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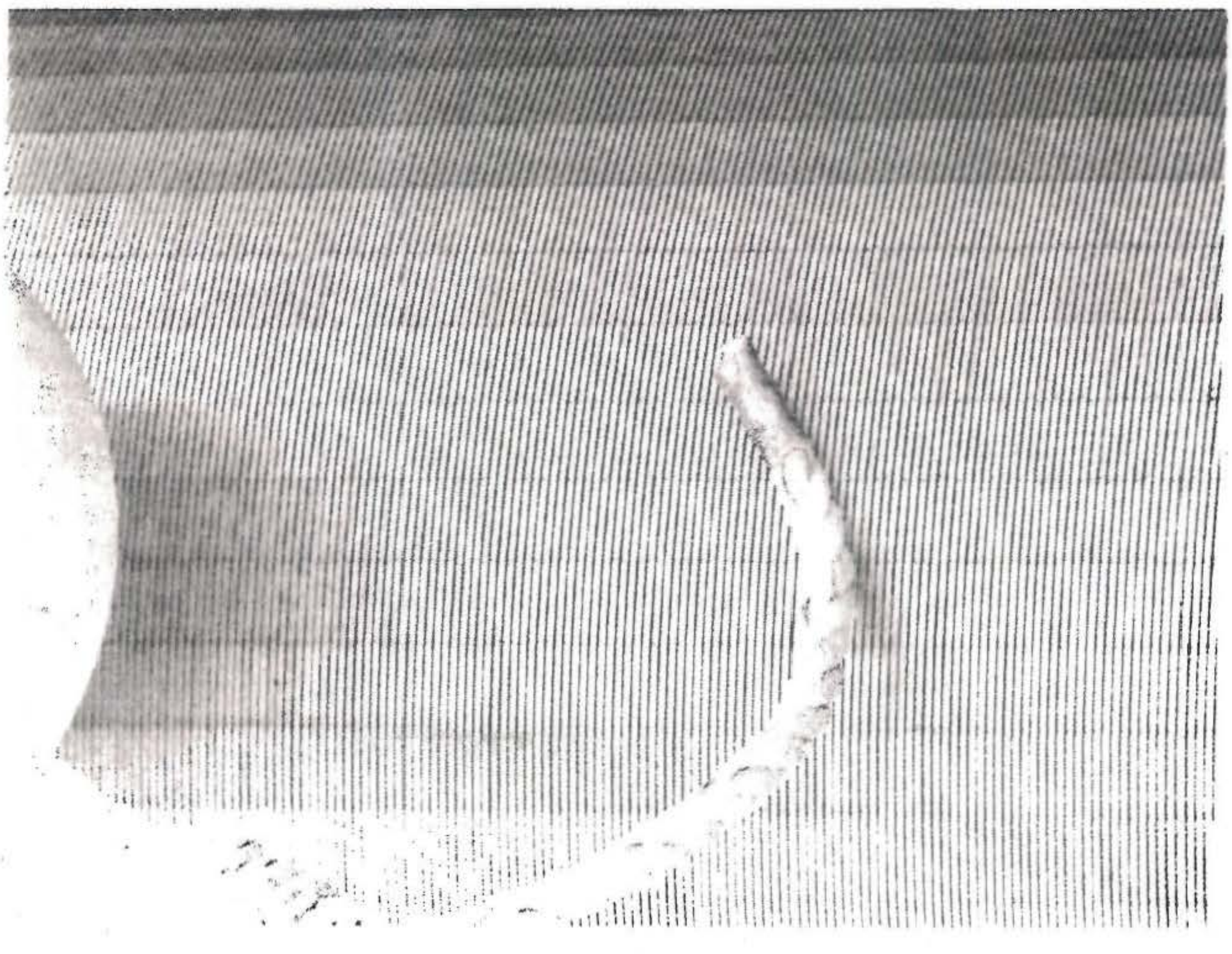
Field Evaluation of Wedgewire Screens for Protecting Early Life Stages of Fish at Cooling Water Intake Structures

Chesapeake Bay Studies

Technical Report



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REPORT SUMMARY

Wedgewire screens are designed to minimize entrainment and impingement of aquatic organisms at power plant cooling water intake structures (CWIS). This report presents the results of a field study evaluating the effectiveness of cylindrical wedgewire screens for protecting the early life stages (eggs and larvae) of fish at cooling water intakes. The study examines multiple screen design parameters and hydraulic conditions in the Chesapeake Bay with a variety of estuarine species. Information in this report increases the performance database for this technology and, as a field evaluation, offers a direct estimate of the effectiveness of this technology for potential applications at cooling and other types of water intakes.

Background

In 2003, EPRI published the results of a laboratory evaluation of wedgewire screens to expand upon the existing database and identify the importance of several design, operational, and biological factors in the effectiveness of these screens for protecting fish at CWIS (EPRI report 1005339). In 2004, as the next step in developing cylindrical wedgewire screens to the point where they could be considered for general CWIS application, EPRI sponsored an evaluation of screens in two different field settings—a New England estuary and a Great Lakes tributary (report 1010112). The present field evaluation expands upon EPRI's previous research and further develops the existing database by evaluating wedgewire screens in a third waterbody type, the Chesapeake Bay, with a different assemblage of estuarine species.

Objectives

- To determine the applicability of previous laboratory studies to potential field applications of cylindrical wedgewire screens at new and existing CWIS sites.
- To identify, under field conditions, the relative importance of various screen design parameters and hydraulic conditions in minimizing entrainment of early life stages of representative fish species.
- To evaluate the effectiveness of cylindrical wedgewire screens for reducing entrainment of early life stages of fish in a mid-Atlantic estuary, the Chesapeake Bay.

Approach

To evaluate the effectiveness of cylindrical wedgewire screens, investigators used a specially designed mobile floating test facility to collect paired entrainment samples simultaneously through an open port and a test screen. Comparison of entrainment rates though the two intakes provided an estimate of the ability of the test screen to reduce entrainment. Testing was performed in the Chesapeake Bay, near Gwynns Island, Virginia. The screen design parameters evaluated included slot width (0.5 and 1.0 mm) and through-slot velocity (0.15 and 0.30 m/s).

Investigators assessed the effect of ambient (or approach flow) velocity on entrainment rates along with the effect of biological factors, including species and larvae size.

Results

While both test screens significantly reduced entrainment of fish larvae and eggs, the reduction was greater with the smaller slot width (0.5 mm). For all species of larvae combined, the 0.5 mm screen reduced entrainment by 72% and 58% at slot velocities of 0.15 and 0.30 m/s, respectively. The reduction provided by the 1.0 mm screen was 36% (0.15 m/s) and 53% (0.30 m/s). Following are some specific results:

- Entrainment of naked goby larvae was significantly reduced by 65% by the 0.5 mm screen and by 52% by the 1.0 mm screen.
- Bay anchovy entrainment was significantly reduced by both the 0.5 mm (84%) and 1.0 mm (21%) screens.
- The 0.5 and 1.0 mm screens significantly reduced entrainment of skilletfish larvae by 51% and 39%, respectively.
- Entrainment of striped blenny larvae was significantly reduced by both the 0.5 mm (62%) and 1.0 mm (44%) test screens.
- Northern pipefish entrainment was significantly reduced by 79% (0.5 mm screen) and 53% (1.0 mm screen).
- Both test screens significantly reduced the entrainment of bay anchovy eggs. At the lower slot velocity, this reduction was substantial for the 0.5 mm screen (87%). However, at the higher slot velocity, both screens provided minimal entrainment reduction (≤19%). At the lower slot velocity, the 1.0 mm screen also provided a minimal reduction (12%).

Although the effect of slot velocity was variable among different species, a slot velocity of 0.15 m/s was generally more effective (by up to 30%) in reducing entrainment of eggs and larvae than a slot velocity of 0.30 m/s. Entrainment reduction increased as ambient velocity (approaching the screen) increased. For all species, entrainment reduction tended to increase with larval length.

EPRI Perspective

This report provides CWIS and other water intake operators with information on the ability of cylindrical wedgewire screens to minimize entrainment and impingement of early life stages of fish and thus comply with the new Clean Water Act Section 316(b) Rule. Research results will allow water intake designers to configure these screens for optimal effectiveness in different water body types, while permitting resource managers to more accurately predict the potential for biological effectiveness at a given site.

Keywords

Fish Protection
Cooling Water Intakes
Clean Water Act Section 316(b)
Wedgewire Screens

ABSTRACT

Cylindrical wedgewire screens are considered a technology that has potential for effectively reducing the entrainment and impingement of fish eggs and larvae at cooling water intake structures. In 2004, to further develop cylindrical wedgewire screens to the point where they can be considered for general application at cooling water intake structures, EPRI sponsored the evaluation of screens in two different field settings, a New England estuary and a Great Lakes tributary. Using a similar study design, an additional study of wedgewire screens was performed in 2005 to expand upon EPRI's previous research and further develop the existing database by evaluating wedgewire screens in a third waterbody type, the Chesapeake Bay, with a different assemblage of species. Paired entrainment samples were simultaneously collected through an open (control) intake and a test screen. The resulting densities were compared to provide an estimate of the ability of the test screen to reduce entrainment relative to the control intake. Sampling was conducted with two different test screens (0.5 and 1.0 mm slot widths) operating at two different intake (or through-slot) velocities (0.15 and 0.30 m/s). Entrained organisms were identified and measured to determine species- and size-specific entrainment rates. Relative to the control intake, both test screens significantly reduced entrainment of fish larvae and eggs, but the reduction was greater with the smaller slot width (0.5 mm).

For all species of larvae combined, the 0.5 mm screen reduced entrainment by 72 and 58 percent, respectively, at slot velocities of 0.15 and 0.30 m/s. The reduction provided by the 1.0 mm screen was 36 (0.15 m/s) and 53 (0.30 m/s) percent. Entrainment of naked goby larvae was significantly reduced by ≥65 percent by the 0.5 mm screen and by ≥52 percent by the 1.0 mm screen. Bay anchovy entrainment was significantly reduced by both the 0.5 mm (≥84 percent) and 1.0 mm (≥21 percent) screens. The 0.5 and 1.0 mm screens significantly reduced entrainment of skilletfish larvae by ≥51 percent and ≥39 percent, respectively. Entrainment of striped blenny larvae was significantly reduced by both the 0.5 mm (≥62 percent) and 1.0 mm (≥44 percent) test screens. Northern pipefish entrainment was significantly reduced by ≥79 percent (0.5 mm screen) and ≥53 percent (1.0 mm screen). Both test screens significantly reduced the entrainment of bay anchovy eggs. At the lower slot velocity, this reduction was substantial for the 0.5 mm screen (87 percent). However, at the higher slot velocity, both screens provided minimal entrainment reduction (≤19 percent). At the lower slot velocity, the 1.0 mm screen also provided a minimal reduction (12 percent). Although the effect of slot velocity was variable among different species, the screens were generally more effective in reducing entrainment of eggs and larvae when the slot velocity was 0.15 m/s (by up to 30 percent) than when the slot velocity was 0.30 m/s. Entrainment reduction increased as ambient velocity (approaching the screen) increased. For all species, entrainment reduction tended to increase with larval length. Research results demonstrate that screens with a slot size of 0.5 mm can meet the Clean Water Act §316(b) Phase II Rule performance standard of 60-90 percent reduction in entrainment.