



Tide Gate Impacts on Juvenile Coho Salmon Movement and Migration

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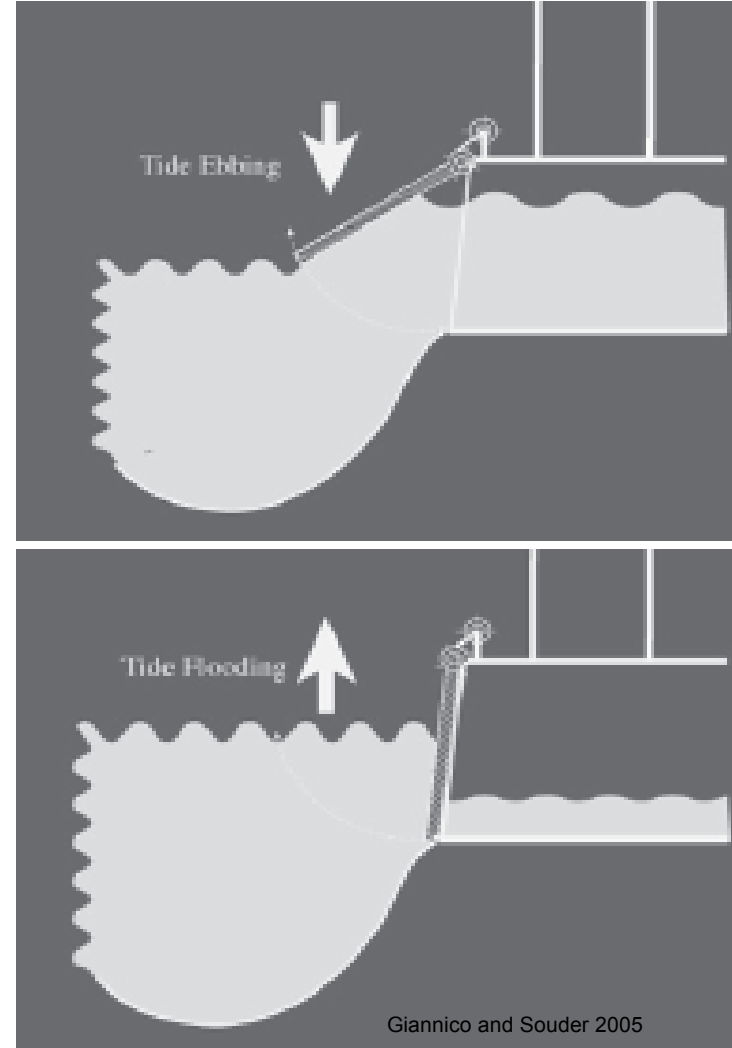
What is a tide gate?



Side Hinged



Top Hinged

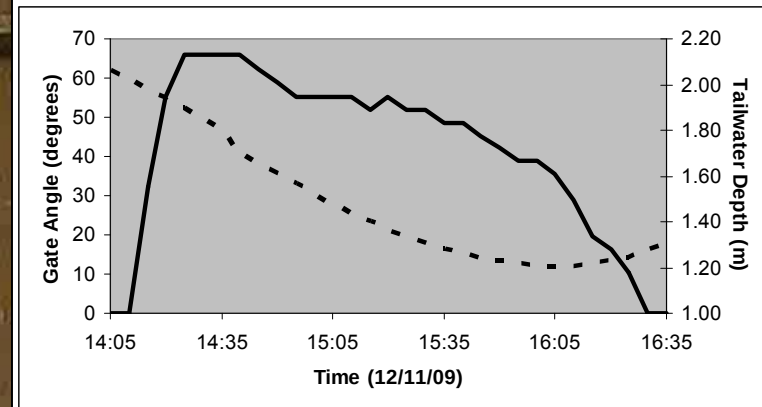


Tide gate function is determined by hydraulic head differential.

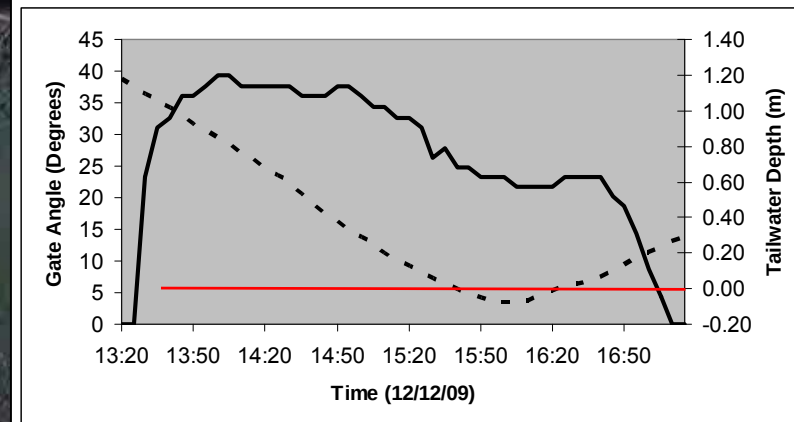
Where are tide gates used?



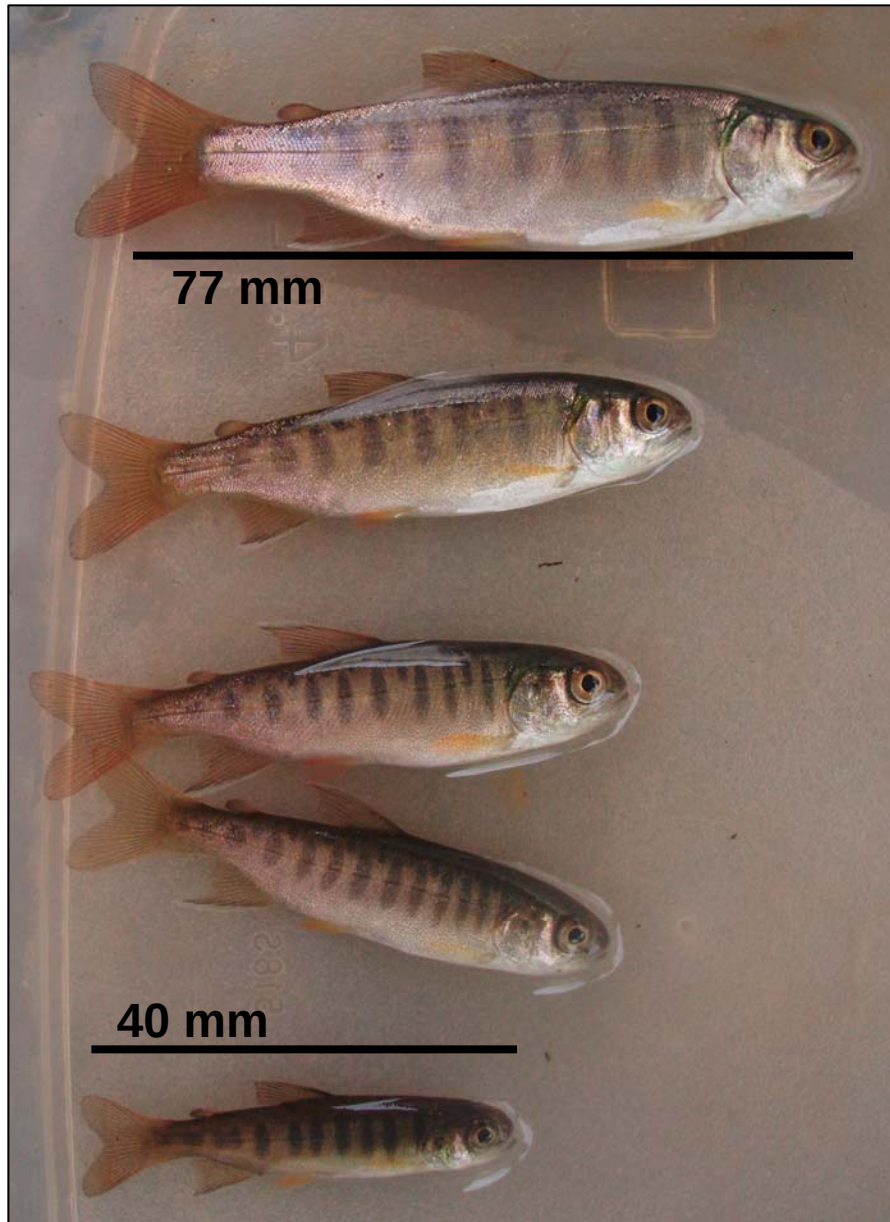
Side-Hinged Gate Opening Cycle



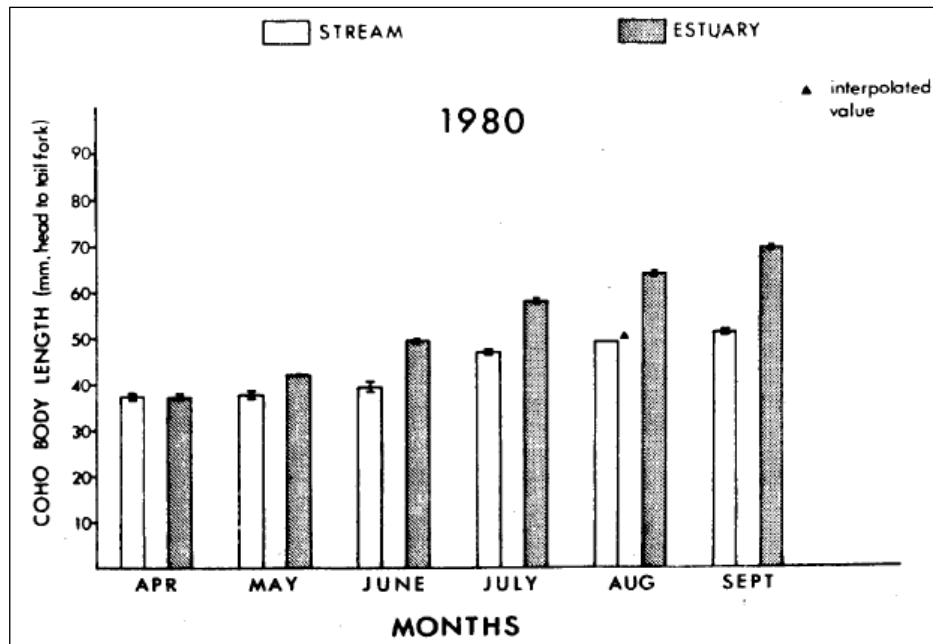
Top-Hinged Gate Opening Cycle



Coho Nomads



- Age 0 coho start arriving in upper estuary in March
- move between streams, return to freshwater
- Grow at higher rate than stream counterparts
- Special case for tide gates



Tschaplinski 1982

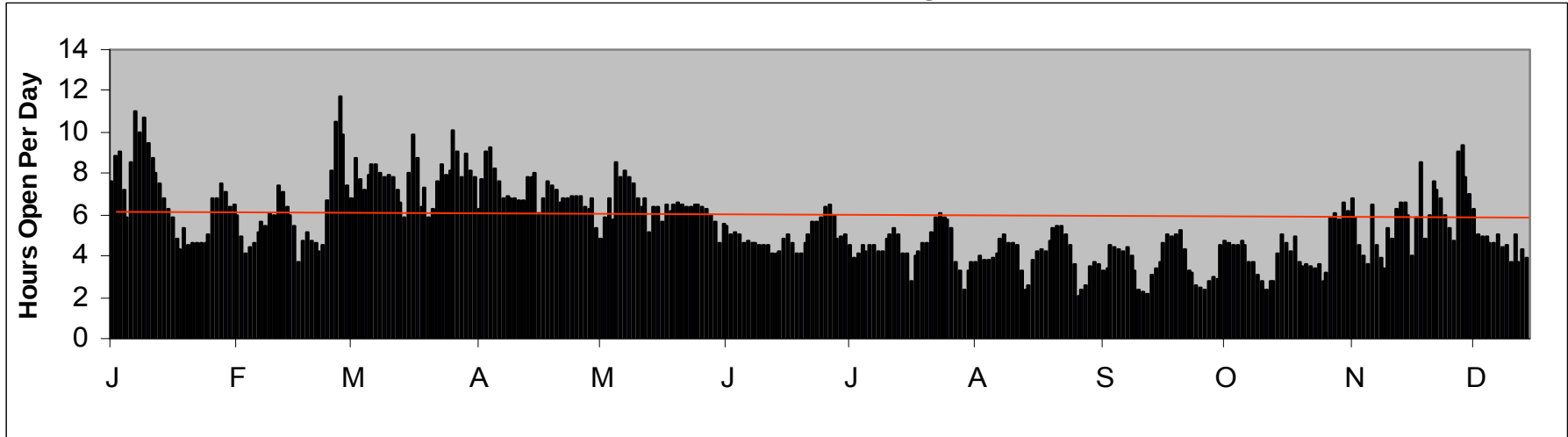
How do tide gates impact fish?

- Habitat Access - Passage
- Water Quality
- Migration Timing
- Rearing Conditions (For Better or Worse)
- Predation

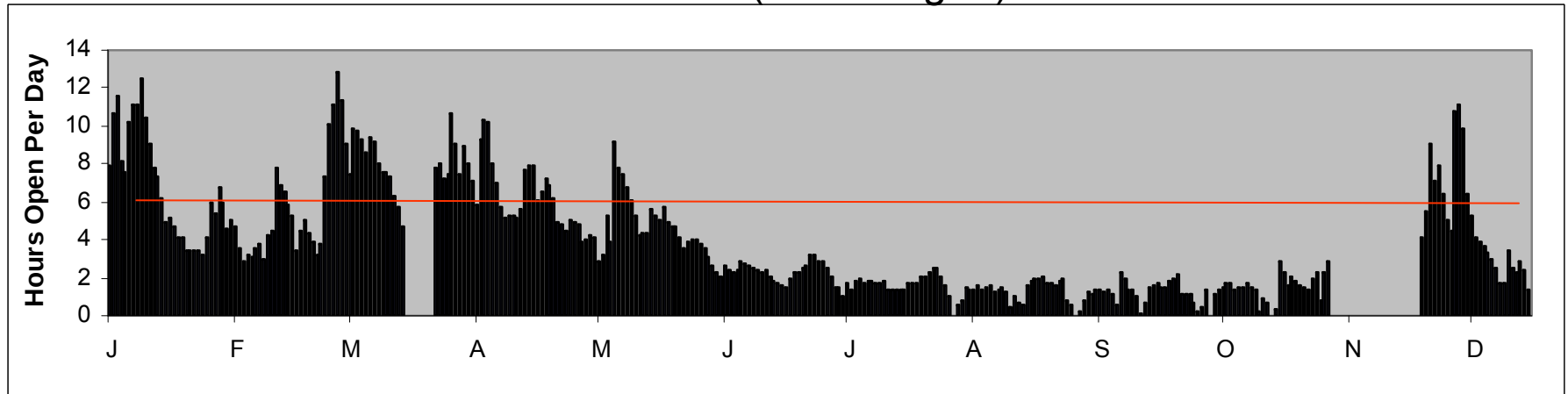


Habitat Access - Passage

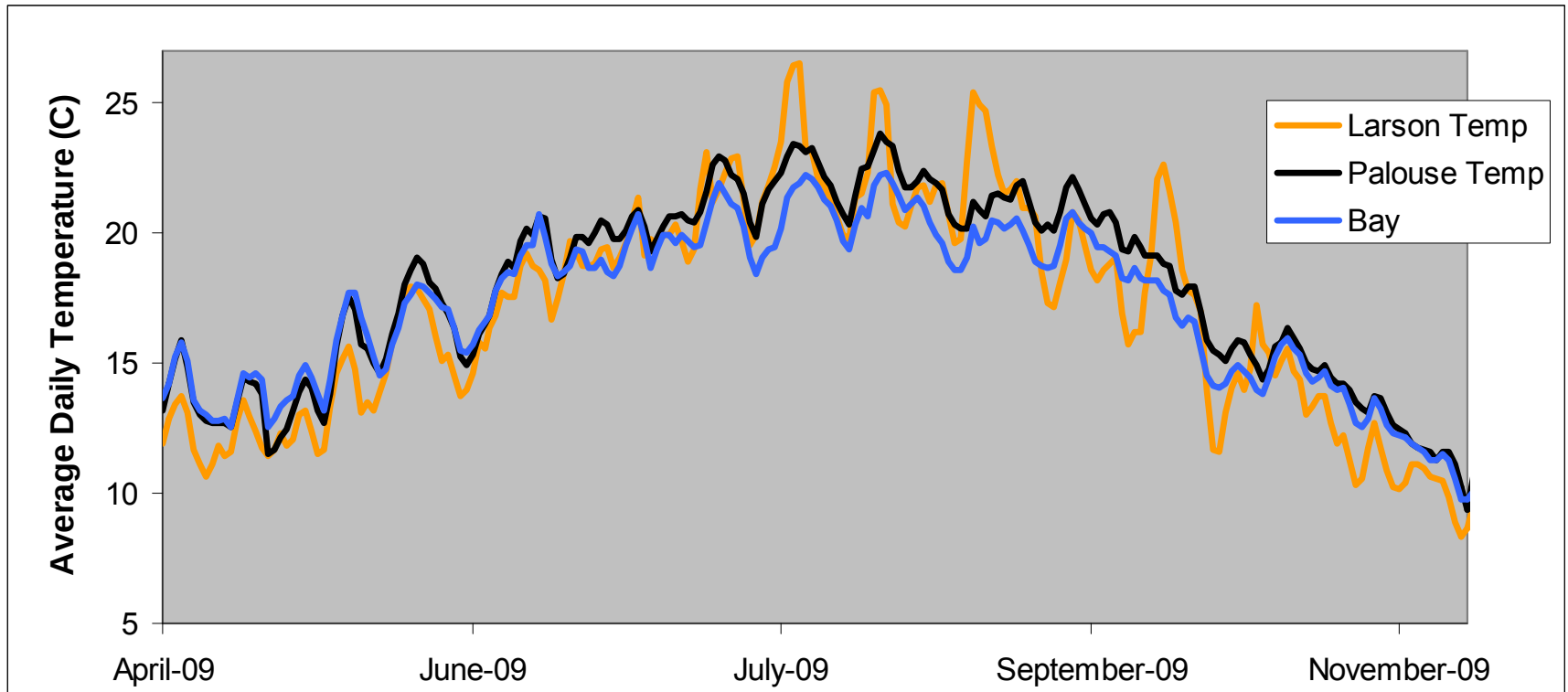
Palouse (Top Hinged)



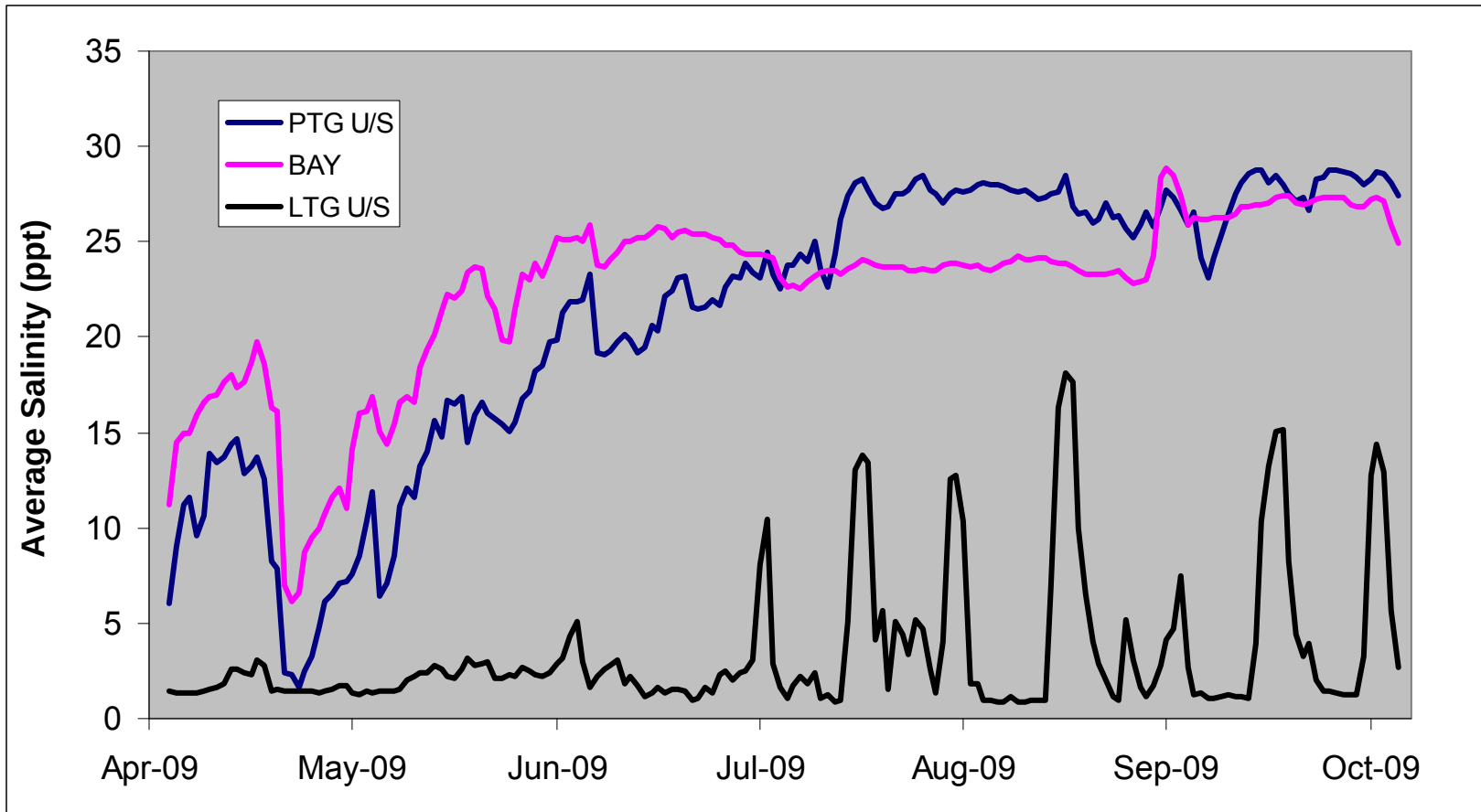
Larson (Side Hinged)



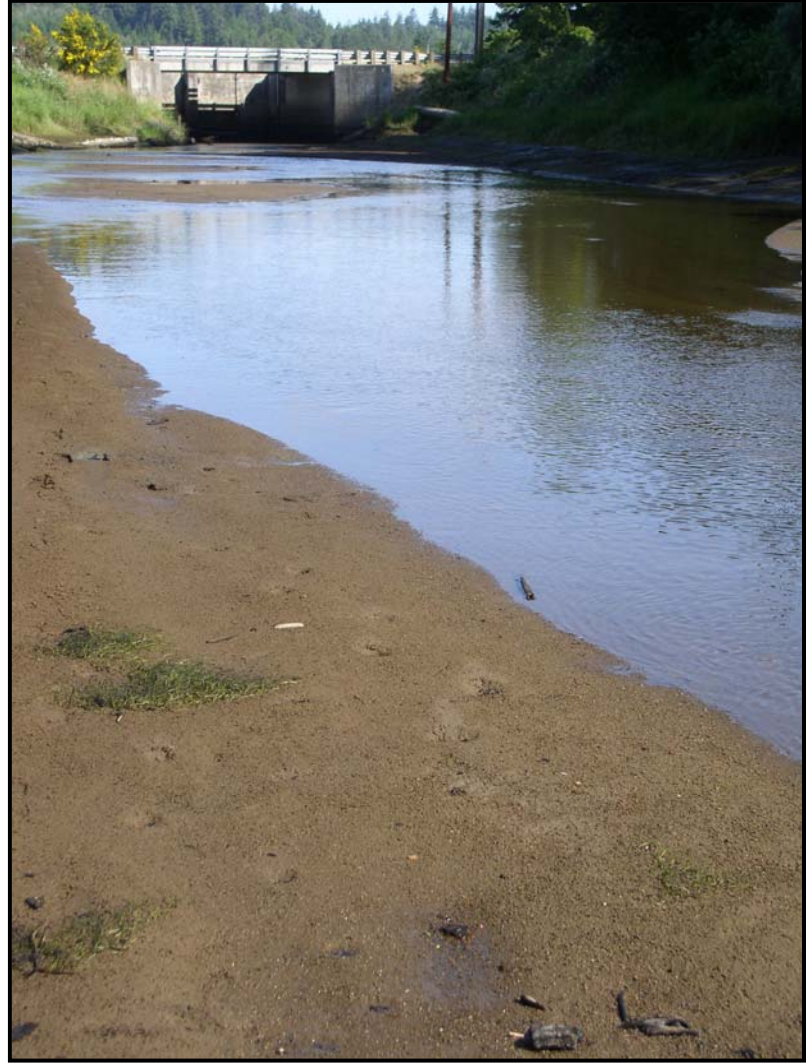
Water Quality: Temperature



Water Quality: Salinity



Rearing Conditions: Substrate and Vegetation

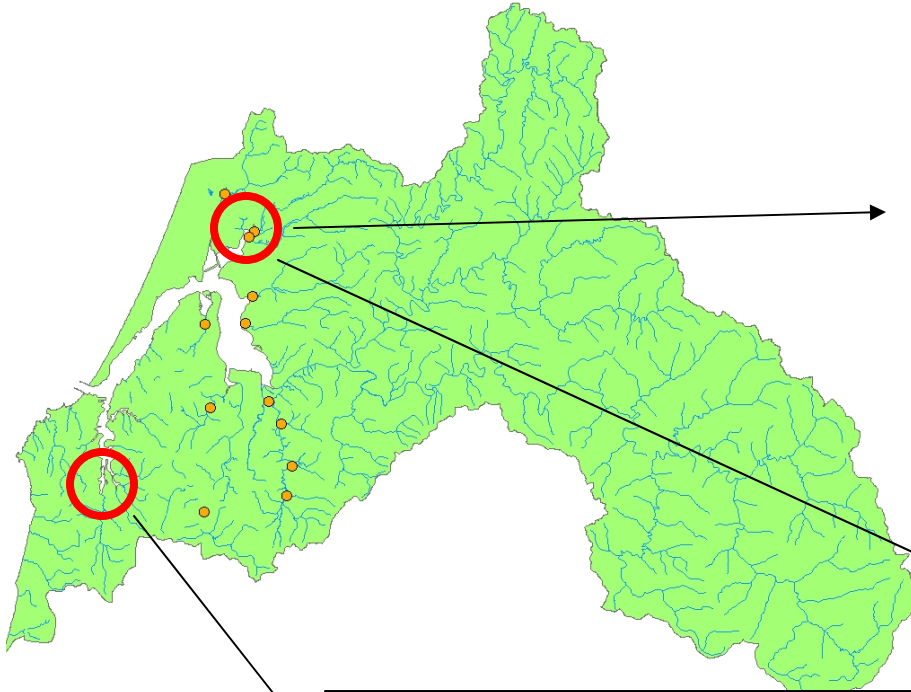


Research Questions

Passage: For what portion of a tide gate's opening cycle is passage possible?

Migration Timing: Do tide gates affect the outmigration rate of coho smolts?

Methods: Field Sites



Side Hinged (Larson)

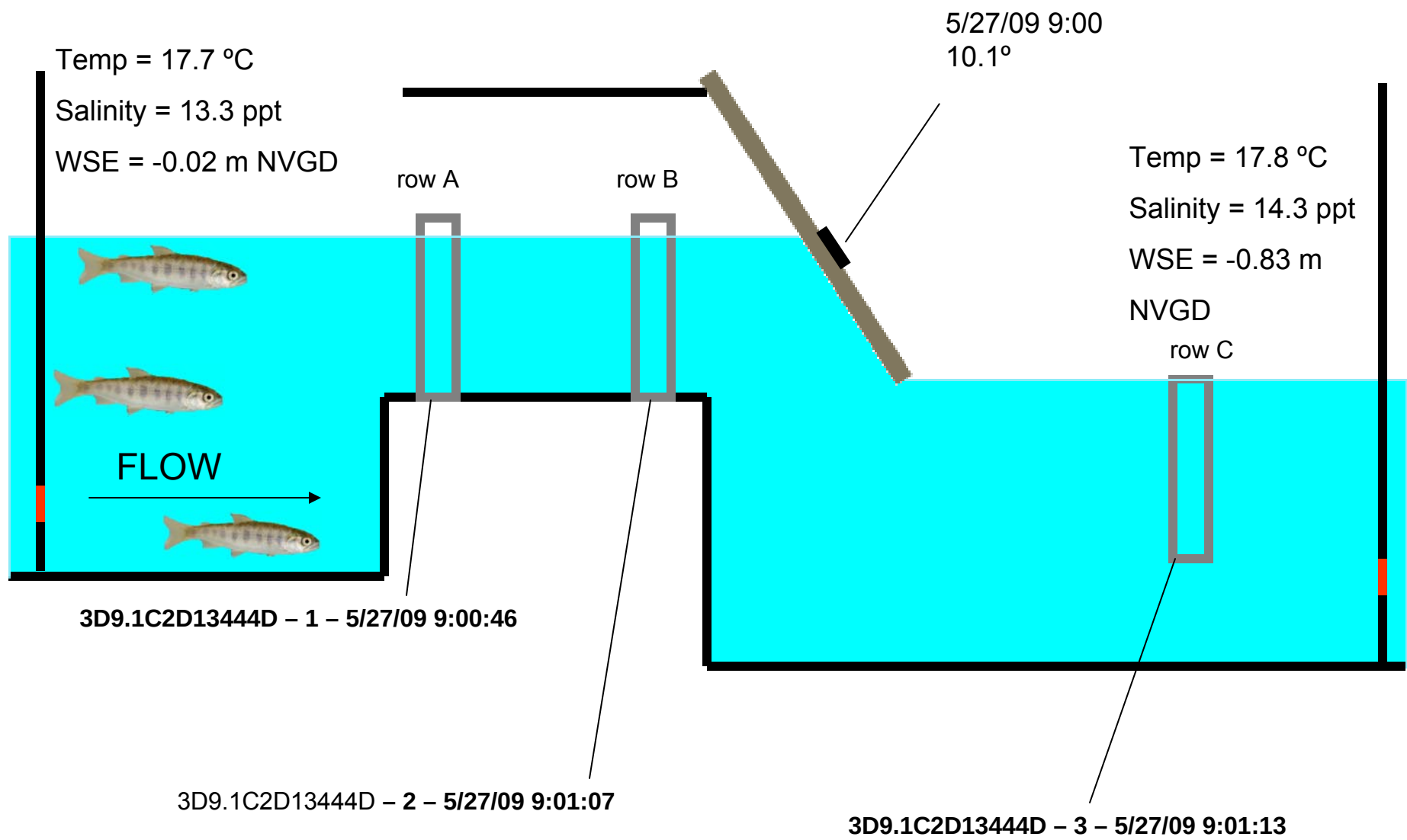
No tide gate
- reference
(Winchester)



Top Hinged
(Palouse)

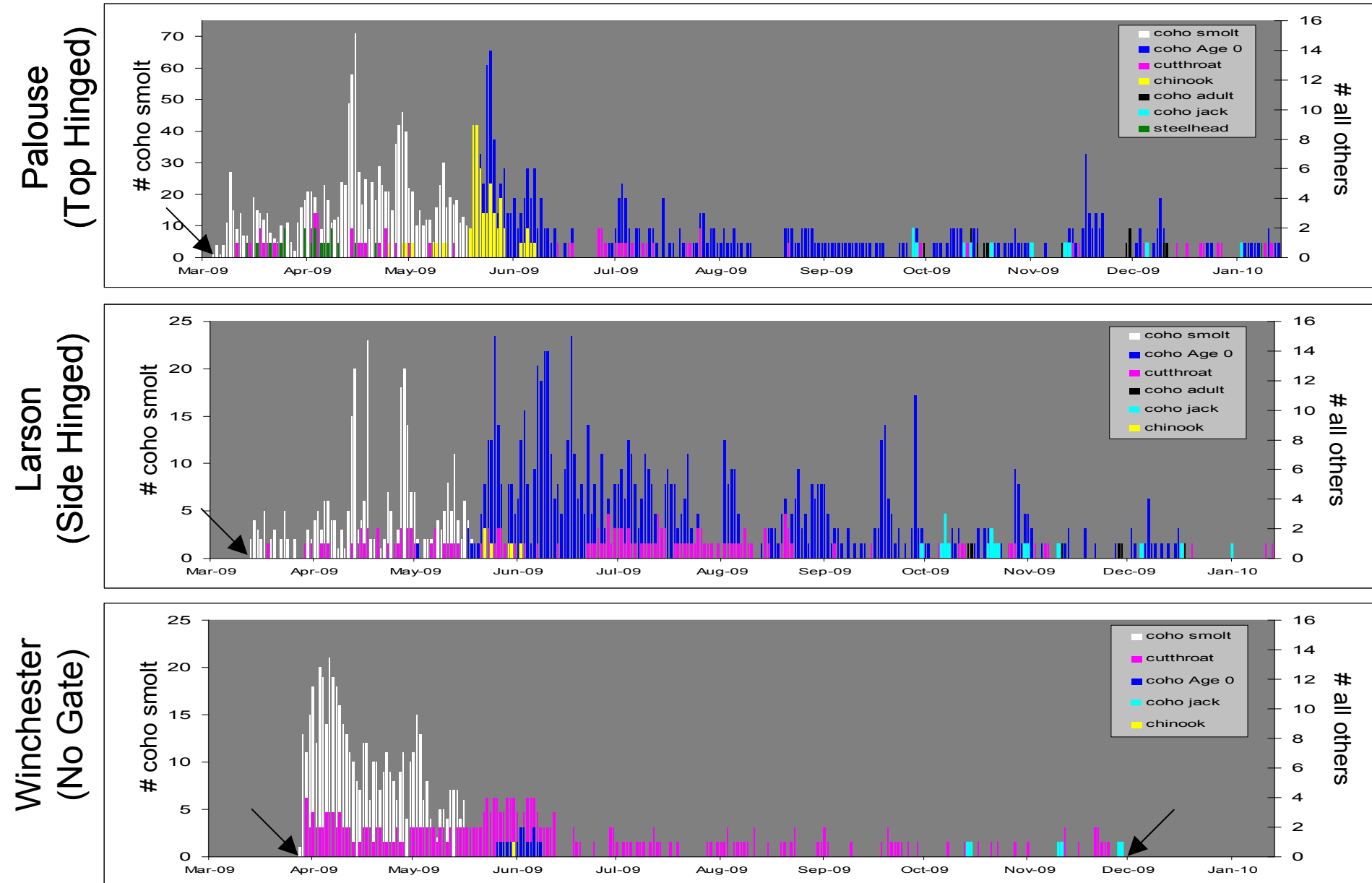


Methods: Data Collection at Tide Gates



3D9.1C2D13444D = coho, 5/18/09, Palouse Reservoir, FL = 108 mm, W = 16.4 g

Salmonid Presence at all Sites



Passage

For what portion of a tide gate's opening cycle is passage possible?

For coho smolts and nomads

Both Upstream and Downstream

Use-Availability Approach

Passage: Gate Variables

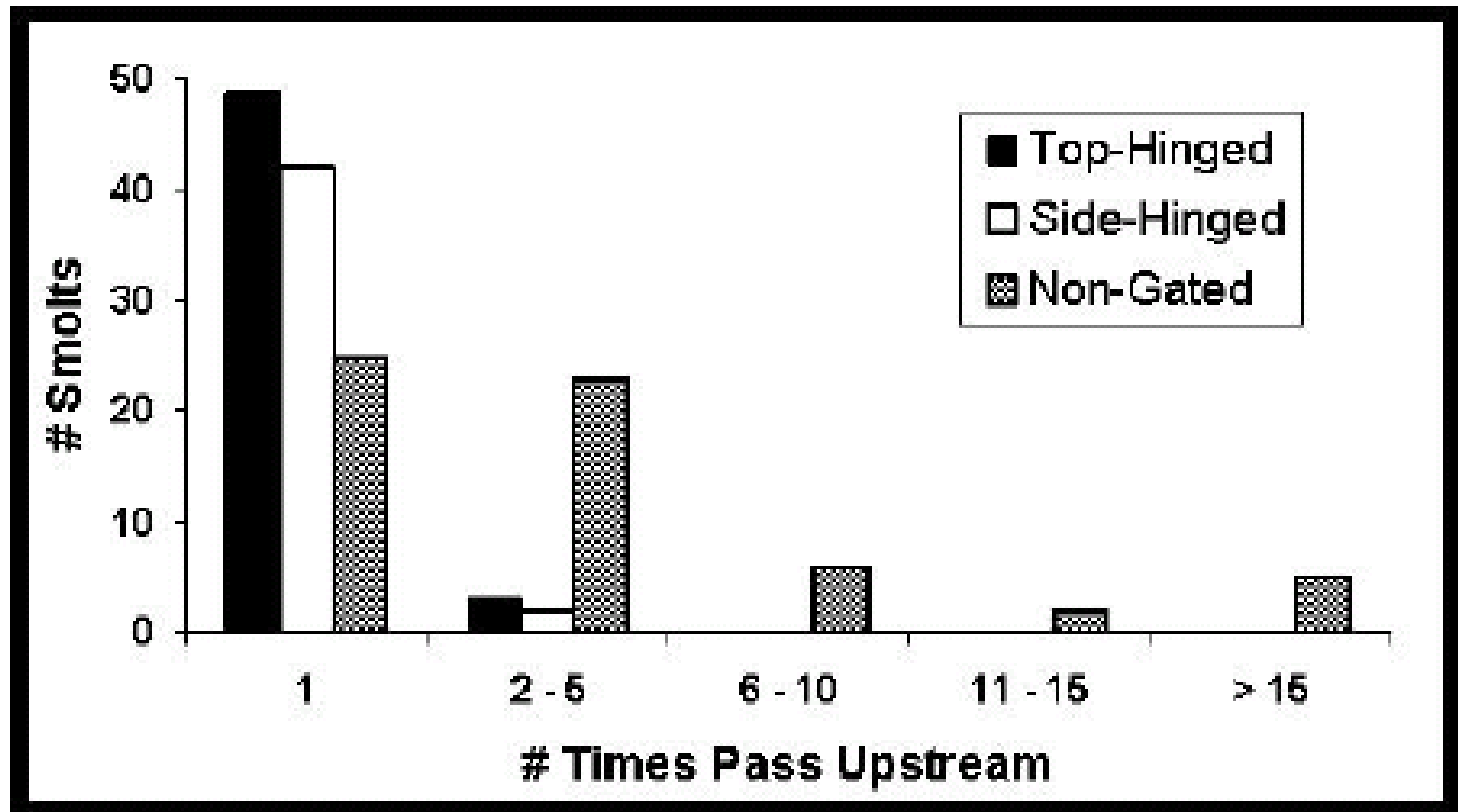


Gate Angle



Tailwater Depth

Passage Results: Smolts in 3 Streams



Passage Results: Use - Availability

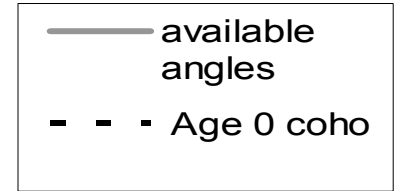
Downstream Passage

- Smolts selected greater angles and deeper tailwater at both gates

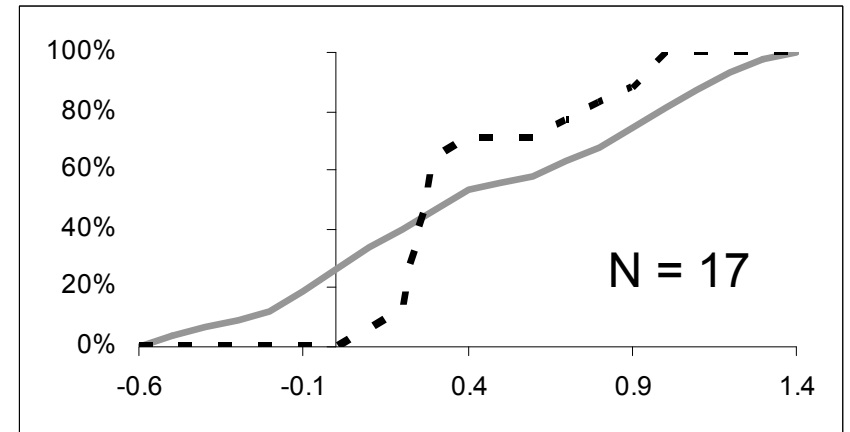
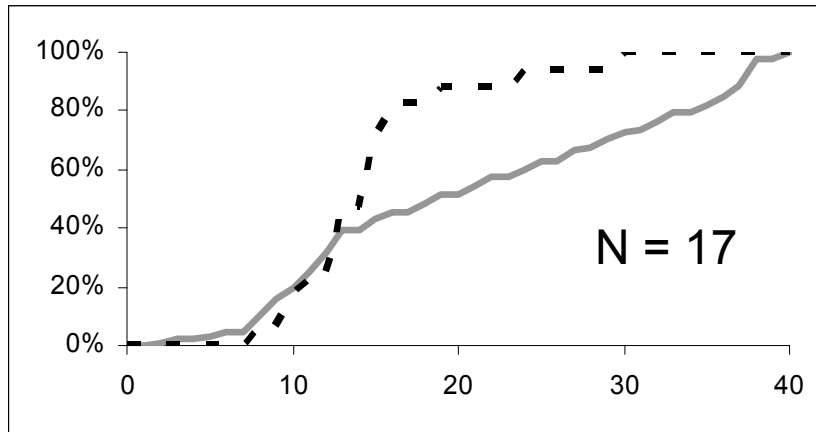
Upstream Passage

- Age 0 selected smaller angles and small range of tailwater at top-hinged

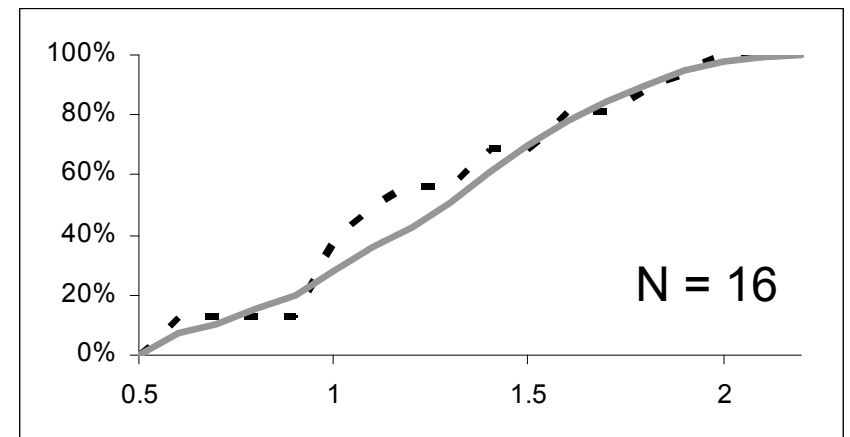
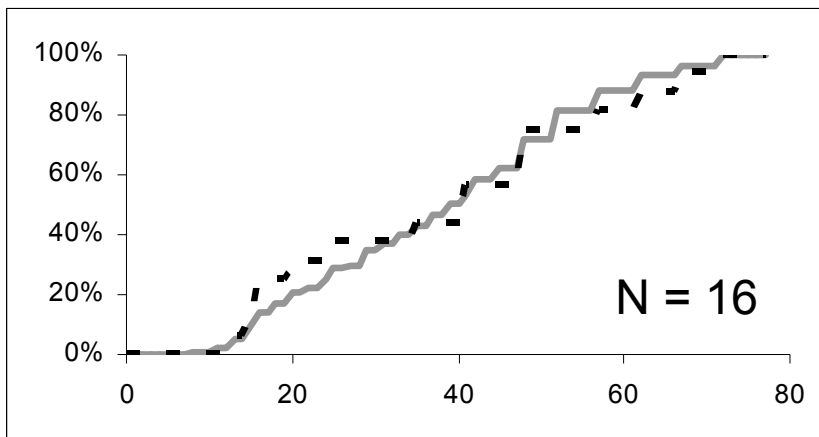
Passage Results: Use - Availability



(Top Hinged)



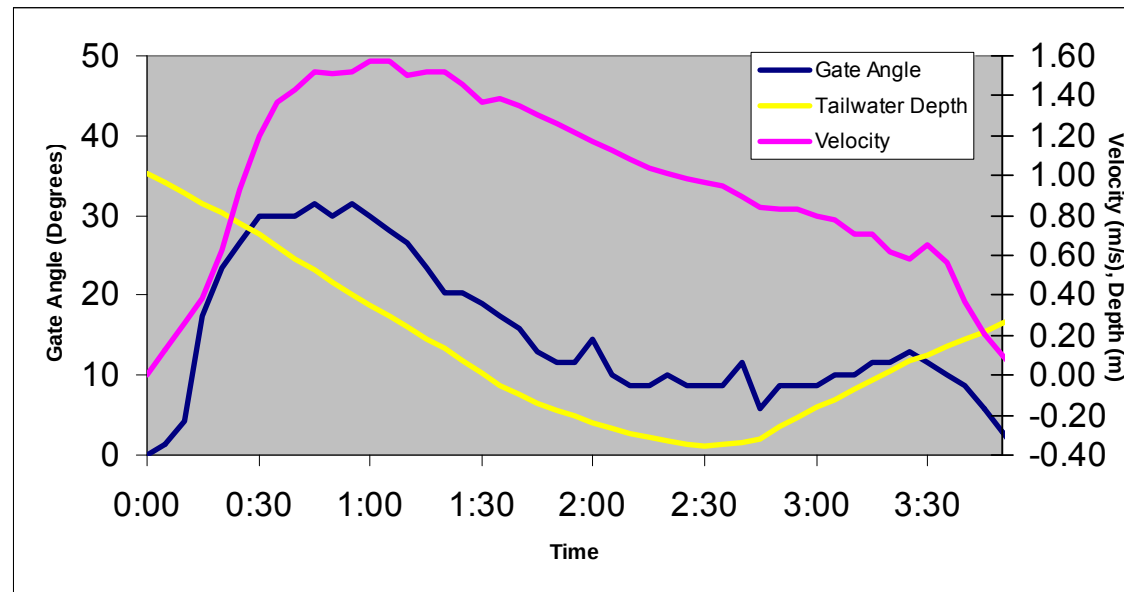
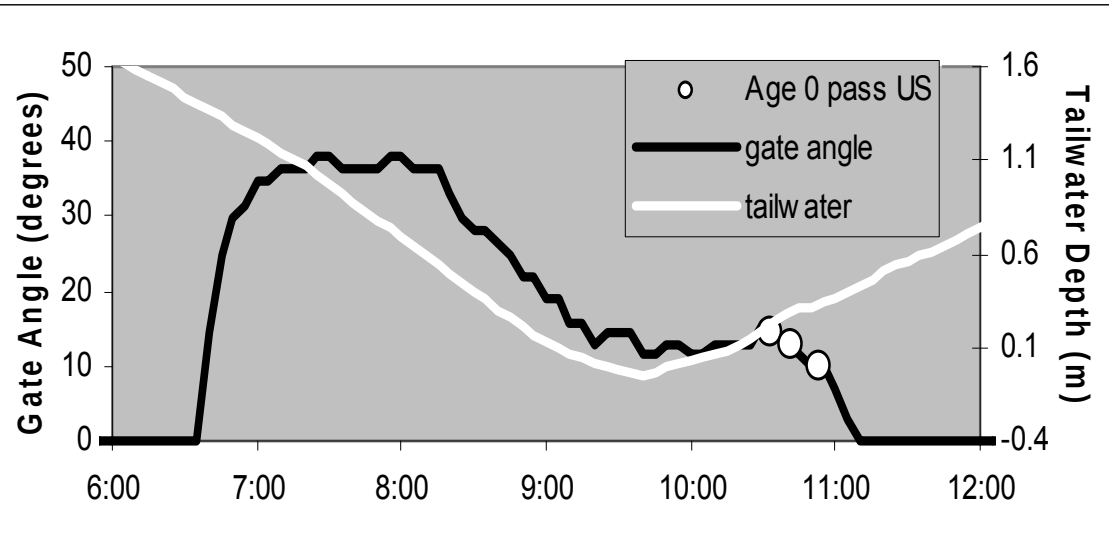
(Side Hinged)



Gate Angle (degrees)

Tailwater Depth (m)

Passage Results: Age 0 coho at Top Hinged Gate



Passage: Conclusions

- Coho smolts showed selectivity at both gates when passing downstream
- Age 0 coho limited to small window for passing upstream at top-hinged gate
- Side-hinged, deep tailwater, leaky tide gate may allow best habitat access

Migration Timing

Do tide gates affect outmigration rate of coho smolts?

- determine whether environmental conditions impacted by tide gates influence migration rate



Migration Timing: Palouse Creek, Top Hinged Gate

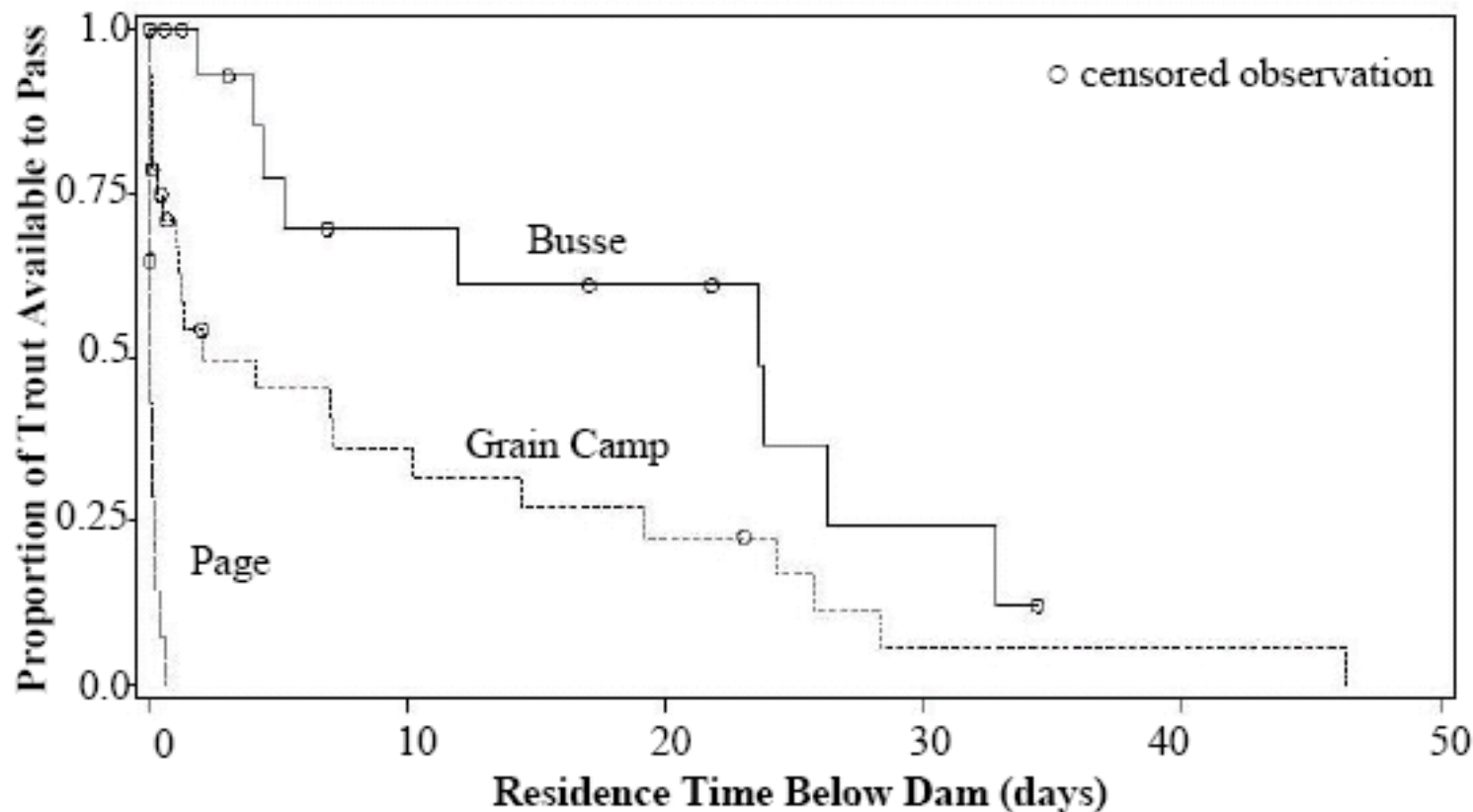


Water Quality Parameters

Migration Timing

Survival Analysis: Proportional Hazards Regression

- Allows censored data
- Estimate timing and duration – compare groups
- Test fixed and time dependent explanatory variables



Anderson 2009: Passage Delays of Migrating Redband Trout

Migration Timing: Proportional Hazards Regression

Explanatory Variables :

- Salinity – 24 hr average
- Temperature – 24 hr average
- Precipitation – 48 hr cumulative
- Fork length at tagging
- Date of Tagging

$$h_{i(t)} = \lambda_0(t) \exp [\beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i}]$$

Product-Limit Survival Estimates
With 95% Confidence Limits

Survival Probability

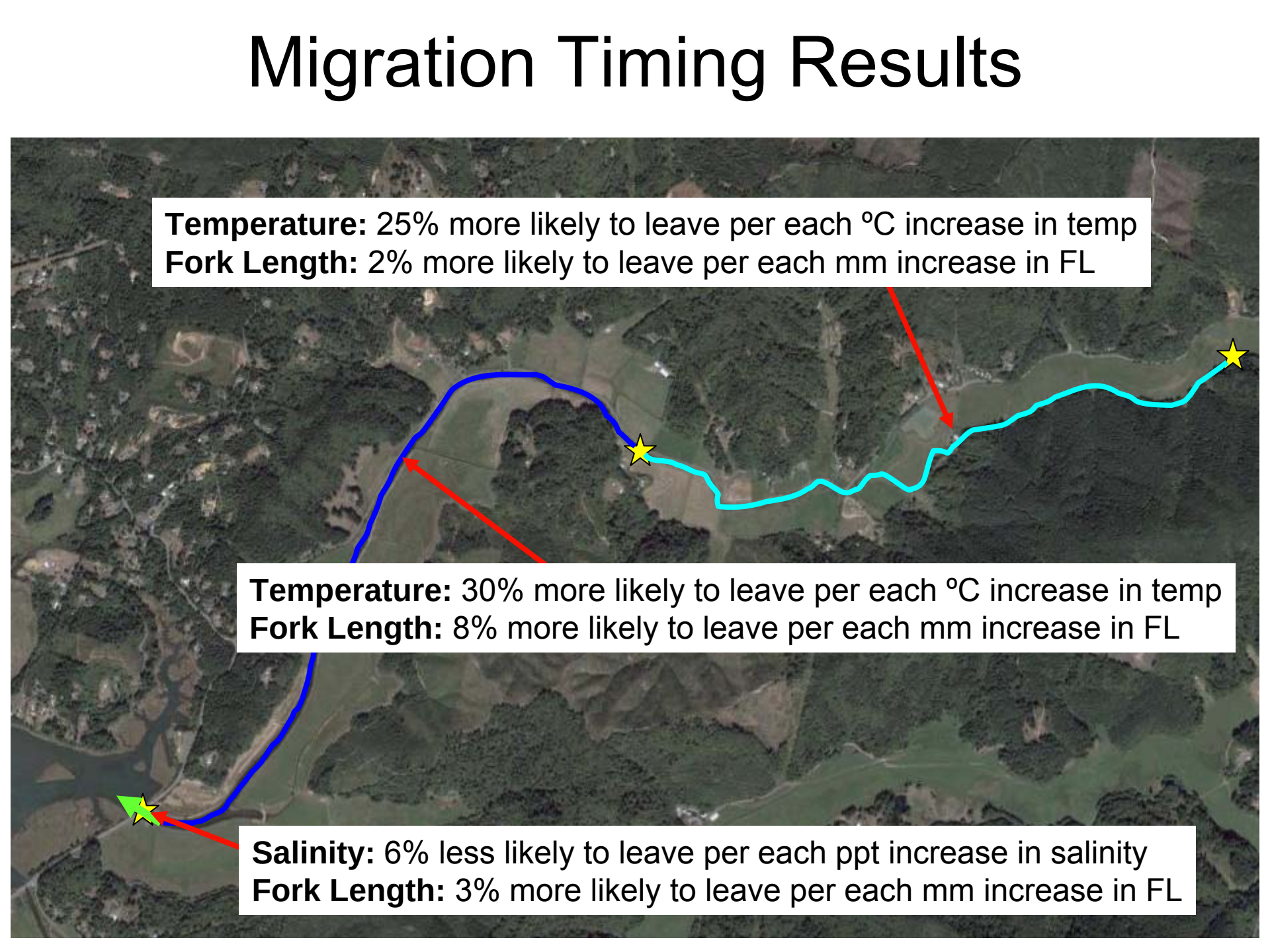
duration

reach gate reservoir stream

+ Censored

Reach	Total	% Censored	Mean Delay (Days)	Median Delay [C.I.]
Stream: rkm 6 to 3	257	39.7	3.4	1.7 [1.4-2.2]
Reservoir: rkm 3 to 0	145	26.9	12.5	9.1 [7.9-11.9]
Through Tide Gate	125	11.2	4.1	0.001 [0.0 – 0.04]

Migration Timing Results



Temperature: 25% more likely to leave per each °C increase in temp
Fork Length: 2% more likely to leave per each mm increase in FL

Temperature: 30% more likely to leave per each °C increase in temp
Fork Length: 8% more likely to leave per each mm increase in FL

Salinity: 6% less likely to leave per each ppt increase in salinity
Fork Length: 3% more likely to leave per each mm increase in FL

Migration Timing: Conclusions

Travel Rate:

- ↑ Fork Length and Temperature = ↑ Emigration Rate
- ↑ Salinity = ↓ Emigration Rate
- Nothing to compare to! No emigration rate baseline

Implication:

- Tide Gates have potential to alter emigration rate
- Easy opening, leaky tide gate may be preferable

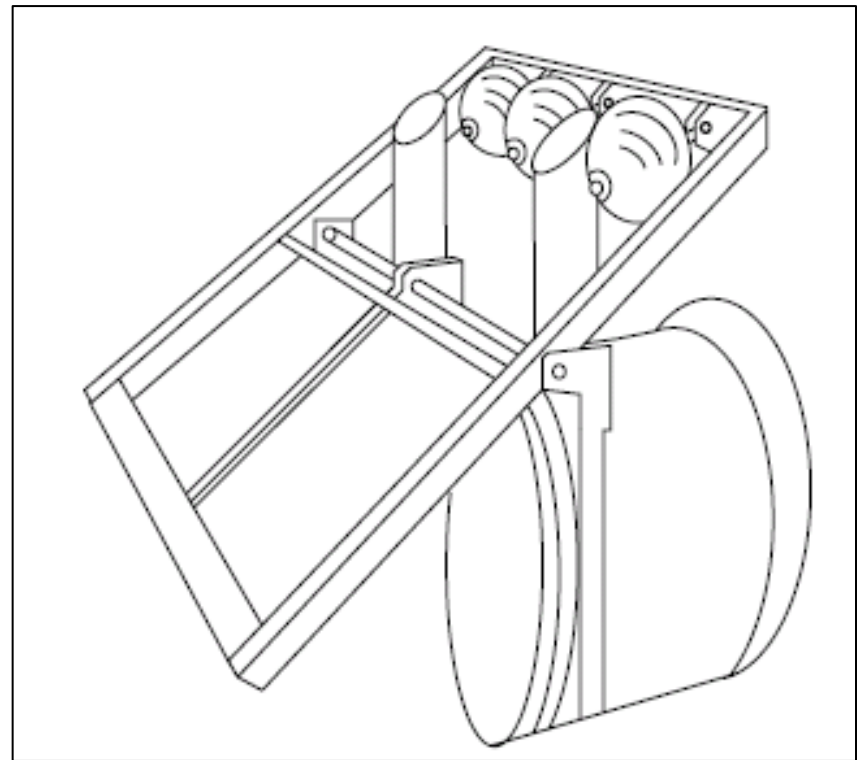
Management

Ideal Tide Gate for fish?

- Easy to Open (Side-hinged)
- “Leaky”
- Deep Tailwater

Options Exist

Each Case is Unique



Needed Research

- Predation at tide gates
- Impact on Coho Nomads
- Acoustic Tags
 - Directly measure survival
 - Follow smolts in estuary
- DIDSON
 - Works well under dynamic conditions
 - Monitor passage of more organisms

Thanks!

Funding: Oregon Watershed Enhancement Board



OSU Oregon State University



NOAA FISHERIES SERVICE



Volunteers

Matt Sloat
Dennis Feeny
Nathan Hostetter
Shivonne Nesbit
Brett Hanshew
Erin Kunisch
Véronique Thériault
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Bruce Hansen
Earl Prentice
Chris Jordan

Giannico Lab

Matt Anderson
George Boxall
Adam Weybright

Field

Adam Weybright
Justin Arriola
Andrew McClary
John Winkowski
Bruce Miller
Donald Danesi

Efficiency info

All values for 12 mm tags

	Palouse Smolts DS	Larson Smolts DS	Palouse Age 0 US
N	69	24	21
E _{row 1}	.58	.21	.76
E _{row 2}	.54	.21	.67
E _{row 3}	.19	.29	.14
E _{combined}	.84	.56	.93
E _{pass}	.31	.04	.51

No efficiency estimates for Winchester