2016 Studies Extend Whooshh Passage Application:

Deeper, Further, Longer

June 2017

Longer

Roza 1,100 ft Whooshh transport – Proof of Concept test for Adult Cle Elum dam passage

Yakama Nation and USBR Adult Survival Reproducibility

Roza dam 3 yr study: Spring Chinook transported to hatchery trucks and hauled to Cle Elum hatchery

Adult Survival

Chinook	H&H	WFTS 40	WFTS 1100	H&H 95% Confidence Limit
2014	90.3%	93.8%		(87.0%-93.0%)
2015	72.5%	76.9%		(68.3%-76.5%)
2016	84.9%	85.7%	81.80%	(81.2%-88.1%)

Roza dam 3 year Study - Egg Viability

Egg Viability

	2014 Viable Eggs		2015 Viable Eggs		2016 Viable Eggs	
	count	% of group	count	% of group	count	% of group
WFTS 40	105920	93.0%	86767	92.8%	163369	92.9%
H&H	636500	95.1%	593068	94.6%	495064	94.6%
WFTS 1100					37743	96.8%
Total	742420		679835		696176	

	2014 Total Eggs		2015 Total Eggs		2016 Total Eggs	
	count	% of total	count	% of total	count	% of total
WFTS 40	113886	14.5%	93470	13.0%	175912	23.8%
H&H	669609	85.5%	627129	87.0%	523570	70.9%
WFTS 1100					38999	5.3%
Total	783495		720599		738481	

Study	Species	Date	Survival	Migration	Passage Delay	Egg Viability	Injury	Homing	Disease Transmission	Behavior	Volitional Entry	Durability/Maintenance	Total # Areas of Interest Covered by a Given Study
			Direct Test: Lab, Field, In-River	Direct Test: In-River	Direct Test: In-River	Direct Test: Field	Direct Test: Lab, Field, In-River	Indirect Test: In-River	Indirect Test: Lab, Field, In-River	Indirect Test: Field, In-River	Direct Test: In-River	Direct & Indirect Tests: Lab, Field, In-River	
Whooshh labs	Rainbow Trout Tilapia Atlantic Salmon		3				3					3	**3**
USGS	Rainbow Trout	2011	1				1			1		1	**4**
WDFW/USGS Kalama Study	Steelhead	2014	1				1			1		1	**4**
WDFW Washougal	Tule Chinook	2014-2016	1		1		1			1		1	**5**
Yakama Nation Roza Dam	Spring Chinook	2014	1			1	1		1	1		1	**6**
PacifiC NW Labs/DOE	Fall Chinook	2014	1										**3**
Puyallup Buckley Study	Pink Salmon	2015	1	1	1					1	1	1	**6**
Yakama Nation Roza Dam	Spring Chinook	2015	1			1	1		1	1	1	1	**7**
Alden Labs	Sturgeon	2015	1				1			1			**3**
FWI Study	Atlantic Salmon	2015	1				1			1			**3**
CRITFC Priest Rapids Study	Sockeye	2016	1	1				1	1	1			**6**
Yakama Nation/USBR Roza Dam	Spring Chinook	2016	1			1	1		1	1		1	**6**
SINTEF Norway Study	Atlantic Salmon	2016	1			1	1		1	1			**5**
Yakama/USBR Prosser Study	Coho Fall Chinook	2016	2			1	1		1	2	2	1	**7**
USGS Great Lakes Fisheries	Gizzard Shad Largemouth Bass Northern Pike Rainbow Trout Common White Sucker Longnose Sucker Walleye	2017	7				7			7			**3**
Brookfield Cataract Dam	American Shad	2017	1				1			1			**3**
USBR Cle Elum	Sockeye	2017	1	1	1			1	1	1	1	1	**8**
Pacific NW Labs SBV DOE	Fall Chinook	2017	1		1		1			1	1	1	**6**
Total Number of Tests Evaluations per Species		**115**	**27**	**3**	**4**	**7**	**23**	**2**	**7**	**23**	**6**	**13**	**88**

Survival
Migration
Passage Delay
Egg Viability
Injury
Homing
Disease Transmission
Behavior
Volitional Entry
Durability/Maintenance

Whooshh Transport: Species moved to date

Pink salmon
Rainbow Trout
Chinook salmon
Sockeye salmon
Coho salmon
Steelhead
Atlantic salmon
Sturgeon

Gizzard Shad
Largemouth Bass
Northern Pike
Common White Sucker
Longnose Sucker
Walleye
American Shad

Deeper, Further, Longer

Study	Species	Date	Survival	Migration	Passage Delay	Egg Viability	Injury	Homing	Disease Transmission	Behavior	Volitional Entry	Durability/Maintenance	Total # Areas of Interest Covered by a Given Study
			Direct Test: Lab, Field, In-River	Direct Test: In-River	Direct Test: In-River	Direct Test: Field	Direct Test: Lab, Field, In-River	Indirect Test: In-River	Indirect Test: Lab, Field, In-River	Indirect Test: Field, In-River	Direct Test: In-River	Direct & Indirect Tests: Lab, Field, In-River	
SINTEF Norway Study	Atlantic Salmon	2016	1			1	1		1	1			**5**
CRITFC Priest Rapids Study	Sockeye	2016	1	1	1			1	1	1			**6**
Yakama Nation/USBR Roza Dam	Spring Chinook	2016	1			1	1		1	1		1	**6**
YN/USBR Prosser Study	Coho Fall Chinook	2016	2			1	1		1	2	2	1	**7**
Total Number of Tests Evaluations per Species		**27**	**5**	**1**	**1**	**3**	**3**	**1**	**4**	**5**	**2**	**2**	**24**

SINTEF: Atlantic Salmon Broodstock Safe Transport Study

SINTEF/NFSA Broodstook Study

Evaluation: **Deeper** look at Atlantic Salmon Broodstock Transport Stress and Injury

Three groups: Control (not transported)
Hand carry transport 100 ft
WFTS transported 100 ft

Scale and Slime Loss

Blood and White Muscle Biochemistry

Cortisol	Chloride	pH
Glucose	Lactate	Temperature

1 wk behavior and latent injury assessment

WHOOSHH INNOVATIONS

Results/Conclusions:

- No mortality or evidence of injury
- Behavior was normal throughout with no descaling or loss of slime
- Blood biochemistry stress levels were low and comparable between hand carry and WFTS
- Muscle biochemistry stress levels analogous to “rested state”

- WFTS provided reduced air exposure
- WFTS provided reduced handling
- WFTS was quicker, safer (reduced handling risk), and less labor-intensive

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CRITFC 2016 Sockeye Migration Study

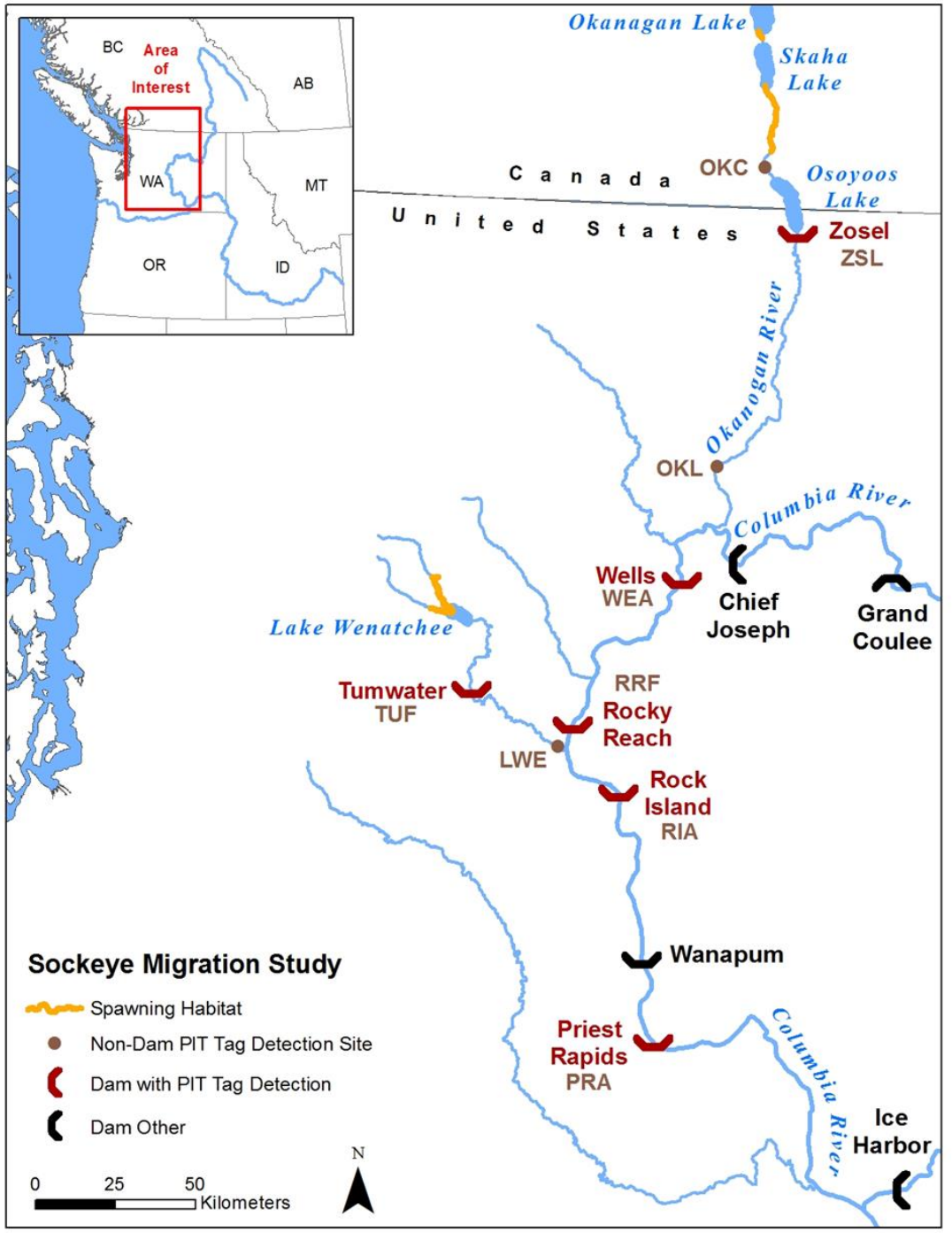
FURTHER

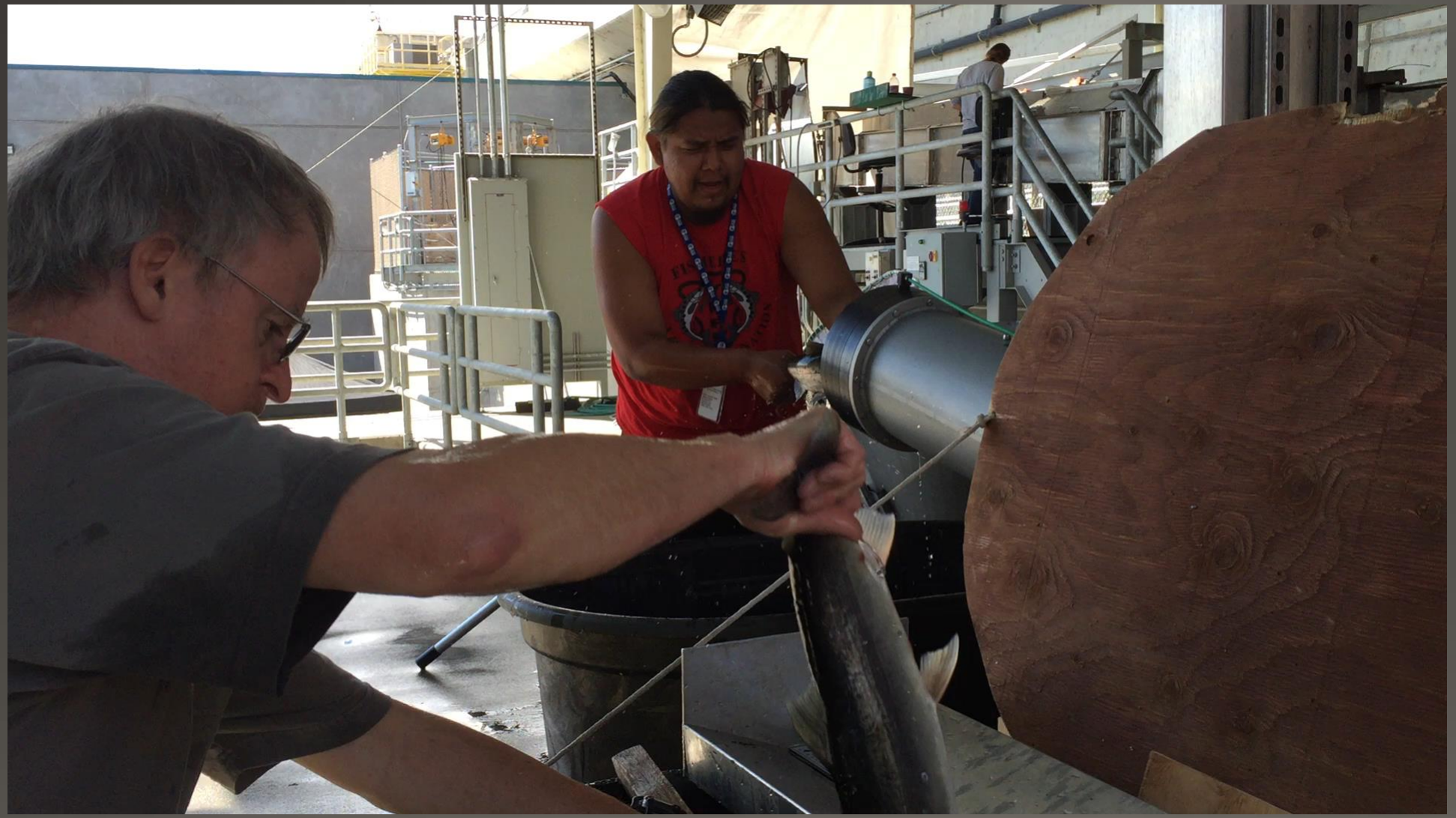
Attributes Directly Assessed:

- Survival
- Migration Time
- Passage Time

Attributes Indirectly Assessed:

- Aberrant Homing
- Increased Disease Transmission
- Abnormal Behavior





Jeff of CRITFC and Jim of YN sampling sockeye and loading into Whooshh system for 100 ft transport to calm water channel and continued passage up Priest Rapids fish ladder

Clam water channel in which sockeye recovered and swam to continue up the ladder

Migration Survival

Wks 27-29 Test: PIT-Tag Sockeye at Priest Rapids Dam Off Ladder Adult Fish Trap

- WFTS: 391 PIT-Tagged Sockeye WFTS tube transported 100 ft to calm water channel to complete ladder passage
- Non-WFTS: 395 PIT-Tagged Sockeye hand carried to calm water channel to complete ladder passage

Results: Upriver survival not affected by WFTS transport

Week	Treatment	Priest Rapids	Rock Island	Rocky Reach	Wells or Tumwater	Zosel	OKC
27-29	Non-WFTS	93.43%	82.7%	60.7%	65.2%	43.9%	24.9%
27-29	WFTS	93.6%	83.7%	55.7%	70.2%	42.7%	25.4%

Wk 30 WFTS Over the Dam Feasibility Test

- WFTS: 54 PIT-Tagged Sockeye WFTS tube transported 180 ft over the dam crest and exited directly into the forebay

- Non WFTS: 56 PIT-Tagged Sockeye hand carried to calm water channel to complete ladder passage

Non-WFTS Passage

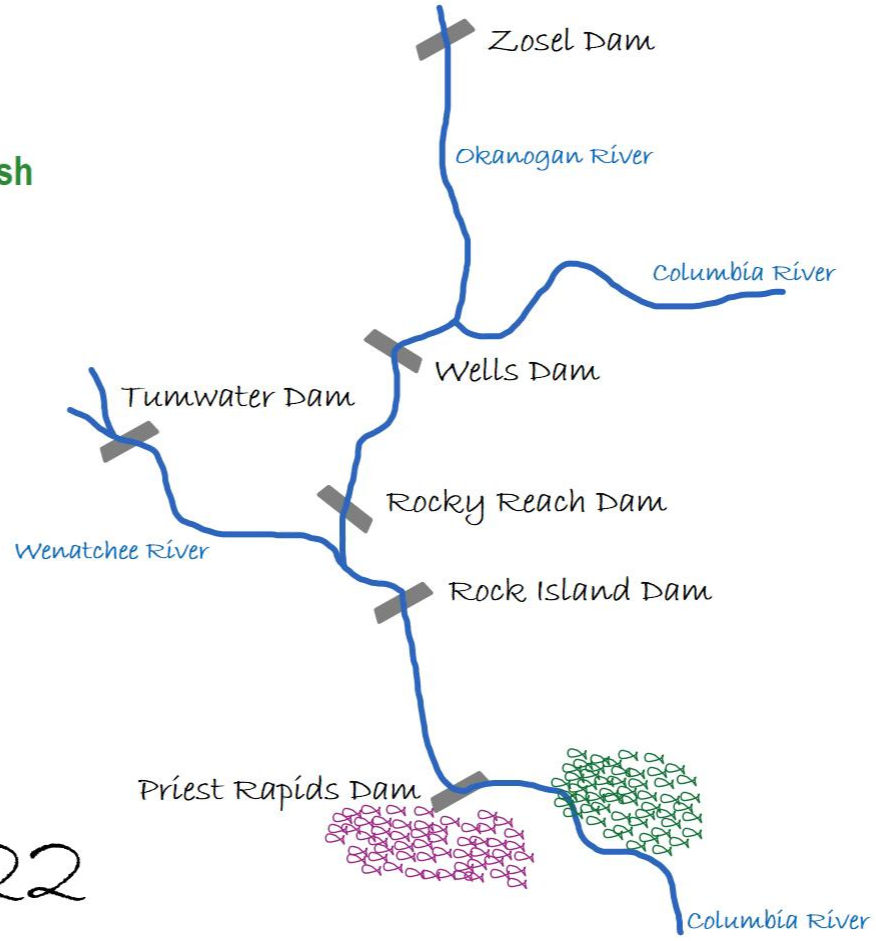
WFTS Passage

WFTS Passage over Priest Rapids Dam crest from OLAFT

WHOOSHH INNOVATIONS

54 Whooshh over the dam fish

56 Ladder swim fish



July 22

Release to site PIT tag detection data

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Wk 30 WFTS Over the Dam Feasibility Test

Results: WFTS over the dam enabled faster migration times (>10% faster) to upstream dams compared to Non-WFTS

Statistically Significant Findings:

- WFTS reached Rock Island dam (91rkm) ~1/2 day faster ($p < 0.01$)

  WFTS: median 3.48 days (n=44) mean 3.89 days

  Non-WFTS: median 4.07 days (n=46) mean 5.39 days

- WFTS reached Rocky Reach dam (124 rkm) ~ one day faster ($p = 0.03$)

  WFTS: median 4.82 days (n=33) mean 5.61 days

  Non-WFTS: median 5.36 days (n=21) mean 6.58 days

Types of Whooshh Transport

Tank to Tank
Trap to Tank
River to Tank

Trap to Truck
River to Truck

Trap to River

Trap to Hatchery
Tank to Hatchery
River to Hatchery

2017 River to River (Reservoir)

WHOOSHH INNOVATIONS

2017 Studies

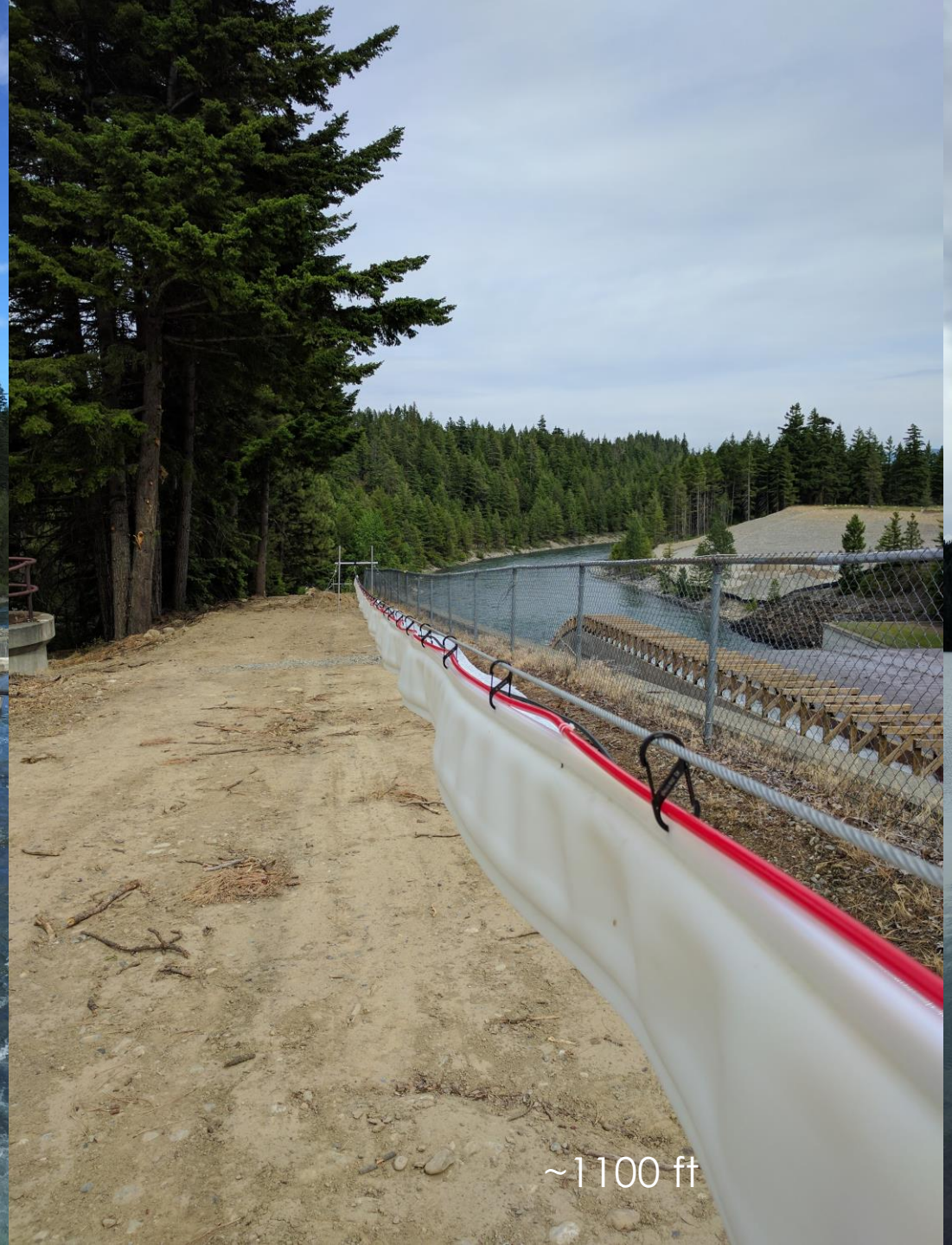
- May 1st - Great Lakes Fisheries Commission – invasive species prevention
  - scanning project passage test – Great Lakes species
- June 15st – Hydropower operators – American Shad passage feasibility
- June 30 – CRITFC / YN – Priest Rapids Over the Dam Migration Study
- **July 1st – U.S. Bureau of Reclamation – Cle Elum Dam**
  - **dam passage proof of concept**
  - **volitional entry**
  - **1,700 ft transport, 165 ft head**
  - **scanning & sorting**
- Sept 15th – Pacific Northwest National Laboratories – volitional entry
  - scanning & sorting
  - injury assessment

Cle Elum Dam – 1,700’ X 165’

Cle Elum River below dam – Whooshh Fish transport system installation

Whooshh scanning and sorting system


~400 ft


~1100 ft


~1700 ft

Thanks to so Many

Dave Fast
Yakama Nation
CRITFC
USGS
USBR
PNNL
NMFS
SINTEF
Elips
WDFW
Biomark
HDR
Sigma 8
USGS Great Lakes Fisheries
PNP
And many others!

Plus the creative, dedicated Whooshh team

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Hand fed Whooshh transport