Laboratory Evaluation of Fine-Mesh Screening for the Protection of Fish Larvae at Intakes

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STONE & WEBSTER ENGINEERING CORPORATION

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FINAL REPORT

by

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Research Sponsored by

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SUMMARY

The purpose of the studies described in this report was to evaluate the potential effectiveness of organism collection and diversion systems in protecting fish larvae at cooling water intakes. It is clear that each system, and its component parts (stresses), varies in potential depending on the species and larval stage to be protected.

With respect to impingement and removal systems (fine-mesh traveling screens), the following general conclusions can be drawn.

Impingement Mortality

Striped bass prolarvae exhibited high impingement mortality under all conditions, while winter flounder, alewife, and yellow perch prolarvae exhibited low mortality; however, high control mortality among bass indicated that the mortality was not solely attributable to impingement. Impingement mortality was highest among winter flounder, alewife, and yellow perch larvae for a short period following absorption of the yolk-sac; however, control mortality was also highest at this time. Among later postlarvae, striped bass exhibited low mortality, the alewife exhibited relatively high mortality, and winter flounder and yellow perch were intermediate to the others.

Fine Mesh Screen Retention

Screen retention was largely a function of mesh size relative to larval length and body depth; it would appear that for some species, a mesh size of 0.5mm or less may be required to effectively retain all larval stages, particularly prolarvae and early postlarvae. Hosever, the present study did not investigate the effects of fine debris which have been shown to aid in retention of larvae at a given mesh size. Therefore, the results should not be considered quantitative, but rather can be used for comparative purposes.

Air Exposure

Air exposure may be a significant factor in mortality for certain species, particularly among postlarvae; it would appear prudent to limit exposure time in fine-mesh screen systems unless specific data are available which indicate that the species of concern at a site are resistant to air exposure stress.

Spraywash Studies

Spraywash studies demonstrated that minor details in the design of a fine-mesh screen can greatly affect overall system effectiveness. Striped bass juvenile showed high survival after removal from two different spraywash systems. Winter flounder, alewife, and yellow perch pro- and early postlarvae were not effectively removed by the spraywash system evaluated. Later, postlarvae were removed to a greater extent and exhibited high latent mortality; however, control mortality was also high.

Diversion Screens and Pumps

With respect to larval diversion and pumping systems, the following conclusions can be drawn.

Angled fine-mesh screens appear to have the potential for diverting older larvae to bypasses provided the proper mesh size and velocity are incorporated into the system design. Among striped bass, diversion efficiencies as high as 50 percent were generally not achieved until the larvae reached a mean length of 10mm. Results with winter flounder, alewife, and yellow perch were limited at smaller sizes (pro- and early postlarvae), diversion was poor; too few test organisms were available at greater lengths to establish the relationship between larval length and diversion efficiency.

Jet and Hidrostal Pumps

Pumps appear to offer a potentially effective means for supplying the energy needed to return fish larvae to a release location following diversion; under the conditions tested, a screw-impeller (Hidrostal), centrifugal pump appeared to induce less mortality among the larvae tested than a jet pump.

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Stone & Webster Engineering Corporation (S&W) and the Alden Research Laboratory (ARL) of Worcester Polytechnic Institute (WPI) have been conducting studies for various utilities since 1973 to develop systems for protecting fish at power plant cooling water intakes. Systems which have been investigated include louvers, angled screens, behavioral barriers, and the pipe and pumping elements which would be incorporated into fish transportation systems. The studies were conducted with juveniles and adults of a variety of species common to Long Island Sound, the Hudson River, or the Great Lakes.

In 1976, the Empire State Electric Energy Research Corporation (ESEERCO) requested that additional studies be conducted to evaluate the design and the operation of several systems under specific environmental conditions. In addition, due to a growing regulatory concern over the loss of entrainable organisms (specifically ichthyoplankton) in cooling water systems, ESEERCO also requested that studies be initiated to develop fine-mesh screening systems which might act to mitigate entrainment losses.

This report presents the results of all larval studies conducted for ESEERCO from 1978 to 1980. The results of studies with juvenile and adult fish are presented in a separate report (ARL/S&W, 1981). The information presented in both cases constitutes data reports.

The objective of the larval studies was to investigate several components of fine-mesh screening systems to determine their potential for collecting, diverting, or transporting larvae of several fish species with low resultant mortality. These systems included:

1. Modified, traveling water screen with fine-mesh screening, lifting buckets, and low pressure sprays,

2. Angled, traveling water screen with fine-mesh material and a bypass,

3. Pumping units which may be required to return collected or diverted larvae to their natural environment.

Species tested included striped bass (Morone saxatilis), winter flounder (Pseudodpleuronectes americanus), alewife (Alosa pseudoharengus), and yellow perch (Perca flavescens).

This report includes descriptions of the various facilities used to evaluate these systems, procedures used in biological testing and statistical analysis.

SECTION 2

RATIONALE

SECTION 2
RATIONALE

Introduction

Two fish protection concepts were evaluated during the study program: (1) collection and removal; and (2) diversion. Each concept is discussed separately below.

The concept of utilizing modified traveling water screens for collecting and removing organisms from an intake flow presently affords a relatively inexpensive and potentially effective method for protecting all life stages of fish at power plants. This impingement concept requires modifications for the protection of larvae including the incorporation of fine-mesh screening material, the addition of lifting buckets which will provide water for the organisms when the screen panels are removed from the flow, and the use of low pressure sprays to wash the organisms into a sluiceway with minimal damage.

The limited research which had been previously conducted on the larval impingement concept indicated that several factors were of importance relative to obtaining acceptable survival. First, the duration of impingement on a screen influenced survival. It had been found that the ability of organisms to withstand impingement over time varied widely by species and age, with acceptable durations ranging from 2 to 16 minutes. Second, when a traveling screen panel cleared the water surface, impinged larvae could be exposed to the air for various lengths of time depending on the screen travel speed. It had been noted that air exposure could seriously affect the survival potential of some species, and this factor should, therefore, be investigated. Finally, the spraywash system used to remove larvae from the screen and lifting bucket could injure them further, and acceptable spray pressures and orientations must be identified. All of these potential sources of stress associated with the impingement concept were investigated in the present study.

In addition to the concept of utilizing fine-mesh traveling screens for collection and removal of small organisms, limited research had been conducted which indicated that such screens may have the potential for guiding motile organisms, thereby protecting them from entrainment through power plants. Diversion studies with juvenile fish indicated that approach flow velocity is an important factor in guidance efficiency. In attempting to divert fish larvae, it could be assumed that the screen mesh size would also affect guidance, and that the relationship between mesh size and efficiency would change as larvae grow and gain greater swimming capabilities. Therefore, mesh size and velocity were primary variables of interest during this study. Since diversion screens guide organisms to a bypass without lifting them, energy must be supplied to induce a bypass flow and to transport the organisms back to their natural environment. During this study, two pumps were selected for this purpose, on the basis of previous laboratory testing (Stone & Webster, 1977).

The criteria for success in the studies were the latent mortality of test organisms and effectiveness of the system in removing organisms from the flow. In survival studies, initial mortality was determined 1 hour after each test, and, in general, live larvae (or a subsample thereof) were then held for 96 hours. In certain cases, it was necessary to reduce the holding period to 48 hours, as discussed later. It was expected that survival would increase as the larvae grew; therefore, larval length was an important variable which was evaluated through replicate testing at specific length intervals. A description of the facilities used for holding test organisms is presented in Section 2.3.

The following is a brief description of the specific rationales used to establish test conditions for each study conducted as part of the ESEERCO program.

2.1 Testing Rationale

Impingement Survival Study

The effectiveness of a modified traveling screen system is dependent on the ability of larvae to survive the stress of impingement on fine-mesh screens. Tests were conducted to investigate the effects of approach flow velocity and impingement duration on mortality. The test matrix consisted of 20 velocity/duration combinations covering the range of conditions which might be expected at power plant intakes.

To eliminate needless replicates after the completion of the full impingement matrix, subsequent testing was concentrated on selected velocity/duration combinations which were chosen based on the observed mortality and the amount of variability in the mortality rates. In this way, a large number of tests could be completed under specific velocity/duration combinations in a shorter period of time, thus providing a larger data base around conditions which yielded at least moderate survival values. In addition, as the length of the larvae increased within each life stage, the conditions at which mortality increased or decreased also changed. The testing matrix was constantly modified with the addition or deletion of velocity/duration combinations, such that a large number of replicates for specific velocity/duration combinations were conducted within each life stage.

Screen Retention Study

In order for a fine-mesh screening system to be effective, the screen mesh must be sized to retain the species/life stage of importance at a particular site. Since mesh size becomes an important factor in the operational reliability and maintenance requirements of a traveling screen when fine-mesh is incorporated (due to increased clogging potential and the need for continuous operation), it is desirable to select the largest mesh size possible which will still retain the organism of interest. The objective of these tests was to determine what size organism could be retained by a specific size mesh.

Screen retention testing began with the smallest available larvae and continued until larvae were retained by the largest mesh for a sustained period of time. Mesh sizes of 0.5, 1.0, 1.5, and 2.0mm were evaluated. Testing began with the 0.5mm mesh. As retention was noted on each mesh, each successive mesh was added to the evaluation sequentially until 100% retention was achieved with the 2.0mm mesh.

Air Exposure Study

As a modified, fine-mesh traveling screen basket rotates to the point where it clears the water surface, it is possible that larvae may adhere to the screen mesh and thereby be exposed to air for a period of time. The duration of exposure would depend on the travel speed of the screen, which determines the time that it takes an individual screen basket to ascend from the water surface to the spraywash system located on the operating deck. If air exposure were found to be detrimental to the survival of important species at a site, it would be necessary to minimize the duration of exposure by operating the screen at a high speed or by incorporating a spraywash header near the water surface to gently wash the larvae into the lifting bucket.

The objective of the study, therefore, was to investigate the survival of larvae at various durations of air exposure.

Spray Wash System Study

The concept of utilizing modified traveling water screens includes the use of low pressure sprays to wash larvae from the fine-mesh screens with minimal damage. Therefore, a study was conducted to determine whether spraywash systems might be expected to contribute substantially to overall mortality in a fine-mesh screening system.

Two types of spraywash systems are commercially available and, therefore, were studied. The first was a frontwash system which removes organisms from the ascending (front) side of the traveling screen. The spraywash consists of an external header with evenly spaced nozzles. The nozzles create a fan-shaped spray which jets into the lifting buckets attached to the bottom of each screen basket and gently washes the contents of the bucket into a collection trough. The mesh itself is not rinsed by the external header.

The second spraywash evaluated was a backwash system in which organisms are removed from the descending (back) side of the traveling screen. As each screen bucket passes over the head sprocket, the contents of the lifting bucket are spilled onto the fine-mesh screening medium. As the basket descends, it intersects an internal, low-pressure spray which washes all organisms on the mesh into a collection trough.

Angled Screen Diversion Study

As previously mentioned, an angled screen diversion system evaluation for fish larvae must consider the effects of mesh size, approach flow velocity, and larval length. On the basis of the literature and the lengths of the larvae proposed for evaluation during the present study, mesh sizes ranging from 1.0 to 9.5mm were selected for study. Approach and bypass velocities of from 0.5 to 2.0 fps were selected to encompass the range of velocities which typically exists at power plant intakes.

Because the potential testing period is limited by the natural period of larval occurrences, it is necessary to test the numerous variables in the shortest length of time. Testing was, therefore, conducted in a sequential manner beginning with the smallest mesh and lowest velocity. Once diversion was observed, the next largest mesh and velocity were added to the testing program until all mesh sizes and velocities had been included. This resulted in a sequential phasing out of testing under each set of conditions as 100 percent efficiency was achieved. This approach eliminated needless replicate testing under conditions where no diversion was occurring or where diversion was consistently 100 percent.

Pump Studies

Pumps that are capable of transporting organisms with low mortality are an important element in systems which return diverted or collected organisms to their natural environment. A peripheral jet pump and a Hidrostal screw impeller pump were chosen for evaluation with larvae.

Jet pumps have been extensively studied by ARL and S&W to evaluate their hydraulic performance and their ability to pump juvenile and adult fish. The results of testing with a number of species, including alewife and menhaden, have shown that the jet pump is very effective in transporting juvenile fish with low mortality. Because the jet pump has no moving parts and has been shown to safely pump juvenile fish as small as 5.0cm, it was felt that the pump would have an excellent potential for pumping larvae (Stone & Webster, 1977).

The Hidrostal screw impeller pump had been used for pumping fish without damage in the processing industry and for handling fruits and vegetables. This pump can operate more efficiently and over a wider range of hydraulic conditions than the jet pump. After initial testing with juvenile fish, it appeared to be efficient at pumping live fish with low mortality and was included in this study.

2.2 Rationale for Statistical Analysis

Data obtained during the various studies were subjected to statistical analyses. The data were analyzed by analysis of variance models (ANOVA) or analysis of covariance models (ANCOVA) when appropriate. ANOVA models were used to study the relation between a dependent variable and one or more categorical independent variables. ANCOVA models enabled the simultaneous testing of categorical and continuous independent variables. Therefore, the ANCOVA models combined the features of analysis of variance and regression analysis. In one case, Student's t-tests were used to supplement an ANCOVA model.

In most cases, the mortality after 96 hours was recorded for each group of test organisms held. The percent mortality was used as the dependent variable to correct for differences in the number of larvae recovered and held during each test. In addition to the experimental design variables, the independent variables which would naturally fluctuate during the operation of the devices were recorded during each test: tank temperature, flume temperature, larval length, and life stage. Since water temperature is a determinant factor in the development and behavior of aquatic organisms (McFadden, 1977), temperature of the stock holding tanks and test flumes, as well as the temperature difference (ΔT) between the tanks and flumes, was recorded for each test to monitor an uncontrolled variable which could potentially influence test results.

Past experience suggested that the response of larvae to a device depended upon their length (Stone & Webster, 1977). Therefore, the relationship between the dependent variable and the experimental design variables was studied after adjusting for differences in larval length. Results from 1979 striped bass testing indicated that, for some devices, this relationship was similar for each life stage. If, in the defined relationship, life stage became an important independent variable, it was either substituted in the ANCOVA model for length or the data were partitioned by life stage.

During the 1980 studies, the water temperatures and the length of larvae were highly correlated (i.e., the temperatures and the length both increased during the test period). Test day was included in these analyses to account for the influence of both temperatures and larval length, since it was not possible to statistically separate out the effects of these variables.

After studying the summary statistics of these variables (mean, variance, range, correlation coefficient), a set of independent variables were included in the full ANOVA or ANCOVA model. The computer program used for the analysis was a least-squares procedure which allowed an unequal number of observations for various experimental combinations (SAS, 1979; Kemp, 1972). The total variability in the dependent variable was divided into components corresponding to the independent variables/interactions (explained variation) and into a component for which no identifiable variable could be found (residual or unexplained variation). The F-statistic was used to determine whether the explained variation for each variable or interaction was significant and thus could explain part of the variation in the dependent variable. F-statistics which had a probability of $\alpha \leq 0.05$ were considered significant. The independent variables and/or interactions with $\alpha > 0.05$ were eliminated from the full model and a second, reduced ANOVA or ANCOVA was performed. ANOVA and ANCOVA models were conducted until only variables and/or interactions which significantly explained the variation in the dependent variable remained.

Histograms of the mortality data were used to determine if the distributions of the dependent variables were normal, such that the assumptions necessary to perform ANOVA or ANCOVA were not violated. Residual plots were also analyzed to ensure that each ANOVA or ANCOVA was appropriate for the data. If the assumptions necessary to perform an ANOVA or ANCOVA were violated, either the dependent variables were transformed or the models were modified.

Significant variables and/or interactions were further studied by least significant differences (LSD) tests, the Tukey method of multiple comparisons, Duncan's Multiple range tests, orthogonal contrasts, and confidence intervals for the differences between means. These tests were employed to estimate the differences between mean mortality rates for different levels of the variable and to decide which means differed significantly. The Tukey method was employed only if there were equal sample sizes per cell. For example, if the velocity at which a test was conducted significantly influenced the mortality rate, the above tests were conducted to determine which levels (0.5, 1.0, 1.5, or 2.0 fps) differed from each other.

Controls were studied to estimate the mortality arising solely from holding, and handling and holding. Control data were qualitatively assessed or analyzed by ANOVA or ANCOVA models. Percent control mortality was determined for various components of fine-mesh screening systems to evaluate any additional stress on test organisms from experiencing the test devices. Since the effect of simply holding, or handling and holding was not removed from the test mortality, test mortality was evaluated relative to controls.

In most cases, means and standard deviations (predicted from ANOVA and ANCOVA models) are presented in the data tables. Occasionally, 95 percent confidence intervals are presented for analyses that required transformations of the data. This was necessary since standard deviations estimated in a transformed scale are not meaningful in the original scale. Also, in some cases, test and control mortalities were high and quite variable. In these instances, estimates of variability would be of little use.

Occasionally, an ANOVA or ANCOVA model fit the observed data well; however, it was not used to predict mean values when mortality was the dependent variable and was high under all test conditions.

2.3 Description of Larval Holding Facility

The larvae of four species were reared and held at the laboratory holding facility. Striped bass and winter flounder were held in closed system brackish water stock holding tanks. Yellow perch and alewife were initially held in a fresh water closed-cycle system connected to a biological filter. As their size and food demands increased, they were transferred to oval steel troughs that operated in a once-through mode and made available natural pond plankton. Water quality parameters were monitored frequently, including temperature, dissolved oxygen, salinity, ammonia, and pH.

To monitor latent mortality of each experiment, the test and control groups of each species were held in a 96 hour holding facility.

Striped Bass

Striped bass larvae (approximately 145,000) were obtained from the Texas Instruments hatchery at Verplanck, New York. They were held in a total of twenty 20, 30, and 50 gallon aquaria (Figure 2.3-1). Each stock holding tank was individually aerated, temperature controlled, and maintained at a salinity of 2 to 4 ppt salinity. The holding tanks received approximately 50 percent water changes daily in order to maintain water clarity and quality. Water quality parameters of the tank were recorded daily. Water was supplied from a large sump containing dechlorinated tap water.

The striped bass were maintained on a diet of *Artemia* nauplii for the first 50 days, and a combination of nauplii and adult frozen brine shrimp for the final 30 days of the study.

Larval length was determined each test day from a sample of 25 larvae removed from the stock holding tanks. The total length of each larvae was measured to the nearest hundredth mm using a vernier caliper under a dissection microscope, and the calculated mean length of the sample was defined as larval length.

Winter Flounder

Fertilized winter flounder eggs (approximately 200,000) were obtained from Marine Research, Inc., Falmouth, Massachusetts, on March 13, 1980. They were transported to ARL at 15 ppt salinity. As the eggs hatched, the sac fry were transferred to eight 30 gallon aquaria (Figure 2.3-1). The eight stock holding tanks were individually aerated and temperature controlled at a salinity of 15 ppt. The holding tanks received approximately 25 percent water change daily (from the sump) in order to maintain water clarity and quality. Water quality parameters of the tanks were recorded daily.

Winter flounder larvae were maintained on a diet of live rotifers (*Brachionus plicatilis*). The rotifers were cultured in 20 gallon aquaria and were maintained with the algae *Dunaliella* sp., which were cultured in 5 gallon carboys. Live *Artemia* nauplii were also available to the larvae but were not accepted during the first 6 weeks after hatching because the flounder were too small to injest the nauplii.

Larval length was determined each test day from a sample of 25 larvae, as with the striped bass.

Alewife

Alewife larvae (approximately 300,000) were obtained from Ecological Analysts, Inc., Middletown, New York. The larvae were held in a larval tank, consisting of ten 20 gallon chambers, connected to a biological filter with the capability of operating in a closed cycle or once-through mode (Figure 2.3-2). The water supply used was dechlorinated tap water stored in a 50,000 gallon sump. The once-through mode was used briefly each day to change about 50 percent of the water in the holding tank and thereby maintain water clarity and quality. At all other times, the system was operated in the closed cycle mode, and the salinity was adjusted to 1.5 to 2.0 ppt to prevent fungal infection and enhance survival. Water quality parameters of the tank were recorded daily.

The alewife larvae were fed plankton obtained with a plankton collector from a pond adjacent to the laboratory. The collector operated continuously and concentrated phytoplankton and zooplankton between 74 and 200 microns into a small volume of water. As the larvae grew and food demand exceeded the supply from the plankton collector, the larvae were transferred to two 192 gallon oval tanks which operated in a once-through mode and thus offered a continuous food supply from a local stream (Figure 2.3-3). There was no adjustment for salinity in the oval tanks and all water quality conditions were ambient. The water supply for the oval tanks was the same as the plankton collector so that larvae could continue feeding on natural plankton. *Artemia* nauplii were also made available to the alewife larvae, but they showed a preference for natural planktonic organisms.

Larval length was determined each test day from a sample of 25 larvae as with the other species.

Yellow Perch

Yellow perch were obtained from two sources. Fertilized eggs (approximately 250,000) were received from the University of Wisconsin Aquaculture Laboratory, Madison, Wisconsin on May 13, 1980. These eggs hatched from May 14-20. The Peterson Trout Farm, Peterson, Minnesota, transported about 220 adult yellow perch in spawning condition to ARL on May 5, 1980.

The gravid females and males were evenly distributed among nine 192 gallon oval tanks. The fish spawned about 400,000 eggs in the tanks from May 6-10. The 81 semi-buoyant ribbons of eggs were transferred soon after water hardening to the larval holding tank where a constant upwelling kept the egg ribbons irrigated. The eggs hatched from May 19-23.

The yellow perch larvae holding tank was the same as that used to hold the alewife larvae and it was connected to the same biological filter (Figure 2.3-2). Water changes and water quality conditions and measurements were concurrent with those of the alewife holding tank.

The yellow perch larvae were fed plankton obtained from the plankton collector. As the food demand exceeded supply, the larvae were transferred to three oval steel tanks, as were the alewives, to make available to them a continuous supply of plankton. The yellow perch larvae exhibited the same preference for natural plankton over Artemia as the alewives.

The mean larval length was determined each test day from a sample of 25 larvae as were the striped bass, winter flounder, and alewife.

96 Hour Holding Facility

Test and control larvae of each experiment were held in 1-liter glass beakers for up to 96 hours following each test to monitor latent survival. The beakers were individually aerated, and temperature was controlled by immersing them in a temperature regulated water bath (Figure 2.3-4). Capacity of the holding facility was 300 beakers (50 beakers per water bath; 6 water baths).

During the early stages of the testing program, a maximum of 25 larvae were held in each beaker. As body length increased beyond 15mm, the larvae from each test were divided into two or more beakers to avoid crowding.

Larvae held in the beakers for up to 96 hours were fed on the same schedule as larvae in the stock tanks. Water quality was also monitored in the same manner as for the stock holding tanks.

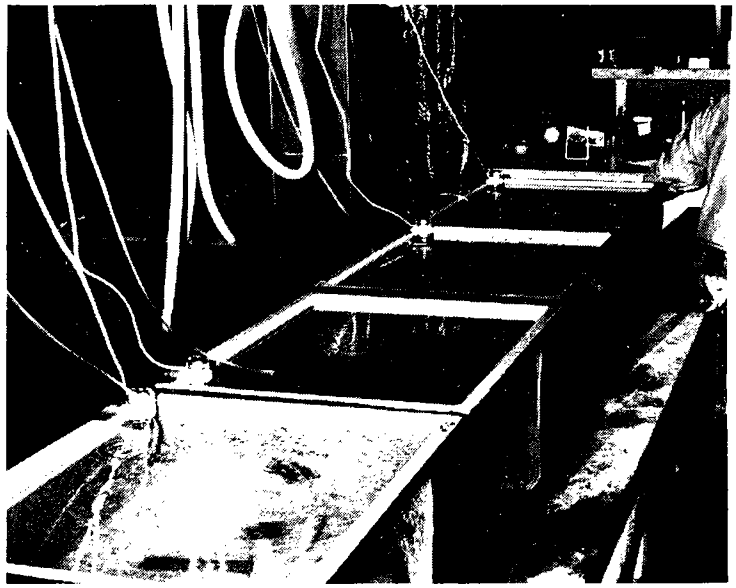


FIGURE 2.3-1 STOCK HOLDING AQUARIA

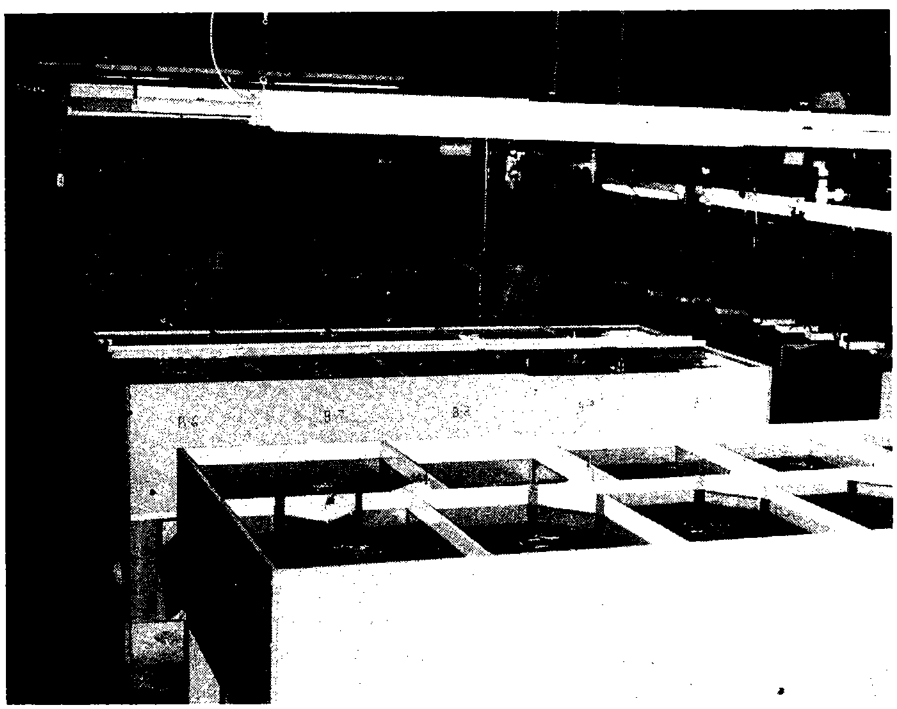


FIGURE 2.3-2 LARVAL HOLDING TABLE WITH BIOFILTER

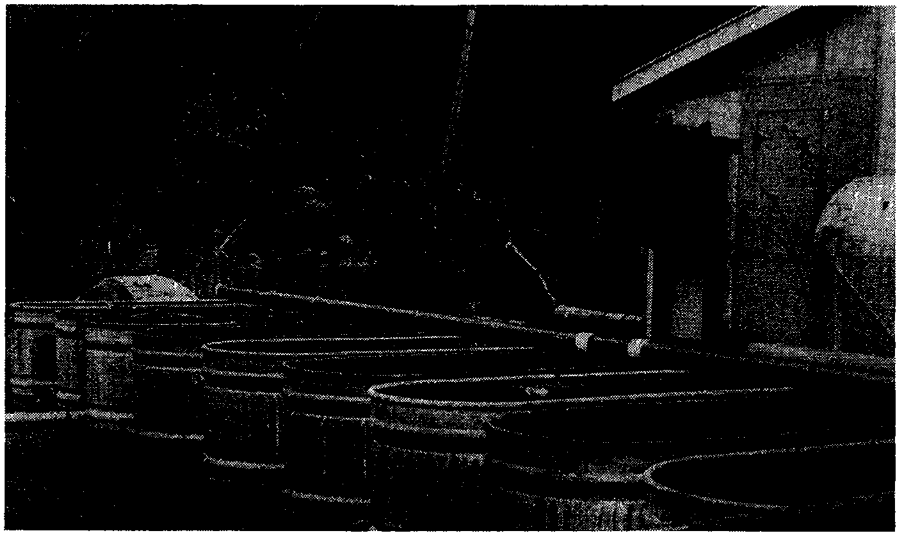


FIGURE 2.3-3 TROUGHS USED TO HOLD LATER YELLOW PERCH AND ALEWIFE LARVAE

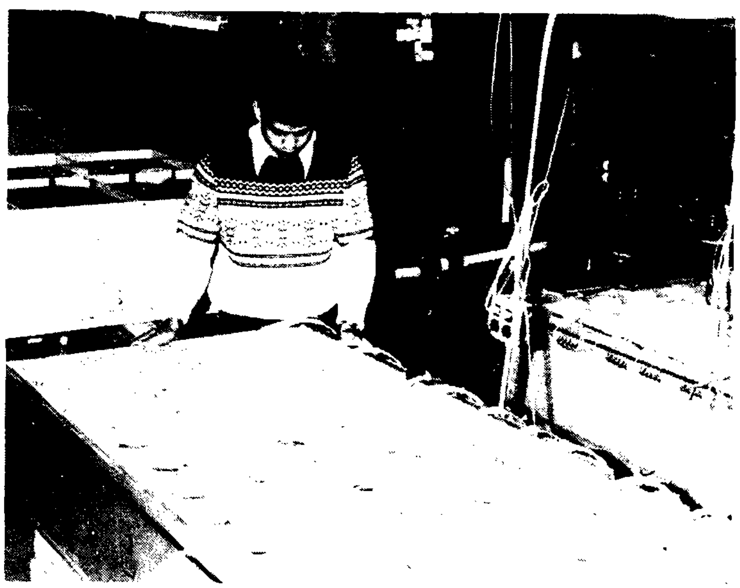


FIGURE 2.3-4 96 HOUR HOLDING FACILITY

SECTION 3

LARVAL IMPINGEMENT SURVIVAL STUDIES

SECTION 3

LARVAL IMPINGEMENT SURVIVAL STUDIES

From June 1979 to June 1980, larvae of the four test species were tested in the impingement facility. The objective of the study was to investigate the survival of larval fish impinged for as long as 16 minutes at specific velocities ranging from 0.5 to 3.0 fps.

3.1 Description of the Facility

Impingement survival studies were conducted using 350 or 500 micron mesh polyester screens mounted perpendicular to the flow direction in a 12 inch wide test segment as shown in Figures 3.1-1 and 3.1-2. Two segments (channels) were built into one flume to allow two tests to be performed concurrently. The 355 micron screen was used to ensure retention of the smallest larvae. When the larval length increased and 100 percent retention was obtained on the 355 micron mesh in the screen retention study (see Section 4), a 500 micron screen was utilized. The mesh size is given as the width of the screen opening for these square-weave polyester screens.

A clear acrylic frame held the impingement screen for each segment and incorporated a collection bucket. During the tests, the frame was located so that its sides were flush with the side walls of the segment and the collection bucket was recessed into the floor. This provided an unobstructed flow to the impingement screen. Acrylic sections in the sides of the flume allowed observation of the organisms during testing. At the end of a pair of tests, a pneumatic cylinder raised the screen frame from the flow and the larvae were gently washed into the collection bucket with a slow stream of water. Figure 3.1-3 shows the impingement screen including the frame and lift buckets in the raised position.

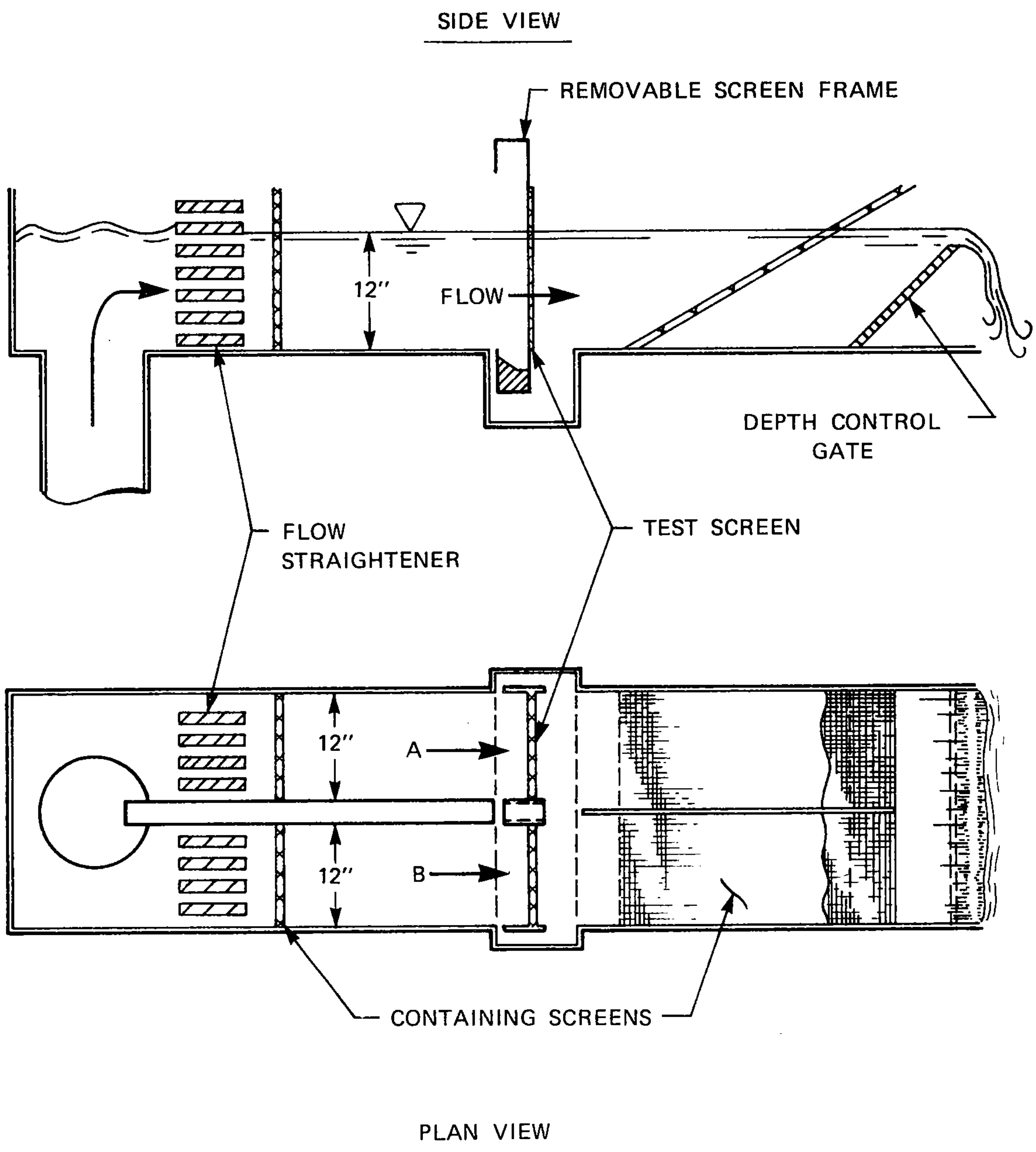


FIGURE 3.1-1 IMPINGEMENT TEST FACILITY

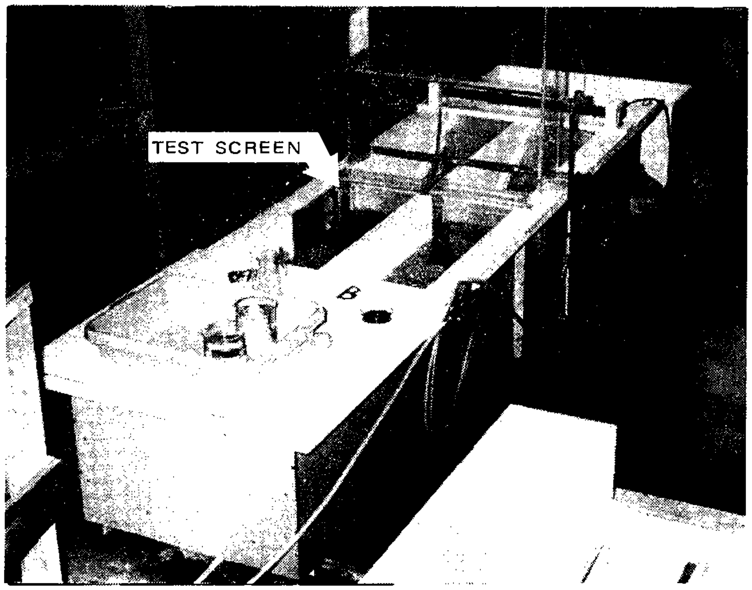


FIGURE 3.1-2 IMPINGEMENT TEST FACILITY, TEST SCREEN IN PLACE

FIGURE 3.1-3 IMPINGEMENT SCREEN IN RAISED POSITION

Declorinated city water was pumped from a 500 gallon sump through a venturi flow meter and a control valve to the flume. The flow entered and exited the test segments through 250 micron containment screens which prevented the loss of any larvae not impinged on the test screen. At the downstream end of the flume, the flow was returned to the sump over a gate that controlled the flow depth.

The impingement velocity was determined at the lower velocities by dividing the measured flowrate by the width and depth of the test section. A uniform distribution could not be obtained over full depth of the channel at higher velocities. A wall was installed on the upstream face of the impingement screen which only allowed flow to pass through the 6 inch high area beneath it. This area was used to determine impingement velocity in these cases. A miniature propeller meter was used to obtain velocity traverses in front of the impingement screens. These traverses were obtained weekly to determine the velocity distribution approaching the screens.

3.2 Biological Testing Procedures

Except where noted in the results section, the following procedures were followed for all four test species.

Prior to each series of tests, 25 larvae, serving as the control for the day's tests, were taken from stock tanks and placed in the collection bucket of the impingement facility for 16 minutes (representing the longest duration tested). The larvae were then removed and held for 96 hours to determine latent mortality. In addition, a separate control group, composed of 25 larvae, was removed from the stock holding tanks and placed directly into holding beakers for 96 hours. This control was utilized to separate out mortality arising solely from holding.

At the start of each test, larvae were introduced into the segments upstream of the fine-mesh test screens. Observations were made during each test of those larvae swimming upstream, swimming in the screen collection bucket, or impinged on the screens. The water temperatures of the stock tanks and the flume and the air temperature were also recorded.

At the conclusion of each pair of tests, the screens were raised and the larvae which had been impinged were gently washed from the screens into the collection buckets. Larvae were then removed from the buckets, enumerated, and placed in holding beakers. Larvae which had been impinged but escaped from the screens while they were being raised (to be collected on the downstream containment screens) were removed from the facility, but were not held for latent mortality since these organisms experienced prolonged air exposure on the downstream containment screens. In general, very few larvae (on the average, 1 to 2 per test) were lost in this fashion.

Larvae which had not been impinged (e.g., those swimming upstream or within the collection trough during the test) were also not held for latent mortality. To avoid influencing the relative percentages of mortality, the 0.5 fps velocity was dropped from the testing matrix when the number of swimmers became consistently large.

The beakers containing those larvae which had impinged were placed in the 96 hour holding facility. A count of initially live and dead larvae in the beakers was made at least 1 hour after the completion of the test, to allow those larvae which had been stunned by impingement time to recover or die. Thereafter, mortality was recorded at 24, 48, 72, and 96 hours. Alewife and yellow perch prolarvae were held for only 48 hours. Since the prolarval stage of both species spans only 2 to 5 days, it was necessary to shorten the holding period to avoid influencing test mortalities with mortalities which occur naturally during the transition to postlarvae.

At the end of the latent effects holding period, beakers were siphoned down, and the number of live larvae was recorded. Cannibalism among the larvae was observed, but was not a major problem. Missing larvae were generally believed to have been cannibalized. However, these larvae were included in the overall test mortality figures. Mortality rates were calculated for control and test larvae.

Testing consisted of introducing groups of larvae into the flume at velocities of 0.5, 1.0, 1.5, 2.0, or 3.0 fps and allowing them to impinge on the fine-mesh screen panels for durations of 2, 4, 8, and 16 minutes. Thus, a complete test series involved filling in the following impingement duration/velocity matrix:

Duration (min.)	Velocity (fps)				
	0.5	1.0	1.5	2.0	3.0
2	X	X	X	X	X
4	X	X	X	X	X
8	X	X	X	X	X
16	X	X	X	X	X

Analytical results of striped bass data gathered in 1979 (as presented in this report) clearly indicated that this matrix could be reduced without jeopardizing the quality of the data. Therefore, testing with winter flounder, yellow perch, and alewife involved use of limited matrices centered on velocity/duration combinations which yielded relatively high survival. This approach eliminated needless replicates of combinations which consistently resulted in high or total mortality. At times, it was necessary to reduce a matrix further than planned due to limitations in the number of organisms available for testing. Matrices were also changed in certain cases when early results indicated that alterations would yield more meaningful data. The way in which matrices were developed, reduced, and changed is discussed in the results section (3.3) for each species.

3.3 Analytical Results

Striped Bass

Impingement testing with striped bass was conducted from June to August 1979. The testing program was conducted in two phases. Four hundred fifty-six tests were conducted during the first phase using prolarvae and postlarvae. During the second phase, one hundred eighty-eight tests were performed with early juveniles. Histograms of the percent mortality obtained at all impingement durations and approach velocities tested are presented in Figure 3.3-1. Data from these tests are presented in Appendix A.

The results of the entire testing program were analyzed by ANCOVA, as summarized in Table 3.3-1. As expected, velocity, duration, and larval length were significant variables and were, therefore, included in all subsequent analyses.

Since striped bass were tested as prolarvae, postlarvae, and early juveniles, results of testing with each group were analyzed separately, as presented below.

Prolarvae (5.4 - 6.4mm)

Results of ANCOVA are presented in Table 3.3-2. These results indicate that:

1. Mortality increased as velocity, impingement duration, and the interaction of these variables increased in value.

2. Percent mortality decreased as tank temperature and larval length increased; however, it is not possible to separate out the effect of either variable since they both increased over time and were, therefore, correlated.

As shown in Table 3.3-3, mean percent mortality among prolarvae was high under all test conditions. Although the ANCOVA model fit the prolarval data well (accounting for 71.7 percent of the total variability), it was not used to test for differences between mean velocity/duration mortality values since all values were high and such comparisons would, therefore, be of little practical use.

Postlarvae (6.5 - 17.1mm)

The majority of testing was conducted at velocities from 0.5 to 2.0 fps and impingement durations of 2, 4, and 8 minutes; results were analyzed by ANCOVA. Only limited testing was conducted at the 3 fps velocity (2 and 4 minutes) and for the 16 minute duration (0.5 to 1.5 fps); therefore, these results were analyzed by t-tests.

Results of the ANCOVA are given in Table 3.3-4. These results, coupled with the mean mortality values (predicted from ANCOVA) given in Table 3.3-5, allow the following conclusions to be drawn:

1. At 0.5 fps, mortalities at durations of 2, 4, and 8 minutes did not differ significantly. At the other test velocities, mortalities at 8 minutes were significantly higher than at 4 minutes.

2. Under each impingement duration, mortalities were not significantly different at each velocity; further, all values under 2 and 4 minute durations were not statistically different.

3. Percent mortality decreased as the larvae grew in length.

As shown in Figure 3.3-2, the effect of larval length on mortality was evaluated (using the ANCOVA model) at each approach velocity and impingement duration.

As mentioned, limited testing was conducted with postlarvae at 3.0 fps and for 16 minute impingement durations; results are given in Table 3.3-6. At 3 fps, the 2 and 4 minute mortalities were significantly different. At an impingement duration of 16 minutes, there was trend toward higher mortality at higher velocity.

Early Juveniles (17.2 - 17.6mm)

Juveniles were tested according to the following matrix:

Duration (min.)	Velocity (fps) 1.0	1.5	2.0
4	X		X
8	X	X	X
16	X	X	

An ANCOVA was conducted (Table 3.3-7) which indicated that impingement duration and velocity, tank temperature, fish length and two interaction terms influenced juvenile mortality. Based on the analysis, the following conclusions can be drawn:

1. Mortality increased as impingement duration and velocity increased.
2. Mortality increased as the juveniles grew.

These relationships are presented graphically in Figure 3.3-3.

Controls

Striped bass controls were studied to determine the mortality attributable to handling and holding, and holding alone. Table 3.3-8 summarizes the results of an analysis of covariance. Mean percent mortalities for handling and holding, and holding groups were 12.7 and 11.7 percent, respectively. Since the percent mortality did not significantly differ by group, handling did not appear to increase mortality.

Figure 3.3-4 depicts the distributions of control mortality for prolarvae, postlarvae, and early juvenile striped bass. The two control groups (handling and holding, and holding) were combined to estimate the control mortalities. The means and medians are summarized for each histogram. Since the distributions of percent mortality of larvae and juveniles are highly skewed, the medians were used to estimate the control mortalities.

The high prolarval control mortalities indicate that this life stage did not respond well to the handling procedures required in conducting the impingement survival tests. Therefore, it is reasonable to assume that correspondingly high test mortalities were also partly a function of handling rather than impingement stress.

The mortality attributable to handling and holding, as determined by control groups, was low for postlarvae and juveniles. Therefore, no attempt was made to adjust test mortalities.

TABLE 3.3-1

Results of ANCOVA - Striped Bass
Entire Impingement Testing Program
96-Hour Mortality

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Velocity	4	51,201.037	12,300.258	19.929	0.0000*
Duration	3	216,170.333	72,056.750	112.185	0.0000*
Segment	1	357.868	357.868	0.557	0.4558
Length	1	45,866.920	45,866.920	71.410	0.0000*
Residual	633	406,579.563	642.306		
TOTAL	642	655,087.688			

*Significant since $\alpha \leq 0.05$

TABLE 3.3-2

Results of ANCOVA - Impingement Model
Striped Bass Prolarvae
96-Hour Mortality

a. Full Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Velocity	3	1.0265	0.3422	8.189	0.0009*
Duration	2	0.5883	0.2941	7.040	0.0048*
V x D	6	0.7116	0.1186	2.838	0.0364*
L x V	3	0.1698	0.0566	1.354	0.2853
L x D	2	0.0206	0.0103	0.246	0.7842
Tank Temperature	1	0.3279	0.3279	7.847	0.0110*
Length	1	0.3719	0.3719	8.901	0.0073*
Residual	20	0.8357	0.4179		
TOTAL	38	3.6249			

b. Reduced Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Velocity	3	0.9143	0.3048	7.428	0.001*
Duration	2	0.5844	0.2922	7.121	0.0036*
V x D	6	0.7509	0.1251	3.05	0.0223*
Tank Temperature	1	0.2197	0.2197	5.355	0.0292*
Length	1	0.2808	0.2808	6.845	0.0149*
Residual	25	1.0257	0.0410		
TOTAL	38	3.6249			

*Significant since $\alpha \leq 0.05$

TABLE 3.3-2
(continued)

$$\ln Y_{ijk} = 4.4 + V_i + D_j + (V_iD_j) - 0.09\ (T_{ijk} - 17.2) + 0.40\ (L_{ijk} - 6.0) + e_{ijk}$$

where

$\ln Y_{ijk}$ = predicted natural logarithm mortality of the ijk^{th} test

V_i = effect of i^{th} velocity

D_j = effect of j^{th} duration

T_{ijk} = tank temperature of ijk^{th} test

L_{ijk} = larval length of ijk^{th} test

e_{ijk} = the residual variance

TABLE 3.3-3

Observed 96-Hour Mean Percent Mortality
and Standard Deviations
Striped Bass Prolarvae (5.4 to 6.4mm)

Velocity (fps)	Duration (min) 2	4	8	16
0.5	72.4 ± 11 (4)	51.2 ± 24.2 (4)	91.8 ± 9.0 (4)	84.6 ± 18.6 (4)
1.0	63.4 ± 4.9 (3)	62.9 ± 6.9 (3)	90.7 ± 8.3 (3)	96.0 ± 6.9 (3)
1.5	70.7 ± 20.5 (3)	92.0 ± 8.0 (3)	98.7 ± 2.3 (3)	100.0 ± 0 (3)
2.0	97.3 ± 4.6 (3)	100.0 ± 0 (3)	100.0 ± 0 (3)	100.0 ± 0 (3)
3.0	---	---	---	---

Four replicates were tested at 0.5 fps velocity for each impingement duration. Three replicates were tested at 1.0, 1.5, and 2.0 fps velocities.

Number of tests is given in parentheses.

TABLE 3.3-4

Results of ANCOVA - Impingement Model
Striped Bass Postlarvae
96-Hour Mortality

a. Full Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Velocity	3	17.4805	5.8268	4.805	0.0028*
Duration	2	76.4545	28.2273	31.521	0.0000*
V x D	6	11.6899	1.9483	1.607	0.1451
L x V	3	2.3202	0.7734	0.638	0.5912
L x D	2	0.0102	0.0051	0.004	0.9948
Tank Temperature	1	2.6359	2.6359	2.173	0.1415
Length	1	89.0904	89.0904	73.461	0.0000*
Residual	284	344.422	1.2128		
TOTAL	302	546.412			

b. Reduced Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Velocity	3	18.8478	6.2826	5.211	0.0016*
Duration	2	82.9164	41.4582	34.388	0.0000*
V x D	6	15.2946	2.5491	2.114	0.0516*
Length	1	116.7549	116.7549	96.845	0.0000*
Residual	296	346.621	1.2056		
TOTAL	302	546.412			

*Significant since $\alpha \leq 0.05$

$$\ln Y_{ijk} = 2.3 + V_i + D_j + (V_i D_j) - 0.24\ (L_{ijk} - 10) + e_{ijk}$$

where

$\ln Y_{ijk}$ = predicted natural logarithm mortality of ijk^{th} test

V_i = effect of i^{th} velocity

D_j = effect of j^{th} duratuion

L_{ijk} = larval length of ijk^{th} test

e_{ijk} = residual variance

TABLE 3.3-5

Predicted 96-Hour Mean Percent Mortality
and 95 Percent Confidence Interval
Striped Bass Postlarvae

Velocity (fps)	Duration (min)		
	2	4	8
0.5	2.1 ≤ 3.8 ≤ 6.6 (26)	3.1 ≤ 5.5 ≤ 9.1 (26)	4.8 ≤ 8.2 ≤ 13.5 (25)
1.0	3.1 ≤ 5.3 ≤ 9.1 (28)	4.1 ≤ 6.8 ≤ 11.0 (28)	11.4 ≤ 17.5 ≤ 26.6 (31)
1.5	4.0 ≤ 6.4 ≤ 10.0 (32)	5.8 ≤ 9.1 ≤ 14.1 (32)	16.5 ≤ 27.3 ≤ 44.7 (23)
2.0	2.1 ≤ 4.2 ≤ 7.8 (20)	3.1 ≤ 6.0 ≤ 10.8 (20)	22.6 ≤ 47.5 ≤ 98.5 (12)

Number of tests is given in parentheses.

TABLE 3.3-6

Observed Mean Percent Mortality
and 95 Percent Confidence Intervals*
Striped Bass Postlarvae (6.5 to 17.1mm)
96-Hour Mortality

	Postlarvae
3.0 fps	
2 minutes	18.35 ± 7.46 (20)
4 minutes	49.13 ± 14.9 (20)
16 minutes	
0.5	43.91 ± 6.63 (25)
1.0	58.91 ± 7.68 (30)
1.5	97.6 ± 9.88 (5)

*Observed means given since no ANCOVA was conducted from which to derive predicted means.

Number of tests is given in parentheses.

TABLE 3.3-7

Results of ANCOVA - Impingement Model
Striped Bass Early Juveniles (17.2 to 27.6mm)
96-Hour Mortality

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Velocity	2	160.146	80.073	24.055	0.0000*
L x V	2	50.245	25.123	7.547	0.0008*
D x V	2	32.946	16.473	4.949	0.0083*
Tank Temperature	1	31.409	31.409	9.436	0.0025*
Length	1	67.720	67.720	20.344	0.0000*
Duration	1	256.278	256.278	76.990	0.0000*
Residual	150	499.305	3.329		
TOTAL	159	1,221.521			

*Significant since $\alpha \leq 0.05$

$$\sqrt{Y_{ijk} + 1} = 6.15 + V_i + LV_i + DV_i - 1.03\,(T_{ijk} - 20.9) + 0.4007\,(L_{ijk} - 21.1) + 0.467\,(D_{ijk} - 9.1) + e_{ijk}$$

where

Y_{ijk} = predicted mortality of ijkth test

V_i = effect of ith velocity

LV_i = effect of interaction between length and velocity

L_{ijk} = larval length of ijkth test

DV_i = effect of interaction between duration and velocity

D_{ijk} = duration of ijkth test

T_{ijk} = tank temperature of ijkth test

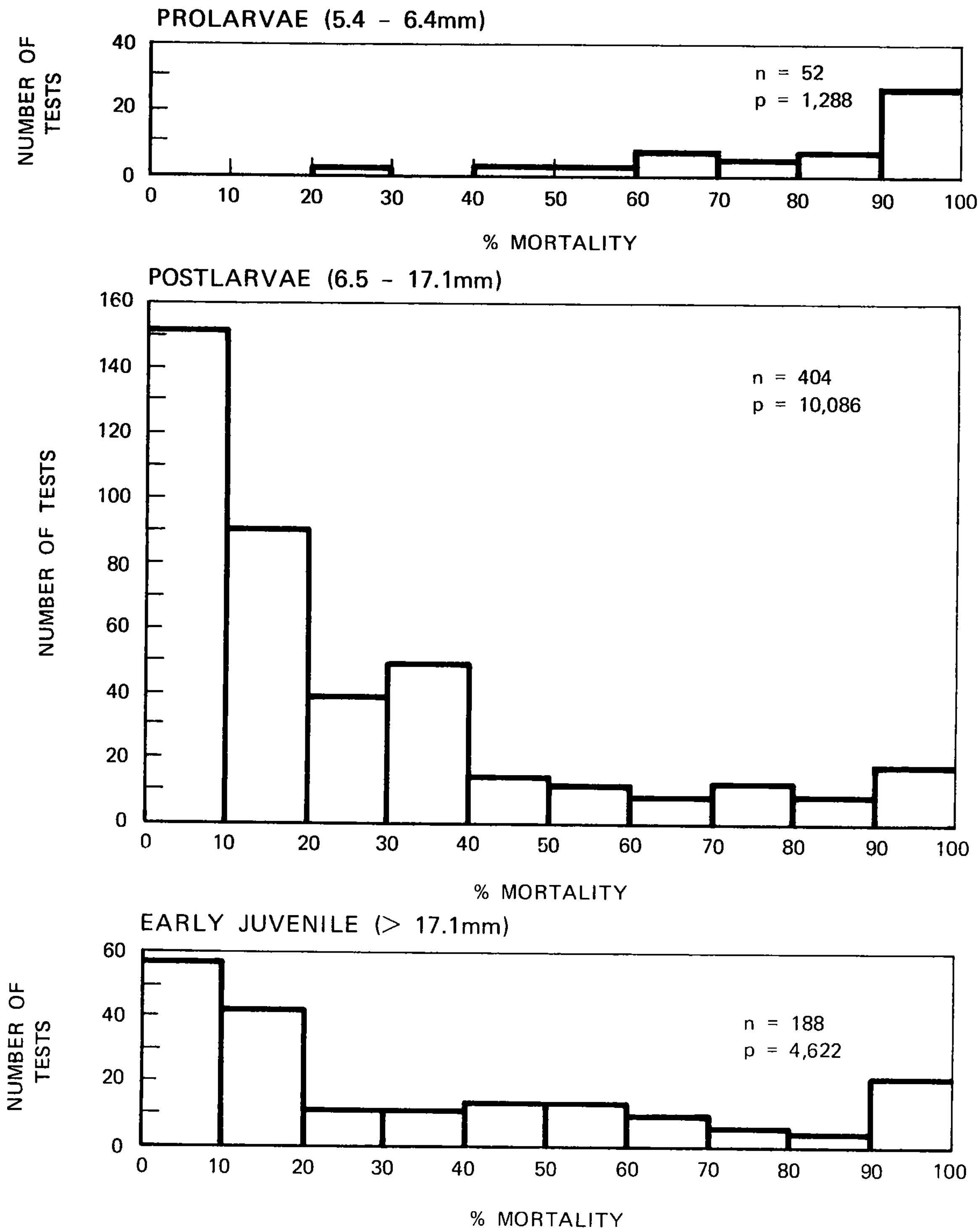
e_{ijk} = the residual variance

TABLE 3.3-8

Results of ANCOVA - Impingement Model
Striped Bass Controls
96-Hour Mortality

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Group	1	17.7488	17.7488	0.047	0.8289
Length	1	6,212.35	6,212.35	16.48	0.0001*
Residual	68	25,632.80	376.95		
TOTAL	70	32,149.69			

*Significant since $\alpha \leq 0.05$



NOTE: n = TOTAL NUMBER OF TESTS
p = TOTAL NUMBER OF ORGANISMS

FIGURE 3.3-1 HISTOGRAMS OF STRIPED BASS 96-HOUR MORTALITY PARTITIONED BY LIFE STAGE

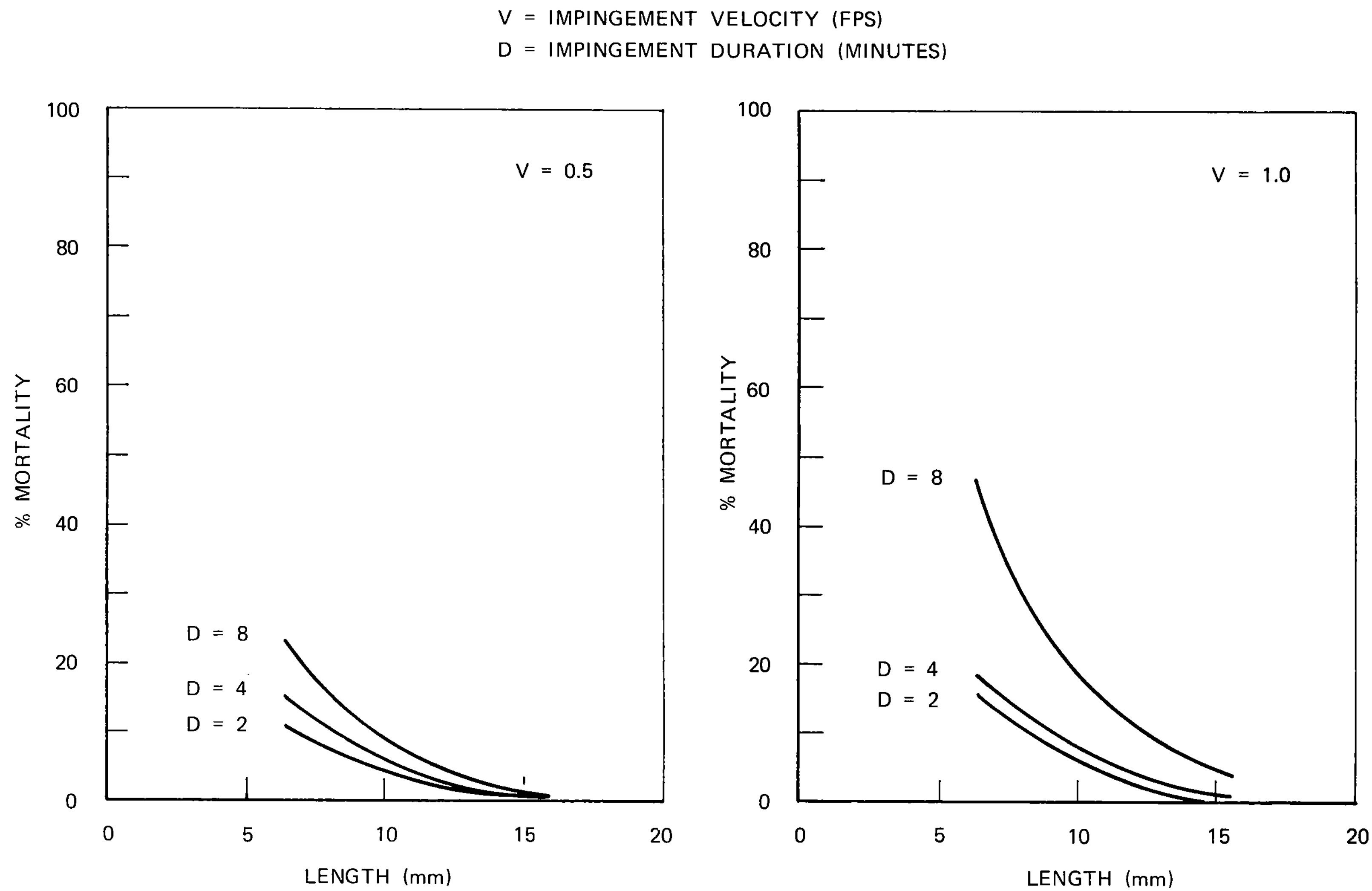


FIGURE 3.3-2a STRIPED BASS IMPINGEMENT TEST MORTALITY (96-HOUR) VERSUS LARVAL LENGTH POSTLARVAE (6.5 - 17.1mm)

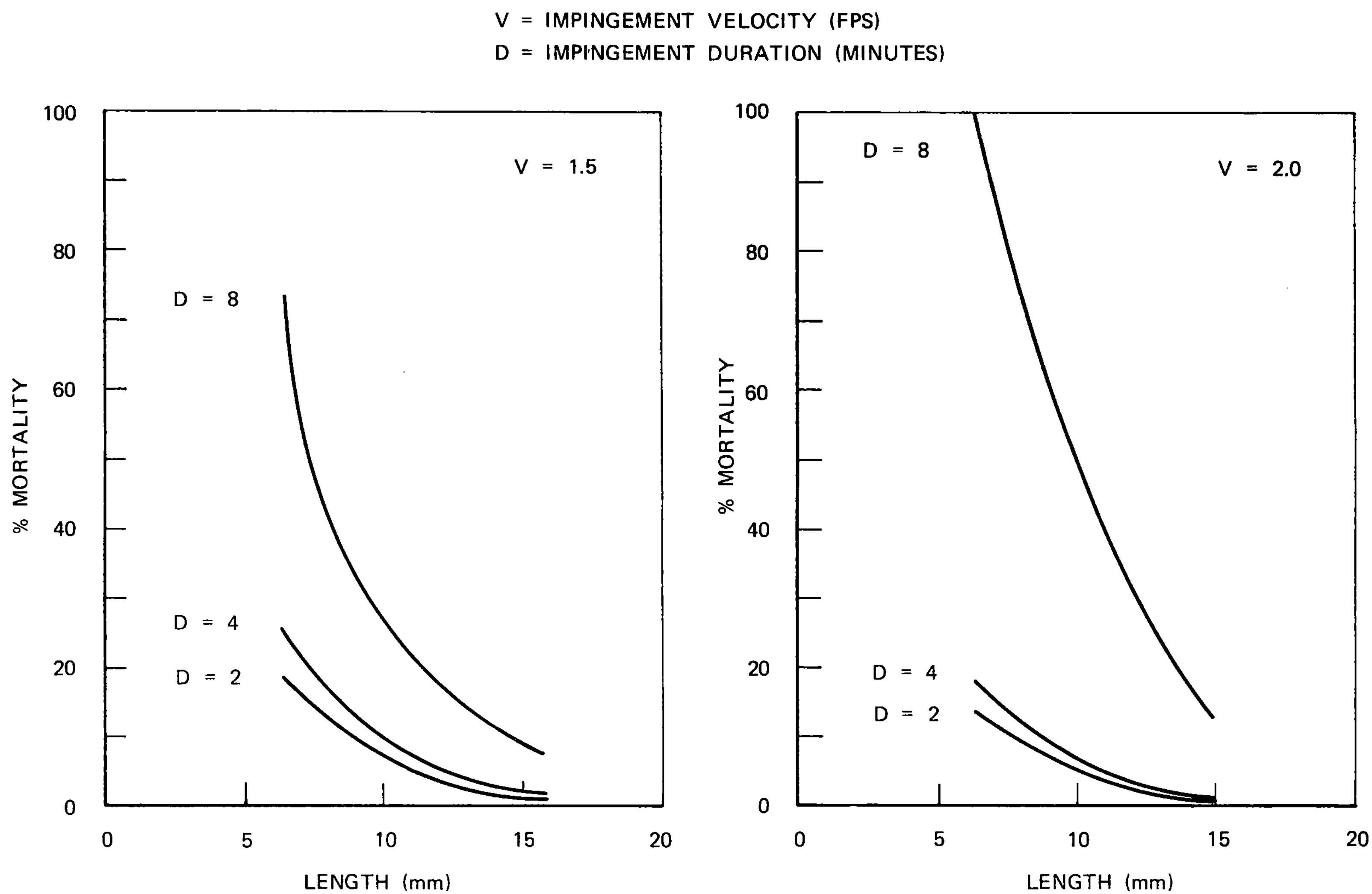
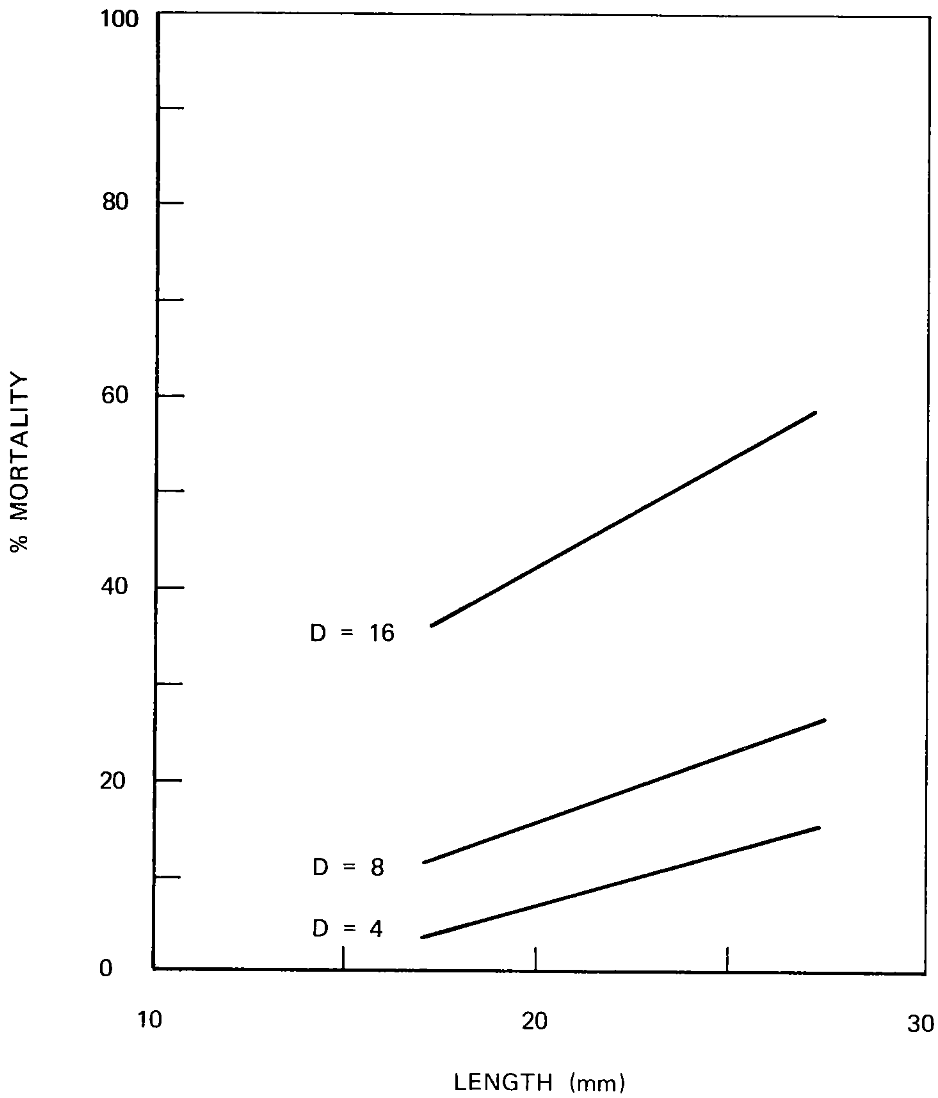
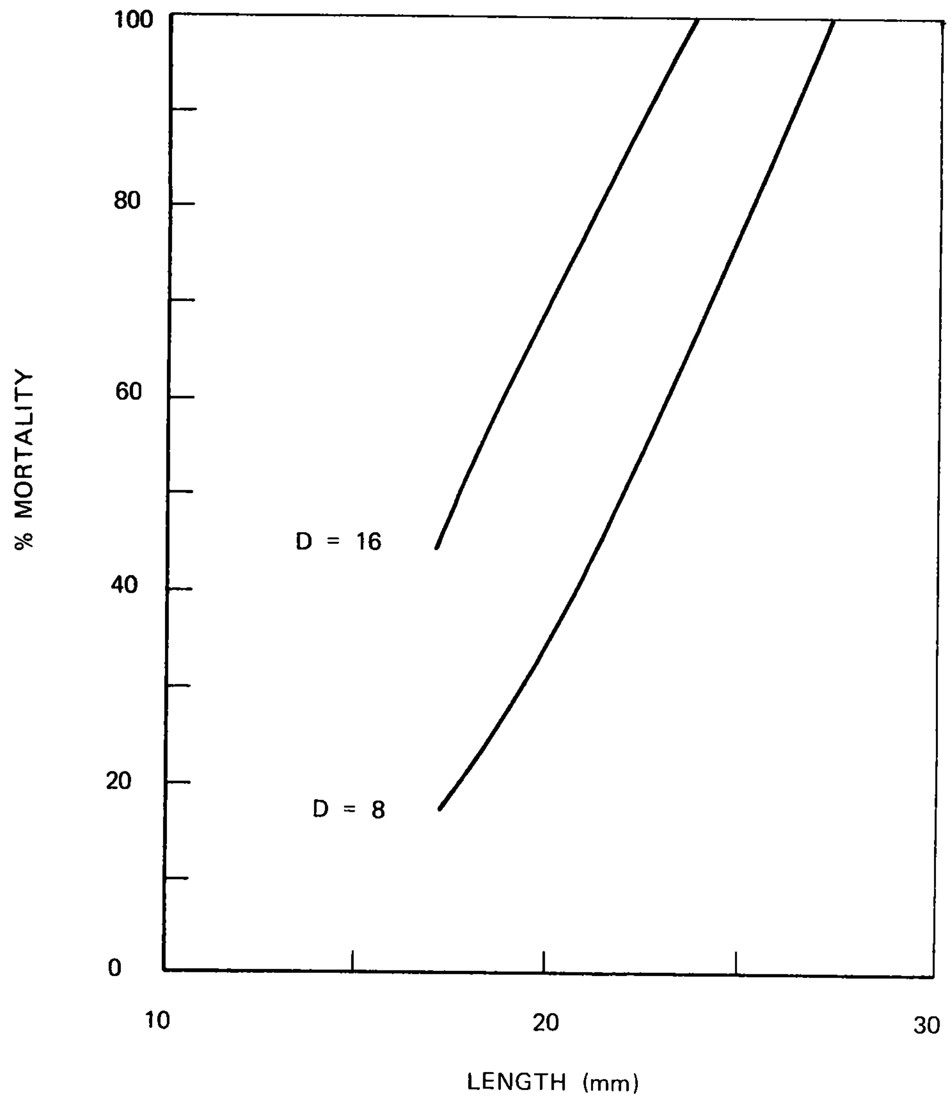


FIGURE 3.3-2b STRIPED BASS IMPINGEMENT TEST MORTALITY (96-HOUR) VERSUS LARVAL LENGTH POSTLARVAE (6.5 - 17.1mm)



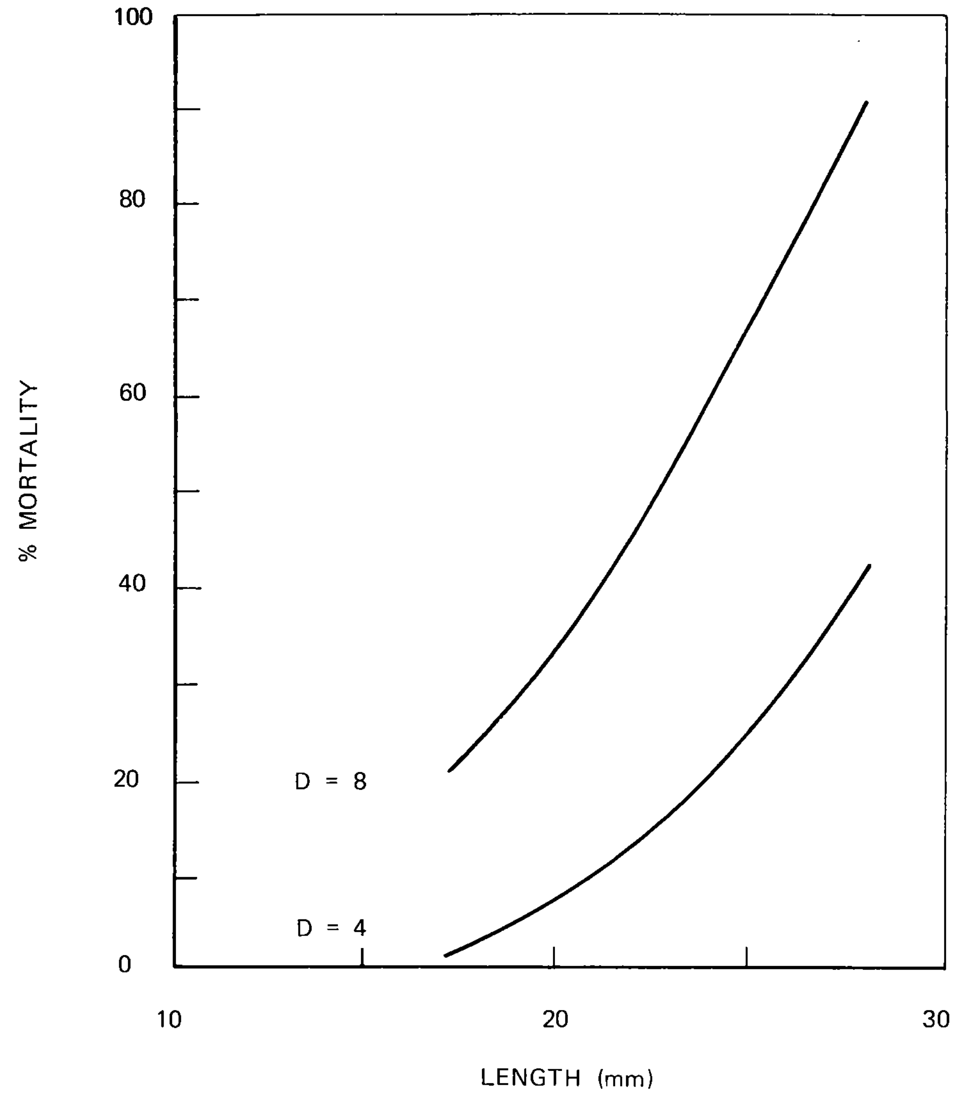
NOTE: IMPINGEMENT VELOCITY = 1.0 FPS
D = IMPINGEMENT DURATION (MINUTES)

FIGURE 3.3-3a EARLY JUVENILE STRIPED BASS (> 17.1mm) IMPINGEMENT TEST MORTALITY (96-HOUR) VERSUS LARVAL LENGTH



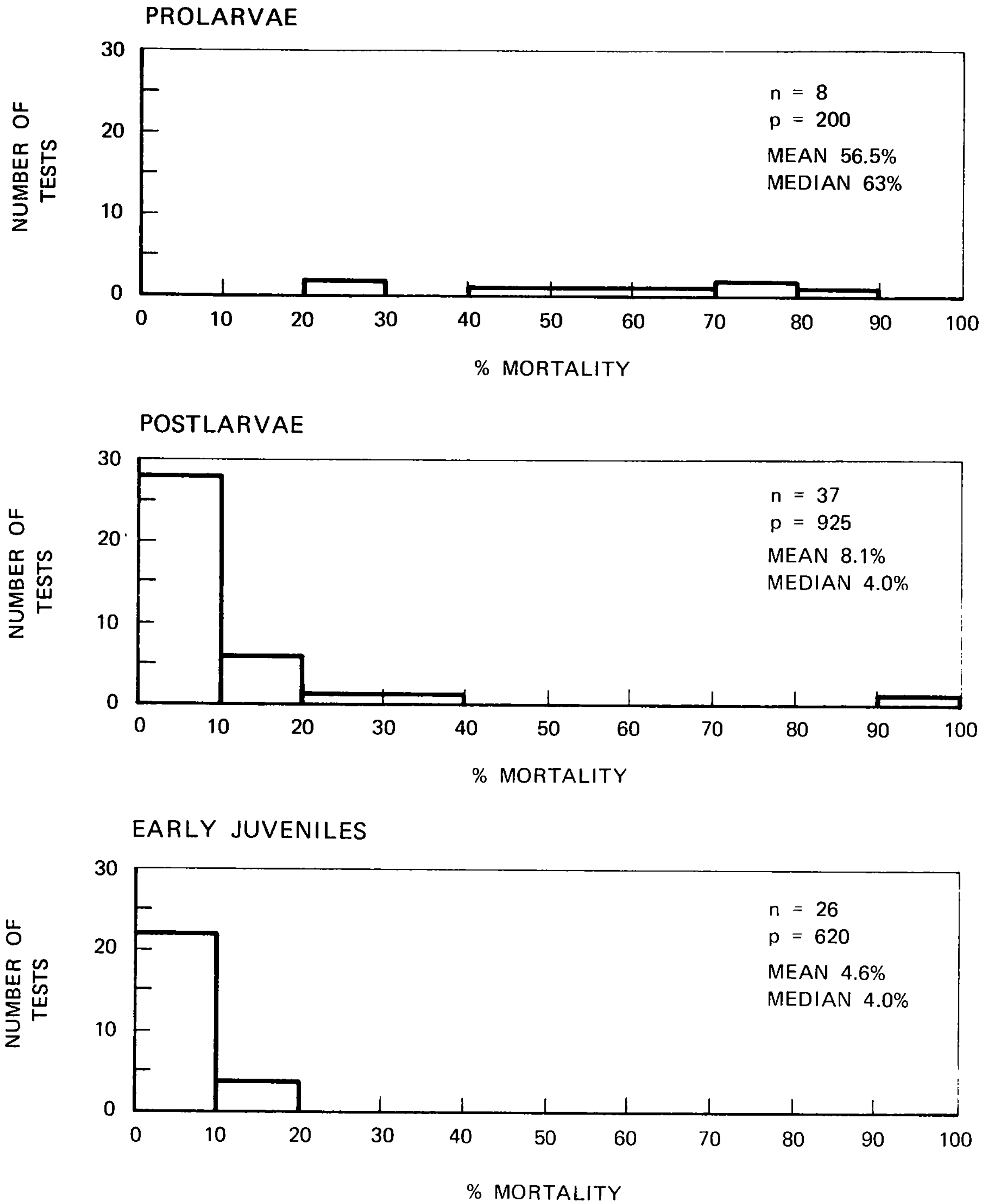
NOTE: IMPINGEMENT VELOCITY = 1.5 FPS
D = IMPINGEMENT DURATION (MINUTES)

FIGURE 3.3-3b EARLY JUVENILE STRIPED BASS (> 17.1mm) IMPINGEMENT TEST MORTALITY (96-HOUR) VERSUS LARVAL LENGTH



NOTE: IMPINGEMENT VELOCITY = 2.0 FPS
D = IMPINGEMENT DURATION (MINUTES)

FIGURE 3.3-3c EARLY JUVENILE STRIPED BASS (> 17.1mm) IMPINGEMENT TEST MORTALITY (96-HOUR) VERSUS LARVAL LENGTH



NOTE: n = TOTAL NUMBER OF TESTS
p = TOTAL NUMBER OF ORGANISMS

FIGURE 3.3-4 HISTOGRAMS OF 96-HOUR STRIPED BASS MORTALITY PARTITIONED BY LIFE STAGE IMPINGEMENT CONTROL GROUPS

Winter Flounder

From March through April 1980, winter flounder larvae were tested in the impingement facility to investigate their ability to withstand impingement. Initially, prolarvae and postlarvae were to be tested in a matrix consisting of 16 velocity/duration combinations. However, the small size and transparent nature of the larvae made their recovery from the impingement facility a time-consuming process. Therefore, to facilitate testing, the matrix was reduced to eight velocity/duration combinations:

Duration (min.)	Velocity (fps) 0.5	1.0	1.5	2.0
2	X	X	X	X
8	X	X	X	X

Limited testing of the 16 minute duration at 0.5 and 1.0 fps was also conducted with postlarvae for comparative purposes.

The impingement facility was as described in Section 3.1; however, due to the very small size of the winter flounder tested, 355 micron mesh screen was employed exclusively to ensure retention of the larvae.

Tests with winter flounder were conducted during two discrete periods (life stages): prolarvae and postlarvae. Therefore, the data for each life stage were analyzed separately, as presented below.

Prolarvae

A total of 32 tests were conducted with prolarvae (4.0 to 4.1mm) during the testing period. Although 25 prolarvae were introduced into each segment of the impingement model, the 25 larvae were not always recovered since their small size and transparent appearance made them very difficult to find. Table 3.3-9 presents the numbers of unaccounted for prolarvae for the specific velocity/duration combinations tested.

The data were analyzed by analysis of variance (ANOVA). The dependent variable was the percent mortality after 96 hours, calculated as:

$$\left(\frac{\text{Total dead after 96 hours}}{\text{Total number held}}\right) \times 100$$

The total number of prolarvae held for 96 hour mortality consisted of those that were recovered alive (i.e., total number tested minus those unaccounted for or initially dead). Therefore, missing prolarvae were not initially included in the latent mortality estimates. However, since unaccounted for prolarvae probably represent individuals which would die as a result of impingement on the fine-mesh screens, a subsequent calculation was made in which the missing prolarvae were considered as initially dead.

Testing was conducted on two separate days when mean larval lengths were nearly identical (4.0 and 4.1mm, respectively). Since length would not have represented a good indicator of possible developmental changes which might have occurred in the larvae between the two sampling days and might have influenced mortality, test day was substituted in the analysis for larval length. Temperature varied little (6 to 8°C) over the test period and was not included in the analysis.

Results of the initial ANOVA (unaccounted for larvae not included) are presented in Table 3.3-10. Within the range of independent variables examined, approach velocity was the only variable which significantly influenced mortality. As shown in Table 3.3-11, there was a general trend toward higher mortality with higher velocity. Duncan's multiple range tests indicated the following: mean mortalities at 0.5, 1.0, and 1.5 fps did not differ significantly; mortalities at 0.5 and 1.0 fps differed significantly from those at 2.0 fps; 1.5 and 2.0 fps mortalities were not significantly different.

Results of the second ANOVA of prolarvae (unaccounted for larvae included) are presented in Table 3.3-12. Again, velocity was the only significant variable. As shown in Table 3.3-13, there was a trend toward increasing mortality as velocity increased. Duncan's multiple range tests indicated that mortalities at 2.0 fps were significantly higher than at the other velocities, which did not differ significantly.

Prolarvae control data were studied to determine the effects of holding and handling. The 96 hour control mortality ranged from 4.0 to 4.2 percent, with a mean of 4.1 percent. Thus, holding and handling winter flounder prolarvae did not appear to contribute significantly to latent mortality.

Postlarvae

Early postlarvae (4.4mm) and late postlarvae (6.1mm) were tested in the impingement facility from late March to mid-April. The designation "early postlarvae" was given to those larvae which had completed the transition from yolk-sac to post-yolk-sac stage but which experienced continued low-level natural die-offs throughout the testing. "Late postlarvae," on the other hand, were larger and more easily reared under laboratory conditions such that natural die-offs were no longer a problem.

Fifty-six tests were performed with early postlarvae (mean length = 4.4mm). The results of testing are summarized in Table 3.3-14. Summary statistics calculated for the ten velocity/duration combinations tested are presented in Table 3.3-15. It is clear from the data that the mortalities of early postlarvae were high.

The high and variable test mortalities for early postlarvae are believed to result primarily from natural causes rather than impingement stress. Mean control mortality at this time was 42.5 percent, supporting the conclusion that many of the larvae died from starvation during the transition from the yolk-sac to post-yolk-sac stage. Natural die-offs of winter flounder larvae during this stage of development have been documented by other researchers (MRI, personal communication). The high or highly variable control mortality makes the evaluation of the effects of impingement stress difficult, since the test mortalities are not representative of the larvae's ability to withstand impingement. However, the added factor of large, naturally-occurring die-offs at this point in their life stage may be indicative of the difficulty of protecting winter flounder during this stage of larval development.

Eighteen tests were conducted with late postlarvae. Results and summary statistics are summarized in Table 3.3-15.

The test mortalities of late postlarvae were not as high as the test mortalities observed for the early postlarvae. However, since only two tests were conducted at each velocity/duration combination due to the limited numbers of late postlarvae available, the results were not analyzed to determine which velocity/duration combinations were significantly different.

Unexpectedly, the mortalities of late postlarvae tested at the least stringent velocity/duration combination (0.5 fps for 2 minutes) are higher than the mortalities at more stringent combinations.

TABLE 3.3-9

Winter Flounder Prolarvae
Number Unaccounted for During
Impingement Testing

Velocity (fps)	Duration (minutes) 2	8
0.5	4	2
	1	1
	1	1
	0	3
1.0	0	0
	0	1
	2	1
	4	1
1.5	0	3
	0	2
	3	3
	0	1
2.0	5	11
	0	7
	2	8
	3	7

NOTE: Twenty-five prolarvae were introduced upstream of the fine-mesh screens. The number of prolarvae unaccounted for after each test is shown.

TABLE 3.3-10

ANOVA of Prolarval Flounder Impingement Data
Unaccounted for Prolarvae Not Included in
96-Hour Mortality Estimates

a. Full Model

Source of Variation	Df	Sum of Squares	Mean Squares	F-Ratio	α Prob.
Velocity	3	15.17	5.06	3.26	0.0407*
Duration	1	1.08	1.08	0.69	0.4135
Day	1	0.04	0.04	0.02	0.8816
Segment	1	5.24	5.24	3.38	0.0795
Velocity x Duration	3	2.90	0.97	0.62	0.6075
Error	22	34.09			
Total	31	58.50			

b. Reduced Model

Source of Variation	Df	Sum of Squares	Mean Squares	F-Ratio	α Prob.
Velocity	3	15.17	5.06	3.27	0.0360*
Error	28	43.33			
Total	31	58.50			

*Significant since $\alpha \leq 0.05$

TABLE 3.3-11

96-Hour Mean Mortalities and 95 Percent Confidence Intervals
Winter Flounder Prolarvae
Unaccounted for Prolarvae Not Included in Mortality Estimates

Velocity (fps)	Mean Mortalities and 95 Percent Confidence Intervals
0.5	0.38 ≤ 2.9 ≤ 10.0 (8)
1.0	0.19 ≤ 2.4 ≤ 8.5 (8)
1.5	2.3 ≤ 8.3 ≤ 25.3 (8)
2.0	5.4 ≤ 17.2 ≤ 50.4 (8)

Number of tests is given in parentheses.

TABLE 3.3-12

ANOVA of Prolarval Flounder Impingement Data
Unaccounted for Prolarvae Included in
96-Hour Mortality Estimates

a. Full Model

Source of Variation	Df	Sum of Squares	Mean Squares	F-Ratio	α Prob.
Velocity	3	9.81	3.27	7.36	0.0014*
Duration	1	0.34	0.34	0.76	0.3920
Day	1	0.40	0.40	0.90	0.3528
Segment	1	0.58	0.58	1.31	0.2656
Velocity x Duration	3	2.21	0.74	1.66	0.2046
Error	22	9.78	0.44		
Total	31	23.12			

b. Reduced Model

Source of Variation	Df	Sum of Squares	Mean Squares	F-Ratio	α Prob.
Velocity	3	9.81	3.27	6.88	0.005*
Error	28	13.31			
Total	31	23.17			

*Significant since $\alpha \leq 0.05$

TABLE 3.3-13

96-Hour Mean Mortalities and 95 Percent Confidence Intervals
Winter Flounder Prolarvae
Unaccounted for Prolarvae Included in Mortality Estimates

Velocity (fps)	Mean Mortalities and 95 Percent Confidence Intervals
0.5	$3.6 \leq 7.3 \leq 13.7$
1.0	$5.6 \leq 10.7 \leq 19.8$
1.5	$8.8 \leq 16.5 \leq 30.2$
2.0	$19.5 \leq 35.6 \leq 64.1$

TABLE 3.3-14

Summary Statistics of Early
Postlarval 96-Hour Mortality
Flounder Impingement Study

Velocity (fps)		Duration (minutes) 2	8	16
0.5	n	8	8	8
	Mean	64.9%	72%	66.8%
	St. Dev.	28.4%	24.0%	18.4%
	Range	12.5 - 92%	22.2 - 100%	32 - 92%
1.0	n	6	6	4
	Mean	93.1%	100%	100%
	St. Dev.	13.1%	0%	0%
	Range	66.7 - 100%		
1.5	n	4	4	
	Mean	93.1%	97.7%	
	St. Dev.	13.9%	2.7%	
	Range	72.2 - 100%	95 - 100%	
2.0	n	4	4	
	Mean	100%	100%	
	St. Dev.	0%	0%	

CONTROL MORTALITY

n = 3
Mean = 42.5%
St. Dev. = 33.8%
Range = 14.3 - 80%

TABLE 3.3-15

Summary Statistics of Late Postlarval 96-Hour Mortality
Flounder Impingement Study

Velocity (fps)		Duration (minutes) 2	8	16
0.5	Mortalities (%)	68; 40	84; 40	52; 4
	Mean	54%	62%	28%
	St. Dev.	19.8%	31.1%	33.9%
1.0		8; 36	56; 16	
		22%	36%	
		19.8%	28.3%	
1.5		44; 24	28; 34.8	
		34%	31.4%	
		14.1%	4.8%	
2.0		16; 16.7	64; 54.2	
		16.4%	59.1%	
		0.5%	6.9%	

Control Mortality: 8.3%

Alewife

From May through June 1980, alewife larvae were tested in the impingement facility to investigate their ability to withstand impingement. As in the case of winter flounder larvae, a reduced velocity/duration matrix was employed to facilitate testing.

Alewife larvae were tested in two distinct groups: prolarvae and postlarvae. As discussed in Section 3.2, prolarvae were held for 48 hours only due to the short duration of this life stage. The results of testing with each life stage were analyzed separately, as presented below.

Prolarvae (5.2 and 5.5mm)

A total of 32 tests were conducted on two separate days. The results of testing and the important summary statistics are presented in Table 3.3-16. The data were analyzed by ANOVA. The dependent variable was the percent mortality after 48 hours. The results of the first analysis are presented in Table 3.3-17. Within the range of independent variables examined, approach velocity and impingement duration significantly influenced mortality. The interaction between velocity and duration was also significant.

Duncan's multiple range tests indicated that the mean percent mortality of prolarvae tested at 2.0 fps for 8 minutes was significantly higher than all other velocity/duration combinations. The mean percent mortality of prolarvae tested at 1.5 fps for 8 minutes was significantly lower than the mean percent mortality of prolarvae tested at 2.0 fps for 8 minutes and was significantly higher than all other velocity/duration combinations. In addition, the mean percent mortality of prolarvae tested at 2.0 fps for 2 minutes was significantly higher than the mean percent mortalities of prolarvae tested at 0.5, 1.0, and 1.5 fps for 2 minutes and 0.5 fps for 8 minutes.

Figure 3.3-5 depicts the relationship between approach velocity and mean percent mortality for the two durations examined. As the velocity increases, the mean percent mortality generally increases. In addition, the differences between the mean percent mortalities of prolarvae tested at 2 and 8 minutes become larger as the velocity increases.

No mortality was recorded among controls during the 48-hour holding period. Thus, holding and handling of alewife prolarvae did not contribute significantly to latent mortality.

Postlarvae

Mortality among alewife postlarvae was substantially higher than with prolarvae. A total of 124 tests were conducted as larvae grew from 6.6 to 14.7mm. Test mortality was generally high, as shown on Table 3.3-18, while control mortality was highly variable, ranging from 4 to 100 percent. Control mortality decreased as the larvae grew, indicating that impingement stress became more important in explaining mortality as the larvae developed, as compared to natural and unexplained mortality which occurred early in the postlarval stage.

TABLE 3.3-16

Test Results and Summary Statistics
of 48-Hour Prolarval Mortality
Alewife Impingement Study

Duration	2 Minutes				8 Minutes			
Velocity (fps)	0.5	1.0	1.5	2.0	0.5	1.0	1.5	2.0
% Mortality - Test Day 1	0 8	33.3 4.8	24 5	34.8 20.8	9.1 7.1	39.1 10.0	44.4 44.4	71.4 60.0
% Mortality - Test Day 2	4.2 8	4.5 4.5	0 13	33.3 24	0 0	18.2 8.3	34.8 52.9	73.7 73.7
Number of Tests	4	4	4	4	4	4	4	4
Mean Mortality	5.1	11.8	10.5	28.2	4.1	18.9	44.1	69.7
Standard Deviation	3.8	14.4	10.5	6.9	4.1	14.1	7.4	6.6

Control Mortality

First day of testing = 0%

Second day of testing = 0%

TABLE 3.3-17

ANOVA of Prolarval Alewife
Impingement Data - Full Model

a. Full Model

Source of Variation	Df	Sum of Squares	Mean Squares	F-Value	α Prob.
Velocity	3	8,699.47	2,899.82	36.10	0.0001*
Duration	1	3,298.75	3,298.75	41.06	0.0001*
Segment	1	201.50	201.50	2.51	0.1275
Day	1	124.43	124.43	1.55	0.2264
Velocity x Duration	3	2,506.41	835.47	10.40	0.0002*
Error	22	1,767.29	80.33		
TOTAL	31	16,597.86			

b. Reduced Model

Source of Variation	Df	Sum of Squares	Mean Squares	F-Value	α Prob.
Velocity	3	8,699.47	2,899.82	33.25	0.0001*
Duration	1	3,298.75	3,298.75	37.82	0.0001*
Velocity x Duration	3	2,506.41	835.47	9.58	0.0002*
Error	24	2,093.22	87.22		
Total	31	16,597.86			

*Significant since $\alpha \leq 0.05$

TABLE 3.3-18

Mean Percent Mortality and Standard Deviation
Alewife Postlarvae - Impingement Study

Duration (min)	Velocity (fps) 0.5	1.0	1.5	2.0
2	76.3 ± 25.8	84.0 ± 20.2	92.5 ± 8.6	90.5 ± 12.1
8	82.7 ± 24.1	92.8 ± 12.3	96.7 ± 5.3	98.6 ± 4.3

Control Mortality

n = 8
Mean = 43.3%
St. Dev. = 36.2%

NOTE: 16 tests were conducted at each duration and velocity except for 2.0 fps at which 14 tests were conducted at each duration.

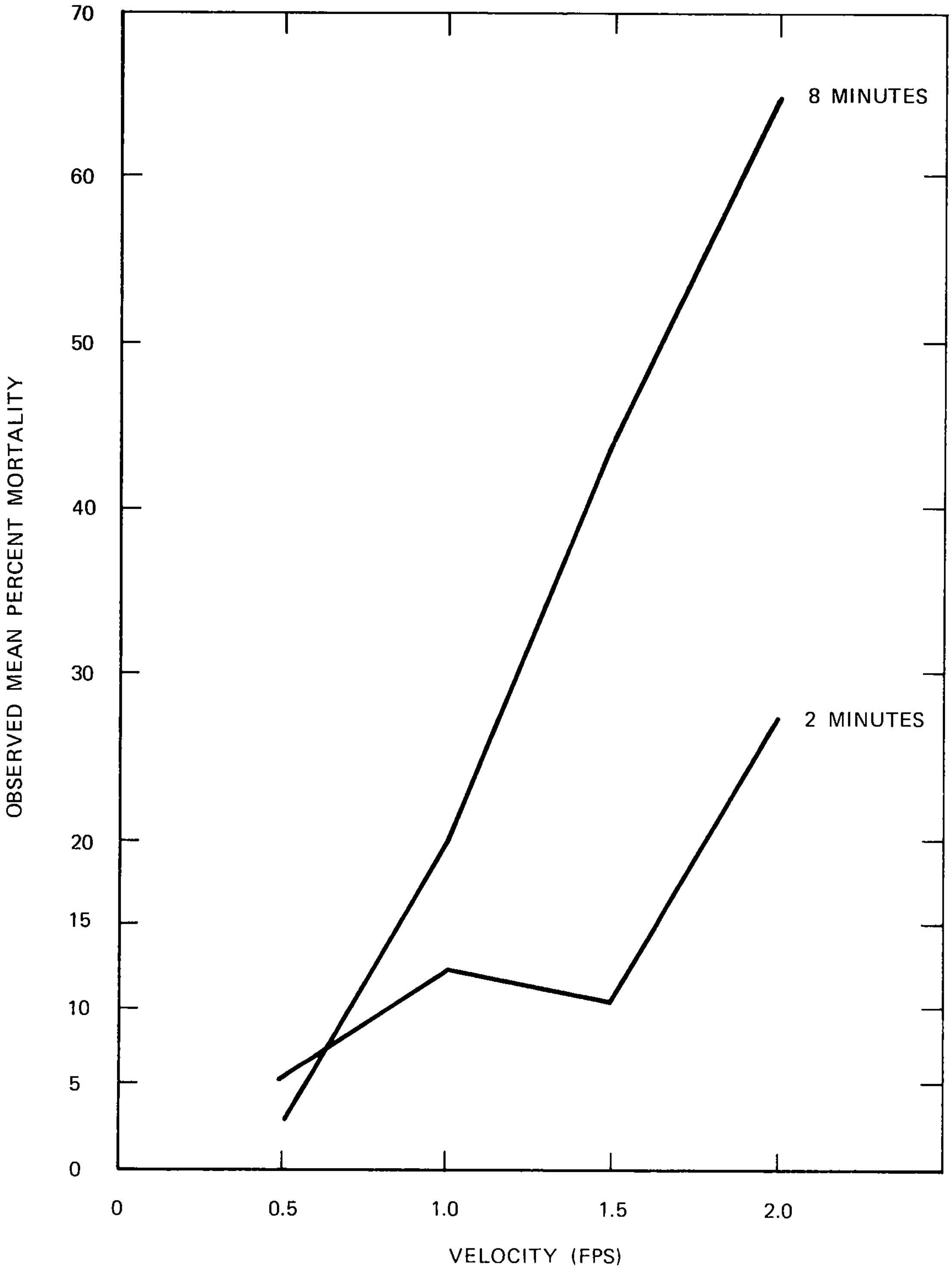


FIGURE 3.3-5 PLOT OF MEAN PERCENT PROLARVAL MORTALITY (48-HOUR) VERSUS APPROACH VELOCITY, ALEWIFE IMPINGEMENT STUDY

Yellow Perch

From May through June 1980, larvae of yellow perch were tested in the impingement facility. As in the case of winter flounder, a reduced matrix consisting of 8 velocity/duration combinations was employed to facilitate testing.

Yellow perch larvae were tested in two distinct groups: prolarvae and postlarvae. As discussed in Section 3.2, prolarvae were held for 48 hours only due to the short duration of this life stage. The results of testing with each group were analyzed separately, as presented below.

Prolarvae (5.8 to 6.0mm)

A total of 32 tests were conducted with prolarvae. The results of testing and important summary statistics are presented in Table 3.3-19.

The data were analyzed by ANOVA. The results of the analysis are presented in Table 3.3-20. Within the range of independent variables examined, approach velocity, impingement duration, and segment significantly influenced mortality. The interaction between velocity and duration was also significant.

The percent mortality of prolarvae was significantly influenced by the segment in which the larvae were tested; however, the difference was not substantial. The mean mortality of prolarvae tested in segment A was 10%, while the mean mortality of prolarvae tested in segment B was 17%. Mean control mortality was 4.1%.

Figure 3.3-6 depicts the relationship between the approach velocity and mean percent mortality for the two durations examined. As the velocity increased, the mean percent mortality generally increased. The mortality also generally increased as the duration increased from 2 minutes to 8 minutes. In addition, the differences between the mean percent mortalities of prolarvae tested at 2 and 8 minutes became larger as the velocity increased.

Duncan's multiple range tests (Table 3.3-21) indicated that the mean mortalities of prolarvae tested for 8 minutes at 1.5 and 2.0 fps were not significantly different. However, the mean mortalities of prolarvae tested at these combinations were significantly greater than the mean mortalities of prolarvae tested at the 6 remaining velocity/duration combinations. Furthermore, the 6 remaining velocity/duration combinations were not significantly different.

Postlarvae

Yellow perch postlarvae were tested in the impingement facility from late May to mid-June. One hundred and twelve tests were performed with postlarvae having mean lengths ranging from 6.32 to 14.28mm. The results of the testing are summarized in Table 3.3-22.

The test results were analyzed by ANCOVA. The results of the analysis are presented in Table 3.3-23. Within the range of independent variables examined, approach velocity, impingement duration, and length significantly influenced mortality. The interaction between the velocity and the length was also significant. As presented in Figure 3.3-7, the mortalities of postlarvae tested at various lengths in the impingement model were quite variable. Although the mean percent mortalities generally decreased as the postlarvae matured, the variability within each group remained quite large. It is clear from the control data presented in Table 3.3-24 that the control mortality (the mortality due to holding and handling) did not consistently decrease as the postlarvae grew in length. While the smallest postlarvae had the highest mean control mortality (85.2%), and the largest postlarvae had the lowest mean control mortality (4%), the control mortalities observed for the other postlarvae tested within this length range fluctuated considerably.

The high control mortality for the smallest postlarvae may be attributable to natural die-offs which occur during this developmental stage. However, the high and/or variable control mortalities for the larger postlarvae cannot be readily explained.

Figure 3.3-8 depicts the relationship between velocity and mean test mortality for the largest 14.3mm postlarvae. This length is selected for further discussion since survival values were relatively high compared to other lengths. The mean percent mortality increased as the approach velocity increased from 0.5 to 1.5 fps for both the 2 and 8 minute durations. However, the mean mortalities decreased from 1.5 to 2.0 fps. Duncan's multiple range tests indicated that the decrease in mean mortality was not significant for postlarvae tested for 2 minutes, but was significant for postlarvae tested for 8 minutes.

Duncan's multiple range tests also indicated that the mean mortality of the postlarvae tested at 1.5 fps for 8 minutes (74%) was significantly higher than mean mortalities of postlarvae tested at all other velocity/duration combinations. The lowest mean mortality (4.3%) was observed for postlarvae tested at an approach velocity of 0.5 fps for 2 minutes. The mean mortality of these postlarvae was significantly lower than the mean mortalities of postlarvae tested at 1.5 fps for 2 minutes. In addition, the mean mortality was significantly lower than the mean mortalities of postlarvae tested at 1.0, 1.5, and 2.0 fps for 8 minutes.

3.4 Summary of Impingement Mortality Studies

Striped bass prolarvae exhibited high impingement mortality under all conditions, while winter flounder, alewife, and yellow perch prolarvae exhibited low mortality; however, high control mortality among bass indicates that the mortality was not solely attributable to impingement. Impingement mortality was highest among winter flounder, alewife, and yellow perch larvae for a short period following absorption of the yolk-sac; however, control mortality was also highest at this time. Among later postlarvae, striped bass exhibited low mortality, alewife exhibited relatively high mortality, and winter flounder and yellow perch were intermediate to the others.

TABLE 3.3-19

Summary Statistics of Prolarval Mortality
Yellow Perch Impingement Study

	2 minutes				8 minutes			
Velocity	0.5	1.0	1.5	2.0	0.5	1.0	1.5	2.0
n	4	4	4	4	4	4	4	4
Range (%)	0-16	0-15.4	0-29.2	4.0-20	0-12	0-8.3	25-40	16-45.8
Mean	5.0	5.9	12.1	9.1	6.9	5.2	32.3	31.5
Standard Deviation	7.6	7.4	12.3	7.5	5.9	4.0	6.1	12.6

Control Mortality

Mean = 4.1%
St. Dev. = 0.14%

TABLE 3.3-20

ANOVA of Prolarval Yellow Perch
Impingement Data - Full Model

a. Full Model

Source of Variation	df	Sum of Squares	Mean Squares	F-Ratio	α Prob.
Velocity	3	1,932.55	644.18	11.77	0.0001*
Duration	1	955.94	955.94	17.46	0.0004*
Segment	1	394.10	394.10	7.20	0.0136*
Day	1	106.95	106.95	1.96	0.1762
Velocity x Duration	3	870.26	290.09	5.30	0.0067*
Error	22	1,204.52	54.75		
Total	31	5,464.31			

b. Reduced Model

Source of Variation	df	Sum of Squares	Mean Squares	F-Ratio	α Prob.
Velocity	3	1,932.55	644.18	11.30	0.0001*
Duration	1	955.94	955.94	16.76	0.0004*
Segment	1	394.10	394.10	6.9	0.0150*
Velocity x Duration	3	870.26	290.09	5.09	0.0076*
Error	23	1,311.47	57.02		
Total	31	5,464.31			

*Significant since $\alpha \leq 0.05$

TABLE 3.3-21

Results of Duncan's Multiple Range Tests - Prolarvae
Yellow Perch Impingement Study

Duration (min.)	Velocity (fps) 0.5	1.0	1.5	2.0
2	5.0	5.9	12.1	9.1
8	6.9	5.2	32.3	31.5

Mean percent mortality under each velocity/duration condition.
Values within dotted lines are not significantly different.

Duration (min.)	Velocity (fps) 0.5	1.0	1.5	2.0
2	7.3 ± 7.4			
8			31.9 ± 9.2	

Mean percent mortality and standard deviation of velocity/duration combinations which were not significantly different.

Mean Control Mortality = 4.1%

TABLE 3.3-22

Mean Percent Mortality and Standard Deviation
Yellow Perch Postlarval Impingement Study

Duration (min.)	Velocity (fps) 0.5	1.0	1.5	2.0
a. 6.3 - 6.5mm postlarvae				
2	97.1 ± 5.8	92.0 ± 8.6	88.7 ± 15.0	91.1 ± 10.6
8	95.0 ± 5.0	93.2 ± 8.0	99.0 ± 2.0	94.9 ± 7.9
b. 7.3 - 14.3mm postlarvae				
2	31.9 ± 25.6	47.7 ± 31.6	55.9 ± 25.8	67.0 ± 26.9
8	40.0 ± 26.2	71.4 ± 22.4	80.0 ± 15.5	83.0 ± 20.3

Control Mortality - all postlarvae

n = 7
Mean = 47.8%
St. Dev. = 36.3%
Range = 4 - 92%

TABLE 3.3-23

ANOVA
Yellow Perch Postlarval 96-Hour Impingement Study

a. Full Model

Source of Variation	df	Sum of Squares	Mean Square	F-Ratio	α Prob.
Velocity	3	11,639.51	3,879.84	16.04	0.0001*
Duration	1	5,357.19	5,357.19	22.15	0.0001*
Length	4	47,837.72	11,959.43	49.45	0.0001*
Segment	1	627.96	627.96	2.6	0.1115
Velocity x Duration	3	904.44	301.48	1.25	0.2991
Velocity x Length	12	10,414.13	867.84	3.59	0.0003*
Duration x Length	4	2,070.25	517.56	2.14	0.0847
Velocity x Duration x Length	12	1,498.52	124.88	0.52	0.8975
Error	71	17,171.69	241.85		
Total	111	97,521.40			

b. Reduced Model

Source of Variation	df	Sum of Squares	Mean Square	F-Ratio	α Prob.
Velocity	3	11,639.51	3,879.84	15.85	0.0001*
Duration	1	5,357.19	5,357.19	21.89	0.0001*
Length	4	47,837.72	11,959.43	48.86	0.0001*
Velocity x Length	12	10,414.13	867.84	3.55	0.0002*
Error	91	22,272.85	244.76		
Total	111	97,521.40			

*Significant since $\alpha \leq 0.05$

TABLE 3.3-24

Mean Postlarval Control Mortality
Yellow Perch Impingement Study

Group	Mean Mortality and Standard Deviation	
1	85.2 ± 9.7	(2)
2	29.3 ± 27.2	(3)
3	72	(1)
4	4	(1)

Number of tests is given in parentheses.

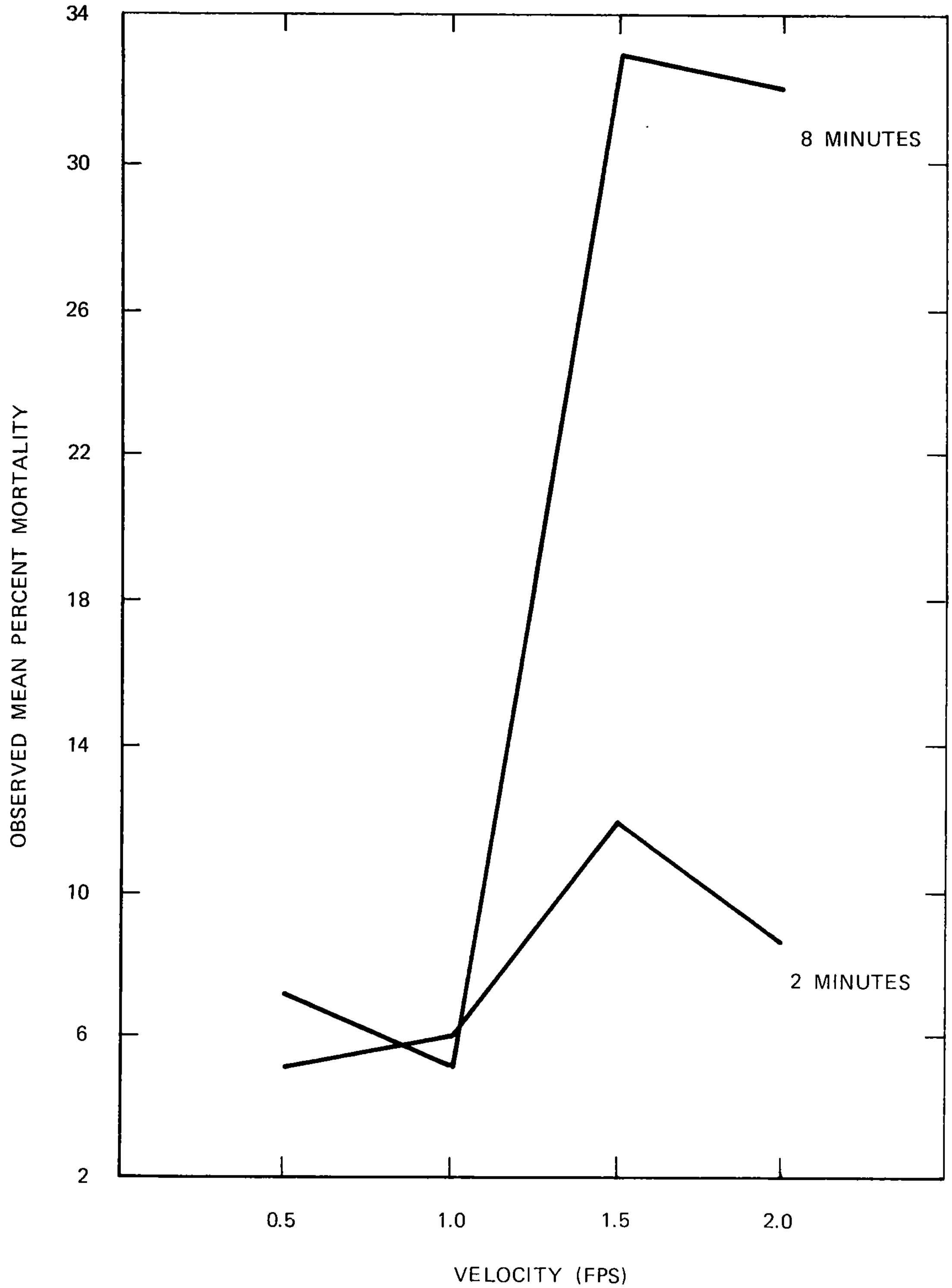


FIGURE 3.3-6 PLOT OF MEAN PROLARVAL MORTALITY (96-HOUR) VERSUS APPROACH VELOCITY, YELLOW PERCH IMPINGEMENT STUDY

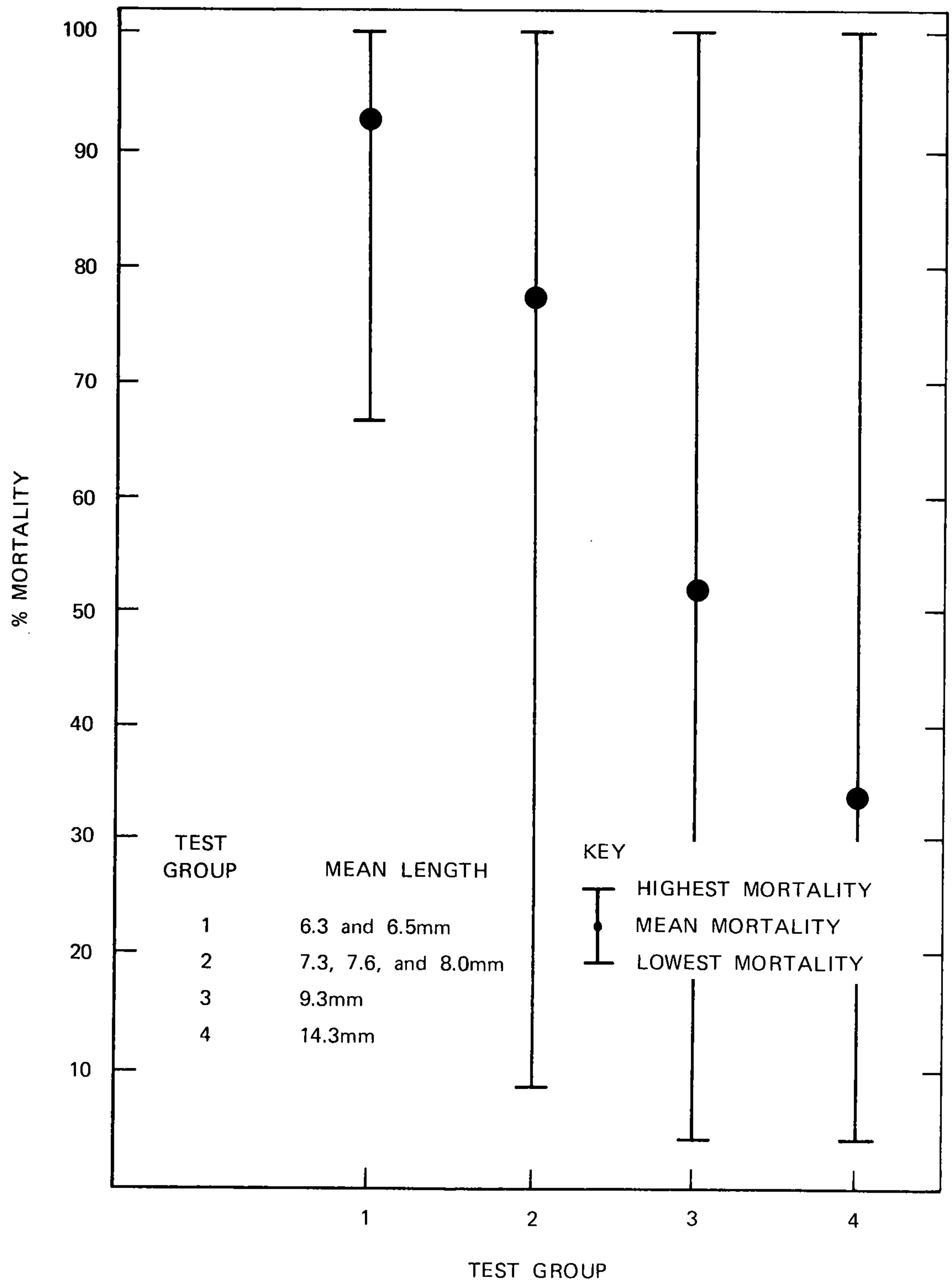


FIGURE 3.3-7 PLOT OF MEAN POSTLARVAL TEST MORTALITY FOR EACH TEST GROUP, YELLOW PERCH IMPINGEMENT STUDY

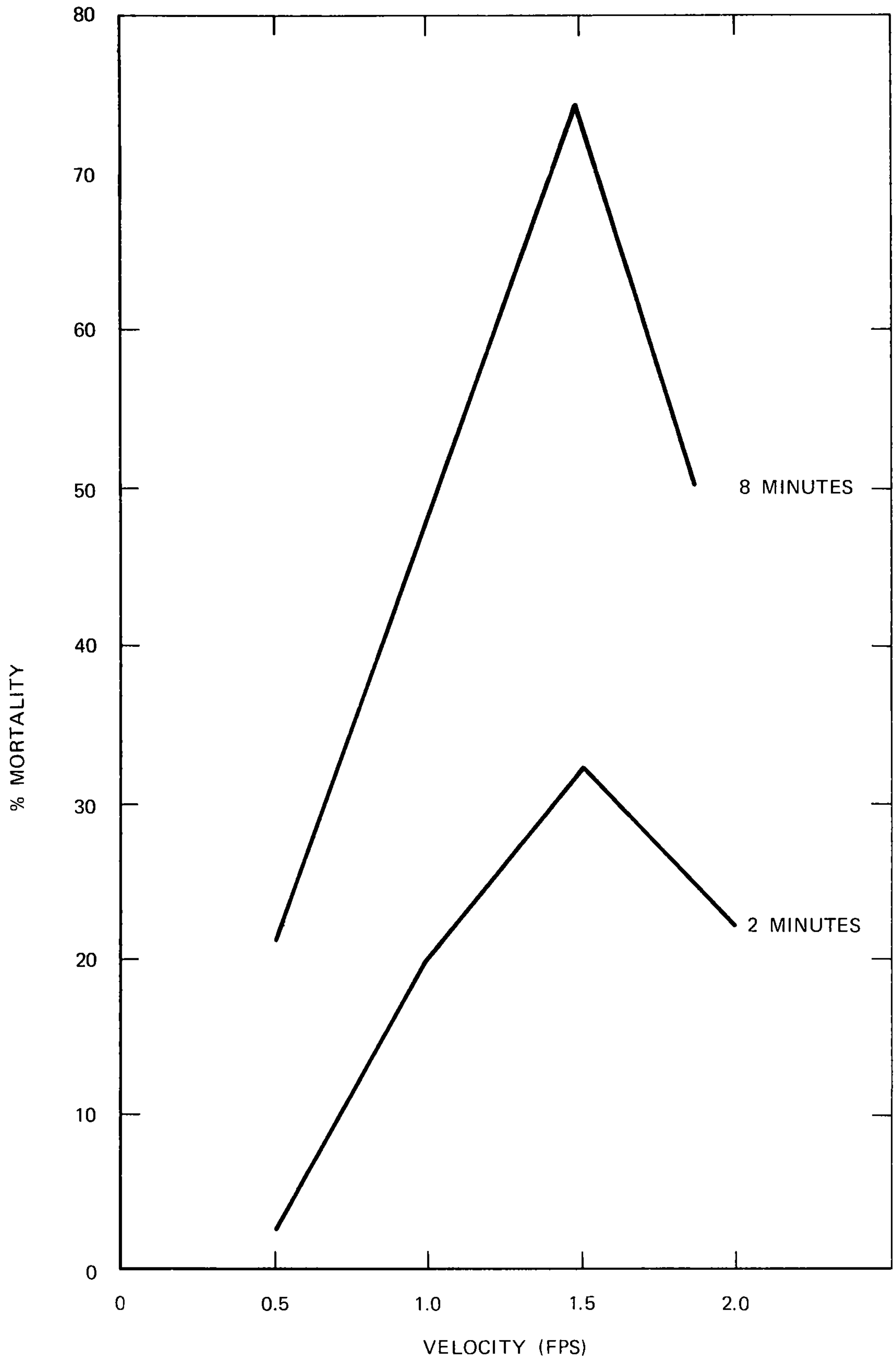


FIGURE 3.3-8 MEAN TEST MORTALITY OF 14.3mm POSTLARVAE VERSUS APPROACH VELOCITY, YELLOW PERCH IMPINGEMENT STUDY

SECTION 4

SCREEN RETENTION STUDY

SECTION 4
SCREEN RETENTION STUDY

Should the concept of impinging and removing small organisms prove to have potential for the protection of species of concern at a given site, an important parameter to consider in designing a full-scale system is the mesh size needed to yield adequate retention of selected species and life stages, as previously discussed in Section 2. Therefore, a study was conducted from June 1979 to June 1980 to determine the ability of four screen mesh sizes to retain the larval stages of the four test species. Since the velocity of water passing through the mesh could influence retention, each mesh was evaluated over a range of approach velocities from 0.5 to 1.5 fps. These velocities were selected to span the range of velocities which commonly occur at power plant intakes. Mesh sizes tested included 0.355, 0.5, 1.0, 1.5, and 2.0mm. The 0.355mm mesh was not included during 1979 striped bass testing since 100 percent retention was obtained on the 0.5mm mesh with the smallest larvae tested (5.4mm). However, in 1980, winter flounder, alewife, and yellow perch larvae were not retained by the 0.5mm mesh and the smaller 0.355mm mesh was added to the program.

4.1 Description of the Facility

Testing in 1979 with striped bass was conducted in a flume with a 3 inch square cross-section. The square weave polyester screens were mounted on interchangeable frames perpendicular to the flow at the end of a 12 inch long test section, as shown in Figure 4.1-1. The flume was constructed of clear acrylic to provide visual observation of the larvae during the tests. A 250 micron screen was installed to retain organisms that passed through the test screen.

A centrifugal pump supplied flow to the flume through a valve which was adjusted to produce the desired velocity. A miniature propeller meter was used to measure the velocity 1/2 inch upstream of the test screen.

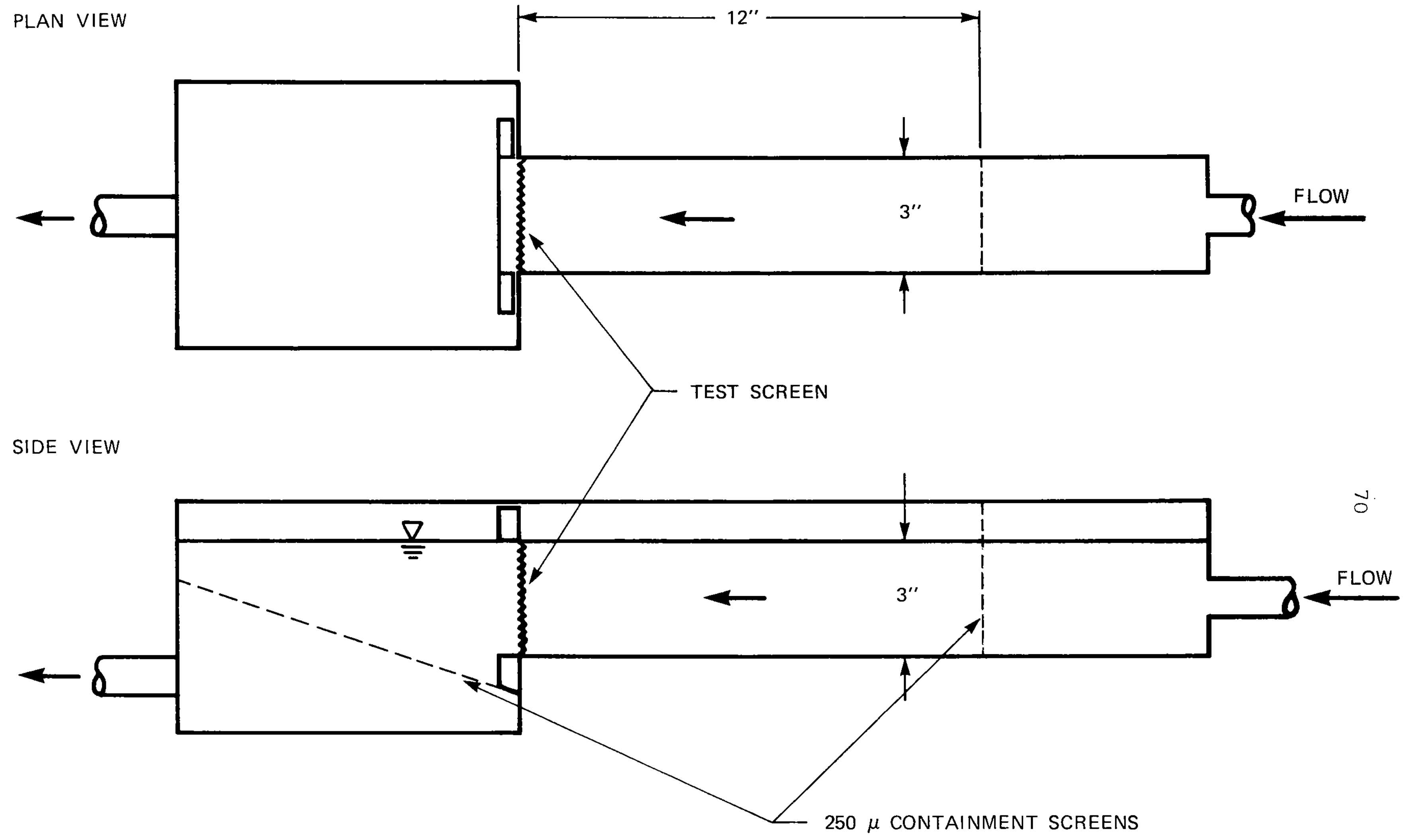


FIGURE 4.1-1 SCREEN RETENTION TEST FACILITY - 1979

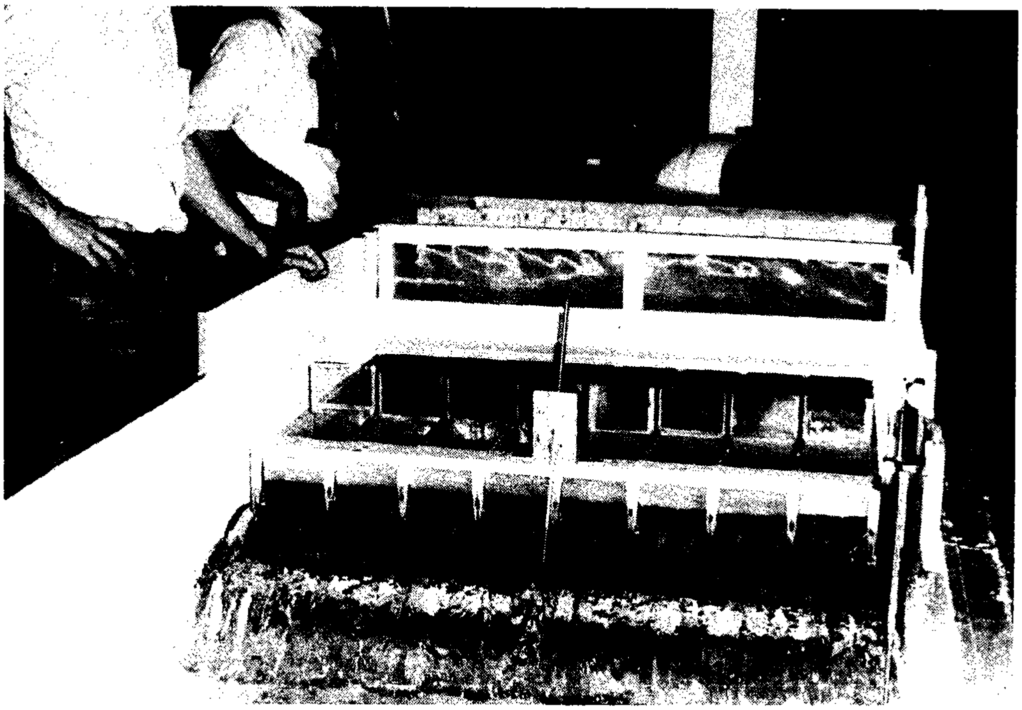


FIGURE 4.1-2 FLOW IN SCREEN RETENTION TEST FACILITY – 1980

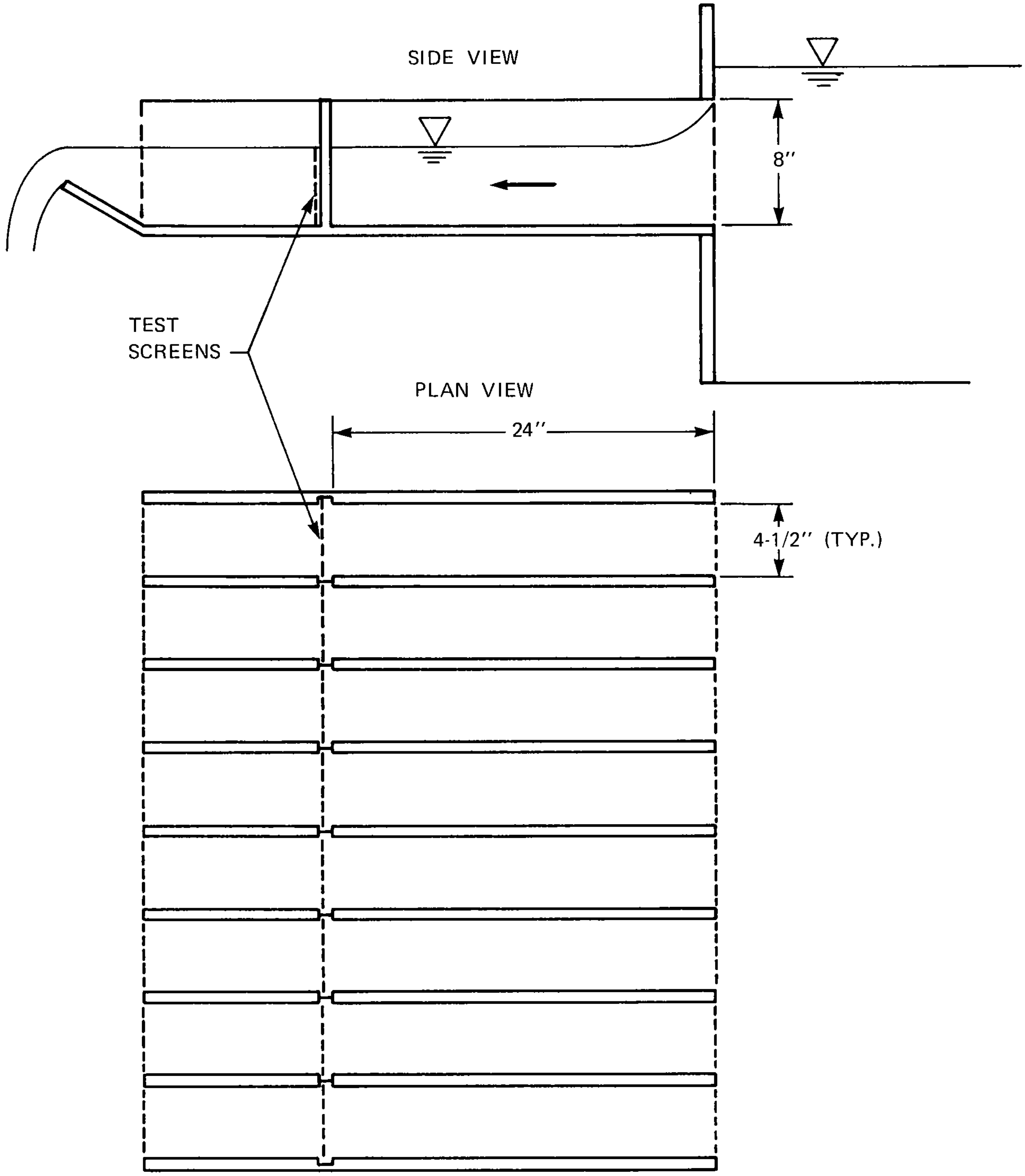


FIGURE 4.1-3 SCREEN RETENTION FACILITY – 1980

In 1980, the screen retention studies were conducted in a facility comprised of eight parallel channels allowing tests to be run concurrently. The channels were constructed of plywood and were 3 ft long, 4.5 inches wide, and 8 inches deep, as shown in Figures 4.1-2 and 4.1-3. The test screens were mounted on interchangeable plastic frames which were positioned in slots in the channel walls and floor. The flow through the screens was not obstructed by the screen frames and was, therefore, relatively uniform through the mesh.

Downstream of the test screens a gate was used to control flow depth and velocity. A miniature propeller meter was used to set the flow. Screens of 250μ mesh were mounted at each end of the channels to prevent the loss of organisms during testing.

4.2 Biological Testing Procedures

In the 1979 striped bass study, 15 larvae were removed from the stock tanks for each test. The larvae were then introduced into the flume operating at a specific velocity (0.5, 0.8, 1.0, or 1.5 fps) with the appropriate mesh size incorporated (0.5, 1.0, 1.5, or 2.0mm). Each test was run until all larvae had been impinged or entrained. Maximum test time was approximately 10 minutes.

Observations were made during each test as to the manner in which larvae were impinged or entrained. At the conclusion of each test, all larvae were removed from the flume and enumerated. None were held for latent mortality studies.

In 1980, procedures were modified slightly to make full utilization of the new model described above. Accordingly, in each test with winter flounder, alewife, and yellow perch, 25 larvae were removed from the stock holding tanks and were introduced into the screen retention facility. The facility was operated at two velocities (0.5 or 1.5 fps) with appropriate mesh sizes incorporated (0.355, 0.5, 1.0, and 1.5mm). Eight tests were conducted simultaneously with each lasting approximately 5 minutes.

At the conclusion of a test, each screen panel was removed from the facility and the larvae which had been impinged were washed into collection beakers and enumerated. Larvae which passed through the test screens were collected on the 250 micron screen and were also removed and enumerated at the completion of each test. Larvae were not held for latent mortality studies.

4.3 Analytical Results

Striped Bass

One hundred and thirty-eight tests were conducted with striped bass: 12 with the 0.5mm mesh, 39 with the 1.0mm mesh, 57 with the 1.5mm mesh, and 30 with the 2.0mm mesh. Four approach velocities were tested in combination with these mesh sizes: 0.5 fps, 0.8 fps, 1.0 fps, and 1.5 fps. During the study, the striped bass grew from 5.4 to 19mm in length. The majority of the tests were conducted with postlarvae. Data from the screen retention tests are presented in Appendix B.

In general, observations during the screen retention tests indicated that larvae were most frequently impinged flat against the screens. Organisms were also found impinged by head or tail or both (collapsed around screen filaments).

The data were analyzed by ANCOVA. The percentage of larvae retained on the fine-mesh screens was the dependent variable. The categorical independent variable was the mesh size of the screen. The covariates included larval length and approach velocity. Approach velocity was treated as a continuous variable in the initial analysis since there was an unequal number of observations at the various mesh size/velocity combinations. The interactions of the independent variables were also included.

The results of the analysis are presented in Table 4.3-1. As expected, the mesh size of the screen significantly influenced the percent of larvae retained. Within the range of independent variables examined, approach velocity did not influence the percent of larvae retained.

Percent retention on each mesh significantly increased with increasing larval length. The two-way interaction between larval length and mesh size was the only significant interaction. Although the relationship between the percent retained and larval length was significant for each mesh tested, the range of lengths tested under each mesh differed.

The results plotted in Figure 4.3-1 depict the relationship between the percent retention and larval length. At the start of the testing program, 5.4mm larvae were successfully being retained with a 0.5mm mesh. Therefore, in Figure 4.3-1, the relationship between larval length and percent retained is seen as a horizontal line. Table 4.3-3 summarizes the relationship between larval length and predicted percent retention for each mesh size.

TABLE 4.3-1

Results of ANCOVA
Striped Bass Screen Retention Study

a. Full Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Mesh Size	3	59,458.20	19,819.40	51.130	0.0000*
Velocity x Mesh	3	110.07	36.69	0.095	0.9629
Length x Mesh	3	10,833.73	3,611.24	9.316	0.0000*
Length	1	7,460.71	7,460.71	19.247	0.0000*
Velocity	1	94.44	94.44	0.244	0.6225
Residual	126	48,841.34	387.63		
Total	137	248,955.69			

*Significant since $\alpha \leq 0.05$

Dependent variable = percent retained

b. Reduced Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Mesh Size	3	112.98	37.66	33.226	0.0000*
Length x Mesh	3	8.99	2.997	3.645	0.0519
Length	1	10.52	10.52	9.282	0.0028*
Residual	130	147.34	1.13		
Total	137	527.64			

*Significant since $\alpha \leq 0.05$

Dependent variable = natural log of percent retained

TABLE 4.3-1
(continued)

$$\ln (Y_{ijk}) = 3.02 + M_i + B_j (L_{ijk} - 10.7) + 0.53 (L_{ijk} - 10.7) + e_{ijk}$$

where

Y_{ijk} = predicted percent retained of the ijk^{th} test

M_i = effect of i^{th} mesh size

B_j = effect of the interaction between larval length and i^{th} mesh

L_{ijk} = larval length of ijk^{th} test

e_{ijk} = the residual variance

TABLE 4.3-2

Larval Length Versus Predicted Percent Retained
Striped Bass Screen Retention Study

Mesh (mm)	Larval Length Tested (mm)	Larval Length and Predicted Percent Retained	
		50%	100%
0.5	5.41 - 6.91	---	5.4mm*
1.0	5.41 - 9.88	9.5mm	10.3mm
1.5	5.41 - 17.40	14.1mm	15.35mm
2.0	10.8 - 21.45	17.5mm	18.65mm

*Observed value

NOTE: Prediction based on the reduced ANCOVA model.

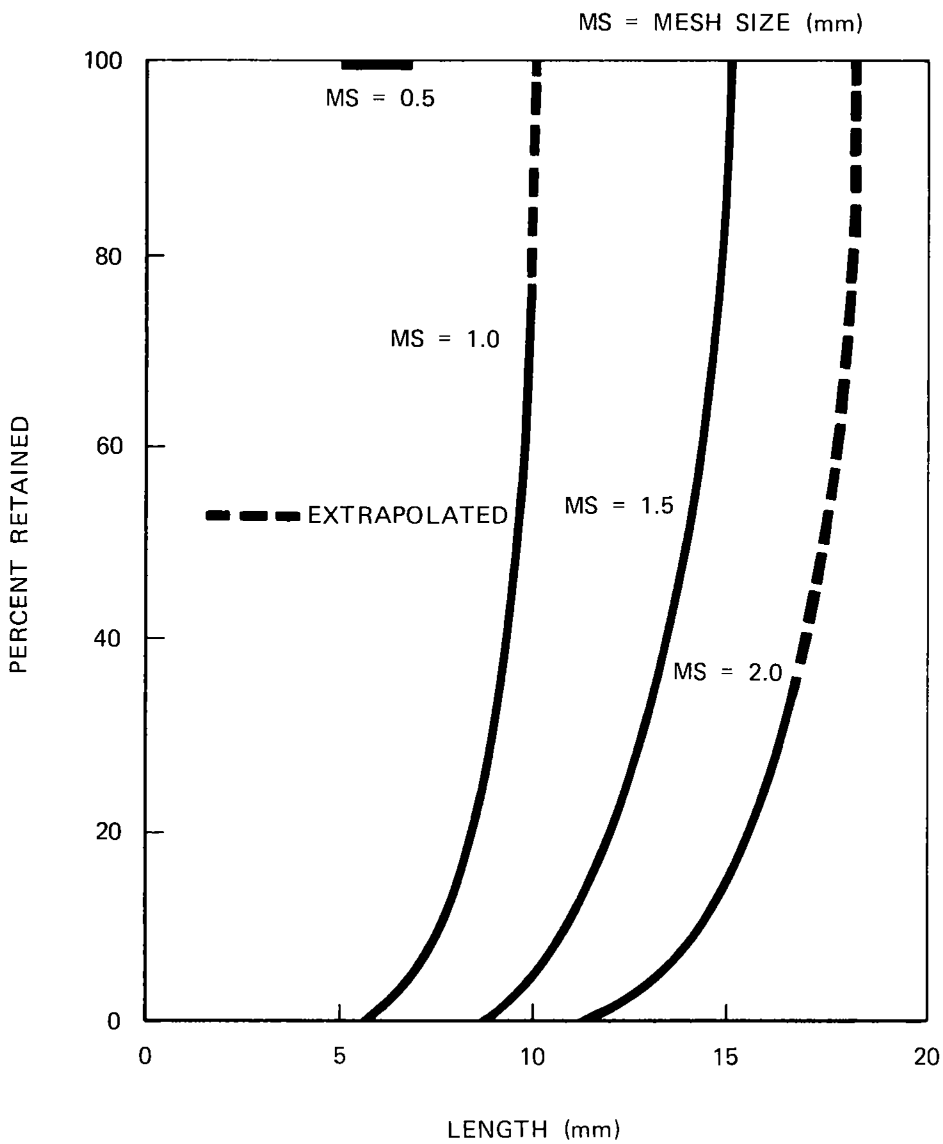


FIGURE 4.3-1 STRIPED BASS RETENTION VERSUS LENGTH AT VARIOUS MESH SIZES

Winter Flounder

Screen retention tests with winter flounder were conducted during two discrete periods (life stages): prolarvae and postlarvae. Because of a lack of available organisms, only two groups of prolarvae and one group of postlarvae were tested. Results of testing with each group are presented individually below.

Prolarvae

A total of 28 tests were conducted on two separate days with prolarvae ranging in length from 3.6 to 4.4mm. Four tests were performed with a 0.355mm mesh, 16 with 0.5mm mesh, and 8 with 1.0mm mesh. No tests were conducted with 1.5mm mesh since retention on the 1.0mm mesh was not appreciable. Mean larval lengths for the two test days were 4.04 and 4.07mm, respectively.

The data obtained with 0.5 and 1.0mm meshes were analyzed by ANOVA. Tests conducted with the 0.355mm mesh were not included in the analysis since nearly 100 percent retention was obtained in all tests. Therefore, twenty-four tests were analyzed. The percentage of prolarvae retained on the fine-mesh screens was the dependent variable. The independent variable "velmesh," which is a combination of approach velocity and mesh size previously used, was included in the ANOVA to compare retention on the fine-mesh screens at different combinations of velocity and mesh size. The independent variables "velocity" and "mesh size" were not included separately in the analysis since the experimental design was unbalanced and the number of combinations was small (3), thereby limiting the usefulness of these variables.

Since the length of the prolarvae did not change appreciably over the short test period, test day was substituted in the analysis to account for any differences in mortality which might occur as the result of larval development, although differences were not expected due to the short duration of the testing program.

The results of the screen retention analysis are presented in Table 4.3-3. As expected, the combination of mesh size and velocity (velmesh) significantly influenced the percent of prolarvae retained. Within the range of independent variables examined, day of testing, and the interaction between day and velmesh did not influence the percent of prolarvae retained.

Results of testing at each velocity/mesh combination are given in Table 4.3-4. Duncan's multiple range tests indicated that there were not significant differences between the mean retention of prolarvae tested with a 0.5mm mesh at 0.5 and 1.5 fps. However, there were significant differences between the mean retention of prolarvae tested with a 0.5mm mesh and a 1.0mm mesh at 0.5 fps.

Postlarvae

Twelve tests were conducted with 4.4mm early postlarvae: 8 with a 0.5mm mesh and 4 with a 1.0mm mesh. Two approach velocities (0.5 and 1.0 fps) were tested in combination with the two mesh sizes (0.5 and 1.0mm). The 0.355mm mesh was not tested with postlarvae since 100 percent retention had occurred with smaller prolarvae. The important summary statistics calculated for the specific mesh size/velocity combinations are presented in Table 4.3-5.

The data were analyzed by ANOVA. The percentage of postlarvae retained on the fine-mesh screens was the dependent variable. Velmesh was the categorical independent variable. Day of testing and flume temperature were not included in the analysis since the larval length did not vary and the temperature varied only slightly (0.2°C).

The results of the screen retention analysis are presented in Table 4.3-6. As expected, the combination of mesh size and velocity significantly influenced the percent of postlarvae retained. Duncan's multiple range tests indicated significant differences at each mesh size/velocity combination. Comparison of postlarvae tested with a 0.5mm mesh and a 1.0mm mesh at 0.5 fps indicates that, as expected, the mesh size significantly influenced the retention of postlarvae. Comparison of postlarvae tested with a 0.5mm mesh at

0.5 and 1.5 fps indicates that the approach velocity also significantly influenced the percent retained. Highest retention was obtained at 0.5mm mesh and 1.5 fps velocity. It might be expected that retention would decrease as velocity increases. However, at the lower velocity (0.5 fps), the larvae tended to orient into the current and were, therefore, aligned perpendicular to the mesh. In this orientation, they were more likely to pass through a mesh opening. At 1.5 fps, the larvae were disoriented and hit the screen in all orientations. Naturally, a parallel alignment to the mesh would cause them to impinge across a number of mesh strands and thereby be held in place.

TABLE 4.3-3

ANOVA
Flounder Screen Retention Study - Prolarvae

a. Full Model

Source of Variation	df	Sum of Squares	Mean Squares	F-Ratio	α Prob.
Velmesh	2	28,065.33	14,032.67	157.47	0.0001*
Day	1	16.67	16.67	0.19	0.6705
Day x Velmesh	2	25.33	12.67	0.14	0.8685
Error	18	1,604.00	89.11		
Corrected Total	23	29,711.33			

b. Reduced Model

Source of Variation	df	Sum of Squares	Mean Squares	F-Ratio	α Prob.
Velmesh	2	28,065.33	14,032.62	179.03	0.0001*
Error	21	1,646.00	78.38		
Corrected Total	23	29,711.33			

*Significant since $\alpha \leq 0.05$

TABLE 4.3-4

Summary Statistics - Prolarvae (4.0 - 4.1mm)
Flounder Screen Retention Study

0.355mm/0.5 fps	0.5mm/0.5 fps	0.5mm/1.5 fps	1.0mm/0.5 fps
n = 4	n = 8	n = 8	n = 8
Range = 92-100%	Range = 56-88%	Range = 64-100%	Range = 0-8%
Mean = 98%	Mean = 69.5%	Mean = 77%	Mean = 1.0%
St. Dev. = 4.0%	St. Dev. = 10%	St. Dev. = 11.3%	St. Dev. = 2.8%

TABLE 4.3-5

Mean Retention and Summary Statistics
Postlarvae (4.4mm)
Flounder Screen Retention Study

0.5mm/0.5 fps	0.5mm/1.5 fps	1.0mm/0.5 fps
n = 4	n = 4	n = 4
Mean = 63%	Mean = 81%	Mean = 12%
Range = 52-76%	Range = 76-88%	Range = 4-24%
St. Dev. = 10%	St. Dev. = 5.03%	St. Dev. = 9.8%

TABLE 4.3-6

ANOVA - Postlarvae
Flounder Screen Retention Study

Source of Variation	Df	Sum of Squares	Mean Squares	F-Ratio	α Prob.
Velmesh	2	10,248.00	5,124.00	69.45	0.001*
Error	9	664.00	73.78		
Total	11	10,912.00			

*Significant since $\alpha \leq 0.05$

Alewife

Alewife were tested in two discrete groups: prolarvae and postlarvae. Results are presented below.

Prolarvae

A total of 12 tests were conducted with alewife prolarvae ranging in length from 5.0 to 5.4mm (mean length of 5.2mm): 8 tests with 0.355mm mesh and 4 tests with 0.5mm mesh. Since low retention was observed with the 0.5mm mesh, larger mesh sizes were not tested. Test results along with the important summary statistics are presented in Table 4.3-7.

An ANOVA was conducted on the test results. The percentage of prolarvae retained on fine-mesh screens was the dependent variable. Velmesh was the categorical independent variable. Mean larval length, tank temperature (15.0°C), and flume temperature (14.8°C) did not vary during testing and were not, therefore, included in the analysis.

The results of the analysis are presented in Table 4.3-8. As expected, the combinations of mesh size and velocity significantly influenced the percent of prolarvae retained.

Pair-wise, mean comparisons indicated that both the mesh size and approach velocity significantly influenced the retention of prolarvae. The mean retention of prolarvae tested with 0.355mm mesh at 0.5 fps was significantly higher than the mean retention of prolarvae tested with 0.5mm mesh at 0.5 fps. In addition, the mean retention of prolarvae tested with 0.355mm at 0.5 fps was significantly lower than those tested at 1.5 fps. Higher retention at higher velocity is probably a function of larval orientation into the flow, as discussed in the previous section.

Postlarvae

Tests with alewife postlarvae were conducted on May 21, May 28, and June 4, 1980. Forty-four tests were conducted: 16 with the 0.355mm mesh, 20 with the 0.5mm mesh, and 8 with the 1.0mm mesh. Mean larval lengths were 6.6mm, 6.6mm, and 9.5mm on the three respective test days. The test results and summary statistics are presented in Table 4.3-9.

It is clear from the data presented that the 6.6mm postlarvae were successfully retained on the 0.355mm mesh. Results of testing with the 0.5mm mesh indicated that retention was low for the 6.6mm postlarvae tested at 0.5 fps. Although the mean retention of 6.6mm postlarvae increases when the approach velocity was increased to 1.5 fps, the retention varied considerably.

The largest postlarvae (9.5mm) were successfully retained on the 0.5mm mesh. The mean percent retention was 89.2 and 92.5 percent at approach velocities of 0.5 and 1.5 fps, respectively. Although the mean retention percentages did not differ significantly at the 95 percent confidence level, the variability decreased as the approach velocity increased.

The 9.5mm postlarvae were also tested with a 1.0mm mesh. No retention was observed at 0.5 fps; however, at the 1.5 fps velocity, some postlarvae were retained with a mean retention of 30 percent.

TABLE 4.3-7

Test Results and Summary Statistics
Alewife Prolarval Screen Retention Study

Mesh (mm)	0.355		0.5
Velocity (fps)	0.5	1.5	0.5
Mean	64	97	2
Standard Deviation	8.6	3.8	2.3
Range	56 - 76	92 - 100	0 - 4

TABLE 4.3-8

ANOVA - Alewife Prolarvae
Screen Retention Study

Source of Variation	df	Sum of Squares	Mean Square	F-Ratio	α Prob.
Velmesh	2	18,610.67	9,305.34	294.85	0.001*
Error	9	284.0	31.56		
Total	11	18,894.67			

*Significant since $\alpha \leq 0.05$

TABLE 4.3-9

Summary Statistics
(Mean and Standard Deviation)
Alewife Postlarval Screen Retention Study

Day of Testing	Mean Length (mm)	0.355mm		0.5mm		1.0mm	
		0.5	1.5	0.5	1.5	0.5	1.5
May 21	6.6	87 ± 14.4	96 ±3.3	10 ± 7			
May 28	6.6	100 ± 0	100 ± 0	20 ± 8.2	77.5 ± 32		
June 4	9.5			89.2 ± 15.7	92.5 ± 5	0 ± 0	30 ± 8.2

NOTE: Four tests were conducted at each velocity/mesh size combination on each date.

Yellow Perch

Yellow perch were tested as prolarvae and postlarvae, as discussed below.

Prolarvae

A total of 20 tests were conducted with yellow perch prolarvae ranging in length from 5.4 to 5.9mm (mean length of 5.8mm): 8 tests with the 0.355mm mesh; 8 with the 0.5mm mesh, and 4 with the 1.0mm mesh. Test results and the important summary statistics calculated for each mesh size/velocity combinations tested, are presented in Table 4.3-10.

An ANOVA was conducted on the results from the 0.355 and 0.5mm mesh tests. Results from the four tests performed with the 1.0mm mesh were not included in the analysis since there was essentially no retention of the prolarvae with this mesh size. Mean larval length and tank and flume temperatures were not included in the analysis since these variables did not vary.

The results of the screen retention analysis are presented in Table 4.3-11. As expected, the mesh size and approach velocity significantly influenced the percent of the larvae retained. The two-way interaction between mesh size and velocity was not significant.

Duncan's multiple range tests indicated significant differences (5% level) for the following mesh size/velocity combinations:

a. 0.5mm mesh/0.5 fps
   0.5mm mesh/1.5 fps

b. 0.355mm mesh/0.5 fps
   0.355mm mesh/1.5 fps

c. 0.355mm mesh/0.5 fps
   0.5mm mesh/0.5 fps

d. 0.355mm mesh/1.5 fps
   0.5mm mesh/0.5 fps

All other possible comparisons were not significant.

Postlarvae

Sixty-four tests were conducted on May 21, May 27, May 29, and June 4, 1980: 8 with the 0.355mm mesh, 22 with the 0.5mm mesh, 26 with the 1.0mm mesh, and 8 with the 1.5mm mesh. The yellow perch postlarvae that were tested had mean lengths of 6.3, 7.3, 8.1, and 9.3mm.

The test results and summary statistics are presented in Table 4.3-12. It is clear from these data that the 6.3mm postlarvae were successfully retained on the 0.355mm mesh. Postlarvae measuring 6.3, 7.3, and 8.1mm in length were successfully retained on the 0.5mm mesh at both approach velocities. One hundred percent retention was observed for all tests conducted with 7.3 and 8.1mm postlarvae using the 0.5mm mesh.

With the 1.0mm mesh, retention increased as the length of the postlarvae increased and as the approach velocity increased. However, only the 9.3mm postlarvae were retained well; 100 percent retention was observed for six of the eight tests conducted.

Since the smaller early postlarvae were not successfully retained with the 1.0mm mesh, only the 9.3mm postlarvae were tested with a 1.5mm mesh. The mean retention was 35 percent and 37.5 percent at 0.5 and 1.5 fps, respectively.

4.4 Summary of Fine-Mesh Screen Retention Studies

Screen retention is largely a function of mesh size relative to larval length and body depth; it would appear that, for some species, a small mesh size may be required to effectively retain all larval stages, particularly prolarvae and early postlarvae. However, the results presented in this section were obtained under conditions of extreme water clarity (no detritus or debris) and are felt to be useful on a comparative basis only. It has been shown that fine detritus in water, which occurs to varying degrees in most water bodies, greatly enhances the retention efficiency of fine-mesh screens (Taft et al., 1981). Therefore, the results presented herein should not be used to quantitatively select mesh sizes for actual power plant application.

TABLE 4.3-10

Test Results and Summary Statistics - Prolarvae
Yellow Perch Screen Retention Study

Mesh Size (mm)	0.355		0.5		1.0
Velocity (fps)	0.5	1.5	0.5	1.5	0.5
Mean	75	97	48	83	1
Standard Deviation	9.45	3.8	14.6	11.9	2

TABLE 4.3-11

ANOVA - Full Model - Prolarvae
Yellow Perch Screen Retention Study

a. Full Model

Source of Variation	df	Sum of Squares	Mean Square	F-Ratio	α Prob.
Mesh	1	1,681.00	1,681.00	14.61	0.001*
Velocity	1	3,249.00	3,249.00	28.25	0.001*
Mesh x Velocity	1	169.00	169.00	1.47	0.250
Error	12	1,380.00	115.00		
Total	15	6,479.00			

b. Reduced Model

Source of Variation	df	Sum of Squares	Mean Square	F-Ratio	α Prob.
Mesh	1	1,681.00	1,681.00	15.26	0.001*
Velocity	1	3,249.00	3,249.00	29.50	0.001*
Error	13	1,432.00	110.15		
Total	15	5,479.00			

*Significant since $\alpha \leq 0.05$

TABLE 4.3-12

Test Results and Summary Statistics - Postlarvae
(Mean Retention and Standard Deviation)
Yellow Perch Screen Retention Study

Mean Length (mm)	Mesh Size / Velocity (fps)	0.355mm		0.5		1.0		1.5	
		0.5	1.5	0.5	1.5	0.5	1.5	0.5	1.5
6.3		92±11.3	98±2.3	91±10.5	97±3.8	0 ± 0			
7.3				100± 0	100±0	6.7± 5.8	36.7±11.5		
8.1				100± 0	100±0	15 ±17.3	37.5±12.6		
9.3						94.5± 6.4	100 ± 0	35±17.3	37.5±12.6

NOTE: Four tests conducted at each velocity/mesh size combination except on May 27 when three tests were run at each combination.

SECTION 5

AIR EXPOSURE STUDY

SECTION 5
AIR EXPOSURE STUDY

To determine the effects of air exposure on larvae, a study was conducted in which test organisms were exposed to air for varying lengths of time. Exposure times were selected to reflect those which larvae could experience at different screen travel speeds. This study was conducted from June 1979 to June 1980.

5.1 Description of the Facility

Twenty gallon aquaria were used for testing the effects of air exposure on the test larvae. In 1979, one aquarium was utilized to test striped bass. In 1980, two aquaria were used to test all species. Ten acrylic cylinders of 4-1/2 inch diameter were supported in each aquarium. These cylinders were open at the top and covered with 355 or 500 micron mesh screening at the bottom, such that when the cylinders were removed from the tank, the larvae were retained on the screen and exposed to the air. One aquarium with test cylinders is shown in Figure 5.1-1.

5.2 Biological Test Procedures

Groups of 25 larvae were removed from the stock tanks for each test and were then placed in ten test cylinders (25 larvae per cylinder) in the air exposure tank. At the start of each test, cylinders 1 through 9 were removed simultaneously from the tank thereby exposing the contained larvae to the air. Cylinder number 10 contained 25 larvae which served as the control for each series of tests. Test larvae were exposed to ambient air for specific durations (0.5 to 30 minutes) after which they were returned to the aquarium. Initial mortality was recorded in each cylinder approximately 1 hour after the conclusion of each test. Thereafter, mortality of striped bass and winter flounder was recorded at 24, 48, 72, and 96 hours. Alewife and yellow perch were held for 48 hours only. The prolarval stage of these species lasts approximately 2 to 5 days. To avoid influencing the test results with high natural mortality which occurs during the transition from pro- to postlarval stage, the holding period was necessarily shortened.

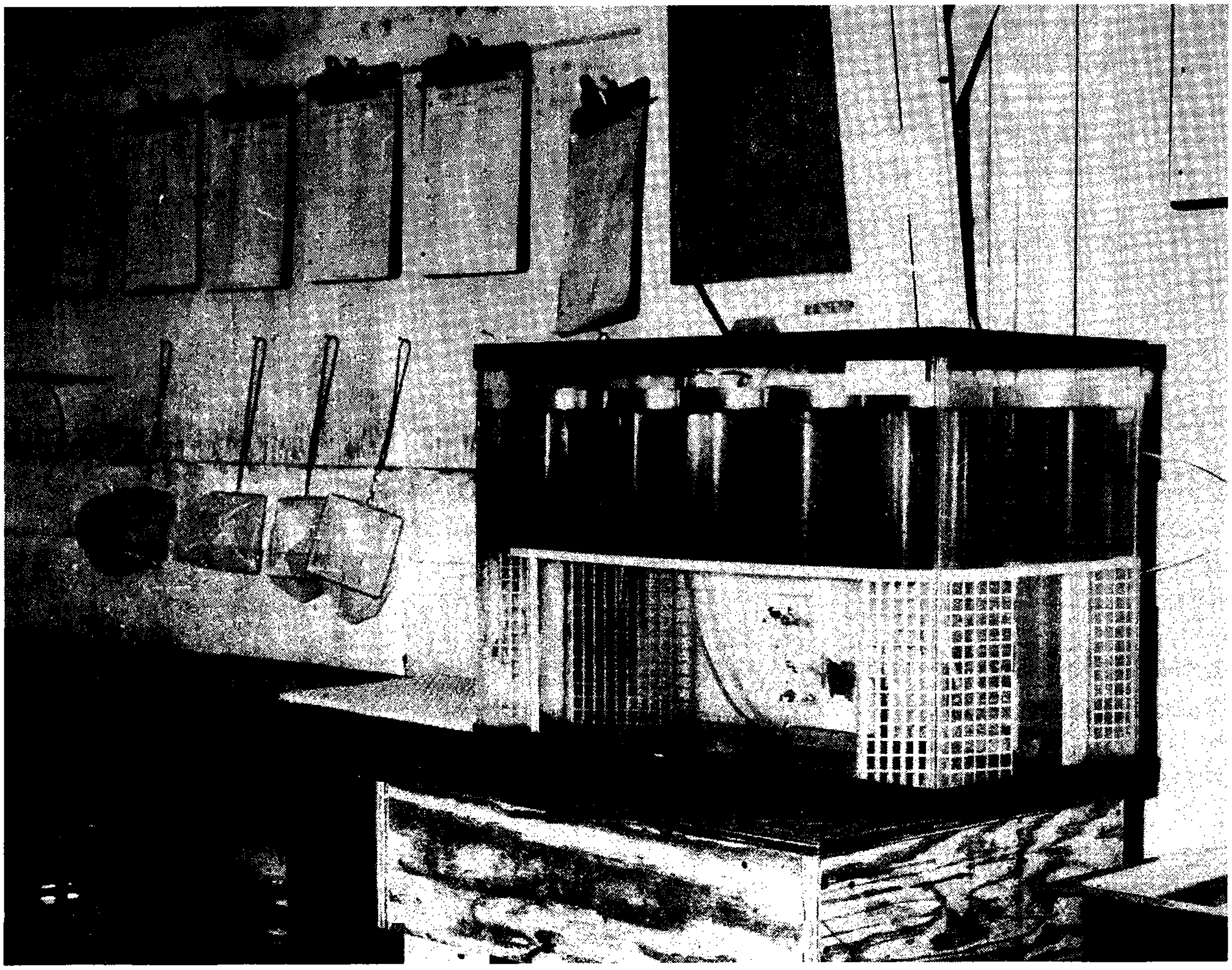


FIGURE 5.1-1 AIR EXPOSURE TEST FACILITY

At the end of 48 or 96 hours, the number of live larvae were recorded for both the test and control cylinders. Percent total mortality was then calculated for each. The air exposure test data are presented in Appendix C.

5.3 Analytical Results

Striped Bass - 1979

A total of 116 tests were conducted with striped bass ranging in length from 5.4 to 22.8mm. Early tests with prolarvae indicated that they could withstand the entire range of exposure times with low mortality. However, as testing progressed with postlarvae and early juveniles, mortalities increased markedly and became more variable over time. Observations suggested that mortality may be strongly influenced by life stage; therefore, for the purpose of analysis, the data were partitioned into four life stages based on Rogers et al (1977): prolarvae (yolk-sac) less than 6.3mm; post yolk-sac larvae, 6.4 to 14.9mm; metamorphosis, 15.0 to 17.5mm; and early juvenile, greater than 17.5mm. Since the data set for the post yolk-sac larvae was much larger than for any other life stage, the data were further divided into two classes (early larvae 6.4 to 10.7mm and late larvae 10.8 to 14.9mm) to increase the precision of the mortality estimates within each class. Data were, therefore, partitioned into 5 classes.

Using these classifications, the entire data set was analyzed by ANCOVA. The dependent variable was the percent mortality after 96 hours. The results of the analysis are presented in Table 5.3-1. Duration of air exposure and life stage significantly influenced mortality. The mortality increased as the duration of exposure increased, and as the larvae matured. The lowest mean mortality was predicted for prolarvae. The two-way interaction between the duration of air exposure and life stage was also significant. Although the relationship between duration and mortality was important for all life stages examined, the association was strongest for larvae undergoing metamorphosis and for early juveniles. The mortalities in these two classes increased appreciably with a small increase in the duration of the air exposure.

The model given on Table 5.3-1 was evaluated for all of the life stage classifications previously described. The results plotted in Figure 5.3-1 depict the relationship between percent mortality after 96 hours versus duration of air exposure for each life stage.

It is evident that prolarvae can survive exposure to air for long durations with little or no ill effects. It was noted during testing that the prolarvae remained stationary on the screen mesh as it was removed from the water. A thin film of water covered each individual which may explain why survival was high.

For larvae tested after absorption of yolk-sac, mortalities increased overall. A strong relationship was found between exposure duration and mortality, with the relationship becoming stronger as the bass developed through the larval stages and metamorphosis, to early juveniles. Toward the end of the study, small increases in exposure time resulted in large increases in mortality.

The highest mean mortality was predicted to occur during metamorphosis (15.0 to 17.5mm). It was noted that during this period of transition from the late larval to the early juvenile stage, the striped bass were extremely sensitive to external stimuli, often going into shock when attempts were made to handle them for testing purposes. It appears that this increased sensitivity may have been a large contributing factor in the higher mortalities observed at this time.

Figure 5.3-2 shows the relationship of larval length versus percent mortality for the control larvae. No mortality was observed in the prolarvae controls. As the larvae increased in length, the control mortality fluctuated. As in the test organisms, the highest mortality was observed during metamorphosis. As in the case of the test mortalities, the increased control mortality is thought to be the result of the increased sensitivity of the larvae during this time. The mortality rate decreased once the larvae developed into early juveniles.

TABLE 5.3-1

Results of ANCOVA
Striped Bass Air Exposure Study

a. Full Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Life Stage (LS)	4	32,177.15	8,044.29	14.575	0.0000*
Duration x LS	4	25,958.71	6,489.68	11.758	0.0000*
Tank Temperature	1	179.79	179.79	0.326	0.5694
Duration	1	39,587.32	39,587.32	71.726	0.0000*
Air Temperature	1	544.45	544.45	0.986	0.3229
Residual	104	57,399.97	551.92		
Total	115	185,390.31			

b. Reduced Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Life Stage (LS)	4	99,488.3	24,872.09	44.341	0.0000*
LS x Duration	4	2,478.55	6,069.66	10.021	0.0000*
Duration	1	44,197.80	44,197.79	78.794	0.0000*
Residual	106	59,458.50	560.93		
Total	115	185,390.32			

*Significant since $\alpha \leq 0.05$

TABLE 5.3-1
(continued)

$$Y_{ijk} = 52.1 + L_i + 6.18\ (D_{ijk} - 6.5) + B_j\ (D_{ijk} - 6.5) + e_{ijk}$$

where

Y_{ijk} = predicted mortality of ijk^{th} test

L_i = effect of the i^{th} life stage

D_{ijk} = duration of exposure of ijk^{th} test

B_j = effect of the interaction between life stage and duration

e_{ijk} = the residual variance

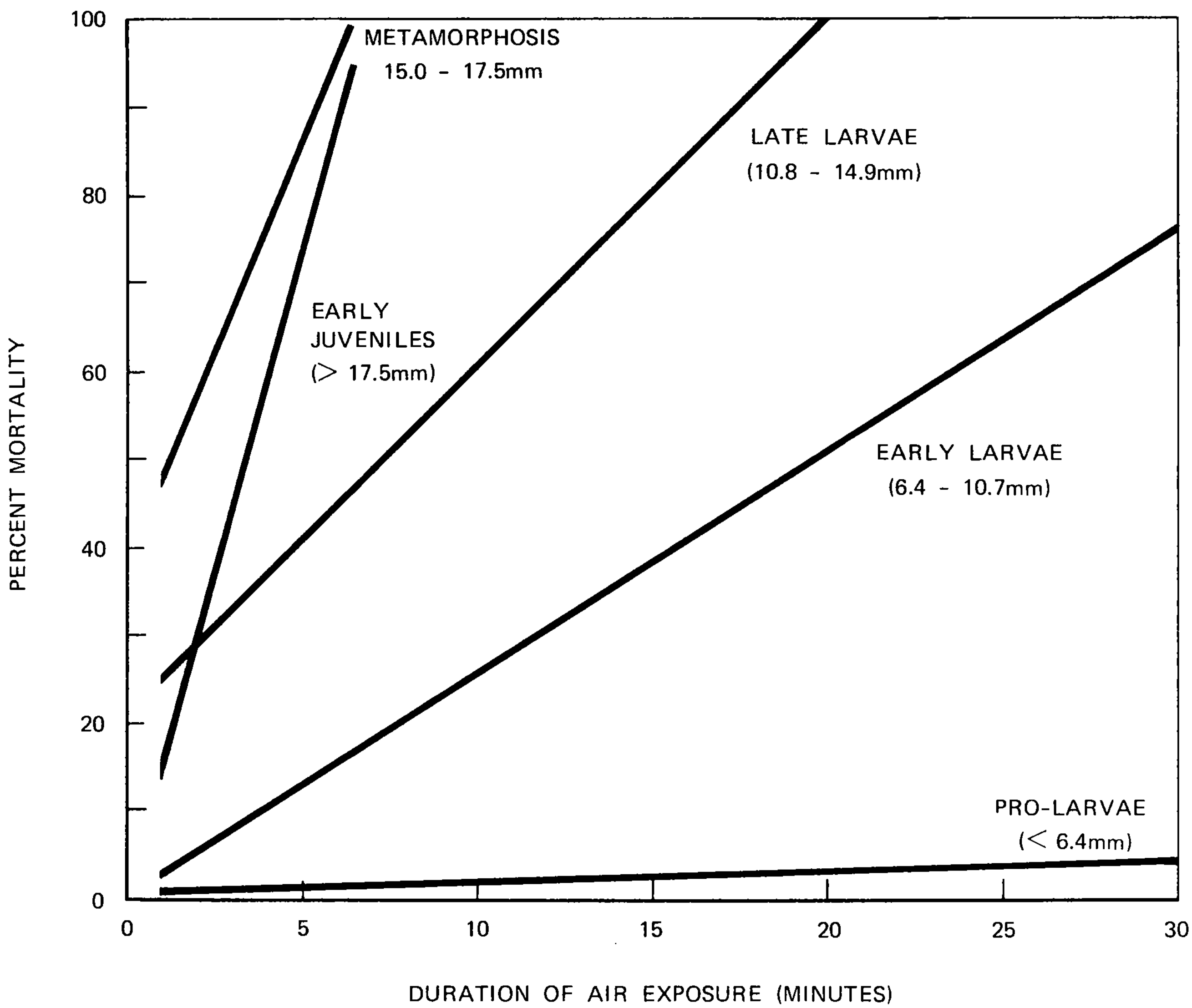


FIGURE 5.3-1 STRIPED BASS TEST MORTALITY (96-HOUR) VERSUS AIR EXPOSURE DURATION PARTITIONED BY LIFE STAGE

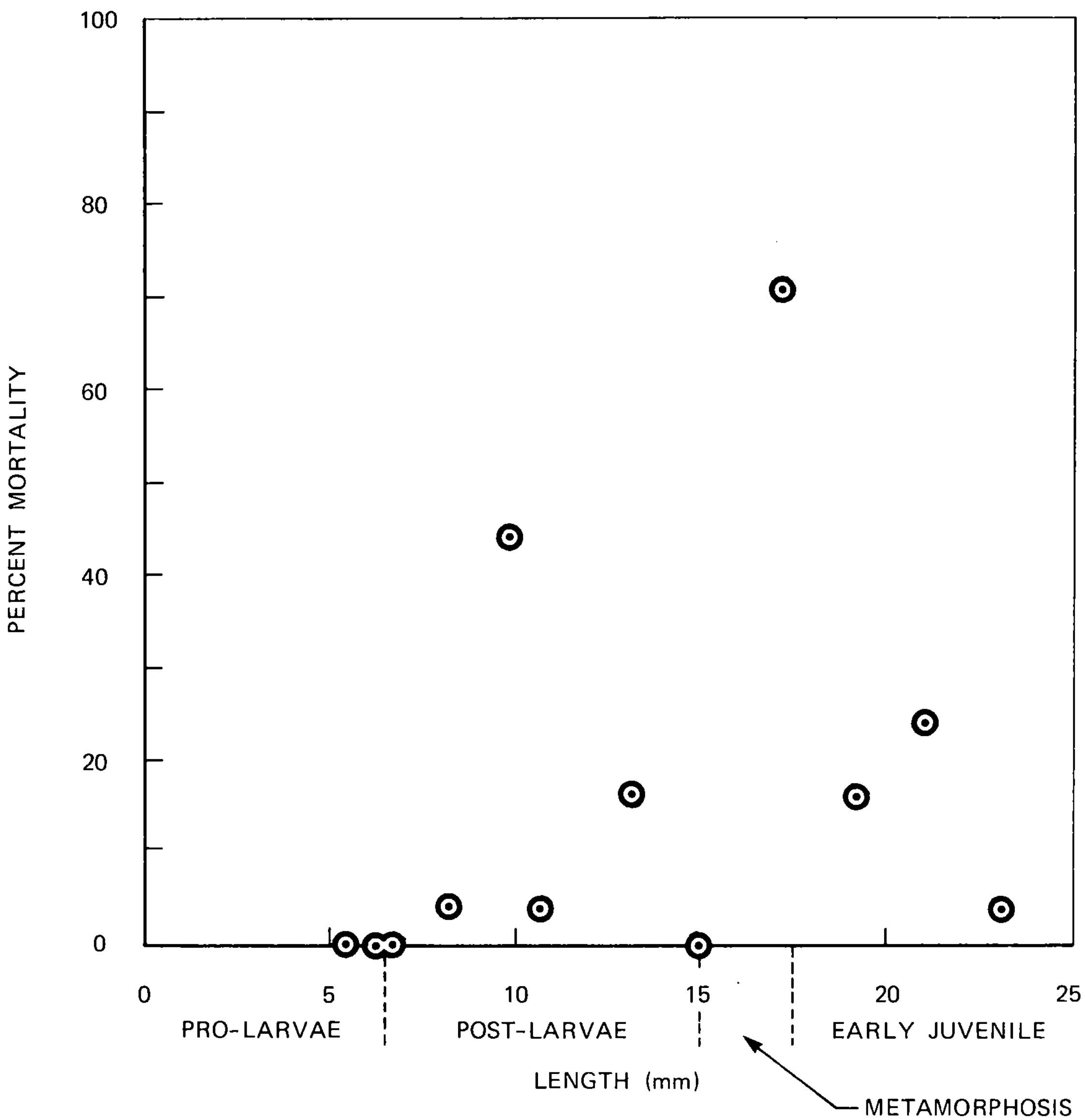


FIGURE 5.3-2 STRIPED BASS CONTROL MORTALITY (96-HOUR) VERSUS LENGTH, AIR EXPOSURE STUDY

Winter Flounder

In 1979, striped bass had been tested at exposure durations of up to 30 minutes. Results indicated that, with the exception of prolarvae, mortality was appreciable at durations over 5 minutes. Further, in actual power plant application, air exposure duration would not be expected to exceed 5 minutes. Therefore, in 1980, winter flounder, alewife, and yellow perch were tested at 1, 3, and 5 minute durations only.

Winter flounder were tested as prolarvae and postlarvae. Results of testing with each life stage are presented individually below.

Prolarvae

A total of 24 tests with prolarvae were conducted on March 14 and March 19, 1980; mean lengths were 3.6mm and 4.1mm, respectively. Histograms of the percent mortality obtained at the specific air exposure durations and the important summary statistics are presented in Figure 5.3-3.

The data were analyzed by ANOVA. The dependent variable was the percent mortality after 96 hours. Results of the analysis are presented in Table 5.3-2. All of the independent variables included in the analysis were found to significantly influence prolarval mortality. However, it is believed that this result was a function of high and unexplained mortalities observed in two tests among the 3.6mm larvae at the 5 minute exposure duration. As shown in Figure 5.3-3, with the exception of these two tests, in which 96 percent mortalities were obtained, mortalities were low. Mortality in each of other two tests conducted with 3.6mm larvae at 5 minutes exposure was 5 percent. Further, slightly larger (4.4mm) larvae tested at a 5 minute duration experienced a mean mortality of only 1.8 percent. For these reasons, the two high mortality values observed are believed to be anomalous. Since these mortalities resulted in a high mean mortality value of 50 percent for 3.6mm larvae tested at a 5 minute exposure duration, it is believed that this value was at least partially responsible for the significance of the independent variables. Therefore, the meaningfulness of these variables is placed in question.

Prolarvae flounder controls were studied to determine the mortality attributable to holding and handling. Only one prolarvae died during the four control tests (4 percent mortality).

Postlarvae

A total of 18 air exposure tests were conducted with winter flounder postlarvae. Twelve tests were conducted with early postlarvae, 4.4mm in length; 6 tests were performed with later postlarvae, 6.1mm in length. Data for each life stage were analyzed separately.

Summary statistics calculated for early postlarvae at specific air exposure durations are presented in Table 5.3-4. The data were analyzed by ANOVA. The dependent variable was the percent mortality after 96 hours. The results of the analysis are presented in Table 5.3-5. As expected, duration of exposure significantly influenced early postlarvae mortality. Duncan's multiple range tests indicated that the mean mortality of postlarvae exposed to the air for 1 minute was significantly lower than the mean mortalities of postlarvae exposed to the air for 3 or 5 minutes. The mortalities were also influenced by the aquarium in which the larvae were tested. Early postlarvae tested in aquarium A had a mean mortality of 38 percent while those tested in aquarium B had a mean mortality of 65.1 percent. The reason for this difference is not clear, particularly since control mortality was zero percent in both aquariums.

Results of testing with later postlarvae are summarized in Table 5.3-6. Since the mortalities were very low and not variable, statistical analyses were not deemed necessary. From the data presented, it is clear that later postlarvae were able to withstand air exposure at all three exposure durations. Control mortality associated with holding and handling was 4 percent.

TABLE 5.3-2

ANOVA - Prolarvae (3.6 to 4.1mm)
Winter Flounder Air Exposure Study

Source of Variation	df	Sum of Squares	Mean Square	F-Ratio	α Prob.
Duration	2	2,953.36	1,476.68	92.09	0.0001*
Day	1	1,913.52	1,913.52	119.33	0.0001*
Aquarium	1	1,881.51	1,881.51	117.33	0.0001*
Duration x Day	2	2,818.96	1,409.48	87.90	0.0001*
Day x Aquarium	1	2,007.51	2,007.51	125.19	0.0001*
Duration x Aquarium x Tank	4	4,858.75	1,214.69	75.75	0.0001*
Error	12	192.42	16.04		
Corrected Total	23	16,626.05			

*Significant since $\alpha \leq 0.05$

TABLE 5.3-3

Percent 96-Hour Mortality and
Standard Deviations for Prolarvae
Winter Flounder Air Exposure Study

Mean Larval Length (mm)	Mean Percent Mortality and Standard Deviation by Duration			Control Mortality (%)
	1 Minute	3 Minutes	5 Minutes	
3.6	0 ± 0	8.0 ± 11.3	50 ± 53.2	4
4.1	1 ± 1.9	1.7 ± 2.0	1.8 ± 3.6	4

TABLE 5.3-4

Summary Statistics - Early Postlarvae
Winter Flounder Air Exposure Study
96-Hour Mortality

1 Minute

n = 4
Mean percent mortality = 32.2%
Standard deviation = 12.4%
Range = 20-48%

3 Minute

n = 4
Mean percent mortality = 63.9%
Standard deviation = 19.4%
Range = 48-87.5%

5 Minute

n = 4
Mean percent mortality = 59.8%
Standard deviation = 25.7%
Range = 32-83.3%

Control Mortality = 0%

TABLE 5.3-5

ANOVA - Early Postlarvae
Winter Flounder Air Exposure Study

a. Full Model

Source of Variation	df	Sum of Squares	Mean Square	F-Ratio	α Prob.
Duration	1	2,254.48	1,127.24	12.88	0.0067*
Aquarium	1	2,208.65	2,208.65	25.24	0.0024*
Duration x Aquarium	2	624.48	312.24	3.57	0.0953
Error	6	525.07	87.51		
Total	11	5,612.69			

b. Reduced Model

Source of Variation	df	Sum of Squares	Mean Square	F-Ratio	α Prob.
Duration	2	2,254.48	1,127.24	7.84	0.0130*
Aquarium	1	2,208.65	2,208.65	15.37	0.0044*
Error	8	1,149.55	143.69		
Total	11	5,612.69			

*Significant since $\alpha \leq 0.05$

TABLE 5.3-6

Percent 96-Hour Mortality - Later Postlarvae
Winter Flounder Air Exposure Study

	Duration (minutes)			
	1	3	5	Control
Percent	0	0	0	
Mortality	0	4	8	4

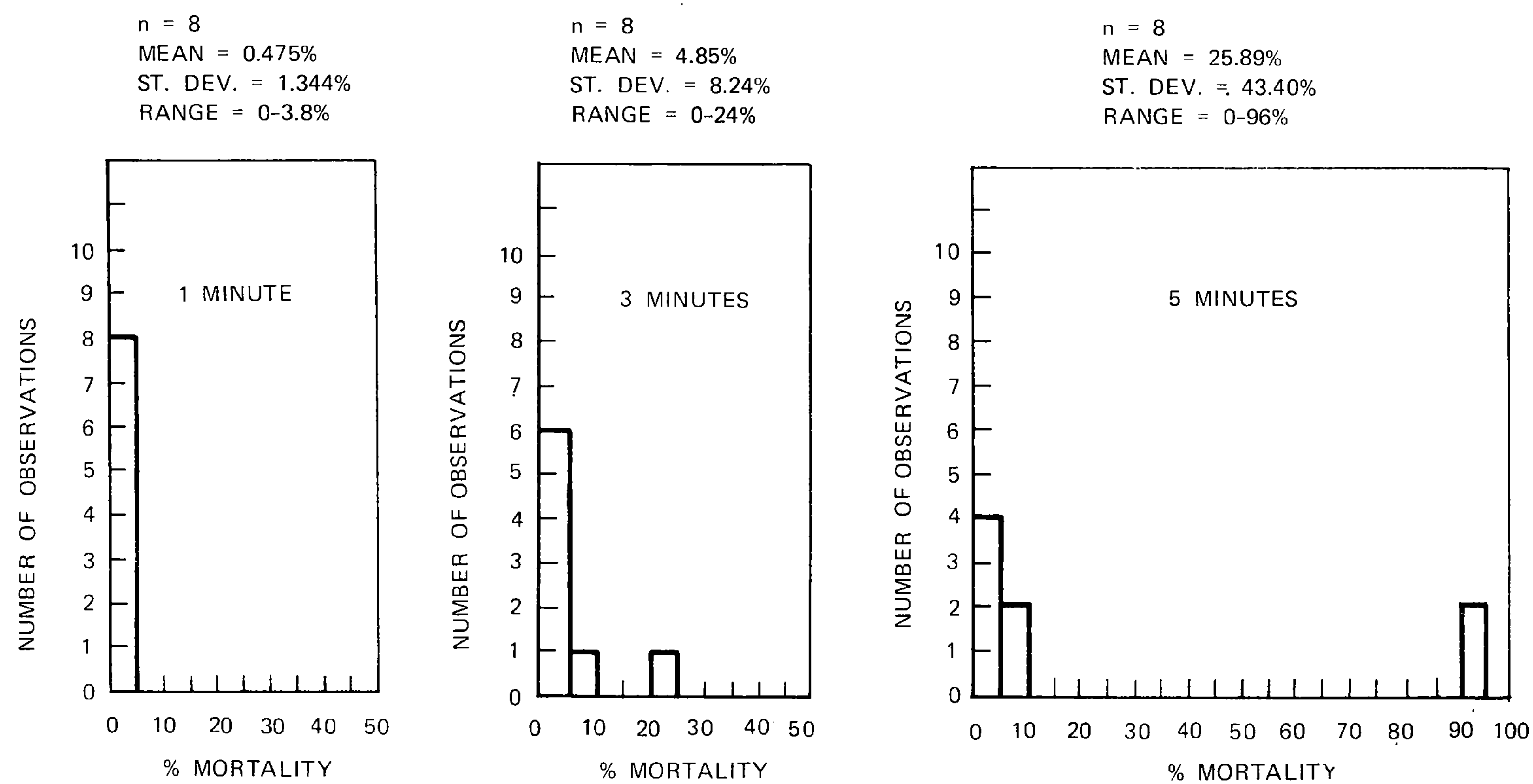


FIGURE 5.3-3 HISTOGRAMS AND SUMMARY STATISTICS -- PROLARVAL 96-HOUR MORTALITY AT DIFFERENT DURATIONS OF EXPOSURE, FLOUNDER AIR EXPOSURE STUDY

Alewife

Alewives were tested as prolarvae and postlarvae, as presented below.

Prolarvae

Nine tests were conducted with prolarvae on May 14, 1980 ranging from 5.0 to 5.4mm (mean 5.2mm) in length. Results of the tests are presented in Table 5.3-7. As discussed previously, prolarvae were held for 48 hours only. During the 48 hour holding period, only one alewive prolarvae died (after exposure to ambient air for 3 minutes) under all conditions. Two prolarvae died in the control group over the holding period (8 percent mortality). Thus, the data suggest that exposure of alewife prolarvae to ambient air for 1, 3, and 5 minutes did not adversely influence their survival. Since mortalities were negligible, statistical analyses were not conducted.

Postlarvae

Tests with postlarvae were conducted on May 28, June 5, and June 6, 1980. A total of 27 air exposure tests were conducted with early and later postlarvae. The mean lengths of early postlarvae were 6.6 and 9.5, while the later postlarvae measured 12.4mm. Data for each life stage and the important summary statistics are presented in Table 5.3-8.

From the data presented, it is clear that the duration of air exposure did not significantly influence the percent mortality and that mortality was very high among 6.6 and 12.4mm larvae. The average percent mortality within each test group exposed to the air for one, three, and five minutes did not significantly differ. However, the percent mortalities observed between the three test groups did differ. The lowest percent mortalities were observed for the 9.5mm early postlarvae while the highest percent mortalities were recorded for the 6.6mm early postlarvae.

The postlarvae controls indicated that the mortality attributable to holding and handling differed significantly for each life stage. All postlarvae died during the control test for the early postlarvae (100 percent mortality). Only six postlarvae died among the 9.5mm postlarval control (24 percent mortality). Nineteen later postlarvae controls died (76 percent mortality).

TABLE 5.3-7

Percent Mortality - Prolarvae
Alewife Air Exposure Study

Duration (min.)	Percent Mortality Replicate 1	Replicate 2	Replicate 3
1	0	0	0
3	0	4	0
5	0	0	0

Control Mortality = 8%

TABLE 5.3-8

Test Results and Summary Statistics - Postlarvae
Alewife Air Exposure Study

Day of Testing	Test Mortality Duration 1	3	5	Control Mortality %
May 28	88	100	100	100
(6.6mm)	100	92	92	
	100	96	96	
Mean	96	96	96	
St. Dev.	6.9	4	4	
June 4	12	12	12	24
(9.5mm)	20	20	8	
	24	12	12	
Mean	18.7	14.7	10.7	
St. Dev.	6.1	4.6	2.3	
June 5	88	80	96	76
(12.4mm)	68	92	92	
	92	88	88	
Mean	82.7	86.7	92	
St. Dev.	12.9	6.1	4	

Yellow Perch

Yellow perch were tested as prolarvae and postlarvae, as presented below.

Prolarvae

Nine tests were conducted on May 14, 1980 with prolarvae ranging in length from 5.4 to 5.9mm (mean 5.8mm). Results of the tests are presented in Table 5.3-9. During the 48 hour holding period, mean mortality for the 1 minute and 5 minute durations was 0.66 and 1.33 percent, respectively. No prolarvae died in the control group. Since mortalities were negligible, no analysis of the data was performed. It is evident that yellow perch prolarvae are very capable of surviving air exposure over the durations tested.

Postlarvae

Tests with postlarvae were conducted on May 21 and May 28, 1980. A total of 27 air exposure tests were conducted with early postlarvae having mean lengths of 6.3 and 7.6mm, respectively. Data for the two test groups and the important summary statistics are presented in Table 5.3-10. From the data presented, it is clear that the duration of air exposure did not significantly influence the percent mortality which was high in all cases. The average percent mortality of early and slightly larger postlarvae exposed to the air for one, three, and five minutes did not significantly differ.

The postlarvae controls indicated that holding and handling contributed significantly to the mortality observed with this life stage. Early postlarvae controls tested in two groups suffered 96% and 100% mortality, respectively. The control mortality of slightly larger early postlarvae was somewhat lower at 88 percent.

5.4 Summary of Air Exposure Studies

Air exposure may be a significant factor in mortality for certain species, particularly among postlarvae; it would appear prudent to limit exposure time in fine-mesh screen systems unless specific data are available which indicate that the species of concern at a site are resistant to air exposure stress.

TABLE 5.3-9

Percent Mortality - Prolarvae
Yellow Perch Air Exposure Study

Duration (min.)	Percent Mortality Replicate 1	Replicate 2	Replicate 3	Mean Mortality
1	2	0	0	0.66
3	0	0	0	0
5	4	0	0	1.33

Control Mortality = 0%

TABLE 5.3-10

Test Results and Summary Statistics - Postlarvae
Yellow Perch Air Exposure Study

	Test Mortality Duration			Control Mortality
Day of Testing	1	3	5	%
May 21, 1980	100	100	100	96
(6.3mm)	100	92	100	
	100	100	100	
May 28, 1980	96.2	100	92	88
(7.6mm)	84.0	100	80	
	76.0	92	76	
Overall Mean	94.7	96.4	92.5	
St. Dev.	8.7	4.7	8.8	

SECTION 6

SPRAY WASH STUDY

SECTION 6
SPRAY WASH STUDY

A study to examine the effects of spraywash devices on the four test species was conducted between July 1979 and June 1980.

As described below, two spraywash systems (front-wash and back-wash) were modeled to facilitate testing. Design and operational factors which might influence larval mortality were carefully simulated. Both systems were tested with striped bass juveniles in 1979. However, 1980 testing with other species was limited to one system. In 1979, numerous changes in design had been made by the screen manufacturers to achieve better washing and survival conditions, particularly with fine-mesh screening systems. Early in 1980, effort was continuing on the design of the front-wash system. It was not deemed cost-effective to continue testing with a design which would not ultimately be utilized in fine-screening systems. Therefore, beginning with winter flounder in 1980, the front-wash spray system was eliminated from further testing.

6.1 Description of the Facility

A 12 inch wide section of one screen panel was reproduced for the evaluation of each of the spraywash systems. The spray nozzles were fixed in position and supplied with dechlorinated city water. A centrifugal pump was used to develop spray pressures of up to 15 psi at each nozzle.

The front-wash test facility was designed using clear acrylic in the shape of the screen and lifting bucket. This spray system is designed to wash the larvae from the lifting bucket to a collection trough and did not require modeling of the screen or its movement. A fixed nozzle was located so that the spray impacted the back of the lifting bucket and washed the water over the front lip. A collection area was incorporated to retrieve the larvae after the test. The test facility is shown in Figures 6.1-1 and 6.1-2.

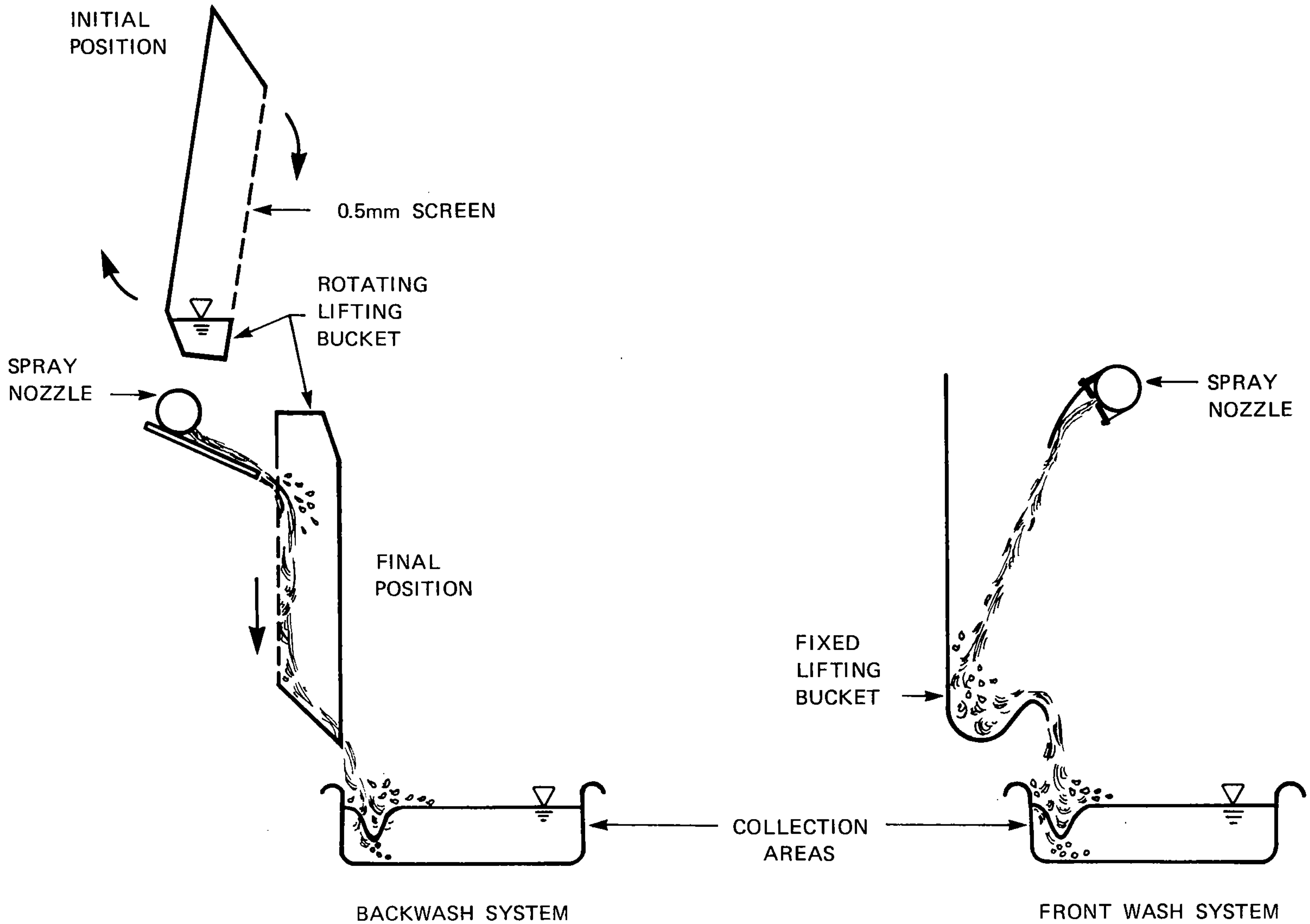


FIGURE 6.1-1 SPRAY WASH TEST FACILITIES

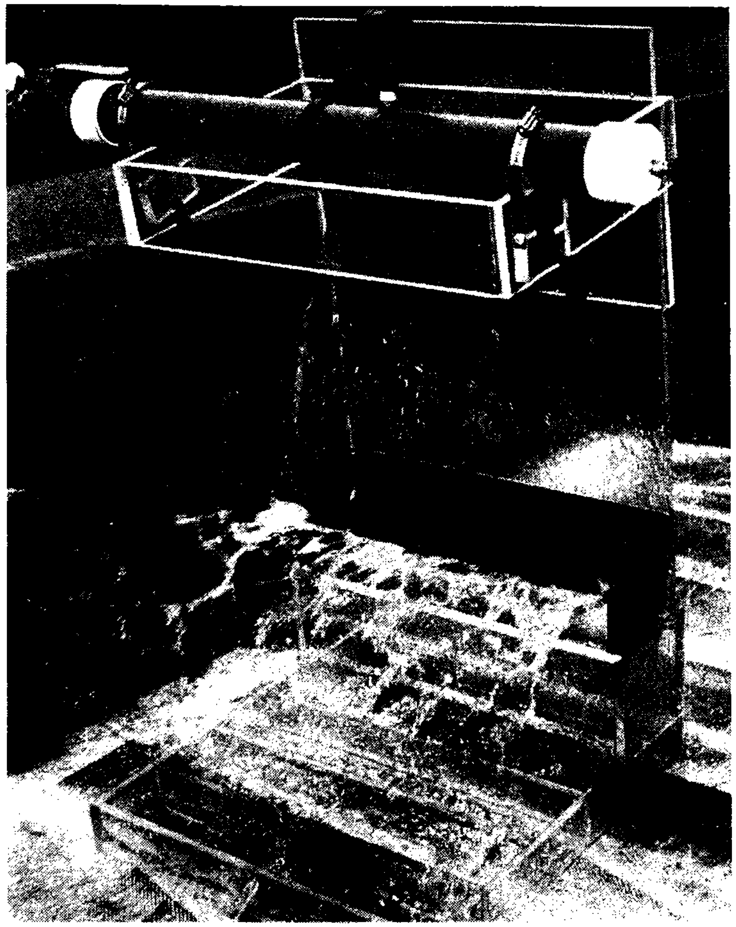


FIGURE 6.1-2 FRONTWASH SPRAY TEST DEVICE
COLLECTION AREA NOT INCLUDED

FIGURE 6.1-3 BACKWASH SPRAY TEST DEVICE
SCREEN INVERTED ABOVE SPRAY NOZZLE

The back-wash spray test facility incorporated a 500 micron screen mounted in an acrylic frame. The frame included a lifting bucket at the bottom of the screen and a deflector which models the seal between screen panels.

The frame was mounted in supports that allowed it to rotate, spilling the contents of the lifting basket onto the screen face. The frame, in the inverted position, could be lowered past a fixed spray nozzle. The water sprayed through the screen traveled down the deflector and into a collection area. The back-wash apparatus is presented in Figures 6.1-1 and 6.1-3.

6.2 Biological Test Procedures

Since the procedures used for testing the back-wash and front-wash systems differed, they are described separately below.

Front-Wash System

Prior to each series of tests, 20 control larvae were placed in the screen bucket. These larvae were allowed to remain in the bucket for approximately 2 minutes and were then removed and placed in a holding beaker for 96 hours. In addition, a separate control consisting of 20 larvae was utilized to identify mortality due to handling or temperature differences. These larvae were removed from the stock tanks and placed directly into holding beakers and held for 96 hours.

At the start of each test, twenty larvae were placed in the lifting bucket of the spraywash test apparatus. The spraywash was then activated and allowed to clean the bucket for approximately 5 seconds, washing the larvae into the collection trough. Larvae were then removed from the trough and placed in holding beakers for 96 hours. Spraywash pressures of 5, 10, and 12 psi were evaluated. Initial mortality was recorded approximately 1 hour after completion of each test. Thereafter, mortality was recorded at 24, 48, 72, and 96 hours.

At the end of the 96 hour holding period, the number of live larvae was recorded. The percent mortality was then calculated for each test, as well as for the two control groups.

Back-Wash System

Common control groups were used for the front- and back-wash tests since both test series were conducted during the same time period.

At the start of each test, twenty larvae were introduced into the screen bucket of the spraywash apparatus. The bucket had been previously filled with water. The screen frame was then rotated 180 degrees. Rotation time was about 20 seconds to simulate passage of the screen basket over the head shaft in an actual power plant. Larvae retained on the mesh were then washed off of the screen into a collection trough. The back-wash spray intercepted the screen at a 45 degree angle, and was operated at a supply pressure of approximately 10 psi.

Larvae were removed from the collection trough and were placed into holding beakers for 96 hours. Initial mortality was recorded approximately 1 hour after the conclusion of each test. Thereafter, mortality was recorded at 24, 48, 72, and 96 hours. At the end of the 96 hour holding period, the number of live larvae were recorded and the percent mortality was calculated for each test. Test data for both spraywash systems are included in Appendix D.

6.3 Analytical Results

Striped Bass

A total of 52 tests were conducted with the spraywash systems with the smallest available striped bass (ranging from 19 to 35.5mm in length): 26 tests with the front-wash system operating at pressures of 5, 10, and 12 psi, and 26 tests with the back-wash system at a pressure of 10 psi.

The data were analyzed by ANCOVA. Mortality was low in most tests, resulting in a skewed distribution of 96-hour mortality (the dependent variable). Therefore, a logarithmic transformation of the dependent variable was required to satisfy the statistical assumptions needed to perform an ANCOVA. Since the mortality values observed under all test conditions were extremely low, no attempt was made to distinguish differences between the three front-wash spray pressures. Observations indicated that all three pressures removed the test fish with little effect on their survival.

The results of the analysis are presented in Table 6.3-1. Within the range of independent variables examined, these variables did not influence the percent mortality. The predicted mean percent mortality of fish tested with the front-wash and back-wash sprays was 2.4 and 2.1 percent, respectively. Since these means were not significantly different, the data from both spray systems were combined to yield an overall mean mortality of 2.3 percent with a 95 percent confidence interval of 1.4 to 3.6 percent.

Control fish were studied to estimate the mortality attributable to holding and handling. The mortality for controls which were simply held ranged from 0 to 8 percent with a mean and standard deviation of 1.3 ±3.3 percent. The control mortality for fish handled and held ranged from 0 to 50 percent with a mean and standard deviation of 9.3 ±18.4 percent. A single 50 percent mortality value was observed for fish that were 35.5mm in length. (The mortality of fish tested at this length did not significantly increase.) Figure 6.3-1 illustrates the mortality for the two control groups.

TABLE 6.3-1

Results of ANCOVA
Striped Bass Spraywash Study

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Spray Type	1	0.0897	0.0897	0.061	0.8053
Length	1	0.69376	0.69376	0.475	0.4941
Air Temperature	1	0.9073	0.9073	0.621	0.4346
Temperature Difference	1	1.5948	1.5948	1.092	0.3014
Residual	47	68.6669	1.4610		
Total	51	72.667			

Spray System	Predicted Mean Mortality Rates and 95% Confidence Intervals
Front-wash	$1.1 \leq 2.4 \leq 4.6$
Back-wash	$0.9 \leq 2.1 \leq 4.2$

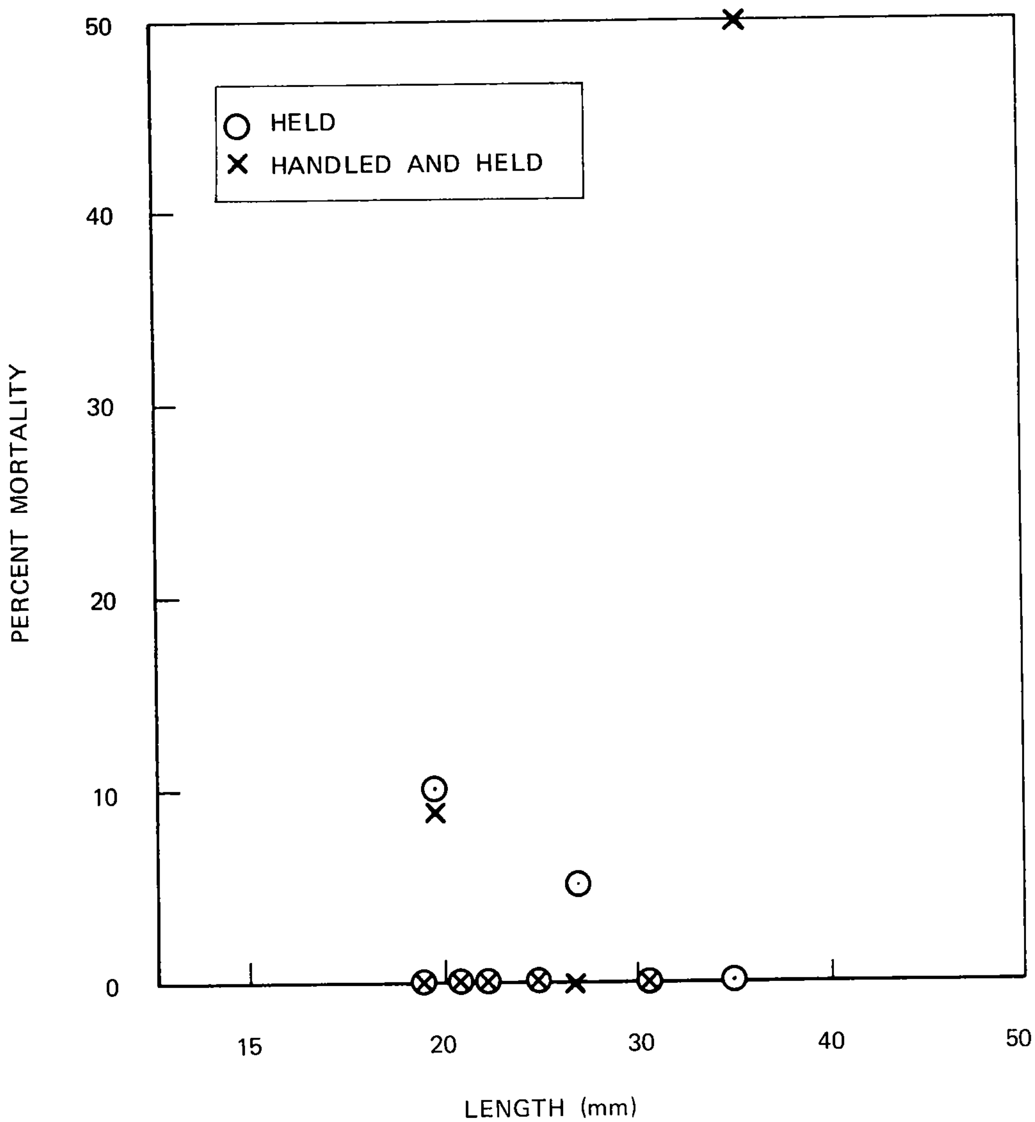


FIGURE 6.3-1 STRIPED BASS CONTROL MORTALITY (96-HOUR) VERSUS LENGTH, SPRAY WASH STUDY

Winter Flounder

Winter flounder prolarvae and early postlarvae were tested in the back-wash spray system from mid-March to mid-April 1980. Eight tests were conducted with prolarvae ranging in length from 3.6 to 4.1mm. Four tests were conducted with early postlarvae averaging 4.4mm.

During the tests, as the screen frame was rotated, the water in the bucket flowed out through the drainage holes in the back, as designed. However, as the water drained out, the small larvae became impinged on the screen at the intersect of the mesh and the bucket. Unlike the considerably larger striped bass early juveniles, the spraywash was not effective in washing the larvae into the collection trough, since the spray did not rinse that portion of the screen.

Attempts were made to modify the backside of the screen in an effort to prevent the larvae from being impinged at this point. However, larvae still consistently remained impinged on the screen. Of the 200 4.0 and 4.1mm prolarvae tested, only seven were washed into the collection trough (Table 6.3-2). None were held for latent mortality. Additional spraywash tests were conducted with early postlarvae (4.4mm). As in the case of prolarvae, these slightly larger postlarvae were not successfully washed into the collection trough.

Although the back-wash system tested was designed to simulate operational features which might be found in an actual power plant, it was obvious that this design was not effective in washing small winter flounder larvae into the collection trough, since an area not washed by the spray existed at the point where the fine-mesh screen joined the bucket. This study suggests, therefore, that the design of a spraywash system for actual power plant operation would necessitate careful avoidance of such dead areas to be an effective system for larvae in the 3 to 5mm range.

TABLE 6.3-2

Test Results
Winter Flounder Spraywash Study

Test No.	Larval Length (mm)	Number Tested	Number Washed Into Collection Trough	Number Remaining in Screen Bucket	Number Not Found
1	4.1	25	2	22	1
2	4.0	25	2	23	0
3	4.0	25	1	24	0
4	4.0	25	0	24	1
5	4.0	25	1	24	0
6	4.0	25	1	24	0
7	4.0	25	0	25	0
8	4.0	25	0	24	1
9	4.4	25	1	23	1
10	4.4	25	0	22	3
11	4.4	25	0	24	1
12	4.4	25	0	25	0

Alewife

Alewife were tested as prolarvae and postlarvae, as discussed below. In these tests, only the back-wash system was evaluated.

Prolarvae

Seven spraywash tests were conducted with alewife prolarvae ranging in length from 5.0 to 5.8mm. During the first 3 tests, only 1 prolarva was washed into the collection trough (Table 6.3-3). Thus, none were held for latent mortality.

Four tests were conducted with prolarvae ranging from 5.3 to 5.8mm (mean of 5.5mm). As previously discussed, alewife prolarvae were held for only 48 hours. While not all of the prolarvae were effectively removed, none of the collected prolarvae died during the 48 hour holding period. In addition, none of the control prolarvae died (Table 6.3-3). Thus, the backwash spray system does not appear to adversely affect survival of alewife prolarvae and presumably, slight modifications to the system would improve washing efficiency.

Postlarvae

Six tests were conducted with alewife postlarvae ranging in length from 8.7 to 13.2mm: three tests with early postlarvae (mean length of 9.6mm); and three tests with later postlarvae (mean length of 12.4mm); (Table 6.3-3). As in the case of the prolarvae, postlarvae were not consistently washed into the collection trough by the spray device.

Test mortalities of the early postlarvae ranged from 12.5 to 46.2 percent, with a mean of 29.8 percent. Control mortality was 8 percent over the 96 hour holding period. Latent mortalities of the later postlarvae ranged from 72.7 to 90.9 percent, with a mean of 79.5 percent. Control mortality was 80.0 percent. Although the test mortalities were substantially higher for the later postlarvae than the early postlarvae, control mortality was also appreciably higher. Thus, the higher mortalities for the older postlarvae are believed to result at least partially to handling stress rather than the effect of the spraywash device.

Thus, although the backwash spray system was not particularly effective in washing alewife prolarvae and postlarvae into the collection trough, test mortalities relative to control mortalities were low for both prolarvae and early postlarvae.

TABLE 6.3-3

Test Results
Alewife Spraywash Study

Life Stage	Test No.	Tank Temp. (°C)	Flume Temp. (°C)	Mean Length (mm)	No. Tested	No. Washed Into Collection Trough	No. Remaining in Screen Bucket	No. Not Found	Initial Live	Initial Dead	24 Hr. Dead	48 Hr. Dead	72 Hr. Dead	96 Hr. Dead	Total Dead	Total Live	% Mortality 48/96 Hr.	Mean Percent Mortality
Prolarvae	1	15.0	17.8	5.2	25	0	23	2										
	2	15.0	17.8	5.2	25	0	18	7	----------Not Held for Mortality----------									
	3	15.0	17.8	5.2	25	1	15	9										
	4	13.8	14.8	5.5	25	18	5	2	18	0	0	0	---	---	0	18	0	
	5	13.8	14.6	5.5	25	16	9	0	16	0	0	0	---	---	0	16	0	0
	6	13.8	14.5	5.5	25	20	5	0	20	0	0	0	---	---	0	20	0	
	7	13.8	14.2	5.5	25	21	4	0	21	0	0	0	---	---	0	21	0	
	Control	13.8	14.8	5.5	25	--	--	--	25	0	0	0	---	---	0	25	0	
Postlarvae	8	16.8	16.9	9.6	25	8	17	0	7	1	0	0	0	0	1	7	12.5	
	9	16.8	16.9	9.6	25	13	12	0	8	5	0	1	0	0	6	7	46.2	
	10	16.8	16.9	9.6	25	13	12	0	11	2	1	1	0	0	4	9	30.8	29.8
	Control	16.8	16.9	9.6	25	--	--	--	25	0	0	1	0	1	2	23	8.0	
	11	16.8	16.9	12.4	25	11	14	0	10	1	0	2	2	5	10	1	90.9	
	12	16.8	16.9	12.4	25	8	15	2	7	1	0	0	0	5	6	2	75.0	
	13	16.8	16.9	12.4	25	11	14	0	6	5	0	1	0	2	8	3	72.7	79.5
	Control	16.8	16.9	12.4	25	--	--	--	25	0	0	2	3	15	20	5	80.0	

Yellow Perch

Yellow perch were tested as prolarvae and postlarvae, as discussed below.

Prolarvae

Four spraywash tests were conducted with yellow perch prolarvae ranging in length from 5.9 to 6.1mm (mean length of 6.0mm); (Table 6.3-4). As in the case of the winter flounder larvae, the majority of the perch prolarvae were not successfully washed into the collection trough by the backwash spray system. Prolarvae from three of the four tests conducted were held for latent mortality.

Mean test mortality was 8.3 percent. No larvae in the control group died over the holding period. Thus, although the spraywash system was not particularly effective in washing the prolarvae into the collection trough, overall test mortality among those larvae washed from the screen was low.

Postlarvae

Eight tests were conducted with yellow perch postlarvae ranging in length from 6.0 to 8.9mm (Table 6.3-4).

Four tests were performed with early postlarvae having a mean length of 6.3mm. As in the case of the prolarvae, postlarvae were not consistently washed into the collection trough by the backwash spray system. Those larvae which were washed into the collection trough were held for 96 hours to determine latent mortality.

Test mortalities ranged from 46.7 to 93.8 percent, with a mean of 73.5 percent. The control group exhibited 100 percent mortality (Table 6.3-4).

Four tests were conducted with later postlarvae having a mean length of 8.1mm. Test mortalities ranged from 91.7 to 100 percent. Control mortality was 72.0 percent.

As shown on Table 6.3-4, the later postlarvae exhibited higher test mortalities than did the early postlarvae. However, since control mortalities for both groups were very high, the contribution of the backwash spray system to test mortalities is difficult to distinguish from natural mortality occurring in the laboratory.

6.4 Summary of Spraywash Studies

Spraywash studies demonstrate that minor details in the design of a fine-mesh screen can greatly affect overall system effectiveness. Striped bass juveniles showed high survival after removal from two different spraywash systems. Winter flounder, alewife, and yellow perch pro- and early postlarvae were not effectively removed by the spraywash system evaluated. Later postlarvae were removed to a greater extent and exhibited high latent mortality; however, control mortality was also high.

TABLE 6.3-4

Test Results
Yellow Perch Spraywash Study

Life Stage	Test No.	Tank Temp. (°C)	Flume Temp. (°C)	Mean Length (mm)	No. Tested	No. Washed Into Collection Trough	No. Remaining in Screen Bucket	No. Not Found	Initial Live	Initial Dead	24 Hr. Dead	48 Hr. Dead	72 Hr. Dead	96 Hr. Dead	Total Dead	Total Live	% Mortality 48/96 Hr.	Mean Percent Mortality
Prolarvae	1	14.0	14.2	6.0	25	9	16	0	9	0	0	0	---	---	0	9	0	
	2	14.0	14.2	6.0	25	14	10	1	14	0	0	0	---	---	0	14	0	8.3
	3	14.0	14.2	6.0	25	4	21	0	4	0	0	1	---	---	1	3	25.0	
	4	14.0	14.2	6.0	25	4	21	0	---------Not Held for Mortality---------									
	Control	14.0	14.2	6.0	25	--	--	--	25	0	0	0	---	---	0	25	0	
Postlarvae	5	15.5	15.2	6.3	25	15	10	0	15	0	0	3	0	4	7	8	46.7	
	6	15.5	15.2	6.3	25	9	16	0	9	0	2	1	1	2	6	3	66.7	
	7	15.5	15.5	6.3	25	16	8	1	16	0	0	8	1	6	15	1	93.8	73.5
	8	15.5	15.5	6.3	25	15	10	0	15	0	3	5	0	5	13	2	86.7	
	Control	15.5	15.5	6.3	25	--	--	--	25	0	2	4	5	14	25	0	100.0	
	9	14.0	14.5	8.1	26	19	7	0	15	4	0	8	2	4	18	1	94.7	
	10	14.0	14.5	8.1	26	12	14	0	11	1	0	7	0	3	11	1	91.7	
	11	14.0	14.5	8.1	25	14	11	0	12	2	3	6	0	3	14	0	100.0	96.6
	12	14.5	14.5	8.1	25	6	19	0	6	0	6	---	---	---	6	0	100.0	
	Control	14.0	14.5	8.1	25	--	--	--	24	1	0	7	1	9	18	7	72.0	

SECTION 7

LARVAL DIVERSION STUDY

SECTION 7
LARVAL DIVERSION STUDY

As discussed in Section 2, another concept for protecting organisms is to utilize a diversion system which will guide them to bypasses from which they can be returned to the natural environment. Since this concept had been shown to be particularly effective with juvenile fish, ESEERCO decided to determine whether the diversion principle could be extended to the larval life stage. Therefore, from June 1978 to June 1980, various fine-mesh angled screen panels, incorporating mesh sizes ranging from 1.0 to 9.5mm, were evaluated in a larval test flume at approach velocities ranging from 0.5 to 2.0 fps. Each panel was set at a 25 degree orientation in the flume. In early studies (1978) with striped bass larvae, two types of mesh were tested at each mesh size: synthetic (square openings, woven polyester), and metallic (oblong slot openings, wire). Subsequent testing (1979) evaluated the efficiency of four square mesh sizes (all synthetic, 1.0, 4.0, 5.0, and 9.5mm) in diverting larval striped bass at four velocities (0.5, 1.0, 1.5, and 2.0 fps). In 1980, these meshes and velocities were evaluated further to determine the guidance capabilities of winter flounder, alewife, and yellow perch larvae.

7.1 Description of the Facility

Larval diversion studies were conducted with six fine-mesh screens mounted on interchangeable aluminum frames. The 8 ft long screens were located in a 4 ft wide flume at an angle of 25° to the direction of flow. These angled screens led to a 6 inch wide bypass channel. The test facility is shown in Figures 7.1-1 and 7.1-2.

A pump recirculated water from a sump through the flume. The flowrate was controlled by adjusting the speed at which the pump operated or by adjusting a valve. The flow through the flume was divided such that 87% passed through the angled screen while 13% passed down the bypass. This flow ratio was established to ensure equal velocity approaching the screen and bypass. The

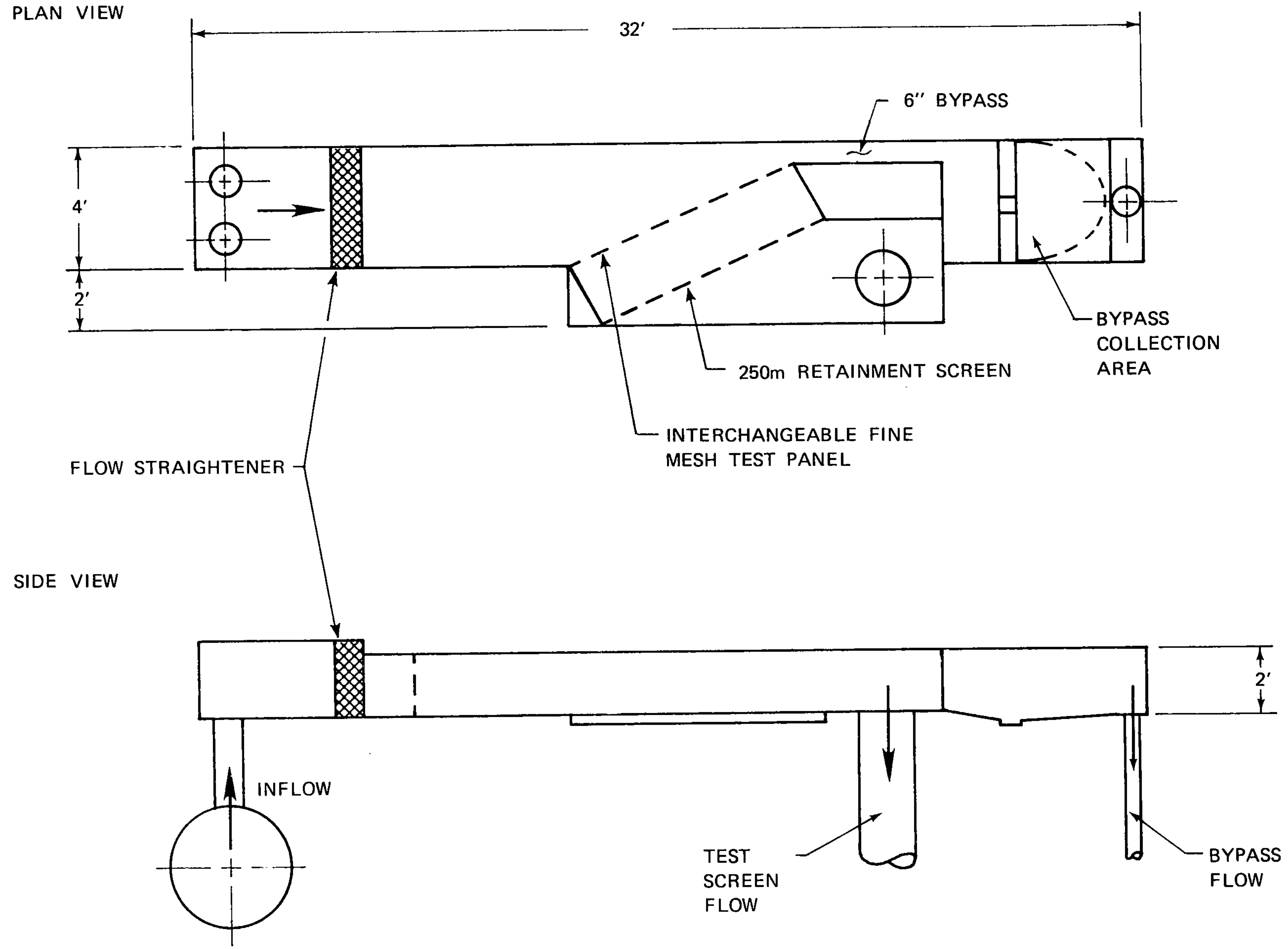


FIGURE 7.1-1 ANGLED, FINE-MESH SCREEN TEST FACILITY

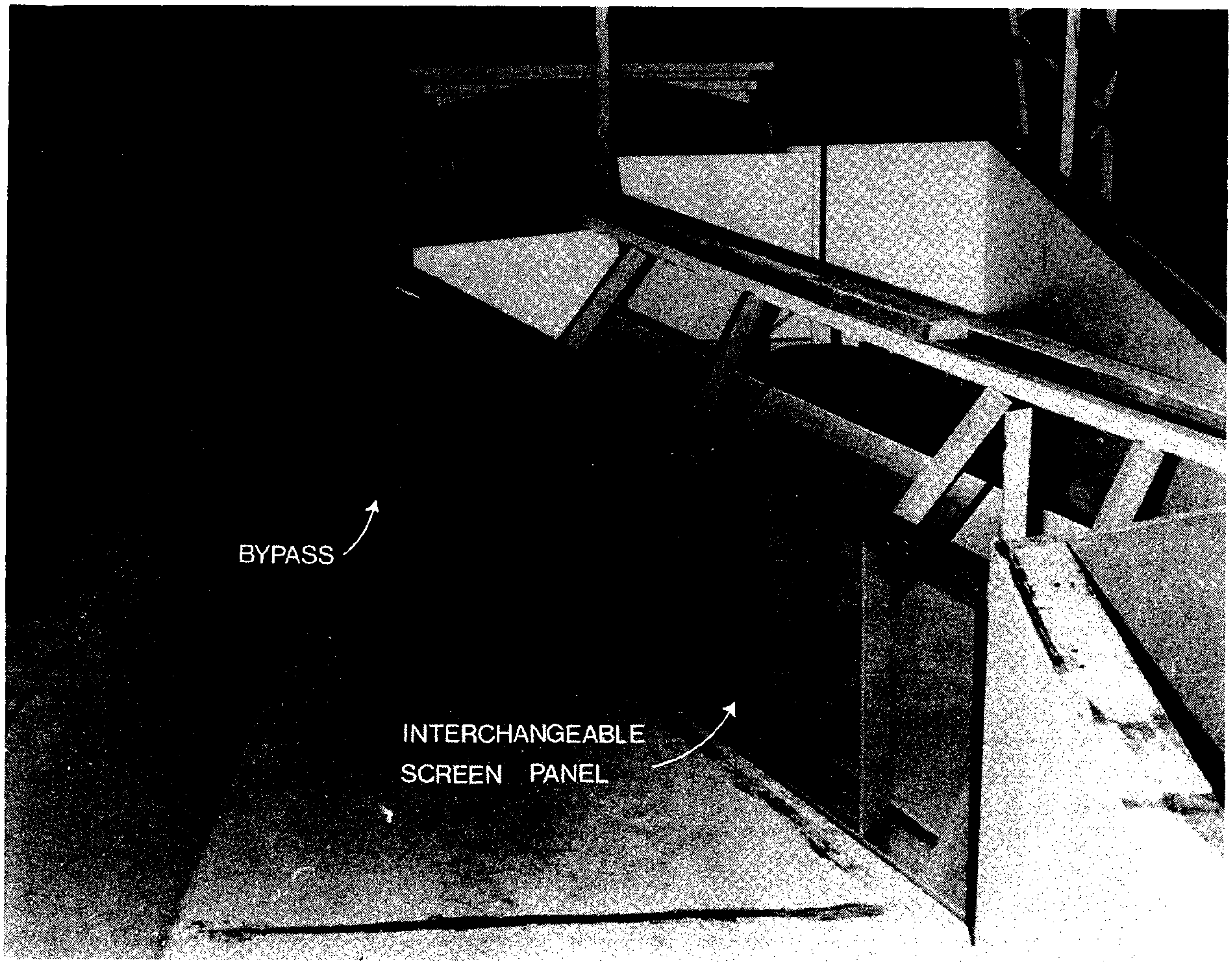
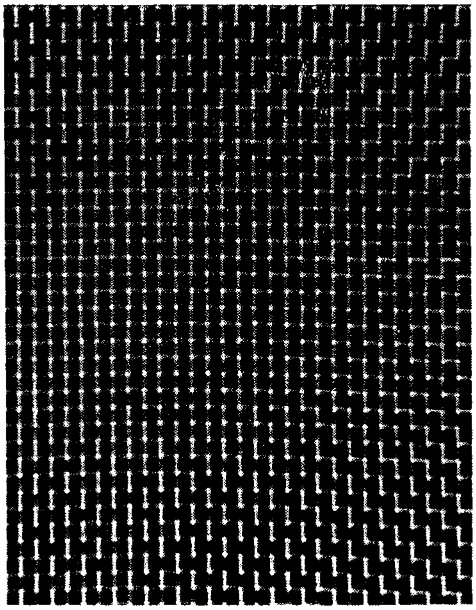
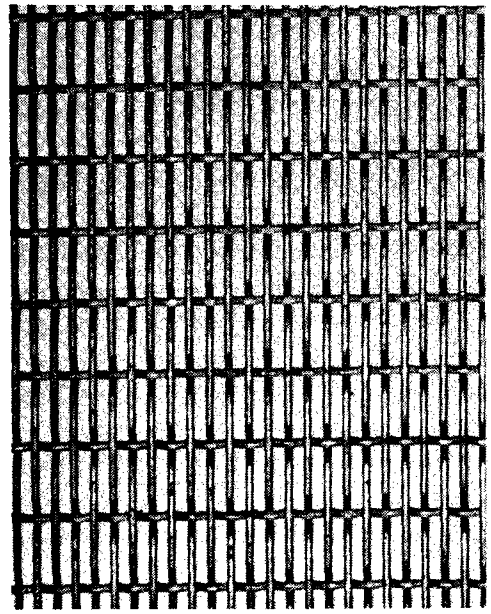


FIGURE 7.1-2 DIVERSION TEST FACILITY LOOKING DOWNSTREAM

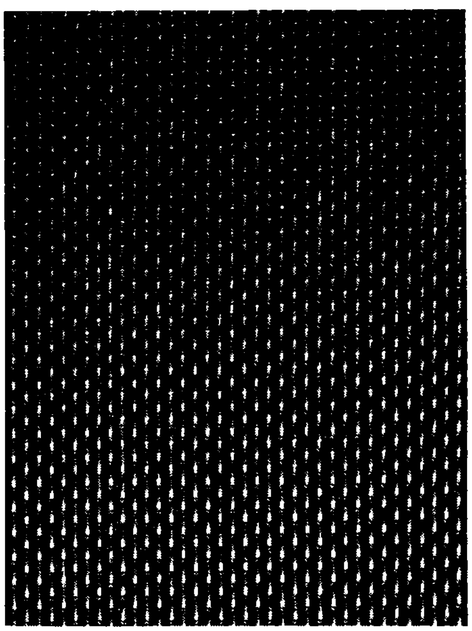


2.5mm

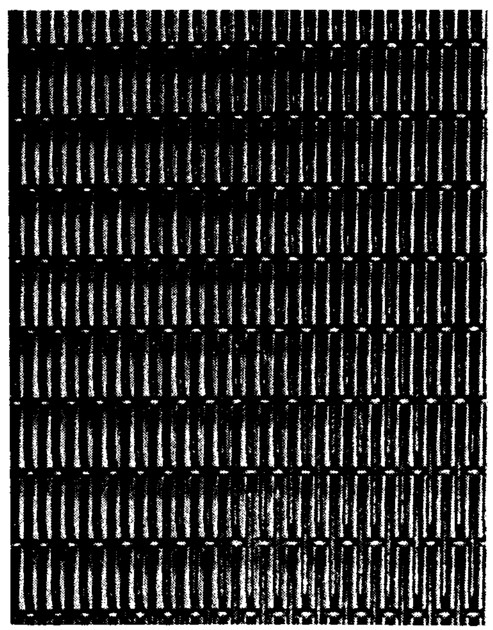


a) SYNTHETIC

b) METALLIC



1.5mm



c) SYNTHETIC

d) METALLIC

FIGURE 7.1-3 SCREEN TYPES USED IN LARVAL TESTING (ACTUAL MESH SIZE) 1978 STUDY flow through the angled screen was filtered through a 250 micron mesh containment screen and returned to the sump over a gate that controlled the flow depth. The bypass flow discharged from the 6 inch wide bypass channel into a 4 ft wide semi-circular collection area. The larger width in this area provided a decrease in velocity before the flow passed through a 250 micron containment screen. The lowered velocity minimized the impingement of bypassed organisms. A second gate behind this containment screen controlled the flowrate through the bypass.

Synthetic and metallic wire screens of 1.5 and 2.5mm mesh were used in the 1978 study with striped bass. The synthetic materials were woven in square mesh while the metallic material was woven in an oblong mesh and rolled to produce a panel with a flat surface ("smooth-tex"). The screen types used are shown in Figure 7.1-3. In the 1979 and 1980 studies, synthetic square mesh screens were used similar to those shown in Figures 7.1-3a and 7.1-3c. Four mesh sizes of 1.0, 4.0, 5.0, and 9.5mm were tested. Mesh size was defined as the horizontal clear opening between adjacent wires.

Prior to each test, the flow was established to yield the desired velocity. The velocity in the bypass was adjusted to equal the velocity in the channel approaching the angled screen based on a traverse of velocity measurements obtained in the approach channel and in the bypass at the start of each test.

7.2 Biological Testing Procedures

1978

Striped bass larvae were tested over a period of 6 weeks during which the larvae grew from approximately 6 to 19mm. For each test, the water depth in the flume was adjusted and the approach and bypass velocity was set at 0.5 or 1.0 fps. Fifty larvae were then introduced into the flume upstream of the test screen and were tested under the established conditions. Larvae which passed through the screen (entrained) were collected on a 0.25mm ed on a 250 micron mesh containment screen and enumerated. Bypassed larvae entered a low velocity collection area where they were contained by another 250 micron screen. From here, larvae were removed and placed in 1.0 liter beakers for 96 hour mortality studies. Testing was conducted under light and dark conditions.

All tests were conducted under lighted conditions during the early stages of the study. As the larvae grew, they became able to swim against the current and could, therefore, maintain their positions in the flume for long periods. To facilitate testing, it was necessary to conduct tests in the dark, since larvae moved downstream more rapidly under darkened conditions. Fifty-nine tests were conducted in the light and 42 tests were conducted in the dark.

1979

Procedures for striped bass testing were essentially the same in 1979 as in 1978. However, four velocities (0.5, 1.0, 1.5, and 2.0 fps) and four screen mesh sizes (1.0, 4.0, 5.0, and 9.5mm) were investigated in the larval diversion model.

Velocities entering the collection area ranged from 0.5 to 2.0 fps, depending on the testing regime for that day. Control larvae were placed in the collection area, removed and held for 96 hours to determine latent mortality. In addition, a second control consisting of 25 larvae was utilized to separate out mortality arising from handling or temperature differences. Larvae for this control were removed from the stock tanks and placed directly into holding beakers for 96 hours.

At the start of each test, 50 larvae were introduced into the flume upstream of the angled screen. All tests were conducted under darkened conditions to facilitate testing since larvae moved more rapidly downstream under darkened conditions. Water temperature was recorded for each test, along with the start/stop time.

Larvae which had been entrained were collected on the containment screen. Larvae which had passed through the bypass were then removed to a holding beaker. A maximum of 25 live bypassed larvae were held for determination of latent mortality during the early stages of testing. As the larvae grew and diversion efficiencies increased, all live bypassed larvae were held for 96 hours. Bypassed larvae were subdivided into smaller lots (generally less than 15 per beaker) to avoid overcrowding.

Larvae which had been impinged on the angled screen, which were swimming in the flume, and which were entrained were removed from the flume at the end of each test but were not held for latent mortality since they were not diverted by the angled screens. As in the case of the impingement study, when a consistently large number of larvae were swimming in the flume at the end of a test at a given velocity, this velocity was removed from the testing matrix.

Mortality of bypassed larvae was recorded at 24, 48, 72, and 96 hours. At the end of the 96 hour holding period, the number of live larvae was recorded. Cannibalism among the larvae was observed but was not a major problem. However, as the larvae grew larger, they frequently jumped out of the holding beakers. Missing larvae were included in the overall test mortality figures in the interest of conservatism.

1980

In 1980, attempts were made to follow the same procedures in testing winter flounder, alewife, and yellow perch as had been employed with striped bass in 1978. However, as discussed in Section 7.3, these three species were difficult to test, particularly in their early life stages, due to their small size and transparent nature. Therefore, some changes in procedures were implemented in an attempt to gather as much data as possible. Since procedures varied by species, they are discussed further in the results section (7.3) for each species.

7.3 Analytical Results

1978 Study - Striped Bass

One hundred and one tests were performed with striped bass larvae during the 1978 larval diversion study. During early stages of the study, most tests were conducted under lighted conditions such that their behavioral responses could be studied. As the larvae grew, they became able to swim against the current and could, therefore, maintain their position in the flume for long periods. In order to facilitate testing, the remaining tests were conducted under darkened conditions. Forty-two tests were conducted in the dark with larvae ranging in length from 7.6mm to 19.1mm. In most power plants in New York, darkness better represents conditions which would exist in screenwells since they are typically enclosed, may be covered with a solid concrete deck, can withdraw water of high turbidity, may be deep, or may contain combinations of these light-limiting factors. Tests conducted in a relatively shallow flume with very clear water under high light conditions were not considered to be representative of natural conditions, but were conducted early in the study program for observational purposes. For these reasons, light tests were not subjected to statistical analysis. Thus, only the 42 dark tests were analyzed: 11 tests with a 1.5 synthetic screen; 10 tests with a 1.5 metallic screen; 10 tests with a 2.5 synthetic screen; and 11 tests with a 2.5 metallic screen.

The measure of success of the screens in diverting larvae without mortality was termed total efficiency (TE), which was a function of the diversion efficiency adjusted for 96-hour mortality. The entire data set are presented in Appendix E-1.

The test results were analyzed by analysis of covariance. The dependent variable used in the analysis was total efficiency. The results of the analysis summarized in Table 7.3-1 indicates that, as expected, mesh size and type significantly influenced total efficiency. On the average, the smaller mesh resulted in greater efficiency. In addition, the mean total efficiency of larvae tested with synthetic screens was higher than the mean total efficiency of larvae tested with the metallic screens. Within the range of independent variables examined, approach velocity and larval length also significantly influenced the total efficiency. The only significant interaction occurred with larval length and mesh size.

The least-squares function was evaluated to depict the relationship between total efficiency and length for all eight combinations of mesh size, mesh type, and velocity. The results for the 1.5mm and 2.5mm mesh are plotted in Figures 7.3-1 and 7.3-2. Based on the results of the analyses presented in Table 7.3-1 and these figures, the following conclusions can be drawn:

1. The total efficiency increased with increasing length. The two-way interaction between larval length and mesh size was significant. Therefore, the relationship between total efficiency and length was significantly different for the different mesh sizes tested. As the striped bass grew in length, the total efficiency of the larvae tested with a 2.5mm mesh increased at a faster rate than the total efficiency of larvae tested with a 1.5mm mesh.

2. For a given mesh size and larval length, the total efficiency of larvae tested with a synthetic screen was higher than the total efficiency of larvae tested with a metallic screen.

As shown on Figure 7.3-1, results of testing with the 1.5mm mesh were highly variable over the range of larval lengths tested. Therefore, the usefulness of the regression lines to predict TE is somewhat limited. However, the general trends given are believed to be fairly accurate, as supported by the 1979 data discussed below.

To further study the relationship between total efficiency and approach velocity, an additional analysis was conducted on larvae greater than or equal to 14.6mm in length, since these larvae were tested at both 0.5 and 1.0 fps. The results summarized in Table 7.3-2 indicate that for these larvae, larval length influenced the total efficiency more than the approach velocity. The difference in total efficiency for the two approach velocities tested was not significant at the 5 percent level.

To further analyze the relationship between total efficiency and the independent variables, the entire 42 dark tests (length range = 7.6 to 19.1mm) were analyzed by ANCOVA models partitioned by approach velocity (0.5 and 1.0 fps). The results of these analyses are presented in Tables 7.3-3 and 7.3-4.

The total efficiency of larvae at an approach velocity of 0.5 fps was significantly influenced by mesh size and larval length. The interaction between larval length and mesh size was marginally significant. However, mesh size did not significantly influence the total efficiency of larvae tested at an approach velocity of 1.0 fps. Within the range of independent variables examined, mesh type and larval length were the only significant variables at 1.0 fps.

The summary statistics from these analyses are presented in Table 7.3-5.

Striped bass controls were studied to determine the mortality attributable to holding and handling. On the average, 21.8 percent of the larvae died from handling and holding, with a 95 percent confidence interval of 9.4 to 34.2 percent. The mortality rates of the larvae tested under darkened conditions were slightly lower than the control mortality. The mean mortality for all tests was 19.7 percent with a 95 percent confidence interval of 9.0 to 30.4 percent. Therefore, the diversion process did not appear to cause additional mortality above handling and holding.

<u>1979 Study - Striped Bass</u>

Results of 203 larval diversion tests were analyzed: 29 with a 1.0mm screen; 38 with a 4.0mm screen; 70 with a 5.0mm screen; and 66 with a 9.5mm screen. The testing program was conducted in a sequential manner beginning with the smallest mesh and lowest velocity. Once diversion was observed, the next largest mesh and velocity were added to the testing regime. During the testing period, the fish grew from 9.9 to 41.1mm. All tests were conducted in the dark.

An analysis of covariance was conducted on the test results using a model similar to the 1978 ANCOVA's to determine the relationship between total efficiency (the dependent variable) and the independent variables: screen size (1.0, 4.0, 5.0, and 9.5mm); approach velocity (0.5, 1.0, 1.5, and 2.0); larval length; and temperature difference (between holding tank and test flume). Different ranges of larval length were tested at each mesh size, therefore, the data were partitioned into two analyses by mesh size: (1) tests conducted with the 1.0 and 4.0mm screens; and (2) tests conducted with the 5.0 and 9.5mm screens.

Tests conducted at 0.5 fps were not included in the second analysis (5.0 and 9.5mm screens), since the number of observations in the experimental cells was low. Fewer tests were run at a velocity of 0.5 fps because as the larvae grew in length, they were able to swim upstream against the lower velocity and, even in the darkened flume, tended to maintain their position upstream of the screens for extended periods. Five tests were conducted at 0.5 fps with the 5.0mm mesh and 7 tests were conducted with the 9.5mm mesh.

The results of the ANCOVA are summarized in Tables 7.3-6a and 7.3-7a. Within the range of independent variables examined, mesh size, temperature difference (1.0 and 4.0mm mesh only), larval length, and approach velocity significantly influenced total efficiency. The independent variables with $\alpha >$ 0.05 were eliminated from each model and second analyses were run. Results of the reduced models are presented in Tables 7.3-6b and 7.3-7b.

Based on the results of the analyses, the following conclusions can be drawn:

1. The total efficiency increased with increasing larval length. Since the interaction between larval length and velocity was not significant, the relationship between total efficiency and length was similar for all velocities tested.

2. The two-way interaction between mesh size and velocity was significant for larvae tested with a 1.0 and 4.0mm screen. The mean total efficiencies predicted for larvae tested with a 1.0mm screen at 0.5 and 1.0 fps were not significantly different but decreased significantly as the approach velocity increased from 1.0 to 1.5 fps and from 1.5 to 2.0 fps. The mean total efficiencies for larvae tested with a 4.0mm screen did not significantly change as the velocity increased.

3. The two-way interaction between mesh size and velocity was not significant for larvae tested with a 5.0 and 9.5mm screen. Efficiency was significantly higher at 1.0 fps than 1.5 fps, but did not significantly change from 1.5 fps to 2.0 fps. Although 0.5 fps was not included in the ANCOVA and data at this velocity were limited, it appears that 0.5 fps efficiencies were higher than the other velocities (Figure 7.3-5).

4. The total efficiencies significantly decreased for larvae tested with 1.0 and 4.0mm screens as the temperature difference between the stock tank and the test flume increased.

Each least squares function was evaluated at the appropriate mesh size. The calculations were made over all approach velocity conditions and at the mean temperature. The results plotted in Figure 7.3-3 depict the relationship between total efficiency and larval length. Table 7.3-8 summarizes the larval length at which a total efficiency of 25, 50, and 100 percent is expected to occur. Figures 7.3-4 and 7.3-5 depict the relationship between total efficiency and larval length at the appropriate velocities for each mesh size since approach velocity accounted for a large percent of the total variability.

The percent mortality of controls was studied by ANCOVA to determine the mortality attributable to holding and holding and handling. Handling did not apparently stress the larvae since the percent mortality did not significantly differ between the "held" controls and the "handled and held" controls ($p < 0.94$). The handled controls were introduced into the collection area of the flume model and subjected to conditions in this area at different test velocities. The analysis indicated that percent mortality was not influenced by velocity ($p < 0.6$). The mean control mortality was 8.4 percent with a 95 percent confidence interval of 4.0 to 12.8 percent.

A comparison between test and control mortalities indicated that the mortality of tested larvae was only slightly higher than control mortality (mean of 9.7 percent versus 8.4 percent, respectively). Since mortality rates of the test and control larvae were similar, it appears that the angled screen device does not contribute appreciably to mortality of the larvae. Thus, since total efficiency of the device takes into consideration mortality, total efficiency may be considered essentially the same as diversion efficiency. To further illustrate this point, the larval length at which 25, 50, and 100 percent diversion efficiency would be expected to occur was calculated (Table 7.3-9). A comparison of Tables 7.3-8 (predicted total efficiency versus larval length) and 7.3-9 (predicted diversion efficiency versus larval length) reveals that there is no appreciable difference between these two parameters.

TABLE 7.3-1

Results of ANCOVA
1978 Striped Bass Total Efficiency
Darkened Conditions

a. Full Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Mesh type	1	2,328.13	2,328.13	7.58	0.0095*
Mesh size	1	2,489.82	2,489.82	8.10	0.0075*
Velocity	1	6,141.27	6,141.27	19.99	0.0001*
Length	1	6,097.24	6,097.24	19.84	0.0001*
Length x velocity	1	542.02	542.02	1.76	0.1932
Length x mesh size	1	1,449.64	1,449.64	4.72	0.0371*
Length x mesh type	1	0.64	0.64	0.00	0.9637
Mesh type x mesh size	1	50.79	50.79	0.17	0.6870
Error	33	10,139.10	307.25	7.77	
Total	41	29,238.63			

b. Reduced Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Mesh type	1	2,328.13	2,328.13	7.89	0.008*
Mesh size	1	2,489.82	2,489.82	8.44	0.0063*
Velocity	1	6,141.27	6,141.27	20.81	0.0001*
Length	1	6,097.24	6,097.24	20.66	0.0001*
Length x mesh size	1	1,556.31	1,556.31	5.27	0.0276*
Error	36	10,625.87	295.16	12.61	
Total	41	29,238.63			

*Significant since $\alpha \leq 0.05$

Mesh Size	Predicted Mean Total Efficiency and 95% Confidence Intervals
1.5mm	$56.6 \leq 64.5 \leq 72.3$
2.5mm	$43.5 \leq 51.3 \leq 59.1$

Mesh Type	
Synthetic	$56.7 \leq 64.5 \leq 72.3$
Metallic	$43.4 \leq 51.3 \leq 59.2$

TABLE 7.3-2

Results of ANCOVA
1978 Striped Bass Total Efficiency - Darkened Conditions
Larvae Greater Than or Equal to 14.6mm in Length

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Velocity	1	1,019.18	1,019.18	3.61	0.0694
Length	1	4,154.37	4,154.37	14.73	0.0008*
Length x velocity	1	67.49	67.49	0.24	0.6292
Error	24	6,769.03	282.04	6.19	
Total	27	12,010.06			

*Significant since $\alpha \leq 0.05$

Velocity	Mean Total Efficiency and 95% Confidence Intervals
0.5 fps	$47.5 \leq 62.2 \leq 76.9$
1.0 fps	$60.4 \leq 68.4 \leq 76.0$

TABLE 7.3-3

Results of ANCOVA
1978 Striped Bass Total Efficiency
Darkened Conditions - 0.5 fps

a. Full Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Mesh type	1	894.73	894.73	2.45	0.1402
Mesh size	1	4,448.61	4,448.61	12.16	0.0036*
Length	1	3,820.22	3,820.22	10.44	0.0060*
Length x mesh type	1	34.07	34.07	0.09	0.7647
Length x mesh size	1	1,176.91	1,176.91	3.22	0.0945**
Mesh type x mesh size	1	47.75	47.75	0.13	0.7233
Length x mesh type x mesh size	1	450.38	450.38	1.23	0.2859
Error	14	5,121.55	365.83		
Total	21	11,544.81			

b. Reduced Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Mesh size	1	4,780.48	4,780.48	14.48	0.0013*
Length	1	3,737.36	3,737.36	11.32	0.0035*
Length x mesh size	1	1,533.74	1,533.74	4.65	0.0449*
Error	18	5,942.63	330.15		
Total	21	15,994.21			

*Significant since $\alpha \leq 0.05$

**Marginally significant since $\alpha \leq 0.01$

TABLE 7.3-4

Results of ANCOVA
1978 Striped Bass Total Efficiency
Darkened Conditions - 1.0 fps

a. Full Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Mesh type	1	1,486.09	1,486.09	5.69	0.0344*
Mesh size	1	9.25	9.25	0.04	0.8539
Length	1	1,755.68	1,755.68	6.72	0.0235*
Length x mesh type	1	552.05	552.05	2.11	0.1716
Length x mesh size	1	18.30	18.30	0.07	0.7957
Mesh type x mesh size	1	9.10	9.10	0.03	0.8551
Length x mesh type x mesh size	1	139.68	139.68	0.54	0.4785
Error	12	3,133.01	261.08		
Total	19	7,103.15			

b. Reduced Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Mesh type	1	1,486.09	1,486.09	6.35	0.0220*
Length	1	1,640.64	1,640.64	7.01	0.0169*
Error	17	3,976.42	233.91	6.68	
Total	19	7,103.15			

*Significant since $\alpha \leq 0.05$

TABLE 7.3-5

1978 Striped Bass Total Efficiency - Darkened Conditions
Summary Statistics - Partitioned by Approach Velocity

	0.5 fps	1.0 fps
n	22	20
Total Efficiency	45.9%	70.1%
Standard Deviation	18.5%	15.5%
Mesh Size ± Standard Deviation		
1.5mm	57.5 ± 6.0	74.1 ± 5.0
2.5mm	33.4 ± 6.2	65.0 ± 5.6
Mesh Type ± Standard Deviation		
Synthetic	51.0 ± 5.6	77.8 ± 5.0
Metallic	39.8 ± 6.6	61.3 ± 5.4

TABLE 7.3-6

Results of ANCOVA (1.0 and 4.0mm mesh)
1979 Striped Bass Total Efficiency

a. Full Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Velocity (V)	3	6,901.16	2,300.39	11.64	0.0000*
Mesh Size (M)	1	16,253.48	16,253.48	82.27	0.0000*
V x M	3	1,627.28	542.43	2.75	0.0520
L x V	3	246.52	82.17	0.416	0.7423
L x M	1	82.21	82.21	0.416	0.5217
Temperature Difference	1	1,570.05	1,570.05	7.947	0.0068*
Length (L)	1	8,302.03	8,302.02	42.022	0.0000*
Residual	53	10,470.89	197.56		
Total	66	60,277.53			

b. Reduced Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Velocity (V)	3	8,632.24	2,877.41	15.259	0.0000*
Mesh Size (M)	1	22,037.69	22,037.68	116.865	0.0000*
V x M	3	4,930.75	1,643.58	8.716	0.0000*
Temperature Difference	1	1,840.05	1,840.05	9.758	0.0020*
Length (L)	1	13,891.14	13,891.14	73.664	0.0000*
Residual	57	10,748.71	188.57		
Total	66	60,277.53			

*Significant since $\alpha \leq 0.05$

MODEL

$$Y_{ijk} = 64.8 + V_i + M_j \ (VM)_{ij} - 5.13 \ (TD_{ijk} + 0.1) + 6.32 \ (L_{ijk} - 15.2) + e_{ijk}$$

where

Y_{ijk} = predicted total efficiency of the ijkth test
V_i = effect of ith velocity
M_j = effect of jth mesh size
TD_{ijk} = temperature difference of ijkth test
L_{ijk} = larval length of ijkth test
e_{ijk} = residual variance

TABLE 7.3-7

Results of ANCOVA (5.0 and 9.5mm Mesh; 1.0 to 2.0 fps)
1979 Striped Bass Total Efficiency

a. Full Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Velocity (V)	2	2,662.43	1,331.22	5.65	0.0046*
Mesh Size (M)	1	31,609.92	31,609.92	134.169	0.0000*
V x M	2	881.99	440.99	1.872	0.1556
L x V	2	569.15	284.58	1.208	0.3026
L x M	1	38.70	38.70	0.164	0.6861
Temperature Difference	1	269.27	269.27	1.143	0.2873
Length (L)	1	42,512.29	42,512.29	180.445	0.0000*
Residual	113	26,622.46	235.60		
Total	123	101,173.06			

b. Reduced Model

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Velocity (V)	2	1,598.34	799.17	3.293	0.0406*
Mesh Size (M)	1	34,578.87	34,578.87	142.46	0.0000*
Temperature Difference	1	501.11	501.11	2.065	0.1534
Length (L)	1	47,738.13	47,738.13	196.679	0.0000*
Residual	118	28,641.09	242.72		
Total	123	101,173.06			

*Significant since $\alpha \leq 0.05$

MODEL

$$Y_{ijk} = 53.3 + V_i + M_j - 2.87\ (TD_{ijk} - 1.2) + 4.11\ (L_{ijk} - 25.19) + e_{ijk}$$

where

Y_{ijk} = predicted total efficiency of the ijkth test
V_i = effect of ith velocity
M_j = effect of jth mesh
TD_{ijk} = temperature difference of ijkth test
L_{ijk} = larval length of ijkth test
e_{ijk} = residual variance

TABLE 7.3-8

Results of ANCOVA
Striped Bass Larval Length at
Predicted Total Efficiencies

Mesh Size (mm)	Range of Larval Lengths (mm) Tested	Predicted Total Efficiency**		
		25%	50%	100%
1.0	9.88 - 18.02	--	8.2mm	16.1mm
4.0	10.35 - 24.65	13.6mm	17.6mm	25.5mm
5.0	16.31 - 31.73*	--	20.0mm	32.1mm
9.5	18.02 - 41.09	22.8mm	28.8mm	41.0mm

*One test was conducted when larvae was 13.77mm.

**Calculation of Total Efficiency includes mortality of bypassed larvae.

TABLE 7.3-9

Results of ANCOVA
Striped Bass Larval Length at
Predicted Diversion Efficiencies

Mesh Size (mm)	Predicted Diversion Efficiency*		
	25%	50%	100%
1.0	--	6.6mm	13.0mm
4.0	14.4mm	17.7mm	24.1mm
5.0	--	19.2mm	29.7mm
9.5	22.4mm	27.6mm	38.1mm

*Diversion Efficiency - Calculation does not consider mortality of bypassed larvae.

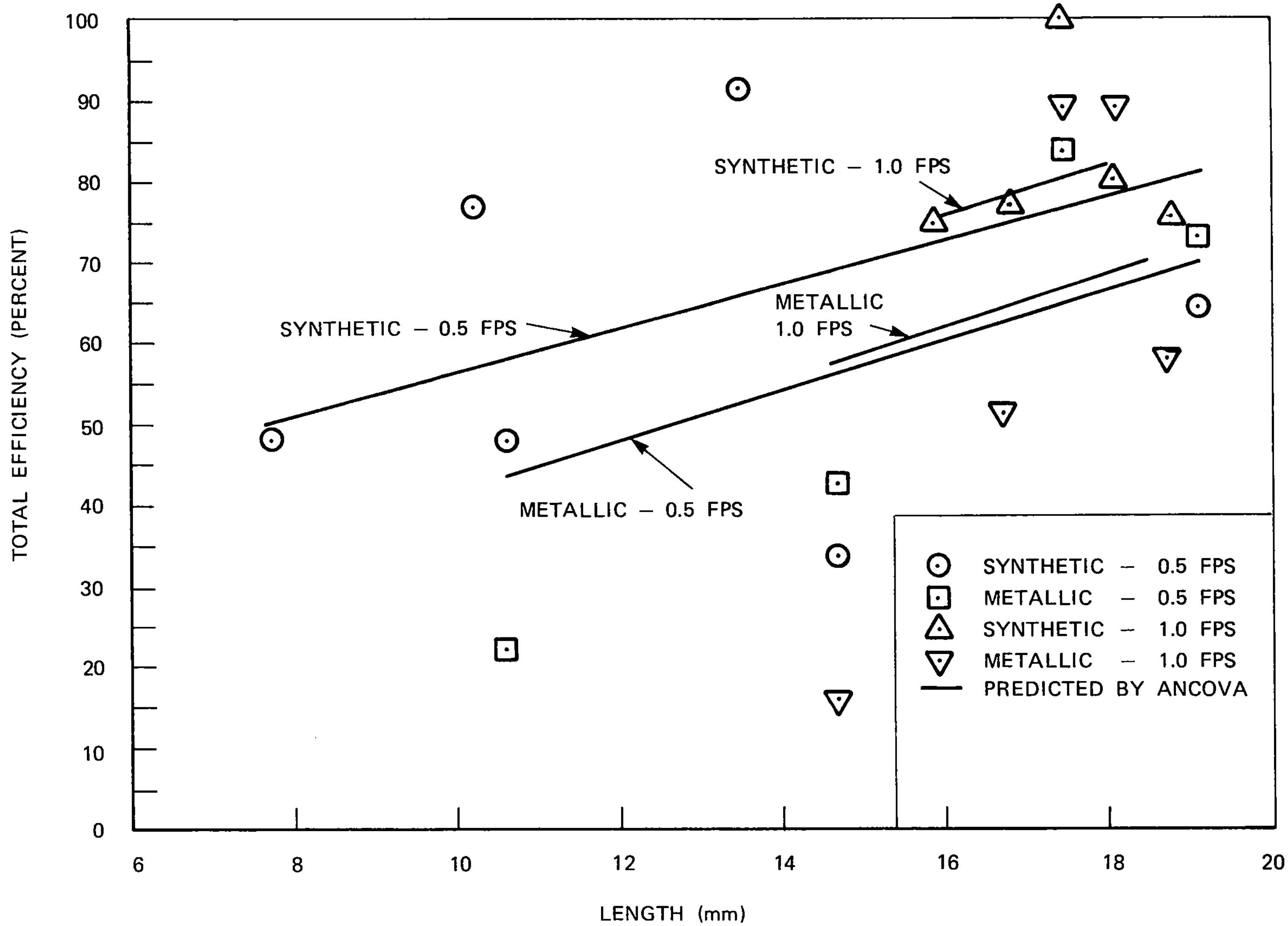


FIGURE 7.3-1 TOTAL EFFICIENCY VERSUS LENGTH FOR 1.5mm MESH 1978 STRIPED BASS DIVERSION STUDY

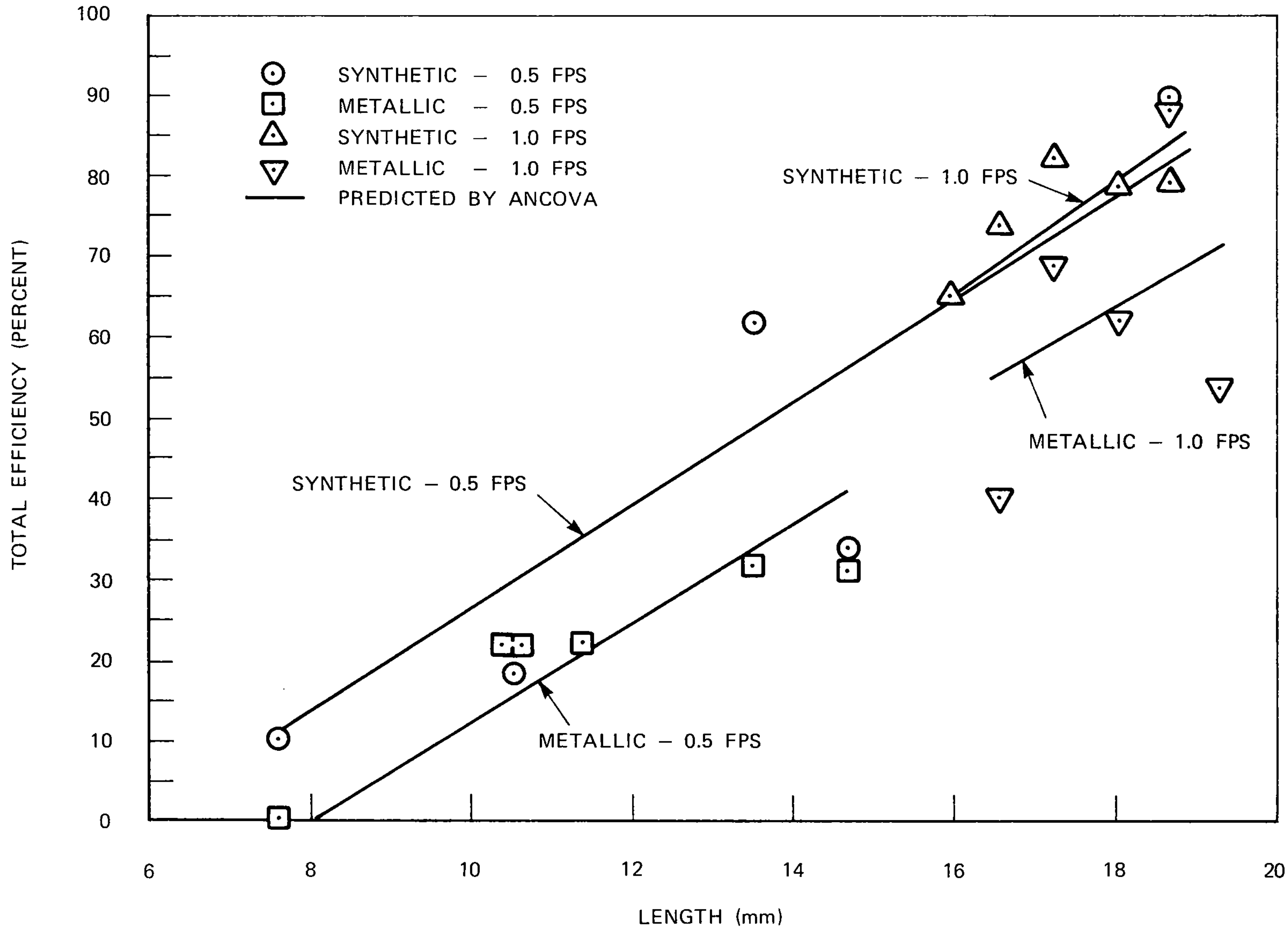


FIGURE 7.3-2 TOTAL EFFICIENCY VERSUS LENGTH FOR 2.5mm MESH 1978 STRIPED BASS DIVERSION STUDY

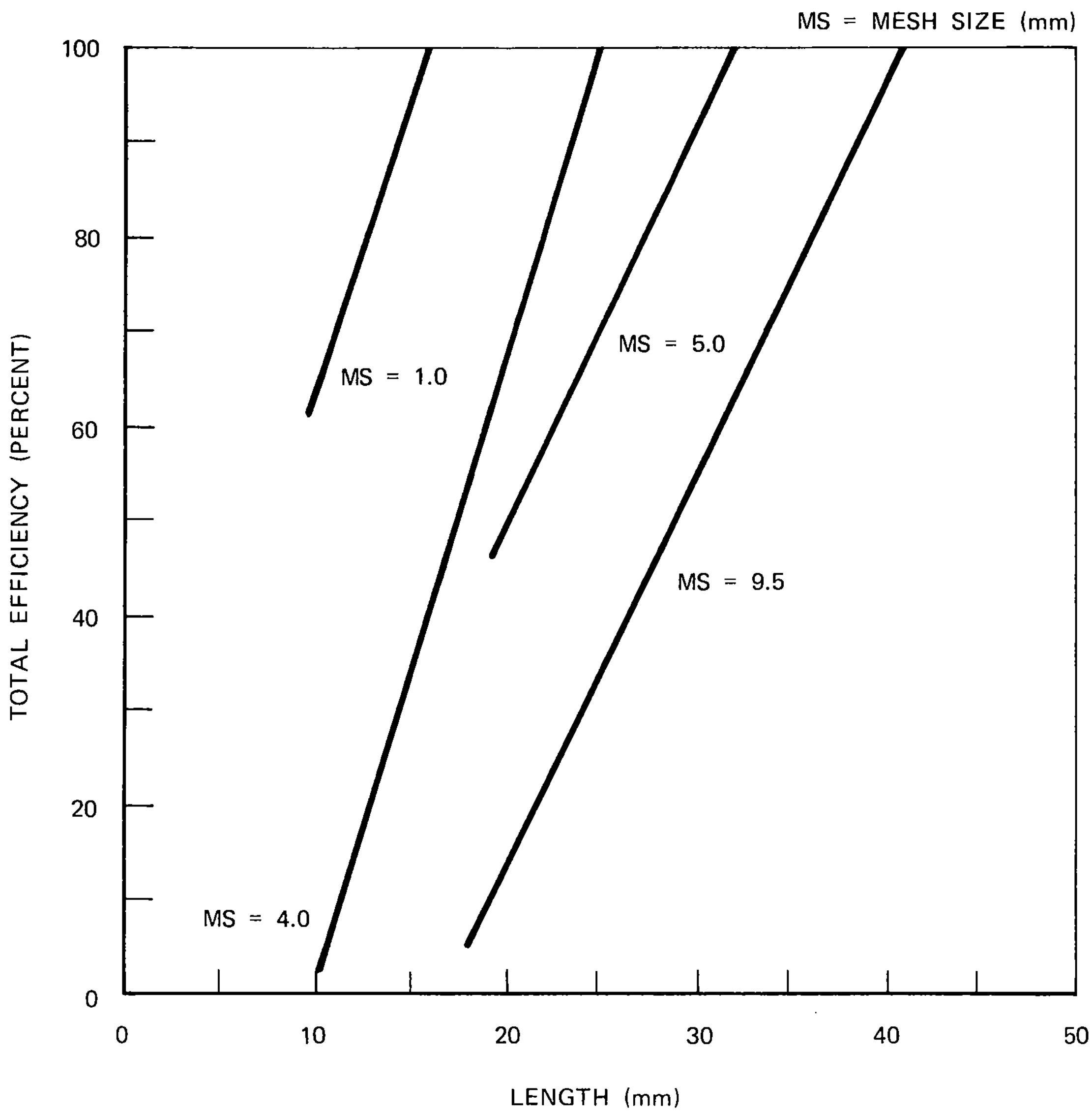


FIGURE 7.3-3 TOTAL EFFICIENCY VERSUS LENGTH AVERAGED OVER ALL VELOCITIES, 1979 STRIPED BASS DIVERSION STUDY

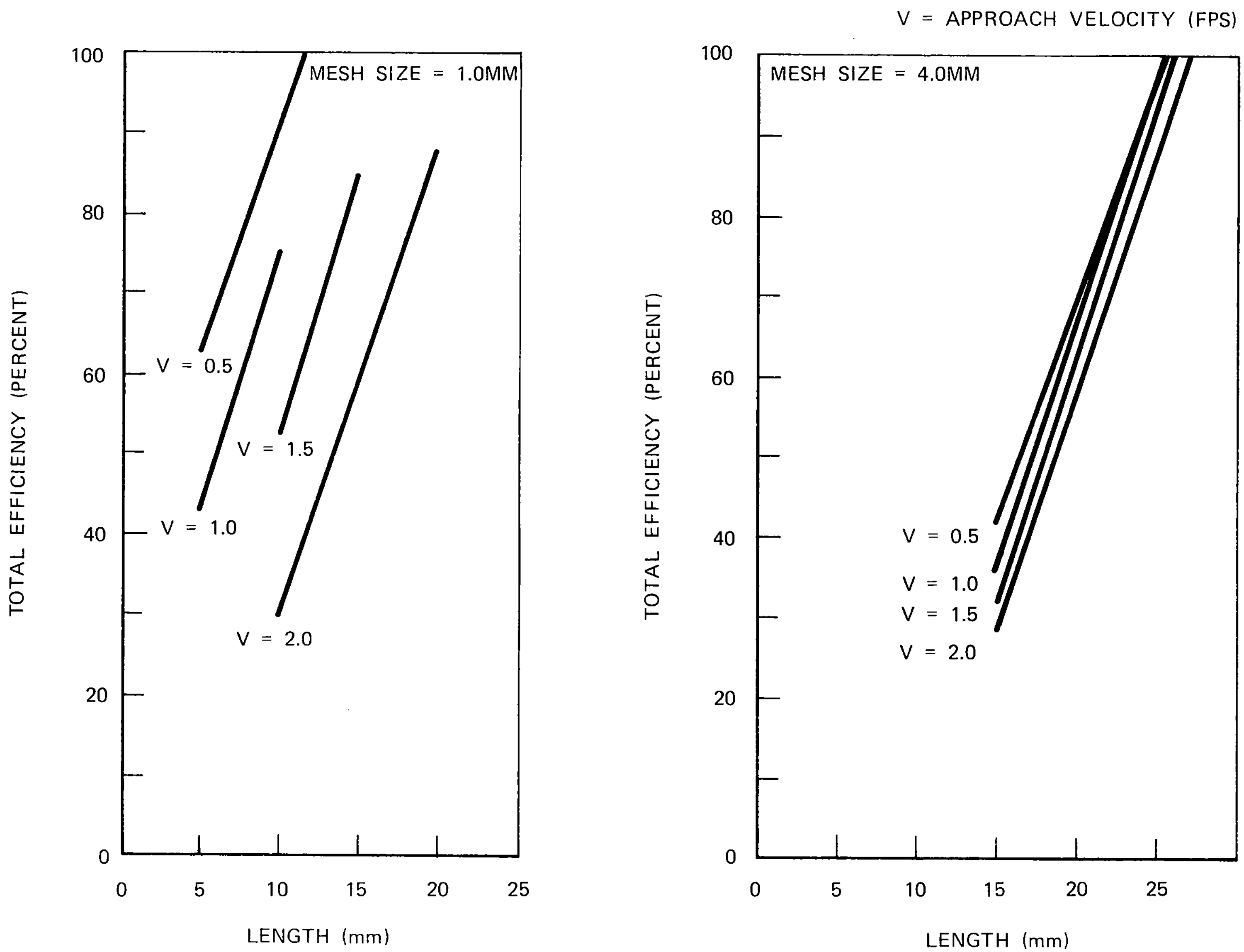


FIGURE 7.3-4 TOTAL EFFICIENCY VERSUS LENGTH — DARKENED CONDITIONS 1979 STRIPED BASS DIVERSION STUDY

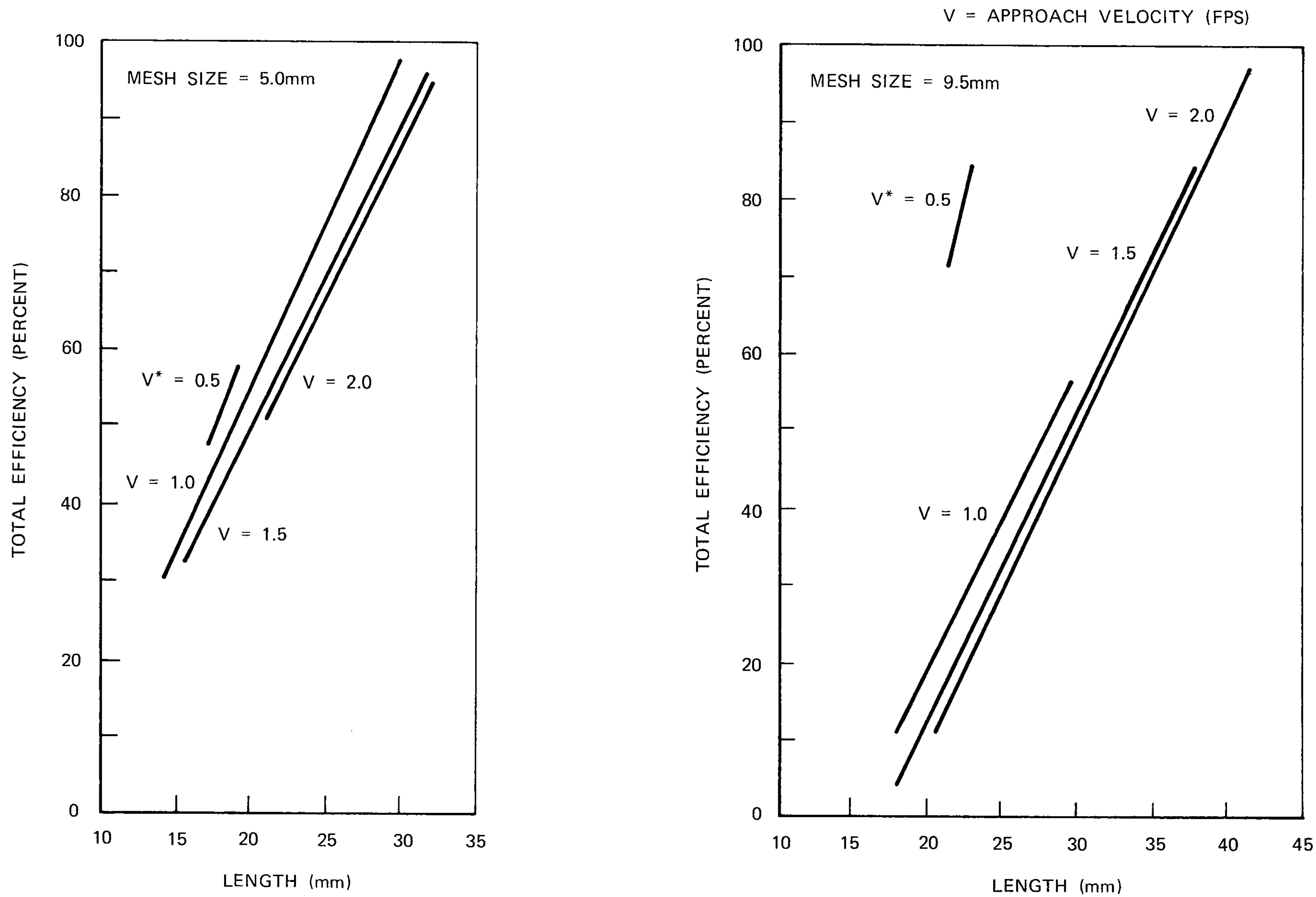


FIGURE 7.3-5 TOTAL EFFICIENCY VERSUS LENGTH, DARKENED CONDITIONS 1979 STRIPED BASS DIVERSION STUDY

*SIMPLE LINEAR REGRESSION ANALYSIS WAS CONDUCTED FOR TESTS AT THIS VELOCITY.

1980 Studies - Winter Flounder, Alewife, Yellow Perch

In 1980, diversion studies were conducted with winter flounder, alewife, and yellow perch. Because of an inability to maintain sufficient numbers of individuals of each species into the larger postlarval length ranges, and since diversion was generally poor among those larvae that were tested, the testing effort in 1980 was greatly reduced from that with striped bass in 1978 and 1979. The results of testing with each species are presented individually below.

Winter Flounder

Attempts were made to investigate the ability of winter flounder prolarvae ranging from 3.6 to 4.1mm in length and 4.4 to 6.1mm postlarvae to guide along fine-mesh angled screens. However, due to the small size and the transparent nature of the larvae, recovery of organisms introduced into the flume was a significant problem (i.e., they could not be found either on the containment screen or in the bypass collection area).

Preliminary tests at the 0.5 fps velocity indicated that both prolarvae and postlarvae were not successfully diverted by 1.0mm fine-mesh screens. Those larvae which were recovered at the end of each test (generally less than 20 percent of the number tested) were consistently found to have been entrained. During the tests conducted, no larvae were found in the bypass collection area (Table 7.3-10).

On the assumption that larvae might have been diverted by the 1.0mm screen but simply were not being found in the collection area, a plankton net (355 micron mesh) was rigged at the end of the bypass. No pro- or postlarvae were collected by the net; thus, it appears that 3.6 to 6.1mm winter flounder larvae were not successfully diverted by the fine-mesh angled screen.

TABLE 7.3-10

Test Results - Winter Flounder
Diversion Study

Test No.	Tank Temp. (°C)	Flume Temp. (°C)	Temp. Diff. (Δt)	Mean Larval Length (mm)	Velocity (fps)	Mesh Size (mm)	No. Tested	No. Diverted	No. Entrained	No. Not Found	Diversion Efficiency (%)
1	7.0	7.2	-0.2	4.0	0.5	1.0	50	0	1	49	0.0
2	8.0	8.0	0.0	4.0	0.5	1.0	50	0	15	35	0.0
3	6.0	6.4	-0.4	4.4	0.5	1.0	50	0	25	25	0.0
4	13.0	11.5	2.5	6.1	0.5	1.0	25	0	18	7	0.0

Alewife

Prolarvae

One test was conducted in mid-May with alewife prolarvae ranging in length from 5.3 to 5.8mm (mean of 5.5mm). The prolarvae exhibited no ability to guide along the 1.0mm angled screen at the 0.5 fps velocity. Of the 25 prolarvae tested, none were bypassed. Twenty-one larvae were entrained and 4 were not found.

Postlarvae

As in the case of the prolarvae, early postlarvae (mean length of 9.5mm) exhibited no ability to guide, but were immediately entrained through the 1.0mm mesh.

Five tests were conducted with older postlarvae: two tests with postlarvae ranging from 10.2 to 13.1mm (mean of 11.2mm) and three tests with postlarvae 13.4 to 17.0mm (mean of 14.7mm); (Table 7.3-11). Diversion efficiencies were 76.9 and 84.0 percent in two tests with smaller postlarvae, and 60.0, 84.6, and 84.0 percent in three tests with larger postlarvae (14.7mm). However, latent mortality of the bypassed postlarvae was high for both groups, with mean values of 97.5 and 80.5 percent, respectively. The majority of postlarvae tested were observed to be impinged for varying periods of time on the screens prior to being bypassed.

The high latent (96 hour) mortalities most likely reflect additional stress of impingement, particularly among the 11.2mm larvae. Mortalities of control postlarvae were 15 and 62.5 percent for the smaller and larger postlarvae, respectively.

The total efficiency of the angled screen device (which takes test mortality into consideration) was calculated for both test groups. Total efficiency for the 11.2mm larvae was 0 and 3.8 percent in the two tests conducted. The larger postlarvae (14.7mm) had total efficiencies of 0, 16.0, and 26.9 percent. Thus, under the conditions tested, the ability of the angled screen device to divert alewife postlarvae with low resultant mortality appeared to be poor for the size of the fish tested. A shortage of alewife postlarvae precluded further evaluation of the ability of this species to guide along the angled screen.

TABLE 7.3-11

Test Results
Alewife Diversion Study

Test No.	Tank Temp. (°C)	Flume Temp. (°C)	Mean Length (mm)	Velocity (fps)	Mesh Size (mm)	No. Tested	No. Diverted	No. Entrained	No. Impinged	No. Not Found	Diversion Efficiency (%)	% Mortality (96 Hr)	Total Efficiency (%)
Pro-larvae (5.54mm)	13.9	14.2	5.54	0.5	1.0	25	0	21	0	4	0	---	---
1	16.2	18.0	9.5	0.5	1.0	25	0	17	1	7	0	---	---
4	15.0	17.0	12.5	0.5	1.0	25	0	3	21	1	0	---	---
2	18.0	16.8	11.2	0.5	1.0	25	21	0	2	2	84.0	100.0	0
3	18.0	16.8	11.2	0.5	1.0	26	20	3	3	0	76.9	95.0	3.8
Con.	18.0	16.8	11.2	0.5		20	--	--	--	--	---	15.0	
5	18.0	17.0	14.7	0.5	1.0	26	22	0	4	0	84.6	68.2	26.9
6	18.0	17.0	14.7	0.5	1.0	25	21	0	4	0	84.0	100.0	0
7	18.0	17.0	14.7	0.5	1.0	25	15	0	9	1	60.0	73.3	16.0
Con.	18.0	17.0	14.7	0.5		24	--	--	--	--	---	62.5	

Yellow Perch

Prolarvae

As in the case of the winter flounder, the small size and transparent nature of the yellow perch prolarvae made their recovery from the flume a significant problem. Prolarvae introduced upstream of the angled screen were not successfully recovered (i.e., could not be found either in the containment screens or in the bypass collection area). Thus, no diversion tests with yellow perch prolarvae were successfully completed.

Postlarvae

Preliminary tests at the 0.5 fps velocity with postlarvae ranging in length from 6.0 to 10.6mm yielded essentially no diversion (Table 7.3-12). Of the 125 early postlarvae tested, only 4 were diverted. Thus, early postlarvae appear to be unable to guide along the angled screen.

Two diversion tests were conducted with later postlarvae 11.7 to 16.7mm in length (mean length of 14.3mm). These slightly larger postlarvae demonstrated an ability to guide along the angled screen, with diversion efficiency of 16.0 and 72.0 percent in two tests. Most of the test organisms were impinged prior to being bypassed; however, latent mortality of the bypassed larvae was generally low (0 to 11.1 percent); (Table 7.3-12). A shortage of yellow perch postlarvae precluded the use of controls as well as any further evaluation of the ability of yellow perch larvae to guide along the angled screen.

7.4 Summary of Larval Diversion Studies

Angled fine-mesh screens appear to have the potential for diverting older larvae to bypasses provided the proper mesh size and velocity are incorporated into the system design. Among striped bass, diversion efficiencies as high as 50 percent were generally not achieved until the larvae reached a mean length of 10mm. Little diversion was observed with early larvae of winter flounder, alewife, and yellow perch; however, too few test organisms were available at greater lengths to establish the relationship between larval length and diversion efficiency.

TABLE 7.3-12

Test Results
Yellow Perch Diversion Study

Test No.	Tank Temp. (°C)	Flume Temp. (°C)	Mean Length (mm)	Velocity (fps)	Mesh Size (mm)	No. Tested	No. Diverted	No. Entrained	No. Impinged	No. Not Found	Diversion Efficiency (%)	% Mortality 96 Hr.
1	13.9	14.2	6.0	0.5	1.0	25	0	0	0	25	0	--
2	15.5	16.3	6.3	0.5	1.0	25	0	17	0	8	0	--
3	14.0	16.2	7.3	0.5	1.0	25	0	21	0	4	0	--
4	14.0	16.2	7.3	0.5	1.0	25	0	13	12	0	0	--
5	16.2	18.0	9.3	0.5	1.0	25	2	0	23	0	8	--
6	16.2	18.0	9.3	0.5	1.0	25	2	1	22	0	8	--
7	18.0	16.2	14.3	0.5	1.0	25	18	0	7	0	72.0	11.1
8	18.0	16.2	14.3	0.5	1.0	25	4	0	18	3	16.0	0

SECTION 8

PUMP STUDIES

SECTION 8
PUMP STUDIES

To determine the effects of passage through a jet pump on larval fish, studies were conducted from June 1979 to June 1980. Mortality associated with passage through the pump was evaluated in this program to determine the effectiveness of the pumping system in transporting larval fish with low mortality. In addition, in 1980, a Hidrostal pump (screw-impeller) was tested to determine the survival potential of alewife and yellow perch larvae after passage through this impeller-type pump.

8.1 Description of the Facility

Jet Pump

A peripheral jet pump was operated to evaluate its effectiveness in transporting larvae with low mortality. The suction tube of the pump was a 3 inch pipe. A high velocity jet is formed at a nozzle around the end of this suction tube inside the pump. A 3-1/2 inch pipe formed the mixing tube for the jet flow and suction flow. The pump is shown in Figure 8.1-1. Hydraulic characteristics of this pump have been previously reported (Smith, 1977).

Following the mixing tube, the discharge pipe was expanded in a conical diffuser to 10 inch diameter before entering a 12 inch deep collection area. Flow was introduced off center in the circular collection area to produce circulation and was discharged through a semi-circular, 250 micron mesh retention screen over a gate controlling the water level. The collection area is shown in Figure 8.1-2.

The intake flow was controlled by a valve in a 6 inch pipeline supplying a tank. A 3 inch suction pipe supplied flow to the jet pump from this tank. A 1-1/4 inch clear flexible hose connected the tank to a larvae introduction box. The suction line, tank, and introduction box is shown in Figure 8.1-3.

In the 1980 study, the introduction tank was replaced by a plexiglass section which connected the 6 inch supply pipe to the 3 inch suction pipe. A 0.75 inch tube entered the plexiglass section and ended at the center of the suction pipe. The test larvae were placed in a chamber which could be drained through this tube to introduce them into the jet pump.

The nozzle velocity was established at each test condition based on a measurement of nozzle flowrate and calculated nozzle area.

Hidrostal Pump

The use of a centrifugal pump has two main advantages over the jet pump. A centrifugal pump operates more efficiently and is capable of pumping across greater water level differences. The disadvantage is that the rotating impeller might damage the fish while they are being pumped.

A Hidrostal pump was chosen for study since its screw-type impeller has been designed to pump flows containing solid objects. The F4F pump included a shroud on the screw section of the impeller to minimize abrasion of the fish against the sides of the pump.

The F4F Hidrostal pump was installed in a line parallel to the jet pump. The 4 inch discharge was vertical and went through an expansion to 10 inch diameter pipe. A short channel on top of the expansion carried the discharge to the jet pump collection area.

Flow to the pump was measured by an orifice meter and controlled by a valve in the 6 inch suction line. A plexiglass section of pipe mounted to the pump intake incorporated a fish introduction system similar to the one used in the jet pump test. Fish were introduced through a 0.75 inch pipe at the center of the suction pipe 14 inches upstream of the pump.

The pump was driven by a five horsepower variable speed motor. A digital tachometer was used to determine the rotational speed of the impeller.

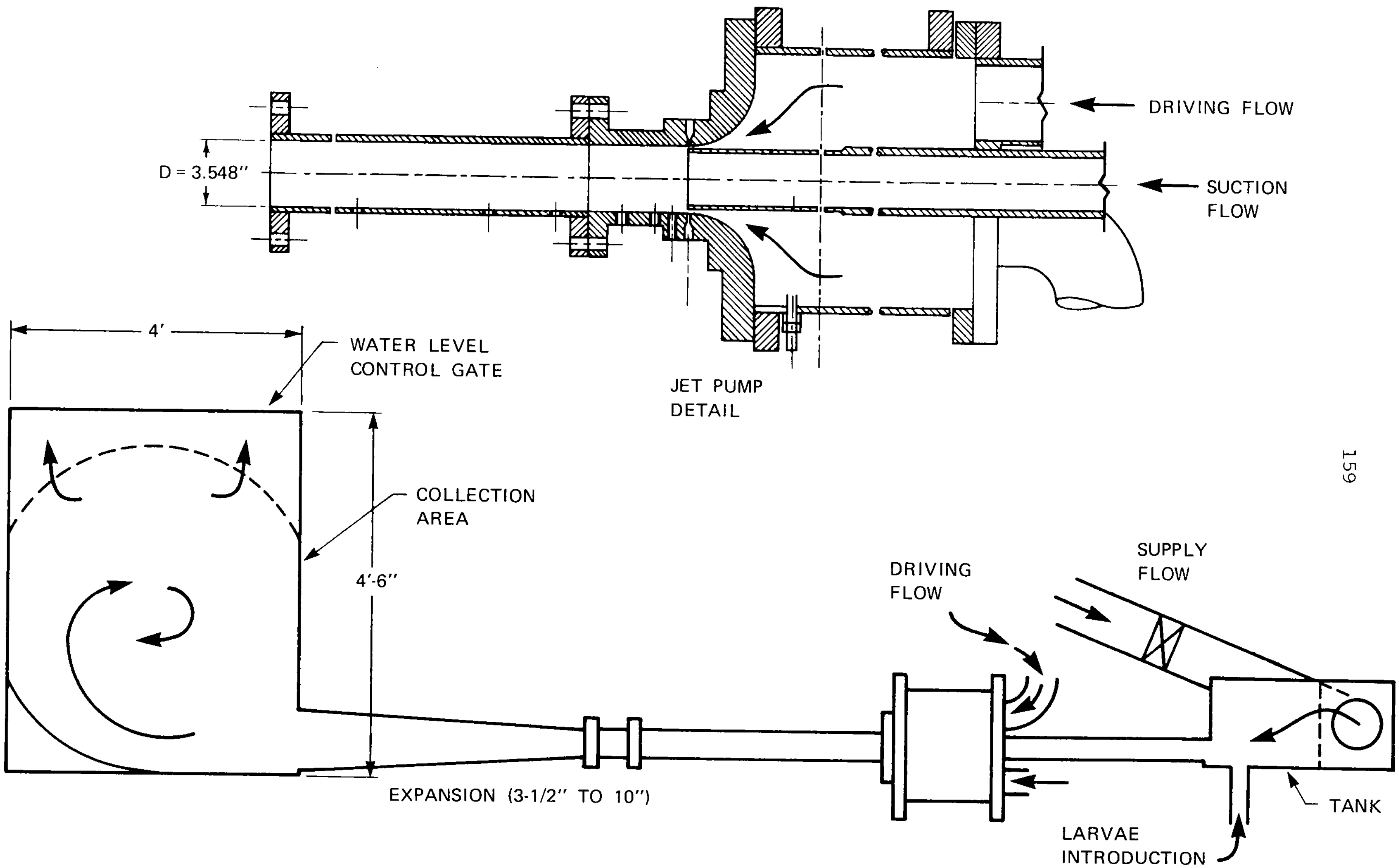


FIGURE 8.1-1 JET PUMP TEST FACILITY

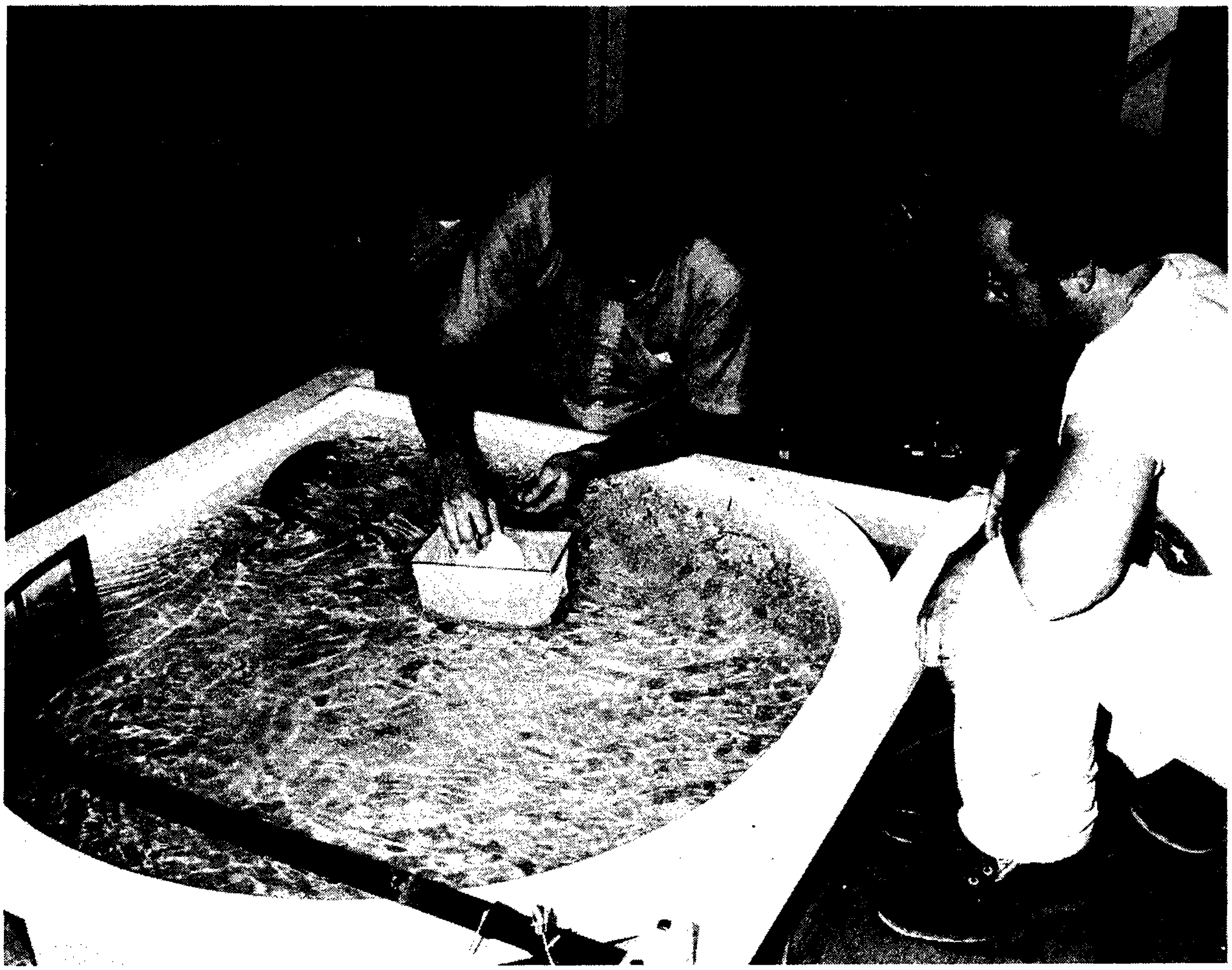


FIGURE 8.1-2 JET PUMP COLLECTION AREA

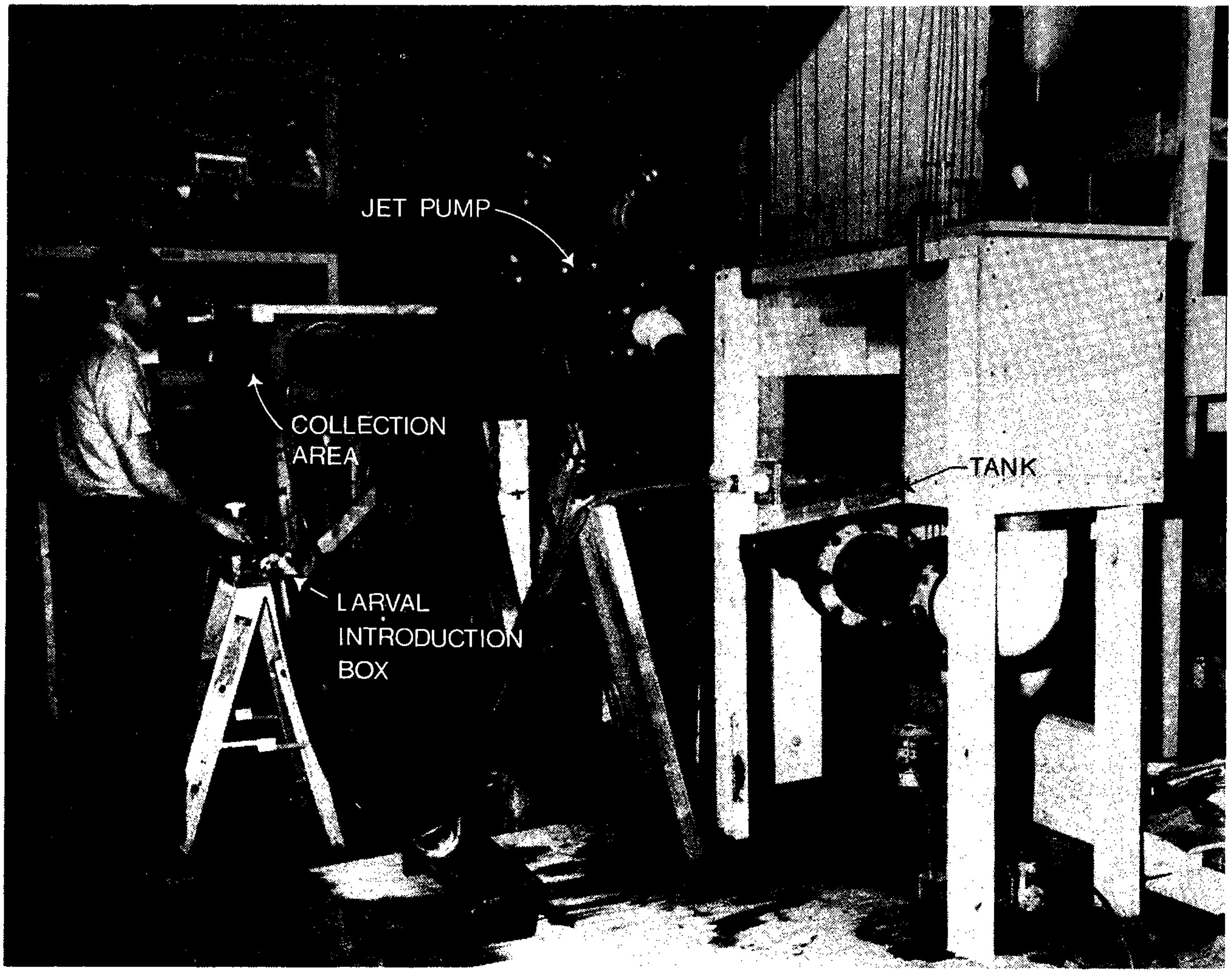


FIGURE 8.1-3 JET PUMP TEST FACILITY

8.2 Biological Test Procedures

Jet Pump

Prior to the start of each test series, 25 control larvae were placed in the collection area of the flume with the jet pump operating. These larvae were then removed from the collection area and were placed in holding beakers for 96 hours. In addition, a separate control was also established which consisted of larvae which were removed from the stock tanks and transferred directly to holding beakers and held for 96 hours.

At the start of each test, 25 larvae were placed in a specially designed introduction box. Upon release, the larvae were drawn up a tube into and through the jet pump, to be discharged into the collection area. The larvae were then removed from the collection area and placed in a holding beaker for 96 hours.

Initial mortality was recorded approximately 1 hour after the conclusion of each test. Thereafter, mortality was recorded at 24, 48, 72, and 96 hours for both test and control larvae with the exception of alewife and yellow perch prolarvae, which were held for only 48 hours. At the conclusion of 96 (or 48) hours, the number of live larvae was recorded and the percent mortality was calculated for each beaker.

Hidrostal Pump

The same procedures were used as with the jet pump.

8.3 Analytical Results

Striped Bass - Jet Pump

One hundred and twenty-six tests were conducted in 1979 with striped bass: 61 tests with a 32 fps nozzle velocity; and 65 tests with a 45 fps nozzle velocity. During the study, larvae and early juveniles ranged in length from 7.54 to 35.51mm.

During the testing period, the holding tank and flume temperature ranged from 18.6° to 23°C and 19° to 25°C, respectively. The temperature difference (ΔT) between the tank and flume ranged from -4.0° to +1.5°C.

The test results were statistically analyzed by an analysis of covariance. The natural logarithm of the percent total mortality was the dependent variable since the histogram shown on Figure 8.3-1 indicated that a logarithmic transformation would normalize the skewed distribution of the percent mortality. The independent variables included nozzle velocity, larval length, and temperature difference.

The results of the analysis are presented in Table 8.3-1. The percent mortality of larvae tested with a nozzle velocity of 32 fps and 45 fps did not significantly differ. The mean mortality for all tests was 4.7 percent with a 95 percent confidence interval of 3.7 to 6.1 percent.

Within the range of independent variables examined, the mortality significantly decreased as the larval length increased. The temperature difference did not significantly influence the percent mortality.

Two control groups were studied to determine mortality attributed to handling and holding and holding alone. The results from an analysis of covariance are summarized in Table 8.3-2. The mean percent mortality for the two control groups did not significantly differ ($p < 0.5$), however, larval length significantly influenced the mortality. As the larval length increased, the mortality significantly decreased. The mean mortality for all controls was 2.6 percent with a 95 percent confidence interval of 1.4 to 4.4 percent.

Since the mortality of striped bass larvae was very low after passage through the jet pump under all test conditions, no attempt was made to adjust test mortality for control values. However, a comparison of test and control mortalities indicates that, under the conditions tested, little mortality occurred as a result of passage through the pump.

Striped bass larvae were not tested in the Hidrostal pump.

TABLE 8.3-1

Results of ANCOVA - Striped Bass Test Larvae
Jet Pump Study

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Nozzle Velocity	1	0.2129	0.2129	0.157	0.6929
Length	1	8.6764	8.6764	6.386	0.0128*
Temperature Difference	1	1.0658	1.0658	0.784	0.3776
Residual	122	165.749			
Total	125	174.883			

*Significant since $\alpha \leq 0.05$

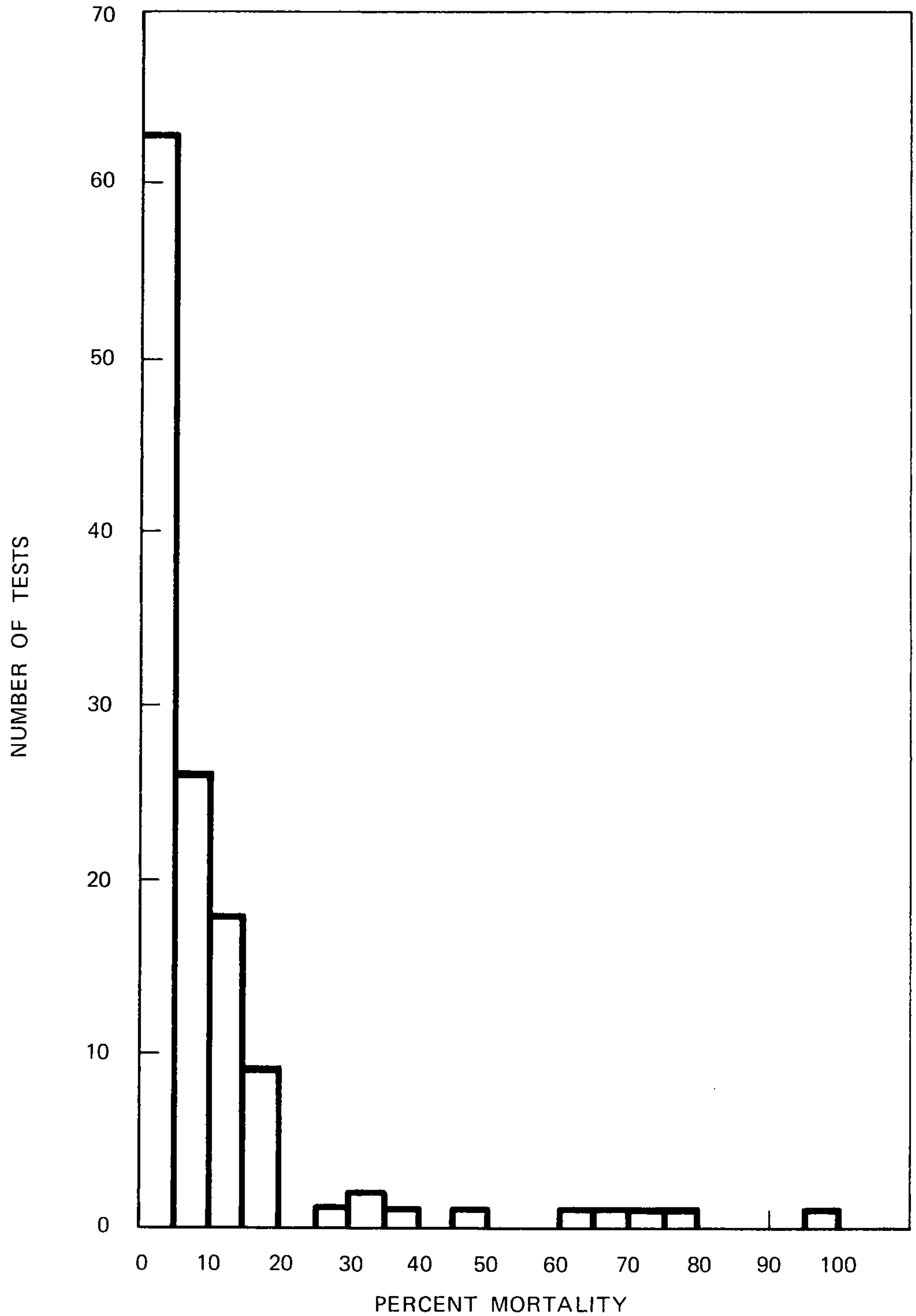
Nozzle Velocity	Predicted Mean Mortality Percent and 95% Confidence Intervals
32 fps	$3.1 \leq 4.5 \leq 6.4$
45 fps	$3.5 \leq 5.0 \leq 7.0$

TABLE 8.3-2

Results of ANCOVA - Striped Bass Control Larvae
Jet Pump Study

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	α Prob.
Group	1	0.57309	0.573	0.541	0.4672
Length	1	13.68047	13.680	12.908	0.0010*
Residual	34	36.0348	1.0598		
Total	36	51.11797			

*Significant since $\alpha \leq 0.05$



NOTE: n = TOTAL NUMBER OF TESTS
p = TOTAL NUMBER OF ORGANISMS

FIGURE 8.3-1 HISTOGRAM OF STRIPED BASS TEST MORTALITY, JET PUMP STUDY

Winter Flounder - Jet Pump

Winter flounder prolarvae (3.6 to 4.1mm) and early postlarvae (4.4mm) were tested in the jet pump from March through mid-April 1980 at a jet nozzle velocity of 45 fps only. Due to the small size and transparent nature of the larvae, no jet pump tests were successfully completed during this time. Larvae which had passed through the pump or which were introduced into the collection area as controls could not be successfully recovered from the collection area. Thus, the ability of the pump to transport these life stages with low mortality could not be assessed.

A second batch of winter flounder postlarvae (mean length of 6.1mm) were successfully tested in the jet pump in late April. However, due to the limited number of postlarvae available, only three pump tests at the 45 fps nozzle velocity were performed. Twenty-one to 23 of the 25 larvae tested were recovered from the collection area per test and were held for 96 hours to determine latent mortality (Table 8.3-3). Most larvae were found impinged on the screens in the collection area. Test mortality ranged from 42.9 to 56.5 percent, with a mean and standard deviation of 52 ±7.8 percent. Control mortality was 8.3 percent. Since many of the larvae recovered from the collection area had been found impinged on the screens, the relatively high mean percent mortality (52 percent) may reflect the added stress of impingement and thus should not be considered as solely representative of passage through the jet pump.

Hidrostal pump tests were not conducted with winter flounder.

TABLE 8.3-3

Test Results - Winter Flounder
Jet Pump Study

Test No.	Tank Temp. (°C)	Flume Temp. (°C)	Temp. Diff. (Δt)	Larval Length (mm)	Nozzle Velocity (fps)	No. Tested	No. Recovered	Initial Live	Initial Dead	24 Hr. Dead	48 Hr. Dead	72 Hr. Dead	96 Hr. Dead	Total Dead	Total Live	96 Hr. % Mortality	Control 96 Hr. % Mortality
1	13.0	12.5	+0.5	6.1	45	25	23	23	0	0	0	4	9	13	10	56.5	8.3
2	13.0	12.5	+0.5	6.1	45	25	21	21	0	0	0	3	6	9	12	42.9	8.3
3	13.0	12.5	+0.5	6.1	45	25	23	23	0	0	0	5	8	13	10	56.5	8.3

Alewife - Jet Pump

Alewife were tested as prolarvae and postlarvae, as presented below, at a single jet nozzle velocity of 45 fps.

Prolarvae

Two tests were conducted with alewife prolarvae ranging in length from 5.7 to 6.2mm (mean length of 6.0mm). Because of the small size and transparent nature of the larvae, it required approximately one hour to complete each test. In addition, the water in the collection area had to be slowly lowered to 1 inch in order to locate and recover the larvae. As shown on Table 8.3-4, only 6 of the 25 prolarvae tested were successfully recovered from the first test, while 19 were recovered from the second test.

The percent mortality at the end of the 48 hour holding period was adjusted to include those larvae which were not found at the conclusion of each test, since the likelihood existed that the missing larvae were killed by their passage through the pump or impingement on the screens in the collection area. Thus, the missing prolarvae were considered as initially dead. Test mortalities ranged from 40.0 to 76.0 percent, with a mean of 58.0 percent. Control mortality (also adjusted to account for missing larvae) was 16.0 percent.

Postlarvae

Six tests were conducted with alewife postlarvae ranging in length from 8.7 to 13.2mm. Three tests were performed with early postlarvae 8.7 to 10.7mm (mean 9.6mm); and three with older postlarvae 11.0 to 13.2mm (mean 12.4mm).

Because the postlarvae were appreciably larger, recovery from the jet pump was not a problem. Therefore, the percent mortality after 96 hours was not adjusted for missing larvae since the majority of the postlarvae were recovered at the conclusion of each test.

Test mortalities for early postlarvae ranged from 63.6 to 88.5 percent, with a mean of 80.0 percent (Table 8.3-4). Mortality associated with holding and handling was 8.3 percent.

Older alewife postlarvae exhibited somewhat lower test mortalities, ranging from 64.0 to 84.0 percent, with a mean of 69.5 percent. Control mortality was higher for this group, however (32.0 percent), suggesting that these larger postlarvae were not as able to withstand the stresses of holding and handling as the younger postlarvae.

Because the control mortality for the older postlarvae was relatively high, the mortalities associated with testing are not good indicators of this group's ability to withstand passage through the jet pump. Therefore, differential mortality (mean test mortality minus control mortality) is useful in examining the contribution of the jet pump to latent mortality for the two groups tested.

In the case of the early postlarvae, the differential mortality was 71.7 percent (Table 8.3-6), indicating that the jet pump was contributing significantly to latent mortality. However, for the older postlarvae, the differential mortality was smaller (37.5 percent), suggesting that the pump was contributing less to latent mortality.

Alewife - Hidrostal Pump

Prolarvae

As in the case of the jet pump, recovery of alewife prolarvae after passage through the Hidrostal pump was a significant problem. Only one Hidrostal pump test was completed using alewife prolarvae ranging from 6.0 to 7.4mm (mean 7.0mm). Of the 25 prolarvae tested, only 8 were recovered at the completion of the test after searching the collection area for more than one hour. Because the prolarvae were in the collection area for an extended period, none of those recovered were held for latent mortality, to avoid handling bias.

Postlarvae

Six tests were conducted with alewife postlarvae ranging in length from 8.7 to 13.2mm. Three tests were performed with early postlarvae, 8.7 to 10.7mm in length (mean 9.6mm), and three with older postlarvae, 11.0 to 13.2mm in length (mean 12.4mm).

Test mortalities for early postlarvae ranged from 13.6 to 31.8 percent, with a mean of 22.3 percent (Table 8.3-5). Control mortality (associated with holding and handling) was 23.1 percent. Older postlarvae exhibited somewhat higher test mortalities ranging from 25.0 to 72.0 percent, with a mean of 46.2 percent. Control mortality was 32.0 percent.

Summary of Alewife Pump Testing

A direct comparison of the two pump types is possible since the postlarvae used for Hidrostal pump testing were from the same batch (parental stock) as those used in the jet pump study, and also because testing of the two pumps occurred on the same day.

As shown by Table 8.3-6, the differential mortalities for early and late postlarvae tested in the Hidrostal pump were 0 and 14.2 percent, respectively. For the jet pump, comparable values were 71.7 and 37.5 percent.

TABLE 8.3-4

Test Results - Alewife
Jet Pump Study

Life Stage	Test No.	Mean Length (mm)	No. Tested	No. Recovered	No. Not Found	Total Dead 48/96 Hr.	% Mortality 48/96 Hr.	Mean % Mortality	Adjusted Total Dead	Adjusted % Mortality	Adjusted Mean (%)
Prolarvae	1	6.0	25	6	19	0	0		19	76.0	
	2	6.0	25	19	6	4	21.1	10.5	10	40.0	58.0
	Control	6.0	25	21	4	0	0		4	16.0	
Postlarvae	3	9.6	25	25	0	22	88.0				
	4	9.6	26	26	0	23	88.5	80.0			
	5	9.6	25	22	3	14	63.6				
	Control	9.6	25	24	1	2	8.3				
	6	12.4	25	21	4	17	81.0				
	7	12.4	25	22	3	14	63.6	69.5			
	8	12.4	25	25	0	16	64.0				
	Control	12.4	25	25	0	8	32.0				

TABLE 8.3-5

Test Results - Alewife
Hidrostal Pump Study

Life Stage	Test No.	Mean Length (mm)	No. Tested	No. Recovered	No. Not Found	Total Dead 48/96 Hr.	% Mortality 48/96 Hr.	Mean % Mortality
Prolarvae	1	7.0	25	8	17	--------------NOT HELD--------------		
Postlarvae	2	9.6	25	22	3	3	13.6	
	3	9.6	25	22	3	7	31.8	22.3
	4	9.6	25	23	2	5	21.7	
	Control	9.6	26	26	0	6	23.1	
	5	12.4	25	25	0	18	72.0	
	6	12.4	25	24	1	6	25.0	46.2
	7	12.4	25	24	1	10	41.7	
	Control	12.4	25	25	0	8	32.0	

TABLE 8.3-6

Comparison of Jet and Hidrostal Pumps
Alewife Test Data

	Mean Test Mortality (%)		Control Mortality (%)	
	Jet	Hidrostal	Jet	Hidrostal
Early Postlarvae	80.0	22.3	8.3	23.1
Later Postlarvae	69.5	46.2	32.0	32.0

Yellow Perch - Jet Pump

Yellow perch were tested as prolarvae and postlarvae as presented below.

Prolarvae

Only one test was conducted with yellow perch prolarvae ranging in length from 5.9 to 6.1mm (mean of 6.0mm). As in the case of alewife prolarvae, it required approximately one hour to recover the yellow perch prolarvae from the collection area; however, all of the larvae were recovered. Test mortality at the end of the 48 hour holding period was 32.0 percent (Table 8.3-7).

Postlarvae

Ten jet pump tests were performed with yellow perch postlarvae ranging in length from 6.1 to 8.9mm: three with early postlarvae, 6.1 to 7.1mm in length (mean 6.5mm); two with slightly older early postlarvae, 6.4 to 8.0mm in length (mean 7.3mm); and four tests with older postlarvae, 7.1 to 8.9mm in length (mean 8.1mm). Two tests were also performed with late postlarvae, 17.8 to 21.2mm in length (mean 19.4mm).

Test mortalities for the 6.5mm early postlarvae ranged from 81.8 to 100.0 percent, with a mean of 91.2 percent. Control mortality was also high at 65.2 percent.

The high control mortality reflects the difficulty of holding the larvae at this stage in their development, for although the larvae had completed the transition from yolk-sac to post-yolk-sac, many were not actively feeding. Thus, both the test and control mortalities were influenced by a continuous natural die-off, as well as the stresses incurred during testing, holding and handling.

Test mortalities for the slightly larger early postlarvae (7.3mm average) were somewhat lower, ranging from 28.0 to 61.5 percent, with a mean of 44.7 percent (Table 8.3-7). Control mortality was also lower for this group of fish (17.4 percent).

Latent mortalities for the 8.1mm postlarvae ranged from 73.9 to 96.2 percent with a mean of 86.5 percent. Control mortality was also high at 79.2 percent. Since this group of larvae were actively feeding, the high control mortality appears reflective of the larvae's inability to withstand holding and handling.

Because the control mortalities are generally high, the mortalities associated with testing are not good indicators of the larvae's ability to withstand passage through the pump. Therefore, the differential mortality (mean test mortality minus the control mortalities) is useful in examining the contribution of the jet pump to latent mortality for the groups tested.

In the case of the early postlarvae (6.5 and 7.3mm), the differential mortality (Table 8.3-9) ranged from 26.0 to 27.3 percent. However, for the older postlarvae (8.1mm), the differential mortality was much smaller (7.3 percent).

Two jet pump tests were performed with late postlarvae, 19.4mm average length. Test mortalities ranged from 0 to 20.0 percent, with a mean of 10.0 percent. No larvae died in the control group (Table 8.3-9), indicating that there was essentially no stress associated with holding and handling these older larvae. Unlike the early postlarvae, the late postlarvae exhibited little or no mortality as a result of their passage through the jet pump.

Yellow Perch - Hidrostal Pump

Prolarvae

A total of three tests were conducted with yellow perch prolarvae 5.9 to 6.5mm (mean 6.1mm) in length. Test mortalities ranged from 0 to 20.0 percent with a mean of 8.3 percent (Table 8.3-8). No prolarvae died in the control group.

Postlarvae

Nine tests were conducted with early postlarvae ranging in length from 6.1 to 9.3mm: three tests with early postlarvae, 6.1 to 7.1mm in length (mean 6.5mm); three tests with postlarvae, 6.5 to 8.0mm in length (mean 7.3mm); and three tests with slightly larger postlarvae, 6.5 to 9.3mm in length (mean 7.6mm); (Table 8.3-8). In addition, two tests were conducted with late postlarvae, 17.8 to 21.2mm in length (mean 19.4mm).

Test mortalities for the early postlarvae (mean 6.5mm) ranged from 91.7 to 96.0 percent, with a mean of 93.2 percent (Table 8.3-8). Control mortality was also high at 72.0 percent, again reflecting the difficulty of holding the larvae at this stage of their development.

The slightly larger early postlarvae (mean 7.3mm) had appreciably lower test mortalities than the smaller early postlarvae. Test mortalities ranged from 4 to 16.0 percent, with a mean of 9.7 percent. Control mortality was relatively low, also, at 20.0 percent.

Test mortalities for the largest early postlarvae (mean 7.6mm) ranged from 20.0 to 73.1 percent with a mean of 52.4 percent. Control mortality was also relatively high at 57.7 percent.

As previously stated, because the control mortalities are generally high, the differential mortalities may be more useful in examining the contribution of the Hidrostal pump to latent mortality.

Although the data for the 7.3 and 7.6mm postlarvae were not combined because the larvae represent two different batches of fish, the trend with respect to the effects of the pump on both groups is similar. In both cases, the differential mortalities are zero, in that control mortalities were higher than mean test mortalities.

With respect to late postlarvae (mean 19.4mm), no larvae died as a result of their passage through the Hidrostal pump (Table 8.3-8). Control mortality was also zero.

8.4 Summary of Jet and Hidrostal Pumps Studies

Pumps appear to offer a potentially effective means for supplying the energy needed to return fish larvae to a release location following diversion; under the conditions tested, a screw-impeller (Hidrostal), centrifugal pump appeared to induce less mortality among the larvae tested than a jet pump.

TABLE 8.3-7

Test Results - Yellow Perch
Jet Pump Study

Life Stage	Test No.	Mean Length (mm)	No. Tested	No. Recovered	No. Not Found	Total Dead 48/96 Hr.	% Mortality 48/96 Hr.	Mean % Mortality
Prolarvae	1	6.0	25	25	0	8	32.0	----
Postlarvae	2	6.5	25	25	0	25	100.0	
(Batch 1)	3	6.5	25	24	1	22	91.7	91.2
	4	6.5	25	22	3	18	81.8	
	Control	6.5	23	23	0	15	65.2	
	5	7.3	26	26	0	16	61.5	
	6	7.3	25	25	0	7	28.0	44.7
	Control	7.3	23	23	0	4	17.4	
	7	8.1	25	23	2	17	73.9	
	8	8.1	25	24	1	23	95.8	
Postlarvae	9	8.1	26	26	0	25	96.2	86.5
(Batch 2)	10	8.1	25	25	0	20	80.0	
	Control	8.1	24	24	0	19	79.2	
Late	11	19.4	10	10	0	0	0	
Postlarvae	12	19.4	10	10	0	2	20.0	10.0
(Batch 2)	Control	19.4	10	10	0	0	0	

TABLE 8.3-8

Test Results - Yellow Perch
Hidrostal Pump Study

Life Stage	Test No.	Mean Length (mm)	No. Tested	No. Recovered	No. Not Found	Total Dead 48/96 Hr.	% Mortality 48/96 Hr.	Mean % Mortality
Prolarvae	1	6.1	25	20	5	4	20.0	
	2	6.1	25	20	5	1	5.0	8.3
	3	6.1	25	16	9	0	0	
	Control	6.1	25	21	4	0	0	
Postlarvae (Batch 1)	4	6.5	25	25	0	24	96.0	
	5	6.5	25	24	1	22	91.7	93.2
	6	6.5	25	25	0	23	92.0	
	Control	6.5	25	25	0	18	72.0	
Batch 1	7	7.3	25	22	3	2	9.1	
	8	7.3	25	25	0	4	16.0	9.7
	9	7.3	25	25	0	1	4.0	
	Control	7.3	25	25	0	5	20.0	
Batch 2	10	7.6	25	25	0	16	64.0	
	11	7.6	25	25	0	5	20.0	52.4
	12	7.6	26	26	0	19	73.1	
	Control	7.6	26	26	0	15	57.7	
Late Postlarvae (Batch 2)	13	19.4	10	10	0	0	0	0
	14	19.4	10	10	0	0	0	
	Control	19.4	10	10	0	0	0	

TABLE 8.3-9

Comparison of Jet and Hidrostal Pumps
Yellow Perch Test Data

	Mean Test Mortality (%)		Control Mortality (%)	
	Jet	Hidrostal	Jet	Hidrostal
Early Postlarvae (Batch 1)	91.2	93.2	65.2	72.0
Older Postlarvae (Batch 1)	44.7	9.7	17.4	20.0
Early Postlarvae (Batch 2)	86.5	52.4	79.2	57.7
Late Postlarvae (Batch 2)	10.0	0	0	0

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APPENDIX A

TABLE A-1

IMPINGEMENT SURVIVAL STUDY
1979 STRIPED BASS DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TEMP DIFF., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION	SEGMENT NO.	TEST									CONTROL						
									INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY %	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
1	1	15.0	17.0	-2.0	5.41	0.5	2	1	21	3	0	0	2	15	20	4	83.3	1	0	7	10	18	7	72.0
2	1	15.0	17.0	-2.0	5.41	0.5	4	2	23	2	2	0	2	10	16	9	64.0	1	0	7	10	18	7	72.0
3	1	15.0	17.0	-2.0	5.41	0.5	8	1	12	13	1	0	3	8	25	0	100.0	1	0	7	10	18	7	72.0
4	1	15.0	17.0	-2.0	5.41	0.5	16	2	10	15	0	0	0	10	25	0	100.0	1	0	7	10	18	7	72.0
5	1	13.0	17.0	-4.0	5.41	1.0	2	1	22	3	2	6	4	2	17	8	68.0	0	6	5	6	17	8	68.0
6	1	13.0	17.0	-4.0	5.41	1.0	4	2	19	6	0	7	2	0	15	10	60.0	0	6	5	6	17	8	68.0
7	1	13.0	17.0	-4.0	5.41	1.0	8	1	12	13	2	3	4	0	22	3	88.0	0	6	5	6	17	8	68.0
8	1	13.0	17.0	-4.0	5.41	1.0	16	2	0	23	0	0	0	0	23	0	100.0	0	6	5	6	17	8	68.0
9	1	14.0	18.2	-4.2	5.41	1.5	2	1	20	5	0	0	2	5	12	13	48.0	0	6	5	6	17	8	68.0
10	1	14.0	18.2	-4.2	5.41	1.5	4	2	0	25	0	0	0	0	25	0	100.0	0	6	5	6	17	8	68.0
11	1	14.0	18.2	-4.2	5.41	1.5	8	1	0	23	0	0	0	0	23	0	100.0	0	6	5	6	17	8	68.0
12	1	14.0	18.2	-4.2	5.41	1.5	16	2	0	24	0	0	0	0	24	0	100.0	0	6	5	6	17	8	68.0
13	1	16.0	18.9	-2.9	5.41	2.0	2	1	2	23	1	0	1	0	25	0	100.0	0	2	3	8	14	10	58.3
14	1	16.0	18.9	-2.9	5.41	2.0	4	2	0	25	0	0	0	0	25	0	100.0	0	2	3	8	14	10	58.3
15	1	16.0	18.9	-2.9	5.41	2.0	8	1	0	25	0	0	0	0	25	0	100.0	0	2	3	8	14	10	58.3
16	1	16.0	19.5	-3.5	5.41	2.0	16	2	0	25	0	0	0	0	25	0	100.0	0	2	3	8	14	10	58.3
17	1	17.0	19.7	-2.7	5.41	0.5	2	2	26	0	0	4	6	7	17	9	65.4	0	2	3	8	14	10	58.3
18	1	17.0	19.7	-2.7	5.41	0.5	4	1	24	0	0	0	1	4	5	19	20.8	0	2	3	8	14	10	58.3
19	1	17.0	19.7	-2.7	5.41	0.5	8	2	22	2	1	4	9	3	19	5	79.2	0	2	3	8	14	10	58.3
20	1	17.0	19.7	-2.7	5.41	0.5	16	1	13	11	0	0	1	3	15	9	62.5	0	2	3	8	14	10	58.3
21	1	18.0	18.0	0.0	6.40	1.0	2	2	22	3	10	3	0	0	16	9	64.0	1	3	0	3	19	6	76.0
22	1	18.0	18.0	0.0	6.40	1.0	4	1	7	17	0	0	0	0	17	7	70.8	1	3	0	3	19	6	76.0
23	1	18.0	18.0	0.0	6.40	1.0	8	2	8	17	3	0	0	1	21	4	84.0	1	3	0	3	19	6	76.0
24	1	18.0	18.0	0.0	6.40	1.0	16	1	0	25	0	0	0	0	25	0	100.0	1	3	0	3	19	6	76.0
25	1	18.0	18.6	-0.6	6.40	1.5	2	2	13	12	5	0	3	2	22	3	88.0	1	3	0	3	19	6	76.0
26	1	18.0	18.6	-0.6	6.40	1.5	4	1	12	13	3	3	0	2	21	4	84.0	1	3	0	3	19	6	76.0
27	1	18.0	19.1	-1.1	6.40	1.5	8	2	0	25	0	0	0	0	25	0	100.0	1	3	0	3	19	6	76.0
28	1	18.0	19.1	-1.1	6.40	1.5	16	1	0	25	0	0	0	0	25	0	100.0	1	3	0	3	19	6	76.0
29	1	18.0	19.5	-1.5	6.40	2.0	2	2	0	25	0	0	0	0	25	0	100.0	3	4	1	0	11	14	44.0
30	1	18.0	19.5	-1.5	6.40	2.0	4	1	0	25	0	0	0	0	25	0	100.0	3	4	1	0	11	14	44.0
31	1	18.0	19.5	-1.5	6.40	2.0	8	2	0	24	0	0	0	0	24	0	100.0	3	4	1	0	11	14	44.0
32	1	18.0	19.5	-1.5	6.40	2.0	16	1	0	24	0	0	0	0	24	0	100.0	3	4	1	0	11	14	44.0
33	1	18.0	20.0	-2.0	6.40	0.5	2	1	16	9	10	1	0	1	21	4	84.0	3	4	1	0	11	14	44.0
34	1	18.0	20.0	-2.0	6.40	0.5	4	2	16	9	2	7	1	0	19	6	76.0	3	4	1	0	11	14	44.0
35	1	18.0	20.0	-2.0	6.40	0.5	8	1	3	22	1	0	1	0	24	1	96.0	3	4	1	0	11	14	44.0
36	1	18.0	20.0	-2.0	6.40	0.5	16	2	0	25	0	0	0	0	25	0	100.0	3	4	1	0	11	14	44.0
37	1	19.0	19.0	0.0	6.34	1.0	2	1	17	7	7	0	0	0	14	11	58.3	7	0	0	0	20	5	80.0
38	1	19.0	19.0	0.0	6.34	1.0	4	2	16	9	4	0	0	1	14	11	56.0	7	0	0	0	20	5	80.0
39	1	19.0	19.0	0.0	6.34	1.0	8	1	0	25	0	0	0	0	25	0	100.0	7	0	0	0	20	5	80.0
40	1	19.0	19.0	0.0	6.34	1.0	16	2	6	19	1	1	0	1	22	9	88.0	7	0	0	0	20	5	80.0
41	1	19.0	18.0	1.0	6.34	1.5	2	1	9	16	2	1	0	0	19	6	76.0	7	0	0	0	20	5	80.0
42	1	19.0	18.0	1.0	6.34	1.5	4	2	5	20	1	0	0	2	23	2	92.0	7	0	0	0	20	5	80.0
43	1	19.0	18.0	1.0	6.34	1.5	8	1	1	24	0	0	0	0	24	1	96.0	7	0	0	0	20	5	80.0
44	1	19.0	18.0	1.0	6.34	1.5	16	2	0	25	0	0	0	0	25	0	100.0	7	0	0	0	20	5	80.0
45	1	19.0	18.0	1.0	6.34	2.0	2	1	2	23	0	0	0	0	23	2	92.0	7	0	0	0	20	5	80.0
46	1	19.0	18.0	1.0	6.34	2.0	4	2	0	24	0	0	0	0	24	0	100.0	7	0	0	0	20	5	80.0
47	1	19.0	18.0	1.0	6.34	2.0	8	1	0	25	0	0	0	0	25	0	100.0	7	0	0	0	20	5	80.0
48	1	19.0	18.0	1.0	6.34	2.0	16	2	0	25	0	0	0	0	25	0	100.0	7	0	0	0	20	5	80.0
49	1	19.0	18.0	1.0	6.34	0.5	2	2	14	11	0	1	1	3	16	9	64.0	1	1	0	2	7	20	25.9
50	1	19.0	18.0	1.0	6.34	0.5	4	1	18	7	2	2	0	0	11	14	44.0	1	1	0	2	7	20	25.9
51	1	19.0	18.0	1.0	6.34	0.5	8	2	2	23	0	0	0	0	23	4	92.0	1	1	0	2	7	20	25.9
52	1	19.0	18.0	1.0	6.34	0.5	16	1	8	17	2	0	0	0	19	6	76.0	1	1	0	2	7	20	25.9
53	1	15.2	16.9	-1.7	6.46	1.0	2	2	24	1	2	0	0	1	4	21	16.0	0	0	0	1	1	24	4.0

TABLE A-1

IMPINGEMENT SURVIVAL STUDY
1979 STRIPED BASS DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TEMP DIFF., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION	SEGMENT NO.	TEST: INITIAL LIVE	TEST: INITIAL DEAD	TEST: 24-HR. DEAD	TEST: 48-HR. DEAD	TEST: 72-HR. DEAD	TEST: 96-HR. DEAD	TEST: TOTAL DEAD	TEST: TOTAL LIVE	TEST: 96-HR. MORTALITY %	CONTROL: 24-HR. DEAD	CONTROL: 48-HR. DEAD	CONTROL: 72-HR. DEAD	CONTROL: 96-HR. DEAD	CONTROL: TOTAL DEAD	CONTROL: TOTAL LIVE	CONTROL: 96-HR. MORTALITY, %
54	1	15.2	16.9	-1.7	6.46	1.0	4	1	21	4	2	2	0	1	9	16	36.0	0	0	0	1	1	24	4.0
55	1	15.2	16.9	-1.7	6.46	1.0	8	2	6	19	0	0	0	0	19	6	76.0	0	0	0	1	1	24	4.0
56	1	15.2	16.9	-1.7	6.46	1.0	16	1	4	21	0	0	0	0	21	4	84.0	0	0	0	1	1	24	4.0
57	1	15.5	17.5	-2.0	6.46	0.5	2	1	24	2	0	1	0	2	5	21	19.0	0	0	0	1	1	24	4.0
58	1	15.5	17.5	-2.0	6.46	0.5	4	2	25	0	0	0	0	0	0	25	0.0	0	0	0	1	1	24	4.0
59	1	15.5	17.0	-1.5	6.46	0.5	8	1	19	6	1	0	0	3	10	15	40.0	0	0	0	1	1	24	4.0
60	1	15.5	17.0	-1.5	6.46	0.5	16	2	13	12	0	2	0	0	14	11	56.0	0	0	0	1	1	24	4.0
61	1	15.2	17.0	-1.8	6.46	1.0	2	1	20	6	0	0	0	4	10	16	38.5	0	0	0	1	1	24	4.0
62	1	15.2	17.0	-1.8	6.46	1.0	4	2	13	12	0	0	3	0	15	10	60.0	0	0	0	1	1	24	4.0
63	1	15.2	16.9	-1.7	6.46	1.0	8	1	15	10	0	0	0	2	12	13	48.0	0	0	0	1	1	24	4.0
64	1	15.2	16.9	-1.7	6.46	1.0	16	2	0	25	0	0	0	0	25	0	100.0	0	0	0	1	1	24	4.0
65	1	15.2	17.5	-2.3	6.46	1.5	2	2	12	13	2	1	0	2	18	7	72.0	0	0	0	1	1	24	4.0
66	1	15.2	17.5	-2.3	6.46	1.5	4	1	7	18	0	1	0	0	19	6	76.0	0	0	0	1	1	24	4.0
67	1	15.2	17.2	-2.0	6.46	1.5	2	1	17	7	0	0	0	0	7	17	29.2	0	0	0	1	1	24	4.0
68	1	15.2	17.2	-2.0	6.46	1.5	4	2	3	22	0	0	2	0	24	1	96.0	0	0	0	1	1	24	4.0
69	1	16.5	17.5	-1.0	6.58	0.5	2	2	26	0	0	2	0	1	3	23	11.5	0	0	0	1	1	24	4.0
70	1	16.5	17.5	-1.0	6.58	0.5	4	1	25	0	1	0	0	2	3	22	12.0	0	0	0	1	1	24	4.0
71	1	17.0	17.9	-0.9	6.58	0.5	8	2	25	0	0	1	0	4	5	20	20.0	0	0	0	1	1	24	4.0
72	1	17.0	17.9	-0.9	6.58	0.5	16	1	10	16	0	0	3	3	22	4	84.6	0	0	0	1	1	24	4.0
73	1	17.0	17.1	-0.1	6.58	1.0	2	2	25	0	0	0	0	0	0	25	0.0	0	0	0	1	1	24	4.0
74	1	17.0	17.1	-0.1	6.58	1.0	4	1	25	0	0	1	0	2	3	22	12.0	0	0	0	1	1	24	4.0
75	1	17.0	17.2	-0.2	6.58	1.0	8	2	16	8	0	0	0	1	9	15	37.5	0	0	0	1	1	24	4.0
76	1	17.0	17.2	-0.2	6.58	1.0	16	1	0	25	0	0	0	0	25	0	100.0	0	0	0	1	1	24	4.0
77	1	17.0	17.7	-0.7	6.58	1.5	2	2	19	6	0	0	1	1	8	17	32.0	0	0	0	1	1	24	4.0
78	1	17.0	17.7	-0.7	6.58	1.5	4	1	18	7	0	1	1	0	9	16	36.0	0	0	0	1	1	24	4.0
79	1	17.0	17.9	-0.9	6.58	1.0	2	1	24	1	0	1	0	2	4	21	16.0	0	0	0	1	1	24	4.0
80	1	17.0	17.9	-0.9	6.58	1.0	4	2	15	9	1	0	0	0	10	14	41.7	0	0	0	1	1	24	4.0
81	1	18.9	18.9	0.0	6.91	0.5	2	2	24	3	0	0	0	0	3	24	11.1	0	0	0	2	2	24	7.7
82	1	18.9	18.9	0.0	6.91	0.5	4	1	24	1	2	0	0	1	4	21	16.0	0	0	0	2	2	24	7.7
83	1	18.9	18.9	0.0	6.91	0.5	8	2	23	2	0	0	1	2	5	20	20.0	0	0	0	2	2	24	7.7
84	1	18.9	18.8	0.1	6.91	0.5	16	1	16	9	2	0	1	2	14	11	56.0	0	0	0	2	2	24	7.7
85	1	18.9	19.2	-0.3	6.91	0.5	2	1	24	1	1	0	1	1	4	21	16.0	0	0	0	2	2	24	7.7
86	1	18.9	19.2	-0.3	6.91	0.5	4	2	25	0	2	1	0	1	4	21	16.0	0	0	0	2	2	24	7.7
87	1	18.9	19.2	-0.3	6.91	0.5	8	1	23	2	1	0	0	0	3	22	12.0	0	0	0	2	2	24	7.7
88	1	18.9	19.2	-0.3	6.91	0.5	16	2	17	5	0	1	0	0	6	16	27.3	0	0	0	2	2	24	7.7
89	1	18.9	19.9	-1.0	6.91	1.0	2	2	25	0	0	0	0	2	2	23	8.0	0	0	0	2	2	24	7.7
90	1	18.9	19.9	-1.0	6.91	1.0	4	1	25	0	0	0	0	0	0	25	0.0	0	0	0	2	2	24	7.7
91	1	18.9	19.9	-1.0	6.91	1.0	8	2	11	14	0	0	0	0	14	11	56.0	0	0	0	2	2	24	7.7
92	1	18.9	19.9	-1.0	6.91	1.0	16	1	1	24	0	0	0	0	24	1	96.0	0	0	0	2	2	24	7.7
93	1	18.9	19.9	-1.0	6.91	1.0	2	1	25	0	1	1	0	1	3	22	12.0	0	0	0	2	2	24	7.7
94	1	18.9	19.9	-1.0	6.91	1.0	4	2	18	5	0	1	0	0	6	17	26.1	0	0	0	2	2	24	7.7
95	1	18.9	19.9	-1.0	6.91	1.0	8	2	14	11	0	0	0	0	11	14	44.0	0	0	0	2	2	24	7.7
96	1	18.9	19.9	-1.0	6.91	1.0	16	2	0	25	0	0	0	0	25	0	100.0	0	0	0	2	2	24	7.7
97	1	18.9	20.0	-1.1	6.91	1.5	2	1	19	6	0	2	0	2	10	15	40.0	0	0	0	2	2	24	7.7
98	1	18.9	20.0	-1.1	6.91	1.5	4	2	11	14	0	0	0	1	15	10	60.0	0	0	0	2	2	24	7.7
99	1	18.9	20.0	-1.1	6.91	1.5	2	2	21	4	1	1	0	1	7	18	28.0	0	0	0	2	2	24	7.7
100	1	18.9	20.0	-1.1	6.91	1.5	4	1	0	25	0	0	0	0	25	0	100.0	0	0	0	2	2	24	7.7
101	1	19.5	18.8	0.7	7.54	0.5	2	2	25	0	1	0	0	0	1	24	4.0	0	0	0	1	1	24	4.0
102	1	19.5	18.8	0.7	7.54	0.5	4	1	25	0	1	0	1	2	4	21	16.0	0	0	0	1	1	24	4.0
103	1	19.5	19.3	0.2	7.54	0.5	8	2	25	0	1	0	0	0	1	24	4.0	0	0	0	1	1	24	4.0
104	1	19.5	19.3	0.2	7.54	0.5	16	1	11	15	1	1	0	0	17	9	65.4	0	0	0	1	1	24	4.0
105	1	19.5	19.3	0.2	7.54	0.5	2	1	25	0	0	0	0	0	0	25	0.0	0	0	0	1	1	24	4.0
106	1	19.5	19.3	0.2	7.54	0.5	4	2	25	0	0	0	0	1	1	24	4.0	0	0	0	1	1	24	4.0

TABLE A-1

IMPINGEMENT SURVIVAL STUDY
1979 STRIPED BASS DATA

									TEST									CONTROL						
TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TEMP DIFF., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION	SEGMENT NO.	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY %	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
107	1	19.5	19.3	0.2	7.54	0.5	8	1	21	4	2	0	0	1	7	18	28.0	0	0	0	1	1	24	4
108	1	19.5	19.3	0.2	7.54	0.5	16	2	16	10	0	0	0	3	3	13	50.0	0	0	0	1	1	24	4
109	1	19.5	19.7	-0.2	7.54	1.0	2	1	24	1	1	0	0	1	3	22	12.0	0	0	0	1	1	24	4
110	1	19.5	19.7	-0.2	7.54	1.0	4	2	25	0	0	3	0	0	3	22	12.0	0	0	0	1	1	24	4
111	1	19.5	19.7	-0.2	7.54	1.0	8	1	24	1	0	0	0	0	1	24	4.0	0	0	0	1	1	24	4
112	1	19.5	19.7	-0.2	7.54	1.0	16	2	12	13	0	1	0	2	16	9	64.0	0	0	0	1	1	24	4
113	1	19.0	18.7	0.3	7.94	1.0	2	2	25	0	1	0	1	0	2	23	8.0	0	0	0	1	1	24	4
114	1	19.0	18.7	0.3	7.94	1.0	4	1	26	0	0	0	0	0	0	26	0.0	0	0	0	1	1	24	4
115	1	19.0	18.7	0.3	7.94	1.0	8	2	21	4	0	0	1	0	5	20	20.0	0	0	0	1	1	24	4
116	1	19.0	18.7	0.3	7.94	1.0	16	1	24	1	1	0	1	0	3	21	12.0	0	0	0	1	1	24	4
117	1	19.0	18.7	0.3	7.94	1.5	2	2	24	1	0	0	0	1	2	22	8.0	0	0	0	1	1	24	4
118	1	19.0	18.7	0.3	7.94	1.5	4	1	24	1	2	0	1	0	4	21	16.0	0	0	0	1	1	24	4
119	1	19.0	18.7	0.3	7.94	1.5	2	1	26	0	0	0	2	1	3	23	11.5	0	0	0	1	1	24	4
120	1	19.0	18.7	0.3	7.94	1.5	4	2	26	0	0	0	0	0	0	26	0.0	0	0	0	1	1	24	4
121	1	19.2	18.7	0.5	7.94	0.5	2	1	24	1	1	0	0	0	2	23	8.0	0	0	0	1	1	24	4
122	1	19.2	18.7	0.5	7.94	0.5	4	2	25	0	5	0	2	1	8	17	32.0	0	0	0	1	1	24	4
123	1	19.3	18.7	0.6	7.94	0.5	8	1	19	6	1	0	0	0	7	18	28.0	0	0	0	1	1	24	4
124	1	19.3	18.7	0.6	7.94	0.5	16	2	8	17	0	0	0	0	17	8	68.0	0	0	0	1	1	24	4
125	1	19.3	18.7	0.6	7.94	0.5	2	2	25	1	0	0	2	0	3	23	11.5	0	0	0	1	1	24	4
126	1	19.3	18.7	0.6	7.94	0.5	4	1	24	1	0	0	0	3	4	21	16.0	0	0	0	1	1	24	4
127	1	19.3	18.7	0.6	7.94	0.5	8	2	18	7	0	0	0	1	8	17	32.0	0	0	0	1	1	24	4
128	1	19.3	18.7	0.6	7.94	0.5	16	1	7	18	0	0	0	1	19	6	76.0	0	0	0	1	1	24	4
129	1	19.3	18.7	0.6	7.94	1.0	2	1	25	1	0	0	0	0	1	25	3.8	0	0	0	1	1	24	4
130	1	19.0	18.7	0.3	7.94	1.0	4	2	25	0	1	1	0	0	2	23	8.0	0	0	0	1	1	24	4
131	1	19.3	18.7	0.6	7.94	1.0	8	1	24	4	1	0	2	2	9	19	32.1	0	0	0	1	1	24	4
132	1	19.3	18.7	0.6	7.94	1.0	16	2	12	13	0	0	0	4	17	8	68.0	0	0	0	1	1	24	4
133	1	19.3	19.2	0.1	7.94	1.0	2	2	25	0	0	0	1	1	2	23	8.0	0	0	0	1	1	24	4
134	1	19.3	19.2	0.1	7.94	1.0	4	1	21	4	3	0	0	1	8	17	32.0	0	0	0	1	1	24	4
135	1	19.3	19.2	0.1	7.94	1.0	8	2	20	5	0	0	2	1	8	17	32.0	0	0	0	1	1	24	4
136	1	19.3	19.2	0.1	7.94	1.0	16	1	17	8	0	0	0	1	9	16	36.0	0	0	0	1	1	24	4
137	1	19.3	19.5	-0.2	7.94	1.5	2	2	24	1	2	0	0	1	4	21	16.0	0	0	0	1	1	24	4
138	1	19.3	19.5	-0.2	7.94	1.5	4	1	19	6	2	0	1	0	9	16	36.0	0	0	0	1	1	24	4
139	1	19.3	19.2	0.1	7.94	1.5	2	1	23	4	1	0	1	1	7	20	25.9	0	0	0	1	1	24	4
140	1	19.3	19.2	0.1	7.94	1.5	4	2	19	6	0	0	2	0	8	17	32.0	0	0	0	1	1	24	4
141	1	19.0	19.1	-0.1	8.21	0.5	2	1	23	0	0	0	0	4	4	19	17.4	0	2	1	0	3	22	12
142	1	19.0	19.1	-0.1	8.21	0.5	4	2	25	0	1	0	2	1	4	21	16.0	0	2	1	0	3	22	12
143	1	19.0	19.1	-0.1	8.21	0.5	8	1	23	2	3	5	0	0	10	15	40.0	0	2	1	0	3	22	12
144	1	19.0	19.1	-0.1	8.21	0.5	16	2	11	14	3	0	0	1	18	7	72.0	0	2	1	0	3	22	12
145	1	19.0	19.1	-0.1	8.21	0.5	2	2	25	0	2	1	1	2	6	19	24.0	0	2	1	0	3	22	12
146	1	19.0	19.1	-0.1	8.21	0.5	4	1	23	2	0	2	1	0	5	20	20.0	0	2	1	0	3	22	12
147	1	19.0	19.1	-0.1	8.21	0.5	2	1	25	0	1	0	0	3	4	21	16.0	0	2	1	0	3	22	12
148	1	19.0	19.1	-0.1	8.21	0.5	4	2	23	3	0	2	0	1	5	20	23.1	0	2	1	0	3	22	12
149	1	19.0	20.0	-1.0	8.21	0.5	8	2	25	1	7	7	2	2	19	7	73.1	0	2	1	0	3	22	12
150	1	19.0	20.0	-1.0	8.21	0.5	16	1	8	19	2	1	0	0	22	5	81.5	0	2	1	0	3	22	12
151	1	19.0	20.0	-1.0	8.21	1.0	2	1	24	1	1	1	0	1	4	21	16.0	0	2	1	0	3	22	12
152	1	19.0	20.0	-1.0	8.21	1.0	4	2	25	0	1	2	1	0	4	21	16.0	0	2	1	0	3	22	12
153	1	19.0	20.0	-1.0	8.21	1.0	8	1	21	4	2	1	2	0	9	16	36.0	0	2	1	0	3	22	12
154	1	19.0	20.0	-1.0	8.21	1.0	16	2	11	14	0	3	0	0	17	8	68.0	0	2	1	0	3	22	12
155	1	19.0	20.0	-1.0	8.21	1.0	2	2	24	0	0	0	1	4	5	19	20.8	0	2	1	0	3	22	12
156	1	19.0	20.0	-1.0	8.21	1.0	4	1	26	0	0	0	3	2	5	21	19.2	0	2	1	0	3	22	12
157	1	19.0	20.0	-1.0	8.21	1.0	8	2	15	10	0	0	0	1	11	14	44.0	0	2	1	0	3	22	12
158	1	19.0	20.0	-1.0	8.21	1.0	16	1	4	21	0	0	0	0	21	4	84.0	0	2	1	0	3	22	12
159	1	19.0	20.0	-1.0	8.21	1.5	2	1	24	1	0	3	1	1	6	19	24.0	0	2	1	0	3	22	12

TABLE A-1

IMPINGEMENT SURVIVAL STUDY
1979 STRIPED BASS DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TEMP DIFF., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION	SEGMENT NO.	TEST: INITIAL LIVE	TEST: INITIAL DEAD	TEST: 24-HR. DEAD	TEST: 48-HR. DEAD	TEST: 72-HR. DEAD	TEST: 96-HR. DEAD	TEST: TOTAL DEAD	TEST: TOTAL LIVE	TEST: 96-HR. MORTALITY %	CONTROL: 24-HR. DEAD	CONTROL: 48-HR. DEAD	CONTROL: 72-HR. DEAD	CONTROL: 96-HR. DEAD	CONTROL: TOTAL DEAD	CONTROL: TOTAL LIVE	CONTROL: 96-HR. MORTALITY, %
160	1	19.0	20.0	-1.0	8.21	1.5	4	2	11	14	0	0	0	0	14	11	56.0	0	2	1	0	3	22	12
161	1	19.0	20.5	-1.5	8.21	1.5	8	1	0	25	0	0	0	0	25	0	100.0	0	2	1	0	3	22	12
162	1	19.0	20.5	-1.5	8.21	1.5	16	2	0	25	0	0	0	0	25	0	100.0	0	2	1	0	3	22	12
163	1	19.0	20.0	-1.0	8.21	1.5	2	2	26	0	1	2	0	1	4	22	15.4	0	2	1	0	3	22	12
164	1	19.0	20.5	-1.5	8.21	1.5	4	1	20	5	0	2	0	1	8	17	32.0	0	2	1	0	3	22	12
165	1	19.0	19.2	-0.2	8.19	0.5	2	1	25	0	6	0	0	1	7	18	28.0	0	0	0	3	3	22	12
166	1	19.0	19.2	-0.2	8.19	0.5	2	2	25	0	0	1	0	4	4	21	20.0	0	0	0	3	3	22	12
167	1	19.0	19.1	-0.1	8.19	0.5	4	1	25	0	1	2	0	0	3	22	12.0	0	0	0	3	3	22	12
168	1	19.0	19.1	-0.1	8.19	0.5	4	2	25	0	0	0	1	3	4	21	16.0	0	0	0	3	3	22	12
169	1	19.0	19.0	0.0	8.19	0.5	8	1	25	0	0	0	7	0	7	18	28.0	0	0	0	3	3	22	12
170	1	19.0	19.0	0.0	8.19	0.5	8	2	26	0	0	0	2	5	7	19	26.9	0	0	0	3	3	22	12
171	1	19.0	19.0	0.0	8.19	0.5	16	1	25	0	2	1	1	0	4	21	16.0	0	0	0	3	3	22	12
172	1	19.0	19.0	0.0	8.19	0.5	16	2	23	2	4	3	0	1	10	15	40.0	0	0	0	3	3	22	12
173	1	19.0	19.3	-0.3	8.19	1.0	2	1	25	0	3	4	0	0	7	18	28.0	0	0	0	3	3	22	12
174	1	19.0	19.3	-0.3	8.19	1.0	2	2	25	0	2	0	0	3	5	20	20.0	0	0	0	3	3	22	12
175	1	19.0	19.5	-0.5	8.19	1.0	4	1	21	4	1	2	0	1	8	17	32.0	0	0	0	3	3	22	12
176	1	19.0	19.5	-0.5	8.19	1.0	4	2	24	1	1	0	0	0	2	23	8.0	0	0	0	3	3	22	12
177	1	19.0	19.3	-0.3	8.19	1.0	8	1	22	3	2	1	0	3	9	16	36.0	0	0	0	3	3	22	12
178	1	19.0	19.3	-0.3	8.19	1.0	8	2	21	4	2	0	0	0	6	19	24.0	0	0	0	3	3	22	12
179	1	19.0	19.5	-0.5	8.19	1.0	16	1	20	5	1	1	0	2	9	16	36.0	0	0	0	3	3	22	12
180	1	19.0	19.5	-0.5	8.19	1.0	16	2	16	10	1	0	0	0	11	15	42.3	0	0	0	3	3	22	12
181	1	19.0	19.5	-0.5	8.19	1.5	2	1	25	0	0	1	0	1	2	23	8.0	0	0	0	3	3	22	12
182	1	19.0	19.5	-0.5	8.19	1.5	2	2	24	1	3	2	1	1	8	17	32.0	0	0	0	3	3	22	12
183	1	19.0	20.1	-1.1	8.19	1.5	4	1	24	0	0	1	0	1	2	22	8.3	0	0	0	3	3	22	12
184	1	19.0	20.1	-1.1	8.19	1.5	4	2	21	4	1	3	3	2	13	12	52.0	0	0	0	3	3	22	12
185	1	19.0	20.1	-1.1	8.19	1.5	8	1	19	6	3	0	0	3	12	13	48.0	0	0	0	3	3	22	12
186	1	19.0	20.1	-1.1	8.19	1.5	8	2	18	8	0	2	0	0	10	16	38.5	0	0	0	3	3	22	12
187	1	19.0	20.1	-1.1	8.19	1.5	16	1	1	24	0	1	0	0	25	0	100.0	0	0	0	3	3	22	12
188	1	19.0	20.1	-1.1	8.19	1.5	16	2	3	22	2	0	0	0	24	1	96.0	0	0	0	3	3	22	12
189	1	19.2	19.2	0.0	9.07	0.5	2	1	25	0	0	0	1	0	1	24	4.0	0	0	0	2	2	23	8
190	1	19.2	19.2	0.0	9.07	0.5	2	2	25	0	0	0	0	0	0	25	0.0	0	0	0	2	2	23	8
191	1	19.2	19.2	0.0	9.07	0.5	4	1	25	0	0	1	0	0	1	24	4.0	0	0	0	2	2	23	8
192	1	19.2	19.2	0.0	9.07	0.5	4	2	26	0	3	0	0	5	8	18	30.8	0	0	0	2	2	23	8
193	1	19.2	19.2	0.0	9.07	0.5	8	1	25	0	0	0	0	0	0	25	0.0	0	0	0	2	2	23	8
194	1	19.2	19.2	0.0	9.07	0.5	8	2	26	0	5	0	0	2	7	19	26.9	0	0	0	2	2	23	8
195	1	19.2	19.2	0.0	9.07	0.5	16	1	21	5	1	2	0	0	8	18	30.8	0	0	0	2	2	23	8
196	1	19.2	19.2	0.0	9.07	0.5	16	2	21	4	4	1	2	0	11	14	44.0	0	0	0	2	2	23	8
197	1	19.8	19.8	0.0	9.07	1.0	2	1	25	0	0	0	0	0	0	25	0.0	0	0	0	2	2	23	8
198	1	19.8	19.8	0.0	9.07	1.0	2	2	25	0	0	1	0	2	3	22	12.0	0	0	0	2	2	23	8
199	1	19.8	19.8	0.0	9.07	1.0	4	1	25	0	0	1	1	0	2	23	8.0	0	0	0	2	2	23	8
200	1	19.8	19.8	0.0	9.07	1.0	4	2	25	0	1	0	0	0	1	24	4.0	0	0	0	2	2	23	8
201	1	19.8	19.8	0.0	9.07	1.0	8	1	24	0	0	0	0	1	1	23	4.2	0	0	0	2	2	23	8
202	1	19.8	19.8	0.0	9.07	1.0	8	2	22	3	1	0	0	2	6	19	24.0	0	0	0	2	2	23	8
203	1	19.8	19.8	0.0	9.07	1.0	16	1	18	7	0	0	0	1	8	17	32.0	0	0	0	2	2	23	8
204	1	19.8	19.8	0.0	9.07	1.0	16	2	22	3	0	0	0	2	5	20	20.0	0	0	0	2	2	23	8
205	1	19.9	20.0	-0.1	9.07	1.5	2	1	25	0	0	0	0	1	1	24	4.0	0	0	0	2	2	23	8
206	1	19.9	20.0	-0.1	9.07	1.5	2	2	25	0	1	1	0	0	2	23	8.0	0	0	0	2	2	23	8
207	1	19.9	20.0	-0.1	9.07	1.5	4	1	25	0	1	0	1	0	2	23	8.0	0	0	0	2	2	23	8
208	1	19.9	20.0	-0.1	9.07	1.5	4	2	24	1	1	2	1	0	5	20	20.0	0	0	0	2	2	23	8
209	1	19.9	20.0	-0.1	9.07	1.5	8	1	18	7	1	0	0	0	8	17	32.0	0	0	0	2	2	23	8
210	1	19.9	20.0	-0.1	9.07	1.5	8	2	19	6	4	0	0	0	10	15	40.0	0	0	0	2	2	23	8
211	1	19.9	20.0	-0.1	9.07	2.0	2	1	25	0	2	0	0	0	2	23	8.0	0	0	0	2	2	23	8
212	1	19.9	20.0	-0.1	9.07	2.0	2	2	25	0	0	0	0	1	1	24	4.0	0	0	0	2	2	23	8

TABLE A-1

IMPINGEMENT SURVIVAL STUDY
1979 STRIPED BASS DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TEMP DIFF., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION	SEGMENT NO.	INITIAL LIVE	TEST: INITIAL DEAD	TEST: 24-HR. DEAD	TEST: 48-HR. DEAD	TEST: 72-HR. DEAD	TEST: 96-HR. DEAD	TEST: TOTAL DEAD	TEST: TOTAL LIVE	TEST: 96-HR. MORTALITY %	CONTROL: 24-HR. DEAD	CONTROL: 48-HR. DEAD	CONTROL: 72-HR. DEAD	CONTROL: 96-HR. DEAD	CONTROL: TOTAL DEAD	CONTROL: TOTAL LIVE	CONTROL: 96-HR. MORTALITY, %
213	1	19.9	20.0	-0.1	9.07	2.0	4	1	25	0	3	1	0	2	6	19	24.0	0	0	0	2	2	23	8.0
214	1	19.9	20.0	-0.1	9.07	2.0	4	2	25	0	3	0	0	1	4	21	16.0	0	0	0	2	2	23	8.0
215	1	20.0	20.0	0.0	9.07	3.0	2	1	17	8	0	0	0	1	9	16	36.0	0	0	0	2	2	23	8.0
216	1	20.0	20.0	0.0	9.07	3.0	2	2	23	3	1	1	0	1	6	20	23.1	0	0	0	2	2	23	8.0
217	1	20.0	20.0	0.0	9.07	3.0	4	1	3	22	1	0	0	0	23	2	92.0	0	0	0	2	2	23	8.0
218	1	20.0	20.0	0.0	9.07	3.0	4	2	12	13	6	0	1	0	20	5	80.0	0	0	0	2	2	23	8.0
219	1	19.0	21.2	-2.2	10.35	0.5	2	1	23	0	2	2	0	0	4	19	17.4	2	1	0	0	3	23	11.5
220	1	19.0	21.2	-2.2	10.35	0.5	2	2	25	0	0	0	0	0	0	25	0.0	2	1	0	0	3	23	11.5
221	1	19.0	21.2	-2.2	10.35	0.5	4	1	24	1	1	0	0	2	4	21	16.0	2	1	0	0	3	23	11.5
222	1	19.0	21.2	-2.2	10.35	0.5	4	2	25	0	0	0	0	0	0	25	0.0	2	1	0	0	3	23	11.5
223	1	19.0	21.2	-2.2	10.35	0.5	8	1	24	1	0	0	0	3	4	21	16.0	2	1	0	0	3	23	11.5
224	1	19.0	21.2	-2.2	10.35	0.5	8	2	23	1	1	0	0	2	4	20	16.7	2	1	0	0	3	23	11.5
225	1	19.0	21.2	-2.2	10.35	0.5	16	1	10	13	1	0	0	1	15	8	65.2	2	1	0	0	3	23	11.5
226	1	19.0	21.2	-2.2	10.35	0.5	16	2	24	1	2	0	2	3	8	17	32.0	2	1	0	0	3	23	11.5
227	1	19.0	21.3	-2.3	10.35	1.0	2	1	24	4	0	0	0	2	6	22	21.4	2	1	0	0	3	23	11.5
228	1	19.0	21.3	-2.3	10.35	1.0	2	2	24	1	1	1	0	1	4	21	16.0	2	1	0	0	3	23	11.5
229	1	19.0	21.3	-2.3	10.35	1.0	4	1	20	5	1	0	0	1	7	18	28.0	2	1	0	0	3	23	11.5
230	1	19.0	21.3	-2.3	10.35	1.0	4	2	22	3	1	0	0	0	4	21	16.0	2	1	0	0	3	23	11.5
231	1	19.0	21.8	-2.8	10.35	1.0	8	1	18	8	1	0	0	0	9	17	34.6	2	1	0	0	3	23	11.5
232	1	19.0	21.8	-2.8	10.35	1.0	8	2	14	11	0	0	0	4	15	10	60.0	2	1	0	0	3	23	11.5
233	1	19.0	21.8	-2.8	10.35	1.0	16	1	3	22	0	0	0	0	22	3	88.0	2	1	0	0	3	23	11.5
235	1	18.8	19.0	-0.2	9.88	1.5	2	1	23	1	0	0	0	0	1	23	4.2	0	0	0	0	0	25	0.0
236	1	18.8	19.0	-0.2	9.88	1.5	2	2	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0.0
237	1	18.8	19.0	-0.2	9.88	1.5	4	1	26	0	0	0	0	0	0	26	0.0	0	0	0	0	0	25	0.0
238	1	18.8	19.0	-0.2	9.88	1.5	4	2	23	2	0	0	0	0	2	23	8.0	0	0	0	0	0	25	0.0
239	1	18.8	19.0	-0.2	9.88	1.5	8	1	21	4	0	0	0	0	4	21	16.0	0	0	0	0	0	25	0.0
240	1	18.8	19.0	-0.2	9.88	1.5	8	2	12	13	0	0	0	0	13	12	52.0	0	0	0	0	0	25	0.0
241	1	19.0	19.3	-0.3	9.88	2.0	2	1	25	1	0	0	0	1	2	24	7.7	0	0	0	0	0	25	0.0
242	1	19.0	19.3	-0.3	9.88	2.0	2	2	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0.0
243	1	19.0	19.3	-0.3	9.88	2.0	4	1	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0.0
244	1	19.0	19.3	-0.3	9.88	2.0	4	2	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0.0
245	1	19.0	19.3	-0.3	9.88	3.0	2	1	22	4	0	0	1	2	7	19	26.9	0	0	0	0	0	25	0.0
246	1	19.0	19.3	-0.3	9.88	3.0	2	2	24	1	0	1	0	1	3	22	12.0	0	0	0	0	0	25	0.0
247	1	19.0	19.3	-0.3	9.88	3.0	4	1	13	12	0	0	0	1	13	12	52.0	0	0	0	0	0	25	0.0
248	1	19.0	19.3	-0.3	9.88	3.0	4	2	19	6	1	0	0	0	7	18	28.0	0	0	0	0	0	25	0.0
249	1	19.0	19.7	-0.7	9.88	0.5	2	1	25	0	0	0	0	1	1	24	4.0	0	1	0	0	1	24	4.0
250	1	19.0	19.7	-0.7	9.88	0.5	2	2	25	0	0	0	0	0	0	25	0.0	0	1	0	0	1	24	4.0
251	1	19.0	19.7	-0.7	9.88	0.5	4	1	25	0	0	0	0	2	2	23	8.0	0	1	0	0	1	24	4.0
252	1	19.0	19.7	-0.7	9.88	0.5	4	2	25	0	0	0	0	0	0	25	0.0	0	1	0	0	1	24	4.0
253	1	19.0	19.7	-0.7	9.88	0.5	8	1	22	0	0	0	0	0	0	22	0.0	0	1	0	0	1	24	4.0
254	1	19.0	19.7	-0.7	9.88	0.5	8	2	25	0	0	0	1	1	2	23	8.0	0	1	0	0	1	24	4.0
255	1	19.0	19.7	-0.7	9.88	0.5	16	1	18	7	0	0	1	0	8	17	32.0	0	1	0	0	1	24	4.0
256	1	19.0	19.7	-0.7	9.88	0.5	16	2	18	6	3	0	0	0	9	15	37.5	0	1	0	0	1	24	4.0
257	1	19.1	19.8	-0.7	9.88	1.0	2	1	24	1	0	0	0	0	1	24	4.0	0	0	0	0	0	25	0.0
258	1	19.1	19.8	-0.7	9.88	1.0	2	2	25	0	2	0	0	0	2	23	8.0	0	0	0	0	0	25	0.0
259	1	19.2	19.9	-0.7	9.88	1.0	4	1	23	1	0	0	0	0	1	23	4.2	0	0	0	0	0	25	0.0
260	1	19.2	19.9	-0.7	9.88	1.0	4	2	25	0	0	0	0	1	1	24	4.0	0	0	0	0	0	25	0.0
261	1	19.0	19.7	-0.7	9.88	1.0	8	1	24	1	0	0	0	0	1	24	4.0	0	0	0	0	0	25	0.0
262	1	19.0	19.7	-0.7	9.88	1.0	8	2	24	1	1	0	0	1	3	22	12.0	0	0	0	0	0	25	0.0
263	1	19.0	19.7	-0.7	9.88	1.0	16	1	26	0	1	0	0	0	1	25	3.8	0	0	0	0	0	25	0.0
264	1	19.0	19.7	-0.7	9.88	1.0	16	2	25	0	1	0	0	0	1	24	4.0	0	0	0	0	0	25	0.0
265	1	18.8	20.9	-2.1	9.88	1.5	2	1	25	0	0	1	0	0	1	24	4.0	0	1	0	0	1	24	4.0
266	1	18.8	20.9	-2.1	9.88	1.5	2	2	25	0	0	0	0	1	1	24	4.0	0	1	0	0	1	24	4.0

TABLE A-1

IMPINGEMENT SURVIVAL STUDY
1979 STRIPED BASS DATA

									TEST									CONTROL						
TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TEMP DIFF., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION	SEGMENT NO.	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY %	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
267	1	18.8	21.0	-2.2	9.88	1.5	4	1	25	0	0	0	0	0	0	25	0.0	0	1	0	0	1	24	4.0
268	1	18.8	21.0	-2.2	9.88	1.5	4	2	25	0	0	0	0	1	1	24	4.0	0	1	0	0	1	24	4.0
269	1	18.8	21.0	-2.2	9.88	1.5	8	1	25	0	0	0	0	0	0	25	0.0	0	1	0	0	1	24	4.0
270	1	18.8	21.0	-2.2	9.88	1.5	8	2	21	4	0	0	0	1	5	20	20.0	0	1	0	0	1	24	4.0
271	1	18.8	21.0	-2.2	9.88	2.0	2	1	25	0	0	0	0	0	0	25	0.0	0	1	0	0	1	24	4.0
272	1	18.8	21.0	-2.2	9.88	2.0	2	2	25	0	0	0	0	0	0	25	0.0	0	1	0	0	1	24	4.0
273	1	18.8	21.0	-2.2	9.88	2.0	4	1	24	1	0	0	1	1	3	22	12.0	0	1	0	0	1	24	4.0
274	1	18.8	21.0	-2.2	9.88	2.0	4	2	25	0	0	0	0	0	0	25	0.0	0	1	0	0	1	24	4.0
275	1	18.8	21.0	-2.2	9.88	3.0	2	1	23	2	0	2	0	0	4	21	16.0	0	1	0	0	1	24	4.0
276	1	18.8	21.0	-2.2	9.88	3.0	2	2	22	5	1	0	1	1	8	19	29.6	0	1	0	0	1	24	4.0
277	1	18.8	21.0	-2.2	9.88	3.0	4	1	6	18	0	0	0	0	18	6	75.0	0	1	0	0	1	24	4.0
278	1	18.8	21.0	-2.2	9.88	3.0	4	2	13	12	0	0	0	0	12	13	48.0	0	1	0	0	1	24	4.0
279	1	18.2	19.0	-0.8	10.83	0.5	2	1	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0.0
280	1	18.2	19.0	-0.8	10.83	0.5	2	2	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0.0
281	1	18.2	19.0	-0.8	10.83	0.5	4	1	23	0	0	1	0	1	2	21	8.7	0	0	0	0	0	25	0.0
282	1	18.2	19.0	-0.8	10.83	0.5	4	2	25	0	0	2	0	0	2	23	8.0	0	0	0	0	0	25	0.0
283	1	18.2	19.0	-0.8	10.83	0.5	8	1	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0.0
284	1	18.2	19.0	-0.8	10.83	0.5	8	2	25	0	1	0	0	1	2	23	8.0	0	0	0	0	0	25	0.0
285	1	18.2	19.0	-0.8	10.83	0.5	16	1	21	4	0	0	0	0	4	21	16.0	0	0	0	0	0	25	0.0
286	1	18.2	19.0	-0.8	10.83	0.5	16	2	20	5	0	0	0	0	5	20	20.0	0	0	0	0	0	25	0.0
287	1	18.2	19.1	-0.9	10.83	1.0	2	1	25	0	0	0	0	2	2	23	8.0	0	0	0	0	0	25	0.0
288	1	18.2	19.1	-0.9	10.83	1.0	2	2	25	0	0	0	0	2	2	23	8.0	0	0	0	0	0	25	0.0
289	1	18.2	19.1	-0.9	10.83	1.0	4	1	26	0	0	0	0	1	1	25	3.8	0	0	0	0	0	25	0.0
290	1	18.2	19.1	-0.9	10.83	1.0	4	2	25	0	0	0	0	2	2	23	8.0	0	0	0	0	0	25	0.0
291	1	19.0	19.2	-0.2	10.83	1.0	8	1	15	11	0	0	0	1	12	14	46.2	0	0	0	0	0	25	0.0
292	1	19.0	19.2	-0.2	10.83	1.0	8	2	16	9	0	0	0	0	9	16	36.0	0	0	0	0	0	25	0.0
293	1	19.0	19.2	-0.2	10.83	1.0	16	1	0	24	0	0	0	0	24	0	100.0	0	0	0	0	0	25	0.0
294	1	19.0	19.2	-0.2	10.83	1.0	16	2	0	24	0	0	0	0	24	0	100.0	0	0	0	0	0	25	0.0
295	1	18.0	19.5	-1.5	10.83	1.5	2	1	23	2	0	0	0	0	2	23	8.0	0	0	0	0	0	25	0.0
296	1	18.0	19.5	-1.5	10.83	1.5	2	2	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0.0
297	1	18.0	19.7	-1.7	10.83	1.5	4	1	22	3	0	0	0	2	5	20	20.0	0	0	0	0	0	25	0.0
298	1	18.0	19.7	-1.7	10.83	1.5	4	2	24	1	0	0	0	4	5	20	20.0	0	0	0	0	0	25	0.0
299	1	18.0	19.7	-1.7	10.83	1.5	8	1	0	25	0	0	0	0	25	0	100.0	0	0	0	0	0	25	0.0
300	1	18.0	19.7	-1.7	10.83	1.5	8	2	3	21	0	0	0	0	21	3	87.5	0	0	0	0	0	25	0.0
301	1	20.0	19.0	1.0	10.80	2.0	2	1	25	0	3	1	2	1	7	18	28.0	1	0	0	0	1	24	4.0
302	1	20.0	19.0	1.0	10.80	2.0	2	2	24	0	1	0	0	0	1	23	4.2	1	0	0	0	1	24	4.0
303	1	20.0	19.0	1.0	10.80	2.0	4	1	23	2	0	0	2	2	6	19	24.0	1	0	0	0	1	24	4.0
304	1	20.0	19.0	1.0	10.80	2.0	4	2	23	2	7	2	1	1	13	12	52.0	1	0	0	0	1	24	4.0
305	1	20.0	19.0	1.0	10.80	3.0	2	1	18	7	0	0	0	1	8	17	32.0	1	0	0	0	1	24	4.0
306	1	20.0	19.0	1.0	10.80	3.0	2	2	17	9	1	0	0	1	11	15	42.3	1	0	0	0	1	24	4.0
307	1	20.0	19.0	1.0	10.80	3.0	4	1	3	22	0	0	0	0	22	3	88.0	1	0	0	0	1	24	4.0
308	1	20.0	19.0	1.0	10.80	3.0	4	2	7	17	0	0	0	1	18	6	75.0	1	0	0	0	1	24	4.0
309	1	21.8	21.0	0.8	11.89	0.5	2	1	25	0	0	0	2	1	3	22	12.0	0	1	0	1	2	24	7.7
310	1	21.8	21.0	0.8	11.89	0.5	4	2	24	1	0	0	0	1	2	23	8.0	0	1	0	1	2	24	7.7
311	1	21.8	21.0	0.8	11.89	0.5	8	1	26	0	0	0	0	2	2	24	7.7	0	1	0	1	2	24	7.7
312	1	21.8	21.0	0.8	11.89	0.5	16	2	23	2	2	4	0	1	9	16	36.0	0	1	0	1	2	24	7.7
313	1	21.8	21.0	0.8	11.89	1.0	2	1	24	0	1	1	1	0	3	21	12.5	0	1	0	1	2	24	7.7
314	1	21.8	21.0	0.8	11.89	1.0	4	2	24	1	1	0	0	2	4	21	16.0	0	1	0	1	2	24	7.7
315	1	21.8	21.5	0.3	11.89	1.0	8	1	20	5	0	3	0	0	8	17	32.0	0	1	0	1	2	24	7.7
316	1	21.8	21.5	0.3	11.89	1.0	16	2	17	8	0	0	0	2	10	15	40.0	0	1	0	1	2	24	7.7
317	1	21.8	21.6	0.2	11.89	1.5	2	1	26	0	2	1	0	4	7	19	26.9	0	1	0	1	2	24	7.7
318	1	21.8	21.6	0.2	11.89	1.5	4	2	26	0	3	0	0	6	9	17	34.6	0	1	0	1	2	24	7.7
319	1	21.8	21.6	0.2	11.89	1.5	8	1	15	10	0	0	0	0	10	15	40.0	0	1	0	1	2	24	7.7

TABLE A-1

IMPINGEMENT SURVIVAL STUDY
1979 STRIPED BASS DATA

									TEST									CONTROL						
TEST NO.	SPECIES	TANK TEMP, °C	FLUME TEMP., °C	TEMP DIFF., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION	SEGMENT NO.	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY %	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
320	1	21.8	21.6	0.2	11.89	1.5	8	2	17	6	0	0	0	0	6	17	26.1	0	1	0	1	2	24	7.7
321	1	21.8	21.6	0.2	11.89	1.5	16	1	1	24	0	0	0	0	24	1	96.0	0	1	0	1	2	24	7.7
322	1	21.8	21.6	0.2	11.89	1.5	16	2	1	24	0	0	0	0	24	1	96.0	0	1	0	1	2	24	7.7
323	1	22.0	22.0	0.0	11.89	2.0	2	1	25	0	1	1	1	0	3	22	12.0	0	1	0	1	2	24	7.7
324	1	22.0	22.0	0.0	11.89	2.0	2	2	24	1	0	2	1	1	5	20	20.0	0	1	0	1	2	24	7.7
325	1	22.0	22.0	0.0	11.89	2.0	4	1	24	1	0	2	0	0	3	22	12.0	0	1	0	1	2	24	7.7
326	1	22.0	22.0	0.0	11.89	2.0	4	2	24	0	1	2	0	0	3	21	12.5	0	1	0	1	2	24	7.7
327	1	22.0	22.0	0.0	11.89	2.0	8	1	14	11	0	0	0	0	11	14	44.0	0	1	0	1	2	24	7.7
328	1	22.0	22.0	0.0	11.89	2.0	8	2	5	20	0	0	1	0	21	4	84.0	0	1	0	1	2	24	7.7
329	1	22.0	22.0	0.0	11.89	3.0	2	1	16	9	0	0	0	1	10	15	40.0	0	1	0	1	2	24	7.7
330	1	22.0	22.0	0.0	11.89	3.0	2	2	20	5	1	0	0	0	6	19	24.0	0	1	0	1	2	24	7.7
331	1	22.0	22.0	0.0	11.89	3.0	4	1	5	19	0	0	0	0	19	5	79.2	0	1	0	1	2	24	7.7
332	1	22.0	22.0	0.0	11.89	3.0	4	2	6	16	0	0	0	0	16	6	72.7	0	1	0	1	2	24	7.7
333	1	19.8	21.0	-1.2	13.08	0.5	2	2	24	0	1	0	0	0	1	23	4.2	0	0	0	0	0	25	0.0
334	1	19.8	21.0	-1.2	13.08	0.5	4	1	24	0	1	0	2	1	4	20	16.7	0	0	0	0	0	25	0.0
335	1	19.8	21.0	-1.2	13.08	0.5	8	2	24	1	0	0	1	0	2	23	8.0	0	0	0	0	0	25	0.0
336	1	19.8	21.0	-1.2	13.08	0.5	16	1	19	7	1	0	1	0	9	17	34.6	0	0	0	0	0	25	0.0
337	1	19.8	21.0	-1.2	13.08	1.0	2	2	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0.0
338	1	19.8	21.0	-1.2	13.08	1.0	4	1	24	1	0	2	0	0	3	22	12.0	0	0	0	0	0	25	0.0
339	1	19.8	21.0	-1.2	13.08	1.0	8	1	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0.0
340	1	19.8	21.0	-1.2	13.08	1.0	8	2	25	0	0	0	0	1	1	24	4.0	0	0	0	0	0	25	0.0
341	1	20.0	21.1	-1.1	13.08	1.0	16	1	0	25	0	0	0	0	25	0	100.0	0	0	0	0	0	25	0.0
342	1	20.0	21.1	-1.1	13.08	1.0	16	2	5	20	0	0	0	0	20	5	80.0	0	0	0	0	0	25	0.0
343	1	20.0	21.1	-1.1	13.08	1.5	2	1	24	1	1	0	1	0	3	22	12.0	0	0	0	0	0	25	0.0
344	1	20.0	21.1	-1.1	13.08	1.5	2	2	25	0	0	2	1	0	3	22	12.0	0	0	0	0	0	25	0.0
345	1	20.0	21.1	-1.1	13.08	1.5	4	1	23	2	3	0	2	0	7	18	28.0	0	0	0	0	0	25	0.0
346	1	20.0	21.1	-1.1	13.08	1.5	4	2	24	1	2	0	0	2	5	20	20.0	0	0	0	0	0	25	0.0
347	1	20.0	21.8	-1.8	13.08	1.5	8	1	19	6	0	2	0	1	9	16	36.0	0	0	0	0	0	25	0.0
348	1	20.0	21.8	-1.8	13.08	1.5	8	2	18	7	1	0	0	0	8	17	32.0	0	0	0	0	0	25	0.0
349	1	19.3	22.0	-2.7	13.08	2.0	2	1	28	0	1	1	0	0	2	26	7.1	0	0	0	0	0	25	0.0
350	1	19.3	22.0	-2.7	13.08	2.0	2	2	25	0	0	1	0	1	2	23	8.0	0	0	0	0	0	25	0.0
351	1	19.3	22.0	-2.7	13.08	2.0	4	1	23	2	0	2	0	0	4	21	16.0	0	0	0	0	0	25	0.0
352	1	19.3	22.0	-2.7	13.08	2.0	4	2	23	2	0	1	1	0	4	21	16.0	0	0	0	0	0	25	0.0
353	1	19.3	22.0	-2.7	13.08	2.0	8	1	12	13	0	0	0	0	13	12	52.0	0	0	0	0	0	25	0.0
354	1	19.3	22.0	-2.7	13.08	2.0	8	2	6	19	0	0	0	0	19	6	76.0	0	0	0	0	0	25	0.0
355	1	19.3	22.0	-2.7	13.08	3.0	2	1	15	9	0	1	0	0	10	14	41.7	0	0	0	0	0	25	0.0
356	1	19.3	22.0	-2.7	13.08	3.0	2	2	18	4	0	2	0	0	6	16	27.3	0	0	0	0	0	25	0.0
357	1	19.3	22.0	-2.7	13.08	3.0	4	1	6	19	0	0	0	0	19	6	76.0	0	0	0	0	0	25	0.0
358	1	19.3	22.0	-2.7	13.08	3.0	4	2	2	23	0	0	0	0	23	2	92.0	0	0	0	0	0	25	0.0
359	1	19.2	16.5	2.7	11.69	0.5	2	1	24	0	1	1	0	1	3	21	12.5	2	2	0	2	6	19	24.0
360	1	19.2	16.5	2.7	11.69	0.5	4	2	25	0	0	0	0	0	0	25	0.0	2	2	0	2	6	19	24.0
361	1	19.2	17.1	2.1	11.69	0.5	8	1	24	1	1	0	0	0	2	23	8.0	2	2	0	2	6	19	24.0
362	1	19.2	17.1	2.1	11.69	0.5	16	2	17	8	0	1	0	0	9	16	36.0	2	2	0	2	6	19	24.0
363	1	19.2	17.2	2.0	11.69	1.0	2	1	25	0	0	0	0	0	0	25	0.0	2	2	0	2	6	19	24.0
364	1	19.2	17.2	2.0	11.69	1.0	4	2	25	0	1	1	0	0	2	23	8.0	2	2	0	2	6	19	24.0
365	1	19.2	17.2	2.0	11.69	1.0	8	1	20	6	0	0	0	0	6	20	23.1	2	2	0	2	6	19	24.0
366	1	19.2	17.2	2.0	11.69	1.0	8	2	22	3	0	0	2	1	6	19	24.0	2	2	0	2	6	19	24.0
367	1	19.2	17.5	1.7	11.69	1.0	16	1	15	10	0	0	0	0	10	15	40.0	2	2	0	2	6	19	24.0
368	1	19.2	17.5	1.7	11.69	1.0	16	2	18	7	0	0	0	1	8	17	32.0	2	2	0	2	6	19	24.0
369	1	19.3	18.1	1.2	11.69	1.5	2	1	25	0	0	0	0	0	0	25	0.0	2	2	0	2	6	19	24.0
370	1	19.3	18.1	1.2	11.69	1.5	2	2	24	0	0	0	1	0	1	23	4.2	2	2	0	2	6	19	24.0
371	1	19.3	18.2	1.1	11.69	1.5	4	1	25	0	0	0	0	0	0	25	0.0	2	2	0	2	6	19	24.0
372	1	19.3	18.2	1.1	11.69	1.5	4	2	25	0	0	0	0	0	0	25	0.0	2	2	0	2	6	19	24.0

TABLE A-1

IMPINGEMENT SURVIVAL STUDY
1979 STRIPED BASS DATA

									TEST									CONTROL						
TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TEMP DIFF., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION	SEGMENT NO.	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY %	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
373	1	19.3	18.2	1.1	11.69	1.5	8	1	25	0	0	1	0	0	1	24	4.0	2	2	0	2	6	19	24
374	1	19.3	18.2	1.1	11.69	1.5	8	2	25	0	0	1	1	1	3	22	12.0	2	2	0	2	6	19	24
375	1	19.3	18.9	0.4	11.69	2.0	2	1	24	0	0	0	0	0	0	24	0.0	2	2	0	2	6	19	24
376	1	19.3	18.9	0.4	11.69	2.0	2	2	26	0	0	0	2	0	2	24	7.7	2	2	0	2	6	19	24
377	1	19.3	19.0	0.3	11.69	2.0	4	1	23	0	0	0	0	0	0	23	0.0	2	2	0	2	6	19	24
378	1	19.3	19.0	0.3	11.69	2.0	4	2	25	0	0	0	2	0	2	23	8.0	2	2	0	2	6	19	24
379	1	19.3	19.0	0.3	11.69	2.0	8	1	25	0	0	1	1	1	3	22	12.0	2	2	0	2	6	19	24
380	1	19.3	19.0	0.3	11.69	2.0	8	2	20	5	0	0	1	1	7	18	28.0	2	2	0	2	6	19	24
381	1	19.3	20.0	-0.7	11.69	3.0	2	1	25	0	0	0	0	0	0	25	0.0	2	2	0	2	6	19	24
382	1	19.3	20.0	-0.7	11.69	3.0	2	2	25	0	0	0	0	0	0	25	0.0	2	2	0	2	6	19	24
383	1	19.3	20.0	-0.7	11.69	3.0	4	1	20	5	0	0	0	0	5	20	20.0	2	2	0	2	6	19	24
384	1	19.3	20.0	-0.7	11.69	3.0	4	2	24	1	1	0	0	1	3	22	12.0	2	2	0	2	6	19	24
385	1	20.3	21.1	-0.8	13.31	0.5	2	2	24	0	0	0	1	0	1	23	4.2	0	0	0	0	0	23	0
386	1	20.3	21.1	-0.8	13.31	0.5	4	1	24	0	1	0	0	0	1	23	4.2	0	0	0	0	0	23	0
387	1	20.3	21.1	-0.8	13.31	0.5	8	2	24	0	0	2	0	0	2	22	8.3	0	0	0	0	0	23	0
388	1	20.3	21.1	-0.8	13.31	0.5	16	1	24	0	2	0	3	0	5	19	20.8	0	0	0	0	0	23	0
389	1	20.3	21.5	-1.2	13.31	1.0	2	2	25	0	0	0	1	0	1	24	4.0	0	0	0	0	0	23	0
390	1	20.3	21.5	-1.2	13.31	1.0	4	1	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	23	0
391	1	20.3	21.5	-1.2	13.31	1.0	8	1	24	1	0	1	0	0	2	23	8.0	0	0	0	0	0	23	0
392	1	20.3	21.5	-1.2	13.31	1.0	8	2	25	1	2	0	0	3	6	20	23.1	0	0	0	0	0	23	0
393	1	20.3	21.8	-1.5	13.31	1.0	16	1	13	13	0	3	2	0	18	8	69.2	0	0	0	0	0	23	0
394	1	20.3	21.8	-1.5	13.31	1.0	16	2	13	15	4	0	0	0	19	9	67.9	0	0	0	0	0	23	0
395	1	20.3	22.0	-1.7	13.31	1.5	2	1	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	23	0
396	1	20.3	22.0	-1.7	13.31	1.5	2	2	26	0	0	0	0	1	1	25	3.8	0	0	0	0	0	23	0
397	1	20.3	22.0	-1.7	13.31	1.5	4	1	25	0	0	0	0	1	1	24	4.0	0	0	0	0	0	23	0
398	1	20.3	22.0	-1.7	13.31	1.5	4	2	26	0	0	0	0	0	0	26	0.0	0	0	0	0	0	23	0
399	1	20.3	22.0	-1.7	13.31	1.5	8	1	21	4	0	0	0	1	5	20	20.0	0	0	0	0	0	23	0
400	1	20.3	22.0	-1.7	13.31	1.5	8	2	25	0	1	1	2	0	4	21	16.0	0	0	0	0	0	23	0
401	1	20.3	22.0	-1.7	13.31	2.0	2	1	25	0	0	0	0	1	1	24	4.0	0	0	0	0	0	23	0
402	1	20.3	22.0	-1.7	13.31	2.0	2	2	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	23	0
403	1	20.3	22.0	-1.7	13.31	2.0	4	1	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	23	0
404	1	20.3	22.0	-1.7	13.31	2.0	4	2	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	23	0
405	1	20.3	22.0	-1.7	13.31	2.0	8	1	20	6	0	1	0	0	7	19	26.9	0	0	0	0	0	23	0
406	1	20.3	22.0	-1.7	13.31	2.0	8	2	20	5	0	0	0	0	5	20	20.0	0	0	0	0	0	23	0
407	1	20.3	22.0	-1.7	13.31	3.0	2	1	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	23	0
408	1	20.3	22.0	-1.7	13.31	3.0	2	2	23	2	1	1	0	0	4	21	16.0	0	0	0	0	0	23	0
409	1	20.3	22.0	-1.7	13.31	3.0	4	1	20	5	0	0	0	0	5	20	20.0	0	0	0	0	0	23	0
410	1	20.3	22.0	-1.7	13.31	3.0	4	2	21	4	0	0	0	0	4	21	16.0	0	0	0	0	0	23	0
411	1	19.8	18.8	1.0	15.75	0.5	2	1	22	0	0	0	0	0	0	22	0.0	0	0	0	0	0	25	0
412	1	19.8	18.8	1.0	15.75	0.5	4	2	24	0	0	0	0	0	0	24	0.0	0	0	0	0	0	25	0
413	1	19.8	18.8	1.0	15.75	0.5	8	1	23	0	0	0	0	0	0	23	0.0	0	0	0	0	0	25	0
414	1	19.8	18.8	1.0	15.75	0.5	16	2	22	0	0	0	0	0	0	22	0.0	0	0	0	0	0	25	0
415	1	19.8	19.0	0.8	15.75	1.0	2	1	22	0	0	0	0	0	0	22	0.0	0	0	0	0	0	25	0
416	1	19.8	19.0	0.8	15.75	1.0	4	2	24	0	0	0	1	0	1	23	4.2	0	0	0	0	0	25	0
417	1	19.8	19.0	0.8	15.75	1.0	8	1	22	3	0	0	1	0	4	21	16.0	0	0	0	0	0	25	0
418	1	19.8	19.0	0.8	15.75	1.0	16	2	20	5	6	0	0	0	11	14	44.0	0	0	0	0	0	25	0
419	1	19.8	19.2	0.6	15.75	1.5	2	1	26	0	0	0	0	0	0	26	0.0	0	0	0	0	0	25	0
420	1	19.8	19.2	0.6	15.75	1.5	2	2	27	0	0	0	0	0	0	27	0.0	0	0	0	0	0	25	0
421	1	19.8	19.2	0.6	15.75	1.5	4	1	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0
422	1	19.8	19.2	0.6	15.75	1.5	4	2	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0
423	1	19.8	19.2	0.6	15.75	1.5	8	1	25	0	1	1	0	0	2	23	8.0	0	0	0	0	0	25	0
424	1	19.8	19.2	0.6	15.75	1.5	8	2	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0
425	1	19.8	19.5	0.3	15.75	2.0	2	1	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0

TABLE A-1

IMPINGEMENT SURVIVAL STUDY
1979 STRIPED BASS DATA

									TEST									CONTROL						
TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TEMP DIFF., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION	SEGMENT NO.	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY %	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
426	1	19.8	19.5	0.3	15.75	2.0	2	2	24	0	0	0	0	0	0	24	0.0	0	0	0	0	0	25	0
427	1	19.8	19.5	0.3	15.75	2.0	4	1	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0
428	1	19.8	19.5	0.3	15.75	2.0	4	2	25	0	1	0	0	0	1	24	4.0	0	0	0	0	0	25	0
429	1	19.8	19.6	0.2	15.75	2.0	8	1	23	2	0	1	0	2	5	20	20.0	0	0	0	0	0	25	0
430	1	19.8	19.6	0.2	15.75	2.0	8	2	20	4	0	0	1	0	5	19	20.8	0	0	0	0	0	25	0
431	1	19.8	19.8	0.0	15.75	3.0	2	1	24	0	0	0	0	0	0	24	0.0	0	0	0	0	0	25	0
432	1	19.8	19.8	0.0	15.75	3.0	2	2	24	0	0	0	0	0	0	24	0.0	0	0	0	0	0	25	0
433	1	19.8	19.8	0.0	15.75	3.0	4	1	25	0	0	3	0	0	3	22	12.0	0	0	0	0	0	25	0
434	1	19.8	19.8	0.0	15.75	3.0	4	2	25	0	0	0	2	0	2	23	8.0	0	0	0	0	0	25	0
435	1	20.5	19.0	1.5	16.32	1.0	2	1	24	1	0	0	0	0	1	24	4.0	0	0	0	0	0	25	0
436	1	20.5	19.0	1.5	16.32	1.0	4	2	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0
437	1	20.5	19.0	1.5	16.32	1.0	8	1	23	0	0	0	0	0	0	23	0.0	0	0	0	0	0	25	0
438	1	20.5	19.0	1.5	16.32	1.0	8	2	21	4	0	0	0	0	4	21	16.0	0	0	0	0	0	25	0
439	1	20.5	19.2	1.3	16.32	1.0	16	1	21	4	0	0	0	1	5	20	20.0	0	0	0	0	0	25	0
440	1	20.5	19.2	1.3	16.32	1.0	16	2	16	9	0	0	0	0	9	16	36.0	0	0	0	0	0	25	0
441	1	20.5	20.0	0.5	16.32	1.5	2	1	25	0	0	0	0	1	1	24	4.0	0	0	0	0	0	25	0
442	1	20.5	20.0	0.5	16.32	1.5	2	2	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0
443	1	20.5	20.0	0.5	16.32	1.5	4	1	24	1	0	0	0	0	1	24	4.0	0	0	0	0	0	25	0
444	1	20.5	20.0	0.5	16.32	1.5	4	2	24	0	0	0	0	1	1	23	4.2	0	0	0	0	0	25	0
445	1	20.5	20.0	0.5	16.32	1.5	8	1	21	4	1	0	0	0	5	20	20.0	0	0	0	0	0	25	0
446	1	20.5	20.0	0.5	16.32	1.5	8	2	23	2	0	0	0	0	2	23	8.0	0	0	0	0	0	25	0
447	1	20.5	19.2	1.3	16.32	2.0	2	1	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0
448	1	20.5	19.2	1.3	16.32	2.0	2	2	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0
449	1	20.5	19.6	0.9	16.32	2.0	4	1	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0
450	1	20.5	19.6	0.9	16.32	2.0	4	2	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0
451	1	20.5	19.6	0.9	16.32	2.0	8	1	25	2	0	0	0	0	2	25	7.4	0	0	0	0	0	25	0
452	1	20.5	19.6	0.9	16.32	2.0	8	2	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0
453	1	20.5	20.0	0.5	16.32	3.0	2	1	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0
454	1	20.5	20.0	0.5	16.32	3.0	2	2	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0
455	1	20.5	20.0	0.5	16.32	3.0	4	1	20	5	0	0	0	0	5	20	20.0	0	0	0	0	0	25	0
456	1	20.5	20.0	0.5	16.32	3.0	4	2	21	3	1	0	0	0	4	20	16.7	0	0	0	0	0	25	0
457	1	20.5	20.9	-0.4	17.40	1.0	2	1	25	0	0	0	0	4	4	21	16.0	0	0	0	0	0	26	0
458	1	20.5	20.9	-0.4	17.40	1.0	4	2	25	0	0	0	0	2	2	23	8.0	.	.	.	.	.	.	0
459	1	20.5	20.9	-0.4	17.40	1.0	8	1	25	0	2	0	0	2	4	21	16.0	.	.	.	.	.	.	0
460	1	20.5	20.9	-0.4	17.40	1.0	16	2	14	11	0	0	0	1	12	13	48.0	.	.	.	.	.	.	0
461	1	20.5	21.0	-0.5	17.40	1.5	2	1	23	2	0	0	0	2	4	21	16.0	.	.	.	.	.	.	0
462	1	20.5	21.0	-0.5	17.40	1.5	4	2	25	1	0	0	0	0	1	25	3.8	.	.	.	.	.	.	0
463	1	20.5	21.0	-0.5	17.40	1.5	8	1	24	3	1	0	0	0	4	23	14.8	.	.	.	.	.	.	0
464	1	20.5	21.2	-0.7	17.40	2.0	2	1	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	0
465	1	20.5	21.2	-0.7	17.40	2.0	4	2	24	1	1	0	0	3	5	20	20.0	.	.	.	.	.	.	0
466	1	20.5	21.1	-0.6	17.40	2.0	8	1	20	5	0	0	2	0	7	18	28.0	.	.	.	.	.	.	0
467	1	20.5	21.5	-1.0	17.40	3.0	2	1	24	0	1	0	0	3	4	20	16.7	.	.	.	.	.	.	0
468	1	20.5	21.5	-1.0	17.40	3.0	4	2	23	1	0	0	0	0	1	23	4.2	.	.	.	.	.	.	0
469	1	20.3	19.9	0.4	18.02	1.0	2	1	24	0	0	0	0	0	0	24	0.0	0	0	0	0	0	25	0
470	1	20.3	19.9	0.4	18.02	1.0	4	2	25	0	0	0	0	1	1	24	4.0	.	.	.	.	.	.	0
471	1	20.3	20.0	0.3	18.02	1.0	8	1	25	0	0	0	1	1	2	23	8.0	.	.	.	.	.	.	0
472	1	20.3	20.0	0.3	18.02	1.0	8	2	24	1	0	1	0	1	3	22	12.0	.	.	.	.	.	.	0
473	1	20.3	20.0	0.3	18.02	1.0	16	1	10	15	0	0	1	0	16	9	64.0	.	.	.	.	.	.	0
474	1	20.3	20.0	0.3	18.02	1.0	16	2	20	5	1	0	0	0	6	19	24.0	.	.	.	.	.	.	0
475	1	20.3	20.2	0.1	18.02	1.5	2	1	24	0	0	0	0	1	1	23	4.2	.	.	.	.	.	.	0
476	1	20.3	20.2	0.1	18.02	1.5	2	2	25	0	0	0	22	2	24	1	96.0	.	.	.	.	.	.	0
477	1	20.3	20.2	0.1	18.02	1.5	4	1	25	0	0	0	1	0	1	24	4.0	.	.	.	.	.	.	0
478	1	20.3	20.2	0.1	18.02	1.5	4	2	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	25	0

TABLE A-1

IMPINGEMENT SURVIVAL STUDY
1979 STRIPED BASS DATA

									TEST									CONTROL						
TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TEMP DIFF., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION	SEGMENT NO.	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY %	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
479	1	20.3	20.2	0.1	18.02	1.5	8	1	24	1	0	0	0	1	2	23	8.0	.	.	.	.	.	.	0
480	1	20.3	20.2	0.1	18.02	1.5	8	2	24	1	0	0	0	0	1	24	4.0	.	.	.	.	.	.	0
481	1	20.3	20.9	-0.6	18.02	2.0	2	1	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	0
482	1	20.3	20.9	-0.6	18.02	2.0	2	2	24	1	0	0	0	1	2	23	8.0	.	.	.	.	.	.	0
483	1	20.3	20.9	-0.6	18.02	2.0	4	1	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	0
484	1	20.3	20.9	-0.6	18.02	2.0	4	2	23	2	0	0	1	0	3	22	12.0	.	.	.	.	.	.	0
485	1	20.3	21.1	-0.8	18.02	2.0	8	1	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	0
486	1	20.3	21.1	-0.8	18.02	2.0	8	2	19	6	0	0	0	0	6	19	24.0	.	.	.	.	.	.	0
487	1	20.3	21.2	-0.9	18.02	3.0	2	1	25	0	0	1	1	0	2	23	8.0	.	.	.	.	.	.	0
488	1	20.3	21.2	-0.9	18.02	3.0	2	2	25	0	0	1	0	0	1	24	4.0	.	.	.	.	.	.	0
489	1	20.3	21.2	-0.9	18.02	3.0	4	1	23	2	0	0	1	0	3	22	12.0	.	.	.	.	.	.	0
490	1	20.3	21.2	-0.9	18.02	3.0	4	2	24	1	0	0	1	0	2	23	8.0	.	.	.	.	.	.	0
491	1	20.3	23.1	-2.8	21.45	1.0	2	1	21	0	0	0	1	0	1	20	4.8	.	.	.	.	.	.	0
492	1	20.3	23.1	-2.8	21.45	1.0	4	2	20	0	0	2	5	2	9	11	45.0	.	.	.	.	.	.	0
493	1	20.3	23.1	-2.8	21.45	1.0	8	1	24	0	9	0	2	0	11	13	45.8	.	.	.	.	.	.	0
494	1	20.3	23.1	-2.8	21.45	1.0	16	2	8	19	2	0	1	0	22	5	81.5	.	.	.	.	.	.	0
495	1	20.3	23.1	-2.8	21.45	1.5	2	1	24	0	0	1	0	0	1	23	4.2	.	.	.	.	.	.	0
496	1	20.3	23.1	-2.8	21.45	1.5	4	1	25	2	0	0	5	2	9	18	33.3	.	.	.	.	.	.	0
497	1	20.3	23.1	-2.8	21.45	1.5	8	1	17	8	4	3	8	1	24	1	96.0	.	.	.	.	.	.	0
498	1	20.3	23.1	-2.8	21.45	1.5	16	2	0	25	0	0	0	0	25	0	100.0	0	0	0	0	0	25	0
499	1	20.3	23.3	-3.0	21.45	2.0	2	1	24	1	1	1	2	1	6	19	24.0	.	.	.	.	.	.	0
500	1	20.3	23.3	-3.0	21.45	2.0	4	2	22	3	1	0	0	0	4	21	16.0	.	.	.	.	.	.	0
501	1	20.3	23.5	-3.2	21.45	2.0	8	1	17	8	7	0	0	0	15	10	60.0	.	.	.	.	.	.	0
502	1	20.3	23.5	-3.2	21.45	2.0	16	2	0	25	0	0	0	0	25	0	100.0	.	.	.	.	.	.	0
503	1	20.3	23.5	-3.2	21.45	3.0	2	1	25	0	2	1	1	1	5	20	20.0	.	.	.	.	.	.	0
504	1	20.3	23.5	-3.2	21.45	3.0	4	2	20	5	8	0	0	0	13	12	52.0	.	.	.	.	.	.	0
505	1	20.5	19.5	1.0	17.20	1.0	4	1	24	0	0	1	2	0	3	21	12.5	0	0	2	0	3	22	12
506	1	20.5	19.5	1.0	17.20	1.0	4	2	24	0	0	0	0	0	0	24	0.0	.	.	.	.	.	.	12
507	1	20.5	19.5	1.0	17.20	1.0	8	1	25	0	1	1	0	1	3	22	12.0	.	.	.	.	.	.	12
508	1	20.5	19.5	1.0	17.20	1.0	8	2	25	0	1	0	0	0	1	24	4.0	.	.	.	.	.	.	12
509	1	20.5	19.5	1.0	17.20	1.0	16	1	24	1	0	2	1	0	4	21	16.0	.	.	.	.	.	.	12
510	1	20.5	19.5	1.0	17.20	1.0	16	2	20	5	1	0	0	0	6	19	24.0	.	.	.	.	.	.	12
511	1	20.5	20.0	0.5	17.20	1.5	8	1	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	12
512	1	20.5	20.0	0.5	17.20	1.5	8	2	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	12
513	1	20.5	20.0	0.5	17.20	1.5	16	1	21	4	1	0	0	0	5	20	20.0	.	.	.	.	.	.	12
514	1	20.5	20.0	0.5	17.20	1.5	16	2	21	4	0	0	1	0	5	20	20.0	.	.	.	.	.	.	12
515	1	20.5	20.1	0.4	17.20	2.0	4	1	23	2	1	1	0	0	4	21	16.0	.	.	.	.	.	.	12
516	1	20.5	20.1	0.4	17.20	2.0	4	2	24	0	0	0	0	0	0	24	0.0	.	.	.	.	.	.	12
517	1	20.5	20.1	0.4	17.20	2.0	8	1	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	12
518	1	20.5	20.1	0.4	17.20	2.0	8	2	23	2	0	0	0	0	2	23	8.0	.	.	.	.	.	.	12
519	1	20.5	21.5	-1.0	18.96	1.0	4	1	24	0	0	1	0	2	3	21	12.5	0	1	0	0	1	24	4
520	1	20.5	21.5	-1.0	18.96	1.0	4	2	22	1	0	2	0	1	4	19	16.0	.	.	.	.	.	.	4
521	1	20.5	21.5	-1.0	18.96	1.0	8	1	19	3	0	0	0	0	3	19	13.6	.	.	.	.	.	.	4
522	1	20.5	21.5	-1.0	18.96	1.0	8	2	21	4	0	1	0	0	5	20	20.0	.	.	.	.	.	.	4
523	1	20.5	21.5	-1.0	18.96	1.0	16	1	4	21	0	0	0	0	21	4	87.5	.	.	.	.	.	.	4
524	1	20.5	21.5	-1.0	18.96	1.0	16	2	2	24	1	0	0	0	25	1	96.2	.	.	.	.	.	.	4
525	1	20.5	22.0	-1.5	18.96	1.5	8	1	13	10	0	1	5	0	16	7	64.0	.	.	.	.	.	.	4
526	1	20.5	22.0	-1.5	18.96	1.5	8	2	16	9	1	2	7	0	19	6	76.0	.	.	.	.	.	.	4
527	1	20.5	22.0	-1.5	18.96	1.5	16	1	0	25	0	0	0	0	25	0	100.0	.	.	.	.	.	.	4
528	1	20.5	22.0	-1.5	18.96	1.5	16	2	3	22	1	0	0	0	23	2	92.0	.	.	.	.	.	.	4
529	1	20.5	22.2	-1.7	18.96	2.0	8	1	8	17	0	0	0	0	17	8	68.0	.	.	.	.	.	.	4
530	1	20.5	22.2	-1.7	18.96	2.0	8	2	3	22	2	0	0	0	24	1	96.0	.	.	.	.	.	.	4
531	1	20.2	20.2	0.0	19.52	2.0	4	1	24	1	0	1	0	0	2	23	8.0	0	0	0	0	0	25	0

TABLE A-1

IMPINGEMENT SURVIVAL STUDY
1979 STRIPED BASS DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TEMP DIFF., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION	SEGMENT NO.	TEST: INITIAL LIVE	TEST: INITIAL DEAD	TEST: 24-HR. DEAD	TEST: 48-HR. DEAD	TEST: 72-HR. DEAD	TEST: 96-HR. DEAD	TEST: TOTAL DEAD	TEST: TOTAL LIVE	TEST: 96-HR. MORTALITY %	CONTROL: 24-HR. DEAD	CONTROL: 48-HR. DEAD	CONTROL: 72-HR. DEAD	CONTROL: 96-HR. DEAD	CONTROL: TOTAL DEAD	CONTROL: TOTAL LIVE	CONTROL: 96-HR. MORTALITY, %
532	1	20.5	20.2	0.3	19.52	2.0	4	2	24	1	0	0	0	0	1	24	4.0							0
533	1	20.5	22.0	-1.5	19.52	1.0	4	1	24	0	0	0	1	1	2	22	8.3	.	.	.	.	.	.	0
534	1	20.0	22.0	-2.0	19.52	1.0	4	2	23	0	0	0	1	1	2	21	8.0	.	.	.	.	.	.	0
535	1	20.5	22.5	-2.0	19.52	1.0	8	1	12	13	0	0	0	2	15	10	60.0	.	.	.	.	.	.	0
536	1	20.5	22.5	-2.0	19.52	1.0	8	2	19	6	0	0	2	2	10	15	40.0	.	.	.	.	.	.	0
537	1	20.5	22.5	-2.0	19.52	1.0	16	1	10	15	0	0	0	0	15	10	60.0	.	.	.	.	.	.	0
538	1	20.5	22.5	-2.0	19.52	1.0	16	2	14	11	1	0	0	0	12	13	48.0	.	.	.	.	.	.	0
539	1	20.5	22.5	-2.0	19.52	1.5	8	1	12	14	1	0	0	0	15	10	60.0	.	.	.	.	.	.	0
540	1	20.5	22.5	-2.0	19.52	1.5	8	2	16	10	1	0	0	0	11	15	42.3	.	.	.	.	.	.	0
541	1	20.5	23.0	-2.5	19.52	1.5	16	1	15	11	6	0	0	0	17	9	65.4	.	.	.	.	.	.	0
542	1	20.5	23.0	-2.5	19.52	1.5	16	2	9	16	2	0	2	0	[illegible]	[illegible]	[illegible]	:	:	:	:	:	:	[illegible]
543	1	20.2	21.3	-1.1	22.79	1.0	4	1	25	0	1	0	0	3	4	21	16.0	0	1	0	0	1	24	4
544	1	20.2	21.3	-1.1	22.79	1.0	4	2	26	0	1	0	1	0	2	24	8.0	.	.	.	.	.	.	4
545	1	20.2	21.3	-1.1	22.79	1.0	8	1	22	3	0	1	4	1	9	16	36.0	.	.	.	.	.	.	4
546	1	20.2	21.3	-1.1	22.79	1.0	8	2	22	3	16	6	0	0	25	0	100.0	.	.	.	.	.	.	4
547	1	20.2	21.8	-1.6	22.79	1.0	16	1	12	13	0	0	2	0	15	10	60.0	.	.	.	.	.	.	4
548	1	20.2	21.8	-1.6	22.79	1.0	16	2	11	14	0	1	1	0	16	9	64.0	.	.	.	.	.	.	4
549	1	20.8	21.9	-1.1	22.79	1.5	8	1	12	13	0	0	2	0	15	10	60.0	.	.	.	.	.	.	4
550	1	20.8	21.9	-1.1	22.79	1.5	8	2	14	11	0	2	4	1	18	7	72.0	.	.	.	.	.	.	4
551	1	20.8	21.9	-1.1	22.79	1.5	16	1	4	21	0	0	1	1	23	2	92.0	.	.	.	.	.	.	4
552	1	20.8	21.9	-1.1	22.79	1.5	16	2	3	22	0	0	1	0	23	2	92.0	.	.	.	.	.	.	4
553	1	20.8	22.1	-1.3	22.79	2.0	4	1	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	4
554	1	20.8	22.1	-1.3	22.79	2.0	4	2	24	1	0	0	0	1	2	23	8.0	.	.	.	.	.	.	4
555	1	20.8	22.1	-1.3	22.79	2.0	4	1	23	2	0	0	0	0	2	23	8.0	.	.	.	.	.	.	4
556	1	20.8	22.1	-1.3	22.79	2.0	4	2	24	1	0	0	0	2	3	22	12.0	.	.	.	.	.	.	4
557	1	20.8	22.3	-1.5	22.79	2.0	8	1	17	8	0	0	3	1	12	13	48.0	.	.	.	.	.	.	4
558	1	20.8	22.3	-1.5	22.79	2.0	8	2	18	7	0	1	0	1	9	16	36.0	.	.	.	.	.	.	4
559	1	20.8	22.3	-1.5	22.79	2.0	8	1	21	4	0	0	0	1	5	20	20.0	.	.	.	.	.	.	4
560	1	20.8	22.3	-1.5	22.79	2.0	8	2	13	13	0	0	2	0	15	11	60.0	.	.	.	.	.	.	4
561	1	20.1	22.0	-1.9	18.98	1.0	4	1	25	0	1	0	0	0	1	24	4.0	0	0	0	2	2	23	8
562	1	20.1	22.0	-1.9	18.98	1.0	4	2	25	0	0	0	0	1	1	24	4.0	.	.	.	.	.	.	8
563	1	20.1	22.0	-1.9	18.98	1.0	8	1	26	0	0	1	1	0	2	24	7.7	.	.	.	.	.	.	8
564	1	20.1	22.0	-1.9	18.98	1.0	8	2	25	0	0	0	0	3	3	22	12.0	.	.	.	.	.	.	8
565	1	20.1	22.1	-2.0	18.98	1.0	16	1	20	5	0	0	0	0	5	20	20.0	.	.	.	.	.	.	8
566	1	20.1	22.1	-2.0	18.98	1.0	16	2	20	5	0	1	0	0	6	19	24.0	.	.	.	.	.	.	8
567	1	20.1	22.6	-2.5	18.98	1.5	8	1	23	2	1	2	2	2	9	16	36.0	.	.	.	.	.	.	8
568	1	20.1	22.6	-2.5	18.98	1.5	8	2	21	4	0	1	2	0	7	18	28.0	.	.	.	.	.	.	8
569	1	20.1	22.6	-2.5	18.98	1.5	16	1	5	20	0	0	1	1	22	3	88.0	.	.	.	.	.	.	8
570	1	20.1	22.6	-2.5	18.98	1.5	16	2	8	17	0	0	0	0	17	8	68.0	.	.	.	.	.	.	8
571	1	20.1	23.0	-2.9	18.98	2.0	4	1	25	0	1	1	0	0	2	23	8.0	.	.	.	.	.	.	8
572	1	20.1	23.0	-2.9	18.98	2.0	4	1	24	0	1	0	0	0	1	24	4.2	.	.	.	.	.	.	8
573	1	20.1	23.0	-2.9	18.98	2.0	8	1	17	8	0	1	1	0	10	15	40.0	.	.	.	.	.	.	8
574	1	20.1	23.0	-2.9	18.98	2.0	8	2	18	7	16	2	0	0	25	0	100.0	.	.	.	.	.	.	8
575	1	21.2	22.0	-0.8	20.86	1.0	4	1	25	0	0	0	0	0	0	25	0.0	0	1	0	0	1	24	4
576	1	21.2	22.0	-0.8	20.86	1.0	4	2	25	0	0	3	0	0	3	22	12.0	.	.	.	.	.	.	4
577	1	21.2	22.0	-0.8	20.86	1.0	8	1	24	1	0	0	0	2	3	22	12.0	.	.	.	.	.	.	4
578	1	21.2	22.0	-0.8	20.86	1.0	8	2	25	0	0	2	0	0	2	23	8.0	.	.	.	.	.	.	4
579	1	21.2	22.0	-0.8	20.86	1.0	16	1	13	12	0	1	0	0	13	12	52.0	.	.	.	.	.	.	4
580	1	21.2	22.0	-0.8	20.86	1.0	16	2	14	11	1	1	0	0	13	12	52.0	.	.	.	.	.	.	4
581	1	21.2	22.8	-1.6	20.86	1.5	8	1	20	5	1	1	3	0	10	15	40.0	.	.	.	.	.	.	4
582	1	21.2	22.8	-1.6	20.86	1.5	8	2	17	8	0	1	1	0	10	15	40.0	.	.	.	.	.	.	4
583	1	21.2	22.9	-1.7	20.86	1.5	16	1	2	23	0	0	0	0	23	2	92.0	.	.	.	.	.	.	4
584	1	21.2	22.9	-1.7	20.86	1.5	16	2	0	25	0	0	0	0	25	0	100.0	.	.	.	.	.	.	4

TABLE A-1

IMPINGEMENT SURVIVAL STUDY
1979 STRIPED BASS DATA

									TEST									CONTROL						
TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TEMP DIFF., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION	SEGMENT NO.	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY %	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
585	1	21.2	23.0	-1.8	20.86	2.0	4	1	25	0	0	1	0	0	1	24	4.0	.	.	.	.	.	.	4.0
586	1	21.2	23.0	-1.8	20.86	2.0	4	2	22	3	0	0	0	0	3	22	12.0	.	.	.	.	.	.	4.0
587	1	21.2	23.1	-1.9	20.86	2.0	8	1	15	10	1	0	0	0	11	14	44.0	.	.	.	.	.	.	4.0
588	1	21.2	23.1	-1.9	20.86	2.0	8	2	14	11	1	0	0	0	12	13	48.0	.	.	.	.	.	.	4.0
589	1	21.0	21.2	-0.2	22.84	1.0	4	1	22	0	0	0	0	0	0	22	0.0	0	0	0	0	0	25	0.0
590	1	21.0	21.2	-0.2	22.84	1.0	4	2	17	0	0	0	0	0	0	17	0.0	.	.	.	.	.	.	0.0
591	1	21.0	21.2	-0.2	22.84	1.0	8	1	25	0	0	1	0	0	1	24	4.0	.	.	.	.	.	.	0.0
592	1	21.0	21.2	-0.2	22.84	1.0	8	2	25	0	0	0	1	0	1	24	4.0	.	.	.	.	.	.	0.0
593	1	21.0	21.2	-0.2	22.84	1.0	16	1	24	1	0	1	0	0	2	23	8.0	.	.	.	.	.	.	0.0
594	1	21.0	21.2	-0.2	22.84	1.0	16	2	20	4	0	2	3	1	10	14	41.7	.	.	.	.	.	.	0.0
595	1	21.0	21.8	-0.8	22.84	1.5	8	1	20	3	0	6	1	0	10	13	43.5	.	.	.	.	.	.	0.0
596	1	21.0	21.8	-0.8	22.84	1.5	8	2	19	6	5	6	4	0	21	4	84.0	.	.	.	.	.	.	0.0
597	1	21.0	21.8	-0.8	22.84	1.5	16	1	9	16	0	6	1	0	23	2	92.0	.	.	.	.	.	.	0.0
598	1	21.0	21.8	-0.8	22.84	1.5	16	2	11	14	0	7	2	0	23	2	92.0	.	.	.	.	.	.	0.0
599	1	21.5	22.2	-0.7	22.84	2.0	4	1	25	1	2	2	6	0	11	15	42.3	.	.	.	.	.	.	0.0
600	1	21.5	22.2	-0.7	22.64	2.0	4	2	21	4	0	0	1	0	5	20	20.0	.	.	.	.	.	.	0.0
601	1	21.5	22.2	-0.7	22.84	2.0	8	1	15	9	0	2	1	0	12	12	50.0	.	.	.	.	.	.	0.0
602	1	21.5	22.2	-0.7	22.84	2.0	8	2	13	9	0	1	6	0	16	6	72.7	.	.	.	.	.	.	0.0
603	1	22.0	23.5	-1.5	22.74	1.0	4	1	24	0	0	0	0	0	0	24	0.0	.	.	.	.	.	.	0.0
604	1	22.0	23.5	-1.5	22.74	1.0	4	2	24	1	0	0	0	1	2	23	8.0	.	.	.	.	.	.	0.0
605	1	22.0	24.0	-2.0	22.74	1.0	8	1	23	2	0	1	0	2	5	20	20.0	.	.	.	.	.	.	0.0
606	1	22.0	24.0	-2.0	22.74	1.0	8	2	20	4	0	0	0	2	6	18	25.0	.	.	.	.	.	.	0.0
607	1	22.0	24.0	-2.0	22.74	1.0	16	1	9	15	0	0	0	1	16	8	66.7	.	.	.	.	.	.	0.0
608	1	22.0	24.0	-2.0	22.74	1.0	16	2	9	13	0	0	0	0	13	9	59.1	.	.	.	.	.	.	0.0
609	1	22.0	24.1	-2.1	22.74	1.5	8	1	21	4	0	0	3	3	10	15	40.0	.	.	.	.	.	.	0.0
610	1	22.0	24.1	-2.1	22.74	1.5	8	2	20	5	0	0	0	0	5	20	20.0	.	.	.	.	.	.	0.0
611	1	22.0	24.1	-2.1	22.74	1.5	16	1	3	22	0	3	0	0	25	0	100.0	.	.	.	.	.	.	0.0
612	1	22.0	24.1	-2.1	22.74	1.5	16	2	1	24	0	0	0	0	24	1	96.0	.	.	.	.	.	.	0.0
613	1	22.0	24.8	-2.8	22.74	2.0	4	1	24	1	0	1	3	0	5	20	20.0	.	.	.	.	.	.	0.0
614	1	22.0	24.8	-2.8	22.74	2.0	4	2	23	2	0	0	2	0	4	21	16.0	.	.	.	.	.	.	0.0
615	1	22.0	24.8	-2.8	22.74	2.0	8	1	9	16	0	0	0	0	16	9	64.0	.	.	.	.	.	.	0.0
616	1	22.0	24.8	-2.8	22.74	2.0	8	2	17	8	2	15	0	0	25	0	100.0	.	.	.	.	.	.	0.0
617	1	21.7	23.0	-1.3	24.69	1.0	4	1	25	0	0	0	1	2	3	22	12.0	0	0	0	0	0	26	0.0
618	1	21.7	23.0	-1.3	24.69	1.0	4	2	25	0	0	0	0	7	7	18	28.0	.	.	.	.	.	.	0.0
619	1	21.7	23.0	-1.3	24.69	1.0	8	1	24	1	0	0	0	0	1	24	4.0	.	.	.	.	.	.	0.0
620	1	21.7	23.0	-1.3	24.69	1.0	8	2	24	1	0	0	1	1	3	22	12.0	.	.	.	.	.	.	0.0
621	1	21.7	23.1	-1.4	24.69	1.0	16	1	15	8	0	0	0	0	8	15	34.8	.	.	.	.	.	.	0.0
622	1	21.7	23.1	-1.4	24.69	1.0	16	2	10	16	0	0	0	0	16	10	61.5	.	.	.	.	.	.	0.0
623	1	22.0	23.5	-1.5	24.69	1.5	8	1	19	6	1	0	0	0	7	18	28.0	.	.	.	.	.	.	0.0
624	1	22.0	23.5	-1.5	24.69	1.5	8	2	21	4	0	20	0	0	24	1	96.0	.	.	.	.	.	.	0.0
625	1	22.0	23.6	-1.6	24.69	1.5	16	1	4	22	0	2	0	1	25	1	96.2	.	.	.	.	.	.	0.0
626	1	22.0	23.6	-1.6	24.69	1.5	16	2	8	17	0	1	2	0	20	5	80.0	.	.	.	.	.	.	0.0
627	1	22.0	24.0	-2.0	24.69	2.0	4	1	23	2	0	1	0	0	3	22	12.0	.	.	.	.	.	.	0.0
628	1	22.0	24.0	-2.0	24.69	2.0	4	2	22	3	0	0	0	2	5	20	20.0	.	.	.	.	.	.	0.0
629	1	22.0	24.0	-2.0	24.69	2.0	8	1	21	4	0	0	0	0	4	21	16.0	.	.	.	.	.	.	0.0
630	1	22.0	24.0	-2.0	24.69	2.0	8	2	18	6	0	0	0	0	6	18	25.0	.	.	.	.	.	.	0.0
631	1	22.5	24.2	-1.7	27.60	1.0	4	1	24	1	0	0	0	0	1	23	4.0	0	0	0	2	2	24	7.7
632	1	22.5	24.2	-1.7	27.60	1.0	4	2	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	7.7
633	1	22.5	24.5	-2.0	27.60	1.0	8	1	17	0	0	0	0	1	1	16	5.9	.	.	.	.	.	.	7.7
634	1	22.5	24.5	-2.0	27.60	1.0	8	2	22	0	0	0	0	1	1	21	4.5	.	.	.	.	.	.	7.7
635	1	22.5	24.8	-2.3	27.60	1.0	16	1	16	3	0	0	0	0	3	16	15.8	.	.	.	.	.	.	7.7
636	1	22.5	24.8	-2.3	27.60	1.0	16	2	19	4	0	0	0	0	4	19	17.4	.	.	.	.	.	.	7.7
637	1	22.5	25.0	-2.5	27.60	1.5	8	1	11	14	0	0	0	0	14	11	56.0	.	.	.	.	.	.	7.7

TABLE A-1

IMPINGEMENT SURVIVAL STUDY
1979 STRIPED BASS DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TEMP DIFF., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION	SEGMENT NO.	TEST: INITIAL LIVE	TEST: INITIAL DEAD	TEST: 24-HR. DEAD	TEST: 48-HR. DEAD	TEST: 72-HR. DEAD	TEST: 96-HR. DEAD	TEST: TOTAL DEAD	TEST: TOTAL LIVE	TEST: 96-HR. MORTALITY %	CONTROL: 24-HR. DEAD	CONTROL: 48-HR. DEAD	CONTROL: 72-HR. DEAD	CONTROL: 96-HR. DEAD	CONTROL: TOTAL DEAD	CONTROL: TOTAL LIVE	CONTROL: 96-HR. MORTALITY, %
638	1	22.5	25.0	-2.5	27.6	1.5	8	2	13	12	0	0	1	1	14	11	56.0	.	.	.	.	.	.	7.7
639	1	22.5	25.0	-2.5	27.6	1.5	16	1	7	16	0	0	0	0	16	7	69.6	.	.	.	.	.	.	7.7
640	1	22.5	25.0	-2.5	27.6	1.5	16	2	6	19	0	0	0	0	19	6	76.0	.	.	.	.	.	.	7.7
641	1	23.0	25.5	-2.5	27.6	3.0	4	1	24	2	0	0	0	1	3	23	11.5	.	.	.	.	.	.	7.7
642	1	22.5	25.5	-3.0	27.6	3.0	4	2	24	1	0	0	0	0	1	24	4.0	.	.	.	.	.	.	7.7
643	1	23.0	25.8	-2.8	27.6	3.0	8	1	14	10	0	0	0	0	10	14	41.7	.	.	.	.	.	.	7.7
644	1	23.0	25.8	-2.8	27.6	3.0	8	2	17	8	0	0	0	0	8	17	32.0	.	.	.	.	.	.	7.7

TABLE A-2

IMPINGEMENT SURVIVAL STUDY
1980 WINTER FLOUNDER, ALEWIFE, AND YELLOW PERCH DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION (min.)	SEGMENT NO.	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
009	5	6	8.0	4.07	0.5	2	1	21	0	0	0	0	0	0	21	0.0
010	5	6	8.0	4.07	0.5	2	2	23	1	0	0	0	0	1	23	4.2
011	5	6	8.5	4.07	0.5	8	1	23	0	0	0	0	2	2	21	8.7
012	5	6	8.5	4.07	0.5	8	2	23	1	0	0	0	1	2	22	8.3
013	5	6	8.7	4.07	1.0	2	1	27	0	0	0	0	1	1	26	3.7
014	5	6	8.7	4.07	1.0	2	2	25	0	0	0	0	5	5	20	20.0
015	5	6	9.0	4.07	1.0	8	1	25	0	0	0	0	0	0	25	0.0
016	5	6	9.0	4.07	1.0	8	2	24	0	0	0	0	4	4	20	16.7
017	5	7	9.0	4.07	1.5	2	1	25	0	0	0	0	7	7	18	28.0
018	5	7	9.0	4.07	1.5	2	2	25	0	0	0	0	2	2	23	8.0
019	5	7	9.5	4.07	1.5	8	1	22	0	0	0	0	0	0	22	0.0
020	5	7	9.5	4.07	1.5	8	2	23	0	0	0	0	2	2	21	8.7
021	5	7	10.0	4.07	2.0	2	1	20	0	0	0	0	0	0	20	0.0
022	5	7	10.0	4.07	2.0	2	2	25	0	0	0	0	2	2	23	8.0
023	5	7	10.0	4.07	2.0	8	1	14	0	0	1	0	8	9	5	64.3
024	5	7	10.0	4.07	2.0	8	2	18	0	0	0	0	2	2	16	11.1
025	5	6	9.0	4.04	0.5	2	1	24	0	0	0	0	0	0	24	0.0
026	5	6	9.0	4.04	0.5	2	2	27	0	0	0	0	3	3	24	11.1
027	5	6	10.0	4.04	0.5	8	1	24	0	0	0	0	2	2	22	8.3
028	5	6	10.0	4.04	0.5	8	2	22	0	0	0	0	0	0	22	0.0
029	5	6	10.0	4.04	1.0	2	1	23	0	0	0	0	0	0	23	0.0
030	5	6	10.0	4.04	1.0	2	2	21	0	0	0	0	0	0	21	0.0
031	5	6	10.0	4.04	1.0	8	1	24	0	0	0	0	0	0	24	0.0
032	5	6	10.0	4.04	1.0	8	2	24	0	0	0	0	2	2	22	8.3
033	5	6	10.0	4.04	1.5	2	1	22	0	0	0	0	1	1	21	4.5
034	5	6	10.0	4.04	1.5	2	2	26	0	0	0	0	3	3	23	11.5
035	5	7	10.5	4.04	1.5	8	1	22	0	0	0	0	2	2	20	9.1
036	5	7	10.5	4.04	1.5	8	2	24	0	0	0	0	7	7	17	29.2
037	5	7	10.5	4.04	2.0	2	1	23	0	0	0	0	6	6	17	26.1
038	5	7	10.5	4.04	2.0	2	2	22	0	0	0	0	10	10	12	45.5
039	5	7	10.8	4.04	2.0	8	1	13	4	0	0	0	1	5	12	29.4
040	5	7	10.8	4.04	2.0	8	2	15	2	0	0	0	6	8	9	47.1
041	5	6	9.0	4.38	0.5	2	1	12	12	0	0	0	9	21	3	87.5
042	5	6	9.0	4.38	0.5	2	2	16	11	0	0	0	12	23	4	85.2
043	5	6	9.0	4.38	0.5	8	1	12	8	0	0	0	12	20	0	100.0
044	5	6	9.0	4.38	0.5	8	2	12	12	0	0	0	10	22	2	91.7
045	5	6	9.0	4.38	0.5	16	1	13	12	0	0	0	10	22	3	88.0
046	5	6	9.0	4.38	0.5	16	2	21	4	0	0	0	19	23	2	92.0
047	5	6	9.0	4.38	1.0	2	1	14	9	0	0	0	14	23	0	100.0
048	5	6	9.0	4.38	1.0	2	2	5	16	0	0	0	5	21	0	100.0
049	5	6	9.0	4.38	1.0	8	1	8	11	0	0	0	8	19	0	100.0
050	5	6	9.0	4.38	1.0	8	2	10	10	0	0	0	10	20	0	100.0
051	5	6	9.3	4.38	1.0	16	1	6	11	0	0	0	6	17	0	100.0
052	5	6	9.3	4.38	1.0	16	2	3	12	0	0	0	3	15	0	100.0
053	5	6	9.5	4.38	1.5	2	1	2	22	0	0	0	2	24	0	100.0
054	5	6	9.5	4.38	1.5	2	2	5	20	0	0	0	5	25	0	100.0
055	5	6	9.8	4.38	1.5	8	1	3	12	0	0	0	3	15	0	100.0
056	5	6	9.8	4.38	1.5	8	2	6	15	0	0	0	6	21	0	100.0
057	5	6	10.0	4.38	2.0	2	1	6	14	0	0	0	6	20	0	100.0
058	5	6	10.0	4.38	2.0	2	2	5	18	0	0	0	5	23	0	100.0
059	5	6	10.0	4.38	2.0	8	1	4	17	0	0	0	4	21	0	100.0

TABLE A-2

IMPINGEMENT SURVIVAL STUDY
1980 WINTER FLOUNDER, ALEWIFE, AND YELLOW PERCH DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION (min.)	SEGMENT NO.	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
060	5	6.0	10.0	4.38	2.0	8	2	4	12	0	0	0	4	16	0	100.0
061	5	7.0	9.8	4.38	0.5	2	1	25	0	0	0	0	9	9	16	36.0
062	5	7.0	9.8	4.38	0.5	2	2	24	0	0	0	0	3	3	21	12.5
063	5	7.0	9.8	4.38	0.5	8	1	26	0	0	0	0	15	15	11	57.7
064	5	7.0	9.8	4.38	0.5	8	2	27	0	0	0	0	6	6	21	22.2
065	5	7.0	10.0	4.38	0.5	16	1	25	0	0	0	0	8	8	17	32.0
066	5	7.0	10.0	4.38	0.5	16	2	25	0	0	0	0	17	17	8	68.0
067	5	7.0	10.0	4.38	1.0	2	1	24	0	0	0	0	23	23	1	95.8
068	5	7.0	10.0	4.38	1.0	2	2	24	0	0	0	0	16	16	8	66.7
069	5	7.0	10.0	4.38	1.0	8	1	23	0	0	0	0	23	23	0	100.0
070	5	7.0	10.0	4.38	1.0	8	2	22	0	0	0	0	22	22	0	100.0
071	5	7.0	10.3	4.38	1.0	16	1	17	0	0	0	0	17	17	0	100.0
072	5	7.0	10.3	4.38	1.0	16	2	21	0	0	0	0	21	21	0	100.0
073	5	7.0	10.2	4.38	1.5	2	1	21	0	0	0	0	21	21	0	100.0
074	5	7.0	10.2	4.38	1.5	2	2	18	0	0	0	0	13	13	5	72.2
075	5	7.0	10.5	4.38	1.5	8	1	24	0	0	0	0	23	23	1	95.8
076	5	7.0	10.5	4.38	1.5	8	2	20	0	0	0	0	19	19	1	95.0
077	5	7.0	11.0	4.38	2.0	2	1	20	0	0	0	0	20	20	0	100.0
078	5	7.0	11.0	4.38	2.0	2	2	18	0	0	0	0	18	18	0	100.0
079	5	7.0	11.0	4.38	2.0	8	1	20	0	0	0	0	20	20	0	100.0
080	5	7.0	11.0	4.38	2.0	8	2	18	0	0	0	0	18	18	0	100.0
081	5	10.4	8.3	4.39	0.5	2	1	25	0	.	.	.	23	23	2	92.0
082	5	10.4	8.3	4.39	0.5	2	2	25	0	.	.	.	21	21	4	84.0
083	5	10.4	8.7	4.39	0.5	8	1	25	0	.	.	.	20	20	5	80.0
084	5	10.4	8.7	4.39	0.5	8	2	25	0	.	.	.	17	17	8	68.0
085	5	11.3	9.2	4.39	0.5	16	1	24	0	.	.	.	15	15	9	62.5
086	5	11.3	9.2	4.39	0.5	16	2	25	0	.	.	.	16	16	9	64.0
087	5	11.3	9.5	4.39	1.0	8	1	25	0	.	.	.	24	24	1	96.0
088	5	11.3	9.5	4.39	1.0	8	2	18	0	.	.	.	18	18	0	100.0
089	5	11.3	10.3	4.39	0.5	2	1	24	0	.	.	.	14	14	10	58.3
090	5	11.3	10.3	4.39	0.5	2	2	25	0	.	.	.	16	16	9	64.0
091	5	11.3	10.3	4.39	0.5	8	1	25	0	.	.	.	20	20	5	80.0
092	5	11.3	10.3	4.39	0.5	8	2	25	0	.	.	.	19	19	6	76.0
093	5	11.3	10.5	4.39	0.5	16	1	25	0	.	.	.	15	15	10	60.0
094	5	11.3	10.5	4.39	0.5	16	2	25	0	.	.	.	17	17	8	68.0
095	5	11.3	10.8	4.39	1.0	8	1	20	0	.	.	.	20	20	0	100.0
096	5	11.3	10.8	4.39	1.0	8	2	16	0	.	.	.	16	16	0	100.0
097	5	13.0	11.0	6.13	0.5	2	1	25	0	4	2	1	10	17	8	68.0
098	5	13.0	11.0	6.13	0.5	2	2	25	0	1	0	1	8	10	15	40.0
099	5	13.0	11.0	6.13	0.5	8	1	25	0	0	0	2	19	21	4	84.0
100	5	13.0	11.0	6.13	0.5	8	2	25	0	1	1	1	7	10	15	40.0
101	5	13.0	12.0	6.13	0.5	16	1	25	0	3	4	1	5	13	12	52.0
102	5	13.0	12.0	6.13	0.5	16	2	25	0	0	0	0	1	1	24	4.0
103	5	13.0	12.0	6.13	1.0	2	1	25	0	0	0	0	2	2	23	8.0
104	5	13.0	12.0	6.13	1.0	2	2	25	0	1	0	1	7	9	16	36.0
105	5	13.0	12.2	6.13	1.0	8	1	25	0	8	0	2	4	14	11	56.0
106	5	13.0	12.2	6.13	1.0	8	2	25	0	0	0	0	4	4	21	16.0
107	5	13.0	12.5	6.13	1.5	2	1	25	0	0	0	1	10	11	14	44.0
108	5	13.0	12.5	6.13	1.5	2	2	25	0	0	0	0	6	6	19	24.0
109	5	13.0	12.5	6.13	1.5	8	1	25	0	0	0	0	7	7	18	28.0
110	5	13.0	12.5	6.13	1.5	8	2	23	0	0	2	0	6	8	15	34.8

TABLE A-2

IMPINGEMENT SURVIVAL STUDY
1980 WINTER FLOUNDER, ALEWIFE, AND YELLOW PERCH DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION (min.)	SEGMENT NO.	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
111	5	13.0	12.5	6.13	2.0	2	1	25	0	0	0	0	4	4	21	16.0
112	5	13.0	12.5	6.13	2.0	2	2	24	0	0	0	0	4	4	20	16.7
113	5	13.0	13.0	6.13	2.0	8	1	25	0	0	0	0	16	16	9	64.0
114	5	13.0	13.0	6.13	2.0	8	2	24	0	0	0	0	13	13	11	54.2
C	5	6.0	8.0	4.07	.	.	1	24	0	0	0	0	1	1	23	4.2
C	5	6.0	9.0	4.04	.	.	1	25	0	0	0	0	1	1	24	4.0
C	5	6.0	9.0	4.38	.	.	1	21	0	0	0	0	3	3	18	14.3
C	5	7.0	9.8	4.38	.	.	1	24	0	0	0	0	8	8	16	33.3
C	5	10.4	8.3	4.39	.	.	1	25	0	.	.	.	20	20	5	80.0
C	5	13.0	11.0	6.13	.	.	1	24	0	0	0	0	2	2	22	8.3
001	6	15.0	15.5	5.22	0.5	2	1	24	0	0	1	.	.	1	23	4.1
002	6	15.0	15.5	5.22	0.5	2	2	25	0	0	1	.	.	2	23	8.0
003	6	15.0	15.7	5.22	0.5	8	1	11	0	0	1	.	.	1	10	9.1
004	6	15.0	15.7	5.22	0.5	8	2	14	0	1	0	.	.	1	13	7.1
005	6	15.0	15.9	5.22	1.0	2	1	24	0	0	8	.	.	8	16	33.3
006	6	15.0	15.9	5.22	1.0	2	2	21	0	0	1	.	.	1	20	4.8
007	6	15.0	16.0	5.22	1.0	8	1	23	0	3	6	.	.	9	14	39.1
008	6	15.0	16.0	5.22	1.0	8	2	20	0	2	0	.	.	2	18	10.0
009	6	15.0	16.5	5.22	1.5	2	1	25	0	1	5	.	.	6	19	24.0
010	6	15.0	16.5	5.22	1.5	2	2	20	0	1	0	.	.	1	19	5.0
011	6	15.0	16.8	5.22	1.5	8	1	27	0	2	10	.	.	12	15	44.4
012	6	15.0	16.8	5.22	1.5	8	2	18	0	6	2	.	.	8	10	44.4
013	6	15.0	17.0	5.22	2.0	2	1	23	0	2	6	.	.	8	15	34.8
014	6	15.0	17.0	5.22	2.0	2	2	24	0	4	1	.	.	5	19	20.8
015	6	15.0	17.0	5.22	2.0	8	1	21	0	7	8	.	.	15	6	71.4
016	6	15.0	17.0	5.22	2.0	8	2	20	0	6	6	.	.	12	8	60.0
017	6	14.0	15.1	5.54	0.5	2	1	24	0	0	1	.	.	1	23	4.2
018	6	14.0	15.1	5.54	0.5	2	2	25	0	0	2	.	.	2	23	8.0
019	6	14.0	15.0	5.54	0.5	8	1	16	0	0	0	.	.	0	16	0.0
020	6	14.0	15.0	5.54	0.5	8	2	20	0	0	0	.	.	0	20	0.0
021	6	14.0	14.5	5.54	1.0	2	1	22	0	0	1	.	.	1	21	4.5
022	6	14.0	14.5	5.54	1.0	2	2	22	0	0	1	.	.	1	21	4.5
023	6	14.0	14.2	5.54	1.0	8	1	22	0	0	4	.	.	4	18	18.2
024	6	14.0	14.2	5.54	1.0	8	2	24	0	0	2	.	.	2	22	8.3
025	6	14.0	14.8	5.54	1.5	2	1	22	0	0	0	.	.	0	22	0.0
026	6	14.0	14.8	5.54	1.5	2	2	23	0	0	3	.	.	3	20	13.0
027	6	14.0	15.0	5.54	1.5	8	1	23	0	1	7	.	.	8	15	34.8
028	6	14.0	15.0	5.54	1.5	8	2	17	0	1	8	.	.	9	8	52.9
029	6	14.0	15.2	5.54	2.0	2	1	21	0	0	7	.	.	7	14	33.3
030	6	14.0	15.2	5.54	2.0	2	2	25	0	1	5	.	.	6	19	24.0
031	6	14.0	15.2	5.54	2.0	8	1	19	0	2	12	.	.	14	5	73.7
032	6	14.0	15.2	5.54	2.0	8	2	19	0	0	14	.	.	14	5	73.7
033	6	14.9	14.0	6.59	0.5	2	1	24	0	8	2	1	13	24	0	100.0
034	6	14.9	14.0	6.59	0.5	2	2	25	0	10	0	4	11	25	0	100.0
035	6	14.9	14.2	6.59	0.5	8	1	24	0	13	2	1	8	24	0	100.0
036	6	14.9	14.2	6.59	0.5	8	2	21	0	20	0	0	1	21	0	100.0
037	6	14.9	14.5	6.59	1.0	2	1	25	0	9	0	13	3	25	0	100.0
038	6	14.9	14.5	6.59	1.0	2	2	27	0	15	0	3	9	27	0	100.0
039	6	14.9	14.6	6.59	1.0	8	1	25	0	11	2	4	5	22	3	88.0
040	6	14.9	14.6	6.59	1.0	8	2	24	0	21	2	0	1	24	0	100.0
041	6	14.9	14.9	6.59	1.5	2	1	27	0	12	10	2	3	27	0	100.0

TABLE A-2

IMPINGEMENT SURVIVAL STUDY 1980 WINTER FLOUNDER, ALEWIFE, AND YELLOW PERCH DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION (min.)	SEGMENT NO.	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
042	6	14.9	14.9	6.59	1.5	2	2	24	0	11	3	1	8	23	1	95.8
043	6	14.9	14.9	6.59	1.5	8	1	24	0	20	0	0	4	24	0	100.0
044	6	14.9	14.9	6.59	1.5	8	2	26	0	25	0	0	1	26	0	100.0
045	6	14.9	15.0	6.59	2.0	2	1	26	0	21	0	1	4	26	0	100.0
046	6	14.9	15.0	6.59	2.0	2	2	26	0	15	0	2	8	25	1	96.2
047	6	14.9	15.1	6.59	2.0	8	1	25	0	20	1	1	3	25	0	100.0
048	6	14.9	15.1	6.59	2.0	8	2	25	0	25	0	0	0	25	0	100.0
049	6	13.6	14.5	6.75	0.5	2	1	20	3	5	6	2	6	22	1	95.7
050	6	13.6	14.5	6.75	0.5	2	2	23	0	10	5	1	5	21	2	91.3
051	6	13.6	14.8	6.75	0.5	8	1	19	5	5	0	2	10	22	2	91.7
052	6	13.6	14.8	6.75	0.5	8	2	20	1	14	2	2	1	20	1	95.2
053	6	13.6	14.8	6.75	1.0	2	1	24	1	19	2	1	0	23	2	92.0
054	6	13.6	14.8	6.75	1.0	2	2	19	6	9	3	0	2	20	5	80.0
055	6	13.6	14.2	6.75	1.0	8	1	6	19	0	2	2	1	24	1	96.0
056	6	13.6	14.2	6.75	1.0	8	2	6	23	4	0	0	0	27	2	93.1
057	6	13.6	13.8	6.75	1.5	2	1	12	12	3	4	2	1	22	2	91.7
058	6	13.6	13.8	6.75	1.5	2	2	15	9	10	2	1	1	23	1	95.8
059	6	13.6	13.8	6.75	1.5	8	1	12	14	6	6	0	0	26	0	100.0
060	6	13.6	13.8	6.75	1.5	8	2	1	22	0	0	0	0	22	1	95.7
061	6	13.6	14.9	6.75	2.0	2	1	8	17	2	1	2	0	22	3	88.0
062	6	13.6	14.9	6.75	2.0	2	2	5	20	1	0	0	2	23	2	92.0
063	6	13.6	15.0	6.75	2.0	8	1	2	23	2	0	0	0	25	0	100.0
064	6	13.6	15.0	6.75	2.0	8	2	4	21	1	1	1	1	25	0	100.0
065	6	16.4	17.9	9.52	0.5	2	1	23	2	4	2	1	0	9	16	36.0
066	6	16.4	17.9	9.52	0.5	2	2	24	1	2	1	0	1	5	20	20.0
067	6	16.4	17.8	9.52	0.5	8	1	20	5	1	5	1	1	13	12	52.0
068	6	16.4	17.8	9.52	0.5	8	2	20	5	3	0	1	1	10	15	40.0
069	6	16.4	17.1	9.52	1.0	2	1	22	2	5	2	1	0	10	14	41.7
070	6	16.4	17.1	9.52	1.0	2	2	22	3	6	1	1	2	13	12	52.0
071	6	16.5	17.0	9.52	1.0	8	1	21	4	7	1	2	0	14	11	56.0
072	6	16.5	17.0	9.52	1.0	8	2	16	9	9	0	2	2	22	3	88.0
073	6	16.5	16.8	9.52	1.5	2	1	14	11	5	1	1	0	18	7	72.0
074	6	16.5	16.8	9.52	1.5	2	2	9	16	3	4	0	0	23	2	92.0
075	6	16.5	16.2	9.52	1.5	8	1	14	11	8	2	0	0	21	4	84.0
076	6	16.5	16.2	9.52	1.5	8	2	6	19	3	0	0	0	22	3	68.0
077	6	16.5	16.3	9.52	2.0	2	1	18	6	6	2	1	1	16	8	66.7
078	6	16.5	16.3	9.52	2.0	2	2	17	8	7	1	0	0	16	9	64.0
079	6	16.5	16.3	9.52	2.0	8	1	16	9	14	0	0	2	25	0	100.0
080	6	16.5	16.3	9.52	2.0	8	2	20	5	17	1	0	1	24	1	96.0
081	6	16.8	17.3	9.63	0.5	2	1	22	2	2	1	2	3	10	14	41.7
082	6	16.8	17.3	9.63	0.5	2	2	23	2	2	3	3	3	13	12	52.0
083	6	16.8	17.0	9.63	0.5	8	1	21	4	10	0	0	0	14	11	56.0
084	6	16.8	17.0	9.63	0.5	8	2	22	3	0	2	1	1	7	18	28.0
085	6	16.8	16.9	9.63	1.0	2	1	21	4	7	2	0	1	14	11	56.0
086	6	16.8	16.9	9.63	1.0	2	2	22	2	9	2	0	2	15	9	62.5
087	6	16.8	16.6	9.63	1.0	8	1	16	9	12	2	0	1	24	1	96.0
088	6	16.8	16.6	9.63	1.0	8	2	18	7	10	0	0	1	18	7	72.0
089	6	16.8	16.2	9.63	1.5	2	1	19	6	13	0	0	0	19	6	76.0
090	6	16.8	16.2	9.63	1.5	2	2	11	14	8	1	0	0	23	2	92.0
091	6	16.8	16.2	9.63	1.5	8	1	12	13	8	0	1	0	22	3	88.0
092	6	16.8	16.2	9.63	1.5	8	2	11	14	11	0	0	0	25	0	100.0

TABLE A-2

IMPINGEMENT SURVIVAL STUDY 1980 WINTER FLOUNDER, ALEWIFE, AND YELLOW PERCH DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION (min.)	SEGMENT NO.	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
093	6	16.8	16.3	9.63	2.0	2	1	18	7	7	3	3	0	20	5	80.0
094	6	16.8	16.3	9.63	2.0	2	2	16	9	12	2	0	0	23	2	92.0
095	6	16.8	16.3	9.63	2.0	8	1	16	9	12	0	0	0	21	4	84.0
096	6	16.8	16.3	9.63	2.0	8	2	16	9	16	0	0	0	25	0	100.0
097	6	16.8	16.9	12.40	0.5	2	1	23	2	8	1	1	6	18	7	72.0
098	6	16.8	16.9	12.40	0.5	2	2	24	1	7	1	1	10	20	5	80.0
099	6	16.8	16.9	12.40	0.5	8	1	19	6	7	2	1	5	21	4	84.0
100	6	16.8	16.9	12.40	0.5	8	2	22	3	8	0	1	11	23	2	92.0
101	6	16.8	17.0	12.40	1.0	2	1	19	5	12	1	2	4	24	0	100.0
102	6	16.8	17.0	12.40	1.0	2	2	18	7	16	0	0	2	25	0	100.0
103	6	16.8	17.1	12.40	1.0	8	1	10	15	10	0	0	0	25	0	100.0
104	6	16.8	17.1	12.40	1.0	8	2	10	15	3	2	0	5	25	0	100.0
105	6	16.8	17.2	12.40	1.5	2	1	17	8	7	2	1	4	22	3	88.0
106	6	16.8	17.2	12.40	1.5	2	2	17	8	17	0	0	0	25	0	100.0
107	6	16.8	17.2	12.40	1.5	8	1	4	21	3	0	0	1	25	0	100.0
108	6	16.8	17.2	12.40	1.5	8	2	3	22	3	0	0	0	25	0	100.0
109	6	16.8	17.2	12.40	2.0	2	1	10	15	5	2	2	1	25	0	100.0
110	6	16.8	17.2	12.40	2.0	2	2	18	6	6	4	1	5	22	2	91.7
111	6	16.8	17.2	12.40	2.0	8	1	0	25	0	0	0	0	25	0	100.0
112	6	16.8	17.2	12.40	2.0	8	2	0	25	0	0	0	0	25	0	100.0
113	6	15.0	15.8	12.50	0.5	2	1	22	3	6	6	2	3	20	5	80.0
114	6	15.0	15.8	12.50	0.5	2	2	20	5	13	4	1	1	24	1	96.0
115	6	15.0	15.8	12.50	0.5	8	1	18	7	10	3	3	2	25	0	100.0
116	6	15.0	15.8	12.50	0.5	8	2	20	5	9	7	3	1	25	0	100.0
117	6	15.0	15.5	12.50	1.0	2	1	19	6	8	4	2	1	21	4	84.0
118	6	15.0	15.5	12.50	1.0	2	2	16	8	3	6	0	2	19	5	79.2
119	6	15.0	15.5	12.50	1.0	8	1	9	16	7	1	1	0	25	0	100.0
120	6	15.0	15.5	12.50	1.0	8	2	10	15	9	0	1	0	25	0	100.0
121	6	15.0	15.3	12.50	1.5	2	1	17	8	12	2	3	0	25	0	100.0
122	6	15.0	15.3	12.50	1.5	2	2	10	15	4	0	0	2	21	4	84.0
123	6	15.0	15.3	12.50	1.5	8	1	8	17	6	1	0	0	24	1	96.0
124	6	15.0	15.3	12.50	1.5	8	2	5	20	5	0	0	0	25	0	100.0
125	6	15.0	15.1	12.50	2.0	2	1	5	20	1	1	0	2	24	1	96.0
126	6	15.0	15.1	12.50	2.0	2	2	6	19	1	2	0	3	25	0	100.0
127	6	15.0	15.1	12.50	2.0	8	1	0	25	0	0	0	0	25	0	100.0
128	6	15.0	15.1	12.50	2.0	8	2	0	24	0	0	0	0	24	0	100.0
129	6	18.0	18.0	11.17	0.5	2	1	25	0	25	0	0	0	25	0	100.0
130	6	18.0	18.0	11.17	0.5	2	2	26	0	22	0	0	0	22	4	84.6
131	6	18.0	18.0	11.17	0.5	8	1	25	0	23	0	0	1	24	1	96.0
132	6	18.0	18.0	11.17	0.5	8	2	25	0	25	0	0	0	25	0	100.0
133	6	18.0	18.5	11.17	1.0	2	1	25	0	24	0	0	0	24	1	96.0
134	6	18.0	18.5	11.17	1.0	2	2	25	0	25	0	0	0	25	0	100.0
135	6	18.0	18.5	11.17	1.0	8	1	26	0	25	0	1	0	26	0	100.0
136	6	18.0	18.5	11.17	1.0	8	2	25	0	25	0	0	0	25	0	100.0
137	6	18.0	18.7	11.17	1.5	2	1	26	0	26	0	0	0	26	0	100.0
138	6	18.0	18.7	11.17	1.5	2	2	26	0	26	0	0	0	26	0	100.0
139	6	18.0	18.7	11.17	1.5	8	1	25	0	25	0	0	0	25	0	100.0
140	6	18.0	18.7	11.17	1.5	8	2	25	0	25	0	0	0	25	0	100.0
141	6	18.0	18.9	11.17	2.0	2	1	27	0	27	0	0	0	27	0	100.0
142	6	18.0	18.9	11.17	2.0	2	2	26	0	26	0	0	0	26	0	100.0
143	6	18.0	18.9	11.17	2.0	8	1	23	0	23	0	0	0	23	0	100.0

TABLE A-2

IMPINGEMENT SURVIVAL STUDY
1980 WINTER FLOUNDER, ALEWIFE, AND YELLOW PERCH DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION (min.)	SEGMENT NO.	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
144	6	18.0	18.9	11.17	2.0	8	2	25	0	25	0	0	0	25	0	100.0
145	6	18.0	19.0	14.70	0.5	2	1	10	14	3	0	0	0	17	7	70.8
146	6	18.0	19.0	14.70	0.5	2	2	4	21	3	0	0	1	25	0	100.0
147	6	18.0	18.9	14.70	0.5	8	1	5	20	3	0	0	0	23	2	92.0
148	6	18.0	18.9	14.70	0.5	8	2	3	21	2	0	0	0	23	1	95.8
149	6	18.0	18.2	14.70	1.0	2	1	0	25	0	0	0	0	25	0	100.0
150	6	18.0	18.2	14.70	1.0	2	2	4	21	2	2	0	0	25	0	100.0
151	6	18.0	18.2	14.70	1.0	8	1	4	21	3	0	0	0	24	1	96.0
152	6	18.0	18.2	14.70	1.0	8	2	0	25	0	0	0	0	25	0	100.0
153	6	18.0	17.0	14.70	1.5	2	1	25	0	24	0	0	0	24	1	96.0
154	6	18.0	17.0	14.70	1.5	2	2	25	0	24	0	0	0	24	1	96.0
155	6	18.0	17.0	14.70	1.5	8	1	25	0	25	0	0	0	25	0	100.0
156	6	18.0	17.0	14.70	1.5	8	2	25	0	24	0	0	0	24	1	96.0
C	6	15.0	15.5	5.22	.	.	1	25	0	0	0	.	.	0	25	0.0
C	6	14.0	15.1	5.54	.	.	1	23	0	0	0	.	.	0	23	0.0
C	6	14.9	14.0	6.59	.	.	1	24	0	16	4	3	1	24	0	100.0
C	6	13.6	14.5	6.75	.	.	1	24	0	0	8	5	8	21	3	87.5
C	6	16.4	17.9	9.52	.	.	1	23	1	2	0	0	3	6	18	25.0
C	6	16.8	17.3	9.63	.	.	1	25	0	1	1	0	6	8	17	32.0
C	6	16.8	16.9	12.40	.	.	2	24	1	0	3	3	9	16	9	64.0
C	6	15.0	15.8	12.50	.	.	1	23	0	0	1	2	3	6	17	26.1
C	6	18.0	18.0	11.17	.	.	2	25	0	0	0	2	0	2	23	8.0
C	6	18.0	19.0	14.70	.	.	2	26	0	0	0	0	1	1	25	3.8
001	7	15.2	17.5	5.75	0.5	2	1	26	0	1	0	.	.	1	25	3.8
002	7	15.2	17.5	5.75	0.5	2	2	25	0	2	2	.	.	4	21	16.0
003	7	15.2	17.5	5.75	0.5	8	1	23	0	0	0	.	.	0	23	0.0
004	7	15.2	17.5	5.75	0.5	8	2	25	0	1	2	.	.	3	22	12.0
005	7	15.2	17.9	5.75	1.0	2	1	26	0	1	3	.	.	4	22	15.4
006	7	15.2	17.9	5.75	1.0	2	2	24	0	1	1	.	.	2	22	8.3
007	7	15.2	17.9	5.75	1.0	8	1	23	0	0	0	.	.	0	23	0.0
008	7	15.2	17.9	5.75	1.0	8	2	24	0	0	2	.	.	2	22	8.3
009	7	15.2	18.0	5.75	1.5	2	1	27	0	2	1	.	.	3	24	11.1
010	7	15.2	18.0	5.75	1.5	2	2	25	0	0	2	.	.	2	23	8.0
011	7	15.2	18.0	5.75	1.5	8	1	25	0	8	2	.	.	10	15	40.0
012	7	15.2	18.0	5.75	1.5	8	2	25	0	4	4	.	.	8	17	32.0
013	7	15.2	18.1	5.75	2.0	2	1	25	0	1	1	.	.	2	23	8.0
014	7	15.2	18.1	5.75	2.0	2	2	25	0	2	3	.	.	5	20	20.0
015	7	15.2	18.1	5.75	2.0	8	1	25	0	2	2	.	.	4	21	16.0
016	7	15.2	18.1	5.75	2.0	8	2	24	0	7	4	.	.	11	13	45.8
017	7	14.0	15.0	6.01	0.5	2	1	25	0	0	0	.	.	0	25	0.0
018	7	14.0	15.0	6.01	0.5	2	2	21	0	0	0	.	.	0	21	0.0
019	7	14.0	15.0	6.01	0.5	8	1	25	0	1	0	.	.	1	24	4.0
020	7	14.0	15.0	6.01	0.5	8	2	26	0	0	3	.	.	3	23	11.5
021	7	14.0	14.0	6.01	1.0	2	1	25	0	0	0	.	.	0	25	0.0
022	7	14.0	14.0	6.01	1.0	2	2	25	0	0	0	.	.	0	25	0.0
023	7	14.0	14.0	6.01	1.0	8	1	25	0	0	1	.	.	1	24	4.0
024	7	14.0	14.0	6.01	1.0	8	2	24	0	0	2	.	.	2	22	8.3
025	7	14.0	14.2	6.01	1.5	2	1	25	0	0	0	.	.	0	25	0.0
026	7	14.0	14.2	6.01	1.5	2	2	24	0	3	4	.	.	7	17	29.2
027	7	14.0	14.2	6.01	1.5	8	1	24	0	4	2	.	.	6	18	25.0
028	7	14.0	14.2	6.01	1.5	8	2	25	0	0	8	.	.	8	17	32.0

TABLE A-2

IMPINGEMENT SURVIVAL STUDY
1980 WINTER FLOUNDER, ALEWIFE, AND YELLOW PERCH DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION (min.)	SEGMENT NO.	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
029	7	14.0	14.3	6.01	2.0	2	1	25	0	0	1	.	.	1	24	4.0
030	7	14.0	14.3	6.01	2.0	2	2	24	0	0	1	.	.	1	23	4.2
031	7	14.0	14.3	6.01	2.0	8	1	25	0	1	6	.	.	7	18	28.0
032	7	14.0	14.3	6.01	2.0	8	2	25	0	3	6	.	.	9	16	36.0
033	7	15.5	15.9	6.32	0.5	2	1	23	0	0	16	4	3	23	0	100.0
034	7	15.5	15.9	6.32	0.5	2	2	26	0	0	20	2	1	23	3	88.5
035	7	15.5	15.8	6.32	0.5	8	1	25	0	0	15	9	1	25	0	100.0
036	7	15.5	15.8	6.32	0.5	8	2	25	0	1	14	2	7	24	1	96.0
037	7	15.5	15.5	6.32	1.0	2	1	26	0	2	20	2	2	26	0	100.0
038	7	15.5	15.5	6.32	1.0	2	2	25	0	0	10	1	9	20	5	80.0
039	7	15.5	15.1	6.32	1.0	8	1	25	0	1	16	3	5	25	0	100.0
040	7	15.5	15.1	6.32	1.0	8	2	25	0	0	15	2	5	22	3	88.0
041	7	15.5	15.5	6.32	1.5	2	1	26	0	1	13	1	10	25	1	96.2
042	7	15.5	15.5	6.32	1.5	2	2	25	0	0	12	0	11	23	2	92.0
043	7	15.5	15.5	6.32	1.5	8	1	24	0	12	12	0	0	24	0	100.0
044	7	15.5	15.5	6.32	1.5	8	2	25	0	20	5	0	0	25	0	100.0
045	7	15.5	15.9	6.32	2.0	2	1	25	0	16	6	0	3	25	0	100.0
046	7	15.5	15.9	6.32	2.0	2	2	24	0	1	9	1	8	19	5	79.2
047	7	15.5	15.9	6.32	2.0	8	1	24	0	8	7	2	3	20	4	83.3
048	7	15.5	15.9	6.32	2.0	8	2	26	0	14	9	8	3	26	0	100.0
049	7	14.1	14.9	6.54	0.5	2	1	25	0	19	0	0	6	25	0	100.0
050	7	14.1	14.9	6.54	0.5	2	2	25	0	15	1	2	7	25	0	100.0
051	7	14.1	14.9	6.54	0.5	8	1	25	0	18	0	0	4	22	3	88.0
052	7	14.1	14.9	6.54	0.5	8	2	25	0	13	1	5	5	24	1	96.0
053	7	14.1	15.2	6.54	1.0	2	1	24	0	13	1	4	5	23	1	95.8
054	7	14.1	15.2	6.54	1.0	2	2	25	0	15	1	3	4	23	2	92.0
055	7	14.1	15.2	6.54	1.0	8	1	26	0	13	4	1	4	22	4	84.6
056	7	14.1	15.2	6.54	1.0	8	2	23	0	22	0	1	0	23	0	100.0
057	7	14.1	15.2	6.54	1.5	2	1	25	0	15	3	3	4	25	0	100.0
058	7	14.1	15.2	6.54	1.5	2	2	24	0	10	2	1	3	16	8	66.7
059	7	14.1	15.0	6.54	1.5	8	1	25	0	16	3	3	2	24	1	96.0
060	7	14.1	15.0	6.54	1.5	8	2	24	0	19	0	0	5	24	0	100.0
061	7	15.0	15.2	6.54	2.0	2	1	25	0	20	1	2	2	25	0	100.0
062	7	15.0	15.2	6.54	2.0	2	2	27	0	21	2	0	0	23	4	85.2
063	7	15.0	15.2	6.54	2.0	8	1	23	0	21	2	0	0	23	0	100.0
064	7	15.0	15.2	6.54	2.0	8	2	26	0	20	3	0	2	25	1	96.2
065	7	14.2	15.5	7.27	0.5	2	1	27	1	1	2	3	4	11	16	40.7
066	7	14.2	15.5	7.27	0.5	2	2	25	0	1	2	5	6	14	11	56.0
067	7	14.2	15.0	7.27	0.5	8	1	25	0	1	1	0	8	10	15	40.0
068	7	14.2	15.0	7.27	0.5	8	2	24	0	5	5	0	3	13	11	54.2
069	7	14.2	14.8	7.27	1.0	2	1	25	0	3	1	0	4	8	17	32.0
070	7	14.2	14.8	7.27	1.0	2	2	25	0	10	1	0	2	13	12	52.0
071	7	14.2	14.8	7.27	1.0	8	1	25	0	3	6	0	2	11	14	44.0
072	7	14.2	14.8	7.27	1.0	8	2	25	0	17	3	0	0	20	5	80.0
073	7	14.2	14.2	7.27	1.5	2	1	25	0	4	0	0	5	9	16	36.0
074	7	14.2	14.2	7.27	1.5	2	2	25	0	12	0	1	2	15	10	60.0
075	7	14.2	14.2	7.27	1.5	8	1	25	0	10	1	0	1	12	13	48.0
076	7	14.2	14.2	7.27	1.5	8	2	25	0	19	3	0	1	23	2	92.0
077	7	14.2	14.8	7.27	2.0	2	1	26	0	5	4	2	5	16	10	61.5
078	7	14.2	14.8	7.27	2.0	2	2	25	0	12	2	0	2	16	9	64.0
079	7	14.2	14.8	7.27	2.0	8	1	25	0	17	0	0	1	18	7	72.0

TABLE A-2

IMPINGEMENT SURVIVAL STUDY
1980 WINTER FLOUNDER, ALEWIFE, AND YELLOW PERCH DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION (min.)	SEGMENT NO.	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
080	7	14.2	14.8	7.27	2.0	8	2	25	0	25	0	0	0	25	0	100.0
081	7	16.0	14.1	7.98	0.5	2	1	25	0	1	0	0	4	5	20	20.0
082	7	16.0	14.1	7.98	0.5	2	2	24	0	0	0	0	2	2	22	8.3
083	7	16.0	14.3	7.98	0.5	8	1	25	0	5	4	0	0	9	16	36.0
084	7	16.0	14.3	7.98	0.5	8	2	25	0	1	2	1	1	5	20	20.0
085	7	16.0	14.4	7.98	1.0	2	1	25	0	6	3	1	9	19	6	76.0
086	7	16.0	14.4	7.98	1.0	2	2	25	0	15	3	2	2	22	3	88.0
087	7	16.0	14.5	7.98	1.0	8	1	25	0	11	0	0	9	20	5	80.0
088	7	16.0	14.5	7.98	1.0	8	2	26	0	11	1	1	13	26	0	100.0
089	7	16.0	14.8	7.98	1.5	2	1	25	0	7	2	0	1	10	15	40.0
090	7	16.0	14.8	7.98	1.5	2	2	25	0	16	4	0	2	22	3	88.0
091	7	16.0	15.0	7.98	1.5	8	1	26	0	9	5	0	5	19	7	73.1
092	7	16.0	15.0	7.98	1.5	8	2	25	0	20	1	1	0	22	3	88.0
093	7	16.0	15.0	7.98	2.0	2	1	25	0	6	3	0	8	17	8	68.0
094	7	16.0	15.0	7.98	2.0	2	2	25	0	1	3	10	6	20	5	80.0
095	7	16.0	15.0	7.98	2.0	8	1	25	0	5	16	1	2	24	1	96.0
096	7	16.0	15.0	7.98	2.0	8	2	25	0	4	13	3	4	24	1	96.0
097	7	14.6	16.0	7.58	0.5	2	1	26	0	1	2	6	8	17	9	65.4
098	7	14.6	16.0	7.58	0.5	2	2	24	1	4	0	6	5	16	9	64.0
099	7	14.6	16.0	7.58	0.5	8	1	25	0	0	3	8	4	15	10	60.0
100	7	14.6	16.0	7.58	0.5	8	2	23	0	0	0	20	3	23	0	100.0
101	7	14.6	14.8	7.58	1.0	2	1	25	0	1	0	1	13	15	10	60.0
102	7	14.6	14.8	7.58	1.0	2	2	21	4	4	11	2	3	24	1	96.0
103	7	14.6	14.5	7.58	1.0	8	1	25	0	0	6	12	6	24	1	96.0
104	7	14.6	14.5	7.58	1.0	8	2	23	1	5	5	12	1	24	1	96.0
105	7	14.6	14.2	7.58	1.5	2	1	25	0	5	7	5	4	21	4	84.0
106	7	14.6	14.2	7.58	1.5	2	2	24	1	1	6	12	5	25	0	100.0
107	7	14.6	14.2	7.58	1.5	8	1	24	1	1	11	9	2	24	1	96.0
108	7	14.6	14.2	7.58	1.5	8	2	25	2	13	7	1	4	27	0	100.0
109	7	14.6	14.8	7.58	2.0	2	1	24	0	4	8	10	2	24	0	100.0
110	7	14.6	14.8	7.58	2.0	2	2	24	1	10	6	2	6	25	0	100.0
111	7	14.6	14.8	7.58	2.0	8	1	26	0	12	6	0	5	23	3	88.5
112	7	14.6	14.8	7.58	2.0	8	2	24	1	12	6	2	4	25	0	100.0
113	7	16.5	17.1	9.25	0.5	2	1	25	1	0	0	0	1	2	24	7.7
114	7	16.5	17.1	9.25	0.5	2	2	20	5	0	2	2	3	12	13	48.0
115	7	16.5	17.1	9.25	0.5	8	1	24	1	2	1	0	5	9	16	36.0
116	7	16.5	17.1	9.25	0.5	8	2	25	0	0	0	0	3	3	22	12.0
117	7	16.5	16.9	9.25	1.0	2	1	24	1	4	0	0	2	7	18	28.0
118	7	16.5	16.9	9.25	1.0	2	2	24	0	0	0	0	1	1	23	4.2
119	7	16.5	16.9	9.25	1.0	8	1	18	7	6	1	2	2	18	7	72.0
120	7	16.5	16.9	9.25	1.0	8	2	13	12	1	0	0	0	13	12	52.0
121	7	16.5	16.1	9.25	1.5	2	1	21	5	3	1	0	1	10	16	38.5
122	7	16.5	16.1	9.25	1.5	2	2	21	4	5	0	0	3	12	13	48.0
123	7	16.5	16.1	9.25	1.5	8	1	8	17	4	0	0	0	21	4	84.0
124	7	16.5	16.1	9.25	1.5	8	2	8	17	1	0	0	0	18	7	72.0
125	7	16.5	16.3	9.25	2.0	2	1	18	7	7	1	2	2	19	6	76.0
126	7	16.5	16.3	9.25	2.0	2	2	8	17	1	0	0	0	18	7	72.0
127	7	16.5	16.3	9.25	2.0	8	1	11	14	3	0	0	2	19	6	76.0
128	7	16.5	16.3	9.25	2.0	8	2	0	25	0	0	0	0	25	0	100.0
129	7	18.0	19.5	14.28	0.5	2	1	23	0	1	0	0	0	1	22	4.3
130	7	18.0	19.5	14.28	0.5	2	2	22	1	0	0	0	0	1	22	4.3

TABLE A-2

IMPINGEMENT SURVIVAL STUDY
1980 WINTER FLOUNDER, ALEWIFE,
AND YELLOW PERCH DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION (min.)	SEGMENT NO.	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
131	7	18.0	19.5	14.28	0.5	8	1	24	1	2	0	0	1	4	21	16.0
132	7	18.0	19.5	14.28	0.5	8	2	22	1	0	1	3	1	6	17	26.1
133	7	18.0	19.6	14.28	1.0	2	1	24	1	2	2	1	0	6	19	24.0
134	7	18.0	19.6	14.28	1.0	2	2	23	1	0	0	1	2	4	20	16.7
135	7	18.0	19.6	14.28	1.0	8	1	17	9	1	1	0	0	11	15	42.3
136	7	18.0	19.6	14.28	1.0	8	2	15	10	0	0	2	1	13	12	52.0
137	7	18.0	19.8	14.28	1.5	2	1	20	5	0	1	2	1	9	16	36.0
138	7	18.0	19.8	14.28	1.5	2	2	22	3	1	1	2	0	7	18	28.0
139	7	18.0	19.8	14.28	1.5	8	1	6	19	1	0	0	0	20	5	80.0
140	7	18.0	19.8	14.28	1.5	8	2	8	17	0	0	0	0	17	8	68.0
141	7	18.0	18.0	14.28	2.0	2	1	23	2	2	1	3	1	9	16	36.0
142	7	18.0	18.0	14.28	2.0	2	2	24	1	1	1	0	0	3	22	12.0
143	7	18.0	18.0	14.28	2.0	8	1	23	2	2	1	5	0	10	15	40.0
144	7	18.0	18.0	14.28	2.0	8	2	12	14	2	0	0	0	16	10	61.5
C	7	15.2	17.5	5.75	.	.	1	25	0	0	1	.	.	1	24	4.0
C	7	14.0	15.0	6.01	.	.	1	24	0	0	1	.	.	1	23	4.2
C	7	15.5	15.9	6.32	.	.	1	25	0	0	8	11	4	23	2	92.0
C	7	14.1	14.9	6.54	.	.	1	23	0	2	1	4	11	18	5	78.3
C	7	14.2	15.2	7.27	.	.	1	25	0	0	0	1	4	5	20	20.0
C	7	16.0	14.3	7.98	.	.	1	25	0	0	0	0	2	2	23	8.0
C	7	14.6	14.8	7.58	.	.	1	25	0	6	0	2	7	15	10	60.0
C	7	16.5	17.1	9.25	.	.	1	18	7	1	1	2	7	18	7	72.0
C	7	18.0	19.5	14.28	.	.	1	25	0	0	0	0	1	1	24	4.0

NOTES: 1) SPECIES - 5 = WINTER FLOUNDER
6 = ALEWIFE
7 = YELLOW PERCH

2) "C" UNDER "TEST NO." DESIGNATES CONTROL MORTALITY FOR EACH TEST SERIES.

TABLE A-3

IMPINGEMENT SURVIVAL STUDY
1980 WINTER FLOUNDER DATA WITH
UNACCOUNTED FOR LARVAE ASSUMED DEAD

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	LARVAL LENGTH (mm)	VELOCITY (fps)	DURATION (min.)	SEGMENT	TOTAL INITIAL LIVE	TOTAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %
009	5	6	8.0	4.07	0.5	2	1	21	0	0	0	0	0	0	21	16.0
010	5	6	8.0	4.07	0.5	2	2	23	1	0	0	0	0	1	23	8.0
011	5	6	8.5	4.07	0.5	8	1	23	0	0	0	0	2	2	21	16.0
012	5	6	8.5	4.07	0.5	8	2	23	1	0	0	0	1	2	22	12.0
013	5	6	8.7	4.07	1.0	2	1	27	0	0	0	0	1	1	26	0.0
014	5	6	8.7	4.07	1.0	2	2	25	0	0	0	0	5	5	20	20.0
015	5	6	9.0	4.07	1.0	8	1	25	0	0	0	0	0	0	25	0.0
016	5	6	9.0	4.07	1.0	8	2	24	0	0	0	0	4	4	20	20.0
017	5	7	9.0	4.07	1.5	2	1	25	0	0	0	0	7	7	18	28.0
018	5	7	9.0	4.07	1.5	2	2	25	0	0	0	0	2	2	23	8.0
019	5	7	9.5	4.07	1.5	8	1	22	0	0	0	0	0	0	22	12.0
020	5	7	9.5	4.07	1.5	8	2	23	0	0	0	0	2	2	21	16.0
021	5	7	10.0	4.07	2.0	2	1	20	0	0	0	0	0	0	20	20.0
022	5	7	10.0	4.07	2.0	2	2	25	0	0	0	0	2	2	23	8.0
023	5	7	10.0	4.07	2.0	8	1	14	0	0	1	0	8	9	5	80.0
024	5	7	10.0	4.07	2.0	8	2	18	0	0	0	0	2	2	16	36.0
025	5	6	9.0	4.04	0.5	2	1	24	0	0	0	0	0	0	24	4.0
026	5	6	9.0	4.04	0.5	2	2	27	0	0	0	0	3	3	24	11.1
027	5	6	10.0	4.04	0.5	8	1	24	0	0	0	0	2	2	22	12.0
028	5	6	10.0	4.04	0.5	8	2	22	0	0	0	0	0	0	22	12.0
029	5	6	10.0	4.04	1.0	2	1	23	0	0	0	0	0	0	23	8.0
030	5	6	10.0	4.04	1.0	2	2	21	0	0	0	0	0	0	21	16.0
031	5	6	10.0	4.04	1.0	8	1	24	0	0	0	0	0	0	24	4.0
032	5	6	10.0	4.04	1.0	8	2	24	0	0	0	0	2	2	22	12.0
033	5	6	10.0	4.04	1.5	2	1	22	0	0	0	0	1	1	21	16.0
034	5	6	10.0	4.04	1.5	2	2	26	0	0	0	0	3	3	23	12.0
035	5	7	10.5	4.04	1.5	8	1	22	0	0	0	0	2	2	20	20.0
036	5	7	10.5	4.04	1.5	8	2	24	0	0	0	0	7	7	17	32.0
037	5	7	10.5	4.04	2.0	2	1	23	0	0	0	0	6	6	17	32.0
038	5	7	10.5	4.04	2.0	2	2	22	0	0	0	0	10	10	12	52.0
039	5	7	10.8	4.04	2.0	8	1	13	4	0	0	0	1	5	12	52.0
040	5	7	10.8	4.04	2.0	8	2	15	2	0	0	0	6	8	9	60.0

SPECIES = 5 = WINTER FLOUNDER

APPENDIX B

TABLE B-1

SCREEN RETENTION STUDY
1979 STRIPED BASS TEST DATA

TEST NO.	TANK TEMP., °C	FLUME TEMP., °C	ΔT, °C	LARVAL LENGTH (mm)	MESH	VELOCITY	NO. IMPINGED	NO. ENTRAINED	NO. SWIMMING	% RETAINED
2.	14.0	28.5	-14.5	5.41	0.5	1.5	23.00	2.00	0.0	92.0
3.	16.9	21.0	-4.1	5.41	0.5	0.8	21.00	4.00	0.0	84.0
4.	16.9	23.0	-6.1	5.41	1.0	0.8	2.00	23.00	0.0	8.7
5.	16.9	23.0	-6.1	5.41	1.0	1.5	7.00	18.00	0.0	28.0
6.	16.9	23.0	-6.1	5.41	1.5	0.8	0.0	25.00	0.0	0.0
7.	16.9	33.0	-16.1	5.41	1.5	1.5	0.0	25.00	0.0	0.0
8.	18.0	18.6	-0.6	6.40	0.5	1.5	25.00	0.0	0.0	100.0
9.	18.0	19.1	-1.1	6.40	0.5	0.8	24.00	1.00	0.0	96.0
10.	18.0	19.1	-1.1	6.40	1.0	1.5	5.00	20.00	0.0	20.0
11.	18.0	19.5	-1.5	6.40	1.0	0.8	0.0	24.00	0.0	0.0
12.	18.0	19.5	-1.5	6.40	1.5	0.8	0.0	25.00	0.0	0.0
13.	18.0	20.0	-2.0	6.40	1.5	1.5	0.0	24.00	0.0	0.0
14.	15.0	16.0	-1.0	6.46	0.5	0.8	25.00	0.0	0.0	100.0
15.	15.0	16.0	-1.0	6.46	0.5	1.5	25.00	0.0	0.0	100.0
16.	15.0	16.2	-1.2	6.46	1.0	0.8	4.00	21.00	0.0	16.0
17.	15.0	16.2	-1.2	6.46	1.0	1.5	3.00	22.00	0.0	12.0
18.	15.3	17.0	-1.7	6.46	1.5	0.8	0.0	25.00	0.0	0.0
19.	15.3	17.0	-1.7	6.46	1.5	1.5	1.00	24.00	0.0	4.0
20.	15.3	17.0	-1.7	6.46	1.0	0.8	0.0	25.00	0.0	0.0
21.	15.3	17.0	-1.7	6.46	1.0	1.5	0.0	25.00	0.0	0.0
22.	15.3	17.0	-1.7	6.46	0.5	0.6	25.00	0.0	0.0	100.0
23.	15.3	17.0	-1.7	6.46	0.5	1.5	25.00	0.0	0.0	100.0
24.	15.5	16.9	-1.4	6.46	1.0	0.8	1.00	25.00	0.0	3.8
25.	15.5	16.9	-1.4	6.46	1.0	1.5	0.0	25.00	0.0	0.0
26.	15.5	16.9	-1.4	6.46	1.5	0.8	0.0	25.00	0.0	0.0
27.	15.5	16.9	-1.4	6.46	1.5	1.5	1.00	24.00	0.0	4.0
28.	15.5	16.9	-1.4	6.46	0.5	0.8	25.00	0.0	0.0	100.0
29.	15.5	16.9	-1.4	6.46	0.5	1.5	24.00	0.0	0.0	100.0
30.	18.9	19.2	-0.3	6.91	0.5	0.8	25.00	0.0	0.0	100.0
31.	18.9	19.2	-0.3	6.91	0.5	1.5	25.00	0.0	0.0	100.0
32.	18.9	19.2	-0.3	6.91	1.0	0.8	0.0	25.00	0.0	0.0
33.	18.9	20.0	-1.1	6.91	1.0	1.5	1.00	24.00	0.0	4.0
34.	18.9	20.0	-1.1	6.91	1.0	0.8	0.0	25.00	0.0	0.0
35.	18.9	20.0	-1.1	6.91	1.0	1.5	2.00	23.00	0.0	8.0
36.	18.9	20.0	-1.1	6.91	1.5	0.8	0.0	25.00	0.0	0.0
37.	18.9	20.0	-1.1	6.91	1.5	1.5	0.0	25.00	0.0	0.0
38.	18.9	20.0	-1.1	6.91	1.0	0.8	0.0	25.00	0.0	0.0
39.	18.9	20.0	-1.1	6.91	1.0	1.5	2.00	23.00	0.0	8.0
40.	19.3	19.7	-0.4	7.94	1.0	0.5	2.00	13.00	0.0	13.3
41.	19.3	19.7	-0.4	7.94	1.0	1.0	0.0	15.00	0.0	0.0
42.	19.3	19.7	-0.4	7.94	1.5	0.5	0.0	15.00	0.0	0.0
43.	19.3	19.7	-0.4	7.94	1.5	0.5	0.0	15.00	0.0	0.0
44.	19.3	19.7	-0.4	7.94	1.0	0.5	2.00	13.00	0.0	13.3
45.	19.3	19.7	-0.4	7.94	1.0	1.0	0.0	15.00	0.0	0.0
46.	19.3	19.7	-0.4	7.94	1.0	1.5	0.0	16.00	0.0	0.0
47.	19.3	19.7	-0.4	7.94	1.5	1.0	0.0	15.00	0.0	0.0
49.	19.3	19.7	-0.4	7.94	1.5	1.0	0.0	15.00	0.0	0.0
49.	19.3	19.7	-0.4	7.94	1.5	1.5	0.0	15.00	0.0	0.0
50.	19.2	19.2	0.0	9.07	1.0	0.5	8.00	7.00	0.0	53.3
51.	19.2	19.2	0.0	9.07	1.0	1.0	7.00	8.00	0.0	46.7
52.	19.2	19.2	0.0	9.07	1.0	1.5	6.00	9.00	0.0	40.0
53.	19.2	19.2	0.0	9.07	1.0	0.5	13.00	2.00	0.0	86.7
54.	19.2	19.2	0.0	9.07	1.0	1.0	9.00	6.00	0.0	60.0

TABLE B-1

SCREEN RETENTION STUDY
1979 STRIPED BASS TEST DATA

TEST NO.	TANK TEMP., °C	FLUME TEMP., °C	ΔT, °C	LARVAL LENGTH (mm)	MESH	VELOCITY	NO. IMPINGED	NO. ENTRAINED	NO. SWIMMING	% RETAINED
55.	19.2	19.2	0.0	9.07	1.0	1.5	9.00	6.00	0.0	60.0
56.	19.2	20.0	-0.8	9.07	1.5	0.5	0.0	15.00	0.0	0.0
57.	19.2	20.0	-0.8	9.07	1.5	1.0	0.0	15.00	0.0	0.0
58.	19.2	20.0	-0.8	9.07	1.5	1.5	0.0	15.00	0.0	0.0
59.	19.2	20.0	-0.8	9.07	1.5	0.5	1.00	14.00	0.0	6.7
60.	19.2	20.0	-0.8	9.07	1.5	1.0	0.0	15.00	0.0	0.0
61.	19.2	20.0	-0.8	9.07	1.5	1.5	0.0	15.00	0.0	0.0
62.	19.2	20.0	-0.8	9.07	1.0	0.5	11.00	3.00	1.00	78.6
63.	19.2	20.0	-0.8	9.07	1.0	1.0	6.00	9.00	0.0	40.0
64.	19.2	20.0	-0.8	9.07	1.0	1.5	4.00	11.00	0.0	26.7
65.	18.9	19.2	-0.3	9.92	1.0	0.5	13.00	1.00	1.00	92.9
66.	18.9	19.2	-0.3	9.92	1.0	1.0	15.00	0.0	0.0	100.0
67.	18.9	19.2	-0.3	9.92	1.0	1.5	13.00	2.00	0.0	86.7
68.	18.9	20.0	-1.1	9.92	1.0	0.5	11.00	0.0	4.00	100.0
69.	18.9	20.0	-1.1	9.92	1.0	1.0	15.00	0.0	0.0	100.0
70.	18.9	20.0	-1.1	9.92	1.0	1.5	15.00	0.0	0.0	100.0
71.	18.9	20.1	-1.2	9.92	1.5	0.5	0.0	15.00	0.0	0.0
72.	18.9	20.1	-1.2	9.92	1.5	1.0	0.0	15.00	0.0	0.0
73.	18.9	20.1	-1.2	9.92	1.5	1.5	0.0	15.00	0.0	0.0
74.	17.8	19.3	-1.5	9.88	1.0	0.5	14.00	0.0	1.00	100.0
75.	17.8	19.3	-1.5	9.88	1.0	1.0	15.00	0.0	0.0	100.0
76.	17.8	19.3	-1.5	9.88	1.0	1.5	15.00	0.0	0.0	100.0
77.	18.8	20.6	-1.8	9.89	1.5	0.5	0.0	15.00	0.0	0.0
78.	18.8	20.6	-1.8	9.89	1.5	1.0	0.0	15.00	0.0	0.0
79.	18.8	20.6	-1.8	9.89	1.5	1.5	1.00	14.00	0.0	6.7
80.	20.1	21.7	-1.6	10.80	1.5	0.5	2.00	13.00	0.0	13.3
81.	20.1	21.3	-1.2	10.80	1.5	1.0	1.00	14.00	0.0	6.7
82.	20.1	21.2	-1.1	10.80	1.5	1.5	1.00	14.00	0.0	6.7
83.	20.1	21.3	-1.2	10.80	1.5	0.5	2.00	13.00	0.0	13.3
84.	20.1	21.0	-0.9	10.80	1.5	1.0	1.00	14.00	0.0	6.7
85.	20.1	21.2	-1.1	10.80	1.5	1.5	2.00	13.00	0.0	13.3
86.	20.1	21.8	-1.7	10.80	2.0	0.5	0.0	15.00	0.0	0.0
87.	20.1	21.8	-1.7	10.80	2.0	1.0	0.0	15.00	0.0	0.0
88.	20.1	21.3	-1.2	10.80	2.0	1.5	0.0	15.00	0.0	0.0
89.	19.3	22.1	-2.8	13.08	1.5	0.5	4.00	3.00	8.00	57.1
90.	19.3	22.2	-2.9	13.08	1.5	1.0	8.00	7.00	0.0	53.3
91.	19.3	22.2	-2.9	13.08	1.5	1.5	10.00	5.00	0.0	66.7
92.	19.3	22.2	-2.9	13.08	1.5	0.5	10.00	5.00	0.0	66.7
93.	19.3	22.2	-2.9	13.08	1.5	1.0	12.00	3.00	0.0	80.0
94.	19.3	22.2	-2.9	13.08	1.5	1.5	6.00	9.00	0.0	40.0
95.	19.3	21.8	-2.5	13.08	2.0	0.5	1.00	13.00	1.00	7.1
96.	19.3	22.0	-2.7	13.08	2.0	1.0	0.0	15.00	0.0	0.0
97.	19.3	22.0	-2.7	13.08	2.0	1.5	0.0	15.00	0.0	0.0
98.	19.8	19.9	-0.1	13.77	1.5	0.5	11.00	2.00	2.00	84.6
99.	19.8	19.9	-0.1	13.77	1.5	1.0	5.00	10.00	0.0	33.3
100.	19.8	19.9	-0.1	13.77	1.5	1.5	7.00	8.00	0.0	46.7
101.	19.8	20.1	-0.3	13.77	1.5	0.5	11.00	2.00	2.00	84.6
102.	19.8	20.1	-0.3	13.77	1.5	1.0	5.00	10.00	0.0	33.3
103.	19.8	20.1	-0.3	13.77	1.5	1.5	6.00	9.00	0.0	40.0
104.	19.8	21.2	-1.4	13.77	2.0	0.5	0.0	14.00	1.00	0.0
105.	19.8	21.2	-1.4	13.77	2.0	1.0	0.0	15.00	0.0	0.0
106.	19.8	21.2	-1.4	13.77	2.0	1.5	0.0	15.00	0.0	0.0
107.	20.3	21.1	-0.8	13.31	1.5	0.5	12.00	1.00	2.00	92.3
108.	20.3	21.1	-0.8	13.31	1.5	1.0	13.00	2.00	0.0	86.7
109.	20.3	21.8	-1.5	13.31	1.5	1.5	13.00	2.00	0.0	86.7
110.	20.3	21.1	-0.8	13.31	1.5	0.5	10.00	0.0	5.00	100.0
111.	20.3	21.1	-0.8	13.31	1.5	1.0	12.00	3.00	0.0	80.0
112.	20.3	21.8	-1.5	13.31	1.5	1.5	12.00	3.00	0.0	80.0
113.	20.3	21.9	-1.6	13.31	2.0	0.5	1.00	14.00	0.0	6.7
114.	20.3	21.9	-1.6	13.31	2.0	1.0	0.0	15.00	0.0	0.0

TABLE B-1

SCREEN RETENTION STUDY
1979 STRIPED BASS TEST DATA

TEST NO.	TANK TEMP., °C	FLUME TEMP., °C	ΔT, °C	LARVAL LENGTH (mm)	MESH	VELOCITY	NO. IMPINGED	NO. ENTRAINED	NO. SWIMMING	% RETAINED
115.	20.3	21.9	-1.6	13.31	2.0	1.5	0.0	15.00	0.0	0.0
116.	19.8	19.6	0.2	14.95	2.0	0.5	10.00	4.00	1.00	71.4
117.	19.8	19.6	0.2	14.95	2.0	0.5	7.00	8.00	0.0	46.7
118.	19.8	19.6	0.2	14.95	2.0	1.0	5.00	10.00	0.0	33.3
119.	19.0	19.6	0.2	14.95	2.0	1.0	9.00	6.00	0.0	60.0
120.	19.6	19.8	-0.2	14.95	2.0	1.5	5.00	10.00	0.0	33.3
121.	19.6	19.0	-0.2	14.95	2.0	1.5	7.00	8.00	0.0	46.7
122.	19.6	19.8	-0.2	14.95	1.5	0.5	10.00	0.0	5.00	100.0
123.	19.6	19.8	-0.2	14.95	1.5	1.0	15.00	0.0	0.0	100.0
124.	19.6	19.0	-0.2	14.95	1.5	1.5	15.00	0.0	0.0	100.0
125.	20.5	20.9	-0.4	17.40	1.5	0.5	4.00	0.0	11.00	100.0
126.	20.5	20.9	-0.4	17.40	1.5	1.0	15.00	0.0	0.0	100.0
127.	20.5	20.9	-0.4	17.40	1.5	1.5	15.00	0.0	0.0	100.0
128.	20.9	21.1	-0.2	17.40	2.0	0.5	1.00	0.0	14.00	100.0
129.	20.9	21.1	-0.2	17.40	2.0	0.5	1.00	0.0	14.00	100.0
130.	20.9	21.1	-0.2	17.40	2.0	1.0	15.00	0.0	0.0	100.0
131.	20.9	21.1	-0.2	17.40	2.0	1.0	15.00	0.0	0.0	100.0
132.	20.9	21.1	-0.2	17.40	2.0	1.5	15.00	0.0	0.0	100.0
133.	20.9	21.1	-0.2	17.40	2.0	1.5	14.00	1.00	0.0	93.3
134.	20.2	21.8	-1.6	18.02	2.0	0.5	8.00	0.0	7.00	100.0
135.	20.2	21.0	-1.6	10.02	2.0	1.0	14.00	1.00	0.0	93.3
136.	20.2	21.0	-1.6	18.02	2.0	1.5	14.00	1.00	0.0	93.3
137.	20.4	20.9	-0.5	21.45	2.0	0.5	1.00	0.0	14.00	100.0
138.	20.4	20.9	-0.5	21.45	2.0	1.0	12.00	0.0	3.00	100.0
139.	20.4	20.9	-0.5	21.45	2.0	1.5	15.00	0.0	0.0	100.0

TABLE B-2

SCREEN RETENTION STUDY
1980 WINTER FLOUNDER, ALEWIFE, AND YELLOW PERCH DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	LENGTH	MESH SIZE	VELOCITY	NO. IMPINGED	NO. ENTRAINED	NO. SWIMMING	% RETAINED
001	5	6	6.5	4.07	0.500	0.5	17	8	0	68
002	5	6	6.5	4.07	0.500	0.5	15	10	0	60
003	5	6	6.5	4.07	0.500	0.5	19	6	0	76
004	5	6	6.5	4.07	0.500	0.5	18	7	0	72
005	5	6	6.5	4.07	0.355	0.5	25	0	0	100
006	5	6	7.0	4.07	0.355	0.5	27	0	0	100
007	5	6	7.0	4.07	0.355	0.5	25	0	0	100
008	5	6	7.0	4.07	0.355	0.5	23	2	0	92
009	5	6	6.8	4.07	1.000	0.5	2	23	0	8
010	5	6	6.8	4.07	1.000	0.5	0	25	0	0
011	5	6	6.8	4.07	1.000	0.5	0	25	0	0
012	5	6	7.0	4.07	1.000	0.5	0	25	0	0
013	5	6	7.2	4.07	0.500	1.5	20	5	0	80
014	5	6	7.2	4.07	0.500	1.5	26	0	0	100
015	5	6	7.2	4.07	0.500	1.5	18	7	0	72
016	5	6	7.2	4.07	0.500	1.5	16	9	0	64
017	5	8	7.3	4.04	0.500	0.5	16	9	0	64
018	5	8	7.2	4.04	0.500	0.5	18	7	0	72
019	5	8	7.3	4.04	0.500	0.5	22	3	0	88
020	5	8	7.3	4.04	0.500	0.5	14	11	0	56
021	5	8	7.3	4.04	1.000	0.5	0	25	0	0
022	5	8	7.3	4.04	1.000	0.5	0	25	0	0
023	5	8	7.3	4.04	1.000	0.5	0	25	0	0
024	5	8	7.3	4.04	1.000	0.5	0	25	0	0
025	5	8	7.6	4.04	0.500	1.5	17	8	0	68
026	5	8	7.6	4.04	0.500	1.5	18	7	0	72
027	5	8	7.6	4.04	0.500	1.5	21	4	0	84
028	5	8	7.6	4.04	0.500	1.5	19	6	0	76
029	5	6	6.2	4.38	0.500	0.5	16	9	0	64
030	5	6	6.2	4.38	0.500	0.5	19	6	0	76
031	5	6	6.2	4.38	0.500	0.5	15	10	0	60
032	5	6	6.2	4.38	0.500	0.5	13	12	0	52
033	5	6	6.2	4.38	1.000	0.5	4	21	0	16
034	5	6	6.2	4.38	1.000	0.5	1	24	0	4
035	5	6	6.2	4.38	1.000	0.5	1	24	0	4
036	5	6	6.2	4.38	1.000	0.5	6	19	0	24
037	5	6	6.4	4.38	0.500	1.5	20	5	0	80
038	5	6	6.4	4.38	0.500	1.5	20	5	0	80
039	5	6	6.4	4.38	0.500	1.5	19	6	0	76
040	5	6	6.4	4.38	0.500	1.5	22	3	0	88
001	6	15	14.8	5.22	0.355	0.5	15	10	0	60
002	6	15	14.8	5.22	0.355	0.5	16	9	0	64
003	6	15	14.8	5.22	0.355	0.5	19	6	0	76
004	6	15	14.8	5.22	0.355	0.5	14	11	0	56
005	6	15	14.8	5.22	0.500	0.5	1	24	0	4
006	6	15	14.8	5.22	0.500	0.5	0	25	0	0
007	6	15	14.8	5.22	0.500	0.5	0	25	0	0
008	6	15	14.8	5.22	0.500	0.5	1	24	0	4
009	6	15	14.8	5.22	0.355	1.5	24	1	0	96
010	6	15	14.8	5.22	0.355	1.5	23	2	0	92
011	6	15	15.0	5.22	0.355	1.5	25	0	0	100

TABLE B-2

SCREEN RETENTION STUDY
1980 WINTER FLOUNDER, ALEWIFE, AND YELLOW PERCH DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	LENGTH	MESH SIZE	VELOCITY	NO. IMPINGED	NO. ENTRAINED	NO. SWIMMING	% RETAINED
012	6	15.0	15.0	5.22	0.355	1.5	25	0	0	100.0
017	6	15.5	16.5	6.61	0.355	0.5	24	1	0	96.0
018	6	15.5	16.5	6.61	0.355	0.5	17	8	0	68.0
019	6	15.5	16.5	6.61	0.355	0.5	25	0	0	100.0
020	6	15.5	16.5	6.61	0.355	0.5	21	4	0	84.0
021	6	15.5	16.5	6.61	0.500	0.5	1	24	0	4.0
022	6	15.5	16.5	6.61	0.500	0.5	4	21	0	16.0
023	6	15.5	16.5	6.61	0.500	0.5	4	21	0	16.0
024	6	15.5	16.5	6.61	0.500	0.5	1	24	0	4.0
025	6	15.5	16.5	6.61	0.355	1.5	24	1	0	96.0
026	6	15.5	16.5	6.61	0.355	1.5	24	1	0	96.0
027	6	15.5	16.5	6.61	0.355	1.5	23	2	0	92.0
028	6	15.5	16.5	6.61	0.355	1.5	25	0	0	100.0
029	6	14.8	15.8	6.59	0.355	0.5	10	0	0	100.0
030	6	14.8	15.8	6.59	0.355	0.5	10	0	0	100.0
031	6	14.8	15.8	6.59	0.355	0.5	10	0	0	100.0
032	6	14.8	15.8	6.59	0.355	0.5	10	0	0	100.0
033	6	14.8	15.8	6.59	0.500	0.5	2	8	0	20.0
034	6	14.8	15.8	6.59	0.500	0.5	1	9	0	10.0
035	6	14.8	15.8	6.59	0.500	0.5	3	7	0	30.0
036	6	14.8	15.8	6.59	0.500	0.5	2	8	0	20.0
037	6	14.8	16.0	6.59	0.355	1.5	10	0	0	100.0
038	6	14.8	16.0	6.59	0.355	1.5	12	0	0	100.0
039	6	14.8	16.0	6.59	0.355	1.5	10	0	0	100.0
040	6	14.8	16.0	6.59	0.355	1.5	10	0	0	100.0
041	6	14.8	16.0	6.59	0.500	1.5	3	7	0	30.0
042	6	14.8	16.0	6.59	0.500	1.5	9	1	0	90.0
043	6	14.8	16.0	6.59	0.500	1.5	11	0	0	100.0
044	6	14.8	16.0	6.59	0.500	1.5	9	1	0	90.0
045	6	16.2	17.1	9.52	0.500	0.5	9	0	1	100.0
046	6	16.2	17.1	9.52	0.500	0.5	6	3	1	66.7
047	6	16.2	17.1	9.52	0.500	0.5	9	1	0	90.0
048	6	16.2	17.1	9.52	0.500	0.5	10	0	0	100.0
049	6	16.2	17.1	9.52	1.000	0.5	0	10	0	0.0
050	6	16.2	17.1	9.52	1.000	0.5	0	10	0	0.0
051	6	16.2	17.1	9.52	1.000	0.5	0	10	0	0.0
052	6	16.2	17.1	9.52	1.000	0.5	0	10	0	0.0
053	6	16.2	17.6	9.52	0.500	1.5	9	1	0	90.0
054	6	16.2	17.6	9.52	0.500	1.5	9	1	0	90.0
055	6	16.2	17.6	9.52	0.500	1.5	10	0	0	100.0
056	6	16.2	17.6	9.52	0.500	1.5	9	1	0	90.0
057	6	16.2	17.6	9.52	1.000	1.5	4	6	0	40.0
058	6	16.2	17.6	9.52	1.000	1.5	3	7	0	30.0
059	6	16.2	17.6	9.52	1.000	1.5	3	7	0	30.0
060	6	16.2	17.6	9.52	1.000	1.5	2	8	0	20.0
001	7	15.0	15.3	5.75	0.355	0.5	22	3	0	88.0
002	7	15.0	15.3	5.75	0.355	0.5	17	8	0	68.0
003	7	15.0	15.3	5.75	0.355	0.5	19	6	0	76.0
004	7	15.0	15.3	5.75	0.355	0.5	17	8	0	68.0
005	7	15.0	15.3	5.75	0.500	0.5	10	15	0	40.0
006	7	15.0	15.3	5.75	0.500	0.5	14	11	0	56.0

TABLE B-2

SCREEN RETENTION STUDY
1980 WINTER FLOUNDER, ALEWIFE,
AND YELLOW PERCH DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	LENGTH	MESH SIZE	VELOCITY	NO. IMPINGED	NO. ENTRAINED	NO. SWIMMING	% RETAINED
007	7	15.0	15.3	5.75	0.500	0.5	16	9	0	64
008	7	15.0	15.3	5.75	0.500	0.5	8	17	0	32
009	7	15.0	15.3	5.75	0.355	1.5	24	1	0	96
010	7	15.0	15.3	5.75	0.355	1.5	25	0	0	100
011	7	15.0	15.3	5.75	0.355	1.5	25	0	0	100
012	7	15.0	15.3	5.75	0.355	1.5	23	2	0	92
013	7	15.0	15.3	5.75	0.500	1.5	17	8	0	68
014	7	15.0	15.3	5.75	0.500	1.5	24	1	0	96
015	7	15.0	15.3	5.75	0.500	1.5	20	5	0	80
016	7	15.0	15.3	5.75	0.500	1.5	22	3	0	88
017	7	15.0	15.3	5.75	1.000	0.5	0	25	0	0
018	7	15.0	15.3	5.75	1.000	0.5	0	25	0	0
019	7	15.0	15.3	5.75	1.000	0.5	0	25	0	0
020	7	15.0	15.3	5.75	1.000	0.5	1	24	0	4
021	7	15.5	16.2	6.32	0.355	0.5	25	0	0	100
022	7	15.5	16.2	6.32	0.355	0.5	25	0	0	100
023	7	15.5	16.2	6.32	0.355	0.5	23	2	0	92
024	7	15.5	16.2	6.32	0.355	0.5	19	6	0	76
025	7	15.5	16.2	6.32	0.500	0.5	24	1	0	96
026	7	15.5	16.2	6.32	0.500	0.5	19	6	0	76
027	7	15.5	16.2	6.32	0.500	0.5	23	2	0	92
028	7	15.5	16.2	6.32	0.500	0.5	25	0	0	100
029	7	15.5	16.2	6.32	1.000	0.5	0	25	0	0
030	7	15.5	16.2	6.32	1.000	0.5	0	25	0	0
031	7	15.5	16.2	6.32	1.000	0.5	0	25	0	0
032	7	15.5	16.2	6.32	1.000	0.5	0	25	0	0
033	7	15.5	16.5	6.32	0.355	1.5	25	0	0	100
034	7	15.5	16.5	6.32	0.355	1.5	24	1	0	96
035	7	15.5	16.5	6.32	0.355	1.5	24	1	0	96
036	7	15.5	16.5	6.32	0.355	1.5	25	0	0	100
037	7	15.5	16.5	6.32	0.500	1.5	25	0	0	100
038	7	15.5	16.5	6.32	0.500	1.5	23	2	0	92
039	7	15.5	16.5	6.32	0.500	1.5	24	1	0	96
040	7	15.5	16.5	6.32	0.500	1.5	25	0	0	100
041	7	14.5	15.5	7.27	0.500	0.5	10	0	0	100
042	7	14.5	15.5	7.27	0.500	0.5	10	0	0	100
043	7	14.5	15.5	7.27	0.500	0.5	10	0	0	100
044	7	14.5	15.5	7.27	1.000	0.5	1	9	0	10
045	7	14.5	15.5	7.27	1.000	0.5	0	10	0	0
046	7	14.5	15.5	7.27	1.000	0.5	1	9	0	10
047	7	14.5	15.5	7.27	0.500	1.5	10	0	0	100
048	7	14.5	15.5	7.27	0.500	1.5	10	0	0	100
049	7	14.5	15.5	7.27	0.500	1.5	10	0	0	100
050	7	14.5	15.5	7.27	1.000	1.7	5	5	0	50
051	7	14.5	15.5	7.27	1.000	1.7	3	7	0	30
052	7	14.5	15.5	7.27	1.000	1.7	3	7	0	30
053	7	14.0	15.5	8.14	0.500	0.5	10	0	0	100
054	7	14.0	15.5	8.14	0.500	0.5	10	0	0	100
055	7	14.0	15.5	8.14	0.500	0.5	10	0	0	100
056	7	14.0	15.5	8.14	0.500	0.5	10	0	0	100
057	7	14.0	15.5	8.14	1.000	0.5	0	10	0	0

TABLE B-2

SCREEN RETENTION STUDY
1980 WINTER FLOUNDER, ALEWIFE, AND YELLOW PERCH DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	LENGTH	MESH SIZE	VELOCITY	NO. IMPINGED	NO. ENTRAINED	NO. SWIMMING	% RETAINED
058	7	14.0	15.5	8.14	1.0	0.5	1	9	0	10.0
059	7	14.0	15.5	8.14	1.0	0.5	1	9	0	10.0
060	7	14.0	15.5	8.14	1.0	0.5	4	6	0	40.0
061	7	14.0	15.5	8.14	0.5	1.5	10	0	0	100.0
062	7	14.0	15.5	8.14	0.5	1.5	10	0	0	100.0
063	7	14.0	15.5	8.14	0.5	1.5	10	0	0	100.0
064	7	14.0	15.5	8.14	0.5	1.5	10	0	0	100.0
065	7	14.0	15.5	8.14	1.0	1.5	5	5	0	50.0
066	7	14.0	15.5	8.14	1.0	1.5	4	6	0	40.0
067	7	14.0	15.5	8.14	1.0	1.5	2	8	0	20.0
068	7	14.0	15.5	8.14	1.0	1.5	4	6	0	40.0
069	7	16.2	17.8	9.25	1.5	0.5	3	7	0	30.0
070	7	16.2	17.8	9.25	1.5	0.5	3	7	0	30.0
071	7	16.2	17.8	9.25	1.0	0.5	8	1	1	88.9
072	7	16.2	17.8	9.25	1.0	0.5	10	0	0	100.0
073	7	16.2	17.8	9.25	1.0	0.5	8	1	1	88.9
074	7	16.2	17.8	9.25	1.5	0.5	6	4	0	60.0
075	7	16.2	17.8	9.25	1.5	0.5	2	8	0	20.0
076	7	16.2	17.8	9.25	1.0	0.5	10	0	0	100.0
077	7	16.2	18.0	9.25	1.0	1.5	10	0	0	100.0
078	7	16.2	18.0	9.25	1.0	1.5	10	0	0	100.0
079	7	16.2	18.0	9.25	1.0	1.5	10	0	0	100.0
080	7	16.2	18.0	9.25	1.0	1.5	10	0	0	100.0
081	7	16.2	18.0	9.25	1.5	1.5	4	6	0	40.0
082	7	16.2	18.0	9.25	1.5	1.5	4	6	0	40.0
083	7	16.2	18.0	9.25	1.5	1.5	5	5	0	50.0
084	7	16.2	18.0	9.25	1.5	1.5	2	8	0	20.0

NOTE: 1) SPECIES - 5 = WINTER FLOUNDER
6 = ALEWIFE
7 = YELLOW PERCH

APPENDIX C

TABLE C-1

AIR EXPOSURE STUDY
1979 STRIPED BASS DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TANK	LARVAL LENGTH (mm)	DURATION (min)	AIR TEMP., °C	TEST: INITIAL LIVE	TEST: INITIAL DEAD	TEST: 24-HR. DEAD	TEST: 48-HR. DEAD	TEST: 72-HR. DEAD	TEST: 96-HR. DEAD	TEST: TOTAL DEAD	TEST: TOTAL LIVE	TEST: 96-HR. MORTALITY, %
1	1	15.0	14.5	0	5.4	1	15.0	25	0	0	0	0	0	0	25	0.0
2	1	15.0	14.5	0	5.4	1	15.0	25	0	0	0	0	0	0	25	0.0
3	1	15.0	14.5	0	5.4	2	15.0	25	0	0	0	0	0	0	25	0.0
4	1	15.0	14.5	0	5.4	2	15.0	25	0	0	0	0	0	0	25	0.0
5	1	15.0	14.5	0	5.4	4	15.0	25	0	0	0	0	0	0	25	0.0
6	1	15.0	14.5	0	5.4	4	15.0	25	0	0	0	0	0	0	25	0.0
7	1	15.0	14.5	0	5.4	5	15.0	25	0	0	0	0	0	0	25	0.0
8	1	15.0	14.5	0	5.4	10	15.0	25	0	0	0	0	0	0	25	0.0
9	1	17.0	17.0	0	6.3	1	22.0	25	0	0	0	0	1	1	24	4.0
10	1	17.0	17.0	0	6.3	2	22.0	25	0	0	0	2	0	2	23	8.0
11	1	17.0	17.0	0	6.3	4	22.0	25	0	0	0	0	0	0	25	0.0
12	1	17.0	17.0	0	6.3	5	22.0	25	0	0	0	0	0	0	25	0.0
13	1	17.0	17.0	0	6.3	10	22.0	25	0	0	0	0	0	0	25	0.0
14	1	17.0	17.0	0	6.3	10	22.0	25	1	0	0	0	0	1	24	4.0
15	1	17.0	17.0	0	6.3	15	22.0	25	0	0	0	0	0	0	25	0.0
16	1	17.0	17.0	0	6.3	15	22.0	25	0	0	0	0	0	0	25	0.0
17	1	17.0	17.0	0	6.3	20	22.0	24	1	1	0	0	0	2	23	8.0
18	1	19.0	18.0	0	6.9	1	18.0	25	0	0	0	0	3	3	22	12.0
19	1	19.0	18.0	0	6.9	2	18.0	25	0	0	0	0	1	1	24	4.0
20	1	19.0	18.0	0	6.9	4	18.0	25	0	0	0	0	3	3	22	12.0
21	1	19.0	18.0	0	6.9	5	18.0	25	0	0	0	1	0	1	24	4.0
22	1	19.0	18.0	0	6.9	10	19.0	25	0	0	1	4	0	5	20	20.0
23	1	19.0	18.0	0	6.9	10	18.0	25	0	0	0	1	1	2	23	8.0
24	1	19.0	18.0	0	6.9	15	18.0	25	0	0	0	0	1	1	24	4.0
25	1	19.0	18.0	0	6.9	15	18.0	25	0	0	0	0	1	1	24	4.0
26	1	19.0	18.0	0	6.9	20	18.0	25	0	0	0	0	0	0	25	0.0
27	1	19.0	18.8	0	8.2	1	20.1	25	0	0	0	1	1	2	23	8.0
28	1	19.0	18.8	0	8.2	2	20.1	25	0	0	0	0	2	2	23	8.0
29	1	19.0	18.8	0	8.2	4	20.1	25	0	0	1	2	0	3	22	12.0
30	1	19.0	18.8	0	8.2	5	20.1	25	0	0	0	0	0	0	25	0.0
31	1	19.0	18.8	0	8.2	10	20.1	25	0	0	0	0	1	1	24	4.0
32	1	19.0	18.8	0	8.2	10	20.1	25	0	0	0	0	1	1	24	4.0
33	1	19.0	18.8	0	8.2	15	20.1	25	1	0	0	0	2	3	22	12.0
34	1	19.0	18.8	0	8.2	15	20.1	25	1	0	0	3	2	6	19	24.0
35	1	19.0	18.8	0	8.2	20	20.1	19	6	2	2	0	0	10	15	40.0
36	1	18.9	19.0	0	9.9	2	19.6	25	0	0	5	0	1	6	19	24.0
37	1	18.9	19.0	0	9.9	4	19.6	25	0	0	3	1	1	5	20	20.0
38	1	18.9	19.0	0	9.9	10	19.6	22	4	7	0	0	1	12	14	46.2
39	1	18.9	19.0	0	9.9	10	19.6	23	4	0	10	0	1	15	12	55.6
40	1	18.9	19.0	0	9.9	15	19.6	8	17	0	0	0	0	17	8	68.0
41	1	18.9	19.0	0	9.9	15	19.6	7	18	0	1	0	0	19	6	76.0
42	1	18.9	19.0	0	9.9	20	19.6	3	22	0	0	0	0	22	3	88.0
43	1	18.9	19.0	0	9.9	20	19.6	7	18	1	0	1	0	20	5	80.0
44	1	18.9	19.0	0	9.9	30	19.6	1	24	0	0	0	0	24	1	96.0
45	1	20.1	20.0	0	10.8	2	21.0	25	0	2	0	1	0	3	22	12.0
46	1	20.1	20.0	0	10.8	4	21.0	23	2	1	0	0	0	3	22	12.0
47	1	20.1	20.0	0	10.8	10	21.0	0	25	0	0	0	0	25	0	100.0
48	1	20.1	20.0	0	10.8	10	21.0	0	25	0	0	0	0	25	0	100.0
49	1	20.1	20.0	0	10.8	15	21.0	0	25	0	0	0	0	25	0	100.0
50	1	20.1	20.0	0	10.8	15	21.0	0	25	0	0	0	0	25	0	100.0
51	1	20.1	20.0	0	10.8	20	21.0	0	25	0	0	0	0	25	0	100.0
52	1	20.1	20.0	0	10.8	20	21.0	0	25	0	0	0	0	25	0	100.0
53	1	20.1	20.0	0	10.8	30	21.0	0	25	0	0	0	0	25	0	100.0

TEST NO.	CONTROL: 24-HR. DEAD	CONTROL: 48-HR. DEAD	CONTROL: 72-HR. DEAD	CONTROL: 96-HR. DEAD	CONTROL: TOTAL DEAD	CONTROL: TOTAL LIVE	CONTROL: 96-HR MORTALITY, %
1	0	0	0	0	0	25	0
2	.	.	.	.	.	.	0
3	.	.	.	.	.	.	0
4	.	.	.	.	.	.	0
5	.	.	.	.	.	.	0
6	.	.	.	.	.	.	0
7	.	.	.	.	.	.	0
8	.	.	.	.	.	.	0
9	0	0	0	0	0	25	0
10	.	.	.	.	.	.	0
11	.	.	.	.	.	.	0
12	.	.	.	.	.	.	0
13	.	.	.	.	.	.	0
14	.	.	.	.	.	.	0
15	.	.	.	.	.	.	0
16	.	.	.	.	.	.	0
17	.	.	.	.	.	.	0
18	0	0	0	0	0	25	0
19	.	.	.	.	.	.	0
20	.	.	.	.	.	.	0
21	.	.	.	.	.	.	0
22	.	.	.	.	.	.	0
23	.	.	.	.	.	.	0
24	.	.	.	.	.	.	0
25	.	.	.	.	.	.	0
26	.	.	.	.	.	.	0
27	0	0	0	1	1	24	4
28	.	.	.	.	.	.	4
29	.	.	.	.	.	.	4
30	.	.	.	.	.	.	4
31	.	.	.	.	.	.	4
32	.	.	.	.	.	.	4
33	.	.	.	.	.	.	4
34	.	.	.	.	.	.	4
35	.	.	.	.	.	.	4
36	1	10	0	0	11	14	44
37	.	.	.	.	.	.	44
38	.	.	.	.	.	.	44
39	.	.	.	.	.	.	44
40	.	.	.	.	.	.	44
41	.	.	.	.	.	.	44
42	.	.	.	.	.	.	44
43	.	.	.	.	.	.	44
44	.	.	.	.	.	.	44
45	0	1	0	0	1	24	4
46	.	.	.	.	.	.	4
47	.	.	.	.	.	.	4
48	.	.	.	.	.	.	4
49	.	.	.	.	.	.	4
50	.	.	.	.	.	.	4
51	.	.	.	.	.	.	4
52	.	.	.	.	.	.	4
53	.	.	.	.	.	.	4

TABLE C-1

AIR EXPOSURE STUDY
1979 STRIPED BASS DATA

								TEST									CONTROL						
TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TANK	LARVAL LENGTH (mm)	DURATION (min)	AIR TEMP., °C	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR MORTALITY, %
54	1	19.0	19.2	0	13.1	0.5	19.0	25	0	0	0	0	6	6	19	24.0	1	0	0	3	4	21	16
55	1	19.0	19.2	0	13.1	1.0	19.0	25	0	0	0	0	5	5	20	20.0	.	.	.	.	.	.	16
56	1	19.0	19.2	0	13.1	1.5	19.0	25	0	0	0	0	5	5	20	20.0	.	.	.	.	.	.	16
57	1	19.0	19.2	0	13.1	2.0	19.0	25	0	0	0	0	6	6	19	24.0	.	.	.	.	.	.	16
58	1	19.0	19.2	0	13.1	2.5	19.0	25	0	0	0	0	9	9	16	36.0	.	.	.	.	.	.	16
59	1	19.0	19.2	0	13.1	3.0	19.0	25	0	0	0	0	5	5	20	20.0	.	.	.	.	.	.	16
60	1	19.0	19.2	0	13.1	4.0	19.0	24	1	0	0	0	6	7	18	28.0	.	.	.	.	.	.	16
61	1	19.0	19.2	0	13.1	5.0	19.0	23	2	0	0	0	4	6	19	24.0	.	.	.	.	.	.	16
62	1	19.0	19.2	0	13.1	10.0	19.0	6	19	0	0	0	1	20	5	80.0	.	.	.	.	.	.	16
63	1	19.7	19.0	0	15.0	0.5	19.0	25	0	0	0	0	1	1	24	4.0	0	0	0	0	0	25	0
64	1	19.7	19.0	0	15.0	1.0	19.0	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	0
65	1	19.7	19.0	0	15.0	1.5	19.0	24	1	0	1	0	1	3	22	12.0	.	.	.	.	.	.	0
66	1	19.7	19.0	0	15.0	2.0	19.0	24	1	0	0	0	2	3	22	12.0	.	.	.	.	.	.	0
67	1	19.7	19.0	0	15.0	2.5	19.0	26	0	0	0	0	1	1	25	3.8	.	.	.	.	.	.	0
68	1	19.7	19.0	0	15.0	3.0	19.0	22	3	0	1	0	2	6	19	24.0	.	.	.	.	.	.	0
69	1	19.7	19.0	0	15.0	4.0	19.0	5	20	0	0	0	0	20	5	80.0	.	.	.	.	.	.	0
70	1	19.7	19.0	0	15.0	5.0	19.0	1	24	0	0	0	0	24	1	96.0	.	.	.	.	.	.	0
71	1	19.7	19.0	0	15.0	10.0	19.0	0	25	0	0	0	0	25	0	100.0	.	.	.	.	.	.	0
72	1	21.4	22.1	0	17.4	1.0	20.7	25	0	20	0	0	0	20	5	80.0	16	3	0	0	19	6	76
73	1	21.4	22.1	0	17.4	2.0	20.7	10	15	5	0	0	1	21	4	84.0	.	.	.	.	.	.	76
74	1	21.4	22.1	0	17.4	2.5	20.7	17	9	10	2	0	0	21	5	80.8	.	.	.	.	.	.	76
75	1	21.4	22.1	0	17.4	3.0	20.7	12	13	10	0	0	0	23	2	92.0	.	.	.	.	.	.	76
76	1	21.4	22.1	0	17.4	3.5	20.7	10	15	3	2	0	0	20	5	80.0	.	.	.	.	.	.	76
77	1	21.4	22.1	0	17.4	4.0	20.7	3	22	1	2	0	0	25	0	100.0	.	.	.	.	.	.	76
78	1	21.4	22.1	0	17.4	4.5	20.7	1	24	0	0	0	0	24	1	96.0	.	.	.	.	.	.	76
79	1	21.4	22.1	0	17.4	5.0	20.7	0	25	0	0	0	0	25	0	100.0	.	.	.	.	.	.	76
80	1	21.4	22.1	0	17.4	10.0	20.7	0	25	0	0	0	0	25	0	100.0	.	.	.	.	.	.	76
81	1	20.6	21.1	0	21.0	1.0	21.6	24	1	0	0	1	3	5	20	20.0	0	0	2	4	6	19	24
82	1	20.6	21.1	0	21.0	2.0	21.6	24	1	0	0	1	3	5	20	20.0	.	.	.	.	.	.	24
83	1	20.6	21.1	0	21.0	2.5	21.6	22	3	0	0	2	4	9	16	36.0	.	.	.	.	.	.	24
84	1	20.6	21.1	0	21.0	3.0	21.6	18	7	1	0	1	3	12	13	48.0	.	.	.	.	.	.	24
85	1	20.6	21.1	0	21.0	3.5	21.6	21	4	3	0	0	5	12	13	48.0	.	.	.	.	.	.	24
86	1	20.6	21.1	0	21.0	4.0	21.6	2	23	0	0	0	0	23	2	92.0	.	.	.	.	.	.	24
87	1	20.6	21.1	0	21.0	4.5	21.6	0	25	0	0	0	0	25	0	100.0	.	.	.	.	.	.	24
88	1	20.6	21.1	0	21.0	5.0	21.6	0	25	0	0	0	0	25	0	100.0	.	.	.	.	.	.	24
89	1	20.6	21.1	0	21.0	10.0	21.6	0	25	0	0	0	0	25	0	100.0	.	.	.	.	.	.	24
90	1	20.0	20.5	0	17.2	2.0	21.0	25	0	4	6	5	0	15	10	60.0	1	17	0	0	18	7	72
91	1	20.0	20.5	0	17.2	3.0	21.0	24	1	4	12	6	0	23	2	92.0	.	.	.	.	.	.	72
92	1	20.0	20.5	0	17.2	3.5	21.0	19	6	10	7	1	0	24	1	96.0	.	.	.	.	.	.	72
93	1	20.0	20.5	0	17.2	3.5	21.0	23	4	6	8	2	0	20	7	74.1	.	.	.	.	.	.	72
94	1	20.0	20.5	0	17.2	4.0	21.0	16	10	1	10	3	0	24	2	92.3	.	.	.	.	.	.	72
95	1	20.0	20.5	0	17.2	4.0	21.0	13	12	4	8	1	0	25	0	100.0	.	.	.	.	.	.	72
96	1	20.0	20.5	0	17.2	4.5	21.0	7	18	1	4	0	0	23	2	92.0	.	.	.	.	.	.	72
97	1	20.0	20.5	0	17.2	5.0	21.0	6	19	1	5	0	0	25	0	100.0	.	.	.	.	.	.	72
98	1	20.0	20.5	0	17.2	6.0	21.0	1	24	0	1	0	0	25	0	100.0	.	.	.	.	.	.	72
99	1	21.5	22.0	0	19.5	1.0	20.2	25	0	0	0	1	0	1	24	4.0	0	0	0	4	4	21	16
100	1	21.5	22.0	0	19.5	2.0	20.2	24	1	1	1	1	2	6	19	24.0	.	.	.	.	.	.	16
101	1	21.5	22.0	0	19.5	2.5	20.2	25	0	0	0	1	4	5	20	20.0	.	.	.	.	.	.	16
102	1	21.5	22.0	0	19.5	3.0	20.2	21	4	0	1	0	0	5	20	20.0	.	.	.	.	.	.	16
103	1	21.5	22.0	0	19.5	3.5	20.2	8	17	0	0	0	0	17	8	68.0	.	.	.	.	.	.	16
104	1	21.5	22.0	0	19.5	4.0	20.2	1	24	0	0	0	0	24	1	96.0	.	.	.	.	.	.	16
105	1	21.5	22.0	0	19.5	4.5	20.2	2	23	0	0	0	0	23	2	92.0	.	.	.	.	.	.	16
106	1	21.5	22.0	0	19.5	5.0	20.2	0	25	0	0	0	0	25	0	100.0	.	.	.	.	.	.	16

TABLE C-1

AIR EXPOSURE STUDY
1979 STRIPED BASS DATA

								TEST									CONTROL						
TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TANK	LARVAL LENGTH (mm)	DURATION (min)	AIR TEMP., °C	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR MORTALITY, %
107	1	21.5	22	0	19.5	8.0	20.2	0	25	0	0	0	0	25	0	100	.	.	.	.	.	.	16
108	1	22.0	22	0	22.8	2.5	23.0	25	0	1	0	0	0	1	24	4	0	0	1	0	1	24	4
109	1	22.0	22	0	22.8	2.5	23.0	25	0	0	0	1	0	1	24	4	.	.	.	.	.	.	4
110	1	22.0	22	0	22.8	3.0	23.0	22	3	0	0	0	0	3	22	12	.	.	.	.	.	.	4
111	1	22.0	22	0	22.8	3.0	23.0	24	1	0	0	0	0	1	24	4	.	.	.	.	.	.	4
112	1	22.0	22	0	22.8	3.5	23.0	12	13	0	0	0	0	13	12	52	.	.	.	.	.	.	4
113	1	22.0	22	0	22.8	3.5	23.0	8	17	0	0	0	0	17	8	68	.	.	.	.	.	.	4
114	1	22.0	22	0	22.8	4.0	23.0	7	18	0	1	0	0	19	6	76	.	.	.	.	.	.	4
115	1	22.0	22	0	22.8	4.0	23.0	10	15	1	0	0	0	16	9	64	.	.	.	.	.	.	4
116	1	22.0	22	0	22.8	5.0	23.0	0	25	0	0	0	0	25	0	100	.	.	.	.	.	.	4

TABLE C-2

AIR EXPOSURE STUDY
1980 WINTER FLOUNDER, ALEWIFE, AND YELLOW PERCH DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TANK NO.	LARVAL LENGTH (mm)	DURATION (min.)	AIR TEMP., °C	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. TEST MORTALITY
001	5	6.6	9.4	1	3.60	1	12.0	25	0	0	0	0	0	0	25	0.0
002	5	6.6	9.4	1	3.60	1	12.0	25	0	0	0	0	0	0	25	0.0
003	5	6.6	9.4	1	3.60	3	12.0	25	0	0	0	0	0	0	25	0.0
004	5	6.6	9.4	1	3.60	3	12.0	25	0	0	0	0	0	0	25	0.0
005	5	6.6	9.4	1	3.60	5	12.0	25	0	0	0	0	0	0	25	0.0
006	5	6.6	9.4	1	3.60	5	12.0	25	0	1	0	0	1	2	23	8.0
C	5	6.6	9.4	1	3.60	.	12.0	25	0	0	0	0	1	1	24	4.0
007	5	6.6	9.4	2	3.60	1	12.0	26	0	0	0	0	0	0	26	0.0
008	5	6.6	9.4	2	3.60	1	12.0	26	0	0	0	0	0	0	26	0.0
009	5	6.6	9.4	2	3.60	3	12.0	25	0	0	0	0	2	2	23	8.0
010	5	6.6	9.4	2	3.60	3	12.0	24	1	0	0	0	5	6	19	24.0
011	5	6.6	9.4	2	3.60	5	12.0	24	1	0	0	0	23	24	1	96.0
012	5	6.6	9.4	2	3.60	5	12.0	25	0	0	0	0	24	24	1	96.0
C	5	6.6	9.4	2	3.60	.	12.0	25	0	0	0	0	0	0	25	0.0
013	5	7.0	8.0	1	4.07	1	15.0	25	0	0	0	0	0	0	25	0.0
014	5	7.0	8.0	1	4.07	1	15.0	26	0	0	0	0	1	1	25	3.8
015	5	7.0	8.0	1	4.07	3	15.0	29	0	0	1	0	0	1	28	3.4
016	5	7.0	8.0	1	4.07	3	15.0	29	0	0	1	0	0	1	28	3.4
017	5	7.0	8.0	1	4.07	5	15.0	29	0	0	0	0	0	0	29	0.0
018	5	7.0	8.0	1	4.07	5	15.0	29	0	0	0	0	0	0	29	0.0
C	5	7.0	8.0	1	4.07	.	15.0	25	0	0	0	0	0	0	25	0.0
019	5	7.0	8.0	2	4.07	1	15.0	25	0	0	0	0	0	0	25	0.0
020	5	7.0	8.0	2	4.07	1	15.0	25	0	0	0	0	0	0	25	0.0
021	5	7.0	8.0	2	4.07	3	15.0	25	0	0	0	0	0	0	25	0.0
022	5	7.0	8.0	2	4.07	3	15.0	27	0	0	0	0	0	0	27	0.0
023	5	7.0	8.0	2	4.07	5	15.0	25	0	0	0	0	0	0	25	0.0
024	5	7.0	8.0	2	4.07	5	15.0	28	0	0	0	0	2	2	26	7.1
C	5	7.0	8.0	2	4.07	.	15.0	30	0	0	0	0	0	0	30	0.0
025	5	6.0	6.0	1	4.38	1	8.0	25	0	0	0	0	5	5	20	20.0
026	5	6.0	6.0	1	4.38	1	8.0	25	0	0	0	0	9	9	16	36.0
027	5	6.0	6.0	1	4.38	3	8.0	25	0	1	0	0	11	12	13	48.0
028	5	6.0	6.0	1	4.38	3	8.0	25	0	0	4	0	8	12	13	48.0
029	5	6.0	6.0	1	4.38	5	8.0	25	0	0	0	0	8	8	17	32.0
030	5	6.0	6.0	1	4.38	5	8.0	25	0	1	0	0	10	11	14	44.0
C	5	6.0	6.0	1	4.38	.	8.0	25	0	0	0	0	0	0	25	0.0
031	5	6.0	6.0	2	4.38	1	8.0	24	0	0	0	0	6	6	18	25.0
032	5	6.0	6.0	2	4.38	1	8.0	25	0	0	4	0	8	12	13	48.0
033	5	6.0	6.0	2	4.38	3	8.0	25	0	0	0	0	18	18	7	72.0
034	5	6.0	6.0	2	4.38	3	8.0	24	0	0	0	0	21	21	3	87.5
035	5	6.0	6.0	2	4.38	5	8.0	25	0	0	0	0	20	20	5	80.0
036	5	6.0	6.0	2	4.38	5	8.0	24	0	0	0	0	20	20	4	83.3
C	5	6.0	6.0	2	4.38	.	8.0	23	0	0	0	0	0	0	23	0.0
037	5	13.0	13.0	1	6.13	1	16.4	25	0	0	0	0	0	0	25	0.0
038	5	13.0	13.0	1	6.13	1	16.4	25	0	0	0	0	0	0	25	0.0
039	5	13.0	13.0	1	6.13	3	16.4	25	0	0	0	0	0	0	25	0.0
040	5	13.0	13.0	1	6.13	3	16.4	25	0	0	0	0	1	1	24	4.0
041	5	13.0	13.0	1	6.13	5	16.4	25	0	0	0	0	0	0	25	0.0
042	5	13.0	13.0	1	6.13	5	16.4	25	0	1	0	0	1	2	23	8.0
C	5	13.0	13.0	1	6.13	.	16.4	25	0	0	0	0	1	1	24	4.0
001	6	15.0	16.0	2	5.22	1	21.0	25	0	0	0	.	.	0	25	0.0
002	6	15.0	16.0	2	5.22	1	21.0	25	0	0	1	.	.	1	24	4.0

TABLE C-2

AIR EXPOSURE STUDY
1980 WINTER FLOUNDER, ALEWIFE, AND YELLOW PERCH DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TANK NO.	LARVAL LENGTH (mm)	DURATION (min.)	AIR TEMP., °C	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. TEST MORTALITY
003	6	15.0	16.0	2	5.22	1	21.0	25	0	0	1	.	.	1	24	4
004	6	15.0	16.0	2	5.22	3	21.0	25	0	0	1	.	.	1	24	4
005	6	15.0	16.0	2	5.22	3	21.0	25	0	0	1	.	.	1	24	4
006	6	15.0	16.0	2	5.22	3	21.0	25	0	0	1	.	.	1	24	4
007	6	15.0	16.0	2	5.22	5	21.0	25	0	0	0	.	.	0	25	0
008	6	15.0	16.0	2	5.22	5	21.0	25	0	0	0	.	.	0	25	0
009	6	15.0	16.0	2	5.22	5	21.0	25	0	0	0	.	.	0	25	0
C	6	15.0	16.0	2	5.22	.	21.0	25	0	0	2	.	.	2	23	8
010	6	14.8	14.9	1	6.59	1	18.0	25	0	6	3	6	7	22	3	88
011	6	14.8	14.9	1	6.59	1	18.0	25	0	4	8	6	7	25	0	100
012	6	14.8	14.9	1	6.59	1	18.0	22	3	2	7	7	6	25	0	100
013	6	14.8	14.9	1	6.59	3	18.0	20	5	5	10	2	3	25	0	100
014	6	14.8	14.9	1	6.59	3	18.0	22	3	6	6	2	6	23	2	92
015	6	14.8	14.9	1	6.59	3	18.0	22	3	4	7	2	8	24	1	96
016	6	14.8	14.9	1	6.59	5	18.0	24	1	4	11	5	4	25	0	100
017	6	14.8	14.9	1	6.59	5	18.0	23	2	8	5	2	6	23	2	92
018	6	14.8	14.9	1	6.59	5	18.0	19	6	5	6	5	2	24	1	96
C	6	14.8	14.9	1	6.59	.	18.0	25	0	1	10	5	9	25	0	100
019	6	17.1	17.5	1	9.52	1	22.0	25	0	0	0	1	2	3	22	12
020	6	17.1	17.5	1	9.52	3	22.0	25	0	0	0	1	2	3	22	12
021	6	17.1	17.5	1	9.52	5	22.0	25	0	1	0	0	2	3	22	12
022	6	17.1	17.5	1	9.52	1	22.0	25	0	2	0	2	1	5	20	20
023	6	17.1	17.5	1	9.52	3	22.0	25	0	1	0	1	3	5	20	20
024	6	17.1	17.5	1	9.52	5	22.0	25	0	1	0	0	1	2	23	8
025	6	17.1	17.5	1	9.52	1	22.0	25	0	1	1	1	3	6	19	24
026	6	17.1	17.5	1	9.52	3	22.0	25	0	0	1	0	2	3	22	12
027	6	17.1	17.5	1	9.52	5	22.0	25	0	1	1	0	1	3	22	12
C	6	17.1	17.5	1	9.52	.	22.0	25	0	1	1	0	4	6	19	24
028	6	16.8	16.5	2	12.42	1	19.0	25	0	3	0	7	12	22	3	88
029	6	16.8	16.5	2	12.42	1	19.0	25	0	7	1	3	6	17	8	68
030	6	16.8	16.5	2	12.42	1	19.0	24	1	0	1	5	16	23	2	92
031	6	16.8	16.5	2	12.42	3	19.0	25	0	3	1	4	12	20	5	80
032	6	16.8	16.5	2	12.42	3	19.0	25	0	4	1	5	13	23	2	92
033	6	16.8	16.5	2	12.42	3	19.0	23	2	2	2	4	12	22	3	88
034	6	16.8	16.5	2	12.42	5	19.0	23	2	2	0	6	14	24	1	96
035	6	16.8	16.5	2	12.42	5	19.0	24	1	5	4	3	10	23	2	92
036	6	16.8	16.5	2	12.42	5	19.0	25	0	2	1	5	14	22	3	88
C	6	16.8	16.5	2	12.42	.	19.0	25	0	0	3	2	14	19	6	76
001	7	15.0	15.9	1	5.75	1	21.0	50	0	0	1	.	.	1	49	2
002	7	15.0	15.9	1	5.75	1	21.0	50	0	0	0	.	.	0	50	0
003	7	15.0	15.9	1	5.75	1	21.0	50	0	0	0	.	.	0	50	0
004	7	15.0	15.9	1	5.75	3	21.0	50	0	0	0	.	.	0	50	0
005	7	15.0	15.9	1	5.75	3	21.0	25	0	0	0	.	.	0	25	0
006	7	15.0	15.9	1	5.75	3	21.0	25	0	0	0	.	.	0	25	0
007	7	15.0	15.9	1	5.75	5	21.0	25	0	0	1	.	.	1	24	4
008	7	15.0	15.9	1	5.75	5	21.0	25	0	0	0	.	.	0	25	0
009	7	15.0	15.9	1	5.75	5	21.0	25	0	0	0	.	.	0	25	0
C	7	15.0	15.9	1	5.75	.	21.0	25	0	0	0	.	.	0	25	0
010	7	15.5	15.0	1	6.32	1	15.5	19	6	3	6	5	5	25	0	100
011	7	15.5	15.0	1	6.32	1	15.5	25	0	1	5	17	2	25	0	100
012	7	15.5	15.0	1	6.32	1	15.5	25	0	4	4	14	3	25	0	100

TABLE C-2

AIR EXPOSURE STUDY
1980 WINTER FLOUNDER, ALEWIFE, AND YELLOW PERCH DATA

TEST NO.	SPECIES	TANK TEMP., °C	FLUME TEMP., °C	TANK NO.	LARVAL LENGTH (mm)	DURATION (min.)	AIR TEMP., °C	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. TEST MORTALITY
013	7	15.5	15	1	6.32	3	15.5	25	0	0	6	11	8	25	0	100.0
014	7	15.5	15	1	6.32	3	15.5	25	0	1	7	11	4	23	2	92.0
015	7	15.5	15	1	6.32	3	15.5	24	2	3	9	8	4	26	0	100.0
016	7	15.5	15	1	6.32	5	15.5	24	1	3	4	12	5	25	0	100.0
017	7	15.5	15	1	6.32	5	15.5	25	0	8	6	4	7	25	0	100.0
018	7	15.5	15	1	6.32	5	15.5	25	0	4	9	5	7	25	0	100.0
C	7	15.5	15	1	6.32	.	15.5	24	1	0	5	7	11	24	1	96.0
019	7	15.5	15	2	6.32	1	15.5	25	0	5	7	9	3	24	1	96.0
020	7	15.5	15	2	6.32	1	15.5	24	1	5	15	3	1	25	0	100.0
021	7	15.5	15	2	6.32	1	15.5	21	4	8	7	5	1	25	0	100.0
022	7	15.5	15	2	6.32	3	15.5	25	0	1	2	10	12	25	0	100.0
023	7	15.5	15	2	6.32	3	15.5	25	0	2	4	9	7	22	3	88.0
024	7	15.5	15	2	6.32	3	15.5	25	0	1	3	8	12	24	1	96.0
025	7	15.5	15	2	6.32	5	15.5	25	0	2	5	11	6	24	1	96.0
026	7	15.5	15	2	6.32	5	15.5	25	0	15	3	1	5	24	1	96.0
027	7	15.5	15	2	6.32	5	15.5	26	1	3	11	7	3	25	2	92.6
C	7	15.5	15	2	6.32	.	15.5	23	2	5	12	4	2	25	0	100.0
028	7	14.8	15	2	7.58	1	18.0	25	1	3	9	4	8	25	1	96.2
029	7	14.8	15	2	7.58	1	18.0	25	0	1	5	8	7	21	4	84.0
030	7	14.8	15	2	7.58	1	18.0	25	0	1	5	4	9	19	6	76.0
031	7	14.8	15	2	7.58	3	18.0	25	0	19	1	3	2	25	0	100.0
032	7	14.8	15	2	7.58	3	18.0	26	0	22	3	0	1	26	0	100.0
033	7	14.8	15	2	7.58	3	18.0	23	2	9	4	4	4	23	2	92.0
034	7	14.8	15	2	7.58	5	18.0	25	0	10	4	7	2	23	2	92.0
035	7	14.8	15	2	7.58	5	18.0	25	0	5	4	6	5	20	5	80.0
036	7	14.8	15	2	7.58	5	18.0	25	0	6	1	4	8	19	6	76.0
C	7	14.8	15	2	7.58	.	18.0	25	0	2	5	7	8	22	3	88.0

NOTES: 1) SPECIES - 5 = WINTER FLOUNDER
6 = ALEWIFE
7 = YELLOW PERCH

2) "C" UNDER "TEST NO." DESIGNATES CONTROL FOR EACH TEST SERIES.

APPENDIX D

TABLE D-1

SPRAYWASH STUDY
1979 STRIPED BASS DATA

							TEST									CONTROL
TEST NO.	TANK TEMP., °C	FLUME TEMP., °C	TEMP. DIFF., °C	LARVAL LENGTH (mm)	AIR TEMP., °C	TYPE OF WASH	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	96-HR. MORTALITY, %	96-HR. MORTALITY, %
1.	19.8	20.0	-0.2	22.90	19.1	1.	20.	0.	1.	0.	1.	1.	3.	17.	15.0	0.0
2.	19.8	20.0	-0.2	22.90	19.5	1.	20.	0.	0.	0.	0.	1.	1.	19.	5.0	0.0
3.	19.8	20.1	-0.3	22.90	19.5	1.	20.	0.	0.	0.	0.	2.	2.	18.	10.0	0.0
1.	19.8	20.8	-1.0	22.90	18.1	2.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	0.0
2.	19.8	20.8	-1.0	22.90	19.0	2.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	0.0
3.	19.8	20.1	-0.3	22.90	19.5	2.	20.	0.	0.	0.	0.	1.	1.	19.	5.0	0.0
4.	20.1	20.6	-0.5	19.52	25.0	2.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	10.0
6.	20.1	20.6	-0.5	19.52	25.0	2.	20.	0.	1.	0.	0.	0.	1.	19.	5.0	10.0
5.	20.1	20.6	-0.5	19.52	25.0	2.	20.	0.	0.	0.	1.	0.	1.	19.	5.0	10.0
7.	20.1	21.9	-1.8	19.52	25.0	2.	20.	0.	0.	0.	3.	0.	3.	17.	15.0	10.0
8.	20.1	21.9	-1.6	19.52	25.0	2.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	10.0
4.	20.2	20.8	-0.6	19.52	25.0	1.	20.	0.	0.	1.	0.	0.	1.	19.	5.0	10.0
5.	20.2	20.8	-0.6	19.52	25.0	1.	20.	0.	0.	0.	0.	1.	1.	19.	5.0	10.0
6.	20.2	20.8	-0.6	19.52	25.0	1.	19.	0.	0.	0.	0.	0.	0.	19.	0.0	10.0
7.	20.2	21.0	-0.8	19.52	25.0	1.	20.	0.	0.	1.	0.	1.	2.	18.	10.0	10.0
8.	20.2	21.0	-0.8	19.52	25.0	1.	20.	0.	0.	1.	0.	0.	1.	19.	5.0	10.0
9.	21.5	22.7	-1.2	18.98	27.0	1.	20.	0.	0.	0.	0.	1.	1.	19.	5.0	0.0
10.	21.5	22.7	-1.2	18.98	27.0	1.	20.	0.	0.	0.	0.	2.	2.	18.	10.0	0.0
11.	21.5	22.7	-1.2	18.98	27.0	1.	20.	0.	0.	0.	0.	1.	1.	19.	5.0	0.0
12.	21.5	22.7	-1.2	18.98	27.0	1.	21.	0.	1.	0.	0.	0.	1.	20.	5.0	0.0
13.	21.5	22.7	-1.2	18.98	29.0	1.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	0.0
9.	21.5	28.5	-7.0	18.98	30.0	2.	20.	0.	0.	0.	0.	1.	1.	19.	5.0	0.0
10.	21.5	28.5	-7.0	18.98	30.0	2.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	0.0
11.	21.5	28.5	-7.0	18.98	30.0	2.	20.	0.	0.	0.	0.	1.	1.	19.	5.0	0.0
12.	21.5	28.5	-7.0	18.98	30.0	2.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	0.0
13.	21.5	28.5	-7.0	18.98	30.0	2.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	0.0
14.	20.0	22.0	-2.0	24.65	21.0	2.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	0.0
15.	20.0	22.0	-2.0	24.65	21.0	2.	20.	0.	0.	0.	0.	2.	2.	18.	10.0	0.0
16.	20.0	22.5	-2.5	24.65	22.0	2.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	0.0
17.	20.0	22.5	-2.5	24.65	22.0	2.	20.	0.	5.	0.	0.	0.	5.	15.	25.0	0.0
14.	20.0	23.0	-3.0	24.65	24.0	1.	25.	0.	1.	0.	0.	0.	1.	24.	4.0	0.0
15.	20.0	23.0	-3.0	24.65	24.0	1.	25.	0.	11.	0.	0.	0.	11.	14.	44.0	0.0
16.	20.0	23.5	-3.5	24.65	25.0	1.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	0.0
17.	20.0	23.5	-3.5	24.65	25.0	1.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	0.0
18.	22.7	25.2	-2.5	27.60	24.0	1.	20.	0.	0.	0.	0.	1.	1.	19.	5.0	5.0
19.	22.7	25.2	-2.5	27.60	24.0	1.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	5.0
20.	22.7	25.2	-2.5	27.60	24.0	1.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	5.0
18.	22.7	25.2	-2.5	27.60	24.0	2.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	5.0
19.	22.7	25.2	-2.5	27.60	24.0	2.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	5.0
20.	22.7	25.7	-3.0	27.60	24.0	2.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	5.0
21.	23.0	24.0	-1.0	31.73	26.1	1.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	0.0
22.	23.0	24.0	-1.0	31.73	27.2	1.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	0.0
23.	23.0	24.4	-1.4	31.73	27.4	1.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	0.0
21.	23.0	24.0	-1.0	31.73	26.1	2.	20.	0.	0.	0.	0.	1.	1.	19.	5.0	0.0
22.	23.0	24.0	-1.0	31.73	26.5	2.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	0.0
23.	23.0	24.0	-1.0	31.73	26.5	2.	20.	0.	1.	0.	0.	0.	1.	19.	5.0	0.0
24.	23.0	24.8	-1.8	35.52	25.2	2.	21.	0.	0.	0.	3.	1.	4.	17.	19.0	50.0
24.	23.0	24.8	-1.8	35.52	0.0	1.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	50.0
25.	23.0	24.8	-1.8	35.52	25.2	2.	20.	0.	0.	0.	0.	0.	0.	20.	0.0	50.0
25.	23.0	24.8	-1.8	35.52	0.0	1.	17.	2.	0.	0.	0.	0.	2.	17.	10.0	50.0
26.	23.0	24.8	-1.8	35.52	25.2	2.	20.	0.	0.	0.	1.	5.	6.	14.	30.0	50.0
26	23.0	24.8	-1.8	35.52	0.0	1.	21.	0.	0.	0.	2.	0.	2.	19.	9.5	50.0

TYPE OF WASH:
1= Frontwash
2= Backwash

APPENDIX E

TABLE E-1

1978 LARVAL DIVERSION STRIPED BASS DATA

TEST NO.	LIGHT/DARK	FLUME TEMP., °C	LARVAL LENGTH	VELOCITY	MESH TYPE	MESH SIZE	NO. TESTED	NO. BYPASSED	NO. SWIMMING	INITIAL DEAD	DIVERSION EFFICIENCY	TEST MORTALITY			CONTROL MORTALITY			TOTAL EFFICIENCY
												NO. HELD	NO. DEAD	PERCENT DEAD	NO. HELD	NO. DEAD	PERCENT DEAD	
1	1	19.5	6.41	1	1	1	50	9	0	1	18.0	8	1	11.1	25	0	0	16.0
2	1	20.5	6.41	1	2	1	50	11	0	1	22.0	10	3	27.3	25	0	0	16.0
3	1	21.0	6.41	1	2	2	50	16	0	0	32.0	16	0	0	25	0	0	32.0
4	1	22.0	6.41	1	1	2	50	3	0	0	6.0	3	0	0	25	0	0	6.0
5	1	19.5	7.35	2	1	2	50	1	0	0	2.0	1	0	0	25	2	8.0	2.0
6	1	21.5	7.35	2	2	2	50	2	0	0	4.0	2	0	0	25	2	8.0	4.0
7	1	22.0	7.80	2	1	1	50	0	0	0	0	0	0	0	25	2	8.0	0.0
8	1	22.0	7.80	2	2	1	50	1	0	0	2.0	1	0	0	25	2	8.0	2.0
9	1	21.0	7.80	1	2	1	50	26	0	2	52.0	24	7	26.9	25	8	32.0	38.0
10	1	21.0	7.80	1	1	1	50	18	0	0	36.0	18	1	5.5	25	8	32.0	34.0
11	1	22.0	7.80	1	2	2	50	30	0	1	60.0	30	6	23.3	25	8	32.0	46.0
12	1	22.0	7.80	1	1	2	50	25	0	0	50.0	25	4	16.0	25	8	32.0	42.0
13	1	19.5	7.52	2	1	2	50	3	0	0	6.0	3	2	66.7	25	7	28.0	2.0
14	1	20.0	7.52	2	2	2	50	0	0	0	0	0	0	0	25	7	28.0	0.0
15	1	21.0	7.52	2	1	1	50	0	0	0	0	0	0	0	25	7	28.0	0.0
16	1	21.0	7.52	2	2	1	50	1	0	0	2.0	1	0	0	25	7	28.0	2.0
17	1	19.0	7.91	1	2	1	50	35	1	0	71.0	35	23	65.7	25	14	56.0	24.3
18	1	20.0	7.91	1	1	1	50	22	0	0	44.0	22	18	81.8	25	14	56.0	8.0
19	1	20.0	7.91	1	2	2	50	46	0	0	92.0	25	17	68.0	25	14	56.0	29.4
20	1	20.0	7.91	1	1	2	50	30	3	0	64.0	30	27	90.0	25	14	56.0	6.4
21	1	19.5	10.22	2	1	2	50	0	0	0	0	0	0	0	25	13	52.0	0.0
22	1	19.5	10.22	2	2	2	50	1	0	0	2.0	1	1	100.0	25	13	52.0	0.0
23	1	20.5	10.49	2	1	1	50	15	0	0	30.0	15	0	0	25	13	52.0	30.0
24	1	21.0	10.49	2	2	1	50	14	0	1	28.0	13	3	21.4	25	13	52.0	22.0
25	1	21.0	10.14	1	2	1	50	43	4	0	93.5	25	5	20.0	25	3	12.0	74.8
26	2	21.5	10.14	1	1	1	50	40	0	0	80.0	25	1	4.0	25	3	12.0	76.8
27	1	22.0	7.58	1	2	2	50	44	1	0	89.8	25	1	4.0	25	3	12.0	86.2
28	1	22.0	7.58	1	1	2	50	39	0	0	78.0	25	0	0	25	3	12.0	78.0
29	1	21.0	7.14	2	1	2	50	1	0	0	2.0	0	0	0	25	2	8.0	0.0
30	1	21.0	7.14	2	2	2	42	2	0	0	4.8	2	0	0	25	2	8.0	4.8
31	1	21.5	7.14	2	1	1	50	2	0	0	4.0	2	0	0	25	2	8.0	4.0
32	1	22.0	7.14	2	2	1	50	6	0	0	12.0	6	0	0	25	2	8.0	12.0
33	1	22.0	7.63	1	2	1	50	45	0	0	90.0	25	1	10.4	25	2	8.0	80.6
34	2	22.0	7.63	1	1	1	50	25	0	1	50.0	24	1	4.0	25	2	8.0	48.0
34	1	23.0	7.63	1	1	1	50	33	6	0	75.0	25	2	8.0	25	2	8.0	69.0
35	2	22.0	7.63	1	2	2	50	0	0	0	0	0	0	0	25	2	8.0	0.0
35	1	22.0	7.63	1	2	2	50	40	1	0	81.6	25	0	0	25	2	8.0	81.6

TABLE E-1

1978 LARVAL DIVERSION
STRIPED BASS DATA

												TEST MORTALITY			CONTROL MORTALITY			
TEST NO.	LIGHT/DARK	FLUME TEMP., °C	LARVAL LENGTH	VELOCITY	MESH TYPE	MESH SIZE	NO. TESTED	NO. BYPASSED	NO. SWIMMING	INITIAL DEAD	DIVERSION EFFICIENCY	NO. HELD	NO. DEAD	PERCENT DEAD	NO. HELD	NO. DEAD	PERCENT DEAD	TOTAL EFFICIENCY
36	2	23.0	7.63	1	1	2	50	5	0	0	10.0	5	0	0	25	2	8.0	10.0
36	1	23.0	9.99	1	1	2	50	24	0	1	48.0	23	9	37.5	25	1	4.0	30.0
37	1	21.0	9.99	2	1	1	50	0	0	0	0	0	0	0	25	1	4.0	0.0
37	1	23.0	9.99	2	1	1	50	13	0	0	26.0	13	3	30.8	25	1	4.0	18.0
38	1	21.5	9.99	2	2	2	50	7	0	0	14.0	7	0	0	25	1	4.0	14.0
39	1	22.0	9.99	2	1	2	50	3	0	0	6.0	3	0	0	25	1	4.0	6.0
40	1	22.0	9.99	2	2	1	50	4	0	0	8.0	4	0	0	25	1	4.0	8.0
41	2	20.5	10.51	1	1	1	50	30	0	0	60.0	25	5	20.0	25	6	24.0	48.0
42	2	21.0	10.51	1	2	1	50	18	0	1	36.0	17	7	38.9	25	6	24.0	22.0
43	2	21.5	10.51	1	1	2	50	11	0	0	22.0	11	1	18.2	25	6	24.0	18.0
44	2	22.0	10.51	1	2	2	50	12	0	0	24.0	12	1	8.3	25	6	24.0	22.0
44	2	22.0	10.51	1	2	2	50	12	0	0	24.0	12	1	8.3	25	6	24.0	22.0
45	1	21.0	10.57	2	1	2	50	0	0	0	0	0	0	0	25	5	20.0	0.0
46	1	21.5	10.57	2	2	2	50	1	0	0	2.0	1	1	100.0	25	5	20.0	0.0
47	1	22.0	10.57	2	1	1	50	0	0	0	0	0	0	0	25	5	20.0	0.0
48	1	22.5	10.57	2	2	1	50	7	0	0	14.0	7	1	14.3	25	5	20.0	12.0
48	1	23.0	10.57	2	2	1	50	3	0	0	6.0	6	0	0	25	5	20.0	6.0
49	2	22.0	11.44	1	2	1	50	44	0	1	88.0	25	2	6.2	25	2	8.0	82.5
50	2	22.5	11.44	1	2	2	50	11	0	0	22.0	11	0	0	25	2	8.0	22.0
51	1	22.5	11.44	2	2	2	50	7	0	0	14.0	7	0	0	25	2	8.0	14.0
52	1	23.5	11.44	2	2	1	50	26	0	1	52.0	25	1	3.8	25	2	8.0	50.0
53	1	18.0	12.76	2	2	1	50	18	0	1	36.0	17	1	5.5	25	4	16.0	34.0
54	1	18.5	12.76	2	1	1	50	41	0	1	82.0	25	2	6.3	25	4	16.0	76.8
55	1	19.5	12.76	2	2	2	50	10	0	0	20.0	10	0	0	25	4	16.0	20.0
56	1	20.0	12.76	2	1	2	50	34	1	1	69.4	25	4	14.6	25	4	16.0	59.3
56	1	20.5	12.76	2	1	2	50	27	0	1	54.0	25	3	11.4	25	4	16.0	47.8
57	2	20.0	13.50	1	1	2	50	39	2	0	81.0	25	6	24.0	25	4	16.0	61.0
58	1	20.0	13.50	1	2	1	50	45	2	1	94.0	25	3	10.0	25	4	16.0	84.6
59	2	21.0	13.50	1	2	2	50	20	0	1	40.0	19	4	20.0	25	3	12.0	32.0
60	2	22.0	13.50	1	1	1	50	49	1	1	100.0	25	3	9.9	25	3	12.0	90.1
61	1	21.0	13.61	2	2	1	50	38	0	3	76.0	25	12	41.0	25	11	44.0	44.8
62	1	21.0	13.61	2	1	1	50	46	0	0	92.0	25	11	44.0	25	11	44.0	51.5
62	1	22.5	13.61	2	1	1	50	49	0	0	98.0	26	18	69.2	25	6	24.0	30.2
63	1	22.0	13.61	2	2	2	50	18	0	0	36.0	18	6	33.3	25	6	24.0	24.0
64	1	22.0	13.61	2	1	2	50	41	0	0	82.0	25	11	44.0	25	6	24.0	45.9
65	2	23.5	14.63	1	1	2	50	48	0	0	96.0	25	16	64.0	25	12	48.0	34.6
66	2	23.5	14.63	1	2	2	50	39	0	0	78.0	25	15	60.0	25	12	48.0	31.2
67	2	24.5	14.63	1	1	1	50	42	6	0	95.0	25	16	64.0	25	12	48.0	34.2
68	1	24.5	14.63	2	2	2	50	37	0	0	74.0	25	14	56.0	25	12	48.0	32.6
69	2	25.0	14.63	2	2	1	50	36	0	14	72.0	22	28	77.8	25	12	48.0	16.0

TABLE E-1

1978 LARVAL DIVERSION
STRIPED BASS DATA

TEST NO.	LIGHT/DARK	FLUME TEMP., °C	LARVAL LENGTH	VELOCITY	MESH TYPE	MESH SIZE	NO. TESTED	NO. BYPASSED	NO. SWIMMING	INITIAL DEAD	DIVERSION EFFICIENCY	TEST MORTALITY NO. HELD	TEST MORTALITY NO. DEAD	TEST MORTALITY PERCENT DEAD	CONTROL MORTALITY NO. HELD	CONTROL MORTALITY NO. DEAD	CONTROL MORTALITY PERCENT DEAD	TOTAL EFFICIENCY
70	2	25.0	14.63	1	2	1	50	44	3	1	93.6	25	14	53.1	25	12	48.0	43.9
71	2	21.5	15.87	2	1	1	50	49	0	0	98.0	25	6	24.0	25	2	8.0	74.5
72	2	22.0	15.87	2	1	2	50	45	0	4	90.0	25	9	27.1	25	2	8.0	65.6
74	2	21.0	16.61	2	2	1	50	48	0	16	96.0	25	21	46.7	25	4	16.0	51.2
76	2	21.5	16.61	2	2	2	50	23	0	0	46.0	23	3	13.0	25	1	4.0	40.0
77	2	21.0	16.61	2	1	2	50	42	0	0	84.0	25	3	12.0	25	1	4.0	73.9
78	2	22.0	16.61	2	1	1	50	50	0	0	100.0	25	6	24.0	25	1	4.0	76.0
79	2	21.5	17.24	2	2	2	50	34	1	0	69.4	25	0	0	25	1	4.0	69.4
80	2	22.0	17.24	2	1	2	50	46	0	3	92.0	25	4	10.3	25	1	4.0	82.5
81	2	22.5	17.24	2	1	1	50	49	1	0	100.0	25	0	0	25	1	4.0	100.0
82	2	22.5	17.24	2	2	1	50	49	0	3	98.0	25	4	9.9	25	1	4.0	88.3
83	2	23.0	17.24	1	2	1	50	37	13	0	100.0	25	4	16.0	25	1	4.0	84.0
84	2	23.0	18.12	2	1	1	50	48	2	0	100.0	25	5	20.0	25	9	36.0	80.0
85	2	23.5	18.12	2	1	2	50	49	0	0	98.0	25	5	20.0	25	9	36.0	78.4
86	2	24.0	18.12	2	2	1	50	50	0	0	100.0	25	3	12.0	25	9	36.0	88.0
87	2	24.0	18.12	2	2	2	50	37	0	0	74.0	25	4	16.0	25	9	36.0	62.2
88	2	23.0	18.70	2	2	2	50	50	0	2	100.0	25	4	11.7	25	4	16.0	88.3
89	2	24.0	18.70	2	1	1	50	49	1	0	100.0	25	6	24.0	25	4	16.0	76.0
90	2	24.0	18.70	2	2	1	50	48	0	0	96.0	25	10	40.0	25	4	16.0	57.6
91	2	24.0	18.70	2	1	2	50	50	0	0	100.0	25	5	20.0	25	4	16.0	80.0
92	2	25.0	18.70	1	1	2	50	33	17	1	100.0	24	3	11.1	25	4	16.0	88.9
93	2	24.5	19.12	2	2	2	50	41	3	6	87.2	25	13	38.5	25	15	60.0	53.6
94	2	25.0	19.12	1	2	1	49	22	27	0	100.0	22	6	27.3	25	15	60.0	72.7
95	2	26.0	19.12	1	1	1	50	46	4	5	100.0	25	12	35.8	25	15	60.0	64.2

NOTE:

LIGHTING LIGHT = 1, DARK = 2   MESH TYPE SYNTHETIC = 1, SMOOTH TEX = 2   MESH SIZE 1.5mm = 1, 2.5mm = 2   VELOCITY 0.5 fps = 1, 1.0 fps = 2

TABLE E-2

LARVAL DIVERSION STUDY
1979 STRIPED BASS DATA

													TEST									CONTROL								
TEST NO.	TANK TEMP., °C	FLUME TEMP., °C	ΔT, °C	LARVAL LENGTH (mm)	VELOCITY (fps)	SCREEN TYPE	SCREEN SIZE	NO. TESTED	NO. SWIMMING	NO. DEAD IN BYPASS	NO. BYPASSED	DIVERSION EFFICIENCY, %	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	MORTALITY, %	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	MORTALITY, %	TEST MORTALITY (FRACTION)	TOTAL EFFICIENCY, %
1	19.0	19.5	-0.5	10.35	0.5	1	2	50	0	0	6	12.0	6	0	0	0	0	0	0	6	0.0	0	0	0	0	0	24	0.0	0.000	12.000
2	19.0	19.5	-0.5	10.35	1.0	1	2	50	0	0	0	0.0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	24	0.0	0.000	0.000
3	19.0	19.5	-0.5	10.35	1.0	1	1	49	0	11	49	100.0	25	0	2	0	0	1	3	22	31.7	0	0	0	0	0	24	0.0	0.317	68.300
4	19.0	19.5	-0.5	10.35	1.5	1	1	50	0	19	49	98.0	25	0	0	0	0	1	1	24	41.2	0	0	0	0	0	24	0.0	0.412	57.624
6	19.0	20.0	-1.0	10.35	0.5	1	1	50	0	0	50	100.0	25	0	0	0	0	0	0	25	0.0	0	0	0	0	0	24	0.0	0.000	100.000
7	19.0	19.0	0.0	9.88	0.5	1	2	50	0	0	4	8.0	4	0	0	0	0	0	0	4	0.0	1	0	0	0	1	23	4.2	0.000	8.000
9	19.0	19.0	0.0	9.88	1.5	1	1	49	0	27	42	85.7	15	0	0	1	0	0	1	14	66.6	1	0	0	0	1	23	4.2	0.666	28.624
10	19.0	19.0	0.0	9.88	1.0	1	1	50	0	0	50	100.0	25	0	0	0	0	1	1	24	4.0	1	0	0	0	1	23	4.2	0.040	96.000
11	18.8	19.0	-0.2	9.88	0.5	1	1	50	0	0	50	100.0	25	0	2	0	0	1	1	24	4.0	1	0	0	0	1	23	4.2	0.040	96.000
13	19.5	18.0	1.5	10.83	0.5	1	1	50	0	0	50	100.0	25	0	0	0	1	2	3	22	12.0	0	0	0	0	0	24	0.0	0.120	88.000
14	19.0	19.0	0.0	10.83	1.0	1	1	52	0	1	52	100.0	25	0	0	0	0	0	0	25	1.9	0	0	0	0	0	24	0.0	0.019	90.100
15	19.0	19.0	0.0	10.83	1.5	1	1	50	0	25	50	100.0	25	0	1	3	0	0	4	21	58.0	0	0	0	0	0	24	0.0	0.580	42.000
16	19.0	19.0	0.0	10.83	2.0	1	1	50	0	20	29	58.0	9	0	0	0	0	0	0	9	69.0	0	0	0	0	0	24	0.0	0.690	17.980
17	19.5	19.0	0.5	10.80	2.0	1	1	50	0	12	19	38.0	7	0	0	0	0	0	0	7	63.1	1	0	0	5	6	19	24.0	0.631	14.022
18	19.5	19.0	0.5	10.80	1.5	1	1	48	0	25	47	97.9	22	0	6	1	0	0	7	15	68.1	1	0	0	5	6	19	24.0	0.691	31.230
19	19.5	19.0	0.5	10.80	1.0	1	1	50	0	0	50	100.0	25	0	1	1	2	2	6	19	24.0	1	0	0	5	6	19	24.0	0.240	76.000
20	19.5	19.0	0.5	10.80	0.5	1	1	49	0	0	49	100.0	25	0	0	0	0	0	0	25	0.0	1	0	0	5	6	19	24.0	0.000	100.000
21	19.5	20.0	-0.5	10.80	0.5	1	2	50	0	9	9	18.0	9	0	0	0	0	0	0	9	0.0	1	0	0	5	6	19	24.0	0.000	18.000
22	22.0	22.0	0.0	11.89	0.5	1	2	50	0	0	19	38.0	19	0	0	0	1	0	1	18	5.3	1	0	1	0	2	22	8.3	0.053	35.986
24	22.0	22.0	0.0	11.89	1.0	1	1	50	0	1	49	98.0	25	0	0	0	0	0	0	25	2.0	1	0	1	0	2	22	8.3	0.020	96.040
25	22.0	22.0	0.0	11.89	1.5	1	1	49	0	4	49	100.0	25	0	0	1	0	0	1	24	11.8	1	0	1	0	2	22	8.3	0.118	88.200
26	22.0	23.0	-1.0	11.89	2.0	1	1	50	0	11	26	52.0	15	0	0	0	1	0	1	14	46.2	1	0	1	0	2	22	8.3	0.462	27.976
27	19.5	21.0	-1.5	13.08	1.0	1	1	50	0	0	50	100.0	25	0	4	0	0	2	6	19	24.0	0	0	0	0	0	25	0.0	0.240	76.000
28	19.5	21.0	-1.5	13.08	1.5	1	1	50	0	4	49	98.0	25	0	0	0	0	0	0	25	8.2	0	0	0	0	0	25	0.0	0.082	89.964
29	19.5	21.0	-1.5	13.08	2.0	1	1	50	0	21	46	92.0	25	0	1	0	0	0	1	24	47.8	0	0	0	0	0	25	0.0	0.478	48.024
30	19.5	21.3	-1.8	13.08	0.5	1	2	50	2	1	15	31.3	14	0	0	0	0	0	0	14	6.7	0	0	0	0	0	25	0.0	0.067	29.203
32	19.3	20.0	-0.7	11.69	0.5	1	2	50	2	0	6	12.5	6	0	0	0	0	0	0	6	0.0	0	0	0	0	0	25	0.0	0.000	12.500
34	19.3	20.5	-1.2	11.69	1.0	1	1	50	0	0	50	100.0	25	0	2	1	1	0	4	21	16.0	0	0	0	0	0	25	0.0	0.160	84.000
35	19.3	21.0	-1.7	11.69	1.5	1	1	49	0	0	49	100.0	25	0	0	1	0	0	1	24	4.0	0	0	0	0	0	25	0.0	0.040	96.000
36	19.3	21.0	-1.7	11.69	2.0	1	1	50	0	20	51	100.0	25	0	0	0	0	0	0	25	39.2	0	0	0	0	0	25	0.0	0.392	60.800
37	20.5	20.0	0.5	13.77	2.0	1	1	49	0	8	50	100.0	42	0	4	0	2	1	7	35	30.0	2	0	1	0	3	22	12.0	0.300	70.000
38	20.5	20.0	0.5	13.77	1.5	1	1	50	0	1	50	100.0	49	0	1	6	5	0	12	37	26.0	2	0	1	0	3	22	12.0	0.260	74.000
39	20.5	20.0	0.5	13.77	1.0	1	1	49	0	2	49	100.0	47	0	5	0	0	0	5	42	14.3	2	0	1	0	3	22	12.0	0.143	85.700
40	20.5	20.5	0.0	13.77	1.0	1	2	50	0	0	14	27.5	14	0	0	0	0	0	0	14	0.0	2	0	1	0	3	22	12.0	0.000	27.500
41	20.5	21.0	-0.5	13.77	0.5	1	2	48	0	0	21	43.8	21	0	1	4	0	0	5	16	23.8	2	0	1	0	3	22	12.0	0.238	33.376
42	20.5	21.0	-0.5	13.77	1.0	1	3	50	0	0	5	10.0	5	0	0	0	0	0	0	5	0.0	2	0	1	0	3	22	12.0	0.000	10.000
43	19.8	18.2	1.6	14.95	2.0	1	1	49	0	24	49	100.0	25	0	1	0	0	1	2	23	53.1	0	0	0	0	0	0	0.0	0.531	46.900
44	19.8	19.0	0.8	14.95	1.5	1	1	50	0	0	50	100.0	50	0	5	0	1	0	6	44	12.0	0	0	0	0	0	0	0.0	0.120	88.000
45	19.8	19.0	0.8	14.95	1.0	1	2	50	0	0	16	32.0	16	0	0	0	0	0	0	16	0.0	0	0	0	0	0	0	0.0	0.000	32.000
46	19.8	19.0	0.8	14.95	0.5	1	2	50	4	0	25	50.0	25	0	0	1	0	0	1	24	4.0	0	0	0	0	0	0	0.0	0.040	48.000
47	20.2	18.5	1.7	15.75	0.5	1	2	50	14	0	15	30.0	15	0	0	0	0	0	0	15	0.0	0	1	0	0	1	24	4.0	0.000	30.000
48	20.2	18.8	1.4	15.75	1.0	1	2	50	1	0	14	28.6	14	0	0	0	1	0	1	13	7.1	0	1	0	0	1	24	4.0	0.071	26.569
49	20.5	18.0	2.5	16.32	1.0	1	2	49	0	0	24	49.0	24	0	2	0	0	0	2	22	8.3	0	0	1	1	2	23	8.0	0.083	44.933
50	20.5	18.2	2.3	16.32	1.5	1	2	49	0	0	17	34.0	17	0	0	0	0	1	1	16	5.9	0	0	1	1	2	23	8.0	0.059	31.994
51	20.5	18.4	2.1	16.32	2.0	1	2	49	0	0	3	6.1	0	0	0	0	0	0	0	0	0.0	0	0	1	1	2	23	8.0	0.000	6.100
52	20.5	19.4	1.1	16.32	1.5	1	3	49	0	0	12	24.0	12	0	0	0	0	0	0	12	0.0	0	0	1	1	2	23	8.0	0.000	24.000
53	20.5	20.0	0.5	16.32	1.0	1	3	51	0	0	15	29.4	15	0	15	0	0	0	15	0	100.0	0	0	1	1	2	23	8.0	1.000	0.000
54	20.1	18.7	1.4	17.40	1.0	1	2	50	0	0	39	78.0	39	0	33	1	0	0	34	5	61,5	25	0	0	0	25	0	100.0	0.615	30.030
55	20.1	19.0	1.1	17.40	1.5	1	2	50	0	0	30	60.0	25	0	2	0	0	0	2	23	13.3	25	0	0	0	25	0	100.0	0.133	52.020
56	20.1	19.0	1.1	17.40	2.0	1	2	50	0	0	20	40.0	20	0	6	0	0	0	6	14	30.0	25	0	0	0	25	0	100.0	0.300	28.000
57	20.1	19.8	0.3	17.40	0.5	1	3	50	13	0	28	75.7	28	0	13	0	0	0	13	16	46.4	25	0	0	0	25	0	100.0	0.464	40.575
58	20.1	20.0	0.1	17.40	1.0	1	3	49	1	0	22	45.8	22	0	5	0	0	2	7	15	31.0	25	0	0	0	25	0	100.0	0.318	31.236

TABLE E-2

1979 LARVAL DIVERSION
STRIPED BASS DATA

													TEST									CONTROL								
TEST NO.	TANK TEMP., °C	FLUME TEMP., °C	ΔT, °C	LARVAL LENGTH (mm)	VELOCITY (fps)	SCREEN TYPE	SCREEN SIZE	NO. TESTED	NO. SWIMMING	NO. DEAD IN BYPASS	NO. BYPASSED	DIVERSION EFFICIENCY, %	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	MORTALITY, %	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	MORTALITY, %	TEST MORTALITY (FRACTION)	TOTAL EFFICIENCY, %
59	20.1	20.0	0.1	17.40	1.5	1	3	51	0	0	13	25.5	13	0	1	2	0	0	3	10	23.1	25	0	0	0	25	0	100	0.231	19.6095
60	20.3	19.8	0.5	18.02	1.5	1	1	50	0	1	50	100.0	49	0	0	0	0	3	3	46	8.0	0	0	0	0	0	25	0	0.080	92.0000
61	20.3	21.0	-0.7	18.02	1.0	1	4	49	0	0	17	34.7	17	0	0	0	0	0	0	17	0.0	.	.	.	.	.	.	0	0.000	34.7000
62	20.3	21.0	-0.7	18.02	1.5	1	4	50	0	0	9	18.0	9	0	0	0	0	0	0	9	0.0	.	.	.	.	.	.	0	0.000	18.0000
63	20.3	21.0	-0.7	18.02	1.0	1	3	50	0	0	23	46.0	23	0	0	0	0	0	0	23	0.0	.	.	.	.	.	.	0	0.000	46.0000
64	20.0	21.0	-1.0	20.97	2.0	1	3	49	0	0	19	38.8	19	0	0	0	0	0	0	19	0.0	.	.	.	.	.	.	0	0.000	38.8000
65	20.0	21.0	-1.0	20.97	1.5	1	3	49	0	1	28	57.1	27	0	0	0	0	0	0	27	3.6	.	.	.	.	.	.	0	0.036	55.0444
66	20.0	21.0	-1.0	20.97	1.0	1	3	50	0	0	38	76.0	38	0	0	0	0	0	0	38	0.0	.	.	.	.	.	.	0	0.000	76.0000
67	20.0	21.0	-1.0	20.97	1.0	1	2	50	0	1	46	92.0	45	0	1	0	0	0	1	44	4.3	.	.	.	.	.	.	0	0.043	88.0440
68	20.0	21.2	-1.2	20.97	1.5	1	2	49	0	1	45	91.8	44	0	0	0	0	0	0	44	2.2	.	.	.	.	.	.	0	0.022	89.7804
69	20.0	21.2	-1.2	20.97	2.0	1	2	50	0	0	40	80.0	40	0	0	0	0	0	0	40	0.0	.	.	.	.	.	.	0	0.000	80.0000
70	20.6	20.9	-0.3	21.45	0.5	1	4	48	41	0	4	57.1	4	0	0	0	0	0	0	4	0.0	.	.	.	.	.	.	0	0.000	57.1000
71	20.2	21.2	-1.0	21.45	1.0	1	4	49	0	1	16	32.7	15	0	0	0	1	0	1	14	12.5	.	.	.	.	.	.	24	0.125	28.6125
72	20.2	21.3	-1.1	21.45	1.5	1	4	50	0	0	6	12.0	6	0	0	0	0	0	0	6	0.0	.	.	.	.	.	.	24	0.000	12.0000
73	20.2	21.8	-1.6	21.45	2.0	1	4	50	0	0	10	20.0	10	0	0	0	0	0	0	10	0.0	.	.	.	.	.	.	24	0.000	20.0000
74	20.2	22.0	-1.8	21.45	2.0	1	3	51	0	4	40	78.4	36	0	0	1	1	1	3	33	17.5	.	.	.	.	.	.	24	0.175	64.6800
75	20.2	22.0	-1.8	21.45	2.0	1	3	50	0	3	32	64.0	29	0	0	1	1	1	3	26	18.8	.	.	.	.	.	.	24	0.188	51.9680
76	20.2	22.0	-1.8	21.45	1.5	1	3	50	0	0	40	80.0	40	0	0	0	0	0	0	40	0.0	.	.	.	.	.	.	24	0.000	80.0000
77	20.2	22.0	-1.8	21.45	1.5	1	3	50	0	0	35	70.0	35	0	0	0	0	1	1	34	2.9	.	.	.	.	.	.	24	0.029	67.9700
78	20.0	18.8	1.2	22.90	1.0	1	3	50	0	0	45	90.0	45	0	0	0	0	0	0	45	0.0	0	0	5	1	6	19	24	0.000	90.0000
79	20.0	18.8	1.2	22.90	1.0	1	3	50	0	0	42	84.0	42	0	0	0	1	1	2	40	4.8	.	.	.	.	.	.	24	0.048	79.9680
80	20.0	19.4	0.6	22.90	1.5	1	3	50	0	0	36	72.0	36	0	0	1	0	3	4	32	11.1	.	.	.	.	.	.	24	0.111	64.0080
81	20.0	19.4	0.6	22.90	1.5	1	3	50	0	2	33	66.0	31	0	0	0	1	1	2	29	12.1	.	.	.	.	.	.	24	0.121	58.0140
82	20.0	19.5	0.5	22.90	2.0	1	3	50	0	0	40	80.0	40	0	0	0	3	0	3	37	7.5	.	.	.	.	.	.	24	0.075	74.0000
83	20.0	19.5	0.5	22.90	2.0	1	3	50	0	0	28	56.0	28	0	0	0	0	1	1	27	3.6	.	.	.	.	.	.	24	0.036	53.9840
84	20.0	19.9	0.1	22.90	2.0	1	2	50	0	0	38	76.0	38	0	0	0	0	3	3	35	7.9	.	.	.	.	.	.	24	0.079	69.9960
85	20.0	19.9	0.1	22.90	2.0	1	2	49	0	0	45	91.8	45	0	1	0	0	2	3	42	6.7	.	.	.	.	.	.	24	0.067	85.6494
86	19.3	17.5	1.8	17.20	1.0	1	2	50	0	0	28	56.0	28	0	0	0	0	0	0	28	0.0	0	0	2	0	2	23	8	0.000	56.0000
87	19.3	19.0	0.3	17.20	1.0	1	2	50	0	1	20	40.0	19	0	1	0	0	0	1	18	10.0	.	.	.	.	.	.	8	0.100	36.0000
88	19.3	19.0	0.3	17.20	1.5	1	2	50	0	0	22	44.0	22	0	0	0	0	0	0	22	0.0	.	.	.	.	.	.	8	0.000	44.0000
89	19.3	19.2	0.1	17.20	1.5	1	2	49	0	0	11	22.4	11	0	0	0	0	0	0	11	0.0	.	.	.	.	.	.	8	0.000	22.4000
90	19.3	19.2	0.1	17.20	0.5	1	3	50	15	0	19	54.3	19	0	0	0	0	0	0	19	0.0	.	.	.	.	.	.	8	0.000	54.3000
91	19.3	19.5	-0.2	17.20	0.5	1	3	49	20	0	15	51.7	15	0	0	0	0	0	0	15	0.0	.	.	.	.	.	.	8	0.000	51.7000
92	19.3	19.6	-0.3	17.20	1.0	1	3	51	0	0	17	33.3	17	0	0	0	0	0	0	17	0.0	.	.	.	.	.	.	8	0.000	33.3000
93	19.3	19.6	-0.3	17.20	1.0	1	3	50	0	0	12	24.0	12	0	1	0	0	0	1	11	8.3	.	.	.	.	.	.	8	0.083	22.0080
94	20.5	19.8	0.7	18.96	0.5	1	3	49	22	0	14	52.0	14	0	0	0	0	0	0	14	0.0	1	0	0	0	1	24	4	0.000	52.0000
95	20.5	19.8	0.7	18.96	0.5	1	3	51	19	1	24	75.0	23	0	0	0	2	0	2	21	12.5	.	.	.	.	.	.	4	0.125	65.6250
96	20.5	21.0	-0.5	18.96	2.0	1	4	50	0	0	2	4.0	0	0	0	0	0	0	0	0	0.0	.	.	.	.	.	.	4	0.000	4.0000
97	20.5	21.0	-0.5	18.96	2.0	1	4	50	0	0	1	2.0	0	0	0	0	0	0	0	0	0.0	.	.	.	.	.	.	4	0.000	2.0000
98	20.5	21.0	-0.5	18.96	0.5	1	4	50	9	2	25	61.0	23	0	0	0	0	1	1	22	12.0	.	.	.	.	.	.	4	0.120	53.6800
99	20.5	20.8	-0.3	19.52	0.5	1	4	49	30	0	14	73.7	14	0	0	0	0	0	0	14	0.0	2	2	2	1	7	18	28	0.000	73.7000
100	20.5	20.8	-0.3	19.52	0.5	1	4	49	16	0	26	78.8	26	0	0	1	0	0	1	25	3.8	.	.	.	.	.	.	28	0.038	75.8056
101	20.5	21.0	-0.5	19.52	0.5	1	4	50	17	1	22	66.7	21	0	0	1	0	1	2	19	13.6	.	.	.	.	.	.	28	0.136	57.6288
102	20.5	21.0	-0.5	19.52	1.5	1	2	50	0	0	43	86.0	43	0	1	1	0	0	2	41	4.7	.	.	.	.	.	.	28	0.047	81.9580
103	20.5	21.0	-0.5	19.52	1.5	1	2	50	0	0	36	72.0	36	0	0	0	0	3	3	33	8.3	.	.	.	.	.	.	28	0.083	66.0240
104	20.5	21.8	-1.3	19.52	2.0	1	2	51	0	0	42	82.4	42	0	0	0	0	3	3	39	7.1	.	.	.	.	.	.	28	0.071	76.5496
105	20.5	21.8	-1.3	19.52	2.0	1	2	50	0	5	42	84.0	37	0	2	0	0	0	2	35	16.7	.	.	.	.	.	.	28	0.167	69.9720
106	20.0	21.0	-1.0	22.79	1.5	1	3	50	0	0	16	32.0	16	0	2	0	0	0	2	14	25.0	0	0	0	0	0	25	0	0.250	24.0000
107	20.0	21.0	-1.0	22.79	1.5	1	3	50	0	0	8	16.0	8	0	1	0	0	0	1	7	12.5	.	.	.	.	.	.	0	0.125	14.0000
108	20.0	21.0	-1.0	22.79	1.5	1	3	50	0	0	23	46.0	23	0	0	0	0	0	0	23	0.0	.	.	.	.	.	.	0	0.000	46.0000
109	20.0	21.0	-1.0	22.79	2.0	1	3	50	0	0	17	34.0	17	0	0	0	1	0	1	16	5.9	.	.	.	.	.	.	0	0.059	31.9940
110	20.0	21.2	-1.2	22.79	2.0	1	3	50	0	0	19	38.0	19	0	0	2	0	0	2	17	10.5	.	.	.	.	.	.	0	0.105	34.0100

TABLE E-2

1979 LARVAL DIVERSION
STRIPED BASS DATA

													TEST									CONTROL								
TEST NO.	TANK TEMP., °C	FLUME TEMP., °C	ΔT, °C	LARVAL LENGTH (mm)	VELOCITY (fps)	SCREEN TYPE	SCREEN SIZE	NO. TESTED	NO. SWIMMING	NO. DEAD IN BYPASS	NO. BYPASSED	DIVERSION EFFICIENCY, %	INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	MORTALITY, %	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	MORTALITY, %	TEST MORTALITY (FRACTION)	TOTAL EFFICIENCY, %
111	20.0	21.2	-1.2	22.79	2.0	1	3	50	0	0	13	26.0	13	0	0	0	0	0	0	13	0.0	.	.	.	.	.	.	0	0.000	26.0000
112	20.0	21.2	-1.2	18.98	1.0	1	3	51	0	0	31	60.8	31	0	2	0	12	1	15	16	48.4	0	0	1	0	1	24	4	0.484	31.3728
113	20.0	21.3	-1.3	18.98	1.0	1	3	50	0	0	27	54.0	27	0	2	1	0	0	3	24	11.1	.	.	.	.	.	.	4	0.111	48.0060
114	20.0	21.3	-1.3	18.98	1.0	1	3	50	0	0	33	66.0	33	0	0	0	0	2	2	31	6.1	.	.	.	.	.	.	4	0.061	61.9740
115	20.0	21.3	-1.3	18.98	1.0	1	4	50	0	0	11	22.0	11	0	0	0	0	0	0	11	0.0	.	.	.	.	.	.	4	0.000	22.0000
116	20.0	21.5	-1.5	18.98	1.0	1	4	50	0	0	4	8.0	4	0	0	0	0	0	0	4	0.0	.	.	.	.	.	.	4	0.000	8.0000
117	20.0	21.5	-1.5	18.98	1.0	1	4	49	0	0	4	8.2	4	0	0	0	0	0	0	4	0.0	.	.	.	.	.	.	4	0.000	8.2000
118	20.0	21.5	-1.5	18.98	1.5	1	4	50	0	0	3	6.0	0	0	0	0	0	0	0	0	0.0	.	.	.	.	.	.	4	0.000	6.0000
119	20.0	21.5	-1.5	18.98	1.5	1	4	50	0	0	3	6.0	0	0	0	0	0	0	0	0	0.0	.	.	.	.	.	.	4	0.000	6.0000
120	20.0	21.5	-1.5	18.98	1.5	1	4	50	0	0	1	2.0	0	0	0	0	0	0	0	0	0.0	.	.	.	.	.	.	4	0.000	2.0000
121	20.5	22.0	-1.5	20.86	1.0	1	3	50	0	0	30	60.0	30	0	0	0	0	0	0	30	0.0	0	0	0	0	0	25	0	0.000	60.0000
122	20.5	22.0	-1.5	20.86	1.0	1	3	50	0	0	26	52.0	26	0	0	0	0	0	0	26	0.0	.	.	.	.	.	.	0	0.000	52.0000
123	20.5	22.0	-1.5	20.86	1.0	1	3	50	0	0	21	42.0	21	0	0	0	0	1	1	20	4.8	.	.	.	.	.	.	0	0.048	39.9840
124	20.5	22.5	-2.0	20.86	1.5	1	3	49	0	0	30	61.2	30	0	0	0	0	1	1	29	3.3	.	.	.	.	.	.	0	0.033	59.1804
125	20.5	22.5	-2.0	20.86	1.5	1	3	50	0	0	26	52.0	26	0	0	0	0	1	1	25	3.8	.	.	.	.	.	.	0	0.039	50.0240
126	20.5	22.5	-2.0	20.86	1.5	1	3	51	0	0	36	70.6	36	0	0	0	0	0	0	36	0.0	.	.	.	.	.	.	0	0.000	70.6000
127	20.5	22.5	-2.0	20.86	2.0	1	3	50	0	0	30	60.0	30	0	0	0	1	2	3	27	10.0	.	.	.	.	.	.	0	0.100	54.0000
128	20.5	22.6	-2.1	20.86	2.0	1	3	50	0	0	24	48.0	24	0	1	0	0	0	1	23	4.2	.	.	.	.	.	.	0	0.042	45.9840
129	21.0	22.5	-1.5	22.84	0.5	1	4	50	16	1	32	94.1	31	0	0	0	0	0	0	31	3.1	1	0	0	3	4	21	16	0.031	91.1829
130	21.0	22.5	-1.5	22.84	0.5	1	4	50	38	0	10	83.3	10	0	0	0	0	0	0	10	0.0	.	.	.	.	.	.	16	0.000	83.3000
131	21.0	22.5	-1.5	22.84	1.0	1	4	50	0	0	17	34.0	17	0	0	0	0	0	0	17	0.0	.	.	.	.	.	.	16	0.000	34.0000
132	21.0	22.5	-1.5	22.84	1.0	1	4	49	2	0	8	17.0	8	0	0	0	0	0	0	8	0.0	.	.	.	.	.	.	16	0.000	17.0000
133	21.0	23.0	-2.0	22.84	1.5	1	4	50	0	0	4	8.0	4	0	0	0	0	0	0	4	0.0	.	.	.	.	.	.	16	0.000	8.0000
134	21.0	23.0	-2.0	22.84	1.5	1	4	50	0	0	8	16.0	8	0	0	0	0	0	0	8	0.0	.	.	.	.	.	.	16	0.000	16.0000
135	22.5	23.0	-0.5	22.84	2.0	1	4	50	0	0	9	18.0	9	0	0	0	0	0	0	9	0.0	.	.	.	.	.	.	16	0.000	18.0000
136	22.5	23.0	-0.5	22.84	2.0	1	4	50	0	0	13	26.0	13	0	0	1	0	0	1	12	7.7	.	.	.	.	.	.	16	0.077	23.9980
137	21.5	22.8	-1.3	22.74	2.0	1	3	51	0	0	42	82.4	42	0	0	6	0	1	7	35	16.7	0	0	0	0	0	25	0	0.167	68.6392
138	21.5	22.8	-1.3	22.74	2.0	1	3	49	0	0	45	91.8	45	0	0	0	0	0	0	45	0.0	.	.	.	.	.	.	0	0.000	91.8000
139	21.5	22.8	-1.3	22.74	2.0	1	3	50	0	1	43	86.0	42	0	0	0	0	1	1	41	4.6	.	.	.	.	.	.	0	0.046	82.0440
140	22.0	23.0	-1.0	22.74	1.5	1	3	50	0	1	45	90.0	44	0	0	0	0	3	3	41	8.8	.	.	.	.	.	.	0	0.088	82.0800
141	22.0	23.0	-1.0	22.74	1.5	1	3	50	0	0	38	76.0	38	0	0	0	1	0	1	37	2.6	.	.	.	.	.	.	0	0.026	74.0240
142	22.0	23.0	-1.0	22.74	1.5	1	3	50	0	0	42	84.0	42	0	0	0	0	1	1	41	2.4	.	.	.	.	.	.	0	0.024	81.9840
143	22.0	22.8	-0.8	22.74	1.0	1	3	50	1	0	37	75.5	37	0	0	0	0	0	0	37	0.0	.	.	.	.	.	.	0	0.000	75.5000
144	22.0	22.8	-0.8	22.74	1.0	1	3	50	1	1	29	59.2	28	0	0	0	0	0	0	28	3.4	.	.	.	.	.	.	0	0.034	57.1872
145	22.0	22.8	-0.8	22.74	1.0	1	3	50	3	1	33	70.2	32	0	0	1	0	1	2	30	9.1	.	.	.	.	.	.	0	0.091	63.8118
146	21.5	22.8	-1.3	24.69	1.0	1	4	50	2	0	21	43.8	21	0	0	0	0	1	1	20	4.8	.	.	.	.	.	.	0	0.048	41.6976
147	21.5	22.8	-1.3	24.69	1.0	1	4	50	2	0	17	35.4	17	0	0	0	0	0	0	17	0.0	.	.	.	.	.	.	0	0.000	35.4000
148	21.5	22.9	-1.4	24.69	1.0	1	4	50	0	0	17	34.0	17	0	0	0	0	0	0	17	0.0	.	.	.	.	.	.	0	0.000	34.0000
149	22.0	23.0	-1.0	24.69	1.5	1	4	50	0	0	7	14.0	7	0	2	0	0	0	2	5	28.6	.	.	.	.	.	.	0	0.286	9.9960
150	22.0	23.0	-1.0	24.69	1.5	1	4	50	0	0	8	16.0	8	0	0	0	0	1	1	7	12.5	.	.	.	.	.	.	0	0.125	14.0000
151	22.0	23.0	-1.0	24.69	1.5	1	4	50	0	1	19	38.0	18	0	0	0	0	2	2	16	15.8	.	.	.	.	.	.	0	0.158	31.9960
152	22.0	23.0	-1.0	24.69	2.0	1	4	50	0	0	10	20.0	10	0	0	0	0	0	0	10	0.0	.	.	.	.	.	.	0	0.000	20.0000
153	22.0	23.0	-1.0	24.69	2.0	1	4	50	0	0	12	24.0	12	0	0	0	0	0	0	12	0.0	.	.	.	.	.	.	0	0.000	24.0000
154	22.0	23.0	-1.0	24.69	2.0	1	4	50	0	1	11	22.0	10	0	0	0	0	1	1	9	18.2	0	0	0	1	1	24	4	0.182	17.9960
155	20.0	22.0	-1.0	24.65	1.5	1	2	50	0	0	50	100.0	50	0	2	7	3	4	14	26	32.0	.	.	.	.	.	.	4	0.320	68.0000
156	20.0	22.0	-2.0	24.65	1.5	1	2	50	0	1	49	98.0	48	0	0	1	0	0	1	47	4.1	.	.	.	.	.	.	4	0.041	93.9820
157	20.0	22.0	-2.0	24.65	1.5	1	2	49	0	0	49	100.0	49	0	0	0	0	2	2	47	4.1	.	.	.	.	.	.	4	0.041	95.9000
158	20.0	22.0	-2.0	24.65	2.0	1	2	50	0	0	50	100.0	50	0	0	0	0	3	3	47	6.0	.	.	.	.	.	.	4	0.060	94.0000
159	20.0	22.0	-2.0	24.65	2.0	1	2	50	0	0	50	100.0	50	0	0	0	2	2	4	46	8.0	.	.	.	.	.	.	4	0.080	92.0000
160	20.2	22.0	-1.8	24.65	2.0	1	2	50	0	0	50	100.0	50	0	0	0	0	2	2	48	4.0	.	.	.	.	.	.	4	0.040	96.0000
161	20.2	22.0	-1.8	24.89	1.0	1	3	50	6	0	43	97.7	43	0	0	0	1	1	2	41	4.7	0	0	0	0	0	25	0	0.047	93.1081
162	20.2	22.0	-1.8	24.89	1.0	1	3	50	12	0	37	97.4	37	0	0	0	0	2	2	35	5.4	.	.	.	.	.	.	0	0.054	92.1404

TABLE E-2

1979 LARVAL DIVERSION
STRIPED BASS DATA

TEST NO.	TANK TEMP., °C	FLUME TEMP., °C	ΔT, °C	LARVAL LENGTH (mm)	VELOCITY (fps)	SCREEN TYPE	SCREEN SIZE	NO. TESTED	NO. SWIMMING	NO. DEAD IN BYPASS	NO. BYPASSED	DIVERSION EFFICIENCY, %	TEST									CONTROL							TEST MORTALITY (FRACTION)	TOTAL EFFICIENCY, %
													INITIAL LIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	MORTALITY, %	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	MORTALITY, %		
163	20.2	22.4	-2.2	24.89	1.5	1	3	49	0	0	47	95.9	47	0	1	0	0	0	1	46	2.1	.	.	.	.	.	.	0	0.021	93.886
164	20.2	22.4	-2.2	24.89	1.5	1	3	50	0	0	47	94.0	47	0	0	0	0	1	1	46	2.1	.	.	.	.	.	.	0	0.021	92.026
165	21.0	22.4	-1.4	24.89	2.0	1	3	50	0	0	42	84.0	42	0	0	0	0	1	1	41	2.4	.	.	.	.	.	.	0	0.024	81.984
166	21.0	22.4	-1.4	24.89	2.0	1	3	50	0	1	43	86.0	42	1	1	0	0	1	2	40	6.9	.	.	.	.	.	.	0	0.069	80.066
167	22.0	22.8	-0.8	29.07	1.0	1	4	50	12	0	31	81.6	31	0	0	0	0	1	1	30	3.2	0	0	0	1	1	24	4	0.032	78.989
168	22.0	22.8	-0.8	29.07	1.0	1	4	50	10	0	31	77.5	31	0	0	1	0	1	2	29	6.5	.	.	.	.	.	.	4	0.065	72.462
169	22.0	23.0	-1.0	29.07	1.5	1	4	50	0	0	18	36.0	18	0	0	0	0	1	1	17	5.6	.	.	.	.	.	.	4	0.056	33.984
170	22.0	23.0	-1.0	29.07	1.5	1	4	50	0	0	20	40.0	20	0	1	0	0	0	1	19	5.0	.	.	.	.	.	.	4	0.050	38.000
171	22.3	23.1	-0.8	29.07	2.0	1	4	50	0	0	22	44.0	12	0	0	0	0	0	0	22	0.0	.	.	.	.	.	.	4	0.000	44.000
172	22.5	23.1	-0.6	29.07	2.0	1	4	49	0	0	22	44.9	22	0	0	0	0	0	0	22	0.0	.	.	.	.	.	.	4	0.000	44.900
173	22.2	23.6	-1.4	27.60	1.5	1	3	50	0	0	48	96.0	48	0	0	0	0	1	1	47	2.1	0	0	0	3	3	22	12	0.021	93.984
174	22.2	23.6	-1.4	27.60	1.5	1	3	49	0	0	45	91.8	45	0	0	0	0	1	1	44	2.2	.	.	.	.	.	.	12	0.022	89.780
175	22.2	23.6	-1.4	27.60	2.0	1	3	51	0	0	48	94.1	48	0	0	0	0	2	2	46	4.2	.	.	.	.	.	.	12	0.042	90.148
176	22.2	23.6	-1.4	27.60	2.0	1	3	50	0	0	47	94.1	47	0	0	2	4	1	7	40	14.9	.	.	.	.	.	.	12	0.149	80.079
177	22.6	23.8	-1.2	27.60	2.0	1	4	50	0	0	32	64.0	32	0	0	0	0	1	1	31	3.1	.	.	.	.	.	.	12	0.031	62.016
178	22.6	23.8	-1.2	27.60	2.0	1	4	49	0	0	25	51.0	25	0	0	1	3	1	5	20	20.0	.	.	.	.	.	.	12	0.200	40.800
179	23.0	23.9	-0.9	27.60	1.5	1	4	50	5	0	31	68.9	31	0	0	1	0	0	1	30	3.2	.	.	.	.	.	.	12	0.032	66.695
180	23.0	23.9	-0.9	27.60	1.5	1	4	49	0	0	24	49.0	24	0	0	0	0	1	1	23	4.2	.	.	.	.	.	.	12	0.042	46.942
181	23.0	23.9	-0.9	27.60	1.5	1	4	50	0	1	27	54.0	26	0	0	0	2	0	2	24	11.1	.	.	.	.	.	.	12	0.111	48.006
182	21.5	24.0	-2.5	27.60	1.0	1	4	50	5	1	41	91.1	40	0	0	0	1	1	2	38	7.3	.	.	.	.	.	.	12	0.073	84.450
183	21.5	24.0	-2.5	27.60	1.0	1	4	50	7	0	32	74.4	32	0	0	0	0	0	0	32	0.0	.	.	.	.	.	.	12	0.000	74.400
184	22.9	23.9	-1.0	30.19	1.0	1	3	50	24	0	26	100.0	26	0	12	0	0	0	12	14	46.2	0	0	0	0	0	25	0	0.462	53.800
185	22.9	24.0	-1.1	30.19	1.0	1	3	50	33	0	15	88.2	15	0	0	0	0	0	0	15	0.0	.	.	.	.	.	.	0	0.000	88.200
186	23.0	24.0	-1.0	30.19	1.5	1	4	50	0	0	31	62.0	31	0	0	0	0	0	0	31	0.0	.	.	.	.	.	.	0	0.000	62.000
187	23.0	24.0	-1.0	30.19	1.5	1	4	50	1	0	28	57.1	28	0	1	0	0	0	1	27	3.6	.	.	.	.	.	.	0	0.036	55.044
188	23.0	24.3	-1.3	30.19	2.0	1	4	50	0	0	23	46.0	23	0	0	0	0	0	0	23	0.0	.	.	.	.	.	.	0	0.000	46.000
189	23.0	24.3	-1.3	30.19	2.0	1	4	50	0	0	27	54.0	27	0	0	0	0	0	0	27	0.0	.	.	.	.	.	.	0	0.000	54.000
190	23.6	24.8	-1.2	31.73	2.0	1	3	50	0	0	48	96.0	48	0	10	0	0	0	10	38	20.8	.	.	.	.	.	.	0	0.208	76.032
191	23.6	24.9	-1.3	31.73	2.0	1	3	50	0	0	50	100.0	50	0	0	1	0	0	1	49	2.0	.	.	.	.	.	.	0	0.020	98.000
192	23.6	24.9	-1.3	31.73	2.0	1	3	50	0	0	50	100.0	50	0	0	0	0	0	0	50	0.0	.	.	.	.	.	.	0	0.000	100.000
193	23.6	24.9	-1.3	31.73	1.5	1	3	50	4	0	44	95.7	44	0	3	3	2	0	8	36	18.2	.	.	.	.	.	.	0	0.182	78.283
194	23.6	25.0	-1.4	31.73	1.5	1	3	49	12	0	37	100.0	37	0	1	0	0	0	1	36	2.7	.	.	.	.	.	.	0	0.027	97.300
195	23.6	25.0	-1.4	31.73	1.5	1	3	50	5	0	42	93.3	42	0	0	0	2	0	2	40	4.8	.	.	.	.	.	.	0	0.048	88.822
196	23.4	24.5	-1.1	35.51	1.5	1	4	50	8	0	36	85.7	36	0	0	0	0	0	0	36	0.0	.	.	.	.	.	.	0	0.000	85.700
197	23.4	24.5	-1.1	35.51	1.5	1	4	50	0	0	42	84.0	42	0	1	0	0	0	1	41	2.4	.	.	.	.	.	.	0	0.024	81.984
198	24.0	25.0	-1.0	35.51	2.0	1	4	50	0	0	37	74.0	37	0	0	0	0	0	0	37	0.0	.	.	.	.	.	.	0	0.000	74.000
199	24.0	25.0	-1.0	35.51	2.0	1	4	50	0	0	35	70.0	35	0	1	0	0	0	1	34	2.9	.	.	.	.	.	.	0	0.029	67.970
200	24.0	25.0	-1.0	35.51	1.5	1	4	50	19	0	25	80.6	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	0	0.000	80.600
201	22.9	25.6	-2.7	37.71	1.5	1	4	50	14	0	34	94.4	34	0	1	0	0	0	1	33	2.9	0	0	0	1	1	24	4	0.029	91.662
202	22.9	25.6	-2.7	37.71	1.5	1	4	50	14	0	32	88.9	32	0	0	0	0	0	0	32	0.0	.	.	.	.	.	.	4	0.000	88.900
203	22.9	25.6	-2.7	37.71	1.5	1	4	49	17	0	26	81.3	26	0	0	0	0	0	0	26	0.0	.	.	.	.	.	.	4	0.000	81.300
204	23.0	25.6	-2.6	37.71	2.0	1	4	51	2	0	46	93.9	46	0	1	0	0	0	1	45	2.2	.	.	.	.	.	.	4	0.022	91.834
205	23.0	25.6	-2.6	37.71	2.0	1	4	50	2	1	47	97.9	46	0	0	0	0	0	0	46	2.1	.	.	.	.	.	.	4	0.021	95.844
206	23.0	25.6	-2.6	37.71	2.0	1	4	50	2	2	41	85.4	39	0	0	0	0	1	1	38	7.3	.	.	.	.	.	.	4	0.073	79.166
207	21.0	23.9	-2.9	41.09	2.0	1	4	50	3	1	44	93.6	43	0	0	1	0	1	2	41	6.8	0	0	0	0	0	25	0	0.068	87.235
208	21.0	23.9	-2.9	41.09	2.0	1	4	50	11	0	37	94.9	37	0	1	0	0	0	1	36	2.7	.	.	.	.	.	.	0	0.027	92.338
209	21.0	23.9	-2.9	41.09	1.5	1	4	50	26	0	19	79.2	19	0	1	0	0	0	1	18	5.3	.	.	.	.	.	.	0	0.053	75.002

NOTE:

SCREEN SIZE		VELOCITY	
	1.0mm = 1		0.5 fps = 1
	4.0mm = 2		1.0 fps = 2
	5.0mm = 3		1.5 fps = 3
	9.5mm = 4		2.0 fps = 4

APPENDIX F

TABLE F-1

JET PUMP STUDY
1979 STRIPED BASS DATA

						TEST									CONTROL								
TEST NO.	TANK TEMP., °C	FLUME TEMP., °C	ΔT, °C	LARVAL LENGTH (mm)	VELOCITY (fps)	TOTAL INITIAL LIVE	TOTAL INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	TEST MORTALITY, %	INITIAL ALIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	CONTROL MORTALITY, %
1	19.0	19.0	0.0	7.54	35	23	0	1	0	0	0	1	22	4.3	25	0	0	0	0	1	1	24	4.0
2	19.3	19.2	0.1	7.94	32	23	0	0	0	0	0	0	23	0.0	.	.	.	.	.	.	.	.	4.0
3	19.3	19.2	0.1	7.94	32	23	0	2	0	0	0	2	23	8.7	.	.	.	.	.	.	.	.	4.0
4	19.3	19.2	0.1	7.94	32	23	1	0	1	0	0	2	23	8.7	.	.	.	.	.	.	.	.	4.0
7	19.0	20.1	-1.1	8.19	45	32	15	0	3	0	4	22	25	46.8	20	3	1	1	0	2	7	16	30.4
8	19.0	19.2	-0.2	9.92	32	25	0	0	1	1	0	2	23	8.0	25	0	1	1	0	0	2	23	8.0
9	19.0	19.2	-0.2	9.92	32	26	0	0	0	1	0	1	25	3.8	.	.	.	.	.	.	.	.	8.0
10	19.0	19.2	-0.2	9.92	32	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	8.0
11	19.0	19.2	-0.2	9.92	45	24	0	0	1	0	0	1	23	4.2	.	.	.	.	.	.	.	.	8.0
12	19.5	20.1	-0.6	9.92	45	24	1	0	1	1	0	3	22	12.0	.	.	.	.	.	.	.	.	8.0
13	19.5	20.1	-0.6	9.92	45	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	8.0
14	18.6	20.0	-1.4	9.88	32	25	0	1	0	0	1	2	23	8.0	25	0	0	0	0	0	0	25	0.0
15	18.6	21.0	-2.4	9.88	45	25	1	1	0	0	0	2	24	7.7	.	.	.	.	.	.	.	.	0.0
16	19.0	21.0	-2.0	9.88	45	24	1	1	0	0	0	2	23	8.0	.	.	.	.	.	.	.	.	0.0
17	19.0	21.0	-2.0	9.88	45	24	1	1	0	0	0	2	23	8.0	.	.	.	.	.	.	.	.	0.0
18	19.0	21.0	-2.0	9.88	45	23	3	0	0	0	0	3	23	11.5	.	.	.	.	.	.	.	.	0.0
19	21.8	23.0	-1.2	11.89	45	28	0	0	0	1	1	2	26	7.1	24	0	1	2	0	2	5	19	20.8
20	21.8	23.0	-1.2	11.89	45	22	0	18	2	1	0	21	1	95.5	.	.	.	.	.	.	.	.	20.8
21	21.8	23.0	-1.2	11.89	45	24	0	0	9	0	0	9	15	37.5	.	.	.	.	.	.	.	.	20.8
22	21.8	22.0	-0.2	11.89	45	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	20.8
31	20.1	19.5	0.6	13.77	32	24	1	0	1	0	0	2	23	8.0	25	1	0	1	0	0	2	24	7.7
32	20.1	20.2	-0.1	13.77	32	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	7.7
33	20.1	20.2	-0.1	13.77	32	24	1	1	0	0	0	2	23	8.0	.	.	.	.	.	.	.	.	7.7
34	20.1	20.2	-0.1	13.77	32	24	2	0	1	0	1	4	22	15.4	.	.	.	.	.	.	.	.	7.7
35	20.1	21.8	-1.7	13.77	45	23	1	0	0	1	0	2	21	8.7	.	.	.	.	.	.	.	.	7.7
36	20.1	21.8	-1.7	13.77	45	25	2	1	2	0	0	5	21	19.2	.	.	.	.	.	.	.	.	7.7
37	20.1	21.8	-1.7	13.77	45	24	1	0	2	0	0	3	21	12.5	.	.	.	.	.	.	.	.	7.7
38	20.1	21.8	-1.7	13.77	45	25	0	0	1	1	1	3	22	12.0	.	.	.	.	.	.	.	.	7.7
39	20.5	20.0	0.5	13.31	32	24	0	1	0	0	0	1	23	4.2	25	0	0	1	0	1	2	23	8.0
40	20.5	20.0	0.5	13.31	32	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	8.0
41	20.5	20.2	0.3	13.31	32	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	8.0
42	20.5	20.2	0.3	13.31	32	25	0	1	3	0	0	4	21	16.0	.	.	.	.	.	.	.	.	8.0
43	20.5	20.3	0.2	13.31	45	25	0	2	0	0	6	8	17	32.0	.	.	.	.	.	.	.	.	8.0
44	20.5	20.3	0.2	13.31	45	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	8.0
45	20.5	20.3	0.2	13.31	45	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	8.0
46	20.5	20.3	0.2	13.31	45	26	0	0	0	0	1	1	25	3.8	.	.	.	.	.	.	.	.	8.0
47	20.5	19.0	1.5	16.32	45	27	0	7	0	0	0	7	20	25.9	21	4	5	0	0	0	9	16	36.0
48	20.5	19.2	1.3	16.32	45	24	0	17	1	0	0	18	6	75.0	.	.	.	.	.	.	.	.	36.0
49	20.5	19.2	1.3	16.32	45	26	0	2	0	0	1	3	23	11.5	.	.	.	.	.	.	.	.	36.0
50	20.5	19.2	1.3	16.32	45	25	0	0	0	0	1	1	24	4.0	.	.	.	.	.	.	.	.	36.0
51	20.5	19.5	1.0	16.32	32	24	0	0	0	0	0	0	24	0.0	.	.	.	.	.	.	.	.	36.0
52	20.5	20.0	0.5	16.32	32	27	0	17	2	0	0	19	8	70.4	.	.	.	.	.	.	.	.	36.0
53	20.5	20.0	0.5	16.32	32	25	0	14	1	0	1	16	9	64.0	.	.	.	.	.	.	.	.	36.0
54	20.5	20.0	0.5	16.32	32	25	1	7	0	0	0	8	18	30.8	.	.	.	.	.	.	.	.	36.0
55	20.3	20.0	0.3	18.02	32	25	1	0	0	0	0	1	25	3.8	24	1	0	0	0	5	6	19	24.0
56	20.3	20.0	0.3	18.02	32	22	3	1	0	0	1	5	20	20.0	.	.	.	.	.	.	.	.	24.0
57	20.3	20.0	0.3	18.02	32	24	1	0	0	0	0	1	24	4.0	.	.	.	.	.	.	.	.	24.0
58	20.3	20.0	0.3	18.02	32	24	2	0	0	0	0	2	24	7.7	.	.	.	.	.	.	.	.	24.0
59	20.3	21.2	-0.9	18.02	45	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	24.0
60	20.3	21.2	-0.9	18.02	45	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	24.0
61	20.3	21.2	-0.9	18.02	45	24	1	0	1	1	1	4	21	16.0	.	.	.	.	.	.	.	.	24.0
62	20.3	21.2	-0.9	18.02	45	24	1	0	0	1	2	4	21	16.0	.	.	.	.	.	.	.	.	24.0
63	20.5	21.8	-1.3	21.45	32	22	3	0	0	0	0	3	22	12.0	25	0	0	0	0	0	0	25	0.0
64	20.5	21.8	-1.3	21.45	32	25	0	0	1	0	0	1	24	4.0	.	.	.	.	.	.	.	.	0.0
65	20.5	21.8	-1.3	21.45	32	24	1	0	0	0	0	1	24	4.0	.	.	.	.	.	.	.	.	0.0
66	20.5	21.8	-1.3	21.45	32	24	1	0	0	0	2	3	22	12.0	.	.	.	.	.	.	.	.	0.0

TABLE F-1

JET PUMP STUDY
1979 STRIPED BASS DATA

						TEST									CONTROL								
TEST NO.	TANK TEMP., °C	FLUME TEMP., °C	ΔT, °C	LARVAL LENGTH (mm)	VELOCITY (fps)	TOTAL INITIAL LIVE	TOTAL INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	TEST MORTALITY, %	INITIAL ALIVE	INITIAL DEAD	24-HR. DEAD	48-HR. DEAD	72-HR. DEAD	96-HR. DEAD	TOTAL DEAD	TOTAL LIVE	CONTROL MORTALITY, %
67	20.1	22.8	-2.7	21.45	45	25	0	1	0	0	0	1	24	4.0	.	.	.	.	.	.	.	.	0.0
68	20.1	22.8	-2.7	21.45	45	24	1	0	1	0	0	2	23	8.0	.	.	.	.	.	.	.	.	0.0
69	20.1	22.8	-2.7	21.45	45	24	1	0	0	1	1	3	22	12.0	.	.	.	.	.	.	.	.	0.0
70	20.1	22.8	-2.7	21.45	45	25	0	0	1	0	0	1	24	4.0	.	.	.	.	.	.	.	.	0.0
71	20.0	19.5	0.5	22.90	32	25	0	0	1	0	0	1	24	4.0	26	0	0	0	0	0	0	26	0.0
72	20.0	19.5	0.5	22.90	32	25	0	0	0	0	1	1	24	4.0	.	.	.	.	.	.	.	.	0.0
73	20.0	19.5	0.5	22.90	32	25	0	0	2	0	2	4	21	16.0	.	.	.	.	.	.	.	.	0.0
74	20.0	19.5	0.5	22.90	32	25	0	0	1	0	1	2	23	8.0	.	.	.	.	.	.	.	.	0.0
75	20.0	19.5	0.5	22.90	45	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	0.0
76	20.0	19.5	0.5	22.90	45	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	0.0
77	20.0	19.5	0.5	22.90	45	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	0.0
78	20.0	19.5	0.5	22.90	45	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	0.0
79	20.4	22.0	-1.6	19.52	45	23	2	0	0	0	0	2	23	8.0	25	0	0	0	1	1	2	23	8.0
80	20.4	22.0	-1.6	19.52	45	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	8.0
81	20.4	22.1	-1.7	19.52	45	23	2	0	0	1	0	3	22	12.0	.	.	.	.	.	.	.	.	8.0
82	20.4	22.1	-1.7	19.52	45	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	8.0
83	20.4	23.0	-2.6	19.52	32	25	0	1	0	0	1	2	23	8.0	.	.	.	.	.	.	.	.	8.0
84	20.4	23.0	-2.6	19.52	32	23	2	0	0	0	0	2	23	8.0	.	.	.	.	.	.	.	.	8.0
85	20.4	23.0	-2.6	19.52	32	25	0	1	0	1	0	2	23	8.0	.	.	.	.	.	.	.	.	8.0
86	20.4	23.0	-2.6	19.52	32	23	2	0	0	0	0	2	23	8.0	.	.	.	.	.	.	.	.	8.0
87	21.0	21.9	-0.9	22.79	45	25	0	0	0	0	0	0	25	0.0	27	0	0	0	0	1	1	26	3.7
88	21.0	21.9	-0.9	22.79	45	25	0	0	0	0	4	4	21	16.0	.	.	.	.	.	.	.	.	3.7
89	21.0	21.9	-0.9	22.79	45	25	0	0	0	1	1	2	23	8.0	.	.	.	.	.	.	.	.	3.7
90	21.0	21.9	-0.9	22.79	45	25	0	0	0	2	1	3	22	12.0	.	.	.	.	.	.	.	.	3.7
91	21.0	21.9	-0.9	22.79	32	26	0	1	0	1	0	2	24	7.7	.	.	.	.	.	.	.	.	3.7
92	21.0	21.9	-0.9	22.79	32	25	0	0	0	0	1	1	24	4.0	.	.	.	.	.	.	.	.	3.7
93	21.0	21.9	-0.9	22.79	32	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	3.7
94	21.0	21.9	-0.9	22.79	32	25	0	0	0	0	3	3	22	12.0	.	.	.	.	.	.	.	.	3.7
95	22.0	22.0	0.0	20.86	45	25	0	0	0	0	1	1	24	4.0	25	0	0	0	0	0	0	25	0.0
96	22.0	22.0	0.0	20.86	45	25	0	1	0	0	0	1	24	4.0	.	.	.	.	.	.	.	.	0.0
97	22.0	22.0	0.0	20.86	45	25	0	0	2	0	0	2	23	8.0	.	.	.	.	.	.	.	.	0.0
98	22.0	22.0	0.0	20.86	45	25	0	1	0	0	0	1	24	4.0	.	.	.	.	.	.	.	.	0.0
99	22.0	23.0	-1.0	20.86	32	24	1	0	0	0	1	2	23	8.0	.	.	.	.	.	.	.	.	0.0
100	22.0	23.0	-1.0	20.86	32	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	0.0
101	22.0	23.0	-1.0	20.86	32	25	0	0	0	0	1	1	24	4.0	.	.	.	.	.	.	.	.	0.0
102	22.0	23.0	-1.0	20.86	32	25	0	0	1	0	0	1	24	4.0	.	.	.	.	.	.	.	.	0.0
103	22.1	24.0	-1.9	22.74	45	25	0	0	0	0	0	0	25	0.0	25	0	0	0	0	1	1	24	4.0
104	22.1	24.0	-1.9	22.74	45	25	0	0	0	0	1	1	24	4.0	.	.	.	.	.	.	.	.	4.0
105	22.1	24.0	-1.9	22.74	45	24	1	0	0	0	0	1	24	4.0	.	.	.	.	.	.	.	.	4.0
106	22.1	24.0	-1.9	22.74	45	25	0	0	2	0	1	3	22	12.0	.	.	.	.	.	.	.	.	4.0
107	22.5	25.0	-2.5	22.74	32	25	0	1	0	0	0	1	24	4.0	.	.	.	.	.	.	.	.	4.0
108	22.5	25.0	-2.5	22.74	32	25	0	0	0	0	1	1	24	8.0	.	.	.	.	.	.	.	.	4.0
109	22.5	25.0	-2.5	22.74	32	25	0	2	2	0	0	4	21	16.0	.	.	.	.	.	.	.	.	4.0
110	22.5	25.0	-2.5	22.74	32	25	0	0	0	0	1	1	24	4.0	.	.	.	.	.	.	.	.	4.0
111	20.5	24.5	-4.0	24.89	32	25	0	0	0	0	0	0	25	0.0	25	0	0	0	0	0	0	25	0.0
112	20.5	24.5	-4.0	24.89	32	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	0.0
113	20.5	24.5	-4.0	24.89	32	25	0	0	0	0	1	1	24	4.0	.	.	.	.	.	.	.	.	0.0
114	20.5	24.5	-4.0	24.89	32	23	2	1	0	0	0	3	22	12.0	.	.	.	.	.	.	.	.	0.0
115	21.0	24.8	-3.8	24.89	45	23	2	0	0	0	1	3	22	12.0	25	0	1	0	0	3	4	21	16.0
116	21.0	24.8	-3.8	24.89	45	25	0	0	0	0	1	1	24	4.0	.	.	.	.	.	.	.	.	16.0
117	21.0	24.5	-3.5	24.89	45	23	2	0	0	0	2	4	21	16.0	.	.	.	.	.	.	.	.	16.0
118	21.0	24.5	-3.5	24.89	45	25	0	0	0	0	2	2	23	8.0	.	.	.	.	.	.	.	.	16.0
119	22.9	25.2	-2.3	27.60	32	25	0	0	0	0	1	1	24	4.0	25	0	0	1	0	0	1	24	4.0
120	22.9	25.2	-2.3	27.60	32	25	0	0	0	0	0	0	25	0.0	.	.	.	.	.	.	.	.	4.0
121	22.9	25.2	-2.3	27.60	32	25	0	1	0	0	1	2	23	8.0	.	.	.	.	.	.	.	.	4.0
122	21.5	26.0	-4.5	27.60	45	25	0	1	0	0	2	3	22	12.0	.	.	.	.	.	.	.	.	4.0

TABLE F-1

JET PUMP STUDY
1979 STRIPED BASS DATA

TEST NO.	TANK TEMP., °C	FLUME TEMP., °C	ΔT, °C	LARVAL LENGTH (mm)	VELOCITY (fps)	TEST: TOTAL INITIAL LIVE	TEST: TOTAL INITIAL DEAD	TEST: 24-HR. DEAD	TEST: 48-HR. DEAD	TEST: 72-HR. DEAD	TEST: 96-HR. DEAD	TEST: TOTAL DEAD	TEST: TOTAL LIVE	TEST: TEST MORTALITY, %	CONTROL: INITIAL ALIVE	CONTROL: INITIAL DEAD	CONTROL: 24-HR. DEAD	CONTROL: 48-HR. DEAD	CONTROL: 72-HR. DEAD	CONTROL: 96-HR. DEAD	CONTROL: TOTAL DEAD	CONTROL: TOTAL LIVE	CONTROL: CONTROL MORTALITY, %
123	21.5	26.0	-4.5	27.60	45	25	0	0	1	0	2	3	22	12	.	.	.	.	.	.	.	.	4
124	21.5	26.0	-4.5	27.60	45	25	0	0	0	0	0	0	25	0	.	.	.	.	.	.	.	.	4
125	23.0	24.0	-1.0	31.73	45	25	0	1	0	0	0	1	24	4	25	0	0	0	0	0	0	25	0
126	23.0	24.0	-1.0	31.73	45	25	0	0	0	0	2	2	23	8	.	.	.	.	.	.	.	.	0
127	23.0	24.0	-1.0	31.73	45	24	1	0	0	0	0	1	24	4	.	.	.	.	.	.	.	.	0
128	23.0	24.2	-1.2	31.73	32	24	1	0	0	0	0	1	24	4	25	0	0	0	1	0	1	24	4
129	23.0	24.2	-1.2	31.73	32	25	0	0	0	0	0	0	25	0	.	.	.	.	.	.	.	.	4
130	23.0	24.2	-1.2	31.73	32	25	0	0	0	0	1	1	24	4	.	.	.	.	.	.	.	.	4
131	24.0	24.7	-0.7	35.51	32	25	0	0	0	0	0	0	25	0	25	0	0	0	0	0	0	25	0
132	24.0	24.7	-0.7	35.51	32	25	0	0	0	0	0	0	25	0	25	0	0	0	0	0	0	25	0
133	24.0	24.7	-0.7	35.51	32	25	0	0	0	0	0	0	25	0	25	0	0	0	0	0	0	25	0
134	24.2	24.9	-0.7	35.51	45	25	0	0	0	1	0	1	24	4	25	0	0	0	0	0	0	25	0
135	24.2	24.9	-0.7	35.51	45	25	0	0	0	0	0	0	25	0	25	0	0	0	0	0	0	25	0
136	24.2	24.9	-0.7	35.51	45	24	1	0	1	0	1	3	22	12	25	0	0	0	0	0	0	25	0