An experiment Utilizing an Aquatic Acoustic Barrier for Crayfish

By Lawrence Mullen- August 2025

I. **The problem:** Over the last decade, the invasive rusty crayfish have been observed to have a growing and sustained population in Pike Lake in Cook County. These observations have been made by Cook County AIS, the US Forest Service, commercial trappers and lake residents. The Rusties have a migration path available to them to Caribou Lake via Murmur Creek. Rusty crayfish were first found in Caribou Lake in 2020 at the inlet from Murmur creek by the US Forest Service. The number trapped totaled 50. It is strongly believed the Rusties had migrated from Pike Lake. The population has been growing in Caribou Lake with 125,000 trapped in the summer of 2025 by volunteers of the Caribou Lake Property Owners' Association and commercial trappers. Trapping efforts of the Rusties have been expanded in Caribou Lake with the goal of managing the population. It is recognized though that in order to manage the population in Caribou Lake, the migration from Pike Lake has to be stopped.

II. **The question**: How can rusty crayfish be prevented from migrating from Pike Lake to Caribou Lake without the use of a physical barrier or use of chemicals?

III. **Research that formed the hypothesis:**

1. **Sound sensory systems of crayfish:** Crayfish are decapod crustaceans, just like lobsters, so they share the same fundamental sensory systems. Studies showing the effects of sound done on Lobsters could be considered also applicable to crayfish.

   A key study showing that lobsters react to sound is "Sound detection by the American lobster (*Homarus americanus*)" published in the *Journal of Experimental Biology* in 2021 by Jézéquel et al.

   Key Findings of Lobster Study :
   Auditory Evoked Potentials (AEPs): The researchers used AEP methods, which involve placing electrodes near the lobster's brain, to measure neurophysiological responses to sound. This allowed them to detect when the lobsters' nervous systems were reacting to the acoustic stimuli.

Best Sensitivity: The study found that American lobsters have a hearing range from about 80 to 250 Hz, with their best sensitivity occurring at 80–120 Hz. There were no significant differences between the auditory thresholds of males and females.

Sensory Organ: The study also identified that "hairfans," external cuticular hairs covering the lobster's body, are the primary sensory organs responsible for sound detection, not the statocysts as previously thought. When these hairs were immobilized, the AEP responses were significantly reduced or eliminated. Crayfish have evolved to detect particle motion (water moving back and forth) rather than sound pressure.

Ecological Implications: The study notes that the lobsters' hearing range overlaps with the low-frequency buzzing sounds they produce. This suggests that sound is used for communication between lobsters, particularly during aggressive encounters.

Source:https://journals.biologists.com/jeb/article/224/6/jeb240747/237913/Sound-detection-by-the-American-lobster-Homarus

2. **The physics of copper:** The speed for sound is 4,600 meters per second in copper. With its elasticity and thus ability to vibrate in place easily, sound travels through it quickly. The presence of water inside a copper pipe will diminish (attenuate) the sound wave that radiates from the pipe. This is due to the phenomenon known as fluid-structure interaction.

IV. Hypothesis: If a crayfish encounters a low frequency sound in the neighborhood of 100 Hz, it will perceive it as danger and avoid the area. The sound conductivity of an empty copper pipe makes it a good delivery system of sound to a specific area, like across a creek bed. A copper pipe connected to a source producing a sound in the neighborhood of 100 HZ will generate aquatic particle motion, from sound vibrations emitting from the pipe's exterior, sensitive to the crayfish causing them to avoid the area, in essence creating a barrier.

V. **Tests:** The tests were conducted with eight mixed gender rusty crayfish that were harvested from Caribou Lake. The tests were conducted on the same day as the crayfish were harvested. The crayfish were put into a two-foot wide by four-foot long, by six-inch-deep yellow plastic bin filled with lake water for the tests. The bin was elevated on a stand 4 feet off the ground. It was a closed environment with no water flow or turbulence in the bin. The tester remained out of sight of the crayfish and ensured no walking in the area or movement of the bin during the tests. The tests were conducted in a shady outside area. Videos were taken from some segments.

The design of the test was to send sound of different wave types and frequencies through a ½ inch copper pipe that laid across the bin and measure reactions of the crayfish to independent variables of 1) sound wave types (sine, sinc, half-wave, full-wave, square, triangle, sawtooth, ECG, Exp-rise, EXP-Decay, Lorenze, and Guassian,) and 2) frequencies in the 50 Hz to 150 Hz range.

A FG-200 DDS Frequency Generator was used to produce the wave type and frequency sound. It was connected to a 40 watt amplifier that powered a heavy duty 2-inch bass speaker. The speaker was contained in a rubber cylinder enclosure that was connected to the copper pipe.

Both pulsating and constant sounds were tested.

VI. **Observations:**

The Sine wave at 100Hz produced the best results as follows:

The "Tail Flip" Escape: Where the sound pulses or turns on, the crayfish approaching the pipe immediately performs a rapid "scoot" backward. This is the Caridoid escape reaction. It is a reflexive behavior designed to propel them away from a predator.

Flinching/Startle Response: When the frequency generator pulses The crayfish visibly twitch or jerk. This indicates the vibration is stimulating their sensory nerves directly, likely overloading their senses.

Avoidance: Where the sound is a constant drone, the crayfish are often found huddled in corners or attempting to climb the walls of the yellow bin to get as far from the copper pipe as possible.

Antennule Flicking: You can see their small antennae (antennules) waving frantically. They use these to "taste" and "feel" the water, trying to locate the source of the disturbance.

Habituation: When the vibration is constant (a drone) for a period, the crayfish appear to become accustomed to it. Possibly the crayfish's brain categorizes it as "environmental noise" (like a rushing stream) and they stop reacting.

VII. Discussion:

The observations support the hypothesis. The Sensory Hairs (Setae) that cover the Crayfish legs, antennae, and tail fan most likely caused their response to the copper pipe's vibration of the water that physically shakes these hairs. Contributing factors supporting the hypothesis were the biological link between lobsters and crayfish with respect to neurophysiological responses to sound and the physics of sound transmission in an empty copper pipe.

VIII. Conclusion:

We have a potential answer to the question of how can Rusty Crayfish be prevented from migrating from Pike Lake to Caribou Lake without the use of a physical barrier or use of chemicals.

The tests demonstrate that acoustic sine wave transmitted at frequencies around 100Hz through an empty copper pipe acts as a crayfish repellent. An aquatic acoustic barrier is established.

A pulsing sound seems more effective at triggering a "jump and retreat" response, while the constant drone triggers a "freeze and hide" response.

Creating a pulsing aquatic barrier across Murmur creek has potential in stopping the migration of the Rusty Crayfish.

IX. Next Steps

Testing now needs to be done in an open environment, like a creek bed. The impact of turbulence, such as water rushing over the copper pipe, needs to be evaluated. The impact on other aquatics species needs to be evaluated. Improvements to the testing apparatus could be made by having the speaker enclosure made of copper instead of rubber and increasing the wattage output of the amplifier.

X. Other thoughts.

One concern is that a barrier of the type tested would also frighten fish and consequently inhibit their movement. Another hypothesis, yet to be tested, is that fish will be attracted to the barrier, not repelled, interpreting the sound generated from the barrier as a nearby food source, namely a crayfish. Factors in this hypothesis are that the low frequency sounds generated by the barrier would mimic the sound that a crayfish would make when communicating.