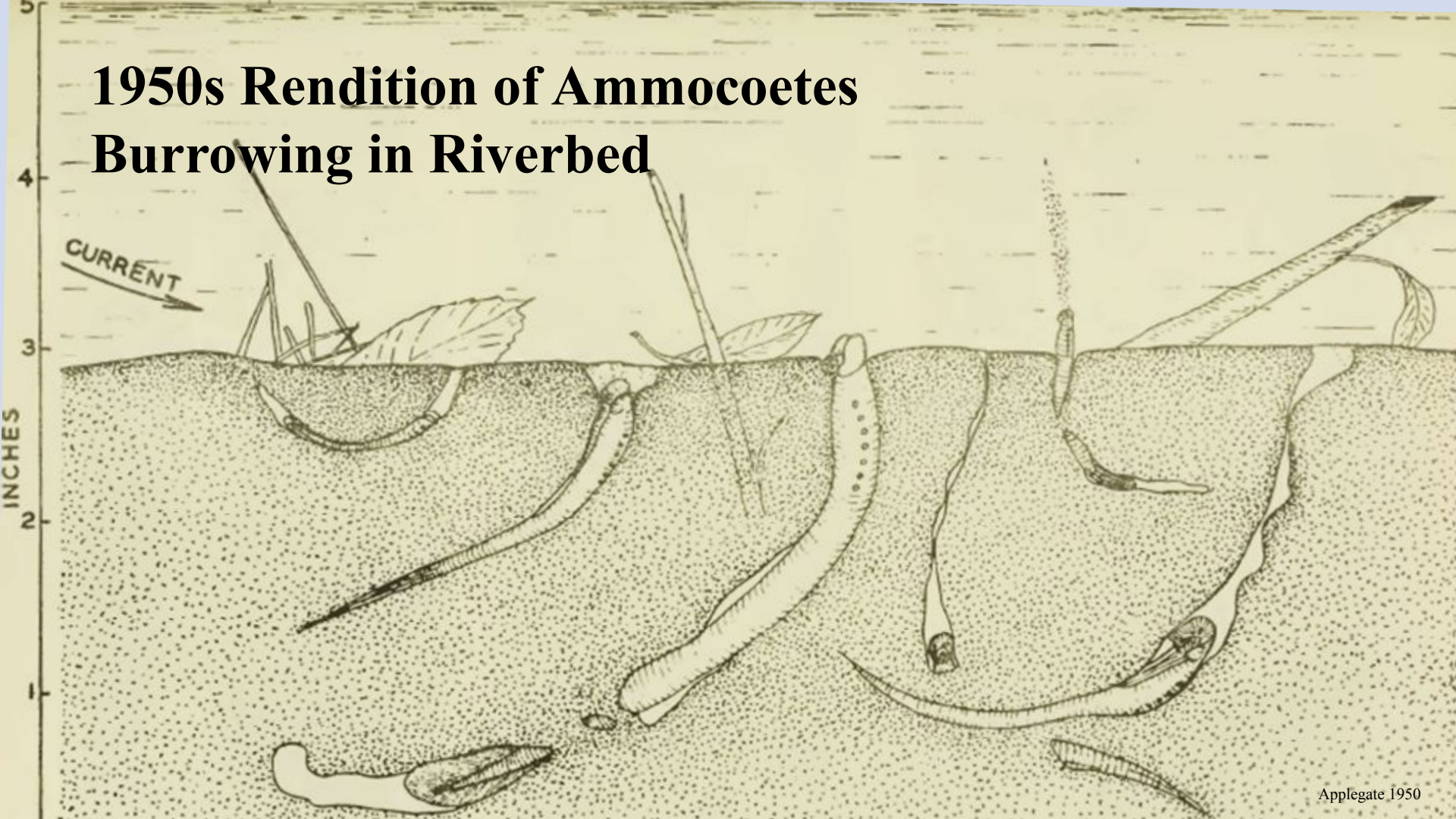
- Adults- Parasitic
  - Feed in Open Ocean
  - Migrate into freshwater to spawn
- Larval - Ammocoete
  - Burrow into sediment of freshwater streams
  - Filter feed for 2-7 years
  - No eyes
- Macropthalmia - Juvenile
  - “With eye”
  - Migrating out to ocean



https://critfc.org/fish-and-watersheds/columbia-river-fish-species/lamprey/
Harris et al. 2020; Reid and Goodman 2021

Image Credit: fws.gov/lampreylifecycle

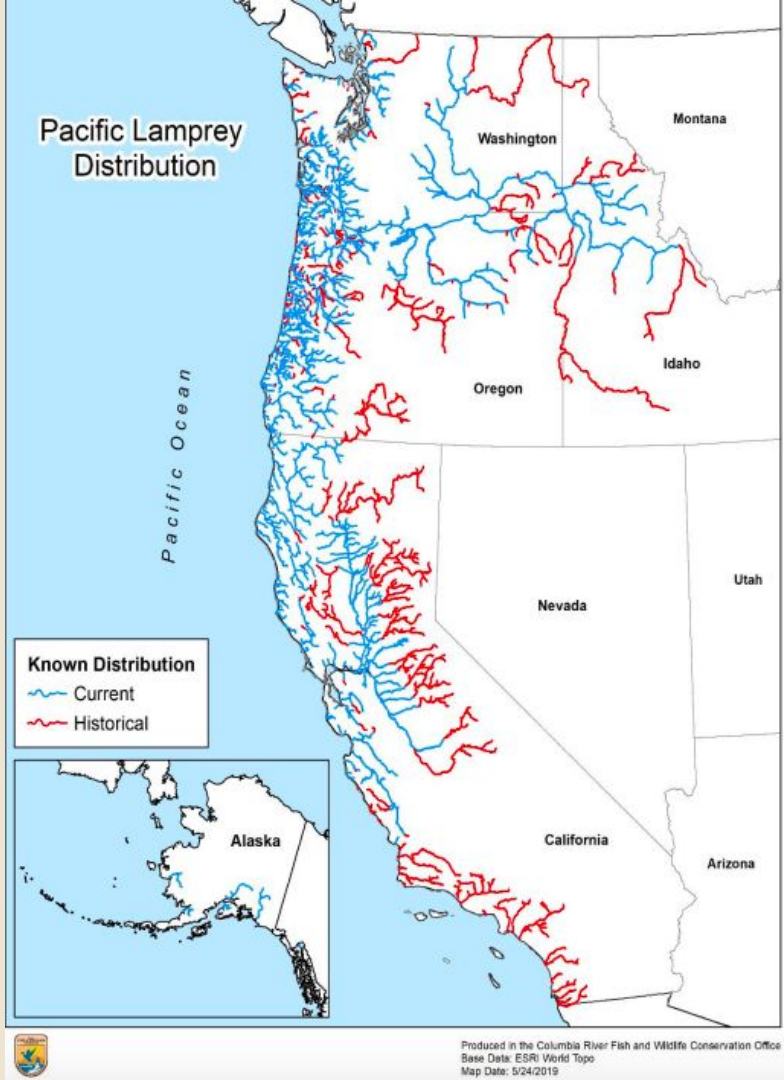
1950s Rendition of Ammocoetes Burrowing in Riverbed



Applegate 1950

Distribution

- Historically Broad Distribution
  - Entire Pacific Rim from Japan, Alaska, and down into Baja
- Range Retraction
  - Dams alone have blocked 40% of historic range
  - SLO Creek is at the southern extent of current range



Goodman and Reid 2012, 2016; Ruiz-Campos and Gonzalez-Guzman 1996; Scott and Crossman 1973

Story Time: The Lamp Ramp

- Documented presence of Pacific lamprey
- 2004 a “notch” was installed to increase accessibility for Steelhead
- Inadvertently extirpated lamprey
- 2013 “Lamp Ramp” installed
- March 2017 spawning adults seen in Mission Plaza
- In parallel to lamprey absence water quality in SLO Creek declined

Filter-Feeding Pacific Lamprey (*Entosphenus tridentatus*) Ammocetes Can Reduce Suspended Concentrations of *E. coli* Bacteria

by Parker Kalan [1,2,*], John Steinbeck [2], Freddy Otte [3], Sean C. Lema [1] and Crow White [1]

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Potential utility of filter feeding ammocoetes

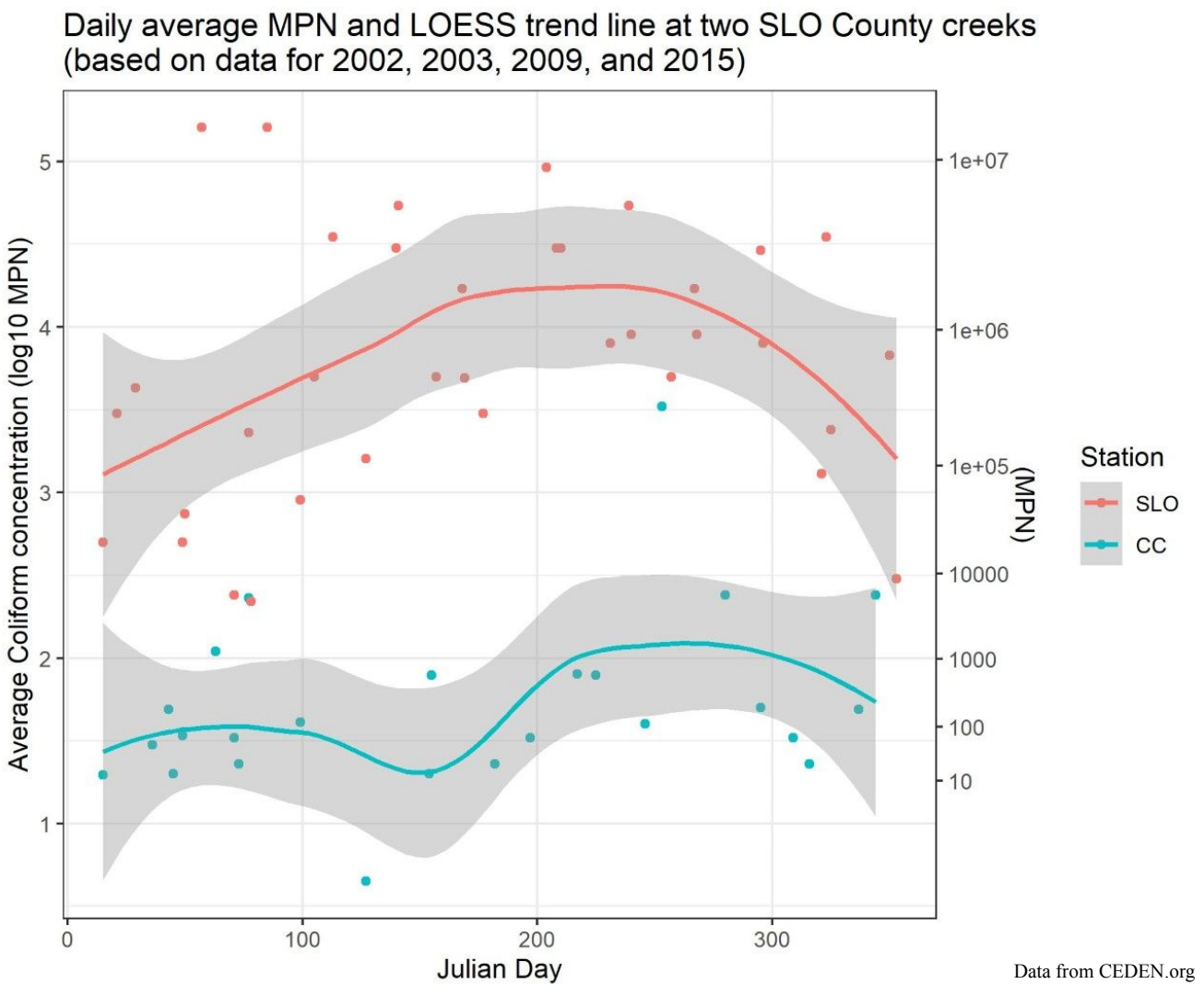
1. Background on contaminated watershed
2. Experimental design
    a. Ammocoete collection
    b. Water collection
    c. IDEXX
3. Results
4. Implications and applications

Water Quality

- Maintaining rivers with high water quality is a shared goal
- Increased bacterial loads in water is a common problem
- Filter feeding and detrital processing of water by aquatic organisms, such as bivalves and sponges can enhance water quality in watersheds is a well documented ecological phenomenon

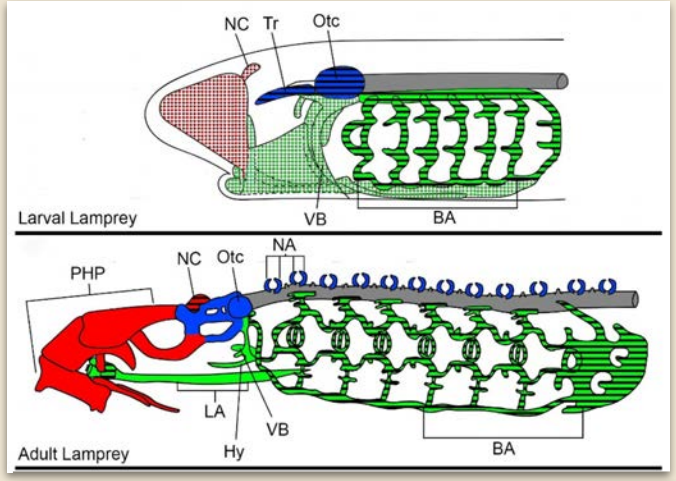
Image Credit: plantedtank.com/dirty-tank-water-with-oysters-Before-and-after

Burge et al. 2016; Cardindale 2011; Hooper et al. 2005; Karr and Dudley 1981; Kellog et al. 2013; Nizzoli et al. 2006; Silva and Domingues 2014; Smyth et al. 2018; USEPA 2002;


Daily average MPN and LOESS trend line at two SLO County creeks
(based on data for 2002, 2003, 2009, and 2015)
Average Coliform concentration (log10 MPN)
5
4
3
2
1
1e+07
1e+06
1e+05
10000
1000
100
10
(MPN)
0
100
200
300
Julian Day
Station
SLO
CC
Data from CEDEN.org

Filter Feeding Ammocoetes

- Ammocoetes use specialized pharyngeal morphology to pump water over their gills
- Suspended detritus is trapped and transported to the digestive tract
    - 4 -200 µm
    - *E. coli* Gram negative bacteria rod 1-2 µm
- Well documented morphological trait, however, limited research on ecological implication



Creaser and Hann 1929; Mallat 1981; Nikitina et al. 2009; Root et al. 2021

Hypothesis

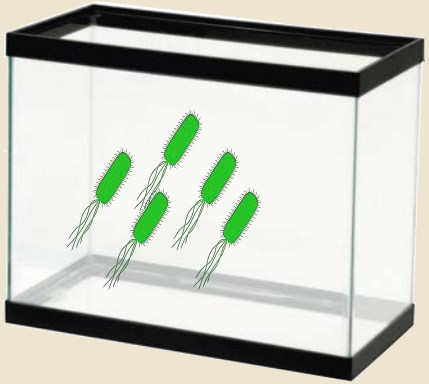
Hypothesis: P. lamprey ammocoetes will reduce pathogenic bacteria concentrations via their filter feeding mechanism and feeding strategy.

If true: IDEXX will show greater reduction in *E. coli* within treatment tanks containing P. lamprey ammocoetes.

Approach: Design multiple aquaria with identical starting concentration of *E. coli* and expose to different treatments: filter feeding P. lamprey ammocoetes, non-filter feeding P. lamprey macropthalmia, and control tanks with no P. lamprey.

Methods: Experimental Design

Control

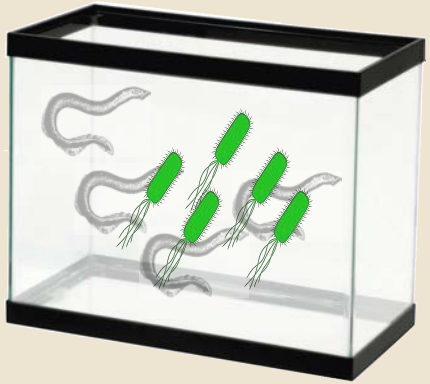


x5

Macropthalmia

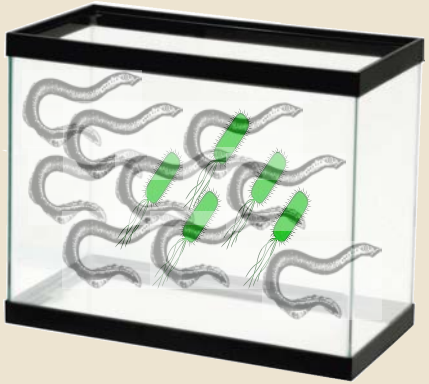
x2

Ammocoete

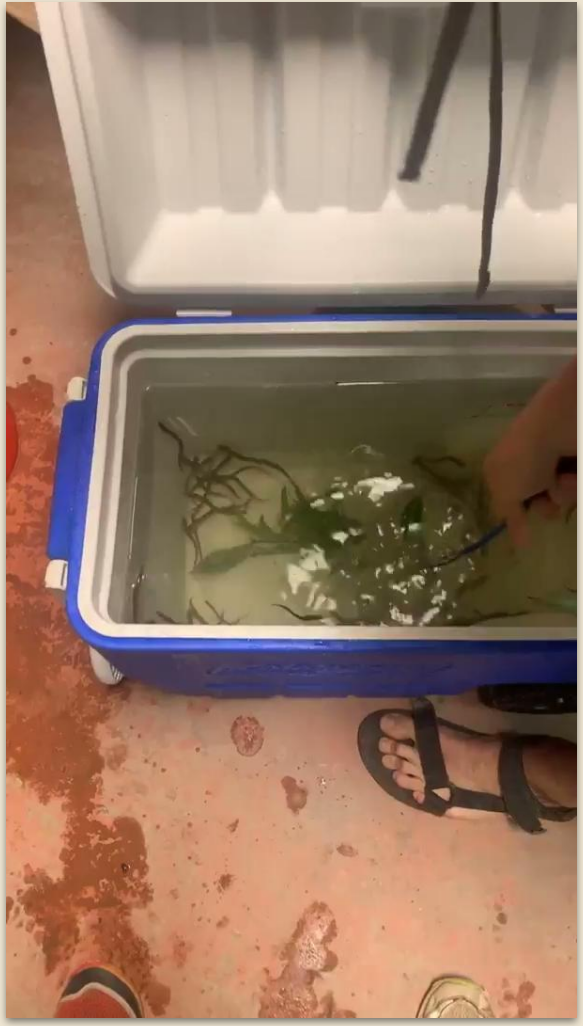


x4

Ammocoete High



x1

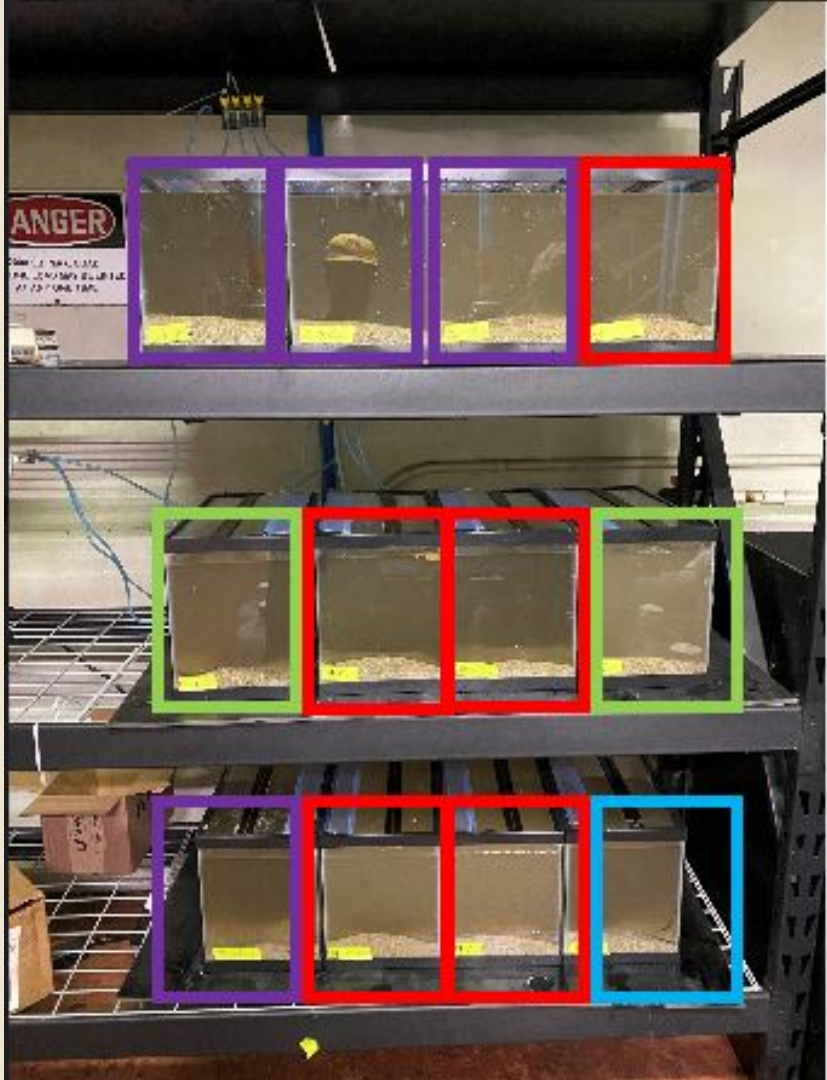


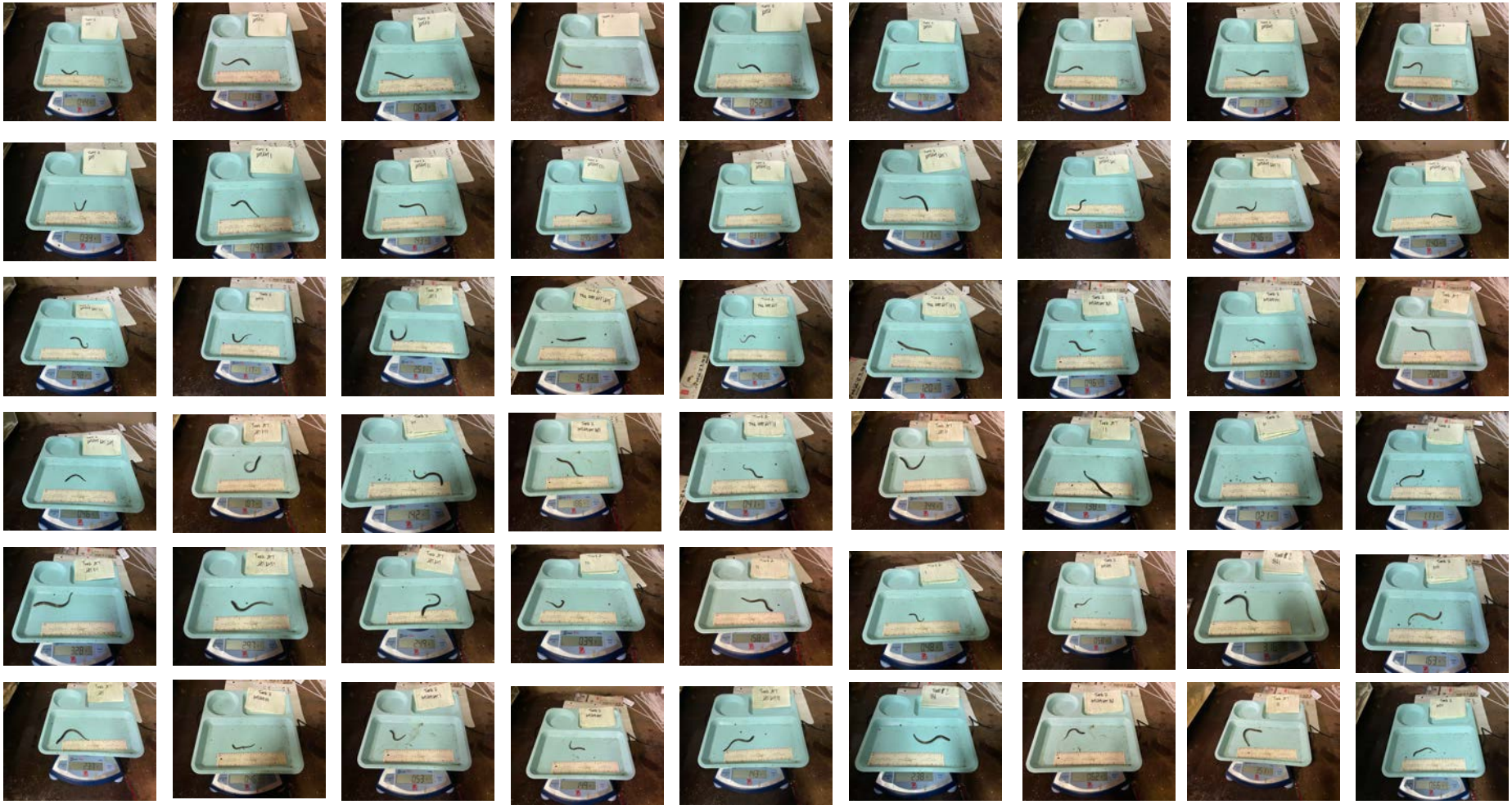
Water Collection

- SLO Creek has high levels of E. coli and increased levels of fecal coliform
- Collected water in clean carboys and immediately transferred to experimental aquaria
- Consistent starting concentration of bacteria across all aquaria

CEDEN, California Environmental Data Exchange Network, 2022 (www.CEDEN.org)

Treatment	# of Fish	Biomass (g)
Ammocoete	20	15.69
	20	19.19
	20	20.58
	20	21.58
Ammocoete High	57	40.05
Macropthalmia	20	36.99
	20	21.15
Control	0	-
	0	-
	0	-
	0	-
	0	-



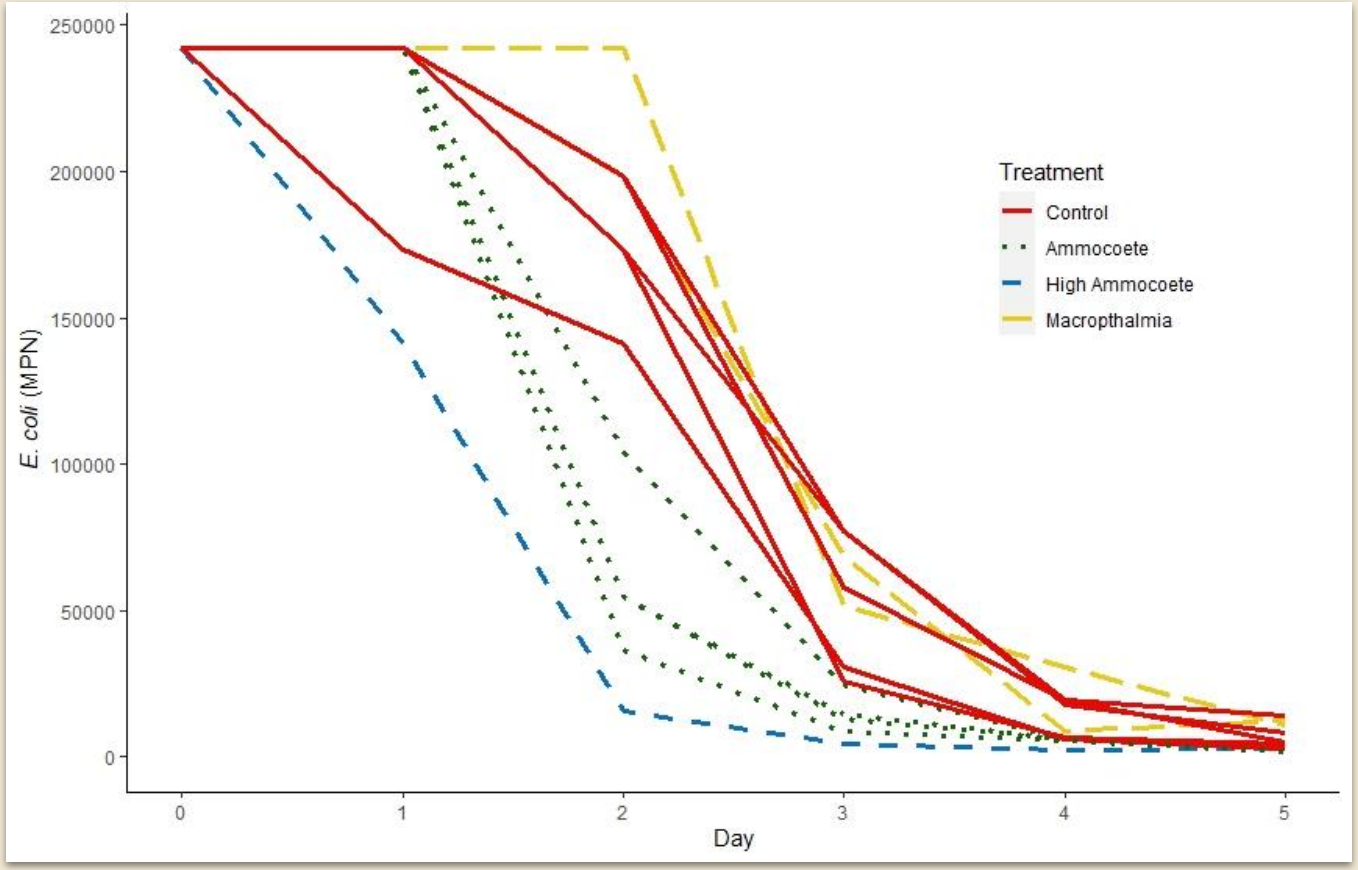


IDEXX

- Approved methodology according to the US EPA Standard Methods to quantify bacterial loads in water
- Involves treating a known volume of water with ColiLert™ reagent
- Incubate for 24 hours
- Most Probable Number (MPN) of colony forming units

EPA: https://www.epa.gov/cwa-methods/approved-cwa-microbiological-methods-wastewater-and-sewage-sludge

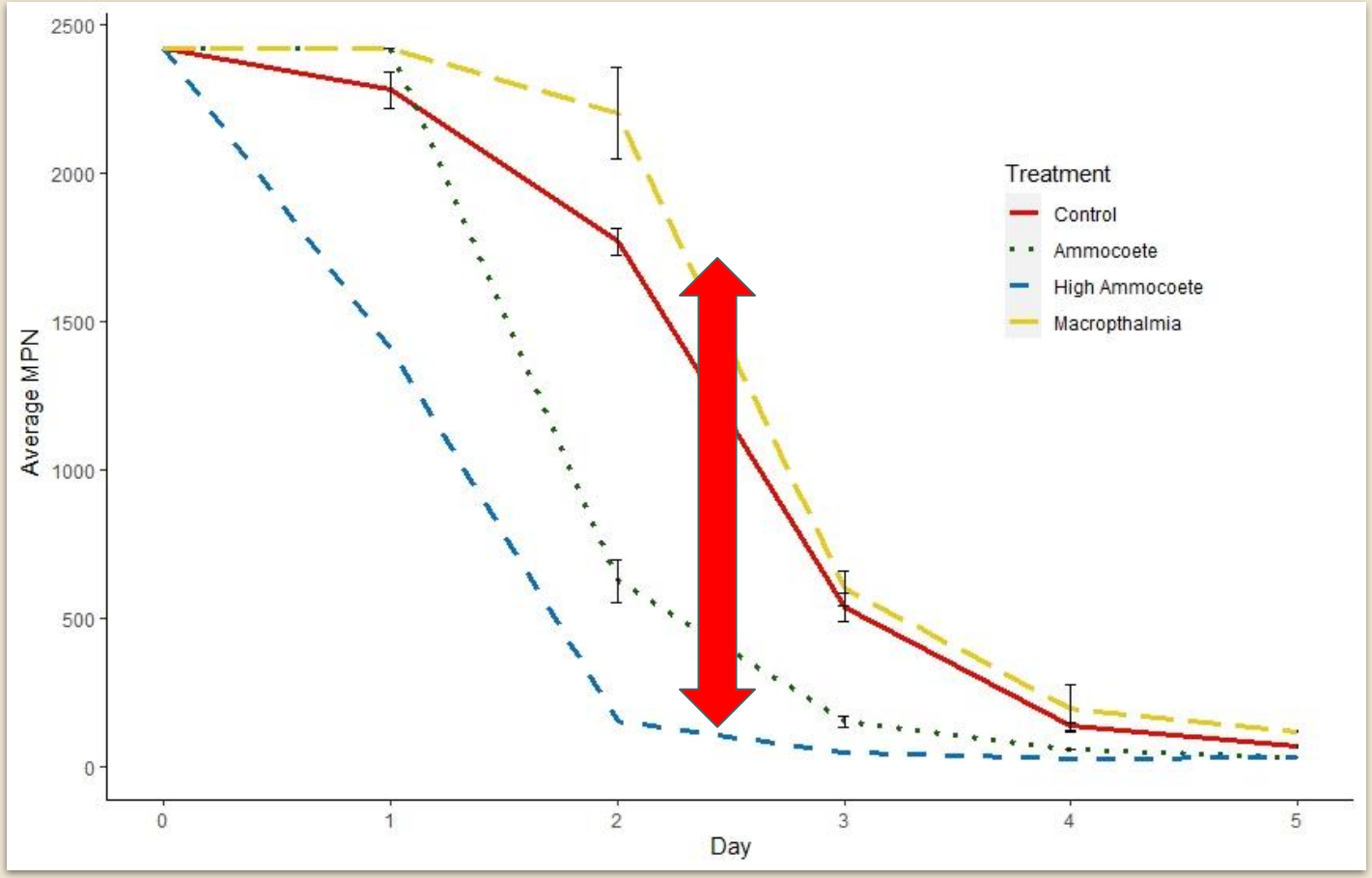
Each tank was tested daily with IDEXX



E. coli concentration in each replicate aquaria for each treatment over the 5-day study period. The Ammocoete High treatment was not included in the statistical analysis.

Effect	Degrees of Freedom	F-value	P-value
Treatment	2	6.38	0.0221
Day	4	316.45	<0.0001
Treatment*Day	8	14.03	0.0006

Mixed model output with unstructured covariance structure. Note that the High Ammocoete treatment was not included in the statistical analysis.



Mean +/- Standard Error *E. coli* concentration among replicate aquaria for each treatment over the 5-day study period. The Ammocoete High treatment was not included in the statistical analysis.

Implications and further research

- Ammocoete reduction ~5x faster reducing bacteria in comparison to control tanks
- Additional experimentation:
  - Continuous bacteria source
  - Modeling potential utility per ammocoete
  - Control/impacted streams
- How can this be applied in urban watershed management scenarios?

Acknowledgements

Primary funding for this project was received from the City of San Luis Obispo

Freddy Otte

Water Resource Recovery Facility

Additional thanks...

- Tenera Environmental
  - John Steinbeck
- Stewart Reid (Western Fishes)
- Michael Gates
- CDFW

Outreach in new ways…

NOAH

SHOP BLOG LOOKBOOKS FABRICS ABOUT STORES SHIPPING TO

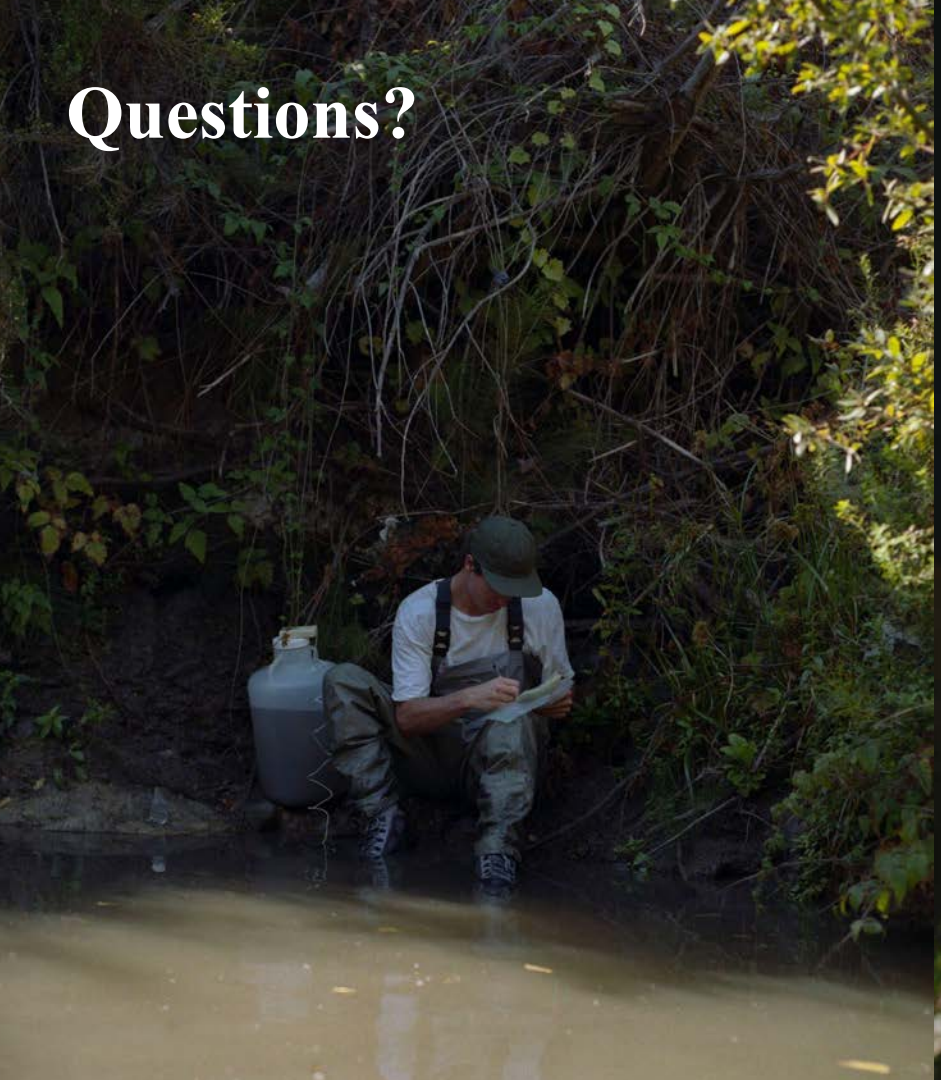
Field days start early, this one was no different. I strapped on my waders and headed to the creek. Watershed research means cold mornings, muddy clothes, and fishy conditions. I love it. I dropped down the bank of the creek brushing past the reeds and dodging poison oak. I was collecting water that had been contaminated by urban run-off. The plan is to take this "dirty" creek water back to my lab where I could effectively "treat" it with larval pacific lamprey. Filling up the carboys with contaminated water I thought, 'How can I relate this experiment to a broad audience?' Contributing to river health seems so natural to me, but at large, what do we all have to gain from an experiment like this? I lugged the dirty water back to my lab and filled up an experimental tank.

Back at the lab for the fun part: catching lamprey out of the holding tanks. This involves slowly dredging sediment with your fingers until you spook a lamprey out of its burrow. Once spooked, a "skilled" lab assistant stands by with an aquarium net and hopefully catches the free-swimming lamprey. Not an easy task. After chasing these mysterious creatures around a big aquarium tank we collected 6 beautiful specimens. This new cohort of lamprey will live in the experimental tank with "dirty" creek water for several weeks. During this time, I'll be monitoring the levels of bacteria in the water.

Upcoming Research

- Funding to continue Lamprey Monitoring in SLO County
- eDNA at watersheds of interest
- Revitalizing camera monitoring at Marre Weir
- Pacific lamprey public relations

Questions?



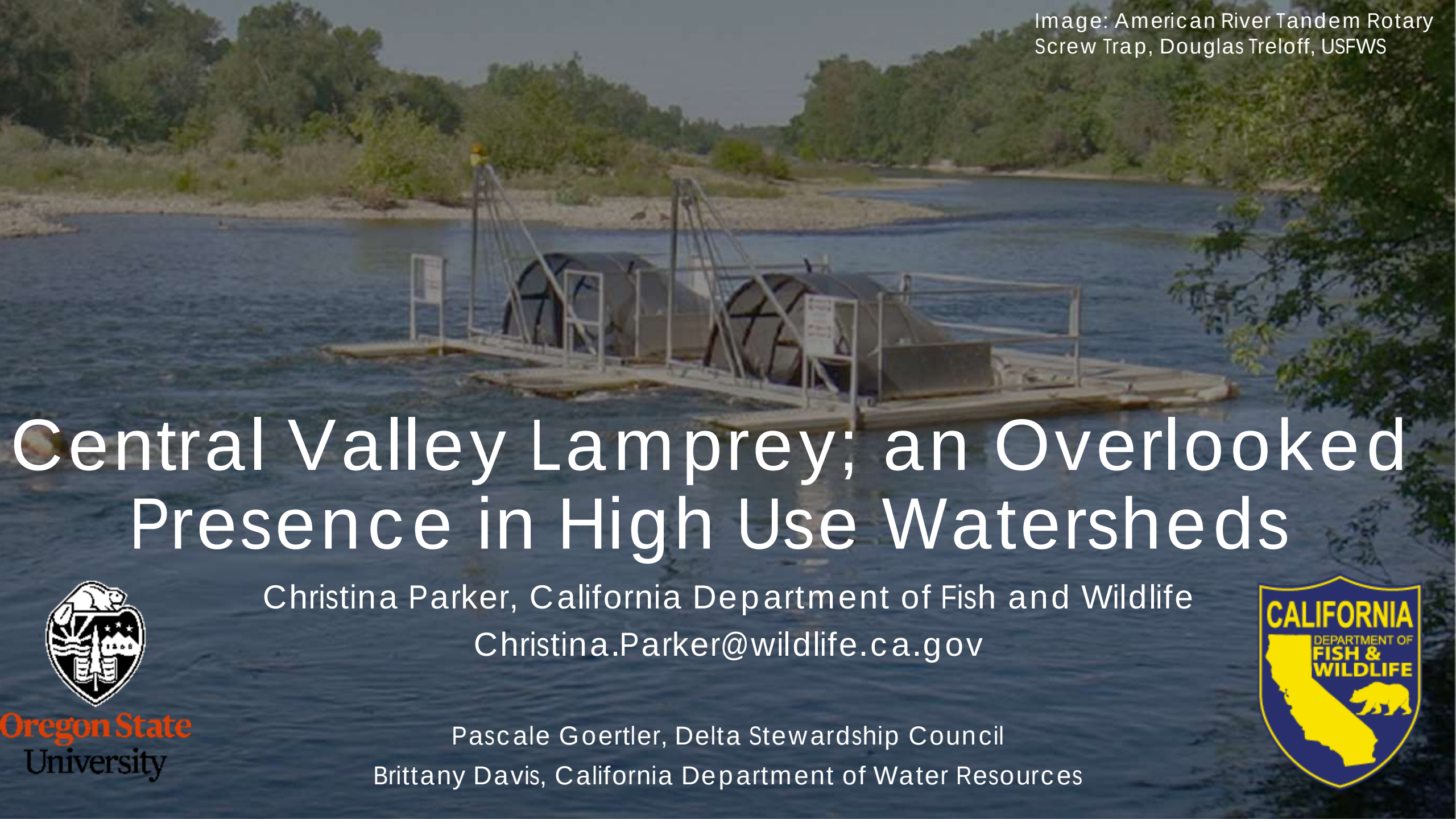


Image: American River Tandem Rotary Screw Trap, Douglas Treloff, USFWS

Central Valley Lamprey; an Overlooked Presence in High Use Watersheds

Christina Parker, California Department of Fish and Wildlife

Christina.Parker@wildlife.ca.gov

Pascale Goertler, Delta Stewardship Council

Brittany Davis, California Department of Water Resources

Oregon State University

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

Lamprey appear to be declining throughout their range

Threats to lamprey:

- Barriers to migration
- Habitat loss and degradation
- Loss of prey species
- Increasing water temperatures

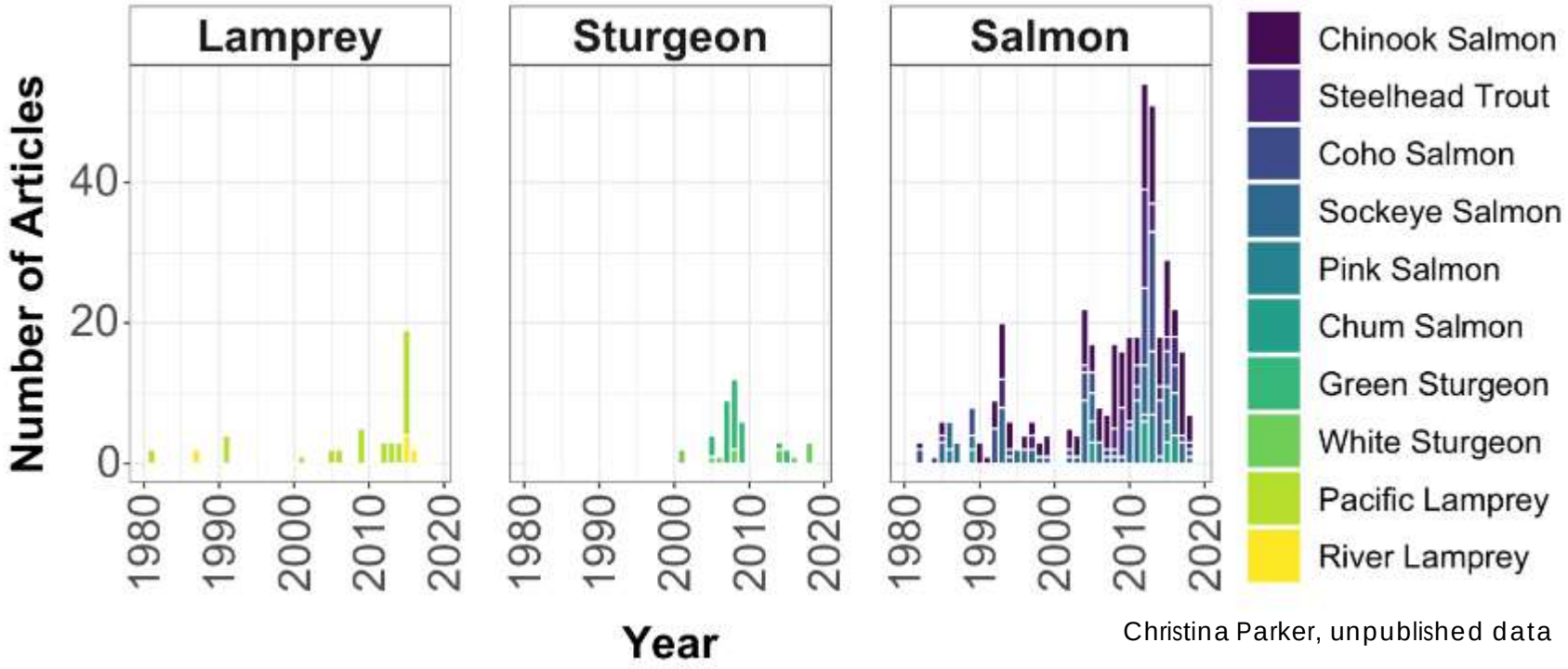
Valuable part of diet and culture, and the ecosystem as prey and source of marine derived nutrients

River Otter eating a lamprey
USFWS Pacific Region, Talia Rose 2017

Limited understanding of distribution and life history:

- Limited publications on lamprey
- Other species are higher priority for CA monitoring
- No long running lamprey specific studies
- Efforts are starting to increase with traps at a single location and downstream[1]

Publications on Migration for West Coast Anadromous Species



Christina Parker, unpublished data

[1]Goodman et al. 2015, Goertler et al. 2019

Central Valley Lamprey Species

Central Valley, California has 4 lamprey species:

- 2 anadromous lampreys (*Lampetra* and *Entosphenus*)
  - Pacific Lamprey (*E. tridentatus*)
  - Western River Lamprey (*L. ayresii*)
- 2 resident brook lampreys (*Lampetra*)
  - Western Brook Lamprey (*L. richardsoni*)
    - Previously listed as Pacific Brook (*L. pacifica*)
  - Kern Brook Lamprey (*L. hubbsi*)

All species identified as of moderate or high concern within their California range[1]

[1]Moyle et al. 2015

Why rotary screw traps?

- Currently operating and part of funded operations
- Geographically wide-spread in upstream habitats
- Long-running surveys
- Operational time frame overlaps with part of lamprey migration timing

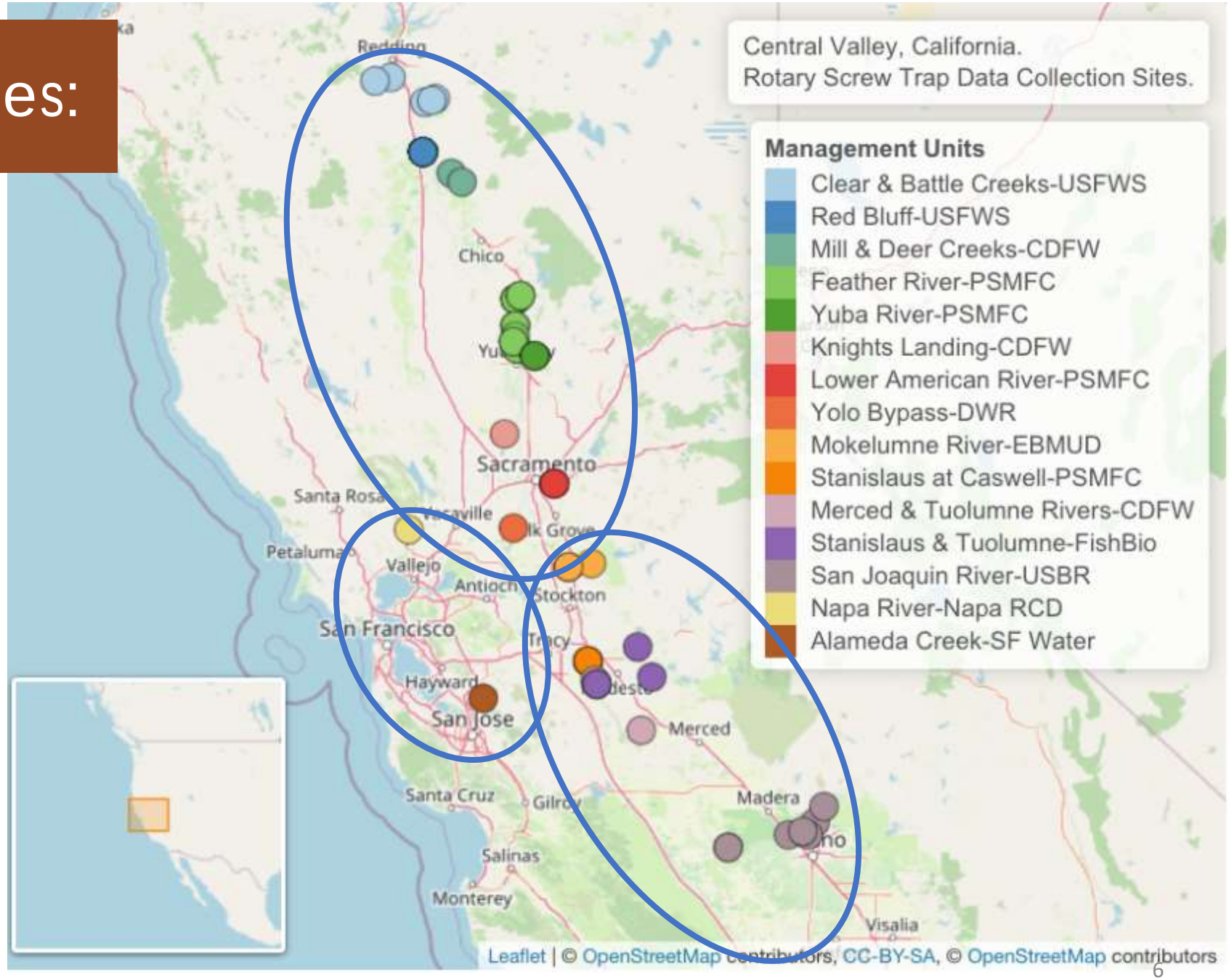
Tisdale Tandem Trap, Sacramento River

Data Collection Sites:

78 traps in 15 management units

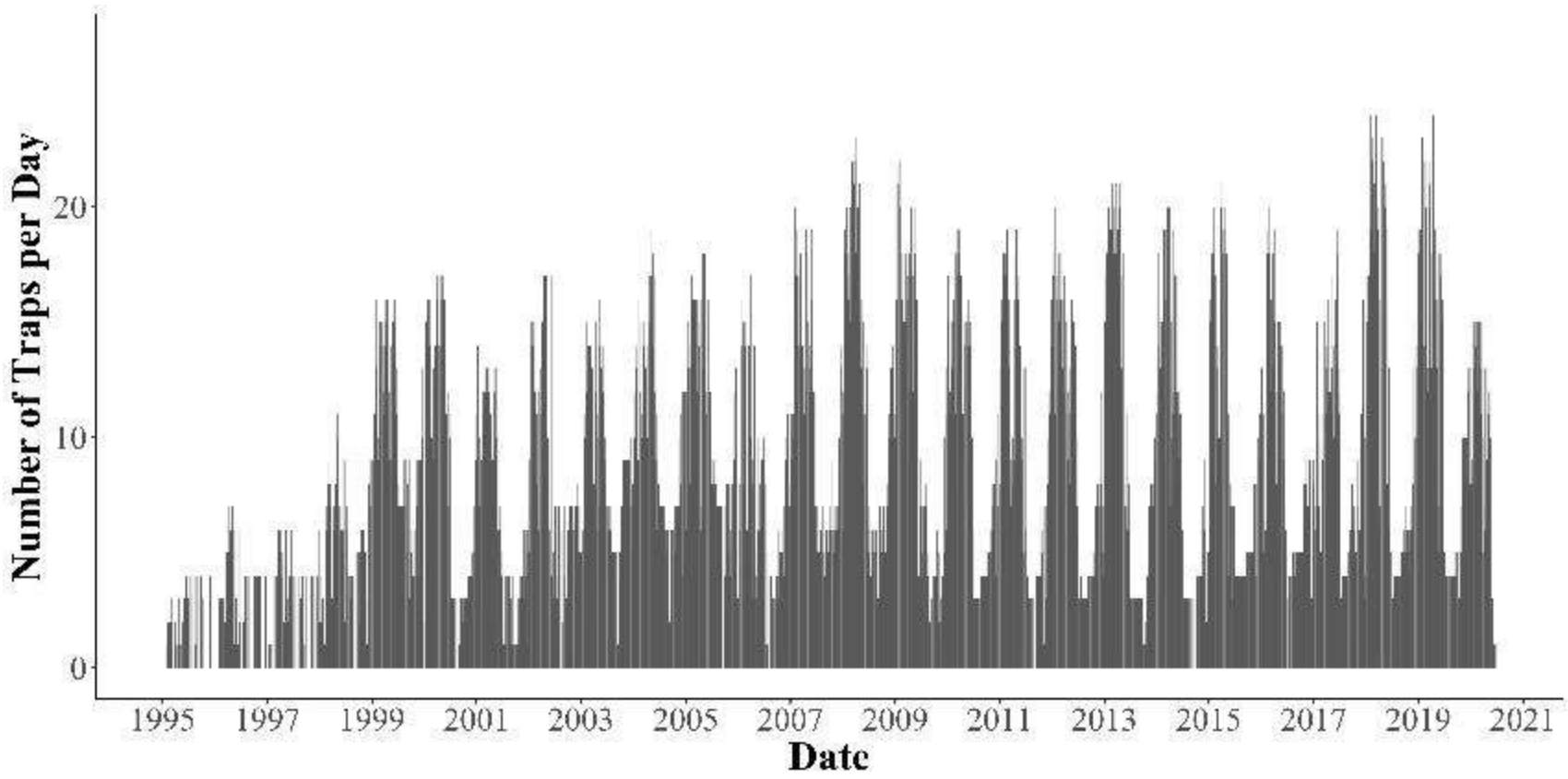
- 51 in Sacramento Valley
- 25 in San Joaquin Valley
- 2 in San Francisco Estuary (California S.F. Bay RMU)

16 creeks and rivers of various sizes



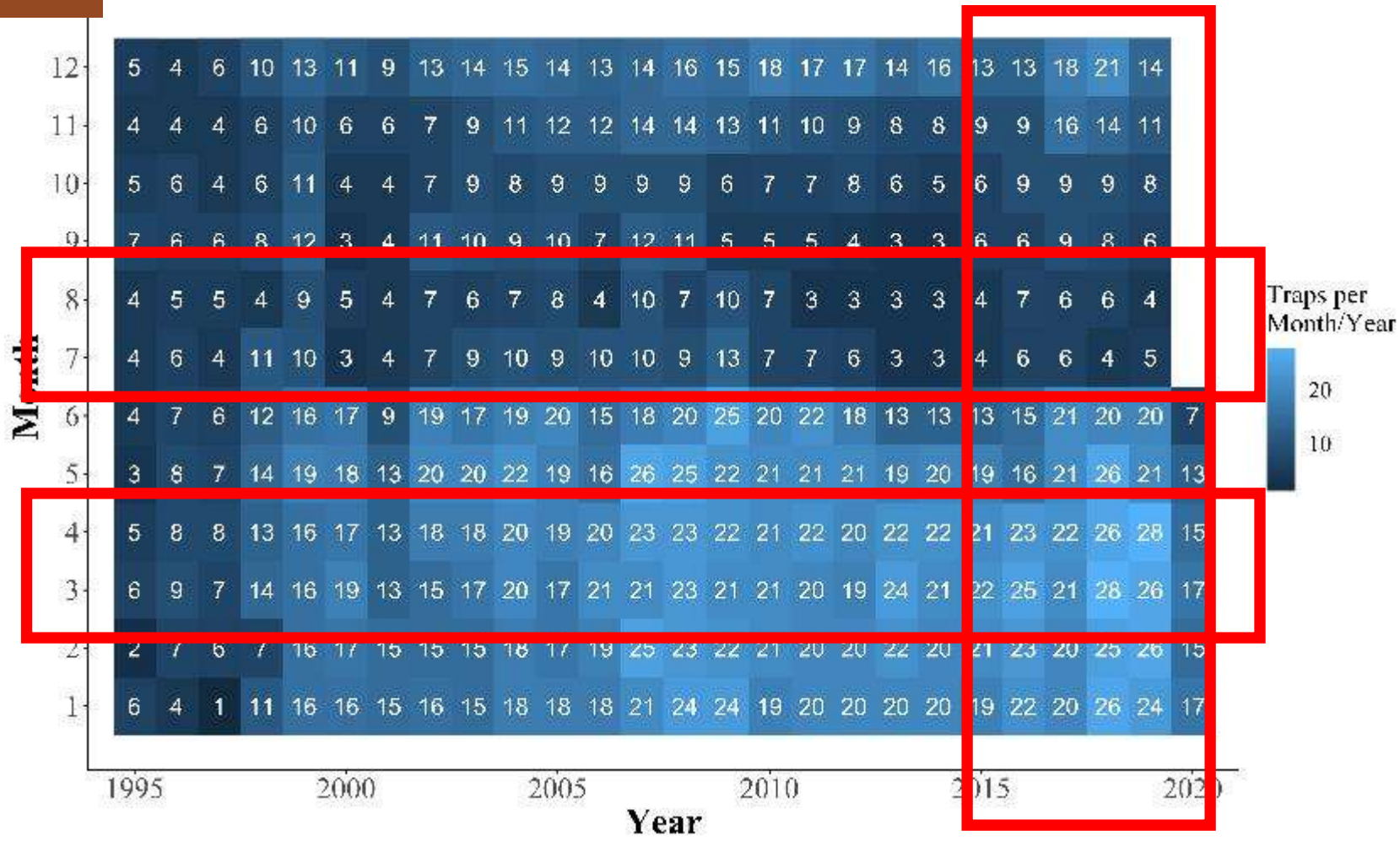
Time Series

- Dates range Jan 1995 through June 2020
- 18 traps operated in all 12 months
- 7 traps have operated in more than 24 years
- Most traps operate seasonally



Seasonal Operations

- Greatest number of traps operating in March and April
- Least in July and August
- Increased number of traps in more recent years



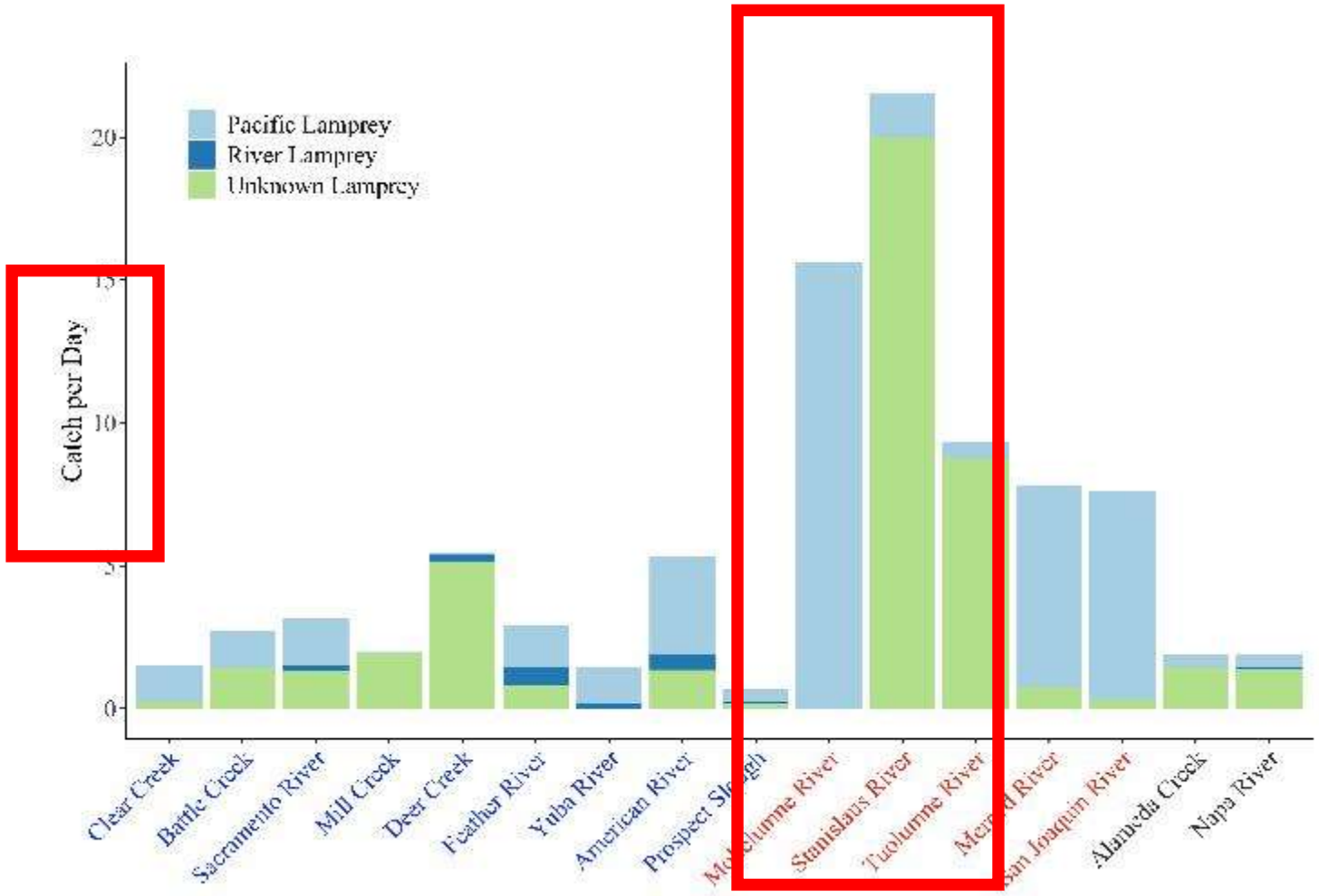
Spatial Catch: Variation in Rivers

Using day as metric for effort:

All San Joaquin rivers have greater catch compared to Sacramento rivers

Out of 78 traps, 16 traps account for 80% of total catch per day

- 10 are in San Joaquin Watershed

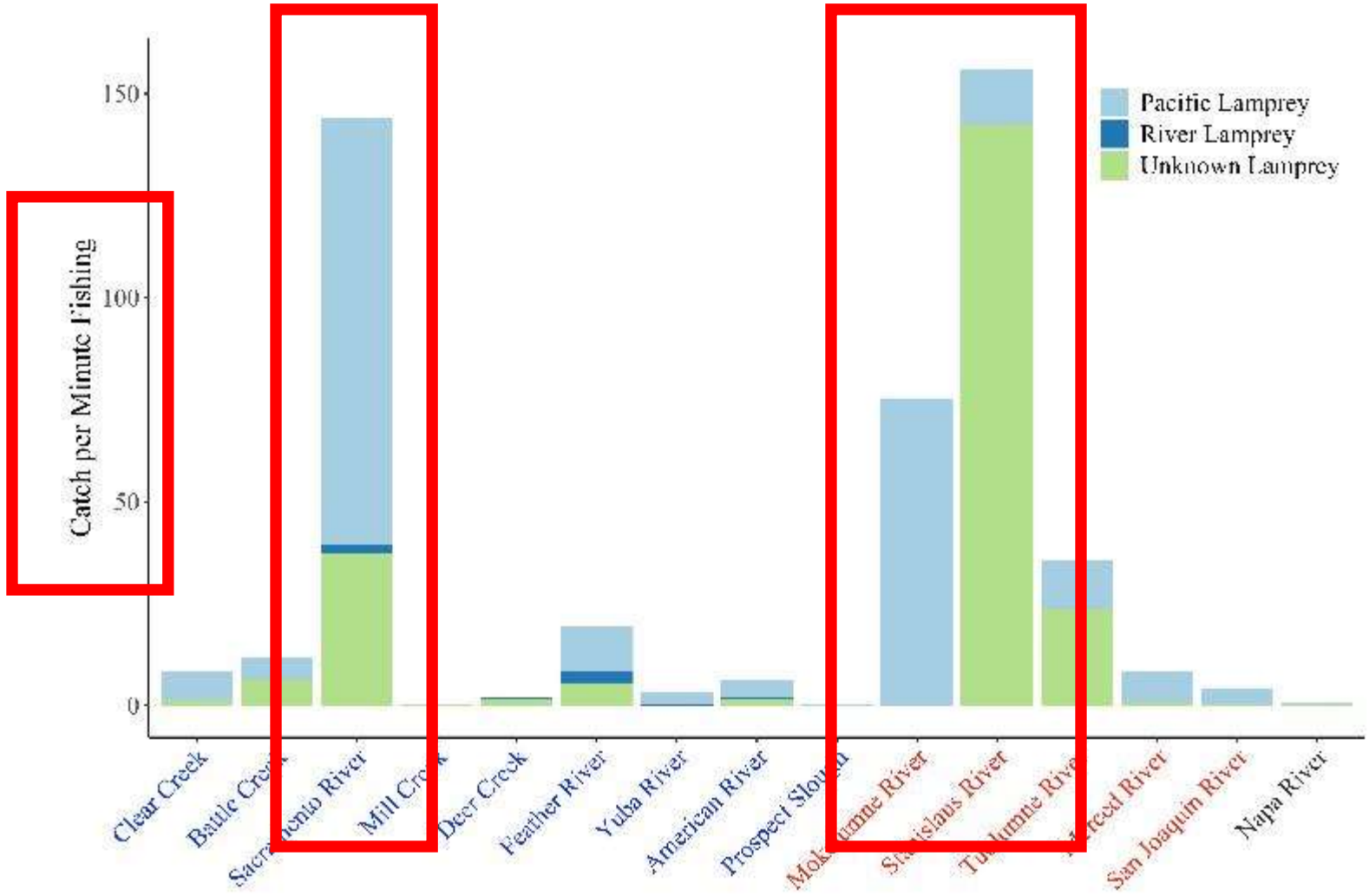


Spatial Catch: Variation in Rivers

Using minutes as metric for effort:

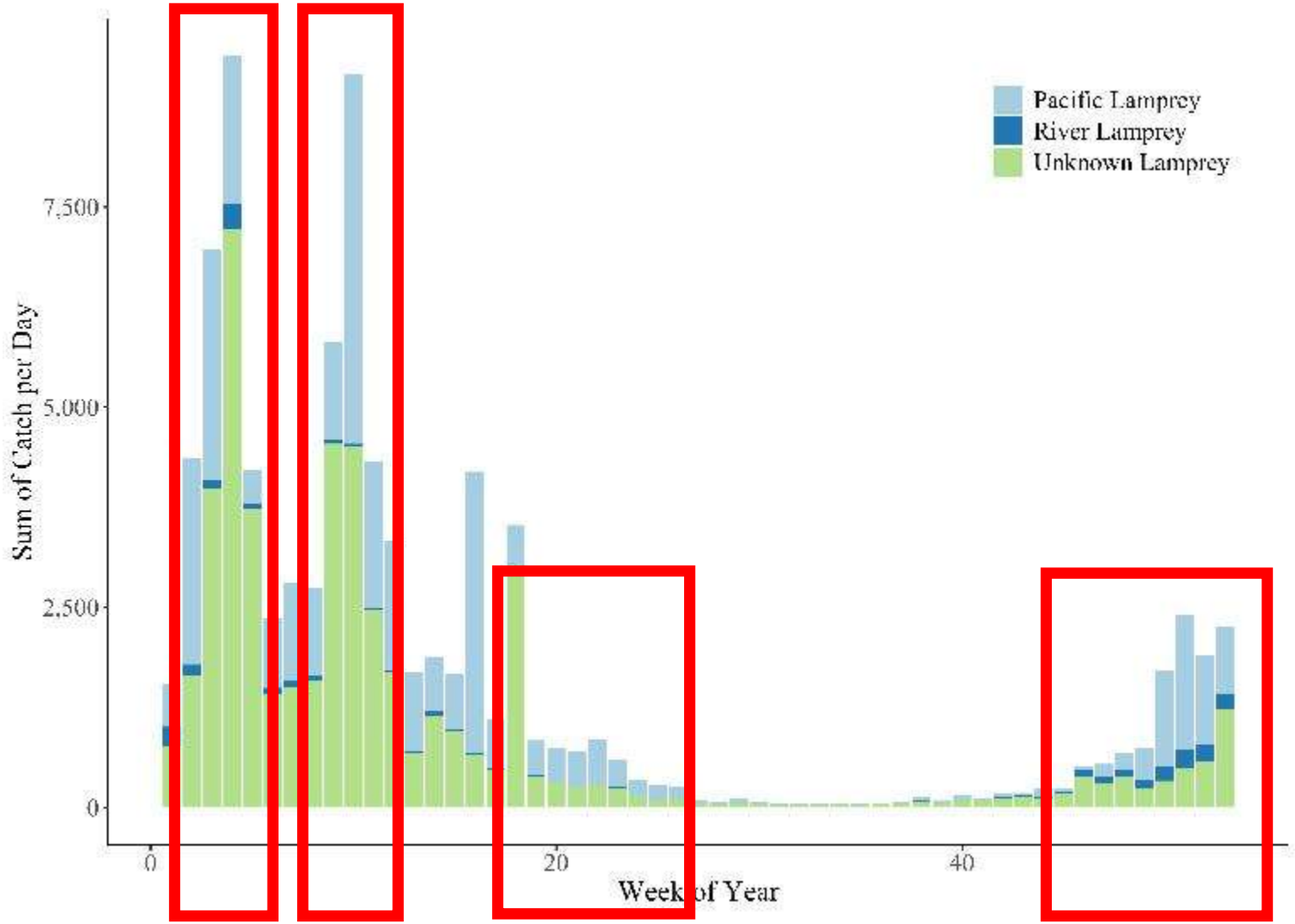
Stanislaus River still greatest catch

Sacramento River has much higher catch per effort with this metric



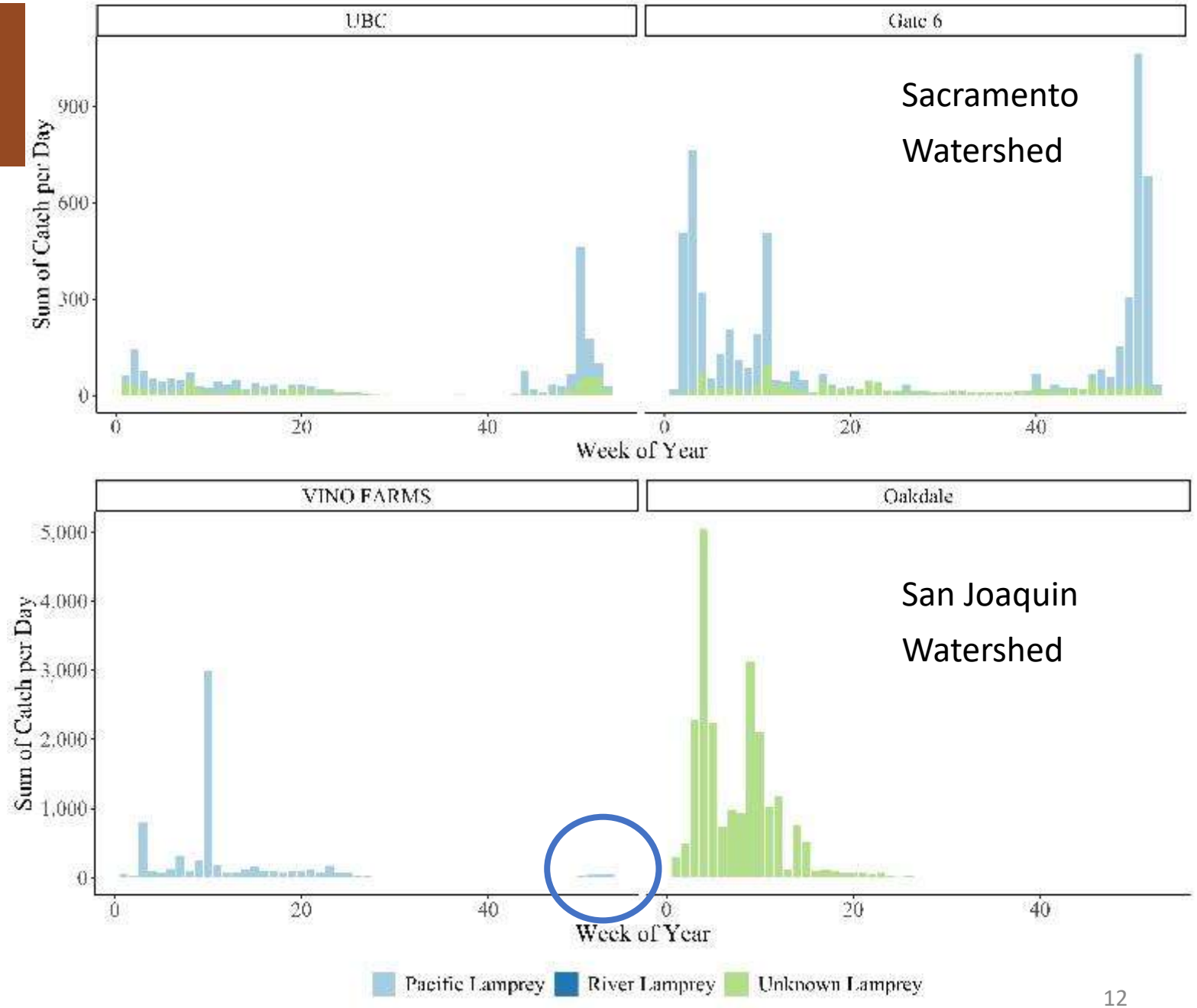
Weekly Catch

- Sum of catch is greatest in weeks 4 and 10 (January and March)
- Catch tapers off in May and increases in November and December



Weekly Catch in Watersheds

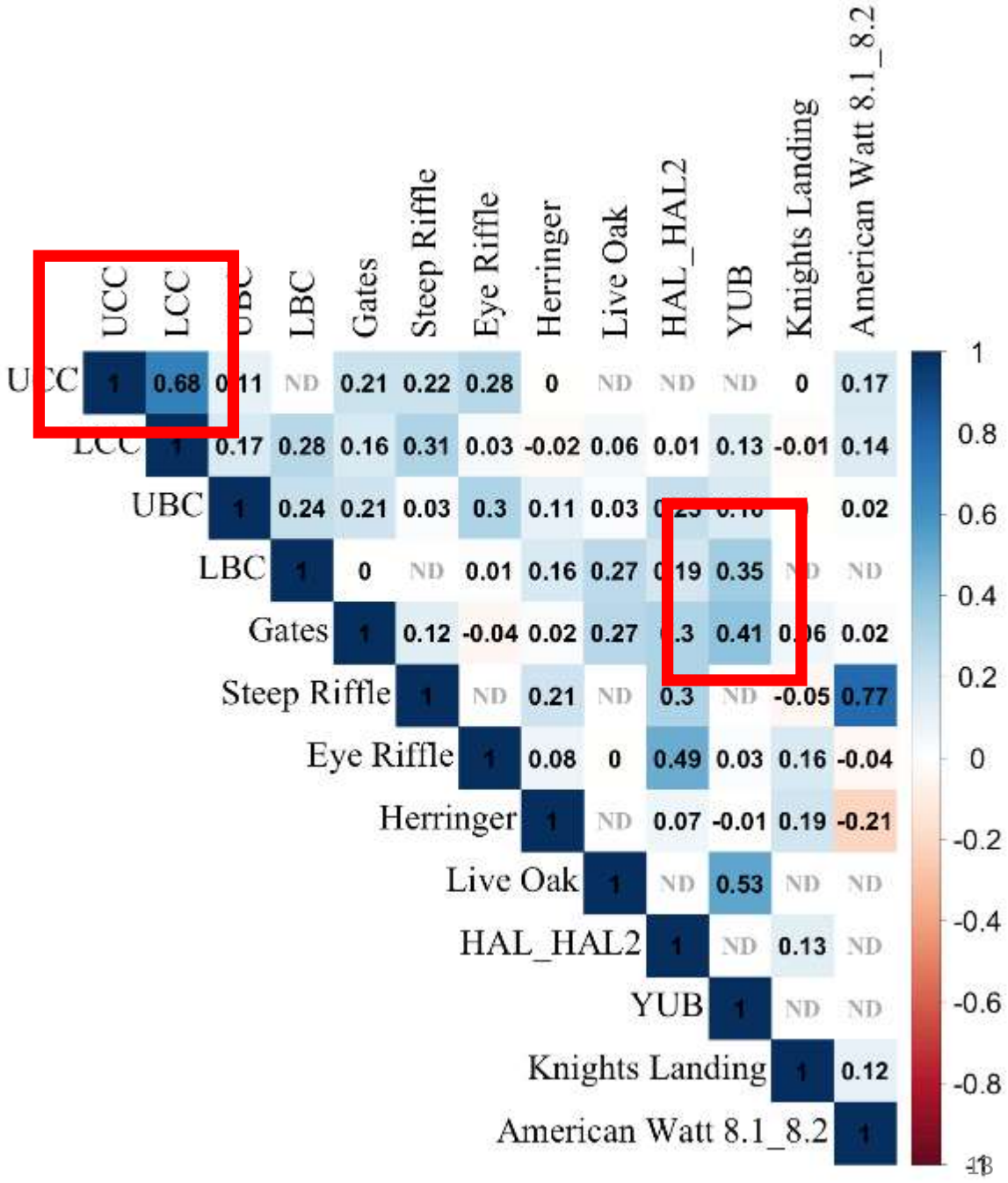
- Increased catch December through Spring is present in both:
  - Sacramento (top)
  - San Joaquin (bottom)



Correlated Weekly Catch: Sacramento Watershed

Weekly Correlation of Catch per Day:

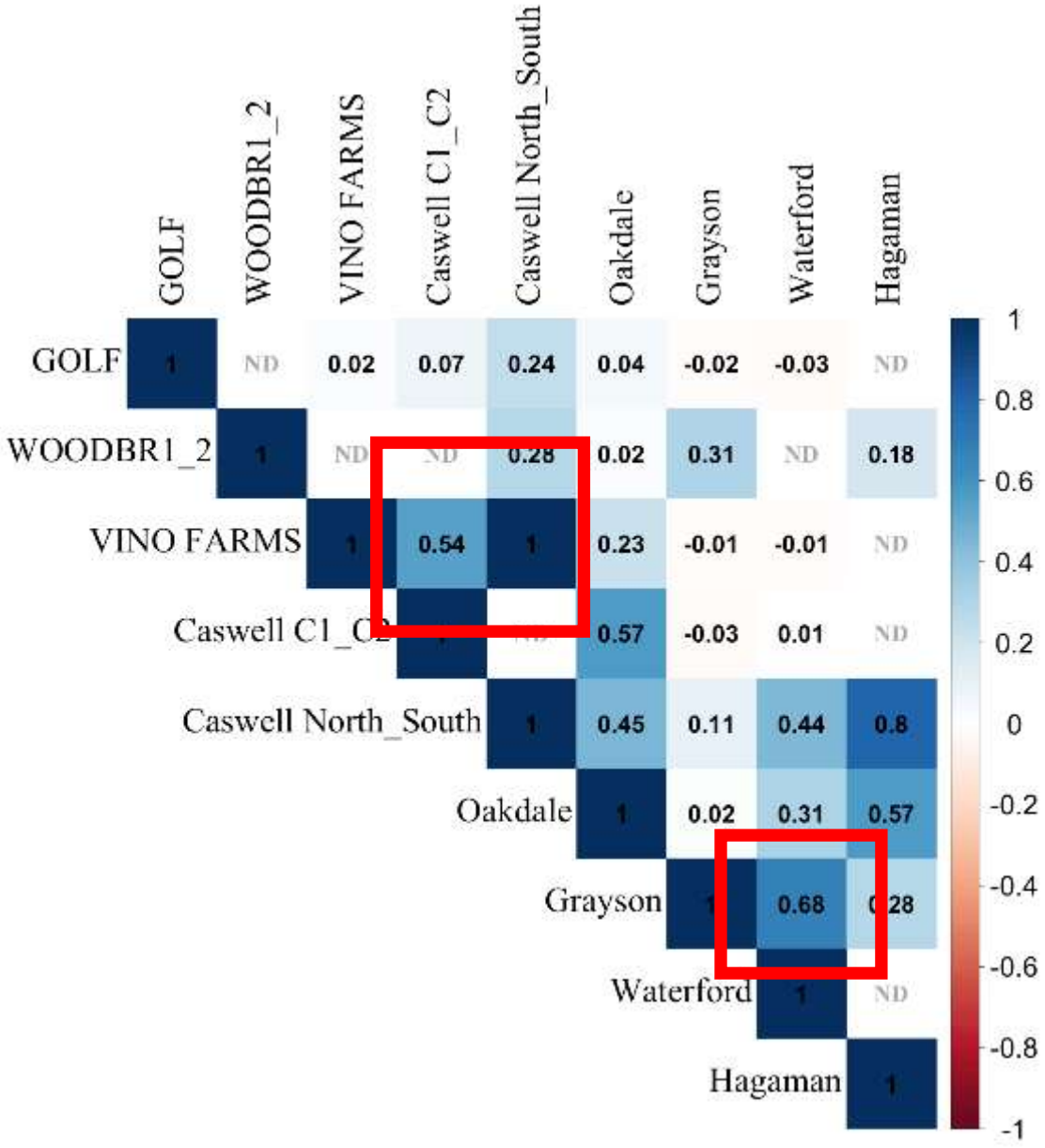
- Majority positive
- None of the negative correlations were significant
- 9 of positive correlations were significant



Correlated Weekly Catch: San Joaquin Watershed

Weekly Correlation of Catch per Day:

- Majority positive
- None of the negative correlations were significant
- 8 of positive correlations were significant



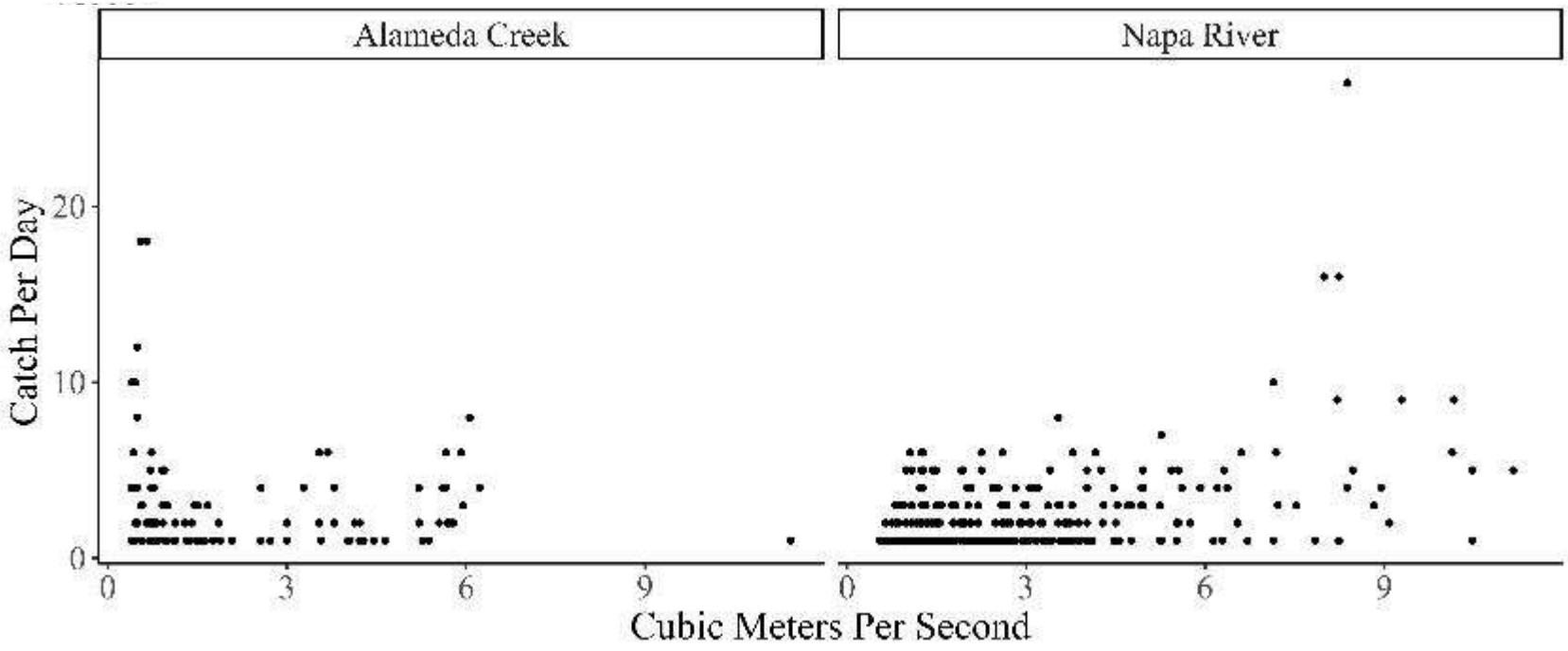
Catch Occurred in All Streamflow

Cubic meters per second (cms) from U.S. Geological Survey gages that operate near traps

In all watersheds, catch occurred throughout range of cms

Greater catch per day in lower half of cms

San Francisco Bay Tributaries



Limitations of survey method:

Traps are not designed or operated for emigrating lamprey:

- Do not cover all potential emigration period
- Operations need to mitigate affect on listed species
  - When operations are limited, often excludes nighttime
- Traps removed in high flow
- Lack of catch does not equate to lack of presence[1]

Lack of time and knowledge for species identification

Lamprey challenging to see in debris

Cone of Tisdale Trap, Sacramento River

[1]Hayes et al. 2013

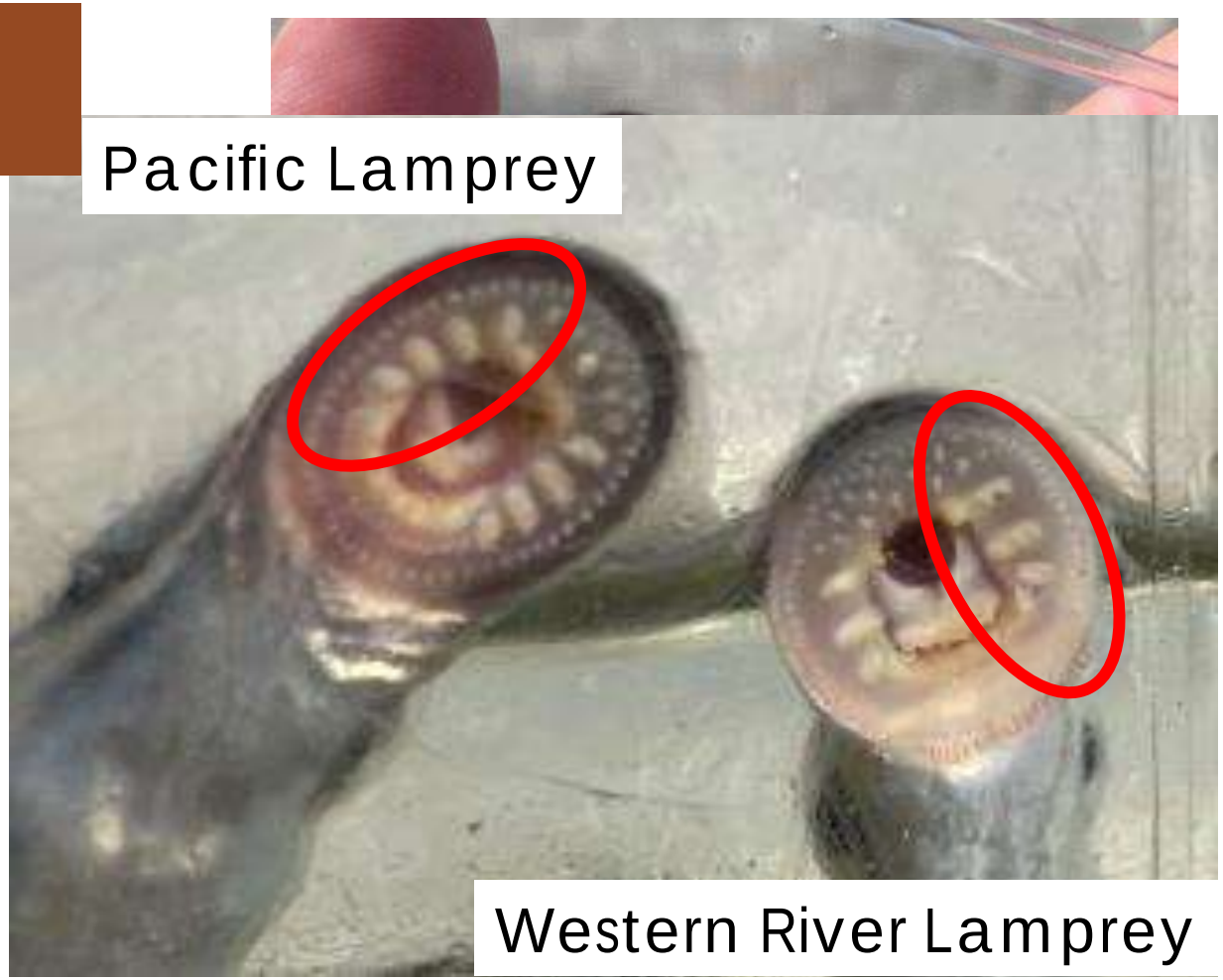
Summary

- Less studies and publications focused on non-salmonids
- Traps that operate year-round have increased catch per day in December-June
- Catch occurred during almost all streamflow conditions
- Positive correlated weekly catch per day in Sacramento and San Joaquin watersheds show synchrony and migratory signals

Pacific Lamprey, Tisdale Trap, Sacramento River

Recommendations:

- Data repository
- Side by side with other lamprey specific studies (electrofishing)
- Upstream tagging to determine length of emigration in different conditions
- Improved species identification



CalFish Stanislaus River (Caswell) – RST Monitoring, 2018. https://www.calfish.org/ProgramsData/ConservationandManagement/CentralValleyMonitoring/SacramentoValleyTributaryMonitoring/StanislausRiver-RSTMonitoring.aspx

Questions?

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