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# Pushing and Pulling I: Acoustically Guided Avoidance Responses in Three Invasive Carp Species

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# Acoustically guided avoidance responses in three invasive carp species

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# The Problem – Asian Carp



- Silver and Bighead Carp
  - Highly fecund and fast growing
  - Disrupt aquatic food webs
  - Silver carp jump
- Not yet established in Upper Mississippi River
- Lock-and-Dams likely restrict passage



# Blocking Silver and Bighead carp at Lock-and-Dams

Objectives:

1. Use acoustic deterrents to guide carp away from the lock
2. Modify gate operation to create velocity barrier

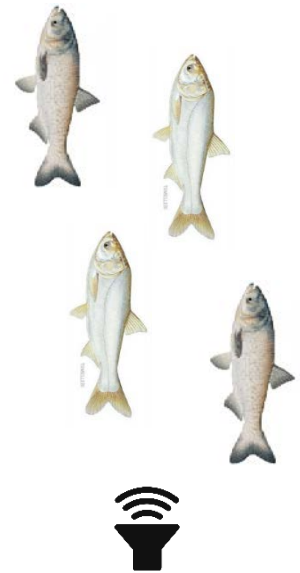


# Acoustic deterrents – what do we know?

- Studies have examine broad scale responses
- Potentially taxon specific
- Alternative to physical barriers
  - At cost of lower efficacy

**It is unclear what orientation mechanism is used to guide avoidance response**

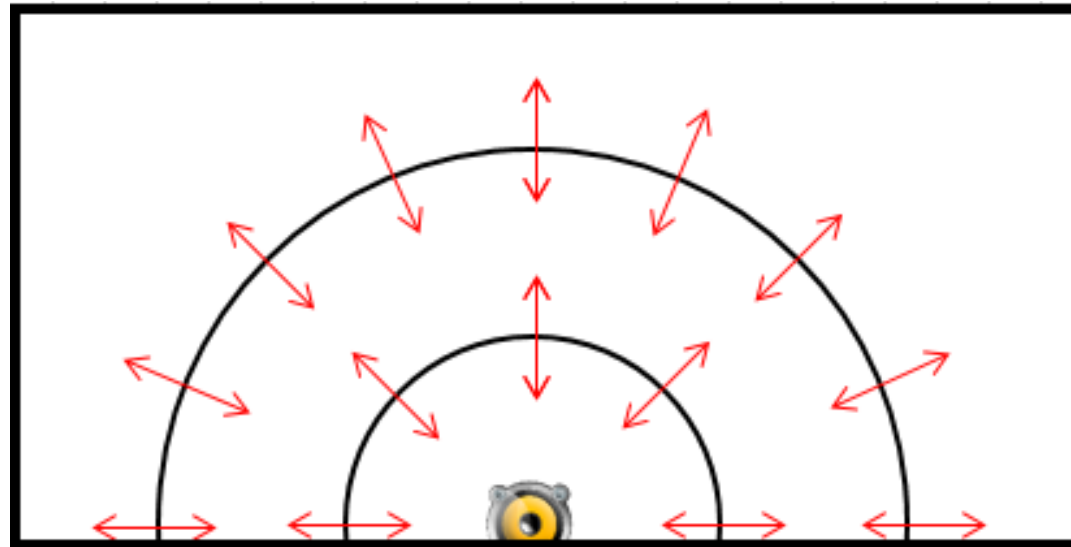
**i.e. is the response random or directional?**



# Underwater Acoustics

- Sound is a longitudinal wave of vibrating fluid particles
- Results in a traveling pressure wave and local particle motion

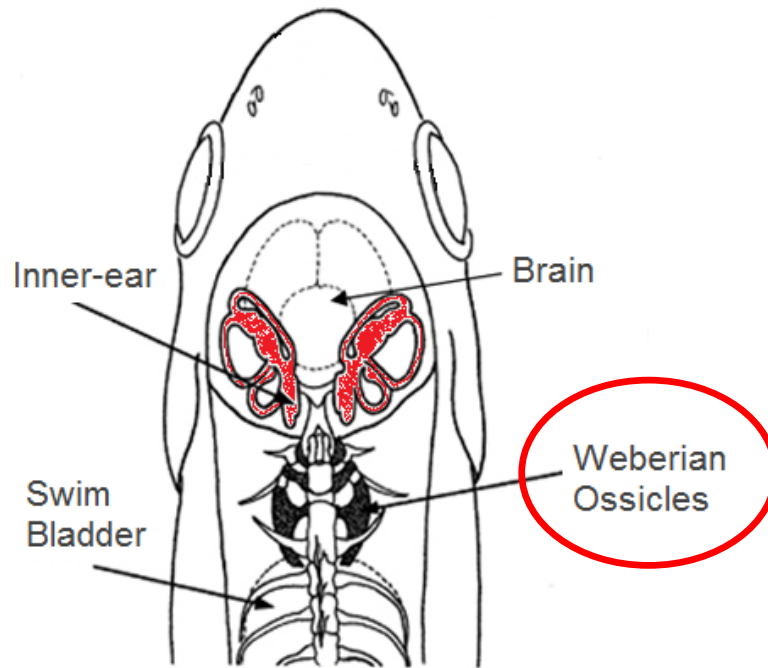
Pressure waves emanating from a monopole source.



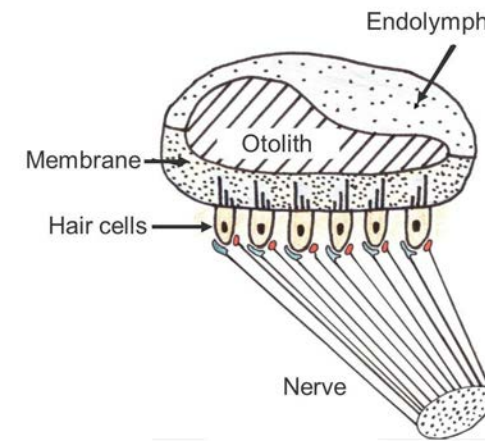
Local oscillation of particles. Note, particle motion vectors are orthogonal to pressure contours.

# Fish Hearing

- Fish detect sound through the use of their Octavolateralis system
  - Inner-ear = accelerometer to detect particle motion
  - Swim Bladder = pressure transducer (Carp hearing specialization)



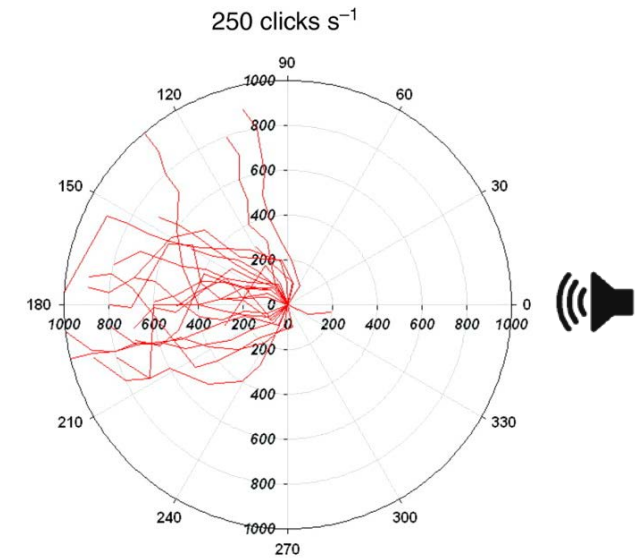
Webb et al. 2009



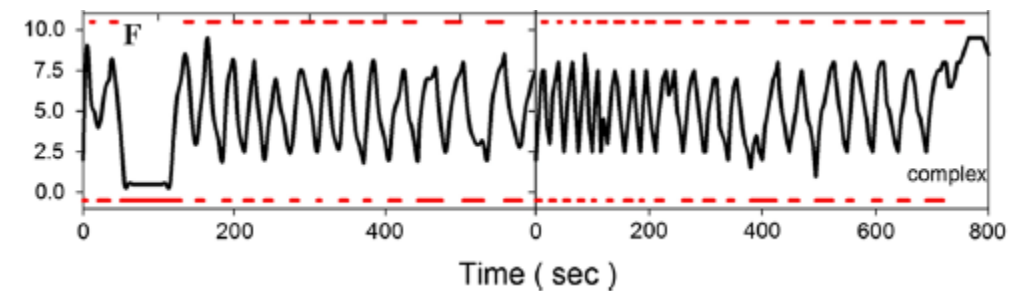
Source: Lesse Amundsen

# Behavioral Response to Sounds

- Approach behaviors are guided by sound field without visual cues (Zeddies and others, 2010, 2012, 2014)
- Avoidance  $\neq$  Approach
- Evidence of negative phonotaxis (Vetter et al. 2015, Wilson et al. 2008, 2011)
  - But movements have not been compared to either sound field component without visual cues



Trajectories of Allis shad avoiding a sound source in the dark (Wilson et al., 2011)



Silver carp ping-pong away from complex sounds (Vetter et al. 2015)



# Laboratory Experiment

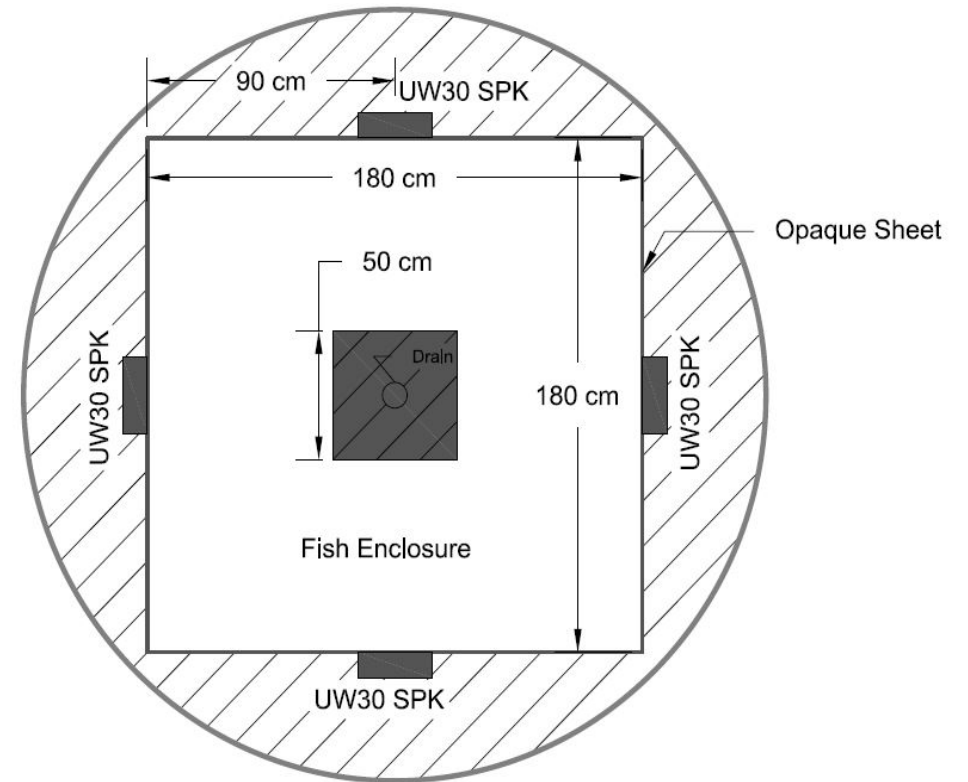
**Objective: Characterize how silver, bighead, and common carp avoid a complex sound in the absence of visual cues**

Q1: Are all three carp negatively phonotactic in the absence to visual cues

Q2: What are the relative roles of sound pressure and particle motion

# Experimental Design

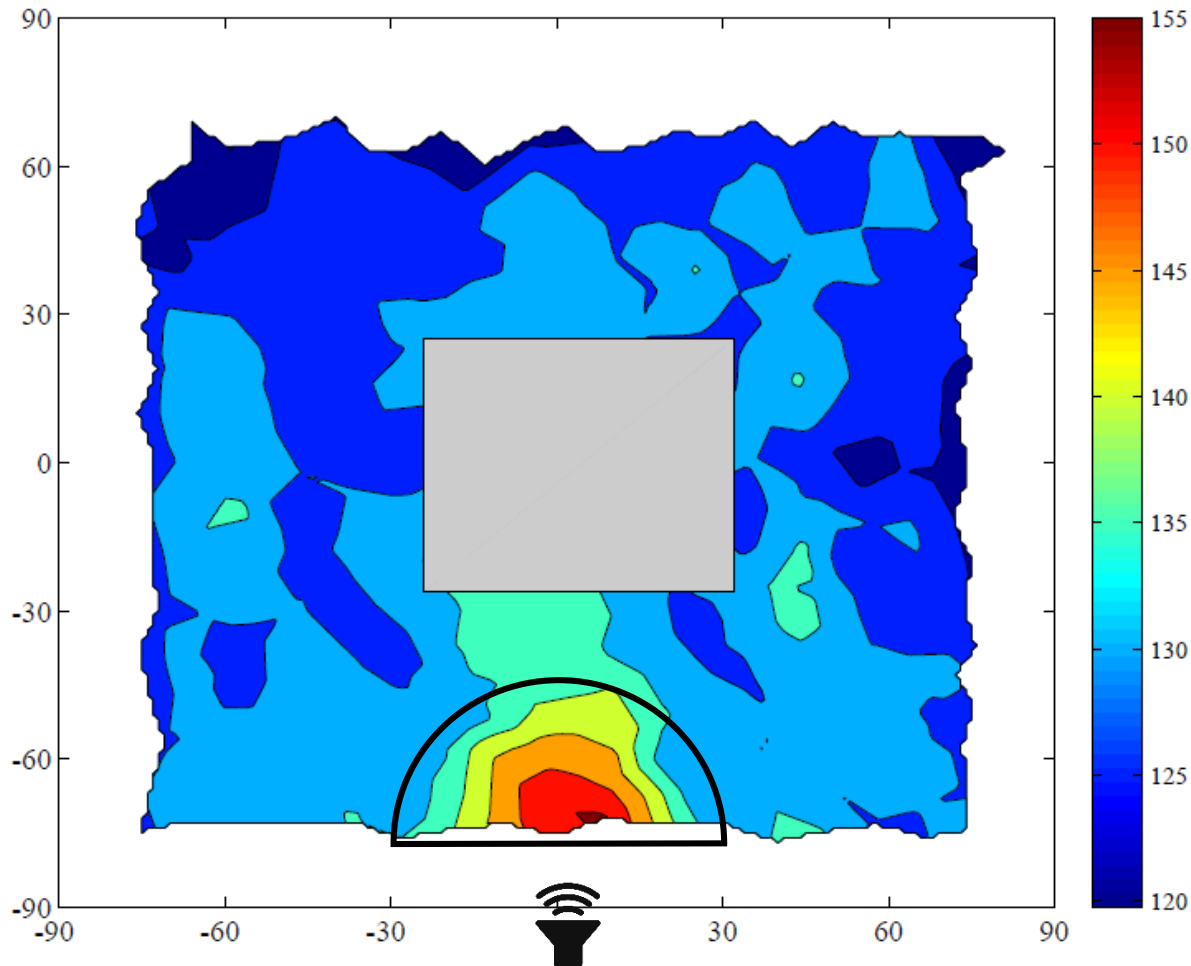
- Expose each species to sound in darkness
- Repeat 150 s control and 150 s treatment
- Treatment: complex outboard motor sounds
  - Stressful to carp (Wysocki et al. 2006)
  - Silver carp avoid in lab (Vetter et al. 2015)
- Relate position and swimming trajectories to sound field



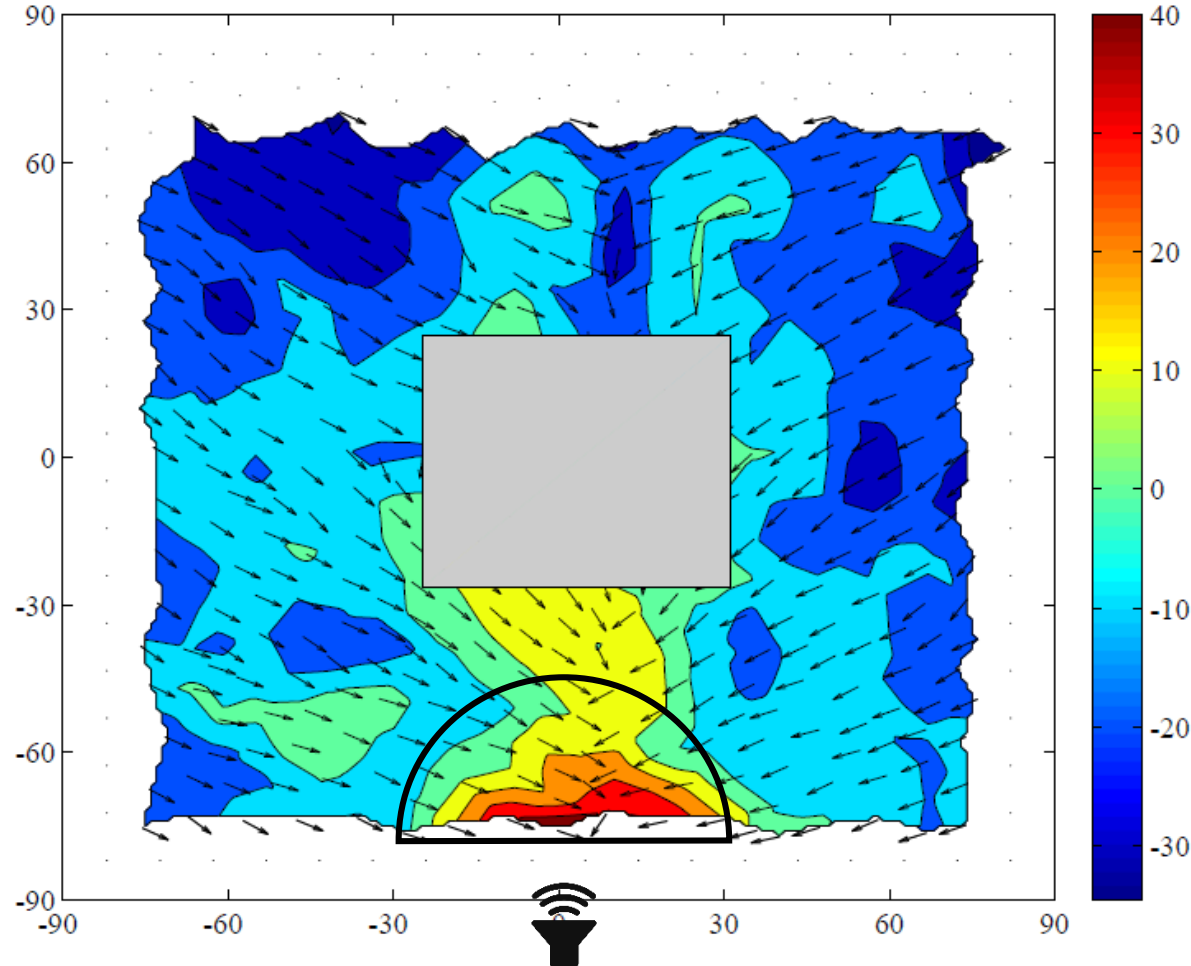
Experimental tank (30 cm deep)

# Sound Field

Peak Sound Pressure Level (dB ref. 1  $\mu\text{Pa}$ )

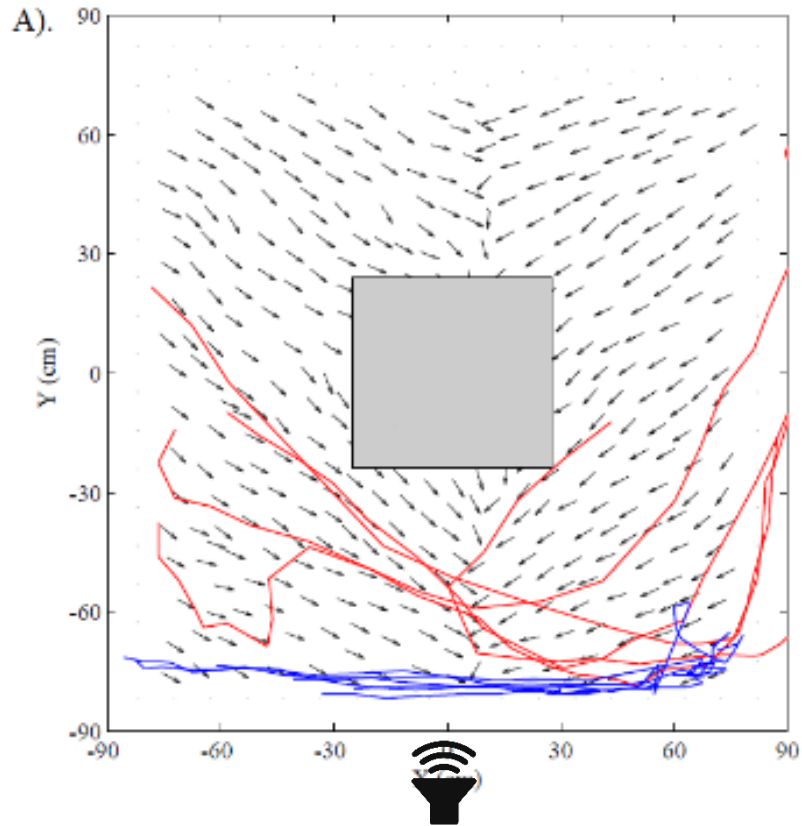


Particle Acceleration (dB ref. 1  $\text{cm s}^{-2}$ )

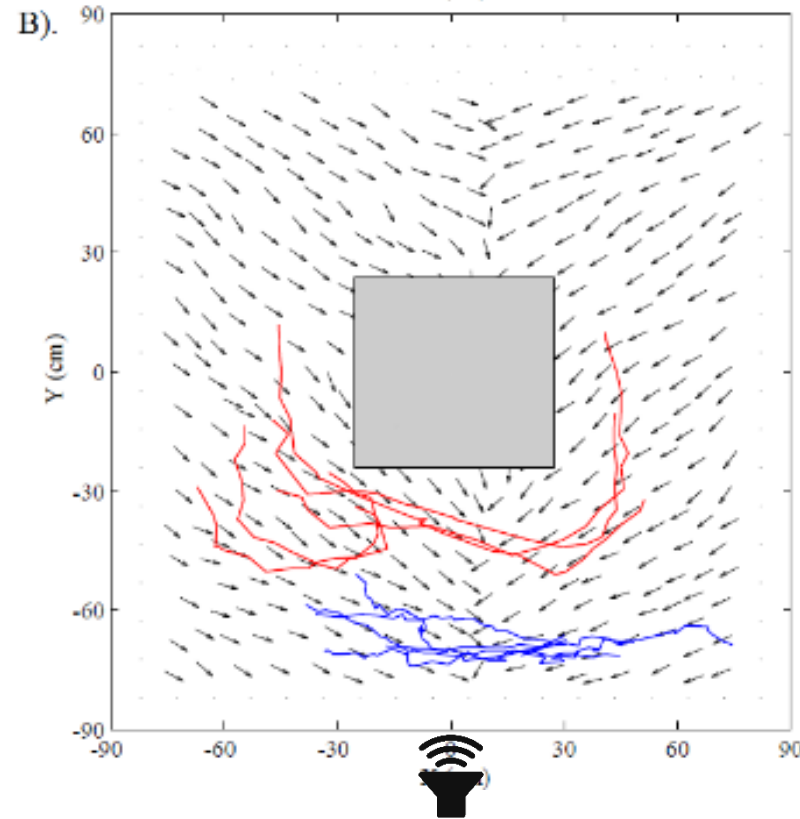


# Results – Do carp avoid complex sound?

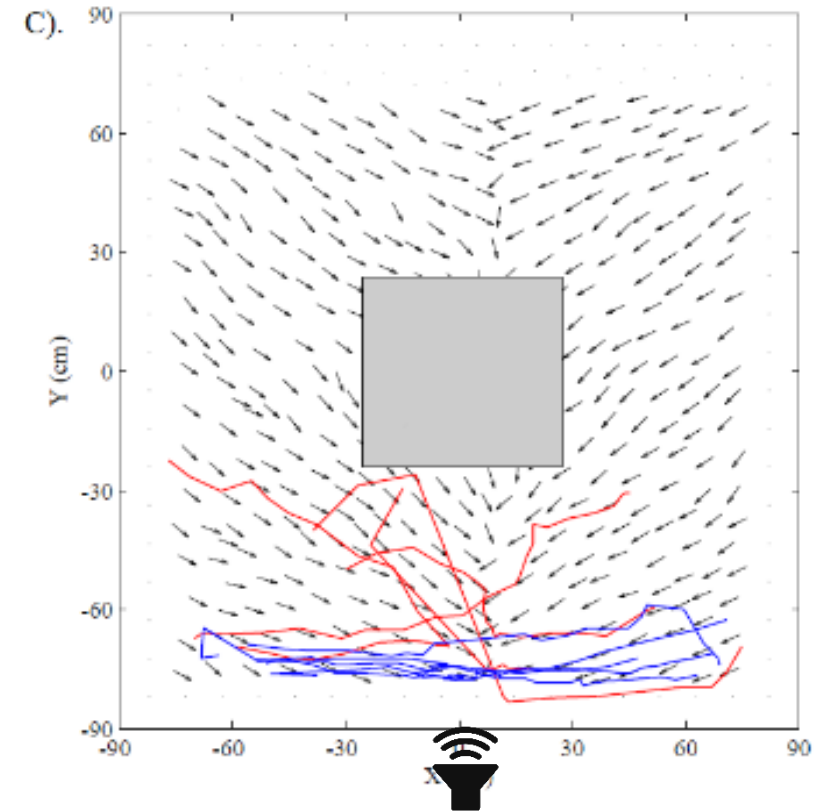
Common carp



Silver carp



Bighead carp

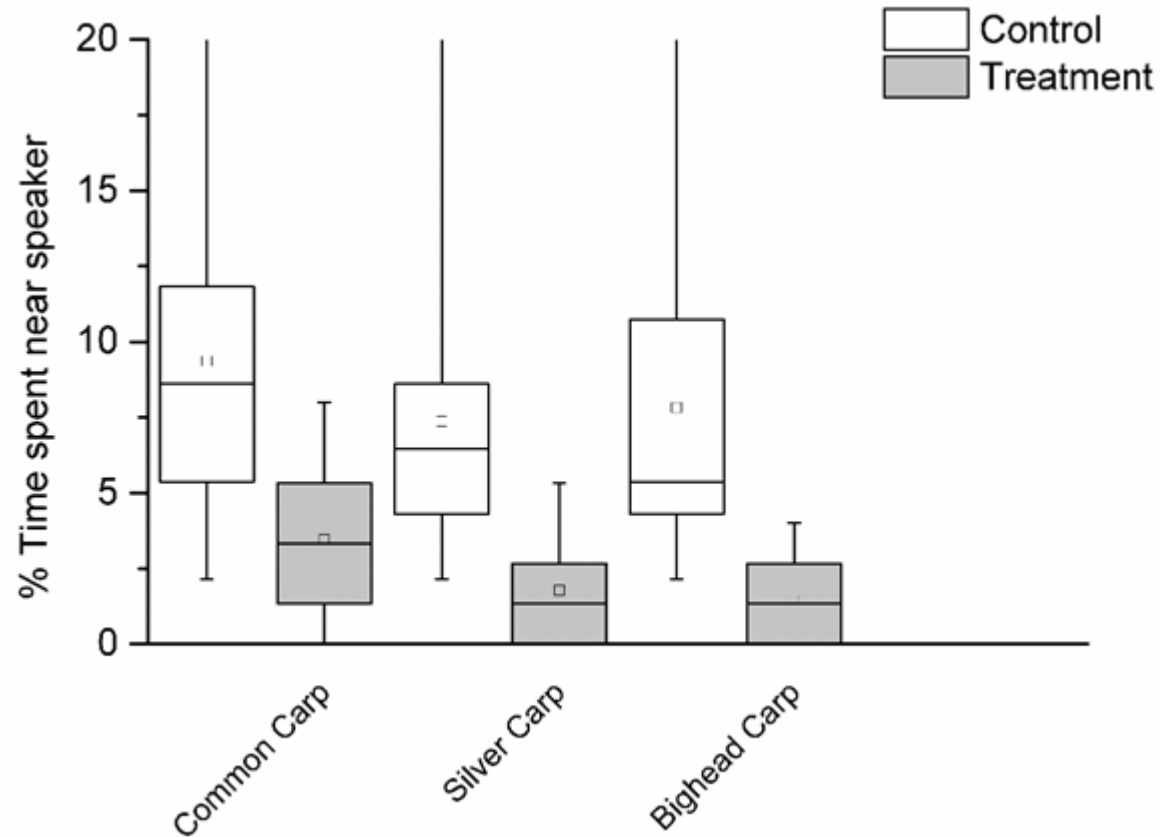


Key

—Treatment

—Control

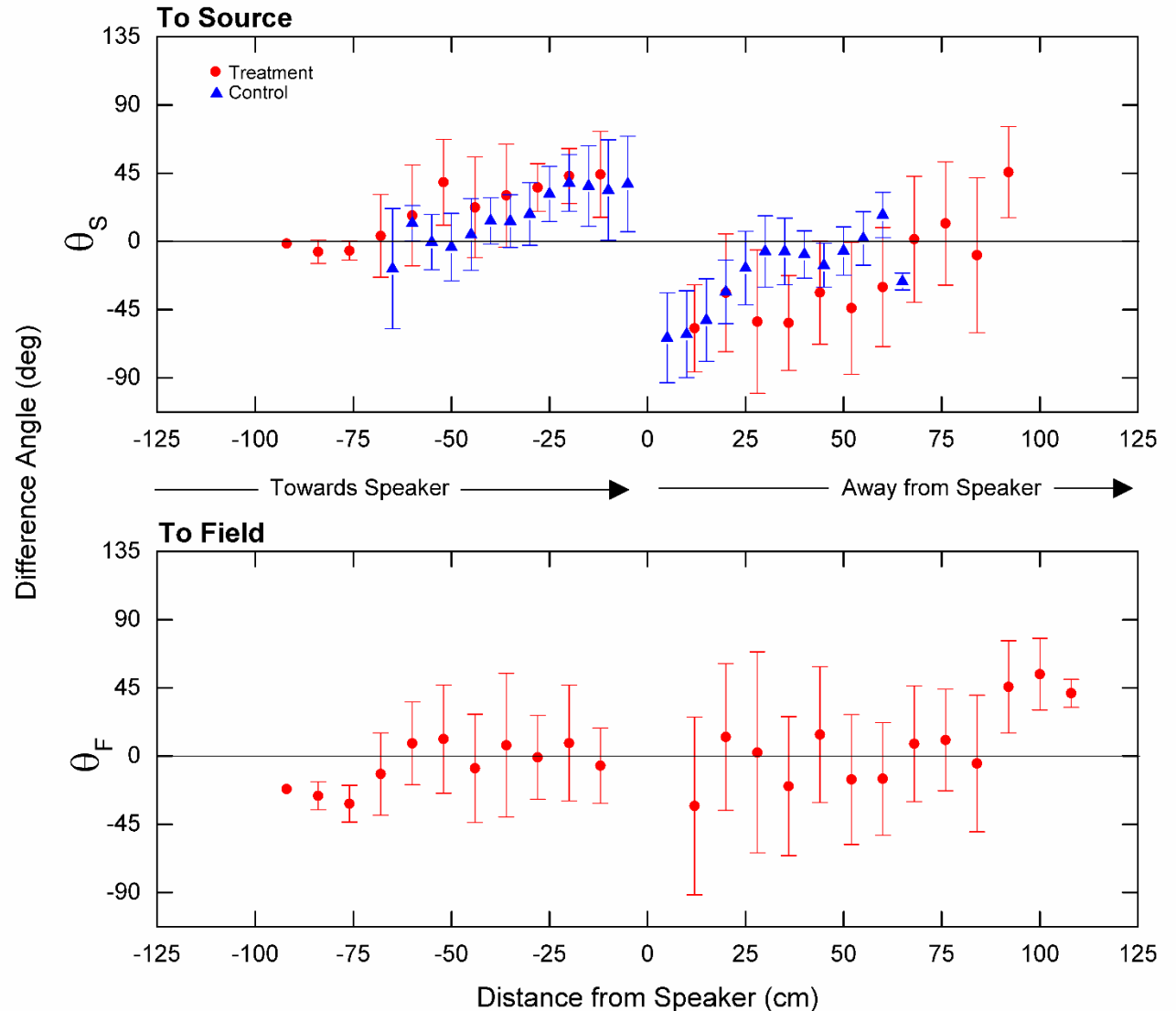
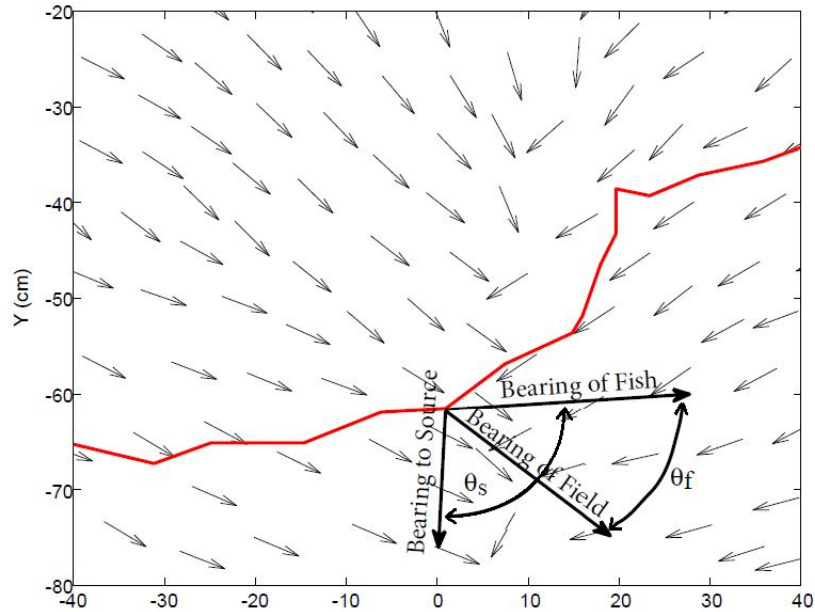
# Results – Do carp avoid complex sound?



- All three species exhibited >70% reduction in time spent near the speaker

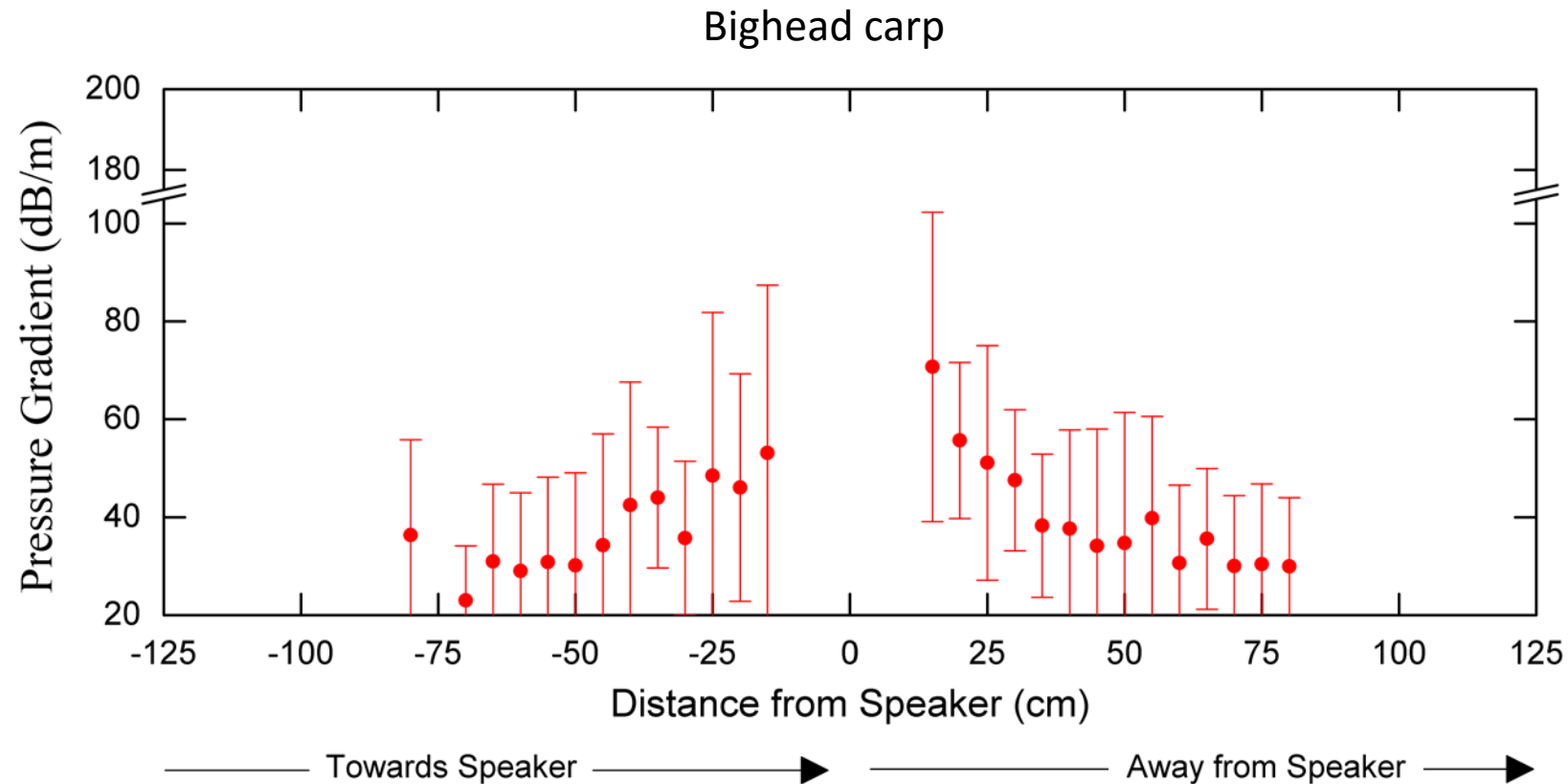
# Results - What is the role of the sound field?

## Analysis of orientation



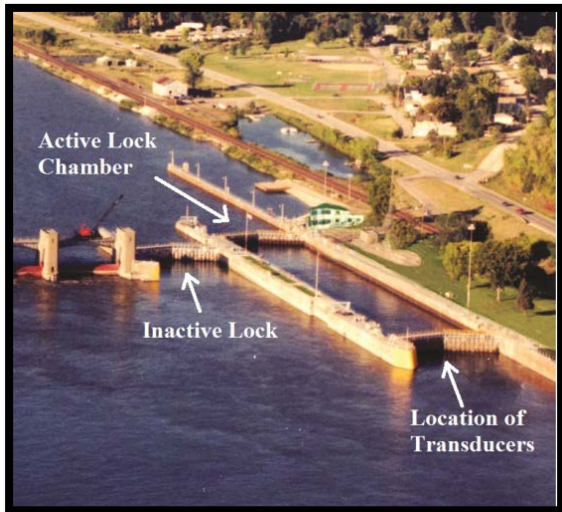
# Results - What is the role of the sound field?

- Sound pressure gradient at maximum when fish turned away

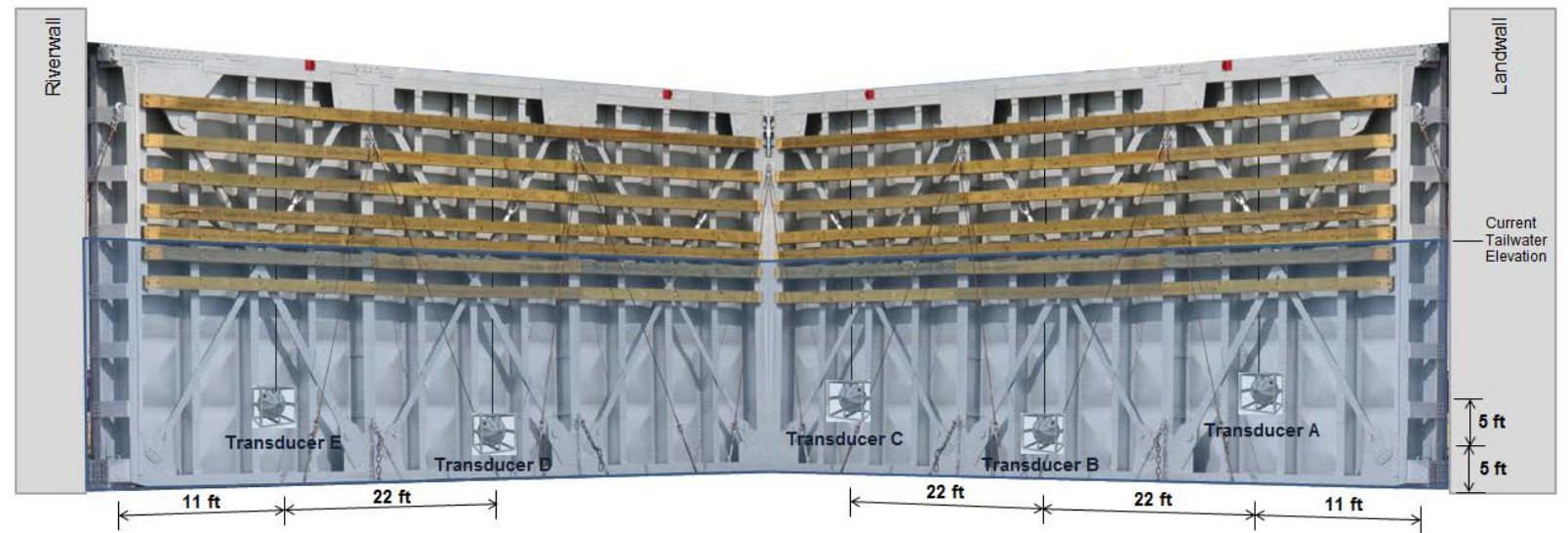


# Next Steps

- An array of 5 underwater speakers have been installed on the downstream lock gates of Lock and Dam #8 (MN-IA border)
- Monitor fish response (native and invasive) with high resolution sonar this summer
- Common carp as model species



Lock and Dam #8 near Genoa, WI



Underwater speaker array



# Minnesota Aquatic Invasive Species Research Center • MAISRC



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## Thank You

Contact me at  
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