Acoustics Exposure Experimentation for Sensitive Fish Species

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February 2017

Project Overview

Acoustics Exposure Experimentation for Sensitive Fish Species

The Challenge:

- Concern of impacts to aquatic organisms by a variety of mechanisms has slowed the licensing and deployment of marine and hydrokinetic (MHK) devices
- The effect of tidal turbine noise on fish behavior (e.g., interruption of normal movement patterns) is largely unknown and difficult to assess in high energy environments where turbines are deployed
- Active sites with operating hydrokinetic turbines for testing have been rare
- An alternative for testing was needed

The Solution:

- Noise exposure tests were conducted in an environment where exposure volume and duration could be tightly controlled and fish responses closely monitored

Partners: none

Program Strategic Priorities

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Technology Maturity

- Test and demonstrate prototypes
- Develop cost effective approaches for installation, grid integration, operations and maintenance
- Conduct R&D for Innovative MHK systems & components
- Develop tools to optimize device and array performance and reliability
- Develop and apply quantitative metrics to advance MHK technologies

Deployment Barriers

- Identify potential improvements to regulatory processes and requirements
- **Support research focused on retiring or mitigating environmental risks and reducing costs**
- Build awareness of MHK technologies
- Ensure MHK interests are considered in coastal and marine planning processes
- Evaluate deployment infrastructure needs and possible approaches to bridge gaps

Market Development

- Support project demonstrations to reduce risk and build investor confidence
- Assess and communicate potential MHK market opportunities, including off-grid and non-electric
- Inform incentives and policy measures
- Develop, maintain and communicate our national strategy
- Support development of standards
- Expand MHK technical and research community

Crosscutting Approaches

- Enable access to testing facilities that help accelerate the pace of technology development
- Improve resource characterization to optimize technologies, reduce deployment risks and identify promising markets
- Exchange of data information and expertise

Program Strategic Priorities

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The Impact

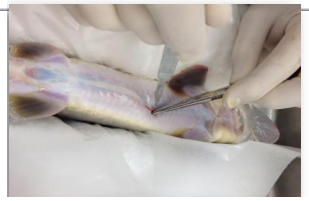
- Developers will likely have difficulty getting licenses to deploy if they are unable to convince regulators that noise created by a single turbine or an array of turbines will not significantly affect aquatic organisms.
- Knowledge of how different species of fish respond to turbine noise will help developers:
  - Inform project siting
  - Assess impact mitigation
  - Reduce impact uncertainty
  - Focus environmental studies
  - Reduce mitigation costs
  - Speed licensing
- Experimental results to be published in peer-reviewed journals and made known to stakeholders via inclusion in Pacific Northwest National Laboratory's (PNNL's) Tethys knowledgebase.

Technical Approach

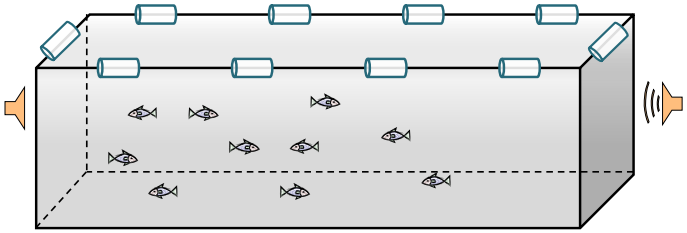
SOUND EXPOSURE STUDIES

Objective: Test the behavioral response of fish to turbine sound in net pen mesocosms.

- Largemouth bass, freshwater drum, redhorse sucker, and rainbow trout (14-20 at a time).
- Pre-recorded turbine sound replayed at different volumes and durations
- Fish location tracked by surgically implanted transmitters and submersible acoustic receivers.
- Location data used to evaluate attraction, avoidance, and change in activity.



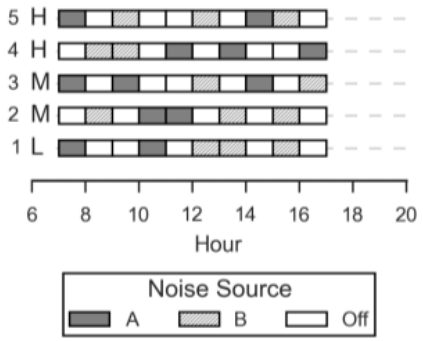
Transmitters surgically implanted for tracking.

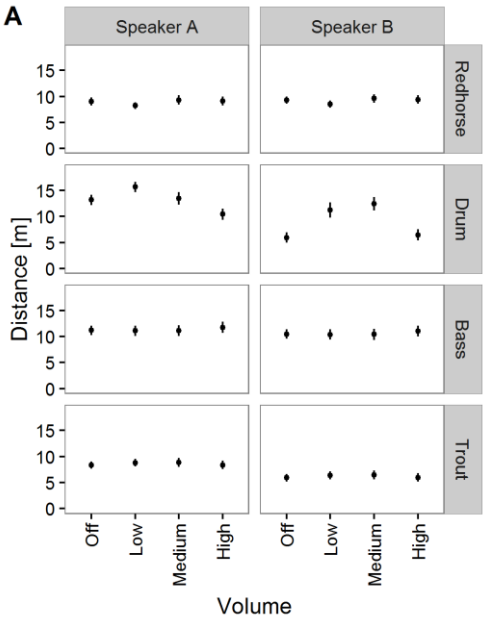


Floating Net Pen (6m wide x 20m long x 1.5m deep)

SHORT-TERM EXPOSURE

- Randomized 1-hr exposures to sound at different volumes and speakers over five days





RESULTS

- Mixed results. Only minor effects observed.
- Freshwater drum—mixed avoidance and attraction behaviors to turbine noise.
- Redhorse, bass, and trout models did not indicate any response.

Technical Approach

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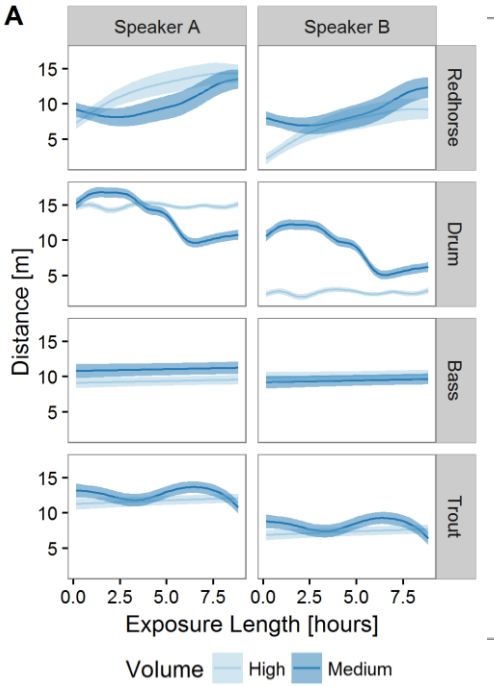
LONG-TERM EXPOSURE

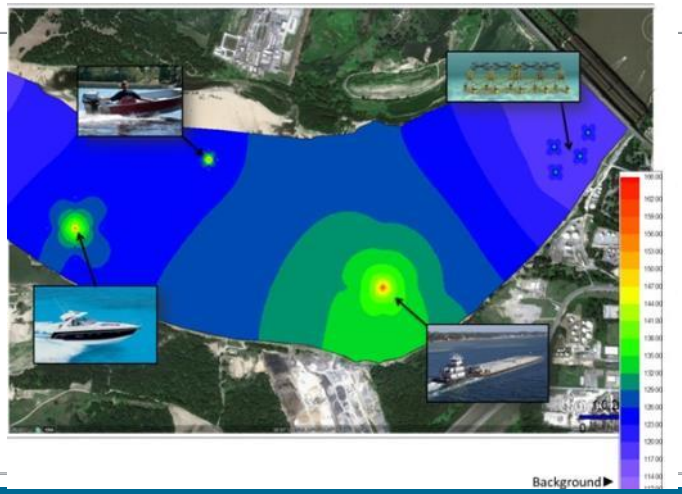
- Several blocks of 9-hr exposures to medium and high volumes

RESULTS

- Mixed results. Only minor effects observed.
- Redhorse—responded to sustained turbine noise by increasing distance from the noise source.
- Drum—mixed avoidance and attraction behaviors to turbine noise.
- Largemouth bass and rainbow trout models did not indicate any likely response.

CONCLUSION - The sound produced by a single horizontal axis turbine is unlikely to have meaningful behavioral impacts to the fish species tested.
More studies are needed; especially at operating turbines.





PUBLICATION OF PREVIOUSLY FUNDED ACOUSTIC STUDY

Objective: Compare hydrokinetic turbine sound output to other anthropogenic sources in large river setting

Results: Sound levels created by hydrokinetic turbines are lower than all vessels measured.

Conclusion: Compared to the existing noisy environment of most large rivers, the addition of one or a few turbines should contribute relatively little noise to an already noisy environment.

Accomplishments and Progress

Bottom Line:

Studies completed that provide evidence of little likely impact of turbine noise to fish in an environment that is already very noisy.

FY14

Completed pond studies with three representative fish species; completed data analysis

FY15

Completed quarry studies with four representative fish species

Published article comparing turbine and anthropogenic sounds in large rivers

Bevelhimer, M., D. Deng, and C. Scherelis. 2016. Characterizing large river sounds: Providing context for understanding the environmental effects of noise produced by hydrokinetic turbines. J. Acoustical Society of America 139(1):85-92.

FY16

Submitted article for journal publication (Fisheries Research); revised after conditional acceptance and waiting on final decision

Schramm, M., M. Bevelhimer, and C. Scherelis (in review) Effects of hydrokinetic turbine sound on the behavior of four species of fish within an experimental mesocosm.

Project Plan & Schedule

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- Experiments exposing fish to turbine noise began in late FY14 and were completed in FY15
- Data analysis and reporting was begun in FY15 and completed in FY16
- Article for journal publication submitted in FY16
- Go/No-Go decision: FY15—Gaining permission to use quarry located in a secured area of the Oak Ridge Reservation
- For a variety of logistical and equipment reasons the initiation of the quarry net pen studies was delayed putting the project behind schedule but still within budget.
  - Permission for quarry access took longer than planned and delayed our start by 5–6 months
  - Telemetry receiver system had to be designed and fabricated to synchronize signal reception of four receivers

Project Budget

Budget History					
FY2014		FY2015		FY2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$300K	$0	$0	$0	$0	$0

- Project budget has been expended.

Research Integration & Collaboration

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Partners, Subcontractors, and Collaborators:

- Oak Ridge Associated Universities for student technician
- D. Deng (PNNL) provided assistance on acoustic signal interpretation
- Ocean Renewable Power Company provided the turbine recording used in exposure experiments

Communications and Technology Transfer:

Publications

Bevelhimer, Deng, and Scherelis. 2016. Characterizing large river sounds: Providing context for understanding the environmental effects of noise produced by hydrokinetic turbines. J. Acoustical Society of America 139(1):85-92.

Schramm, Bevelhimer, and Scherelis. (Accepted with revision). Effects of hydrokinetic turbine noise on the behavior of four species of fish within an experimental mesocosm. Fisheries Research 00:000-000.

Presentations

Unconventional impacts from unconventional hydropower: The effects of hydrokinetic devices on fish. Presentation at the Western Division of the American Fisheries Society, Mazatlan, Mexico, April 7-11, 2014.

Next Steps and Future Research

FY17/Current research: Project is completed

Proposed future research:

- Better assessment of the minimum hearing thresholds of fish species likely to encounter hydrokinetic turbines
- Additional field testing with sound from a wider variety of turbine types and with different fish species
- Characterize the sound produced by different turbine designs
- Characterize the cumulative sound of turbine arrays to further assess potential ecological impacts of multiple turbines