Water Reuse Systems, Water Velocities and Fish Fitness – What is the Connection?

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Chris Good and Steve Summerfelt

Why are we talking about water reuse and recirculation?

- Insufficient water available for flow-through fish culture
- Place wastes into relatively small & concentrated effluent flows
- Provide strict biosecurity
- Achieve the controlled environment

WATER

WASTE

DISEASE

ENERGY

Large Scale Examples of Dual-Drain Circular Tank-based Water Reuse/Recirc

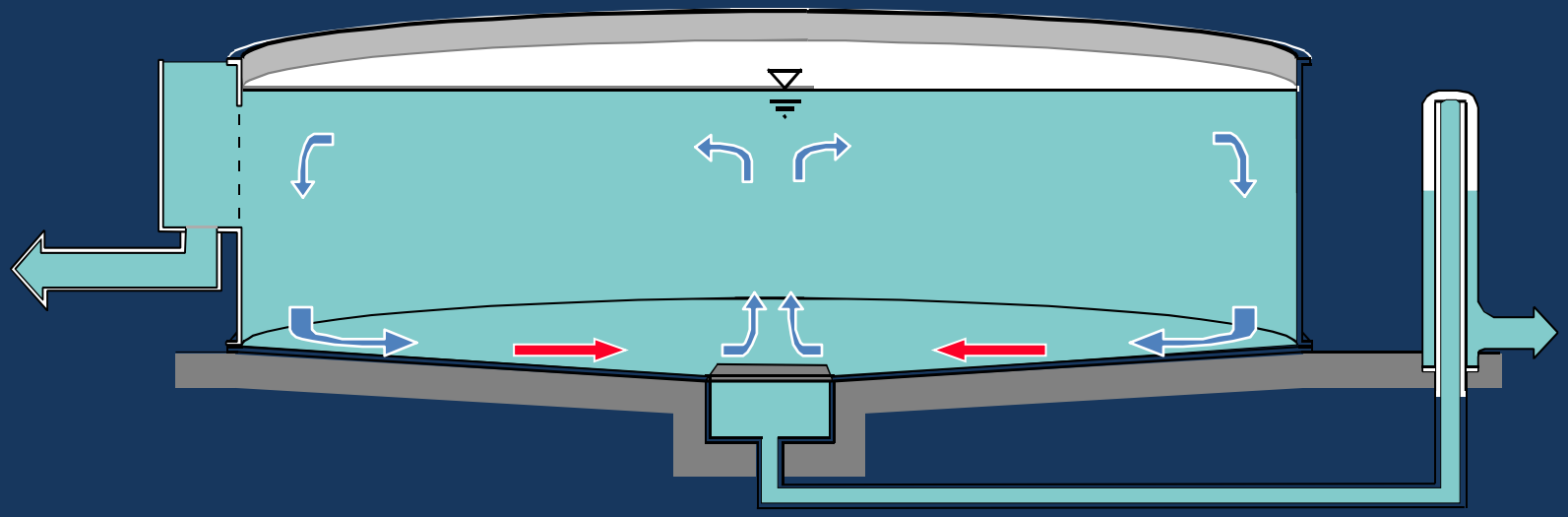
- Partial water reuse systems at White River NFH in Vermont (2003)
- Partial water reuse systems at Eastbank (2008) and Chiwawa fish hatcheries (2009) in Washington
- Partial water reuse and fully recirculating systems at Ruth Burnett and William Hernandez fish hatcheries in Alaska (2011)

Chiwawa Fish Hatchery (WA)

White River NFH (VT)

William J. Hernandez Fish Hatchery (AK)

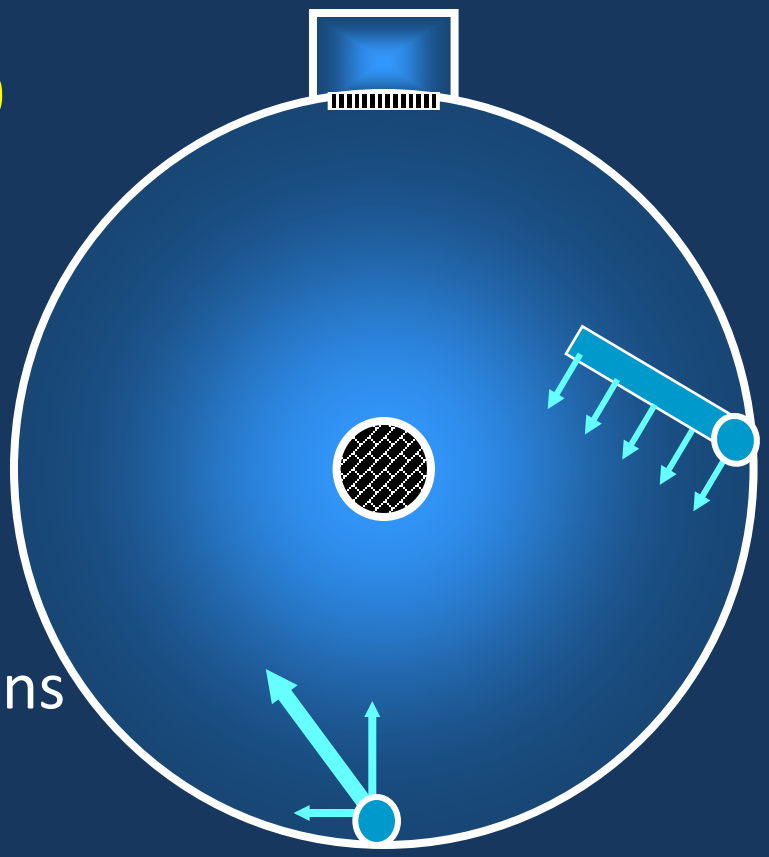
Circular Tanks: Self-Cleaning



- Primary rotating flow creates secondary radial flow:
  - transports settleable solids to bottom center
  - creates self-cleaning tank

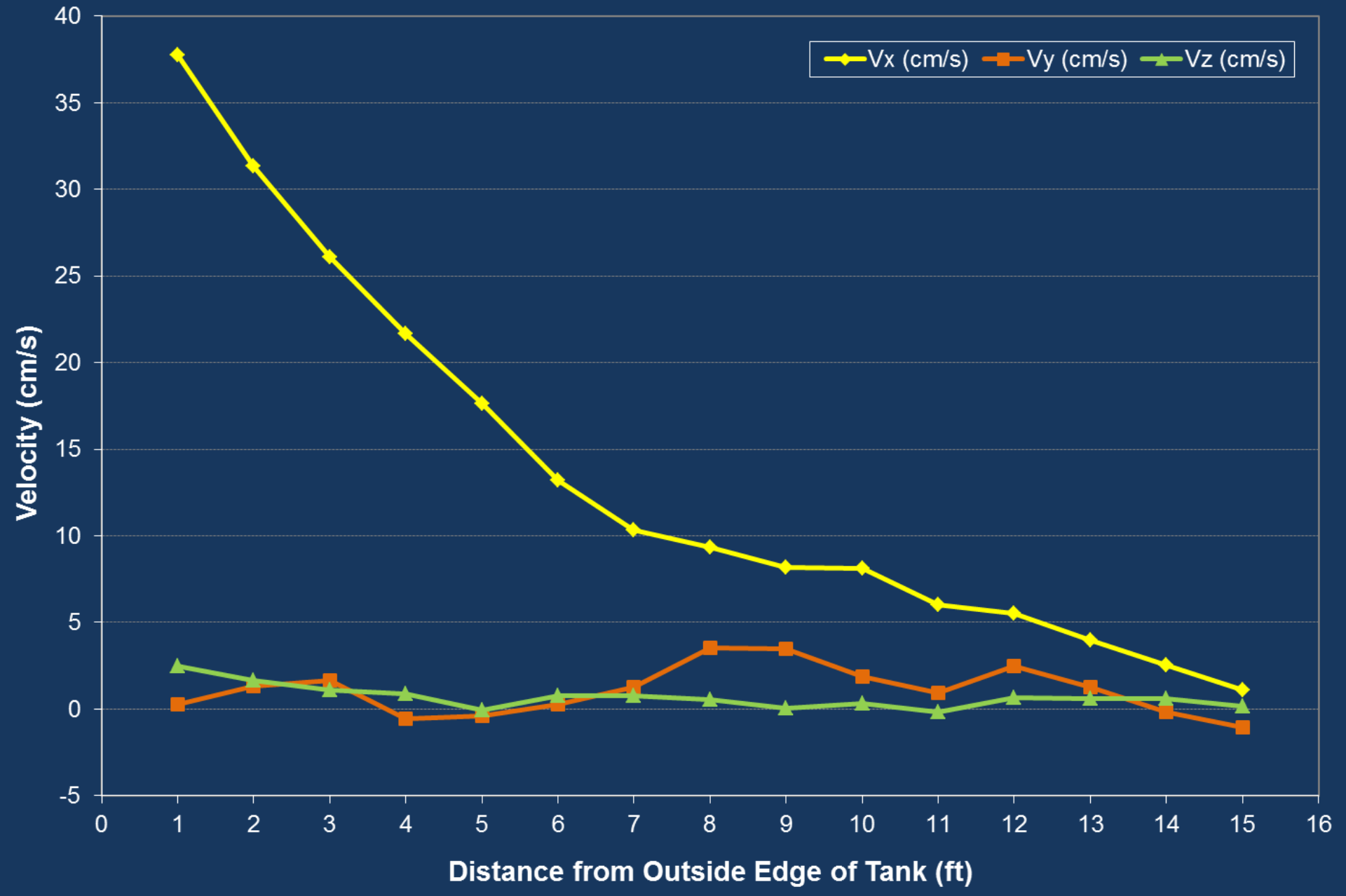
Design Guidelines for Dual-Drain Tanks

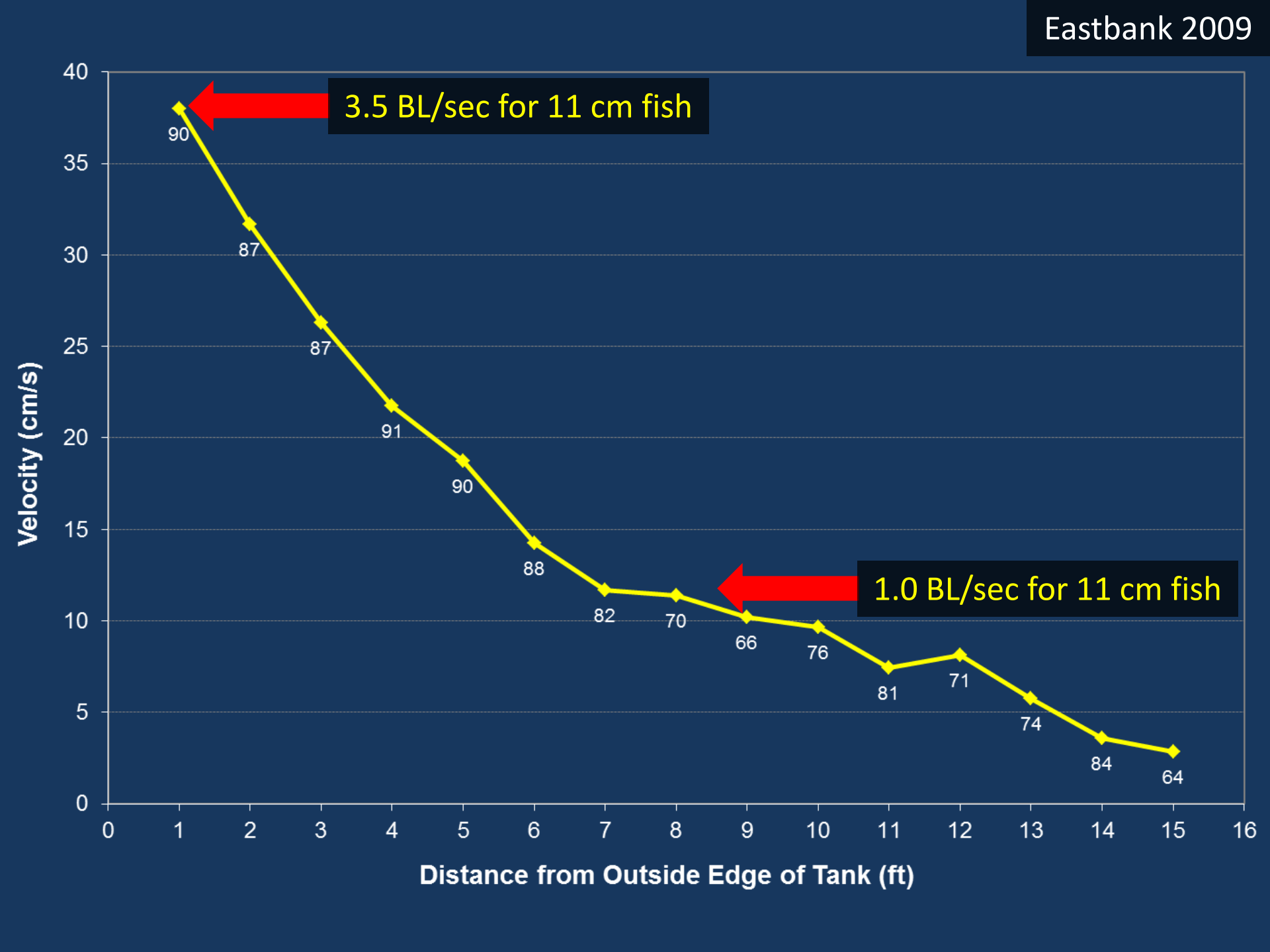
- Diameter:Depth of 4–6
- **Design 0.6–1.2 m water pressure behind inlet jets to achieve a 60–90 sec rotational period**
- HRT of 30–45 minutes
- Bottom center drain flow of > 0.15 gpm/ft^2
- Size center drain o.d. > 10% tank diameter
- Size open area for center & side drains to provide 15–30 cm/s velocity
- Orientation of inlet jets is critical for mixing & solids flushing



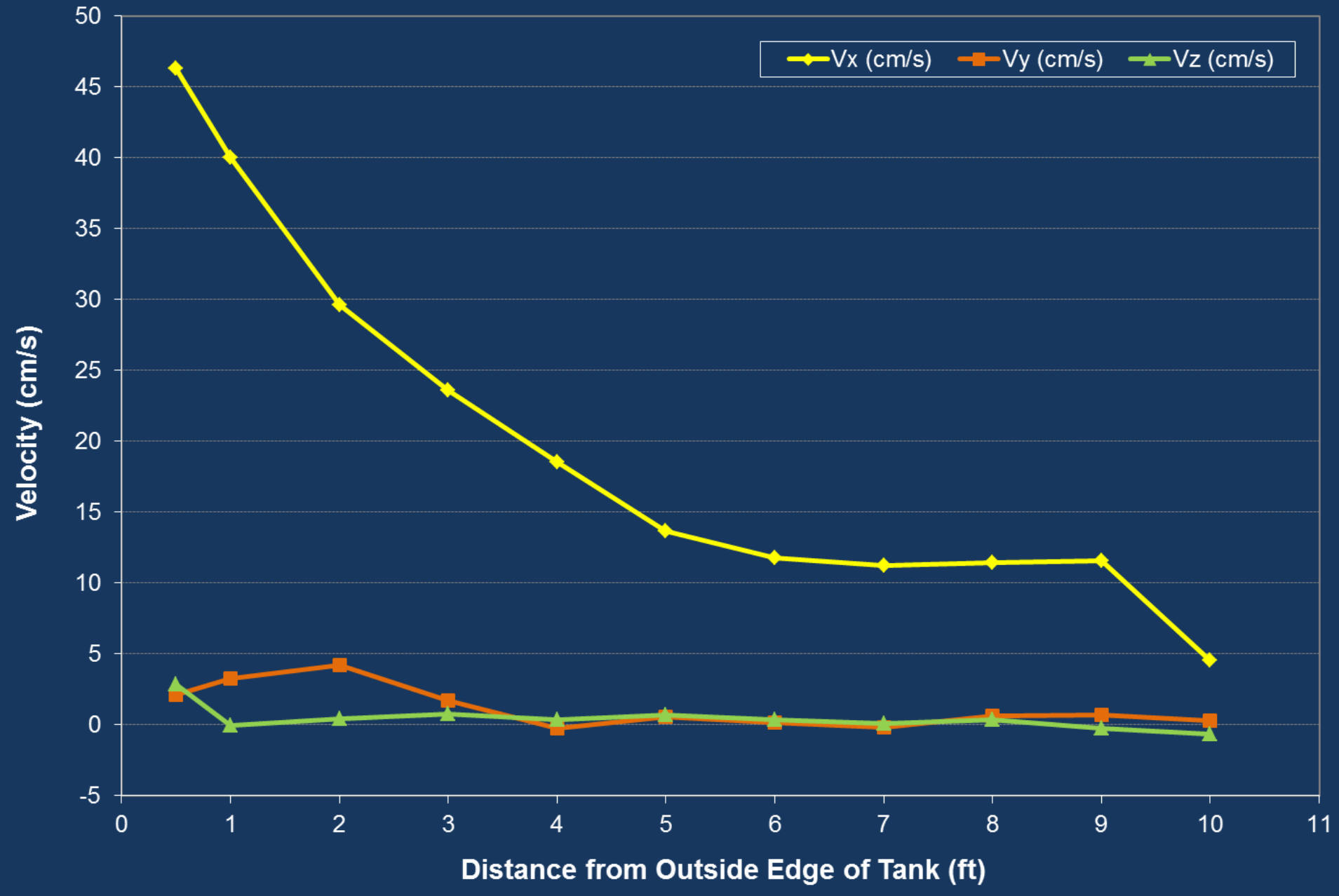
Acoustic Doppler Velocity Probe
DELL
SonTek

Eastbank 2009

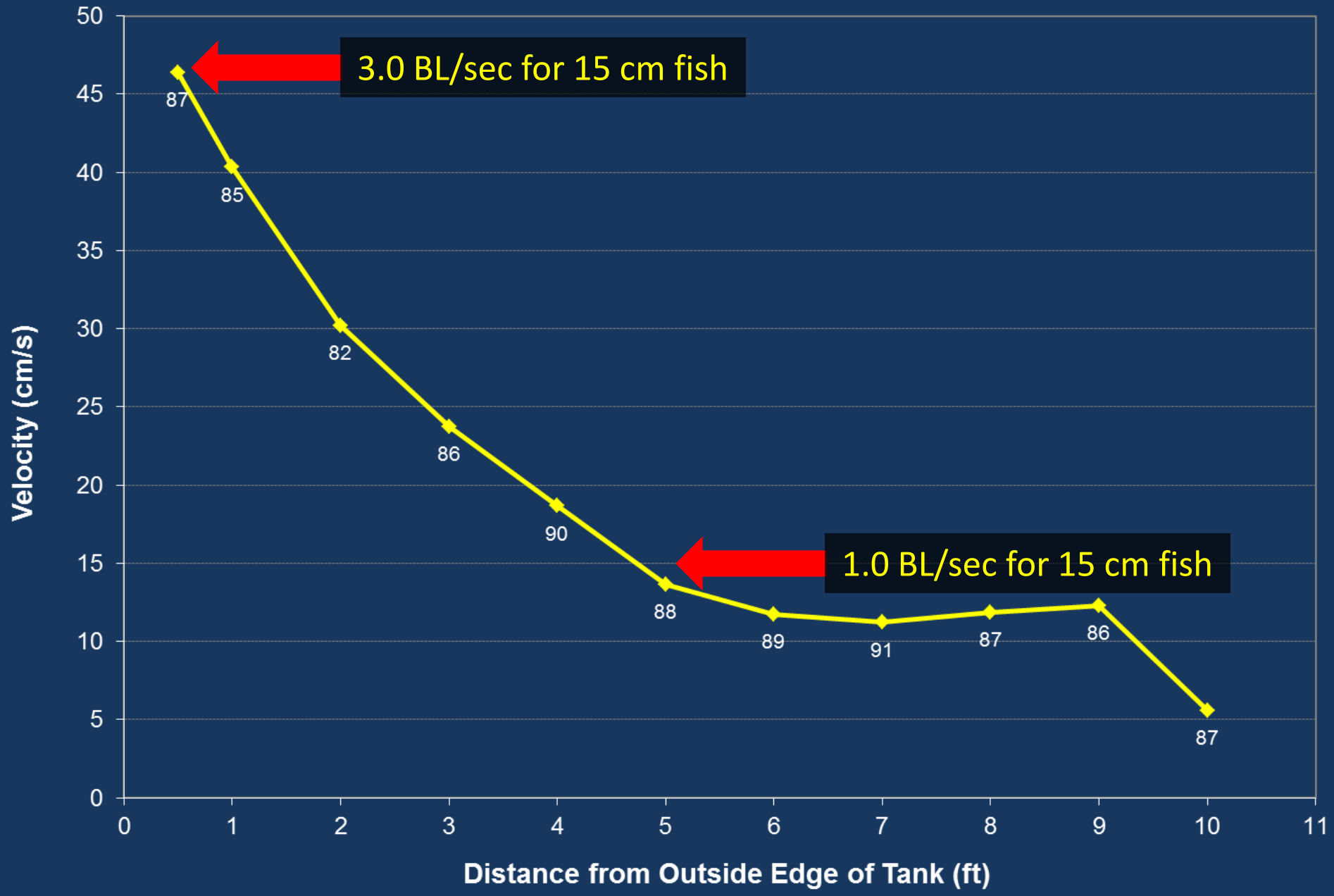



Eastbank 2009
3.5 BL/sec for 11 cm fish
1.0 BL/sec for 11 cm fish
Velocity (cm/s)
Distance from Outside Edge of Tank (ft)
0
5
10
15
20
25
30
35
40
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
90
87
87
91
90
88
82
70
66
76
81
71
74
84
64

Chiwawa 2010



Chiwawa 2010



Swimming Speed Research at FI

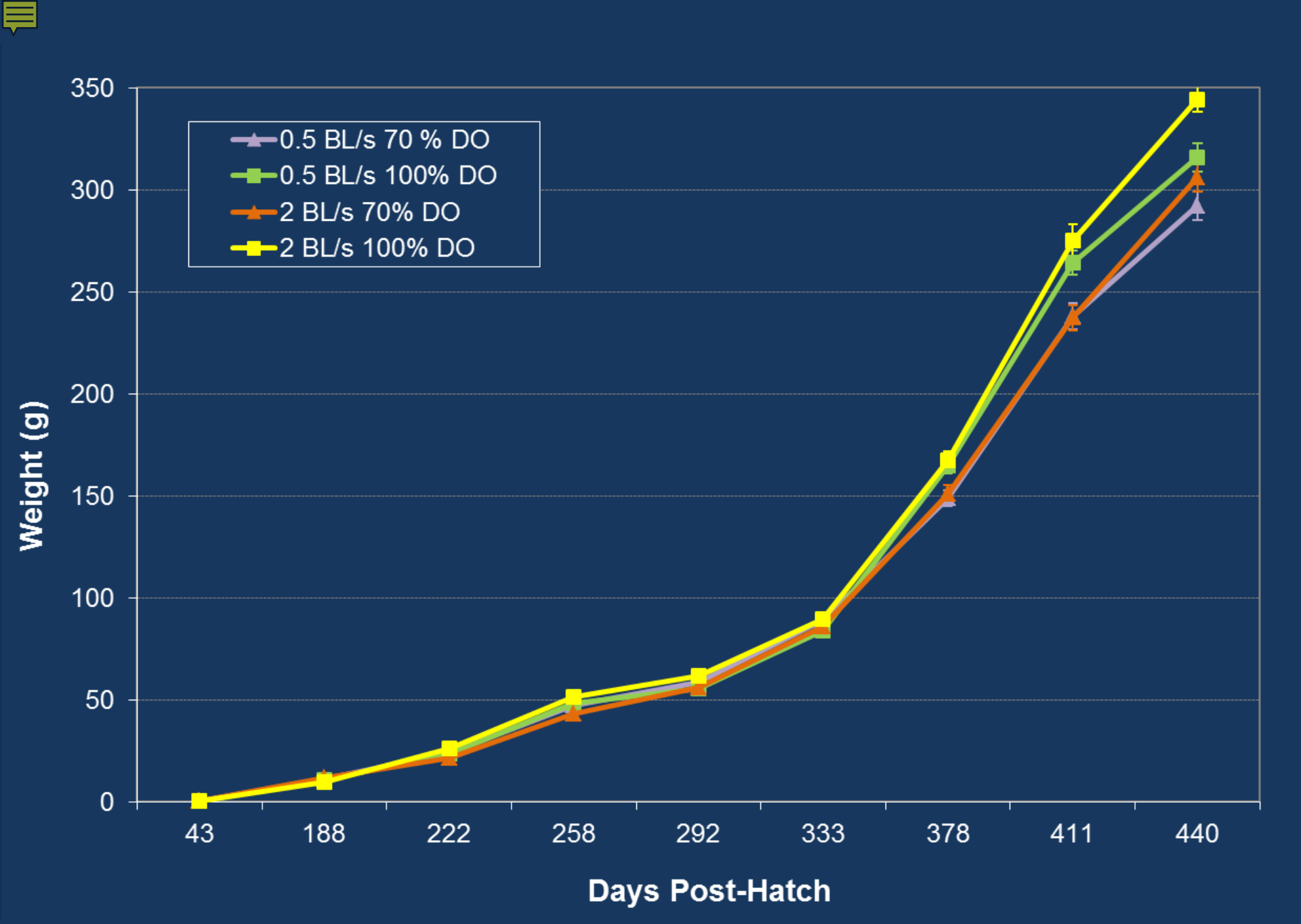
<0.5 BL/s

2 BL/s

Study also evaluated dissolved oxygen in a 2x2 factorial:
70% DO and 100% DO

Materials & Methods

- Identical 4-ft circular tanks in single pass flow
- 12 tanks total with 3 replicates of each swimming speed x DO combination


0.5 BL/s 70 % DO
0.5 BL/s 100% DO
2 BL/s 70% DO
2 BL/s 100% DO
Weight (g)
350
300
250
200
150
100
50
0
43
188
222
258
292
333
378
411
440
Days Post-Hatch

Results

	DO 100% saturation		DO 70% saturation	
	2 BL/s	0.5 BL/s	2 BL/s	0.5 BL/s
Weight (g)	344.3 ± 6.3	315.8 ± 7.5	306.0 ± 6.87	292.2 ± 6.9

Treatment	df	F	p-value
Swimming speed	1	9.86	0.0018
Dissolved oxygen	1	18.95	<0.0001
Swimming speed x Dissolved oxygen	1	1.35	0.2451

Results

Precocious Males

2 BL/sec:	**6.4%**
< 0.5 BL/sec:	**11.5%**

Logistic regression model reporting odds ratios for the probability of precocious males within each treatment group:

Treatment	Odds ratio	(95% CI)	p-value
0.5 BL/s	1.896	(1.121, 3.208)	0.017
70% DO	0.945	(0.546, 1.636)	0.839

Performance Evaluation at Chelan PUD

<0.5 BL/s

1-4 BL/s

Wenatchee Steelhead at Turtle Rock and Chiwawa

Performance Evaluation at Chelan PUD

<0.5 BL/s

1-4 BL/s

Summer Chinook at Eastbank

Length, Weight, Condition Factor, Coefficient of Variation, Fin Index

Histopathology, Bacteriology, Virology, Blood Chemistry and Gas

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COMMUNICATION

Assessing the Suitability of a Partial Water Reuse System for Rearing Juvenile Chinook Salmon for Stocking in Washington State

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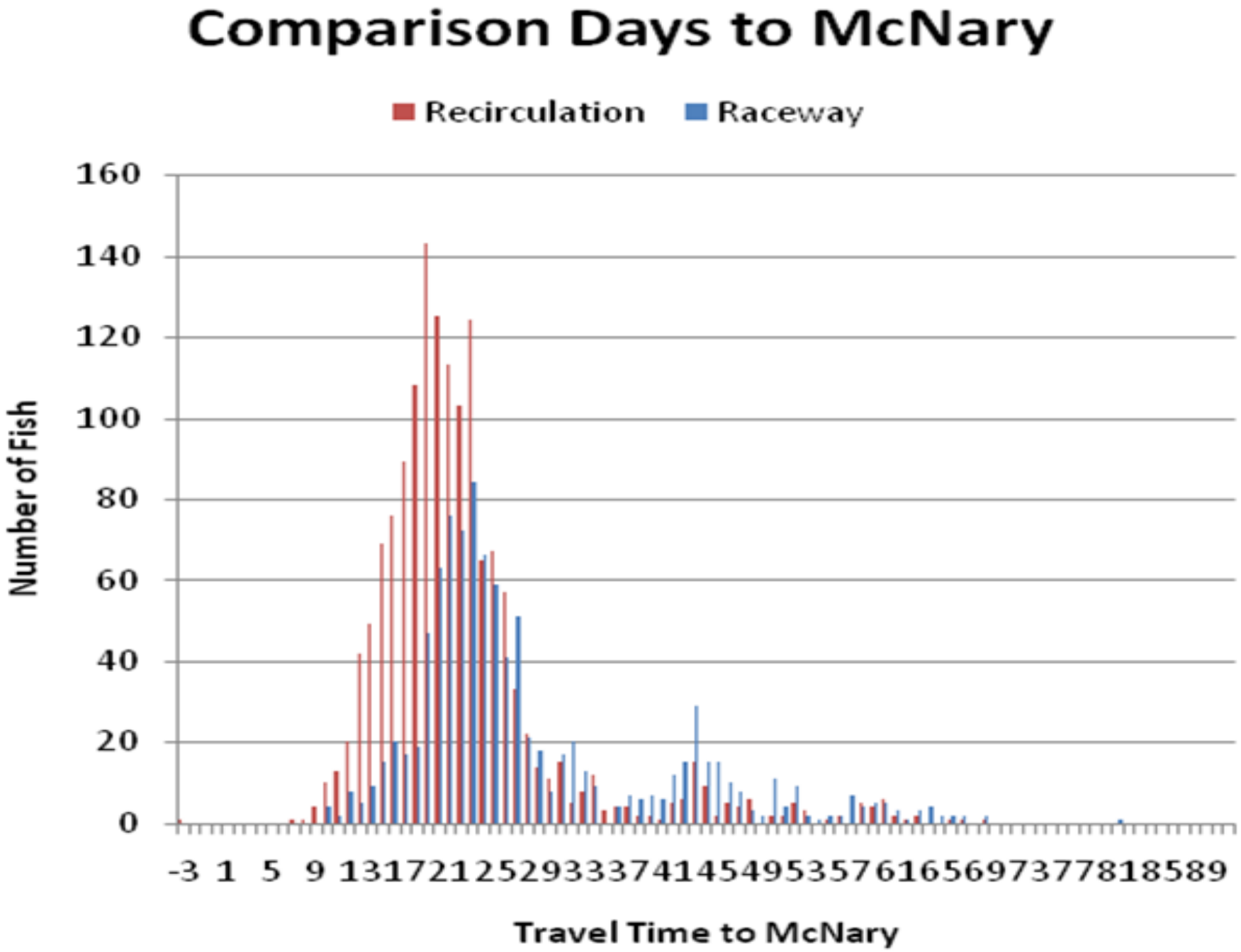
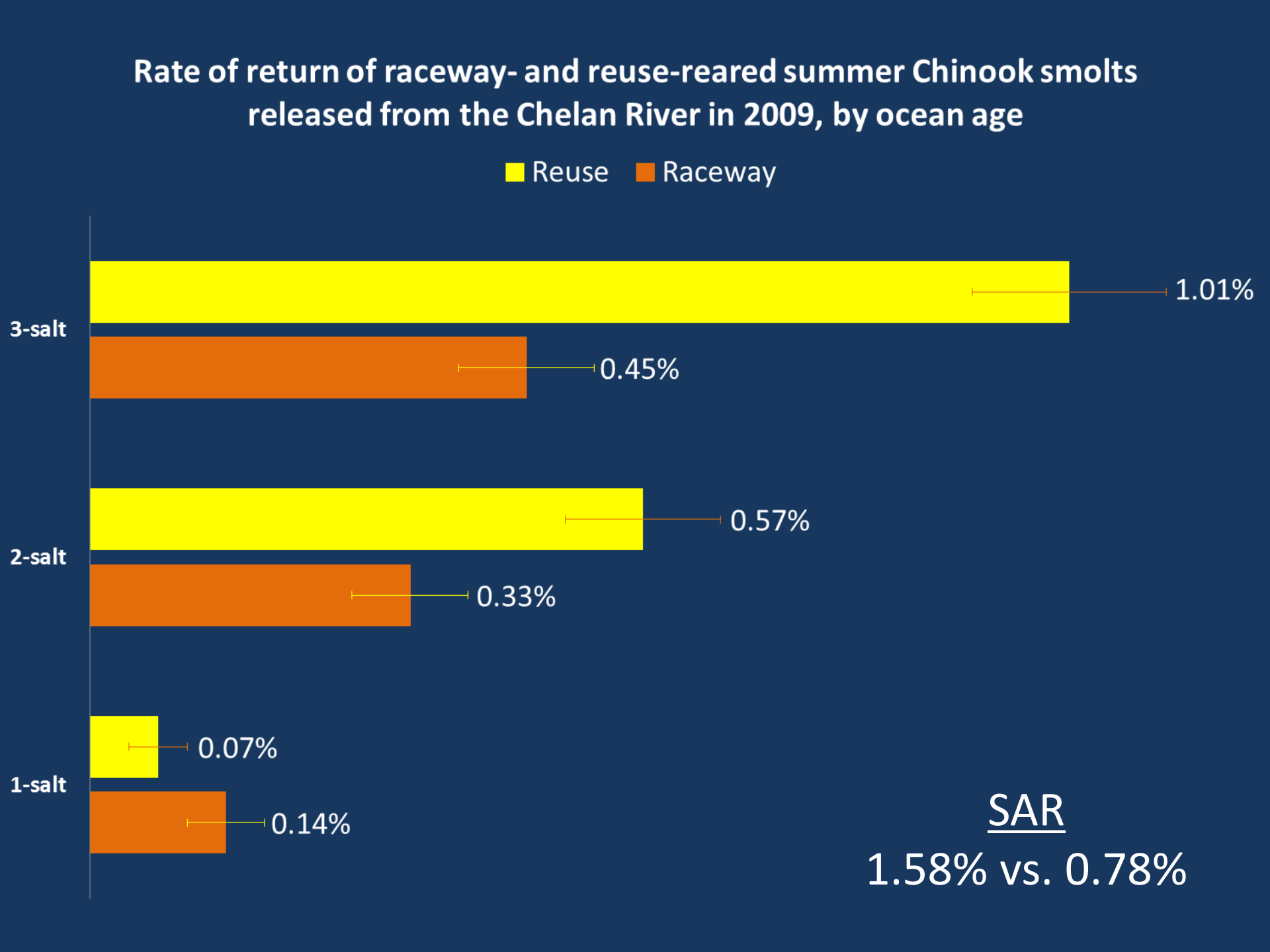
Abstract

To assess the suitability of water reuse technology for raising Pacific salmon *Oncorhynchus* spp. for stocking purposes, fish health and welfare were compared between two groups of juvenile Chinook salmon *O. tshawytscha* from the same spawn: one group was reared in a pilot partial water reuse system (circular tanks), and the other group was reared in a flow-through raceway. This observational study was carried out over a 21-week period in Washington State. Reuse and raceway fish were sampled repeatedly for pathogen screening and histopathology; fin erosion and whole-

ing the upper Columbia River and surrounding waters. These fish are currently raised in a series of facilities that employ traditional flow-through rearing units; however, as water usage and discharge permits in the region become increasingly restricted, Chelan County PUD managers are considering the adoption of new technologies, such as partial water reuse systems that use circular tanks, for raising the fish. Such water reuse systems are capable of conserving water, concentrating waste for ease of removal, and increasing overall production capacity (Summerfelt et al. 2004; Vinci et al. 2004). However, before


Comparison Days to McNary
Recirculation
Raceway
Number of Fish
160
140
120
100
80
60
40
20
0
-3 1 5 9 13 17 21 25 29 33 37 41 45 49 53 57 61 65 69 73 77 81 85 89
Travel Time to McNary


Rate of return of raceway- and reuse-reared summer Chinook smolts released from the Chelan River in 2009, by ocean age
Reuse
Raceway
3-salt
1.01%
0.45%
2-salt
0.57%
0.33%
1-salt
0.07%
0.14%
SAR
1.58% vs. 0.78%

That’s nice but…

- Observational studies not controlled experiments
- No physiological characteristic has been identified as different between groups (?)
- Not only are water velocities different but so are the rearing environments (e.g., DO)

Does it Matter?

- Rearing environment is having a significant effect on fish performance in multiple areas of interest:
  - Downstream migration
  - Early maturation
  - SAR

More to Come…

- **Josh Murauskas,** Chelan County PUD, Wenatchee WA. Increased Performance of Spring Chinook Salmon Reared in Partial Re-Use Circular Vessels Compared to Flow Through Raceways