How can we reduce stressors that influence fish impingement survival?

Fish Impingement and Entrainment Conference
Liverpool, England

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316“b” Rule in US

- *“Best technology available (BTA) for minimizing adverse environmental impact.”*

- *Impingement Compliance Alternative 5, “A facility must operate modified traveling water screens that the director determines meets the definition at § 125.92(s). Facilities will demonstrate that they have optimized performance of their traveling screen to minimize IM (impingement mortality)”*

- *“…fish return[s] must be fish friendly and provide sufficient water and minimize turbulence.”*

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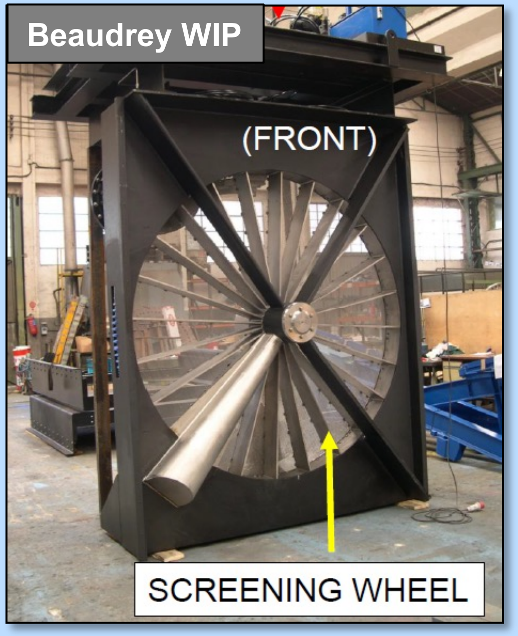
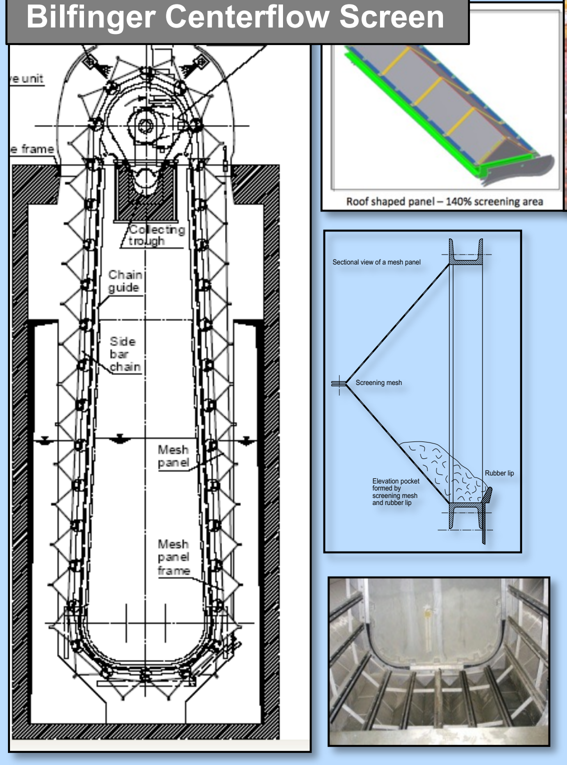
Modified Traveling Water Screen (MTWS)

Bilfinger MultiDisc

Beaudrey WIP

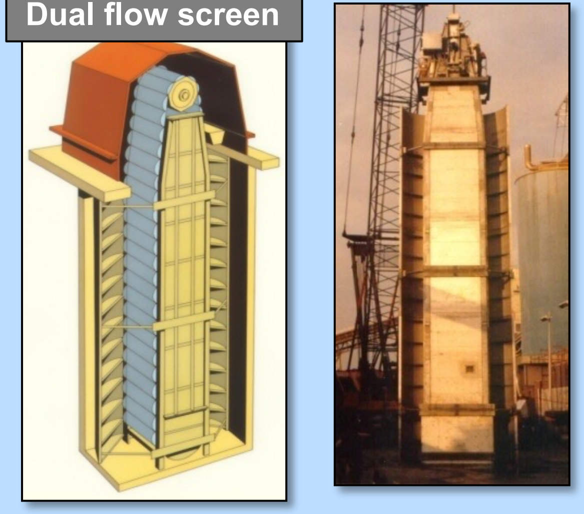


Bilfinger Centerflow Screen



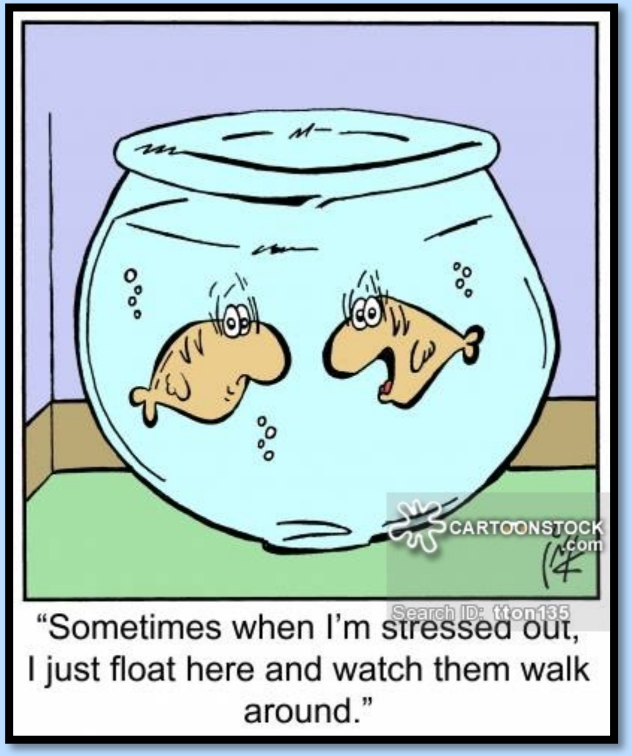
Hydrolox

Dual flow screen



Stressors

- Stress (spray wash volume and pressure)
- Abrasion (mesh, debris, and fish return)
- Turbulence (lift buckets, fish return)
- Impacts (in-line drops, discharge)
- Environmental (water quality, temperature, predation, biofouling)
- Re-impingement
- Air exposure



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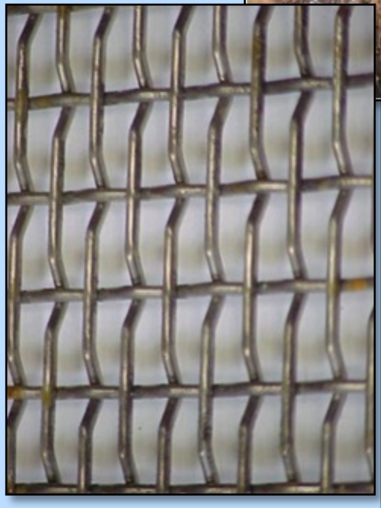
Potential Reduction in Stressors- Screens

- Spraywash
  - Low pressure
  - Angle
  - Sufficient volume
- Rotational Speed
  - Continuous or Near-continuous
  - Faster speeds
- Mesh
  - Smooth surfaces
- Air Exposure
  - Fish lift buckets will retain fish in water



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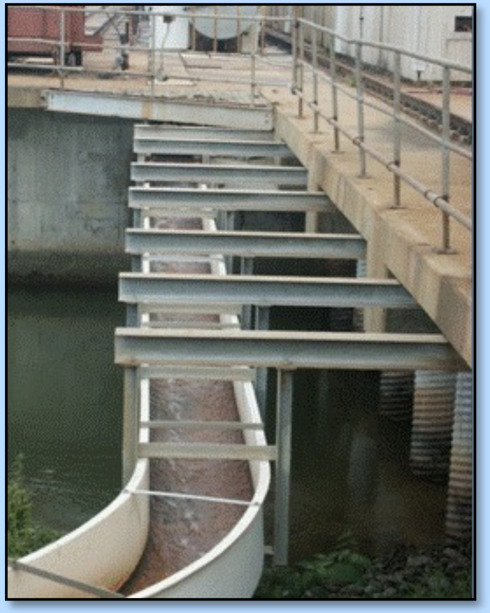
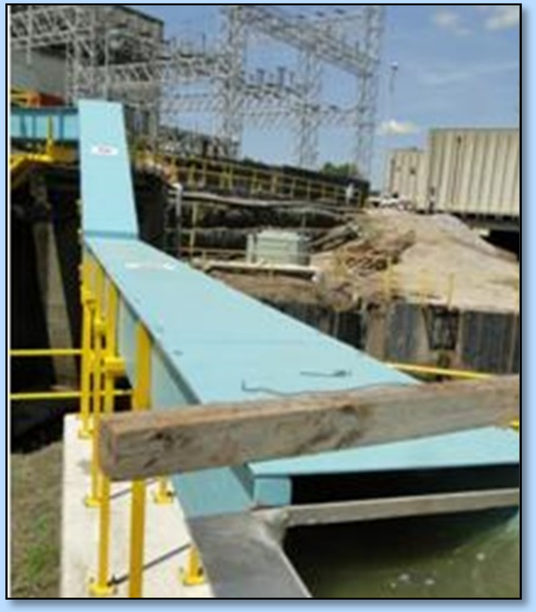
Potential Reduction in Stressors- Returns

- Turbulence and Impacts
  - Reduce velocity in fish returns
  - Large radius bends
  - Limited drops in fish returns
- Environmental
  - Shaded fish return
  - Discharge locations (limit potential for re-impingement and poor water quality)
  - Limit exposure to predators
- Re-impingement
  - Discharge location
  - Continuous rotation





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EPRI MTWS desktop, Field, and Laboratory Research

EPRI Product ID	Title
1005497	Development and Design of a Cooling Water Intake Structure Database
1008470	Impingement Abundance Monitoring Technical Support Document
1011278	Impingement and Entrainment Survival Studies Technical Support Document
1013065	Latent Impingement Mortality Assessment of the Geiger MultiDisc® Screening System at the Potomac River Generating Station
1013238	Laboratory Evaluation of Modified Ristroph Traveling Screens for Protecting Fish at Cooling Water Intakes
1013308	Technical Resource Document for Modified Ristroph Traveling Screens
1016807	Evaluation of Continuous Screen Rotation and Fish Survival
1018490	Beaudrey Water Intake Protection (WIP) Screen Pilot-Scale Impingement Survival Study
1018540	Ohio River Ecological Research Program: Impingement Mortality Characterization Study at 15 Power Stations
1019594	EPRI and Omaha Public Power District Successfully Test New Fish Protection Technology
1019864	Laboratory Evaluation of the Beaudrey Water Intake Protection Screen for Protecting Early Life Stages of Fish at Cooling Water Intake Structures
1021372	Evaluation of Factors Affecting Juvenile and Larval Fish Survival in Fish Return Systems at Cooling Water Intakes
1022612	Alabama Power Company Teams with EPRI to Advance Fish Protection at Cooling Water Intake Structures
1023769	Fine Mesh Traveling and Vacuum Screens, Approach Velocity, Impingement Survival and Spraywash Pressure: Supplemental Laboratory Studies
1024999	Effects of Fouling and Debris on Larval Fish Within a Fish Return System
3002000180	Post-Impingement Survival of Juvenile and Adult Fish with a Geiger Multi-Disc Screen: Laboratory Evaluations
3002000231	Fish Protection Technology Manual (see Section 2)
3002001422	Design of Fish Return Systems and Operations/Maintenance Guidelines
3002001467	Effects of Distance and Debris Exposure on Survival and Injury of Juvenile Fish within a Fish Return System
3002003380	Ristroph-Modified Traveling Water Screen Fish Impingement and Survival Case Study at Plant Gorgas Generating Station
3002005115	Hydrolox Traveling Water Screens for Fish Protection Successfully Demonstrated at Alabama Power Company
3002005832	Hydrolox Traveling Water Screen Fish Impingement and Survival Case Study: Plant Barry Generating Station
3002008265	Laboratory Traveling Water Screen Optimization Evaluations
3002011144	Operation and Maintenance Issues Associated with the Continuous Operation of Traveling Water Screens, Along with other Fish Protection Modifications
3002013681	Effect of Intermittent Traveling Water Screen Operation on Impinged Fish Survival
3002013683	Fish Protection Technical Brief: Fish Return Optimization
3002014811	Traveling Water Screen Optimization Pilot Field Demonstrations: Plants Barry and Gorgas Generating Stations
3002016534	Dairyland John P. Madgett Optimization Study
3002016554	Biological Feasibility of Routing Fish Returns to Thermal Discharges: Warmwater Species Field Evaluations
3002018724	Fish Holding Design for Optimization Studies

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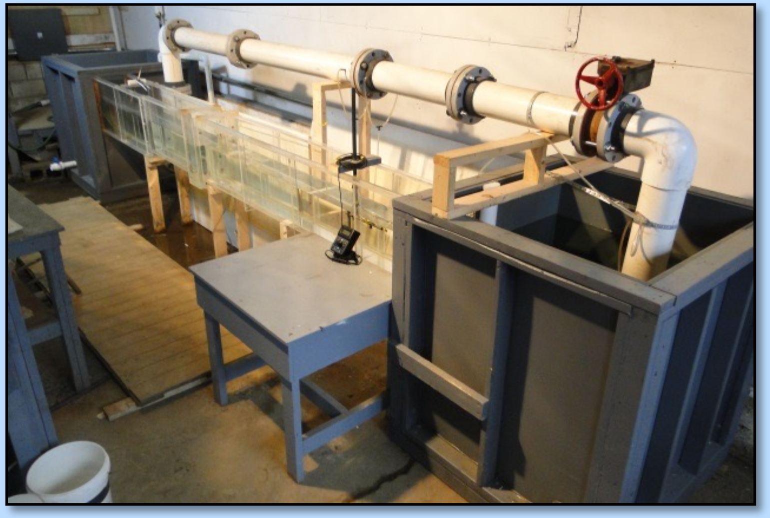
Laboratory Results



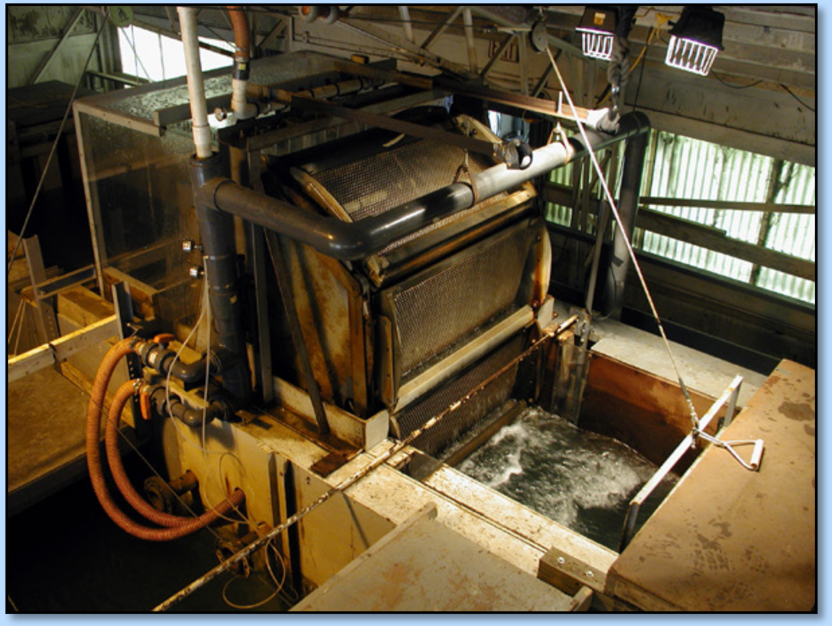
- EPRI Screen Optimization
  - Tested rotation speed (1.5 and 3 m/min)
  - Approach velocities (0.3 and 0.6 m/sec)
  - Spraywash pressure (69 and 138 kPa)
  - Impingement duration (5 and 10 mins)
  - Two mesh sizes (6x12 mm stainless steel and 2 mm polyester mesh)
  - Post-impingement thermal exposure (11 degrees higher then season ambient - 4 seasons)
  - Evaluated Immediate and 24 hr latent Survival, Injury, and Scale loss

Laboratory Results

- EPRI Screen Optimization Continued
  - Small Difference in mortality between
    - Rotational speeds
    - Approach velocities and pressure spraywash
    - Impingement duration and mesh size
  - Higher injury and scale loss
    - Slower rotational speeds
    - High approach velocities and pressure spraywash
    - Longer Impingement duration and smaller mesh
  - Thermal Exposure
    - Low survival rates at summer and winter temperatures
    - High survival rates at intermediate seasons with more mild temperature ranges

Laboratory Results

- EPRI Modified Traveling Water Screen Velocities
  - Tested 0.3, 0.6, and 0.9 m/s approach velocity with 3 different collection times (15, 60, and 120 mins) with a modified TWS
  - <5% mortality in all test conditions
  - Higher injury and scale loss rates with higher velocities (>0.3 m/s)



  - At lower velocities fish could swim freely whereas at the higher velocity most fish were impinged and collected within the first 15mins (71-100%)

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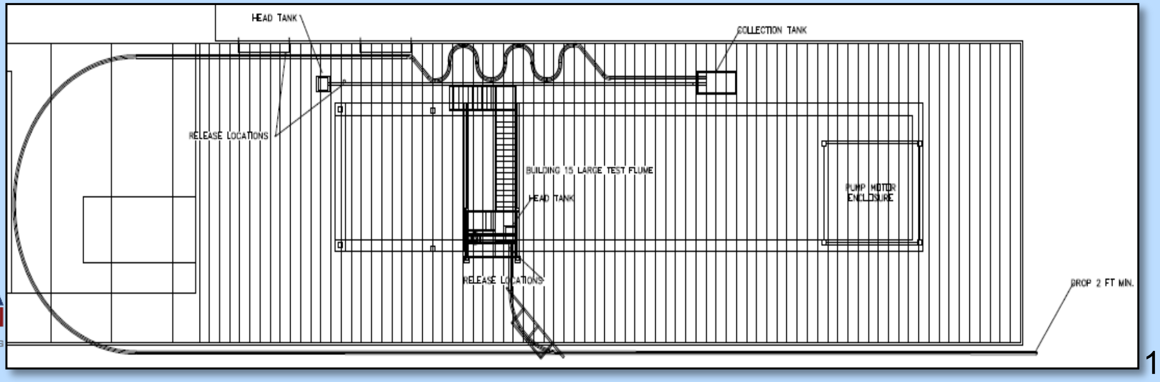
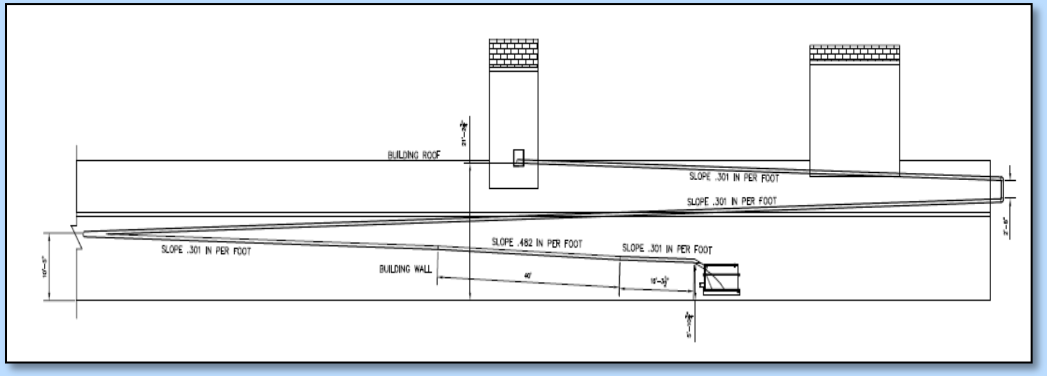
Black and Perry 2014, EPRI 2006

Laboratory Results

- EPRI larvae and juvenile fish return system evaluations
  - Tested four to five species
  - Evaluated
    - Two fish return length (21.6 and 131 m),
    - Two drop height (0.6 and 1.2 m),
    - Two Bend angles (45° and 180°),
    - Two velocities (0.6 and 1.8 m/s)
  - Assessed immediate, 24 hr and 48 latent mortality





Laboratory Results

- EPRI larvae and juvenile fish return system evaluations
  - Survival ranged from 20-90% with larvae and 70-100% with juveniles
  - Higher survival for larger fish (<11.0 mm)
  - Lifestage and species was a better predictor of survival than fish return length, drop height, bends, or velocity

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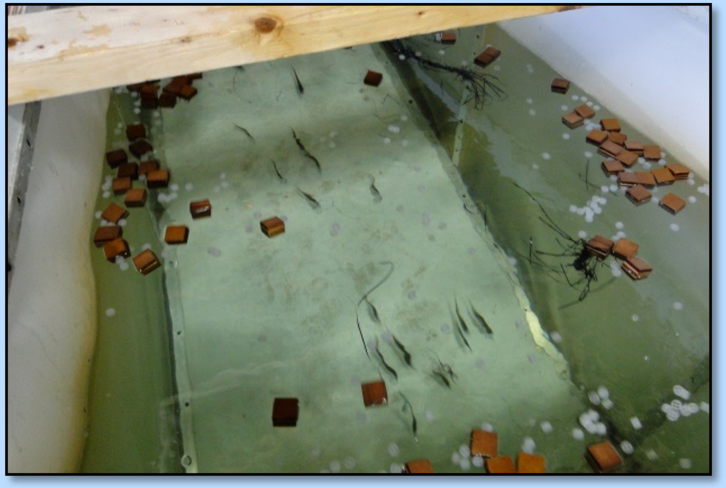
Laboratory Results

- EPRI Fish Return System Evaluation
  - Tested 2 fish return lengths (60 and 305 m)
  - Seven species
  - With and without debris (woody, filamentous (grass/weeds) and plastic material (trash))
  - Immediate, 24 and 48hr mortality, injury and scale loss



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Laboratory Results

- EPRI Fish Return System Evaluation
  - Average survival was 98.4% on average (Alewife was 84.1%)
  - No effect of debris on survival, injury, or scale loss
  - Fish return length had no effect on survival, injury, or scale loss except for Alewife (higher survival at shorter length)
  - Scale loss was low (<10% of fish exhibiting scale loss greater than >3%)

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Laboratory Results

- EPRI Traveling Water Screen Continuous Rotation Study
  - Test different stationary duration of dual flow screen (2, 4, 6, 12 hr)
  - 3 species (Bluegill, Common Carp, Golden Shiner)
  - Preliminary tests in small acrylic flume- three approach velocities (0.3, 0.45, and 0.6 m/s)
  - Full scale tests in large recirculating flume- two approach velocities (0.3 and 0.45 m/s)
  - All fish were evaluated for immediate and 24hr latent mortality, injury, and scale loss

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Rackovan et al. 2021

Laboratory Results

- EPRI Traveling Water Screen Continuous Rotation Study Results
  - Preliminary Tests
    - Survival was >91% for 0.3 m/s, 35-100% for 0.45 m/s, and 13-87% for 0.6 m/s
  - Full Scale Tests
    - Survival was 67-92% for all stationary trials at 0.3 m/s
    - Survival was 3-62% for all stationary trials at 0.6 m/s
    - Continuous trial survival was 95-100%
  - Velocity plays more of an important role in injury, scale loss, and survival than duration
  - Survival decreases with increasing velocity
  - Continuous operation reduces mortality

Rackovan et al. 2021

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Conclusions/Best Practices

- Lower approach velocities - **reduces impingement potential**
- Higher rotational speeds - **reduces impingement duration**
- Lower pressure spraywash- **reduces injury**
- Fish Return does not need to be separate from debris - **takes advantage of increased flows**
- Fish Return focus should be on discharge location and predator protection and less concern about length, velocity, or bends - **places fish into a safe place**

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Questions?