



# **Use of a Sweeping Low Frequency Pulsed DC Electrical Field to Control Bighead and Silver Carp**

**Jackson Gross PhD, Alecia Stewart-Malone,  
M O'Farrell PhD, LeeRoy Carstensen**

**Smith – Root Inc**

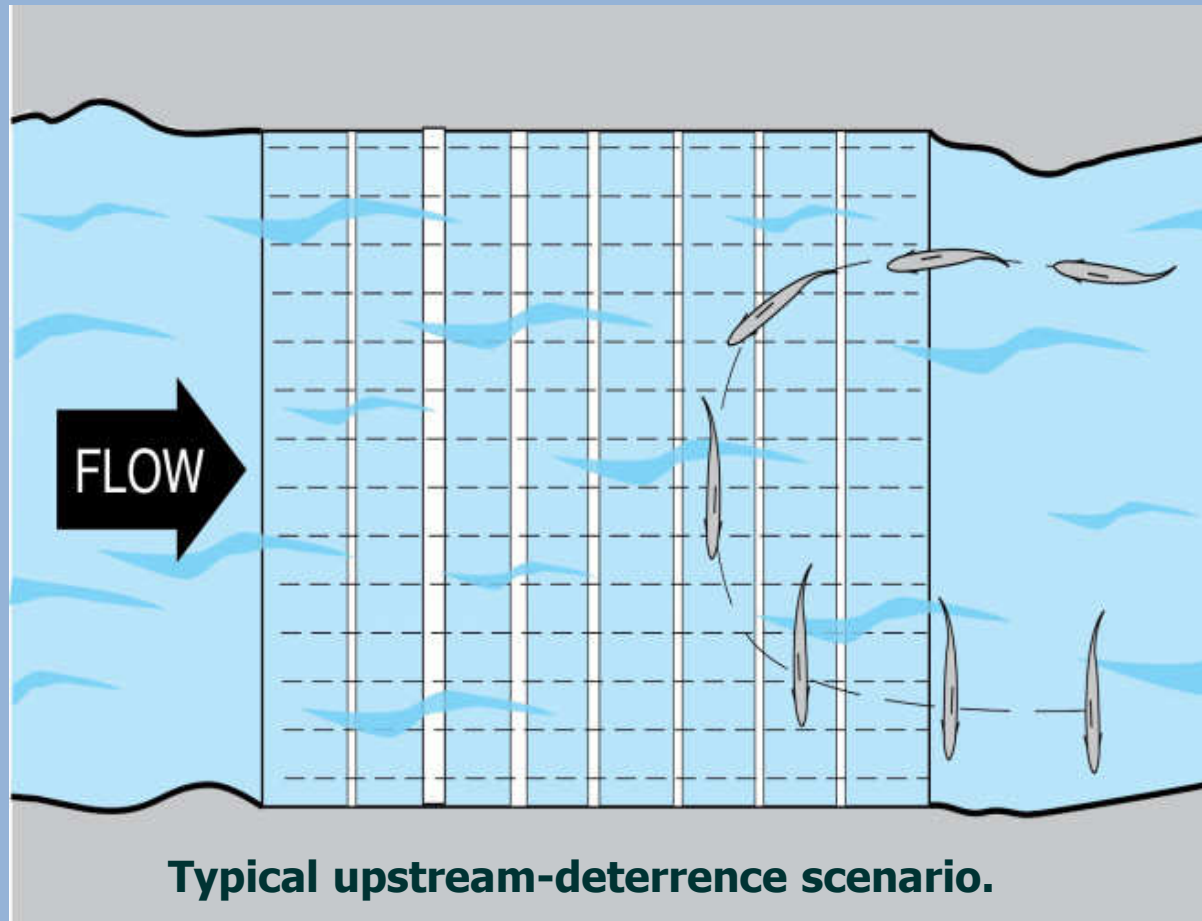
**Vancouver Washington**



**Minnesota**

**Department of Natural Resources**

# Upstream electrical fish barriers utilize water flow to direct fish.



---- Dashed horizontal lines represent electric current

|||| Vertical bars represent electrodes

**Need exists to deter or direct fish away from areas with little water flow.**



# **Solution: Develop a sweeping electric field for limited flow environments**

- **Challenges**

- **Lack of environmental cues**
- **Early detection**
- **Voluntary**
- **Inhibition of mobility**
- **Fish sizes and tolerance**
- **Water chemistry**



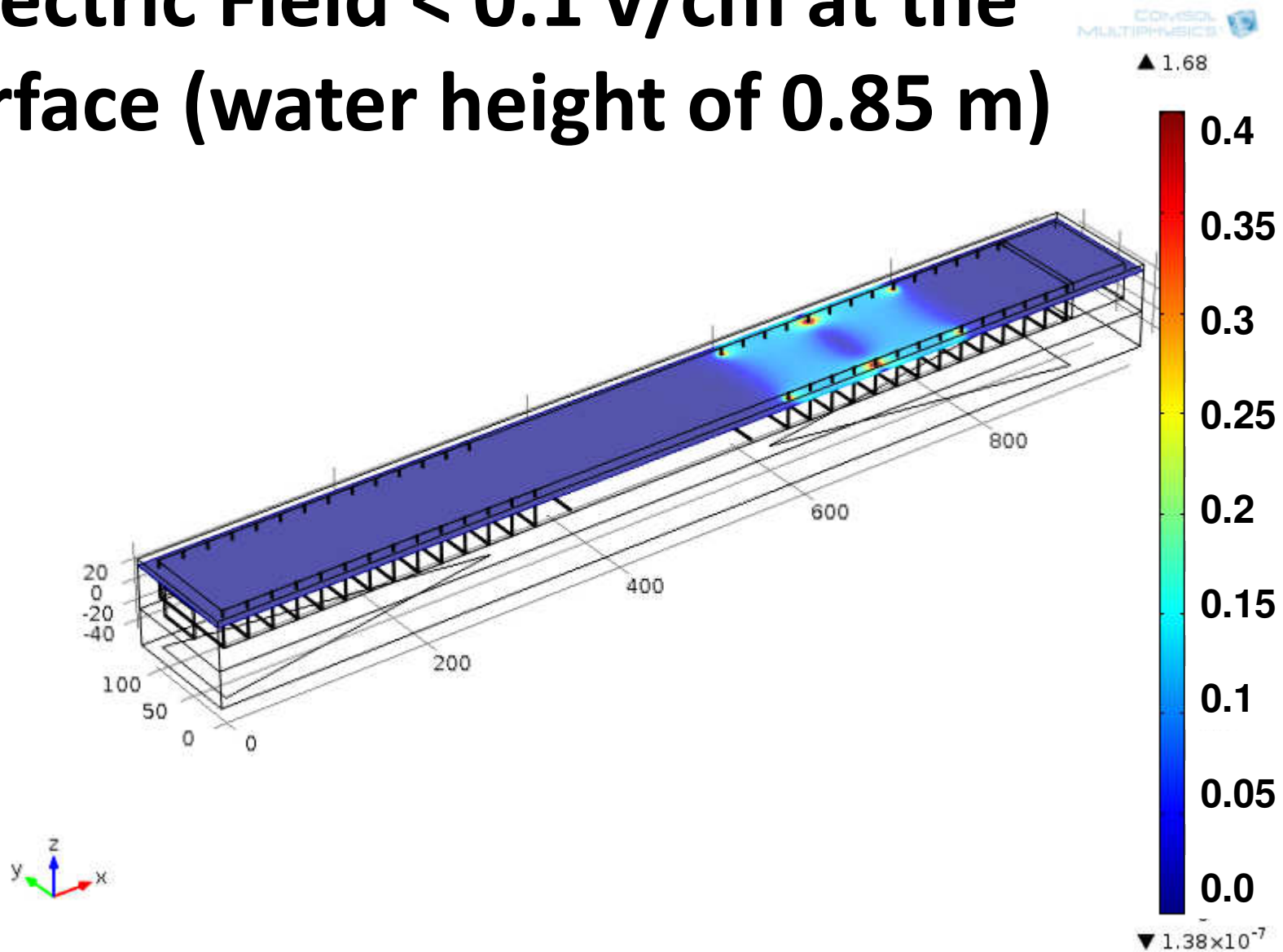
# Tested the ability to move and incapacitate bighead and silver carps



Jake Wolf  
Memorial  
Fish  
Hatchery  
IDNR

- 23 x 2.4 x 1 m deep raceway
- 1 Static 4.9 m terminal field
- 2 Dynamic 8 m sweeping fields
- 3 sizes of bighead
- 1 size of silver
- Video surveillance

# Sweeping Barrier: Electric Field < 0.1 v/cm at the surface (water height of 0.85 m)

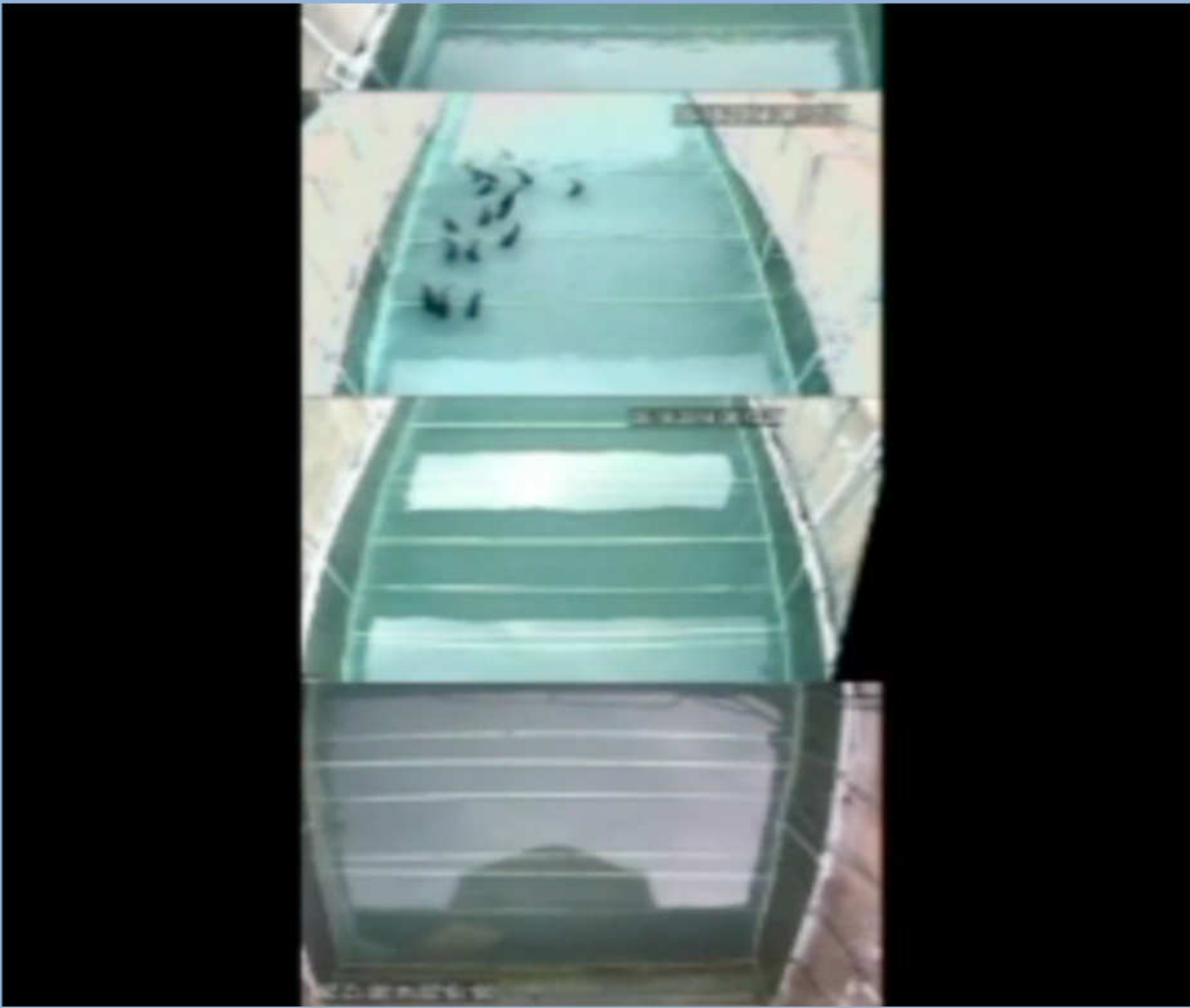


[Control] [ ----- Electric Barrier Energized and Moving ----- ]

0:00-0:30 0:30-1:00 1:00-1:30 1:30-2:00 2:00-2:30 2:30-3:00 3:00-3:30



**Large bighead carp (TL mean 51.3 cm, range 45.3-58.5 cm)**



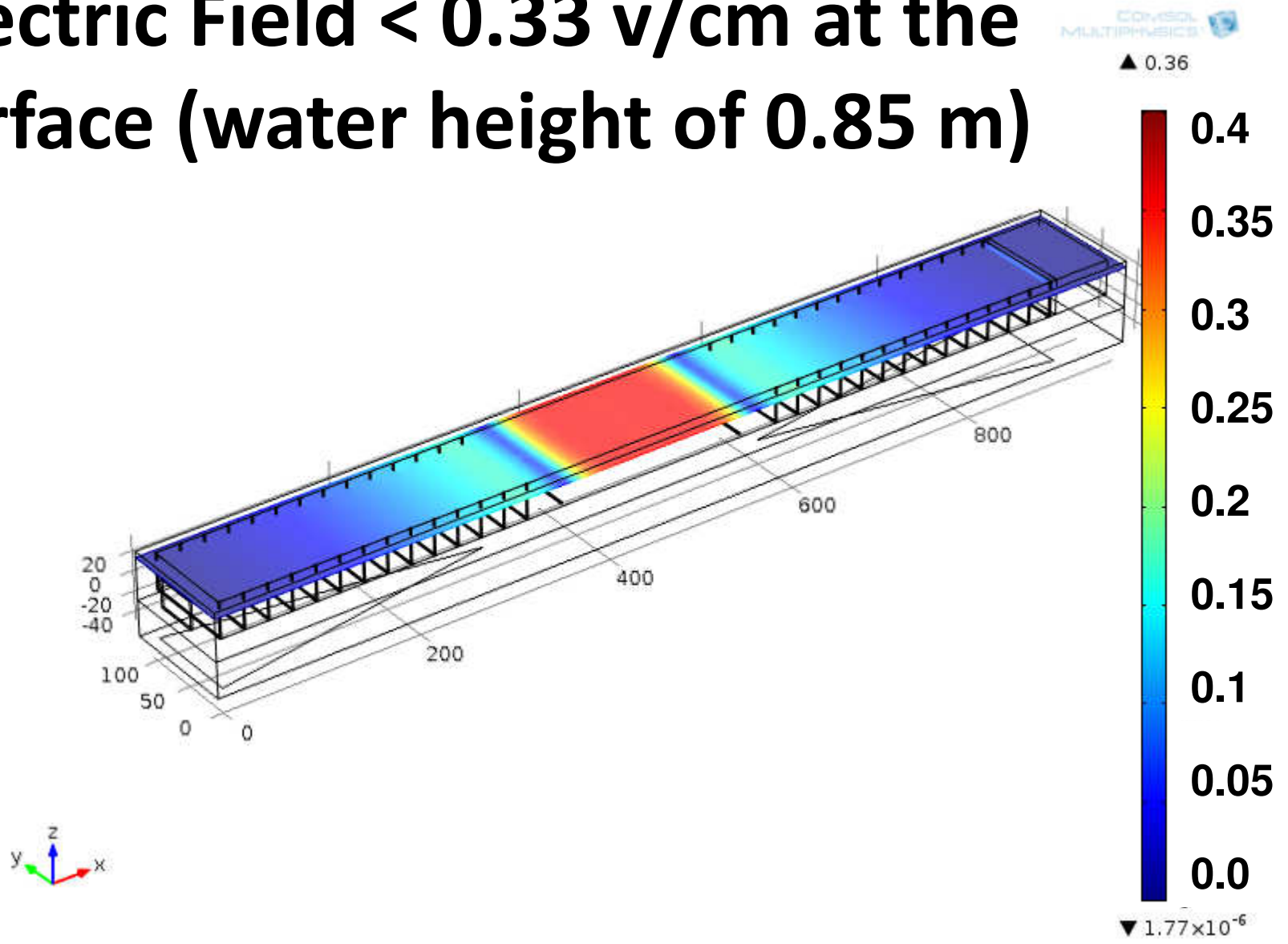


# Ability to move all carp at settings considered safe for human health

Species (Mean TL cm, range TL cm)	Setting A (low)		Setting B (high)	
	# sweeps (Mean± SE)	Time (mins) (Mean± SE)	# sweeps (Mean± SE)	Time (mins) (Mean± SE)
Silver* (17.5, 13.1-26.4)	1.4 (± 0.17)	2.65 (± 0.58)	2.0 (± 0.89)	3.76 (± 1.90)
Med bighead (22.8, 18.5-26.6)	1.6 (± 0.47)	2.38 (± 1.14)	1.2 (± 0.25)	1.85 (± 0.71)
Lrg bighead (51.3, 45.3-58.5)	2.8 (± 1.10)	6.21 (± 2.19)	2.3 (± 1.08)	4.37 (± 2.58)

# Terminal Barrier:

Electric Field < 0.33 v/cm at the surface (water height of 0.85 m)



# Inhibit 100% of silver carp passage

TL mean 17.5 cm, range 13.1-26.4 cm



# Terminal barrier was capable of inhibiting 100% of silver and large bighead carp passage

		Med bighead carp		Lrg bighead carp		Silver carp	
		Passage (%) Mean(± SE)	N	Passage (%) (Mean± SE)	N	Passage (%) (Mean± SE)	N
Cathode 1 <sup>st</sup> ↑	Increasing frequency	-	-	-	-	9 (± 0.03)	2
		-	-	-	-	31	1
		-	-	-	-	19	1
		13 (± 0.09)	5	0 (± 0.00)	4	73	1
Anode 1 <sup>st</sup> ↑	Increasing frequency	-	-	-	-	0 (± 0.00)	3
		2 (± 0.02)	3	0 (± 0.00)	4	-	-



# Collaborations: Where do we go from here?

- **Potential applications:**
  - **Hydropower**
    - **Draft tube entry**
  - **Lamprey and eel control**
    - **U-shaped electrodes may inhibit climbing**
  - **Fish lifts /elevators**
    - **Push fish out of elevators upstream into mainstem**
    - **Keep fish from moving into elevators downstream**
  - **Aquaculture**
  - **Other applications?**

# Acknowledgements

- **Minnesota Dept of Natural Resources**
- **Steve Krueger and staff at IDNR Jake Wolf Memorial Fish Hatchery**
- **Osage Catfisheries**
- **Andrew Casper PhD  
Illinois Natural History Survey Havana Biological Research Station**
- **Duane Chapman  
USGS-Columbia Environmental Research Center**