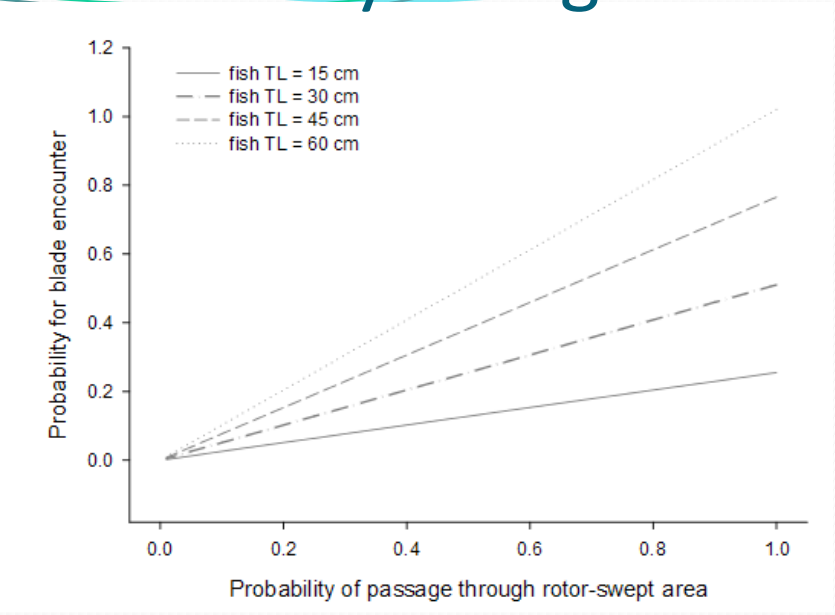
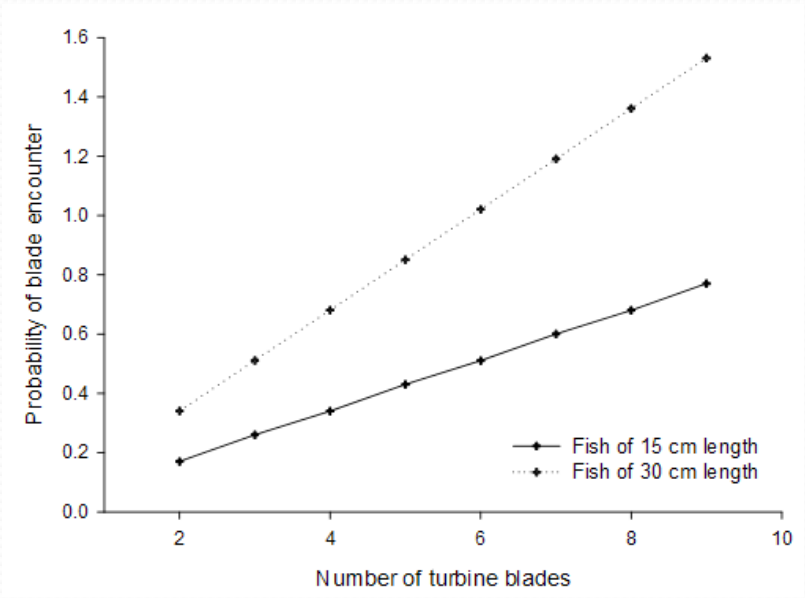
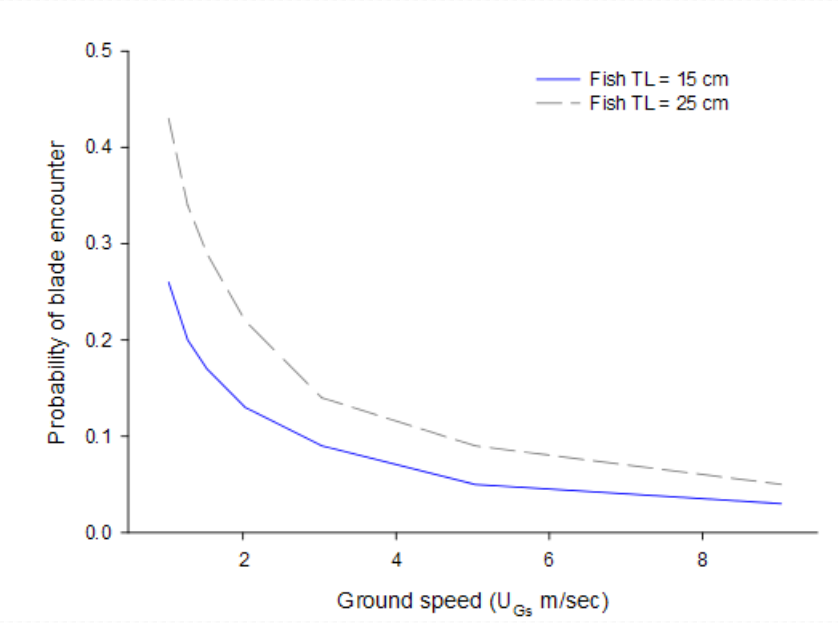
Strike Probability is a Function of Many Things

- Fish Length
- Ground speed (velocity)
- Number of Turbine Blades



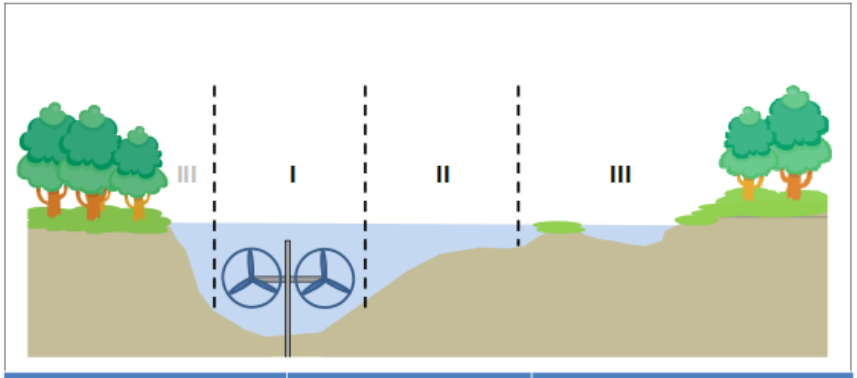




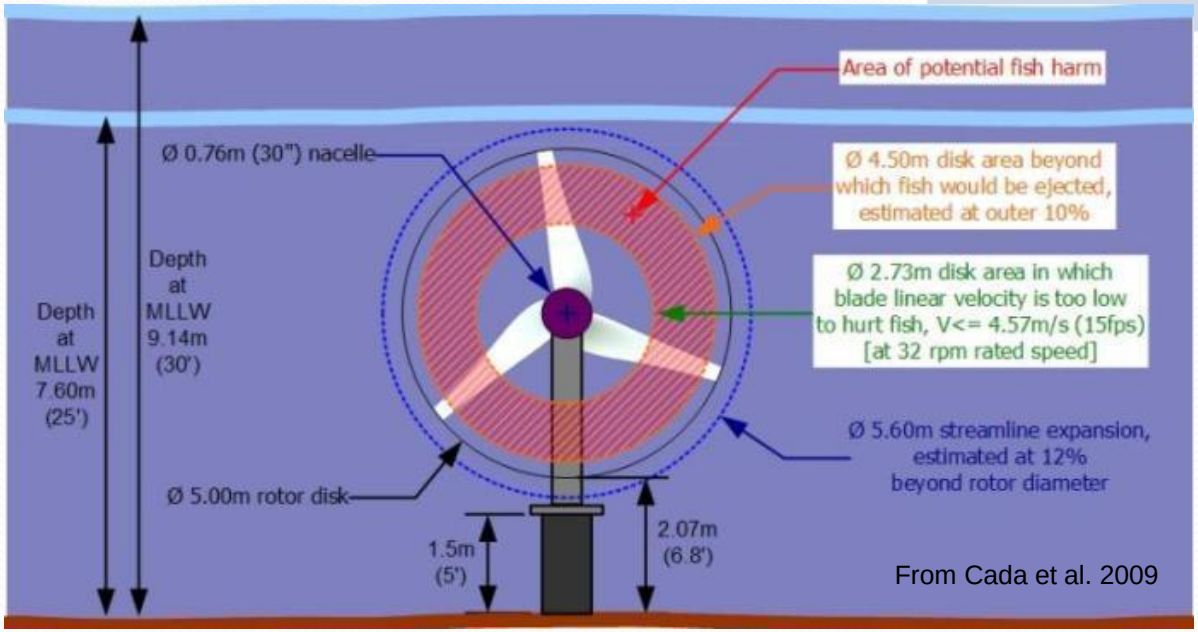
Strike Probability is a Function of Many Things

- Species-specific habitat choice and movement behavior

- Probabilities of injury differ depending on what part of blade is encountered.



I – Main channel	II – Off-channel	III – Shoreline and backwater
Freshwater drum Gizzard shad Striped bass Sauger/walleye Channel catfish Sturgeon species	Common carp Black buffalo Small mouth buffalo	Centrarchids; Spotted bass Largemouth bass Cyprinids; Emerald shiner Spotfin shiner Darter species



From Cada et al. 2009

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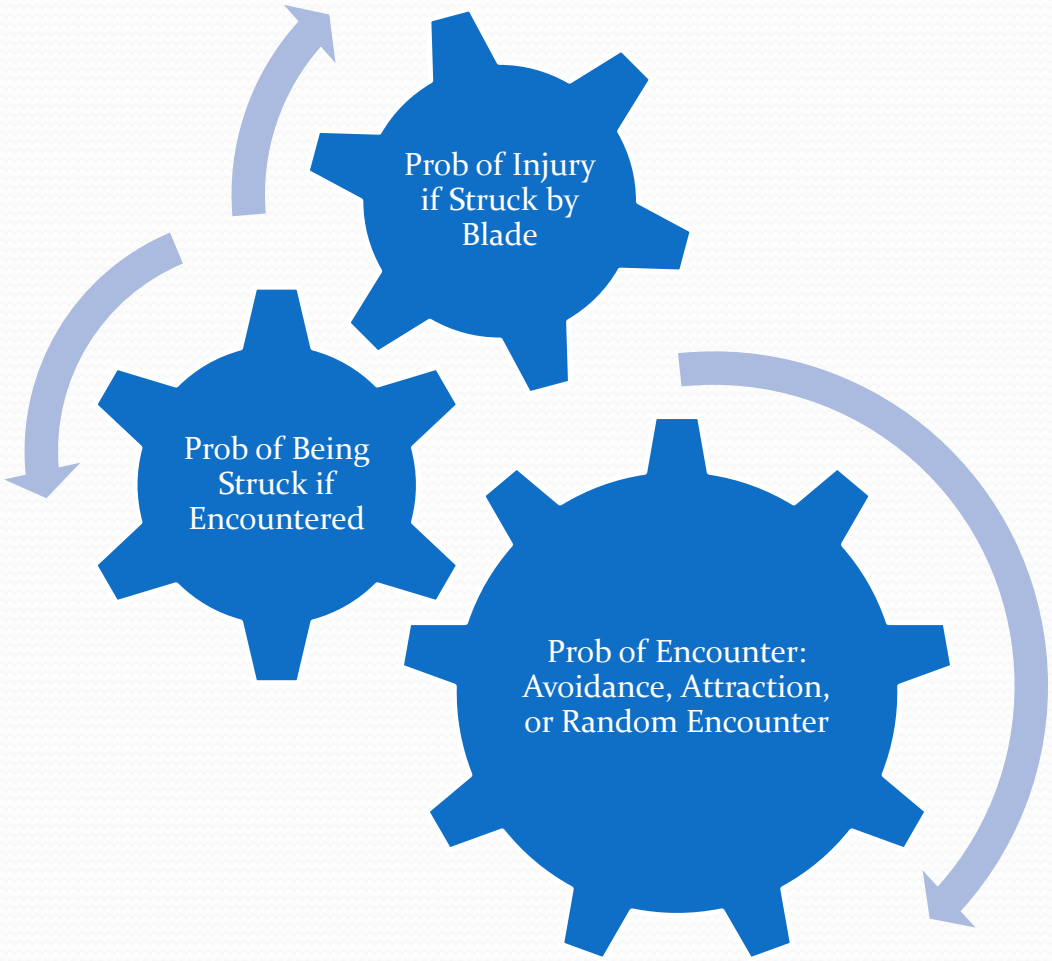
Laboratory Experiments, Field Observations, and Modeling all play a part.



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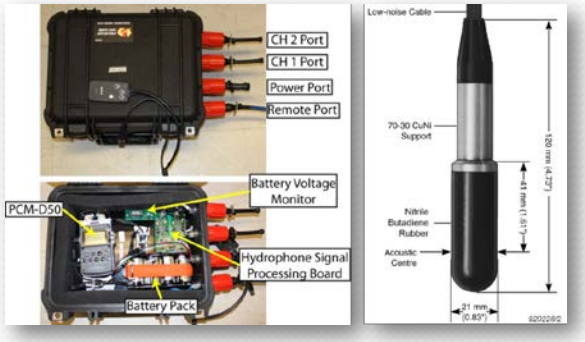
Understanding the Effects of MHK-generated Noise and EMF on Aquatic Organisms

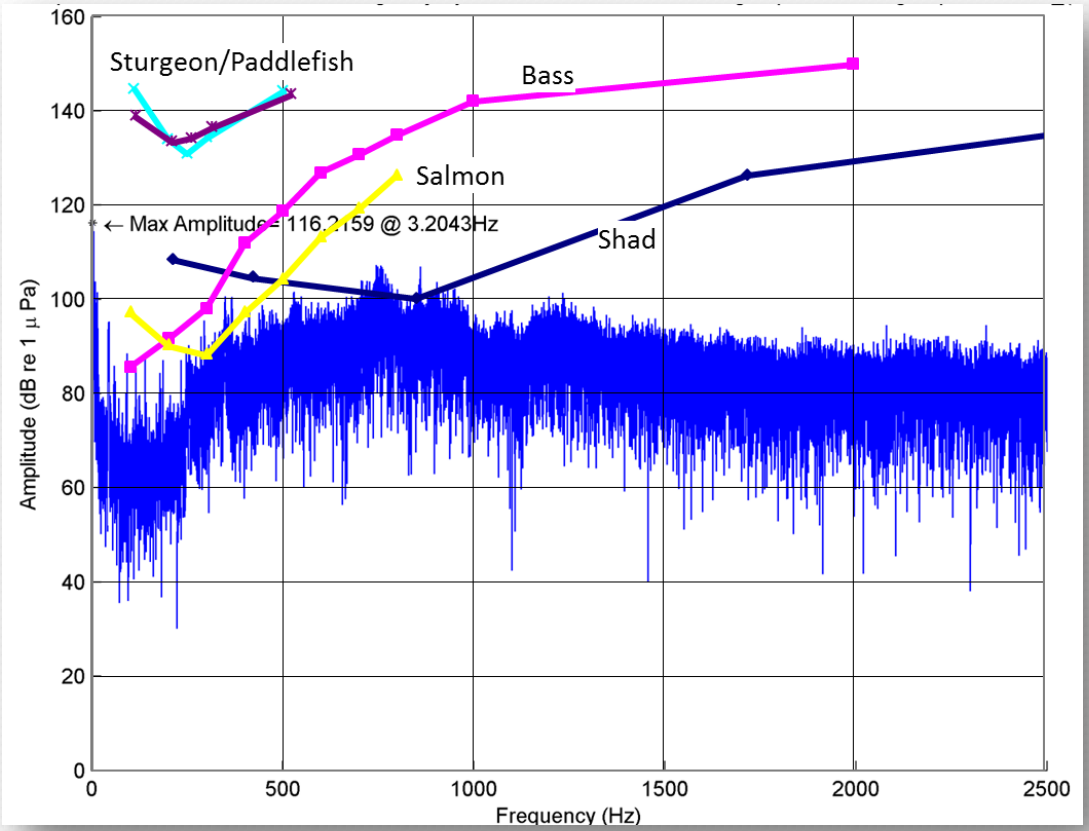
Dr. Mark Bevelhimer

Oak Ridge National Laboratory

Noise – Field Measurements

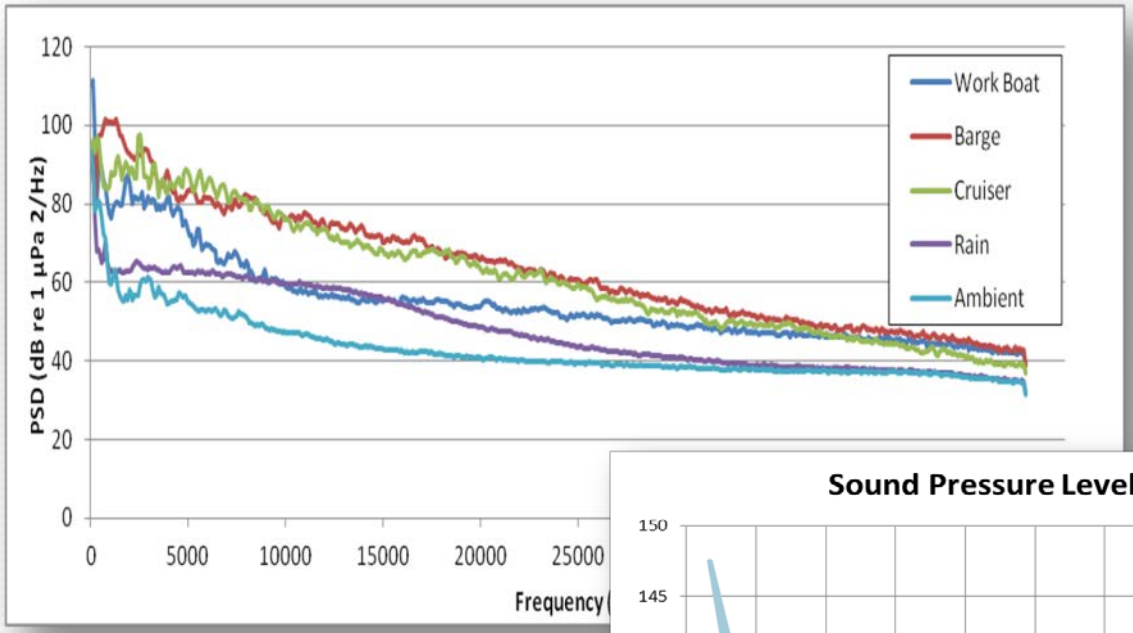
- Underwater sound emitted from a variety of natural (wind and rain) and anthropogenic sources (passing vessels of various sizes) were recorded and analyzed



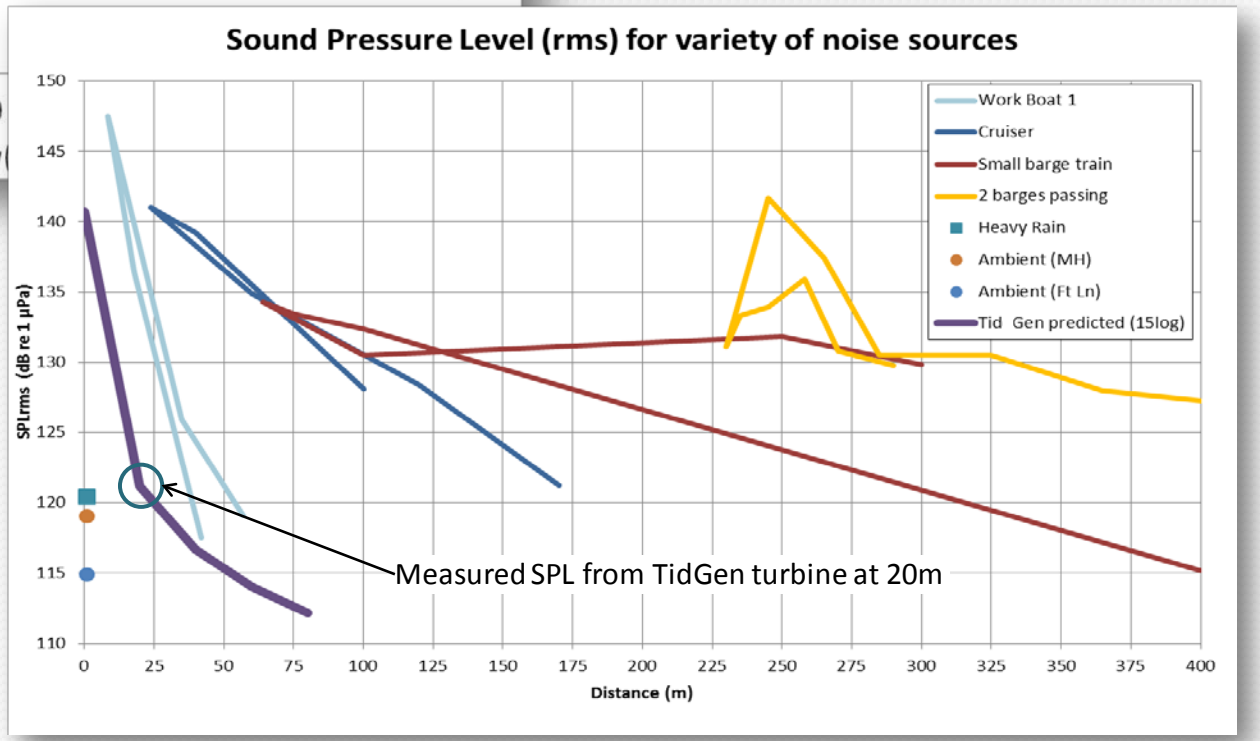


AAMI software (PNNL)
Ren et al. 2013.
Sensors 12:7438-7450
Doi:10.3390/s120607438

Noise – Field Measurements

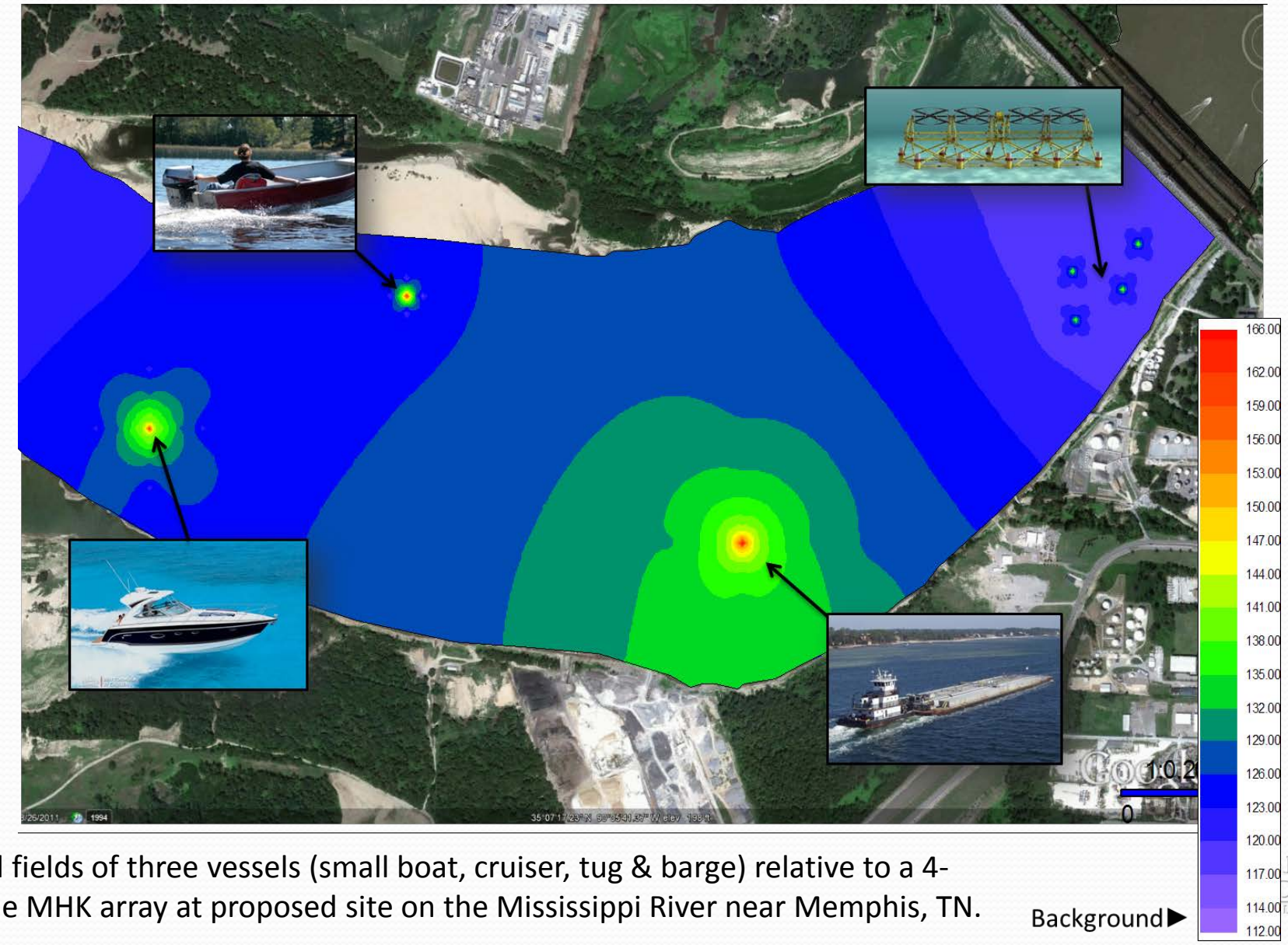


Relative power spectral densities for five noise sources: work boat with 25 hp motor, tugboat and barge train, cabin cruiser with twin diesel engines, rain, and ambient background in a non-flowing lake.



Noise levels of passing vessels of various sizes on the Tennessee and Mississippi rivers exceed measured and predicted levels of the ORPC TidGen turbine as recorded in Cobscook Bay, Maine.

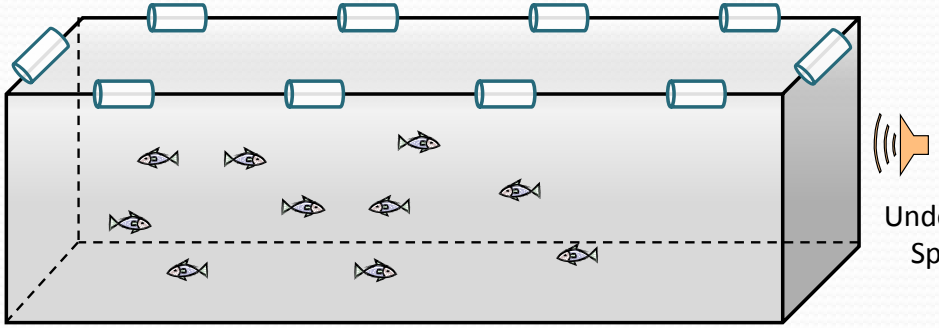
Noise – Field Measurements



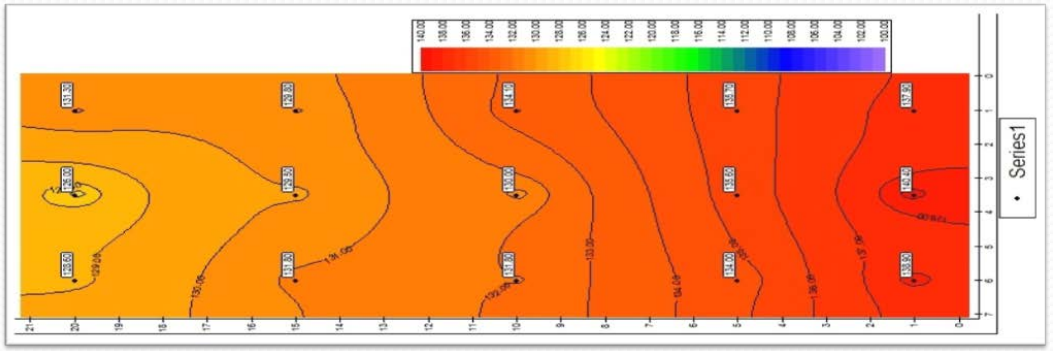
Sound fields of three vessels (small boat, cruiser, tug & barge) relative to a 4-turbine MHK array at proposed site on the Mississippi River near Memphis, TN.

Noise – Mesocosm Studies

- Behavioral responses to recorded HK device sound evaluated in net pen studies.
- Largemouth bass, paddlefish, and pallid sturgeon (7-10 at a time).
- Pre-recorded device noise replayed at different volumes representing distances of 0-60 m from device.
- Fish movement tracked by surgically implanted transmitters and submersible acoustic receivers.
- Location data used to evaluate attraction, avoidance, and change in activity.



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

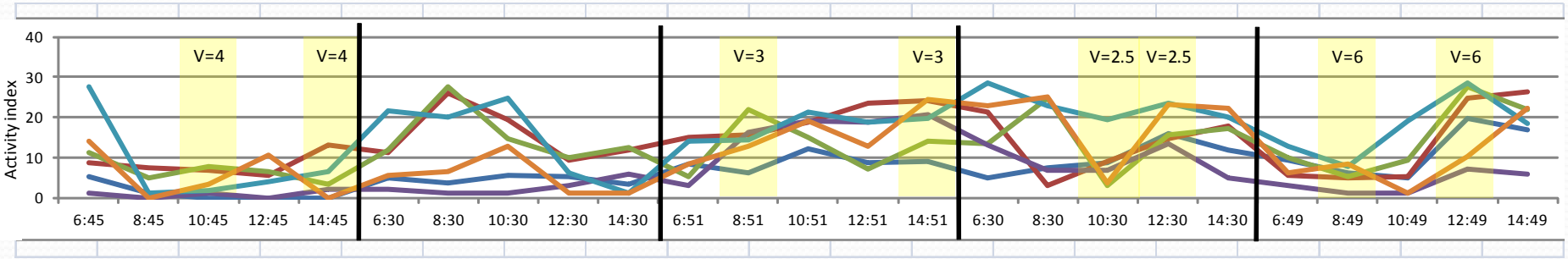


Arial view of sound levels in net pen at V=6 setting (SPL range 126-140 dB)

Noise – Mesocosm Studies

RESULTS

- Level of activity varied among the 3 species.
- No consistent trends of attraction or avoidance to the sound at any volume.
- No consistent changes in activity in response to sound at any volume.



No apparent change in activity of 6 Paddlefish in response to random 2-hr blocks (yellow) of MHK turbine noise at 4 volumes relative to periods of no sound.

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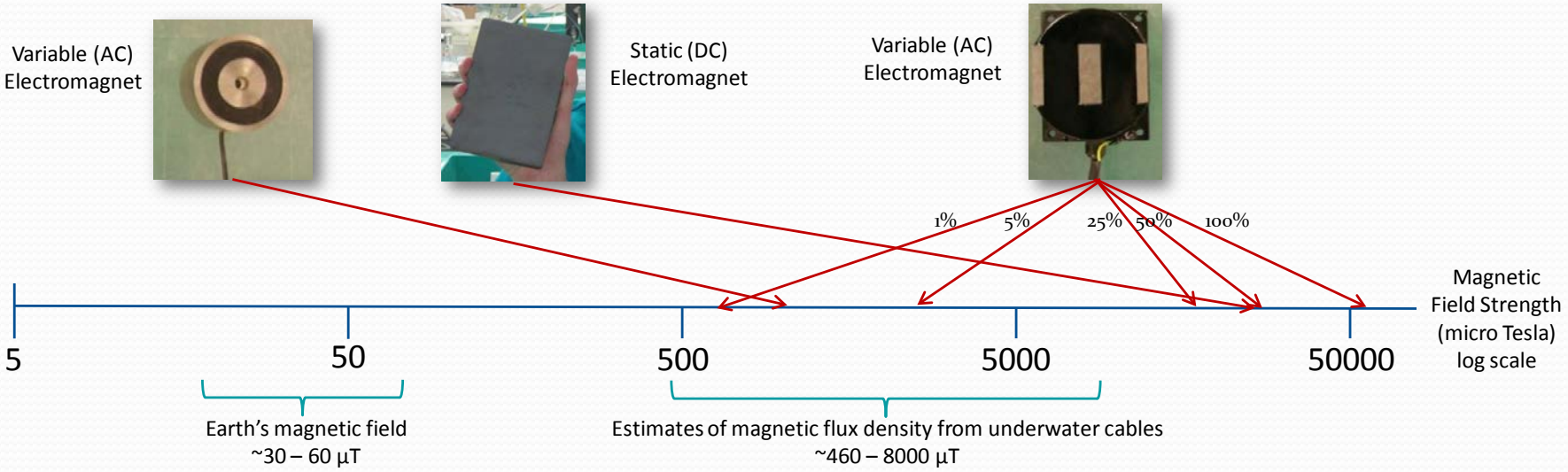
EMF – Laboratory Studies

I. SHORT-TERM EXPOSURE

II. IMMEDIATE EXPOSURE



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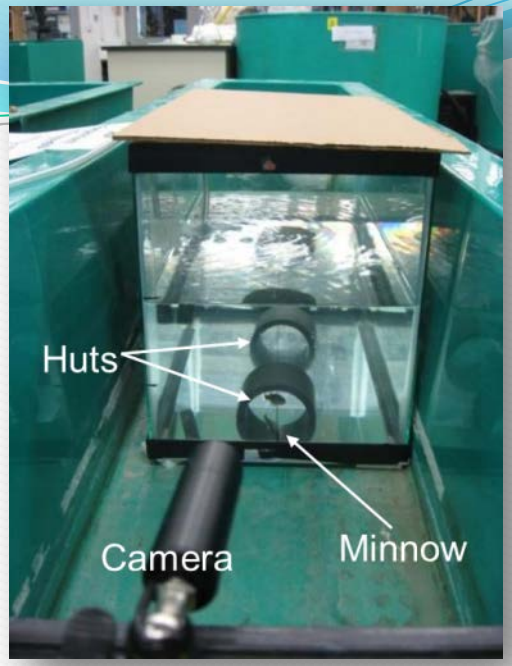
EMF – Laboratory Studies

SHORT-TERM EXPOSURE METHODS

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

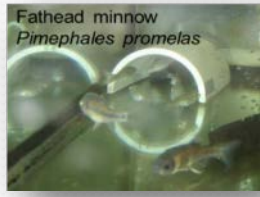


EMF – Laboratory Studies

SHORT-TERM EXPOSURE RESULTS

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

- 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.



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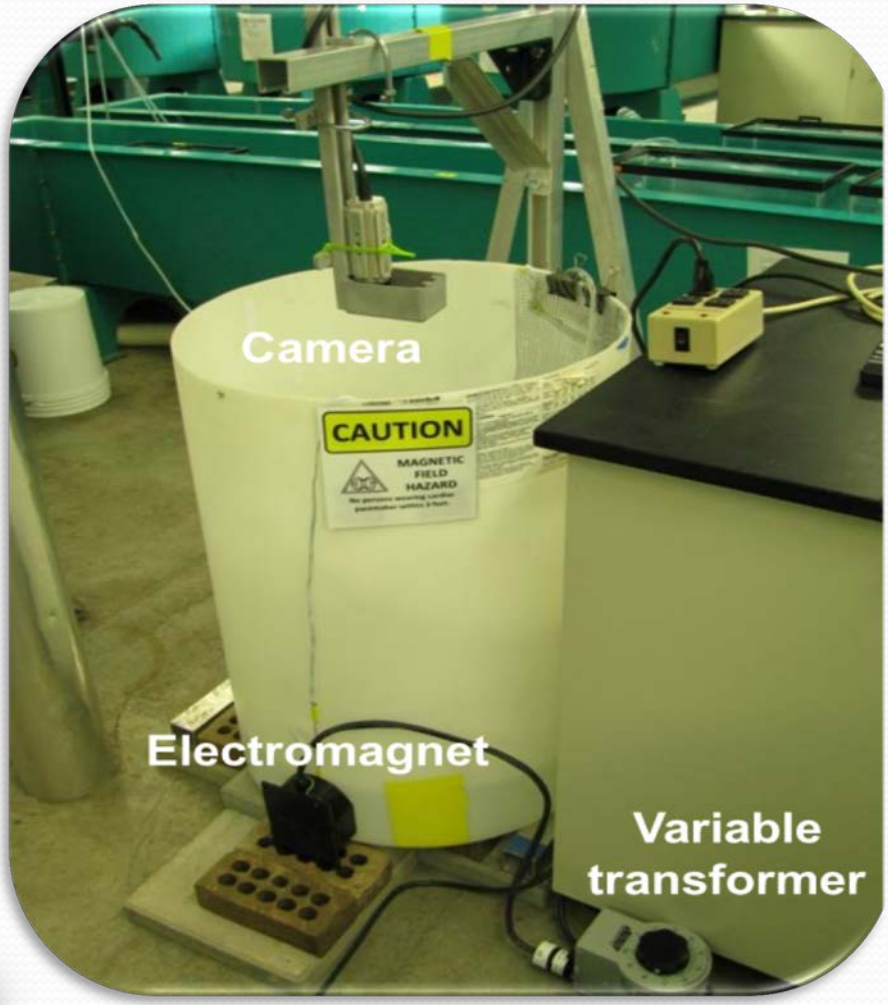
EMF – Laboratory Studies

IMMEDIATE EXPOSURE METHODS

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



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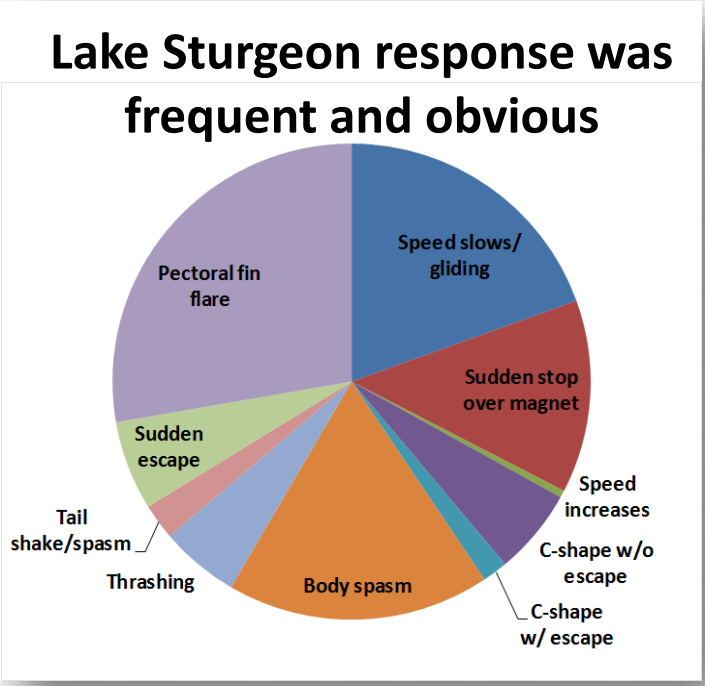
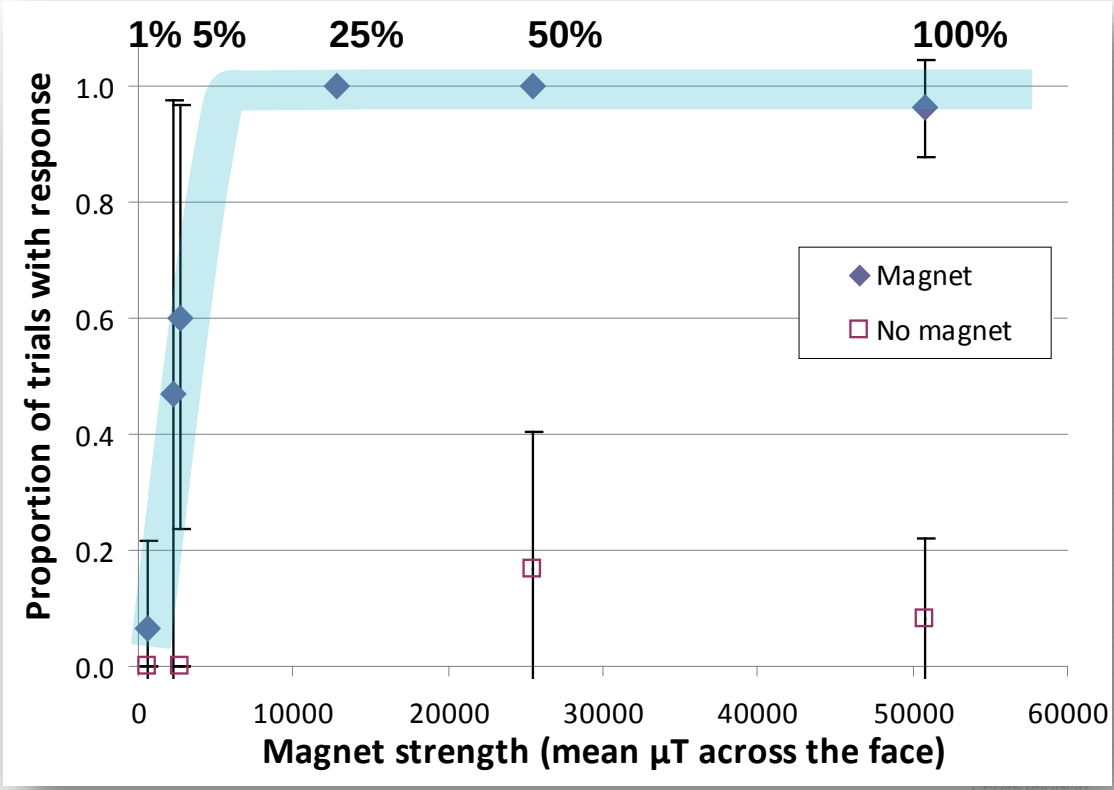
EMF – Laboratory Studies

IMMEDIATE EXPOSURE RESULTS

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



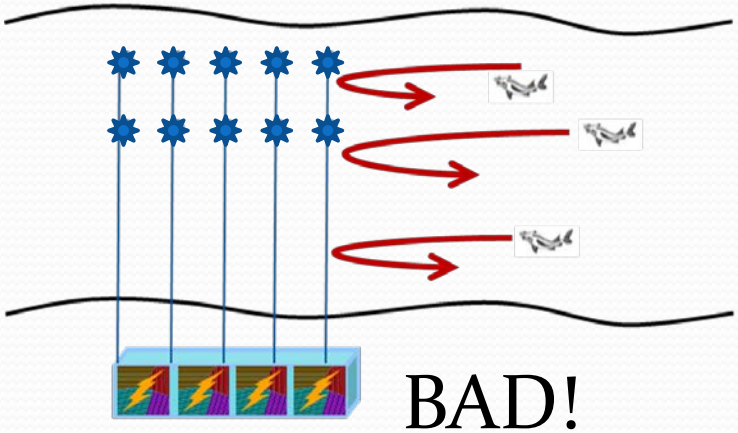


EMF – Laboratory Studies

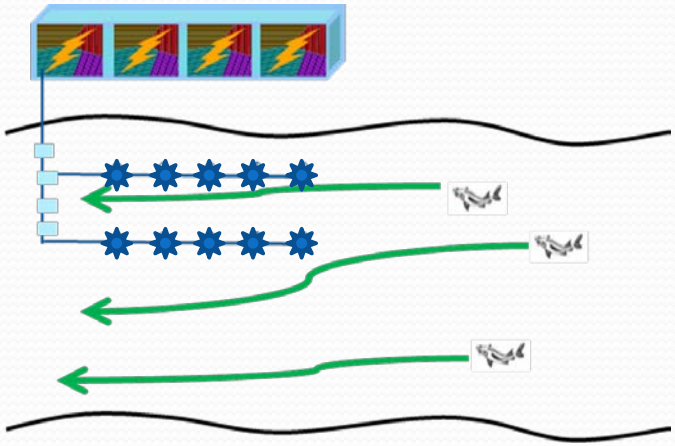
CONCLUSIONS AND IMPLICATIONS

- Response among freshwater fish is species-specific and primarily at high EMF levels or in close proximity to EMF sources.
- Minimizing the amount of transmission cable that crosses migration pathways by aligning in parallel with migration direction or by burial will decrease impacts on sturgeon.

- RIVER DEPLOYED TURBINES



BAD!



GOOD!

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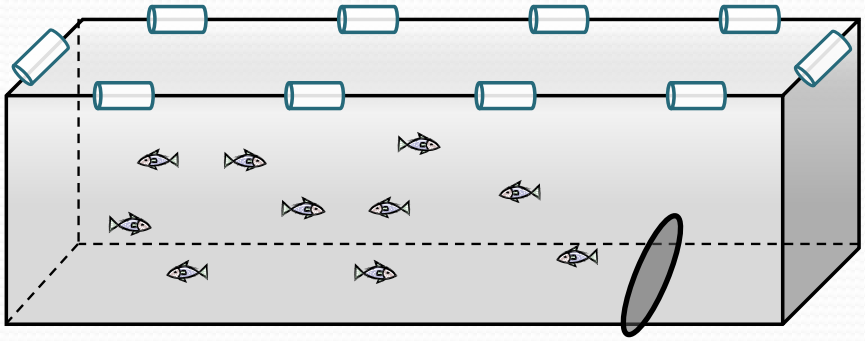
Bevelhimer et al. 2013. Trans. of the American Fisheries Soc. 33:000-000

EMF – Mesocosm Studies

- To begin soon. Will follow similar design as noise studies.
  - EMF provided in cable arrangement that will run under the net pen
  - Pallid sturgeon, padddlefish, and largemouth bass to be tested



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

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