

DISCREDITING ASSUMPTIONS OF FISH IMPINGEMENT BEHAVIOR AND MORTALITY RELATED TO FISH RECOVERY AND RETURN SYSTEMS IN THE UNITED STATES

INSTITUTE OF FISHERIES MANAGEMENT ENVIRONMENT AGENCY FISH IMPINGEMENT AND ENTRAINMENT CONFERENCE 11-13 JULY 2023 : LIVERPOOL, UK

DAN GIZA PRINCIPAL SCIENTIST, ASA ANALYSIS & COMMUNICATION, INC. DR. JOHN YOUNG (PRESENTER) VICE PRESIDENT & PRINCIPAL SCIENTIST, ASA ANALYSS & COMMUNICATION, INC.

IMPINGEMENT VSENTRAINMENT - UNITED STATES (U.S) DEFINITION

Impingement and Entrainment are a function of fish and mesh size

Impingement Retained on a 9.5 mm (3/8 inch) mesh

- Juvenile and adult fish
- Swimming ability sufficient to overcome slow flows (< 0.15 m/sec)

Entrainment Pass through 9.5 mm (3/8 inch) mesh

• Eggs and larvae

Flow

• Quasi-passive particle (no or limited swimming ability)







HISTORICALVIEW AND ASSUMPTIONS OF FISH IMPINGEMENT

Historically (pre-1970's) environmental and hydraulic conditions at a water intake screens lead to assumptions and concerns which drove the U.S regulation to require reducing impingement mortality.

Assumptions include:

- > High Velocities: Fish are drawn in and held against the screen mesh.
- > Entrapment: Fish are unable to overcome intake velocities to escape or seek refuge.
- > Environmental Conditions: Fish of good health are impinged throughout the year.
- Abundance: Fish of various species are continuously impinged at high numbers throughout the year.
- > Screen Operation: Continuous rotation of screens is ideal for fish collection and survival.









MEETING IMPINGEMENT MORTALITY REDUCTION IN THE U.S.

Chosen Method(s) of Compliance with Impingement Mortality Standard

Option I – Operate a Closed Cycle Re-Circulation Cooling System

Option 2 – Reduce the Maximum Design Through-Screen Velocity not to Exceed 0.15 meters per second (m/sec)

Option 3 – Demonstrate Actual Through-Screen Velocity is ≤0.15 m/sec

Option 4 – Have an Existing Velocity Cap (Minimum 800 ft Offshore)

Option 5 – Install Modified Traveling Water Screens and Optimize Performance in a Two-Year Study

Option 6 – Integrated System of Technologies, and Operational Measures that are Optimized in a Two-Year Study and Provide Comparable Results to those Required in the Following Option 7; and

Option 7 – Demonstrate that Impingement Mortality is Reduced to No More than 24% Annually Based on Monthly Monitoring





COOLING WATER INTAKE & TRAVELING WATER SCREEN



MEETING IMPINGEMENT MORTALITY REDUCTION IN THE U.S.

Impingement Mortality Compliance under Option 5 requires that the Modified Traveling Water Screens (MTWS) meet the regulatory definition and include:

- > Collection buckets designed to minimize turbulence
- > Guard rail or barrier to prevent escape
- > Smooth mesh to minimize abrasion or de-scaling
- Continuous or near-continuous screen rotation
- Fish removal by low pressure spray wash or vacuum prior to high pressure wash for debris

Fish Return System



CONVENTIONALVS MODIFIED TRAVELING WATER SCREEN



Historical Traveling Water Screen Research

- Conventional Traveling Water Screen (TWS)
 - Have a debris lip but no fish bucket
- Ristroph Bucket Design and Development
 - Turbulent early design;

JAS/

Modified-Ristroph Design or Modified TWS (MTWS)



Bucket Hydraulics – Before and After Video Credit: Alden

EPRI MTW S DESKTOP, FIELD, AND LABORATORY RESEARCH

AS

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				

TRAVELING WATER SCREEN RESEARCH – LABORATORY

- EPRI evaluated mortality, injury, and scale loss related to interaction with MTWS
- > Ten species of juvenile freshwater fish (50-100 mm)
- > Three approach velocities: 0.3, 0.6, & 0.9 m/s (1, 2, & 3 fps)
- > Some Key Findings:
 - Mortality was low regardless of species or velocity (<5%)
 - Injury rates were variable by species and dominated by fin damage (40%), bruising or hemorrhaging (30%), and disease or fungus (20%)
 - Scale loss variable by species and linked to scale type
 - Mortality, injury, and scale loss generally increased with water velocity, but velocity was only a significant predictor of mortality for bluegill (P<0.05)





TRAVELING WATER SCREEN RESEARCH – LABORATORY



Discredited Assumption:

- Fish are drawn in and held against the screen mesh.
- Fish are unable to overcome the high velocities to escape or seek refuge.
- Video observations identified three paths to collection:
 - I. Impinged briefly then wiggle to bucket.
 - 2. Tail tapped followed by burst swim then scooped by bucket at surface.
 - 3. Sought refuge in bucket w/o screen interaction.
- Important to note the flow velocities (0.3 m/sec) juvenile size of fish (50-100 mm).



TRAVELING WATER SCREEN RESEARCH – FIELD: SOUTHERN U.S.

- EPRI evaluated the rate, mortality, and health of fish impinged at two southern U.S power plants.
- > Multi-year study evaluating conventional screens and MTWS
- Evaluated various MTW Soperating parameters to optimize fish survival.
- > Some Key Findings:
 - Mortality varied by MTW Soperating parameters with no clear optimal condition.
 - Impingement mortality varied seasonally and with water temperatures (i.e., high mortality in summer months).
 - Survivability and fish health assessment identified that most impinged catfish were of compromised health.







TRAVELING WATER SCREEN RESEARCH – FIELD: SOUTHERN U.S.



Relationship **B**etween Impingement Mortality Rates and Mean Water Temperatures at Southern U.S. Power Plant

Discredited Assumption:

- Fish of good health are impinged throughout the year.
- Mortality highest in late summer at maximum water temperatures and decreased in fall under cooler temperatures.
- Health assessments reported the prevalence of fish disease was strongly correlated with water temperatures.



TRAVELING WATER SCREEN RESEARCH – FIELD: NORTHERN U.S.



Screen Rotation F requency	D uration	Total Impinged	Number Dead	Collected per 24 hrs.
Continuous	2 hr	378	22	37
Stationary	2 hr	214	П	21
Continuous	4 hr	986	36	48
Stationary	4 hr	433	22	21

- EPRI and ASA evaluated various MTW Soperating parameters to optimize fish impingement survival at a northern U.S power plant.
- Multi-year study with monthly events consisting of 4 consecutive days of sampling.
- > Fish behavior monitored via video observation.
- Some Key Findings:
 - Mortality varied among species, season, and across events with no clear optimal MTW Soperating condition.
 - I of 28 sampling events over the 2 years collected less than 100 fish/event, while a single event collected 2,700 fish.
 - Fewer fish were collected after the screen was held stationary for 2- or 4-hr (then rotated/cleaned), when compared to continuous screen rotation.

TRAVELING WATER SCREEN RESEARCH – FIELD: NORTHERN U.S.

- > Discredited Assumption:
 - Fish of various species are continuously impinged at high numbers throughout the year.
 - Continuous rotation of screens is ideal for fish collection and survival.
- Impingement is episodic in nature events are often resulting from a sudden change in environmental conditions.



- > Video observations confirmed fish are actively avoiding impingement
- Stationary screen hold (2-hr or 4-hr) may result in lower mean collection rates when compared to continuous rotation (continued EPRI research topic).



SUMMARY - IMPINGEMENT ASSUMPTIONS VS RESEARCH FINDINGS



- Fish are drawn in and held against the screen mesh.
 - Research findings indicate that fish do not impinge in the traditional sense.
 - Various behaviors have been observed, many result in bucket collection.
- > Fish are unable to overcome intake velocities to escape or seek refuge.
 - At low approach velocities (≤ 0.6 m/s) juvenile fish have been observed swimming freely in front of screens and seeking out low hydraulic zones.
- > Fish of good health are impinged throughout the year.
 - Impingement of fish with poor health during extreme water temperatures.
- Fish of various species are continuously impinged at high numbers throughout the year.
 - Impingement is episodic by nature.
- Continuous rotation of screens is ideal for fish collection and survival.
 - Rotating the screen continuously may have a higher rate of collection than stationary.
 - A topic of continued research for EPRI.





Questions

DR. JOHN YOUNG VICE PRESIDENT & PRINCIPAL SCIENTIST ASA ANALYSIS & COMMUNICATIONS, INC. 814.278.0482 JYOUNG@ASAAC.COM DAN GIZA PRINCIPAL SCIENTIST ASA ANALYSIS & COMMUNICATIONS, INC. 774.502.6154 DGIZA@ASAAC.COM

www.asaac.com