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HYDROACOUSTIC EVALUATION OF HAMMER EFFECTIVENESS AT INDIAN POINT UNIT 3

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by:

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Prepared Under Contract With:

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Central Hudson Gas and Electric Corporation
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1.0 INTRODUCTION

The New York Power Authority (NYPA) is evaluating the use of underwater steel drums, or "hammers," as a means of deterring fish from entering cooling water intakes at the Indian Point Nuclear Power Plants on the Hudson River near Peekskill, NY. The hammers were supplied through contract by Ontario Hydro Inc., Toronto, ON.

In 1985 and again in 1988, BioSonics, Inc. was contracted to study fish behavior in response to underwater sound sources near Indian Point Power Plants. The 1985 feasibility study was a contract with Consolidated Edison Co. of New York, to evaluate the effectiveness of underwater compressed-air "poppers" in keeping fish away from Unit 2, Intake 26. The 1988 feasibility study was contracted to BioSonics, Inc. by New York Power Authority. The primary objective was to determine the effectiveness of hammers as a means of deterring fish from approaching Intakes 34, 35 and 36 at Unit 3. Hydroacoustics were selected as a tool for monitoring fish behavior and patterns of movement near the intakes.

BioSonics employed fixed-location hydroacoustic techniques for both the 1985 and 1988 studies. Fixed-location hydroacoustic techniques are especially well-suited to investigations of this type because they can obtain meaningful information on behavioral activity, particularly short term changes in both activity and distribution. Additionally, by monitoring 24 hours/day, hydroacoustics could provide fish presence/absence and abundance information, which was critical for determining the timing of hammer tests.

Initial equipment installation took place from January 9 to January 22, 1988. Deployment configurations were changed several times during the study, however, in efforts to provide optimal behavioral data for this feasibility study. Hydroacoustic data collection occurred continuously from January 16 to February 22, 1988. Additional blocks of data were collected between February 23 and March 4, 1988.

2.0 METHODS

2.1 Instrumentation

Two types of hydroacoustic data collection systems were used at Indian Point Power Plant Unit 3 in 1988. The primary type was a single-beam system (Figure 1), operated 24 hours/day. Data from the single-beam system were used to evaluate fish behavior during hammer tests and to estimate fish abundance at the test site 24 hours/day. The single-beam system uses transducers which transmit and receive on the same electronic element. The detected fish data are recorded on paper charts or "echograms." In the echo counting technique which can be used with single-beam systems, echograms provide the basis for data interpretation, behavioral observations, and abundance estimates.

The secondary data collection technique used a dual-beam hydroacoustic system to estimate fish sizes or "target strengths" at the study site. In this system, a dual-beam echo sounder transmits on the narrow-beam element of a dual-beam transducer, and receives echoes on both the narrow- and wide-beams of the transducer. The difference between the return voltages on the narrow and wide elements provides information which can be used to calculate target strengths.

Equipment used for this study included a dual-beam echo sounder (also used as a single-beam sounder), two chart recorders, a multiplexer/equalizer, an oscilloscope, and seven transducers. Four single-beam transducers and one dual-beam transducer were deployed. Single-beam transducers included three with circular cross sections, and one with an elliptical cross section. Two of the circular-beam transducers had beam angles of 15°, and the other had a 6° beam angle. The 6° X 12° elliptical-beam transducer had a 12° beam angle on the *x* axis and a 6-degree beam angle on the *y* axis. The narrow and wide beam angles of the dual-beam transducer were 6° and 15°, respectively. With a wide variety of beam angles, it was possible to sample in confined areas while maximizing sampling volume at areas of interest. The elliptical-beam transducer allowed horizontal sampling 40 meters out into the river.

One of the 15° circular-beam transducers was principal in data collection during this study. It was rigidly mounted about 0.5 m below mean low water level (MLW), at the bottom of a relatively short, 25 ft vertical aluminum pole which was positioned immediately in front of the trashrack in a 40-cm slot at Intake 35 (Figure 2). The transducer was aimed obliquely down and out into the river, with the axis of the beam about 35° from vertical.

This transducer monitored fish close to the intake, providing data on fish movement, vertical distribution and abundance.

Another 15° circular-beam transducer was mounted at the same depth on a longer 30 ft aluminum pole, with an oblique aiming angle of 30° rather than 35°. The 6° X 12° elliptical-beam and 6° circular-beam transducers were suspended in mid-water from the long pole mount (Figures 2 and 3). Both transducers were aimed horizontally into the river. The 6° circular-beam transducer was attached to a rotator, which allowed adjustments of aiming angle in the horizontal plane while the transducer was deployed. To minimize interference from the river bottom and water surface, the elliptical transducer was orientated with the narrow (6°) axis in the vertical plane, and the wide (12°) axis in the horizontal plane. The primary purposes of these transducers were to monitor for any patterns in fish abundance with respect to distance from the intake, and to collect directional movement data in the inshore-offshore dimension.

Another mount configuration using the dual-beam transducer and the 6° X 12° elliptical-beam transducer is illustrated in Figure 4. This configuration was employed toward the end of the study period, after 24-hour/day monitoring had ended. To be able to compare target-strength data with length frequency tables, a dorsal aspect view of the target fish is required. The dual-beam transducer was mounted at the catwalk 0.5 m below MLW, and aimed vertically down in front of Intake 35. This transducer was later relocated in front of Intake 36 with a similar orientation. Hammer tests were conducted during target-strength data collection.

The 6° X 12° elliptical-beam transducer was mounted near the intake floor and aimed horizontally into the river in front of Intake 36 with a range of 40 m (Figure 4). Bottom interference was minimized by orientating the narrow axis of the transducer in the vertical plane and the wide axis in the horizontal plane. This transducer's purpose was to observe inshore and offshore fish movement near the river bottom.

All single- and dual-beam transducer mount configurations were evaluated during and after the study. Data from four of these configurations were selected for analysis to address the study objectives. Criteria used for selecting transducer mount configurations and data for analysis are discussed in Sections 2.2 and 2.3, respectively.

2.2 Data Collection

With the exception of several brief interruptions for maintenance or transducer redeployment, data were collected continuously from January 16, 0000 h to February 22, 1600 h. Most of these data were collected using two transducers: the 15°, obliquely aimed circular-beam transducer mounted on the short pole; and the 6° X 12°, horizontally aimed elliptical-beam transducer. Because of excessive noise and solid target interference, the 15°, obliquely aimed transducer mounted on the long pole was rarely sampled. Also, minimal data were collected using the 6°, circular-beam horizontal transducer with rotator because of limited sample volume and ambiguous data interpretation. Additional blocks of data were collected using the dual-beam transducer and the bottom-mounted 6° X 12° transducer from February 23 to March 4.

During continuous data collection, technicians monitored chart recorders for real-time fish abundance information. When fish abundance reached an approximate threshold level of 45-60 raw[1] fish detections in 15 consecutive minutes, hammer tests were initiated. This level of fish abundance was regarded as sufficient for evaluating fish avoidance response to the hammers.

Generally, a testing period began with a control period lasting 10-15 minutes, followed by a hammer test lasting several minutes, then another control period, another hammer test, and so on. The hammer tests continued as long as fish abundance was sufficient to warrant testing. Hammer testing periods lasted from about 20 minutes to several hours.

During the individual hammer tests within a testing period, the frequency of hammer firing was varied. For example, hammers were sometimes turned on and off in 1-minute intervals, or they may have been turned on for 10 seconds, and off for 20 seconds. The patterns of hammer on/off times, referred to as "treatments," were recorded directly on the echograms, and in a logbook.

Preliminary observations were made from the echograms during and after data collection. These observations allowed evaluation of various transducer deployments, and provided information for the selection of subsets for further data analysis.

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[1] "Raw" fish detections are those that appear on the echograms and oscilloscope. They have not yet been adjusted or "weighted" for transducer beam spread according to the fish's distance from the transducer.

2.3 Data Analysis

Several periods of hammer test data were selected for analysis. The criteria for this selection included: high or moderate fish densities; continuous data collection throughout the hammer test period; and periods when hammer treatments were long enough to allow at least 2 consecutive beats of one hammer while hammers were on.

There were two periods when very high fish densities occurred: the night of January 26-27 from 2100 h to 0000 h; and the night of January 13 from 2000 h to 2300 h. Both these periods were included in the hammer test analysis. Moderate and consistent fish densities occurred during hammer testing on these dates: February 4 from 0100 h to 0400 h; February 18 from 0100 h to 2300 h; February 19 from 0000 to 1400 h; and February 20 from 0000 h to 2200 h. These periods were also selected for hammer test data analysis.

For all the hammer tests listed above, data were collected using the 15° circular-beam transducer aimed obliquely from the short pole, and the mid-water 6° X 12° elliptical-beam transducer aimed horizontally out into the river.

Additional hammer test data from periods of moderate fish density were selected for analysis. These data were collected using the surface-mounted 6° element of the dual-beam transducer aimed vertically downward and the bottom-mounted 6° X 12° elliptical transducer aimed horizontally out across the bottom. These data analysis periods included: February 23 from 1800 h to 2000 h, February 24 from 1300 h to 2200 h; February 25 from 0900 h to 2000 h; February 26 from 0800 h to 2300 h; February 27 from 0000 h to 1800 h; March 3 from 0300 h to 1800 h; and March 4 from 0300 h to 0500 h.

As mentioned above in Section 2.1, data were recorded by a chart recorder on echograms. Traces on the echogram were visually interpreted for fish, and the traces grouped into four categories corresponding to distinct fish behaviors, illustrated in Figure 5. The trace type categories were defined as follows:

LS: Long-to-Short range movement; a fish moving generally toward the transducer.

SL: Short-to-Long range movement; a fish moving generally away from the transducer.

NC: No Change in range; a fish moving across the transducer beam perpendicular to its axis, moving neither toward nor away from the transducer.

WW: Wallower; a relatively stationary fish spending many seconds in the beam without distinct directional movement. This often indicates a resident fish which is not migrating through the study area.

The behavioral meaning of the trace depends on the specific deployment of the transducer. For example, with the mid-water 6° X 12° elliptical-beam transducer aimed horizontally into the river, LS traces describe fish moving inshore (toward the intake), while SL traces are fish moving offshore. NC traces indicate movement in upstream or downstream directions, across the transducer beam. When the 15° circular-beam transducer aimed obliquely down into the intake was sampled, virtually all traces were LS. This could indicate two types of movement; either inshore (toward the intake) or vertically upward.

The interpretation of fish traces from the surface-mounted 6° element of the dual-beam transducer aimed vertically downward is different than that for the two transducers described above. At this transducer, which sampled immediately in front of the intake, LS traces indicated movement toward the surface, while SL traces would indicate fish moving toward the bottom. Traces with no change-in-range (NC) indicated no vertical movement, but could be moving horizontally in any direction.

To account for the spreading sampling volume at increasing ranges from the transducer, fish numbers were weighted according to distance (range) from the transducer. A transducer's maximum range was divided into range bins or strata, with numbers and sizes of strata specific to each transducer. For the 15° obliquely aimed transducer, there were four strata of 2 m each; for the 6° X 12° elliptical-beam horizontal transducer, there were five to eight strata of 5 m each; and for the surface-mounted 6° circular-beam transducer aimed vertically downward, there were seven strata of 1 m each. The number of raw fish detections within each stratum was multiplied by a constant stratum "weighting factor," unique to that particular stratum. This weighting factor represented the proportion of the width of the intake to the width of the beam at the stratum being analyzed, with stratum width measured at the stratum's midpoint range. Thus, as the sampling volume increased with range from the transducer, the numerator of the weighting factor became larger and the weighting decreased.

Fish detections in the first 1.3 m from the transducer were not processed due to over amplification of detections in this range. Ranges listed in the tables begin from this "blanking" range (1.3 m from the transducers).

To evaluate the effectiveness of the hammers, each hammer test was divided into a "before", "during", and "after" phase. Each test was normally from five to ten minutes in duration. When hammer tests were contiguous, only the during and after phases were analyzed. To evaluate each hammer test a chi-square test was performed. The chi-square distribution is a probability density function in which the null-hypothesis would assume an even distribution throughout a hammer test. That is, in evaluating a relatively short time period consisting of 15–30 minutes, the fish densities would be expected to be evenly distributed between the before, during and after phases of a hammer test if hammer operations had no effect on fish behavior. When there were three phases for a particular hammer test, an expected frequency of 33.33% was assumed for each phase and range bin. When only two phases occurred, a 50.00% expected frequency was assumed.

3.0 RESULTS

During the first part of the study, hammer tests were monitored by only one transducer at a time. The 6° X 12° transducer was selected as the main monitoring transducer to observe inshore movement of fish schools. The 15° circular-beam transducer aimed obliquely downward monitored fish movement close to the intakes.

During the high fish densities observed on the night of January 26-27, a total of seven hammer tests were performed. Six of these tests were monitored by the 6° X 12° horizontally-aimed elliptical-beam transducer, and only one test by the 15° circular-beam transducer aimed obliquely downward (Table 1, Appendices C and D). Echogram traces from the 6° X 12° transducer showed a dense band of fish within the first three range bins (0-15 m, see Figure 6). The trace type analysis (Section 2.3) for the 6° X 12° transducer showed that these fish schools maintained a constant distance approximately 5–15 m from the intake. The 15° transducer, however, showed an overall movement toward the intake (Figure 7). The trace types observed from both monitoring locations failed to show any noticeable effect from hammer operations.

In six of the seven tests, fish densities were significantly different from the expected frequencies, with three of these tests having the highest fish densities in the after phase. These results may have been due to natural fluctuations in fish densities during hammer testing periods rather than any effect by hammer operations. Evaluating the hammer tests by range bins did not show any apparent effect on fish densities with respect to the hammers being on or off (Figures 8-14).

Similar results were observed when high fish densities occurred again on the night of February 13, when a total of ten tests were conducted (Table 2, Appendices C and D). These hammer tests were monitored by both the 15° circular-beam transducer aimed obliquely downward, and by the 6° X 12° elliptical-beam transducer aimed horizontally into the river. For the 15° transducer, five of the ten tests showed fish densities which were significantly different from expected frequencies. Highest fish densities were present in four of the five tests in the "after" phase, and only one in the "during" phase. For the 6° X 12° transducer, five of the ten tests were significant with three of the five tests having the highest densities in the "during" phase, one in the "before" phase, and one in the "after" phase. Again, no apparent effect of hammer operation on fish densities by range bin was observed (Figures 15-34).

Other periods during the season when fish densities were high enough to warrant hammer testing occurred on February 4, 18, 19, and 20 (Tables 3-6, Appendices C and D). These tests were monitored by both the 15° oblique transducer and the 6° X 12° elliptical transducer. A total of 50 hammer tests were conducted during these days.

For the 15° oblique transducer, 23 of the 50 tests showed fish densities which were significantly different from the expected frequencies. The highest densities were present in 17 of the 23 tests in the "during" phase, 5 were highest in the "after" phase, and only 1 showed highest densities in the "before" phase. Eight of the 17 tests in which the highest densities were observed in the "during" phases occurred on February 18.

For the 6° X 12° horizontal transducer, only 7 of the 50 tests showed fish densities which were significantly different from the expected frequencies. Of those seven tests, six showed highest densities in the "during" phase, and only one in the "after" phase.

Directional data (i.e. from the fish trace type analysis) for all 50 tests indicated that inshore movement predominated during all test phases. Of the 50 hammer tests, there were only 5 when the 15° oblique and the 6° X 12° horizontal transducers had significantly different test phase numbers for the same hammer test. It is not surprising that the results from the two transducers would be different for the same test, since they effectively sampled different zones near the intake. The maximum sampling volume of the 15° obliquely-aimed transducer was located at the river bottom, very close to the intake. In contrast, the 6° X 12° elliptical-beam transducer was mounted at mid-water depth and aimed horizontally into the river. Its maximum sampling zone was mid-water, at ranges of up to 40 m from the intake. If the effect of the hammers was only at close range (see Appendix G), it is unlikely that the 6° X 12° elliptical-beam transducer would have been able to monitor this response.

Any observed increase in fish density for the "during" phase of the hammer tests might be explained if there was a response from bottom-oriented fish located directly in front of the intakes. With the 15° oblique transducer aimed 35° off the vertical face of the intake, a 3.5-m area directly in front of the intake was not within the transducer's sampling volume. An increase in fish numbers in the "during" phase of a hammer test would occur if a reaction by bottom-oriented fish resulted in an upward swimming movement. Fish would then enter the beam of the transducer. This type of behavior was observed using a 6° narrow element of a dual-beam transducer aimed vertically downward. This transducer configuration was only in effect during the latter part of the study season, during collection of target strength data at Intakes 35 and 36. See Appendix B for a discussion of target strength analysis and results.

Table 7, Appendix E shows data from the hammer tests at Intake 35, which occurred from February 23 to February 27. These data were collected using the 6° element of the 6° X 15° dual-beam transducer aimed vertically downward in front of Intake 35. A total of 36 hammer tests were conducted. Of these, 21 showed significant differences between test phases, with 16 tests showing the highest fish densities for the "during" phase, 2 were highest in the "after" phase, and 2 highest in the "before" phase. Of the 16 tests with highest densities for the "during" phase, 13 had a significant increase in LS fish traces. At this transducer configuration, a LS trace type would indicate the fish swimming upward toward the surface.

On March 3 and 4, Intake 36 was sampled using the same 6° element of the dual-beam transducer mounted at the surface and aimed vertically downward. The 6° X 12° elliptical-beam transducer was also deployed at Intake 36, mounted near the bottom and aimed horizontally out across the river bottom. These two transducers simultaneously monitored all hammer tests conducted at Intake 36.

On these two days, a total of 23 hammer tests were conducted (Tables 8 and 9, Appendices E and F). For data collected using the 6° vertical transducer, a total of seven tests showed fish densities which were significantly different from expected frequencies. Six of these tests showed an increase in fish density for the "during" phase and one showed an increase in the "before" phase. The 6° X 12° horizontal elliptical-beam transducer showed a total of ten hammer tests with fish densities significantly different from expected. Of the ten tests, nine showed an increase for the "during" phase and one for the "after" phase.

Of the 23 hammer tests conducted on March 3 and 4, there were only 4 tests when the surface-mounted 6° vertical and the bottom-mounted 6° X 12° horizontal transducers showed significantly different fish densities between test phases for the same hammer tests. All four of these tests had higher fish densities in the "during" phase.

Results obtained from the hammer tests conducted on March 3 and 4 show that there may be less of a response to hammer operations at Intake 36 compared to Intake 35. An explanation for this may be that of the three intakes (34, 35, and 36), Intake 36 was furthest upstream and flow rates into this intake appeared to be greater than at Intake 35.

Fish located in front of this intake would be in the faster moving water and may not be able to maintain a stationary position for any long period of time. This behavior was evidenced by a majority of LS traces observed at Intake 36. Hammer operations at this location did not seem to have an effect on fish entrained within this faster flow.

Fish located in front of Intake 35 would be in the quieter water zone and would be able to maintain relatively stationary positions. This is supported by a majority of NC traces observed at this location. When hammers were operating at Intake 35, the observed trace types changed from the noted NC traces to LS traces, indicating an upward movement response to the hammers.

4.0 CONCLUSIONS AND RECOMMENDATIONS

1. The hammers used in this study did not appear to be an effective means of influencing fish movement at distances of 2 m or more from the intakes during heavy and moderate fish densities.

2. Hammer effectiveness may be dependent on intake flow patterns and velocities.

3. Bottom-oriented fish close to the intakes may respond to hammer operation by swimming upward several feet off the bottom.

4. The underwater hammers used in this study were tested in the lab previous to the field season. However, in-season sound spectra testing indicated that the hammers emitted different sound frequencies *in situ* than in the lab. We recommend extensive *in situ* testing of alternative underwater sound sources before selecting equipment for permanent installation at Indian Point Unit 3.

5. Studies of fish abundance and distribution at Indian Point Power Plants must take into consideration the variability of fish densities over 24-h periods and with tidal fluctuations (see Appendix A).

5.0 ACKNOWLEDGMENTS

BioSonics, Inc. would like to thank Dennis Dunning and Quentin Ross of the New York Power Authority for their assistance during the completion of this study. We would also like to thank Paul Geoghegan, Jim Reichle, John Kvartec and technicians Peter Catano, Fred Fields, and Frank Paukner of Normandeau Associates, Inc., without whose hard work and dedication this project would not have been successful. A special thanks to Janusz Burczynski, Gary Johnson, Pat Nealson and Gary Raemhild for assistance during the study and to Ravi Bhatia, Janie Civille and Gabrielle Toutonghi of BioSonics, Inc. for helping in data processing and analysis for this project. We are indebted to Pat Nealson for dual-beam data analysis and for writing Appendix B.

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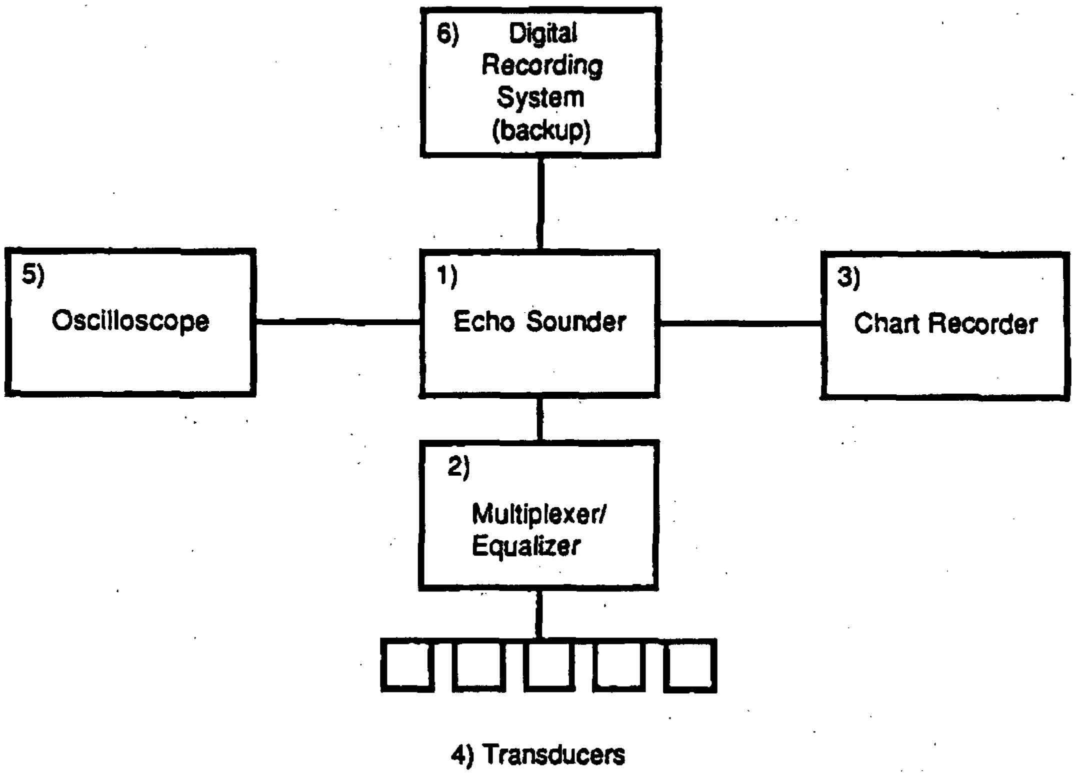


1. BioSonics, Inc. Model 101 Echo Sounder
2. BioSonics, Inc. Model 151 Multiplexer/Equalizer
3. BioSonics, Inc. Model 115 Chart Recorder
4. BioSonics, Inc. 420 kHz transducers
5. Hitachi, Inc. Model V-422 oscilloscope
6. Recording system included:
   Sony Betamax recorder SL-2000
   Sony Digitizer PCM-F1
   BioSonics, Inc. Model 171 Recorder Interface

Figure 1. A block diagram of the data collection system used at Indian Point Power Plant Unit 3, Intakes 35 and 36, from January 16 to March 4, 1988. The specifications of this equipment can be obtained from BioSonics, Inc.

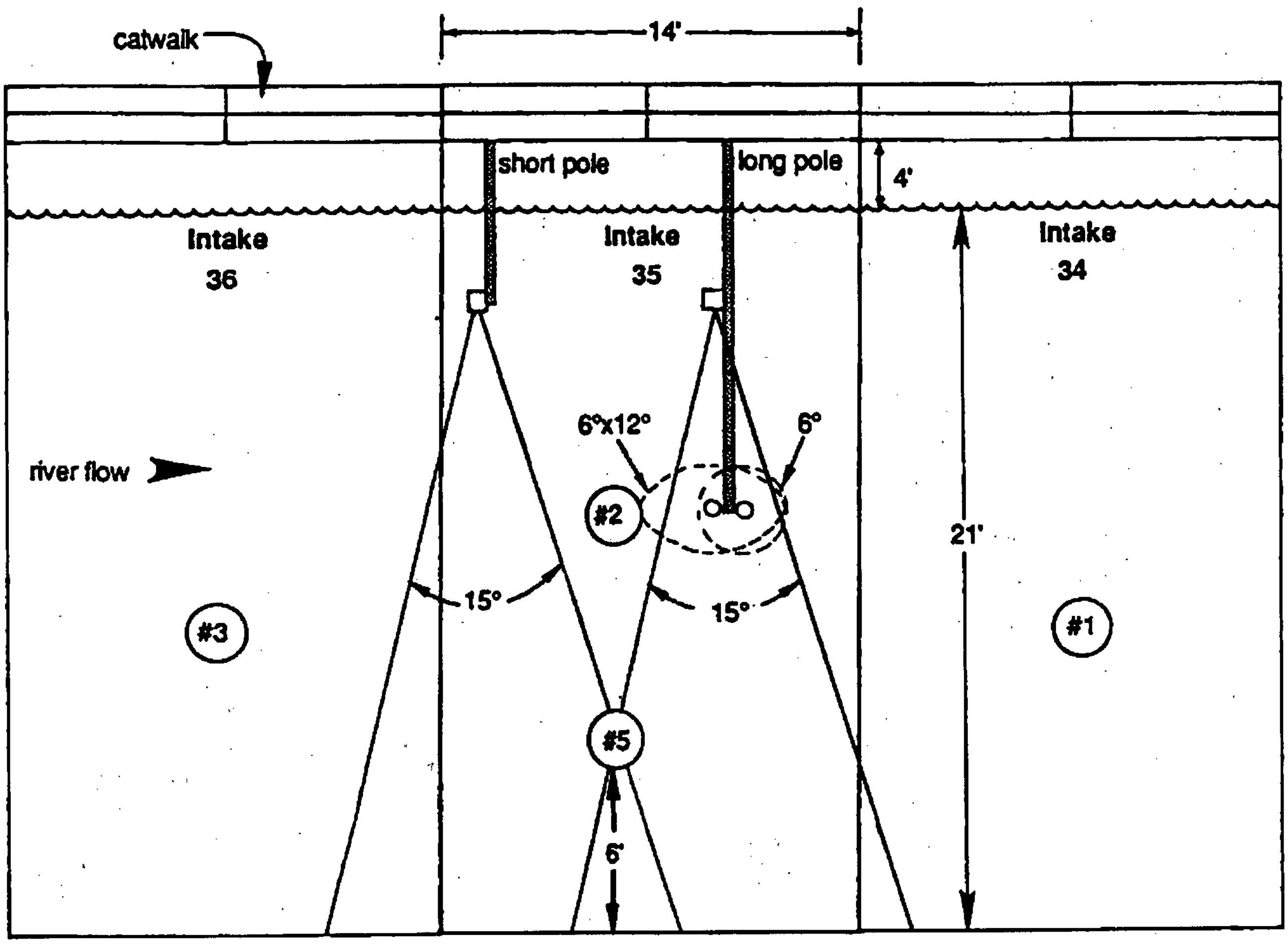


Figure 2. A front view of the short and long pole mounts deployed in front of the trash rack at Unit 3, Intake 35. The solid-line cones are the 15° oblique transducers, the dashed lines indicate the horizontal mid-water 6°x12° elliptical transducer and the 6° transducer with rotator, with the area sampled at a range of 15 m. Small circles indicate approximate location of hammers, for Intakes 34, 35, and 36. Hammer numbers are designated by the respective channel number on the hammer control box.

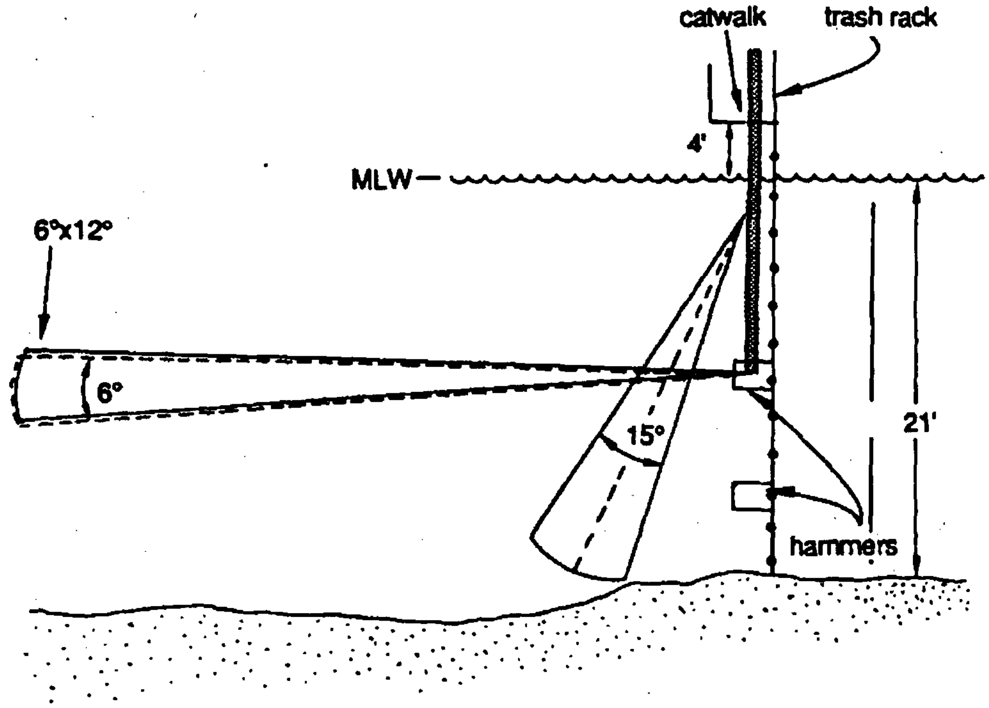


Figure 3. This side-view diagram shows the deployment of the long pole mounted transducers. The cones represent the "acoustic beams" of the transducers. The solid-line cone is the 15° oblique transducer, the dashed lines are the horizontal mid-water 6°x12° elliptical transducer and the 6° transducer connected to a rotator. Squares indicate approximate location of hammers, at -9 ft and -15 ft. MLW.

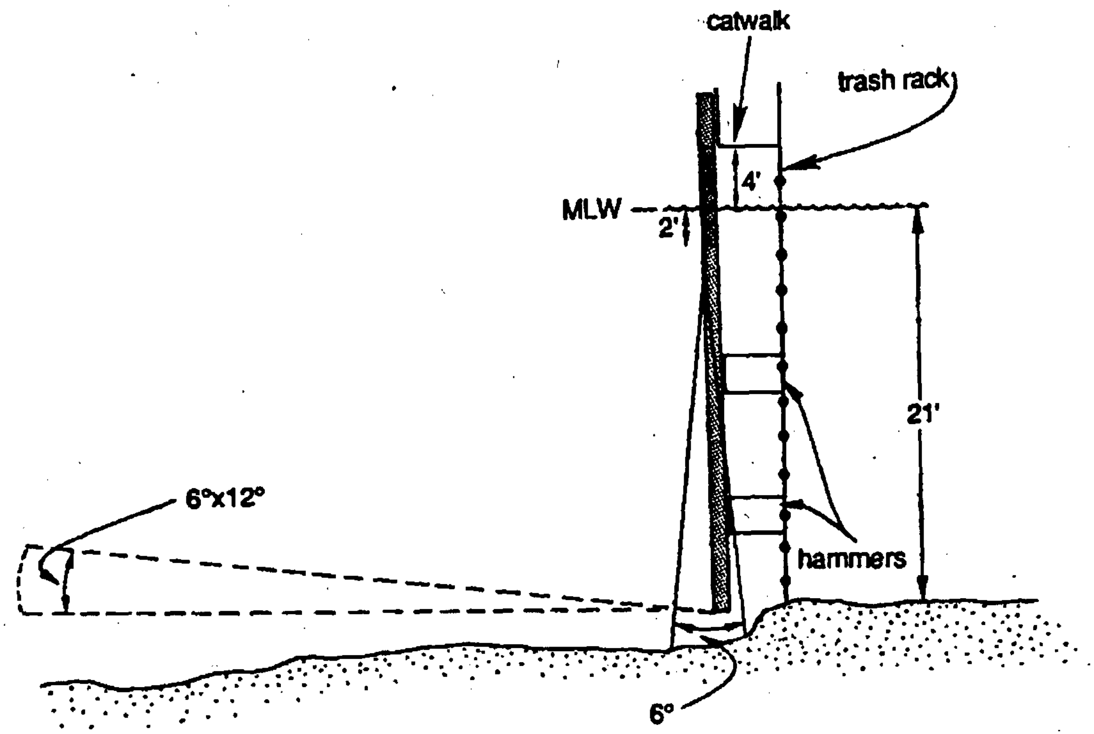


Figure 4. This side-view diagram shows the post-season deployment of the transducers used at Intakes 35 and 36. The solid cone represents the 6° vertical transducer, and the dashed line is the horizontal bottom 6°x12° elliptical transducer. Squares indicate the approximate location of hammers.

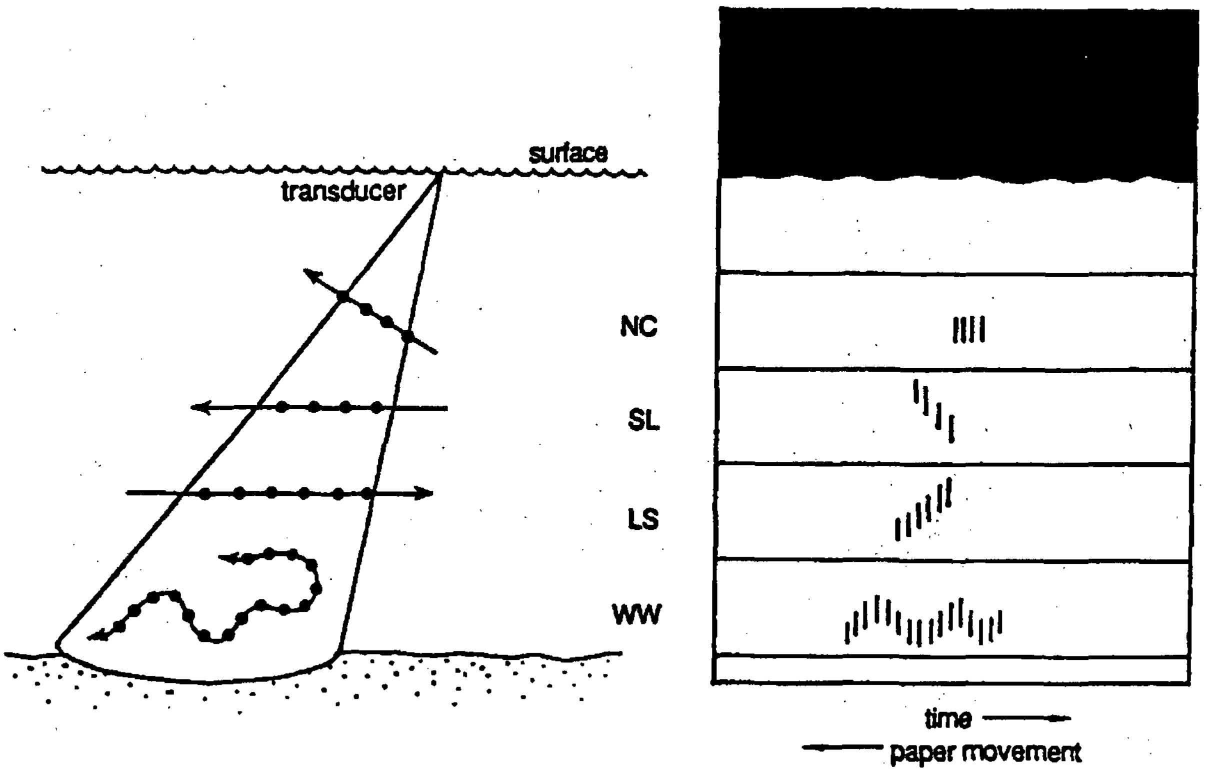


Figure 5. Fish behavior in the acoustic beam of a transducer (left) results in distinct traces on the chart recorder, or echogram (right). The change in range on the echogram traces indicates changing distance of the fish from the transducer. Arrows indicate the path of a fish through the acoustic beam. Dots along the arrows indicate successive ensonifications, or "pings", each leaving a mark on the echogram.

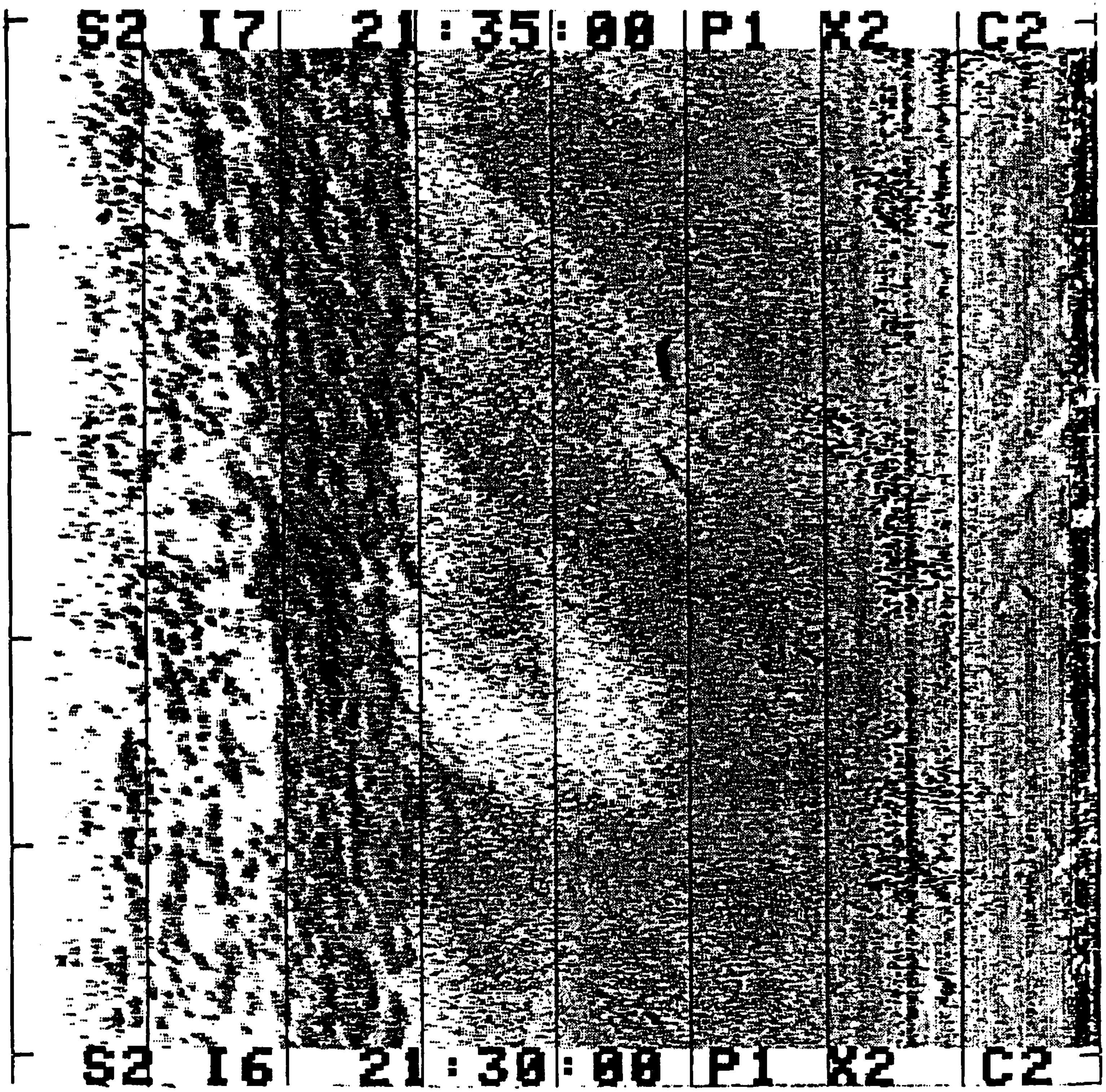


Figure 6a. Photocopy of an echogram showing fish traces during high fish densities sampled with the 6°x12° elliptical horizontal transducer at 2135 h on January 26, 1988. The grid lines are set at 5 m intervals.

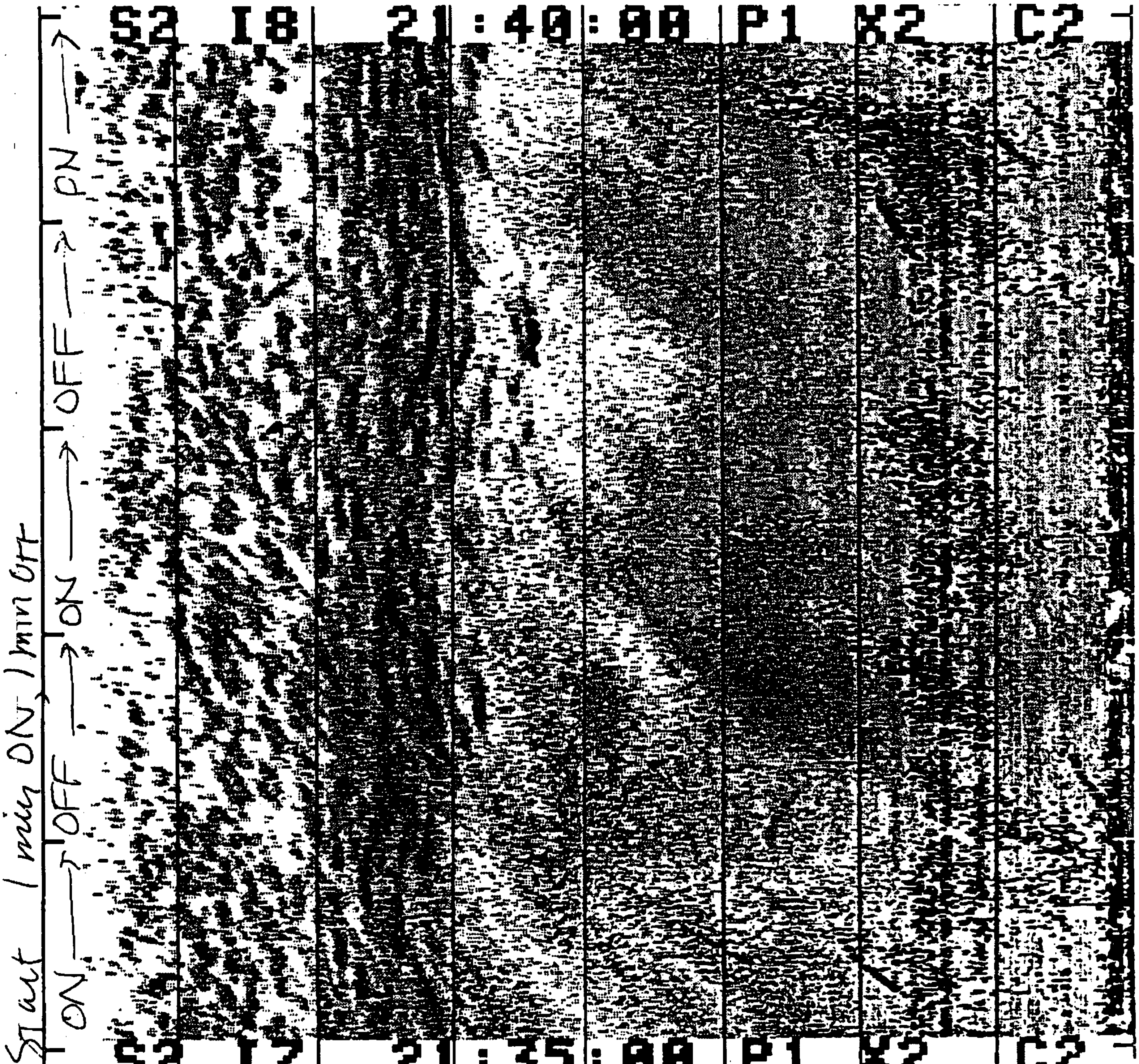


Figure 6b. Photocopy of an echogram showing fish traces during high fish densities sampled with the 6°x12° elliptical horizontal transducer at 2140 h on January 26, 1988. The grid lines are set at 5 m intervals.

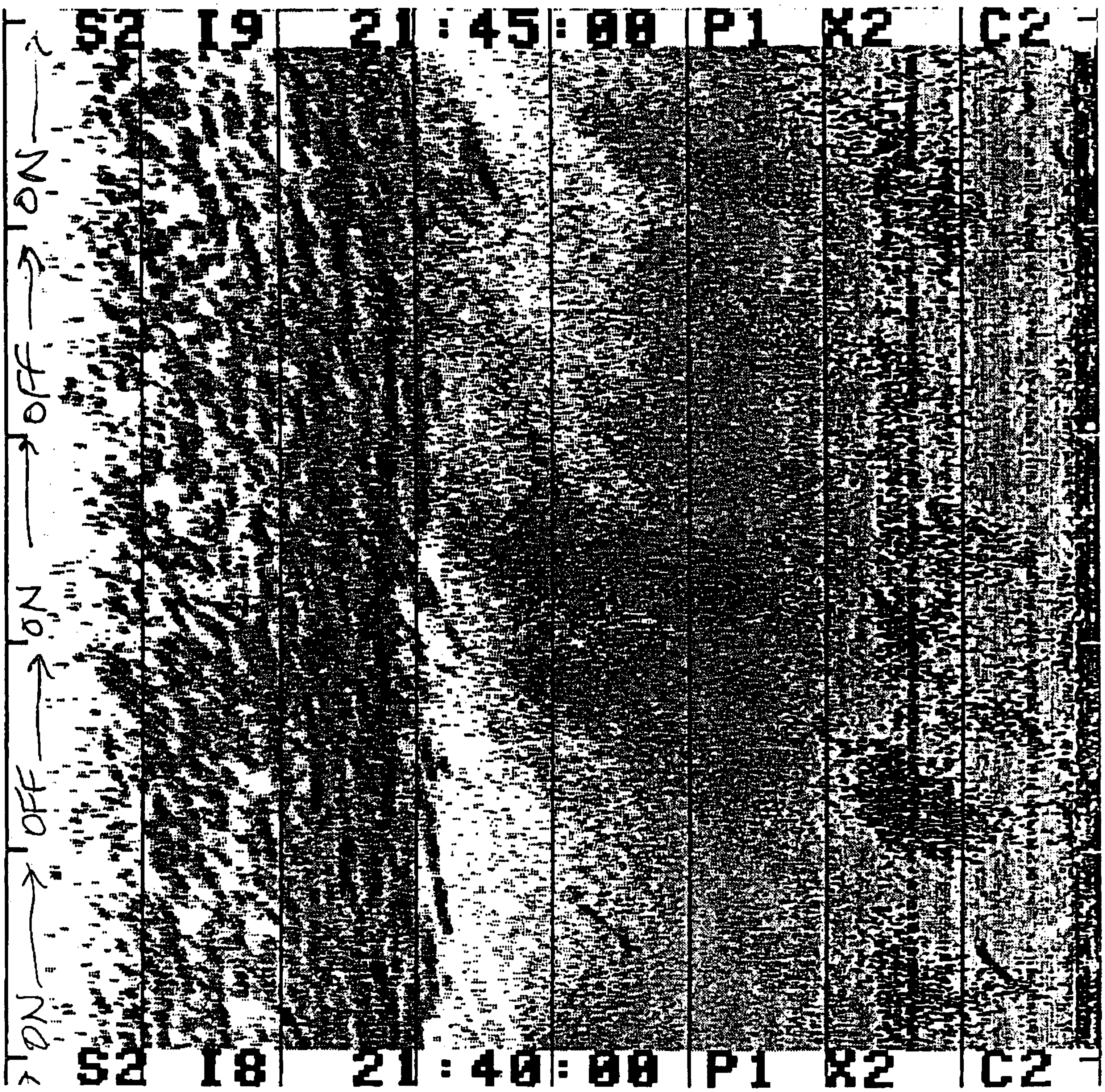


Figure 6c. Photocopy of an echogram showing fish traces during high fish densities sampled with the 6°x12° elliptical horizontal transducer at 2145 h on January 26, 1988. The grid lines are set at 5 m intervals.

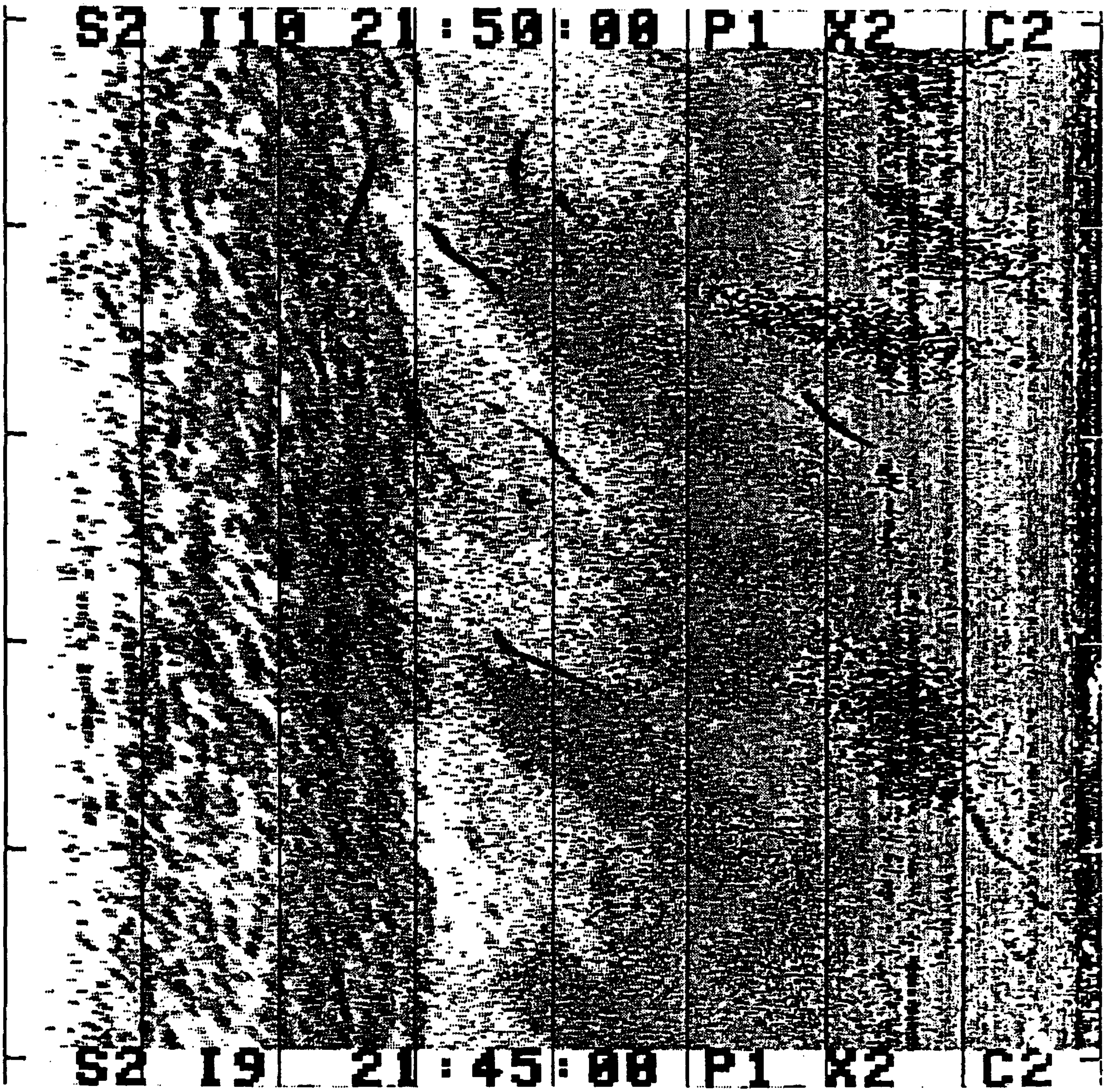


Figure 6d. Photocopy of an echogram showing fish traces during high fish densities sampled with the 6°x12° elliptical horizontal transducer at 2150 h on January 26, 1988. The grid lines are set at 5 m intervals.

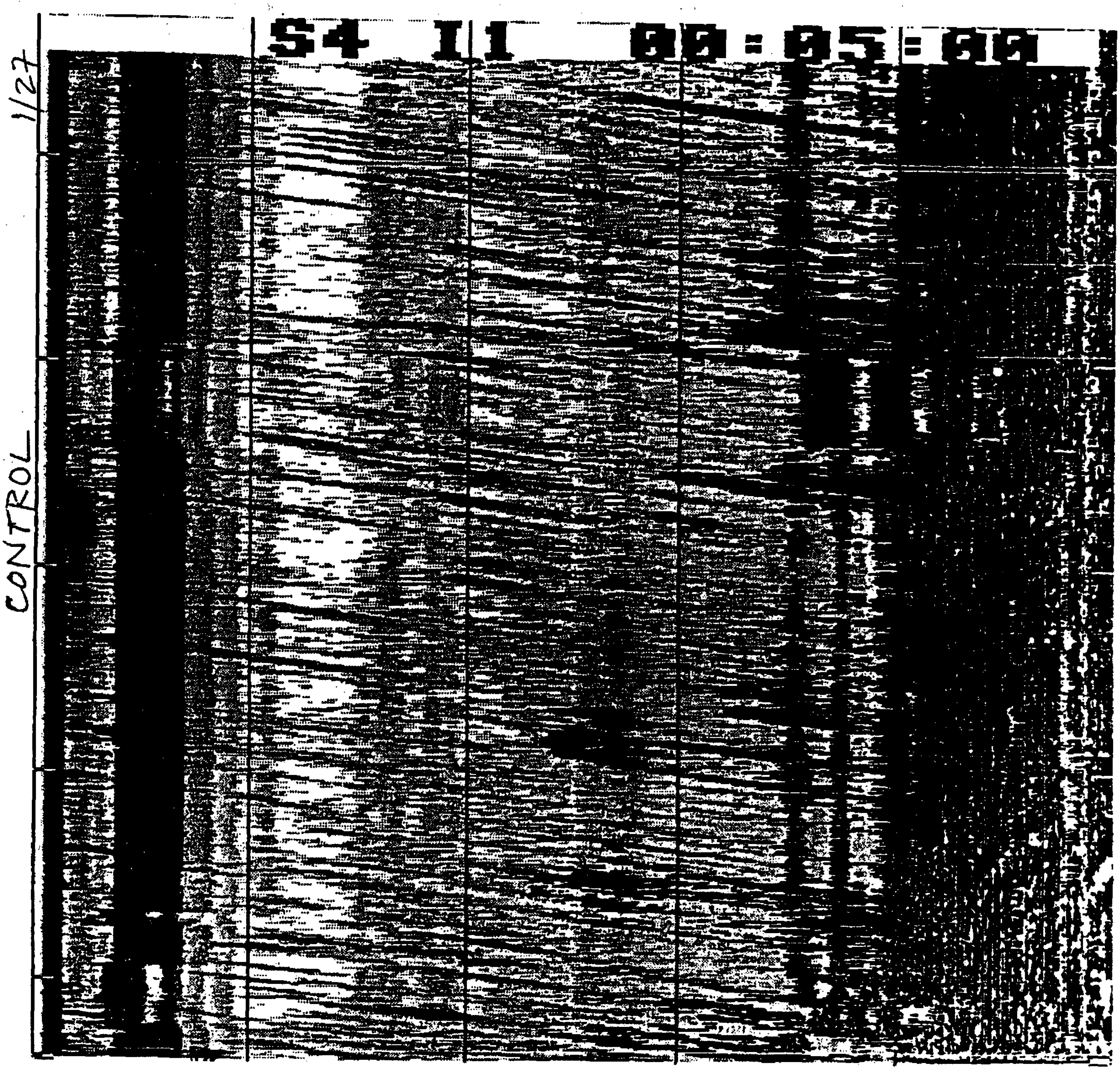


Figure 7a. Photocopy of echogram showing fish traces during high fish densities with the 15° conical oblique transducer at 0005 h on January 27, 1988. The grid lines are set at 2 m intervals.

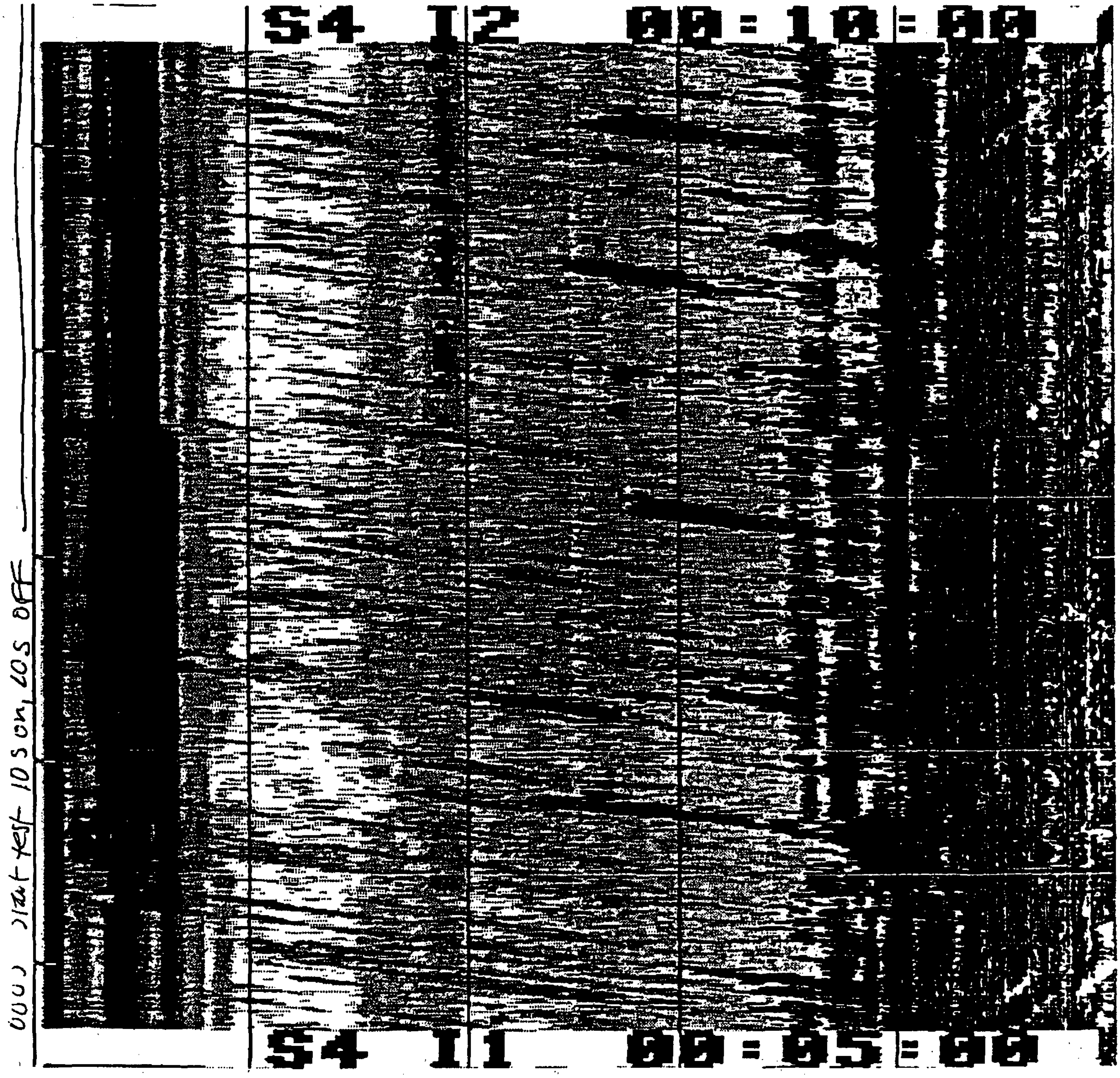


Figure 7b. Photocopy of echogram showing fish traces during high fish densities with the 15° conical oblique transducer at 0010 h on January 27, 1988. The grid lines are set at 2 m intervals.

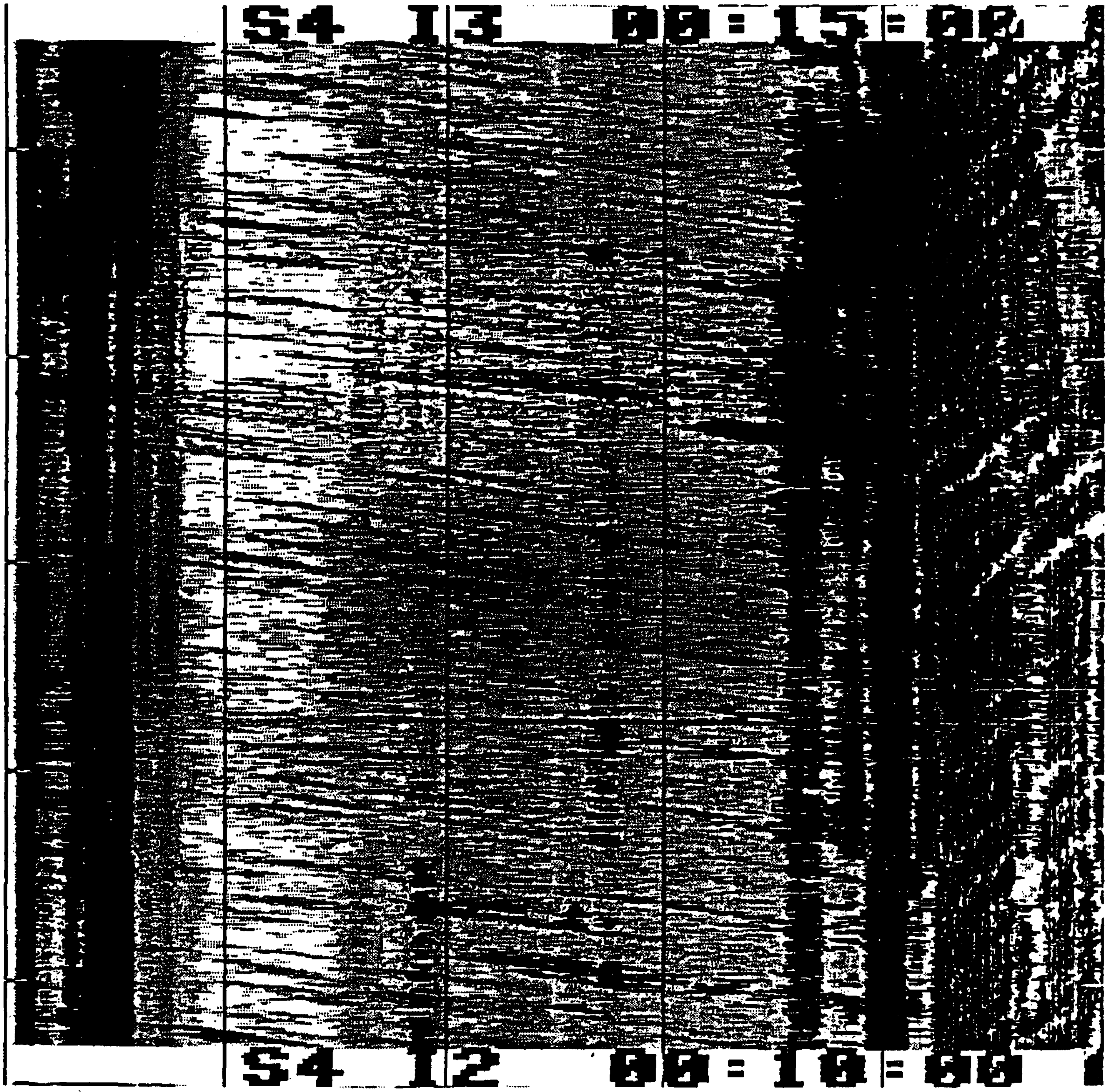


Figure 7c. Photocopy of echogram showing fish traces during high fish densities with the 15° conical oblique transducer at 0015 h on January 27, 1988. The grid lines are set at 2 m intervals.

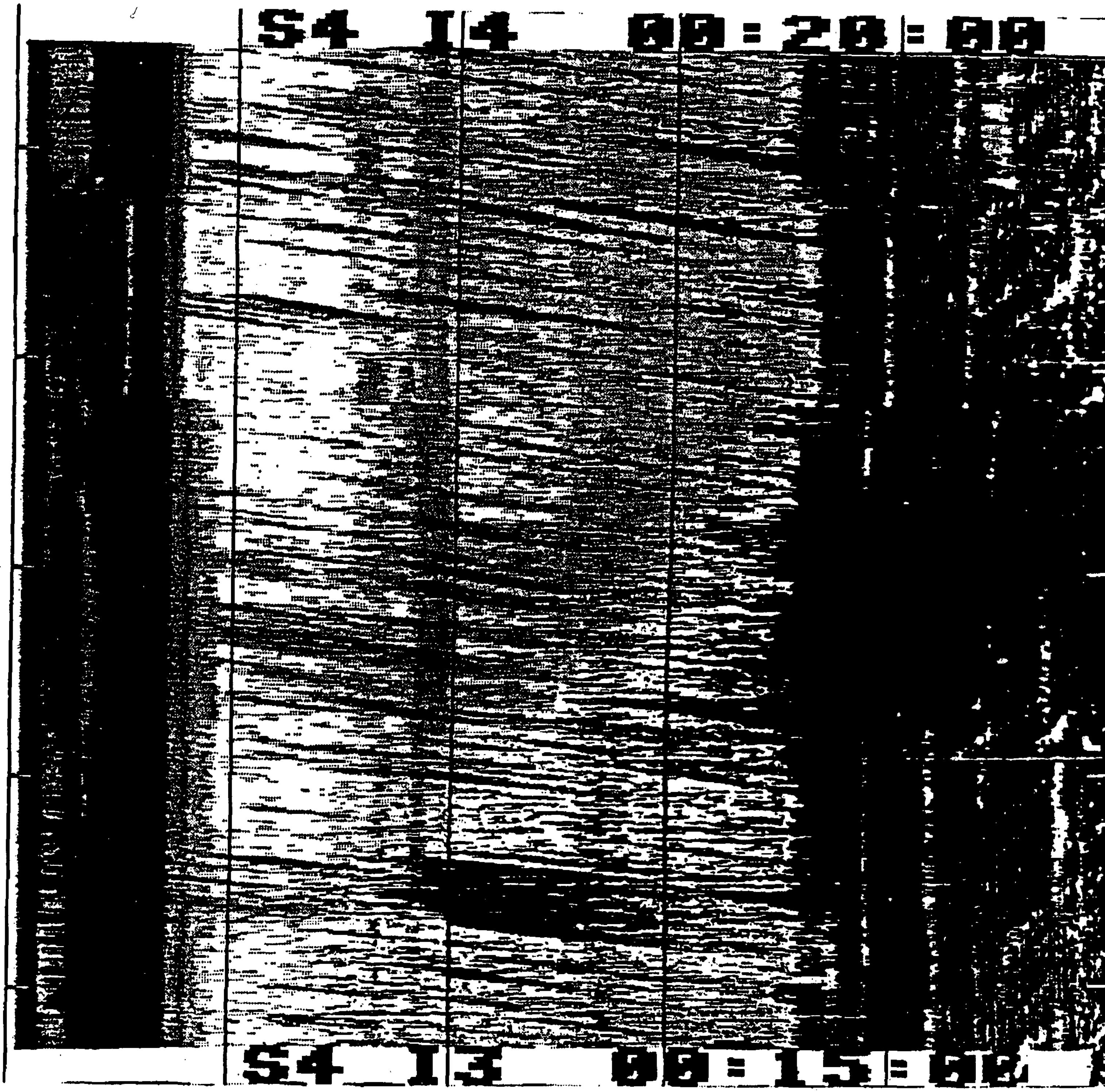


Figure 7d. Photocopy of echogram showing fish traces during high fish densities with the 15° conical oblique transducer at 0020 h on January 27, 1988. The grid lines are set at 2 m intervals.

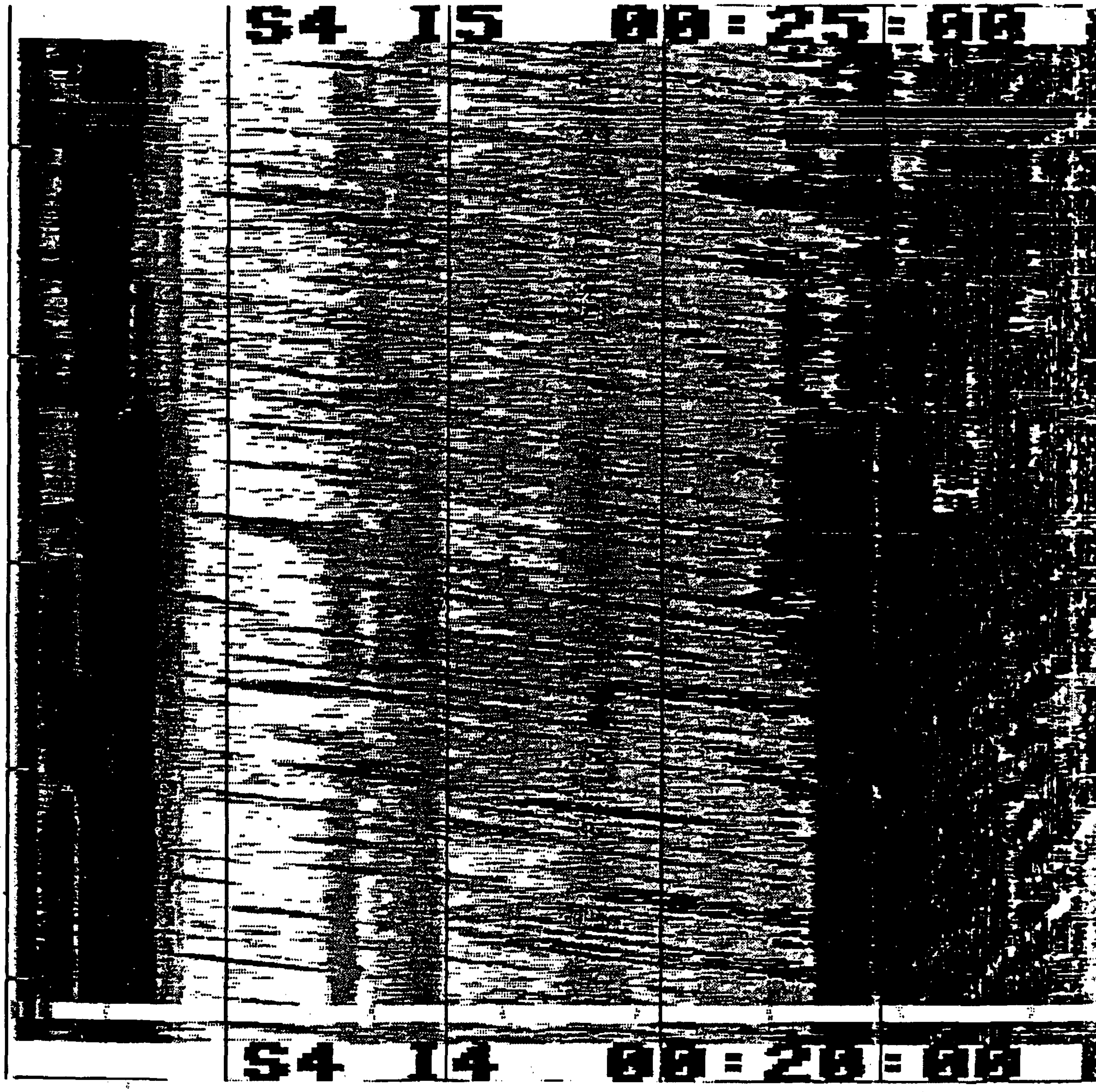


Figure 7e. Photocopy of echogram showing fish traces during high fish densities with the 15° conical oblique transducer at 0025 h on January 27, 1988. The grid lines are set at 2 m intervals.

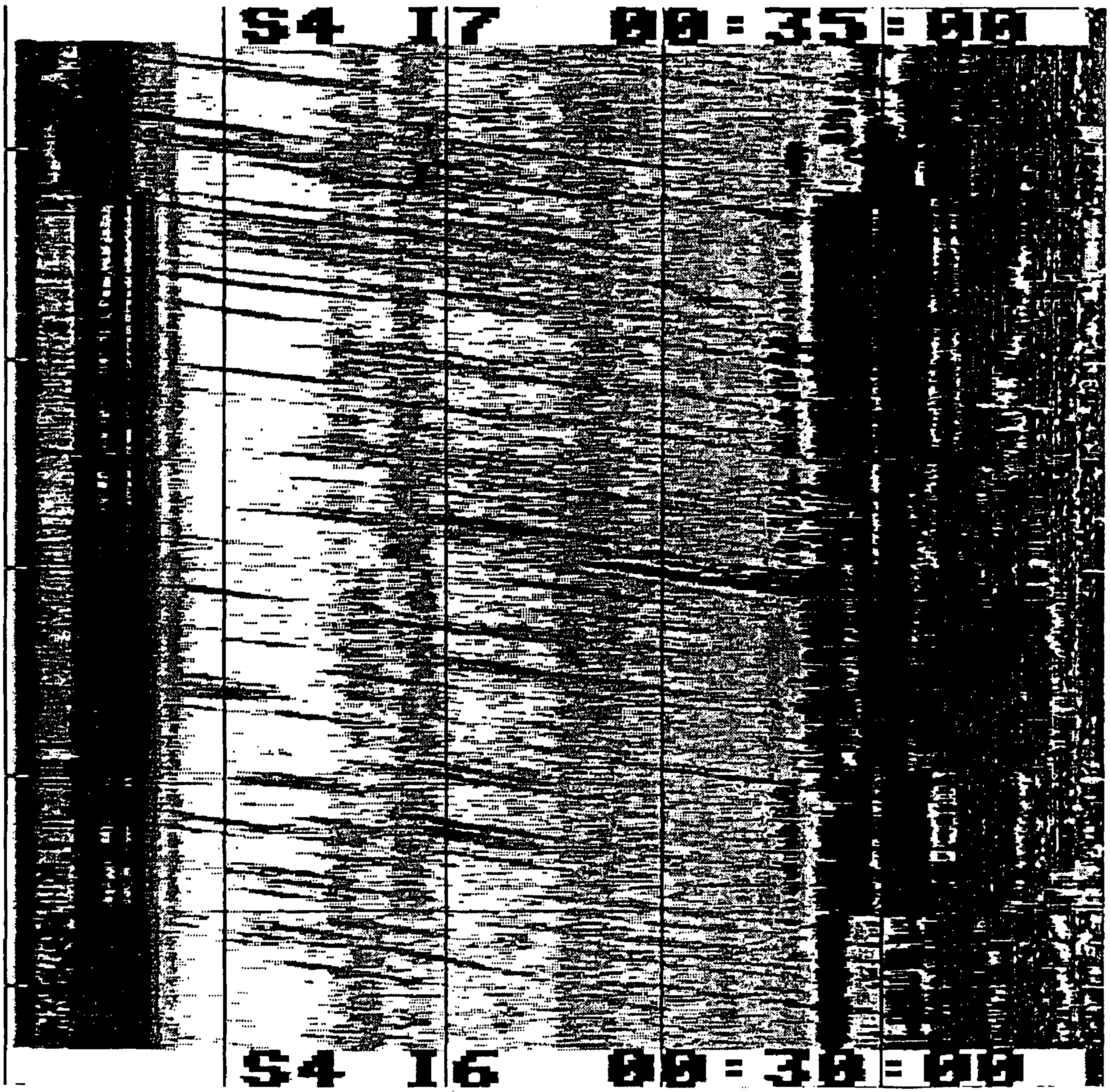
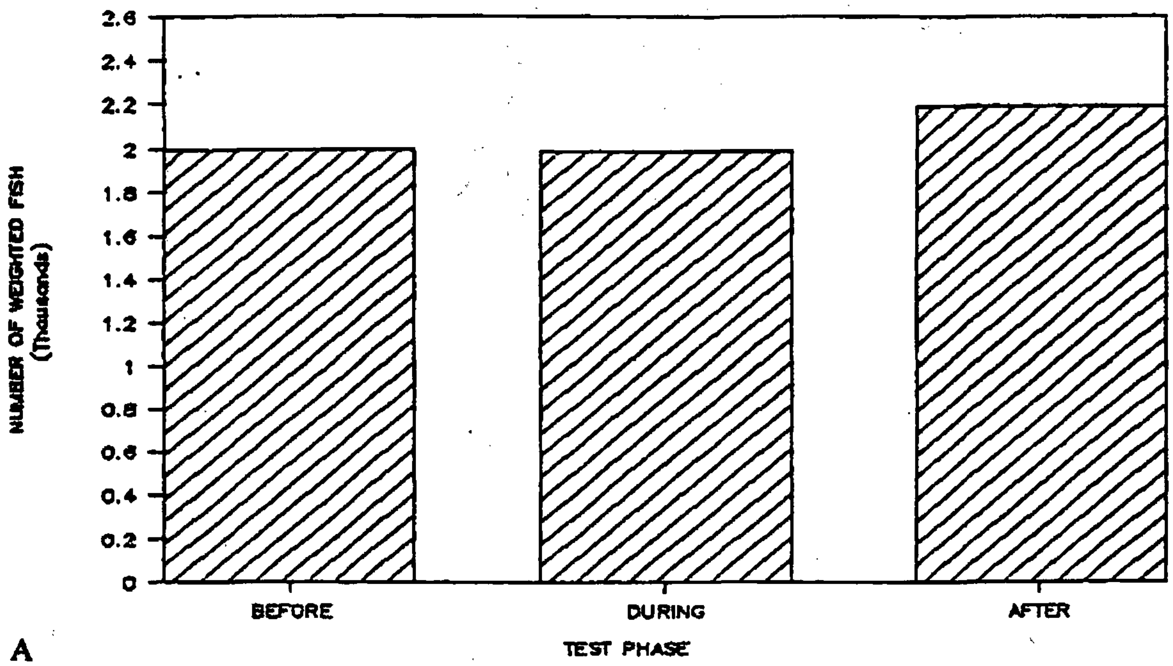
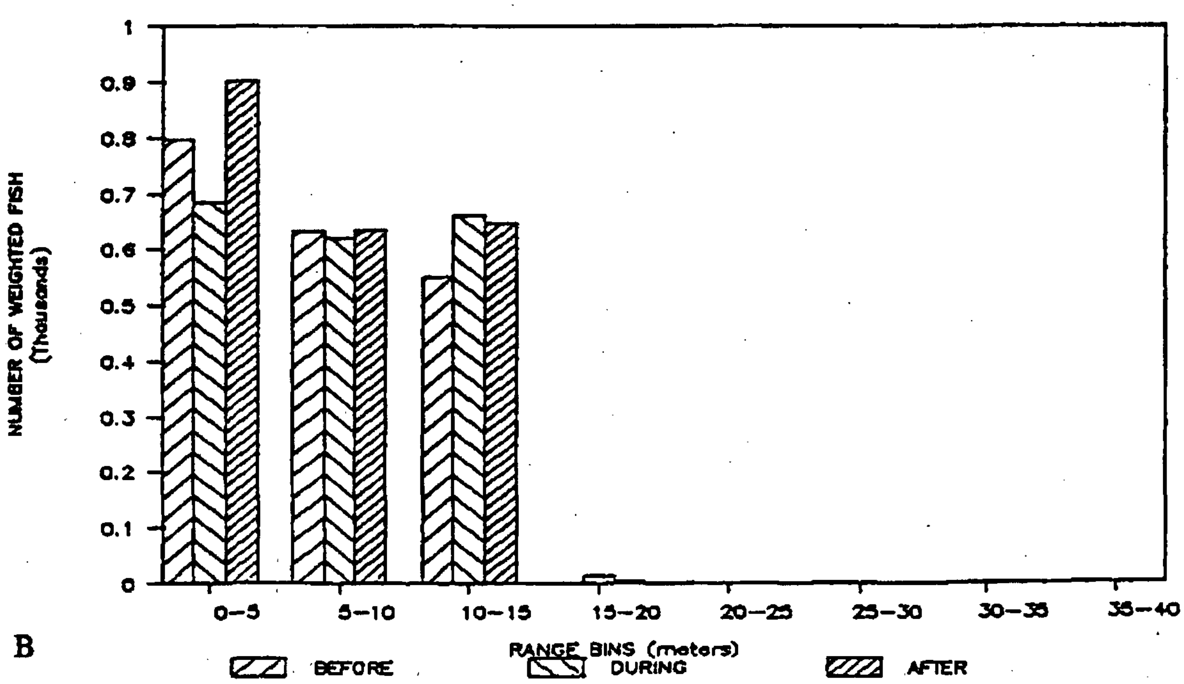


Figure 7f. Photocopy of echogram showing fish traces during high fish densities with the 15° conical oblique transducer at 0035 h on January 27, 1988. The grid lines are set at 2 m intervals.

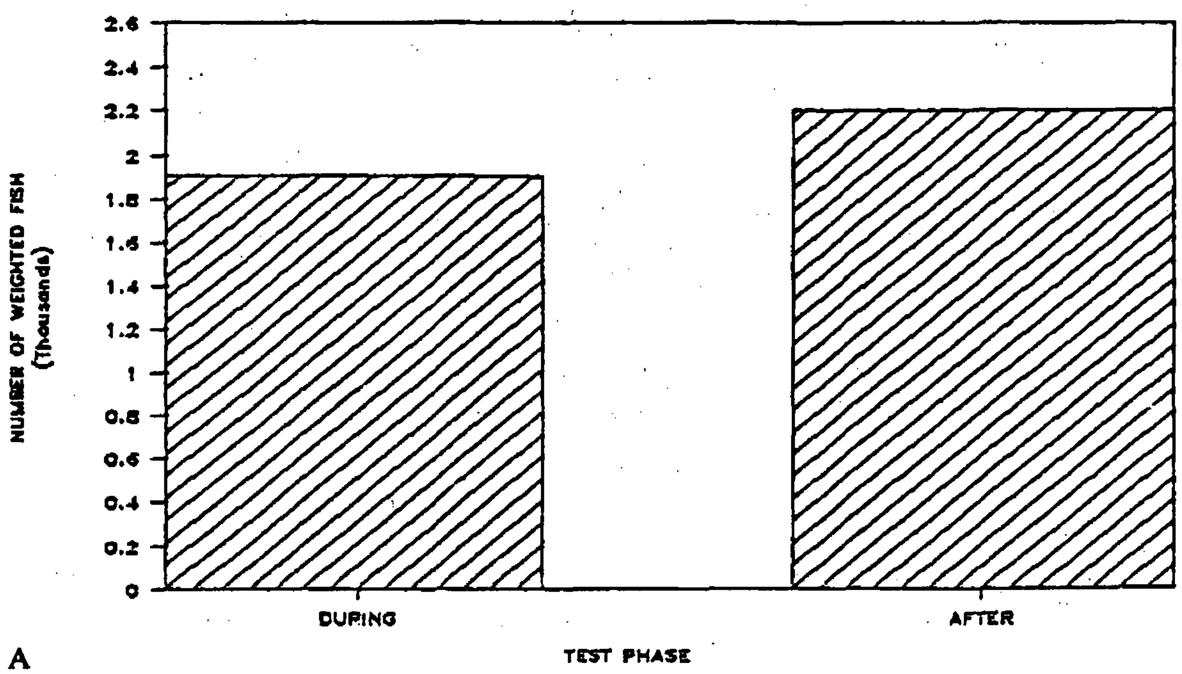


A

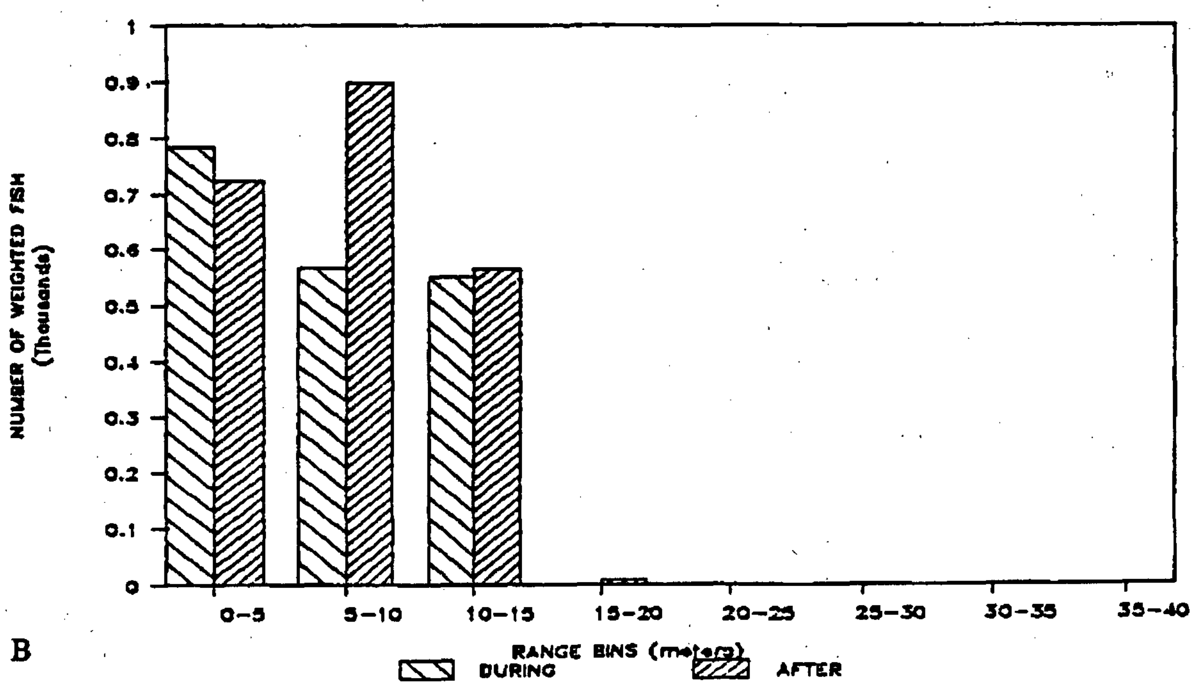


B

Figure 8. Fish density data from the mid-water 6°x12° horizontal transducer at Intake 35 for the January 26, 2135 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.



A



B

Figure 9. Fish density data from the mid-water 6°x12° horizontal transducer at Intake 35 for the January 26, 2155 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

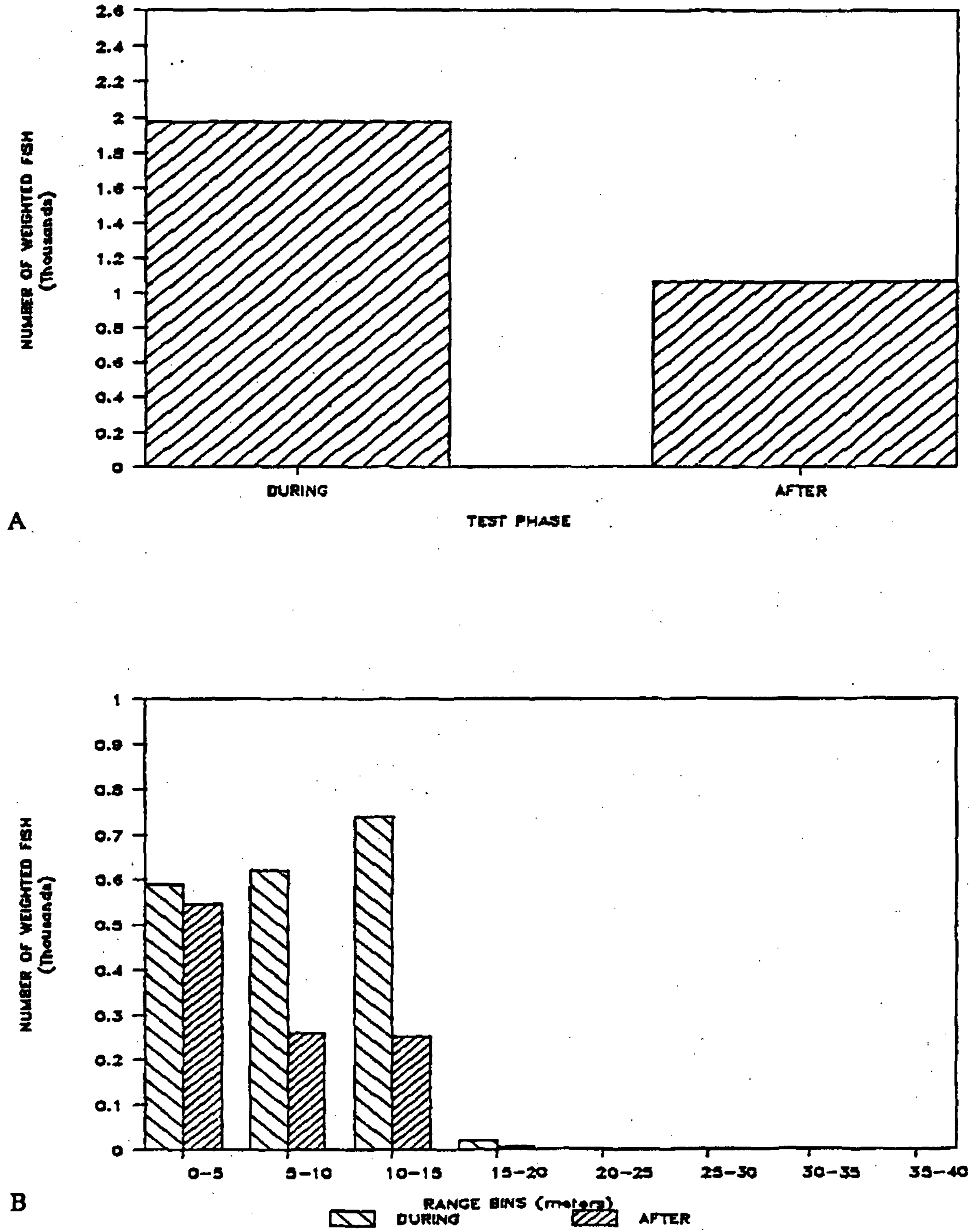
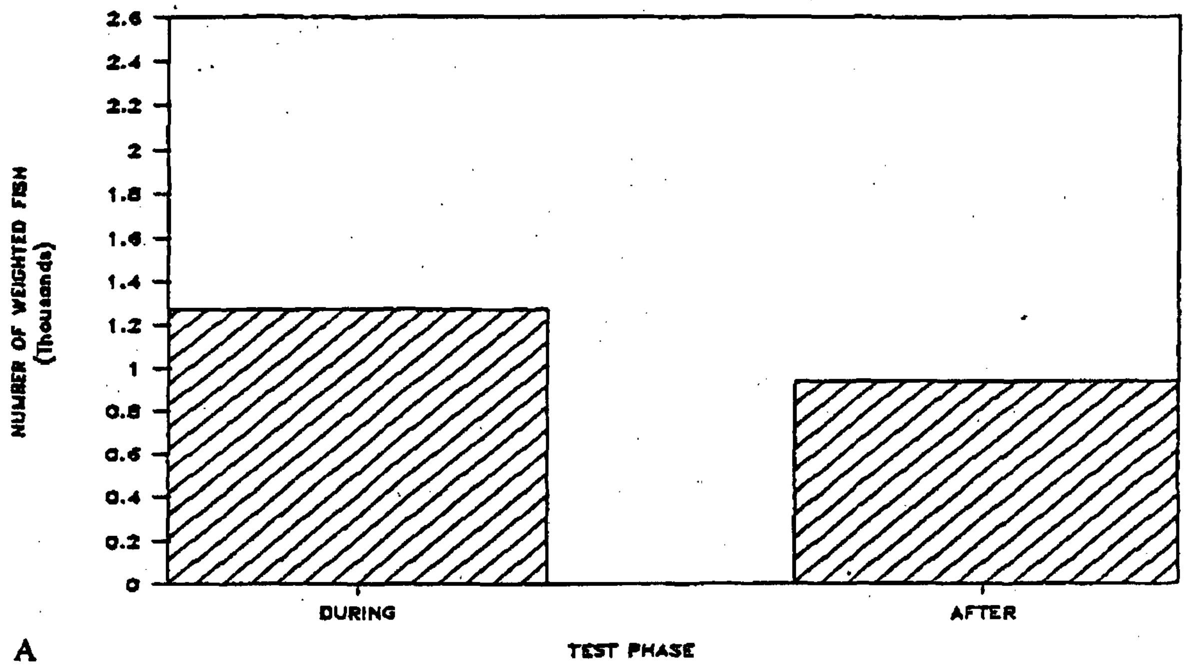
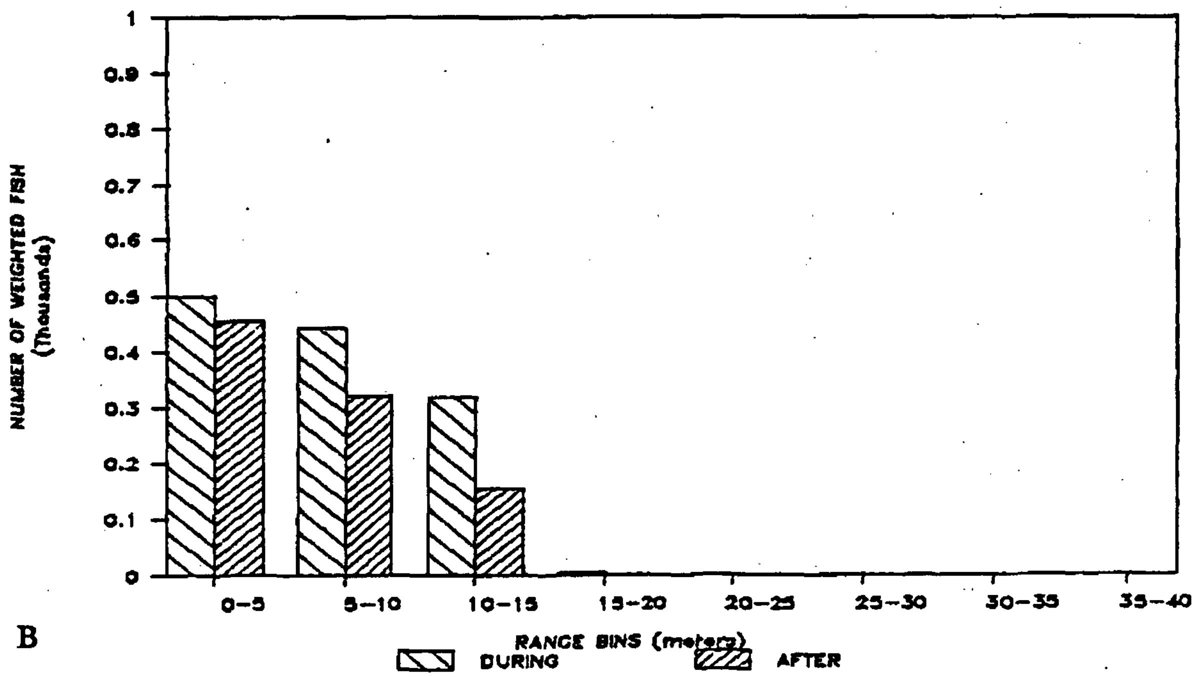


Figure 10. Fish density data from the mid-water 6°x12° horizontal transducer at Intake 35 for the January 26, 2220 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

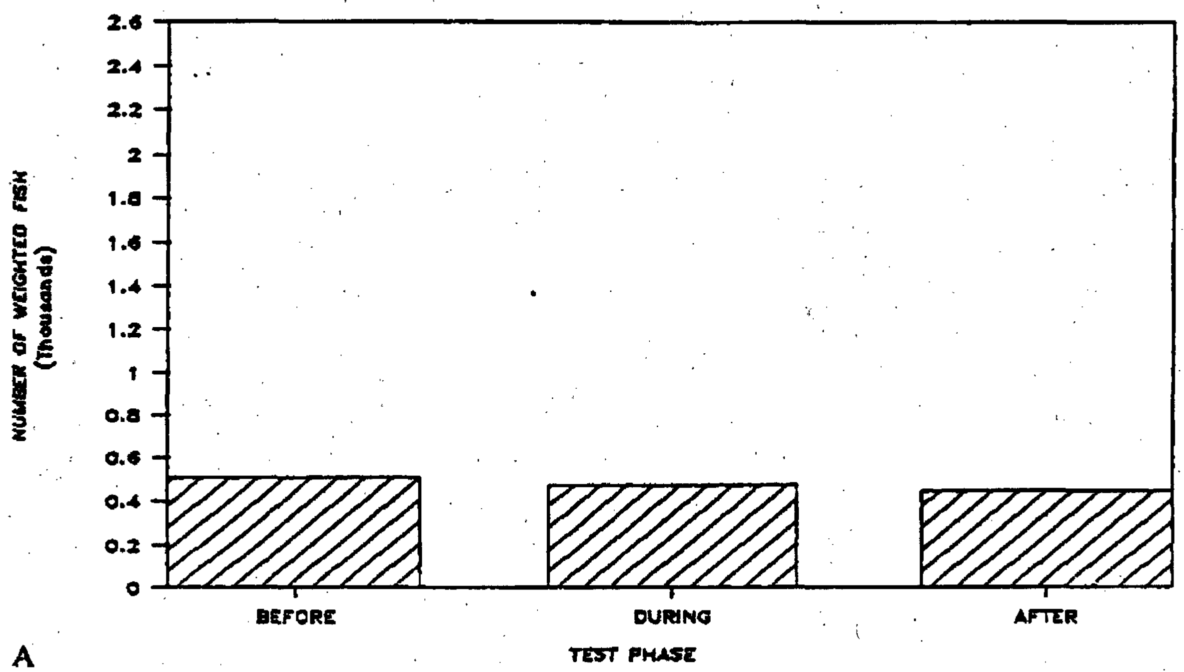


A

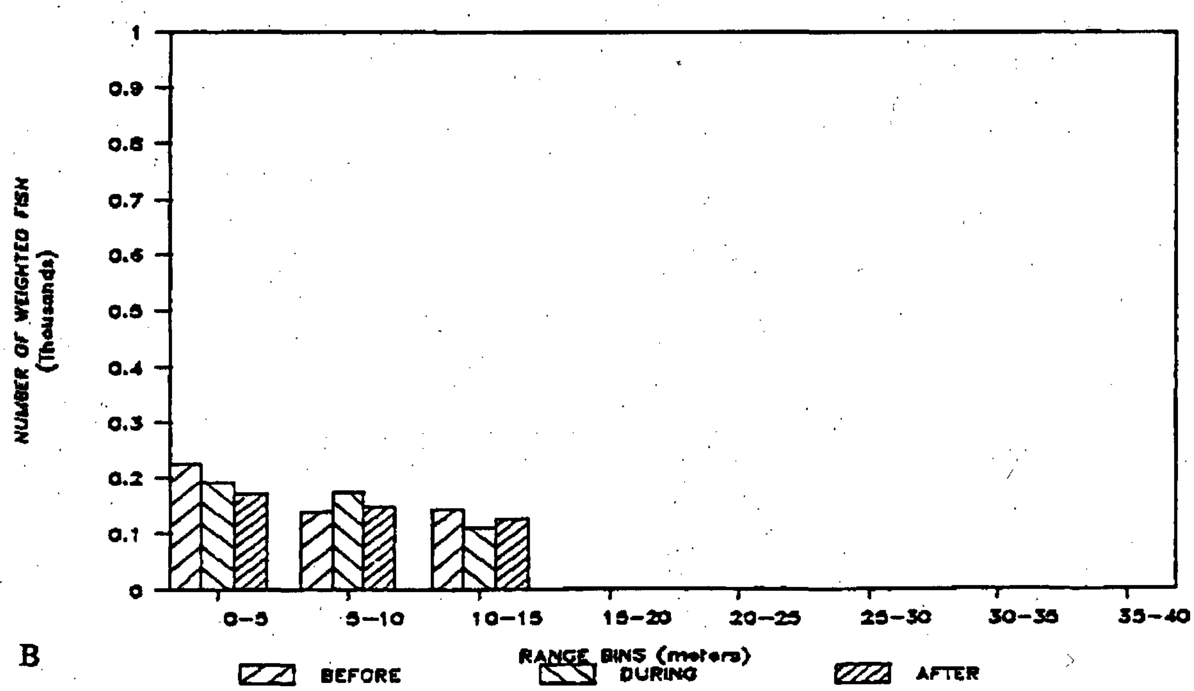


B

Figure 11. Fish density data from the mid-water 6°x12° horizontal transducer at Intake 35 for the January 26, 2245 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

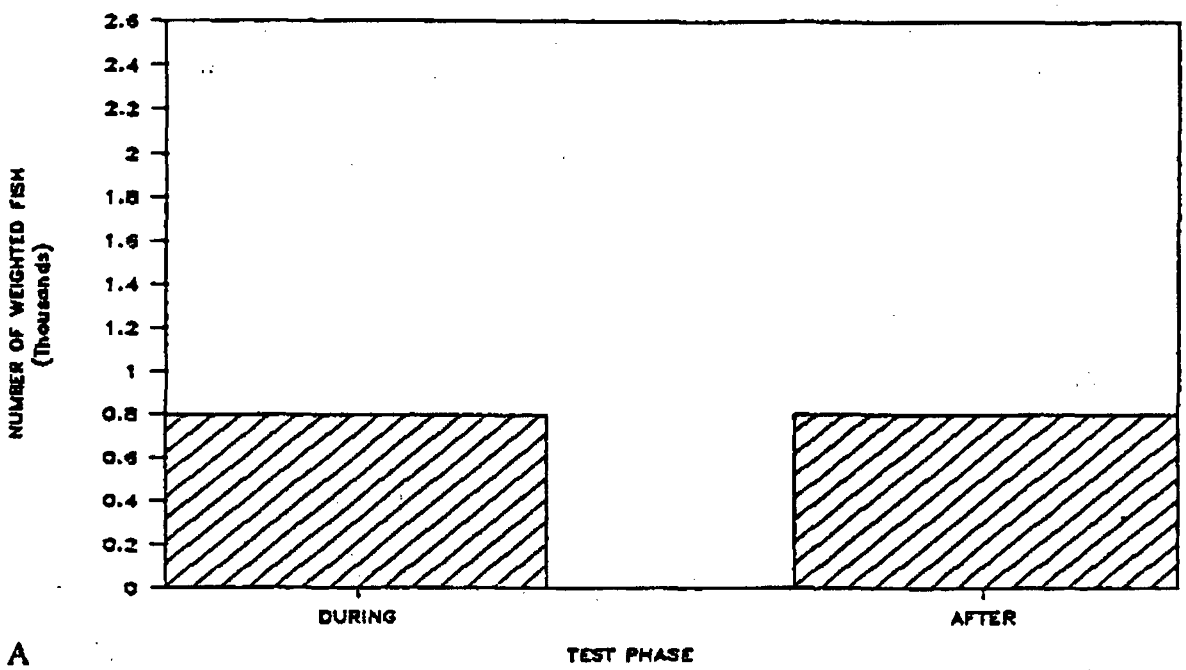


A

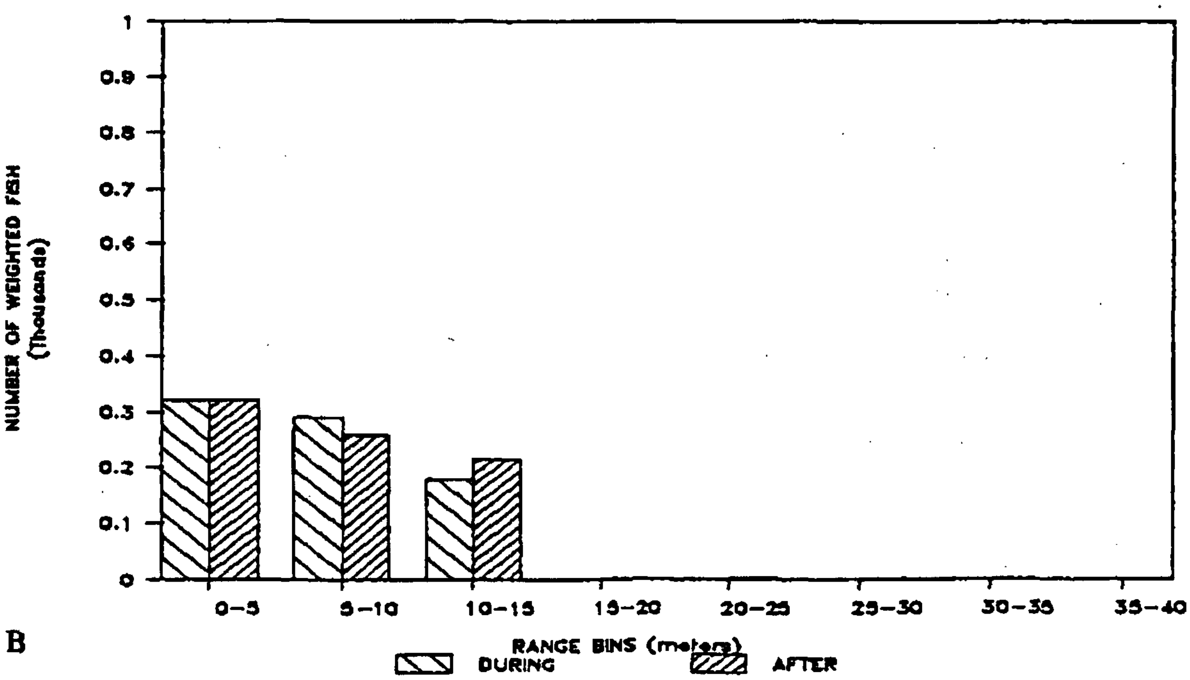


B

Figure 12. Fish density data from the mid-water 6°x12° horizontal transducer at Intake 35 for the January 26, 2305 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

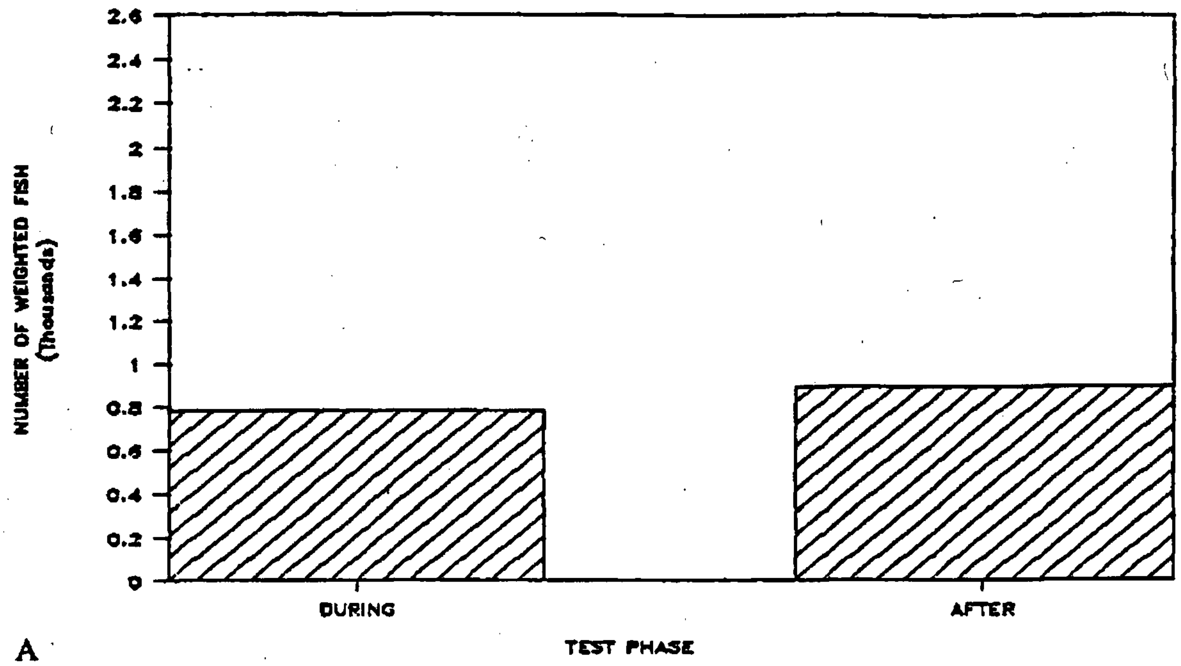


A

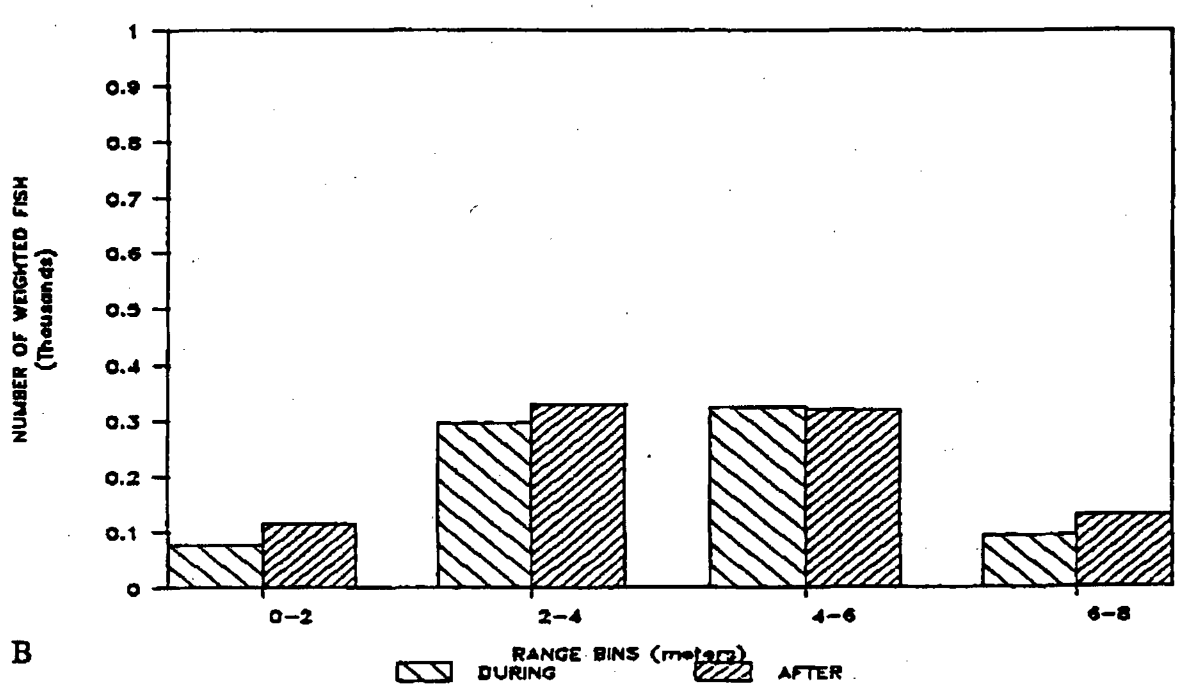


B

Figure 13. Fish density data from the mid-water 6°x12° horizontal transducer at Intake 35 for the January 26, 2320 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

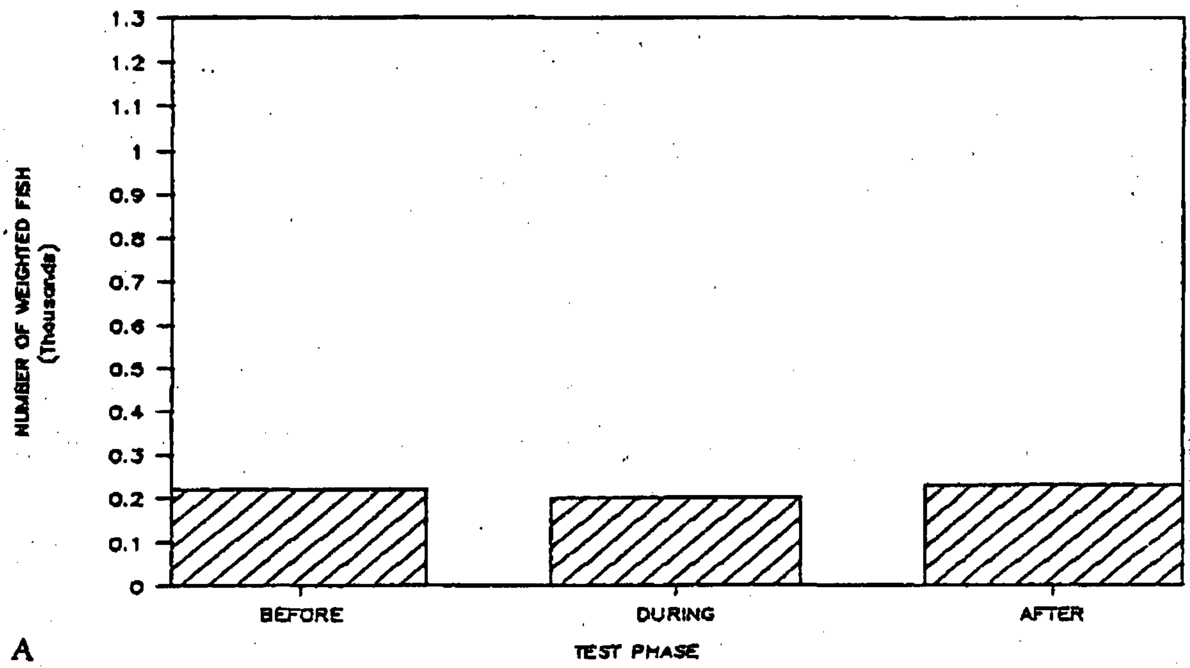


A

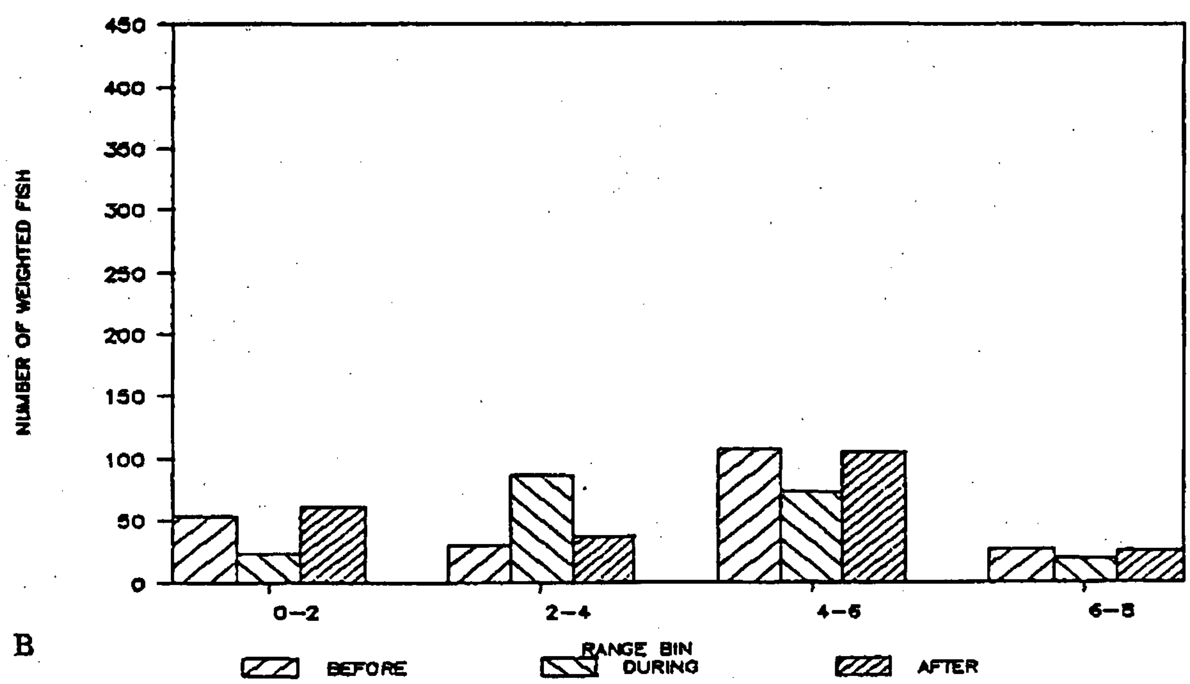


B

Figure 14. Fish density data from the 15° oblique transducer at Intake 35 for the January 26, 0005 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

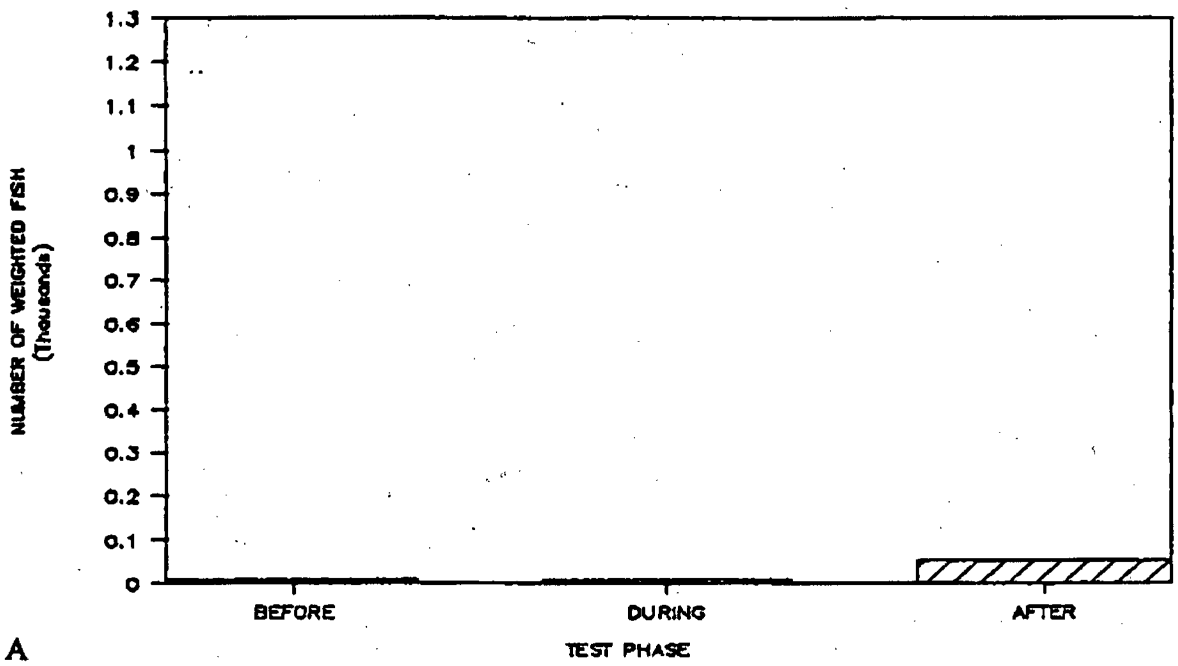


A

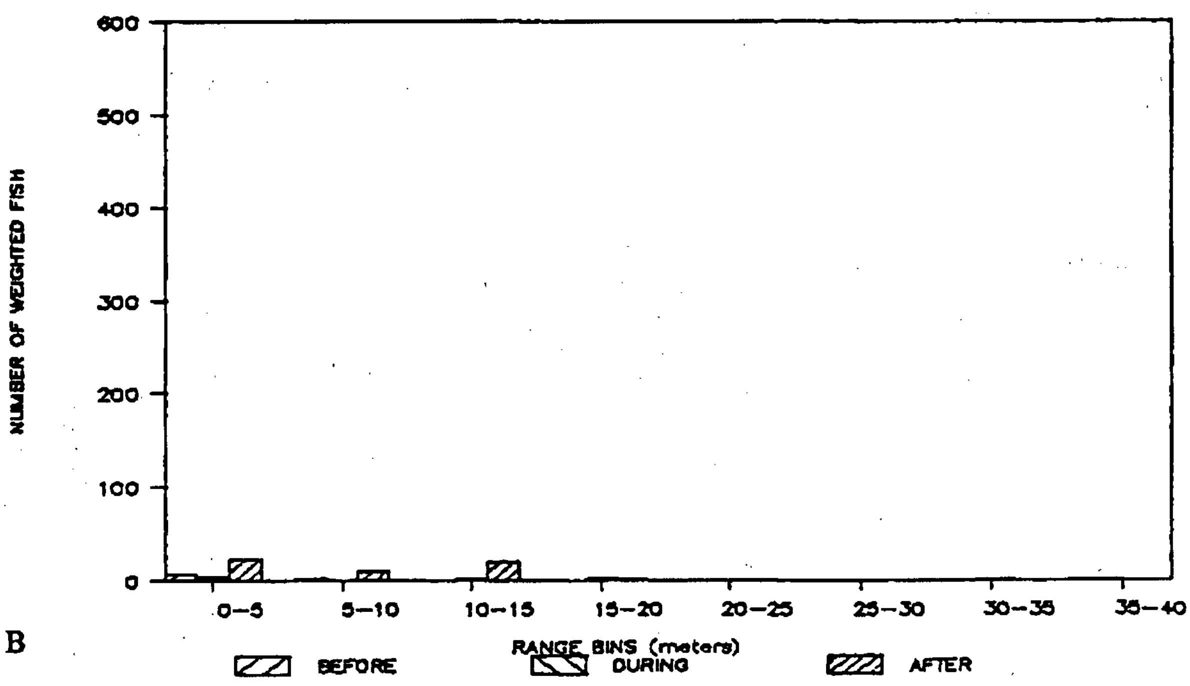


B

Figure 15. Fish density data from the 15° oblique transducer at Intake 35 for the February 13, 1047 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.



A



B

Figure 16. Fish density data from the mid-water 6°x12° horizontal transducer at Intake 35 for the February 13, 1047 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

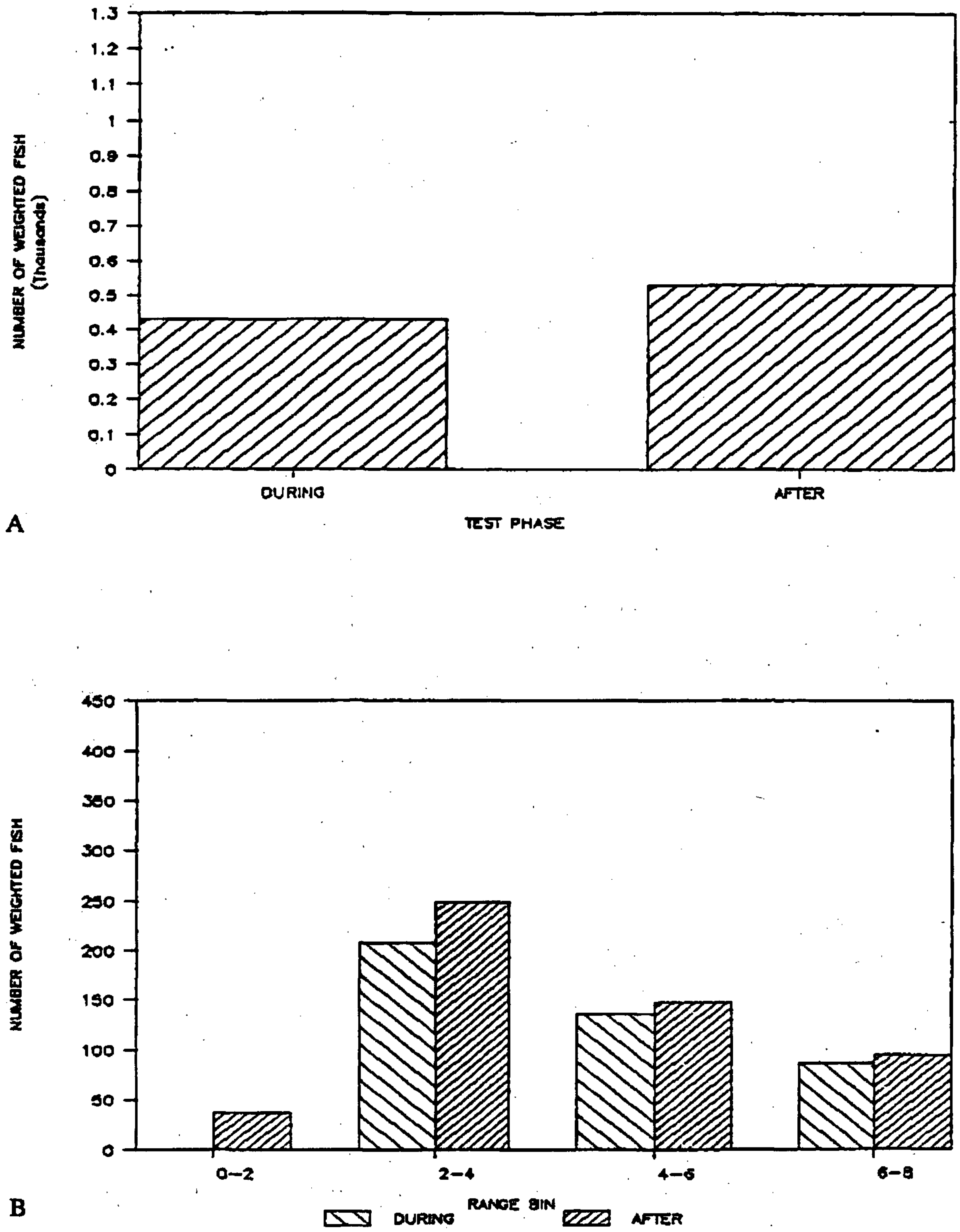
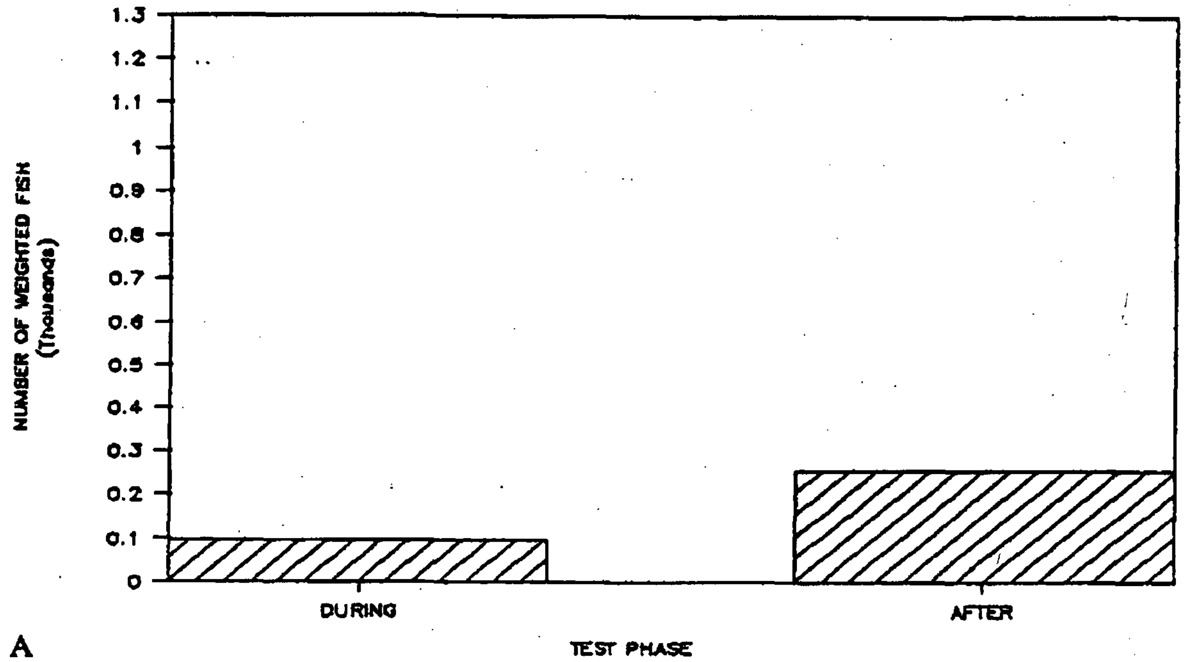
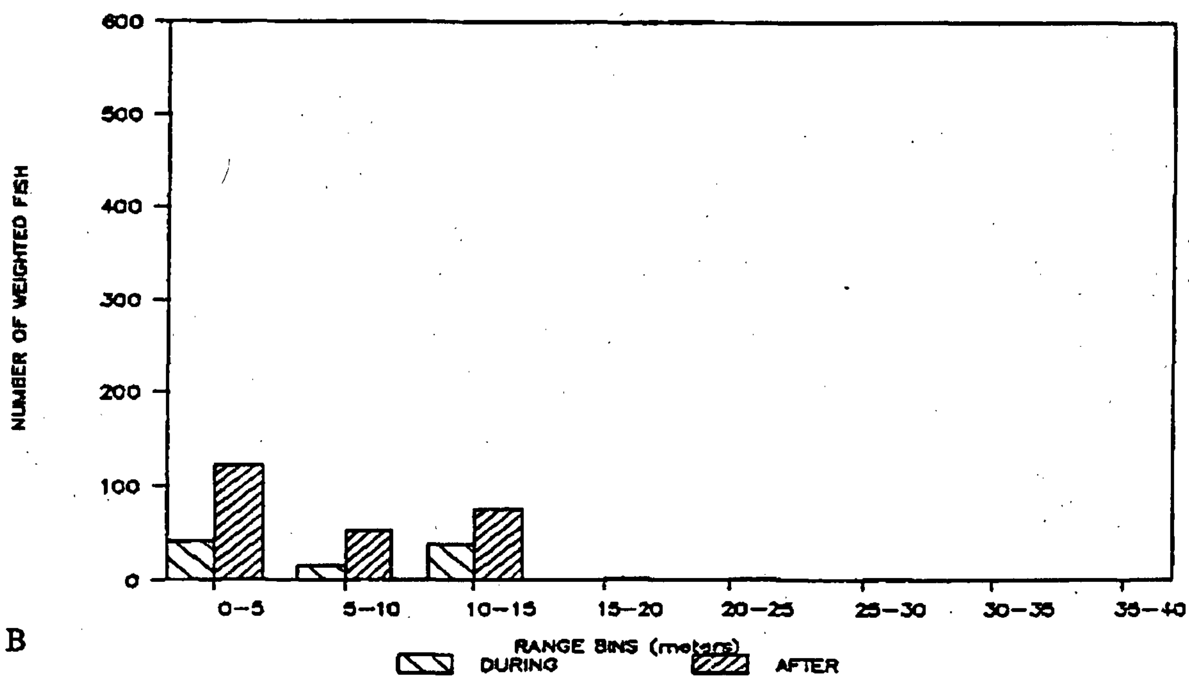


Figure 17. Fish density data from the 15° oblique transducer at Intake 35 for the February 13 1107 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

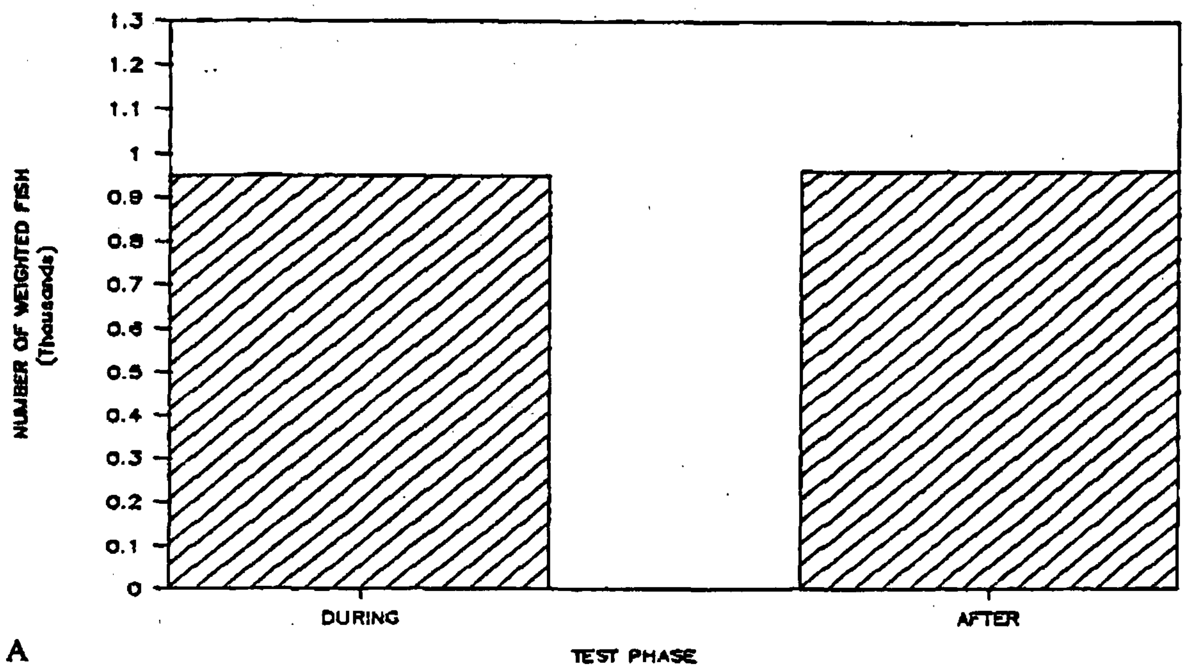


A

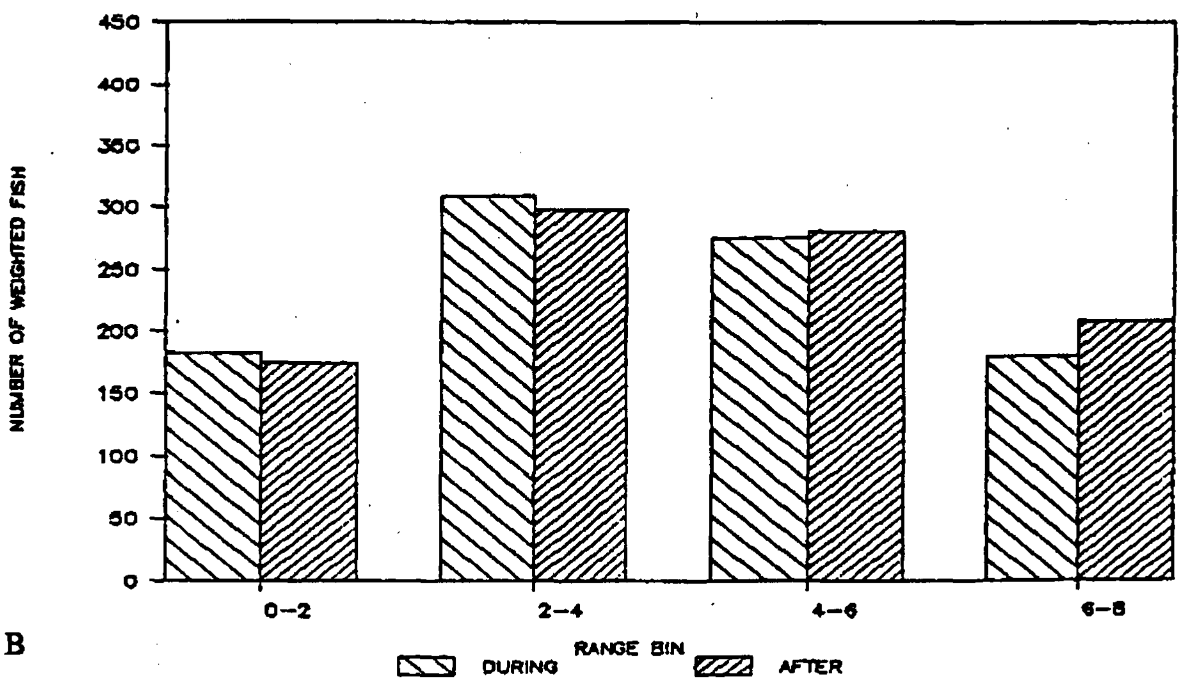


B

Figure 18. Fish density data from the mid-water 6°x12° horizontal transducer at Intake 35 for the February 13, 1107 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

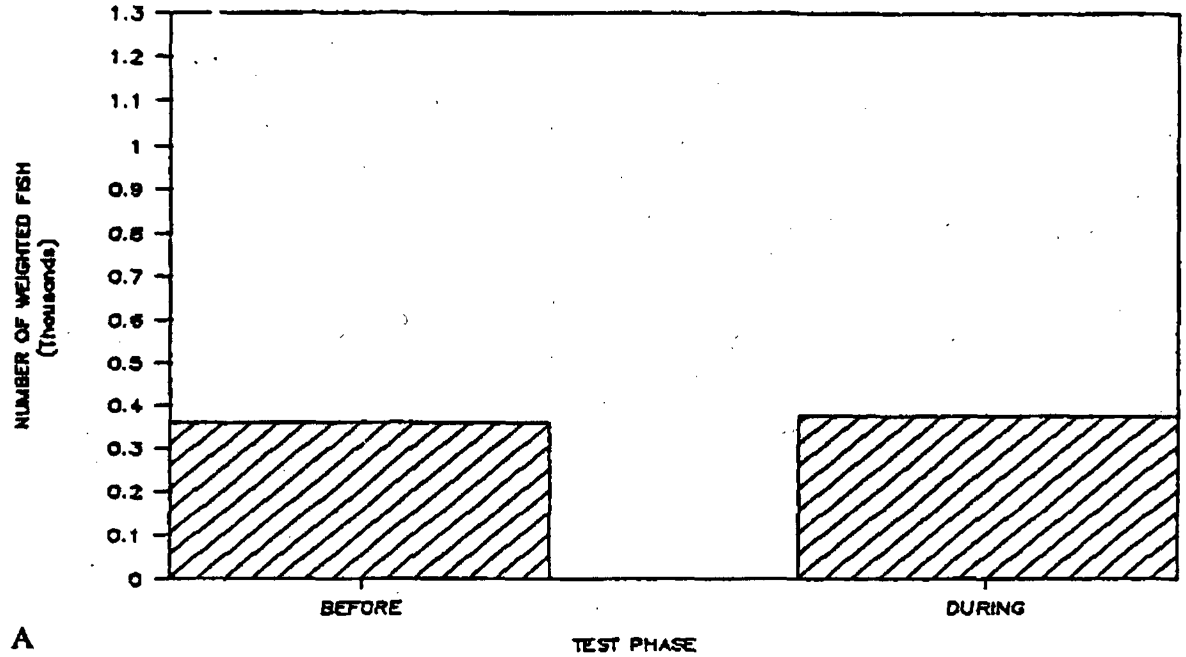


A

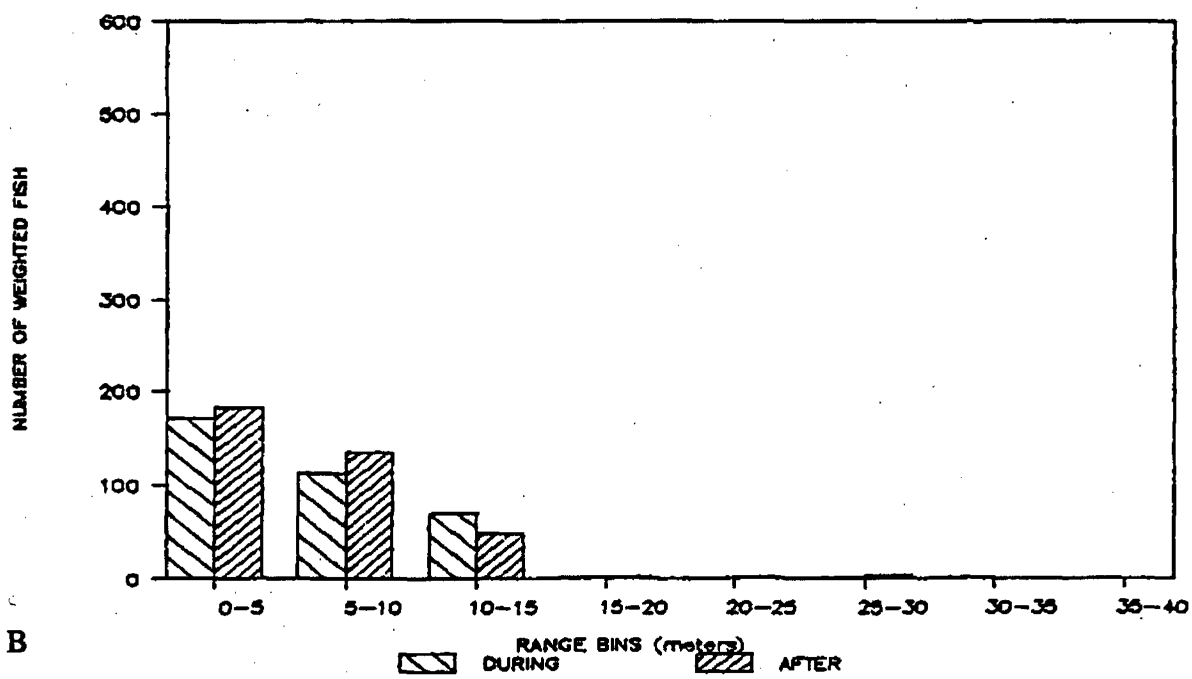


B

Figure 19. Fish density data from the 15° oblique transducer at Intake 35 for the February 13, 1127 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

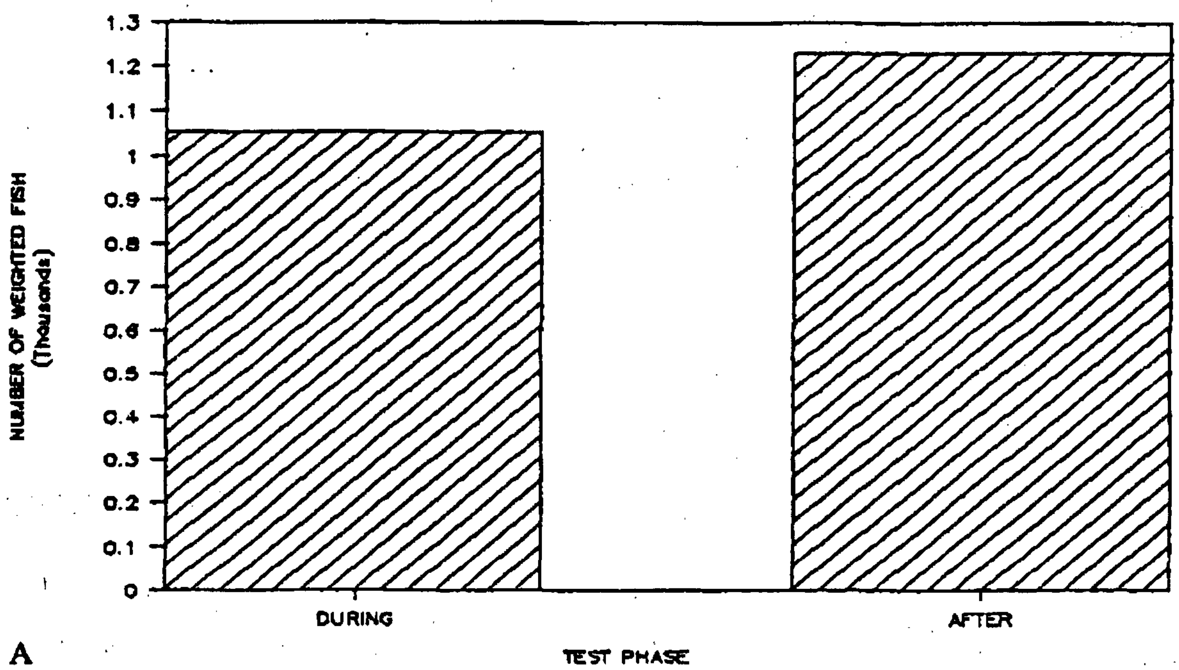


A

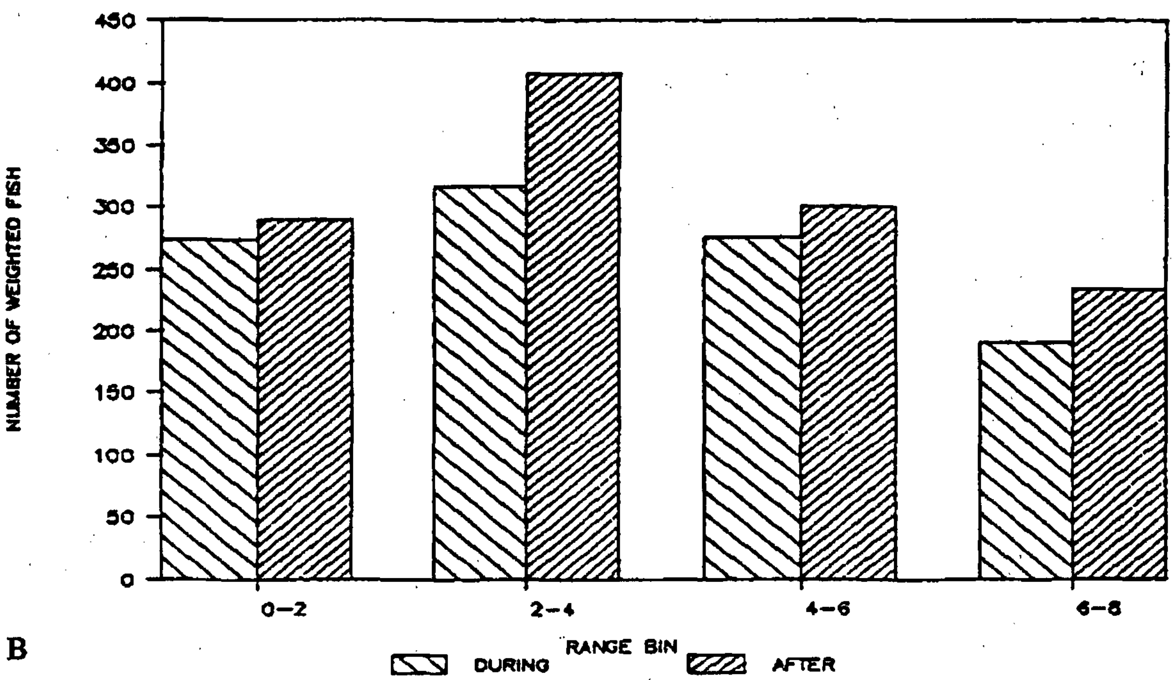


B

Figure 20. Fish density data from the mid-water 6°x12° horizontal transducer at Intake 35 for the February 13, 1127 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

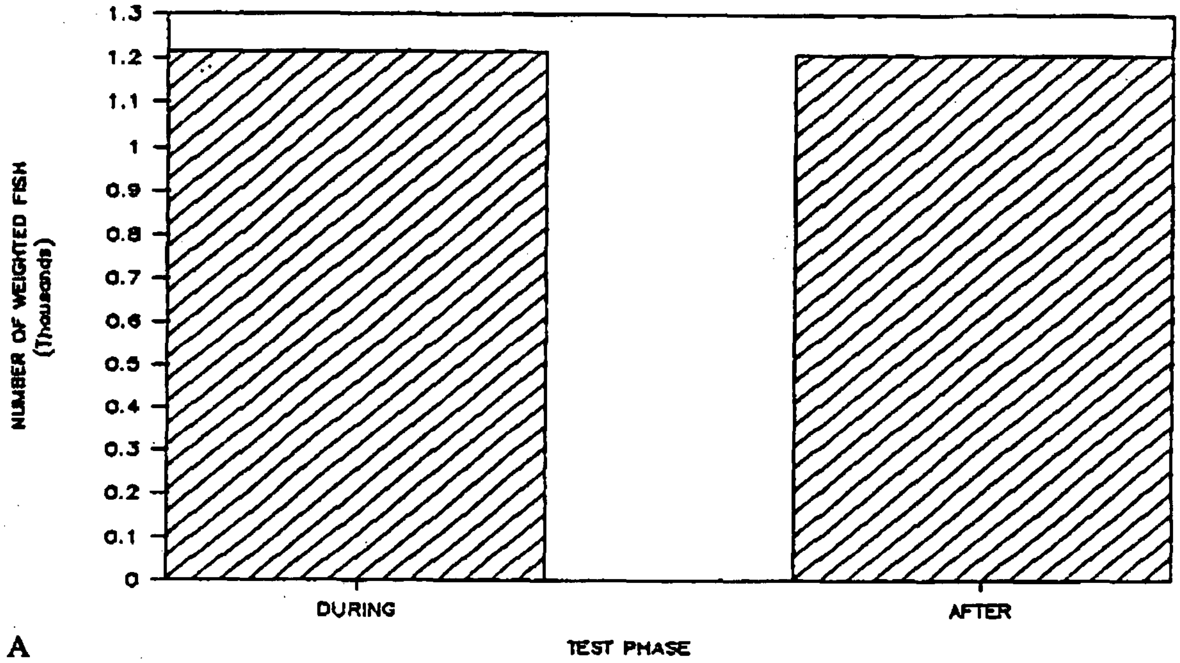


A

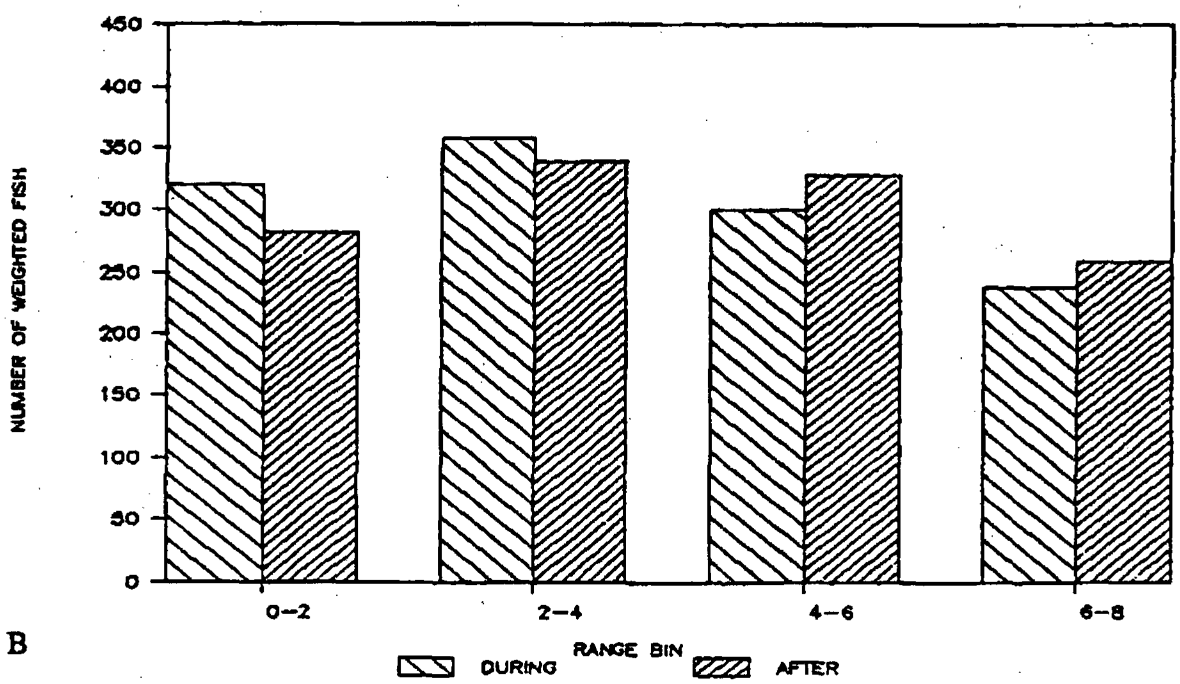


B

Figure 21. Fish density data from the 15° oblique transducer at Intake 35 for the February 13, 1147 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

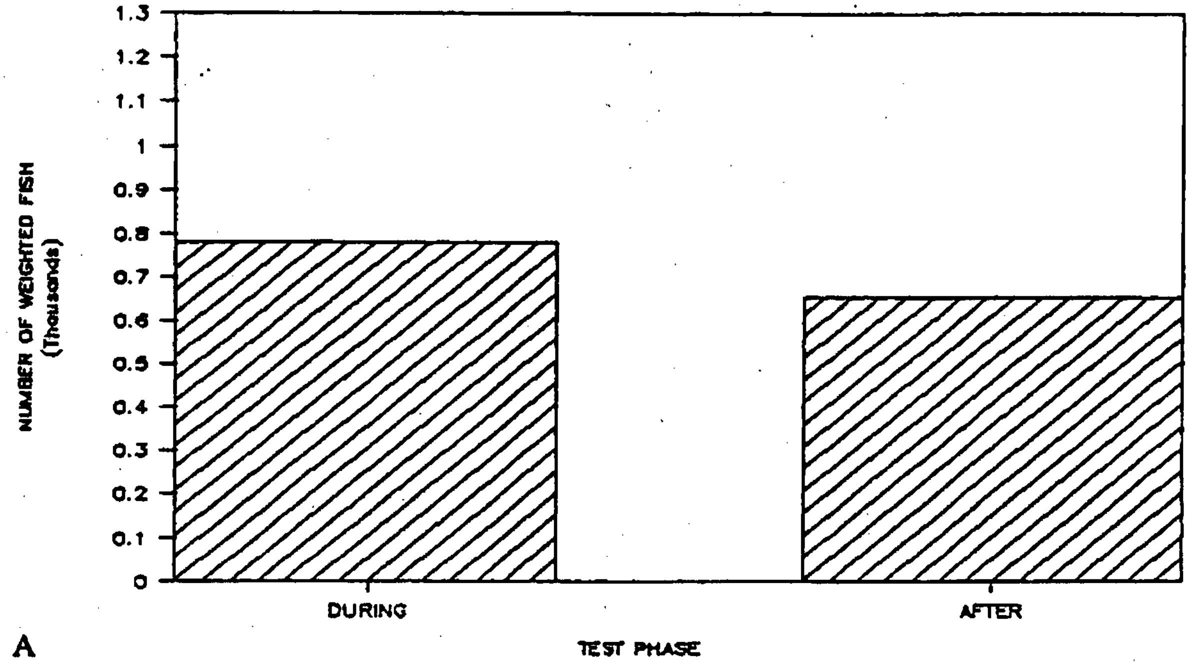


A

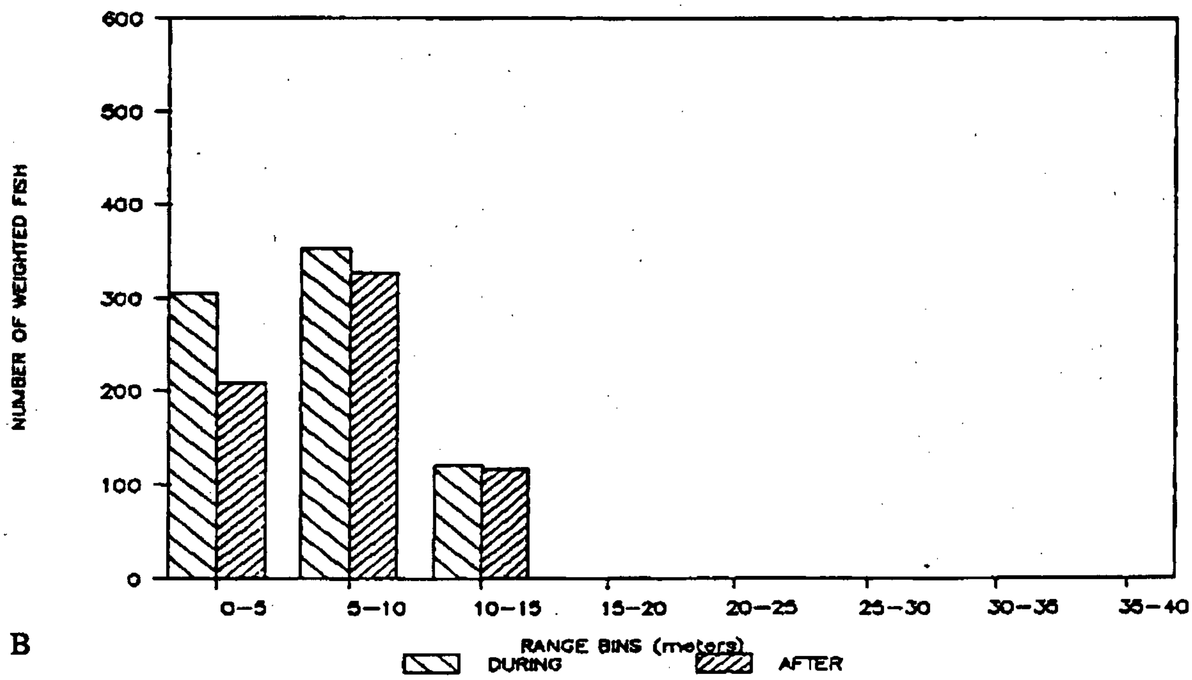


B

Figure 23. Fish density data from the 15° oblique transducer at Intake 35 for the February 13, 1207 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

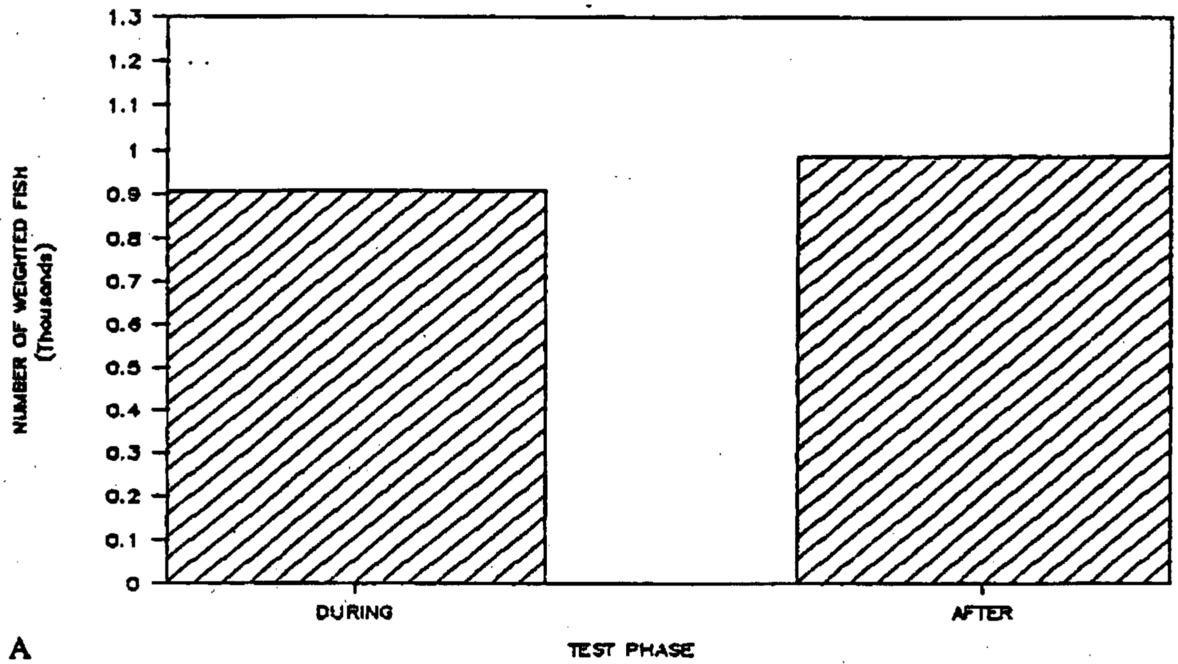


A

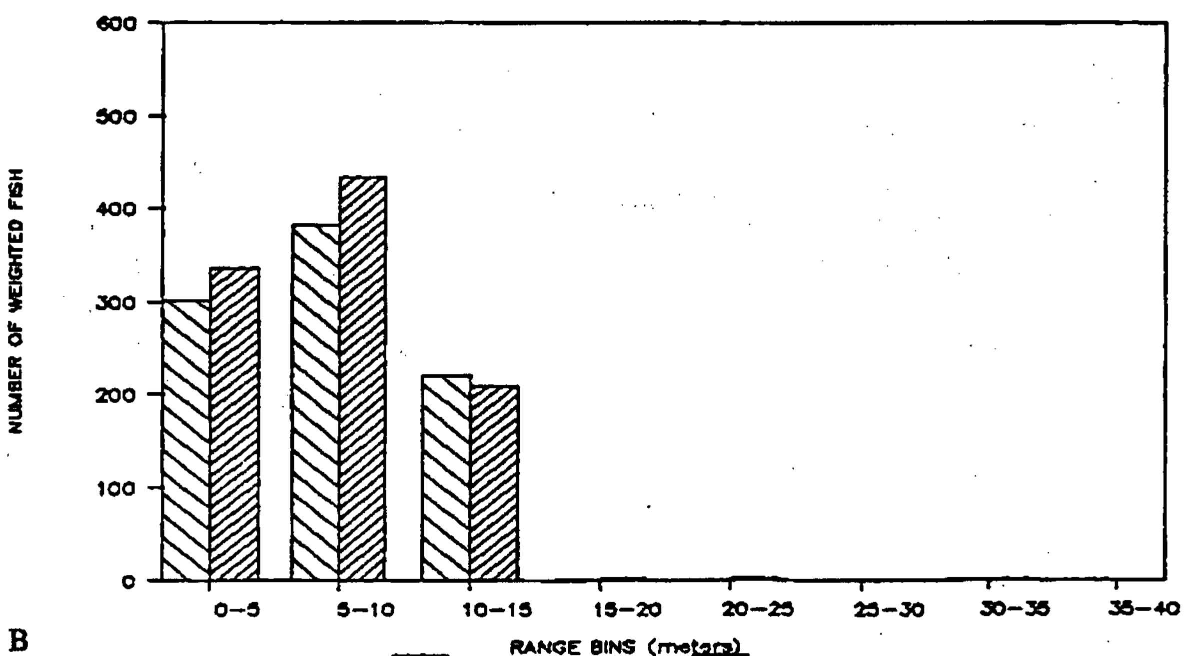


B

Figure 22. Fish density data from the mid-water 6°x12° horizontal transducer at Intake 35 for the February 13, 1147 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

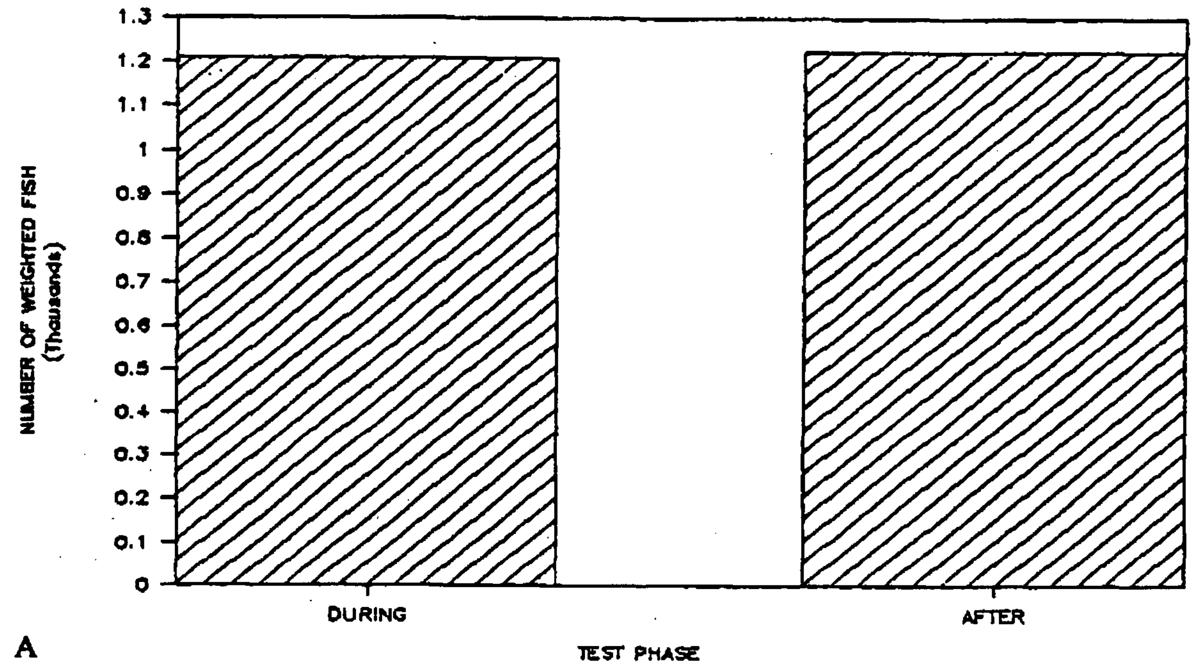


A

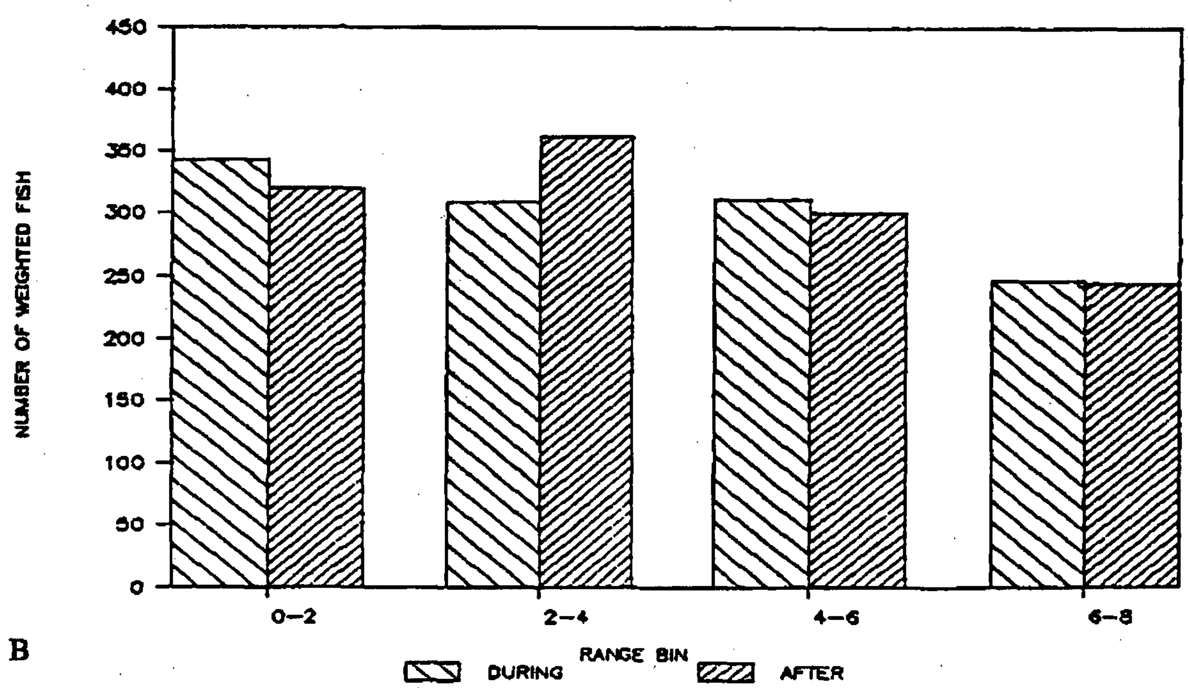


B

Figure 24. Fish density data from the mid-water 6°x12° horizontal transducer at Intake 35 for the February 13, 1207 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

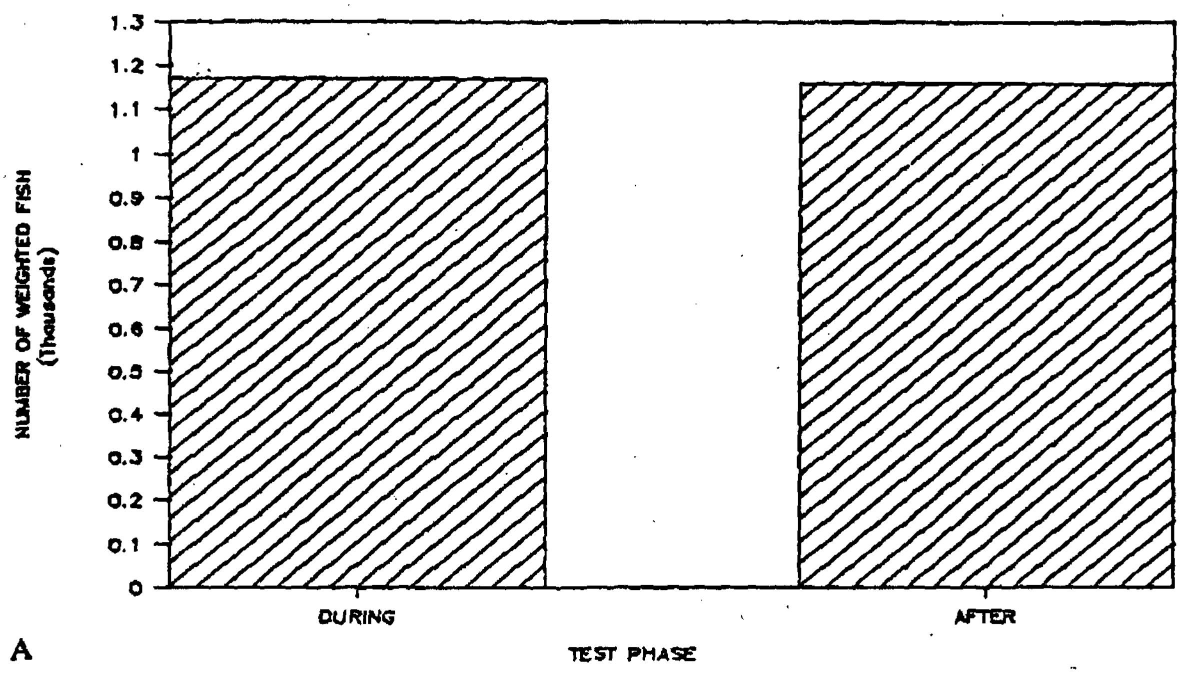


A

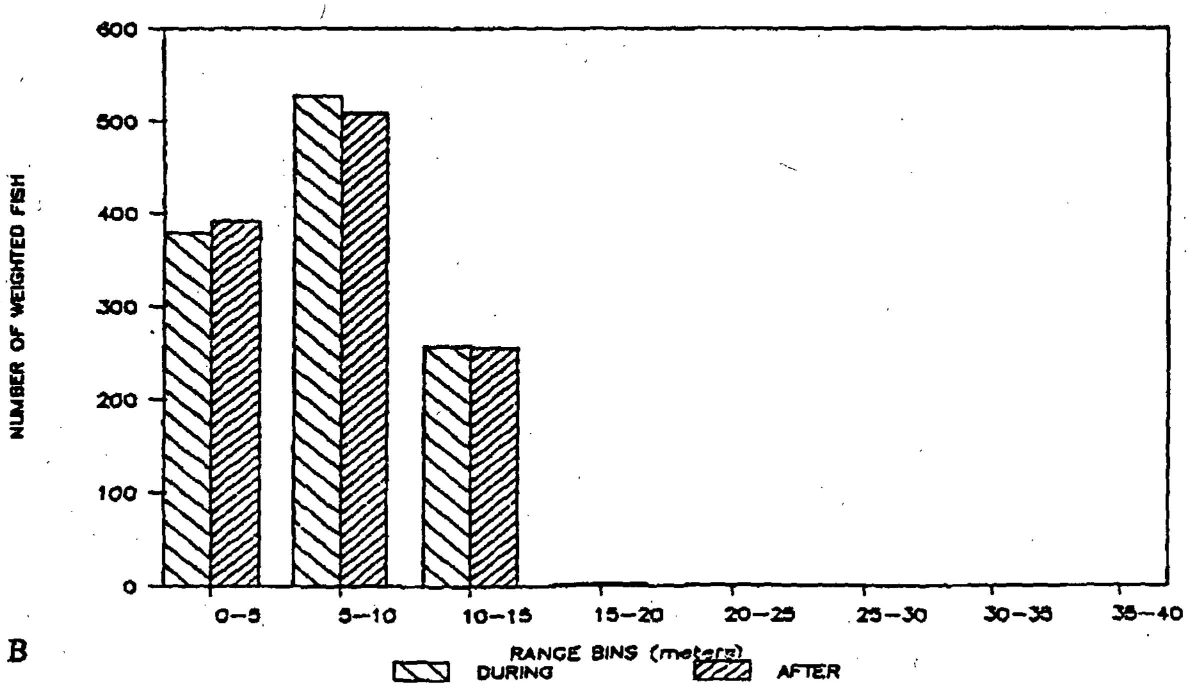


B

Figure 25. Fish density data from the 15° oblique transducer at Intake 35 for the February 13, 1227 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

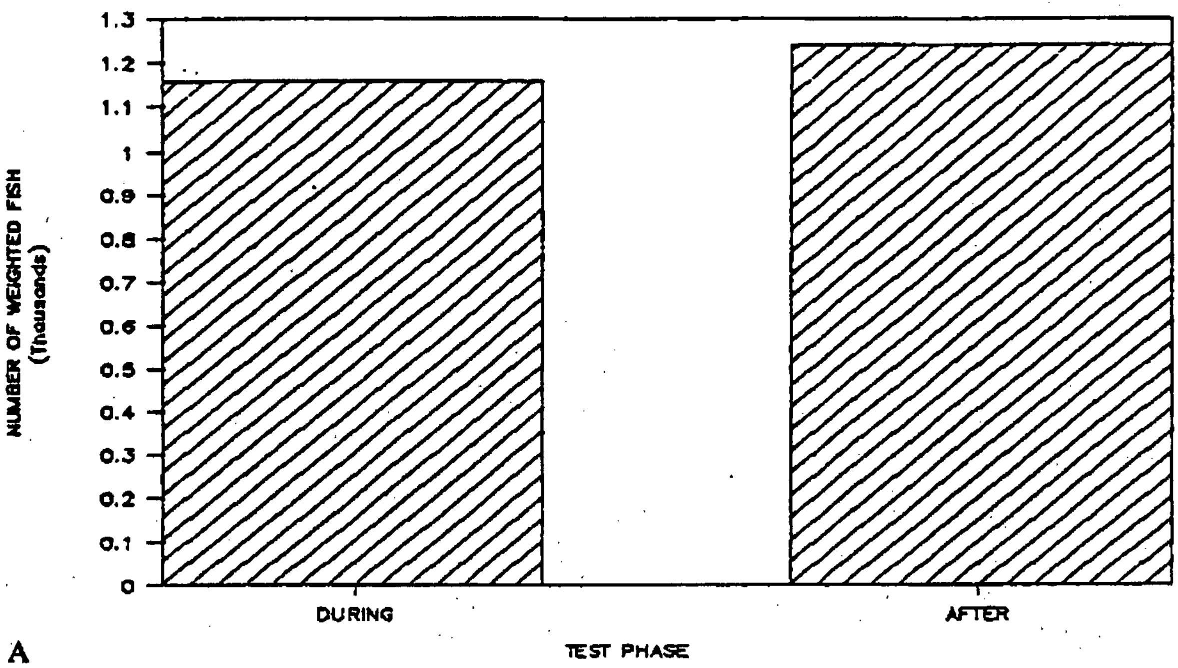


A

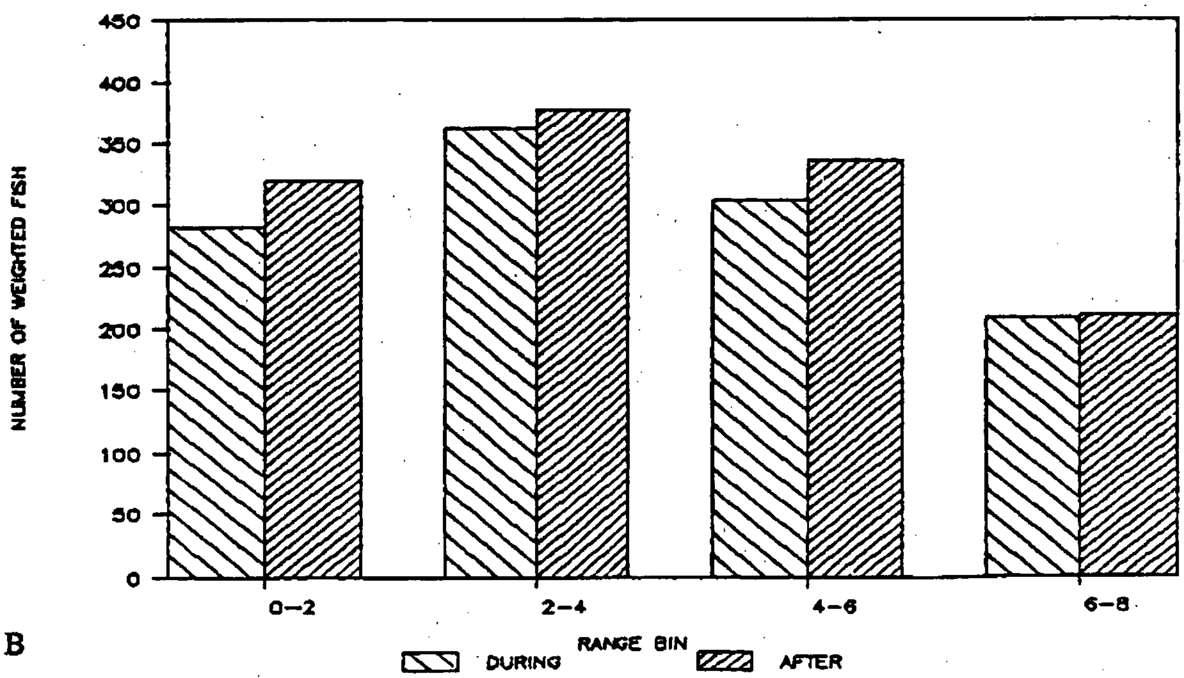


B

Figure 26. Fish density data from the mid-water 6°x12° horizontal transducer at Intake 35 for the February 13, 1227 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

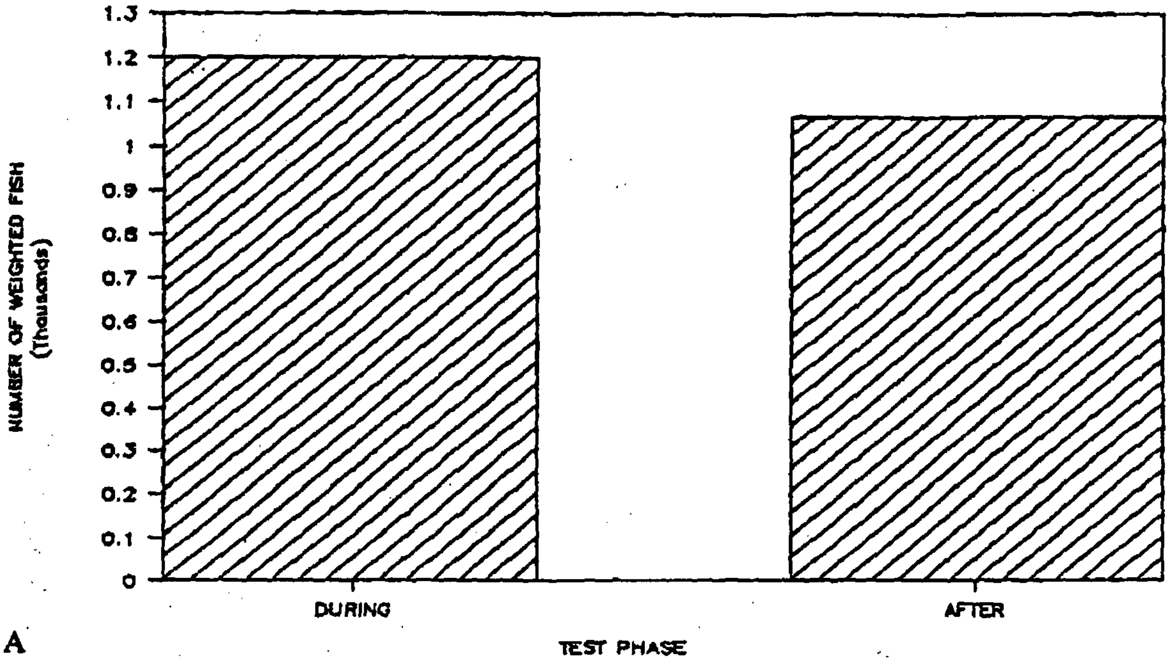


A

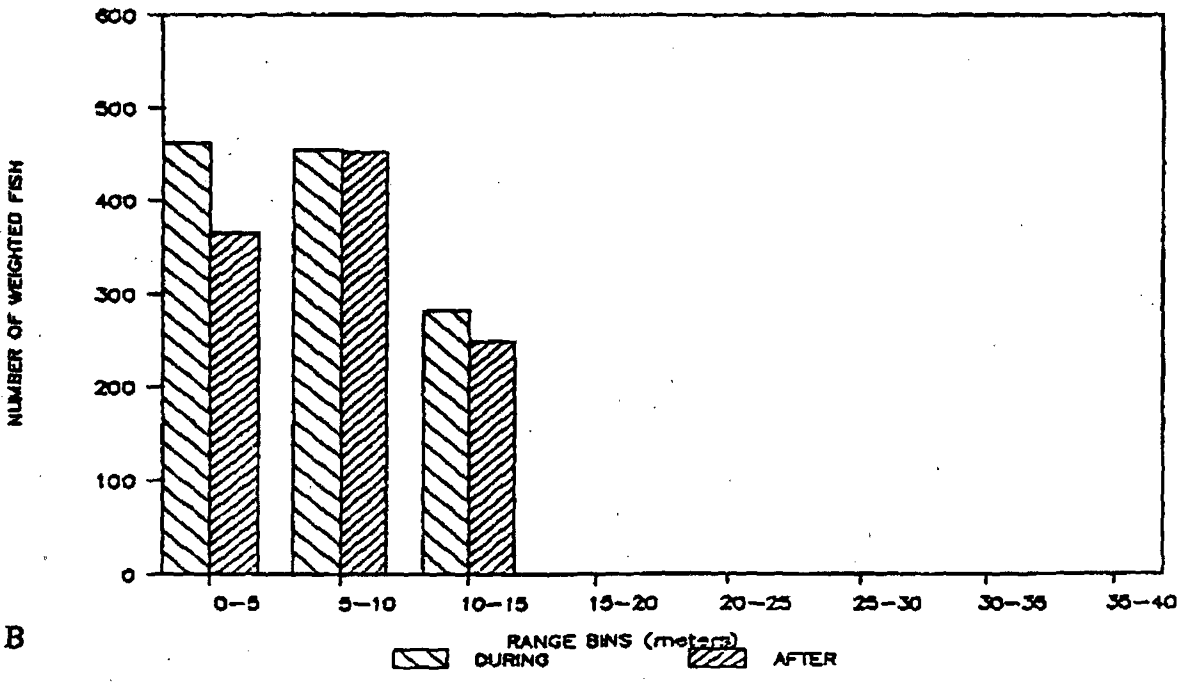


B

Figure 27. Fish density data from the 15° oblique transducer at Intake 35 for the February 13, 1247 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

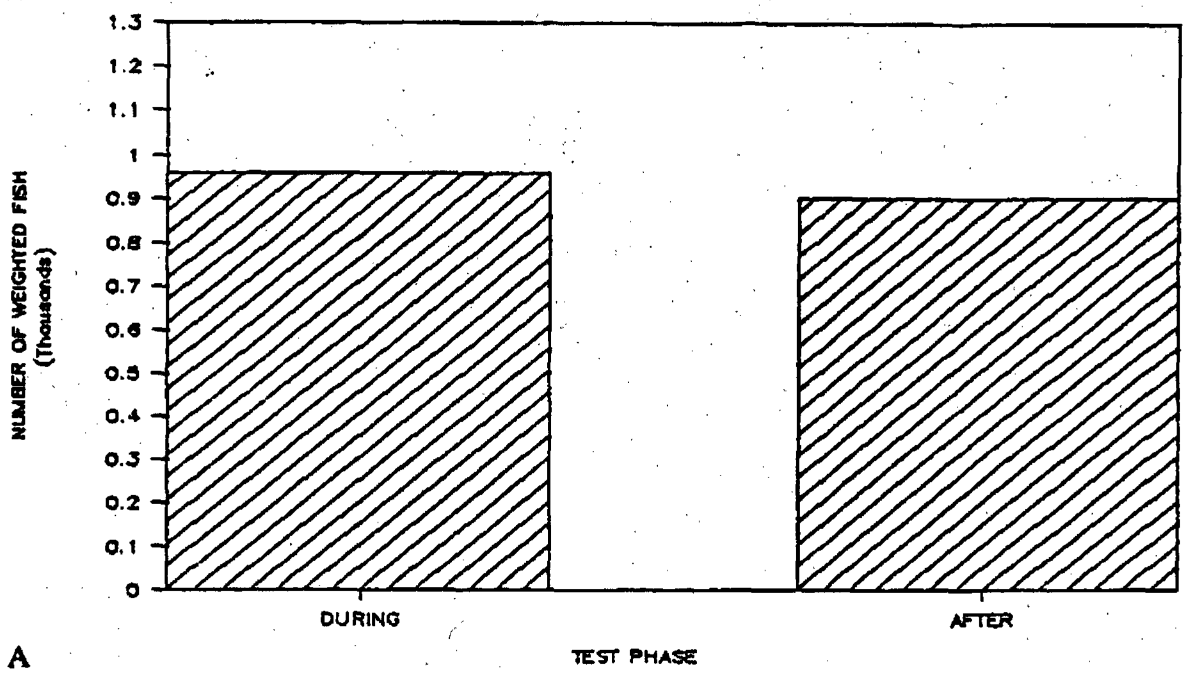


A

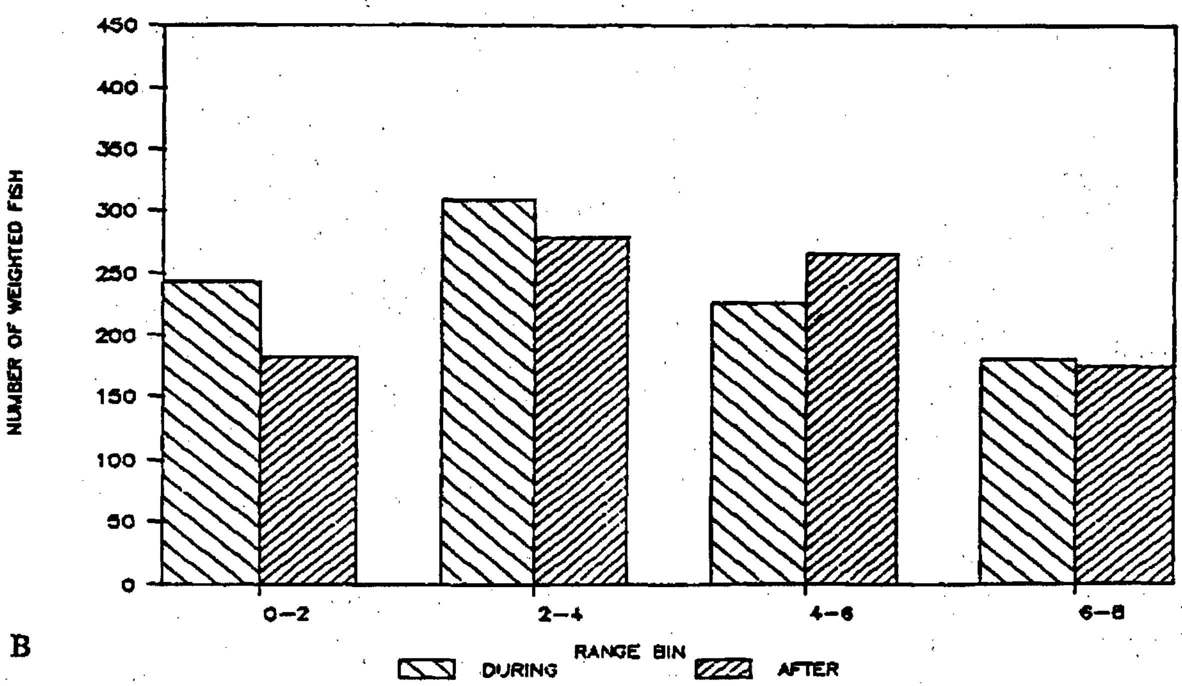


B

Figure 28. Fish density data from the mid-water 6°x12° horizontal transducer at Intake 35 for the February 13, 1247 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

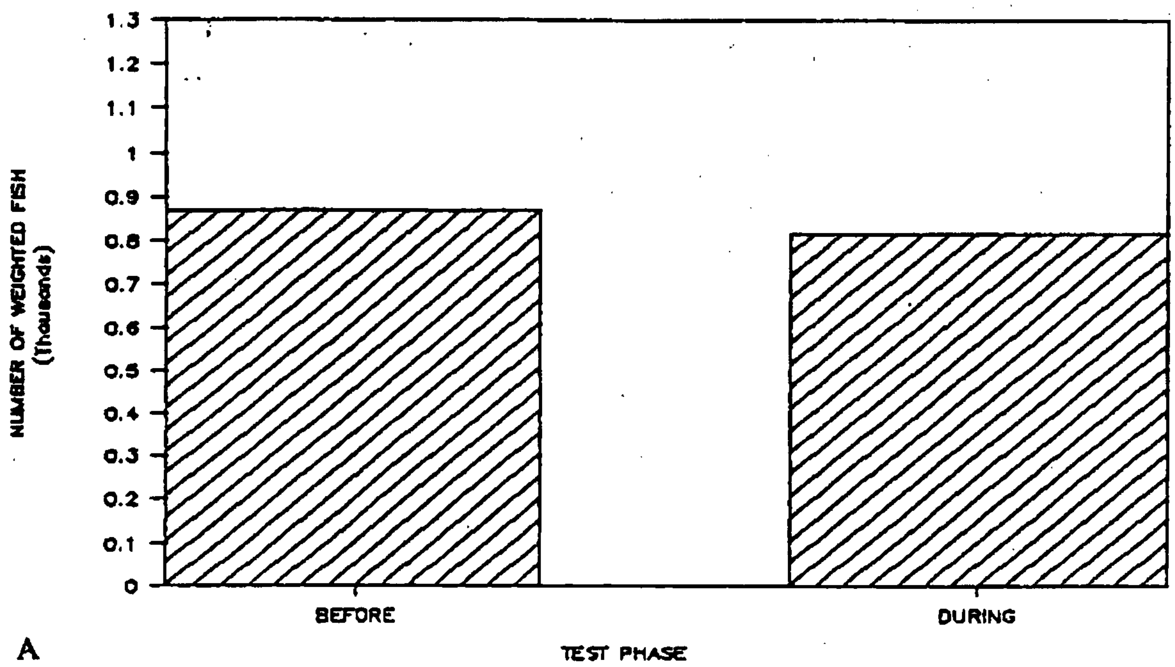


A

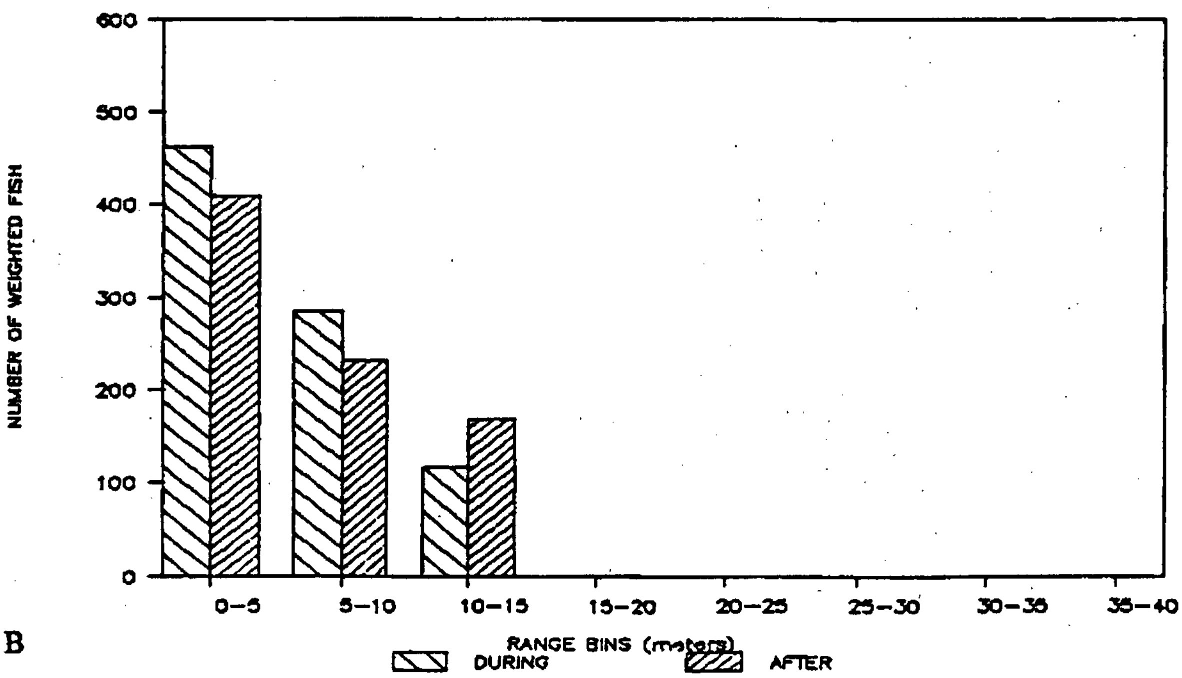


B

Figure 29. Fish density data from the 15° oblique transducer at Intake 35 for the February 13 1307 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

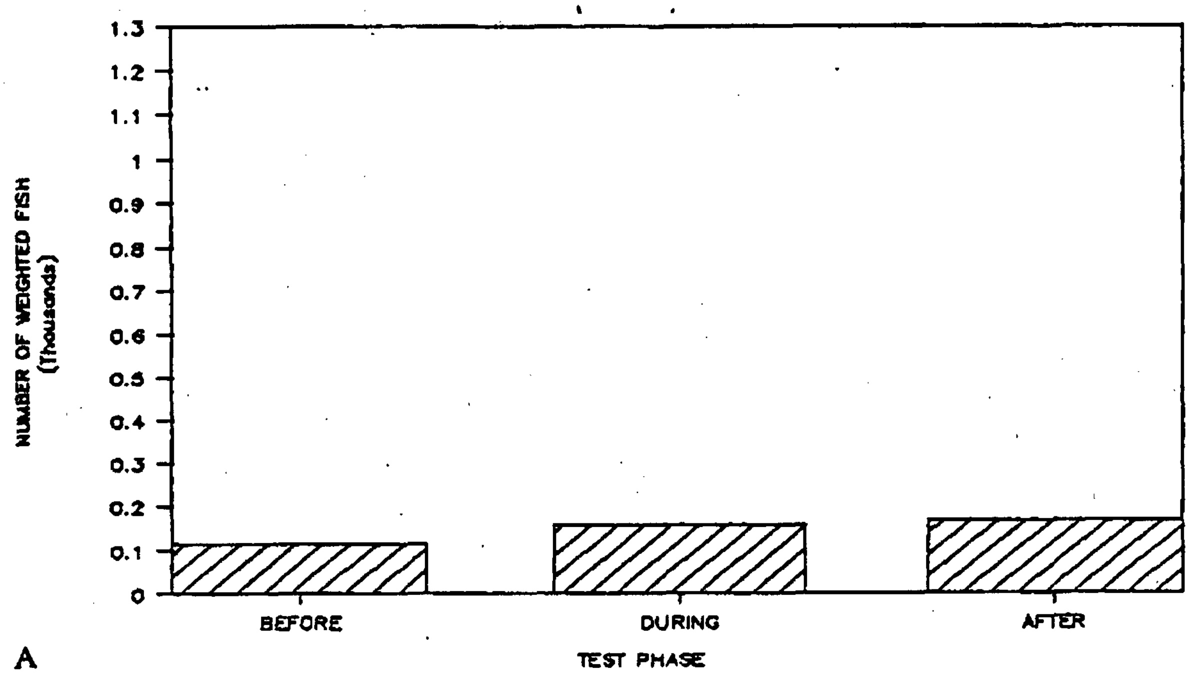


A

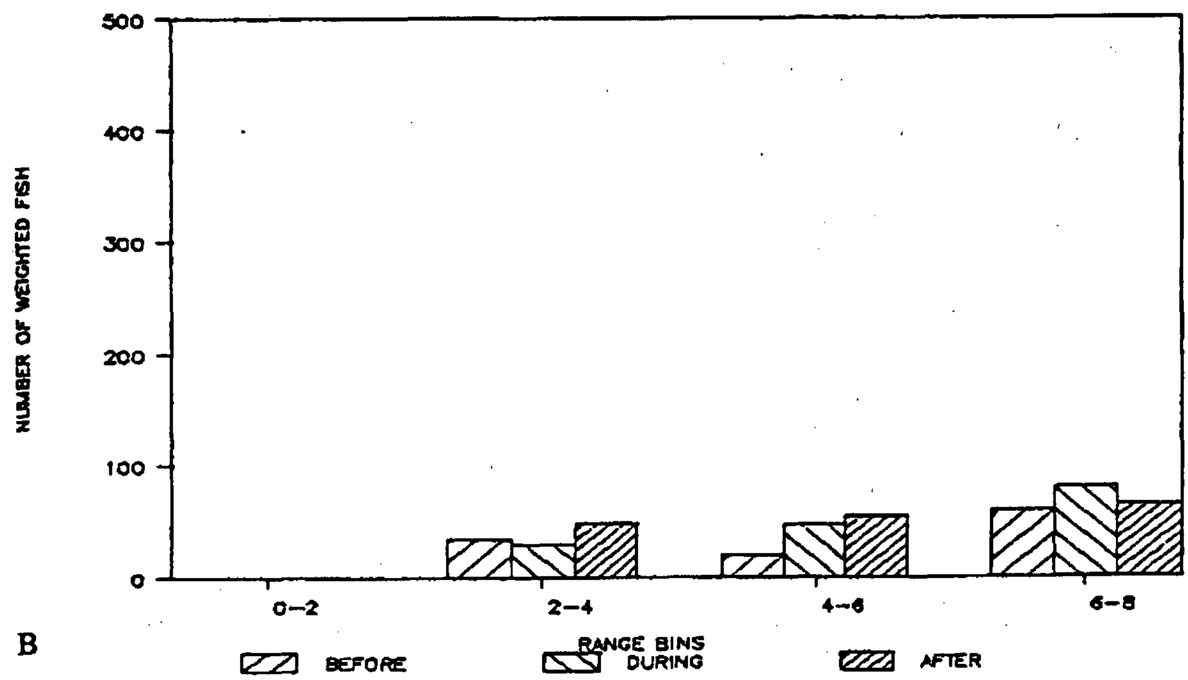


B

Figure 30. Fish density data from the mid-water 6°x12° horizontal transducer at Intake 35 for the February 13, 1307 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.



A



B

Figure 31. Fish density data from the 15° oblique transducer at Intake 35 for the February 13, 2330 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

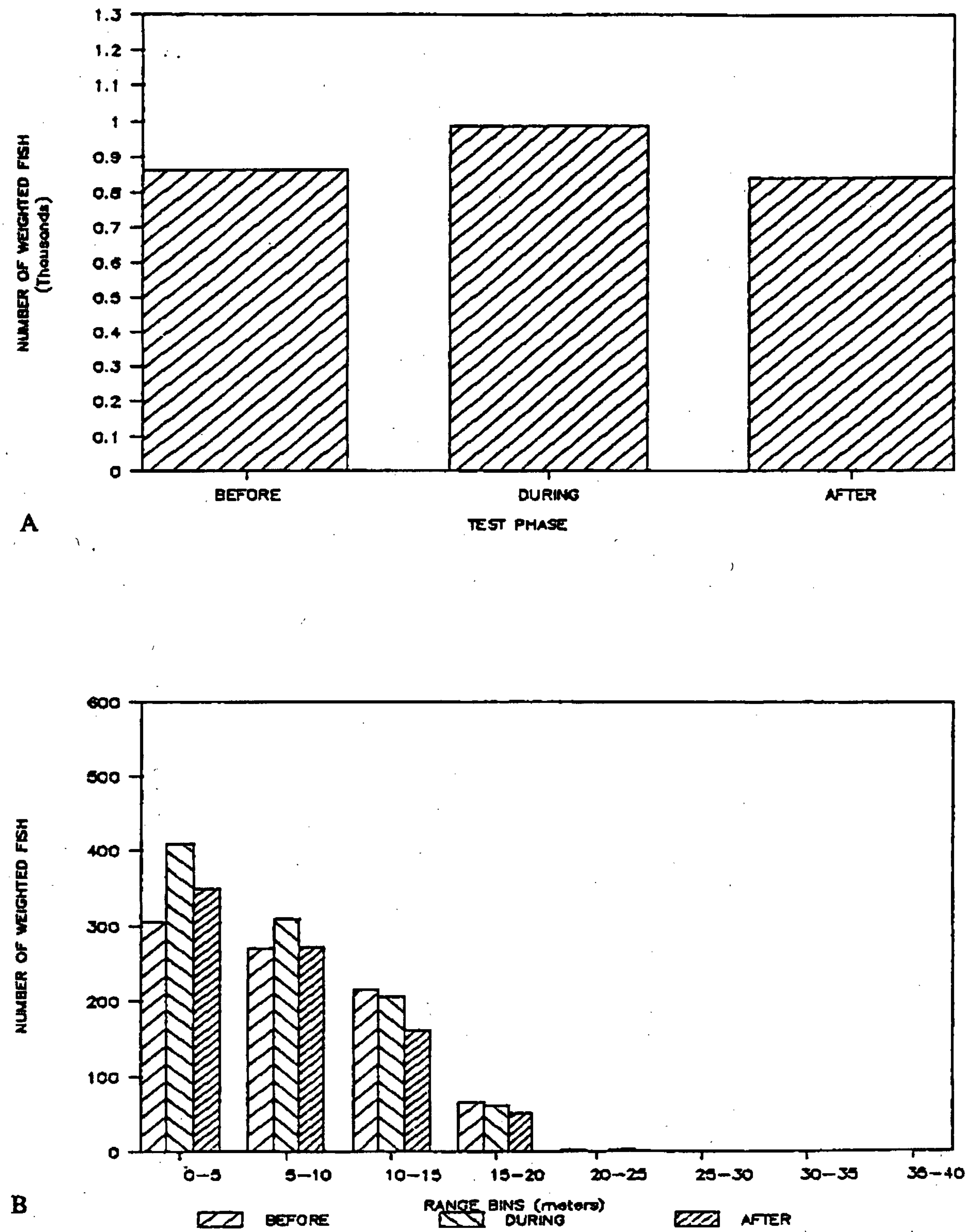
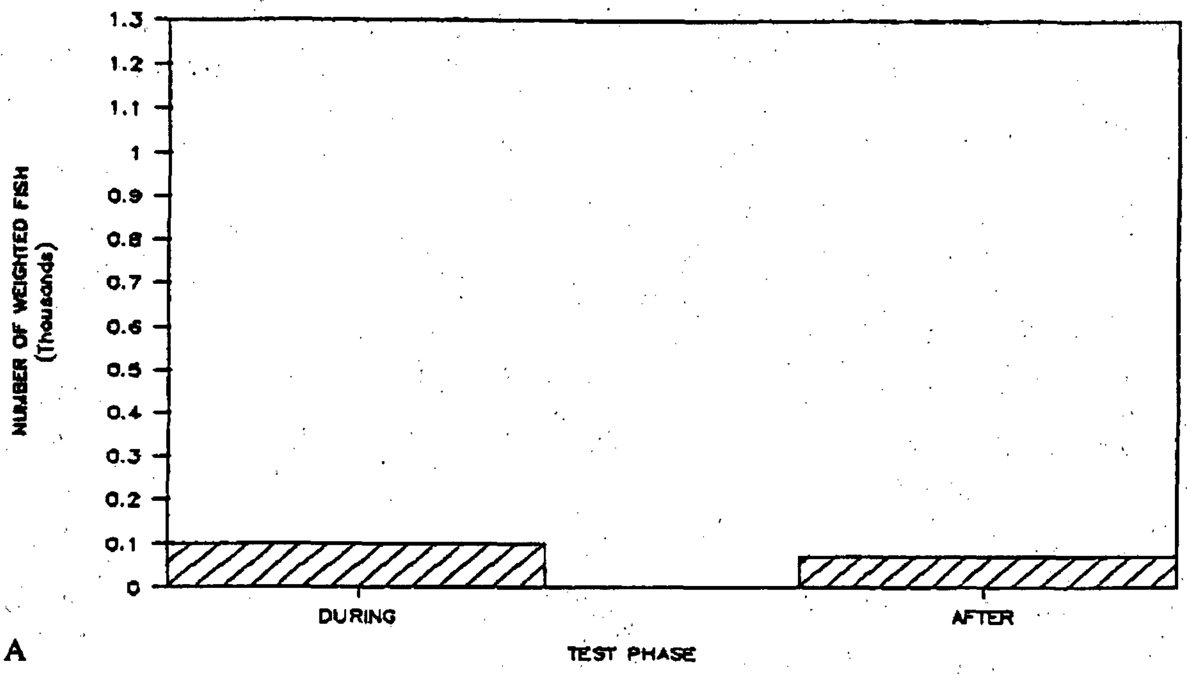
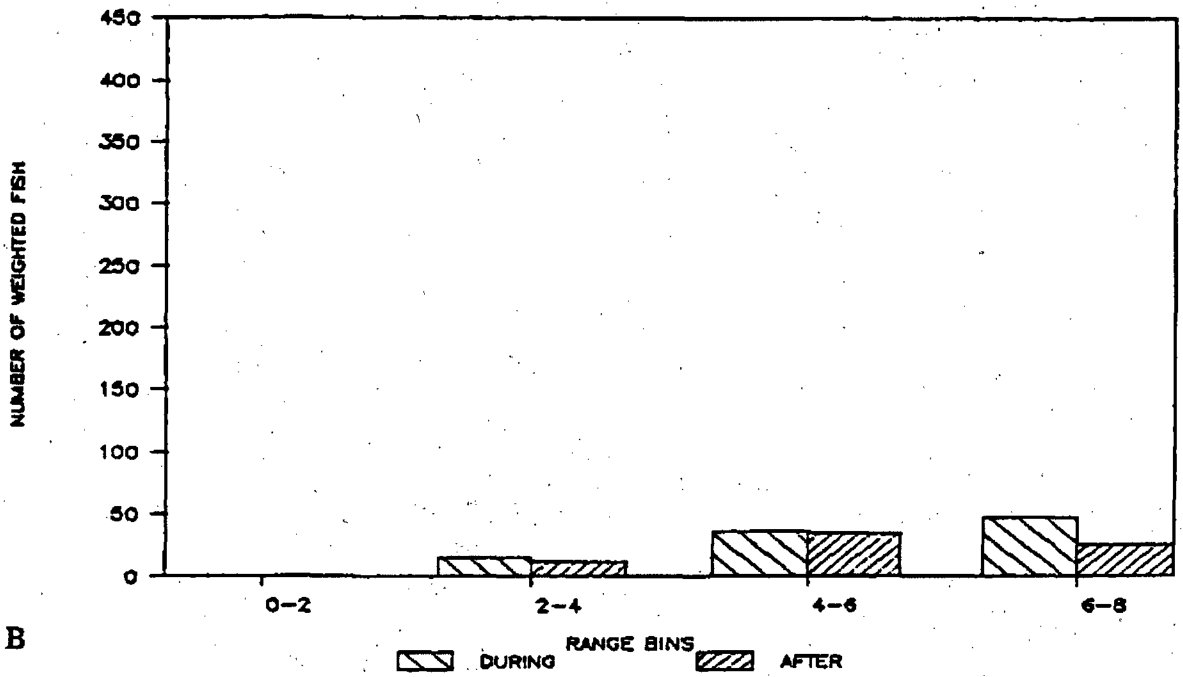


Figure 32. Fish density data from the mid-water 6°x12° horizontal transducer at Intake 35 for the February 13, 2330 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.



A



B

Figure 33. Fish density data from the 15° oblique transducer at Intake 35 for the February 13, 2350 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

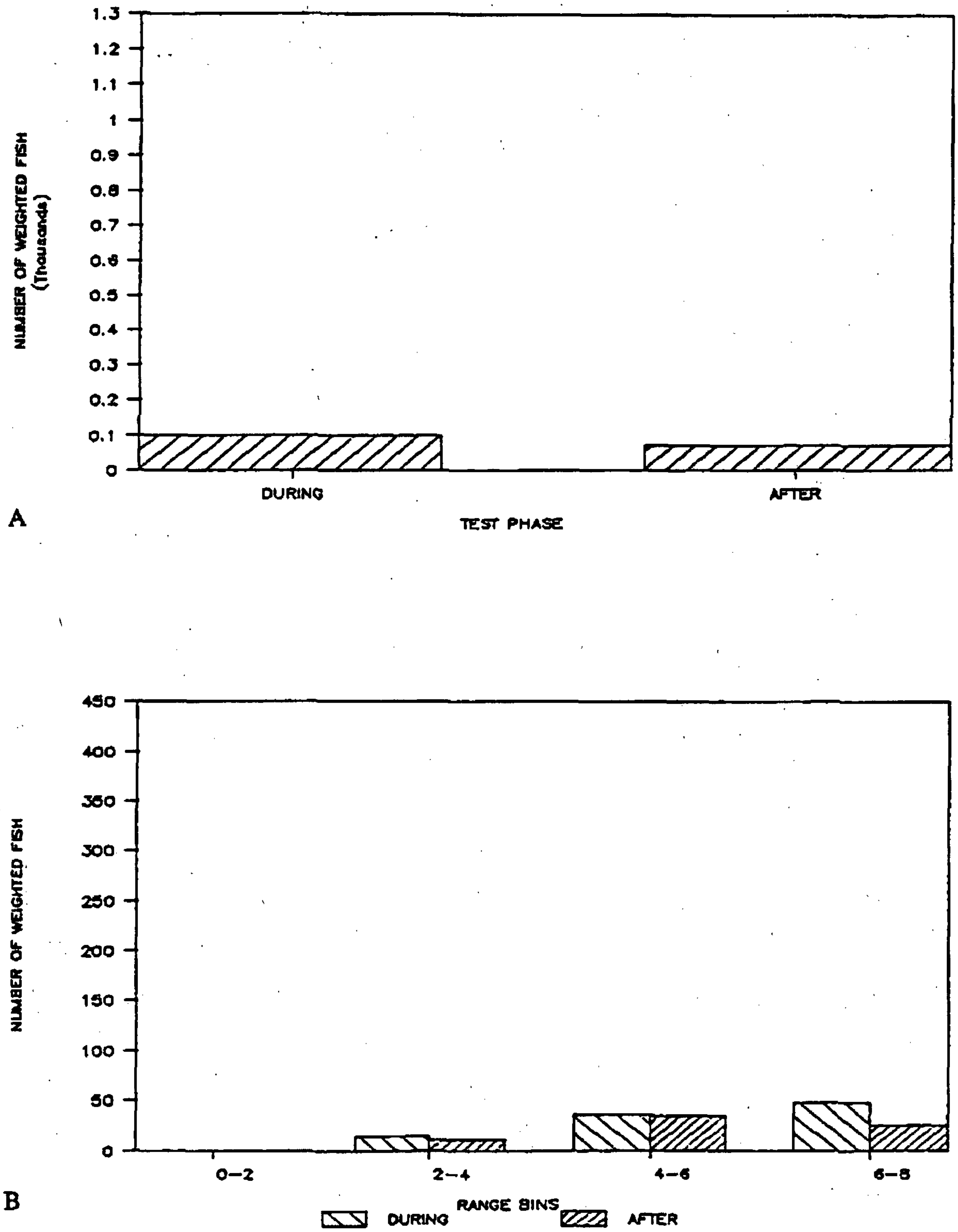
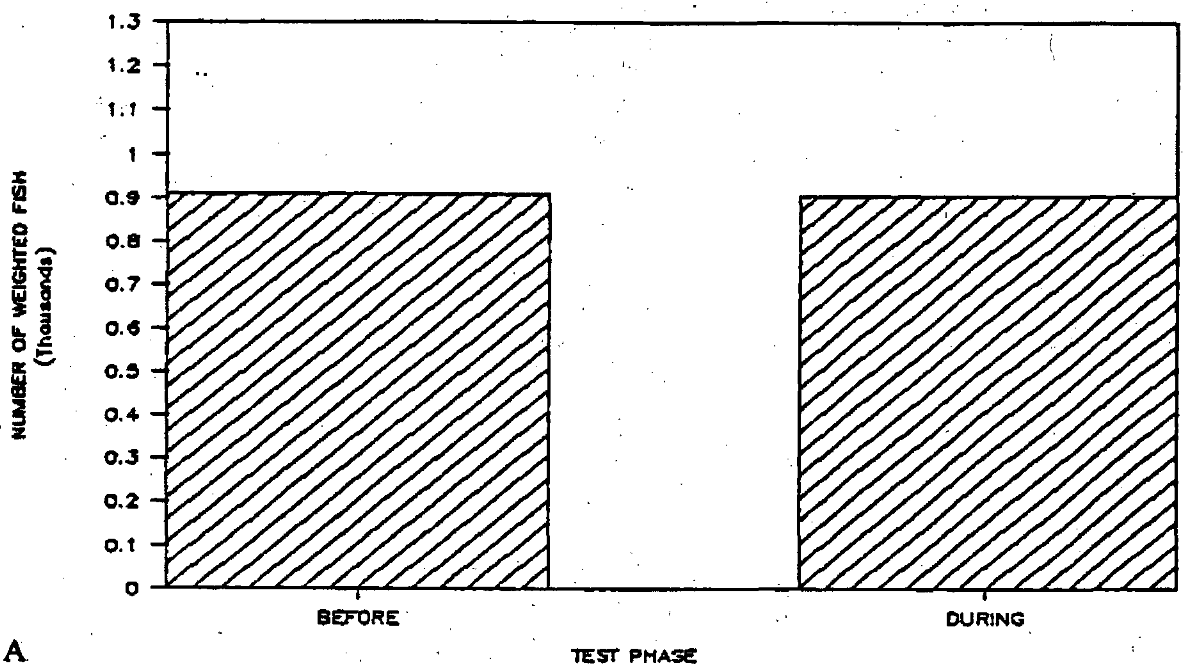
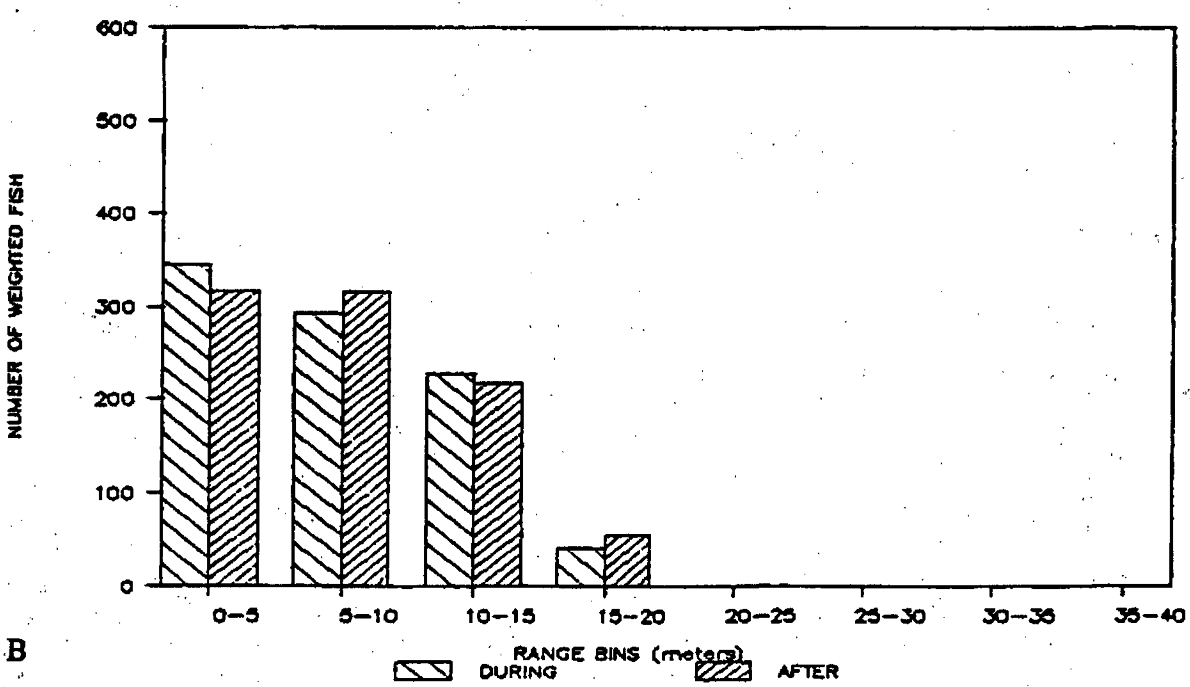


Figure 33. Fish density data from the 15° oblique transducer at Intake 35 for the February 13, 2350 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.



A



B

Figure 34. Fish density data from the mid-water 6°x12° horizontal transducer at Intake 35 for the February 13, 2350 h hammer test. Figure A shows the number of weighted fish for each test phase, and figure B shows the number of weighted fish for each range bin.

Table 1. Hammer test monitoring in front of Unit 3, Intake 35, using a 15° oblique transducer and a 6° x 12° horizontal transducer on January 26 and 27. Indian Point, 1988.

Time of Test	Hammers[1]	Treatment[2]	Test Phase[3] 15°	Test Phase[3] 6°x12°	Range Bins[3] (meters) 15° 0-2	2-4	4-6	6-8	6° x 12° 0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40
2135	1, 2, 3	1':1'		A					A	N	D	D	N	N	N	N
2155	1, 2, 3	10": 20"		A					N	A	N	N	N	N	N	N
2220	2	10": 20"		D					N	D	D	D	N	N	N	N
2245	2	10": 20"		D					N	D	D	N	N	N	N	N
2305	2	5": 10"		B					B	N	B	N	N	—	N	—
2320	1, 2, 3	10": 20"		N												
0005	1, 2, 3	10": 20"	A		A	N	N	A								

[1]Hammers that were on for test, referred to by control box channel number.

[2]Amount of time that hammers were on and off during the test. Ex 1':1' = 1 minute on, 1 minute off; 10": 20" = 10 seconds on, 20 seconds off; cont. = continously on.

[3]Hammer tests and range bins with statistically significant differences (α=.05) in weighted fish numbers between test phases from expected frequencies. Phase with highest numbers noted as: B=Before, D=During, A=After, N=No significant difference between phases. Dashed line indicates no traces.

Table 2. Hammer test monitoring in front of Unit 3, Intake 35, using a 15° oblique transducer and a 6° x 12° horizontal transducer on February 13. Indian Point, 1988.

Time of Test	Hammers[1]	Treatment[2]	Test Phase[3] 15°	Test Phase[3] 6°x12°	Range Bins[3] (meters) 15° 0–2	2–4	4–6	6–8	6° x 12° 0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40
1047	3, 5	10": 20"	N	A	A	D	B	N	A	A	A	N	—	—	—	—
1107	3, 5	10": 30"	A	D	A	N	N	N	A	A	A	N	N	N	N	N
1127	3, 5	10": 40"	N	N												
1147	3, 5	20": 20"	A	B	N	A	N	A	D	N	N	N	—	—	—	—
1207	3, 5	20": 30"	N	N												
1227	3, 5	20": 40"	N	N												
1247	3, 5	30": 20"	N	B					D	N	N	N	—	N	—	—
1307	3, 5	30": 20"	N	N												
2330	3, 5	10": 20"	A	D	—	N	A	N	D	N	B	N	N	—	—	—
2350	3, 5	10": 30"	D	N	—	N	N	D								

1 Hammers that were on for test, referred to by control box channel number.

2 Amount of time that hammers were on and off during the test. Ex 1':1' = 1 minute on, 1 minute off; 10": 20" = 10 seconds on, 20 seconds off; cont. = continously on.

3 Hammer tests and range bins with statistically significant differences (α=.05) in weighted fish numbers between test phases from expected frequencies. Phase with highest numbers noted as: B=Before, D=During, A=After, N=No significant difference between phases. Dashed line indicates no traces.

Table 3. Hammer test monitoring in front of Unit 3, Intake 35, using a 15° oblique transducer and a 6° x 12° horizontal transducer on February 4. Indian Point, 1988.

					Range Bins[3] (meters)											
Time of			Test Phase[3]		15°				6° x 12°							
Test	Hammers[1]	Treatment[2]	15°	6°x12°	0–2	2–4	4–6	6–8	0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40
0100	5	10": 20"	D	A	A	D	D	N	A	A	N	N	D	N	N	N
0140	5	10": 20"	N	D					D	A	N	N	N	N	N	N
0200	5	10": 30"	N	N												
0220	5	10": 40"	N	N												
0240	5	20": 20"	N	N												
0300	5	20": 30"	N	N												
0320	5	20": 40"	N	N												
0340	5	30": 20"	D	N	—	D	D	N								
0400	5	30": 30"	A	N	A	A	N	A								
0420	5	30": 40"	N	N												

[1]Hammers that were on for test, referred to by control box channel number.

[2]Amount of time that hammers were on and off during the test. Ex 1':1' = 1 minute on, 1 minute off; 10": 20" = 10 seconds on, 20 seconds off; cont. = continously on.

[3]Hammer tests and range bins with statistically significant differences (α=.05) in weighted fish numbers between test phases from expected frequencies. Phase with highest numbers noted as: B=Before, D=During, A=After, N=No significant difference between phases. Dashed line indicates no traces.

Table 4. Hammer test monitoring in front of Unit 3, Intake 35, using a 15° oblique transducer and a 6° x 12° horizontal transducer on February 18. Indian Point, 1988.

					Range Bins[3] (meters)											
Time of			Test Phase[3]		15°				6° x 12°							
Test	Hammers[1]	Treatment[2]	15°	6°x12°	0-2	2-4	4-6	6-8	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40
0153	1, 2, 3	10": 20"	B	N	—	D	B	B								
0215	1, 2, 3	10": 10"	N	N												
0235	1, 2, 3	10": 40"	A	N	—	A	A	A								
0255	1, 2, 3	20": 20"	N	D					N	N	D	N	N	N	N	N
0315	1, 2, 3	20": 30"	N	N												
1155	1, 2, 3	20": 40"	A	N	—	A	A	N								
1215	1, 2, 3	30": 20"	N	N												
1235	1, 2, 3	30": 30"	D	N	—	D	—	N								
1620	3, 5	10": 30"	D	N	D=A	—	B	N								
1640	3, 5	10": 30"	N	N												
1700	3, 5	10": 40"	D	N	—	D	—	N								
2045	3, 5	10": 20"	N	N												
2115	3, 5	10": 30"	N	N												
2225	3, 5	10": 20"	D	N	B	D	N	A								
2245	3, 5	10": 30"	N	N												
2305	3, 5	10": 40"	A	D	A	A	N	N	—	D	N	—	N	N	—	—
2345	3, 5	20": 20"	N	N												

[1]Hammers that were on for test, referred to by control box channel number.

[2]Amount of time that hammers were on and off during the test. Ex 1':1' = 1 minute on, 1 minute off; 10": 20" = 10 seconds on, 20 seconds off; cont. = continously on.

[3]Hammer tests and range bins with statistically significant differences (α=.05) in weighted fish numbers between test phases from expected frequencies. Phase with highest numbers noted as: B=Before, D=During, A=After, N=No significant difference between phases. Dashed line indicates no traces.

Table 5. Hammer test monitoring in front of Unit 3, Intake 35, using a 15° oblique transducer and a 6° x 12° horizontal transducer on February 19. Indian Point, 1988.

Time of Test	Hammers[1]	Treatment[2]	Test Phase[3] 15°	Test Phase[3] 6°x12°	Range Bins[3] (meters) 15° 0-2	2-4	4-6	6-8	6° x 12° 0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40
0035	1, 2, 3	20": 30"	D	D	—	N	D	N	N	N	N	N	N	N	N	—
0125	1, 2, 3	30": 20"	B=D	N	B=D	N	D	N								
0335	1, 2, 3	30": 30"	N	N												
0355	1, 2, 3	30": 40"	D	N	—	D	D	A								
0415	1, 2, 3	30": 20"	N	N												
0435	1, 2, 3	30": 30"	D	N	—	D	N	N								
1235	1, 2, 3	10": 20"	D	N	—	N	N	N								
1255	1, 2, 3	10": 30"	N	N												
1315	1, 2, 3	10": 40"	D	N	—	N	D	N								
1335	1, 2, 3	20": 20"	D	D	D	N	N	D	D	D	N	N	N	N	N	N
1355	1, 2, 3	20": 30"	D	N	—	N	N	N								
1415	1, 2, 3	20": 40"	N	N												

[1]Hammers that were on for test, referred to by control box channel number.

[2]Amount of time that hammers were on and off during the test. Ex 1':1' = 1 minute on, 1 minute off; 10": 20" = 10 seconds on, 20 seconds off; cont. = continously on.

[3]Hammer tests and range bins with statistically significant differences (α=.05) in weighted fish numbers between test phases from expected frequencies. Phase with highest numbers noted as: B=Before, D=During, A=After, N=No significant difference between phases. Dashed line indicates no traces.

Table 6. Hammer test monitoring in front of Unit 3, Intake 35, using a 15° oblique transducer and a 6° x 12° horizontal transducer on February 20. Indian Point, 1988.

					Range Bins[3] (meters)											
Time of			Test Phase[3]		15°				6° x 12°							
Test	Hammers[1]	Treatment[2]	15°	6°x12°	0–2	2–4	4–6	6–8	0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40
0015	3	20": 30"	N	N												
0035	3	20": 40"	D	N	—	D	N	D								
0055	3	20": 20"	N	N												
0445	3	30": 30"	A	D	—	A	A	A	N	A	D	N	N	N	N	N
0505	3	30": 40"	N	N												
0525	3	40": 20"	N	N												
0545	3	40": 30"	D	N	D	N	N	N								
0605	3	40": 40"	N	N												
2155	3	10": 20"	N	N												
2235	3	10": 40"	N	N												
2255	3	10": 20"	D	N	—	D	N	N								

[1]Hammers that were on for test, referred to by control box channel number.

[2]Amount of time that hammers were on and off during the test. Ex 1':1' = 1 minute on, 1 minute off; 10": 20" = 10 seconds on, 20 seconds off; cont. = continously on.

[3]Hammer tests and range bins with statistically significant differences (α=.05) in weighted fish numbers between test phases from expected frequencies. Phase with highest numbers noted as: B=Before, D=During, A=After, N=No significant difference between phases. Dashed line indicates no traces.

Table 7. Hammer test monitoring in front of Unit 3, Intake 35, using a 6° vertical transducer on February 23, 24, 25, 26, and 27. Indian Point, 1988.

Date	Time	Hammers[1]	Treatment[2]	Test Phase[3]	LS[4]	Range Bins[3] (meters) 0–1	1–2	2–3	3–4	4–5	5–6	6–7
2/23	1822	1, 3	CONT.	N								
2/23	1941	1, 3	CONT.	N								
2/23	2015	1, 3	CONT.	N								
2/24	1330	1, 3	CONT.	N								
2/24	1358	1, 3	CONT.	D	D	—	—	—	N	N	D	N
2/24	1419	1, 3	CONT.	D	N	—	—	—	N	D	N	N
2/24	1957	1, 3, 5	CONT.	N								
2/24	2244	1, 3, 5	CONT.	D	D	—	—	—	D	D	—	—
2/25	0954	1, 3, 5	CONT.	N								
2/25	1215	1, 3, 5	CONT.	D	D	—	—	—	N	D	N	N
2/25	2026	1, 3, 5	CONT.	D	D	—	—	N	—	—	D	—
2/26	0806	1, 3, 5	CONT.	D	D	—	—	D	N	N	N	N
2/26	0814	1, 3, 5	CONT.	N								
2/26	0828	1, 3	CONT.	D	D	—	—	—	—	—	D	N
2/26	0849	1, 3, 5	CONT.	N								
2/26	0924	1, 3, 5	CONT.	N								
2/26	1007	5	CONT.	B	B	—	A	—	—	D	B	B=D
2/26	1027	1, 3	CONT.	D	D	—	—	—	D	N	N	N

[1]Hammers that were on for test, referred to by control box channel number.

[2]Amount of time that hammers were on and off during the test. Ex 1':1' = 1 minute on, 1 minute off; 10": 20" = 10 seconds on, 20 seconds off; cont. = continously on.

[3]Hammer tests and range bins with statistically significant differences (α=.05) in weighted fish numbers between test phases from expected frequencies. Phase with highest numbers noted as: B=Before, D=During, A=After, N=No significant difference between phases. Dashed line indicates no traces.

[4]Test phase with statistically significant difference in weighted Long to Short trace types between test phases from expected frequencies. Test phase with highest LS trace types noted as in footnote 3.

Table 7, cont.

Date	Time	Hammers[1]	Treatment[2]	Test Phase[3]	LS[4]	Range Bins[3] (meters) 0–1	1–2	2–3	3–4	4–5	5–6	6–7
2/26	1047	1, 3, 5	CONT.	N								
2/26	1348	1, 3, 5	CONT.	B=D	D	—	—	D	N	N	B	B
2/26	1800	1, 3, 5	CONT.	B=A	N	—	—	B=A	N	N	N	—
2/26	2040	5	CONT.	N								
2/26	2100	1, 3, 5	CONT.	N								
2/26	2123	1, 3	CONT.	N								
2/26	2140	5	CONT.	D	D	—	D	—	D	D	N	N
2/26	2200	1, 3, 5	CONT.	D	D	—	D	N	N	N	N	N
2/26	2220	1, 3	CONT.	A	N	—	A	—	N	N	A	N
2/26	2240	5	CONT.	A	N	—	—	—	—	N	N	N
2/26	2300	1, 3, 5	CONT.	D	D	—	—	—	D	D	N	N
2/26	2320	1, 3, 5	CONT.	D	D	—	—	—	N	D	N	N
2/26	2342	1, 3, 5	CONT.	D	N	—	—	—	N	D	N	N
2/27	0002	1, 3, 5	CONT.	D	D	D	—	N	N	D	N	N
2/27	1750	1, 3, 5	CONT.	D	N	—	—	N	D	D	B	N
2/27	1810	1, 3, 5	CONT.	N								
2/27	1830	1, 3, 5	CONT.	D	D	D	—	N	D	D	N	N
2/27	1850	1, 3	CONT.	N								

[1]Hammers that were on for test, referred to by control box channel number.

[2]Amount of time that hammers were on and off during the test. Ex 1':1' = 1 minute on, 1 minute off; 10": 20" = 10 seconds on, 20 seconds off; cont. = continously on.

[3]Hammer tests and range bins with statistically significant differences (α=.05) in weighted fish numbers between test phases from expected frequencies. Phase with highest numbers noted as: B=Before, D=During, A=After, N=No significant difference between phases. Dashed line indicates no traces.

[4]Test phase with statistically significant difference is weighted Long to Short trace types between test phases from expected frequencies. Test phase with highest LS trace types noted as in footnote 3.

Table 8. Hammer test monitoring in front of Unit 3, Intake 36, using a 6° oblique transducer and the bottom oriented 6° x 12° horizontal transducer on March 3. Indian Point, 1988.

Time of Test	Hammers[1]	Treatment[2]	Test Phase[3] 6°	Test Phase[3] 6°x12°	Range Bins[3] (meters) 6° LS[4]	0–1	1–2	2–3	3–4	4–5	5–6	6–7	6° x 12° 0–5	5–10	10–15	15–20	20–25
0320	1, 3	10": 20"	N	D									N	D	N	N	N
0340	1, 3	CONT.	N	N													
0350	1, 3	CONT.	N	N													
0400	1, 3	10": 20"	D	N	D	D	D	D	D	N	N	N					
0410	1, 3	10": 20"	D	N	D	—	D	N	D	N	A	N					
0420	1, 3	CONT.	N	D									D	D	N	N	N
0440	1, 3, 5	10": 20"	D	N	D	D	D	N	N	N	N	N					
0450	1, 3, 5	10": 20"	N	N													
1600	1, 3, 5	CONT.	B=D	D	D	D	D	B	B	N	D	—	D	D	D=A	D	N
1620	1, 3, 5	CONT.	N	N													
1643	1, 3, 5	CONT.	N	D									D	N	N	N	—
1700	1, 3, 5	CONT.	N	N													
1720	1, 3, 5	10": 20"	N	N													
1740	1, 3, 5	10": 20"	N	N													
1800	1, 3, 5	CONT.	N	N													

[1]Hammers that were on for test, referred to by control box channel number.

[2]Amount of time that hammers were on and off during the test. Ex 1':1' = 1 minute on, 1 minute off; 10": 20" = 10 seconds on, 20 seconds off; cont. = continously on.

[3]Hammer tests and range bins with statistically significant differences (α=.05) in weighted fish numbers between test phases from expected frequencies. Phase with highest numbers noted as: B=Before, D=During, A=After, N=No significant difference between phases. Dashed line indicates no traces.

[4]Test phase with statistically significant difference in weighted Long to Short trace types between test phases from expected frequencies. Test phase with highest LS trace types noted as in footnote 3.

Table 9. Hammer test monitoring in front of Unit 3, Intake 36, using a 6° vertical transducer and the bottom oriented 6° x 12° horizontal transducer on March 4. Indian Point, 1988.

Time of			Test Phase[3]		Range Bins[3] (meters)												
					6°								6° x 12°				
Test	Hammers[1]	Treatment[2]	6°	6°x12°	LS[4]	0–1	1–2	2–3	3–4	4–5	5–6	6–7	0–5	5–10	10–15	15–20	20–25
0330	1, 3	20": 20"	N	D									A	A	N	N	N
0350	1, 3	CONT.	N	D									N	D	N	N	N
0410	1, 3	20": 20"	N	N													
0430	3	CONT.	D	D	N	—	A	—	D	N	N	N	N	N	D	N	N
0450	3	CONT.	N	D									N	N	D	N	N
0510	3	CONT.	D	A	D	D	—	—	N	N	D	—	A	N	N	N	N
0530	3	CONT.	N	N													
0550	3	CONT.	D	D	D	D	D	N	N	N	D	N	D	N	N	N	N

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[1]Hammers that were on for test, referred to by control box channel number.

[2]Amount of time that hammers were on and off during the test. Ex 1':1' = 1 minute on, 1 minute off; 10": 20" = 10 seconds on, 20 seconds off; cont. = continously on.

[3]Hammer tests and range bins with statistically significant differences (α=.05) in weighted fish numbers between test phases from expected frequencies. Phase with highest numbers noted as: B=Before, D=During, A=After, N=No significant difference between phases. Dashed line indicates no traces.

[4]Test phase with statistically significant difference in weighted Long to Short trace types between test phases from expected frequencies. Test phase with highest LS trace types noted as in footnote 3.

APPENDIX A:

Fish Abundance Data

APPENDIX A: Fish Abundance Data

Fish abundance estimates were calculated for the period of January 16 to February 22, with only several brief periods when monitoring was interrupted. The mid-water 6° X 12° horizontal transducer was used to gather the hourly estimates of fish density in front of Unit 3, Intake 35. Fish traces were enumerated from the echograms, weighted by range bin and extrapolated if sample time was less than an hour.

Tidal information was obtained during the project with high and low tide values used for New York (The Battery), N.Y. Correction factors used to adjust tide times for Peekskill, N.Y. were high = +2:28 h and low = +3:03 h.

During the first week of the study (January 16 to January 23), high peak fish densities were generally associated with mid-tide levels, and low fish densities occurred at low tide. This trend continued on through the second week and the beginning of the third week (January 24 to February 2). Towards the end of the third week fish densities decreased dramatically, remaining at low densities on into the fifth week (February 4 to February 12). Toward the middle of the fifth week of the study until the end of the 24 h monitoring (February 14 to February 22), overall fish densities began to increase gradually with the same trend for high and low peak fish densities as was observed in the beginning of the project.

The two time periods when the highest fish densities of the project were observed (January 26–27, and January 13), both occurred just before or during low tides.

A possible explanation for the trends observed in fish densities in front of the intakes may be related to the behavior of fish following the freshwater zones of the river influenced by tidal variations. As the saltwater wedge recedes downriver during an ebb tide, fish upriver within the freshwater zone may move downstream. The river channels in front of the power plant may then funnel these fish toward the plant's intakes.

Fish density increases prior to high tide could be related to fish milling near the power plant's outflow. During the onset of high tide, a freshwater plume, caused by the outflow of the power plant, may be pushed upriver and directed by the river channels into the power plant's intakes. Fish within this plume would then be directed toward the intakes.

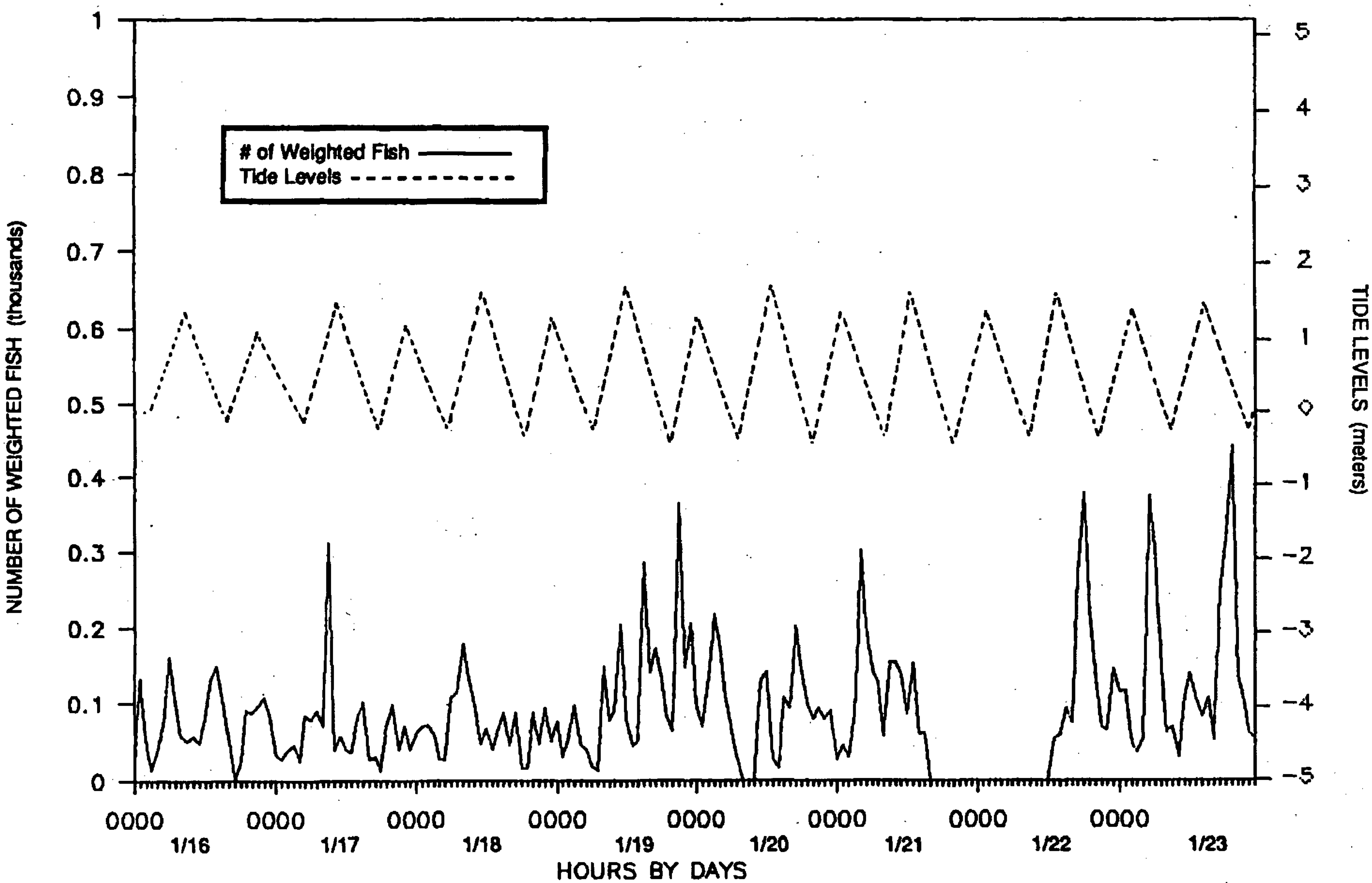


Figure A1. Hourly estimates of fish abundance with high and low tide levels in front of Unit 3, Intake 35 for January 16 to 23, Indian Point, 1988.

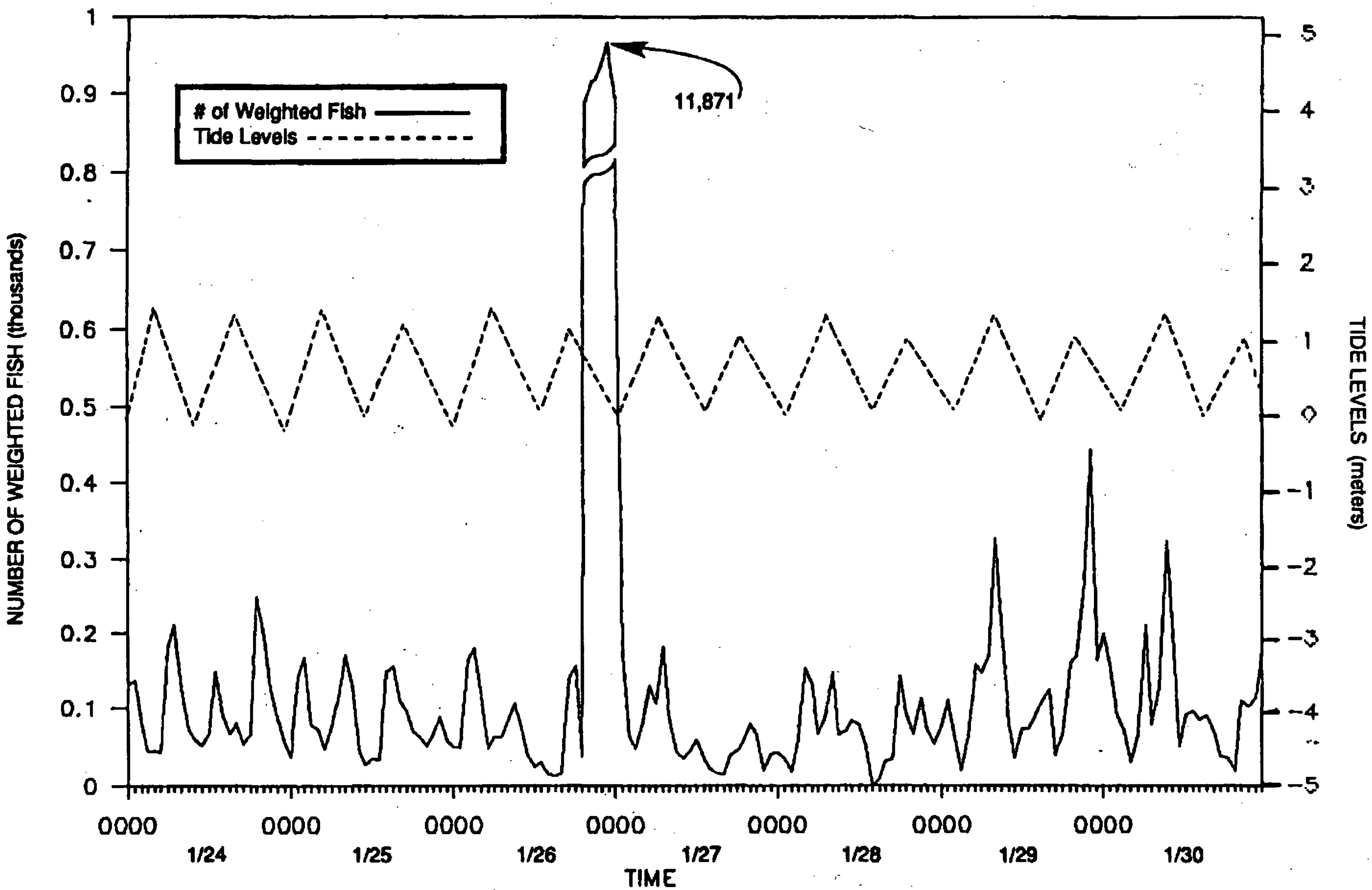


Figure A2. Hourly estimates of fish abundance with high and low tide levels in front of Unit 3, Intake 35 for January 24 to 30, Indian Point, 1988.

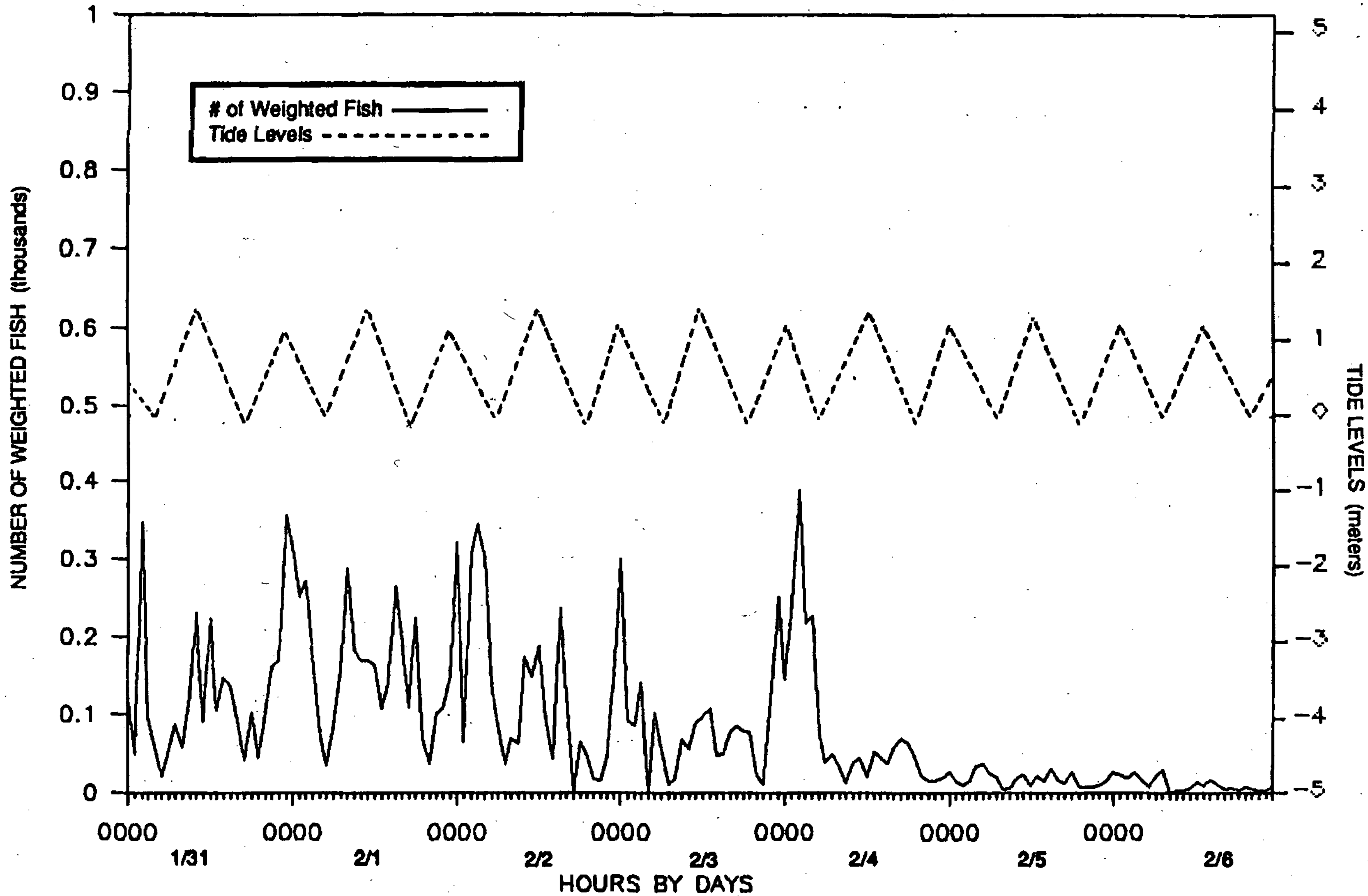


Figure A3. Hourly estimates of fish abundance with high and low tide levels in front of Unit 3, Intake 35 for January 31 to February 6, Indian Point, 1988.

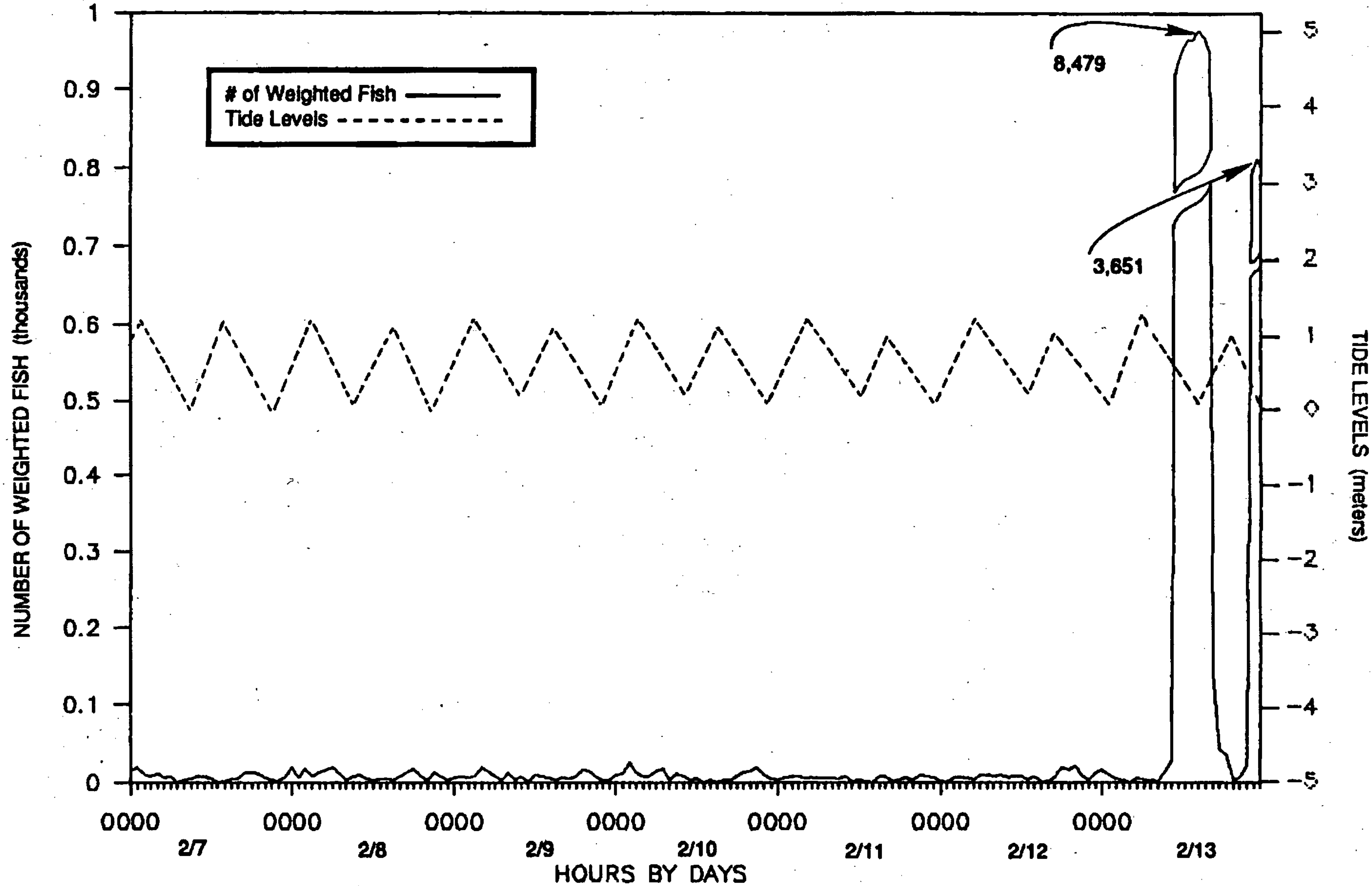


Figure A4. Hourly estimates of fish abundance with high and low tide levels in front of Unit 3, Intake 35 for February 7 to 13, Indian Point, 1988.

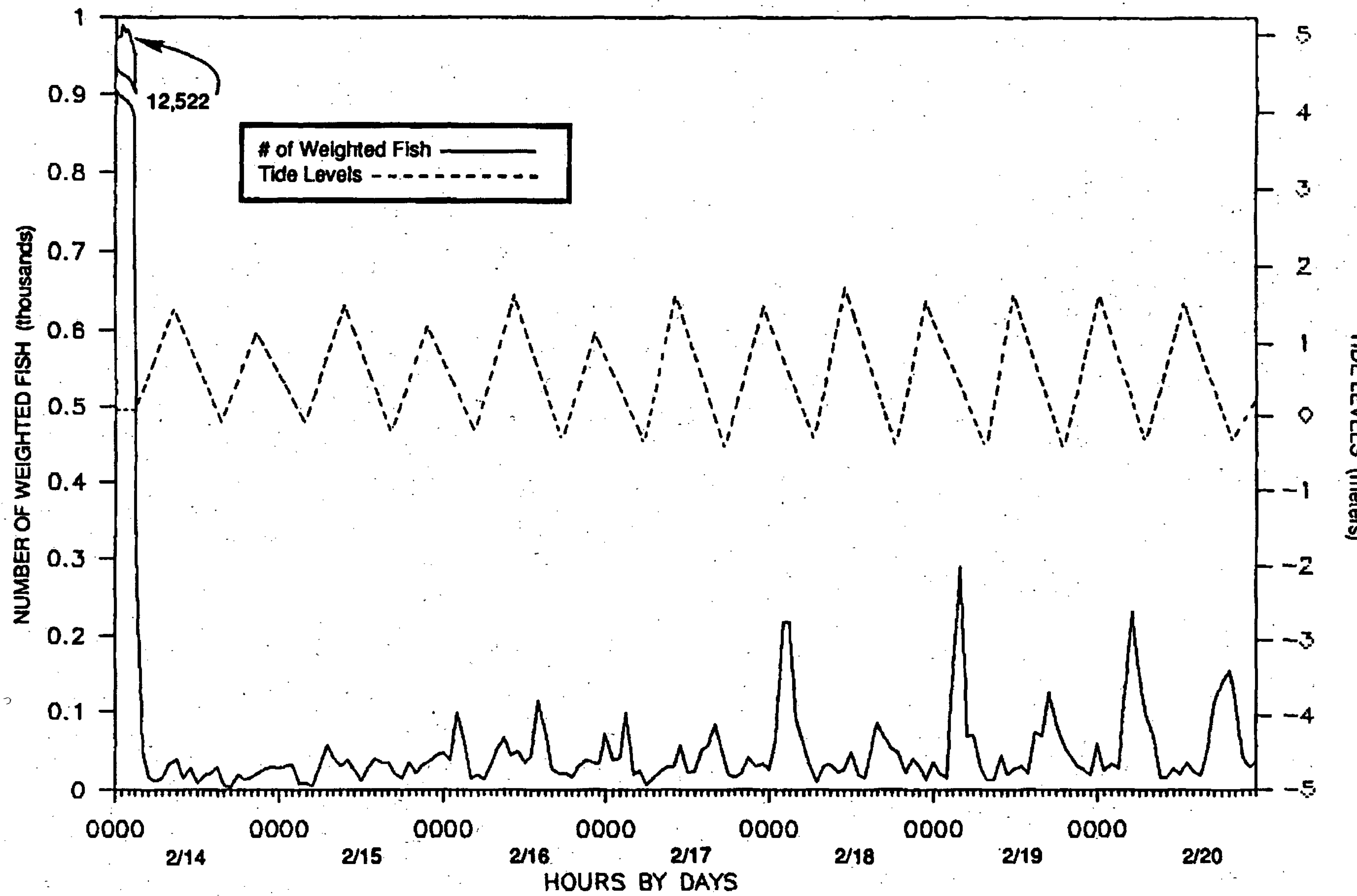


Figure A5. Hourly estimates of fish abundance with high and low tide levels in front of Unit 3, Intake 35 for February 14 to 20, Indian Point, 1988.

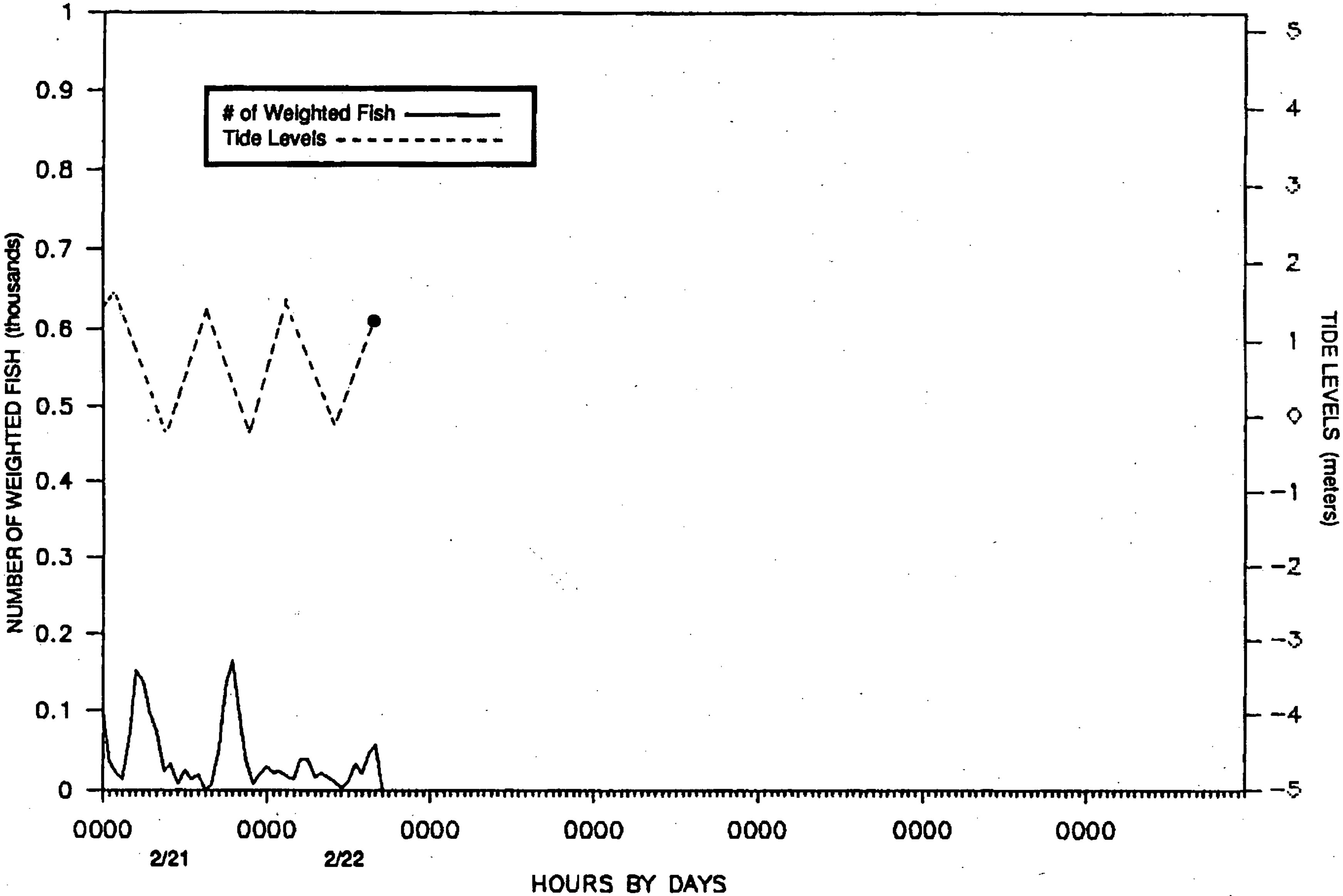


Figure A6. Hourly estimates of fish abundance with high and low tide levels in front of Unit 3, Intake 35 for February 21 to 22, Indian Point, 1988.

Table A1. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for January 16. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL [1]	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	0	0	0	0	1	1	1	1	2	2	1	1	2	1	0	0	21	18
0100	1	4	6	11	8	10	11	10	2	2	3	2	9	5	0	0	120	132
0200	0	0	3	6	2	2	1	1	5	4	1	1	0	0	0	0	36	42
0300	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	12
0400	1	4	1	2	5	6	0	0	1	1	0	0	0	0	0	0	24	39
0500	3	11	3	6	6	7	0	0	0	0	0	0	0	0	0	0	36	72
0600	4	15	7	13	16	19	6	5	1	1	1	1	0	0	0	0	105	162
0700	1	4	1	2	7	8	14	13	5	4	3	2	1	1	1	0	99	102
0800	0	0	2	4	3	4	7	6	6	5	0	0	0	0	0	0	54	57
0900	0	0	4	8	3	4	2	2	0	0	1	1	4	2	0	0	42	51
1000	0	0	1	2	4	5	5	5	3	2	3	2	5	3	0	0	63	57
1100	0	0	0	0	4	5	3	3	4	3	2	1	8	4	1	0	66	48
1200	0	0	3	6	3	4	3	3	1	1	7	4	18	9	1	0	108	81
1300	0	0	5	9	6	7	5	5	1	1	25	15	14	7	0	0	168	132
1400	0	0	4	8	3	4	14	13	19	14	11	7	7	4	0	0	174	150
1500	0	0	2	4	5	6	11	10	16	12	4	2	2	1	0	0	120	105
1600	0	0	0	0	2	2	7	6	11	8	0	0	1	1	0	0	63	51
1700	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1800	1	4	2	4	0	0	0	0	1	1	0	0	0	0	0	0	12	27
1900	2	7	8	15	7	8	0	0	0	0	0	0	0	0	0	0	51	90
2000	2	7	4	8	8	10	3	3	1	1	0	0	0	0	0	0	54	87
2100	0	0	7	13	4	5	8	7	7	5	3	2	0	0	0	0	87	96
2200	4	15	2	4	3	4	5	5	7	5	2	1	4	2	0	0	81	108
2300	1	4	4	8	2	2	2	2	3	2	8	5	8	4	1	0	87	81
Bin Total	21	79	69	133	102	123	108	100	96	74	75	47	83	44	4	0	1674	1800

1) Numbers have been extrapolated for 20 minute sample time.

Table A2. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for January 17. Indian Point, 1988.

Hour	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40 [1]		HOURLY TOTAL [2]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	0	0	1	2	2	2	0	0	2	2	4	2	5	3	0	0	42	33
0100	1	4	0	0	0	0	2	2	0	0	5	3	0	0	0	0	24	27
0200	0	0	1	2	1	1	1	1	1	1	8	5	6	3	0	0	54	39
0300	0	0	0	0	0	0	1	1	6	5	9	5	8	4	0	0	72	45
0400	0	0	2	4	0	0	1	1	0	0	4	2	1	1	0	0	24	24
0500	2	7	7	13	4	5	1	1	1	1	1	1	0	0	0	0	48	84
0600	3	11	2	4	1	1	6	5	5	4	2	1	0	0	0	0	57	78
0700	3	11	4	8	4	5	6	5	0	0	0	0	1	1	0	0	54	90
0800	1	4	3	6	6	7	4	4	3	2	0	0	0	0	0	0	51	69
0900	1	4	15	28	27	92	24	22	10	8	13	8	3	2	0	0	279	312
1000	1	4	0	0	3	4	2	2	2	2	0	0	1	1	0	0	27	39
1100	1	4	0	0	2	2	4	4	5	4	5	3	4	2	0	0	63	57
1200	1	4	0	0	2	2	2	2	4	3	3	2	0	0	0	0	36	39
1300	0	0	0	0	1	1	4	4	1	1	8	5	1	1	0	0	45	36
1400	1	4	1	2	4	5	4	4	8	6	5	3	6	3	0	0	87	81
1500	1	4	0	0	5	6	9	8	8	6	8	5	9	5	0	0	120	102
1600	0	0	1	2	2	2	0	0	1	1	5	3	2	1	0	0	33	27
1700	1	4	0	0	0	0	1	1	2	2	4	2	2	1	0	0	30	30
1800	0	0	0	0	0	0	0	0	3	2	2	1	2	1	0	0	21	12
1900	1	4	1	2	7	8	6	5	2	2	1	1	1	1	0	0	57	69
2000	1	4	5	9	8	10	8	7	3	2	2	1	0	0	0	0	81	99
2100	1	4	1	2	4	5	0	0	2	2	0	0	0	0	0	0	24	39
2200	1	4	4	8	3	4	4	4	1	1	1	1	1	1	0	0	45	69
2300	0	0	0	0	1	1	4	4	4	3	4	2	6	3	0	0	57	39
Bin Total	21	81	48	92	87	103	94	87	74	60	94	56	59	34	0	0	1431	1539

1/ Range bin obstructed by echogram noise.
2/ Numbers have been extrapolated for 20 minute sample time.

Table A3. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for January 18. Indian Point, 1988.

Hour	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40 [1]		HOURLY TOTAL [2]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	0	0	0	0	3	4	4	4	7	5	8	5	4	2		0	78	60
0100	0	0	1	2	3	4	7	6	2	2	8	5	7	4		0	84	69
0200	0	0	1	2	4	5	6	5	7	5	6	4	5	3		0	87	72
0300	0	0	1	2	5	6	1	1	6	5	4	2	7	4		0	72	60
0400	0	0	0	0	1	1	1	1	3	2	4	2	5	3		0	42	27
0500	1	4	1	2	1	1	0	0	0	0	0	0	3	2		0	18	27
0600	3	11	5	9	9	11	2	2	3	2	1	1	0	0		0	69	108
0700	2	7	9	17	2	2	7	6	7	5	2	1	0	0		0	87	114
0800	6	22	7	13	12	14	9	8	2	2	0	0	1	1		0	111	180
0900	2	7	7	13	9	11	9	8	7	5	2	1	0	0		0	108	135
1000	0	0	6	11	9	11	3	3	5	4	5	3	3	2		0	93	102
1100	1	4	2	4	2	2	1	1	2	2	5	3	0	0		0	39	48
1200	0	0	6	11	0	0	5	5	2	2	5	3	2	1		0	60	66
1300	0	0	0	0	3	4	3	3	4	3	3	2	2	1		0	45	39
1400	0	0	0	0	2	2	8	7	8	6	5	3	6	3		0	87	63
1500	0	0	1	2	2	2	12	11	10	8	8	5	1	1		0	102	87
1600	1	4	1	2	0	0	1	1	4	3	5	3	3	2		0	45	45
1700	0	0	6	11	4	5	4	4	3	2	8	5	4	2		0	87	87
1800	0	0	0	0	1	1	1	1	0	0	3	2	2	1		0	21	15
1900	0	0	0	0	1	1	1	1	2	2	0	0	1	1		0	15	15
2000	1	4	5	9	10	12	2	2	3	2	0	0	0	0		0	63	87
2100	0	0	1	2	6	7	3	3	4	3	1	1	0	0		0	45	48
2200	0	0	3	6	7	8	12	11	6	5	1	1	0	0		0	87	93
2300	1	4	2	4	3	4	2	2	2	2	0	0	1	1		0	93	51
Bin Total	18	67	65	122	99	118	104	96	99	77	84	52	57	34	0	0	1578	1698

1) Range bin obstructed by echogram noise.
2) Numbers have been extrapolated for 20 minute sample time.

Table A4. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for January 19. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL 1	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	0	0	5	9	3	4	3	3	7	5	3	2	4	2	0	0	75	75
0100	0	0	0	0	5	6	1	1	0	0	2	1	4	2	0	0	36	30
0200	0	0	1	2	3	4	1	1	7	5	5	3	5	3	2	1	72	57
0300	1	4	4	8	2	2	10	9	2	2	7	4	6	3	0	0	96	96
0400	0	0	4	8	1	1	1	1	0	0	5	3	3	2	1	0	45	45
0500	1	4	1	2	1	1	1	1	1	1	1	1	6	3	0	0	36	39
0600	0	0	0	0	0	0	3	3	1	1	1	1	1	1	0	0	18	18
0700	0	0	1	2	1	1	0	0	0	0	1	1	0	0	0	0	9	12
0800	3	11	7	13	12	14	10	9	4	3	0	0	0	0	0	0	108	150
0900	1	4	4	8	3	4	7	6	2	2	2	1	1	1	0	0	60	78
1000	2	7	9	17	5	6	10	9	7	5	1	1	0	0	0	0	68	90
1100	10	37	11	21	21	25	10	9	7	5	6	4	4	2	0	0	138	206
1200	1	4	8	15	7	8	4	4	7	5	1	1	4	2	0	0	64	78
1300	1	4	2	4	3	4	5	5	7	5	0	0	0	0	0	0	36	44
1400	1	4	1	2	2	2	8	7	8	6	5	3	3	2	0	0	56	52
1500	3	11	11	21	12	14	21	19	28	21	11	7	4	2	0	0	270	285
1600	1	4	5	9	10	12	10	9	8	6	5	3	7	4	0	0	138	141
1700	6	22	5	9	6	7	8	7	9	7	6	4	3	2	0	0	129	174
1800	3	11	7	13	5	6	1	1	9	7	5	3	5	3	0	0	105	132
1900	3	11	1	2	4	5	1	1	5	4	5	3	3	2	0	0	66	84
2000	1	4	4	8	6	7	1	1	1	1	0	0	0	0	0	0	39	63
2100	9	34	27	51	17	20	15	14	4	3	0	0	0	0	0	0	216	366
2200	1	4	11	21	7	8	9	8	10	8	0	0	0	0	0	0	114	147
2300	7	26	9	17	11	13	9	8	6	5	0	0	0	0	0	0	126	207
Bin Total	55	206	138	262	147	174	149	136	140	107	72	46	63	36	3	1	2120	2669

1) Numbers have been extrapolated for 20 minute sample time.

Table A5. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for January 20. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY	TOTAL [1]
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	4	15	5	9	2	2	3	3	5	4	0	0	0	0	0	0	57	99
0100	1	4	3	6	4	5	4	4	5	4	0	0	0	0	0	0	51	69
0200	2	7	4	8	7	8	6	5	10	8	11	7	3	2	0	0	129	135
0300	1	4	7	13	12	14	21	19	20	15	11	7	2	1	0	0	222	219
0400	1	4	6	11	8	10	17	15	9	7	15	9	3	2	0	0	177	174
0500	1	4	7	13	6	7	5	5	2	2	7	4	4	2	0	0	96	111
0600	1	4	4	8	3	4	0	0	6	5	4	2	0	0	0	0	54	69
0700	0	0	2	4	2	2	1	1	0	0	3	2	2	1	0	0	30	30
0800 2		0		0		0		0		0		0		0	0	0	0	0
0900 2		0		0		0		0		0		0		0	0	0	0	0
1000 2		0		0		0		0		0		0		0	0	0	0	0
1100	4	15	8	15	5	6	6	5	1	1	1	1	0	0	0	0	75	129
1200	3	11	10	19	6	7	5	5	6	5	2	1	0	0	0	0	96	144
1300	0	0	1	2	2	2	2	2	3	2	0	0	1	1	0	0	27	27
1400	0	0	0	0	1	1	1	1	2	2	1	1	0	0	0	0	15	15
1500	1	4	5	9	5	6	10	9	5	4	7	4	0	0	0	0	99	108
1600	0	0	7	13	6	7	4	4	7	5	3	2	0	0	0	0	81	93
1700	2	7	7	13	16	19	9	8	17	13	13	8	0	0	0	0	192	204
1800	1	4	8	15	17	20	15	14	18	14	9	5	0	0	0	0	136	144
1900	1	4	4	8	12	14	13	12	8	6	6	4	0	0	0	0	88	96
2000	2	7	4	8	4	5	9	8	12	9	5	3	0	0	0	0	72	80
2100	3	11	6	11	7	8	8	7	10	8	3	2	0	0	0	0	74	94
2200	4	15	4	8	7	8	8	7	3	2	0	0	0	0	0	0	52	80
2300	3	11	6	11	10	12	7	6	5	4	1	1	0	0	0	0	64	90
Bin Total	35	131	108	204	142	167	154	140	154	120	102	63	15	9	0	0	1887	2210

1) Numbers have been extrapolated for 20 or 30 minute sample time.
2) Monitoring shut down for redeployment.

Table A6. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for January 21. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35[1]		35-40[1]		HOURLY TOTAL[2]	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	1	4	2	4	3	4	0	0	1	1	0	0		0		0	14	26
0100	1	4	6	11	3	4	3	3	1	1	0	0		0		0	28	46
0200	1	4	2	4	1	1	4	4	3	2	0	0		0		0	22	30
0300	0	0	7	13	12	14	9	8	6	5	5	3		0		0	78	86
0400	4	15	19	36	28	34	34	31	41	31	6	4		0		0	264	302
0500	1	4	9	17	23	28	32	29	21	16	3	2		0		0	178	192
0600	2	7	6	11	12	14	22	20	22	17	3	2		0		0	134	142
0700	1	4	4	8	4	5	5	5	10	8	3	2		0		0	108	128
0800	0	0	2	4	6	7	11	10	5	4	5	3		0		0	58	56
0900	3	11	9	17	22	26	16	14	13	10		0		0		0	126	156
1000	5	19	12	23	11	13	13	12	14	11		0		0		0	110	156
1100	2	7	11	21	15	18	14	13	13	10		0		0		0	110	198
1200	2	7	6	11	8	10	9	8	9	7		0		0		0	68	86
1300	6	22	9	17	17	20	12	11	9	7		0		0		0	106	154
1400	2	7	5	9	3	4	5	5	7	5		0		0		0	44	60
1500	1	4	0	0	6	7	9	8	10	8	7	4		0		0	66	62
1600 3		0		0		0		0		0		0		0		0	0	0
1700 3		0		0		0		0		0		0		0		0	0	0
1800 3		0		0		0		0		0		0		0		0	0	0
1900 3		0		0		0		0		0		0		0		0	0	0
2000 3		0		0		0		0		0		0		0		0	0	0
2100 3		0		0		0		0		0		0		0		0	0	0
2200 3		0		0		0		0		0		0		0		0	0	0
2300 3		0		0		0		0		0		0		0		0	0	0
Bin Total	32	119	109	206	174	209	198	181	185	143	32	20	0	0	0	0	1514	1820

1) Range bin obstructed by echogram noise.
2) Numbers have been extrapolated for 30 minute sample time.

Table A7. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for January 22. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL[1]	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000 2		0		0		0		0		0		0		0		0	0	0
0100 2		0		0		0		0		0		0		0		0	0	0
0200 2		0		0		0		0		0		0		0		0	0	0
0300 2		0		0		0		0		0		0		0		0	0	0
0400 2		0		0		0		0		0		0		0		0	0	0
0500 2		0		0		0		0		0		0		0		0	0	0
0600 2		0		0		0		0		0		0		0		0	0	0
0700 2		0		0		0		0		0		0		0		0	0	0
0800 2		0		0		0		0		0		0		0		0	0	0
0900 2		0		0		0		0		0		0		0		0	0	0
1000 2		0		0		0		0		0		0		0		0	0	0
1100 2		0		0		0		0		0		0		0		0	0	0
1200 2		0		0		0		0		0		0		0		0	0	0
1300	0	0	2	4	3	4	0	0	1	1	0	0	0	0	0	0	36	54
1400	2	7	3	6	5	6	4	4	1	1	5	3	4	2	0	0	48	58
1500	5	19	3	6	9	11	5	5	3	2	5	3	2	1	0	0	64	94
1600	4	15	2	4	5	6	3	3	7	5	5	3	2	1	1	0	58	74
1700	3	11	9	17	15	18	24	22	24	18	44	26	31	16	16	7	332	270
1800	6	22	21	39	25	30	33	30	34	26	26	16	21	11	35	16	402	380
1900	8	30	8	15	13	16	19	17	13	10	14	8	19	10	12	5	212	222
2000	0	0	3	6	13	16	10	9	12	9	21	13	17	9	9	4	170	132
2100	1	4	0	0	4	5	9	8	7	5	8	5	7	4	6	3	84	68
2200	1	4	2	4	3	4	4	4	7	5	6	4	9	5	4	2	72	64
2300	5	19	7	13	16	19	13	12	7	5	5	3	3	2	1	0	114	146
Bin Total	35	131	60	114	111	135	124	114	116	87	139	84	115	61	84	37	1592	1562

1) Numbers have been extrapolated for 30 minute sample time.
2) Monitoring shut down for redeployment.

Table A8. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for January 23. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL [1]	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	3	11	4	8	8	10	9	8	14	11	11	7	4	2	3	1	112	116
0100	3	11	7	13	15	18	10	9	7	5	4	2	2	1	0	0	96	118
0200	2	7	3	6	2	2	5	5	4	3	0	0	1	1	0	0	34	48
0300	0	0	1	2	5	6	3	3	2	2	3	2	1	1	4	2	38	36
0400	3	11	3	6	1	1	4	4	3	2	4	2	4	2	1	0	46	56
0500	2	7	16	30	32	38	33	30	45	34	55	33	20	10	14	6	434	376
0600	1	4	8	15	27	32	35	32	30	23	40	24	18	9	15	7	522	292
0700	1	4	3	6	16	19	13	12	16	12	18	11	10	5	12	5	178	148
0800	0	0	0	0	10	12	2	2	4	3	11	7	11	6	3	1	82	62
0900	2	7	3	6	3	4	4	4	5	4	7	4	8	4	5	2	74	70
1000	1	4	3	6	0	0	1	1	1	1	1	1	3	2	1	0	22	30
1100	3	11	5	9	9	11	13	12	5	4	6	4	4	2	5	2	100	110
1200	5	19	10	19	10	12	10	9	7	5	6	4	3	2	0	0	102	140
1300	3	11	8	15	10	12	6	5	7	5	7	4	2	1	0	0	86	106
1400	5	19	6	11	3	4	4	4	2	2	1	1	0	0	0	0	42	82
1500	6	22	5	9	5	6	7	6	6	5	6	4	4	2	0	0	78	108
1600	2	7	1	2	1	1	9	8	6	5	2	1	2	1	4	2	54	54
1700	2	7	11	21	35	42	31	28	37	28	46	28	16	8	6	3	276	248
1800	4	15	22	41	49	59	66	59	71	53	92	55	49	25	27	12	380	319
1900	12	45	47	88	75	90	93	84	78	59	63	38	38	19	43	19	449	442
2000	1	4	10	19	23	28	25	23	27	20	22	13	33	17	29	13	170	137
2100	8	30	8	15	12	14	12	11	13	10	23	14	13	7	17	8	106	109
2200	0	0	9	17	8	10	14	13	12	9	7	4	9	5	5	2	64	60
2300	3	11	6	11	6	7	4	4	9	7	7	4	9	5	8	4	52	53
Bin Total	72	267	199	375	365	438	413	376	411	312	442	267	264	137	202	89	3597	3320

1) Numbers have been extrapolated for 20, 30 or 60 minute sample time.

Table A9. Hourly estimates of raw and weighted fish numbers (with high and low tide heights)[1] in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer for week 1, January 16 to 23. Indian Point, 1988.

	JAN 16			JAN 17			JAN 18			JAN 19			JAN 20			JAN 21			JAN 22			JAN 23			WEEKLY TOTAL	
Hour	RAW	WF	Tide	RAW	WF	Tide	RAW	WF	Tide	RAW	WF	Tide	RAW	WF	Tide	RAW	WF	Tide	RAW	WF	Tide	RAW	WF	Tide	RAW	WF
0000	21	18		42	33		78	60		75	75		57	99		14	26	1.4	0	0		112	116		399	427
0100	120	132		24	27		84	69		36	30		51	69		28	46		0	0	1.4	96	118		439	491
0200	36	42	0.0	54	39		87	72		72	57		129	135		22	30		0	0		34	48	1.4	434	423
0300	3	12		72	45	-0.1	72	60		96	96		222	219		78	86		0	0		38	36		581	554
0400	24	39		24	24		42	27	-0.2	45	45		177	174		264	302		0	0		46	56		622	667
0500	36	72		48	84		18	27		36	39	-0.2	96	111		178	192		0	0		434	376		846	901
0600	105	162		57	78		69	108		18	18		54	69	-0.3	134	142		0	0		522	292		959	869
0700	99	102		54	90		87	114		9	12		30	30		108	128	-0.3	0	0		178	148		565	624
0800	54	57	1.4	51	69		111	180		108	150		0	0		58	56		0	0	-0.3	82	62	-0.2	464	574
0900	42	51		279	312	1.5	108	185		60	78		0	0		126	156		0	0		74	70		689	802
1000	63	57		27	39		93	102	1.6	68	90		0	0		110	156		0	0		22	30		383	474
1100	66	48		63	57		39	48		138	206	1.7	75	129		110	138		0	0		100	110		591	736
1200	108	81		36	39		60	66		64	78		96	144	1.7	68	86	1.6	0	0		102	140		534	634
1300	168	132		45	36		45	39		36	44		27	27		106	154		36	54	1.6	86	106		549	592
1400	174	150		87	81		87	63		56	52		15	15		44	60		48	58		42	82	1.5	553	561
1500	120	105	-0.1	120	102		102	87		270	285		99	108		66	62		64	94		78	108		919	951
1600	63	51		33	27	-0.2	45	45		138	141		81	93		0	0		58	74		54	54		472	485
1700	0	0		90	30		87	87	-0.3	129	174		192	204		0	0		332	270		276	248		1046	1013
1800	12	27		21	12		21	15		105	132	-0.4	136	144		0	0		402	380		380	319		1077	1029
1900	51	90		57	69		15	15		66	84		88	96	-0.4	0	0	-0.4	212	222		449	442		938	1018
2000	54	87	1.1	81	99		63	87		39	63		72	80		0	0		170	132	-0.3	170	137		649	685
2100	87	96		24	39	1.2	45	48		216	366		74	94		0	0		84	68		106	109	-0.2	636	820
2200	81	108		45	69		87	93	1.3	114	147		52	80		0	0		72	64		64	60		515	621
2300	87	81		57	39		33	51		126	207	1.3	64	90		0	0		114	146		52	53		593	667
Daily Total	1674	1800		1431	1539		1578	1698		2120	2669		1887	2210		1514	1820		1592	1562		3597	3319		15393	14818

1) Tide heights for low and high tide only, New York (the Battery), N.Y. and times adjusted for Indian Point Location.

Table A10. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for January 24. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL[1]	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	8	30	12	23	26	31	21	19	21	16	11	7	7	4	0	0	106	130
0100	6	22	17	32	34	41	23	21	7	5	22	13	6	3	0	0	115	137
0200	2	7	12	23	21	25	13	12	4	3	6	4	3	2	0	0	61	76
0300	5	19	5	9	5	6	6	5	3	2	2	1	4	2	0	0	30	44
0400	3	11	8	15	5	6	2	2	8	6	4	2	3	2	1	0	34	44
0500	0	0	1	2	12	14	9	8	9	7	14	8	4	2	3	1	52	42
0600	4	15	27	51	28	34	28	25	27	20	34	20	18	9	15	7	181	181
0700	12	45	25	47	28	34	29	26	26	20	27	16	33	17	14	6	194	211
0800	6	22	15	28	20	24	22	20	13	10	10	6	14	7	17	8	117	125
0900	6	22	9	17	11	13	9	8	6	5	9	5	2	1	2	1	54	72
1000	3	11	6	11	11	13	10	9	6	5	9	5	6	3	2	1	53	58
1100	4	15	4	8	4	5	7	6	9	7	9	5	6	3	2	1	45	50
1200	1	4	8	15	13	16	18	16	9	7	7	4	8	4	1	0	65	66
1300	7	26	13	24	30	36	20	18	17	13	33	20	15	8	6	3	141	148
1400	6	22	9	17	17	20	16	14	11	8	11	7	3	2	1	0	74	90
1500	6	22	6	11	8	10	7	6	9	7	8	5	4	2	2	1	50	64
1600	7	26	10	19	11	13	10	9	8	6	6	4	4	2	3	1	59	80
1700	4	15	4	8	9	11	3	3	8	6	6	4	6	3	4	2	44	52
1800	3	11	5	9	9	11	12	11	11	8	11	7	10	5	7	3	68	65
1900	14	52	28	53	41	49	29	26	31	23	36	22	25	13	26	12	230	250
2000	5	19	26	49	27	32	30	27	26	20	33	20	30	15	31	14	208	196
2100	6	22	17	32	26	31	16	14	12	9	10	6	11	6	12	5	110	125
2200	3	11	11	21	20	24	9	8	9	7	13	8	8	4	10	5	83	88
2300	2	7	6	11	5	6	9	8	10	8	8	5	5	3	10	5	55	53
Bin Total	123	456	284	535	421	505	358	321	300	228	339	204	235	122	169	76	2229	2447

1) Numbers have been extrapolated for 60 minute sample time.

Table A11. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for January 25. Indian Point, 1988.

Hour	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	HOURLY TOTAL Raw	HOURLY TOTAL WF [1]
0000	2	7	1	2	1	1	5	5	6	5	6	4	0	0	1	0	33	36
0100	9	34	9	17	28	34	23	21	25	19	24	14	4	2	0	0	122	141
0200	7	26	21	39	27	32	27	24	26	20	31	19	8	4	6	3	153	167
0300	5	19	5	9	20	24	15	14	10	8	2	1	4	2	1	0	62	77
0400	2	7	11	21	15	18	10	9	9	7	12	7	3	2	1	0	63	71
0500	3	11	4	8	5	6	7	6	7	5	11	7	4	2	1	0	42	45
0600	4	15	9	17	15	18	6	5	10	8	10	6	10	5	4	2	68	76
0700	5	19	9	17	17	20	17	15	29	22	21	13	12	6	10	5	120	117
0800	10	37	10	19	21	25	28	25	30	23	35	21	24	12	17	8	175	170
0900	6	22	16	30	24	29	22	20	11	8	13	8	11	6	11	5	114	128
1000	3	11	6	11	5	6	8	7	6	5	6	4	3	2	1	0	38	46
1100	2	7	1	2	3	4	8	7	4	3	2	1	1	1	4	2	25	27
1200	1	4	4	8	4	5	6	5	6	5	4	2	1	1	9	4	35	34
1300	2	7	5	9	5	6	3	3	2	2	7	4	2	1	3	1	29	33
1400	10	37	16	30	30	36	15	14	24	18	17	10	5	3	0	0	117	148
1500	8	30	16	30	17	20	22	20	35	26	39	23	9	5	2	1	148	155
1600	5	19	18	34	13	16	11	10	12	9	16	10	21	11	2	1	98	110
1700	7	26	11	21	12	14	12	11	20	15	12	7	4	2	3	1	81	97
1800	2	7	7	13	11	13	17	15	11	8	14	8	8	4	5	2	75	70
1900	4	15	10	19	7	8	9	8	5	4	6	4	2	1	5	2	48	61
2000	1	4	6	11	9	11	7	6	12	9	5	3	5	3	9	4	54	51
2100	3	11	6	11	12	14	11	10	8	6	3	2	9	5	10	5	62	64
2200	4	15	9	17	14	17	19	17	10	8	8	5	7	4	13	6	84	89
2300	2	7	6	11	10	12	11	10	10	8	5	3	3	2	7	3	54	56
Bin Total	107	397	216	406	325	389	319	287	328	251	309	186	160	86	125	55	1900	2069

1) Numbers have been extrapolated for 60 minute sample time.

Table A12. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for January 26. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	0	0	5	9	8	10	8	7	14	11	10	6	7	4	4	2	56	49
0100	3	11	9	17	4	5	6	5	7	5	7	4	2	1	2	1	40	49
0200	8	30	23	43	23	28	26	23	33	25	15	9	5	3	6	3	139	164
0300	10	37	25	47	23	28	29	26	37	28	19	11	4	2	2	1	149	180
0400	8	30	17	32	15	18	19	17	13	10	13	8	2	1	1	0	88	116
0500	1	4	9	17	9	11	5	5	6	5	7	4	1	1	3	1	41	48
0600	5	19	8	15	7	8	9	8	7	5	7	4	2	1	2	1	47	61
0700	3	11	5	9	6	7	12	11	11	8	13	8	8	4	6	3	64	61
0800	4	15	9	17	11	13	15	14	9	7	14	8	4	2	7	3	73	79
0900	6	22	11	21	15	18	15	14	11	8	17	10	14	7	13	6	102	106
1000	2	7	4	8	13	16	14	13	17	13	16	10	13	7	10	5	89	79
1100	3	11	6	11	8	10	4	4	2	2	3	2	0	0	1	0	27	40
1200	1	4	1	2	8	10	2	2	2	2	0	0	3	2	2	1	19	23
1300	4	15	0	0	3	4	2	2	4	3	2	1	5	3	2	1	22	29
1400	0	0	2	4	0	0	2	2	1	1	1	1	0	0	1	0	12	14
1500	0	0	3	6	2	2	1	1	0	0	2	1	1	1	2	1	11	12
1600	1	4	1	2	3	4	3	3	3	2	0	0	1	1	0	0	12	16
1700	6	22	24	45	13	16	26	23	22	17	15	9	7	4	8	4	121	140
1800	6	22	13	24	13	16	23	21	28	21	12	7	8	4	5	2	144	156
1900	2	7	2	4	7	8	7	6	6	5	9	5	2	1	2	1	37	37
2000	498	1858	456	857	584	701	6	5	6	5	2	1	1	1	3	1	3112	6858
2100	1176	4386	1710	3215	2358	2830	20	18	9	7	7	4	11	6	17	8	5308	10474
2200	1104	4118	1980	3722	3312	3974	96	92	13	10	8	5	12	6	9	4	6474	11671
2300	736	2745	1320	2482	2208	2650	10	9	3	2	1	1	3	2	3	1	6426	11838
Bin Total	3587	13378	5643	10609	8653	10387	300	271	264	202	200	119	116	64	111	50	22613	42499

1) Numbers have been extrapolated for 20-60 minute sample time.

Table A13. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for January 27. Indian Point, 1988.

Hour	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	HOURLY TOTAL Raw	HOURLY TOTAL WF
0000	1	4	72	135	42	50	3	3	2	2	1	1	0	0	2	1	492	784
0100	4	15	22	41	52	62	5	5	3	2	25	15	2	1	2	1	138	170
0200	3	11	9	17	11	13	6	5	16	12	2	1	2	1	3	1	52	61
0300	2	7	5	9	8	10	8	7	6	5	10	6	5	3	3	1	47	48
0400	4	15	5	9	10	12	10	9	17	13	23	14	10	5	9	4	88	81
0500	3	11	12	23	26	31	26	23	20	15	37	22	10	5	1	0	135	130
0600	6	22	13	24	14	17	14	13	17	13	16	10	10	5	6	3	96	107
0700	17	63	22	41	20	24	20	18	28	21	10	6	13	7	5	2	135	182
0800	6	22	8	15	15	18	15	14	12	9	12	7	8	4	5	2	81	91
0900	0	0	2	4	11	13	11	10	4	3	4	2	3	2	5	2	48	43
1000	2	7	0	0	9	11	9	8	0	0	2	1	0	0	5	2	32	35
1100	3	11	5	9	4	5	4	4	8	6	6	4	5	3	5	2	40	44
1200	1	4	8	15	11	13	11	10	7	5	8	5	5	3	8	4	59	59
1300	1	4	4	8	5	6	5	5	2	2	0	0	1	1	1	0	25	35
1400	0	0	5	9	1	1	1	1	5	4	2	1	1	1	7	3	22	20
1500	1	4	2	4	0	0	0	0	4	3	3	2	1	1	2	1	13	15
1600	1	4	2	4	0	0	0	0	0	0	4	2	5	3	1	0	13	13
1700	0	0	4	8	7	8	7	6	10	8	8	5	5	3	3	1	44	39
1800	2	7	4	8	8	10	8	7	6	5	3	2	7	4	3	1	41	44
1900	2	7	7	13	9	11	9	8	12	9	8	5	2	1	3	1	52	55
2000	3	11	9	17	12	14	12	11	13	10	21	13	4	2	5	2	79	80
2100	3	11	7	13	9	11	9	8	18	14	3	2	8	4	6	3	63	66
2200	1	4	1	2	2	2	2	2	4	3	7	4	2	1	3	1	22	19
2300	0	0	6	11	5	6	5	5	3	2	6	4	1	1	5	2	41	41
Bin Total	66	244	234	439	291	348	200	182	217	166	221	134	110	61	98	40	1859	2262

1) Numbers have been extrapolated for 15-60 minute sample time.

Table A14. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for January 28. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL[1]	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	1	4	6	11	2	2	3	3	10	8	13	8	7	4	5	2	47	42
0100	2	7	3	6	5	6	5	5	4	3	6	4	4	2	4	2	33	35
0200	0	0	2	4	3	4	1	1	4	3	7	4	0	0	3	1	20	17
0300	1	4	4	8	7	8	11	10	18	14	16	10	3	2	6	3	66	59
0400	4	15	12	23	10	12	24	22	23	17	16	10	6	3	2	1	146	155
0500	9	34	12	23	28	34	12	11	13	10	21	13	7	4	2	1	104	130
0600	4	15	9	17	9	11	12	11	10	8	5	3	2	1	0	0	51	66
0700	6	22	8	15	16	19	8	7	14	11	15	9	5	3	2	1	74	87
0800	10	37	21	39	25	30	17	15	19	14	15	9	6	3	1	0	114	147
0900	4	15	7	13	2	2	9	8	15	11	16	10	8	4	4	2	65	65
1000	5	19	5	9	5	6	11	10	15	11	10	6	17	9	1	0	69	70
1100	4	15	7	13	14	17	9	8	13	10	14	8	11	6	13	6	85	83
1200	1	4	7	13	7	8	12	11	23	17	16	10	21	11	7	3	94	77
1300	2	7	1	2	10	12	8	7	7	5	9	5	10	5	8	4	55	47
1400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1500	0	0	1	2	1	1	0	0	2	2	1	1	4	2	1	0	10	8
1600	0	0	2	4	3	4	4	4	10	8	14	8	3	2	3	1	39	31
1700	3	11	3	6	1	1	2	2	6	5	6	4	6	3	2	1	29	33
1800	5	19	21	39	3	4	36	32	43	32	21	13	4	2	5	2	138	143
1900	4	15	13	24	12	14	15	14	18	14	13	8	8	4	3	1	86	94
2000	2	7	8	15	9	11	11	10	12	9	16	10	10	5	1	0	69	67
2100	1	4	13	24	16	19	25	23	24	18	29	17	13	7	4	2	125	114
2200	1	4	5	9	7	8	11	10	27	20	21	13	13	7	1	0	86	71
2300	1	4	3	6	10	12	6	5	9	7	14	8	17	9	7	3	67	54
Bin Total	70	262	173	325	205	245	252	229	339	257	314	191	185	98	85	36	1672	1695

1) Numbers have been extrapolated for 40-60 minute sample time.

Table A15. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for January 29. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL[1]	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	5	19	7	13	6	7	13	12	7	5	14	8	18	9	11	5	81	78
0100	3	11	11	21	14	17	19	17	20	15	24	14	13	7	19	9	123	111
0200	1	4	7	13	3	4	5	5	18	14	19	11	14	7	5	2	72	60
0300	1	4	0	0	4	5	4	4	4	3	4	2	2	1	1	0	20	19
0400	1	4	8	15	8	10	8	7	15	11	18	11	3	2	4	2	65	62
0500	9	34	22	41	21	25	19	17	32	24	21	13	4	2	6	3	134	159
0600	9	34	21	39	25	30	16	14	23	17	22	13	2	1	0	0	118	148
0700	14	52	22	41	18	22	22	20	25	19	19	11	8	4	2	1	130	170
0800	16	60	51	96	41	49	55	50	45	34	47	28	13	7	9	4	277	328
0900	15	56	23	43	24	29	31	28	17	13	33	20	15	8	14	6	172	203
1000	4	15	9	17	18	22	13	12	9	7	5	3	4	2	5	2	67	80
1100	2	7	3	6	2	2	10	9	7	5	8	5	2	1	2	1	36	36
1200	2	7	3	6	11	13	15	14	12	9	13	8	21	11	11	5	88	73
1300	0	0	5	9	11	13	11	10	16	12	24	14	13	7	17	8	97	73
1400	1	4	7	13	18	22	13	12	17	13	14	8	16	8	17	8	103	88
1500	1	4	5	9	14	17	16	14	30	23	46	28	18	9	15	7	145	111
1600	8	30	5	9	16	19	21	19	23	17	39	23	16	8	3	1	131	126
1700	1	4	5	9	2	2	11	10	8	6	11	7	0	0	2	1	40	39
1800	7	26	3	6	7	8	7	6	10	8	13	8	4	2	7	3	58	67
1900	7	26	16	30	30	36	31	28	28	21	19	11	13	7	4	2	148	161
2000	9	34	21	39	16	19	28	25	29	22	36	22	13	7	7	3	159	171
2100	20	75	39	73	34	41	40	36	27	20	29	17	11	6	6	3	206	271
2200	42	157	57	107	49	59	46	41	40	30	37	22	41	21	13	6	325	443
2300	9	34	13	24	15	18	26	23	35	26	37	22	29	15	8	4	172	166
Bin Total	187	701	363	679	407	489	480	433	497	374	552	329	293	152	188	86	2967	3243

1) Numbers have been extrapolated for 60 minute sample time.

Table A16. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for January 30. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL [1]	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	11	41	9	17	8	10	10	9	67	50	87	52	26	13	18	8	236	200
0100	11	41	22	41	3	4	3	3	35	26	40	24	15	8	12	5	141	152
0200	2	7	2	4	12	14	15	14	21	16	35	21	19	10	11	5	117	91
0300	1	4	5	9	5	6	14	13	21	16	17	10	9	5	14	6	86	69
0400	1	4	3	6	3	4	3	3	2	2	10	6	6	3	5	2	33	30
0500	6	22	6	11	5	6	6	5	17	13	6	4	4	2	4	2	54	65
0600	13	48	29	55	25	30	27	24	36	27	34	20	14	7	7	3	185	214
0700	3	11	7	13	15	18	18	16	15	11	15	9	1	1	0	0	74	79
0800	10	37	11	21	25	30	18	16	16	12	19	11	3	2	0	0	102	129
0900	16	60	34	64	53	64	81	73	35	26	42	25	20	10	8	4	289	326
1000	14	52	19	36	31	37	28	25	27	20	31	19	16	8	4	2	170	199
1100	2	7	5	9	9	11	6	5	11	8	10	6	7	4	0	0	50	50
1200	1	4	4	8	15	18	24	22	21	16	24	14	9	5	11	5	109	92
1300	2	7	3	6	10	12	21	19	23	17	39	23	17	9	7	3	122	96
1400	1	4	1	2	4	5	14	13	26	20	41	25	15	8	20	9	122	86
1500	2	7	2	4	9	11	15	14	34	26	23	14	15	8	13	6	113	90
1600	0	0	6	11	14	17	22	20	9	7	16	10	5	3	4	2	76	70
1700	0	0	0	0	4	5	13	12	12	9	14	8	3	2	2	1	48	37
1800	0	0	1	2	6	7	6	5	14	11	11	7	4	2	5	2	47	36
1900	0	0	3	6	0	0	3	3	3	2	9	5	3	2	3	1	24	19
2000	0	0	10	19	21	25	23	21	30	23	27	16	12	6	4	2	127	112
2100	3	11	16	30	17	20	14	13	16	12	13	8	11	6	7	3	97	103
2200	2	7	21	39	19	23	16	14	20	15	22	19	8	4	3	1	111	116
2300	6	22	21	39	23	28	30	27	26	20	37	22	26	13	18	8	187	179
Bin Total	107	396	240	452	336	405	430	389	537	405	622	372	268	141	180	80	2720	2640

1) Numbers have been extrapolated for 60 minute sample time.

Table A17. Hourly estimates of raw and weighted fish numbers (with high and low tide heights) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer for week 2, January 24 to 30. Indian Point, 1988.

	JAN 24			JAN 25			JAN 26			JAN 27			JAN 28			JAN 29			JAN 30			WEEKLY TOTAL	
Hour	RAW	WF	Tide	RAW	WF	Tide	RAW	WF	Tide	RAW	WF	Tide	RAW	WF	Tide	RAW	WF	Tide	RAW	WF	Tide	RAW	WF
0000	106	130		33	36		56	49		492	784	0.0	47	42		81	78		236	200		1051	1319
0100	115	137		122	141		40	49		138	170		33	35	0.0	123	111		141	152		712	795
0200	61	76		153	167		139	164		52	61		20	17		72	60	0.1	117	91		614	636
0300	30	44	1.4	62	77		149	180		47	48		66	59		20	19		86	69	0.1	460	496
0400	34	44		63	71	1.4	88	116		88	81		146	155		65	62		33	30		517	559
0500	52	42		42	45		41	48	1.4	135	130		104	130		134	159		54	65		562	619
0600	181	181		68	76		47	61		96	107	1.3	51	66		118	148		185	214		746	853
0700	194	211		120	117		64	61		135	182		74	87	1.2	130	170		74	79		791	907
0800	117	125		175	170		73	79		81	91		114	147		277	328	1.3	102	129		939	1069
0900	54	72	-0.1	114	128		102	106		48	43		65	65		172	203		289	326	1.3	844	943
1000	53	58		38	46	0.0	89	79		32	35		69	70		67	80		170	199		518	567
1100	45	50		25	27		27	40		40	44		85	83		86	36		50	50		308	330
1200	65	66		35	34		19	23	0.1	59	59		94	77		88	73		109	92		469	424
1300	141	148		29	33		22	29		25	35	0.1	55	47		97	73		122	96		491	461
1400	74	90		117	148		12	14		22	20		0	0	0.1	103	88		122	86		450	446
1500	50	64	1.3	148	155		11	12		13	15		10	8		145	111	0.0	113	90	0.0	490	455
1600	59	80		98	110	1.2	12	16		13	13		39	31		131	126		76	70		428	446
1700	44	52		81	97		121	140	1.1	44	39		29	33		40	39		48	37		407	437
1800	68	65		75	70		144	156		41	44	1.0	138	143		58	67		47	36		571	581
1900	230	250		48	61		87	97		52	55		86	94	1.0	148	161		24	19		625	677
2000	208	196		54	51		3112	6858		79	80		69	67		159	171	1.0	127	112		3808	7535
2100	110	125		62	64		5308	10474		63	66		125	114		206	271		97	103	1.0	5971	11217
2200	83	88	-0.2	84	89		6474	11871		22	19		86	71		325	443		111	116		7185	12697
2300	55	53		54	56	-0.1	6426	11838		41	41		67	54		172	166		187	179		7002	12387
Daily Total	2229	2447		1900	2069		22612	42499		1859	2262		1672	1695		2967	3243		2720	2640		35959	56855

1) Tide heights for low and high tide only, New York (the Battery), N.Y. and times adjusted for Indian Point Location.

Table A18. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for January 31. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	4	15	15	28	9	11	20	18	26	20	37	22	14	7	14	6	139	127
0100	0	0	1	2	2	2	10	9	8	6	23	14	26	13	8	4	78	50
0200	2	7	8	15	22	26	26	23	35	26	47	28	420	214	19	9	579	348
0300	4	15	5	9	15	18	14	13	10	8	22	13	19	10	20	9	109	95
0400	0	0	0	0	8	10	14	13	8	6	23	14	16	8	7	3	76	54
0500	1	4	2	4	2	2	3	3	4	3	6	4	2	1	1	0	21	21
0600	8	30	2	4	2	2	7	6	13	10	5	3	4	2	0	0	41	57
0700	2	7	11	21	14	17	14	13	13	10	19	11	13	7	3	1	89	87
0800	0	0	9	17	7	8	10	9	11	8	17	10	10	5	5	2	69	59
0900	2	7	13	24	18	22	27	24	28	21	28	17	8	4	6	3	130	122
1000	10	37	31	58	43	52	30	27	41	31	32	19	12	6	3	1	202	231
1100	1	4	9	17	9	11	17	15	18	14	27	16	11	6	18	8	110	91
1200	1	4	5	9	16	19	14	13	15	11	27	16	11	6	12	5	273	224
1300	0	0	5	9	10	12	15	14	28	21	54	32	17	9	18	8	147	105
1400	3	11	15	28	15	18	20	18	29	22	43	26	24	12	26	12	175	147
1500	0	0	25	47	28	34	14	13	18	14	18	11	13	7	22	10	138	136
1600	3	11	5	9	19	23	15	14	17	13	23	14	12	6	7	3	101	93
1700	1	4	4	8	3	4	4	4	10	8	17	10	5	3	2	1	46	42
1800	5	19	15	28	6	7	16	14	17	13	18	11	11	6	7	3	95	101
1900	1	4	4	8	3	4	4	4	10	8	17	10	5	3	12	5	56	46
2000	5	19	15	28	6	7	16	14	17	13	18	11	11	6	7	3	95	101
2100	2	7	18	34	31	37	28	25	31	23	39	23	17	9	11	5	177	163
2200	10	37	24	45	29	35	20	18	17	13	26	16	8	4	6	3	140	171
2300	21	78	33	62	47	56	59	53	70	53	48	29	40	20	13	6	331	357
Bin Total	86	320	274	514	364	437	417	377	494	375	634	380	729	374	247	110	3417	3028

1) Numbers have been extrapolated for 22-60 minute sample time.

Table A19. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for February 1. Indian Point, 1988.

Hour	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	HOURLY TOTAL[1] Raw	HOURLY TOTAL[1] WF
0000	7	26	43	81	51	61	47	42	54	41	62	37	40	20	14	6	318	314
0100	1	4	14	26	27	32	44	40	65	49	78	47	45	23	26	12	324	252
0200	4	15	15	28	23	28	50	45	84	63	109	65	27	14	26	12	338	270
0300	2	7	14	26	16	19	27	24	43	32	76	46	22	11	26	12	226	177
0400	4	15	1	2	5	6	20	18	14	11	16	10	15	8	12	5	87	75
0500	0	0	3	6	3	4	6	5	9	7	7	4	13	7	7	3	48	36
0600	1	4	10	19	16	19	9	8	21	16	24	14	7	4	5	2	93	86
0700	6	22	17	32	24	29	29	26	35	26	28	17	12	6	2	1	153	159
0800	14	52	41	77	53	64	43	39	44	33	31	19	6	3	0	0	232	287
0900	8	30	29	55	26	31	27	24	26	20	25	15	13	7	2	1	156	183
1000	9	34	24	45	26	31	27	24	23	17	19	11	16	8	3	1	147	171
1100	9	34	24	45	26	31	27	24	23	17	19	11	16	8	3	1	147	171
1200	8	30	14	26	16	19	17	15	32	24	43	26	29	15	24	11	183	166
1300	4	15	4	8	11	13	24	22	15	11	27	16	17	9	26	12	128	106
1400	2	7	5	9	8	10	22	20	36	27	40	24	55	28	34	15	202	140
1500	5	19	13	24	33	40	56	50	70	53	68	41	39	17	44	20	322	264
1600	4	15	11	21	36	43	38	34	38	29	48	29	30	15	23	10	228	196
1700	2	7	10	19	12	14	22	20	25	19	21	13	10	5	10	5	121	110
1800	0	0	3	6	14	17	7	6	16	12	42	25	11	6	5	2	297	224
1900	2	7	5	9	4	5	10	9	12	9	29	17	16	8	6	3	88	70
2000	3	11	4	8	3	4	1	1	5	4	10	6	4	2	5	2	35	38
2100	2	7	1	2	5	6	2	2	6	5	4	2	2	1	0	0	88	100
2200	2	7	1	2	11	13	15	14	14	11	15	9	0	0	1	0	113	108
2300	10	37	20	38	17	20	21	19	21	16	25	15	4	2	0	0	118	147
Bin Total	109	405	326	614	466	559	591	531	731	552	866	519	443	227	304	136	4192	3850

1) Numbers have been extrapolated for 15-60 minute sample time.

Table A20. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for February 2. Indian Point, 1988.

Hour	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	HOURLY TOTAL Raw	HOURLY TOTAL WF
0000	3	11	12	23	14	17	28	25	17	13	28	17	11	6	73	33	413	322
0100	4	15	4	8	5	6	15	14	16	12	17	10	2	1	2	1	65	67
0200	7	26	26	49	41	49	42	38	76	57	86	52	48	24	25	11	351	306
0300	16	60	32	60	42	50	50	45	78	59	67	40	36	18	31	14	352	346
0400	3	11	37	70	45	54	43	39	67	50	89	53	22	11	24	11	330	299
0500	2	7	16	30	21	25	22	20	23	17	38	23	19	10	16	7	157	139
0600	1	4	10	19	8	10	15	14	12	9	35	21	8	4	12	5	101	86
0700	1	4	3	6	3	4	6	5	4	3	18	11	4	2	4	2	43	37
0800	3	11	7	13	5	6	16	14	10	8	19	11	10	5	4	2	74	70
0900	1	4	7	13	9	11	15	14	14	11	13	8	2	1	2	1	63	63
1000	12	45	25	47	25	30	32	29	17	13	18	11	0	0	0	0	129	175
1100	12	45	18	34	16	19	19	17	27	20	17	10	7	4	0	0	116	149
1200	8	30	14	26	36	43	39	35	37	28	27	16	19	10	3	1	183	189
1300	1	4	6	11	22	26	21	19	16	12	19	11	14	7	12	5	111	95
1400	1	4	2	4	3	4	9	8	8	6	5	3	16	8	13	6	57	43
1500	2	7	21	39	31	37	52	47	35	26	38	23	33	17	44	20	282	238
1600	0	0	1	2	3	4	3	3	4	3	4	2	0	0	2	1	142	125
1700	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1800	1	4	7	13	14	17	13	12	4	3	8	5	9	2	7	3	63	65
1900	2	7	4	8	6	7	7	6	7	5	12	7	8	4	12	5	58	49
2000	0	0	0	0	4	5	5	5	1	1	6	4	2	1	2	1	20	17
2100	0	0	1	2	3	4	3	3	4	3	3	2	2	1	0	0	16	15
2200	2	7	5	9	7	8	10	9	9	7	9	5	3	2	0	0	45	47
2300	0	0	10	19	29	28	41	37	35	26	33	29	21	11	10	5	179	149
Bin Total	82	306	268	505	386	464	506	458	521	392	615	368	290	149	298	134	3349	3090

1) Numbers have been extrapolated for 7-60 minute sample time.

Table A21. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for February 3. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	2	7	2	4	1	1	21	19	10	8	12	7	7	4	3	1	341	300
0100	0	0	1	2	6	7	4	4	8	6	15	9	13	7	8	4	131	93
0200	1	4	5	9	17	20	16	14	24	18	23	14	5	3	9	4	100	86
0300	1	4	10	19	33	40	36	32	18	14	24	14	10	5	2	1	147	142
0400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0500	3	11	7	13	12	14	6	5	6	5	13	8	8	4	8	4	100	101
0600	4	15	8	15	9	11	7	6	5	4	7	4	4	2	2	1	46	58
0700	0	0	0	0	1	1	6	5	1	1	2	1	2	1	2	1	14	10
0800	0	0	0	0	5	6	2	2	6	5	1	1	0	0	1	0	18	17
0900	3	11	2	4	8	10	12	11	9	7	13	8	3	2	1	0	65	68
1000	0	0	1	2	11	13	13	12	21	16	15	9	4	2	6	3	71	57
1100	1	4	9	17	18	22	21	19	18	14	15	9	6	3	2	1	90	89
1200	3	11	4	8	20	24	19	17	21	16	17	10	13	7	10	5	107	98
1300	2	7	13	24	8	10	16	14	24	18	17	10	13	7	12	5	120	108
1400	1	4	4	8	8	10	5	5	10	8	10	6	12	6	4	2	54	49
1500	1	4	4	8	5	6	11	10	15	11	9	5	12	6	2	1	59	51
1600	0	0	4	8	12	14	16	14	21	16	29	17	12	6	12	5	106	80
1700	0	0	1	2	7	8	4	4	9	7	13	8	11	6	2	1	112	86
1800	0	0	8	15	14	17	19	17	7	5	23	14	20	10	3	1	94	79
1900	1	4	4	8	20	24	12	11	7	5	20	12	24	12	5	2	93	78
2000	1	4	2	4	0	0	5	5	4	3	3	2	3	2	5	2	23	22
2100	0	0	0	0	0	0	0	0	1	1	3	2	0	0	2	1	16	11
2200	4	15	16	30	18	22	18	16	20	15	13	8	4	2	2	1	105	120
2300	2	7	10	19	8	10	11	10	12	9	8	5	4	2	2	1	228	252
Bin Total	30	112	115	219	241	290	280	252	277	212	305	183	190	99	105	47	2239	2054

1) Numbers have been extrapolated for 10-60 minute sample time.

Table A22. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for February 4. Indian Point, 1988.

Hour	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	HOURLY TOTAL Raw	HOURLY TOTAL WF
0000	1	4	16	30	28	34	24	22	16	12	18	11	6	3	2	1	139	146
0100	10	37	34	64	38	46	19	17	50	38	45	27	19	10	15	7	230	246
0200	6	22	18	34	30	36	42	38	39	29	40	24	18	9	6	3	398	390
0300	2	7	9	17	17	20	23	21	21	16	29	17	12	6	14	6	254	220
0400	4	15	14	26	44	53	42	38	49	37	59	35	33	17	16	7	261	228
0500	0	0	4	8	16	19	15	14	20	15	23	14	12	6	8	4	98	80
0600	0	0	1	2	7	8	10	9	4	3	20	12	5	3	6	3	53	40
0700	1	4	4	8	5	6	9	8	10	8	6	4	12	6	14	6	61	50
0800	1	4	3	6	4	5	3	3	6	5	8	5	6	3	4	2	35	33
0900	0	0	1	2	4	5	1	1	2	2	2	1	1	1	1	0	12	12
1000	1	4	1	2	10	12	7	6	6	5	6	4	4	2	1	0	40	39
1100	2	7	5	9	5	6	11	10	9	7	6	4	4	2	0	0	42	45
1200	0	0	2	4	2	2	6	5	8	6	7	4	0	0	0	0	25	21
1300	3	11	3	6	10	12	10	9	15	11	5	3	1	1	0	0	47	53
1400	1	4	4	8	6	7	11	10	11	8	10	6	1	1	2	1	46	45
1500	0	0	6	11	4	5	7	6	5	4	12	7	2	1	1	0	41	38
1600	1	4	9	17	5	6	13	12	12	9	8	5	5	3	5	2	58	58
1700	2	7	5	9	8	10	15	14	24	18	10	6	6	3	7	3	77	70
1800	2	7	5	9	10	12	14	13	9	7	15	9	14	7	2	1	71	65
1900	2	7	1	2	9	11	9	8	8	6	12	7	13	7	2	1	56	49
2000	1	4	1	2	3	4	5	5	4	3	1	1	3	2	2	1	20	22
2100	0	0	2	4	3	4	1	1	3	2	2	1	2	1	5	2	18	15
2200	1	4	2	4	1	1	0	0	2	2	1	1	4	2	1	0	13	15
2300	1	4	1	2	3	4	4	4	2	2	2	1	1	1	1	0	15	18
Bin Total	42	156	151	286	272	328	301	274	335	255	347	209	184	97	115	50	2109	1998

1) Numbers have been extrapolated for 30-60 minute sample time.

Table A23. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for February 5. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	0	0	5	9	6	7	6	5	7	5	2	1	0	0	0	0	26	27
0100	0	0	2	4	1	1	4	4	4	3	3	2	0	0	0	0	15	15
0200	0	0	1	2	1	1	1	1	2	2	2	1	3	2	1	0	11	9
0300	1	4	0	0	0	0	3	3	5	4	3	2	0	0	0	0	12	13
0400	7	26	0	0	1	1	1	1	4	3	2	1	0	0	4	2	19	34
0500	2	7	0	0	3	4	5	5	10	8	17	10	5	3	1	0	43	37
0600	1	4	0	0	8	10	6	5	2	2	4	2	2	1	1	0	24	24
0700	1	4	3	6	2	2	2	2	2	2	7	4	2	1	0	0	19	21
0800	0	0	0	0	0	0	1	1	0	0	3	2	0	0	1	0	6	3
0900	0	0	0	0	2	2	1	1	0	0	0	0	1	1	0	0	5	5
1000	0	0	2	4	3	4	1	1	1	1	0	0	0	0	0	0	13	19
1100	0	0	6	11	4	5	2	2	4	3	2	1	1	1	0	0	19	23
1200	0	0	1	2	0	0	2	2	4	3	2	1	1	1	0	0	10	9
1300	0	0	2	4	10	12	3	3	2	2	1	1	0	0	0	0	18	22
1400	0	0	3	6	1	1	2	2	3	2	2	1	0	0	3	1	14	13
1500	1	4	1	2	3	4	9	8	8	6	7	4	6	3	1	0	36	31
1600	0	0	1	2	3	4	4	4	5	4	4	2	0	0	0	0	17	16
1700	0	0	1	2	2	2	2	2	3	2	3	2	1	1	0	0	13	12
1800	1	4	2	4	1	1	6	5	4	3	10	6	5	3	1	0	30	26
1900	1	4	0	0	0	0	1	1	2	2	0	0	0	0	0	0	4	7
2000	1	4	0	0	0	0	1	1	2	2	0	0	0	0	0	0	4	7
2100	0	0	1	2	1	1	3	3	3	2	0	0	0	0	0	0	8	8
2200	0	0	0	0	3	4	2	2	2	2	1	1	0	0	0	0	8	9
2300	1	4	1	2	5	6	2	2	1	1	1	1	0	0	0	0	11	16
Bin Total	17	65	32	62	60	72	70	66	80	64	76	45	27	17	13	3	385	406

1)/ Numbers have been extrapolated for 32-60 minute sample time.

Table A24. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer, for February 6. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	2	7	4	8	3	4	5	5	3	2	2	1	0	0	0	0	19	27
0100	1	4	2	4	6	7	1	1	3	2	3	2	2	1	0	0	19	23
0200	1	4	2	4	3	4	4	4	1	1	2	1	0	0	0	0	13	18
0300	0	0	1	2	6	7	6	5	10	8	4	2	2	1	2	1	31	26
0400	0	0	4	8	0	0	3	3	3	2	3	2	1	1	3	1	17	17
0500	1	4	1	2	0	0	1	1	0	0	2	1	0	0	1	0	6	8
0600	0	0	4	8	6	7	2	2	7	5	0	0	0	0	0	0	19	22
0700	1	4	3	6	11	13	1	1	4	3	4	2	0	0	0	0	24	29
0800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0900	0	0	1	2	0	0	0	0	0	0	1	1	0	0	0	0	2	3
1000	0	0	1	2	0	0	1	1	0	0	0	0	0	0	0	0	2	3
1100	0	0	2	4	0	0	1	1	0	0	0	0	1	1	0	0	4	6
1200	0	0	3	6	1	1	4	4	3	2	1	1	0	0	0	0	12	14
1300	1	4	2	4	0	0	1	1	0	0	0	0	0	0	0	0	4	9
1400	0	0	2	4	3	4	7	6	2	2	0	0	1	1	0	0	15	17
1500	0	0	3	6	1	1	0	0	4	3	0	0	0	0	0	0	8	10
1600	0	0	1	2	0	0	1	1	1	1	0	0	0	0	0	0	3	4
1700	0	0	0	0	0	0	1	1	4	3	1	1	0	0	1	0	7	5
1800	0	0	0	0	0	0	0	0	1	1	2	1	0	0	1	0	4	2
1900	0	0	2	4	2	2	1	1	0	0	0	0	2	1	0	0	7	8
2000	0	0	1	2	0	0	1	1	0	0	0	0	1	1	0	0	3	4
2100	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	2	2
2200	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	2	2
2300	0	0	1	2	1	1	1	1	3	2	1	1	0	0	0	0	7	7
Bin Total	7	27	40	80	43	51	43	41	49	37	27	17	12	9	8	2	230	266

1) Numbers have been extrapolated for 55-60 minute sample time.

Table A25. Hourly estimates of raw and weighted fish numbers (with high and low tide heights) in front of unit 3, intake 35 using 6 X 12 degree horizontal transducer for week 3, January 31 to February 6. Indian Point, 1988.

Hour	JAN 31 RAW	JAN 31 WF	Tide	FEB 1 RAW	FEB 1 WF	Tide	FEB 2 RAW	FEB 2 WF	Tide	FEB 3 RAW	FEB 3 WF	Tide	FEB 4 RAW	FEB 4 WF	Tide	FEB 5 RAW	FEB 5 WF	Tide	FEB 6 RAW	FEB 6 WF	Tide	WEEKLY TOTAL RAW	WEEKLY TOTAL WF
0000	139	127		318	314		418	322		341	300		139	146	1.2	26	27	1.2	19	27		1395	1263
0100	78	50		324	252		65	67		131	93		230	246		15	15		19	23	1.2	862	745
0200	579	348		338	270		351	306		100	86		398	390		11	9		13	18		1790	1427
0300	109	95	0.0	226	177		352	346		147	142		254	220		12	13		31	26		1131	1019
0400	76	54		87	75	0.0	330	299		0	0		261	228		19	34		17	17		790	707
0500	21	21		48	36		157	139	0.0	100	101		98	80		43	37		6	8		473	422
0600	41	57		93	86		101	86		46	58	-0.1	53	40	0.0	24	24		19	22		377	373
0700	89	87		153	159		43	37		14	10		61	50		19	21	0.0	24	29	0.0	403	393
0800	69	59		232	207		74	70		18	17		35	33		6	3		0	0		434	469
0900	130	122	1.4	156	183		63	63		65	68		12	12		5	5		2	3		434	456
1000	202	231		147	171	1.4	129	175		71	57		40	39		13	19		2	3		604	694
1100	110	91		147	171		116	149	1.4	90	89	1.4	42	45		19	28		4	6		528	574
1200	273	224		183	166		183	189		107	98		25	21	1.4	10	9	1.3	12	14		793	721
1300	147	105		128	106		111	95		120	108		47	53		18	22		4	9	1.2	575	498
1400	175	147		202	140		57	43		54	49		46	45		14	13		15	17		563	454
1500	138	136		322	264		282	298		59	51		41	38		36	31		8	10		886	767
1600	101	93	-0.1	228	196		142	125		106	80		58	58		17	16		3	4		655	572
1700	46	42		121	110	-0.1	0	0		112	86		77	70		13	12		7	5		376	325
1800	95	101		297	224		63	65	-0.1	94	79	-0.1	71	65		30	26		4	2		654	562
1900	86	46		88	70		88	49		98	78		56	49	-0.1	4	7	-0.1	7	8		362	307
2000	95	101		35	38		20	17		23	22		20	22		4	7		3	4	0.0	200	211
2100	177	163		88	100		16	15		16	11		18	15		8	8		2	2		325	314
2200	140	171	1.1	113	108	1.1	45	47		105	120		13	15		8	9		2	2		426	472
2300	331	357		118	147		179	149	1.2	228	252		15	18		11	16		7	7		889	946
Daily Total	3417	3028		4192	3850		3949	3090		2239	2054		2109	1998		385	406		230	266		15921	14692

1) Tide heights for low and high tide only, New York (the Battery), N.Y. and times adjusted for Indian Point Location.

Table A26. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer, for February 7. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	1	4	1	2	2	2	2	2	3	2	3	2	0	0	0	0	12	14
0100	0	0	0	0	2	2	0	0	7	5	2	1	2	1	0	0	27	19
0200	0	0	0	0	2	2	0	0	6	5	4	2	0	0	1	0	13	9
0300	0	0	0	0	1	1	1	1	3	2	3	2	2	1	2	1	12	8
0400	0	0	2	4	2	2	0	0	4	3	0	0	0	0	2	1	10	10
0500	0	0	0	0	0	0	0	0	2	2	1	1	1	1	2	1	6	5
0600	1	4	0	0	1	1	0	0	2	2	1	1	0	0	1	0	6	8
0700	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0800	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	2	2
0900	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
1000	0	0	0	0	3	4	3	3	1	1	0	0	0	0	0	0	7	8
1100	0	0	0	0	3	4	3	3	1	1	0	0	0	0	0	0	7	8
1200	0	0	1	2	1	1	1	1	0	0	0	0	0	0	0	0	3	4
1300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1400	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
1500	0	0	0	0	2	2	0	0	1	1	1	1	0	0	0	0	4	4
1600	0	0	0	0	2	2	0	0	1	1	1	1	0	0	0	0	4	4
1700	0	0	0	0	2	2	2	2	4	3	5	3	1	1	0	0	14	11
1800	0	0	3	6	1	1	0	0	2	2	3	2	1	1	0	0	10	12
1900	0	0	2	4	1	1	1	1	4	3	1	1	0	0	1	0	10	10
2000	0	0	0	0	0	0	2	2	1	1	3	2	2	1	0	0	8	6
2100	0	0	0	0	0	0	0	0	0	0	2	1	2	1	1	0	5	2
2200	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
2300	0	0	1	2	0	0	0	0	4	3	3	2	1	1	0	0	9	8
Bin Total	3	12	10	20	26	28	15	15	49	40	33	22	12	8	10	3	172	158

1) Numbers have been extrapolated for 29-60 minute sample time.

Table A27. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer, for February 8. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	0	0	3	6	4	5	3	3	0	0	5	3	1	1	0	0	16	18
0100	0	0	0	0	1	1	1	1	3	2	1	1	0	0	0	0	6	5
0200	0	0	5	9	2	2	2	2	2	2	1	1	1	1	0	0	13	17
0300	0	0	1	2	2	2	1	1	1	1	1	1	0	0	1	0	7	7
0400	0	0	3	6	1	1	1	1	3	2	1	1	2	1	0	0	11	12
0500	0	0	2	4	2	2	4	4	3	2	5	3	2	1	0	0	18	16
0600	1	4	1	2	1	1	2	2	6	5	7	4	2	1	1	0	21	19
0700	0	0	5	9	0	0	1	1	0	0	0	0	0	0	0	0	6	10
0800	0	0	0	0	0	0	2	2	1	1	0	0	0	0	0	0	3	3
0900	1	4	1	2	1	1	0	0	0	0	0	0	0	0	0	0	3	7
1000	0	0	1	2	2	2	3	3	1	1	1	1	0	0	0	0	9	10
1100	0	0	1	2	0	0	2	2	0	0	0	0	0	0	0	0	3	4
1200	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	2	2
1300	0	0	1	2	1	1	0	0	1	1	0	0	0	0	0	0	3	4
1400	0	0	1	2	1	1	0	0	1	1	0	0	0	0	0	0	3	4
1500	0	0	0	0	0	0	0	0	3	2	1	1	0	0	1	0	5	3
1600	0	0	1	2	1	1	0	0	0	0	2	1	3	2	2	1	9	7
1700	3	11	0	0	1	1	0	0	0	0	0	0	0	0	1	0	5	12
1800	1	4	2	4	1	1	3	3	2	2	2	1	4	2	1	0	16	17
1900	0	0	1	2	2	2	1	1	0	0	0	0	1	1	2	1	7	7
2000	0	0	0	0	0	0	2	2	0	0	0	0	0	0	1	0	3	2
2100	1	4	0	0	0	0	3	3	1	1	2	1	0	0	4	2	11	11
2200	1	4	0	0	0	0	1	1	1	1	0	0	1	1	1	0	5	7
2300	0	0	1	2	0	0	0	0	0	0	0	0	0	0	1	0	2	2
Bin Total	8	31	30	58	23	24	32	32	30	25	30	20	17	11	16	4	187	206

1) Numbers have been extrapolated for 55-60 minute sample time.

Table A28. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer, for February 9. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	0	0	1	2	2	2	0	0	1	1	1	1	0	0	0	0	5	[illegible]
0100	0	0	0	0	1	1	5	5	0	0	1	1	0	0	0	0	7	[illegible]
0200	0	0	0	0	0	0	2	2	0	0	3	2	3	2	0	0	8	[illegible]
0300	0	0	2	4	0	0	1	1	1	1	1	1	2	1	1	0	8	[illegible]
0400	1	4	1	2	1	1	6	5	1	1	3	2	3	2	2	1	18	[illegible]
0500	0	0	2	4	0	0	3	3	2	2	4	2	1	1	1	0	13	[illegible]
0600	0	0	1	2	0	0	3	3	1	1	1	1	1	1	0	0	7	[illegible]
0700	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	2	[illegible]
0800	0	0	4	8	2	2	0	0	2	2	0	0	0	0	0	0	8	[illegible]
0900	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	2	[illegible]
1000	0	0	1	2	1	1	0	0	2	2	0	0	3	2	0	0	7	[illegible]
1100	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	[illegible]
1200	1	4	1	2	1	1	2	2	0	0	0	0	0	0	1	0	6	[illegible]
1300	0	0	3	6	1	1	0	0	0	0	1	1	0	0	0	0	5	[illegible]
1400	0	0	0	0	0	0	2	2	2	2	2	1	0	0	0	0	6	[illegible]
1500	0	0	0	0	0	0	0	0	3	2	1	1	0	0	0	0	4	[illegible]
1600	0	0	0	0	1	1	1	1	2	2	3	2	0	0	0	0	7	[illegible]
1700	0	0	0	0	0	0	1	1	0	0	3	2	0	0	0	0	5	[illegible]
1800	0	0	0	0	3	4	0	0	1	1	3	2	1	1	0	0	8	[illegible]
1900	0	0	0	0	0	0	2	2	6	5	6	4	5	3	3	1	22	[illegible]
2000	0	0	2	4	0	0	2	2	1	1	5	3	6	3	0	0	16	[illegible]
2100	0	0	0	0	0	0	1	1	2	2	0	0	0	0	6	3	9	[illegible]
2200	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	2	[illegible]
2300	0	0	1	2	0	0	1	1	0	0	0	0	0	0	0	0	2	[illegible]
Bin Total	2	8	19	38	14	15	36	35	28	26	38	26	26	17	14	5	178	17

1) Numbers have been extrapolated for 52-60 minute sample time.

Table A29. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer, for February 10. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	1	4	1	2	1	1	1	1	1	1	0	0	0	0	0	0	5	9
0100	1	4	0	0	1	1	2	2	2	2	1	1	0	0	0	0	7	10
0200	1	4	4	8	3	4	4	4	4	3	2	1	0	0	0	0	18	2[illegible]
0300	0	0	0	0	5	6	1	1	1	1	4	2	0	0	0	0	14	13
0400	0	0	0	0	2	2	2	2	2	2	2	1	0	0	0	0	8	7
0500	0	0	0	0	2	2	1	1	1	1	2	1	2	1	4	2	12	6
0600	0	0	2	4	2	2	3	3	3	2	4	2	1	1	1	0	16	1[illegible]
0700	1	4	1	2	2	2	2	2	2	2	4	2	3	2	2	1	17	17
0800	0	0	0	0	1	1	0	0	0	0	2	1	2	1	1	0	6	3
0900	0	0	0	0	2	2	1	1	1	1	3	2	7	4	0	0	14	1[illegible]
1000	2	7	0	0	1	1	0	0	0	0	0	0	0	0	0	0	3	[illegible]
1100	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	2	[illegible]
1200	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	4	[illegible]
1300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1400	0	0	1	2	0	0	0	0	0	0	1	1	0	0	1	0	3	3
1500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1600	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	3	3
1700	0	0	1	2	1	1	0	0	0	0	0	0	0	0	0	0	2	3
1800	1	4	0	0	1	1	0	0	0	0	1	1	2	1	0	0	5	7
1900	0	0	0	0	5	6	1	1	1	1	1	1	1	1	0	0	10	11
2000	0	0	4	8	3	4	1	1	1	1	0	0	0	0	0	0	9	14
2100	0	0	2	4	4	5	5	5	5	4	0	0	0	0	1	0	17	16
2200	0	0	0	0	0	0	3	3	3	2	1	1	3	2	2	1	12	[illegible]
2300	0	0	1	2	0	0	1	1	1	1	0	0	0	0	1	0	4	[illegible]
Bin Total	7	27	17	34	39	44	30	30	30	26	29	18	22	14	13	4	191	201

1) Numbers have been extrapolated for 48-60 minute sample time.

Table A30. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer, for February 11. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	0	0	0	0	2	2	0	0	0	0	0	0	1	1[1]	1	0	4	3
0100	1	4	0	0	0	0	0	0	1	1	1	1	0	0[1]	1	0	4	6
0200	0	0	1	2	1	1	4	4	0	0	0	0	0	0[1]	0	0	6	7
0300	0	0	3	6	0	0	0	0	1	1	1	1	0	0[1]	0	0	5	8
0400	0	0	0	0	2	2	0	0	2	2	2	1	0	0[1]	0	0	6	5
0500	0	0	0	0	2	2	0	0	2	2	2	1	0	0[1]	0	0	6	5
0600	0	0	1	2	1	1	0	0	1	1	1	1	2	1[1]	0	0	6	6
0700	0	0	1	2	0	0	0	0	2	2	2	1	1	1	1	0	7	6
0800	0	0	0	0	1	1	0	0	4	3	4	2	0	0	0	0	9	6
0900	0	0	0	0	3	4	0	0	0	0	0	0	0	0	0	0	3	4
1000	1	4	0	0	2	2	1	1	0	0	0	0	0	0	0	0	4	7
1100	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
1200	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	2	2
1300	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	2	1
1400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1500	1	4	0	0	1	1	1	1	1	1	0	0	0	0	0	0	4	7
1600	0	0	1	2	0	0	1	1	0	0	1	1	0	0	0	0	6	8
1700	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
1800	0	0	0	0	1	1	1	1	0	0	0	0	0	0	1	0	3	2
1900	0	0	1	2	1	1	1	1	0	0	0	0	2	1	0	0	5	5
2000	0	0	1	2	0	0	0	0	1	1	0	0	0	0	0	0	2	3
2100	0	0	0	0	0	0	1	1	6	5	1	1	3	2	1	0	12	9
2200	0	0	0	0	0	0	1	1	3	2	6	4	0	0	0	0	10	7
2300	0	0	0	0	1	1	0	0	2	2	3	2	2	1	1	0	9	6
Bin Total	3	12	9	18	19	20	12	12	27	24	25	17	12	8	7	0	117	115

1/ Numbers have been extrapolated for 32-60 minute sample time.

Table A31. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer, for February 12. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL[1]	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
0100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0200	0	0	0	0	1	1	2	2	1	1	1	1	0	0	0	0	5	5
0300	0	0	0	0	2	2	2	2	1	1	0	0	0	0	0	0	5	5
0400	0	0	0	0	0	0	2	2	2	2	1	1	1	1	0	0	6	6
0500	0	0	0	0	1	1	0	0	1	1	1	1	0	0	1	0	4	3
0600	0	0	0	0	2	2	3	3	3	2	2	1	1	1	1	0	13	9
0700	1	4	0	0	0	0	1	1	0	0	1	1	1	1	2	1	6	8
0800	0	0	1	2	1	1	1	1	2	2	0	0	0	0	4	2	9	8
0900	0	0	2	4	1	1	0	0	3	2	0	0	1	1	2	1	9	9
1000	0	0	0	0	1	1	2	2	0	0	0	0	1	1	2	1	6	5
1100	1	4	0	0	0	0	1	1	0	0	1	1	2	1	1	0	6	7
1200	0	0	1	2	1	1	1	1	0	0	1	1	2	1	2	1	8	7
1300	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	3	3
1400	0	0	0	0	3	4	1	1	1	1	0	0	0	0	1	0	6	6
1500	0	0	0.	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
1600	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	2	1
1700	0	0	2	4	1	1	0	0	0	0	0	0	0	0	0	0	3	5
1800	0	0	4	8	2	2	3	3	2	2	3	2	2	1	1	0	17	18
1900	0	0	2	4	4	5	5	5	3	2	0	0	0	0	0	0	14	16
2000	1	4	1	2	3	4	4	4	4	3	1	1	3	2	0	0	17	20
2100	0	0	0	0	3	4	1	1	0	0	3	2	0	0	0	0	7	7
2200	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	2	2
2300	1	4	0	0	2	2	3	3	3	2	2	1	0	0	0	0	11	12
Bin Total	4	16	13	26	28	32	34	34	28	23	19	15	16	12	18	6	161	165

1) Numbers have been extrapolated for 55-60 minute sample time.

Table A32. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer, for February 13. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL[1]	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	0	0	1	2	3	4	1	1	6	5	1	1	2	1	4	2	18	16
0100	1	4	1	2	0	0	2	2	0	0	1	1	0	0	1	0	6	9
0200	0	0	0	0	1	1	0	0	1	1	1	1	0	0	3	1	6	4
0300	0	0	0	0	0	0	1	1	0	0	1	1	1	1	0	0	3	3
0400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0500	0	0	1	2	1	1	1	1	1	1	0	0	0	0	0	0	4	5
0600	0	0	0	0	1	1	2	2	0	0	0	0	0	0	1	0	4	3
0700	0	0	0	0	1	1	0	0	1	1	1	1	0	0	0	0	3	3
0800	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
0900	1	4	1	2	4	5	2	2	0	0	0	0	0	0	0	0	8	13
1000	5	19	0	0	7	8	1	1	0	0	0	0	0	0	1	0	14	28
1100	72	269	78	147	55	66	0	0	5	4	5	3	0	0	0	0	1264	2875
1200	115	429	146	274	79	95	6	5	3	2	0	0	0	0	0	0	2052	4733
1300	173	645	227	427	166	199	172	155	15	11	6	4	2	1	0	0	4475	8479
1400	111	414	142	267	95	114	2	2	2	2	2	1	0	0	1	0	2087	4704
1500	17	63	58	109	68	82	5	5	0	0	0	0	0	0	0	0	870	1523
1600	3	11	23	43	61	73	17	15	0	0	1	1	0	0	1	0	106	143
1700	0	0	4	8	24	29	5	5	0	0	0	0	0	0	0	0	33	42
1800	1	4	9	17	5	6	4	4	2	2	1	1	0	0	0	0	22	34
1900	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	2	2
2000	0	0	1	2	2	2	1	1	0	0	1	1	0	0	0	0	5	6
2100	2	7	4	8	0	0	0	0	5	4	1	1	0	0	0	0	12	20
2200	6	22	63	118	69	83	18	16	0	0	0	0	0	0	0	0	917	1405
2300	83	310	68	128	93	112	67	60	12	9	5	3	0	0	0	0	1929	3657
Bin Total	590	2201	827	1556	735	882	308	279	53	42	28	21	6	4	12	3	13842	27709

1) Numbers have been extrapolated for 10-60 minute sample time.

Table A33. Hourly estimates of raw and weighted fish numbers (with high and low tide heights) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer for week 4, February 7 to 13. Indian Point, 1988.

Hour	FEB 7 RAW	FEB 7 WF	FEB 7 Tide	FEB 8 RAW	FEB 8 WF	FEB 8 Tide	FEB 9 RAW	FEB 9 WF	FEB 9 Tide	FEB 10 RAW	FEB 10 WF	FEB 10 Tide	FEB 11 RAW	FEB 11 WF	FEB 11 Tide	FEB 12 RAW	FEB 12 WF	FEB 12 Tide	FEB 13 RAW	FEB 13 WF	FEB 13 Tide	WEEKLY TOTAL RAW	WEEKLY TOTAL WF
0000	12	14		16	18		5	6		5	9		4	3		1	1		18	16		61	67
0100	27	19	1.2	6	5		7	7		7	10		4	6		0	0		6	9	0.1	58	56
0200	18	9		13	17	1.2	8	6	1.2	18	24		6	7		5	5		6	4		69	72
0300	12	8		7	7		8	8		14	13	1.2	5	8		5	5		3	3		54	52
0400	10	10		11	12		18	18		8	7		6	5	1.2	6	6		0	0		59	58
0500	6	5		18	16		13	12		12	8		6	5		4	3	1.2	4	5		63	54
0600	6	8		21	19		7	8		16	14		6	6		13	9		4	3	1.3	73	67
0700	0	0		6	10		2	2		17	17		7	6		6	8		3	3		41	46
0800	2	2	0.0	3	3	0.1	8	12		6	3		9	6		9	8		1	1		38	35
0900	1	4		3	7		2	2	0.2	14	10		3	4		9	9		8	13		40	49
1000	7	8		9	10		7	7		3	8	0.2	4	7		6	5		14	28		50	73
1100	7	8		3	4		1	1		2	2		1	1		6	7		1264	2875		1284	2898
1200	9	4		2	2		6	9		4	4		2	2	0.2	8	7		2052	4733		2077	4761
1300	0	0	1.2	3	4		5	8		0	0		2	1		3	3	0.2	4475	8479		4488	8495
1400	1	1		3	4	1.1	6	5	1.1	3	3		0	0		6	6		2087	4704	0.1	2107	4723
1500	4	4		5	3		4	3		0	0	1.1	4	7		1	1		870	1523		888	1541
1600	4	4		9	7		7	6		3	3		6	8	1.0	2	1		106	143		137	172
1700	14	11		5	12		5	3		2	8		1	1		3	5	1.0	33	42		68	77
1800	10	12		16	17		8	8		5	7		3	2		17	18		22	34		81	98
1900	10	10		7	7		22	15		10	11		5	5		14	16		2	2	1.0	70	66
2000	8	6	0.0	3	2	0.0	16	13		9	14		2	3		17	20		5	6		60	64
2100	5	2		11	11		9	6	0.1	17	18		12	9		7	7		12	20		73	73
2200	1	1		5	7		2	2		12	9	0.1	10	7		2	2		917	1405		949	1433
2300	9	8		2	2		2	3		4	4		9	6	0.1	11	12		1929	3657		1966	3692
Daily Total	172	158		187	206		178	171		191	201		117	115		161	145		13842	27709		14848	28725

1) Tide heights for low and high tide only. New York (the Battery), N.Y. and times adjusted for Indian Point Location.

Table A34. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer, for February 14. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL [1]	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	136	507	147	276	142	170	64	58	36	27	3	2	0	0	1	0	6369	12522
0100	102	380	150	282	135	162	63	57	4	3	0	0	1	1	2	1	5502	10667
0200	67	250	136	256	117	140	77	69	5	4	0	0	0	0	0	0	4840	8657
0300	10	37	66	124	110	132	50	45	16	12	8	5	1	1	1	0	262	356
0400	0	0	13	24	12	14	8	7	2	2	1	1	1	1	1	0	38	49
0500	1	4	2	4	2	2	1	1	1	1	5	3	1	1	0	0	13	16
0600	1	4	2	4	1	1	0	0	0	0	1	1	0	0	0	0	5	10
0700	1	4	3	6	0	0	0	0	1	1	2	1	1	1	0	0	8	13
0800	0	0	2	4	3	4	12	11	10	8	3	2	5	3	0	0	35	32
0900	0	0	7	13	4	5	8	7	9	7	3	2	5	3	3	1	39	38
1000	0	0	1	2	2	2	3	3	2	2	6	4	2	1	1	0	17	14
1100	0	0	2	4	2	2	4	4	3	2	19	11	4	2	2	1	36	26
1200	0	0	1	2	1	1	2	2	1	1	2	1	0	0	0	0	7	7
1300	0	0	0	0	0	0	2	2	6	5	7	4	6	3	7	3	28	17
1400	0	0	0	0	4	5	1	1	8	6	5	3	4	2	6	3	28	20
1500	2	7	1	2	3	4	3	3	4	3	9	5	1	1	6	3	29	28
1600	0	0	0	0	2	2	0	0	0	0	2	1	3	2	1	0	8	5
1700	0	0	1	2	1	1	0	0	0	0	0	0	0	0	0	0	2	3
1800	1	4	1	2	3	4	3	3	2	2	3	2	1	1	0	0	14	18
1900	0	0	0	0	6	7	3	3	0	0	2	1	0	0	0	0	11	11
2000	0	0	1	2	4	5	2	2	2	2	6	4	1	1	0	0	16	16
2100	2	7	2	4	3	4	4	4	1	1	2	1	0	0	1	0	15	21
2200	0	0	2	4	6	7	9	8	5	4	5	3	0	0	0	0	27	26
2300	1	4	2	4	0	0	7	6	8	6	5	3	2	1	0	0	30	28
Bin Total	324	1208	542	1021	563	674	326	296	126	99	99	60	39	25	32	12	17379	32600

1) Numbers have been extrapolated for 5-60 minute sample time.

Table A35. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer, for February 15. Indian Point, 1988.

Hour	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	HOURLY TOTAL [1] Raw	HOURLY TOTAL [1] WF
0000	1	4	1	2	2	2	6	5	8	6	7	4	3	2	4	2	32	27
0100	0	0	1	2	8	10	5	5	8	6	8	5	2	1	2	1	34	30
0200	0	0	2	4	3	4	3	3	14	11	9	5	3	2	5	2	39	31
0300	0	0	1	2	1	1	0	0	4	3	2	1	0	0	1	0	9	7
0400	0	0	1	2	2	2	1	1	0	0	3	2	0	0	1	0	8	7
0500	0	0	0	0	1	1	1	1	2	2	0	0	0	0	0	0	4	4
0600	0	0	2	4	7	8	4	4	7	5	4	2	0	0	0	0	31	29
0700	2	7	3	6	13	16	10	9	17	13	8	5	2	1	0	0	55	57
0800	0	0	6	11	8	10	7	6	6	5	9	5	7	4	0	0	43	41
0900	0	0	2	4	11	13	8	7	3	2	3	2	1	1	1	0	29	29
1000	0	0	2	4	7	8	12	11	5	4	5	3	7	4	8	4	46	38
1100	0	0	1	2	4	5	5	5	6	5	5	3	8	4	3	1	32	25
1200	0	0	0	0	2	2	3	3	1	1	3	2	1	1	2	1	12	10
1300	0	0	4	8	4	5	6	5	4	3	5	3	4	2	5	2	32	28
1400	2	7	2	4	1	1	9	8	7	5	14	8	6	3	8	4	49	40
1500	0	0	2	4	6	7	8	7	4	3	8	5	4	2	13	6	45	34
1600	2	7	2	4	8	10	1	1	5	4	8	5	1	1	5	2	32	34
1700	0	0	1	2	4	5	6	5	6	5	2	1	2	1	1	0	22	19
1800	0	0	1	2	2	2	4	4	4	3	2	1	3	2	0	0	16	14
1900	2	7	3	6	6	7	5	5	4	3	8	5	1	1	0	0	29	34
2000	0	0	2	4	2	2	5	5	6	5	7	4	2	1	0	0	24	21
2100	0	0	2	4	5	6	5	5	10	8	8	5	5	3	0	0	35	31
2200	1	4	2	4	5	6	6	5	15	11	7	4	3	2	0	0	39	36
2300	0	0	3	6	5	6	11	10	10	8	10	6	12	6	3	1	54	43
Bin Total	10	36	46	91	117	139	131	120	156	121	145	86	77	44	62	26	751	669

1) Numbers have been extrapolated for 47-60 minute sample time.

Table A36. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer, for February 16. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	0	0	2	4	6	7	4	4	11	8	12	9	9	5	15	7	64	48
0100	1	4	1	2	1	1	4	4	7	5	14	11	9	5	10	5	47	37
0200	4	15	5	9	12	14	17	15	14	11	23	17	21	11	16	7	112	99
0300	2	7	4	8	9	11	14	13	19	14	11	8	6	3	8	4	73	68
0400	0	0	1	2	3	4	3	3	0	0	2	2	1	1	2	1	12	13
0500	1	4	1	2	5	6	2	2	2	2	1	1	1	1	1	0	14	18
0600	0	0	0	0	7	8	3	3	1	1	0	0	0	0	1	0	12	12
0700	2	7	2	4	6	7	7	6	1	1	6	5	1	1	0	0	25	31
0800	2	7	7	13	8	10	11	10	9	7	5	4	1	1	0	0	43	52
0900	8	30	8	15	6	7	7	6	4	3	5	4	2	1	0	0	40	66
1000	1	4	4	8	9	11	8	7	10	8	7	5	1	1	0	0	40	44
1100	0	0	4	8	10	12	9	8	12	9	12	9	2	1	4	2	53	49
1200	0	0	0	0	3	4	8	7	7	5	12	9	10	5	9	4	49	34
1300	0	0	2	4	6	7	5	5	7	5	10	8	15	8	11	5	56	42
1400	1	4	10	19	18	22	22	20	21	16	24	18	12	6	19	9	127	114
1500	1	4	5	9	18	22	15	14	14	11	11	8	15	8	1	0	80	76
1600	1	4	1	2	4	5	6	5	5	4	1	1	10	5	2	1	30	27
1700	0	0	0	0	10	12	2	2	1	1	2	2	4	2	2	1	21	20
1800	0	0	2	4	4	5	3	3	1	1	6	5	9	2	2	1	21	21
1900	2	7	0	0	0	0	1	1	5	4	3	2	4	2	1	0	16	16
2000	1	4	5	9	3	4	7	6	5	4	2	2	2	1	0	0	25	30
2100	2	7	4	8	4	5	7	6	11	8	5	4	0	0	0	0	33	38
2200	2	7	1	2	9	11	8	7	1	1	5	4	3	2	1	0	30	34
2300	1	4	1	2	5	6	5	5	7	5	9	7	6	3	0	0	34	32
Bin Total	32	119	70	134	166	201	178	162	175	134	188	145	138	75	105	47	1057	1021

1) Numbers have been extrapolated for 55-60 minute sample time.

Table A37. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer, for February 17. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL [1]	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	1	4	5	9	6	7	13	12	26	20	17	10	15	8	4	2	87	72
0100	0	0	2	4	4	5	7	6	11	8	10	6	14	7	4	2	52	38
0200	0	0	3	6	10	12	8	7	6	5	9	5	5	3	6	3	47	41
0300	1	4	4	8	26	31	18	16	19	14	21	13	13	7	10	5	112	98
0400	0	0	0	0	1	1	5	5	9	7	3	2	4	2	4	2	26	19
0500	0	0	3	6	5	6	4	4	4	3	3	2	4	2	1	0	24	23
0600	1	4	0	0	0	0	0	0	0	0	1	1	0	0	1	0	3	5
0700	0	0	1	2	2	2	4	4	4	3	4	2	0	0	0	0	17	15
0800	0	0	3	6	5	6	5	5	3	2	5	3	0	0	0	0	21	22
0900	2	7	6	11	2	2	4	4	2	2	3	2	0	0	0	0	19	28
1000	1	4	6	11	5	6	7	6	1	1	0	0	0	0	0	0	20	28
1100	8	30	5	9	11	13	1	1	1	1	3	2	0	0	0	0	29	56
1200	0	0	4	8	6	7	2	2	2	2	2	1	3	2	1	0	20	22
1300	0	0	5	9	3	4	4	4	2	2	2	1	5	3	0	0	21	23
1400	0	0	4	8	8	10	8	7	12	9	11	7	11	6	7	3	61	50
1500	2	7	4	8	6	7	8	7	8	6	12	7	15	8	14	6	69	56
1600	0	0	4	8	22	26	15	14	13	10	19	11	20	10	9	4	102	83
1700	1	4	5	9	13	16	8	7	3	2	13	8	3	2	5	2	51	50
1800	1	4	0	0	3	4	5	5	2	2	4	2	2	1	1	0	18	18
1900	0	0	3	6	3	4	1	1	2	2	2	1	1	1	0	0	12	15
2000	1	4	2	4	6	7	1	1	3	2	2	1	1	1	1	0	17	20
2100	2	7	4	8	6	7	12	11	6	5	4	2	1	1	0	0	35	41
2200	2	7	4	8	2	2	9	8	5	4	2	1	0	0	0	0	24	30
2300	4	15	3	6	4	5	6	5	1	1	2	1	0	0	0	0	20	33
Bin Total	27	101	80	154	159	190	155	142	145	113	154	91	117	64	68	29	907	886

1) Numbers have been extrapolated for 52-60 minute sample time.

Table A38. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer, for February 18. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	1	4	4	8	2	2	3	3	7	5	1	1	1	1	2	1	21	25
0100	1	4	4	8	12	14	20	18	16	12	8	5	9	5	4	2	74	68
0200	0	0	17	32	41	49	46	41	45	34	76	46	22	11	14	6	261	219
0300	2	7	4	8	26	31	19	17	27	20	20	12	19	10	12	5	258	220
0400	2	7	2	4	8	10	3	3	6	5	17	10	5	3	7	3	100	90
0500	0	0	2	4	4	5	5	5	5	4	12	7	4	2	2	1	68	56
0600	2	7	3	6	4	5	7	6	3	2	3	2	2	1	2	1	26	30
0700	0	0	0	0	1	1	2	2	4	3	2	1	3	2	0	0	12	9
0800	2	7	4	8	3	4	4	4	6	5	4	2	0	0	1	0	24	30
0900	0	0	3	6	8	10	9	8	5	4	3	2	1	1	0	0	29	31
1000	1	4	0	0	6	7	5	5	6	5	1	1	0	0	0	0	19	22
1100	0	0	2	4	5	6	4	4	5	4	6	4	5	3	0	0	27	25
1200	1	4	8	15	12	14	4	4	11	8	2	1	2	1	0	0	40	47
1300	0	0	2	4	3	4	5	5	2	2	1	1	2	1	3	1	18	18
1400	1	4	1	2	1	1	4	4	1	1	1	1	1	1	1	0	11	14
1500	0	0	4	8	5	6	10	9	17	13	18	11	7	4	5	2	66	53
1600	0	0	5	9	15	18	25	23	20	15	17	10	12	6	9	4	103	85
1700	2	7	10	19	9	11	10	9	6	5	17	10	7	4	5	2	66	67
1800	2	7	2	4	9	11	11	10	10	8	9	5	7	4	6	3	56	52
1900	3	11	3	6	8	10	10	9	10	8	2	1	1	1	2	1	39	47
2000	1	4	2	4	1	1	3	3	4	3	6	4	1	1	1	0	19	20
2100	2	7	10	19	6	7	6	5	1	1	2	1	0	0	0	0	27	40
2200	0	0	4	8	9	11	4	4	5	4	4	2	0	0	0	0	26	29
2300	0	0	3	6	2	2	0	0	4	3	1	1	0	0	0	0	10	12
Bin Total	23	84	99	192	200	240	219	201	226	174	233	141	111	62	76	32	1400	1309

1) Numbers have been extrapolated for 30-60 minute sample time.

Table A39. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer, for February 19. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	0	0	8	15	6	7	7	6	4	3	4	2	4	2	1	0	34	35
0100	0	0	3	6	4	5	3	3	6	5	2	1	0	0	1	0	19	20
0200	0	0	2	4	2	2	2	2	2	2	4	2	5	3	2	1	19	16
0300	1	4	14	26	27	32	31	28	28	21	52	31	21	11	17	8	191	161
0400	4	15	17	32	15	18	29	26	32	24	40	24	2	1	12	5	302	290
0500	0	0	2	4	7	8	9	8	9	7	9	5	3	2	0	0	78	68
0600	1	4	2	4	6	7	6	5	7	5	11	7	5	3	1	0	78	70
0700	0	0	0	0	1	1	1	1	7	5	6	4	3	2	0	0	36	26
0800	0	0	0	0	4	5	2	2	3	2	2	1	2	1	0	0	13	11
0900	0	0	1	2	4	5	1	1	3	2	2	1	1	1	0	0	12	12
1000	3	11	1	2	16	19	6	5	5	4	3	2	0	0	0	0	34	43
1100	0	0	2	4	4	5	4	4	4	3	3	2	0	0	0	0	17	18
1200	0	0	4	8	6	7	3	3	4	3	8	5	1	1	0	0	26	27
1300	2	7	3	6	5	6	8	7	2	2	0	0	3	2	1	0	24	30
1400	2	7	2	4	1	1	2	2	2	2	4	2	2	1	3	1	18	20
1500	0	0	1	2	2	2	1	1	3	2	3	2	0	0	0	0	83	75
1600	0	0	5	9	7	8	16	14	9	7	28	17	18	9	9	4	92	68
1700	1	4	6	11	17	20	20	18	28	21	51	31	24	12	21	9	168	126
1800	0	0	4	8	10	12	22	20	21	16	26	16	14	7	15	7	112	86
1900	1	4	3	6	12	14	8	7	11	8	18	11	8	4	7	3	68	57
2000	1	4	2	4	4	5	9	8	11	8	12	7	11	6	2	1	52	43
2100	1	4	1	2	10	12	8	7	3	2	2	1	0	0	2	1	27	29
2200	1	4	1	2	5	6	8	7	4	3	5	3	0	0	0	0	24	25
2300	0	0	3	6	6	7	3	3	2	2	2	1	0	0	0	0	16	19
Bin Total	18	68	87	167	181	214	209	188	210	159	297	178	127	68	94	40	1543	1375

1) Numbers have been extrapolated for 7-60 minute sample time.

Table A40. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer, for February 20. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	5	19	8	15	8	10	6	5	9	7	4	2	0	0	0	0	40	58
0100	0	0	1	2	8	10	9	8	3	2	2	1	0	0	1	0	24	23
0200	1	4	4	8	7	8	4	4	4	3	6	4	2	1	0	0	28	32
0300	0	0	1	2	7	8	5	5	7	5	4	2	6	3	5	2	35	27
0400	1	4	5	9	22	26	25	23	39	29	43	26	16	8	14	6	165	131
0500	1	4	12	23	47	56	47	42	46	35	91	55	30	15	10	5	284	235
0600	0	0	13	24	32	38	28	25	24	18	30	18	28	14	18	8	173	145
0700	4	15	4	8	19	23	25	23	7	5	23	14	15	8	5	2	102	98
0800	0	0	8	15	16	19	23	21	7	5	14	8	6	3	2	1	76	72
0900	0	0	1	2	2	2	3	3	6	5	3	2	2	1	1	0	18	15
1000	0	0	3	6	1	1	1	1	3	2	7	4	1	1	0	0	16	15
1100	2	7	1	2	6	7	4	4	2	2	6	4	0	0	0	0	21	26
1200	0	0	3	6	3	4	3	3	2	2	5	3	0	0	0	0	16	18
1300	2	7	6	11	3	4	6	5	5	4	3	2	2	1	0	0	27	34
1400	0	0	4	8	4	5	4	4	3	2	4	2	4	2	0	0	23	23
1500	1	4	1	2	2	2	3	3	1	1	5	3	4	2	1	0	18	17
1600	1	4	1	2	3	4	6	5	14	11	28	17	10	5	11	5	74	53
1700	2	7	7	13	12	14	25	23	28	21	37	22	14	7	14	6	139	113
1800	3	11	14	26	34	41	29	26	19	14	18	11	15	8	6	3	138	140
1900	3	11	20	38	30	36	38	34	19	14	24	14	11	6	5	2	150	155
2000	2	7	17	32	26	31	18	16	14	11	13	8	18	9	4	2	112	116
2100	4	15	1	2	3	4	13	12	5	4	1	1	4	2	2	1	33	41
2200	2	7	3	6	2	2	3	3	4	3	7	4	2	1	4	2	27	28
2300	2	7	3	6	7	8	5	5	8	6	5	3	3	2	0	0	33	37
Bin Total	36	133	141	268	304	363	333	303	279	211	383	230	193	99	103	45	1772	1652

1) Numbers have been extrapolated for 60 minute sample time.

Table A41. Hourly estimates of raw and weighted fish numbers (with high and low tide heights)[1] in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer for week 5, February 14 to 20. Indian Point, 1988.

	FEB 14			FEB 15			FEB 16			FEB 17			FEB 18			FEB 19			FEB 20			WEEKLY TOTAL	
Hour	RAW	WF	Tide	RAW	WF	Tide	RAW	WF	Tide	RAW	WF	Tide	RAW	WF	Tide	RAW	WF	Tide	RAW	WF	Tide	RAW	WF
0000	6369	12522		32	27		64	48		87	72		21	25		34	35		40	58		6647	12786
0100	5502	10667		34	30		47	37		52	38		74	68		19	20		24	23	1.6	5752	10883
0200	4840	8657	0.1	39	31		112	99		47	41		261	219		19	16		28	32		5346	9095
0300	262	356		9	7	-0.1	73	68		112	98		258	220		191	161		35	27		940	937
0400	38	49		8	7		12	13	-0.2	26	19		100	90		302	290		165	131		651	599
0500	13	16		4	4		14	18		24	23	-0.3	68	56		78	68		284	235		485	420
0600	5	10		31	29		12	12		3	5		26	30	-0.3	78	70		173	145		328	301
0700	8	13		55	57		25	31		17	15		12	9		36	26	-0.4	102	98	-0.3	255	249
0800	35	32	1.4	43	41		43	52		21	22		24	30		13	11		76	72		255	260
0900	39	38		29	29	1.5	40	66		19	28		29	31		12	12		18	15		166	219
1000	17	14		46	38		40	44	1.6	20	28	1.6	19	22		34	43		16	15		192	204
1100	36	26		32	25		53	49		29	56		27	25	1.7	17	18		21	26		215	225
1200	7	7		12	10		49	34		20	22		40	47		26	27	1.6	16	18		170	165
1300	28	17		32	28		56	42		21	23		18	18		24	30		27	34	1.5	206	192
1400	28	20		49	40		127	114		61	50		11	14		18	20		23	23		317	281
1500	29	28	-0.1	45	34		80	76		69	56		66	53		83	75		18	17		390	339
1600	8	5		32	34	-0.2	30	27		102	83		103	85		92	68		74	53		441	355
1700	2	3		22	19		21	20	-0.3	51	50	-0.4	66	67		168	126		139	118		469	398
1800	14	18		16	14		21	21		18	18		56	52	-0.4	112	86		138	140		375	349
1900	11	11		29	34		16	16		12	15		39	47		68	57	-0.4	150	155		325	335
2000	16	16	1.1	24	21		25	30		17	20		19	20		52	43		112	116	-0.3	265	266
2100	15	21		35	31	1.2	33	38		35	41		27	40		27	29		83	41		205	241
2200	27	26		39	36		30	34	1.1	24	30		26	29		24	25		27	28		197	208
2300	30	28		54	43		34	32		20	33	1.5	10	12	1.6	16	19		33	37		197	204
Daily Total	17379	32600		751	669		1057	1021		907	886		1400	1309		1543	1375		1772	1652		24809	39512

1) Tide heights for low and high tide only, New York (the Battery), N.Y. and times adjusted for Indian Point Location.

Table A42. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer, for February 21. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL[1]	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	2	7	6	11	12	14	21	19	25	19	14	8	1	1	0	0	104	101
0100	0	0	2	4	8	10	8	7	11	8	8	5	2	1	0	0	39	35
0200	1	4	3	6	2	2	4	4	3	2	4	2	0	0	0	0	17	20
0300	0	0	1	2	3	4	3	3	2	2	1	1	3	2	0	0	13	14
0400	1	4	4	8	9	11	13	12	15	11	25	15	11	6	12	5	90	72
0500	1	4	11	21	14	17	24	22	35	26	65	39	27	14	22	10	199	153
0600	3	11	7	13	20	24	26	23	29	22	45	27	15	8	22	10	167	138
0700	3	11	6	11	20	24	23	21	16	12	12	7	13	7	10	5	103	98
0800	3	11	10	19	14	17	10	9	5	4	11	7	7	4	4	2	64	73
0900	0	0	2	4	4	5	2	2	7	5	5	3	2	1	6	3	28	23
1000	1	4	4	8	9	11	3	3	5	4	1	1	2	1	2	1	27	33
1100	0	0	0	0	1	1	3	3	2	2	0	0	3	2	1	0	10	8
1200	0	0	5	9	3	4	6	5	6	5	3	2	0	0	0	0	23	25
1300	0	0	2	4	1	1	0	0	6	5	4	2	1	1	0	0	14	13
1400	1	4	0	0	2	2	1	1	0	0	2	1	1	1	0	0	14	18
1500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1600	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	8	8
1700	1	4	4	8	11	13	14	13	8	6	9	5	5	3	2	1	54	53
1800	2	7	7	13	18	22	35	32	41	31	26	16	19	10	11	5	159	136
1900	3	11	22	41	32	38	26	23	29	22	37	22	7	4	12	5	168	166
2000	3	11	21	39	10	12	14	13	11	8	8	5	5	3	2	1	74	92
2100	1	4	2	4	4	5	5	5	8	6	19	11	5	3	0	0	44	38
2200	1	4	0	0	0	0	1	1	1	1	2	1	0	0	1	0	6	7
2300	2	7	1	2	0	0	4	4	2	2	2	1	1	1	0	0	14	20
Bin Total	29	108	120	227	197	237	246	225	269	205	303	181	130	73	107	48	1439	1345

1) Numbers have been extrapolated for 15-60 minute sample time.

Table A43. Hourly estimates of raw and weighted fish numbers by range bin (in meters) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer, for February 22. Indian Point, 1988.

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		HOURLY TOTAL [1]	
Hour	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
0000	1	4	2	4	8	10	5	5	4	3	7	4	0	0	0	0	27	30
0100	0	0	2	4	5	6	3	3	6	5	6	4	0	0	0	0	22	22
0200	1	4	1	2	5	6	6	5	4	3	5	3	0	0	0	0	22	23
0300	0	0	1	2	6	7	4	4	3	2	2	1	2	1	1	0	19	17
0400	0	0	1	2	4	5	5	5	0	0	1	1	0	0	2	1	13	14
0500	1	4	3	6	2	2	10	9	9	7	13	8	4	2	3	1	45	39
0600	0	0	3	6	6	7	5	5	12	9	7	4	7	4	9	4	49	39
0700	0	0	2	4	2	2	3	3	2	2	8	5	0	0	0	0	17	16
0800	0	0	3	6	3	4	2	2	6	5	4	2	1	1	5	2	24	22
0900	1	4	1	2	2	2	1	1	2	2	2	1	0	0	0	0	12	15
1000	0	0	3	6	1	1	0	0	2	2	1	1	0	0	1	0	8	10
1100	0	0	0	0	1	1	0	0	1	1	1	1	0	0	1	0	4	3
1200	0	0	0	0	1	1	7	6	3	2	2	1	0	0	0	0	13	10
1300	2	7	3	6	10	12	3	3	2	2	5	3	0	0	0	0	25	33
1400	0	0	4	8	3	4	4	4	4	3	1	1	2	1	0	0	18	21
1500	2	7	6	11	7	8	13	12	3	2	8	5	3	2	2	1	44	48
1600	1	4	3	6	5	6	5	5	3	2	4	2	7	4	1	0	57	57
1700		0		0		0		0		0		0		0		0	0	0
1800		0		0		0		0		0		0		0		0	0	0
1900		0		0		0		0		0		0		0		0	0	0
2000		0		0		0		0		0		0		0		0	0	0
2100		0		0		0		0		0		0		0		0	0	0
2200		0		0		0		0		0		0		0		0	0	0
2300		0		0		0		0		0		0		0		0	0	0
Bin Total	9	34	38	75	71	84	76	72	66	52	77	47	26	15	25	9	419	420

1) Numbers have been extrapolated for 31-60 minute sample time.

Table A44. Hourly estimates of raw and weighted fish numbers (with high and low tide heights) in front of unit 3, intake 35 using 6 X 12 degree elliptical horizontal transducer for week 6, February 21 to 22. Indian Point, 1988.

Hour	FEB 21 RAW	FEB 21 WF	FEB 21 Tide	FEB 22 RAW	FEB 22 WF	FEB 22 Tide	DAY 3 RAW	DAY 3 WF	DAY 3 Tide	DAY 4 RAW	DAY 4 WF	DAY 4 Tide	DAY 5 RAW	DAY 5 WF	DAY 5 Tide	DAY 6 RAW	DAY 6 WF	DAY 6 Tide	DAY 7 RAW	DAY 7 WF	DAY 7 Tide	WEEKLY TOTAL RAW	WEEKLY TOTAL WF
0000	104	101		27	30																	131	131
0100	39	35	1.6	22	22																	61	57
0200	17	20		22	23	1.5																39	43
0300	13	14		19	17																	32	31
0400	90	72		19	14																	109	86
0500	199	153		45	39																	244	192
0600	167	138		49	39																	216	177
0700	103	98		17	16																	120	114
0800	64	73	-0.2	24	22																	88	95
0900	28	23		12	15	-0.1																40	38
1000	27	33		8	10																	35	43
1100	10	8		4	3																	14	11
1200	23	25		13	10																	36	35
1300	14	13		25	33																	39	46
1400	14	18	1.4	18	21																	32	39
1500	0	0		44	48	1.3																44	48
1600	8	8		57	57																	65	65
1700	54	53		0	0																	54	53
1800	159	136		0	0																	159	136
1900	168	166		0	0																	168	166
2000	74	92	-0.2	0	0																	74	92
2100	44	38		0	0																	44	38
2200	6	7		0	0																	6	7
2300	14	20		0	0																	14	20
Daily Total	1439	1345		419	420		0	0		0	0		0	0		0	0		0	0		1858	1765

1/ Tide heights for low and high tide only, New York (the Battery), N.Y. and times adjusted for Indian Point Location.

APPENDIX B:

Target Strength Data

APPENDIX B:

Dual-beam Target Strength Measurements and Interpretation

Introduction

A fish's target strength is a measure of its echo reflecting power. The larger the target strength, the greater the sound energy reflected by a fish when it is ensonified by an acoustic beam. Acoustic backscattering from a fish is a complex phenomenon. The intensity of an echo reflected from a fish depends on a variety of factors, including acoustic frequency, fish size, orientation in the beam, and swim bladder characteristics. Despite the many variables, empirical relationships have been derived between average fish length and average target strength for many species of fish. (Haslett 1969, Love 1971, McCartney and Stubbs 1971). In the last decade, techniques have been developed to measure target strengths of freely swimming fish in their natural habitats (Burczinski and Dawson 1984; Ehrenberg 1984a, 1984b).

Target strengths are expressed on a logarithmic scale in decibel units. Typical values for fish range from -60 to -20 dB. The arithmetic equivalent of target strength (TS) is the backscattering cross section (σ_{bs}) in units of m^{-2} where:

$$TS = 10 \log(\sigma_{bs}) \qquad (1)$$

The voltage output of a single-beam system is related to a fish's backscattering cross section (and target strength) by the following equation:

$$V^2 = k\, \sigma_{bs}\, b^2(\theta, \varnothing) \qquad (2)$$

where

V = detected output of an echo sounder at a 40 log R time-varied gain. The echo intensity (I) is proportional to V^2.

k = a constant determined from system calibration and equipment settings.

bs = backscattering cross section of the fish. This is a measure of the power of the fish's acoustic return to the transducer. Target strength is related to TS by equation (1).

$b(\theta,0)$ = beam pattern factor of the transducer. This is the ratio of the acoustic beam's transmitted intensity (I) at the angular coordinates $(\theta,\emptyset)$ to that at the acoustic axis of the transducer, i.e.,

$$b(\theta,\emptyset) = \frac{I(\theta,\emptyset)}{I(0,0)}$$

$b(\theta,\emptyset)$ is also a measure of the transducer's receiving sensitivity. Because a single-beam echo sounder uses the same transducer for both transmitting and receiving, this quantity is squared in equation (2).

Under controlled laboratory conditions, the values of V^2, k, and $b^2(\theta,\emptyset)$ can be measured and equation (2) solved for σ_{bs}. However, in the open environment, the b^2 value cannot be measured because there is no way to determine a fish's exact coordinates $(\theta,\emptyset)$ in the beam. In other words, a single-beam system cannot make direct *in situ* target strength measurements because the fundamental equation (2) contains two unknowns (σ_{bs}, b^2).

A dual-beam system overcomes this problem by utilizing a second transducer element, and hence a second equation. The b^2 value is factored out and equations (3) and (4) are solved for σ_{bs}. Specifically, a dual-beam system transmits pulses on a narrow-beam transducer element and receives the returning echoes on both narrow- and wide-beam elements. The narrow- and wide-beam squared voltage outputs are:

$$V_n^2 = k_n \, \sigma_{bs} \, b_n^2(\theta,\emptyset) \quad (3)$$

$$V_w^2 = k_w \, \sigma_{bs} \, b_w^2(\theta,\emptyset) \quad (4)$$

By assuming the dual-beam system is designed such that $b_w(\theta,\varnothing) = 1$ over the main lobe of the narrow beam, the squared voltages (3) and (4) from the received echo signal become:

$$\frac{V_n^2}{V_w^2} = \frac{k_n\, b_n(\theta,\varnothing)}{k_w} \qquad (5)$$

This can be rearranged into the form:

$$b_n(\theta,\varnothing) = \frac{V_n^2\, k_w}{V_w^2\, k_n} \qquad (6)$$

Inserting this $b_n(\theta,\varnothing)$ value into equation (3) and rearranging the formula allows computation of a fish's backscattering cross section according to:

$$\sigma_{bs} = \frac{V_w^2\, k_n}{V_n^2\, k_w^2} \qquad (7)$$

The backscattering cross section value can then be converted into target strength using equation (1).

2.0 METHODS

Dual-beam data were collected at the Indian Point Unit 3 intakes between January 13 and March 4, 1988. Approximately 34 hours of data were recorded over the study period and used to evaluate changes in mean acoustic size of the fish population over time, with depth, and in response to hammer operation.

2.1 Instrumentation

The equipment used to collect target strength information consisted of a BioSonics Model 101 dual-beam echo sounder, two BioSonics Model 111 thermal chart recorders, an oscilloscope, a BioSonics 6° X 15° dual-beam transducer and a digital tape recording system. The recording system used a BioSonics Model 171 tape interface, Sony digitizer, and Sony Beta VCR to digitally encode the data on video tape. These tapes were then shipped to Seattle for further analysis.

2.2 Data Collection

The dual-beam transducer was mounted on the end of a 10 ft long steel pole, which was attached to the catwalk approximately one meter in front of the intake at a depth of 0.5 meters below the mean low water level (MLW). This mount was located at Intake 35 during the first six weeks of the study. After February 28, the transducer was moved to Intake 36, due to the failure of the two hammers at Intake 35. At both locations, the mount was centered in the intake directly above the hammers.

Dual-beam data were collected at three different transducer orientations. Objectives were to evaluate target strength distributions at various distances offshore from the intake and also to verify that the single-beam system threshold was correctly set. The location, transducer orientation and time of dual-beam data collection are shown in Table B1. On January 13 and 20, dual-beam data were collected with the transducer aimed 35° from vertical (0° = straight down), the same orientation as the 15° oblique transducer. On January 28 and February 22, side-scan data were collected at a 90° vertical aiming angle and used to evaluate the population being sampled by the horizontally-aimed 6° X 12° elliptical transducer. After February 22, all data were collected with the transducer aimed straight down, at a 0° vertical aiming angle. These data were used to estimate the acoustic size of the population directly in front of the intake and to evaluate any changes in target strength distribution with respect to hammer operation. This orientation also provided the least variable estimate of the population target strength.

Table B1. Dual-beam sampling schedule, Indian Point Unit 3, 1988.

Date	St. Time	End Time	Tape #	Location	Orientation
1/12	1328	1533	1	35	35°
1/20	0900	1107	2	35	35°
1/28	1335	1540	3	35	90°
2/22	1700	1955	4	35	90°
2/22	2000	2244	5	35	90°
2/23	1745	2041	6	35	0°
2/24	1015	1220	7	35	0°
2/24	1915	2128	8	35	0°
2/24	2136	2228	9	35	0°
2/25	1130	1239	9	35	0°
2/26	0753	1100	10	35	0°
2/27	0022	0327	11	35	0°
2/27	1011	1150	12	35	0°
2/27	1750	1911	12	35	0°
2/28	1405	1515	13	35	0°
3/03	0515	0706	13	36	0°
3/04	1815	1834	14	36	0°

2.3 Data Analysis

After dual-beam data collection was complete, the data tapes were returned to Seattle and processed using a BioSonics Model 181 Dual-beam Processor. The Model 181 operates by first selecting only single target echoes based on detection criteria entered by the user. Returns from noise, structure, multiple echoes, and other non-fish targets were excluded from the output data, which was dumped to an IBM–compatible computer file. These files were then analyzed using TS, a BioSonics software program, which outputs target strength distribution by depth. Comparisons between different conditions and locations were made by combining the appropriate input files.

Fish detections in the first 1.3 m from the transducer were not used for target strength calculations, as an accurate 40 log R amplification is not applied within this range. Transducer sampling ranges varied with mount orientation, with 6.5 meters range on the vertical mount, 9 meters on the oblique, and 40 meters range on the side-scan mount. Changes in target strength with depth on the vertically-oriented transducer were evaluated at 1 m intervals. The mean target strength over the sample range was used to evaluate system performance at the other two orientations.

3.0 RESULTS

Data were collected on January 12 and 20 with the transducer aimed obliquely into the river 35° out from vertical (0° = straight down). This information was analyzed and used to evaluate the target strength of the population sampled by the 15° oblique single-beam transducer. The axis of this transducer intersected the bottom about 5 m out from the intake trashrack. The mean target strength of the population on January 12 was found to be -41.02 dB, while on January 20 a mean target strength of -48.97 dB was observed, indicating smaller fish were present on the latter date (Table B2). Both values were significantly greater than the -60 dB minimum detection threshold of the single-beam system, indicating that all targets of interest were acoustically visible.

The dual-beam information acquired on January 28 and February 22 was used to assess the detection threshold of the side-scan transducers. On January 28, a mean target strength in side-aspect of -46.70 was observed. This result was 4 to 6 dB larger than the two samples acquired on the evening of February 22, which showed target strengths of -50.63 dB and -52.15 dB. All of these values are well within the -60 detection threshold of the hydroacoustic system.

Between February 23 and March 4, data were collected with the transducer aimed straight down at a 0° vertical aiming angle. This orientation provided the least variable estimate of target strength distribution as fish are more uniform reflectors when ensonified in dorsal aspect. At other aspects, small changes in orientation may result in significant changes in target strength. For this reason, data collected at different aspects should not be compared with one another.

To evaluate changes in the acoustic size of the fish population over time, dorsal target strength estimates were grouped on a daily basis. These values are presented in Table B3. Dual-beam data collected during periods of low fish activity were not included.

Table B3. Mean Target Strength vs. Hammer Operation, Indian Point Unit 3, 1988.

Seq #	Date	St. Time	End Time	Hammers On/Off	Sample	TS
1	2/23	1804	1822	Off	228	-50.60
2	2/23	1822	1837	1&3 On	172	-50.02
3	2/23	1915	1941	Off	103	-50.21
4	2/23	1941	1959	1&3 On	222	-49.24
5	2/23	1959	2015	Off	524	-52.42
6	2/23	015	2026	1&3 On	828	-52.14
7	2/23	2026	2041	Off	590	-52.09
8	2/24	1923	1957	Off	552	-50.50
9	2/24	1957	2010	1&3 On	627	-52.94
10	2/24	2010	2128	Off	817	-51.23
11	2/26	0756	0806	Off	439	-49.20
12	2/26	0806	0810	1,3&5 On	506	-50.88
13	2/26	0810	0814	Off	222	-50.56
14	2/26	0814	0817	5 On	274	-50.03
15	2/26	0817	0822	1&3 On	482	-51.19
16	2/26	0822	0828	Off	596	-50.43
17	2/26	0828	0835	1&3 On	57	-50.73
18	2/26	0825	0849	Off	143	-51.07
19	2/26	0849	0859	1,3&5 On	670	-49.32
20	2/26	0859	0924	Off	2221	-49.57
21	2/26	0924	0934	1,3&5 On	2191	-50.22
22	2/26	0934	1007	Off	3574	-49.73
23	2/26	1007	1017	5 On	723	-50.33
24	2/27	1750	1800	1,3&5 On	2066	-51.60
25	2/27	1800	1810	Off	1358	-52.28
26	2/27	1810	1820	1,3&5 On	584	-51.23
27	2/27	1820	1830	Off	786	-51.44
28	2/27	1830	1840	1,3&5 On	2297	-52.00
29	2/27	1840	1851	Off	616	-50.92
30	2/27	1851	1900	1&3 On	724	-50.83
31	2/27	1900	1910	Off	643	-51.74

The mean observed target strength of the population did not change significantly over the 11 day sample period (Table B3). The average acoustic size of the fish were also similar between Intakes 35 and 36, with measured target strengths between -50.0 dB and -52.4 dB. A target strength of -51.0 dB would correspond to a fish length of 5.0 cm, using Love's equation, an empirical relationship relating average dorsal-aspect target strength to fish length (Love 1971).

Average target strength comparisons were also made between individual hammer on and hammer off treatments to evaluate if the mean acoustic size of the population was different when the hammers were operating. This might indicate a size-dependent or species-specific response to the hammers (Table B4).

However, mean target strength over the test period did not appear to be correlated with hammer operation. The observed values were consistent, between -49.20 dB and -52.94 dB, and consistant changes in response to hammer operation were not observed. The average target strength of fish in the smaple area appeared to be similar, regardless of hammer condition. This does not necessarily indicate that the same population was present during hammer-on and hammer-off treatments. If the size distribution was fairly homogeneous across the intake, movement through the acoustic beam could occur without significantly affecting the observed mean target strength.

Table B4. Mean Target Strength by Day, 2/23 – 3/4/88, Indian Point Unit 3, 1988.

Date	St. Time	End Time	Tape #	Location	Mean TS
2/23	1745	2041	6	Intake 35	-51.60
2/24	1015	1220	7	Intake 35	-50.62
2/24	1915	2128	8	Intake 35	-51.57
2/26	0753	1100	10	Intake 35	-50.00
2/27	1750	1911	12	Intake 35	-51.67
2/28	1405	1515	13	Intake 35	-51.27
3/03	0515	0706	13	Intake 36	-52.40
3/04	1815	1834	14	Intake 36	-50.67

To evaluate vertical changes in target strength distribution in response to the hammers, four dual-beam hammer tests were analyzed with respect to depth. These data were collected between February 23 and 27 at Intake 35. Mean target strength values were calculated for 5 strata between 1.3 m and 6 m range from the transducer. Preliminary results from the vertical 6° transducer indicated some fish may have been exhibiting vertical movement in response to hammer operation. For each test, target strength estimates were generated in one-meter strata, comparing hammer-on and hammer-off conditions. This was done to determine whether the acoustic size of fish was correlated with the vertical response to the hammers. The frequency of target strength vs. depth were also calculated. These results are presented graphically in Figures B1 through B5.

On a daily basis, vertical changes in target strength distribution in response to hammer operation were somewhat variable. On February 23, an increase in target strength was noted in the upper two meters with the hammers on. However, on February 24, larger fish targets appeared to move out of these upper strata when the hammers were operating. Results from February 26 and 27 were ambiguous, with similar target strengths observed below 3 m depth and scattered fish of differing size present in the upper two strata.

When data for all four days were combined and evaluated with respect to hammer operation, significant differences with depth were not observed. Both treatments exhibited a general decrease in mean target strength from the surface down to 5.0 m depth and an increase in acoustic size in the stratum nearest the bottom. The largest fish appeared to orient at the bottom and near the surface. However, the overall size distribution was not large. Using Love's equation, the range of observed mean target strengths, -49.05 dB to -52.25 dB, corresponded to mean fish lengths of between 4.3 cm and 6.3 cm.

Target strength frequency with depth was also compared to hammer operation. In most cases, greater numbers of targets were detected in the upper water column when the hammers were on. This is illustrated by the 3-D plots in Figures B1 through B5. Figures B1, B2, B4 and B5 show a shift in the number of targets observed towards the surface during hammer treatments. While mean fish target strength was generally similar with depth, more of the population was observed higher in the water.

4.0 CONCLUSIONS

1. The detection threshold of the hydroacoustic system employed for the Indian Point Unit 3 study in 1988 was well below the target strength of the fish population. All fish of interest in the sampled areas were readily detected by the equipment.

2. The mean target strength of the population was generally uniform between February 23 and March 4, 1988; and between Intakes 35 and 36.

3. Consistent changes in target strength distribution were not observed in response to hammer operation.

4. Bottom-oriented fish near the face of a hammer may move higher vertically in the water column when the hammer is operating.

Mean Target Strength by Depth 2/23/88 – 2/27/88

Depth (m)	1.3-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	MeanTS
Hammers On	-49.05	-50.59	-51.81	-52.25	-49.91	-51.14
Hammers Off	-49.58	-49.98	-51.08	-51.98	-50.07	-50.58

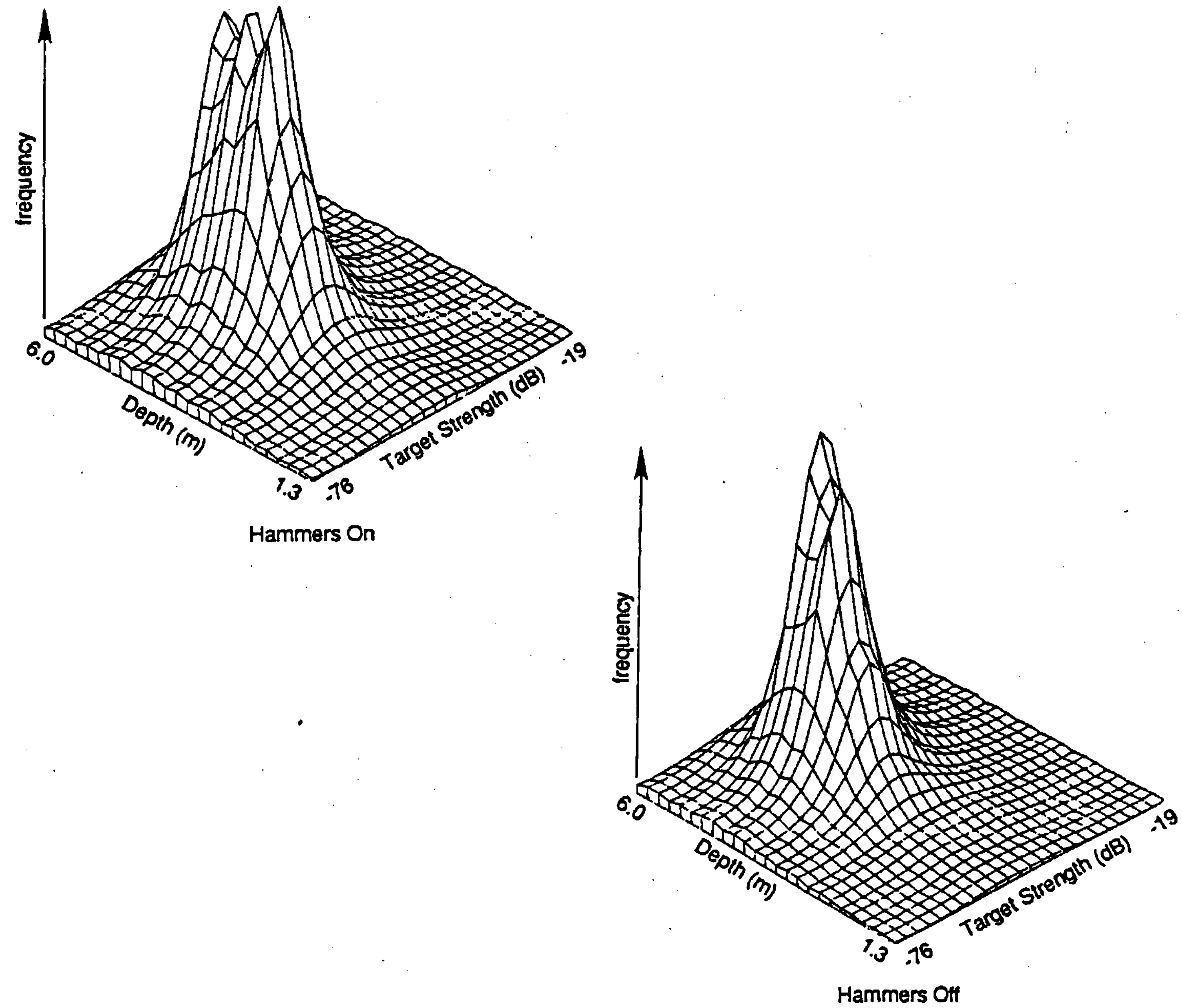
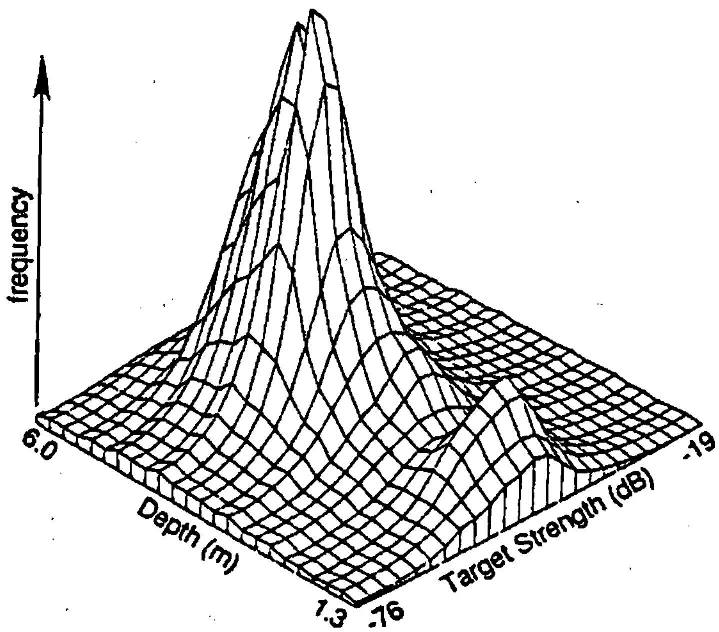


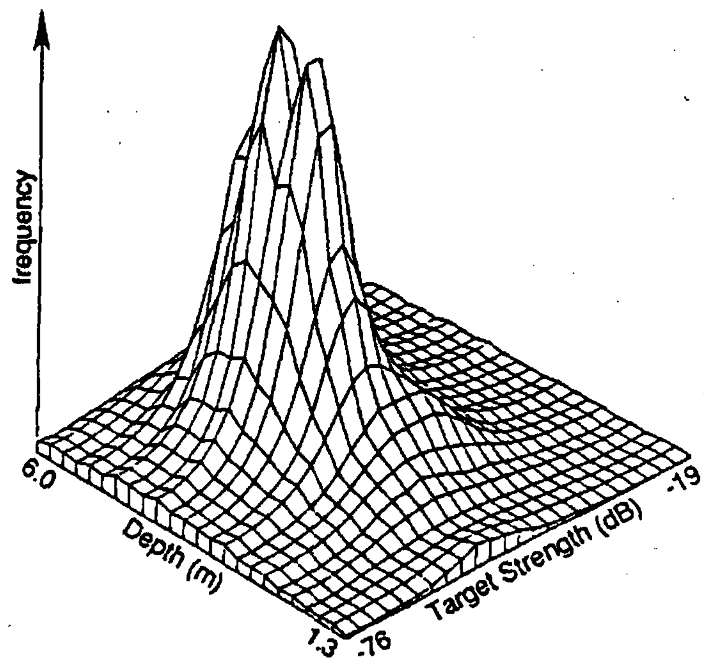
Figure B1. Target strength vs. depth, shown with hammers on and off, for February 23-27, Indian Point Power Plant Unit 3, 1988.

Target Strength by Depth 2/23/88 1804 – 2041 h

Depth (m)	1.3-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	MeanTS
Hammers On	-48.72	-49.02	-49.65	-52.81	-50.60	-51.31
Hammers Off	-52.82	-51.94	-49.08	-52.77	-51.62	-51.84



Hammers On

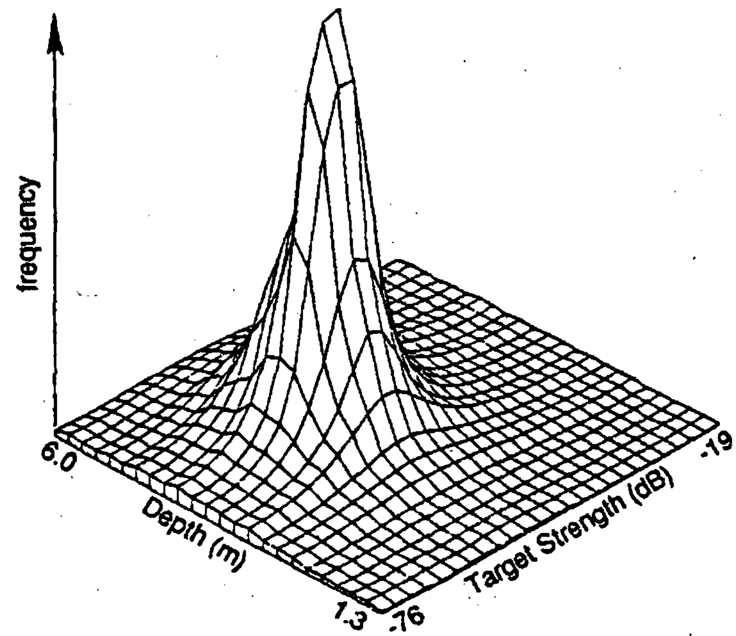


Hammers Off

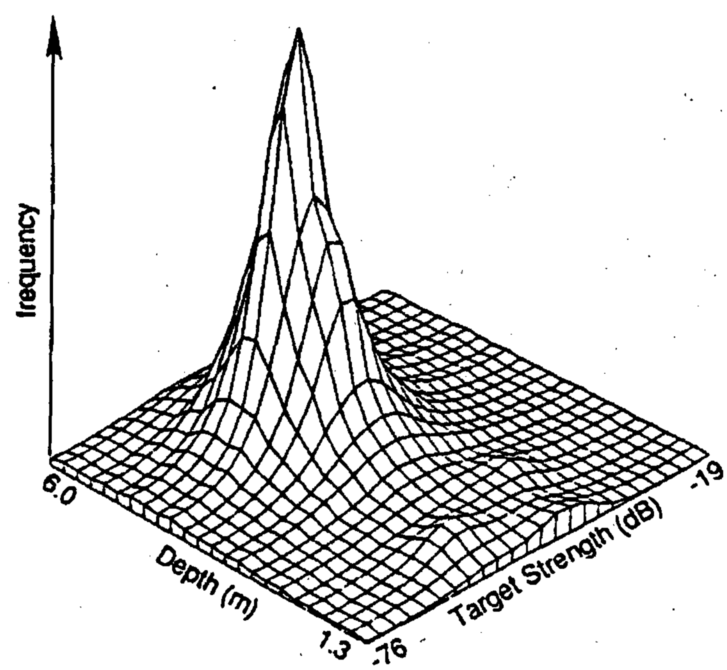
Figure B2. Target strength vs. depth, shown with hammers on and off, for February 23, Indian Point Power Plant Unit 3, 1988.

Target Strength by Depth 2/24/88 1923 – 2128 h

Depth (m)	1.3-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	MeanTS
Hammers On			-53.35	-53.68	-50.02	-52.94
Hammers Off	-47.59	-48.39	-49.22	-51.50	-51.16	-50.94



Hammers On

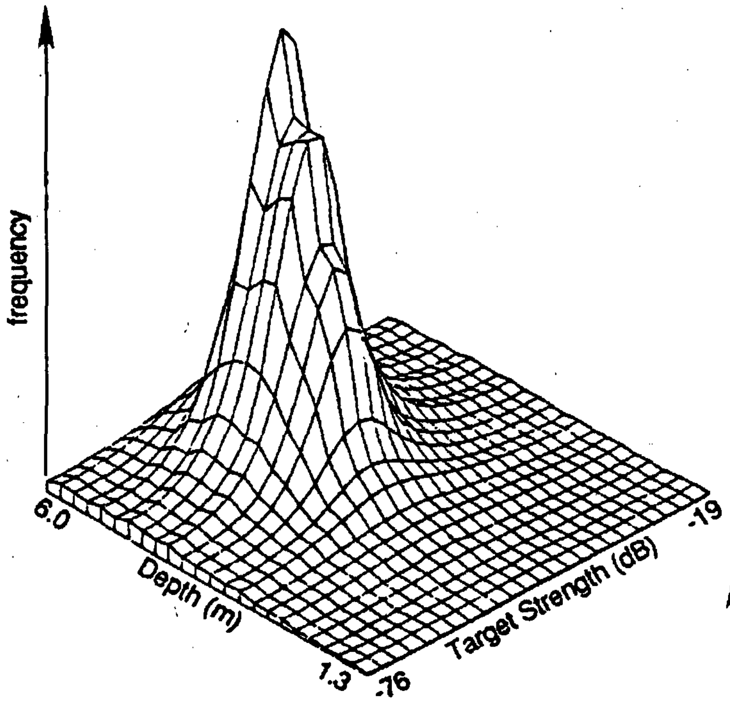


Hammers Off

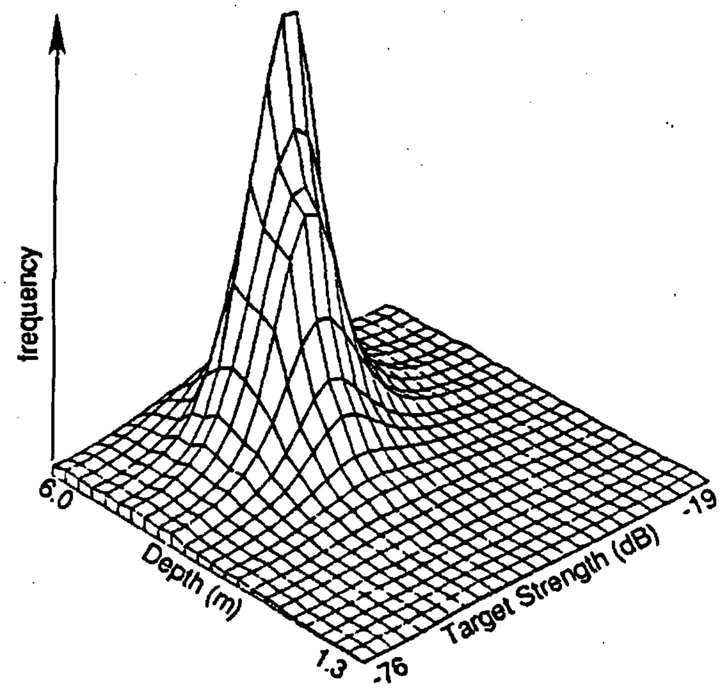
Figure B3. Target strength vs. depth, shown with hammers on and off, for February 24, Indian Point Power Plant Unit 3, 1988.

Target Strength by Depth 2/26/88 0849 – 1017 h

Depth (m)	1.3-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	MeanTS
Hammers On		-51.07	-49.49	-51.67	-49.74	-50.35
Hammers Off	-54.57		-47.51	-51.65	-49.45	-49.78



Hammers On

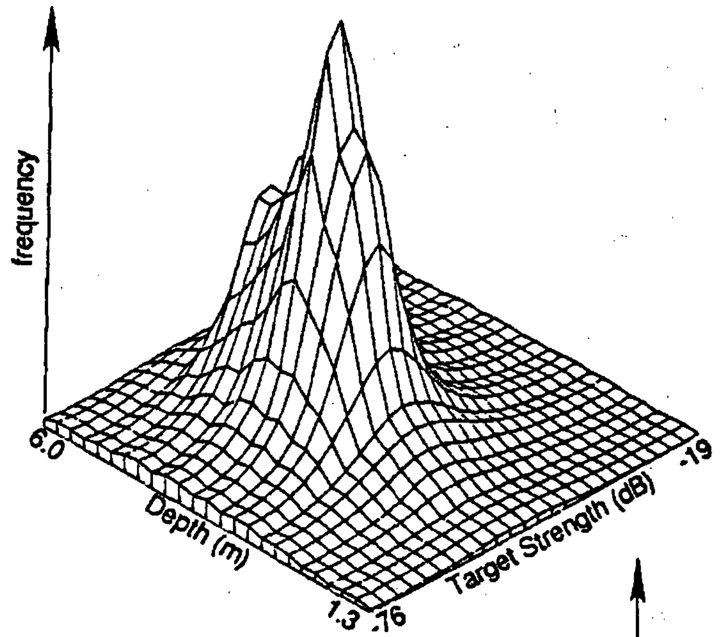


Hammers Off

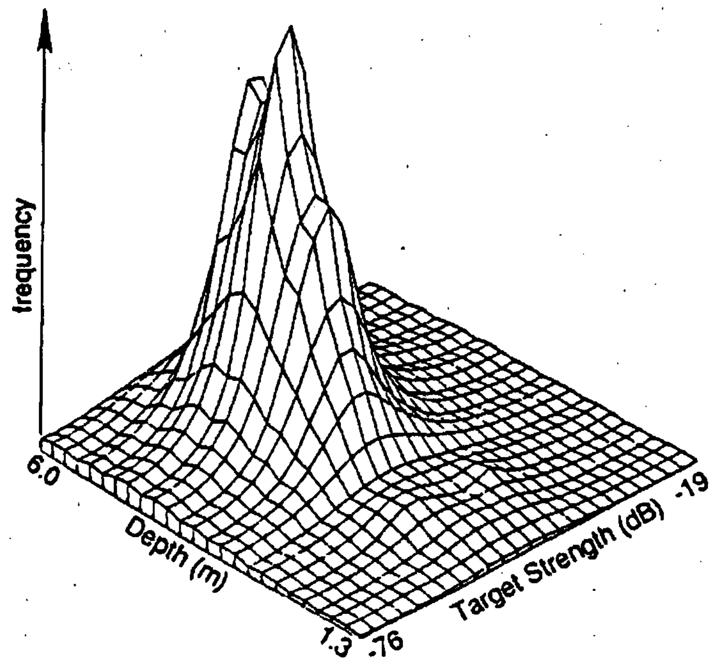
Figure B4. Target strength vs. depth, shown with hammers on and off, for February 26, Indian Point Power Plant Unit 3, 1988.

Target Strength by Depth 2/27/88 1750 - 1910 h

Depth (m)	1.3-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	MeanTS
Hammers On	-49.60	-52.56	-52.22	-52.24	-50.11	-51.62
Hammers Off		-50.25	-53.43	-52.11	-51.41	-51.74



Hammers On



Hammers Off

Figure B5. Target strength vs. depth, shown with hammers on and off, for February 27, Indian Point Power Plant Unit 3, 1988.

APPENDIX C:

Hammer Tests Monitored By

15° Oblique Transducer

Table C1. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: At low tide

Duration of Test: 15 min, hmrs 1,2&3

Treatment Type: 10 sec on, 20 sec off

Test Date: 1/27/88

Test Time: 0005

15 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2[1] Raw	0-2[1] WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[2] Raw	Total[2] WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	7	53	55	207	81	203	36	68	179	531	168	527
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	3	23	23	87	48	120	13	25	87	255	114	313
WW	0	0	0	0	0	0	0	0	0	0	0	0
Total	10	76	78	294	129	323	49	93	266	786	282	839

15 MINUTES AFTER TEST PERIOD[2]

RANGE (meters)

Trace Type	0-2[1] Raw	0-2[1] WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[2] Raw	Total[2] WF
LS	14	107	61	230	47	118	35	67	157	522
SL	0	0	0	0	0	0	0	0	0	0
NC	1	8	26	98	80	201	33	63	140	370
WW	0	0	0	0	0	0	0	0	0	0
Total	15	115	87	328	127	319	68	130	297	892

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	1.440	0.077
SL	--	--
NC	12.374	21.160
WW	--	--
TOTAL	1.707	6.696

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	11	80	58	219	64	161	36	68
SL	0	0	0	0	0	0	0	0
NC	2	16	25	93	64	161	23	44
WW	0	0	0	0	0	0	0	0
TOTAL	13	96	83	311	128	321	59	112

CHI-SQUARE VALUES	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	2.333	18.225	0.310	1.211	9.031	22.508	0.014	0.007
SL	--	--	--	--	--	--	--	--
NC	1.000	7.258	0.184	0.654	8.000	20.439	8.696	16.409
WW	--	--	--	--	--	--	--	--
TOTAL	1.000	7.963	0.491	1.859	0.016	0.025	3.085	6.139

1) Range bin obstructed by echogram noise.
2) Numbers presented are a minimum estimation for test periods.

Table C2. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2 Hrs after High Tide — Duration of Test: 10 min Hmr 5 only — Treatment Type: 10 sec on 20 sec off — Test Date: 2/4/88 — Test Time: 0100

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	4	10	2	4	7	18
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	4	5	13	2	4	8	21

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	3	11	20	50	2	4	25	65
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	3	11	21	53	2	4	26	68

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	8	20	4	8	12	28
SL	0	0	0	0	0	0	0	0	0	0
NC	1	8	1	4	1	3	1	2	4	17
WW	0	0	0	0	0	0	0	0	0	0
Total	1	8	1	4	9	23	5	10	16	45

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	1	5	11	27	3	5
SL	0	0	0	0	1	2	0	0
NC	0	3	0	1	0	1	0	1
WW	0	0	0	0	0	0	0	0
TOTAL	0	3	2	6	12	30	3	6

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	6.000	12.400	11.636	31.111	0.000	3.200
SL	--	--	--	--	0.000	3.000	--	--
NC	--	13.333	--	12.000	--	6.000	--	2.000
WW	--	--	--	--	--	--	--	--
TOTAL	--	13.333	0.500	6.500	10.583	27.900	2.000	4.000

CHI-SQUARE F-HAT FOR 3 TEST PERIODS

	Raw	WF
LS	15	37
SL	1	2
NC	1	6
WW	0	0
Total	17	44

CHI-SQUARE VALUES FOR 3 TEST PERIODS

	Raw	WF
LS	10.533	33.136
SL	0.000	3.000
NC	12.000	31.167
WW	--	--
TOTAL	8.588	27.136

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

Table C3. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2 Hrs after High Tide

Duration of Test: 10 min Hmr 5 only

Treatment Type: 10 sec on, 20 sec off

Test Date: 2/4/88

Test Time: 0140

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	15	38	2	4	18	46
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	1	3	0	0	1	3
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	4	16	41	2	4	19	49

CHI-SQUARE F-HAT FOR 3 TEST PERIODS

Raw	WF
21	51
1	3
1	2
0	1
23	56

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	3	11	11	28	7	13	21	52
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	0	0	0	0	1	2	1	2
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	3	11	12	31	8	15	23	57

CHI-SQUARE VALUE FOR 3 TEST PERIODS

	Raw	WF
LS	0.857	3.216
SL	2.000	3.333
NC	0.000	1.500
WW	--	6.000
TOTAL	1.391	5.339

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	2	8	11	28	11	21	24	57
SL	0	0	0	0	2	5	0	0	2	5
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	1	3	0	0	1	3
Total	0	0	2	8	14	36	11	21	27	65

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	2	8	12	31	7	13
SL	0	0	0	0	1	3	0	0
NC	0	0	0	0	0	1	0	1
WW	0	0	0	0	0	1	0	0
TOTAL	0	0	2	8	14	36	7	13

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	1.000	2.125	1.917	3.161	4.857	10.154
SL	--	--	--	--	2.000	3.333	--	--
NC	--	--	--	--	--	6.000	--	2.000
WW	--	--	--	--	--	6.000	--	--
TOTAL	--	--	1.000	2.125	0.571	1.389	6.000	12.462

Table C4. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs after High Tide
Duration of Test: 10 min Hmr 5 only
Treatment Type: 10 sec on, 30 sec off
Test Date: 2/4/88
Test Time: 0200

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	3	11	9	23	11	21	23	55
SL	0	0	0	0	0	0	1	2	1	2
NC	0	0	0	0	3	8	0	0	3	8
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	3	11	12	31	12	23	27	65

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	21	49
SL	2	5
NC	5	13
WW	1	2
Total	27	69

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	3	11	6	15	9	17	18	43
SL	0	0	2	8	0	0	0	0	2	8
NC	0	0	2	8	3	8	1	2	6	18
WW	0	0	0	0	1	3	0	0	1	3
Total	0	0	7	27	10	26	10	19	27	72

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.610	1.469
SL	0.333	3.600
NC	1.000	3.846
WW	1.000	3.000
TOTAL	0.000	0.358

CHI-SQUARE = 3.841 (d.f. = 1) (alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	3	11	8	19	10	19
SL	0	0	1	4	0	0	1	1
NC	0	0	1	4	3	8	1	1
WW	0	0	0	0	1	2	0	0
TOTAL	0	0	5	19	11	29	11	21

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	0.000	0.000	0.600	1.684	0.200	0.421
SL	--	--	2.000	8.000	--	--	1.000	2.000
NC	--	--	2.000	8.000	0.000	0.000	1.000	2.000
WW	--	--	--	--	1.000	3.000	--	--
TOTAL	--	--	1.600	6.737	0.182	0.439	0.182	0.381

Table C5. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2.5 Hr after High Tide | Duration of Test: 10 min Hmr 5 only | Treatment Type: 10 sec on, 40 sec off | Test Date: 2/4/88 | Test Time: 0220

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	2	8	9	23	1	2	12	33	11	29
SL	0	0	0	0	0	0	1	2	1	2	1	1
NC	0	0	0	0	1	3	0	0	1	3	2	5
WW	0	0	0	0	0	0	0	0	0	0	1	2
Total	0	0	2	8	10	26	2	4	14	38	14	36

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	8	20	2	4	10	24
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	3	6	3	6
WW	0	0	0	0	1	3	0	0	1	3
Total	0	0	0	0	9	23	5	10	14	33

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.182	1.421
SL	1.000	2.000
NC	1.000	1.000
WW	1.000	3.000
TOTAL	0.000	0.352

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	4	9	22	2	3
SL	0	0	0	0	0	0	1	1
NC	0	0	0	0	1	2	2	3
WW	0	0	0	0	1	2	0	0
TOTAL	0	0	1	4	10	25	4	7

CHI-SQUARE VALUES	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	2.000	8.000	0.059	0.209	0.333	0.667
SL	--	--	--	--	--	--	1.000	2.000
NC	--	--	--	--	1.000	3.000	3.000	6.000
WW	--	--	--	--	1.000	3.000	--	--
TOTAL	--	--	2.000	8.000	0.053	0.184	1.286	2.571

Table C6. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 3 Hr after High Tide

Duration of Test: 10 min Hmr 5 only

Treatment Type: 20 sec on, 20 sec Off

Test Date: 2/4/88

Test Time: 0240

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	2	8	7	18	1	2	10	28	7	19
SL	0	0	0	0	0	0	0	0	0	0	1	2
NC	0	0	0	0	0	0	0	0	0	0	1	1
WW	0	0	0	0	1	3	0	0	1	3	1	3
Total	0	0	2	8	8	21	1	2	11	31	9	25

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	2	5	0	0	3	9
SL	0	0	0	0	0	0	2	4	2	4
NC	0	0	0	0	0	0	1	2	1	2
WW	0	0	0	0	1	3	0	0	1	3
Total	0	0	1	4	3	8	3	6	7	18

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	3.769	9.757
SL	2.000	4.000
NC	1.000	2.000
WW	0.000	0.000
TOTAL	0.889	3.449

CHI-SQUARE = 3.841 (d.f. = 1) (alpha = .05)

CHI-SQUARE F-HAT	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	2	6	5	12	1	1
SL	0	0	0	0	0	0	1	2
NC	0	0	0	0	0	0	1	1
WW	0	0	0	0	1	3	0	0
TOTAL	0	0	2	6	6	15	2	4

CHI-SQUARE VALUES	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	0.333	1.333	2.778	7.348	1.000	2.000
SL	--	--	--	--	--	--	2.000	4.000
NC	--	--	--	--	--	--	1.000	2.000
WW	--	--	--	--	0.000	0.000	--	--
TOTAL	--	--	0.333	1.333	2.273	5.828	1.000	2.000

Table C7. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2 Hr before Low Tide | Duration of Test: 10 min Hmr 5 only | Treatment Type: 20 sec on, 30 sec off | Test Date: 2/4/88 | Test Time: 0300

15 DEGREE OBLIQUE

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	6	23	2	5	0	0	8	28
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	6	23	2	5	0	0	8	28

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	9	25
SL	0	0
NC	0	0
WW	0	0
Total	9	25

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	6	15	3	6	9	21
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	6	15	3	6	9	21

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.059	1.000
SL	--	--
NC	--	--
WW	--	--
TOTAL	0.059	1.000

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	3	12	4	10	2	3
SL	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0
TOTAL	0	0	3	12	4	10	2	3

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	6.000	23.000	2.000	5.000	3.000	6.000
SL	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--
WW	--	--	--	--	--	--	--	--
TOTAL	--	--	6.000	23.000	2.000	5.000	3.000	6.000

Table C8. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 3 Hr before Low Tide
Duration of Test: 10 min Hmr 5 only
Treatment Type: 20 sec on, 40 sec off
Test Date: 2/4/88
Test Time: 0320

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	2	5	4	8	7	17
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	4	3	8	4	8	8	20

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	7	16
SL	1	2
NC	1	2
WW	0	0
Total	8	19

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	3	8	3	6	6	14
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	1	3	0	0	1	3
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	4	11	3	6	7	17

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.077	0.290
SL	1.000	3.000
NC	1.000	3.000
WW	--	--
TOTAL	0.067	0.243

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	1	2	3	7	4	7
SL	0	0	0	0	1	2	0	0
NC	0	0	0	0	1	2	0	0
WW	0	0	0	0	0	0	0	0
TOTAL	0	0	1	2	4	10	4	7

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	1.000	4.000	0.200	0.692	0.143	0.286
SL	--	--	--	--	1.000	3.000	--	--
NC	--	--	--	--	1.000	3.000	--	--
WW	--	--	--	--	--	--	--	--
TOTAL	--	--	1.000	4.000	0.143	0.474	0.143	0.286

Table C9. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2.5 Hr before Low Tide | Duration of Test: 10 min Hmr 5 only | Treatment Type: 30 sec on, 20 sec off | Test Date: 2/4/88 | Test Time: 0340

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	8	20	11	21	19	41
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	1	4	0	0	1	2	2	6
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	4	9	23	12	23	22	50

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	15	31
SL	1	3
NC	2	4
WW	0	0
Total	17	38

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	3	8	7	13	10	21
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	0	0	0	0	1	2	1	2
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	4	11	8	15	12	26

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	2.793	6.452
SL	0.000	0.000
NC	0.333	2.000
WW	--	--
TOTAL	2.941	7.579

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	0	0	6	14	9	17
SL	0	0	0	0	1	3	0	0
NC	0	0	1	2	0	0	1	2
WW	0	0	0	0	0	0	0	0
TOTAL	0	0	1	2	7	17	10	19

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	--	--	2.273	5.143	0.889	1.882
SL	--	--	--	--	0.000	0.000	--	--
NC	--	--	1.000	4.000	--	--	0.000	0.000
WW	--	--	--	--	--	--	--	--
TOTAL	--	--	1.000	4.000	1.923	4.235	0.800	1.684

Table C10. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase:	2 Hr before Low Tide	Duration of Test:	10 min Hmr 5 only	Test Date:	2/4/88
		Treatment Type:	30 sec on, 30 sec off	Test Time:	0400

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	3	8	3	6	6	14	15	35
SL	0	0	0	0	2	5	0	0	2	5	1	3
NC	0	0	0	0	3	8	0	0	3	8	3	10
WW	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	8	21	3	6	11	27	18	47

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	2	8	12	30	9	17	23	55
SL	0	0	0	0	0	0	0	0	0	0
NC	1	8	1	4	0	0	0	0	2	12
WW	0	0	0	0	0	0	0	0	0	0
Total	1	8	3	12	12	30	9	17	25	67

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	9.966	24.362
SL	2.000	5.000
NC	0.200	0.800
WW	—	—
TOTAL	5.444	17.021

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	1	4	8	19	6	12
SL	0	0	0	0	1	3	0	0
NC	1	4	1	2	2	4	0	0
WW	0	0	0	0	0	0	0	0
TOTAL	1	4	2	6	10	26	6	12

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	—	—	2.000	8.000	5.400	12.737	3.000	5.261
SL	—	—	—	—	2.000	5.000	—	—
NC	1.000	8.000	1.000	4.000	3.000	8.000	—	—
WW	—	—	—	—	—	—	—	—
TOTAL	1.000	8.000	3.000	12.000	0.800	1.588	3.000	5.261

Table C11. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase:	1.5 Hr before Low Tide	Duration of Test:	10 min Hmr 5 only	Test Date:	2/4/88
		Treatment Type:	30 sec on, 40 sec off	Test Time:	0420

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	9	23	11	21	20	44
SL	0	0	0	0	2	5	0	0	2	5
NC	1	8	0	0	0	0	1	2	2	10
WW	0	0	0	0	1	3	0	0	1	3
Total	1	8	0	0	12	31	12	23	25	62

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	19	42
SL	2	4
NC	1	5
WW	1	2
Total	22	53

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	6	15	11	21	18	40
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	4	7	18	11	21	19	43

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.105	0.190
SL	0.333	0.500
NC	2.000	10.000
WW	1.000	3.000
TOTAL	0.818	3.438

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	1	2	8	19	11	21
SL	0	0	0	0	2	4	0	0
NC	1	4	0	0	0	0	1	1
WW	0	0	0	0	1	2	0	0
TOTAL	1	4	1	2	10	25	12	22

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	1.000	4.000	0.600	1.684	0.000	0.000
SL	--	--	--	--	0.333	0.500	--	--
NC	1.000	8.000	--	--	--	--	1.000	2.000
WW	--	--	--	--	1.000	3.000	--	--
TOTAL	1.000	8.000	1.000	4.000	1.316	3.449	0.043	0.091

Table C12. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 3 hrs before low tide
Duration of Test: 10 min hrs 3&5
Treatment Type: 10 sec on, 20 sec off
Test Date: 2/13/88
Test Time: 1047

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	6	46	8	30	42	105	14	27	70	208
SL	1	8	0	0	0	0	0	0	1	8
NC	0	0	0	0	1	3	0	0	1	3
WW	0	0	0	0	0	0	0	0	0	0
Total	7	54	8	30	43	108	14	27	72	219

CHI-SQUARE F-HAT FOR 3 TEST PERIODS

	Raw	WF
LS	69	211
SL	0	3
NC	0	1
WW	0	0
Total	69	215

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	3	23	23	87	29	73	10	19	65	202
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	3	23	23	87	29	73	10	19	65	202

CHI-SQUARE VALUE FOR 3 TEST PERIODS

	Raw	WF
LS	1.478	7.962
SL	--	13.333
NC	--	6.000
WW	--	--
TOTAL	3.594	6.772

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	8	61	10	38	42	105	13	25	73	229
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	8	61	10	38	42	105	13	25	73	229

CHI-SQUARE F-HAT	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	6	43	14	52	38	94	12	24
SL	0	3	0	0	0	0	0	0
NC	0	0	0	0	0	1	0	0
WW	0	0	0	0	0	0	0	0
TOTAL	6	46	14	52	38	95	12	24

CHI-SQUARE VALUES	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	1.167	18.047	8.500	35.635	1.974	8.266	1.750	0.458
SL	--	13.333	--	--	--	--	--	--
NC	--	--	--	--	--	6.000	--	--
WW	--	--	--	--	--	--	--	--
TOTAL	2.333	17.783	8.500	35.635	3.211	8.926	1.750	0.458

1) Numbers presented are a minimum estimation for test periods.

Table C13. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 3 hrs before low tide | Duration of Test: 10 min hours 3&5 | Treatment Type: 10 sec on, 30 sec off | Test Date: 2/13/87 | Test Time: 1107

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	0	0	54	204	54	136	45	86	153	426
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	4	0	0	0	0	1	4
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	55	208	54	136	45	86	154	430

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	167	478
SL	0	0
NC	1	2
WW	0	0
Total	167	480

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	5	38	66	249	59	148	50	95	180	530
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	5	38	66	249	59	148	50	95	180	530

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	2.189	11.314
SL	--	--
NC	1.000	4.000
WW	--	--
TOTAL	2.024	10.417

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	3	19	60	227	57	142	48	91
SL	0	0	0	0	0	0	0	0
NC	0	0	1	2	0	0	0	0
WW	0	0	0	0	0	0	0	0
TOTAL	3	19	61	229	57	142	48	91

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	5.000	38.000	1.200	4.470	0.221	0.507	0.263	0.448
SL	--	--	--	--	--	--	--	--
NC	--	--	1.000	4.000	--	--	--	--
WW	--	--	--	--	--	--	--	--
TOTAL	5.000	38.000	1.000	3.678	0.221	0.507	0.263	0.448

1) Numbers presented are minimum estimates for test periods.

Table C14. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2.5 hrs before low tide Duration of Test: 10 min hmrs 3&5 Treatment Type: 10 sec on, 40 sec off Test Date: 02/13/88 Test Time: 1127

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	24	183	82	309	110	276	95	181	311	949
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	24	183	82	309	110	276	95	181	311	949

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

Trace Type	Raw	WF
LS	318	956
SL	0	0
NC	0	0
WW	0	0
Total	318	956

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	23	175	79	298	112	281	110	209	324	963
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	23	175	79	298	112	281	110	209	324	963

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.266	0.103
SL	--	--
NC	--	--
WW	--	--
TOTAL	0.266	0.103

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	24	179	81	304	111	279	103	195
SL	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0
TOTAL	24	179	81	304	111	279	103	195

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0.021	0.179	0.056	0.199	0.018	0.045	1.098	2.010
SL	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--
WW	--	--	--	--	--	--	--	--
TOTAL	0.021	0.179	0.056	0.199	0.018	0.045	1.098	2.010

1) Numbers presented are minimum numbers for test periods.

Table C15. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs before low tide   Duration of Test: 10 min hmrs 3&5   Treatment Type: 20 sec on, 20 sec off   Test Date: 2/13/88   Test Time: 1147

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	36	274	84	317	110	276	100	190	330	1057
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	36	274	84	317	110	276	100	190	330	1057

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	360	1145
SL	0	0
NC	0	0
WW	0	0
Total	360	1145

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	38	290	108	407	120	301	123	234	389	1232
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	38	290	108	407	120	301	123	234	389	1232

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	4.841	13.379
SL	--	--
NC	--	--
WW	--	--
TOTAL	4.841	13.379

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	37	282	96	362	115	289	112	212
SL	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0
TOTAL	37	282	96	362	115	289	112	212

CHI-SQUARE VALUES	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0.054	0.454	3.000	11.188	0.435	1.083	2.372	4.566
SL	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--
WW	--	--	--	--	--	--	--	--
TOTAL	0.054	0.454	3.000	11.188	0.435	1.083	2.372	4.566

1) Numbers presented are minimum estimations for test periods.

Table C16. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs before low tide | Duration of Test: 10 min hwrs 3&5 | Treatment Type: 20 sec on, 30 sec off | Test Date: 2/13/88 | Test Time: 1207

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	42	320	95	358	120	301	125	238	382	1217	389	1214
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0
Total	42	320	95	358	120	301	125	238	382	1217	389	1214

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	37	282	90	339	131	329	137	260	395	1210
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	37	282	90	339	131	329	137	260	395	1210

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.218	0.020
SL	--	--
NC	--	--
WW	--	--
TOTAL	0.218	0.020

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	40	301	93	349	126	315	131	249
SL	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0
TOTAL	40	301	93	349	126	315	131	249

CHI-SQUARE VALUES	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0.316	2.399	0.135	0.518	0.482	1.244	0.550	0.972
SL	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--
WW	--	--	--	--	--	--	--	--
TOTAL	0.316	2.399	0.135	0.518	0.482	1.244	0.550	0.972

1) Numbers presented are minimum estimates for test periods.

Table C17. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 36.

Tidal Phase: 1.5 hrs before low tide Duration of Test: 10 min hmrs 3&5 Treatment Type: 20 sec on, 40 sec off Test Date: 2/13/88 Test Time: 1227

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	45	343	82	309	124	311	130	247	381	1210
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	45	343	82	309	124	311	130	247	381	1210

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	384	1219
SL	0	0
NC	0	0
WW	0	0
Total	384	1219

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	42	320	96	362	120	301	129	245	387	1228
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	42	320	96	362	120	301	129	245	387	1228

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.047	0.133
SL	--	--
NC	--	--
WW	--	--
TOTAL	0.047	0.133

CHI-SQUARE = 3.841 (d.f. = 1) (alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	44	332	89	336	122	306	130	246
SL	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0
TOTAL	44	332	89	336	122	306	130	246

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0.103	0.798	1.101	4.186	0.066	0.163	0.004	0.008
SL	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--
WW	--	--	--	--	--	--	--	--
TOTAL	0.103	0.798	1.101	4.186	0.066	0.163	0.004	0.008

1) Numbers presented are minimum estimates for test periods.

Table C18. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 30 min before low tide

Duration of Test: 10 min hmrs 3&5

Treatment Type: 30 sec on, 20 sec off

Test Date: 2/13/88

Test Time: 1247

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	37	282	96	362	121	304	110	209	364	1157
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	37	282	96	362	121	304	110	209	364	1157

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

Raw	WF
376	1201
0	0
0	0
0	0
376	1201

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	42	320	100	377	134	336	111	211	387	1244
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	42	320	100	377	134	336	111	211	387	1244

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.704	3.152
SL	--	--
NC	--	--
WW	--	--
TOTAL	0.704	3.152

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	40	301	98	370	128	320	111	210
SL	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0
TOTAL	40	301	98	370	128	320	111	210

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0.316	2.399	0.082	0.304	0.663	1.600	0.005	0.010
SL	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--
WW	--	--	--	--	--	--	--	--
TOTAL	0.316	2.399	0.082	0.304	0.663	1.600	0.005	0.010

1) Numbers presented are minimum estimations for test periods.

Table C19. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 30 min before low tide — Duration of Test: 10 min hmrs 3&5 — Treatment Type: 30 sec on, 30 sec off — Test Date: 2/13/88 — Test Time: 1307

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	32	244	82	309	90	226	95	181	299	960
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	32	244	82	309	90	226	95	181	299	960

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	298	932
SL	0	0
NC	0	0
WW	0	0
Total	298	932

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	24	183	74	279	106	266	92	175	296	903
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	24	183	74	279	106	266	92	175	296	903

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.015	1.744
SL	--	--
NC	--	--
WW	--	--
TOTAL	0.015	1.744

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	28	214	78	294	98	246	94	178
SL	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0
TOTAL	28	214	78	294	98	246	94	178

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	1.143	8.714	0.410	1.531	1.306	3.252	0.048	0.101
SL	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--
WW	--	--	--	--	--	--	--	--
TOTAL	1.143	8.714	0.410	1.531	1.306	3.252	0.048	0.101

1) Numbers presented are minimum estimates for test periods.

Table C20. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 3 hrs before low tide | Duration of Test: 10 min hmrs 3&5 | Treatment Type: 10 sec on, 20 sec off | Test Date: 2/13/88 | Test Time: 2330

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	9	34	8	20	31	59	48	113
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	9	34	8	20	31	59	48	113

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	0	0	0	0	19	48	0	0	19	48
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	8	30	0	0	42	80	50	110
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	8	30	19	48	42	80	69	158

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	13	49	22	55	34	65	69	169
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	13	49	22	55	34	65	69	169

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	0	0	6	16	0	0
SL	0	0	0	0	0	0	0	0
NC	0	0	10	38	10	25	36	68
WW	0	0	0	0	0	0	0	0
TOTAL	0	0	10	38	16	41	36	68

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	--	--	41.167	96.000	--	--
SL	--	--	--	--	--	--	--	--
NC	--	--	1.400	4.289	24.800	62.000	0.806	3.441
WW	--	--	--	--	--	--	--	--
TOTAL	--	--	1.400	4.289	7.813	16.732	0.806	3.441

CHI-SQUARE F-HAT FOR 3 TEST PERIODS

	Raw	WF
LS	6	16
SL	0	0
NC	55	129
WW	0	0
Total	61	145

CHI-SQUARE VALUE FOR 3 TEST PERIODS

	Raw	WF
LS	41.167	96.000
SL	--	--
NC	6.909	22.186
WW	--	--
TOTAL	7.869	17.200

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

1) Numbers presented are a minimum estimation for test periods.
2) Range bins obscured by echogram noise.

Table C21. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2.5 hrs before low tide   Duration of Test: 10 min hmrs 3&5   Treatment Type: 10 sec on, 30 sec off   Test Date: 2/13/88   Test Time: 2350

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	0	0	4	15	3	8	3	6	10	29
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	11	28	22	42	33	70
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	4	15	14	36	25	48	43	99

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	8	22
SL	0	0
NC	29	63
WW	0	0
Total	37	85

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total[1] Raw	Total[1] WF
LS	0	0	3	11	0	0	2	4	5	15
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	14	35	11	21	25	56
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	3	11	14	35	13	25	30	71

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	1.667	4.455
SL	--	--
NC	1.103	1.556
WW	--	--
TOTAL	2.315	4.612

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	4	13	2	4	3	5
SL	0	0	0	0	0	0	0	0
NC	0	0	0	0	13	32	17	32
WW	0	0	0	0	0	0	0	0
TOTAL	0	0	4	13	14	36	19	37

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	0.143	0.615	3.000	8.000	0.200	0.400
SL	--	--	--	--	--	--	--	--
NC	--	--	--	--	0.360	0.778	3.667	7.000
WW	--	--	--	--	--	--	--	--
TOTAL	--	--	0.143	0.615	0.000	0.014	3.789	7.247

1) Numbers presented are minimum estimates for test periods.
2) Range bins obscured by echogram noise.

Table C22. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 4 hrs before low tide | Duration of Test: 10 min hwrs 1,2&3 | Treatment Type: 10 sec on, 20 sec off | Test Date: 2/18/88 | Test Time: 0153

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total		CHI-SQUARE F-HAT FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	6	15	5	10	11	25	6	15
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	3	8	5	10	8	18	5	11
WW	0	0	0	0	1	3	0	0	1	3	0	1
Total	0	0	0	0	10	26	10	20	20	46	11	27

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	2	8	2	5	2	4	6	17
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	1	3	1	2	2	5
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	2	8	3	8	3	6	8	22

CHI-SQUARE VALUE FOR 3 TEST PERIODS

	Raw	WF
LS	8.333	16.533
SL	--	--
NC	2.800	8.727
WW	--	6.000
TOTAL	11.456	21.556

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	3	0	0	1	3
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	4	2	5	1	2	4	11
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	4	3	8	1	2	5	14

CHI-SQUARE F-HAT	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	3	3	8	2	5
SL	0	0	0	0	0	0	0	0
NC	0	0	0	1	2	5	2	5
WW	0	0	0	0	0	1	0	0
TOTAL	0	0	1	4	5	14	5	9

CHI-SQUARE VALUES	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	2.000	13.333	4.667	9.375	7.500	9.200
SL	--	--	--	--	--	--	--	--
NC	--	--	--	12.000	1.000	3.600	6.500	7.600
WW	--	--	--	--	--	6.000	--	--
TOTAL	--	--	2.000	8.000	7.600	15.429	8.000	20.889

Table C23. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 3.5 hrs before low tide | Duration of Test: 10 min hmrs 1,2&3 | Treatment Type: 10 sec on, 10 sec off | Test Date: 2/18/88 | Test Time: 0215

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	0	0	1	2	1	2	3	6
SL	0	0	0	0	0	0	0	0	0	0	1	2
NC	0	0	2	8	4	10	0	0	6	18	5	14
WW	0	0	0	0	0	0	0	0	0	0	1	3
Total	0	0	2	8	4	10	1	2	7	20	9	24

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	2	5	2	4	4	9
SL	0	0	1	4	0	0	0	0	1	4
NC	0	0	1	4	2	5	0	0	3	9
WW	0	0	0	0	2	5	0	0	2	5
Total	0	0	2	8	6	15	2	4	10	27

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	1.800	4.455
SL	1.000	4.000
NC	1.000	3.000
WW	2.000	5.000
TOTAL	0.529	1.043

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	0	0	1	3	2	3
SL	0	0	1	2	0	0	0	0
NC	0	0	2	6	3	8	0	0
WW	0	0	0	0	1	3	0	0
TOTAL	0	0	2	8	5	13	2	3

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	--	--	2.000	5.000	0.333	0.667
SL	--	--	1.000	4.000	--	--	--	--
NC	--	--	0.333	1.333	0.667	1.667	--	--
WW	--	--	--	--	2.000	5.000	--	--
TOTAL	--	--	0.000	0.000	0.400	1.000	0.333	0.667

Table C24. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 3 hrs before low tide | Duration of Test: 10 min hwrs 1,2&3 | Treatment Type: 10 sec on, 40 sec off | Test Date: 2/10/88 | Test Time: 0235

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	0	0	0	0	0	0	1	2
SL	0	0	0	0	0	0	0	0	0	0	3	7
NC	0	0	0	0	0	0	1	2	1	2	3	9
WW	0	0	1	4	0	0	0	0	1	4	2	4
Total	0	0	1	4	0	0	1	2	2	6	8	21

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	0	0	0	0	1	4
SL	0	0	0	0	2	5	4	8	6	13
NC	0	0	2	8	2	5	1	2	5	15
WW	0	0	0	0	0	0	2	4	2	4
Total	0	0	3	12	4	10	7	14	14	36

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	1.000	4.000
SL	6.000	13.000
NC	2.667	9.941
WW	0.333	0.000
TOTAL	9.000	21.429

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	1	2	0	0	0	0
SL	0	0	0	0	1	3	2	4
NC	0	0	1	4	1	3	1	2
WW	0	0	1	2	0	0	1	2
TOTAL	0	0	2	8	2	5	4	8

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	1.000	4.000	--	--	--	--
SL	--	--	--	--	2.000	5.000	4.000	8.000
NC	--	--	2.000	8.000	2.000	5.000	0.000	0.000
WW	--	--	1.000	4.000	--	--	2.000	4.000
TOTAL	--	--	1.000	4.000	4.000	10.000	4.500	9.000

Table C25. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2.5 hrs before low tide
Duration of Test: 10 min hmrs 1,263
Treatment Type: 20 sec on, 20 sec off
Test Date: 2/18/88
Test Time: 0255

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	2	8	1	3	1	2	4	13	5	13
SL	0	0	0	0	3	8	0	0	3	8	2	4
NC	0	0	2	8	2	5	4	8	8	21	6	16
WW	0	0	0	0	0	0	0	0	0	0	1	3
Total	0	0	4	16	6	16	5	10	15	42	13	35

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	4	1	3	3	6	5	13
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	3	8	1	2	4	10
WW	0	0	0	0	1	3	1	2	2	5
Total	0	0	1	4	5	14	5	10	11	28

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.111	0.000
SL	3.000	8.000
NC	1.333	3.903
WW	2.000	5.000
TOTAL	0.615	2.800

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	2	6	1	3	2	4
SL	0	0	0	0	2	4	0	0
NC	0	0	1	4	3	7	3	5
WW	0	0	0	0	1	2	1	1
TOTAL	0	0	3	10	6	15	5	10

CHI-SQUARE VALUES	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	0.333	1.333	0.000	0.000	1.000	2.000
SL	--	--	--	--	3.000	8.000	--	--
NC	--	--	2.000	8.000	0.200	0.692	1.800	3.600
WW	--	--	--	--	1.000	3.000	1.000	2.000
TOTAL	--	--	1.800	7.200	0.091	0.133	0.000	0.000

Table C26. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs before low tide | Duration of Test: 10 min hmrs 1,2&3 | Treatment Type: 20 sec on, 30 sec off | Test Date: 2/18/88 | Test Time: 0315

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	4	10	1	2	5	12
SL	0	0	0	0	0	0	3	6	3	6
NC	0	0	0	0	5	13	3	6	8	19
WW	0	0	0	0	1	3	3	6	4	9
Total	0	0	0	0	10	26	10	20	20	46

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	4	9
SL	4	8
NC	7	16
WW	3	6
Total	17	39

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	3	6	3	6
SL	0	0	0	0	3	8	1	2	4	10
NC	0	0	0	0	3	8	2	4	5	12
WW	0	0	0	0	1	3	0	0	1	3
Total	0	0	0	0	7	19	6	12	13	31

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.500	2.000
SL	0.143	1.000
NC	0.692	1.581
WW	1.800	3.000
TOTAL	1.485	2.922

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	0	0	2	5	2	4
SL	0	0	0	0	2	4	2	4
NC	0	0	0	0	4	11	3	5
WW	0	0	0	0	1	3	2	3
TOTAL	0	0	0	0	9	23	8	16

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	--	--	4.000	10.000	1.000	2.000
SL	--	--	--	--	3.000	8.000	1.000	2.000
NC	--	--	--	--	0.500	1.190	0.200	0.400
WW	--	--	--	--	0.000	0.000	3.000	6.000
TOTAL	--	--	--	--	0.529	1.089	1.000	2.000

Table C27. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 30 min after high tide   Duration of Test: 10 min hmrs 1,2&3   Treatment Type: 20 sec on, 40 sec off   Test Date: 2/18/88   Test Time: 1155

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	1	3	2	4	3	7
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	4	1	3	2	4	4	11
WW	0	0	0	0	1	3	0	0	1	3
Total	0	0	1	4	3	9	4	8	8	21

CHI-SQUARE F-HAT FOR 3 TEST PERIODS

	Raw	WF
LS	4	11
SL	1	2
NC	7	20
WW	4	9
Total	16	42

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	3	8	0	0	4	12
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	4	1	3	5	10	7	17
WW	0	0	0	0	3	8	3	6	6	14
Total	0	0	2	8	7	19	8	16	17	43

CHI-SQUARE VALUE FOR 3 TEST PERIODS

	Raw	WF
LS	0.500	0.909
SL	2.000	7.500
NC	4.571	16.300
WW	3.500	8.222
TOTAL	7.125	22.024

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	2	5	2	4	5	13
SL	0	0	0	0	2	5	0	0	2	5
NC	0	0	5	19	5	13	1	2	11	34
WW	0	0	0	0	2	5	3	6	5	11
Total	0	0	6	23	11	28	6	12	23	63

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	1	3	2	5	1	3
SL	0	0	0	0	1	2	0	0
NC	0	0	2	9	2	6	3	5
WW	0	0	0	0	2	5	2	4
TOTAL	0	0	3	12	7	19	6	12

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	0.000	2.667	1.000	3.600	4.000	2.667
SL	--	--	--	--	2.000	7.500	--	--
NC	--	--	6.500	16.667	6.500	12.167	2.000	8.000
WW	--	--	--	--	1.000	3.600	3.000	6.000
TOTAL	--	--	4.667	15.750	4.571	8.526	1.333	2.667

Table C28. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 1 hr after high tide | Duration of Test: 10 min hrs 1,2&3 | Treatment Type: 30 sec on, 20 sec off | Test Date: 2/16/88 | Test Time: 1215

15 DEGREE OBLIQUE

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	0	0	1	2	1	2	3	7
SL	0	0	0	0	0	0	1	2	1	2	3	6
NC	0	0	2	8	7	18	6	11	15	37	10	26
WW	0	0	1	4	1	3	1	2	3	9	2	6
Total	0	0	3	12	8	21	9	17	20	50	17	44

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	1	3	2	4	4	11
SL	0	0	0	0	3	8	1	2	4	10
NC	0	0	1	4	3	8	1	2	5	14
WW	0	0	0	0	0	0	1	2	1	2
Total	0	0	2	8	7	19	5	10	14	37

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	1.800	6.231
SL	1.800	5.333
NC	5.000	10.373
WW	1.000	4.455
TOTAL	1.059	1.943

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	1	2	1	2	2	3
SL	0	0	0	0	2	4	1	2
NC	0	0	2	6	5	13	4	7
WW	0	0	1	2	1	2	1	2
TOTAL	0	0	3	10	8	20	7	14

CHI-SQUARE VALUES	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	1.000	4.000	1.000	3.000	0.333	0.667
SL	--	--	--	--	3.000	8.000	0.000	0.000
NC	--	--	0.333	1.333	1.600	3.846	3.571	6.231
WW	--	--	1.000	4.000	1.000	3.000	0.000	0.000
TOTAL	--	--	0.200	0.800	0.067	0.100	1.143	1.815

Table C29. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 3S.

Tidal Phase: 1.5 hrs after high tide | Duration of Test: 10 min hrs 1,2&3 | Treatment Type: 30 sec on, 30 sec off | Test Date: 2/18/88 | Test Time: 1235

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	4	0	0	3	6	4	10	2	5
WW	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	4	0	0	3	6	4	10	3	6

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	2	1	2
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	1	2	1	2

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	1.000	2.000
SL	--	--
NC	4.000	10.000
WW	--	--
TOTAL	1.800	5.333

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	1
SL	0	0	0	0	0	0	0	0
NC	0	0	1	2	0	0	2	3
WW	0	0	0	0	0	0	0	0
TOTAL	0	0	1	2	0	0	2	4

CHI-SQUARE VALUES

	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	--	--	1.000	2.000
SL	--	--	--	--	--	--	--	--
NC	--	--	1.000	4.000	--	--	3.000	6.000
WW	--	--	--	--	--	--	--	--
TOTAL	--	--	1.000	4.000	--	--	1.000	2.000

Table C30. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 1.5 hrs before low tide   Duration of Test: 10 min hmrs 3&5   Treatment Type: 10 sec on, 20 sec off   Test Date: 2/18/86   Test Time: 1620

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	1	3	1	2	2	5
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	0	0	4	10	4	8	8	18
WW	0	0	0	0	0	0	1	2	1	2
Total	0	0	0	0	6	16	6	12	12	28

CHI-SQUARE F-HAT FOR 3 TEST PERIODS

	Raw	WF
LS	2	8
SL	1	5
NC	5	11
WW	1	1
Total	9	25

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	1	3	1	2	2	5
SL	1	8	0	0	1	3	0	0	2	11
NC	0	0	0	0	3	8	3	6	6	14
WW	0	0	0	0	0	0	1	2	1	2
Total	1	8	0	0	5	14	5	10	11	32

CHI-SQUARE VALUE FOR 3 TEST PERIODS

	Raw	WF
LS	0.000	4.375
SL	2.000	12.000
NC	5.200	13.636
WW	0.000	4.000
TOTAL	4.222	6.320

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	1	8	0	0	1	3	1	2	2	13
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	2	1	2
WW	0	0	0	0	0	0	0	0	0	0
Total	1	8	0	0	1	3	2	4	4	15

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	3	0	0	1	3	1	2
SL	0	3	0	0	1	2	0	0
NC	0	0	0	0	2	6	3	5
WW	0	0	0	0	0	0	1	1
TOTAL	1	5	0	0	4	11	4	9

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	13.333	--	--	0.000	0.000	0.000	0.000
SL	--	13.333	--	--	0.000	3.000	--	--
NC	--	--	--	--	5.500	9.333	0.667	4.800
WW	--	--	--	--	--	--	0.000	4.000
TOTAL	0.000	9.600	--	--	3.500	8.909	3.250	2.889

Table C31. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 1.5 hrs before low tide | Duration of Test: 10 min hmrs 3&5 | Treatment Type: 10 sec on, 30 sec off | Test Date: 2/18/88 | Test Time: 1640

10 MINUTES DURING TEST PERIOD

RANGE <meters>

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	1	3	0	0	1	3
SL	0	0	0	0	0	0	2	4	2	4
NC	0	0	0	0	4	10	0	0	4	10
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	5	13	2	4	7	17

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	2	6
SL	2	5
NC	4	9
WW	1	1
Total	8	20

10 MINUTES AFTER TEST PERIOD

RANGE <meters>

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	0	0	2	4	3	8
SL	0	0	0	0	2	5	0	0	2	5
NC	0	0	0	0	1	3	2	4	3	7
WW	0	0	0	0	0	0	1	2	1	2
Total	0	0	1	4	3	8	5	10	9	22

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	1.000	2.273
SL	0.000	0.111
NC	0.143	0.529
WW	1.000	2.000
TOTAL	0.250	0.641

CHI-SQUARE = 3.841
<d.f. = 1>
<alpha = .05>

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	1	2	1	2	1	2
SL	0	0	0	0	1	3	1	2
NC	0	0	0	0	3	7	1	2
WW	0	0	0	0	0	0	1	1
TOTAL	0	0	1	2	4	11	4	7

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	1.000	4.000	1.000	3.000	2.000	4.000
SL	--	--	--	--	2.000	6.000	2.000	4.000
NC	--	--	--	--	1.800	3.769	2.000	4.000
WW	--	--	--	--	--	--	1.000	2.000
TOTAL	--	--	1.000	4.000	0.500	1.190	1.286	2.571

Table C32. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 1 hr before low tide
Duration of Test: 10 min hmrs 3&5
Treatment Type: 10 sec on, 40 sec off
Test Date: 2/18/88
Test Time: 1700

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	0	0	2	4	3	8
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	4	0	0	0	0	1	4
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	2	8	0	0	2	4	4	12

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	2	4
SL	0	0
NC	1	3
WW	0	0
Total	3	7

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	2	1	2
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	1	2	1	2

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	3.000	8.000
SL	--	--
NC	0.000	0.667
WW	--	--
TOTAL	1.800	7.143

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	1	2	0	0	1	2
SL	0	0	0	0	0	0	0	0
NC	0	0	1	2	0	0	1	1
WW	0	0	0	0	0	0	0	0
TOTAL	0	0	1	4	0	0	2	3

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	1.000	4.000	--	--	2.000	4.000
SL	--	--	--	--	--	--	--	--
NC	--	--	1.000	4.000	--	--	1.000	2.000
WW	--	--	--	--	--	--	--	--
TOTAL	--	--	2.000	8.000	--	--	0.333	0.667

Table C33. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 3 hrs before high tide | Duration of Test: 10 min, hmrs 3&5 | Treatment Type: 10 sec on, 20 sec off | Test Date: 2/18/88 | Test Time: 2045

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	2	5	1	2	3	7
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	0	0	0	0	1	2	1	2
WW	0	0	0	0	1	3	3	6	4	9
Total	0	0	0	0	4	11	5	10	9	21

CHI-SQUARE F-HAT FOR 3 TEST PERIODS

Trace Type	Raw	WF
LS	4	9
SL	1	2
NC	5	11
WW	2	5
Total	12	27

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	1	3	3	6	4	9
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	4	10	2	4	6	14
WW	0	0	0	0	0	0	3	6	3	6
Total	0	0	0	0	5	13	8	16	13	29

CHI-SQUARE VALUE FOR 3 TEST PERIODS

	Raw	WF
LS	0.500	0.889
SL	0.000	3.000
NC	5.200	13.636
WW	5.600	8.400
TOTAL	1.167	3.407

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	1	3	4	8	5	11
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	1	4	1	3	6	11	8	18
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	4	3	9	10	19	14	32

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	0	0	1	4	3	5
SL	0	0	0	0	1	2	0	0
NC	0	0	0	1	2	4	3	6
WW	0	0	0	0	0	1	2	4
TOTAL	0	0	0	1	4	11	8	15

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	--	--	2.000	-0.250	0.667	4.800
SL	--	--	--	--	0.000	3.000	--	--
NC	--	--	--	12.000	3.500	14.250	4.667	6.500
WW	--	--	--	--	--	6.000	3.000	6.000
TOTAL	--	--	--	12.000	0.500	0.727	0.625	2.800

Table C34. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2.5 hrs before high tide Duration of Test: 10 min hwrs 3&5 Treatment Type: 10 sec on, 30 sec off Test Date: 2/18/88 Test Time: 2115

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0
NC	1	8	0	0	3	8	2	4	6	20
WW	0	0	0	0	0	0	0	0	0	0
Total	1	8	0	0	3	8	2	4	6	20

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	1	4
SL	0	0
NC	6	18
WW	0	0
Total	7	22

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	1	8	0	0	0	0	0	0	1	8
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	4	1	3	4	8	6	15
WW	0	0	0	0	0	0	0	0	0	0
Total	1	8	1	4	1	3	4	8	7	23

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	1.000	8.000
SL	--	--
NC	0.000	0.714
WW	--	--
TOTAL	0.077	0.209

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	1	4	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0
NC	1	4	1	2	2	6	3	6
WW	0	0	0	0	0	0	0	0
TOTAL	1	8	1	2	2	6	3	6

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	1.000	8.000	--	--	--	--	--	--
SL	--	--	--	--	--	--	--	--
NC	1.000	8.000	1.000	4.000	1.000	2.273	0.667	1.333
WW	--	--	--	--	--	--	--	--
TOTAL	0.000	0.000	1.000	4.000	1.000	2.273	0.667	1.333

Table C35. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 1 hr before high tide

Duration of Test: 10 min hmrs 3&5

Treatment Type: 10 sec on, 20 sec off

Test Date: 2/18/88

Test Time: 2225

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	5	13	0	0	5	13
SL	0	0	0	0	0	0	0	0	0	0
NC	1	8	4	15	2	5	1	2	8	30
WW	0	0	0	0	0	0	0	0	0	0
Total	1	8	4	15	7	18	1	2	13	43

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	4	3	8	1	2	5	14
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	8	30	4	10	2	4	14	44
WW	0	0	0	0	2	6	0	0	2	6
Total	0	0	9	34	10	26	3	6	22	66

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	3	8	3	6	6	14
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	3	11	4	10	1	2	8	23
WW	0	0	0	0	1	3	3	6	4	9
Total	0	0	3	11	9	24	7	14	19	49

CHI-SQUARE F-HAT FOR 3 TEST PERIODS

	Raw	WF
LS	5	14
SL	1	2
NC	10	32
WW	2	5
Total	18	52

CHI-SQUARE VALUE FOR 3 TEST PERIODS

	Raw	WF
LS	1.200	-0.929
SL	0.000	3.000
NC	2.400	8.156
WW	4.000	7.200
TOTAL	2.333	7.500

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	1	4	10	1	3
SL	0	0	0	0	1	2	0	0
NC	0	3	5	19	3	8	1	3
WW	0	0	0	0	1	3	1	2
TOTAL	0	3	5	20	9	23	4	7

CHI-SQUARE VALUES

	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	12.000	-0.250	0.700	6.000	5.333
SL	--	--	--	--	0.000	3.000	--	--
NC	--	13.333	2.800	9.579	2.000	3.125	2.000	0.000
WW	--	--	--	--	2.000	3.333	6.000	12.000
TOTAL	--	13.333	5.200	15.100	-0.444	0.522	3.750	11.714

Table C36. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 30 min before high tide | Duration of Test: 10 min hwrs 3&5 | Treatment Type: 10 sec on, 30 sec off | Test Date: 2/18/88 | Test Time: 2245

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	3	11	1	3	2	4	6	18
WW	0	0	0	0	4	10	2	4	6	14
Total	0	0	3	11	5	13	4	8	12	32

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

Trace Type	Raw	WF
LS	2	4
SL	0	0
NC	7	22
WW	4	9
Total	12	34

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	1	3	2	4	3	7
SL	0	0	0	0	0	0	0	0	0	0
NC	1	8	1	4	5	13	0	0	7	25
WW	0	0	0	0	1	3	0	0	1	3
Total	1	8	1	4	7	19	2	4	11	35

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	3.000	7.000
SL	--	--
NC	0.077	1.140
WW	3.571	7.118
TOTAL	0.043	0.134

CHI-SQUARE = 3.841 (d.f. = 1) (alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	0	0	1	2	1	2
SL	0	0	0	0	0	0	0	0
NC	1	4	2	8	3	8	1	2
WW	0	0	0	0	3	7	1	2
TOTAL	1	4	2	8	6	16	3	6

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	--	--	1.000	3.000	2.000	4.000
SL	--	--	--	--	--	--	--	--
NC	1.000	8.000	1.000	3.267	2.667	6.250	2.000	4.000
WW	--	--	--	--	1.800	3.769	2.000	4.000
TOTAL	1.000	8.000	1.000	3.267	0.333	1.126	0.667	1.333

Table C37. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 30 min before high tide   Duration of Test: 10 min hrs 3&5   Treatment Type: 10 sec on, 40 sec off   Test Date: 2/18/88   Test Time: 2305

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	4	10	1	2	5	12
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	4	10	1	2	5	12

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	2	7
SL	0	0
NC	7	19
WW	1	2
Total	9	28

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	1	8	1	4	0	0	1	2	3	14
SL	0	0	0	0	0	0	0	0	0	0
NC	1	8	1	4	3	8	3	6	8	26
WW	0	0	0	0	1	3	0	0	1	3
Total	2	16	2	8	4	11	4	8	12	43

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	3.000	14.000
SL	--	--
NC	0.692	5.158
WW	1.000	3.000
TOTAL	2.882	17.473

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	1	4	1	2	0	0	1	1
SL	0	0	0	0	0	0	0	0
NC	1	4	1	2	4	9	2	4
WW	0	0	0	0	1	2	0	0
TOTAL	1	8	1	4	4	11	3	5

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	1.000	8.000	1.000	4.000	--	--	1.000	2.000
SL	--	--	--	--	--	--	--	--
NC	1.000	8.000	1.000	4.000	0.143	0.222	1.000	2.000
WW	--	--	--	--	1.000	3.000	--	--
TOTAL	2.000	16.000	2.000	8.000	0.000	0.048	1.800	3.600

Table C38. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 1.0 hr after high tide | Duration of Test: 10 min hmrs 3&5 | Treatment Type: 20 sec on, 20 sec off | Test Date: 2/18/88 | Test Time: 2345

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	1	3	4	8	5	11	3	7
SL	0	0	0	0	0	0	1	2	1	2	1	3
NC	1	8	3	11	4	10	2	4	10	33	11	34
WW	0	0	0	0	0	0	2	4	2	4	3	7
Total	1	8	3	11	5	13	9	18	18	50	18	50

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	1	2	1	2
SL	0	0	1	4	0	0	0	0	1	4
NC	0	0	5	19	5	13	1	2	11	34
WW	0	0	0	0	2	5	2	4	4	9
Total	0	0	6	23	7	18	4	8	17	49

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	2.667	6.231
SL	0.000	0.667
NC	0.048	0.015
WW	0.667	1.923
TOTAL	0.029	0.010

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	0	0	1	2	3	5
SL	0	0	1	2	0	0	1	1
NC	1	4	4	15	5	12	2	3
WW	0	0	0	0	1	3	2	4
TOTAL	1	4	5	17	6	16	7	13

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	--	--	--	--	1.000	2.000
SL	--	--	--	--	--	--	--	--
NC	1.000	8.000	1.000	4.000	0.111	0.391	0.333	0.667
WW	--	--	--	--	2.000	5.000	--	--
TOTAL	1.000	8.000	1.000	4.235	0.333	0.806	1.923	3.846

Table C39. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 1 hr after high tide   Duration of Test: 10 min hrs 1,283   Treatment Type: 20 sec on, 30 sec off   Test Date: 2/19/80   Test Time: 0035

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	2	5	2	4	4	9
SL	0	0	1	4	1	3	0	0	2	7
NC	0	0	1	4	2	5	5	10	8	19
WW	0	0	0	0	1	3	0	0	1	3
Total	0	0	2	8	6	16	7	14	15	38

CHI-SQUARE F-HAT FOR 3 TEST PERIODS

	Raw	WF
LS	6	13
SL	1	3
NC	10	27
WW	2	4
Total	18	47

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	4	10	5	10	9	20
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	3	11	11	28	2	4	16	43
WW	0	0	0	0	2	5	1	2	3	7
Total	0	0	3	11	18	46	8	16	29	73

CHI-SQUARE VALUE FOR 3 TEST PERIODS

	Raw	WF
LS	1.833	5.231
SL	2.000	9.333
NC	5.900	14.667
WW	0.500	3.500
TOTAL	11.222	22.553

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	1	3	3	6	4	9
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	2	8	3	8	2	4	7	20
WW	0	0	0	0	0	0	1	2	1	2
Total	0	0	2	8	4	11	6	12	12	31

CHI-SQUARE F-HAT	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	0	0	2	6	3	7
SL	0	0	0	1	1	2	0	0
NC	0	0	2	8	5	14	3	6
WW	0	0	0	0	1	5	1	1
TOTAL	0	0	2	9	9	24	7	14

CHI-SQUARE VALUES	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	--	--	3.500	4.333	2.667	1.714
SL	--	--	--	12.000	0.000	3.000	--	--
NC	--	--	1.000	2.125	10.800	21.357	2.000	4.000
WW	--	--	--	--	2.000	3.333	0.000	4.000
TOTAL	--	--	1.500	0.667	13.778	30.075	0.286	0.571

Table C40. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs after high tide | Duration of Test: 10 min, hwrs 1,2&3 | Treatment Type: 30 sec on, 20 sec off | Test Date: 2/19/80 | Test Time: 0125

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	8	0	0	0	0	5	10	6	18
SL	0	0	0	0	0	0	1	2	1	2
NC	0	0	1	4	1	3	3	6	5	13
WW	0	0	0	0	0	0	0	0	0	0
Total	1	8	1	4	1	3	9	18	12	33

CHI-SQUARE F-HAT FOR 3 TEST PERIODS

	Raw	WF
LS	6	15
SL	0	1
NC	3	11
WW	0	0
Total	9	26

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	4	2	5	5	10	8	19
SL	0	0	0	0	0	0	0	0	0	0
NC	1	8	1	4	1	3	1	2	4	17
WW	0	0	0	0	0	0	0	0	0	0
Total	1	8	2	8	3	8	6	12	12	36

CHI-SQUARE VALUE FOR 3 TEST PERIODS

	Raw	WF
LS	1.167	4.933
SL	--	2.000
NC	4.000	10.000
WW	--	--
TOTAL	5.778	16.577

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	4	0	0	2	4	3	8
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	2	1	2
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	4	0	0	3	6	4	10

CHI-SQUARE F-HAT

	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	3	1	3	1	2	4	8
SL	0	0	0	0	0	0	0	1
NC	0	3	1	3	1	2	2	3
WW	0	0	0	0	0	0	0	0
TOTAL	1	5	1	5	1	4	6	12

CHI-SQUARE VALUES

	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	13.333	0.000	2.667	2.000	7.500	1.500	3.000
SL	--	--	--	--	--	--	--	2.000
NC	--	13.333	0.000	2.667	0.000	3.000	0.500	4.667
WW	--	--	--	--	--	--	--	--
TOTAL	0.000	9.600	2.000	3.200	6.000	7.250	3.000	6.000

Table C41. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 3 hrs before low tide | Duration of Test: 10 min hmrs 1,2&3 | Treatment Type: 30 sec on, 30 sec off | Test Date: 2/19/88 | Test Time: 0335

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	0	0	1	2	2	6
SL	0	0	0	0	1	3	1	2	2	5
NC	0	0	1	4	1	3	1	2	3	9
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	2	8	2	6	3	6	7	20

CHI-SQUARE F-HAT FOR 3 TEST PERIODS

	Raw	WF
LS	1	2
SL	1	3
NC	5	12
WW	0	0
Total	6	17

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	0	0	3	8	3	6	6	14
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	4	11	3	6	7	17

CHI-SQUARE VALUE FOR 3 TEST PERIODS

	Raw	WF
LS	2.000	12.000
SL	2.000	3.333
NC	0.000	2.417
WW	--	--
TOTAL	1.500	1.059

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	4	3	8	1	2	5	14
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	4	3	8	1	2	5	14

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	0	1	0	0	0	1
SL	0	0	0	0	1	2	0	1
NC	0	0	1	3	2	6	2	3
WW	0	0	0	0	0	0	0	0
TOTAL	0	0	1	4	3	8	2	5

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	--	12.000	--	--	--	2.000
SL	--	--	--	--	0.000	3.000	--	2.000
NC	--	--	0.000	2.667	2.500	3.833	0.500	4.667
WW	--	--	--	--	--	--	--	--
TOTAL	--	--	2.000	8.000	0.667	2.625	2.500	1.200

Table C42. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 3.5 hrs before low tide Duration of Test: 10 min hrs 1,2a5 Treatment Type: 30 sec on, 40 sec off Test Date: 2/19/88 Test Time: 0355

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF	CHI-SQUARE F-MAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-MAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	1	3	0	0	1	3	2	4
SL	0	0	1	4	1	3	0	0	2	7	2	5
NC	0	0	3	11	7	18	1	2	11	31	6	21
WW	0	0	1	4	1	3	0	0	2	7	2	6
Total	0	0	5	19	10	27	1	2	16	48	13	35

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	3-4 Raw	3-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	2	4	2	4
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	1	4	2	5	1	2	4	11
WW	0	0	0	0	0	0	2	4	2	4
Total	0	0	1	4	3	8	5	10	9	22

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.333	0.143
SL	0.333	1.600
NC	3.267	9.524
WW	0.000	0.818
TOTAL	1.960	9.657

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-MAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	0	0	1	2	1	2
SL	0	0	1	2	1	3	0	0
NC	0	0	2	8	5	12	1	2
WW	0	0	1	2	1	2	1	2
TOTAL	0	0	3	12	7	18	3	6

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	--	--	1.000	3.000	2.000	4.000
SL	--	--	1.000	4.000	0.000	0.000	--	--
NC	--	--	1.000	3.267	2.778	7.348	0.000	0.000
WW	--	--	1.000	4.000	1.000	3.000	2.000	4.000
TOTAL	--	--	2.667	9.783	3.769	10.314	2.667	5.333

Table C43. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2.5 hrs before low tide; Duration of Test: 10 min hmrs 1,203; Treatment Type: 30 sec on, 20 sec off; Test Date: 2/19/88; Test Time: 0415

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	1	4	7	18	3	6	11	28	9	23
SL	0	0	0	0	0	0	0	0	0	0	1	3
NC	0	0	2	8	6	15	1	2	9	25	10	30
WW	0	0	0	0	0	0	0	0	0	0	1	3
Total	0	0	3	12	13	33	4	8	20	53	20	58

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	3	11	1	3	2	4	6	18
SL	0	0	0	0	1	3	1	2	2	5
NC	1	8	4	15	3	8	2	4	10	35
WW	0	0	0	0	2	5	0	0	2	5
Total	1	8	7	26	7	19	5	10	20	63

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	1.471	2.174
SL	2.000	5.000
NC	0.053	1.667
WW	2.000	5.000
TOTAL	0.000	0.862

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	2	8	4	11	3	5
SL	0	0	0	0	1	2	1	1
NC	1	4	3	12	5	12	2	3
WW	0	0	0	0	1	3	0	0
TOTAL	1	4	5	19	10	26	5	9

CHI-SQUARE VALUES	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	1.000	3.267	4.500	10.714	0.200	0.400
SL	--	--	--	--	1.000	3.000	1.000	2.000
NC	1.000	8.000	0.667	2.130	1.000	2.130	0.333	0.667
WW	--	--	--	--	2.000	5.000	--	--
TOTAL	1.000	8.000	1.600	5.158	1.800	3.763	0.111	0.222

Table C44. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs before low tide — Duration of Test: 10 min hmrs 1,283 — Treatment Type: 30 sec on, 30 sec off — Test Date: 2/19/88 — Test Time: 0435

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	4	2	5	1	2	4	11
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	2	8	2	5	3	6	7	19
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	3	12	4	10	4	8	11	30

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	3	8
SL	0	0
NC	5	13
WW	0	0
Total	8	21

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	4	0	0	0	0	1	4
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	1	3	2	4	3	7
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	4	1	3	2	4	4	11

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	1.800	3.267
SL	--	--
NC	1.600	5.538
WW	--	--
TOTAL	3.267	8.805

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	4	1	3	1	1
SL	0	0	0	0	0	0	0	0
NC	0	0	1	4	2	4	3	5
WW	0	0	0	0	0	0	0	0
TOTAL	0	0	2	8	3	7	3	6

CHI-SQUARE VALUES

	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	0.000	0.000	2.000	5.000	1.000	2.000
SL	--	--	--	--	--	--	--	--
NC	--	--	2.000	8.000	0.333	0.500	0.200	0.400
WW	--	--	--	--	--	--	--	--
TOTAL	--	--	1.000	4.000	1.800	3.764	0.667	1.333

Table C45. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 30 min after high tide | Duration of Test: 10 min hmrs 1,203 | Treatment Type: 10 sec on, 20 sec off | Test Date: 2/19/80 | Test Time: 1235

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	2	8	3	8	4	8	9	24	7	18
SL	0	0	0	0	1	3	0	0	1	3	1	3
NC	0	0	0	0	1	3	9	17	10	20	9	21
WW	0	0	0	0	3	8	0	0	3	8	2	4
Total	0	0	2	8	8	22	13	25	23	55	19	45

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	1	3	4	8	5	11
SL	0	0	0	0	0	0	1	2	1	2
NC	0	0	1	4	5	13	2	4	8	21
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	4	6	16	7	14	14	34

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	1.143	4.829
SL	0.000	0.200
NC	0.222	0.024
WW	3.000	8.000
TOTAL	2.189	4.955

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	1	4	2	6	4	8
SL	0	0	0	0	1	2	1	1
NC	0	0	1	2	3	8	6	11
WW	0	0	0	0	2	4	0	0
TOTAL	0	0	2	6	7	19	10	20

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	2.000	8.000	1.000	2.273	0.000	0.000
SL	--	--	--	--	1.000	3.000	1.000	2.000
NC	--	--	1.000	4.000	2.667	6.250	4.455	8.048
WW	--	--	--	--	3.000	8.000	--	--
TOTAL	--	--	0.333	1.333	0.286	0.947	1.800	3.103

Table C46. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 1 hr after high tide — Duration of Test: 10 min hrs 1,283 — Treatment Type: 10 sec on, 30 sec off — Test Date: 2/19/80 — Test Time: 1255

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	2	4	2	4	2	3
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	4	5	13	4	8	10	25	9	22
WW	0	0	0	0	2	5	1	2	3	7	3	6
Total	0	0	1	4	7	18	7	14	15	36	13	31

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	2	1	2
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	4	10	4	8	8	18
WW	0	0	0	0	2	5	0	0	2	5
Total	0	0	0	0	6	15	5	10	11	25

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.333	0.667
SL	--	--
NC	0.222	1.140
WW	0.200	0.333
TOTAL	0.615	1.984

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	2	3
SL	0	0	0	0	0	0	0	0
NC	0	0	1	2	5	12	4	8
WW	0	0	0	0	2	5	1	1
TOTAL	0	0	1	2	7	17	6	12

CHI-SQUARE VALUES	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	--	--	0.333	0.667
SL	--	--	--	--	--	--	--	--
NC	--	--	1.000	4.000	0.111	0.391	0.000	0.000
WW	--	--	--	--	0.000	0.000	1.000	2.000
TOTAL	--	--	1.000	4.000	0.077	0.273	0.333	0.667

Table C47. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 1 hr after high tide   Duration of Test: 10 min hmrs 1,2&3   Treatment Type: 10 sec on, 40 sec off   Test Date: 2/19/88   Test Time: 1315

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	2	4	2	4
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	3	11	10	25	3	6	16	42
WW	0	0	0	0	1	3	1	2	2	5
Total	0	0	3	11	11	28	6	12	20	51

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	2	3
SL	0	0
NC	12	32
WW	2	4
Total	15	39

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	1	2	1	2
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	2	8	3	8	3	6	8	22
WW	0	0	0	0	1	3	0	0	1	3
Total	0	0	2	8	4	11	4	8	10	27

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.333	0.667
SL	--	--
NC	2.667	6.250
WW	0.333	0.500
TOTAL	3.333	7.385

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	0	0	0	0	2	3
SL	0	0	0	0	0	0	0	0
NC	0	0	3	10	7	17	3	6
WW	0	0	0	0	1	3	1	1
TOTAL	0	0	3	10	8	20	5	10

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	--	--	--	--	0.333	0.667
SL	--	--	--	--	--	--	--	--
NC	--	--	0.200	0.474	3.769	8.758	0.000	0.000
WW	--	--	--	--	0.000	0.000	1.000	2.000
TOTAL	--	--	0.200	0.474	3.267	7.410	0.400	0.800

Table C48. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 1.5 hrs after high tide | Duration of Test: 10 min hmrs 1,2&3 | Treatment Type: 20 sec on, 20 sec off | Test Date: 2/19/88 | Test Time: 1335

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	3	11	2	5	1	2	6	18
SL	0	0	0	0	0	0	0	0	0	0
NC	1	8	3	11	2	5	2	4	8	28
WW	0	0	0	0	0	0	2	4	2	4
Total	1	8	6	22	4	10	5	10	16	50

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	6	19
SL	1	2
NC	6	18
WW	1	2
Total	13	40

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	3	11	3	8	0	0	6	19
SL	0	0	1	4	0	0	0	0	1	4
NC	0	0	0	0	2	5	1	2	3	7
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	4	15	5	13	1	2	10	30

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.000	0.027
SL	1.000	4.000
NC	2.273	12.600
WW	2.000	4.000
TOTAL	1.385	5.000

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	3	11	3	7	1	1
SL	0	0	1	2	0	0	0	0
NC	1	4	2	6	2	5	2	3
WW	0	0	0	0	0	0	1	2
TOTAL	1	4	5	19	5	12	3	6

CHI-SQUARE VALUES

	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	0.000	0.000	0.200	0.692	1.000	2.000
SL	--	--	1.000	4.000	--	--	--	--
NC	1.000	8.000	3.000	11.000	0.000	0.000	0.333	0.667
WW	--	--	--	--	--	--	2.000	4.000
TOTAL	1.000	8.000	0.400	1.324	0.111	0.391	2.667	5.333

Table C49. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 1 hr before high tide | Duration of Test: 10 min hwrs 1,2&3 | Treatment Type: 20 sec on, 30 sec off | Test Date: 2/19/68 | Test Time: 1355

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	1	4	1	3	0	0	2	7	1	4
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	1	3	4	8	5	11	4	10
WW	0	0	1	4	0	0	0	0	1	4	1	2
Total	0	0	2	8	2	6	4	8	8	22	6	16

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	4	1	3	1	2	3	9
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	4	1	3	1	2	3	9

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	2.000	7.000
SL	--	--
NC	0.500	0.200
WW	1.000	4.000
TOTAL	2.273	5.452

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	1	2	1	2	0	0
SL	0	0	0	0	0	0	0	0
NC	0	0	1	2	1	3	3	5
WW	0	0	1	2	0	0	0	0
TOTAL	0	0	2	6	2	5	3	5

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	1.000	4.000	1.000	3.000	--	--
SL	--	--	--	--	--	--	--	--
NC	--	--	1.000	4.000	0.000	0.000	1.800	3.600
WW	--	--	1.000	4.000	--	--	--	--
TOTAL	--	--	0.333	1.333	0.333	1.000	1.800	3.600

Table C50. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs after high tide   Duration of Test: 10 min hmrs 1,2a3   Treatment Type: 20 sec on, 40 sec off   Test Date: 2/19/88   Test Time: 1415

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	4	1	3	1	2	3	9	2	6
WW	0	0	0	0	0	0	0	0	0	0	1	1
Total	0	0	1	4	1	3	1	2	3	9	3	7

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	1	3	0	0	1	3
WW	0	0	0	0	0	0	1	2	1	2
Total	0	0	0	0	1	3	1	2	2	5

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	--	--
SL	--	--
NC	1.000	3.000
WW	1.000	2.000
TOTAL	0.200	1.143

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0
NC	0	0	1	2	1	3	1	1
WW	0	0	0	0	0	0	1	1
TOTAL	0	0	1	2	1	3	1	2

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	--	--	--	--	--	--
SL	--	--	--	--	--	--	--	--
NC	--	--	1.000	4.000	0.000	0.000	1.000	2.000
WW	--	--	--	--	--	--	1.000	2.000
TOTAL	--	--	1.000	4.000	0.000	0.000	0.000	0.000

Table C51. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: At high tide   Duration of Test: 10 min, hmr 3 only   Test Date: 2/20/88
Treatment Type: 20 sec on, 30 sec off   Test Time: 0015

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	2	5	0	0	3	9
SL	0	0	1	4	0	0	0	0	1	4
NC	0	0	3	11	2	5	4	8	9	24
WW	0	0	0	0	1	3	2	4	3	7
Total	0	0	5	19	5	13	6	12	16	44

CHI-SQUARE F-HAT FOR 3 TEST PERIODS

Raw	WF
3	8
1	3
7	19
2	5
13	35

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	2	5	1	2	4	11
SL	0	0	1	4	0	0	0	0	1	4
NC	0	0	0	0	2	5	1	2	3	7
WW	0	0	0	0	0	0	1	2	1	2
Total	0	0	2	8	4	10	3	6	9	24

CHI-SQUARE VALUE FOR 3 TEST PERIODS

	Raw	WF
LS	0.667	3.375
SL	0.000	2.667
NC	5.143	13.263
WW	1.000	1.600
TOTAL	2.000	5.886

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	1	3	1	2	2	5
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	2	8	5	13	3	6	10	27
WW	0	0	0	0	2	5	0	0	2	5
Total	0	0	2	8	8	21	4	8	14	37

CHI-SQUARE F-HAT	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	1	3	2	4	1	1
SL	0	0	1	3	0	0	0	0
NC	0	0	2	6	3	8	3	5
WW	0	0	0	0	1	3	1	2
TOTAL	0	0	3	12	6	15	4	9

CHI-SQUARE VALUES	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	0.000	2.667	-0.500	1.750	0.000	4.000
SL	--	--	0.000	2.667	--	--	--	--
NC	--	--	1.500	11.833	2.000	4.375	0.667	4.800
WW	--	--	--	--	2.000	3.333	2.000	4.000
TOTAL	--	--	2.000	5.750	0.500	3.333	2.250	1.111

Table C52. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: At high tide   Duration of Test: 10 min, hmr 3 only   Test Date: 2/20/80
Treatment Type: 20 sec on, 40 sec off   Test Time: 0035

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	3	11	2	5	0	0	5	16
SL	0	0	2	8	3	8	0	0	5	16
NC	0	0	4	15	4	10	8	15	16	40
WW	0	0	0	0	0	0	1	2	1	2
Total	0	0	9	34	9	23	9	17	27	74

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	4	12
SL	3	8
NC	12	32
WW	2	4
Total	20	55

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	1	3	0	0	2	7
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	3	11	4	10	1	2	8	23
WW	0	0	0	0	1	3	1	2	2	5
Total	0	0	4	15	6	16	2	4	12	35

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	1.286	3.522
SL	5.000	16.000
NC	2.667	4.587
WW	0.333	1.286
TOTAL	5.769	13.954

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	2	8	2	4	0	0
SL	0	0	1	4	2	4	0	0
NC	0	0	4	13	4	10	5	9
WW	0	0	0	0	1	2	1	2
TOTAL	0	0	7	25	8	20	6	11

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	1.000	3.267	0.333	0.500	--	--
SL	--	--	2.000	8.000	3.000	8.000	--	--
NC	--	--	0.143	0.615	0.000	0.000	5.444	9.941
WW	--	--	--	--	1.000	3.000	0.000	0.000
TOTAL	--	--	1.923	7.367	0.600	1.256	4.455	8.048

Table C53. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 30 min after high tide
Duration of Test: 10 min, hmr 3 only
Treatment Type: 20 sec on, 20 sec off
Test Date: 2/20/88
Test Time: 0055

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	3	8	0	0	3	8
SL	0	0	0	0	0	0	0	0	0	0
NC	1	8	2	8	1	3	4	8	8	27
WW	0	0	0	0	0	0	3	6	3	6
Total	1	8	2	8	4	11	7	14	14	41

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	3	8
SL	0	0
NC	10	30
WW	2	3
Total	15	40

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	2	5	1	2	3	7
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	3	11	6	15	3	6	12	32
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	3	11	8	20	4	8	15	39

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.000	0.067
SL	--	--
NC	0.800	0.424
WW	3.000	6.000
TOTAL	0.034	0.050

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	3	7	1	1
SL	0	0	0	0	0	0	0	0
NC	1	4	3	10	4	9	4	7
WW	0	0	0	0	0	0	2	3
TOTAL	1	4	3	10	6	16	6	11

CHI-SQUARE VALUES	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	0.200	0.692	1.000	2.000
SL	--	--	--	--	--	--	--	--
NC	1.000	8.000	0.200	0.474	3.571	8.000	0.143	0.286
WW	--	--	--	--	--	--	3.000	6.000
TOTAL	1.000	8.000	0.200	0.474	1.333	2.613	0.818	1.636

Table C54. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2.5 hrs before low tide   Duration of Test: 10 min, hwr 3 only   Treatment Type: 30 sec on, 30 sec off   Test Date: 2/20/88   Test Time: 0445

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	4	0	0	0	0	1	4
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	4	0	0	0	0	1	4

CHI-SQUARE F-HAT FOR 3 TEST PERIODS

	Raw	WF
LS	3	7
SL	0	1
NC	3	7
WW	0	0
Total	6	15

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	2	5	1	2	3	7
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	2	1	2
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	2	5	2	4	4	9

CHI-SQUARE VALUE FOR 3 TEST PERIODS

	Raw	WF
LS	3.333	11.143
SL	--	6.000
NC	4.667	14.000
WW	--	--
TOTAL	9.833	26.533

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	2	5	2	4	5	13
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	1	4	2	5	3	6	6	15
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	2	8	5	13	5	10	12	31

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	0	1	1	3	1	2
SL	0	0	0	0	0	1	0	0
NC	0	0	1	3	1	2	1	3
WW	0	0	0	0	0	0	0	0
TOTAL	0	0	1	4	2	6	2	5

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	--	12.000	4.000	6.667	2.000	4.000
SL	--	--	--	--	--	6.000	--	--
NC	--	--	0.000	2.667	2.000	7.500	6.000	5.333
WW	--	--	--	--	--	--	--	--
TOTAL	--	--	2.000	8.000	7.500	14.333	7.500	9.200

Table C55. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs before low tide   Duration of Test: 10 min, hmr 3 only   Treatment Type: 30 sec on, 40 sec off   Test Date: 2/20/88   Test Time: 0505

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	2	1	2
SL	0	0	0	0	0	0	1	2	1	2
NC	0	0	0	0	0	0	2	4	2	4
WW	0	0	0	0	1	3	0	0	1	3
Total	0	0	0	0	1	3	4	8	5	11

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	2	5
SL	1	3
NC	4	8
WW	1	2
TOTAL	7	16

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	3	2	4	3	7
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	0	0	2	5	3	6	5	11
WW	0	0	0	0		0	0	0	0	0
Total	0	0	0	0	4	11	5	10	9	21

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	1.000	2.778
SL	0.000	0.200
NC	1.286	3.267
WW	1.000	3.000
TOTAL	1.143	3.125

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	2	2	3
SL	0	0	0	0	1	2	1	1
NC	0	0	0	0	1	3	3	5
WW	0	0	0	0	1	2	0	0
TOTAL	0	0	0	0	3	7	5	9

CHI-SQUARE VALUES

	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	1.000	3.000	0.333	0.667
SL	--	--	--	--	1.000	3.000	1.000	2.000
NC	--	--	--	--	2.000	5.000	0.200	0.400
WW	--	--	--	--	1.000	3.000	--	--
TOTAL	--	--	--	--	1.800	4.571	0.111	0.222

Table C56. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 1.5 hrs before low tide   Duration of Test: 10 min, hmr 3 only   Treatment Type: 40 sec on, 20 sec off   Test Date: 2/20/88   Test Time: 0525

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	1	3	1	2	2	5
SL	0	0	0	0	2	5	1	2	3	7
NC	0	0	1	4	0	0	2	4	3	8
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	4	3	8	4	8	8	20

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

Raw	WF
4	10
2	4
3	9
2	4
10	25

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	3	8	1	2	5	14
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	4	1	3	1	2	3	9
WW	0	0	0	0	2	5	1	2	3	7
Total	0	0	2	8	6	16	3	6	11	30

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	1.286	4.263
SL	3.000	7.000
NC	0.000	0.059
WW	3.000	7.000
TOTAL	0.474	2.000

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	1	2	2	6	1	2
SL	0	0	0	0	1	3	1	1
NC	0	0	1	4	1	2	2	3
WW	0	0	0	0	1	3	1	1
TOTAL	0	0	2	6	5	12	4	7

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	1.000	4.000	1.000	2.273	0.000	0.000
SL	--	--	--	--	2.000	5.000	1.000	2.000
NC	--	--	0.000	0.000	1.000	3.000	0.333	0.667
WW	--	--	--	--	2.000	5.000	1.000	2.000
TOTAL	--	--	0.333	1.333	1.000	2.667	0.143	0.286

Table C57. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 1 hr before low tide | Duration of Test: 10 min, hmr 3 only | Treatment Type: 40 sec on, 30 sec off | Test Date: 2/20/88 | Test Time: 0545

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	4	30	1	4	0	0	1	2	6	36
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	4	2	5	1	2	4	11
WW	0	0	0	0	2	5	0	0	2	5
Total	4	30	2	8	4	10	2	4	12	52

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	4	20
SL	2	3
NC	5	12
WW	1	3
Total	11	37

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	1	3	0	0	1	3
SL	0	0	0	0	0	0	3	6	3	6
NC	0	0	1	4	1	3	3	6	5	13
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	4	2	6	6	12	9	22

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	3.571	27.923
SL	3.000	6.000
NC	0.111	0.167
WW	2.000	5.000
TOTAL	0.429	12.162

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	2	15	1	2	1	2	1	1
SL	0	0	0	0	0	0	2	3
NC	0	0	1	4	2	4	2	4
WW	0	0	0	0	1	3	0	0
TOTAL	2	15	2	6	3	8	4	8

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	4.000	30.000	1.000	4.000	1.000	3.000	1.000	2.000
SL	--	--	--	--	--	--	3.000	6.000
NC	--	--	0.000	0.000	0.333	0.500	1.000	2.000
WW	--	--	--	--	2.000	5.000	--	--
TOTAL	4.000	30.000	0.333	1.333	0.667	1.000	2.000	4.000

Table C58. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 1 hr before low-tide | Duration of Test: 10 min, hmr 3 only | Treatment Type: 40 sec on, 40 sec off | Test Date: 2/20/88 | Test Time: 0605

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	2	5	0	0	2	5
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	4	4	10	1	2	6	16
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	4	6	15	1	2	8	21

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	3	7
SL	1	1
NC	4	11
WW	1	2
Total	8	20

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	1	3	3	6	4	9
SL	0	0	0	0	0	0	1	2	1	2
NC	0	0	0	0	2	5	0	0	2	5
WW	0	0	0	0	1	3	0	0	1	3
Total	0	0	0	0	4	11	4	8	8	19

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.667	1.143
SL	1.000	2.000
NC	2.000	5.762
WW	1.000	3.000
TOTAL	0.000	0.100

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	0	0	2	4	2	3
SL	0	0	0	0	0	0	1	1
NC	0	0	1	2	3	8	1	1
WW	0	0	0	0	1	2	0	0
TOTAL	0	0	1	2	5	13	3	5

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	--	--	0.333	0.500	3.000	6.000
SL	--	--	--	--	--	--	1.000	2.000
NC	--	--	1.000	4.000	0.667	1.667	1.000	2.000
WW	--	--	--	--	1.000	3.000	--	--
TOTAL	--	--	1.000	4.000	0.400	0.615	1.800	3.600

Table C59. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs after low tide   Duration of Test: 10 min, hmr 3 only   Treatment Type: 10 sec on, 20 sec off   Test Date: 2/20/88   Test Time: 2155

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	2	4	2	4
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	2	8	3	8	4	8	9	24
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	2	8	4	11	6	12	12	31

CHI-SQUARE F-HAT FOR 3 TEST PERIODS

	Raw	WF
LS	3	7
SL	1	2
NC	6	18
WW	1	2
Total	11	29

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	0	0	0	0	1	4
SL	0	0	1	4	0	0	0	0	1	4
NC	1	8	1	4	4	10	2	4	8	26
WW	0	0	0	0	0	0	1	2	1	2
Total	1	8	3	12	4	10	3	6	11	36

CHI-SQUARE VALUE FOR 3 TEST PERIODS

	Raw	WF
LS	2.000	7.714
SL	0.000	5.500
NC	5.833	16.444
WW	2.000	7.500
TOTAL	-0.545	5.517

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	1	3	3	6	5	13
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	2	4	2	4
WW	0	0	0	0	1	3	1	2	2	5
Total	0	0	1	4	2	6	6	12	9	22

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	1	3	0	1	2	3
SL	0	0	0	1	0	1	0	0
NC	0	3	1	4	2	6	3	5
WW	0	0	0	0	0	1	1	1
TOTAL	0	3	2	8	3	9	5	10

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	0.000	2.667	--	6.000	1.500	7.333
SL	--	--	--	12.000	--	6.000	--	--
NC	--	13.333	2.000	8.000	5.500	9.333	0.000	3.200
WW	--	--	--	--	--	6.000	0.000	4.000
TOTAL	--	13.333	1.000	4.000	2.000	1.556	1.200	2.400

Table C60. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 1.5 hrs after low tide | Duration of Test: 10 min, hmr 3 only | Treatment Type: 10 sec on, 30 sec off | Test Date: 2/20/88 | Test Time: 2215

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	3	8	3	6	6	14
SL	0	0	0	0	0	0	0	0	0	0
NC	0	0	3	11	3	8	4	8	10	27
WW	0	0	0	0	0	0	1	2	1	2
Total	0	0	3	11	6	16	8	16	17	43

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

Raw	WF
6	14
1	4
6	15
2	4
14	36

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	1	4	0	0	5	10	6	14
SL	0	0	1	4	1	3	0	0	2	7
NC	0	0	0	0	1	3	0	0	1	3
WW	0	0	0	0	1	3	1	2	2	5
Total	0	0	2	8	3	9	6	12	11	29

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.000	0.000
SL	2.000	7.000
NC	7.364	19.200
WW	0.333	1.286
TOTAL	1.286	2.722

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	1	2	2	4	4	8
SL	0	0	1	2	1	2	0	0
NC	0	0	2	6	2	6	2	4
WW	0	0	0	0	1	2	1	2
TOTAL	0	0	3	10	5	13	7	14

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	1.000	4.000	3.000	8.000	0.500	1.000
SL	--	--	1.000	4.000	1.000	3.000	--	--
NC	--	--	3.000	11.000	1.000	2.273	4.000	8.000
WW	--	--	--	--	1.000	3.000	0.000	0.000
TOTAL	--	--	0.200	0.474	1.000	1.960	0.286	0.571

Table C61. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs after low tide

Duration of Test: 10 min, hwr 3 only

Treatment Type: 10 sec on, 40 sec off

Test Date: 2/20/88

Test Time: 2235

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	3	6	3	6	4	9
SL	0	0	0	0	1	3	0	0	1	3	1	3
NC	0	0	4	15	5	13	3	6	12	34	9	25
WW	0	0	0	0	1	3	0	0	1	3	1	2
Total	0	0	4	15	7	19	6	12	17	46	14	38

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2		2-4		4-6		6-8		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	4	2	5	1	2	4	11
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	2	8	2	5	1	2	5	15
WW	0	0	0	0	0	0	0	0	0	0
Total	0	0	3	12	5	13	2	4	10	29

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	0.143	1.471
SL	0.000	0.000
NC	2.882	7.367
WW	1.000	3.000
TOTAL	1.815	3.853

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	1	3	2	4
SL	0	0	0	0	1	3	0	0
NC	0	0	3	12	4	9	2	4
WW	0	0	0	0	1	2	0	0
TOTAL	0	0	4	14	6	16	4	8

CHI-SQUARE VALUES	0-2		2-4		4-6		6-8	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	1.000	4.000	2.000	5.000	1.000	2.000
SL	--	--	--	--	0.000	0.000	--	--
NC	--	--	0.667	2.130	1.286	3.556	1.000	2.000
WW	--	--	--	--	1.000	3.000	--	--
TOTAL	--	--	0.143	0.333	0.333	1.125	2.000	4.000

Table C62. Indian Point hammer test monitoring using 15 degree oblique transducer located at unit 3, intake 35.

Tidal Phase: 2.5 hrs after low tide
Duration of Test: 10 min, hmr 3 only
Treatment Type: 10 sec on, 20 sec off
Test Date: 2/20/88
Test Time: 2255

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	5	19	2	5	3	6	10	30
SL	0	0	0	0	0	0	1	2	1	2
NC	0	0	1	4	4	10	2	4	7	18
WW	0	0	1	4	0	0	1	2	2	6
Total	0	0	7	27	6	15	7	14	20	56

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

	Raw	WF
LS	8	22
SL	1	3
NC	5	14
WW	2	5
Total	16	43

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF	Total Raw	Total WF
LS	0	0	0	0	3	8	3	6	6	14
SL	0	0	0	0	1	3	0	0	1	3
NC	0	0	1	4	1	3	1	2	3	9
WW	0	0	0	0	1	3	0	0	1	3
Total	0	0	1	4	6	17	4	8	11	29

CHI-SQUARE VALUE FOR 2 TEST PERIODS

	Raw	WF
LS	1.000	5.818
SL	0.000	0.200
NC	1.600	3.000
WW	0.333	1.000
TOTAL	2.613	8.576

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	0	0	3	10	3	7	3	6
SL	0	0	0	0	1	2	1	1
NC	0	0	1	4	3	7	2	3
WW	0	0	1	2	1	2	1	1
TOTAL	0	0	4	16	6	16	6	11

CHI-SQUARE VALUES

	0-2 Raw	0-2 WF	2-4 Raw	2-4 WF	4-6 Raw	4-6 WF	6-8 Raw	6-8 WF
LS	--	--	5.000	19.000	0.200	0.692	0.000	0.000
SL	--	--	--	--	1.000	3.000	1.000	2.000
NC	--	--	0.000	0.000	1.800	3.769	0.333	0.667
WW	--	--	1.000	4.000	1.000	3.000	1.000	2.000
TOTAL	--	--	4.500	17.065	0.000	0.125	0.818	1.636

APPENDIX D:

Hammer Tests Monitored By

6°x12° Horizontal Transducer

Table D1. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs before low tide | Duration of Test: 10 min, hmrs 1,2&3 | Treatment Type: 1 min on, 1 min off | Test Date: 1/26/88 | Test Time: 2135

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total[1] Raw	Total[1] WF
LS	0	0	0	0	0	0	2	2	2	2	2	1	3	2	2	1	11	8
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	214	798	336	632	458	550	0	0	1	1	0	0	0	0	0	0	1009	1981
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	214	798	336	632	458	550	2	2	3	3	2	1	3	2	2	1	1020	1989

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total[1] Raw	Total[1] WF
LS	0	0	0	0	0	0	0	0	0	0	2	1	4	2	4	2	10	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	184	686	330	620	552	662	14	13	0	0	0	0	0	0	0	0	1080	1981
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	184	686	330	620	552	662	14	13	0	0	2	1	4	2	4	2	1090	1986

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total[1] Raw	Total[1] WF
LS	0	0	0	0	0	0	3	3	1	1	0	0	1	1	2	1	7	6
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	242	903	338	635	538	646	1	1	0	0	0	0	0	0	0	0	1119	2185
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	242	903	338	635	538	646	4	4	1	1	0	0	1	1	2	1	1126	2191

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 3 TEST PERIODS WF
LS	0	0	0	0	0	0	2	2	1	1	1	1	3	2	3	1	9	6
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	213	795	334	628	515	619	5	5	0	0	0	0	0	0	0	0	1059	2029
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	213	795	334	628	515	619	7	6	1	1	1	1	3	2	3	1	1068	2035

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 3 TEST PERIODS Raw	CHI-SQUARE VALUES FOR 3 TEST PERIODS WF
LS	--	--	--	--	--	--	1.500	1.500	2.000	2.000	4.000	0.000	0.667	-0.500	0.000	2.000	2.000	1.833
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	8.901	31.628	2.108	3.205	12.994	12.856	24.400	20.000	--	--	--	--	--	--	--	--	37.177	74.265
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	8.901	31.628	2.108	3.205	12.994	12.856	10.857	12.500	6.000	6.000	4.000	0.000	0.667	-0.500	0.000	2.000	37.760	75.178

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

1) Numbers presented are a minimum estimation for test periods.

Table D2. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs before low tide | Duration of Test: 15 min hmrs 1,2&3 | Treatment Type: 10 sec on, 20 sec off | Test Date: 1/26/88 | Test Time: 2155

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	5	4
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	210	783	302	568	458	550	1	1	1	1	0	0	0	0	0	0	972	1903
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	210	783	302	568	458	550	2	2	3	3	1	1	1	1	1	0	978	1908

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	3	3	0	0	2	1	2	1	1	0	8	5
SL	0	0	0	0	0	0	2	2	1	1	0	0	0	0	0	0	3	3
NC	194	724	478	899	472	566	3	3	1	1	0	0	0	0	0	0	1148	2193
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
Total	194	724	478	899	472	566	8	8	2	2	2	1	3	2	1	0	1160	2202

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	2	2	1	1	2	1	2	1	1	0	7	5
SL	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	2	2
NC	202	754	390	734	465	558	2	2	1	1	0	0	0	0	0	0	1060	2048
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
TOTAL	202	754	390	734	465	558	5	5	3	3	2	1	2	2	1	0	1069	2055

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	--	--	1.000	1.000	1.000	1.000	0.333	0.000	0.333	0.000	0.000	--	0.692	0.111
SL	--	--	--	--	--	--	2.000	2.000	0.000	0.000	--	--	--	--	--	--	1.000	1.000
NC	0.634	2.310	39.713	74.684	0.211	0.229	1.000	1.000	0.000	0.000	--	--	--	--	--	--	14.611	20.532
WW	--	--	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--	1.000	1.000
TOTAL	0.634	2.310	39.713	74.684	0.211	0.229	3.600	3.600	0.200	0.200	0.333	0.000	1.000	0.333	0.000	--	15.493	21.031

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

1) Numbers presented are a minimum estimation for test periods.

Table D3. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1 hr before low tide | Duration of Test: 10 min, hmr 2 only | Test Date: 1/26/88
Treatment Type: 10 sec on, 20 sec off | Test Time: 2220

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total [1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	2	2
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
NC	158	589	330	620	616	739	24	22	0	0	0	0	0	0	0	0	1128	1970
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	158	589	330	620	616	739	24	22	1	1	1	1	1	1	0	0	1131	1973

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total [1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	4	4	0	0	1	1	1	1	0	0	6	6
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	146	545	138	259	208	250	2	2	0	0	0	0	0	0	0	0	494	1056
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	146	548	138	259	208	250	6	6	0	0	1	1	1	1	0	0	500	1062

CHI-SQUARE F-MAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-MAT FOR 2 TEST PERIOD:	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	2	2	1	1	1	1	1	1	0	0	4	4
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
NC	152	567	234	440	412	495	13	12	0	0	0	0	0	0	0	0	811	1513
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	152	567	234	440	412	495	15	14	1	1	1	1	1	1	0	0	816	1518

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIOD:	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	--	--	4.000	4.000	1.000	1.000	1.000	1.000	0.000	0.000	--	--	2.000	[illegible]
SL	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--	--	--	1.000	1.000
NC	0.474	1.707	78.769	148.261	202.019	241.781	10.615	16.667	--	--	--	--	--	--	--	--	247.815	[illegible]
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.474	1.707	78.769	148.261	202.019	241.781	10.800	9.143	1.000	1.000	0.000	0.000	0.000	0.000	--	--	244.121	[illegible]

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

1) Numbers presented are a minimum estimation for test periods.

Table D4. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs before low tide   Duration of Test: 10 min, hmr 2 only   Treatment Type: 10 sec on, 20 sec off   Test Date: 1/26/88   Test Time: 2245

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total[1] Raw	Total[1] WF
LS	0	0	0	0	0	0	3	3	1	1	0	0	0	0	0	0	4	4
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	134	500	236	444	264	317	3	3	0	0	1	1	0	0	0	0	638	1265
WW	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
Total	134	500	236	444	264	317	7	7	2	2	1	1	0	0	0	0	644	1271

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total[1] Raw	Total[1] WF
LS	0	0	0	0	0	0	2	2	0	0	0	0	0	0	1	0	3	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	122	455	170	320	130	156	0	0	1	1	0	0	0	0	0	0	423	932
WW	0	0	0	0	0	0	1	1	1	1	0	0	0	0		0	2	2
Total	122	455	170	320	130	156	3	3	2	2	0	0	0	0	1	0	428	936

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	0	0	0	0	0	0	3	3	1	1	0	0	0	0	1	0	4	3
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	128	478	203	382	197	237	2	2	1	1	1	1	0	0	0	0	531	1099
WW	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	2	2
TOTAL	128	478	203	382	197	237	5	5	2	2	1	1	0	0	1	0	536	1104

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	--	--	--	--	--	--	0.200	0.200	1.000	1.000	--	--	--	--	1.000	--	0.143	0.667
SL	--	--	--	--	--	--	--	--	1.000	1.000	--	--	--	--	--	--	1.000	1.000
NC	0.563	2.120	10.729	20.126	45.574	54.801	3.000	3.000	1.000	1.000	1.000	1.000	--	--	--	--	43.567	50.473
WW	--	--	--	--	--	--	0.000	0.000	1.000	1.000	--	--	--	--	--	--	0.333	0.333
TOTAL	0.563	2.120	10.729	20.126	45.574	54.801	1.600	1.600	0.000	0.000	1.000	1.000	--	--	1.000	--	43.522	50.850

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

1) Numbers presented are a minimum estimation for test periods.

Table 05. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1 hr before low tide | Duration of Test: 10 min, hmr 2 only | Test Date: 1/26/88
Treatment Type: 5 sec on, 10 sec off | Test Time: 2305

5 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	2	2	1	1	1	1	0	0	1	1	0	0	5	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	60	224	74	139	118	142	0	0	0	0	0	0	0	0	0	0	252	505
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	60	224	74	139	120	144	1	1	1	1	0	0	1	1	0	0	257	510

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	51	190	92	173	92	110	0	0	0	0	0	0	0	0	0	0	235	473
WW	0	0	0	0	0	0	1	1	0	0		0	0	0	0	0	1	1
Total	51	190	92	173	92	110	2	2	0	0	0	0	0	0	0	0	237	475

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	3	3	1	1	0	0	1	1	0	0	5	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	46	172	78	147	104	125	0	0	0	0	0	0	0	0	0	0	228	444
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	46	172	78	147	104	125	3	3	1	1	0	0	1	1	0	0	233	449

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	1	2	2	1	1	0	0	1	1	0	0	4	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	52	195	81	153	105	126	0	0	0	0	0	0	0	0	0	0	236	469
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	52	195	81	153	105	126	2	2	1	1	0	0	1	1	0	0	240	473

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	2.000	2.000	0.500	0.500	0.000	0.000	--	--	0.000	0.000	--	--	1.750	1.750
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	2.942	8.154	3.210	4.131	2.229	3.071	--	--	--	--	--	--	--	--	--	--	8.360	19.130
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	2.942	8.154	3.210	4.131	4.762	5.611	1.000	1.000	0.000	0.000	--	--	0.000	0.000	--	--	8.446	19.121

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

1) Numbers presented are a minimum estimation for test periods.

Table D6. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: .5 hr before low tide

Duration of Test: 10 min hrs 1,2&3

Treatment Type: 10 sec on, 20 sec off

Test Date: 1/26/88

Test Time: 2320

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	4	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MC	86	321	154	290	150	180	0	0	4	3	0	0	0	0	0	0	394	794
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	86	321	154	290	150	180	0	0	4	3	0	0	0	0	4	2	398	796

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	2	2	2	2	4	3	2	1	0	0	0	0	10	8
SL	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	2	2
MC	86	321	138	259	178	214	0	0	0	0	0	0	0	0	0	0	402	794
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	86	321	138	259	180	216	2	2	6	5	2	1	0	0	0	0	414	804

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	1	1	1	2	2	1	1	0	0	2	1	7	5
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
MC	86	321	146	275	164	197	0	0	2	2	0	0	0	0	0	0	398	794
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	86	321	146	275	165	198	1	1	5	4	1	1	0	0	2	1	406	800

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	2.000	2.000	2.000	2.000	4.000	3.000	2.000	1.000	--	--	4.000	2.000	2.571	3.600
SL	--	--	--	--	--	--	--	--	2.000	2.000	--	--	--	--	--	--	2.000	2.000
MC	0.000	0.000	0.877	1.750	2.390	2.934	--	--	4.000	3.000	--	--	--	--	--	--	0.080	0.000
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.000	0.000	0.877	1.750	2.727	3.273	2.000	2.000	0.400	0.500	2.000	1.000	--	--	4.000	2.000	0.315	0.040

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

1) Numbers presented are a minimum estimation for test periods.

Table D7. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2 Hrs after High Tide

Duration of Test: 10 min Hmr 5 only
Treatment Type: 10 sec on 20 sec off

Test Date: 2/4/88
Test Time: 0108

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	5	9	5	6	4	4	7	5	9	5	1	1	0	0	31	30
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	5	9	5	6	4	4	7	5	9	5	1	1	0	0	31	30

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	4	8	7	8	9	8	14	11	6	4	2	1	1	0	43	40
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	1	2	1	1	1	1	1	1	0	0	0	0	0	0	5	9
WH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	5	10	8	9	10	9	15	12	6	4	2	1	1	0	48	49

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	2	7	9	17	10	12	5	5	3	2	2	1	3	2	1	0	35	46
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	2	7	1	2	0	0	0	0	0	0	1	1	0	0	0	0	4	10
WH	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
Total	4	14	11	21	10	12	5	5	3	2	3	2	3	2	1	0	40	58

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	2	6	11	7	9	6	6	8	6	6	3	2	1	1	0	36	38
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	3	6
WH	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL	2	6	7	13	8	9	6	6	8	6	6	4	2	1	1	0	39	45

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	2.000	17.500	2.333	5.455	2.857	1.111	2.333	0.500	7.750	7.000	3.167	4.000	1.000	2.000	0.000	--	3.083	5.474
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	2.000	5.250	0.000	4.000	--	--	--	--	--	--	--	--	--	--	--	--	4.667	11.167
WH	--	--	--	2.000	--	--	--	--	--	--	--	--	--	--	--	--	--	2.000
TOTAL	3.500	17.333	3.429	7.846	0.625	2.000	4.500	2.333	10.375	9.833	3.000	0.250	1.000	2.000	0.000	--	5.744	11.111

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

Table D8. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase:	2 Hrs after High Tide	Duration of Test: Treatment Type:	10 min Hmr 5 only 10 sec on 20 sec off	Test Date: Test Time:	2/4/88 0140

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	1	4	0	0	4	5	8	7	6	5	7	4	5	3	2	1	33	29
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	2	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	0	0	4	5	8	7	8	7	8	5	5	3	2	1	36	32

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	1	4	5	9	8	10	17	15	11	8	10	6	3	2	2	1	57	55
SL	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
NC	2	7	2	4	0	0	0	0	3	2	1	1	0	0	0	0	8	14
WW	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
Total	5	19	7	13	8	10	17	15	14	10	11	7	3	2	2	1	67	77

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	7	13	7	8	10	9	11	8	12	7	4	2	1	0	52	47
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	2	7	1	2	0	0	0	0	0	0	0	0	1	1	0	0	4	10
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	7	8	15	7	8	10	9	12	9	12	7	5	3	1	0	57	58

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	WF
LS	1	3	4	7	6	8	12	10	9	7	10	6	4	2	2	1	47	43
SL	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	2
NC	1	5	1	2	0	0	0	0	1	1	1	1	0	0	0	0	5	9
WW	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL	3	10	5	9	6	8	12	10	11	9	10	6	4	3	2	1	53	55

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 3 TEST PERIODS Raw	WF
LS	0.000	2.667	6.500	13.714	2.500	0.625	2.750	4.500	2.889	0.857	0.300	-0.167	0.500	1.500	-0.500	0.000	7.030	10.279
SL	--	12.000	--	--	--	--	--	--	0.000	0.000	--	--	--	--	--	--	0.000	3.800
NC	4.000	5.600	2.000	4.000	--	--	--	--	6.000	2.000	0.000	0.000	--	--	--	--	2.800	7.333
WW	--	12.000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	12.800
TOTAL	2.000	12.600	7.600	15.778	2.500	0.625	2.750	4.500	2.727	-0.444	1.900	1.500	1.750	-0.667	-0.500	0.000	10.453	20.582

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

Table D9. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2 Hrs after High tide | Duration of Test: 10 min Hmr 5 only | Test Date: 2/4/88
Treatment Type: 10 sec on 30 sec off | Test Time: 0200

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	1	4	7	13	6	7	7	6	12	9	14	8	6	3	1	0	54	50
SL	0	0	0	0	2	2	1	1	1	1	0	0	0	0	0	0	4	4
NC	2	7	0	0	0	0	0	0	1	1	3	2	1	1	0	0	7	11
WN	0	0	1	2	2	2	0	0	0	0	0	0	0	0	0	0	3	4
Total	3	11	8	15	10	11	8	7	14	11	17	10	7	4	1	0	68	69

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	3	11	6	11	11	13	19	17	18	14	12	7	6	3	0	0	75	76
SL	0	0	2	4	0	0	0	0	0	0	0	0	0	0	0	0	2	4
NC	2	7	0	0	2	2	0	0	1	1	1	1	0	0	1	0	7	11
WN	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
Total	5	18	9	17	13	15	19	17	19	15	13	8	6	3	1	0	85	93

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	2	8	7	12	9	10	13	12	15	12	13	8	6	3	1	0	65	63
SL	0	0	1	2	1	1	1	1	1	1	0	0	0	0	0	0	3	4
NC	2	7	0	0	1	1	0	0	1	1	2	2	1	1	1	0	7	11
WN	0	0	1	2	1	1	0	0	0	0	0	0	0	0	0	0	2	3
TOTAL	4	15	9	16	12	13	14	12	17	13	15	9	7	4	1	0	77	81

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	1.000	3.267	0.077	0.167	1.471	1.800	5.538	5.261	1.200	1.087	0.154	0.067	0.000	0.000	1.000	--	3.419	5.365
SL	--	--	2.000	4.000	2.000	2.000	1.000	1.000	1.000	1.000	--	--	--	--	--	--	0.667	0.800
NC	0.000	0.000	--	--	2.000	2.000	--	--	0.000	0.000	1.000	0.333	1.000	1.000	1.000	--	0.000	0.800
WN	--	--	0.000	0.000	2.000	2.000	--	--	--	--	--	--	--	--	--	--	1.000	0.167
TOTAL	0.500	1.690	0.059	0.125	0.391	0.615	4.481	4.167	0.758	0.615	0.533	0.222	0.077	0.143	0.000	--	1.889	3.556

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D10. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2.5 Hrs after High Tide | Duration of Test: 10 min Hwr 5 only | Test Date: 2/4/88
Treatment Type: 10 sec on 40 sec off | Test Time: 0220

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	4	1	2	12	14	12	11	14	11	14	8	10	5	4	2	68	57
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	1	4	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2	5
WW	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
Total	2	8	2	4	12	14	12	11	15	12	15	9	10	5	4	2	72	65

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	4	3	6	9	11	11	10	11	8	5	3	4	2	3	1	47	45
SL	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
NC	0	0	1	2	1	1	0	0	0	0	1	1	0	0	0	0	3	4
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	5	10	10	12	11	10	11	8	6	4	4	2	3	1	51	51

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	4	2	4	11	13	12	11	13	10	10	6	7	4	4	2	58	51
SL	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	1	2
NC	1	2	1	1	1	1	0	0	0	0	1	1	0	0	0	0	3	5
WW	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	2	6	4	7	11	13	12	11	13	10	11	7	7	4	4	2	62	58

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0.000	0.000	1.000	2.000	0.429	0.360	0.043	0.048	0.360	0.474	4.263	2.273	2.571	1.286	0.143	0.333	3.835	1.412
SL	--	--	1.000	2.000	--	--	--	--	1.000	1.000	--	--	--	--	--	--	0.000	0.333
NC	1.000	4.000	1.000	2.000	1.000	1.000	--	--	--	--	0.000	0.000	--	--	--	--	0.200	0.111
WW	--	--	1.000	2.000	--	--	--	--	--	--	--	--	--	--	--	--	1.000	2.000
TOTAL	0.333	1.333	1.286	2.571	0.182	0.154	0.043	0.048	0.615	0.800	3.857	1.923	2.571	1.286	0.143	0.333	3.585	1.690

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D11. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase:	3 Hrs after High Tide	Duration of Test:	10 min Hmr 5 only	Test Date:	2/4/88
		Treatment Type:	20 sec on 20 sec off	Test Time:	0240

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	4	8	11	13	9	8	7	5	9	5	2	1	1	0	43	40
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	5	10	11	13	9	8	7	5	9	5	2	1	1	0	44	42

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	4	8	2	2	11	10	5	4	13	8	3	2	2	1	40	35
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
Total	0	0	4	8	2	2	12	11	5	4	14	9	3	2	2	1	42	37

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	4	8	7	8	10	9	6	5	11	7	3	2	2	1	42	38
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
NC	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
WW	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
TOTAL	0	0	5	9	7	8	11	10	6	5	12	7	3	2	2	1	43	40

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	0.000	0.000	6.231	0.067	0.200	0.222	0.333	0.111	0.727	0.692	0.200	0.333	0.333	1.000	0.108	0.333
SL	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--	--	--	1.000	1.000
NC	--	--	1.000	2.000	--	--	--	--	--	--	--	--	--	--	--	--	1.000	2.000
WW	--	--	--	--	--	--	1.000	1.000	--	--	--	--	--	--	--	--	1.000	1.000
TOTAL	--	--	0.111	0.222	6.231	0.067	0.429	0.474	0.333	0.111	1.087	1.143	0.200	0.333	0.333	1.000	0.047	0.316

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D12. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase:	3 Hrs before high tide	Duration of Test:	10 min Hmr 5 only	Test Date:	2/4/88
		Treatment Type:	20 sec on 30 sec off	Test Time:	0300

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	1	2	4	5	5	5	10	8	12	7	1	1	3	1	36	29
SL	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	3	3
NC	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	2	5	6	7	7	11	9	12	7	1	1	3	1	40	33

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	2	4	3	4	6	5	8	6	17	10	1	1	1	0	38	30
SL	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
NC	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
WW	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
Total	0	0	2	4	3	4	8	7	9	7	17	10	1	1	1	0	41	33

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	0	0	2	3	4	5	6	5	9	7	15	9	1	1	2	1	37	30
SL	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	2	2
NC	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	1	1
WW	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
TOTAL	0	0	2	3	4	5	8	7	10	8	15	9	1	1	2	1	41	33

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	--	--	0.333	0.667	0.143	0.111	0.091	0.000	0.222	0.286	0.862	0.529	0.000	0.000	1.000	1.000	0.054	0.017
SL	--	--	--	--	1.000	1.000	0.000	0.000	1.000	1.000	--	--	--	--	--	--	1.000	1.000
NC	--	--	--	--	--	--	1.000	1.000	1.000	1.000	--	--	--	--	--	--	0.000	0.000
WW	--	--	--	--	--	--	1.000	1.000	--	--	--	--	--	--	--	--	1.000	1.000
TOTAL	--	--	0.333	0.667	0.500	0.400	0.067	0.000	0.200	0.250	0.862	0.529	0.000	0.000	1.000	1.000	0.012	0.000

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D13. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 3 Hrs before Low tide | Duration of Test: 10 min Hmr 5 only | Treatment Type: 20 sec on 40 sec off | Test Date: 2/4/88 | Test Time: 0320

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	5	9	5	6	4	4	5	4	11	7	5	3	2	1	37	34
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MC	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	5	9	6	7	4	4	5	4	11	7	5	3	2	1	38	35

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	4	3	6	7	8	3	3	5	4	14	8	4	2	3	1	40	36
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MC	0	0	2	4	0	0	0	0	0	0	1	1	0	0	0	0	3	5
WW	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Total	1	4	5	10	8	9	3	3	5	4	15	9	4	2	3	1	44	42

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	2	4	8	6	7	4	4	5	4	13	8	5	3	3	1	39	35
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MC	0	0	1	2	1	1	0	0	0	0	1	1	0	0	0	0	2	3
WW	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	1	2	5	10	7	8	4	4	5	4	13	8	5	3	3	1	41	39

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1.000	4.000	0.500	0.600	0.333	0.286	0.143	0.143	0.000	0.000	0.360	0.067	0.111	0.200	0.200	0.000	0.117	0.057
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MC	--	--	2.000	4.000	1.000	1.000	--	--	--	--	1.000	1.000	--	--	--	--	1.000	2.667
WW	--	--	--	--	1.000	1.000	--	--	--	--	--	--	--	--	--	--	1.000	1.000
TOTAL	1.000	4.000	0.000	0.053	0.286	0.250	0.143	0.143	0.000	0.000	0.615	0.250	0.111	0.200	0.200	0.000	0.439	0.636

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D14. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2.5 Hr before Low Tide — Duration of Test: 10 min Hmr 5 only — Treatment Type: 30 sec on 20 sec off — Test Date: 2/4/88 — Test Time: 0340

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	2	4	4	5	9	8	8	6	12	7	4	2	5	2	44	34
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MC	1	4	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	5
WW	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Total	1	4	2	4	5	6	9	8	8	6	12	7	5	3	5	2	47	40

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	1	2	7	8	6	5	7	5	5	3	3	2	4	2	33	27
SL	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
MC	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
WW	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	2	2
Total	1	4	1	2	8	9	8	7	7	5	5	3	3	2	4	2	37	34

CHI-SQUARE F-HAT

	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	0	0	2	3	6	7	8	7	8	6	9	5	4	2	5	2	39	31
SL	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
MC	1	4	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	5
WW	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	2	2
TOTAL	1	4	2	3	7	8	9	8	8	6	9	5	4	3	5	2	42	37

CHI-SQUARE VALUES

	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	—	—	0.333	0.667	0.818	0.692	0.600	0.692	0.067	0.091	2.882	1.600	0.143	0.000	0.111	0.000	1.571	0.803
SL	—	—	—	—	—	—	1.000	1.000	—	—	—	—	—	—	—	—	1.000	1.000
MC	0.000	0.000	—	—	—	—	—	—	—	—	—	—	1.000	1.000	—	—	0.333	0.111
WW	—	—	—	—	0.000	0.000	1.000	1.000	—	—	—	—	—	—	—	—	0.333	0.333
TOTAL	0.000	0.000	0.333	0.667	0.692	0.600	0.059	0.067	0.067	0.091	2.882	1.600	0.500	0.200	0.111	0.000	1.198	0.486

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D15. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 3S.

Tidal Phase:	2 Hrs before Low Tide	Duration of Test:	10 min Hwr 5 only	Test Date:	2/4/88
		Treatment Type:	30 sec on 30 sec off	Test Time:	0400

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	5	9	16	19	13	12	9	7	12	7	7	4	2	1	64	59
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	3	4	0	0	0	0	0	0	0	0	0	0	3	4
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	5	9	19	23	13	12	9	7	12	7	7	4	2	1	67	63

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	3	6	10	12	7	6	11	8	11	7	5	3	4	2	51	44
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	0	0	1	2	0	0	1	1	0	0	0	0	0	0	0	0	2	3
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	4	8	10	12	8	7	12	9	11	7	5	3	4	2	54	48

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	4	8	13	16	10	9	10	8	12	7	6	4	3	2	58	52
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	0	0	1	1	2	2	1	1	0	0	0	0	0	0	0	0	3	4
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	5	9	15	18	11	10	11	8	12	7	6	4	3	2	61	56

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	0.500	0.600	1.385	1.581	1.800	2.000	0.200	0.067	0.043	0.000	0.333	0.143	0.667	0.333	1.478	2.184
SL	--	--	--	--	--	--	--	--	1.000	1.000	--	--	--	--	--	--	1.000	1.000
NC	--	--	1.000	2.000	3.000	4.000	1.000	1.000	--	--	--	--	--	--	--	--	0.208	0.143
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	--	--	0.111	0.059	2.793	3.457	1.190	1.316	0.429	0.250	0.043	0.000	0.333	0.143	0.667	0.333	1.397	2.027

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D16. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1.5 Hrs before Low Tide — Duration of Test: 10 min Hwr 5 only — Treatment Type: 30 sec on 40 sec off — Test Date: 2/4/89 — Test Time: 0420

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	2	4	8	10	8	7	10	8	11	7	8	4	2	1	49	41
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	2	4	8	10	8	7	10	8	11	7	8	4	2	1	49	41

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	2	7	0	0	3	4	4	4	11	8	8	5	7	4	4	2	39	34
SL	0	0	1	2	0	0	1	1	0	0	0	0	0	0	0	0	2	3
NC	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	3	11	1	2	3	4	5	5	11	8	8	5	7	4	4	2	42	41

CHI-SQUARE F-HAT

	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	1	4	1	2	6	7	6	6	11	8	10	6	8	4	3	2	44	38
SL	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	1	2
NC	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	2	6	2	3	6	7	7	6	11	8	10	6	8	4	3	2	46	41

CHI-SQUARE VALUES

	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	2.000	7.000	2.000	4.000	2.273	2.571	1.333	0.818	0.048	0.000	0.474	0.333	0.067	0.000	0.667	0.333	1.136	0.653
SL	--	--	1.000	2.000	--	--	1.000	1.000	--	--	--	--	--	--	--	--	2.000	3.000
NC	1.000	4.000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.000	4.000
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	3.000	11.000	0.333	0.667	2.273	2.571	0.692	0.333	0.048	0.000	0.474	0.333	0.067	0.000	0.667	0.333	0.538	0.000

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

Table 017. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 3 hrs before low tide | Duration of Test: 10 min hwrs 365 | Test Date: 2/13/88
Treatment Type: 10 sec on, 20 sec off | Test Time: 1047

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	2	7	1	2	0	0	0	0	0	0	0	0	0	0	0	0	3	9
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	7	1	2	0	0	0	0	0	0	0	0	0	0	0	0	3	9

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	0	0	2	2	1	1	0	0	0	0	1	1	0	0	5	8
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	0	0	2	2	2	2	0	0	0	0	1	1	0	0	6	9

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	2	2	1	1	0	0	0	0	0	0	0	0	3	3
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	6	22	5	9	15	18	0	0	0	0	0	0	0	0	0	0	26	49
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	6	22	5	9	17	20	1	1	0	0	0	0	0	0	0	0	29	52

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	3	11	2	4	5	7	0	0	0	0	0	0	0	0	0	0	11	22
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3	11	2	4	6	7	1	1	0	0	0	0	0	0	0	0	13	23

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	2.000	2.000	0.000	0.000	--	--	--	--	--	--	--	--	6.000	6.000
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	4.667	16.909	7.000	10.250	21.167	26.857	--	--	--	--	--	--	--	--	--	--	30.545	49.727
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	4.667	16.909	7.000	10.250	29.833	35.714	2.000	2.000	--	--	--	--	--	--	--	--	30.154	54.609

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

Table D18. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 3 hrs before low tide
Duration of Test: 10 min, hwrs 3&5
Treatment Type: 10 sec on, 30 sec off
Test Date: 2/13/88
Test Time: 1107

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	11	41	8	15	32	38	0	0	0	0	0	0	0	0	0	0	51	94
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	11	41	8	15	32	38	0	0	0	0	0	0	1	1	0	0	52	95

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	2	2	1	1	1	1	0	0	2	1	6	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	33	123	28	53	63	76	0	0	0	0	0	0	0	0	0	0	124	252
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	33	123	28	53	63	76	2	2	1	1	1	1	0	0	2	1	130	257

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	4	3
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	22	82	18	34	48	57	0	0	0	0	0	0	0	0	0	0	88	173
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	22	82	18	34	48	57	1	1	1	1	1	1	1	1	1	1	91	176

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	--	--	2.000	2.000	1.000	1.000	1.000	1.000	1.000	1.000	2.000	1.000	3.571	2.667
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	11.000	41.000	11.111	21.235	10.116	12.667	--	--	--	--	--	--	--	--	--	--	30.451	72.150
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	11.000	41.000	11.111	21.235	10.116	12.667	2.000	2.000	1.000	1.000	1.000	1.000	1.000	1.000	2.000	1.000	33.429	74.557

CHI-SQUARE = 3.841 (d.f. =1, alpha = .05)

1) Numbers presented are a minimum estimation for test periods.

Table 019. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2.5 hrs before low tide
Duration of Test: 10 min, hmrs 3&5
Treatment Type: 10 sec on, 40 sec off
Test Date: 2/13/88
Test Time: 1127

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total[1] Raw	Total[1] WF
LS	0	0	0	0	4	5	1	1	1	1	1	1	0	0	1	0	8	8
SL	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
NC	46	172	60	113	54	65	0	0	0	0	0	0	0	0	0	0	160	350
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
Total	46	172	60	113	58	70	2	2	1	1	1	1	1	1	1	0	170	360

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total[1] Raw	Total[1] WF
LS	0	0	0	0	0	0	2	2	2	2	6	4	0	0	0	0	10	8
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	49	183	73	137	40	48	0	0	0	0	0	0	0	0	0	0	162	368
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	49	183	73	137	40	48	2	2	2	2	6	4	0	0	0	0	172	376

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	2	3	2	2	2	2	4	3	0	0	1	0	9	8
SL	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
NC	48	178	67	125	47	57	0	0	0	0	0	0	0	0	0	0	161	359
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
TOTAL	48	178	67	125	49	59	2	2	2	2	4	3	1	1	1	0	171	368

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	CHI-SQUARE VALUES FOR 2 TEST PERIODS WF
LS	--	--	--	--	4.000	5.000	0.333	0.333	0.333	0.333	3.571	1.800	--	--	1.000	--	0.222	0.000
SL	--	--	--	--	--	--	1.000	1.000	--	--	--	--	--	--	--	--	1.000	1.000
NC	0.095	0.341	1.271	2.304	2.085	2.558	--	--	--	--	--	--	--	--	--	--	0.012	0.451
WW	--	--	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--	1.000	1.000
TOTAL	0.095	0.341	1.271	2.304	3.306	4.102	0.000	0.000	0.333	0.333	3.571	1.800	1.000	1.000	1.000	--	0.012	0.348

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

1) Numbers presented are a minimum estimation for test periods.

Table D20. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs before low tide | Duration of Test: 10 min, hrs 3&5 | Treatment Type: 20 sec on, 20 sec off | Test Date: 2/13/88 | Test Time: 1147

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	82	306	188	353	102	122	0	0	0	0	0	0	0	0	0	0	372	781
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	82	306	188	353	102	122	0	0	0	0	0	0	0	0	0	0	372	781

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	56	209	174	327	98	118	0	0	0	0	0	0	0	0	0	0	328	654
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	56	209	174	327	98	118	1	1	0	0	0	0	0	0	0	0	329	655

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	69	258	181	340	100	120	0	0	0	0	0	0	0	0	0	0	350	718
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	69	258	181	340	100	120	1	1	0	0	0	0	0	0	0	0	351	718

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	--	--	1.000	1.000	--	--	--	--	--	--	--	--	1.000	1.000
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	4.899	18.270	0.541	0.994	0.080	0.067	--	--	--	--	--	--	--	--	--	--	2.766	11.240
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	4.899	18.270	0.541	0.994	0.080	0.067	1.000	1.000	--	--	--	--	--	--	--	--	2.638	11.056

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

1) Numbers presented are a minimum estimation for test periods.

Table D21. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs before low tide | Duration of Test: 10 min, hrs 3&5 | Treatment Type: 20 sec on, 30 sec off | Test Date: 2/13/88 | Test Time: 1207

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	1	0	0	0	0	2	1	1	0	4	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	81	302	203	382	184	221	0	0	0	0	0	0	0	0	0	0	468	905
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	81	302	203	382	184	221	1	1	0	0	0	0	2	1	1	0	472	907

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	2	2	3	2	0	0	1	1	0	0	6	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	90	336	231	434	175	210	0	0	0	0	0	0	0	0	0	0	496	980
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	90	336	231	434	175	210	2	2	3	2	0	0	1	1	0	0	502	985

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	2	2	2	1	0	0	2	1	1	0	5	-4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	86	319	217	408	180	216	0	0	0	0	0	0	0	0	0	0	482	943
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	86	319	217	408	180	216	2	2	2	1	0	0	2	1	1	0	487	946

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	--	--	0.333	0.333	3.000	2.000	--	--	0.333	0.000	1.000	--	0.400	1.286
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	0.474	1.812	1.806	3.314	0.226	0.281	--	--	--	--	--	--	--	--	--	--	0.813	2.984
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.474	1.812	1.806	3.314	0.226	0.281	0.333	0.333	3.000	2.000	--	--	0.333	0.000	1.000	--	0.924	3.216

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

1) Numbers presented are a minimum estimation for test periods.

Table D22. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1.5 hrs before low tide | Duration of Test: 10 min, hrs 3&5 | Treatment Type: 20 sec on, 40 sec off | Test Date: 2/13/88 | Test Time: 1227

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	2	2	1	1	1	1	0	0	0	0	4	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	102	380	281	528	216	259	0	0	0	0	0	0	0	0	0	0	599	1167
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	102	380	281	528	216	259	2	2	1	1	1	1	0	0	0	0	603	1171

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	3	3	1	1	0	0	0	0	0	0	4	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	105	392	270	508	214	257	0	0	0	0	0	0	0	0	0	0	589	1157
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	105	392	270	508	214	257	3	3	1	1	0	0	0	0	0	0	593	1161

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	3	3	1	1	1	1	0	0	0	0	4	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	104	386	276	518	215	258	0	0	0	0	0	0	0	0	0	0	594	1162
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	104	386	276	518	215	258	3	3	1	1	1	1	0	0	0	0	598	1166

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	--	--	0.200	0.200	0.000	0.000	1.000	1.000	--	--	--	--	0.000	0.000
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	0.043	0.187	0.220	0.386	0.009	0.008	--	--	--	--	--	--	--	--	--	--	0.084	0.043
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.043	0.187	0.220	0.386	0.009	0.008	0.200	0.200	0.000	0.000	1.000	1.000	--	--	--	--	0.084	0.043

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

1) Numbers presented are a minimum estimation for test periods.

Table D23. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 30 min before low tide | Duration of Test: 10 min, hrs 3&5 | Treatment Type: 30 sec on, 20 sec off | Test Date: 2/13/88 | Test Time: 1247

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	124	463	242	455	236	283	1	1	0	0	0	0	0	0	0	0	603	1202
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	124	463	242	455	236	283	1	1	0	0	1	1	0	0	0	0	604	1203

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	98	366	241	453	208	250	0	0	0	0	0	0	0	0	0	0	547	1069
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	98	366	241	453	208	250	0	0	0	0	0	0	0	0	0	0	547	1069

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	111	415	242	454	222	267	1	1	0	0	0	0	0	0	0	0	575	1136
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	111	415	242	454	222	267	1	1	0	0	1	1	0	0	0	0	576	1136

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--	--	--	1.000	1.000
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	3.045	11.350	0.002	0.004	1.766	2.043	1.000	1.000	--	--	--	--	--	--	--	--	2.727	7.789
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	3.045	11.350	0.002	0.004	1.766	2.043	1.000	1.000	--	--	1.000	1.000	--	--	--	--	2.823	7.903

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

1) Numbers presented are a minimum estimation for test periods.

Table D24. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 30 MIN before low tide
Duration of Test: 10 min, hrs 3&5
Treatment Type: 30 sec on, 20 sec off
Test Date: 2/13/88
Test Time: 1307

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	124	463	152	286	98	118	1	1	0	0	0	0	0	0	0	0	375	868
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	124	463	152	286	98	118	1	1	0	0	0	0	0	0	0	0	376	868

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total[1]	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	110	410	124	233	142	170	0	0	0	0	0	0	0	0	0	0	376	813
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	110	410	124	233	142	170	1	1	0	0	0	0	0	0	0	0	377	814

CHI-SQUARE F-HAT

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	117	437	138	260	120	144	1	1	0	0	0	0	0	0	0	0	376	841
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	117	437	138	260	120	144	1	1	0	0	0	0	0	0	0	0	376	841

CHI-SQUARE VALUES

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	--	--	1.000	1.000	--	--	--	--	--	--	--	--	1.000	1.000
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	0.838	3.218	2.841	5.412	8.067	9.389	1.000	1.000	--	--	--	--	--	--	--	--	0.001	1.800
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.838	3.218	2.841	5.412	8.067	9.389	0.000	0.000	--	--	--	--	--	--	--	--	0.005	1.734

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

1) Numbers presented are a minimum estimation for test periods.

Table D25. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 3 hrs before low tide

Duration of Test: 10 min hurs 345

Treatment Type: 10 sec on, 20 sec off

Test Date: 2/13/88

Test Time: 2330

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total[1] Raw	Total[1] WF
LS	0	0	0	0	0	0	0	0	4	3	0	0	0	0	0	0	4	3
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	82	306	144	271	180	216	72	65	0	0	0	0	0	0	0	0	478	858
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	82	306	144	271	180	216	72	65	4	3	0	0	0	0	0	0	482	861

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total[1] Raw	Total[1] WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	110	410	165	310	172	206	68	61	0	0	0	0	0	0	0	0	515	987
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	110	410	165	310	172	206	68	61	0	0	0	0	0	0	0	0	515	987

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total[1] Raw	Total[1] WF
LS	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	2	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	94	351	145	273	135	162	58	52	0	0	0	0	0	0	0	0	432	838
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	94	351	145	273	135	162	58	52	2	2	0	0	0	0	0	0	434	840

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 3 TEST PERIODS WF
LS	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	2	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	95	355	151	284	162	194	66	59	0	0	0	0	0	0	0	0	470	885
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	95	355	151	284	162	194	66	59	2	2	0	0	0	0	0	0	472	887

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 3 TEST PERIODS Raw	CHI-SQUARE VALUES FOR 3 TEST PERIODS WF
LS	--	--	--	--	--	--	--	--	4.000	1.500	--	--	--	--	--	--	4.000	1.500
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	5.158	17.330	2.861	5.401	8.117	10.515	1.576	2.508	--	--	--	--	--	--	--	--	22.617	43.076
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	5.158	17.330	2.861	5.401	8.117	10.515	1.576	2.508	4.000	1.500	--	--	--	--	--	--	22.189	41.526

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

1) Numbers presented are a minimum estimation for test periods.

Table D26. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2.5 hrs before low tide | Duration of Test: 10 min, hrs 3&5 | Treatment Type: 10 sec on, 30 sec off | Test Date: 2/13/88 | Test Time: 2350

10 MINUTES DURING TEST PERIOD

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total[1] Raw	Total[1] WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HC	93	347	156	293	191	229	45	41	0	0	0	0	0	0	0	0	485	910
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	93	347	156	293	191	229	45	41	0	0	0	0	0	0	0	0	465	910

10 MINUTES AFTER TEST PERIOD

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total[1] Raw	Total[1] WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HC	85	317	168	316	182	218	62	56	0	0	0	0	0	0	0	0	497	907
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	85	317	168	316	182	218	62	56	0	0	0	0	0	0	0	0	497	907

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HC	89	332	162	305	187	224	54	49	0	0	0	0	0	0	0	0	491	909
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	89	332	162	305	187	224	54	49	0	0	0	0	0	0	0	0	491	909

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	CHI-SQUARE VALUES FOR 2 TEST PERIODS WF
LS	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HC	0.360	1.355	0.444	0.869	0.217	0.271	2.701	2.320	--	--	--	--	--	--	--	--	0.147	0.005
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.360	1.355	0.444	0.869	0.217	0.271	2.701	2.320	--	--	--	--	--	--	--	--	0.147	0.005

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

1) Numbers presented are a minimum estimation for test periods.

Table D27. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 4 hrs before low tide — Duration of Test: 10 min. hwrs 1,2&3 — Test Date: 2/10/88
Treatment Type: 10 sec on, 20 sec off — Test Time: 0153

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	1	4	1	2	2	2	3	3	7	5	1	1	3	2	3	1	21	20
SL	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
NC	0	0	1	2	1	1	0	0	2	2	0	0	0	0	0	0	4	5
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	2	4	3	3	4	4	9	7	1	1	3	2	3	1	26	26

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	3	6	4	5	9	8	3	2	11	7	6	3	1	0	37	31
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	1	2	2	1	1	0	0	0	0	4	4
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	3	6	4	5	10	9	5	4	12	8	6	3	1	0	41	35

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	1	2	2	2	2	2	4	3	8	5	4	2	2	1	23	17
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	2	7	1	2	0	0	0	0	0	0	0	0	4	2	1	0	8	11
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	7	2	4	2	2	2	2	5	4	8	5	8	4	3	1	32	29

CHI-SQUARE F-HAT

	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	WF
LS	0	1	2	3	3	3	5	4	5	3	7	4	4	2	2	1	27	22
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
NC	1	2	1	1	0	0	0	0	1	1	0	0	1	1	0	0	5	7
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	4	2	5	3	3	5	5	6	5	7	5	6	3	2	1	33	30

CHI-SQUARE VALUES

	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 3 TEST PERIODS Raw	WF
LS	--	12.000	0.500	4.667	0.000	2.000	4.800	6.250	0.000	2.667	6.571	5.750	2.250	1.500	1.000	0.000	5.630	7.000
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.000	0.000
NC	2.000	17.500	0.000	4.000	--	--	--	--	4.000	4.000	--	--	12.000	2.000	--	--	3.200	3.143
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	2.000	5.250	1.500	-0.400	0.667	2.667	8.000	5.200	2.833	1.200	8.857	4.000	1.167	0.667	2.500	0.000	3.455	1.400

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

Table D28. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase:	3.5 hrs before low tide	Duration of Test:	10 min, hwrs 1,2&3	Test Date:	2/18/88
		Treatment Type:	10 sec on, 30 sec off	Test Time:	0215

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	4	8	9	11	13	12	4	3	30	18	3	2	2	1	65	55
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	1	2	4	5	7	6	4	3	2	1	1	1	0	0	20	22
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	5	10	13	16	20	18	8	6	32	19	4	3	2	1	85	77

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	1	4	7	13	12	14	12	11	9	7	12	7	4	2	0	0	57	58
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	0	0	2	2	2	2	2	2	2	1	1	1	1	0	11	12
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	8	7	13	14	16	14	13	11	9	14	8	5	3	1	0	68	70

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	1	2	6	11	11	13	13	12	7	5	21	13	4	2	1	1	61	57
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	1	1	3	4	5	4	3	3	2	1	1	1	1	0	16	17
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	2	6	6	12	14	16	17	16	10	8	23	14	5	3	2	1	77	74

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	1.000	4.000	0.818	1.190	0.429	0.360	0.040	0.043	1.923	1.600	7.714	4.840	0.143	0.000	2.000	1.000	0.625	0.880
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	0.000	0.000	1.000	2.000	0.667	1.286	2.778	2.000	0.667	0.200	0.000	0.000	0.000	0.000	1.000	--	2.613	2.341
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.333	1.333	0.333	0.391	0.037	0.000	1.059	0.806	0.474	0.600	7.043	4.481	0.111	0.000	0.333	1.000	1.889	0.333

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D29. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 3 hrs before low tide
Duration of Test: 10 min, hrs 1,2&3
Treatment Type: 10 sec on, 40 sec off
Test Date: 2/10/88
Test Time: 0235

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	2	4	1	1	2	2	4	3	9	5	5	3	3	1	26	19
SL	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
NC	0	0	1	2	1	1	1	1	0	0	1	1	1	1	1	0	6	6
WW	0	0	1	2	0	0	0	0	1	1	0	0	0	0	1	0	3	3
Total	0	0	4	8	2	2	4	4	5	4	10	6	6	4	5	1	36	29

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	2	4	3	4	10	9	6	5	10	6	2	1	3	1	36	30
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	2	1	1	0	0	3	2	1	1	0	0	1	0	7	6
WW	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	2	2
Total	0	0	3	6	4	5	10	9	10	8	12	8	2	1	4	1	45	38

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	0	0	2	4	2	3	6	6	5	4	10	6	4	2	3	1	31	25
SL	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
NC	0	0	1	2	1	1	1	1	2	1	1	1	1	1	1	0	7	6
WW	0	0	1	1	0	0	0	0	1	1	1	1	0	0	1	0	3	3
TOTAL	0	0	4	7	3	4	7	7	8	6	11	7	4	3	5	1	41	34

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	--	--	0.000	0.000	1.000	1.800	5.333	4.455	0.400	0.500	0.053	0.091	1.286	1.000	0.000	0.000	1.613	2.469
SL	--	--	--	--	--	--	1.000	1.000	--	--	--	--	--	--	--	--	1.000	1.000
NC	--	--	0.000	0.000	0.000	0.000	1.000	1.000	3.000	2.000	0.000	0.000	1.000	1.000	0.000	--	0.077	0.000
WW	--	--	1.000	2.000	--	--	--	--	0.000	0.000	1.000	1.000	--	--	1.000	--	0.200	0.200
TOTAL	--	--	0.143	0.286	0.667	1.286	2.571	1.923	1.667	1.333	0.182	0.286	2.000	1.800	0.111	0.000	1.000	1.209

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table 030. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 2.5 hrs before low tide | Duration of Test: 10 min, hwrs 1,2&3 | Test Date: 2/18/88
Treatment Type: 20 sec on, 20 sec off | Test Time: 0255

30 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	1	2	10	12	7	6	6	5	15	9	4	2	1	0	44	36
SL	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
NC	2	7	2	4	3	4	2	2	2	2	3	2	1	1	0	0	15	22
WB	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
Total	2	7	4	8	13	16	9	8	9	8	18	11	5	3	1	0	61	61

30 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	0	0	3	4	4	4	7	5	6	4	3	2	2	1	25	20
SL	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
NC	1	4	1	2	1	1	1	1	0	0	0	0	0	0	0	0	4	8
WB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	1	2	5	6	5	5	7	5	6	4	3	2	2	1	30	29

CHI-SQUARE F-HAT

	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	1	1	7	8	6	5	7	5	11	7	4	2	2	1	35	28
SL	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	2
NC	2	6	2	3	2	3	2	2	1	1	2	1	1	1	0	0	10	15
WB	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
TOTAL	2	6	3	5	9	11	7	7	8	7	12	8	4	3	2	1	46	45

CHI-SQUARE VALUES

	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	CHI-SQUARE VALUES FOR 2 TEST PERIODS WF
LS	--	--	1.000	2.000	3.769	4.000	0.818	0.400	0.077	0.000	3.857	1.923	0.143	0.000	0.333	1.000	5.232	4.571
SL	--	--	1.000	2.000	1.000	1.000	--	--	--	--	--	--	--	--	--	--	0.000	0.333
NC	0.333	0.818	0.333	0.667	1.000	1.800	0.333	0.333	2.000	2.000	3.000	2.000	1.000	1.000	--	--	6.368	6.533
WB	--	--	--	--	--	--	--	--	1.000	1.000	--	--	--	--	--	--	1.000	1.800
TOTAL	0.333	0.818	1.800	3.600	3.556	4.545	1.143	0.692	0.250	0.692	6.000	3.267	0.500	0.200	0.333	1.000	10.560	11.578

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D31. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs before low tide — Duration of Test: 10 min, hrs 1,2&3 — Test Date: 2/18/88
Treatment Type: 20 sec on, 30 sec off — Test Time: 0315

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	0	0	3	4	3	3	5	4	12	7	2	1	1	0	26	19
SL	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	2	2
NC	1	4	1	2	2	2	3	3	2	2	4	2	0	0	0	0	13	15
WW	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
Total	1	4	2	4	6	7	7	7	7	6	16	9	2	1	1	0	42	38

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	2	4	4	5	6	5	9	7	7	4	4	2	3	1	35	28
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	2	3	4	1	1	2	2	2	1	0	0	0	0	9	10
WW	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	2	2
Total	0	0	3	6	8	10	8	7	11	9	9	5	4	2	3	1	46	40

CHI-SQUARE F-HAT

	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	0	0	1	2	4	5	5	4	7	6	10	6	3	2	2	1	31	24
SL	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	1	1
NC	1	2	1	2	3	3	2	2	2	2	3	2	0	0	0	0	11	13
WW	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	2	2
TOTAL	1	2	3	5	7	9	8	7	9	8	13	7	3	2	2	1	44	39

CHI-SQUARE VALUES

	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF
LS	---	---	2.000	4.000	0.143	0.111	1.000	0.500	1.143	0.818
SL	---	---	---	---	1.000	1.000	1.000	1.000	---	---
NC	1.000	4.000	0.000	0.000	0.200	0.667	1.000	1.000	0.000	0.000
WW	---	---	1.000	2.000	1.000	1.000	1.000	1.000	---	---
TOTAL	1.000	4.000	0.200	0.400	0.286	0.529	0.067	0.000	0.889	0.600

	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	1.316	0.818	0.667	0.333	1.000	1.000	1.328	1.723
SL	---	---	---	---	---	---	2.000	2.000
NC	0.667	0.333	---	---	---	---	0.727	1.000
WW	---	---	---	---	---	---	0.333	0.000
TOTAL	1.960	1.143	0.667	0.333	1.000	1.000	0.182	0.951

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D32. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 30 min after high tide | Duration of Test: 10 min, hwrs 1,2&3 | Test Date: 2/10/88
Treatment Type: 20 sec on, 40 sec off | Test Time: 1155

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	0	0	1	1	0	0	0	0	1	1	0	0	3	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	2	1
NC	2	7	2	4	0	0	0	0	0	0	0	0	0	0	0	0	4	11
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	7	3	6	0	0	1	1	0	0	0	0	3	2	0	0	9	16

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	3	6	0	0	0	0	1	1	1	1	0	0	0	0	5	8
SL	1	4	0	0	0	0	0	0	1	1	0	0	0	0	0	0	2	5
NC	1	4	0	0	1	1	0	0	1	1	0	0	1	1	0	0	4	7
WW	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
Total	2	8	4	8	1	1	0	0	3	3	1	1	1	1	0	0	12	22

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	2	2	0	0	2	2	1	1	1	1	0	0	6	6
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
WW	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	2	2
Total	0	0	1	2	3	3	0	0	3	3	1	1	1	1	0	0	9	10

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	3	1	1	0	0	1	1	1	1	1	1	0	0	5	6
SL	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2
NC	1	4	1	2	0	0	0	0	0	0	0	0	0	0	0	0	3	7
WW	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	1	5	3	5	1	1	0	0	2	2	1	1	2	1	0	0	10	16

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	---	---	6.000	5.333	2.000	2.000	---	---	2.000	2.000	0.000	0.000	0.000	0.000	---	---	0.000	1.333
SL	---	12.000	---	---	---	---	---	---	---	---	---	---	2.000	---	---	---	4.000	7.800
NC	2.000	5.250	2.000	4.000	---	---	---	---	---	---	---	---	---	---	---	---	2.000	4.857
WW	---	---	---	2.000	---	---	---	---	---	---	---	---	---	---	---	---	2.000	4.000
TOTAL	4.000	7.600	0.667	4.800	6.000	6.000	---	---	3.000	3.000	0.000	0.000	0.500	2.000	---	---	0.600	4.500

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

Table D33. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1 hr after high tide

Duration of Test: 10 min, hwrs 1,2&3

Treatment Type: 30 sec on, 20 sec off

Test Date: 2/18/88

Test Time: 1215

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	2	4	0	0	0	0	0	0	0	0	0	0	0	0	2	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	2	7	1	2	2	2	0	0	1	1	0	0	1	1	1	0	8	13
WW	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	2	2
Total	2	7	3	6	2	2	0	0	2	2	0	0	2	2	1	0	12	19

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	2	7	0	0	2	2	0	0	1	1	1	1	1	1	0	0	7	12
SL	0	0	1	2	0	0	0	0	1	1	0	0	0	0	0	0	2	3
NC	1	4	2	4	1	1	0	0	0	0	0	0	0	0	0	0	4	9
WW	0	0	0	0	1	1	1	1	0	0	2	1	0	0	0	0	4	3
Total	3	11	3	6	4	4	1	1	2	2	3	2	1	1	0	0	17	27

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	1	4	1	2	1	1	0	0	1	1	1	1	1	1	0	0	5	8
SL	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	1	2
NC	2	6	2	3	2	2	0	0	1	1	0	0	1	1	1	0	6	11
WW	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	3	3
TOTAL	3	9	3	6	3	3	1	1	2	2	2	1	2	2	1	0	15	23

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	CHI-SQUARE VALUES FOR 2 TEST PERIODS WF
LS	2.000	7.000	2.000	4.000	2.000	2.000	--	--	1.000	1.000	1.000	1.000	1.000	1.000	--	--	2.778	4.800
SL	--	--	1.000	2.000	--	--	--	--	1.000	1.000	--	--	--	--	--	--	2.000	3.800
NC	0.333	0.818	0.333	0.667	0.333	0.333	--	--	1.000	1.000	--	--	1.000	1.000	1.000	--	1.333	0.727
WW	--	--	--	--	1.000	1.000	1.000	1.000	1.000	1.000	2.000	1.000	1.000	1.000	--	--	0.667	0.200
TOTAL	0.200	0.889	0.000	0.000	0.667	0.667	1.000	1.000	0.000	0.000	3.000	2.000	0.333	0.333	1.000	--	0.862	1.391

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table 034. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1.5 hrs after high tide

Duration of Test: 10 min hwrs 1,283

Treatment Type: 30 sec on, 30 sec off

Test Date: 2/18/88

Test Time: 1235

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	1	2	2	1	1	2	1	1	1	0	0	7	6
SL	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
NC	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	2	1
WW	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
Total	0	0	0	0	1	1	3	3	2	2	2	1	2	2	1	0	11	9

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	2	4	1	1	0	0	0	0	0	0	0	0	0	0	3	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	1	1	1	2	1	0	0	0	0	4	3
WW	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
Total	0	0	2	4	1	1	1	1	2	2	2	1	0	0	0	0	8	9

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	1	1	1	1	1	1	1	1	1	1	0	0	5	6
SL	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
NC	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	3	2
WW	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
TOTAL	0	0	1	2	1	1	2	2	2	2	2	1	1	1	1	0	10	9

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	2.000	4.000	0.000	0.000	2.000	2.000	1.000	1.000	2.000	1.000	1.000	1.000	--	--	1.600	0.091
SL	--	--	--	--	--	--	1.000	1.000	--	--	--	--	--	--	--	--	1.600	1.000
NC	--	--	--	--	--	--	1.000	1.000	1.000	1.000	2.000	1.000	1.000	1.000	1.000	--	0.667	1.000
WW	--	--	--	--	--	--	--	--	0.000	0.000	--	--	--	--	--	--	0.000	0.000
TOTAL	--	--	2.000	4.000	0.000	0.000	1.000	1.000	0.000	0.000	0.000	0.000	2.000	2.000	1.000	--	0.474	0.000

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D35. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1.5 hrs before low tide   Duration of Test: 10 min, hwrs 3&5   Test Date: 2/10/88
Treatment Type: 10 sec on, 30 sec off   Test Time: 1620

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	6	7	1	1	4	3	5	3	1	1	2	1	20	18
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	2	1	1	4	4	0	0	2	1	0	0	0	0	8	8
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	2	4	7	8	5	5	4	3	7	4	1	1	2	1	28	26

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	1	6	5	5	4	2	1	2	1	2	1	18	13
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	2	7	1	2	0	0	1	1	0	0	0	0	0	0	0	0	4	10
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	7	1	2	1	1	7	6	6	5	2	1	2	1	2	1	23	24

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	2	2	3	3	1	1	3	2	4	2	2	1	16	13
SL	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
NC	0	0	0	0	1	1	0	0	0	0	0	0	1	1	1	0	3	2
WW	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	2	2
Total	0	0	1	2	4	4	3	3	2	2	4	3	5	3	3	1	22	18

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	1	3	3	3	3	3	3	3	2	2	1	2	1	18	15
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
NC	1	2	1	1	1	1	2	2	0	0	1	0	0	0	0	0	5	7
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	1	2	1	3	4	4	5	5	4	3	4	3	3	2	2	1	24	22

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	0.000	4.000	4.667	0.000	5.333	2.667	4.000	0.667	2.667	1.000	3.500	2.000	0.000	0.000	0.444	0.133
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.000	0.000
NC	2.000	17.500	0.000	4.000	0.000	0.000	3.500	3.500	--	--	2.000	ERR	--	--	--	--	2.800	4.000
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.000	2.000
TOTAL	2.000	17.500	2.000	0.000	4.500	7.250	1.600	0.000	2.000	2.667	4.250	0.667	2.000	0.500	1.500	0.000	1.875	3.636

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

Table D36. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1.5 hrs before low tide | Duration of Test: 10 min, hwrs 3&5 | Test Date: 2/18/88
Treatment Type: 10 sec on, 30 sec off | Test Time: 1640

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	1	2	1	1	3	3	2	2	1	1	2	1	2	1	12	11
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
WW	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
Total	0	0	1	2	1	1	4	4	2	2	2	2	2	1	2	1	14	13

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	0	0	3	4	6	5	4	3	3	2	3	2	3	1	22	17
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
NC	0	0	1	2	0	0	0	0	1	1	0	0	1	1	0	0	3	4
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	2	3	4	6	5	5	4	4	3	4	3	3	1	26	22

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	0	0	1	1	2	3	5	4	3	3	2	2	3	2	3	1	17	14
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
NC	0	0	1	1	0	0	0	0	1	1	1	1	1	1	0	0	2	3
WW	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
TOTAL	0	0	1	2	2	3	5	5	4	3	3	3	3	2	3	1	20	19

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	--	--	1.000	2.000	1.000	1.800	1.000	0.500	0.667	0.200	1.000	0.333	0.200	0.333	0.200	0.000	2.941	1.286
SL	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--	--	--	1.000	1.800
NC	--	--	1.000	2.000	--	--	--	--	1.000	1.000	1.000	1.000	1.000	1.000	--	--	1.000	1.800
WW	--	--	--	--	--	--	1.000	1.000	--	--	--	--	--	--	--	--	1.000	1.800
TOTAL	--	--	0.000	0.000	1.000	1.800	0.400	0.111	1.286	0.667	0.667	0.200	0.667	1.000	0.200	0.000	3.600	2.314

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D37. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1 hr before low tide	Duration of Test: 10 min, hwrs 3&5	Treatment Type: 10 sec on, 40 sec off	Test Date: 2/18/88 Test Time: 1700

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	3	6	2	2	8	7	2	2	5	3	1	1	1	0	22	21
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
NC	0	0	2	4	1	1	0	0	0	0	0	0	0	0	0	0	3	5
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	5	10	3	3	8	7	2	2	6	4	1	1	1	0	26	27

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	3	6	1	1	1	1	2	2	4	2	0	0	2	1	13	13
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	1	0	0	1	1	0	0	3	1	5	3
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
Total	0	0	3	6	1	1	2	2	2	2	5	3	1	1	5	2	19	17

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	0	0	3	6	2	2	5	4	2	2	5	3	1	1	2	1	18	17
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
NC	0	0	1	2	1	1	1	1	0	0	1	1	0	0	2	1	4	4
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
TOTAL	0	0	4	8	2	2	5	5	2	2	6	4	1	1	3	1	23	22

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	--	--	0.000	0.000	0.333	0.333	5.444	4.500	0.000	0.000	0.111	0.200	1.000	1.000	0.333	1.000	2.314	1.882
SL	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--	--	--	1.000	1.000
NC	--	--	2.000	4.000	1.000	1.000	1.000	1.000	--	--	1.000	1.000	--	--	3.000	1.000	0.500	0.500
WW	--	--	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--	1.000	1.000
TOTAL	--	--	0.500	1.000	1.000	1.000	3.600	2.778	0.000	0.000	0.091	0.143	0.000	0.000	2.667	2.000	1.089	2.273

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D38. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 3 hrs before high tide | Duration of Test: 10 min. hmrs 3& 5 | Treatment Type: 10 sec on, 20 sec off | Test Date: 2/18/88 | Test Time: 2045

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	2	7	1	2	0	0	0	0	1	1	3	2	1	1	2	1	10	14
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	7	1	2	0	0	0	0	1	1	4	3	1	1	2	1	11	15

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	2	2	1	1	0	0	0	0	0	0	3	3
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
WW	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
Total	1	4	0	0	0	0	2	2	1	1	1	1	0	0	0	0	5	8

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	2	7	0	0	0	0	0	0	1	1	1	1	0	0	0	0	4	9
WW	0	0	2	4	1	1	0	0	0	0	0	0	0	0	0	0	3	5
Total	2	7	2	4	1	1	0	0	1	1	1	1	0	0	0	0	7	14

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	WF
LS	1	2	0	1	0	0	1	1	1	1	1	1	0	0	1	0	4	6
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2	5
WW	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	2
TOTAL	2	6	1	2	0	0	1	1	1	1	2	2	0	0	1	0	8	12

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 3 TEST PERIODS Raw	WF
LS	2.000	17.500	--	2.000	--	--	2.000	2.000	0.000	0.000	6.000	2.000	--	--	2.000	--	14.250	17.167
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	2.000	5.250	--	--	--	--	--	--	--	--	0.000	0.000	--	--	--	--	3.000	5.100
WW	--	--	2.000	12.000	--	--	--	--	--	--	--	--	--	--	--	--	6.000	7.800
TOTAL	-0.500	1.000	2.000	4.000	--	--	2.000	2.000	0.000	0.000	3.000	0.500	--	--	2.000	--	1.375	3.417

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

Table D39. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2.5 hrs before high tide | Duration of Test: 10 min, hmrs 3&5 | Treatment Type: 10 sec on, 30 sec off | Test Date: 2/10/88 | Test Time: 2115

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	2	4	1	1	1	1	0	0	0	0	0	0	0	0	4	6
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	3	6	1	1	1	1	0	0	0	0	0	0	0	0	5	8

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	1	1	2	2	0	0	0	0	2	1	0	0	6	6
SL	0	0	1	2	0	0	1	1	0	0	0	0	0	0	0	0	2	3
NC	0	0	0	0	2	2	0	0	1	1	1	1	0	0	0	0	4	4
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	2	4	3	3	3	3	1	1	1	1	2	1	0	0	12	13

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	1	1	1	1	0	0	0	0	1	1	0	0	4	4
SL	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	1	2
NC	0	0	1	2	2	2	1	1	1	1	1	1	0	0	0	0	4	5
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	3	5	2	2	2	2	1	1	1	1	1	1	0	0	9	11

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	0.000	0.000	1.000	1.000	2.000	2.000	--	--	--	--	2.000	1.000	--	--	3.571	2.800
SL	--	--	1.000	2.000	--	--	1.000	1.000	--	--	--	--	--	--	--	--	2.000	3.800
NC	--	--	2.000	4.000	0.333	0.333	1.000	1.000	1.000	1.000	1.000	1.000	--	--	--	--	0.000	0.400
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	--	--	0.200	0.400	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	2.000	1.000	--	--	2.882	1.190

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D40. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1 hr before high tide   Duration of Test: 10 min, hwrs 3&5   Treatment Type: 10 sec on, 20 sec off   Test Date: 2/18/88   Test Time: 2225

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	1	4	0	0	3	4	1	1	0	0	0	0	0	0	0	0	5	9
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	2	2
WW	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Total	1	4	0	0	5	6	1	1	1	1	0	0	0	0	0	0	8	12

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	0	0	1	1	0	0	1	1	0	0	1	1	0	0	3	3
SL	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
NC	1	4	2	4	0	0	1	1	0	0	1	1	0	0	0	0	5	10
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	2	4	2	2	1	1	1	1	1	1	1	1	0	0	9	14

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	3	11	0	0	1	1	1	1	0	0	0	0	0	0	0	0	5	13
WW	0	0	1	2	0	0	1	1	0	0	0	0	0	0	0	0	2	3
Total	3	11	1	2	1	1	2	2	0	0	0	0	0	0	0	0	7	16

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	WF
LS	0	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	3	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	5	1	1	1	1	1	1	0	0	0	0	0	0	0	0	4	8
WW	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	2	6	1	2	3	3	1	1	1	1	0	0	0	0	0	0	8	14

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 3 TEST PERIODS Raw	WF
LS	ERR	12.000	ERR	ERR	6.000	3.500	--	--	--	--	--	--	--	--	--	--	3.333	10.500
SL	ERR	ERR	ERR	ERR	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	6.000	12.400	2.000	12.000	0.000	0.000	0.000	0.000	--	--	--	--	--	--	--	--	1.500	9.125
WW	ERR	ERR	ERR	2.000	--	--	--	--	--	--	--	--	--	--	--	--	2.000	6.000
TOTAL	0.500	6.500	2.000	4.000	2.000	4.667	2.000	2.000	0.000	0.000	--	--	--	--	--	--	0.250	0.571

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

Table B41. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 30 min before high tide | Duration of Test: 10 min, hrs 3&5 | Treatment Type: 10 sec on, 30 sec off | Test Date: 2/10/88 | Test Time: 2245

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	2	2	1	1	0	0	0	0	0	0	3	3
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	1	4	1	2	1	1	0	0	0	0	0	0	0	0	0	0	3	7
WW	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
Total	1	4	2	4	1	1	2	2	2	2	0	0	0	0	0	0	8	13

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	0	0	1	1	0	0	2	2	1	1	0	0	0	0	4	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	2	0	0	0	0	1	1	0	0	0	0	0	0	2	3
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	2	1	1	0	0	3	3	1	1	0	0	0	0	6	7

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	0	0	0	0	1	1	1	1	2	2	1	1	0	0	0	0	4	4
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	1	2	1	2	1	1	0	0	1	1	0	0	0	0	0	0	3	5
WW	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	1	2	2	3	1	1	1	1	3	3	1	1	0	0	0	0	7	10

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	--	--	--	--	1.000	1.000	2.000	2.000	0.333	0.333	1.000	1.000	--	--	--	--	0.143	0.143
SL	--	--	--	--	--	--	--	--	1.000	1.000	--	--	--	--	--	--	1.000	1.800
NC	1.000	4.000	0.000	0.000	1.000	1.000	--	--	1.000	1.000	--	--	--	--	--	--	0.200	1.600
WW	--	--	1.000	2.000	--	--	--	--	--	--	--	--	--	--	--	--	1.000	2.800
TOTAL	1.000	4.000	0.333	0.667	0.000	0.000	2.000	2.000	0.200	0.200	1.000	1.000	--	--	--	--	0.286	1.800

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D42. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 30 min before high tide | Duration of Test: 10 min, hrs 3&5 | Test Date: 2/10/88
Treatment Type: 10 sec on, 40 sec off | Test Time: 2305

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	0	0	0	0	1	1	1	1	0	0	0	0	3	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	2	1	1	0	0	0	0	0	0	0	0	0	0	2	3
WN	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	2	2
Total	0	0	2	4	3	3	0	0	1	1	1	1	0	0	0	0	7	9

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	1	0	0	0	0	1	1	1	1	0	0	0	0	2	3
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	2
WN	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	0	0	1	2	2	2	0	0	1	1	1	1	0	0	0	0	4	5

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	1.000	2.000	--	--	--	--	0.000	0.000	1.000	1.000	--	--	--	--	1.000	1.800
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	1.000	2.000	1.000	1.000	--	--	--	--	--	--	--	--	--	--	2.000	3.000
WN	--	--	--	--	2.000	2.000	--	--	--	--	--	--	--	--	--	--	2.000	2.000
TOTAL	--	--	2.000	4.000	3.000	3.000	--	--	0.000	0.000	1.000	1.000	--	--	--	--	4.500	6.400

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D43. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1 hr after high tide
Duration of Test: 10 min, hrs 3&5
Treatment Type: 20 sec on, 20 sec off
Test Date: 2/18/88
Test Time: 2345

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
WW	0	0	2	4	0	0	0	0	0	0	0	0	0	0	0	0	2	4
Total	0	0	3	6	0	0	0	0	0	0	1	1	0	0	0	0	4	7

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	1	4	0	0	0	0	1	1	1	1	0	0	1	1	0	0	4	7
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	1	4	1	2	0	0	0	0	1	1	2	1	0	0	0	0	5	8
WW	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
Total	2	8	2	4	0	0	1	1	3	3	2	1	1	1	0	0	11	18

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	1	2	1	1	0	0	1	1	1	1	0	0	1	1	0	0	3	5
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	1	2	1	1	0	0	0	0	1	1	2	1	0	0	0	0	3	5
WW	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	2	3
TOTAL	1	4	3	5	0	0	1	1	2	2	2	1	1	1	0	0	8	13

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	1.000	4.000	1.000	2.000	—	—	1.000	1.000	1.000	1.000	—	—	1.000	1.000	—	—	1.800	2.778
SL	—	—	—	—	—	—	—	—	1.000	1.000	—	—	—	—	—	—	1.000	1.000
NC	1.000	4.000	1.000	2.000	—	—	—	—	1.000	1.000	0.333	0.000	—	—	—	—	2.667	5.444
WW	—	—	0.333	0.667	—	—	—	—	—	—	—	—	—	—	—	—	0.333	0.667
TOTAL	2.000	8.000	0.200	0.400	—	—	1.000	1.000	3.000	3.000	0.333	0.000	1.000	1.000	—	—	3.267	4.840

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D44. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1 hr after high tide — Duration of Test: 10 min, hrs 1,2&3 — Test Date: 2/19/88
Treatment Type: 20 sec on, 30 sec off — Test Time: 0035

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
NC	2	7	1	2	0	0	0	0	0	0	1	1	0	0	0	0	4	10
WW	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Total	2	7	1	2	1	1	1	1	0	0	1	1	0	0	0	0	6	12

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	2	7	1	2	0	0	2	2	0	0	1	1	0	0	0	0	6	12
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	2	7	2	4	0	0	0	0	1	1	0	0	0	0	0	0	5	12
WW	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
Total	4	14	4	8	0	0	2	2	2	2	1	1	0	0	0	0	13	27

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	1	1	1	0	0	0	0	1	1	0	0	3	3
SL	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	2	1
NC	2	7	1	2	1	1	0	0	1	1	0	0	1	1	0	0	6	12
WW	0	0	1	2	0	0	0	0	1	1	0	0	0	0	0	0	2	3
Total	2	7	2	4	2	2	1	1	2	2	0	0	4	3	0	0	13	19

CHI-SQUARE F-HAT

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	2	0	1	0	0	1	1	0	0	0	0	0	0	0	0	3	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1
NC	2	7	1	3	0	0	0	0	1	1	0	0	0	0	0	0	5	11
WW	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	2
TOTAL	3	9	2	5	1	1	1	1	1	1	1	1	1	1	0	0	11	19

CHI-SQUARE VALUES

	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	2.000	17.500	--	2.000	--	--	2.000	2.000	--	--	--	--	--	--	--	--	6.000	15.600
SL	--	--	--	--	--	--	--	--	--	--	--	--	2.000	--	--	--	2.000	0.000
NC	0.000	0.000	2.000	0.000	--	--	--	--	0.000	0.000	--	--	--	--	--	--	0.400	1.273
WW	--	--	0.000	4.000	--	--	--	--	--	--	--	--	--	--	--	--	2.000	1.000
TOTAL	0.000	4.667	3.500	2.800	2.000	2.000	2.000	2.000	4.000	4.000	0.000	0.000	12.000	6.000	--	--	2.000	6.947

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

Table D45. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs after high tide | Duration of Test: 10 min, hhrs 1,2&3 | Test Date: 2/19/88
Treatment Type: 30 sec on, 20 sec off | Test Time: 0125

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	1	0	0	2	2	2	1	0	0	0	0	5	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	2	2	1	1	1	1	0	0	2	1	6	5
WW	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0
Total	0	0	0	0	1	1	2	2	3	3	3	2	0	0	2	1	11	9

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	2	2	0	0	1	1	1	1	0	0	0	0	4	4
SL	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
NC	1	4	0	0	0	0	1	1	0	0	0	0	0	0	0	0	2	5
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	1	2	2	2	1	1	1	1	1	1	0	0	0	0	7	11

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	2	4	2	2	0	0	0	0	0	0	1	1	0	0	6	11
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	2	4	2	2	0	0	0	0	0	0	1	1	0	0	6	11

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	1	0	0	1	1	1	1	0	0	0	0	3	3
SL	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
NC	1	3	1	1	1	1	1	1	0	0	0	0	0	0	1	0	5	7
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	3	1	2	2	2	1	1	1	1	1	1	0	0	1	0	8	10

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	2.000	2.000	--	--	2.000	2.000	2.000	0.000	--	--	--	--	4.667	2.667
SL	--	--	--	2.000	--	--	--	--	--	--	--	--	--	--	--	--	--	2.000
NC	0.000	2.667	2.000	12.000	2.000	2.000	2.000	2.000	--	--	--	--	--	--	2.000	--	1.200	1.429
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.000	2.667	2.000	4.000	-0.500	-0.500	2.000	2.000	6.000	6.000	6.000	2.000	--	--	2.000	--	1.750	1.300

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

Table D46. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 3 hrs before low tide | Duration of Test: 10 min, hrs 1,2&3 | Test Date: 2/19/88
Treatment Type: 30 sec on, 03 sec off | Test Time: 0335

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	0	0	3	4	9	8	5	4	18	11	5	3	2	1	42	31
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	2	4	1	1	0	0	0	0	2	1	0	0	0	0	5	6
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	2	4	4	5	9	8	5	4	20	12	5	3	2	1	47	37

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	3	6	3	4	6	5	8	6	12	7	3	2	5	2	40	32
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	1	1	1	4	2	0	0	0	0	6	4
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	3	6	3	4	7	6	9	7	16	9	3	2	5	2	46	36

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	1	4	1	2	7	8	7	6	4	3	13	8	4	2	3	1	40	34
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	3	6	2	2	0	0	0	0	1	1	0	0	0	0	6	9
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	4	8	9	10	7	6	4	3	14	9	4	2	3	1	46	43

CHI-SQUARE F-HAT (last two columns: CHI-SQUARE F-HAT FOR 3 TEST PERIODS)

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Raw	WF
LS	0	1	1	3	4	5	7	6	6	4	14	9	4	2	3	1	40	32
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	2	3	1	1	0	0	0	0	2	1	0	0	0	0	6	6
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	1	3	6	5	6	8	7	6	5	17	10	4	2	3	1	46	38

CHI-SQUARE VALUES (last two columns: CHI-SQUARE VALUES FOR 3 TEST PERIODS)

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Raw	WF
LS	—	12.000	6.000	5.333	3.750	3.200	1.714	1.833	0.500	2.250	2.500	0.000	0.500	1.500	2.667	2.000	2.100	1.156
SL	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
NC	—	—	1.500	7.333	2.000	2.000	—	—	—	—	3.500	2.000	—	—	—	—	-0.833	3.167
WW	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL	—	12.000	0.667	1.333	5.200	4.500	-0.625	-0.571	2.333	0.800	0.118	0.600	0.500	1.500	2.667	2.000	1.022	2.789

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

Table D47. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 3S.

Tidal Phase: 3.5 hrs before low tide   Duration of Test: 10 min, hwrs 1,2&3   Test Date: 2/19/88
Treatment Type: 30 sec on, 40 sec off   Test Time: 0355

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	4	8	5	6	9	8	2	2	16	10	0	0	3	1	39	35
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	2	2	0	0	2	2	0	0	1	1	0	0	5	5
WW	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
Total	1	4	4	8	7	8	9	8	4	4	16	10	1	1	3	1	45	44

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	1	4	3	6	6	7	5	5	8	6	9	5	4	2	3	1	39	36
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	2	1	1	1	1	2	2	2	1	0	0	0	0	7	7
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	4	8	7	8	6	6	10	8	11	6	4	2	3	1	46	43

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	1	2	4	7	6	7	7	7	5	4	13	8	2	1	3	1	39	36
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	1	2	2	1	1	2	2	1	1	1	1	0	0	6	6
WW	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
TOTAL	1	4	4	8	7	6	8	7	7	6	14	8	3	2	3	1	46	44

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	1.000	4.000	0.143	0.286	0.091	0.077	1.143	0.692	3.600	2.000	1.960	1.667	4.000	2.000	0.000	0.000	0.000	0.014
SL	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
NC	---	---	1.000	2.000	0.333	0.333	1.000	1.000	0.000	0.000	2.000	1.000	1.000	1.000	---	---	0.333	0.333
WW	1.000	4.000	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1.000	4.000
TOTAL	0.000	0.000	0.000	0.000	0.000	0.000	0.600	0.286	2.571	1.333	0.926	1.000	1.800	0.333	0.000	0.000	0.011	0.011

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D48. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2.5 hrs before low tide	Duration of Test: 10 min, hrs 1,2&3	Treatment Type: 30 sec on, 20 sec off	Test Date: 2/19/88 Test Time: 0415

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	5	9	3	4	7	6	16	12	23	14	7	4	2	1	63	50
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	2	2	3	3	1	1	3	2	0	0	0	0	9	8
WW	0	0	1	2	0	0	0	0		0	0	0	0	0	0	0	1	2
Total	0	0	6	11	5	6	10	9	17	13	26	16	7	4	2	1	73	60

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	4	8	10	12	11	10	15	11	12	7	7	4	10	5	69	57
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	2	1	1	1	1	1	1	0	0	0	0	0	0	4	5
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	5	10	11	13	12	11	16	12	12	7	7	4	10	5	73	62

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	0	0	5	9	7	8	9	8	16	12	18	11	7	4	6	3	66	54
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	1	2	2	2	2	1	1	2	1	0	0	0	0	7	7
WW	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	0	0	6	11	8	10	11	10	17	13	19	12	7	4	6	3	73	61

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	--	--	0.111	0.059	3.769	4.000	0.889	1.000	0.032	0.043	3.457	2.333	0.000	0.000	5.333	2.667	0.273	0.458
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	1.000	2.000	0.333	0.333	1.000	1.000	0.000	0.000	3.000	2.000	--	--	--	--	1.923	0.692
WW	--	--	1.000	2.000	--	--	--	--	--	--	--	--	--	--	--	--	1.000	2.000
TOTAL	--	--	0.091	0.048	2.250	2.579	0.182	0.200	0.030	0.040	5.158	3.522	0.000	0.000	5.333	2.667	0.000	0.033

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D49. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs before low tide | Duration of Test: 10 min, hmr 1,2&3 | Test Date: 2/19/88
Treatment Type: 30 sec on, 30 sec off | Test Time: 0435

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	1	4	4	8	4	5	5	5	10	8	5	3	6	3	6	3	41	39
SL	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
NC	2	7	1	2	1	1	2	2	1	1	0	0	1	1	1	0	9	14
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	4	15	5	10	5	6	7	7	11	9	5	3	7	4	7	3	51	57

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	5	9	5	6	8	7	3	2	2	1	3	2	3	1	29	28
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	2	7	2	4	0	0	0	0	3	2	0	0	0	0	0	0	7	13
WW	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Total	2	7	7	13	6	7	8	7	6	4	2	1	3	2	3	1	37	42

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	1	2	5	9	5	6	7	6	7	5	4	2	5	3	5	2	35	34
SL	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
NC	2	7	2	3	1	1	1	1	2	2	0	0	1	1	1	0	8	14
WW	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	3	11	6	12	6	7	8	7	9	7	4	2	5	3	5	2	44	50

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	1.000	4.000	0.111	0.059	0.111	0.091	0.692	0.333	3.769	3.600	1.286	1.000	1.000	0.200	1.000	1.000	2.057	1.806
SL	1.000	4.000	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1.000	4.000
NC	0.000	0.000	0.333	0.667	1.000	1.000	2.000	2.000	1.000	0.333	---	---	1.000	1.000	1.000	ERR	0.250	0.037
WW	---	---	---	---	1.000	1.000	---	---	---	---	---	---	---	---	---	---	1.000	1.000
TOTAL	0.667	2.909	0.333	0.391	0.091	0.077	0.067	0.000	1.471	1.923	1.286	1.000	1.600	0.667	1.600	1.000	2.227	2.273

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D50. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 30 min after high tide | Duration of Test: 10 min, hwrs 1,2&3 | Treatment Type: 10 sec on, 20 sec off | Test Date: 2/19/88 | Test Time: 1235

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	0	0	1	1	1	1	1	1	0	0	1	1	0	0	4	4
SL	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
NC	1	4	0	0	1	1	0	0	0	0	1	1	0	0	0	0	3	6
WW	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
Total	2	8	1	2	2	2	1	1	1	1	1	1	1	1	0	0	9	16

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	2	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	1	2	0	0	0	0	0	0	1	1	0	0	0	0	3	7
WW	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	2	2
Total	1	4	1	2	1	1	1	1	1	1	2	2	0	0	0	0	7	11

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	0	0	1	1	1	1	0	0	1	1	0	0	0	0	3	3
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	1	2	0	0	1	1	0	0	0	0	0	0	0	0	3	7
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	1	2	1	1	2	2	0	0	1	1	0	0	0	0	6	10

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	WF
LS	0	0	0	0	1	1	1	1	0	0	1	1	0	0	0	0	3	3
SL	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
NC	1	4	1	1	0	0	0	0	0	0	1	1	0	0	0	0	3	7
WW	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
TOTAL	1	5	1	2	1	1	1	1	1	1	1	1	0	0	0	0	7	12

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 3 TEST PERIODS Raw	WF
LS	---	---	---	---	0.000	0.000	0.000	0.000	---	---	0.000	0.000	---	---	---	---	0.667	1.667
SL	---	---	---	2.000	---	---	---	---	---	---	---	---	---	---	---	---	---	1.000
NC	0.000	0.000	0.000	4.000	---	---	---	---	---	---	0.000	0.000	---	---	---	---	0.000	-1.857
WW	---	12.000	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2.000	4.000
TOTAL	2.000	3.200	0.000	0.000	2.000	2.000	2.000	2.000	0.000	0.000	2.000	2.000	---	---	---	---	1.714	1.750

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

Table DS1. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1 hr after high tide | Duration of Test: 10 min, hrs 1,2&3 | Treatment Type: 10 sec on, 30 sec off | Test Date: 2/19/88 | Test Time: 1255

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	2	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	2	7	0	0	1	1	1	1	0	0	0	0	0	0	0	0	4	9
WW	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Total	2	7	0	0	3	3	1	1	1	1	0	0	0	0	0	0	7	12

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	1	1	0	0	0	0	0	0	1	1	0	0	3	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
WW	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
Total	1	4	2	4	1	1	0	0	0	0	0	0	1	1	0	0	5	10

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	1	1	1	0	0	1	1	0	0	1	1	0	0	3	3
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	2	6	0	0	1	1	1	1	0	0	0	0	0	0	0	0	3	7
WW	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	2
TOTAL	2	6	1	2	2	2	1	1	1	1	0	0	1	1	0	0	6	11

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	1.000	2.000	0.000	0.000	--	--	1.000	1.000	--	--	1.000	1.000	--	--	0.200	0.667
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	0.333	0.818	--	--	1.000	1.000	1.000	1.000	--	--	--	--	--	--	--	--	1.800	1.923
WW	--	--	1.000	2.000	1.000	1.000	--	--	--	--	--	--	--	--	--	--	0.000	0.333
TOTAL	0.333	0.818	2.000	4.000	1.000	1.000	1.000	1.000	1.000	1.000	--	--	1.000	1.000	--	--	0.333	0.182

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D52. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1 hr after high tide — Duration of Test: 10 min, hrs 1,2&3 — Treatment Type: 10 sec on, 40 sec off — Test Date: 2/19/88 — Test Time: 1315

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MC	1	4	1	2	2	2	0	0	0	0	1	1	0	0	0	0	5	9
WW	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	2	2
Total	1	4	1	2	3	3	1	1	0	0	1	1	1	1	0	0	8	12

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	1	2	0	0	3	3	0	0	0	0	1	1	0	0	5	6
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MC	0	0	1	2	1	1	0	0	0	0	0	0	0	0	0	0	2	3
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	2	4	1	1	3	3	0	0	0	0	1	1	0	0	7	9

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	1	1	0	0	2	2	0	0	0	0	1	1	0	0	3	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MC	1	2	1	2	2	2	0	0	0	0	1	1	0	0	0	0	4	6
WW	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	1	1
TOTAL	1	2	2	3	2	2	2	2	0	0	1	1	1	1	0	0	8	11

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	CHI-SQUARE VALUES FOR 2 TEST PERIODS WF
LS	--	--	1.000	2.000	--	--	1.000	1.000	--	--	--	--	1.000	1.000	--	--	2.667	3.571
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MC	1.000	4.000	0.000	0.000	0.333	0.333	--	--	--	--	1.000	1.000	--	--	--	--	1.286	3.000
WW	--	--	--	--	1.000	1.000	--	--	--	--	--	--	1.000	1.000	--	--	2.000	2.000
TOTAL	1.000	4.000	0.333	0.667	1.000	1.000	1.000	1.000	--	--	1.000	1.000	0.000	0.000	--	--	0.067	6.429

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D53. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase:	1.5 hrs before high tide	Duration of Test:	10 min, hwrs 1,2&3	Test Date:	2/19/88
		Treatment Type:	20 sec on, 20 sec off	Test Time:	1335

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	4	2	4	0	0	2	2	1	1	0	0	0	0	0	0	6	11
SL	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
NC	1	4	0	0	2	2	1	1	0	0	1	1	1	1	0	0	6	9
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	8	2	4	2	2	3	3	1	1	1	1	2	2	0	0	13	21

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
SL	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
NC	0	0	0	0	0	0	1	1	0	0	2	1	1	1	0	0	4	3
WW	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
Total	0	0	0	0	0	0	3	3	1	1	2	1	1	1	0	0	7	6

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	2	1	2	0	0	2	2	1	1	0	0	0	0	0	0	4	6
SL	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	1	1
NC	1	2	0	0	1	1	1	1	0	0	2	1	1	1	0	0	5	6
WW	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
TOTAL	1	4	1	2	1	1	3	3	1	1	2	1	2	2	0	0	10	14

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1.000	4.000	2.000	4.000	--	--	0.333	0.333	1.000	1.000	--	--	--	--	--	--	3.571	4.333
SL	--	--	--	--	--	--	1.000	1.000	--	--	--	--	1.000	1.000	--	--	0.000	0.000
NC	1.000	4.000	--	--	2.000	2.000	0.000	0.000	--	--	0.333	0.000	0.000	0.000	--	--	0.400	3.000
WW	--	--	--	--	--	--	--	--	1.000	1.000	--	--	--	--	--	--	1.000	1.000
TOTAL	2.000	8.000	2.000	4.000	2.000	2.000	0.000	0.000	0.000	0.000	0.333	0.000	0.333	0.333	--	--	1.800	4.333

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D64. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1 hr after high tide | Duration of Test: 10 min, hrs 1,2&3 | Test Date: 2/19/88
Treatment Type: 20 sec on, 30 sec off | Test Time: 1355

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	2	7	1	2	0	0	0	0	0	0	2	1	0	0	1	0	6	10
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	4
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	3	11	1	2	0	0	0	0	0	0	2	1	0	0	2	0	8	14

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	0	0	1	1	0	0	0	0	1	1	1	0	4	4
SL	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
NC	1	4	0	0	0	0	1	1	0	0	0	0	0	0	0	0	2	5
WW	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Total	2	8	1	2	1	1	2	2	0	0	0	0	1	1	1	0	8	14

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	4	1	2	0	0	1	1	0	0	1	1	1	1	1	0	5	7
SL	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
NC	1	4	0	0	0	0	1	1	0	0	0	0	0	0	1	0	2	5
WW	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	3	10	1	2	1	1	1	1	0	0	1	1	1	1	2	0	8	14

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	2.000	7.000	0.000	0.000	--	--	1.000	1.000	--	--	2.000	1.000	1.000	1.000	0.000	--	0.400	2.571
SL	1.000	4.000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.000	4.000
NC	0.000	0.000	--	--	--	--	1.000	1.000	--	--	--	--	--	--	1.000	--	0.000	0.111
WW	--	--	--	--	1.000	1.000	--	--	--	--	--	--	--	--	--	--	1.000	1.000
TOTAL	0.200	0.474	0.000	0.000	1.000	1.000	2.000	2.000	--	--	2.000	1.000	1.000	1.000	0.333	--	0.000	0.000

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D55. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs after high tide | Duration of Test: 10 min, hmrs 1,2&3 | Test Date: 2/19/88
Treatment Type: 20 sec on, 40 sec off | Test Time: 1415

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	2	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	2	2

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	1	1	2	1	1	0	4	2
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	0	0	0	0	0	0	1	1	1	1	2	1	1	0	6	7

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	1	0	0	1	1	2	1	1	0	3	2
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	2	0	0	0	0	1	1	1	1	1	1	2	1	1	0	4	5

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	--	--	1.000	1.000	--	--	1.000	1.000	0.333	0.000	1.000	--	0.667	[illegible].000
SL	--	--	--	--	--	--	--	--	1.000	1.000	--	--	--	--	--	--	1.000	1.000
NC	1.000	4.000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.000	4.000
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	1.000	4.000	--	--	--	--	1.000	1.000	1.000	1.000	1.000	1.000	0.333	0.000	1.000	--	2.000	2.778

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D56. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: At high tide

Duration of Test: 10 min, hwr 3 only
Treatment Type: 20 sec on, 20 sec off
Test Date: 2/20/88
Test Time: 0015

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LE	0	0	0	0	2	2	1	1	1	1	1	1	1	1	0	0	6	6
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	3	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	11
WL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	3	11	0	0	2	2	1	1	1	1	1	1	1	1	0	0	9	17

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LE	1	4	0	0	1	1	0	0	1	1	1	1	1	1	0	0	5	8
SL	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	2	2
NC	1	4	0	0	0	0	1	1	0	0	0	0	0	0	0	0	2	5
WL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	8	0	0	2	2	2	2	1	1	1	1	1	1	0	0	9	15

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LE	0	0	2	4	0	0	1	1	2	2	1	1	0	0	0	0	6	8
SL	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
NC	1	4	0	0	0	0	0	0	0	0	2	1	0	0	0	0	3	5
WL	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Total	1	4	3	6	1	1	1	1	2	2	3	2	0	0	0	0	11	16

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	WF
LE	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	6	7
SL	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
NC	2	6	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	7
WL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	2	8	1	2	2	2	1	1	1	1	2	1	1	1	0	0	10	16

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 3 TEST PERIODS Raw	WF
LE	--	12.000	2.000	12.000	2.000	2.000	0.000	0.000	2.000	2.000	0.000	0.000	0.000	0.000	--	--	-0.833	1.429
SL	--	--	--	2.000	--	--	--	--	--	--	--	--	--	--	--	--	2.000	4.000
NC	0.500	6.500	--	--	--	--	--	--	--	--	2.000	--	--	--	--	--	-0.667	3.429
WL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	1.000	2.125	6.000	12.000	-0.500	-0.500	2.000	2.000	2.000	2.000	0.500	2.000	0.000	0.000	--	--	-0.700	0.125

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

Table D57. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: At high tide | Duration of Test: 10 min, hmr 3 only | Test Date: 2/20/88
Treatment Type: 20 sec on, 40 sec off | Test Time: 0035

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	2	7	0	0	2	2	2	2	4	3	0	0	0	0	0	0	10	14
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MC	2	7	2	4	0	0	0	0	1	1	1	1	0	0	0	0	6	13
WW	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
Total	4	14	3	6	2	2	2	2	5	4	1	1	0	0	0	0	17	29

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	2	2
SL	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
MC	1	4	0	0	0	0	0	0	1	1	0	0	0	0	1	0	3	5
WW	2	7	3	6	0	0	0	0	0	0	0	0	0	0	0	0	5	13
Total	3	11	4	8	1	1	1	1	1	1	0	0	0	0	1	0	11	22

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	4	0	0	2	2	2	2	2	2	0	0	0	0	0	0	6	8
SL	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
MC	2	6	1	2	0	0	0	0	1	1	1	1	0	0	1	0	5	9
WW	1	4	2	4	0	0	0	0	0	0	0	0	0	0	0	0	3	8
TOTAL	4	13	4	7	2	2	2	2	3	3	1	1	0	0	1	0	14	26

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	2.000	7.000	--	--	0.333	0.333	0.333	0.333	4.000	3.000	--	--	--	--	--	--	5.333	9.000
SL	--	--	1.000	2.000	--	--	--	--	--	--	--	--	--	--	--	--	1.000	2.000
MC	0.333	0.818	2.000	4.000	--	--	--	--	0.000	0.000	1.000	1.000	--	--	1.000	--	1.000	3.556
WW	2.000	7.000	1.000	2.000	--	--	--	--	--	--	--	--	--	--	--	--	2.667	8.067
TOTAL	0.143	0.360	0.143	0.286	0.333	0.333	0.333	0.333	2.667	1.800	1.000	1.000	--	--	1.000	--	1.286	0.961

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D58. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 30 min after high tide

Duration of Test: 10 min, hmr 3 only

Treatment Type: 20 sec on, 20 sec off

Test Date: 2/20/88

Test Time: 0055

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	3	3	1	1	1	1	0	0	0	0	5	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	4	15	2	4	3	4	0	0	0	0	0	0	0	0	0	0	9	23
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	4	15	2	4	3	4	3	3	1	1	1	1	0	0	0	0	14	28

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	2	4	3	4	0	0	0	0	0	0	1	1	0	0	6	9
SL	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
NC	3	11	1	2	1	1	0	0	0	0	0	0	0	0	0	0	5	14
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	3	11	3	6	5	6	0	0	0	0	0	0	1	1	0	0	12	24

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	2	2	2	2	1	1	1	1	1	1	0	0	6	7
SL	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
NC	4	13	2	3	2	3	0	0	0	0	0	0	0	0	0	0	7	19
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	4	13	3	5	4	5	2	2	1	1	1	1	1	1	0	0	13	26

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	2.000	4.000	3.000	4.000	3.000	3.000	1.000	1.000	1.000	1.000	1.000	1.000	--	--	0.091	1.143
SL	--	--	--	--	1.000	1.000	--	--	--	--	--	--	--	--	--	--	1.000	1.000
NC	0.143	0.615	0.333	0.667	1.000	1.800	--	--	--	--	--	--	--	--	--	--	1.143	2.189
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.143	0.615	0.200	0.400	0.500	0.400	3.000	3.000	1.000	1.000	1.000	1.000	1.000	1.000	--	--	0.154	0.308

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D59. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2.5 hrs before low tide | Duration of Test: 10 min, hwr 3 only | Test Date: 2/20/88
Treatment Type: 30 sec on, 30 sec off | Test Time: 0445

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	4	4	8	6	14	8	4	2	1	0	31	20
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	1	2	0	0	0	0	0	0	1	1	0	0	0	0	3	7
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	1	2	0	0	4	4	8	6	15	9	4	2	1	0	34	27

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	2	4	12	14	8	7	13	10	18	11	4	2	4	2	61	50
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	1	2	1	1	1	1	1	1	0	0	1	1	0	0	6	10
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	3	6	13	15	9	8	14	11	18	11	5	3	4	2	67	60

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	3	6	5	6	2	2	5	4	12	7	7	4	1	0	35	29
SL	0	0	1	2	0	0	0	0	0	0	0	0	0	0	1	0	2	2
NC	0	0	0	0	1	1	2	2	3	2	3	2	0	0	0	0	9	7
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	4	8	6	7	4	4	8	6	15	9	7	4	2	0	46	38

CHI-SQUARE F-HAT

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	2	3	6	7	5	4	9	7	15	9	5	3	2	1	42	33
SL	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
NC	1	3	1	1	1	1	1	1	1	1	1	1	0	0	0	0	6	8
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	3	3	5	6	7	6	5	10	8	16	10	5	3	2	1	49	41

CHI-SQUARE VALUES

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	1.500	7.333	11.167	13.143	2.800	4.250	2.667	1.714	0.267	0.000	1.200	0.000	3.000	2.000	13.643	14.364
SL	--	--	--	2.000	--	--	--	--	--	--	--	--	--	--	--	--	2.000	2.000
NC	0.000	2.667	0.000	4.000	0.000	0.000	2.000	2.000	6.000	2.000	6.000	2.000	--	--	--	--	3.000	0.750
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.000	2.667	0.667	4.000	15.167	17.143	1.833	3.200	2.400	1.125	0.375	-0.700	2.000	0.667	3.500	2.000	11.388	15.805

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

Table D60. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs before low tide | Duration of Test: 10 min, hwr 3 only | Treatment Type: 30 sec on, 40 sec off | Test Date: 2/20/88 | Test Time: 0505

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	3	3	9	7	9	5	3	2	2	1	26	18
SL	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	2	2
NC	0	0	2	4	2	2	3	3	2	2	2	1	1	1	1	0	13	13
WW	0	0	1	2	3	4	1	1	0	0	0	0	0	0	0	0	5	7
Total	0	0	3	6	7	8	7	7	11	9	11	6	4	3	3	1	46	40

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	Total Raw	Total WF
LS	1	4	0	0	4	5	4	4	7	5	10	6	3	2	2	1	31	27
SL	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
NC	0	0	1	2	1	1	0	0	1	1	2	1	0	0	0	0	5	5
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	1	2	5	6	5	5	8	6	12	7	3	2	2	1	37	33

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	1	2	0	0	2	3	4	4	8	6	10	6	3	2	2	1	29	23
SL	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	2	2
NC	0	0	2	3	2	2	2	2	2	2	2	1	1	1	1	0	9	9
WW	0	0	1	1	2	2	1	1	0	0	0	0	0	0	0	0	3	4
TOTAL	1	2	2	4	6	7	6	6	10	8	12	7	4	3	3	1	42	37

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	25-30 Raw	25-30 WF	30-35 Raw	30-35 WF	35-40 Raw	35-40 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	1.000	4.000	--	--	4.000	5.000	0.143	0.143	0.250	0.333	0.053	0.091	0.000	0.000	0.000	0.000	0.439	1.800
SL	--	--	--	--	2.000	2.000	1.000	1.000	--	--	--	--	--	--	--	--	0.333	0.333
NC	--	--	0.333	0.667	0.333	0.333	3.000	3.000	0.333	0.333	0.000	0.000	1.000	1.000	1.000	--	3.556	3.556
WW	--	--	1.000	2.000	3.000	4.000	1.000	1.000	--	--	--	--	--	--	--	--	5.000	7.000
TOTAL	1.000	4.000	1.000	2.000	0.333	0.286	0.333	0.333	0.474	0.600	0.043	0.077	0.143	0.200	0.200	0.000	0.976	0.671

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D61. Indian Point hammer test monitoring using 6x12 degree
horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1.5 hrs before low tide | Duration of Test: 10 min, hmr 3 only | Test Date: 2/20/88
Treatment Type: 40 sec on, 20 sec off | Test Time: 0525

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	8	10	4	4	10	8	20	12	7	4	3	1	52	39
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	0	0	1	1	4	4	1	1	1	1	0	0	0	0	8	11
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	0	0	9	11	8	8	11	9	21	13	7	4	3	1	60	50

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	4	2	4	9	11	11	10	13	10	14	8	4	2	2	1	56	50
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	2	4	1	1	1	1	1	1	1	1	0	0	1	0	8	12
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	8	4	8	10	12	12	11	14	11	15	9	4	2	3	1	64	62

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	2	1	2	9	11	8	7	12	9	17	10	6	3	3	1	64	45
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	1	2	1	1	3	3	1	1	1	1	0	0	1	0	8	12
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	2	6	2	4	10	12	10	10	13	10	18	11	6	3	3	1	62	56

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1.000	4.000	2.000	4.000	0.059	0.048	3.267	2.571	0.391	0.222	1.059	0.800	0.818	0.667	0.200	0.000	0.148	1.360
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	0.000	0.000	2.000	4.000	0.000	0.000	1.800	1.800	0.000	0.000	0.000	0.000	--	--	1.000	--	0.000	0.043
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.333	1.333	4.000	8.000	0.053	0.043	0.800	0.474	0.360	0.200	1.000	0.727	0.818	0.667	0.000	0.000	0.129	1.286

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D62. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase:	1 hr before low tide	Duration of Test:	10 min, hmr 3 only	Test Date:	2/20/88
		Treatment Type:	40 sec on, 30 sec off	Test Time:	0545

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	9	11	5	5	3	2	5	3	4	2	1	0	28	25
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	1	4	1	2	1	1	1	1	1	1	0	0	1	1	0	0	6	10
WW	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
Total	1	4	2	4	10	12	6	6	5	4	6	4	5	3	1	0	36	37

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	7	8	4	4	3	2	6	4	6	3	3	1	29	22
SL	0	0	1	2	0	0	1	1	0	0	0	0	0	0	0	0	2	3
NC	1	4	1	2	1	1	1	1	1	1	1	1	0	0	0	0	6	10
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	2	4	8	9	6	6	4	3	7	5	6	3	3	1	37	35

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	1	8	10	5	5	3	2	6	4	5	3	2	1	29	24
SL	0	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	2	2
NC	1	4	1	2	1	1	1	1	1	1	1	1	1	1	0	0	6	10
WW	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
TOTAL	1	4	2	4	9	11	6	6	5	4	7	5	6	3	2	1	37	36

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	1.000	2.000	0.250	0.474	0.111	0.111	0.000	0.000	0.091	0.143	0.400	0.200	1.000	1.000	0.018	0.191
SL	--	--	1.000	2.000	--	--	1.000	1.000	1.000	1.000	--	--	--	--	--	--	0.333	1.000
NC	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000	--	--	0.000	0.000
WW	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--	--	--	1.000	1.000
TOTAL	0.000	0.000	0.000	0.000	0.222	0.429	0.000	0.000	0.111	0.143	0.077	0.111	0.091	0.000	1.000	1.000	0.014	0.056

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D63. Indian Point hammer test monitoring using 6x12 degree
horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1 hr before low tide | Duration of Test: 10 min, hwr 3 only | Treatment Type: 40 sec on, 40 sec off | Test Date: 2/20/88 | Test Time: 0605

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	3	6	12	14	6	5	3	2	7	4	16	8	9	4	56	43
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	2	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	3	6	12	14	7	6	3	2	7	4	16	8	10	4	58	44

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	3	6	1	1	3	3	5	4	6	4	4	2	2	1	24	21
SL	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
NC	1	4	0	0	0	0	0	0	1	1	1	1	0	0	0	0	3	6
WW	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Total	1	4	3	6	3	3	3	3	6	5	7	5	4	2	2	1	29	29

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	3	6	7	8	5	4	4	3	7	4	10	5	6	3	40	32
SL	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
NC	1	2	0	0	0	0	1	1	1	1	1	1	0	0	1	0	3	4
WW	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	1	2	3	6	8	9	5	5	5	4	7	5	10	5	6	3	44	37

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	0.000	0.000	9.308	11.267	1.000	0.500	0.500	0.667	0.077	0.000	7.200	3.600	4.455	1.800	12.800	7.563
SL	--	--	--	--	1.000	1.000	--	--	--	--	--	--	--	--	--	--	1.000	1.000
NC	1.000	4.000	--	--	--	--	1.000	1.000	1.000	1.000	1.000	1.000	--	--	1.000	--	0.200	3.571
WW	--	--	--	--	1.000	1.000	--	--	--	--	--	--	--	--	--	--	1.000	1.000
TOTAL	1.000	4.000	0.000	0.000	5.400	7.118	1.600	1.000	1.000	1.286	0.000	0.111	7.200	3.600	5.333	1.800	9.667	3.082

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D64. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs after low tide | Duration of Test: 10 min, hmr 3 only | Test Date: 2/20/88
Treatment Type: 20 sec on, 20 sec off | Test Time: 2155

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	1	3	3	2	2	0	0	0	0	0	0	6	6
SL	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
NC	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	2	2
WW	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
Total	0	0	1	2	2	2	4	4	3	3	0	0	0	0	0	0	10	11

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	2	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
NC	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
WW	1	4	0	0	1	1	0	0	1	1	1	1	0	0	0	0	4	7
Total	4	15	0	0	1	1	0	0	2	2	1	1	0	0	0	0	8	19

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	0	0	0	0	1	1	2	1	0	0	1	0	5	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	0	0	0	0	0	0	0	0	0	0	2	1	0	0	3	5
WW	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	2	1
Total	1	4	1	2	0	0	0	0	1	1	3	2	2	1	2	0	10	10

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	2	0	1	0	0	1	1	1	1	1	0	0	0	0	0	4	6
SL	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
NC	1	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	4
WW	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2	3
TOTAL	2	6	1	1	1	1	1	1	2	2	1	1	1	0	1	0	9	13

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	2.000	17.500	—	2.000	—	—	6.000	6.000	2.000	2.000	2.000	—	—	—	—	—	3.250	-0.167
SL	—	—	—	2.000	—	—	—	—	—	—	—	—	—	—	—	—	0.000	2.000
NC	0.000	2.667	—	—	—	—	—	—	—	—	—	—	2.000	—	—	—	1.000	0.250
WW	—	12.000	—	—	—	—	—	—	—	—	0.000	0.000	—	—	—	—	3.500	8.000
TOTAL	3.500	21.167	0.000	4.000	2.000	2.000	12.000	12.000	1.000	1.000	6.000	2.000	2.000	ERR	2.000	—	1.333	4.769

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

Table D65. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 1.5 hrs after low tide

Duration of Test: 10 min hmr 3 only

Treatment Type: 10 sec on, 30 sec off

Test Date: 2/20/88

Test Time: 2215

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	1	1	1	0	0	1	1	1	1	1	0	5	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
WW	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
Total	1	4	0	0	1	1	2	2	0	0	1	1	1	1	1	0	7	9

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	1	0	0	1	1	1	1	1	0	4	3
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
Total	0	0	0	0	0	0	1	1	0	0	1	1	2	2	1	0	5	4

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	1	1	1	0	0	1	1	1	1	1	0	5	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
WW	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	1	1
TOTAL	1	2	0	0	1	1	2	2	0	0	1	1	2	2	1	0	6	7

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	1.000	1.000	0.000	0.000	--	--	0.000	0.000	0.000	0.000	0.000	--	0.111	0.143
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	1.000	4.000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.000	4.000
WW	--	--	--	--	--	--	1.000	1.000	--	--	--	--	1.000	1.000	--	--	0.000	0.000
TOTAL	1.000	4.000	--	--	1.000	1.000	0.333	0.333	--	--	0.000	0.000	0.333	0.333	0.000	--	0.333	1.923

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D66. Indian Point hammer test monitoring using 6x12 degree
horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2 hrs after low tide | Duration of Test: 10 min, hmr 3 only | Test Date: 2/20/88
Treatment Type: 10 sec on, 40 sec off | Test Time: 2235

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	2	7	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	7
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
Total	2	7	0	0	0	0	0	0	0	0	1	1	1	1	1	0	5	9

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	2	1
WW	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	2	2
Total	0	0	1	2	0	0	2	2	0	0	1	1	0	0	1	0	5	5

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	1	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	0	0	0	0	0	0	0	0	1	1	0	0	1	0	3	4
WW	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	2	2
TOTAL	1	4	1	1	0	0	1	1	0	0	1	1	1	1	1	0	5	7

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	1.000	2.000	--	--	--	--	--	--	1.000	1.000	--	--	--	--	0.000	0.333
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	2.000	7.000	--	--	--	--	--	--	--	--	1.000	1.000	--	--	0.000	--	0.200	4.500
WW	--	--	--	--	--	--	2.000	2.000	--	--	--	--	1.000	1.000	--	--	0.333	0.333
TOTAL	2.000	7.000	1.000	2.000	--	--	2.000	2.000	--	--	0.000	0.000	1.000	1.000	0.000	--	0.000	1.143

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table D67. Indian Point hammer test monitoring using 6x12 degree horizontal transducer located at unit 3, intake 35.

Tidal Phase: 2.5 hrs after low tide | Duration of Test: 10 min, hmr 3 only | Treatment Type: 20 sec on, 20 sec off | Test Date: 2/20/88 | Test Time: 2255

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	4	1	2	0	0	1	1	0	0	0	0	0	0	0	0	3	7
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	1	2	1	1	0	0	0	0	0	0	0	0	0	0	3	7
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	8	2	4	1	1	1	1	0	0	0	0	0	0	0	0	6	14

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	2	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	3	11	0	0	1	1	0	0	0	0	1	1	0	0	1	0	6	13
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	3	11	0	0	1	1	0	0	2	2	1	1	0	0	1	0	8	15

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	2	1	1	0	0	1	1	1	1	0	0	0	0	0	0	3	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	2	8	1	1	1	1	0	0	0	0	1	1	0	0	1	0	5	10
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3	10	1	2	1	1	1	1	1	1	1	1	0	0	1	0	7	15

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		25-30		30-35		35-40		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1.000	4.000	1.000	2.000	--	--	1.000	1.000	2.000	2.000	--	--	--	--	--	--	0.200	2.778
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	1.000	3.267	1.000	2.000	0.000	0.000	--	--	--	--	1.000	1.000	--	--	1.000	--	1.000	1.800
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.200	0.474	2.000	4.000	0.000	0.000	1.000	1.000	2.000	2.000	1.000	1.000	--	--	1.000	--	0.286	0.034

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

APPENDIX E:

Hammer Tests Monitored By

6° Vertical Transducer

Table E1. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 3.5 Hr before Low Tide

Duration of Test: 15 min Hmr 183 on
Treatment Type: 15 min continuous

Test Date: 2/23/88
Test Time: 1822

15 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	2	0	0	0	0	0	0	1	2	7	10
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	2	5	2	4	3	5	3	4	3	3	13	21	9	14
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	2	5	3	6	3	5	3	4	3	3	14	23	14	23

15 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	2	5	8	4	5	0	0	10	15
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	5	0	0	0	0	1	2	1	1	2	2	5	10
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	5	0	0	1	2	6	10	5	6	2	2	15	25

CHI-SQUARE VALUES FOR 3 TEST PERIODS

	Raw	WF
LS	6.000	9.800
SL	---	--
NC	4.375	4.786
WW	---	--
TOTAL	1.071	2.174

15 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	2	5	0	0	0	0	6	7	1	1	9	13
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	2	5	0	0	3	5	0	0	0	0	5	10
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	4	10	0	0	3	5	6	7	1	1	14	23

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	2	1	1	2	3	3	4	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	2	1	3	1	1	2	4	1	2	2	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	2	2	5	1	3	4	7	5	6	2	2

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	---	2.000	7.500	0.000	4.000	7.500	13.333	7.333	6.500	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	7.500	4.000	6.667	2.000	12.000	2.500	1.500	6.000	3.500	1.500	1.500
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	--	--	--	7.500	4.000	10.000	6.000	5.333	1.500	1.429	0.000	-0.167	1.000	1.000

Table E2. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 2.5 Hr before Low Tide

Duration of Test: 10 min Hmr 1&3 on
Treatment Type: 10 min continuous

Test Date: 2/23/88
Test Time: 1941

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 3 TEST PERIODS WF
LS	1	7	1	5	0	0	0	0	0	0	2	2	0	0	4	14	6	10
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	1	3	1	2	1	2	0	0	0	0	3	7	6	12
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Total	1	7	1	5	1	3	1	2	1	2	2	2	0	0	7	21	13	22

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0	8	10	4	4	12	14
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	3	8	1	2	0	0	0	0	0	0	4	10
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	3	8	1	2	0	0	8	10	4	4	16	24

CHI-SQUARE VALUES FOR 3 TEST PERIODS

	Raw	WF
LS	9.833	10.300
SL	--	--
NC	9.167	4.417
WW	6.000	6.000
TOTAL	4.154	1.227

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	2	4	5	8	5	6	0	0	12	18
WW	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3
Total	0	0	0	0	0	0	2	4	5	8	6	7	3	3	16	22

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	2	0	2	0	0	0	0	0	0	4	4	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	1	4	1	3	2	3	2	2	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	0	2	0	2	1	4	1	3	2	3	5	6	2	2

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	17.500	--	7.500	--	--	--	--	--	--	6.250	13.250	12.000	12.000
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	6.000	7.250	2.000	0.000	7.000	12.667	7.500	12.000	--	--
WW	--	--	--	--	--	--	--	--	--	--	--	--	6.000	6.000
TOTAL	--	17.500	--	7.500	6.000	7.250	2.000	0.000	7.000	12.667	4.800	6.500	5.500	5.500

Table E3. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 2 Hr before Low Tide | Duration of Test: 11 min Hmr 1&3 on | Treatment Type: 11 min continuous | Test Date: 2/23/88 | Test Time: 2015

11 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	1	5	2	5	4	8	2	3	3	4	1	1	13	26	14	35
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	3	6	5	8	4	5	2	2	14	21	12	17
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Total	0	0	1	5	2	5	7	14	7	11	7	9	3	3	27	47	26	52

11 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS	Raw	WF
LS	2	14	2	9	1	3	7	14	1	2	1	1	0	0	14	43	LS	0.037	4.188
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	—	--
NC	0	0	0	0	0	0	1	2	2	3	3	4	3	3	9	12	NC	1.087	2.455
WW	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	WW	1.000	1.000
Total	2	14	2	9	1	3	8	16	3	5	5	6	3	3	24	56	TOTAL	0.176	0.786

CHI-SQUARE = 3.841 (d.f. = 1) (alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	1	7	2	7	2	4	6	11	2	3	2	3	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	2	4	4	6	4	5	3	3
WW	0	0	0	0	0	0	0	0	0	0	1	1	0	0
TOTAL	1	7	2	7	2	4	8	15	5	8	6	8	3	3

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	2.000	14.000	0.333	1.143	0.333	0.500	0.818	1.636	0.333	0.200	1.000	1.800	1.000	1.000
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	1.000	2.000	1.286	2.273	0.143	0.111	0.200	0.200
WW	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--
TOTAL	2.000	14.000	0.333	1.143	0.333	0.500	0.067	0.133	1.600	2.250	0.333	0.600	0.000	0.000

Table E4. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 3 Hrs before High Tide | Duration of Test: 5 min Hmr 1&3 on | Treatment Type: 5 min continuous | Test Date: 2/24/88 | Test Time: 1330

5 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 3 TEST PERIODS WF
LS	0	0	0	0	0	0	2	4	3	5	0	0	0	0	5	9	8	13
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	2	4	3	5	1	1	1	1	7	11	10	15

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 3 TEST PERIODS	Raw	WF
LS	0	0	0	0	0	0	5	10	3	5	4	5	0	0	12	20	LS	3.250	6.308
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	---	---
NC	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	NC	-0.500	-0.500
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	---	---
Total	0	0	0	0	0	0	5	10	3	5	4	5	1	1	13	21	TOTAL	0.900	3.733

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

CHI-SQUARE = 5.991 (d.f. = 2) (alpha = .05)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	3	6	2	3	2	2	0	0	7	11
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	2	2	0	0	2	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	3	6	2	3	4	4	0	0	9	13

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	0	0	3	7	3	4	2	2	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	3	7	3	4	3	3	1	1

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	---	---	---	---	---	---	2.667	1.714	-0.667	1.750	4.000	7.500	---	---
SL	---	---	---	---	---	---	---	---	---	---	---	---	---	---
NC	---	---	---	---	---	---	---	---	---	---	2.000	2.000	0.000	0.000
WW	---	---	---	---	---	---	---	---	---	---	---	---	---	---
TOTAL	---	---	---	---	---	---	2.667	1.714	-0.667	1.750	2.000	4.000	0.000	0.000

Table E5. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 2.5 Hr before High Tide

Duration of Test: 8 min Hmr 1&3 on

Treatment Type: 8 min continuous

Test Date: 2/24/88

Test Time: 1350

8 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 3 TEST PERIODS WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	5

8 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 3 TEST PERIODS	Raw	WF
LS	0	0	0	0	0	0	0	0	1	2	4	5	0	0	5	7	LS	7.500	8.667
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	--	--
NC	0	0	0	0	0	0	1	2	0	0	0	0	0	0	1	2	NC	--	2.000
WW	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	WW	4.000	4.000
Total	0	0	0	0	0	0	1	2	1	2	5	6	1	1	8	11	TOTAL	8.000	12.400

8 MINUTES AFTER TEST PERIOD

RANGE (meters)

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0	2	2	0	0	2	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2
Total	0	0	0	0	0	0	0	0	0	0	3	3	1	1	4	4

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	0	0	0	0	0	1	2	2	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	1	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	1	1	1	1
TOTAL	0	0	0	0	0	0	0	1	0	1	3	3	1	1

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	--	--	--	--	--	--	--	2.000	4.000	7.500	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	2.000	--	--	--	--	--	--
WW	--	--	--	--	--	--	--	--	--	--	0.000	0.000	0.000	0.000
TOTAL	--	--	--	--	--	--	--	2.000	--	2.000	3.333	6.000	0.000	0.000

Table E6. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 2 Hrs before High Tide

Duration of Test: 6 min Hmr 1&3 on
Treatment Type: 6 min continuous

Test Date: 2/24/88
Test Time: 1419

6 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 3 TEST PERIODS WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
Total	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	4	5

6 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	2	1	2	3	4	1	1	6	9
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Total	0	0	0	0	0	0	1	2	2	4	3	4	2	2	8	12

CHI-SQUARE VALUES FOR 3 TEST PERIODS

	Raw	WF
LS	--	2.000
SL	--	--
NC	11.500	17.333
WW	0.000	0.000
TOTAL	6.250	14.800

6 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Total	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	0	0	0	0	0	1	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	1	0	1	1	2	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	0	0	0	0	0	0	0	1	1	1	1	2	1	1

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	--	--	--	--	--	--	--	2.000	--	--	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	2.000	--	2.000	6.000	3.500	--	--
WW	--	--	--	--	--	--	--	--	--	--	--	--	0.000	0.000
TOTAL	--	--	--	--	--	--	--	2.000	2.000	12.000	6.000	3.500	2.000	2.000

Table E7. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase:	3 Hrs before Low Tide	Duration of Test:	13 min hwrs 1&3 on	Test Date:	2/24/88
		Treatment Type:	13 min continuous	Test Time:	1957

13 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	2	5	0	0	0	0	0	0	0	0	2	5	3	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	7	9	1	1	8	10	9	13
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Total	0	0	0	0	2	5	0	0	0	0	7	9	1	1	10	15	13	18

13 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE VALUES FOR 3 TEST PERIODS		
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF		Raw	WF
LS	0	0	0	0	0	0	0	0	2	3	2	2	1	1	5	6	LS	2.667	0.400
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	—	—
NC	0	0	0	0	0	0	1	2	3	5	3	4	1	1	8	12	NC	0.667	0.462
WW	0	0	0	0	0	0	0	0	1	2	0	0	1	1	2	3	WW	2.000	6.000
Total	0	0	0	0	0	0	1	2	6	10	5	6	3	3	15	21	TOTAL	1.077	3.222

13 MINUTES AFTER TEST PERIOD

RANGE (meters)

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	3	4	0	0	3	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	1	3	0	0	3	5	3	4	4	4	11	16
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	1	3	0	0	3	5	6	8	4	4	14	20

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	2	0	0	1	1	2	2	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	1	0	1	2	3	4	6	2	2
WW	0	0	0	0	0	0	0	0	0	1	0	0	0	0
TOTAL	0	0	0	0	1	3	0	1	3	5	6	8	3	3

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	2.000	7.500	--	--	2.000	6.000	1.500	4.000	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	6.000	--	2.000	3.000	6.667	3.750	1.833	3.000	3.000
WW	--	--	--	--	--	--	--	--	--	2.000	--	--	--	--
TOTAL	--	--	--	--	2.000	3.333	--	2.000	6.000	10.000	0.333	-0.375	0.667	0.667

Table E8. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 30 min before Low Tide | Duration of Test: 10 min Hmr 1,345 on | Test Date: 2/24/88
Treatment Type: 10 min continuous | Test Time: 2244

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 3 TEST PERIODS WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	2	4	2	3	0	0	0	0	4	7	3	6
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	2	4	2	3	0	0	0	0	4	7	5	10

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 3 TEST PERIODS	Raw	WF
LS	0	0	0	0	1	3	3	6	1	2	1	1	0	0	6	12	LS	12.000	24.000
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	—	—
NC	0	0	0	0	0	0	2	4	3	5	0	0	0	0	5	9	NC	4.000	4.833
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	—	—
Total	0	0	0	0	1	3	5	10	4	7	1	1	0	0	11	21	TOTAL	11.600	20.100

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	0	1	1	2	0	1	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	3	2	3	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	1	2	5	2	3	0	0	0	0

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	—	—	—	—	—	6.000	6.000	12.000	—	2.000	—	—	—	—
SL	—	—	—	—	—	—	—	—	—	—	—	—	—	—
NC	—	—	—	—	—	—	4.000	2.667	1.500	3.333	—	—	—	—
WW	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL	—	—	—	—	—	6.000	7.500	9.200	4.000	9.333	—	—	—	—

Table E9. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: At High Tide | Duration of Test: 20 min Hmr 1,3,&5 on | Treatment Type: 20 min continuous | Test Date: 2/25/88 | Test Time: 0954

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 3 TEST PERIODS WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	2	2	0	0	2	2	2	2
WB	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
Total	0	0	0	0	0	0	0	0	0	0	2	2	1	1	3	3	4	7

20 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 3 TEST PERIODS	Raw	WF
LS	0	0	0	0	1	3	0	0	1	2	3	4	0	0	5	9	LS	7.500	8.400
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	--	--
NC	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	NC	-0.500	-0.500
WB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WB	--	--
Total	0	0	0	0	1	3	0	0	1	2	4	5	1	1	7	11	TOTAL	3.750	4.571

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

CHI-SQUARE = 5.991 (d.f. = 2) (alpha = .05)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	1	5	0	0	0	0	0	0	0	0	1	1	2	6
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
WB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	5	0	0	0	0	0	0	0	0	2	2	3	7

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	2	0	1	0	0	0	1	1	1	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	1	1
WB	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	2	0	1	0	0	0	1	2	2	1	1

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	--	7.500	--	6.000	--	--	--	2.000	6.000	12.000	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--	--	--	2.000	2.000	0.000	0.000
WB	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	--	--	--	7.500	--	6.000	--	--	--	2.000	4.000	7.500	2.000	2.000

Table E10. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: At Low Tide | Duration of Test: 10 min Hwr 1,325 on | Test Date: 2/25/88
Treatment Type: 10 min continuous | Test Time: 1215

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	3	3	4	4
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	1	1	3	3	4	4

CHI-SQUARE F-HAT FOR 3 TEST PERIODS

	Raw	WF
LS	3	4
SL	0	0
NC	2	2
WW	0	0
Total	5	6

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	2	4	4	6	1	1	0	0	7	11
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	2	4	4	6	1	1	1	1	8	12

CHI-SQUARE VALUES FOR 3 TEST PERIODS

	Raw	WF
LS	8.667	18.250
SL	--	--
NC	3.500	3.500
WW	--	--
TOTAL	2.800	9.167

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	1	2	0	0	0	0	0	0	1	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
Total	0	0	0	0	0	0	1	2	0	0	1	1	0	0	2	3

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

CHI-SQUARE F-HAT

	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	0	0	1	2	1	2	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	1	2	1	2	1	1	1	1

CHI-SQUARE VALUES

	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	--	--	--	--	2.000	4.000	12.000	12.000	--	--	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--	--	--	--	--	6.000	6.000
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	--	--	--	--	--	--	2.000	4.000	12.000	12.000	0.000	0.000	6.000	6.000

Table E11. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 4 Hr before Low Tide | Duration of Test: 11 min Hmr 1,3A5 on | Treatment Type: 11 min continuous | Test Date: 2/25/88 | Test Time: 2026

11 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	3	0	0	0	0	6	7	0	0	7	10	4	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	1	3	0	0	0	0	6	7	0	0	7	10	4	5

11 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CHI-SQUARE VALUES FOR 2 TEST PERIODS	Raw	WF
LS	7.000	10.000
SL	--	--
NC	--	--
WW	--	--
TOTAL	7.000	10.000

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	2	0	0	0	0	3	4	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	1	2	0	0	0	0	3	4	0	0

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	1.000	3.000	--	--	--	--	6.000	7.000	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--	--	--	--	--	--	--
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	--	--	--	--	1.000	3.000	--	--	--	--	6.000	7.000	--	--

Table E12. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 2 Hr after High Tide

Duration of Test: 4 min Hmr 1,345 on
Treatment Type: 4 min continuous

Test Date: 2/26/88
Test Time: 0806

4 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS: Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	2	2	3	3	4	3	3	9	12	11	14
WB	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	3	3
Total	0	0	0	0	0	0	1	2	2	3	3	4	4	4	10	13	15	19

4 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	2	5	1	2	0	0	0	0	0	0	3	7
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	4	6	8	10	3	3	15	19
WB	0	0	0	0	0	0	0	0	0	0	2	2	1	1	3	3
Total	0	0	0	0	2	5	1	2	4	6	10	12	4	4	21	29

CHI-SQUARE VALUES FOR 3 TEST PERIODS:

	Raw	WF
LS	6.000	17.500
SL	—	—
NC	1.636	2.214
WW	2.667	2.667
TOTAL	3.333	9.000

4 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	2	3	5	6	1	1	8	10
WB	0	0	0	0	0	0	0	0	0	0	2	2	3	3	5	5
Total	0	0	0	0	0	0	0	0	2	3	7	8	4	4	13	15

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	1	2	0	1	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	1	3	4	5	7	2	2
WB	0	0	0	0	0	0	0	0	0	0	1	1	2	2
TOTAL	0	0	0	0	1	2	1	1	3	4	7	8	4	4

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	—	—	—	—	2.000	7.500	—	2.000	—	—	—	—	—	—
SL	—	—	—	—	—	—	—	—	—	—	—	—	—	—
NC	—	—	—	—	—	—	—	2.000	0.000	1.500	3.600	1.714	2.500	2.500
WB	—	—	—	—	—	—	—	—	—	—	4.000	4.000	0.500	0.500
TOTAL	—	—	—	—	2.000	7.500	0.000	4.000	0.000	1.500	2.571	4.000	0.000	0.000

Table E13. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 2 Hrs after High Tide   Duration of Test: 8 min Hmr 1,3&5 on   Treatment Type: 3 min HS, 5 min H1,3   Test Date: 2/26/88   Test Time: 0814

8 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	2	2	3	8	10	1	1	12	16	9	11
WW	0	0	0	0	0	0	0	0	0	0	2	2	4	4	6	6	6	7
Total	0	0	0	0	0	0	1	2	2	3	11	13	5	5	19	23	15	18

8 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	2	3	1	1	2	2	5	6
WW	0	0	0	0	0	0	0	0	0	0	3	4	3	3	6	7
Total	0	0	0	0	0	0	0	0	2	3	4	5	5	5	11	13

CHI-SQUARE VALUES FOR 2 TEST PERIODS

	Raw	WF
LS	1.000	1.000
SL	--	--
NC	2.882	4.545
WW	0.000	0.077
TOTAL	2.133	2.778

CHI-SQUARE F-HAT

	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	0	0	0	0	0	0	1	1	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	1	2	3	5	6	2	2
WW	0	0	0	0	0	0	0	0	0	0	3	3	4	4
TOTAL	0	0	0	0	0	0	1	1	2	3	8	9	5	5

CHI-SQUARE VALUES

	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	1.000	2.000	0.000	0.000	5.444	7.364	0.333	0.333
WW	--	--	--	--	--	--	--	--	--	--	0.200	0.667	0.143	0.143
TOTAL	--	--	--	--	--	--	1.000	2.000	0.000	0.000	3.267	3.556	0.000	0.000

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

Table E14. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 2.5 Hrs after High Tide Duration of Test: 6 min Hrs 1&3 only Treatment Type: 6 min continuous Test Date: 2/26/88 Test Time: 0828

6 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	0	0	0	0	0	0	4	5	0	0	4	5	2	3
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	2	2	3	3	5	5	3	3
WW	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	1	1
Total	0	0	0	0	0	0	0	0	0	0	6	7	5	5	11	12	6	7

6 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	LS	4.000	5.000
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	--	--
NC	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	NC	2.667	2.667
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	2.000	2.000
Total	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	TOTAL	8.333	9.308

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	0	0	0	0	0	0	2	3	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	2	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	0	0	0	0	0	0	0	0	0	0	3	4	3	3

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	--	--	--	--	--	--	--	--	4.000	5.000	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--	--	--	2.000	2.000	1.000	1.000
WW	--	--	--	--	--	--	--	--	--	--	--	--	2.000	2.000
TOTAL	--	--	--	--	--	--	--	--	--	--	6.000	7.000	2.667	2.667

Table E15. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 3 Hrs after High Tide | Duration of Test: 10 min Hmrs 1,3&5 on | Treatment Type: 10 min continuous | Test Date: 2/26/88 | Test Time: 0849

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	2	9	0	0	0	0	1	2	0	0	0	0	3	11
SL	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	2
NC	0	0	0	0	0	0	0	0	0	0	3	4	6	6	9	10
WW	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
Total	0	0	2	9	0	0	0	0	2	4	4	5	6	6	14	24

CHI-SQUARE F-HAT FOR 3 TEST PERIODS

	Raw	WF
LS	1	4
SL	0	1
NC	15	17
WW	3	3
Total	20	25

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	2	3	12	15	4	4	18	22
WW	0	0	0	0	0	0	0	0	0	0	3	4	3	3	6	7
Total	0	0	0	0	0	0	0	0	2	3	16	20	7	7	25	30

CHI-SQUARE VALUES FOR 3 TEST PERIODS

	Raw	WF
LS	6.000	10.500
SL	--	2.000
NC	5.067	7.294
WW	4.667	8.000
TOTAL	3.100	3.200

CHI-SQUARE = 5.991 (d.f. = 2) (alpha = .05)

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	10	12	9	9	19	21
WW	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2
Total	0	0	0	0	0	0	0	0	0	0	11	13	10	10	21	23

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	3	0	0	0	0	0	1	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	1	0	0	0	0
NC	0	0	0	0	0	0	0	0	1	1	8	10	6	6
WW	0	0	0	0	0	0	0	0	0	0	2	2	1	1
TOTAL	0	0	1	3	0	0	0	0	1	2	10	13	8	8

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	2.000	10.000	--	--	--	--	--	2.000	--	--	--	--
SL	--	--	--	--	--	--	--	--	--	2.000	--	--	--	--
NC	--	--	--	--	--	--	--	--	2.000	6.000	6.625	7.500	3.167	3.167
WW	--	--	--	--	--	--	--	--	--	--	0.500	3.000	6.000	6.000
TOTAL	--	--	2.000	10.000	--	--	--	--	4.000	5.500	8.300	7.692	0.125	0.125

Table E16. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 3.5 Hrs after High Tide | Duration of Test: 10 min Hmrs 1,3&5 on | Treatment Type: 10 min continuous | Test Date: 2/26/88 | Test Time: 0924

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 3 TEST PERIODS WF
LS	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	3	3
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	13	20	12	15	7	7	32	42	28	36
WW	0	0	0	0	0	0	0	0	0	0	5	6	4	4	9	10	8	9
Total	0	0	0	0	0	0	0	0	13	20	18	22	11	11	42	53	39	48

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	12	18	14	17	4	4	30	39
WW	0	0	0	0	0	0	0	0	0	0	5	6	1	1	6	7
Total	0	0	0	0	0	0	0	0	12	18	19	23	10	10	41	51

CHI-SQUARE VALUES FOR 3 TEST PERIODS

	Raw	WF
LS	2.667	4.000
SL	--	--
NC	2.000	4.028
WW	0.750	0.667
TOTAL	0.974	3.458

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	1	2	2	2	0	0	3	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	4	6	15	19	3	3	22	28
WW	0	0	0	0	0	0	0	0	0	0	5	6	4	4	9	10
Total	0	0	0	0	0	0	0	0	5	8	22	27	7	7	34	42

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	0	0	0	0	0	1	1	1	2	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	10	15	14	17	5	5
WW	0	0	0	0	0	0	0	0	0	0	5	6	3	3
TOTAL	0	0	0	0	0	0	0	0	10	15	19	24	9	9

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	--	--	--	--	--	--	--	2.000	2.000	2.000	7.500	7.500
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--	3.900	6.667	-0.643	0.471	0.800	0.800
WW	--	--	--	--	--	--	--	--	--	--	0.000	0.000	2.000	2.000
TOTAL	--	--	--	--	--	--	--	--	3.800	6.533	2.526	0.583	2.000	2.000

Table E17. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 3 Hrs before Low Tide | Duration of Test: 10 min Hwr 5 only | Treatment Type: 10 min continuous | Test Date: 2/26/88 | Test Time: 1007

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 3 TEST PERIODS WF
LS	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	2	1	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	1	2	15	19	10	11	26	32	19	23
WW	0	0	0	0	0	0	0	0	0	0	2	2	2	2	4	4	2	2
Total	0	0	0	0	0	0	0	0	2	4	17	21	12	13	31	38	22	28

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	4	6	11	14	12	13	27	33
WW	0	0	0	0	0	0	0	0	0	0	2	2	1	1	3	3
Total	0	0	0	0	0	0	0	0	4	6	13	16	13	14	30	36

CHI-SQUARE VALUES FOR 3 TEST PERIODS

	Raw	WF
LS	0.000	7.500
SL	--	--
NC	17.263	22.435
WW	5.500	5.500
TOTAL	19.227	17.179

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	1	5	0	0	0	0	0	0	0	0	0	0	1	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	4	5	1	1	5	6
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	5	0	0	0	0	0	0	4	5	1	1	6	11

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	2	0	0	0	0	0	1	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	2	3	10	13	8	8
WW	0	0	0	0	0	0	0	0	0	0	1	1	1	1
TOTAL	0	0	0	2	0	0	0	0	2	3	11	14	9	9

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	--	7.500	--	--	--	--	--	2.000	--	--	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--	3.500	5.333	6.200	6.769	7.625	11.375
WW	--	--	--	--	--	--	--	--	--	--	4.000	4.000	2.000	2.000
TOTAL	--	--	--	7.500	--	--	--	--	4.000	7.333	9.091	9.571	8.889	12.667

Table E18. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 2.5 Hrs before Low Tide | Duration of Test: 10 min Hmr 103 only | Treatment Type: 10 min continuous | Test Date: 2/26/88 | Test Time: 1027

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	0	0	3	6	1	2	1	1	0	0	5	9	3	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	1	2	4	5	4	4	9	11	6	8
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Total	0	0	0	0	0	0	3	6	2	4	5	6	4	4	14	20	9	13

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	1	2	1	1	1	1	3	4
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Total	0	0	0	0	0	0	0	0	1	2	1	1	2	2	4	5

CHI-SQUARE VALUES FOR 2 TEST PERIODS

	Raw	WF
LS	5.000	9.000
SL	--	--
NC	3.000	3.267
WW	1.000	1.000
TOTAL	5.556	9.000

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	0	0	2	3	1	1	1	1	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	1	2	3	3	3	3
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	0	0	0	0	0	0	2	3	2	3	3	4	3	3

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	--	--	--	--	3.000	6.000	1.000	2.000	1.000	1.000	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--	0.000	0.000	1.800	2.567	1.800	1.800
WW	--	--	--	--	--	--	--	--	--	--	--	--	1.000	1.000
TOTAL	--	--	--	--	--	--	3.000	6.000	0.333	0.667	2.667	3.571	0.667	0.667

Table E19. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 2 Hrs before Low Tide | Duration of Test: 10 min Hmr 1,3A5 on | Treatment Type: 10 min continuous | Test Date: 2/26/88 | Test Time: 1047

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	1	3	0	0	0	0	0	0	0	0	1	3	1	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	4	4
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	1	3	0	0	0	0	0	0	2	2	3	5	4	6

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	1	2	0	0	4	4	5	6
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	1	2	0	0	4	4	5	6

CHI-SQUARE VALUES FOR 2 TEST PERIODS

	Raw	WF
LS	1.000	3.000
SL	--	--
NC	1.286	2.000
WW	--	--
TOTAL	0.500	0.091

CHI-SQUARE = 3.841 (d.f. = 1) (alpha = .05)

CHI-SQUARE F-HAT

	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	1	2	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	1	1	0	0	3	3
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	1	2	0	0	1	1	0	0	3	3

CHI-SQUARE VALUES

	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	--	--	1.000	3.000	--	--	--	--	--	--	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--	1.000	2.000	--	--	0.667	0.667
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	--	--	--	--	1.000	3.000	--	--	1.000	2.000	--	--	0.667	0.667

Table E20. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 30 min after Low Tide   Duration of Test: 10 min Hmr 1,3,&5 on   Treatment Type: 10 min continuous   Test Date: 2/26/88   Test Time: 1348

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	2	0	0	4	5	3	3	8	10	5	8
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	4	5	0	0	4	5	1	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	1	2	0	0	8	10	3	3	12	15	7	10

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE VALUES FOR 3 TEST PERIODS		
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF		Raw	WF
LS	0	0	0	0	2	5	2	4	1	2	3	4	0	0	8	15	LS	9.600	15.625
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	—	--
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NC	12.000	7.500
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	—	--
Total	0	0	0	0	2	5	2	4	1	2	3	4	0	0	8	15	TOTAL	9.714	15.000

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

CHI-SQUARE = 5.991 (d.f. = 2) (alpha = .05)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	2	1	2	0	1	2	3	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	2	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	1	2	1	2	0	1	4	5	1	1

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	—	—	—	—	2.000	7.500	2.000	4.000	—	2.000	5.500	4.667	6.000	6.000
SL	—	—	—	—	—	—	—	—	—	—	—	—	—	—
NC	—	—	—	—	—	—	—	—	—	—	12.000	7.500	—	—
WW	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL	—	—	—	—	2.000	7.500	2.000	4.000	—	2.000	7.250	9.200	6.000	6.000

Table E21. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 30 min before High Tide

Duration of Test: 10 min Hmr 1,3,A5 on
Treatment Type: 10 min continuous

Test Date: 2/26/88
Test Time: 1800

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 3 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	2	5	0	0	0	0	1	1	0	0	3	6	2	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	1	2	2	2	0	0	3	4	3	4
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	2	5	0	0	1	2	3	3	0	0	6	10	5	8

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CHI-SQUARE VALUES FOR 3 TEST PERIODS

	Raw	WF
LS	1.500	4.250
SL	--	--
NC	6.000	8.000
WW	--	--
TOTAL	6.000	10.625

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	2	5	0	0	0	0	0	0	0	0	2	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	2	2	3	2	2	1	1	6	8
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	2	5	1	2	2	3	2	2	1	1	8	13

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	3	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	1	1	2	1	1	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	1	3	0	1	1	2	2	2	0	0

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	4.000	6.667	--	--	--	--	--	--	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	2.000	2.000	1.500	4.000	4.000	--	--
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	--	--	--	--	4.000	6.667	--	2.000	2.000	1.500	1.500	1.500	--	--

Table E22. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 2 Hrs after High Tide | Duration of Test: 10 min Hmr 5 only | Treatment Type: 10 min continuous | Test Date: 2/26/88 | Test Time: 2040

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS:	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	2	3	8	10	1	1	11	14	11	14
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	2	3	8	10	1	1	11	14	11	14

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE VALUES FOR 2 TEST PERIODS:		
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF		Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	LS	--	--
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	--	--
NC	0	0	0	0	0	0	0	0	1	2	8	10	1	1	10	13	NC	0.048	0.037
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	--	--
Total	0	0	0	0	0	0	0	0	1	2	8	10	1	1	10	13	TOTAL	0.048	0.037

CHI-SQUARE = 3.841 (d.f. = 1) (alpha = .05)

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	2	3	8	10	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	2	3	8	10	1	1

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--	0.333	0.200	0.000	0.000	0.000	0.000
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	--	--	--	--	--	--	--	--	0.333	0.200	0.000	0.000	0.000	0.000

Table E23. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 4.5 Hrs before Low Tide | Duration of Test: 10 min 1,3,&5 on | Treatment Type: 10 min continuous | Test Date: 2/26/88 | Test Time: 2100

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-MAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-MAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	3	6	4	6	6	7	0	0	13	19	14	19
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	3	6	4	6	6	7	0	0	13	19	14	19

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	LS	--	--
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	--	--
NC	0	0	0	0	0	0	1	2	2	3	8	10	4	4	15	19	NC	0.143	0.000
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	--	--
Total	0	0	0	0	0	0	1	2	2	3	8	10	4	4	15	19	TOTAL	0.143	0.000

CHI-SQUARE F-MAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	2	4	3	5	7	9	2	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	2	4	3	5	7	9	2	2

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	1.000	2.000	0.667	1.000	0.286	0.529	4.000	4.000
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	--	--	--	--	--	--	1.000	2.000	0.667	1.000	0.286	0.529	4.000	4.000

Table E24. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 4 Hrs before Low Tide Duration of Test: 7 min 1&3 only Treatment Type: 7 min continuous Test Date: 2/26/88 Test Time: 2123

7 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	1	3	0	0	2	3	0	0	0	0	3	6	4	7
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	3	5	6	7	0	0	9	12	13	17
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Total	0	0	0	0	1	3	0	0	5	8	6	7	0	0	12	18	17	24

7 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS	Raw	WF
LS	0	0	0	0	0	0	4	8	0	0	0	0	0	0	4	8	LS	0.143	0.286
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	--	--
NC	0	0	0	0	0	0	1	2	3	5	5	6	8	8	17	21	NC	2.462	2.455
WW	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	WW	1.000	1.000
Total	0	0	0	0	0	0	5	10	3	5	6	7	8	8	22	30	TOTAL	2.941	3.000

CHI-SQUARE = 3.841 (d.f. = 1) (alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	1	2	2	4	1	2	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	1	3	5	6	7	4	4
WW	0	0	0	0	0	0	0	0	0	0	1	1	0	0
TOTAL	0	0	0	0	1	2	3	5	4	7	6	7	4	4

CHI SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	--	--	1.000	3.000	4.000	8.000	2.000	3.000	--	--	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	1.000	2.000	0.000	0.000	0.091	0.077	8.000	8.000
WW	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--
TOTAL	--	--	--	--	1.000	3.000	5.000	10.000	0.500	0.692	0.000	0.000	8.000	8.000

Table E25. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 3.5 Hrs before Low Tide | Duration of Test: 10 min Hmr 5 only | Treatment Type: 10 min continuous | Test Date: 2/26/88 | Test Time: 2140

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	5	0	0	2	4	2	3	1	1	0	0	6	13	4	7
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	3	6	14	21	15	19	4	4	36	50	26	35
WN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	5	0	0	5	10	16	24	16	20	4	4	42	63	29	42

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE VALUES FOR 2 TEST PERIODS		
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF		Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	LS	3.571	10.286
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	--	--
NC	0	0	0	0	0	0	0	0	4	6	7	9	4	4	15	19	NC	8.647	13.928
WN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WN	--	--
Total	0	0	0	0	0	0	0	0	4	6	8	10	4	4	16	20	TOTAL	11.655	22.277

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	3	0	0	1	2	1	2	1	1	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	2	3	9	14	11	14	4	4
WN	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	1	3	0	0	3	5	10	15	12	15	4	4

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	1.000	5.000	--	--	2.000	4.000	2.000	3.000	0.000	0.000	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	3.000	6.000	5.556	8.333	2.909	3.571	0.000	0.000
WN	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	--	--	1.000	5.000	--	--	5.000	10.000	7.200	10.800	2.667	3.333	0.000	0.000

Table E26. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 3 Hrs before Low Tide

Duration of Test: 10 min 1,3,05 on
Treatment Type: 10 min continuous

Test Date: 2/26/88
Test Time: 2200

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS: Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS: WF
LS	0	0	1	5	1	3	1	2	0	0	0	0	0	0	3	10	2	6
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	2	3	1	1	0	0	3	4	3	4
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	5	1	3	1	2	2	3	1	1	0	0	6	14	5	10

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS:	Raw	WF
LS	0	0	0	0	0	0	1	2	0	0	0	0	0	0	1	2	LS	1.000	5.333
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	--	--
NC	0	0	0	0	0	0	0	0	1	2	0	0	1	1	2	3	NC	0.200	0.143
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	--	--
Total	0	0	0	0	0	0	1	2	1	2	0	0	1	1	3	5	TOTAL	1.000	4.263

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	1	3	1	2	1	2	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	2	3	1	1	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	1	3	1	2	1	2	2	3	1	1	1	1

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	1.000	5.000	1.000	3.000	0.000	0.000	--	--	--	--	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--	0.333	0.200	1.000	1.000	1.000	1.000
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	--	--	1.000	5.000	1.000	3.000	0.000	0.000	0.333	0.200	1.000	1.000	1.000	1.000

Table E2?. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 3 Hrs before Low Tide   Duration of Test: 10 min 1&3 only   Treatment Type: 10 min continuous   Test Date: 2/26/88   Test Time: 2220

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	0	0	1	2	1	2	0	0	0	0	2	4	2	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	6
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Total	0	0	0	0	0	0	1	2	1	2	0	0	0	0	2	4	7	11

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	1	5	0	0	0	0	0	0	0	0	0	0	1	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	1	2	6	7	3	3	10	12
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Total	0	0	1	5	0	0	0	0	1	2	6	7	4	4	12	18

CHI-SQUARE VALUES FOR 2 TEST PERIODS

	Raw	WF
LS	0.333	0.111
SL	--	--
NC	10.000	12.000
WW	1.000	1.000
TOTAL	7.143	8.909

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	1	3	0	0	1	1	1	1	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	1	1	3	4	2	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	0	0	1	3	0	0	1	1	1	2	3	4	2	2

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	1.000	5.000	--	--	1.000	2.000	1.000	2.000	--	--	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--	1.000	2.000	6.000	7.000	3.000	3.000
WW	--	--	--	--	--	--	--	--	--	--	--	--	1.000	1.000
TOTAL	--	--	1.000	5.000	--	--	1.000	2.000	0.000	0.000	6.000	7.000	4.000	4.000

Table E2R. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 2.5 Hrs before Low Tide | Duration of Test: 10 min Hmr 5 only | Treatment Type: 10 min continuous | Test Date: 2/26/88 | Test Time: 2240

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS:	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	3	3
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
MC	0	0	0	0	0	0	0	0	3	5	7	9	2	2	12	16	19	25
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Total	0	0	0	0	0	0	0	0	3	5	8	10	2	2	13	17	23	30

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE VALUES FOR 2 TEST PERIODS		
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF		Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	3	4	1	1	4	5	LS	1.800	2.667
SL	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	SL	1.000	1.000
MC	0	0	0	0	0	0	0	0	10	15	11	14	5	5	26	34	MC	5.158	6.400
WW	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	WW	2.000	2.000
Total	0	0	0	0	0	0	0	0	10	15	14	18	9	9	33	42	TOTAL	9.696	10.533

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	2	3	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	1	1
MC	0	0	0	0	0	0	0	0	7	10	9	12	4	4
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	0	0	0	0	0	0	0	0	7	10	11	14	6	6

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	--	--	--	--	--	--	1.000	1.800	1.000	1.000
SL	--	--	--	--	--	--	--	--	--	--	--	--	1.000	1.000
MC	--	--	--	--	--	--	--	--	3.769	5.000	0.889	1.087	1.286	1.286
WW	--	--	--	--	--	--	--	--	--	--	--	--	2.000	2.000
TOTAL	--	--	--	--	--	--	--	--	3.769	5.000	1.636	2.286	4.455	4.455

Table E29. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 2.5 Hrs before Low Tide | Duration of Test: 10 min 1,3,45 on | Test Date: 2/26/88
Treatment Type: 10 min continuous | Test Time: 2300

10 MINUTES DURING TEST PERIOD

RANGE <meters>

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	2	1	2	2	2	0	0	4	6	2	3
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	2	15	23	12	15	8	8	36	48	26	34
WW	0	0	0	0	0	0	0	0	0	0	2	2	1	1	3	3	5	5
Total	0	0	0	0	0	0	2	4	16	25	16	19	9	9	43	57	32	41

10 MINUTES AFTER TEST PERIOD

RANGE <meters>

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE VALUES FOR 2 TEST PERIODS		
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF		Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	LS	4.000	6.000
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	--	--
NC	0	0	0	0	0	0	0	0	4	6	9	11	2	2	15	19	NC	8.647	12.552
WW	0	0	0	0	0	0	0	0	0	0	2	2	4	4	6	6	WW	1.000	1.000
Total	0	0	0	0	0	0	0	0	4	6	11	13	6	6	21	25	TOTAL	7.563	12.488

CHI-SQUARE = 3.841
<d.f. = 1>
<alpha = .05>

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	1	1	1	1	1	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	1	10	15	11	13	5	5
WW	0	0	0	0	0	0	0	0	0	0	2	2	3	3
TOTAL	0	0	0	0	0	0	1	2	10	16	14	16	8	8

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	--	--	--	--	1.000	2.000	1.000	2.000	2.000	2.000	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	1.000	2.000	6.368	9.966	0.429	0.615	3.600	3.600
WW	--	--	--	--	--	--	--	--	--	--	0.000	0.000	1.800	1.800
TOTAL	--	--	--	--	--	--	2.000	4.000	7.200	11.645	0.926	1.125	0.600	0.600

Table E30. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 2 Hrs before Low Tide

Duration of Test: 10 min 1,3,65 on

Treatment Type: 10 min continuous

Test Date: 2/26/88

Test Time: 2320

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	2	4	5	8	4	5	0	0	11	17
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	2	12	18	11	14	5	5	29	39
WW	0	0	0	0	0	0	0	0	2	3	3	4	3	3	8	10
Total	0	0	0	0	0	0	3	6	19	29	18	23	8	8	48	66

CHI-SQUARE F-HAT FOR 2 TEST PERIODS:

Trace Type	Raw	WF
LS	8	12
SL	0	0
NC	24	32
WW	7	8
Total	38	51

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	3	5	1	1	0	0	4	6
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	2	4	6	12	15	1	1	18	24
WW	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5
Total	0	0	0	0	0	0	1	2	7	11	13	16	6	6	27	35

CHI-SQUARE VALUES FOR 2 TEST PERIODS:

	Raw	WF
LS	3.267	5.261
SL	--	--
NC	2.574	3.571
WW	0.692	1.667
TOTAL	5.890	9.515

CHI-SQUARE = 3.841 (d.f. = 1) (alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	0	0	1	2	4	7	3	3	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	2	8	12	12	15	3	3
WW	0	0	0	0	0	0	0	0	1	2	2	2	4	4
TOTAL	0	0	0	0	0	0	2	4	13	20	16	20	7	7

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	--	--	--	--	2.000	4.000	0.500	0.692	1.800	2.667	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	0.000	0.000	4.000	6.000	0.043	0.034	2.667	2.667
WW	--	--	--	--	--	--	--	--	2.000	3.000	3.000	4.000	0.500	0.500
TOTAL	--	--	--	--	--	--	1.000	2.000	5.538	8.100	0.806	1.256	0.286	0.286

Table E31. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 1.5 Hrs before Low Tide | Duration of Test: 10 min 1,3,&5 on | Test Date: 2/26/88
Treatment Type: 10 min continuous | Test Time: 2342

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	0	0	0	0	0	0	2	2	0	0	2	2	4	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
NC	0	0	0	0	0	0	4	8	19	29	18	22	4	4	45	63	33	45
WW	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	3	3
Total	0	0	0	0	0	0	4	8	19	29	20	24	6	6	49	67	41	54

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS	Raw	WF
LS	0	0	0	0	0	0	0	0	1	2	5	6	0	0	6	8	LS	2.000	3.600
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	SL	1.000	1.000
NC	0	0	0	0	0	0	1	2	5	8	8	10	7	7	21	27	NC	8.727	14.400
WW	0	0	0	0	0	0	0	0	0	0	2	2	2	2	4	4	WW	0.667	0.667
Total	0	0	0	0	0	0	1	2	6	10	16	19	9	9	32	40	TOTAL	3.568	6.813

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	0	0	0	0	1	1	4	4	0	0
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0
NC	0	0	0	0	0	0	3	5	12	19	13	16	6	6
WW	0	0	0	0	0	0	0	0	0	0	1	1	2	2
TOTAL	0	0	0	0	0	0	3	5	13	20	18	22	8	8

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	--	--	--	--	--	--	1.000	2.000	1.286	2.000	--	--
SL	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--
NC	--	--	--	--	--	--	1.800	3.600	8.167	11.919	3.846	4.500	0.818	0.818
WW	--	--	--	--	--	--	--	--	--	--	2.000	2.000	0.000	0.000
TOTAL	--	--	--	--	--	--	1.800	3.600	6.760	9.256	0.444	0.581	0.600	0.600

Table E32. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 1.5 Hr before Low Tide | Duration of Test: 10 min 1,3,65 on | Treatment Type: 10 min continuous | Test Date: 2/27/88 | Test Time: 0002

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	4	27	0	0	0	0	0	0	8	12	2	2	1	1	15	42	9	25
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	1	3	1	2	7	11	10	12	3	3	22	31	22	30
WW	0	0	0	0	0	0	0	0	1	2	0	0	3	3	4	5	4	4
Total	4	27	0	0	1	3	1	2	16	25	12	14	7	7	41	78	34	58

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	1	3	1	2	1	2	0	0	0	0	3	7
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	2	5	8	13	16	2	2	21	28
WW	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3
Total	0	0	0	0	1	3	2	4	6	10	13	16	5	5	27	38

CHI-SQUARE VALUES FOR 2 TEST PERIODS

	Raw	WF
LS	8.000	25.000
SL	--	--
NC	0.023	0.153
WW	0.143	0.500
TOTAL	2.882	13.793

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	2	14	0	0	1	2	1	1	5	7	1	1	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	1	2	1	2	6	10	12	14	3	3
WW	0	0	0	0	0	0	0	0	1	1	0	0	3	3
TOTAL	2	14	0	0	1	3	2	3	11	18	13	15	6	6

CHI-SQUARE VALUES

	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	4.000	27.000	--	--	1.000	3.000	1.000	2.000	5.444	7.143	2.000	2.000	1.000	1.000
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	1.000	3.000	0.000	0.000	0.333	0.474	0.391	0.571	0.200	0.200
WW	--	--	--	--	--	--	--	--	1.000	2.000	--	--	0.000	0.000
TOTAL	4.000	27.000	--	--	0.000	0.000	0.333	0.667	4.545	6.429	0.040	0.133	0.333	0.333

Table E33. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 1.5 Hr before High Tide

Duration of Test: 10 min 1,3,65 on
Treatment Type: 10 min continuous

Test Date: 2/27/88
Test Time: 1750

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 3 TEST PERIODS WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
SL	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	2	1	2
NC	0	0	0	0	0	0	2	4	0	0	11	14	2	2	15	20	22	32
WW	0	0	0	0	0	0	0	0	0	0	8	10	7	7	15	17	9	11
Total	0	0	0	0	0	0	2	4	1	2	19	24	9	9	31	39	33	45

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2
SL	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	2
NC	0	0	0	0	1	3	9	17	8	12	10	12	9	9	37	53
WW	0	0	0	0	0	0	0	0	3	5	2	2	1	1	6	8
Total	0	0	0	0	1	3	9	17	12	19	13	15	11	11	46	65

CHI-SQUARE VALUES FOR 3 TEST PERIODS

	Raw	WF
LS	2.000	2.000
SL	0.000	-0.500
NC	16.091	21.281
WW	6.444	4.909
TOTAL	9.697	14.889

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
NC	0	0	0	0	2	5	2	4	4	6	4	5	4	4	16	24
WW	0	0	0	0	0	0	0	0	0	0	3	4	4	4	7	8
Total	0	0	0	0	2	5	2	4	4	6	8	10	8	8	24	33

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0
NC	0	0	0	0	1	3	4	8	4	6	8	10	5	5
WW	0	0	0	0	0	0	0	0	1	2	4	5	4	4
TOTAL	0	0	0	0	1	3	4	8	6	9	13	16	9	9

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SL	--	--	--	--	--	--	--	--	0.000	4.000	--	--	--	--
NC	--	--	--	--	2.000	3.333	9.250	15.125	8.000	12.000	4.625	5.500	5.200	5.200
WW	--	--	--	--	--	--	--	--	6.000	7.500	6.250	8.000	4.500	4.500
TOTAL	--	--	--	--	2.000	3.333	9.250	15.125	9.833	17.556	5.692	7.313	1.556	1.556

Table E34. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 1.5 Hr before High Tide | Duration of Test: 10 min 1,3,&5 on | Treatment Type: 10 min continuous | Test Date: 2/27/88 | Test Time: 1810

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	5	0	0	0	0	0	0	0	0	0	0	1	5	2	4
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	2	0	0	8	10	9	9	18	21	19	24
WW	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	2	3	4
Total	0	0	1	5	0	0	1	2	1	2	8	10	9	9	20	28	24	31

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE VALUES FOR 2 TEST PERIODS		
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF		Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	2	2	0	0	2	2	LS	0.333	1.286
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	--	--
NC	0	0	0	0	1	3	0	0	7	11	3	4	9	9	20	27	NC	0.105	0.750
WW	0	0	0	0	0	0	0	0	0	0	1	1	4	4	5	5	WW	2.667	1.286
Total	0	0	0	0	1	3	0	0	7	11	6	7	13	13	27	34	TOTAL	1.043	0.581

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	3	0	0	0	0	0	0	1	1	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	1	2	1	1	4	6	6	7	9	9
WW	0	0	0	0	0	0	0	0	1	1	1	1	2	2
TOTAL	0	0	1	3	1	2	1	1	4	7	7	9	11	11

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	1.000	5.000	--	--	--	--	--	--	2.000	2.000	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	1.000	3.000	1.000	2.000	7.000	11.000	2.273	2.571	0.000	0.000
WW	--	--	--	--	--	--	--	--	1.000	2.000	1.000	1.000	4.000	4.000
TOTAL	--	--	1.000	5.000	1.000	3.000	1.000	2.000	4.500	6.231	0.286	0.529	0.727	0.727

Table E35. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase: 1 Hr before High Tide

Duration of Test: 10 min Hmr 1,3,&5 on

Treatment Type: 10 min continuous

Test Date: 2/27/88

Test Time: 1830

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	7	0	0	0	0	0	0	1	2	0	0	1	1	3	10	2	6
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	1
NC	0	0	0	0	1	3	12	23	15	23	10	12	4	4	42	65	32	48
WW	0	0	0	0	0	0	1	2	3	5	2	2	2	2	8	11	5	6
Total	1	7	0	0	1	3	13	25	19	30	13	15	7	7	54	87	39	60

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE VALUES FOR 2 TEST PERIODS		
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF		Raw	WF
LS	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	2	LS	1.000	5.333
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	1.000	1.000
NC	0	0	0	0	1	3	1	2	5	8	11	14	3	3	21	30	NC	7.000	12.895
WW	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	WW	5.444	8.333
Total	0	0	0	0	1	3	1	2	6	10	11	14	4	4	23	33	TOTAL	12.481	24.300

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	4	0	0	0	0	0	0	1	2	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0
NC	0	0	0	0	1	3	7	13	10	16	11	13	4	4
WW	0	0	0	0	0	0	1	1	2	3	1	1	2	2
TOTAL	1	4	0	0	1	3	7	14	13	20	12	15	6	6

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1.000	7.000	--	--	--	--	--	--	0.000	0.000	--	--	1.000	1.000
SL	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--
NC	--	--	--	--	0.000	0.000	9.308	17.640	5.000	7.258	0.040	0.154	0.143	0.143
WW	--	--	--	--	--	--	1.000	2.000	3.000	5.000	2.000	2.000	0.333	0.333
TOTAL	1.000	7.000	--	--	0.000	0.000	10.286	19.593	6.760	10.000	0.167	0.034	0.818	0.818

Table E36. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 35.

Tidal Phase:	30 min before High Tide	Duration of Test:	10 min Hmr 1&3 on	Test Date:	2/27/1850
		Treatment Type:	10 min continuous	Test Time:	1850

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	5	0	0	0	0	1	2	0	0	0	0	2	7	2	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	5	1	3	0	0	5	8	7	9	4	4	18	29	17	24
WW	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	2	2
Total	0	0	2	10	1	3	0	0	6	10	8	10	4	4	21	37	20	30

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	2	0	0	0	0	0	0	1	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	4	6	9	11	2	2	15	19
WW	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2
Total	0	0	0	0	0	0	1	2	4	6	9	11	4	4	18	23

CHI-SQUARE VALUES FOR 2 TEST PERIODS	Raw	WF
LS	0.333	2.778
SL	—	ERR
NC	0.273	2.083
WW	0.333	0.333
TOTAL	0.231	3.267

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	3	0	0	1	1	1	1	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	3	1	2	0	0	5	7	8	10	3	3
WW	0	0	0	0	0	0	0	0	0	0	1	1	1	1
TOTAL	0	0	1	5	1	2	1	1	5	8	9	11	4	4

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	—	—	1.000	5.000	—	—	1.000	2.000	1.000	2.000	—	—	—	—
SL	—	—	—	—	—	—	—	—	—	—	—	—	—	—
NC	—	—	1.000	5.000	1.000	3.000	—	—	0.111	0.286	0.250	0.200	0.667	0.667
WW	—	—	—	—	—	—	—	—	—	—	1.000	1.000	2.000	2.000
TOTAL	—	—	2.000	10.000	1.000	3.000	1.000	2.000	0.400	1.000	0.059	0.048	0.000	0.000

Table E37. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 2 Hrs before low tide | Duration of Test: 5 min, hrs 1&3 | Treatment Type: 10 sec on, 20 sec off | Test Date: 3/3/88 | Test Time: 0320

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	3	8	3	6	4	6	2	2	0	0	12	22	15	28
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	3	8	3	6	4	6	2	2	0	0	12	22	15	28

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS	Raw	WF
LS	1	7	1	5	0	0	0	0	10	15	6	7	0	0	18	34	LS	1.200	2.571
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	--	--
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NC	--	--
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	--	--
Total	1	7	1	5	0	0	0	0	10	15	6	7	0	0	18	34	TOTAL	1.200	2.571

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	1	4	1	3	2	4	2	3	7	11	4	5	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	4	1	3	2	4	2	3	7	11	4	5	0	0

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	1.000	7.000	1.000	5.000	3.000	8.000	3.000	6.000	2.571	3.857	2.000	2.778	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--	--	--	--	--	--	--
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	1.000	7.000	1.000	5.000	3.000	8.000	3.000	6.000	2.571	3.857	2.000	2.778	--	--

CHI-SQUARE = 3.841 (d.f. = 1) (alpha = .05)

Table E38. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 1.5 hrs before low tide | Duration of Test: 5 min, hwrs 1&3 | Treatment Type: 5 min continuously | Test Date: 3/3/88 | Test Time: 0340

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	1	2	2	3	6	7	0	0	9	12	9	17
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	2
NC	0	0	0	0	0	0	0	0	1	2	1	1	0	0	2	3	1	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	1	2	3	5	8	9	0	0	12	16	11	20

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE VALUES FOR 2 TEST PERIODS		
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF		Raw	WF
LS	1	7	1	5	0	0	0	0	3	5	4	5	0	0	9	22	LS	0.000	2.941
SL	0	0	0	0	0	0	1	2	0	0	0	0	0	0	1	2	SL	0.000	0.333
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NC	2.000	3.000
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	—	—
Total	1	7	1	5	0	0	1	2	3	5	4	5	0	0	10	24	TOTAL	0.182	1.600

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	4	1	3	0	0	1	1	3	4	5	6	0	0
SL	0	0	0	0	0	0	1	1	0	0	1	1	0	0
NC	0	0	0	0	0	0	0	0	1	1	1	1	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	4	1	3	0	0	1	2	3	5	6	7	0	0

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1.000	7.000	1.000	5.000	—	—	1.000	2.000	0.200	0.500	0.400	0.333	—	—
SL	—	—	—	—	—	—	1.000	2.000	—	—	1.000	1.000	—	—
NC	—	—	—	—	—	—	—	—	1.000	2.000	1.000	1.000	—	—
WW	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL	1.000	7.000	1.000	5.000	—	—	0.000	0.000	0.000	0.000	1.333	1.143	—	—

Table E39. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 1.5 hrs before low tide   Duration of Test: 5 min, hwrs 1&3   Treatment Type: 5 min continuously   Test Date: 3/3/88   Test Time: 0350

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	1	7	0	0	1	3	0	0	1	2	2	2	4	4	9	18	9	23
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
NC	0	0	0	0	0	0	1	2	0	0	2	2	1	1	4	5	2	3
WB	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	1
Total	1	7	0	0	1	3	1	2	1	2	5	5	5	5	14	24	12	27

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	2	14	1	5	1	3	1	2	0	0	3	4	0	0	8	28
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	14	1	5	1	3	1	2	0	0	4	5	0	0	9	29

CHI-SQUARE VALUES FOR 2 TEST PERIODS	Raw	WF
LS	0.059	2.174
SL	1.000	1.000
NC	4.000	5.000
WW	1.000	1.000
TOTAL	1.087	0.472

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	2	11	1	3	1	3	1	1	1	1	3	3	2	2
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0
NC	0	0	0	0	0	0	1	1	0	0	1	1	1	1
WB	0	0	0	0	0	0	0	0	0	0	1	1	0	0
TOTAL	2	11	1	3	1	3	1	2	1	1	5	5	3	3

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0.333	2.333	1.000	5.000	0.000	0.000	1.000	2.000	1.000	2.000	0.200	0.667	4.000	4.000
SL	---	---	---	---	---	---	---	---	---	---	1.000	1.000	---	---
NC	---	---	---	---	---	---	1.000	2.000	---	---	2.000	2.000	1.000	1.000
WB	---	---	---	---	---	---	---	---	---	---	1.000	1.000	---	---
TOTAL	0.333	2.333	1.000	5.000	0.000	0.000	0.000	0.000	1.000	2.000	0.111	0.000	5.000	5.000

Table E40. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 1.2 hrs before low tide | Duration of Test: 5 min, hrs 1&3 | Treatment Type: 10 sec on, 20 sec off | Test Date: 3/3/88 | Test Time: 0400

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	7	1	5	3	8	3	6	1	2	4	5	0	0	13	33	9	19
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MC	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	7	1	5	3	8	3	6	1	2	5	6	1	1	15	35	10	20

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	4	5	0	0	4	5
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	4	5	0	0	4	5

CHI-SQUARE VALUES FOR 2 TEST PERIODS

	Raw	WF
LS	4.765	20.632
SL	—	—
MC	2.000	2.000
WW	—	—
TOTAL	6.368	22.500

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	4	1	3	2	4	2	3	1	1	4	5	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MC	0	0	0	0	0	0	0	0	0	0	1	1	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	4	1	3	2	4	2	3	1	1	5	6	1	1

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1.000	7.000	1.000	5.000	3.000	8.000	3.000	6.000	1.000	2.000	0.000	0.000	—	—
SL	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MC	—	—	—	—	—	—	—	—	—	—	1.000	1.000	1.000	1.000
WW	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL	1.000	7.000	1.000	5.000	3.000	8.000	3.000	6.000	1.000	2.000	0.111	0.091	1.000	1.000

Table E41. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 1 hr before low tide | Duration of Test: 5 min, hrs 1&3 | Test Date: 3/03/88
Treatment Type: 10 sec on, 20 sec off | Test Time: 0410

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	2	9	2	5	9	17	1	2	4	5	3	3	21	41	18	32
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	3
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	2	9	2	5	9	17	1	2	5	6	4	4	23	43	20	35

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE VALUES FOR 2 TEST PERIODS		
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF		Raw	WF
LS	0	0	0	0	1	3	1	2	1	2	12	15	0	0	15	22	LS	1.000	5.730
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	--	--
NC	0	0	0	0	1	3	0	0	0	0	0	0	1	1	2	4	NC	0.000	0.667
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	--	--
Total	0	0	0	0	2	6	1	2	1	2	12	15	1	1	17	26	TOTAL	0.900	4.188

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	5	2	4	5	10	1	2	8	10	2	2
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	1	2	0	0	0	0	1	1	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	1	5	2	6	5	10	1	2	9	11	3	3

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	2.000	9.000	0.333	0.500	6.400	11.842	0.000	0.000	4.000	5.000	3.000	3.000
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	1.000	3.000	--	--	--	--	1.000	1.000	0.000	0.000
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	--	--	2.000	9.000	0.000	0.091	6.400	11.842	0.000	0.000	2.882	3.857	1.800	1.800

Table E42. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 1 hr before low tide — Duration of Test: 5 min, hrs 1&3 — Treatment Type: 5 min continuously — Test Date: 3/3/88 — Test Time: 0420

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	1	7	2	9	1	3	1	2	1	2	4	5	2	2	12	30	10	30
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	7	2	9	1	3	1	2	1	2	4	5	2	2	12	30	11	31

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS	Raw	WF
LS	2	14	2	9	2	5	0	0	0	0	1	1	0	0	7	29	LS	1.316	0.017
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	--	--
NC	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	NC	2.000	2.000
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	--	--
Total	2	14	2	9	2	5	0	0	0	0	2	2	1	1	9	31	TOTAL	0.429	0.016

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	2	11	2	9	2	4	1	1	1	1	3	3	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	2	11	2	9	2	4	1	1	1	1	3	4	2	2

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0.333	2.333	0.000	0.000	0.333	0.500	1.000	2.000	1.000	2.000	1.800	2.667	2.000	2.000
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--	--	--	1.000	1.000	1.000	1.000
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.333	2.333	0.000	0.000	0.333	0.500	1.000	2.000	1.000	2.000	0.667	1.286	0.333	0.333

Table E43. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 50 min before low tide | Duration of Test: 5 min, hmrs 1,365 | Test Date: 3/3/88
Treatment Type: 5 min continuously | Test Time: 0430

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	4	11	4	8	2	3	6	7	0	0	16	29	13	28
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	4	11	4	8	2	3	7	8	0	0	17	30	14	29

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS	Raw	WF
LS	0	0	3	14	2	5	0	0	3	5	2	2	0	0	10	26	LS	1.385	0.164
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	--	--
NC	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	NC	0.000	0.000
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	--	--
Total	0	0	3	14	2	5	0	0	3	5	3	3	0	0	11	27	TOTAL	1.286	0.158

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	2	7	3	8	2	4	3	4	4	5	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	2	7	3	8	2	4	3	4	5	6	0	0

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	3.000	14.000	0.667	2.250	4.000	8.000	0.200	0.500	2.000	2.778	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--	--	--	0.000	0.000	--	--
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	--	--	3.000	14.000	0.667	2.250	4.000	8.000	0.200	0.500	1.600	2.273	--	--

Table E44. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 40 min before low tide | Duration of Test: 5 min, hrs 1,3&5 | Treatment Type: 10 sec on, 20 sec off | Test Date: 3/03/88 | Test Time: 0440

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	2	14	2	9	0	0	0	0	1	2	3	4	0	0	8	29	8	21
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	14	2	9	0	0	0	0	1	2	3	4	0	0	8	29	8	21

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	3	1	2	3	5	2	2	0	0	7	12
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	1	3	1	2	3	5	2	2	0	0	7	12

CHI-SQUARE VALUES FOR 2 TEST PERIODS	Raw	WF
LS	0.067	7.049
SL	--	--
MC	--	--
WW	--	--
TOTAL	0.067	7.049

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	7	1	5	1	2	1	1	2	4	3	3	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MC	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	7	1	5	1	2	1	1	2	4	3	3	0	0

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	2.000	14.000	2.000	9.000	1.000	3.000	1.000	2.000	1.000	1.286	0.200	0.667	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MC	--	--	--	--	--	--	--	--	--	--	--	--	--	--
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	2.000	14.000	2.000	9.000	1.000	3.000	1.000	2.000	1.000	1.286	0.200	0.667	--	--

Table E45. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 30 min before low tide | Duration of Test: 5 min, hmrs 1,385 | Test Date: 3/03/88
Treatment Type: 10 sec on, 20 sec off | Test Time: 0450

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	1	7	1	5	4	11	4	8	4	6	4	5	2	2	20	44	16	40
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	2	2	1	1	3	3	2	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	7	1	5	4	11	4	8	4	6	6	7	3	3	23	47	17	41

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	2	14	1	5	3	8	1	2	1	2	3	4	0	0	11	35
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	14	1	5	3	8	1	2	1	2	3	4	0	0	11	35

CHI-SQUARE VALUES FOR 2 TEST PERIODS	Raw	WF
LS	2.613	1.025
SL	--	--
NC	3.000	3.000
WW	--	--
TOTAL	4.235	1.756

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	2	11	1	5	4	10	3	5	3	4	4	5	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	2	11	1	5	4	10	3	5	3	4	5	6	2	2

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0.333	2.333	0.000	0.000	0.143	0.474	1.800	3.600	1.800	2.000	0.143	0.111	2.000	2.000
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--	--	--	2.000	2.000	1.000	1.000
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.333	2.333	0.000	0.000	0.143	0.474	1.800	3.600	1.800	2.000	1.000	0.818	3.000	3.000

Table E46. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 1.4 hrs before low tide | Duration of Test: 10 min, hwrs 1,365 | Treatment Type: 10 min continuously | Test Date: 3/03/88 | Test Time: 1600

10 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 3 TEST PERIODS WF
LS	0	0	0	0	3	8	8	16	2	3	2	2	0	0	15	29	14	29
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	5	3	8	0	0	0	0	2	2	0	0	6	15	2	6
WW	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	2	1	1
Total	0	0	1	5	6	16	8	16	3	5	4	4	0	0	22	46	17	37

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	2	14	1	5	1	3	3	6	3	5	10	12	0	0	20	45
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	14	1	5	1	3	3	6	3	5	10	12	0	0	20	45

CHI-SQUARE VALUES FOR 3 TEST PERIODS

	Raw	WF
LS	6.214	17.586
SL	--	--
NC	11.500	21.000
WW	0.000	4.000
TOTAL	5.765	11.730

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	1	7	0	0	0	0	2	4	1	2	2	2	0	0	6	15
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	1	3	0	0	0	0	0	0	0	0	1	3
WW	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	2
Total	1	7	0	0	1	3	2	4	2	4	2	2	0	0	8	20

CHI-SQUARE = 5.991
(d.f. = 2)
(alpha = .05)

CHI-SQUARE F-HAT

	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	1	7	0	2	1	4	4	9	2	3	5	5	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	2	1	4	0	0	0	0	1	1	0	0
WW	0	0	0	0	0	0	0	0	1	1	0	0	0	0
TOTAL	1	7	1	3	3	7	4	9	3	5	5	6	0	0

CHI-SQUARE VALUES

	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	2.000	14.000	--	7.500	6.000	7.250	6.250	8.222	1.000	2.667	7.600	14.400	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	7.500	6.000	7.250	--	--	--	--	2.000	2.000	--	--
WW	--	--	--	--	--	--	--	--	0.000	4.000	--	--	--	--
TOTAL	2.000	14.000	0.000	6.667	4.667	17.143	6.250	8.222	-0.667	-0.800	8.000	9.333	--	--

Table E47. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 1 hr before low tide | Duration of Test: 10 min, hwrs 1,365 | Test Date: 3/03/88
Treatment Type: 10 min continuously | Test Time: 1620

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	7	1	5	0	0	1	2	3	5	2	2	0	0	8	21
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	1	2	3	4	0	0	4	6
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	7	1	5	0	0	1	2	4	7	5	6	0	0	12	27

CHI-SQUARE F-HAT FOR 2 TEST PERIODS

Trace Type	Raw	WF
LS	11	26
SL	0	0
NC	3	4
WW	0	0
Total	14	30

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	7	1	5	0	0	3	6	8	12	1	1	0	0	14	31
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	7	1	5	0	0	3	6	9	14	1	1	0	0	15	33

CHI-SQUARE VALUES FOR 2 TEST PERIODS

	Raw	WF
LS	1.636	1.923
SL	--	--
NC	1.800	2.000
WW	--	--
TOTAL	0.333	0.600

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	7	1	5	0	0	2	4	6	9	2	2	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	1	2	2	2	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	7	1	5	0	0	2	4	7	11	3	4	0	0

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0.000	0.000	0.000	0.000	--	--	1.000	2.000	2.273	2.882	0.333	0.333	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--	0.000	0.000	3.000	4.000	--	--
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.000	0.000	0.000	0.000	--	--	1.000	2.000	1.923	2.333	2.667	3.571	--	--

Table E48. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 20 min before low tide | Duration of Test: 7 min, hmrs 1,345 | Treatment Type: 7 min continuously | Test Date: 3/03/88 | Test Time: 1643

7 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	1	7	1	5	3	8	1	2	0	0	2	2	0	0	8	24	8	27
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	7	1	5	3	6	1	2	0	0	2	2	0	0	8	24	9	28

7 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	2	14	1	5	1	3	3	6	0	0	1	1	0	0	8	29
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
NC	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	14	1	5	1	3	3	6	0	0	3	3	0	0	10	31

CHI-SQUARE VALUES FOR 2 TEST PERIODS

	Raw	WF
LS	0.000	0.472
SL	1.000	1.000
NC	1.000	1.000
WW	--	--
TOTAL	0.222	0.891

CHI-SQUARE = 3.841 (d.f. = 1) (alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	2	11	1	5	2	6	2	4	0	0	2	2	0	0
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	2	11	1	5	2	6	2	4	0	0	3	3	0	0

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0.333	2.333	0.000	0.000	1.000	2.273	1.000	2.000	--	--	0.333	0.333	--	--
SL	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--
NC	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.333	2.333	0.000	0.000	1.000	2.273	1.000	2.000	--	--	0.200	0.200	--	--

Table E49. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: At low tide

Duration of Test: 10 min, hmrs 1,385 — Treatment Type: 10 min continuously

Test Date: 3/03/88 — Test Time: 1700

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	4	27	5	23	2	5	2	4	3	5	6	7	0	0	22	71	26	76
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	3	4	0	0	3	4	2	3
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	4	27	5	23	2	5	2	4	3	5	9	11	0	0	25	75	28	78

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS	Raw	WF
LS	2	14	7	32	1	3	5	10	9	14	6	7	0	0	30	80	LS	1.231	0.536
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	--	--
NC	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	NC	1.000	1.800
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	--	--
Total	2	14	7	32	1	3	5	10	9	14	6	7	1	1	31	81	TOTAL	0.643	0.231

CHI-SQUARE = 3.841 (d.f. = 1) (alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	3	21	6	28	2	4	4	7	6	10	6	7	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	2	2	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3	21	6	28	2	4	4	7	6	10	8	9	1	1

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0.667	4.122	0.333	1.473	0.333	0.500	1.286	2.571	3.000	4.263	0.000	0.000	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	--	--	--	--	3.000	4.000	1.000	1.000
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.667	4.122	0.333	1.473	0.333	0.500	1.286	2.571	3.000	4.263	0.600	0.889	1.000	1.000

Table E50. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 20 min after low tide
Duration of Test: 10 min, hrs 1,385
Treatment Type: 10 sec on, 20 sec off
Test Date: 3/03/88
Test Time: 1720

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	6	41	5	23	12	33	5	10	6	9	9	11	0	0	43	127	36	109
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5
NC	0	0	0	0	0	0	0	0	1	2	1	1	0	0	2	3	2	3
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	6	41	5	23	12	33	5	10	7	11	10	12	0	0	45	130	40	116

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE VALUES FOR 2 TEST PERIODS		
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF		Raw	WF
LS	4	27	7	32	5	14	2	4	4	6	5	6	2	2	29	91	LS	2.722	5.945
SL	1	7	0	0	0	0	0	0	0	0	2	2	0	0	3	9	SL	3.000	9.000
NC	0	0	0	0	0	0	0	0	0	0	2	2	0	0	2	2	NC	0.000	0.200
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	--	--
Total	5	34	7	32	5	14	2	4	4	6	9	10	2	2	34	102	TOTAL	1.532	3.379

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	5	34	6	28	9	24	4	7	5	8	7	9	1	1
SL	1	4	0	0	0	0	0	0	0	0	1	1	0	0
NC	0	0	0	0	0	0	0	0	1	1	2	2	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	6	38	6	28	9	24	4	7	6	9	10	11	1	1

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0.400	2.882	0.333	1.473	2.882	7.681	1.286	2.571	0.400	0.600	1.143	1.471	2.000	2.000
SL	1.000	7.000	--	--	--	--	--	--	--	--	2.000	2.000	--	--
NC	--	--	--	--	--	--	--	--	1.000	2.000	0.333	0.333	--	--
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.091	0.653	0.333	1.473	2.882	7.681	1.286	2.571	0.818	1.471	0.053	0.182	2.000	2.000

Table E51. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 40 min after low tide | Duration of Test: 10 min, hmrs 1,345 | Treatment Type: 10 sec on, 20 sec off | Test Date: 3/03/88 | Test Time: 1740

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	3	20	5	23	5	14	6	12	0	0	5	6	0	0	24	75	22	66
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	2	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	3	20	5	23	5	14	6	12	0	0	6	7	0	0	25	76	23	68

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	4	27	2	9	1	3	1	2	9	14	2	2	0	0	19	57
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	4	27	2	9	1	3	1	2	9	14	3	3	1	1	21	59

CHI-SQUARE VALUES FOR 2 TEST PERIODS

	Raw	WF
LS	0.581	2.455
SL	—	—
NC	0.333	0.333
WW	—	—
TOTAL	0.348	2.141

CHI-SQUARE F-HAT

	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	4	24	4	16	3	9	4	7	5	7	4	4	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	1	1	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	4	24	4	16	3	9	4	7	5	7	5	5	1	1

CHI-SQUARE VALUES

	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0.143	1.043	1.286	6.125	2.667	7.118	3.571	7.143	9.000	14.000	1.286	2.000	—	—
SL	—	—	—	—	—	—	—	—	—	—	—	—	—	—
NC	—	—	—	—	—	—	—	—	—	—	0.000	0.000	1.000	1.000
WW	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL	0.143	1.043	1.286	6.125	2.667	7.118	3.571	7.143	9.000	14.000	1.000	1.600	1.000	1.000

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

Table E52. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 1 hr after low tide | Duration of Test: 10 min, hwrs 1,3&5 | Treatment Type: 10 min continuously | Test Date: 3/03/88 | Test Time: 1800

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	2	14	2	9	2	5	3	6	2	3	3	4	0	0	14	41	14	34
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
MC	0	0	0	0	0	0	0	0	0	0	2	2	0	0	2	2	2	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	14	2	9	2	5	3	6	2	3	5	6	0	0	16	43	16	36

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE VALUES FOR 2 TEST PERIODS		
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF		Raw	WF
LS	1	7	0	0	1	3	3	6	4	6	3	4	1	1	13	27	LS	0.037	2.882
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	SL	1.000	1.000
MC	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	MC	0.333	0.333
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	—	—
Total	1	7	0	0	1	3	3	6	4	6	5	6	1	1	15	29	TOTAL	0.032	2.722

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	2	11	1	5	2	4	3	6	3	5	3	4	1	1
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0
MC	0	0	0	0	0	0	0	0	0	0	2	2	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	2	11	1	5	2	4	3	6	3	5	5	6	1	1

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0.333	2.333	2.000	9.000	0.333	0.500	0.000	0.000	0.667	1.000	0.000	0.000	1.000	1.000
SL	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--
MC	--	--	--	--	--	--	--	--	--	--	0.333	0.333	--	--
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	0.333	2.333	2.000	9.000	0.333	0.500	0.000	0.000	0.667	1.000	0.000	0.000	1.000	1.000

Table E53. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 2.5 hrs before low tide   Duration of Test: 10 min, hwrs 163   Test Date: 3/04/88
Treatment Type: 20 sec on, 20 sec off   Test Time: 0330

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS: Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS: WF
LS	0	0	0	0	2	5	0	0	2	3	6	7	1	1	11	16	6	9
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
NC	0	0	0	0	0	0	1	2	2	3	0	0	0	0	3	5	6	9
WW	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	1
Total	0	0	0	0	2	5	1	2	4	6	7	8	1	1	15	22	14	21

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS:	Raw	WF
LS	0	0	0	0	0	0	1	2	0	0	0	0	0	0	1	2	LS	8.333	10.88
SL	0	0	0	0	0	0	1	2	1	2	0	0	0	0	2	4	SL	2.000	4.00
NC	0	0	0	0	0	0	0	0	3	5	5	6	1	1	9	12	NC	3.000	2.882
WW	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	WW	0.000	0.00
Total	0	0	0	0	0	0	2	4	4	7	6	7	1	1	13	19	TOTAL	0.143	0.22

CHI-SQUARE = 3.84
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	1	3	1	1	1	2	3	4	1	1
SL	0	0	0	0	0	0	1	1	1	1	0	0	0	0
NC	0	0	0	0	0	0	1	1	3	4	3	3	1	1
WW	0	0	0	0	0	0	0	0	0	0	1	1	0	0
TOTAL	0	0	0	0	1	3	2	3	4	7	7	8	1	1

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	--	--	2.000	5.000	1.000	2.000	2.000	3.000	6.000	7.000	1.000	1.000
SL	--	--	--	--	--	--	1.000	2.000	1.000	2.000	--	--	--	--
NC	--	--	--	--	--	--	1.000	2.000	0.200	0.500	5.000	6.000	1.000	1.000
WW	--	--	--	--	--	--	--	--	--	--	0.000	0.000	--	--
TOTAL	--	--	--	--	2.000	5.000	0.333	0.667	0.000	0.077	0.077	0.067	0.000	0.000

Table E54. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 2 hrs before low tide | Duration of Test: 10 min, hrs 1&3 | Treatment Type: 10 min continuously | Test Date: 3/04/88 | Test Time: 0350

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	0	0	3	8	1	2	2	3	0	0	0	0	6	13	4	8
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
MC	0	0	0	0	0	0	0	0	2	3	12	15	2	2	16	20	16	19
WW	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	2	1	1
Total	0	0	0	0	3	8	1	2	5	8	12	15	2	2	23	35	21	29

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS	Raw	WF
LS	0	0	0	0	0	0	0	0	2	3	0	0	0	0	2	3	LS	2.000	6.250
SL	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	2	SL	1.000	2.000
MC	0	0	0	0	0	0	0	0	0	0	14	17	1	1	15	18	MC	0.032	0.105
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	1.000	2.000
Total	0	0	0	0	0	0	0	0	3	5	14	17	1	1	18	23	TOTAL	0.610	2.403

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	2	4	1	1	2	3	0	0	0	0
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0
MC	0	0	0	0	0	0	0	0	1	2	13	16	2	2
WW	0	0	0	0	0	0	0	0	1	1	0	0	0	0
TOTAL	0	0	0	0	2	4	1	1	4	7	13	16	2	2

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	--	--	--	--	3.000	8.000	1.000	2.000	0.000	0.000	--	--	--	--
SL	--	--	--	--	--	--	--	--	1.000	2.000	--	--	--	--
MC	--	--	--	--	--	--	--	--	2.000	3.000	0.154	0.125	0.333	0.333
WW	--	--	--	--	--	--	--	--	1.000	2.000	--	--	--	--
TOTAL	--	--	--	--	3.000	8.000	1.000	2.000	0.500	0.692	0.154	0.125	0.333	0.333

Table E55. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase:	2 hrs before low tide	Duration of Test:	10 min, hrs 1&3
		Treatment Type:	20 sec on, 20 sec off
Test Date:	3/04/88	Test Time:	0410

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS: Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS: WF
LS	0	0	0	0	0	0	0	0	0	0	3	4	0	0	3	4	3	4
SL	0	0	0	0	0	0	0	0	0	0	2	2	0	0	2	2	1	1
NC	0	0	0	0	0	0	1	2	3	5	1	1	1	1	6	9	5	7
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	1	2	3	5	6	7	1	1	11	15	9	12

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS:	Raw	WF
LS	0	0	0	0	0	0	0	0	1	2	1	1	1	1	3	4	LS	0.000	0.00
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	2.000	2.00
NC	0	0	0	0	0	0	0	0	2	3	1	1	0	0	3	4	NC	1.000	1.92
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	—	—
Total	0	0	0	0	0	0	0	0	3	5	2	2	1	1	6	8	TOTAL	1.471	2.00

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	0	0	0	0	0	0	0	0	1	1	2	3	1	1
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0
NC	0	0	0	0	0	0	1	1	3	4	1	1	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	1	1	3	5	4	5	1	1

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	—	—	—	—	—	—	—	—	1.000	2.000	1.000	1.800	1.000	1.000
SL	—	—	—	—	—	—	—	—	—	—	2.000	2.000	—	—
NC	—	—	—	—	—	—	1.000	2.000	0.200	0.500	0.000	0.000	1.000	1.000
WW	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL	—	—	—	—	—	—	1.000	2.000	0.000	0.000	2.000	2.778	0.000	0.000

Table E56. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase:	1.5 hrs before low tide	Duration of Test:	10 min, hmr 3 only	Test Date:	3/04/88
		Treatment Type:	10 min continuously	Test Time:	0430

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	2	4	3	5	3	4	2	2	10	15	8	14
SL	0	0	0	0	0	0	1	2	0	0	5	6	0	0	6	8	3	4
NC	0	0	0	0	0	0	6	12	9	14	3	4	0	0	18	30	15	24
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Total	0	0	0	0	0	0	9	18	12	19	11	14	2	2	34	53	27	43

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total		CHI-SQUARE VALUES FOR 2 TEST PERIODS		
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF		Raw	WF
LS	0	0	1	5	0	0	2	4	0	0	3	4	0	0	6	13	LS	1.000	0.143
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	6.000	8.000
NC	0	0	0	0	0	0	1	2	5	8	4	5	2	2	12	17	NC	1.200	3.596
WW	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	2	WW	1.000	2.000
Total	0	0	1	5	0	0	3	6	6	10	7	9	2	2	19	32	TOTAL	4.245	5.188

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	3	0	0	2	4	2	3	3	4	1	1
SL	0	0	0	0	0	0	1	1	0	0	3	3	0	0
NC	0	0	0	0	0	0	4	7	7	11	4	5	1	1
WW	0	0	0	0	0	0	0	0	1	1	0	0	0	0
TOTAL	0	0	1	3	0	0	6	12	9	15	9	12	2	2

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	1.000	5.000	--	--	0.000	0.000	3.000	5.000	0.000	0.000	2.000	2.000
SL	--	--	--	--	--	--	1.000	2.000	--	--	5.000	6.000	--	--
NC	--	--	--	--	--	--	3.571	7.143	1.143	1.636	0.143	0.111	2.000	2.000
WW	--	--	--	--	--	--	--	--	1.000	2.000	--	--	--	--
TOTAL	--	--	1.000	5.000	--	--	3.000	6.000	2.000	2.793	0.889	1.087	0.000	0.000

Table E57. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 1 hr before low tide

Duration of Test: 10 min, hmr 3 only
Treatment Type: continuous

Test Date: 3/04/88
Test Time: 0450

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	2	4	3	5	4	5	2	2	11	16
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	2	4	3	5	5	6	2	2	12	17

CHI-SQUARE F-HAT FOR 2 TEST PERIODS:

	Raw	WF
LS	2	5
SL	0	0
NC	6	8
WW	0	0
Total	8	13

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1		1-2		2-3		3-4		4-5		5-6		6-7		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	5	0	0	1	2	0	0	1	1	0	0	3	8
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	5	0	0	1	2	0	0	1	1	0	0	3	8

CHI-SQUARE VALUES FOR 2 TEST PERIODS:

	Raw	WF
LS	1.000	5.444
SL	--	--
NC	11.000	16.000
WW	--	--
TOTAL	5.400	3.240

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	3	0	0	1	1	0	0	1	1	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	1	2	2	3	2	3	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	1	3	0	0	2	3	2	3	3	4	1	1

CHI-SQUARE VALUES	0-1		1-2		2-3		3-4		4-5		5-6		6-7	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	1.000	5.000	--	--	1.000	2.000	--	--	0.000	0.000	--	--
SL	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	--	--	--	--	2.000	4.000	3.000	5.000	4.000	5.000	2.000	2.000
WW	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	--	--	1.000	5.000	--	--	0.333	0.667	3.000	5.000	2.667	3.571	2.000	2.000

Table E58. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 30 min before low tide | Duration of Test: 10 min, hmr 3 only | Treatment Type: 10 min continuously | Test Date: 3/04/88 | Test Time: 0510

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	1	7	0	0	0	0	2	4	0	0	7	9	0	0	10	20	7	13
SL	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	2	1	1
MC	0	0	0	0	0	0	0	0	1	2	1	1	0	0	2	3	2	2
WW	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	1
Total	1	7	0	0	0	0	2	4	2	4	9	11	0	0	14	26	10	17

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS	Raw	WF
LS	0	0	0	0	0	0	1	2	1	2	2	2	0	0	4	6	LS	2.571	7.538
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	1.000	2.000
MC	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	MC	0.333	1.000
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	1.000	1.000
Total	0	0	0	0	0	0	1	2	1	2	3	3	0	0	5	7	TOTAL	4.263	10.939

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	1	4	0	0	0	0	2	3	1	1	5	6	0	0
SL	0	0	0	0	0	0	0	0	1	1	0	0	0	0
MC	0	0	0	0	0	0	0	0	1	1	1	1	0	0
WW	0	0	0	0	0	0	0	0	0	0	1	1	0	0
TOTAL	1	4	0	0	0	0	2	3	2	3	6	7	0	0

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	1.000	7.000	--	--	--	--	0.333	0.667	1.000	2.000	2.778	4.455	--	--
SL	--	--	--	--	--	--	--	--	1.000	2.000	--	--	--	--
MC	--	--	--	--	--	--	--	--	1.000	2.000	0.000	0.000	--	--
WW	--	--	--	--	--	--	--	--	--	--	1.000	1.000	--	--
TOTAL	1.000	7.000	--	--	--	--	0.333	0.667	0.333	0.667	3.000	4.571	--	--

Table E59. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: 20 min before low tide — Duration of Test: 10 min, hmr 3 only — Test Date: 3/04/88
Treatment Type: 10 min continuously — Test Time: 0530

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS: Raw	WF
LS	0	0	0	0	0	0	1	2	0	0	2	2	0	0	3	4	4	8
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	1
NC	0	0	0	0	0	0	0	0	1	2	0	0	1	1	2	3	4	5
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	1	2	1	2	3	3	1	1	6	8	8	13

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS:	Raw	WF
LS	1	7	0	0	0	0	0	0	2	3	1	1	0	0	4	11	LS	0.143	3.267
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SL	1.000	1.000
NC	0	0	0	0	0	0	0	0	2	3	2	2	1	1	5	6	NC	1.286	1.000
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	WW	—	—
Total	1	7	0	0	0	0	0	0	4	6	3	3	1	1	9	17	TOTAL	0.600	3.240

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	1	4	0	0	0	0	1	1	1	2	2	2	0	0
SL	0	0	0	0	0	0	0	0	0	0	1	1	0	0
NC	0	0	0	0	0	0	0	0	2	3	1	1	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	4	0	0	0	0	1	1	3	4	3	3	1	1

CHI-SQUARE VALUES	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	1.000	7.000	—	—	—	—	1.000	2.000	2.000	3.000	0.333	0.333	—	—
SL	—	—	—	—	—	—	—	—	—	—	1.000	1.000	—	—
NC	—	—	—	—	—	—	—	—	0.333	0.200	2.000	2.000	0.000	0.000
WW	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL	1.000	7.000	—	—	—	—	1.000	2.000	1.800	2.000	0.000	0.000	0.000	0.000

Table E60. Indian Point hammer test monitoring using 6 degree vertical transducer located at unit 3, intake 36.

Tidal Phase: At low tide

Duration of Test: 10 min, hwr 3 only
Treatment Type: 10 min continuously

Test Date: 3/04/88
Test Time: 0550

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	2	14	2	9	2	5	1	2	2	3	11	14	0	0	20	47	10	24
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	14	2	9	2	5	1	2	2	3	11	14	1	1	21	48	11	26

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF	Total Raw	Total WF
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	1	3	0	0	0	0	0	0	0	0	1	3
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	1	3	0	0	0	0	0	0	0	0	1	3

CHI-SQUARE VALUES FOR 2 TEST PERIODS

	Raw	WF
LS	20.000	47.000
SL	—	—
NC	0.000	1.000
WW	—	—
TOTAL	18.182	39.706

CHI-SQUARE = 3.841
(d.f. = 1)
(alpha = .05)

CHI-SQUARE F-HAT

	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	1	7	1	5	1	3	1	1	1	2	6	7	0	0
SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	0	0	1	2	0	0	0	0	0	0	1	1
WW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	7	1	5	2	4	1	1	1	2	6	7	1	1

CHI-SQUARE VALUES

	0-1 Raw	0-1 WF	1-2 Raw	1-2 WF	2-3 Raw	2-3 WF	3-4 Raw	3-4 WF	4-5 Raw	4-5 WF	5-6 Raw	5-6 WF	6-7 Raw	6-7 WF
LS	2.000	14.000	2.000	9.000	2.000	5.000	1.000	2.000	2.000	3.000	11.000	14.000	—	—
SL	—	—	—	—	—	—	—	—	—	—	—	—	—	—
NC	—	—	—	—	1.000	3.000	—	—	—	—	—	—	1.000	1.000
WW	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL	2.000	14.000	2.000	9.000	0.333	0.500	1.000	2.000	2.000	3.000	11.000	14.000	1.000	1.000

APPENDIX F:

Hammer Tests Monitored By

Bottom 6°x12° Horizontal Transducer

Table F1. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 2 hrs before low tide

Duration of Test: 5 min, hmrs 1&3

Treatment Type: 10 sec on, 20 sec off

Test Date: 3/3/88

Test Time: 0320

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	0	0	1	1	2	2	2	2	5	5
SL	0	0	1	2	3	4	2	2	0	0	6	8
NC	1	4	16	30	20	24	8	7	4	3	49	68
WW	0	0	0	0	4	5	9	8	2	2	15	15
Total	1	4	17	32	28	34	21	19	8	7	75	96

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	4	0	0	3	4	4	4	3	2	11	14
SL	0	0	0	0	1	1	2	2	0	0	3	3
NC	0	0	5	9	12	14	7	6	1	1	25	30
WW	0	0	2	4	0	0	2	2	0	0	4	6
Total	1	4	7	13	16	19	15	14	4	3	43	53

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	2	0	0	2	3	3	3	3	2	8	10
SL	0	0	1	1	2	3	2	2	0	0	5	6
NC	1	2	11	20	16	19	8	7	3	2	37	49
WW	0	0	1	2	2	3	6	5	1	1	10	11
TOTAL	1	4	12	23	22	27	18	17	6	5	59	75

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1.000	4.000	--	--	1.000	1.800	0.667	0.667	0.200	0.000	2.250	4.263
SL	--	--	1.000	2.000	1.000	1.800	0.000	0.000	--	--	1.000	2.273
NC	1.000	4.000	5.762	11.308	2.000	2.632	0.067	0.077	1.800	1.000	7.784	14.735
WW	--	--	2.000	4.000	4.000	5.000	4.455	3.600	2.000	2.000	6.368	3.057
TOTAL	0.000	0.000	4.167	8.022	3.273	4.245	1.000	0.758	1.333	1.600	8.678	12.409

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F2. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 2 hrs before low tide | Duration of Test: 5 min, hrs 1&3 | Treatment Type: 5 min continuously | Test Date: 3/3/8… | Test Time: 0340

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	0	0	1	1	14	13	6	5	21	19
SL	0	0	0	0	6	7	1	1	0	0	7	8
NC	2	7	19	36	14	17	3	3	0	0	38	63
WW	1	4	4	8	4	5	3	3	0	0	12	20
Total	3	11	23	44	25	30	21	20	6	5	78	110

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	0	0	4	5	7	6	1	1	12	12
SL	0	0	11	21	10	12	4	4	1	1	26	38
NC	3	11	7	13	7	8	3	3	0	0	20	35
WW	0	0	2	4	1	1	4	4	2	2	9	11
Total	3	11	20	38	22	26	18	17	4	4	67	96

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	0	0	0	0	3	3	11	10	4	3	17	16
SL	0	0	6	11	8	10	3	3	1	1	17	23
NC	3	9	13	25	11	13	3	3	0	0	29	49
WW	1	2	3	6	3	3	4	4	1	1	11	16
TOTAL	3	11	22	41	24	28	20	19	5	5	73	103

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	--	--	--	--	1.800	2.667	2.333	2.579	3.571	2.667	2.455	1.581
SL	--	--	11.000	21.000	1.000	1.316	1.800	1.800	1.000	1.000	10.939	19.565
NC	0.200	0.889	5.538	10.796	2.333	3.240	0.000	0.000	--	--	5.586	8.000
WW	1.000	4.000	0.667	1.333	1.800	2.667	0.143	0.143	2.000	2.000	0.429	2.613
TOTAL	0.000	0.000	0.209	0.439	0.191	0.286	0.231	0.243	0.400	0.111	0.834	0.951

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F3. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 1.5 hrs before low tide | Duration of Test: 5 min, hwrs 1&3 | Treatment Type: 5 min continuosly | Test Date: 3/3/8 | Test Time: 0350

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	1	4	8	15	7	8	2	2	1	1	19	30
SL	0	0	1	2	0	0	1	1	1	1	3	4
NC	2	7	6	11	5	6	2	2	0	0	15	26
WW	0	0	3	6	3	4	1	1	0	0	7	11
Total	3	11	18	34	15	18	6	6	2	2	44	71

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	7	13	5	6	2	2	1	1	15	22
SL	1	4	1	2	0	0	0	0	1	1	3	7
NC	1	4	7	13	6	7	1	1	0	0	15	25
WW	0	0	3	6	3	4	2	2	0	0	8	12
Total	2	8	18	34	14	17	5	5	2	2	41	66

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	1	2	8	14	6	7	2	2	1	1	17	26
SL	1	2	1	2	0	0	1	1	1	1	3	6
NC	2	6	7	12	6	7	2	2	0	0	15	26
WW	0	0	3	6	3	4	2	2	0	0	8	12
TOTAL	3	10	18	34	15	18	6	6	2	2	43	69

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	1.000	4.000	0.067	0.143	0.333	0.286	0.000	0.000	0.000	0.000	0.471	1.231
SL	1.000	4.000	0.000	0.000	—	—	1.000	1.000	0.000	0.000	0.000	0.818
NC	0.333	0.818	0.077	0.167	0.091	0.077	0.333	0.333	--	--	0.000	0.020
WW	--	--	0.000	0.000	0.000	0.000	0.333	0.333	--	--	0.067	0.043
TOTAL	0.200	0.474	0.000	0.000	0.034	0.029	0.091	0.091	0.000	0.000	0.106	0.182

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F4. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 1.2 hrs before low tide | Duration of Test: 5 min, hwrs 1&3 | Treatment Type: 10 sec on, 20 sec off | Test Date: 3/3 | Test Time: 040

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	3	6	5	6	2	2	1	1	11	15
SL	0	0	0	0	5	6	0	0	0	0	5	6
NC	3	11	8	15	6	7	1	1	0	0	18	34
WW	0	0	2	4	0	0	0	0	0	0	2	4
Total	3	11	13	25	16	19	3	3	1	1	36	59

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	1	2	5	6	1	1	0	0	7	9
SL	0	0	1	2	0	0	0	0	0	0	1	2
NC	3	11	6	11	3	4	0	0	1	1	13	27
WW	0	0	2	4	3	4	1	1	0	0	6	9
Total	3	11	10	19	11	14	2	2	1	1	27	47

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	0	0	2	4	5	6	2	2	1	1	9	12
SL	0	0	1	1	3	3	0	0	0	0	3	4
NC	3	11	7	13	5	6	1	1	1	1	16	31
WW	0	0	2	4	2	2	1	1	0	0	4	7
TOTAL	3	11	12	22	14	17	3	3	1	1	32	53

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	--	--	1.000	2.000	0.000	0.000	0.333	0.333	1.000	1.000	0.889	1.500
SL	--	--	1.000	2.000	5.000	6.000	--	--	ERR	ERR	2.667	2.000
NC	0.000	0.000	0.286	0.615	1.000	0.818	1.000	1.000	1.000	1.000	0.806	0.803
WW	--	--	0.000	0.000	3.000	4.000	1.000	1.000	ERR	ERR	2.000	1.923
TOTAL	0.000	0.000	0.391	0.818	0.926	0.758	0.200	0.200	0.000	0.000	1.286	1.358

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F5. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 1 hr before low tide | Duration of Test: 5 min, hwrs 1&3 | Treatment Type: 10 sec on, 20 sec off | Test Date: 3/3/88 | Test Time: 0410

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	1	2	4	5	2	2	0	0	7	9
SL	0	0	0	0	1	1	0	0	0	0	1	1
NC	2	7	1	2	4	5	0	0	0	0	7	14
WW	0	0	1	2	1	1	0	0	0	0	2	3
Total	2	7	3	6	10	12	2	2	0	0	17	27

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	2	4	1	1	1	1	1	1	5	7
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	3	6	2	2	0	0	0	0	6	12
WW	1	4	1	2	0	0	0	0	0	0	2	6
Total	2	8	6	12	3	3	1	1	1	1	13	25

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	0	0	2	3	3	3	2	2	1	1	6	8
SL	0	0	0	0	1	1	0	0	0	0	1	1
NC	2	6	2	4	3	4	0	0	0	0	7	13
WW	1	2	1	2	1	1	0	0	0	0	2	5
TOTAL	2	8	5	9	7	8	2	2	1	1	15	26

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	--	--	0.333	0.667	1.800	2.667	0.333	0.333	1.000	1.000	0.333	0.250
SL	--	--	--	--	1.000	1.000	--	--	--	--	1.000	1.000
NC	0.333	0.818	1.000	2.000	0.667	1.286	--	--	--	--	0.077	0.154
WW	1.000	4.000	0.000	0.000	1.000	1.000	--	--	--	--	0.000	1.000
TOTAL	0.000	0.067	1.000	2.000	3.769	5.400	0.333	0.333	1.000	1.000	0.533	0.077

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F6. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 1 hr before low tide — Duration of Test: 5 min, hrs 1&3 — Treatment Type: 5 min continuously — Test Date: 3/3/88 — Test Time: 0420

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	1	4	1	2	2	2	0	0	0	0	4	8
SL	1	4	0	0	0	0	0	0	0	0	1	4
MC	2	7	8	15	1	1	0	0	0	0	11	23
WW	0	0	2	4	0	0	0	0	0	0	2	4
Total	4	15	11	21	3	3	0	0	0	0	18	39

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	1	2	1	1	1	1	1	1	4	5
SL	0	0	0	0	0	0	0	0	0	0	0	0
MC	1	4	1	2	0	0	0	0	0	0	2	6
WW	0	0	1	2	0	0	0	0	0	0	1	2
Total	1	4	3	6	1	1	1	1	1	1	7	13

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	1	2	1	2	2	2	1	1	1	1	4	7
SL	1	2	0	0	0	0	0	0	0	0	1	2
MC	2	6	5	9	1	1	0	0	0	0	7	15
WW	0	0	2	3	0	0	0	0	0	0	2	3
TOTAL	3	10	7	14	2	2	1	1	1	1	13	26

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	1.000	4.000	0.000	0.000	0.333	0.333	1.000	1.000	1.000	1.000	0.000	0.692
SL	1.000	4.000	--	--	--	--	--	--	--	--	1.000	4.000
MC	0.333	0.818	5.444	9.941	1.000	1.000	--	--	--	--	6.231	9.966
WW	--	--	0.333	0.667	--	--	--	--	--	--	0.333	0.667
TOTAL	1.800	6.368	4.571	8.333	1.000	1.000	1.000	1.000	1.000	1.000	4.840	13.000

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F7. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 50 min before low tide | Duration of Test: 50 min, hrs 1,3&5 | Treatment Type: 5 min continuously | Test Date: 3/3/88 | Test Time: 0430

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	0	0	1	1	0	0	0	0	1	1
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	3	11	2	4	0	0	1	1	0	0	6	16
WS	1	4	2	4	0	0	0	0	1	1	4	9
Total	4	15	4	8	1	1	1	1	1	1	11	26

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	2	4	1	1	1	1	0	0	4	6
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	4	15	4	8	1	1	0	0	0	0	9	24
WS	0	0	0	0	0	0	0	0	0	0	0	0
Total	4	15	6	12	2	2	1	1	0	0	13	30

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	0	0	1	2	1	1	1	1	0	0	3	4
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	4	13	3	6	1	1	1	1	0	0	8	20
WS	1	2	1	2	0	0	0	0	1	1	2	5
TOTAL	4	15	5	10	2	2	1	1	1	1	12	28

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	--	--	2.000	4.000	0.000	0.000	1.000	1.000	--	--	1.800	3.571
SL	--	--	--	--	--	--	--	--	--	--	ERR	ERR
NC	0.143	0.615	0.667	1.333	1.000	1.000	1.000	1.000	--	--	0.600	1.600
WS	1.000	4.000	2.000	4.000	--	--	--	--	1.000	1.000	4.000	9.000
TOTAL	0.000	0.000	0.400	0.800	0.333	0.333	0.000	0.000	1.000	1.000	0.167	0.286

CHI-SQUARE = 3.814 (d.f. = 1, alpha = .05)

Table F8. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 40 min before low tide | Duration of Test: 5 min, hrs 1,345 | Treatment Type: 10 sec on, 20 sec off | Test Date: 3/3/88 | Test Time: 0440

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	0	0	4	5	1	1	1	1	6	7
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	2	7	3	6	1	1	0	0	0	0	6	14
WW	1	4	2	4	0	0	0	0	1	1	4	9
Total	3	11	5	10	5	6	1	1	2	2	16	30

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	1	2	1	1	0	0	1	1	3	4
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	3	11	1	2	0	0	0	0	0	0	4	13
WW	0	0	0	0	0	0	0	0	0	0	0	0
Total	3	11	2	4	1	1	0	0	1	1	7	17

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	CHI-SQUARE F-HAT FOR 2 TEST PERIODS WF
LS	0	0	1	1	3	3	1	1	1	1	5	6
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	3	9	2	4	1	1	0	0	0	0	5	14
WW	1	2	1	2	0	0	0	0	1	1	2	5
TOTAL	3	11	4	7	3	4	1	1	2	2	12	24

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	CHI-SQUARE VALUES FOR 2 TEST PERIODS WF
LS	--	--	1.000	2.000	1.800	2.667	1.000	1.000	0.000	0.000	1.000	0.818
SL	--	--	--	--	--	--	--	--	--	--	ERR	ERR
NC	0.200	0.889	1.000	2.000	1.000	1.000	--	--	--	--	0.400	0.037
WW	1.000	4.000	2.000	4.000	--	--	--	--	1.000	1.000	4.000	9.000
TOTAL	0.000	0.000	1.286	2.571	2.667	3.571	1.000	1.000	0.333	0.333	3.522	3.596

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F9. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 30 min before low tide | Duration of Test: 5 min, hwrs 1,385 | Test Date: 3/3/88
Treatment Type: 10 sec on, 20 sec off | Test Time: 0450

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	1	4	1	2	1	1	0	0	0	0	3	7
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	2	7	3	6	0	0	1	1	0	0	6	14
WW	0	0	1	2	0	0	0	0	0	0	1	2
Total	3	11	5	10	1	1	1	1	0	0	10	23

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	1	2	0	0	0	0	0	0	1	2
SL	0	0	1	2	0	0	0	0	0	0	1	2
NC	1	4	4	8	2	2	0	0	0	0	7	14
WW	0	0	2	4	0	0	0	0	0	0	2	4
Total	1	4	8	16	2	2	0	0	0	0	11	22

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	1	2	1	2	1	1	0	0	0	0	2	5
SL	0	0	1	1	0	0	0	0	0	0	1	1
NC	2	6	4	7	1	1	1	1	0	0	7	14
WW	0	0	2	3	0	0	0	0	0	0	2	3
TOTAL	2	8	7	13	2	2	1	1	0	0	11	23

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	1.000	4.000	0.000	0.000	1.000	1.000	--	--	--	--	1.000	2.778
SL	--	--	1.000	2.000	--	--	--	--	--	--	1.000	2.000
NC	0.333	0.818	0.143	0.286	2.000	2.000	1.000	1.000	--	--	0.077	0.000
WW	--	--	0.333	0.667	--	--	--	--	--	--	0.333	0.667
TOTAL	1.000	3.267	0.692	1.385	0.333	0.333	1.000	1.000	--	--	0.048	0.022

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F10. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 1.4 hrs before low tide — Duration of Test: 10 min, hwrs 1,3&5 — Treatment Type: 10 min continuously — Test Date: 3/3/88 — Test Time: 1600

5 MINUTES BEFORE TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	:	Total Raw	Total WF
LS	0	0	0	0	0	0	3	3	5	4	:	8	7
SL	1	4	3	6	2	2	0	0	1	1	:	7	13
NC	1	4	1	2	1	1	1	1	0	0	:	4	8
WW	0	0	0	0	1	1	1	1	2	2	:	4	4
Total	2	8	4	8	4	4	5	5	8	7	:	23	32

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	:	Total Raw	Total WF
LS	0	0	1	2	0	0	8	7	7	5	:	16	14
SL	0	0	7	13	6	7	6	5	0	0	:	19	25
NC	1	4	8	15	4	5	5	5	2	2	:	20	31
WW	0	0	1	2	4	5	2	2	0	0	:	7	9
Total	1	4	17	32	14	17	21	19	9	7	:	62	79

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	:	Total Raw	Total WF
LS	0	0	1	2	0	0	11	10	4	3	:	16	15
SL	0	0	4	8	3	4	1	1	0	0	:	8	13
NC	0	0	5	9	4	5	2	2	1	1	:	12	17
WW	0	0	1	2	5	6	0	0	1	1	:	7	9
Total	0	0	11	21	12	15	14	13	6	5	:	43	54

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	:	CHI-SQUARE F-HAT FOR 3 TEST PERIODS Raw	WF
LS	0	0	1	1	0	0	7	7	5	4	:	13	12
SL	0	1	5	9	4	4	2	2	0	0	:	11	17
NC	1	3	5	9	3	4	3	3	1	1	:	12	18
WW	0	0	1	1	3	4	1	1	1	1	:	6	7
TOTAL	1	4	11	20	10	12	13	12	8	6	:	42	54

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	:	CHI-SQUARE VALUES FOR 3 TEST PERIODS Raw	WF
LS	--	--	0.000	4.000	--	--	5.714	2.571	2.000	0.500	:	4.308	3.167
SL	--	--	0.800	2.889	1.250	4.250	11.500	7.000	--	--	:	9.091	5.647
NC	0.000	2.667	4.000	8.444	2.000	1.750	2.000	2.000	2.000	2.000	:	10.667	17.000
WW	--	--	0.000	4.000	4.000	3.500	2.000	2.000	2.000	2.000	:	1.000	3.429
TOTAL	2.000	8.000	6.727	15.450	5.600	8.167	10.923	9.250	-0.375	1.500	:	20.143	23.537

CHI-SQUARE = 5.991 (d.f. = 2, alpha = .05)

Table F11. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 1 hr before low tide

Duration of Test: 10 min, hmrs 1,3&5
Treatment Type: 10 min continuously

Test Date: 3/3/88
Test Time: 1620

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	4	8	6	7	10	9	4	3	24	27
SL	0	0	1	2	0	0	0	0	0	0	1	2
NC	2	7	4	8	4	5	1	1	0	0	11	21
WW	0	0	1	2	1	1	0	0	0	0	2	3
Total	2	7	10	20	11	13	11	10	4	3	38	53

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	6	11	4	5	2	2	4	3	16	21
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	2	7	5	9	1	1	0	0	0	0	8	17
WW	6	22	2	4	2	2	0	0	0	0	10	28
Total	8	29	13	24	7	8	2	2	4	3	34	66

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	0	0	5	10	5	6	6	6	4	3	20	24
SL	0	0	1	1	0	0	0	0	0	0	1	1
NC	2	7	5	9	3	3	1	1	0	0	10	19
WW	3	11	2	3	2	2	0	0	0	0	6	16
TOTAL	5	18	12	22	9	11	7	6	4	3	36	60

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	--	--	0.400	0.474	0.400	0.333	5.333	4.455	0.000	0.000	1.600	0.750
SL	--	--	1.000	2.000	--	--	--	--	--	--	1.000	2.000
NC	0.000	0.000	0.111	0.059	1.800	2.667	1.000	1.000	--	--	0.474	0.421
WW	6.000	22.000	0.333	0.667	0.333	0.333	--	--	--	--	5.333	20.161
TOTAL	3.600	13.444	0.391	0.364	0.889	1.190	6.231	5.333	0.000	0.000	0.222	1.420

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F12. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase:	20 min before low tide	Duration of Test:	7 min, hmrs 1,3&5	Test Date:	3/3/88
		Treatment Type:	7 min continuously	Test Time:	1643

E MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LE	0	0	2	4	3	4	3	3	0	0	8	11
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	4	15	2	4	0	0	0	0	0	0	6	19
WB	0	0	1	2	0	0	0	0	0	0	1	2
Total	4	15	5	10	3	4	3	3	0	0	15	32

E MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LE	1	4	1	2	2	2	1	1	0	0	5	9
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	1	2	0	0	0	0	0	0	1	2
WB	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	2	4	2	2	1	1	0	0	6	11

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LE	1	2	2	3	3	3	2	2	0	0	7	10
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	2	8	2	3	0	0	0	0	0	0	4	11
WB	0	0	1	1	0	0	0	0	0	0	1	1
TOTAL	3	10	4	7	3	3	2	2	0	0	11	22

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LE	1.000	4.000	0.333	0.667	0.200	0.667	1.000	1.000	—	—	0.692	0.200
SL	—	—	—	—	—	—	—	—	—	—	—	—
NC	4.000	15.000	0.333	0.667	—	—	—	—	—	—	3.571	13.762
WB	—	—	1.000	2.000	—	—	—	—	—	—	1.000	2.000
TOTAL	1.800	6.368	1.286	2.571	0.200	0.667	1.000	1.000	—	—	3.857	10.256

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F13. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: At high tide

Duration of Test: 10 min, hmrs 1,345
Treatment Type: 10 min continuously

Test Date: 3/3/
Test Time: 170

10 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	1	4	1	2	0	0	2	2	1	1	5	9
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	4	15	4	8	0	0	1	1	0	0	9	24
WW	0	0	1	2	0	0	0	0	0	0	1	2
Total	5	19	6	12	0	0	3	3	1	1	15	35

10 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	1	2	1	1	4	4	1	1	7	8
SL	0	0	1	2	0	0	0	0	0	0	1	2
NC	3	11	0	0	0	0	0	0	0	0	3	11
WW	0	0	0	0	0	0	0	0	0	0	0	0
Total	3	11	2	4	1	1	4	4	1	1	11	21

CHI-SQUARE F-HAT

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	1	2	1	2	1	1	3	3	1	1	6	9
SL	0	0	1	1	0	0	0	0	0	0	1	1
NC	4	13	2	4	0	0	1	1	0	0	6	18
WW	0	0	1	1	0	0	0	0	0	0	1	1
TOTAL	4	15	4	8	1	1	4	4	1	1	13	28

CHI-SQUARE VALUES

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	1.000	4.000	0.000	0.000	1.000	1.000	0.667	0.667	0.000	0.000	0.333	0.059
SL	--	--	1.000	2.000	--	--	--	--	--	--	1.000	2.000
NC	0.143	0.615	4.000	8.000	--	--	1.000	1.000	--	--	3.000	4.829
WW	--	--	1.000	2.000	--	--	--	--	--	--	1.000	2.000
TOTAL	0.500	2.133	2.000	4.000	1.000	1.000	0.143	0.143	0.000	0.000	0.615	3.500

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F14. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 20 min after low tide

Duration of Test: 10 min, hmrs 1,3&5
Treatment Type: 10 sec on, 20 sec off

Test Date: 3/3/68
Test Time: 1720

6 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LE	0	0	6	11	2	2	1	1	2	2	11	16
SL	1	4	0	0	0	0	0	0	0	0	1	4
NC	4	15	3	6	1	1	0	0	0	0	8	22
WL	0	0	1	2	1	1	0	0	0	0	2	3
Total	5	19	10	19	4	4	1	1	2	2	22	45

6 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LE	0	0	6	11	1	1	0	0	1	1	8	13
SL	0	0	0	0	1	1	0	0	0	0	1	1
NC	2	7	3	6	0	0	0	0	0	0	5	13
WL	0	0	4	8	1	1	0	0	0	0	5	9
Total	2	7	13	25	3	3	0	0	1	1	19	36

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LE	0	0	6	11	2	2	1	1	2	2	10	15
SL	1	2	0	0	1	1	0	0	0	0	1	3
NC	3	11	3	6	1	1	0	0	0	0	7	18
WL	0	0	3	5	1	1	0	0	0	0	4	6
TOTAL	4	13	12	22	4	4	1	1	2	2	21	41

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LE	--	--	0.000	0.000	0.333	0.333	1.000	1.000	0.333	0.333	0.474	0.310
SL	1.000	4.000	--	--	1.000	1.000	--	--	--	--	0.000	1.800
NC	0.667	2.909	0.000	0.000	1.000	1.000	--	--	--	--	0.692	2.314
WL	--	--	1.800	3.600	0.000	0.000	--	--	--	--	1.286	3.000
TOTAL	1.286	5.538	0.391	0.818	0.143	0.143	1.000	1.000	0.333	0.333	0.220	1.000

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F15. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 46 min after low tide

Duration of Test: 10 min, hmrs 1,385
Treatment Type: 10 sec on, 20 sec off

Test Date: 3/3/88
Test Time: 1740

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	1	1	2	2	1	1	5	6
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	3	6	0	0	0	0	0	0	4	10
WW	1	4	1	2	1	1	0	0	0	0	3	7
Total	2	8	5	10	2	2	2	2	1	1	12	23

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	1	1	2	2	0	0	4	5
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	0	0	0	0	0	0	0	0	1	4
WW	0	0	2	4	0	0	0	0	0	0	2	4
Total	1	4	3	6	1	1	2	2	0	0	7	13

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	1	2	1	1	2	2	1	1	5	6
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	1	4	2	3	0	0	0	0	0	0	3	7
WW	1	2	2	3	1	1	0	0	0	0	3	6
TOTAL	2	6	4	8	2	2	2	2	1	1	10	18

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	0.000	0.000	0.000	0.000	0.000	0.000	1.000	1.000	0.111	0.091
SL	--	--	--	--	--	--	--	--	--	--	--	--
NC	0.000	0.000	3.000	6.000	--	--	--	--	--	--	1.800	2.571
WW	1.000	4.000	0.333	0.667	1.000	1.000	--	--	--	--	0.200	0.818
TOTAL	0.333	1.333	0.500	1.000	0.333	0.333	0.000	0.000	1.000	1.000	1.316	2.778

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F16. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 1 hr after low tide | Duration of Test: 10 min, hrs 1,3&5 | Test Date: 3/3/88
Treatment Type: 10 min continuously | Test Time: 1800

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LE	0	0	2	4	2	2	1	1	1	1	6	8
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	2	7	3	6	0	0	0	0	0	0	5	13
WL	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	7	5	10	2	2	1	1	1	1	11	21

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LE	0	0	2	4	0	0	1	1	1	1	4	6
SL	1	4	0	0	0	0	0	0	0	0	1	4
NC	0	0	0	0	1	1	0	0	0	0	1	1
WL	0	0	0	0	3	4	0	0	0	0	3	4
Total	1	4	2	4	4	5	1	1	1	1	9	15

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LE	0	0	2	4	1	1	1	1	1	1	5	7
SL	1	2	0	0	0	0	0	0	0	0	1	2
NC	1	4	2	3	1	1	0	0	0	0	3	7
WL	0	0	0	0	2	2	0	0	0	0	2	2
TOTAL	2	6	4	7	3	4	1	1	1	1	10	18

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LE	--	--	0.000	0.000	2.000	2.000	0.000	0.000	0.000	0.000	0.400	0.286
SL	1.000	4.000	--	--	--	--	--	--	--	--	1.000	4.000
NC	2.000	7.000	3.000	6.000	1.000	1.000	--	--	--	--	2.667	10.286
WL	--	--	--	--	3.000	4.000	--	--	--	--	3.000	4.000
TOTAL	0.333	0.818	1.286	2.571	0.667	1.286	0.000	0.000	0.000	0.000	0.200	1.000

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F17. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 2.5 hrs before low tide | Duration of Test: 10 min, hwrs 1&3 | Treatment Type: 20 sec on, 20 sec off | Test Date: 3/4/88 | Test Time: 0330

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	1	4	1	2	4	5	10	9	5	4	21	24
SL	1	4	5	9	5	6	1	1	0	0	12	20
NC	1	4	6	11	9	11	9	8	1	1	26	35
WW	0	0	8	15	23	28	16	14	5	4	52	61
Total	3	12	20	37	41	50	36	32	11	9	111	140

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	1	4	8	15	18	22	25	23	18	14	70	78
SL	0	0	1	2	0	0	1	1	0	0	2	3
NC	8	30	11	21	12	14	2	2	3	2	36	69
WW	2	7	13	24	8	10	6	5	3	2	32	48
Total	11	41	33	62	38	46	34	31	24	18	140	198

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	1	4	5	9	11	14	18	16	12	9	46	51
SL	1	2	3	6	3	3	1	1	0	0	7	12
NC	5	17	9	16	11	13	6	5	2	2	31	52
WW	1	4	11	20	16	19	11	10	4	3	42	55
TOTAL	7	27	27	50	40	48	35	32	18	14	126	169

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	0.000	0.000	5.444	9.941	8.909	10.704	6.429	6.125	7.348	5.556	26.385	28.588
SL	1.000	4.000	2.667	4.455	5.000	6.000	0.000	0.000	--	--	7.143	12.565
NC	5.444	19.882	1.471	3.125	0.429	0.360	4.455	3.600	1.000	0.333	1.613	11.115
WW	2.000	7.000	1.190	2.077	7.258	8.526	4.545	4.263	0.500	0.667	4.762	1.550
TOTAL	4.571	15.868	3.189	6.313	0.114	0.167	0.057	0.016	4.829	3.000	3.351	9.953

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F18. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 2.5 hrs before low tide | Duration of Test: 10 min, hmrs 1&3 | Test Date: 3/4/88
Treatment Type: 20 sec on, 20 sec off | Test Time: 0350

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	1	4	7	13	22	26	29	26	16	12	75	81
SL	0	0	3	6	4	5	0	0	0	0	7	11
NC	4	15	7	13	2	2	0	0	1	1	14	31
WW	0	0	5	9	8	10	4	4	0	0	17	23
Total	5	19	22	41	36	43	33	30	17	13	113	146

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	1	4	3	6	14	17	10	9	10	8	38	44
SL	1	4	2	4	7	8	0	0	1	1	11	17
NC	2	7	3	6	7	8	3	3	2	2	17	26
WW	1	4	3	6	6	7	6	5	1	1	17	23
Total	5	19	11	22	34	40	19	17	14	12	83	110

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	1	4	5	10	18	22	20	18	13	10	57	63
SL	1	2	3	5	6	7	0	0	1	1	9	14
NC	3	11	5	10	5	5	2	2	2	2	16	29
WW	1	2	4	8	7	9	5	5	1	1	17	23
TOTAL	5	19	17	32	35	42	26	24	16	13	98	128

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	0.000	0.000	1.600	2.579	1.778	1.884	9.256	8.257	1.385	0.800	12.115	10.952
SL	1.000	4.000	0.200	0.400	0.818	0.692	--	--	1.000	1.000	0.889	1.286
NC	0.667	2.909	1.600	2.579	2.778	3.600	3.000	3.000	0.333	0.333	0.290	0.439
WW	1.000	4.000	0.500	0.600	0.286	0.529	0.400	0.111	1.000	1.000	0.000	0.000
TOTAL	0.000	0.000	3.667	5.730	0.057	0.108	3.769	3.596	0.290	0.040	4.592	5.063

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F19. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 2 hrs before low tide
Duration of Test: 10 min, hrs 1&3
Treatment Type: 20 sec on, 20 sec off
Test Date: 3/4/88
Test Time: 0410

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	2	7	6	11	6	7	1	1	2	2	17	28
SL	0	0	16	30	10	12	9	8	3	2	38	52
NC	5	19	10	19	2	2	3	3	4	3	24	46
WW	0	0	8	15	15	18	14	13	2	2	39	48
Total	7	26	40	75	33	39	27	25	11	9	118	174

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	2	4	12	14	3	3	1	1	18	22
SL	1	4	6	11	19	23	18	16	7	5	51	59
NC	5	19	8	15	3	4	6	5	2	2	24	45
WW	0	0	9	17	11	13	8	7	3	2	31	39
Total	6	23	25	47	45	54	35	31	13	10	124	165

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	1	4	4	8	9	11	2	2	2	2	18	25
SL	1	2	11	21	15	18	14	12	5	4	45	56
NC	5	19	9	17	3	3	5	4	3	3	24	46
WW	0	0	9	16	13	16	11	10	3	2	35	44
TOTAL	7	25	33	61	39	47	31	28	12	10	121	170

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	2.000	7.000	2.000	3.267	2.000	2.333	1.000	1.000	0.333	0.333	0.029	0.720
SL	1.000	4.000	4.545	8.805	2.793	3.457	3.000	2.667	1.600	1.286	1.899	0.441
NC	0.000	0.000	0.222	0.471	0.200	0.667	1.000	0.500	0.667	0.200	0.000	0.011
WW	--	--	0.059	0.125	0.615	0.806	1.636	1.800	0.200	0.000	0.914	0.931
TOTAL	0.077	0.184	3.462	6.426	1.846	2.419	1.032	0.643	0.167	0.053	0.149	0.239

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F20. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 1.5 hrs before low tide | Duration of Test: 10 min, hwr 3 only | Treatment Type: 10 min continuously | Test Date: 3/4/88 | Test Time: 0430

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	4	15	3	6	20	24	3	3	3	2	33	50
SL	1	4	7	13	1	1	0	0	0	0	9	18
NC	7	26	5	9	0	0	0	0	1	1	13	36
WB	0	0	10	19	14	17	3	3	0	0	27	39
Total	12	45	25	47	35	42	6	6	4	3	82	143

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	3	11	13	24	6	7	1	1	1	1	24	44
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	6	22	2	4	0	0	0	0	0	0	8	26
WB	0	0	4	8	2	2	0	0	0	0	6	10
Total	9	33	19	36	8	9	1	1	1	1	38	80

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	4	13	8	15	13	16	2	2	2	2	29	47
SL	1	2	4	7	1	1	0	0	0	0	5	9
NC	7	24	4	7	0	0	0	0	1	1	11	31
WB	0	0	7	14	8	10	2	2	0	0	17	25
TOTAL	11	39	22	42	22	26	4	4	3	2	60	112

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	0.143	0.615	6.250	10.800	7.538	9.323	1.000	1.000	1.000	0.333	1.421	0.383
SL	1.000	4.000	7.000	13.000	1.000	1.000	--	--	--	--	9.000	18.000
NC	0.077	0.333	1.286	1.923	--	--	--	--	1.000	1.000	1.190	1.613
WB	--	--	2.571	4.481	9.000	11.842	3.000	3.000	--	--	13.364	17.163
TOTAL	0.429	1.846	0.818	1.458	16.953	21.353	3.571	3.571	1.800	1.000	16.133	17.798

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F21. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 1 hr before low tide

Duration of Test: 10 min, hmr 3 only
Treatment Type: 10 min continuously

Test Date: 3/4/88
Test Time: 0450

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	1	4	5	9	5	6	2	2	1	1	14	22
SL	0	0	2	4	0	0	0	0	0	0	2	4
NC	2	7	1	2	4	5	0	0	0	0	7	14
WW	0	0	7	13	0	0	1	1	0	0	8	14
Total	3	11	15	28	9	11	3	3	1	1	31	54

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	4	8	2	2	1	1	1	1	8	12
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	2	7	4	8	0	0	0	0	0	0	6	15
WW	0	0	3	6	1	1	0	0	0	0	4	7
Total	2	7	11	22	3	3	1	1	1	1	18	34

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	1	2	5	9	4	4	2	2	1	1	11	17
SL	0	0	1	2	0	0	0	0	0	0	1	2
NC	2	7	3	5	2	3	0	0	0	0	7	15
WW	0	0	5	10	1	1	1	1	0	0	6	11
TOTAL	3	9	13	25	6	7	2	2	1	1	25	44

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	1.000	4.000	0.111	0.059	1.286	2.000	0.333	0.333	0.000	0.000	1.636	2.941
SL	--	--	2.000	4.000	--	--	--	--	--	--	2.000	4.000
NC	0.000	0.000	1.800	3.600	4.000	5.000	--	--	--	--	0.077	0.034
WW	--	--	1.600	2.579	1.000	1.000	1.000	1.000	--	--	1.333	2.333
TOTAL	0.200	0.889	0.615	0.720	3.000	4.571	1.000	1.000	0.000	0.000	3.449	4.545

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F22. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 30 min before low tide

Duration of Test: 10 min, hmr 3 only
Treatment Type: 10 min continuously

Test Date: 3/4/88
Test Time: 0510

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	2	4	1	1	2	2	2	2	7	9
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	0	0	2	4	1	1	0	0	0	0	3	5
WW	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	4	8	2	2	2	2	2	2	10	14

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5		5-10		10-15		15-20		20-25		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	3	6	4	5	0	0	1	1	8	12
SL	1	4	0	0	1	1	0	0	0	0	2	5
NC	4	15	1	2	1	1	1	1	0	0	7	19
WW	1	4	2	4	1	1	0	0	0	0	4	9
Total	6	23	6	12	7	8	1	1	1	1	21	45

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0	0	3	5	3	3	1	1	2	2	8	11
SL	1	2	0	0	1	1	0	0	0	0	1	3
NC	2	8	2	3	1	1	1	1	0	0	5	12
WW	1	2	1	2	1	1	0	0	0	0	2	5
TOTAL	3	12	5	10	5	5	2	2	2	2	16	30

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	--	--	0.200	0.400	1.800	2.667	2.000	2.000	0.333	0.333	0.067	0.429
SL	1.000	4.000	--	--	1.000	1.000	--	--	--	--	2.000	5.000
NC	4.000	15.000	0.333	0.667	0.000	0.000	1.000	1.000	--	--	1.600	8.167
WW	1.000	4.000	2.000	4.000	1.000	1.000	--	--	--	--	4.000	9.000
TOTAL	6.000	23.000	0.400	0.800	2.778	3.600	0.333	0.333	0.333	0.333	3.903	16.288

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F23. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: 20 min before low tide

Duration of Test: 10 min, hmr 3 only
Treatment Type: 10 min continuously

Test Date: 3/4/88
Test Time: 0530

5 MINUTES DURING TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	0	0	3	6	4	5	5	5	2	2	14	18
SL	0	0	0	0	0	0	0	0	0	0	0	0
NC	3	11	4	8	2	2	1	1	0	0	10	22
WW	0	0	4	8	2	2	0	0	0	0	6	10
Total	3	11	11	22	8	9	6	6	2	2	30	50

5 MINUTES AFTER TEST PERIOD

RANGE (meters)

Trace Type	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	Total Raw	Total WF
LS	1	4	3	6	5	6	2	2	1	1	12	19
SL	1	4	2	4	0	0	0	0	0	0	3	8
NC	1	4	2	4	1	1	0	0	0	0	4	9
WW	0	0	4	8	2	2	0	0	0	0	6	10
Total	3	12	11	22	8	9	2	2	1	1	25	46

CHI-SQUARE F-HAT	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE F-HAT FOR 2 TEST PERIODS Raw	WF
LS	1	2	3	6	5	6	4	4	2	2	13	19
SL	1	2	1	2	0	0	0	0	0	0	2	4
NC	2	8	3	6	2	2	1	1	0	0	7	16
WW	0	0	4	8	2	2	0	0	0	0	6	10
TOTAL	3	12	11	22	8	9	4	4	2	2	28	48

CHI-SQUARE VALUES	0-5 Raw	0-5 WF	5-10 Raw	5-10 WF	10-15 Raw	10-15 WF	15-20 Raw	15-20 WF	20-25 Raw	20-25 WF	CHI-SQUARE VALUES FOR 2 TEST PERIODS Raw	WF
LS	1.000	4.000	0.000	0.000	0.111	0.091	1.286	1.286	0.333	0.333	0.154	0.027
SL	1.000	4.000	2.000	4.000	--	--	--	--	--	--	3.000	8.000
NC	1.000	3.267	0.667	1.333	0.333	0.333	1.000	1.000	--	--	2.571	5.452
WW	--	--	0.000	0.000	0.000	0.000	--	--	--	--	0.000	0.000
TOTAL	0.000	0.043	0.000	0.000	0.000	0.000	2.000	2.000	0.333	0.333	0.455	0.167

CHI-SQUARE = 3.841 (d.f. = 1, alpha = .05)

Table F24. Indian Point hammer test monitoring using bottom orientated 6x12 degree horizontal transducer located at unit 3, intake 36.

Tidal Phase: At low tide

Duration of Test: 10 min, hmr 3 only
Treatment Type: 10 min continuously

Test Date: 3/4/88
Test Time: 0550

5 MINUTES DURING TEST PERIOD

RANGE <meters>

Trace Type	0-5		5-10		10-15		15-20		20-25		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	2	7	0	0	1	1	2	2	0	0	5	10
SL	3	11	1	2	1	1	0	0	0	0	5	14
NC	5	19	6	11	2	2	0	0	0	0	13	32
WW	0	0	3	6	2	2	0	0	0	0	5	8
Total	10	37	10	19	6	6	2	2	0	0	28	64

5 MINUTES AFTER TEST PERIOD

RANGE <meters>

Trace Type	0-5		5-10		10-15		15-20		20-25		Total	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	1	4	1	2	2	2	2	2	1	1	7	11
SL	0	0	1	2	0	0	0	0	0	0	1	2
NC	1	4	3	6	1	1	0	0	0	0	5	11
WW	1	4	3	6	5	6	0	0	0	0	9	16
Total	3	12	8	16	8	9	2	2	1	1	22	40

CHI-SQUARE F-HAT	0-5		5-10		10-15		15-20		20-25		CHI-SQUARE F-HAT FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	2	6	1	1	2	2	2	2	1	1	6	11
SL	2	6	1	2	1	1	0	0	0	0	3	8
NC	3	12	5	9	2	2	0	0	0	0	9	22
WW	1	2	3	6	4	4	0	0	0	0	7	12
TOTAL	7	25	9	18	7	8	2	2	1	1	25	52

CHI-SQUARE VALUES	0-5		5-10		10-15		15-20		20-25		CHI-SQUARE VALUES FOR 2 TEST PERIODS	
	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF	Raw	WF
LS	0.333	0.818	1.000	2.000	0.333	0.333	0.000	0.000	1.000	1.000	0.333	0.048
SL	3.000	11.000	0.000	0.000	1.000	1.000	--	--	--	--	2.667	9.000
NC	2.667	9.783	1.000	1.471	0.333	0.333	--	--	--	--	3.556	10.256
WW	1.000	4.000	0.000	0.000	1.286	2.000	--	--	--	--	1.143	2.667
TOTAL	3.769	12.755	0.222	0.257	0.286	0.600	0.000	0.000	1.000	1.000	0.720	5.538

CHI-SQUARE = 3.841 <d.f. = 1, alpha = .05>

APPENDIX G:

Quarry Hammer Test

APPENDIX G: Quarry Hammer Test

G.1 Introduction

After the hydroacoustic sampling had ended at Indian Point Power Plant Unit 3, an additional test was conducted at a nearby rock quarry by NYPA and Normandeau Associates, Inc. personnel . The quarry, located a mile downstream of the Indian Point Nuclear Power Plants, was used to perform an open-water test of the avoidance response of white perch to underwater hammer devices. Observations were visual, from above the water surface. The test took place on March 11, 1988.

G.2 Methods

The quarry has a maximum depth of about 100 ft, is 1/2-mile across and irregularly shaped. At the test site, the bottom is muddy and the depth is about 8-10 ft. The hammer was hanging off an underwater wall, and positioned about 3 ft deep. A fish trap was always directly in front of the hammer.

White perch were collected off the IP2 Ristroph screen at about 0800 h and transported shortly thereafter to the quarry, where they were placed in 3-ft by 3-ft by 6-ft box traps. The fish were held in the box traps for about 5 hours. Live fish were then transferred to a single box trap for testing. The trap was generally orientated with the 6-ft side horizontal. The fish depth remained about 3 ft. During hammer tests, the trap was placed at different distances from the hammer. It started out at a position 10 ft from the hammer, then was moved closer. To check for a vertical response, the trap was also orientated with the 6-ft side vertical.

The test fish were those that could maintain their position in the middle of the box trap while it was being moved. Fish that bumped into the sides of the trap during moving were ignored during hammer tests, as were fish that were apparently highly stressed.

Water temperature was 4.5° C. The quarry contains very clear freshwater. Testing was conducted from approximately 1500 h to 1600 h, with a clear sky.

Two hundred test fish were used in this hammer test. Test fish lengths are presented in Table G1.

G.3 Results

When the fish were within about 10 ft of the operating hammer, they consistently oriented away from the hammer and moved to the far side of the box trap. The same response was elicited if the hammer was right up next to the net, or if the net was 4 ft from the hammer, which gives a total distance of 10 ft from the hammer at the outside wall of the trap (4 ft + 6-ft trap length). At more than 10 ft, there was not much of a response.

No vertical response was observed, even when the trap was oriented vertically with a 6-ft depth.

It was not until about 2 or 3 beats of the hammer that most of the fish turned and moved away. In other words, the response was not instantaneous for all of the fish that moved.

G.4 Discussion

It is not known whether the behavior in the quarry was artificial due to the possibility of fish receiving visual cues off the net walls of the box trap.

Quarry results do not account for other possible factors which could have affected the effectiveness of the hammers at the power plant, such as flow velocity, lower water temperature, salinity, etc.

Quarry tests did show a response within 10 ft of the hammer, demonstrating that the hammers could elicit an avoidance response in an acoustically different environment than the sampling tank at Ontario Hydro. To rate success, it is necessary to concentrate on the hydroacoustic data from the near-hammer ranges at the power plant.

Table 1. Numbers and lengths of white perch used in quarry hammer test, March 11, 1988.

Fish #	L (mm)	Fish #	L (mm)	Fish #	L (mm)	Fish #	L (mm)
1	78	51	85	101	76	151	84
2	83	52	104	102	60	152	77
3	84	53	92	103	76	153	85
4	79	54	81	104	61	154	75
5	69	55	71	105	82	155	71
6	82	56	82	106	78	156	84
7	73	57	71	107	82	157	92
8	70	58	76	108	77	158	95
9	82	59	83	109	59	159	84
10	75	60	80	110	84	160	88
11	74	61	80	111	83	161	76
12	80	62	79	112	73	162	78
13	81	63	65	113	74	163	66
14	78	64	85	114	76	164	65
15	79	65	76	115	75	165	73
16	85	66	72	116	57	166	69
17	89	67	70	117	76	167	76
18	95	68	78	118	78	168	77
19	83	69	90	119	75	169	68
20	59	70	86	120	76	170	70
21	81	71	79	121	74	171	84
22	52	72	90	122	77	172	54
23	79	73	115	123	74	173	64
24	84	74	121	124	63	174	70
25	75	75	85	125	84	175	61
26	84	76	64	126	76	176	71
27	81	77	84	127	80	177	72
28	73	78	62	128	86	178	77
29	77	79	92	129	83	179	73
30	84	80	69	130	72	180	74
31	88	81	78	131	55	181	64
32	84	82	81	132	70	182	88
33	83	83	77	133	70	183	85
34	71	84	77	134	77	184	72
35	74	85	70	135	77	185	89
36	72	86	73	136	–	186	83
37	84	87	76	137	–	187	65
38	80	88	85	138	–	188	68
39	77	89	76	139	–	189	63
40	85	90	86	140	68	190	66
41	81	91	58	141	77	191	54
42	80	92	78	142	82	192	77
43	65	93	74	143	76	193	79
44	75	94	59	144	85	194	–
45	83	95	77	145	84	195	74
46	80	96	71	146	83	196	82
47	78	97	79	147	74	197	78
48	62	98	66	148	67	198	86
49	75	99	85	149	89	199	79
50	64	100	82	150	72	200	81

EVALUATION OF DURABILITY, DEBRIS RETENTION, AND CLEANABILITY OF FINE MESH PANELS ON A RISTROPH-MODIFIED THROUGH-FLOW TRAVELING WATER INTAKE SCREEN AT INDIAN POINT UNIT NO. 2

Prepared for

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ORANGE AND ROCKLAND UTILITIES, INC., CENTRAL HUDSON GAS & ELECTRIC CORPORATION, AND NEW YORK POWER AUTHORITY

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1.0 INTRODUCTION

Recent advances in the design of fish-saving features of Ristroph-modified through-flow traveling water intake screens (Fletcher 1990a) outfitted with conventional-sized mesh (e.g. 3/8" sq.; 1/4x1/2" rect.) for purposes of reduction of impingement mortality prompted consideration of the use of similarly modified screens outfitted with fine mesh as a means to reduce entrainment mortality. However, uncertainty of the reliability of fine mesh panels on water intake screens (Fletcher 1990b) mandated tests of mechanical aspects of screen baskets outfitted with fine mesh prior to investigations of fish-saving potentials. A test program was implemented to evaluate the durability, debris retention and cleanability of alternative sizes of fine mesh installed on Ristroph-modified through-flow traveling water intake screen baskets at the Indian Point Unit No. 2 Generating Station.

Durability of fine mesh was of special concern because of reported failings, particularly at the attachment points to basket frames (Fletcher 1990b). Failings in a number of incidences had appeared as material fatigue brought about by the periodic flexing of the mesh within the frames as they were exposed to intake water pressures first on one side and then the other as the baskets rotated in an endless loop around the sprockets of the machine.

Debris retention by fine mesh, particularly the retention of filamentous algae (e.g. *Lyngbia* sp.), was also of special interest in the study. Historically, the types of debris most frequently observed at the Indian Point Station consist primarily of marsh grasses, tree leaves, eel grass and algae. Average daily quantities collected from individual screens range from a few gallons to nearly 200 gallons (Appendix A). Occasionally, filamentous algae is present in bloom-type conditions and may be washed from the screens in substantially greater quantities (1985 Indian Point Impingement Monitoring Program, unpublished data). One species of algae, *Lyngbia* sp., is particularly troublesome because its filamentous strands readily entwine on the wires of the mesh, and is removed only with great difficulty by the high pressure spray wash system. When it is present, substantial intake water head losses can occur across the intake screens as a result of the entwinement of algae on the mesh.

In 1985, observations made during a post-impingement viability study of a Ristroph-modified through-flow screen at Indian Point Unit No. 2 indicated that the filamentous algae could entangle fish collected in screen basket rails and hinder their return alive to the source water. The present study was designed to evaluate filamentous algae retention as a function of screen mesh size. Retention by matting on the surface was considered to be desirable because it would enhance the potential for removal by a front-mounted high-pressure spray wash system. Entwinement, however, was considered to be undesirable, because removal by the high pressure wash might be difficult.

Cleanability of the mesh by the screen's front-mounted high pressure spray wash system was also of interest. Uncertainty existed as to whether the fine mesh in conjunction with a coarse backing mesh would disrupt the spray and reduce its effectiveness in removing debris from the mesh.

This report summarizes the test plan and observations of performance of the mechanical aspects of the twelve of fine mesh panels installed on a Ristroph-modified through-flow screen at Indian Point Unit No. 2.

2.0 MATERIALS AND METHODS

The Ristroph-modified through-flow traveling water intake screen no. 26 at Indian Point Unit No. 2 was selected for use in this fine mesh screen basket evaluation. It is situated in a 13.4' wide by 27' deep (at mean sea level) water intake, and consists of 52 baskets, which measure 2 ft high by 12 ft long. Each basket is outfitted with a fish recovery rail that measures approximately 12 ft long by 3 inches deep by 5 inches wide, and holds approximately 9 gallons of water. The conventional mesh on these baskets has 1/4"x1/2" clear openings woven with 0.08" diameter stainless steel wire. The mesh provides 65% open area.

Circulating water is drawn through the intake at seasonally adjusted rates of 84,000 gpm and 140,000 gpm. At the reduced flow rate, which occurs generally from December through April, intake water approach velocities are approximately 0.5 fps. At full flow, which occurs generally from May through November, approach velocities are approximately 0.9 fps. Approach velocities vary slightly depending on the stage of the tide, the range of which is approximately 3 ft. Debris is filtered from the intake water by the screen, which under normal operation rotates continuously at 2.5 fpm. One revolution requires approximately 42 minutes. Debris is removed from the mesh with a front-mounted high pressures (90 psig.+/-) spray wash system. Fish are removed from the screen rails with a low pressure (10 psig) spray wash system mounted on the rear side of the machine. A secondary high pressure (90 psig) spray wash system located below the fish spray system removes any debris that may remain after the screen baskets have rotated through both the front-mounted high pressure wash and the low pressure fish spray wash system.

Prior to performance of the present study, improvements were made in the manner of attachment of fine mesh panels to screen basket frames by the screen manufacturer. Fine mesh panels were pretensioned for attachment to a screen basket by first binding them to a coarse backing mesh (1" sq.) that had, itself been tensioned by being bowed along its longitudinal centerline (Figure 1). The binding consisted of first placing the top and bottom edges of both meshes into a U-shaped channel of light gauge stainless steel that was then pressed into an S-shaped profile. Pretensioning was expected to reduce panel flexing, while the S-shaped binding was expected to alleviate the mechanical stress of a fixed attachment point such as that formed when a mesh panel is clamped directly to the screen basket frame. The final assembly of fine and coarse mesh was bolted to the screen basket frame (Envirex 1993).

Three sizes of fine mesh in two types of material were selected for evaluation of durability, debris retention and cleanability, particularly during periods when filamentous algae was present. Mesh sizes were 1mm, 2mm, and 3mm. The two types of material were selected for evaluation: stainless steel and polyester. The synthetic material was selected for testing because in other evaluation programs, it withstood flexing somewhat better than metallic mesh, although it was more susceptible to punctures and cuts from sharp-edged objects (Fletcher

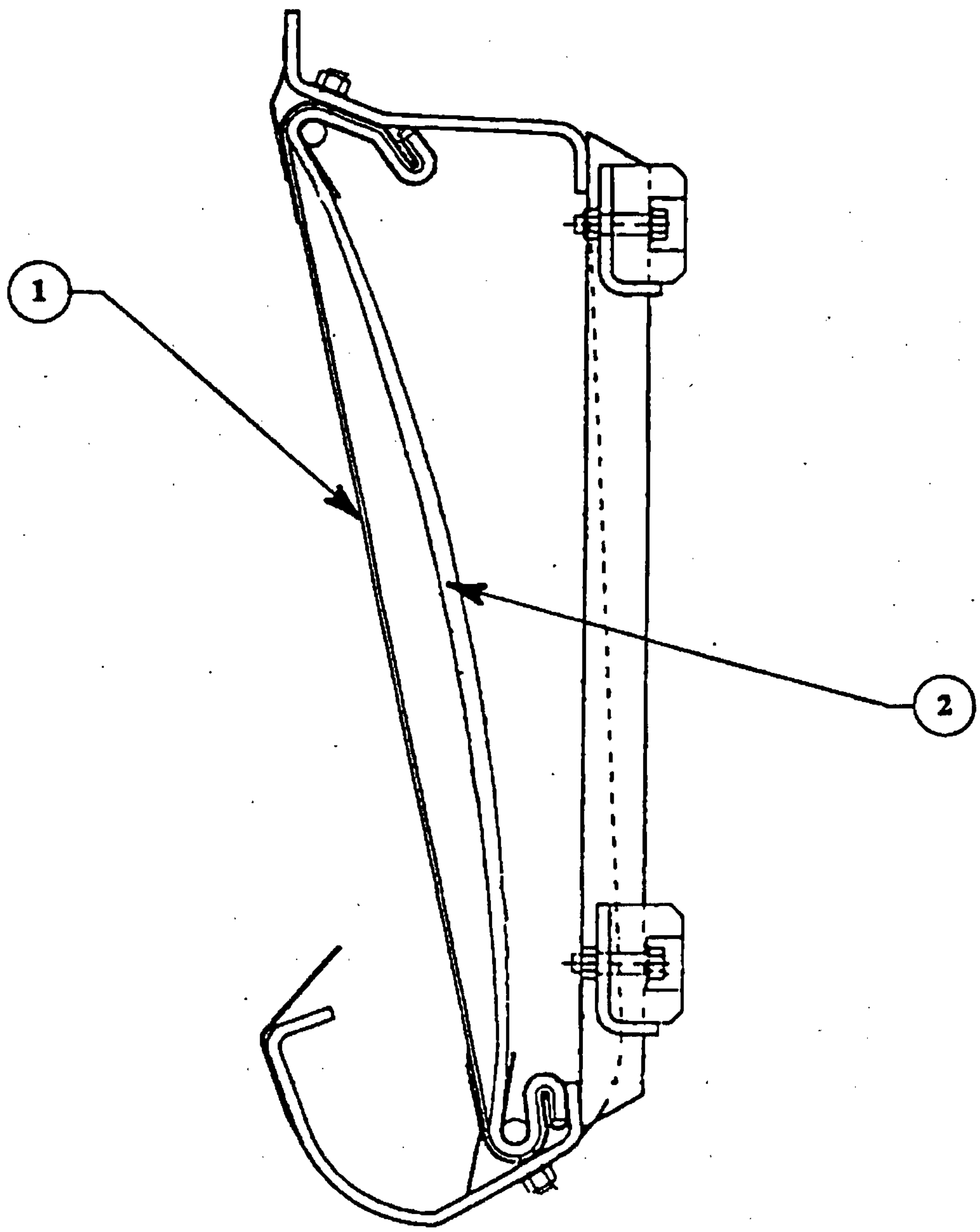

Figure 1. Cross section of Ristroph screen fine mesh panel. (1) Fine mesh panel. (2) Bowed 1x1 inch stainless steel mesh.

1990b). The type of fine mesh and order of installation of test panels on Ristroph-modified through-flow Screen No. 26 at Indian Point Unit No. 2 in March 1993 are delineated in Table 1.

TABLE 1. TYPE AND ORDER OF INSTALLATION OF FINE AND STANDARD MESH PANELS ON THE RISTROPH-MODIFIED THROUGH-FLOW TEST SCREEN NO . 26 AT INDIAN POINT UNIT NO. 2.

MATERIAL	MESH SIZE (mm)	WIRE SIZE (mm)	PERCENT OPEN AREA	NUMBER OF PANELS
Stainless Steel	2x2	0.63	56	3
Stainless Steel	6.3x12.7	2.03	65	10
Stainless Steel	1x1	0.46	51	3
Stainless Steel	6.3x12.7	2.03	65	10
Stainless Steel	3x3	0.63	52	3
Stainless Steel	6.3x12.7	2.03	65	10
Pecap Polyester	1x1	0.50	45	3
Stainless Steel	6.3x12.7	2.03	65	10

Analyses of the durability, debris retention, and cleanability of the 12 fine mesh panels, as well as that for the conventional mesh panels on the test screen, were made through direct observation during the interval May 1993 through November 1994. Photographs of fine mesh and adjacent 1/4 x 1/2 inch mesh panels were taken during periodic inspections as the basket rotated out of the water intake. The 35 mm waterproof camera was fitted to the end of a specially designed extension arm and shutter release that facilitated photographing the mesh panels while the screen was operating. All photographs were of the same general section of each mesh panel (approximately a 2 foot square area approximately 2 feet from the left hand end of the 12 foot long buckets) over the entire evaluation period. In addition to the still photographs, a camcorder was used to make VCR tapes of the panels as they rotated on 4 August 1993, 22 November 1993, and 15 July 1994. During observation periods, the front high pressure spray was operated at approximately 90 psi and the low pressure spray operated at approximately 10 psi. The front mounted high pressure wash was turned off to facilitate observations and the taking of photographs. The screen panels rotated at 2.5 ft/minute almost continuously throughout the test period. Intake water flow velocities averaged approximately 0.9 fps for approximately 75% (15 months) of the 20 month study and approximately 0.5 fps during the remaining 25% (5 months). Approximately 20,000 revolutions of the traveling screen were made during the study period, which reflects the approximate number of cycles of the fine mesh flexing back and forth as the screen rotated around the machine.

During the approximately 20 month long study at Indian Point Unit No. 2, filamentous algal blooms did not develop, and, as a consequence, assessments of the potential for algal entwinement about the wires of the mesh, and efficiency at which it could be removed by the spray wash system could not be directly assessed. On none of the days when the screen panels were inspected was debris loading rates found to be substantial. Evaluations focused on the durability of this screen mesh, particularly with respect to breaks that might have been caused by flexing, or from punctures by heavy debris. The screen panels were inspected for stretching (blousing) of mesh material, which could also increase the potential for flexing at points of attachment to the screen basket frame. The potential for stretching existed because the mesh was exposed to inflow water pressure on first one side of the panels as the basket rose out of the intake bay and then on the opposite side as they descended down the backside of the machine into the bay. The following are synopses of observations of screen condition during each inspection:

<u>18 May 1993</u>

The first observations were made in May 1993, after the panels had been installed for two months. There was no evidence of breaks, tears or punctures in any of the panels. Debris loads were very light. None of the panels showed any blousing and all attachment points for all panels were intact. The 1/4x1/2 mesh on the standard panels that separated the test panels appeared to be in excellent condition and free of any breaks, tears or other damage.

2 June 1993

Three months after installation there was no evidence of breaks, tears, punctures in any of the panels. None of the panels showed any blousing and all attachment points for all panels were intact. Debris loads were light, and the debris present washed cleanly off of all panels as they rotated past the rear high pressure wash onto the back side of the screen. The fine mesh panels did not appear to impede the cleaning ability of the rear spray wash system. The standard 1/4x1/2 mesh panels were also cleaned by the spray system with no problems.

4 August 1993

There was no evidence of breaks, tears, blousing or punctures in any of the panels five months after installation. The light debris present was washed off cleanly by the high pressure spray. The flap seal appeared to be properly positioned and in good condition.

22 November 1993

By November of 1993 the panels had been installed for eight months. No breaks, tears, or punctures were observed in any of the panels and all attachment points for all panels were intact. Some blousing was observed in the second panel of the 1x1 mm synthetic mesh; the mesh no longer appeared to be tightly stretched within the basket frame.

29 March 1994

The panels had been installed for 12 months by March of 1994. Attachment points on all panels were intact and there were no breaks, tears or punctures. Small amounts of debris were present and all debris washed cleanly off of all panels. Blousing was observed in the second 1x1 mm synthetic mesh panel. In addition, slight blousing was observed in the second panel of 2x2 mm stainless steel.

10 June 1994

Fifteen months after installation, some blousing was observed on the second 1x1 mm synthetic panel and the second 2x2 mm stainless steel panel. No blousing, tears, breaks or punctures were observed on any other panel.

15 July 1994

Sixteen months after installation, all three 1x1 synthetic panels exhibited moderate blousing. At the center of the panels there was approximately a 25 mm gap between the synthetic mesh and the stainless steel support mesh. The center panel of the 2x2 mm stainless steel mesh also showed slight blousing. All other fine mesh panels were intact with no blousing, breaks, tears, or punctures. The 1/4x1/2 inch mesh panels also appeared to be in excellent condition (see photographs, Appendix B).

23 November 1994

No significant changes in the conditions of the fine mesh panels were observed between July 1994 and November 1994. Twenty months after installation a 25 mm gap was present between all the synthetic mesh panels and the stainless steel support mesh. The center panel of the 2x2 mm stainless steel mesh also showed slight blousing. All other fine mesh panels were intact with no blousing, breaks, tears, or punctures. The 1/4x1/2 inch mesh panels also appeared to be in excellent condition.

21 September 1995

A follow-up inspection be Con Edison at approximately 28 months of service disclosed that all panels of each of the three sets of stainless steel mesh appeared to be in excellent condition. All bindings appeared to be tight, and there was no signs of punctures, tears, or breaks in any of the panels. Slight blousing was observed in one panel of 1 mm stainless steel mesh. Slight blousing observed in one panel of 2 mm stainless steel mesh at 12 months of service, noted above, did not appear to have increased. The polyester mesh appeared to have continued to stretch, although it was still fully intact and had no observable cuts, tears or breaks. The gap between the polyester mesh and its support mesh appeared to be approximately 75 mm at the center of the panel.

3.0 DISCUSSION

The fine mesh panels on Screen No. 26 were inspected for durability, debris retention, and cleanability on eight occasions over a 20 month evaluation period. During this period, test panels experienced approximately 20,000 cycles (rotations) between the front and the rear side of the machine at an approximate rate of one cycle every 42 minutes. During each revolution, the mesh was subjected to intake water pressure first on one side and then on the opposite, which caused flexing in one direction and then the opposite as the baskets rotated around the sprockets. Installation of the fine mesh panels on a backing mesh appeared to limit inward flexing on the front side of the baskets, but did not prevent outward flexing when the baskets were on the backside of the machine.

At the end of the test period, all panels, as well as the adjacent conventional panels, were found to essentially free of any form of damage such as breaks in wires due to flexing, or tears or punctures such as those that might occur from contact with sharp-edged objects (Photograph sets A through E). Although not discernible from examination of the photographs, the polyester mesh in all three test panels lost its original tension in the screen basket frame as a result of stretching after approximately 8 months of service (8,300 cycles). This condition was considered undeniable. Excessive stretching could accelerate the deterioration of mesh. A slight amount of stretching of the 2x2mm stainless steel mesh occurred in one of the three test panels after approximately 12 months of service (12,500 cycles). In laboratory tests, the screen manufacturer, Envirex, Inc., exposed 2x2mm pretensioned stainless steel mesh mounted in a 10 ft long by 2 ft wide screen basket to a periodic pressure equivalent to a 1 ft water head differential and found no significant mechanical deterioration after 270,000 flex cycles (Envirex 1993).

Debris loading during inspection periods was "light" to "normal", which, based on records of debris accumulations at the station (Appendix A), was equivalent to approximately 0.02 to 0.05 gallons (1/4 to 1 cup) per screen basket rail per rotation through the intake water column. Assessments of filamentous algae retention as a function of mesh size, as well as cleanability by the high pressure wash system, could not be accomplished because the algae was never observed in bloom-type quantities during the study period. The fact that accumulations of any types of debris were not entwined in the mesh of test panels suggested that cleanability had not been impaired by any of the three fine mesh sizes plus respective backing (tensioning) meshes tested.

4.0 REFERENCES

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Fletcher, R.I. (1990b). A Review of Reported Fine Mesh Screen Applications for High Volume Water-Intake Systems, and Recommendations for Further Investigations. Report to Consolidated Edison Company of New York, Inc.

Envirex, Inc. (1993). A Report on TWS Basket Endurance Test No. 13., 10' Tensioned Mesh @ 1' D.P. Project No. RD94015-06D.

APPENDIX A

INDIAN POINT GENERATING STATION DEBRIS DATA
TRAVELING WATER SCREENS 21-25

				DEBRIS IN GALLONS, FIVE SCREENS COMBINED			
YEAR	MONTH[a]	NO. OF DAYS	TOTAL/ MONTH	MAX/DAY	MIN/DAY	AVG/DAY	TYPE[b]
89	JAN	31	1,673	120	15	54	1, 4
89	FEB	28	709	50	4	25	1, 4
89	MAR	18	386	70	5	21	1, 4
89	JULY	28	3,473	320	30	124	2
89	AUG	31	3,242	260	10	105	2
89	SEPT	29	5,190	520	60	179	2
89	OCT	30	3,560	355	30	119	2
89	NOV	30	2,920	280	25	97	2, 4
89	DEC	29	763	100	5	26	1
90	JAN	29	656	60	2	23	1
90	FEB	26	1,495	175	5	58	1, 4
90	JUNE	14	840	200	5	60	STKS
90	JULY	31	1,338	185	3	43	STKS
90	AUG	31	2,745	225	25	89	2, STKS
90	SEPT	29	2,865	325	5	99	2
90	OCT	31	2,110	220	10	68	2
90	NOV	29	3,325	600	5	115	2, 4
90	DEC	30	1,695	255	10	56	1, 4

[a]Missing months - Unit was out of service, debris collections were not recorded.

[b]1-algae
2-eel grass
3-*Spartina*
4-leaf litter
5-Other
STKS-sticks

INDIAN POINT GENERATING STATION DEBRIS DATA
TRAVELING WATER SCREEN 26

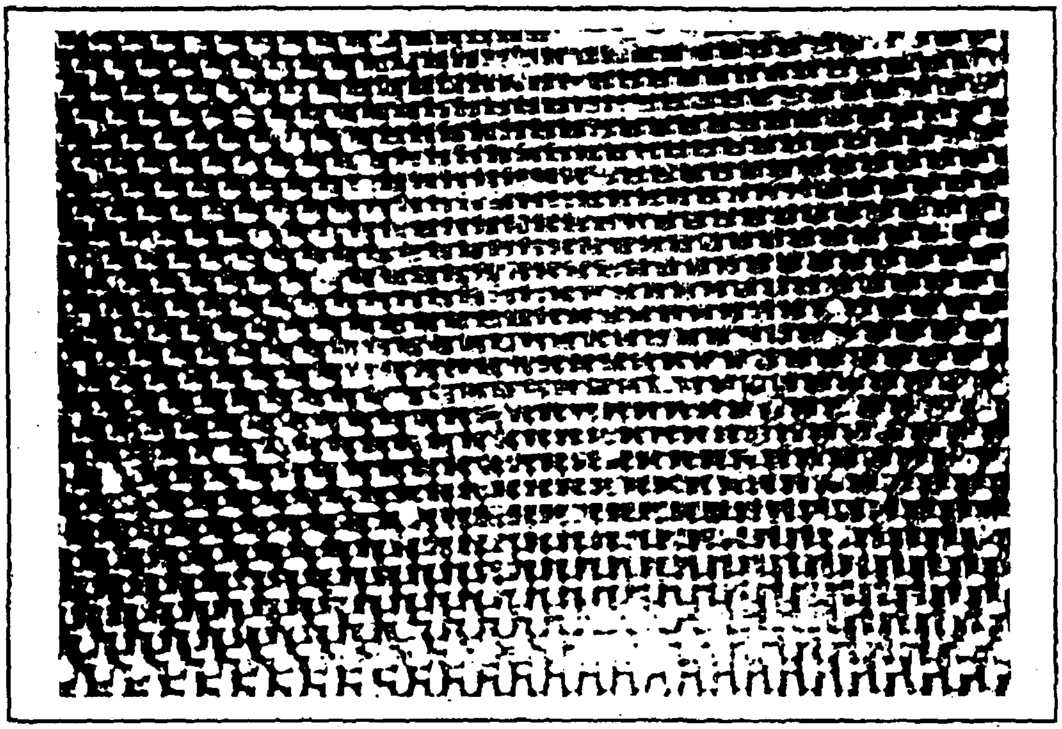
YEAR	MONTH[a]	NO. OF DAYS	TOTAL/ MONTH	DEBRIS IN GALLONS, FIVE SCREENS COMBINED			TYPE[b]
				MAX/DAY	MIN/DAY	AVG/DAY	
89	JAN	31	208	20	1	7	1, 4
89	FEB	28	106	12	1	4	1, 4
89	MAR	19	88	10	1	5	4
89	JULY	26	200	20	2	8	2
89	AUG	31	296	35	1	10	2
89	SEPT	29	317	60	2	11	2
89	OCT	30	479	50	2	16	2
89	NOV	30	814	80	1	27	2, 4
89	DEC	29	338	40	4	12	1
90	JAN	29	286	35	3	10	1
90	FEB	28	293	35	2	10	1, 4
90	JUNE	18	372	90	5	21	1, 4
90	JULY	22	283	30	3	13	2
90	AUG	27	931	175	1	34	2
90	SEPT	29	498	45	1	17	2
90	OCT	17	398	150	1	23	2,4
90	NOV	20	819	195	5	41	4
90	DEC	28	440	150	1	16	1, 4

[a]Missing months - Unit was out of service, debris collections were not recorded.

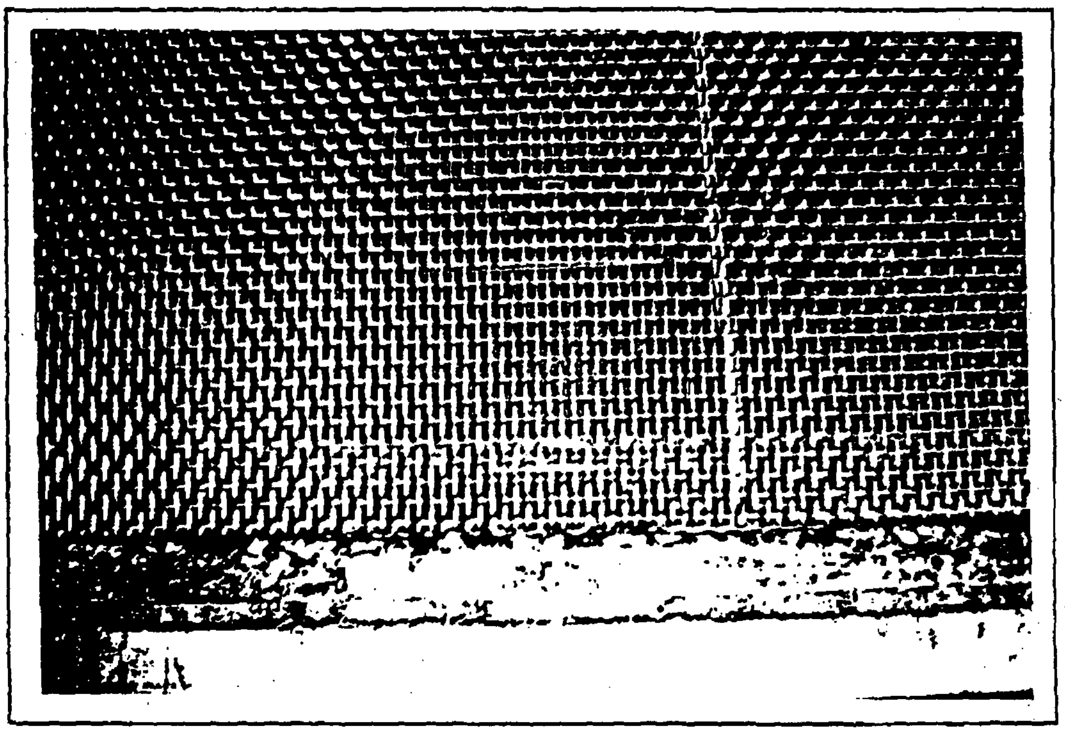
[b]1-algae 4-leaf litter
2-eel grass 5-Other
3-*Spartina* STKS-sticks

APPENDIX B

Photographs of fine mesh and conventional mesh panels on Intake Screen No. 26 of Indian Point No. 2, May 1993 through November 1994.



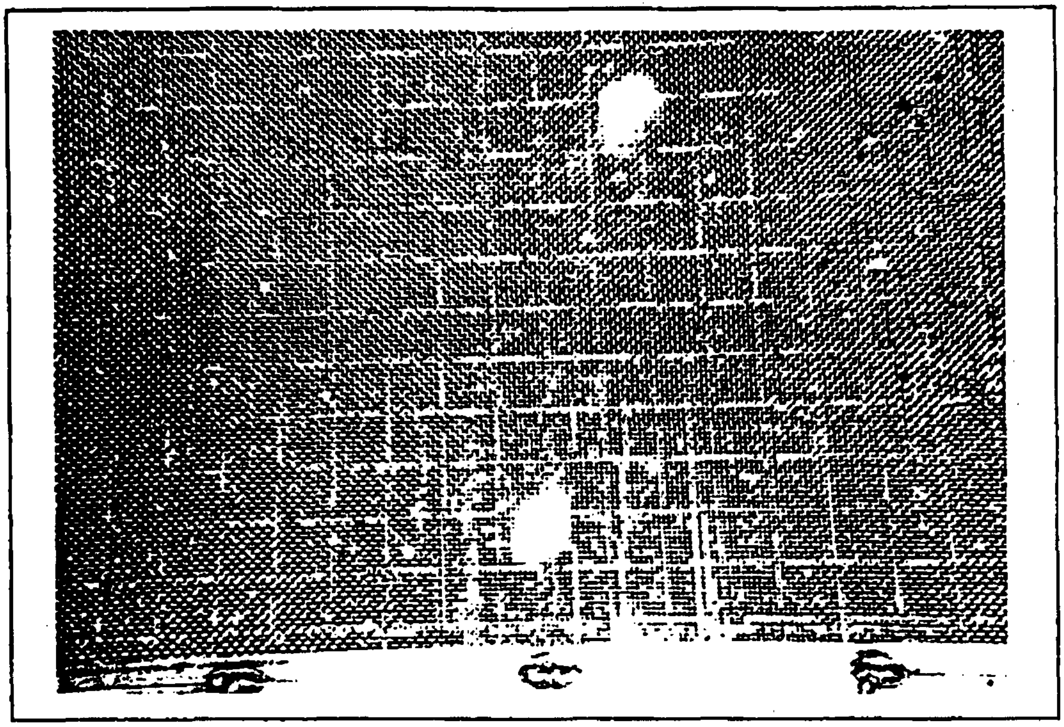
A. May, 1993



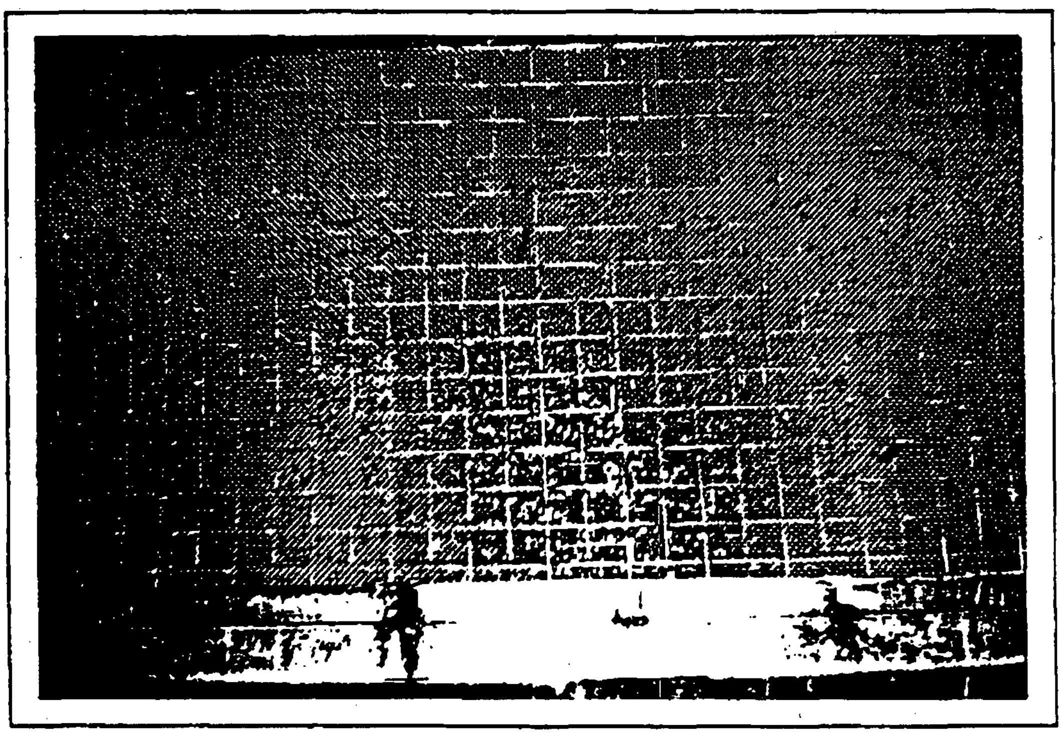
B. July, 1994

Photo Set A.

Photographs of 1/4x1/2 inch standard stainless steel mesh panels.



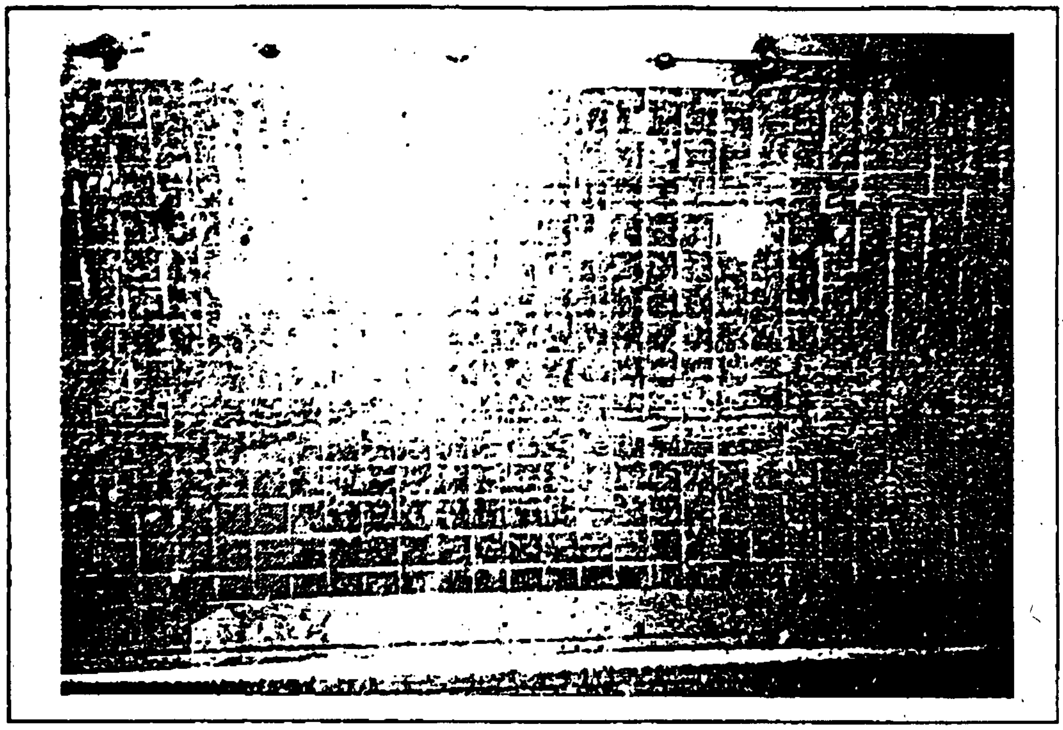
A. May, 1993



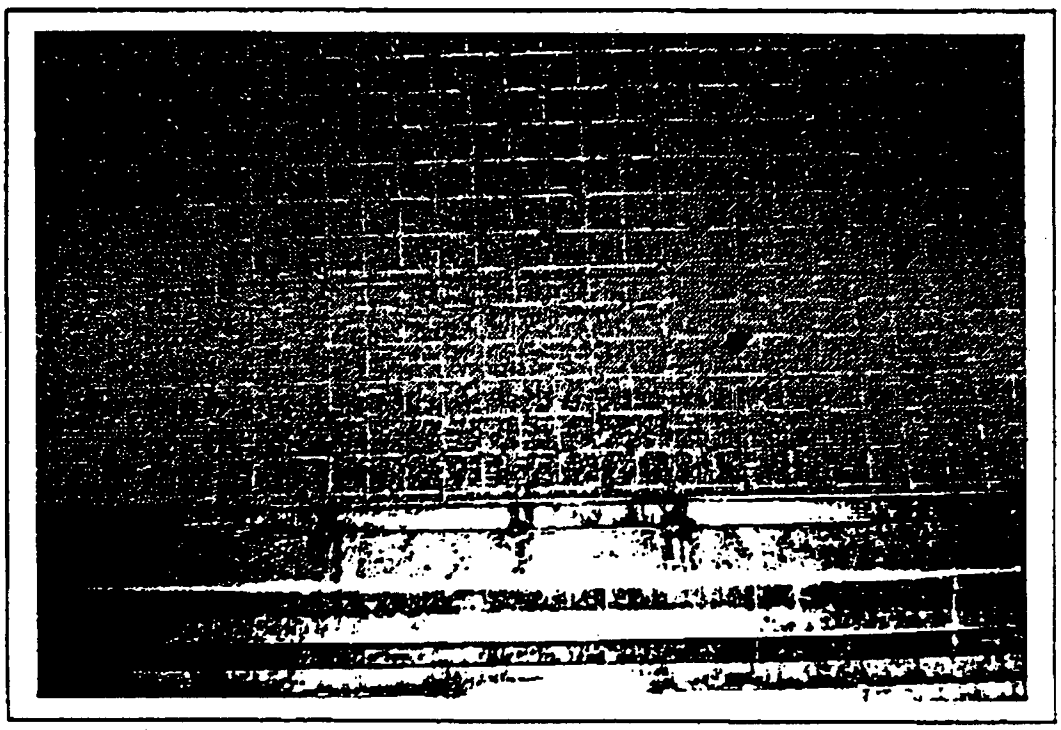
B. July, 1994

Photo Set B.

Photographs of 2x2 mm stainless steel mesh panels.



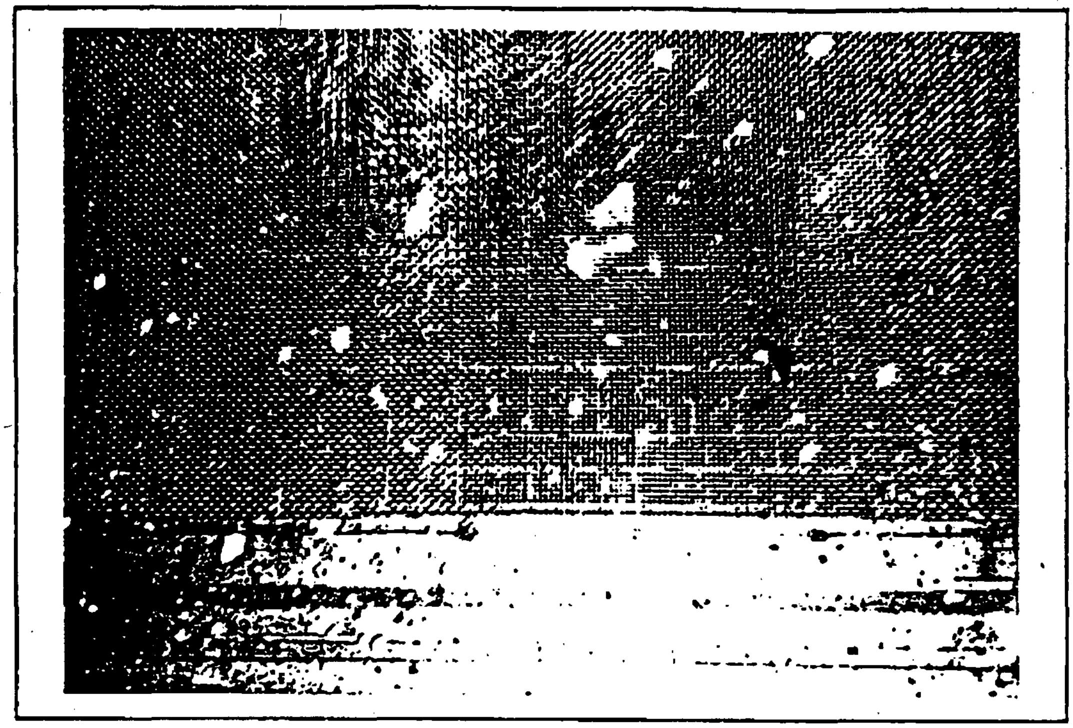
A. May, 1993



B. July, 1994

Photo Set C.

Photographs of 1x1 mm stainless steel mesh panels.



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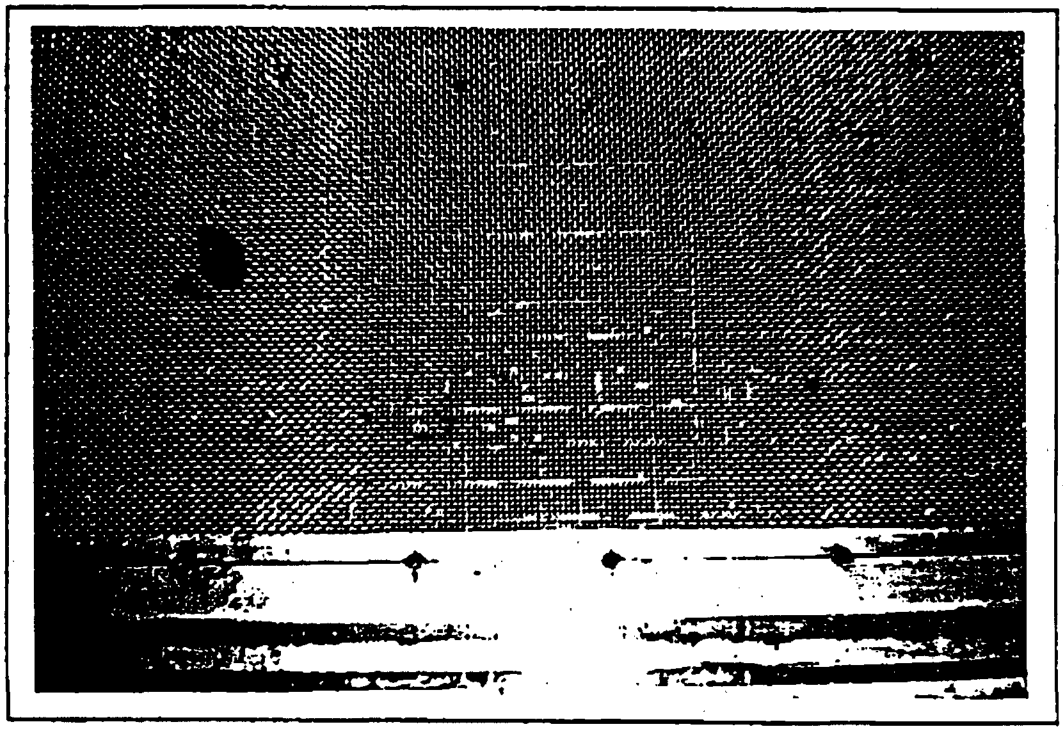
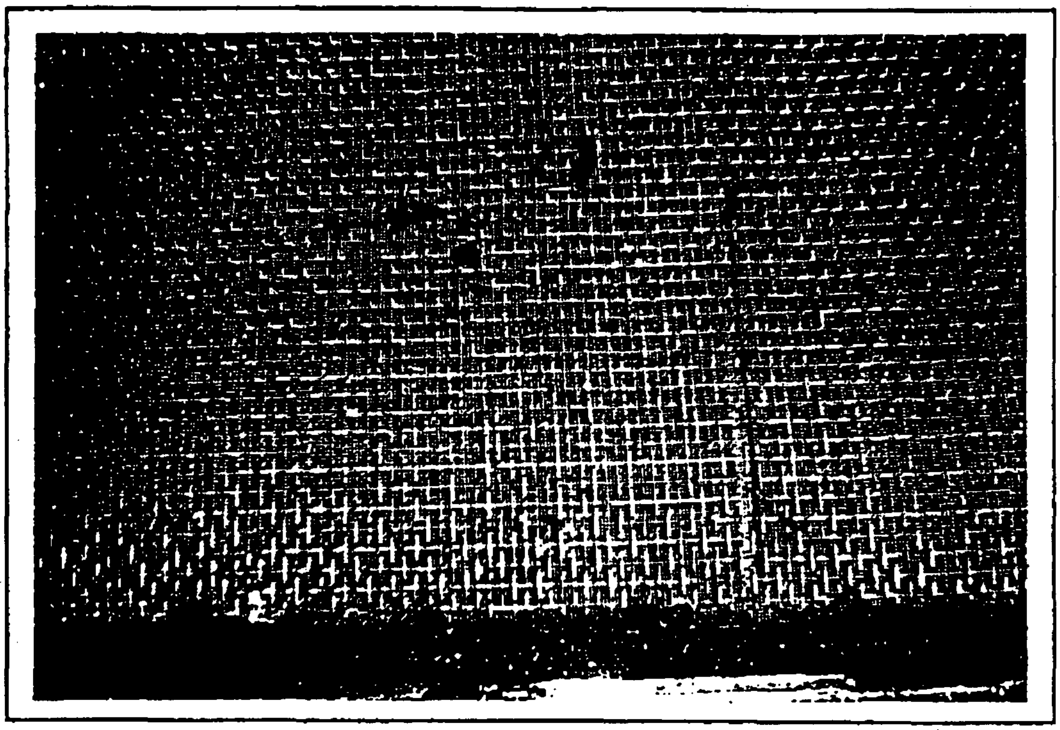


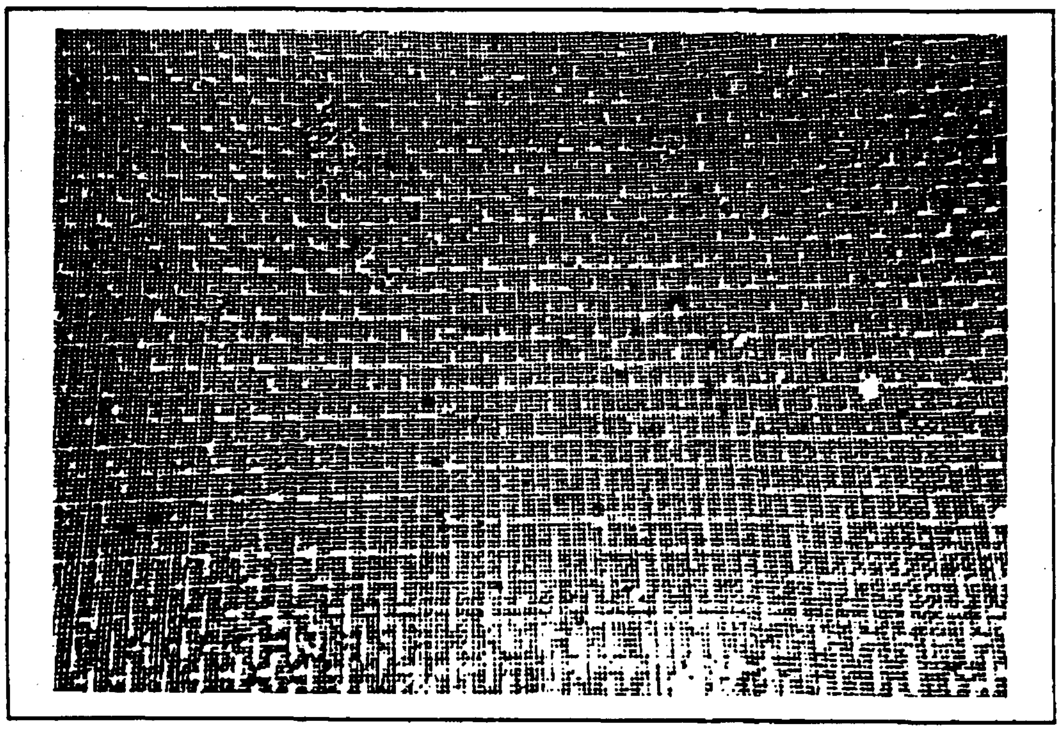
B. July, 1994

Photo Set D.

Photographs of 3x3 mm stainless steel mesh panels.



A. May, 1993



B. July, 1994

Photo Set E.

Photographs of 1x1 mm Pecap polyester mesh panels.

Transactions of the American Fisheries Society 123:866–885, 1994

Flows and Fish Behavior: Large Double-Entry Screening Systems

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Abstract.—Facilities that draw water in large quantities from natural sources are commonly equipped with mechanically driven barrier screens for removing indrawn debris and captive fish. Owing to the mistransport of debris into the works of the facility by the cyclic action of conventional screening apparatus, many plant operators favor the refitting of intake systems with alternative devices called dual-flow screens, whose manner of operation precludes the deposition of debris downstream of the screen location. Fish-catching devices, otherwise suited to the flows and mechanics of a conventional screen, are often attached without alteration to the screen panels of a dual-flow machine in the hopes of rescuing entrapped fish. Dual-flow machines are thought to be superior to conventional intake screening systems in saving impounded fish, but the full-scale experiments reported here show why the flow patterns and water speeds associated with a (double-entry) dual-flow screen are actually more adverse to live fish recovery than flows through a conventional screen. Owing to flow separations at the entries of these devices and the resulting concentration of flow over a restricted portion of the screening, fluid speeds comparable to flows of 30 and 45 cm/s through conventional screens increased to 90 and 140 cm/s at free-flow regions of the screenfront. In experiments with two species of juvenile fishes, survival without injury was nil. Flow trajectories were mapped by streak photography, and details of fish behavior were recorded on videotape and 35-mm film. Equations for the flow distributions were resolved from two-component vector measurements of water velocities. Also shown is an experimental apparatus (a frontwall fairing) that eliminates the flow separations, resulting in a redistribution of the inflow across the full width of the available screening.

Electricity generating stations and other facilities that divert or withdraw large volumes of water from natural sources in their operations are commonly equipped with mechanically active barrier screening. The screens have the principal function of halting and removing debris from the inflowing water, but they also collect and kill entrapped fish, often in large numbers. A conventional water intake system consists usually of several sumps, each supplied from a free-surface forebay and each fitted with a motor-driven machine that moves a set of linked screen panels around sprockets in the manner of an endless chain, as indicated by Figure 1. The inflowing water is drawn directly through the ascending and descending halves of the traveling screen assembly; indrawn matter not otherwise extruded through the screen mesh is forced onto the upward moving screen by the inflow, then carried above the water surface for disposal.

Material captured and raised from the water by the screen is forcibly removed by one or more rows of directed, high-pressure water jets that blow through the screening from locations above the machinery deck and between the moving halves of the screen. Very often, such indrawn matter as plastic bags and filamentous macrophytes, in being stapled into the screenmesh, is not completely removed by the spraywash. In consequence, the unremoved debris is carried back to the water by the descending side of the screen and released into the sump by the force of the main water flow. In some cases, the transport, or carry-over, of unwanted debris into the sumps of a water intake system (and hence into the plant works by way of the water pumps) is great enough to degrade the operating efficiency of the facility or to require increased maintenance.

Owing to the annoyances connected with the mistransport of debris by conventional rotating screens, many plant operators favor the refitting of intake systems with alternative devices, called dual-flow screens, whose manner of operation precludes the downstream deposition of debris. Although consisting of linked panels and driven around sprockets in a conventional fashion, a dual-flow screen is placed at an attitude 90° to the approaching flow, water passing through its moving halves according to either of two configurations, one called a double-entry, single-exit screen (as in Figure 2b) and the other a single-entry, double-exit screen. The double-entry arrangement is the design more often employed, and it was the design adopted for the experimental work reported here.

In contrast to the straight-through flow geom-

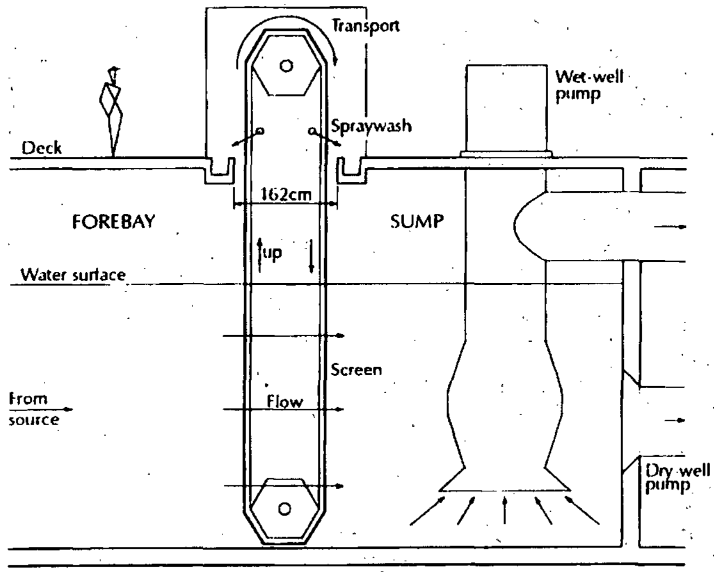


FIGURE 1.—Arrangement of a large water intake system equipped with a conventional rotating screen. Typical water speeds through the screen range from 30 to 60 cm/s, and a typical elevation speed is 5 cm/s. Pump capacities (of either the wet well or dry well configuration) range from 260,000 to 530,000 L/min.

etry of a conventional rotating screen (Figure 2a), water drawn through a double-entry screen arrangement must bifurcate around a plate or frontwall (which closes off the upstream side of the machine) and pass through the ascending and descending halves of the screening by way of two alley-like portals at the sidewalls of the forebay. The flow then enters the sump area through a narrow penstock, at the rear of the machine, which is no more than the open framework between the moving halves of the screen. As shown by the studies reported here, the peculiarities of the flow approaching and passing into the screen pose special problems in the mechanics of live fish recovery.

Although the problem of fish kills by various

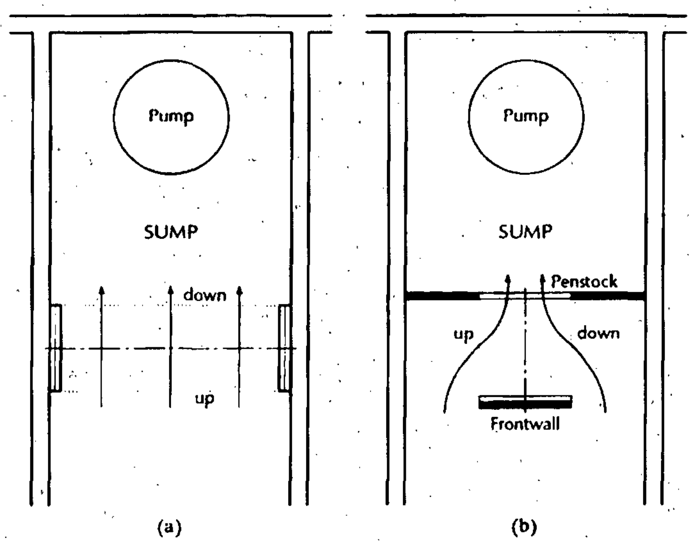


FIGURE 2.—(a) Plan of typical intake channel equipped with a conventional rotating screen, as in Figure 1. (b) Conversion of the intake channel to a double-entry, single-exit rotating screen.

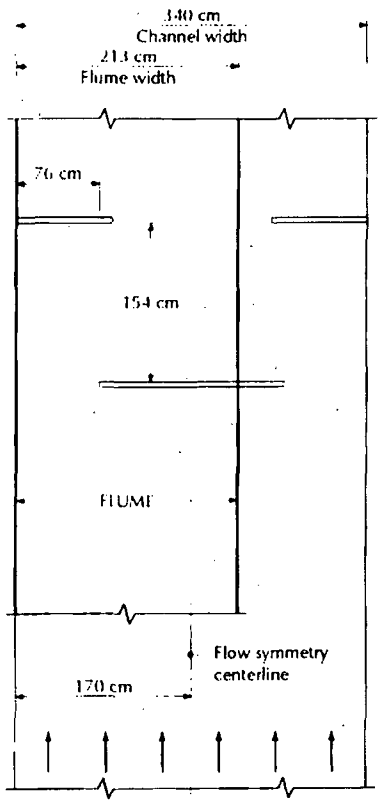


FIGURE 3.—Relationship between the width of the laboratory flume and the geometry of a typical dual-flow screen conversion for a standard-width intake channel.

intake screening systems has received considerable attention over the years from regulatory agencies, fishermen, citizen's action groups, the power industry, and screen manufacturers, little work has been done in the past in the way of direct observations of the full-scale flow patterns and fish behavior associated with any screening system. Costly apparatus meant to rescue entrapped fish, or to divert them in some way from encounters with the screening, is manufactured and installed with scant foreknowledge of its likelihood of succeeding or failing. Such intuitively derived schemes and devices as sound generators, electric barriers, dangling chains, bubble clouds, angled screens, horizontally traveling screens, and fish-scooping devices, although promising in concept, have not proven to be very effective in reducing fish kills at large water intake systems (see Fletcher 1985 for a list of representative references). The poor performances of these fish-saving appliances can often be traced to imperfect understandings of fluid flows and the related responses of fish to currents and obstacles. As shown in a recent study of a device known as a Ristroph screen (Fletcher 1990a), casual suppositions about the nature of complex fluid flows can be so misleading that one is apt to anticipate an outcome wholly at odds with reality. In the case of the Ristroph screen experiments, once the actual interactions between fish and flows were observed, alterations to the device that conformed to reality followed and fish kills were reduced.

For the dual-flow experiments reported here, a full-scale entry portal and frontwall of a dual-flow screen, typical of the double-entry configuration, were installed in a large hydrodynamics flume. Flow patterns and velocity fields were retrieved from vector-resolving current measurements and from two flow-marking schemes, one of particle motion recorded on videotape and one of particle streaking by time exposures on 35-mm film. Test fish were also released upstream and their dispositions in the flow fields were recorded on videotape and 35-mm photographs. As in the Ristroph screen study, this research was meant to discover and clarify those peculiarities of flows and fish behavior that instruct both the biologist and the design engineer.

Experimental Apparatus

In the usual circumstance where conventional rotating screens are replaced with dual-flow machines, the overall breadth of the device is limited by the width of the access slot, or well opening, in the machinery deck of the facility (see Figure 1), the standard dimension being 1.62 m (5 ft, 4 in). The long dimension of the well opening corresponds to the width of the intake channel. A common dimension is 3.4 m (11 ft, 2 in), but intake channels range in width from 2.74 m to 3.96 m. Short of altering the civil works of a plant, these dimensions effectively limit the arrangements of dual-flow machines designed expressly to replace conventional screens. The experimental apparatus for the work reported here was configured around the basic dual-flow geometry prescribed by the manufacturers of such devices and installed in the Royce hydrodynamics flume in Houston, Texas.

The Royce flume is equipped with underwater viewing ports, an overhead camera gantry, flow-measuring instruments, fish-releasing cages, and fish-holding tanks. The flume and its equipment were more fully described by Fletcher (1990a). Although the 340-cm width of a typical intake channel is greater than the 213-cm width of the labo-

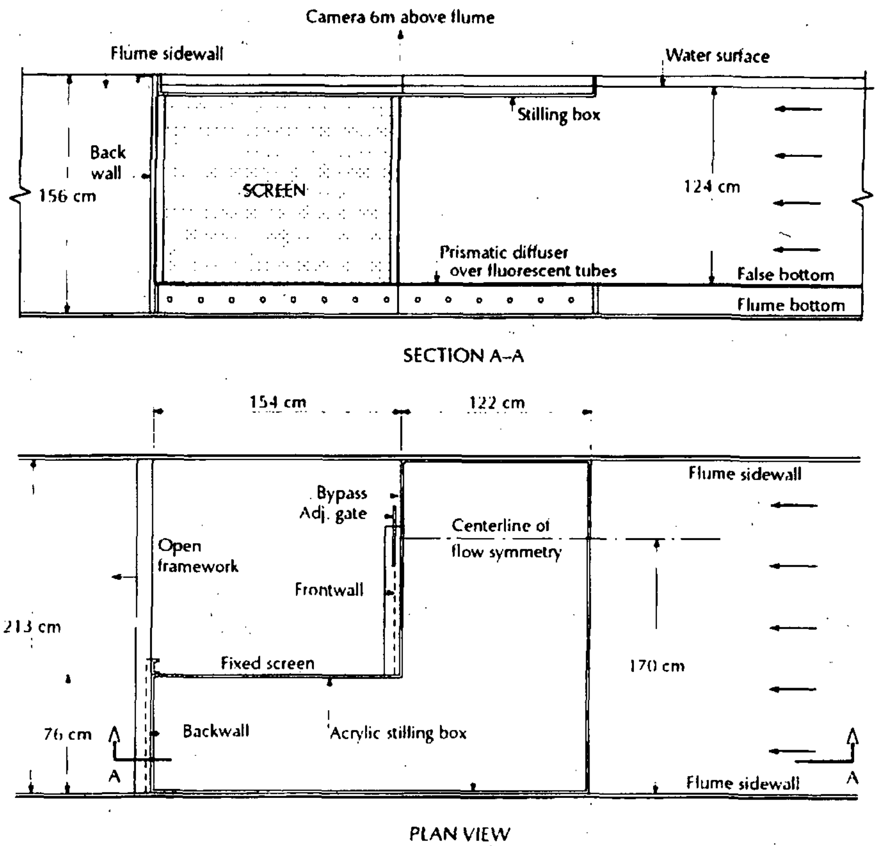


FIGURE 4.—Plan and section of experimental apparatus, as arranged in the laboratory flume for the flow-marking and fish behavior experiments. The location of the stagnation streamline was controlled by means of the frontwall bypass and adjustable gate. For the flow-marking experiments, slot lighting through underwater viewing ports was employed. All filming was done from an overhead gantry.

ratory flume, duplications of full-scale flow fields were still possible by virtue of the mechanical and fluid dynamical symmetries characteristic of the dual-flow screen geometry. The relationship of those symmetries to the configuring of the flume for the experimental work is indicated by Figure 3, which shows the flume width superimposed on the layout typical of a full-scale dual-flow screen. That portion of the dual-flow apparatus falling within the boundaries of the laboratory flume (the frontwall of the screen and one entry portal) was built and installed in the flume, and the location of the stagnation streamline (the flow centerline indicated on the figure) was controlled by means of a bypass and gate located at the far end of the screen frontwall.

The arrangement of the laboratory flume for this work is more fully described by Figure 4. For the fish behavior experiments, the bottom of the flume in the vicinity of the modeled dual-flow machine was lighted by rows of sealed fluorescent tubes, covered over with a prismatic diffusing plate, which allowed for overhead silhouette filming of fish movements. As an aid to the overhead video and photographic work, an L-shaped stilling box, constructed of a clear plastic material and containing a layer of water, was clamped in place at the flume water surface, directly over the bottom lighting. Because the purpose of the research did not extend to the testing of any proposed or existing fish-rescuing attachments, none of the mechanism for actually moving the entry screen was needed for the work, so the screening itself was merely fixed in place, as indicated on the figure.

Flume calibration.—All experiments were repeated at two mean upstream flow speeds, 30 and 45 cm/s—testing standards recommended by the Electric Power Research Institute. The free-flow distribution in the laboratory flume is controlled

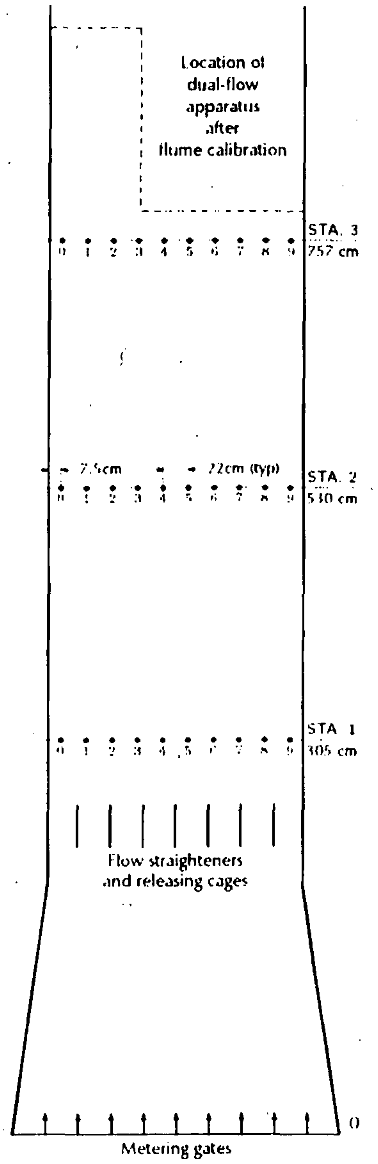


FIGURE 5.—Channel portion of the laboratory flume showing locations of reference stations for calibrating the free-flow geometry. Water velocities were measured at each station on a vertical reference grid of 70 points (7 rows, 10 columns). The 98 metering gates were adjusted until the desired flow pattern was achieved.

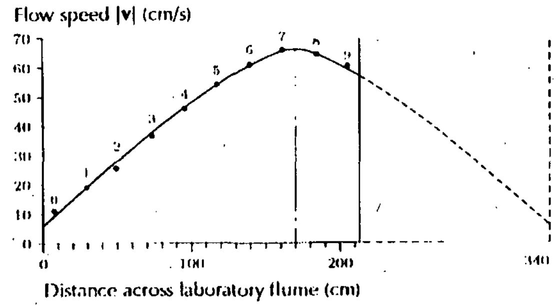


FIGURE 6.—Velocity distribution across the laboratory flume, middepth at station 3, with the upstream flow set at 45 cm/s before installation of the dual-flow apparatus. Points denote instrument values. Velocity profile in the 213-cm-wide flume simulates flow in a 340-cm-wide open channel.

by 98 metering gates, located in the bulkhead of the inlet chamber, which were set in a pattern, prior to installation of the dual-flow apparatus, that put the (offset) core of the unobstructed flow along a line corresponding to the symmetry centerline of a 340-cm-wide intake channel. The selected flow geometry was meant to simulate the flow typical of an open, elongated channel, which takes on a characteristic nonuniform distribution where the fluid speed at the core of the flow may be four to five times the speed near the channel boundaries (see Sellin 1970 or White 1986). Thus, the 120-cm vertical distance from the flume bottom to the underside of the stilling box (Figure 4) represents a like-size section across the core (and below the surface) of a deep channel.

For the flume calibrations, an electromagnetic current meter was attached to a digital converter, with input to a microprocesser, which gave three-dimensional displays of the corresponding velocity vectors at the three flume stations indicated in Figure 5. At each of those reference stations, velocity measurements were taken on a vertical reference grid of 70 points distributed over the width and depth of the flume. A representative cross-channel distribution from those measurements is shown by Figure 6. The velocity pattern for each of the mean test speeds was calculated from a normalized distribution and the metering gates of the flume were set accordingly. Following the flume calibrations, the dual-flow apparatus was installed in the flume; the correct location of the offset, flow-symmetry centerline was maintained by means of a gated bypass located in the front wall of the dual-flow apparatus. The centerline of the unobstructed flow became the stagnation streamline of the flow into the dual-flow apparatus. The complete velocity measurements from the flume calibrations are given in the laboratory report (Fletcher 1990b).

Exceptions to the experimental conditions.—In circumstances where the intake channels of a facility open onto a flowing water source (as in a

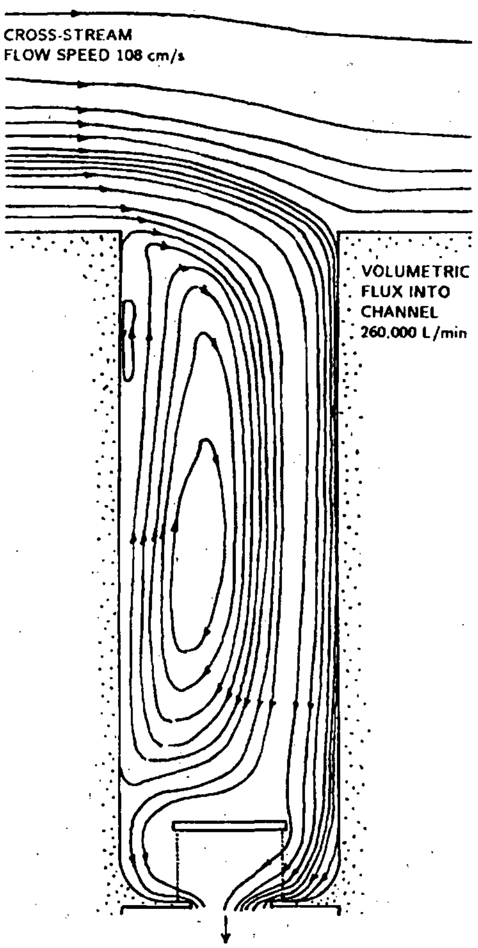


FIGURE 7.—Calculated transport trajectories at Arthur Kill Generating Unit 2 (Staten Island, New York), showing the influence of a tidally driven and wind-enhanced crosscurrent on the flow into a typical intake channel of the plant. Channel width is 3.4 m and water depth in the sump varies from 3.6 m to 6.4 m with the tide. (From Fletcher 1988.)

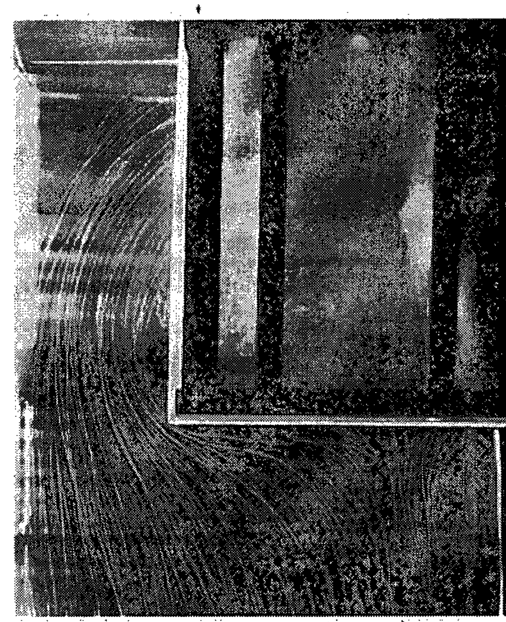


FIGURE 8.—Pathline streaks in the vicinity of the experimental apparatus, at the 30-cm/s mean flow setting, as delineated by reflective flow markers (which were illuminated by slot lighting through underwater viewing ports). At the corner of the entry portal, the main flow separates from the frontwall and passes through the screenmesh a distance downstream from the corner, thus creating a gyre of reverse flow through the upstream portion of the screening.

river), the realized flow distributions may differ somewhat from the flow patterns employed in the experiments here, owing to the influence of the crosscurrent at the channel entries. In the case of a conventional screening arrangement (as portrayed in Figures 1 and 2a), an asymmetric forcing of the intake flow is not especially deleterious to the operation of the intake system, but in the case of a double-entry system, the flow speeds through one portal may be elevated significantly above design limits (and, consequently, to speeds even greater than those recorded in the flume experiments here). Figure 7 shows the transport trajectories of just such a case. The unbalanced flow through the penstock created an adverse pump condition called pre-swirl, which was partly corrected by the attachment of vertical guide vanes at the penstock exit. Downstream flow corrections, however, do not readily ease the upstream hydraulic heads or the asymmetric burdens of momentum on the screen structure occasioned by such severely skewed and accelerated approaching flows. In the winter of 1992–1993, for example, a double-entry test screen at the Roseton generating station on the Hudson River was collapsed by a storm surge, while the conventional rotating screens in the proximate intake channels of the plant suffered no apparent harm.

Flow Trajectories and Velocity Fields

Pathlines of the flows in the vicinity of the modelled dual-flow screen were recorded on videotape

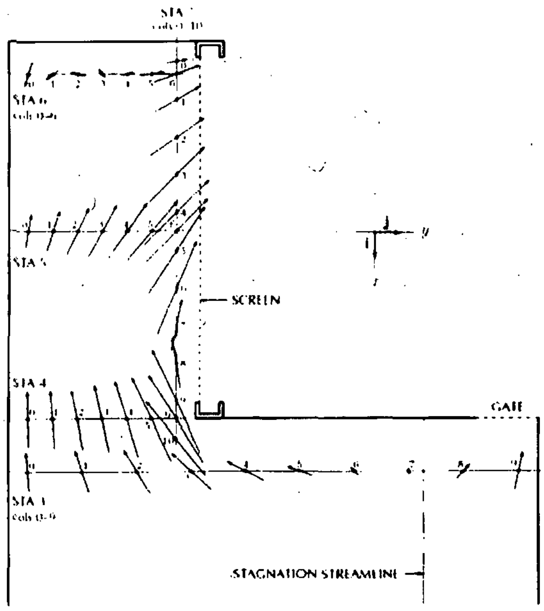


FIGURE 9.—Plot of velocity vectors at middepth, at the 45-cm/s mean flow setting, as measured with a component resolving current meter. The points of measurement lie at the arrow midpoints. The length of a vector arrow corresponds to water speed (to velocity magnitude); the orientation of the arrow corresponds to the instantaneous direction of flow at the reference point. See Table 1 for component values.

and 35-mm photographs. The cameras were equipped with telephoto lenses and located 6 m above the flume (an arrangement for reducing visual parallax). Pathline trajectories for the streak photography were delineated by small, neutrally buoyant plastic particles released 5 m upstream of the dual-flow apparatus. For each such release, six successive exposures were made at 1.2-s intervals with shutter speeds of 0.6 to 0.9 s. Streak lines typical of that technique are shown in Figure 8. Because the flows were steady and the mass of a plastic particle was very small, the pathline streaks can also be viewed as velocity streamlines. As indicated by Figure 8, the flow along the front-wall of a dual-flow screen must turn 180° to enter the screening. Owing to the high momentum of the fluid in that turning region, a large standing flow separation occurred at the upstream corner of the screen entry. In consequence of the displacement of flow past the separation, the main efflux of water through the screen was concentrated over the downstream portion of the screening at both of the employed test speeds.

Flow separations like that of Figure 8 are not usually perceived at the surface of a channel flow when the intake pump is located deep in the water column. Unlike a purely gravity-driven flow, where the high-speed core commonly occurs at or near

TABLE 1.—Middepth velocity measurements (cm/s) corresponding to the vector field shown in Figure 9. The symbol |v| signifies flow speed (velocity magnitude); symbols v_x and v_y denote the measured cartesian components of fluid velocity **v** according to the orientation indicated on Figure 9.

Velocity component	Instrument location (column)										
	0	1	2	3	4	5	6	7	8	9	10
					Station 3						
v_x	−57	−62	−64	−52	−27	−14	−11	−9	−21	−55	
v_y	−4	−20	−39	−57	−53	−37	−11	−1	18	11	
|v|	57	65	75	77	59	39	15	9	28	56	
					Station 4						
v_x	−80	−83	−88	−97	−109	−120	−126				
v_y	−2	−7	−17	−23	−34	−57	−80				
|v|	80	83	89	100	114	133	149				
					Station 5						
v_x	−50	−57	−66	−74	−80	−86	−92				
v_y	9	18	32	41	57	74	92				
|v|	51	60	73	85	98	113	130				
					Station 6						
v_x	34	14	−5	−14	−5	−5	−23				
v_y	−11	−20	−20	−11	18	34	66				
|v|	36	24	21	18	19	34	70				
					Station 7						
v_x	−6	−30	−55	−80	−103	−125	−135	−76	−75	−149	−107
v_y	32	66	80	91	94	83	57	15	−11	−70	−87
|v|	33	72	97	121	138	150	146	77	76	165	138

the free surface, the main, high-speed region of a pumped channel flow is drawn to greater depths, and a retarded or even reversed flow at the surface is not an unusual feature. Again, the laboratory flows were meant to be representative of the main flow regimes of such distributions. The flow separations (the breaking away of flow pathlines from solid boundaries) that attend the higher-speed regions beneath the surface of deep channels are no less real than the separation evident in the photograph of Figure 8.

For quantifying the flow pattern around the dual-flow apparatus, velocity measurements were taken at the reference stations indicated in Figure 9. The measurements at each station were made on a location grid of 7 rows and n columns (n = 10 for station 3, n = 7 for stations 4, 5, and 6, and n = 11 for station 7). The vector diagrams of Figure 9 portray the instrument readings from middepth (row 4) when the 45-cm/s flow setting was used; the corresponding component values are given in Table 1. The complete velocity data for the 30- and 45-cm/s settings are contained in the laboratory report (Fletcher 1990b).

The length and direction of a vector arrow in Figure 9 indicates the magnitude of water velocity and the instantaneous direction of flow at the arrow midpoint (the point of measurement). That is, any vector arrow of Figure 9 lies tangent to the (curving) velocity steamline that passes through the corresponding point of measurement. Owing to the extreme crowding of the main flow streamlines in passing through the narrow entry portal and around the corner separation, the water velocities at the screen (and the corresponding momenta of flow) were greatly elevated. Velocity magnitudes at the screen were on the order of 140 cm/s at the 45-cm/s setting and 90 cm/s at the 30-cm/s setting. The asymmetric nature of the flow through the entry portal and screening is more clearly defined by Figures 10–12. The separation of the main flow from the corner of the entry portal effectively blocked off 50% of the screen area to the main flow at the 45-cm/s setting and 38% at the 30-cm/s setting. In each case, the clockwise circulation of the corner separation created backflow in the upstream portion of the screening.

As shown variously by Figures 9–12, the geometry of the flow associated with a conventional cross-channel screen (Figure 6) is drastically altered by the substitution of a dual-flow screen. The high-speed core of the unobstructed flow through a conventional screen becomes the upstream region of lowest fluid speed, and the main transport

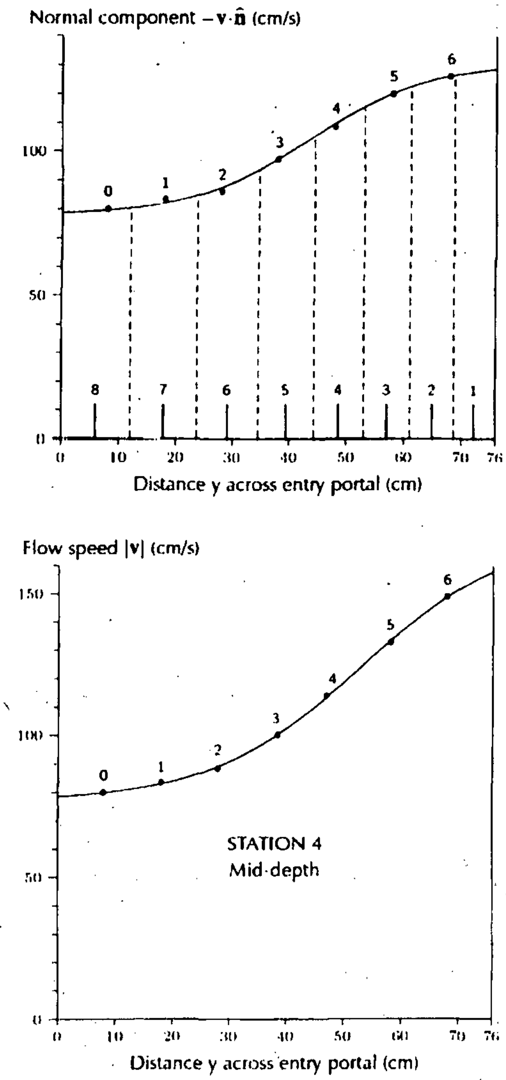
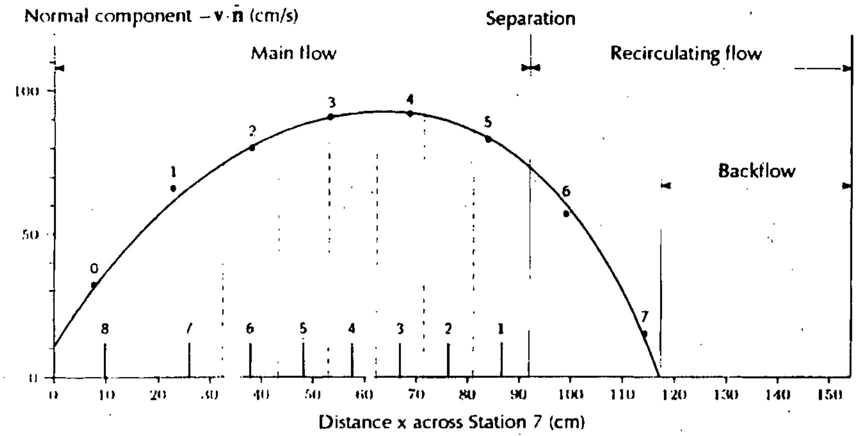


FIGURE 10.—**Top panel:** distribution graph at station 4 of normal component $-\mathbf{v}\cdot\hat{\mathbf{n}}$ at the 45-cm/s mean flow setting. Points are instrument values; see v_x values in Table 1. Area under the graph is volumetric transport Q^* through station 4. Equal areas bounded by dashed lines correspond to the eight numbered transport trajectories of Figure 12. **Bottom panel:** distribution graph of corresponding velocity magnitudes at station 4; see $|\mathbf{v}|$ values in Table 1.

of water is deflected away from the center of the channel to the narrow entry portals at the channel sidewalls. At the entry portal, fluid speed is greatest at the corner of the frontwall, corresponding to the velocity maximum along the boundary of the flow separation and into the center of the screening.

The distribution graphs of fluid transport and



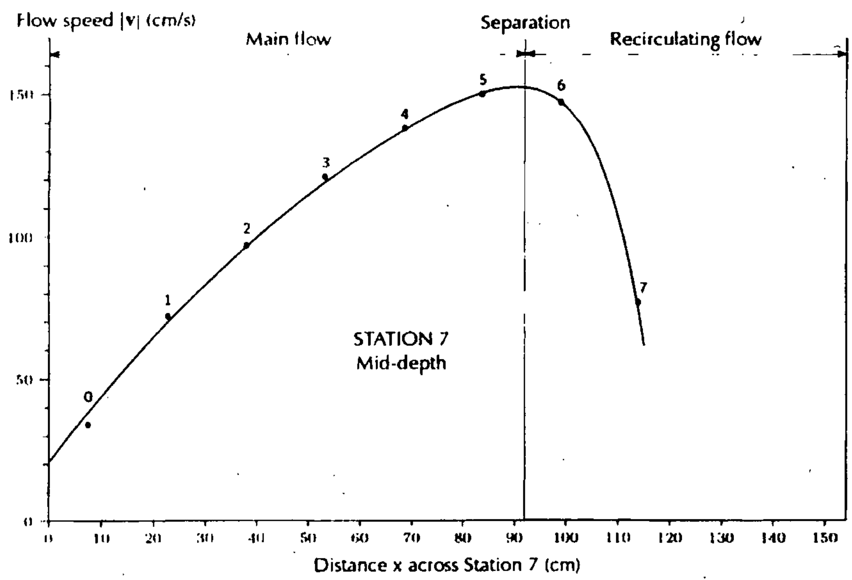


FIGURE 11.—**Top panel**: distribution graph of normal component $-\mathbf{v}\cdot\hat{\mathbf{n}}$ at the 45-cm/s mean flow setting, station 7 (8 cm upstream of screen). Points are instrument values; see v_y values in Table 1. Area under the graph is volumetric transport Q^* through station 7. Equal areas bounded by dashed lines correspond to the eight numbered transport trajectories of Figure 12. Region to the right of the separation is transport of secondary flow. **Bottom panel**: distribution graph of corresponding velocity magnitudes; see $|\mathbf{v}|$ values in Table 1.

velocity magnitudes at station 4 (across the entry portal) and station 7 (just upstream of the screen-mesh) are shown in Figures 10 and 11. The data points on the graphs of velocity magnitude $|\mathbf{v}|$, as well as the lengths of the vector arrows in Figure 9, are given by the relationship $|\mathbf{v}| = (v_x^2 + v_y^2)^{1/2}$, while the graph points of scalar quantity $-\mathbf{v}\cdot\hat{\mathbf{n}}$ correspond to the normal components of flux across the reference station. That is, the area under the graph of $-\mathbf{v}\cdot\hat{\mathbf{n}}$ is Q^*, volumetric flux of water per centimeter of depth through the reference station. The cartesian axes indicated on Figure 9 (x positive towards the inlet end of the flume and y positive from left to right when one faces downstream) were chosen for their conveniences in representing these transport and velocity distributions. In most general terms, the volumetric rate of flow Q through an arbitrary region R of an area A is

$$Q = -\iint_R \mathbf{v}\cdot\hat{\mathbf{n}}\, dA,$$

$\hat{\mathbf{n}}$ being an (outward) unit normal over region R. In the present case, velocity $\mathbf{v} = v_x\,\mathbf{i} + v_y\,\mathbf{j}$, where

$v_x = v_x(y)$ and $v_y = v_y(x)$ at the reference stations, both v_x and v_y being time independent because the flow is steady. At station 4, the unit normal $\hat{\mathbf{n}}$ over the (vertical) surface R represented by the grid of instrument points is simply the unit basis vector $\mathbf{i}$. Consequently, the normal components of flow across station 4 are $-\mathbf{v}\cdot\hat{\mathbf{n}} = -v_x$, and the volumetric flux of water (per centimeter of depth) through the entry portal becomes

$$Q^* = -\int_{y=0}^{76\text{ cm}} v_x\, dy,$$

which must also be equivalent to the upstream transport. For the 30-cm/s flow setting, Q^* would be 5,100 cm^2/s (or 30 cm/s × 170 cm, the breadth of the upstream flow). For the 45-cm/s setting, Q^* is 7,650 cm^2/s, which is the area under the distribution curve of $-\mathbf{v}\cdot\hat{\mathbf{n}}$ in Figure 10. At station 7, just ahead of the screen, $\hat{\mathbf{n}} = \mathbf{j}$, hence

$$Q^* = \int_{x=0}^{S} v_y\, dx,$$

where limit S signifies the location of the separation boundary where it crosses station 7. That is, Q^* in this case sums to the total 30- or 45-cm/s transport rate at the separation boundary. The excess transport to the right of the separation (as in Figure 11) is a consequence of the backflow of water through the upstream half of the screen.

In Figures 10 and 11 the eight equal-valued areas under the distribution graphs of $-\mathbf{v}\cdot\hat{\mathbf{n}}$ correspond to the numbered flux lines of Figure 12, whose locations were resolved by partitioning the Q^* integrals at reference stations 3, 4, 5, and 7. The distribution graphs of v_x, v_y, and $|\mathbf{v}|$ were resolved from the autonomous differential equation

$$z' + az^2 + bz + c = 0, \qquad (1)$$

which permits of nondimensionalizing and its adaptation to volumetric rates of flow and apparatus dimensions that differ from those treated here. In equation (1) the rate of change in quantity z (in v_x, v_y, or $|\mathbf{v}|$) is strictly a function of the magnitude of z, independent of the independent variable (dimension x or y). The independent variable is specified in the solution and the boundary conditions.

At station 4, the fitted solution of equation (1) for the distribution of fluid speed across the entry portal at the 45-cm/s mean flow setting became

$$|\mathbf{v}| = \frac{78 + 2.9e^{0.077y}}{1 + 0.0169e^{0.077y}} \qquad (2)$$

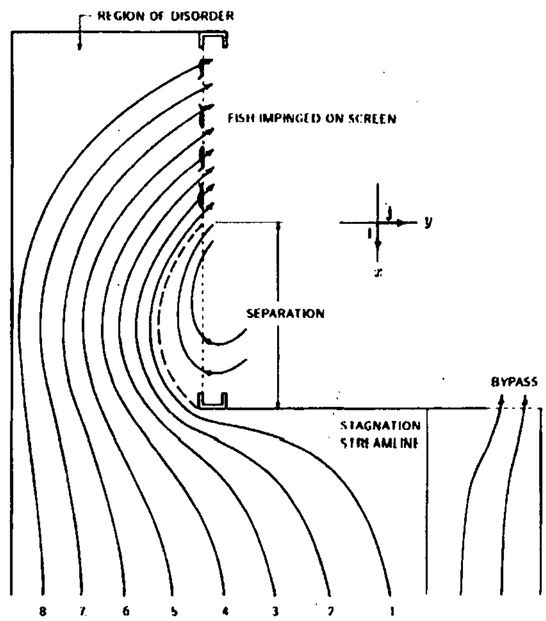


FIGURE 12.—Plot of equal-valued transport trajectories at the 45-cm/s mean flow setting. Each trajectory represents a volume transport of ~956 cm^2/s per centimeter of depth. The corner separation extended to 50% of the screenmesh width at the 45-cm/s setting and to 38% at the 30-cm/s setting.

(y in cm, $|\mathbf{v}|$ in cm/s), which is the curve in the lower graph of Figure 10. Close to the left sidewall boundary, the flow speed $|\mathbf{v}|$ was 79 cm/s; it rose to twice that value, or 158 cm/s, at the corner of the entry portal. The distribution across the entry portal of the normal component of flow (which is $-v_x$ here) became

$$-\mathbf{v}\cdot\hat{\mathbf{n}} = \frac{78 + 1.9165e^{0.0967y}}{1 + 0.0147e^{0.0967y}}, \qquad (3)$$

which is the curve in the upper graph of Figure 10. The boundaries of the eight transport areas under the graph of $-\mathbf{v}\cdot\hat{\mathbf{n}}$ were located by numerically integrating equation (3) in eight partition steps, each of 956 cm^2/s in value.

At station 7 the separation imposes a nonlinearity on the flow geometry more severe than that of governing equation (1). Therefore, for that circumstance I employed the linear terms of equation (1) and matched its (outer) solution to perturbation terms. The result for the distribution of the $|\mathbf{v}|$ data points at the 45-cm/s setting became

$$|\mathbf{v}| = 244(1 - 0.9139e^{-0.0109x}) - 183e^{(x-120)0.10764} \qquad (4)$$

(x in cm, $|\mathbf{v}|$ in cm/s), which is the curve in the lower graph of Figure 11. In turn, the distribution across station 7 of the normal component of flow (v_y here) became

$$-\mathbf{v}\cdot\hat{\mathbf{n}} = 134(1 - 0.9105e^{\ 0.025x}) - 131e^{(x\ \ 118)0.03817}, \qquad (5)$$

which is the curve in the upper graph of Figure 11. The eight equal-valued transport partitions under the distribution curve were resolved in the same manner as those of Figure 10, but here the right boundary was determined by setting the Q^* integral of equation (5) to 7,650 cm^2/s, the known volumetric transport of the main flow, and numerically resolving the upper limit S. The location of S at 92 cm from the backwall of the dual-flow screen coincided with the location of maximum $|\mathbf{v}|$ at the separation boundary (as it should have). Solution methods for equations (2)–(5) are given as an appendix.

The flux lines of Figure 12 portray the complex nature of the flow through the dual-flow screen. The corner separation blocks off the forward portion of the screening to the main flow, which passes through the rear portion of the screening at an angle so sharp that over a distance of 8 cm (the distance between station 7 and the screenmesh) the separation boundary is displaced from the 92-cm location at station 7 (Figure 11) to about 75 cm at the screenmesh, which is an angle of attack of approximately 60° (the angle away from a perpendicular to the plane of the screenmesh). At lower inflow speeds (at lower pumping rates), the separation recedes but the angle of attack increases (the flow at the separation becomes more nearly parallel to the screenmesh).

As indicated on Figure 12 and the upper graph of Figure 11, the recirculation of water through station 7 (and the screenmesh) was a consequence of a trapped eddy that was shear-driven by the passage of the main flow around the corner separation. In the recirculation zone, the flow through the screen (and station 7) reverses direction. Note the sign change in the normal component v_y between columns 7 and 8 of Table 1 for station 7, which in turn corresponds to the zero value of the $-\mathbf{v}\cdot\hat{\mathbf{n}}$ graph in Figure 11. The velocity magnitude $|\mathbf{v}|$ at that point does not fall to zero, however, because the flow is parallel to the screen (and to station 7; note the values of tangential component v_x in Table 1). In the region of backflow, fluid velocities are high, although reversed in direction, as indicated by the elevated values of $|\mathbf{v}|$ in columns 8, 9, and 10 of station 7 on Table 1. These flow complications influenced the dispositions of fish drawn to the screen. The flow reversal and asymmetric distribution of fluid momentum also imposes a cross-stream moment on the screen structure.

Fish Behavior Experiments

The fish used in the behavior experiments were 246 juvenile striped bass *Morone saxatilis* of Hudson River origin, 5.9 cm in mean length, and 240 each of golden shiners *Notemigonus crysoleucas* 5.6 cm and 7.2 cm in mean lengths. The striped bass were shipped by air to Houston and the shiners were obtained from a local fish farm. We employed the golden shiners as representatives of tender species having moderate endurance and swimming strength, in contrast to the striped bass, which are strong swimmers, hardy, and not so readily damaged.

The fish were held apart by size and species in large fish tanks until used in the experiments. Tank water was aerated, filtered, and monitored for temperature, pH, ammonia concentration, and conductivity. The flume water was continuously filtered and circulated; temperature, pH, and conductivity were measured between experiments. For each behavior experiment, the fish of a sample were released 5 m upstream of the dual-flow apparatus by species, size, and water speed.

At each of the 30- and 45-cm/s mean flow settings, the striped bass were released in five sample batches of 20 and one batch of 15; 8 other fish were released one at a time (a total of 28 trials with 246 fish). Golden shiners of each size were released at each of the flow settings in four batches of 25 and one batch of 10; 10 other fish were released one at a time (a total of 60 trials with 480 fish). For the silhouette photography, a video camera and a 35-mm camera were located 6 m above the stilling box (see Figure 4). During an experiment the video camera ran continuously. The mounted 35-mm camera, which was equipped with a motor-driven shutter and film advance, was operated at will, at the rate of three frames per second, by the observer on the camera gantry. For all of the fish behavior photographs reproduced here, the shutter speed of the 35-mm camera was set at 1/1000 s and the video camera was equipped with a 1/100 s digital clock, which was imaged on the video frames. All of the behavior experiments were carried out after dark, the only light in the flume building being the flume bottom lighting in the vicinity of the dual-flow apparatus, an arrangement that allayed our worries over the unknown influences on the fish of surface reflections and other visual disturbances during daylight hours.

The discussion here of the findings from the behavior experiments is aided by the several photographs of fish locations reproduced in this section, but they should be viewed in their relationships to the flow patterns and velocity vectors depicted in Figures 8, 9, and 12. A velocity vector in Figure 9 indicates the (instantaneous) direction of flow at its midpoint; the comparative lengths of the vector arrows give an indication of the differences in fluid speeds from location to location across a station, or from station to station in the flow. The streak lines of Figure 8 indicate the paths taken by the flowing water, and the flux lines of Figure 12 correspond to the transport of water along those paths of motion. The flow accelerates along any flux line; the closer together flux lines are, the greater the speed of flow. Along flux line 1 in Figure 12, for example, the fluid speed is about 30 cm/s where it crosses station 3 (compare with Figure 9 and Table 1). Over the short distance between that point and station 4 at the entry portal, however, the fluid speed along flux line 1 increases fivefold to 150 cm/s, a speed maintained through station 7 and into the screening. The dispositions of fish in the vicinity of the dual-flow apparatus were governed by these fluid accelerations and patterns of flow.

A typical episode of fish being drawn into the vicinity of the dual-flow apparatus and through the entry portal is shown by the three (successive) photographs of Figure 13. The fish are large golden shiners of a batch of 25 released upstream at the 30-cm/s setting. The elapsed time was 2.25 s between frames (a) and (b), and 1.87 s between (b) and (c). Individuals were identified and their paths of motion were tracked by matching the 35-mm photographs with the videotape (viewed frame by frame, with time increments read from the imaged camera clock).

In frame (a) of Figure 13, the fish are being transported into view by the flow at about 50 cm/s. The net downstream movement of fish, despite their apparent orientations in the photograph, followed generally along the lines of flow indicated in Figure 12. All of the fish appearing in frame (a) were drawn rapidly into the vicinity of the dual-flow apparatus, as indicated in frame (b), with the exception of the individual in the lower center of frame (b), which arrived slightly later. Few fish (of either tested species) were observed to orient themselves directly into the flow until they were close upon the frontwall of the apparatus or the corner of the entry portal. Despite furious swimming efforts, few of the individuals transported to the high-speed corner region of the entry portal were able to keep station beyond a few seconds, but most significantly, these were usually the only fish arriving at the entry portal that did make at-

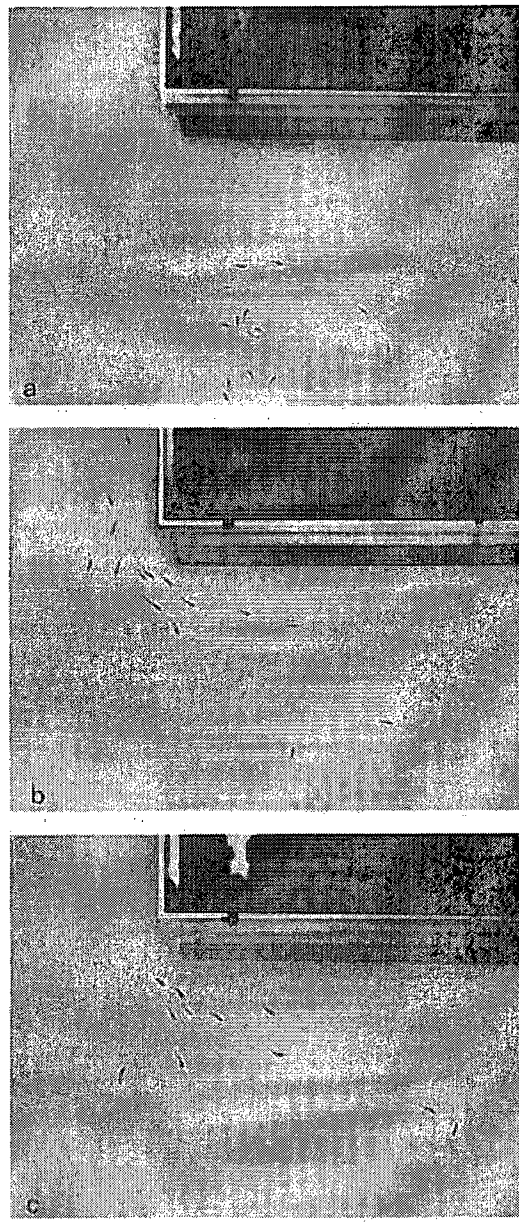


FIGURE 13.—Successive positions of large golden shiners drawn to the dual-flow apparatus at the 30-cm/s mean flow setting. The time interval was 2.25 s between frames (a) and (b), and 1.87 s between frames (b) and (c).

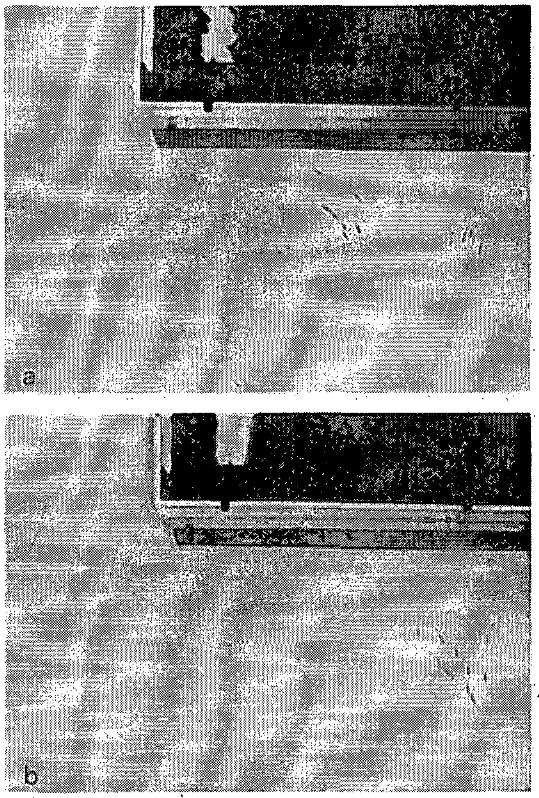


FIGURE 14.—Successive positions of small golden shiners converging on the stagnation streamline at the 30-cm/s mean flow setting. The time interval between frames (a) and (b) was 3.7 s.

tempts at maintaining station. As a rule, fishes drawn to the entry portal some distance from the frontwall corner were swept passively downstream to a sudden encounter with the screening.

Seven of the fish in the region of the frontwall corner in frame (b), plus two individuals already out of camera view, were carried downstream to the screen, in random orientations, at about 85 cm/s, the speed of the flow itself. Their paths of motion coincided with the flux lines shown in Figure 12, indicating little voluntary motion on the part of any individual. Three of the fish close upon the frontwall corner exhibited vigorous tail beats and were able, momentarily, to stem the flow (which was about 95 cm/s at that location), but they were suddenly swept from view, also at the approximate speed of the flow. Four of the fish in frame (c) held out somewhat longer, but only one individual in the high-speed corner region made any significant progess away from the apparatus. The three fish in the middle ground of frame (c), just upstream of the frontwall corner, were late arrivals (if 1.87 s can be called late). They were transported, swiftly and passively, through the entry portal at the speed of the flow, but one of the three reappeared and swam close along the sidewall of the flume a distance of half a meter or so upstream of the entry portal, where it remained for some time. That behavior was repeated by individual fish when released to the far left of the flume center.

At 10 s after the first appearance of the fish in frame (a), the only members of the released sample remaining in camera view were the one fish at the flume sidewall and the two rightmost fish of frame (c)—joined by one late arrival—in the region of the stagnation streamline. Two fish of the 25 released were not observed on camera, but at the conclusion of the experiment we found them upstream, swimming along the sidewall of the flume, an occurrence less typical of the shiners than of the striped bass.

The two rightmost fish in frame (c) of Figure 13 were swimming in the (symmetric) velocity gradients on either side of the stagnation streamline and more or less holding station in the flow, a distance removed from any solid boundaries. That behavior was observed several times in experiments with both the shiners and the striped bass. Some fish of a released sample, if they arrived at the dual-flow apparatus in the slower current to the right of the entry portal, turned about and converged on the stagnation streamline. Schooling behavior was also strongest in that region, in contrast to the small evidence of schooling tendencies in regions of swifter flows. The tendency to school in the vicinity of the stagnation streamline is indicated in the photographs of Figure 14. In that experiment, a sample of 25 small golden shiners was released more to the right of the flume center than usual; 13 of the 25 were ultimately carried through the entry portal and impinged (flattened against the screening), but five fish were transported to the apparatus on the right side of the stagnation streamline (the five fish to the right in frame a of Figure 14), and seven of those arriving to the left of the stagnation streamline reversed direction in the vicinity of the flume frontwall and joined the other five, as indicated by frame (b). This behavior is especially worthy of note, because it demonstrates the tendencies of fish to respond to the velocity *gradients*, as opposed to responding directly to the stationary obstacles or solid surfaces that actually induce the gradients into the flow.

Although juvenile striped bass exhibited similar behavior in the region of the stagnation streamline, they were also more active as individuals than golden shiners of either size. In the swifter regions of flow, the striped bass were generally transported to the screening somewhat less directly along the flux paths of the water transport than the shiners; individuals made darting motions, seemingly at random and independent of one another. More striped bass of a given release found the upstream sidewalls of the flume (or, more explicitly, the slow-speed boundary layer at the flume wall) than did golden shiners of a similar release. And being much the stronger swimmers, the striped bass were able to stem the flow at the entry portal for longer periods, particularly at the 30-cm/s mean flow setting. At the 45-cm/s setting, however, few of the striped bass (and none of the shiners) were able to keep station at the corner of the entry portal, the fluid speed in that region being about 150 cm/s.

The liveliness (or excitability) of the striped bass juveniles is captured in the two (successive) photographs of Figure 15. In frame (a), 13 individuals of an upstream release of 20 had just arrived in the vicinity of the dual-flow apparatus at the 45-cm/s mean flow setting. Fluid speeds in the vicinity of the dual-flow apparatus were considerably greater in this experiment than the fluid speeds at the 30-cm/s setting of Figures 13 and 14, so events transpired more rapidly. Note the absence of schooling and the random orientations of individual fish in both frames of Figure 15. The time interval between the two frames was only 1.12 s, but owing to the independent darting motions of individuals, the relative positions of fish changed rapidly, although their net paths of motion towards the entry portal were still a consequence of the pattern and speed of the flow directly upstream of the dual-flow frontwall. In frame (b), at least five fish had responded to the fluid acceleration at the entry corner by aligning themselves headmost into the flow. Despite the furious swimming efforts of these individuals, all except two were carried backwards (still swimming furiously) during a 1.87-s interval after frame (b) and flattened against the screening.

Without exception, fish transported through the entry portal and impinged on the screenmesh struck the screening well aft of the corner separation—as did the flow markers when released upstream at any location between the stagnation streamline and the left sidewall of the flume. At site installations of dual-flow screens, similar impingements of fish on the downstream portion of the screening have also been observed but not understood (E. Radle, New York State Department of Environmental Conservation, personal communication).

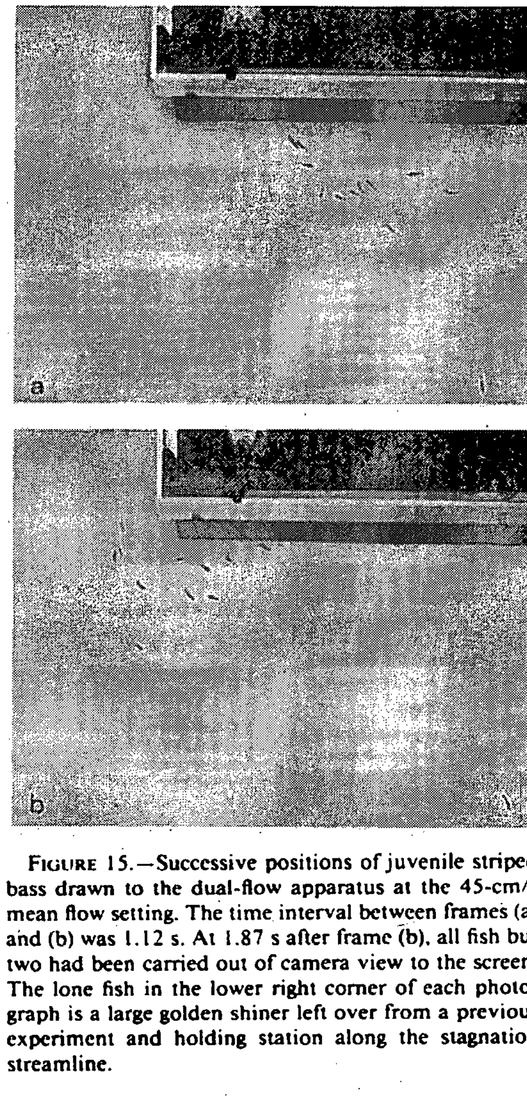


FIGURE 15.—Successive positions of juvenile striped bass drawn to the dual-flow apparatus at the 45-cm/s mean flow setting. The time interval between frames (a) and (b) was 1.12 s. At 1.87 s after frame (b), all fish but two had been carried out of camera view to the screen. The lone fish in the lower right corner of each photograph is a large golden shiner left over from a previous experiment and holding station along the stagnation streamline.

At each of the experimental flow settings, all impinged fish suffered death or injury, although the duration of an experiment, from release of the sample to shutdown of the flow, never exceeded 3 min. Owing to the streamline crowding of the main flow in passing through the entry portal and around the corner separation, fluid speeds at the screenmesh were greatly elevated over the 30- and 45-cm/s mean upstream velocities. At the 30-cm/s setting, the speed $|\mathbf{v}|$ of the flow distributed across station 7 ranged from 50 to 100 cm/s; at the 45-

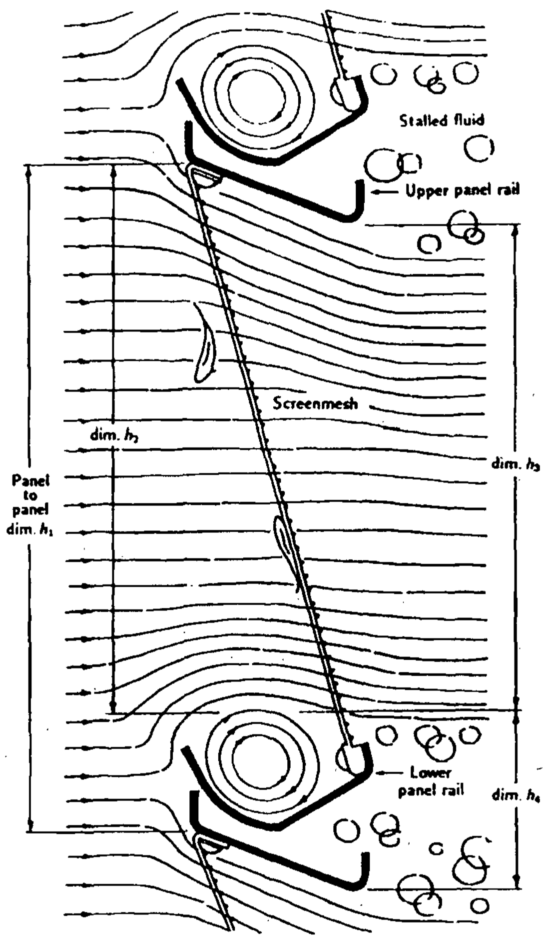


FIGURE 16.—Vertical section through a typical panel of a traveling screen, showing pathlines of water flow. Dimension h_1 is panel-to-panel distance; dimension h_2 is the region of sensible free flow through the screenmesh; dimension h_4 is the projected frontal height of the screen rails; ratio h_3/h_1 governs the streamline compression.

cm/s setting, $|v|$ ranged from 80 to 150 cm/s. The pressure forces of these high-speed flows against impinged fish were great enough to impose mortal injuries to shiners and striped bass alike. In view of the findings from previous laboratory and field experiments on other screening systems, these wholesale injuries were unexpected. As reported in another work (Fletcher 1990a), injuries to impinged fish were not extensive at fluid speeds to 50 cm/s through a conventional cross-flume screen equipped with a smooth-woven screenmesh, and injuries were only slightly greater when the screen was fitted with the same standard crimped mesh employed here. Apparently, the risk of mortality to impinged fish increases sharply in the range of fluid speeds between 50 and 80 cm/s.

Influence of Structural Components

Owing to the presence of the crossrails and screen troughs of a working dual-flow screen, the realized water speeds through the screenmesh would be somewhat greater for a given flow setting than the speeds recorded here. As opposed to the unobstructed screenmesh of the experimental apparatus, a traveling dual-flow screen of the kind most often employed in water intake systems is composed of linked, rectangular screen panels whose horizontal framing members offer significant impedence to the approaching flow. The influence of the crossrails of one such panel configuration is shown in Figure 16. The illustrated flow pattern was traced from the photographs of dyed pathlines taken during full-scale experiments on a variety of screen panels. The increase in sensible speeds at the screenmesh is determined by the (vertical) breadths of the panel rails and by the influences on the main flow of such secondary blocking flows as the trough vortices shown in the figure. Dimension h_4 of Figure 16 determines the true projected frontal area of the illustrated panel railings, and the ratio of dimensions h_3 and h_1 determines the actual streamline compression of the flow passing through the screen panel.

The rail profiles and corresponding details of flow through a screen panel differ somewhat from one manufacturer's design to another, but the ratio of the sensible free-flow area at the screenfront (dimension h_2 of Figure 16) to the overall panel dimension h_1 is typically 80% or less at a standard panel spacing of 61 cm (24 in). Therefore, since continuity, for a given volumetric flux Q, requires that $h_1V_1 = h_2V_2$ (V_1 being the mean speed of flow at the unobstructed screen and V_2 the mean speed of flow at the panel screening), then the 90-cm/s unobstructed screen speeds of the 30-cm/s flow settings would increase to about 110 cm/s if standard height screen panels were employed, and the 140-cm/s speeds through the unobstructed screen would increase to about 170 cm/s in the case of the 45-cm/s mean flow setting.

The concave rails of the screen panels shown in Figure 16 are meant to capture and rescue impounded fish as the screen structure ascends through the water column. They represent one manufacturer's version of the so-called Ristroph troughs often found on conventional cross-channel screens. In a series of flow studies on Ristroph screen panels (Fletcher 1990a), the longitudinal trough vortices depicted in Figure 16 were found to be typical of all manufacturer's trough designs known at the time of the work. Fish caught in these shear-driven vortices were swirled about and severely battered. At moderate flow speeds, the associated injuries and mortalities were greater than the damages imparted to fish by simple impingements against the screen mesh.

When a Ristroph apparatus is employed in the manner of a conventional cross-channel screen (as in Figures 1 and 2a), captured fish are raised from the water on the upstream side of the (upward) moving screen, then dumped into a sluice for their return to the source waters as each panel overturns on its rotation over the uppermost sprocket of the machine. These trough-equipped screens are also employed, without significant modification, as dual-flow screens and offered by their makers as putative fish-conserving devices. Aside from the adverse flow conditions characteristic of the Ristroph troughs, such adaptations are ill-suited to the workings of a dual-flow screen. Owing to the double-entry configuration, water and fish are drawn to both the ascending and descending halves of the moving screen. The fish troughs on the descending side are inverted and travel downwards, which negates their intended fish-catching function. Although the problem of the trough vortex has been ameliorated by at least one new design (Fletcher 1990a, 1992), no known Ristroph device is really suited to the peculiar functionings of a dual-flow screen.

Flow Correction

As shown by the flume experiments reported here, the elevated flow speeds and increased fish kills associated with dual-flow screen conversions are owed in part to the concentration of the inflow over restricted portions of the available screen width. Because the flow approaching the machine must turn nearly 180° around the frontwall to enter the screenmesh, the flow separates from the frontwall corner in the manner illustrated by the various diagrams of this report. By reducing the turning angle (by whatever means), the separation is reduced and the area of the screenmesh receiving the inflow is increased. To that end, I experimented with fairing shapes for the frontwall that reduced the turning angle by 90°. The most successful shape has the elliptical curvature shown in Figure 17, whose formulation is

$$x^2 + (1 - \epsilon^2)y^2 = a^2, \quad (6)$$

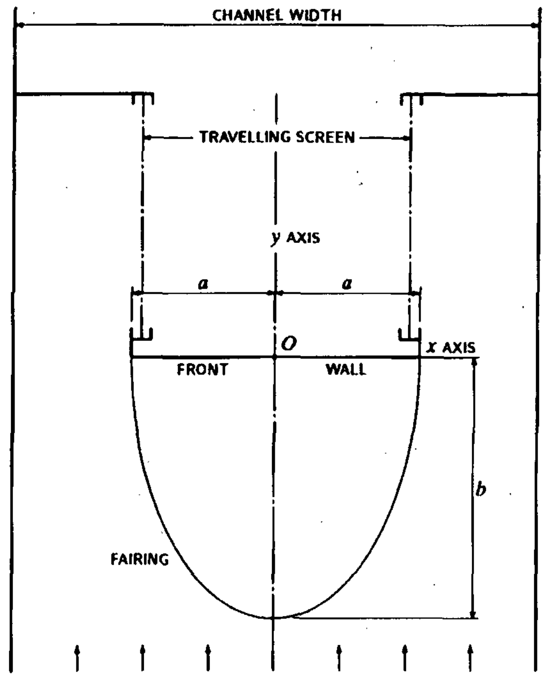


FIGURE 17.—Design of an elliptical frontwall fairing for a dual-flow machine.

where $2a$ is the frontwall width (quantity a being the semi-minor axis of the elliptical curve). Quantity ϵ is the elliptical eccentricity and it governs projection b (the semi-major axis) in the relation

$$b = \frac{a}{\sqrt{1 - \epsilon^2}}.$$

Within certain limits, the greater the projection dimension b, the smoother the flow deflection. For mean upstream flow speeds to 50 cm/s, I found the minimum effective relation of projection b to dimension a to be about $a/b = 0.56$ (an eccentricity ϵ of 0.83). Shapes with smaller values of ϵ failed to eliminate the flow separation at the higher test speeds.

Figure 18 shows the realized pattern of flow into the entry portal of the laboratory apparatus when a fairing of eccentricity 0.83 was attached to the frontwall. Experimental fairings of the same shape and constructed of reinforced fiberglass have recently been installed on two of the dual-flow machines at the Arthur Kill steam generating plant on Staten Island. To what extent the corrected flows may lessen the fish mortalities otherwise associated with those machines will be determined by a 2-year testing program.

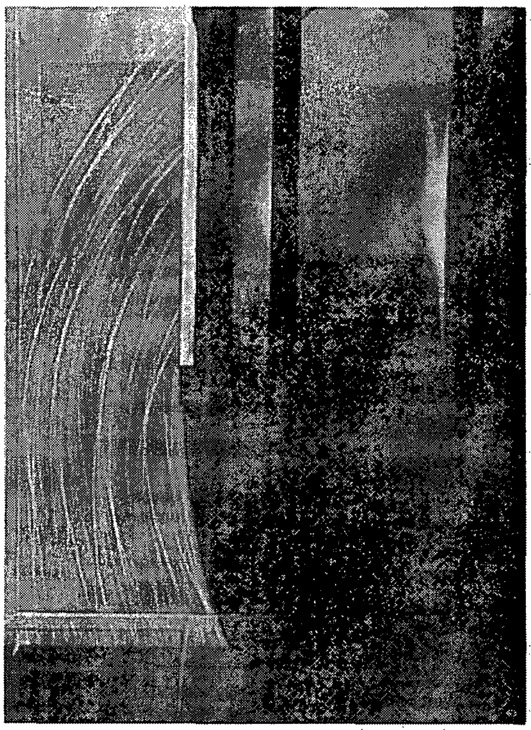


FIGURE 18.—Pathlines of flow into the entry portal of the laboratory apparatus when a fairing of eccentricity 0.83 was fitted to the frontwall, photographed through the stilling box at the water surface. Mean upstream flow speed was 45 cm/s.

Concluding Remarks

If the flows through each portal of a double-entry screen were perfectly distributed over the whole extent of the available screenmesh, fluid speeds would be dramatically lower than those observed. That perception of (ideal) flow distribution is apparently the motivation for mistaken beliefs about the potential fish-conserving merits of dual-flow screens, as typified by the following statement from a publication of the Electric Power Research Institute (EPRI; Lawler, Matusky & Skelly 1989):

> The principles that make the dual-flow screen advantageous for debris handling may also make it a good system for decreasing fish impingement impacts by increasing survival. The greater screen filtration area allows lower through-screen velocities, which lowers stress on impinged organisms; the faster operating speeds decrease impingement exposure time, especially for organisms impinged on the ascending side.

At least for the arrangement and size of the device examined here, the dual-flow geometry is probably the *worst* of all screen configurations for retrieving entrapped fish by mechanical means and returning them undamaged to the source waters. While some rectification of the streamline crowding (and corresponding high fluid speeds) at the screenface is achievable by means of flow guides or by fairing the frontwall in the manner shown here, no practical fish-rescuing apparatus suited to the descending side of the screen has yet been devised (a shortcoming acknowledged, at least implicitly, in the quoted passage above). In the summary section of the EPRI report, the author seems to express a genuine puzzlement over failed expectations with the following lines:

> The hydraulic changes associated with the installation of dual-flow screens may result in higher impingement survival; however, information currently available does not indicate any real increase over conventional traveling screens...

In fact, the "hydraulic changes" associated with dual-flow screens virtually guarantee increased fish kills. Nevertheless, the debris-excluding virtues of dual-flow screens have such appeal to plant operators that many conversions of the intake systems of power plants have already been made, and many more are planned. Regulatory agencies concerned with fish conservation are sure to stall the permitting process, at least in some locations, if the swapping of screening systems threatens to increase fish kills to magnitudes greater than those imposed by the systems replaced. Some practical fish-saving apparatus, better adapted than Ristroph troughs to the peculiar functionings of dual-flow screens, is obviously needed.

As an added caution to plant operators contemplating conversions from conventional through-flow screens to dual-flow screens, the flow issuing from the narrow dual-flow penstock and into the sump region of the intake system is apt to create sump conditions deleterious to pump operation. The penstock flow takes on the character of a highly turbulent and unstable jet. Consequently, the water behind the backwalls, on either side of the penstock, will be in a state of stall, and the inflow jet, being unstable, will tend to attach itself to one sidwall of the sump. As I discovered in hydraulic modeling for a typical plant conversion (Fletcher 1988), the flow asymmetry just described created pre-swirl extremely adverse to the (axial-radial) pump. I also found evidence of vapor core vortices, drawn from the sump floor into the pump bellmouth, thus increasing the likelihood of impeller cavitation and hammering of the shaft bearings. The adverse flows were partially corrected with an assembly of adjustable guide vanes located behind the penstock entry to the sump.

Acknowledgments

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Appendix: Solution Methods for Text Equations (2)-(5)

Differential equation (1) is suited to virtually any flow distribution at the entry portal of a dual-flow machine. In the z, z' phase plane, equation (1) is a parabolic curve where $z' = 0$ at the quadratic roots r_1, r_2 of $az^2 + bz + c$, which project to the asymptotes of the solution graph as indicated in Figure A.1. Provided roots r_1, r_2 are real, the general solution form of equation (1) is

$$(z - r_1)/(z - r_2) = C_0 e^{at(r_2 - r_1)}, \quad \text{(A.1)}$$

where independent variable t is dimension x or y in the fitted solutions (2) and (3), and C_0 is the integration constant. The solution graph of equation (A.1) may be monotonic increasing (as in Figure 10) or monotonic decreasing (as it would be at the right entry portal) according as

$$m = \frac{b^2}{4a} - c$$

is positive or negative. Quantity m is the extremum value of z' of equation (1) in the

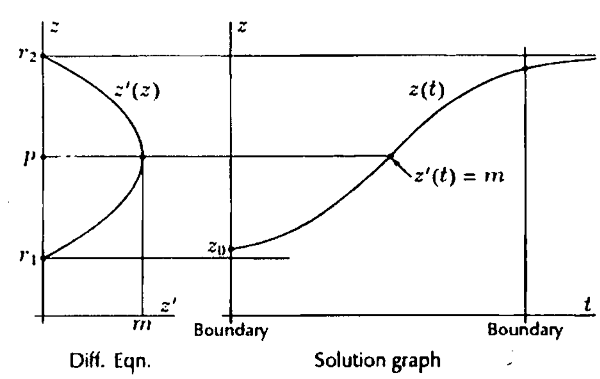

FIGURE A.1.—Graph trajectories of differential equation (1) and its general solution (equation A.1).

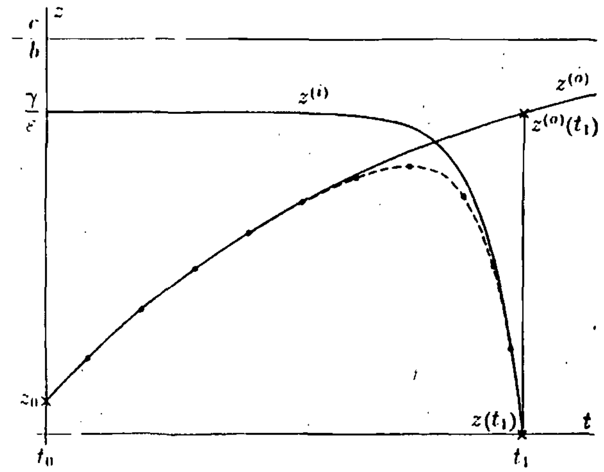

FIGURE A.2.—Graph of outer solution $z^{(o)}$ (equation A.2), inner solution $z^{(i)}$ (equation A.4), and composite solution $z(t)$ (equation A.6), whose trajectory is denoted by the dashed curve. Boundary values satisfied by $z(t)$ are $z(t_1)$ on the right and z_0 at t_0 on the left. Dots along the dashed curve represent fitted data points.

phase plane, corresponding to the slope of solution (A.1) at its inflection point p, which occurs at $z = (r_1 + r_2)/2$ in both the phase and solution planes. Therefore, with the exception of the boundary condition, all the parameters for fitting the solution graph to datum points can be resolved in terms of z and z' in the phase plane, independent of the independent variable t, with the aid of a routine numerical method for estimating $z'(z)$ from the measures of Δz. The relationship between $z(t)$ and t in the solution plane is then resolved by specifying the boundary condition z_0 (that is, by determining its value from the best fit to the t, z data values), as was the case in equation (2) from the $(y, |\mathbf{v}|)$ data and in equation (3) from the (y, v_x) data.

Owing to the effects of the flow separation, each distribution of $|\mathbf{v}|$ and $-\mathbf{v}\cdot\hat{\mathbf{n}}$ downstream of the entry portal exhibits an extremum between two lesser boundary values, as portrayed by the graphs of Figure 11. The perturbation imposed on the flow geometry by the presence of the separation imposes in turn a perturbation on the general distribution equation (1). The altered solution trajectories (4) and (5) for station 7 were determined by matching a general outer solution

$$z^{(o)}(t) = \left(z_0 + \frac{c}{b}\right)e^{-bt} - \frac{c}{b} \tag{A.2}$$

of the linear portion of equation (1), which is

$$z' + bz + c = 0, \tag{A.3}$$

to an inner solution

$$z^{(i)}(t) = z^{(o)}(t_1) - z^{(o)}(t_1)e^{(t-t_1)\epsilon} + z(t_1)e^{(t-t_1)\epsilon} \tag{A.4}$$

of the first two terms of a perturbation expansion

$$z' = \gamma + \epsilon z, \tag{A.5}$$

γ being a constant of convenience and ϵ the perturbation factor. Graph trajectories of inner and outer solutions (A.2) and (A.4) are shown in Figure A.2.

As portrayed in Figure A.2, the composite solution $z(t)$ has the boundary values $z(t_0)$ on the left and $z(t_1)$ on the right, either of which may be zero or nonzero. Outer solution $z^{(o)}(t)$ satisfies the left boundary condition (symbolized z_0 in equation A.2, where, without loss of generality, $t_0 = 0$), while inner solution $z^{(i)}(t)$ satisfies the right boundary condition (which is quantity $z(t_1)$ in equation A.4). The quantity $z^{(o)}(t_1)$ is the value of the outer solution at t_1 (the location of the right boundary). In equation (A.4), $z^{(o)}(t_1)$ replaces γ/ϵ with small error. The composite solution is recovered by combining the inner and outer solutions and eliminating the overlap, or

$$z(t) = -\frac{c}{b}\left[1 - \left(\frac{bz_0}{c} + 1\right)e^{-bt}\right] - \left[z^{(o)}(t_1) - z(t_1)\right]e^{(t-t_1)\epsilon}, \tag{A.6}$$

which is the form taken by the distribution equations (4) and (5). In the region near the left boundary where the outer solution is valid, the constants c and b of equation (A.2) can be resolved from the measures of Δz in the z, z' plane where governing equation (A.3) has a straight-line graph. The boundary value z_0 can then be determined by fitting outer solution (A.2) to the t, z data points in that region. A similar procedure can sometimes be followed for resolving perturbation parameter ϵ with equation (A.5), but when the distribution of interest drops off sharply at the boundary, the data points in the boundary region are often too few to suit that procedure. In most cases, ϵ is more accurately resolved in the composite solution (A.6).

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NOTES

The Failure and Rehabilitation of a Fish-Conserving Device

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Abstract.—A flow spoiler designed for attachment to the fish-catching rails of large water-intake screens was previously reported as being successful in reducing injuries to fish during the capture process. That spoiler and rail configuration failed to function as intended when applied to screens equipped with superfine screencloth. The desired fluid dynamical properties of the spoiler were restored by a change in the spoiler's geometry.

In a recent article (Fletcher 1990) I reported the results of laboratory and field testings of some improvements made to the fish-conserving apparatus of screening systems commonly installed in large water pumping facilities. From detailed studies in a laboratory flume, a flow spoiler had been devised that damped out certain vortex actions found deleterious to fish captured by the cross rails of rotating debris barriers known as Ristroph screens. The rail-mounted spoilers served to retard the actions of a harmful, secondary circulation within the rails by introducing a turbulent wake between the rail water and the shearing action of the main flow over the rail, an effect depicted in Figure 8 of the cited report. Although that rail and spoiler configuration proved effective in applications to coarse-mesh wire screening, it unexpectedly failed when the screen panels were fitted with fine-mesh overlays.

That discovery was made while experimenting with other innovations related to screening apparatus equipped with superfine mesh—work funded by the Consolidated Edison Company of New York and other Hudson River utilities as a hoped-for means of preventing excessive entrainments into power plant cooling systems of eggs, larvae, early juveniles, and small invertebrates. This note is meant to caution others about unexamined applications of the reported rail and spoiler to screening systems fitted with fine mesh (especially of gauges ranging from 0.5 mm to 3 mm in pore size), and also to report on the properties of an improved spoiler that did function satisfactorily in fine-mesh trials.

The general flow conditions associated with the unrevised spoiler and a mesh of fine gauge are illustrated by Figure 1. The test apparatus is mounted in a large hydrodynamics flume and viewed from underwater ports, as described in Fletcher (1990). The pathlines of flow are marked by the transport of small, neutrally buoyant plastic particles, recorded by time exposures on 35-mm film. The flow geometries portrayed were similar for approaching flow speeds of 15, 30, and 45 cm/s, although the angular speed of the rotating vortex increased with increasing speed of the main flow. As revealed in the top photograph of Figure 1, the desired wake does not develop and the main flow penetrates deep into the rear of the rail owing to the influence of the fine mesh in reordering the near-field pressure distribution along the screenface. In consequence, the shearing force of the main flow over the rail drives the rail water into the form of an ordered, longitudinal vortex like that originally observed in tests of conventional fish rails without spoilers. Organisms caught in these rail vortices are swirled about and killed or damaged from the effects of forcible contact with the rail and screen boundaries.

The change in flow properties attributable to the increased resistance of superfine screencloth calls for a spoiler of a more severe geometry (Figure 2). The restoration of a turbulent wake being shed from the trailing edge of the revised spoiler can be seen in the top photograph. The main flow does not penetrate as far into the rail confines and the turbulence proceeding aft of the spoiler again separates the rail water from the direct shearing action of the main flow. Some disordered water motion within the trough occurs, owing to the transport of vorticity across the wake, but captured fish are able to maintain reasonably stable swimming attitudes (Figure 2, bottom photo). The fish depicted are striped bass *Morone saxatilis* of Hudson River origin, 5.6 cm in mean length.

In arriving at the spoiler shape portrayed here, other constraints had to be taken into account as well: the frontal area of the device and its increased blockage of the main flow, an entry space between the spoiler and screenface sufficient to encourage the entry of fish, the geometric restrictions associated with the articulation of the hinged

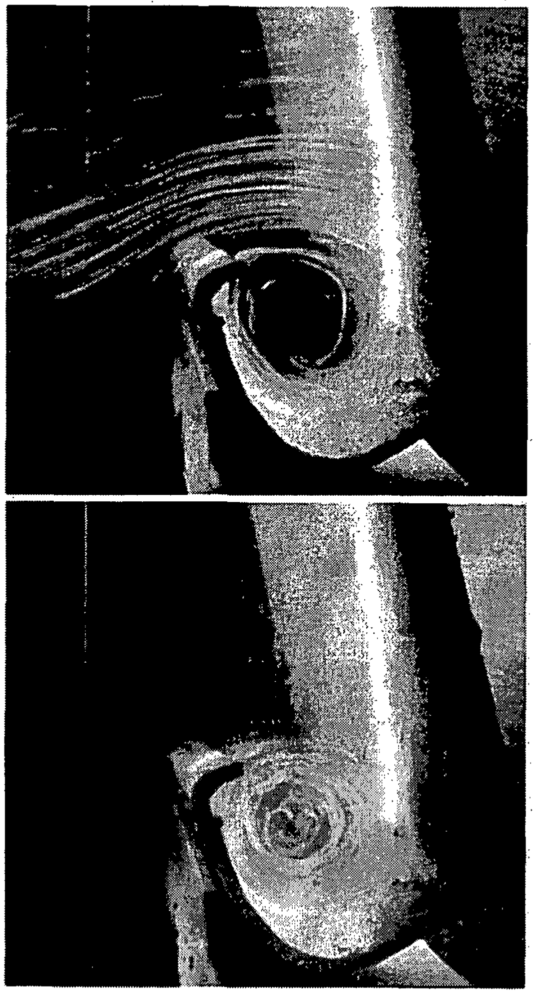

FIGURE 1.—Streaklines of flow in the vicinity of screen panels overlayed with 1-mm nylon mesh and equipped with the fish rail and spoiler described by Fletcher (1990). Speed of approaching flow is 30 cm/s and proceeds from left to right. **Top:** geometry of the main flow through the screen panel. **Bottom:** particles introduced directly into the fish rail delineate the shear-driven (and clockwise spinning) vortex that develops when the screen panels are fitted with superfine mesh.

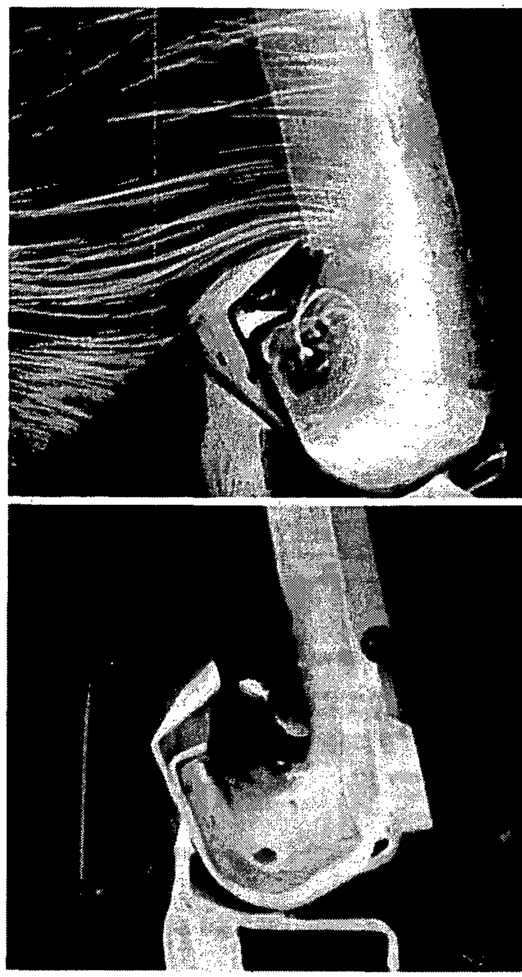

FIGURE 2.—**Top:** streaklines of the main flow and the random motion of water in the rail of a fine-mesh panel equipped with the reconfigured spoiler. Speed of the approaching flow is 30 cm/s. **Bottom:** attitudes of sheltered striped bass (5.6 cm mean length) captured by the reconfigured fish rail and subjected to flow conditions identical to those of the top photo.

screen panels in passing around the sprockets of the machine, and finally, ease of manufacture. Although other, more radical designs can be envisioned, the downstream consequences of surface shaping and boundary effects are not simple to predict, and, as a parting reminder to industry biologists, nothing takes the place of direct, empirical verification of one's assumptions.

Acknowledgments

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Reference

Fletcher, R. I. 1990. Flow dynamics and fish recovery experiments: water intake systems. Transactions of the American Fisheries Society 119:393–415.

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Flume Study of the Flow Dynamics and Fish Behavior associated with Double-entry Screening Systems of Large Volumetric Flux

Report of results to the
HUDSON RIVER FOUNDATION
March 1990

R. Ian Fletcher
Great Salt Bay Experimental Station

Contents

1. Introduction

Electricity generating stations and other facilities that withdraw large volumes of water from natural sources in their operations are commonly equipped with mechanically active barrier screening, which has the principal function of halting and removing debris from the inflowing water, but indrawn fish are also collected and killed by the screens, often in large numbers. A conventional water intake system consists of one or more sumps, each supplied from a free-surface reservoir, or forebay, which in turn is fitted with a motor driven machine that moves a set of linked screen panels around sprockets in the manner of an endless chain, as indicated by Figure 1. The inflowing water is drawn directly through the ascending and descending halves of the travelling screen assembly; indrawn matter not otherwise extruded through the screen mesh is forced onto the upward moving screen structure by the inflow, then carried above the water surface for disposal.

Material captured and raised from the water by the screen is forcibly removed by one or more rows of directed, high-pressure water jets that blow through the screening from locations above the machinery deck and between the moving halves of the screen. Very often, such indrawn flotsam as plastic bags and filamentous macrophytes, in being stapled into the screenmesh, is not completely removed by the spraywash. In consequence, unremoved debris is carried back to the water by the descending side of the screen and released into the sump by the force of the main water flow. In some cases, the transport, or carry-over, of unwanted debris into the sumps of a water intake system (and hence into the plant works by way of the water pumps) is great enough to degrade the operating efficiency of the facility or require increased maintenance.

Owing to the annoyances connected with the mistransport of debris by conventional rotating screens, many plant operators favor the refitting of intake systems with alternative devices, called dual-flow screens, whose manner of operation precludes the downstream deposition of debris. Although consisting of linked panels and driven around sprockets in a conventional fashion, a dual-flow screen is placed at an attitude 90° to the approaching flow, water passing through its moving halves according to either of two configurations, one called a double-entry, single-exit screen (as indicated by Figure 2(b)) and the other a single-entry, double-exit screen. The double-entry arrangement is the design more often employed, and it was the design adopted for the experimental work reported here.

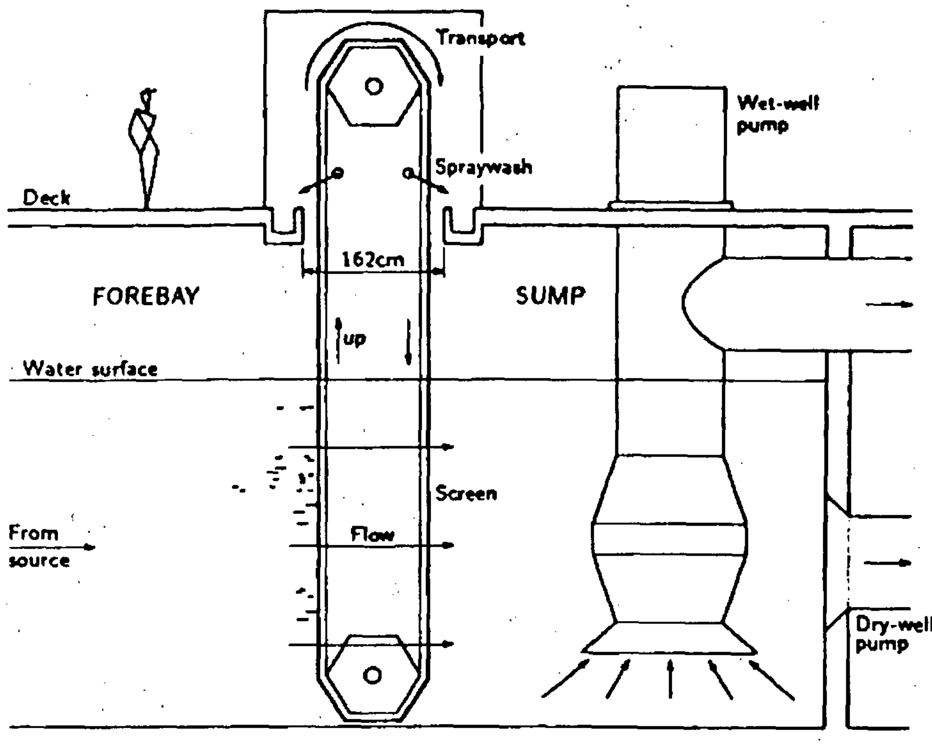


FIGURE 1.–Arrangement of a large water-intake system equipped with a conventional rotating screen. Water speeds through the screen range from 30 to 60 cm/s, and a typical elevation speed is 5 cm/s. Pump capacities (of either the wet-well or dry-well configuration) range from 265,000 L/min to 530,000 L/min.

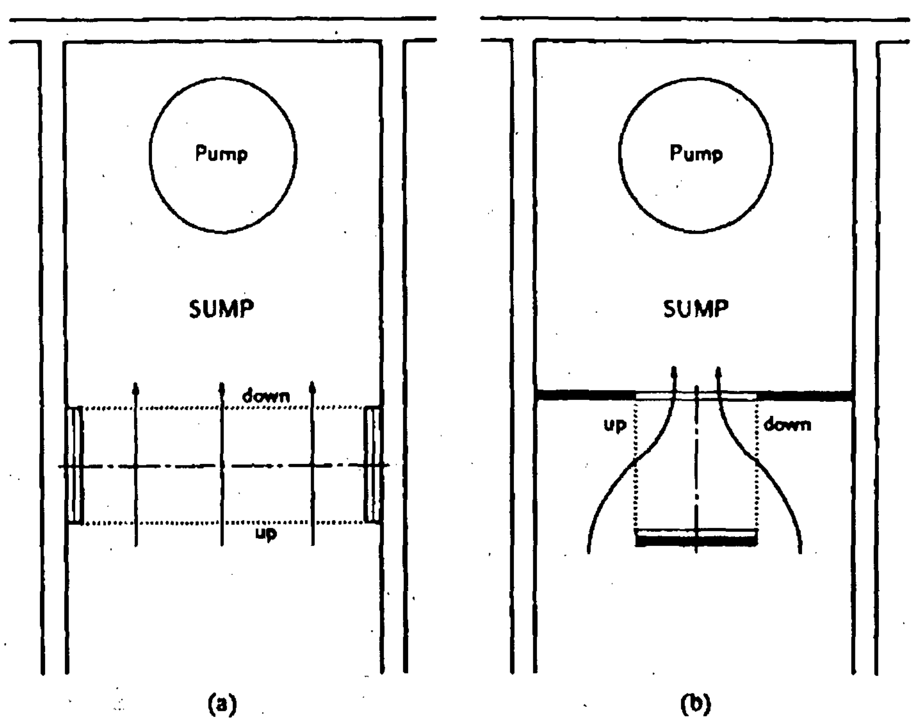


FIGURE 2.–(a) Plan of a typical intake channel equipped with a conventional rotating screen (as in Fig. 1). (b) Conversion of the intake bay to a double-entry, single-exit rotating screen.

In contrast to the straight-through flow geometry of a conventional rotating screen (Figure 2(a)), water drawn through a double-entry screen arrangement must bifurcate around a plate or frontwall (which closes off the upstream side of the machine) and pass through the ascending and descending halves of the screening by way of two alley-like portals at the sidewalls of the forebay. The flow then enters the sump area through a narrow penstock, at the rear of the machine, which is no more than the open framework between the moving halves of the screen. As shown by the studies reported here, the peculiarities of the flow approaching and passing into the screen pose special problems in the mechanics of large, flexible linkages subjected to asymmetric loadings, and special problems in the mechanics of live fish recovery.

Although the problem of fish kills by various intake screening systems has received considerable attention over the years from regulatory agencies, fishermen, citizen's action groups, the power industry, and screen manufacturers, little work has been done in the past in the way of direct observations of the full-scale flow patterns and fish behavior associated with any screening system. Costly apparatus meant to rescue entrapped fish, or to divert them in some way from encounters with intake screening, is manufactured and installed with virtually no foreknowledge of its likelihood of succeeding or failing. Such intuitively-derived schemes and devices as sound generators, electric barriers, dangling chains, bubble clouds, angled screens, horizontally-travelling screens, and fish scooping devices, although apparently promising in concept, have not proven to be very effective at reducing fish kills to the levels of natural mortality (see Fletcher 1985 for a list of representative references). The poor performances of these fish-saving appliances can be traced, almost invariably, to imperfect understandings of fluid flows and the related responses of fish to currents and obstacles. As shown in a recent study of a commonly employed device known as a Ristroph screen (Fletcher 1990), one's casual suppositions about the nature of complex fluid flows can be so misleading that one is apt to anticipate an outcome wholly at odds with reality. In the case of the Ristroph screen experiments, once the actual transactions between fish and flows were observed and recorded, alterations to the device that conformed to reality followed and fish kills were reduced.

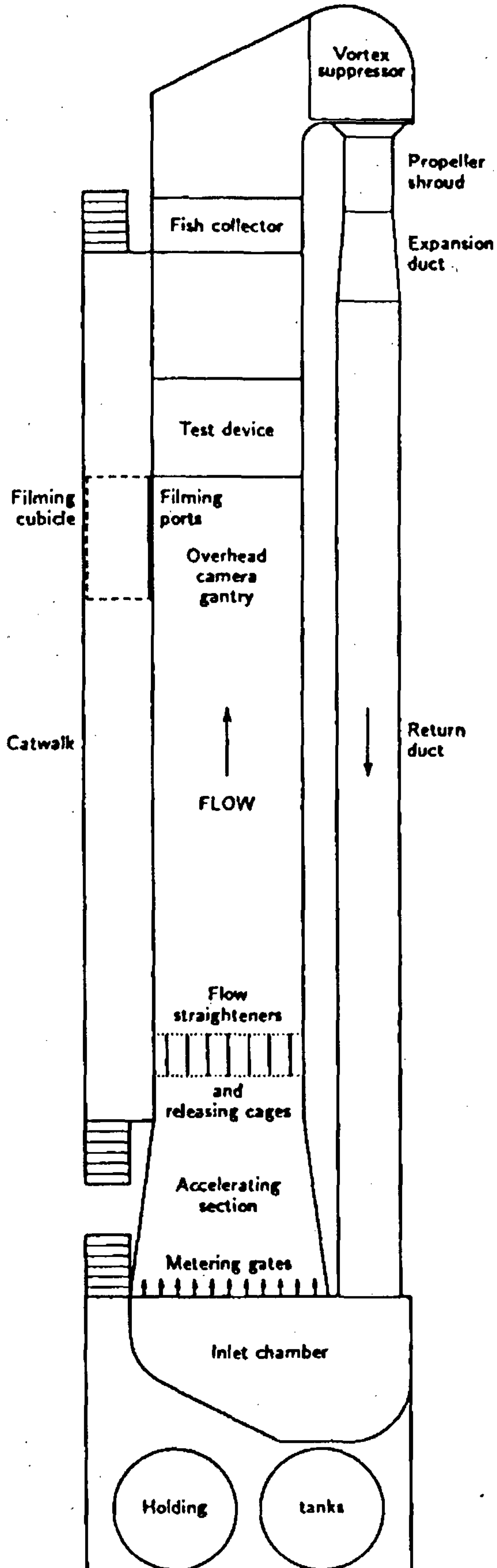
For the dual-flow experiments reported here, a full-scale entry portal and frontwall of a dual-flow screen, typical of the double-entry configuration, was installed in a large hydrodynamics flume. Flow patterns and velocity fields were retrieved from vector-resolving current measurements and from two flow marking schemes, one of particle motion recorded on video tape and one of particle streaking by time exposures on 35 mm film. Test fish were also released upstream and their dispositions in the flow fields were recorded on video tape and 35 mm photographs. Richard Ewbank of the McGinnis/Royce Corporation built the apparatus for this project and assisted with all the experiments. As in the Ristroph screen study, these researches were meant to record and clarify those peculiarities of fish and flows that instruct the designer and separate the probable from the impossible.

2. The experimental apparatus

In the usual circumstance where conventional rotating screens are replaced with dual-flow machines, the overall breadth of the device, and hence of the screening itself, is limited by the width of the access slot, or well opening, in the machinery deck of the facility (see Figure 1), the standard dimension being 162 cm (5 ft 4 in). The long dimension of the well opening corresponds to the width of the intake channel, which is usually 340 cm (11 ft 2 in), although some intake channels are narrower. Short of altering the civil works of a plant, these dimensions effectively prescribe the basic geometry and dimensions of those dual-flow machines designed expressly for replacing conventional screens, irrespective of the manufacturer. The experimental apparatus for the work reported here was configured around that basic dual-flow geometry and installed in the Royce hydrodynamics flume in Houston, Texas.

The Royce flume is equipped with underwater viewing ports, an overhead camera gantry, flow-measuring instruments, fish releasing cages, and fish holding tanks. The flume and its equipment are more fully described by Figure 3. Although the 340-cm width of a typical intake channel is greater than the 213-cm width of the laboratory flume, duplication of full scale flow fields were still possible, by virtue of the mechanical and fluid dynamical symmetries characteristic of the basic dual-flow screen geometry. The relationship of those symmetries to the configuring of the flume for the experimental work is indicated by Figure 4, which shows the flume width superimposed on the layout of a dual-flow screen designed for replacing a conventional screen. That portion of the dual-flow apparatus falling within the boundaries of the laboratory flume (the frontwall of the screen and one entry portal) was built and installed in the flume, and the location of the stagnation streamline (the flow centerline indicated on the figure) was controlled by means of a screened bypass and adjustable gate located at the far end of the screen frontwall.

The arrangement of the laboratory flume for this work is more fully described by Figure 5 (page 7). The bottom of the flume in the vicinity of the modelled dual-flow machine was lighted by rows of sealed fluorescent tubes, covered over with a prismatic diffusing plate, which allowed for overhead silhouette filming of flow trajectories and fish movements. For the video and photographic work, an L-shaped stilling box, constructed of a clear acrylic material, was fixed in place at the water surface, directly over the bottom lighting. Because the purpose of the research was not meant to extend to the testing of any proposed or existing fish-rescuing attachments, none of the mechanism for actually moving the entry screen was needed for the work, so the screening itself was merely fixed in place, as indicated on the figure.



SPECIFICATIONS

Flume type: open channel, recirculating.

Construction: steel, Carboline epoxy coating.

Dimensions: length 15.3 m; channel depth 152 cm; channel width 213 cm.

Fluid: 60,500 L fresh water, continuous filtration.

Fluid driver: shrouded propeller 61 cm dia, hydraulically driven.

Prime mover: 112,000 W electric motor, connected to pumps of hydraulic system.

Hydraulic system: dual pumps, 378 L/min at 138 bar; 1135 L reservoir and auxiliary coolers.

Flow distribution: 98 metering gates from inlet chamber. Mean free-flow velocities 0–60 cm/s in channel.

Flow monitoring: electromagnetic velocity meters with x-y analog readout; attached to digital converter.

Recording apparatus: color video camera; low light ccd camera; 35 mm cameras. White and infrared lighting; underwater filming ports and overhead camera gantry.

FIGURE 3.–Diagram of the Royce hydrodynamics flume.

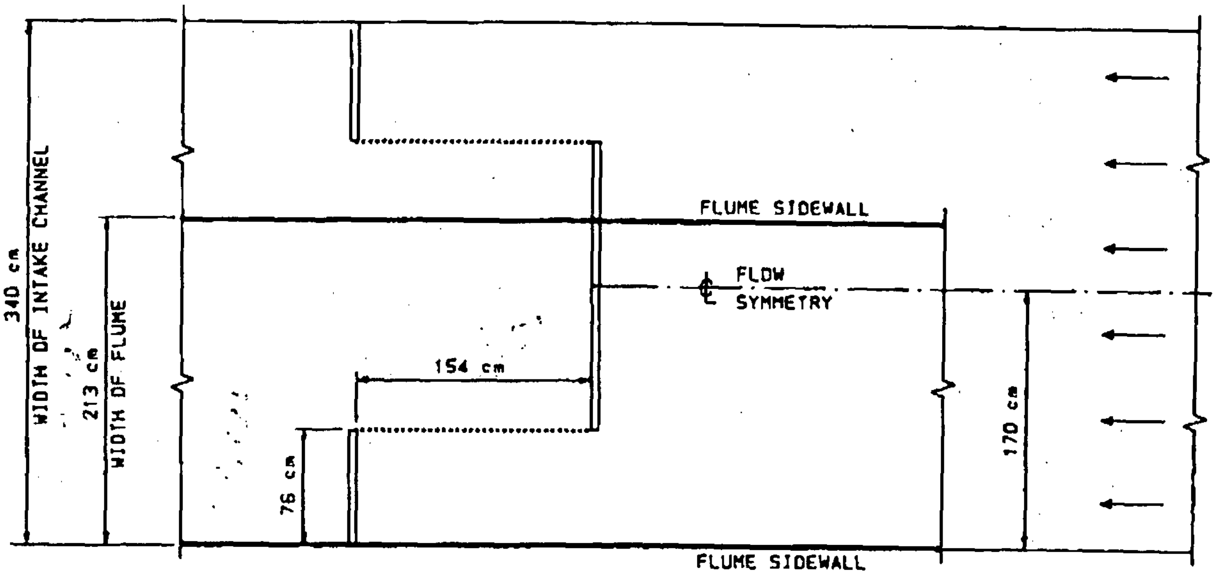


FIGURE 4.– Relationship between the width of the laboratory flume and the geometry of a typical dual-flow screen installation.

"industry standard"?

All experiments were repeated at two mean upstream flow speeds—30 and 45 cm/s—in conformity with the testing standards recommended by the Electric Power Research Institute. The free-flow geometry of the Royce flume is controlled by 98 metering gates, located in the bulkhead of the inlet chamber (see Figure 3), which were set in a pattern that put the (offset) core of the unobstructed flow along a line corresponding to the symmetry centerline of a standard, 340-cm wide intake channel. Calibrating the flume in this manner was necessary before the dual-flow apparatus was placed in the flume, because the free-flow of water in an open channel takes on a characteristic, nonuniform distribution where the fluid velocity at the core of the flow may be four to five times the velocities near the channel boundaries. See, for example, the open-channel flow diagrams in White (1986) and Sellin (1970). We appealed to those reference sources as a guide to setting the free-flow velocity distributions in the laboratory flume.

For the flume calibrations we employed a Marsh-McBurney model 511M electromagnetic current meter attached to a digital converter, with input to a microprocesser, which gave us 3D displays of the corresponding velocity vectors at the three reference stations indicated on Figure 6(a). At each of the reference stations, velocity measurements were taken on a cross-section grid of 70 points, distributed over the width and depth of the flume. A representative cross-channel distribution from those measurements is shown by Figure 6(c). The comparative distribution shown by Figure 6(b) was calculated from the normalized velocity diagrams given in White (1986). Following the flume calibrations the dual-flow apparatus was installed in the flume; we maintained the correct location of the offset, flow-symmetry centerline by means of a gated bypass located in the front plate of the dual-flow apparatus. The centerline of the unobstructed flow became the stagnation streamline of the flow into the dual-flow apparatus. The complete velocity measurements from the flume calibrations are given in Appendix A.

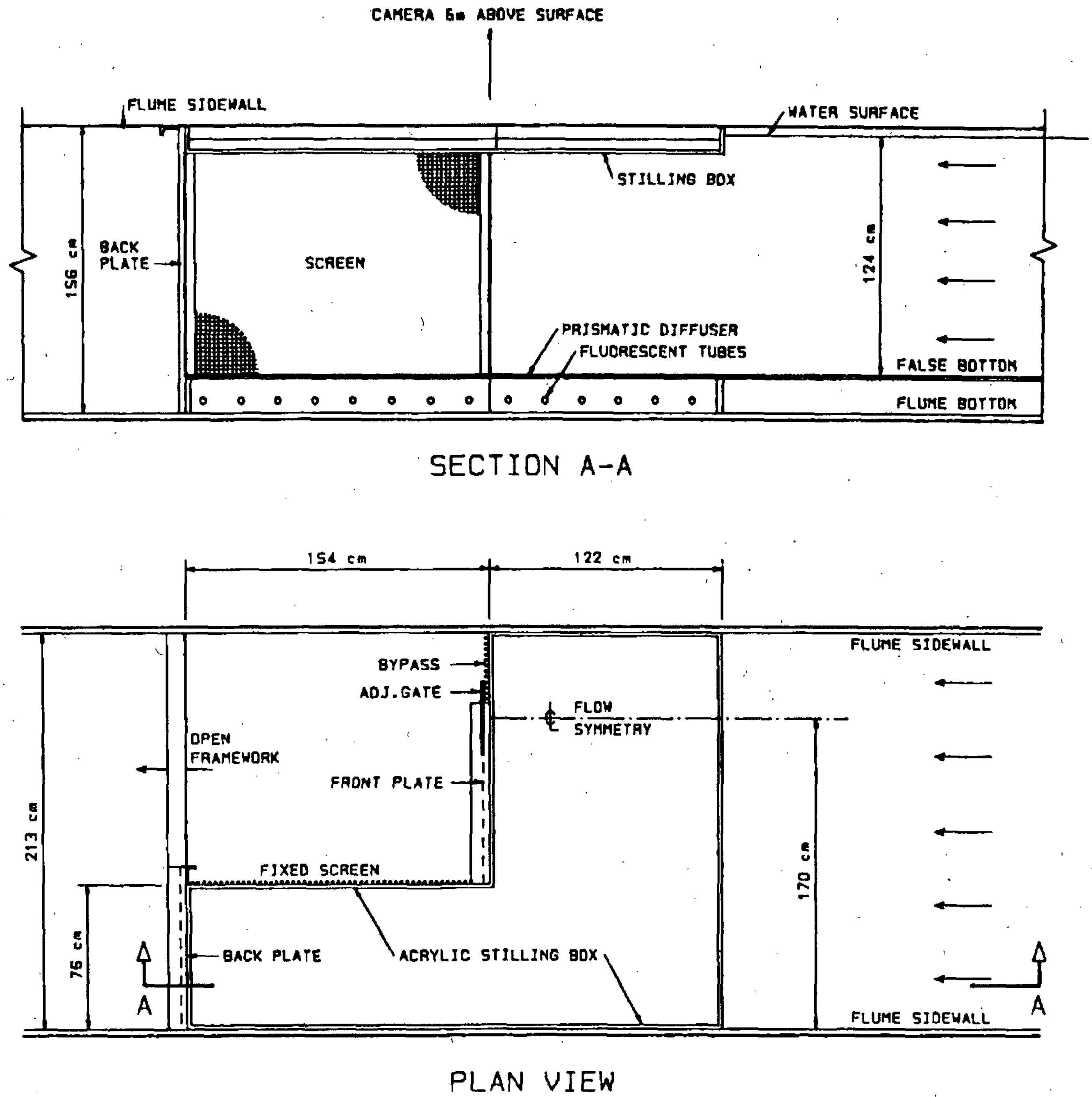
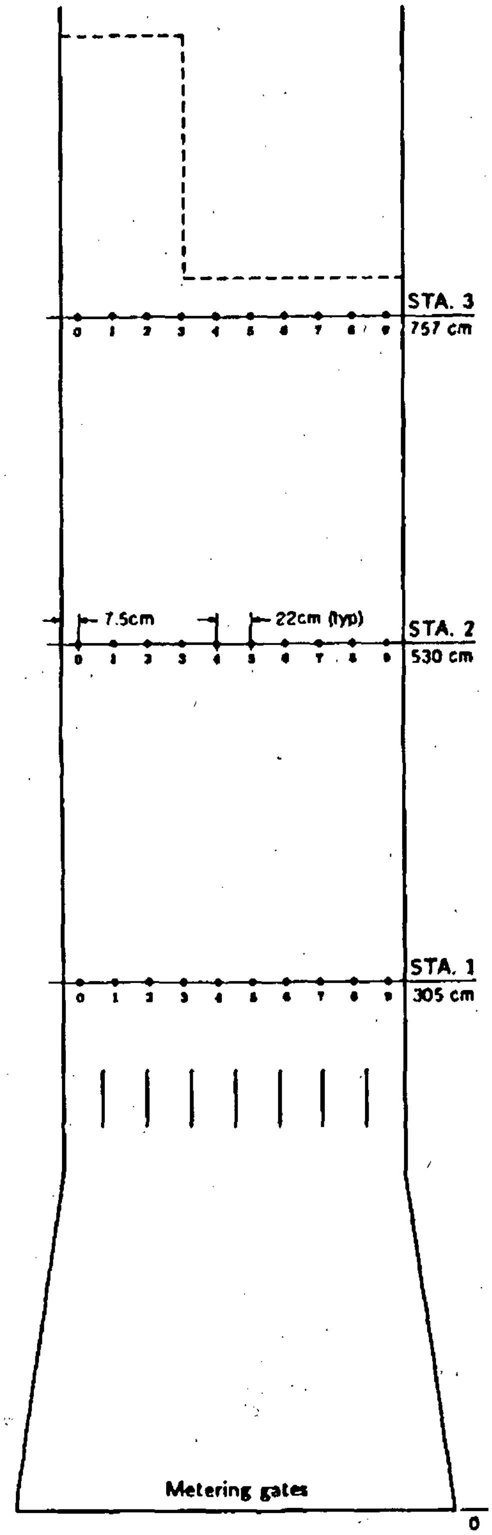
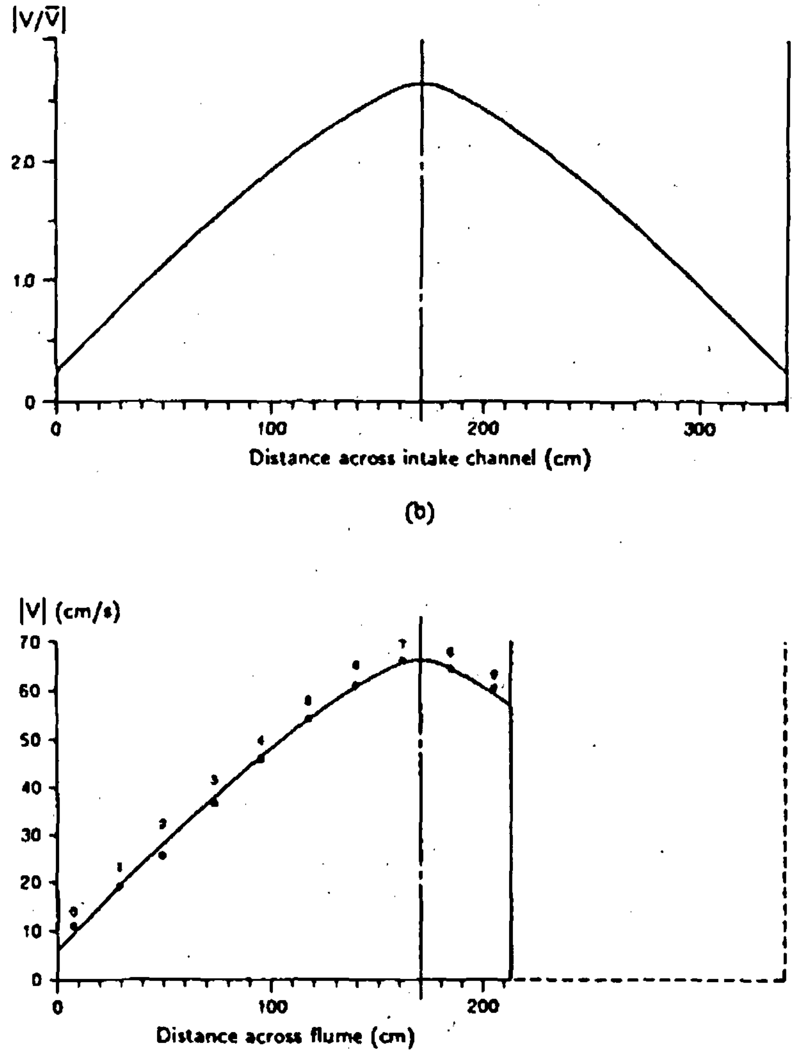


FIGURE 5.– Plan and section of the experimental apparatus, as arranged in the flume for the flow marking and fish behavior experiments. The location of the stagnation streamline in the flow approaching the modelled dual-flow machine was controlled by means of the frontwall bypass and gate. Filming was done from an overhead gantry and through viewing ports located in the near sidewall of the flume.



(a)



(b)

(c)

FIGURE 6.–(a) Diagram of laboratory flume showing locations of reference stations for calibrating the free-flow geometry. Velocities were monitored on a cross-section grid of 70 points at each station. The metering gates were adjusted until the desired flow pattern was achieved. (b) Typical velocity distribution in open channel flow. Normalized distribution calculated from the flow patterns given in White (1986). (c) Velocity distribution across the flume, mid-depth at Station 3, 45-cm/s setting, before installation of the dual-flow apparatus.

3. Flow trajectories and velocity fields

Pathline trajectories of the flows in the vicinity of the modelled dual-flow screen were recorded on video tape and 35 mm photographs. The cameras were equipped with telephoto lenses and located 6 m above the flume (an arrangement that helped to reduce visual parallax). For the video work, submerged flow markers, in the form of pre-wetted charcoal bits, were released, *en masse* at mid-depth, 5 m upstream of the apparatus. The charcoal bits were very nearly neutrally-buoyant. Their mean falling time from release (measured over a fall of 50 cm in a 10 cm cylinder) was 0.3 cm/s.

The pathline trajectories for the 35 mm photographs were delineated by reflective Mylar confetti, also released at mid-depth 5 m upstream of the dual-flow apparatus. For each such release, six succesive exposures were made at 1.2 sec intervals, with shutter speeds of 0.6 to 0.9 sec. Streak trajectories typical of that technique are shown in Figure 7. Because the flows were steady and the mass of a Mylar particle was very small, the pathline streaks can also be viewed as velocity streamlines. As indicated by the photographs of Figure 7, the flow along the frontwall of a dual-flow screen must turn 180° to enter the screening. Owing to the high momentum of the fluid in that turning region, a large, standing separation occurred at the upstream corner of the screen entry. In consequence of the displacement of flow past the separation, the main efflux of water through the screen was concentrated over the downstream half of the screening, at both of the employed test speeds.

The surface effects of the corner separations are shown in Figure 8 (the stilling box having been removed). The geometry of the separation was essentially a function of the volumetric flux (hence, the velocity) of water received by the entry portal. The fillet plate appearing in one of the photographs is a feature employed by one screen manufacturer, more as an aid to the mechanical stability of the dual-flow machine than any perceived benefit to the distribution of flow through the screening. Aside from slight streamline crowding at the downstream end of the screening, the effects of the fillet on the corner separation and the main flow were negligible. With or without the fillet, the flow trajectories at the surface conformed to the orientation of flow at depth. The surface disorder apparent in the photographs is the (minor) effect of backwash from the sidewall and backwall boundaries. The water immediately behind the front plate of the apparatus remained in a state of stall. A diver wearing a weight belt was able to stand erect in that area without effort.

FIGURE 7–(overleaf) Typical flow pathlines in the vicinity of the modelled dual-flow screen, produced by time exposures of reflective flow markers.

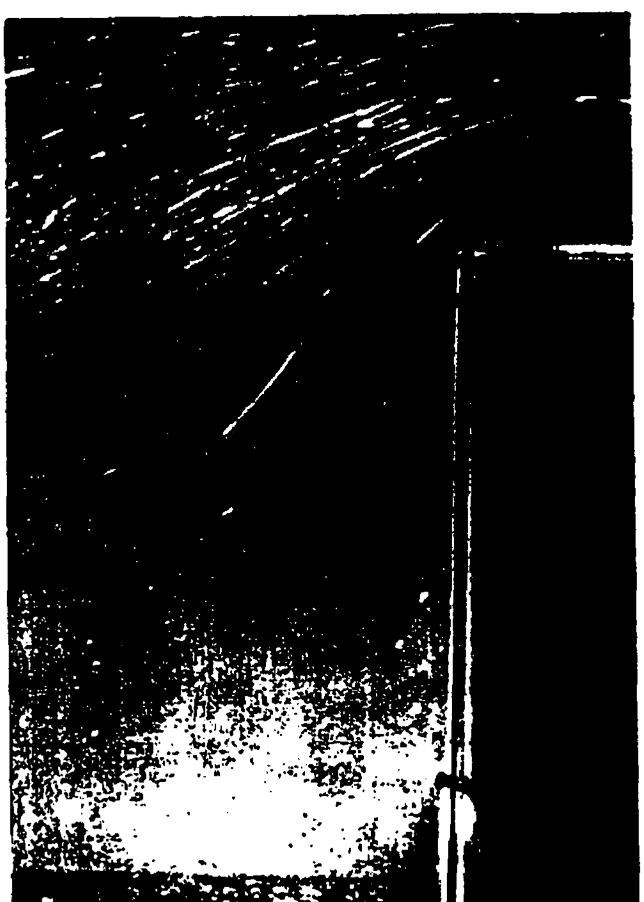
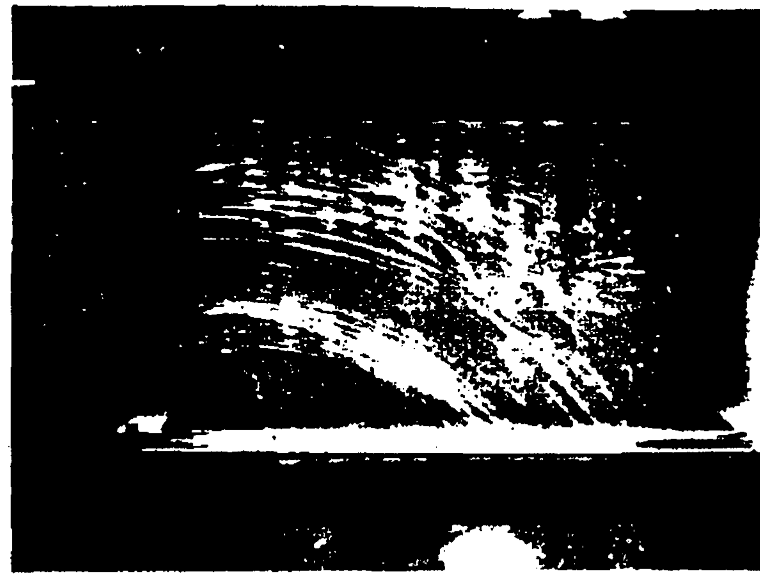




FIGURE 8.–Top photo: surface configuration of flow at the screen entry, 45-cm/s mean flow setting. Depth of the depression at the center of the separation gyre was 21 cm below the free surface. Bottom photo: surface configuration at the 30-cm/s setting. Surface backwash in both photos obscures the true geometry of the main flow through the screen.

TABLE 1.–Velocity measurements (in cm/sec) corresponding to the vector field shown in Figure 9. The symbol $|\mathbf{v}|$ signifies velocity magnitude; symbols v_x and v_y denote the measured cartesian components, where $\mathbf{v} = v_x\mathbf{i} + v_y\mathbf{j}$ according to the orientation indicated on Figure 10.

Col	0	1	2	3	4	5	6	7	8	9	10
					Station 3						
v_x	-57	-62	-64	-52	-27	-14	-11	-9	-21	-55	
v_y	-4	-20	-39	-57	-53	-37	-11	-1	18	11	
$\|\mathbf{v}\|$	57	65	75	77	59	39	15	9	28	56	
					Station 4						
v_x	-80	-83	-88	-97	-109	-120	-126				
v_y	-2	-7	-17	-23	-34	-57	-80				
$\|\mathbf{v}\|$	80	83	89	100	114	133	149				
					Station 5						
v_x	-50	-57	-66	-74	-80	-86	-92				
v_y	9	18	32	41	57	74	92				
$\|\mathbf{v}\|$	51	60	73	85	98	113	130				
					Station 6						
v_x	34	14	-5	-14	-5	-5	-23				
v_y	-11	-20	-20	-11	18	34	66				
$\|\mathbf{v}\|$	36	24	21	18	19	34	70				
					Station 7						
v_x	-6	-30	-55	-80	-103	-125	-135	-76	-75	-149	-107
v_y	32	66	80	91	94	83	57	15	-11	-70	-87
$\|\mathbf{v}\|$	33	72	97	121	138	150	146	77	76	165	138

We took velocity measurements of the entry flows at the reference stations shown in Figure 9. The measurements at each station were made on a location grid of 7 rows and n columns ($n = 10$ for station 3, $n = 7$ for stations 4, 5, and 6, and $n = 11$ for station 7). The vector diagram of Figure 9 was constructed from the instrument readings taken at mid-depth (row 4) at the 45 cm/s setting; the corresponding component values are given on Table 1. The complete velocity data for the 30- and 45-cm/s settings are contained in Appendix A.

The length and direction of a vector arrow in Figure 9 indicates the magnitude of water velocity and the instantaneous direction of flow at the arrow midpoint (the point of measurement). That is, any vector arrow of Figure 9 lies tangent to the (curving) velocity steamline that passes through the corresponding point of measurement. Owing to the extreme crowding of the main flow streamlines in passing through the narrow entry portal and around the corner separation, the water velocities at the screen (and the corresponding momenta of flow) were greatly elevated. Velocity magnitudes at the screen were on the order of 120 cm/sec (4 fps) at the 45-cm/s setting and 80 cm/s (2.6 fps) at the 30-cm/s setting.

The asymmetric nature of the flow through the entry portal and screening is more clearly indicated by Figures 10—12. The corner separation effectively blocked off 50% of the screen area to the main flow at the 45-cm/s setting, and 38% at the the 30-cm/s setting. In each case, the clockwise circulation of the corner separation created backflow in the upstream portion of the screening.

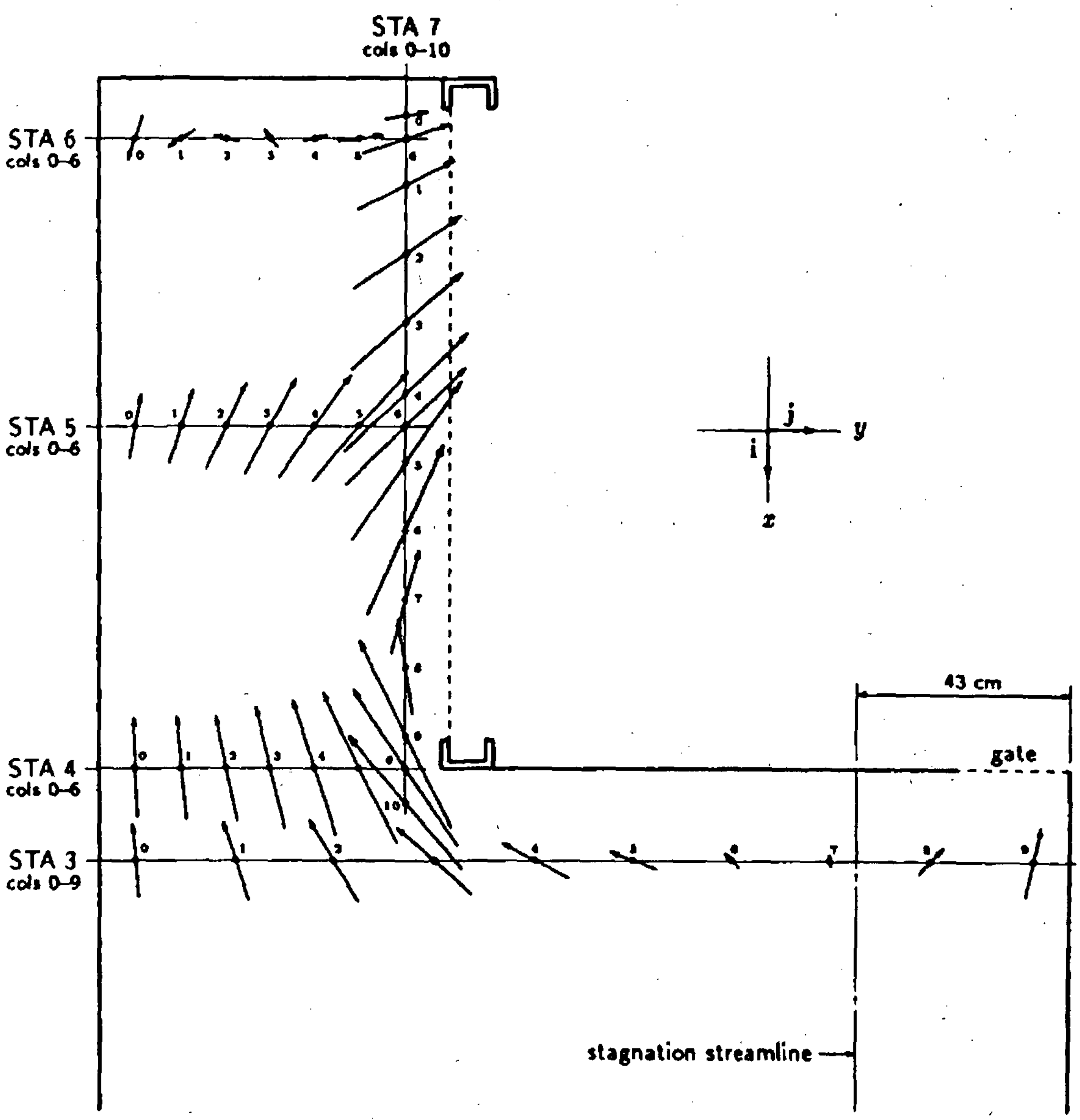


FIGURE 9.–Plot of velocity vectors at mid-depth, 45-cm/s setting, as measured with a component-resolving current meter. The points of measurement lie at the arrow mid-points. The length of a vector arrow corresponds to velocity magnitude; the direction of an arrow corresponds to the instantaneous direction of flow at the reference point. See Table 1 for component values.

As shown by Figures 7–12, the geometry of the flow approaching and passing through a conventional cross-channel screen (which resembles the open channel flow depicted by Figure 6(b)) is drastically altered by the substitution of a dual-flow screen. The high-speed core of the unobstructed flow (or the flow through the conventional screen) becomes the upstream region of lowest fluid speed, and the main transport of water is deflected away from the center of the forebay to the narrow entry portals at the forebay sidewalls. At the entry portal, fluid speed is greatest at the corner of the frontwall, corresponding to the velocity maximum along the boundary of the separation and into the center of the screening.

The distributions graphs of fluid transport and velocity magnitudes at station 4 (across the entry portal) and station 7 (just upstream of the screenmesh) are shown in Figures 10 and 11. The data points on the graphs of velocity magnitudes $|\mathbf{v}|$, as well as the lengths of the vector arrows in Figure 9, are given by the relationship

$$|\mathbf{v}| = \sqrt{v_x^2 + v_y^2},$$

while the graph points of quantities $-\mathbf{v}\cdot\hat{\mathbf{n}}$ correspond to the normal components of flow across the reference station, the area under the graph being Q^*, volumetric flux per cm of depth through the reference station. The cartesian axes indicated on Figures 9 and 12 (x positive towards the inlet end of the flume and y positive from left to right when facing downstream) were chosen for their conveniences in representing these transport and velocity distributions.

In general, the volumetric rate of flow Q through an arbitrary region R of area A is

$$Q = -\iint_{\mathrm{R}} \mathbf{v}\cdot\hat{\mathbf{n}}\, dA,$$

$\hat{\mathbf{n}}$ being an (outward) unit normal vector over region R. In our case here, velocity $\mathbf{v} = v_x\mathbf{i} + v_y\mathbf{j}$, where $v_x = v_x(y)$ and $v_y = v_y(x)$ at the reference stations, both v_x and v_y being time independent, since we have steady flow. At station 4, the unit normal $\hat{\mathbf{n}}$ over the (vertical) surface R represented by the grid of instrument points is simply the unit basis vector $\mathbf{i}$. Consequently, $-\mathbf{v}\cdot\hat{\mathbf{n}} = -v_x$ at station 4, and the volumetric flux of water (per cm of depth) through the entry portal is

$$Q^* = -\int_{y=0}^{76\text{ cm}} v_x dy,$$

which must be equivalent, of course, to the upstream transport. For the 30-cm/s setting, Q^* would be 5100 cm^2/s (or 30 cm/s × 170 cm, the breadth of the upstream flow). For the 45-cm/s setting, Q^* is 7650 cm^2/s, which is the area under the distribution curve of $-\mathbf{v}\cdot\hat{\mathbf{n}}$ in Figure 10. At station 7, just ahead of the screen, $\hat{\mathbf{n}} = -\mathbf{j}$, hence

$$Q^* = \int_{x=0}^{S} v_y dx,$$

where limit S signifies the location of the separation boundary where it crosses station 7. That is, Q^* in this case sums to the total 30 or 45-cm/s transport rate

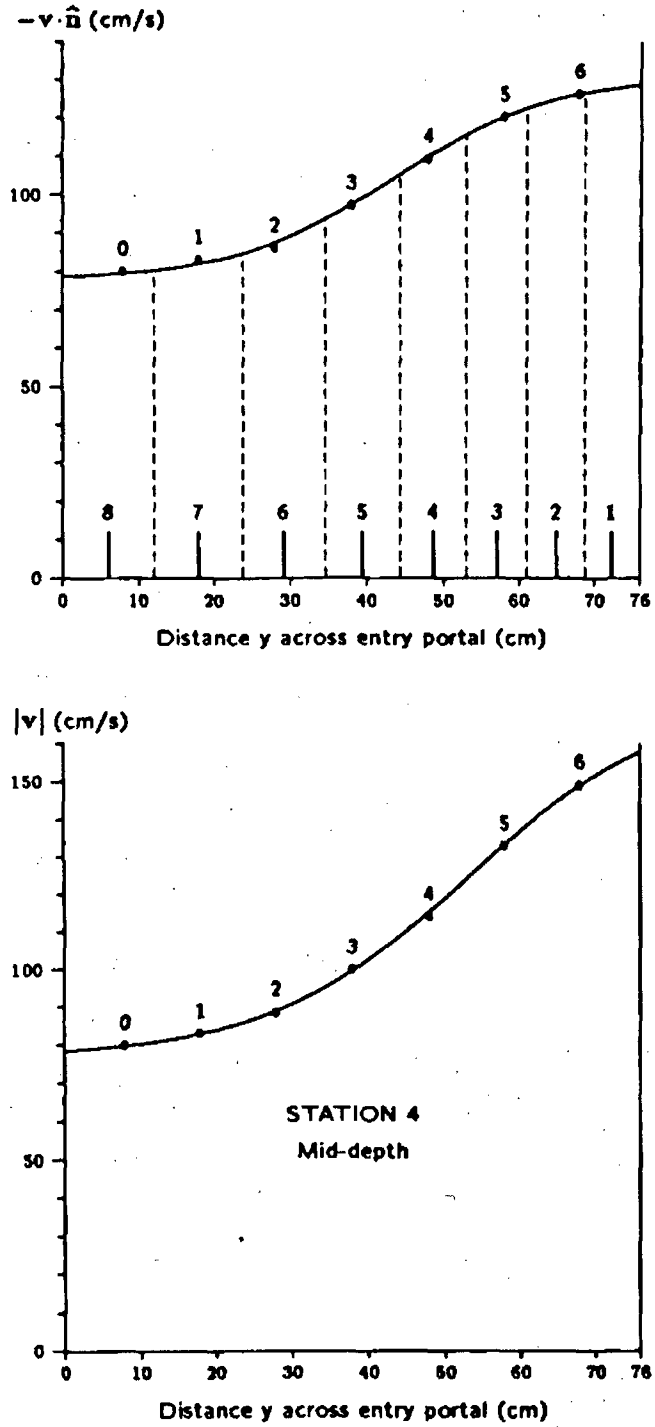


FIGURE 10.—Top panel: distribution graph of $-\mathbf{v}\cdot\hat{\mathbf{n}}$ at mid-depth, reference station 4. Instrument values are denoted by (•); see v_x values, Table 1. Area under the graph is volumetric transport per cgs unit of depth through station 4. Equal areas bounded by dashed lines correspond to the eight transport trajectories of Figure 12. Bottom panel: distribution graph of velocity magnitudes at mid-depth, station 4; see $|\mathbf{v}|$ values, Table 1.

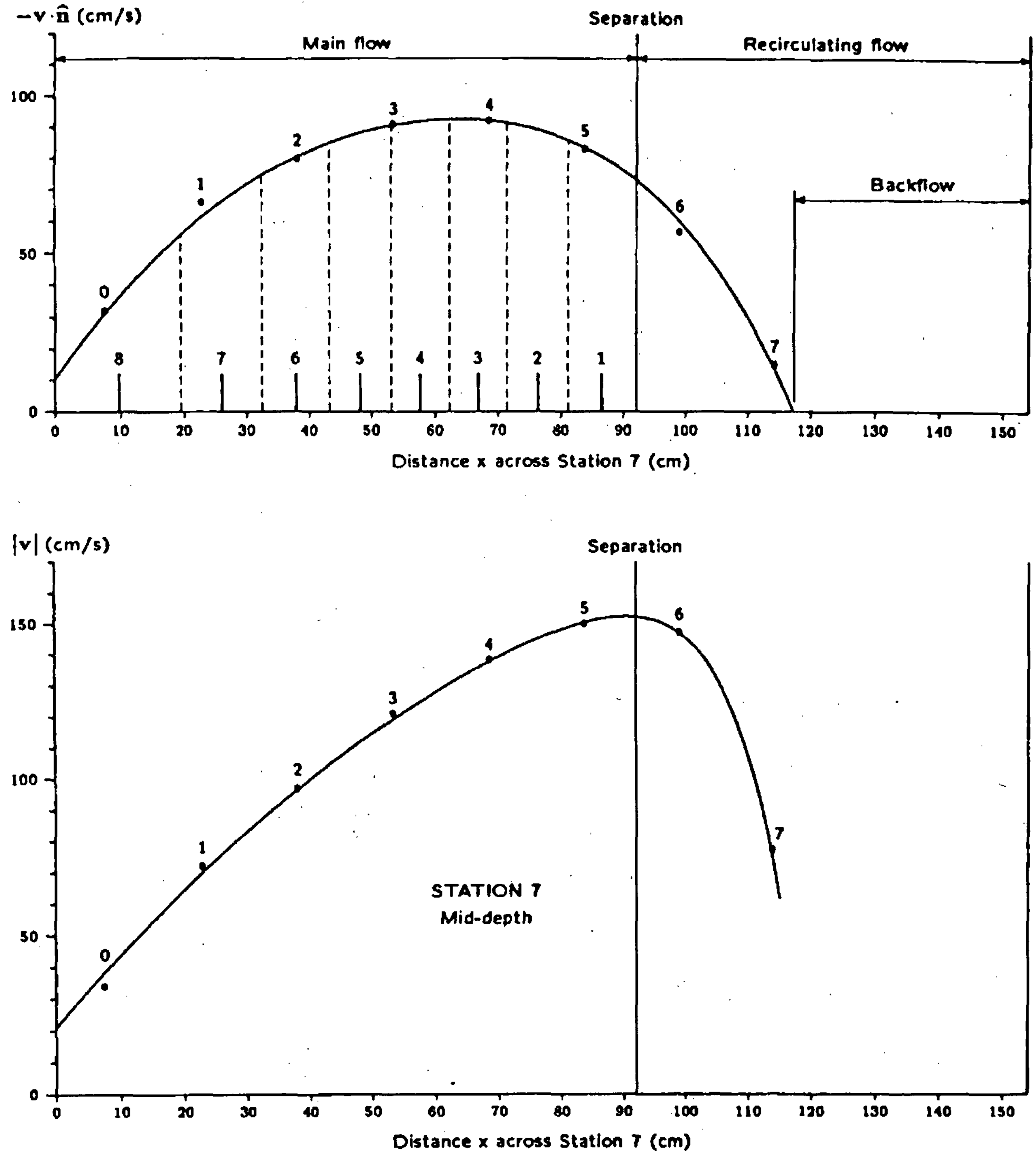


FIGURE 11.–Top panel: distribution graph of $-\mathbf{v}\cdot\hat{\mathbf{n}}$ at mid-depth, reference station 7 (8 cm upstream of screen). Instrument values are denoted by (•); see v_y values, Table 1. Area under the graph is volumetric transport per cgs unit of depth through station 7. Equal areas bounded by dashed lines correspond to the eight transport trajectories of Figure 12. Region to the right of the separation is transport of secondary flow. Bottom panel: distribution graph of corresponding velocity magnitudes; see $|\mathbf{v}|$ values, Table 1.

at the separation boundary, the excess transport to the right of the separation (as in Figure 11) being a consequence of the recirculation of water through the upstream half of the screen.

In Figures 10 and 11 the eight equal-valued areas under the distribution graphs of $-\mathbf{v}\cdot\hat{\mathbf{n}}$ correspond to the numbered flux lines of Figure 12, whose locations were resolved by partitioning the Q^* integrals at reference stations 3, 4, 5, and 7. The distribution graphs of v_x, v_y, and $|\mathbf{v}|$ were resolved from the general autonomous form

$$z' + az^2 + bz + c = 0, \qquad (1)$$

which permits of nondimensionalizing and its adaptation to volumetric rates of flow and apparatus dimensions that differ from those treated here. In equation (1) the rate of change in quantity z (in v_x, v_y, or $|\mathbf{v}|$) is strictly a function of the magnitude of z, independent of the independent variable t (dimension x or y). The independent variable appears solely in the boundary or side conditions. Provided the roots of equation (1) are real, its general solution $z(t)$ is

$$(z - r_1)/(z - r_2) = C_0 e^{at(r_2 - r_1)}, \qquad (2)$$

where C_0 is the integration constant and r_1, r_2 are the quadratic roots of (1), which also become the asymptotes of solution (2).

At station 4, the fitted solution form (2) for the distribution of fluid speed across the entry portal at the 45-cm/s mean flow setting became

$$|\mathbf{v}| = \frac{78 + 2.9\,e^{0.077y}}{1 + 0.0169\,e^{0.077y}} \qquad (3)$$

(y in cm, $|\mathbf{v}|$ in cm/s), which is the curve in the lower graph of Figure 10. Close to the left sidewall boundary, the flow speed $|\mathbf{v}| = 79$ cm/s, which rises to twice that value, or 158 cm/s, at the corner of the entry portal.

The distribution across the entry portal of the normal component of flow (which is $-v_x$ here) became

$$-\mathbf{v}\cdot\hat{\mathbf{n}} = \frac{78 + 1.9165\,e^{0.0967y}}{1 + 0.0147\,e^{0.0967y}}, \qquad (4)$$

which is the curve in the upper graph of Figure 10. The boundaries of the eight transport areas under the graph of $-\mathbf{v}\cdot\hat{\mathbf{n}}$ were located by numerically integrating equation (4) in eight partition steps, each of 956 cm^2/s in value.

At station 7 the separation imposes a nonlinearity on the flow geometry more severe than that of governing equation (1). Therefore, for that circumstance I employed the linear terms of (1) and matched its (outer) solution to perturbation terms. The result for the distribution of the $|\mathbf{v}|$ data points at the 45-cm/s setting became

$$|\mathbf{v}| = 244(1 - 0.9139\,e^{-0.0109x}) - 183\,e^{(x-120)0.10764} \qquad (5)$$

(x in cm, $|\mathbf{v}|$ in cm/s), which is the curve in the lower graph of Figure 11. In turn, the distribution across station 7 of the normal component of flow (v_y here) became

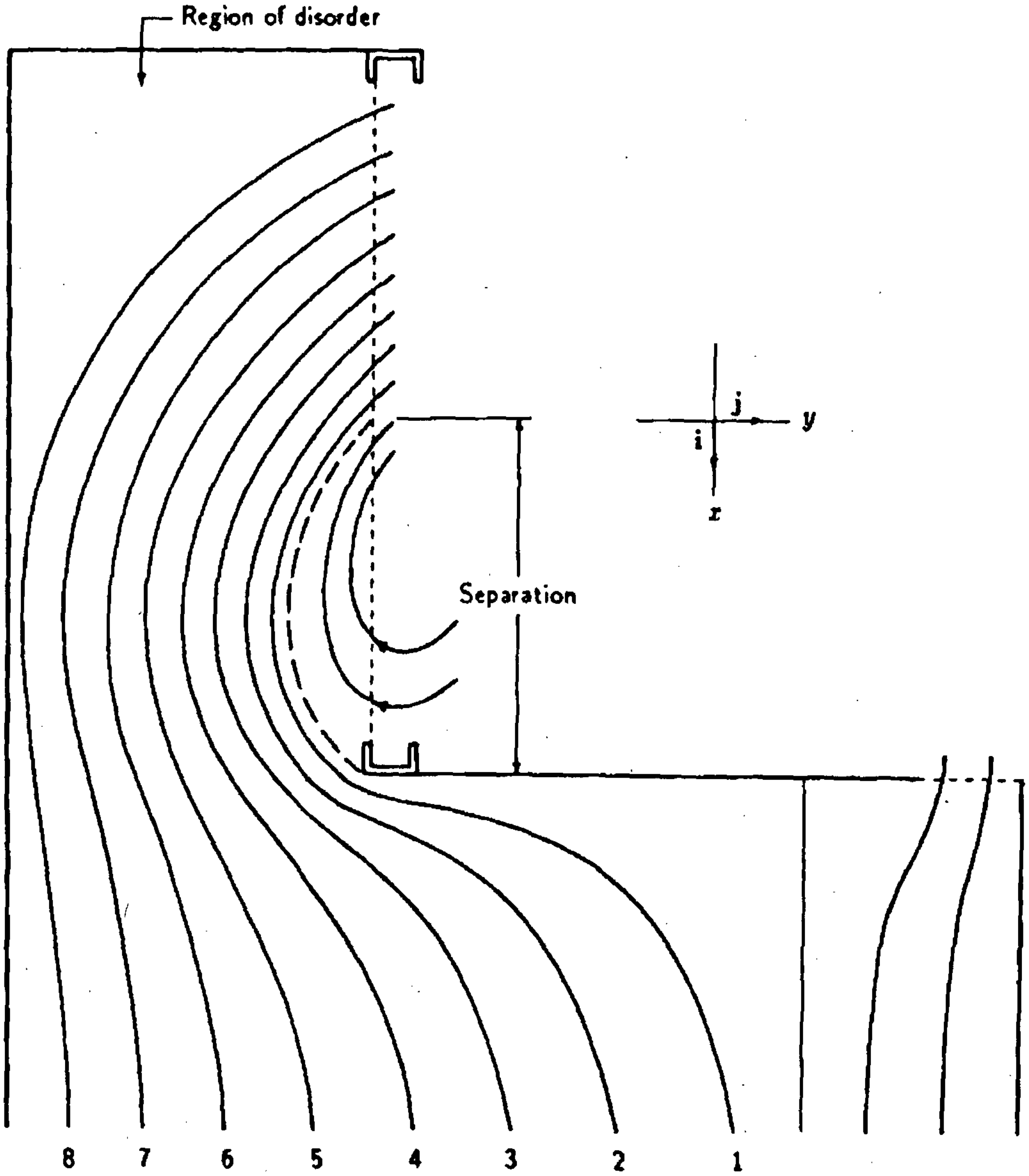


FIGURE 12.—Plot of equal-valued transport trajectories, 45-cm/s setting. Each trajectory represents a volume transport of ~956 cm^2/s per cm of depth. The corner separation extended to 50% of the screen width at the 45-cm/s setting and 38% at the 30-cm/s setting.

$$-\mathbf{v}\cdot\hat{\mathbf{n}} = 134\left(1 - 0.9105\,e^{-0.025x}\right) - 131\,e^{(x-118)0.03817}, \qquad (6)$$

which is the curve in the upper graph of Figure 11. The eight equal-valued transport partitions under the distribution curve were resolved in the same manner as those of Figure 10, but here the right hand boundary was determined by setting the Q^* integral of equation (6) to 7650 cm^2/s, the known volumetric transport of the main flow, and numerically resolving the upper limit S. The location of S at 92 cm from the backwall of the dual-flow screen coincided with the location of maximum $|\mathbf{v}|$ at the separation boundary (as it should have).

The flux lines of Figure 12 portray the complex nature of the flow through the dual-flow screen. The corner separation blocks off the forward portion of the screening to the main flow, which passes through the rear portion of the screening at an angle so sharp that over a distance of 8 cm (the distance between station 7 and the screenmesh) the separation boundary is displaced from the 92 cm location at station 7 (Figure 11) to about 75 cm at the screenmesh, which is an angle of attack of ~60° (the angle away from a perpendicular to the plane of the screenmesh). At lower inflow speeds (at lower pumping rates), the separation recedes but the angle of attack increases (the flow at the separation becomes more nearly parallel to the screenmesh).

As indicated on Figure 12 and the upper graph of Figure 11, the recirculation of water through station 7 (and the screenmesh) was a consequence of a trapped eddy that was shear-driven by the passage of the main flow around the corner separation. In the recirculation zone, the flow through the screen (and station 7) reverses direction. Note the sign change in the normal component v_y between columns 7 and 8 of Table 1 for station 7, which in turn corresponds to the zero value of the $-\mathbf{v}\cdot\hat{\mathbf{n}}$ graph in Figure 11. The velocity magnitude $|\mathbf{v}|$ at that point does not fall to zero, however, because the flow is parallel to the screen (and to station 7; note the values of tangential component v_x on Table 1). In the region of backflow, fluid velocities are high, although reversed in direction, as indicated by the elevated values of $|\mathbf{v}|$ in columns 8, 9, and 10 of station 7 on Table 1. These flow complications influenced the disposition and behavior of fish drawn to the screen. The flow reversal and asymmetric distribution of fluid momentum also imposes a cross-stream torque on the screen structure.

Solution methods

In the z, z' phase plane, governing equation (1) is a parabolic curve where $z' = 0$ at the quadratic roots r_1, r_2 of $az^2 + bz + c$, which project to the asymptotes of (2) in the solution plane, as indicated in Figure 13. The solution graph of (2) may be monotonic increasing (as in Figure 10) or monotonic decreasing (as it would be at the right hand entry portal) according as

$$m = \frac{b^2}{4a} - c$$

is positive or negative. Quantity m is the maximum (or minimum) value of z' of (1) in the phase-plane, corresponding to the slope of solution (2) at its inflection point p, which occurs at $z = (r_1 + r_2)/2$ in both the phase and solution planes.

Therefore, with the exception of the boundary condition, all the parameters for fitting the solution graph to datum points can be resolved in terms of z and z' in the phase plane, independent of the independent variable t, with the aid of a routine method for estimating $z'(z)$ from the measures of Δz (see Appendix B). The relationship between $z(t)$ and t in the solution plane is then resolved by specifying the boundary condition z_0 (that is, by determining its value from the best fit of solution (2) to the t, z data values).

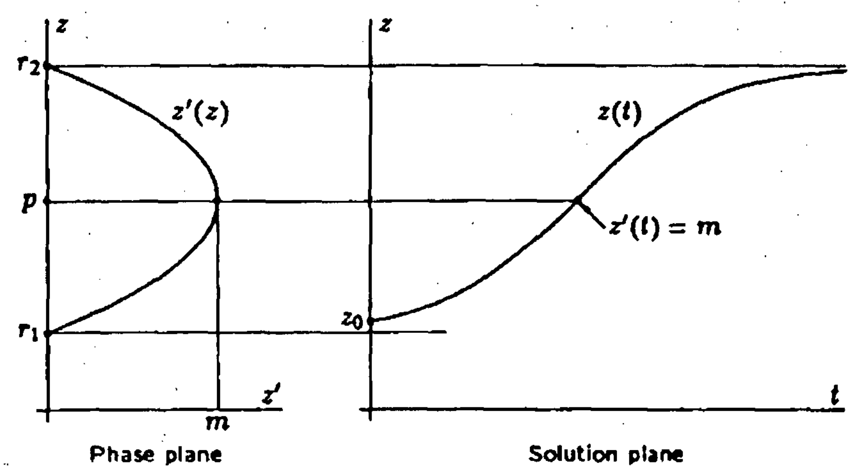


FIGURE 13.–Graph trajectories of differential equation (1) and its solution (2).

Owing to the effects of the flow separation, the distributions of $|\mathbf{v}|$ and $-\mathbf{v}\cdot\hat{\mathbf{n}}$ downstream of the entry portal each exhibits an extremum between two lesser boundary values, as portrayed by the graphs of Figure 11. The perturbation imposed on the flow geometry by the presence of the separation imposes in turn a (mathematical) perturbation on the general distribution equation (1) and its solution graph (2). The altered solution trajectories (5) and (6) for station 7 were determined by matching a general outer solution

$$z^{(o)}(t) = \left(z_0 + \frac{c}{b}\right)e^{-bt} - \frac{c}{b} \tag{7}$$

of the linear portion

$$z' + bz + c = 0 \tag{8}$$

of (1) to an inner solution

$$z^{(i)}(t) = z^{(o)}(t_1) - z^{(o)}(t_1)e^{(t-t_1)\epsilon} + z(t_1)e^{(t-t_1)\epsilon} \tag{9}$$

of the first two terms of a perturbation expansion

$$z' = \gamma + \epsilon z, \tag{10}$$

where γ is a constant and ϵ is the perturbation factor. Graph trajectories of equations (7) and (9) are shown in Figure 14.

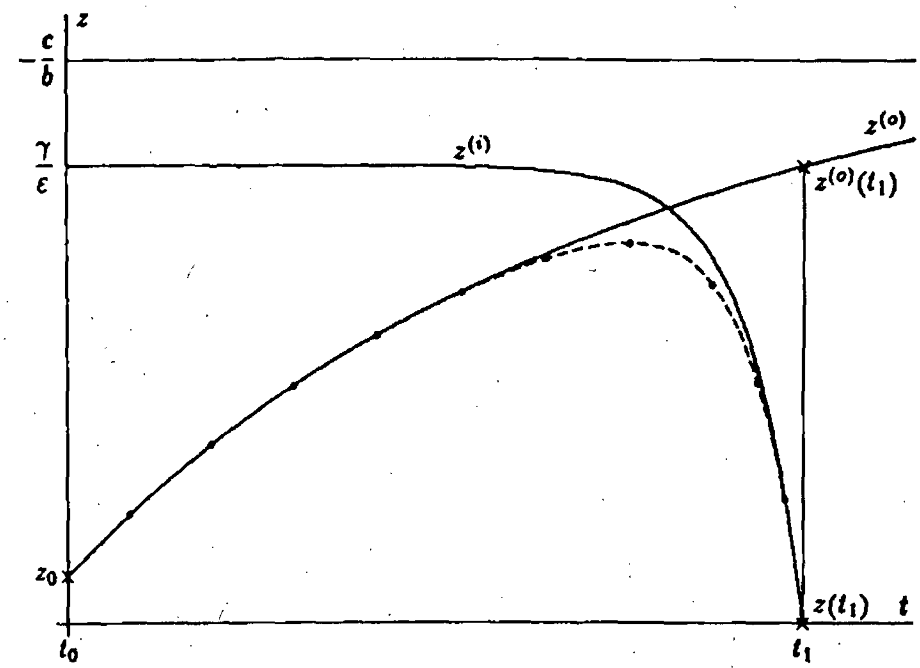


FIGURE 14.–Graphs of outer solution $z^{(o)}$ (equation 7), inner solution $z^{(i)}$ (equation 9), and composite solution $z(t)$ (equation 11), whose trajectory is denoted by the dashed curve. Boundary values satisfied by $z(t)$ are $z(t_1)$ on the right and z_0 at $t_0 = 0$. Symbols (•) represent fitted data points.

As portrayed in Figure 14, the composite solution $z(t)$ has the boundary values $z(t_0)$ on the left and $z(t_1)$ on the right, either of which may be zero or nonzero. Outer solution $z^{(o)}(t)$ satisfies the left hand boundary condition (symbolized z_0 in equation 7), where, without loss of generality, $t_0 = 0$), while inner solution $z^{(i)}(t)$ satisfies the right hand boundary condition (quantity $z(t_1)$ in equation 9). The quantity $z^{(o)}(t_1)$ is the value of the outer solution at t_1 (the location of the right hand boundary). In equation (9), $z^{(o)}(t_1)$ replaces γ/ε with small error. The composite solution is recovered by combining the inner and outer solutions and eliminating the overlap, or

$$z(t) = -\frac{c}{b}\left[1 - \left(\frac{bz_0}{c} + 1\right)e^{-bt}\right] - \left[z^{(o)}(t_1) - z(t_1)\right]e^{(t-t_1)\varepsilon}, \qquad (11)$$

which is the form taken by the distribution equations (5) and (6). In the region near the left hand boundary where the outer solution is valid, the constants c and b of (7) can be resolved from the measures of Δz in the z, z' plane where governing equation (8) will have a straight line graph. The boundary value z_0 can then be determined by fitting outer solution (7) to the t, z data points in that region. A similar procedure can sometimes be followed for resolving perturbation parameter ε with equation (10), but when the distribution of interest drops off sharply at the boundary, the data points in the boundary region are often too few to suit that procedure. In most cases, ε is more accurately resolved in the composite solution (11).

4. Fish behavior experiments

The fish used in the behavior experiments were 246 juvenile striped bass *Morone saxatilis* of Hudson River origin, 5.9 cm in mean standard length, and 260 each of golden shiners *Notemigonus crysoleucas* 5.6 cm and 7.2 cm in mean standard lengths, obtained from a local fish farm. The striped bass were shipped by air to Houston. Of the 250 received, four were judged unfit for use (owing to erratic swimming behavior). We employed the golden shiners as representatives of tender species having moderate endurance and swimming strength, in contrast to the striped bass, which are typical strong swimmers, hardy, and not so readily damaged.

The fish were held apart by size and species in large fish tanks until used in the experiments. Tank water was aerated, filtered, and monitored for temperature, pH, ammonia concentration, and conductivity. The flume water was continuously filtered and circulated; temperature, pH, and conductivity were measured between experiments. For each behavior experiment, the fish of a sample were released 5 m upstream of the dual-flow apparatus by species, size, and water speed.

At each of the 30- and 45-cm/s mean flow settings, the striped bass were released in five sample batches of 20, one batch of 15, and eight of one fish at a time (a total of 28 trials). The two sizes of shiners were released at each of the flow settings in four batches of 25, one batch of 10, and ten of one fish at at time (a total of 60 trials with the shiners). For the silhouette photography, a video camera and a 35 mm camera were located 6 m above the stilling box (see Figure 5) while an observer viewed the fish through the sidewall ports of a darkened cubicle (see Figure 3). During an experiment the video camera ran continuously. The mounted 35 mm camera, which was equipped with a motor-driven shutter and film advance, was operated at will, at the rate of three frames per second, by the observer on the camera gantry. The two observers were equipped for communication with earphones and voice-activated transmitters. A few trial experiments were conducted during daylight hours, with the flume upstream of the stilling box covered over with black plastic sheeting, but we abandoned that procedure early on. All of the behavior experiments discussed here were carried out after dark, the only light in the flume building being the flume bottom lighting in the vicinity of the dual-flow apparatus, an arrangement that allayed our worries over the unknown influences on the fish of surface reflections and other visual disturbances.

The discussion here of the findings from the behavior experiments is aided by the several photographs of fish locations reproduced in this section, which should be viewed in their relationships to the flow patterns and velocity vectors depicted in Figures 7, 9, and 12. A velocity vector of Figure 9 indicates the (instantaneous) direction of flow at its midpoint; the comparative lengths of the vector arrows give an indication of the differences in fluid speeds from location across a station, or from station to station in the flow. The streak lines of Figure 7 indicate the paths taken by the flowing water, and the flux lines of Figure 9 (or those shown on the diagrams of this section) correspond to the gross transport of water along those paths of motion. The flow accelerates along any flux line; the closer together they are, the greater the speed of flow. Along flux line 1 in Figure 12, for example, the fluid speed is about 30 cm/s where it crosses station 3 (compare with Figure 9 and Table 1). Over the short distance between that point and station 4 at the entry portal, however, the fluid speed along flux line 1 increases fivefold to 150 cm/s, a speed maintained through station 7 and into the screening. The dispositions of fish in the vicinity of the dual-flow apparatus were governed by these fluid accelerations and patterns of flow.

A typical episode of fish being drawn into the vicinity of the dual-flow apparatus and through the entry portal is shown by the three (successive) photographs of Figure 14 and the accompanying tracings of Figure 15. The fish are large golden shiners of a batch of 25 released upstream at the 30 cm/s setting. The elapsed time was 2.25 s between frames (a) and (b), and 1.87 s between (b) and (c). Individuals were identified and their paths of motion tracked by matching the 35 mm photographs with the video tape. The flow pattern at the 30 cm/s mean flow setting (Figure 15) differs somewhat from the flow pattern at the 45 cm/s setting (Figure 12).

In frame (a) of Figure 14, the fish are being transported into view by the flow, at about 50 cm/s. The net downstream movement of fish, despite their apparent orientations in the photograph, followed generally along the lines of flow indicated in Figure 15. All of the fish appearing in frame (a) were drawn rapidly into the vicinity of the dual-flow apparatus. Fishes 1, 2, and 3 of frame (b) arrived slightly later than those numbered 4 to 16 in Figure 15. Few fish (of either tested species) were observed to orient themselves directly into the flow until they were close upon the frontwall of the apparatus or the corner of the entry portal. Despite furious swimming efforts, few of the individuals transported to the high speed corner region of the entry portal were able to keep station beyond a few seconds, but most significantly, these were usually the only fish arriving at the entry portal that did make attempts at maintaining station. As a rule, fishes drawn to the entry portal some distance from the corner were carried almost passively downstream to a sudden encounter with the screening.

Fishes 12–16 in frame (b), plus two individuals already out of camera view, were swept downstream to the screen, in apparent random orientations, at about 85 cm/s, the speed of the flow itself. Their paths of motion coincided with the flux lines shown in Figure 15, indicating little voluntary motion on the part of any individual. The speed of transit in that region of the screen portal was so great, however, that net departures from the flow trajectories were difficult to detect. Fishes 8, 10 and 11, which exhibited vigorous tail beats, were able, momentarily, to stem the flow (which was about 95 cm/s at the locations of fishes

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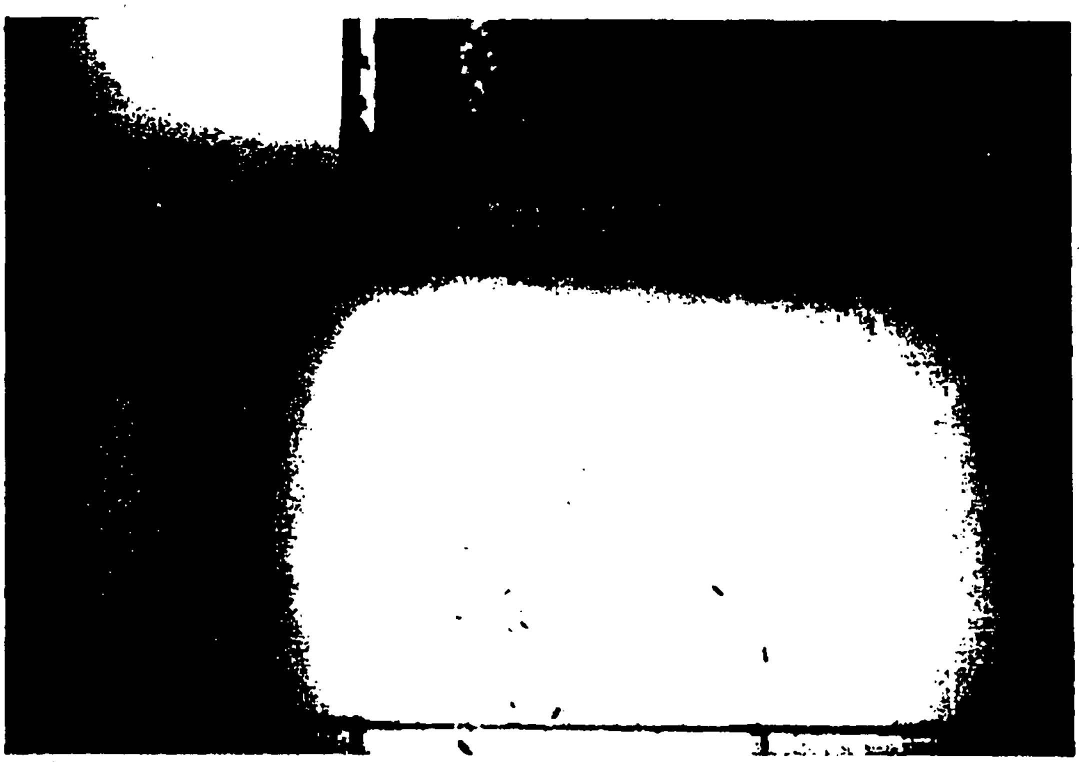
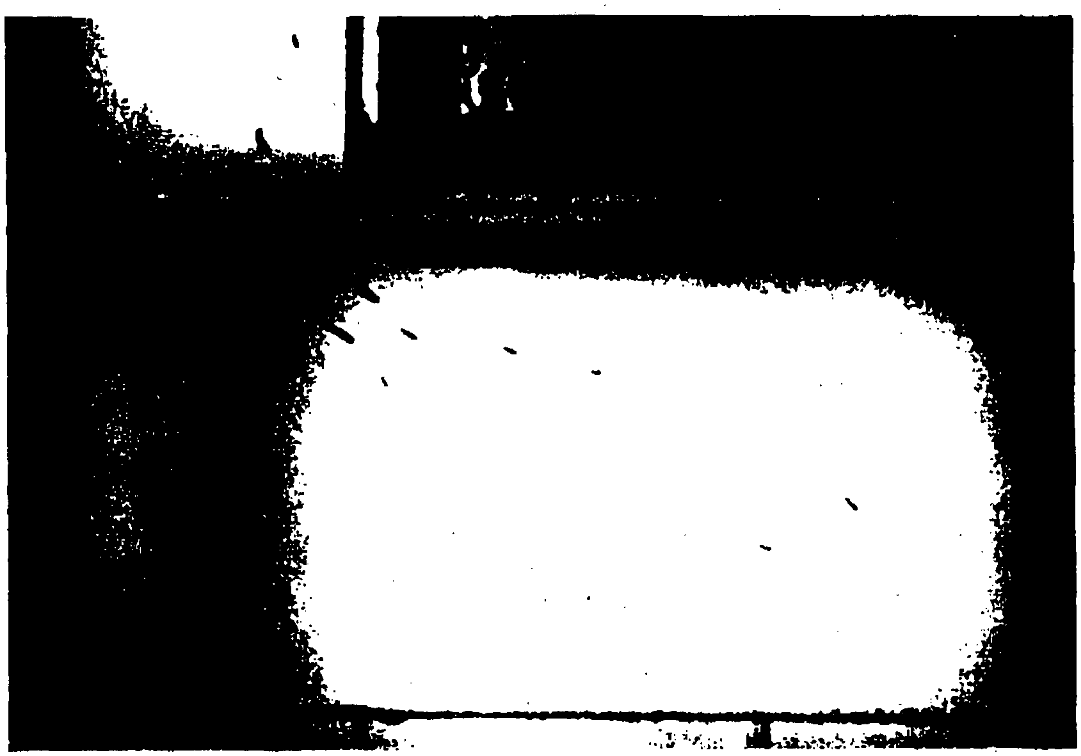


(a)

FIGURE 14.–Successive positions of large golden shiners drawn to the dual-flow apparatus at the 30 cm/s mean flow setting. The time interval was 2.25 s between frames (a) and (b), and 1.87 s between (b) and (c). Individual fish and their paths of motion are identified in Figure 15.

(c)



(b)

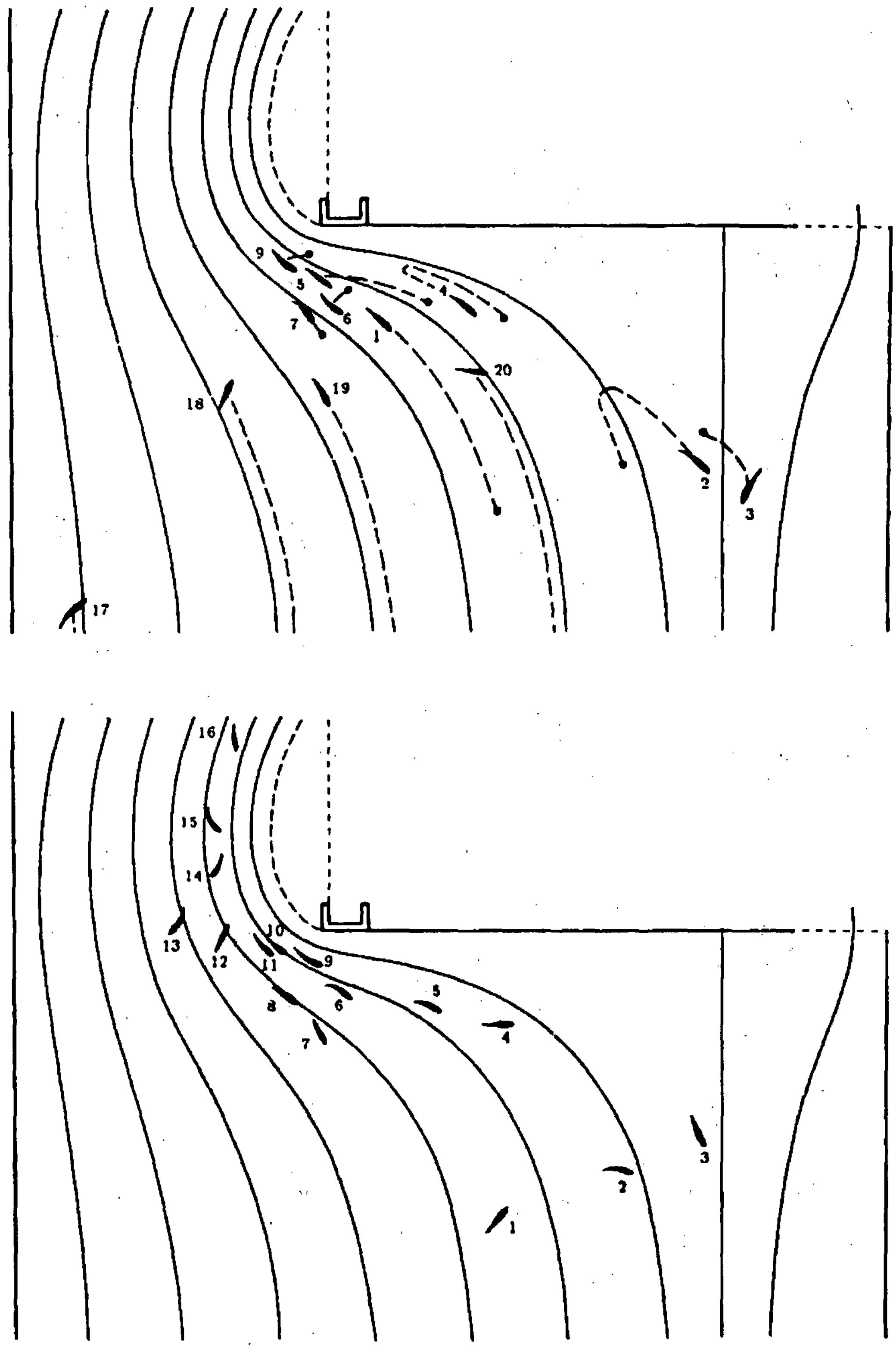


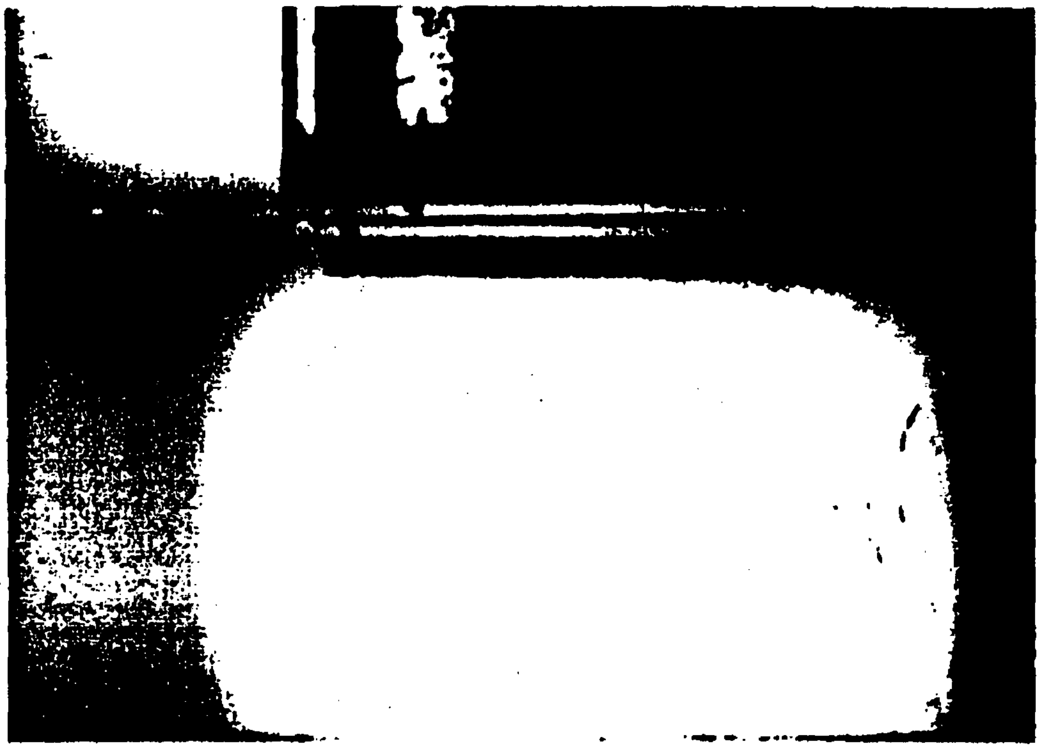
FIGURE 15.–Diagram of flux lines (30 cm/s setting) and identities of the fish appearing in photographs (b) and (c) of Figure 14. The flume outline and fish locations have been adjusted for camera parallax.

9–11), but they were suddenly swept from view, also at the approximate speed of the flow. Fishes 5, 6, 7, and 9 held out somewhat longer, but fish 4 was the only individual in the high speed region that made any significant progess away from the apparatus. The later arrivals 17, 18, and 19 of frame (c) were transported, swiftly and passively, through the entry portal at the speed of the flow, but fish 17 reappeared and swam close along the left sidewall of the flume a distance of a meter or so upstream, where it remained for some time. That behavior was occasionally repeated by individual fish when released to the far left of the flume center. Fish 20, on arriving at the entry corner, exhibited the orientation and vigorous swimming behavior typical of many fish (such as numbers 5–11 of the experiment) when transported through that high speed region.

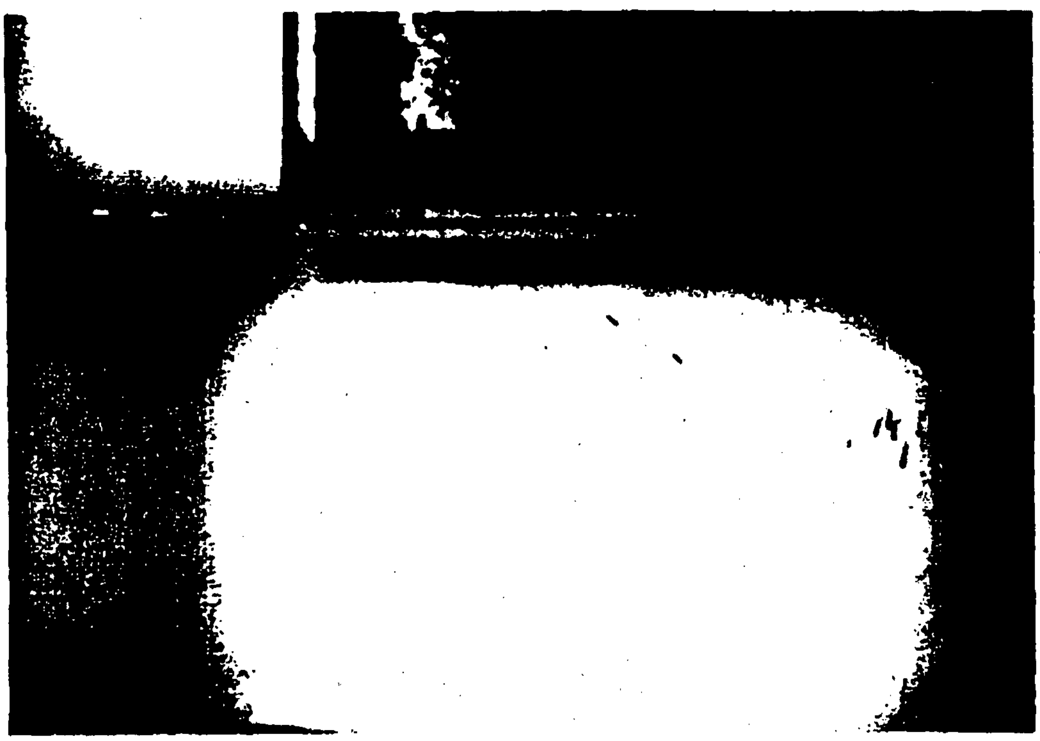
At ten seconds after the first appearance of the fish in frame (a), the only members of the released sample remaining in camera view were fish 17 at the flume sidewall, fishes 2 and 3, joined by one late arrival, in the region of the stagnation streamline, and fish 4, which had moved some distance to the right into the more slowly moving flow. Two fish of the 25 released were not observed on camera, but at the conclusion of the experiment we found them upstream, swimming along the sidewall of the flume, an occurrence less typical of the shiners than of the striped bass.

The behavior of fishes 2 and 3 in Figure 14 was observed several times in experiments with both the shiners and the striped bass. Some fish of a released sample, if they arrived at the dual-flow apparatus in the slower current to the right of the entry portal, would turn about and converge on the stagnation streamline. Schooling behavior was also strongest in that region, in contrast to the small evidence of schooling tendencies in the (observed) regions of swifter flows. The photographs of Figure 16 show small golden shiners schooling and converging on the stagnation streamline. In this experiment a sample of 25 shiners was released more to the right of the flume center than usual; 13 of the 25 were ultimately carried through the entry portal and impinged (flattened against the screening), but 5 were transported to the apparatus on the right side of the stagnation streamline (the five fish to the right in frame (a)), while 7 of those arriving to the left of the stagnation streamline reversed direction in the vicinity of the flume frontwall and joined the other five, as indicated by frame (b) of Figure 16. This behavior is especially worthy of note, because it demonstrates the tendencies of fish to respond to the peculiarities of the fluid flow itself, as opposed to responding directly to the stationary obstacles or surfaces (such as the flume sidewall) that actually induce the peculiarities into the flow.

Although juvenile striped bass also exhibited similar behavior in the region of the stagnation streamline, they were also more active as individuals than either size of golden shiners. In the swifter regions of flow they were generally transported to the screening somewhat less directly along the flux paths of the water transport than the shiners, individuals making darting motions, seemingly at random and independent of one another. More striped bass of a given release would find the upstream sidewalls of the flume (or, more explicitly, the slow-speed boundary layer at the flume wall) than those of a similar release of golden shiners. And being much the stronger swimmers, they were able to stem the flow



(b)



(a)

FIGURE 16.–Successive positions of small golden shiners converging on the stagnation streamline at the 30 cm/s mean flow setting. The time interval was 3.7 s between frames (a) and (b).

at the entry portal for longer periods, particularly at the 30 cm/s mean flow setting. At the 45 cm/s setting, however, few of the striped bass (and none of the golden shiners) were able to keep station at the corner of the entry portal, the fluid speed in that region being about 150 cm/s.

The liveliness (or excitability) of the striped bass juveniles is captured in the three (successive) photographs of Figure 17. In frame (a), 13 individuals of an upstream release of 20 have just arrived in the vicinity of the dual-flow apparatus at the 45 cm/s mean flow setting. Fluid speeds in the vicinity of the dual-flow apparatus were considerably greater in this experiment than the fluid speeds at the 30 cm/s setting of Figures 14 and 15, so events transpired more rapidly. Note the absence of schooling and the random orientations of individual fish in frames (a) and (b) of Figure 17. The time interval between frames (a) and (b) was only 1.12 s, but owing to the independent darting motions of individuals, the relative positions of fish changed considerably, although their net paths of motion towards the entry portal were still a consequence of the pattern and speed of the flow directly upstream of the dual-flow frontwall. In frame (b), at least five fish have responded to the fluid acceleration at the entry corner by aligning themselves headmost into the flow. Despite the furious swimming efforts of the individuals that did respond in that manner, all except two, during the 1.87 s interval between frames (b) and (c), were carried backwards (still swimming furiously) and flattened against the screening. The lone fish appearing in the lower right hand corner of each photograph is a large golden shiner, swimming in the vicinity of the stagnation streamline, that was left over from a previous experiment.

With virtually no exceptions, fish transported through the entry portal and impinged on the screenmesh struck the screening well aft of the corner separation—as did plant matter and the charcoal markers when released upstream at any location between the stagnation streamline and the left sidewall of the flume. A typical transport of fish through the entry portal and to the screening is shown in the photograph and accompanying diagram of Figure 18. All of the fish of the photograph were moved along the flux line paths to the downstream portion of the screen (to the far right in the photograph). Fish already impinged can be seen in that vicinity of the screening.

At both of the experimental flow settings, impingement was fatal to all tested fish. Owing to the streamline crowding of the main flow in passing through the entry portal and around the corner separation, fluid speeds at the screenmesh were greatly elevated over the 30- and 45-cm/s mean upstream velocities. At the 30-cm/s setting, the speed $|v|$ of the main flow across station 7 ranged from 50 to 100 cm/s (corresponding, say, to about the order of 80 cm/s at the screen). At the 45-cm/s setting, the speed of the main flow across station 7 ranged from 80 cm/s to 150 cm/s (corresponding to the order, say, of 120 cm/s at the screen). The pressure forces of these high-speed flows against impinged fish were great enough to impose death or mortal injuries to shiners and striped bass alike. Typical (external) damages exhibited by impinged fish are described on Table 2.

In view of the findings from previous laboratory and field experiments, these wholesale mortalities were unexpected. As reported in another work on

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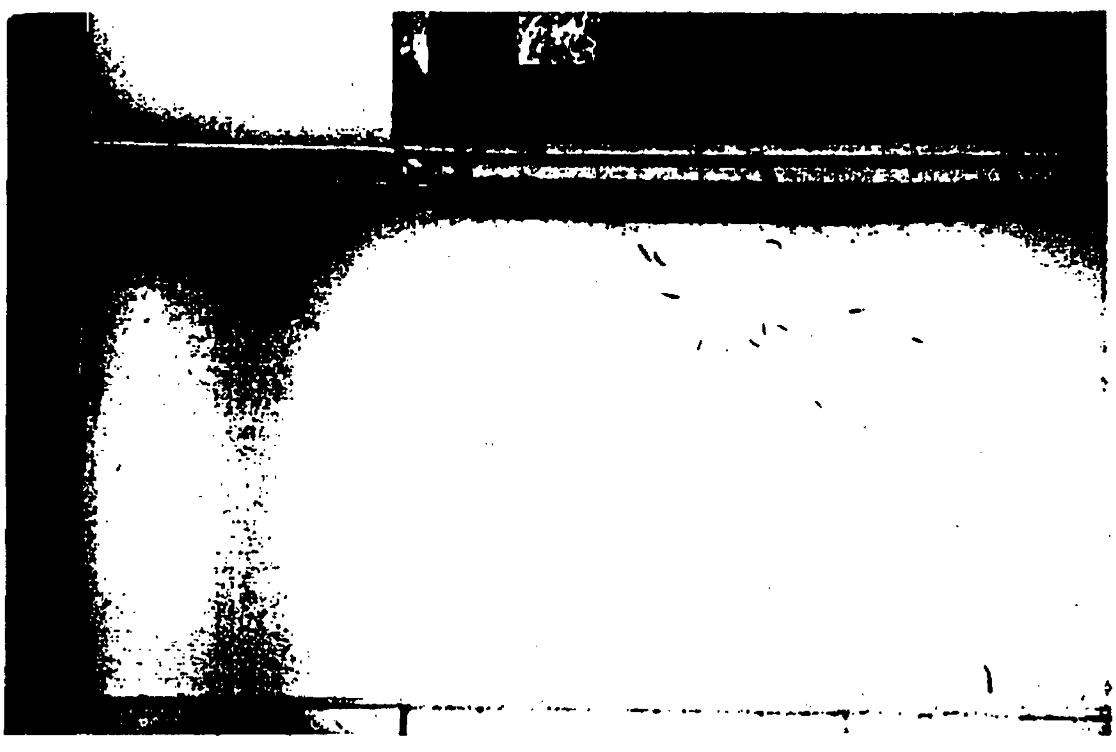
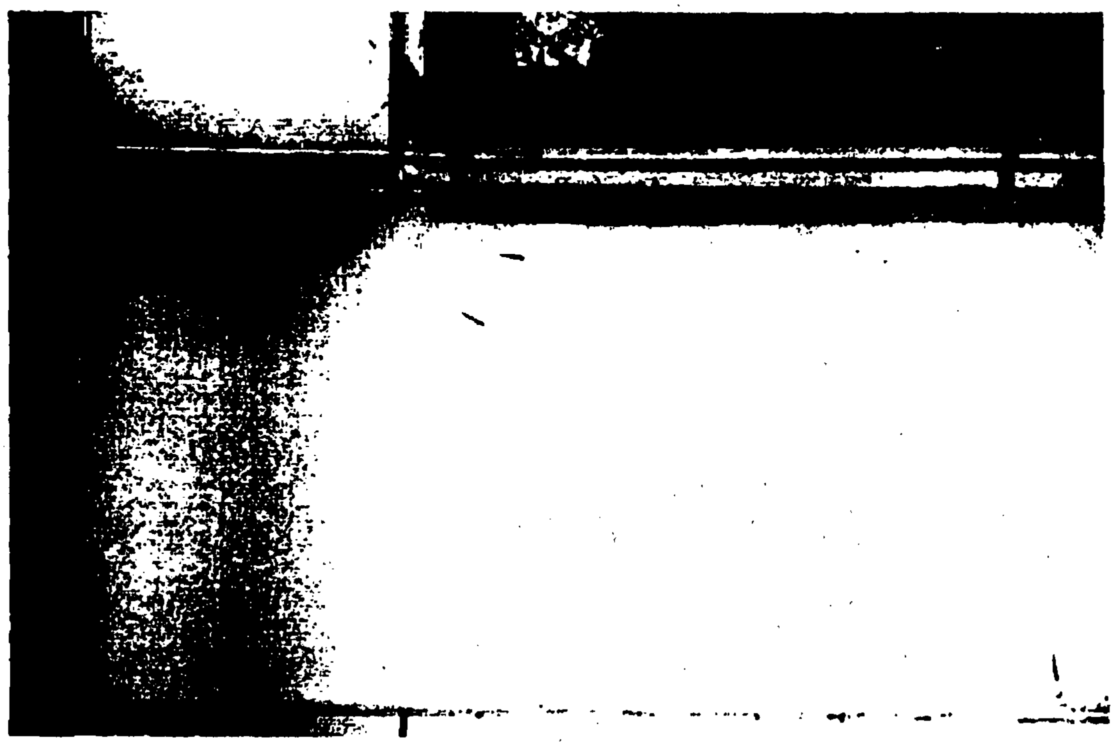
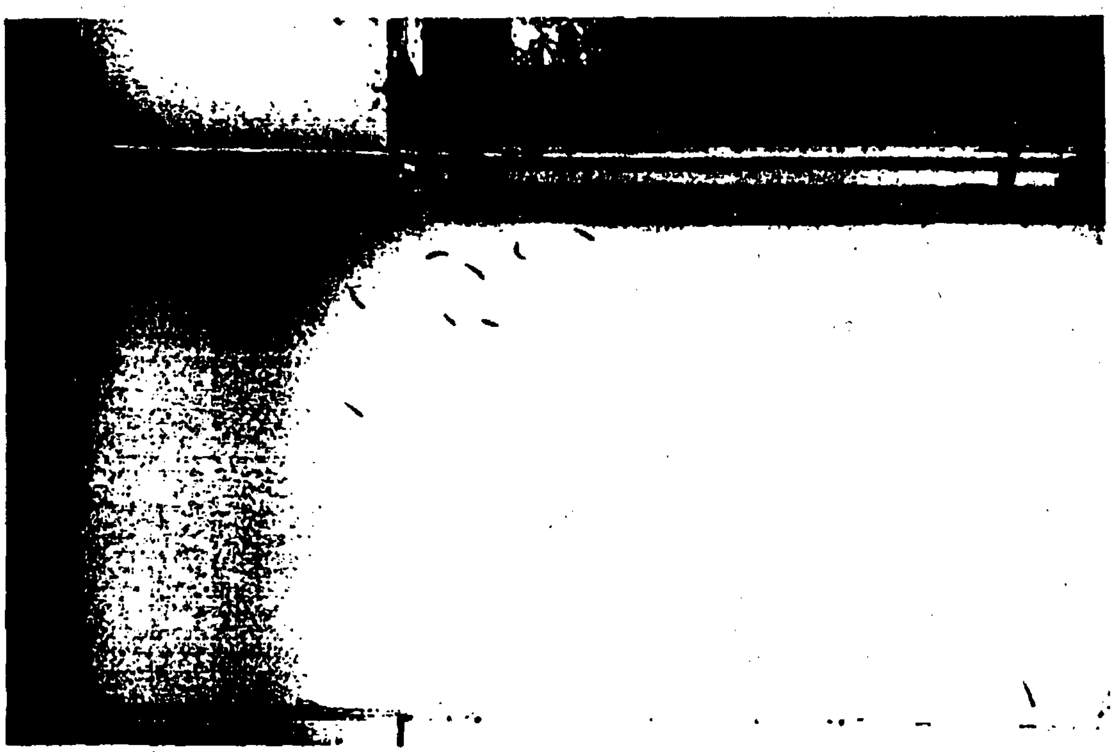


(a)

FIGURE 17.–Successive positions of juvenile stiped bass drawn to the dual-flow apparatus at the 45 cm/s mean flow setting. The time interval was 1.12 s between frames (a) and (b), and 1.87 s between (b) and (c).



(c)



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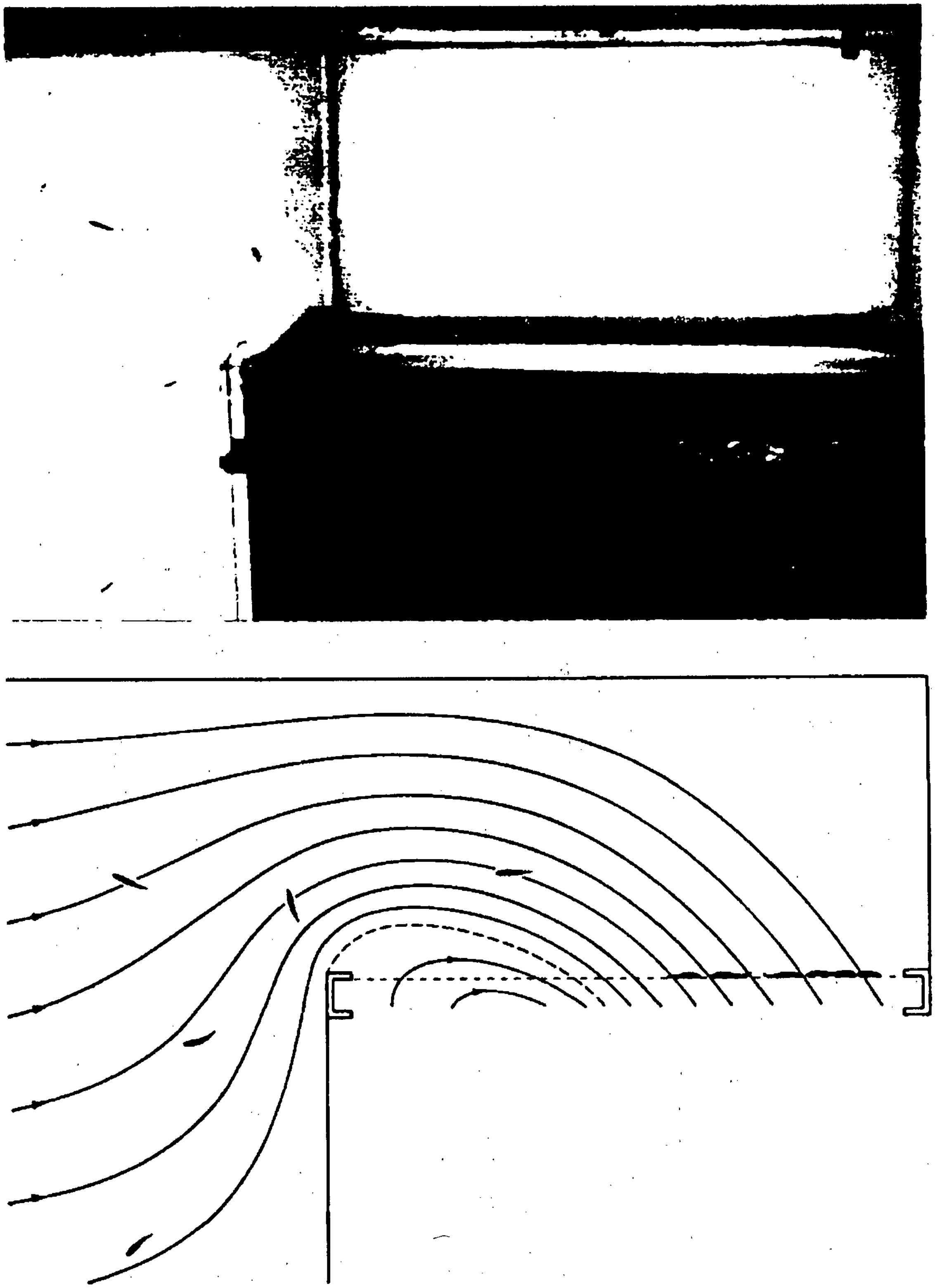

FIGURE 18.–Small golden shiners transported through the entry portal and impinged on the screenmesh at the 30 cm/s mean flow setting. The diagram shows the positions of the fish in the photograph and the corresponding flux lines of flow, adjusted for camera parallax.

TABLE 2.–Injuries typical of fish collected from the test screen at the conclusions of experiments. Durations of impingements ranged from 6 to 15 minutes. Standard length L in cm.

#	Std L	Damage
		Striped bass, 30 cm/s setting
1	6.3	10% descaled, operculum torn, body crushed.
2	5.2	Telson split, body crushed.
3	—	Operculum torn, telson avulsed.
4	6.7	15% descaled, body crushed.
5	6.6	Operculum torn, head and body crushed.
6	5.6	Telson split, body crushed.
7	5.6	10% descaled, eye avulsed, head crushed.
8	5.9	15% descaled, head and body crushed.
9	6.0	Operculum torn, body crushed.
10	5.4	10% descaled, operculum torn, head crushed.
		Small golden shiners, 45-cm/s setting
1	5.8	60% descaled, body crushed.
2	5.6	20% descaled, body crushed.
3	5.0	40% descaled, body crushed.
4	5.7	20% descaled, head and body crushed.
5	6.0	60% descaled, head 90% avulsed.
6	6.0	20% descaled, eye avulsed, body crushed.
7	5.6	40% descaled, head crushed.
8	5.1	50% descaled, operculum torn, body crushed.
9	5.5	40% descaled, body crushed.
10	5.4	40% descaled, operculum torn, body crushed.
		Large golden shiners, 45-cm/s setting
1	7.0	20% descaled, body crushed.
2	7.2	40% descaled, body crushed.
3	6.9	60% descaled, body crushed.
4	6.8	50% descaled, head 90% avulsed.
5	—	80% descaled, telson avulsed.
6	7.2	60% descaled, body crushed.
7	7.4	40% descaled, body crushed.
8	7.6	80% descaled, body crushed.
9	7.2	40% descaled, body crushed.
10	6.9	60% descaled, head 50% avulsed, body crushed.

screening systems (Fletcher 1990), injuries to impinged fish were not extensive at fluid speeds to 50 cm/s through a conventional cross-flume screen equipped with a smooth-surface screen mesh, and only slightly greater when fitted with the same standard mesh employed in the dual-flow experiments. Apparently then, in the range of fluid speeds between 50 and 80 cm/s at the screenmesh the risk of mortality to impinged fish increases sharply.

Also, the fluid speeds at the screenmesh of a working, linked-panel screen would actually be greater, for a given flow setting, than those of the experiments reported here. As opposed to the unobstructed screenmesh of the experimental apparatus, a travelling dual-flow screen of the kind most often employed in large water intake systems is composed of linked, rectangular screen panels whose horizontal framing members offer significant impedence to the approach-

Fluid sp. is most imp factor more. Maybe
J. F.'s Fluid sp. in Flume was much greater than at Dunkirk

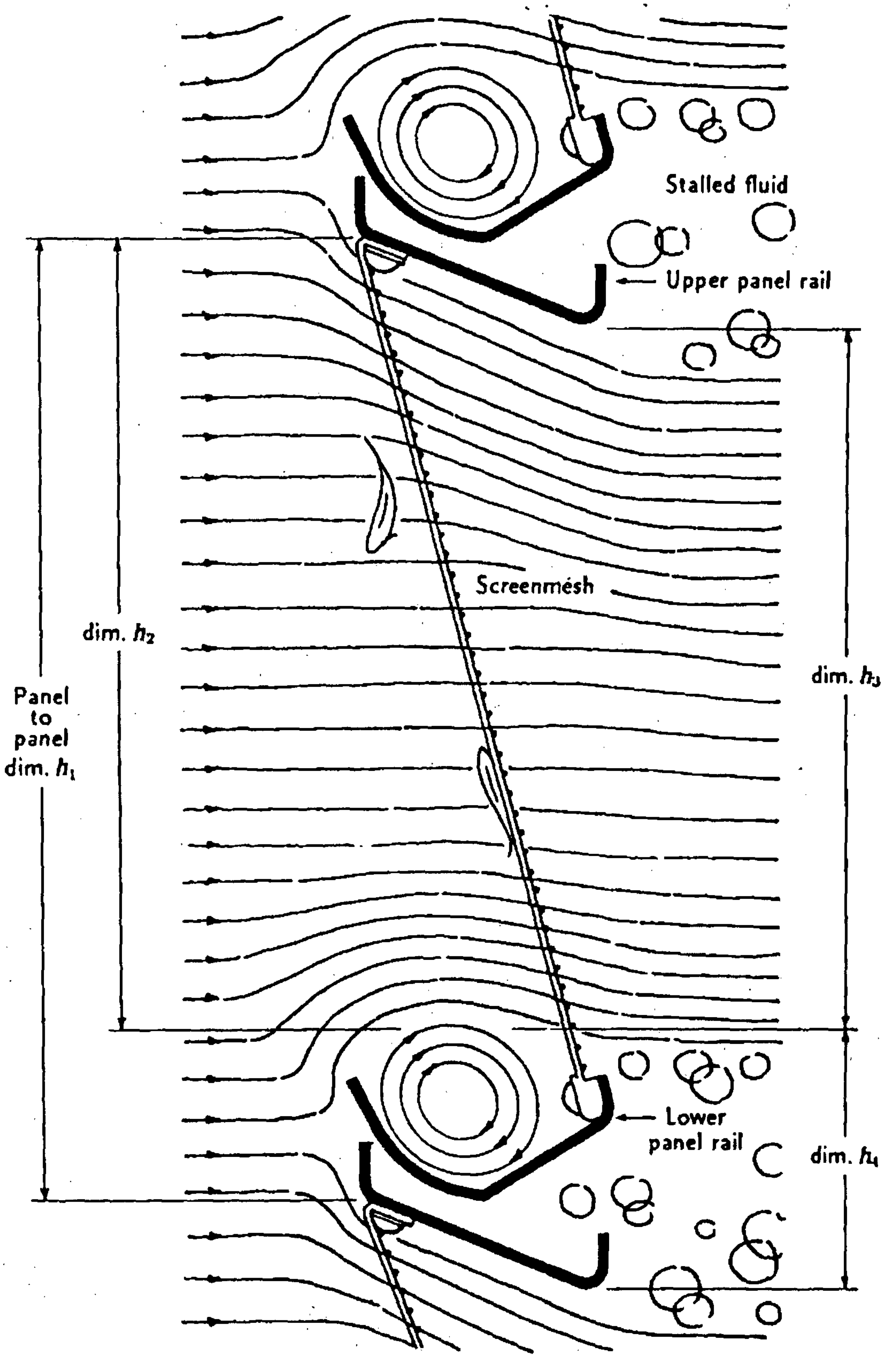

FIGURE 19.–Vertical section through typical panel of a travelling screen showing path-lines of flow. Dimension h_1 is panel-to-panel spacing; dimension h_2 is the sensible free-flow area at the screenmesh; dimension h_3 is the effective free-flow area through the panel structure; dimension h_4 is the projected (dynamic) frontal area of the screen railings.

ing flow. The influence of the cross-members, or rails, of one manufacturer's panel design is indicated in Figure 19. The flow pattern shown on the diagram was traced from the photographs of dyed pathlines recovered in (full-scale) experiments on screen panels by Fletcher (1990). The sensible flow at the screen-mesh of any such panel configuration is determined by the (vertical) breadths of the panel rails and by the influences on the main flow of such secondary blocking flows as the trough vortices shown in the figure.

The rail profiles and details of flow through the mesh of a screen panel differ somewhat from one manufacturer's design to another, but the ratio of the sensible free-flow area at the screenmesh (dimension h_2 of Figure 19) to panel spacing h_1 is typically 80% or less at a standard panel spacing of 61 cm (24 in). Therefore, since continuity, for a given volumetric flux Q, requires that $h_1V_1 = h_2V_2$ (V_1 being the mean speed of flow at the unobstructed screen and V_2 the mean speed of flow at the panel screening), then the 80-cm/s unobstructed screen speeds of the 30-cm/s mean flow experiments would increase to about 100 cm/s if standard height screen panels were employed, and the 120-cm/s order of magnitude speeds through the unobstructed screen would increase to about 150 cm/s in the case of the 45-cm/s mean flow setting.

The concave rails of the screen panels shown in Figure 19 are meant to capture and rescue impounded fish as the screen structure ascends through the water column. They represent one manufacturer's version of the so-called Ristroph concept often found on conventional cross-channel screens. In a series of flow studies on Ristroph screen panels (Fletcher *et al.* 1988, and Fletcher 1990), the longitudinal trough vortices depicted in Figure 19 were found to be typical of all manufacturer's Ristroph designs known at the time of the work. Fish caught in these shear-driven trough vortices were swirled about and severely battered; the associated injuries and mortalities were greater than those imparted to fish by simple impingements against the screen mesh (at moderate flow speeds).

When a Ristroph apparatus is employed in the manner of a conventional cross-channel screen (Figures 1 and 2(a)), captured fish are raised from the water on the upstream side of the (upward) moving screen, then dumped into a sluice for their return to the source waters as each panel overturns on its rotation over the uppermost sprocket of the machine. Ristroph screens are also employed, without modification, as dual flow screens, and offered by their makers as putative fish-conserving devices. Aside from the adverse flow conditions characteristic of Ristroph troughs, these adaptations are ill-suited to the workings of a dual-flow screen. Owing to its dual-entry configuration (Figure 2(b)), water and fish are drawn to both the ascending and descending sides of the moving screen. The fish troughs on the descending side are inverted and travel downwards, which negates their intended fish-catching function. Although the problem of the trough vortex has been resolved by at least one new design (Fletcher 1990), no known Ristroph device is really suited to the peculiar functionings of a dual-flow screen.

For mechanical purposes and the calculations of moments and pressure forces, dimension h_4 of Figure 19 represents the true projected frontal area of the illustrated panel railings, and the ratio of dimensions h_3 and h_4 determine the actual streamline compression of the flow passing through the screen panel. These effects are clearly visible in the dye-marking photographs reproduced in Fletcher (1990).

5. References

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Appendix A
Velocity measurements.

The velocity measurements tabulated here were read directly from the two-component analog gauges of a model 511M Marsh-McBirney electromagnetic current meter (see Figure 9 for the x-y coordinate orientation in the flume). Units of the tabulated component values are cm/s. Velocity magnitude $|\mathbf{v}|$ at a measurement point can be calculated from the corresponding x, y components as $(v_x^2 + v_y^2)^{1/2}$.

Flume calibrations. For the calibrations of the free-flow conditions at the 30- and 45-cm/s mean velocity settings, the cross-flume velocity distributions were set in patterns like that shown in Figure 6(c). The x and y components of fluid velocities were measured at the reference stations 1, 2, and 3 identified in Figure 6(a). A suite of instrument measurements at each station consisted of 70 pairs of component values taken on a vertical grid of 70 points arrayed in 7 rows spaced over the depth of the flume and 10 columns (numbered 0 to 9) across the breadth of the flume.

Dual-flow measurements. For the velocity distributions of the flows approaching and entering the dual-flow screen, the x and y velocity components were measured at stations 3 and 4 (70 grid points each), stations 5 and 6 (49 grid points each), and station 7 (77 grid points); see Figure 9 for station locations. At either of the (30- or 45-cm/s) mean flow settings, the volumetric flux of water through the flume with the dual-flow apparatus in place was equal to that of the corresponding free-flow calibration.

Flume calibration, 30 cm/s mean flow setting

STATION 1		Column									
Row	Comp.	0	1	2	3	4	5	6	7	8	9
1	v_x	-15	-20	-24	-27	-30	-38	-40	-42	-42	-38
	v_y	3	3	3	4	3	3	4	4	4	2
2	v_x	-14	-18	-22	-26	-32	-38	-42	-43	-39	-40
	v_y	4	3	4	4	4	4	4	4	4	4
3	v_x	-15	-16	-20	-23	-30	-36	-42	-44	-44	-40
	v_y	2	4	4	4	4	4	4	4	4	4
4	v_x	-14	-15	-20	-22	-30	-36	-42	-44	-40	-38
	v_y	2	3	4	4	4	4	4	4	4	2
5	v_x	-10	-12	-17	-22	-28	-34	-42	-44	-41	-38
	v_y	4	2	4	4	4	2	4	2	2	2
6	v_x	-10	-10	-14	-16	-24	-30	-38	-42	-40	-40
	v_y	2	2	4	2	2	2	4	4	2	2
7	v_x	-8	-12	-16	-16	-20	-26	-36	-38	-40	-40
	v_y	2	4	2	4	2	2	2	2	2	2
STATION 2		Column									
Row	Comp.	0	1	2	3	4	5	6	7	8	9
1	v_x	-13	-18	-24	-27	-31	-41	-44	-50	-42	-39
	v_y	2	2	3	3	3	4	4	4	4	3
2	v_x	-11	-16	-21	-26	-31	-38	-42	-46	-40	-40
	v_y	2	1	2	2	3	3	3	3	3	2
3	v_x	-12	-16	-21	-26	-32	-37	-42	-43	-40	-38
	v_y	2	2	2	3	3	4	4	3	3	3
4	v_x	-10	-16	-18	-26	-32	-37	-42	-44	-42	-40
	v_y	2	2	2	2	4	4	4	4	4	4
5	v_x	-10	-14	-20	-24	-30	-33	-42	-48	-40	-40
	v_y	2	2	2	0	3	2	3	3	3	3
6	v_x	-8	-12	-15	-19	-24	-30	-44	-46	-42	-40
	v_y	-2	2	0	0	2	2	4	0	4	4
7	v_x	-8	-10	-14	-16	-24	-30	-36	-38	-42	-40
	v_y	0	2	0	0	2	2	2	2	2	2
STATION 3		Column									
Row	Comp.	0	1	2	3	4	5	6	7	8	9
1	v_x	-12	-18	-24	-26	-32	-40	-44	-50	-48	-42
	v_y	2	0	2	2	2	2	2	2	0	2
2	v_x	-16	-19	-26	-29	-39	-42	-43	-48	-43	-43
	v_y	2	0	0	0	4	2	2	4	4	2
3	v_x	-12	-17	-20	-26	-36	-40	-44	-50	-48	-46
	v_y	0	0	0	0	2	4	4	2	4	6
4	v_x	-13	-19	-22	-27	-38	-40	-45	-48	-47	-42
	v_y	0	0	0	0	2	4	4	2	4	6
5	v_x	-11	-16	-22	-28	-34	-40	-44	-46	-46	-42
	v_y	0	0	0	0	0	4	2	0	0	4
6	v_x	-10	-16	-20	-26	-34	-38	-40	-47	-48	-40
	v_y	0	0	0	0	0	0	0	0	0	4
7	v_x	-11	-12	-20	-18	-34	-39	-42	-50	-41	-42
	v_y	0	2	0	0	2	2	2	2	2	2

Flume calibration, 45 cm/s mean flow setting

STATION 1		Column									
Row	Comp.	0	1	2	3	4	5	6	7	8	9
1	v_x	−18	−29	−35	−38	−46	−58	−61	−61	−59	−59
	v_y	6	6	6	6	6	6	6	8	8	4
2	v_x	−16	−26	−29	−38	−47	−56	−61	−62	−61	−59
	v_y	4	4	6	8	6	6	6	6	6	4
3	v_x	−16	−23	−27	−35	−44	−53	−64	−64	−60	−59
	v_y	2	4	4	6	4	4	4	4	4	4
4	v_x	−14	−21	−26	−29	−44	−53	−61	−65	−61	−59
	v_y	4	6	6	6	5	6	6	6	6	5
5	v_x	−11	−17	−24	−30	−41	−49	−60	−65	−61	−56
	v_y	6	4	6	6	6	4	6	4	4	4
6	v_x	−10	−15	−24	−24	−38	−45	−58	−60	−60	−59
	v_y	4	4	6	4	4	4	5	5	4	4
7	v_x	−8	−18	−21	−29	−36	−40	−52	−53	−54	−53
	v_y	4	6	4	6	4	4	4	4	4	2
STATION 2		Column									
Row	Comp.	0	1	2	3	4	5	6	7	8	9
1	v_x	−14	−20	−28	−31	−46	−50	−53	−60	−60	−58
	v_y	4	4	6	6	6	6	6	0	6	6
2	v_x	−14	−23	−29	−38	−44	−56	−65	−65	−59	−59
	v_y	4	2	4	4	0	6	6	6	6	6
3	v_x	−20	−23	−29	−35	−44	−53	−62	−63	−59	−56
	v_y	4	4	4	6	0	4	6	6	6	6
4	v_x	−14	−23	−26	−33	−44	−53	−64	−64	−59	−59
	v_y	4	0	4	4	4	6	6	6	6	5
5	v_x	−12	−20	−29	−34	−42	−47	−61	−59	−59	−59
	v_y	4	4	4	2	6	0	6	6	6	6
6	v_x	−11	−18	−21	−26	−36	−44	−61	−68	−62	−60
	v_y	−2	4	2	2	2	4	4	6	2	6
7	v_x	−11	−15	−21	−27	−32	−41	−55	−55	−60	−58
	v_y	2	4	2	2	4	4	0	0	4	4
STATION 3		Column									
Row	Comp.	0	1	2	3	4	5	6	7	8	9
1	v_x	−16	−22	−30	−38	−50	−59	−62	−69	−64	−57
	v_y	4	2	4	4	4	4	4	2	2	4
2	v_x	−12	−23	−28	−36	−46	−58	−64	−66	−64	−60
	v_y	4	2	2	2	6	4	4	6	6	4
3	v_x	−13	−20	−28	−33	−42	−53	−62	−64	−61	−57
	v_y	2	0	2	2	2	6	4	8	6	6
4	v_x	−12	−19	−25	−36	−46	−54	−61	−66	−64	−60
	v_y	2	0	2	2	−4	6	6	4	−6	8
5	v_x	−12	−21	−24	−34	−48	−57	−63	−67	−67	−62
	v_y	2	2	0	−2	−2	2	−2	0	2	2
6	v_x	−12	−18	−23	−33	−46	−56	−62	−69	−67	−64
	v_y	2	2	0	−2	−2	2	−2	0	2	6
7	v_x	−12	−14	−24	−34	−44	−55	−62	−71	−65	−63
	v_y	2	−2	−2	−4	2	−2	−4	−4	−2	4

Dual-flow apparatus, 30 cm/s mean flow setting

STATION 3		Column									
Row	Comp.	0	1	2	3	4	5	6	7	8	9
1	v_x	-33	-35	-38	-42	-30	-14	-8	-4	-14	-33
	v_y	-1	-19	-22	-25	-36	-32	-9	-2	6	2
2	v_x	-34	-35	-40	-42	-30	-16	-7	-3	-14	-36
	v_y	-2	-17	-23	-25	-37	-34	-9	-2	7	2
3	v_x	-33	-37	-41	-43	-32	-15	-6	-4	-11	-36
	v_y	-4	-18	-23	-27	-37	-33	-8	-3	9	0
4	v_x	-33	-37	-40	-42	-32	-15	-7	-4	-12	-36
	v_y	-1	-18	-23	-27	-38	-33	-8	-3	9	2
5	v_x	-32	-36	-40	-43	-32	-15	-6	-5	-12	-35
	v_y	-1	-16	-22	-27	-38	-33	-9	-3	9	2
6	v_x	-33	-37	-42	-44	-34	-14	-7	-4	-12	-37
	v_y	-2	-16	-20	-26	-38	-34	-8	-4	9	2
7	v_x	-33	-35	-40	-42	-36	-12	-5	-3	-11	-32
	v_y	0	-19	-21	-23	-39	-30	-10	-3	8	2

STATION 4		Column						
Row	Comp.	0	1	2	3	4	5	6
1	v_x	-48	-54	-60	-63	-68	-74	*
	v_y	-5	-9	-13	-20	-29	-38	*
2	v_x	-50	-54	-60	-66	-69	-78	-80
	v_y	-3	-6	-11	-18	-27	-35	-46
3	v_x	-53	-55	-60	-67	-71	-78	-84
	v_y	-2	-5	-11	-17	-24	-33	-46
4	v_x	-54	-56	-61	-65	-73	-80	-84
	v_y	-1	-4	-10	-15	-23	-33	-45
5	v_x	-54	-55	-59	-66	-73	-79	-84
	v_y	0	-4	-9	-16	-23	-32	-46
6	v_x	-54	-57	-60	-66	-73	-80	-85
	v_y	-1	-5	-10	-16	-22	-30	-44
7	v_x	-56	-58	-61	-67	-74	-78	-83
	v_y	-3	-8	-13	-18	-23	-30	-44

STATION 5		Column						
Row	Comp.	0	1	2	3	4	5	6
1	v_x	-30	-39	-43	-50	-54	-58	-60
	v_y	7	12	16	23	30	42	57
2	v_x	-33	-38	-42	-51	-55	-59	-63
	v_y	8	13	18	23	32	42	58
3	v_x	-34	-39	-42	-50	-55	-60	-63
	v_y	7	13	18	26	32	42	58
4	v_x	-33	-38	-42	-50	-54	-58	-62
	v_y	8	13	19	26	33	41	58
5	v_x	-32	-38	-41	-49	-55	-58	-62
	v_y	8	14	19	25	33	42	58
6	v_x	-33	-40	-42	-48	-54	-56	-62
	v_y	8	12	20	26	32	41	58
7	v_x	-37	-41	-44	-51	-55	-57	-61
	v_y	7	12	17	23	31	39	56

Dual-flow apparatus, 30 cm/s mean flow setting

STATION 6		Column						
Row	Comp.	0	1	2	3	4	5	6
1	v_x	14	0	−14	4	−5	−8	−6
	v_y	−2	−7	10	−4	−12	40	42
2	v_x	14	−1	−18	8	−5	−6	−6
	v_y	−2	−8	12	−5	14	26	45
3	v_x	18	3	−18	8	−3	−4	−10
	v_y	0	−12	12	−6	15	24	48
4	v_x	20	3	−12	6	−2	−6	−14
	v_y	2	−12	15	−6	13	24	46
5	v_x	19	2	−20	2	−2	−3	−14
	v_y	0	−10	14	−8	10	25	44
6	v_x	15	0	−20	10	−8	−7	−11
	v_y	−2	−8	14	−12	16	20	44
7	v_x	12	0	−23	15	−10	−10	−20
	v_y	−2	−6	8	−22	16	18	37

STATION 7		Column										
Row	Comp.	0	1	2	3	4	5	6	7	8	9	10
1	v_x	−12	−20	−28	−35	−50	−63	−77	*	*	−105	−74
	v_y	16	32	44	56	58	51	22	*	*	−29	−55
2	v_x	−4	−21	−30	−39	−55	−73	−86	−92	−32	−106	−73
	v_y	19	37	48	58	61	57	46	30	−4	−28	−55
3	v_x	−4	−24	−30	−36	−53	−74	−88	−93	−30	−106	−72
	v_y	18	39	48	58	60	59	47	28	−2	−28	−55
4	v_x	−3	−22	−29	−38	−54	−74	−89	−90	−28	−105	−74
	v_y	19	39	50	60	62	61	48	26	0	−28	−55
5	v_x	−6	−20	−30	−38	−52	−72	−91	−94	−27	−105	−74
	v_y	20	39	48	58	60	60	50	23	−2	−27	−56
6	v_x	−5	−23	−30	−37	−52	−70	−92	−92	−25	−106	−73
	v_y	21	37	46	58	60	57	46	25	−3	−28	−57
7	v_x	−8	−25	−33	−38	−50	−71	−90	−93	−30	−105	−74
	v_y	18	35	42	55	52	55	44	25	−4	−26	−59

*Water surface depressed below reference point (see Figure 8).

Dual-flow apparatus, 45 cm/s mean flow setting

STATION 3		Column									
Row	Comp.	0	1	2	3	4	5	6	7	8	9
1	v_x	-55	-57	-55	-41	-25	-14	-11	-9	-25	-46
	v_y	-9	-27	-39	-53	-48	-34	-23	0	14	4
2	v_x	-57	-60	-60	-46	-25	-14	-9	-9	-25	-57
	v_y	-9	-27	-44	-57	-48	-39	-14	-1	18	9
3	v_x	-59	-62	-67	-46	-23	-16	-7	-7	-18	-55
	v_y	-6	-25	-41	-59	-53	-37	-14	-1	23	11
4	v_x	-57	-62	-64	-52	-27	-14	-11	-9	-21	-55
	v_y	-4	-20	-39	-57	-53	-37	-11	-1	18	11
5	v_x	-55	-61	-69	-57	-30	-18	-7	-9	-23	-55
	v_y	-7	-21	-34	-53	-55	-34	-11	-2	18	9
6	v_x	-55	-62	-69	-53	-30	-14	-7	-9	-23	-53
	v_y	-2	-21	-37	-53	-50	-39	-16	-1	16	9
7	v_x	-55	-59	-64	-46	-18	-9	-4	-4	-18	-46
	v_y	-2	-27	-46	-64	-57	-34	-14	0	18	7

STATION 4		Column						
Row	Comp.	0	1	2	3	4	5	6
1	v_x	-66	-74	-86	-93	-97	*	*
	v_y	-9	-18	-27	-41	-52	*	*
2	v_x	-66	-76	-90	-97	-104	-115	-115
	v_y	-5	-9	-20	-32	-46	-63	-80
3	v_x	-80	-83	-91	-97	-105	-115	-126
	v_y	-2	-10	-20	-32	-45	-63	-80
4	v_x	-80	-83	-88	-97	-109	-120	-126
	v_y	-2	-7	-17	-23	-34	-57	-80
5	v_x	-80	-83	-88	-97	-109	-125	-126
	v_y	0	-6	-11	-23	-34	-52	-75
6	v_x	-80	-86	-92	-102	-110	-120	-126
	v_y	-2	-7	-11	-20	-34	-52	-69
7	v_x	-86	-87	-92	-97	-109	-116	-126
	v_y	-6	-16	-22	-30	-35	-50	-70

STATION 5		Column						
Row	Comp.	0	1	2	3	4	5	6
1	v_x	-45	-60	-69	-75	-80	-86	-87
	v_y	9	18	28	34	48	74	92
2	v_x	-57	-63	-67	-80	-89	-92	-97
	v_y	11	18	25	37	53	74	92
3	v_x	-46	-66	-76	-85	-89	-93	-97
	v_y	14	21	27	39	52	69	92
4	v_x	-50	-57	-66	-74	-80	-86	-92
	v_y	9	18	32	41	57	74	92
5	v_x	-55	-62	-65	-73	-77	-80	-86
	v_y	11	23	32	42	60	75	92
6	v_x	-55	-63	-69	-71	-74	-77	-81
	v_y	9	21	34	44	55	69	86
7	v_x	-66	-69	-73	-77	-79	-81	-82
	v_y	9	14	19	29	46	57	64

Dual-flow apparatus, 45 cm/s mean flow setting

STATION 6		Column						
Row	Comp.	0	1	2	3	4	5	6
1	v_x	21	-23	25	-11	-23	-14	-4
	v_y	-21	-14	-7	7	21	30	50
2	v_x	18	17	0	-23	-23	-18	-12
	v_y	-18	-14	-11	11	23	34	55
3	v_x	21	21	0	-21	-18	-14	-12
	v_y	-14	-23	-11	11	23	39	69
4	v_x	34	14	-5	-14	-5	-5	-23
	v_y	-11	-21	-21	11	18	34	66
5	v_x	34	14	-7	-14	-5	-5	-21
	v_y	-11	-11	-11	2	7	37	62
6	v_x	21	-34	-39	-30	-23	-23	-11
	v_y	-7	-11	-2	7	23	37	60
7	v_x	-5	-41	-23	-41	-44	-34	-34
	v_y	-5	-7	-11	7	25	30	41

STATION 7		Column										
Row	Comp.	0	1	2	3	4	5	6	7	8	9	10
1	v_x	-23	-39	-52	-66	-81	-86	*	*	*	-103	-86
	v_y	24	37	55	69	86	29	*	*	*	-57	-81
2	v_x	-7	-43	-59	-80	-102	-132	-120	-100	-98	-149	-101
	v_y	30	57	71	78	86	80	62	0	-11	-71	-86
3	v_x	-2	-37	-60	-79	-101	-126	-133	-103	-86	-149	-106
	v_y	23	64	74	78	82	80	53	17	-8	-73	-85
4	v_x	-6	-30	-55	-80	-103	-125	-135	-76	-75	-149	-107
	v_y	32	66	80	91	94	83	57	15	-11	-70	-87
5	v_x	-2	-38	-56	-80	-94	-117	-124	-89	-86	-147	-110
	v_y	39	69	78	83	88	80	62	14	-11	-69	-86
6	v_x	-12	-40	-57	-79	-92	-110	-120	-86	-80	-149	-110
	v_y	39	59	69	80	76	69	62	14	-11	-67	-89
7	v_x	-35	-57	-74	-80	-92	-106	-110	-84	-97	-147	-110
	v_y	23	39	46	60	69	62	55	14	-14	-64	-93

*Water surface depressed below reference point (see Figure 8).

Appendix B
Method for estimating instantaneous rates

Because the general governing equations (1) and (8) of the text are autonomous (the independent variable does not appear), their coefficients, and hence the coefficients of their solution graphs, can often be resolved from phase-plane fittings of the governing equations themselves. Equation (1) has a parabolic trajectory in the z, z' plane (as shown in Figure 13), while equation (2) has a straight line trajectory. For such a procedure, however, values of z' must first be determined from the (t, z) data set. The following method was employed for estimating z' values from the (t, z) measures associated with equations (3), (4), and (5).

Given a set $\{\ldots,(t,z),\ldots\}$ of discrete points measured at regular intervals Δt, we assume that a continuous function $F(t)$ exists such that $z = F(t)$ for all such points. Let $\{(t_1, z_1),\ldots,(t_5, z_5)\}$ be a set of any five sequential points of $F(t)$ and presume that we wish to estimate

$$\frac{dF(t_3)}{dt} \tag{i}$$

when $t_{i+1} - t_i$ ($\equiv \Delta t$) is constant for $i = 1,\ldots,4$. Three arcs of a degree 2 polynomial are now fitted to the data, three points at a time; (i) is estimated from each of the arcs and the three estimates averaged. Write the polynomial as

$$z = \alpha t^2 + \beta t + \zeta \tag{ii}$$

(a standard position parabola), whose derivative is

$$\frac{dz}{dt} = 2\alpha t + \beta. \tag{iii}$$

Without loss of generality, let $t_3 = 0$ so that

$$\begin{aligned} t_1 &= -2\Delta t,\\ t_2 &= -\Delta t,\\ t_3 &= 0,\\ t_4 &= \Delta t,\\ t_5 &= 2\Delta t. \end{aligned}$$

For the first three points $\{(t_1, z_1),(t_2, z_2),(t_3, z_3)\}$, the corresponding values of z from equation (ii) are

$$\begin{aligned} z_1 &= 4\alpha(\Delta t)^2 - 2\beta\Delta t + \zeta,\\ z_2 &= \alpha(\Delta t)^2 - \beta\Delta t + \zeta,\\ z_3 &= \zeta. \end{aligned} \tag{iv}$$

From equation (iii) it is clear that we need only find coefficient β, since, in general, we want to determine (i) where $t_3 = 0$. Therefore, by solving equation set (iv) simultaneously for β, we can write

$$\beta = \frac{z_1 - 4z_2 + 3z_3}{2\Delta t} = \frac{dF_1(t_3)}{dt}. \tag{v}$$

Similarly, for the second set of points $\{(t_2, z_2), (t_3, z_3), (t_4, z_4)\}$, we have

$$z_2 = \alpha(\Delta t)^2 - \beta\Delta t + \zeta,$$
$$z_3 = \zeta,$$
$$z_4 = \alpha(\Delta t)^2 + \beta(\Delta t) + \zeta,$$

by which the second value of coefficient β becomes

$$\beta = \frac{z_4 - z_2}{2\Delta t} = \frac{dF_2(t_3)}{dt}. \tag{vi}$$

For the final set of points $\{(t_3, z_3), (t_4, z_4), (t_5, z_5)\}$,

$$z_3 = \zeta,$$
$$z_4 = \alpha(\Delta t)^2 + \beta\Delta t + \zeta,$$
$$z_5 = 4\alpha(\Delta t)^2 + 2\beta\Delta t + \zeta,$$

and the third value of β becomes

$$\beta = \frac{4z_4 - z_5 - 3z_3}{2\Delta t} = \frac{dF_3(t_3)}{dt}. \tag{vii}$$

The desired quantity (i), which is the estimate of z' at $z(t_3)$, is recovered by averaging β over equations (v), (vi), and (vii), or

$$\frac{d\widehat{F}(t_3)}{dt} = \frac{z_1 - 5z_2 + 5z_4 - z_5}{6\Delta t}. \tag{viii}$$

The foregoing calculations are incorporated into the Fortran program that follows. The program will yield $n - 4$ sequential estimates of z' for n-many points.

```
1          DIMENSION T(100),Z(100),DF(100)
2        1 READ(5,55)N,DT
3       55 FORMAT(I3,F10.0)
4          DO 3 I=1,N
5        3 READ(5,33)T(I),Z(I)
6       33 FORMAT(2F10.0)
7          WRITE(6,44)
8       44 FORMAT(' I  T(I)  Z(I)  DF(I)'/)
9          NN=N-2
10         DO 7 I=3,NN
11         Q=Z(I-2)-5.*Z(I-1)+5.*Z(I+1)-Z(I+2)
12         DF(I)=Q/6./DT
13       7 WRITE(6,66)I,T(I),Z(I),DF(I)
14      66 FORMAT(I3,3F12.5)
15         GO TO 1
16         END
```

N : number of data points.
T : independent variable t (distance x or y).
Z : dependent variable z ($-\mathbf{v}\cdot\hat{\mathbf{n}}$ or $|\mathbf{v}|$).
DT : constant distance interval Δt between data points.
DF : the estimate of $dF(t_3)/dt$.
Lines 11 and 12: equation (viii).

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Flow Dynamics and Fish Recovery Experiments: Water Intake Systems[1,2]

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Abstract.—Large water-use facilities are often equipped with vertically travelling debris barriers known as Ristroph screens. Although made in a variety of configurations, all such screens are equipped with some manner of fish-catching troughs or rails, and all operate on the principle of direct contact and active removal of impounded fish and debris. The imposed fish mortalities associated with these machines are commonly attributed to the consequences of impingements (to fish being flattened against the screening by the force of the inflowing water), but the laboratory and field experiments reported here imply that in those circumstances where the screens travel continuously and where water speeds are moderate, the major underwater injuries are attributable instead to buffeting of captured fish within the fish troughs proper. Dye studies of the flows peculiar to various manufacturer's trough designs showed the water within a trough confines to be shear-driven by the main flow, which produced a longitudinal vortex of such strength that captive fish were swirled about and thrust repeatedly against the screen structure. Captured fish often escaped an ascending trough just before its leading edge broke the water surface, and their repeated encounters with the fish recovery apparatus increased the risk of mortality. From flow analyses of reshaped trough and screen profiles, a flow spoiler was devised that eliminates the trough vortex and buffeting of captive fish. The escape of fish at the water surface was eliminated by means of an auxiliary screen affixed to the leading edge of each fish trough. Field experiments revealed other sources of mortality, chief of which was the entanglement of fish in captured debris. As a countermeasure, the order of removing fish and debris was reversed. A reconfigured machine, including the redesigned fish-catching apparatus, was installed and tested at a nuclear generating station on the Hudson River estuary. In tests similar to those on the unimproved machine, injuries and deaths were reduced from 53 to 9% for striped bass *Morone saxatilis*, from 64 to 14% for white perch *Morone americana*, from 80 to 17% for Atlantic tomcod *Microgadus tomcod*, and from 47 to 7% for pumpkinseed *Lepomis gibbosus*. Striped bass losses to the debris removal system were reduced from 23% of recoveries to zero, white perch losses from 33% to 1.3%, and Atlantic tomcod losses from 20% to 0.3%. Release–recovery experiments with juvenile striped bass and white perch revealed probabilities of capture characteristic of weak and strong swimmers.

Facilities that draw water in large volumes from natural sources are commonly equipped with some form of barrier screens for removing unwanted debris from the indrawn water. Quantities of local organisms are also carried into the screenwells by the inflows and killed. Such small organisms as

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[2] Research supported by Hudson River Fishermen's Association, Consolidated Edison Company of New York, New York State Power Authority, and Envirex, Inc.

fish eggs, fish larvae, early juveniles, and invertebrates that pass through the meshes of the barrier screening are said to be entrained; fishes flattened against the screening by the force of the flow—generally those larger than 45 to 50 mm in length—are said to be impinged.

The mortalities imposed on fish stocks by entrainments and impingements are often very great. The annual cooling water demand of the Salem nuclear generating plant in New Jersey accounts for an estimated 11% direct reduction in the year-classes of weakfish *Cynoscion regalis* of the Delaware River estuary and a 31% direct reduction in those of the bay anchovy *Anchoa mitchilli* (Versar 1986). In the Hudson River estuary during summer periods of high electric power demands, the water diversions of the several generating plants often exceed the freshwater input to the river. Impingement croppings alone reduce the annual year-class abundances of Hudson River white perch *Morone americana* by 20% or more (Van Winkle et al. 1980), and the year-class losses of striped bass *Morone saxatilis* to entrainments and impingements are 10 to 15% (Barnthouse and Van Winkle 1988; Boreman and Goodyear 1988). The long-term consequences of these annual reductions remain unknown, largely because of the unresolved debates over "compensation" in fish stocks (the hypothesis that reduced mortality among the young ensues from reductions in their abundances) and the difficulties of separating long-term productivity reductions from natural variations in recruitments. In many cases, nonetheless, the effects of continued water withdrawals are believed to pose serious threats to the perpetuation of indigenous species, especially where such facilities as municipal pumping stations, electricity generating plants, pulp mills, pumped storage intakes, and inlets to pumped irrigation canals are located on spawning and nursery grounds.

In the Hudson estuary, some mitigation of entrainment loss has been realized through reductions in withdrawals of power plant cooling water during spring and summer, when the early life stages of most fish species are abundant. This net, seasonal reduction in water usage was one of the settlement provisions of the 1977–1980 adjudicatory proceedings of the U.S. Environmental Protection Agency known as the Hudson River power plant case (Sandler and Schoenbrod 1981; Limburg et al. 1985; Englert et al. 1988).

Reducing impingement losses (which are greatest during winter) has been a more difficult problem, because few of the intake systems of the Hudson River plants had been designed with fish conservation in mind. The settlement agreement called for replacing the debris screens in the twelve intake bays of the Indian Point nuclear stations (the sources of greatest impingement kills) with angled screens and pumped fish bypasses, and for considerable alterations to the civil works of the plants. Owing, however, to a subsequent analysis that showed the proposed angled screen designs to offer little promise of bringing about significant reductions in impingement kills, the settlement parties ultimately rejected angled screens in favor of "alternative mitigation measures," as allowed by the settlement agreement. The operators of the Indian Point plants (Consolidated Edison and the Power Authority of New York State) then elected to install and test a candidate device, known generically as a Ristroph screen, in one intake bay of Indian Point nuclear unit 2 (the Consolidated Edison plant).

Although virtually every manufacturer of screening devices for water intake systems has its own version of the Ristroph screen, the operating principles and intended functions of each are similar. As originally manufactured by the Royce Equipment Company of Houston, Texas, the trial machine was configured essentially around a standard, continuously travelling, through-flow screen where linked, rectangular screen panels are moved vertically around large sprockets in the manner of an endless chain, the whole being normal to the inflowing water and spanning the width of the intake bay. When the panels of such a screen are fitted with small troughs or concave rails for drawing entrapped fish from the water, the device is commonly regarded as a Ristroph screen, without distinction. The fish-catching rails of the Royce trial machine were semicircular in profile, and the surface of each screen panel was inclined to the flow, a geometry peculiar to the Royce design that proved to be somewhat helpful in reducing injuries to fish once they were impinged (thrust against the screen mesh). In general, as a screen assembly so configured travels around its driving sprockets, the linked screen panels and their attached fish troughs ascend from the water on the upstream side of the machine. As a screen panel rotates over the uppermost sprocket, the fish trough spills out its captive water and fish. The released fish are then meant to fall or slide along the incline of the overturning panel and into a sluice for their return to the source waters. As the screen panels continue their descent past the fish sluice, debris and fish remaining on the panels are forcibly blown into a debris sluice by a row of high pressure water jets.

The testing bay at Indian Point, like each of the twelve intake bays, is 3.4 m wide, the water depth is about 8 m, depending on the tide, and the overall screenwall depth is 12.8 m from the machinery deck to the floor of the intake bay. These dimensions are fairly typical of power plant intake sumps where steam condensers are cooled by water drawn from natural sources. The trial machine (called screen version 1 here) was operated in a normal fashion in the testing bay over a 3-month period from 16 January to 19 April 1985, during which time opportunistic collections of recovered river fish were made by Normandeau Associates, contractors to Consolidated Edison. The collected samples were examined for deaths and injuries, held for 96 h, examined again, then tallied, measured, and identified. As revealed by this field test (Consolidated Edison 1985), the trial machine imposed high mortalities on several collected species, not unlike the magnitudes of mortality observed at other power plants employing similar screening devices. Owing to its unexceptional performance, the trial machine was judged by certain of the settlement parties (EPA, the Hudson River Fishermen's Association, the Natural Resources Defense Council, and the Department of Environmental Conservation of New York State) to be no more acceptable as the device of choice than the rejected angled screen system.

Failings of Screen Version 1

At the request of the Hudson River Fishermen's Association, I examined the trial screen and its operations with a view to recommending alterations in the design of the machine that might reduce the kills of recovered fish to more acceptable levels. Some of the conditions adverse to fish survival, especially in the functionings of the apparatus above the water surface, were fairly obvious. Those shortcomings and their remedies are reviewed only briefly here. The topics of greater immediate interest are those previously unexamined transactions between fish and flows beneath the water surface and the postulated events governing fish captures and kills that proved erroneous.

Above-Water Fixes

In addition to such easily cured failings as captive fish being stuck fast to the overturning panel troughs, fish otherwise released from the troughs often become entangled in a matrix of screen debris instead of falling into the fish return sluice as intended. Fish so immobilized on the screen panels were carried past the fish sluice into the path of the high-pressure debris jets and killed. Fish lost in this manner accounted for large proportions of the observed mortalities.

The trial machine had been fitted with a directed, low-pressure spray that was meant to aid in freeing fish from the surfaces of the overturning screen panels by spraying water through the screen mesh from a location between the ascending and descending halves of the machine. When the screen was not fouled with debris, the fish spray functioned as intended, but during winter and spring months the Hudson is burdened with a tough, filamentous macrophyte that thoroughly clogs the screening. In being drawn into the plant intakes and stapled into the meshes of the barrier screening by the force of the inflow, the algae form a tangled blanket of matter over the screen panels not easily penetrated by the fish sprays. The problem of debris and fish separation was resolved by reversing the sequence of removal (debris first, fish last). The related alterations to the trial machine (see items E, F, H, J, K, L of Figure 1) were essentially five in number.

(1) The primary high-pressure debris header was repositioned (to location J) so that its jets blow through the ascending screen panels.

(2) The primary debris sluice (K) was relocated to the ascending side of the machine.

(3) Spray deflectors were added to the fish rails for preventing disturbance to captured fish as the ascending rails pass through the relocated debris jets.

(4) An articulated shield (L) was added for protecting the ascending fish rails against the debris that otherwise falls into the rails as the screen panels pass through the relocated high-pressure debris spray.

(5) Inside and outside low-pressure fish sprays (E, F) were added and the fish sluice (H) was widened.

In both full-scale flume experiments and site testing, the relocated high-pressure jets removed embedded debris from the screening as intended; fish carried by the fish rails passed undisturbed through the debris spray, and the mistransport of fish to the rear debris sluice was virtually eliminated.

Although the problems of fish and debris separation were remedied by the modifications listed

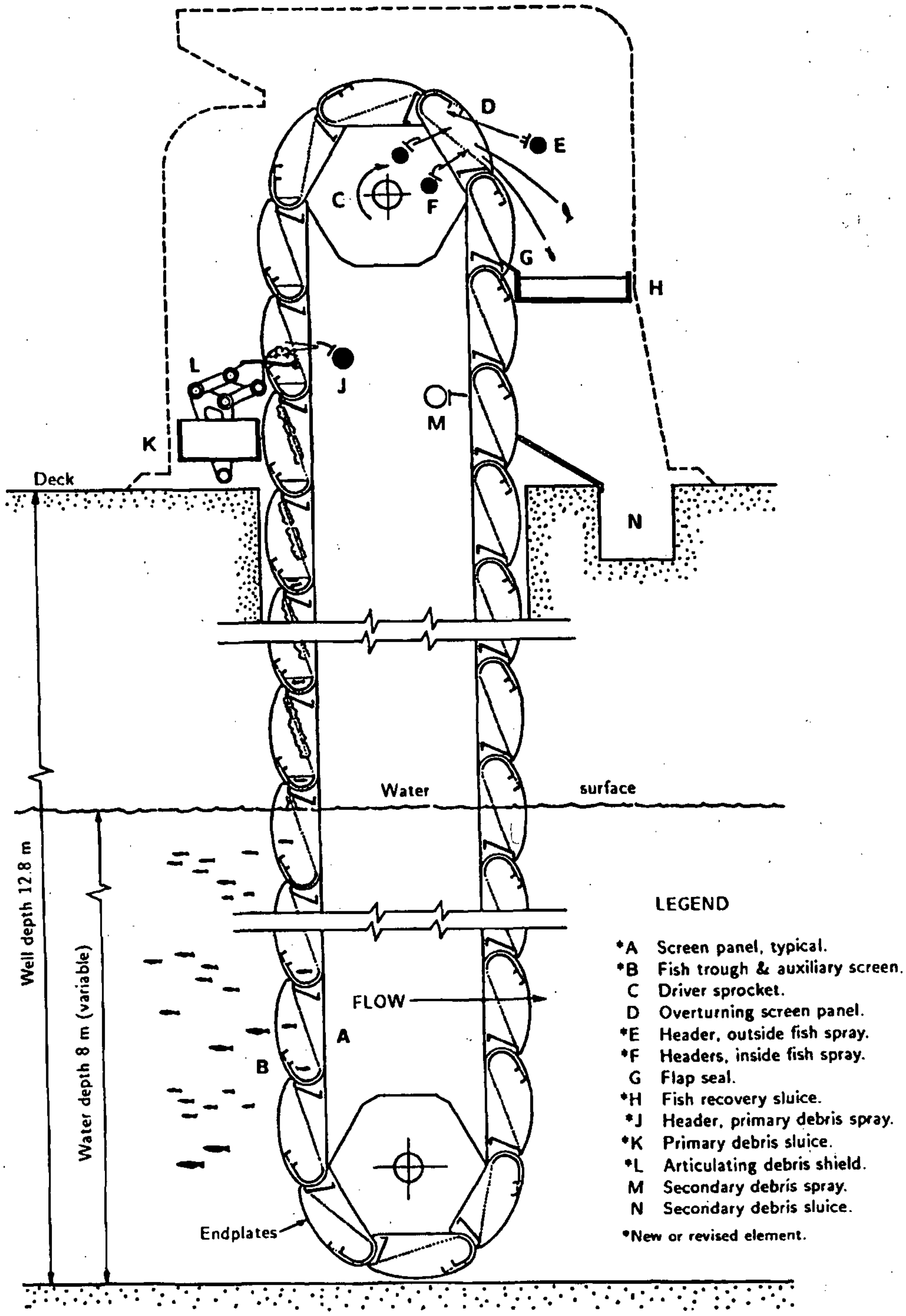


FIGURE 1.—Vertical section of a prototype Ristroph machine showing the modifications incorporated into the reconfigured version. The screening apparatus proper, whose principal function is the protection of an intake sump from water-borne debris, consists of linked, rectangular screen panels that are moved vertically around motor-driven sprockets. Debris and fish captured from the water by a screen panel (A) and its attached fish rail or trough (B) are carried from the water for disposal. As a panel (D) rotates over the uppermost sprocket (C), the fish rail spills out its captive water and fish; released fish fall or slide along the incline of the overturning panel into a fish

above, those remedies were limited to the observable functionings of the screening system above the water surface. Whether the fish rails actively captured entrapped fish or merely lifted impinged fish from the water, and the extent to which the design of the screen and fish-rail system itself might be contributing to death and injury of captured fish, were questions still unresolved.

Fish and Flow Experiments in a Hydrodynamics Flume

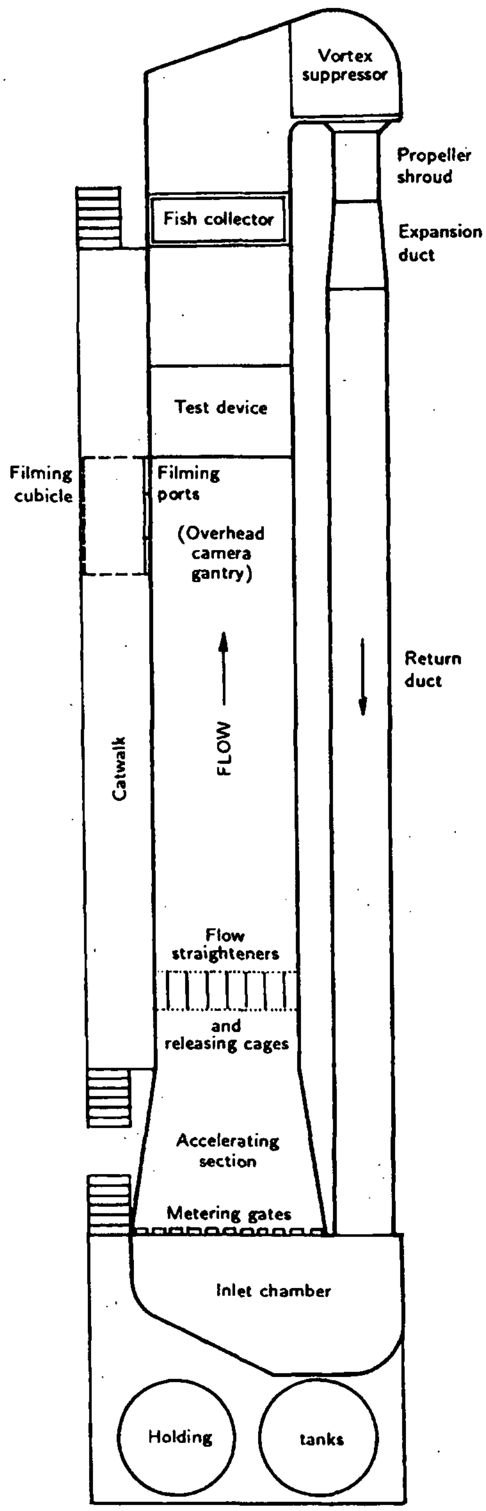
Although I searched 30 years' worth of industry and refereed literature, I found no evidence that the flow patterns and fish behavior associated with any of the various Ristroph fish-trough and screen designs had ever been observed. Aside from unsupported suppositions about the mechanics of impingement and fish capture, reported testings of Ristroph machines are limited by custom to black-box field experiments, so to speak, in which only the output signals (the opportunistic appearances of fish and their condition on recovery) are measured. Except for a rare marking experiment, input signals (the rates of fish entrapment and screen encounter) and signal processing (the physical and probabilistic processes governing capture and injury) are not examined.

By good fortune, the manufacturer of the Indian Point trial machine, on receiving notice of the machine's rejection and a copy of the field report to the fishermen, constructed a duplicate of the machine in that company's instrumented hydrodynamics flume in Houston, all of which was made available to me for experimental work, along with the services of a fabricating shop and the assistance of two skilled technicians, Trent T. Gathright and Richard Ewbank. The flume was equipped with underwater filming ports, a color video camera and monitor, 35-mm cameras, and a low-light charge-coupled device (for filming in near darkness). The flume and its equipment are more fully described by Figure 2. In addition to the conveniences for developing and testing the above-water improvements already described, the full-scale structure of the flume-installed machine enabled us to study, directly and under laboratory conditions, the nature of subsurface flows and the realistic behavior of fish in contact with the screening and recovery apparatus.

We commenced our underwater experiments by releasing fish upstream in the flume and filming their behavior as they were carried downstream to the operating machine. Most of the fish employed in these early experiments were juvenile golden shiners *Notemigonus crysoleucas*, a tender species we found useful in detecting sources of injury and descaling. (In later experiments we also employed striped bass and white perch from the Hudson.) We released two sizes of Golden shiners (of 6.5- and 11-cm fork lengths) in batches of 20 to 50, and repeated experiments at two flow speeds (30 and 45 cm/s, speeds representative of large water intake systems). At both water speeds fish behavior was similar, although the smaller fish were less able to stem the flow at either speed. We discovered that actively swimming fish (those able to maintain station ahead of the screen face) were not readily caught by the (upward moving) fish troughs. Virtually all of the test fish that did enter the fish troughs had been forced down the inclined surfaces of the panel screening (an action induced by the oblique attack of the flow) after being impinged (flattened) against the screen mesh. Once in the vicinity of a fish trough, they were caught in a secondary flow, interior to the trough, that swirled them about in rapid orbital motions, as depicted by Figure 3. Fish captured in this fashion were injured less by their motions along the screen mesh (which, in the trial machine, had a smooth-woven surface) than by the battering they received in the fish troughs. We also discovered that captured fish often escaped an ascending fish trough just before the leading edge of the trough broke the surface, as indicated on Figure 3. Apparently, the fish were able to sense their nearness to the

←

sluice (H) and thence to a conduit for their return to the source waters. In the standard version, debris and fish that remained on the screen panels were blown from the screening into a rear debris sluice (N) by a row of high-pressure water jets (M). In the revised version, debris is removed from the screening by a high-pressure spraywash (J) that blows through the ascending side of the screen. The spray is interrupted by deflectors on the spray sides of the fish rails, which prevent disturbance to the water and fish contained in the rails. Released debris, which would otherwise fall into the fish rails and displace the captured fish, is deflected by a five-pin articulating shield (L) into a relocated debris sluice (K). The standard high-pressure header (M) and debris sluice (N) are retained as secondary devices. New and relocated low-pressure sprays (E and F) aid in the release of fish from the overturning screen panels and fish rails. A redesigned fish rail and an added auxiliary screen (B) lessen the injuries imposed on fish during the capture process.



SPECIFICATIONS

Flume type: open channel, recirculating.

Construction: steel, Carboline epoxy coating.

Dimensions: length 15.3 m; channel depth 152 cm; channel width 214 cm.

Fluid: 60,500 L fresh water, continuous filtration.

Fluid driver: shrouded propeller, 61 cm dia., hydraulically driven and controlled.

Prime mover: 112,000 W electric motor connected to pumps of hydraulic system.

Hydraulic system: dual pumps, 378 L/min at 138 bar; 1135 L reservoir and auxiliary coolers.

Flow distribution: 98 metering gates from inlet chamber.

Flow geometry: laminar in test section at flow speeds to 60 cm/s.

Flow monitoring: electromagnetic velocity meter with x-y analog readout; attached to digital converter. Three-dimensional velocity display on monitor and plotter.

Recording apparatus: color video camera; low light ccd camera; 35mm cameras. White and infrared lighting; underwater filming ports.

FIGURE 2.—Diagram of the Royce hydrodynamics flume.

water surface; some reacted to it by darting out from the trough confines into deeper water.

The smooth-woven screen mesh employed by the maker of the trial machine differs from the more standard crimped or welded wire mesh customarily employed in water screens. In the interests of completeness, therefore, we fitted panels of our test machine with standard 0.95-cm (⅜-in) crimped mesh and found that golden shiners impinged on that material suffered considerable descaling in comparison to the near absence of descaling with the smooth-surface mesh.

We also held the screen stationary in the flow and allowed impinged fish to remain flattened against the screen panels (panels equipped with the woven mesh) for increasing periods of time. Fish that died after prolonged immobilization (30 min or longer) apparently suffocated, owing to impairment of opercular movement, but impingement periods of 10 min imposed no apparent trauma on any species of tested fish. Post-event mortalities were no greater over 48-h holding periods than those of control fish (which were generally less than 1%).

In the field testing of the original trial machine (of screen version 1) by Consolidated Edison, collected fish exhibited such injuries as contusions, descalings, anal hemorrhaging, and lacerations. Some of the fish dead on collection bore no visible injuries, and some fish, otherwise without integument damage, appeared to be stunned and exhibited erratic swimming behavior. Such injuries, like those observed in field testings of fish screens at other locations, were presumed to have been the consequences of impingements—of violent, flow-induced encounters with the screening material proper. Our flume observations contradict that assumption.

For the original field testing of screen version 1, the screen panels had been fitted with the smooth-woven mesh, and the screen was rotated continuously (as it was designed to do). At its (vertical) operating speed of 3 m/min, the maximum period of fish impingement could not have exceeded 3 min. Fish that escaped the ascending troughs at (or below) the water surface experienced repeated impingements or captures, of course, thus increasing their injury risks, but in view of the results of the flume experiments, the most probable injury risk to a fish eventually recovered would not have been impingement as such, but rather the battering it was likely to have received after its capture (or repeated capture) by a

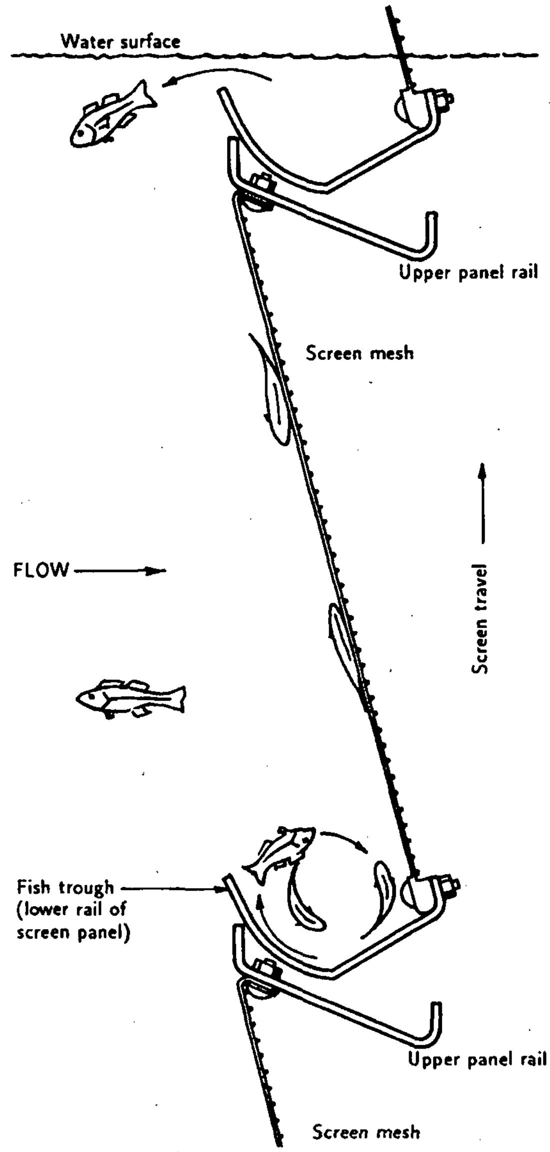


FIGURE 3.—Vertical section through screen panel of the trial machine (screen version 1) indicating the effects of the flow on captured fish. Overall height of each panel is 60 cm. Width of fish trough is 15 cm; depth is 7 cm. Most of the test fish that entered a fish trough had worked their way down the screen mesh after encountering the screen, a net movement induced by the oblique forcing angle between the flow and screen surface. Once in a trough, fish were caught in a secondary flow that swirled them about in rapid orbital motions. Captured fish often escaped just before the leading edge of the trough broke the water surface.

Ristroph trough, the very device meant to rescue the fish from the consequences of impingement.

For more detailed study of flows and fish behavior, we constructed cross-sectional replicates of various manufacturer's trough and panel designs, each with its end nearest the camera capped off with a clear acrylic plate, which allowed direct viewing into the interior of the troughs. Figure 4 shows two such configurations suspended in the flume and the effects of the trough vortices on captured fish. In these experiments, injuries imposed on fish, irrespective of trough shape, were like those observed in Consolidated Edison's field tests.

Flow Mapping

As the means for establishing flow profiles of trough and panel configurations, we injected dye (potassium permanganate) into the main flow at 1-cm vertical intervals, just upstream of the subject, and photographed each dyed pathline (40 to 50 per profile). Two such pathlines of flow are shown by Figure 5. From the photographs we constructed composite pathlines and established the complete flow profiles of various trough and panel designs. Figure 6 shows a typical trough vortex where dye has been injected directly into the trough. The dyed region immediately downstream of the panel rails in Figure 6 reveals a zone of stalled fluid. At the two experimental (mean upstream) flow speeds of 30 and 45 cm/s, the flow geometries of a particular trough and panel section were similar except for the angular velocity of the trough vortex, which increased with increased flow speed. The two water speeds selected for the flume experiments are consistent with those reported for power industry testings of screening systems. At the Indian Point station where the field work was done, the mean upstream water speed in the testing bay varied with the tidal cycle but rarely exceeded 30 cm/s.

Figure 7 depicts the composite pathlines of flow recovered from the dye studies on the trough and panel design of the Royce trial machine (screen version 1). Although panel sections were held stationary in the flow for the dye studies, the vertical speed of a travelling screen is nearly an order of magnitude less than the upstream water speed (and considerably less than the speeds of the accelerated flows around the panel railings and through the screen mesh) and therefore imposes no significant distortion on the flow geometry as depicted.

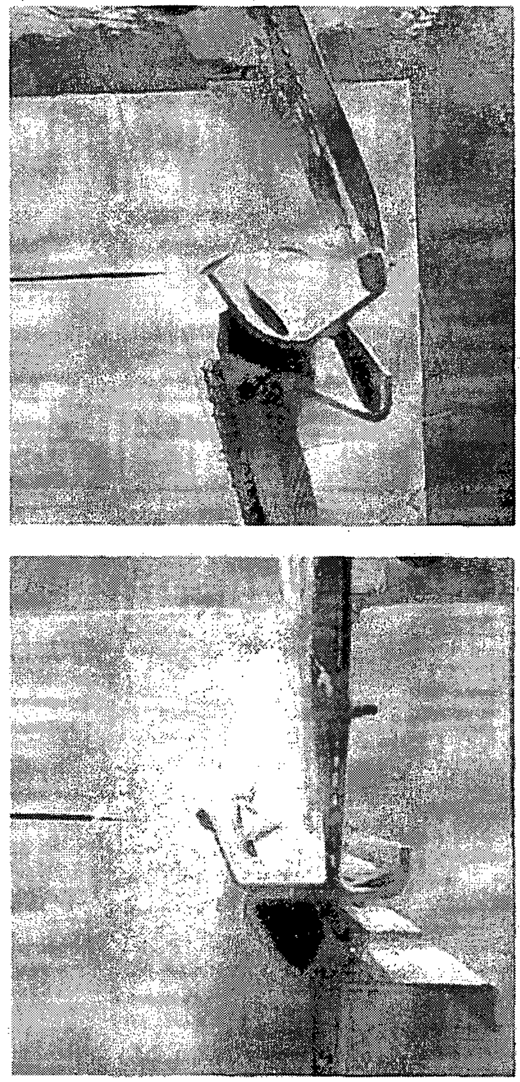
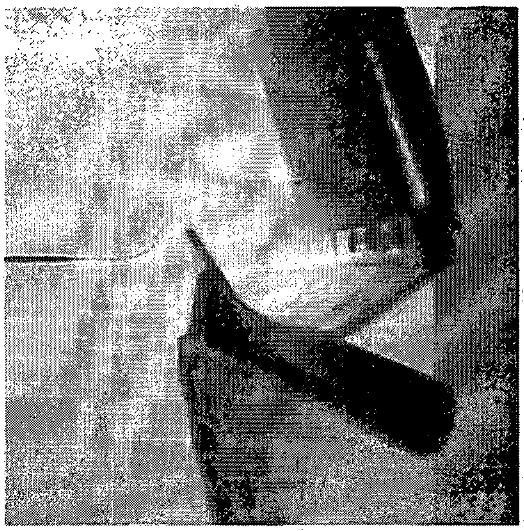


FIGURE 4.—Arrangement in flume of typical cross-sectional testing panels showing action of shear-driven trough vortices on captured golden shiners. The trough and panel design of the trial machine is shown above; a more standard Ristroph design is shown below. The main flow was moving from left to right in both views; fish were swirled in a clockwise direction. The upstream flow speed in both photos was 30 cm/s. Note the several fish impinged on the screen mesh in the upper photograph.

Redesigning the Fish Troughs

In addition to wanting a fish-catching trough that reduced the probability of injury to captured fish, we had to accommodate several other constraints in our experiments with alternate designs.



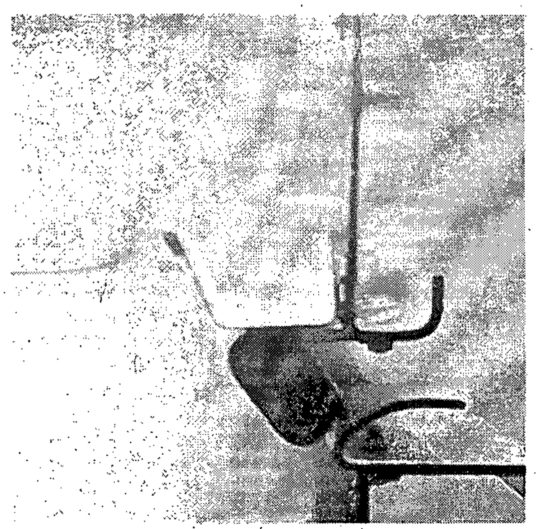


FIGURE 5.—Typical dye marking of flow pathlines, trough and panel section of the trial machine (above) and a standard Ristroph design (below). Complete profiles of flow pathlines consisted of similar dye releases at vertical intervals of 1 cm.

FIGURE 6.—Dye injected directly into fish trough reveals the standing vortex. Speed of the approaching flow was 30 cm/s. The dyed area behind the panel railings reveals a region of stalled fluid; areas above and below have been swept clear of dye by the main flow.

An acceptable trough had to retain water as well as fish during its ascent from the surface of the source water to its overturn at the upper sprocket of the machine. Although panel troughs (or baskets) constructed of wire mesh or having perforated bottoms are furnished by some manufacturers, such designs work against fish survival. Fish tend to flop about in a trough empty of water, thereby increasing their risks of mechanical injury, and during winter in boreal locales like the Hudson, exposing a small fish to the atmosphere, even for a few minutes, can bring on rapid cooling and drying and the risk of flash freezing. The geometry of any new trough design also had to accommodate the linking of screen panels and their articulation in passing around the driving sprockets of the machine. Most importantly, of course, the troughs had to catch fish, whether impinged or swimming in the vicinity of a moving trough.

Mindful of the foregoing constraints, we devised several trough shapes around two fluid dynamical precepts. Because we wanted the water interior to the trough to be free of motion with respect to the trough boundaries, or nearly so, we either had to devise a compound trough shape that would bring about a flow stall immediately upstream of its entry, or add some feature to the trough that might create a turbulent boundary region between the shearing action of the main flow and the fluid interior to the trough. I elected to try the flow-stalling alternative by way of finite-element modelling of shapes and flows on the computer. Of the various trial geometries analyzed in that manner, the most promising was a G-shaped affair where the stagnation streamline was precisely centered on the trough entry. In flow trials, however, that pre-

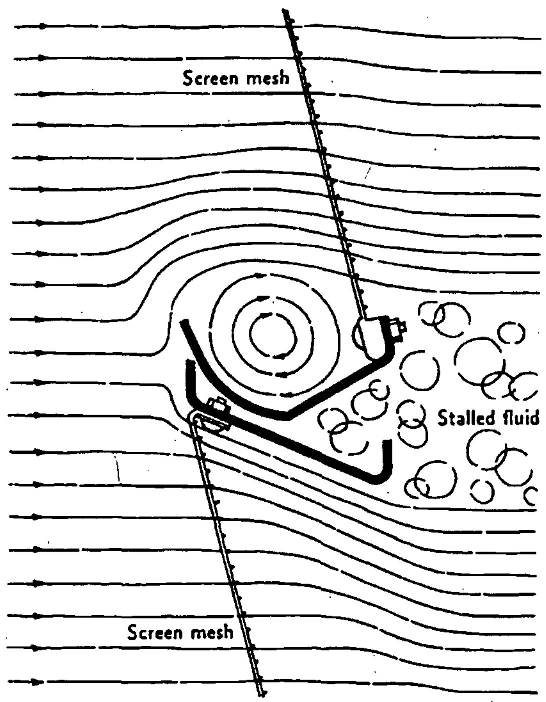


FIGURE 7.—Composite flow profile at the panel railings of the trial machine, reconstructed from photographed dye releases. At (approaching) flow speeds of 30 and 45 cm/s the flow geometries were similar, but the angular velocity of the trough vortex was approximately 7.5 rad/s at the 30-cm/s flow speed and 11 rad/s at the 45-cm/s flow speed. The trough water is independent of the freestream flow through the screen except for turbulent exchange across the (shearing) boundary between the two.

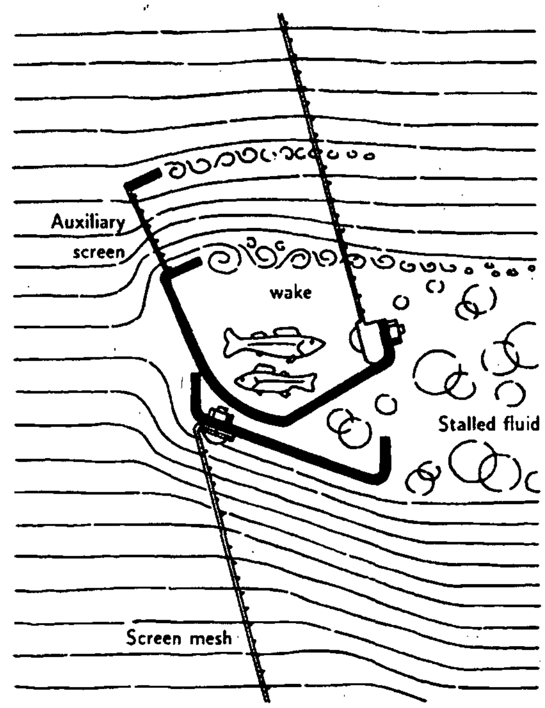


FIGURE 8.—Composite flow profile at the panel railings of the reconfigured machine, reconstructed from photographed dye releases. At test speeds of 30 and 45 cm/s, the flow geometries were similar. The spoiler at the leading edge of the fish trough trips the main flow and creates a trail of disordered, small-scale vortices that separates the shearing action of the freestream flow from the fluid within the trough, leaving the trough interior in an undisturbed state where captured fish are able to maintain stable attitudes. Once captured, fish are prevented from escaping the (upward moving) trough by an auxiliary screen affixed to the flow spoiler. Freely swimming fish did not avoid the turbulent entry behind the auxiliary screen and its supporting bar as consistently as they avoided the accelerated flow over the unimproved fish trough.

ciseness proved overly crucial to stability. Imposed, upstream perturbations in the approach flow (like those one might expect in natural intake flows) displaced the stagnation streamline and the unwanted vortex appeared inside the trough confines.

In the meanwhile, the technicians were experimenting with trough compositions of their own devisings. Gathright stuck on the simple but successful stratagem of recurving the leading edge of the Royce trough into various angles of attack until he arrived at a configuration that created a trail of disordered flow over the trough of a strength sufficient to separate the shearing action of the main flow from the trough interior. Because of the unstable (or fluctuating) nature of a turbulent wake, the front of the trough was elevated as shown in Figure 8 to prevent intrusions of the wake into the trough interior. Except for turbulent exchange across the wake, the fluid interior to the trough was effectively separated from the main flow; captured fish were well sheltered and remained upright in normal swimming attitudes at (approaching) flow speeds to 60 cm/s. In both flume and field tests, deaths and injuries of captured fish were low in comparison to the results of the field tests on screen version 1.

We eliminated the escape of fish at the water surface by attaching a low auxiliary screen to the leading edge of the redesigned trough, as shown in Figure 8. Although the auxiliary screen imparts only minor impedence to free flow, it creates a downstream turbulence, typical of screened flow, that apparently is favorable to fish capture. In flume experiments on the reconfigured machine, many of the test fish that moved into the vicinity of the screen front were observed to dive preferentially behind the auxiliary screen and into the fish trough, as opposed to the active avoidance reactions of fish swimming in the flow above the unmodified troughs.

Flume Tests on the Reconfigured Machine

We fitted the flume machine with the redesigned trough and panel assemblies and reconstructed its above-water portions according to the modifications already described. For the flume tests on the reconfigured machine (called screen version 2 here), 750 white perch and striped bass juveniles of Hudson River origins were shipped by air to Houston. Alosids and like species common to the Hudson were considered too fragile for transport, so we employed the locally obtained golden shiners as representatives of tender species. Fish were held apart by species in tanks until used in the experiments. Tank water was aerated, filtered, adjusted to the pH of the waters of origin with $NaHSO_4$ and HCl, and monitored for temperature, ammonia concentration, and conductivity. Flume water was continuously filtered and circulated; temperature, pH, and conductivity were measured for each experiment. Flow speeds in the flume were set and monitored with a Marsh McBurney model 511M electromagnetic current meter and a digital converter to 3D velocity field read-outs at three flume cross-sections.

For the underwater portion of the flume tests, the measurement of interest was the empirical probability that a fish, released upstream of the moving screen, would be captured and removed from the water on its first encounter with the screen and recovery apparatus. For each such trial, fish were released 5 m upstream of the operating screen by species, size, and water speed (30 and 45 cm/s), in sample sizes of 20 to 50 fish. The flume was covered and darkened (to simulate the field conditions most common to intake systems); the screen was operated in normal fashion and the observations were recorded on video tape with an ultra-sensitive charge-coupled device (which was also connected to a monitor for remote viewing). Such secular information as times of release, fish residence times, and frequencies of events were extracted from the camera clock (imaged on the video frames). The data were later extracted, usually frame by frame, from the video tapes. In 18 of 26 trials (releases), some fish were lost from camera view (and therefore were not countable as a capture or an escape), but because events occurred so rapidly, visual observations and hand tabulations were too inaccurate for use. Information from these experiments is given by Table 1.

Of the larger golden shiners released, 62% of those observed on camera and not lost from view were captured and retained by the redesigned fish troughs on first encounter with the screen. Of the smaller golden shiners observed, 91% were captured and retained on first encounter, but most of these smaller fish, being less able to swim against the flow, were impinged before capture. The proportions were identical at both water speeds. In the experiments with white perch, 77% of the observed fish were caught and retained on first encounter at the 30-cm/s water speed, and 80% at the 45-cm/s water speed (the 3% difference is statistically insignificant). At both water speeds, many of the white perch were impinged before capture. Recovery rates (the rates at which the fish were removed from the water by the machine) were consistent with the recovery rates in release–recapture field tests on the reconfigured machine. In the flume test with striped bass, 76% of those observed to encounter the screen were caught on first contact, all of which were freely swimming fish.

Other segments of the flume tests on the reconfigured machine were meant to produce information, under controlled conditions, on the several modifications incorporated into the functionings of the apparatus above water. Those experiments and their results are given in Fletcher et al. (1988).

Site Tests on the Reconfigured Machine

During the summer of 1986, the original trial machine (screen version 1) was removed from the Indian Point testing bay and the reconfigured machine (screen version 2) installed in its place. The experiments and tests described here were carried out by field crews of Normandeau Associates from 26 August to 24 October 1986, a test period assigned to us by the plant operators. The supervising biologist for Consolidated Edison was Kenneth Marcellus.

Of the several modifications incorporated into screen version 2, those that influence the transport of fish from the water surface to the fish return sluice on the downstream side of the machine were tested at the Indian Point site in a manner similar to the above-water flume testings. In the site tests on the passage of fish through the front debris spray to the fish return sluice (locations J and H of Figure 1), 641 of 664 test fish were recovered

TABLE 1.—Underwater flume experiments; capture of golden shiners[a], striped bass[b], and white perch[b] by a reconfigured Ristroph screen (screen version 2). Fish of each trial were released 5 m upstream of the operating screen and filmed at the screenfront through an underwater viewing port. The measurement of interest was the empirical probability that a released fish would be captured and retained by the apparatus on its first contact with the screen. On the table, mean water speed is the mean speed of the water immediately upstream of the test screen, and numbers S in parentheses are sample sizes of test fish.

			Numbers of fish			
Mean fork length (cm)	Mean water speed (cm/s)	Number of trials (S)	Observed by camera	Lost from view	Caught on contact	Escaped screen
Golden shiners, 16-18 July 1986, 24-28°C						
6.5	30	2 (20, 20)				
	45	2 (20, 20)	63	6	52	5
11.0	30	6 (20, 20, 20, 50, 50, 40)	90	26	40	24
White perch, 13 Aug 1986, 28°C						
5.0	30	3 (25, 25, 25)				
	45	2 (25, 25)	49	19	23	7
Striped bass, 14-15 Aug 1986, 28°C						
7.1	30	1 (25)				
	45	1 (25)	13	2	8	3
7.1	45	5 (25 each)	20	1	15	4

[a] Golden shiners obtained from a local fish farm.
[b] Striped bass and white perch came from the Hudson River.

from the fish return sluice, none from the primary debris sluice (K of Figure 1), and 23 from the secondary debris sluice (N of Figure 1). Of the 641 from the fish sluice, 35 were stunned (swimming erratically) or missing scales, for a casualty total of 9% (including the 23 misdirected fish).

Release–Recapture Experiments

Recapture experiments with known sample sizes of striped bass and white perch released upstream in the intake bay were meant to provide information on expected recovery rates and the risks of death and injury to fish captured by the reconfigured apparatus. Before and during each of those experiments, a fixed screen was placed at the river entry of the intake bay, not to prevent the released fish from escaping, but to prevent contamination of the collections by fish entering from the river. For reasons not well understood, fish have a greater propensity for entering intake systems than leaving. The samples were released upstream in the intake bay, just behind the fixed screen. On the thesis of random encounter with the escape route (a travelling fish trough in this case) and the success rates of capture (the first-encounter probabilities) observed in the flume experiments, the recovery rates of freely swimming fish were expected to follow Poisson processes, as hypothesized by Fletcher (1985). In such a process, the probability of an event occurring in a time interval is proportional to the duration of the interval, the event in this case being ΔR, the numbers of released fish recovered during a sampling interval. Therefore, should the intervals of observation be adjusted to equal probabilities of the event occurring, then ΔR should be a constant value over each interval. In anticipation of such recapture distributions, returns were collected at the fish sluice on a geometric time scale as a means of reducing sample variance and improving the accuracy of the time-dependent recovery cumulations. The sampling intervals were calculated from the following formulas

Duration of experiment:	T (= 36 h for all experiments).
Number of observations:	n.
Sampling index:	$j = 1, 2, \ldots, n$.
Sampling times:	$t_j = t_1, t_2, \ldots, t_n$ ($t_1 = 0$, $t_n = T$).
Intervals:	$\Delta t_j = t_{j+1} - t_j$.
Scaling factor:	δ (resolved from T and n).
In general:	$T = \delta^n - \delta$,
	$t_j = e^{j \log_e \delta} - \delta$,
	$\Delta t_j = (\delta - 1)e^{j \log_e \delta}$.

The first collection ($j = 1$ at $t_1 = 0$) after release of a sample was taken on the first appearance in the collection sluice of any individuals from the release. For those (freely swimming) fishes for

TABLE 2.—Release–recapture experiments, screen version 2, 4–13 September 1986 at Indian Point nuclear unit 2. Samples were released at the forebay entrance, captured by the test screen, and recovered at the fish sluice over a period of 36 h. Mean water speed in the approaches to the screen was approximately 30 cm/s (varying with the tide), water temperature was 24–25°C, and conductivity was 5,900–6,500 µS/cm. The vertical travelling speed of the screen was 3 m/min, the water pressure of the primary and secondary debris sprays was 62 kPa, and the fish spray pressure was 2.7 kPa. Key: t_j is elapsed time of fish collection, j corresponding to the (nonlinear) sampling intervals $j = 1, 2, \ldots, 12$; reference time $t_1 = 0$ corresponds to the first appearance in the collection sluice of fish from the released sample; $t_1 - t_0$ is the time between release of a sample and the first collection; $t_{12} = 36$ h; S is the number of fish released and R the number of fish recovered in a sample; Cum R is cumulative numbers of fish recovered; FL is mean fork length of fish in a sample or range thereof; dead 8 h is the number of fish that died during 8-h morbidity observations but exhibited no apparent trauma when collected.

	Time of sample collection												Dead on collection	Injured	Dead 8 h
Measure	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}	t_{12}			
Experiment 1: striped bass (FL = 7.6 cm; $S = 250$; $t_1 - t_0 = 3$ min)															
R	10	26	26	12	14	21	25	25[a]	3	38	15	13			
Cum R	10	36	62	74	88	109	134	159	162	200	215	228	10	1	1
Experiment 2: white perch (FL = 5.0-15.2 cm; $S = 67$; $t_1 - t_0 = 6$ min)															
R	5	19	16	3	2	0	0	1	0	2	3	3			
Cum R	5	24	40	43	45	45	45	46	46	48	51	54	3	0	1
Experiment 3: striped bass (FL = 7.6 cm; $S = 250$; $t_1 - t_0 = 3$ min)															
R	1	10	24	9	17	45	22	14	25	29	22	5			
Cum R	1	11	35	44	61	106	128	142	167	196	218	223	5	0	1
Experiment 4: white perch (FL = 5.0-15.2 cm; $S = 66$; $t_1 - t_0 = 5$ min)															
R	11	17	4	6	1	3	0	0	4	4	3	2			
Cum R	11	28	32	38	39	42	42	42	46	50	53	55	1	0	1
Experiment 5: white perch (FL = 5.0-15.2 cm; $S = 250$; $t_1 - t_0 = 3$ min)															
R	5	100	29	10	8	19	12	16	1	25	0	0			
Cum R	5	105	134	144	152	171	183	199	200	225	225	225	1	4	1
Experiment 6: white perch (FL = 5.0-15.2 cm; $S = 250$; $t_1 - t_0 = 5$ min)															
R	11	48	67	21	6	1	13	8	4	23	14	6			
Cum R	11	59	126	147	153	154	167	175	179	202	216	224	0	0	0

[a] Spraywashes were shut down 15 min during recovery; nine fish killed.

which the random encounter hypothesis holds, recoveries R_j should then accumulate on j as

$$\sum_j R_j = R_1 + \Delta R(j - 1), \qquad (1)$$

R_1 being the size of the first collection at $j = 1$.

In the release–recapture experiments, all apparent injuries and deaths were tallied on recovery, and only those fish *not* exhibiting trauma on collection were held in aquariums for 8-h morbidity observations. These protocols differ somewhat from the standard industry practices for scoring "system efficiencies" (see the discussion at the conclusion of this article). The experimental variables and data from the six release–recapture experiments are given by Table 2. The 36-h limitation on recovery periods was a consequence of the total time we were allowed by the plant operators for holding the fixed screens in place at the river entry of the intake bay.

In the two recapture experiments (1 and 3) with striped bass (of 7.6 cm mean fork length), each of 250 releases, 228 were recovered in experiment 1 over the 36-h collection period, and 223 in experiment 3. Of the totals collected from both releases, one fish was damaged and 15 were dead (either on collection or during the 8-h morbidity tests), for an observed casualty total of 3%. The observed deaths and injuries were too few for constructing reliable risk distributions, but the empirical probability of imposed trauma (injury or death to an individual fish) was 0.052 in experiment 1 (some of which was owed to a spray failure during collection period t_8) and 0.027 in experiment 3.

The recovery cumulations from experiments 1 and 3 (the striped bass releases) are plotted in Figures 9 and 10. The hypothesis of random encounter is supported by the regression of equation (1) on the cumulative recoveries. Apparently, the striped bass were actively captured by the recon-

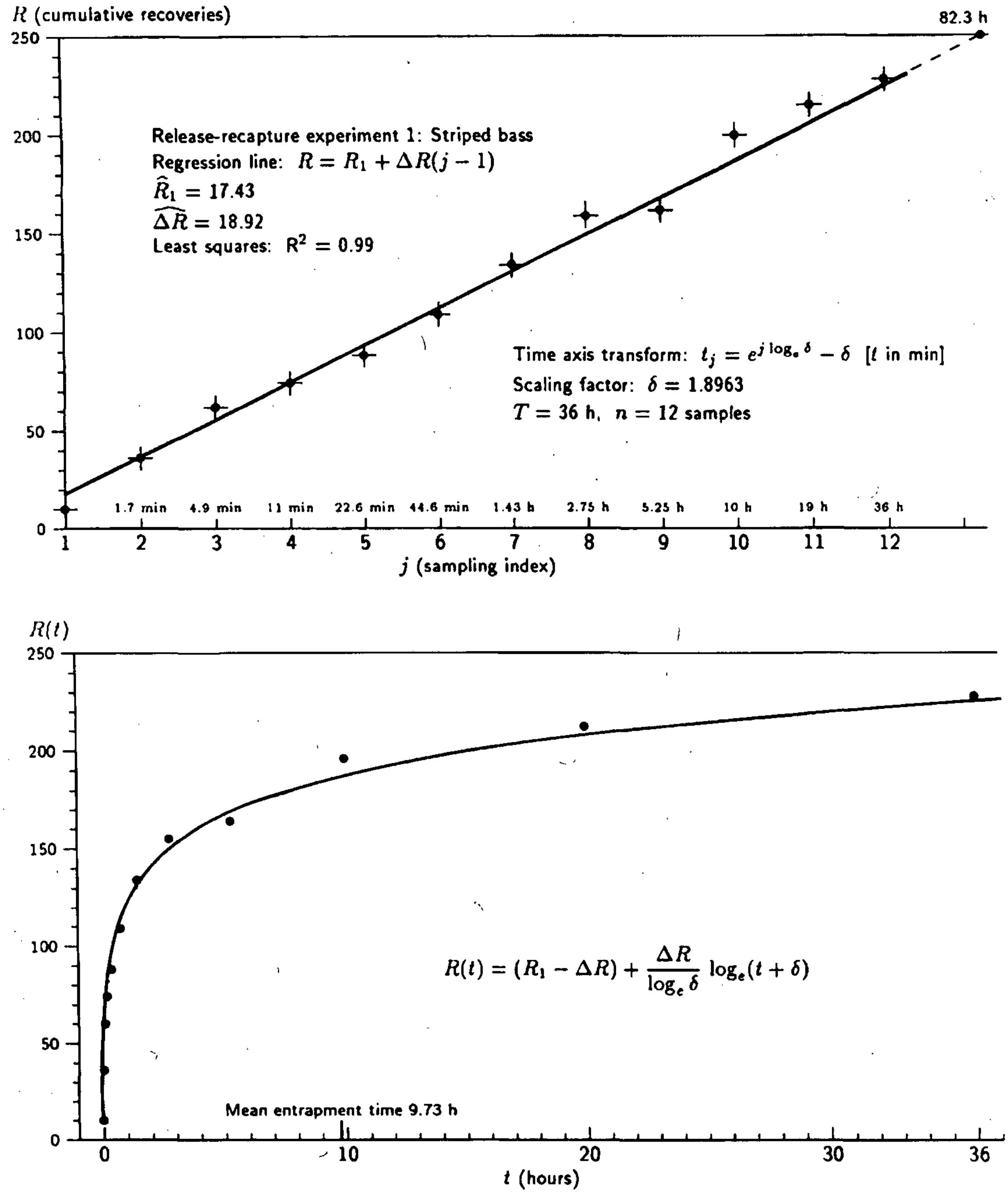


FIGURE 9.—Release-recapture experiment 1; 250 striped bass released in the plant forebay. Duration of the recovery period was 36 h. Upper graph shows cumulative recoveries R against (nonlinear) sampling intervals Δj with sampling times t_j preadjusted for expected ΔR constant. Release time $t_0 = -3$ min. Reference time $t_1 = 0$ corresponds to the first recovery sample at $j = 1$. Symbols $\hat{R}_1$ and $\widehat{\Delta R}$ denote the regression values (of R on j). The lower graph shows the transformation of the data and the regression to linear time.

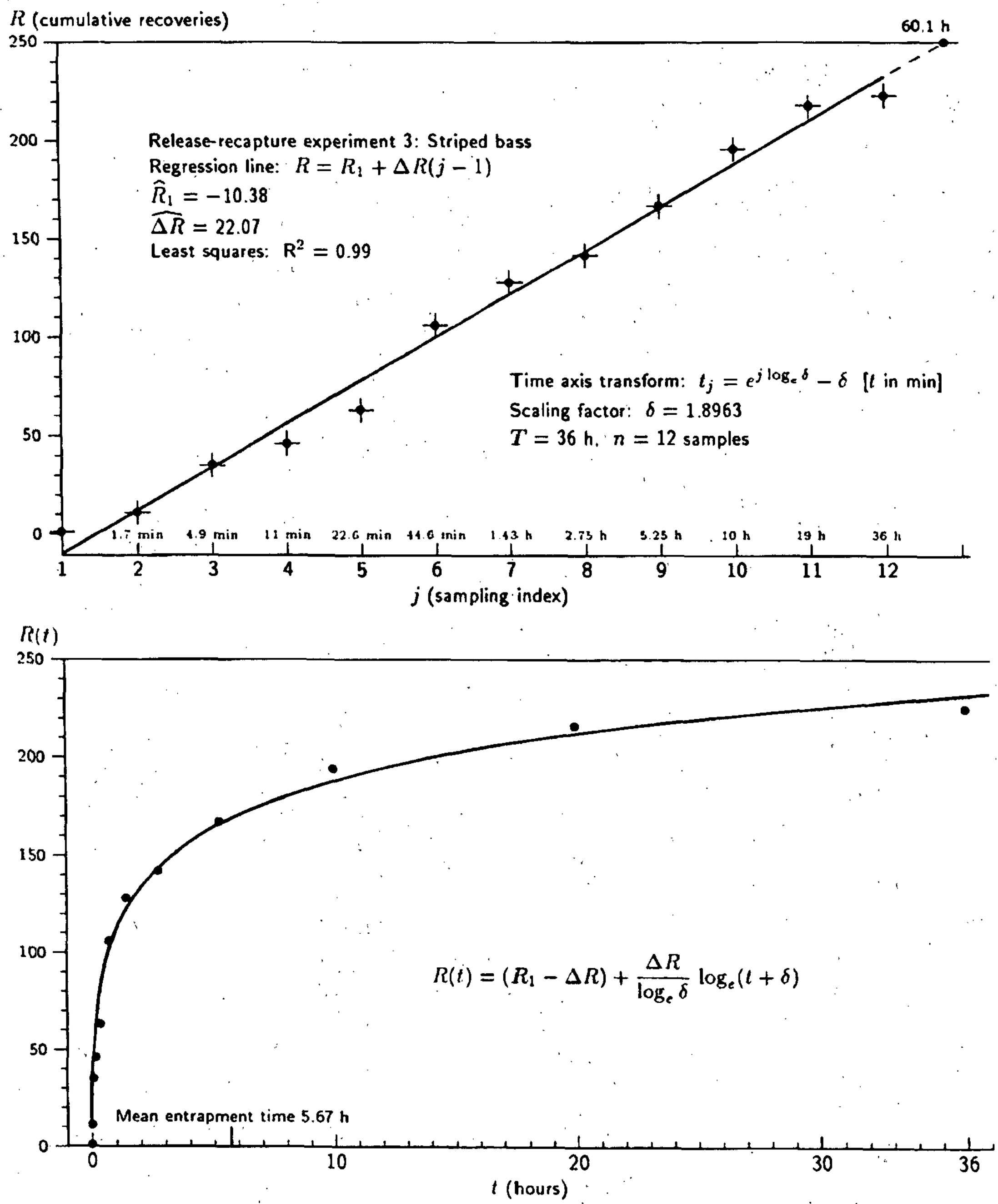


FIGURE 10.—Release-recapture experiment 3; 250 striped bass released in the plant forebay. Duration of the recovery period was 36 h. Upper graph shows cumulative recoveries R against (nonlinear) sampling intervals Δj, with sampling times t_j preadjusted for expected ΔR constant. Release time $t_0 = -6$ min. Reference time $t_1 = 0$ corresponds to the first recovery sample at $j = 1$. Symbols $\hat{R}_1$ and $\widehat{\Delta R}$ denote the regression values (of R on j). The lower graph shows the transformation of the data and the regression to linear time.

figured fish troughs, few being impinged beforehand. As observed in the Houston flume tests, juvenile striped bass of the sizes employed in these field experiments were capable of sustained swimming at flow speeds greater than the 30-cm/s flow speed in the Indian Point intake forebay. The mean entrapment time before capture was 9.73 h in experiment 1 and 5.67 h in experiment 3, as calculated directly from

$$\bar{t} = \frac{\int_0^T t[S - R(t)]\, dt}{\int_0^T [S - R(t)]\, dt}, \tag{2}$$

S standing for the initial sample size and $R(t)$ the transformed regression (1), or

$$R(t) = (R_1 - \Delta R) + \frac{\Delta R}{\log_e \delta} \log_e(t + \delta). \tag{3}$$

In the four recapture experiments with 633 white perch (experiments 2, 4, 5, and 6, of sample sizes 67, 66, 250, and 250 and length ranges 5.0–15.2 cm), 556 were recovered during the four 36-h sampling periods, of which 4 were damaged and 7 were dead (on collection or during the morbidity tests), for an observed casualty total of 2%. Unlike the striped bass experiments, the recapture results from all four white perch experiments signify instead a high impingement rate and rapid recovery of small fish unable to swim (or swim very long) at speeds equal to the water speeds at the face of the barrier screen. Each of the white perch releases contained a mixture of fish lengths ranging from 5 to 15.2 cm. Figure 11 illustrates the efflux rate (Q) of the smaller fish over the first 45 min of experiment 2, a pattern typical of all four white perch experiments, when a sudden surge of the smaller perch appeared in the collection sluice shortly after release. Of the total fish recovered in experiment 2, 83% (or 67% of the total release) were recovered in 22.5 min (by $j = 5$), including 100% of the releases less than 8 cm long. The graph of Figure 11 has the form

$$Q(t) = at^{-2}e^{-b/t^2}, \tag{4}$$

derived from equations (50) and (52) of Fletcher (1985) for circumstances where a school of fish entrapped by a barrier screen suddenly encounters an escape route (a bypass) by moving a distance along the face of the screen. The analogy here to the Dirac delta distribution in space ($\delta(\Delta x)$ at a reference location x_0) becomes a time interval distribution $\delta(\Delta t)$ at a reference time t_0. In turn, the

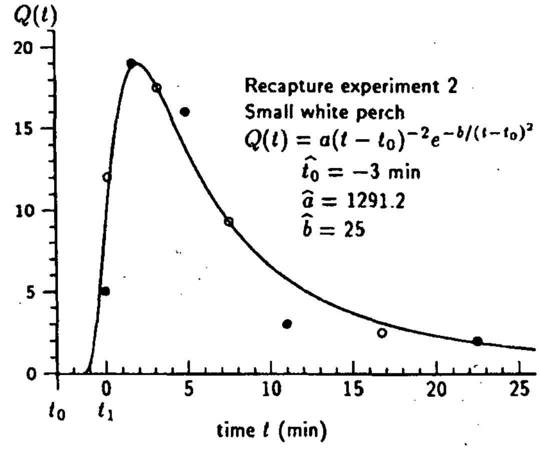


FIGURE 11.—Efflux $Q(t)$ ($=dR/dt$) of white perch smaller than 8 cm in release–recapture experiment 2, R being cumulative recoveries over time t from release time t_0. Reference time $t_1 = 0$ corresponds to the first appearance in the collection sluice of individuals from the released sample. Finite interval recoveries $\Delta R/\Delta t$ are denoted by solid bullets (●). Mid-interval adjustments to dQ/dt are denoted by open bullets (○). Quantities $\hat{a}$, etc., are the regression values.

quantities L (screen length), ρ (concentration of fish at x_0 per unit length of L), and a fish activity coefficient D map to equation (4) in the ratios

$$\frac{L\rho\delta(\Delta x)}{D^{1/2}} \Rightarrow \frac{C_0\delta(\Delta t)}{\gamma}, \tag{5}$$

C_0 being the concentration of fish at the screen front at reference time t_0, and γ the risk (or chance) per unit time that a randomly selected individual of C_0 will be impinged (and hence recovered). From mapping (5), the coefficients of equation (4) take on the proportionalities

$$a \propto \frac{C_0}{\gamma} \text{ and } b \propto \gamma^{-2},$$

with corresponding adjustments to the powers of t.

The equal probability of capture hypothesis—to the extent that the selected value of scaling parameter δ was more suited to the constant incremental recoveries ΔR of the striped bass samples—failed to hold for either the small white perch or the large ones (those greater in length than 8 cm). Despite the ill-suited progression of sampling intervals for white perch, the larger fish of the samples still seemed to be governed by the case-1 Poisson process discussed by Fletcher (1985), whereby expected recoveries from S accumulate as

$$R(t) = S(1 - e^{-\gamma(t-t_0)}), \tag{6}$$

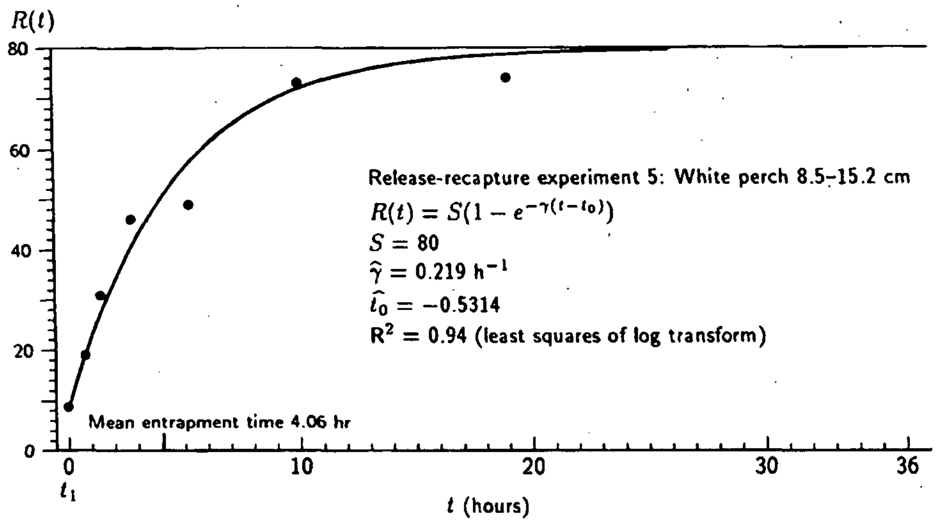


FIGURE 12.—Cumulative recoveries R of the 80 larger white perch released in recapture experiment 5. Reference time $t_1 = 0$ corresponds to the appearance in the collection sluice of the first individual(s) from the released sample. Symbol $\hat{\gamma}$ denotes the regression value of γ, the individual risk per unit time of capture by the screen. Symbol $\hat{t}_0$ denotes the regression value of t_0, a parameter of convenience that does not in this case correspond to the release of the sample, because the domain of validity of $R(t)$ does not extend to the left of t_1.

the random variable (Y, say) being the time that an arbitrarily designated individual of S is captured. The recovery data from experiments 5 and 6 (the white perch experiments having the greater number of releases S) are plotted in Figures 12 and 13. The regressions shown in the figures were fitted to the log transform of equation (6), or

$$\log_e\left(1 - \frac{R}{S}\right) = \gamma t_0 - \gamma t, \qquad (7)$$

γt_0 and γ being the parameters estimated. The mean entrapment times shown on the figures were extracted from the probability density function associated with regression (7). That is,

$$E[Y] = \int_0^\infty t \cdot \gamma e^{-\gamma(t-t_0)}\, dt = \frac{e^{\gamma t_0}}{\gamma}. \qquad (8)$$

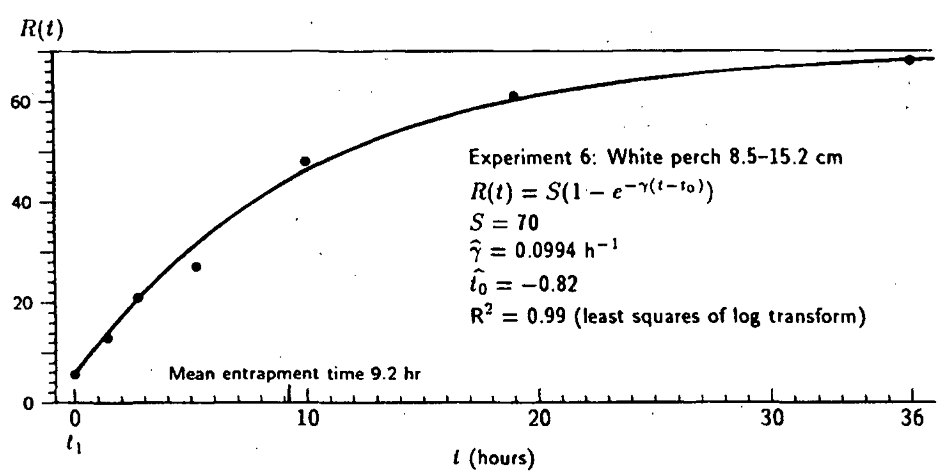


FIGURE 13.—Cumulative recoveries R of the 70 larger white perch released in recapture experiment 6. Reference time $t_1 = 0$ corresponds to the appearance in the collection sluice of the first individual(s) from the released sample. Symbol $\hat{\gamma}$ denotes the regression value of γ, the individual risk per unit time of capture by the screen. Symbol $\hat{t}_0$ denotes the regression value of t_0, a parameter of convenience that does not in this case correspond to the release of the sample because the domain of validity of $R(t)$ does not extend to the left of t_1.

Equation (8) yields a mean entrapment time of 4.06 h for the 80 larger fish of experiment 5, and 9.2 h for the 70 larger fish of experiment 6.

Opportunistic Collections

Following the release–recapture experiments, the fixed screen was removed from the forebay entrance, the circulating pump of the test bay was operated for extended periods at its full intake rate of river water (~529,000 L/min), and the reconfigured screen was allowed to function in its normal fashion. Over the period 16 September to 24 October 1986, 146 2-h collections were taken of captured river fish. The dead and injured were tallied on collection; fish not exhibiting visible trauma were held in aquariums for 8-h morbidity observations. In addition, 29 extended collections were made that ranged in duration from 6 to 28 h. Fish from these extended collections were examined at the end of each collection period for deaths and apparent trauma, but were not held for the additional 8 h of observation.

In the 175 collections, 8,882 fish were recovered from the fish and debris sluices and 34 species were identified (Table 3). Collection data on the 13 most numerous species are given by Table 4. The fish exhibiting the highest proportions of deaths and injuries in the opportunistic collections were bay anchovy, alewife, American shad, blueback herring, Atlantic menhaden, and American eel, all but American eel being tender species easily descaled. As the data show, fish of these species that were transferred to aquariums suffered higher proportions of latent mortality than those from the extended collections, which were held directly in the collection tanks. Nevertheless, no adjustments have been made here to the collection data for handling mortality.

TABLE 3.—Fish collected in 175 samples from fish and debris sluices, 16 September to 24 October 1986, during field tests of screen version 2 at Indian Point nuclear unit 2.

Bay anchovy *Anchoa mitchilli*	1,060
American shad *Alosa sapidissima*	169
Bluegill *Lepomis macrochirus*	192
Pumpkinseed *Lepomis gibbosus*	212
Hogchoker *Trinectes maculatus*	3,543
Largemouth bass *Micropterus salmoides*	1
Blueback herring *Alosa aestivalis*	277
Rainbow smelt *Osmerus mordax*	4
Striped bass *Morone saxatilis*	86
White catfish *Ictalurus catus*	25
Yellow perch *Perca flavenscens*	1
Lookdown *Selene vomer*	7
Atlantic needlefish *Strongylura marina*	1
Weakfish *Cynoscion regalis*	467
Butterfish *Peprilus triacanthus*	8
Rough silverside *Membras martinica*	1
Naked goby *Gobiosoma bosci*	13
Alewife *Alosa pseudoharengus*	72
Bluefish *Pomatomus saltatrix*	16
Brown bullhead *Ictalarus nebulosus*	6
American eel *Anguilla rostrata*	65
Banded killifish *Fundulus diaphanus*	134
Atlantic menhaden *Brevoortia tyrannus*	24
Atlantic silverside *Menidia menidia*	3
Spottail shiner *Notropis hudsonius*	2
Atlantic tomcod *Microgadus tomcod*	603
White perch *Morone americana*	1,806
Northern pipefish *Syngnathus fuscus*	4
Redbreast sunfish *Lepomis auritus*	4
Crevalle jack *Caranx hippos*	6
Clupeid sp.	1
Centrachid sp.	39
Summer flounder *Paralichthys dentatus*	29
Grey snapper *Lutjanus griseus*	1

Screen Versions 1 and 2 Compared

The experiments described in preceding sections of this paper were intended to provide enough empirical information for making a reliable assessment of the likely reductions in fish kills and injuries attributable to the reconfiguring of the prototype machine, as compared in particular to the first version. Comparisons between the opportunistic field collections from the two machines suffer somewhat from dissimilarities in experimental variables. The machines were tested during unlike seasons of the year; the low water temperature of the river during the testing of version 1 probably increased susceptibility of trauma of some of the sampled species, and because of the difference in seasons the species compositions of the collections also differed considerably.

During Consolidated Edison's field testing of screen version 1, the experimenters collected 45,608 fish in their samplings of the fish and debris sluices. Of 36 identified species, 20 also appeared in the sampled recoveries from screen version 2. Discounting those species represented by only one fish reduces the shared species to 15 (Table 5).

From the 36 species collected during Consolidated Edison's testing of screen version 1, the experimenters selected the 10 most abundantly represented for their "latent survival" tests. Eight of those 10 are among the shared species appearing on Table 5 (those starred). Of the eight common species, two from the version-2 samplings (rainbow smelt and spottail shiner) were not collected in numbers sufficient for mortality comparisons. The deaths and injuries accrued to the remaining six species are given in Table 6.

The information on the version-1 survival testing appearing on Table 6 was taken from Consolidated Edison (1985), in which the numbers of fish "tested" were apparently subsamples of the version-1 collections; the actual totals collected are given in Table 5. The quantities listed in Table 6 for screen version 2 are the actual totals from the opportunistic collections (2-h and extended collections combined; see Table 4 for clarification). The large recovery of fish from the debris sluice of the version-1 machine was attributed to the entanglement of fish in the filamentous alga mentioned earlier. Of the total numbers of fish collected during those winter tests, 31% were recovered from the debris sluice (as opposed to 4% during the testing of the version-2 machine). The actual proportion was probably greater than the reported 31%, owing to the difficulties in searching through the debris, which formed a nearly inseparable mass of fish and algae when recovered. (On two site visits during the testing of screen version 1, I observed quantities of uncounted fish in the discarded debris.)

The screen-fouling problem is also reflected in the high mortalities observed during the version-1 tests. Of the white perch collected, 32% were recovered from the debris; of the striped bass, 23% from the debris; of the rainbow smelt, 44%, and so on. Therefore, when the casualties of the fish-sluice and debris-sluice collections are combined (Table 6), the importance of the alterations to the above-water portions of the version 2 machine becomes more obvious. Since the completion of our experimental work in 1986, the test screen at the Indian Point plant has been operated routinely, including operations during three winter–spring seasons of high debris loading. As reported to me by Kenneth Marcellus, supervising biologist for Consolidated Edison, the apparatus has continued to function as intended; apparently, the results reported here are valid representations of the improvements incorporated into the reconfigured machine, particularly in regards to the problem of fish and debris separation.

Comment on Sampling and Scoring Protocols

The procedures and scoring methods employed in the field samplings reported here differ from those of standard industry practice. Deaths and visible trauma accrued to recovered fish were tallied and classified on collection. Those fish exhibiting no apparent trauma were held in aquariums or collection tanks for 8 h (or longer) after collection (but see Table 4 for clarification). Deaths and revealed injuries from these latent morbidity observations were added to those tallied on collection for calculating total casualties. Damages to the dead and injured were classified by type and frequency of occurrence.

In testings of barrier screens and fish conservation apparatus by the power industry (most particularly for state and federal regulatory demonstrations), fish on collection are customarily scored as "live" (able to swim normally), "stunned" (all injuries, irrespective of kind), and "dead." All fish not dead (those classed as live and stunned) are held in aquariums for periods ranging from 48 to 96 h and the injured allowed to recover. At the end of the latent survival test (so named), the aquarium fish are then reclassified as either dead or alive, the "live" now being any fish exhibiting opercular movement or response to prodding. The ratio of these final live (injured and uninjured) to the total sample size (live plus dead) is reported as "percent survival" or "total system efficiency."

The differences in scorings between the two procedures are sometimes significant. In a comparative test, 10 fish were dead on collection and 40 injured (to one extent or another) out of a sample of 100. In accordance with the first procedure, the 50 apparently uninjured were held for the 8-h latent morbidity observation. Out of those 50, 3 died and 2 exhibited erratic swimming. In accordance with the second procedure, the 90 not dead were held for 96 h, during which time 20 died and 22 of the originally injured were still alive (exhibiting opercular movement or response to prodding). By the first method of scoring, there were 55% casualties (50 + 3 + 2 fish) or a 45% survival without injury. By the second method survival was scored as 70% (100 − 10 − 20).

The first method might be viewed as overly stringent, but the second is decidedly misleading if one presumes the objective common to all displacement schemes is that of rescuing fish from intake structures and returning them to the source waters unharmed. Partial corrections to reported survivals in industry studies can sometimes be made by noting from the raw data the numbers recorded as stunned on collection, with the understanding that the classification is a euphemism for all injuries, however severe. Such uses and scoring procedures are departures from the recognized protocols in other biological sciences where animal deaths and morbidities are the measures of interest. Not only are the data subverted by such practices, we are also denied the injury clas-

TABLE 4.—Collection data on the 12 most numerous species in the opportunistic fish collections, screen version 2, 16 September–24 October 1986, Indian Point nuclear unit 2. Fish drawn from the river and captured by the screen were sampled in 146 2-h collections and 29 extended collections of 6–28 h duration. Mean water speed in the forebay was approximately 30 cm/s (varying with the tide), river water temperature was 24–25°C, conductivity was 5,900–6,500 μS/cm, and the vertical speed of the test screen was 3 m/min. Key: Fish sluice[1] and debris sluice[1] signify fish from 2-h collections that were transferred to aquariums for 8-h morbidity observations. Fish sluice[2] and debris sluice[2] signify fish from 2-h collections that were shunted to collection tanks, with no handling, for 8-h observations. Fish sluice[3] and debris sluice[3] signify fish of the extended collections, all of which were shunted to tanks and examined at the end of a collection period.

Recovery	On collection			After 8 h			Cumulative dead and injured
	Normal	Damaged	Dead	Normal	Damaged	Dead	
Bay anchovy (1,060 collected[a])							
Fish sluice[1]	60	8	12	41	12	27	
Rear debris sluice[1]	0	0	3	0	0	3	
Fish sluice[2]				42	13	12	
Fish sluice[3]	723	24	147				
Rear debris sluice[3]	6	1	8				23%
American shad (169 collected)							
Fish sluice[1]	10	9	9	9	3	16	
Rear debris sluice[1]	0	0	2	0	0	2	
Fish sluice[2]				18	2	9	
Fish sluice[3]	83	2	25				
Rear debris sluice[3]	0	0	0				35%
Bluegill (192 collected)							
Fish sluice[1]	119	0	0	119	0	0	
Rear debris sluice[1]	0	0	0				
Fish sluice[2]				15	0	1	
Fish sluice[3]	56	0	1				
Rear debris sluice[3]	0	0	0				1%
Pumpkinseed (212 collected[a])							
Fish sluice[1]	40	2	0	39	3	0	
Rear debris sluice[1]	1	0	0	1	0	0	
Fish sluice[2]				29	0	2	
Fish sluice[3]	127	3	6				
Rear debris sluice[3]	1	0	0				7%
American eel (65 collected)							
Fish sluice[1]	16	8	0	15	7	2	
Rear debris sluice[1]	0	0	0	0	0	0	
Fish sluice[2]				9	1	2	
Fish sluice[3]	23	0	0				
Rear debris sluice[3]	0	0	0				28%
Hogchoker (3,543 collected[a])							
Fish sluice[1]	486	1	4	486	0	5	
Front debris sluice[1]	46	0	1	45	1	2	
Fish sluice[2]				561	2	13	
Rear debris sluice[2]				101	2	7	
Fish sluice[3]	2,094	1	407				
Rear debris sluice[3]	176	0	4				13%
Banded killifish (134 collected)							
Fish sluice[1]	75	0	0	74	0	1	
Rear debris sluice[1]	0	0	0				
Fish sluice[2]				14	1	0	
Rear debris sluice[2]				2	0	0	
Fish sluice[3]	42	0	0				
Rear debris sluice[3]	0	0	0				1%
Blueback herring (277 collected)							
Fish sluice[1]	24	7	3	16	5	13	
Rear debris sluice[1]	0	0	0				
Fish sluice[2]				72	0	25	
Fish sluice[3]	118	3	25				
Rear debris sluice[3]	0	0	0				26%

TABLE 4.—Continued.

Recovery	On collection: Normal	On collection: Damaged	On collection: Dead	After 8 h: Normal	After 8 h: Damaged	After 8 h: Dead	Cumulative dead and injured
			Striped bass (86 collected)				
Fish sluice[1]	7	0	0	7	0	0	
Rear debris sluice[1]	0	0	0				
Fish sluice[2]				11	1	0	
Fish sluice[3]	60	2	5				
Rear debris sluice[3]	0	0	0				9%
			Atlantic tomcod (603 collected)				
Fish sluice[1]	52	21	1	51	21	2	
Rear debris sluice[1]	0	0	0				
Fish sluice[2]				36	3	5	
Fish sluice[3]	410	8	65				
Rear debris sluice[3]	1	0	1				17%
			White perch (1,806 collected[a])				
Fish sluice[1]	486	18	15	476	7	36	
Rear debris sluice[1]	6	1	0	6	1	0	
Fish sluice[2]				276	11	24	
Rear debris sluice[2]				8	2	0	
Fish sluice[3]	787	35	132				
Rear debris sluice[3]	5	0	0				14%
			Weakfish (467 collected)				
Fish sluice[1]	19	2	0	14	3	7	
Rear debris sluice[1]	1	0	0	0	1	0	
Fish sluice[2]				21	0	7	
Fish sluice[3]	368	7	25				
Rear debris sluice[3]	11	3	3				12%

[a] One bay anchovy, 1 pumpkinseed, 13 hogchokers, and 1 white perch were recovered from the front debris sluice.

sifications that give us clues to the sources of injury. I see no legitimate reason for suppressing such important information for the sake of inflating survival statistics; I urge the supervising biologists of such studies to adopt more accurate classification and scoring protocols. However the collection samples might be divided for extended observations, the numbers (or percentages) of fish dead and injured should be reported and the practice of scoring the injured as "live" abandoned.

Conclusions and Remarks

The tests of the reconfigured machine in the hydrodynamics flume were meant to verify the causal findings that led to the innovations now incorporated into the device, and the site experiments at Indian Point were meant to produce information on the likelihood that fish mortalities would be substantially reduced, as compared to the first version of the machine and other screening systems. The flume tests essentially substantiated the earlier findings that led to the re-ordering of the debris and fish removal procedures and to the redesigning of the fish-catching apparatus. The probabilities of capture on first encounter with the screen were significantly increased, and all test species, once captured, suffered less buffeting in the redesigned fish troughs than they did in any of the standard troughs tested. The release-recapture experiments at Indian Point confirmed our

TABLE 5.—Numbers of fish collected of 15 species common to the field testings of screen versions 1 and 2. Asterisks denote species used in "latent survival" tests, screen version 1.

Species	Screen version 1	Screen version 2
Alewife*	117	72
Bluegill	9	192
Brown bullhead	15	6
Pumpkinseed*	144	212
American eel	131	65
Hogchoker	198	3,543
Banded killifish	61	134
Blueback herring	29	277
Rainbow smelt*	373	4
Spottail shiner*	217	2
Striped bass*	5,546	86
Atlantic tomcod*	413	603
White catfish*	443	25
White perch*	37,536	1,806
Northern pipefish	4	4

TABLE 6.—Casualty observations after opportunistic field collections from Indian Point test screens; versions 1 and 2 compared.

Species and collection sluice	Screen version 1 Tested	Screen version 1 Dead and injured	Screen version 2 Tested	Screen version 2 Dead and injured
Alewife				
Fish sluice	22	98%	71	62%
Debris sluices	3		1	
Atlantic tomcod				
Fish sluice	32	75%	601	17%
Debris sluices	8		2	
Combined	40	80%	603	17%
Pumpkinseed				
Fish sluice	17	46%	210	7%
Debris sluices	0		2	
Striped bass				
Fish sluice	860	48%	86	9%
Debris sluices	264		0	
Combined	1,124	53%	86	9%
White catfish				
Fish sluice	85	39%	25	40%
Debris sluices	25		0	
Combined	110	53%	25	40%
White perch				
Fish sluice	4,227	58%	1,783	13%
Debris sluices	2,051		23	
Combined	6,278	64%	1,806	14%

findings from the flume experiments that juveniles of some species are rapidly impinged at flow speeds as low as 30 cm/s, but we also discovered that impingement as such is not the proximate agency of high mortality it was thought to be, provided the durations of impingement are short and the speed of the water approaching the screen is moderate. Given such conditions, we found that captured fish were harmed more by injuries imposed during the recovery process.

In the case of fish able to swim against the flow for extended periods, the release–recapture experiments tended to confirm the hypothesis of random encounter and active capture by the redesigned fish troughs. Mean entrapment times (9.73 h, 5.67 h, 4.06 h, 9.2 h) were an order of magnitude less than those documented from similar experiments with a competing device when reported water speeds were about 30 cm/s. In mark–recapture experiments at the Oswego generating station on Lake Ontario, during field tests on an angled screen and bypass system (Lawler, Matusky & Skelly 1982), estimated mean entrapment times were 73 h for white perch, 295 h for smallmouth bass *Micropterus dolomieui*, 20 h for yellow perch, 200 h for brown trout *Salmo trutta*, 76 h for white bass *Morone chrysops*, and 41 h for bluegill. In the opportunistic collections at Oswego, extended entrapment times were also reflected, at least partly, in the high percentages of observed deaths and injuries. From even the simple assumption of constant risk of death per unit time (μ), extended entrapment times imply decreased probabilities of survival (whether the fish removal device is a Ristroph screen or an angled screen and bypass system), because the individual probability of death from exposure to constant mortality risk increases in time approximately as $1 - e^{-\mu t}$ (for more complex distributions of mortality risk, including analyses of the Oswego and other fish recovery experiments, see Fletcher 1985).

The reconfigured machine has been approved by the parties to the power plant settlement for installation in the 12 intake bays of the Indian Point plants, and the New York State Department of Environmental Conservation now employs the performance of the prototype as the state's best available technology standard for reducing fish impingements at water intake systems. If the machine continues to operate as well as the flume and field testings indicate, it probably can be regarded as the screening device most likely to impose the least mortalities in the rescue of entrapped fish by mechanical means. In view of the great numbers of fish typically exposed to mortality risk from large-scale water withdrawals, however, even the (comparatively) low percentages of kills and injuries observed during the prototype testings may still represent significant reductions in some stocks.

At locations where water speeds approaching screening devices are significantly greater than those examined here, impingement proper undoubtedly inflicts its share of casualties. In a later series of flume experiments on a special intake and screening geometry, water speeds at the screen were on the order of 120–150 cm/s. Fish were thrust against the screen mesh with such force that most were crushed or beheaded. Survival of test fish (again, golden shiners, striped bass, and white perch) was nil.

Further refinements to the Ristroph family of screening systems are possible, of course, but I do not believe that improvements beyond those reported here are apt to bring about greatly enhanced reductions in fish kills. Owing to the operating principles of these devices, captured fish would still be exposed to the hazards of direct mechanical encounter and removal. If some new device is to be better at conserving fish life, it must bring about a reduction in mean entrapment time through some active means of removal or diversion of fish from intake systems, but some active means not dependent on forcible contact with the fish or their extraction from the source waters.

The reconfigured machine, as tested at the Indian Point plant and described here, is now manufactured by Envirex, Inc., of Waukesha, Wisconsin.

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ON THE RECONFIGURATION AND EMPIRICAL EVALUATION OF A PROTOTYPE SCREENING DEVICE AT INDIAN POINT NUCLEAR UNIT 2

FINAL REPORT TO

HUDSON RIVER FISHERMEN'S ASSOCIATION

1 December 1986

R. Ian Fletcher
Great Salt Bay Experimental Station

CONTENTS

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Brief history

At full pumping capacity, the two operating nuclear plants at Indian Point divert approximately 1,680,000 gallons per minute of Hudson River water for condenser cooling. This water is withdrawn by circulating pumps through intake bays, each 13 feet wide and (about) 27 feet deep, that open onto the river. Each plant is equipped with six such bays and circulating pumps. Hence, a single bay accounts for about 140,000 gallons per minute of water withdrawal and heated discharge at full operating capacity. In addition, each plant has a service water bay that withdraws an additional 30,000 gallons per minute (or 60,000 gpm combined).

Each intake bay is furnished with a barrier screen that prevents indrawn debris from passing into the circulating pumps. Because of the large volumetric intake of river water, quantities of fish are regularly drawn with the water flow into the barrier screens and killed. As one intended means of reducing these fish kills, the Settlement Agreement of 10 December 1980 called for the replacement of the existing screens with barrier devices known as "angled screens."

Owing, however, to a subsequent analysis that showed the proposed angled screen design as offering little promise for significantly reducing fish kills (Fletcher 1984a), the settlement parties ultimately rejected angled screens in favor of an option in the Settlement Agreement that allowed for "alternative mitigation measures." That provision was interpreted, in turn, as allowing for alternative barrier devices that provide for the conservation of entrapped fish. One such device, known somewhat erroneously as a Ristroph screen, is now being tested, and it is the principal subject of this report. As currently configured, this test device little resembles the standard Ristroph design.

On rejection of the angled screens, Consolidated Edison elected to install and test the Ristroph device as manufactured by the Royce Equipment Company of Houston, Texas. The first test version of the Royce screen was placed in intake bay number 6 of Indian Point unit 2 (the Consolidated Edison plant) the latter part of 1984, and Consolidated Edison commenced its initial fish collection studies in January 1985. These collections continued for three months, the results of which were reported in Con Ed (1985).

Figure 1 on page 8 shows the general mechanical arrangement of the prototype screen as it was configured during those initial tests. Site arrangements of the screen and the sampling apparatus are depicted in Con Ed (1985) by Figures 2-1, 2-2, and 2-3. Although similar in principal to the existing screening devices at both Indian Point plants, the Royce standard screen is equipped with fish-catching troughs (the so-called Ristroph modification) and it is designed for continuous operation (continuous travel and debris removal) as opposed to the intermittant mode of rotation of the existing screens.

As reported in Con Ed (1985), the initial version of the prototype screen (called "Royce version 1" here) imposed high mortalities on several collected species, not unlike the levels of mortality measured at other intake systems (other power plants) employing similar screening devices (reviewed in Fletcher 1984b). During the initial testing program at Indian Point, conditions adverse to fish conservation were noted, namely, (1) fish adhered to the metal screen troughs, (2) fish entangled in unreleased algal matting, (3) inadequate width and shape of fish recovery sluice, and (4) ill-positioned flap seal (items reported in Fletcher 1985 and reviewed here in Section 1). Owing to the unexceptional performance of the test screen in its fish recovery portions, the device, as then configured, was judged by HRFA to be no more desirable than the rejected angled screen system.

As reported to you in Fletcher (1985), I examined the operation of the test machine in detail, then conferred with Dr. Marcellus of Consolidated Edison and devised a number of possible fixes for improving the debris removal and fish recovery performance of the device (of Royce version 1). That information was transmitted to the manufacturer, who in turn constructed a working replicate of the test screen in the Royce hydrodynamics flume (in Houston) and proceeded thereafter with the mechanical design and testing of the recommended alterations. I participated in that work, the results of which were reported to you in Fletcher (1986a and 1986b).

The problems connected with fish recovery and debris separation (the adverse conditions noted above) seemed to have been resolved, at least in principle, by the several modifications tested in Houston, but those modifications were limited to the observed portions of the machine above the water. Whether or not the fish-catching rails (those affixed to each screen panel) actively captured freely swimming fish (as opposed to merely lifting impinged fish from the water), or to what extent the screen and rail system below water might be contributing to death and injury of empounded fish, were questions still unresolved.

In response to those questions, the manufacturer installed an underwater filming port in the side of the hydrodynamics flume, and carried out a series of flow and fish experiments, which I designed and supervised. Those experiments revealed flow patterns in the vicinity of the fish-catching rails not altogether compatable with fish behavior and injury-free recovery. The rails were then redesigned and certain apparatus added that brought about increased rates of fish capture, as well as reduced incidence of imposed injury. Results of the fluid dynamical experiments were reported to you in Fletcher (1986b and 1986c); some of that experimental information is given in more detail in Section 2 of this report. The modifications and improvements developed in the Houston test flume were then incorporated into the prototype screen at Indian Point. The manufacturer removed the machine (Royce version 1), reconfigured it as indicated on Figure 2, then reinstalled it in the test bay (as Royce version 2).

Although we had conducted an extensive series of mechanical and fluid dynamical experiments on Royce version 2 in the Houston flume, the accompanying flume experiments with fish were circumstantial in nature and could not be considered sufficiently rigorous for probabilistic examination, nor could flume experiments alone be thought adequate for assessing the overall risks associated with field conditions. Therefore, I drew up a proposed, two-part testing program (Fletcher 1986c) that consisted of site tests at Indian Point and further tests in the Royce hydrodynamics flume. I circulated the proposal to HRFA, DEC, EPA, PASNY, and Con Ed for comments, and then composed an improved experimental design for the flume tests. At the request of Consolidated Edison, I also assisted Dr. Marcellus in drawing up a detailed working plan for the site tests at Indian Point (Con Ed 1986).

The tests proposed for the Royce flume were meant to test the causal findings that led to some of the innovations now incorporated into the reconfigured device, while the proposed *in situ* tests at Indian Point were meant to produce information on the likelihood of decrease in fish mortalities, as compared to the mortalities associated with the device as originally configured and tested. Both parts of the testing program were structured in a sequence of discrete steps that allowed for a detailed examination of each station or operation of the machine in turn, with the view to identifying and further improving any particular apparatus or functioning of the machine that might be imposing undue damage on captive fish.

The tests in the Houston hydrodynamics flume (some of which were conducted with striped bass and white perch from the Hudson) essentially substantiated the earlier findings that led to the redesigned fish-catching apparatus. The probabilities of capture (the chance that a fish would be caught on its first encounter with the barrier screen) were significantly increased for some species, and all test fish, once caught, suffered less buffeting in the redesigned fish rails than they did in the standard rails of Royce version 1. See Section 3 for the testing results, and Appendix A for the corresponding data register.

The field tests at Indian Point with known samples of released fish (the mark and recapture tests reported in Section 4) confirmed our findings from the flume experiments that juveniles of some species are rapidly impinged at a fluid speed of 30 cm/sec, the speed of the intake flow at the Indian Point plants, but we also determined that impingement is not the proximate agency of high mortality it is thought to be. Captured fish were harmed more by injuries imposed on them during the recovery process. In the case of fishes able to swim against the flow for extended periods, the mark and recapture experiments confirmed a hypothesis of random encounter and active capture by the redesigned fish rails.

Over the period 16 September to 24 October, the reconfigured machine and the circulating pump of the test bay were allowed to operate in the manner required for maximum intake of cooling water. During this period, 146 two-hour collections of captured fish were taken and held for 8-hour morbidity tests, Also, 29 collections were taken that ranged from six to 29 hours duration. The results of these fish collection experiments are given in Section 4. A comparison between these data and the tests by Consolidated Edison on the machine as originally configured showed significant reductions in imposed deaths and injuries to captured fish (see Section 5). Because the two testing programs were conducted during unlike seasons (version 1 in winter, version 2 in summer), the problem of algal matting was not tested, however. The indrawn debris during the summer testing of the version 2 machine was mostly eel grass, which was not stapled firmly into screen mesh like the winter alga encountered during the tests on the version 1 machine. Nor was there evidence to suppose that fish mortalities were increased by the presence of the eel grass.

None of the testing or experimental work was directed to an examination of any fish conservation apparatus beyond the confines of the single barrier device. No investigative work has yet been done on the mechanism for returning recovered fish to the source waters. For further commentary on testing not yet completed or undertaken, see pages 11, 32, 38–39, 50, and 53.

EXPANDED CAPTIONS

Figure 1 (page 8). Mechanical arrangement of the prototype screening device as originally configured and tested in January–April 1985 (Con Ed 1985); called Royce version 1 here. The screening apparatus proper, whose principal function is the protection of the intake sump from water-borne debris, consists of rectangular screen panels, linked together as an endless chain, that travel vertically and so accomodate the removal of captive debris from the meshes and auxiliary structure of the panels. To that extent, the prototype device is similar to the existing debris screens at both Indian Point plants, but unlike the existing screens it is constructed of stainless steel (as opposed to plain carbon steel), it is designed for continuous rotation and cleaning (as opposed to intermittant rotation), and it is equipped with fish recovery apparatus. The bottom rail (B) of each screen panel (A) has a concave shape that retains water and captive fish as the panels ascend to the driver sprocket (C). As a panel (D) rotates over the sprocket, the fish rail affixed to the panel spills out its captive water and fish. Released fish are meant to fall or slide along the incline of the descending panel into a fish sluice (H) and thence to a conduit for their return to the source waters. The release of fish from the rail and screen surface is aided by two rows of low-pressure sprays (E) and (F). A wide strip of flexible material (G), called a flap seal, is meant to prevent released fish and debris from falling behind the fish sluice and into the intake flow. Debris and fish remaining on the screen panels are blown into a debris sluice (K) by a row of high-pressure water jets (J).

Figure 2 (page 9). Mechanical arrangement of the reconfigured prototype as currently installed at Indian Point and tested in August–October 1986; called Royce version 2 here. Each screen panel (A) now has an auxiliary screen attached to the leading edge of its (reshaped) fish rail (BB). Debris embedded in the meshes of a screen panel (and its auxiliary screen) is blown free as the panel ascends through a row of high-pressure jets (JJ). The spray is interrupted by deflectors, mounted on the fish rails, that prevent disturbance to the water and fish contained in the rails. Released debris that would otherwise fall into the fish rails is deflected by an articulated shield (L) to a debris sluice (KK). As a screen panel (D), now free of debris, rotates over the driver sprocket (C), captive fish slide or fall into a fish sluice (HH). The release of fish from the metal fish rails is aided by a low-pressure spray (EE), and the release of fish from the surfaces of the descending screen panels is aided by two rows of fish sprays (FF). During the field tests on the reconfigured machine, the seal (at GG) was removed.

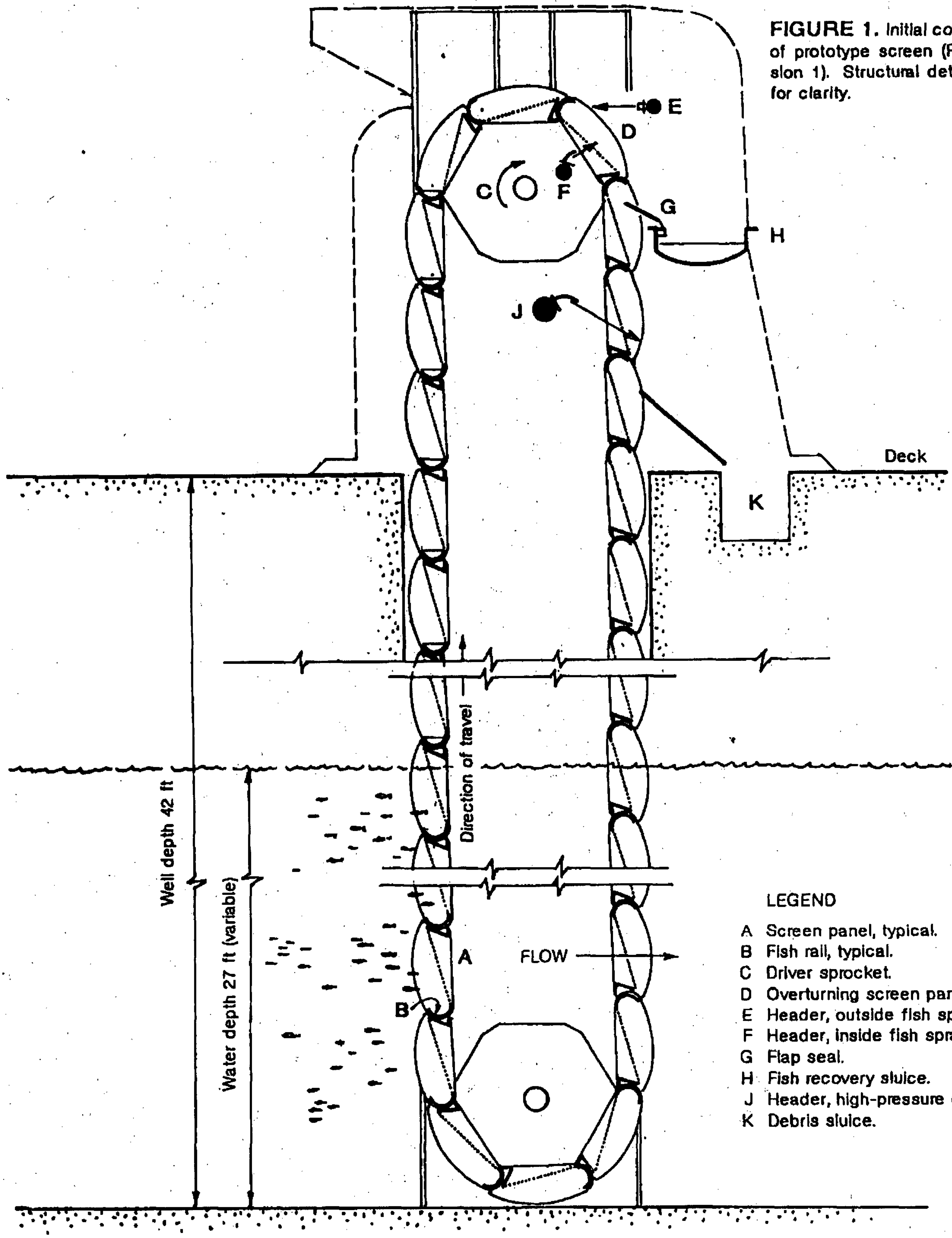

FIGURE 1. Initial configuration of prototype screen (Royce version 1). Structural detail omitted for clarity.

LEGEND

A Screen panel, typical.
B Fish rail, typical.
C Driver sprocket.
D Overturning screen panel.
E Header, outside fish spray.
F Header, inside fish spray.
G Flap seal.
H Fish recovery sluice.
J Header, high-pressure debris spray.
K Debris sluice.

VERTICAL CROSS SECTION

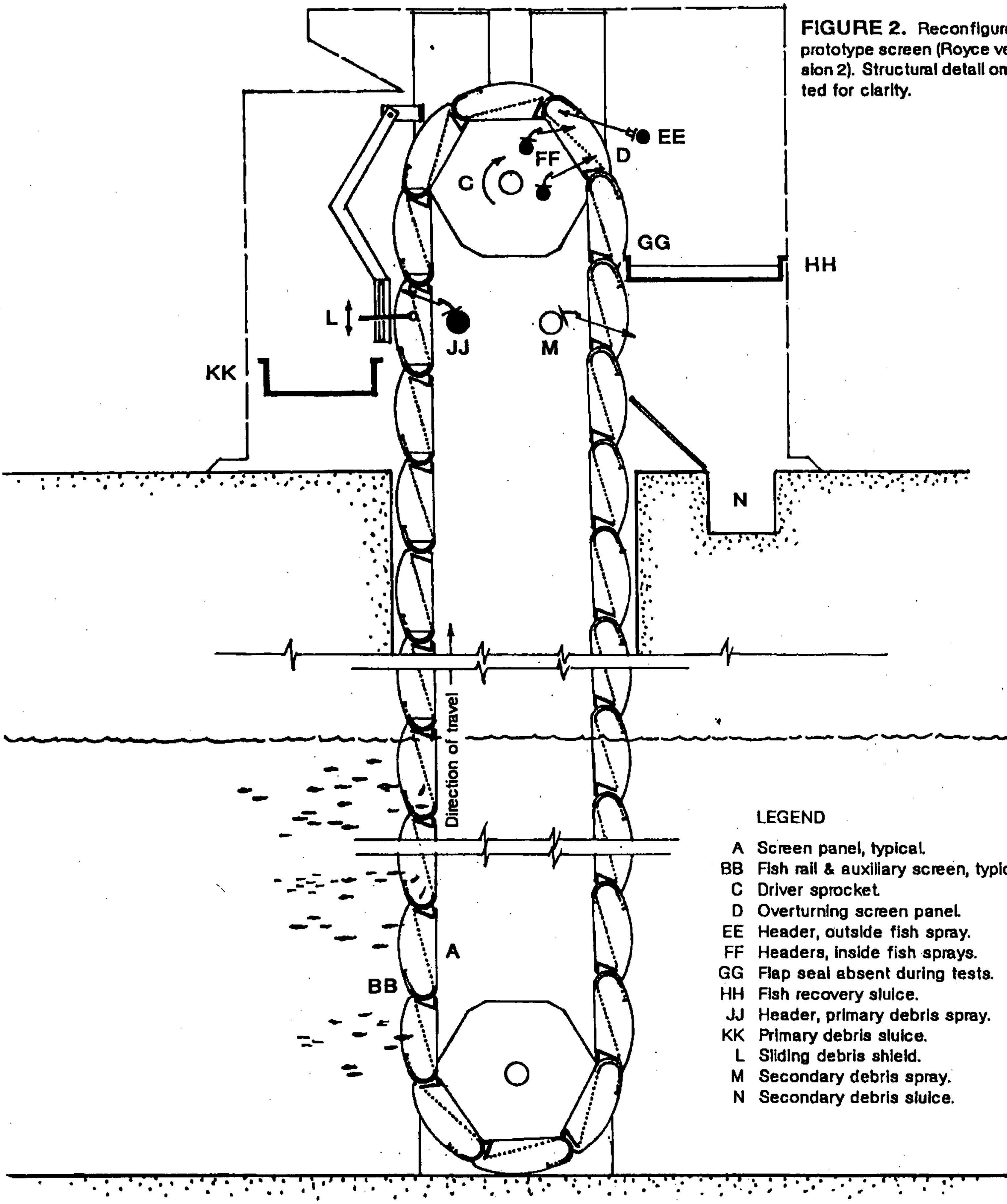

FIGURE 2. Reconfigured prototype screen (Royce version 2). Structural detail omitted for clarity.

LEGEND

A Screen panel, typical.
BB Fish rail & auxiliary screen, typical.
C Driver sprocket.
D Overturning screen panel.
EE Header, outside fish spray.
FF Headers, inside fish sprays.
GG Flap seal absent during tests.
HH Fish recovery sluice.
JJ Header, primary debris spray.
KK Primary debris sluice.
L Sliding debris shield.
M Secondary debris spray.
N Secondary debris sluice.

VERTICAL CROSS SECTION

SECTION 1.
Notes on the field and flume tests of Royce version 1

During the Con Ed tests of January–April 1985 on the device as it was originally configured (as Royce version 1) or during my flume experiments on its replica, the following deficiencies were observed. Each has been addressed by the manufacturer, and the various fixes noted below have been incorporated into the reconfigured prototype, Royce version 2. The effectiveness of each such alteration in performing its intended function was observed and measured during the course of the two-part testing program documented in this report. Those testing procedures are described more fully in Section 3 (flume tests) and Section 4 (field tests); the corresponding data registers are contained in Appendices A and B. Section 2 contains a description of the Royce hydrodynamics flume, together with some information on the flow and fish experiments that led to the redesigning of the fish rails. In the following narrative, references to components and locations of the test machines are keyed to the letter codings (A,B,C,...) that appear on Figures 1 and 2.

1. Fish adhered to the metal fish rails. As a screen panel (D, Figure 1) rotates over the top of the upper driving sprockets of the machine, the fish rail (or trough) affixed to that panel spills out its captive water. In turn, captive fish are also meant to spill from the rail and slide along the incline of the moving panel to the fish return sluice (H). During the initial field tests of Royce version 1, some fish remained in the overturned screen rails, apparently stuck fast to the metal surfaces, and were carried past the fish collection sluice and into the debris sluice below (at K) or into the intake flow behind the screen. As recommended by Dr. Marcellus of Con Ed, the manufacturer repositioned the outside low-pressure spray header (from E of version 1 to EE of version 2), which cured the problem of unreleased fish, at least while the spraywash was functioning at its intended rate of flow. But during the field tests on version 2, I observed inadequate spray patterns from all three low-pressure headers (EE and FF) owing to clogged spray nozzles, an apparent fault of poor debris straining at the service pump.

2. Obstruction of the inside fish spray by algal matting. If captive fish spill as intended from an overturning fish rail and onto the inclined surface of the descending screen panel, then the freeing of fish from the panel surface is aided by a row of directed low-pressure jets (F on Figure 1) that spray water *through* the descending panels from a location between the ascending and descending halves of the travelling screen. But during the months (January to April) of the initial tests on Royce version 1, that fish spray was ineffective owing to a covering, over the extent of every screen panel, of an embedded filamentous alga, which prevented much of the spray from penetrating the screen mesh. As a consequence, many fish were not freed from the surface of the algal matrix, but were carried past the fish collection sluice (H) into the high-pressure debris spray (at J on version 1), and thus were blown into the debris sluice (K) with the algae and other debris. Although the river loading of filamentous algae is highest during winter months, I observed this problem, although to a lesser extent, as late as June. The magnitude of fish loss attributable to this process is not known with any precision owing to the difficulties of inspecting large quantities of debris.

As recommended in Fletcher (1985), a fundamental reordering of the fish and debris removal systems was incorporated into the design of the reconfigured device (Royce version 2; Figure 2). The related alterations were essentially five in number:

i. a repositioning of the primary high-pressure debris header (from J of version 1 to JJ of version 2) so that its jets now blow through the *ascending* screen panels;
ii. a relocating of the primary debris sluice (KK) to the ascending side of the screen;
iii. the adding of an inside low-pressure fish spray and a repositioning of the existing inside fish spray (location FF);
iv. the adding of longitudinal spray deflectors to the backs of the panel rails, as a means of preventing disturbance to captured fish as the ascending fish rails pass in turn through the relocated high-pressure debris spray;
v. the adding of an articulated metal shield (L) for protecting the ascending fish rails against the debris that would otherwise fall into the rails as the screen panels pass through the (relocated) high-pressure debris spray.

This reordering of the debris removal and fish recovery systems was meant to resolve the problem of poor fish recovery associated with the obstruction of the inside fish spray by the algal matting, the intention being that if the algal mat were blown loose from the ascending side of the screen—and if that removal should leave the ascending fish rails (and the fish within) undisturbed in the process—then the low pressure fish sprays (at FF on the descending side of the screen) might do their work as intended. In experiments with debris loading of the replicate device in the Houston flume, the relocated high-pressure jets removed embedded (or "stapled") filamentous algae as intended. In both the flume tests and the site tests, captive fish passed undisturbed through the high-pressure spray, but debris tests at Indian Point (on Royce version 2) were inconclusive, as no filamentous algae were present in the river during the testing period (August–October 1986). Although the articulated shielding device (L) fulfilled its function in the flume tests, its mechanical reliability, as currently designed, remains uncertain.

3. Inadequate width and shape of the fish collection sluice. Should the fish recovery system operate as intended, the fish spilled from the overturning screen rails are meant to slide or fall into a fish sluice at the rear of the device, and from there be carried by a common conduit back to the source waters. The fish sluice is supplied, at its farthermost end from the return conduit, with a stream of running water. Owing to the semicircular shape of the original sluice (H), the effective width of the stream was too narrow, irrespective of the speed of the stream flow. As observed during the initial field tests (of Royce version 1), the livlier fish would often spring loose from an overturning screen panel (at D) and sail over the fish sluice altogether or strike the far side of it, instead of falling directly into the sluice water as intended. As recommended, the manufacturer increased the width of the sluice and changed its shape from semicircular to rectangular (HH), thus increasing the effective width of the stream). The desired width was determined from filmed trajectories of falling fish.

4. Ill-positioned flap seal. As a part of the manufacturer's standard design, a panel of flexible material (G), called a flap seal, is affixed to the inward edge of the fish collection sluice and extends across the width of the screen. In its relaxed position, the flap seal is inclined upwards and it projects slightly into the path of travel of the downward moving panel rails (hence the "flap"). When correctly positioned, the flap seal is meant to prevent fish from dropping between the screen and the fish sluice. During the initial field tests (of Royce version 1), the flap seal had been relocated in a position that left a sizeable gap between the seal and the travelling panels, a positioning that allowed debris (and entangled fish) to pile atop it in heaps. Because debris is now removed from the screen panels at the front side of the machine (at JJ), little debris should reach the back side, so a standard flap seal (at GG) would probably perform as intended. Although the flap seal was effective in the flume tests, it was not tested in the field trials of the reconfigured machine. An alternate device, designed by Dr. Marcellus, had been installed in its place, but this alternate device interfered with the fall of fish to the collection sluice, so it was removed during the field tests. Even in the absence of any shielding device whatever, few fish fell into the gap between the screen and fish sluice, but the flap seal (or alternative device) should be installed and observed especially during winter months when the intake of filamentous algae is highest.

5. Shear-driven vortices in the fish rails. Underwater dye studies of the flow path lines around the manufacturer's standard fish rails (B, Figure 1) revealed longitudinal vortices along the lateral axes of the rails that were strong enough to impose orbital motions and consequential buffeting on the fish captured by the rails. The dye studies showed these vortices to be shear driven by the acceleration imparted to the main flow by the leading edges of the fish rails (see Figure 7, page 22). The redesigned fish rail (installed on Royce version 2) now has an elevated leading edge that creates a flow stall immediately behind the elevated portion, which provides a somewhat sheltered region for captive fish. With this rail design (and the auxiliary rail screen discussed in the next item), swimming fish are now more actively caught by the ascending fish rails, and once caught the fish suffer less buffeting and damage.

6. Avoidance and escape of actively swimming fish. Fish and flow experiments on the standard fish rail revealed small proclivity on the part of actively swimming fish to remain sufficiently within the bounds of the ascending fish rails to be captured and raised from the water. The redesigned rail now has an auxiliary screen, 3 inches in height, attached to its leading edge. Swimming fish enter this new profile preferentially, and once within it they tend to remain (as opposed to repeated escape from the standard rails of Royce version 1). The increase in the removal rate of impounded fish is an important improvement, since the frequencies of imposed death and injury increase in proportion to entrapment time and repeated contact with the barrier screen.

SECTION 2.
Fish and flow experiments in the hydrodynamics flume

This section contains a description of the Royce hydrodynamics flume, together with some of the experimental findings that led to the redesigning of the fish catching rails.

Following HRFA's disapproval of the prototype screen as originally configured, the manufacturer constructed a replica of the machine in the hydrodynamics flume in Houston and reconfigured it after the recommendations reported in Fletcher (1985) (and reviewed in Section 1). As later reported to you in Fletcher (1986a and 1986b), I conducted flume experiments on those revisions, including underwater filming of debris loading and recovery of fish. The flow marking experiments on the fish rails and screen panels, however, are described more fully here than in previous reports.

With the exception of the design of the articulated debris shield (L on Figure 2) and a trial apparatus, favored by Dr. Marcellus, for replacing the flap seal (G), I believed the various modifications to have been sufficiently proven by this experimental work to merit a formal retesting of the screening system. A two-part testing program (on Royce version 2) was eventually carried out, the results of which are documented in other sections of this report.

A diagram of the Royce hydrodynamics flume is shown by Figure 3 (page 15), and the installation of the replicate screen is shown by the photographs on page 17. The overall length of the flume and inlet chamber is about 49 feet, and in its test section the flume is 7 feet wide with sides 5 feet high. For the experimental work on the replica, water depth was 4 feet. The system contains about 12,000 gallons of water, which is circulated by a 24 inch propeller (a bow thruster) located in the return ducting. The propeller will drive the flow at speeds to 60 cm/sec in the test section of the flume. More complete specifications of the flume and its apparatus are given in the caption to Figure 3. The flume is operated and maintained by Trent Gathright of the Royce Equipment Company. Although I designed the flume, Mr. Gathright directed its engineering and construction. He was also an active participant in the experimental work, more often as collaborator than assistant.

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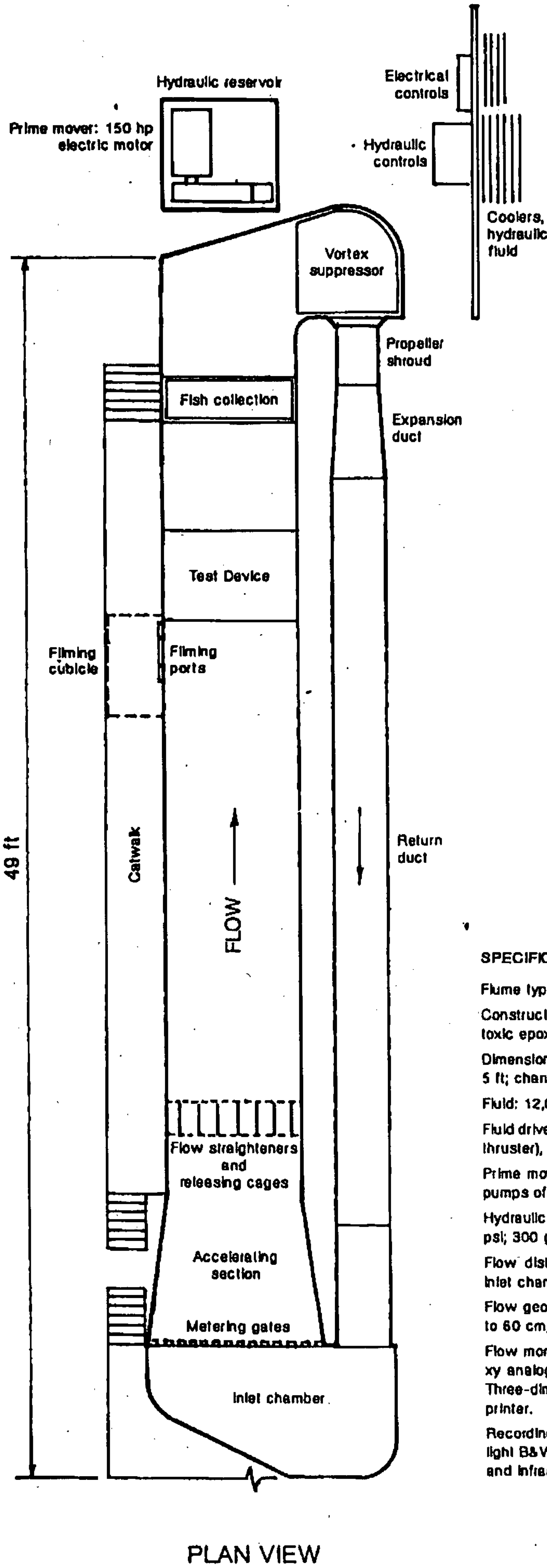


FIGURE 3. Diagram of Royce hydrodynamics flume.

SPECIFICATIONS

Flume type: Open channel, recirculating.

Construction: Steel, coated with Carboline (a non-toxic epoxy).

Dimensions: Overall length 49 ft; channel depth 5 ft; channel width main flume 7 ft.

Fluid: 12,000 gals fresh water; continuous filtration.

Fluid driver: 24 in diameter shrouded propeller (bow thruster), hydraulically driven and controlled.

Prime mover: 150 hp electric motor connected to pumps of hydraulic system.

Hydraulic system: Dual pumps, 100 gpm at 2000 psi; 300 gal reservoir and auxiliary coolers.

Flow distribution: 98 gated metering tubes from inlet chamber.

Flow geometry: Laminar in test section at speeds to 60 cm/sec.

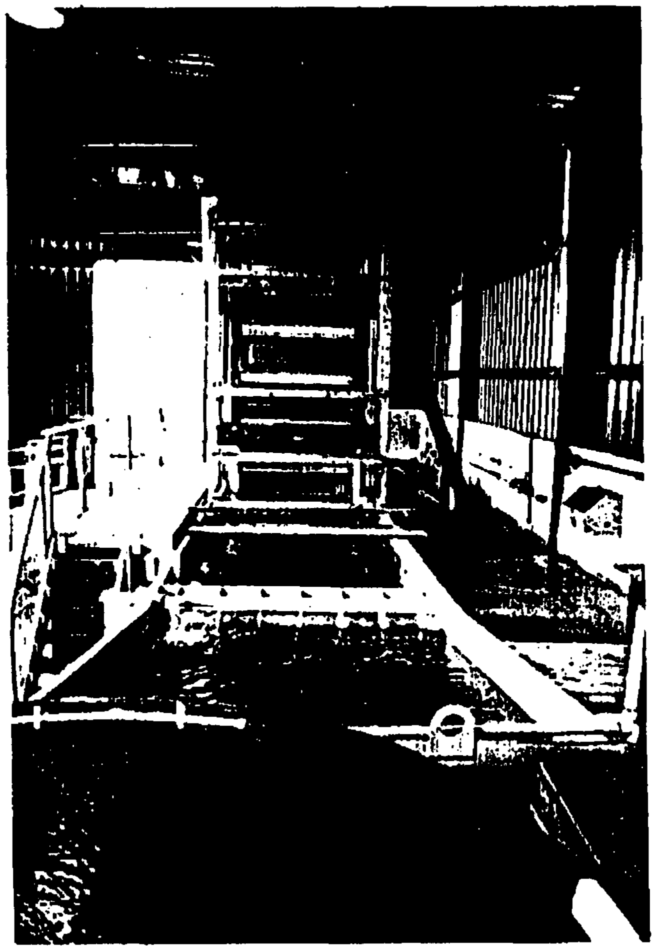
Flow monitoring: Electromagnetic flow meter with xy analog readouts; attached to digital converter. Three-dimensional velocity display on monitor and printer.

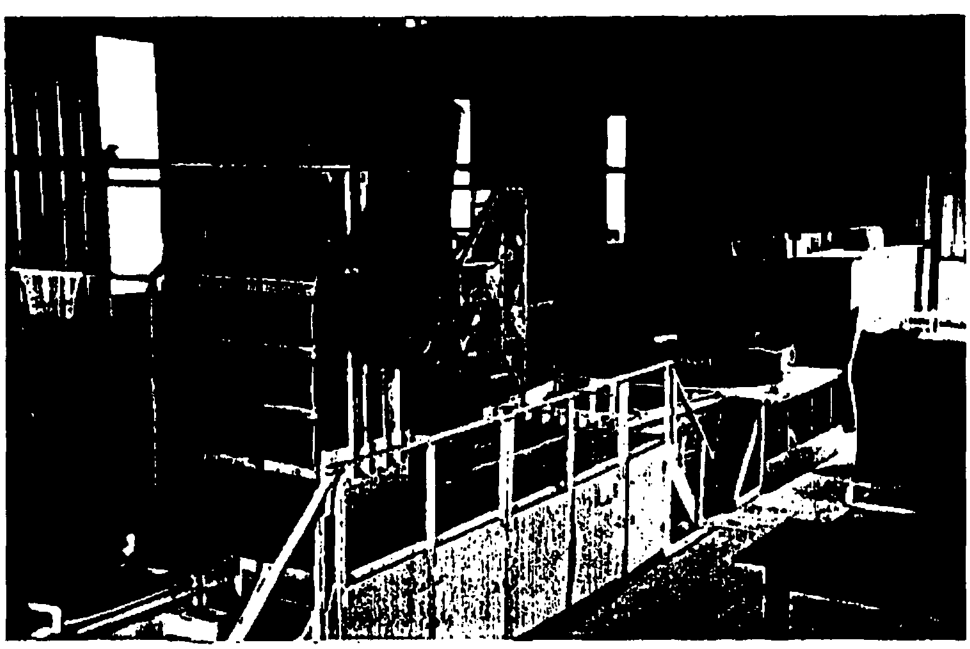
Recording apparatus: Color ccd video camera; low light B&W ccd video camera; 35mm camera. White and infrared lighting; underwater filming ports.

Figure 4 (facing).

Top: View of hydrodynamics flume looking downstream from inlet end. Circular structure in immediate foreground is one of two fish holding tanks on a platform above the flume. Flow straighteners can be seen in middle foreground. The surface disturbance visible in the photograph is owed to the discharge from an outlet pipe of the filtration system (at the left end of the flow straighteners). The filtration flow is usually turned off during experiments.

Bottom: Installation of the Indian Point replica. Except for the depth below the water surface and the width of the screen panelling, the replicate machine is identical to the prototype machine at Indian Point. The technician in the photograph (Mr. Gathright) is standing on the catwalk directly over the underwater filming cubicle.





Flow marking experiments.
The initial experimental work in the Houston flume, on the modifications eventually incorporated into the reconfigured machine, was undertaken, for the most part, over the period 2 December 1985 to 24 February 1986 (as reported in Fletcher 1986a and 1986b). The six major alterations addressed in that work are itemized in Section 1 (pages 10–13) of this report. Many of the underwater experiments were recorded on video tape or 35mm film (referenced in the data register, Appendix A). In this section, the topics of interest from that experimental work are the findings that led to the redesigning of the fish catching rails.

We commenced our underwater experiments by releasing fish upstream in the flume and observing their behavior as they were carried downstream to the screen. Most of the fish employed in these early experiments were juvenile shiners, *Notemigonus crysoleucas,* obtained locally. At the two water speeds employed in the experiments (30 and 45 cm/sec), fish behavior was similar, although the juvenile shiners, in not being strong swimmers, were less able to stem the flow at the higher flow speed. At both flow speeds, we discovered that actively swimming fish (those able to maintain station) were not readily caught by the (upward moving) fish rails.

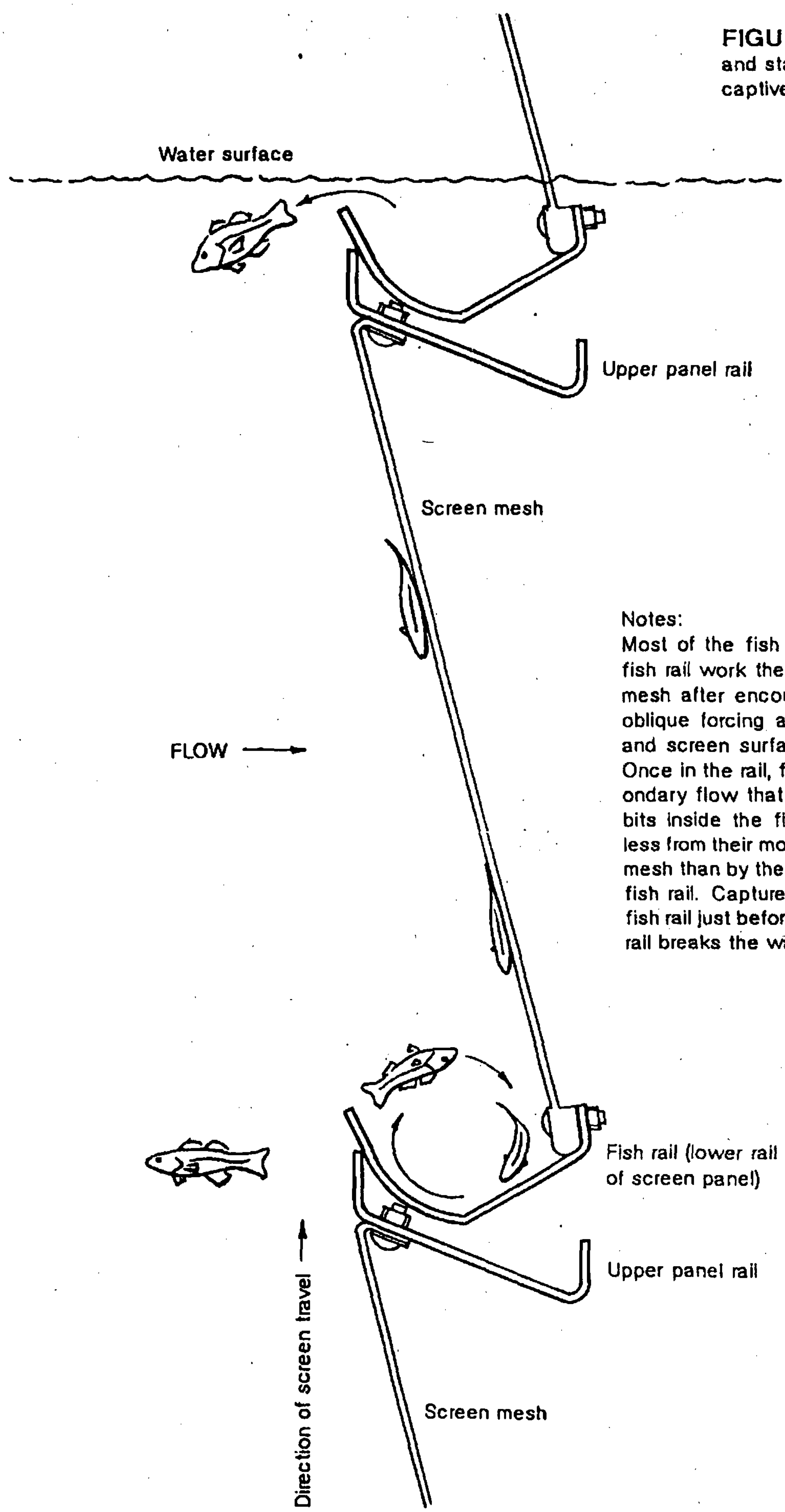
Virtually all of the test fish that entered the fish rails had worked their way down the inclined screen mesh (or were carried down the mesh by the oblique force of the water flow) after being flattened ("impinged") against the screen. Once in the vicinity of a fish rail, they were caught in a secondary flow, interior to the rail, that swirled them about in the manner depicted on Figure 5 (page 19). Fish captured in this fashion were injured less by their motions along the screen mesh (which, in the Royce device, has a smooth surface) than by the buffeting they received in the fish rails.

We also discovered that captured fish would often escape an ascending fish rail just before the leading edge of the rail broke the surface, as indicated on Figure 5. Apparently, the fish were able to sense their nearness to the water surface and reacted to it by darting out from the rail confines into deeper water.

As a means for examining the flow geometry at the screen panels and rails, we constructed dye releasing apparatus and established flow profiles of the Royce standard screen panel, the Ristroph panel of another manufacturer, and several trial shapes of our own devising. For each profile, we released the dye (potassium permanganate) on 1 cm vertical intervals, just upstream of the subject, and photographed each dye release (40 to 50 per profile). Figure 6 on page 20 shows two such dye tracings. From these photographic records, we assembled complete flow profiles of the panel sections (as in Figure 7 on page 22).

Continued on page 21

FIGURE 5. Effects of flow and standard screen panel on captive fish.



Notes:
Most of the fish that enter the standard fish rail work their way down the screen mesh after encountering the screen; the oblique forcing angle between the flow and screen surface aids that movement. Once in the rail, fish are caught in a secondary flow that swirls them in rapid orbits inside the fish rail. Fish are injured less from their movement down the screen mesh than by the buffeting received in the fish rail. Captured fish often escape the fish rail just before the leading edge of the rail breaks the water surface.

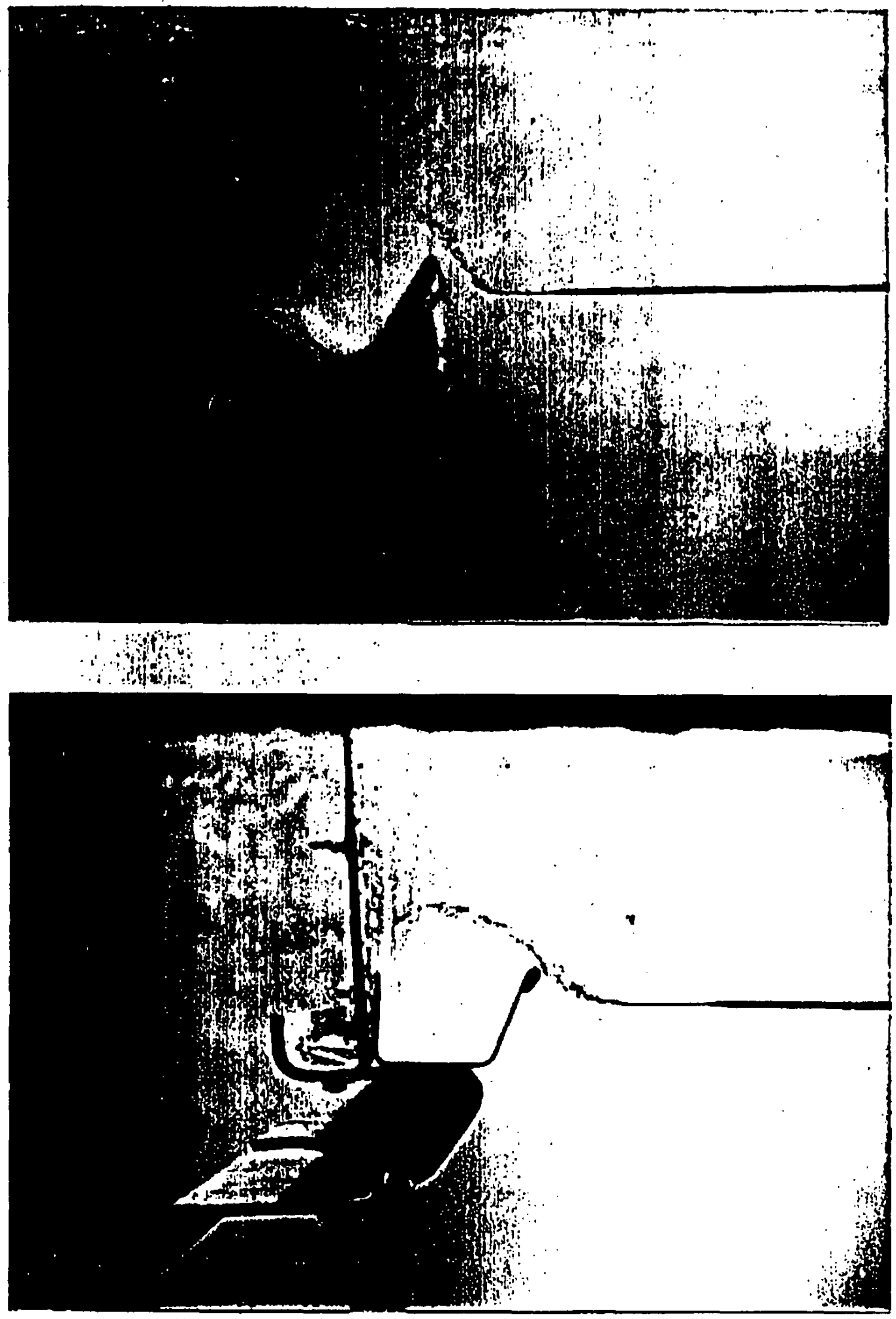


Figure 6. Top: Typical dye marking of a flow pathline, screen panel of Royce version 1. Bottom: Typical dye marking of a flow pathline, standard Ristroph panel, as manufactured by the Rexnord Company. A complete profile of flow pathlines consisted of similar dye releases at vertical intervals spaced 1 cm apart.

As illustrated by Figure 7 (page 22), the dye studies of the Royce standard screen panel revealed the cause of the rapid orbiting of the fish caught in a fish rail. The water interior to the rail was being shear driven, by the main flow through the screening, in the form of an independent, longitudinal vortex of such strength that test fish were not able to maintain a stable position within the rail. In consequence of these imposed swirling motions, captive fish were often injured by repeated contact with the screen structure at the rear interior of the fish rail.

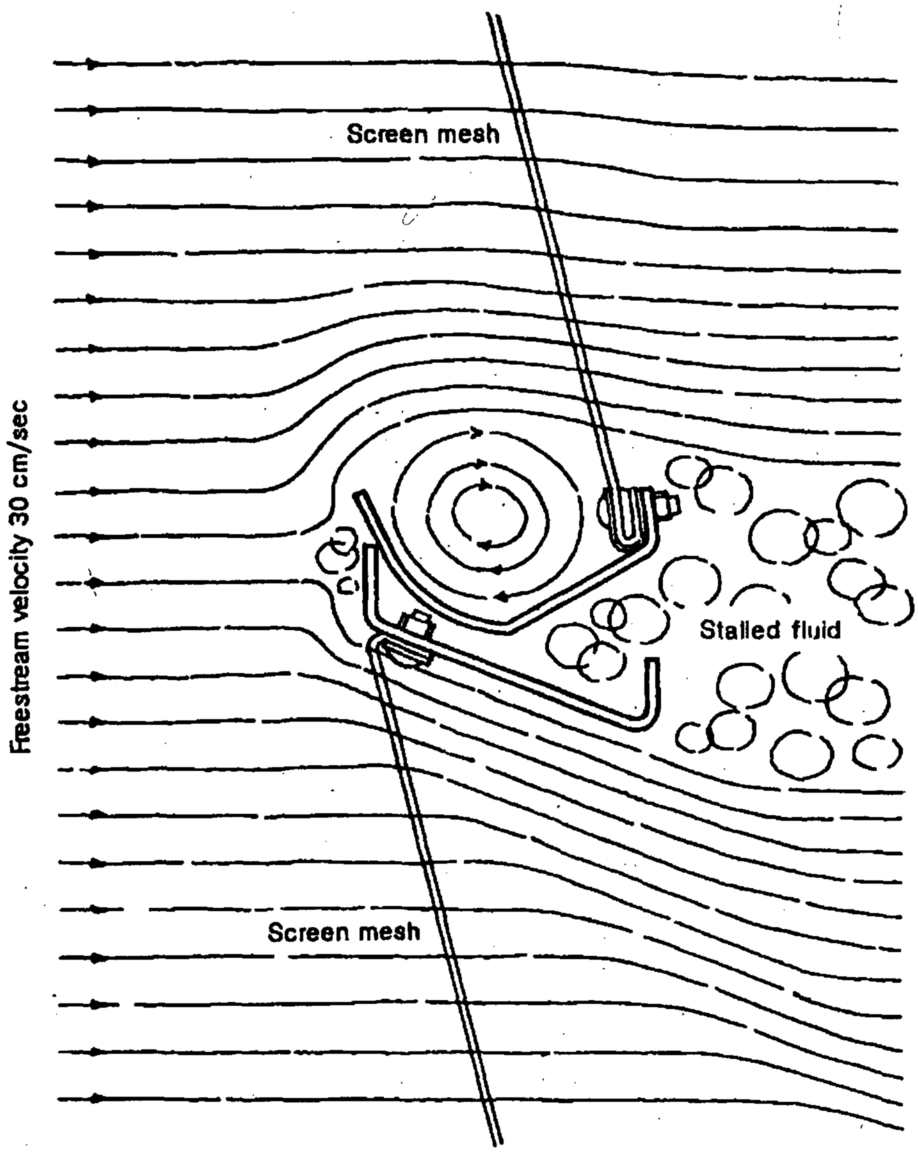
The independence of the rail vortex was evident from the long (and visible) duration of dyed fluid spinning within the rail following shut off of the dye supply. The fading in color of the dyed vortex was also an indication of the rate of turbulent exchange between the main flow and the captive rail water.

Because the fish rail is also a structural member of the screen panel, the latitude allowed us in reshaping the rail was somewhat restricted, but I believed the vortex could be eliminated by replacing it with a flow stall immediately ahead of the rail (or, more precisely, ahead of its back wall). I hoped to bring about that alteration in flow geometry by recurving the rail profile, by lowering its leading edge, and, to prevent the escape of captured fish, by affixing a low auxiliary screen to the leading edge. We did some initial studies on rail shaping, but that developmental work was not completed in the time alloted to us. Instead, Mr. Gathright employed the alternate strategem of merely elevating the leading edge of the standard rail, which is now the rail shape of the reconfigured machine (Figure 2).

As shown on Figure 8 (page 23), the elevated leading edge of the modified rail trips the main flow, and the resulting turbulence immediately behind the front wall of the rail provides a somewhat sheltered region for captured fish. The diminished vortex at the rear of the rail imposes less disturbance to the fish than the vortex of the unmodified rail. The auxiliary screen proposed for the leading edge of the modified rail was retained, but the screening is made from expanded metal (with diamond shaped perforations) instead of wire mesh, apparently for ease of construction. The perforations are large in comparison to the mesh size of the screen panels, but in tests with fish small enough to fit through the perforations of the auxiliary screen, the numbers of fish escaping the rails in that manner were insignificant.

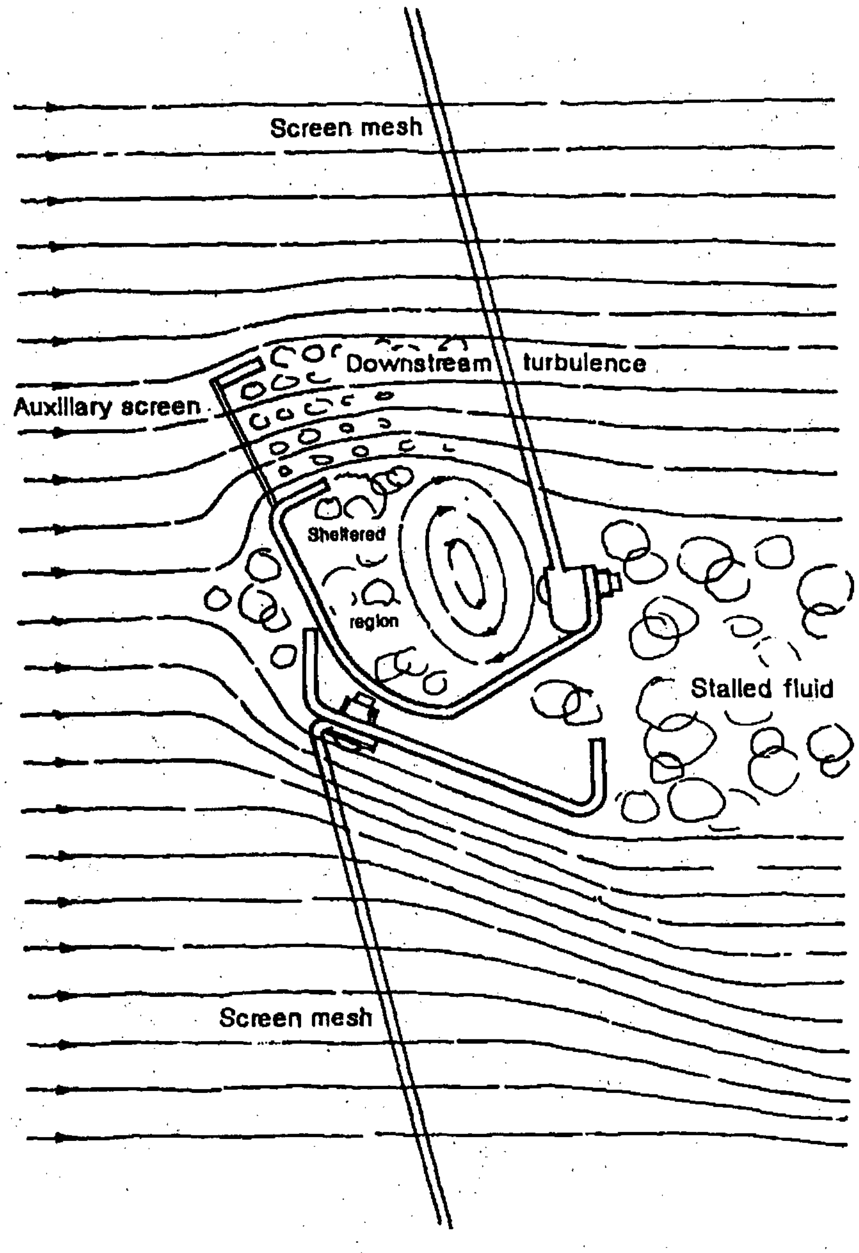
The auxiliary screen creates a downstream turbulence apparently favorable to fish capture. In experiments with shiners, and later, in the flume tests with white perch from the Hudson, many of the fish that moved into the vicinity of the rails were observed to dive, preferentially, behind the auxiliary screen and into the rail (and remaining there), as opposed to the active avoidance reactions of fish swimming freely in the accelerated flow above the unmodified rails of Royce version 1.

FIGURE 7. Flow profile of Royce standard screen panel and rails.



Notes:
Composite pattern of flow pathlines reconstructed from photographed dye releases spaced at 1 cm vertical intervals. The flow geometry surrounding the adjoining panel rails was similar at the (upstream) test speeds of 30 and 45 cm/sec, although the angular velocity of the captive vortex in the fish rail was greater at the higher fluid speed. The rail vortex is independent of the flow through the screen mesh, except for turbulent exchange across the (shearing) boundary between the two.

FIGURE 8. Flow profile of reconfigured fish rail.



Notes:
Composite geometry of flow pathlines reconstructed from photographed dye releases spaced at 1 cm vertical intervals. Elevated leading edge of the fish rail alters the flow geometry by moving the rail vortex rearwards, thus creating a region of stalled, captive fluid where fish are able to maintain swimming equilibrium. Once captured, fish are prevented from escaping the (upward moving) rail by the auxiliary screen. Freely swimming fish do not avoid the turbulent entry behind the auxiliary screen and its supporting bar as consistently as they avoid the accelerated flow over the standard fish rail (Figure 7).

SECTION 3.
Flume tests, final testing program, Royce version 2.

Sections 3 and 4 of this report contain the results of the final, two-part program of tests on the fish conserving properties of Royce version 2, the reconfigured prototype screen. These results are evaluated in Section 5 by comparing them to the field and flume observations of Royce version 1 and to the results from the testing by Consolidated Edison of version 1 (Con Ed 1985). The requirements of the testing program for Royce version 2 were given in Fletcher (1986c); for convenience of reference the test flume portion is outlined below. The flume tests were carried out over the periods 15–18 July and 12–15 August 1986 by myself, Mr. Gathright, and assistants from the Royce Equipment Company.

Outline of required tests, Royce hydrodynamics flume.

A. Underwater system
  1. Documentation, by underwater filming and quantitative measures, of events associated with capture and avoidance:
     a. Water speeds: 30 cm/sec and 45 cm/sec.
     b. Species: local shiners; juvenile white perch and striped bass from Hudson River.
     c. Sample sizes: Upstream release of 20 to 50 fish, each sample, for underwater filming at moving screen; 3 or more replicates, each set of experimental variables.
     d. Environmental records: Temperatures and chemical properties of water in holding tanks and flume.
     e. Temporal records: Holding times; re-use of samples. Camera clock for flume experiments.
  2. Report of results.
     a. Register of experiments and experimental variables.
     b. Sythesis of experimenters' descriptive observations.
     c. Calculations of capture probabilities.

B. Above-water system
  1. Contemporary observations and quantitative measures of events:
     a. Examinations of [items 1–4, pages 10–12 of this report].
  2. Report of results
     a. Register of experiments and experimental variables.
     b. Compilation of data and synthesis of experimenters' descriptive observations.

Instrumentation employed in flume tests:

Cole Parmer model 5983 pH meter.
Fisher Scientific model 152 conductivity meter.
Marsh McBirney model 511M electromagnetic current meter.
Aquarist #35100 ammonia test kit.
Stem thermometers.
Panasonic model WV-3230 ccd color video camera.
Chugai model BS-704R high resolution B&W video camera.
Canon model AE-1 35mm camera.

Flume underwater tests

The measurement of importance from the flume underwater tests is the empirical probability that a fish, released upstream, will be captured and removed from the water on its first contact with the screening device.

16–17 July 1986

Species: *Notemigonus crysoleucas,* 11.0 cm mean fork length.
Water of origin (fish farm): pH 6.95, temperature 24°C.
Holding tank: pH 8.3, temperature 24°C.
Flume water: 3 days residence before tests, continuously filtered and circulated; pH 8.1, temperature 26°C, conductivity 1.5×10^3 μmho/cm (distilled water 64 μmho/cm).
Experimenters: I. Fletcher, T. Gathright, R. Ewbank, C. Sunley.

Fish samples released 15 feet upstream of travelling water screen; low light levels (covered flume); fish behavior at screen front recorded on video tape with the Chugai BS–704R ccd through underwater filming port; dark camera cubicle. The following results were extracted from the tapes.

Trial No.	*Sample size*	*Water speed cm/s*	*Total fish observed*	*Lost from view*	*Escaped screen*	*Caught on contact*
1	20	30	10	1	1	8
2	20	30	16	7	5	4
3	20	30	8	2	1	5
4	50	30	18	6	1	11
5	50	30	19	5	8	6
6	40	30	19	5	8	6
			90	26	24	40

18 July 1986

Species: *Notemigonus crysoleucas,* 6.5 cm mean fork length.
Water of origin (fish farm): pH 6.95, temperature 24°C.
Holding tank: pH 8.1, temperature 31°C.
Flume water: 5 days residence time before tests, continuously filtered; pH 8.1, temperature 31°C, conductivity 1.5×10^3 μmho/cm.
Experimenters: T. Gathright, R. Ewbank, C. Sunley.

Fish samples released 15 feet upstream of travelling screen; low light levels (covered flume); fish behavior at screen front recorded on video tape with the Chugai BS-704R ccd through underwater filming port; dark camera cubicle. The following results (overleaf) were extracted from the tapes.

Trial No.	Sample size	Water speed cm/s	Total fish observed	Lost from view	Escaped screen	Caught on contact
1	20	30	11	0	1	10
2	20	45	15	0	0	15
3	20	45	18	3	2	13
4	20	45	19	3	2	14
			63	6	5	52

12 August 1986

White perch juveniles from the Hudson River and striped bass juveniles from the Verplankt hatchery shipped by air to Houston. Of 750 fish in six containers, approximately one-third survived in a condition suitable for use in the flume tests. The pH of the water in the shipping containers measured 7.0; ammonia levels were off scale. Conductivity of the water of origin reported to be 500 μmho/cm, but since 5 per mille salt had been added to the container water, we did not test its conductivity. As the fish were red in the gills and sluggish, we transferred them as quickly as possible to the (two) holding tanks (which were fitted with O_2 bubblers), but we first lowered the pH of the tank water from 8.2 to 7.5 in one tank with sodium bisulfate, and to 7.8 in the other with hydrochloric acid. The temperatures of both the container water and the tank water were 28°C.

13 August 1986

Species: *Morone americana,* 5.0 cm mean fork length.

Holding tank: pH 7.5, temperature 28°C.

Flume water: 3 weeks residence time, continuously filtered and aerated; pH 8.2, temperature 28°C, conductivity 1500 μmho/cm.

Experimenters: I. Fletcher, T. Gathright, R. Ewbank.

Fish samples released 15 feet upstream of travelling screen; low light levels (covered flume); fish behavior recorded on video tape with the Chugai BS-704R ccd through underwater filming port; dark camera cubicle. The following results were extracted from the tapes.

Trial No.	Sample size	Water speed cm/s	Total fish observed	Lost from view	Escaped screen	Caught on contact
1	25	30	*			
2	25	30	10	5	1	4
3	25	30	14	6	3	5
4	25	30	11	2	1	8
5	25	45	6**	1	1	4
6	25	45	5**	3	0	2
7	25	45	7	2	1	4
8	25	45	7	4	1	2
			60	23	8	29

* Trial terminated after release of fish; screen not operating. Fish in this sample drifted with the flow in a tight group to the screen face, then scattered. Two of about 15 at the screen front were impinged; 3 or 4 darted downwards into a fish rail and remained there; 4 darted forward after contacting the screen; the remainder were lost from view.

** 10 to 15 fish of the sample were drawn to the screen along the bottom of the flume and could not be accounted for with any accuracy.

14 August 1986

Species: *Morone saxatilis,* 7.1 cm mean fork length.

Holding tank: pH 7.8, temperature 28°C.

Flume water: three weeks residence time prior to tests, continuously filtered and aerated; pH 8.2, temperature 28°C, conductivity 1500 μmho/cm.

Experimenters: I. Fletcher, T. Gathright, R. Ewbank.

Fish samples released 15 feet upstream of travelling screen, except as noted; covered flume, low light levels except as noted; fish behavior at screen front recorded on video tape with the Chugai BS-704R ccd through underwater filming port; dark camera cubicle.

Trial No.	*Sample size*	*Water speed cm/s*	*Total fish observed*	*Lost from view*	*Escaped screen*	*Caught on contact*
1	25	30	*			
2	25	30	3	0	2	1
3	25	45	10	2	1	7
			13	2	3	8

* Trial terminated. Experimenter reported (orally, on tape) that all the fish went immediately to the bottom upstream and remained there, apparently because a light had been left on in the flume.

In none of the tests with striped bass did fish of a released sample reach the screen in quantity. In experiment 2, no fish appeared at the screen within 3 minutes of release; the flume was then made totally dark for 30 seconds, but the fish remained upstream. After an hour of observation, only three fish had come into view at the screenfront. In experiment 3, fish were released in a dark flume; the low-level lighting was turned on 1 minute after release. Although the fish had moved farther along the flume bottom than usual, they still tended to keep station upstream of the screen. During an hour of observation, ten fish came into view at the screenfront.

15 August 1986

Species: *Morone saxatilis,* 7.1 cm mean fork length.

Holding tank: pH 7.8, temperature 29°C.

Flume water: three weeks residence time prior to tests, continuously filtered and aerated; pH 8.2, temperature 29°C, conductivity 1500 μmho/cm.

Experimenters: T. Gathright, R. Ewbank.

Fish samples released 15 feet upstream of travelling screen, except as noted; covered flume, low light levels; fish behavior at screen front recorded on video tape with the Chugai BS-704R ccd through underwater filming port; dark camera cubicle. The following results were extracted from the tapes.

Trial No.	*Sample size*	*Water speed cm/s*	*Total fish observed*	*Lost from view*	*Escaped screen*	*Caught on contact*
1	25	45	1	0	1	0
2	25	45	2	0	1	1
3	25	45	2	0	0	2
4	25	45	6	0	0	6
5	25	45	8	0	2	6
			19	0	4	15

(Footnote overleaf)

In trials 1, 2, 3, and 4, released fish went immediately to the bottom of the flume and kept station 6 to 8 feet upstream of the travelling screen. In trial 3, after 10 minutes into the experiment, the flume was darkened for 2 minutes, but the fish did not move any closer to the screen. After 30 minutes, two fish had come into view. In trial 4, of the six fish recovered, four were dead. In trial 5, the fish were released 4 feet upstream of the screen. The fish came suddenly into view at the screen front; six entered fish rails. Two of the six escaped before the rails ascended to the water surface. The remainder of the sample darted upstream and again kept station at the bottom of the flume.

Summary, flume underwater tests and experiments. On the question of conserving fishlife with a barrier device that operates on the principle of direct contact with the entrapped fish, impingement is inevitable, and what matters is the effectiveness of the fish-catching apparatus in removing the entrapped (and impinged) fish quickly and with little added harm. As revealed by the flume experiments of December 1985–February 1986, freely swimming fish were not readily captured (or retained) by the fish rails of screen version 1. We also determined from those experiments that test fish were injured less from impingement (from being flattened against the screen mesh) than from the buffeting imposed on the captured fish by the vortex action in the fish rails (Figure 5). The low rate of impingement injury is apparently owed to the smooth surface of the (Smooth-Tex) brand of screening mesh employed by Royce, as opposed to the more abrasive surface of standard wire mesh. Also, the oblique forcing angle between the inflow and the inclined surface of the Royce screen panel tends to move a struggling, impinged fish down the panel towards the fish rail, whereas in the more standard Ristroph design (Figure 6, bottom), the flow is normal to the surface of the screen panel and tends to hold the impinged fish in place.

Two alterations to the Royce fish rail were incorporated into the design of the reconfigured machine: the elevation of the fish rail's leading edge and the addition of the auxiliary screen (Figure 8). As determined from the flow and fish experiments discussed in Section 2, the modified rail profile reduced the vortex buffeting of captured fish. As determined from the tests reported in this section, the modified rails increased the likelihood of capture and retention of a fish on its first encounter with the device.

In the experiments on the standard (version 1) rails with juvenile shiners, virtually all the fish captured by the rails had first been impinged. Fish able to swim against the flow actively avoided the rail openings, and impinged fish that entered an ascending rail often escaped the rail before it cleared the water surface. In the testing of the reconfigured rails (reported in this section), 62% of the larger shiners were captured and retained on first encounter (of those fish that encountered the screen). In the tests with the smaller shiners, which were less able to stem the flow, 91% were captured and retained on first encounter, but most of these smaller fish, being weaker swimmers, were impinged before capture. These proportions were identical at both the water speeds employed (30 and 45 cm/s).

In the tests with Hudson River white perch, 77% were caught and retained on first encounter at the 30 cm/s water speed, while 80% were caught and retained on first encounter at the 45 cm/s water speed. The two proportions are statistically indistiguishable, as the 3% difference between them is well within the bounds of uncertainty. At both water speeds, many of the white perch were impinged before capture. The high impingement rates of both the white perch and the shiners is a consequence of the inability of the fish to keep station ahead of the screen, and not inconsistent with the recovery rates of weak swimmers in the field tests.

In the tests with the hatchery striped bass, 76% were caught and retained on first encounter (test speeds combined), most of which were freely swimming fish. Although few were impinged before capture, few of the released fish encountered the screen during the observations. The striped bass results should be viewed as inconclusive, owing to behavior probably not representative of striped bass behavior in the plant intake bays. The recovery rates of striped bass in the test flume were not consistent with the recovery rates of striped bass samples introduced into the test bay at Indian Point (a topic of Section 4).

Above water tests

Of the several modifications enumerated in Section 1 (pages 10–13) and incorporated into the modified machine, the above water flume tests were meant to produce information, under controllable conditions, on those items that influence the transport of captured fish from the upstream side of the machine to the fish sluice at the downstream side.

17 July 1986

Test: effectiveness of relocated, outside fish spray (EE of Figure 2) in freeing fish from overturning rail; see item 1, page 10.

Test species: *Notemigonus crysoleucas,* 6.5 and 11.0 cm mean fork lengths.

Experimenters: I. Fletcher, T. Gathright, R. Ewbank.

Each sample loaded into water-filled fish rail on upstream side of machine. Screen then activated until loaded rail had passed over the driver sprocket and through the outside spray wash.

Trial No.	*Sample size*	*Fish state*	*Not freed*
1	10	live	0
2	10	live	0
3	10	live	0
4	10	moribund	0
5	10	moribund	0

During these trials we noted the interference of a debris shield (location GG of Figure 2) with the trajectories of fish as they fell from the overturning screen panel to the collection sluice (events recorded on video tape). The manufacturer had substituted this shield (a suspended, swinging device made of a rigid plastic material) for the standard, flexible flap seal of screen version 1 (G of Figure 1). Because a large proportion of the fish in these tests struck the blade of the shield when falling from the overturning screen panels, we removed the shield altogether for the remainder of the above water tests.

Test: trajectories of falling fish, and reception of fish by collection sluice (HH of Figure 2); see item 3, page 12. No flap seal.
Species: ***Notemigonus crysoleucas,*** 6.5 and 11.0 cm mean fork lengths.
Experimenters: I. Fletcher, T. Gathright, R. Ewbank.

Each sample loaded into water-filled fish rail on upstream side of machine. Screen then activated until loaded rail had passed over the driver sprocket and past the fish collection sluice. In this test, numbers "misdirected" are fish that struck the inner sluice edge or fell between the sluice and the travelling screen—fish that failed to fall directly into the sluice as intended.

Ttial No.	*Fish sprays*	*Sample size*	*Mis-directed*	*Trial No.*	*Fish sprays*	*Sample size*	*Mis-directed*
1	off	10	4	11	on	10	1
2	off	10	1	12	on	10	0
3	off	10	2	13	on	10	2
4	off	10	1	14	on	10	0
5	off	10	2	15	on	10	3
6	off	10	4	16	on	10	2
7	off	10	1	17	on	10	1
8	off	10	3			70	9
9	off	10	3				
10	off	10	2				
		100	23				

17–18 July 1986

Test: passage of fish rail through high-pressure debris spray (JJ of Figure 2). No debris shield (L).
Species: ***Notemigonus crysoleucas,*** 6.5 and 11.0 cm mean fork lengths.
Spraywash pressure: 105 psi.
Experimenters: T. Gathright, R. Ewbank, C. Sunley.

Samples of ten fish loaded into each of two water-filled fish rails just above water surface on upstream side of machine. Travelling screen activated until loaded rails had passed through debris spray. Screen halted, spray shut off, rails examined for missing fish and for fish exhibiting apparent trauma (such as erratic swimming). Missing fish replaced, travelling screen then reversed and rails lowered to initial position above water surface. Spray turned on, described routine repeated ten times (20 rail replicates).

Trial No.	*Sample size*	*Escaped or missing*	*Apparent trauma*
1	20	0	none
2	20	0	none
3	20	0	none
4*	20	0	none
5	20	0	none
6	20	0	none
7	20	1	none
8	20	0	none
9	20	0	none
10	20	0	**
	200	1	

*Last trial on 17 July; test fish left in fish rails overnight; trials resumed 18 July, fish upright and swimming vigorously in rails; none replaced.
**See following tabulation (overleaf).

Individual examination of the 20 test fish at conclusion:

1. 1–2 scales missing.
2. 8–12 scales missing.
3. 6–8 scales missing.
4. 10–15 scales missing.
5. 6–8 scales missing.
6. 1–2 scales missing.
7. 3–4 scales missing.
8. No visible injury.
9. No visible injury.
10. 3–4 scales missing.
11. 1 scale missing.
12. 2–3 scales missing.
13. 2–3 scales missing.
14. 20–25 scales missing one side.
15. 6–8 scales missing.
16. No visible injury.
17. 4–5 scales missing.
18. No visible injury.
19. 1–2 scales missing.
20. 10–12 scales missing.

Summary, above-water tests and experiments. The above-water modifications incorporated into the prototype machine at Indian Point were brought about, for the most part, by a fundamental reordering of its debris removal and fish recovery systems (as discussed in Section 1). Screen version 1 had been designed with the intent of removing the captive fish before removing the captive debris (Figure 1); those removals are reversed in version 2 (Figure 2).

As a screen panel rises from the water on the upstream side of the reconfigured machine, it passes first through a high-pressure debris spray (JJ on Figure 2). The spray is prevented from blowing into the bottom rail (the fish rail) of the panel by a deflector now affixed to the spray side of each rail. If the deflector functions as intended, the spray jets blow water through the mesh of the screen panel but leave the rail water and captured fish undisturbed. From the testing evidence (page 30), the deflectors function as intended. Fish damage was limited to descaling, most of it minor, and at least some believed to be a consequence of handling.

We did not load the screen panels with debris during these tests, so the sliding debris shield (L of Figure 2) was not tested. This shielding function will be critical during winter and spring months in the Hudson, owing to the expected burdens of filamentous algae like those that prevented the fish-conserving apparatus of screen version 1 from functioning as intended. As reported in Section 4, the debris shield has not yet been tested on site, since the field testing of screen version 2 was completed during months when the winter algae were nearly absent from the river.

We discovered the need for rail shielding during the design and experimental phase of the flume work (December 1985–February 1986). We loaded the screen panels of the replicate machine with a filamentous pond alga by merely dumping it into the upstream end of the flume and running the machine until the alga had travelled downstream and covered several panels. The pond alga, which was similar to the winter algae of the Hudson, at least in its physical nature, was stapled firmly into the screen mesh by the force of the water flow and formed a cohesive matrix over each screen panel like the matting observed during the winter testing of prototype version 1 at Indian Point (Con Ed 1985). As we learned from our flume experiments, the high-pressure debris spray does not blow the stapled algal matrix clear of the screen mesh, but peels it downward instead, as the panel ascends through the spray. The lower panel rail (the fish rail), if unprotected, receives the whole of the algal mat, which displaces the rail water. The captured fish, if not otherwise washed out of the rail, become entangled in the algal mat, and the resulting mixture of fish and debris is carried over the driver sprocket and dumped into the fish sluice at the downstream side of the machine.

Both Mr. Gathright and I designed articulated debris shields, Gathright's a sliding device and mine a four-pin pivoting device. As Gathright's device, although unrefined, seemed to fulfill its intended function, mine was not constructed. The manufacturer adopted the Gathright design for screen version 2; the device has since been revised owing to some mechanical failings. Irrespective of the ultimate form of the front debris shield, it must be reliable enough to withstand continuous operation during the months of high algae intake at Indian Point.

Once through the high pressure spray, the screen panel travels over the driver sprocket of the machine and overturns. The captured fish are then meant to slide or fall from the inverted rail to a fish sluice. During the Con Ed field tests of screen version 1, some fish remained in the overturned rails, apparently stuck fast to the metal surfaces of the rails. In our flume tests of the repositioned fish spray (page 29), all test fish were freed from the overturning rails. But during these tests we noted the interference of a rear shielding device with the trajectories of fish as they fell from the overturning screen panels. The manufacturer had substituted this shield (a suspended, swinging device made of rigid PVC material) for the standard flap seal of screen version 1 (G of Figure 1). We removed the shield for the remainder of the above-water tests.

The fish released from the overturning rails are meant to fall directly into the flowing water of the fish sluice. During the field tests of screen version 1, lively fish were observed to spring away from the overturning panels and sail completely over the fish sluice or strike its far side. For screen version 2, the sluice was reshaped and widened. Our flume tests of fish trajectories (page 30) showed the reconfigured sluice to be adequate in width, at least for the species tested. None of the test fish trajectories reached the far side of the sluice. Some fish fell between the screen and the inner edge of the sluice, however, owing to the absence of the flap seal (location GG of Figure 2). For the sake of clear filming of fish trajectories, we ran 10 trials with the fish sprays off. With the sprays operating, fewer fish fell between the screen and sluice, but a flap seal that does not project into the paths of falling fish should be devised and tested.

SECTION 4.
Site tests, final testing program, Royce version 2.

The requirements of the testing program for Royce version 2 were given in Fletcher (1986c); for convenience of reference the site testing portion is outlined below. The Con Ed work scope for the testing program is reproduced in Appendix C. The site tests were carried out over the period August–October 1986 by Normandeau Associates, and Kenneth Marcellus was senior project biologist for Consolidated Edison. I observed the site testing routines at Indian Point on 26–27 August, 5 September, and 9–10 September. Some of those routines were recorded on video tape.

Outline of required tests, Indian Point test site

A. Above-water system
   1. Contemporary observations, descriptive records and quantitative measures of events.
      a. Transport of fish samples through high-pressure spraywash, with and without debris loading of screen; samples introduced into fish rails between water surface and debris wash; fractions lost and fractions injured.
      b. Recovery of samples at fish sluice, with and without debris loading of screen; samples introduced (or tallied) at station between debris wash and upper driver sprockets of machine; fractions lost and fractions injured.
      c. Examination and monitoring of items 1–4 under "Components of special interest" [see pages 10–12, this report].
   2. Report of results.
      a. Register of experiments and experimental variables.
      b. Sythesis of experimenters' descriptive observations.
      c. Compilation of data from experiments, and calculations of expectations of success, items A.1.a and A.1.b.

B. Recovery of impounded fish, known samples
   1. Documentation of capture probabilities and expectations of trauma.
      a. Species: juvenile white perch and striped bass; other species of convenience.
      b. Sample sizes: release of marked (or entrapped) samples in forebay, in sets of 100 or more; 2 or more replicates each species; collection of recoveries at fish sluice on logarithmic time intervals (see attachment); recovered fish examined immediately for injuries (death, damaged integuments, bleeding, avulsions, and abnormal swimming); fish not exhibiting observable trauma on collection to be held 8 hours and examined for latent mortality.

c. Environmental records: Intake water speeds; water temperatures; time of day and tide on release of sample; cycling speed of machine.

2. Report of results
   a. Register of experiments and experimental variables.
   b. Synthesis of experimenter's descriptive observations.
   c. Compilation of data; calculations of capture expectations and empirical probabilities of injury, each test species.

C. Opportunistic collections of impounded fish
1. Contemporary observations; descriptive records and quantitative measures of events.
   a. Collection of impounded, indigenous species; counts and identifications on collection (same observational protocols as item B.1.b).
2. Report of results.
   a. Register of collections and experimental variables.
   b. Compilation of data and observational results (rates of capture, fractions injured).

D. Sampling intervals, recovery of marked (impounded) fish:

Because of the nonexistence of field data on capture expectations for the prototype machine (or any similar device), sampling intervals corresponding to items B.1.b will have to be adjusted in the field on the basis of trial results. The initial trial recommended here [36 hours, 12 samples] is a best guess from test flume experiments. In any case, calculate all sampling schedules for recovery of marked (or impounded) releases by the following formulae (which, on the expectation of random encounter by freely swimming fish and active capture by the fish rails, will reduce uncertainty in the estimates of capture probabilities):

Duration of experiment:	T
Number of observations:	n
Sampling index:	$j = 1, 2, \ldots, n$
Sampling times:	$t_j = t_1, t_2, \ldots, t_n$ ($t_1 = 0$, $t_n = T$)
Intervals:	$\Delta t_j = t_{j+1} - t_j$
Scaling factor	δ (resolved by iteration)
In general:	

$$j = \frac{\ln(t + \delta)}{\ln \delta},$$

$$T = \delta^n - \delta,$$

$$t_j = e^{j \ln \delta} - \delta.$$

The first collection ($j = 1$ at $t_1 = 0$) after release of the sample should be taken on the first appearance of any individuals from the sample, which will depend on the (unknown) fishing success of the machine and its cycling rate. Sampling intervals will depend on the rate of fishing.

Above-water site tests.
Of the several modifications incorporated into the reconfigured machine, the above-water site tests were meant to produce information, under operating conditions, on the adequacies of the modifications that influence the transport of captured fish from the upstream side of the machine to the fish sluice at the downstream side. The purposes of the modifications are described in items 1–4, pages 10–12 of Section 1, and the tests are similar in their intents to the corresponding above-water flume tests reported in Section 3. The site tests were supervised by James Reichle of Normandeau Associates.

Passage of fish rail through high-pressure debris spray.
These tests were conducted three times in August 1986 (two of which I observed). The striped bass juveniles employed on one day were hatchery fish; the remaining test species had been captured from the intake bay by the machine itself. At the start of a trial, the fish sample was loaded into a fish rail above the water surface on the upstream side of the machine. The travelling screen was then activated until the loaded rail had passed through the debris spray (JJ of Figure 2). The screen was halted, the spray shut off, andthe rail examined for missing and injured fish.

Test date: 5 August 1986.
Spraywash pressure: 80 psi.
Screen travelling speed: 10 fpm.
River water temperature: 27°C.
Conductivity of river water; 3200 μmho/cm.

Trial No.	*Test species*	*Mean length*	*Sample size*	*Escaped or missing*	*Damaged*
1	Tomcod	9 cm	20	0	0
2	Tomcod		17	0	0
3	Tomcod		14	0	0
4	Tomcod		12	0	0
5	Tomcod		11	0	0
6	Bay anchovy	8 cm	10	0	0
7	Bay anchovy		9	0	1 a
8	Bay anchovy		9	0	3 a
9	White perch	7 cm	20	1	0
10	White perch		20	0	0
11	White perch		20	0	0
12	White perch		20	0	0
13	White perch		20	0	0
14	White perch		20	0	3 a
15	White perch		20	0	0
16	White perch		20	0	0
17	White perch		20	0	0
18	White perch		20	0	0
19	Amer. shad	11 cm	20	0	2 a
20	Amer. shad		20	0	2 a
21	Amer. shad		20	0	6 a,*b*
22	Amer. shad		20	0	9 a,*b*
			382	1	26

a Stunned; *b* Missing scales.

Test date: 26 August 1986.
Spraywash pressure: 90 psi.
Screen travelling speed: 11 fpm.
River water temperature: 27°C.
Conductivity of river water: 315 μmho/cm.

Trial No.	*Test species*	*Mean length*	*Sample size*	*Escaped or missing*	*Damaged*
1	Striped bass	7.5 cm	20	0	0
2	Striped bass		20	0	0
3	Striped bass		20	0	0
4	Striped bass		20	0	0
5	Striped bass		20	0	0
6	Striped bass		20	0	0
7	Striped bass		20	0	0
			140	0	0

Test date: 27 August 1986.
Spraywash pressure: 85 psi.
Screen travelling speed: 11 fpm.
River water temperature: 25.5°C.
Conductivity of river water: 349 μmho/cm.

Trial No.	*Test species*	*Mean length*	*Sample size*	*Escaped or missing*	*Damaged*
1	White perch	7 cm	20	0	4 a
2	White perch		20	0	0
3	White perch		20	2	1 a
4	White perch		20	0	1 a
5	White perch		20	0	0
6	White perch		18	1	2 a
7	White perch		20	2	1 a
8	White perch		20	1	0
9	White perch		20	0	1 a
			178	6	10

a Stunned.

Recovery at fish sluice.
The following tests apply to the fish conserving apparatus at the back (the downstream side) of the reconfigured machine, and they correspond to the flume tests on the fish sprays, the flap seal, and the fish sluice reported in Section 3. They were conducted concurrently with the three sets of tests tabulated above. Following the transit of a loaded fish rail through the high-pressure spray in many of those tests, the damaged fish would be removed, the fish sprays turned on, and the screen activated. The remainder of the fish then became the test sample for the apparatus tests at the back side of the machine.

As we also observed in the Houston tests, the swinging shield (at location GG) interfered with the trajectories of fish falling from the overturning screen panels, so it was removed at the end of trial 13 on 5 August. In the following tabulations, the numbers of test fish recovered from the fish sluice and the numbers recovered from the auxiliary debris sluice are entered in the columns "Fish sluice" and "Debris sluice." The observed injured among the fish sluice recoveries are recorded in the last column.

Test date: 5 August 1986.
Pressure, outside fish spray: 5 psi.
Pressure, inside fish sprays: 8 psi.
Screen travelling speed: 10 fpm.
River water temperature: 27°C.
Conductivity of river water: 3200 μmho/cm.

Trial No.	*Test species*	*Mean length*	*Sample size*	*Fish sluice*	*Debris sluice*	*Damaged, fish sluice*
1	Tomcod	9 cm	20	17	0	0
2	Tomcod		17	11	3	0
3	Tomcod		14	14	0	2 a
4	Tomcod		12	12	0	1 a
5	Tomcod		11	10	0	0
6	Tomcod		10	10	0	0
7	Bay anchovy	8 cm	10	9	0	0
8	Bay anchovy		9	9	0	3 a
9	Bay anchovy		9	8	1	2 a
10	White perch	7 cm	19	13	0	0
11	White perch		20	11	0	0
12	White perch		20	13	4	0
13	White perch		21	14	2	0
14*	White perch		20	12	3	0
15	White perch		20	16	2	0
16	White perch		21	19	2	0
17	White perch		20	20	0	0
18	White perch		20	20	0	1 *c*
19	White perch		20	18	2	1 *c*
20	Amer. shad	11 cm	20	20	0	4 a,b
21	Amer. shad		20	19	0	4 a,b
22	Amer. shad		20	20	0	6 a,b
23	Amer. shad		20	17	1	9 a,b
24	Amer. shad		20	16	3	0
			413	348	23	33

*Rear shield removed. a Stunned; *b* Missing scales; *c* Dead.

Test date: 26 August 1986.
Pressure, outside fish spray: 4 psi.
Pressure, inside fish sprays: 4 psi.
Screen travelling speed: 11 fpm.
River water temperature: 26°C.
Conductivity of river water: 315 μmho/cm.

Trial No.	*Test species*	*Mean length*	*Sample size*	*Fish sluice*	*Debris sluice*	*Damaged, fish sluice*
1	Striped bass	7.5 cm	20	20	0	0
2	Striped bass		20	20	0	0
3	Striped bass		21	21	0	0
4	Striped bass		20	20	0	0
5	Striped bass		20	20	0	0
6	Striped bass		19	19	0	0
7	Striped bass		20	20	0	0
			140	140	0	0

Test date: 27 August 1986.
Pressure, outside fish spray: 4 psi.
Pressure, inside fish sprays: 4 psi.
Screen travelling speed: 11 fpm.
River water temperature: 25.5°C.
Conductivity of river water: 349 μmho/cm.

Trial No.	Test species	Mean length	Sample size	Fish sluice	Debris sluice	Damaged, fish sluice
1	White perch	7 cm	17	17	0	0
2	White perch		20	20	0	2 a
3	White perch		18	12	0	0
4	White perch		21	19	0	0
5	White perch		20	20	0	0
6	White perch		15	14	0	0
			111	102	0	2

a Stunned.

Summary, above-water tests. The results of the above-water site tests on the reconfigured machine (Royce version 2) were similar to the results from the above-water flume tests in Houston. As in the Houston tests, the rail deflectors protected the fish rails from disturbance by the high-pressure debris spray, and few fish escaped the rails during their transit through the spraywash. Of 700 fish in 38 trial passages through the debris spray, 7 were lost (1% of the sample total). The seven lost fish apparently escaped through the openings of the auxiliary screens, which are made of perforated metal, but such losses are not so significant as to require a material or fabricating change of inconvenience to the manufacturer. Other apparatus, however, needs refining, some of which will require further study and experimentation.

The sliding debris shield (L of Figure 2) could not be tested with the troublesome alga species that created the debris problem during the winter testing of Royce version 1, as that plant was absent from the indrawn river water during the summer testing of version 2. Owing to some mechanical failings, the shield, which the manufacturer views as a trial apparatus, is being redesigned. When replaced, the shield should be tested for sustained operation during times of heavy debris loading.

The relocated outside fish spray (EE of Figure 2) functioned as intended; fish were consistently freed from the overturning fish rails, at least while the spray jets were open and functioning. Clogging of all three fish sprays (EE and FF of Figure 2) was a consistent problem during the site tests—a problem that was attributed to the passage of river silt through the spraywash pump.

Although the test machine is equipped with a clear Plexiglas housing, accurate visual observations at the rear of the machine are not easily made when the spray washes are operating. To the extent that observations were possible, the trajectories of fish falling from the overturning screen panels did not exceed the far edge of the widened fish trough, but as in the Houston tests, falling fish struck the blade of the swinging sluice shield (location GG), so it was removed early in the testing. But with or without the shield, some fish fell into the gap between the fish sluice and screen. Although the reconfigured fish sluice is closer to the descending screen panels than the version 1 sluice, enough of a clearance gap remains to warrant the installation of a flap seal (or other device of similar function). Of the 664 fish employed in the tests on the recovery apparatus at the rear of the machine, 590 (89%) were recovered from the fish sluice. Of the 11% missing from the fish sluice, 23 fish (3.5% of the sample total) were found in the auxiliary debris sluice (N of Figure 2). The 28 fish not accounted for (7.5% of the sample total) might have fallen through the clearance gap as well, but into the intake flow behind the screen. Of the 590 fish recovered from the fish sluice, 35 (6%) sustained obvious trauma (descaling, impaired swimming). Thus the combined loss (morbidity plus the missing) was 16.4% of the sample total, a reduction significant enough to call for remedial study of the recovery process at the back side of the machine.

Mark and recapture tests

These tests were meant to provide information on the recovery rates and the risks of death or injury to fish captured and removed from the Indian Point test bay by the reconfigured barrier screen. For each of the tests, a fine-mesh fixed screen was emplaced at the entrance of the intake bay and allowed to remain throughout the duration of a test. A diver on site kept the screen free of debris the while. A known sample of fish was introduced to the forebay, between the fixed screen and the operating test screen, and captured fish of the sample were tallied at the fish sluice on the following time scale, which was calculated from the formulations given on page 34. The zero reference time t_1 corresponds to the appearance in the fish sluice of the first recapture. The sample was released into the forebay at time t_0.

t_1 :	0	t_7 :	1.43 hr
t_2 :	1.7 min	t_8 :	2.75 hr
t_3 :	4.9 min	t_9 :	5.25 hr
t_4 :	11 min	t_{10} :	10 hr
t_5 :	22.5 min	t_{11} :	19 hr
t_6 :	44.6 min	t_{12} :	36 hr

Recovered fish were examined on collection for deaths and injuries, then held in aquariums eight hours and monitored for apparent morbidity. The t_1 to t_6 collections were combined; the collections from t_7 to t_{12} were held in separate aquariums.

Six of these recapture tests were completed, two with striped bass and four with white perch. I assisted in the first test on the 5th of September, and I observed the tests of the 9th and 10th of September. Portions of the testing routines were recorded on video tape.

Recapture test 1.
Date at start: 5 September 1986.
Test species: *Morone saxatilis* (hatchery striped bass), 7.6 cm mean length.
Sample size: 250 fish.
Recoveries: 228 in 36 hours.
Water speed in forebay: 30 cm/sec.
Water temperature: 24–25°C.
Conductivity: 5900–6500 μmho/cm.
Screen travelling speed: 11 fpm.
Pressure, debris spray: 90 psi.
Pressure, outside fish spray: 4 psi.
Pressure, inside fish spray: 4 psi.
$t_1 - t_0 = 3$ minutes.

	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}	t_{12}
Recoveries	10	26	26	12	14	21	25	25*	3	38	15	13
Cumulative	10	36	62	74	88	109	134	159	162	200	215	228
Dead							1	8		1		
Damaged								1				
Dead, 8 hr								1				

*Spraywashes shut down 15 minutes during recovery.

See Figure 9 for graph of recoveries. During the 8-hour morbidity tests, one additional fish died, for a total of 11 deaths and one observable injury among the 228 recoveries.

Recapture test 2.
Date at start: 6 September 1986.
Test species: *Morone americana* (Hudson River white perch), 5.0–15.2 cm
Sample size: 67 fish.
Recoveries: 54 in 36 hours.
Water speed in forebay: 30 cm/sec.
Water temperature: 24–25°C.
Conductivity: 5900–6500 μmho/cm.
Screen travelling speed: 11 fpm.
Pressure, debris spray: 90 psi.
Pressure, outside fish spray: 4 psi.
Pressure, inside fish spray: 4 psi.
$t_1 - t_0 = 6$ minutes.

	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}	t_{12}
Recoveries	5	19	16	3	2	0	0	1	0	2	3	3
Cumulative	5	24	40	43	45	45	45	46	46	48	51	54
Dead										1		2
Damaged												
Dead, 8 hr										1		

See Figure 10 for graph of recoveries. During the 8-hour morbidity tests, one fish died for a total of 4 deaths among the 54 recoveries. No observable injuries reported.

Recapture test 5.
Date at start: 9 September 1986.
Test species: *Morone americana* (Hudson River white perch), 5.0–15.2 cm length range.
Sample size: 250 fish.
Recoveries: 225 in 36 hours.
Water speed in forebay: 30 cm/sec.
Water temperature: 24–25°C.
Conductivity: 5900–6500 μmho/cm.
Screen travelling speed: 11 fpm.
Pressure, debris spray: 90 psi.
Pressure, outside fish spray: 4 psi.
Pressure, inside fish spray: 4 psi.
$t_1 - t_0 = 3$ minutes.

	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}	t_{12}
Recoveries	5	100	29	10	8	19	12	16	1	25	0	0
Cumulative	5	105	134	144	152	171	183	199	200	225	225	225
Dead										1		
Damaged		3					1					
Dead, 8 hr		1										

During the 8-hour morbidity tests, one of the injured died for a total of two deaths and three injuries among the 225 recoveries.

Recapture test 6.
Date at start: 10 September 1986.
Test species: *Morone americana* (Hudson River white perch), 5.0–15.2 cm length range.
Sample size: 250 fish.
Recoveries: 222 in 36 hours.
Water speed in forebay: 30 cm/sec.
Water temperature: 24–25°C.
Conductivity: 5900–6500 μmho/cm.
Screen travelling speed: 11 fpm.
Pressure, debris spray: 90 psi.
Pressure, outside fish spray: 4 psi.
Pressure, inside fish spray: 4 psi.
$t_1 - t_0 = 5$ minutes.

	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}	t_{12}
Recoveries	11	48	67	21	6	1	13	8	4	23	14	6
Cumulative	11	59	126	147	153	154	167	175	179	202	216	222
Dead												
Damaged												

During the 8-hour morbidity tests, no fish died and none exhibited trauma symptoms, for a total of zero deaths and zero observable injuries

The recovery data of experiment 1 are plotted on the graphs of Figure 9 (page 44). The hypothesis of random encounter is supported by the regression of cumulative recoveries R against the sampling indices j (on the log transformed time scale). Apparently then, the test fish were actively captured by the reconfigured screen rails, few being impinged beforehand. As previously shown by the Houston flume tests, the juvenile striped bass, of the size employed in the recapture experiments, were capable of sustained swimming at the 30 cm/sec water speed in the forebay. Of the 250 released fish, 228 (or 91%) were recaptured during the 36-hour experiment. The debris sluice was not examined for recoveries, but on the strength of the above-water tests with striped bass (pp 36–37), I discounted any loss to the debris sluice in the calculations of mean residence time and projected sample recovery. The observed deaths and injuries (together with the anomaly at t_8) were too few for constructing a reliable distribution, but the empirical probability of death or injury to a sample member captured by the machine and recovered from the fish sluice was .052. In experiment 3, with similar experimental variables, the empirical probability of death or injury to a recovered sample member was .027.

The results from experiment 3 also support the hypothesis of random encounter and active capture of freely swimming fish (see Figure 11, page 45). But unlike the two experiments with striped bass, the recapture results from the white perch experiments signify instead a high impingement rate and rapid recovery (at least in the case of the smaller fish of the sample), similar to the results from the Houston flume tests. Figure 10 illustrates the recovery rate over the first 45 minutes of experiment 2, a pattern exhibited by the recovery data from all the white perch experiments. The released sample of experiment 2 contained a mixture of fish lengths ranging from 5 to 15.2 cm (as did all four releases of white perch). Of the 45 fish recaptured in 36 hours, 83% (or 67% of the total sample) were recovered in 22.5 minutes (by $j = 5$), including 100% of the recaptures less than 8 cm length.

The high rates of return during the first few minutes of the white perch experiments were a consequence of impingement—of fish unable to swim (or swim very long) at speeds equal to the water speeds at the face of the barrier screen (which are somewhat greater than the mean upstream water speed owing to the accelerated flow geometry at the screen panels). The longer residence times of the larger white perch signify either impingement from progressive exhaustion or random encounter by actively swimming fish (as in the case of the striped bass). The data are not sufficiently detailed for making the distinction. In all four experiments with white perch, however, mean residence times were less than 30 minutes for those portions of the released samples recovered in 36 hours (80% in experiment 2, 83% in experiment 4, 90% in experiment 5, and 89% in experiment 6). Numbers lost to the debris sluice were not reported, but of the fish recovered from the fish sluice, the empirical probability of death or injury to a sample member in the white perch experiments was .019.

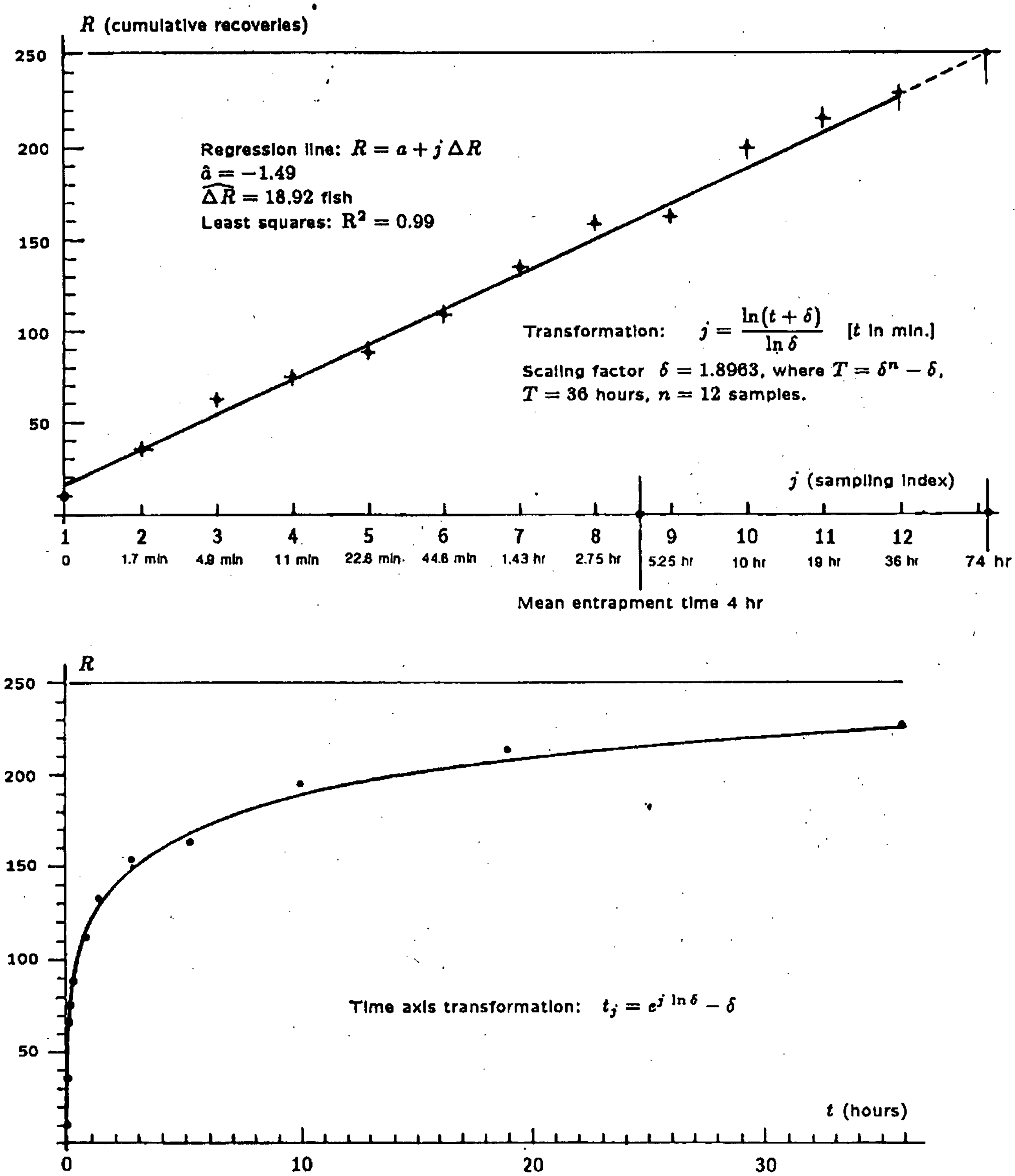


Figure 9. Top: Recapture experiment 1 (5 September 1986), hatchery striped bass. Numbers recovered from fish sluice over sampling intervals j (on logarithmic time scale). Sample size 250 fish in forebay; intake flow speed 30 cm/s; duration of experiment 36 hours. Estimated time of total sample recapture 74 hours (projected from regression). Bottom: Regression line of top graph transformed from logarithmic to linear time scale. Mean entrapment time 4 hours (calculated from regression with 74 hours as time of total sample recapture).

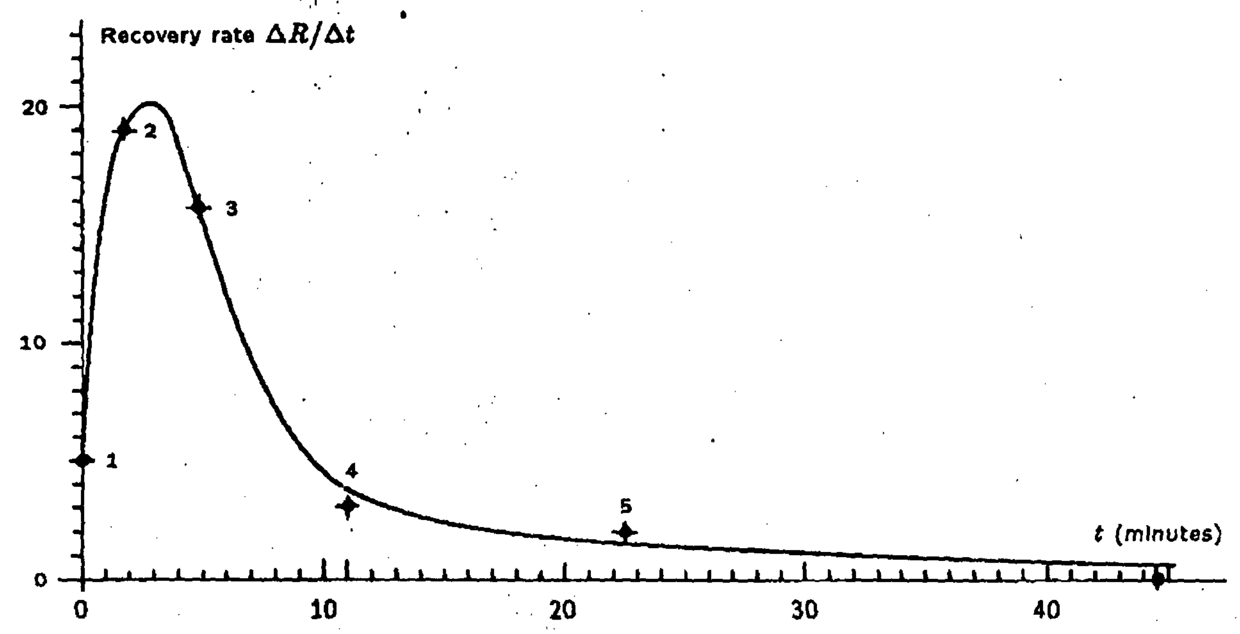


Figure 10. Recapture experiment 2 (6 September 1986), Hudson River white perch. Recoveries 1–6, first 45 minutes of experiment. Sample size 67 fish in forebay; intake flow speed 30 cm/sec. At $j = 6$ (22.6 minutes), 67% of original sample had been recovered.

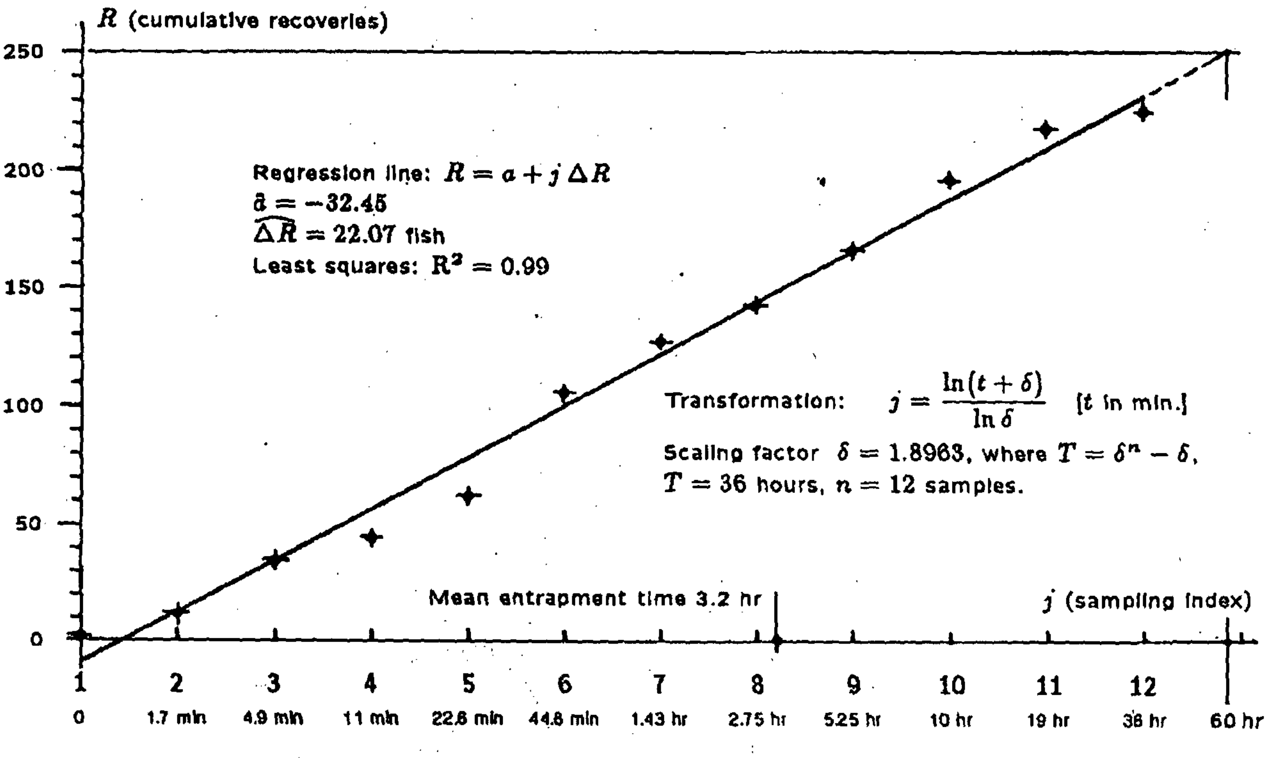


Figure 11. Recapture experiment 3 (7 September 1986), hatchery striped bass. Cumulative recoveries from fish sluice on sampling intervals j (logarithmic time scale). Sample size 250 fish in forebay; intake flow speed 30 cm/sec; duration of experiment 36 hours. Estimated time of total sample recapture 60 hours. Mean entrapment time of 3.2 hours calculated from regression with 60 hours as time of total sample recapture.

Opportunistic fish and debris collections

Following the mark and recapture experiments, the fixed screen was removed; the reconfigured machine and the circulating pump of the test bay were allowed to operate for extended periods in the manner required for maximum intake of cooling water. As specified in item C of the outline of required site tests (page 34), periodic collections of captured indigenous fish were taken from the sluices and tallied. The collected fish were examined for deaths and observable injuries, then held in aquariums (or the collection tanks) 8 hours and monitored for apparent morbidity. Captured debris was also collected, classified, and separately measured (by volume) at the fish sluice and the two debris sluices.

Fish collections

Over the period 16 September to 24 October 1986, 146 two-hour collections were taken and the surviving fish held for the 8-hour morbidity tests. In some cases, when all the available aquariums were occupied, a two-hour collection would be held in the collection tank for the eight-hour morbidity test. Fish collected and held in this manner were examined for deaths and injuries after eight hours, but not on initial recovery. Also, 29 collections were taken that ranged from six to 29 hours duration. Fish from these extended collections were examined for deaths and apparent trauma, but were not held for the additional eight hours of observation. In the 175 collections, a total of 8882 fish were recovered and 34 species identified (as tabulated below). For the more numerous of these, I have summarized the collection data on the tables that follow.

Bay anchovy	1060	Alewife	72
American shad	169	Bluefish	16
Bluegill	192	Brown bullhead	6
Pumpkinseed	212	American eel	65
Hogchoker	3543	Banded killifish	134
Largemouth bass	1	Atlantic menhaden	24
Blueback herring	277	Atlantic silverside	3
Rainbow smelt	4	Spottail shiner	2
Striped bass	86	Atlantic tomcod	603
White catfish	25	White perch	1806
Yellow perch	1	Northern pipefish	4
Lookdown	7	Redbreast sunfish	4
Atlantic needlefish	1	Crevalle jack	6
Weakfish	467	Clupeid sp	1
Butterfish	8	Centrachid sp	39
Rough silverside	1	Summer flounder	29
Naked goby	13	Grey snapper	1

Bay anchovy (1060* collected)

	On collection			After 8 hours			
Two-hour collections	Normal	Damaged	Dead	Normal	Damaged	Dead	Dead & Inj.
Fish sluice[1]	60	8	12	41	12	27	49%
Fish sluice[2]				42	13	12	37%
Rear debris sluice			3			3	
Extended collections							
Fish sluice[3]	723	24	147				19%
Rear debris sluice[3]	6	1	8				60%

*One bay anchovy recovered from front debris sluice.
[1]Held in aquariums. [2]Held in collection tanks. [3]Recovered from collection tanks.

Alewife (72* collected)

Two-hour collections	On collection Normal	Damaged	Dead	After 8 hours Normal	Damaged	Dead	Dead & Inj.
Fish sluice[1]	4	3	10	3	1	13	82%
Extended collections							
Fish sluice[2]	24	3	27				55%

*One alewife recovered from front debris sluice.
[1]Held in aquariums. [2]Recovered from collection tank.

American shad (169 collected)

Two-hour collections	On collection Normal	Damaged	Dead	After 8 hours Normal	Damaged	Dead	Dead & Inj.
Fish sluice[1]	10	9	9	9	3	16	68%
Fish sluice[2]				18	2	9	38%
Rear debris sluice			2			2	
Extended collections							
Fish sluice[3]	83	2	25				25%

[1]Held in aquariums. [2]Held in collection tanks. [3]Recovered from collection tanks.

Bluegill (192 collected)

Two-hour collections	On collection Normal	Damaged	Dead	After 8 hours Normal	Damaged	Dead	Dead & Inj.
Fish sluice[1]	119	0	0	119	0	0	0%
Fish sluice[2]				15	0	1	6%
Extended collections							
Fish sluice[3]	56	0	1				2%

[1]Held in aquariums. [2]Held in collection tanks. [3]Recovered from collection tanks.

Pumpkinseed (212* collected)

Two-hour collections	On collection Normal	Damaged	Dead	After 8 hours Normal	Damaged	Dead	Dead & Inj.
Fish sluice[1]	40	2	0	39	3	0	7%
Fish sluice[2]				29	0	2	6%
Rear debris sluice[1]	1			1			
Extended collections							
Fish sluice[3]	127	3	6				7%
Rear debris sluice[3]	1						

*One pumpkinseed recovered from front debris sluice.
[1]Held in aquariums. [2]Held in collection tanks. [3]Recovered from collection tanks.

American eel (65 collected)

Two-hour collections	On collection Normal	Damaged	Dead	After 8 hours Normal	Damaged	Dead	Dead & Inj.
Fish sluice[1]	16	8	0	15	7	2	38%
Fish sluice[2]				9	1	2	25%
Extended collections							
Fish sluice[3]	23	0	6				21%

[1]Held in aquariums. [2]Held in collection tanks. [3]Recovered from collection tanks.

Hogchoker (3543* collected)

Two-hour collections	On collection Normal	Damaged	Dead	After 8 hours Normal	Damaged	Dead	Dead & Inj.
Fish sluice[1]	486	1	4	486	0	5	1%
Fish sluice[2]				561	2	13	2%
Rear debris sluice[1]	46	0	1	45	1	2	2%
Rear debris sluice[2]				101	2	7	8%
Extended collections							
Fish sluice[3]	2094	1	407				2%
Rear debris sluice[3]	176	0	4				2%

*13 hogchokers recovered from front debris sluice.
[1]Held in aquariums. [2]Held in collection tanks. [3]Recovered from collection tanks.

Banded killifish (134 collected)

Two-hour collections	On collection Normal	Damaged	Dead	After 8 hours Normal	Damaged	Dead	Dead & Inj.
Fish sluice[1]	75	0	0	74	0	1	1%
Fish sluice[2]				14	1	0	7%
Rear debris sluice[2]				2			
Extended collections							
Fish sluice[3]	42	0	0				0%

[1]Held in aquariums. [2]Held in collection tanks. [3]Recovered from collection tanks.

Blueback herring (277 collected)

Two-hour collections	On collection Normal	Damaged	Dead	After 8 hours Normal	Damaged	Dead	Dead & Inj.
Fish sluice[1]	24	7	3	16	5	13	53%
Fish sluice[2]				72	0	25	19%
Extended collections							
Fish sluice[3]	118	3	25				19%

[1]Held in aquariums. [2]Held in collection tanks. [3]Recovered from collection tanks.

Striped bass (86 collected)

Two-hour collections	On collection Normal	Damaged	Dead	After 8 hours Normal	Damaged	Dead	Dead & Inj.
Fish sluice[1]	7	0	0	7	0	0	0%
Fish sluice[2]				11	1	0	1%
Extended collections							
Fish sluice[3]	60	2	5				10%

[1]Held in aquariums. [2]Held in collection tanks. [3]Recovered from collection tanks.

Atlantic tomcod (603 collected)

Two-hour collections	On collection Normal	Damaged	Dead	After 8 hours Normal	Damaged	Dead	Dead & Inj.
Fish sluice[1]	52	21	1	51	21	2	31%
Fish sluice[2]				36	3	5	18%
Extended collections							
Fish sluice[3]	410	8	65				15%
Rear debris sluice[3]	1	0	1				

[1]Held in aquariums. [2]Held in collection tanks. [3]Recovered from collection tanks.

White perch (1806* collected)

Two-hour collections	On collection Normal	Damaged	Dead	After 8 hours Normal	Damaged	Dead	Dead & Inj.
Fish sluice[1]	486	18	15	476	7	36	8%
Fish sluice[2]				276	11	24	11%
Rear debris sluice[1]	6	1	0	6	1	0	14%
Rear debris sluice[2]				8	2	0	20%
Extended collections							
Fish sluice[3]	787	35	132				18%
Rear debris sluice[3]	5						

*One white perch recovered from front debris sluice.
[1]Held in aquariums. [2]Held in collection tanks. [3]Recovered from collection tanks.

Weakfish (467 collected)

Two-hour collections	On collection Normal	Damaged	Dead	After 8 hours Normal	Damaged	Dead	Dead & Inj.
Fish sluice[1]	19	2	0	14	3	7	33%
Fish sluice[2]				21	0	7	25%
Rear debris sluice	1				1		
Extended collections							
Fish sluice[3]	368	7	25				8%
Rear debris sluice[3]	11	3	3				35%

[1]Held in aquariums. [2]Held in collection tanks. [3]Recovered from collection tanks.

Debris collections

During the 146 two-hour collections and the 29 extended collections, 1594 gallons of debris were recovered, of which 27% was collected from the fish sluice, 26% from the front debris sluice, and 47% from the rear debris sluice. The debris consisted of eel grass, accompanied from time to time by a small quantity of tree leaves. Unlike the fine alga species collected during the winter tests on Royce version 1, the eel grass does not staple firmly into the screen mesh, and much of it falls into the fish rails as the screen panels ascend through the water surface.

As indicated by the distribution of collected debris, the eel grass blown from the screen mesh and into the front debris sluice(KK) by the primary debris spray amounted to only 26% of the quantity captured by the ascending screen; the remainder was carried over the driver sprockets by the fish rails and dumped onto the overturning screen panels, about one-third of it sliding into the fish sluice and the rest falling into the rear debris sluice (N) as the panels descended through the auxiliary debris spray (M). Despite the large proportion that reached the back side of the machine, the eel grass did not entangle the fish into an inseparable matrix of debris, as did the filamentous winter algae. The numbers of fish collected from the rear debris sluice, when compared with the above-water tests in the absense of debris, do not indicate that fish were carried past the fish sluice with greater likelihood in the presence of the eel grass, nor is there evidence to suppose that the accumulation of eel grass in the fish rails increased mortality to any significance.

Summary of the fish recovery tests. As in the the Houston flume experiments with golden shiners and white perch, the mark and recapture experiments with white perch show that juveniles of some species are impinged (flattened against the screen mesh) at a high rate when the water velocity is (about) 30 cm/sec, the speed of the intake flow at the higher of the two pumping rates at Indian Point. The recapture experiments with white perch also support our findings from the flume experiments that impingement itself, unless of extended duration, is not the proximate agency of high mortality it was thought to be, even in the case of fishes easily descaled. The captured fish are harmed more by the knocking about imposed on them after their entry into the fish rails. Those risks have been reduced by some of the innovations now incorporated into the reconfigured machine.

The mark and recapture experiments with striped bass are representative of fish capable of swimming against the flow for extended periods. In the flume experiments with striped bass of the size employed in the site experiments, the fish persistently maintained station upstream of the screen (see page 27). and were not readily impinged at flow velocities exceeding 45 cm/sec. Therefore, the hypothesis of random encounter and active capture by the reconfigured fish rails (principally by the auxiliary rail screens) is supported by the results from the recapture experiments.

The fish exhibiting the highest proportions of deaths and injuries in the opportunistic collections were bay anchovy, alewife, American shad, blueback herring, Atlantic menhaden, and American eel, all of which, excepting the eels, are tender species easily descaled. At least some of the observed trauma can be attributed to handling. As the data show, fish of these species that were transferred to aquariums suffered higher proportions of death and injury during the 8-hour morbidity tests than those held in the collection tanks. Striped bass mortalities were low (but only 86 were collected), and white perch mortalities were lower than expected.

Recoveries of fish from the front debris sluice were rare, but the recoveries from the rear debris sluice were sufficiently great, for some species, to substantiate the finding from the above-water testing that certain remedial work is needed on the recovery apparatus at the back side of the machine. The capturing of eel grass by the fish rails did not appear to hinder the separation and recovery of captured fish, but the reconfigured debris removal system was not really tested, since the filamentous winter algae that brought about the need for reconfiguration in the first place were not present in the river during any of the tests on the version 2 screen.

In conclusion, you are reminded that none of the experimentation or testing was directed to an examination of any fish conservation apparatus beyond the confines of the single barrier device. No investigative work has yet been done by me or by Consolidated Edison on the mechanism for returning fish to the source waters. As currently intended by both Consolidated Edison and the Power Authority, a common fish sluice, extending the entire width of the combined intake bays, will serve all six screens (plus the screens of the service water bay, apparently). The sluice, pitched at a slight angle from the horizontal, will feed its accumulated water, fish, and debris into a single pipe for the return of those contents to the river.

At least two sources of potential malfunctioning come immediately to mind—one the eel grass loading in summer and the other the icing of the sluice and flash freezing of fish in the winter. The combined amounts of eel grass dumped into the fish sluice by each of the screens might easily exceed the flushing capabilities of the sluice, and, during winter, ice will probably form in the sluice, at least at the channel boundaries. Several solutions also come to mind, should those problems be serious enough to impair the return of fish, but I suggest that a demonstration sluice be constructed and the problems evaluated first, before the permanent sluices and their accompanying apparatus are installed.

SECTION 5.
Fish conservation, Royce versions 1 and 2 compared.

From the results of Consolidated Edison's testing of Royce version 1, from casual observations during that testing, and from the experimental work in the Houston flume, several sources of fish mortality were identified, which led ultimately to the alterations now part of the reconfigured machine. The experiments described in Sections 3 and 4 of this report were intended to provide enough empirical information for making a reliable assessment of the likely reductions in fish kills attributable to the reconfiguring of the machine, as compared to the first version.

Reliability suffers somewhat here from dissimilarity in experimental variables. The two machines were tested during unlike seasons of the year; the low temperature of the river during the winter testing of version 1 probably increased trauma to some of the sampled species. Because of the difference in seasons, the species compositions of the collections differed considerably, and the captured algae were altogether dissimilar (most particularly in those physical characteristics important to the workings of the fish conserving apparatus). Given the extent of the field sampling and the flume experiments, however, I believe a reasonable assessment of the improvements in fish recovery can be extracted from the data, although a similar assessment of the reconfigured debris removal system, to the extent that it influences fish conservation, must be deferred to a time when testing with the winter alga species is undertaken.

During the winter testing by Consolidated Edison on Royce version 1, the experimenters collected 45,608 fish in their samplings of the fish and debris sluices. Of 36 identified species, 20 also appeared in the sampled recoveries from Royce version 2. Discounting those species where only one of a kind appeared in the collections reduces the shared species to 15, which are identified by the following table. The numbers of each species collected from the version 1 machine appear in column v1 and the numbers from version 2 in column v2. The percentages signify the proportions out of total fish collected (45,608 in the sampling of version 1, and 8,882 in the sampling of version 2); an omission signifies a proportion less than 1%.

	v1	v2		v1	v2
Alewife	117	72	Bluegill	9	192 (2%)
Brown bullhead	15	6	Pumpkinseed	144	121 (1.4%)
American eel	131	65	Hogchoker	198	3,543 (40%)
Banded killifish	61	134 (1.5%)	Blueback herring	29	277 (3%)
Rainbow smelt	373	4	Spottail shiner	217	2
Striped bass	5,546 (12%)	86 (1%)	Atlantic tomcod	413 (1%)	603 (7%)
White catfish	443 (1%)	25	White perch	37,536 (82%)	1,806 (20%)
Northern pipefish	4	4			

From the 36 species collected during the winter testing of Royce version 1, the experimenters selected the ten most abundantly represented for their "latent survival" tests. Eight of those ten are among the species appearing on the preceding table (no red hake or tesselated darter were found during the summer sampling of version 2). Of those eight shared species, two species from the version 2 testing were collected in numbers insufficient for mortality comparisons (rainbow smelt and spottail shiner). The deaths and injuries accrued to the remaining six species are given by the following table. The information on the version 1 survival testing is taken from Con Ed (1985). Apparently, the numbers of fish tested were subsamples of the version 1 collections; totals collected are given by the table on page 51. The quantities listed for version 2 on the following table are taken from the data of the opportunistic collections, two-hour and extended collections combined (see page 46 for clarification).

	Royce version 1		Royce version 2	
	Tested	Dead&Inj.	Tested	Dead&Inj.
Alewife				
Fish sluice	22	98%	71	62%
Debris sluices	3	100%	0	
Atlantic tomcod				
Fish sluice	32	75%	601	32%
Debris sluices	8	76%	2	50%
Pumpkinseed				
Fish sluice	17	46%	192	1%
Debris sluices	0		0	
Striped bass				
Fish sluice	860	48%	86	9%
Debris sluices	264	70%	0	
White catfish				
Fish sluice	85	39%	25	40%
Debris sluices	25	44%	0	
White perch				
Fish sluice	4227	58%	1784	14%
Debris sluices	2051	77%	23	1%

The large numbers of fish recovered from the debris sluice during the testing of the version 1 machine are attributable to the entanglement of fish in the filamentous alga that was captured in such large quantities during the winter. Of the total numbers of fish collected during the winter tests, 31% were recovered from the debris sluice (as opposed to 4% during the testing of the version 2 machine). The actual proportion was probably greater than 31%, owing to the difficulties in searching through the winter debris, which formed a nearly inseparable mass of fish and algae when recovered.

The winter alga problem is also reflected in the high mortalities observed during the version 1 tests. Of the white perch collected, for example, 32% were recovered from the debris; of the striped bass, 23% from the debris; of the rainbow smelt, 44%, and so on. Therefore, when the mortalities of the fish sluice and debris sluice collections are combined, the importance of the alterations to the above-water portions of the machine becomes more obvious. The combined recoveries and observed mortalities for three species are given on the following table.

	Royce version 1 Tested	Royce version 1 Dead&Inj.	Royce version 2 Tested	Royce version 2 Dead&Inj.
Atlantic tomcod				
Collections combined	40	75%	603	32%
Striped bass				
Collections combined	1124	53%	86	9%
White perch				
Collections combined	6278	64%	1807	14%

Whether or not the fish conserving apparatus of the reconfigured machine will continue to operate as sucessfully during times of heavy loading with winter algae remains to be proven.

While the reordering of the fish and debris removal system was brought about by addressing the major problem identified during the winter testing of Royce version 1, other innovations now incorporated into Royce version 2 contributed to the observed reductions in fish mortalities. The flume work, the mark and recapture experiments, and the above-water tests all give evidence of improvements in fish capture and in lessened battering of fish after capture. I also believe that further reductions in fish kills are possible.

Although the altered profile of the fish rails has reduced the (underwater) buffeting of captured fish, a profile can probably be developed that would eliminate the trough vortices altogether. The sliding shield (L) at the location of the debris spray might perform as intended when tested with the winter alga, but the shielding problem at the fish trough (at location GG) has yet to be resolved. As observed during both the flume tests and the site tests on the reconfigured machine, fish still occasionally fall between the screen and the inner edge of the fish trough. The swinging apparatus provided by the manufacturer, in its current configuration, interferes with the free fall of fish to the fish sluice. The original flap seal design of Royce version 1 might yet prove adequate, should the reconfigured debris removal system operate as intended. In any case, these shielding problems cannot be resolved without further experimentation during times when the intake of filamentous algae is similar to the loadings observed during the testing of Royce version 1.

APPENDIX A
Data register, flume experiments and tests.

The documents of the following inventory are stored at the Great Salt Bay Experimental Station, Damariscotta, Maine.

Film documents

Title: Flume experiments, Indian Point replicate machine, Feb–March 1986.
Medium: VHS video tape.
Contents: Fluid dynamics of rail and screen sections. Dye releases, orbiting of captive fish in standard rails. Auxiliary rail screens. Flow profiles of Royce panel, Envirex panel, channel, and streamlined rails. Flow trajectories with fish, Gathright's elevated rail section. Fish response, with and without auxiliary rail screen. Underwater debris loading of panels and rails.

Title: Flow profiles 1, Royce standard panel section, Feb 1986.
Medium: 35mm B&W film.
Contents: Dye marked streamlines of flow, 30 cm/sec, 20 frames.

Title: Flow profiles 2, Royce standard panel section, Feb 1986.
Medium: 35mm B&W film.
Contents: Dye marked streamlines of flow, 45 cm/s, 21 frames.

Title: Flow profiles 1, Ristroph panel (Rexnord), Feb 1986.
Medium: 35mm B&W film.
Contents: Dye marked streamlines of flow, 30 cm/s, 20 frames.

Title: Flow profiles 2, Ristroph panel (Rexnord), Feb 1986.
Medium: 35mm B&W film.
Contents: Dye marked streamlines of flow, 45 cm/s, 22 frames.

Title: Testing program, flume tests, 16–18 July 1986.
Medium: VHS video tape.
Contents: Underwater portion of flume testing program with golden shiners. Fish capture and behavior at 30 cm/sec and 45 cm/sec. Above-water portion of testing program with golden shiners. Trajectories of falling fish.

Title: Testing program, flume tests, 12–15 August 1986
Medium: VHS video tape.
Contents: Underwater portion of testing program with white perch and striped bass. Fish capture and behavior at 30 cm/sec and 45 cm/sec.

Paper documents

Title: Flume tests, 16–18 July, 25 July, 12–15 August 1986.
Contents: Laboratory notes and records, fish capture tests and above-water tests, 17 pages.

Title: Flume tests, data, 17–18 July, 13–15 August 1986.
Contents: Extraction of data from video tapes; fish capture and behavior, 10 experiments with shiners, 8 experiments with white perch, 8 experiments with striped bass, 5 pages.

APPENDIX B
Data register, site tests of Royce version 2

The documents of the following inventory are stored at the Great Salt Bay Experimental Station, Damariscotta, Maine.

Film documents

Title: Indian Point field tests, Royce version 2
Medium: VHS video tape.
Contents: Views of working machine and fish sampling gear; experimental routines.

Paper documents

Title: Site tests, 5 August, 26–27 August 1986.
Contents: Copies of field data records, above-water tests; 75 experiments, 21 pages.

Title: Mark and recapture tests, 5–10 September 1986.
Contents: Copies of field data records, six experiments, 48 pages.

Title: Opportunistic collections 16 Sept–24 Oct 1986.
Contents: Copies of field data records, fish collections and mortalities; 175 experiments, 244 pages.

Title: Debris collections, 16 Sept–24 Oct 1986.
Contents: Compilation of data records, 175 collections, 5 pages.

APPENDIX C

Consolidated Edison work scope for site tests of Royce version 2.

The contents of this appendix were furnished by Consolidated Edison as the scope of work issued to Normandeau Associates, Inc., contractor for the field testing of Royce version 2.

Representative Scope of Work for
Evaluation of Modified Ristroph-Type
Traveling Water Screen at
Indian Point Unit 2 Intake Bay 26
1986

Background

In May, 1986 Royce Equipment company installed five modifications to the Ristroph screen at Indian Point Unit 2. These included 1.) a reordering of low pressure and high pressure wash systems to remove debris before fish are removed to alleviate their potential for entanglement with debris during the transfer to the fish sluice; 2.) an improved low pressure spray wash system to more efficiently wash screen basket troughs to enhance the transfer of fish to the fish sluice; 3.) a 3-foot wide flat-bottomed fish sluice with a diffused supplemental wash system so that fish being transferred from the screen would fall into the return water (As originally designed, the test screen was outfitted with an 18" wide round-bottomed fish sluice, and fish often struck the sides of this sluice.); 4) a modified flap seal to close the gap between the descending screen baskets and the return sluice. (Note: With the installation of a wider fish sluice, placed closer to the descending screen baskets than was the original sluice, the need for the modified seal is less certain.); and 5.) a modification consisting of an extension to the front edge of the fish trough on each screen basket to alleviate water flow conditions within the trough potentially adverse to fish and to enhance the ability of the screen to collect fish before they become exhausted.

Tests of these new components, individually and together, are to be conducted to determine the rates of loss, damage, and mortality they impose on fish collected by the machine. Four species of fish including striped bass, white perch, bay anchovy and Atlantic tomcod are to be evaluated under various operating conditions including with and without debris loads on the Ristroph screen mesh. Test fish inserted into the screen basket troughs, entrapped in the intake forebay, and collected opportunistically are to be examined for initial and latent (8 hour) damage and mortality. Testing will be conducted in part under the supervision of Dr. Ian Fletcher, technical consultant to the Hudson River Fishermen's Association. Data will be provided to Dr. Fletcher for analysis and interpretation in concert with tests he will conduct on a test screen at Royce's facilities in Houston.

Objective I: Provide the comprehensive management required to ensure that all tests are carried out as directed.

Task 1: Provide all personnel, equipment, materials and supplies required to carry out the work described herein.

Task 2: Design, fabricate, and utilize as necessary the following devices.

a. A collection device by which fish can be quickly (within a few seconds) removed from the fish sluice for examination and placement into latent mortality evaluation tanks.

b. A device by which fish washed from the screen by the front mounted high pressure wash system can be collected from the associated debris sluice.

c. A device by which fish washed from the screen by the rear high pressure wash system can be collected.

d. Latent mortality evaluation tanks and associated water systems for use near the Ristroph screen or in the Fish Laboratory at the Unit 1 intake.

e. A device by which fish may be introduced into intake forebay 26 while the fixed screen at the entrance to the bay remains down. (The fish should be placed as close as possible to the fixed screen.)

f. A device by which fish can be placed in the fish troughs on screen baskets at a point below the front mounted high pressure spray wash system.

Objective II: Collect, maintain and provide test fish for Ristroph screen studies at Indian Point and Houston, Texas.

Task 1: Collect and maintain in a healthy condition at the Indian Point Station bay anchovy, juvenile striped bass, white perch and Atlantic tomcod in sufficient numbers to conduct the specified tests. Approximately 2000 individuals of each species may be required. These fish may be collected from the Ristroph screen, or as necessary, by haul seining.

Task 2: At the request of Con Edison, ship live juvenile striped bass and white perch with appropriate governmental approvals to Houston, Texas for use by Dr. Ian Fletcher. (Note: multiple shipments may be required depending upon the capacity of holding tanks at Royce's facilities in Houston, to be provided by Dr. Fletcher.)

Objective III: Determine the extent of damage and mortality that occurs to fish encountering the the Ristroph screen.

Task 1: Coordinate as necessary to ensure that a screen operator will be available on test days.

Task 2: Determine the extent of damage and immediate mortality of bay anchovy, juvenile striped bass, white perch, and Atlantic tomcod following passage through the front mounted high pressure spray wash system.

Subtask 2.1: Place 20 live fish of a given species within a screen trough on the front (river) side of the machine below the high pressure spray wash, and have the screen basket rotated through the high pressure wash.

Subtask 2.2: Observe the fish in the screen trough following passage through the high pressure wash to determine a) the number of individuals that are missing, b) the number that are dead, and c) the number that display signs of damage including, but not limited to, erratic swimming, cuts, bruises, or substantial descaling. (Record the frequency with which each type of damage is noted).

Subtask 2.3: Record qualitatively the amount of debris removed from the screen mesh and transferred to: a) the front debris sluice, and b) the fish trough.

Subtask 2.4: Record the screen rotation speed, the pressure at which the high pressure wash is being operated, the water temperature and salinity.

Subtask 2.5: Repeat subtasks 2.1, to 2.4 five times for each species.

Task 3: Determine the extent of damage and immediate mortality of bay anchovy, juvenile striped bass, white perch and Atlantic tomcod following passage through the low pressure wash and the fish return sluice with the flap seal in operation and with it out of service.

Subtask 3.1: Place 20 fish of a given species within a screen trough on the front side of the machine above the high pressure wash.

Flush all fish from the fish and debris sluices on the rear side of the screen, and then have the screen basket rotated through the low and high pressure washes on the rear side of the machine.

Subtask 3.2: Collect fish from the fish sluice and the debris sluice on the rear side of the screen and determine for each sluice: a) the number recaptured, b) the number dead and, c), the number displaying signs of damage. (Record the frequency at which each type of damage is noted.

Subtask 3.3: Record qualitatively the amount of debris transferred to: a) the fish sluice, and b) rear debris sluice.

Subtask 3.4: Record the screen rotation speed, the pressure at which the low and high pressure washes are being operated, the water temperature and the salinity.

Subtask 3.5: Repeat subtasks 3.1 to 3.4 five times for each species for each test condition.

Task 4: Determine the collection rate of dead fish placed in the fish trough of screen baskets with the rear flap seal in operation and out of service.

Subtask 4.1: Place 20 each of dead bay anchovy, striped bass and white perch in a screen trough following its passage through the front mounted high pressure wash, and record the number of each species collected in the fish return sluice and the debris sluice, and the pressures at which the low pressure wash and the high pressure wash are being operated. Repeat this test 5 times for each species for each test condition.

Ovjective IV: Determine the collection rate, damage and mortality experienced by striped bass, white perch and Atlantic tomcod placed in the intake forebay and subsequently collected in the fish and debris return sluices of the Ristroph screen system.

Task 1: Coordinate to assure that the fixed fine mesh screen to be installed at Intake Bay 26 will be left in the down position for up to 36 hours and that a diver will be available to keep the screen free of debris during a test period.

Task 2: Introduce 250 fish of each given species (striped bass, white perch) into the intake bay 26 between the Ristroph screen and the fixed fine mesh screen.

Task 3: Collect fish recovered by the Ristroph screen and transferred to the fish sluice at the end of the intervals over a 36 hour period as specified by the following schedule:

Time		Action
t_0	=	Fish introduced into bay
t_1	=	the observation of the first released fish in the return sluices; sampling interval initiated
t_2	=	1 minute 42 seconds since t_1: collect first sample
t_3	=	4 minutes 55 seconds since start: collect second sample
t_4	=	11 minutes since start: collect third sample
t_5	=	22 minutes 37 seconds since start: collect fourth sample
t_6	=	44 minutes 34 seconds since start: collect fifth sample
t_7	=	1 hour 26 minutes since start: collect sixth sample
t_8	=	2 hours 45 minutes since start: collect seventh sample
t_9	=	5 hours 15 minutes since start: collect eighth sample
t_{10}	=	9 hours 58 minutes since start: collect ninth sample
t_{11}	=	18 hours 57 minutes since start: collect tenth sample
t_{12}	=	35 hours 57 minutes since start: collect eleventh sample

Immediately following the collection of a sample, examine the fish and record the number of fish that are a) alive and undamaged, b) alive but damaged, and c) dead. For those fish that are damaged record the frequencies of each type of damage. Species other than test fish that are collected should also be examined and their condition recorded.

Task 4: Retain undamaged fish collected in task 3 in ambient temperature Hudson River water for 8 hours and record latent effects, including damage as well as mortality, at 1, 3.5 and 8 hours following collection. (Note: sample Nos. T-1, through T-6 shall be placed in one holding tank for latent effects studies. All succeeding samples are to be placed in separate holding tanks). If sufficient numbers (≥ 10) of species other than test fish are collected, these should also be held for examination.

Subtask 4.1: Record qualitatively the amount of debris transferred to: a) each of the debris sluices, and b) the fish sluice.

Subtask 4.2: Record the screen rotation speed and the pressure at which the high pressure and low pressure washes are being operated, the water temperature, and salinity.

Objective V: Determine the abundance, morbidity and mortality of fish recovered opportunistically from the test Ristroph screen.

Task 1: Collect and record by species and length class all of the fish discharged each day (approximately 24 hour period) from the:

a) front debris sluice
b) rear debris sluice
c) fish sluice

Task 2: Determine the percentage of fish "alive and undamaged", "alive but damaged", "freshly dead", and "old dead" in collections from the fish sluice and from each of the debris sluices.

Subtask 2.1: Three 2-hour long collections are to be made from the fish sluice and each of the debris sluices each day beginning at approximately 7:00 p.m. Collections should be made from the fish sluice by diverting water from that sluice into one of the three adjacent holding tanks for a period of 2 hours. At the end of 2 hours, sweep the fish sluice to remove all fish, and then redirect the flow to another holding tank. Record the time that each test began and ended.

Immediately upon completion of each 2 hour collection interval, remove the fish from the first holding tank and each of the two debris sluice collection basins. Record the numbers of each species that are alive and undamaged, alive but damaged, freshly dead, and old dead in each of the standard impingement length classes. (Note: Fish that have begun to decompose or developed substantial fungus growth, demonstrating beyond any doubt that they were dead for a period of time much longer than the duration of the sample, should be classified as "old dead"; all other dead fish should be considered "freshly dead".)

Place the fish that are "alive and undamaged" and those that are "alive but damaged" from each sluice in separate aquaria. Non-predatory species may be mixed in a single aquarium. Predatory species should be held separately from other species upon which they might prey. The density of fish held in each aquarium should not exceed the capacity of the aquarium. Monitor the collection rate of fish and terminate a sample if the numbers of fish collected are near the holding capacity for the available aquaria. Repeat the above until three 2-hour collections have been transferred to the laboratory.

At the end of 8 hours following the termination of each sample collection interval, tabulate the numbers of each species "alive and undamaged", "alive but damaged", "freshly dead", and "old dead" by length class and sluice.

Subtask 2.2: Following completion of the third 2-hour collections made from the fish sluice and each of the debris sluices, water from the fish sluice should be diverted into one of the three holding tanks for a period of two hours. At the end of 2 hours, sweep the fish sluice on the Ristroph screen to remove all fish, and then redirect the flow to a second holding tank. Do not remove the fish from the holding tank into which the sample was collected.

Remove and classify the fish collected in the debris basins as in Subtask 2.1 at the end of each 2 hour collection interval. Transfer fish collected in the debris basins to the fish laboratory and place in aquaria as described in Subtask 2.1.

At the end of 8 hours following the termination of each 2 hour sample collection, drain the holding tanks in which fish from the fish sluice are being held, and the aquaria in which fish from the debris basins are being held and tabulate the numbers of each species as in Subtask 2.1.

Subtask 2.3: Following completion of the sample collections for Subtask 2.2, redirect the water flow from the fish sluice to the mobile fish collection tank to continuously accumulate fish discharged during the next 12 hours. Separately collect all fish discharged from the front and rear debris sluices over the same 12 hour interval. At the end of approximately 12 hours, tabulate by collection basin, the numbers of each species as in Subtask 2.1.

Subtask 2.4: For each of the fish collections determine the amount and type of debris collected from the associated sluice. Characterize the type of debris of filamentous algae, eel grass, spartina, leaf litter or other.

Task 3: Record operational and environmental data

a) Wash Pressure; debris spray; inside fish spray; outside fish spray
b) Screen travel speed
c) Water temperature
d) Water salinity
e) Circulating water pump flow rate

Objective VI: Schedule and Data Records

Task 1: Complete Objective III by July 15, 1986, Objective IV by August 15, 1986 and Objective V by October 24, 1986.

Task 2: Provide within 72 hours of completion of each of the Objectives III, IV, and V verified results, including compiled data sheets and all written notes of observations made during the study.

ORIGINAL TO GEOGHEGAN
20 DEC 93

Con Edison
Consolidated Edison Company of New York, Inc.
4 Irving Place, New York, N.Y. 10003

December 16, 1993

Dr. Mark Mattson
Normandeau Associates, Inc.
25 Nashua Road
Bedford, New Hampshire C

Post-it™ brand fax transmittal memo 7671	# of pages ▸ 13
To Jim Reichle	From Paul G
Co.	Co.
Dept.	Phone #
Fax #	Fax #

Dear Dr. Mattson:

Enclosed is a scope (fish-saving features insta Kill Generating Station. ... to that performed by NAI with the ...opn-modified through-flow screen at Indian Point Unit No. 2, requires collection efficiency tests as well as monthly latent effects assessments from two modified and one unmodified dual flow screen for a period of one year, beginning as soon as screen modifications are completed in February 1994. Results are to be compared with those from Indian Point.

Please provide a technical proposal to perform this work under the terms and conditions of the impingement and entrainment study contract for Arthur Kill, Purchase Order No. 220385, by January 14, 1994. If you have any questions, please call me at 212-460-6059.

Ken now wants this by 31 Dec. 1993

Sincerely,

Kenneth L Marcellus

Kenneth L. Marcellus, Ph.D.
Senior Scientist

Attachment

cc: Wm. L. Kirk

RECEIVED
DEC 1993

12/16/93

Scope of Work
To Determine the Post-Impingement Viability of Fish and Bluecrabs Impinged on Dual Flow Screens Installed at Arthur Kill Generating Station

Background:

Arthur Kill Station dual flow screens nos. 24 and 31 are being outfitted with Ristroph-type fish-saving features to determine whether post-impingement survival of fish will be similar to that observed following collection from Ristroph-modified through-flow screens at Indian Point Unit No. 2. Dual flow screen modifications are expected to be completed during February 1994. Biological evaluations will start immediately thereafter, and continue monthly for one year. Evaluations will include determination of collection efficiencies for fish released into the intake, transfer efficiencies of fish from screen baskets to return sluices, and initial and latent mortality of recovered fish. Results will be compared with similar evaluations of fish collected from an unmodified dual flow screen as well as from the Ristroph-modified through-flow test screen at Indian Point Unit No. 2 (Attachment 1). Computation of species-specific mortality will be based on total numbers of damaged and dead fish at the end of the latent effects assessment periods relative to the total numbers collected. Fish condition will be classified as follows:

Alive: No visible signs of physical damage; active swimming and orientation behavior.

Damaged: Fish with visible external damage (missing scales, mutilations, or hemorrhages) or showing abnormal or weak swimming and orientation behavior.

Dead: No obvious external signs of life or severe physical mutilation with only slight opercular motion and no other body movement.

Data are to be tabulated in the format established by Fletcher (1986; Attachment 1). Results of the first five months of evaluations will be presented to the NYSDEC in an oral briefing. Based upon the information available at that time, study objectives may be modified.

Work Scope

Objective I. Provide the comprehensive management required to ensure that all evaluations of this Sub-study are carried out in compliance with the terms and conditions of the contract.

Task 1. Provide necessary controls to ensure contract compliance.

Task 2. Provide materials and equipment needed to fulfill the requirements of this scope of work. Major equipment includes, but is not limited to:

a. Three 8 ft x 3 ft x 2 ft 200 gallon tanks, each outfitted with a screened overflow/valved drain pipe and flexible discharge hose, and mounted on wheels, for collection of fish from low pressure wash fish sluices.

b. Three collection baskets for recovery of fish alive and undamaged from the high pressure wash debris sluice for determination of survival and latent effects.

c. Latent effects assessment tanks (Aquaria) for evaluations of up to 50 fish of each of 5 species of fish, including blue crabs, at one time from each of three test screens. The tanks shall be supported on prefabricated metal shelving, which must be appropriately coated to minimize rusting from salt water. Provide all plumbing and drain lines for these tanks.

d. Submersible pump(s) for provision of water to the latent effects assessment tanks.

Task 3. Provide information necessary for Con Edison to evaluate work in progress.

a. Provide oral reports, as requested, on status of evaluations.

b. Document invoices by providing receipts for all expenses exceeding $100, employee time sheets, travel and expense vouchers, and equipment expense charges.

Task 4. Provide standard operating procedures for the performance of fish collection efficiency and latent effects assessments.

a. Provide 5 copies of a draft Standard Operating Procedure (SOP) for performance of tests 10 working days before commencement of tests.

b. Provide updates to the SOP 10 working days after modification of procedures, as necessary.

c. Provide the final SOP as an appendix to the comprehensive study report.

Task 5. Provide personnel for performance of the work plan.

Task 6. Analyze all biological samples fresh. Samples removed from the Arthur Kill premises are the responsibility of the contractor, and disposal must be in accordance with all applicable federal, state and local laws. Samples remaining on the premises may be disposed of with dual-flow screen washings.

Task 7. Check all collected striped bass for magnetic cheek tags. Unless otherwise available, provide magnetic field detector for detection of striped bass tags. Retain frozen all suspected cheek-tagged striped bass for verification under separate contract.

Task 8. Provide special handling for all shortnose sturgeon that might be encountered. Record date, time, location, weight (nearest gm), and length (nearest mm). If fish is alive, release it as soon as possible to the water source. If the fish is dead, record all pertinent data, tag it and store it frozen for up to one year for inspection by the DEC.

Task 9. Modify work scope to improve study procedures at the direction of Con Edison.

Objective II. Determine Effectiveness of Fish-Saving Components of Modified Dual Flow Screens Relative to that of an Unmodified Screen (Controlled Tests).

Task 1. Evaluate fish transfer efficiency from screen baskets to the collection sluices of two Ristroph-modified dual flow screens and to the debris sluice of one unmodified dual flow screen.

Subtask 1. Coordinate with Con Edison to ensure that a screen operator will be available on the test day(s).

Subtask 2. Have Con Edison install the temporary fish sluices into the screen housing of the two dual flow screens outfitted with fish saving features.

Subtask 3. Install fish collection nets within the fish and debris sluice of the modified dual flow screens.

Subtask 4. Turn on the low pressure sprays wash and supplemental sluice water supply to the screens.

Subtask 5. Open the inspection hatch on the ascending side of the modified dual flow screens, and distribute 150 marked, dead specimens of each of two seasonally abundance species among 15 screen baskets as they rotate by the hatch. Record separately, the number of each species recovered from the fish sluice and from the debris sluice of each screen. Identify the number not recovered. To the extent practical, identify the cause for non-recovery of fish in the fish sluice. Repeat this test on an unmodified screen.

Subtask 6.	Perform subtask 5 with two species of live, marked seasonally abundant fish, and determine 8 hour latent effects for those recovered from the fish sluice and the debris sluice of each modified screen. Hold a similar number of marked "control" fish of the two species used in the test to evaluate handling effects. Examine fish at the end of the test and record the nature and extent of observable damage. Record total lengths of test and control fish. Repeat this test on one unmodified screen.
Note:	Test fish should represent each of two relative hardiness groups (i.e. hardy = striped bass, white perch; delicate = bay anchovy, alewife), and may be collected from the dual flow screen. However, live fish must be held for at least 24 hours before testing. Only healthy, undamaged fish are to be used in latent effects assessment tests. Fish density per latent effects assessment tank should not exceed approximately one gram of fish per liter.
Subtask 7.	Record screen rotation speed, and high and low spray wash pressures
Subtask 8.	Record water temperature, salinity and dissolved oxygen within the latent effects assessment tanks at the beginning and the end of each test.
Schedule:	Perform Task 1 during the second month of each quarter, using species of fish that differ from those tested before.

Task 2. Evaluate bluecrab transfer efficiency from screen baskets to the collection sluice.

Subtask 1. Repeat Task 1 with live bluecrabs and perform 8 hour latent effects assessments for recoveries from both the fish sluice and the debris one time during the summer season for Task 1.

Subtask 2. Repeat Subtask 1 on an unmodified screen.

Task 3. Unless otherwise performed in other Arthur Kill Station monitoring programs, evaluate fish collection efficiency from the intake forebay by releasing 150 marked, dead fish (seasonally abundant species) through the bar screen at each intake bay outfitted with a modified dual flow screen and at one unmodified screen. The fish are to be released at approximately 5 feet below the surface of the water at the center line of each intake bay. A 2" pvc pipe may be used to convey the fish to the release point. Monitor sluices for recoveries for one hour. Record the number of fish recovered from the fish and the debris sluices of the respective screens for the intake bays at which the releases were made during the next 24 hours. Perform this test on each of four tidal current stages: low slack, maximum flood, high slack, and maximum ebb tide.

Schedule: Perform Task 3 quarterly on the same schedule that Task 1 is performed.

Objective III. Determine Post-impingement Viability of Fish and Bluecrabs Collected Opportunistically From Modified Dual Flow Screens and From an Unmodified Screen.

Task 1. Coordinate with Con Edison to ensure that a screen operator will be available on the test day(s).

Task 2. Have Con Edison install the temporary fish sluices into the screen housings of each of the two dual flow screens outfitted with fish saving features.

Task 3. Prepare latent assessment holding tanks to receive fish collected from the fish and the debris sluices of the two dual flow screens and one unmodified screen.

Note: Fish density per latent effects assessment tank should not exceed approximately one gram of fish per liter.

Task 4. Install fish collection tanks to receive flow from the fish sluices; place collection nets within the debris sluices.

Task 5. Have Screen Operator turn on the low pressure spray washes (10 psig) and the supplemental collection sluice water supplies, and collect fish for up to one hour from each modified dual flow screen and from the unmodified screen. (Since some fish may have accumulated in the screen sluices before the start of the test, flush these fish from the systems prior to the start of the sampling interval. (Sample collection duration may be shortened/lengthened depending on debris loading and relative abundance of fish and bluecrabs.)

Task 6. At the end of the sample collection period, turn off the low pressure spray washes and the supplemental sluice water supplies.

Subtask 1. Flush out all fish and bluecrabs remaining in the sluices, and carefully remove fish and bluecrabs from the debris collection nets. Examine fish and bluecrabs and record the nature os damage, including mortality, if present. Place only live, undamaged fish and bluecrabs into separate aquaria for 8 hour latent effects assessments. Attempts should be made to hold all alive (normal) fish collected from all collection gear. (Shorten sampling interval if excessive quantities of fish are collected; however, once the requisite number of 50 of a target species has been collected within the monthly sampling interval, further collections of that species may be disregarded. Compatible species of fish may be held within the same aquarium.)

Subtask 2. Drain the fish sluice collection tanks; carefully remove fish and record the nature of damage, including mortality, if any is observed. Place alive (normal) fish into aquaria for 8 hour latent effects assessments.

Subtask 3. Record by sluice, the number of fish collected and determine by species number recovered alive, damaged and dead initially and at the end of 8 hours. Record the total lengths of fish evaluated.

Note: Test fish are to be classified as Alive (Normal), Damaged, or Dead, as follows:

Alive: No visible signs of physical damage; active swimming and orientation behavior.

Damaged: Fish with visible external damage (missing scales, mutilations, or hemorrhages) or showing abnormal or weak swimming and orientation behavior.

Dead: No obvious external signs of life or several physical mutilation with only slight opercular motion and no other body movement.

Task 7. Repeat Task 6 up to three times (at least two hours) per test day per screen (two modified and one unmodified dual flow screen) to attempt to obtain 50 fish of each of 5 target species that are seasonally abundant. Up to 50 fish (or more if space allows) of other seasonally abundant opportunistically collected species are to be held per sampling day as well.

Task 8. At end of the final collection on each of the three test screens each month, drain down the collection tank and remove bluecrabs and debris. Leave the fish in the tank, refill it, and determine latent effects at the end of 8 hours. Record the total lengths of fish evaluated.

Task 9. Have the screen operator remove the fish collection sluice and return the dual flow screens to normal operation.

Notes: Tasks 1 through 9 are to be performed monthly from February 1994 through January 1995.

Sample collection may need to be performed at night in order to increase the likelihood of collecting adequate quantities of target species.

Objective IV. Provide Summary and Comprehensive Study Reports.

Task 1. Following completion of five months of sampling, prepare summary tables of results of fish and bluecrab transfer efficiency and latent effects assessments, intake bay recovery assessments, and post-impingement viability assessments of fish collected opportunistically.

Note: Mortality is to be calculated based on the combined numbers of damaged and dead fish relative to the total number collected and evaluated.

Task 2. Attend and discuss results of studies at meetings (two attendees at two possible meetings) as requested.

Task 3. Following completion of field studies prepare a draft Comprehensive Report on Results.

Subtask 1. Compare and contrast results obtained from the modified dual flow screens with those from the unmodified dual flow screens.

Subtask 2. Compare and contrast results obtained from the modified dual flow screens with those obtained from the modified Ristroph screens installed at Indian Point as reported by Fletcher (1986).

Task 4. Provide Con Edison with the following preliminary data for each sampling date: Species and numbers collected; total length of all test fish, including control fish, evaluated for transfer and collection efficiency, and post-impingement viability. Data must be provided as SAS or ASC-II files three working days following the end of each monthly test period.

Task 5. Provide all final data in standard SAS files having file structure similar to the impingement master data base for the Arthur Kill Station, and provide microfilm records of all corrected data sheets and detailed standard operating procedures within 45 working days after completion of field studies.

Schedule: Objective IV. Task 1.

Submit 5 copies of draft tables of study results 15 days after completion of the fifth month of field studies.

Objective IV. Task 3.

Submit 5 copies of a draft comprehensive report 30 days after completion of field studies. Submit final report within 30 days of resolution of comments.

Keep this page but do not submit

Objective II. Provide Velocity Profile Measurements of Water Passage Through The Dual Flow Screens

Task 1. Conduct velocity profile measurements on both the ascending and descending sides of the dual flow screen on four tidal current stages - low slack, maximum flood, high slack, and maximum ebb tide. Profiles are to be measured at five uniformly spaced locations across the face of the screen basket and at five uniformly-spaced depths within the intake bay. Profiles are to be recorded for x and y coordinates, at a distance of approximately 6 inches from the screen mesh along the horizontal centerline of the basket.

Note: It is anticipated that flow measurement equipment will have to be mounted on screen baskets, which will then be rotated to the required location for recording velocities. An installation plan should be developed and worked out with Con Edison in advance of the test day(s).

Task 2. Coordinate with Con Edison to ensure that a screen operator will be available on the test day(s).

Task 3. Record water temperature and conductivity during each velocity profile assessment.

Schedule: Perform Objective II within the first 3 months of field studies.

TO: Jim Reichle
FROM: Paul G.
DATE: 12/20/93
RE: Survival work at Arthur Kill
cc: M. Ricci

Ken just sent this sole source scope of work to us for the survival work at Arthur Kill Station. He may talk to you about this at Ravenswood on Tuesday. I want you to read the entire RFP and cost out completely, labor (hours by labor grade) and non-labor (include sales tax), the following sections:

Obj I Task 2 (all)
Task 7 (need detector in working condition)
Task 8 (prob. no cost)

Obj II Task 1 (all)
Task 2 (all)
Task 3 (all)

Obj. III All tasks

For each objective and task state all assumptions. For example on Obj. III state how long do we assume collections will be made to make quotas. Do we use two crews? One to make collections and start holding periods, and the other to terminate? Note that in Objective II we will need a lot of fish for transfer and collection efficiency and there will not be any ongoing impingement programs. Also note in Obj. IV Task 4 that lengths will be needed for transfer and collection efficiency and survival work. Ken wants this ASAP. Can you complete costing by 28 December and FAX to me? This is not competitive bid and it is likely that the Scope of Work will change once we start.

AK will be demobilized this week at the end of sampling. Tell Ricci where the AK flow diverters are. You will have 27 December available for this costing. Call me if you have questions.

Transactions of the American Fisheries Society 114:652–694, 1985

Risk Analysis for Fish Diversion Experiments: Pumped Intake Systems[1]

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Damariscotta, Maine 04543

Abstract

Such facilities as power-generating stations, public water systems, and ore-processing plants draw off large quantities of water from estuaries, coastal seawaters, lakes, and rivers. In turn, large numbers of fishes are often drawn into these pumped intake systems and killed if not otherwise removed or diverted. The large mortalities associated with many intake systems threaten the perpetuation of indigenous stocks. The diversion and removal devices most commonly used for protecting fish life from such risks are presumed to operate on principles shown here to be erroneously conceived. In consequence of these faulty theories, the estimators and experimental designs of standard industry practice seldom reveal the true correlations necessary for improvements in fish conservation systems, nor do the assessments of small-scale experiments extend with reliability to full-scale system designs. Such passive devices as angled barrier screens are thought to guide fish in some way into pumped bypassing ducts, but an analysis of existing data supports instead a hypothesis of random encounter whereby the activities of entrapped fish are governed by the probabilistic mechanics associated with random walks and unlike boundary conditions. Experimental designs for separating and assessing time-dependent risks are developed for the case of competing devices in a given test system. From time-dependent comparisons between large and small systems (in particular, between a model system and its full-scale prototype), the net decrease in the probability of fish survival associated with increased system size is shown to be the consequence of increased exposure to the risk of death (increased residence time) rather than the consequence of increases in the unit risk of death itself. Where extensions of small-scale empirical results to full-scale system designs are wanted, arithmetic extrapolations yield erroneous results. Because displacement dependence (fish movement and system size) enters the risk analysis, the scaling problem must be resolved instead from a corresponding system of partial differential equations.

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Industrial and public-service facilities of many and dissimilar functions share a common demand for large volumes of water in their operations. As a rule, such users as power-generating stations, ore-processing plants, public water systems, pumped irrigation canals, and pulp mills draw their supplies, more or less continuously, from such natural sources as rivers, lakes, estuaries, and coastal seawaters. At the two Indian Point nuclear power stations in New York State, for example, upwards of 7.5 million litres per minute of Hudson River water are pumped through the condensers of the generating units (Stone and Webster 1976). Similar quantities are diverted from the San Joaquin and Sacramento rivers at Tracy, California, and pumped into the Delta–Mendota Canal, accounting at times for the entire flow of the San Joaquin River and half the Sacramento flow (Bates and Vinsonhaler 1956).

As with most such diversions of natural waters, quantities of fishes large and small are regularly drawn into the intake structures of the pumping facilities. Once drawn in, the fish tend to move with the water flow until they are blocked in their transit by barrier or "intake" screens. These screens, in one form or another, are universally employed as the means for preventing the passage of debris into the circulating pumps of the facility. Some barrier screens are stationary, but many, as part of a system for removing debris and fish caught in the screen meshes, are moved (are caused to "travel") in a vertical direction around driving sprockets after the manner of an endless belt. Whether stationary or travelling, the barrier screens block the further entrainment of indrawn fish (except for larvae small enough to be extruded through the screen meshes). Up-

[1] Work supported by a grant from the Hudson River Foundation for Science and Environmental Research, 122 East 42nd Street, New York, New York 10168.

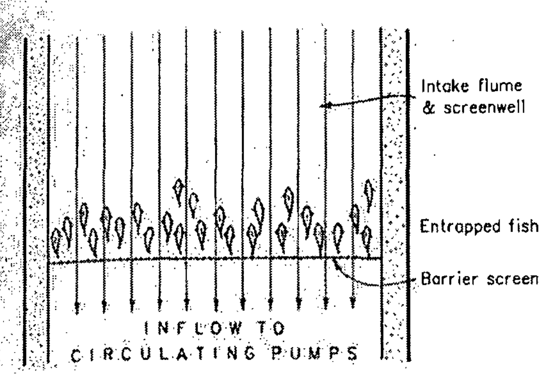


FIGURE 1.—*Fish entrapped in a water intake flume swim headmost into the current.*

wards of 100% of the fish so entrapped remain in the screenwells of the intake structure if not otherwise removed, eventually suffering injury or death from being pressed against the barrier screen or into its meshes by the force of the water flow. Because active fish tend to align themselves parallel with the oncoming flow and headmost into it, they are moved rearwards in their approach to the barrier screen (Schuler 1973; Stone and Webster 1976). As the fish come into tailfirst contact with the barrier screen they may dart out some ways but tend to stand against the flow in the region just ahead of the screenfront (Fig. 1). In so swimming at the net speed of the oncoming flow, the fish must increase their rates of energy expenditure owing to increased swimming effort. As the fish become exhausted over time, they are pressed onto the barrier screen by the force of the inflow (the time to exhaustion depending on such factors as species, size, physiological condition, water velocity, and water temperature).

The fish kills associated with large-volume water diversions are often very great, and the potential for long-term depletion of indigenous populations has been a worrisome problem over several decades for the regulatory agencies of the various states, the U.S. Environmental Protection Agency, and the power industry in particular. The conservation problem, although significant in terms of risks to fish populations, litigation costs, and costs to industry for expensive (but generally ineffective) fish conservation systems, has not been well attended to by the fishery science community at large. Although much industry-funded research has been produced over the years (in the form of test-flume studies, field sampling of full-scale systems, laboratory-scale experiments on fish diversion devices, and hydrological modelling), very little of it has appeared in the open, refereed literature. Because these industry-generated studies are seldom subjected to outside review, they vary in reliability and must be used with caution.

Very often, industry and consulting biologists are forced to deal with problems outside their own fields of specialization, and a hard-pressed investigator is apt to follow without examination the conventions and doctrines of his predecessors. In this way, apparently, several plausible but faulty hypotheses have persisted in the technical literature and, through repetition, become axiomatic. These errors in reasoning and practice, generally arising from misperceptions of critical topics in probability theory, vector mechanics, fluid dynamics, and relative motion, have misled investigators into designing experiments in which inconsequential events are often stressed and the more critical ignored, all to the cost of advancements in conservation designs and the requisite understanding of fish behavior in moving water.

Many of these faulty hypotheses and experimental designs are examined at length in Fletcher (1984), a study sponsored by the New York State Department of Environmental Conservation, and it is not my purpose here to repeat that criticism in detail. But because the analysis and experimental designs outlined here depart so radically from those of industry practice, and because the conclusions reported here are so opposed to the beliefs of many investigators and industry biologists, a certain amount of critical exposition is owed the reader. Some discussion of those difficulties has been incorporated into the narrative that follows; more explicit examples of the estimators and experimental designs associated with current practices can be found in Appendices C and D of this article.

Owing to the (usually) limited circulation of the technical literature on fish conservation, active entry into this important field of inquiry is hindered as much by the inaccessibility of information as it is by the cross-disciplinary demands of the phenomenological problems themselves. The citing of obscure literature in this article is regretted, but it is unavoidable; no other starting point exists at this time. For the benefit of the reader who might be motivated to pursue the problems addressed here, I have augmented the citations with as much source information as possible. For additional assistance in obtain-ing obscure references, two good sources are the Electric Power Research Institute, 3412 Hillview Avenue, Palo Alto, California 94303, and the Empire State Electric Energy Research Corporation, 1217 Avenue of the Americas, New York, New York 10020.

The work of this article applies to systems of pumped (or pressure-driven) flows; it does not extend unaltered to intake systems that operate on gravity-driven flows (such as the turbine intakes of hydroelectric dams). The geometry and velocity distributions of a gravity-driven flow (as well as the disposition of the fish entrapped therein) will differ in some ways from those of a pumped flow. Because of those differences, the risk assessments that apply to systems of gravity-driven flows are deferred to a later paper.

Conservation Devices

Many schemes and appliances have been devised with the common aim of reducing the fish kills associated with large water-intake systems. Various nonmechanical means have been tried with the intended purpose of frightening off the fish prior to their entrapment or inducing their entry into bypassing conduits. No known stratagem of that kind (such as sound waves, bubble generators, strobe lights, shock waves, chemical repellents, or electricity) has yet proven effective in full-scale systems (Kerr 1953; Applegate et al. 1954; Moore and Newman 1956; Johnson et al. 1958; Burner and Moore 1962; Van Derwalker 1966; Bates and Van Derwalker 1969; Bechtel Associates 1970; Pugh et al. 1970; Bell 1973; Texas Instruments 1974; Schuler and Larsen 1974; Stahl 1975; Stone and Webster 1976; Pagano and Smith 1977; Lieberman and Muessig 1978; Patrick and Vascotto 1981; Hadderingh 1982; Haymes et al. 1984; Lawler, Matusky and Skelly 1984; Ontario Hydro 1984).

Various mechanical modifications to the barrier screens themselves have also been tried. In one demonstration, a travelling barrier screen, ordinarily moved in a vertical direction, was redesigned and moved in a lateral direction, crosswise to the flow, with its frontmost side driven in the direction of a bypassing slot located at one end of the moving screen (Bates 1970; Farr and Prentice 1973; Prentice and Ossiander 1973). During experiments in a testing flume (and at least one full-scale installation), the horizontal screen effectively conveyed young salmonids to the bypassing slot with little apparent trauma to the test fish. Although promising in that regard, the device was mechanically unsound. Among other problems, the engineers were unable to devise a suspension system adequate to the scale and to the pressure heads of large intake systems.

Vertical travelling screens of conventional design have also been equipped with troughs affixed at regular intervals and extending across the screenface (the so-called Ristroph modification). The troughs are meant to scoop the fish up from the front of the screen and then raise them through a system of water jets, which, in turn, are meant to wash the fish from the troughs and into a sluice for their return to the source waters. An application of the Ristroph design at the Surrey power station in Virginia is reported by White and Brehmer (1977) as being effective in reducing fish mortalities (although the authors cite no data in their report). Tests with a similar modification at the Danskammer Point power station in New York showed no mortality reductions over conventional travelling screens when the conventional screens themselves were moved through a wash-down system like that of the Ristroph modification (Clock and Huggins 1981; Ecological Analysts 1982). In a series of comparative tests at the Salem nuclear power station on Delaware Bay, a variation on the fish-trough screen by Royce Equipment Company was shown to impose mortalities somewhat lower than those of a more standard Ristroph design (Public Service Electric and Gas Company 1984).

In recent years, many large pumping facilities have been equipped with passive guiding barriers, usually in the form of vertical metal louvres or conventional barrier screens, placed diagonally across the intake flume (or in some way at an angle to the oncoming flow), with a narrow bypassing slot located at the apex of the acute angle between the barrier and the wall of the flume. The thought behind any of these angled barriers is that indrawn fish might somehow be guided or swept along it and into the bypass.

In many tests with angled louvre arrays, the majority of the fish were drawn directly through the louvres and into the pumps of the intake system or into an auxiliary barrier screen (Ducharme 1972; Schuler 1973; Skinner 1974; Texas Instruments 1974; Stone and Webster 1976; Taft and Mussalli 1978). The only louvre arrays that seem to be effective in guiding fish in any way are those whose louvre vanes are designed to create a strong local turbulence within the vane

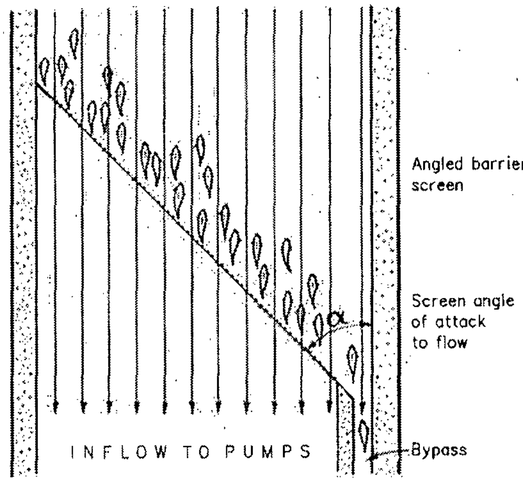


FIGURE 2.—*Typical configuration of angled barrier screen and pumped bypassing slot. Fish swim headmost into the current.*

openings (Bates and Vinsonhaler 1956; Hallock et al. 1968; Stone and Webster 1976; Odenweller and Brown 1982). As a fish comes into tailfirst contact with the zone of turbulence at the louvre face, it tends to move away from the turbulence somewhat more in a direction normal to the angled array than directly into the free-stream current, the net effect being a small lateral displacement that eventually puts the fish, after repeated excursions, into the bypassing current along the flume wall. But the innovation that imparts the gain in fish survival also imparts a loss in efficiency to the plant. Because the turbulence between the louvre vanes impedes the free flow of water into the intake system, the power expended in overcoming the accompanying head losses becomes so great that turbulent barrier systems are judged to be impractical for most facilities.

With conventional barrier screens set at an angle of attack to the flow, no effective turbulence is created (beyond the small-scale disturbance immediately behind each screen wire). As with the barrier screens set normal to the flow, the indrawn fish tend to stand against the oncoming flow in the region just ahead of the screenface (Fig. 2), and their lateral excursions seem to be randomly executed (in contrast to their responses to the turbulent louvre array). Some advocates of angled-screen designs advance the curious hypothesis that while the inflowing water is obviously drawn through the barrier screens by the pumps of the facility, some portion of the water will also flow along the face of the screen, towards the bypassing slot, carrying the fish along with it. Other writers envision the fish as being guided across the oncoming flow and towards the bypass by a velocity vector component. Although the first notion (the criss-crossing flow) is an appeal to a physical impossibility, and the second (the Cartesian vector component) an appeal to a mere mathematical convention, the notions persist and are given wide credence among industry experimenters. At least one of the two arguments appears explicitly in each of the following studies: Schuler (1973); Texas Instruments (1974); Schuler and Larsen (1974); McGroddy et al. (1981); Copeland et al. (1981); Lawler, Matusky and Skelly (1982b).

Although the presumed objective common to all displacement schemes is that of removing fish from intake structures unharmed, the practice in virtually all fish diversion demonstrations is that of emphasizing the "efficiency" (the effectiveness) of a system in diverting fish from the screenwell into a removal device (such as a screen trough or a bypassing duct), whether the fish are alive when diverted or not. This efficiency measure is calculated, over any arbitrary time period, from the ratio

$$\frac{D}{D + I}, \qquad (1)$$

D being the numbers of fish diverted (the numbers collected, dead or alive, after their exit from the screenwell) and I the numbers impinged (the numbers actually embedded in the screen meshes or held fast in some way by the screen structure). So whether all the fish might be alive when collected or all dead, the associated diversion efficiencies (1) would be the same. Although the percentage surviving of the fish passed through the removal system is sometimes accounted for and reported, angled-screen demonstrations in particular are invariably conceived and designed around formula (1), and often with either or both of the mistaken notions about fish guidance as the given assumptions. No distinctions are ever made between actively swimming fish that might enter the bypass without forcible contact with the barrier screen and those that are pressed against the screen and forced along it to the bypass by the oncoming flow. Owing at least partly to this indistinction, misconceptions about the physical properties of the system and the actions of the entrapped fish are perpetuated.

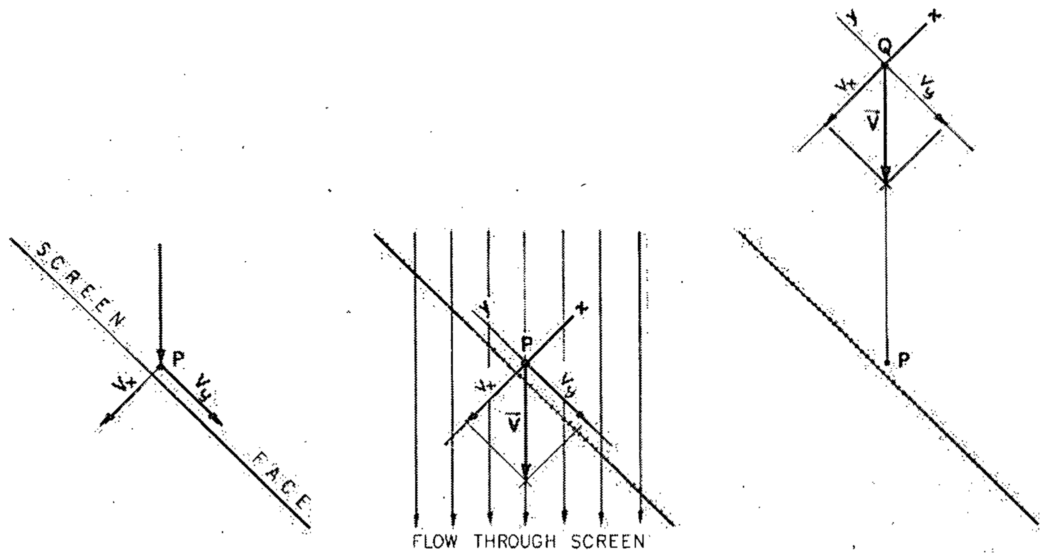


FIGURE 3.—*Left, erroneous interpretation of water flow in the vicinity of an angled screen. Center, correct Cartesian representation of water velocity V (as a vector point function) in the vicinity of a barrier screen, pumped intake flow. Right, reference point (Q) moved a distance directly upstream of P.*

It is common to read of angled-screen installations being 90 to 100% effective in guiding or successfully diverting entrapped fish from a screenwell into a bypassing system. But all that such figures really tell us are the percentages of fish that remain affixed to the barrier screen itself. An angled screen device 99% effective in diverting captive fish and debris into a pumped bypass may leave only 1% of the fish behind, but it may also be ineffective altogether in preserving the lives of the 99% diverted. In a typical study of a full-scale installation of angled barrier screens at a power-generating plant on Lake Ontario (Lawler, Matusky and Skelly 1982b), the "total diversion efficiencies" for one particular month were reported as being 91% for alewives *Alosa pseudoharengus* (9% remaining on the screen meshes, or "impinged"), 92% for rainbow smelt *Osmerus mordax* (8% impinged), and, for another month, 93% for white perch *Morone americana* (7% impinged). But from the data on the bypassed fish it can also be determined that of the bypassed alewives, 86% were dead or injured on arrival in the collection basin, and of the 14% remainder 89% died soon after collection, for an overall mortality of 99%. The corresponding immediate and cumulative mortalities for the rainbow smelt were 59 and 95%, and for the white perch 80 and 84%. Apparently, few of the successfully diverted fish escaped a direct and unhappy encounter with the barrier screen.

In experiments with angled-screen and bypass devices in small test flumes (Stone and Webster 1976; Alden Research Laboratory 1981; Lawler, Matusky and Skelly 1981, 1982a), the imposed deaths and injuries occur in percentages significantly lower than those of large-scale systems, owing principally to the shorter mean times that fish spend in the screenwell prior to encountering the escape route. As shown in films of test flumes, fish swimming in the region just ahead of the barrier screen exhibit small lateral displacements, apparently from cueing on other members of the school, that tend to distribute the fish along the screenfront. Thus, the narrower the intake flume the greater the probability that an actively swimming fish will encounter the narrow band of bypassing current at the flume wall before exhaustion (or chance) overtakes it and the oncoming flow presses it against the barrier screen.

The Guiding-Component Hypothesis

The relationships between fish and barrier screen and the forces of the water flow on the fish are not the same for a fish impressed against the screen as they are for a fish stemming the current just ahead of it. Let us clearly understand at the outset that with a flow and screen configuration like that of Fig. 2, there can be no such thing as a bifurcating flow at the screenface or a guiding water velocity parallel to the screen. Yet in reports of angled barrier studies, the investigator will often illustrate the theory of guiding velocities by showing (or describing) a diagram like the left panel of Fig. 3, where the component $\mathbf{v}_y$ is said to represent the velocity of the flow parallel to the screen and $\mathbf{v}_x$ the velocity of the water flowing through the screen. Neither interpretation is correct. The quantities $\mathbf{v}_x$ and $\mathbf{v}_y$ (often given as $\mathbf{v}_1$ and $\mathbf{v}_2$) are nothing more than the mathematical components (the directed Cartesian components) of *the* water velocity **V** at some arbitrary point ahead of the screen (Fig. 3, center). Nothing in this corporeal universe was ever guided or caused to move by a Cartesian component of velocity. The directions of components $\mathbf{v}_x$ and $\mathbf{v}_y$ merely reflect the author's choice of reference axes (whatever his motivation might have been for choosing them), not independent velocities or directions of flow. Any other orientation of the reference axes would be just as valid for describing velocity **V** as the component sum $\mathbf{v}_x + \mathbf{v}_y$; the choice is arbitrary and wholly independent of the phenomenology of the flow.

It is never made clear just how far in front of the screenface the guiding velocity or guiding flow is thought to extend. Presumably it is not more than several centimeters. In the full-scale study of the Oswego plant by Lawler, Matusky and Skelly (1982b), for example, components $\mathbf{v}_1$ and $\mathbf{v}_2$ were resolved from velocity measurements approximately 15 cm forward of the screenface and so labelled as flows and velocities parallel and perpendicular to the screen. Let us examine that hypothesis by moving the reference point well ahead of the presumed guiding zone, say a distance *ten feet* directly upstream of P to a new location point Q (Fig. 3, right) without a change in orientation of the reference axes. The velocity **V** at point Q will have exactly the same vector components as **V** at point P: $\mathbf{V} = \mathbf{v}_x + \mathbf{v}_y$. If we now put a fish (or any other neutrally buoyant object) at Q, it will no more be guided in the direction of $\mathbf{v}_y$ (or $\mathbf{v}_x$ for that matter) than it would be at point P. It is gratifying to find the following substantiation in at least one report on angled-screen experiments (Alden Research Laboratory 1981):

"Velocity data indicated that the flow in the approach section [of the test flume] was distributed uniformly at a cross-section 10 feet upstream of the angled screen. A traverse of velocity measurements 4 inches upstream of the screenface [revealed] velocities of the same magnitude and same direction as those of the upstream cross-section."

In swimming directly into a freestream flow of water (whether 4 inches or 10 feet upstream of a barrier screen), a fish needs only to resist the straight-on force of the flow in maintaining its position ahead of the screen; the screen imposes no lateral forces on the fish upstream of the screenface. Should the fish fall back against the screen, whether through exhaustion or the inability to swim at a speed equal to the speed of the oncoming flow, *then* the forces of the screen, through frictional roughness (or impediments) and its angle to the flow, will directly influence the disposition of the fish and may then guide it, so to speak, to the bypass. But if our representative fish arrives at the entry to the bypass without forcible contact with the barrier screen, it does so through its own actions and reactions, either through random lateral excursions while swimming, through cueing on or reacting to the excursions of other fish, or through some stimulus that biases its own lateral movements more towards the bypass than away from it. If angled screen devices provide any such bias, it must be a weak one.

Entrapped fish spend surprisingly long periods of time in screenwells merely standing against the flow, just ahead of the barrier screening. In a series of experiments with angled barrier screens in a laboratory test flume, Alden Research Laboratory (1981) evidently found the residence times of test fish in a typical experiment to be greater (sometimes much greater) than the planned duration of the experiment. Although the test flume was less than 2 m wide, the fish were not readily guided to the bypass by screens set at either of two test angles. The Alden experimenters conducted 58 experiments with various combinations of species (striped bass *Morone saxatilis*, white perch, alewife, Atlantic menhaden *Brevoortia tyrannus*), screen angles (25°, 45°), water velocities (30 cm/s, 60 cm/s), and water temperatures (0–22°C). In all but three cases, quantities of fishes (sometimes the majority of the experimental sample) were still swimming in the test flume at the termination times of the experiments. (The Alden data are tabulated on Table C-1, Appendix C of this article.)

Residence times of entrapped fish are even greater in full-scale systems. In the study by Lawler, Matusky and Skelly (1982b) on the angled barrier and bypass system of the Oswego power station, the investigators introduced marked fish of various species into the intake screenwells and found residence times of at least 681 h for brown trout *Salmo trutta,* 1,269 h for smallmouth bass *Micropterus dolomieui,* 48 h for yellow perch *Perca flavescens,* and 546 h for white perch. (Selections from the Oswego data are given in Appendix D.)

The greater the mean residence times of fish entrapped in a screenwell, the greater the chances are that the fish will suffer exhaustion and be thrust against the barrier screen before encountering the bypassing system. That eventuality is reflected in the higher percentages of deaths and injuries for full-scale screen and bypass systems in comparison to small experimental systems. With the thought to overcoming these size-related mortalities, the more recent barrier–bypass installations have been designed around screen angles of attack α as steep as 20 or 25°, and hence longer screen arrays, which in turn require greatly extended forebays for their accommodation (Fig. 4). But lengthening the barrier and steepening its angle (reducing its angle of attack[2] to the flow) does nothing to decrease the cross-flume excursion distance and only increases the distance available for the distribution of fish along the screenface, a factor that seems to work against the rapid exit of actively swimming fish.

Although steeply pitched screens are favored for their high diversion efficiencies (their propensities for lowering impingements), the overall survivals of entrapped fish apparently fail to increase accordingly. In the Alden flume study, for example, the survivals of bypassed fish—although better than in full-scale systems—were not improved by steepened screen pitches, at least in the view of the investigators themselves (Alden Research Laboratory 1981), who concluded that

"Within the range of variables examined, it appears that . . . the angle of the device . . . did not significantly affect total efficiency"

("total efficiency" being the overall survival of the test fish, as opposed to "total diversion efficiency," impingement index [1]). In some earlier studies, Schuler (1973) and Schuler and Larsen (1974) found no significant differences in overall survival of test fish for screen angles of 30°, 45°, and 90°. They say further that

"Results with [angled] screens were generally poor . . . fishes were guided to the bypass with only marginal success . . . . Fishes were impinged against rather than guided along the screen panels."

From another series of experiments on angled screens and bypasses, Stone and Webster (1976) report that their

". . . analysis of the data did not show a significant difference in [fish survival] between 25- and 45-degree orientations . . . . Within the range of variables studied, screen angle . . . had no effect on total efficiency."

The investigators add this revealing observation:

"It was subjectively observed, however, that fish suffered more physical damage in tests conducted with the angled screen at 45 degrees than they did with the screen at 25 degrees."

The advocating of steeper and steeper screen pitches (lessened angles of attack α), despite their reported failures in improving overall survival, is apparently motivated by the importance given to the diversion efficiency index (1) and to the universal acceptance of the guiding actions of angled barrier devices. Although the notions of guiding velocity components can be dismissed out of hand for the reasons already set forth, it is true that the diversion efficiencies (the indices of impingement [1]) of angled barrier screens do seem to increase with steepness of pitch. In the case of a fish pressed against a shallow pitched screen, the starting and developed resistances to sliding and tumbling motions would be greater, for a given inflow velocity, than those of a more steeply pitched screen, owing to the angle between the screen surface and the direction of flow. In consequence of those differing resistances (differing in both direction and magnitude), the resultant force on the fish is more nearly tangent to the screen surface in the case of the steeper screen. With the shallower pitched screen, the resultant is directed more towards the normal; hence the fish is pressed with greater force against the screen the shallower its pitch (the greater the

[2] By convention, a meridional plane normal to a flow is said to have a 90° angle of attack; one parallel to the flow has an angle of attack of 0°. Hence, the less its angle of attack, the "steeper" its pitch.

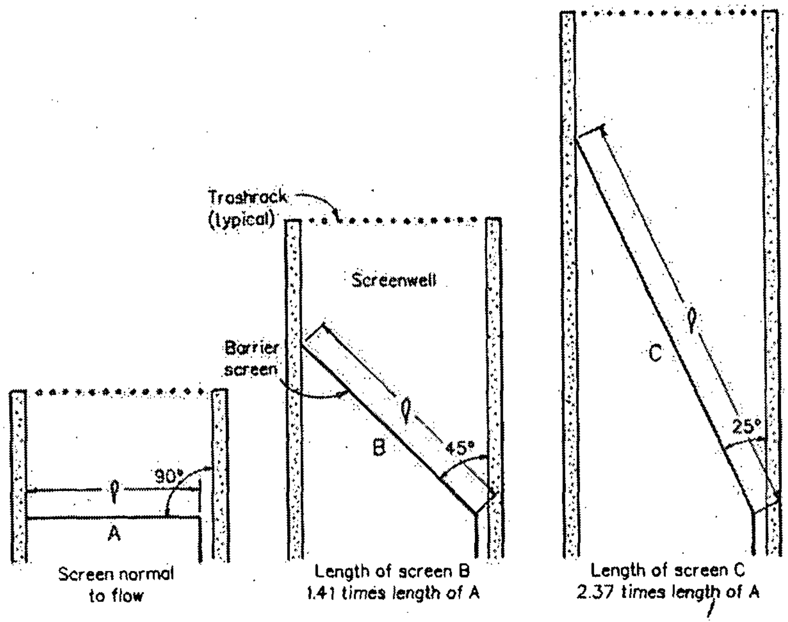


FIGURE 4.—*Comparative screen lengths and forebay extensions for commonly employed attack angles of angled-screen systems.*

angle of attack α) and more nearly into its mesh openings, the result being a greater probability of abrasion or impingement. The subjective observations noted by Stone and Webster (1976) are probably correct.

The actions of flow and screen on a fish thrust against a screen surface are further complicated by the size of the fish and its species, and most importantly by its struggles to remove itself from the screen. In any case, although fewer fish remain immobilized on the fronts of steeply pitched screens, overall survivals do not seem to be improved by lessened angles of attack. Apparently, the rates of exit of live, uninjured fish are related more to the sizes of intake wells (their cross-flume excursion distances) than to the angles of their barrier screens.

Estimators and Conventions of Reported Diversion Experiments

From among the various industry reports on fish diversion experiments, I have selected two for exposition, one of which is representative of empirical modelling in small test flumes (Alden Research Laboratory 1981) and the other of field tests on full-scale operating systems (Lawler, Matusky and Skelly 1982b). Although neither is suited in its experimental design to a separation of competing risks, more useful data were recovered from these two experiments than from other reported projects.

Small-Scale Test System

The Alden Laboratory test flume is wider than most model flumes (1.83 m, as compared to test flumes as narrow as 0.76 m), but the estimators and experimental conventions employed in the Alden work are identical in most respects to those of its relatives. The purpose of the 1981 Alden study is stated on page 13 of the cited report:

"... past angled screen studies had yielded diversion efficiencies of nearly 100 percent at an approach velocity of 1 fps [foot per second] and a screen angle of 25 degrees to the flow. . . . These results indicated that higher velocities and greater angles, both of which would reduce the cost of an angled screen system in a power plant, might also yield acceptable diversion efficiencies. Accordingly, velocity and angle were the primary variables of interest in the ESEERCO study."

Again, the diversion efficiencies stressed in the report are the indices of impingement (1), not the overall survivals of the test fish.

The Alden test facility (Fig. 5) is a water-recirculating flume with an approach section 1.83 m wide, 1.83 m deep, and approximately 10.7 m long. The water velocity is adjustable. The

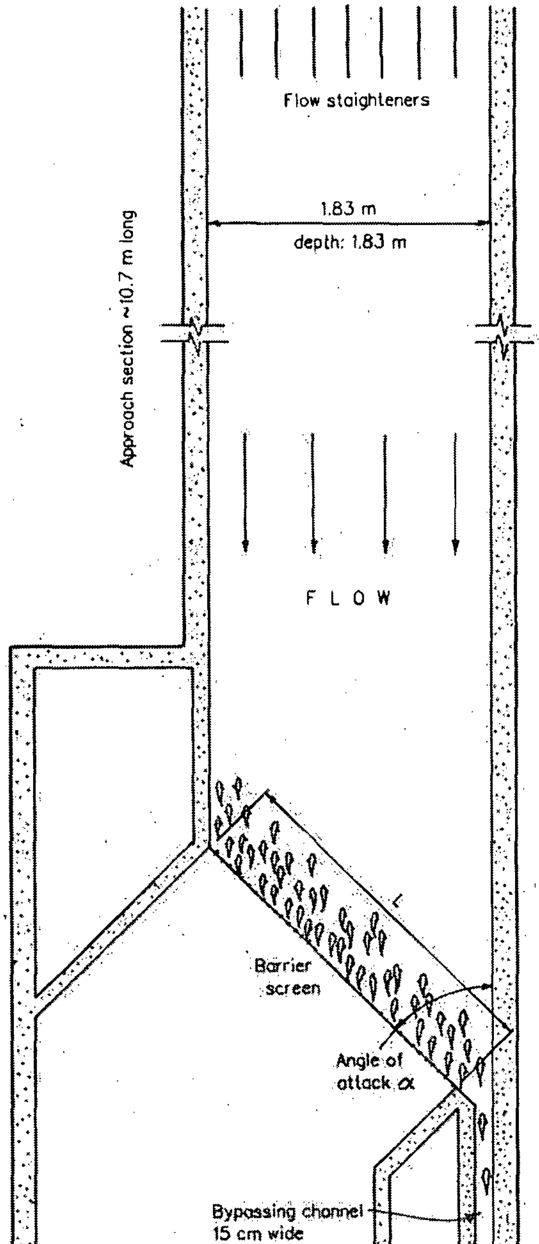


FIGURE 5.—*Alden test flume configuration (Alden Research Laboratory 1981). When screen angle* $\alpha = 45°$, *screen length* L = *2.36 m. When* $\alpha = 25°$, L = *3.96 m.*

flume was equipped with a fish bypass slot 15 cm wide and leading to a collection basin. Fixed barrier screens of 9.5-mm standard wire mesh were employed in the experiments, at test angles of 25° and 45°. In all tests the ratios of water velocities at screen and bypass were said to be 1:1 (reached some time after the release of a fish sample). Structural details and hydraulic tests of the Alden flume are given in Stone and Webster (1976).

As with most such fish-diversion studies, the experimental information from the Alden work was reported in summarized form. The experimental observations do not appear in the report itself, but the investigator's laboratory notes were recovered and transmitted to me by Kenneth Marcellus of the Consolidated Edison Company of New York. Because that information has not been promulgated in any form accessible to the general reader (and because it is especially important in the time-dependent analysis given in another section of this paper), I have included it in Appendix C, Table C-1. Other information discussed here was extracted from the Alden report proper.

Of 58 recorded experiments, 50 were conducted with the 45° barrier screen and eight with the 25° screen. The water velocity for all eight of the experiments with the 25° screen was 30 cm/s; it was 30 cm/s for 34 of the 45° experiments and 60 cm/s for the remaining 16. Juvenile fish were used in all experiments. Length ranges by species were:

- Atlantic menhaden, 3.9 to 7.0 cm (August to October);
- white perch, 5.1 to 9.0 cm (October to February);
- striped bass, 6.6 to 12.0 cm (December to March).

One of the Atlantic menhaden tests (experiment 6; Appendix C) was disqualified because of chlorine contamination of the flume water. Four experiments were also run with alewives (a species especially vulnerable to intake systems), but the results of the alewife tests were not included in the reported analysis, and the observations from the alewife tests were not forwarded to me. With the elimination of the five disallowed experiments, results from the remaining 53 were analyzed statistically by the authors. In 39 of these, sample sizes were 200 or more fish released simultaneously; in the remaining 14, sample sizes were 100 fish each. Owing to the estimating procedures employed in the experiments, the linear regressions and analysis of covariance produced spurious correlations considered "significant but unimportant" by the authors.

In each of the experiments the fish were placed in the flume upstream of the barrier screen and behind a "crowder." The fish were released simultaneously on removal of the crowder, but the flume pump was not started until release of the sample. The starting conditions may have introduced several complications into the experiments not easily accounted for in the experimental results.

(1) Because the tests were run in a darkened flume, the distribution and behavior of the fish in their approach to the barrier screen could not be observed and remains unknown.

(2) Owing to the transient flow geometry in the flume during the start-up period, the possibility cannot be discounted that during that initial period the velocity and pattern of water flow into the bypassing slot may have been altogether different from the flow through the screen. Irregular flow patterns during start-up (probably the first 15 min or so of each experiment) might have been related to the initial washout of fish that was characteristic of all experiments except the first.

(3) Because of the small size of the flume, the simultaneous release of 200 or more fish (in 36 of the experiments) implies a dense packing of fish along the screenfront. Data from the recovered laboratory notes clearly reveal the bypassing rates to be nonlinear (or density-dependent: the greater the number of fish in the flume the greater the bypassing rate). For this reason alone (but also because most of the experiments were terminated before all the fish of a test sample had exited the flume), the 14 experiments with sample sizes of 100 fish are not statistically comparable (without time-dependent corrections) to the experiments where sample sizes were 200 or more.

The durations of individual experiments ranged from 15 min to 12.8 h (Appendix C, Table C-1). Seventeen of the experiments were terminated at 15 min, or during the apparent transient flow period noted above. In 50 of the 53 experiments analyzed by the authors, fish were still swimming in the flume at termination. In 10 of the 24 experiments with striped bass, for example, over 50% of the test fish were swimming in the flume at termination, yet in each case the "diversion efficiency" (the presumed effectiveness of the angled barrier screen in diverting fish into the bypass) was scored as 100%. In five cases, as few as one-fourth of the test fish had been bypassed when the experiments were cut off, but the corresponding diversion efficiencies were still scored as 100%. With regard to the fish remaining in the flume, the investigators say on page 16 of the report:

"Non-bypassed fish (those still swimming in the flume) were removed from the flume at the end of a test, but they were not held for mortality studies; however, they were included in the calculations of efficiency."

This is a curious instruction. In every case the numbers of fish remaining in the flume were subtracted from the calculations as though they had never entered the experiment. Efficiency E is defined (page 17) as

$$\text{“}E = \frac{\text{Number Bypassed}}{(\text{No. Tested}) - (\text{No. Non-Bypassed})}.\text{”}$$

But the quantity of fish still swimming in the flume (the "No. Non-Bypassed") subtracted from the original sample size (the "No. Tested") equals the numbers bypassed. The denominator of E is identically equal to its numerator, irrespective of the quantities bypassed or left swimming in the flume. The ingenious practice of discounting the undetermined portion of a test sample allows the investigators to make the following claim (page 17):

". . . the efficiency E of the device in diverting fish into the bypass . . . was typically 100%."

The ultimate effectiveness of a diversion system in conserving fish life is presumably measured by an index of survival E_T, a quantity called the "total efficiency" or the "system efficiency" (as opposed to "total diversion efficiency" [1]) and customarily defined (as it is in the Alden report) by the formula

$$E_T = E(1 - m). \qquad (2)$$

This is the equation employed in the calculations of the quantities listed on Table 3.1 of the Alden report under the heading "96-hour total efficiency." Quantity E of (2) is the diversion efficiency estimator discussed above; m is defined as "the mortality attributable to the system" (although m does not include the impingement mortalities), or

$$m = M_T - M_C,$$

M_C being the fraction dying of a control subset held apart (usually for 96 h) from the test fish, and M_T the fraction dead (or dying within 96 h) of the fish that pass through the bypass. Quantities E, m, and E_T are employed as probability estimators, and each therefore should satisfy the general inequality $0 \leq X \leq 1$, which they do not (see Appendix C).

Quantity E_T is regarded as the measure of the system's success in conserving entrapped fish (or, the chance that a fish entering the intake system will bypass the system alive), but the estimating procedures adopted for the Alden (and similar) flume experiments cannot possibly reveal the true correlations that link those chances with the experimental variables. The practice of scoring incomplete experiments as perfect or nearly so in diversion efficiency only confounds the correlation testing and frustrates the very purpose of the project.

But even if these kinds of experiments were run to conclusion, little could be gained with the customary estimators, owing to their inability to reflect even time dependence. The events of injury, death, and escape are governed by time-dependent, density-dependent, and displacement-dependent distributions, and no linear statistical analysis or invariant estimators like those of the Alden report should be thought appropriate to such experiments. From plots of the recovered laboratory data, it is obvious that the bypassing rates were nonlinear and dependent over time t on the (changing) size of the test sample, or that

$$\frac{dN}{dt} = f(N),$$

$N(t)$ being the test population swimming in the flume. The nature of that relationship (and its extension to displacement dependence) is explored in other sections of this paper.

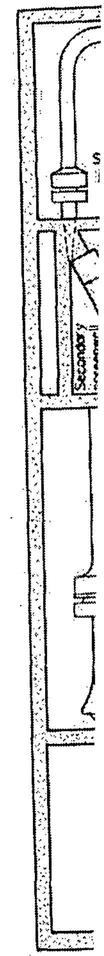
Full-Scale Operating System

In tests of full-scale systems, the estimators (1) and (2) are also employed as the indices of efficiency, but the experimental samples are collected, at various intervals, from the fish drawn (in unknown numbers) into the intake system from the source waters. On occasion, marked fish are placed directly in the intake flume or screenwell. Typical of full-scale studies is the 9-month sampling program on Unit 6 of the Oswego power station by Lawler, Matusky and Skelly (1982b). As stated on page 1.0-1 of the Lawler, Matusky and Skelly (LMS) report, the purpose of the study was an evaluation of

"... the effectiveness of the fish diversion system. ... The effectiveness of the system is defined by the ability of the system to divert, alive, the fish entrapped in the circulating cooling water from the primary screenwell back to the source water body .... These initial studies concentrated on survival subsequent to passage through the diversion system but prior to transport back to the source water body."

At the Oswego station, cooling water from Lake Ontario is drawn into a submerged, cylindrical intake (a "velocity cap") and thence through 366 m of tunnel to the primary screenwell. The water velocity through the tunnel is about 182 cm/s. The primary screenwell is 11.3 m wide and divided into two intake bays (Fig. 6). Water depth in the screenwell varies between 7.3 and 10.1 m. Each bay is equipped with three angled intake ports, each 3.05 m wide. One port of each bay is closed off; the open ports are equipped with vertical travelling screens angled 25° to the inflow. Each intake bay is equipped with a pumped bypassing slot, 15 cm wide and located at the apex of the acute angle between the dividing wall and each downstream barrier screen. The bypasses enter a common conduit that leads to a small secondary well from which the bypassed fish are drawn for their passage back to the lake. The return flow from the secondary well may also be diverted into a collection basin for fish sampling purposes. The flow through the barrier screens is somewhat irregular in distribution and varies over the extent of the screen arrays from about 30 to 65 cm/s. The entry velocities at the bypasses were said to be on the order of 60 cm/s.

Samples of the fish drawn into the intake system were collected intermittently over 9 months, April–December 1981. Fish diverted into the collection basin were classified as live, stunned (injured), and dead (those exhibiting no oper-



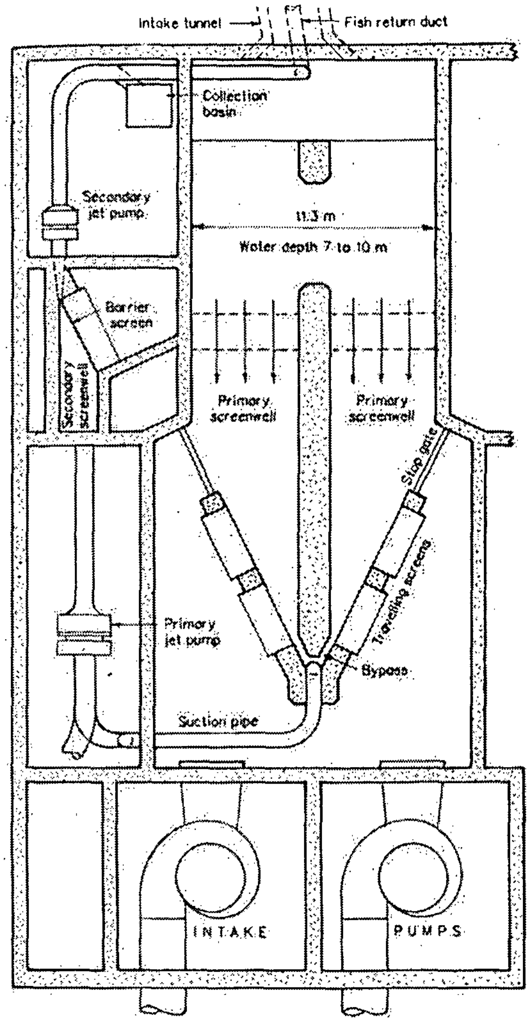


FIGURE 6.—*Intake structure, Unit 6 of the Oswego generating station, Lake Ontario (Lawler, Matusky and Skelly 1982b).*

cular movement). During the sampling periods, the impinged fish (the fish caught and held by the barrier screens) were also collected and counted. The diversion efficiencies of the system were quantified by index (1), the ratio of bypassed fish (dead and alive) to the sum total of collected fish (impinged plus bypassed). This ratio, or nonimpingement index, is the basis for all quantities bearing the designations diversion efficiency, total diversion efficiency, successfully diverted, overall diversion efficiency, and mean monthly diversion efficiency—not to be confused with the "efficiency" of the system in conserving the lives of the entrapped fish. It is the custom in reports on fish-diversion experiments to emphasize these indices, and very often the total mortalities imposed by the system are not reported.

The display of results in the LMS report is not easily interpreted. For the reader's convenience I have reproduced their Table 3.0-8 "Monthly total plant efficiencies," with an appended mortality column, as Table D-1 in Appendix D. The entries on the LMS table are values apparently extrapolated from small samples; the actual quantities of fish collected are not reported. Because the information from the Oswego study is useful in the context of the probabilistic models outlined in the next two sections of this paper, I have recalculated the survival, mortality, and morbidity measures of the various tables from the LMS report so as to accommodate those requirements (Table D-2, Appendix D).

The tagging experiments carried out by LMS at the Oswego plant are also important because they give us some idea of the residence times of fish entrapped in full-scale systems. Varying numbers of marked (fin-clipped) brown trout, white perch, smallmouth bass, yellow perch, white bass *Morone chrysops*, rock bass *Ambloplites rupestris*, and bluegills *Lepomis macrochirus* were released directly into the primary and secondary screenwells of the intake system. The bypassing flow was monitored continuously for a 48-h test period after release, but marked fish were recovered over much longer periods. Table 3.0-9 of the LMS report gives the recovery totals of marked fish. Although Table 3.0-10 purports to give the overall survivals of recovered fish, the impingement mortalities are excluded from those calculations, and the survival statements on page 3.0-24 are incorrect. The tagging data from the LMS study, including the correct mortality figures, are summarized in Appendix D, Table D-3, of this article. In four of six cases, over 50% of the marked fish remained in the screenwell beyond the 48-h test period.

From the tagging information we gain some idea of the mean residence times of fish drawn into full-scale diversion systems. Owing to the obvious nonlinearities of the (cumulative) recoveries of marked fish, a geometric distribution gives us less erroneous results than a linear regression on recoveries. Therefore, I have estimated mean residence times of the marked fish from the quantity $1/\lambda$ where

$$e^{-\lambda t} = 1 - \frac{B(t)}{S}$$

is the fraction of marked sample S unrecovered at time t (=48 h for the test period) and $B(t)$ is cumulative recoveries. Thus, for the white perch, $S = 23$, $B(48) = 11$ (0 live, 11 dead), and the estimated mean residence time for the marked white perch becomes

$$-48/\log_e\left[1 - \frac{11}{23}\right] = 73 \text{ h.}$$

In a similar fashion, the estimated mean residence time is 295 h for the smallmouth bass, 20 h for the yellow perch, 200 h for the brown trout, 76 h for the white bass, and 41 h for the rock bass–bluegill group.

Time-Dependent Risk Analysis

The failures of full-scale diversion systems to bear out the extrapolations drawn from small-scale test flumes are attributable, at least in part, to the misconceptions addressed in preceding sections of this article and to ill-framed estimators of the probabilistic events that should apply with commonality to diversion systems large and small. A search of the conservation literature turned up no probabilistic analysis capable of taking into account the *time-varying* risks that might apply to fish passing through an intake and diversion system, and none in which competing risks could be separated sufficiently well for distinguishing between the risk of death and the chances of escaping that risk. Although no experiments seemed to have been designed with those purposes in mind, some empirical information does exist to guide us along here in the construction of a time-dependent risk analysis.

The analysis of this section applies to the general case when sample size is known (as in the Alden test flume studies or the marking experiments of the Oswego study), but the analysis is system-specific. That is, it will apply to comparisons between devices (tests on angled barriers of various angles, say) in a given system, but because it contains no displacement (or space) variable, it does not extend to predictions of outcomes between systems of unlike sizes. Extension of the analysis to both time and space dependence is treated in the next section.

As our means for distinguishing between the competing risks that govern the passage of fish through a given intake and removal system, we can devise two thought experiments from which (it is hoped) we can construct a valid set of probabilistic statements. As our first step, we consider the time-dependent accruals of deaths (mortal injuries) of entrapped fish. We specify our experimental variables (species and sizes of fish to be tested, inflow velocity, water temperature, and so on); we then put into the intake flume a sample of S-many fish (or, as desired, n-many samples $S_1, S_2, \ldots, S_n$ of differing species or sizes). In this first experiment the intake flume is blocked by a barrier device (of any configuration we care to test), but the fish have no means of escape, the effects of the escape route being a part of the next experiment.

In our first experiment we leave the fish in the screenwell until all are injured (or dead). We now want a time-dependent description of the accruals of those deaths and injuries, and although no experiments of the kind we require have been reported, some evidence of the process can be inferred from marking experiments and test flume experiments (Stone and Webster 1977; Alden Research Laboratory 1981; Lawler, Matusky and Skelly 1982b, and the information in Appendices C and D). As a note of clarification, the designation "live" (as in "live and uninjured") shall mean here a fish uninjured and swimming in a manner natural to its species, whereas "injured" (as in "dead or injured") shall mean a fish incipiently dead, bearing visible trauma, or swimming erratically. The observation of importance in this experiment is the occurrence of injury, not the survival duration following it.

For the sample S of our first experiment, we let ϕ_t signify the time-dependent probability that an individual of S survives without injury, with the condition that $\phi_0 = 1$, and that $\phi_t \to 0$ as t becomes large. We impose the latter condition on ϕ_t because we expect all members of S to eventually suffer death or injury. At any time t during the experiment we expect $S \cdot \phi_t$ individuals to be alive and uninjured. Thus, the cumulative expected deaths or injuries M at time t becomes

$$M(t) = S - S \cdot \phi_t \qquad (3)$$

and the corresponding distribution function for deaths and injuries is

$$P_M(t) = 1 - \phi_t. \qquad (4)$$

Should the death and injury "rate"

$$\frac{1 - \phi_t}{t}$$

over successive time increments be a simple Poisson process with parameter μ (constant risk per unit time of mortal injury), then survival probability ϕ_t reduces to the simple exponential distribution

$$\phi_t = e^{-\mu t} \tag{5a}$$

(see, for example, Feller 1957), and the observed deaths and injuries should accumulate approximately as

$$M(t) = S(1 - e^{-\mu t}) \tag{6a}$$

where

$$P_M = 1 - e^{-\mu t}. \tag{7a}$$

In practice, the parameter μ of (5a) and (7a) would be determined empirically from a regression of (6a) on the experimental data (the observed accumulations of deaths and injuries).

Deaths and injuries might accrue in accord with some distribution that differs markedly from the specified Poisson process, but the nature of the events in question (the chance of death or injury), together with the existing data (as sparse as they are), tends to support the choice, at least for the systems examined. In some cases, however, especially for low intake velocities and hardy species, deaths and injuries accumulate very slowly at first (survival probability remaining high) but then increase more rapidly (apparently owing to the onset of exhaustion) after the manner of a Poisson process. For such cases I have postulated a delayed process having the form

$$\phi_t = \frac{c + 1}{c + e^{\mu t}} \tag{5b}$$

with parameter c providing the delay in the decline of survival probability over time. Parameter c may take on any suitable positive value; the greater the value of c the greater the delay in the accumulation of deaths and injuries. The properties of a distribution function like that of (5b) are examined in Appendix D. With (5b) in place of (5a), the probability distribution for death and injury becomes

$$P_M(t) = 1 - \frac{c + 1}{c + e^{\mu t}}. \tag{7b}$$

The parameters μ and c of (5b) and (7b) are empirically derived by substituting (5b) into (3) and taking a regression on the experimental observations. The random variable (T, say) of either of the distribution functions (7a) or (7b) is the time after introduction of sample S that a randomly designated individual of S suffers injury or death, where

$$P_M(t) = \text{Prob}[T \leq t]$$

for any time t we care to name.

At the conclusion of the first experiment all of the original fish are removed and excluded from further experiments. For the second experiment we restore or introduce the desired means of egress (the pumped bypass or other means of escape). We again put into the intake flume a sample of S-many fish (or the n-many combinations of species or sizes) as identical as possible to the first sample S. As the system is operated, fish will be impinged, bypassed, or otherwise removed (alive, injured, and dead) at some time-dependent frequency. It is that frequency (and its summation) we now wish to determine.

Although our second experiment is similar in some respects to the usual demonstrations of diversion efficiencies, we are not interested here in quantifying the physical absence of fish from the meshes of a barrier screen. A diversion efficiency, as customarily measured by (1), may be a good index of the self-cleansing properties of a barrier screen, but whether a killed fish passes into the removal system for disposal or becomes impinged (affixed to the screen) and removed by other means for disposal is a distinction of little importance in the context of our risk analysis. Let us remember that our population of interest, $N(t)$ say, consists of the *live, uninjured fish swimming in the screenwell.* It is their fate that depends on the probabilities of staying alive and getting out of the screenwell unhurt, so let us consider how their numbers are reduced.

In our second experiment, fish depart population $N(t)$ by two processes, one by death or injury (whether removed from the screenwell or not) and the other by escaping uninjured by means of the removal device. Experiment 1 was designed to give us the probability of entrapped fish surviving death or injury in the absence of any other agency of reduction. That is, probability ϕ_t applies explicitly to the individuals $N(t)$ that remain in the screenwell uninjured and swimming. But $N(t)$ is also being reduced now by the exits of uninjured fish, those events having, say, a probability distribution $1 - \theta_t$. Thus, θ_t is the probability of remaining in $N(t)$, and in that regard θ_t is similar to a survival probability [at least as it influences the size of $N(t)$]. Therefore, in experiment 2 at time t we expect

$$N(t) = S \cdot \phi_t \theta_t \tag{8}$$

individuals to be uninjured and swimming in the screenwell. The expected cumulative "exits" from S (live, dead, or injured, bypassed, impinged, or traumatized) is

$$B(t) = S - N(t), \tag{9}$$

which has the associated probability distribution

$$P_B(t) = 1 - \phi_t \theta_t. \tag{10}$$

We want to extract two probability statements from (10), one describing the likelihood of fish escaping uninjured from the intake system and one describing the probable distribution of deaths or injuries. We accomplish the separation by differentiating (10) and then re-integrating, which gives us the probability density function for the frequency of live exits

$$f(t) = -\phi_t \frac{d}{dt} \theta_t, \tag{11}$$

and the density function for death and injury

$$g(t) = -\theta_t \frac{d}{dt} \phi_t \tag{12}$$

(whether the affected fish remain impinged on the barrier screen or pass through the same removal system as the uninjured). The probability distribution $P_B(t)$ for fish departing population $N(t)$ can now be expressed as the sum of the probability $P_L(t)$ of live (uninjured) escape and the probability $P_D(t)$ of death or injury:

$$P_B(t) = P_L(t) + P_D(t), \tag{13}$$

where

$$P_L(t) = \int_0^t f(t)\, dt,$$

and

$$P_D(t) = \int_0^t g(t)\, dt.$$

Therefore, at time t we can expect a total of $S \cdot P_L(t)$ individuals to have escaped uninjured from sample S and $S \cdot P_D(t)$ to have suffered death or injury.

We now seek an appropriate functional form for probability distribution θ_t. But unlike the procedures of experiment 1, where we were able to deduce the form of survival probability ϕ_t directly from experiments, independent of the influence of probability θ_t, we cannot accomplish the converse. We cannot directly determine the form of escape probability $1 - \theta_t$ independent of deaths and injuries. Experiment 2 gives us instead the combined results of these probabilistic events, so it is from the results of both experiments that we must extract the form of θ_t.

Let us suppose we have run experiment 2 to our (statistical) satisfaction; we have recorded the live exits and those of S dead or injured on some regular sequence of time intervals i. Thus, we have a sequence B_i of numerical estimates of $B(t)$, as well as those of $S \cdot P_L(t)$ and $S \cdot P_D(t)$. Accordingly, our experimental measures of distribution $P_B(t)$ over intervals i become

$$\hat{P}_B(i) = \frac{B_i}{S},$$

and since distribution $P_B(t)$ has the general form of (10), our experimental estimates of product $\phi_t \theta_t$ are given by

$$\widehat{\phi_i \theta_i} = 1 - \frac{B_i}{S}.$$

But function ϕ_t is known from experiment 1. Therefore, the data on $B(i)$ from experiment 2 are converted to empirical measures of probability distribution θ_t as

$$\hat{\theta}_i = \frac{1 - \hat{P}_B(i)}{\phi_i}. \tag{14}$$

From regressions on this time sequence of estimates we extract the most likely form of distribution function θ_t. The measured proportions $S \cdot P_L(i)$ of uninjured escapes and $S \cdot P_D(i)$ of deaths and injuries then provide the means for verification not of the validity of determined function θ_t but of the similarity of conditions (the constancy or inconstancy of the experimental variables) between the two experiments.

Because the kinds of information we need here do not yet exist, we cannot extract applicable forms of θ_t by the methods described above. But from such evidence as incidental films of fish swimming before a screen barrier, from recorded bypassing frequencies of live fish in small-scale test systems where mortalities are low (Appendix C), and from the random-walk analysis of the next section, the density pattern

$$\lambda e^{-\lambda t} \tag{15}$$

seems well suited for describing the frequencies of escape, at least for some tested species, where fish stand against the flow before a barrier screen and by random excursions increase their chances of encountering the escape route. By (11) we can now write

$$f(t) = \lambda e^{-\lambda t} \phi_t,$$

where $d\theta_t/dt = -\lambda e^{-\lambda t}$, and it is obvious that parameter λ reflects the rate at which fish escape the screenwell uninjured. All reported data indicate that λ is greater in a small system than in a larger one of similar geometry. The escape probability that corresponds to density pattern (15) is simply

$$\theta_t = e^{-\lambda t}. \tag{16a}$$

A formal reduction of (15) from a general Poisson distribution is given in Appendix A.

As occurred during the Alden Laboratory experiments, fish of some species tend to stand before the barrier screen for long periods of time, and Bates and Vinsonhaler (1956) describe some species as tending to avoid a bypass current on initial encounter. Because of such behavior, exits from the screenwell accumulate slowly at first but then increase in frequency after the manner of (15). With the simplest analytical provision for such delays incorporated into (16a), escape probability θ_t takes on the altered form

$$\theta_t = \frac{k+1}{k+e^{\lambda t}}. \tag{16b}$$

The properties of (16b) are examined in Appendix B. The influence of delay parameter k can be seen from the regressions of Figs. 7, 8, and 9.

Because of the possibilities of delays in either the probability of live escape, the probability of injury, or both, the probability $P_N(t)$ that governs a fish's chance of remaining in the screenwell, uninjured, could take on any one of four possible combinations.

Case 1, no delays:

$$P_N(t) = e^{-(\mu+\lambda)t}. \tag{17a}$$

Case 2, delay in mortality, no delay in escape:

$$P_N(t) = \frac{(c+1)e^{-\lambda t}}{c+e^{\mu t}}. \tag{17b}$$

Case 3, delay in escape, no delay in mortality:

$$P_N(t) = \frac{(k+1)e^{-\mu t}}{k+e^{\lambda t}}. \tag{17c}$$

Case 4, delay in mortality, delay in escape:

$$P_N(t) = \frac{(c+1)(k+1)}{[c+e^{\mu t}][k+e^{\lambda t}]}. \tag{17d}$$

Case 1: No Delays

For case 1, probabilities ϕ_t and θ_t have the nondelay forms (5a) and (16a); then, by (17a), the expected size of the (uninjured) screenwell population at time t becomes

$$N(t) = Se^{-(\mu+\lambda)t}. \tag{18a}$$

The expected cumulative departures from $N(t)$ now become

$$B(t) = S(1 - e^{-\gamma t}), \tag{19a}$$

where $\gamma = \mu + \lambda$. Should the removal system be a total failure at conserving entrapped fish, then $\lambda = 0$ and $\gamma = \mu$. Should it be a total success, then $\mu = 0$ and $\gamma = \lambda$.

The random variable (Y, say) of our second experiment is the time that a randomly designated individual of S departs $N(t)$. Thus, with $P_B(t)$ as the distribution function that describes the probability of departures (live, dead, or injured) in the following way,

$$\begin{aligned} P_B(t) &= \text{Prob}[Y \le t] \\ &= 1 - \text{Prob}[Y > t] \\ &= 1 - P_N(t) \\ &= 1 - e^{-\gamma t}, \end{aligned}$$

then Y has the probability density function

$$\frac{dP_B}{dt} = \gamma e^{-\gamma t},$$

and the expected mean residence time of fish in the screenwell is

$$\begin{aligned} E[Y] &= \gamma \int_0^\infty te^{-\gamma t}\,dt \\ &= \frac{1}{\gamma} \end{aligned} \tag{20}$$

(which is also the assumption behind the mean residence estimates, shown in the previous section, for the marking data from the Oswego study). By (11) the density function for the frequency of live exits becomes

$$f(t) = \lambda e^{-\lambda t} e^{-\mu t},$$

and by (12) the density function for death and injury is

$$g(t) = \mu e^{-\mu t} e^{-\lambda t}.$$

Thus by (13),

$$P_B(t) = \lambda \int_0^t e^{-\gamma t}\, dt + \mu \int_0^t e^{-\gamma t}\, dt,$$

and the probabilities of interest become

$$P_L(t) = \frac{\lambda}{\gamma}(1 - e^{-\gamma t}), \tag{21a}$$

(which is the probability distribution for live exits) and

$$P_D(t) = \frac{\mu}{\gamma}(1 - e^{-\gamma t}) \tag{22a}$$

(which is the probability distribution for death and injury). Population $N(t)$ is reduced accordingly in the proportions

$$B(t) = S \cdot P_L(t) + S \cdot P_D(t).$$

Case 2: Delay in Mortality, No Delay in Escape

Should the experiments reveal a delay in the accumulation of deaths and injuries (experiment 1), but no delay in live escapes (experiment 2), then ϕ_t and θ_t take the forms (5b) and (16a), and $P_N(t)$ is given by (17b). Therefore,

$$N(t) = \frac{(c + 1)Se^{-\lambda t}}{c + e^{\mu t}}, \tag{18b}$$

and the expected cumulative departures (impinged and bypassed, live, dead, and injured) become

$$B(t) = S\left[1 - \frac{(c + 1)e^{-\lambda t}}{c + e^{\mu t}}\right] \tag{19b}$$

with μ and c known from experiment 1. Parameter γ is determined from a regression of (19b) on the observed B_i of experiment 2. The value of λ is then estimated from the relationship $\lambda = \gamma - \mu$. The shapes of the regression curves are influenced by extended probability (7b), but (7b) has its greatest influence on the proportionings between the live escapes and the dead and injured, $S \cdot P_L$ and $S \cdot P_D$. Those distributions are resolved after the manner of (11), (12), and (13) as before, or

$$P_L(t) = \lambda(c + 1) \int_0^t \frac{e^{-\lambda t}\, dt}{c + e^{\mu t}}; \tag{21b}$$

$$P_D(t) = \mu(c + 1) \int_0^t \frac{e^{(\mu - \lambda)t}\, dt}{(c + e^{\mu t})^2}. \tag{22b}$$

Case 3: Delay in Escape, No Delay in Mortality

Should death and injury (experiment 1) follow a simple exponential distribution, but live fish exhibit a delay in escaping the screenwell (experiment 2), then ϕ_t and θ_t take on the forms (5a) and (16b), and $P_N(t)$ has the form (17c) shown above. Therefore,

$$N(t) = \frac{(k + 1)Se^{-\mu t}}{k + e^{\lambda t}}, \tag{18c}$$

and, as before, $B(t) = S - N(t)$. The distributions P_L and P_D in turn become

$$P_L(t) = \lambda(k + 1) \int_0^t \frac{e^{(\lambda - \mu)t}\, dt}{(k + e^{\lambda t})^2}; \tag{21c}$$

$$P_D(t) = \mu(k + 1) \int_0^t \frac{e^{-\mu t}\, dt}{k + e^{\lambda t}}. \tag{22c}$$

Case 4: Delay in Mortality, Delay in Escape

Should experiments 1 and 2 reveal a delay in the accumulation of deaths and injuries as well as a delay in live escapes from the screenwell, then ϕ_t and θ_t take on the forms (5b) and (16b), and $P_N(t)$ becomes (17d). Therefore,

$$N(t) = \frac{(c + 1)(k + 1)S}{(c + e^{\mu t})(k + e^{\lambda t})}, \tag{18d}$$

$$P_L(t) = \lambda(c + 1)(k + 1) \int_0^t \frac{e^{\lambda t}\, dt}{(c + e^{\mu t})(k + e^{\lambda t})}, \tag{21d}$$

and

$$P_D(t) = \mu(c + 1)(k + 1) \int_0^t \frac{e^{\mu t}\, dt}{(k + e^{\mu t})(c + e^{\lambda t})}. \tag{22d}$$

I have not sought closed forms for equations (21b, c, d) and (22b, c, d) because their basic forms cannot be resolved in terms of elementary functions (Tchebycheff 1853). They can, of course, be approximated with asymptotic series or evaluated numerically, depending on the desired application. In each case, their sum $(1 - P_N)$ is known exactly, so once P_L or P_D is resolved the other is known immediately.

Douglas Robson of Cornell University has suggested a refinement for the distribution functions of case 1. Robson's refinement permits a separation of the probabilities of injured escape and uninjured escape, which could be useful in accommodating the information from survival tests. Robson adds a third parameter η to μ and λ, and gives these definitions:

- η: constant risk (chance per unit time) of injured escape;
- λ: constant risk of uninjured escape (as before);
- μ: constant risk of death or mortal injury (as before);
- $\gamma = \mu + \lambda$ (as before).

Thus, if the distributions (5a) and (16a) of case 1 apply then random variable Y has the probability density function

$$dP_B(t) = \lambda e^{-\gamma t}\,dt + \left[\int_0^t \mu e^{-\gamma x}\,dx \cdot e^{-\eta(t-x)}\right] dt. \tag{23}$$

Integration of (23) from zero reference time (the start of the experiment) yields the distribution function

$$P_B(t) = \frac{\lambda}{\gamma}(1 - e^{-\gamma t}) + \left[\frac{\mu}{\gamma}(1 - e^{-\gamma t}) - \frac{\mu}{\gamma - \eta}(e^{-\eta t} - e^{-\gamma t})\right]. \tag{24}$$

the first term of which is distribution $P_L(t)$ and the second $P_D(t)$. Robson's form of $P_D(t)$ allows a backtracking of mortal injuries, so to speak, and would be especially useful when the actual occurrences of injuries were not known, or, equivalently, when survival tests for all bypassed fish were commenced simultaneously (at termination of the experiment, in particular), irrespective of the actual times the fish were bypassed.

Applications of the Time-Dependent Analysis

Although the Alden experiments (Alden Research Laboratory 1981) were not designed to accommodate the separation of time-dependent risks, a few of the experiments, when supplemented with the recovered laboratory data (Appendix C), can be adapted to the time-dependent analysis of this section. The data from most of the experiments with non-zero differential mortalities are confounded by inseparable delays in either deaths or live escapes, so I have selected three sets of data for regression analysis in which differential mortalities were zero (at least to the termination of the experiment) and relatively few fish were left swimming in the flume (Figs. 7–9). These regressions show three magnitudes of delay in live escape (extended, moderate, and short). A fourth set of data from the Alden series (experiment 13) is especially instructive because the data (apparently) permit a separation of the distributions $P_L(t)$ and $P_D(t)$ (Figs. 10, 11).

As remarked previously, virtually all the data sets of the Alden study reflect an "initial washout" of test fish, which is apparently an artifact of the experimental methods or the effect of an overcrowded flume. The washout effect is reproduced analytically in another section of this article. For the data of Figs. 7–9, the regression formula is

$$N(t) = \frac{(k + 1)(S - W)}{k + e^{\lambda(t - t_0)}}, \tag{25}$$

which is merely an adaptation of (16b). Quantities W and t_0 are regression values that accommodate the initial washout. In general, the cumulative delay period t_d from (16b) (adjusted here for t_0) is given by

$$t_d = \frac{1}{\lambda}\log_e\left(\frac{k}{2} + 1\right) + t_0. \tag{26}$$

Figure 10 shows a regression of (18a) on the decline of test population $N(t)$, Alden experiment 13, again with the regression adjustments t_0 and W, or

$$N(t) = (S - W)e^{-(\mu+\lambda)(t - t_0)}. \tag{27}$$

Figure 11 shows the associated trajectories of $B(t)$, $P_L(t)$, and $P_D(t)$. As described in the calculations that follow, the projected probability for total live escapes is 68.7% of the sample, or

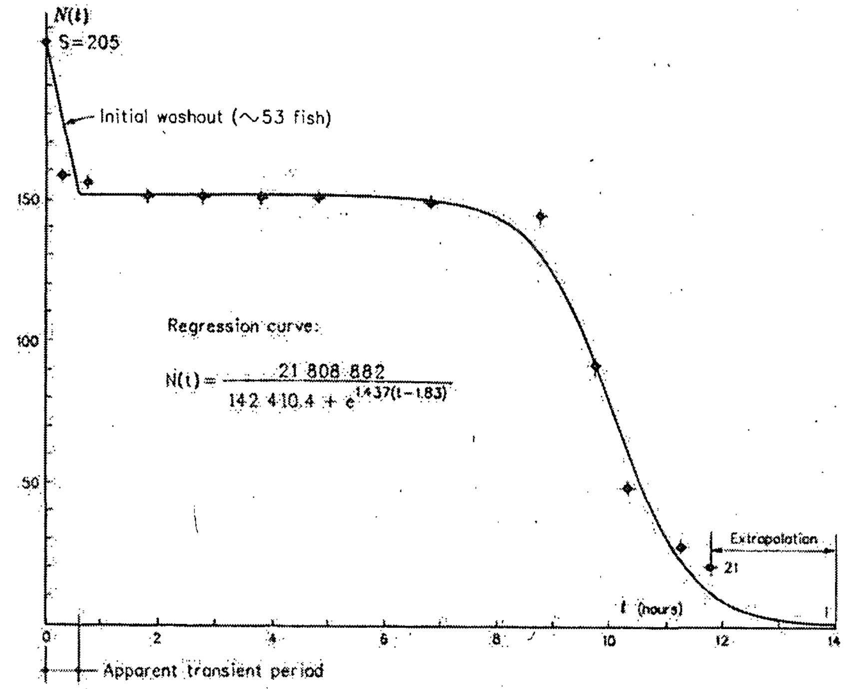
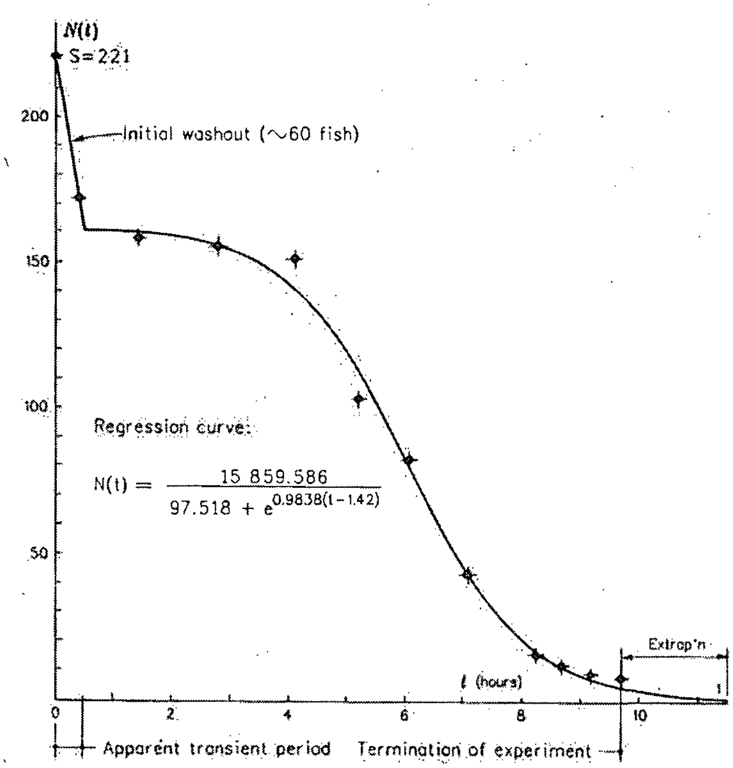


FIGURE 7.—*Regression of equation (25) on data of Alden experiment 2 (Appendix C), illustrating extended delay in escape of fish from the test flume. Test species Atlantic menhaden; screen angle 45°; water velocity 30 cm/s; water temperature 20.5°C. Regression values:* k = *142,410.4,* λ = *1.437/h,* S − W = *153.14,* t_0 = *1.83.*



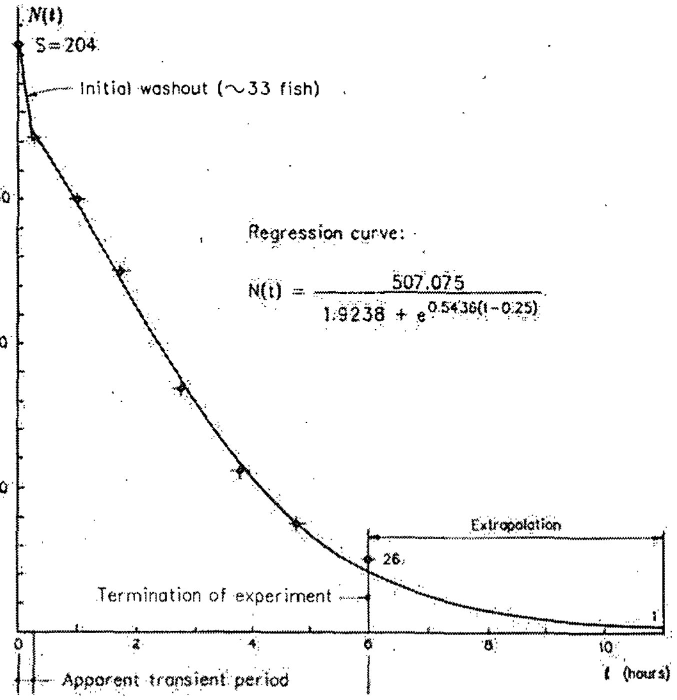


FIGURE 9.—*Regression of equation (25) on data of Alden experiment 15 (Appendix C), illustrating brief delay in escape of fish from the test flume. Test species white perch; screen angle 45°; water velocity 30 cm/s; water temperature 12.9°C. Regression values:* k = *1.9238*, λ = *0.5436/h*, S − W = *173.43*, t_0 = *0.25*.

20 percentage points lower than the reported Alden value of 89% for total efficiency E_T. From the Alden report and the laboratory data the following calculations can be made.

(a) Differential mortality $m = 0.11$ and sample size $S = 207$ implies that $0.11(207) = 23$ fish suffered lethal injuries. One fish was impinged. Therefore, at termination time 5.25 h, $23 + 1 = 24$ fish were dead or injured.

(b) At reference time $t_0 = 0.25$ h, washout $W = 110$; at termination time 5.25 h, $N(\text{observed}) = 18$ fish.

(c) With $S - W = 207 - 110 = 97$, there were $97 - 18 = 79$ cumulative exits from $S - W$ at 5.25 h, of which $79 - 24 = 55$ were live escapes.

Accordingly, the direct estimates of the probabilities of live escape and of death or injury *at the termination of the experiment* are

$$\hat{P}_D(5.25) = \frac{24}{97} = 0.247, \text{ and}$$

$$\hat{P}_L(5.25) = \frac{55}{97} = 0.567$$

(see Fig. 11). From (22a), parameter μ can be resolved as

$$\mu = \frac{\gamma P_D(t)}{1 - e^{-\gamma(t-t_0)}}. \qquad (28)$$

Therefore, with $P_D(5.25) = 0.247$ from the data, with $t_0 = 0.25$, and with $\hat{\gamma} = 0.3114$ from the regression of (27) on the observed data (Fig. 10), the estimate of μ from (28) becomes

$$\hat{\mu} = 0.0975/\text{h},$$

and we have

$$\hat{\lambda} = \hat{\gamma} - \hat{\mu} = 0.2139/\text{h}.$$

←

FIGURE 8.—*Regression of equation (25) on data of Alden experiment 3 (Appendix C), illustrating moderate delay in escape of fish from the test flume. Test species Atlantic menhaden; screen angle 45°; water velocity 30 cm/s; water temperature 23°C. Regression values:* k = *97.518*, λ = *0.9838/h*, S − W = *160.85*, t_0 = *1.42*.

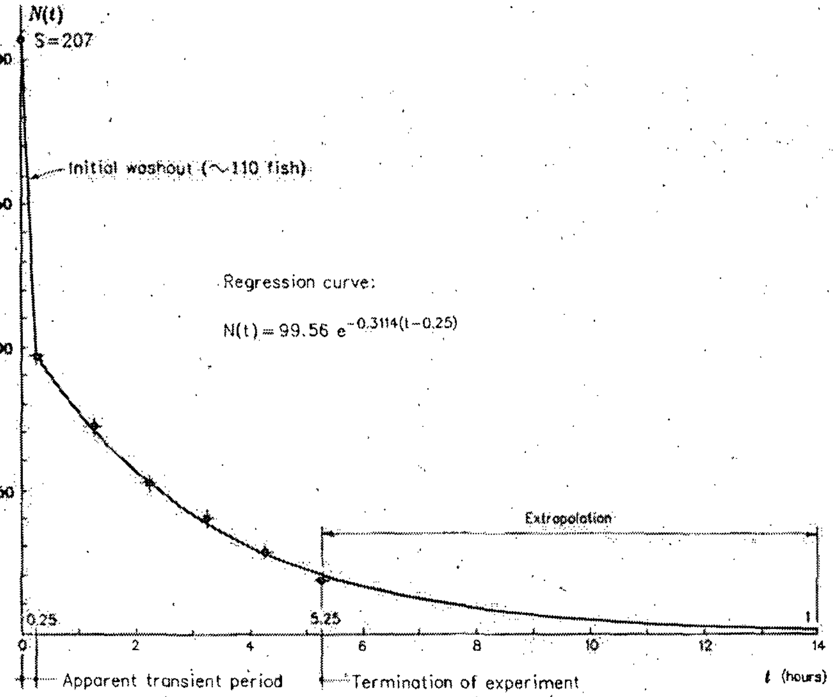


FIGURE 10.—*Regression of equation (27) on data of Alden experiment 13 (Appendix C) showing decline of the screenwell population* N(t), *no delays. Test species Atlantic menhaden; screen angle 45°; water velocity 30 cm/s; water temperature 15°C. Regression values:* $\mu + \lambda = 0.3114/h$, $S - W = 99.56$, $t_0 = 0.25$.

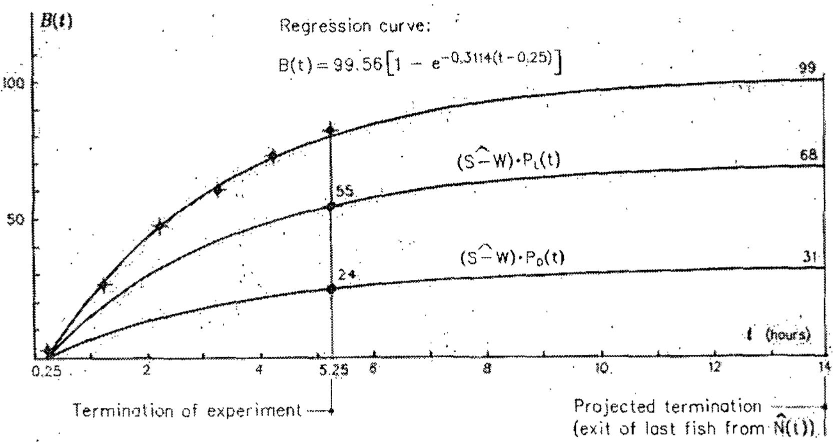


FIGURE 11.—*Regressions on data of Alden experiment 13 (Appendix C) showing cumulative departures* B(t), *probable live escapes* $(S - W)P_L(t)$, *and probable cumulative mortalities* $(S - W)P_D(t)$. *Regression values:* $\mu = 0.0975/h$, $\lambda = 0.2139/h$. *(See also Fig. 10.)*

Thus, the trajectories of the time-dependent distributions of Fig. 11 are given by

$$P_L(t) = \frac{0.2139}{0.3114}[1 - e^{-0.3114(t-0.25)}];$$

$$P_D(t) = \frac{0.0975}{0.3114}[1 - e^{-0.3114(t-0.25)}].$$

At the time of the projected departure of the last fish from sample $S - W$, the expected proportionings between live escapes and deaths (or mortal injuries) become

$$P_L(14^+) = \frac{\lambda}{\mu + \lambda} = 0.687$$

$$= 68.7\% \text{ live escapes;}$$

$$P_D(14^+) = \frac{\mu}{\mu + \lambda} = 0.313$$

$$= 31.3\% \text{ dead, injured.}$$

Large versus Small Diversion Systems

The reported results of diversion experiments in small-scale flumes extend with little reliability to full-scale designs, an apparent consequence of the differing risks of exposure to the risk of death or injury. Those size-related dissimilarities are examined next. Because it is the more vulnerable species that concern us the most, the simpler case-1 equations seem to be suitable distributions from which to draw our lessons here, which are not too greatly altered by the more complex distributions. In practice, of course, simplicity should not be imposed on the experimental data if complexity is warranted. Depending on the mix of species involved, all four sets of distributions might be needed for making sense of some systems.

With the case-1 probabilities (5a) and (16a), parameter μ is our index for assessing the risk of death or injury and λ is our index for assessing the exposure to that risk. The greater the value of μ the greater the risk of death or injury; the greater the value of λ the *lesser* the exposure. Their combined effects for the case-1 equations are given in the ratios μ/γ and λ/γ.

Suppose we are comparing two systems, similar in design but unlike in size, one a small-scale test facility and the other its full-scale prototype, each equipped, let us say, with a pumped bypass and angled barrier screen. Their (unlike) volumetric intakes are adjusted for equal flow velocities, sample sizes are adjusted for equal spatial densities, and all other experimental variables are alike. In the absence of some of the empirical data we need, we assign values to our distribution parameters that appear to be representative of typical ranges of risk and exposure conditions.

First consider thought experiment 2. From the cited reports on residence times of marked or captive fish in large and small systems, the data show that fish of all species exhibit residence times of some duration in the screenwells of diversion systems both large and small, but that residence times of like species are considerably greater in the larger systems. On the basis of the marking experiments from the Oswego study (Appendix D) and the recovered data from the Alden experiments (Appendix C), let us choose 3 h as a representative *mean* residence time for our small system, and 45 h for the full-scale system.

Consider thought experiment 1. Our statistical individual, when introduced to either system, swims ahead of the barrier screen, against the inflow; as time passes its chances of suffering death or injury continue to increase. Because the fish has no means of escape, its eventual demise is certain in either system, but would its death or injury occur any sooner in one system than in the other? Probably not.

For want of contrary evidence or rationale, we must suppose that risk parameter μ (chance of death or injury per unit time of exposure) has equal values for the two systems. Rough estimates from the mortality data from several studies (Stone and Webster 1976, 1977; Alden Research Laboratory 1981) suggest that a half-life on the order 60 h (the time when half the fish of a test sample have suffered death or injury) would be a representative figure for many species (and, in turn, for the fish of our experiment 1, both systems). A half-life of 60 h implies a mean life expectancy (or a mean residence time without death or injury) of 86.6 h. These "findings" give us the value 0.012/h for μ. In summary, we have chosen our parameter values for the two systems in the following way:

Parameter	Small system	Large system
$\gamma = \frac{1}{\bar{Y}}$	$\frac{1}{3\text{ h}} = 0.333/\text{h}$	$\frac{1}{45\text{ h}} = 0.022/\text{h}$
$\mu = \frac{\log_e 2}{60\text{ h}}$	0.012/h	0.012/h
$\bar{T} = \frac{1}{\mu}$	86.6 h	86.6 h
$\lambda = \gamma - \mu$	0.321/h	0.010/h

Although the hazards of the two systems are equal for equal exposures, the differences in probable exposure times have a great influence on the proportionings of fish into live escapes and mortalities. The probability distributions for those proportionings over time are given for case 1 by (21a) and (22a). Thus, for our smaller system,

$$P_L(t) = 0.964(1 - e^{-0.333t}),$$

$$P_D(t) = 0.036(1 - e^{-0.333t});$$

while for the larger,

$$P_L(t) = 0.455(1 - e^{-0.022t}),$$

$$P_D(t) = 0.545(1 - e^{-0.022t}).$$

At the mean residence times $\bar{Y}$ of the fish (when 63.2% of sample S has passed through either system), and at the end of the tests (when all fish have passed through the systems or been impinged), the expected proportionings are

Fate	Small system	Large system
At $\bar{Y}$		
Live escapes: $0.632\lambda/\gamma$	61%	28.8%
Dead, injured: $0.632\mu/\gamma$	2.3%	34.4%
Final		
Live escapes: λ/γ	96.4%	45.5%
Dead, injured: μ/γ	3.6%	54.5%

The differences between these proportionings are attributable to the difference in expected residence times between the two systems, because the only probabilistic dissimilarity between the two is the duration (or chance) of exposure to mortality risk; the risk of death per unit time of exposure we presumed to be the same for either system. In the absence of comparative experiments (like experiment 1) for showing otherwise, we cannot entirely dismiss the possibility that a full-scale system might pose a greater risk of death per unit time than a smaller for some species, but the reported evidence (of greater residence times in larger systems for all species tested) is clearly against the possibility. Increase in risk of death (increase in μ) brings about a *reduction* in residence time, not an increase. Although a decrease in μ would increase the mean residence time, there is little reason to suppose that increased system size might *lessen* the unit risk of death to an entrapped fish (think about experiment 1). Although a decreasing risk of death (decreasing μ) with increasing system size would account for the longer observed residence times in large systems than in small ones, the reduction in unit risk would also reduce the accumulated deaths and injuries to proportions less than those of smaller systems, a consequence contradicted by all reported evidence.

Thus, we are forced to conclude that the extended residence times of full-scale systems are owed not to reduced risk of death and injury but to decreased opportunity for escaping that risk, a consequence of the conservation system whose purpose is to bring about the opposite effect. As the experimental evidence confirms, the successes of small-scale models in conserving test fish are not preserved in geometric similarity. The move to steeper barrier screens and extended forebays seems to be a futile way of pursuing efficiency, because the exposure of fish to risk of injury (the chance of forcible contact with the barrier screen) is apparently increased by such measures, not reduced.

The foregoing risk analysis is applicable to comparative tests, device against device, screen angle against screen angle, in a given setting. And while the analysis also clarifies the qualitative dissimilarities between large and small systems, it is limited to time-dependent problems and time-dependent experiments. The scaling problem (the problem of projecting the probable outcome of a full-scale design from small-scale experiments) cannot be resolved unless a displacement variable (a variable of spatial dimension) is introduced into the probability analysis and the experimental designs. But a problem having two independent variables (time and displacement in our case) implies a treatment with partial differential equations.

Extension of Risk Analysis to Two (and Three) Independent Variables

Except when fish are pressed against a barrier screen and forced along it by the water flow, screen angle seems to have no more influence in directing swimming fish to a bypassing slot than any other stimulus that might provoke random excursions in the screenwell. The mere fact that uninjured fish do escape over time through a bypass could easily give one the impression that *something* must be compelling fish to move in a preferred direction. But the same result can be extracted from a one-dimensional random-walk hypothesis and appropriate boundary conditions.

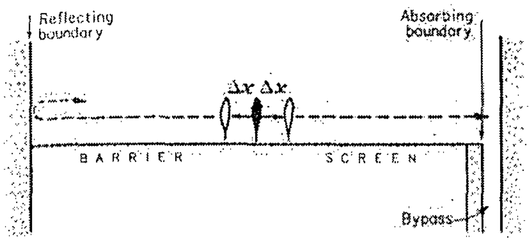


FIGURE 12.—*Fish free to move left or right (with probability ½) along a barrier screen in discrete steps* Δx *with mean period* τ. *At either boundary the probability of a left move is zero. At the left boundary the probability of a right move is 1.*

Figure 12 depicts a fish free to move in one dimension (horizontally, left or right) along a barrier screen. Vertical motions do not compete with horizontal motions in the probability analysis, because only those motions that put the fish towards one boundary or the other enter the observations. For the sake of the argument, the barrier screen is shown normal to the intake flow; with slight alterations for geometry the argument will also apply to an angled screen.

The problem has two boundaries, one perfectly absorbing (the bypass) and one perfectly reflecting (the opposite flume wall). The fish is free to move at random along the screenfront with lateral excursions Δx in either direction, the period between excursions being some finite time τ. If, in some random combination of excursions N, the fish encounters the absorbing boundary on its Nth move (to the right in the figure), then its probability of next moving (left) in the opposite direction and remaining in the flume is zero, because it will have been absorbed (removed) by the boundary (by the bypass). If the fish, instead, encounters the reflecting boundary in the same number N (but different combination) of random excursions Δx, its probability of next moving (left) away from the absorbing boundary is also zero, as it was at the absorbing boundary. Its probability of moving (right) in the opposite direction on its next move, however, is 1. The net effect on a fish (hence, on a sample of fish) is a greater overall probability of moving towards the absorbing boundary and being removed than moving away from it and remaining in the flume. Thus, it is the boundary conditions that provide the bias in guiding actively swimming fish to the bypass, not the path over which they move. To the observer counting the live fish emerging from

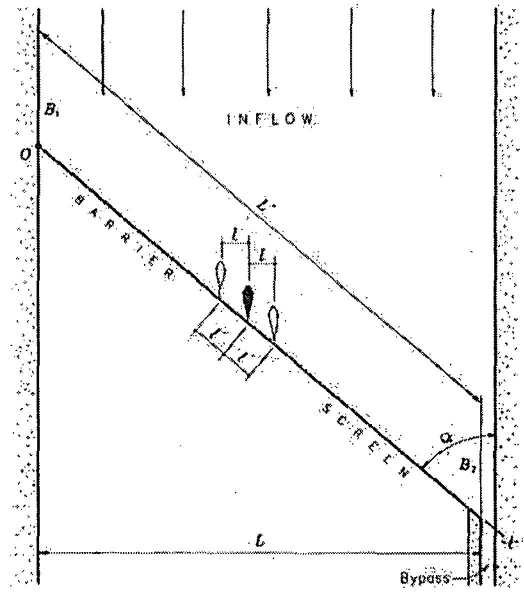


FIGURE 13.—*Typical angled barrier screen and bypass in a flume with pumped inflow. The reflecting boundary is at* B_1 *and the absorbing boundary at* B_2. *Screen length is* L'; *screen angle of attack is* α; *flume width is* $L = L' \sin \alpha$. *Reference axis* x *is coincident with the screen face; its origin is at* B_1. *Fish excursions of mean displacement* l ($= l' \sin \alpha$) *are measured along the* x *axis.*

the bypass, it would seem that *something* were guiding fish along the (nonangled) screen.

In the foregoing process, the rate at which fish escape from the screenwell depends for the most part on the lateral activity of the fish themselves; the more active the fish the more likely their encounter with the bypass. Screen angle might or might not increase the rate of that encounter. Investigators seem to be unanimous in reporting no (apparent) differences between competing screen angles in the diversion rates of uninjured fish, or even in "total efficiencies" (the overall survivals of test fish). Nevertheless, the question is still open and ardently debated, and we can make provisions for the possible effects of screen angle in the analysis that follows.

We are especially concerned here with the initial distribution of fish at the barrier, with the flux rates of fish into a bypass, with the separation of mortalities and live escapes, and with the relationships of those variables to sample size, fish behavior, and flume size. Our system of interest consists of the usual assemblage (Fig. 13):

(1) an intake flume with parallel sidewalls but

of selectable widths, and a steady, pumped intake of water, flowing parallel to the sidewalls;

(2) a barrier screen sufficient in height to span the depth of the indrawn water, its length L' determined by flume width L and selectable angles of attack α, where $0° < \alpha \leq 90°$ and $L' = L/\sin \alpha$;

(3) a pumped bypassing slot against one flume wall, admitting water at an entry velocity equal to that of the flow through the barrier screen.

The limits of displacement x are specified by boundaries B_1 and B_2, a distance L' apart. The flume wall at B_1 is a reflecting boundary, and the bypass at B_2 is an absorbing boundary. The origin O of the displacement axis coincides with B_1, and x is positive in the direction of B_2.

We presume that our probabilistic fish swims headmost into the flow just ahead of the barrier screen and makes small but discrete excursions of mean displacement length l ($=l' \sin \alpha$), at random in either direction along displacement axis x. The mean excursion period is τ. In the most general case, time-dependent variations in the mean values of l and τ are allowed. The fish of sample S may be released all at once (the customary case in test-flume and marking experiments) or the release may be distributed over time.

For experiments where the fish of S are released all at once (where the residence times of individuals commence simultaneously), the dependent variable of our governing equations is a concentration function $U(x,t)$, which describes the time-dependent density of fish along the displacement axis between boundaries B_1 and B_2. At any time t the relationship between screenwell population $N(t)$ (the live and uninjured) and concentration function U is

$$N(t) = \int_0^{L'} U(x,t)\, dx.$$

The behavior of fish along the screenfront may also be density-dependent, excursions increasing or decreasing in length or frequency owing to schooling, avoidance reactions, or even sample size because of the effects of dense or sparse packing. With all of the foregoing constraints and provisions, concentration function U will be governed by the nonlinear relationship

$$\frac{\partial U}{\partial t} = \frac{\partial}{\partial x}\left[D(U,\alpha,t)\frac{\partial U}{\partial x}\right] - \beta(t)\cdot U(x,t). \tag{29}$$

Quantity $\beta(t)$ is a mortality rate. Except for the mortality term and the density-dependent provision of coefficient D, equation (29) is the limiting case of a one-dimensional random-walk process (see, for example, Barber and Ninham 1970 or Zauderer 1983). We already have some notion of the likely forms of β from our previous analysis of risk function ϕ_t. Mortality β has the definition

$$\beta(t) \equiv -\frac{1}{\phi_t}\frac{d\phi_t}{dt}. \tag{30}$$

Coefficient D is our dispersion or fish-activity parameter, defined in the limit as

$$D \equiv \lim_{l,\tau \to 0} [l^2/\sin^2(\alpha/2\tau)]. \tag{31}$$

As an empirical coefficient, D is determined from measurements of the stochastic variables $l^* = E[l]$ and $\tau^* = E[\tau]$ in the relationship

$$\hat{D} = l^{*2}/\sin^2(\alpha/2\tau^*).$$

The values of l^* and τ^* may change over residence time, owing to exhaustion or acclimation of the fish (hence the dependence of D on t in [29]). The possible density-dependent effects of fish behavior are represented in (29) by the dependence of D on U itself (to whatever extent l and τ depend on the density of fish along the screenfront). The value or variation of D, for any combination of screen angle, intake velocity, species, and so on, is an empirical relationship and can be determined only from observed excursion patterns. It is worth noting that D does not depend directly on flume size L (or screen length L'), but the influence of flume size may enter indirectly into D if the mean values of l and τ are density-dependent. Flume size enters the problem explicitly by way of the boundary conditions.

For experiments where the release of fish is distributed in some way over time, each fish or subset of fish in S will have its own time scale of residence (ζ, say) which has a zero value corresponding to arbitrary time t. Although we shall not pursue the analysis for this case here, the analysis (and experimental design) is aided by the introduction of a distribution function $F(x,t,\zeta)$, which describes the probability that a randomly designated fish will be found, at general time t and its own residence time ζ after introduction to the screenwell, at a location between x and $x+dx$ along the displacement axis. The relationship of F to concentration function U and live population N is

$$U(x,t,\zeta) = F(x,t,\zeta)\cdot N(t,\zeta), \tag{32}$$

and F has the governing equation

$$\frac{\partial F}{\partial t} + \frac{\partial F}{\partial \zeta} = \frac{\partial}{\partial x}\left[D(U,\alpha,\zeta)\frac{\partial F}{\partial x}\right] - \beta(\zeta)\cdot F(x,t,\zeta). \tag{33}$$

In general, the diversion rate (the time-dependent flux) $Q(t)$ of fish departing the screenwell (live, dead, and injured) is given by

$$Q(t) = -D\left[\frac{\partial U}{\partial x}\right]_{x=L'} \tag{34}$$

In the interests of clarity and the insight we might gain into the dependence of residence time on flume size, we commence our exploratory analysis from the simplest assumptions. Let us discount mortality and density dependence for the moment and presume that over time all fish of a sample S enter the bypass alive. Governing equation (29) now reduces to

$$\frac{\partial U}{\partial t} = D\frac{\partial^2 U}{\partial x^2}, \tag{35}$$

with coefficient D still defined by (31) but with l and τ constant. The initial and boundary conditions for this special case and all other cases considered are given by (36, 37, 38):

$$\text{at } t = 0, \quad U(x,0) = S_0(x), \tag{36}$$

where $S_0(x)$ describes the initial distribution of fish along the screenfront.

$$\text{At } x = 0, \qquad \frac{\partial U}{\partial x} = 0, \tag{37}$$

which is the condition at B_1 that specifies a reflecting boundary (no flux of fish through B_1).

$$\text{At } x = L', \quad U(L',t) = 0, \tag{38}$$

which is the condition at B_2 that specifies an absorbing boundary (the fish that encounter the bypass are presumed to enter it).

Equation (35) has the form of a simple linear diffusion equation with special boundary conditions. We show here the solution procedures for the problem specified by (35, 36, 37, 38). Except for some additional complexities arising from the time dependencies of coefficient D and mortality β, all of the linear problems treated here are resolved in a similar manner. For the large-time solution of the problem we employ the Fourier method, or

$$U(x,t) = \sum A_n U_n(x,t), \tag{39}$$

where each of the U_n must satisfy the boundary conditions (37, 38) and where the coefficients A_n are determined by (36), the initial distribution of fish along the screenfront. Therefore, by (39) and the usual procedures of separation,

$$A_n U_n(x,t) = A_n(a_n \cos \lambda_n x + b_n \sin \lambda_n x)e^{-\lambda_n^2 Dt}.$$

Because the A_n cannot be zero identically, we must have $b_n \equiv 0$ in order to satisfy boundary condition (37). With no loss of generality, we can now set the $a_n = 1$ and apply boundary condition (38). The eigenvalues of the solution become, for $n = 0, 1, 2, \ldots,$

$$\lambda_n = \frac{(2n+1)\pi}{2L}, \tag{40}$$

and the solution itself now becomes

$$U(x,t) = \sum_{n=0}^{\infty} A_n e^{-\lambda_n^2 Dt} \cos \lambda_n x. \tag{41}$$

The values of coefficients A_n are determined by the initial concentration pattern of fish along the barrier screen. Thus, at time $t = 0$ we assume that (41) converges uniformly to $S_0(x)$, or

$$S_0(x) = U(0,x) = \sum_{n=0}^{\infty} A_n \cos \lambda_n x.$$

Therefore, the Fourier coefficients of function $S_0(x)$ become, for $n = 0, 1, 2, \ldots,$

$$A_n = \frac{1}{L}\int_{-L'}^{L'} S_0(x) \cos \lambda_n x \, dx. \tag{42}$$

With (42) as the n-many coefficients corresponding to the eigenfunctions of (41), we can now write solution (41) in the form

$$U(x,t) = \frac{1}{L}\sum_{n=0}^{\infty} e^{-\lambda_n^2 Dt} \cos \lambda_n x \cdot \int_{-L'}^{L'} S_0(x) \cos \lambda_n x \, dx \tag{43}$$

with the λ_n given by (40). Solution (43) is now useful for examining the likely form of uninjured escapes at large time. As t increases, the minor sums of (43) decay and the asymptotic behavior of the solution becomes

$$U(x,t) \to \frac{1}{L} e^{-\pi^2 Dt/4L^2} \cos\left(\frac{\pi x}{2L}\right) \cdot \int_{-L'}^{L'} S_0(x) \cos\left(\frac{\pi x}{2L}\right) dx \qquad (44)$$

(with the reminder that the definite integral $\int [-L',L']$ is a constant). Thus, at large time, the probability of live escape from the screenwell reduces the sample population as

$$N(t) = \int_0^{L'} U(x,t)\, dx \to \frac{2}{\pi} A_0 \exp\left(-\frac{\pi^2 Dt}{4L^2}\right) \qquad (45)$$

where A_0 is the definite integral of (44). Thus the escape of live fish (a condition of the problem) is governed by the rate parameter

$$\lambda^* = \frac{\pi^2 D}{4L^2}. \qquad (46)$$

Relationship (46) reveals the factors that influence parameter λ of the probability functions θ_t and the data analysis illustrated by Figs. 7–11. The L^2 term in the denominator of (46) is especially ominous. It suggests that the chance per unit time of uninjured escape is inversely proportional to the square of flume width. That is, the characteristic time t^* for movement of live fish out of the screenwell is proportional to $1/\lambda^*$, or

$$t^* \propto \frac{L^2}{D} \qquad (47)$$

We should not be surprised, therefore, to discover from experiments that for a given screen angle and species, the mean residence time of entrapped live fish increases with the square of flume size (and with it the exposure to the risk of death or injury).

For purposes of examination, the small-time behavior of $U(x,t)$ is more conveniently expressed by the method of images. For some time immediately after the start of an experiment, the flux of fish into the bypass and the (changing) distribution of fish along the screenfront will be strongly influenced by the initial distribution of fish as they come down the flume. We continue here for the moment with the assumption of zero mortality risk ($\beta = 0$), with governing equation (35), and with boundary conditions (37, 38). For initial condition (36), however, let us presume in the first instance that the fish are uniformly distributed at $t = 0$, or

$$S_0(x) = \frac{S}{L'}. \qquad (48)$$

With these conditions the small-time solution becomes

$$U(x,t) = \frac{S}{L'}\left\{1 - \sum_{n=0}^{\infty} (-1)^n [\operatorname{erfc}(-\chi_n) + \operatorname{erfc}(\chi_n)]\right\}, \qquad (49)$$

where

$$-\chi_n = \frac{(2n+1)L' - x}{2(Dt)^{1/2}},$$

and

$$\chi_n = \frac{(2n+1)L' + x}{2(Dt)^{1/2}};$$

so,

$$Q(t) = \frac{D^{1/2} S}{(\pi t)^{1/2} L'}\left[1 + 2 \sum_{n=1}^{\infty} (-1)^n e^{-n^2 L'^2/Dt}\right]. \qquad (50)$$

This result suggests that with a uniform initial concentration of fish along the barrier screen, the flux (the bypassing rate) of live fish from the screenwell would be inversely proportional to screen length (which is not surprising), but also proportional to $t^{-1/2}$ (which is).

Let us examine one more case of the small-time solutions above, but with a special initial condition that seems to apply to experiments 35 through 51 of the Alden study. Suppose sample S has been released in the flume in such a way as to result in a cluster of fish around some location x_0 of the barrier screen (Fig. 14). The distance of x_0 from the bypass is $L' - x_0$. We can represent this initial condition with a Dirac delta distribution $\delta(x - x_0)$ at location x_0, or

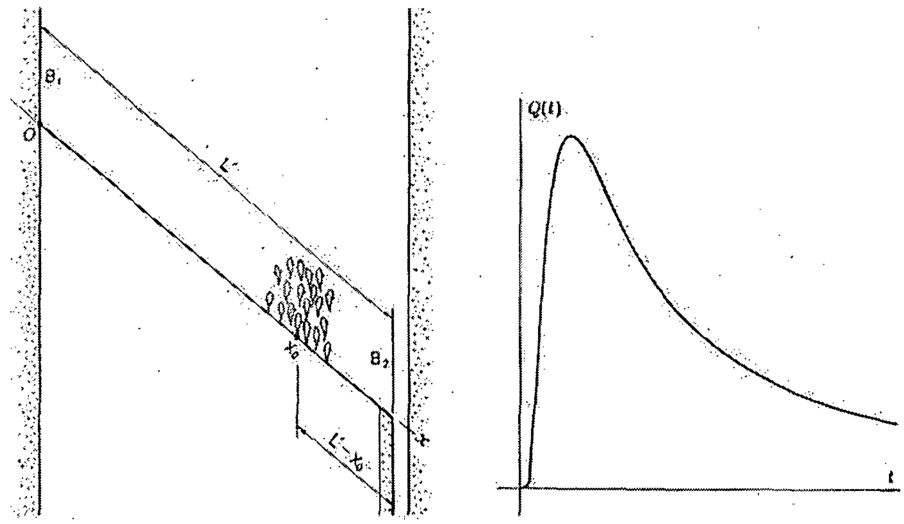


FIGURE 14.—*Left, special case of initial fish distribution in a flume,* $S_0(x)$*, where sample* S *is concentrated on release around location* x_0 *(equation [51]). Right, graph of diversion rate* $Q(t)$ *(equation [52]) for this initial condition.*

$$S_0(x) = \rho\delta(x - x_0), \tag{51}$$

where ρ is the concentration of fish per unit length of screen around x_0. Thus, the small-time approximation of departure rate $Q(t)$ becomes

$$Q(t) \approx \frac{(L' - x_0)\rho}{2(\pi D)^{1/2}t^{3/2}}\, e^{-(L'-x_0)/4Dt}. \tag{52}$$

As indicated by the right panel of Fig. 14, the flux of fish entering the bypass exhibits a sharp increase a short time after release. The surge occurs at a time governed by distance $(L' - x_0)$ and by the activity of the fish (as reflected by the presence of activity coefficient D in [52]).

Let us now introduce the risk of death and injury into the analysis, as well as possible time-dependent variations of activity coefficient D. The governing equation for U becomes

$$\frac{\partial U}{\partial t} = D(t)\frac{\partial^2 U}{\partial x^2} - \beta(t)U(x,t), \tag{53}$$

with $\beta(t)$ defined by (30). Thus, in the case where ϕ_t is defined by (5a),

$$\beta(t) = \mu, \tag{54}$$

and in the case where ϕ_t is defined by (5b),

$$\beta(t) = \frac{\mu}{1 + ce^{-\mu t}}. \tag{55}$$

Over time, a fish might reduce its mean excursion steps l or its frequency of making them, owing to such effects as exhaustion or acclimation. Should mortality be related to exhaustion, say, we can expect the form of $D(t)$ to be functionally similar to probability ϕ_t. In the absence of further knowledge, we can only suppose that D is likely to decay in either of the following ways:

$$D(t) = D_0 e^{-\nu t}, \tag{56}$$

which accommodates a decline in fish activity immediately following introduction of the fish into the screenwell; or

$$D(t) = \frac{(b + 1)D_0}{b + e^{\nu t}}, \tag{57}$$

which accommodates a delay in the reduction of fish activity. In either case, ν governs the rate of decay in activity, and D_0 still depends on screen angle (and so might decay parameter ν and delay parameter b).

The solutions we seek all require integrations of β and D. For convenience of notation, the integrations are given the following symbols:

$$\Lambda(t) \doteq \int_0^t \beta(t)\,dt$$

$$= \begin{cases} \mu t \text{ if } \beta(t) \text{ is (54).} \\ \log_e\left(\dfrac{c + e^{\mu t}}{c + 1}\right) \text{ if } \beta(t) \text{ is (55).} \end{cases}$$

$$\kappa(t) = \int_0^t D(t)\,dt$$

$$= \begin{cases} \dfrac{D_0(1 - e^{-\nu t})}{\nu} \text{ if } D(t) \text{ is (56).} \\ \dfrac{(b + 1)D_0}{b}\left(\nu t - \log_e \dfrac{b + e^{\nu t}}{b + 1}\right) \\ \quad \text{if } D(t) \text{ is (57).} \end{cases}$$

For the analysis and examples that follow, (53) is our governing equation of interest, (37, 38) are the boundary conditions, and (36) is the initial condition, but initial distribution $S_0(x)$ will be specified for each examined application. The Fourier solution of the general problem specified is now

$$U(x,t) = e^{-\Lambda(t)} \sum_{n=0}^{\infty} A_n e^{-\lambda_n^2 \kappa(t)} \cos \lambda_n x, \quad (58)$$

where the λ_n take the values specified by (40) and where the A_n are defined by (42). First suppose the initial distribution of fish along the screen-front to be uniform at $t = 0$. Thus, the initial condition becomes

$$S_0 = \frac{S}{L}, \quad (59)$$

where S is again the number of fish in the test sample. The Fourier coefficients in turn become

$$A_n = (-1)^n \frac{4S}{(2n + 1)\pi L'}. \quad (60)$$

Let us now examine a few cases of (58) that seem to apply to the marking experiments of the Oswego study and to the Alden study. For the first application, presume that mortality $\beta(t) = \mu$, or $\Lambda(t) = \mu t$ (which corresponds to cases 1 and 3 of the time-dependent risk analysis). But let us also suppose that exhaustion plays a role in the behavior of the test species, such that activity parameter D decays in time after the manner of (56). With these conditions on $\Lambda(t)$ and $\kappa(t)$, the asymptotic (or large-time) behavior of concentration function U becomes

$$U(x,t) \to \frac{4S}{\pi L'} \exp\left[-\frac{\pi^2 D_0(1 - e^{-\nu t})}{4L^2 \nu} - \mu t\right] \cdot \cos \frac{\pi x}{2L'}, \quad (61)$$

and the associated diversion rate of fish (live, dead, and injured) is

$$Q(t) \to \frac{2SD_0}{L'^2} \cdot \exp\left[-\frac{\pi^2 D_0(1 - e^{-\nu t})}{4L'^2 \nu} - (\mu + \nu)t\right]. \quad (62)$$

But $\exp(e^{-\nu t}) \approx 1$ at large t, so that

$$U(x,t) \sim e^{-\mu t},$$

and

$$Q(t) \sim e^{-(\nu + \mu)t}.$$

The flux (the departure rate) $Q(t)$ of fish is retarded by the decrease in fish activity (as governed by parameter ν of D), but the decline in overall density of fish in the screenwell is governed by the injury and mortality process. In turn, population N diminishes at large time as

$$N(t) = \int_0^{L'} U(x,t)\,dx \to \frac{8}{\pi^2} \exp\left[-\frac{\pi^2 D_0}{4L'^2 \nu}\right] S e^{-\mu t} \quad (63)$$

and the cumulative departures from N go as

$$B(t) = S - N(t),$$

a process dominated in this case by mortality. The results of this example reflect the influence of the decline in fish activity at the barrier screen and hence the associated increase in exposure to the risk of death or injury. The process seems to apply to the marking experiments on the white perch of the Oswego study (Table D-3, Appendix D) where recoveries were dominated by mortality but only 57% of the marked fish had exited the screenwell at the end of the 48-h test period (all of which were dead). The foregoing example is much the counterpart of result (45) where exits were dominated by live fish on the order of $\exp(-\lambda^* t)$.

In the case of more hardy and active fish, parameter D may decay very little over time. If we

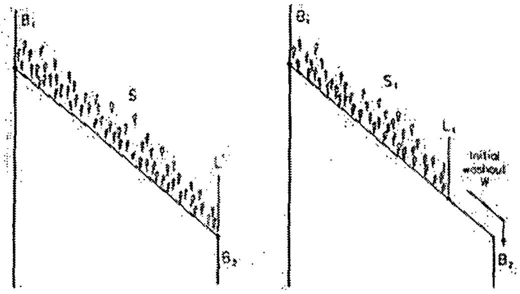


FIGURE 15.—*Left, uniform initial distribution S/L' of fish before a barrier screen. Right, nonuniform distribution* S_1/L_1 *where* $S_1 = S - W$ *in equation (68).*

allow D to be constant in (58), and with $\beta(t) = \mu$ as before, the general solution for U becomes

$$U(x,t) = \frac{4S}{\pi L'} e^{-\mu t} \sum_{n=0}^{\infty} \frac{(-1)^n}{2n+1} e^{-\lambda_n{}^2 Dt} \cos \lambda_n x. \quad (64)$$

At large time the asymptotic term of (64) is now

$$U(x,t) \rightarrow \frac{4S}{\pi L'} e^{-(\mu+\lambda^*)t} \cos \frac{\pi x}{2L'}, \quad (65)$$

and the departure rate of fish from $N(t)$ is now approximately

$$Q(t) \rightarrow \frac{2DS}{L'^2} e^{-(\mu+\lambda^*)t}, \quad (66)$$

which is like the bypassing rate of live and injured (or dead) fish illustrated by Figs. 10 and 11 (Alden experiment 13). From integration of the asymptotic term of (64), the large-time approximation of the decline in the live, uninjured screenwell population becomes

$$N(t) \rightarrow \frac{8}{\pi^2} S e^{-(\mu+\lambda^*)t}, \quad (67)$$

which predicts a large-time decline in N similar to the single-variabled regression function of Fig. 10.

For purposes of examination at small time, the method of images gives us more convenient solutions. Thus, with conditions like those above for (64), the fish concentration function for small t is

$$U(x,t) = \frac{S}{L'} e^{-\mu t} \left\{ 1 - \sum_{n=0}^{\infty} (-1)^n [\mathrm{erfc}(-\chi_n) + \mathrm{erfc}(\chi_n)] \right\}, \quad (68)$$

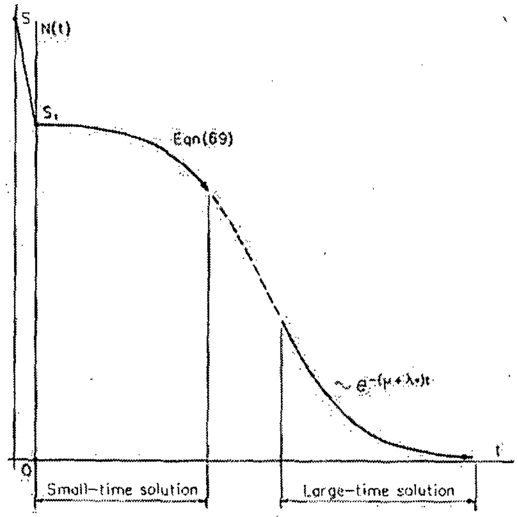


FIGURE 16.—*Delay in departure of fish from flume population* N(t) *owing to an initial nonuniform distribution and its effect on small-time solution (69); see Fig. 15.*

where the functions $-\chi_n(x)$ and $\chi_n(x)$ are identical to those of (49). With regard now to a peculiarity of the Alden data, let us impose a special initial condition on (68). In the previous example we presumed the distribution of fish on their arrival at the screenfront to be more or less uniform (Fig. 15, left). For the conclusion of the example, suppose that in a short period of time after arrival, the initial distribution of fish quickly becomes nonuniform (Fig. 15, right) as a result of an initial washout W, where $S - W = S_1$ (as reflected in the Alden data, Appendix C, and Figs. 7–9). Our initial condition changes accordingly:

$$\text{at } t = 0, \quad S_0(x) = \begin{cases} \dfrac{S_1}{L_1} & \text{where } 0 \leq x \leq L_1 \\ 0 & \text{where } L_1 < x \leq L'. \end{cases}$$

With this initial condition in (68), the small-time solution for $N(t)$ becomes

$$N(t) = \int_0^{L'} U(x,t)\, dx \approx S_1 \left[1 - \left(\frac{D}{\pi L_1{}^2 t} \right)^{1/2} e^{-(L'-L_1)^2/4Dt} \right], \quad (69)$$

which has a trajectory (Fig. 16) similar to those of Figs. 7–9. As this result suggests, the delay following the initial washout in many of the Alden experiments might have been the result of high initial densities of test fish in a small test flume (the effect being most pronounced in experiments where S was 200 or more fish), or even the consequence of the nonuniform flow conditions at the starts of experiments.

As consistently shown by the analysis of this section, the characteristic diffusion time of live and swimming fish in escaping the screenwell depends on flume size L ($=L'\sin\alpha$) and activity coefficient D in the relationship

$$t^* = \frac{4L^2}{\pi^2 D}.$$

Over time, the screenwell population is reduced by death and injuries, as well as by live escapes. Those risks and reductions, and how they combine, may be influenced by any of the several factors discussed here (and perhaps by some that have not been discussed). We have seen how a few of those factors, for such important quantities as mortality β and activity D, may influence escape and survival, as inferred from sparse evidence. But that evidence does not extend to such fundamental questions as the effects of sample density on fish activity [whether or not $D = D(U)$], or even to the nature of initial fish distributions along a screenface [the possible forms of $S_0(x)$]. As the solutions of $U(x,t)$ depend on those unresolved complexities, so does the dependence on flume size L of expected entrapment time, and, most importantly, so do the projections to full-scale designs of the mortality probabilities resolved from small-scale experiments.

The Scaling Problem

Although the governing equations, boundary conditions, initial conditions, and parametric formulations can be written for many conceivable relationships between the quantities of interest, we have pressed the analysis about as far as inference and rational speculation can safely take us. What empirical information we do have at hand does not seem adequate for asking more from the analysis than simple instructions from simple assumptions. With these cautions in mind, and the simplifying assumptions of constant risk of death or injury [$\beta(t) = \mu$], time-invariant fish activity (D constant for a given screen angle), a uniform initial distribution [$S_0(x) = S/L'$], and the disallowance of experimental artifacts, then the dependence on flume size L of the expected entrapment time of a fish at risk in screenwell population $N(t)$ is given by

$$E[Y(L)] = \frac{1}{\mu + \lambda^*} = \frac{L'^2\sin^2\alpha}{\mu L'^2\sin^2\alpha + \dfrac{\pi^2 D}{4}} \tag{70}$$

(see Fig. 17). From the analysis of the Alden test data and the Oswego marking experiments, we have some idea of mean entrapment times and likely value ranges of risk parameters μ and λ for large and small systems. We can also so extract some likely values of coefficient D from that information and the analysis associated with Figs. 10 and 11.

From the regressions of Figs. 10 and 11 on the data of Alden experiment 13, the experimental mean residence time and estimated values of the risk parameters are

$$\bar{Y} = 3.21 \text{ h};$$
$$\hat{\mu} = 0.0975/\text{h};$$
$$\hat{\lambda} = 0.2139/\text{h}.$$

The Alden flume width is $L = 1.83$ m, where screen length $L' = L/\sin\alpha$. For experiment 13, α was 45°, but, in the absence of information on the effects of differing screen angles on D (on mean excursion dimension l'), we calculate D in terms of cross-flume dimension l. The numerical relationship between l and L, for a *given screen angle* will be the same as that between l' and L'. By (46) then, the estimated value of activity coefficient D for the Atlantic menhaden of Alden experiment 13 is

$$\hat{D} = \frac{4L^2\hat{\lambda}}{\pi^2} = 0.29 \text{ m}^2/\text{h}.$$

Another (representative) estimate of D can be extracted from the comparison between the large and small diversion systems given previously. In those calculations the (implied) activity coefficient was the same for both systems. The calculations for the small system were based on the various Alden flume experiments, where flume size and the representative values for mean residence time and the risk parameters were

$$L = 1.83 \text{ m};$$
$$\bar{Y} = 3 \text{ h};$$

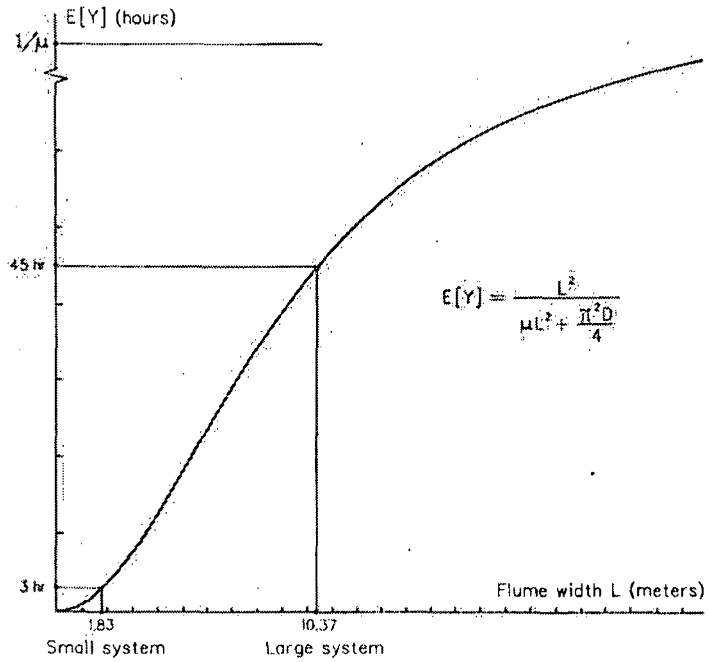


FIGURE 17.—*Expected entrapment time versus flume size from equation (70) with $\mu = 0.012/h$ and D = 0.436 m^2/h.*

$$\mu = 0.012/\text{h};$$
$$\lambda = 0.321/\text{h}.$$

Therefore, the representative value of activity coefficient D for the small system is

$$D = 0.436 \text{ m}^2/\text{h},$$

and it has the identical value for the large system, where

$$L = 10.37 \text{ m};$$
$$\bar{Y} = 45 \text{ h};$$
$$\mu = 0.012/\text{h};$$
$$\lambda = 0.010/\text{h}.$$

Figure 17 depicts relationship (70) with the values of μ and D above (the values of the large- and small-system comparison). The inflection point of (70) occurs at a flume width

$$L = \frac{\pi}{2}\left(\frac{D}{3\mu}\right)^{1/2} \qquad (71)$$

(5.47 m on the example graph). At flume widths greater than (71), the unit risk μ, or death and injury distribution ϕ_t, has a greater influence on mean live entrapment [residence time in $N(t)$] than the live escape distribution $1 - \theta_t$. In fact, the upper (asymptotic) bound on mean residence time is $1/\mu$.

With the same general assumptions as those

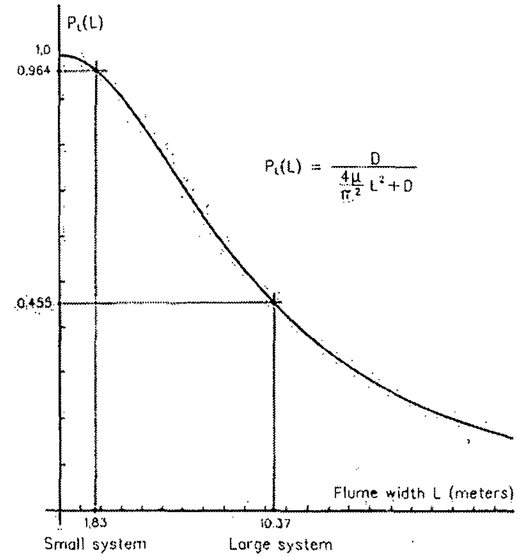


FIGURE 18.—*Probability of live escape $P_L(L)$ versus flume size from equation (72) with $\mu = 0.012/h$ and D = 0.436 m^2/h.*

given for (70), the probability of escape drops off rapidly with flume size in the relationship

$$P_L(L) = 1 - \mu \cdot E[Y(L)]$$
$$= \frac{\pi^2 D}{4\mu L^2 + \pi^2 D} \qquad (72)$$

which has the appearance of Fig. 18 (for the same values as those of Fig. 17). Thus for the small (representative) system, the probability that a fish drawn into the screenwall will escape uninjured is

$$P_L(1.83 \text{ m}) = 0.964,$$

where, as before, $\mu = 0.012/\text{h}$ and $D = 0.0436$ m^2/h. The probability that it will die or be injured is

$$P_D(1.83 \text{ m}) = 1 - 0.964$$
$$= 0.036,$$

or, of a sample S, 3.6% are expected to die or be injured and 96.4% are expected to escape uninjured. For the large (representative) system,

$$P_L(10.37 \text{ m}) = 0.455,$$
$$P_D(10.37 \text{ m}) = 0.545,$$

or 45.5% expected live escapes and 54.5% deaths and injuries.

Relationships (70) and (72) will be further complicated to the extent that activity D and mortality rate β are time- and density-dependent in the solutions of governing equation (29). Whether or not screen angle may influence D cannot be resolved from the existing empirical information, but the possibility cannot be discounted. Nevertheless, from the simplest of assumptions, we can see by (70) and (73) that projections of small-scale experimental results to full-scale designs cannot be made on such simple arithmetic extrapolations as flume-size ratios. And because of the clearly nonlinear relationships between flume size and the competing risks of mortality and escape, the scaling problem cannot be resolved from the experimental designs, estimators, and linear statistical analysis of current practice.

Conclusion

So long as the water supplies demanded by large water-use facilities are drawn from natural sources, the continued entrapment of large numbers of fishes is probably inevitable. Except for such topographical arrangements as porous dikes and barrier nets at the entries of cooling ponds, little in the way of actually preventing entrapment seems possible of achieving. The devices now commonly employed for conserving fish life have all been designed instead with the (conscious or unconscious) intent of reducing exposure to risk once a fish has encountered them. All such devices are mechanical in nature; some are passive (or semi-passive) in their operating principles and some are active. As revealed by the accumulated evidence, no device, active or passive, has proven to be very successful at preventing injury and death to fish in full-scale systems. Such passive devices as angled-screen arrays suffer from decreased effectiveness as they increase in size, and angled-louvre arrays are impractical or ineffective altogether. The known active devices (such as continuously travelling screens with the Ristroph modification) are limited in effectiveness because those devices operate on the expectation of direct encounter with the fish.

As demonstrated by the probabilistic analysis (and as reason tells us once the question has been posed), the expectation of live entrapment (the mean residence time) of fish drawn into a screenwell is lessened both by increased opportunity for escape (decreased exposure to risk of death) and by increased mortality (by increases in the unit risk of death), but the two have opposite effects on survival. With such passive devices as angled barrier screens, survival declines with increase in system size owing to increased residence time (increased exposure) in the absence of any reduction in the unit risk of death itself. In the case of active devices that depend on direct contact with the fish, the durations of entrapment are apparently reduced, but the reductions are brought about by increased risk and the accompanying cost in death and injury. From the foregoing findings, it becomes obvious that if a new design is to be better at conserving fish than the old, it must bring about a reduction in mean entrapment time through some active means of removal, but some active means not dependent on forcible contact with the fish.

In the case of angled barrier screens, whether or not a steepened pitch (a lessened angle of attack) contributes anything to reducing the mortalities of entrapped fish has not been established with certainty. And despite the many reports on

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"diversion efficiencies" of angled screens, whether or not screen angle has any influence at all in directing or guiding actively swimming fish to a bypass is still an undecided proposition. No plausible rationale capable of withstanding examination has ever been posed that would justify such a thesis, and no systematic observations sufficient for testing the guiding hypothesis have ever been reported. Except when fish are pressed against an angled screen and forced along it by the water flow, screen angle seems to have no more influence on swimming fish than any other stimulus that might provoke random excursions in the screenwell.

The barrier screen is always put forth as a conserver of fish, when in fact it is the hazard. In designing experiments on devices whose principal function is that of halting the influx of debris into the plant, it should not be a question of how much efficiency the device bestows on fish, but how much death and injury. If an angled screen and bypass, say, are any less hazardous to fish life than a 90° screen and bypass might be (in terms of the ultimate fate of fish returned to the source waters), nobody knows it for certain.

The behavior of fish entrapped in a screenwell is poorly understood. Whether their movements are systematic in some fashion (as in the guiding hypothesis for angled screens), or essentially stochastic (as in the random-walk hypothesis of this paper), can only be resolved by time-series experiments (such as continuous cinemagraphic measurements) and competent statistical analyses.

On the question of predicting the likely effects of full-scale conservation systems from the results of small-scale experiments, the equations and conditions for making such predictions can be constructed, but the requisite empirical information for quantifying the analysis and resolving parametric relationships does not now exist. An appropriate analysis requires experimental information with respect to (at least) two independent variables, time and displacement. In reported studies, whether of experimental flumes or operating systems, neither variable is taken into account because the experimental designs (hence the statistical analysis) employed in such works are constructed around invariant estimators (E, E_T, m, and so on). Because of that want of dimensional dependence, past experiments have been severely system-dependent and thus extend with little reliability from one system to another.

Because an accurate resolution of the questions addressed in this work attaches with such importance to the conservation of fish life and to the costs for constructing conservation devices that otherwise may prove ineffective, I recommend that much of the past and current research on fish diversion systems be viewed as inconclusive, and that new or revised experimentation be undertaken that will allow a separation of the competing risks identified here.

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Appendix A: Reduction of a Random Walk to Frequency of Escape (Formula 15)

Let escape be a random process with reflecting and absorbing boundaries in one dimension (see, for example, Barber and Ninham 1970). That is, let the entrapped population size n at time t be a Poisson random variable with mean λt (where, at time $t = 0$, $n = n_0$). Therefore, the probability that the population consists of $n\ (\leq n_0)$ entrapped members at time t is

$$P_n(t) = 1 - \frac{(\lambda t)^n}{n!} e^{-\lambda t}.$$

Thus the probability that the population consists of *no* entrapped members at time t becomes

$$P_0(t) = 1 - e^{-\lambda t},$$

which can be viewed as the risk (the chance) that a randomly designated individual of n_0 will have escaped by time t. That is, with T the time of escape, then

$$P_0(t) = \text{Prob}[T \leq t]$$

for any time t. In turn, the probability of the individual's being entrapped at least until time t is

$$\begin{aligned} P_E(t) &= \text{Prob}[T > t] \\ &= 1 - P_0(t) \\ &= e^{-\lambda t}, \end{aligned}$$

and $P_0(t)$ has the corresponding density function

$$\lambda e^{-\lambda t}. \qquad (15)$$

Parameter λ is a rate (in particular, rate of escape) with corresponding dimensions numbers/time.

Appendix B: Delay in Escape Probability (Equation 16a)

Let escape have the probabilistic conditions described for formula (15) of Appendix A, but let there be a time delay in that process. With k the delay parameter, $P_0(t)$ takes the form

$$P_0(t) = 1 - \frac{k+1}{k+e^{\lambda t}},$$

and the probability of continued entrapment in turn becomes

$$P_E(t) = \frac{k+1}{k+e^{\lambda t}}. \qquad (16b)$$

The (cumulative) delay is determined by parameters λt and k on the time domain where

$$\lambda t \leq \log_e\left(\frac{k}{2}+1\right).$$

Behavior of (16b):

at $t = 0$, $P_E(0) = 1$;
as $t \to +\infty$, $P_E(t) \to 0$;
as $k \to 0$, $P_E(t) \to e^{-\lambda t}$ (no delay);
at large t (where $t > \log_e[(k/2) + 1]$),
$P_E(t) \to e^{-\lambda t}$.

Let $f(t) = \frac{d}{dt}P_E(t)$; thus

$$\int_0^\infty f(t)\,dt = -(k+1)\left[\frac{1}{k+e^{\lambda t}}\right]_0^\infty = 1$$

as required.

Appendix C: Alden Test Data

Contained in this appendix are the recovered laboratory data (Table C-1) from the Alden test-flume experiments (Alden Research Laboratory 1981), along with several examples that illustrate the invalidities of the estimating procedures common to such work.

As noted previously, the estimator E, presumed to be a measure of the "diversion efficiency" of a conservation device on a sample of fish, is defined in the Alden report as

$$E = \frac{\text{Number bypassed}}{\text{Number tested} - \text{Number non-bypassed}},$$

the "Number tested" being sample S. The ultimate likelihood E_T, or the "total system efficiency," of the tested diversion system in bypassing fish alive is defined in turn as

$$E_T = E(1-m),$$

quantity m being the differential mortality described heretofore.

Example 1: Termination of experiments at like running times. Suppose that two competing devices are being tested (25° and 45° screens and bypasses, say). All other experimental variables are identical. Let S be 100 fish. Both experiments are terminated, say, after 4 h from start. Suppose the observed results to be the following

Device A: 1 fish bypassed alive, 99 left swimming in the flume.
Device B: 99 fish bypassed alive, 1 left swimming in the flume.

According to the estimating conventions of the Alden (and similar) demonstrations, the diversion efficiencies E for both devices would be 100%, and the total efficiencies E_T would also be 100% for both. The inequities of such measures are obvious. The rate of bypassing in case B is far greater than that of A, and the unknown fate of the one remaining fish of B is insignificant in comparison to the 99 of A, but such differences would not be distinguished by the measures given to E and E_T. In the example, the possibility could not be discounted that all 99 remainders of A might be killed, in which case the true efficiency of the system would fall from 100% to 1%.

Example 2: Termination of experiments when a predetermined number of fish have been bypassed. Again let the sample size for each of two experiments be 100 fish, but let each be terminated at the bypassing of 10 fish, irrespective of time.

Device A: 10 fish bypassed alive in 10 h; 90 left swimming in the flume.
Device B: 10 fish bypassed alive in 1 h; 90 left swimming in the flume.

Device B is obviously more effective at diverting fish than A, but again E would be scored as 100%

for both, and E_T would also be 100%. But device B is less hazardous to its remaining 90 fish than A to its remaining 90 owing to the higher rate of diversion of B (because decreased exposure to risk decreases the likelihood of death). The consequences could only be determined with certainty by running the experiments to conclusion.

Example 3: Arbitrary termination of experiments (typical of the Alden practice). Again let the sample size for each of the experiments be 100 fish, but with the following results.

Device A: One fish bypassed alive in 15 min; 99 left swimming in the flume.

Device B: 97 fish bypassed in 2 h, two dead; one fish left swimming in the flume.

Device B is obviously very effective at bypassing and conserving fish. Device A appears less so, but the test on A is not sufficient for statistical significance. Yet by the standard methods of scoring, the diversion efficiencies E for both would still be 100%, without distinction. The total efficiency E_T for device A is 100%, but E_T for B is 98%, and according to the statistical methods of the Alden report, device B would be deemed inferior to A when the opposite is more likely true.

The foregoing examples are not exaggerations. The portions of test samples S not accounted for in the experiments lead to conclusions like that expressed on page 19 of the report: "The striped bass was the most effectively diverted species (97.8 percent; s.d. = 5.7)." The striped bass, in fact, was the least effectively diverted species. The experiments with the *lowest* percentages of bypassed fish were those with the striped bass. See the tabulated data for experiments 22, 24, 29, 30, 34, 52, 53, 54, 57, and 58, Table C-1, where the portions of S not bypassed ranged from 51% of S to 78%.

The following examples are taken from the Alden report itself. The diversion efficiencies E are not given in the report and must be calculated from the tabulated quantities appearing on Table 3.1 of the report.

Example 4: Alden test 24. Tabulated values:

number tested (sample size): 200;
number bypassed: 51;
number left swimming in flume (not bypassed): 149;
number impinged: 0;
differential mortality m: 0;
E_T given as 100%.

Since $m = 0$, then $E = E_T$, which implies that $E = 1$ (or 100%). For this experiment, then, E was calculated as

$$E = \frac{\text{Number bypassed}}{\text{Number bypassed}} = 1.$$

The 149 non-diverted fish were excluded from the calculations as though they had never entered the experiments.

Example 5: Alden test 50. Tabulated values:

number tested: 100;
number bypassed: 81;
number left swimming in flume: 0;
number impinged: 19;
number held for 96 h: 81;
number of bypassed dead in 96 h: 8;
control mortality: 0;
differential mortality: $m = 0.10$ (as tabulated);
E_T given as 73%.

Although the quantity E is not given, we must now have

$$E = \frac{E_T}{1 - m} = \frac{0.73}{0.9} = 0.81,$$

but let us make a trial calculation of E according to the definition given in the report:

$$\begin{aligned} E &= \frac{\text{Number bypassed}}{\text{Number tested} - \text{Number non-bypassed}} \\ &= \frac{81}{100 - 19} \\ &= \frac{81}{81} \\ &= 1, \end{aligned}$$

which is obviously not what it seems to be. The value of E for this experiment was evidently calculated in the following way:

$$\begin{aligned} E &= \frac{\text{Number bypassed}}{\text{Number bypassed} + \text{Number impinged}} \\ &= \frac{81}{81 + 19} \\ &= 0.81. \end{aligned}$$

But E as calculated for this experiment (and some others) is an invalid estimator *if any likelihood of failure exists.* Suppose, for example, that in a given experiment (sample size 100, say), no fish were bypassed and no fish were impinged during the time allotted for the experiment. Then estimator E, which must accommodate failure as well as success, would have to be *zero* (whether E is viewed as a probability estimator or as the "efficiency" of the system in bypassing fish). But by the method of calculation employed by the authors in test 50, one would have instead:

$$E = \frac{\text{Number bypassed}}{\text{Number bypassed} + \text{Number impinged}}$$

$$= \frac{0}{0 + 0},$$

which is indeterminate, not zero as required. If, instead, we let E be a natural probability estimator, strictly reflecting the experimental results, then it should be defined instead as

$$E' = \frac{\text{Number bypassed}}{\text{Number tested}},$$

whence, for the illustration of failure,

$$E' = \frac{0}{100} = 0$$

as required. And for the results of test 50,

$$E' = \frac{81}{100} = 0.81$$

as required.

The natural estimates merely emphasize the arbitrary nature of the estimating methods employed in the Alden report; they do not rehabilitate the experiments but only reflect the empirical results as those results exist. Because the events of bypassing, injury, and death are governed by time-dependent distributions, no time-invariant estimators or statistical analyses like those appearing in the Alden and similar reports should be considered appropriate to the results of such experiments.

TABLE C-1.—*Recovered experimental data corresponding to summarized results in Alden Research Laboratory (1981).*[a]

Key: *Number preceding species denotes experiment.* α *is screen angle of attack;* V *is water velocity;* T *is water temperature;* m *is differential mortality (test mortality minus control mortality,* $M_T - M_C$*). Elapsed time is measured from the start of each experiment; the last entry represents test termination. Number bypassed includes live, dead, and injured fish bypassed since the previous observation; a value in parentheses gives the number of impinged fish collected at termination of the experiment.* N(t) *is the flume population at each observation time; the first number for each experiment is the sample size* S *and the last is the number of fish left swimming in the flume at termination of the experiment.*

Elapsed time, h	Number bypassed	$N(t)$
1: Atlantic menhaden		
$\alpha = 45°$ V = *30 cm/s*		
T = *20.5°C* m = *0%*		
0	0	200
0.5	0	200
1.0	0	200
2.25	122	78
2.5	49	29
2.75	0	29
3.0	0	29
2: Atlantic menhaden		
$\alpha = 45°$ V = *30 cm/s*		
T = *20.5°C* m = *0%*		
0	0	205
0.34	46	159
0.83	2	157
1.83	5	152
2.83	0	152
3.83	1	151
4.83	0	151
6.83	1	150
8.83	5	145
9.83	52	93
10.83	46	47

Elapsed time, h	Number bypassed	$N(t)$
11.33	18	29
11.83	8	21
12.83	0	21
3: Atlantic menhaden		
$\alpha = 45°$ V = *30 cm/s*		
T = *23°C* m = *0%*		
0	0	221
0.42	49	172
1.42	14	158
2.92	3	155
4.17	4	151
5.17	48	103
6.17	21	82
7.17	39	43
8.17	27	16
8.67	4	12
9.17	2	10
9.67	1	9
4: Atlantic menhaden		
$\alpha = 45°$ V = *30 cm/s*		
T = *22.5°C* m = *0%*		
0	0	205
1.0	22	183
2.0	2	181

Elapsed time, h	Number bypassed	$N(t)$
3.0	2	179
4.0	3	176
4.5	22	154
5.0	76	78
5.75	21	57
6.5	11	46
7.0	7	39
7.5	11	28
5: Atlantic menhaden		
$\alpha = 25°$ V = *30 cm/s*		
T = *21°C* m = *0%*		
0	0	214
0.5	22	192
1.5	6	186
2.5	0	186
3.5	1	185
4.0	73	112
4.5	30	82
5.25	23	59
6.0	24	35
6.5	6	29
7.2	6	23
6: Atlantic menhaden		
$\alpha = 25°$ V = *30 cm/s*		
T = *16.5°C* m = *47%*		

Elapsed time, h	Number bypassed	$N(t)$
0	0	200
0.25	78	122
0.75	15	107
1.75	10	97
2.75	13	84
3.75	7	77
4.25	32	45
4.75	6	39
5.75	7	32
6.25	2	30
7: Atlantic menhaden		
$\alpha = 25°$ V = *30 cm/s*		
T = *17.3°C* m = *4%*		
0	0	204
0.25	83	121
1.25	30	91
2.25	27	64
3.0	9	55
3.75	30	25
4.25	11	14
4.75	5	9
8: Atlantic menhaden		
$\alpha = 45°$ V = *30 cm/s*		
T = *18°C* m = *7%*		

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ults exist. Because the
ary, and death are gov-
t distributions, no time-
statistical analyses like
lden and similar reports
propriate to the results

lden Research Laboratory

s water velocity; T *is water*
– M$_C$). Elapsed time is
nation. Number bypassed
e in parentheses gives the
flume population at each
last is the number of fish

lapsed ime, h	Number bypassed	*N(t)*
0	0	200
0.25	78	122
0.75	15	107
1.75	10	97
2.75	13	84
3.75	7	77
4.25	32	45
4.75	6	39
5.75	7	32
6.25	2	30

7: Atlantic menhaden
α = 25° V = *30 cm/s*
T = *17.3°C* m = *4%*

0	0	204
0.25	83	121
1.25	30	91
2.25	27	64
3.0	9	55
3.75	30	25
4.25	11	14
4.75	5	9

8: Atlantic menhaden
α = 45° V = *30 cm/s*
T = *18°C* m = *7%*

TABLE C-1.—*Continued.*

Elapsed time, h	Number bypassed	*N(t)*
0	0	200
0.42	54	146
1.17	18	128
2.17	31	97
3.17	46	51
3.67	18	33
4.17	10	23
4.67	5	18

9: Atlantic menhaden
α = 25° V = *30 cm/s*
T = *17.5°C* m = *7%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	200
0.25	32	168
1.25	16	152
2.25	41	111
3.25	5	106
4.25	14	92
5.25	28	64
6.25	34	30
6.75	14	16
7.25	5	11

10: Atlantic menhaden
α = 25° V = *30 cm/s*
T = *17.7°C* m = *1%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	200
0.25	31	169
1.25	29	140
1.75	24	116
2.75	55	61
3.75	41	20
4.25	7	13

11: Atlantic menhaden
α = 45° V = *30 cm/s*
T = *12°C* m = *6%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	200
0.5	110	90
1.0	49	41
1.5	4	37
2.0	6	31
2.5	5	26
3.0	8(4)	14

12: Atlantic menhaden
α = 45° V = *30 cm/s*
T = *12.9°C* m = *0%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	209
0.5	79	130
1.5	40	90
2.5	28	62
3.0	21	41
3.5	10	31
4.0	4	27
4.5	2	25
5.0	3	22

13: Atlantic menhaden
α = 45° V = *30 cm/s*
T = *15°C* m = *11%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	207
0.25	110	97
1.25	21	76
2.25	21	55
3.25	13	42
4.25	17	25
5.25	6(1)	18

14: White perch
α = 45° V = *30 cm/s*
T = *13.2°C* m = *8%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	200
0.25	45	155
1.25	23	132
2.25	30	102
2.75	12	90
3.25	12	78
3.75	19	59
4.25	10	49
4.75	5	44

15: White perch
α = 45° V = *30 cm/s*
T = *12.9°C* m = *0%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	204
0.25	33	171
1.0	21	150
1.75	24	126
2.75	43	83
3.75	28	55
4.75	17	38
6.0	12	26

16: White perch
α = 45° V = *30 cm/s*
T = *12.8°C* m = *9%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	208
0.75	82	126
1.75	36	90
2.75	19	71
3.75	26	45
4.75	20	25
5.75	5	20

21: White perch
α = 45° V = *30 cm/s*
T = *4.8°C* m = *15%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	100
0.08	66	34
0.5	8	26
1.0	16	10
1.5	1	9
2.0	0	9

22: Striped bass
α = 45° V = *30 cm/s*
T = *5.3°C* m = *3%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	200
0.25	70	130
0.75	4	126
1.25	11	115
1.75	5	110
2.25	3	107
2.75	4	103
3.25	1	102

24: Striped bass
α = 25° V = *30 cm/s*
T = *3.5°C* m = *0%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	200
0.5	47	153
1.0	2	151
1.5	0	151
2.0	0	151
2.5	2	149
3.0	0	149
3.5	0	149

25: White perch
α = 45° V = *30 cm/s*
T = *2°C* m = *10%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	100
0.5	62	38
1.0	1	37
1.5	4	33
2.0	4	29
2.5	2	27
3.0	1	26
3.5	0	26

29: Striped bass
α = 45° V = *30 cm/s*
T = *2.5°C* m = *2%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	200
0.5	81	119
1.0	3	116
2.0	2	114
2.5	2	112

30: Striped bass
α = 45° V = *30 cm/s*
T = *3°C* m = *2%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	224
0.5	44	180
1.0	2	178
1.5	1	177
2.0	4	173
2.5	4	169
3.0	3	166
3.5	0	166

34: Striped bass
α = 45° V = *30 cm/s*
T = *3.8°C* m = *0%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	200
0.5	50	150
1.5	1	149
2.5	0	149
3.0	0	149
3.5	2	147
4.5	1	146

52: Striped bass
α = 45° V = *30 cm/s*
T = *5.3°C* m = *0%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	200
0.5	42	158
1.0	0	158
1.5	0	158
2.0	0	158
2.5	1	157
3.0	2	155
3.5	9	146
4.0	3	143
4.5	6	137

53: Striped bass
α = 45° V = *30 cm/s*
T = *7°C* m = *1%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	200
0.33	24	176
0.83	1	175
1.33	1	174
1.83	0	174
2.33	2	172
2.83	2	170
3.33	3	167
3.83	2	167
4.33	5	160
4.83	9	151
5.33	5	146

54: Striped bass
α = 45° V = *30 cm/s*
T = *7.2°C* m = *1%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	200
0.5	16	184
1.0	1	183
1.5	0	183
2.0	1	182
2.5	0	182
3.0	0	182
3.5	4	178
4.0	3	175
5.0	6	169
6.0	13	156
6.5	5	151

55: Striped bass
α = 45° V = *60 cm/s*
T = *8°C* m = *0%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	200
0.5	79	121
1.0	3	118
1.5	12	106
2.0	1	105
2.5	1	104
3.0	3	101
3.5	2	99
4.0	1	98
4.5	3	95
5.0	16	79
5.5	18	61
6.0	12	49
6.5	2	47

56: Striped bass
α = 45° V = *60 cm/s*
T = *10°C* m = *0%*

Elapsed time, h	Number bypassed	*N(t)*
0	0	200
0.5	50	150
1.0	2	148
1.5	2	146
2.0	0	146
2.5	3	143
3.0	0	143
3.5	4	139
4.0	6	133
4.5	7	126
5.0	33	93

TABLE C-1.—*Continued.*

Elapsed time, h	Number bypassed	$N(t)$	Elapsed time, h	Number bypassed	$N(t)$	Elapsed time, h	Number bypassed	$N(t)$	Elapsed time, h	Number bypassed	$N(t)$
5.5	11	82	1.0	0	155	5.5	4	118	1.5	3	179
6.0	6	76	1.5	1	154	6.0	8	110	2.0	3	176
6.5	4	72	2.0	2	152				2.5	4	172
			2.5	0	152	***58: Striped bass***			3.0	3	169
57: Striped bass			3.0	2	150	$\alpha = 45°$	V = *60 cm/s*		3.5	4	165
$\alpha = 45°$	V = *60 cm/s*		3.5	4	146	T = *12.5°C*	m = *3%*		4.0	4	161
T = *11°C*	m = *1%*		4.0	8	138	0	0	200	4.5	26	135
0	0	200	4.5	6	132	0.5	17	183	5.0	7	128
0.5	45	155	5.0	10	122	1.0	1	182	5.5	1	127

[a] Data from experiments 17, 18, 19, and 20 on alewives were not released. Experiments 23, 26, 28, 31, 32, and 33 had only two datum points each; experiment 27 had only one point. Experiments 35–51 had only one datum point each, and all were terminated at 15 min.

Appendix D: Oswego Test Data

TABLE D-1.—*Monthly estimated results from the 1981 study at Oswego Steam Unit 6. Data are from Table 3.0-8 of Lawler, Matusky and Skelly (1982b) except the mortality values appended here. Totals are for 9 months.*

Month	Estimated entrapment	Total plant efficiency	Estimated live return	Estimated entrapment	Total plant efficiency	Estimated live return	Estimated entrapment	Total plant efficiency	Estimated live return
		Alewife			***Rainbow smelt***			***Gizzard shad***	
Apr	54,432	33.7	18,344	8,280	75.2	6,227	144	48.2	69
May	91,810	1.5	1,377	3,422	4.2	144	0	?	?
Jun	42,768	9.9	4,234	432	3.8	16	72	48.2	35
Jul	20,088	24.0	4,821	74	3.8	3	0	?	?
Aug	670	8.3	56	0	?	?	0	?	?
Sep	20,952	2.5	524	7,704	10.3	794	1,440	57.0	821
Oct	81,989	17.3	14,184	78,194	20.4	15,952	14,136	60.9	8,609
Nov	7,704	43.5	3,351	80,280	12.7	10,196	4,896	38.9	1,905
Dec	1,042	33.1	345	126,554	5.1	6,424	818	36.1	295
Totals	321,455	14.7[a]	47,236[a]	304,940	13.1	39,786	21,506	54.6	11,734
Mortality		85%			87%			45%	
		Spottail shiner			***Emerald shiner***			***White perch***	
Apr	144	90.6	130	72	94.4	68	432	39.8	172
May	74	90.6	67	74	94.4	70	149	39.8	59
Jun	72	84.0	60	72	94.4	68	72	39.8	29
Jul	298	84.0	250	0	?	?	74	39.8	29
Aug	372	84.0	312	0	?	?	0	?	?
Sep	216	76.8	166	4,824	91.9	4,433	0	?	?
Oct	3,125	85.7	2,678	5,952	91.4	5,440	3,497	49.2	1,721
Nov	360	84.4	304	2,736	85.3	2,334	1,800	26.4	475
Dec	74	86.7	64	818	79.3	649	74	26.4	20
Totals	4,735	85.1	4,031	14,548	89.8	13,062	6,098	41.1	2,505
Mortality		15%			10%			59%	

[a] Correction (error on source table).

TABLE D-2.—*Monthly mortalities and injuries among entrapped fish during the 1981 study at Oswego Steam Unit 6. Values are calculated from Tables 3.0-3, 3.0-5, and 3.0-6 of Lawler, Matusky and Skelly (1982b); + indicates data were not given; empty cell indicates data were not collected.*

Month	Proportion diverted	Proportion live	96-h survival	Dead and injured
		Alewife		
Apr	0.983	+	0.343?	?
May	0.913	0.144	0.112	98.5%
Jun	0.762	0.332	0.324	91.8%
Jul	0.845	0.558	0.490	76.9%
Aug	0.421	0.558	0.414	92.6%
Sep	0.471	0.118	0.143	99.2%
Oct	0.804	0.631	0.332	83.2%
Nov	0.861	0.594	0.795	59.3%
Dec	0.955	0.446	0.600	74.4%
		White perch		
Apr		+	0.429?	?
May	0.927 (Apr–Jul)			?
Jun				?
Jul				?
Aug			0.762?	?
Sep			0.762?	?
Oct	0.889	0.661		55.2%
Nov	0.859 (Nov–Dec)	0.203 (Nov–Dec)	0.762 (Oct–Dec)	86.7%
Dec				86.7%
		Rainbow smelt		
Apr	0.963	+	0.781?	?
May	0.923		0.108	95.9%
Jun		0.416 (May–Aug)	0.108	96.2%
Jul	0.851 (Jun–Aug)			?
Aug				?
Sep	0.760	0.316	0.430 (Sep–Oct)	89.7%
Oct	0.731	0.610		80.8%
Nov	0.647	0.405	0.377	90.1%
Dec	0.753	0.312	0.136	96.8%

TABLE D-3.—*Marking study of fish released into the primary screenwell at Oswego Steam Unit 6. The data, from Lawler, Matusky and Skelly (1982b), are numbers of fish unless indicated otherwise.*

Measure	Yellow perch	White bass	White perch	Brown trout	Smallmouth bass	Rock bass + bluegill
Marked releases	56	64	23	47	60	29
Impinged, dead	7	7	4	0	1	1
Bypassed						
0–8 h						
Live	24	0	0	5	4	5
Dead	13	2	6	1	3	4
8–24 h						
Live	1	3	0	4	0	1
Dead	2	7	1	0	0	2
24–48 h						
Live	3	10	0	0	1	7
Dead	1	1	0	0	0	0
>48 h						
Live	0	8	0	6	10	0
Dead	0	0	2	0	0	0
Total recoveries						
Live	28	21	0	15	15	13
Dead (% of recoveries)	23 (45%)	17 (45%)	13 (100%)	1 (6%)	4 (21%)	7 (35%)
Nonrecoveries (% of releases)	5 (9%)	26 (41%)	10 (43%)	31 (66%)	41 (68%)	9 (31%)