

# Behavioral Responses of Representative Freshwater Fish Species to Electromagnetic Fields

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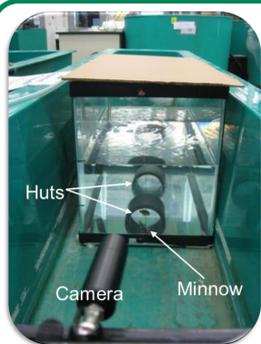
## Background



Power transmission cables and generator magnets associated with MHK energy devices produce electromagnetic fields (EMF) that could affect aquatic organisms. Regulators are concerned that migration, prey detection, feeding effectiveness, and predator avoidance could be affected. Only a few studies have been conducted to test for possible behavioral or physiological responses in fish with few definitive results. We conducted two laboratory experiments and a pond study a more realistic exposure setting to evaluate the behavioral responses of freshwater fish to EMF, such as attraction or avoidance and changes in activity and normal swimming behavior. Of particular concern are species that have highly developed electro-sensory abilities, such as paddlefish and sturgeon.



## Methods

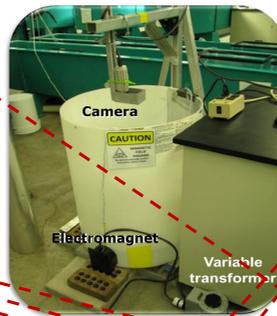


### SHORT-TERM RESPONSE TESTS

- 1 fish per tank in both treatment and control aquaria
- Treatment tanks with 1 of 2 magnet types underneath one side of tank
- Half-pipe cover provided on each side
- 46-hr observation recorded on digital video imaging system
- Location of fish evaluated every 5 min
- Fish location and activity levels compared between magnet exposure and control

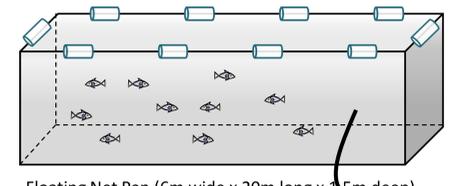
### IMMEDIATE RESPONSE TESTS

- Electromagnet with variable control
- Circular tank and high-speed camera (250 frames/sec)
- One fish tested at a time; 5 trials/fish/treatment
- Magnet and camera activated for 4 sec
- Abnormal behaviors noted as fish encounter magnet
- Magnet strength reduced until 'no effect' observed
- Magnet strengths (0%, 1%, 4%, 5%, 25%, 50%, 100%)
- Species tested: lake sturgeon and paddlefish
- High-speed video analyzed for behavioral responses



### POND STUDIES

- Behavioral responses to cable-produced EMF was evaluated in net pen in ¼ acre pond
- Largemouth bass and pallid sturgeon (7-10 at a time)
- EMF provided with electric cable loop that runs under net pen
- Two levels of EMF (30V and 40V input); both within expected MHK cable EMF range
- Fish position and movement tracked by surgically implanted transmitters
- Location data used to evaluate attraction, avoidance, and change in activity



Floating Net Pen (6m wide x 20m long x 1.5m deep)

Onshore power source



Magnetic Field Strength (micro Tesla) log scale



## Results

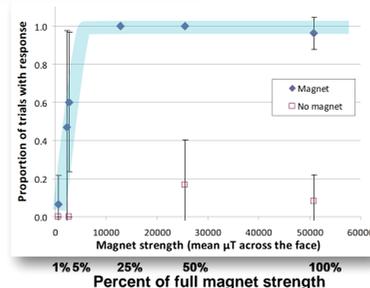
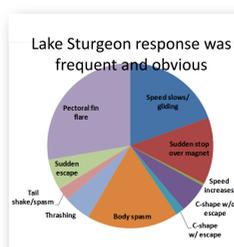
### SHORT-TERM RESPONSE TESTS

- Responses among species and magnets were inconsistent
- Redear sunfish showed a significant but slight attraction to both magnets.
- Fathead minnows increased activity with magnet exposure.

Species	Magnet Type	Distribution Effect	Activity Effect
Fathead minnow	DC (static)	No	Yes
Redear sunfish	DC (static)	Yes	No
Striped bass	DC (static)	No	No
Channel catfish	DC (static)	No	No
Redear sunfish	AC (variable)	Yes	No
Lake sturgeon	AC (variable)	No	No

### IMMEDIATE RESPONSE TESTS

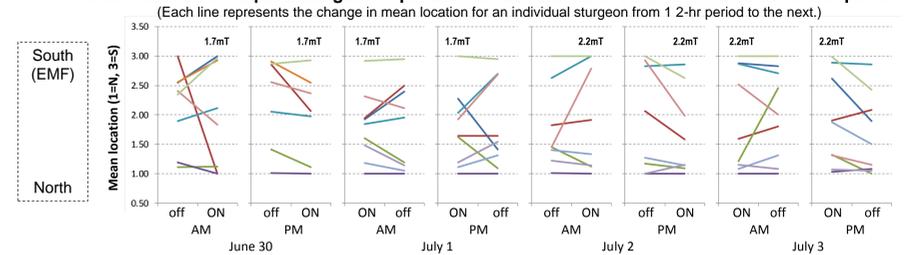
- Lake sturgeon consistently reacted to high levels of EMF (25-100% full strength).
- Responses diminished at levels below about 5,000  $\mu$ T and were normal at 700  $\mu$ T.
- Paddlefish showed no abnormal responses to EMF exposure.



### POND STUDIES

- No consistent trends of attraction or avoidance to either EMF strength when on in 2-hr blocks or for 48 hr
- Level of activity varied among the 2 species, but no consistent change in activity in response to EMF

### Mean location of 10 pallid sturgeon in paired two-hour blocks of on-off EMF at south end of pond.

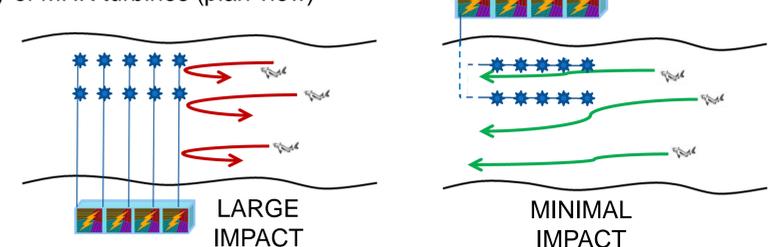


## Conclusions

- Response among freshwater fish is species-specific and primarily at high EMF levels or in close proximity to EMF sources (i.e., within 1-2 meters)
- Because response is likely only at close proximity the total affected area is small relative to width of large rivers where likely to be deployed
- Bottom oriented species (such as sturgeon) are the most likely to be affected by transmission cables
- Poorly located transmission cables could interfere with migration routes

Minimizing the amount of transmission cable that crosses migration pathways by aligning in parallel with migration direction or by burial will decrease impacts on bottom-oriented migrants

### Array of MHK turbines (plan view)



### PUBLICATION

Bevelhimer et al. 2013. Behavioral Responses of Representative Freshwater Fish Species to Electromagnetic Fields. Trans. of the American Fisheries Soc. 33:802-813.