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Turners Falls

Downstream Fish Passage Studies

Downstream Passage of Juvenile Clupeids, Fall 1992

April 1993

Prepared by
Harza Engineering Company
with
RMC Environmental
Services, Inc.

TURNERS FALLS
DOWNSTREAM FISH PASSAGE STUDIES

DOWNSTREAM PASSAGE OF JUVENILE CLUPEIDS, 1992

FINAL DRAFT

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Table of Contents

Table of Contents

List of Tables

List of Figures

Figure 15. Juvenile clupeid passage versus water temperature at Cabot Station, Fall 1992.

DOWNSTREAM PASSAGE OF JUVENILE CLUPEIDS, FALL 1992

SUMMARY

The Turners Falls Juvenile Clupeid Study during the fall of 1992 was designed to meet the following objectives:

- Determine the percentage of emigrating juvenile clupeids successfully bypassed through the trash trough and log sluice, and the percentage entrained through Cabot Station turbines.

- Estimate the number of juvenile clupeids passing downstream through the log sluice.

- Evaluate the passage of juvenile clupeids through trash trough opening 1B.

Percentage bypassed through the log sluice and trash trough was calculated from mean entrainment and bypass rates for each day of concurrent sampling (nearly simultaneous sampling of the log sluice, trash trough, and turbine units during the 1700 to 2100 hours time period). During the study, 88% of all juvenile clupeids approaching the Cabot Station facilities bypassed the station through the log sluice, either directly, or via the trash trough. This represents a 30% increase over the percentage of clupeids bypassed in 1991. By species, 87% of the American shad juveniles and 92% of the blueback herring juveniles bypassed the Cabot Station via the log sluice.

Neither route available during drawdowns

An estimated 1,654,000 clupeids bypassed the Cabot Station by moving through the log sluice and trash trough during the 46-day study period. The number of fish collected in the log sluice sampler during the standard sampling period from 1700 to 2100 hours was extrapolated to a 24-hour estimate using the hourly proportions

determined from eleven diel samples (continuous 24-hour samples of the log sluice only). Of the estimated 1,654,000 clupeids moving through the log sluice, an estimated 86 percent were American shad and 14 percent were blueback herring. During the 1992 study period, the daily peak movement occurred between 1100 and 1500 hours.

Passage into Access to the trash trough through Slot 1B increased the bypass efficiency of the log sluice by approximately 2.5 percent. It appears that, for clupeids, providing access to the trash trough does not significantly increase the effectiveness of the log sluice as a bypass facility.

During the field study, observations of the behavior of fish in the forebay near the entrance to the log sluice suggested the possibility that light may affect the propensity of the fish to enter the log sluice gate. As a consequence of these observations, a preliminary evaluation of the effect of mercury vapor lights, mounted on the log sluice gate superstructure, was conducted.

Preliminary experiments using mercury vapor light to enhance log sluice bypass rates were conducted at the end of the 1992 study. Based on field observations, use of the mercury vapor light appeared to increase the rate of clupeids bypassing through the log sluice. Although the results of these preliminary experiments were not quantified, further investigation of this enhancement is warranted.

INTRODUCTION

Background

A joint state and federal effort has been underway for more than 20 years to restore anadromous fishes, specifically American shad, (Alosa sapidissima), blueback herring (Alosa aestivalis), and Atlantic salmon (Salmo salar), to the Connecticut River (NUSCO 1987). Most of the effort prior to 1990 had been expended to provide upstream passage for these species at existing dams on the Connecticut River. At Northeast Utilities' Hadley Falls Project (FERC No. 2004), a fish lift has provided successful upstream passage around Holyoke Dam since 1955. To complement the Hadley Falls Fish Lift, three fish ladders, one at Cabot Station, one at Turners Falls Dam, and one at Turners Falls Gatehouse, were completed in 1980 to pass upstream migrating fish around the Turners Falls Project (FERC No. 1889). Attention is now focused on the downstream passage of anadromous fishes at hydroelectric facilities on the river.

In 1990, Northeast Utilities Service Company (NUSCO), in a Memorandum of Agreement (MOA) with the U.S. Fish and Wildlife Service and the Connecticut River Atlantic Salmon Commission, agreed to construct downstream fish passage facilities at the Turners Falls Project (NUSCO et al. 1990).

In the Connecticut River, anadromous clupeids (American shad and blueback herring) spawn from early May through mid-June; the specific spawning time is dependent on water temperature. The juveniles remain in the river throughout the summer and usually begin their downstream migration in September. Water temperature is thought to be one of the primary environmental parameters determining the commencement of emigration (O'Leary 1984; O'Leary and Kynard 1986). Emigration begins when water temperature declines to about 19 °C, usually by mid-September, and continues into early November. Marcy (1976) noted that most juveniles had left the river prior to water temperature declining to 6 °C.

During the emigration period, juvenile clupeids in the Connecticut River generally move downstream in late afternoon and evening, with peak numbers moving between 17:00 hours and 22:00 hours (O'Leary and Kynard 1986; Harza and RMC 1992a). Juvenile clupeids appear to migrate in schools (O'Leary and Kynard 1986).

Study Site

The Turners Falls Project generation facilities were built between 1905 and 1915. Project features consist of Turners Falls Dam, a canal gatehouse structure, a 2.1- mile long canal, Turners Falls No. 1 Station and Cabot Station (Figure 1). The Dam is located at River Mile 117 on the Connecticut River, Massachusetts.

Turners Falls Dam consists of the Montague Spillway and Gill Dam. The Montague Spillway has four 120-ft long by 13.5-ft high Bascule gates for pond elevation control. The Gill Dam includes a non-overflow section and three tainter gates. Water is typically either stored or spilled over the dam when river flows exceed approximately 15,000 cfs, the combined hydraulic capacity of Turners Falls Station No. 1 and Cabot Station. The canal gatehouse structure, situated on the east side of the river, is capable of directing up to approximately 15,000 cfs into the power canal.

Turners Falls No. 1 Station is located approximately 0.5 miles downstream from the gatehouse, on a Branch Canal (Figure 1). The station houses five Francis turbines each directly connected to generators with a total nameplate rating of 5.6 MW at a head of 43 feet. The total hydraulic capacity of the units at Turners Falls No. 1 Station is 2,500 cfs. Under normal circumstances, the station is operated only when the daily river flows exceed 12,500 cfs.

Cabot Station, an integral-intake powerhouse, is located at the downstream end of the power canal. The station has six Francis turbines, each directly connected to generators with a total nameplate rating of 51 MW at a nominal head of 60 feet. Water is delivered to each of the turbines through three-bay intakes joined to the respective penstocks. The total hydraulic capacity of the station is 12,500 cfs.

A log sluice adjacent to Cabot Station is used as an alternate route for downstream-migrating fish during emigration periods, as requested by the resource agencies. During downstream migrations the log sluice gate is lowered 2.0 - 2.5 feet below the forebay water surface to produce a discharge of 150 to 220 cfs. A bulkhead insert was designed to enhance the number of fish using the log sluice. It was constructed to narrow and deepen the gate opening while maintaining the same discharge capacity. The insert fits in the stoplog slots of the log sluice, and has a 4-ft deep by 11-ft wide opening. The effect of the bulkhead insert on enhancing the use of the log sluice by downstream migrating fish was initially tested in the spring of 1992 (Harza and RMC 1992b).

An ice and trash trough, behind the top of the Cabot Station trashracks, is aligned perpendicular to the flow of water and discharges into the log sluice. In 1991, three openings were cut into the wall of the ice and trash trough to provide an alternative route for downstream movement of fish past Cabot Station (Figure 2). The maximum flow through any one opening is 123 cfs. If more than one slot is open at the same time, the flow through each slot is correspondingly less than 123 cfs. Each opening can be configured in two ways: 1) 2.8 feet wide and 6 feet deep; or, 2) 2.8 feet wide and 3 feet deep.

Outmigrating juvenile clupeids reared in the Connecticut River normally enter the canal unless sufficiently high flows require use of the Montague Spillway. Having entered the canal, the juveniles must move through the log sluice (either directly, through the log sluice gate, or indirectly, via one or more of the trash trough slots, if open), or through the turbines in Cabot Station. These routes are illustrated in Figures 1 and 3. The wasteway and Turners Falls No. 1 Station normally remain closed, unless there is sufficient flow in the river. If open, these too become alternative migration routes.

Prior Studies at Turners Falls

A pre-feasibility level study (Ruggles 1990) presented evaluations of various techniques that have been used successfully to divert emigrating fish around turbine intakes at other sites. A surface discharge was identified as one of the more effective techniques for diverting fish around hydro facilities and appeared to be suitable for use at Cabot Station. At the request of the Connecticut River Atlantic Salmon Commission, the log sluice had been used to pass fish in previous years. Juvenile clupeids passed through the log sluice, although the number that did so was unknown. Based on the Ruggles (1990) review, the three trash trough openings, described above, were cut into the wall of the ice and trash sluice during the summer of 1991 to provide an additional route for use by emigrating fish.

During fall 1991 (Harza and RMC 1992), the effectiveness of the log sluice and the trash trough openings as bypass routes was evaluated. The proportions of emigrating juvenile clupeids bypassed around and entrained through Cabot Station were estimated with concurrent log sluice and turbine intake samples. An inclined-plane screen and sampling facility were installed in the log sluice to sample fish bypassing through either the log sluice or trash trough. Fyke nets covering the middle intake bay of turbine units 1,4, and 6 sampled entrained fish. Based on concurrent sampling, an estimated 58% of all clupeids bypassed Cabot Station through the log sluice. The proportions of blueback herring and American shad bypassing Cabot Station was estimated to be 65% and 54%, respectively.

During the last week of the 1991 Juvenile Clupeid Study, the openings in the trash trough wall were evaluated as an additional bypass route. Although fish were observed entering the trash trough, the openings did not significantly change the overall proportion of fish using the bypass.

To evaluate the log sluice and trash trough opening as bypass routes for Atlantic salmon smolts, radiotelemetry was used during spring of 1992 to determine the relative proportions of hatchery-reared Atlantic salmon smolts using these routes to bypass Cabot Station (Harza and RMC 1992b). Two log sluice configurations were tested to determine the optimum combination of trash trough opening(s) and log sluice configuration for bypassing Atlantic salmon smolts. Smolts appeared to used the trash trough as the principle route of passage. The optimum configuration to bypass smolts was the log sluice supplemented by trash trough opening 1B (the opening above the middle intake bay of Unit #1). Altering the configuration of the log sluice entrance did not change the proportions of emigrating fish using this bypass route.

In the 1991 Juvenile Clupeid Study (Harza and RMC 1992), fish which bypassed during periods of high rates of passage experienced high mortality in the preliminary log sluice sampler. Subsequent laboratory tests, performed on a 1:7 scale hydraulic model of the preliminary sampler, indicated very turbulent flow conditions near the sampler's upstream end. This turbulence may have been the cause of the mortality. A new log sluice sampler was designed to reduce the turbulence. A hydraulic model study of the new sampling device was conducted by Alden Research Laboratories, Inc. (Nguyen and Hecker 1992). A prototype of the device was constructed for use during the current study.

Current Study

The focus of the 1992 juvenile clupeid study was to evaluate the effectiveness of the log sluice and the log sluice plus trash trough opening 1B in bypassing juvenile clupeids. Specific objectives of the 1992 juvenile clupeid study were:

- Determine the percentage of emigrating juvenile clupeids successfully bypassed through the trash trough and log sluice, and the percentage entrained through Cabot Station turbines.

- Estimate the number of juvenile clupeids passing downstream through the log sluice.

- Evaluate the passage of juvenile clupeids through the trash trough.

Prompted by observations made during the study, a preliminary investigation into the use of mercury vapor lighting to attract juvenile clupeids to the log sluice bypass was conducted. The objective of these investigations was to determine if further investigation would be warranted.

The Plan of Study and relevant correspondence is presented in Attachment 1.

METHODS

Study Design

To determine the relative percentages of juvenile clupeids bypassed and entrained, estimates of the numbers of fish passing into the log sluice, trash trough, and through the turbine intakes were compared. The estimate of the number of fish passing through the log sluice was obtained from a log sluice sampling device designed to collect all fish entering through the log sluice gate (described below) and was integrated with a sluice gate bulkhead which modified the gate opening to the log sluice. Estimates of the numbers of fish entering the log sluice via the trash trough (described below) were obtained from an inclined screen sampling device installed at the downstream end of the trash trough. The number of fish entrained through the turbine intakes was estimated from the numbers of fish collected in fyke nets installed in the middle intake bays of Units 1, 4, and 6 of Cabot Station.

In 1991, analysis of the percent bypassed was complicated by lack of coordination between the log sluice and entrainment sampling efforts because the sampling times did not coincide. For the 1991 study, "concurrent sampling" simply meant that the log sluice and entrainment samples were collected within the 1700-2200 time block but the collections were not necessarily coincident. This lack of coincidence became a problem because the juvenile clupeids tend to emigrate from the forebay in schools at irregular intervals. Thus, if a large school of juveniles entered the log sluice but a proportion of that school was entrained at a time when the entrainment nets were not deployed, the bypass efficiency would be overestimated. Conversely, if entrainment sampling occurred when no log sluice samples were taken, bypass efficiency would be underestimated. To avoid this complication and because of logistical requirements for deploying the intake bay nets, an attempt was made to acquire "concurrent collections" from the log sluice sampler and the entrainment nets. According to the plan of study, collections are considered to have occurred "concurrently" if the sampling time periods for different sampling devices overlapped at least 50 percent of the time. In the field, counts of the fish collected from the log sluice and trash trough were timed to begin when the fyke nets were deployed and to end when the nets were recovered. This was achieved by beginning the log sluice/trash trough counts either when the second pair of fyke nets was set (when 2 or 3 pairs of nets were deployed) or, when only one pair of fyke nets was deployed, at the time the nets were deployed. To the extent possible, the fyke nets were deployed for up to one hour, allowing some time for recovery and redeployment.

Concurrent sampling was conducted daily for approximately one-hour periods from 17:00 hours to 21:00 hours during the peak emigration time period (Harza and RMC 1992a; O'Leary and Kynard 1986). This yielded up to four "concurrent collections" each day. Estimates of the percentage of juvenile clupeids bypassed and entrained for individual were calculated from these concurrent collections for each sampling day. A combined estimate for the entire study period was obtained from the hourly and daily estimates.

To estimate the total number of juvenile clupeids bypassing Cabot Station through the log sluice during the study period, the numbers of fish passing through the log sluice were extrapolated to the entire day based on the proportions of fish exiting the forebay during each hour of the day. This diel pattern of fish movement through the log sluice was obtained one to two times per week throughout the study period. Diel log sluice sampling began at 2100 hours, at the conclusion of daily concurrent sampling, and continued around the clock until next day's standard sampling period beginning at 17:00 hours. The daily number of juvenile clupeids bypassing the turbines on days between the diel sampling was estimated by dividing the numbers collected during the standard sampling period (1700 to 2100 hours) by the proportion of the number passing during the 1700 to 2100 derived from the diel samples. The daily estimates were then summed to obtain the estimate of the total number of juvenile clupeids bypassed through the log sluice on sampled days during the study (September 16 - November 1). The number of clupeids bypassed on days no sampling occurred was estimated by linear interpolation between the preceding and succeeding sampling days. The daily estimated numbers of fish bypassed on sampled and unsampled days were then summed to obtain an estimate of the total number bypassed during the study.

To evaluate the incremental benefit of access to the trash trough via the Slot 1B, access to the trash trough by the juvenile clupeids was provided on alternating days throughout the study. The daily proportions bypassed when the slot to the trash trough was open was compared with the daily proportions bypassed when the slot was closed.

Description of Sampling Devices

Log sluice sampler. The newly constructed log sluice sampling device consisted of a 27.5-foot long stainless steel profile-bar screen that diverts fish into a flume while shedding the majority of the water flowing onto the screen (Figure 7). The sampler was positioned directly behind and downstream of the log sluice gate.

At the mouth of the sampler, the screen was 11 ft. wide, narrowing to 6.4 ft. at the opposite end. The screen consisted of 0.093-inch wide bars, spaced 0.040 inches apart, which provided a clear open area that was 30% of the total screen area. The sampler was framed in steel with 4.5-foot high wooden side-walls.

In the sampling mode, the screen was in a horizontal position, and was designed to be used in conjunction with a log sluice bulkhead insert (Harza and RMC 1992b), through which water spills onto the sampler screen from a narrow (11 ft. wide), deep (4 ft. deep) gate opening. The downstream end of the screen was attached to a fixed pivot point so that the screen and bulkhead could be lifted, allowing clear passage of water under the sampling device during non-sampling periods.

In the sampling mode, water and fish diverted by the screen flowed through a 31-foot long, 1-foot wide flume, onto a sorting table. The flume had an initial depth of 3.0 ft., tapering to 3.75 ft. at the downstream end, and terminating with an inclined section of profile bar screen. The inclined screen diverted fish up onto the sorting table while allowing a portion of the water to flow through to a release valve. The remaining water flowed across the sorting table and drained back into the log sluice through a 12-inch diameter PVC pipe. The sorting table was equipped with a divider, installed length-wise, and gates installed at the point where water flowed onto the table (Figure 7). The gates allowed fish to be diverted to a specific side of the divided table. Removable screens at the end of the table retained fish on the table while water flowed into the drain pipe.

At the beginning of each collection, a crowder (constructed of two wooden brails and a piece of window screen) was used to force fish that had accumulated in the flume during the period between concurrent collections onto the sorting table, then down the drain, so they would not be included in the upcoming collection. At the end of a collection, the crowder was used to force fish holding in the flume onto the sorting table so they could be included in the collection. A subsample of up to 100 fish from each collection period was retained for determining species composition and length distribution. The species of each fish was determined on the basis of peritoneum coloration.

Whenever possible, the total number of fish collected during a "concurrent collection" period or intervening period was determined. However, when the number of fish collected by the sampler was very large, precluding counting individual fish passing during the one-hour sampling period, the numbers of fish collected were estimated from timed subsamples of fish. The crowder, described earlier, was used to force fish from the flume at the beginning and end of each subsample period. This subsampling was required for 26 of the 118 concurrent collections, and 15 of the 220 hourly increments during the diel collections.

When subsampling was required, at least two subsamples were obtained during a high passage rate collection period. The number bypassed during the collection was then estimated using the following equation:

$$n_{LS} = n_{LS,t} * \frac{t_{sp}}{t_{ssp}} \qquad (1)$$

where: n_{LS} is the estimated number captured during the collection; $n_{LS,t}$ is the number of fish collected in the timed subsamples; t_{sp} sample period; and t_{ssp} is the duration of the subsampled period.

Trash trough sampler. Although access to the trash trough was possible during the 1991 Juvenile Clupeid Study, distinction between the numbers of fish entering the log sluice directly or via the trash trough could not be determined. Prior to the start of the 1992 study, a new trash trough sampling device was constructed that separated the fish entering the log sluice via the trash trough from the fish entering the log sluice directly. The trash trough sampling device consisted of an 11.50-foot long by 1.95-foot wide stainless steel profile-bar screen installed at the downstream end of the trash trough where it spills into the log sluice. The screen consisted of 0.093-inch wide bars, spaced 0.125 inches apart, which provided a clear open area that was 57% of the total screen area (Figure 7). In the sampling mode, the screen was inclined 20° from horizontal. Fish bypassing via the trash trough were diverted by the screen into a 12-inch diameter pipe that conveyed water and fish onto a separate sorting table.

Estimates of the numbers of juvenile clupeids passing through the trash trough during each collection period were made in the same manner described above for the log sluice sampler.

<u>Turbine intake fyke nets</u>. To determine the number of fish entrained through Cabot Station, frames, each with two fyke nets attached (Figure 4), were installed in the gatewells of the middle intake bays of Units 1, 4 and 6 (Bay nos. 2, 11, and 17). The frame with attached nets was identical to the equipment used for the 1991 juvenile clupeid study (Harza and RMC 1992).

All of the nets were 8.1 feet wide, 6.8 feet deep, 26 feet long, and were constructed of 1.5-inch stretch mesh nylon netting. The posterior 10 feet of the net contained a fyke and a 1/2-inch stretch mesh inner liner. Two fyke nets were attached to each tubular steel frame that held the nets in fishing position in the respective intake bay. In addition to the two fyke nets, two closure net panels, 3.3 feet long by 2.3 feet deep, constructed of 1/4-inch ace mesh, were attached to the top of the main net frame (Figure 5). These nets reduced the size of the opening between the top of the net frame and the gatewell (Figure 6).

Procedures for deploying the nets were identical to those used in the fall 1991 study (Harza and RMC 1992). Steel frame guides, bolted into the concrete of the intake bays just upstream of the stop log slots, were used to guide and hold the net frames in the fishing position. The frames were raised and lowered using the jib hoist on the headworks travelling crane. Because the nets were occasionally ripped while being raised or lowered, each net was inspected for tears and mended, if necessary, prior to each deployment. The recovery and redeployment of the net frame required between five and ten minutes to complete.

The length of time each fyke net was deployed varied primarily because of the amount of debris that accumulated in the nets. Typically, the nets were deployed for 30 to 60 minutes. The number of deployments occurring on a given day was dependent on the amount of debris loading and the required time to pull, empty, and redeploy the nets. As many hourly samples as possible were collected each day during the daily 1700 to 2100 sampling period.

At the end of each collection period, the net frames were lifted and all fish and debris accumulated in the upper and lower nets were removed from the net. Fish that were caught in the small closure nets at the top of the net frames were arbitrarily included in the number of fish collected in the upper of the two nets attached to the net frame. All fish collected in the fyke nets were counted and the species composition and lengths were determined for up to 100 randomly selected juvenile clupeids.

Estimation of the Proportion Bypassed

On 118 occasions, from September 16 through November 1, collections were made concurrently in the log sluice and trash trough sampler (if open), and the fyke net assemblies. Estimates of the percentage of clupeids bypassing Cabot Station via the log sluice and trash trough were based on the concurrent collections made each day and throughout the entire study period using Eq. 1. For all clupeids, and for each species individually, the percentage bypassed during each day of sampling was computed directly from the entrainment and bypass estimates for the daily concurrent collections. The relative numbers of juvenile clupeids using the log sluice or trash trough as a route through the Cabot Station facilities was estimated using the basic equation:

$$P_{LS} = \frac{N_{LS} + N_{TT}}{N_{LS} + N_{TT} + N_E} * 100 \qquad (2)$$

where P_{LS} is the percentage of the juvenile clupeids bypassed; N_{LS} is the number of fish collected in the log sluice sampler, corrected for gear efficiency; N_{TT} is the number of fish leaving the forebay via the trash trough; and N_E is the number of fish entrained, corrected for gear retention and area of the intakes.

The numbers of fish passing through the log sluice and trash trough and the numbers of fish entrained were calculated from the numbers of fish collected in each of the sampling gears during the concurrent samples. To estimate the numbers of juvenile clupeids passing through the log sluice (N_{LS}) or the trash trough (N_{TT}), and the numbers entrained (N_E) from the actual numbers collected in the respective samplers, it was necessary to correct the respective collections for duration of the sample period, gear efficiency, and sampled area as follows:

$$N_{R,d,s} = n_{R,d,s} * \frac{60}{t_s} * \frac{1}{e_R} * \frac{1}{a_{R,s}} \qquad (3)$$

where: R is the route of emigration, LS, TT or E, from Eq. 1; $N_{R,d,s}$ is the corrected number of fish passing through each route during each concurrent sample (s) on each day (d); $n_{R,d,s}$ is the actual number of fish collected during a concurrent sample; t_s is duration of the concurrent sample, in minutes; e_R is the gear efficiency; and a_s is the proportion of the route area that was sampled (for the log sluice and trash trough samplers, $a_s = 1.0$).

Correction for Sample Duration. For the logistical reasons described above, the durations of the concurrent samples varied from sample to sample. To standardized the time duration of each sample, the numbers of fish collected at each location were corrected to standardize the time represented by each sample. As indicated in Eq. 3, the correction was made as $60/t_s$, where t_s is the actual duration, in minutes, of each concurrent sample.

Correction for gear efficiency. Estimates of the gear efficiencies (e_r in Eq. 3) for the log sluice (e_{LS}) and trash trough (e_{TT}) samplers were obtained by introducing a known number of marked juvenile clupeids onto the log sluice sampler or into the trash trough and counting the numbers of marked fish recaptured at the respective sorting tables. The respective gear efficiencies were then calculated as the proportion of the number of fish introduced that were recaptured by the gear. Estimates of gear efficiencies were tested three to five times during the study period. Specific methods used to conduct the tests and the analytical procedures used to determine the efficiencies are described in Appendix 1.

Estimates of the gear efficiency of the fyke net assemblies, for estimating entrainment, could not be determined directly. Rather, the fyke net gear efficiency (e_E) was determined as the retention of marked fish by the nets and were obtained by introducing known numbers of marked fish directly into the mouth of the respective nets while the nets were deployed. Separate efficiencies were determined for each of the 6 nets comprising the three assemblies. As with the log sluice and trash trough samplers, the retention efficiencies of each net were calculated as the proportion of the number of marked fish released that were retained by the respective nets. Details of the fyke net retention efficiency tests are presented in Appendix 1.

Correction for area sampled. Correction of the numbers collected in each gear were also corrected for the area sampled. For the log sluice and trash trough samplers, the samplers were designed to collected all fish entering the respective routes and a_s from Eq. 3 for these two routes was set at 1.0.

To correct the numbers of fish collected in the fyke net assemblies ($n_{E,d,s}$) for the area of the operating intake area, the numbers of fish collected in the active net assemblies (sum of top and bottom nets of each assembly) were corrected by the proportion of the active intake area actually sampled. The "active intake area" refers to the area of the intakes associated with the turbine generator units that were operating during the concurrent sampling period. Each of the six Units in Cabot Station is equipped with an intake comprised of three bays (a total of 18 bays). The openings of all of the bays are the same size.

Because only three of the intake bays were equipped with the fyke net assemblies, the relative area sampled by each assembly was calculated as the number of bays sampled divided by the number of bays associated with the operating units. In general, it was assumed that the numbers of fish passing through the sampled bays was the same as the number of fish passing through the 2 unsampled bays. Summarizing the calculations to estimate $N_{E,d,s}$ for the number of fish entrained during a concurrent sample (s) on a given sampling date (d):

$$N_{E,d,s} = \frac{a_o}{a_s} * \sum_{i=1,\ 4,\ and\ 6} [(n_{i,u} * e_{i,u})+(n_{i,l} * e_{i,l}) * \frac{60}{t_{s,i}}] \qquad (4)$$

where: a_o is the number of bays associated with active turbine/generator units (= 3 * number of operating units); a_s is the number of bays sampled; $n_{i,u}$ and $n_{i,l}$ are the numbers of fish collected in the upper (u) and lower (l) nets of the net assembly in each sampled intake bay (i); and $e_{i,u}$ and $e_{i,l}$ are the respective retention efficiencies. The other terms are as defined for Eq. 2. When the unit associated with one of the net assemblies was not in operation, t_s and n_i was equal to zero. The total number of fish entrained during the concurrent sampling (N_E), then, is calculated as:

$$N_E = \sum_{d=1}^{40} \sum_{s=1}^{4} N_{E,d,s} \qquad (5)$$

Estimation of the number bypassed through the log sluice

The total number of juvenile clupeids bypassing Cabot Station via the log sluice during the study was estimated from the numbers of fish collected in the log sluice sampler during the four-hour concurrent sampling period and the results of eleven 24-hour samples collected periodically throughout the study period. The basic calculation to estimate the total number bypassed each day was:

where $N_{24\text{-}hr}$ is estimated 24-hour bypass total for a given day, N_{conc} is the total number bypassing during the 17:00 to 21:00 period for that day, and P_{conc} is the proportion of the 24-hour samples that

$$N_{24\text{-}HR} = \frac{N_{conc}}{P_{conc}} \qquad (6)$$

bypassed through the log sluice during the 17:00 to 21:00 period. The calculation of the total number bypassed included both the numbers of fish obtained during the concurrent sampling and the numbers of fish collected in the log sluice sampler between concurrent samples (intermediate counts) within the 1700 to 2100 daily sampling period.

For each day of concurrent sampling, the estimated number of clupeids bypassing through the log sluice during the intermediate periods were added to the estimated numbers bypassing during the concurrent samples to give the total number of clupeids bypassed during the four-hour concurrent sampling period. To obtain the relative proportion of the daily emigration represented by the normal sampling period (P_{conc}), eleven diel samples were obtained which yielded estimates of the numbers and proportions of fish using the log sluice during each hour of the day. From the eleven diel samples the proportion of the daily number of fish bypassing between 1700 and 2100 hours and the numbers bypassing between 2100 and 1700 hours were determined.

The total 24-hour passage of American shad and blueback herring for a sampling day was estimated by taking the diel sample of closest proximity, and applying the proportion of herring and shad from that diel sample to the 24-hour estimate for the sampling day. Total 24-hour passage of shad, herring, and all clupeids combined for the forty sampled days were summed to give estimated total number of shad, herring, and clupeids bypassing through the log sluice on days sampled during the September 16 to November 1 study period. The total number bypassed on unsampled days (a total of three days) was estimated by linear interpolation using the total bypass estimate of the sampled day immediately preceding and following the unsampled day. Total number bypassed on days in which mercury vapor light experiments occurred (a total of three days) were estimated by summing the observed number bypassed between 1700 and 2100 hours with the linearly interpolated number bypassed between 2100 and 1700 hours.

The estimates of number bypassed on sampled, unsampled, and experimental days were then summed giving an estimated number bypassed through the log sluice for the forty-six day study period.

Evaluation of the effect of trash trough on proportion bypassed

Based on results of tests performed in the spring of 1992 on Atlantic salmon smolts (Harza and RMC 1992b), trash trough slot 1B was selected as the slot to be used in the Fall 1992 Juvenile Clupeid Study. In order to test the effect of trash trough slot 1B on the proportion of juvenile clupeids bypassing, trash trough slot 1B and the trash trough sampler were operated on an every-other-sampling-day basis. The proportions of juvenile clupeids bypassing on days with the trash trough open were then compared to the proportions bypassing on days in which only the log sluice was open. Calculations of the proportions bypassed on each day were made using Equation 2.

Other Data Collected

Physical parameters recorded or measured during collection periods included: Cabot Station generation status, canal flow, and water temperature. Non-alosid species of fish captured during sampling was recorded.

The wasteway at Cabot Station (Figure 3) remained closed and unavailable for fish passage for the entire study. Turners Falls No. 1 Station was operating and available for fish bypass on the following occasions: September 30 from 07:51 until 12:36, October 1 from 07:58 until 10:46, and October 21 from 19:07 until 08:15 of the following day. A trash boom, extending across the mouth of the branch canal leading to Turner Falls Station No. 1, was in place during the study.

RESULTS

Proportion of Emigrating Juvenile Clupeids Bypassed

Analysis of the results of the concurrent sampling of the log sluice, trash trough, and turbine units indicated that 88% of the juvenile clupeids emigrating through the Cabot Station facilities bypassed the turbine units through the log sluice, either directly or via the trash trough (Table 1). The estimate of the proportion bypassed was derived from Equation 2 as:

$$P_B = \frac{N_{LS} + N_{TT}}{N_{LS} + N_{TT} + N_E} = \frac{189{,}490 + 8{,}017}{189{,}490 + 8{,}017 + 27{,}748} * 100 = 87.7\% \qquad (7)$$

With respect to the individual species, 88% of the American shad juveniles and 93% of the blueback herring juveniles bypassed Cabot Station through either the log sluice or the trash trough (Tables 2 and 3).

Estimated number through log sluice (N_{LS}), concurrent samples. An estimated 189,490 juvenile clupeids (N_{LS}) moved directly into the log sluice during the concurrent sampling periods on 40 days of sampling. The estimated numbers of clupeids entering the log sluice on each day of concurrent sampling are presented in Table 1, with the hourly estimates of fish entering the log sluice presented in Table 4. The raw numbers of fish collected during each concurrent sampling period are presented in Appendix 3, Table 1, together with the relative numbers of herring and shad in each sample. Appendix 3, Table 2 presents the numbers collected during each concurrent sampling period, normalized to one hour samples.

Prior to summing the numbers of fish using the log sluice to obtain a daily total, the hourly estimates were corrected for gear efficiency based on three tests of gear efficiency conducted during the course of the study. Results of the efficiency tests are presented in Appendix 2. Because the estimated efficiencies varied significantly among the three tests (P = 0.016), the hourly log sluice samples were corrected based on the dates sampled using the appropriate gear efficiencies. The log sluice sampler efficiencies and the applicable dates are summarized in Table 5. The estimated numbers of fish entering the log sluice on each date of the study, together with the total number and average hourly rate, are presented in Table 4. The numbers of fish entering the log sluice on each date are summarized in Table 1, with the estimated numbers of shad and herring presented in Tables 2 and 3, respectively. The relative numbers of shad and herring were determined from the species composition of subsamples of each concurrent sample as presented in Appendix 3.

Estimated number through trash trough (N_{TT}). A major objective of the 1992 Turners Falls Juvenile Clupeid Study was to investigate the contribution of the trash trough to the overall proportion of fish using a bypass route. An estimated 8,017 juveniles entered the log sluice via Slot 1b in the trash trough during the concurrent sampling on 20 days when the slot was open. The numbers of clupeids captured during the concurrent sampling periods and the numbers of herring and shad (based on the species composition of subsamples) are presented in Appendix 4, Table 1. Estimates corrected for sample duration are presented in Appendix 4, Table 2. Hourly estimates, corrected for gear efficiency, are presented in Table 6. The collection efficiency of the trash trough sampler was tested five times during the course of the study. Results of these tests are presented in Appendix 2. As described in Appendix 2, no significant differences was observed among the results of the efficiency tests (N = 15, F = 1.762, P = 0.213). The group means of the five different dates on which the trash trough sampler efficiency was tested were 23.7%, 18.3%, 19.0%, 11.7% and 18.0%, with the pooled efficiency for the five tests being 18.1%. The finding of no significant difference of trash trough efficiency among test dates allowed all trash trough catch rates to be adjusted using the pooled trash trough efficiency.

Estimated number entrained (N_E), concurrent samples. An estimated 27,748 fish were entrained (N_E) during the concurrent sampling periods on 40 days of the study. This estimate was derived from 118 concurrent samples using Equation 2 to estimated the number of fish entrained during each concurrent sample period. A summary of the total estimated number of clupeids entrained on each day is presented in Table 1. The estimated numbers of fish entrained during each concurrent sample are presented in Table 7, together with the mean hourly entrainment rates. These estimates were derived from the numbers of fish collected in three pairs of fyke nets installed in the middle intake bays of Units 1, 4, and 6 of Cabot Station. The raw numbers of fish collected ($n_{E,i}$) in each fyke net and the durations of each concurrent sample are presented in Appendix 5, Table 1. Appendix 5, Table 2 presents the numbers of fish collected in each net normalized to one hour samples ($n_{E,f} * 60/t_h$, from Equation 4). The appendix also includes the numbers of shad and herring in each sample derived from the relative proportion of each species in the fyke nets.

To correct for net retention efficiency ($e_{g,i}$ from Equation 5), the hourly numbers of fish collected in the nets were corrected using the appropriate net retention efficiencies presented in Table 5 (results of net retention tests are presented in Appendix 2, Table 1). Based on Tukey's HSD test, the retention efficiencies determined from the first test period were significantly lower than the those obtained for the second (P = 0.018) and third periods (P

= 0.005). (See Appendix 2 for details of the statistical analysis.) Consequently, the results of the retention efficiency tests for the first test could not be pooled with those of the second and third tests. The dates for which the respective net retention efficiencies were used are included in Table 5.

The estimated number of fish entrained through the areas sampled by the respective top and bottom nets of each fyke net assembly was then summed to obtain a total number entrained through the sampled intake bay. These numbers were then used on a sampled area basis to estimate the total number of fish entrained during each concurrent sample. Because various combinations of turbine/generator units were operated during the sampling period, the intake area sampled (a_s from Equation 4) relative to the intake area through which fish could be entrained (a_o) varied daily and, on some occasions, hourly. Therefore, the estimated numbers of fish entrained in all active intake bays for each concurrent sample was calculated on the basis of the proportion of the total area of the active intake bays which was sampled.

Horizontal Distribution. The horizontal distribution of the entrained fish was determined for 14 combinations of operating turbine units encountered during the study. Average numbers of fish collected in each net under each of the 14 operational combinations are presented in Table 8. These numbers were then used to estimate the number of fish entrained through each operating bay by linear extrapolation or interpolation (as appropriate). Table 9 presents the estimate of the average numbers of fish entrained through each intake bay for each of the 14 operational combinations and are depicted graphically in Figures 8, 9, and 10. For combinations in which at least two units were sampled, estimated entrainment was highest at Units 1 and 6, and decreased in the middle of the station. The exceptions to this situation occurred when Units 1,2,3,4 and 5 were operated, during which estimated entrainment increased from Unit 1 to Unit 5, and when Units 1,4, and 6 were operated, during which entrainment decreased from Unit 1 to Unit 6. The most common combination of operating units occurring during the study was when all six units were in operation (31 collections). The second most common operating condition was when only Unit 1 was operated (19 collections). Collections were obtained when Units 1,4, and 6 were operating on 15 occasions.

Estimate of Total Number Bypassed (N_B)

An estimated 1,654,000 juvenile clupeids bypassed Cabot Station through the log sluice during the 1992 sampling period (September 16 through November 1). Estimates of the numbers of fish passing through the log sluice each day are presented in Table 10. These estimates were derived from the concurrent samples, the intermediate sampling periods (between concurrent samples) and the diel pattern of fish passage. The numbers of fish collected at the log sluice sampler during the intermediate periods between concurrent samples are included in Appendix 3, Table 1. The numbers of fish collected each hour of the eleven 24-hour diel samples are presented in Appendix 6, Table 1.

<u>Diel pattern</u>. After correcting for duration and sampler efficiency, an average number of fish bypassed during each hour of the day (excluding statistical outliers, Appendix 6, Table 2) was used to estimate the proportion of the daily passage occurring during the four hour period when concurrent samples were collected. The raw and corrected numbers (corrected for gear efficiency and time) of juvenile clupeids captured during the eleven diel sampling periods are given in Appendix 6-Table 1. Also presented in the appendix are the numbers of blueback herring and American shad in

the subsamples from each collection. The average hourly log sluice passage rates for the diel samples are listed in Table 11, and depicted graphically in Figure 11, with the relative numbers of fish collected during each hour of the eleven diel samples shown in Figures 12 and 13. As indicated in Figure 11, 20.5 percent of the juvenile clupeids emigrating each day, moved through the log sluice between 1700 and 2100 hours. It is also noted that, based on the results presented in Figure 11, the peak period during the day for movement of juveniles through the log sluice occurred from 1100 to 1500 hours, when approximately 39 percent of the juveniles moved through the log sluice.

Effect of Trash Trough Slot 1b Opening

The opening of Slot 1b to allow the juvenile clupeids access to the trash trough overall increased the overall proportion of fish bypassed by approximately 2.5%. However, this increase was not statistically significant. On days when Slot 1b was closed, the bypass efficiency, as determined from the concurrent samples, was estimated to be 87% (derived from Table 1). When the trash trough was open, approximately 90% of all fish were bypassed. The difference in the bypass efficiencies between days when Slot 1b was closed versus the bypass efficiencies when it was closed was not significant (ANOVA, $N = 40$, $F = 0.174$, $P = 0.679$) (Figure 14).

Additional Results

The catch of non-alosid species during the study is summarized in Table 12. White perch (Morone americana) and American eel (Anguilla rostrata) were the two most common non-alosid species captured. Two Atlantic salmon (one adult and one juvenile) were captured during the study. Both individuals were collected while bypassing through the log sluice.

Power generation and canal flow during individual collections, as well as average daily water temperatures, are contained in Appendix 7. Peak movements of clupeids occurred at water temperatures of 17°-18° (Sept. 25-28), 14° (Oct. 9), and 12° (Oct. 19). Mean daily water temperatures and clupeid passage rates are displayed graphically in Figure 15.

As in the 1991 study (Harza and RMC 1992), power generation did not significantly affect the proportion of fish bypassed at Cabot Station (ANOVA, $N = 53$, $F = 0.329$, $P = 0.569$). The large number of combinations in which turbines were operated during this study precluded any statistical tests of whether specific turbines or operational modes affected the bypass proportions.

The observed responses of juvenile clupeids, schooling in the Cabot Station forebay to forebay light changes prompted a preliminary investigation into the use of mercury vapor light to enhance log sluice bypass rates. This investigation was conducted at the end of the 1992 Juvenile Clupeid Study. The use of mercury vapor lighting appeared to increase the proportion of clupeids bypassing via the log sluice. The methods, results, and discussion of the mercury vapor light investigations are contained in Appendix 8.

DISCUSSION

An estimated total of 1,654,000 juvenile clupeids emigrated from the Turners Falls Canal through the log sluice, thereby, bypassing Cabot Station. This represents approximately 88% of the total number of juveniles leaving the upper Connecticut River basin through the Turners Falls Canal. The provision of access to the log sluice via Slot 1b into the trash trough resulted in a 2.5 percent increase in the proportion of fish using the log sluice over the proportion of fish using the log sluice when access to the trash trough was denied. Whereas a significant portion of the emigrating Atlantic salmon smolts utilized the access to the trash trough during the Spring 1992, the juvenile clupeids did not use this route in significant numbers.

Prior to initiating the evaluation of the proportion of juvenile clupeids bypassing Cabot Station via the log sluice, new sampling devices were installed in both the log sluice and trash trough. These devices were designed to collect all of the fish entering the log sluice, either directly, or via the trash trough, and were designed to distinguish the numbers entering each route. An integral part of the log sluice sampler is a bulkhead insert, installed in the gate tracks of the log sluice gate. With the insert in place, the configuration of the gate opening is narrower and deeper than without the insert.

In general, the new sampling devices provided for a relatively accurate appraisal of the relative numbers of fish emigrating through the log sluice and trash trough. Minor problems were encountered with respect to the logistics involved in handling large numbers of fish on the sorting table associated with the log sluice sampler, and with respect to the volume of water passed and some impingement of fish on the trash trough sampler screen. These problems were minor and some adjustments to the samplers will be made prior to future studies.

Proportion of Emigrating Juvenile Clupeids Bypassed

The estimated proportion of juvenile clupeids bypassing Cabot Station during 1992 (88 percent) represents a considerable increase from the 58 percent bypass efficiency observed in 1991. The reason for this increase is not readily explainable as resulting from major additions to the possible exit routes from the Cabot Station forebay. The only changes to the bypass facilities in 1992 are the provision of the access to the trash trough via Slot 1b, the installation of the new samplers in the log sluice and trash trough, and the integration of the bulkhead insert at the upper end of the log sluice sampler. The accessibility of the trash trough via Slot 1b was shown not to have a significant effect on the proportion of the fish using a bypass route. However, the sampler and the bulkhead insert, together, may have contributed to the overall 29 percent increase in the proportion of fish bypassed.

As discussed above, the provision of the access to the trash trough via Slot 1b did not contribute significantly to the increase in by the proportion of clupeids bypassed. The slight increase of 2.5% is well within the sampling error of the system. Also, the slot was opened on only half of the sampling periods and, consequently, the contribution to the overall increase in efficiency is, in reality, undetectable.

During the 1992 Atlantic salmon smolt study, the effect of a bulkhead insert installed at the gate to the log sluice was evaluated. The bulkhead insert was tested as a consequence of the results of the studies on both juvenile clupeids and salmon smolts conducted at the Hadley Falls bascule gate in 1991 and 1992.

Although no effect was observed for the Atlantic salmon at Turners Falls during the spring 1992 study, the insert may have induced the clupeids to enter the log sluice due to changes to the hydraulic profile at the entrance to the log sluice. However, because the insert was integrated into the design of the new log sluice sampler, the effect of the bulkhead insert on the bypass efficiency could not be tested independently of the sampler.

It is possible that the sampler itself contributed to the increased bypass efficiency. A physical model of the design concept for the new sampler was tested at the Alden Hydraulics Laboratory prior to constructing the prototype installed in the log sluice. The new sampler is based on the design used successfully for the original sampler installed in 1991. Modifications to the design of the sampler installed in 1992 included addition of a sorting and collection table for handling the fish, and a change in the angle of the screen relative to the flow of water. The screen of the new sampler is oriented in a horizontal position (rather than the declined orientation of the 1991 screen), which may have influenced the flow pattern through the bulkhead insert.

Total Number of Juvenile Clupeids Bypassed

The estimated 1,654,000 fish that passed through the log sluice through the log sluice in 1992 is considerably higher than the estimated 201,000 reported passing through the log sluice in 1991. The major reason for the apparent increase is attributable to the fact that the 1991 estimate included only those fish passing between 1700 and 2100 hours. Recalculating the 1992 passage estimate to include only those fish passing during the 1700-2100 time period, the estimated number of fish bypassing through the log sluice in 1992 is 331,000 clupeids (20.5% of 1,654,000), Which is comparable to the 1991 estimate. Additionally, the sampling period was longer in 1992 than in 1991. In 1991, the study period extended from October 2 to October 18. Peak movements occurred on October 2 and October 3. The 1992 study period began September 16 and extended to November 1. Peak movements occurred on September 25 and September 28. It was also noted in the 1991 study (Harza and RMC, 1992) that clupeids were observed bypassing through the log sluice in large numbers prior to the start of sampling on October 2.

It is also possible that the estimate of 1,654,000 fish bypassed is an overestimate of the actual number of fish passing through the log sluice. The estimated number of fish bypassed obtained in 1992 is derived from the numbers of fish collected during the concurrent sampling period, extrapolated to the non-sampled period on the basis of the diel migration pattern observed during eleven 24-hour samples. During the periods when fish were not sampled, the bulkhead insert and sampling screen were removed from the log sluice. A basic assumption of the extrapolation procedure is that the relative numbers of fish bypassed and the propensity of the fish to enter the log sluice are the same with and without the bulkhead insert and sampling screen deployed. If the fish were more likely to enter the log sluice with this equipment in the sampling position, the estimates derived for the non-sample periods are likely to be overestimated. However, because it is not possible to determine the number of fish passing through the log sluice without the bulkhead insert and sampling screen deployed, the assumption cannot be tested.

The pattern of movement indicated by the results of the diel sampling suggests that, at least in 1992, the optimum time for sampling the population was between 1100 to 1500 hours rather than the generalized 1700 - 2200 period suggested by O'Leary (1984). As indicated in Table 11, the diel pattern of fish emigrating from the

Cabot Station forebay indicates that, in 1992, only 20 percent of the fish emigrated during the 1700 to 2100 concurrent sampling period, with the remaining 80 percent moving through the log sluice during the remainder of the day. Further inspection of the 24-hour pattern presented in Table 11 indicates that 38.5 percent of the daily emigration through the log sluice occurred during the four hour period between 1100 and 1500 hours, nearly twice the proportion passing through during the 1700 to 2100 hours period. This shift in the observed movement pattern of the fish may have been partially stimulated by the presence of the bulkhead insert/sampler in the log sluice, or it may be a function of the particular hydrologic, climatic and biologic conditions present in 1992. Whichever may have occurred, the shift in the movement pattern suggests that the concurrent sampling period should probably have been changed to reflect the observed 24-hour pattern. However, because the historical pattern had been one in which the fish generally moved between 1700-2200 hours, and, because the frequency and duration of deviation from this time slot could not be predicted *a priori*, the schedule was not altered in 1992.

Incremental Effect of Trash Trough Opening

An objective of the Spring 1992 Atlantic salmon smolt study (Harza and RMC 1992) was to develop a log sluice/trash trough opening configuration to be tested to determine the incremental benefit of the configuration to bypass juvenile clupeids. The lack of a significant increase in the percent bypassed when the Slot 1b was open is probably due to the behavior of juvenile clupeids. However, the use of the trash trough should not necessarily be excluded from the available routes to bypass the Cabot Station emigrating Atlantic salmon smolts.

The reason few juvenile clupeids used the trash trough as a route of exit from the Cabot Station forebay may be because these fish do not readily enter areas of contrasting light, such as orifices or through shadowed areas. Observations during the experiments with mercury vapor light (Appendix 8) suggest that juvenile clupeids avoid entering areas of light transition. In these experiments, clupeids schooling in the forebay avoided a shadow created by the log sluice headworks and a lamp situated at the south end of the forebay. Fish entering the trash trough are required to move from the lighted forebay into a dark submerged opening, and may be reluctant to do so.

Other Study Observations

The 1992 study encompassed a wide range of power generation levels during sampling. Power generation levels fluctuated daily, and often fluctuated hourly during a concurrent sampling period. The proportion of clupeids bypassing, however, did not fluctuate as a function of power generation. This is further support for the hypothesis that numbers of clupeids present and clupeid behavior, more than plant operation levels, affect the proportion of fish bypassing Cabot Station.

The new log sluice sampling device employed during the 1992 study resulted in vastly improved handling of sampled clupeids, especially during high passage periods. Very little injury due to sampling was observed. Clupeids sampled in the log sluice were held for periods of up to seven days, and experienced negligible delayed mortality. Also, the ability to subsample clupeids during periods of high passage, and the ability to regulate the flow of water onto the sorting table, allowed more precise estimates of the number of fish bypassing during individual collections.

The results of trash trough sampler calibration tests showed the sampler to be less efficient at sampling bypassing clupeids than expected. One possible explanation for this is the tendency of the sampler screen to clog with debris midway through a concurrent sampling period. The enclosed area where the sampler was constructed precluded periodic cleaning of the screen. The trash trough sampler calibration tests were performed before concurrent sampling began on a given day, and would be completed before debris clogging began to affect flow onto the sampler. Therefore, the calibration tests may have overestimated efficiency of the sampler, resulting in an underestimate of actual trash trough bypass numbers.

CONCLUSIONS

1) Using the results of concurrent sampling of fish passing through the log sluice and of fish entrained through the turbines, an estimated 88 percent of the juvenile clupeids emigrated from the Cabot Station forebay via the log sluice. This represents a nearly 30 percent increase over the bypass efficiency determined during the 1991 study at Cabot Station.

2) A likely explanation for the apparent increase in the proportion of fish bypassed in 1992 over that observed in 1991 is the installation of a new sampling device integrated with a bulkhead insert at the upstream entrance to the log sluice. Apparently, the new sampling device\bulkhead insert not only facilitates the sampling effort, but also increases the effectiveness of the log sluice as a bypass route.

3) From September 16 through November 1, an estimated 1,653,770 juvenile clupeids bypassed Cabot Station via the log sluice.

4) The availability of trash trough opening 1B as an alternative bypass route increased the overall proportion of clupeids bypassing Cabot Station by approximately 2.5 percent (from 87.3% without to 89.8% with the trash trough alternative).

5) The results of preliminary experiments with mercury vapor light to attract juvenile clupeids to the log sluice bypass suggest further investigation is warranted.

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Table 1. Number of juvenile clupeids bypassed and entrained during concurrent sampling at Cabot Station, Fall 1992.

DATE	Number bypassed through log sluice	Number bypassed through trash trough	Number entrained	Total bypassed	Percent entrained	Percent bypassed
16-Sep	2,542	---	11	2,542	0.4%	99.6%
17-Sep	4,015	0	0	4,015	0.0%	100.0%
18-Sep	629	---	30	629	4.6%	95.4%
19-Sep	81	---	0	81	0.0%	100.0%
22-Sep	243	0	0	243	0.0%	100.0%
23-Sep	4,080	---	40	4,080	1.0%	99.0%
24-Sep	10,295	93	57	10,389	0.5%	99.5%
25-Sep	18,264	---	4,488	18,264	19.7%	80.3%
26-Sep	10,013	66	1,157	10,079	10.3%	89.7%
28-Sep	19,925	---	2,139	19,925	9.7%	90.3%
29-Sep	6,834	1,020	367	7,854	4.5%	95.5%
30-Sep	11,802	---	1,453	11,802	11.0%	89.0%
01-Oct	1,150	57	2,691	1,207	69.0%	31.0%
02-Oct	942	---	362	942	27.8%	72.2%
03-Oct	909	0	177	909	16.3%	83.7%
04-Oct	374	---	173	374	31.6%	68.4%
05-Oct	8,095	904	0	8,999	0.0%	100.0%
06-Oct	4,123	---	6	4,123	0.1%	99.9%
07-Oct	3,934	0	7	3,934	0.2%	99.8%
08-Oct	312	---	0	312	0.0%	100.0%
09-Oct	15,627	342	328	15,969	2.0%	98.0%
10-Oct	4,791	---	2,467	4,791	34.0%	66.0%
11-Oct	5,214	0	1,382	5,214	21.0%	79.0%
12-Oct	621	---	1,050	621	62.8%	37.2%
13-Oct	6,756	72	902	6,828	11.7%	88.3%
14-Oct	4,209	---	71	4,209	1.7%	98.3%
15-Oct	935	243	537	1,178	31.3%	68.7%
16-Oct	6,535	---	11	6,535	0.2%	99.8%
17-Oct	132	17	131	149	46.8%	53.2%
19-Oct	15,998	696	894	16,694	5.1%	94.9%
20-Oct	6,953	---	447	6,953	6.0%	94.0%
21-Oct	7,058	3,618	2,370	10,676	18.2%	81.8%
22-Oct	3,546	---	1,296	3,546	26.8%	73.2%
23-Oct	1,086	89	93	1,174	7.4%	92.6%
24-Oct	9	---	181	9	95.4%	4.6%
25-Oct	1,180	658	1,398	1,838	43.2%	56.8%
27-Oct	106	43	404	149	73.0%	27.0%
29-Oct	83	99	121	182	39.9%	60.1%
30-Oct	35	---	218	35	86.2%	13.8%
01-Nov	53	---	289	53	84.5%	15.5%
Totals--	**189,490**	**8,017**	**27,748**	**197,506**	**12.3%**	**87.7%**

Table 2. Number of American shad bypassed and entrained during concurrent sampling at Cabot Station, Fall 1992.

DATE	Number bypassed through log sluice	Number bypassed through trash trough	Number entrained	Total bypassed	Percent entrained	Percent bypassed
16-Sep	2,450	---	11	2450	0.4%	99.6%
17-Sep	3,064	0	0	3064	0.0%	100.0%
18-Sep	558	---	30	558	5.1%	94.9%
19-Sep	81	---	0	81	0.0%	100.0%
22-Sep	232	0	0	232	0.0%	100.0%
23-Sep	3,724	---	40	3724	1.1%	98.9%
24-Sep	7,567	88	46	7655	0.6%	99.4%
25-Sep	16,337	---	3,911	16337	19.3%	80.7%
26-Sep	9,015	66	1,117	9081	11.0%	89.0%
28-Sep	17,429	---	1,992	17429	10.3%	89.7%
29-Sep	4,147	938	325	5084	6.0%	94.0%
30-Sep	7,892	---	1,315	7892	14.3%	85.7%
01-Oct	937	47	2,393	983	70.9%	29.1%
02-Oct	807	---	317	807	28.2%	71.8%
03-Oct	759	0	171	759	18.4%	81.6%
04-Oct	253	---	163	253	39.2%	60.8%
05-Oct	5,828	712	0	6540	0.0%	100.0%
06-Oct	3,575	---	6	3575	0.2%	99.8%
07-Oct	3,239	0	7	3239	0.2%	99.8%
08-Oct	277	---	0	277	0.0%	100.0%
09-Oct	14,759	311	298	15071	1.9%	98.1%
10-Oct	4,556	---	2,350	4556	34.0%	66.0%
11-Oct	4,646	0	1,179	4646	20.2%	79.8%
12-Oct	509	---	953	509	65.2%	34.8%
13-Oct	6,123	66	873	6190	12.4%	87.6%
14-Oct	3,514	---	71	3514	2.0%	98.0%
15-Oct	879	243	522	1122	31.8%	68.2%
16-Oct	5,670	---	11	5670	0.2%	99.8%
17-Oct	129	17	119	146	44.9%	55.1%
19-Oct	15,846	669	888	16515	5.1%	94.9%
20-Oct	6,819	---	430	6819	5.9%	94.1%
21-Oct	7,038	3,618	2,350	10656	18.1%	81.9%
22-Oct	3,545	---	1,296	3545	26.8%	73.2%
23-Oct	1,023	89	93	1112	7.7%	92.3%
24-Oct	9	---	181	9	95.4%	4.6%
25-Oct	1,169	658	1,392	1828	43.2%	56.8%
27-Oct	106	43	404	149	73.0%	27.0%
29-Oct	83	99	121	182	39.9%	60.1%
30-Oct	35	---	218	35	86.2%	13.8%
01-Nov	49	---	289	49	85.5%	14.5%
Totals--	**164,678**	**7,663**	**25,883**	**172,341**	**13.1%**	**86.9%**

Table 3. Number of blueback herring bypassed and entrained during concurrent sampling at Cabot Station, Fall 1992.

DATE	Number bypassed through log sluice	Number bypassed through trash trough	Number entrained	Total bypassed	Percent entrained	Percent bypassed
16-Sep	92	---	0	92	0.0%	100.0%
17-Sep	951	0	0	951	0.0%	100.0%
18-Sep	70	---	0	70	0.0%	100.0%
19-Sep	0	---	0	0		
22-Sep	11	0	0	11	0.0%	100.0%
23-Sep	355	---	0	355	0.0%	100.0%
24-Sep	2,729	5	11	2734	0.4%	99.6%
25-Sep	1,927	---	577	1927	23.0%	77.0%
26-Sep	998	0	40	998	3.9%	96.1%
28-Sep	2,497	---	147	2497	5.6%	94.4%
29-Sep	2,688	83	42	2770	1.5%	98.5%
30-Sep	3,911	---	138	3911	3.4%	96.6%
01-Oct	213	10	297	224	57.1%	42.9%
02-Oct	134	---	46	134	25.4%	74.6%
03-Oct	150	0	6	150	3.7%	96.3%
04-Oct	121	---	10	121	7.6%	92.4%
05-Oct	2,266	192	0	2459	0.0%	100.0%
06-Oct	548	---	0	548	0.0%	100.0%
07-Oct	695	0	0	695	0.0%	100.0%
08-Oct	35	---	0	35	0.0%	100.0%
09-Oct	868	31	30	898	3.2%	96.8%
10-Oct	235	---	117	235	33.3%	66.7%
11-Oct	569	0	204	569	26.4%	73.6%
12-Oct	112	---	96	112	46.4%	53.6%
13-Oct	633	6	29	638	4.4%	95.6%
14-Oct	695	---	0	695	0.0%	100.0%
15-Oct	56	0	15	56	21.5%	78.5%
16-Oct	865	---	0	865	0.0%	100.0%
17-Oct	3	0	12	3	80.3%	19.7%
19-Oct	152	27	6	180	3.1%	96.9%
20-Oct	134	---	17	134	11.0%	89.0%
21-Oct	20	0	19	20	49.7%	50.3%
22-Oct	1	---	0	1	0.0%	100.0%
23-Oct	62	0	0	62	0.0%	100.0%
24-Oct	0	---	0	0		
25-Oct	10	0	6	10	36.3%	63.7%
27-Oct	0	0	0	0		
29-Oct	0	0	0	0		
30-Oct	0	---	0	0		
01-Nov	4	---	0	4	0.0%	100.0%
Totals--	**24,812**	**354**	**1,865**	**25,166**	**6.9%**	**93.1%**

Table 4. Estimated rates of bypass (fish/hour) through the log sluice at Cabot Station for collections during the 4-hour concurrent sampling period, and the mean log sluice bypass rate for the day.

Sampling Date	17:00 hour	18:00 hour	19:00 hour	20:00 hour	Total bypassed during concurrent samples	Mean hourly bypass rate
16-Sep	2,444		98		2,542	1,271
17-Sep	0	3,568		447	4,015	1,338
18-Sep	627		0	1	629	210
19-Sep	0	0	6	75	81	20
22-Sep	115		123	4	243	81
23-Sep	3,955		21	105	4,080	1,360
24-Sep	3,878		2,977	3,440	10,295	3,432
25-Sep	17,867		397		18,264	9,132
26-Sep	2,998		6,522	493	10,013	3,338
28-Sep	19,067		39	820	19,925	6,642
29-Sep	3,889		2,854	92	6,834	2,278
30-Sep	6,914		3,342	1,546	11,802	3,934
01-Oct	621	469		60	1,150	383
02-Oct	514	428	0		942	314
03-Oct	668	165	76		909	303
04-Oct	352	22		0	374	125
05-Oct	7,984		43	68	8,095	2,698
06-Oct	2,780	1,342		1	4,123	1,374
07-Oct	3,307	577		50	3,934	1,311
08-Oct	74	47	191		312	104
09-Oct	15,181		414	32	15,627	5,209
10-Oct	4,539		171	81	4,791	1,597
11-Oct	5,157	12	0	45	5,214	1,304
12-Oct	496		42	83	621	207
13-Oct	6,501		141	114	6,756	2,252
14-Oct	3,008	361		840	4,209	1,403
15-Oct		545	390		935	468
16-Oct	6,503	31		1	6,535	2,178
17-Oct	108	24		0	132	44
19-Oct	15,776	83		139	15,998	5,333
20-Oct	6,790		128	35	6,953	2,318
21-Oct	6,218		498	342	7,058	2,353
22-Oct	3,432	16		98	3,546	1,182
23-Oct	682	395		9	1,086	362
24-Oct	0		9		9	4
25-Oct	492	255		432	1,180	393
27-Oct	27		30	49	106	35
29-Oct	16	45		22	83	28
30-Oct	1		15	19	35	12
01-Nov	11	38		4	53	18

Table 5. Summary of results of gear calibration tests performed at Cabot Station during Fall, 1992.

Device	Test Date(s)	Number of Replicates	Number released	Total recaptures	Pooled efficiency	Data stratum
Unit 1, top net	Oct. 5	2	400	210	52.5%	Sept. 16-Oct. 8
Unit 1, top net	Oct. 13 & 20	6	1200	957	79.8%	Oct. 9-Nov. 1
Unit 1, bottom net	Oct. 9	3	600	262	43.7%	Sept. 16-Oct. 10
Unit 1, bottom net	Oct. 13 & 20	6	1200	737	61.4%	Oct. 11-Nov. 1
Unit 4, top net	Oct. 6	3	600	320	53.3%	Sept. 16-Oct. 9
Unit 4, top net	Oct. 14 & 21	6	1200	773	64.4%	Oct. 10-Nov. 1
Unit 4, bottom net	Oct. 6	3	600	322	53.7%	Sept. 16-Oct. 10
Unit 4, bottom net	Oct. 16 & 21	6	1200	965	80.4%	Oct. 11-Nov. 1
Unit 6, top net	Oct. 7	3	600	251	41.8%	Sept. 16-Oct. 10
Unit 6, top net	Oct. 15 & 22	6	1200	584	48.7%	Oct. 11-Nov. 1
Unit 6, bottom net	Oct. 8	3	600	429	71.5%	Sept. 16-Oct. 11
Unit 6, bottom net	Oct. 15 & 23	6	1200	903	75.3%	Oct. 12-Nov. 1
Trash trough	Sept. 22, Oct. 5,13,26, & 29	15	1500	272	18.1%	Sept. 16-Nov. 1
Log sluice	Sept. 19	3	300	243	81.0%	Sept. 16-Sept. 22
Log sluice	Sept. 26	3	300	287	95.7%	Sept. 23-Oct. 5
Log sluice	Oct. 15	3	300	300	100.0%	Oct. 6-Nov. 1

Table 6. Estimated rates of bypass (fish/hour) through the trash trough at Cabot Station for collections during the 4-hour concurrent sampling period, and the mean bypass rate for the day.

Sampling Date	17:00 hour	18:00 hour	19:00 hour	20:00 hour	Total bypassed during concurrent sampling	Mean hourly bypass rate
16-Sep	----------	Trash trough closed	----------		---	---
17-Sep	0	0		0	0	0
18-Sep	----------	Trash trough closed	----------		---	---
19-Sep	----------	Trash trough closed	----------		---	---
22-Sep	0		0	0	0	0
23-Sep	----------	Trash trough closed	----------		---	---
24-Sep	16		22	55	93	31
25-Sep	----------	Trash trough closed	----------		---	---
26-Sep	17		28	22	66	22
28-Sep	----------	Trash trough closed	----------		---	---
29-Sep	369		325	325	1,020	340
30-Sep	----------	Trash trough closed	----------		---	---
01-Oct	0	0		57	57	19
02-Oct	----------	Trash trough closed	----------		---	---
03-Oct	0	0	0		0	0
04-Oct	----------	Trash trough closed	----------		---	---
05-Oct	717		138	50	904	301
06-Oct	----------	Trash trough closed	----------		---	---
07-Oct	0	0		0	0	0
08-Oct	----------	Trash trough closed	----------		---	---
09-Oct	276		33	33	342	114
10-Oct	----------	Trash trough closed	----------		---	---
11-Oct	0	0	0	0	0	0
12-Oct	----------	Trash trough closed	----------		---	---
13-Oct	0		44	28	72	24
14-Oct	----------	Trash trough closed	----------		---	---
15-Oct		0	243		243	121
16-Oct	----------	Trash trough closed	----------		---	---
17-Oct	17	0		0	17	6
19-Oct	474	88		133	696	232
20-Oct	----------	Trash trough closed	----------		---	---
21-Oct	53		1,282	2,283	3,618	1,206
22-Oct	----------	Trash trough closed	----------		---	---
23-Oct	18	17		54	89	30
24-Oct	----------	Trash trough closed	----------		---	---
25-Oct	49	352		257	658	219
27-Oct	6		16	22	43	14
29-Oct	28	33		39	99	33
30-Oct	----------	Trash trough closed	----------		---	---
01-Nov	----------	Trash trough closed	----------		---	---

Table 7. Estimated rates of entrainment (fish/hour) through Cabot Station for collections during the 4-hour concurrent sampling period, and the mean entrainment rate for the day.

Sampling Date	17:00 hour	18:00 hour	19:00 hour	20:00 hour	Total entrained during concurrent sampling	Mean hourly entrainment rate
16-Sep	0		11		11	5
17-Sep	0	0		0	0	0
18-Sep	18		0	12	30	10
19-Sep	0	0	0	0	0	0
22-Sep	0		0	0	0	0
23-Sep	10		0	31	40	13
24-Sep	16		13	28	57	19
25-Sep	998		3,490		4,488	2,244
26-Sep	367		419	371	1,157	386
28-Sep	658		843	637	2,139	713
29-Sep	222		62	83	367	122
30-Sep	520		472	460	1,453	484
01-Oct	295	162		2,234	2,691	897
02-Oct	207	91	64		362	121
03-Oct	126	0	51		177	59
04-Oct	29	80		64	173	58
05-Oct	0		0	0	0	0
06-Oct	0	0		6	6	2
07-Oct	0	0		7	7	2
08-Oct	0	0	0		0	0
09-Oct	104		145	79	328	109
10-Oct	230		1,753	485	2,467	822
11-Oct	56	104	135	1,088	1,382	346
12-Oct	119		790	140	1,050	350
13-Oct	178		590	135	902	301
14-Oct	5	67			71	36
15-Oct		485	52		537	269
16-Oct	8	4		0	11	4
17-Oct	0	131		0	131	44
19-Oct	499	395		0	894	298
20-Oct	297		144	6	447	149
21-Oct	643		1,487	239	2,370	790
22-Oct	543	561		192	1,296	432
23-Oct	83	6		4	93	31
24-Oct	11		102	68	181	60
25-Oct	191	838		369	1,398	466
27-Oct	143		115	145	404	135
29-Oct	0	52		69	121	40
30-Oct	11		94	113	218	73
01-Nov	0	143		147	289	96

Table 8. Mean adjusted turbine net catch rates for each combination of units in operation during concurrent sampling.

UNIT COMBINATION	Mean adjusted catch rate per net per unit combination (fish per hour)					
	Unit 1 Top net	Unit 1 bottom net	Unit 4 Top net	Unit 4 bottom net	Unit 6 Top net	Unit 6 bottom net
Unit 1 only	19	0				
Unit 4 only			0	0		
Unit 6 only					0	0
Units 1 & 4	39	1	6	0		
Units 1,2, & 4	9	0	1	1		
Units 1,4, & 6	18	0	3	0	1	0
Units 1,2,4, & 6	13	0	0	0	3	0
Units 1,3,4, & 6	21	1	3	0	5	2
Units 1,4,5, & 6	16	5	7	2	43	1
Units 1,2,3,4, & 5	22	6	33	0		
Units 1,2,3,4, & 6	16	3	2	0	18	4
Units 1,2,4,5, & 6	71	3	1	1	15	2
Units 1,3,4,5, & 6	16	17	12	2	47	7
All 6 units	33	6	5	2	45	6

Table 9. Mean estimated and linearly interpolated entrainment rates (fish per hour) of juvenile clupeids for different turbine operation combinations at Cabot Station, Fall 1992.

UNIT COMBINATION	Number of collections	UNIT 1			UNIT 2			UNIT 3			UNIT 4			UNIT 5			UNIT 6			Sum of estimated entrainment rates	Sum of interpolated entrainment rates	Proportion estimated
		Bay* 1	Bay 2	Bay* 3	Bay* 4	Bay* 5	Bay* 6	Bay* 7	Bay* 8	Bay* 9	Bay* 10	Bay 11	Bay* 12	Bay* 13	Bay* 14	Bay* 15	Bay* 16	Bay 17	Bay* 18			
Unit 1 only	19	19	19	19																19	38	0.33
Unit 4 only	6										0	0	0							0	1	0.33
Unit 6 only	4																0	0	0	0	0	—
Units 1 & 4	7	43	40	36							10	6	3							46	92	0.33
Units 1,2, & 4	2	10	9	8	8	7	6				3	2	1							11	43	0.21
Units 1,4, & 6	15	20	19	17							5	3	3				2	2	2	23	48	0.33
Units 1,2,4, & 6	5	14	13	12	10	9	7				2	0	1				3	3	4	17	62	0.21
Units 1,3,4, & 6	12	25	23	20				12	9	7	5	3	3				6	6	7	32	94	0.25
Units 1,4,5, & 6	2	22	21	20							10	9	15	21	26	32	38	44	50	74	234	0.24
Units 1,2,3,4, & 5	2	27	28	28	29	29	30	31	31	32	32	33	33	34	35	35				60	406	0.13
Units 1,2,3,4, & 6	5	22	20	18	16	14	12	10	9	7	5	3	6				19	23	26	45	164	0.22
Units 1,2,4,5, & 6	6	82	74	66	58	50	42				10	2	5	7	10	12	15	17	20	93	375	0.20
Units 1,3,4,5, & 6	2	35	33	31				23	21	19	17	15	21	28	34	41	48	54	61	102	377	0.21
All 6 units	31	43	39	36	32	29	25	22	18	15	11	8	15	22	29	36	44	51	58	98	434	0.18
	118																					

□ Mean estimated clupeids entrained through turbine bay calculated from observed catch rate (fish per hour) divided by the appropriate net retention value, then sorted and averaged on the basis of the combination of units that were in operation.

* Unsampled turbine bays where entrainment rate was estimated using linear interpolation (all turbine bays except 2, 11, and 17).

Table 10. Extrapolated 24-hour log sluice bypass estimates for the 1992 Juvenile Clupeid Study at Cabot Station.

	Date	Number bypassed during concurrent and intermediate periods (17:00 - 21:00)	Extrapolated 24-hour total bypass estimate	American shad bypass estimate	Blueback herring bypass estimate
	16-Sep	6,126	29,882	28,360	1,522
	17-Sep	4,467	21,788	20,679	1,110
*	18-Sep	2,074	5,288	5,018	269
	19-Sep	79	385	366	20
**	20-Sep	—	13,153	12,483	670
**	21-Sep	—	25,920	24,599	1,320
	22-Sep	7,931	38,687	35,020	3,667
	23-Sep	18,397	89,741	81,235	8,507
	24-Sep	13,310	64,925	58,771	6,154
*	25-Sep	26,957	42,664	38,620	4,044
	26-Sep	11,930	58,194	52,678	5,516
**	27-Sep	—	108,477	98,195	10,283
	28-Sep	32,546	158,761	98,683	60,078
	29-Sep	10,137	49,450	30,737	18,713
*	30-Sep	17,233	73,046	45,404	27,642
	01-Oct	1,249	6,093	3,787	2,306
*	02-Oct	1,380	12,369	9,166	3,204
	03-Oct	1,023	4,992	3,699	1,293
	04-Oct	783	3,819	2,830	989
	05-Oct	8,173	39,869	33,278	6,590
	06-Oct	5,027	24,522	20,468	4,053
*	07-Oct	5,834	40,643	33,925	6,718
	08-Oct	358	1,746	1,458	289
*	09-Oct	16,985	101,488	88,370	13,118

	Date	Number bypassed during concurrent and intermediate periods (17:00 - 21:00)	Extrapolated 24-hour total bypass estimate	American shad bypass estimate	Blueback herring bypass estimate
	10-Oct	6,078	29,648	25,816	3,832
*	11-Oct	4,128	37,664	32,276	5,388
	12-Oct	704	3,434	2,943	491
	13-Oct	7,946	38,761	33,216	5,545
	14-Oct	4,415	21,536	19,280	2,257
	15-Oct	1,041	5,078	4,546	532
*	16-Oct	6,619	95,926	85,874	10,052
	17-Oct	293	1,429	1,279	150
*	18-Oct	60	35050	31,688	3,362
	19-Oct	9,976	48,663	43,995	4,668
	20-Oct	8,570	41,804	37,795	4,010
	21-Oct	11,714	57,141	56,011	1,129
	22-Oct	9,503	46,356	45,439	916
*	23-Oct	1,265	8,620	8,449	170
	24-Oct	13	63	62	1
	25-Oct	1,553	7,576	7,426	150
***	26-Oct	132,903	136,995	134,287	2,708
*	27-Oct	261	2,719	2,661	59
***	28-Oct	14,203	15,509	15,174	335
	29-Oct	116	566	554	12
	30-Oct	57	278	272	6
***	31-Oct	2,526	2,755	2,695	60
	01-Nov	61	298	291	6
	Total for study =		**1,653,770**	**1,419,855**	**233,914**

* Diel sample conducted, total bypass estimate is from 24 hours of sampling (not an extrapolated total).

** Sampling did not occur, total bypass estimate is linearly interpolated from total bypass estimates of preceding and following sampled days.

*** Mercury vapor light experimental night, total bypass estimate includes actual 17:00 to 21:00 observed bypass total plus the linearly interpolated 21:00 to 17:00 bypass total.

Table 11. Mean number of juvenile clupeids bypassed through the log sluice during the eleven diel samples at Cabot Station.

Collection start time	Mean number bypassed	Percent	
17:00	3,749	15.6%	20.5% of diel pattern
18:00	959	4.0%	
19:00	105	0.4%	
20:00	124	0.5%	
21:00	100	0.4%	79.5% of diel pattern
22:00	25	0.1%	
23:00	24	0.1%	
24:00	78	0.3%	
01:00	71	0.3%	
02:00	8	0.0%	
03:00	37	0.2%	
04:00	17	0.1%	
05:00	25	0.1%	
06:00	132	0.5%	
07:00	3,666	15.2%	
08:00	1,349	5.6%	
09:00	620	2.6%	
10:00	1,851	7.7%	
11:00	2,093	8.7%	
12:00	2,603	10.8%	
13:00	2,881	12.0%	
14:00	1,691	7.0%	
15:00	1,045	4.3%	
16:00	825	3.4%	

Table 12. Non-alosids captured at Cabot Station during the Fall 1992 Juvenile Clupeid Study.

Common Name	Scientific Name	Log Sluice Sampler	Trash Trough Sampler	Unit 1 top net	Unit 1 bottom net	Unit 4 top net	Unit 4 bottom net	Unit 6 top net	Unit 6 bottom net	SPECIES TOTAL
American eel	*Anguilla rostrata*	558	1	11	17	3	6	1	4	601
Atlantic salmon	*Salmo salar*	2	0	0	0	0	0	0	0	2
Black crappie	*Pomoxis nigromaculatus*	2	0	0	0	0	0	0	0	2
Bluegill	*Lepomis macrochirus*	6	0	0	0	1	0	2	3	12
Brook trout	*Salvelinus fontinalis*	1	0	0	0	0	0	0	0	1
Brown bullhead	*Ictalurus nebulosus*	1	0	0	0	0	0	0	0	1
Brown trout	*Salmo trutta*	4	0	0	0	0	0	0	0	4
Gizzard shad	*Dorosoma cepedianum*	2	0	0	0	0	0	0	0	2
Golden shiner	*Notemigonus crysoleucas*	3	0	0	0	0	0	0	0	3
Lampreys	*Petromyzontidae spp.*	5	0	2	0	0	4	0	2	13
Largemouth bass	*Micropterus salmoides*	2	0	0	0	0	0	0	3	5
Pumpkinseed	*Lepomis gibbosus*	4	0	0	0	0	0	0	1	5
Rainbow trout	*Oncorhynchus mykiss*	1	0	0	0	0	0	0	0	1
Rock bass	*Ambloplites rupestris*	19	0	0	0	3	1	7	4	34
Shorthead redhorse	*Moxostoma macrolepidotum*	1	0	0	0	0	0	0	0	1
Smallmouth bass	*Micropterus dolomieui*	18	2	0	0	0	0	0	1	21
Spottail shiner	*Notropis atherinoides*	1	0	0	0	1	0	0	0	2
Striped bass	*Morone saxatilis*	1	0	0	0	0	0	0	0	1
White perch	*Morone americana*	140	3	39	93	16	28	16	16	351
Walleye	*Stizostedion vitreum*	26	0	1	0	0	0	0	0	27
Yellow perch	*Perca flavescens*	1	0	0	0	0	0	0	0	1

Figures

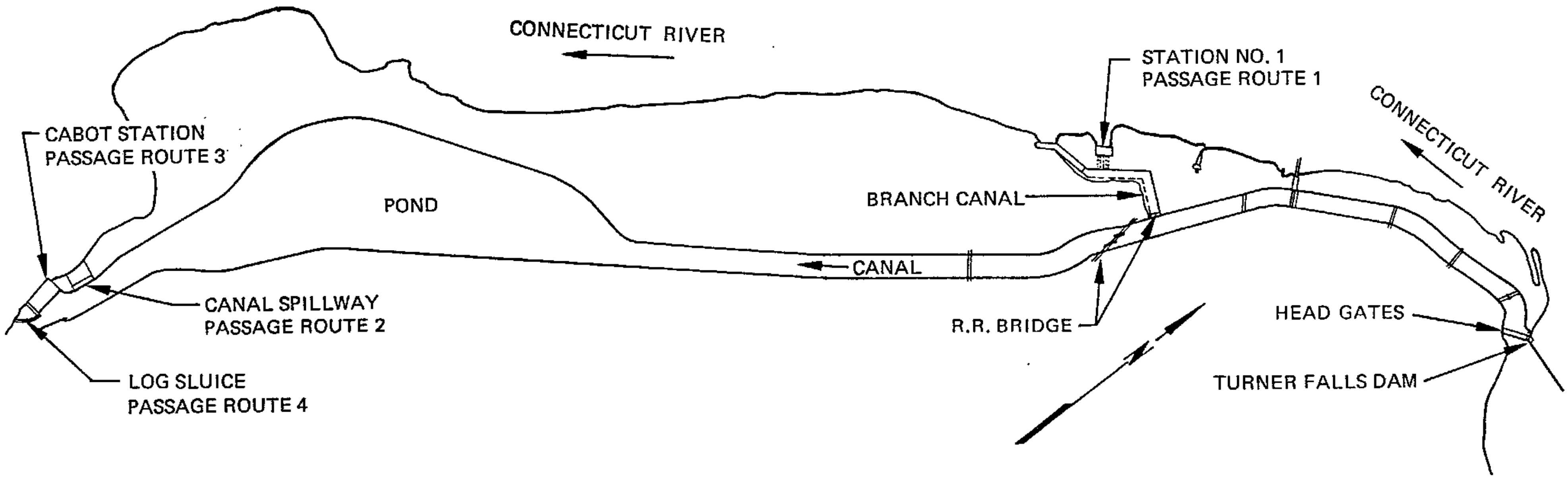
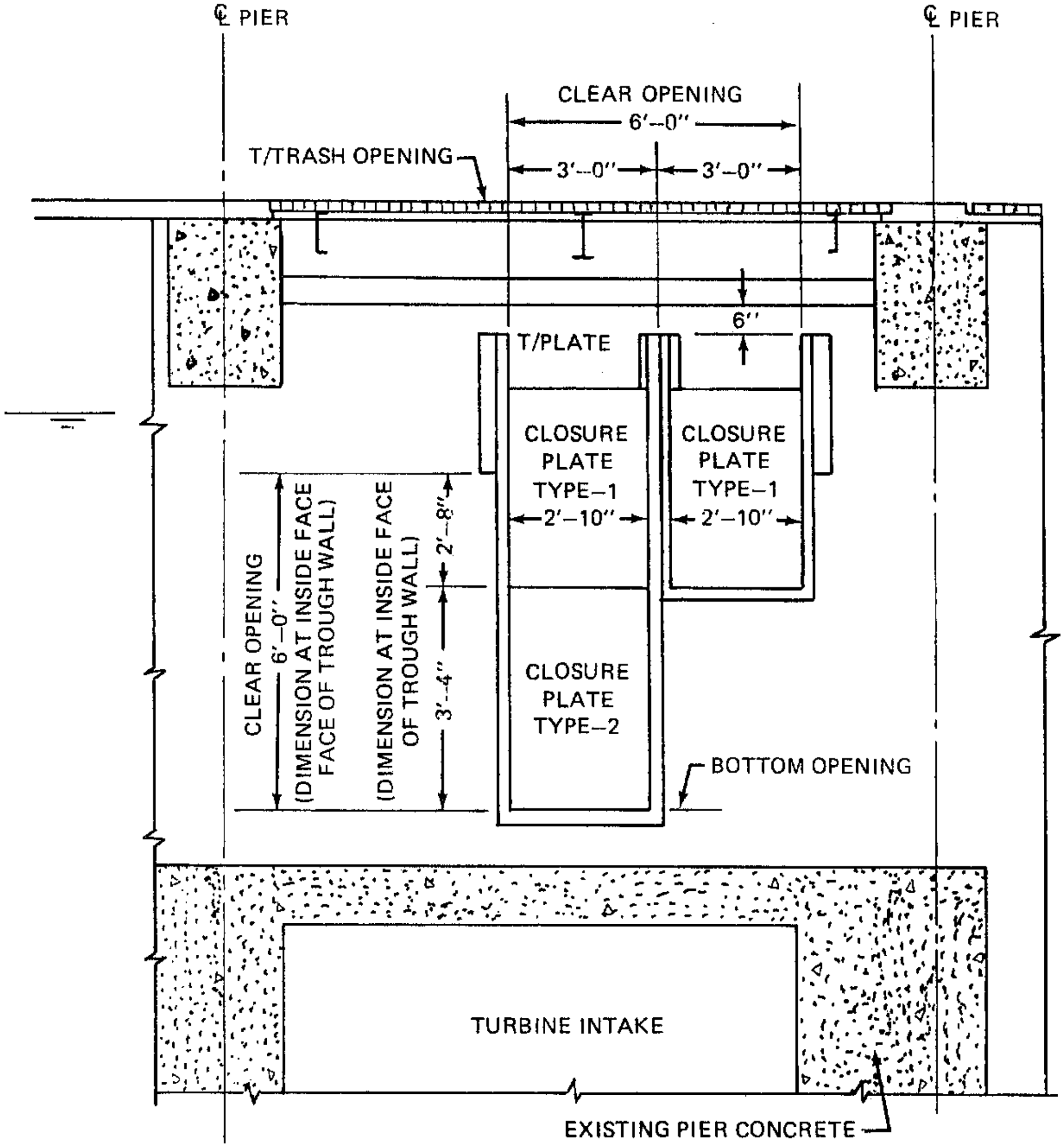


FIGURE 1. PLAN OF CANAL



N.T.S.

FIGURE 2.
CONFIGURATION AND LOCATION OF
ICE AND TRASH SLUICE SLOTS

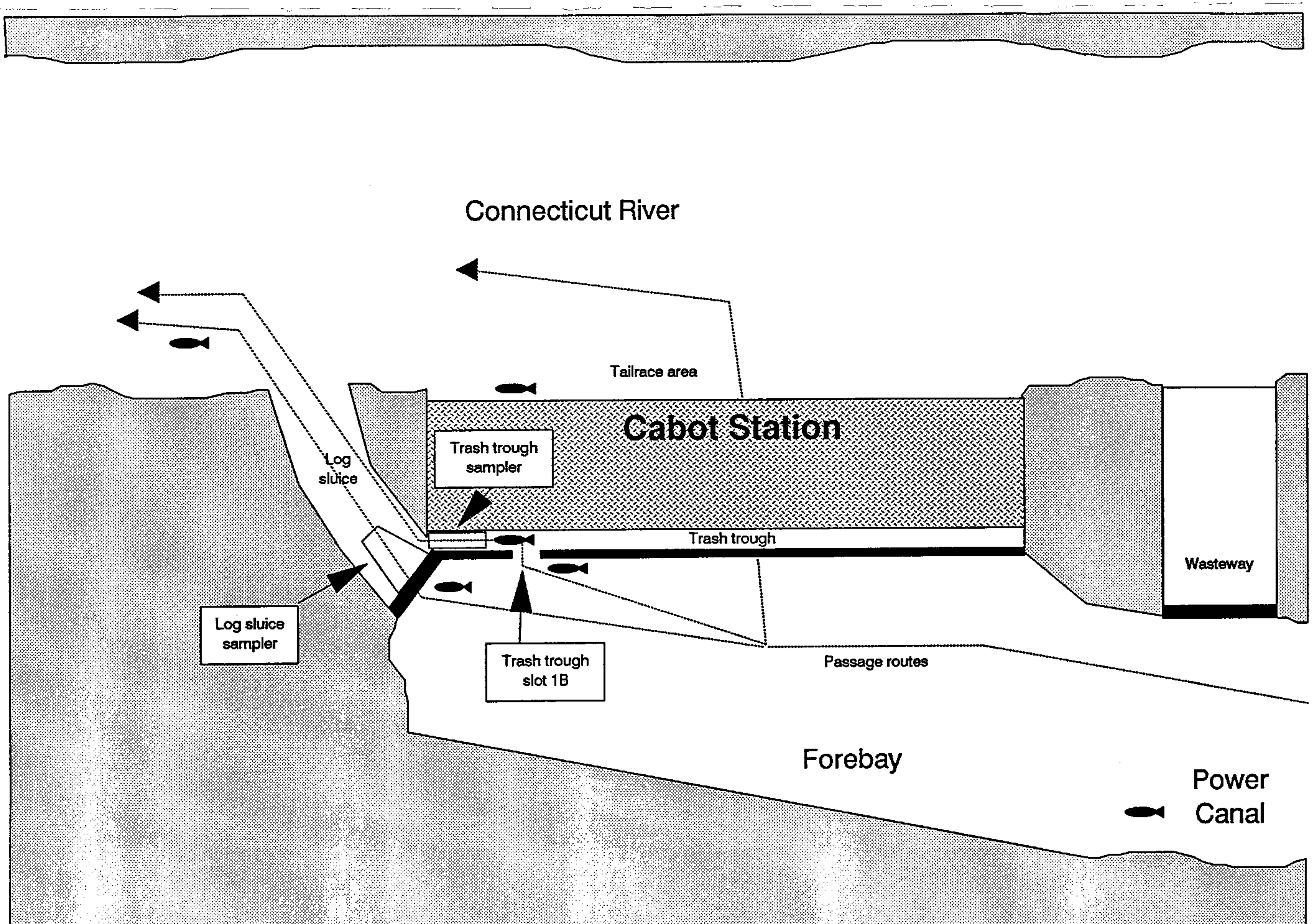


Figure 3. Diagram of passage routes at Cabot Station, Fall 1992.

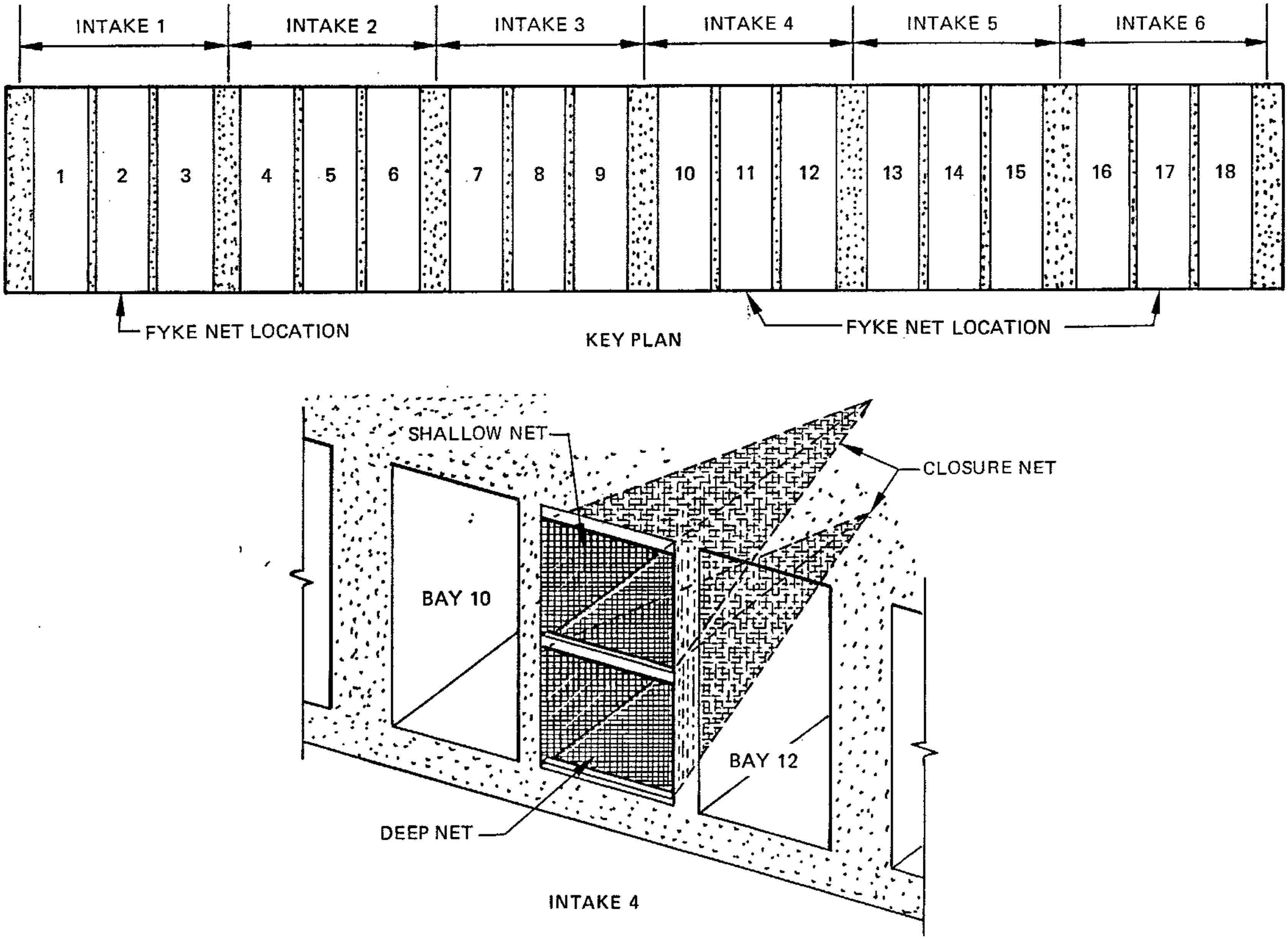


FIGURE 4.
LOCATION OF FYKE–NETS SETS

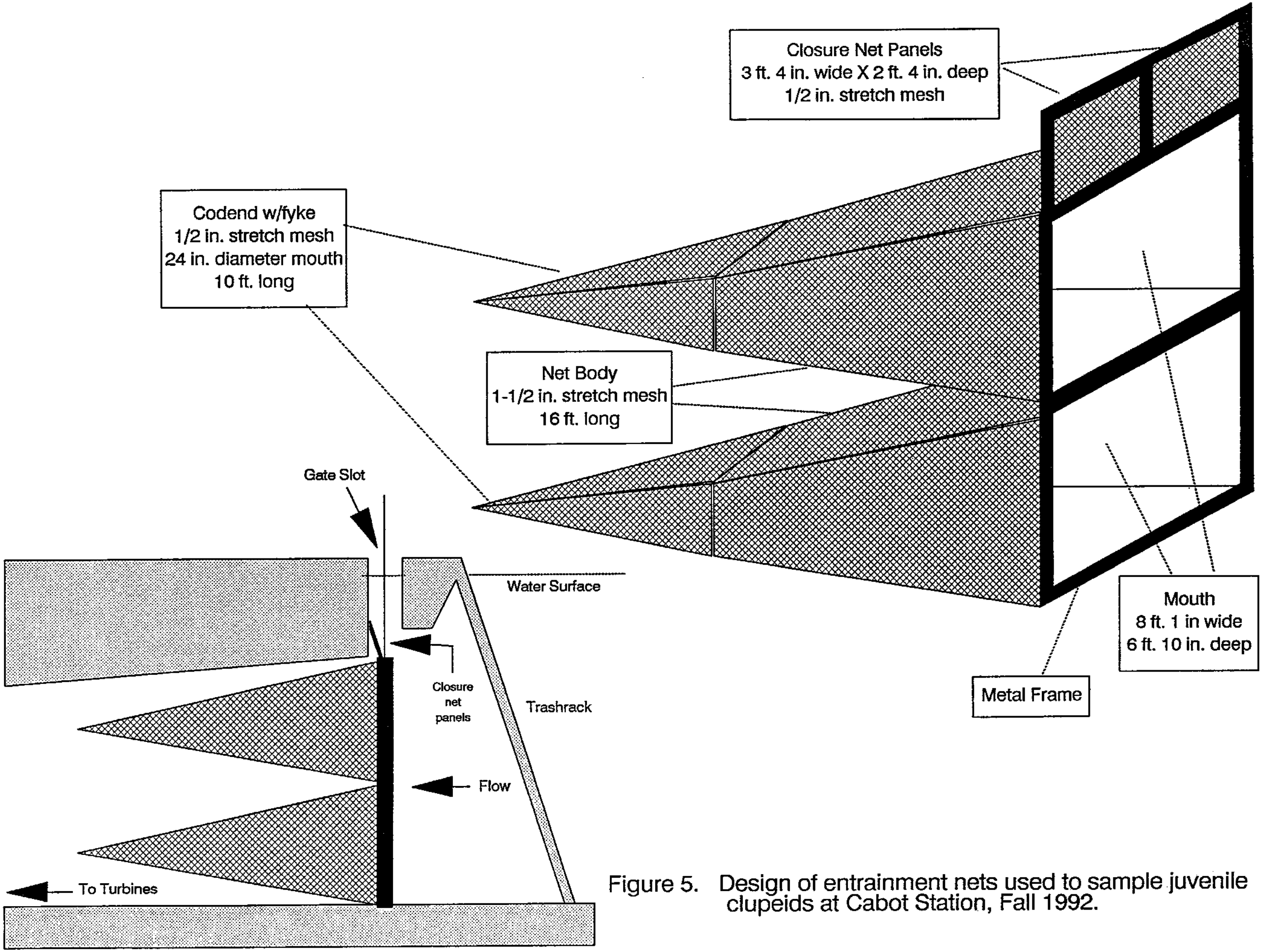


Figure 5. Design of entrainment nets used to sample juvenile clupeids at Cabot Station, Fall 1992.

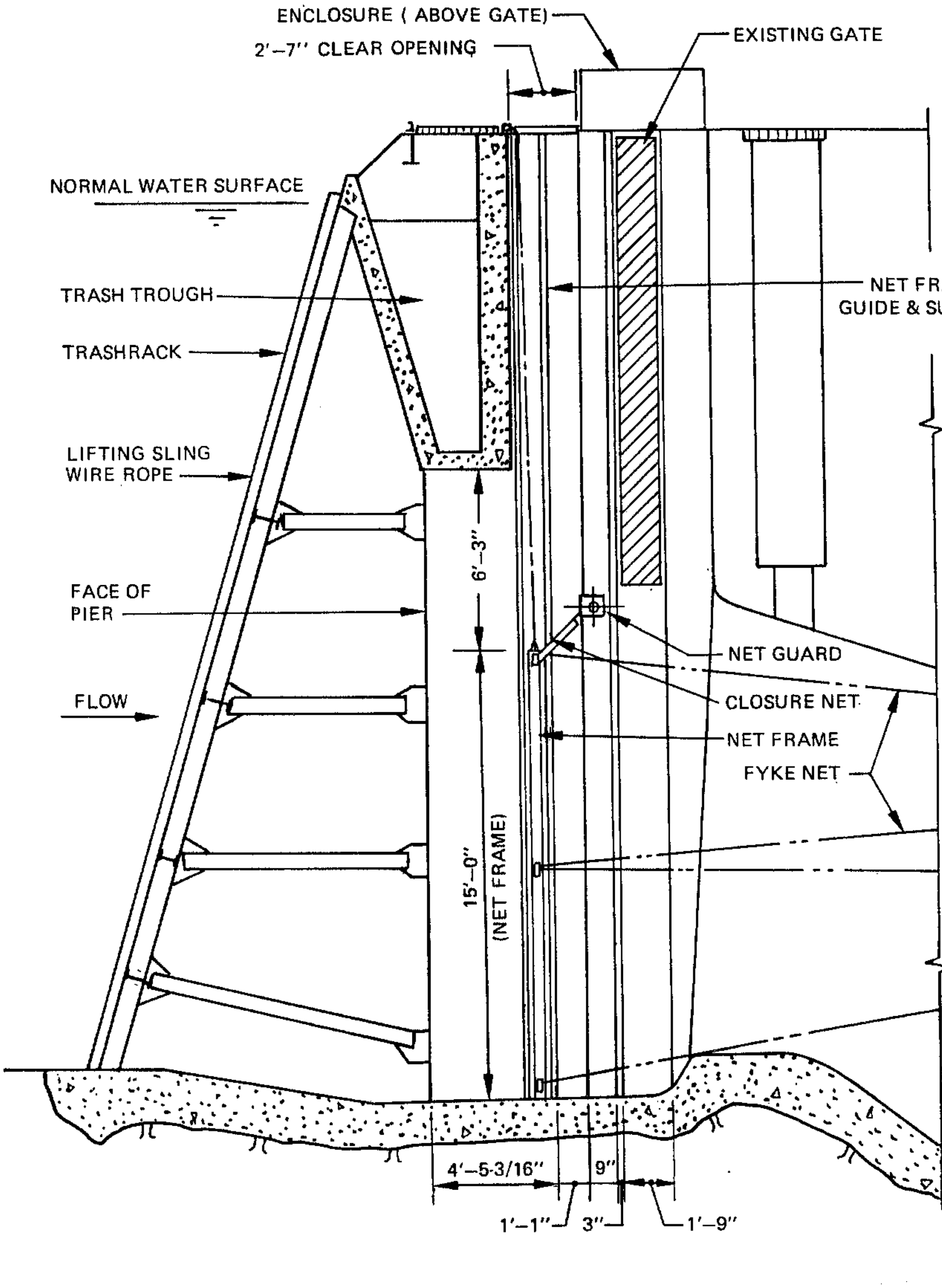


FIGURE 6.
SIDE VIEW OF NET FRAME ILLUSTRATING SAMPLING LOCATION IN THE TURBINE INTAKE

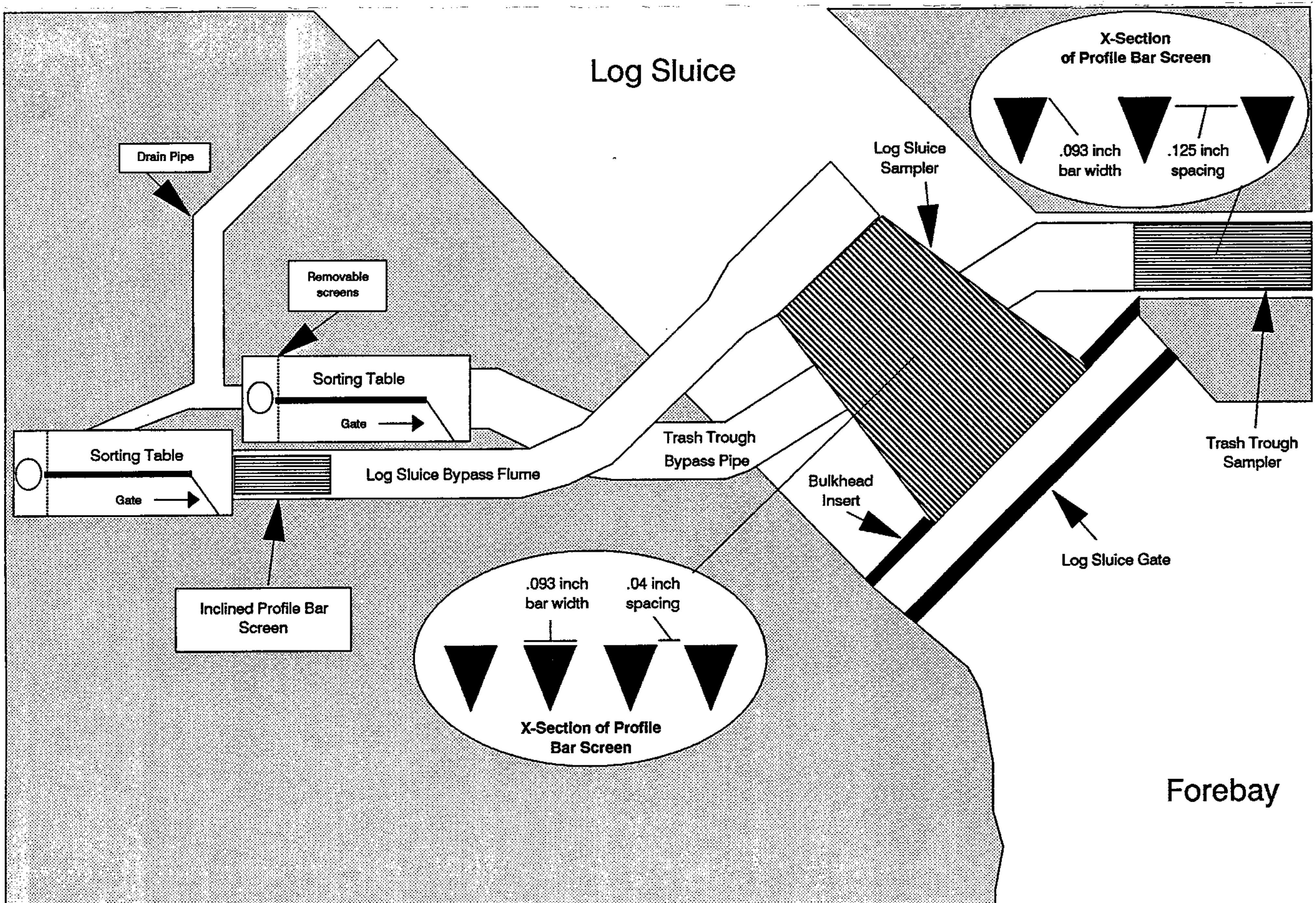


Figure 7. Diagram of log sluice and trash trough samplers used to sample juvenile clupeids at Cabot Station, Fall 1992.

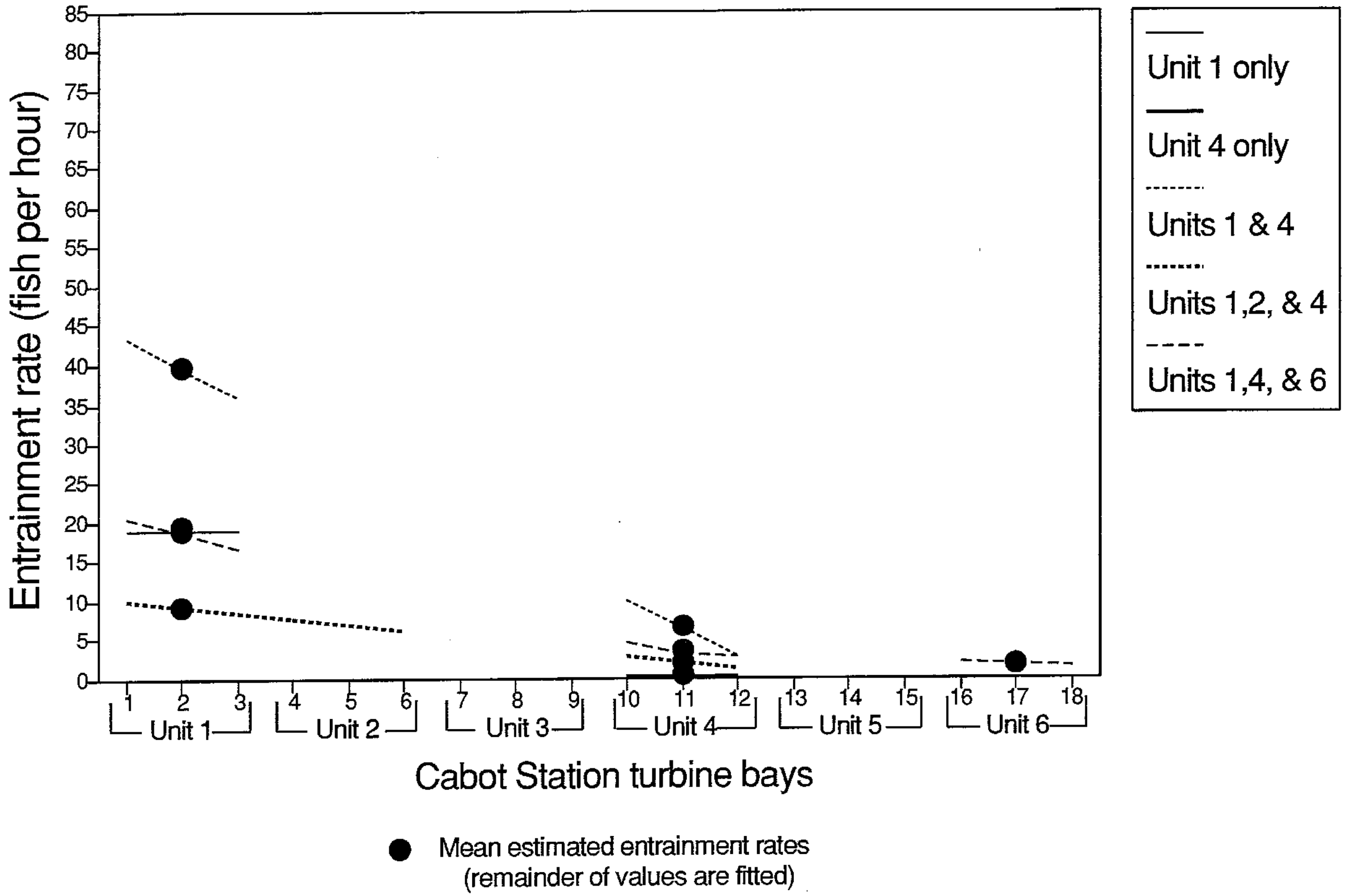


Figure 8. Horizontal distribution of juvenile clupeids entrained through Cabot Station for various combinations of units in operation, Fall 1992.

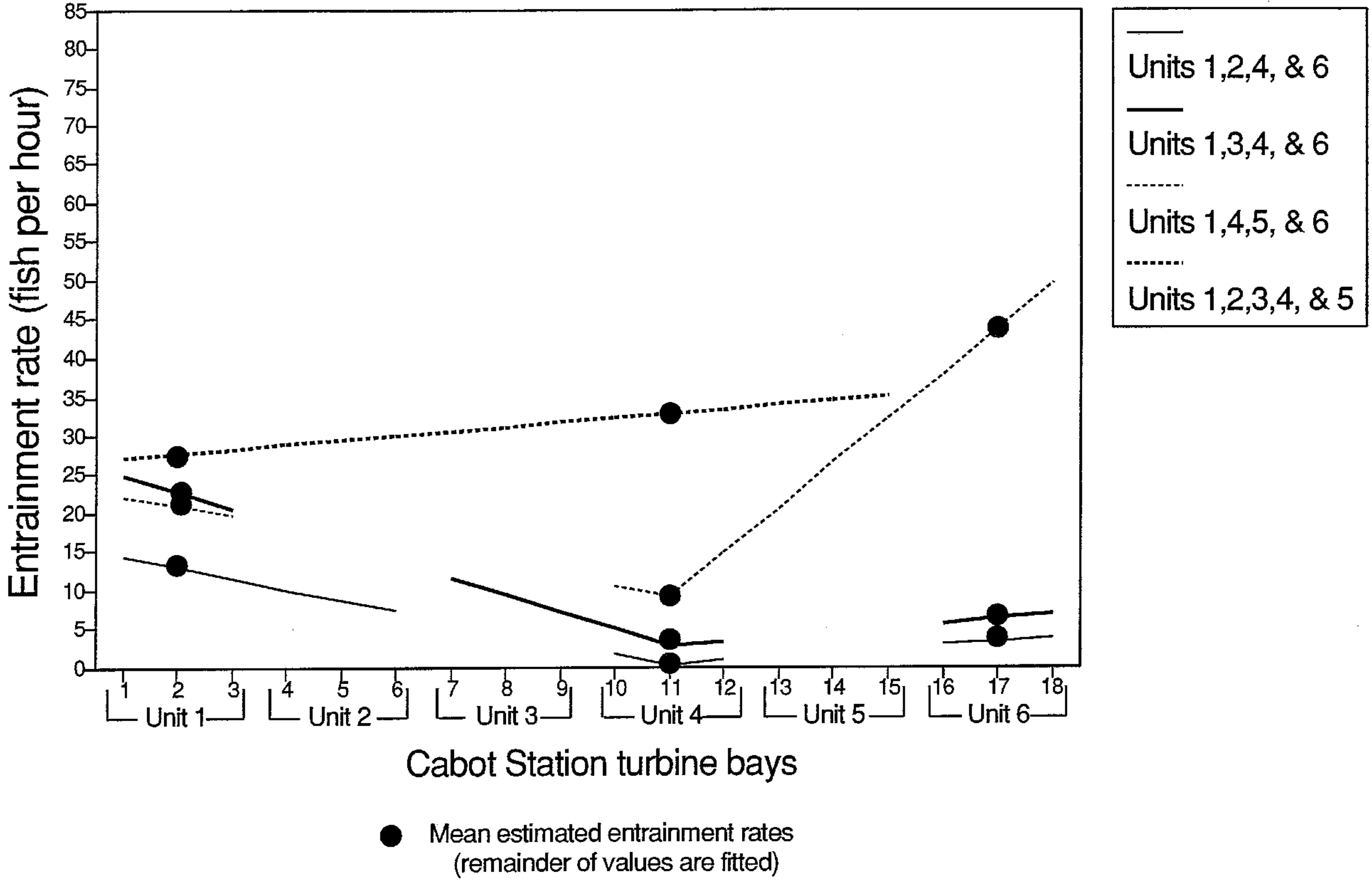


Figure 9. Horizontal distribution of juvenile clupeids entrained through Cabot Station for various combinations of units in operation, Fall 1992.

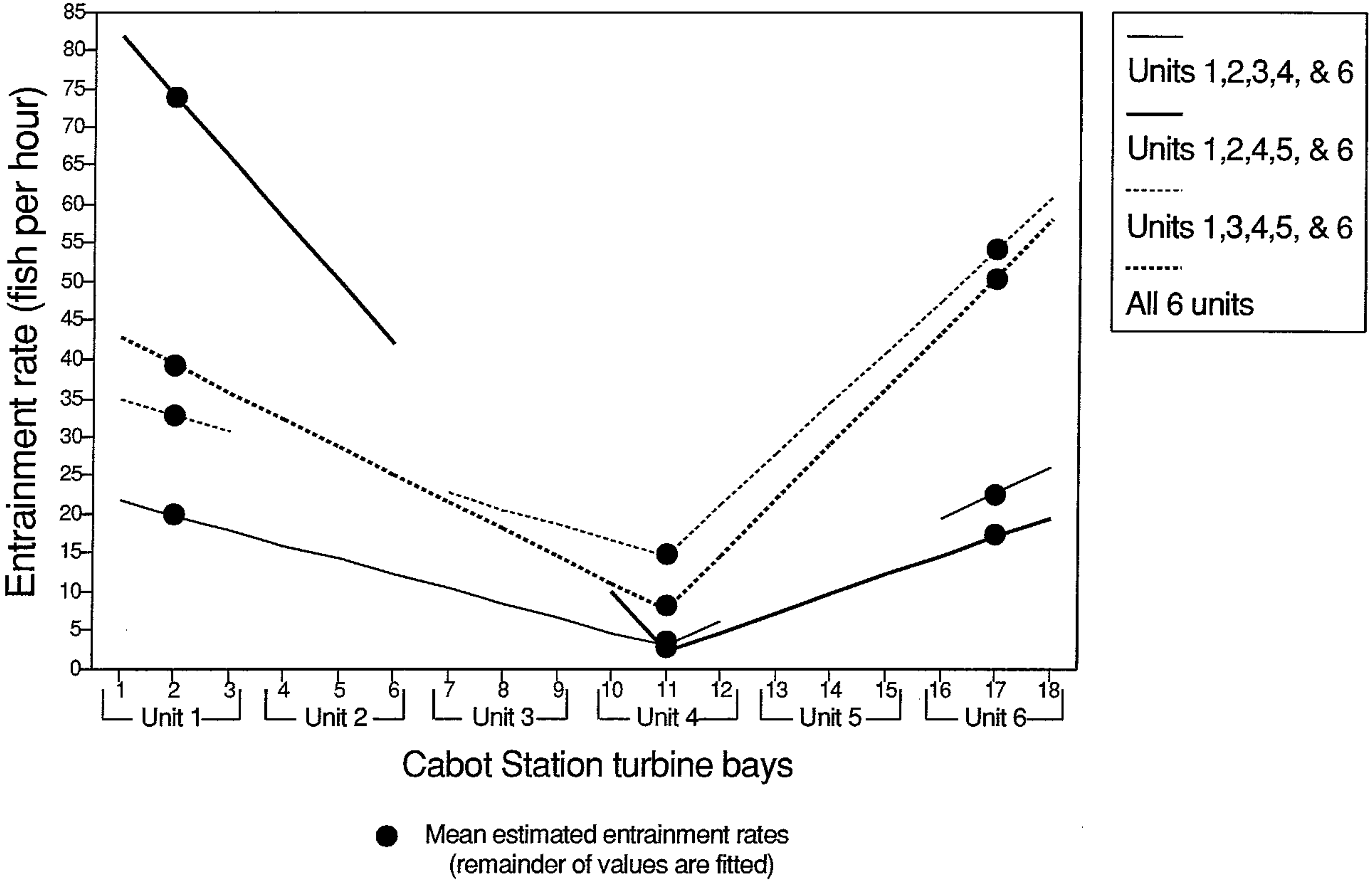


Figure 10. Horizontal distribution of juvenile clupeids entrained through Cabot Station for various combinations of units in operation, Fall 1992.

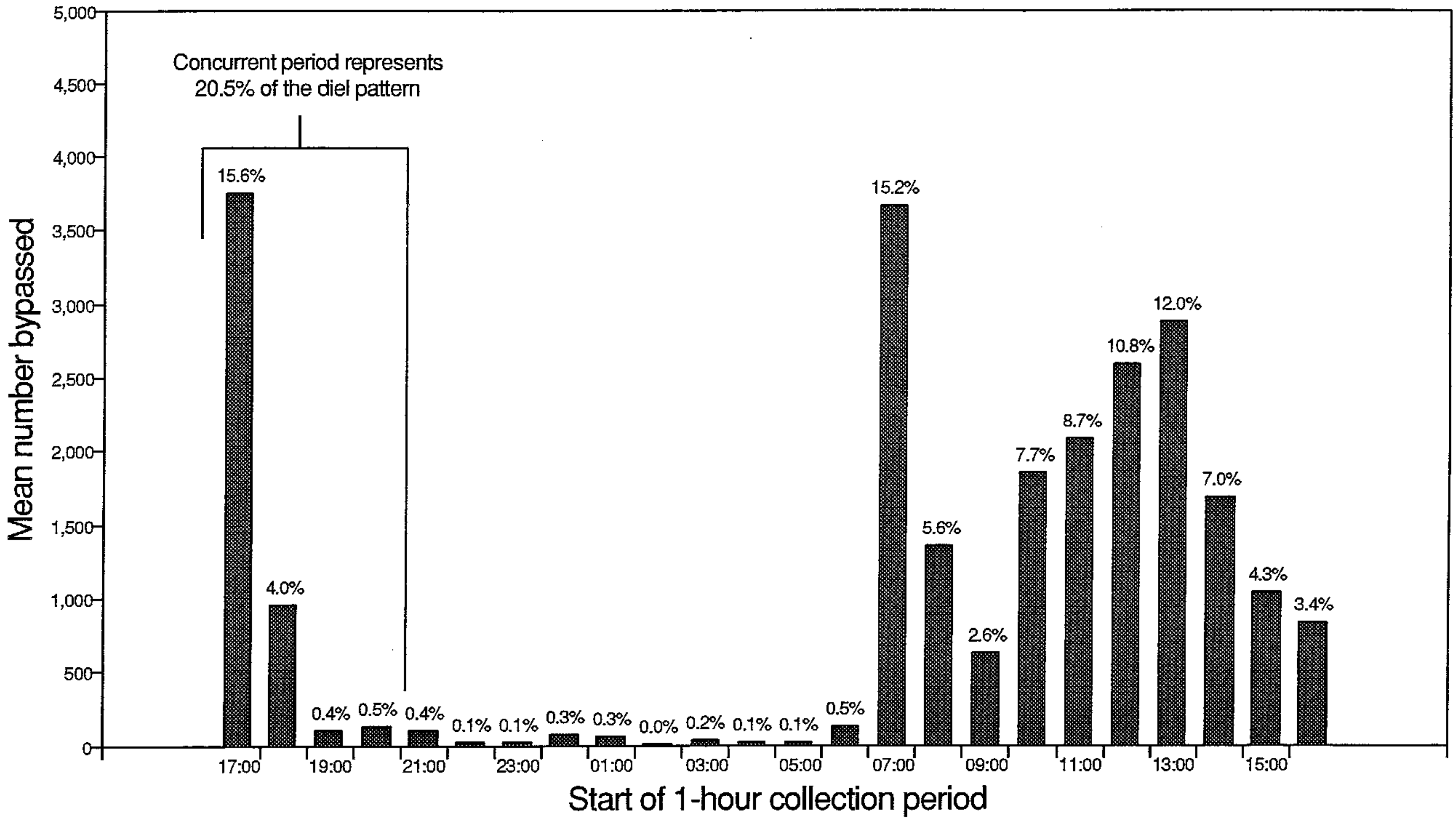


Figure 11. Diel pattern of clupeids bypassing through the log sluice calculated by averaging the number bypassing during 1-hour collections from 11 diel samples on the basis of collection start time.

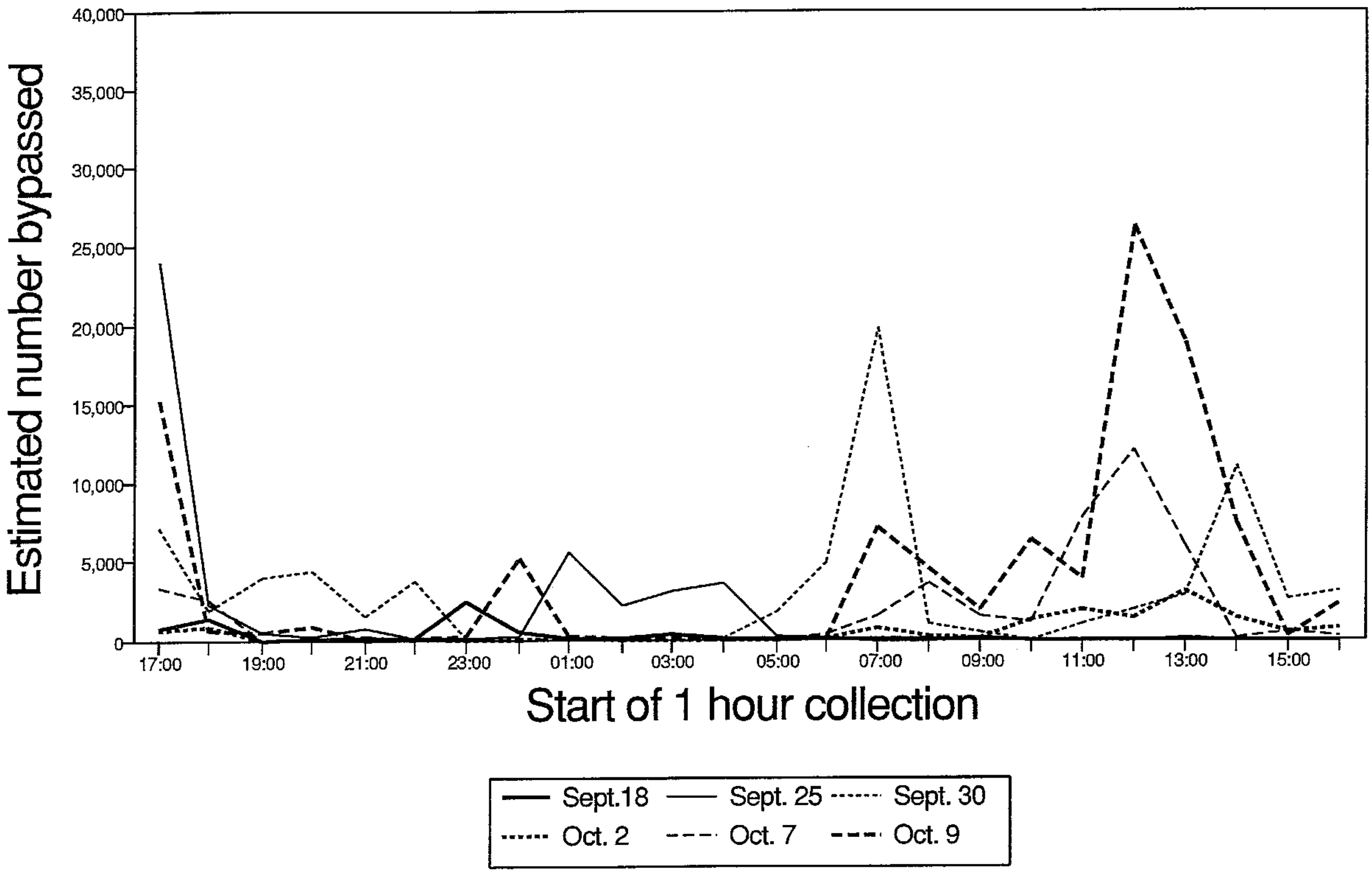


Figure 12. Numbers of clupeids bypassed during six diel log sluice samples from September 18 to October 9, 1992 at Cabot Station.

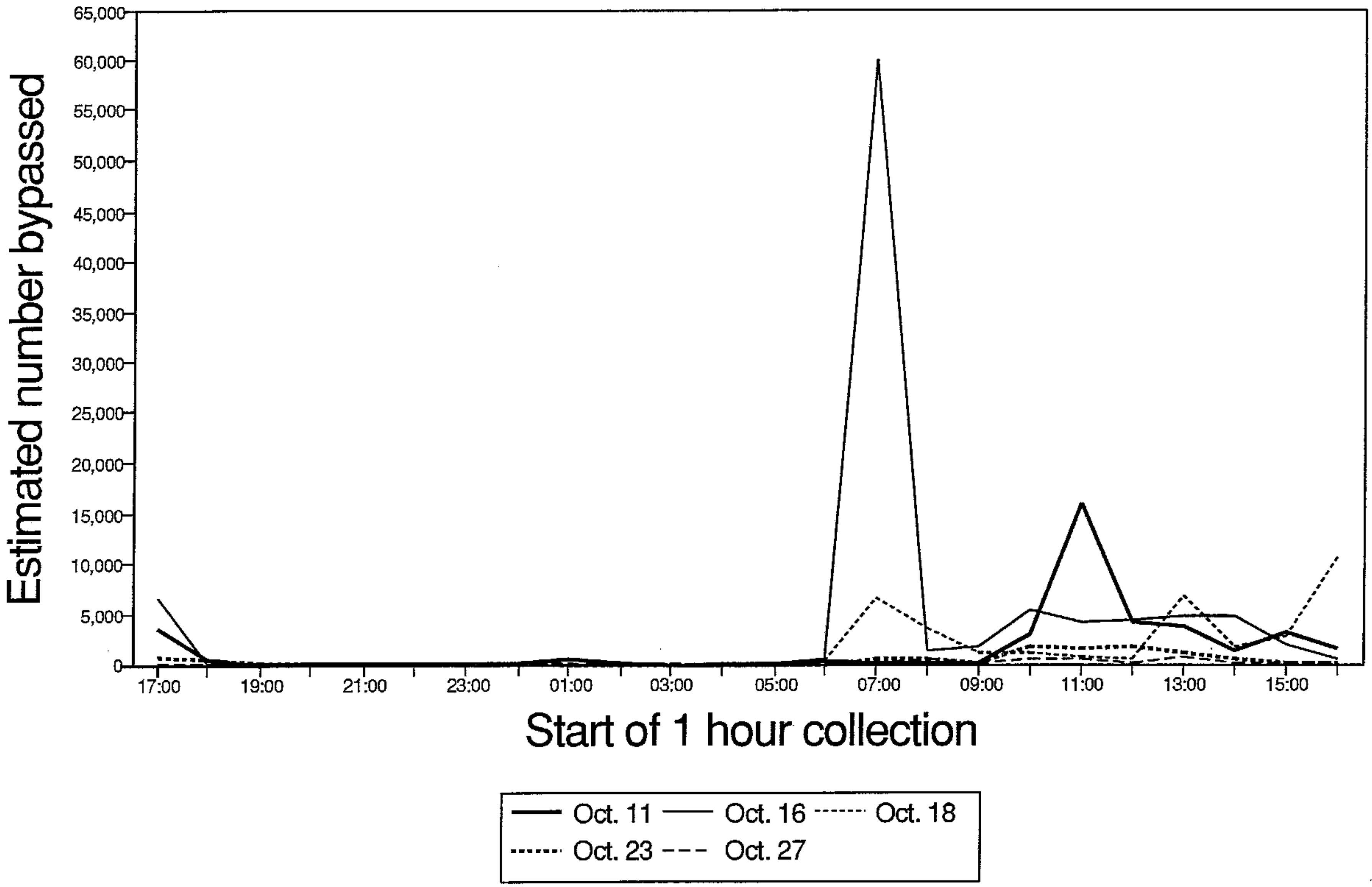


Figure 13. Numbers of clupeids bypassed during five diel log sluice samples from October 11 to October 27, 1992 at Cabot Station.

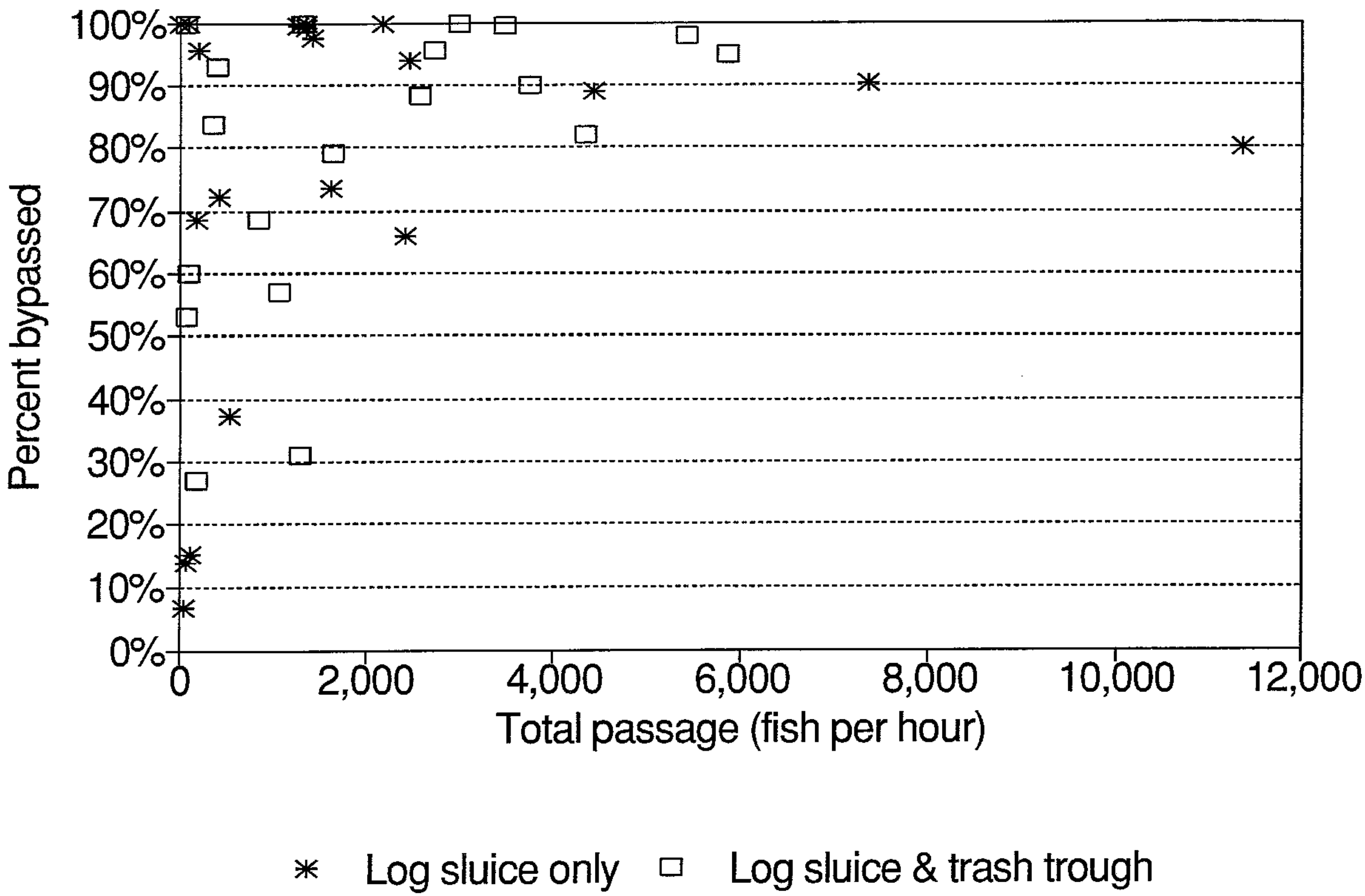


Figure 14. Percent bypassed versus total passage rate for the two bypass conditions at Cabot Station, Fall 1992.

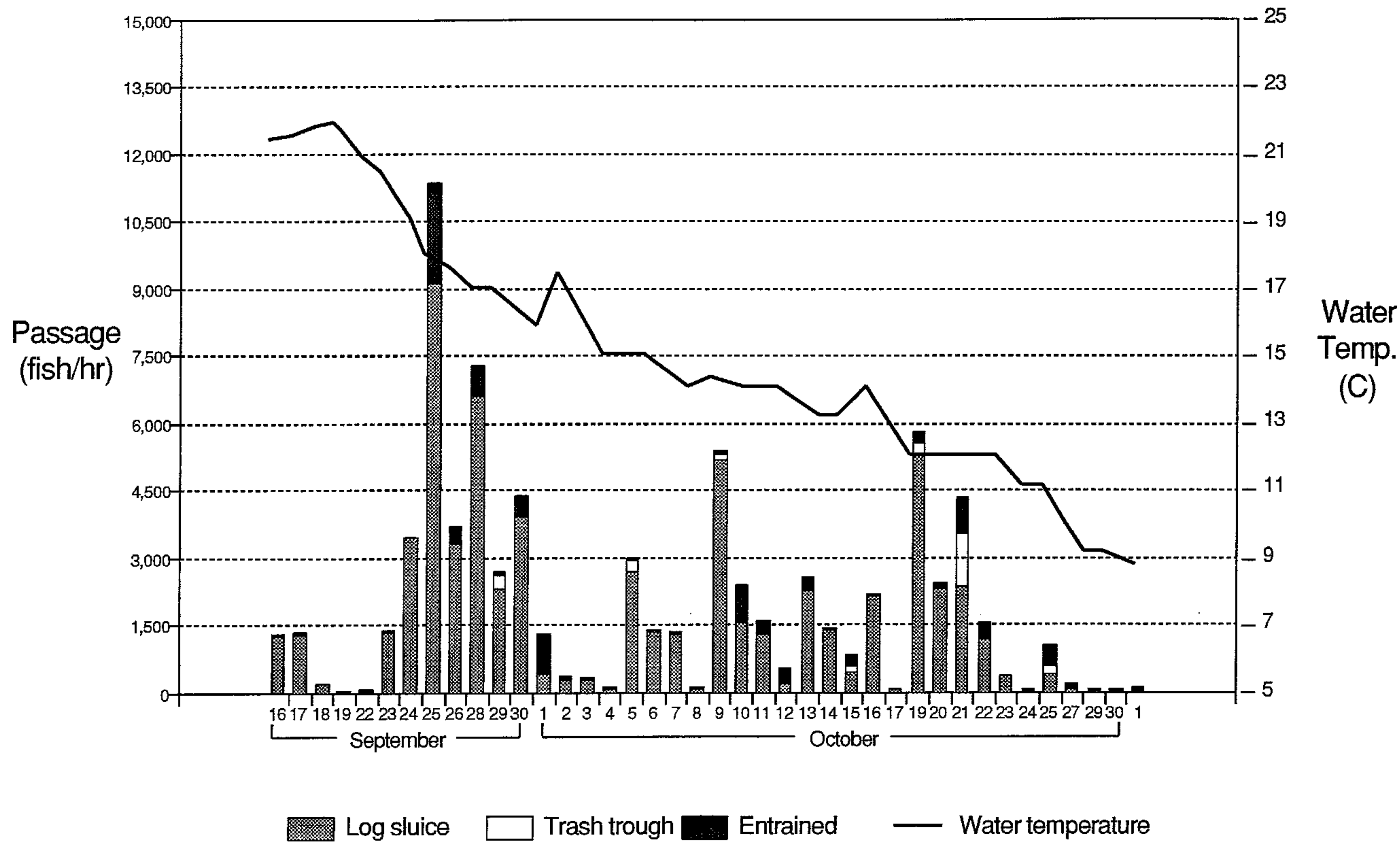


Figure 15. Juvenile clupeid passage versus water temperature at Cabot Station, Fall 1992.

Appendix 1

ANALYTICAL METHODS

Appendix 1. Analytical Methods

Determination of the proportion of fish retained by the turbine intake nets. To estimate the total number of juvenile clupeids entrained through a sampled turbine bay, it was first necessary to estimate the proportion of juvenile clupeids entering the fyke nets that were actually retained by the nets. Tests to determine net retention were conducted using live clupeids that were collected from the log sluice sampler at Cabot Station. The fish were held in a holding facility until they were used in a test. Although the number of mortalities was not recorded, mortality resulting from holding was minimal. Fish remaining in pools after completion of the study were released into the Connecticut River.

Separate tests were conducted for each net. Test fish were marked by staining with Bismark Brown Y biological stain at a concentration of approximately 1:18,750. Two hundred test fish were placed in the stain bath for a period of five minutes and then injected into the net. The test fish were easily distinguished from unmarked fish by the acquired yellow coloration.

An induction system was used to introduce the test specimens into the net mouths. The system consisted of a staining and holding tank (20 gallons), an appropriate length of 4-inch diameter flexible hose, and a pump used to flush the hose (Appendix 1-Figure 1).

The tests were conducted by injecting replicate lots of known numbers of marked clupeids into the immediate vicinity of the net mouth while it was in the fishing position. The nets were left in fishing position for 60 minutes to simulate typical sampling times. Three replicates of 200 clupeids each were included in a test. The percentage of fish retained in the net was then computed.

Determination of log sluice sampler efficiency. Although 100% of the flow into the log sluice was intercepted by the log sluice sampler, the location at which water entered the flume was very turbulent. During high flows, the turbulence was extreme and water would splash out of the sampler. In addition, the crowder used to force fish from the flume was not totally effective. Fish would sometimes pass around the crowder and remain uncounted in the flume. Therefore, to estimate the total number of juvenile clupeids bypassed through the log sluice, it was necessary to determine the capture efficiency of the log sluice sampler.

To estimate the capture efficiency of the log sluice sampler and the process of moving sampled fish onto the sorting table, three replicate groups of 100 live clupeids, stained in 53 ppm Bismark Brown, were released into the sampling device. Previously sampled clupeids taken from the holding facility at Cabot Station were used as test fish. Releases were made by pouring stained fish from a bucket into the log sluice at the point where water spilled through the log sluice bulkhead insert onto the sampler screen. The flume was swept using the crowder at the beginning and end of each replicate release. All fish sampled during a replicate were retained and checked for stain. Replicate sampling periods were 20 minutes in duration. The percent efficiency of the log sluice sampler was then computed as the percent of stained fish that were retained.

Determination of trash trough sampler efficiency. Because of the uneven surface of the trash trough walls, and the presence of a winch device used to lift the trash trough screen, numerous places existed for fish to avoid being sampled. In addition, the location at which water was diverted from the screen into the 12-

inch diameter pipe was extremely turbulent, with water often overflowing into the log sluice. High pond elevations during load change periods created high flows and clogging of the screen by debris which increased overflow. This resulted in the sampler being less than 100% efficient in diverting fish bypassing through the trash trough onto the sorting table. Therefore, to estimate the total number of juvenile clupeids bypassed through the trash trough, it was necessary to determine the efficiency at which the trash trough sampler captured bypassing fish.

To estimate the capture efficiency of the trash trough sampler, three replicate groups of live clupeids, stained in 53 ppm Bismark Brown, were released into the trash trough. Previously sampled clupeids, taken from the holding facility at Cabot Station, were used as test fish. Each replicate of 100 fish was poured from a bucket into the trough directly downstream of the internal trash trough gate and approximately 6 feet upstream of the point where trash trough flow encounters the sampler screen. Replicate sample times were 15 minutes in duration.

All fish flowing onto the sorting table during a replicate were retained and checked for stain. The percent efficiency of the trash trough sampler was then computed as the percent of stained fish that were retained.

<u>Horizontal distributions of fish entering Cabot Station.</u> The pattern of catch rates, adjusted for net retention, in concurrent fyke net collections was the basis for assessing the horizontal distribution of passage through Cabot Station. Unlike the 1991 study (Harza and RMC 1992), during which all six units were in operation for virtually the entire study period, 14 different combinations of units were in operation during the 1992 concurrent sampling, ranging from Unit 1 only, to all six units. Therefore, instead of preparing a single plot of the horizontal

distribution of fish at the intake, 14 plots, one for each combination of units in operation, were generated.

Adjusted catch rates of the fyke nets were arranged on the basis of the combination of units in operation, then averaged to derive a mean estimated entrainment rate per net for each of the different unit combinations. Subsequently, these mean estimated entrainment rates from "sampled" turbine bays were used to linearly interpolate entrainment rates for "non-sampled" turbine bays, resulting in plots showing the pattern of horizontal distribution of entrained fish across the Cabot Station intake for each of the 14 unit combinations.

Estimating entrainment rates of juvenile clupeids through Cabot Station. Estimated rates of entrainment of juvenile clupeids through Cabot Station turbines were based on the number of clupeids captured in concurrent fyke net collections, which were then adjusted for net retention, unsampled intake bays, and for varying collection duration. In general, it was assumed that the numbers of fish passing through the sampled, middle bays of Units 1, 4, and 6, corrected for retention efficiency, was the same as the number of fish passing through the other two bays of the respective intakes. Summarizing the calculations to estimate $N_{E,d,s}$ for the number of fish entrained during a concurrent sample (s) on a given sampling date (d):

$$N_{E,d,s} = \frac{a_o}{a_s} * \sum_{i=1,\ 4,\ and\ 6} [(n_{i,u} * e_{i,u}) + (n_{i,l} * e_{i,l}) * \frac{60}{t_{s,i}}] \qquad (1)$$

where: a_o is the number of bays associated with active turbine/generator units (= 3 * number of operating units); a_s is the number of bays sampled; $n_{i,u}$ and $n_{i,l}$ are the numbers of fish collected in the upper (u) and lower (l) nets of the net assembly in each sampled intake bay (i); and $e_{i,u}$ and $e_{i,l}$ are the respective retention efficiencies. The other terms are as defined for Eq. 2. When the unit associated with one of the net assemblies was not in operation, t_s and n_i was equal to zero. The total number of fish entrained during the concurrent sampling (N_E), then, is calculated as:

$$N_E = \sum_{d=1}^{40} \sum_{s=1}^{4} N_{E,d,s} \qquad (2)$$

The numbers entrained during concurrent collections occuring on the same day were averaged, giving a mean entrainment rate for that day.

Estimating bypass rates of juvenile clupeids through the log sluice and trash trough. Estimated rates of bypass were based on the estimated number of clupeids captured during concurrent log sluice and trash trough collections, which were then adjusted for gear efficiency and varying collection duration. The numbers of juvenile clupeids bypassing during concurrent collections were derived using the following equation:

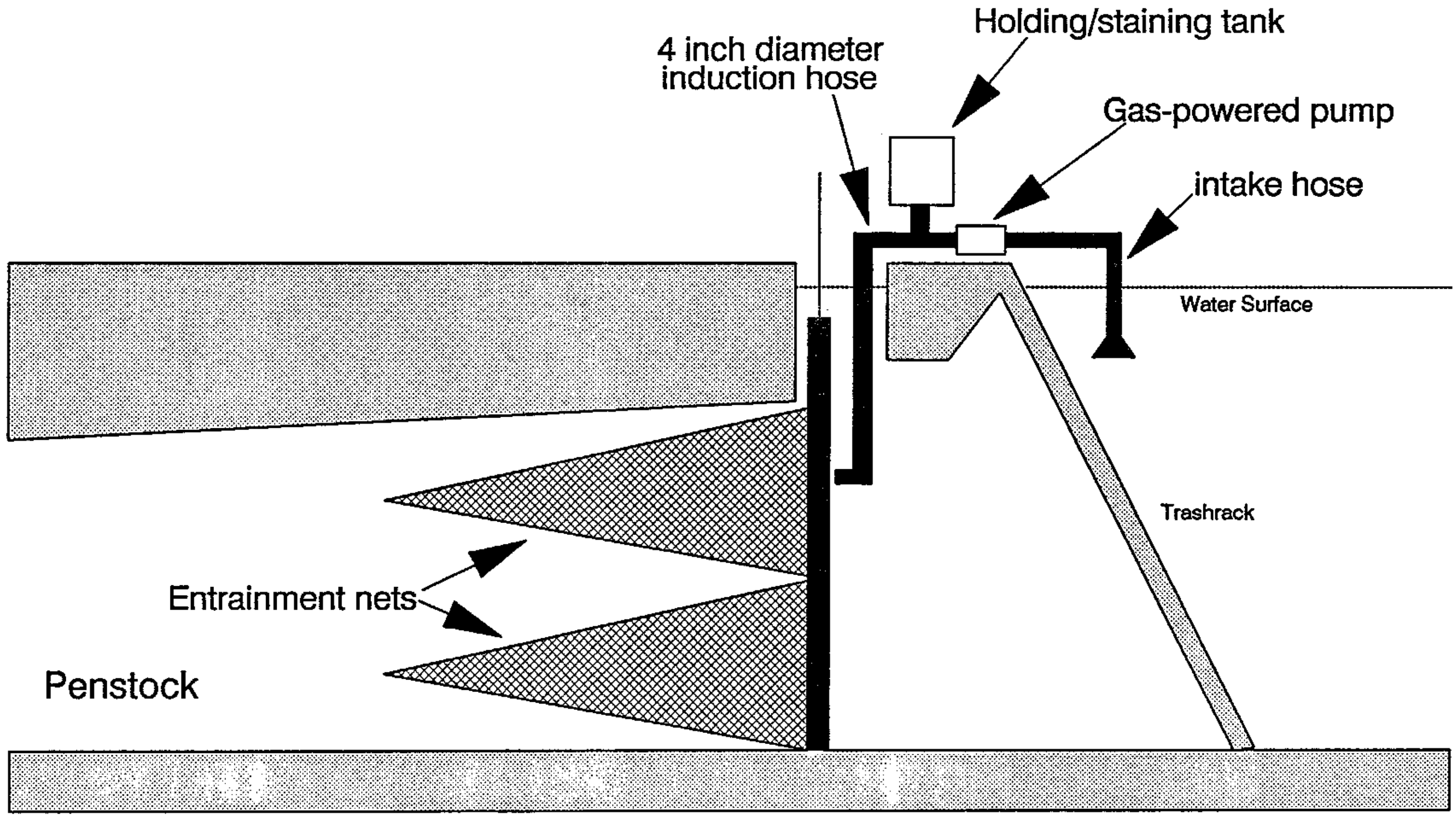
$$N_{bypass} = N_{LS} + N_{TT}$$

Where N_{bypass} is the total number bypassing during a collection; N_{LS} is the number of juvenile clupeids collected in the log sluice sampler adjusted for gear efficiency; and N_{TT} is the number of juvenile clupeids collected in the trash trough sampler adjusted for gear efficiency. The total number bypassing during a collection was then multiplied by the proportion of one hour that the collection period represented, giving the total rate of bypass (fish per hour) for the collection. Bypass rates for individual collections were then averaged within days to give a total estimated bypass rate for that day.

Determining species composition. To develop separate estimates of bypass and entrainment for American shad and blueback herring, the proportions of shad and herring in the subsamples of 100 clupeids from each collection were determined. For each collection, the catch of each species was then estimated by multiplying the total number of clupeids by the observed proportion of that species.

Estimating the diel pattern of fish passage through the log sluice. Eleven diel log sluice samples were conducted during the study period. Diel sampling occurred one to two times per week throughout the study. Diel log sluice sampling began at 21:00 hours, at the conclusion of daily concurrent sampling, and continued around the clock until the beginning of the next days' concurrent sampling at 17:00 hours. Individual collections during a diel sample typically began and ended at the top of the hour, and were one hour in duration. A subsample of 100 juvenile clupeids was taken from each collection, and identified to species.

Catch rates for the collections were calculated, then adjusted, using the log sluice sampler efficiency value, to estimate bypass rates during the hour-long collections. Hourly bypass rates from the eleven groups of collections were then combined and averaged according to the beginning time of the collections, resulting in a mean bypass rate for each hour-long period of the diel sample. The number bypassed during the concurrent sampling period (17:00 hours to 21:00 hours), obtained from concurrent log sluice sampling data plus the counts of clupeids bypassing during the intermediate periods between concurrent collections, was then included to obtain a 24-hour diel pattern of fish bypassing through the log sluice.



Appendix 1-Figure 1. Design of induction system used to induce juvenile clupeids into the penstocks during net retention tests at Cabot Station, Fall 1992.

Appendix 2
GEAR CALIBRATION TEST RESULTS

Appendix 2. Gear Calibration Tests

Entrainment fyke nets were tested for net retention on three occasions during the study. Each test consisted of three replicate releases of 200 stained fish, with the exception of tests performed on turbine unit 1, top net, on Oct. 5, when the net sustained significant damage during the third replicate. Results of fyke net retention tests are summarized in Appendix 2-Table 1.

To determine whether fyke net retention was consistent throughout the study, several statistical analyses were performed on the net retention test results. Significant differences among net retentions with time or depth at which the net was fished requires net retention proportions to be calculated separately for each time or depth. All statistical tests of net retention were performed on arcsine transformed net retention proportion data. Proportion data is known to be binomially distributed, and the arcsine transformation allows the proportion data to more closely conform to the assumptions of the parametric statistical tests used to analyze the sampling data. Significant differences were observed between sampling times for the proportion of marked fish retained during the three tests at Turners Falls. The mean percentages of marked fish retained were 52.8%, 66.6% and 70.1%, respectively for the three time periods tested. Analysis of variance (ANOVA) of the arcsine transformed retention proportions were used to calculate the significance of the retention proportion differences among marked fish release times ($N = 53$, $F = 4.702$, $P = 0.013$). A subsequent Tukey's HSD test on the retention means showed that the proportion of fish retained during the first test period (52.8%) was significantly lower than the retention proportion during both the second ($P = 0.018$) and third periods ($P = 0.005$). No significant difference was observed between net retention during the second and third test periods ($P = 0.581$).

No significant differences were noted between the proportion of fish retained in the top nets and the bottom nets (ANOVA, N = 53, F = 2.464, P = 0.123). The mean proportions retained during all net calibration tests were 59.5% for the top nets and 67.0% for the bottom nets.

As a result of the significant difference in the net retention between the first test period and the second and third test periods, fyke net sampling data collected during the study was divided into two strata, with the partition being the midpoint between each net's first test period date and it's second test period date. Fyke net catch rates in the first data stratum were divided by the pooled efficiency from the first test period replicates, yielding adjusted catch rates. Fyke net catch rates in the second data stratum were divided by the pooled efficiency from the second and third test period replicates. Pooling of fyke net retention test results and data partitioning is summarized in Appendix 2-Table 2. The resulting adjusted catch rates per fyke net per collection are displayed in Appendix 5-Table 3.

Log sluice sampling gear efficiency tests were conducted three times during the study. Each test consisted of three replicates releases of 100 stained clupeids. Results of the individual replicates of each efficiency test are displayed in Appendix 2-Table 1.

Gear efficiencies varied significantly over the three dates the log sluice sampler was tested (ANOVA, N = 9, F = 8.897, P = 0.016). Means of the three different dates on which log sluice gear efficiency was tested were 81.0% on September 19, 1992, 95.7% on September 26, 1992 and 100.0% on October 15, 1992. As two of the individual replicates recaptured more than 100% of the marked fish released (indicating that fish released during a previous replicate were passing through the log sluice), the raw recapture data was transformed by subtracting four fish from all replicate tests. This was necessary so that the recapture proportions could be arcsine transformed for the analysis of variance. A Tukey's HSD test indicated that the bypass efficiency for the test performed on September 19th was significantly lower (P = 0.014) than the test performed on October 15th. No other significant differences among dates were observed.

As a result of the significant difference in gear efficiency between the first and third test periods, log sluice sampling data collected during the study was divided into three strata, with the partitions being the midpoint between the first and second test period dates, and the second and third test period dates. Pooling of gear efficiency replicates and data partitioning is summarized in Appendix 2-Table 2. To estimate total number bypassing during a given collection, collections occurring in the first data stratum were divided by 0.810, collections occurring in the second data stratum were divided by 0.957, and collections occurring in the third data stratum were divided by 1.000.

The trash trough sampler was tested for gear efficiency on five occasions throughout the study period. Each test consisted of three replicate releases of 100 stained clupeids. Results of each replicate from each efficiency test are displayed in Appendix 2-Table 1.

Analysis of variance found no significant differences in gear efficiency over time with the trash trough sampler (N = 15, F = 1.762, P = 0.213). The group means of the five different dates on which the trash trough sampler efficiency was tested were 23.7%, 18.3%, 19.0%, 11.7% and 18.0%. The pooled efficiency for the five trash trough tests was 18.1%. Based on these tests each trash trough collection was divided by 0.181 to estimate number bypassing during that collection.

Appendix 2-Table 1. Results of gear calibration tests.

Device	Date	Replicate	Number released	Total recaptures
Unit 1, top net	10/05/92	1	200	93
Unit 1, top net	10/05/92	2	200	117
			400	210
Unit 1, top net	10/13/92	1	200	151
Unit 1, top net	10/13/92	2	200	180
Unit 1, top net	10/13/92	3	200	161
Unit 1, top net	10/20/92	1	200	161
Unit 1, top net	10/20/92	2	200	150
Unit 1, top net	10/20/92	3	200	154
			1200	957
Unit 1, bottom net	10/09/92	1	200	72
Unit 1, bottom net	10/09/92	2	200	82
Unit 1, bottom net	10/09/92	3	200	108
			600	262
Unit 1, bottom net	10/13/92	1	200	95
Unit 1, bottom net	10/13/92	2	200	99
Unit 1, bottom net	10/13/92	3	200	80
Unit 1, bottom net	10/20/92	1	200	159
Unit 1, bottom net	10/20/92	2	200	163
Unit 1, bottom net	10/20/92	3	200	141
			1200	737
Unit 4, top net	10/06/92	1	200	75
Unit 4, top net	10/06/92	2	200	109
Unit 4, top net	10/06/92	3	200	136
			600	320
Unit 4, top net	10/14/92	1	200	99
Unit 4, top net	10/14/92	2	200	150
Unit 4, top net	10/14/92	3	200	123
Unit 4, top net	10/21/92	1	200	146
Unit 4, top net	10/21/92	2	200	123
Unit 4, top net	10/21/92	3	200	132
			1200	773
Unit 4, bottom net	10/06/92	1	200	122
Unit 4, bottom net	10/06/92	2	200	109
Unit 4, bottom net	10/06/92	3	200	91
			600	322

Appendix 2-Table 1. (Continued).

Device	Date	Replicate	Number released	Total recaptures
Unit 4, bottom net	10/16/92	1	200	161
Unit 4, bottom net	10/16/92	2	200	156
Unit 4, bottom net	10/16/92	3	200	176
Unit 4, bottom net	10/21/92	1	200	100
Unit 4, bottom net	10/21/92	2	200	188
Unit 4, bottom net	10/21/92	3	200	184
			1200	965
Unit 6, top net	10/07/92	1	200	72
Unit 6, top net	10/07/92	2	200	114
Unit 6, top net	10/07/92	4	200	65
			600	251
Unit 6, top net	10/15/92	1	200	148
Unit 6, top net	10/15/92	2	200	45
Unit 6, top net	10/15/92	3	200	117
Unit 6, top net	10/22/92	1	200	152
Unit 6, top net	10/22/92	2	200	24
Unit 6, top net	10/22/92	3	200	98
			1200	584
Unit 6, bottom net	10/08/92	1	200	135
Unit 6, bottom net	10/08/92	2	200	171
Unit 6, bottom net	10/08/92	3	200	123
			600	429
Unit 6, bottom net	10/15/92	1	200	156
Unit 6, bottom net	10/15/92	2	200	146
Unit 6, bottom net	10/15/92	3	200	153
Unit 6, bottom net	10/23/92	1	200	157
Unit 6, bottom net	10/23/92	2	200	158
Unit 6, bottom net	10/23/92	3	200	133
			1200	903

Appendix 2-Table 1. (Continued).

Device	Date	Replicate	Number released	Total recaptures
Trash trough	09/22/92	1	100	14
Trash trough	09/22/92	2	100	35
Trash trough	09/22/92	3	100	22
Trash trough	10/05/92	1	100	19
Trash trough	10/05/92	2	100	21
Trash trough	10/05/92	3	100	15
Trash trough	10/13/92	1	100	23
Trash trough	10/13/92	2	100	18
Trash trough	10/13/92	3	100	16
Trash trough	10/26/92	1	100	14
Trash trough	10/26/92	2	100	7
Trash trough	10/26/92	3	100	14
Trash trough	10/29/92	1	100	13
Trash trough	10/29/92	2	100	20
Trash trough	10/29/92	3	100	21
			1500	272
Log sluice	09/19/92	1	100	79
Log sluice	09/19/92	2	100	81
Log sluice	09/19/92	3	100	83
			300	243
Log sluice	09/26/92	1	100	99
Log sluice	09/26/92	2	100	92
Log sluice	09/26/92	3	100	96
			300	287
Log sluice	10/15/92	1	100	94
Log sluice	10/15/92	2	100	104
Log sluice	10/15/92	3	100	102
			300	300

Appendix 2-Table 2. Summary of results of gear calibration tests performed at Cabot Station during Fall, 1992.

Device	Test Date(s)	Number of Replicates	Number released	Total recaptures	Pooled efficiency	Data stratum
Unit 1, top net	Oct. 5	2	400	210	52.5%	Sept. 16-Oct. 8
Unit 1, top net	Oct. 13 & 20	6	1200	957	79.8%	Oct. 9-Nov. 1
Unit 1, bottom net	Oct. 9	3	600	262	43.7%	Sept. 16-Oct. 10
Unit 1, bottom net	Oct. 13 & 20	6	1200	737	61.4%	Oct. 11-Nov. 1
Unit 4, top net	Oct. 6	3	600	320	53.3%	Sept. 16-Oct. 9
Unit 4, top net	Oct. 14 & 21	6	1200	773	64.4%	Oct. 10-Nov. 1
Unit 4, bottom net	Oct. 6	3	600	322	53.7%	Sept. 16-Oct. 10
Unit 4, bottom net	Oct. 16 & 21	6	1200	965	80.4%	Oct. 11-Nov. 1
Unit 6, top net	Oct. 7	3	600	251	41.8%	Sept. 16-Oct. 10
Unit 6, top net	Oct. 15 & 22	6	1200	584	48.7%	Oct. 11-Nov. 1
Unit 6, bottom net	Oct. 8	3	600	429	71.5%	Sept. 16-Oct. 11
Unit 6, bottom net	Oct. 15 & 23	6	1200	903	75.3%	Oct. 12-Nov. 1
Trash trough	Sept. 22, Oct. 5,13,26, & 29	15	1500	272	18.1%	Sept. 16-Nov. 1
Log sluice	Sept. 19	3	300	243	81.0%	Sept. 16-Sept. 22
Log sluice	Sept. 26	3	300	287	95.7%	Sept. 23-Oct. 5
Log sluice	Oct. 15	3	300	300	100.0%	Oct. 6-Nov. 1

Appendix 3
LOG SLUICE SAMPLING DATA

Appendix 3-Table 1. Numbers captured during concurrent and intermediate log sluice collections.

Sampling device	Start date	Start time	End time	Total clupeids	Bluebacks subsampled	Am shad subsampled	Catch adjusted for gear efficiency
Log sluice	16-Sep	17:00	17:10	5	0	1	6
Log sluice	16-Sep	17:10	18:13	2,079	4	102	2567
Log sluice	16-Sep	18:13	18:57	2,790	0	0	3444
Log sluice	16-Sep	18:57	20:03	87	0	7	107
Log sluice	16-Sep	20:03	20:12	1	0	0	1
Log sluice	17-Sep	17:02	17:08	0	0	0	0
Log sluice	17-Sep	17:08	18:08	0	0	0	0
Log sluice	17-Sep	18:08	18:19	0	0	0	0
Log sluice	17-Sep	18:19	19:19	2,890	27	79	3568
Log sluice	17-Sep	19:19	20:01	362	0	0	447
Log sluice	17-Sep	20:01	21:01	362	11	106	447
Log sluice	17-Sep	21:01	21:15	4	0	0	5
Log sluice	18-Sep	16:57	17:09	0	0	0	0
Log sluice	18-Sep	17:09	18:15	559	12	95	690
Log sluice	18-Sep	18:15	18:58	1,116	0	0	1378
Log sluice	18-Sep	18:58	20:04	0	0	0	0
Log sluice	18-Sep	20:04	20:57	5	0	0	6
Log sluice	19-Sep	17:06	18:06	0	0	0	0
Log sluice	19-Sep	18:06	18:18	0	0	0	0
Log sluice	19-Sep	18:18	19:18	0	0	0	0
Log sluice	19-Sep	19:18	19:32	0	0	0	0
Log sluice	19-Sep	19:32	20:10	3	0	3	4
Log sluice	19-Sep	20:10	20:22	7	0	7	9
Log sluice	19-Sep	20:22	21:15	54	0	54	67
Log sluice	22-Sep	17:00	17:13	1,694	0	0	2091
Log sluice	22-Sep	17:13	18:25	112	11	101	138
Log sluice	22-Sep	18:25	18:54	4,500	0	0	5556
Log sluice	22-Sep	18:54	20:00	110	0	110	136
Log sluice	22-Sep	20:00	20:45	5	0	0	6
Log sluice	22-Sep	20:45	21:35	3	0	0	4
Log sluice	23-Sep	15:25	17:08	7,650	0	0	7997
Log sluice	23-Sep	17:08	18:23	4,729	9	92	4943
Log sluice	23-Sep	18:23	19:02	5,100	0	0	5331
Log sluice	23-Sep	19:02	20:03	20	2	18	21
Log sluice	23-Sep	20:03	20:40	1	0	0	1
Log sluice	23-Sep	20:40	21:40	100	1	99	105
Log sluice	24-Sep	16:50	17:10	400	0	0	418
Log sluice	24-Sep	17:10	18:12	3,834	36	69	4008
Log sluice	24-Sep	18:12	18:40	1,640	0	0	1714
Log sluice	24-Sep	18:40	19:40	2,848	14	85	2977
Log sluice	24-Sep	19:40	20:13	720	0	0	753

Appendix 3-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Total clupeids	Bluebacks subsampled	Am shad subsampled	Catch adjusted for gear efficiency
Log sluice	24-Sep	20:13	21:13	3,291	29	73	3440
Log sluice	25-Sep	17:00	17:10	5,000	0	0	5226
Log sluice	25-Sep	17:10	18:13	17,947	11	91	18760
Log sluice	25-Sep	18:13	18:51	2,150	0	0	2247
Log sluice	25-Sep	18:51	20:04	462	0	100	483
Log sluice	25-Sep	20:04	21:00	230	0	0	240
Log sluice	26-Sep	17:00	17:07	81	0	0	85
Log sluice	26-Sep	17:07	18:07	2,868	25	89	2998
Log sluice	26-Sep	18:07	18:31	1,600	0	0	1672
Log sluice	26-Sep	18:31	19:31	6,239	5	98	6522
Log sluice	26-Sep	19:31	20:06	153	0	0	160
Log sluice	26-Sep	20:06	21:06	472	0	0	493
Log sluice	28-Sep	16:55	17:00	4,800	0	0	5017
Log sluice	28-Sep	17:08	18:09	18,545	14	95	19385
Log sluice	28-Sep	18:09	18:57	6,700	0	0	7003
Log sluice	28-Sep	18:57	19:57	37	0	0	39
Log sluice	28-Sep	19:57	20:28	270	0	0	282
Log sluice	28-Sep	20:28	21:28	784	7	122	820
Log sluice	29-Sep	17:02	17:14	1,000	0	0	1045
Log sluice	29-Sep	17:14	18:16	3,844	65	36	4018
Log sluice	29-Sep	18:16	18:39	1,606	0	0	1679
Log sluice	29-Sep	18:39	19:39	2,730	6	91	2854
Log sluice	29-Sep	19:39	20:11	430	0	0	449
Log sluice	29-Sep	20:11	21:11	88	5	49	92
Log sluice	30-Sep	17:00	17:07	0	0	0	0
Log sluice	30-Sep	17:07	18:08	6,725	42	61	7030
Log sluice	30-Sep	18:08	18:33	1,850	0	0	1934
Log sluice	30-Sep	18:33	19:44	3,783	32	80	3954
Log sluice	30-Sep	19:44	20:24	2,550	0	0	2666
Log sluice	30-Sep	20:24	21:28	1,578	9	93	1649
Log sluice	01-Oct	17:00	17:04	50	0	0	52
Log sluice	01-Oct	17:04	18:04	594	20	90	621
Log sluice	01-Oct	18:04	18:18	28	0	0	29
Log sluice	01-Oct	18:18	19:18	449	10	43	469
Log sluice	01-Oct	19:18	19:35	9	0	0	9
Log sluice	01-Oct	19:35	20:39	61	12	49	64
Log sluice	01-Oct	20:39	20:45	4	0	0	4
Log sluice	02-Oct	16:58	17:01	0	0	0	0
Log sluice	02-Oct	17:01	18:01	492	14	96	514
Log sluice	02-Oct	18:01	18:12	409	0	0	428
Log sluice	02-Oct	18:12	19:12	409	10	52	428

Appendix 3-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Total clupeids	Bluebacks subsampled	Am shad subsampled	Catch adjusted for gear efficiency
Log sluice	02-Oct	19:12	19:22	0	0	0	0
Log sluice	02-Oct	19:22	20:22	0	0	0	0
Log sluice	02-Oct	20:22	21:00	10	0	0	10
Log sluice	03-Oct	17:00	18:00	639	12	93	668
Log sluice	03-Oct	18:00	18:10	29	0	0	30
Log sluice	03-Oct	18:10	19:10	158	27	73	165
Log sluice	03-Oct	19:10	19:20	10	0	0	10
Log sluice	03-Oct	19:20	20:20	73	28	45	76
Log sluice	03-Oct	20:20	20:27	70	0	0	73
Log sluice	04-Oct	17:00	18:00	337	33	67	352
Log sluice	04-Oct	18:00	18:26	388	0	0	406
Log sluice	04-Oct	18:26	19:26	21	5	16	22
Log sluice	04-Oct	19:26	19:56	3	0	0	3
Log sluice	04-Oct	19:56	20:56	0	0	0	0
Log sluice	05-Oct	17:15	18:15	7,638	28	71	7984
Log sluice	05-Oct	18:15	18:32	75	0	0	78
Log sluice	05-Oct	18:32	18:53	41	6	35	43
Log sluice	05-Oct	19:32	19:53	0	0	0	0
Log sluice	05-Oct	19:53	20:53	65	2	63	68
Log sluice	06-Oct	16:55	17:00	0	0	0	0
Log sluice	06-Oct	17:00	18:00	2,780	12	94	2780
Log sluice	06-Oct	18:00	18:11	885	0	0	885
Log sluice	06-Oct	18:11	19:11	1,342	24	114	1342
Log sluice	06-Oct	19:11	19:33	19	0	0	19
Log sluice	06-Oct	19:33	20:33	1	0	1	1
Log sluice	07-Oct	16:55	17:55	3,307	22	100	3307
Log sluice	07-Oct	17:55	18:14	1,900	0	0	1900
Log sluice	07-Oct	18:14	19:14	577	16	86	577
Log sluice	07-Oct	19:14	19:38	0	0	0	0
Log sluice	07-Oct	19:38	20:38	50	0	0	50
Log sluice	07-Oct	20:38	21:00	0	0	0	0
Log sluice	08-Oct	17:00	18:00	74	8	66	74
Log sluice	08-Oct	18:00	18:10	46	0	0	46
Log sluice	08-Oct	18:10	19:10	47	0	0	47
Log sluice	08-Oct	19:10	19:29	0	0	0	0
Log sluice	08-Oct	19:29	20:29	191	11	84	191
Log sluice	09-Oct	17:06	18:06	15,181	6	101	15181
Log sluice	09-Oct	18:06	18:32	595	0	0	595
Log sluice	09-Oct	18:32	19:32	414	4	98	414
Log sluice	09-Oct	19:32	19:57	12	0	0	12
Log sluice	09-Oct	19:57	20:57	32	0	29	32

Appendix 3-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Total clupeids	Bluebacks subsampled	Am shad subsampled	Catch adjusted for gear efficiency
Log sluice	09-Oct	20:57	21:00	751	1	106	751
Log sluice	10-Oct	17:00	17:17	900	0	0	900
Log sluice	10-Oct	17:17	18:22	4,917	6	110	4917
Log sluice	10-Oct	18:22	19:08	40	0	0	40
Log sluice	10-Oct	19:08	19:48	114	0	101	114
Log sluice	10-Oct	19:48	20:25	53	0	0	53
Log sluice	10-Oct	20:25	21:05	54	0	46	54
Log sluice	11-Oct	17:00	17:10	0	0	0	0
Log sluice	11-Oct	17:10	17:51	3,524	11	89	3524
Log sluice	11-Oct	17:51	18:20	565	0	0	565
Log sluice	11-Oct	18:20	19:00	8	0	0	8
Log sluice	11-Oct	19:00	19:28	0	0	0	0
Log sluice	11-Oct	19:28	20:08	0	0	0	0
Log sluice	11-Oct	20:08	20:32	0	0	0	0
Log sluice	11-Oct	20:32	21:13	31	0	31	31
Log sluice	12-Oct	17:00	17:06	50	0	0	50
Log sluice	12-Oct	17:06	18:07	504	23	81	504
Log sluice	12-Oct	18:07	18:37	6	0	0	6
Log sluice	12-Oct	18:37	19:37	42	1	41	42
Log sluice	12-Oct	19:37	20:15	19	0	0	19
Log sluice	12-Oct	20:15	21:15	83	1	82	83
Log sluice	13-Oct	17:00	17:16	1,117	1	0	1117
Log sluice	13-Oct	17:16	18:16	6,501	10	93	6501
Log sluice	13-Oct	18:16	18:48	4	0	0	4
Log sluice	13-Oct	18:48	19:48	141	1	99	141
Log sluice	13-Oct	19:48	20:14	69	0	0	69
Log sluice	13-Oct	20:14	21:14	114	0	96	114
Log sluice	14-Oct	16:55	17:00	0	0	0	0
Log sluice	14-Oct	17:00	18:00	3,008	0	0	3008
Log sluice	14-Oct	18:00	18:24	104	0	0	104
Log sluice	14-Oct	18:24	19:27	379	0	0	379
Log sluice	14-Oct	19:27	20:00	14	14	0	14
Log sluice	14-Oct	20:00	21:05	910	19	96	910
Log sluice	15-Oct	17:25	17:52	1	0	0	1
Log sluice	15-Oct	17:52	18:52	545	9	85	545
Log sluice	15-Oct	18:52	19:28	105	0	0	105
Log sluice	15-Oct	19:28	20:28	390	1	98	390
Log sluice	16-Oct	17:05	17:08	32	0	0	32
Log sluice	16-Oct	17:08	18:08	6,503	17	111	6503
Log sluice	16-Oct	18:08	18:30	45	0	0	45
Log sluice	16-Oct	18:30	19:30	31	1	30	31

Appendix 3-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Total clupeids	Bluebacks subsampled	Am shad subsampled	Catch adjusted for gear efficiency
Log sluice	16-Oct	19:30	20:00	7	0	0	7
Log sluice	16-Oct	20:00	21:00	1	0	1	1
Log sluice	17-Oct	17:00	17:09	70	0	0	70
Log sluice	17-Oct	17:09	18:09	108	3	105	108
Log sluice	17-Oct	18:09	18:28	84	0	0	84
Log sluice	17-Oct	18:28	19:28	24	0	24	24
Log sluice	17-Oct	19:28	19:47	7	0	7	7
Log sluice	17-Oct	19:47	20:29	0	0	0	0
Log sluice	18-Oct	17:10	18:00	0	0	0	0
Log sluice	18-Oct	18:00	19:00	2	0	0	2
Log sluice	18-Oct	19:00	20:00	32	0	32	32
Log sluice	18-Oct	20:00	21:00	26	0	26	26
Log sluice	19-Oct	17:00	17:11	1,750	0	0	1750
Log sluice	19-Oct	17:11	17:41	7,888	1	104	7888
Log sluice	19-Oct	17:41	18:05	6	0	0	6
Log sluice	19-Oct	18:05	19:05	83	1	82	83
Log sluice	19-Oct	19:05	19:44	105	0	0	105
Log sluice	19-Oct	19:44	20:46	144	1	143	144
Log sluice	20-Oct	16:56	17:07	700	0	0	700
Log sluice	20-Oct	17:07	18:07	6,790	2	101	6790
Log sluice	20-Oct	18:07	18:44	233	0	0	233
Log sluice	20-Oct	18:44	19:44	128	2	98	128
Log sluice	20-Oct	19:44	20:19	684	0	0	684
Log sluice	20-Oct	20:19	21:19	35	0	29	35
Log sluice	21-Oct	16:30	17:07	3,323	0	0	3323
Log sluice	21-Oct	17:07	18:10	6,529	0	106	6529
Log sluice	21-Oct	18:10	18:55	569	0	0	569
Log sluice	21-Oct	18:55	19:59	531	4	97	531
Log sluice	21-Oct	19:59	20:44	534	0	0	534
Log sluice	21-Oct	20:41	21:21	228	0	103	228
Log sluice	22-Oct	15:45	16:44	5,700	0	0	5700
Log sluice	22-Oct	16:44	17:44	3,432	0	103	3432
Log sluice	22-Oct	17:44	18:16	176	1	0	176
Log sluice	22-Oct	18:16	19:16	16	0	16	16
Log sluice	22-Oct	19:16	19:39	74	0	0	74
Log sluice	22-Oct	19:39	20:43	105	1	84	105
Log sluice	23-Oct	16:00	17:05	128	0	0	128
Log sluice	23-Oct	17:05	18:05	682	6	84	682
Log sluice	23-Oct	18:05	18:26	5	0	0	5
Log sluice	23-Oct	18:26	19:26	395	4	89	395
Log sluice	23-Oct	19:26	20:00	46	0	0	46

Appendix 3-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Total clupeids	Bluebacks subsampled	Am shad subsampled	Catch adjusted for gear efficiency
Log sluice	23-Oct	20:00	21:03	9	0	2	9
Log sluice	24-Oct	17:00	17:11	0	0	0	0
Log sluice	24-Oct	17:11	18:11	0	0	0	0
Log sluice	24-Oct	18:11	18:41	3	0	0	3
Log sluice	24-Oct	18:41	19:50	10	0	10	10
Log sluice	25-Oct	16:00	16:21	95	0	0	95
Log sluice	25-Oct	16:21	17:22	500	1	77	500
Log sluice	25-Oct	17:22	17:56	154	0	0	154
Log sluice	25-Oct	17:56	18:58	264	0	101	264
Log sluice	25-Oct	18:58	19:30	86	0	0	86
Log sluice	25-Oct	19:30	20:33	454	1	106	454
Log sluice	26-Oct	17:13	18:16	32,832	3	105	32832
Log sluice	26-Oct	18:16	18:50	22,300	0	0	22300
Log sluice	26-Oct	18:50	19:52	63,656	1	105	63656
Log sluice	26-Oct	19:52	20:28	5,200	0	0	5200
Log sluice	26-Oct	20:28	21:29	8,915	2	113	8915
Log sluice	27-Oct	16:25	17:15	96	0	0	96
Log sluice	27-Oct	17:15	18:15	27	0	24	27
Log sluice	27-Oct	18:15	18:50	39	0	0	39
Log sluice	27-Oct	18:50	19:54	32	0	32	32
Log sluice	27-Oct	19:54	20:31	30	0	0	30
Log sluice	27-Oct	20:31	21:16	37	0	37	37
Log sluice	28-Oct	17:00	17:18	0	0	0	0
Log sluice	28-Oct	17:18	18:18	11,958	0	120	11958
Log sluice	28-Oct	18:18	18:48	56	0	0	56
Log sluice	28-Oct	18:48	19:48	1,427	0	100	1427
Log sluice	28-Oct	19:48	20:30	98	0	0	98
Log sluice	28-Oct	20:30	21:30	664	1	104	664
Log sluice	29-Oct	16:42	16:56	0	0	0	0
Log sluice	29-Oct	16:56	17:56	16	0	16	16
Log sluice	29-Oct	17:56	18:19	16	0	0	16
Log sluice	29-Oct	18:19	19:19	45	0	45	45
Log sluice	29-Oct	19:19	19:55	17	0	0	17
Log sluice	29-Oct	19:55	20:55	22	0	22	22
Log sluice	30-Oct	16:04	16:13	4	0	0	4
Log sluice	30-Oct	16:13	17:13	1	0	1	1
Log sluice	30-Oct	17:13	17:40	8	0	1	8
Log sluice	30-Oct	17:40	18:40	15	0	15	15
Log sluice	30-Oct	18:40	19:10	10	0	0	10
Log sluice	30-Oct	19:10	20:10	19	0	19	19
Log sluice	31-Oct	16:05	16:19	0	0	0	0

Appendix 3-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Total clupeids	Bluebacks subsampled	Am shad subsampled	Catch adjusted for gear efficiency
Log sluice	31-Oct	16:19	17:19	1	0	1	1
Log sluice	31-Oct	17:19	17:55	14	0	0	14
Log sluice	31-Oct	17:55	18:55	2,277	2	99	2277
Log sluice	31-Oct	18:55	19:30	70	0	0	70
Log sluice	31-Oct	19:30	20:00	164	0	100	164
Log sluice	01-Nov	16:00	17:00	11	0	11	11
Log sluice	01-Nov	17:00	17:22	2	0	0	2
Log sluice	01-Nov	17:22	18:22	38	4	34	38
Log sluice	01-Nov	18:22	18:53	6	0	0	6
Log sluice	01-Nov	18:53	19:53	4	0	4	4

Appendix 3-Table 2. Log sluice concurrent sample catch per unit effort

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Bluebacks	Am shad
Log sluice	16-Sep	17:10	1,980	75	1,905
Log sluice	16-Sep	18:57	79	0	79
Log sluice	17-Sep	17:08	0	0	0
Log sluice	17-Sep	18:19	2,890	736	2,154
Log sluice	17-Sep	20:01	362	34	328
Log sluice	18-Sep	17:09	508	57	451
Log sluice	18-Sep	18:58	0	0	0
Log sluice	18-Sep	20:57	1	0	1
Log sluice	19-Sep	17:06	0	0	0
Log sluice	19-Sep	18:18	0	0	0
Log sluice	19-Sep	19:32	5	0	5
Log sluice	19-Sep	20:22	61	0	61
Log sluice	22-Sep	17:13	93	9	84
Log sluice	22-Sep	18:54	100	0	100
Log sluice	22-Sep	20:45	4	0	4
Log sluice	23-Sep	17:08	3,783	337	3,446
Log sluice	23-Sep	19:02	20	2	18
Log sluice	23-Sep	20:40	100	1	99
Log sluice	24-Sep	17:10	3,710	1,272	2,438
Log sluice	24-Sep	18:40	2,848	403	2,445
Log sluice	24-Sep	20:13	3,291	936	2,355
Log sluice	25-Sep	17:10	17,092	1,843	15,249
Log sluice	25-Sep	18:51	380	0	380
Log sluice	26-Sep	17:07	2,868	629	2,239
Log sluice	26-Sep	18:31	6,239	303	5,936
Log sluice	26-Sep	20:06	472	23	449
Log sluice	28-Sep	17:08	18,241	2,343	15,898
Log sluice	28-Sep	18:57	37	3	34
Log sluice	28-Sep	20:28	784	43	741
Log sluice	29-Sep	17:14	3,720	2,394	1,326
Log sluice	29-Sep	18:39	2,730	169	2,561
Log sluice	29-Sep	20:11	88	8	80
Log sluice	30-Sep	17:07	6,615	2,697	3,917
Log sluice	30-Sep	18:33	3,197	913	2,284
Log sluice	30-Sep	20:24	1,479	131	1,349
Log sluice	01-Oct	17:04	594	108	486
Log sluice	01-Oct	18:18	449	85	364
Log sluice	01-Oct	19:35	57	11	46
Log sluice	02-Oct	17:01	492	63	429
Log sluice	02-Oct	18:12	409	66	343
Log sluice	02-Oct	19:22	0	0	0
Log sluice	03-Oct	17:00	639	73	566

Appendix 3-Table 2. (Continued).

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Bluebacks	Am shad
Log sluice	03-Oct	18:10	158	43	115
Log sluice	03-Oct	19:20	73	28	45
Log sluice	04-Oct	17:00	337	111	226
Log sluice	04-Oct	18:26	21	5	16
Log sluice	04-Oct	19:56	0	0	0
Log sluice	05-Oct	17:15	7,638	2,160	5,478
Log sluice	05-Oct	18:32	41	6	35
Log sluice	05-Oct	19:53	65	2	63
Log sluice	06-Oct	17:00	2,780	315	2,465
Log sluice	06-Oct	18:11	1,342	233	1,109
Log sluice	06-Oct	19:33	1	0	1
Log sluice	07-Oct	16:55	3,307	596	2,711
Log sluice	07-Oct	18:14	577	91	486
Log sluice	07-Oct	19:38	50	8	42
Log sluice	08-Oct	17:00	74	8	66
Log sluice	08-Oct	18:10	47	5	42
Log sluice	08-Oct	19:29	191	22	169
Log sluice	09-Oct	17:06	15,181	851	14,330
Log sluice	09-Oct	18:32	414	16	398
Log sluice	09-Oct	19:57	32	0	32
Log sluice	10-Oct	17:17	4,539	235	4,304
Log sluice	10-Oct	19:08	171	0	171
Log sluice	10-Oct	20:25	81	0	81
Log sluice	11-Oct	17:10	5,157	567	4,590
Log sluice	11-Oct	18:20	12	1	11
Log sluice	11-Oct	19:28	0	0	0
Log sluice	11-Oct	20:32	45	0	45
Log sluice	12-Oct	17:06	496	110	386
Log sluice	12-Oct	18:37	42	1	41
Log sluice	12-Oct	20:15	83	1	82
Log sluice	13-Oct	17:16	6,501	631	5,870
Log sluice	13-Oct	18:48	141	1	140
Log sluice	13-Oct	20:14	114	0	114
Log sluice	14-Oct	17:00	3,008	497	2,511
Log sluice	14-Oct	18:24	361	60	301
Log sluice	14-Oct	20:00	840	139	701
Log sluice	15-Oct	17:52	545	52	493
Log sluice	15-Oct	19:28	390	4	386
Log sluice	16-Oct	17:08	6,503	864	5,639
Log sluice	16-Oct	18:30	31	1	30
Log sluice	16-Oct	20:00	1	0	1
Log sluice	17-Oct	17:09	108	3	105

Appendix 3-Table 2. (Continued).

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Bluebacks	Am shad
Log sluice	17-Oct	18:28	24	0	24
Log sluice	17-Oct	19:47	0	0	0
Log sluice	19-Oct	17:11	15,776	150	15,626
Log sluice	19-Oct	18:05	83	1	82
Log sluice	19-Oct	19:44	139	1	138
Log sluice	20-Oct	17:07	6,790	132	6,658
Log sluice	20-Oct	18:44	128	3	125
Log sluice	20-Oct	20:19	35	0	35
Log sluice	21-Oct	17:07	6,218	0	6,218
Log sluice	21-Oct	18:55	498	20	478
Log sluice	21-Oct	20:41	342	0	342
Log sluice	22-Oct	16:44	3,432	0	3,432
Log sluice	22-Oct	18:16	16	0	16
Log sluice	22-Oct	19:39	98	1	97
Log sluice	23-Oct	17:05	682	45	637
Log sluice	23-Oct	18:26	395	17	378
Log sluice	23-Oct	20:00	9	0	9
Log sluice	24-Oct	17:11	0	0	0
Log sluice	24-Oct	18:41	9	0	9
Log sluice	25-Oct	16:21	492	6	485
Log sluice	25-Oct	17:56	255	0	255
Log sluice	25-Oct	19:30	432	4	428
Log sluice	27-Oct	17:15	27	0	27
Log sluice	27-Oct	18:50	30	0	30
Log sluice	27-Oct	20:31	49	0	49
Log sluice	29-Oct	16:56	16	0	16
Log sluice	29-Oct	18:19	45	0	45
Log sluice	29-Oct	19:55	22	0	22
Log sluice	30-Oct	16:13	1	0	1
Log sluice	30-Oct	17:40	15	0	15
Log sluice	30-Oct	19:10	19	0	19
Log sluice	01-Nov	16:00	11	0	11
Log sluice	01-Nov	17:22	38	4	34
Log sluice	01-Nov	18:53	4	0	4

Appendix 4
TRASH TROUGH SAMPLING DATA

Appendix 4-Table 1. Numbers captured during concurrent and intermediate trash trough collections.

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled	Catch adjusted for gear efficiency
Trash trough	17-Sep	17:02	17:08	00:06	0	0	0	0
Trash trough	17-Sep	17:08	18:08	01:00	0	0	0	0
Trash trough	17-Sep	18:08	18:19	00:11	0	0	0	0
Trash trough	17-Sep	18:19	19:19	01:00	0	0	0	0
Trash trough	17-Sep	19:19	20:01	00:42	0	0	0	0
Trash trough	17-Sep	20:01	21:01	01:00	0	0	0	0
Trash trough	17-Sep	21:01	21:15	00:14	0	0	0	0
Trash trough	22-Sep	17:15	18:25	01:10	0	0	0	0
Trash trough	22-Sep	18:25	18:54	00:29	0	0	0	0
Trash trough	22-Sep	18:54	20:00	01:06	0	0	0	0
Trash trough	22-Sep	20:00	20:45	00:45	0	0	0	0
Trash trough	22-Sep	20:45	21:35	00:50	0	0	0	0
Trash trough	24-Sep	17:10	18:12	01:02	3	1	2	17
Trash trough	24-Sep	18:12	18:40	00:28	0	0	0	0
Trash trough	24-Sep	18:40	19:40	01:00	4	0	4	22
Trash trough	24-Sep	19:40	20:13	00:33	2	0	2	11
Trash trough	24-Sep	20:13	21:13	01:00	10	0	10	55
Trash trough	26-Sep	17:00	17:07	00:07	0	0	0	0
Trash trough	26-Sep	17:07	18:07	01:00	3	0	3	17
Trash trough	26-Sep	18:07	18:31	00:24	2	0	0	11
Trash trough	26-Sep	18:31	19:31	01:00	5	0	0	28
Trash trough	26-Sep	19:31	20:06	00:35	0	0	0	0
Trash trough	26-Sep	20:06	21:06	01:00	4	0	4	22
Trash trough	26-Sep	21:06	21:26	00:20	1	0	1	6
Trash trough	29-Sep	17:02	17:14	00:12	3	0	0	17
Trash trough	29-Sep	17:16	18:16	01:00	67	13	54	370
Trash trough	29-Sep	18:16	18:39	00:23	3	0	0	17
Trash trough	29-Sep	18:39	19:39	01:00	59	2	57	326
Trash trough	29-Sep	19:39	20:11	00:32	18	0	0	99
Trash trough	29-Sep	20:11	21:11	01:00	59	0	59	326
Trash trough	01-Oct	17:15	18:04	00:49	0	0	0	0
Trash trough	01-Oct	18:04	18:18	00:14	0	0	0	0
Trash trough	01-Oct	18:18	19:18	01:00	0	0	0	0
Trash trough	01-Oct	19:18	19:35	00:17	0	0	0	0
Trash trough	01-Oct	19:35	20:39	01:04	11	2	9	61
Trash trough	01-Oct	20:39	20:45	00:06	7	1	6	39
Trash trough	03-Oct	17:00	18:00	01:00	0	0	0	0
Trash trough	03-Oct	18:00	18:10	00:10	0	0	0	0
Trash trough	03-Oct	18:10	19:10	01:00	0	0	0	0
Trash trough	03-Oct	19:10	19:20	00:10	0	0	0	0
Trash trough	03-Oct	19:20	20:20	01:00	0	0	0	0
Trash trough	03-Oct	20:20	20:27	00:07	0	0	0	0

Appendix 4-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled	Catch adjusted for gear efficiency
Trash trough	05-Oct	17:15	18:15	01:00	130	23	77	718
Trash trough	05-Oct	18:15	18:32	00:17	66	0	0	365
Trash trough	05-Oct	18:32	19:32	01:00	25	5	20	138
Trash trough	05-Oct	19:32	19:53	00:21	2	0	2	11
Trash trough	05-Oct	19:53	20:53	01:00	9	0	9	50
Trash trough	07-Oct	16:55	17:55	01:00	0	0	0	0
Trash trough	07-Oct	17:55	18:14	00:19	1	0	0	6
Trash trough	07-Oct	18:14	19:14	01:00	0	0	0	0
Trash trough	07-Oct	19:14	19:38	00:24	0	0	0	0
Trash trough	07-Oct	19:38	20:38	01:00	0	0	0	0
Trash trough	09-Oct	17:06	18:06	01:00	50	5	45	276
Trash trough	09-Oct	18:06	18:32	00:26	0	0	0	0
Trash trough	09-Oct	18:32	19:32	01:00	6	0	0	33
Trash trough	09-Oct	19:32	19:57	00:25	2	0	0	11
Trash trough	09-Oct	19:57	20:57	01:00	6	0	6	33
Trash trough	11-Oct	17:00	17:10	00:10	0	0	0	0
Trash trough	11-Oct	17:10	17:51	00:41	0	0	0	0
Trash trough	11-Oct	17:51	18:20	00:29	0	0	0	0
Trash trough	11-Oct	18:20	19:00	00:40	0	0	0	0
Trash trough	11-Oct	19:00	19:28	00:28	0	0	0	0
Trash trough	11-Oct	19:28	20:08	00:40	0	0	0	0
Trash trough	11-Oct	20:08	20:32	00:24	0	0	0	0
Trash trough	11-Oct	20:32	21:10	00:38	0	0	0	0
Trash trough	13-Oct	17:00	17:16	00:16	0	0	0	0
Trash trough	13-Oct	17:16	18:16	01:00	0	0	0	0
Trash trough	13-Oct	18:16	18:48	00:32	0	0	0	0
Trash trough	13-Oct	18:48	19:48	01:00	8	1	7	44
Trash trough	13-Oct	19:48	20:14	00:26	7	0	0	39
Trash trough	13-Oct	20:14	21:14	01:00	5	0	5	28
Trash trough	15-Oct	17:40	17:52	00:12	0	0	0	0
Trash trough	15-Oct	17:52	18:52	01:00	0	0	0	0
Trash trough	15-Oct	18:52	19:28	00:36	5	0	0	28
Trash trough	15-Oct	19:28	20:28	01:00	44	0	44	243
Trash trough	17-Oct	17:00	17:09	00:09	0	0	0	0
Trash trough	17-Oct	17:09	18:09	01:00	3	0	3	17
Trash trough	17-Oct	18:09	18:28	00:19	1	0	1	6
Trash trough	17-Oct	18:28	19:28	01:00	0	0	0	0
Trash trough	17-Oct	19:28	19:47	00:19	0	0	0	0
Trash trough	17-Oct	19:47	20:24	00:37	0	0	0	0
Trash trough	19-Oct	16:56	17:11	00:15	17	0	0	94
Trash trough	19-Oct	17:11	17:41	00:30	43	2	41	238
Trash trough	19-Oct	17:41	18:05	00:24	7	0	0	39

Appendix 4-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled	Catch adjusted for gear efficiency
Trash trough	19-Oct	18:05	19:05	01:00	16	0	6	88
Trash trough	19-Oct	19:05	19:44	00:39	0	0	0	0
Trash trough	19-Oct	19:44	20:46	01:02	25	1	24	138
Trash trough	21-Oct	16:42	17:07	00:25	4	0	0	22
Trash trough	21-Oct	17:07	18:10	01:03	10	0	10	55
Trash trough	21-Oct	18:10	18:55	00:45	7	0	0	39
Trash trough	21-Oct	18:55	19:59	01:04	248	0	134	1370
Trash trough	21-Oct	19:59	20:41	00:42	14	0	0	77
Trash trough	21-Oct	20:41	21:21	00:40	276	0	0	1525
Trash trough	23-Oct	17:10	18:05	00:55	3	0	3	17
Trash trough	23-Oct	18:05	18:26	00:21	0	0	0	0
Trash trough	23-Oct	18:26	19:26	01:00	3	0	3	17
Trash trough	23-Oct	19:26	20:00	00:34	0	0	0	0
Trash trough	23-Oct	20:00	20:55	00:55	9	0	2	50
Trash trough	25-Oct	16:10	16:21	00:11	1	0	0	6
Trash trough	25-Oct	16:21	17:22	01:01	9	0	9	50
Trash trough	25-Oct	17:22	17:56	00:34	36	0	0	199
Trash trough	25-Oct	17:56	18:58	01:02	66	0	56	365
Trash trough	25-Oct	18:58	19:30	00:32	86	0	0	475
Trash trough	25-Oct	19:30	20:33	01:03	49	0	0	271
Trash trough	27-Oct	16:55	17:15	00:20	0	0	0	0
Trash trough	27-Oct	17:15	18:15	01:00	1	0	1	6
Trash trough	27-Oct	18:15	18:50	00:35	0	0	0	0
Trash trough	27-Oct	18:50	19:54	01:04	3	0	3	17
Trash trough	27-Oct	19:54	20:31	00:37	1	0	0	6
Trash trough	27-Oct	20:31	21:16	00:45	3	0	3	17
Trash trough	29-Oct	16:42	16:56	00:14	1	0	0	6
Trash trough	29-Oct	16:56	17:56	01:00	5	0	5	28
Trash trough	29-Oct	17:56	18:19	00:23	3	0	0	17
Trash trough	29-Oct	18:19	19:19	01:00	6	0	6	33
Trash trough	29-Oct	19:19	19:55	00:36	0	0	0	0
Trash trough	29-Oct	19:55	20:55	01:00	7	0	7	39
Trash trough	31-Oct	16:05	16:19	00:14	0	0	0	0
Trash trough	31-Oct	16:19	17:19	01:00	0	0	0	0
Trash trough	31-Oct	17:19	17:55	00:36	1	0	0	6
Trash trough	31-Oct	17:55	18:55	01:00	78	0	76	431
Trash trough	31-Oct	18:55	19:30	00:35	0	0	0	0
Trash trough	31-Oct	19:30	20:30	01:00	5	0	5	28

Appendix 4-Table 2. Trash trough catch per unit effort.

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Bluebacks	Am shad
Trash trough	17-Sep	17:08	0	0	0
Trash trough	17-Sep	18:19	0	0	0
Trash trough	17-Sep	20:01	0	0	0
Trash trough	22-Sep	17:15	0	0	0
Trash trough	22-Sep	18:54	0	0	0
Trash trough	22-Sep	20:45	0	0	0
Trash trough	24-Sep	17:10	3	1	2
Trash trough	24-Sep	18:40	4	0	4
Trash trough	24-Sep	20:13	10	0	10
Trash trough	26-Sep	17:07	3	0	3
Trash trough	26-Sep	18:31	5	0	5
Trash trough	26-Sep	20:06	4	0	4
Trash trough	29-Sep	17:16	67	13	54
Trash trough	29-Sep	18:39	59	2	57
Trash trough	29-Sep	20:11	59	0	59
Trash trough	01-Oct	17:15	0	0	0
Trash trough	01-Oct	18:18	0	0	0
Trash trough	01-Oct	19:35	10	2	8
Trash trough	03-Oct	17:00	0	0	0
Trash trough	03-Oct	18:10	0	0	0
Trash trough	03-Oct	19:20	0	0	0
Trash trough	05-Oct	17:15	130	30	100
Trash trough	05-Oct	18:32	25	5	20
Trash trough	05-Oct	19:53	9	0	9
Trash trough	07-Oct	16:55	0	0	0
Trash trough	07-Oct	18:14	0	0	0
Trash trough	07-Oct	19:38	0	0	0
Trash trough	09-Oct	17:06	50	5	45
Trash trough	09-Oct	18:32	6	1	5
Trash trough	09-Oct	19:57	6	0	6
Trash trough	11-Oct	17:10	0	0	0
Trash trough	11-Oct	18:20	0	0	0
Trash trough	11-Oct	19:28	0	0	0
Trash trough	11-Oct	20:32	0	0	0
Trash trough	13-Oct	17:16	0	0	0
Trash trough	13-Oct	18:48	8	1	7
Trash trough	13-Oct	20:14	5	0	5
Trash trough	15-Oct	17:52	0	0	0
Trash trough	15-Oct	19:28	44	0	44
Trash trough	17-Oct	17:09	3	0	3
Trash trough	17-Oct	18:28	0	0	0
Trash trough	17-Oct	19:47	0	0	0

Appendix 4-Table 2. (Continued).

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Bluebacks	Am shad
Trash trough	19-Oct	17:11	86	4	82
Trash trough	19-Oct	18:05	16	0	16
Trash trough	19-Oct	19:44	24	1	23
Trash trough	21-Oct	17:07	10	0	10
Trash trough	21-Oct	18:55	232	0	232
Trash trough	21-Oct	20:41	414	0	414
Trash trough	23-Oct	17:10	3	0	3
Trash trough	23-Oct	18:26	3	0	3
Trash trough	23-Oct	20:00	10	0	10
Trash trough	25-Oct	16:21	9	0	9
Trash trough	25-Oct	17:56	64	0	64
Trash trough	25-Oct	19:30	47	0	47
Trash trough	27-Oct	17:15	1	0	1
Trash trough	27-Oct	18:50	3	0	3
Trash trough	27-Oct	20:31	4	0	4
Trash trough	29-Oct	16:56	5	0	5
Trash trough	29-Oct	18:19	6	0	6
Trash trough	29-Oct	19:55	7	0	7

Appendix 5

ENTRAINMENT NET SAMPLING DATA

Appendix 5-Table 1. Numbers captured during concurrent turbine net collections.

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled
Unit 1-top	16-Sep	17:00	18:00	01:00	0	0	0
Unit 1-bottom	16-Sep	17:00	18:00	01:00	0	0	0
Unit 4-top	16-Sep	17:10	18:13	01:03	0	0	0
Unit 4-bottom	16-Sep	17:10	18:13	01:03	0	0	0
Unit 6-top	16-Sep	17:20	18:34	01:14	0	0	0
Unit 6-bottom	16-Sep	17:20	18:34	01:14	0	0	0
Unit 1-top	16-Sep	18:50	19:50	01:00	0	0	0
Unit 1-bottom	16-Sep	18:50	19:50	01:00	0	0	0
Unit 4-top	16-Sep	18:57	20:03	01:06	0	0	0
Unit 4-bottom	16-Sep	18:57	20:03	01:06	0	0	0
Unit 6-top	16-Sep	19:01	20:12	01:11	1	0	1
Unit 6-bottom	16-Sep	19:01	20:12	01:11	0	0	0
Unit 4-top	17-Sep	17:08	18:08	01:00	0	0	0
Unit 4-bottom	17-Sep	17:08	18:08	01:00	0	0	0
Unit 4-top	17-Sep	18:19	19:19	01:00	0	0	0
Unit 4-bottom	17-Sep	18:19	19:19	01:00	0	0	0
Unit 4-top	17-Sep	20:01	21:01	01:00	0	0	0
Unit 4-bottom	17-Sep	20:01	21:01	01:00	0	0	0
Unit 1-top	18-Sep	17:00	18:00	01:00	0	0	0
Unit 1-bottom	18-Sep	17:00	18:00	01:00	0	0	0
Unit 4-top	18-Sep	17:09	18:15	01:06	0	0	0
Unit 4-bottom	18-Sep	17:09	18:15	01:06	0	0	0
Unit 6-top	18-Sep	17:13	18:28	01:15	2	0	2
Unit 6-bottom	18-Sep	17:13	18:28	01:15	0	0	0
Unit 1-top	18-Sep	18:50	19:50	01:00	0	0	0
Unit 1-bottom	18-Sep	18:50	19:50	01:00	0	0	0
Unit 4-top	18-Sep	18:58	20:04	01:06	0	0	0
Unit 4-bottom	18-Sep	18:58	20:04	01:06	0	0	0
Unit 1-top	18-Sep	20:52	21:52	01:00	0	0	0
Unit 1-bottom	18-Sep	20:52	21:52	01:00	0	0	0
Unit 4-top	18-Sep	20:57	22:00	01:03	0	0	0
Unit 4-bottom	18-Sep	20:57	22:00	01:03	0	0	0
Unit 6-top	18-Sep	21:01	22:05	01:04	1	0	1
Unit 6-bottom	18-Sep	21:01	22:05	01:04	0	0	0
Unit 1-top	19-Sep	17:06	18:06	01:00	0	0	0
Unit 1-bottom	19-Sep	17:06	18:06	01:00	0	0	0
Unit 1-top	19-Sep	18:18	19:18	01:00	0	0	0
Unit 1-bottom	19-Sep	18:18	19:18	01:00	0	0	0
Unit 1-top	19-Sep	19:32	20:10	00:38	0	0	0
Unit 1-bottom	19-Sep	19:32	20:10	00:38	0	0	0

Appendix 5-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled
Unit 1-top	19-Sep	20:22	21:15	00:53	0	0	0
Unit 1-bottom	19-Sep	20:22	21:15	00:53	0	0	0
Unit 1-top	22-Sep	17:09	18:09	01:00	0	0	0
Unit 1-bottom	22-Sep	17:09	18:09	01:00	0	0	0
Unit 4-top	22-Sep	17:13	18:25	01:12	0	0	0
Unit 4-bottom	22-Sep	17:13	18:25	01:12	0	0	0
Unit 6-top	22-Sep	17:19	18:32	01:13	0	0	0
Unit 6-bottom	22-Sep	17:19	18:32	01:13	0	0	0
Unit 1-top	22-Sep	18:46	19:50	01:04	0	0	0
Unit 1-bottom	22-Sep	18:46	19:50	01:04	0	0	0
Unit 4-top	22-Sep	18:54	20:00	01:06	0	0	0
Unit 4-bottom	22-Sep	18:54	20:00	01:06	0	0	0
Unit 6-top	22-Sep	19:16	20:07	00:51	0	0	0
Unit 6-bottom	22-Sep	19:16	20:07	00:51	0	0	0
Unit 1-top	22-Sep	20:35	21:28	00:53	0	0	0
Unit 1-bottom	22-Sep	20:35	21:28	00:53	0	0	0
Unit 4-top	22-Sep	20:45	21:35	00:50	0	0	0
Unit 4-bottom	22-Sep	20:45	21:35	00:50	0	0	0
Unit 1-top	23-Sep	17:04	18:09	01:05	1	0	1
Unit 1-bottom	23-Sep	17:04	18:09	01:05	0	0	0
Unit 4-top	23-Sep	17:08	18:23	01:15	0	0	0
Unit 4-bottom	23-Sep	17:08	18:23	01:15	0	0	0
Unit 6-top	23-Sep	17:14	18:30	01:16	0	0	0
Unit 6-bottom	23-Sep	17:14	18:30	01:16	0	0	0
Unit 1-top	23-Sep	18:50	19:55	01:05	0	0	0
Unit 1-bottom	23-Sep	18:50	19:55	01:05	0	0	0
Unit 4-top	23-Sep	19:02	20:03	01:01	0	0	0
Unit 4-bottom	23-Sep	19:02	20:03	01:01	0	0	0
Unit 6-top	23-Sep	19:11	20:10	00:59	0	0	0
Unit 6-bottom	23-Sep	19:11	20:10	00:59	0	0	0
Unit 1-top	23-Sep	20:28	21:28	01:00	0	0	0
Unit 1-bottom	23-Sep	20:28	21:28	01:00	0	0	0
Unit 4-top	23-Sep	20:40	21:40	01:00	2	0	2
Unit 4-bottom	23-Sep	20:40	21:40	01:00	1	0	1
Unit 6-top	23-Sep	20:52	21:52	01:00	0	0	0
Unit 6-bottom	23-Sep	20:52	21:52	01:00	0	0	0
Unit 1-top	24-Sep	17:05	18:05	01:00	1	0	1
Unit 1-bottom	24-Sep	17:05	18:05	01:00	0	0	0
Unit 4-top	24-Sep	17:10	18:12	01:02	0	0	0
Unit 4-bottom	24-Sep	17:10	18:12	01:02	0	0	0

Appendix 5-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled
Unit 1-top	24-Sep	18:29	19:29	01:00	0	0	0
Unit 1-bottom	24-Sep	18:29	19:29	01:00	0	0	0
Unit 4-top	24-Sep	18:40	19:40	01:00	0	0	0
Unit 4-bottom	24-Sep	18:40	19:40	01:00	0	0	0
Unit 6-top	24-Sep	18:48	19:48	01:00	0	0	0
Unit 6-bottom	24-Sep	18:48	19:48	01:00	2	0	2
Unit 1-top	24-Sep	20:03	21:03	01:00	2	0	2
Unit 1-bottom	24-Sep	20:03	21:03	01:00	1	1	0
Unit 4-top	24-Sep	20:13	21:13	01:00	0	0	0
Unit 4-bottom	24-Sep	20:13	21:13	01:00	0	0	0
Unit 6-top	24-Sep	20:24	21:24	01:00	0	0	0
Unit 6-bottom	24-Sep	20:24	21:24	01:00	0	0	0
Unit 1-top	25-Sep	17:04	18:04	01:00	92	8	84
Unit 1-bottom	25-Sep	17:04	18:04	01:00	0	0	0
Unit 4-top	25-Sep	17:10	18:13	01:03	1	0	1
Unit 4-bottom	25-Sep	17:10	18:13	01:03	0	0	0
Unit 6-top	25-Sep	17:16	18:24	01:08	3	0	3
Unit 6-bottom	25-Sep	17:16	18:24	01:08	0	0	0
Unit 1-top	25-Sep	18:41	19:41	01:00	77	3	74
Unit 1-bottom	25-Sep	18:41	19:41	01:00	0	0	0
Unit 4-top	25-Sep	18:51	20:04	01:13	11	0	11
Unit 4-bottom	25-Sep	18:51	20:04	01:13	1	0	1
Unit 6-top	25-Sep	19:02	20:25	01:23	266	18	83
Unit 6-bottom	25-Sep	19:02	20:25	01:23	16	3	13
Unit 1-top	26-Sep	17:02	18:02	01:00	63	7	56
Unit 1-bottom	26-Sep	17:02	18:02	01:00	1	0	1
Unit 4-top	26-Sep	17:07	18:07	01:00	0	0	0
Unit 4-bottom	26-Sep	17:07	18:07	01:00	0	0	0
Unit 1-top	26-Sep	18:22	19:22	01:00	45	0	45
Unit 1-bottom	26-Sep	18:22	19:22	01:00	0	0	0
Unit 4-top	26-Sep	18:31	19:31	01:00	7	0	7
Unit 4-bottom	26-Sep	18:31	19:31	01:00	1	0	1
Unit 6-top	26-Sep	18:45	19:45	01:00	2	0	2
Unit 6-bottom	26-Sep	18:45	19:45	01:00	0	0	0
Unit 1-top	26-Sep	19:55	20:55	01:00	44	0	44
Unit 1-bottom	26-Sep	19:55	20:55	01:00	0	0	0
Unit 4-top	26-Sep	20:06	21:06	01:00	5	0	5
Unit 4-bottom	26-Sep	20:06	21:06	01:00	0	0	0
Unit 6-top	26-Sep	20:15	21:15	01:00	0	0	0
Unit 6-bottom	26-Sep	20:15	21:15	01:00	0	0	0

Appendix 5-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled
Unit 1-top	28-Sep	17:02	18:02	01:00	52	6	46
Unit 1-bottom	28-Sep	17:02	18:02	01:00	0	0	0
Unit 4-top	28-Sep	17:08	18:09	01:01	1	0	1
Unit 4-bottom	28-Sep	17:08	18:09	01:01	0	0	0
Unit 6-top	28-Sep	17:13	18:25	01:12	15	3	12
Unit 6-bottom	28-Sep	17:13	18:25	01:12	0	0	0
Unit 1-top	28-Sep	18:47	19:47	01:00	81	2	79
Unit 1-bottom	28-Sep	18:47	19:47	01:00	0	0	0
Unit 4-top	28-Sep	18:57	19:57	01:00	1	0	1
Unit 4-bottom	28-Sep	18:57	19:57	01:00	0	0	0
Unit 6-top	28-Sep	19:05	20:05	01:00	3	0	3
Unit 6-bottom	28-Sep	19:05	20:05	01:00	3	3	0
Unit 1-top	28-Sep	20:20	21:20	01:00	57	2	55
Unit 1-bottom	28-Sep	20:20	21:20	01:00	0	0	0
Unit 4-top	28-Sep	20:28	21:28	01:00	2	0	2
Unit 4-bottom	28-Sep	20:28	21:28	01:00	0	0	0
Unit 6-top	28-Sep	20:36	21:36	01:00	6	0	6
Unit 6-bottom	28-Sep	20:36	21:36	01:00	0	0	0
Unit 1-top	29-Sep	17:07	18:10	01:03	25	3	22
Unit 1-bottom	29-Sep	17:07	18:10	01:03	0	0	0
Unit 4-top	29-Sep	17:14	18:16	01:02	0	0	0
Unit 4-bottom	29-Sep	17:14	18:16	01:02	0	0	0
Unit 1-top	29-Sep	18:31	19:31	01:00	4	1	3
Unit 1-bottom	29-Sep	18:31	19:31	01:00	0	0	0
Unit 4-top	29-Sep	18:39	19:39	01:00	1	0	1
Unit 4-bottom	29-Sep	18:39	19:39	01:00	0	0	0
Unit 6-top	29-Sep	18:43	19:43	01:00	1	0	1
Unit 6-bottom	29-Sep	18:43	19:43	01:00	1	1	0
Unit 1-top	29-Sep	20:04	21:04	01:00	5	0	5
Unit 1-bottom	29-Sep	20:04	21:04	01:00	0	0	0
Unit 4-top	29-Sep	20:11	21:11	01:00	1	0	1
Unit 4-bottom	29-Sep	20:11	21:11	01:00	0	0	0
Unit 6-top	29-Sep	20:20	21:20	01:00	1	0	1
Unit 6-bottom	29-Sep	20:20	21:20	01:00	1	0	1
Unit 1-top	30-Sep	17:01	18:01	01:00	77	3	74
Unit 1-bottom	30-Sep	17:01	18:01	01:00	2	0	2
Unit 4-top	30-Sep	17:07	18:08	01:01	12	1	11
Unit 4-bottom	30-Sep	17:07	18:08	01:01	0	0	0
Unit 1-top	30-Sep	18:23	19:23	01:00	18	6	12
Unit 1-bottom	30-Sep	18:23	19:23	01:00	0	0	0

Appendix 5-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled
Unit 6-top	04-Oct	20:04	21:04	01:00	0	0	0
Unit 6-bottom	04-Oct	20:04	21:04	01:00	0	0	0
Unit 1-top	05-Oct	17:15	18:15	01:00	0	0	0
Unit 1-bottom	05-Oct	17:15	18:15	01:00	0	0	0
Unit 1-top	05-Oct	18:25	19:25	01:00	0	0	0
Unit 1-bottom	05-Oct	18:25	19:25	01:00	0	0	0
Unit 4-top	05-Oct	18:32	19:32	01:00	0	0	0
Unit 4-bottom	05-Oct	18:32	19:32	01:00	0	0	0
Unit 1-top	05-Oct	19:44	20:44	01:00	0	0	0
Unit 1-bottom	05-Oct	19:44	20:44	01:00	0	0	0
Unit 4-top	05-Oct	19:53	20:53	01:00	0	0	0
Unit 4-bottom	05-Oct	19:53	20:53	01:00	0	0	0
Unit 6-top	05-Oct	19:58	20:58	01:00	0	0	0
Unit 6-bottom	05-Oct	19:58	20:58	01:00	0	0	0
Unit 4-top	06-Oct	17:00	18:00	01:00	0	0	0
Unit 4-bottom	06-Oct	17:00	18:00	01:00	0	0	0
Unit 4-top	06-Oct	18:11	19:11	01:00	0	0	0
Unit 4-bottom	06-Oct	18:11	19:11	01:00	0	0	0
Unit 1-top	06-Oct	19:25	20:25	01:00	1	0	1
Unit 1-bottom	06-Oct	19:25	20:25	01:00	0	0	0
Unit 4-top	06-Oct	19:33	20:33	01:00	0	0	0
Unit 4-bottom	06-Oct	19:33	20:33	01:00	0	0	0
Unit 6-top	06-Oct	19:42	20:42	01:00	0	0	0
Unit 6-bottom	06-Oct	19:42	20:42	01:00	0	0	0
Unit 6-bottom	07-Oct	16:55	17:55	01:00	0	0	0
Unit 6-top	07-Oct	18:14	19:14	01:00	0	0	0
Unit 6-bottom	07-Oct	18:14	19:14	01:00	0	0	0
Unit 1-top	07-Oct	19:28	20:28	01:00	0	0	0
Unit 1-bottom	07-Oct	19:28	20:28	01:00	0	0	0
Unit 4-top	07-Oct	19:38	20:38	01:00	0	0	0
Unit 4-bottom	07-Oct	19:38	20:38	01:00	0	0	0
Unit 6-top	07-Oct	19:48	20:48	01:00	1	0	1
Unit 6-bottom	07-Oct	19:48	20:48	01:00	0	0	0
Unit 6-top	08-Oct	17:00	18:00	01:00	0	0	0
Unit 6-bottom	08-Oct	17:00	18:00	01:00	0	0	0
Unit 6-top	08-Oct	18:10	19:10	01:00	0	0	0
Unit 6-bottom	08-Oct	18:10	19:10	01:00	0	0	0
Unit 6-top	08-Oct	19:20	20:20	01:00	0	0	0
Unit 6-bottom	08-Oct	19:20	20:20	01:00	0	0	0
Unit 4-top	08-Oct	19:29	20:29	01:00	0	0	0

Appendix 5-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled
Unit 4-bottom	08-Oct	19:29	20:29	01:00	0	0	0
Unit 1-top	08-Oct	19:37	20:37	01:00	0	0	0
Unit 1-bottom	08-Oct	19:37	20:37	01:00	0	0	0
Unit 1-top	09-Oct	17:00	18:00	01:00	19	3	16
Unit 1-bottom	09-Oct	17:00	18:00	01:00	0	0	0
Unit 4-top	09-Oct	17:06	18:06	01:00	0	0	0
Unit 4-bottom	09-Oct	17:06	18:06	01:00	0	0	0
Unit 6-top	09-Oct	17:12	18:12	01:00	1	0	1
Unit 6-bottom	09-Oct	17:12	18:12	01:00	0	0	0
Unit 1-top	09-Oct	18:24	19:24	01:00	29	3	26
Unit 1-bottom	09-Oct	18:24	19:24	01:00	0	0	0
Unit 4-top	09-Oct	18:32	19:32	01:00	0	0	0
Unit 4-bottom	09-Oct	18:32	19:32	01:00	0	0	0
Unit 6-top	09-Oct	18:41	19:41	01:00	0	0	0
Unit 6-bottom	09-Oct	18:41	19:41	01:00	0	0	0
Unit 1-top	09-Oct	19:48	20:48	01:00	3	0	3
Unit 1-bottom	09-Oct	19:48	20:48	01:00	0	0	0
Unit 4-top	09-Oct	19:57	20:57	01:00	12	0	1
Unit 4-bottom	09-Oct	19:57	20:57	01:00	0	0	0
Unit 1-top	10-Oct	17:12	18:12	01:00	28	8	20
Unit 1-bottom	10-Oct	17:12	18:12	01:00	1	0	1
Unit 4-top	10-Oct	17:17	18:22	01:05	1	0	1
Unit 4-bottom	10-Oct	17:17	18:22	01:05	1	0	1
Unit 6-top	10-Oct	17:21	18:39	01:18	1	0	1
Unit 6-bottom	10-Oct	17:21	18:39	01:18	3	0	3
Unit 1-top	10-Oct	19:00	19:40	00:40	76	4	72
Unit 1-bottom	10-Oct	19:00	19:40	00:40	9	0	9
Unit 4-top	10-Oct	19:08	19:48	00:40	2	0	2
Unit 4-bottom	10-Oct	19:08	19:48	00:40	4	0	4
Unit 6-top	10-Oct	19:16	20:16	01:00	53	2	51
Unit 6-bottom	10-Oct	19:16	20:16	01:00	4	0	4
Unit 1-top	10-Oct	20:16	21:00	00:44	32	0	32
Unit 1-bottom	10-Oct	20:16	21:00	00:44	3	0	3
Unit 4-top	10-Oct	20:25	21:05	00:40	0	0	0
Unit 4-bottom	10-Oct	20:25	21:05	00:40	1	0	1
Unit 6-top	10-Oct	20:35	21:15	00:40	5	0	5
Unit 6-bottom	10-Oct	20:35	21:15	00:40	2	0	2
Unit 1-top	11-Oct	17:06	17:46	00:40	0	0	0
Unit 1-bottom	11-Oct	17:06	17:46	00:40	1	0	1
Unit 4-top	11-Oct	17:10	17:51	00:41	7	1	6

Appendix 5-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled
Unit 4-bottom	11-Oct	17:10	17:51	00:41	0	0	0
Unit 6-top	11-Oct	17:14	17:58	00:44	0	0	0
Unit 6-bottom	11-Oct	17:14	17:58	00:44	0	0	0
Unit 1-top	11-Oct	18:12	18:52	00:40	18	1	17
Unit 1-bottom	11-Oct	18:12	18:52	00:40	0	0	0
Unit 4-top	11-Oct	18:20	19:00	00:40	0	0	0
Unit 4-bottom	11-Oct	18:20	19:00	00:40	0	0	0
Unit 6-top	11-Oct	18:28	19:08	00:40	0	0	0
Unit 6-bottom	11-Oct	18:28	19:08	00:40	0	0	0
Unit 1-top	11-Oct	19:20	20:00	00:40	10	0	10
Unit 1-bottom	11-Oct	19:20	20:00	00:40	0	0	0
Unit 4-top	11-Oct	19:28	20:08	00:40	9	1	8
Unit 4-bottom	11-Oct	19:28	20:08	00:40	0	0	0
Unit 6-top	11-Oct	19:35	20:15	00:40	0	0	0
Unit 6-bottom	11-Oct	19:35	20:15	00:40	2	0	2
Unit 1-top	11-Oct	20:25	21:05	00:40	28	1	27
Unit 1-bottom	11-Oct	20:25	21:05	00:40	1	0	1
Unit 4-top	11-Oct	20:33	21:13	00:40	6	0	6
Unit 4-bottom	11-Oct	20:33	21:13	00:40	0	0	0
Unit 6-top	11-Oct	20:46	21:26	00:40	39	9	30
Unit 6-bottom	11-Oct	20:46	21:26	00:40	5	2	3
Unit 1-top	12-Oct	17:00	18:00	01:00	31	9	22
Unit 1-bottom	12-Oct	17:00	18:00	01:00	0	0	0
Unit 4-top	12-Oct	17:06	18:07	01:01	0	0	0
Unit 4-bottom	12-Oct	17:06	18:07	01:01	0	0	0
Unit 6-top	12-Oct	17:10	18:13	01:03	0	0	0
Unit 6-bottom	12-Oct	17:10	18:13	01:03	0	0	0
Unit 1-top	12-Oct	18:30	19:30	01:00	15	1	14
Unit 1-bottom	12-Oct	18:30	19:30	01:00	5	0	5
Unit 4-top	12-Oct	18:37	19:37	01:00	8	0	8
Unit 4-bottom	12-Oct	18:37	19:37	01:00	2	0	2
Unit 6-top	12-Oct	18:44	19:45	01:01	44	5	39
Unit 6-bottom	12-Oct	18:44	19:45	01:01	11	0	11
Unit 1-top	12-Oct	20:05	20:53	00:48	14	0	14
Unit 1-bottom	12-Oct	20:05	20:53	00:48	2	0	2
Unit 4-top	12-Oct	20:15	21:15	01:00	2	0	2
Unit 4-bottom	12-Oct	20:15	21:15	01:00	0	0	0
Unit 6-top	12-Oct	20:25	21:25	01:00	3	0	3
Unit 6-bottom	12-Oct	20:25	21:25	01:00	0	0	0
Unit 4-top	13-Oct	17:16	18:16	01:00	0	0	0

Appendix 5-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled
Unit 4-bottom	13-Oct	17:16	18:16	01:00	0	0	0
Unit 6-top	13-Oct	17:28	18:28	01:00	6	0	6
Unit 6-bottom	13-Oct	17:28	18:28	01:00	0	0	0
Unit 1-top	13-Oct	18:39	19:39	01:00	9	0	9
Unit 1-bottom	13-Oct	18:39	19:39	01:00	16	0	16
Unit 4-top	13-Oct	18:48	19:48	01:00	10	0	10
Unit 4-bottom	13-Oct	18:48	19:48	01:00	1	0	1
Unit 6-top	13-Oct	18:55	19:55	01:00	32	3	29
Unit 6-bottom	13-Oct	18:55	19:55	01:00	4	0	4
Unit 1-top	13-Oct	20:14	21:14	01:00	32	0	32
Unit 1-bottom	13-Oct	20:14	21:14	01:00	3	0	3
Unit 4-top	14-Oct	17:00	18:00	01:00	1	0	1
Unit 4-bottom	14-Oct	17:00	18:00	01:00	0	0	0
Unit 6-top	14-Oct	18:20	19:20	01:00	2	0	2
Unit 6-bottom	14-Oct	18:20	19:20	01:00	1	0	1
Unit 4-top	14-Oct	18:24	19:27	01:03	0	0	0
Unit 4-bottom	14-Oct	18:24	19:27	01:03	0	0	0
Unit 1-top	14-Oct	18:35	19:36	01:01	4	0	4
Unit 1-bottom	14-Oct	18:35	19:36	01:01	4	0	4
Unit 1-top	15-Oct	17:46	18:46	01:00	0	0	0
Unit 1-bottom	15-Oct	17:46	18:46	01:00	1	0	1
Unit 4-top	15-Oct	17:52	18:52	01:00	0	0	0
Unit 4-bottom	15-Oct	17:52	18:52	01:00	1	0	1
Unit 6-top	15-Oct	17:57	18:57	01:00	5	0	5
Unit 6-bottom	15-Oct	17:57	18:57	01:00	0	0	0
Unit 1-top	15-Oct	19:20	20:20	01:00	21	0	21
Unit 1-bottom	15-Oct	19:20	20:20	01:00	6	1	5
Unit 4-top	15-Oct	19:28	20:28	01:00	7	0	7
Unit 4-bottom	15-Oct	19:28	20:28	01:00	4	0	4
Unit 6-top	15-Oct	19:41	20:41	01:00	30	1	29
Unit 6-bottom	15-Oct	19:41	20:41	01:00	2	0	2
Unit 1-top	16-Oct	17:00	18:00	01:00	0	0	0
Unit 1-bottom	16-Oct	17:00	18:00	01:00	0	0	0
Unit 4-top	16-Oct	17:08	18:08	01:00	0	0	0
Unit 4-bottom	16-Oct	17:08	18:08	01:00	0	0	0
Unit 1-top	16-Oct	18:22	19:22	01:00	2	0	2
Unit 1-bottom	16-Oct	18:22	19:22	01:00	0	0	0
Unit 4-top	16-Oct	18:30	19:30	01:00	0	0	0
Unit 4-bottom	16-Oct	18:30	19:30	01:00	0	0	0
Unit 6-top	16-Oct	18:40	19:40	01:00	0	0	0

Appendix 5-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled
Unit 6-bottom	16-Oct	18:40	19:40	01:00	0	0	0
Unit 1-top	16-Oct	20:00	21:00	01:00	1	0	1
Unit 1-bottom	16-Oct	20:00	21:00	01:00	0	0	0
Unit 1-top	17-Oct	17:00	18:00	01:00	0	0	0
Unit 1-bottom	17-Oct	17:00	18:00	01:00	0	0	0
Unit 4-top	17-Oct	17:09	18:09	01:00	0	0	0
Unit 4-bottom	17-Oct	17:09	18:09	01:00	0	0	0
Unit 1-top	17-Oct	18:21	19:21	01:00	0	0	0
Unit 1-bottom	17-Oct	18:21	19:21	01:00	0	0	0
Unit 4-top	17-Oct	18:28	19:28	01:00	0	0	0
Unit 4-bottom	17-Oct	18:28	19:28	01:00	0	0	0
Unit 1-top	17-Oct	19:40	20:20	00:40	3	0	3
Unit 1-bottom	17-Oct	19:40	20:20	00:40	0	0	0
Unit 4-top	17-Oct	19:47	20:29	00:42	1	0	1
Unit 4-bottom	17-Oct	19:47	20:29	00:42	0	0	0
Unit 6-top	17-Oct	19:55	20:37	00:42	8	1	7
Unit 6-bottom	17-Oct	19:55	20:37	00:42	0	0	0
Unit 1-top	19-Oct	17:00	17:30	00:30	0	0	0
Unit 1-bottom	19-Oct	17:00	17:30	00:30	0	0	0
Unit 4-top	19-Oct	17:11	17:41	00:30	0	0	0
Unit 4-bottom	19-Oct	17:11	17:41	00:30	0	0	0
Unit 1-top	19-Oct	17:56	18:56	01:00	28	0	28
Unit 1-bottom	19-Oct	17:56	18:56	01:00	4	0	4
Unit 4-top	19-Oct	18:05	19:05	01:00	0	0	0
Unit 4-bottom	19-Oct	18:05	19:05	01:00	2	0	2
Unit 6-top	19-Oct	18:15	19:15	01:00	26	0	26
Unit 6-bottom	19-Oct	18:15	19:15	01:00	8	0	8
Unit 1-top	19-Oct	19:35	20:35	01:00	33	1	32
Unit 1-bottom	19-Oct	19:35	20:35	01:00	5	0	5
Unit 4-top	19-Oct	19:44	20:46	01:02	8	0	8
Unit 4-bottom	19-Oct	19:44	20:46	01:02	0	0	0
Unit 6-top	19-Oct	19:53	20:54	01:01	10	0	10
Unit 6-bottom	19-Oct	19:53	20:54	01:01	3	0	3
Unit 1-top	20-Oct	17:00	18:00	01:00	0	0	0
Unit 1-bottom	20-Oct	17:00	18:00	01:00	0	0	0
Unit 4-top	20-Oct	17:07	18:07	01:00	0	0	0
Unit 4-bottom	20-Oct	17:07	18:07	01:00	0	0	0
Unit 6-top	20-Oct	17:13	18:13	01:00	1	0	1
Unit 6-bottom	20-Oct	17:13	18:13	01:00	0	0	0
Unit 1-top	20-Oct	18:35	19:35	01:00	20	1	19

Appendix 5-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled
Unit 1-bottom	20-Oct	18:35	19:35	01:00	5	0	5
Unit 4-top	20-Oct	18:44	19:44	01:00	0	0	0
Unit 4-bottom	20-Oct	18:44	19:44	01:00	1	0	1
Unit 6-top	20-Oct	18:53	19:53	01:00	10	1	9
Unit 6-bottom	20-Oct	18:53	19:53	01:00	3	0	3
Unit 1-top	20-Oct	20:09	21:09	01:00	3	0	3
Unit 1-bottom	20-Oct	20:09	21:09	01:00	4	0	4
Unit 4-top	20-Oct	20:19	21:19	01:00	0	0	0
Unit 4-bottom	20-Oct	20:19	21:19	01:00	1	0	1
Unit 6-top	20-Oct	20:28	21:28	01:00	7	0	7
Unit 6-bottom	20-Oct	20:28	21:28	01:00	2	0	2
Unit 1-top	21-Oct	17:00	18:00	01:00	21	0	21
Unit 1-bottom	21-Oct	17:00	18:00	01:00	0	0	0
Unit 4-top	21-Oct	17:07	18:10	01:03	6	0	6
Unit 4-bottom	21-Oct	17:07	18:10	01:03	0	0	0
Unit 6-top	21-Oct	17:13	18:19	01:06	4	0	4
Unit 6-bottom	21-Oct	17:13	18:19	01:06	1	0	1
Unit 1-top	21-Oct	18:43	19:43	01:00	29	0	29
Unit 1-bottom	21-Oct	18:43	19:43	01:00	13	0	13
Unit 4-top	21-Oct	18:55	19:59	01:04	3	0	3
Unit 4-bottom	21-Oct	18:55	19:59	01:04	2	0	2
Unit 6-top	21-Oct	19:07	20:07	01:00	23	0	23
Unit 6-bottom	21-Oct	19:07	20:07	01:00	5	0	5
Unit 1-top	21-Oct	20:30	21:10	00:40	52	1	51
Unit 1-bottom	21-Oct	20:30	21:10	00:40	13	0	13
Unit 4-top	21-Oct	20:41	21:21	00:40	6	0	6
Unit 4-bottom	21-Oct	20:41	21:21	00:40	0	0	0
Unit 1-top	22-Oct	16:37	17:37	01:00	50	0	50
Unit 1-bottom	22-Oct	16:37	17:37	01:00	0	0	0
Unit 4-top	22-Oct	16:44	17:44	01:00	0	0	0
Unit 4-bottom	22-Oct	16:44	17:44	01:00	0	0	0
Unit 6-top	22-Oct	16:50	17:51	01:01	0	0	0
Unit 6-bottom	22-Oct	16:50	17:51	01:01	0	0	0
Unit 1-top	22-Oct	18:07	19:07	01:00	34	0	34
Unit 1-bottom	22-Oct	18:07	19:07	01:00	6	0	6
Unit 4-top	22-Oct	18:16	19:16	01:00	0	0	0
Unit 4-bottom	22-Oct	18:16	19:16	01:00	0	0	0
Unit 1-top	22-Oct	19:30	20:30	01:00	28	0	28
Unit 1-bottom	22-Oct	19:30	20:30	01:00	9	0	9
Unit 4-top	22-Oct	19:39	20:43	01:04	3	0	3

Appendix 5-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled
Unit 4-bottom	22-Oct	19:39	20:43	01:04	0	0	0
Unit 1-top	23-Oct	17:05	18:05	01:00	1	0	1
Unit 1-bottom	23-Oct	17:05	18:05	01:00	0	0	0
Unit 1-top	23-Oct	18:17	19:17	01:00	8	0	8
Unit 1-bottom	23-Oct	18:17	19:17	01:00	1	0	1
Unit 4-top	23-Oct	18:26	19:26	01:00	0	0	0
Unit 4-bottom	23-Oct	18:26	19:26	01:00	0	0	0
Unit 6-top	23-Oct	18:35	19:35	01:00	3	0	3
Unit 6-bottom	23-Oct	18:35	19:35	01:00	0	0	0
Unit 1-top	23-Oct	19:53	20:53	01:00	1	0	1
Unit 1-bottom	23-Oct	19:53	20:53	01:00	0	0	0
Unit 4-top	23-Oct	20:00	21:03	01:03	0	0	0
Unit 4-bottom	23-Oct	20:00	21:03	01:03	0	0	0
Unit 1-top	24-Oct	16:00	17:00	01:00	18	0	18
Unit 1-bottom	24-Oct	16:00	17:00	01:00	0	0	0
Unit 1-top	24-Oct	17:11	18:11	01:00	3	0	3
Unit 1-bottom	24-Oct	17:11	18:11	01:00	0	0	0
Unit 1-top	24-Oct	18:24	19:38	01:14	17	0	17
Unit 1-bottom	24-Oct	18:24	19:38	01:14	0	0	0
Unit 4-top	24-Oct	18:41	19:47	01:06	2	0	2
Unit 4-bottom	24-Oct	18:41	19:47	01:06	1	0	1
Unit 1-top	25-Oct	16:15	17:15	01:00	1	0	1
Unit 1-bottom	25-Oct	16:15	17:15	01:00	1	0	1
Unit 4-top	25-Oct	16:21	17:22	01:01	3	0	3
Unit 4-bottom	25-Oct	16:21	17:22	01:01	0	0	0
Unit 6-top	25-Oct	16:27	16:37	00:10	2	0	2
Unit 6-bottom	25-Oct	16:27	16:37	00:10	2	0	2
Unit 1-top	25-Oct	17:47	18:47	01:00	16	0	16
Unit 1-bottom	25-Oct	17:47	18:47	01:00	20	0	20
Unit 4-top	25-Oct	17:56	18:58	01:02	4	0	4
Unit 4-bottom	25-Oct	17:56	18:58	01:02	1	0	1
Unit 6-top	25-Oct	18:05	19:05	01:00	40	0	40
Unit 6-bottom	25-Oct	18:05	19:05	01:00	9	0	9
Unit 1-top	25-Oct	19:21	20:21	01:00	16	1	15
Unit 1-bottom	25-Oct	19:21	20:21	01:00	5	0	5
Unit 4-top	25-Oct	19:30	20:33	01:03	6	0	6
Unit 4-bottom	25-Oct	19:30	20:33	01:03	3	0	3
Unit 6-top	25-Oct	19:38	20:42	01:04	15	0	15
Unit 6-bottom	25-Oct	19:38	20:42	01:04	7	0	7
Unit 1-top	27-Oct	17:05	18:05	01:00	6	0	6

Appendix 5-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled
Unit 1-bottom	27-Oct	17:05	18:05	01:00	2	0	2
Unit 4-top	27-Oct	17:15	18:15	01:00	2	0	2
Unit 4-bottom	27-Oct	17:15	18:15	01:00	3	0	3
Unit 6-top	27-Oct	17:24	18:25	01:01	3	0	3
Unit 6-bottom	27-Oct	17:24	18:24	01:00	2	0	2
Unit 1-top	27-Oct	18:42	19:42	01:00	7	0	7
Unit 1-bottom	27-Oct	18:42	19:42	01:00	1	0	1
Unit 4-top	27-Oct	18:50	19:54	01:04	0	0	0
Unit 4-bottom	27-Oct	18:50	19:54	01:04	0	0	0
Unit 6-top	27-Oct	19:00	20:00	01:00	2	0	2
Unit 6-bottom	27-Oct	19:00	20:00	01:00	5	0	5
Unit 1-top	27-Oct	20:22	21:08	00:46	7	0	7
Unit 1-bottom	27-Oct	20:22	21:08	00:46	0	0	0
Unit 4-top	27-Oct	20:32	21:16	00:44	2	0	2
Unit 4-bottom	27-Oct	20:32	21:16	00:44	0	0	0
Unit 6-top	27-Oct	20:43	21:24	00:41	3	0	3
Unit 6-bottom	27-Oct	20:43	21:24	00:41	1	0	1
Unit 1-top	29-Oct	16:45	17:45	01:00	0	0	0
Unit 1-bottom	29-Oct	16:45	17:45	01:00	0	0	0
Unit 4-top	29-Oct	16:56	17:56	01:00	0	0	0
Unit 4-bottom	29-Oct	16:56	17:56	01:00	0	0	0
Unit 1-top	29-Oct	18:10	19:10	01:00	4	0	4
Unit 1-bottom	29-Oct	18:10	19:10	01:00	2	0	2
Unit 4-top	29-Oct	18:19	19:19	01:00	0	0	0
Unit 4-bottom	29-Oct	18:19	19:19	01:00	0	0	0
Unit 6-top	29-Oct	18:25	19:25	01:00	0	0	0
Unit 6-bottom	29-Oct	18:25	19:25	01:00	1	0	1
Unit 1-top	29-Oct	19:45	20:45	01:00	9	0	9
Unit 1-bottom	29-Oct	19:45	20:45	01:00	0	0	0
Unit 4-top	29-Oct	19:55	20:55	01:00	0	0	0
Unit 4-bottom	29-Oct	19:55	20:55	01:00	0	0	0
Unit 6-top	29-Oct	20:06	21:06	01:00	0	0	0
Unit 6-bottom	29-Oct	20:06	21:06	01:00	1	0	1
Unit 1-top	30-Oct	16:07	17:07	01:00	0	0	0
Unit 1-bottom	30-Oct	16:07	17:07	01:00	0	0	0
Unit 4-top	30-Oct	16:13	17:13	01:00	0	0	0
Unit 4-bottom	30-Oct	16:13	17:13	01:00	0	0	0
Unit 6-top	30-Oct	16:22	17:22	01:00	1	0	1
Unit 6-bottom	30-Oct	16:22	17:22	01:00	0	0	0
Unit 1-top	30-Oct	17:32	18:32	01:00	4	0	4

Appendix 5-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled
Unit 1-bottom	30-Oct	17:32	18:32	01:00	0	0	0
Unit 4-top	30-Oct	17:40	18:40	01:00	0	0	0
Unit 4-bottom	30-Oct	17:40	18:40	01:00	0	0	0
Unit 6-top	30-Oct	17:47	18:47	01:00	6	0	6
Unit 6-bottom	30-Oct	17:47	18:47	01:00	0	0	0
Unit 1-top	30-Oct	19:01	20:01	01:00	2	0	2
Unit 1-bottom	30-Oct	19:01	20:01	01:00	2	0	2
Unit 4-top	30-Oct	19:10	20:10	01:00	0	0	0
Unit 4-bottom	30-Oct	19:10	20:10	01:00	1	0	1
Unit 6-top	30-Oct	19:18	20:18	01:00	6	0	6
Unit 6-bottom	30-Oct	19:18	20:18	01:00	1	0	1
Unit 1-top	01-Nov	16:00	17:00	01:00	0	0	0
Unit 1-bottom	01-Nov	16:00	17:00	01:00	0	0	0
Unit 1-top	01-Nov	17:12	18:12	01:00	5	0	5
Unit 1-bottom	01-Nov	17:12	18:12	01:00	5	0	5
Unit 4-top	01-Nov	17:22	18:22	01:00	2	0	2
Unit 4-bottom	01-Nov	17:22	18:22	01:00	1	0	1
Unit 6-top	01-Nov	17:31	18:31	01:00	3	0	3
Unit 6-bottom	01-Nov	17:31	18:31	01:00	1	0	1
Unit 1-top	01-Nov	18:46	19:46	01:00	2	0	2
Unit 1-bottom	01-Nov	18:46	19:46	01:00	0	0	0
Unit 4-top	01-Nov	18:53	19:53	01:00	4	0	4
Unit 4-bottom	01-Nov	18:53	19:53	01:00	2	0	2
Unit 6-top	01-Nov	19:01	20:01	01:00	7	0	7
Unit 6-bottom	01-Nov	19:01	20:01	01:00	1	0	1

Appendix 5-Table 2. Turbine net catch per unit effort.

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 1-top	16-Sep	17:00	0	0	0
Unit 1-bottom	16-Sep	17:00	0	0	0
Unit 4-top	16-Sep	17:10	0	0	0
Unit 4-bottom	16-Sep	17:10	0	0	0
Unit 6-top	16-Sep	17:20	0	0	0
Unit 6-bottom	16-Sep	17:20	0	0	0
Unit 1-top	16-Sep	18:50	0	0	0
Unit 1-bottom	16-Sep	18:50	0	0	0
Unit 4-top	16-Sep	18:57	0	0	0
Unit 4-bottom	16-Sep	18:57	0	0	0
Unit 6-top	16-Sep	19:01	1	0	1
Unit 6-bottom	16-Sep	19:01	0	0	0
Unit 4-top	17-Sep	17:08	0	0	0
Unit 4-bottom	17-Sep	17:08	0	0	0
Unit 4-top	17-Sep	18:19	0	0	0
Unit 4-bottom	17-Sep	18:19	0	0	0
Unit 4-top	17-Sep	20:01	0	0	0
Unit 4-bottom	17-Sep	20:01	0	0	0
Unit 1-top	18-Sep	17:00	0	0	0
Unit 1-bottom	18-Sep	17:00	0	0	0
Unit 4-top	18-Sep	17:09	0	0	0
Unit 4-bottom	18-Sep	17:09	0	0	0
Unit 6-top	18-Sep	17:13	2	0	2
Unit 6-bottom	18-Sep	17:13	0	0	0
Unit 1-top	18-Sep	18:50	0	0	0
Unit 1-bottom	18-Sep	18:50	0	0	0
Unit 4-top	18-Sep	18:58	0	0	0
Unit 4-bottom	18-Sep	18:58	0	0	0
Unit 1-top	18-Sep	20:52	0	0	0
Unit 1-bottom	18-Sep	20:52	0	0	0
Unit 4-top	18-Sep	20:57	0	0	0
Unit 4-bottom	18-Sep	20:57	0	0	0
Unit 6-top	18-Sep	21:01	1	0	1
Unit 6-bottom	18-Sep	21:01	0	0	0
Unit 1-top	19-Sep	17:06	0	0	0
Unit 1-bottom	19-Sep	17:06	0	0	0
Unit 1-top	19-Sep	18:18	0	0	0
Unit 1-bottom	19-Sep	18:18	0	0	0
Unit 1-top	19-Sep	19:32	0	0	0
Unit 1-bottom	19-Sep	19:32	0	0	0

Appendix 5-Table 2. (Continued).

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 1-top	19-Sep	20:22	0	0	0
Unit 1-bottom	19-Sep	20:22	0	0	0
Unit 1-top	22-Sep	17:09	0	0	0
Unit 1-bottom	22-Sep	17:09	0	0	0
Unit 4-top	22-Sep	17:13	0	0	0
Unit 4-bottom	22-Sep	17:13	0	0	0
Unit 6-top	22-Sep	17:19	0	0	0
Unit 6-bottom	22-Sep	17:19	0	0	0
Unit 1-top	22-Sep	18:46	0	0	0
Unit 1-bottom	22-Sep	18:46	0	0	0
Unit 4-top	22-Sep	18:54	0	0	0
Unit 4-bottom	22-Sep	18:54	0	0	0
Unit 6-top	22-Sep	19:16	0	0	0
Unit 6-bottom	22-Sep	19:16	0	0	0
Unit 1-top	22-Sep	20:35	0	0	0
Unit 1-bottom	22-Sep	20:35	0	0	0
Unit 4-top	22-Sep	20:45	0	0	0
Unit 4-bottom	22-Sep	20:45	0	0	0
Unit 1-top	23-Sep	17:04	1	0	1
Unit 1-bottom	23-Sep	17:04	0	0	0
Unit 4-top	23-Sep	17:08	0	0	0
Unit 4-bottom	23-Sep	17:08	0	0	0
Unit 6-top	23-Sep	17:14	0	0	0
Unit 6-bottom	23-Sep	17:14	0	0	0
Unit 1-top	23-Sep	18:50	0	0	0
Unit 1-bottom	23-Sep	18:50	0	0	0
Unit 4-top	23-Sep	19:02	0	0	0
Unit 4-bottom	23-Sep	19:02	0	0	0
Unit 6-top	23-Sep	19:11	0	0	0
Unit 6-bottom	23-Sep	19:11	0	0	0
Unit 1-top	23-Sep	20:28	0	0	0
Unit 1-bottom	23-Sep	20:28	0	0	0
Unit 4-top	23-Sep	20:40	2	0	2
Unit 4-bottom	23-Sep	20:40	1	0	1
Unit 6-top	23-Sep	20:52	0	0	0
Unit 6-bottom	23-Sep	20:52	0	0	0
Unit 1-top	24-Sep	17:05	1	0	1
Unit 1-bottom	24-Sep	17:05	0	0	0
Unit 4-top	24-Sep	17:10	0	0	0
Unit 4-bottom	24-Sep	17:10	0	0	0

Appendix 5-Table 2. (Continued).

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 1-top	24-Sep	18:29	0	0	0
Unit 1-bottom	24-Sep	18:29	0	0	0
Unit 4-top	24-Sep	18:40	0	0	0
Unit 4-bottom	24-Sep	18:40	0	0	0
Unit 6-top	24-Sep	18:48	0	0	0
Unit 6-bottom	24-Sep	18:48	2	0	2
Unit 1-top	24-Sep	20:03	2	0	2
Unit 1-bottom	24-Sep	20:03	1	1	0
Unit 4-top	24-Sep	20:13	0	0	0
Unit 4-bottom	24-Sep	20:13	0	0	0
Unit 6-top	24-Sep	20:24	0	0	0
Unit 6-bottom	24-Sep	20:24	0	0	0
Unit 1-top	25-Sep	17:04	92	8	84
Unit 1-bottom	25-Sep	17:04	0	0	0
Unit 4-top	25-Sep	17:10	1	0	1
Unit 4-bottom	25-Sep	17:10	0	0	0
Unit 6-top	25-Sep	17:16	3	0	3
Unit 6-bottom	25-Sep	17:16	0	0	0
Unit 1-top	25-Sep	18:41	77	3	74
Unit 1-bottom	25-Sep	18:41	0	0	0
Unit 4-top	25-Sep	18:51	9	0	9
Unit 4-bottom	25-Sep	18:51	1	0	1
Unit 6-top	25-Sep	19:02	192	34	158
Unit 6-bottom	25-Sep	19:02	12	2	9
Unit 1-top	26-Sep	17:02	63	7	56
Unit 1-bottom	26-Sep	17:02	1	0	1
Unit 4-top	26-Sep	17:07	0	0	0
Unit 4-bottom	26-Sep	17:07	0	0	0
Unit 1-top	26-Sep	18:22	45	0	45
Unit 1-bottom	26-Sep	18:22	0	0	0
Unit 4-top	26-Sep	18:31	7	0	7
Unit 4-bottom	26-Sep	18:31	1	0	1
Unit 6-top	26-Sep	18:45	2	0	2
Unit 6-bottom	26-Sep	18:45	0	0	0
Unit 1-top	26-Sep	19:55	44	0	44
Unit 1-bottom	26-Sep	19:55	0	0	0
Unit 4-top	26-Sep	20:06	5	0	5
Unit 4-bottom	26-Sep	20:06	0	0	0
Unit 6-top	26-Sep	20:15	0	0	0
Unit 6-bottom	26-Sep	20:15	0	0	0

Appendix 5-Table 2. (Continued).

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 1-top	28-Sep	17:02	52	6	46
Unit 1-bottom	28-Sep	17:02	0	0	0
Unit 4-top	28-Sep	17:08	1	0	1
Unit 4-bottom	28-Sep	17:08	0	0	0
Unit 6-top	28-Sep	17:13	12	2	10
Unit 6-bottom	28-Sep	17:13	0	0	0
Unit 1-top	28-Sep	18:47	81	2	79
Unit 1-bottom	28-Sep	18:47	0	0	0
Unit 4-top	28-Sep	18:57	1	0	1
Unit 4-bottom	28-Sep	18:57	0	0	0
Unit 6-top	28-Sep	19:05	3	0	3
Unit 6-bottom	28-Sep	19:05	3	3	0
Unit 1-top	28-Sep	20:20	57	2	55
Unit 1-bottom	28-Sep	20:20	0	0	0
Unit 4-top	28-Sep	20:28	2	0	2
Unit 4-bottom	28-Sep	20:28	0	0	0
Unit 6-top	28-Sep	20:36	6	0	6
Unit 6-bottom	28-Sep	20:36	0	0	0
Unit 1-top	29-Sep	17:07	24	3	21
Unit 1-bottom	29-Sep	17:07	0	0	0
Unit 4-top	29-Sep	17:14	0	0	0
Unit 4-bottom	29-Sep	17:14	0	0	0
Unit 1-top	29-Sep	18:31	4	1	3
Unit 1-bottom	29-Sep	18:31	0	0	0
Unit 4-top	29-Sep	18:39	1	0	1
Unit 4-bottom	29-Sep	18:39	0	0	0
Unit 6-top	29-Sep	18:43	1	0	1
Unit 6-bottom	29-Sep	18:43	1	1	0
Unit 1-top	29-Sep	20:04	5	0	5
Unit 1-bottom	29-Sep	20:04	0	0	0
Unit 4-top	29-Sep	20:11	1	0	1
Unit 4-bottom	29-Sep	20:11	0	0	0
Unit 6-top	29-Sep	20:20	1	0	1
Unit 6-bottom	29-Sep	20:20	1	0	1
Unit 1-top	30-Sep	17:01	77	3	74
Unit 1-bottom	30-Sep	17:01	2	0	2
Unit 4-top	30-Sep	17:07	12	1	11
Unit 4-bottom	30-Sep	17:07	0	0	0
Unit 1-top	30-Sep	18:23	18	6	12
Unit 1-bottom	30-Sep	18:23	0	0	0

Appendix 5-Table 2. (Continued).

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 4-top	30-Sep	18:33	14	0	14
Unit 4-bottom	30-Sep	18:33	0	0	0
Unit 1-top	30-Sep	20:14	5	0	5
Unit 1-bottom	30-Sep	20:14	5	0	5
Unit 4-top	30-Sep	20:24	21	2	19
Unit 4-bottom	30-Sep	20:24	0	0	0
Unit 1-top	01-Oct	17:00	52	4	48
Unit 1-bottom	01-Oct	17:00	0	0	0
Unit 1-top	01-Oct	18:18	30	0	30
Unit 1-bottom	01-Oct	18:18	0	0	0
Unit 1-top	01-Oct	19:30	61	4	57
Unit 1-bottom	01-Oct	19:30	0	0	0
Unit 4-top	01-Oct	19:35	30	0	30
Unit 4-bottom	01-Oct	19:35	19	0	19
Unit 6-top	01-Oct	19:40	61	18	43
Unit 6-bottom	01-Oct	19:40	41	0	41
Unit 1-top	02-Oct	17:01	35	8	27
Unit 1-bottom	02-Oct	17:01	1	0	1
Unit 1-top	02-Oct	18:12	16	0	16
Unit 1-bottom	02-Oct	18:12	0	0	0
Unit 1-top	02-Oct	19:22	10	0	10
Unit 1-bottom	02-Oct	19:22	1	0	1
Unit 1-top	03-Oct	17:00	22	1	21
Unit 1-bottom	03-Oct	17:00	0	0	0
Unit 1-top	03-Oct	18:10	0	0	0
Unit 1-bottom	03-Oct	18:10	0	0	0
Unit 1-top	03-Oct	19:20	9	0	9
Unit 1-bottom	03-Oct	19:20	0	0	0
Unit 1-top	04-Oct	17:00	5	1	4
Unit 1-bottom	04-Oct	17:00	0	0	0
Unit 1-top	04-Oct	18:16	12	0	12
Unit 1-bottom	04-Oct	18:16	0	0	0
Unit 4-top	04-Oct	18:26	1	0	1
Unit 4-bottom	04-Oct	18:26	0	0	0
Unit 6-top	04-Oct	18:31	0	0	0
Unit 6-bottom	04-Oct	18:31	1	1	0
Unit 1-top	04-Oct	19:47	10	0	10
Unit 1-bottom	04-Oct	19:47	0	0	0
Unit 4-top	04-Oct	19:56	1	0	1
Unit 4-bottom	04-Oct	19:56	0	0	0

Appendix 5-Table 2. (Continued).

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 6-top	04-Oct	20:04	0	0	0
Unit 6-bottom	04-Oct	20:04	0	0	0
Unit 1-top	05-Oct	17:15	0	0	0
Unit 1-bottom	05-Oct	17:15	0	0	0
Unit 1-top	05-Oct	18:25	0	0	0
Unit 1-bottom	05-Oct	18:25	0	0	0
Unit 4-top	05-Oct	18:32	0	0	0
Unit 4-bottom	05-Oct	18:32	0	0	0
Unit 1-top	05-Oct	19:44	0	0	0
Unit 1-bottom	05-Oct	19:44	0	0	0
Unit 4-top	05-Oct	19:53	0	0	0
Unit 4-bottom	05-Oct	19:53	0	0	0
Unit 6-top	05-Oct	19:58	0	0	0
Unit 6-bottom	05-Oct	19:58	0	0	0
Unit 4-top	06-Oct	17:00	0	0	0
Unit 4-bottom	06-Oct	17:00	0	0	0
Unit 4-top	06-Oct	18:11	0	0	0
Unit 4-bottom	06-Oct	18:11	0	0	0
Unit 1-top	06-Oct	19:25	1	0	1
Unit 1-bottom	06-Oct	19:25	0	0	0
Unit 4-top	06-Oct	19:33	0	0	0
Unit 4-bottom	06-Oct	19:33	0	0	0
Unit 6-top	06-Oct	19:42	0	0	0
Unit 6-bottom	06-Oct	19:42	0	0	0
Unit 6-bottom	07-Oct	16:55	0	0	0
Unit 6-top	07-Oct	18:14	0	0	0
Unit 6-bottom	07-Oct	18:14	0	0	0
Unit 1-top	07-Oct	19:28	0	0	0
Unit 1-bottom	07-Oct	19:28	0	0	0
Unit 4-top	07-Oct	19:38	0	0	0
Unit 4-bottom	07-Oct	19:38	0	0	0
Unit 6-top	07-Oct	19:48	1	0	1
Unit 6-bottom	07-Oct	19:48	0	0	0
Unit 6-top	08-Oct	17:00	0	0	0
Unit 6-bottom	08-Oct	17:00	0	0	0
Unit 6-top	08-Oct	18:10	0	0	0
Unit 6-bottom	08-Oct	18:10	0	0	0
Unit 6-top	08-Oct	19:20	0	0	0
Unit 6-bottom	08-Oct	19:20	0	0	0
Unit 4-top	08-Oct	19:29	0	0	0

Appendix 5-Table 2. (Continued).

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 4-bottom	08-Oct	19:29	0	0	0
Unit 1-top	08-Oct	19:37	0	0	0
Unit 1-bottom	08-Oct	19:37	0	0	0
Unit 1-top	09-Oct	17:00	19	3	16
Unit 1-bottom	09-Oct	17:00	0	0	0
Unit 4-top	09-Oct	17:06	0	0	0
Unit 4-bottom	09-Oct	17:06	0	0	0
Unit 6-top	09-Oct	17:12	1	0	1
Unit 6-bottom	09-Oct	17:12	0	0	0
Unit 1-top	09-Oct	18:24	29	3	26
Unit 1-bottom	09-Oct	18:24	0	0	0
Unit 4-top	09-Oct	18:32	0	0	0
Unit 4-bottom	09-Oct	18:32	0	0	0
Unit 6-top	09-Oct	18:41	0	0	0
Unit 6-bottom	09-Oct	18:41	0	0	0
Unit 1-top	09-Oct	19:48	3	0	3
Unit 1-bottom	09-Oct	19:48	0	0	0
Unit 4-top	09-Oct	19:57	12	0	12
Unit 4-bottom	09-Oct	19:57	0	0	0
Unit 1-top	10-Oct	17:12	28	8	20
Unit 1-bottom	10-Oct	17:12	1	0	1
Unit 4-top	10-Oct	17:17	1	0	1
Unit 4-bottom	10-Oct	17:17	1	0	1
Unit 6-top	10-Oct	17:21	1	0	1
Unit 6-bottom	10-Oct	17:21	2	0	2
Unit 1-top	10-Oct	19:00	114	6	108
Unit 1-bottom	10-Oct	19:00	13	0	13
Unit 4-top	10-Oct	19:08	3	0	3
Unit 4-bottom	10-Oct	19:08	6	0	6
Unit 6-top	10-Oct	19:16	53	2	51
Unit 6-bottom	10-Oct	19:16	4	0	4
Unit 1-top	10-Oct	20:16	44	0	44
Unit 1-bottom	10-Oct	20:16	4	0	4
Unit 4-top	10-Oct	20:25	0	0	0
Unit 4-bottom	10-Oct	20:25	1	0	1
Unit 6-top	10-Oct	20:35	7	0	7
Unit 6-bottom	10-Oct	20:35	3	0	3
Unit 1-top	11-Oct	17:06	0	0	0
Unit 1-bottom	11-Oct	17:06	1	0	1
Unit 4-top	11-Oct	17:10	10	1	9

Appendix 5-Table 2. (Continued).

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 4-bottom	11-Oct	17:10	0	0	0
Unit 6-top	11-Oct	17:14	0	0	0
Unit 6-bottom	11-Oct	17:14	0	0	0
Unit 1-top	11-Oct	18:12	27	1	25
Unit 1-bottom	11-Oct	18:12	0	0	0
Unit 4-top	11-Oct	18:20	0	0	0
Unit 4-bottom	11-Oct	18:20	0	0	0
Unit 6-top	11-Oct	18:28	0	0	0
Unit 6-bottom	11-Oct	18:28	0	0	0
Unit 1-top	11-Oct	19:20	15	0	15
Unit 1-bottom	11-Oct	19:20	0	0	0
Unit 4-top	11-Oct	19:28	13	1	12
Unit 4-bottom	11-Oct	19:28	0	0	0
Unit 6-top	11-Oct	19:35	0	0	0
Unit 6-bottom	11-Oct	19:35	3	0	3
Unit 1-top	11-Oct	20:25	42	1	40
Unit 1-bottom	11-Oct	20:25	1	0	1
Unit 4-top	11-Oct	20:33	9	0	9
Unit 4-bottom	11-Oct	20:33	0	0	0
Unit 6-top	11-Oct	20:46	58	13	45
Unit 6-bottom	11-Oct	20:46	7	3	4
Unit 1-top	12-Oct	17:00	31	9	22
Unit 1-bottom	12-Oct	17:00	0	0	0
Unit 4-top	12-Oct	17:06	0	0	0
Unit 4-bottom	12-Oct	17:06	0	0	0
Unit 6-top	12-Oct	17:10	0	0	0
Unit 6-bottom	12-Oct	17:10	0	0	0
Unit 1-top	12-Oct	18:30	15	1	14
Unit 1-bottom	12-Oct	18:30	5	0	5
Unit 4-top	12-Oct	18:37	8	0	8
Unit 4-bottom	12-Oct	18:37	2	0	2
Unit 6-top	12-Oct	18:44	43	5	38
Unit 6-bottom	12-Oct	18:44	11	0	11
Unit 1-top	12-Oct	20:05	18	0	18
Unit 1-bottom	12-Oct	20:05	3	0	3
Unit 4-top	12-Oct	20:15	2	0	2
Unit 4-bottom	12-Oct	20:15	0	0	0
Unit 6-top	12-Oct	20:25	3	0	3
Unit 6-bottom	12-Oct	20:25	0	0	0
Unit 4-top	13-Oct	17:16	0	0	0

Appendix 5-Table 2. (Continued).

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 4-bottom	13-Oct	17:16	0	0	0
Unit 6-top	13-Oct	17:28	6	0	6
Unit 6-bottom	13-Oct	17:28	0	0	0
Unit 1-top	13-Oct	18:39	9	0	9
Unit 1-bottom	13-Oct	18:39	16	0	16
Unit 4-top	13-Oct	18:48	10	0	10
Unit 4-bottom	13-Oct	18:48	1	0	1
Unit 6-top	13-Oct	18:55	32	3	29
Unit 6-bottom	13-Oct	18:55	4	0	4
Unit 1-top	13-Oct	20:14	32	0	32
Unit 1-bottom	13-Oct	20:14	3	0	3
Unit 4-top	14-Oct	17:00	1	0	1
Unit 4-bottom	14-Oct	17:00	0	0	0
Unit 6-top	14-Oct	18:20	2	0	2
Unit 6-bottom	14-Oct	18:20	1	0	1
Unit 4-top	14-Oct	18:24	0	0	0
Unit 4-bottom	14-Oct	18:24	0	0	0
Unit 1-top	14-Oct	18:35	4	0	4
Unit 1-bottom	14-Oct	18:35	4	0	4
Unit 1-top	15-Oct	17:46	0	0	0
Unit 1-bottom	15-Oct	17:46	1	0	1
Unit 4-top	15-Oct	17:52	0	0	0
Unit 4-bottom	15-Oct	17:52	1	0	1
Unit 6-top	15-Oct	17:57	5	0	5
Unit 6-bottom	15-Oct	17:57	0	0	0
Unit 1-top	15-Oct	19:20	21	0	21
Unit 1-bottom	15-Oct	19:20	6	1	5
Unit 4-top	15-Oct	19:28	7	0	7
Unit 4-bottom	15-Oct	19:28	4	0	4
Unit 6-top	15-Oct	19:41	30	1	29
Unit 6-bottom	15-Oct	19:41	2	0	2
Unit 1-top	16-Oct	17:00	0	0	0
Unit 1-bottom	16-Oct	17:00	0	0	0
Unit 4-top	16-Oct	17:08	0	0	0
Unit 4-bottom	16-Oct	17:08	0	0	0
Unit 1-top	16-Oct	18:22	2	0	2
Unit 1-bottom	16-Oct	18:22	0	0	0
Unit 4-top	16-Oct	18:30	0	0	0
Unit 4-bottom	16-Oct	18:30	0	0	0
Unit 6-top	16-Oct	18:40	0	0	0

Appendix 5-Table 2. (Continued).

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 6-bottom	16-Oct	18:40	0	0	0
Unit 1-top	16-Oct	20:00	1	0	1
Unit 1-bottom	16-Oct	20:00	0	0	0
Unit 1-top	17-Oct	17:00	0	0	0
Unit 1-bottom	17-Oct	17:00	0	0	0
Unit 4-top	17-Oct	17:09	0	0	0
Unit 4-bottom	17-Oct	17:09	0	0	0
Unit 1-top	17-Oct	18:21	0	0	0
Unit 1-bottom	17-Oct	18:21	0	0	0
Unit 4-top	17-Oct	18:28	0	0	0
Unit 4-bottom	17-Oct	18:28	0	0	0
Unit 1-top	17-Oct	19:40	4	0	4
Unit 1-bottom	17-Oct	19:40	0	0	0
Unit 4-top	17-Oct	19:47	1	0	1
Unit 4-bottom	17-Oct	19:47	0	0	0
Unit 6-top	17-Oct	19:55	11	1	10
Unit 6-bottom	17-Oct	19:55	0	0	0
Unit 1-top	19-Oct	17:00	0	0	0
Unit 1-bottom	19-Oct	17:00	0	0	0
Unit 4-top	19-Oct	17:11	0	0	0
Unit 4-bottom	19-Oct	17:11	0	0	0
Unit 1-top	19-Oct	17:56	28	0	28
Unit 1-bottom	19-Oct	17:56	4	0	4
Unit 4-top	19-Oct	18:05	0	0	0
Unit 4-bottom	19-Oct	18:05	2	0	2
Unit 6-top	19-Oct	18:15	26	0	26
Unit 6-bottom	19-Oct	18:15	8	0	8
Unit 1-top	19-Oct	19:35	33	1	32
Unit 1-bottom	19-Oct	19:35	5	0	5
Unit 4-top	19-Oct	19:44	8	0	8
Unit 4-bottom	19-Oct	19:44	0	0	0
Unit 6-top	19-Oct	19:53	10	0	10
Unit 6-bottom	19-Oct	19:53	3	0	3
Unit 1-top	20-Oct	17:00	0	0	0
Unit 1-bottom	20-Oct	17:00	0	0	0
Unit 4-top	20-Oct	17:07	0	0	0
Unit 4-bottom	20-Oct	17:07	0	0	0
Unit 6-top	20-Oct	17:13	1	0	1
Unit 6-bottom	20-Oct	17:13	0	0	0
Unit 1-top	20-Oct	18:35	20	1	19

Appendix 5-Table 2. (Continued).

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 1-bottom	20-Oct	18:35	5	0	5
Unit 4-top	20-Oct	18:44	0	0	0
Unit 4-bottom	20-Oct	18:44	1	0	1
Unit 6-top	20-Oct	18:53	10	1	9
Unit 6-bottom	20-Oct	18:53	3	0	3
Unit 1-top	20-Oct	20:09	3	0	3
Unit 1-bottom	20-Oct	20:09	4	0	4
Unit 4-top	20-Oct	20:19	0	0	0
Unit 4-bottom	20-Oct	20:19	1	0	1
Unit 6-top	20-Oct	20:28	7	0	7
Unit 6-bottom	20-Oct	20:28	2	0	2
Unit 1-top	21-Oct	17:00	21	0	21
Unit 1-bottom	21-Oct	17:00	0	0	0
Unit 4-top	21-Oct	17:07	6	0	6
Unit 4-bottom	21-Oct	17:07	0	0	0
Unit 6-top	21-Oct	17:13	4	0	4
Unit 6-bottom	21-Oct	17:13	1	0	1
Unit 1-top	21-Oct	18:43	29	0	29
Unit 1-bottom	21-Oct	18:43	13	0	13
Unit 4-top	21-Oct	18:55	3	0	3
Unit 4-bottom	21-Oct	18:55	2	0	2
Unit 6-top	21-Oct	19:07	23	0	23
Unit 6-bottom	21-Oct	19:07	5	0	5
Unit 1-top	21-Oct	20:30	78	1	76
Unit 1-bottom	21-Oct	20:30	19	0	19
Unit 4-top	21-Oct	20:41	9	0	9
Unit 4-bottom	21-Oct	20:41	0	0	0
Unit 1-top	22-Oct	16:37	50	0	50
Unit 1-bottom	22-Oct	16:37	0	0	0
Unit 4-top	22-Oct	16:44	0	0	0
Unit 4-bottom	22-Oct	16:44	0	0	0
Unit 6-top	22-Oct	16:50	0	0	0
Unit 6-bottom	22-Oct	16:50	0	0	0
Unit 1-top	22-Oct	18:07	34	0	34
Unit 1-bottom	22-Oct	18:07	6	0	6
Unit 4-top	22-Oct	18:16	0	0	0
Unit 4-bottom	22-Oct	18:16	0	0	0
Unit 1-top	22-Oct	19:30	28	0	28
Unit 1-bottom	22-Oct	19:30	9	0	9
Unit 4-top	22-Oct	19:39	3	0	3

Appendix 5-Table 2. (Continued).

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 4-bottom	22-Oct	19:39	0	0	0
Unit 1-top	23-Oct	17:05	1	0	1
Unit 1-bottom	23-Oct	17:05	0	0	0
Unit 1-top	23-Oct	18:17	8	0	8
Unit 1-bottom	23-Oct	18:17	1	0	1
Unit 4-top	23-Oct	18:26	0	0	0
Unit 4-bottom	23-Oct	18:26	0	0	0
Unit 6-top	23-Oct	18:35	3	0	3
Unit 6-bottom	23-Oct	18:35	0	0	0
Unit 1-top	23-Oct	19:53	1	0	1
Unit 1-bottom	23-Oct	19:53	0	0	0
Unit 4-top	23-Oct	20:00	0	0	0
Unit 4-bottom	23-Oct	20:00	0	0	0
Unit 1-top	24-Oct	16:00	18	0	18
Unit 1-bottom	24-Oct	16:00	0	0	0
Unit 1-top	24-Oct	17:11	3	0	3
Unit 1-bottom	24-Oct	17:11	0	0	0
Unit 1-top	24-Oct	18:24	14	0	14
Unit 1-bottom	24-Oct	18:24	0	0	0
Unit 4-top	24-Oct	18:41	2	0	2
Unit 4-bottom	24-Oct	18:41	1	0	1
Unit 1-top	25-Oct	16:15	1	0	1
Unit 1-bottom	25-Oct	16:15	1	0	1
Unit 4-top	25-Oct	16:21	3	0	3
Unit 4-bottom	25-Oct	16:21	0	0	0
Unit 6-top	25-Oct	16:27	12	0	12
Unit 6-bottom	25-Oct	16:27	12	0	12
Unit 1-top	25-Oct	17:47	16	0	16
Unit 1-bottom	25-Oct	17:47	20	0	20
Unit 4-top	25-Oct	17:56	4	0	4
Unit 4-bottom	25-Oct	17:56	1	0	1
Unit 6-top	25-Oct	18:05	40	0	40
Unit 6-bottom	25-Oct	18:05	9	0	9
Unit 1-top	25-Oct	19:21	16	1	15
Unit 1-bottom	25-Oct	19:21	5	0	5
Unit 4-top	25-Oct	19:30	6	0	6
Unit 4-bottom	25-Oct	19:30	3	0	3
Unit 6-top	25-Oct	19:38	14	0	14
Unit 6-bottom	25-Oct	19:38	7	0	7
Unit 1-top	27-Oct	17:05	6	0	6

Appendix 5-Table 2. (Continued).

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 1-bottom	27-Oct	17:05	2	0	2
Unit 4-top	27-Oct	17:15	2	0	2
Unit 4-bottom	27-Oct	17:15	3	0	3
Unit 6-top	27-Oct	17:24	3	0	3
Unit 6-bottom	27-Oct	17:24	2	0	2
Unit 1-top	27-Oct	18:42	7	0	7
Unit 1-bottom	27-Oct	18:42	1	0	1
Unit 4-top	27-Oct	18:50	0	0	0
Unit 4-bottom	27-Oct	18:50	0	0	0
Unit 6-top	27-Oct	19:00	2	0	2
Unit 6-bottom	27-Oct	19:00	5	0	5
Unit 1-top	27-Oct	20:22	9	0	9
Unit 1-bottom	27-Oct	20:22	0	0	0
Unit 4-top	27-Oct	20:32	3	0	3
Unit 4-bottom	27-Oct	20:32	0	0	0
Unit 6-top	27-Oct	20:43	4	0	4
Unit 6-bottom	27-Oct	20:43	1	0	1
Unit 1-top	29-Oct	16:45	0	0	0
Unit 1-bottom	29-Oct	16:45	0	0	0
Unit 4-top	29-Oct	16:56	0	0	0
Unit 4-bottom	29-Oct	16:56	0	0	0
Unit 1-top	29-Oct	18:10	4	0	4
Unit 1-bottom	29-Oct	18:10	2	0	2
Unit 4-top	29-Oct	18:19	0	0	0
Unit 4-bottom	29-Oct	18:19	0	0	0
Unit 6-top	29-Oct	18:25	0	0	0
Unit 6-bottom	29-Oct	18:25	1	0	1
Unit 1-top	29-Oct	19:45	9	0	9
Unit 1-bottom	29-Oct	19:45	0	0	0
Unit 4-top	29-Oct	19:55	0	0	0
Unit 4-bottom	29-Oct	19:55	0	0	0
Unit 6-top	29-Oct	20:06	0	0	0
Unit 6-bottom	29-Oct	20:06	1	0	1
Unit 1-top	30-Oct	16:07	0	0	0
Unit 1-bottom	30-Oct	16:07	0	0	0
Unit 4-top	30-Oct	16:13	0	0	0
Unit 4-bottom	30-Oct	16:13	0	0	0
Unit 6-top	30-Oct	16:22	1	0	1
Unit 6-bottom	30-Oct	16:22	0	0	0
Unit 1-top	30-Oct	17:32	4	0	4

Appendix 5-Table 2. (Continued).

Sampling device	Start date	Start time	Catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 1-bottom	30-Oct	17:32	0	0	0
Unit 4-top	30-Oct	17:40	0	0	0
Unit 4-bottom	30-Oct	17:40	0	0	0
Unit 6-top	30-Oct	17:47	6	0	6
Unit 6-bottom	30-Oct	17:47	0	0	0
Unit 1-top	30-Oct	19:01	2	0	2
Unit 1-bottom	30-Oct	19:01	2	0	2
Unit 4-top	30-Oct	19:10	0	0	0
Unit 4-bottom	30-Oct	19:10	1	0	1
Unit 6-top	30-Oct	19:18	6	0	6
Unit 6-bottom	30-Oct	19:18	1	0	1
Unit 1-top	01-Nov	16:00	0	0	0
Unit 1-bottom	01-Nov	16:00	0	0	0
Unit 1-top	01-Nov	17:12	5	0	5
Unit 1-bottom	01-Nov	17:12	5	0	5
Unit 4-top	01-Nov	17:22	2	0	2
Unit 4-bottom	01-Nov	17:22	1	0	1
Unit 6-top	01-Nov	17:31	3	0	3
Unit 6-bottom	01-Nov	17:31	1	0	1
Unit 1-top	01-Nov	18:46	2	0	2
Unit 1-bottom	01-Nov	18:46	0	0	0
Unit 4-top	01-Nov	18:53	4	0	4
Unit 4-bottom	01-Nov	18:53	2	0	2
Unit 6-top	01-Nov	19:01	7	0	7
Unit 6-bottom	01-Nov	19:01	1	0	1

Appendix 5-Table 3. Catch rates adjusted for net retention.

Sampling device	Start date	Start time	Adjusted catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 1-top	16-Sep	17:00	0	0	0
Unit 1-bottom	16-Sep	17:00	0	0	0
Unit 4-top	16-Sep	17:10	0	0	0
Unit 4-bottom	16-Sep	17:10	0	0	0
Unit 6-top	16-Sep	17:20	0	0	0
Unit 6-bottom	16-Sep	17:20	0	0	0
Unit 1-top	16-Sep	18:50	0	0	0
Unit 1-bottom	16-Sep	18:50	0	0	0
Unit 4-top	16-Sep	18:57	0	0	0
Unit 4-bottom	16-Sep	18:57	0	0	0
Unit 6-top	16-Sep	19:01	2	0	2
Unit 6-bottom	16-Sep	19:01	0	0	0
Unit 4-top	17-Sep	17:08	0	0	0
Unit 4-bottom	17-Sep	17:08	0	0	0
Unit 4-top	17-Sep	18:19	0	0	0
Unit 4-bottom	17-Sep	18:19	0	0	0
Unit 4-top	17-Sep	20:01	0	0	0
Unit 4-bottom	17-Sep	20:01	0	0	0
Unit 1-top	18-Sep	17:00	0	0	0
Unit 1-bottom	18-Sep	17:00	0	0	0
Unit 4-top	18-Sep	17:09	0	0	0
Unit 4-bottom	18-Sep	17:09	0	0	0
Unit 6-top	18-Sep	17:13	4	0	4
Unit 6-bottom	18-Sep	17:13	0	0	0
Unit 1-top	18-Sep	18:50	0	0	0
Unit 1-bottom	18-Sep	18:50	0	0	0
Unit 4-top	18-Sep	18:58	0	0	0
Unit 4-bottom	18-Sep	18:58	0	0	0
Unit 1-top	18-Sep	20:52	0	0	0
Unit 1-bottom	18-Sep	20:52	0	0	0
Unit 4-top	18-Sep	20:57	0	0	0
Unit 4-bottom	18-Sep	20:57	0	0	0
Unit 6-top	18-Sep	21:01	2	0	2
Unit 6-bottom	18-Sep	21:01	0	0	0
Unit 1-top	19-Sep	17:06	0	0	0
Unit 1-bottom	19-Sep	17:06	0	0	0
Unit 1-top	19-Sep	18:18	0	0	0
Unit 1-bottom	19-Sep	18:18	0	0	0
Unit 1-top	19-Sep	19:32	0	0	0

Appendix 5-Table 3. (Continued).

Sampling device	Start date	Start time	Adjusted catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 1-bottom	19-Sep	19:32	0	0	0
Unit 1-top	19-Sep	20:22	0	0	0
Unit 1-bottom	19-Sep	20:22	0	0	0
Unit 1-top	22-Sep	17:09	0	0	0
Unit 1-bottom	22-Sep	17:09	0	0	0
Unit 4-top	22-Sep	17:13	0	0	0
Unit 4-bottom	22-Sep	17:13	0	0	0
Unit 6-top	22-Sep	17:19	0	0	0
Unit 6-bottom	22-Sep	17:19	0	0	0
Unit 1-top	22-Sep	18:46	0	0	0
Unit 1-bottom	22-Sep	18:46	0	0	0
Unit 4-top	22-Sep	18:54	0	0	0
Unit 4-bottom	22-Sep	18:54	0	0	0
Unit 6-top	22-Sep	19:16	0	0	0
Unit 6-bottom	22-Sep	19:16	0	0	0
Unit 1-top	22-Sep	20:35	0	0	0
Unit 1-bottom	22-Sep	20:35	0	0	0
Unit 4-top	22-Sep	20:45	0	0	0
Unit 4-bottom	22-Sep	20:45	0	0	0
Unit 1-top	23-Sep	17:04	2	0	2
Unit 1-bottom	23-Sep	17:04	0	0	0
Unit 4-top	23-Sep	17:08	0	0	0
Unit 4-bottom	23-Sep	17:08	0	0	0
Unit 6-top	23-Sep	17:14	0	0	0
Unit 6-bottom	23-Sep	17:14	0	0	0
Unit 1-top	23-Sep	18:50	0	0	0
Unit 1-bottom	23-Sep	18:50	0	0	0
Unit 4-top	23-Sep	19:02	0	0	0
Unit 4-bottom	23-Sep	19:02	0	0	0
Unit 6-top	23-Sep	19:11	0	0	0
Unit 6-bottom	23-Sep	19:11	0	0	0
Unit 1-top	23-Sep	20:28	0	0	0
Unit 1-bottom	23-Sep	20:28	0	0	0
Unit 4-top	23-Sep	20:40	4	0	4
Unit 4-bottom	23-Sep	20:40	2	0	2
Unit 6-top	23-Sep	20:52	0	0	0
Unit 6-bottom	23-Sep	20:52	0	0	0
Unit 1-top	24-Sep	17:05	2	0	2
Unit 1-bottom	24-Sep	17:05	0	0	0

Appendix 5-Table 3. (Continued).

Sampling device	Start date	Start time	Adjusted catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 4-top	24-Sep	17:10	0	0	0
Unit 4-bottom	24-Sep	17:10	0	0	0
Unit 1-top	24-Sep	18:29	0	0	0
Unit 1-bottom	24-Sep	18:29	0	0	0
Unit 4-top	24-Sep	18:40	0	0	0
Unit 4-bottom	24-Sep	18:40	0	0	0
Unit 6-top	24-Sep	18:48	0	0	0
Unit 6-bottom	24-Sep	18:48	3	0	3
Unit 1-top	24-Sep	20:03	4	0	4
Unit 1-bottom	24-Sep	20:03	2	2	0
Unit 4-top	24-Sep	20:13	0	0	0
Unit 4-bottom	24-Sep	20:13	0	0	0
Unit 6-top	24-Sep	20:24	0	0	0
Unit 6-bottom	24-Sep	20:24	0	0	0
Unit 1-top	25-Sep	17:04	175	15	160
Unit 1-bottom	25-Sep	17:04	0	0	0
Unit 4-top	25-Sep	17:10	2	0	2
Unit 4-bottom	25-Sep	17:10	0	0	0
Unit 6-top	25-Sep	17:16	6	0	6
Unit 6-bottom	25-Sep	17:16	0	0	0
Unit 1-top	25-Sep	18:41	147	6	141
Unit 1-bottom	25-Sep	18:41	0	0	0
Unit 4-top	25-Sep	18:51	17	0	17
Unit 4-bottom	25-Sep	18:51	2	0	2
Unit 6-top	25-Sep	19:02	460	82	378
Unit 6-bottom	25-Sep	19:02	16	3	13
Unit 1-top	26-Sep	17:02	120	13	107
Unit 1-bottom	26-Sep	17:02	2	0	2
Unit 4-top	26-Sep	17:07	0	0	0
Unit 4-bottom	26-Sep	17:07	0	0	0
Unit 1-top	26-Sep	18:22	86	0	86
Unit 1-bottom	26-Sep	18:22	0	0	0
Unit 4-top	26-Sep	18:31	13	0	13
Unit 4-bottom	26-Sep	18:31	2	0	2
Unit 6-top	26-Sep	18:45	5	0	5
Unit 6-bottom	26-Sep	18:45	0	0	0
Unit 1-top	26-Sep	19:55	84	0	84
Unit 1-bottom	26-Sep	19:55	0	0	0
Unit 4-top	26-Sep	20:06	9	0	9

Appendix 5-Table 3. (Continued).

Sampling device	Start date	Start time	Adjusted catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 4-bottom	26-Sep	20:06	0	0	0
Unit 6-top	26-Sep	20:15	0	0	0
Unit 6-bottom	26-Sep	20:15	0	0	0
Unit 1-top	28-Sep	17:02	99	11	88
Unit 1-bottom	28-Sep	17:02	0	0	0
Unit 4-top	28-Sep	17:08	2	0	2
Unit 4-bottom	28-Sep	17:08	0	0	0
Unit 6-top	28-Sep	17:13	30	6	24
Unit 6-bottom	28-Sep	17:13	0	0	0
Unit 1-top	28-Sep	18:47	154	4	150
Unit 1-bottom	28-Sep	18:47	0	0	0
Unit 4-top	28-Sep	18:57	2	0	2
Unit 4-bottom	28-Sep	18:57	0	0	0
Unit 6-top	28-Sep	19:05	7	0	7
Unit 6-bottom	28-Sep	19:05	4	4	0
Unit 1-top	28-Sep	20:20	109	4	105
Unit 1-bottom	28-Sep	20:20	0	0	0
Unit 4-top	28-Sep	20:28	4	0	4
Unit 4-bottom	28-Sep	20:28	0	0	0
Unit 6-top	28-Sep	20:36	14	0	14
Unit 6-bottom	28-Sep	20:36	0	0	0
Unit 1-top	29-Sep	17:07	45	5	40
Unit 1-bottom	29-Sep	17:07	0	0	0
Unit 4-top	29-Sep	17:14	0	0	0
Unit 4-bottom	29-Sep	17:14	0	0	0
Unit 1-top	29-Sep	18:31	8	2	6
Unit 1-bottom	29-Sep	18:31	0	0	0
Unit 4-top	29-Sep	18:39	2	0	2
Unit 4-bottom	29-Sep	18:39	0	0	0
Unit 6-top	29-Sep	18:43	2	0	2
Unit 6-bottom	29-Sep	18:43	1	1	0
Unit 1-top	29-Sep	20:04	10	0	10
Unit 1-bottom	29-Sep	20:04	0	0	0
Unit 4-top	29-Sep	20:11	2	0	2
Unit 4-bottom	29-Sep	20:11	0	0	0
Unit 6-top	29-Sep	20:20	2	0	2
Unit 6-bottom	29-Sep	20:20	1	0	1
Unit 1-top	30-Sep	17:01	147	6	141
Unit 1-bottom	30-Sep	17:01	5	0	5

Appendix 5-Table 3. (Continued).

Sampling device	Start date	Start time	Adjusted catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 4-top	30-Sep	17:07	22	2	20
Unit 4-bottom	30-Sep	17:07	0	0	0
Unit 1-top	30-Sep	18:23	34	11	23
Unit 1-bottom	30-Sep	18:23	0	0	0
Unit 4-top	30-Sep	18:33	27	0	27
Unit 4-bottom	30-Sep	18:33	0	0	0
Unit 1-top	30-Sep	20:14	10	0	10
Unit 1-bottom	30-Sep	20:14	11	0	11
Unit 4-top	30-Sep	20:24	39	4	35
Unit 4-bottom	30-Sep	20:24	0	0	0
Unit 1-top	01-Oct	17:00	98	7	91
Unit 1-bottom	01-Oct	17:00	0	0	0
Unit 1-top	01-Oct	18:18	57	0	57
Unit 1-bottom	01-Oct	18:18	0	0	0
Unit 1-top	01-Oct	19:30	116	8	109
Unit 1-bottom	01-Oct	19:30	0	0	0
Unit 4-top	01-Oct	19:35	56	0	56
Unit 4-bottom	01-Oct	19:35	35	0	35
Unit 6-top	01-Oct	19:40	145	43	102
Unit 6-bottom	01-Oct	19:40	58	0	58
Unit 1-top	02-Oct	17:01	67	15	51
Unit 1-bottom	02-Oct	17:01	2	0	2
Unit 1-top	02-Oct	18:12	30	0	30
Unit 1-bottom	02-Oct	18:12	0	0	0
Unit 1-top	02-Oct	19:22	19	0	19
Unit 1-bottom	02-Oct	19:22	2	0	2
Unit 1-top	03-Oct	17:00	42	2	40
Unit 1-bottom	03-Oct	17:00	0	0	0
Unit 1-top	03-Oct	18:10	0	0	0
Unit 1-bottom	03-Oct	18:10	0	0	0
Unit 1-top	03-Oct	19:20	17	0	17
Unit 1-bottom	03-Oct	19:20	0	0	0
Unit 1-top	04-Oct	17:00	10	2	8
Unit 1-bottom	04-Oct	17:00	0	0	0
Unit 1-top	04-Oct	18:16	23	0	23
Unit 1-bottom	04-Oct	18:16	0	0	0
Unit 4-top	04-Oct	18:26	2	0	2
Unit 4-bottom	04-Oct	18:26	0	0	0
Unit 6-top	04-Oct	18:31	0	0	0

Appendix 5-Table 3. (Continued).

Sampling device	Start date	Start time	Adjusted catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 6-bottom	04-Oct	18:31	1	1	0
Unit 1-top	04-Oct	19:47	19	0	19
Unit 1-bottom	04-Oct	19:47	0	0	0
Unit 4-top	04-Oct	19:56	2	0	2
Unit 4-bottom	04-Oct	19:56	0	0	0
Unit 6-top	04-Oct	20:04	0	0	0
Unit 6-bottom	04-Oct	20:04	0	0	0
Unit 1-top	05-Oct	17:15	0	0	0
Unit 1-bottom	05-Oct	17:15	0	0	0
Unit 1-top	05-Oct	18:25	0	0	0
Unit 1-bottom	05-Oct	18:25	0	0	0
Unit 4-top	05-Oct	18:32	0	0	0
Unit 4-bottom	05-Oct	18:32	0	0	0
Unit 1-top	05-Oct	19:44	0	0	0
Unit 1-bottom	05-Oct	19:44	0	0	0
Unit 4-top	05-Oct	19:53	0	0	0
Unit 4-bottom	05-Oct	19:53	0	0	0
Unit 6-top	05-Oct	19:58	0	0	0
Unit 6-bottom	05-Oct	19:58	0	0	0
Unit 4-top	06-Oct	17:00	0	0	0
Unit 4-bottom	06-Oct	17:00	0	0	0
Unit 4-top	06-Oct	18:11	0	0	0
Unit 4-bottom	06-Oct	18:11	0	0	0
Unit 1-top	06-Oct	19:25	2	0	2
Unit 1-bottom	06-Oct	19:25	0	0	0
Unit 4-top	06-Oct	19:33	0	0	0
Unit 4-bottom	06-Oct	19:33	0	0	0
Unit 6-top	06-Oct	19:42	0	0	0
Unit 6-bottom	06-Oct	19:42	0	0	0
Unit 6-bottom	07-Oct	16:55	0	0	0
Unit 6-top	07-Oct	18:14	0	0	0
Unit 6-bottom	07-Oct	18:14	0	0	0
Unit 1-top	07-Oct	19:28	0	0	0
Unit 1-bottom	07-Oct	19:28	0	0	0
Unit 4-top	07-Oct	19:38	0	0	0
Unit 4-bottom	07-Oct	19:38	0	0	0
Unit 6-top	07-Oct	19:48	2	0	2
Unit 6-bottom	07-Oct	19:48	0	0	0
Unit 6-top	08-Oct	17:00	0	0	0

Appendix 5-Table 3. (Continued).

Sampling device	Start date	Start time	Adjusted catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 6-bottom	08-Oct	17:00	0	0	0
Unit 6-top	08-Oct	18:10	0	0	0
Unit 6-bottom	08-Oct	18:10	0	0	0
Unit 6-top	08-Oct	19:20	0	0	0
Unit 6-bottom	08-Oct	19:20	0	0	0
Unit 4-top	08-Oct	19:29	0	0	0
Unit 4-bottom	08-Oct	19:29	0	0	0
Unit 1-top	08-Oct	19:37	0	0	0
Unit 1-bottom	08-Oct	19:37	0	0	0
Unit 1-top	09-Oct	17:00	24	4	20
Unit 1-bottom	09-Oct	17:00	0	0	0
Unit 4-top	09-Oct	17:06	0	0	0
Unit 4-bottom	09-Oct	17:06	0	0	0
Unit 6-top	09-Oct	17:12	2	0	2
Unit 6-bottom	09-Oct	17:12	0	0	0
Unit 1-top	09-Oct	18:24	36	4	33
Unit 1-bottom	09-Oct	18:24	0	0	0
Unit 4-top	09-Oct	18:32	0	0	0
Unit 4-bottom	09-Oct	18:32	0	0	0
Unit 6-top	09-Oct	18:41	0	0	0
Unit 6-bottom	09-Oct	18:41	0	0	0
Unit 1-top	09-Oct	19:48	4	0	4
Unit 1-bottom	09-Oct	19:48	0	0	0
Unit 4-top	09-Oct	19:57	23	0	23
Unit 4-bottom	09-Oct	19:57	0	0	0
Unit 1-top	10-Oct	17:12	35	10	25
Unit 1-bottom	10-Oct	17:12	2	0	2
Unit 4-top	10-Oct	17:17	1	0	1
Unit 4-bottom	10-Oct	17:17	2	0	2
Unit 6-top	10-Oct	17:21	2	0	2
Unit 6-bottom	10-Oct	17:21	3	0	3
Unit 1-top	10-Oct	19:00	143	8	135
Unit 1-bottom	10-Oct	19:00	31	0	31
Unit 4-top	10-Oct	19:08	5	0	5
Unit 4-bottom	10-Oct	19:08	11	0	11
Unit 6-top	10-Oct	19:16	127	5	122
Unit 6-bottom	10-Oct	19:16	6	0	6
Unit 1-top	10-Oct	20:16	55	0	55
Unit 1-bottom	10-Oct	20:16	9	0	9

Appendix 5-Table 3. (Continued).

Sampling device	Start date	Start time	Adjusted catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 4-top	10-Oct	20:25	0	0	0
Unit 4-bottom	10-Oct	20:25	3	0	3
Unit 6-top	10-Oct	20:35	18	0	18
Unit 6-bottom	10-Oct	20:35	4	0	4
Unit 1-top	11-Oct	17:06	0	0	0
Unit 1-bottom	11-Oct	17:06	2	0	2
Unit 4-top	11-Oct	17:10	16	2	14
Unit 4-bottom	11-Oct	17:10	0	0	0
Unit 6-top	11-Oct	17:14	0	0	0
Unit 6-bottom	11-Oct	17:14	0	0	0
Unit 1-top	11-Oct	18:12	34	2	32
Unit 1-bottom	11-Oct	18:12	0	0	0
Unit 4-top	11-Oct	18:20	0	0	0
Unit 4-bottom	11-Oct	18:20	0	0	0
Unit 6-top	11-Oct	18:28	0	0	0
Unit 6-bottom	11-Oct	18:28	0	0	0
Unit 1-top	11-Oct	19:20	19	0	19
Unit 1-bottom	11-Oct	19:20	0	0	0
Unit 4-top	11-Oct	19:28	21	2	19
Unit 4-bottom	11-Oct	19:28	0	0	0
Unit 6-top	11-Oct	19:35	0	0	0
Unit 6-bottom	11-Oct	19:35	4	0	4
Unit 1-top	11-Oct	20:25	53	2	51
Unit 1-bottom	11-Oct	20:25	2	0	2
Unit 4-top	11-Oct	20:33	14	0	14
Unit 4-bottom	11-Oct	20:33	0	0	0
Unit 6-top	11-Oct	20:46	120	28	92
Unit 6-bottom	11-Oct	20:46	10	4	6
Unit 1-top	12-Oct	17:00	39	11	28
Unit 1-bottom	12-Oct	17:00	0	0	0
Unit 4-top	12-Oct	17:06	0	0	0
Unit 4-bottom	12-Oct	17:06	0	0	0
Unit 6-top	12-Oct	17:10	0	0	0
Unit 6-bottom	12-Oct	17:10	0	0	0
Unit 1-top	12-Oct	18:30	19	1	18
Unit 1-bottom	12-Oct	18:30	8	0	8
Unit 4-top	12-Oct	18:37	12	0	12
Unit 4-bottom	12-Oct	18:37	2	0	2
Unit 6-top	12-Oct	18:44	89	10	79

Appendix 5-Table 3. (Continued).

Sampling device	Start date	Start time	Adjusted catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 6-bottom	12-Oct	18:44	14	0	14
Unit 1-top	12-Oct	20:05	22	0	22
Unit 1-bottom	12-Oct	20:05	4	0	4
Unit 4-top	12-Oct	20:15	3	0	3
Unit 4-bottom	12-Oct	20:15	0	0	0
Unit 6-top	12-Oct	20:25	6	0	6
Unit 6-bottom	12-Oct	20:25	0	0	0
Unit 4-top	13-Oct	17:16	0	0	0
Unit 4-bottom	13-Oct	17:16	0	0	0
Unit 6-top	13-Oct	17:28	12	0	12
Unit 6-bottom	13-Oct	17:28	0	0	0
Unit 1-top	13-Oct	18:39	11	0	11
Unit 1-bottom	13-Oct	18:39	26	0	26
Unit 4-top	13-Oct	18:48	16	0	16
Unit 4-bottom	13-Oct	18:48	1	0	1
Unit 6-top	13-Oct	18:55	66	6	60
Unit 6-bottom	13-Oct	18:55	5	0	5
Unit 1-top	13-Oct	20:14	40	0	40
Unit 1-bottom	13-Oct	20:14	5	0	5
Unit 4-top	14-Oct	17:00	2	0	2
Unit 4-bottom	14-Oct	17:00	0	0	0
Unit 6-top	14-Oct	18:20	4	0	4
Unit 6-bottom	14-Oct	18:20	1	0	1
Unit 4-top	14-Oct	18:24	0	0	0
Unit 4-bottom	14-Oct	18:24	0	0	0
Unit 1-top	14-Oct	18:35	5	0	5
Unit 1-bottom	14-Oct	18:35	6	0	6
Unit 1-top	15-Oct	17:46	0	0	0
Unit 1-bottom	15-Oct	17:46	2	0	2
Unit 4-top	15-Oct	17:52	0	0	0
Unit 4-bottom	15-Oct	17:52	1	0	1
Unit 6-top	15-Oct	17:57	10	0	10
Unit 6-bottom	15-Oct	17:57	0	0	0
Unit 1-top	15-Oct	19:20	26	0	26
Unit 1-bottom	15-Oct	19:20	10	2	8
Unit 4-top	15-Oct	19:28	11	0	11
Unit 4-bottom	15-Oct	19:28	5	0	5
Unit 6-top	15-Oct	19:41	62	2	60
Unit 6-bottom	15-Oct	19:41	3	0	3

Appendix 5-Table 3. (Continued).

Sampling device	Start date	Start time	Adjusted catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 1-top	16-Oct	17:00	0	0	0
Unit 1-bottom	16-Oct	17:00	0	0	0
Unit 4-top	16-Oct	17:08	0	0	0
Unit 4-bottom	16-Oct	17:08	0	0	0
Unit 1-top	16-Oct	18:22	3	0	3
Unit 1-bottom	16-Oct	18:22	0	0	0
Unit 4-top	16-Oct	18:30	0	0	0
Unit 4-bottom	16-Oct	18:30	0	0	0
Unit 6-top	16-Oct	18:40	0	0	0
Unit 6-bottom	16-Oct	18:40	0	0	0
Unit 1-top	16-Oct	20:00	1	0	1
Unit 1-bottom	16-Oct	20:00	0	0	0
Unit 1-top	17-Oct	17:00	0	0	0
Unit 1-bottom	17-Oct	17:00	0	0	0
Unit 4-top	17-Oct	17:09	0	0	0
Unit 4-bottom	17-Oct	17:09	0	0	0
Unit 1-top	17-Oct	18:21	0	0	0
Unit 1-bottom	17-Oct	18:21	0	0	0
Unit 4-top	17-Oct	18:28	0	0	0
Unit 4-bottom	17-Oct	18:28	0	0	0
Unit 1-top	17-Oct	19:40	6	0	6
Unit 1-bottom	17-Oct	19:40	0	0	0
Unit 4-top	17-Oct	19:47	2	0	2
Unit 4-bottom	17-Oct	19:47	0	0	0
Unit 6-top	17-Oct	19:55	23	3	21
Unit 6-bottom	17-Oct	19:55	0	0	0
Unit 1-top	19-Oct	17:00	0	0	0
Unit 1-bottom	19-Oct	17:00	0	0	0
Unit 4-top	19-Oct	17:11	0	0	0
Unit 4-bottom	19-Oct	17:11	0	0	0
Unit 1-top	19-Oct	17:56	35	0	35
Unit 1-bottom	19-Oct	17:56	7	0	7
Unit 4-top	19-Oct	18:05	0	0	0
Unit 4-bottom	19-Oct	18:05	2	0	2
Unit 6-top	19-Oct	18:15	53	0	53
Unit 6-bottom	19-Oct	18:15	11	0	11
Unit 1-top	19-Oct	19:35	41	1	40
Unit 1-bottom	19-Oct	19:35	8	0	8
Unit 4-top	19-Oct	19:44	12	0	12

Appendix 5-Table 3. (Continued).

Sampling device	Start date	Start time	Adjusted catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 4-bottom	19-Oct	19:44	0	0	0
Unit 6-top	19-Oct	19:53	20	0	20
Unit 6-bottom	19-Oct	19:53	4	0	4
Unit 1-top	20-Oct	17:00	0	0	0
Unit 1-bottom	20-Oct	17:00	0	0	0
Unit 4-top	20-Oct	17:07	0	0	0
Unit 4-bottom	20-Oct	17:07	0	0	0
Unit 6-top	20-Oct	17:13	2	0	2
Unit 6-bottom	20-Oct	17:13	0	0	0
Unit 1-top	20-Oct	18:35	25	1	24
Unit 1-bottom	20-Oct	18:35	8	0	8
Unit 4-top	20-Oct	18:44	0	0	0
Unit 4-bottom	20-Oct	18:44	1	0	1
Unit 6-top	20-Oct	18:53	21	2	18
Unit 6-bottom	20-Oct	18:53	4	0	4
Unit 1-top	20-Oct	20:09	4	0	4
Unit 1-bottom	20-Oct	20:09	7	0	7
Unit 4-top	20-Oct	20:19	0	0	0
Unit 4-bottom	20-Oct	20:19	1	0	1
Unit 6-top	20-Oct	20:28	14	0	14
Unit 6-bottom	20-Oct	20:28	3	0	3
Unit 1-top	21-Oct	17:00	26	0	26
Unit 1-bottom	21-Oct	17:00	0	0	0
Unit 4-top	21-Oct	17:07	9	0	9
Unit 4-bottom	21-Oct	17:07	0	0	0
Unit 6-top	21-Oct	17:13	7	0	7
Unit 6-bottom	21-Oct	17:13	1	0	1
Unit 1-top	21-Oct	18:43	36	0	36
Unit 1-bottom	21-Oct	18:43	21	0	21
Unit 4-top	21-Oct	18:55	4	0	4
Unit 4-bottom	21-Oct	18:55	2	0	2
Unit 6-top	21-Oct	19:07	47	0	47
Unit 6-bottom	21-Oct	19:07	7	0	7
Unit 1-top	21-Oct	20:30	98	2	96
Unit 1-bottom	21-Oct	20:30	32	0	32
Unit 4-top	21-Oct	20:41	14	0	14
Unit 4-bottom	21-Oct	20:41	0	0	0
Unit 1-top	22-Oct	16:37	63	0	63
Unit 1-bottom	22-Oct	16:37	0	0	0

Appendix 5-Table 3. (Continued).

Sampling device	Start date	Start time	Adjusted catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 4-top	22-Oct	16:44	0	0	0
Unit 4-bottom	22-Oct	16:44	0	0	0
Unit 6-top	22-Oct	16:50	0	0	0
Unit 6-bottom	22-Oct	16:50	0	0	0
Unit 1-top	22-Oct	18:07	43	0	43
Unit 1-bottom	22-Oct	18:07	10	0	10
Unit 4-top	22-Oct	18:16	0	0	0
Unit 4-bottom	22-Oct	18:16	0	0	0
Unit 1-top	22-Oct	19:30	35	0	35
Unit 1-bottom	22-Oct	19:30	15	0	15
Unit 4-top	22-Oct	19:39	4	0	4
Unit 4-bottom	22-Oct	19:39	0	0	0
Unit 1-top	23-Oct	17:05	1	0	1
Unit 1-bottom	23-Oct	17:05	0	0	0
Unit 1-top	23-Oct	18:17	10	0	10
Unit 1-bottom	23-Oct	18:17	2	0	2
Unit 4-top	23-Oct	18:26	0	0	0
Unit 4-bottom	23-Oct	18:26	0	0	0
Unit 6-top	23-Oct	18:35	6	0	6
Unit 6-bottom	23-Oct	18:35	0	0	0
Unit 1-top	23-Oct	19:53	1	0	1
Unit 1-bottom	23-Oct	19:53	0	0	0
Unit 4-top	23-Oct	20:00	0	0	0
Unit 4-bottom	23-Oct	20:00	0	0	0
Unit 1-top	24-Oct	16:00	23	0	23
Unit 1-bottom	24-Oct	16:00	0	0	0
Unit 1-top	24-Oct	17:11	4	0	4
Unit 1-bottom	24-Oct	17:11	0	0	0
Unit 1-top	24-Oct	18:24	17	0	17
Unit 1-bottom	24-Oct	18:24	0	0	0
Unit 4-top	24-Oct	18:41	3	0	3
Unit 4-bottom	24-Oct	18:41	1	0	1
Unit 1-top	25-Oct	16:15	1	0	1
Unit 1-bottom	25-Oct	16:15	2	0	2
Unit 4-top	25-Oct	16:21	5	0	5
Unit 4-bottom	25-Oct	16:21	0	0	0
Unit 6-top	25-Oct	16:27	25	0	25
Unit 6-bottom	25-Oct	16:27	16	0	16
Unit 1-top	25-Oct	17:47	20	0	20

Appendix 5-Table 3. (Continued).

Sampling device	Start date	Start time	Adjusted catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 1-bottom	25-Oct	17:47	33	0	33
Unit 4-top	25-Oct	17:56	6	0	6
Unit 4-bottom	25-Oct	17:56	1	0	1
Unit 6-top	25-Oct	18:05	82	0	82
Unit 6-bottom	25-Oct	18:05	12	0	12
Unit 1-top	25-Oct	19:21	20	1	19
Unit 1-bottom	25-Oct	19:21	8	0	8
Unit 4-top	25-Oct	19:30	9	0	9
Unit 4-bottom	25-Oct	19:30	4	0	4
Unit 6-top	25-Oct	19:38	29	0	29
Unit 6-bottom	25-Oct	19:38	9	0	9
Unit 1-top	27-Oct	17:05	8	0	8
Unit 1-bottom	27-Oct	17:05	3	0	3
Unit 4-top	27-Oct	17:15	3	0	3
Unit 4-bottom	27-Oct	17:15	4	0	4
Unit 6-top	27-Oct	17:24	6	0	6
Unit 6-bottom	27-Oct	17:24	3	0	3
Unit 1-top	27-Oct	18:42	9	0	9
Unit 1-bottom	27-Oct	18:42	2	0	2
Unit 4-top	27-Oct	18:50	0	0	0
Unit 4-bottom	27-Oct	18:50	0	0	0
Unit 6-top	27-Oct	19:00	4	0	4
Unit 6-bottom	27-Oct	19:00	7	0	7
Unit 1-top	27-Oct	20:22	11	0	11
Unit 1-bottom	27-Oct	20:22	0	0	0
Unit 4-top	27-Oct	20:32	4	0	4
Unit 4-bottom	27-Oct	20:32	0	0	0
Unit 6-top	27-Oct	20:43	9	0	9
Unit 6-bottom	27-Oct	20:43	2	0	2
Unit 1-top	29-Oct	16:45	0	0	0
Unit 1-bottom	29-Oct	16:45	0	0	0
Unit 4-top	29-Oct	16:56	0	0	0
Unit 4-bottom	29-Oct	16:56	0	0	0
Unit 1-top	29-Oct	18:10	5	0	5
Unit 1-bottom	29-Oct	18:10	3	0	3
Unit 4-top	29-Oct	18:19	0	0	0
Unit 4-bottom	29-Oct	18:19	0	0	0
Unit 6-top	29-Oct	18:25	0	0	0
Unit 6-bottom	29-Oct	18:25	1	0	1

Appendix 5-Table 3. (Continued).

Sampling device	Start date	Start time	Adjusted catch rates (fish per hour) Clupeids	Blueback	Am shad
Unit 1-top	29-Oct	19:45	11	0	11
Unit 1-bottom	29-Oct	19:45	0	0	0
Unit 4-top	29-Oct	19:55	0	0	0
Unit 4-bottom	29-Oct	19:55	0	0	0
Unit 6-top	29-Oct	20:06	0	0	0
Unit 6-bottom	29-Oct	20:06	1	0	1
Unit 1-top	30-Oct	16:07	0	0	0
Unit 1-bottom	30-Oct	16:07	0	0	0
Unit 4-top	30-Oct	16:13	0	0	0
Unit 4-bottom	30-Oct	16:13	0	0	0
Unit 6-top	30-Oct	16:22	2	0	2
Unit 6-bottom	30-Oct	16:22	0	0	0
Unit 1-top	30-Oct	17:32	5	0	5
Unit 1-bottom	30-Oct	17:32	0	0	0
Unit 4-top	30-Oct	17:40	0	0	0
Unit 4-bottom	30-Oct	17:40	0	0	0
Unit 6-top	30-Oct	17:47	12	0	12
Unit 6-bottom	30-Oct	17:47	0	0	0
Unit 1-top	30-Oct	19:01	3	0	3
Unit 1-bottom	30-Oct	19:01	3	0	3
Unit 4-top	30-Oct	19:10	0	0	0
Unit 4-bottom	30-Oct	19:10	1	0	1
Unit 6-top	30-Oct	19:18	12	0	12
Unit 6-bottom	30-Oct	19:18	1	0	1
Unit 1-top	01-Nov	16:00	0	0	0
Unit 1-bottom	01-Nov	16:00	0	0	0
Unit 1-top	01-Nov	17:12	6	0	6
Unit 1-bottom	01-Nov	17:12	8	0	8
Unit 4-top	01-Nov	17:22	3	0	3
Unit 4-bottom	01-Nov	17:22	1	0	1
Unit 6-top	01-Nov	17:31	6	0	6
Unit 6-bottom	01-Nov	17:31	1	0	1
Unit 1-top	01-Nov	18:46	3	0	3
Unit 1-bottom	01-Nov	18:46	0	0	0
Unit 4-top	01-Nov	18:53	6	0	6
Unit 4-bottom	01-Nov	18:53	2	0	2
Unit 6-top	01-Nov	19:01	14	0	14
Unit 6-bottom	01-Nov	19:01	1	0	1

Appendix 6

DIEL LOG SLUICE SAMPLING DATA

Appendix 6-Table 1. Diel log sluice samples.

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled	Catch per unit effort adjusted for sampler efficiency
Log sluice	18-Sep	20:57	22:00	01:03	1	12	95	1
Log sluice	18-Sep	22:00	23:00	01:00	6	0	6	7
Log sluice	18-Sep	23:00	00:00	01:00	1904	3	100	2351
Log sluice	19-Sep	00:00	01:00	01:00	387	3	103	478
Log sluice	19-Sep	01:00	02:00	01:00	41	0	16	51
Log sluice	19-Sep	02:00	03:00	01:00	1	0	1	1
Log sluice	19-Sep	03:00	04:00	01:00	247	13	118	305
Log sluice	19-Sep	04:00	05:00	01:00	1	0	1	1
Log sluice	19-Sep	05:00	06:00	01:00	1	0	1	1
Log sluice	19-Sep	06:00	07:00	01:00	13	0	13	16
Log sluice	19-Sep	07:00	08:00	01:00	0	0	0	0
Log sluice	19-Sep	08:00	09:00	01:00	0	0	0	0
Log sluice	19-Sep	09:00	10:00	01:00	1	0	1	1
Log sluice	19-Sep	10:00	11:00	01:00	0	0	0	0
Log sluice	19-Sep	11:00	12:00	01:00	0	0	0	0
Log sluice	19-Sep	12:00	13:00	01:00	0	0	0	0
Log sluice	19-Sep	13:00	14:00	01:00	0	0	0	0
Log sluice	19-Sep	14:00	15:00	01:00	0	0	0	0
Log sluice	25-Sep	21:00	22:00	01:00	685	0	106	716
Log sluice	25-Sep	22:00	23:00	01:00	67	0	67	70
Log sluice	25-Sep	23:00	00:00	01:00	25	0	25	26
Log sluice	26-Sep	00:00	01:00	01:00	238	16	97	249
Log sluice	26-Sep	01:00	02:00	01:00	5294	0	124	5534
Log sluice	26-Sep	02:00	03:00	01:00	2063	12	130	2156
Log sluice	26-Sep	03:00	04:00	01:00	2973	4	61	3108
Log sluice	26-Sep	04:00	05:00	01:00	3424	20	87	3579
Log sluice	26-Sep	05:00	06:00	01:00	232	9	112	243
Log sluice	26-Sep	06:00	07:00	01:00	18	1	17	19
Log sluice	26-Sep	07:00	08:00	01:00	4	0	4	4
Log sluice	26-Sep	08:00	09:00	01:00	2	0	2	2
Log sluice	26-Sep	09:00	10:00	01:00	0	0	0	0
Log sluice	26-Sep	10:00	11:00	01:00	0	0	0	0
Log sluice	26-Sep	11:00	12:00	01:00	0	0	0	0
Log sluice	26-Sep	12:00	13:00	01:00	0	0	0	0
Log sluice	26-Sep	13:00	14:00	01:00	2	1	1	2
Log sluice	26-Sep	14:00	15:00	01:00	0	0	0	0
Log sluice	26-Sep	15:00	16:00	01:00	0	0	0	0
Log sluice	26-Sep	16:00	17:00	01:00	0	0	0	0
Log sluice	30-Sep	20:24	21:28	01:04	1578	9	93	1546
Log sluice	30-Sep	22:00	23:00	01:00	3571	15	98	3733
Log sluice	30-Sep	23:00	00:00	01:00	73	6	67	76
Log sluice	01-Oct	00:00	01:00	01:00	24	0	24	25

Appendix 6-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled	Catch per unit effort adjusted for sampler efficiency
Log sluice	01-Oct	01:00	02:00	01:00	59	55	4	62
Log sluice	01-Oct	02:00	03:00	01:00	50	7	43	52
Log sluice	01-Oct	03:00	04:00	01:00	0	0	0	0
Log sluice	01-Oct	04:00	05:00	01:00	19	0	19	20
Log sluice	01-Oct	05:00	06:00	01:00	1643	82	50	1717
Log sluice	01-Oct	06:00	07:00	01:00	4741	74	17	4956
Log sluice	01-Oct	07:00	08:00	01:00	19020	55	44	19882
Log sluice	01-Oct	08:00	09:00	01:00	966	19	92	1010
Log sluice	01-Oct	09:00	10:00	01:00	450	70	46	470
Log sluice	01-Oct	10:00	11:00	01:00	0	0	0	0
Log sluice	01-Oct	11:00	12:00	01:00	966	43	87	1010
Log sluice	01-Oct	12:00	13:00	01:00	1817	35	79	1899
Log sluice	01-Oct	13:00	14:00	01:00	2704	34	127	2826
Log sluice	01-Oct	14:00	15:00	01:00	10477	17	76	10952
Log sluice	01-Oct	15:00	16:00	01:00	2364	13	93	2471
Log sluice	01-Oct	16:00	17:00	01:00	2971	31	99	3106
Log sluice	02-Oct	21:00	22:00	01:00	1	0	1	1
Log sluice	02-Oct	22:00	23:00	01:00	4	0	4	4
Log sluice	02-Oct	23:00	00:00	01:00	0	0	0	0
Log sluice	03-Oct	00:00	01:00	01:00	0	0	0	0
Log sluice	03-Oct	01:00	02:00	01:00	1	1	0	1
Log sluice	03-Oct	02:00	03:00	01:00	0	0	0	0
Log sluice	03-Oct	03:00	04:00	01:00	0	0	0	0
Log sluice	03-Oct	04:00	05:00	01:00	0	0	0	0
Log sluice	03-Oct	05:00	06:00	01:00	0	0	0	0
Log sluice	03-Oct	06:00	07:00	01:00	36	13	23	38
Log sluice	03-Oct	07:00	08:00	01:00	740	59	45	774
Log sluice	03-Oct	08:00	09:00	01:00	99	31	68	103
Log sluice	03-Oct	09:00	10:00	01:00	15	8	7	16
Log sluice	03-Oct	10:00	11:00	01:00	1200	41	66	1254
Log sluice	03-Oct	11:00	12:00	01:00	1800	33	82	1882
Log sluice	03-Oct	12:00	13:00	01:00	1223	26	75	1278
Log sluice	03-Oct	13:00	14:00	01:00	2985	15	87	3120
Log sluice	03-Oct	14:00	15:00	01:00	1253	35	68	1310
Log sluice	03-Oct	15:00	16:00	01:00	465	19	99	486
Log sluice	03-Oct	16:00	17:00	01:00	691	23	77	722
Log sluice	07-Oct	21:00	22:00	01:00	178	0	101	178
Log sluice	07-Oct	22:00	23:00	01:00	78	2	76	78
Log sluice	07-Oct	23:00	00:00	01:00	1	0	1	1
Log sluice	08-Oct	00:00	01:00	01:00	0	0	0	0
Log sluice	08-Oct	01:00	02:00	01:00	12	0	12	12
Log sluice	08-Oct	02:00	03:00	01:00	6	0	6	6

Appendix 6-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled	Catch per unit effort adjusted for sampler efficiency
Log sluice	08-Oct	03:00	04:00	01:00	1	0	1	1
Log sluice	08-Oct	04:00	05:00	01:00	3	0	3	3
Log sluice	08-Oct	05:00	06:00	01:00	0	0	0	0
Log sluice	08-Oct	06:00	07:00	01:00	299	44	81	299
Log sluice	08-Oct	07:00	08:00	01:00	1560	41	100	1560
Log sluice	08-Oct	08:00	09:00	01:00	3590	16	75	3590
Log sluice	08-Oct	09:00	10:00	01:00	1524	13	104	1524
Log sluice	08-Oct	10:00	11:00	01:00	1103	16	88	1103
Log sluice	08-Oct	11:00	12:00	01:00	7720	18	90	7720
Log sluice	08-Oct	12:00	13:00	01:00	12106	11	97	12106
Log sluice	08-Oct	13:00	14:00	01:00	5942	32	89	5942
Log sluice	08-Oct	14:00	15:00	01:00	83	6	77	83
Log sluice	08-Oct	15:00	16:00	01:00	401	9	93	401
Log sluice	08-Oct	16:00	17:00	01:00	202	16	88	202
Log sluice	09-Oct	21:00	22:00	01:00	0	0	0	0
Log sluice	09-Oct	22:00	23:00	01:00	26	0	26	26
Log sluice	09-Oct	23:00	00:00	01:00	106	3	103	106
Log sluice	10-Oct	00:00	01:00	01:00	5243	68	80	5243
Log sluice	10-Oct	01:00	02:00	01:00	217	5	103	217
Log sluice	10-Oct	02:00	03:00	01:00	3	2	1	3
Log sluice	10-Oct	03:00	04:00	01:00	66	0	66	66
Log sluice	10-Oct	04:00	05:00	01:00	0	0	0	0
Log sluice	10-Oct	05:00	06:00	01:00	4	0	4	4
Log sluice	10-Oct	06:00	07:00	01:00	10	0	10	10
Log sluice	10-Oct	07:00	08:00	01:00	7082	39	71	7082
Log sluice	10-Oct	08:00	09:00	01:00	4428	17	108	4428
Log sluice	10-Oct	09:00	10:00	01:00	1936	13	128	1936
Log sluice	10-Oct	10:00	11:00	01:00	6420	7	94	6420
Log sluice	10-Oct	11:00	12:00	01:00	3808	9	93	3808
Log sluice	10-Oct	12:00	13:00	01:00	26380	1	130	26380
Log sluice	10-Oct	13:00	14:00	01:00	18883	23	102	18883
Log sluice	10-Oct	14:00	15:00	01:00	7336	31	79	7336
Log sluice	10-Oct	15:00	16:00	01:00	232	6	93	232
Log sluice	10-Oct	16:00	17:00	01:00	2323	10	103	2323
Log sluice	11-Oct	20:32	21:13	00:41	31	0	31	45
Log sluice	11-Oct	22:00	23:00	01:00	51	0	51	51
Log sluice	11-Oct	23:00	00:00	01:00	13	0	13	13
Log sluice	12-Oct	00:00	01:00	01:00	26	0	26	26
Log sluice	12-Oct	01:00	02:00	01:00	361	9	98	361
Log sluice	12-Oct	02:00	03:00	01:00	19	0	19	19
Log sluice	12-Oct	03:00	04:00	01:00	0	0	0	0
Log sluice	12-Oct	04:00	05:00	01:00	0	0	0	0

Appendix 6-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled	Catch per unit effort adjusted for sampler efficiency
Log sluice	12-Oct	05:00	06:00	01:00	0	0	0	0
Log sluice	12-Oct	06:00	07:00	01:00	177	21	110	177
Log sluice	12-Oct	07:00	08:00	01:00	99	11	88	99
Log sluice	12-Oct	08:00	09:00	01:00	16	10	6	16
Log sluice	12-Oct	09:00	10:00	01:00	103	57	46	103
Log sluice	12-Oct	10:00	11:00	01:00	2905	7	100	2905
Log sluice	12-Oct	11:00	12:00	01:00	15927	22	83	15927
Log sluice	12-Oct	12:00	13:00	01:00	4155	6	94	4155
Log sluice	12-Oct	13:00	14:00	01:00	3744	7	95	3744
Log sluice	12-Oct	14:00	15:00	01:00	1232	5	96	1232
Log sluice	12-Oct	15:00	16:00	01:00	3160	20	83	3160
Log sluice	12-Oct	16:00	17:00	01:00	1503	9	95	1503
Log sluice	16-Oct	21:00	22:00	01:00	0	0	0	0
Log sluice	16-Oct	22:00	23:00	01:00	0	0	0	0
Log sluice	16-Oct	23:00	00:00	01:00	0	0	0	0
Log sluice	17-Oct	00:00	01:00	01:00	0	0	0	0
Log sluice	17-Oct	01:00	02:00	01:00	0	0	0	0
Log sluice	17-Oct	02:00	03:00	01:00	0	0	0	0
Log sluice	17-Oct	03:00	04:00	01:00	0	0	0	0
Log sluice	17-Oct	04:00	05:00	01:00	147	9	101	147
Log sluice	17-Oct	05:00	06:00	01:00	5	0	5	5
Log sluice	17-Oct	06:00	07:00	01:00	568	19	84	568
Log sluice	17-Oct	07:00	08:00	01:00	60065	12	83	60065
Log sluice	17-Oct	08:00	09:00	01:00	1336	4	99	1336
Log sluice	17-Oct	09:00	10:00	01:00	1700	10	91	1700
Log sluice	17-Oct	10:00	11:00	01:00	5463	13	88	5463
Log sluice	17-Oct	11:00	12:00	01:00	3998	3	100	3998
Log sluice	17-Oct	12:00	13:00	01:00	4269	2	98	4269
Log sluice	17-Oct	13:00	14:00	01:00	4818	4	95	4818
Log sluice	17-Oct	14:00	15:00	01:00	4782	1	95	4782
Log sluice	17-Oct	15:00	16:00	01:00	1830	2	104	1830
Log sluice	17-Oct	16:00	17:00	01:00	326	3	91	326
Log sluice	18-Oct	17:10	18:00	00:50	0	0	0	0
Log sluice	18-Oct	18:00	19:00	01:00	2	0	16	2
Log sluice	18-Oct	19:00	20:00	01:00	32	0	32	32
Log sluice	18-Oct	20:00	21:00	01:00	26	0	26	26
Log sluice	18-Oct	21:00	22:00	01:00	5	0	5	5
Log sluice	18-Oct	22:00	23:00	01:00	0	0	0	0
Log sluice	18-Oct	23:00	00:00	01:00	0	0	0	0
Log sluice	19-Oct	00:00	01:00	01:00	0	0	0	0
Log sluice	19-Oct	01:00	02:00	01:00	0	0	0	0
Log sluice	19-Oct	02:00	03:00	01:00	0	0	0	0

Appendix 6-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled	Catch per unit effort adjusted for sampler efficiency
Log sluice	19-Oct	03:00	04:00	01:00	0	0	0	0
Log sluice	19-Oct	04:00	05:00	01:00	1	0	1	1
Log sluice	19-Oct	05:00	06:00	01:00	0	0	0	0
Log sluice	19-Oct	06:00	07:00	01:00	157	10	106	157
Log sluice	19-Oct	07:00	08:00	01:00	6674	12	153	6674
Log sluice	19-Oct	08:00	09:00	01:00	3411	2	98	3411
Log sluice	19-Oct	09:00	10:00	01:00	979	5	107	979
Log sluice	19-Oct	10:00	11:00	01:00	949	5	97	949
Log sluice	19-Oct	11:00	12:00	01:00	692	8	94	692
Log sluice	19-Oct	12:00	13:00	01:00	531	9	94	531
Log sluice	19-Oct	13:00	14:00	01:00	6701	4	106	6701
Log sluice	19-Oct	14:00	15:00	01:00	1675	1	102	1675
Log sluice	19-Oct	15:00	16:00	01:00	2711	77	152	2711
Log sluice	19-Oct	16:00	17:00	01:00	10504	15	95	10504
Log sluice	23-Oct	22:00	23:00	01:00	0	0	0	0
Log sluice	23-Oct	23:00	00:00	01:00	1	0	1	1
Log sluice	24-Oct	00:00	01:00	01:00	1	0	1	1
Log sluice	24-Oct	01:00	02:00	01:00	0	0	0	0
Log sluice	24-Oct	02:00	03:00	01:00	0	0	0	0
Log sluice	24-Oct	03:00	04:00	01:00	0	0	0	0
Log sluice	24-Oct	04:00	05:00	01:00	0	0	0	0
Log sluice	24-Oct	05:00	06:00	01:00	0	0	0	0
Log sluice	24-Oct	06:00	07:00	01:00	0	0	0	0
Log sluice	24-Oct	07:00	08:00	01:00	530	1	116	530
Log sluice	24-Oct	08:00	09:00	01:00	468	4	120	468
Log sluice	24-Oct	09:00	10:00	01:00	25	25	0	25
Log sluice	24-Oct	10:00	11:00	01:00	1735	1	119	1735
Log sluice	24-Oct	11:00	12:00	01:00	1379	3	146	1379
Log sluice	24-Oct	12:00	13:00	01:00	1658	0	109	1658
Log sluice	24-Oct	13:00	14:00	01:00	1018	0	99	1018
Log sluice	24-Oct	14:00	15:00	01:00	494	1	102	494
Log sluice	24-Oct	15:00	16:00	01:00	140	1	97	140
Log sluice	24-Oct	16:00	17:00	01:00	25	0	25	25
Log sluice	27-Oct	20:31	21:16	00:45	37	0	37	49
Log sluice	27-Oct	22:00	23:00	01:00	10	0	10	10
Log sluice	27-Oct	23:00	00:00	01:00	12	0	12	12
Log sluice	28-Oct	00:00	01:00	01:00	2	0	2	2
Log sluice	28-Oct	01:00	02:00	01:00	2	0	2	2
Log sluice	28-Oct	02:00	03:00	01:00	0	0	0	0
Log sluice	28-Oct	03:00	04:00	01:00	2	0	2	2
Log sluice	28-Oct	04:00	05:00	01:00	0	0	0	0
Log sluice	28-Oct	05:00	06:00	01:00	0	0	0	0

Appendix 6-Table 1. (Continued).

Sampling device	Start date	Start time	End time	Sample duration	Total clupeids	Bluebacks subsampled	Am shad subsampled	Catch per unit effort adjusted for sampler efficiency
Log sluice	28-Oct	06:00	07:00	01:00	33	0	33	33
Log sluice	28-Oct	07:00	08:00	01:00	59	0	59	59
Log sluice	28-Oct	08:00	09:00	01:00	470	3	98	470
Log sluice	28-Oct	09:00	10:00	01:00	68	3	55	68
Log sluice	28-Oct	10:00	11:00	01:00	531	4	97	531
Log sluice	28-Oct	11:00	12:00	01:00	441	3	112	441
Log sluice	28-Oct	12:00	13:00	01:00	129	2	127	129
Log sluice	28-Oct	13:00	14:00	01:00	638	1	101	638
Log sluice	28-Oct	14:00	15:00	01:00	1	0	1	1
Log sluice	28-Oct	15:00	16:00	01:00	68	0	68	68
Log sluice	28-Oct	16:00	17:00	01:00	39	0	39	39

Appendix 6-Table 2. Diel sample data showing those collections determined to be statistical outliers by the standard deviate test (Sokal and Rohlf 1969).

	Diel sample date										
Collection	Sept. 18	Sept. 25	Sept. 30	Oct. 2	Oct. 7	Oct. 9	Oct. 11	Oct. 16	Oct. 18	Oct. 23	Oct. 27
17:00	690	23,986	7,030	514	3,307	15,181	3,524	6,535	0	682	27
18:00	1,378	2,247	1,934	856	2,477	595	573	45	2	400	39
19:00	0	483	3,954	0	0	414	0	38	32	46	32
20:00	6	240	4,315	10	50	795	31	1	26	9	67
21:00	1	716	1,546	1	178	0	45	0	5	9	49
22:00	7	70	3,733	4	78	26	51	0	0	0	10
23:00	2,351	26	76	0	1	106	13	0	0	1	12
00:00	478	249	25	0	0	5,243	26	0	0	1	2
01:00	51	5,534	62	1	12	217	361	0	0	0	2
02:00	1	2,156	52	0	6	3	19	0	0	0	0
03:00	305	3,108	0	0	1	66	0	0	0	0	2
04:00	1	3,579	20	0	3	0	0	147	1	0	0
05:00	1	243	1,717	0	0	4	0	5	0	0	0
06:00	16	19	4,956	38	299	10	177	568	157	0	33
07:00	0	4	19,882	774	1,560	7,082	99	60,065	6,674	530	59
08:00	0	2	1,010	103	3,590	4,428	16	1,336	3,411	468	470
09:00	1	0	470	16	1,524	1,936	103	1,700	979	25	68
10:00	0	0	0	1,254	1,103	6,420	2,905	5,463	949	1,735	531
11:00	0	0	1,010	1,882	7,720	3,808	15,927	3,998	692	1,379	441
12:00	0	0	1,899	1,278	12,106	26,380	4,155	4,269	531	1,658	129
13:00	0	2	2,826	3,120	5,942	18,883	3,744	4,818	6,701	1,018	638
14:00	0	0	10,952	1,310	83	7,336	1,232	4,782	1,675	494	1
15:00	0	0	2,471	486	401	232	3,160	1,830	2,711	140	68
16:00	0	0	3,106	722	202	2,323	1,503	326	10,504	25	39

[box] Statistical outlier of 95% confidence interval.

Appendix 7

POWER GENERATION, CANAL FLOW AND WATER TEMPERATURE

Appendix 7-Table 1. Power generation and canal flow during concurrent sampling at Cabot Station.

Sample date	Start time	End time	Power generation (MW) Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Canal flow(cfs)
16-Sep	17:10	18:13	8.7		8.0	7.6		8.2	8,661
16-Sep	18:57	20:03	8.6	8.2	8.4	7.8	8.3	7.9	12,113
17-Sep	17:08	18:08				7.0			1,903
17-Sep	18:19	19:19				7.0			1,903
17-Sep	20:01	21:01				7.0			1,903
18-Sep	17:09	18:15	7.7	6.4		6.4		7.0	7,000
18-Sep	18:58	20:04	7.5	7.6	7.2	6.2	6.7	6.7	10,000
18-Sep	20:57	22:00	7.6	7.6	6.8	6.2	6.4	6.8	10,000
19-Sep	17:06	18:06	5.7						2,032
19-Sep	18:18	19:18	5.7						2,032
19-Sep	19:32	20:10	5.7						2,032
19-Sep	20:22	21:15	5.7						2,032
22-Sep	17:13	18:25	7.4		7.2	6.0		6.3	5,892
22-Sep	18:54	20:00	7.4		7.2	6.0		6.3	5,892
22-Sep	20:45	21:35	7.4		7.2	6.0		6.3	5,892
23-Sep	17:08	18:23	7.1	6.7	7.7	6.0	6.6	6.7	10,000
23-Sep	19:02	20:03	7.1	6.7	7.7	6.0	6.6	6.7	10,000
23-Sep	20:40	21:40	7.1	6.7	7.7	6.0	6.6	6.7	10,000
24-Sep	17:10	18:12	7.4	6.6	6.2	6.2		5.7	8,100
24-Sep	18:40	19:40	7.4	6.6	6.2	6.2		5.7	8,100
24-Sep	20:13	21:13	7.4	6.6	6.2	6.2		5.7	8,100
25-Sep	17:10	18:13	8.8	8.6	8.8	7.9	8.4	8.2	12,522
25-Sep	18:51	20:04	8.8	8.6	8.8	7.9	8.4	8.2	12,522
26-Sep	17:07	18:07	7.4			6.7			3,009
26-Sep	18:31	19:31	7.4		7.8	6.6		6.6	3,009
26-Sep	20:06	21:06	7.4		7.8	6.6		6.6	7,000
28-Sep	17:08	18:09	7.4	7.0		7.0	7.2	7.4	8,200
28-Sep	18:57	19:57	7.4	7.0		7.0	7.2	7.4	8,200
28-Sep	20:28	21:28	7.4	7.0		7.0	7.2	7.4	8,200
29-Sep	17:14	18:16	6.4	6.2		6.8	6.2		6,700
29-Sep	18:39	19:39	6.4	6.2		6.8		6.1	6,700
29-Sep	20:11	21:11	6.2	6.0	7.4	6.6	6.6	5.6	6,700
30-Sep	17:07	18:08	6.6			7.2			2,270
30-Sep	18:33	19:44	8.4	8.0	8.2	7.8	8.0		9,800
30-Sep	20:24	21:28	8.4	8.0	8.2	7.8	8.0		9,800
01-Oct	17:04	18:04	7.0						2,700
01-Oct	18:18	19:18	7.0			7.2		6.6	5,726
01-Oct	19:35	20:39	8.6	8.4	8.6	8.0	8.2	8.2	12,400
02-Oct	17:01	18:01	7.8						2,400

Appendix 7-Table 1. (Continued).

Sample date	Start time	End time	Power generation (MW) Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Canal flow(cfs)
02-Oct	18:12	19:12	7.8						2,400
02-Oct	19:22	20:22	7.8						2,400
03-Oct	17:00	18:00	7.4						4,000
03-Oct	18:10	19:10	7.4						4,000
03-Oct	19:20	20:20	7.4						4,000
04-Oct	17:00	18:00	7.8						2,565
04-Oct	18:26	19:26	7.7			6.2		7.7	5,500
04-Oct	19:56	20:56	9.0			8.4		6.6	7,200
05-Oct	17:15	18:15	7.0						2,300
05-Oct	18:32	19:32	7.4			7.2			4,500
05-Oct	19:53	20:53	7.3			7.0		6.1	5,469
06-Oct	17:00	18:00				7.0			2,314
06-Oct	18:11	19:11				7.0			2,331
06-Oct	19:33	20:33	7.4			7.0		7.0	3,240
07-Oct	16:55	17:55						7.0	2,000
07-Oct	18:14	19:14						7.0	2,000
07-Oct	19:38	20:38	7.8			6.8		6.6	5,861
08-Oct	17:00	18:00						8.2	2,575
08-Oct	18:10	19:10						7.8	2,575
08-Oct	19:29	20:29	7.0	7.0		7.0		7.0	7,200
09-Oct	17:06	18:06	7.6		7.2	6.2		6.5	7,259
09-Oct	18:32	19:32	7.6		7.2	6.2		6.5	7,259
09-Oct	19:57	20:57	7.0			7.0			3,959
10-Oct	17:17	18:22	7.0	7.0		7.0	7.0	7.0	8,993
10-Oct	19:08	19:48	8.5	8.6		8.5	8.5	8.5	12,353
10-Oct	20:25	21:05	8.5	8.6		8.5	8.5	8.5	12,353
11-Oct	17:10	17:51	7.0			7.0		7.0	5,324
11-Oct	18:20	19:00	7.0			7.0		7.0	5,324
11-Oct	19:28	20:08	7.0			7.0		7.0	5,324
11-Oct	20:32	21:13	7.0	7.0	7.0	7.0	7.0	7.0	5,466
12-Oct	17:06	18:07	6.5			7.0		7.6	5,300
12-Oct	18:37	19:37	7.6	7.7	7.4	7.1	7.9	6.9	10,292
12-Oct	20:15	21:15	7.5		7.2	6.6		7.0	7,000
13-Oct	17:16	18:16	7.0			7.0		7.0	
13-Oct	18:48	19:48	8.4		7.4	7.8	8.2	8.2	10,000
13-Oct	20:14	21:14	8.4						2,300
14-Oct	17:00	18:00				7.0			2,000
14-Oct	18:24	19:27	7.4		7.0	6.0		6.8	2,300
14-Oct	20:00	21:05	7.4		7.0	6.0		6.8	7,178

Appendix 7-Table 1. (Continued).

Sample date	Start time	End time	Power generation (MW) Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Canal flow(cfs)
15-Oct	17:52	18:52	7.2		7.4	6.8		6.4	6,415
15-Oct	19:28	20:28	8.4			7.8	8.5	7.6	8,753
16-Oct	17:08	18:08	7.6			7.3			4,061
16-Oct	18:30	19:30	7.4			7.0		7.1	5,000
16-Oct	20:00	21:00	7.0						4,161
17-Oct	17:09	18:09	7.6			6.4			4,000
17-Oct	18:28	19:28	7.4			6.8			4,000
17-Oct	19:47	20:29	7.4			6.8	7.4	7.6	9,000
19-Oct	17:11	17:41	7.0			7.0		7.0	4,193
19-Oct	18:05	19:05	7.6	6.9	7.4	6.7		7.1	8,300
19-Oct	19:44	20:46	7.6	6.9	7.4	6.7		7.1	8,300
20-Oct	17:07	18:07	7.6			5.6		6.8	5,333
20-Oct	18:44	19:44	7.4	6.6		7.0	6.8	6.2	8,300
20-Oct	20:19	21:19	7.4	6.6		7.0	6.8	6.2	8,300
21-Oct	17:07	18:10	6.8	7.4	7.0	6.4	7.2	6.6	9,944
21-Oct	18:55	19:59	8.0	8.0	8.0	8.0	8.0	8.0	13,025
21-Oct	20:41	21:21	8.0	8.0	8.0	8.0	8.0	8.0	13,025
22-Oct	16:44	17:44	7.9			7.0		6.5	6,200
22-Oct	18:16	19:16	7.6	7.5	7.1	6.7	6.7	6.3	9,800
22-Oct	19:39	20:43	7.9			7.0		6.5	9,800
23-Oct	17:05	18:05	7.0						1,700
23-Oct	18:26	19:26	7.6	7.2		6.4		7.0	6,500
23-Oct	20:00	21:03	7.6	7.2		6.4			5,000
24-Oct	17:11	18:11	7.0						
24-Oct	18:41	19:50	7.0	7.0		7.0			2,690
25-Oct	16:21	17:22	7.2		7.2	6.6		6.7	6,900
25-Oct	17:56	18:58	7.0	6.5	6.9	6.2	6.9	6.4	10,000
25-Oct	19:30	20:33	7.2	7.1	6.4	6.4	7.0	6.5	8,200
27-Oct	17:15	18:15	7.2	6.2	7.2	6.8	6.9	7.0	10,200
27-Oct	18:50	19:54	7.2	6.2	7.2	6.8	6.9	7.0	10,200
27-Oct	20:31	21:16	7.2	6.2	7.2	6.8	6.9	7.0	10,200
29-Oct	16:56	17:56	7.0	7.0	7.4	5.7	6.5	6.7	10,000
29-Oct	18:19	19:19	7.0	7.0	7.4	5.7	6.5	6.7	10,000
29-Oct	19:55	20:55	7.0	7.0	7.4	5.7	6.5	6.7	10,000
30-Oct	16:13	17:13	7.2	7.0	7.0	6.6	7.7	7.0	11,000
30-Oct	17:40	18:40	7.2	7.0	7.0	6.6	7.7	7.0	11,000
30-Oct	19:10	20:10	7.2	7.0	7.0	6.6	7.7	7.0	11,000
01-Nov	16:00	17:00	7.8						
01-Nov	17:22	18:22	7.5	6.8	7.2	6.8	6.5	6.7	10,000

Appendix 7-Table 1. (Continued).

Sample date	Start time	End time	Power generation (MW)						Canal flow(cfs)
			Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	
01-Nov	18:53	19:53	7.5	6.8	7.2	6.8	6.5	6.7	10,000

Appendix 7-Table 2. Average water temperature during concurrent sampling period.

Sampling date	Average water temperature (C)
16-Sep	21.5
17-Sep	21.6
18-Sep	21.9
19-Sep	22.0
22-Sep	21.0
23-Sep	20.5
24-Sep	19.5
25-Sep	18.0
26-Sep	17.7
28-Sep	17.0
29-Sep	17.0
30-Sep	16.5
01-Oct	15.8
02-Oct	17.4
03-Oct	16.0
04-Oct	15.0
05-Oct	15.0
06-Oct	15.0
07-Oct	14.4
08-Oct	13.9
09-Oct	14.2
10-Oct	14.1
11-Oct	14.0
12-Oct	14.0
13-Oct	13.5
14-Oct	13.0
15-Oct	13.0
16-Oct	13.9
17-Oct	12.9
19-Oct	12.0
20-Oct	12.0
21-Oct	12.0
22-Oct	12.0
23-Oct	12.0
24-Oct	11.1
25-Oct	11.0
27-Oct	9.8
29-Oct	9.0
30-Oct	9.0
01-Nov	8.7

Appendix 8

INVESTIGATION INTO THE USE OF MERCURY VAPOR LIGHT TO ATTRACT JUVENILE CLUPEIDS TO THE LOG SLUICE BYPASS

Appendix 8. Investigation into the use of mercury vapor light

During the course of the Fall 1992 Juvenile Clupeid Study at Cabot Station, observations of the response of juvenile clupeids to the station's headworks lights suggested that the lighting conditions in the forebay influenced clupeid movement within the forebay and their bypass rate. In particular, the following responses were noted:

1) Clupeids schooling in the forebay in the vicinity of turbine units 1 and 2 appeared to avoid the log sluice entrance during night time hours because of a shadow cast by the headworks bridge extending over the log sluice gate in the light of the mercury vapor lamp that illuminates the south end of the forebay. Schools of clupeids would usually form after dark in the illuminated area at the south end of the forebay, with all individuals oriented in an upstream swimming position. Occasionally the downstream portion of the school would be pushed into the shaded area near the log sluice, then would quickly swim out of the shadow back into the illuminated area.

2) During a diel log sluice sample, which began on the night of October 11, lightning struck Cabot Station, temporarily knocking out all the station's headworks lights including the mercury vapor lamp which illuminates the south end of the forebay. This event was immediately followed by an extremely large surge of clupeids bypassing via the log sluice.

3) Field personnel operating the turbine intake nets observed that schools of clupeids would follow the mercury vapor lights mounted on the travelling crane as it moved along the length of the station intake during

net retrieval.

These observations prompted experimenting with mercury vapor lights to enhance bypass rates.

Experiment No. 1

On October 14, during a concurrent log sluice-turbine intake sample which began at 20:00 hours, the mercury vapor lamp illuminating the south end of the forebay was turned off to remove the shadow created by the headworks bridge. A large school of clupeids immediately thereafter bypassed via the log sluice. An estimated 1,871 clupeids bypassed through log sluice in the 20 minutes following turning out the light, where as only 483 had bypassed in the preceding two hours. The large catch in the log sluice was accompanied by a large catch in turbine intake net #1. An estimated 1,884 clupeids were entrained through Turbine #1 during this one hour sample. The results of this experiment suggest that the sudden turning off of the forebay lamp may have elicited a fright response in the school of clupeids, causing them to scatter, and resulting in increased catches in both the log sluice sampler and the entrainment net sampling turbine #1.

Experiment No. 2

Additional experimentation into the effect of mercury vapor lighting was conducted on the night of October 26. To eliminate the shadow near the log sluice gate, a 400 watt, portable mercury vapor lamp, identical to the lamp illuminating the forebay, was suspended underneath the headworks bridge directly over the log sluice gate. The lamp (referred to as the log sluice lamp) was aimed downward and slightly upstream so that it would illuminate the entire area beneath the headworks bridge and the immediate vicinity in the forebay. In this experiment, all outside station lights were turned off, except for the south forebay lamp, during the concurrent sampling period. The log sluice lamp was then turned on at 18:00 hours during the last 16 minutes of the concurrent sample. Immediately thereafter, a large group of clupeids were observed swimming towards the log sluice where the increased water velocity swept them over the gate. Where as only 20 fish had been bypassed through the log sluice from 17:13 to 18:00, an estimated 32,812 bypassed from the time the log sluice lamp was turned on at 18:00 until the end of the sample at 18:16. An estimated 273 fish were entrained through Unit #1 during this sample.

Large numbers of clupeids were still visible in the forebay when the next concurrent sample began at 18:50. This time the log sluice lamp remained on, while the south forebay lamp was turned off. Immediately upon turning off the forebay lamp, large groups of clupeids were observed swimming directly towards the log sluice and into the sampler. The number bypassed during this sample was estimated to be 63,656 fish, while estimated number entrained through Unit #1 was estimated to be 414 fish. This experiment was repeated during the period between concurrent samples, with an estimated 5,200 clupeids bypassed in 36 minutes.

<u>Experiment No. 3</u>

In the third concurrent sample on the night of October 26, the south forebay lamp was switched on, allowing the clupeids remaining in the forebay to regroup into a school. Approximately 30 minutes later, the forebay lamp was switched off, while the log sluice lamp remained on. As in the previous experiments, a large group of clupeids immediately were observed swimming towards the log sluice and were bypassed. An estimated 8,915 clupeids bypassed via the log sluice during this sample, with an estimated 795 fish entrained through Unit #1.

In all, an estimated 105,403 clupeids bypassed via the log sluice during concurrent sampling on October 26. This is in stark contrast to prior samples in that the number of clupeids bypassed via the log sluice had not exceed 16,000 during any of the previous sampling nights since October 1. An estimated 1,482 fish were entrained through turbine Unit #1 during the experiments on October 26. This was also significantly higher than most previous nights, although the number was not higher than the estimated 1,884 entrained through Unit #1 during the experiment on October 14.

The addition of the log sluice lamp for the experiments performed on October 26 appeared to enhance the reaction that was observed on October 14. The increased catches experienced in the nets sampling Unit #1 on both nights suggest that switching off the south forebay lamp produced a fright response causing the clupeids that had schooled in the illuminated area to scatter. With the addition of the log sluice lamp on October 26, passage rates increased dramatically, suggesting that, when the forebay lamp was switched off, large groups of fish were drawn to the only other light source available, namely, the log sluice lamp. Supporting this is the observation that entrainment on October 26 (using log sluice lamp), although elevated, was less than that experienced on October 14 (log sluice lamp was not used). Additionally, when the forebay lamp was switched off, the group of fish that initiated the bypass surge on October 26 appeared to have come from in front of Units #1 and #2, and swam directly into the illuminated area created by the log sluice lamp.

Subsequent identical experiments, performed during sampling on October 28 and 31, and November 2 and 3, produced the same response from clupeids schooling in the forebay. Although the number bypassing during these subsequent experiments was proportionally lower than that on October 26, due to reduced number of clupeids present in the forebay, the use of the log sluice lamp significantly increased passage via the log sluice. Each experimental sample had significantly greater numbers of clupeids bypassed than the preceding sample nights when lighting experiments were not conducted. It was observed during these later experiments, when numbers of clupeids present in the forebay were reduced, that turning on the log sluice lamp when the south forebay lamp was on would not draw the fish to the log sluice as effectively as using the log sluice lamp with the south forebay lamp turned off. Appendix 8-Table 1 summarizes the last 4 weeks of sampling during which the experiments occurred. Appendix 8-Table 2 lists the estimated number of clupeids bypassed through the log sluice during concurrent and intermediate collections on days when experiments were conducted.

Results of these experiments support further investigation into the use or manipulation of lighting as a means of enhancing the log sluice bypass route. These initial experiments were conducted late in the study following the peak of emigration. Similar experiments conducted prior to and during the peak would be required to fully evaluate the application.

Appendix 8-
Table 1. Estimated log sluice bypass rates (fish/hour) and estimated Unit 1 entrainment rates at Cabot Station for the period during which mercury vapor light experiments occurred.

	DATE	Estimated log sluice bypass rate (fish/hour)	Estimated Unit 1 Entrainment rate (fish/hour)
	07-Oct	1,311	0
	08-Oct	104	0
	09-Oct	5,209	64
	10-Oct	1,597	263
	11-Oct	1,304	83
	12-Oct	207	92
	13-Oct	2,252	123
	14-Oct	1,403	34
**	14-Oct	1,986	1,884
	15-Oct	468	57
	16-Oct	2,178	4
	17-Oct	44	6
	19-Oct	5,333	91
	20-Oct	2,318	43
	21-Oct	2,353	213
	22-Oct	1,182	165
	23-Oct	362	14
	24-Oct	4	44
	25-Oct	393	84
*	26-Oct	33,880	494
	27-Oct	35	33
*	28-Oct	4,683	357
	29-Oct	28	20
	30-Oct	12	11
*	31-Oct	869	50
	01-Nov	18	17
*	02-Nov	324	93
*	03-Nov	36	5

* Mercury vapor light experimental sampling nights.
**Experimented only during the last hour of the four hour concurrent sampling period.

Appendix 8-

Table 2. Number of clupeids bypassing through the log sluice during collections on days in which mercury vapor light experiments were conducted.

Date	Start time	End time	Number of clupeids bypassing
26-Oct	17:13	18:16	32,832
26-Oct	18:16	18:50	22,300
26-Oct	18:50	19:52	63,656
26-Oct	19:52	20:28	5,200
26-Oct	20:28	21:29	8,915
28-Oct	17:00	17:18	0
28-Oct	17:18	18:18	11,958
28-Oct	18:18	18:48	56
28-Oct	18:48	19:48	1,427
28-Oct	19:48	20:30	98
28-Oct	20:30	21:30	664
31-Oct	16:05	16:19	0
31-Oct	16:19	17:19	1
31-Oct	17:19	17:55	14
31-Oct	17:55	18:55	2,277
31-Oct	18:55	19:30	70
31-Oct	19:30	20:00	164
02-Nov	16:14	17:14	14
02-Nov	17:14	17:48	45
02-Nov	17:48	18:50	894
02-Nov	18:50	19:18	34
02-Nov	19:18	20:18	94
03-Nov	16:10	17:10	3
03-Nov	17:10	17:46	97
03-Nov	17:46	18:46	72
03-Nov	18:46	19:19	15
03-Nov	19:19	20:19	34

Attachment 1

PLAN OF STUDY AND AGENCY CORRESPONDENCE

NORTHEAST UTILITIES

THE CONNECTICUT LIGHT AND POWER COMPANY
WESTERN MASSACHUSETTS ELECTRIC COMPANY
HOLYOKE WATER POWER COMPANY
NORTHEAST UTILITIES SERVICE COMPANY
NORTHEAST NUCLEAR ENERGY COMPANY

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June 5, 1992

FERC Project No. 1889
Turners Falls

D05549

Mr. Ronald Lambertson, Chairman
Connecticut River Atlantic Salmon Commission
c/o U.S. Fish and Wildlife Service
One Migratory Way
P.O. Box 71
Turners Falls, MA 01376

Reference: Letter (D05438), R. A. Reckert to D. F. Egan, dated April 9, 1992.

Dear Mr. Lambertson:

Turners Falls Project: Downstream Fish Passage
1992 Plan of Study for Juvenile Clupeids

Northeast Utilities Service Company (NUSCO), on behalf of Western Massachusetts Electric Company, has undertaken numerous downstream fish passage studies in conformance with the Memorandum of Agreement signed with the Connecticut River Atlantic Salmon Commission and its member agencies.

Enclosed for your review is the 1992 Plan of Study for Juvenile Clupeids at the Turners Falls Project. This study is an expanded follow-up study of work completed in 1991 (reference).

If you choose to submit comments, please forward them by July 15, 1992. If you have any questions, please contact Mr. Richard W. Thomas, NUSCO Generation and Environmental Licensing, at (203) 665-3719.

Very truly yours,

NORTHEAST UTILITIES SERVICE COMPANY
As Agent for Western Massachusetts
Electric Company

R. A. Reckert
Vice President

Enclosure
cc: see next page

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DOWNSTREAM PASSAGE OF JUVENILE CLUPEIDS AT CABOT STATION FALL 1992

PLAN OF STUDY

Introduction

In 1990, the Northeast Utilities Service Company (NUSCO) signed a memorandum of agreement (MOA) with the Fish and Wildlife Service and the Connecticut River Atlantic Salmon Commission, agreeing to construct downstream fish passage facilities at the Turners Falls Project. A study of downstream movements of juvenile clupeids was performed in the fall of 1991. The 1992 plan, presented below, describes a continuation of the 1991 study with certain refinements to provide more detailed information concerning the effectiveness of the bypass system tested in 1991 and to test the incremental effect of an additional method for bypassing the juveniles. It is NUSCO's intent that the results of the 1991 study and the results of the 1992 study will lead to a practical mechanism to facilitate passage of emigrating anadromous fish through the Turners Falls complex. Target species for the fall studies include American shad (*Alosa sapidissima*) and blueback herring (*Alosa aestivalis*). In addition to studies to facilitate downstream passage of the clupeids, comparable studies to facilitate downstream passage of Atlantic salmon (*Salmo salar*) are continuing. Results of the studies to facilitate emigration of Atlantic salmon smolts conducted in the springs of 1991 and 1992 are used for determining the experimental configurations of the Cabot Station facilities to evaluate the emigration routes of the juvenile clupeids.

In the Connecticut River, anadromous clupeids (American shad and blueback herring) spawn from early May through mid-June, depending on water temperature. The juveniles remain in the river throughout the summer and usually begin their downstream migration in September. Water temperature is an indicator of when emigration of juvenile clupeids begins (O'Leary 1984; O'Leary and Kynard 1986). In the Connecticut River, emigration normally begins when water temperature declines to approximately 19 °C, usually in mid-September, and continues into early November each year. Marcy (1976) noted that most juveniles had left the river prior to water temperature reaching 6 °C. Most juvenile clupeids in the Connecticut River emigrate in schools in late afternoon and evening, peaking between 1700 hours and 2200 hours (O'Leary and Kynard 1986).

Project Description

Cabot Station, an integral-intake powerhouse, is located at the downstream end of a 2.1 mile-long power canal. A second powerhouse, Turners Falls Station 1 is also served by the same power canal. Collectively, the two powerhouses, dam and gated entrance to the power canal, and the power canal, are known as the Turners Falls Project (See Figure 1). Cabot Station is equipped with six identical Francis-type turbines. Water is supplied to each turbine through a three-bay intake for a total of 18 intake bays.

A trash rack extends from the bottom of the power canal to approximately two feet above the water surface. Flow into the turbines can be regulated by wicket gates . Dewatering of the penstocks and turbines is accomplished by closing headgates located immediately behind the trash racks. Gate wells are accessed from a deck along the upstream side of the powerhouse. The trash racks are periodically cleaned with a rake positioned on the gatewell deck. A log sluice located at the south (left) end of the power house is used primarily to facilitate removal of ice and other riverborne debris from the forebay area.

Cabot Station is also equipped with a fish ladder to enable spawning adult American shad, blueback herring, and Atlantic salmon movement to upstream spawning areas in the spring. The entrance to the ladder is located at the downstream face of the powerhouse and the exit is located in the power canal approximately 100 m upstream from Cabot Station. A second fish ladder is located at the dam spillway and a third fish ladder is located at thegatehouse at the upstream end of the power canal.

Previous studies

Juvenile clupeids, spawned and reared upstream of Turners Falls, emigrate from the Connecticut River in September and October each year. The juveniles enter the power canal through gates at the upper end and move downstream to Cabot Station. (There is some evidence that juvenile shad and herring rear in the power canal, however, no estimates of the number rearing in the canal are available.) Before the present series of studies was begun, the emigrant juveniles passed through the turbines or the log sluice.

The initial phase of studies of the emigrating juvenile clupeids, conducted in 1991, was designed to estimate the number of juvenile clupeid that pass through the Cabot Station facilities and the proportion bypassed through the log sluice. At Cabot Station, each of the penstocks for a unit are divided into three bays. During the summer of 1991, NUSCO equipped the middle intake bays of turbines 1, 4, and 6 with guides to permit installation of net frames, each holding two entrainment nets. The three net frames, depicted in Figure 2, are identical and are designed to sample the juvenile shad passing into the penstocks and turbines.

During 1991, NUSCO also constructed and installed a framed, inclined plane screen sampler in the log sluice. The sampler was designed to intercept the entire log sluice flow and divert all fish to a collection facility. An estimated 201,000 juvenile clupeids were diverted to the log sluice between 1700 hours and 2200 hours from October 2 through October 18 in 1991. Daily estimates of the proportion of fish that bypassed the turbines by moving through the log sluice varied from nearly zero to 83 percent, with no clear explanation why the percentage varied from night to night. The overall bypass efficiency was estimated to be 58 percent.

Because the hydraulic characteristics of the sampler used during the 1991 study made the logistics of efficient handling of the fish difficult, certain refinements to the log sluice sampler were recommended. The modifications to the sampler will be made based on experimental designs being evaluated in a physical model of the log sluice configuration. These modifications will be made during the summer prior to the start of the outmigration period.

The trash sluice (trash trough) located at the top of trash racks is aligned perpendicular to the flow of water through Cabot Station. In 1991, three openings were cut into the wall of the trash trough to provide an alternate route for juvenile clupeids to exit the power canal (Figure 3). Each opening can be configured either in a deep (3 feet wide by 6 feet deep) configuration, or in a shallow (3 feet wide by 3 feet deep) opening. Preliminary tests of the effectiveness of the trash trough openings were conducted in 1991. Although no noticeable differences were observed in the bypass rates, fish were observed entering the openings and presumably were carried to the log sluice. Water entering the trash trough flows to the log sluice where it mixes with the water passing through the log sluice gates. In this configuration, the relative contribution of the trash trough to the bypass efficiency cannot be evaluated because fish entering the trash trough could not be segregated and counted separately from those passing through the log sluice.

Objectives of the 1992 Juvenile Clupeid Study.

The objectives of the 1992 juvenile clupeid study are similar to those for the 1991 study. The focus of this study will be to provide more detailed analysis of the effectiveness of the log sluice releases in diverting juvenile clupeids from the turbine intakes and to evaluate any incremental effectiveness of diverting juvenile clupeids through the trash trough wall openings. In particular, the objectives of the 1992 Juvenile Clupeid Studies for the Turners Falls Project are:

- Determine the proportion of emigrating juvenile clupeids successfully passed through the trash trough openings and log sluice versus passing through Cabot Station turbines.

- Evaluate passage of juvenile clupeids through the trash trough openings.

- Estimate the number of juvenile clupeids passing downstream through the log sluice and trash trough.

These objectives will be achieved through implementation of the three tasks defined below.

Methods and Materials

Test Configurations

The experimental design of the Fall, 1992 study of emigrating juvenile clupeids will, in part, be dependent upon results of the spring 1992 salmon smolt study. Because the smolt study has not yet been performed, certain of the experimental conditions described below are presented in generic language and can only be finalized after sampling and preliminary analysis of the 1992 smolt study results are available.

For the fall 1992 juvenile clupeid study, the incremental effectiveness of the trash trough openings will be investigated in conjunction with estimation of the bypass efficiency and number of fish passing through the log sluice at Cabot Station. Although three openings were cut into the trash trough, only two trash trough/log sluice configurations will be compared during the fall 1992 studies. One configuration to be tested will be with all trash trough openings closed. The second configuration, with one or more of the trash trough openings open, will be the optimum condition observed during the Atlantic salmon smolt study conducted during the spring 1992.

To determine the number of fish passing through the trash trough, a sampling device will be installed to permit separate enumeration of fish entering the trash trough and the fish entering the log sluice directly.

TASK 1: Determination of the proportion of fish passing through the turbines, the log sluice and the trash trough openings.

Sampling Protocol. To determine the proportion of the outmigrating juvenile clupeid population passing through each of the possible paths passed the Cabot Station facilities, three sets of estimates are required: An estimate of the number of fish passing through the turbines (P_t), an estimate of the number of fish passing through the log sluice (P_{ls}), and an estimate of the number of fish diverted into the trash trough (P_{TT}). The incremental effect of diverting fish into the trash trough will be obtained by estimating the proportions of fish through the routes under two conditions: First, estimates of the proportions of the outmigrating clupeids will be made with the trash trough openings closed, i.e. $P_{TT} = 0$. Second, estimates of the proportions will be made with the optimal configuration of the trash trough opening and log sluice opening determined from the salmon smolt study conducted in the Spring. The two conditions (trash trough opening closed and trash trough opening open) will be tested on alternate nights throughout the sampling period to account for the variation in the numbers, species composition and sizes of outmigrating fish and discharge, water temperature and weather conditions through the sampling period.

At least three estimates of the numbers of fish passing through each route will be obtained from nearly simultaneous sampling of the juveniles through each route on each sampling date (one night). During September and October, sampling will be conducted between 1700 hours and 2200 hours, 5 days per week prior to and after the peak emigration period and 7 days per week during the peak emigration period. Peak emigration time will be determined by the numbers of fish obtained each night and water temperature as in 1991. Coordination of the sampling effort at each of the three locations will assure that the hour long sample periods at each location will overlap by at least 50 percent of the time to assure concurrent samples.

To estimate the proportion of fish passing through the turbines each night (P_t), the turbine nets used in 1991 and described above will be used. Because these nets sample only one sixth of the intake area (three of 18 intake bays servicing the six units) the estimated numbers of fish (N_{tr}) collected in the nets will be extrapolated to the entire intake area. If warranted by the data, estimates of the rates of entrainment to non-sampled intake bays will be made on the basis of linear interpolation and extrapolation from the sampled bays as was done for the results of the 1991 study. If the linear interpolation is not indicated by the data, the extrapolation will be on a proportional area basis. The numbers of fish collected during the hourly samples for each night will be reported separately to enable statistical analyses within and between sampling dates.

Estimates of the proportion of fish passing through the log sluice (P_{ls}) will also be determined each night. The numbers of fish (N_{ls}) collected in the log sluice sampler during each hour of sampling (between 1700 and 2200 hours) will be recorded separately. This will enable coordination of the concurrent estimates with the entrainment net samples, and trash trough samples. Also, separate records of the hourly numbers of fish passing through the log sluice will enable statistical analysis of the incremental effects of the trash trough on total bypass efficiency.

To estimate the proportion of the outmigrating clupeids passing through the trash trough (P_{TT}), a sampling system will be installed in the trash trough that will sample the entire trash trough flow. Although not yet constructed, the trash trough sampler will be designed to collect all fish passing into the trash trough. (Calibration of the trash trough sampler will be conducted to verify this assumption, see below.) The trash trough opening and sampler will be accessible to the fish on alternate nights through the sampling period. For those nights when the trash trough opening is closed, the number of fish passing through the trash trough (N_{TT}) will be 0. For the alternate nights when the trash trough opening is open, hourly collections of fish (coinciding with the hourly samples from the entrainment nets and the log sluice sampler) will be recorded separately. Maintenance of the separate records for each hourly sample on a given night will enable statistical analysis of multiple replicates for evaluating any enhancement of bypassing fish attributable to the trash trough access.

For each coincident sample on each night, estimates of the proportions of the outmigrating juvenile clupeids will be calculated as follows:

Turbine Proportion: $P_t = [N_t / (N_t + N_{ls} + N_{TT})] * 100$

Log Sluice Proportion: $P_{ls} = [N_{ls} / (N_t + N_{ls} + N_{TT})] * 100$

Trash Trough Proportion:

Open $P_{TT} = [N_{TT} / (N_t + N_{ls} + N_{TT})] * 100$

Closed $P_{TT} = 0$

The sampling protocol and calculations are dependent on the efficiency of the sampling gear. Consequently, it will be necessary to adjust the observed numbers of fish by a factor corresponding to the efficiency of the respective samplers in collecting and retaining the fish. To determine the efficiency of each gear type, releases of a known number of marked fish into the vicinity of each sampler will be made. For each release, the marked fish recovered in the sampling gear will be counted and compared with the number released to estimate gear collection and retention efficiency.

This calibration procedure is essential for extrapolating the number of fish collected in the entrainment nets to estimate the total number of fish passing through the turbines. Estimates of entrainment net retention efficiency will be determined on three occasions through the study period to account for differences in the sizes of the fish, flow conditions, and debris load (See the Fall 1991 Juvenile Clupeid Report, Harza 1992). The efficiency of retention of fish in each of the six entrainment nets (three net frames consisting of two nets each) will be estimated on each occasion. The retention efficiency for a given net will be calculated on the basis of 3 replicate releases for each occasion. The estimate of retention efficiency for each replicate will be calculated from the number of marked fish released at the mouth of the net (200 fish per replicate) and the number retained in the net at the end of a sampling period (normally one hour). The fish will be injected into the mouth of the net with the same apparatus used in the 1991 (Harza 1992, See Figure 5). The retention efficiency of each net ($RE_{i,j}$, where i = turbine bay and j = upper or lower net) for each replicate will be calculated as:

$$RE_{i,j} = (N_{rec}/N_m) * 100$$

where, N_{rec} = number of marked fish recovered in the net and N_m = number of marked fish released. The estimated retention efficiencies will be incorporated into the extrapolations of the numbers of fish collected in the entrainment nets to the total number of fish entrained through the operating turbines. (all turbines may not be operating on all sampling dates due to variations in the total river flow through the study period). The tests will be conducted when individual generators are operating within the range 7.0 to 8.8 MW, which is typical generation.

It will be assumed that the log sluice sampler intercepts 100% of the log sluice discharge. The location at which the water comes in contact with the sampler is turbulent and some splashing and water overflow may allow for some fish to be excluded from the sample. The efficiency of the sampler, therefore, will also be estimated on three occasions during the study period. Each estimate will be based on the release of three groups of 100 marked fish. Each group of 100 fish will be released to the log sluice immediately downstream of the gate. The log sluice sampler efficiency (SE_{ls}) will be estimated for each replicate on each occasion. Calculation of the sampler efficiency will be as follows:

$$SE_{ls} = (N_{rec} / N_m) * 100$$

where N_{rec} and N_m are as defined above.

Similarly, the trash trough sampler efficiency will be tested by releasing three groups of 100 marked fish immediately upstream of the sampler on each of three occasions during the study period. As for the log sluice sampler, the trash trough sampler efficiency (SE_{TT}), will be calculated for each replicate as:

$$SE_{ls} = (N_{rec} / N_m) * 100$$

Fish for use in the efficiency tests will be obtained and handled in the same manner used in 1991. A holding facility, consisting of a 2,500 gallon pool with water maintained between 2 and 4 ppt (parts per thousand) salinity, aerated, filtered and shaded, will be established in the vicinity of Cabot Station. The test fish will be either acquired from the log sluice sampler or obtained from the holding tanks at the Hadley Falls/Holyoke station. Sufficient numbers of fish to conduct the efficiency tests will be placed in the holding tank within 24 hours of each test occasion.

<u>Associated</u> <u>Data</u> <u>Records</u>. In addition to numbers of clupeids recovered in the samplers, information to be obtained each sampling period will include a determination of the species composition of the clupeids (American shad or blueback herring) and total lengths of the fish. The species and total lengths will be determined from the first 50 juvenile clupeids collected from each of the sampling devices (entrainment nets, log sluice sampler and trash trough sampler) each sampling period. In conjunction with the evaluation

of bypass efficiencies, total river discharge at Turners Falls, discharge through the Cabot Station turbines, discharge through Station 1, and discharge through the spillway will be recorded each day through the study period. The information recorded each day will also include the bypass configuration being tested, water temperature, air temperature, trash raking time period, and prevailing weather conditions. Identification of the individual hourly samples will be accomplished by recording the sampler location (entrainment net number, log sluice sampler or trash trough sampler), and the start time and duration of each sample.

Task 2: Evaluation of Incremental Effect of Trash Trough Opening.

As described above for determining the proportions of fish moving through each possible passage route, the effect of the trash trough opening will be determined by opening and closing the trash trough opening on alternate nights throughout the study period. To evaluate the incremental effect of the trash trough opening, the bypass efficiencies, as calculated above, for those nights the trash trough is closed will be compared with the bypass efficiencies for those nights the trash trough is open. It is expected that considerable variation in the bypass efficiencies, under both configurations, will be evident in the data as observed in 1991. The incremental effect of the trash trough, then, will be determined on a statistical basis. Weighted average bypass estimates will be calculated to account for night to night differences in the numbers of fish observed in the various sampling devices. As an initial evaluation, the average bypass efficiencies with and without the trash trough open will be compared using an appropriate statistic (e.g. the matched Student's t-statistic on arcsin-transformed bypass efficiencies obtained from Task 1). If deemed appropriate, analysis of variance calculations will be conducted to determine the significance of the incremental effect of the trash trough bypass route.

Task 3: Estimate of the Total Number of Clupeids Passing Cabot Station in 1992.

An estimate of the total number of juvenile clupeids passing Cabot Station in 1992 will be based on the nightly samples described for Task 1, augmented by hourly samples collected through a 24-hour period ten times during the study period. Twenty four-hour samples will be collected at least twice prior to, twice during, and twice after the peak outmigration period. The hourly numbers of fish passing Cabot Station calculated from the 24-hour samples will be used to extrapolate the nightly numbers of fish passing the Station (Task 1) to the entire 24-hour period for each date. The daily estimated numbers of fish will then be summed to estimate the total number of fish passing the Station during the study period.

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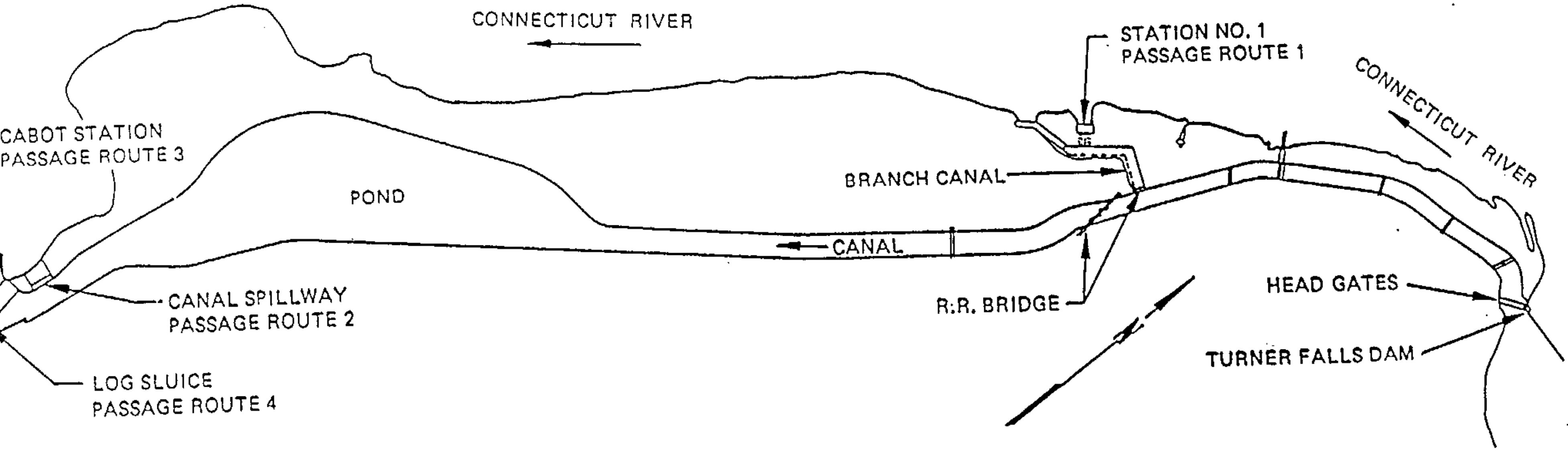

FIGURE 1. PLAN OF CANAL

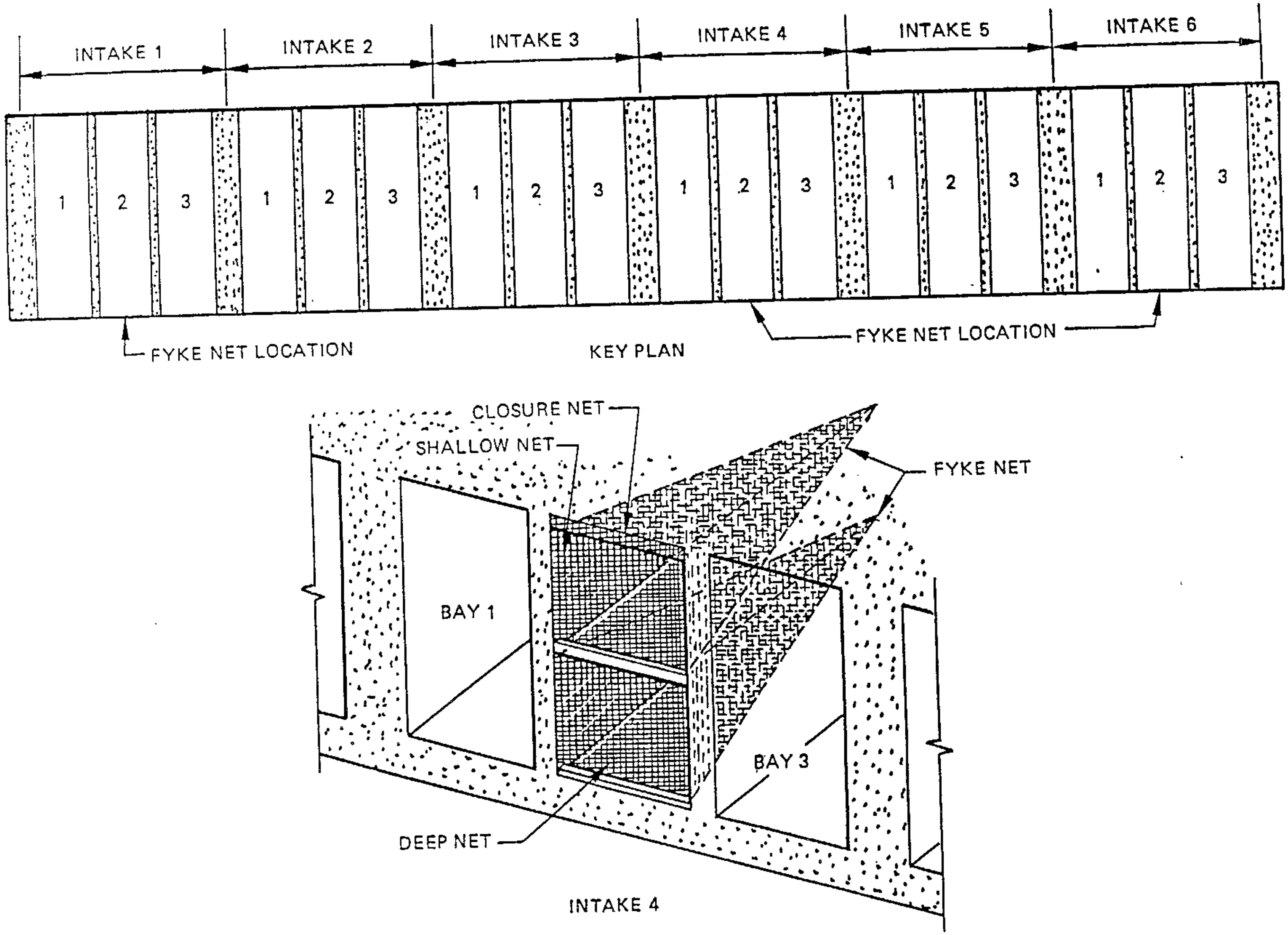

FIGURE 2.
LOCATION OF FYKE–NET SETS

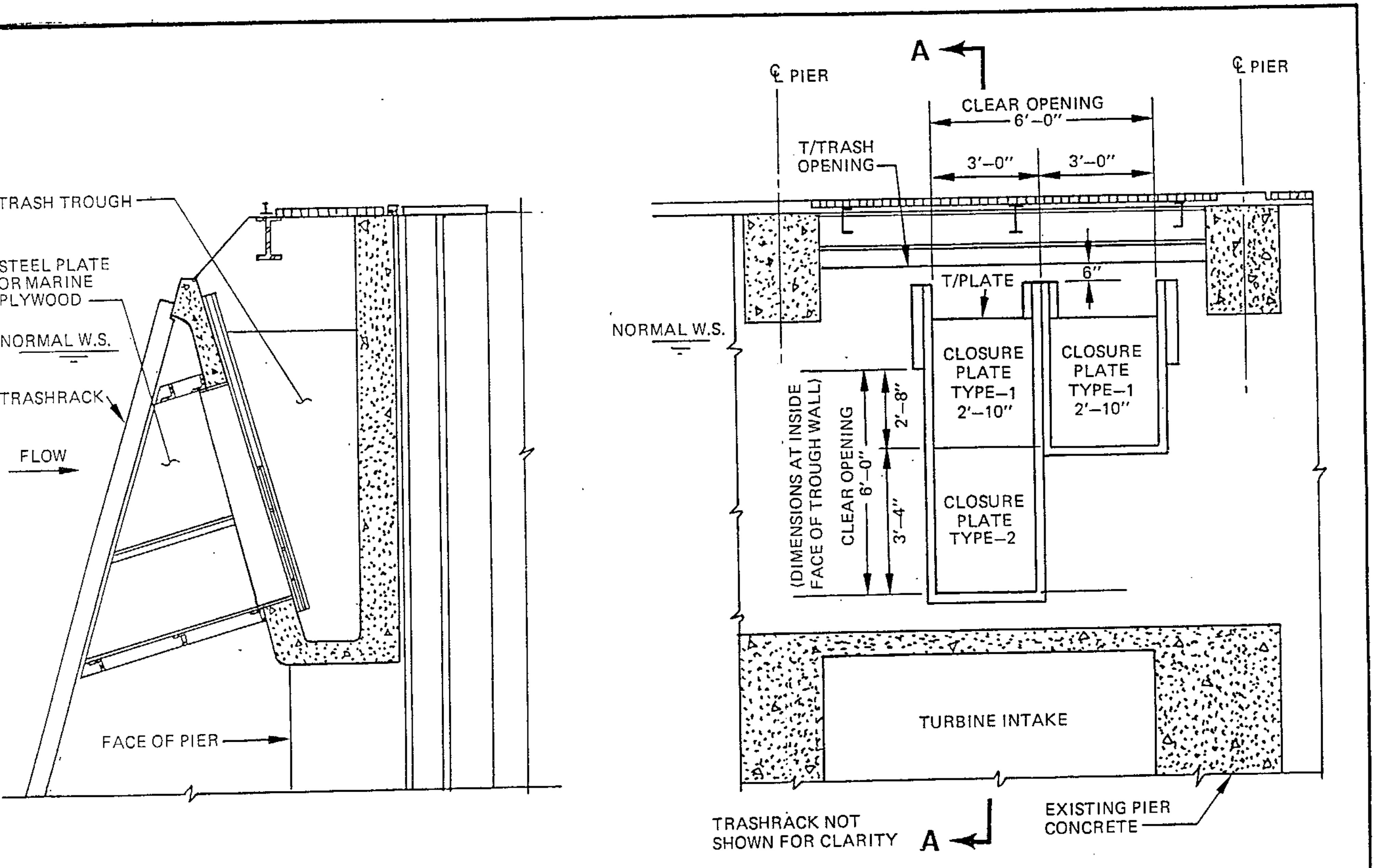

FIGURE 3
CONFIGURATION AND LOCATIONS OF ICE AND TRASH SLUICE SLOTS