FINAL

INDIAN POINT GENERATING STATION 1988 ENTRAINMENT SURVIVAL STUDY

Prepared under Contract with

Consolidated Edison Company of New York, Inc.
New York, New York

and

New York Power Authority
New York, New York

Jointly Funded by

Central Hudson Gas and Electric Corporation
Consolidated Edison Company of New York, Inc.
New York Power Authority
Niagara Mohawk Power Corporation
Orange and Rockland Utilities, Inc.

Prepared by

EA Engineering, Science and Technology
Northeast Operations

EA Report 10648.03
August 1989

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4 Irving Place
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1. INTRODUCTION

The Indian Point Generating Station uses a once-through cooling system to dissipate waste heat. In the process, cooling water from the Hudson River is pumped through condensers where heat from steam leaving the turbines is transferred to the cooling water, which is returned to the River. The two electric power generating units in operation at the Indian Point Generating Station withdraw up to 6,360 m^3 per minute (1.68 x 10^6 gpm) of water from the Hudson River for cooling purposes. Aquatic organisms small enough to pass through the intake screens may be carried through the cooling water system (entrained) where they are exposed to abrupt changes in temperature and hydrostatic pressure, mechanical buffeting, and velocity shear forces. Determining the survival of these organisms following entrainment is an important step in assessing potential effects of power plant operation on the aquatic environment.

Studies to examine survival of ichthyoplankton entrained through the condenser cooling water system of the Indian Point plant were conducted from the early 1970s through 1980 and again in 1985. Over the course of these studies, sampling gear was continually improved to remove biases associated with collection procedures, and to minimize stresses associated with sampling (Muessig et al. 1988). The results of entrainment studies at Indian Point have been instrumental in supporting and promoting state-of-the-art developments in entrainment survival sampling and assessment.

Ichthyoplankton of species commonly entrained at Indian Point do survive the entrainment process, particularly when the discharge water temperature remains below lethal levels, generally about 32 C (EA 1982; Kellogg et al. 1984). Under these conditions, which commonly are present during the periods of highest entrainment for many species, mortality is due primarily to stress caused by physical damage during passage through the pumps and condenser tubes. This type of mortality is called mechanical mortality. Additional mortality due to thermal stress (thermal mortality) occurs at temperatures above 33 C.

During the summer and early fall of 1984, dual speed cooling water pumps were installed at the Indian Point Unit 2 Generating Station. The pumps, which have rated capacities of 318 m^3 per minute at low speed and 530 m^3 per minute at high speed, operate with a higher efficiency and lower impeller speed than the old pumps, thus mechanical mortality of ichthyoplankton during passage through the pumps is not expected to increase from previous levels, and in fact may be lower with the new pumps. In 1985, variable speed pumps were installed at Unit 3. The 1988 studies were undertaken to document entrainment survival rates with the newly installed pumps in accordance with the specific objectives listed in Chapter 2.

This report presents the results of the 1988 Entrainment Survival studies conducted at the Indian Point Generating Station. The primary taxa collected were bay anchovy (Anchoa mitchilli), striped bass (Morone saxatilis), and white perch (Morone americana). Entrainment survival was estimated for these taxa when sample size was sufficient. The results of the 1988 studies are also discussed with regard to the significance of organism size on entrainment survival. In addition, potential biases to entrainment survival estimates were evaluated by comparing sampling stress at the intake and discharge samplers.

Supplemental information is contained in the appendixes. Results of quality control sampling is presented in Appendix A. Daily average ichthyoplankton density data is contained in Appendix B. Length frequency data appears in Appendix C. Appendix D summarizes Unit 2 and Unit 3 cooling water flow for the month of June 1988.

2. SUMMARY

Dual-speed circulating water pumps were installed in the Indian Point Generating Station Unit 2 cooling water system in 1984. Variable speed pumps were installed at Unit 3 in 1985. An Entrainment Survival Study was conducted during June 1988 to determine whether the level of mechanically-induced mortality of entrained ichthyoplankton differed from mortality rates observed when the older single-speed pumps were in use. The specific objectives of the study were to:

1. Estimate the initial and extended survival of ichthyoplankton entrained in the Unit 2 and Unit 3 cooling water flow and compare mechanical mortality estimates with those from previous years.

2. Determine whether live and dead ichthyoplankton are randomly dispersed in the Indian Point Generating Station discharge canal at sampling Station D2.

3. Assess whether the thermal and mechanical components of entrainment stress are independent.

Sampling for entrainment survival estimates was conducted with rear-draw flume samplers from 8 June through 30 June. A total of 12,333 ichthyoplankton were captured, 1,132 at the intake station and 11,201 at the discharge. Bay anchovy comprised 67 percent of all ichthyoplankton; striped bass, 26 percent; and white perch, 3 percent. Three flumes were used. One was located at the Unit 3 intake to provide control samples. The other two units were deployed in the discharge canal at Station D2 where simultaneous samples were collected from surface and bottom strata.

Initial entrainment survival was estimated for five taxa/life stage groups: bay anchovy post yolk-sac larvae (0.25 ± 0.05), striped bass yolk-sac larvae (0.72 ± 0.05), striped bass post yolk-sac larvae (0.76 ± 0.02), white perch post yolk-sac larvae (0.45 ± 0.10), and *Alosa* spp. post yolk-sac larvae (0.53 ± 0.13). Results from this study are generally similar to those observed in previous studies.

Surface and bottom discharge survival data were compared for five species/life stage groups: bay anchovy post yolk-sac larvae, striped bass yolk-sac larvae, striped bass post yolk-sac larvae, white perch post yolk-sac larvae, and *Alosa* spp. post yolk-sac larvae. Significant differences between surface and bottom survival were found only for striped bass post yolk-sac larvae (66.1 percent live in surface samples, 70.5 percent live in bottom samples) and white perch post yolk-sac larvae (26.2 percent live in surface samples, 6.2 percent live in bottom samples).

Additional samples for ichthyoplankton dispersion estimates were taken in the plant discharge canal with plankton nets on three dates in June. These samples provided a total of 59,884 specimens for analysis, including striped bass (62 percent), bay anchovy (32 percent), and *Alosa* spp. (3 percent). Analysis of flume and net sample densities by depth indicated that the distribution of both live and dead ichthyoplankton was generally unstratified.

The influence of temperature, salinity, and larval length on survival was tested for four species: bay anchovy, striped bass, white perch, and *Alosa* spp. Length was a highly significant factor in all analyses except for striped bass at the plant intake. The effects of temperature and salinity were significant only for striped bass in discharge samples. A logistic regression model to define the relationship between length and both intake and discharge, survival was developed for these four species which generates predicted survival values which are in good agreement with observed data.

A series of sampling stress evaluation experiments were conducted using hatchery-reared striped bass eggs and larvae. Results indicated that the influence of sampling stress on survival estimates was low. Length dependent survival patterns were also noted in these experiments.

Testing the independence of the thermal and mechanical components of entrainment stress was not possible during this study. Discharge temperature exceeded the level at which significant thermal stress would be expected (33 C) on only one date (28 June 1988).

3. STUDY DESCRIPTION

3.1 SITE DESCRIPTION

3.1.1 The River

The Indian Point Generating Station is located on the east bank of the Hudson River, between Peekskill and Haverstraw bays, near the Town of Buchanan, New York. The plant is 69 river kilometers (43 mi) north of the Battery in New York City (Figure 3-1). In the vicinity of the Indian Point plant, the Hudson River has a surface width of approximately 1,500 m (5,000 ft) and a cross-sectional area of approximately 15,000 m^2 (160,000 ft^2). Within 60 m (200 ft) of the plant, river depths range from about 3 to 12 m (10-40 ft) below mean sea level.

Flow rates in this section of the river are controlled predominantly by the tides. Mean tidal flows are on the order of 7,000 m^3 per second (250,000 cfs), whereas average freshwater flows (at Green Island) typically range from about 160 m^3 per second (5,500 cfs) in August to about 900 m^3 per second (32,000 cfs) in April (TI 1971).

Seasonal trends in salinity are controlled primarily by freshwater flow. The salt front (0.1 ppt salinity) generally remains below Indian Point during the months of March, April, and May when freshwater flows often exceed 600 m^3 per second (20,000 cfs) (TI 1971). During periods of low runoff (generally July-October), the salinity in the vicinity of Indian Point increases and may fluctuate rapidly as a function of freshwater flow and tidal amplitude (TI 1971). These salinity fluctuations determine, to a large extent, the species composition of the ichthyoplankton in the Indian Point vicinity.

Ambient river temperatures in the Indian Point area typically range from 0 to 30 C (32-86 F) over the course of a year (Con Edison 1977, 1984).

3.1.2 The Plant

The Indian Point Generating Station consists of two operational nuclear-fueled, electric generating units. Unit 1, owned by Consolidated Edison Company of New York, Inc. (Con Edison), has not operated since 1974. Unit 2, owned and operated by Con Edison, has been in operation since 28 September 1973, and has a net rated capacity of 873 MWe. Unit 3, owned and operated by the New York Power Authority, has been in operation since 30 August 1976 and has a net capacity of 965 MWe. Both operating units use Hudson River water for once-through cooling.

Each unit has a separate shoreline intake structure for the withdrawal of water from the Hudson River (Figure 3-2). The intakes at Unit 2 are equipped with fixed screens at the entrance to the intake bays and vertical traveling screens located behind the fixed screens; whereas the intake to Unit 3 has only vertical traveling screens at the entrance to the intake bays. At Unit 2, the five southern-most fixed screens are 9.5-mm (0.375-in.) square mesh. The northern-most intake (26) has a Ristroph-type traveling screen with 6.3-mm x 12.6-mm (0.25-in. x 0.5-in.) slotted mesh.

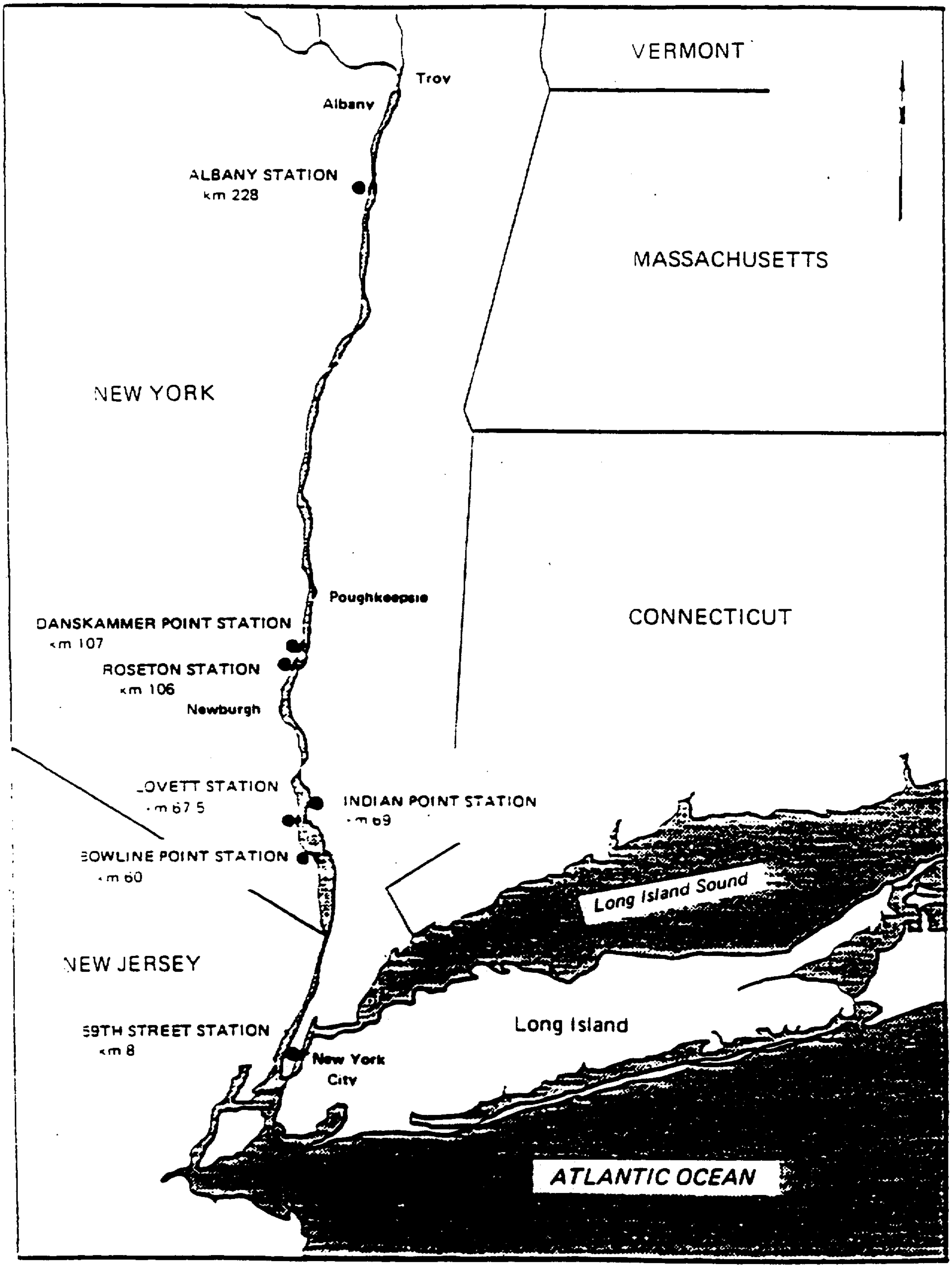

Figure 3-1. Location of the Indian Point Generating Station on the Hudson River estuary.

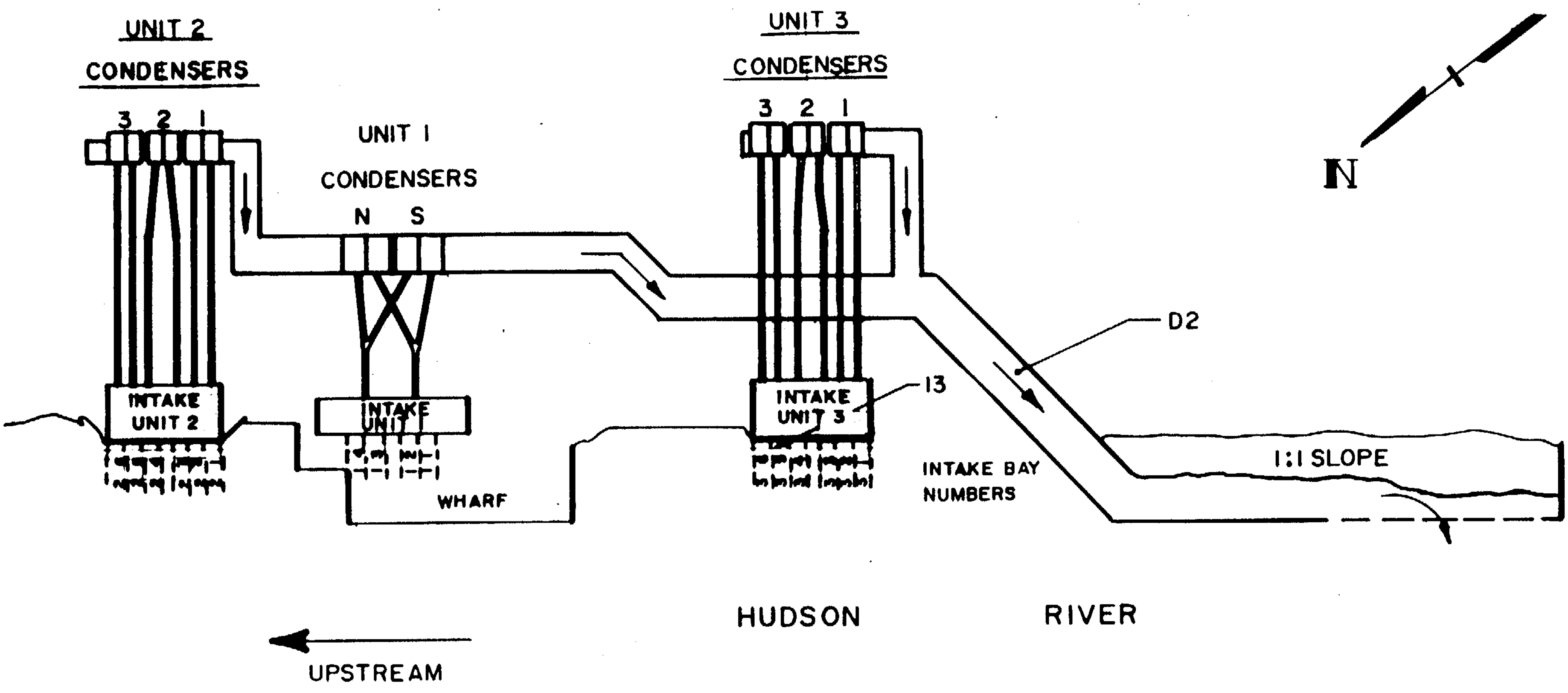

FIGURE 3-2. DIAGRAM OF THE INDIAN POINT GENERATING STATION CIRCULATING WATER SYSTEM SHOWING LOCATION OF SAMPLING STATIONS USED DURING THE 1988 ENTRAINMENT SURVIVAL STUDY.

Six circulating water pumps, each with rated capacity of 530 m^3 per minute (140,000 gpm), are used to pump Hudson River water through the condenser cooling system of each unit. Additionally, each unit has six service water pumps, each capable of pumping at a rated capacity of 5,000 gpm which draws service water through separate intake forebays located at the center of each intake (Figure 3-2), thus providing a total service flow for each unit of 114 m^3 per minute (30,000 gpm). The circulating water systems for Units 2 and 3 are operated so as to minimize the volume of river water drawn into plants consistent with efficient operation of the station in accordance with the Settlement Agreement (Sandler and Schoenhard 1981). Actual flow rates are dependent upon ambient river water temperature, generation load, cooling system efficiency, pump design, and the need to meet water quality standards or other permit requirements. In general, pumps will operate at low speed (approximately 504,000 gpm/unit) from 1 January to 15 May and from 1 November to 31 December. From 9 June to 30 September, pumps will operate at high speed. At other times, a combination of high and low pump flow will be used, dependent upon aforementioned conditions.

The cooling water and service water from both units flow into a common discharge canal. The combined discharge is returned to the Hudson River via an outfall structure located downstream of Unit 3. The outfall structure consists of 12 ports submerged 3.6 m below the surface (12 ft from center of port to water surface) at mean low water.

Calculated transit times of cooling water traveling from intake to river outfall for Units 2 and 3, when operating at full pumping capacity, is 9.7 minutes for Unit 2 and 5.6 minutes for Unit 3 (EA 1980). The calculated transit time from the intake to the condensers is about 1.5 minutes, and the calculated transit time through the condensers is 0.14 minutes for both units. Thus, much of the total transit time through the cooling water systems of Unit 2 and Unit 3 occurs in the discharge canal. Because the discharge canal receives cooling water from both units, transit times through the canal are dependent upon the total circulating water flow through all units combined.

Estimated velocities of the cooling water vary as a function of the cross-sectional area at different locations within the Indian Point plant cooling water system. Estimated flow velocities are lowest at the intakes, 0.84 ft/sec at full flow (NYU 1978). Estimated water velocities in the common discharge canal vary according to the number of circulating water pumps operating at each unit and the cross-sectional area of the discharge canal. At the point of sampling in the common discharge canal (Figure 3-2), estimated maximum average velocity would be 4.55 ft/sec with all pumps operating at 100 percent at both units and 2.17 ft/sec with only Unit 2 pumps operational. At the discharge structure, however, gates to the submerged ports are opened or closed to maintain an estimated velocity of 10.0 ft/sec through the ports, regardless of the number of units operating.

The temperature rise (delta-T) encountered by organisms passing through the condenser cooling systems of the Indian Point plant depends upon the cooling water flow rates and levels of power output (Con Edison 1977, Tables 1-13 and 1-14). At Unit 2, with six pumps operating at full flow and the unit at 100 percent capacity, the predicted condenser temperature rise ranges from 8.8 to 8.9 C (15.8-16.1 F), depending upon river temperature. During full-capacity winter operation, with Unit 2 circulating pumps operating at

60 percent flow capacity, the predicted condenser temperature rise is approximately 14.7 C (26.5 F). At Unit 3, the predicted condenser temperature rise ranges from 9.5 to 9.7 C (17.1-17.4 F) for 100 percent capacity with six pumps operating at full flow. During winter operation, the predicted temperature rise is approximately 16.1 C (29 F). The higher predicted condenser temperature rise for Unit 3, compared to that for Unit 2, results since Unit 3 has a higher generating capacity than Unit 2 but uses the same volume of cooling water.

3.2 MATERIALS AND METHODS

3.2.1 Sampling Locations

The desire to estimate survival rates for the new pumps at Unit 2 and Unit 3 constrained the study to sample the discharge water downstream from the point at which Unit 2 and Unit 3 discharges join. Station D2 was the preferred historical discharge sampling location that would meet this requirement (Figure 3-2).

Entrainment viability sampling was conducted at two locations at Unit 3: Station I3 in front of the intake structure, and Station D2 downstream from the point at which discharge flow from Unit 2 and Unit 3 join (Figure 3-2). At Station I3, sampling was conducted from a raft anchored in front of Intake 35. At Station D2, sampling equipment was deployed from a similar but larger raft moored in the discharge canal downstream from a steel catwalk extending across the canal. Additional sampling was conducted at Station D2 using plankton nets arrayed in a sampling frame accessible from the catwalk across the canal.

3.2.2 Gear Description

Ichthyoplankton for entrainment survival estimates were collected with rear-draw sampling flumes (Figure 3-3) similar to those used in previous studies at Indian Point (EA 1981a, 1982). Each flume and its associated deployment raft, hoisting gear, and water pumping equipment formed a sampling system designed to minimize collection stress on sensitive ichthyoplankton through the control of water flow within the flume and the elimination of pump passage for collected organisms.

Three flumes were used at Indian Point in 1988. At intake Station I3 (Figure 3-4), sampled water was conducted to the inlet of a single flume through a 12-m long, 15-cm inside-diameter flexible tube whose mouth was suspended approximately 1 m from the river bottom in front of intake bay No. 35. Two flumes were used at discharge Station D2. Two 12-m lengths of 15-cm inside-diameter tubing connected to the flume inlets were clamped to the movable net frame, one at the bottom and one approximately 0.75 m from the top of the net frame to provide samples from the bottom and near the surface of the discharge canal (Figure 3-5). Sample flow into the flume was maintained by 10-cm (4-in.) Homelite trash pumps which withdrew water from behind the 500-micron mesh diversion screens through rear-facing slotted stand pipes. Discharge water from each flume was passed through a Sparling Instruments "Masterflo" flowmeter to measure sampling rate and volume. Water was also pumped from behind screened surfaces in each collection box to induce water containing organisms and detritus filtered by the diversion screens to flow

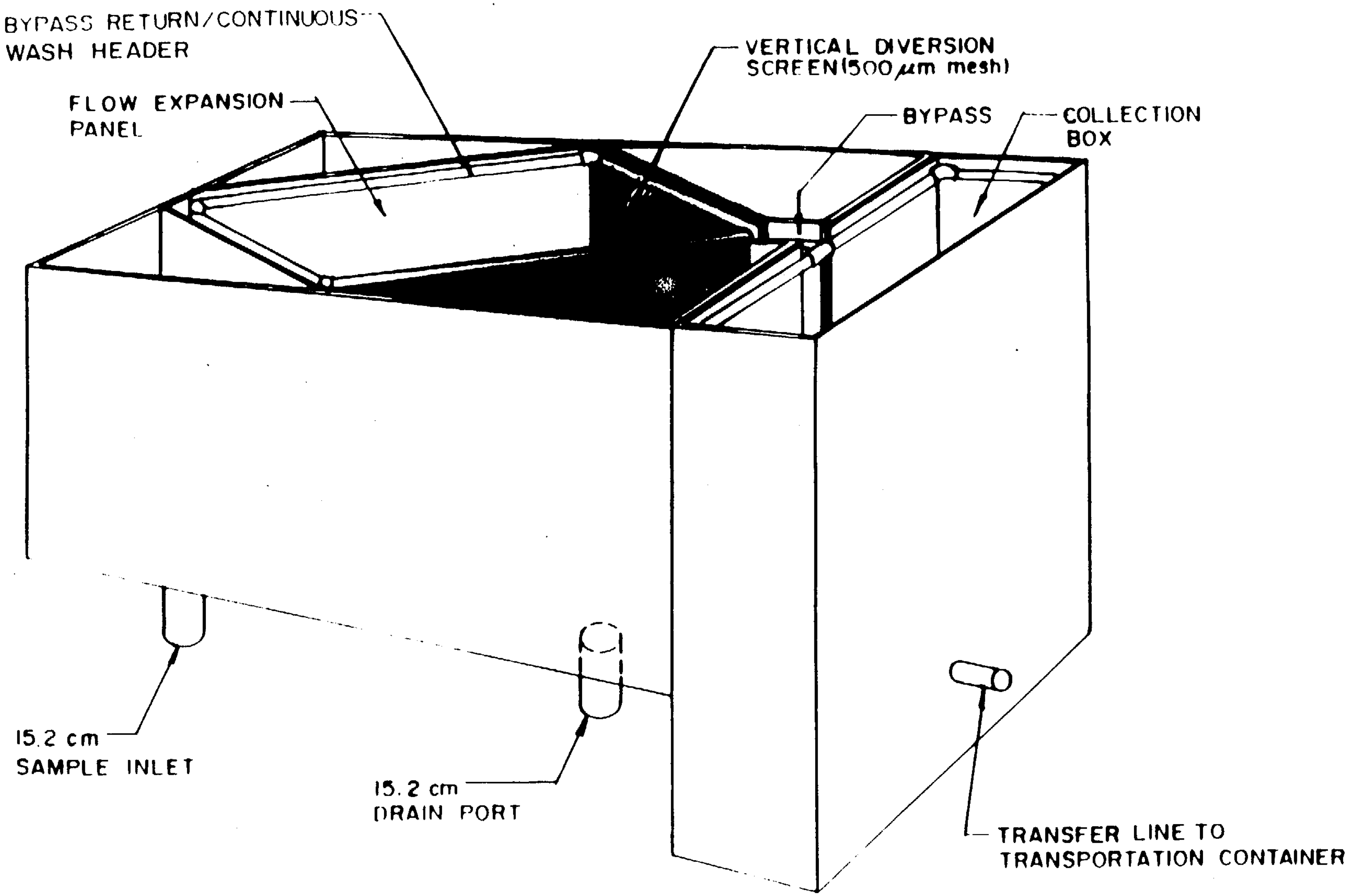

FIGURE 3.3 DESIGN OF THE COLLECTION FLUME USED IN THE PUMPLESS AND REAR-DRAW SAMPLERS DURING THE 1988 ENTRAINMENT SURVIVAL STUDY AT INDIAN POINT GENERATING STATION.

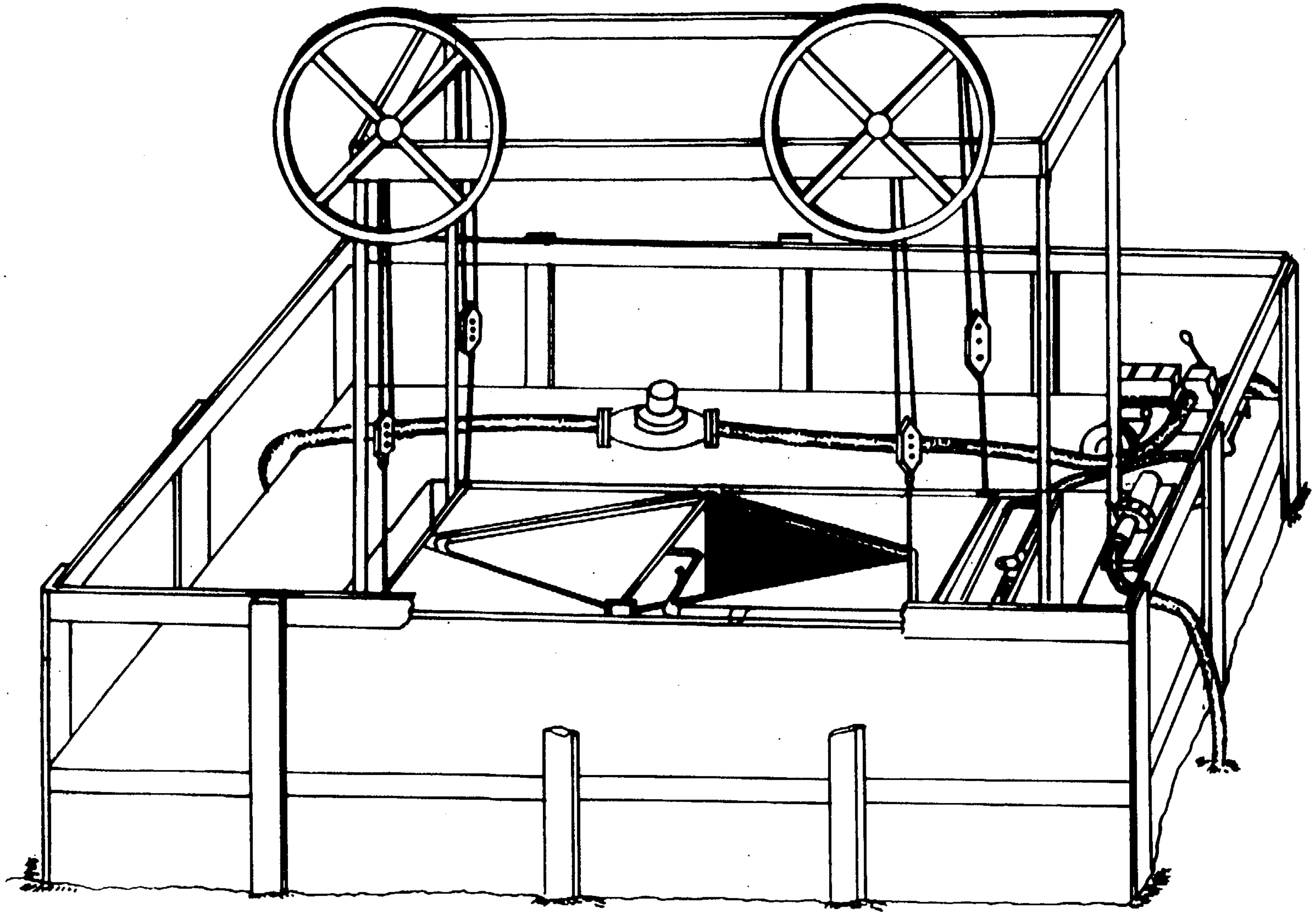

FIGURE 3-4 REAR-DRAW PLANKTON SAMPLING FLUME SYSTEM USED AT THE UNIT 3 INTAKE (STATION I3) DURING THE ENTRAINMENT SURVIVAL STUDY, INDIAN POINT GENERATING STATION, 1988.

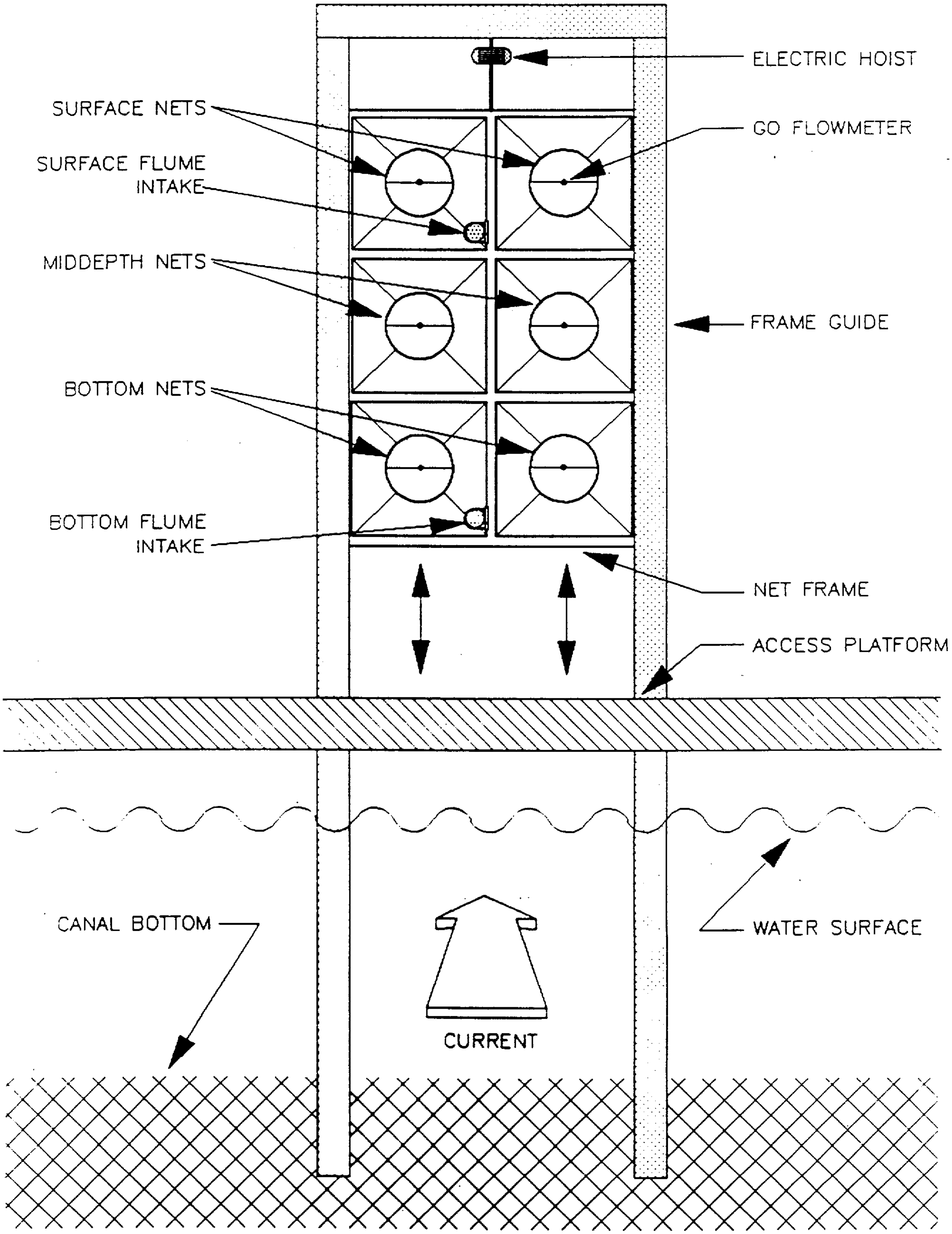

Figure 3-5. Schematic view of net-frame and flume intake assembly at Station D2 (Indian Point discharge canal).

Water removed from the collection box was reintroduced into the flume through a spray manifold system which provided continuous washing of vertical surfaces while producing no net bias on sampling volume.

Study objectives also required the collection of entrainment abundance samples to test for the randomness of ichthyoplankton dispersion in the discharge canal. These samples were taken with a 2 x 3 array of 500-micron mesh plankton nets. The 0.5 m (mouth diameter) by 2 m (length) nets were installed in the movable net frame at Station D2 (Figure 3-5). An individually calibrated General Oceanics Model 2030R flowmeter was fitted in the mouth of each net to provide sample volume estimates.

3.2.3 Sampling Methodology

3.2.3.1 Entrainment Survival Sampling

The study was designed to sample 180 m^3 per day with each flume system (one at intake Station I3, two at discharge Station D2) on 3 days each week from 23 May through 30 June. The specific daily volume targets and number of sampling days (18) were meant to ensure that sufficient numbers of organisms (primarily eggs, yolk-sac larvae, and post yolk-sac larvae) would be collected to meet study objectives. For a variety of reasons, including delays experienced in obtaining, outfitting, and deploying the sampling equipment, sampling began on 8 June. Sampling was conducted on 13 days through 30 June. Although volume specifications (approximately 18 m^3/sample) for individual 15-minute samples were generally met, the time necessary to process frequently large catches in the onsite laboratory prevented the collection of the required numbers (10) of samples on most days. Average daily sample volume of the intake was 143.3 m^3; at the discharge, the average daily combined volume sampled with both flumes was 271.2 m^3. The sampling program was conducted during afternoon and evening hours (1300-2300).

Identical sample collection procedures were followed at both intake and discharge stations. The flumes were prepared for sampling by lowering them into the water with the sample inlets plugged and allowing them to fill through drain ports located behind the diversion screens. After the flumes were locked in place in the lowered position, both the Homelite sampling pumps and the bypass/screenwash pumps were started. The Homelite pumps were adjusted to yield a pumping rate of 1,250 liters/minute. The bypass pumps were throttled to produce a bypass flow of 150 liters/minute. Sampling was initiated simultaneously at all stations by removing the sample inlet plugs and inserting plugs in the drain ports behind the diversion screens.

At the end of the sampling interval, the Homelite pumps were shut down. After water in the flumes had risen to the observed presampling level, plugs were installed in the sample inlets and removed from the drain ports behind the diversion screens. The flumes were drained by slowly raising them out of the water. Bypass flow was maintained during the drain period to ensure movement of concentrated sample material into the collection boxes and to provide a continuous gentle rising of all vertical surfaces within the flume.

Rinsing of the horizontal flume surfaces was supplemented with a gentle spray from garden hoses also fed by the bypass pumps. Once the samples were concentrated in the collection boxes, the bypass pumps were stopped. Organisms and detritus were then drained into detachable transportation containers through 3-cm diameter tubing at the bottom of the collection boxes. The samples were transferred to the onsite laboratory for sorting. Between samples, flumes and collection boxes were thoroughly rinsed with a high pressure spraywash to prevent contamination of subsequent samples with residual detritus or organisms still adhered to the interior surfaces of the samplers. Water temperature, salinity, dissolved oxygen, and pH measurements were taken within each flume during every sample and recorded on the appropriate field data sheet.

3.2.3.2 Sampling Stress Evaluations

Survival estimates for ichthyoplankton entrained through the cooling water system of the Indian Point Generating Station are calculated from the proportions of organisms that survive collection at the intake (control) and discharge (experimental) sampling stations. A critical assumption is that mortality due to sampling stress is identical for the intake and discharge collection systems (Boreman and Goodyear 1981). This portion of the study was designed to examine that assumption by estimating the survival of organisms collected in the flumes used at the Unit 3 intake (Station I3) and discharge (Station D2) during the 1988 Entrainment Survival Study. Hatchery-reared striped bass were used in these experiments to allow greater control of factors which might affect susceptibility to sampling stress (e.g., organism age and size) and to increase the sample size available for statistical purposes. Results are assumed to be applicable to other taxa. The study design specified five sets of experiments, one with each of four life stages: eggs, yolk-sac larvae, early post yolk-sac larvae, and late post yolk-sac larvae. As a result of rearing difficulties experienced at the hatchery, availability of striped bass was limited. Three of the five intended sets of experiments were completed, using eggs, yolk-sac larvae, and late post yolk-sac larvae.

Striped bass used in sampling stress evaluation tests were obtained from the EA hatchery facility in Verplanck, New York and transported to Indian Point in 19-liter plastic pails. Since the hatchery process water was composed of nearly 100 percent Hudson River water during the period when fish were taken, only temperature acclimation was required once the fish arrived at the plant. The transport pails were aerated and immersed in the ambient water holding trough in the onsite laboratory, where they remained until the water in the pails was within 0.5 C of the ambient water bath. Each experiment was conducted by releasing approximately 100 striped bass into each flume and collecting them after a 15- and 30- or 60-minute sampling period.

Gear operating procedures during the collection system stress evaluation tests were the same as those for entrainment survival sampling except that organisms were introduced into the flumes from 0.5-liter jars at the beginning of the sample. The open jars containing the larvae were submerged at the inlet end of the flumes, inverted, and slowly removed to facilitate the gentle introduction of fish into the samplers. After retrieving the test organisms from the flumes, the number of recovered live and dead striped bass was determined to assess initial survival. All striped bass ichthyoplankton recovered alive were maintained at the onsite laboratory for up to 24 hours (96 hours for eggs) to assess extended survival.

Control samples were taken with each set of tests to assess the effects of handling and increased water temperatures in the discharge canal. At the beginning of each stress evaluation test, approximately 300 striped bass were placed in transportation containers (100 per container) filled with ambient temperature river water (Station I3 handling control, and Station D2 handling control), and discharge water at the discharge station (Station D2 thermal control). Control organisms remained in these containers during the 15-minute test period and the period of flume drainage. They were then transported with the fish recovered from the samplers to the onsite laboratory at the end of the calibration test. Approximately 100 additional striped bass were placed directly in appropriate holding containers filled with ambient water (hatchery control) to assess the general health of each batch of hatchery-reared larvae, the effects of transportation from the hatchery to the Indian Point site, and the effects of minimal handling. Survival of control organisms was determined immediately after testing and was monitored for up to 24 hours (96 hours for eggs) in the same manner as for organisms exposed to sampling stress.

3.2.3.3 Direct Release Studies

Both live and dead dyed striped bass were released at the Indian Point Unit 2 and Unit 3 intakes as part of a study to provide entrainment information supplemental to that gained from the entrainment survival sampling conducted for wild organisms. The study had three objectives: (1) to provide increased sample size for estimating entrainment survival through the release of large numbers of live organisms at the plant intake, (2) to test for differences in striped bass survival at high and low cooling water pump operating speeds, and (3) to investigate potential differences in the spatial distribution of live and dead organisms in the cooling water discharge flow.

The experimental design developed to address the study objectives required releases of test organisms within the intake bay of a circulating water pump operating at high (530 m^3/min) and low (318 m^3/min) speed at Unit 2 and Unit 3 coupled with a recovery sampling effort at discharge Station D2 with flumes and plankton nets described in Section 3.2.2. Four sets of release experiments (Unit 2 high and low speed, Unit 3 high and low speed) were to have been conducted at approximately weekly intervals with the striped bass life stage dominant in wild collections at the time. Operational considerations at Unit 3 prevented the low speed operation of a cooling water pump for these tests. Limited availability of test organisms further restricted the number of release events. In all, three sets of release experiments were performed as shown in Table 3-1.

Striped bass obtained from the EA hatchery in Verplanck, New York were used for both direct release experiments and sampling stress evaluations as described in Section 3.2.3.2. Dead post yolk-sac larvae for direct release were a product of incidental mortality occurring in the hatchery. These fish were fixed in 5 percent formalin and stained deep pink with rose bengal. Prior to use, the stained fish were thoroughly rinsed with fresh water to prevent formaldehyde contamination of the release apparatus.

TABLE 3-1 SUMMARY OF DIRECT RELEASE EXPERIMENTS CONDUCTED AT INDIAN POINT, JUNE 1988

Release Event	Release Location	Pump Speed	Striped Bass Life Stage	Number Released
1	Unit 2, Bay 22	High	Live eggs	260,000
	Unit 2, Bay 22	Low	Live eggs	260,000
	Unit 3, Bay 35	High	Live eggs	253,000
2	Unit 2, Bay 22	High	Live YSL	225,000
			Dead, dyed PYSL	24,000
	Unit 2, Bay 22	Low	Live YSL	225,000
			Dead, dyed PYSL	24,000
	Unit 3, Bay 35	High	Live PYSL	266,000
			Dead, dyed PYSL	39,700
3	Unit 3, Bay 35	High	Dead, dyed PYSL	53,600

Test organisms were released at the plant intakes approximately 3 m below the river surface by gently flushing them out of a holding vessel with river water through a 4-cm ID plastic tube. The release location at Unit 2 was in front of pump bay 22 where the end of the release tube was brought into contact with the fixed screen at the bay entrance before fish transfer began. At Unit 3, the release tube was passed between the trash bars protecting intake bay No. 35. In all experiments where both live and preserved fish were used, live fish were released first to prevent mortality produced by any residual formaldehyde.

Sampling began at discharge Station D2 immediately after the fish release was completed and continued for 15 minutes. Standard sampling procedures were followed as described in Section 3.2.3. Sample processing procedures are described in Section 3.2.4.

Subsampling techniques were used to estimate the number of fish in each release lot. Volumetric methods were used for live organisms while dead fish were enumerated on a drained weight basis.

3.2.4 Sample Processing

3.2.4.1 Flume Samples

Live and dead ichthyoplankton were sorted from the transportation containers immediately after sample collection and then processed. Ichthyoplankton were classified as live, stunned, or dead, according to the following criteria:

Live: Fish swim vigorously, no orientation difficulty. Eggs are translucent with complete chorion, no cloudiness in any internal portion.

Stunned: Fish swim abnormally, struggle, swim on side or upside down, or are non-motile except when gently probed (eggs - not applicable).

Dead: Fish show no vital signs, i.e., no body or opercular movement, and/or no response to gentle probing. Eggs are opaque with chorion ruptured or cloudy in any internal portion.

Dead ichthyoplankton were removed from the sample and preserved in a 5 percent solution of buffered formalin. Live and stunned larvae were transferred with spoons from sorting trays to separate holding jars of filtered ambient river water. A maximum of five specimens were placed in each holding jar, and young larvae were separated from older larvae and juveniles to reduce risks of cannibalism. Holding jars were aerated and maintained in an ambient temperature water bath (up to 24 hours for larvae, 96 hours for eggs). Live eggs were transferred to small holding cups constructed with mesh bottoms to allow continuous water circulation, and held on a grid in the ambient water bath. Invertebrates and residual detritus from all samples were preserved in 10 percent buffered formalin. Preserved residual sample material and initial dead specimens were transported to EA's laboratory for resorting, identification, and classification according to taxon and life stage. The total length of each preserved specimen was determined to the nearest 0.1 mm.

The survival of live and stunned ichthyoplankton was monitored for 24 hours (larvae) and 96 hours (eggs) after collection. Latent effects checks were made 6, 12, and 24 hours after collection (based on start of sample collection time). At each check interval, dead organisms were removed from the holding jars and preserved in vials containing 5 percent buffered formalin. All organisms alive at the last check interval (24 or 96 hours) were enumerated and preserved.

3.2.4.2 Net Samples

Samples collected with plankton nets at Station D2 during direct release events were preserved with 10 percent formalin in the field and transported to EA's laboratory for processing. In the lab, all ichthyoplankton were removed from each sample, identified to species and life stage, and counted. In addition, up to 25 individuals selected at random from each species/life stage combination in a sample were measured to the nearest 0.1 mm.

3.2.5 Data Analysis Procedures

Initial survival proportions of larval and juvenile life stages collected at intake and discharge stations were calculated as the ratio of fish found alive and stunned immediately following collection to the total number of fish collected:

$$P_I \text{ or } P_D = \frac{\text{No. of live and stunned fish}}{\text{Total no. of fish collected}}$$

where

P_I = proportion surviving at the intake station
P_D = proportion surviving at the discharge station.

Stunned fish were grouped with live fish in the analysis of initial survival proportions to avoid potential bias associated with the subjective stunned category. If fish classified as stunned have reduced viability, the extended survival proportions would reflect it appropriately.

Extended survival (24-hour) rates of larval and juvenile life stages collected at intake and discharge stations were compared to determine if mortality caused by entrainment was manifested beyond the initial survival observation. For these comparisons, survival at each extended survival observation was calculated as follows:

$$P_{Ii} \text{ or } P_{Di} = \frac{\text{No. of fish alive at time i}}{\text{Total no. of fish collected}}$$

where

P_{Ii} = survival proportion at time i for fish collected at the intake
P_{Di} = survival proportion at time i for fish collected at the discharge.

This method of calculation of extended survival proportions differs from the normalized extended survival proportions used in previous studies (EA 1982). The advantage of the present method is that extended survival proportions reflect total mortality, thus differences between gear or station are more easily discerned.

Entrainment survival estimates were based on the ratio of survival proportions at the intake and discharge stations. Entrainment survival estimates were calculated according to the following assumptions: (1) all organisms, live and dead, are randomly sampled at both stations; (2) survival at the intake station is the conditional probability of surviving sampling; (3) survival at the discharge station is the product of the conditional probabilities of surviving entrainment and sampling; (4) there is no interaction between the two stresses; and (5) each life stage consists of a homogeneous population in which all organisms have the same probability of surviving to the next life stage. Entrainment survival was estimated by a formula developed by Abbott (1925):

$$S_e = \frac{P_D}{P_I}$$

where

S_e = entrainment survival
P_D = survival proportion at the discharge station
P_I = survival proportion at the intake station.

Calculation of the entrainment survival estimate was restricted to species and life stages whose sample sizes at intake and discharge stations were sufficient to provide a 95 percent confidence interval narrower than 1.0. According to Vaughan and Kumar (1982) confidence interval width can be determined as:

$$L = 2 \cdot 1.96 \cdot [(1/P_I)\sqrt{P_D(1-P_D)/N_D + (P_D/P_I)^2 \; P_I(1-P_I)/N_I}]$$

where

L = width of the 95 percent confidence interval
N_I = number of organisms in the intake sample
N_D = number of organisms in the discharge sample.

Statistical tests were calculated by standard methodology referenced in the results (Chapter 4).

3.2.6 Quality Assurance and Quality Control

The Quality Assurance and Quality Control (QA/QC) Program for the study was stringently designed to ensure that all aspects of the study would be of high quality. The specific tasks covered by the QA/QC Program, and the QA/QC measures are as follows:

a. Sample Collection and Processing - Adhere to specified standard operating procedures which are to be documented by unannounced audits conducted during the field and lab portion of the study.

b. Sampling Stress Evaluation - Conduct a set of controlled experiments designed to measure sampling stress in order to assure comparability between samplers. Evaluate test results within 48 hours and take remedial action if necessary.

c. Field Sorting for Live Ichthyoplankton - Completely reanalyze all flume samples--all samples will be sorted by another qualified individual other than the original sorter.

d. Laboratory Sorting for Dead Ichthyoplankton - Perform a 100 percent reanalysis of flume samples; a 5 percent AOQL plan for net samples.

e. Identification of Ichthyoplankton - Perform a 5 percent AOQL plan for identification of ichthyoplankton in all samples.

f. Data Recording in Field and Laboratory - Perform a 100 percent examination of data sheets prior to data entry.

g. Data Entry - Double keypunch all data. Perform a 100 percent comparison of data files with field data sheets. Use error-checking software to identify outliers.

h. Data Calculations and Data Tables - Test run all computer programs used to generate data tables and create calculated values to ensure inclusion of proper variables and accuracy of formulas.

i. Instrument Calibration - Inline flowmeters--test by manufacturer prior to sampling to assure ± 2 percent accuracy. Net flowmeters--flume test all meters prior to use. Use regression analysis of individual meter's calibration results to calculate sample volumes. Water quality meters--calibrate daily in the field against appropriate standards. Maintain backup equipment onsite.

j. Training - Provide SOP training and hands-on practice with equipment. Use experienced staff in key positions.

k. Performance Audits - Provide job site audits of SOP compliance by senior staff members.

4. RESULTS AND DISCUSSION

4.1 GENERAL STUDY CONDITIONS AND SPECIES ABUNDANCE

Sampling with rear-draw flumes was initiated on 8 June 1988 at intake (I3) and discharge (D2) stations. Daily sample volumes at the intake ranged from 41.7 to 188.0 m^3 with a mean of 143.3 m^3. At the discharge, the range was from 71.7 to 378.0 with a mean of 274.2 m^3 (Figure 4-1). Deviations from the daily sample volumes specified in the study design (180 and 360 m^3 per day at the intake and discharge, respectively) occurred primarily as a consequence of the time required to process frequently large catches which reduced the number of sample runs which could be completed within a day.

Measurements of water temperature, salinity, dissolved oxygen, and pH were taken during each flume sample at the intake and discharge. During the period 8 June through 30 June 1988, the daily average sample temperature at the intake ranged from 20.3 C to 23.8 C, displaying a very gradual warming trend throughout the month (Figure 4-2).

Average daily salinity was very similar between intake and discharge stations. Minimum average salinity, 0.3 ppt, was observed on 9 June 1988. Thereafter, average salinity increased steadily, with a sharp rise at the end of the month to a maximum of 4.1 ppt on 30 June 1988 (Figure 4-2).

Daily average dissolved oxygen ranged between 7.5 and 9.0 ppm at the intake and between 6.8 and 8.9 ppm at the discharge, displaying a general downward trend with time consistent with the gradually rising temperature. Dissolved oxygen was generally higher at the intake than at the discharge, a function of the lower temperature there (Figure 4-3).

The mean pH was generally similar at intake and discharge stations, ranging between 6.8 and 8.0 during the study period (Figure 4-3). The reason for the extreme range observed at the intake on 21 June 1988 and the group of low mean values seen on 28-30 June 1988 is unknown.

Total residual chlorine (TRC) was not monitored as part of the entrainment survival studies. Continuous chlorination of Unit 2 service water was performed during the study period, but dilution of the service water by cooling water flow from Unit 2 and Unit 3 was expected to reduce TRC to below detectable levels. There were several events of service water or cooling water chlorination at Unit 3 which occurred on days when survival sampling was conducted (Table 4-1). Sampling and chlorination overlapped on one date (22 June 1988). During the overlap, four samples were collected at discharge Station D2. Although the peak TRC level observed (0.20 ppm) during this event could be expected to produce some mortality in striped bass and other species (Morgan and Prince 1977), the effect on overall estimates of entrainment survival would be insignificant because of the small number of samples involved.

Flume samples collected during June 1988 produced 12,333 ichthyoplankton specimens, 1,132 at the intake station and 11,201 at the discharge (Table 4-2). Bay anchovy post yolk-sac larvae were the most common taxon in the samples, comprising 59.8 percent of all ichthyoplankton. Striped bass post yolk-sac larvae were the second most common at 21.7 percent, followed by bay anchovy

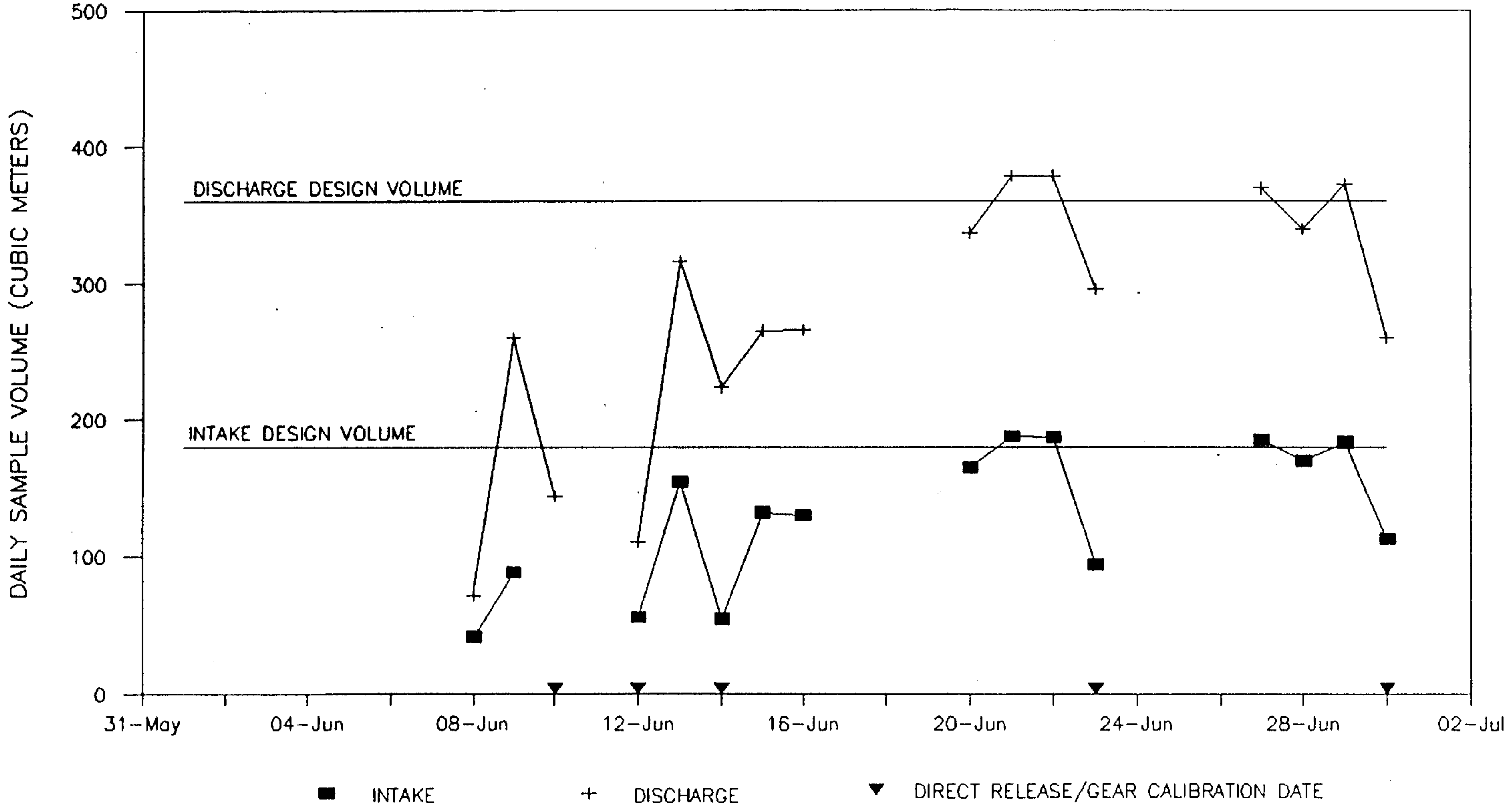

Figure 4-1. Daily volume sampled with rear-draw flumes at intake and discharge stations during entrainment survival studies at Indian Point Generating Station, 1988.

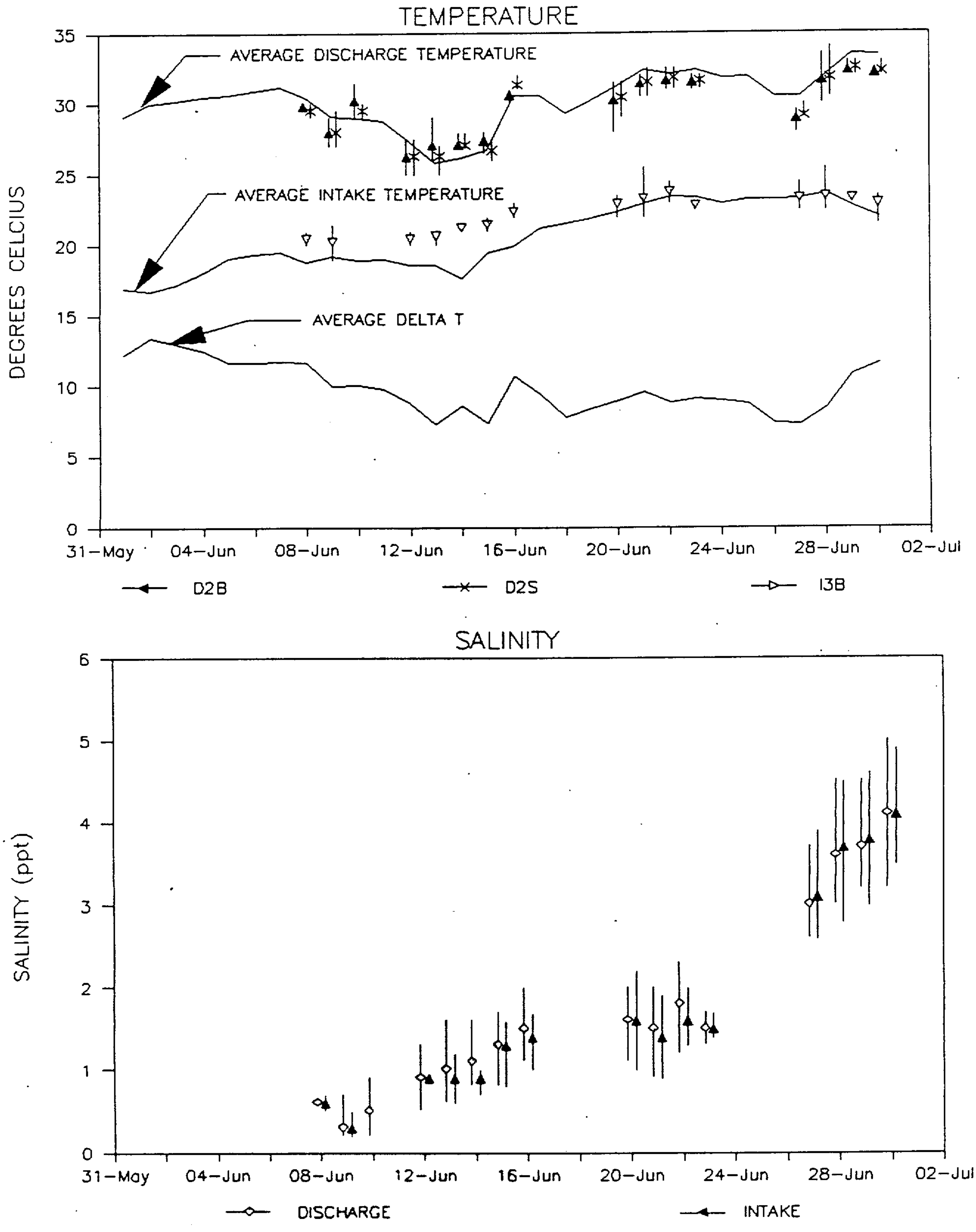

Figure 4-2. Minimum, maximum, and mean temperature and salinity in flume samples during entrainment survival studies at Indian Point Generating Station, 1988.

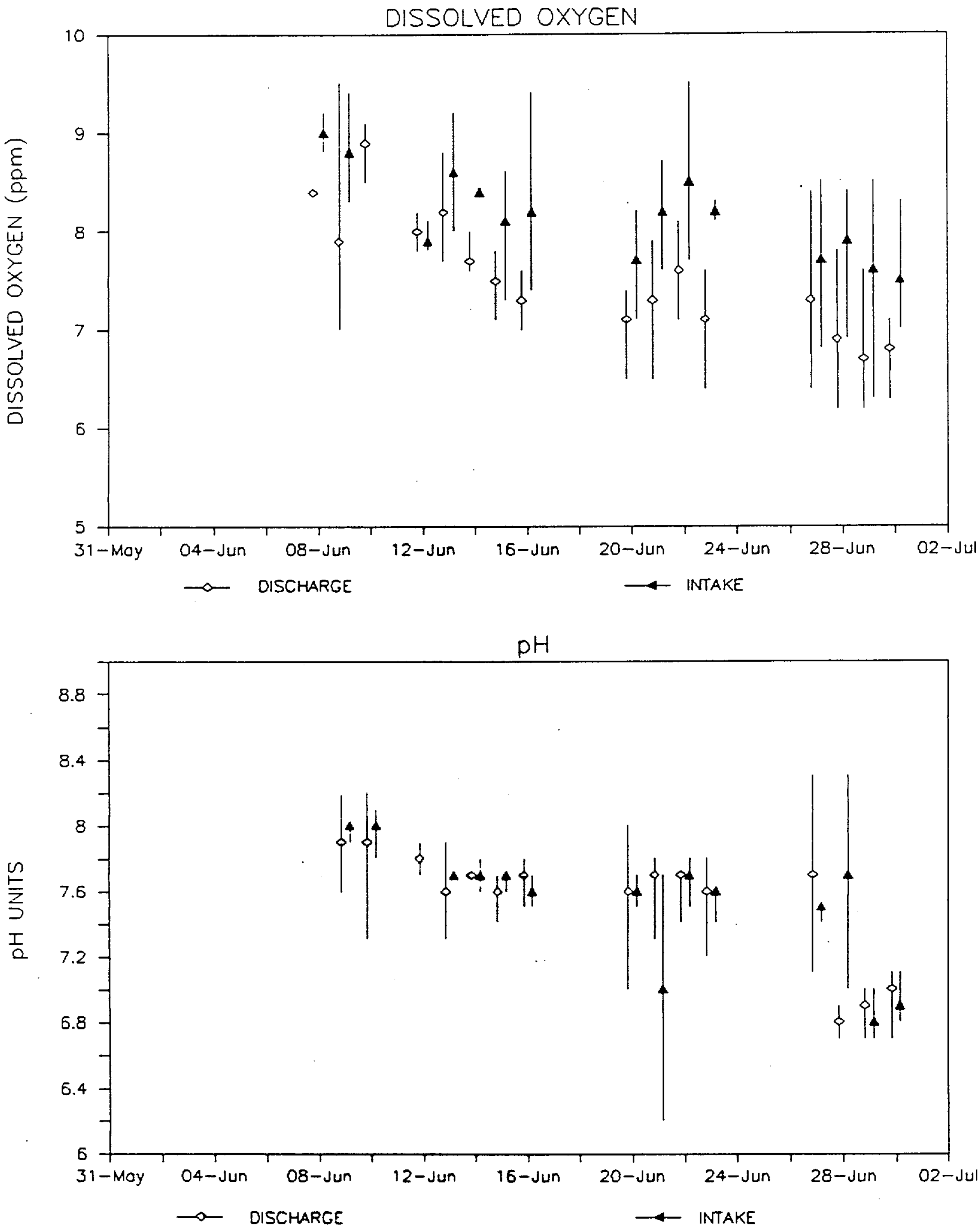

Figure 4-3. Minimum, maximum, and mean dissolved oxygen and pH in flume samples during entrainment survival studies at Indian Point Generating Station, 1988.

TABLE 4-1 SUMMARY OF UNIT 3 SERVICE WATER AND COOLING WATER CHLORINATION AT INDIAN POINT GENERATING STATION, JUNE 1988

Date	Time	Peak TRC at Discharge Station D2*
07 JUN**	1000-1105	0.016
08 JUN**	1020-1120	0.067
10 JUN**	1340-1440	0.057
22 JUN	1035-1127	0.10
22 JUN	1235-1353	0.20
23 JUN	0842-0933	0.06
23 JUN	0934-1023	0.07

* Data from NYPA monitoring records.
** Service water chlorination only.

TABLE 4-2 NUMBER AND PERCENT COMPOSITION OF ICHTHYOPLANKTON COLLECTED DURING ENTRAINMENT SURVIVAL STUDIES AT INDIAN POINT GENERATING STATION, 1988 (DISCHARGE AND INTAKE SAMPLES)

Taxon	Egg Number Collected	Egg % of Taxon	Yolk-Sac Larvae Number Collected	Yolk-Sac Larvae % of Taxon	Post Yolk-Sac Larvae Number Collected	Post Yolk-Sac Larvae % of Taxon	Juvenile Number Collected	Juvenile % of Taxon	Unidentifed Number Collected	Unidentifed % of Taxon	Total Number Collected	Total % of Total
Discharge Flume Samples												
Dyed striped bass	---	---	---	---	32	100.00	---	---	---	---	32	0.29
Bay anchovy	191	2.52	462	6.09	6,929	91.38	1	0.01	---	---	7,583	67.70
Hogchoker	---	---	6	20.00	24	80.00	---	---	---	---	30	0.27
Tessellated darter	---	---	---	---	4	100.00	---	---	---	---	4	0.04
Rainbow smelt	---	---	---	---	15	39.47	23	60.53	---	---	38	0.34
Striped bass	151	5.26	312	10.88	2,398	83.61	7	0.24	---	---	2,868	25.60
White perch	4	1.09	23	6.25	341	92.66	---	---	---	---	368	3.29
Alosa spp.	---	---	---	---	195	100.00	---	---	---	---	195	1.74
Cyprinid spp.	1	20.00	3	60.00	1	20.00	---	---	---	---	5	0.04
Morone spp.	---	---	---	---	18	56.25	---	---	14	43.75	32	0.29
Gobiid spp.	---	---	---	---	37	100.00	---	---	---	---	37	0.33
Mutilated	---	---	---	---	3	33.33	---	---	6	66.67	9	0.08
Total	347	3.10	806	7.20	9,997	89.25	31	0.28	20	0.18	11,201	100.00
Intake Flume Samples												
Bay anchovy	55	7.99	192	27.91	441	64.10	---	---	---	---	688	60.78
Hogchoker	---	---	10	58.82	7	41.18	---	---	---	---	17	1.50
Rainbow smelt	---	---	---	---	---	---	2	100.00	---	---	2	0.18
Striped bass	3	0.84	80	22.47	273	76.69	---	---	---	---	356	31.45
White perch	---	---	2	5.00	38	95.00	---	---	---	---	40	3.53
Northern pipefish	---	---	---	---	---	---	1	100.00	---	---	1	0.09
Alosa spp.	---	---	---	---	11	100.00	---	---	---	---	11	0.97
Morone spp.	---	---	---	---	11	100.00	---	---	---	---	11	0.97
Gobiid spp.	---	---	---	---	2	100.00	---	---	---	---	2	0.18
Unidentified	2	100.00	---	---	---	---	---	---	---	---	2	0.18
Mutilated	---	---	---	---	1	50.00	---	---	1	50.00	2	0.18
Total	60	5.30	284	25.09	784	69.26	3	0.27	1	0.09	1,132	100.00

yolk-sac larvae accounting for 5.3 percent. White perch post yolk-sac larvae and striped bass yolk-sac larvae were nearly equal in abundance, comprising 3.1 and 3.2 percent of the collection, respectively. A total of 10 distinct taxa were collected, but most contributed only a few or single individuals.

Although bay anchovies were the most abundant taxon collected, they were present in large numbers only during the last week of sampling (27-30 June 1988) (Figure 4-4; Appendix Table B-1) when salinity was at its highest value. Post yolk-sac larvae were collected on all but the first three days of sampling. Eggs and yolk-sac larvae were present only at the end of June. Bay anchovy larvae ranged in size from 1.3 to 21.0 mm total length. Most were between 2 and 5 mm. One 26-mm juvenile was collected (Appendix Table C-1).

Striped bass were collected every day that samples were taken (Figure 4-5; Table B-2). The temporal pattern of abundance was similar to that seen in previous years, with peak densities of eggs occurring early, followed by yolk-sac larvae, and later, post yolk-sac larvae. The number of striped bass collected, however, was higher than in any year when similar studies were conducted (EA 1981a, 1982, and 1986). Most of the striped bass in flume collections were between 5 and 9 mm long, although the minimum and maximum lengths were 2.3 and 20.0 mm, respectively (Table C-2).

White perch were also collected on every sampling date, but at a much lower density (Figure 4-6; Table B-3). Compared to post yolk-sac larvae, eggs and yolk-sac larvae were collected in low numbers, while juveniles were entirely absent. Most white perch were between 3 and 5 mm in length (Table C-3).

Herrings, excluding American shad (Alosa spp.), were the only other taxon to contribute more than 1 percent to ichthyoplankton collections. Densities of post yolk-sac larvae, the only life stage recovered, were highest on the first days of sampling and declined rapidly thereafter (Figure 4-7; Table B-4), suggesting that peak river density had occurred prior to the initiation of sampling. This pattern of temporal occurrence is consistent with that observed as part of entrainment abundance studies in prior years (EA 1984, 1985). Approximately 52 percent of herring larvae were between 8 and 12 mm long, with a range in size of 3.4-20 mm (Table C-4).

Net samples taken at Station D2 on three dates in June yielded 59,884 ichthyoplankton specimens. The collections were dominated by striped bass (62 percent) and bay anchovy (32 percent) (Table 4-3). Length frequency data for selected taxa in net samples are presented in Tables C-10 through C-14.

4.2 OVERALL SURVIVAL RATES

4.2.1 Intake Survival

A total of 1,132 individual organisms were collected in intake flume sampling in front of Indian Point Unit 3 during 1988 (Table 4-4). Among the 18 species/life stage groupings collected, initial survival from intake flume samples ranged from 0 to 100 percent. The initial survival was low for those species which are too delicate to survive even the most carefully controlled sampling procedures. For species such as striped bass, which are generally accepted to be tolerant of gentle stresses, intake survival ranged up to 90 percent.

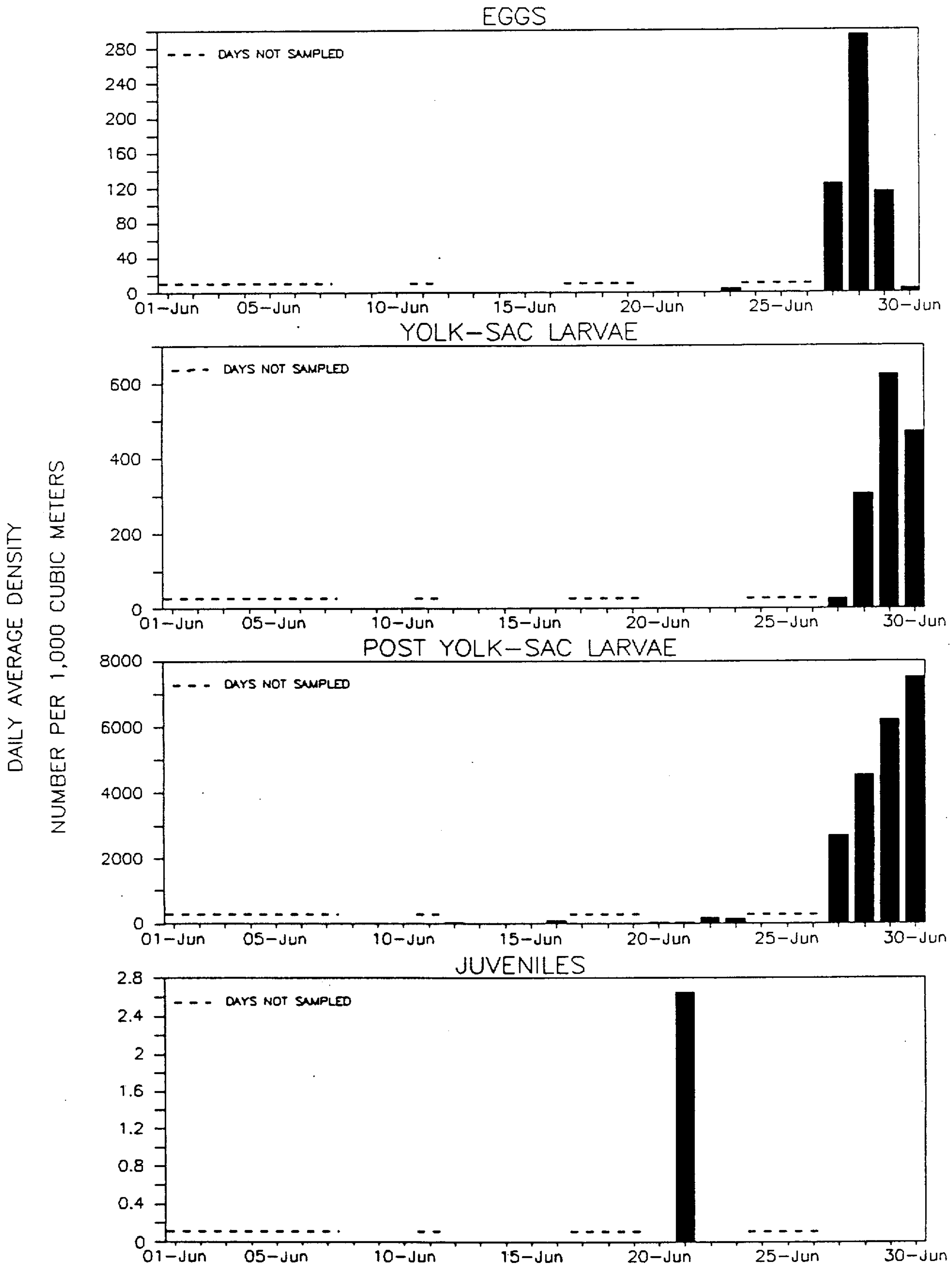

Figure 4-4. Daily average density (no./1,000 cubic meters) of bay anchovies collected in flume samples at discharge Station D2 during entrainment survival studies at Indian Point Generating Station, 1988.

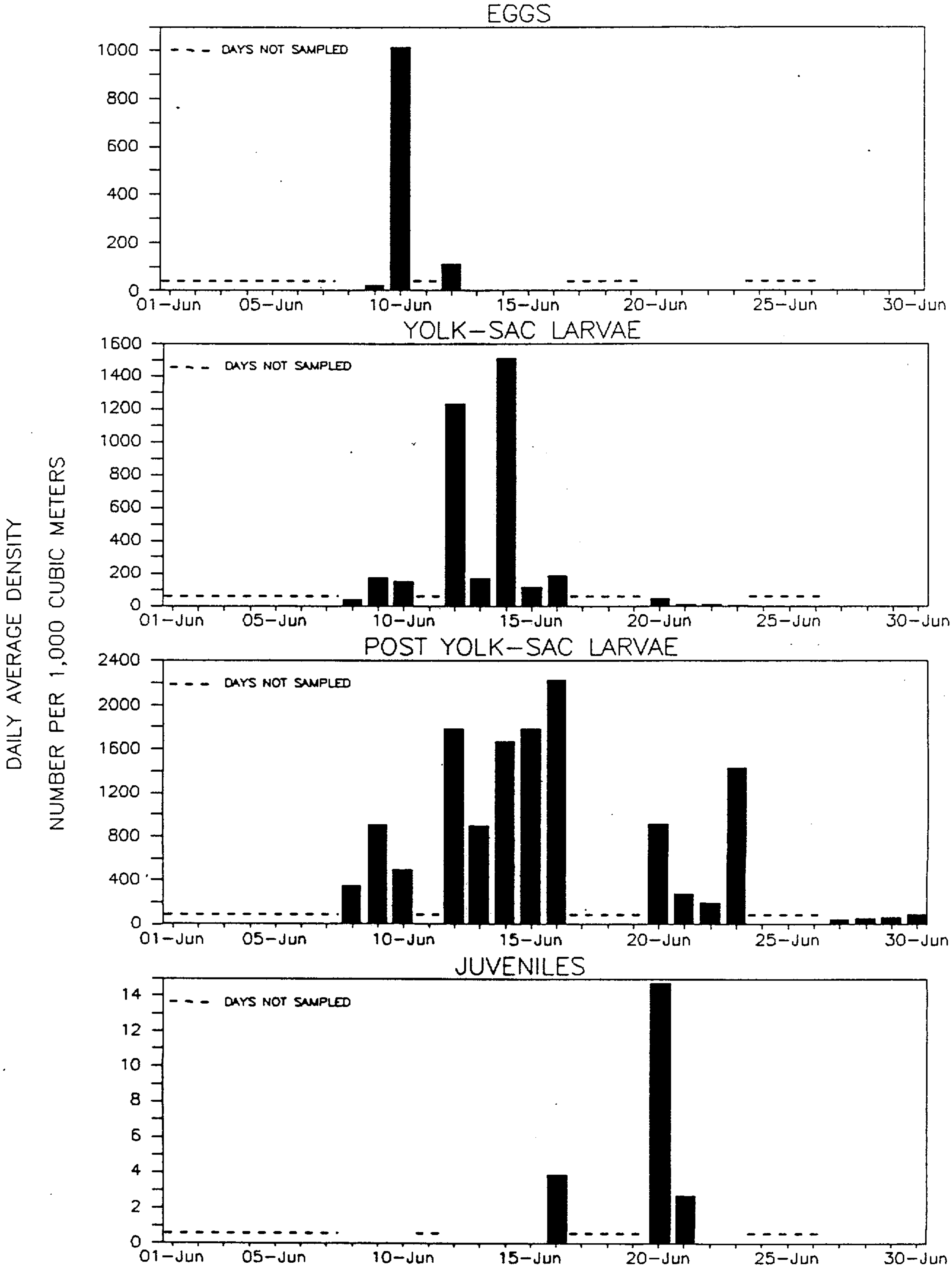

Figure 4-5. Daily average density (no./1,000 cubic meters) of striped bass collected in flume samples at discharge Station D2 during entrainment survival studies at Indian Point Generating Station, 1988.

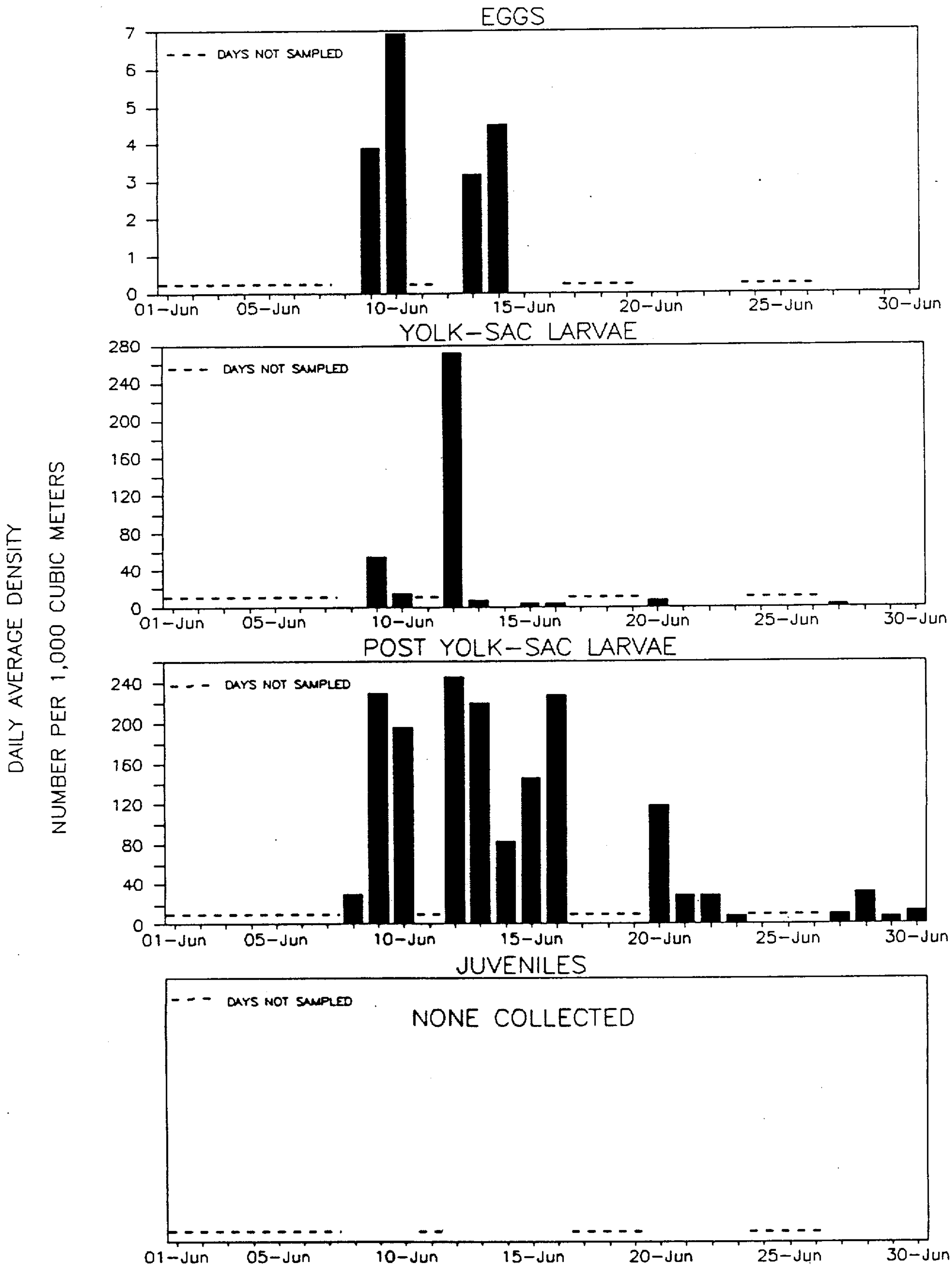

Figure 4-6. Daily average density (no./1,000 cubic meters) of white perch collected in flume samples at discharge Station D2 during entrainment survival studies at Indian Point Generating Station, 1988.

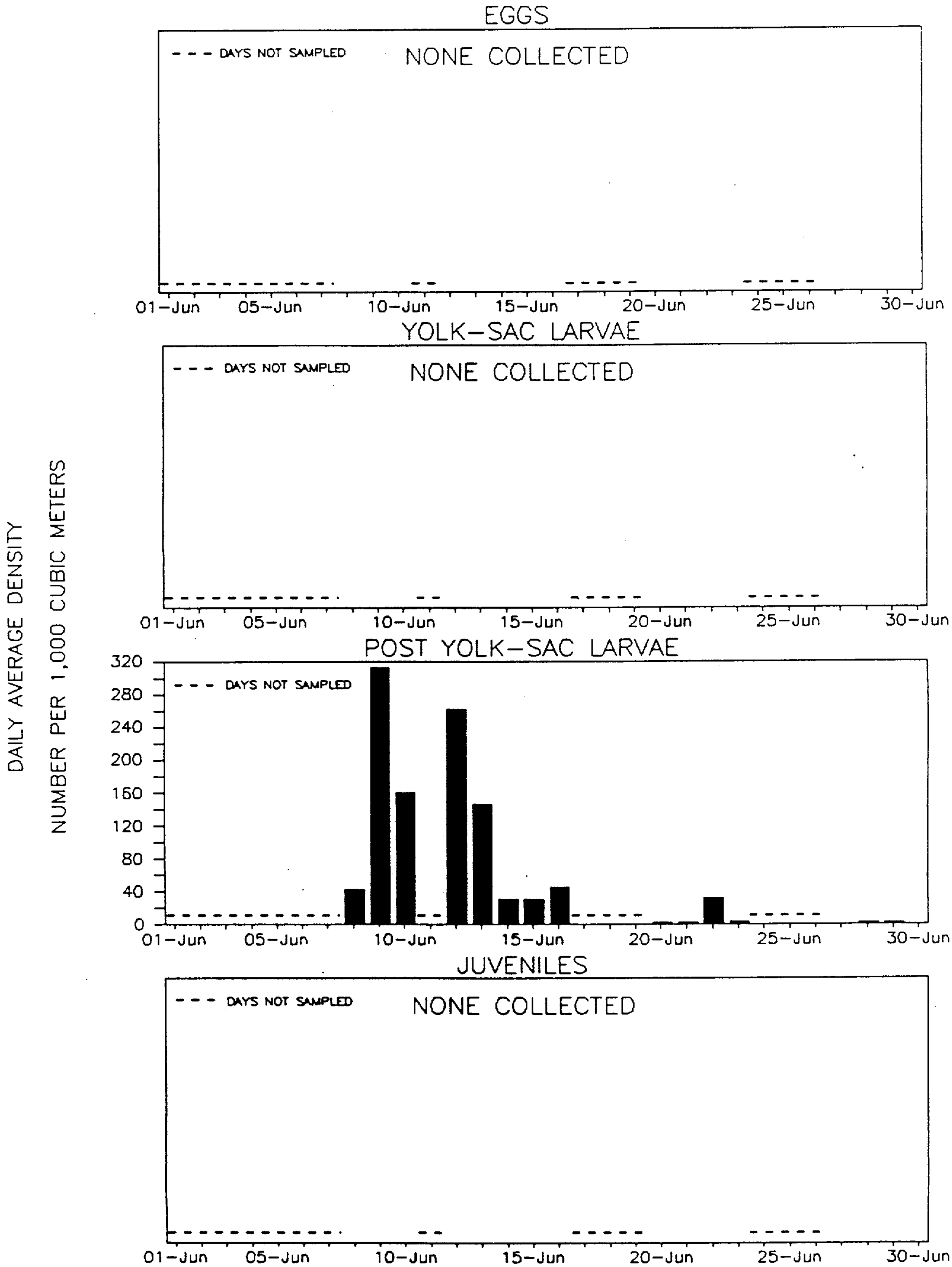

Figure 4-7. Daily average density (no./1,000 cubic meters) of herrings (*Alosa spp.*) collected in flume samples at discharge Station D2 during entrainment survival studies at Indian Point Generating Station, 1988.

TABLE 4-3 NUMBER AND PERCENT COMPOSITION OF ICHTHYOPLANKTON COLLECTED DURING ENTRAINMENT SURVIVAL STUDIES AT INDIAN POINT GENERATING STATION, 1988 (NET SAMPLES)

Net Samples, All Depths

Taxon	Egg		Yolk-Sac Larvae		Post Yolk-Sac Larvae		Juvenile		Unidentifed		Total	
	Number Collected	% of Taxon	Number Collected	% of Taxon	Number Collected	% of Taxon	Number Collected	% of Taxon	Number Collected	% of Taxon	Number Collected	% of Total
Bay anchovy	24	0.13	---	---	19,070	99.87	---	---	---	---	19,094	31.88
American shad	---	---	---	---	5	100.00	---	---	---	---	5	0.01
Brown bullhead	---	---	---	---	---	---	1	100.00	---	---	1	0.00
American eel	---	---	---	---	---	---	1	100.00	---	---	1	0.00
Hogchoker	---	---	1	50.00	1	50.00	---	---	---	---	2	0.00
Tessellated darter	---	---	11	73.33	4	26.67	---	---	---	---	15	0.03
Rainbow smelt	---	---	---	---	82	63.08	48	36.92	---	---	130	0.22
Striped bass	242	0.65	2,594	7.00	34,202	92.34	---	---	---	---	37,038	61.85
White perch	4	0.62	78	12.17	558	87.05	1	0.16	---	---	641	1.07
Alosa spp.	---	---	---	---	2,005	100.00	---	---	---	---	2,005	3.35
Cyprinid spp.	14	41.18	7	20.59	13	38.24	---	---	---	---	34	0.06
Morone spp.	---	---	---	---	216	27.76	---	---	562	72.24	778	1.30
Eastern mudminnow	---	---	---	---	1	100.00	---	---	---	---	1	0.00
Windowpane	---	---	---	---	1	50.00	1	50.00	---	---	2	0.00
Gobiid spp.	---	---	---	---	123	100.00	---	---	---	---	123	0.21
Fundulus spp.	---	---	---	---	1	100.00	---	---	---	---	1	0.00
Menidia spp.	---	---	---	---	2	100.00	---	---	---	---	2	0.00
Unidentified	2	100.00	---	---	---	---	---	---	---	---	2	0.00
Mutilated	---	---	---	---	3	33.33	---	---	6	66.67	9	0.02
Total	286	0.48	2,691	4.49	56,287	93.99	52	0.09	568	0.95	59,884	100.00

TABLE 4-4 INITIAL AND 24-HOUR SURVIVAL PROPORTIONS FOR ICHTHYOPLANKTON IN INTAKE FLUME SAMPLES AT INDIAN POINT GENERATING STATION, 1988

Taxa	Life Stage	Ni	Initial P(i)		Initial S.E.	24-Hour P(i)		24-Hour S.E.
Bay anchovy	Egg	55	0.00	+/-	0.00	0.00	+/-	0.00
	Yolk-sac larvae	192	0.00	+/-	0.00	0.00	+/-	0.00
	Post yolk-sac larvae	441	0.08	+/-	0.01	0.00	+/-	0.00
	Juvenile	0	--	+/-	--	--	+/-	--
Hogchoker	Yolk-sac larvae	10	0.00	+/-	0.00	0.00	+/-	0.00
	Post yolk-sac larvae	7	0.00	+/-	0.00	0.00	+/-	0.00
Tessellated darter	Post yolk-sac larvae	0	--	+/-	--	--	+/-	--
Rainbow smelt	Post yolk-sac larvae	0	--	+/-	--	--	+/-	--
	Juvenile	2	1.00	+/-	0.00	1.00	+/-	0.00
Striped bass	Egg	3	0.00	+/-	0.00	0.00	+/-	0.00
	Yolk-sac larvae	80	0.86	+/-	0.04	0.40	+/-	0.05
	Post yolk-sac larvae	273	0.90	+/-	0.02	0.56	+/-	0.03
	Juvenile	0	--	+/-	--	--	+/-	--
White perch	Egg	0	--	+/-	--	--	+/-	--
	Yolk-sac larvae	2	0.00	+/-	0.00	0.00	+/-	0.00
	Post yolk-sac larvae	38	0.40	+/-	0.08	0.26	+/-	0.07
Northern pipefish	Juvenile	1	1.00	+/-	0.00	1.00	+/-	0.00
Alosa spp.	Post yolk-sac larvae	11	0.64	+/-	0.14	0.18	+/-	0.12
Cyprinid spp.	Egg	0	--	+/-	--	--	+/-	--
	Yolk-sac larvae	0	--	+/-	--	--	+/-	--
	Post yolk-sac larvae	0	--	+/-	--	--	+/-	--
Morone spp.	Post yolk-sac larvae	11	1.00	+/-	0.00	1.00	+/-	0.00
	Unidentified	0	--	+/-	--	--	+/-	--
Gobiid spp.	Post yolk-sac larvae	2	0.50	+/-	0.35	0.50	+/-	0.35
Unidentified	Egg	2	0.00	+/-	0.00	0.00	+/-	0.00
Mutilated	Post yolk-sac larvae	1	0.00	+/-	0.00	0.00	+/-	0.00
	Unidentified	1	1.00	+/-	0.00	0.00	+/-	0.00
Total		1,132						

NOTE: N(i) = Number collected at intake.
P(i) = Survival proportion at the intake.

These results, confirmed by stress tests conducted with hatchery-reared striped bass larvae (Appendix A.2), indicate that the entrainment sampling process in 1988 introduced relatively limited sampling mortality which could potentially bias estimates of through-plant entrainment survival. However, the extent to which the observed intake mortality was due to the sampling process as opposed to natural mortality occurring prior to sampling cannot be determined.

Intake survival 24 hours after collection also ranged from 0 to 100 percent across the species and life stages collected and generally paralleled the pattern of initial survival (Table 4-4). Survival over the 24-hour period from initial evaluation (extended survival) ranged from 0 for the few surviving bay anchovy post yolk-sac larvae to 100 percent for those groups with no initial mortality. With the exception of Alosa spp. post yolk-sac larvae (28 percent extended survival), extended survival for the others was from 47 to 65 percent.

In general, the intake survival rates observed in 1988 were within the range reported for previous studies in 1977-1980 and 1985 (Figure 4-8). Samples in the years prior to 1979 were collected using pumped flumes. During 1979, samples were collected with a combination of rear-draw flumes at the intake and a pumpless flume at the discharge port. During 1980, modified rear-draw flumes were used at the intake; a gear identical to that used in the current study, and a pumpless flume were used at the discharge port. In 1985, barrel samplers were used as a replacement for the rear-draw flumes.

Compared to the year with the most identical sampling program (1980), initial intake survival in 1988 was similar (within 10 percent) for the two larval stages of striped bass and slightly lower for Alosa spp. post yolk-sac larvae although the sample sizes for the latter taxon in both years was quite small (i.e., 9 and 11, respectively). For white perch and bay anchovy post yolk-sac larvae, initial intake survival was considerably lower in the current study than in 1980 although the sample size for white perch in 1988 was much smaller than in 1980. The reasons for the variability in initial intake survival across the years is not known but possibly related to changes in sampling gear and techniques or differences in the natural condition of the organisms prior to being entrained. Factors which could be related to stress tolerance of larvae are evaluated in Section 4.4.

4.2.2 Discharge Survival

A total of 11,169 fish eggs and larvae were collected in the flume sampling in the combined discharge for Indian Point Units 2 and 3 (Table 4-5). Among the 26 species/life stage groupings collected, initial discharge survival ranged from 0 to 86 percent. The pattern in discharge survival among species was similar to that observed in intake samples with delicate species, such as bay anchovy, exhibiting no or low survival and hardier species, such as striped bass, exhibiting much higher initial discharge survival.

Total discharge survival 24 hours after collection ranged from 0 to 86 percent; the same range as for initial discharge survival (Table 4-5). Survival over the 24-hour period after initial examination (extended survival) ranged from 0 to 100 percent. As with the intake samples, extended survival was low for the relatively delicate species and higher for those species considered much hardier.

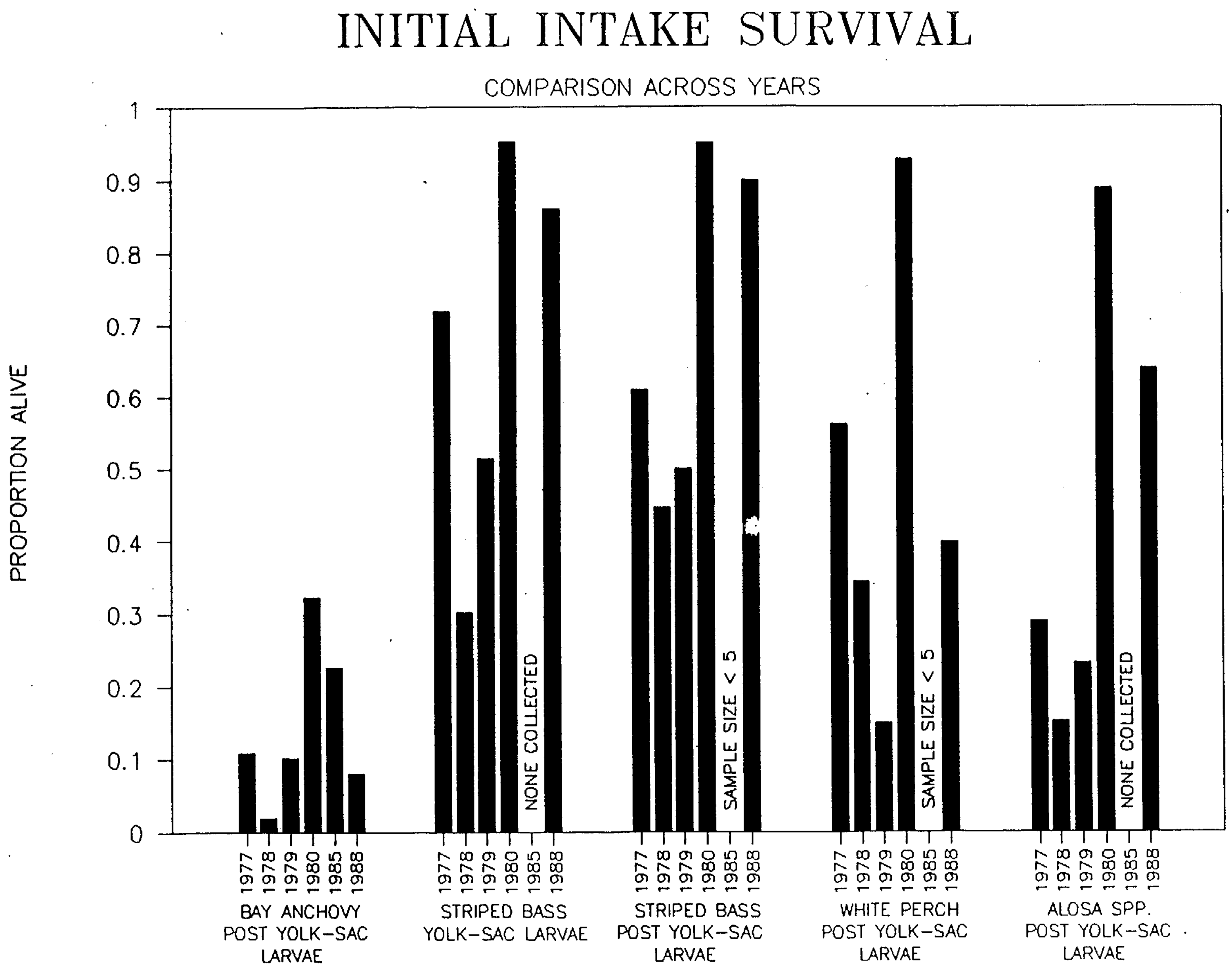

Figure 4-8. Initial intake survival for selected taxa observed during entrainment survival studies at Indian Point Generating Station, 1977-1988.

TABLE 4-5 INITIAL AND 24-HOUR SURVIVAL PROPORTIONS FOR ICHTHYOPLANKTON IN FLUME, WILD, AND DIRECT RELEASE SAMPLES, DISCHARGE SURFACE AND BOTTOM COMBINED, INDIAN POINT GENERATING STATION, 1988

Taxa	Life Stage	Nd	Initial P(d)		Initial S.E.	24-Hour P(d)		24-Hour S.E.
Bay anchovy	Egg	191	0.00	+/-	0.00	0.00	+/-	0.00
	Yolk-sac larvae	462	0.00	+/-	0.00	0.00	+/-	0.00
	Post yolk-sac larvae	6,929	0.02	+/-	0.00	0.00	+/-	0.00
	Juvenile	1	0.00	+/-	0.00	0.00	+/-	0.00
Hogchoker	Yolk-sac larvae	6	0.00	+/-	0.00	0.00	+/-	0.00
	Post yolk-sac larvae	24	0.00	+/-	0.00	0.00	+/-	0.00
Tessellated darter	Post yolk-sac larvae	4	0.00	+/-	0.00	0.00	+/-	0.00
Rainbow smelt	Post yolk-sac larvae	15	0.26	+/-	0.11	0.06	+/-	0.06
	Juvenile	23	0.04	+/-	0.04	0.04	+/-	0.04
Striped bass	Egg	151	0.00	+/-	0.00	0.00	+/-	0.00
	Yolk-sac larvae	312	0.62	+/-	0.03	0.24	+/-	0.02
	Post yolk-sac larvae	2,398	0.68	+/-	0.01	0.44	+/-	0.01
	Juvenile	7	0.86	+/-	0.13	0.86	+/-	0.13
White perch	Egg	4	0.00	+/-	0.00	0.00	+/-	0.00
	Yolk-sac larvae	?3	0.00	+/-	0.00	0.00	+/-	0.00
	Post yolk-sac larvae	341	0.18	+/-	0.02	0.10	+/-	0.02
Northern pipefish	Juvenile	0	--	+/-	--	--	+/-	--
<u>Alosa</u> spp.	Post yolk-sac larvae	195	0.34	+/-	0.03	0.04	+/-	0.01
<u>Cyprinid</u> spp.	Egg	1	0.00	+/-	0.00	0.00	+/-	0.00
	Yolk-sac larvae	3	0.00	+/-	0.00	0.00	+/-	0.00
	Post yolk-sac larvae	1	0.00	+/-	0.00	0.00	+/-	0.00
<u>Morone</u> spp.	Post yolk-sac larvae	18	0.12	+/-	0.08	0.00	+/-	0.00
	Unidentified	14	0.08	+/-	0.07	0.00	+/-	0.00
<u>Gobiid</u> spp.	Post yolk-sac larvae	37	0.56	+/-	0.08	0.22	+/-	0.07
Unidentified	Egg	0	--	+/-	--	--	+/-	--
Mutilated	Post yolk-sac larvae	3	0.00	+/-	0.00	0.00	+/-	0.00
	Unidentified	6	0.34	+/-	0.19	0.00	+/-	0.00
Total		11,169						

NOTE: N(d) = Number collected at the discharge.
P(d) = Survival proportion at the discharge.

Initial discharge survival was within the range reported for previous years (Figure 4-9). Differences in initial discharge survival between 1980 and 1988, years with the most comparable sampling, paralleled the pattern in differences observed in initial intake survival. This pattern suggests that the factors related to observed differences in survival across the years affected both intake and discharge samples to the same relative degree. As previously noted, factors potentially related to entrainment stress tolerance are evaluated in Section 4.4.

4.2.3 Entrainment Survival Estimates

Sufficient numbers of individuals were collected in both intake and discharge samples (minimum sample size of five in each) for calculation of entrainment survival for five species/life stage combinations. Based on this criteria, estimates of initial entrainment survival using initial evaluations ranged from 25 percent for bay anchovy post yolk-sac larvae to 76 percent for striped bass post yolk-sac larvae (Table 4-6). Four other species/life stage combinations, bay anchovy eggs and yolk-sac larvae and hogchoker yolk-sac and post yolk-sac larvae, exhibited complete mortality in both intake and discharge samples. Consequently, estimation of entrainment survival was not possible. Finally, the confidence interval width for Gobiid spp. post yolk-sac larvae exceeded one and the entrainment estimate was not considered valid. Estimates of entrainment survival based upon 24-hour evaluations ranged from 22 percent for Alosa spp. post yolk-sac larvae to 79 percent for striped bass post yolk-sac larvae. Calculation of estimates for bay anchovy post yolk-sac larvae based upon 24-hour evaluations was not possible as none survived from either intake or discharge samples for 24 hours. With the exception of striped bass post yolk-sac larvae, estimates based upon 24-hour evaluations were lower than those based upon initial evaluations. Except for Alosa spp. post yolk-sac larvae, the differences were not substantial.

These estimates of entrainment survival based upon initial observations were generally comparable to estimates from previous studies (Figure 4-10). With the exception of white perch post yolk-sac larvae, estimates from the current study were similar (±0.15) to those from the two most recent studies, 1980 and 1985. For white perch post yolk-sac larvae, the value for the current study was similar to all previous results with the sole exception of 1980. The reason for the relatively high survival for this species/life stage combination in 1980 is not known; however, the pattern for the other years suggest that the entrainment survival observed in 1988 may be more typical of most years. For striped bass yolk-sac larvae, entrainment survival estimated for 1988 was higher than that observed in any of the previous four Indian Point studies in which this life stage was collected and was based on a sample size more than three times that for any previous study.

Overall,the results of this analysis indicate that the yolk-sac/post yolk-sac larval stages of striped bass exhibit relatively high entrainment survival (i.e. >70 percent) at Indian Point. Substantial numbers of white perch and Alosa spp. post yolk-sac larvae can also survive that entrainment process (i.e., 45-53 percent survival). Bay anchovy post yolk-sac larvae exhibited some entrainment survival (25 percent in 1988) based on initial observations although generally none survive any length of time from either the intake or discharge stations making it impossible to evaluate potential latent effects for this species.

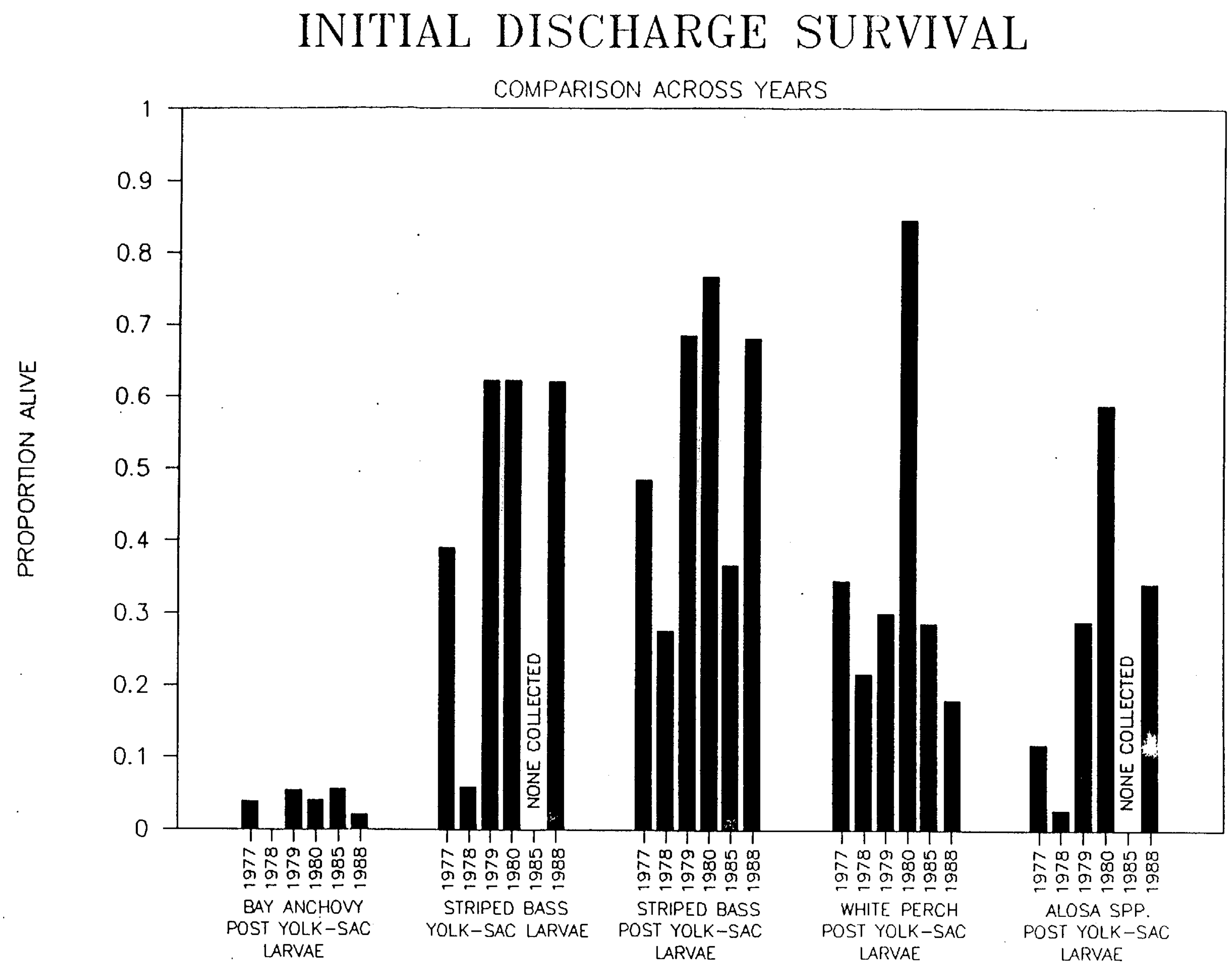

Figure 4-9. Initial discharge survival for selected taxa observed during entrainment survival studies at Indian Point Generating Station, 1977-1988.

TABLE 4-6 ENTRAINMENT SURVIVAL ESTIMATES BASED UPON INITIAL AND 24-HOUR EVALUATIONS, INDIAN POINT GENERATING STATION, 1988

Taxa	Life Stage	Total Number	Initial Se	+/-	Initial S.E.	24-Hour Se	+/-	24-Hour S.E.
Bay anchovy	Egg	246	*	+/-	--	*	+/-	--
	Yolk-sac larvae	654	*	+/-	--	*	+/-	--
	Post yolk-sac larvae	7,370	0.25	+/-	0.05	--	+/-	--
	Juvenile	1	--	+/-	--	--	+/-	--
Hogchoker	Yolk-sac larvae	16	*	+/-	--	*	+/-	--
	Post yolk-sac larvae	31	*	+/-	--	*	+/-	--
Tessellated darter	Post yolk-sac larvae	4	--	+/-	--	--	+/-	--
Rainbow smelt	Post yolk-sac larvae	15	--	+/-	--	--	+/-	--
	Juvenile	25	**	+/-	--	**	+/-	--
Striped bass	Egg	154	--	+/-	--	--	+/-	--
	Yolk-sac larvae	392	0.72	+/-	0.05	0.60	+/-	0.10
	Post yolk-sac larvae	2,671	0.76	+/-	0.02	0.79	+/-	0.05
	Juvenile	7	--	+/-	--	--	+/-	--
White perch	Egg	4	--	+/-	--	--	+/-	--
	Yolk-sac larvae	25	--	+/-	--	--	+/-	--
	Post yolk-sac larvae	379	0.45	+/-	0.10	0.38	+/-	0.12
Northern pipefish	Juvenile	1	--	+/-	--	--	+/-	--
Alosa spp.	Post yolk-sac larvae	206	0.53	+/-	0.13	0.22	+/-	0.16
Cyprinid spp.	Egg	1	--	+/-	--	--	+/-	--
	Yolk-sac larvae	3	--	+/-	--	--	+/-	--
	Post yolk-sac larvae	1	--	+/-	--	--	+/-	--
Gobiid spp.	Post yolk-sac larvae	39	***	+/-	0.81	***	+/-	0.34

* No survival in either intake or discharge samples.

** Number collected in intake samples <5.

*** Confidence interval width (i.e., 2 x 1.96 x S.E.) >1.0.

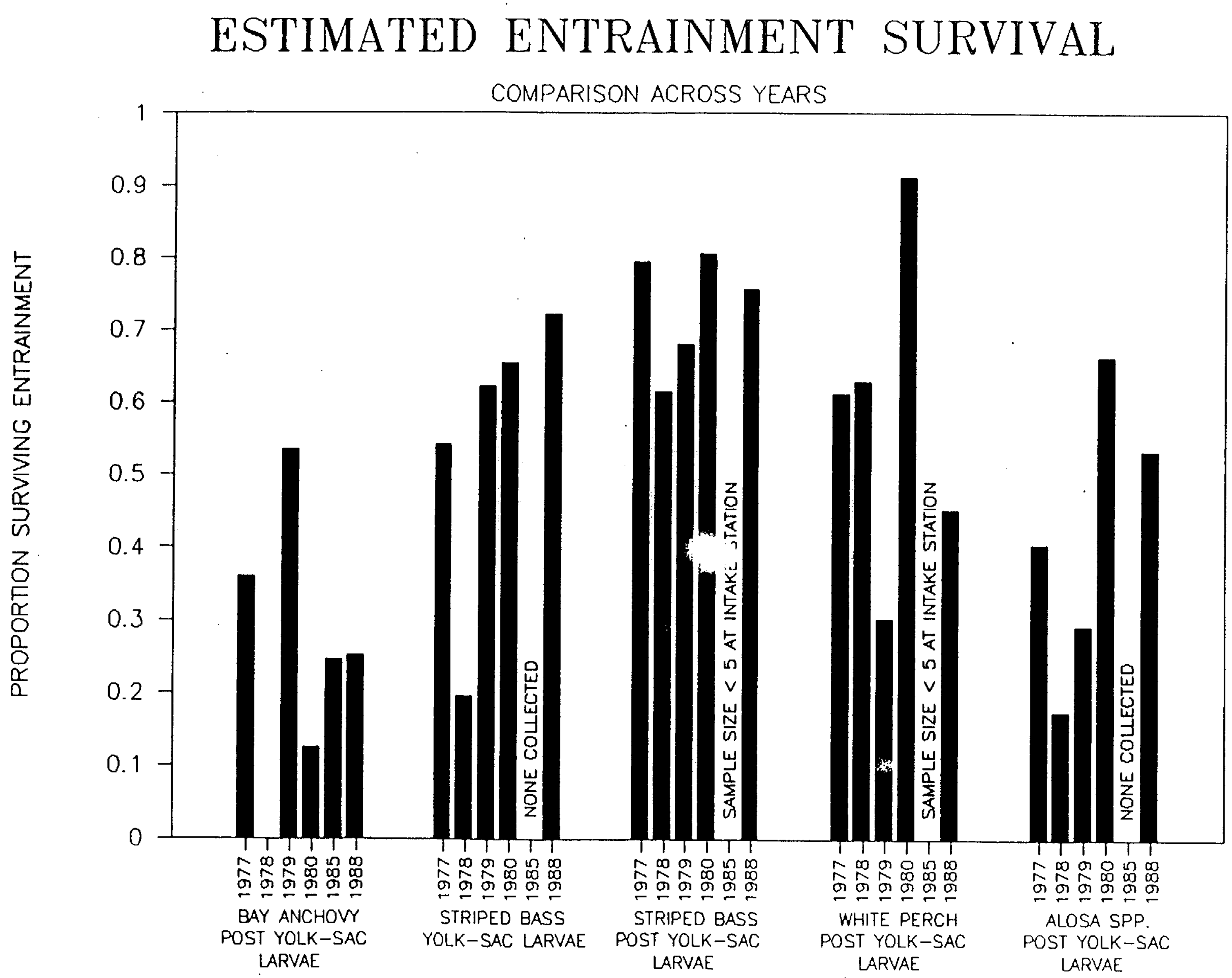

Figure 4-10. Estimated initial entrainment survival for selected taxa observed during entrainment survival studies at Indian Point Generating Station, 1977-1988.

Clearly, the variability in estimated entrainment survival observed both within and across years suggest that some factor or factors can affect the survival of fish eggs and larvae at Indian Point. Identification of these factors is the focus of Section 4.4.

4.3 VERTICAL DISTRIBUTION PATTERNS IN THE DISCHARGE CANAL

The vertical distribution of organisms within discharge canals of electric generating stations has been a matter of debate since the earliest entrainment studies (Boreman and Goodyear 1981). While a variety of studies have been attempted at several stations, the results have been somewhat equivocal, most likely a result of different sampling methodologies and plant operating conditions. However, assumptions as to the vertical distribution of organisms can have a major effect on inferences made concerning both entrainment rates and survival of key species. Thus, an understanding of true vertical distribution patterns for these species is often necessary for estimation of environmental impact due to plant operation.

In their recent review of the Hudson River studies, Versar (1987), based on studies conducted from 1973 to 1975 (NYU 1976a, 1976b, and 1977) on striped bass, concluded that the distribution of fish eggs and larvae was not random within Indian Point's discharge canal. However, this conclusion appears to be largely based on the results of the 1973 studies as there were no significant differences across depths in 1974 and only one difference, striped bass post yolk-sac larvae (surface > bottom), was found in 1975. Previous studies by EA (1980) revealed no significant difference across depths for striped bass eggs and larvae. On the other hand, recent studies on the distribution of larger juvenile fish demonstrated that they were not randomly distributed at Station D1 within the Indian Point discharge canal (NAI 1982). Clearly, despite these studies, questions remain as to vertical density patterns of ichthyoplankton within the discharge canal at Indian Point.

As to the relative distribution of live versus dead organisms within the discharge canal, Versar (1987) concluded that live striped bass post yolk-sac larvae were more abundant near the surface of the Indian Point discharge canal, whereas dead individuals appeared to be more randomly distributed with respect to depth. These conclusions, however, were made on the basis of recovery rates of live versus dead direct released organisms, and not based on direct survival measurements. If these conclusions are correct, sampling conducted near the surface would tend to overestimate true survival, whereas sampling conducted near the bottom would tend to underestimate true survival.

One principal focus of the 1988 Entrainment Survival Program conducted at Indian Point was to address the important issue of vertical distribution of ichthyoplankton within the discharge canal, especially as it relates to potential bias in estimation of entrainment survival. To this end, simultaneous survival sampling was conducted near the surface and near the bottom in the discharge canal. In addition, net sampling at three depths (surface, middepth, and bottom) to evaluate overall distribution patterns was conducted. The purpose of this section is to present the results of these studies and to compare these results to those from prior studies. Finally, all these results will be interpreted in light of overall vertical gradient patterns within the Indian Point discharge canal for the early life stages of a variety of key fish species.

4.3.1 Depth Distribution in Density and Length Flume Collections

The first step in analysis of this data set was a comparison of the density of selected ichthyoplankters (live and dead combined) between surface and bottom flume samples collected at the same time. Sufficient numbers of organisms were collected for the following six species/life stage combinations to permit analysis:

- Bay anchovy - Yolk-sac larvae
- Bay anchovy - Post yolk-sac larvae
- Striped bass - Yolk-sac larvae
- Striped bass - Post yolk-sac larvae
- White perch - Post yolk-sac larvae
- Alosa spp. - Post yolk-sac larvae

Density comparisons were made using one-way analysis of variance (ANOVA) on $\log_{10}$ (density +1), where the density is expressed as numbers per 1,000 m^3. For this analysis, the statistically significant level was chosen as $\alpha = 0.05$.

The results of these analyses revealed significant differences between surface and bottom flume densities for two of the six species/life stage combinations tested; striped bass yolk-sac larvae and white perch post yolk-sac larvae (Table 4-7). For both, mean densities were higher in surface collections than they were in bottom collections (Table 4-8). For the other four species and life stages, there was no evidence of vertical density differences within the Indian Point discharge canal.

To investigate possible changes in the depth distribution with size, striped bass post yolk-sac larvae were grouped into the following six length intervals:

$\leq$6.0 mm TL
6.1 - 7.0 mm TL
7.1 - 8.0 mm TL
8.1 - 9.0 mm TL
9.1 - 11.0 mm TL
$\geq$11.1 mm TL

Based on this length stratification, the density of organisms within each length group was then calculated for each flume sample. These length-specific densities were then subjected to a two-way ANOVA to investigate possible inter-relationships between length and vertical distribution for striped bass post yolk-sac larvae.

There were no significant differences between surface and bottom flume densities for striped bass post yolk-sac larvae (Table 4-9). The depth by length group interaction was also not significant, indicating that vertical density distribution was not related to the size of the larvae. For the samples used in this analysis, the majority of the striped bass post yolk-sac larvae ranged from 6 to 12 mm in length (Figure 4-11).

TABLE 4-7 ANALYSIS OF VARIANCE OF DEPTH PATTERNS FOR SELECTED SPECIES AND LIFE STAGES COLLECTED IN REAR-DRAW FLUMES IN THE DISCHARGE CANAL OF INDIAN POINT, 1988

Species	Life Stage	Source	DF	MS	MSe	F	Prob
Bay anchovy	YSL	D	1	15.89	5.45	2.92	0.0936
Bay anchovy	PYSL	D	1	3.87	8.07	0.48	0.4900
Striped bass	YSL	D	1	51.17	5.13	9.98	0.0022*
Striped bass	PYSL	D	1	3.07	4.60	0.67	0.4153
White perch	PYSL	D	1	34.07	4.17	8.17	0.0049*
Alosa spp.	PYSL	D	1	5.42	4.85	1.12	0.2939

* Denotes a significant F value <.05.

NOTE: D = Depths; DF = Degrees of Freedom; F = F-value; MSe = Mean Square Error; Prob = Prob >F.

TABLE 4-8 AVERAGE DENSITY (NO./1,000 M^3) BY LIFE STAGE OF SELECTED SPECIES COLLECTED IN REAR-DRAW FLUMES IN THE DISCHARGE CANAL OF INDIAN POINT, 1988

Species	Life Stage	N	Bottom		Surface	
			Mean	Std Err	Mean	Std Err
Bay anchovy	YSL	27	559	101	348	100
Bay anchovy	PYSL	67	2,880	445	2,651	426
Striped bass	YSL	42	125	31	258	53
Striped bass	PYSL	87	773	149	660	125
White perch	PYSL	69	104	15	155	22
Alosa spp.	PYSL	38	128	28	134	31

NOTE: N = Number of Samples Per Depth; Std Err = Standard Error of Mean; Mean = Average Density.

TABLE 4-9 ANALYSIS OF VARIANCE OF LENGTH AND DEPTH PATTERNS FOR STRIPED BASS POST YOLK-SAC LARVAE COLLECTED IN REAR-DRAW FLUMES IN THE DISCHARGE CANAL OF INDIAN POINT, 1988

Source	DF	SS	MS	F	Prob
L	5	4.27	0.85	1.63	0.1508
D	1	0.32	0.32	0.60	0.4388
L X D	5	1.15	0.23	0.44	0.8229
Error	4.64	243.46	0.52		

NOTE: L = Length Intervals; D = Depths; DF = Degrees of Freedom; SS = Sums of Square; F = F-value; Prob = Prob >F.

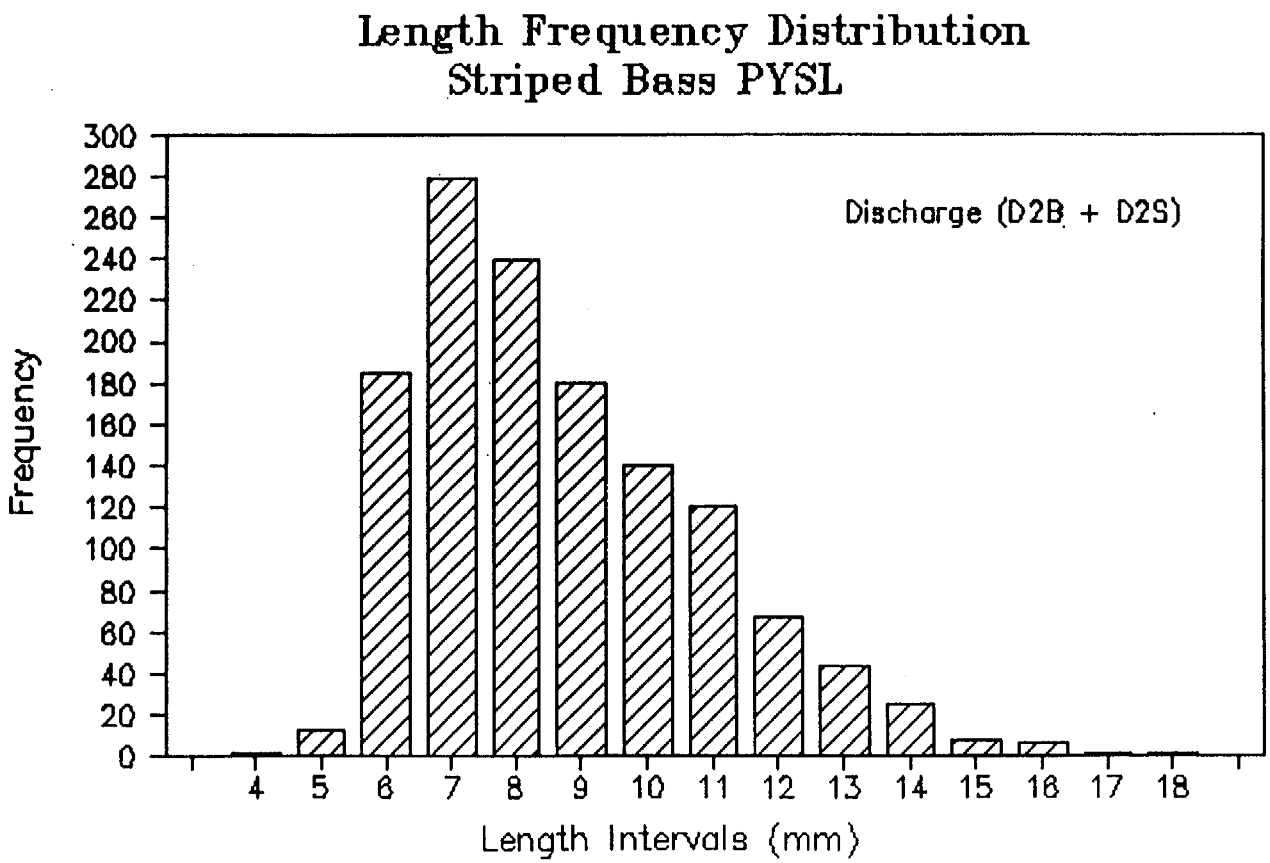

Figure 4-11. Length-frequency distribution of striped bass post yolk-sac larvae collected in discharge flume samples during entrainment survival studies at Indian Point Generating Station, 1988.

Net Collections

To further investigate possible differences in the depth distribution of selected ichthyoplankters, densities of the following seven species/life stage combinations collected in a total of 42 net samples were subject to one-way ANOVA:

- . Bay anchovy - Post yolk-sac larvae
- . Striped bass - Yolk-sac larvae
- . Striped bass - Post yolk-sac larvae
- . Striped bass - Post yolk-sac larvae (dead, direct release)
- . White perch - Post yolk-sac larvae
- . *Morone* spp. - Post yolk-sac larvae
- . *Alosa* spp. - Post yolk-sac larvae

The net sampling program was conducted during seven sampling periods across three days. Two net collections were made at each of three distinct depth stations; surface, middepth, and bottom. As with the previous analysis, densities were expressed as numbers per 1,000 m^3 and a $\log_{10}$ (x+1) transformation was used to account for variance heterogeneity.

There were no significant differences in density across the depth station for any of the seven species/life stage combinations evaluated (Table 4-10). In addition to this lack of significance, mean densities in the net collections exhibited no consistent pattern for the species/life stage combinations evaluated (Table 4-11).

4.3.2 Discharge Survival as a Function of Depth

Having addressed vertical density patterns in the previous section, the next step in the analysis was evaluation of possible differences in the vertical distribution between live and dead ichthyoplankters in the Indian Point discharge canal. This evaluation was based on a comparison of the relative abundance of live and dead organisms in the surface and bottom flume collections using contingency table analysis. A sufficient number of larvae were collected from the following five species/life stage combinations to warrant analysis:

- . Bay anchovy - Post yolk-sac larvae
- . Striped bass - Yolk-sac larvae
- . Striped bass - Post yolk-sac larvae
- . White perch - Post yolk-sac larvae
- . *Alosa* spp. - Post yolk-sac larvae

In addition, analysis was conducted for *Morone* spp. post yolk-sac larvae combining the catch of striped bass, white perch, and unidentified *Morone* spp. For two of the six species/life stage combinations evaluated (striped bass and white perch post yolk-sac larvae), the abundance of live and dead organisms was significantly different between the surface and bottom flume samples (Table 4-12). However, the pattern observed between surface and bottom samples for these two groups was opposite (Figure 4-12). Live post yolk-sac larvae were

TABLE 4-10 ANALYSIS OF VARIANCE OF DEPTH PATTERNS FOR SELECTED SPECIES AND LIFE STAGES COLLECTED BY NETS IN THE DISCHARGE CANAL OF INDIAN POINT, 1988

Species	Life Stage	Source	DF	MS	MSe	F	Prob
Striped bass	PYSL (DDR)*	D	2	0.95	5.93	0.16	0.8531
Bay anchovy	PYSL	D	2	0.14	10.43	0.01	0.9870
Striped bass	YSL	D	2	0.28	5.91	0.05	0.9539
Striped bass	PYSL	D	2	0.11	2.20	0.05	0.9528
White perch	PYSL	D	2	0.42	1.96	0.21	0.8094
Alosa spp.	PYSL	D	2	0.17	3.01	0.06	0.9438
Morone spp.	PYSL	D	2	0.09	2.27	0.04	0.9591

* DDR = Hatchery-reared dyed direct release larvae.

NOTE: D = Depths; DF = Degrees of Freedom; F = F-value;
MSe = Mean Square Error; Prob = Prob >F.

TABLE 4-11 AVERAGE DENSITY (NO./1,000 M^3) BY LIFE STAGE FOR SELECTED SPECIES AND LIFE STAGES COLLECTED BY NETS IN THE DISCHARGE CANAL OF INDIAN POINT, 1988

			Bottom		Middle		Surface	
Species	Life Stage	N	Mean	SE	Mean	SE	Mean	SE
Striped bass	PYSL (DDR)*	14	56	25	90	34	92	40
Bay anchovy	PYSL	14	1,161	791	1,385	942	1,043	742
Striped bass	YSL	14	91	39	139	56	321	141
Striped bass	PYSL	14	2,070	692	2,257	747	2,302	695
White perch	PYSL	14	32	10	29	7	39	10
Alosa spp.	PYSL	14	94	25	103	29	110	31
Morone spp.	PYSL	14	50	25	32	13	24	7

* DDR = Hatchery-reared dyed direct release larvae.

NOTE: N = Number of Samples Per Depth; SE = Standard Error of Mean; Mean = Average Density.

TABLE 4-12 COMPARISON OF THE RELATIVE ABUNDANCE OF LIVE AND DEAD LARVAE BETWEEN SURFACE AND BOTTOM FLUME COLLECTIONS IN THE INDIAN POINT DISCHARGE CANAL, 1988

Species	Life Stage	Sample Location	Number Dead	Number Live	Percent Live	df	Chi-square	Probability
Bay anchovy	Post yolk-sac larvae	Bottom	3,689	98	2.6	1	0.6298	0.4274
		Surface	3,070	72	2.3			
Striped bass	Yolk-sac larvae	Bottom	46	64	58.2	1	0.9737	0.3238
		Surface	73	129	63.9			
Striped bass	Post yolk-sac larvae	Bottom	398	950	70.5	1	5.2518	0.0219
		Surface	356	694	66.1			
White perch	Post yolk-sac larvae	Bottom	137	9	6.2	1	23.0084	<0.0001
		Surface	144	51	26.2			
Alosa spp.	Post yolk-sac larvae	Bottom	66	33	33.3	1	0.0000	1.0000
		Surface	64	32	33.3			
Total *Morone*	Post yolk-sac larvae	Bottom	546	961	63.8	1	6.5573	0.0104
		Surface	518	746	59.0			

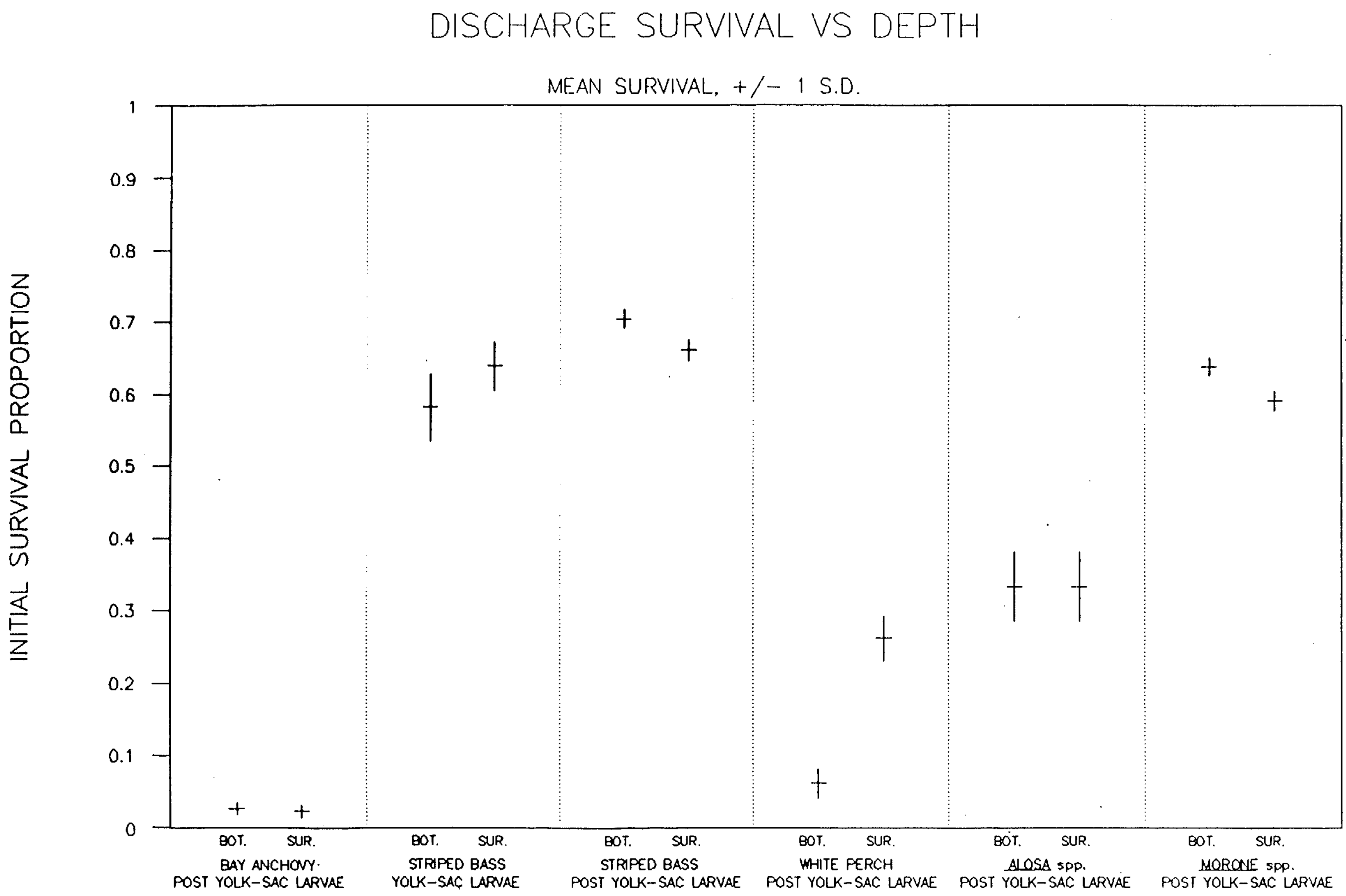

Figure 4-12. Initial survival of selected species collected in discharge surface and bottom flume samples during entrainment survival studies at Indian Point Generating Station, 1988.

significantly more abundant than dead ones in bottom samples for striped bass, but more abundant in surface samples for white perch. Because of overwhelming abundance of striped bass larvae when compared to white perch larvae, the pattern for total Morone spp. post yolk-sac larvae was the same as for striped bass. For the other four species/life stage combinations, the differences between surface and bottom collections were not significant.

The results of this analysis indicate that for most species and life stages, live and dead organisms were equally distributed. While the differences in the relative abundance of live versus dead individuals between surface and bottom samples were significant for striped bass post yolk-sac larvae, the actual differences in percent live between surface and bottom samples were relatively small (66 and 71 percent, respectively). Thus, it appears that differences in the vertical distribution patterns between live and dead striped bass post yolk-sac larvae in the Indian Point discharge canal were relatively small. On the other hand, differences in percent live between surface and bottom collections for white perch post yolk-sac larvae were greater (25 and 6 percent, respectively).

4.3.3 Discussion

The current study provides one of the most comprehensive evaluations of vertical distribution patterns within the discharge canal of Indian Point for the larval stages of a variety of key fish species. These results, together with analyses conducted on data collected since Unit 2 began operation (1974), provide a fairly consistent pattern supporting the contention that fish eggs and larvae tend to be randomly distributed within the discharge canal at Indian Point. The only exceptions to this pattern across the 22 species/life stage evaluations made across the years were for striped bass post yolk-sac larvae in 1975 and for striped bass yolk-sac larvae and white perch post yolk-sac larvae in flume samples from the current study. In all three cases, surface densities were greater than bottom densities.

During 1973, when only Unit 1 was operating at Indian Point, significant vertical distribution patterns were observed across all life stages of striped bass. However, when Unit 1 alone is operating, as in 1973, cross-sectional flow velocities in the Indian Point discharge canal at the two points of sampling was 0.2-0.3 m/sec. On the other hand, beginning in 1974, when Unit 1 ceased operation and Unit 2 began, and continued through the present, cross-sectional flow velocities at the same sampling points ranged from 0.7 to 1.3 m/sec, a substantial increase. Thus, it appears that apparent differences in the vertical distribution between 1973 and subsequent years are related to changes in cooling water flow velocities and resultant turbulence in Indian Point's discharge canal. Under current operating conditions, flow velocities within the discharge canal appear to be too great to permit fish larvae to redistribute themselves vertically within the canal as they might in the river. However, studies conducted in 1981 (NAI and Con Edison 1982) indicate that once the fish grow to the juvenile stage, their swimming abilities are sufficient to permit them to overcome the turbulence at least at Staton D1.

The results of the comparison of the live versus dead larval distributions indicate that live and dead larvae were generally distributed the same between surface and bottom areas of the canal. The significant differences observed for striped bass post yolk-sac larvae were sufficiently small enough as to introduce little bias in estimation of entrainment survival. Only for white perch were the differences large enough to warrant further consideration. However, further studies will be necessary to determine if these differences are real or related to some, as yet, undetermined factors.

4.4 FACTORS AFFECTING SURVIVAL

During passage through the cooling water systems, entrained organisms are subject to a variety of stresses, the sum total of which results in the levels of mortality observed. A variety of factors, both biotic and abiotic, can affect the response of organisms to these stresses and, hence, affect the resultant level of entrainment mortality. While definitive studies evaluating the effect of all potential factors have not as yet been completed, prior studies do suggest several factors which can act to affect the portion recovered alive at the intake and discharge stations. These include discharge temperature and length of the entrained organisms. In addition, salinity is known to have an ameliorating effect on stress for the larvae and juvenile fish of a variety of species under culture conditions. Based on these prior studies, this section presents an evaluation of the potential effects of these three factors (discharge temperature, length, and salinity) on mortality rates observed in this study at the intake and discharge stations for four key species; bay anchovy, striped bass, white perch, and *Alosa* spp. The results of this analysis are then discussed in light of potential factors affecting entrainment survival at Indian Point.

4.4.1 Methods of Statistical Analysis

The categorical Model (CATMOD) procedure was utilized to examine the effects of fish length, water temperature, and salinity on survival (SAS 1985). All three variables were categorized such that all categories had approximately equal sample size. Categorical variables were used in the analysis instead of continuous variables because temperature and salinity values were unique for a particular sample. Data for each species were analyzed separately for intake and discharge stations. However, all non-egg individuals collected were included to increase the length range for analysis. Intake samples of white perch and *Alosa* spp. were not examined because of small sample sizes (n=39 and 10, respectively).

The Chi-square statistic (Wald statistic) was used to test each effect in the model. The likelihood ratio (LR) statistic is an appropriate goodness-of-fit test for the model, since it compares the specified model with the unrestricted (fully saturated) model. For this study, only the main effects of length, salinity, and temperature were tested. If the chi-square value of the LR statistic is not significant ($\alpha = 0.05$), then the main effect model fits; otherwise significant interactions exist.

Parameters of the model were estimated using the maximum likelihood (ML) method because of zero frequencies (zeros in the cross-tabulation table). The ML method calculates the parameters iteratively by the Newton-Raphson method until it converges. In this study, the convergence criterion is equal to $1x10^{-8}$. The iteration estimation process stops when the proportion change in the log likelihood is less than $1x10^{-8}$. If convergence is achieved for the model, valid results are indicated.

A logistic regression model was used to establish the relationship between survival and length. Both theoretical and empirical considerations suggest that when the dependent variable is a categorical variable (in this study, whether a larva was alive or dead), a curvilinear relationship is frequently found between dependent and independent variables. The logistic regression model has been found appropriate in many instances involving a binary dependent variable (Neter, Wasserman, and Kutner 1983). Therefore, for the binary model, the probability that an individual was alive at capture is given by:

$$P(Y=Live|L)=1/(1+exp(-(B_0+B_1L))),$$

or in its logit form:

$$P'=Loge(P/(1-P))=B_0+B_1L$$

where

Y = larval condition.
L = length (continuous).

Parameters (B_0 and B_1) were estimated using the ML method. Survival probabilities were estimated for each species and station from the model above. The observed survival values given in the output table of CATMOD procedure by every observed length values were not used in this study. This is because, when there are zero frequencies, the ML method could result in exact observed values and residuals. However, the ML method yields valid results for the parameter estimates and all of the predicted values (SAS 1985). Therefore, the observed survival rate presented in this study was computed for each length group of 1-mm intervals.

4.4.2 Results and Discussion

Analysis using the ML categorical model revealed length to be a highly significant factor in all analyses with the exception of striped bass collected at the plant intake (Table 4-13). Salinity was a significant factor for striped bass at both stations; discharge temperature was also significant at the discharge station. No other factors were significantly related to survival across the six individual analyses conducted.

For all analyses, including striped bass in intake samples, survival appeared to be an increasing function of length (Figures 4-13 through 4-18). The relationship between survival and length appeared to be especially strong for striped bass, white perch, and Alosa spp. collected at the discharge station. For the other two parameters, no consistent pattern across species and sampling locations was evident. For striped bass at the discharge station where both parameters were significantly related to survival, no readily explainable pattern was evident for salinity, while survival appeared slightly lower at higher discharge temperatures. At the intake station, survival appeared lowest at salinities $\leq$0.8 ppt, although relatively constant at higher salinities.

The results of this analysis indicate a strong positive relationship between survival and length for the larval stages of four key species at both the intake and discharge sampling stations at Indian Point in 1988. Effects

TABLE 4-13 RESULTS OF MAXIMUM LIKELIHOOD ANALYSIS USING A CATEGORICAL MODEL RELATING LENGTH, SALINITY, AND DISCHARGE TEMPERATURE TO OBSERVED SURVIVAL AT INTAKE AND DISCHARGE STATIONS AT INDIAN POINT, 1988

Species	Location	Source	df	Chi-Square	Prob
Bay anchovy	Discharge	Intercept	1	230.91	0.0000
		Length	1	49.91	0.0000*
		Salinity	2	2.93	0.2308
		Temperature	1	0.02	0.9018
		Likelihood Ratio	7	18.01	0.0119
	Intake	Intercept	1	128.06	0.0000
		Length	1	14.46	0.0001*
		Salinity	1	0.22	0.6356
		Temperature	1	0.22	0.6425
		Likelihood Ratio	4	10.46	0.0333
Striped bass	Discharge	Intercept	1	28.19	0.0000
		Length	7	107.73	0.0000*
		Salinity	3	14.08	0.0028*
		Temperature	2	29.46	0.0000*
		Likelihood Ratio	74	167.64	0.0000
	Intake	Intercept	1	100.65	0.0000
		Length	3	5.20	0.1577
		Salinity	3	8.52	0.0364*
		Temperature	2	4.76	0.0923
		Likelihood Ratio	23	29.71	0.1579
White perch	Discharge	Intercept	1	58.53	0.0000
		Length	3	33.11	0.0000*
		Salinity	3	5.93	0.1153
		Temperature	2	1.43	0.4904
		Likelihood Ratio	36	36.21	0.4589
Alosa spp.	Discharge	Intercept	1	17.92	0.0000
		Length	2	21.89	0.0000*
		Salinity	2	3.63	0.1630
		Temperature	1	0.81	0.3684
		Likelihood Ratio	12	18.48	0.1018

* Significant at $\alpha = 0.05$.

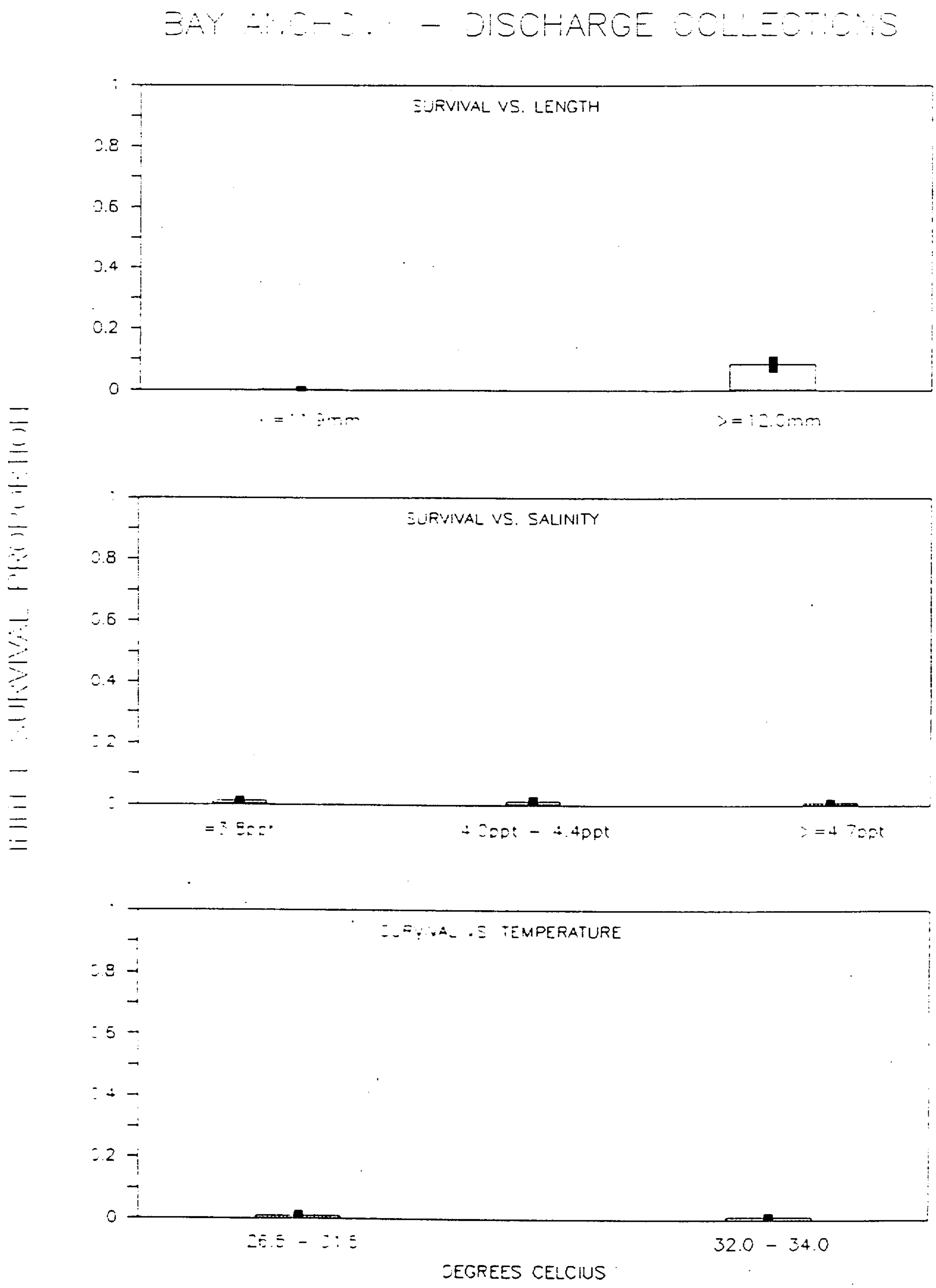

Figure 4-13. Mean survival (±1 S.E.) by length, salinity, and temperature group for bay anchovy larvae collected at the Indian Point discharge station, 1988.

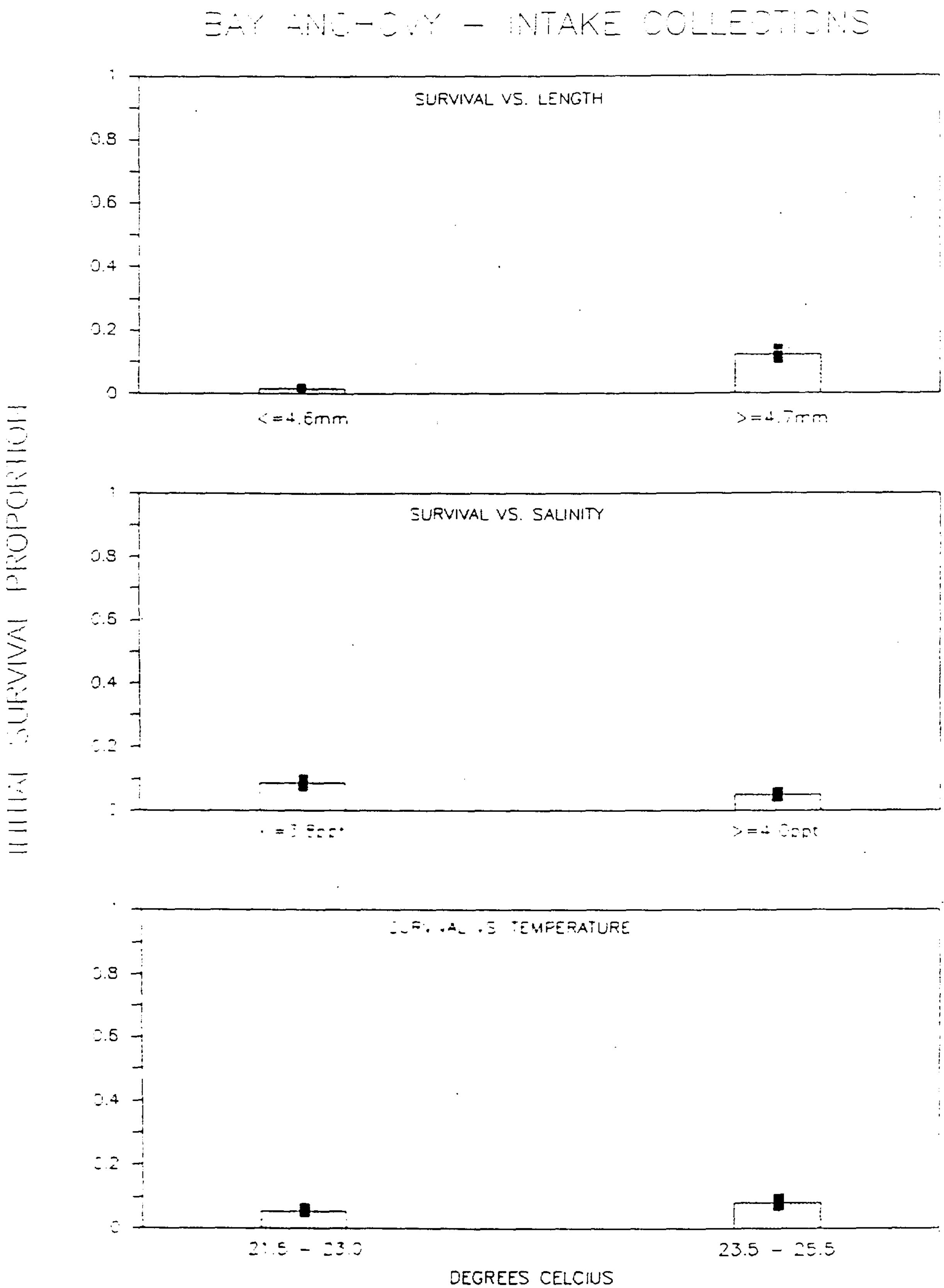

Figure 4-14. Mean survival (±1 S.E.) by length, salinity, and temperature group for bay anchovy larvae collected at the Indian Point intake station, 1988.

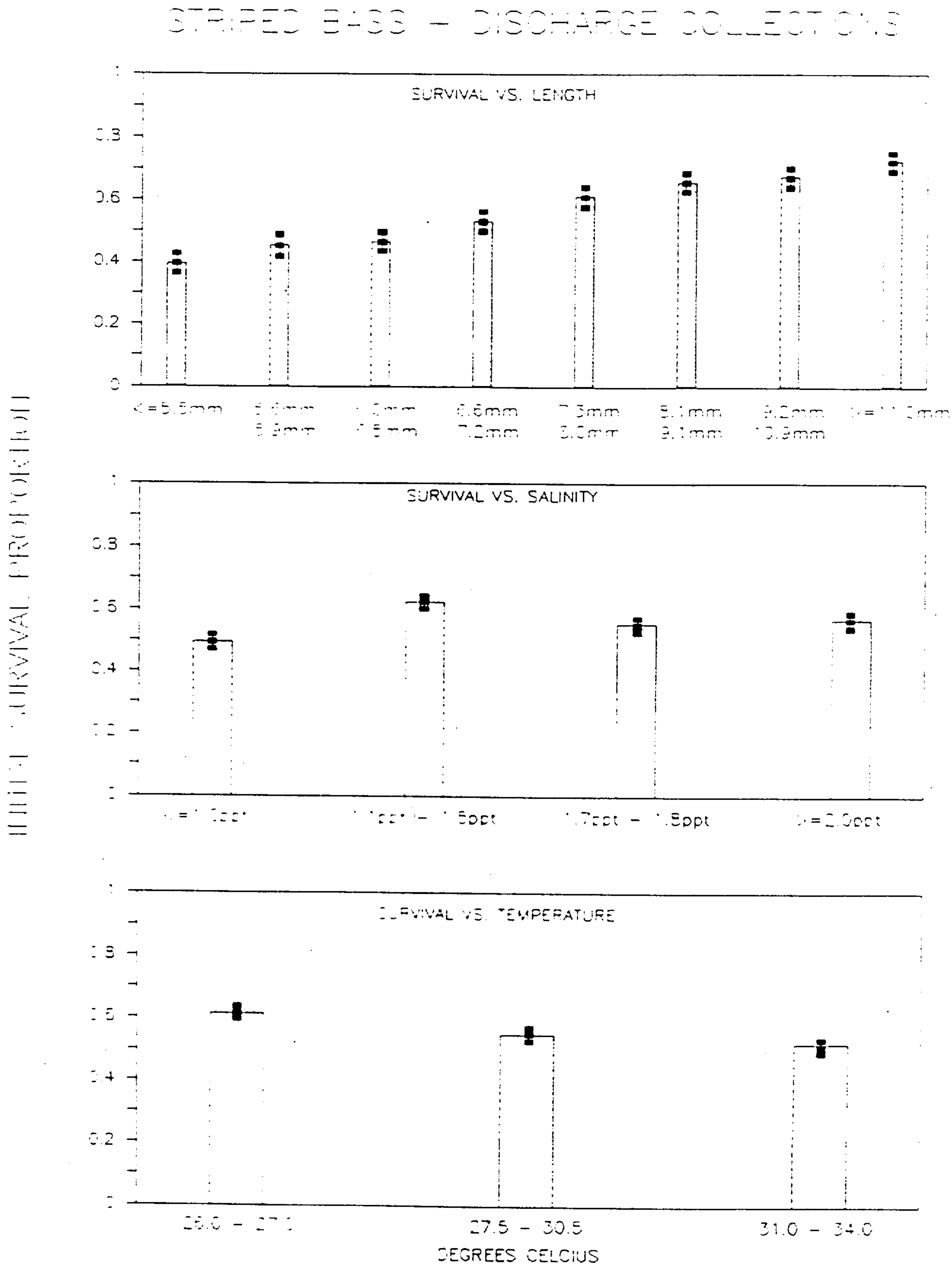

Figure 4-15. Mean survival (±1 S.E.) by length, salinity, and temperature group for striped bass larvae collected at the Indian Point discharge station, 1988.

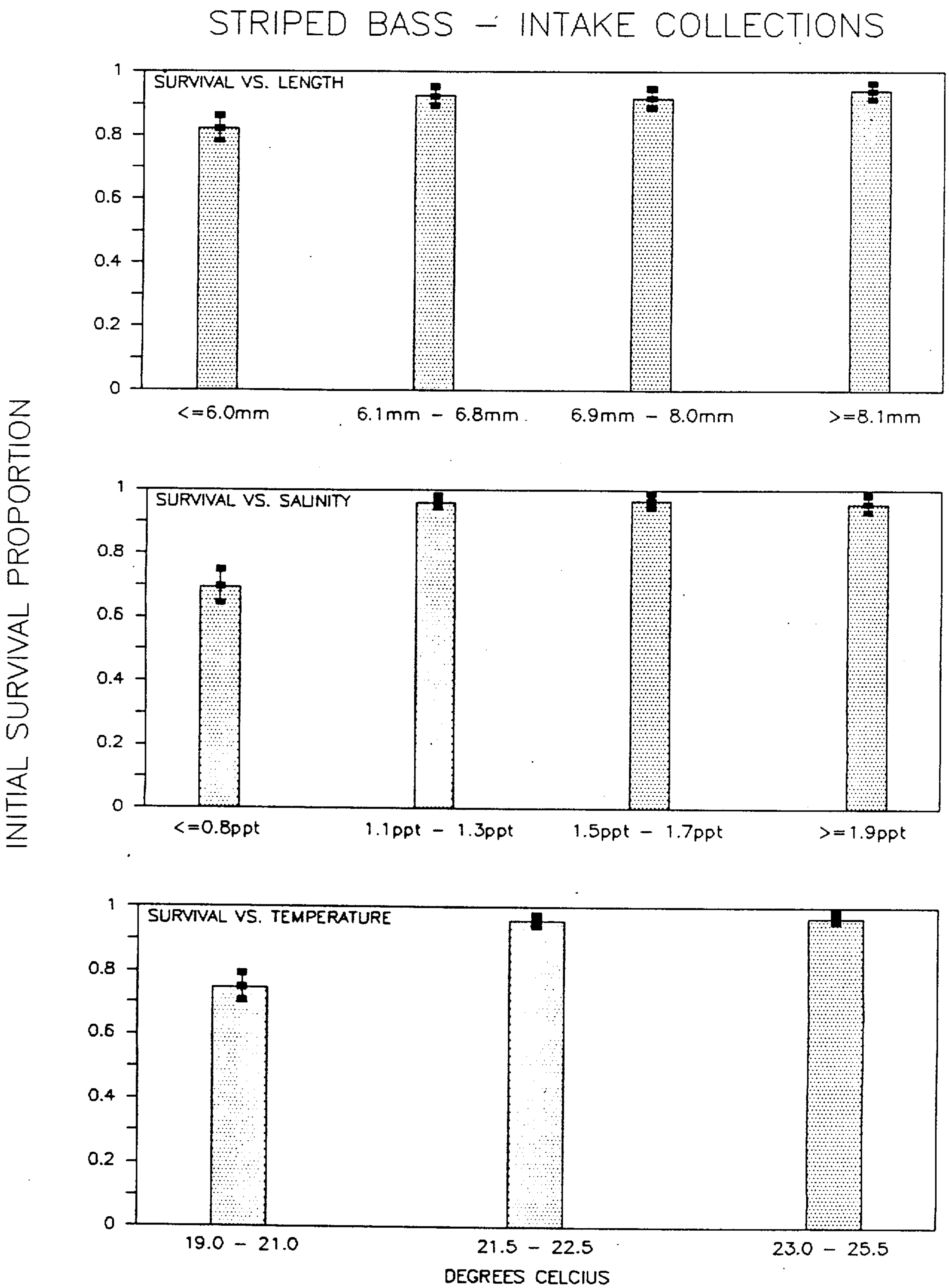

Figure 4-16. Mean survival (±1 S.E.) by length, salinity, and temperature group for striped bass larvae collected at the Indian Point intake station, 1988.

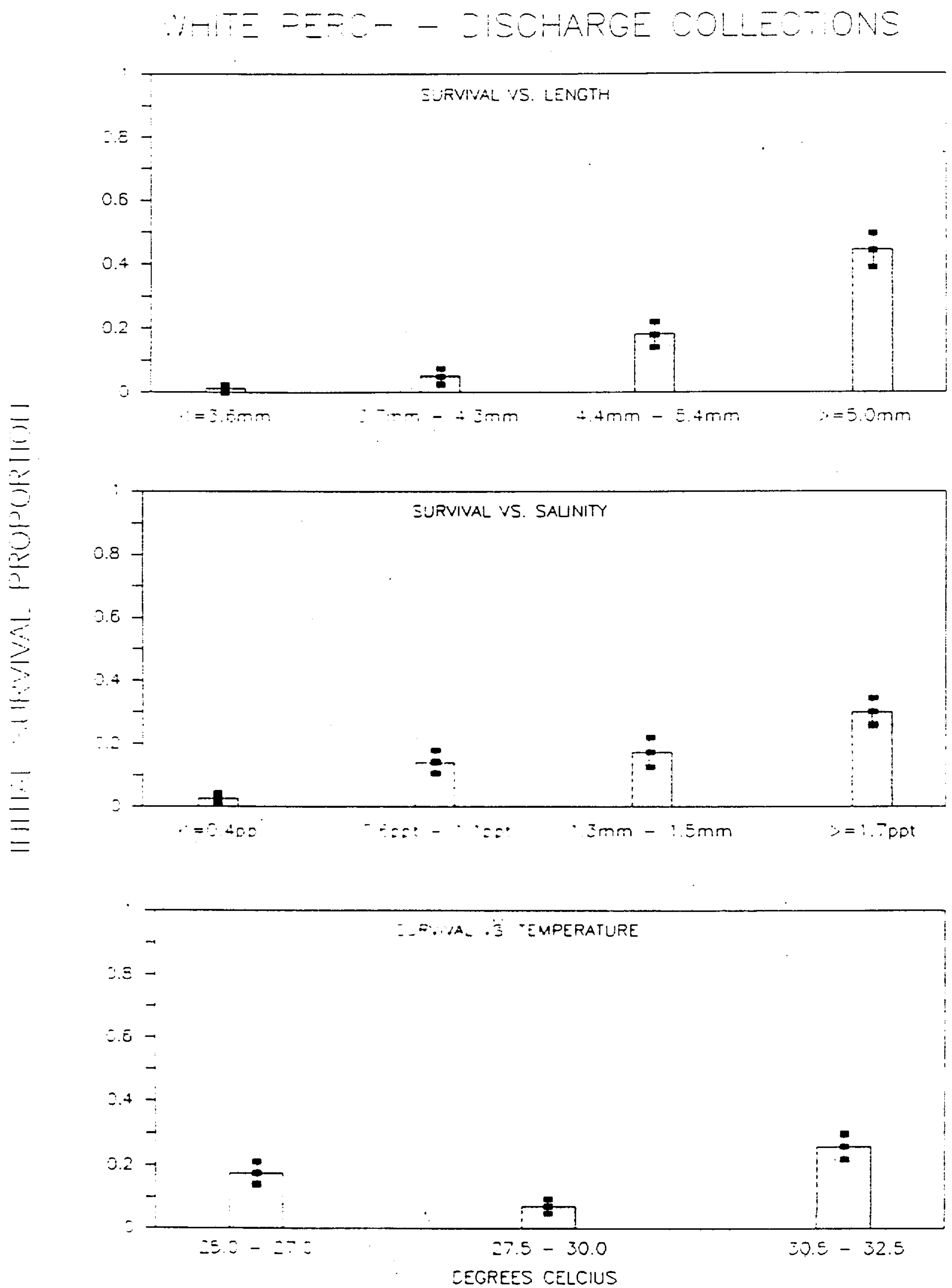

Figure 4-17. Mean survival (±1 S.E.) by length, salinity, and temperature group for white perch larvae collected at the Indian Point discharge station, 1988.

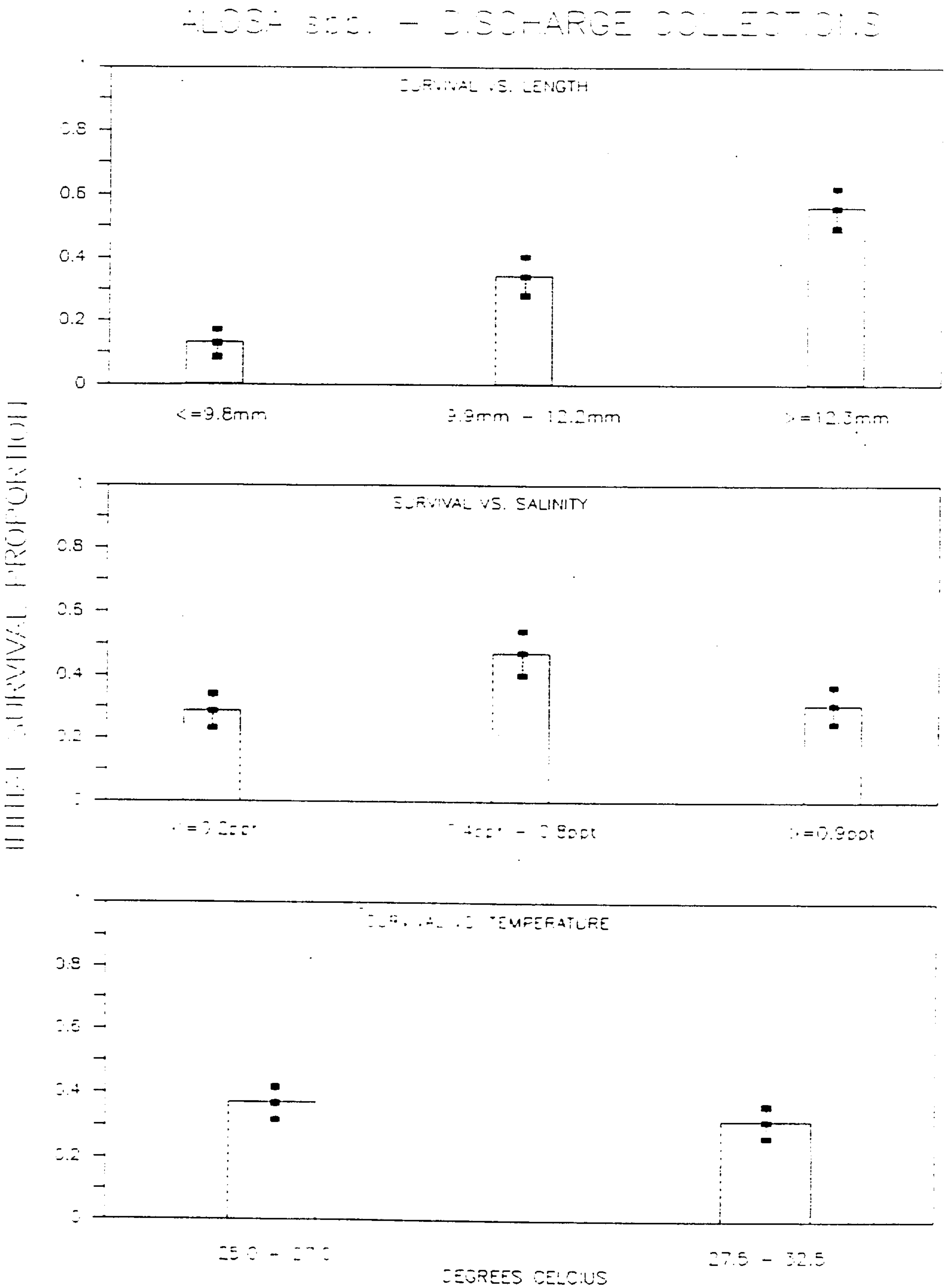

Figure 4-18. Mean survival (+1 S.E.) by length, salinity, and temperature group for *Alosa* spp. larvae collected at the Indian Point discharge station, 1988.

of salinity and discharge temperature (if any) appear considerably smaller and inconsistent. These results are consistent with those observed with hatchery-reared striped bass larvae in sampling stress evaluations conducted during this study (Appendix A) in 1980 (EA 1982) and in 1979 (EA 1981a).

During sampling stress evaluations conducted in 1985, no consistent relationship was evident between length and survival although larvae used in these tests were generally larger than in the other three studies. These results are also consistent with length survival patterns observed at Roseton in 1980 for striped bass, white perch, and Alosa spp. (EA 1983), as well as for white perch at Bowline from 1975 through 1979 (EA 1981b). Results for striped bass at Bowline during the period 1975 through 1979 also indicate a general trend of increasing survival with length at the discharge station, although considerable variability was evident (EA 1981b). At the intake, no relationship between survival and length was evident (EA 1981b).

The results of the current study, together with information gathered in other Hudson River studies, clearly indicate that the proportion of larvae collected alive at both the intake and discharge stations is a function of larval length for the key species entrained at Indian Point. This pattern is consistent with the fact that older, and presumably larger, larvae are generally better able to withstand stresses, including those due to entrainment as well as the collection process. The other two factors, salinity and discharge temperature, did not have a consistent demonstrable effect on survival at either station. The lack of a pattern with discharge temperature is consistent with laboratory studies which demonstrate a relatively low thermal effect at discharge temperatures within the range (25-34 C) observed during this study (Kellogg and Jinks 1985). At discharge temperatures higher than those observed, mortality due to thermal effects increases rapidly to 100 percent, overwhelming any mechanical effects.

To better define the relationship between larval length and estimated survival at the intake and discharge stations, a logistic regression model using the ML method was developed to define the relationship between proportion alive and length for four taxonomic groups (Table 4-14). In most cases, the logistic regression revealed a significant fit (LR PROB 0.05), although for white perch and Alosa spp. at the intake station (both with small sample size), the estimate for the length effect was non-significant.

Comparison of observed survival estimates by station to the ML logistic regression model results revealed good agreement between the two (Figures 4-19 through 4-22). With the exception of striped bass, survival at the intake was generally characterized by a rapid increase from relatively low survival (<20 percent) for smaller sizes (<5 mm) to high survival (approaching 100 percent) for larger sizes (>10 mm). Striped bass larvae exhibited relatively high survival of all lengths at the intake station. The consistently high survival at the intake stations for the larger larvae confirm the ability of the sampling gear to collect larvae, even those from relatively delicate species, with minimal sampling stress. The relatively low intake survival of larvae of the smaller sizes could be either a result of greater sensitivity of smaller individuals to sampling stress or to the natural occurrence of previously dead larvae in the wild population. At the discharge station, survival increased 80 percent or more with length, except for bay anchovy.

TABLE 4-14 RESULTS OF MAXIMUM LIKELIHOOD LOGISTIC REGRESSION RELATING LENGTH TO OBSERVED INITIAL SURVIVAL AT INTAKE AND DISCHARGE STATIONS AT INDIAN POINT, 1988

Species	Location	Length Range	Maximum Likelihood Estimates of Logistic Regression						
			Parameter	df	Estimate	Standard Error	Chi-Square	Prob	LR Prob
Bay anchovy	Discharge	1.3-21.0	Intercept	1	-8.0285	0.7129	126.84	0.0000	1.0000
			Length	1	0.3641	0.0502	52.62	0.0000	
	Intake	1.5-26.0	Intercept	1	-6.4246	0.6540	96.49	0.0000	0.9860
			Length	1	0.5742	0.0807	50.69	0.0000	
Striped bass	Discharge	2.3-20.0	Intercept	1	-1.3222	0.1769	55.89	0.0000	0.1087
			Length	1	0.2041	0.0225	82.52	0.0000	
	Intake	3.4-16.7	Intercept	1	-0.0722	0.8962	0.01	0.9358	0.6212
			Length	1	0.3276	0.1338	6.00	0.0143	
White perch	Discharge	2.1-11.5	Intercept	1	-5.7061	0.5829	95.83	0.0000	0.1943
			Length	1	0.7664	0.1008	57.86	0.0000	
	Intake	2.3-10.6	Intercept	1	-29.9798	15.2801	3.85	0.0498	0.9998
			Length	1	6.0034	3.0875	3.78	0.518	
Alosa spp.	Discharge	3.4-24.0	Intercept	1	-2.9214	0.7059	17.13	0.0000	0.0619
			Length	1	0.1973	0.0589	11.23	0.0008	
	Intake	7.3-18.5	Intercept	1	-8.8632	5.6690	2.44	0.1179	0.6461
			Length	1	0.8360	0.4987	2.81	0.0937	

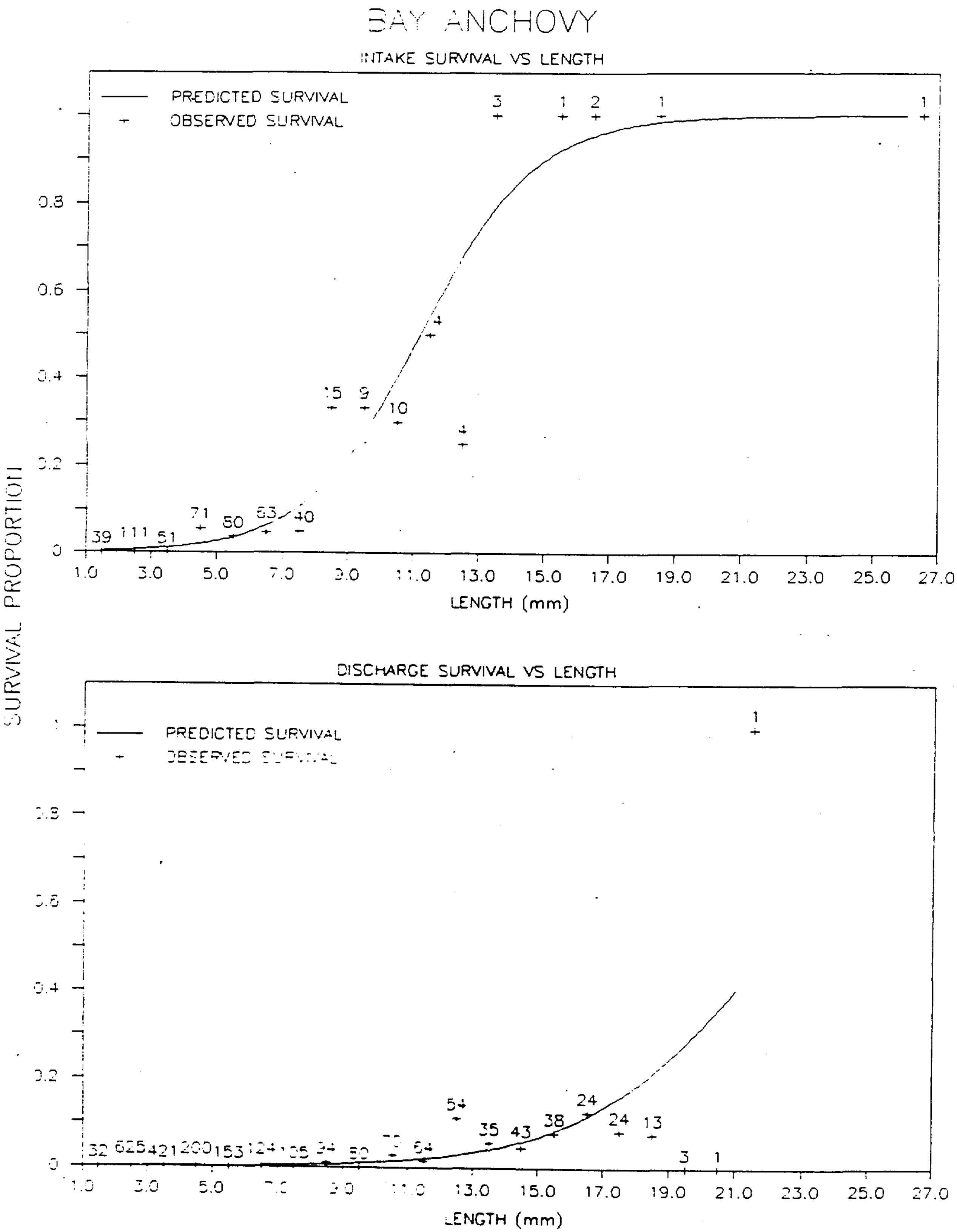

Figure 4-19. **Comparison of observed and predicted initial survival of bay anchovy larvae by length collected at the intake and discharge stations at Indian Point, 1988.**

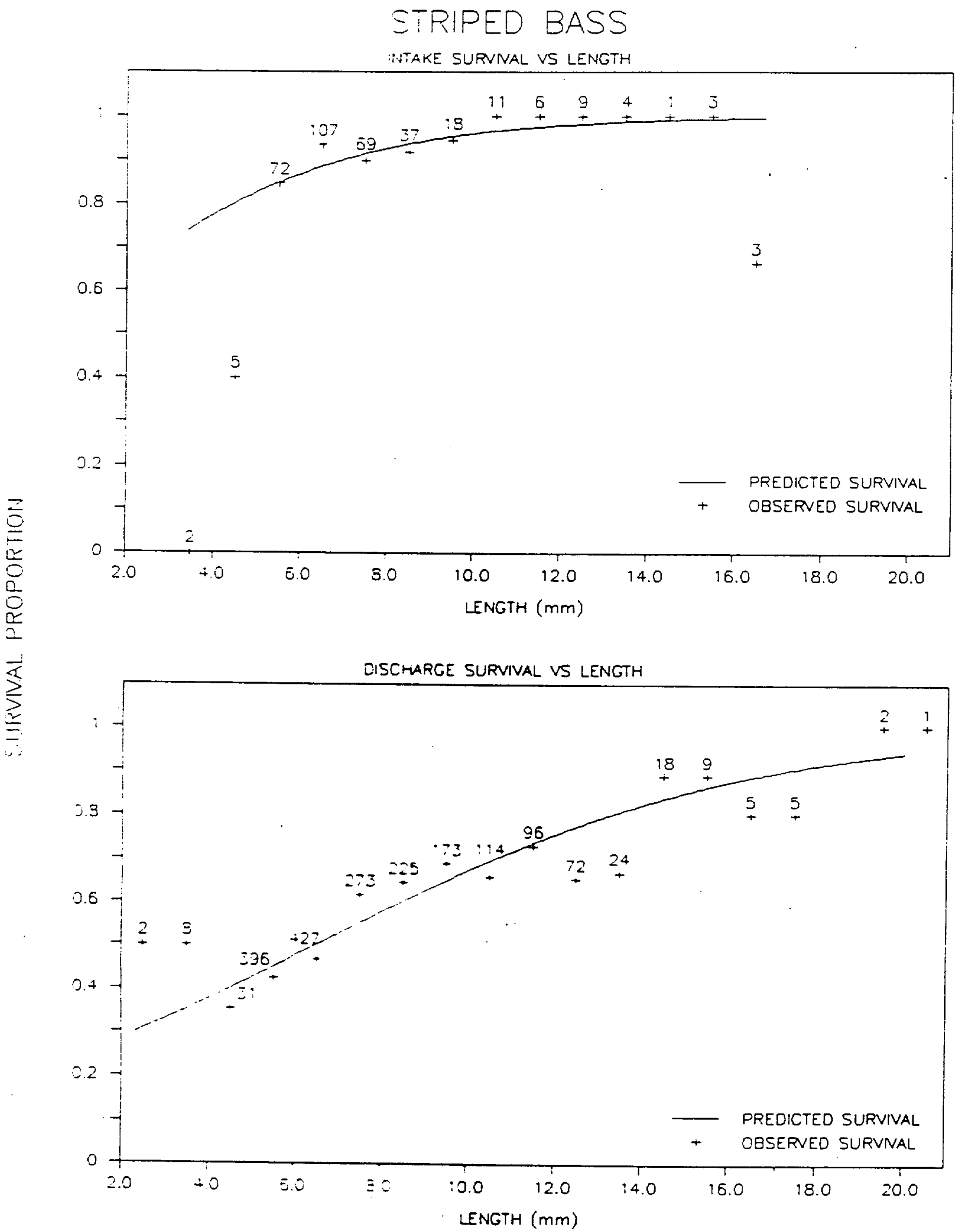

Figure 4-20. Comparison of observed and predicted survival of striped bass larvae by length collected at the intake and discharge stations at Indian Point, 1988.

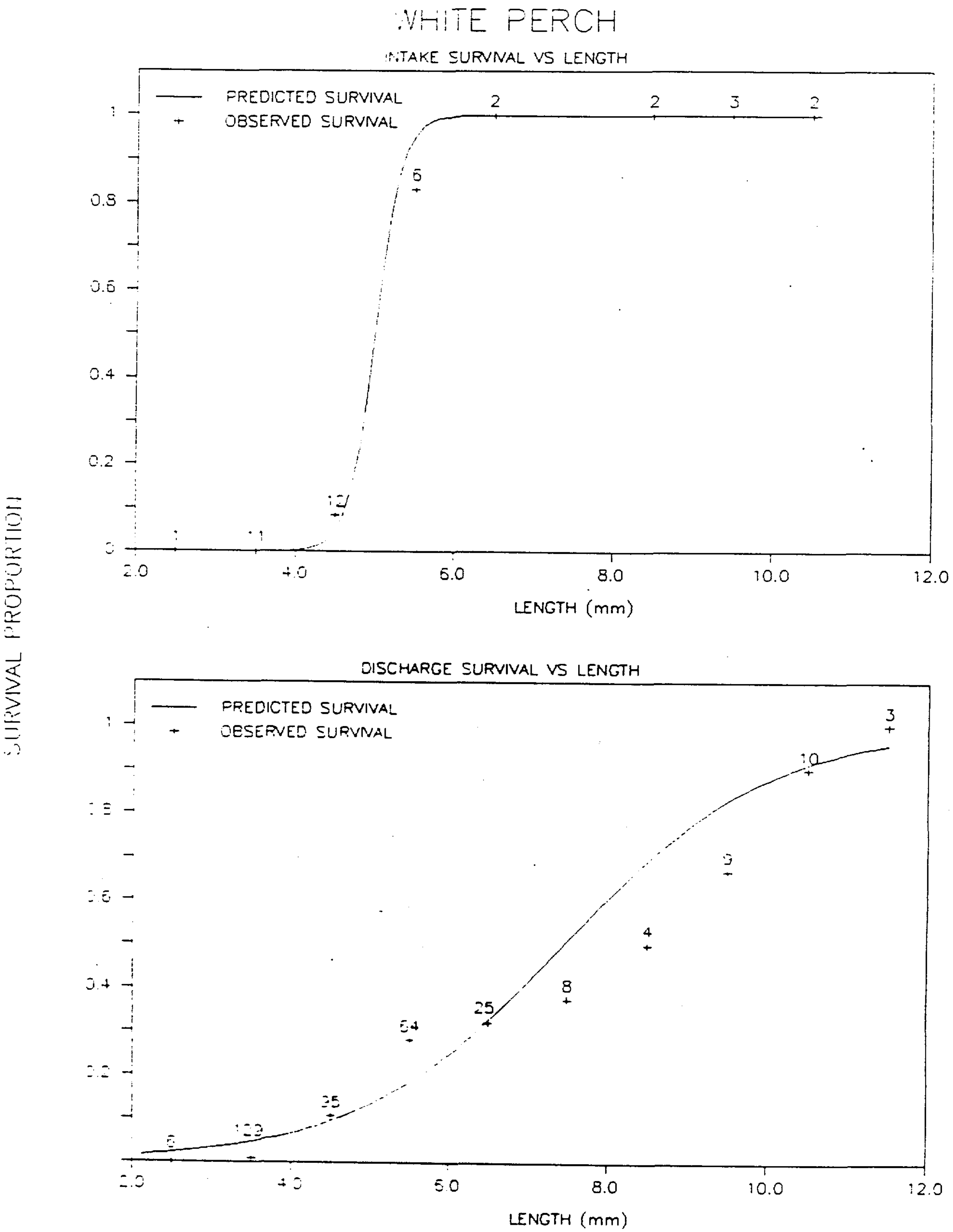

Figure 4-21. Comparison of observed and predicted survival of white perch larvae by length collected at the intake and discharge stations at Indian Point, 1988.

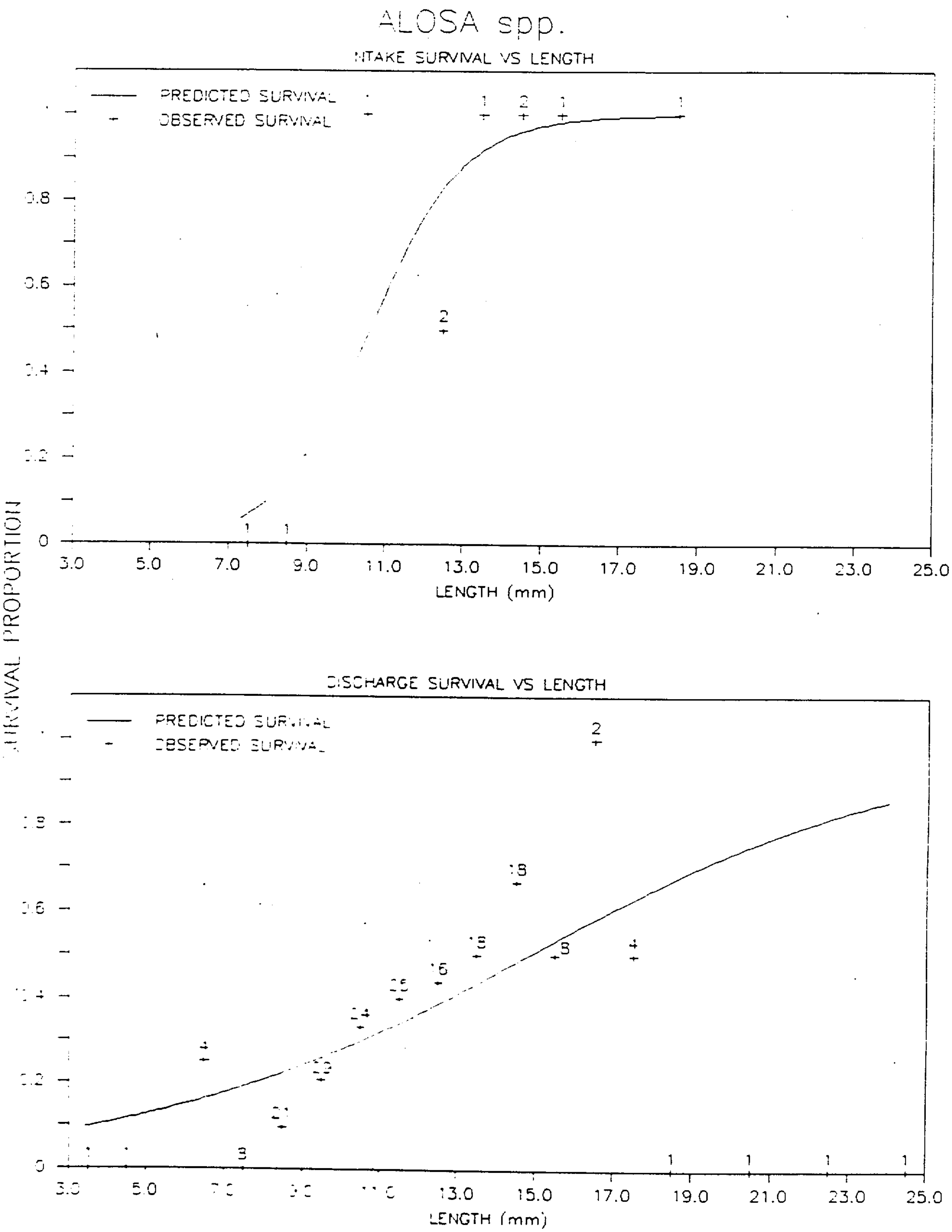

Figure 4-22. Comparison of observed and predicted initial survival of <u>Alosa</u> spp. larvae by length collected at the intake and discharge stations at Indian Point, 1988.

As a final step in this evaluation process, the ML logistic regression model for the discharge station was divided by the ML logistic regression model for the intake station to generate an overall equation relating entrainment survival to length for striped bass larvae. This species was selected for three reasons. First, there were relatively large numbers collected at both the intake and discharge stations. Second, the models at both the intake and discharge stations were significant. Third, as opposed to bay anchovy, entrainment survival was greater than zero over the entire length range.

The resulting relationship in a reduced form is as follows:

$$S_e = \frac{\exp[-(-0.0722 + 0.3276(L))] + 1}{\exp[-(-1.3222 + 0.2041(L))] + 1}$$

where

S_e = estimated entrainment survival.

L = length (mm).

This equation predicts an increase in entrainment survival from just over 50 percent to almost 90 percent over the length range of 5-16 mm (TL). These predicted values were consistent with estimates of entrainment survival calculated for 1-mm length intervals using the observed intake and discharge values (Figure 4-23). This consistency between observed and predicted values lends support to the validity of this equation to predict entrainment survival at Indian Point based on length for striped bass larvae at temperatures below those necessary to induce thermal mortality.

The relationship between larval length and survival provides a means to compare the results of entrainment survival studies conducted at Indian Point in other years. In 1980, initial intake and discharge survival for striped bass larvae was 5-10 percent higher than in 1988. The range of intake temperature (1980: 19.7-25 C, 1988: 19-25.5 C) and salinity (1980: 1.5-3.1 ppt, 1988: 0.3-4.1 ppt) was similar in both studies, but the length-frequency distribution of striped bass in discharge samples was not (Figure 4-24). The greater proportion of smaller larvae collected in 1988 is sufficient to explain the difference in entrainment survival between 1980 and 1988.

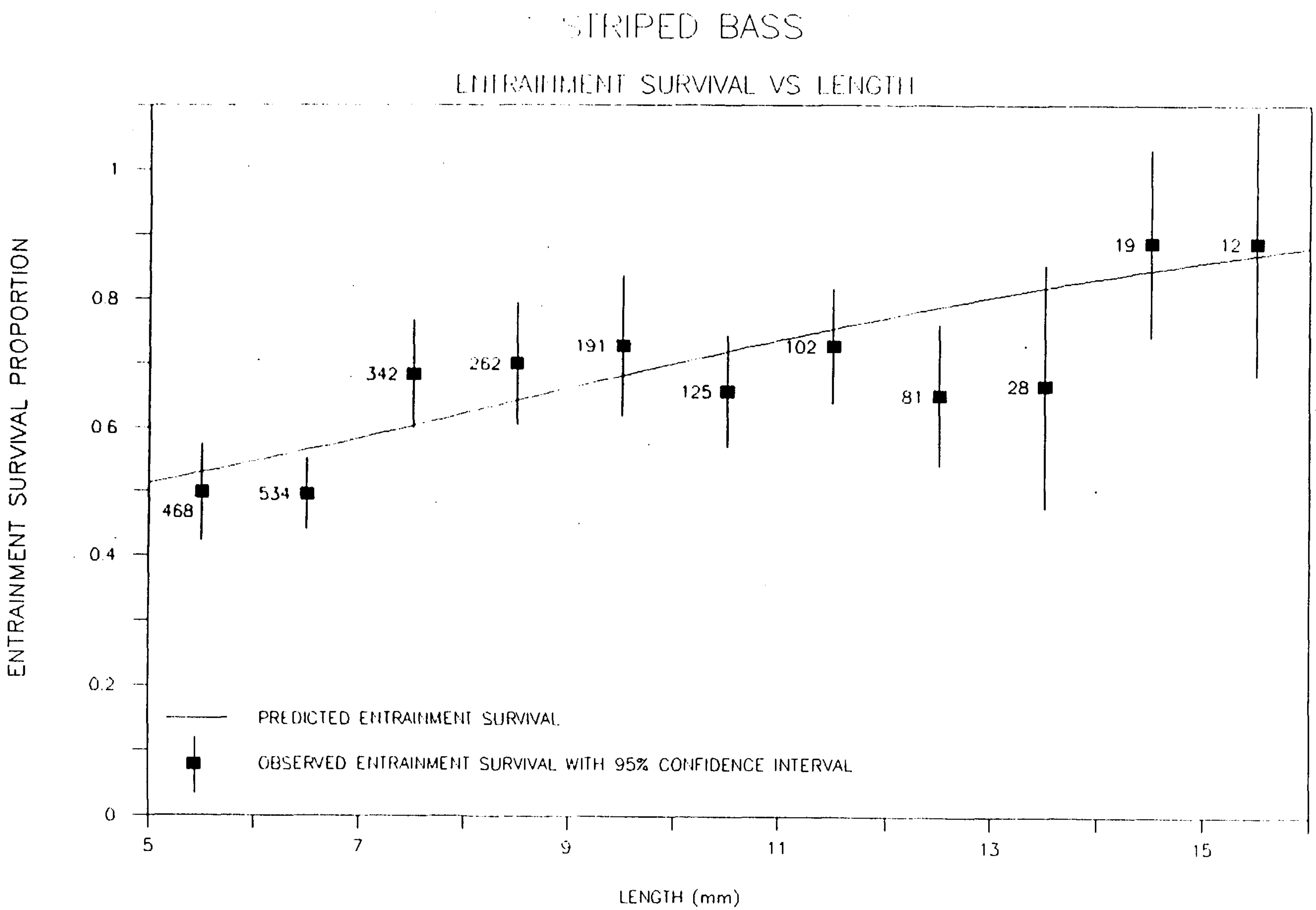

Figure 4-23. Comparison of observed and predicted initial entrainment survival versus length for striped bass larvae collect at Indian Point, 1988.

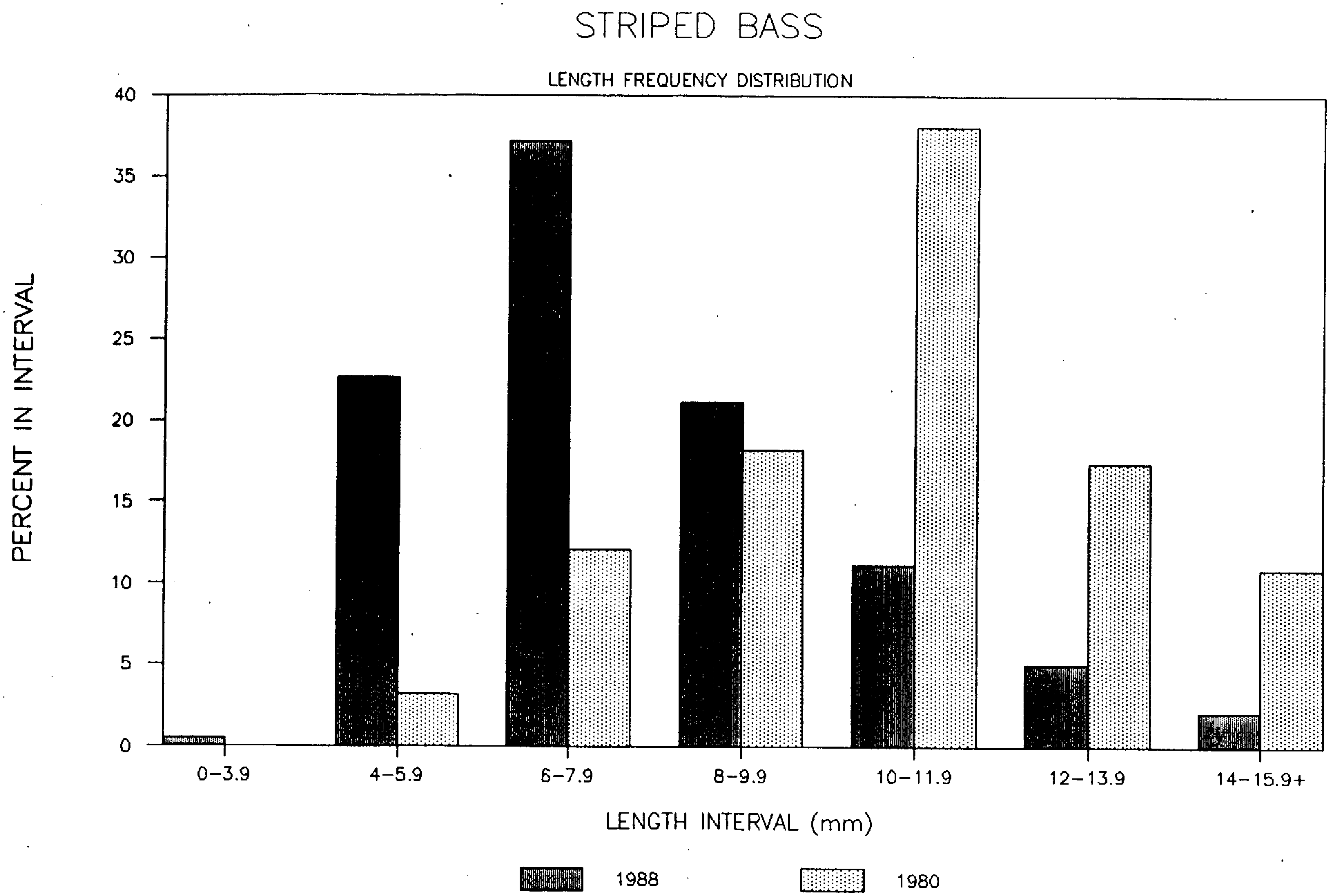

Figure 4-24. Comparison of length frequency distribution of striped bass larvae collected at Indian Point Point during entrainment survival studies, 1980 and 1988.

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APPENDIX A

QUALITY CONTROL SAMPLING

A.1 ICHTHYOPLANKTON SORTING AND IDENTIFICATION
A.2 SAMPLING STRESS EVALUATIONS

LIST OF FIGURES

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APPENDIX A.1

ICHTHYOPLANKTON SORTING AND IDENTIFICATION

APPENDIX A.1

QUALITY CONTROL SAMPLING

Quality control sampling procedures were applied to ichthyoplankton sorting and identification for flume and net samples collected during the 1988 Entrainment Survival Study. For flume samples, the initial sorting effort occurred at the onsite laboratory immediately after the sample was collected. The sample was examined to remove live ichthyoplankton, checked for accuracy by another qualified individual, then re-examined to determine if any dead organisms remained in the sample. After field sorting was complete, the sample residue was preserved with formalin and transported to EA's laboratory facility. All samples were then resorted to determine whether any organisms had been missed. Laboratory sorting of flume samples returned 5,030 additional organisms, 35.4 percent of the total number collected (Table A.1-1). The majority of larvae were missed during the last week of sampling. Between 8 and 23 June 1988, 10.7 percent of the catch for the period were not sorted in the field; from 27 through 30 June 1988, 47.2 percent were missed (Table A.1-1). The change in the sorting success rate coincided with the appearance of large numbers of very small (median length 3.7-4.0 mm) bay anchovy larvae (Figure A.1-1, Table C-2) in samples, suggesting that small size was a major factor affecting sorting efficiency under field conditions. Larvae not sorted from samples in the field were presumed to have been collected dead for the purposes of survival calculations. This was in fact their most likely condition, since length was correlated with low probability of live capture (Section 4.2.2), even for larvae large enough to be seen and efficiently removed from samples in the field. The effective reduction in entrainment survival values resulting from apparent field sorting bias against smaller larvae (particularly bay anchovy) was considered to be negligible.

Net samples were preserved in the field and transported to the offsite laboratory for sorting. After sorting, samples (net and flume) entered a pool subject to reinspection based on a continuous sampling plan (Duncan 1974). The first 10 samples completed were resorted. If all 10 samples were within tolerance (no more than 5 percent additional organisms recovered), one sample was resorted at random from each subsequent lot of 10 samples completed. If a resorted sample was out of tolerance, subsequent samples were resorted consecutively until 10 samples in a row were found within tolerance. Concurrently, steps were taken to improve the accuracy of the primary sorting effort.

Quality control sorting for flume and net samples returned 301 missed organisms (Table A.1-1). There were five failures from 122 samples reinspected, for an AOQ of 4.1 percent. The organism error rate was 0.4 percent.

Identification quality control consisted of reidentification of ichthyoplankton in selected samples as described above. An error was defined as a difference in count or identification between the two identifiers for any taxon and life stage. A sample was considered to have failed inspection if the total number of errors was greater than 10 percent of the number of organisms in the sample.

Five of 88 samples reidentified had error rates greater than 10 percent, for a defective rate of 5.7 percent. Overall, the number of errors as a fraction of total organisms was 2.0 percent.

TABLE A.1-1 SUMMARY OF QUALITY CONTROL SAMPLING FOR SORTING AND IDENTIFICATION

Sorting

Lab sort as QC on field sort of flume samples (including sampling stress samples): 100 percent reinspection.

Number of Samples	638
Total Ichthyoplankton	14,226
Number of Organisms Missed	5,030
Error Rate	
Before 27 June 1988	10.7 percent (lab count/total count)
After 27 June 1988	47.2 percent

QC on laboratory sorting (all samples).

Total Number of Samples	680
Total Ichthyoplankton	75,277
Samples Reinspected	122
Number of Organisms Missed	301
Number of Failed[a] Samples	5
Error Rates	
Sample	4.1 percent (failed samples/samples reinspected)
Organism	0.40 percent (QC count/total count)
Average, Per Sample	0.62 percent (sum of sample error rate/total samples reinspected)

Identification (all samples)

Total Samples	369
Samples Reinspected	88
Total Ichthyoplankton	5,769
Total Errors	160
Failed Samples[b]	5
Error Rates	
Sample	5.7 percent (failed samples/samples reinspected)
Organism	2.0 percent (total errors/total count)

a. Failure defined as (number missed/total organisms) >5 percent.
b. Failure defined as (number missed/total organisms) >10 percent.

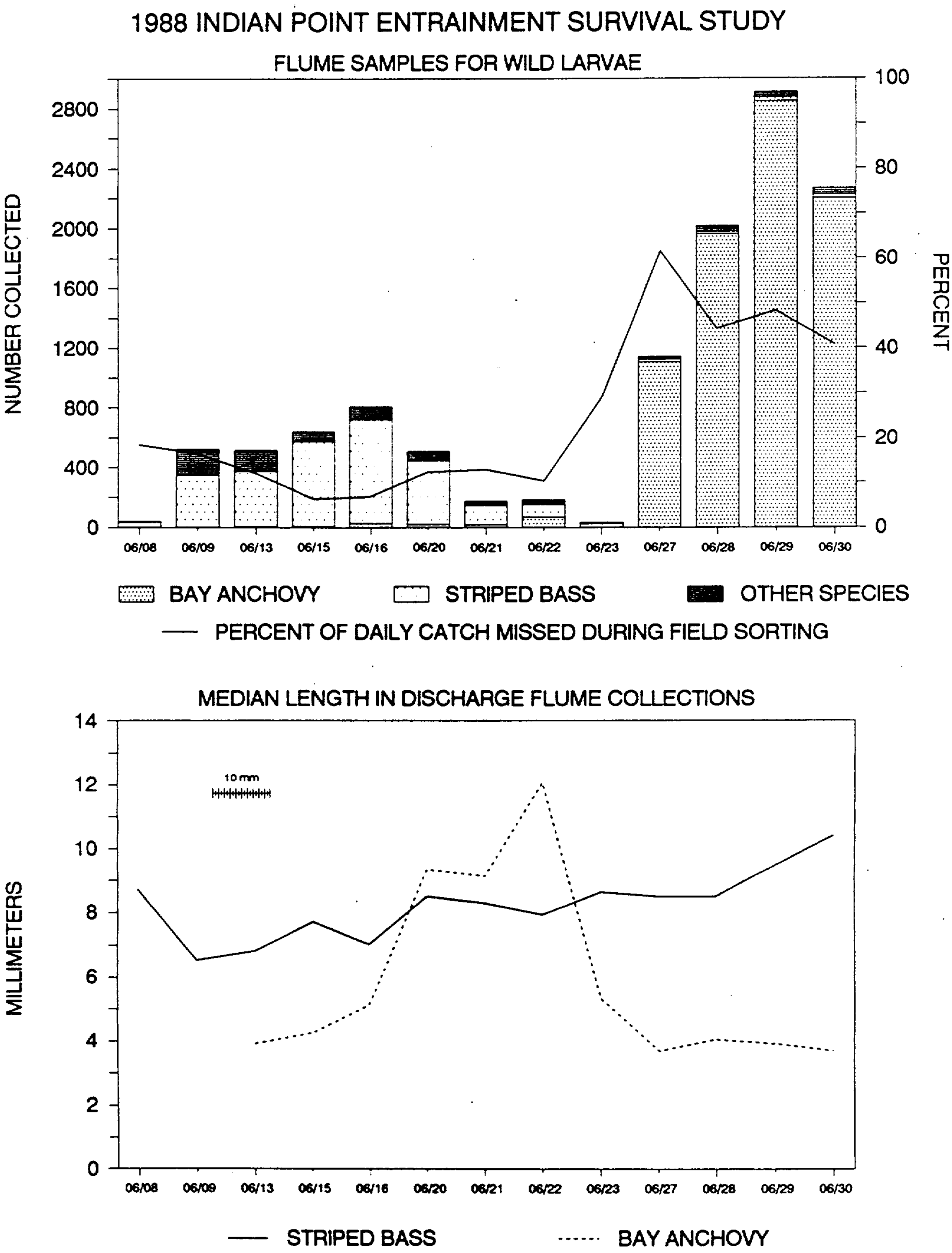

Figure A.1-1. Comparison of daily flume sample size, species composition, field sorting efficiency, and medial length for striped bass and bay anchovy.

APPENDIX A.2

SAMPLING STRESS EVALUATIONS

APPENDIX A.2

SAMPLING STRESS EVALUATION

The objective of the stress evaluation study was to estimate the stress associated with the separate components of the sampling process (collection of organisms, handling, and thermal stress), and to test whether these stresses were the same at the intake and discharge stations. Only through this type of evaluation can it be ensured that entrainment survival estimates will be unbiased and, since the precision of entrainment survival estimates is inversely related to sampling stress (Vaughan and Kumar 1982), maximally precise. In 1988, as in the past, early life stages of striped bass were used for the sampling stress evaluation. This species was used because it is the primary species of interest on the Hudson River, it was available in suitable quantities from EA's striped bass hatchery facility, and results should be applicable to other Hudson River species, at least on a relative basis.

Sampling stress evaluation studies conducted with hatchery-reared striped bass indicated considerable variability in initial survival among the different trials (dates), treatments within trials, and among life stages (Tables A.2-1 and A.2-2). Survival of yolk-sac larvae was typically less than observed for post yolk-sac larvae across all treatments and trials ($x^2 = 39.51$; $p < 0.001$). This is apparent comparing Figures A.2-1 and A.2-2. Yolk-sac larvae control survival was high (0.789-1.00), but slightly lower than for post yolk-sac (0.98-1.00). In contrast, gear associated survival for yolk-sac larvae (0.205-0.471) was considerably lower than for post yolk-sac larvae (0.81-0.93). Consequently, the evaluation of other sources of variability in survival was conducted separately by life stages identified in the samples. A multi-dimensional contingency analysis (Sokal and Rohlf 1969) confirmed the non-independence of survival and the various experimental treatments for yolk-sac ($G = 281.34$; $p < 0.001$) (Table A.2-3) and post yolk-sac larvae ($G = 41.38$; $p < 0.001$) (Table A.2-4). The lack of independence identified between survival and date (yolk-sac, $G = 281.34$; post yolk-sac, $G = 11.65$) probably reflects differences in sensitivity among roe batches used on different dates and increased tolerance with age within each life stage. The test of treatment X date independence (i.e., equality of sample sizes for all trials) and the survival X treatment X date interaction were also highly significant. Since the survival X treatment independence test was of primary interest, the G-value was partitioned into single-degree-of-freedom orthogonal comparisons (Tables A.2-3 and A.2-4 and Figures A.2-1 and A.2-2). (NOTE: The critical G-value for a 1 degree-of-freedom test is 3.84.) These comparisons indicate that for yolk-sac larvae: (1) survival rates varied significantly among the intake and the discharge samplers; (2) survival of intake handling controls and discharge handling controls and the thermal controls did not vary significantly; (3) the survival of thermal and handling controls was significantly different than the holding controls ($G = 23.62$); and (4) control survival differed significantly from gear survival ($G = 233.39$). For post yolk-sac larvae, the following conclusions are made: (1) handling holding and thermal control survival were not significantly different; (2) no significant difference in survival was observed between the two discharge samplers ($G = 3.15$); (3) survival in the intake and discharge samplers differed significantly ($G = 6.21$); and (4) survival of control treatment and gear treatments were significantly different ($G = 58.68$).

TABLE A.2-1 INITIAL SURVIVAL OF HATCHERY-REARED STRIPED BASS YOLK-SAC LARVAE IN SAMPLING STRESS EVALUATION STUDIES, INDIAN POINT GENERATING STATION, 1988

Date	Duration (Minutes)		Hatchery Control (HC)	Intake Handling Control (IHC)	Intake Sampler (I)	Discharge Handling Control (DHC)	Thermal Control (DTC)	Discharge Sampler Surface (DS)	Discharge Sampler Bottom (DB)	Total
12JUN	15	p	1.000	0.903	0	1.000	0.935	0.200	0.588	0.761
		n	55	62	28	59	46	30	34	314
	30	p	---	---	0	---	---	0.094	0	0.025
		n	---	---	49	---	---	32	40	121
14JUN	15	p	1.000	0.885	0.333	0.746	0.700	0.216	0.425	0.640
		n	58	61	45	71	80	37	87	439
	30	p	---	---	0.491	---	---	0.657	0.811	0.641
		n	---	---	53	---	---	102	37	192
23JUN	15	p	---	---	---	---	---	---	---	---
		n	---	---	---	---	---	---	---	---
	60	p	---	---	---	---	---	0	1.000	0.500
		n	---	---	---	---	---	1	1	2
28JUN	15	p	---	---	---	---	---	---	---	---
		n	---	---	---	---	---	---	---	---

TABLE A.2-2 INITIAL SURVIVAL OF HATCHERY-REARED STRIPED BASS POST YOLK-SAC LARVAE AND JUVENILES IN SAMPLING STRESS EVALUATION STUDIES, INDIAN POINT GENERATING STATION, 1988

Date	Duration (Minutes)		Hatchery Control (HC)	Intake Handling Control (IHC)	Intake Sampler (I)	Discharge Handling Control (DHC)	Thermal Control (DTC)	Discharge Sampler Surface (DS)	Discharge Sampler Bottom (DB)	Total
12JUN	15	p	---	---	0.600	---	0	0.671	0.767	0.707
		n	---	---	25	---	1	76	103	205
	30	p	---	---	0.915	---	---	0.833	0.333	0.846
		n	---	---	47	---	---	12	6	65
14JUN	15	p	---	---	1.000	---	---	0.691	1.000	0.717
		n	---	---	1	---	---	55	4	60
	30	p	---	---	0.833	---	---	0.643	0.755	0.736
		n	---	---	6	---	---	28	110	144
23JUN	15	p	1.000	1.000	1.000	1.000	0.990	0.990	0.990	0.995
		n	100	101	69	100	100	98	97	665
	60	p	---	---	0.978	---	---	0.963	0.981	0.74
		n	---	---	90	---	---	109	106	305
28JUN	15	p	---	---	0.984	---	---	---	---	0.984
		n	---	---	64	---	---	---	---	64

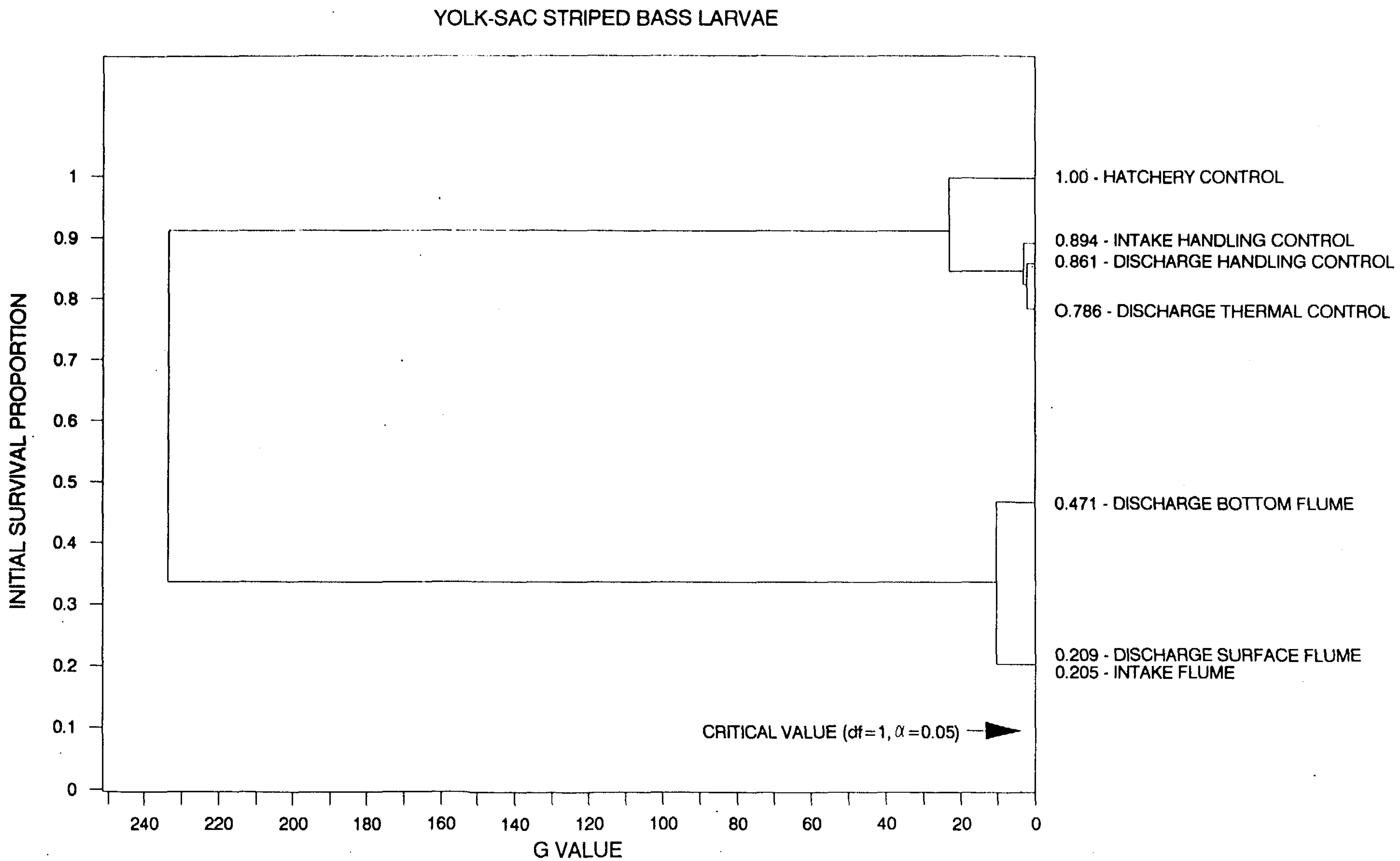

Figure A.2-1. Partitioned G-tests for survival (initial) x treatment independence test (Table A.2-4) for hatchery-reared striped bass yolk-sac larvae in sampling stress evaluation studies, Indian Point Generating Station, 1988.

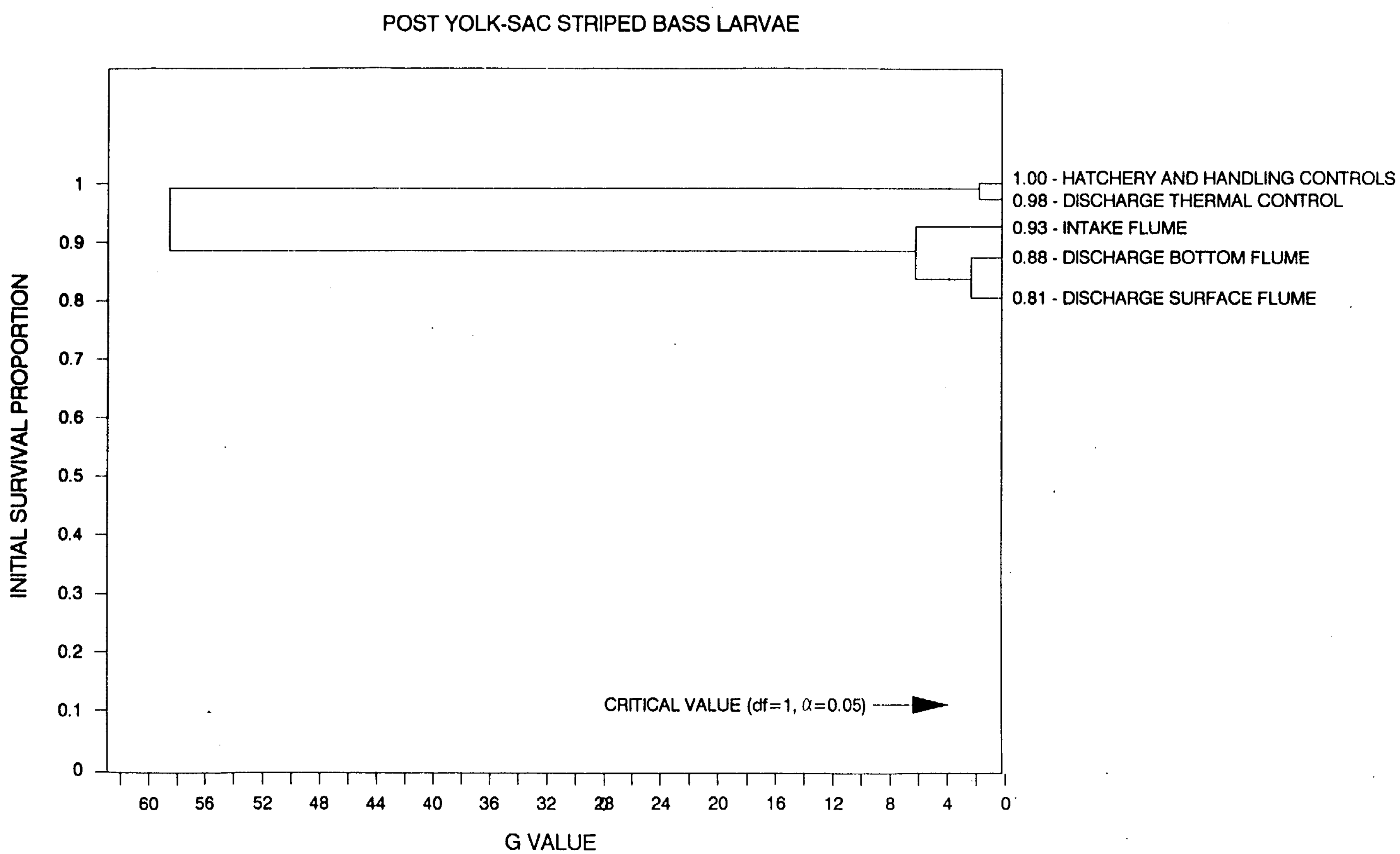

Figure A.2-2. Partitioned G-tests for the survival (initial) x treatment independence test (Table A.2-3) for hatchery-reared striped bass post yolk-sac larvae in sampling stress evaluation studies, Indian Point Generating Station, 1988.

TABLE A.2-3 THREE-WAY TEST OF INDEPENDENCE OF SURVIVAL (INITIAL), TREATMENT, AND DATE FOR YOLK-SAC STRIPED BASS IN SAMPLING STRESS EVALUATION STUDIES, INDIAN POINT GENERATING STATION, 1988

Test	df	G
Survival x Treatment Independence	6	218.34*
DS vs. DB	(1)	12.15*
(DS + DB) vs. I	(1)	6.79*
DHC vs. DTC	(1)	2.39
(DHC + TC) vs. IHC	(1)	2.99
(IHC + DHC + TC) vs. HC	(1)	23.62*
(IHC + DHC + TC + HC) vs. (DS + DB+ I)	(1)	233.39*
Survival x Date Independence	1	11.65*
Treatment x Date Independence	6	17.74*
Survival x Treatment x Date Interaction	6	31.86*
Survival x Treatment x Date Independence	19	342.59*

* Significant at $\alpha = 0.05$.

NOTE: HC = hatchery control; IHC = intake handling control; DHC = discharge handling control; I = intake sampler; DS = surface discharge sampler; DB = bottom discharge sampler; TC = discharge thermal control.

TABLE A.2-4 THREE-WAY TEST OF INDEPENDENCE OF SURVIVAL (INITIAL), TREATMENT, AND DATE FOR POST YOLK-SAC STRIPED BASS IN SAMPLING STRESS EVALUATION STUDIES, INDIAN POINT GENERATING STATION, 1988

Test	df	G
Survival x Treatment Independence	6	41.38*
DHC vs. TC	(1)	1.88
(DHC + TC) vs. IHC	(1)	0.85
DHC + TC + IHC vs. HC	(1)	0.47
DB vs. DS	(1)	3.15
(DB + DS) vs. I	(1)	6.21*
(HC + IHC + DHC + TC) vs. (DB + DS + I)	(1)	58.68*
Survival x Date Independence	3	199.12*
Treatment x Date Independence	4	705.45*
Survival x Treatment x Date Interaction	6	89.41*
Survival x Treatment x Date Independence	19	856.65*

* Significant at $\alpha = 0.05$.

NOTE: HC = hatchery control; IHC = intake handling control; DHC = discharge handling control; I = intake sampler; DS = surface discharge sampler; DB = bottom discharge sampler; TC = discharge thermal control.

Based on initial survival, gear stress for post yolk-sac larvae was higher at the discharge than at the intake station. This difference of 0.09 (pooling the surface and bottom samplers) between stations would, if undetected, result in a downward bias in survival estimates for entrained larvae. Survival proportions at the intake and discharge, 0.931 and 0.843, respectively, were lower than observed for similar rear-draw flumes in 1980, 0.995 and 0.965 (EA 1982), or barrel samplers in 1985, 0.953 and 0.904 (EA 1986).

Differences between intake and discharge gear were not as well defined for yolk-sac larvae. Survival in the bottom discharge samplers (0.471) was more than twice that observed in the surface sampler (0.209). Survival at the intake (0.205) was similar to that observed for the surface discharge sampler.

Based on initial survival, yolk-sac larvae were considerably more sensitive to gear stress than post yolk-sac larvae. Although this is consistent with previous studies (EA 1982), the magnitude of the difference was much greater than in 1980 using similar gear. Intake and discharge survival in 1980 was 0.926 and 0.856 for yolk-sac larvae whereas in 1988 survival was 0.205 and 0.378, respectively.

As in previous studies (EA 1982, 1986), survival was found to increase with size of the larvae. Resistance to the stress of handling and sampling increased with size (Figures A.2-3 and A.2-4). Above 10 mm total length, all larvae generally survived. Initial survival of controls was generally higher than for the same size fish from the sampling gear. Survival of handling controls between 2 and 10 mm was typically greater than 70 percent with an apparent increase in sensitivity for 5 and 6 mm larvae (Figure A.2-3). This is the approximate size of transition to post yolk-sac larvae, establishment of a functional gut, and the initiation of exogenous feeding. The smallest larvae (1-3 mm) generally did not survive sampling stress at the intake or discharge (Figure A.2-4). Because striped bass yolk-sac larvae are generally 3 mm or larger at hatching, it is likely that these larvae (<3 mm) were premature due to rupture of the chorionic membrane of eggs during testing. Above 3 mm, survival increased steadily to 100 percent as larvae approached 11 mm. Larvae between 3 and 6 mm demonstrated higher survival in the bottom discharge flume than in the intake or surface discharge flumes which is consistent with the observation that survival of yolk-sac larvae was significantly higher in the bottom discharge flume than the intake and surface discharge flume.

The apparent increase in sampling stress between the 1985 and 1988 studies was a function of the difference in size distribution of larvae between the two studies. The smallest larvae during the 1985 study were 8 mm, whereas 65, 53, and 43 percent of the larvae from the bottom and surface discharge and intake samplers, respectively, were less than 8 mm during 1988. Initial survival for larvae 8 mm and larger was similar between the two years.

It has been observed in past studies that the duration of sampling can affect survival of larvae; however, this relationship was not clear from the 1988 studies. Initial yolk-sac survival was significantly different between 15- and 30-minute tests ($G = 3.27$) (Table A.2-5). Significant differences were observed for post yolk-sac larvae among the three test durations (15, 30, and 60 minutes) (Table A.2-6); however, no clear pattern related to duration was observed. The longest duration (60 minutes) produced the highest survival

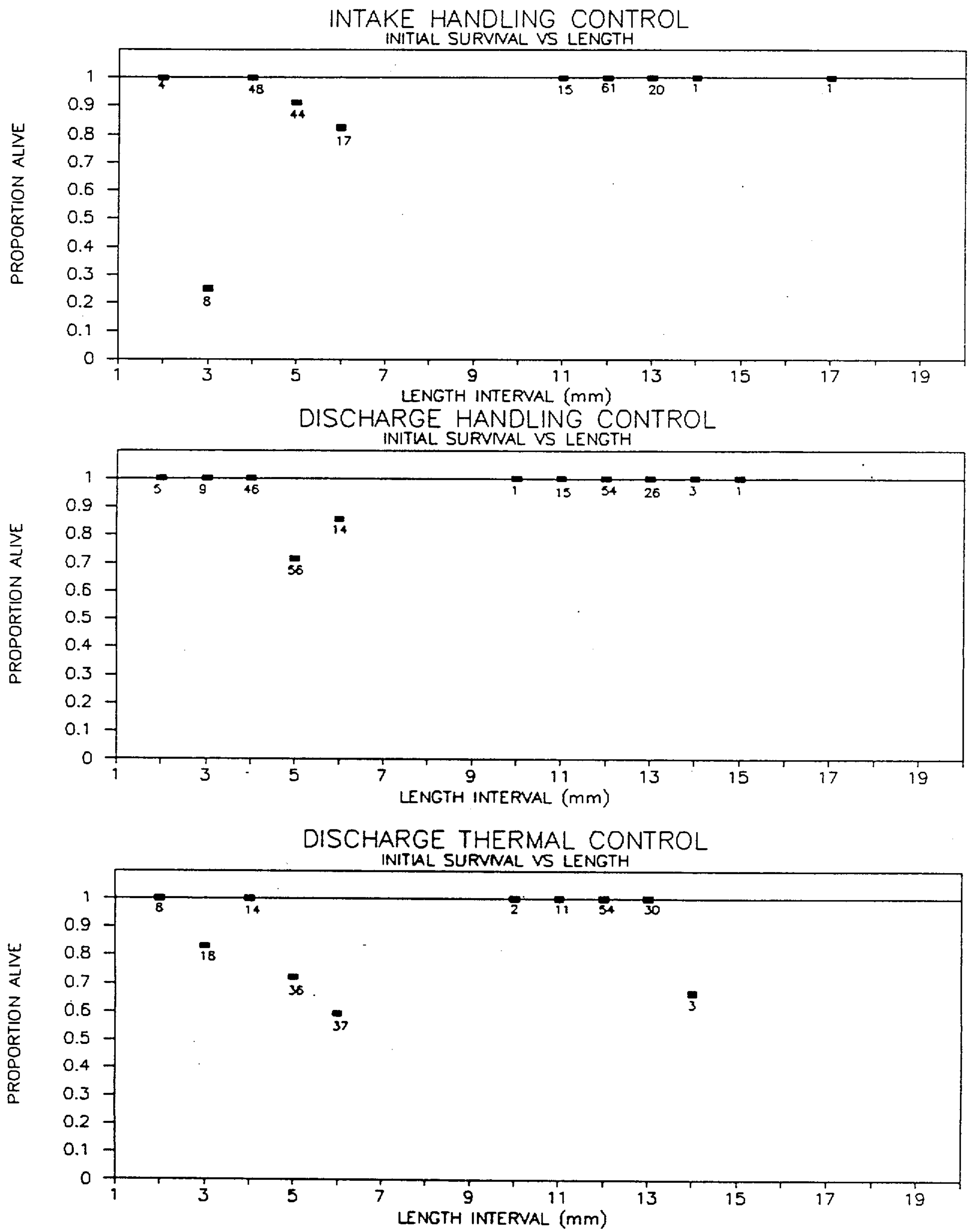

Figure A.2-3. Initial survival as a function of length for hatchery-reared striped bass in handling and thermal controls of the sampling stress evaluation studies, Indian Point Generating Station, 1988. (Numbers below data points indicate sample size.)

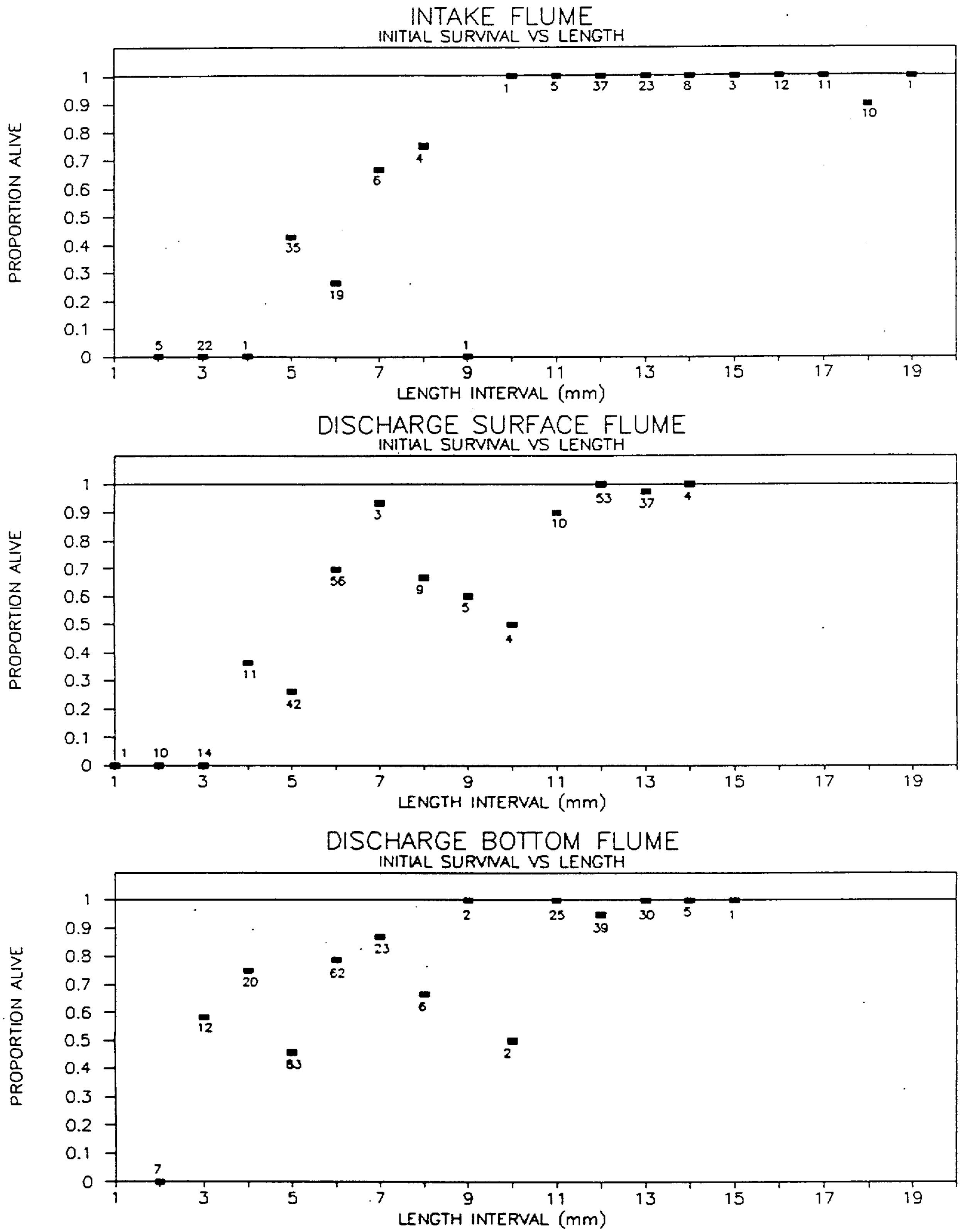

Figure A.2-4. Initial survival as a function of length for hatchery-reared striped bass in intake and discharge flumes in the sampling stress evaluation studies, Indian Point Generating Station, 1988. (Numbers below data points indicate sample size.)

TABLE A.2-5 THREE-WAY TEST OF INDEPENDENCE OF SURVIVAL (INITIAL), TREATMENT, AND DURATION OF SAMPLE OPERATION FOR YOLK-SAC STRIPED BASS IN SAMPLING STRESS EVALUATION STUDIES, INDIAN POINT GENERATING STATION, 1988

Test	df	G
Survival x Treatment Independence	2	20.76*
Survival x Duration Independence	1	3.27
Treatment x Duration Independence	2	32.74*
Survival x Treatment x Duration Interaction	2	17.61*
Survival x Treatment x Duration Independence	7	74.38

* Significant at $\alpha = 0.05$.

TABLE A.2-6 THREE-WAY TEST OF INDEPENDENCE OF SURVIVAL (INITIAL), TREATMENT, AND DURATION OF SAMPLE OPERATION FOR POST YOLK-SAC STRIPED BASS IN SAMPLING STRESS EVALUATION STUDIES, INDIAN POINT GENERATING STATION, 1988

Test	df	G
Survival x Treatment Independence	2	5.19
Survival x Duration Independence	2	60.77*
15 vs. 30	(1)	5.96
(15 + 30) vs. 60	(1)	54.81*
Treatment x Duration Independence	4	50.62*
Survival x Treatment x Duration Interaction	4	6.04
Survival x Treatment x Duration Independence	12	122.61*

* Significant at $\alpha = 0.05$.

(0.974) while the intermediate 30-minute duration produced the lowest survival (0.767). The affects of duration may have been masked by differences in roe batch sensitivity and the age (length) of larvae between test dates. This variability is particularly apparent in the 15-minute exposure tests (Table A.2-2) for which survival improved over the first three test dates with maximum survival on 23 June, the same date as roe batch as the only 60-minute duration test.

Extended survival generally declined through the 24-hour observation period following the test treatment exposure (Figure A.2-5). The rate of decline was greater for yolk-sac larvae than post yolk-sac larvae. For post yolk-sac larvae, survival was nearly 100 percent through the 24-hour observation period for all control treatments and the 60-minute gear exposures while the greatest mortality occurred for the 30-minute gear exposure. Differences among gear exposure durations are probably an artifact of a limited number of replicate for each exposure and variability in sensitivity of larvae from different roe batches and of different ages used for each test date. Although some gear effects on extended survival are apparent for post yolk-sac larvae when compared to control treatment, no consistent pattern was observed to indicate that delayed mortality differed between the intake and discharge stations. For yolk-sac larvae, the mortality rates during the 24-hour observation period were generally similar among control, intake, and discharge gear treatments.

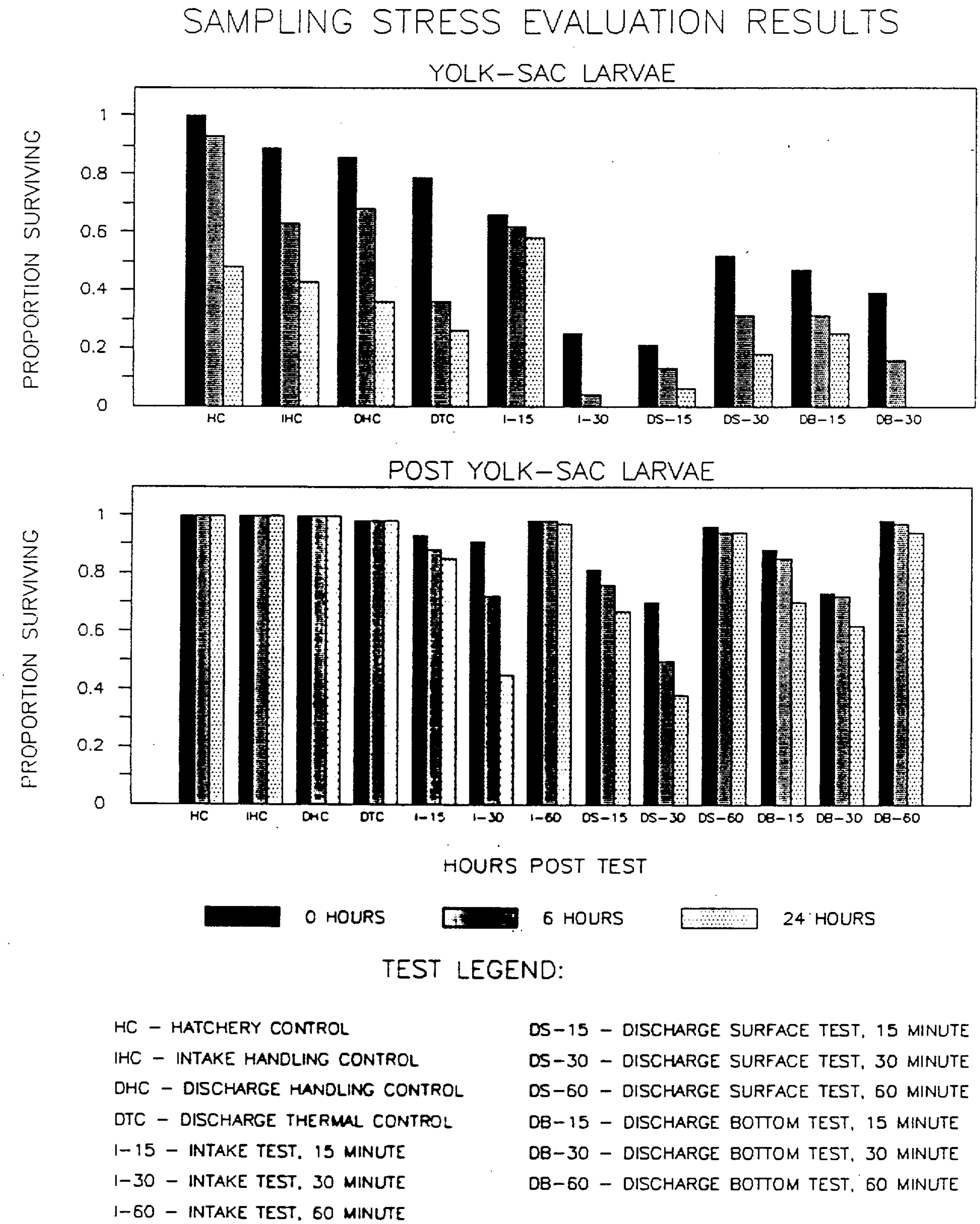

Figure A.2-5. Extended survival of hatchery-reared striped bass observed during sampling stress evaluation studies, Indian Point Generating Station, 1988.

APPENDIX A
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APPENDIX B

DAILY AVERAGE DENSITY DATA FOR BAY ANCHOVY, STRIPED BASS, WHITE PERCH, AND HERRINGS (*ALOSA* SPP.) COLLECTED DURING ENTRAINMENT SURVIVAL STUDIES AT INDIAN POINT GENERATING STATION, 1988

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TABLE B-1 DAILY AVERAGE DENSITY OF BAY ANCHOVIES IN INTAKE AND DISCHARGE FLUME SAMPLES AND DISCHARGE NET SAMPLES COLLECTED DURING ENTRAINMENT SURVIVAL STUDIES AT INDIAN POINT GENERATING STATION, 1988

Date	Total Volume (Cu. m)	Daily Average Density (No./1,000 cu. m) Egg	Yolk-Sac Larvae	Post Yolk-Sac Larvae	Juvenile	Total (Non-Egg)
Discharge Flume Samples						
12JUN88	110.7	0.00	0.00	36.13	0.00	36.13
13JUN88	316.2	0.00	0.00	12.65	0.00	12.65
14JUN88	223.5	0.00	0.00	4.47	0.00	4.47
15JUN88	265.1	0.00	0.00	15.09	0.00	15.09
16JUN88	265.6	0.00	0.00	86.60	0.00	86.60
20JUN88	336.8	0.00	0.00	41.57	0.00	41.57
21JUN88	378.0	0.00	0.00	34.39	2.65	37.04
22JUN88	378.5	0.00	0.00	174.37	0.00	174.37
23JUN88	295.6	3.38	0.00	159.00	0.00	159.00
27JUN88	369.8	124.39	24.34	2696.05	0.00	2,720.39
28JUN88	339.9	294.20	300.09	4,510.15	0.00	4,810.24
29JUN88	372.2	115.53	617.95	6,200.97	0.00	6,818.91
30JUN88	260.2	3.84	465.03	7,478.86	0.00	7,943.89
Intake Flume Samples						
15JUN88	131.9	0.00	0.00	7.58	0.00	7.58
16JUN88	130.0	0.00	0.00	15.38	0.00	15.38
20JUN88	165.5	0.00	0.00	24.17	0.00	24.17
21JUN88	188.0	0.00	0.00	5.32	0.00	5.32
22JUN88	187.2	0.00	0.00	10.68	0.00	10.68
23JUN88	94.2	0.00	0.00	21.23	0.00	21.23
27JUN88	185.3	86.35	0.00	199.68	0.00	199.68
28JUN88	170.2	111.63	481.79	734.43	0.00	1,216.22
29JUN88	183.3	103.66	458.27	894.71	0.00	1,352.97
30JUN88	112.8	8.87	230.50	939.72	0.00	1,170.21
Discharge Net Samples						
10JUN88	8,863.5	0.00	0.00	0.11	0.00	0.11
14JUN88	6,218.3	0.16	0.00	0.96	0.00	0.96
30JUN88	2,254.8	10.20	0.00	8,454.41	0.00	8,454.41

TABLE B-2 DAILY AVERAGE DENSITY OF STRIPED BASS IN INTAKE AND DISCHARGE FLUME SAMPLES AND DISCHARGE NET SAMPLES COLLECTED DURING ENTRAINMENT SURVIVAL STUDIES AT INDIAN POINT GENERATING STATION, 1988

		Daily Average Density (No./1,000 cu. m)				
Date	Total Volume (Cu. m)	Egg	Yolk-Sac Larvae	Post Yolk-Sac Larvae	Juvenile	Total (Non-Egg)
Discharge Flume Samples						
08JUN88	71.7	0.00	41.84	334.73	0.00	376.57
09JUN88	259.7	19.25	180.98	893.34	0.00	1,074.32
10JUN88	144.2	1,012.48	152.57	485.44	0.00	638.00
12JUN88	110.7	108.40	1,228.55	1,779.58	0.00	3,008.13
13JUN88	316.2	0.00	173.94	885.52	0.00	1,059.46
14JUN88	223.5	0.00	1,516.78	1,659.96	0.00	3,176.73
15JUN88	265.1	0.00	116.94	1,780.46	0.00	1,897.40
16JUN88	265.6	0.00	192.02	2,217.62	3.77	2,413.40
20JUN88	336.8	0.00	50.48	905.58	14.85	970.90
21JUN88	378.0	0.00	13.23	267.20	2.65	283.07
22JUN88	378.5	0.00	13.21	187.58	0.00	200.79
23JUN88	295.6	0.00	6.77	1,420.84	0.00	1,427.60
27JUN88	369.8	0.00	0.00	37.86	0.00	37.86
28JUN88	339.9	0.00	0.00	44.13	0.00	44.13
29JUN88	372.2	0.00	0.00	53.73	0.00	53.73
30JUN88	260.2	0.00	0.00	80.71	0.00	80.71
Intake Flume Samples						
08JUN88	41.7	0.00	0.00	119.90	0.00	119.90
09JUN88	88.6	33.86	180.59	507.90	0.00	688.49
12JUN88	55.6	17.99	1,384.89	1,294.96	0.00	2,679.86
13JUN88	154.7	0.00	77.57	129.28	0.00	206.85
14JUN88	54.7	0.00	1,791.59	127.97	0.00	1,919.56
15JUN88	131.9	0.00	113.72	363.91	0.00	477.63
16JUN88	130.0	0.00	76.92	338.46	0.00	415.38
20JUN88	165.5	0.00	138.97	459.21	0.00	598.19
21JUN88	188.0	0.00	10.64	101.06	0.00	111.70
22JUN88	187.2	0.00	10.68	37.39	0.00	48.08
23JUN88	94.2	0.00	0.00	1,687.90	0.00	1,687.90
27JUN88	185.3	0.00	0.00	16.19	0.00	16.19
28JUN88	170.2	0.00	0.00	293.77	88.13	381.90
29JUN88	183.3	0.00	0.00	27.28	0.00	27.28
Discharge Net Samples						
10JUN88	8,863.5	27.30	33.06	527.90	0.00	560.95
14JUN88	6,218.3	0.00	370.04	4,715.92	0.00	5,085.96
30JUN88	2,254.8	0.00	0.00	87.81	0.00	87.81

TABLE B-3 DAILY AVERAGE DENSITY OF WHITE PERCH IN INTAKE AND DISCHARGE FLUME SAMPLES AND DISCHARGE NET SAMPLES COLLECTED DURING ENTRAINMENT SURVIVAL STUDIES AT INDIAN POINT GENERATING STATION, 1988

		Daily Average Density (No./1,000 cu. m)				
Date	Total Volume (Cu. m)	Egg	Yolk-Sac Larvae	Post Yolk-Sac Larvae	Juvenile	Total (Non-Egg)
Discharge Flume Samples						
08JUN88	71.7	0.00	0.00	27.89	0.00	27.89
09JUN88	259.7	3.85	53.91	227.19	0.00	281.09
10JUN88	144.2	6.93	13.87	194.17	0.00	208.04
12JUN88	110.7	0.00	271.00	243.90	0.00	514.91
13JUN88	316.2	3.16	6.33	218.22	0.00	224.54
14JUN88	223.5	4.47	0.00	80.54	0.00	80.54
15JUN88	265.1	0.00	3.77	143.34	0.00	147.11
16JUN88	265.6	0.00	3.77	225.90	0.00	229.67
20JUN88	336.8	0.00	5.94	115.80	0.00	121.73
21JUN88	378.0	0.00	0.00	26.46	0.00	26.46
22JUN88	378.5	0.00	0.00	26.42	0.00	26.42
23JUN88	295.6	0.00	0.00	6.77	0.00	6.77
27JUN88	369.8	0.00	2.70	8.11	0.00	10.82
28JUN88	339.9	0.00	0.00	29.42	0.00	29.42
29JUN88	372.2	0.00	0.00	5.37	0.00	5.37
30JUN88	260.2	0.00	0.00	11.53	0.00	11.53
Intake Flume Samples						
08JUN88	41.7	0.00	23.98	0.00	0.00	23.98
09JUN88	88.6	0.00	0.00	56.43	0.00	56.43
12JUN88	55.6	0.00	359.71	89.93	0.00	449.64
13JUN88	154.7	0.00	0.00	64.64	0.00	64.64
14JUN88	54.7	0.00	0.00	146.25	0.00	146.25
15JUN88	131.9	0.00	0.00	45.49	0.00	45.49
16JUN88	130.0	0.00	0.00	23.08	0.00	23.08
20JUN88	165.5	0.00	0.00	24.17	0.00	24.17
21JUN88	188.0	0.00	0.00	10.64	0.00	10.64
22JUN88	187.2	0.00	0.00	32.05	0.00	32.05
23JUN88	94.2	0.00	0.00	10.62	0.00	10.62
27JUN88	185.3	0.00	5.40	0.00	0.00	5.40
28JUN88	170.2	0.00	0.00	11.75	0.00	11.75
Discharge Net Samples						
10JUN88	8,863.5	0.45	8.24	24.48	0.11	32.83
14JUN88	6,218.3	0.00	0.80	54.52	0.00	55.32
30JUN88	2,254.8	0.00	0.00	0.89	0.00	0.89

TABLE B-4 DAILY AVERAGE DENSITY OF HERRINGS (*ALOSA* SPP.) IN INTAKE AND DISCHARGE FLUME SAMPLES AND DISCHARGE NET SAMPLES COLLECTED DURING ENTRAINMENT SURVIVAL STUDIES AT INDIAN POINT GENERATING STATION, 1988

		Daily Average Density (No./1,000 cu. m)	
Date	Total Volume (Cu. m)	Post Yolk-Sac Larvae	Total (Non-Egg)
Discharge Flume Samples			
08JUN88	71.7	41.84	41.84
09JUN88	259.7	311.90	311.90
10JUN88	144.2	159.50	159.50
12JUN88	110.7	261.97	261.97
13JUN88	316.2	145.48	145.48
14JUN88	223.5	31.32	31.32
15JUN88	265.1	30.18	30.18
16JUN88	265.6	45.18	45.18
20JUN88	336.8	2.97	2.97
21JUN88	378.0	2.65	2.65
22JUN88	378.5	31.70	31.70
23JUN88	295.6	3.38	3.38
28JUN88	339.9	2.94	2.94
29JUN88	372.2	2.69	2.69
Intake Flume Samples			
08JUN88	41.7	23.98	23.98
09JUN88	88.6	22.57	22.57
12JUN88	55.6	107.91	107.91
13JUN88	154.7	32.32	32.32
14JUN88	54.7	18.28	18.28
16JUN88	130.0	7.69	7.69
20JUN88	165.5	6.04	6.04
21JUN88	188.0	5.32	5.32
Discharge Net Samples			
10JUN88	8,863.5	192.81	192.81
14JUN88	6,218.3	47.44	47.44
30JUN88	2,254.8	0.44	0.44

TABLE B-5 DAILY AVERAGE DENSITY OF DYED STRIPED BASS DISCHARGE FLUME AND NET SAMPLES COLLECTED DURING ENTRAINMENT SURVIVAL STUDIES AT INDIAN POINT GENERATING STATION, 1988

Date	Total Volume (Cu. m)	Daily Average Density (No./1,000 cu. m) Post Yolk-Sac Larvae	Total (Non-Egg)
Discharge Flume Samples			
14JUN88	223.5	58.17	58.17
30JUN88	260.2	73.02	73.02
Discharge Net Samples			
14JUN88	6,218.3	80.09	80.09
30JUN88	2,254.8	296.70	296.70

APPENDIX C

LENGTH-FREQUENCY DISTRIBUTION OF SELECTED ICHTHYOPLANKTON TAXA COLLECTED IN FLUME AND NET SAMPLES DURING ENTRAINMENT SURVIVAL STUDIES AT INDIAN POINT GENERATING STATION, 1988

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TABLE C-1 LENGTH-FREQUENCY DISTRIBUTION OF BAY ANCHOVY COLLECTED DURING THE ENTRAINMENT VIABILITY STUDY AT THE INDIAN POINT GENERATING STATION, JUNE 1988, INTAKE FLUME SAMPLES

Date	1.0-1.9	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-8.9	10.0-10.9	11.0-11.9+	N	P	X	MIN	MED	MAX	SD
15JUN88	0	0	0	0	0	1	0	0	0	0	0	1	0	6.6	6.6	6.6	6.6	0
16JUN88	0	0	0	1	0	0	1	0	0	0	0	2	0	6.0	4.9	6.0	7.0	1.5
20JUN88	0	0	0	0	0	1	2	0	0	0	1	4	0	8.1	6.1	7.7	11.1	2.1
21JUN88	0	0	0	0	0	0	0	0	0	0	1	1	0	12.0	12.0	12.0	12.0	0
22JUN88	0	0	0	0	1	1	0	0	0	0	0	2	0	5.7	5.0	5.7	6.5	1.1
27JUN88	0	2	5	5	6	4	5	2	1	3	3	36	17	6.6	2.7	6.0	16.4	3.2
28JUN88	7	54	12	14	23	26	17	5	6	6	8	178	47	5.3	1.7	5.0	26.0	3.3
29JUN88	29	32	19	34	32	19	8	3	2	0	3	181	86	4.3	1.5	4.3	13.6	2.2
30JUN88	3	23	15	17	18	11	7	5	0	1	0	100	33	4.6	1.7	4.5	10.2	1.9
Total	39	111	51	71	80	63	40	15	9	10	16	505	183					

NOTE: N=Number of lengths, MIN=Minimum length, P=Number not measured, MED=Median length, X=Mean length, MAX=Maximum length, SD=Standard deviation.

TABLE C-2 LENGTH-FREQUENCY DISTRIBUTION OF BAY ANCHOVY COLLECTED DURING THE ENTRAINMENT VIABILITY STUDY AT THE INDIAN POINT GENERATING STATION, JUNE 1988, DISCHARGE FLUME SAMPLES

Date	1.0-1.9	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9
13JUN88	0	0	2	1	0	0	0	0	1	0	0	0	0
15JUN88	0	0	1	2	1	0	0	0	0	0	0	0	0
16JUN88	0	0	3	5	7	2	2	1	1	0	0	0	0
20JUN88	0	0	0	0	1	0	2	1	1	0	3	1	0
21JUN88	0	0	0	1	3	0	0	0	2	0	2	1	1
22JUN88	0	1	0	1	0	1	2	2	5	7	12	11	8
23JUN88	0	1	4	3	5	2	2	1	0	0	0	1	1
27JUN88	1	150	99	27	27	16	18	21	20	23	11	10	5
28JUN88	15	130	101	32	30	29	22	30	19	23	13	9	8
29JUN88	13	209	128	84	47	41	39	30	22	10	13	12	5
30JUN88	3	134	83	44	32	33	18	8	9	7	10	9	7
Total	32	625	421	200	153	124	105	94	80	70	64	54	35

Date	14.0-14.9	15.0-15.9	16.0-16.9	17.0-17.9	18.0-18.9+	N	P	X	MIN	MED	MAX	SD
13JUN88	0	0	0	0	0	4	0	5.0	3.2	3.9	9.0	2.7
15JUN88	0	0	0	0	0	4	0	4.5	3.9	4.2	5.7	0.8
16JUN88	0	0	0	0	0	21	2	5.5	3.5	5.1	9.5	1.6
20JUN88	0	0	0	0	0	9	5	9.3	5.9	9.3	12.0	2.2
21JUN88	0	0	0	0	0	10	4	8.7	4.1	9.1	13.6	3.5
22JUN88	6	3	3	1	0	63	3	11.6	2.9	12.0	17.0	2.6
23JUN88	0	0	0	0	0	20	2	6.0	2.9	5.3	13.7	2.8
27JUN88	7	18	2	7	4	466	586	5.9	1.8	3.7	21.0	4.2
28JUN88	14	11	8	7	7	508	1,227	6.1	1.5	4.0	19.0	4.3
29JUN88	12	3	6	6	4	684	1,897	5.2	1.3	3.9	20.0	3.5
30JUN88	4	3	5	3	3	415	1,653	5.2	1.8	3.7	18.0	3.5
Total	43	38	24	24	13	2,204	5,379					

NOTE: N=Number of lengths, MIN=Minimum length, P=Number not measured, MED=Median length, X=Mean length, MAX=Maximum length, SD=Standard deviation.

TABLE C-3 LENGTH-FREQUENCY DISTRIBUTION OF STRIPED BASS COLLECTED DURING THE ENTRAINMENT VIABILITY STUDY AT THE INDIAN POINT GENERATING STATION, JUNE 1988, INTAKE FLUME SAMPLES

Date	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9+	N	P	X	MIN	MED	MAX	SD
08JUN88	0	0	0	0	2	1	1	0	0	1	0	5	0	8.9	7.3	8.5	12.0	1.9
09JUN88	1	1	19	15	8	5	1	2	1	6	1	60	4	7.3	3.7	6.2	13.0	2.3
13JUN88	1	1	7	14	.3	1	1	0	0	0	1	29	3	6.5	3.4	6.1	15.1	2.0
15JUN88	0	1	8	13	15	5	2	5	5	2	6	62	1	8.5	4.3	7.5	16.7	3.0
16JUN88	0	1	16	14	14	4	3	1	0	0	1	54	0	6.8	4.9	6.3	13.6	1.6
20JUN88	0	1	19	36	14	16	9	2	0	0	1	98	1	7.1	4.5	6.8	13.0	1.4
21JUN88	0	0	2	7	8	4	0	0	0	0	0	21	0	7.0	5.8	7.0	8.2	0.8
22JUN88	0	0	0	6	2	0	0	1	0	0	0	9	0	7.2	6.2	6.9	10.0	1.1
27JUN88	0	0	0	1	1	0	1	0	0	0	0	3	0	7.6	6.5	7.3	9.1	1.3
28JUN88	0	0	0	0	1	0	0	0	0	0	0	1	0	7.5	7.5	7.5	7.5	0
29JUN88	0	0	1	1	1	1	0	0	0	0	1	5	0	8.7	5.5	7.2	16.0	4.2
Total	2	5	72	107	69	37	18	11	6	9	11	347	9					

NOTE: N=Number of lengths, MIN=Minimum length, P=Number not measured, MED=Median length, X=Mean length, MAX=Maximum length, SD=Standard deviation.

TABLE C-4 LENGTH-FREQUENCY DISTRIBUTION OF STRIPED BASS COLLECTED DURING THE ENTRAINMENT VIABILITY STUDY AT THE INDIAN POINT GENERATING STATION, JUNE 1988, DISCHARGE FLUME SAMPLES

Date	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9
08JUN88	0	0	0	4	3	2	5	0	4	3	3
09JUN88	0	2	5	67	90	21	24	22	7	19	12
10JUN88	2	5	3	15	17	9	4	9	7	6	6
13JUN88	0	0	3	54	91	59	20	13	11	4	4
14JUN88	0	0	5	88	46	32	13	9	2	5	8
15JUN88	0	0	3	50	37	37	31	23	19	12	5
16JUN88	0	0	10	71	56	32	34	24	20	11	8
20JUN88	0	0	0	30	38	38	43	43	19	17	14
21JUN88	0	1	2	7	18	16	26	12	9	10	2
22JUN88	0	0	0	6	14	19	15	9	7	2	3
23JUN88	0	0	0	1	2	1	1	2	1	1	0
27JUN88	0	0	0	0	3	1	3	3	2	0	0
28JUN88	0	0	0	2	7	3	0	0	1	0	1
29JUN88	0	0	0	1	1	1	5	3	2	2	3
30JUN88	0	0	0	0	4	2	1	1	3	4	3
Total	2	8	31	396	427	273	225	173	114	96	72

Date	13.0-13.9	14.0-14.9	15.0-15.9+	N	P	X	MIN	MED	MAX	SD
08JUN88	0	0	0	24	3	8.8	5.2	8.7	12.9	2.4
09JUN88	5	0	0	274	10	7.4	3.4	6.5	13.5	2.2
10JUN88	1	0	1	85	153	7.7	2.3	7.0	15.0	2.7
13JUN88	4	0	2	265	70	7.2	4.7	6.8	15.5	1.8
14JUN88	2	0	0	210	40	6.8	4.3	6.1	13.5	1.9
15JUN88	2	5	6	230	273	8.1	4.6	7.7	16.5	2.5
16JUN88	2	4	3	275	366	7.7	4.0	7.0	17.5	2.3
20JUN88	6	3	9	260	67	8.8	5.0	8.5	20.0	2.7
21JUN88	0	1	1	105	2	8.4	3.1	8.3	17.0	2.1
22JUN88	0	1	0	76	0	8.2	5.0	7.9	14.0	1.8
23JUN88	0	0	0	9	1	8.4	5.5	8.6	11.5	2.0
27JUN88	1	0	0	13	1	8.7	6.0	8.5	13.4	2.0
28JUN88	0	1	0	15	0	7.7	5.2	6.8	14.0	2.5
29JUN88	1	1	0	20	0	9.8	5.9	9.5	14.1	2.2
30JUN88	0	2	0	20	1	10.0	6.0	10.4	14.9	2.5
Total	24	18	22	1,881	987					

NOTE: N=Number of lengths, MIN=Minimum length, P=Number not measured, MED=Median length, X=Mean length, MAX=Maximum length, SD=Standard deviation.

TABLE C-5 LENGTH-FREQUENCY DISTRIBUTION OF WHITE PERCH COLLECTED DURING THE ENTRAINMENT VIABILITY STUDY AT THE INDIAN POINT GENERATING STATION, JUNE 1988, INTAKE FLUME SAMPLES

Date	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9+	N	P	X	MIN	MED	MAX	SD
08JUN88	0	1	0	0	0	0	0	0	0	1	0	3.2	3.2	3.2	3.2	0
09JUN88	0	2	1	0	0	0	1	0	0	4	1	5.1	3.4	4.2	8.7	2.5
13JUN88	0	3	4	2	0	0	0	1	0	10	0	4.7	3.5	4.2	9.0	1.6
15JUN88	0	4	2	0	0	0	0	0	0	6	0	3.6	3.1	3.6	4.1	0.4
16JUN88	0	0	1	0	0	0	0	1	1	3	0	8.2	4.9	9.6	10.2	2.9
20JUN88	0	0	0	3	0	0	1	0	0	4	0	6.1	5.0	5.3	8.7	1.8
21JUN88	0	0	1	0	0	0	0	1	0	2	0	7.2	4.9	7.2	9.6	3.3
22JUN88	0	1	2	0	2	0	0	0	1	6	0	6.1	3.7	5.6	10.6	2.5
27JUN88	1	0	0	0	0	0	0	0	0	1	0	2.3	2.3	2.3	2.3	0
28JUN88	0	0	1	1	0	0	0	0	0	2	0	5.0	4.6	5.0	5.4	0.6
Total	1	11	12	6	2	0	2	3	2	39	1					

NOTE: N=Number of lengths, MIN=Minimum length, P=Number not measured, MED=Median length, X=Mean length, MAX=Maximum length, SD=Standard deviation.

TABLE C-6 LENGTH-FREQUENCY DISTRIBUTION OF WHITE PERCH COLLECTED DURING THE ENTRAINMENT VIABILITY STUDY AT THE INDIAN POINT GENERATING STATION, JUNE 1988, DISCHARGE FLUME SAMPLES

Date	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9+	N	P	X	MIN	MED	MAX	SD
08JUN88	0	1	0	0	0	1	0	0	0	2	0	5.3	3.3	5.3	7.3	2.8
09JUN88	1	39	18	9	5	1	0	0	0	73	1	4.2	2.8	3.8	7.9	1.0
10JUN88	2	20	3	2	1	0	0	0	0	28	3	3.7	2.8	3.5	6.6	0.8
13JUN88	1	18	27	17	7	1	0	0	0	71	1	4.6	2.7	4.5	7.0	1.0
14JUN88	0	4	2	1	1	0	0	0	0	8	1	4.2	3.3	3.9	6.2	1.0
15JUN88	0	16	16	5	2	0	0	0	0	39	0	4.3	3.2	4.2	6.7	0.8
16JUN88	1	18	13	10	2	3	1	3	8	59	2	5.7	2.8	4.7	11.3	2.5
20JUN88	0	8	5	4	3	2	2	6	4	34	7	6.6	3.2	6.0	11.3	2.6
21JUN88	0	2	4	2	1	0	0	0	1	10	0	5.4	3.2	4.7	11.5	2.4
22JUN88	0	2	3	4	0	0	1	0	0	10	0	5.0	3.3	4.9	8.3	1.4
27JUN88	1	1	0	2	0	0	0	0	0	4	0	3.9	2.1	4.3	5.1	1.4
28JUN88	0	0	2	6	2	0	0	0	0	10	0	5.4	4.3	5.5	6.2	0.6
29JUN88	0	0	1	1	0	0	0	0	0	2	0	5.2	4.8	5.2	5.5	0.5
30JUN88	0	0	1	1	1	0	0	0	0	3	0	5.7	4.7	5.9	6.5	0.9
Total	6	129	95	64	25	8	4	9	13	353	15					

NOTE: N=Number of lengths, MIN=Minimum length, P=Number not measured, MED=Median length, X=Mean length, MAX=Maximum length, SD=Standard deviation.

TABLE C-7 LENGTH-FREQUENCY DISTRIBUTION OF *ALOSA* SPP. COLLECTED DURING THE ENTRAINMENT VIABILITY STUDY AT THE INDIAN POINT GENERATING STATION, JUNE 1988, INTAKE FLUME SAMPLES

Date	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9+	N	P	X	MIN	MED	MAX	SD
08JUN88	0	0	0	0	0	1	0	0	0	1	0	12.0	12.0	12.0	12.0	0
09JUN88	1	0	0	0	0	0	1	0	0	2	0	10.5	7.3	10.5	13.7	4.5
13JUN88	0	1	0	1	0	1	0	1	0	4	1	11.4	8.5	11.2	14.5	2.6
16JUN88	0	0	0	0	0	0	0	0	1	1	0	15.0	15.0	15.0	15.0	0
20JUN88	0	0	0	0	0	0	0	1	0	1	0	14.7	14.7	14.7	14.7	0
21JUN88	0	0	0	0	0	0	0	0	1	1	0	18.5	18.5	18.5	18.5	0
Total	1	1	0	1	0	2	1	2	2	10	1					

NOTE: N=Number of lengths, MIN=Minimum length, P=Number not measured, MED=Median length, X=Mean length, MAX=Maximum length, SD=Standard deviation.

TABLE C-8 LENGTH-FREQUENCY DISTRIBUTION OF *ALOSA* SPP. COLLECTED DURING THE ENTRAINMENT VIABILITY STUDY AT THE INDIAN POINT GENERATING STATION, JUNE 1988, DISCHARGE FLUME SAMPLES

Date	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9
08JUN88	0	0	0	0	0	0	0	0	0	0
09JUN88	0	0	0	1	8	19	12	11	9	6
10JUN88	0	0	0	1	0	0	6	3	1	4
13JUN88	0	0	0	1	0	0	8	7	8	3
14JUN88	1	0	0	0	0	1	1	2	0	0
15JUN88	0	0	0	0	0	0	1	1	3	0
16JUN88	0	1	0	1	0	0	0	0	3	0
20JUN88	0	0	0	0	0	0	0	0	0	0
21JUN88	0	0	0	0	0	0	0	0	0	0
22JUN88	0	0	0	0	0	1	1	0	1	2
28JUN88	0	0	0	0	0	0	0	0	0	1
29JUN88	0	0	0	0	0	0	0	0	0	0
Total	1	1	0	4	8	21	29	24	25	16

Date	13.0-13.9	14.0-14.9+	N	P	X	MIN	MED	MAX	SD
08JUN88	0	0	0	3	0	0	0	0	0
09JUN88	5	7	78	3	10.3	6.0	9.9	16.3	2.3
10JUN88	2	5	22	1	11.9	6.8	11.7	22.0	3.0
13JUN88	6	12	45	1	12.1	6.1	11.5	17.0	2.4
14JUN88	0	1	6	0	9.3	3.4	9.6	14.0	3.4
15JUN88	1	2	8	0	12.2	9.1	11.1	17.0	2.6
16JUN88	1	4	10	2	12.1	4.0	12.4	18.0	4.5
20JUN88	1	0	1	0	13.0	13.0	13.0	13.0	0
21JUN88	0	1	1	0	20.0	20.0	20.0	20.0	0
22JUN88	2	3	10	2	12.5	8.7	12.6	15.4	2.2
28JUN88	0	0	1	0	12.0	12.0	12.0	12.0	0
29JUN88	0	1	1	0	24.0	24.0	24.0	24.0	0
Total	18	36	183	12					

NOTE: N=Number of lengths, MIN=Minimum length, P=Number not measured, MED=Median length, X=Mean length, MAX=Maximum length, SD=Standard deviation.

TABLE C-10 LENGTH-FREQUENCY DISTRIBUTION OF BAY ANCHOVY COLLECTED DURING THE ENTRAINMENT VIABILITY STUDY AT THE INDIAN POINT GENERATING STATION, JUNE 1988, NET SAMPLES

SURFACE

Date	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9
14JUN88	1	0	0	0	0	0	0	0	0	0	0	0
30JUN88	4	9	9	3	4	5	1	1	2	1	2	1
Total	5	9	9	3	4	5	1	1	2	1	2	1

Date	16.0-16.9	17.0-17.9	18.0-18.9	19.0-19.9+	N	P	X	MIN	MED	MAX	SD
14JUN88	0	0	0	0	1	0	4.2	4.2	4.2	4.2	0
30JUN88	2	2	3	1	50	4,732	9.5	4.4	7.8	19.0	4.6
Total	2	2	3	1	51	4,732					

MID

Date	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9
10JUN88	0	0	0	0	0	0	0	0	0	1	0	0
14JUN88	1	0	0	0	0	0	0	1	0	0	0	0
30JUN88	0	4	4	2	4	8	4	2	4	2	3	3
Total	1	4	4	2	4	8	4	3	4	3	3	3

Date	16.0-16.9	17.0-17.9	18.0-18.9	19.0-19.9+	N	P	X	MIN	MED	MAX	SD
10JUN88	0	0	0	0	1	0	13.5	13.5	13.5	13.5	0
14JUN88	0	0	0	0	2	0	7.9	4.5	7.9	11.3	4.8
30JUN88	1	3	4	2	50	6,987	11.5	5.2	10.5	19.5	4.2
Total	1	3	4	2	53	6,987					

TABLE C-10 (Cont.)

BOTTOM

Date	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15.0-15.9
14JUN88	0	1	2	0	0	0	0	0	0	0	0	0
30JUN88	0	3	6	5	10	7	2	2	1	4	2	2
Total	0	4	8	5	10	7	2	2	1	4	2	2

Date	16.0-16.9	17.0-17.9	18.0-18.9	19.0-19.9+	N	P	X	MIN	MED	MAX	SD
14JUN88	0	0	0	0	3	1	6.1	5.5	6.2	6.7	0.6
30JUN88	2	0	2	2	50	7,217	10.5	5.1	9.1	23.0	4.1
Total	2	0	2	2	53	7,218					

NOTE: N=Number of lengths, MIN=Minimum length, P=Number not measured, MED=Median length, X=Mean length, MAX=Maximum length, SD=Standard deviation.

TABLE C-11 LENGTH-FREQUENCY DISTRIBUTION OF STRIPED BASS COLLECTED DURING THE ENTRAINMENT VIABILITY STUDY AT THE INDIAN POINT GENERATING STATION, JUNE 1988, NET SAMPLES

SURFACE

Date	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9
10JUN88	4	20	62	39	17	10	12	11	17	18
14JUN88	0	25	78	41	40	16	4	6	14	13
30JUN88	0	0	0	0	1	5	5	10	12	5
Total	4	45	140	80	58	31	21	27	43	36

Date	13.0-13.9	14.0-14.9+	N	P	X	MIN	MED	MAX	SD
10JUN88	15	3	228	1,432	7.8	3.1	6.7	15.0	2.9
14JUN88	4	5	246	8,933	7.2	4.4	6.5	16.0	2.5
30JUN88	2	3	43	10	10.9	7.8	11.0	15.1	1.7
Total	21	11	517	10,375					

MID

Date	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9
10JUN88	2	11	53	31	21	15	14	14	16	12
14JUN88	0	51	74	65	34	9	7	5	14	8
30JUN88	0	0	1	3	5	6	3	3	10	13
Total	2	62	128	99	60	30	24	22	40	33

Date	13.0-13.9	14.0-14.9+	N	P	X	MIN	MED	MAX	SD
10JUN88	9	8	206	1,487	8.1	3.5	7.2	15.6	2.9
14JUN88	5	1	273	9,959	6.7	4.0	6.1	17.2	2.3
30JUN88	1	5	50	20	10.7	5.3	11.5	16.0	2.5
Total	15	14	529	11,466					

TABLE C-11 (Cont.)

BOTTOM

Date	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9
10JUN88	2	35	67	49	19	17	12	16	14	12
14JUN88	1	53	61	36	20	13	12	13	18	18
30JUN88	0	0	0	0	2	2	7	7	11	10
Total	3	88	128	85	41	32	31	36	43	40

Date	13.0-13.9	14.0-14.9+	N	P	X	MIN	MED	MAX	SD
10JUN88	7	3	253	1,608	7.3	3.6	6.3	15.0	2.6
14JUN88	3	1	249	11,966	7.2	3.4	6.2	15.5	2.7
30JUN88	8	3	50	25	11.4	7.7	11.4	14.6	1.7
Total	18	7	552	13,599					

NOTE: N=Number of lengths, MIN=Minimum length, P=Number not measured, MED=Median length, X=Mean length, MAX=Maximum length, SD=Standard deviation.

TABLE C-12 LENGTH-FREQUENCY DISTRIBUTION OF WHITE PERCH COLLECTED DURING THE ENTRAINMENT VIABILITY STUDY AT THE INDIAN POINT GENERATING STATION, JUNE 1988, NET SAMPLES

SURFACE

Date	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9+	N	P	X	MIN	MED	MAX	SD
10JUN88	3	26	13	6	48	25	3.9	2.5	3.7	5.8	0.8
14JUN88	1	38	41	10	90	24	4.2	2.9	4.2	6.5	0.7
30JUN88	0	1	0	1	2	0	4.5	3.6	4.5	5.3	1.2
Total	4	65	54	17	140	49					

MID

Date	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9+	N	P	X	MIN	MED	MAX	SD
10JUN88	5	39	15	18	77	24	4.2	2.3	3.8	9.7	1.2
14JUN88	1	29	32	18	80	9	4.4	2.8	4.2	6.6	0.9
Total	6	68	47	36	157	33					

BOTTOM

Date	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9+	N	P	X	MIN	MED	MAX	SD
10JUN88	1	70	16	4	91	30	3.7	2.9	3.5	8.1	0.7
14JUN88	1	45	36	8	90	51	4.1	2.9	3.9	5.9	0.6
Total	2	115	52	12	181	81					

NOTE: N=Number of lengths, MIN=Minimum length, P=Number not measured, MED=Median length, X=Mean length, MAX=Maximum length, SD=Standard deviation.

TABLE C-13 LENGTH-FREQUENCY DISTRIBUTION OF *ALOSA* SPP. COLLECTED DURING THE ENTRAINMENT VIABILITY STUDY AT THE INDIAN POINT GENERATING STATION, JUNE 1988, NET SAMPLES

SURFACE

Date	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9
10JUN88	2	1	5	20	14	19	18	20	11	12
14JUN88	0	1	3	4	10	9	11	7	10	7
30JUN88	0	0	0	0	0	0	0	0	0	0
Total	2	2	8	24	24	28	29	27	21	19

Date	15.0-15.9	16.0-16.9+	N	P	X	MIN	MED	MAX	SD
10JUN88	11	10	143	346	11.5	5.2	11.0	18.0	2.6
14JUN88	6	13	81	5	12.4	6.9	12.0	22.0	3.2
30JUN88	0	1	1	0	18.5	18.5	18.5	18.5	0
Total	17	24	225	351					

MID

Date	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9
10JUN88	0	1	6	16	20	19	16	20	13	19
14JUN88	2	1	2	9	9	10	16	10	7	7
Total	2	2	8	25	29	29	32	30	20	26

Date	15.0-15.9	16.0-16.9+	N	P	X	MIN	MED	MAX	SD
10JUN88	7	4	141	486	11.5	6.1	11.1	18.0	2.4
14JUN88	6	11	90	6	11.9	5.3	11.0	22.0	3.2
Total	13	15	231	492					

TABLE C-13 (Cont.)

BOTTOM

Date	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9
10JUN88	0	1	10	17	29	27	23	14	13	4
14JUN88	0	1	2	5	11	15	14	19	9	10
Total	0	2	12	22	40	42	37	33	22	14

Date	15.0-15.9	16.0-16.9+	N	P	X	MIN	MED	MAX	SD
10JUN88	5	5	148	445	10.9	6.8	10.4	20.0	2.4
14JUN88	5	14	105	8	12.3	6.3	12.0	20.0	2.9
Total	10	19	253	453					

NOTE: N=Number of lengths, MIN=Minimum length, P=Number not measured, MED=Median length, X=Mean length, MAX=Maximum length, SD=Standard deviation.

TABLE C-14 LENGTH-FREQUENCY DISTRIBUTION OF STRIPED BASS (DYED) COLLECTED DURING THE ENTRAINMENT VIABILITY STUDY AT THE INDIAN POINT GENERATING STATION, JUNE 1988, NET SAMPLES

SURFACE

Date	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9+	N	P	X	MIN	MED	MAX	SD
14JUN88	5	2	9	13	8	4	0	0	0	41	116	9.1	6.5	9.3	11.2	1.4
30JUN88	0	0	0	1	2	11	21	7	8	50	161	12.4	9.1	12.0	15.8	1.4
Total	5	2	9	14	10	15	21	7	8	91	277					

MID

Date	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9+	N	P	X	MIN	MED	MAX	SD
14JUN88	9	3	4	17	11	1	1	2	0	48	161	9.2	6.2	9.5	13.0	1.7
30JUN88	0	0	0	0	3	2	7	8	5	25	196	12.9	10.2	13.0	17.0	1.7
Total	9	3	4	17	14	3	8	10	5	73	357					

BOTTOM

Date	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9+	N	P	X	MIN	MED	MAX	SD
14JUN88	3	2	1	1	5	4	3	1	1	21	111	10.0	6.0	10.0	14.0	2.3
30JUN88	0	0	0	0	1	7	7	5	5	25	212	12.7	10.3	12.6	15.3	1.2
Total	3	2	1	1	6	11	10	6	6	46	323					

NOTE: N=Number of lengths, MIN=Minimum length, P=Number not measured, MED=Median length, X=Mean length, MAX=Maximum length, SD=Standard deviation.

APPENDIX D

INDIAN POINT GENERATING STATION
COOLING WATER FLOW TABLES

LIST OF TABLES

TABLE D-1 UNIT 2 CIRCULATOR OPERATION DATA, INDIAN POINT GENERATING STATION, JUNE 1988

Pump Number:	C 21		C 22		C 23		C 24		C 25		C 26		Average Station Discharge Rate (gpm X 1,000)
Flow Rate:	84	140	84	140	84	140	84	140	84	140	84	140	
Date	Hours at Flow Rate (Gallons Per Minute x 1000)												
01-JUN	0	24	0	24	24	0	24	0	0	24	24	0	1,441.4
02-JUN	0	24	0	24	24	0	0	24	0	24	24	0	1,509.1
03-JUN	0	24	0	24	24	0	0	24	0	24	24	0	1,496.9
04-JUN	0	24	0	24	24	0	0	24	0	24	24	0	1,482.6
05-JUN	0	24	0	24	24	0	0	24	0	24	24	0	1,493.1
06-JUN	0	24	0	24	24	0	0	24	0	24	24	0	1,495.2
07-JUN	0	24	0	24	24	0	0	24	0	24	24	0	1,504.0
08-JUN	0	24	0	24	24	0	0	24	0	24	24	0	1,504.1
09-JUN	0	24	0	24	0	24	0	24	0	24	0	24	1,730.7
10-JUN	0	24	4	20	0	24	0	24	0	24	0	24	1,710.8
11-JUN	0	24	2	20	0	24	0	24	0	24	0	24	1,722.0
12-JUN	0	24	0	11	0	24	0	24	0	24	0	24	1,561.3
13-JUN	0	24	0	24	0	24	0	24	0	24	0	24	1,400.0
14-JUN	0	24	1	23	0	24	0	24	0	24	0	24	1,399.7
15-JUN	0	24	0	24	0	24	0	24	0	24	0	24	1,496.6
16-JUN	0	24	0	24	0	24	0	24	0	24	0	24	1,637.2
17-JUN	0	24	0	24	0	24	0	24	0	24	0	24	1,745.5
18-JUN	0	24	0	11	0	11	0	24	0	11	0	24	1,506.8
19-JUN	0	24	0	0	0	0	0	24	0	0	0	24	1,326.0
20-JUN	0	16	0	0	0	0	0	16	0	0	0	24	1,228.0
21-JUN	0	0	0	0	0	1	0	0	0	0	0	24	1,040.2
22-JUN	0	0	0	0	0	24	0	0	0	0	0	0	1,029.6
23-JUN	0	0	0	0	0	24	0	0	0	0	0	0	1,030.7
24-JUN	0	0	0	0	0	24	0	0	0	0	0	0	1,043.0
25-JUN	0	1	0	1	0	24	0	3	0	3	0	2	1,100.3
26-JUN	0	24	0	24	0	24	0	6	0	6	0	23	1,532.5
27-JUN	0	24	0	24	0	24	0	0	0	0	0	7	1,369.2
28-JUN	0	24	0	24	0	24	0	9	0	9	0	18	1,532.5
29-JUN	0	24	0	24	0	24	0	24	0	24	0	22	1,734.9
30-JUN	0	24	0	24	0	24	0	24	0	24	0	24	1,732.6

TABLE D-2 UNIT 3 CIRCULATOR OPERATION DATA, INDIAN POINT GENERATING STATION, JUNE 1988

	Hours at Flow Rate (Gallons Per Minute X 1,000)																								U1	U2	U3
Pump No.	C 31				C 32				C 33				C 34				C 35				C 36				SWP	SWP	SWP
Flow Rate:	83.5	110	120	140	83.5	110	120	140	83.5	110	120	140	83.5	110	120	140	83.5	110	120	140	83.5	110	120	140	16	5	5
Date																											
01-JUN	0	4	21	0	0	4	21	0	0	4	21	0	0	4	21	0	0	4	21	0	0	4	21	0	24	96	111
02-JUN	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	24	96	120
03-JUN	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	5	107	113
04-JUN	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	120	92
05-JUN	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	120	97
06-JUN	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	1	118	105
07-JUN	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	24	96	96
08-JUN	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	24	96	96
09-JUN	0	0	1	23	0	0	1	23	0	0	1	23	0	0	1	23	0	0	1	23	0	0	1	23	24	96	96
10-JUN	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	24	72	96
11-JUN	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	24	96	96
12-JUN	7	0	0	17	7	0	0	17	7	0	0	17	7	0	0	17	7	0	0	17	7	0	0	17	24	96	96
13-JUN	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	111	96
14-JUN	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	120	96
15-JUN	17	0	0	7	17	0	0	7	17	0	0	7	17	0	0	7	17	0	0	7	17	0	0	7	24	120	96
16-JUN	0	14	0	10	0	14	0	10	0	14	0	10	0	14	0	10	0	14	0	10	0	14	0	10	24	118	96
17-JUN	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	24	118	120
18-JUN	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	23	24	97	120
19-JUN	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	24	120	120
20-JUN	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	24	120	109
21-JUN	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	24	105	96
22-JUN	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	24	96	96
23-JUN	0	0	0	24	0	0	0	23	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	24	113	104
24-JUN	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	24	106	120
25-JUN	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	24	120	120
26-JUN	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	24	120	120
27-JUN	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	24	120	120
28-JUN	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	24	120	120
29-JUN	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	24	120	120
30-JUN	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	0	0	0	24	24	120	120