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)

Source: Lesse Amundsen

Webb et al. 2009
Behavioral Response to Sounds

• Approach behaviors are guided by sound field without visual cues (Zeddies and others, 2010, 2012, 2014)

• Avoidance ≠ 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 phonotaxic 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
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

What to expect?

- Zig-zag movements (spatial-temporal sampling)
- Direct movement away from speaker
- Constant orientation to particle motion vector
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
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Thank You

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