ELECTRIC POWER RESEARCH INSTITUTE

2017 Fish Protection Technology Developments

Technical Brief — *Fish Protection (P54)*

Introduction

EPRI's key information resources on fish protection technologies for reducing impingement and entrainment are contained in the report *Fish Protection at Cooling Water Intake Structures: A Technical Reference Manual – 2012 Update* (3002000231) published in 2013. That report discusses technology design and operation, performance information, case studies, and approximate capital and O&M costs. Since its publication, there have been new applications and advancements in existing technologies for fish protection and intake O&M. EPRI tracks these developments, and this technical brief reviews important recent technology developments relative to meeting the 2014 U.S. Environmental Protection Agency (EPA) Clean Water Act § 316(b) Rule. Technologies reviewed herein include:

- Wedge wire screens
- Traveling water screens
- Curtain walls
- Barrier nets
- Behavioral barriers (electric, sound, light)

Wedge Wire Screens

Most of the new developments in fish protection technology design and application for cooling water intake structures (CWIS) relate to wedge wire screens, particularly narrow slot (<2.0 mm). The following summarizes new applications not previously reviewed by EPRI.

We Energies Valley Power Plant

The Valley Power Plant (VAPP) is located on the Menomonee River in Milwaukee, WI. This natural gas fired cogeneration facility has a design intake flow of ~172 MGD (actual intake flow ~ 107 MGD). In 2016, We Energies completed the installation of two sets of three narrow slot (2.0 mm) cylindrical wedge wire screens (Figure 1). The project involved building a new platform over the former intake forebay. The screens in operation position (Figure 2) are cleaned internally and externally with mechanical brushes (i.e., the screens rotate over the brushes) (Figure 3). The screens can also be retrieved (as illustrated in Figure 1) to the access platform for additional cleaning and inspection. Each screen has an internal flow modifier to ensure uniform flow at a design rate of 0.5 feet per second (fps). There are also emergency gates in case of blockage and a warming line to prevent frazil ice formation.

Figure 1. Cylindrical Narrow Slot (2.0 mm) Screens (3) Installed at We Energies Valley Power Plant in Milwaukee, WI [photo courtesy of We Energies]

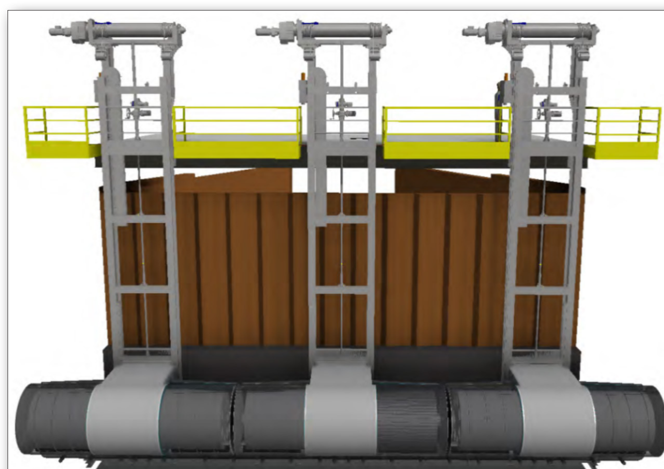

Figure 2. Schematic of cylindrical wedge wire screens in operational position [Image courtesy of We Energies/ISI]

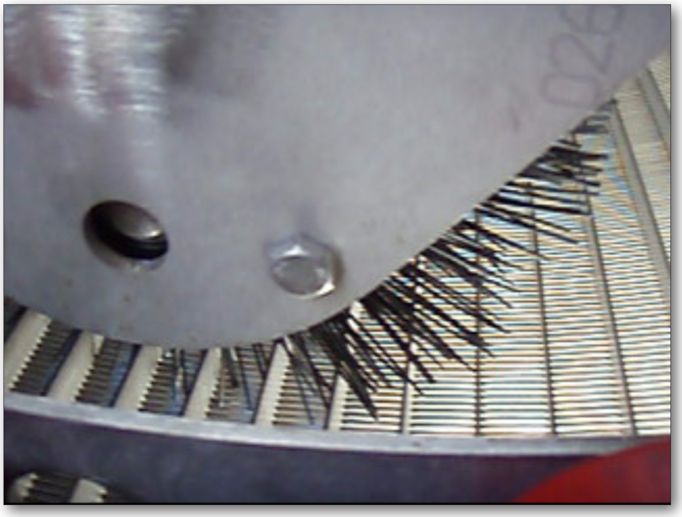

Figure 3. Internal brushes in ISI wedge wire screens (photo courtesy of ISI)

The 2.0 mm slot size was selected based on available space (river frontage and depth) and expected performance. Expected performance focused on analysis of larval fish head capsule depth (HCD) and lengths of larval fish for local ichthyoplankton. An HCD analysis (see EPRI 3002003432) for 1.75 mm indicated an estimated entrainment reduction performance of 84.5% (the combined impingement mortality and entrainment reduction estimate was ~97%). The 2.0-mm slot size was a "sweet spot" that maximized biological performance within the limited space available for the existing CWIS footprint, met EPA's definition of "fine mesh," and was close to the manufacturer's typical slot size used to make screens for the last 20 years.

An entrainment study to verify performance as recommended by Wisconsin Department of Natural Resources (WDNR) was performed in 2016. Paired sampling was conducted in the river and inside the intake forebay (after passage through the wedge wire screens) from April through September. Data analysis indicated that entrainment reduction was >78%. We Energies is awaiting WDNR's final permit entrainment Best Technology Available (BTA) determination. Proposed impingement compliance BTA was submitted for EPA Compliance Alternative 2; i.e., design through-slot velocity of < 0.5 fps.

Cayuga Power Plant

Cayuga Power Plant (formerly Milliken Station) is a coal fired plant located on the eastern shore of Cayuga Lake in central NY (Finger Lake Region) and operated by Riesling Power, LLC. In 2016, the facility (~250 MGD) installed a radial design, 16 screens, 0.75 mm slot width, cylindrical wedge wire array in 50 feet of water, 250 feet from shore (Figure 4). Fouling is controlled by rotating the wedge wire cylinders over internal and external brushes (Figures 3 and 5). The radial design was selected based on obtaining an optimal hydraulic flow based on computational fluid dynamic analysis, access to the screens and supporting structures by divers, and fish protection.

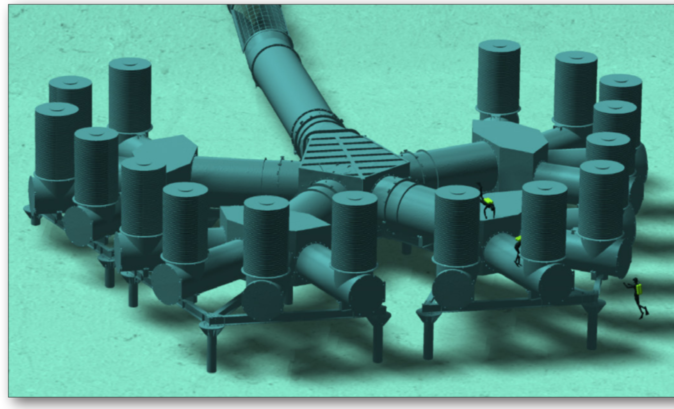

Figure 4. Schematic of deep water (50 ft) cylindrical wedge wire half screens at Cayuga Lake Power Plant in NY - note images of divers for scale of the screen system [Image courtesy of Makai Ocean Engineering]

Figure 5. Cylindrical wedge wire half screen with external (and internal) cleaning brush [photo courtesy of ISI]

Other than wind driven lake seiche, there is no "sweeping current" to move organisms away from the screens. After more than eight months in operation, there have been no O&M issues with the screens. No entrainment reduction performance information is available for the screens; however, at 0.75 mm slot width (Figure 6) and a flow of 0.5 fps, entrainment reduction of 95% or higher is expected.

Figure 6. Wedge wire slot width of 0.75 mm at Cayuga Power Station [photo courtesy of ISI]

Traveling Water Screens

There have been no major developments on the design and operation of fish protection-modified traveling water screens including band, rotary, molded polymer and vacuum screens. New screen installations have primarily been replacements because of O&M issues or because old screens had degraded to the point that replacement was required. Fish protection-modified traveling water screens will begin to be installed and optimized in greater numbers beginning in approximately 2018–2020 depending on site-specific permit schedules as the Rule is implemented.

EPRI has been engaged, however, in important fish protection-modified traveling water screen research including (1) comparison of survival between ichthyoplankton excluded by fine-mesh screens and transferred to a fish return system to those entrained through the plant cooling system, (2) research on screen optimization challenges from compliance with EPA Compliance Alternative 5, and (3) investigating the potential for intermittent rather than continuous rotation of traveling water screens. Each of these research topics are briefly reviewed in the following paragraphs.

Entrainment Survival Versus Fine-Mesh Screen Collection and Transfer Survival

In 2016, EPRI, in collaboration with Consolidated Edison of New York (ConEd) began a first ever project to compare ichthyoplankton fine-mesh traveling screen collection and transfer survival to entrainment survival at their East River Generating Station (ERGS). The project was completed in 2017 (see *Survival of Ichthyoplankton Entrained or Excluded on Fine-Mesh Screens at East River Generating Station* 3002007590 for details on the methodology, results and their interpretation). The conclusion of this study was that fish eggs survive entrainment at the ERGS substantially better than they survive exclusion by fine-mesh screens. Exclusion of entrainable organisms as an entrainment mortality reduction strategy is only reasonable if excluded organisms will survive better than entrained organisms. The results for fish eggs (too few larvae were collected to draw conclusions for this life stage) demonstrated that the use of fine-mesh screen panels on the dual-flow traveling screens will not reduce entrainment mortality at the ERGS. Because of this project, ConEd's ERGS permit director, New York State Department of Environmental Conservation, allowed the facility to remove the fine-mesh panels which had become an O&M problem due to clogging.

Recognizing that the ConEd ERGS results are for one location under one set of plant operating conditions and only for eggs of a few marine species, EPRI has continued the research to develop a more robust data set on this subject. In 2017, EPRI initiated a collaborative project with DTE Energy at their Monroe Generating Station on eastern Lake Erie. The sampling design and implementation matched what was utilized at ERGS. At Monroe, the majority of collected ichthyoplankton were larval stages rather than eggs. Results to date are preliminary but are consistent with that observed at ERGS; i.e., larvae that are entrained survive better than those excluded and collected by fine-mesh traveling screens. Results from Monroe will be published in the Spring of 2018.

Traveling Water Screen Optimization R&D Summary

The 316(b) Rule's Impingement Compliance Alternative 5 – Use of Fish Protection-modified Traveling Water Screens and a Fish Return System is the most likely compliance alternative to be implemented by the power industry. This is because replacing existing screens is relatively easy compared to the costs associated with the other EPA impingement reduction compliance alternatives unless a facility already has an installed BTA. However, this alternative does require that the screens and fish return system performance be optimized in a two-year field study following their installation. Optimization involves finding the combination of operational (e.g., screen rotation speed, spray wash pressure, fish return water depth and velocity) and maintenance practices (e.g., system inspection and cleaning) that maximizes fish survival.

In 2015, EPRI began a research project involving field and laboratory flume studies to investigate the technical challenges involved in conducting optimization studies. The long-term goal is a technical resource document describing the EPA regulatory requirements, methods for conducting optimization studies, challenges to be overcome and findings on the field and laboratory efforts. The first technical update was published in 2015 titled *Traveling Water Screen Optimization Technical Resource Report: 2015 Technical Update* (3002006308). For the initial field studies, EPRI teamed with Alabama Power Company to investigate optimization challenges at their Barry Generating Station (with molded polymer fish protection modified screens) on the Mobile River near Mobile, AL and their Gorgas Generating Station (with traditional band fish protection-modified screens) on the Bankhead Reservoir an impounded section of the Black Warrior River. The first report from this collaboration was *Ristroph-modified Traveling Water Screen Fish Impingement and Survival Case Study* *at Plant Gorgas Generating Station* (2015, 3002003380). Two additional reports are in preparation for early 2018 publication (1) *Laboratory Traveling Water Screen Optimization Evaluations* (30020TBD) and (2) *Traveling Water Screen Optimization Field Demonstration: Plant Barry and Gorgas Generating Stations* (3002008265). The results of these two research projects will be presented in an updated Technical Resource Document along with additional information on optimization challenges and approaches. Key EPRI preliminary research findings to date include:

- Securing a sufficient sample size (impinged fish) to detect significant differences in survival for different operational practices will be a major challenge during optimization studies;
- Field and laboratory studies have failed to detect differences in survival associated with screen rotation speed/impingement duration and spraywash pressure.
- Laboratory thermal exposure tests simulating fish return discharge to a thermal effluent indicated that discharge of recovered fish from a screen into significantly warmer water during fall-winter-spring months had high survival; however, discharge to thermal effluents during summer months could lead to high mortality rates for some fish species.

Despite research conducted to date, optimizing fish protection-modified traveling screens and fish return systems will likely be a challenge for industry. EPRI plans to continue to pursue research in 2018 that can yield results to simplify their conduct and potentially avoid costly repetitive compliance studies with an unlikely probability of success.

Evaluation of Intermittent Screen Operation

EPA's definition of "fish protection modified traveling water screens" includes "continuous or ***near continuous***" [underline is emphasis added as subsequently explained] rotation of the screens. The Rule or its supporting information does not define "near continuous". Continuous rotation requires a constant power draw for all screens and pumps and the rotation can impart significant wear and tear on the screens and resulting in higher O&M costs and, potentially screen replacement. One rough estimate of the additional power requirements is $300,000 per year to support five screens. O&M may require one screen overhaul per year at $100,000. Additional costs for continuous screen operation, therefore, may approach $500,000/year for small intakes and as much as $1 million or more for facilities with 10 or more screens. Given that impingement is typically episodic and not chronic, near-continuous or intermittent operation offers opportunity for significant cost savings to power plant operations.

In 2017, EPRI, in collaboration with ConEd, initiated a project to compare fish impingement survival under continuous rotation and various intermittent rotation periods at their ERGS. Sampling, or attempts to sample, began in June and continued for 11 weeks until they were suspended in October. None of the sampling events (44 total) collected sufficient impinged fish to detect significant differences in fish survival for the screen rotation scenarios under study (sample size ranged from a low of two fish to a maximum of 58 fish and 7 weekly events had samples of less than 10 fish).

The issue of sample size was noted above under the traveling screen optimization issue. Laboratory flume studies and pilot screens allow for control of sample size and different fish species. EPRI is considering pursuing such a study to evalaute intermittent screen survival performance in 2018. EPRI is also considering re-starting the field project with ConEd again in 2018 with a focus on spring sampling when impingement numbers are typically higher at the station. EPRI is also considering laboratory and field testing the utility of hydroacoustics for detecting fish in intake bays and triggering screen rotation. As a precursor to these potential projects, EPRI has initiated a literature review of existing studies as well as desktop analyses of a theoretical hydroacoustic application for a prototypical CWIS to evaluate feasibility. Results of the literature review will be available by spring of 2018.

Curtain Walls

In 2017, EPRI published *Curtain Wall Entrainment Reduction: Literature Review and Study Plan* (3002008263).

Efforts to identify viable entrainment reduction technologies for once-through cooled power plants increased after the Rule was implemented. Typical shoreline power plant intakes withdraw cooling water from the water column at depth or near the surface. Installation of a curtain, skimmer, or baffle wall in front of the intake structure facilitates cooling water withdrawal from lower strata of the water column, which could potentially result in entrainment reductions when compared to an unwalled intake structure. A wall designed with openings along the bottom acts to passively screen pelagic or buoyant entrainable organisms by utilizing the natural hydrodynamics of the waterbody, while taking an organism's behavior and ecology into account. Furthermore, in deeper waterbodies, the water column may become stratified from a salinity gradient or varying temperature gradients and larval fish and shellfish may become stratified either in response to the water column stratification or another environmental or behavioral cue. Because larval distribution can be influenced by fish behavior, larval stratification can occur in mixed or stratified water columns.

A literature search was conducted to compile and review peer-reviewed journal articles and industry reports on the efficacy of walls on reducing entrainment. Results from one study indicated entrainment reduction with only a few taxa-life stage combinations, while the majority of entrainable organisms in the waterbody did not benefit from a wall. Results from five other studies, however, documented substantial entrainment reductions where a wall was in place. No clear determination can be made from these previous studies, but considerable entrainment reduction was noted under most scenarios that included a wall. Water column mixing and water depth did not appear to be significant determining factors, but at one facility, raising the wall opening slightly off the waterbody bottom did prove beneficial for some taxa whose larvae resided near the bottom. A small ledge or other structure that shifts the wall opening above the bottom reduced entrainment of bottom-associated larvae. Based on the literature review, a generic study plan was developed for a facility with identical, but independent, intakes (one walled and the other unwalled) that could be tested to determine the wall's efficacy at reducing entrainment.

The literature review indicates that walls may be an effective method for reducing entrainment; however, the supporting data are extremely limited. Because this technology can be inexpensive compared to other entrainment reducing options, further research is needed to eliminate some of the uncertainty associated with biological performance. The study plan included in the report may be used as the basis for further research and development (R&D) to be pursued in 2018.

Barrier Nets

Barrier nets are a low cost alternative for controlling impingement either as part of EPA Compliance Alternative 2 when they are designed with a 0.5 fps through net velocity and deployed year-round or as part of the system of technologies in EPA Compliance Alternative 6. EPRI Information on barrier nets is contained in (1) *Cooling Water Intake Structure Fish Protection Reference Manual* (2013, 3002000231), (2) *Design Considerations and Specifications for Fish Barrier Net Deployment at Cooling Water Intake Structures* (2008, 1013309), and (3) *Numeric and Physical Model Study of Fish Barrier Net Designs for Large Rivers* (2008, 1016808).

The key issue with barrier nets, where they can be deployed, is O&M and associated costs, particularly biofouling (e.g., hydroids, mussels). In 2018, EPRI is considering research on net panels in frames in several different waterbodies to determine fouling rates, fouling organism types, and ease of cleaning biofouling organisms. Variables to be evaluated would include waterbody type, salinity, water depth, mesh material, and treated vs. untreated fibers.

Behavioral Barriers

Electric Barriers for Fish Protection at Cooling Water Intakes: 2017 Update (3002011590) is an update of an EPRI report published in 2014. The report has been updated with the most recent information on electric barrier use and performance. A summary of the new report follows.

Electric barriers have been used to modify fish behavior. However, there has been limited application at CWIS in the U.S. One of the options for reducing impingement mortality would be installation of an integrated system of technologies, practices, and operational measures (Compliance Alternative 6). Despite their infrequent application, electric barriers could be considered for application at CWIS. This report reviews the factors that impact electric barrier design, vendor-specific information on the commercial electric barriers, impacts of electric fields on fish, and case studies on the performance of electric barriers used to modify fish behavior.

The following behavioral barrier papers have been recently published in the peer-reviewed literature. The citation, internet access link for purchase, and abstract for each paper is provided.

Tomanova, S., D. Courret, A. Alric. 2017. Protecting fish from entering turbines: the efficiency of a low-sloping rack for downstream migration of Atlantic salmon smolts. *La Houille Blanche-Revue Internationale de l'eau* I:11-13. https://hal.archives-ouvertes.fr/hal-01591909/.

In April 2015, the efficiency of a system of low-sloping rack and bypass has been assessed for Atlantic salmon smolts at the small hydroelectric plant (HEP) of Auterrive on the Gave d'Oloron River (France; turbine discharge: 7.8 m^3s^{-1}; rack inclination: 26° relative to the horizontal; bar spacing: 20 mm ; bypass discharge: 0.5 m^3s^{-1}). 239 hatchery smolts (mean length 185 mm) were PIT-tagged and released 100 m upstream the HEP, in 5 groups at different times of the day. Their passages downstream the HEP by the bypass and as well by the fishpass for upstream migration were monitored with RFID antennae. On average 80.7% of smolts migrated through the HEP bypass and 3.8% of smolts descended through the fishpass. In total, 84.5% (min-max: 75.5–91.9%) of smolts migrated downstream the HEP via safe routes. 50% of them did it in less than 23 minutes since their release and 75% of them did it in less than 2 hours. Fish migration time was similar for afternoon, evening and night releases (median times between 19 and 21min), but was significantly longer when the fishes were released in the morning (median migration time: 3hours 17min). Our findings give credence to the recommended design criteria for low-sloping racks, which is the main solution implemented in France for small HEPs.

Ford, M. I., C. K. Elvidge, D. Baker, T. C. Pratt, K.E. Smokorowski, P. Patrick, M. Sills, and S. J. Cooke. 2017. Evaluating a light-louver system for behavioural guidance of age-0 white sturgeon. *River Research and Applications* 33(8): 1286-1294. http://dx.doi.org/10.1002/rra.3186**.**

Water diversions for hydropower and other applications are some of the most disruptive alterations affecting fish populations in lotic systems. Although many different strategies have been developed to reduce lethal encounters with such infrastructure, few studies have evaluated different forms of behavioural guidance concurrently. Here, we combine an LED-based light guidance device (LGD) equipped with adjustable wavelength and strobing output with a reverse-configured louver rack to assess the effectiveness of this two-part behavioural guidance system on downstream movement through a bypass by age-0 white sturgeon (*Acipenser transmontanus*). Several combinations of LGD and louver settings were tested under simulated day and night (low light) conditions in a laboratory setting. In the absence of the LGD, louver slat spacings of 10 or 20 cm were most effective at achieving downstream bypasses with greater success rates (~ two-fold greater) under night conditions than under day conditions. Incorporating the LGD operating at the most attractive setting (green light strobing at 20 Hz) with the louver spacings of 10 or 20 cm achieved the highest rates of bypass usage (100% and 97%, respectively) under day and night conditions while the control treatment (no LGD or louver) resulted in the lowest bypass rate (46%) among fish that moved downstream. Collectively, these results demonstrate that complementary cues can enhance the behavioural guidance of fishes and highlight the importance of continuing to explore the use of multiple strategies to mitigate entrainment for high priority fish species.

Jones, M. J., L. J. Baumgartner, B. P. Zampatti and K. Beyer. 2017. Low light inhibits native fish movement through a vertical-slot fishway: Implications for engineering design. *Fisheries Management and Ecology* 24(3):177-185. http://dx.doi.org/10.1111/fme.12205**.**

Light intensity within a vertical-slot fishway was manipulated to determine the effect on fish movement. Three treatments (darkness, low light, artificial light) were tested with natural daylight used as a control. Light intensity varied from 0 to 1,692 lux for the three treatments and from 1 to 4,550 lux for the control. Light intensity outside the fishway ranged from 31 to 80,900 lux. A total of 64,385 fish were collected from six species. The abundance of Australian Smelt *Retropinna semoni* (Webber), Unspecked Hardyhead *Craterocephalus stercusmuscarum fulvus Ivantsoff* (Crowley and Allen), Bony Herring *Nematalosa erebi* (Günther), Carp Gudgeon *Hypseleotris* spp. and Eastern Gambusia *Gambusia holbrooki* (Girard) moving upstream reduced significantly under low-light conditions. Conversely, movement of macroinvertebrates (freshwater shrimp *Macrobrachium australiense* Holthuis and freshwater prawn *Paratya australiensis* Kemp) increased at low-light intensities. The number of fish moving under artificial light (28,617) was similar to that under natural daylight (33,919). Movements of Australian freshwater fish and macroinvertebrates were found to be influenced by changes in light intensity. Instream structures that alter light conditions, such as road culverts, may thus act as behavioural barriers to fish movement, and this could be mitigated by the provision of natural or artificial light.

Murchy, K. A., A. R. Cupp, J. J. Amberg, B. J. Vetter, K. T. Fredricks, M. P. Gaikowski and A. F. Mensinger. 2017. Potential implications of acoustic stimuli as a non-physical barrier to silver carp and bighead carp. *Fisheries Management and Ecology* 24(3):208-216. http://dx.doi.org/10.1111/fme.12220**.**

The effectiveness of an acoustic barrier to deter the movement of silver carp, *Hypophthalmichthys molitrix* (Valenciennes) and bighead carp, *H. nobilis* (Richardson) was evaluated. A pond (10 m × 5 m × 1.2 m) was divided in half by a concrete-block barrier with a channel (1 m across) allowing fish access to each side. Underwater speakers were placed on each side of the barrier opening, and an outboard motor noise (broadband sound; 0.06–10 kHz) was broadcast to repel carp that approached within 1 m of the channel. Broadband sound was effective at reducing the number of successful crossings in schools of silver carp, bighead carp and a combined school. Repulsion rates were 82.5% (silver carp), 93.7% (bighead carp) and 90.5% (combined). This study demonstrates that broadband sound is effective in deterring carp and could be used as a deterrent in an integrated pest management system.

Vetter, B. J., K. A Murchy, A. R. Cupp, J. J. Amberg, M. P. Gaikowski, and A. F. Mensinger. 2017. Acoustic deterrence of bighead carp (*Hypophthalmichthys nobilis*) to a broadband sound stimulus. *Journal of Great Lakes Research* 43(1):163-171. http://www.sciencedirect.com/science/article/pii/S0380133016302155.

Recent studies have shown the potential of acoustic deterrents against invasive silver carp (*Hypophthalmichthys molitrix*). This study examined the phonotaxic response of the bighead carp (*H. nobilis*) to pure tones (500–2000 Hz) and playbacks of broadband sound from an underwater recording of a 100 hp outboard motor (0.06–10 kHz) in an outdoor concrete pond (10 × 5 × 1.2 m) at the U.S. Geological Survey Upper Midwest Environmental Science Center in La Crosse, WI. The number of consecutive times the fish reacted to sound from alternating locations at each end of the pond was assessed. Bighead carp were indifferent to the pure tones with median consecutive responses ranging from 0 to 2 reactions away from the sound source. However, fish consistently exhibited significantly (P < 0.001) greater negative phonotaxis to the broadband sound (outboard motor recording) with a median response of 20 consecutive reactions during the 10 min trials. In over 50% of broadband sound tests, carp were still reacting to the stimulus at the end of the trial, implying that fish were not habituating to the sound. This study suggests that broadband sound may be an effective deterrent to bighead carp and provides a basis for conducting studies with wild fish.

Miehls, S. M., N. S. Johnson, and P. J. Hrodey. 2017. Test of a Nonphysical Barrier Consisting of Light, Sound, and Bubble Screen to Block Upstream Movement of Sea Lampreys in an Experimental Raceway. *North American Journal of Fisheries Management* 37(3):660-666. [http://dx.doi.org/10.1080/02755947.2017.1308892.](http://dx.doi.org/10.1080/02755947.2017.1308892)

Control of the invasive Sea Lamprey *Petromyzon marinus* is critical for management of commercial and recreational fisheries in the Laurentian Great Lakes. Use of physical barriers to block Sea Lampreys from spawning habitat is a major component of the control program. However, the resulting interruption of natural streamflow and blockage of nontarget species present substantial challenges. Development of an effective nonphysical barrier would aid the control of Sea Lampreys by eliminating their access to spawning locations while maintaining natural streamflow. We tested the effect of a nonphysical barrier consisting of strobe lights, low-frequency sound, and a bubble screen on the movement of Sea Lampreys in an experimental raceway designed as a two-choice maze with a single main channel fed by two identical inflow channels (one control and one blocked). Sea Lampreys were more likely to move upstream during trials when the strobe light and low-frequency sound were active compared with control trials and trials using the bubble screen alone. For those Sea Lampreys that did move upstream to the confluence of inflow channels, no combination of stimuli or individual stimulus significantly influenced the likelihood that Sea Lampreys would enter the blocked inflow channel, enter the control channel, or return downstream.

Kim, J. and N. E. Mandrak. 2017. Effects of strobe lights on the behaviour of freshwater fishes. *Environmental Biology of Fishes* 100(11):1427-1434. https://doi.org/10.1007/s10641-017-0653-7.

When dealing with invasive fishes, permanent barriers may be best in preventing spread; however, they may not be feasible due to various costs and/or logistical constraints. Alternatively, various non-permanent barriers using electricity, light, sound, pressure, bubbles, and CO_2 are being developed and deployed in efforts to limit the spread of aquatic invasive species or to achieve fish guidance and conservation. However, the effectiveness of these barriers is variable, and testing is often lacking for target and non-target species. We conducted a series of laboratory trials to examine the effects of strobe light on behaviour of Common Carp, Brown Bullhead, and Largemouth Bass. In response to strobe lights, Common Carp and Brown Bullhead stayed significantly farther away compared to the control period and resumed their normal activity once the strobe light was turned off. This suggests that strobe lights may prove to be a useful fish deterrent in the field. Our results also highlight the importance of examining the response of target and non-target species when evaluating fish deterrent technologies.

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