Northwest **Power** and **Conservation** Council

August 4, 2020

MEMORANDUM

TO: **Fish and Wildlife Committee Members**

FROM: **Mark Fritsch**

SUBJECT: **Up and Over: Improving upstream passage of adult Pacific lamprey in the Columbia River basin**

BACKGROUND:

Presenter: Kinsey Frick, Research Fisheries Biologist, Northwest Fisheries Science Center.

Summary: Kinsey will provide an overview of the importance of Pacific lamprey in the Columbia Basin, a species that has inhabited the Northwest for nearly 350 million years. She will emphasize the work being done at the mainstem's major hydropower dams to benefit upstream lamprey passage and improve their success at passing these barriers. Over the past decade the fish and wildlife managers in the basin have been working to understand passage problems and design lamprey-friendly modifications and innovative approaches to address the upstream migration issues.

Relevance: The Fish and Wildlife Program recognizes Pacific Lamprey as not only an ecologically important species, but also a key cultural species to the Tribes in the Columbia Basin. This effort addresses the Program's emerging priority #5[1] and touches on some of the actions implemented through Project #2017-005-00, *Pacific Lamprey Conservation Initiative Columbia River Basin Projects*. In addition, the work also addresses

[1] Emerging priority #5 – Implement additional sturgeon and lamprey measures (passage and research).

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several specific measures in the Program's Lamprey strategy regarding lamprey passage and monitoring.

Workplan: Fish and Wildlife Division preliminary work plan 2020; Program Implementation (2014 Program and 2020 addendum): Other program implementation.

Background: Pacific Lamprey, *Entosphenus tridentatus (*formerly *Lampetra tridentate)*, have inhabited the Pacific for nearly 350 million years (same age as coal). Historic runs of Pacific Lamprey in the Columbia River Basin numbered in the hundreds of thousands, but the distribution and abundance of lampreys have decreased and currently they return in drastically smaller numbers. They migrate from the mouth of the Columbia River to Chief Joseph and Hells Canyon dams, in the mainstem Columbia and Snake rivers, respectively. Threats to Pacific Lamprey occur throughout the entire range of the species and include but are not limited to: restricted mainstem and tributary passage, reduced flows and dewatering of streams, stream and floodplain degradation, degraded water quality, predation and changing marine and climate conditions.

In 1994, the Council approved the first lamprey project in the Fish and Wildlife Program. The project (Project #1994-026-00, *Pacific Lamprey Research and Restoration Project*) proposed by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) called for research and restoration of Pacific Lamprey throughout tribal ceded lands. This effort was followed by additional projects in 2002, 2007, 2008 and 2018. Currently, there are six active projects that focus on Pacific Lamprey funded through the F&W Program. These projects have a variety of goals and objectives, but aim at establishing population status and trends, documenting distribution, identifying limiting factors, and develop reintroduction and supplementation actions

In addition, the USACE developed a Passage Improvement Plan as part of the MOA with Tribes and CRITFC. The goal of this 10-year plan was to improve adult and juvenile passage and survival through the Federal Columbia River Power System with emphasis on improvements at Bonneville, John Day, and McNary dams.

More Info:

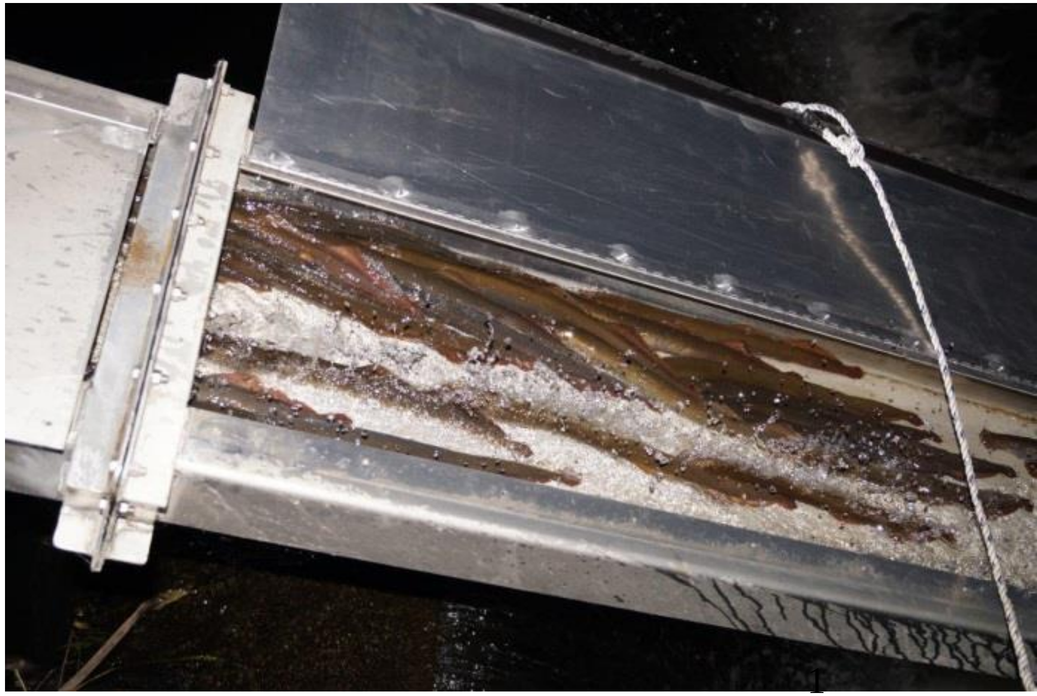
- Conservation Agreement
- Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin

Up and Over: Improving upstream passage of adult Pacific lamprey in the Columbia River basin

Kinsey Frick

NOAA Fisheries

Northwest Fisheries Science Center
Seattle, WA



Confederated Tribes of the Umatilla Indian Reservation
Treaty of 1855
Fisheries Program
Department of Natural Resources

Yakama Nation Fisheries

NOAA
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Bonneville Power Administration

U.S. Department of the Interior
Bureau of Reclamation

Idaho • Oregon • Alaska
Pacific States Marine Fisheries Commission
Washington • California

U.S. Fish & Wildlife Service
Department of the Interior

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NWFSC
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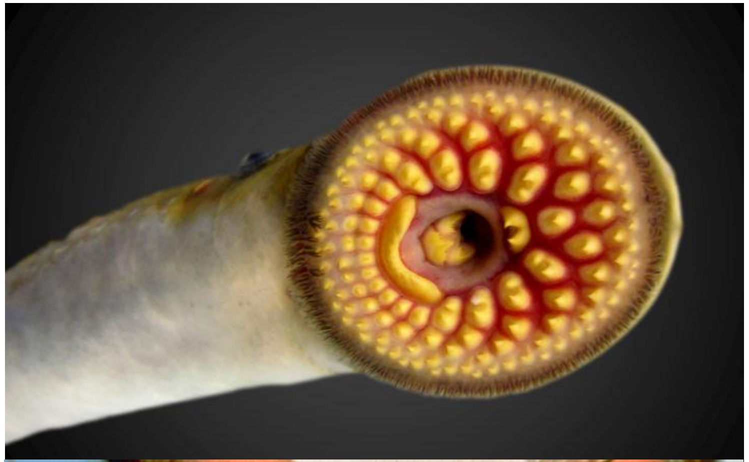
USGS
science for a changing worl

An Image Crisis

Pacific lamprey ≠ Sea lamprey

≠

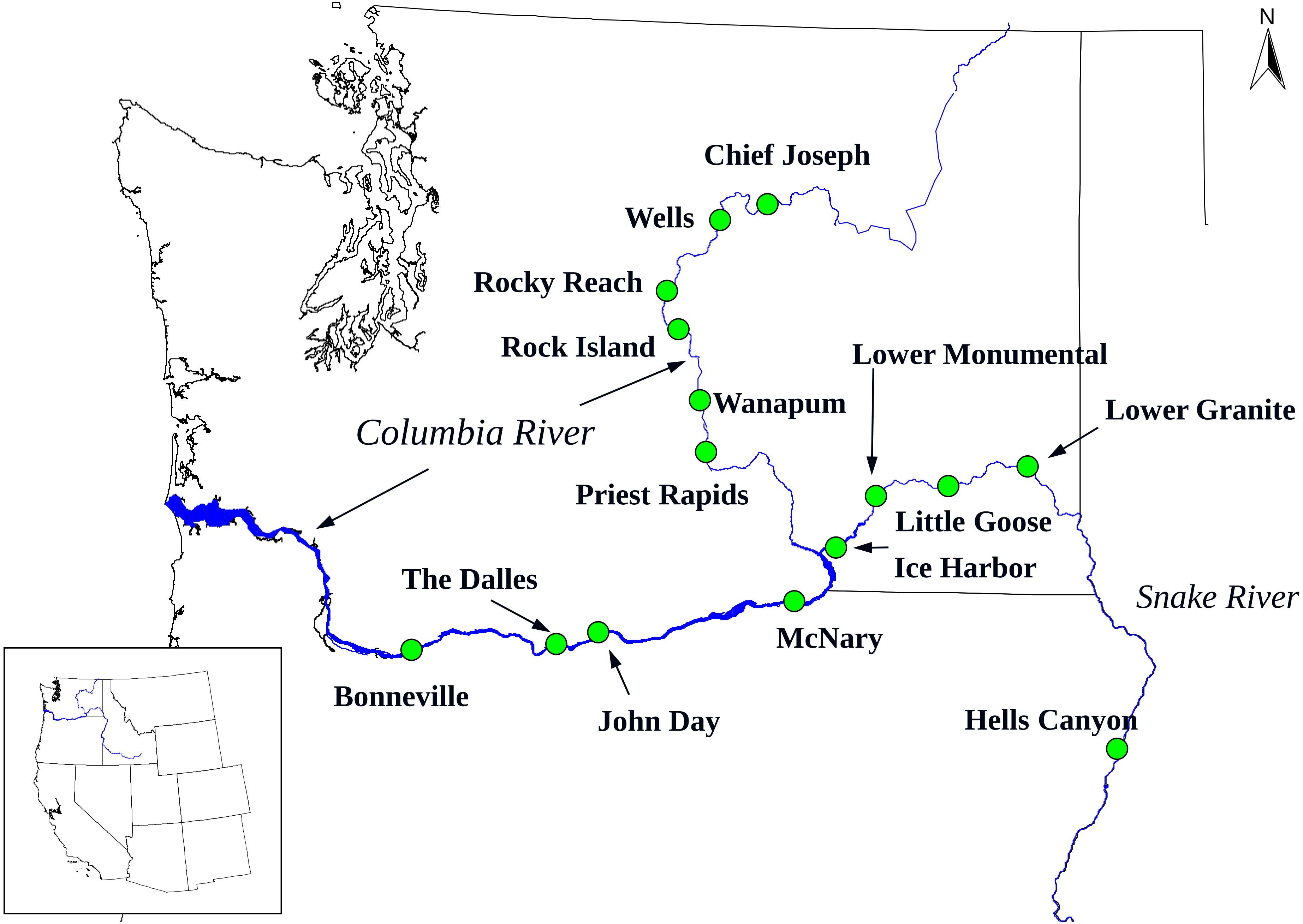


Importance of Pacific lamprey


Photo courtesy of the Confederated Tribes of the Umatilla Indian Reservation


Photo courtesy of Alaska Sportsman


Photos courtesy of Karuk Tribal Fisheries Program


N
Chief Joseph
Wells
Rocky Reach
Rock Island
Lower Monumental
Wanapum
Lower Granite
Columbia River
Priest Rapids
Little Goose
Ice Harbor
The Dalles
Snake River
McNary
Bonneville
John Day
Hells Canyon



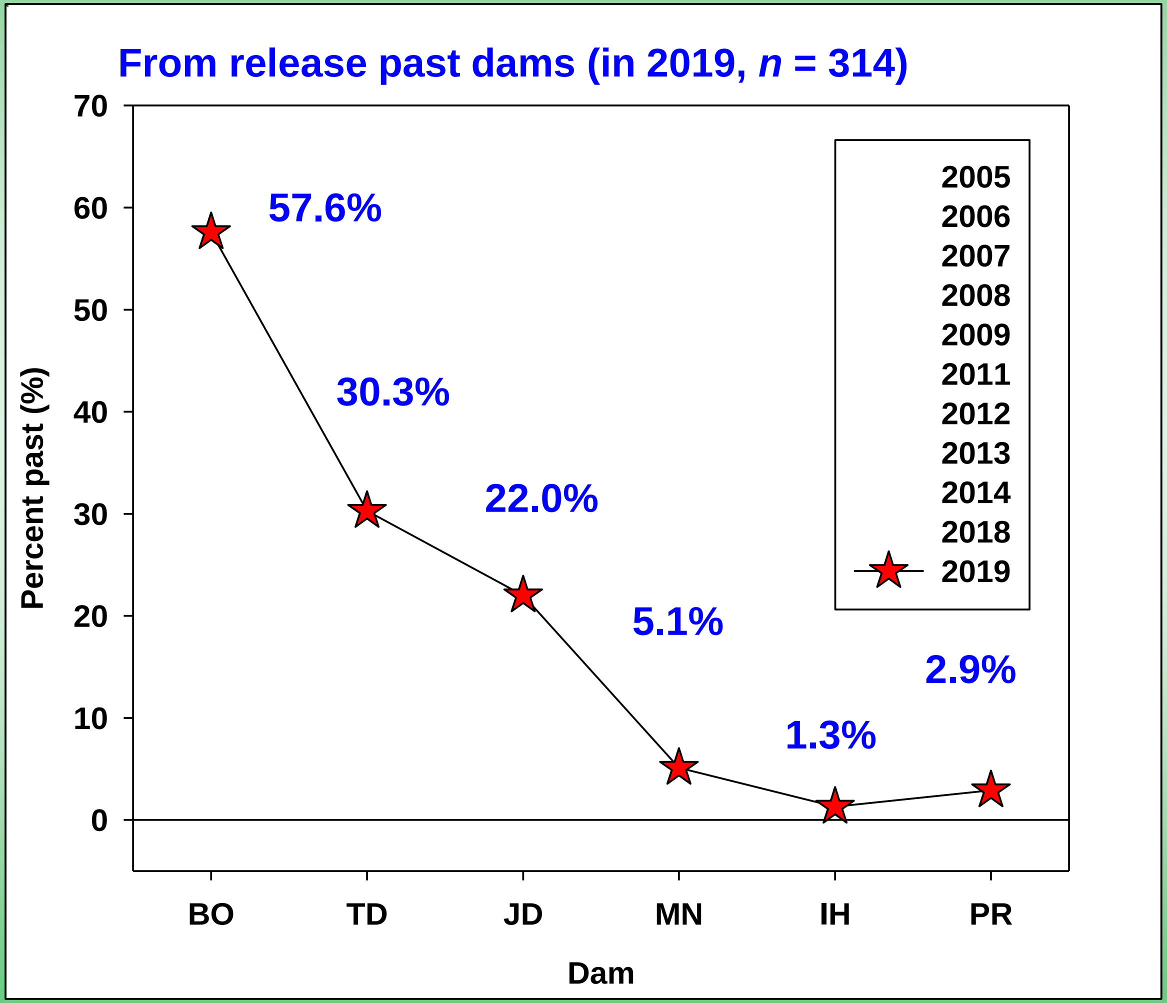
Fish ladders are built for SALMON

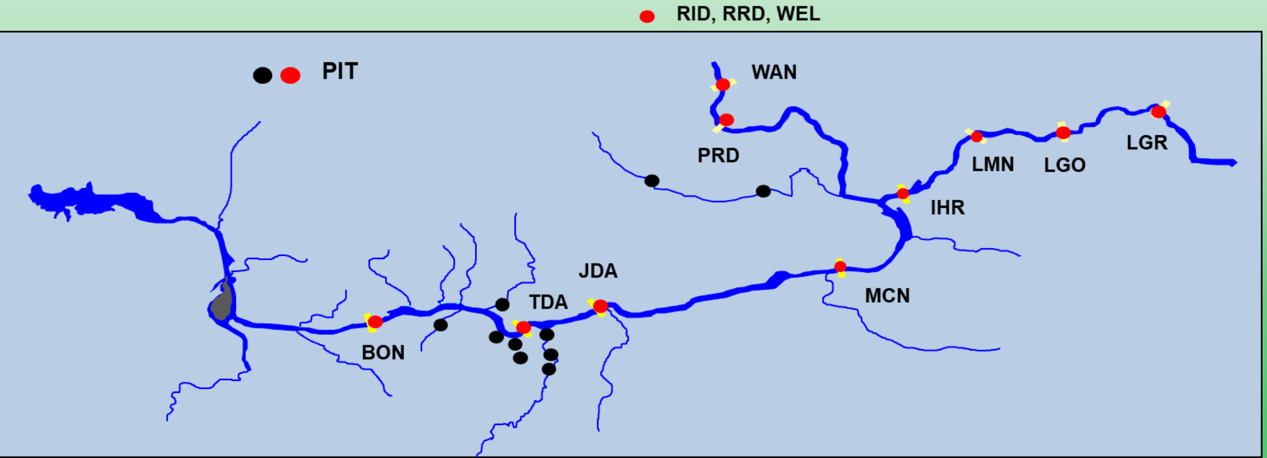



Pacific lamprey
(*Entosphenus tridentatus*)
also need to pass the dams

Escapement past dams



- Passage success at major hydropower dams is poor (<50% per project, based on HD PIT detections).



University of Idaho
College of Natural Resources

Improving Pacific lamprey migration success at barriers

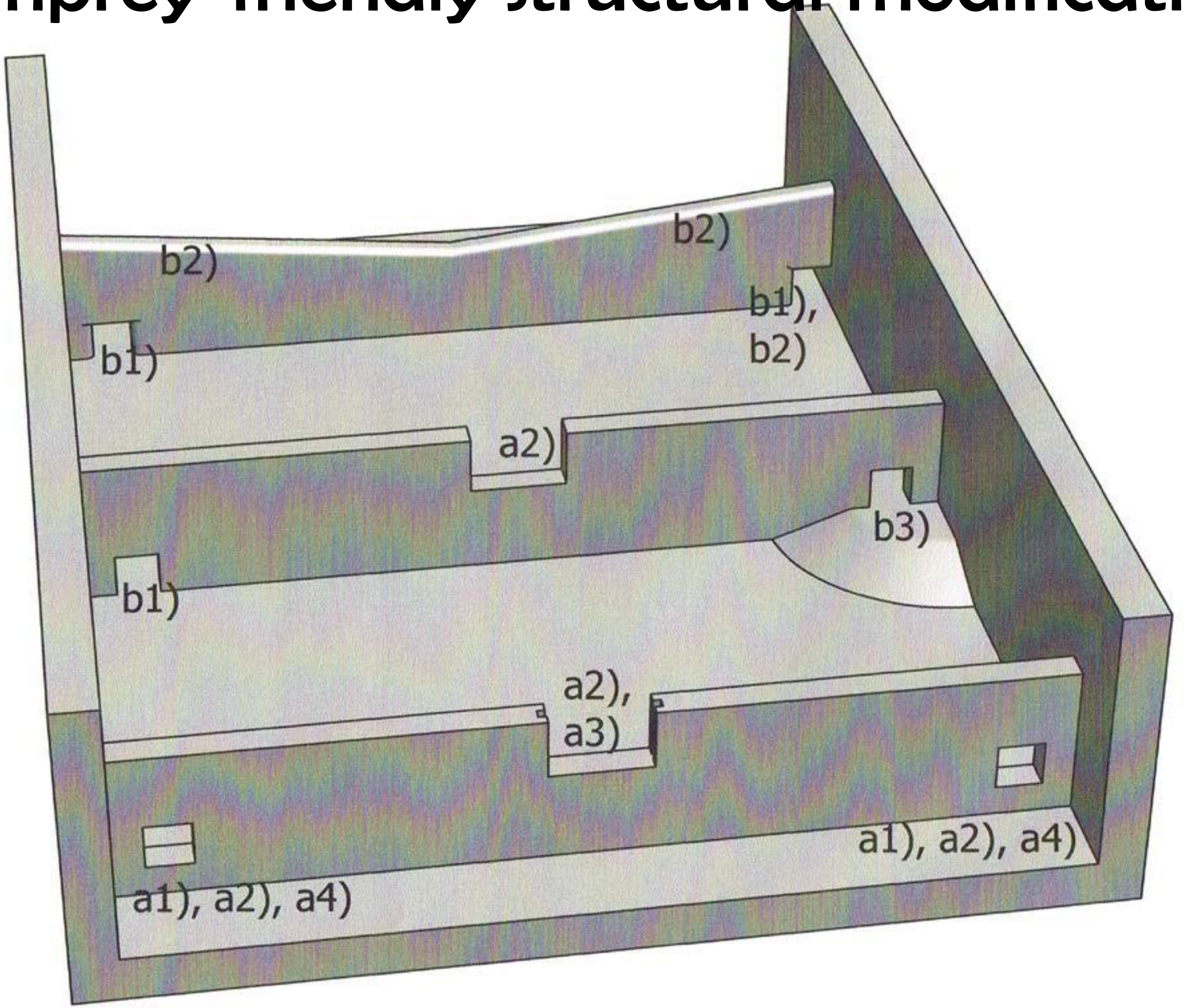
- Lamprey-friendly structural modifications
- Velocity reduction
- Lamprey-specific fishways


TABLE 1. Pacific Lamprey swimming abilities and behaviors relative to water velocities. Great Lakes Sea Lamprey in red.		
Parameter	Speed	Source
Sustained swimming speed	0.9 m/sec (3.0 fps)	Bell (1991)
Critical swimming speed	0.9 (+/- .075) m/sec, 2.8 fps (+/- 0.25) fps)	Mesa et al. (2003) Moser and Mesa (2009) estimate "conservative"
Burst swimming speed	2.1 m/sec (7.0 fps) 1.4-1.5 m/sec (4.6-4.9 fps) for 50 s >80% passage for 2.4 m/sec (7.9 fps) in lab tests- (thus length of sustained burst and presence of turbulence interacts with velocities)	Bell (1991) Kirk et al. (2016) McCauley (1996) Bergstedt et al. (1981)
Free-swimming abilities	<1.2 m/sec "Lamprey more readily moved through sections where water velocity was ≤ 1.2 m/sec (3.9 fps), below the estimated burst swim speed for adults."	Keefer et al. (2011) Keefer et al. (2012)
Barrier: Head differential	Slot entrance with > 0.4 m (1.5 feet) head – may eliminate passage	Keefer et al. (2010)
Behaviorally- lamprey change to burst and attach locomotion	>0.6 m/sec (~2.0 fps)	Daigle et al. (2005)
Burst swim speed and burst and attach locomotion exceeded; attach and burst locomotion "ineffective"	2.5 - 3.0 m/sec (8.2 - 9.8 fps) When velocities exceed burst swim speed (2.1 m/sec (7.0 fps)) or confusing stimuli guide fish to impassable areas	Keefer et al. (2010); Kirk et al. (2016) Moser et al. (2009)
Exclusion Grating	Open space ≤ 1.9 cm (0.75 inches) for new migrants entering the Columbia River, as determined at Bonneville Dam. At other locations, reduced gap size is likely needed because lamprey shrink over time. Pacific Lamprey in the upper Columbia Basin, and perhaps other lamprey in different drainages, are probably smaller and could get through this gap size.	Moser et al. (2008) Moser, pers. comm. (2016)
Climbing abilities	Able to climb vertical or near vertical surfaces when appropriate attachment surface is provided, and can use climbing behaviors to move past areas with high velocities. No vertical climbing ability.	Reinhardt et al. (2008) Kemp et al. (2009) Moser et al. (2009)

Passage Barriers

- Physical impediments to progress
  - Weir openings
  - 3D barriers
- Velocity barriers:
  - Fishways typically 2.1 – 3.0 m/sec (7 – 10 fps), Lamprey burst speed 2.1 m/s (7 fps)
  - Target 0.3 – 0.5 m (1.0 – 1.5 ft) head differential, Lamprey obstructed by head differential > 0.5 m (1.5 ft)

Lamprey-friendly structural modifications

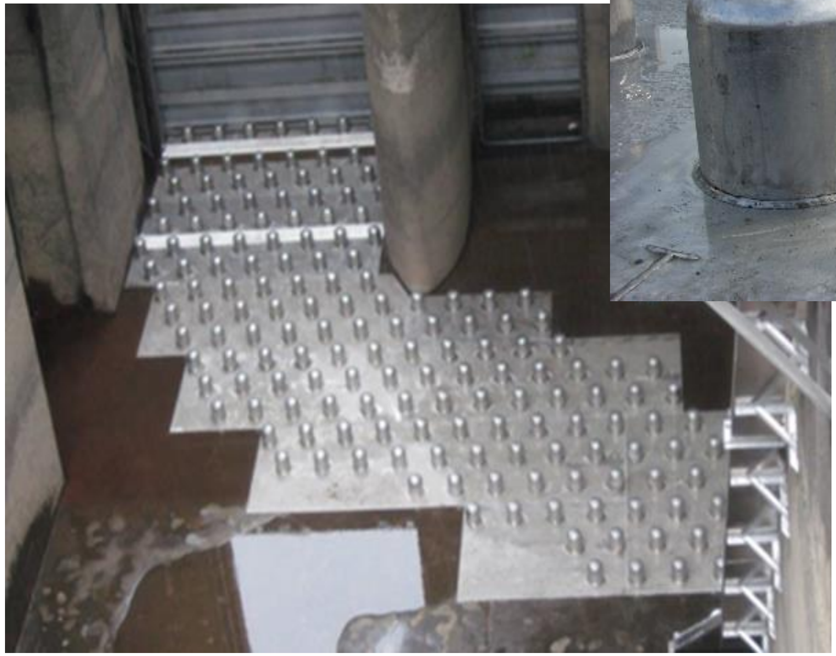


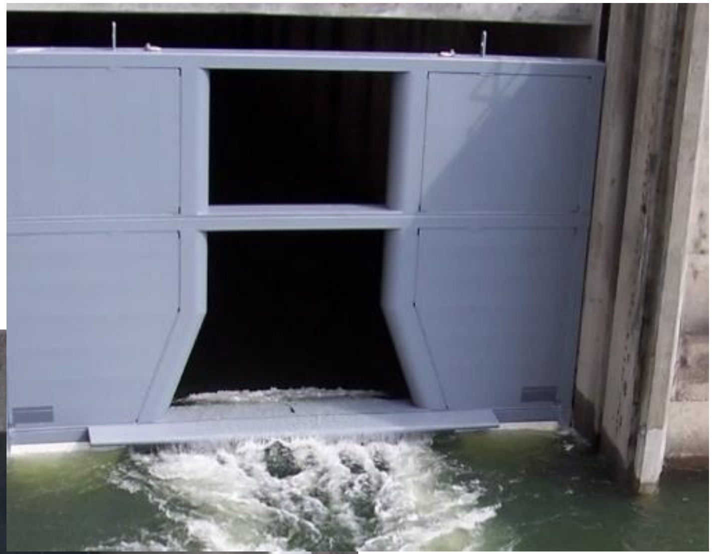
Mind the (vertical) gap!

Velocity reduction

Approaches taken to reduce bottom velocities (Bonneville Dam, Cascades Island entrance):

- Bollard field to LPS entrance (desirable passage option)
- Variable width weir

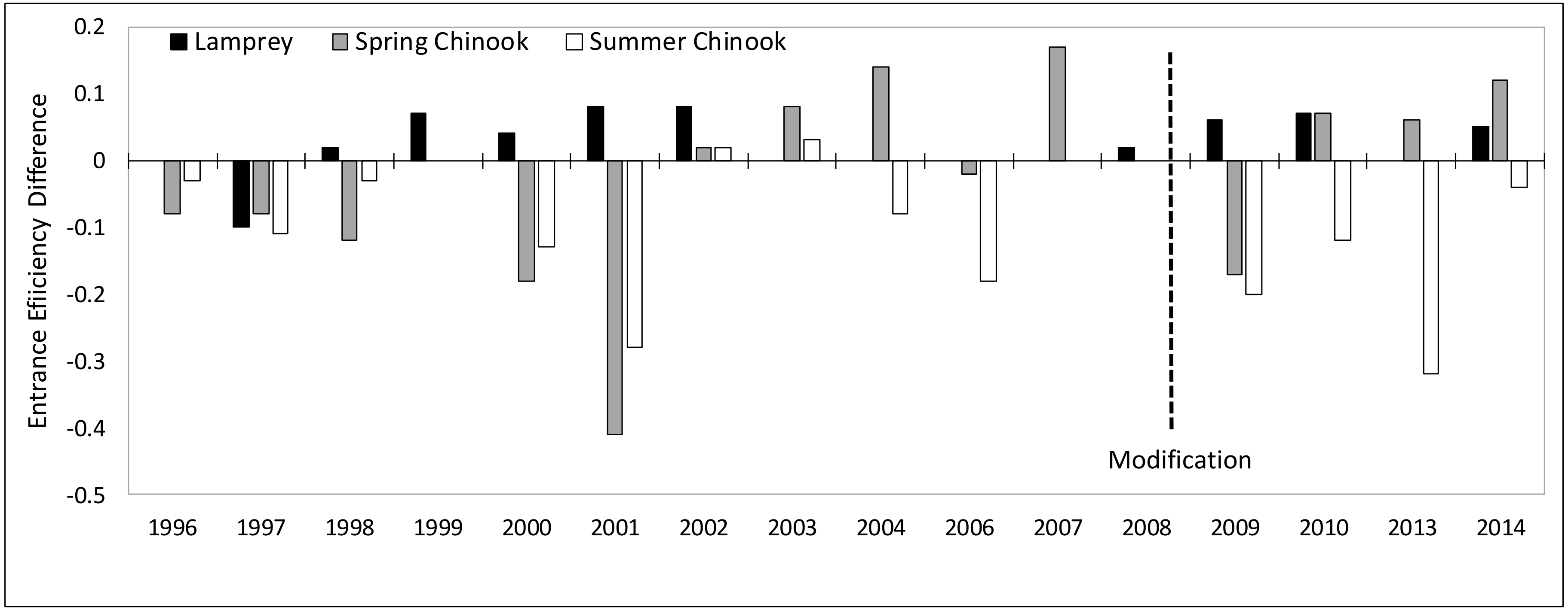




Velocity reduction

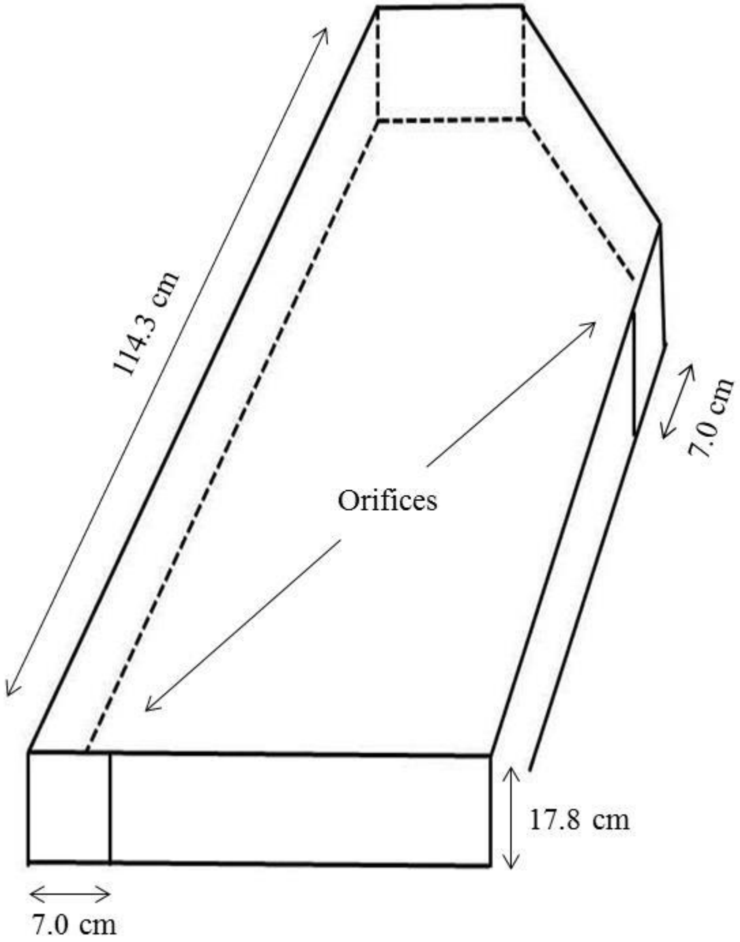
Approaches taken (Bonneville Dam, Cascades Island entrance):

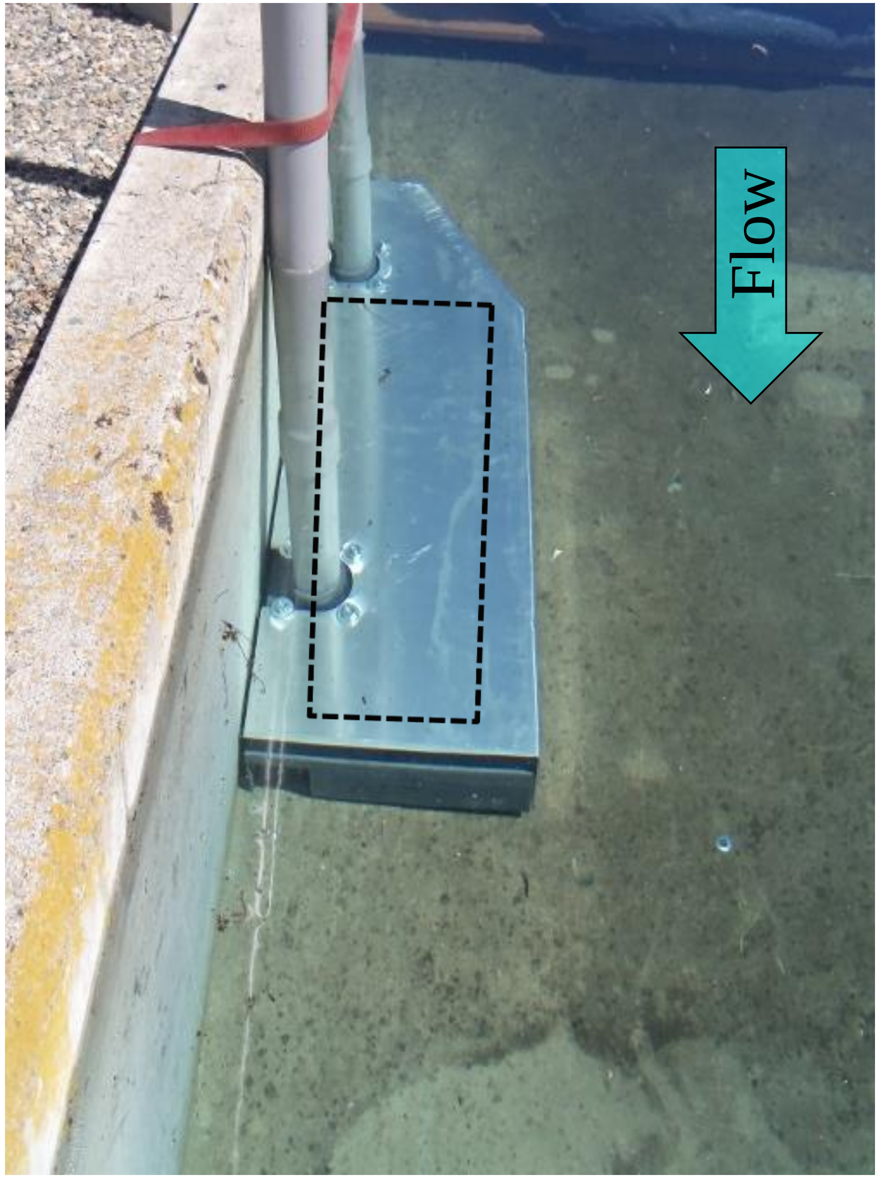
- Evaluate entrance efficiency for modified and unmodified (Bradford Island) fishway entrances for adult Pacific lamprey, spring and summer Chinook salmon

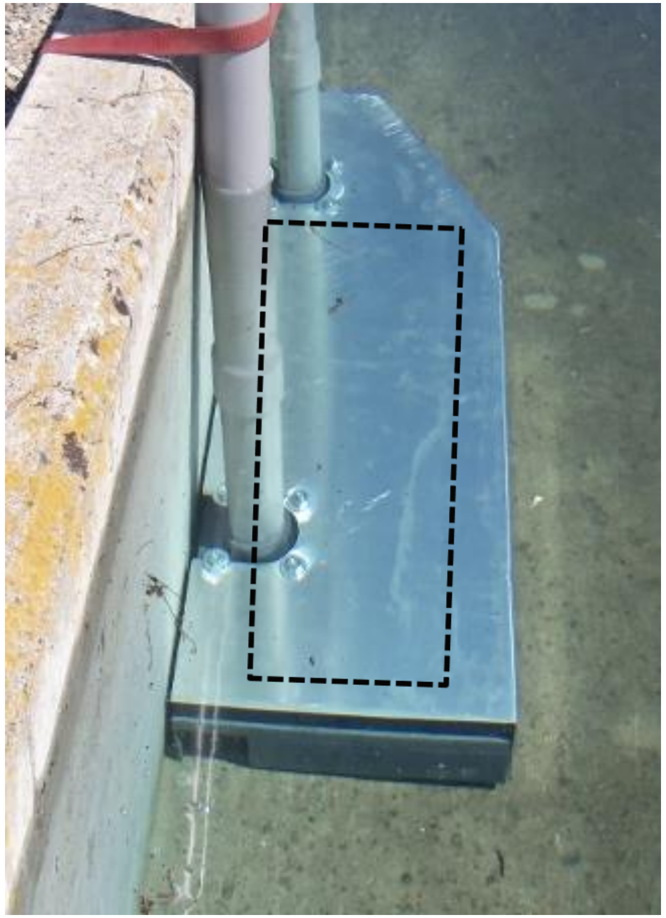


Results: No significant improvement for lamprey, use for Chinook salmon not significantly diminished

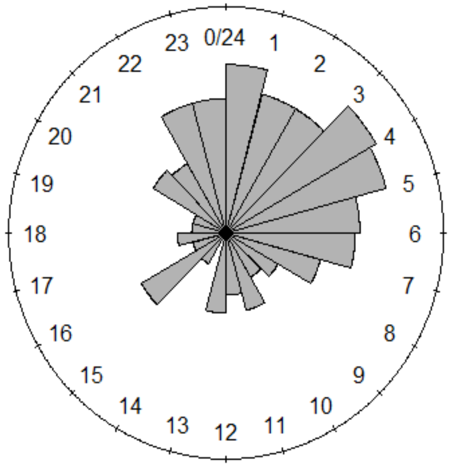
Lamprey-friendly structural modifications



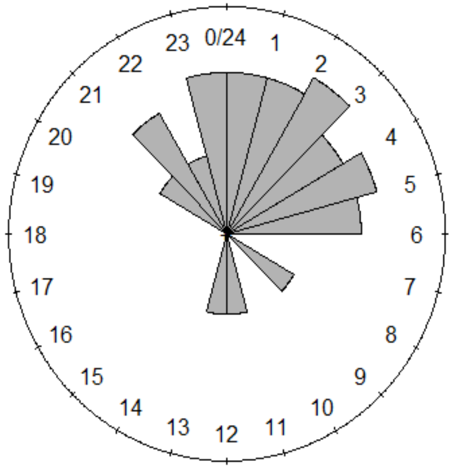




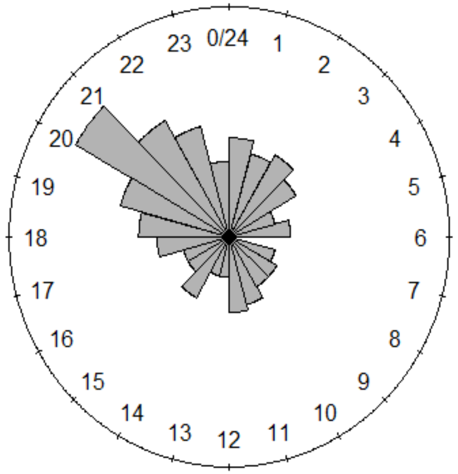
South Refuge Entries



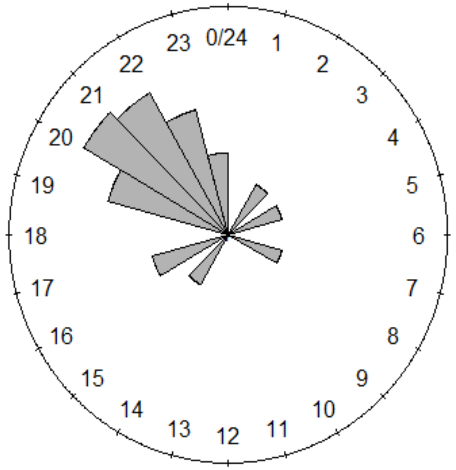
North Refuge Entries



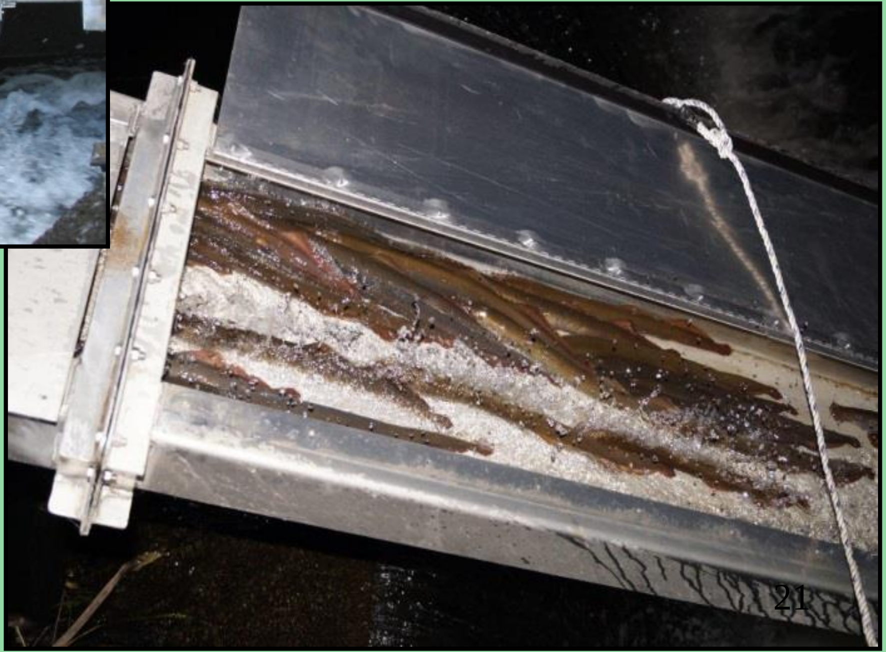
South Refuge Exits



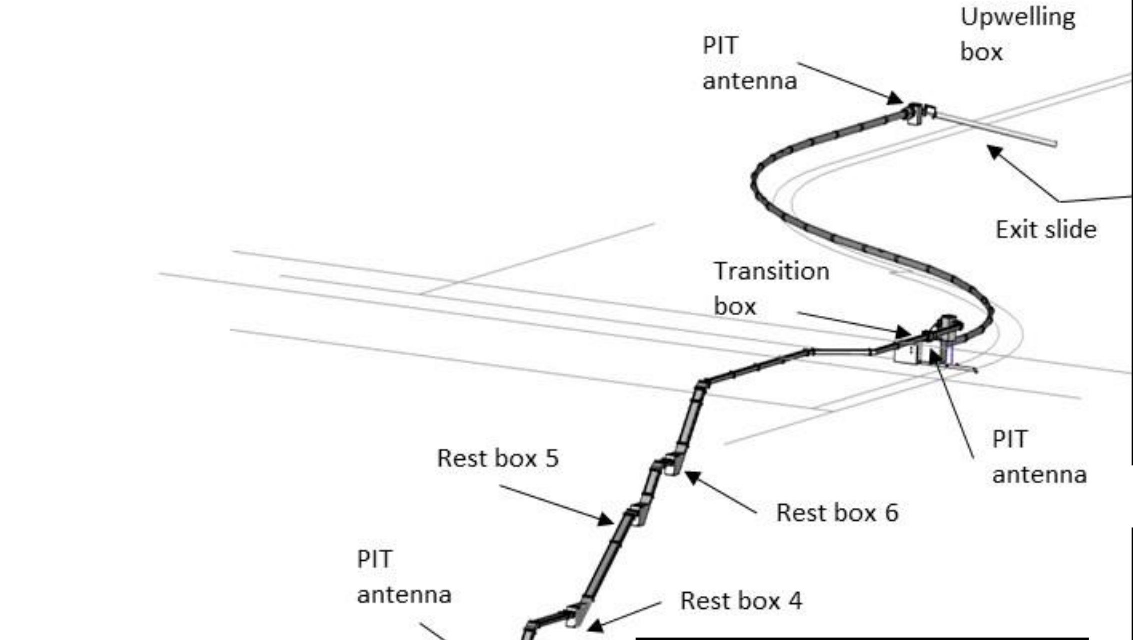
North Refuge Exits

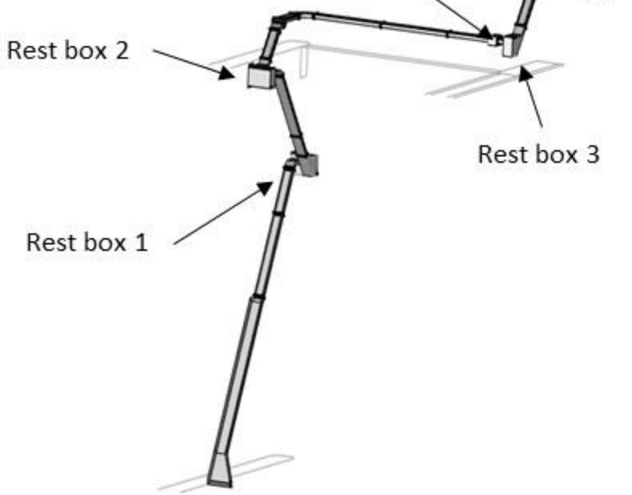


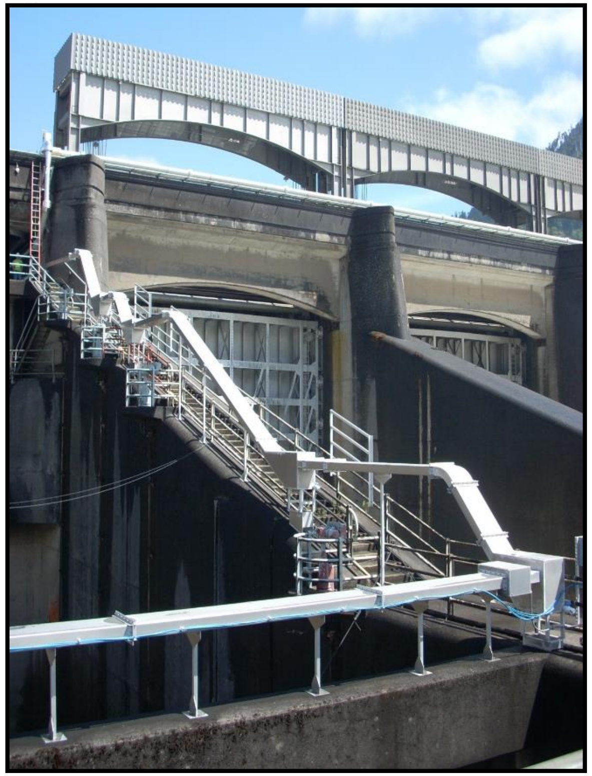
	2012	2013	2014
Lamprey released (total n)	977	1,073	1,198
Detected in WA-shore fishway (total n)	198	297	301
Detected in refuge box (n)	36	153	174
Percent in WA-shore fishway that used refuge	18%	52%	58%
Detected at fishway exit (total n)	187	243	147
Did not use refuge (n)	162	144	127
Used refuge (n)	25	99	120
Percent of refuge users detected at fishway exit	69 %	65%	69%
Detected upstream from BON (total n)	106	220	165
Did not use refuge (n)	92	143	104
Percent of non-users detected upstream	57 %	99%	82%
Used refuge (n)	14	77	61
Percent of refuge users detected upstream	56%	78%	51%



Lamprey Passage Structures


Upwelling box
PIT antenna
Exit slide
Transition box
PIT antenna
Rest box 5
Rest box 6
PIT antenna
Rest box 4


Rest box 2
Rest box 3
Rest box 1



Cool Adaptations

LPS constraints in fishways

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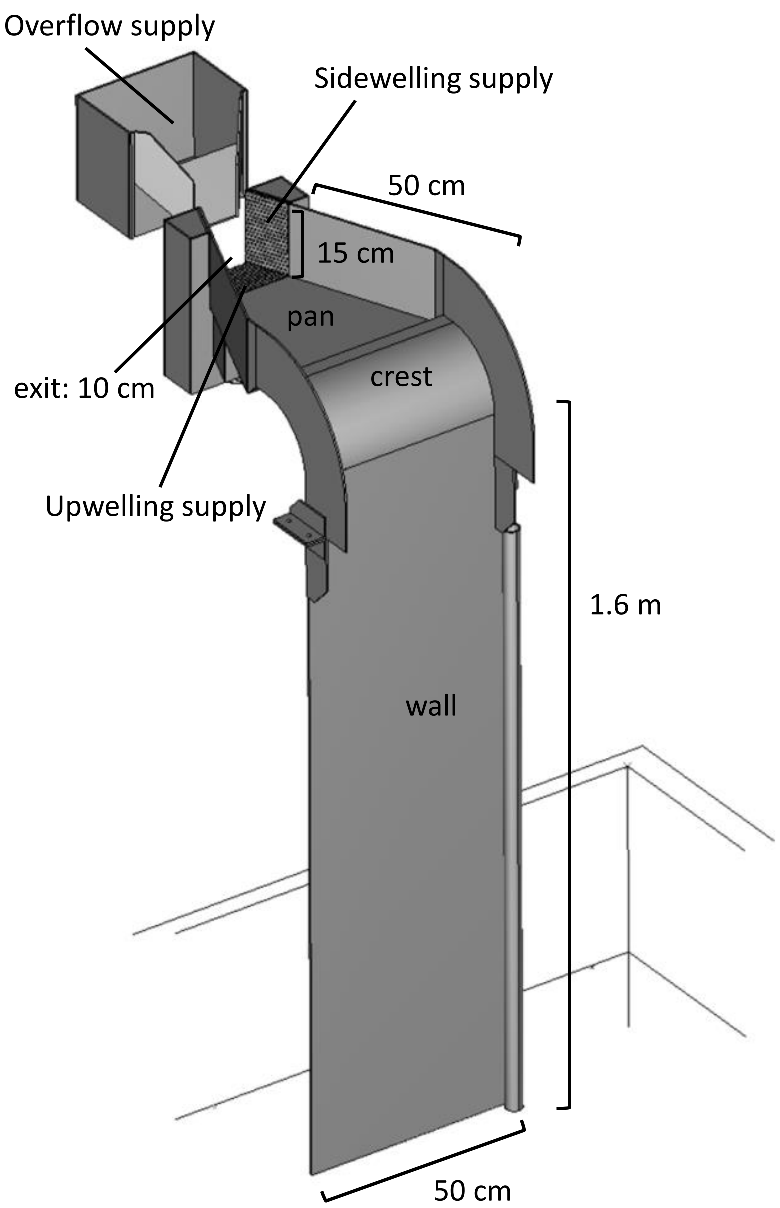
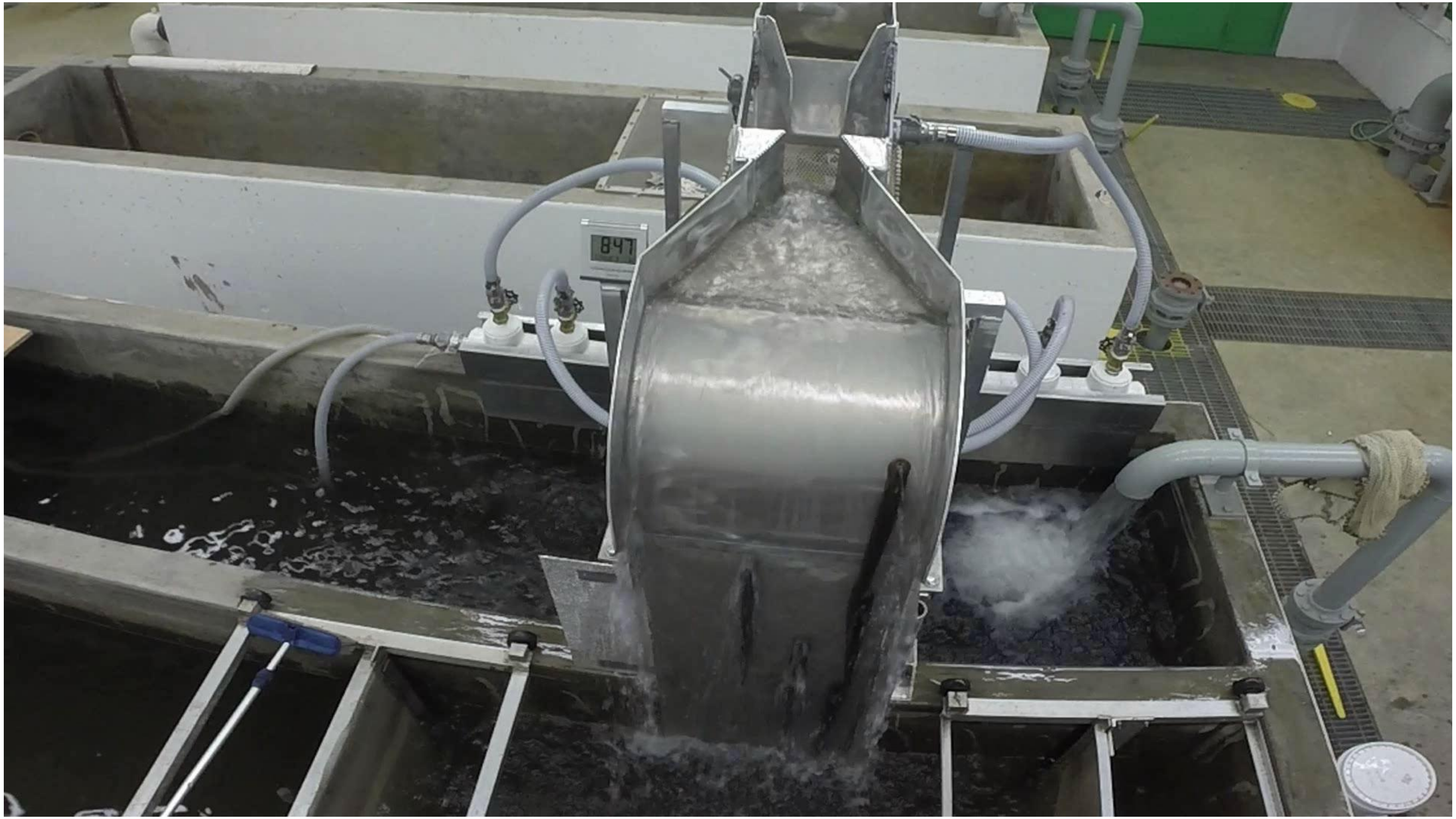
Cool Adaptations

Vertical Climbing

Wetted Wall Climbing Structure



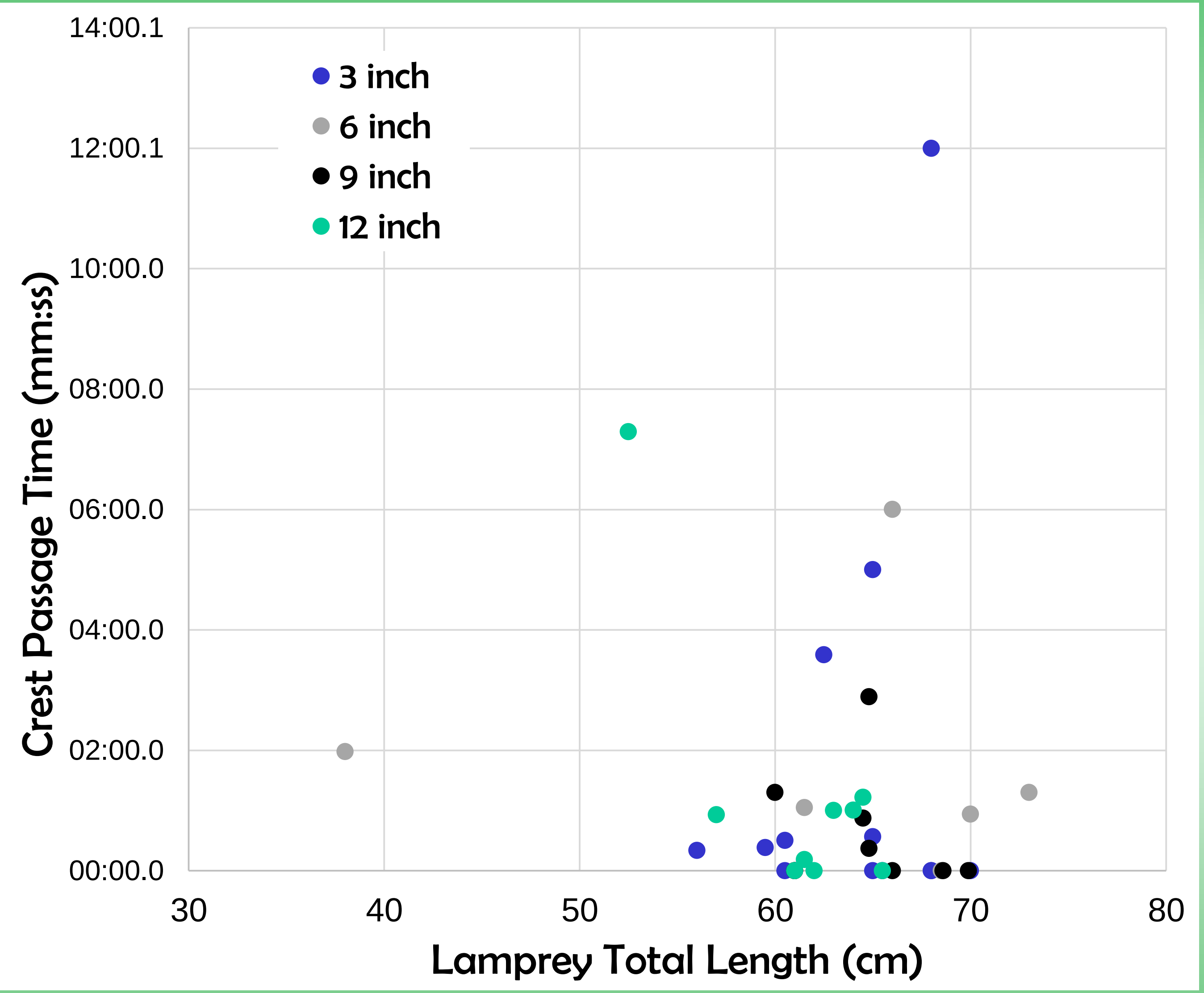


Wetted wall experiments

- Water supply mechanism
- Water flow level
- Crest radius

Results from wetted wall experiments

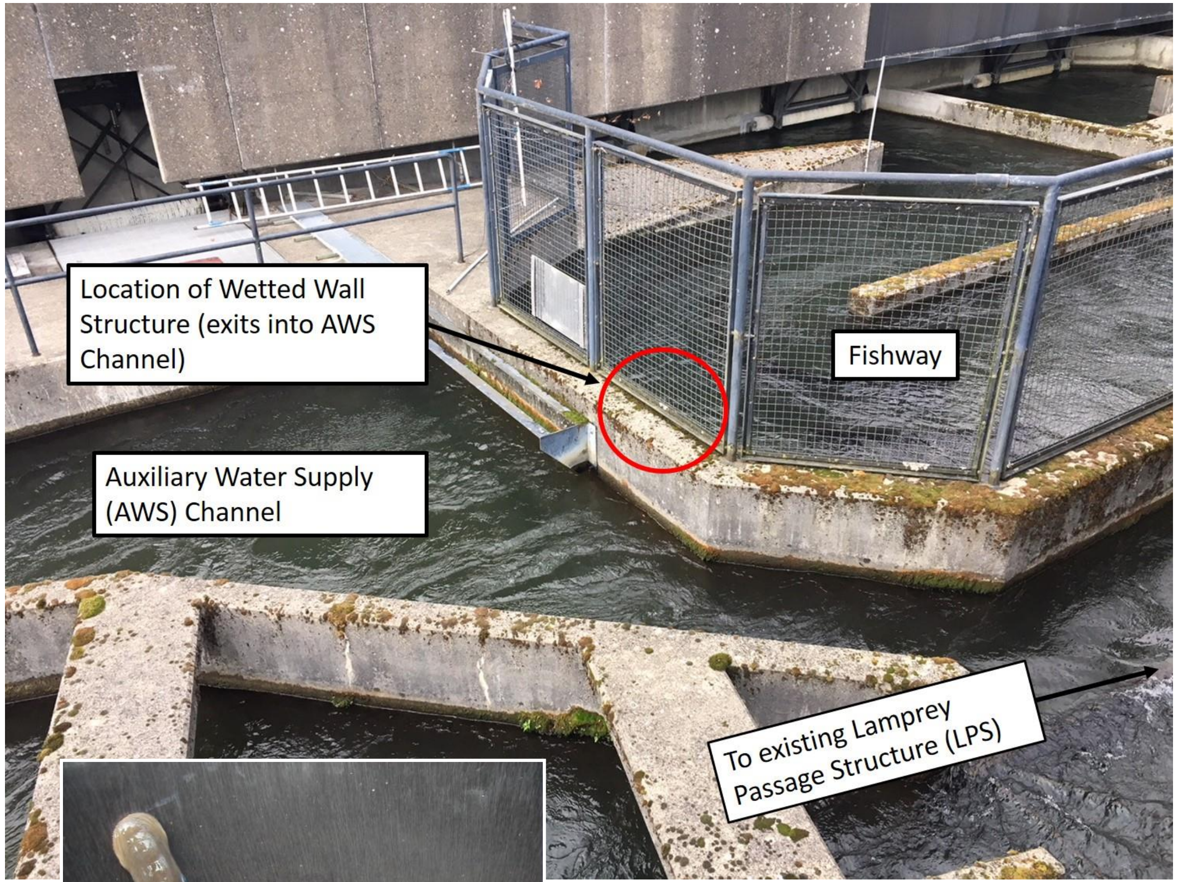
- Various water supply mechanisms were effective
- More than minimum sheeting flow is required
- Neither crest radius nor lamprey length affected successful passage time
- Unsuccessful fish were longer than successful fish



Opportunity

- At Bonneville's Bradford Island fishway, adjacent AWS has an LPS

- Fishway wall is short

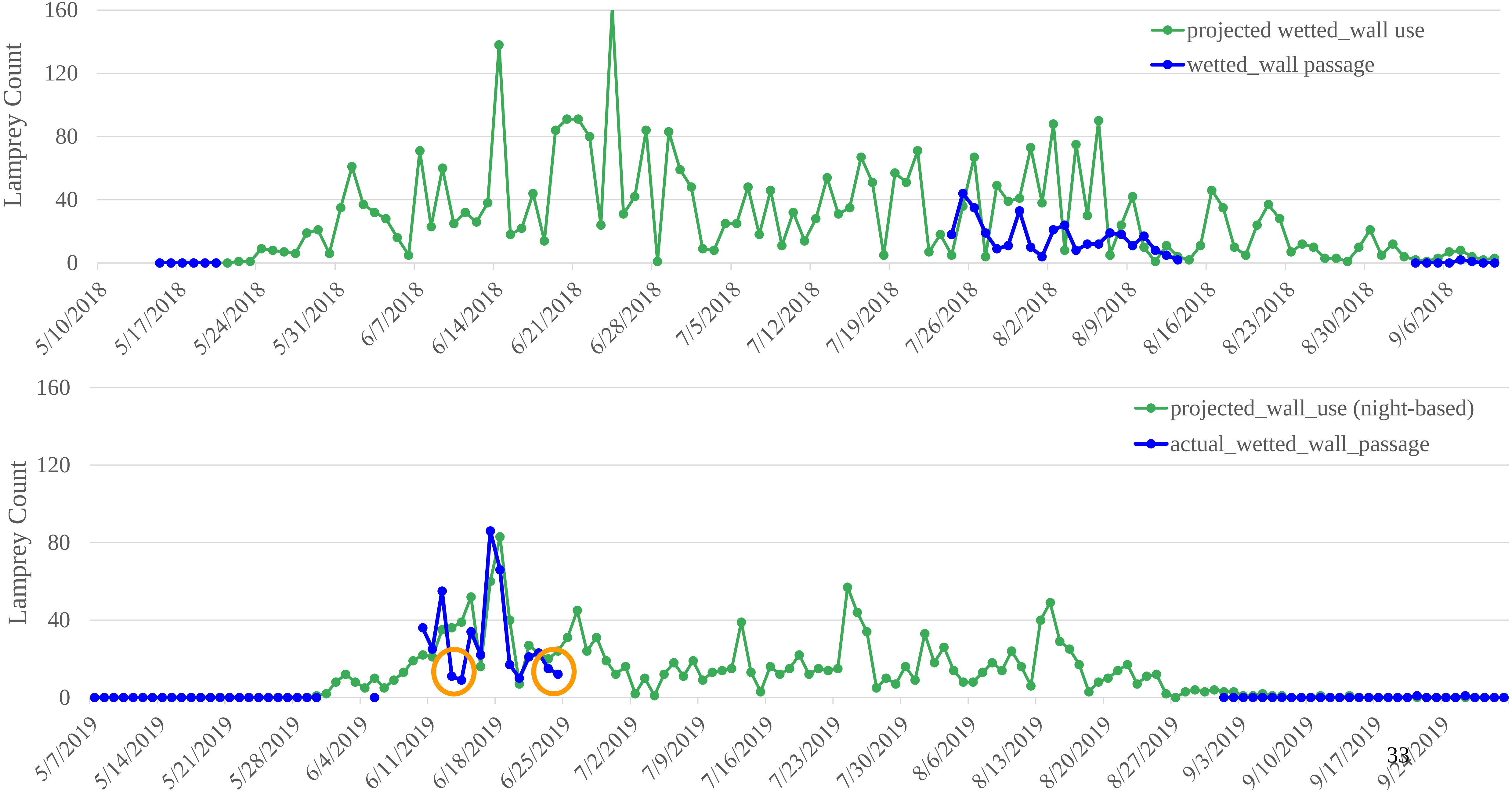


Bradford Island wetted wall – new in 2018!

Features:

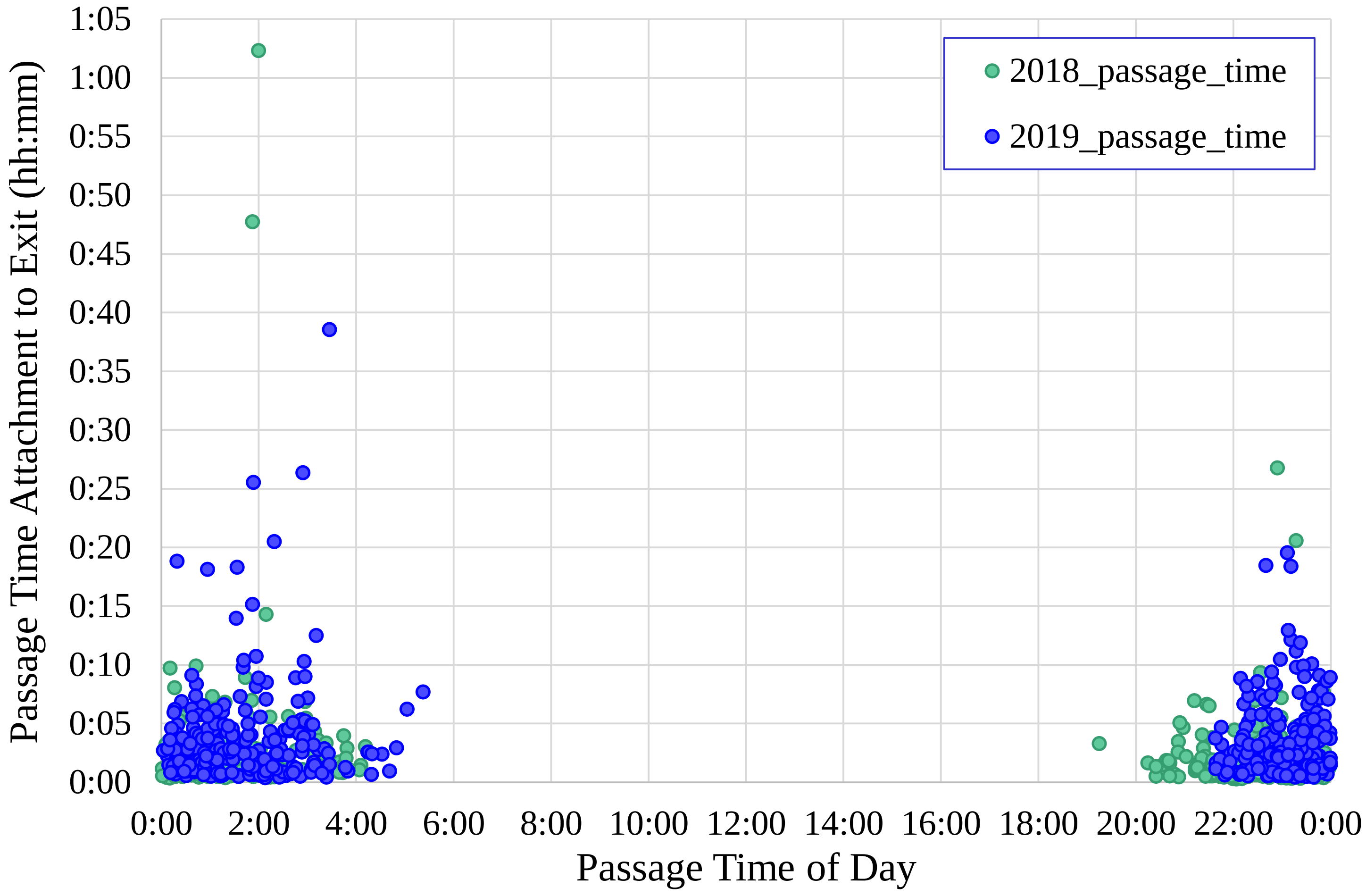
- Sidewelling water supply
- Hood: protect from predation, reduce light
- Pan > lamprey length
- PIT antenna at exit
- Attached video camera

Wetted Wall Use (Counted and Projected) Lamprey projected to have used wall (2018): 3,205 (2019): 1,713



Passage metrics

- Almost exclusively nighttime passage events
- Time on structure fairly evenly divided on average, longer in 2019:



	2018	2019
Total passage avg (max)	00:02:21 (1:02:19)	00:04:01 (00:38:33) N=435
Wall average (max)	00:01:09 (00:09:37)	00:01:43 (00:26:20) N=458
Pan average (max)	00:01:14 (1:00:19)	00:02:22 (00:35:20) N=435

Passage observations

- Fallback/multiple attempt count:
  - 2018 = 91
  - 2019 = 107 (2/3 from crest of structure)
- Exit attachment
- Predation potential
- No salmon interactions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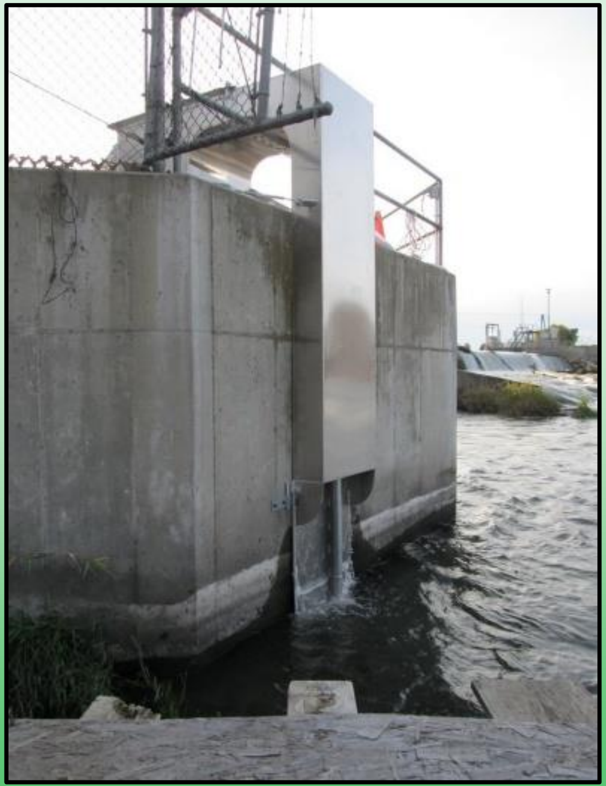
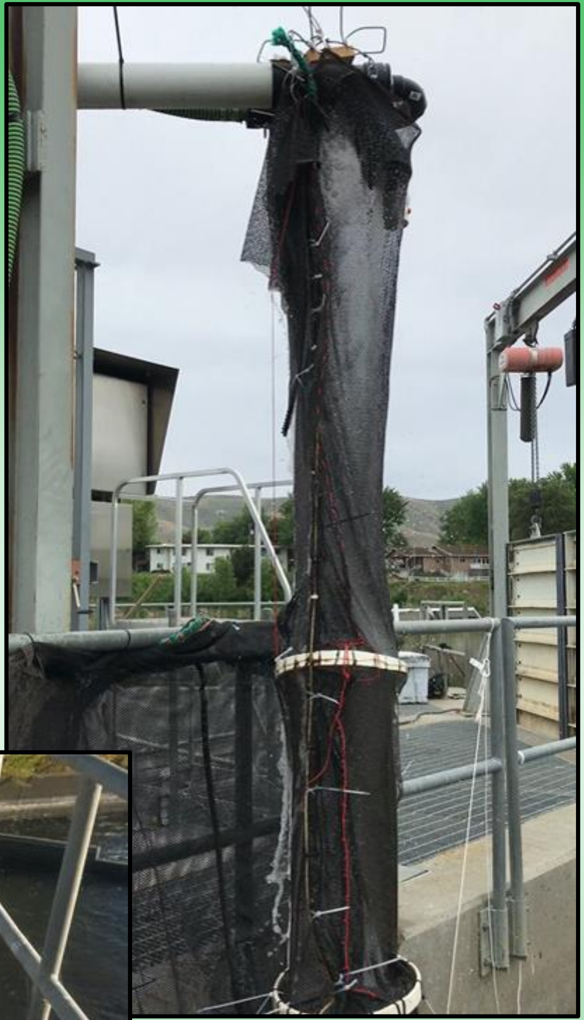
CAM02

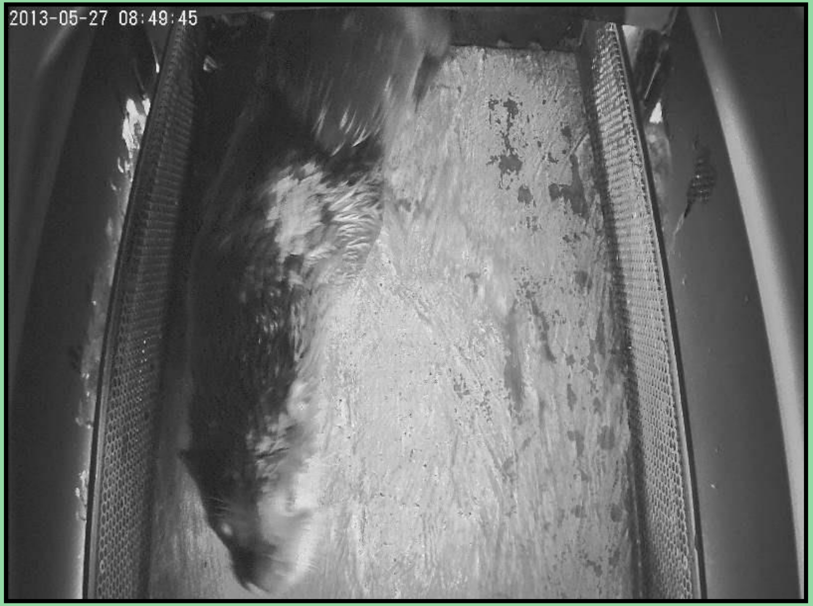
Pacific Lamprey Conservation Initiative CRB Project: Prosser Dam Wall





Other considerations: Predators


Photo courtesy of D. Dow, Woodland Park Zoo



Conclusions: Improving lamprey migration success at barriers

- Species-specific designs can be effective
  - Lamprey-friendly structural modifications: rounding corners, ramps, openings in line with bottom of fishway
  - Velocity reduction: bollards, entrances in lower flow areas
  - Lamprey-specific fishways: site-specific designs

Questions?

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