INDIAN POINT GENERATING STATION ENTRAINMENT SURVIVAL AND RELATED STUDIES

1978 ANNUAL REPORT

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Consolidated Edison Company of New York, Inc.
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ECOLOGICAL
ANALYSTS
INC.

EA Report CON84F

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Prepared for:

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CONTENTS

CONTENTS (CONT.)

LIST OF FIGURES

LIST OF FIGURES (CONT.)

LIST OF TABLES

LIST OF TABLES (CONT.)

LIST OF TABLES (CONT.)

LIST OF TABLES (CONT.)

CHAPTER 1: INTRODUCTION

The Indian Point Generating Station employs a once through cooling system to dissipate waste heat. In the cooling process, water from the Hudson River is pumped through condensers where heat is transferred from the exhaust steam to the cooling water; the warmed water is then returned to the river. The two electrical power generating units in operation at the Indian Point plant* withdraw up to 6,360 m^3/minute (1.68 million gallons per minute) of water from the Hudson River for cooling purposes. Aquatic organisms small enough to pass through the intake screens (9.5 mm bar mesh) may be carried through the cooling water system (entrainment) where they are exposed to abrupt temperature changes, changes in hydrostatic pressure, mechanical buffeting, and velocity shear forces. Determination of the survival of these organisms following entrainment is an important step in realistically estimating the potential ecological effects of plant operation upon the aquatic environment.

The entrainment survival studies described herein were conducted at the Indian Point plant from 1 May to 13 July 1978. They were designed to supplement ichthyoplankton survival information collected by New York University Medical Center (NYU) from 1971 to 1977 (NYU 1973, 1974, 1975, 1976a, 1976b, 1978), and by Ecological Analysts, Inc. during 1977 (EA 1978a). Both NYU and Ecological Analysts evaluated entrainment effects based on initial and latent survival of ichthyoplankton collected at intake and discharge stations, but employed different sampling methodologies. NYU researchers used stationary nets to collect ichthyoplankton samples; however, survival estimates based on this collection technique have been shown to be affected by variations in water velocities between intake and discharge sampling stations (O'Connor and Schaffer 1977). During the present studies, as well as those conducted by Ecological Analysts in 1977, samples were obtained by pumping water from the intake or discharge into a flume (larval table) that served to reduce the velocity of water and concentrate the organisms collected. This sampling technique, referred to as the pump/larval table collection system, was specifically designed to eliminate the effect of intake and discharge velocity differences on survival and has been used extensively by Ecological Analysts during entrainment survival studies at other generating facilities on the Hudson River (EA 1977).

The studies addressed in this report include entrainment survival experiments conducted at the Indian Point plant using the pump/larval table collection system, as well as a gear comparison study to evaluate the densities (abundance) of ichthyoplankton collected with a pump versus stationary nets. The survival studies focused on four major fish species of the Hudson River--striped bass (Morone saxatilis), white perch (M. americana), herrings (Clupeidae), and bay anchovy (Anchoa mitchilli). Density estimates for entrained ichthyoplankton that occurred in pump and stationary net samples were compared for all taxa collected in sufficient numbers for analysis. Additional experiments designed

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* Unit 1 has not operated for commercial production since October 1974. Unit 2 is owned and operated by Consolidated Edison Company of New York, Inc. (Con Edison). Unit 3 is owned and operated by the Power Authority of the State of New York.

to assess the recovery and survival of hatchery-reared striped bass released directly into the cooling water system of the plant (direct release study) are described in Appendix A.

CHAPTER 2: SUMMARY

2.1 ENTRAINMENT SURVIVAL

Studies were conducted at the Indian Point Generating Station from 1 May to 12 July 1978 to determine the survival of larval and juvenile fishes entrained through the plant condenser cooling water system. Samples were collected with 4 in. pumps that delivered water to a concentrating flume (larval table) at five sampling locations: the Unit 2 intake (I2), the Unit 3 intake (I3), the Unit 2 discharge (D1), the Unit 3 discharge (D3), and the discharge common to all three units (DP). Survival was determined initially and at predetermined time intervals up to 96 hours following collection. The effects of entrainment were examined by comparing survival at the discharge stations with survival at the intakes, which served as controls on the effects of sampling and holding.

Striped bass, white perch, bay anchovy, and members of the herring family (Clupeidae) were the most abundant taxa collected during the study. Peak numbers of striped bass and white perch were collected during June at ambient water temperatures of about 18 to 20 C. All bay anchovy were collected during July, whereas the majority of the herring were collected during the first two weeks of June. Most of the ichthyoplankton collected during the study were post yolk-sac larvae.

Plant operation varied considerably throughout the study; Unit 3 only was in operation until 27 May, both Units 2 and 3 were in operation from 27 May to 8 June, and Unit 2 only was in operation for the remainder of the study period. Plant operation during most of the sampling effort resulted in a cooling water temperature rise of about 9 to 12 C and transit times from intake to river discharge of about 9 (Unit 3 alone) to 15 (Unit 2 alone) minutes. Temperatures at the discharge stations ranged from 19 to 36 C during the study period; however, the majority of ichthyoplankton, with the exception of anchovy (Engraulidae) larvae, were collected at discharge temperatures ranging from 30 to 33 C. Most anchovy larvae were collected at discharge temperatures greater than 33 C.

Entrainment survival estimates for white perch and striped bass were generally higher later in the study period (12 June to 12 July), when the majority of ichthyoplankton were collected, than during the earlier portion of the sampling season. During 12 June to 12 July, entrainment survival estimates for striped bass and white perch post yolk-sac larvae ranged from 65 to 67 percent at discharge temperatures of 30.0 to 32.9 C; no striped bass or white perch were collected at discharge temperatures less than 30 C during this time and few were collected at temperatures greater than 32.9 C. Survival estimates of striped bass and white perch larvae collected during the early portion of the study were low (0 to 7 percent, all temperatures combined); however, the number of striped bass and white perch collected during this time comprised only 20 percent of the Morone collected during the entire study. The entrainment survival estimate for striped bass juveniles (all temperatures combined) was 71 percent.

Survival of herring larvae remained relatively constant throughout the study, in spite of the higher discharge temperatures prevalent during the latter portion of the sampling period; for all temperatures combined, survival estimates were 13 percent during 1 May to 7 June and 17 percent during 12 June to 12 July. No anchovy larvae were collected alive at discharge stations, and only 2 percent of the anchovies collected at intake stations were alive.

Entrainment survival estimates determined from 1977 survival data were consistently higher than estimates determined from the 1978 survival data. The survival estimates for striped bass and white perch post yolk-sac larvae (for combined units and combined temperature conditions) were 85 and 77 percent, respectively, during 1977, compared to 66 and 71 percent, respectively, during 1978. The slightly lower survival estimates for 1978 may have resulted from the higher discharge temperatures prevalent throughout most of the 1978 sampling season. The majority of ichthyoplankton entrained during 1978 were collected at discharge temperatures ranging from 30.0 to 32.9 C, whereas few ichthyoplankton (with the exception of anchovy larvae) were collected at discharge temperatures greater than 30.0 C during 1977.

2.2 PUMP-NET COMPARISON STUDIES

Studies were conducted at Indian Point discharge station D1 from 2 June to 13 July 1978 to assess the comparability of ichthyoplankton densities determined by sampling with a 6 in. pump and a larval table with densities determined by sampling with a 0.5 m conical plankton net. Statistical analyses to compare the collection efficiencies of the two gear types were conducted for early life stages (egg, yolk-sac larva, post yolk-sac larva, and juvenile) of all ichthyoplankton taxa combined, i.e., "total ichthyoplankton," as well as for various life stages of selected taxa that were collected in sufficient numbers for analysis. Analytical comparisons for specific taxa included: eggs of bay anchovy, striped bass, and white perch; yolk-sac larvae of bay anchovy, striped bass, darter, and Cyprinidae; and post yolk-sac larvae of bay anchovy, striped bass, white perch, darter, Cyprinidae, *Alosa* spp., and smelt. Juveniles of specific taxa were not collected frequently enough for analysis.

Results of the pump-net comparison analyses indicated that the numbers of ichthyoplankton collected per volume were comparable for the two gear types; the average ichthyoplankton density (all life stages and taxa) collected by the pump was approximately 3.0 per cubic meter, whereas the average density collected by the net was approximately 3.3 per cubic meter. Bay anchovy eggs and larvae accounted for 81.0 and 84.6 percent of the total catch in the pump and net samples, respectively, whereas 70.5 and 72.0 percent of the respective catches consisted of bay anchovy eggs alone. Additionally, within the "total ichthyoplankton" category, no significant differences ($\alpha = 0.05$) were found between density estimates determined from pump versus net samples for any of the early life stage categories.

Analyses conducted for life stages of specific taxa also indicated that the two gear types were generally comparable in terms of numbers of organisms collected per volume of water sampled. Density estimates for all selected taxa of eggs and yolk-sac larvae, as well as density estimates for six of the seven taxa of post yolk-sac larvae examined, did not vary significantly ($\alpha = 0.05$) when compared for the two gear types. A significant difference in densities collected by the two gear types occurred only for bay anchovy post yolk-sac larvae. However, this difference was likely due to difficulty in identifying bay anchovy larvae to species or life stage, in view of their high sensitivity to collection damage or abrasion, rather than to real differences in the collection efficiencies of the two types of gear relative to this single taxon and life stage (Section 5.4).

The 1978 findings thus support the results of the 1977 pump-net comparison study which indicated that densities of striped bass, white perch, and clupeid ichthyoplankton were comparable for pump and net samples. On the basis of these studies, it is concluded that pump collection systems are a practical alternative to net collection systems for estimating the abundance of ichthyoplankton entrained at the Indian Point plant.

CHAPTER 3: SITE DESCRIPTION

3.1 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 1,524 m (5,000 ft) and a cross-sectional area of approximately 14,865 m^2 (160,000 ft^2). Within 60 m (200 ft) of the plant, river depths range from about 3 to 12 m (10 to 40 ft) below mean sea level.

Flow rates in this section of the river are controlled predominately by the tides. Mean tidal flows are on the order of 3,964 m^3/second (140,000 cfs), whereas freshwater flows range from 156 m^3/second (5,500 cfs) in August to 906 m^3/second (32,000 cfs) in April (Con Edison 1977a, p. 2-1). Seasonal trends in salinity are controlled primarily by freshwater flow. The salt-front (0.01 ppt salinity) remains below Indian Point during the months of March, April, and May when freshwater flows of greater than 566 m^3/second (20,000 cfs) are normally present. During the period of low runoff, (generally July through October [Con Edison 1977a, Table 2-2]), the salinity in the vicinity of Indian Point may fluctuate rapidly as a function of tidal stage and height. Ambient river temperatures typically range from 0 to 27.2 C throughout the year in the Indian Point area (Con Edison 1977a, Table 2-3).

3.2 THE PLANT

The Indian Point Generating Station consists of three nuclear-fueled generating units. Unit 1, owned by Con Edison, started operation in 1962. It has a capacity of 285 MWe, and requires 1,204 m^3/minute (318,000 gpm) of water at maximum flow (280,000 gpm is used to cool the condensers, 38,000 gpm is used for service water). Unit 1 has not been in operation for commercial production since 1 October 1974, although its circulating water and service water pumps are operated periodically. 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 Power Authority of the State of New York, has been in operation since 30 August 1976 and has a net rated capacity of 965 MWe. Units 2 and 3 each require 3,293 m^3/minute (870,000 gpm) of water at maximum flow (840,000 gpm is used to cool the condensers, 30,000 gpm is used for service water). The combined pumping capacity of all three units is 7,790 m^3/minute (2,058,000 gpm).

Each of the three units has a separate shoreline intake structure (Figure 3-2). Unit 1 has two 530 m^3/minute (140,000 gpm) circulating water pumps and service water pumps with a combined capacity of 72 m^3/minute (19,000 gpm). Both circulating water pumps and service water pumps draw water from four intake bays. Units 2 and 3 each have six 530 m^3/minute (140,000 gpm) circulating pumps. Each pump draws water through one intake bay. Units 2 and 3 each have service water pumps with a total capacity of 114 m^3/minute (30,000 gpm) that draw through a separate service water bay located in the middle of each unit's intake structure. Table 3-1 summarizes total water flow (service water and

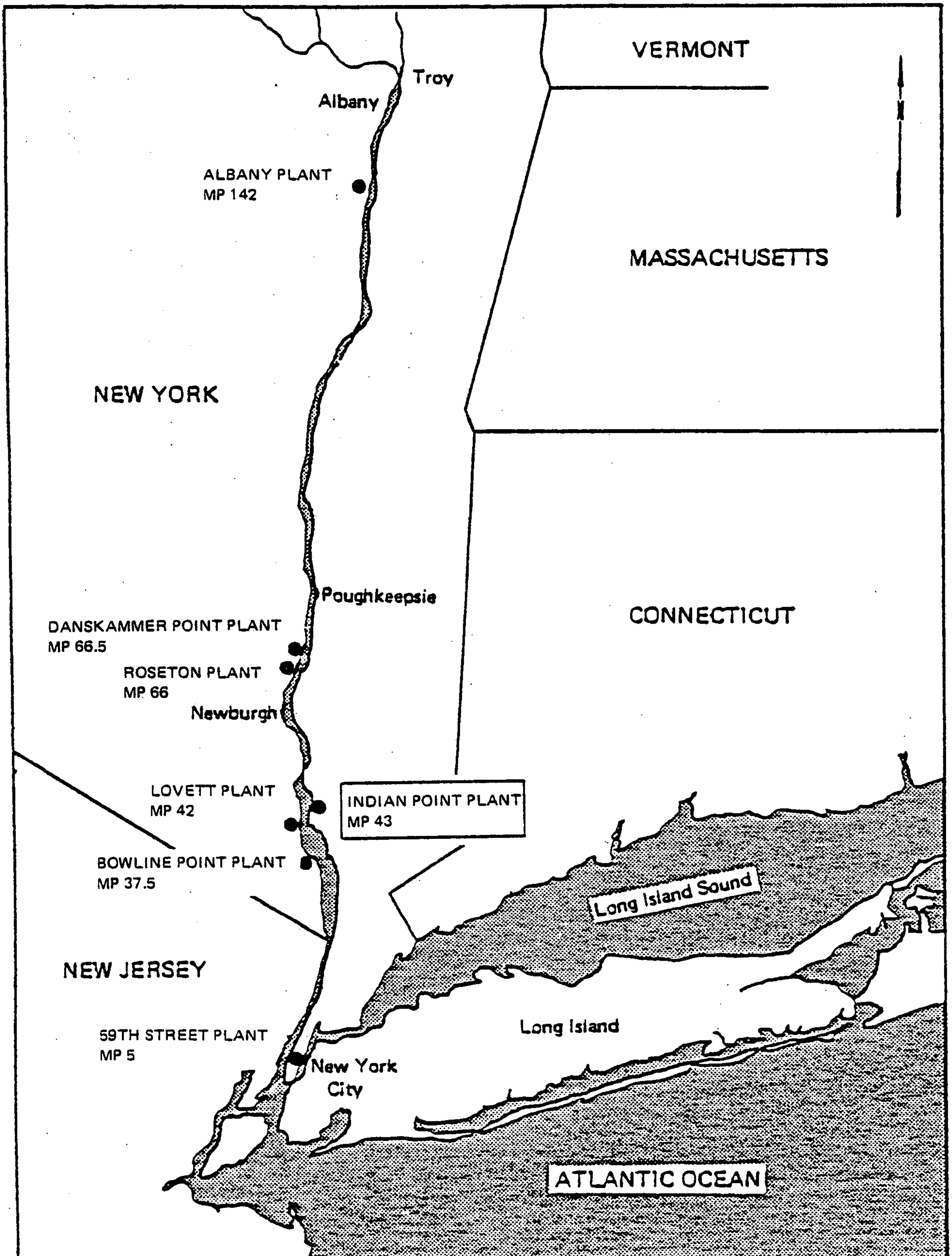

Figure 3-1. Location of the Indian Point Generating Station relative to other generating stations on the Hudson River Estuary (Scale: 1:1,267,200) (adapted from ORU 1978).

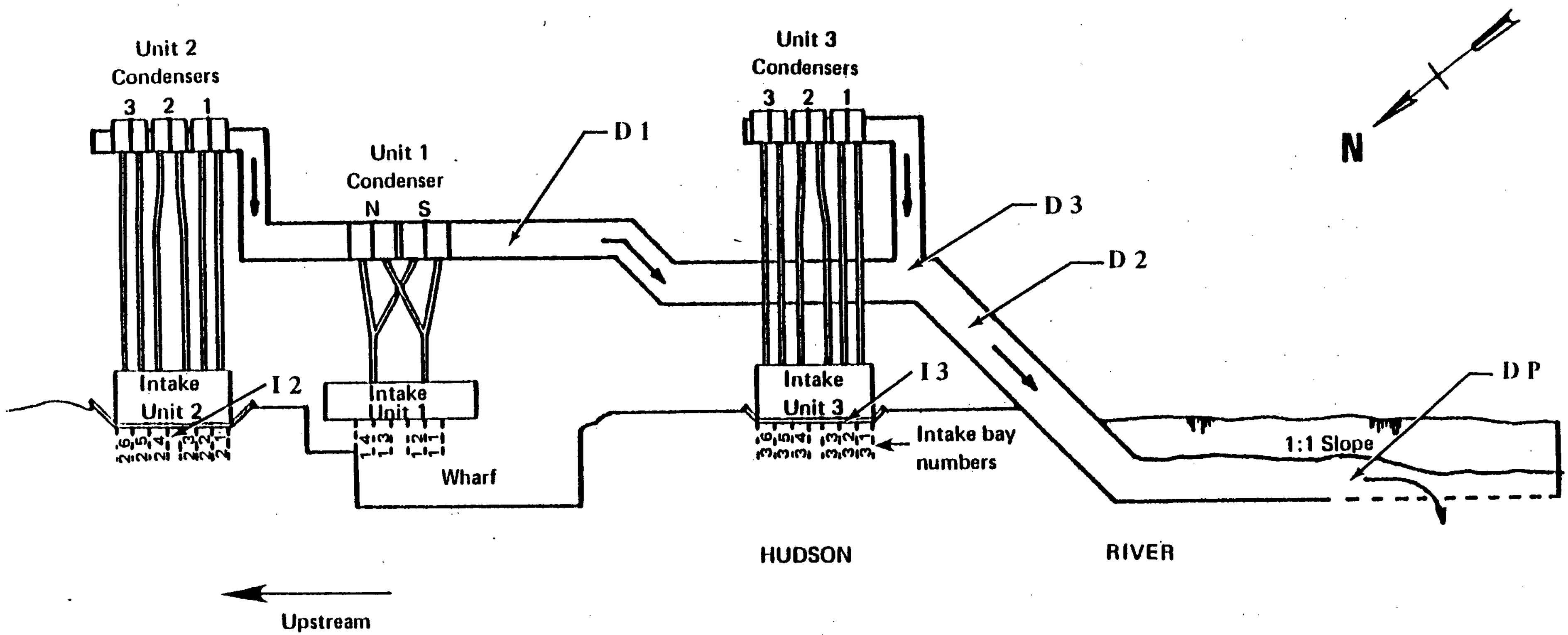

Figure 3-2. Diagram of the Indian Point Generating Station circulating water system showing location of sampling stations (from Con Edison 1977b).

TABLE 3-1 CIRCULATING WATER FLOW INCLUDING SERVICE WATER THROUGH INDIAN POINT GENERATING STATION DURING ENTRAINMENT SURVIVAL STUDIES, APRIL-JULY 1978

	Circulating Water Flow (Gallons per Day x 10^{-6})											
	Unit 1				Unit 2				Unit 3			
Day	APR	MAY	JUN	JUL	APR	MAY	JUN	JUL	APR	MAY	JUN	JUL
1	27	25	25	27	14	14	1,246	1,253	634	1,038	1,044	14
2	27	25	25	27	14	14	1,246	1,253	634	1,037	1,044	14
3	27	25	25	27	14	14	1,246	1,253	634	1,037	1,044	14
4	27	25	25	27	14	14	1,246	1,253	634	1,037	1,044	14
5	27	25	25	158	14	14	1,246	1,253	634	1,037	1,004	14
6	27	25	223	229	14	14	1,246	1,253	640	1,037	990	14
7	26	25	154	120	14	16	1,246	1,253	641	1,037	929	14
8	25	25	25	27	14	26	1,246	1,253	641	1,041	675	14
9	25	25	25	27	14	29	1,246	1,253	641	1,044	648	14
10	25	25	25	27	14	24	1,246	1,253	641	1,044	442	14
11	25	25	122	27	14	22	1,246	1,253	641	1,044	245	14
12	25	27	32	27	14	22	1,246	1,253	641	1,044	245	14
13	100	27	27	66	14	22	1,246	1,253	641	1,044	245	14
14	181	27	118	27	14	22	1,246	1,200	641	1,044	245	14
15	181	27	213	27	14	28	1,246	1,051	641	1,044	245	14
16	181	27	27	27	14	22	1,246	1,229	641	1,014	245	14
17	181	27	27	86	14	22	1,246	1,253	641	1,010	245	21
18	181	27	27	229	14	22	1,246	1,253	641	1,044	235	22
19	181	46	27	229	14	22	1,246	1,253	641	1,044	230	22
20	181	27	27	229	14	34	1,246	1,251	641	1,044	230	22
21	181	27	27	231	14	227	1,246	1,250	641	1,044	230	22
22	181	25	27	233	14	230	1,246	1,253	641	1,044	230	22
23	181	25	27	229	14	509	1,246	1,253	641	1,044	230	22
24	91	25	27	229	14	1,044	1,246	1,224	641	1,044	230	22
25	25	25	27	229	14	973	1,246	1,253	641	1,044	203	22
26	25	25	27	229	14	1,044	1,248	1,253	617	1,044	14	22
27	25	25	27	229	14	1,185	1,241	1,253	697	1,044	14	22
28	25	25	27	174	14	1,246	1,250	1,245	770	1,044	14	22
29	25	25	27	27	14	1,246	1,253	1,134	958	1,044	14	22
30	25	25	27	27	14	1,246	1,253	1,071	1,044	1,044	14	19
31		25		102		1,246		1,104		1,044		14

Source: 401 certification data.

cooling water) through all three units during the 1978 entrainment survival studies (April through July).

Units 1 and 2 have fixed screens at the entrance to the intake bays and vertical traveling screens behind the fixed screens. Unit 3 has only vertical traveling screens located at the entrance to the intake bays. Unit 1 has one experimental fine mesh (2.5 mm) traveling screen. All other screens are 9.5 mm (0.375 in.) square mesh.

The cooling water and service water from all three units discharge into a common discharge canal. This flow is returned to the river through a series of submerged discharge ports located near the downstream end of the canal (Figure 3-3). The port design provides rapid mixing of the cooling water with river water to minimize potential thermal impact in the river.

The average predicted transit times for Unit 2 and 3 cooling water traveling from the respective intake structures to the common discharge ports are presented in Table 3-2. For Units 2 and 3, the normal operational mode is to have all six circulating pumps at each unit operating at full capacity. One circulating pump at Unit 1 was operated during part of the 1978 entrainment survival sampling season because tests were being conducted at the Unit 1 intake. During the 1978 entrainment survival studies, unit outages occurred from 1 April to 27 May at Unit 2 and from 8 June to 17 August at Unit 3.

The temperature rise (delta-T) encountered by organisms passing through the Indian Point plant depends on the cooling water flow rates and levels of power output (Con Edison 1977a, Tables 1-13 and 1-14). Plant operation during most of the sampling effort resulted in a cooling water temperature rise of about 9 to 12 C.

A more detailed description of the Indian Point Generating Station, and the adjacent Hudson River aquatic environs, is given in "Near-Field Effects of Once-Through Cooling System Operation on Hudson River Biota, Indian Point Units 2 and 3" (Con Edison 1977a, Sections 1 and 2).

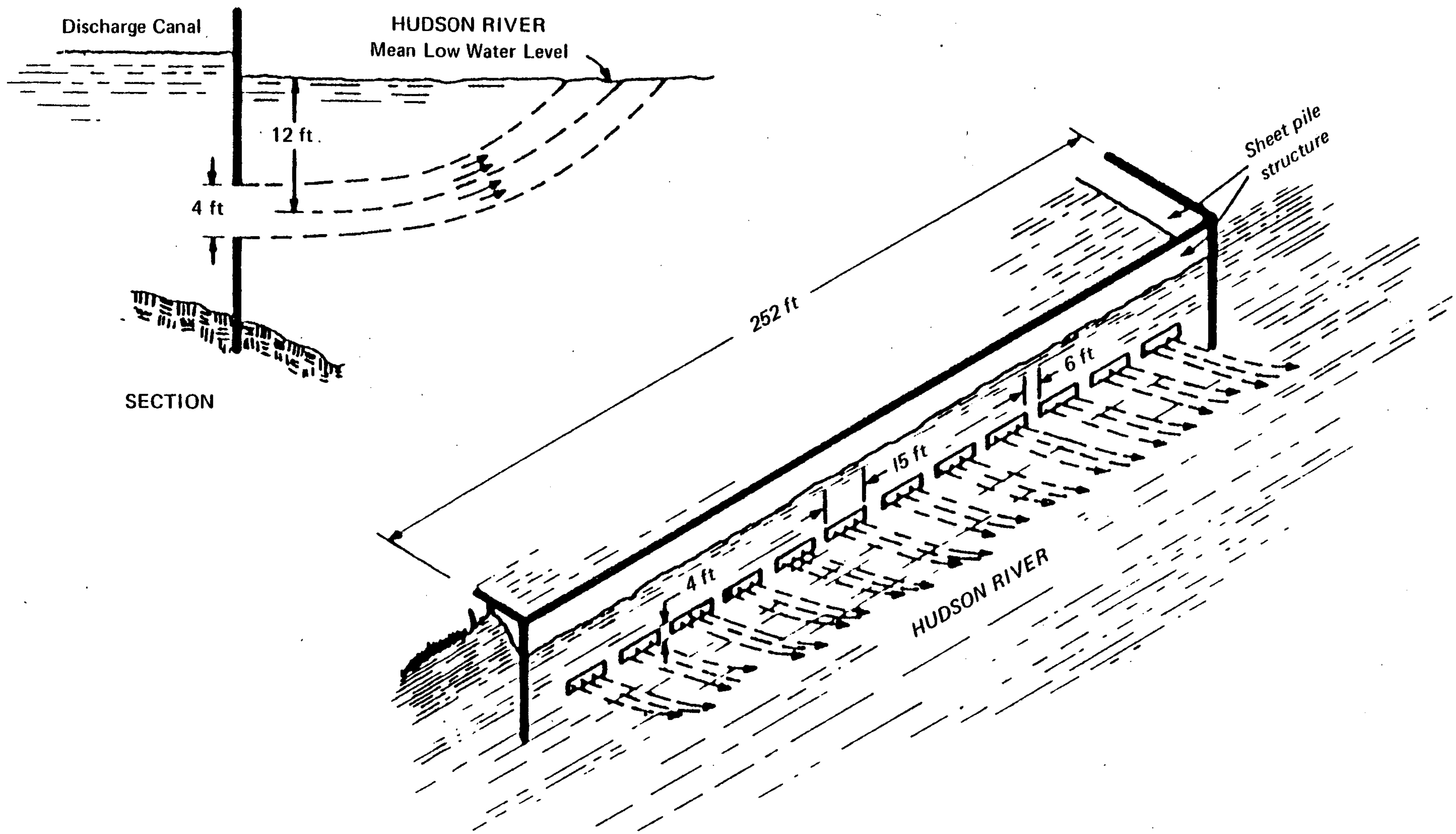

Figure 3-3. Diagrammatic sketch of Indian Point Generating Station discharge structure (from Con Edison 1974).

TABLE 3-2 AVERAGE TRANSIT TIMES FOR COOLING WATER DURING FULL FLOW OPERATION OF INDIAN POINT GENERATING STATION--UNITS 1, 2, AND 3 OPERATING INDIVIDUALLY AND SIMULTANEOUSLY

Individual Operation (Time in Minutes)[a]

	Unit 1	Unit 2	Unit 3
Intake to Common Discharge Ports	33.23	12.85	8.77

Simultaneous Operation: Unit 2 Intake to Common Discharge Ports[b] (Time In Minutes)

	With Indian Point Unit 1 Not Operating				With One Circulating Pump Operating at Unit 1				With Two Circulating Pumps Operating at Unit 1			
	Circulating Pumps Operating at Unit 2				Circulating Pumps Operating at Unit 2				Circulating Pumps Operating at Unit 2			
Circ. Pumps Operating at Unit No. 3	3	4	5	6	3	4	5	6	3	4	5	6
3	19.4	15.4	12.6	10.8	16.9	13.7	12.0	11.0	15.3	12.5	11.0	10.0
4	18.6	14.6	12.1	10.3	16.3	13.1	11.1	10.0	14.8	12.1	10.2	9.2
5	17.8	14.1	11.6	10.0	15.3	12.7	10.7	9.3	14.1	11.7	9.9	8.7
6	17.3	13.6	11.3	9.7	14.7	12.1	10.4	9.0	13.5	11.2	9.7	8.5

Simultaneous Operation: Unit 3 Intake to Common Discharge Ports[c] (Time In Minutes)

	With Indian Point Unit 1 Not Operating				With One Circulating Pump Operating at Unit 1				With Two Circulating Pumps Operating at Unit 1			
	Circulating Pumps Operating at Unit 2				Circulating Pumps Operating at Unit 2				Circulating Pumps Operating at Unit 2			
Circ. Pumps Operating at Unit No. 3	3	4	5	6	3	4	5	6	3	4	5	6
3	11.2	10.5	9.7	9.2	10.3	8.5	7.8	7.3	9.6	8.0	7.2	6.7
4	9.2	8.5	8.0	7.5	9.7	7.9	6.8	6.3	9.2	7.5	6.4	5.9
5	7.7	8.0	6.7	6.4	7.9	7.5	6.4	5.6	8.4	7.2	6.1	5.4
6	6.7	7.2	5.9	5.6	6.4	6.9	6.1	5.4	7.8	6.6	5.9	5.2

(a) Source: NYU 1978, Table 1-1.
(b) Source: Con Edison 1977a, Tables 1-3, 1-4, and 1-5.
(c) Source: Con Edison 1977a, Tables 1-6, 1-7, and 1-8.

Note: Transit times are based on pumps operating at 100 percent flow (312 cfs); Transit time through condenser: 0.14 minutes.

CHAPTER 4: ENTRAINMENT SURVIVAL STUDY

4.1 INTRODUCTION

The 1978 entrainment survival study was designed to determine the survival of ichthyoplankton that passed through the condenser cooling systems at the Indian Point Generating Station. This study was a continuation of the entrainment survival study conducted by Ecological Analysts in 1977 (EA 1978a). Ichthyoplankton samples were collected at the Unit 2 and Unit 3 intakes and at three stations located along a common discharge canal using pump/larval table collection systems. Initial survival was determined from the number of live and dead ichthyoplankton collected; the survival of live organisms was monitored for 96 hours to evaluate latent effects. Entrainment survival estimates were determined for early developmental stages of four primary taxa: striped bass (*Morone saxatilis*), white perch (*M. americana*), herrings (Clupeidae), and bay anchovy (*Anchoa mitchilli*).

4.2 METHODS AND MATERIALS

4.2.1 Sampling Procedures

4.2.1.1 Sampling Schedule and Station Locations

Ichthyoplankton entrainment survival sampling was conducted from 1 May through 12 July 1978, coincident with the primary spawning and nursery seasons of striped bass, white perch, and clupeids (herrings). During this period, an average of six samples per station were collected on two consecutive nights each week (a total of 22 sampling days). Sampling was conducted between 1800 and 0200 hours to coincide with the diurnal period of peak ichthyoplankton abundance.

The pump/larval table collection systems used during entrainment survival sampling were positioned at three stations along the discharge canal (Stations D1, D3, and DP), and at the Unit 2 and Unit 3 intakes (Stations I2 and I3) (Figure 3-2). The discharge station locations were selected such that ichthyoplankton entrained through various units could be sampled for survival analysis. Station D1 was located upstream of the point where discharge water from Unit 3 enters the discharge canal; the collection system at this station sampled discharge water from Unit 2 and Unit 1 (when Unit 1 circulating pumps were in operation). The Station D3 collection system was located at the point where the cooling water discharge from Unit 3 enters the discharge canal, and sampled only discharge water from Unit 3. The collection system at Station DP was located near the end of the discharge canal, and sampled a mixture of discharge water from all three units. Intake stations I2 and I3, at which ichthyoplankton were collected before entrance into the condenser cooling water system, served as controls.

Each pump/larval table collection system was equipped with two pumps used to simultaneously collect samples from two locations per station. Pump intake hoses at each discharge station were approximately 2 m (6.6 ft) apart and sampled water from 1 to 3 m (3.3 to 9.9 ft) below the water surface. The intake hoses at Station D3 were oriented vertically, whereas at Stations D1 and DP, the intake hoses were oriented horizontally facing the current.

At intake station I2 samples were collected at middepth from intake bays 22 and 25, and at Station I3 samples were collected at middepth from intake bays 33 and 35.

Specific stations at which collections were made depended upon plant operation; consequently, samples were not collected at all five stations throughout the sampling season. The dates of operation for Unit 2 and Unit 3 and the stations at which sampling was conducted during these periods are presented in the following table:

Sampling Date	Units Operating	Sampling Stations
1-23 MAY	3	I3, D3, DP
30 MAY - 7 JUN	2 and 3	I2, I3, D3, DP
12 JUN - 12 JUL	2	I2, D1, DP

Although Unit 1 was not in operation during this study, the circulating pumps at Unit 1 were in operation on two sampling days (6 June and 6 July). A summary of the days on which samples were collected and the number of circulating pumps operating during sampling is presented in Table 4-1.

4.2.1.2 Gear Description

The pump/larval table collection system used at each sampling station consisted of two 10 cm (4 in.) diameter Homelite trash pumps with 10 cm diameter intake hoses and a modular two screen larval table* (Figure 4-1). The Homelite pumps were centrifugal pumps with a two vane open impeller capable of passing solids up to about 5 cm (2 in.). Flows and volumes of water pumped into each collection system were monitored with inline Sparling "Masterflo" flowmeters.

Samples were collected and concentrated in larval tables measuring approximately 8.2 m long, 1.2 m wide, and 0.6 m deep (27 x 4 x 2 ft) (Figure 4-1). The front of each table expanded from the two 10 cm (4 in.) hose openings to the full table width, thus reducing the velocity and turbulence of the pumped water. At the end of the expansion section, two directional screens (505 μ mesh) diverted organisms, debris, and a small portion of the water into a collection box. A valve (Q2 valve) controlled the flow of water through the collection box during sampling and was also used to drain the collection box at the end of the sampling interval. The remaining water exited through the overflow weirs behind the two directional screens. The Q1 valves located adjacent to the overflow weirs were used to drain the table at the end of the sampling interval. After the sample was collected, the filtered debris and organisms passed through a 3 cm (1.2 in.) diameter vinyl tube into a detachable transportation container.

An ambient injection system was used to reduce the exposure of organisms to elevated discharge temperatures during collection (Figure 4-1). This system

* The larval table is an Ecological Analysts' modification of the original design described by McGroddy and Wyman (1977). The ambient injection system and collection box were designed by Ecological Analysts and are patent pending.

TABLE 4-1 SUMMARY OF CIRCULATING PUMP OPERATION DURING ENTRAINMENT SURVIVAL STUDIES AT THE INDIAN POINT GENERATING STATION, 1978

Sampling Date	Number of Circulating Pumps Operating by Unit[a]		
	Unit 1	Unit 2	Unit 3
1 MAY	0	0	5
2 MAY	0	0	5
8 MAY	0	0	5
9 MAY	0	0	5
15 MAY	0	0	5
16 MAY	0	0	5
22 MAY	0	1	5
23 MAY	0	4	5
30 MAY	0	6	5
31 MAY	0	6	5
6 JUN (0236-2000)	1	6	5
6 JUN (2000-2400)	1	6	4
7 JUN	0	6	4
12 JUN	0	6	1
13 JUN	0	6	1
19 JUN	0	6	1
20 JUN	0	6	1
27 JUN	0	6	0
28 JUN	0	6	0
6 JUL	1	6	0
7 JUL	0	6	0
11 JUL	0	6	0
12 JUL	0	6	0

(a) Circulating water pumps were run at full capacity during entrainment survival and related studies.

Source: Section 401 certification data.

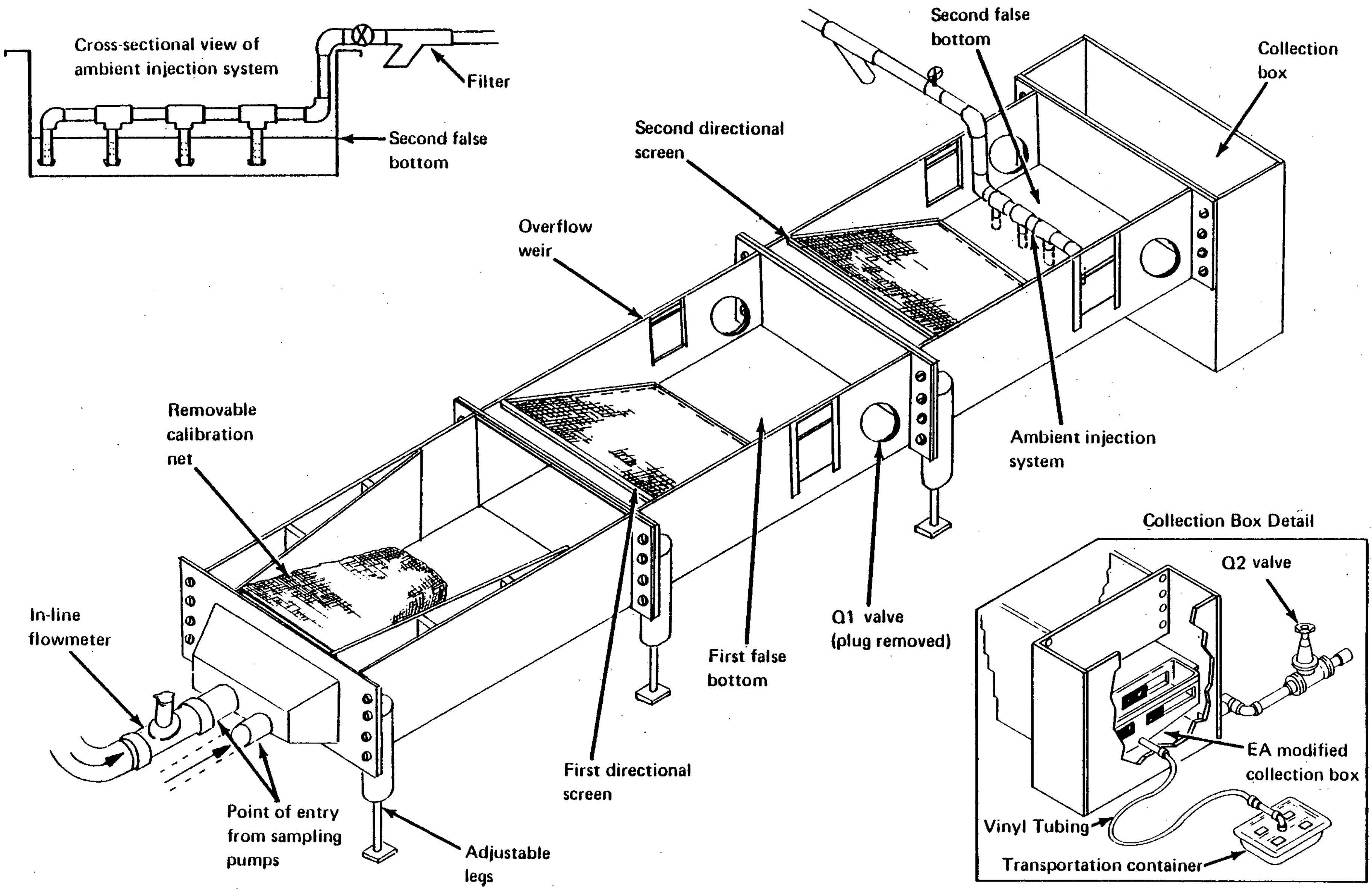

Figure 4-1. Design of the larval table collection system used in the Indian Point Generating Station entrainment survival study, 1978.

injects filtered ambient temperature river water into the larval table below the second false bottom at a rate of about 75 liters per minute, reducing the delta-T in the collection system by approximately 35 to 50 percent at the discharge stations.* Limiting thermal exposure during collection was necessary because normal through-plant transit times are about 5 to 10 minutes as compared to a 40-minute exposure in the larval table (sampling time plus table draining time). The ambient injection system was also used at the intake stations to maintain comparability of methods at intake (control) and discharge (experimental) stations.

Specific information relative to sampling gear and associated sampling conditions at each station are presented in Appendix B.

4.2.1.3 Collection Procedures

Each sample was collected by pumping water through the pump/larval table collection system for 15 minutes. Prior to sampling, the pumps were started and the table was filled with water. The speed of the pumps was adjusted to 1,800-2,000 rpm and maintained at this speed throughout sample collection. A removable calibration net (505 μ mesh) inserted near the front of the table prevented contamination of the sample with organisms that may have been collected during the start-up period. The ambient injection system was also started prior to sampling.

Sampling was initiated simultaneously at intake and discharge stations by removing the calibration net at each larval table. The total volume of water sampled at each table during the 15-minute sampling period ranged from 10 to 26 m^3.

At the end of the 15-minute sampling interval, the pumps were turned off and the table was drained. The ambient injection system remained on until the water in the table reached the level of the false bottom. The table was continually rinsed with a gentle flow of filtered ambient temperature river water as the table drained. Organisms and detritus were then drained from the collection box into the transportation container and the sample was transferred to the on-site laboratory for sorting. The time required to rinse and drain the table was approximately 25 minutes. The larval tables were thoroughly rinsed between samples with a high pressure spray wash to prevent contamination of subsequent samples by detritus and/or organisms adhering to the sides of the table and the screens.

4.2.1.4 Sorting Procedures

Live and dead ichthyoplankton were sorted from the transportation containers immediately after sample collection (Figure 4-2). Ichthyoplankton were classified as live, stunned, or dead according to the following criteria:

* Temperatures within the collection box did not exceed 32 C throughout the study. Results of laboratory thermal tolerance experiments (EA 1978b) have shown that most ichthyoplankton are able to tolerate thermal exposures similar to those encountered by ichthyoplankton during collection when the ambient injection system was used.

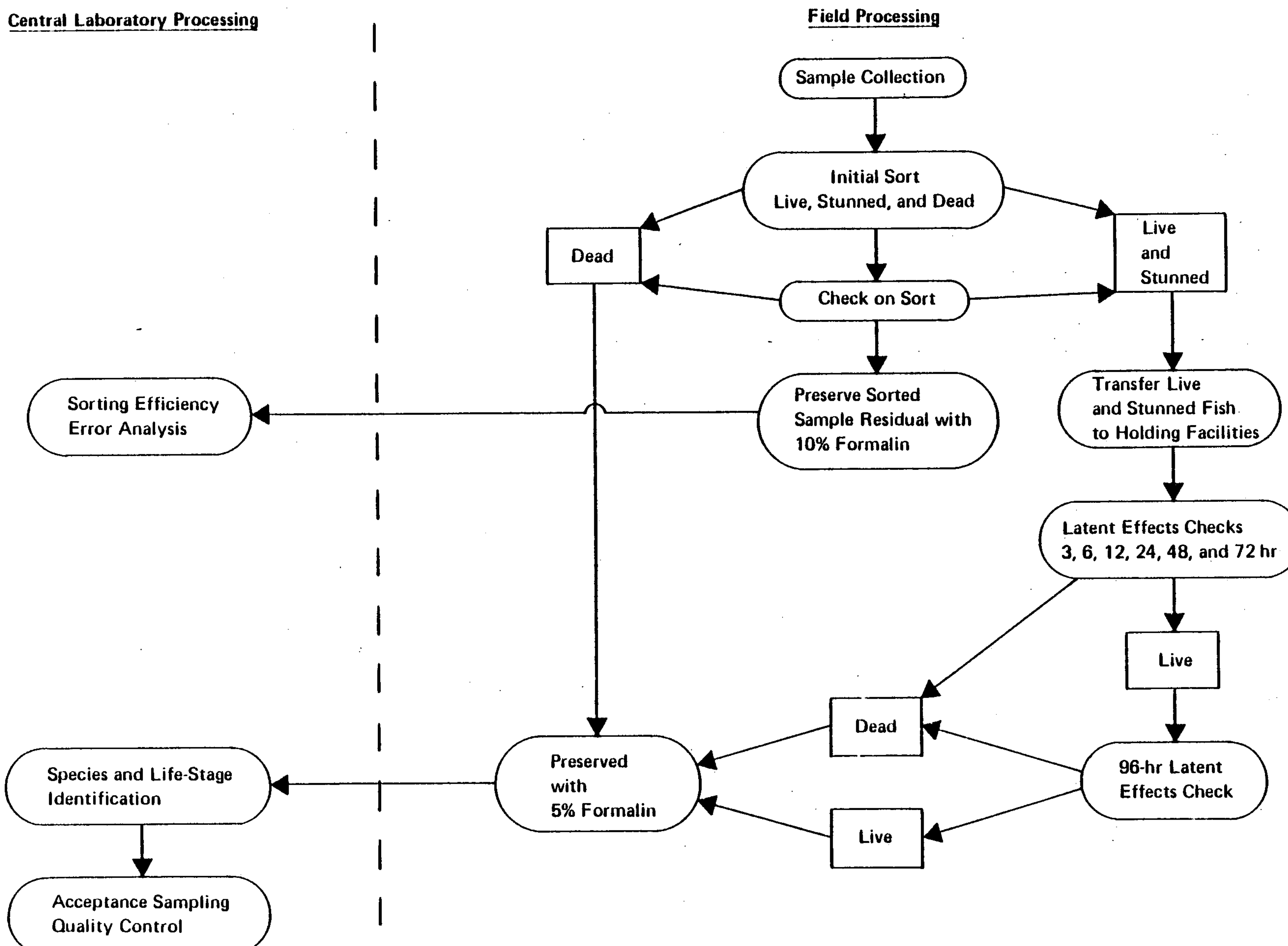

Figure 4-2. Work-flow chart for ichthyoplankton survival determinations.

Live: Fish--swimming vigorously, no apparent orientation difficulty
Eggs--translucent, chorion complete, not cloudy in any internal portion

Stunned: Fish only--swimming abnormally, struggling, swimming on side or upside down; or nonmotile except when gently probed

Dead: Fish--no vital life signs, no body or opercular movement, no response to gentle probing
Eggs--opaque, chorions ruptured or cloudy in any internal portion

All dead ichthyoplankton were removed from the sample and preserved in 5 percent buffered formalin. Live and stunned ichthyoplankton were carefully transferred with a large bore pipette to 1 liter jars containing filtered ambient river water. A maximum of five specimens were placed in each holding jar. Young larvae were separated from the older larvae and juveniles to reduce the possibility of cannibalism. The holding containers were aerated and maintained in an ambient temperature water bath for 96 hours after collection. Residual detritus and invertebrates from the samples were preserved in 10 percent buffered formalin.

During the last week of entrainment survival sampling (11 to 12 July), on-site sample handling and processing were complicated by relatively high catches of larval bay anchovies and heavy detritus concentrations. So as not to prolong sample processing to the extent that the viability of organisms within the samples would be jeopardized, a maximum sample sorting time was established (~90 minutes). Live, stunned, and dead ichthyoplankton, with the exception of dead bay anchovy larvae, were initially removed from the sample. After this was accomplished, as many dead bay anchovy larvae as possible were removed from the sample within the time limit. The remaining dead bay anchovy larvae were preserved with the sample detritus, and were sorted from the preserved samples at a later date.

4.2.1.5 Latent Survival Observation Procedures

The survival of live and stunned ichthyoplankton was monitored for 96 hours after collection (Figure 4-2). Interim mortality assessments (latent effects checks) were made 3, 6, 12, 24, 48, and 72 hours after collection. At each latent effects check, dead organisms were removed from the holding containers and preserved in vials containing 5 percent buffered formalin. All organisms remaining alive at the 96-hour check were enumerated and preserved in an identical manner.

4.2.1.6 Ichthyoplankton Identification

Preserved specimens were transported to Ecological Analysts' Central Laboratory in Middletown, New York, for identification and classification according to life stage. The total length of each specimen was determined to the nearest millimeter.

4.2.1.7 Water Quality Measurements

Measurements of water temperature, conductivity, dissolved oxygen, and pH were taken during each sampling effort. Water temperature was recorded at each station during sample collection. Conductivity, dissolved oxygen, and pH were measured during the first, middle, and last samples of the night at one of the intake stations. Water quality data collected at the intake stations throughout the entrainment survival study are presented in Table 4-2.

4.2.1.8 Quality Assurance and Control

Quality control and assurance procedures were employed throughout the sampling effort to insure the accuracy of the data. Quality control procedures established at the on-site laboratory consisted of (1) sorting efficiency checks conducted immediately after the initial sort, (2) a color coded labeling system for holding containers and vials, and (3) records of the number of live and dead fish at each latent effects observation. In addition, the Entrainment Discipline Coordinator conducted periodic inspections of the field sampling program to document strict adherence to standard operating procedures. Quality control procedures established at the Central Laboratory included resorting of randomly selected samples (preserved) to document the sorting efficiency at the on-site laboratory, and application of statistical quality control procedures to ensure the precision of ichthyoplankton identification.

4.2.2 Analytical Procedures

Initial and 96-hour survival at the intake and discharge stations was calculated as the ratio of organisms found alive to the total number of organisms collected.

$$P_I \text{ or } P_D = \frac{\text{No. of alive and stunned fish}}{\text{Total number of fish}}$$

where

P_I = survival at intake
P_D = survival at discharge.

Stunned fish were grouped with live fish in the analysis to avoid potential bias associated with the subjective stunned categorization. The standard error of the survival proportion was calculated according to the following equation:

$$\text{Standard error} = \sqrt{\frac{P(1-P)}{n}}$$

where

P = proportion surviving
n = total number of organisms.

The z statistic (one-tailed test) (Snedecor and Cochran 1971, p. 221) was used to determine if the survival proportion for fish collected at the discharge

TABLE 4-2 AVERAGE TEMPERATURE, DISSOLVED OXYGEN, pH, AND CONDUCTIVITY RECORDED AT THE INTAKE STATIONS DURING THE ENTRAINMENT SURVIVAL STUDY AT THE INDIAN POINT GENERATING STATION, 1978

Date	Temperature (C)	Dissolved Oxygen (ppm)	Conductivity (μmho)	pH
1 MAY	11.2	10.6	119	8.5
2 MAY	11.5	9.9	109	8.2
8 MAY	11.5	10.5	100	8.1
9 MAY	12.6	10.0	106	8.4
15 MAY	13.1	10.9	115	8.0
16 MAY	12.8	11.2	305	8.0
22 MAY	15.9	10.7	--	8.3
23 MAY	16.0	10.6	--	8.2
30 MAY	19.6	9.8	--	8.0
31 MAY	19.5	10.6	--	7.6
6 JUN	20.4	8.6	142	8.0
7 JUN	20.8	8.5	1,740	--
12 JUN	21.6	8.2	151	--
13 JUN	20.9	7.9	149	7.8
19 JUN	22.0	7.5	1,360	--
20 JUN	22.0	10.2	677	7.6
27 JUN	24.2	7.5	961	7.4
28 JUN	24.3	--	853	7.5
6 JUL	23.6	11.1	2,580	7.3
7 JUL	24.2	6.9	3,493	6.6
11 JUL	24.2	5.9	3,403	7.5
12 JUL	24.3	5.9	3,597	7.5

Note: Dashes (--) indicate data not available.

was significantly lower ($P = 0.05$) than the survival proportion for fish collected at the intake.

$$z = \frac{P_I - P_D}{\sqrt{\bar{p}\,\bar{q}\,(1/n_I + 1/n_D)}}$$

where

$$\bar{p} = \frac{\text{No. surviving at intake and discharge}}{\text{No. collected at intake and discharge}}$$

$$\bar{q} = 1 - \bar{p}$$

Latent survival of fish collected at the discharge was compared to latent survival of fish collected at the intake to determine if mortality resulting from entrainment was manifested beyond the initial survival observation. For these comparisons, survival at each latent effects observation was calculated as a proportion of the initial number of alive and stunned fish (i.e., normalized survival). The standard error of these normalized survival proportions and the z statistic were determined as shown above.

The proportions surviving at the intake and discharge immediately following sample collection were compared to determine the effects of entrainment. Survival at the discharge station is the result of the conditional probabilities of surviving entrainment and sampling. Assuming there is no interaction between the two stresses:

$$P_D = P_s \times P_e$$

where

P_D = probability of surviving at the discharge
P_s = probability of surviving sampling
P_e = probability of surviving entrainment.

The intake survival was used as an estimate of P_s, and entrainment survival was quantified by use of the equation:

$$S_e(\%) = P_e \times 100 = \frac{P_D}{P_I} \times 100$$

where

S_e = entrainment survival.

The value S_e thus represents the percentage of organisms that survive passage through the plant circulating water system.

4.3 RESULTS AND DISCUSSION

4.3.1 Collection of Ichthyoplankton for Survival Determinations

The most abundant taxonomic group of ichthyoplankton collected at the Indian Point plant during the 1978 entrainment survival sampling season was the herring family (Clupeidae) followed by (in order of decreasing abundance) striped bass (*Morone saxatilis*), anchovies (Engraulidae) and white perch (*M. americana*) (Table 4-3). These four taxa comprised 91 percent of the ichthyoplankton collected in entrainment samples.

The majority of ichthyoplankton were collected during June when intake temperatures ranged from 18 to 20 C (Figures 4-3 through 4-6). Striped bass eggs and herring larvae were the predominant ichthyoplankton collected during May, and anchovies comprised most of the ichthyoplankton collected during July.

Post yolk-sac larvae were collected in larger numbers than other life stages (Table 4-3). Consequently, it was possible to determine entrainment survival for post yolk-sac larvae of all four major taxa. All life stages of striped bass were collected in sufficient numbers for entrainment survival determinations. The number of eggs, yolk-sac larvae, and juveniles collected for other taxa were too low to estimate entrainment survival. Weekly length-frequency distributions of striped bass collected for survival determinations are presented in Table 4-4.

Temperatures at the discharge stations ranged from 19 to 36 C during the study period (Figures 4-3 through 4-6); however, the majority of ichthyoplankton were collected at discharge temperatures ranging from 30 to 33 C. The percentages of ichthyoplankton collected at discharge stations when temperatures were greater than 30 C were 93 percent for striped bass larvae, 89 percent for white perch larvae, and 75 percent for herring larvae. Most of the engraulids were collected at discharge temperatures of 34 to 35 C. Few ichthyoplankton other than Engraulidae were collected at discharge temperatures greater than 33 C.

4.3.2 Initial Survival

The initial survival of entrained ichthyoplankton was examined for various plant operating and discharge temperature conditions. Initial survival proportions were determined for ichthyoplankton collected during the operation of Unit 3 only (1 May to 7 June), during simultaneous operation of Unit 2 and Unit 3 (30 May to 7 June), and during the operation of Unit 2 only (12 June to 12 July). The proportions of ichthyoplankton surviving entrainment during each of these periods were determined for three discharge temperature categories--less than 30.0 C, 30.0 to 32.9 C, and greater than 32.9 C.

4.3.2.1 Survival Proportions During Operation of Unit 3

Unit 3 was on-line from the beginning of the entrainment survival study (1 May) until 7 June. The initial survival of fish entrained through Unit 3 was evaluated by determining survival proportions for ichthyoplankton collected at Stations I3 and D3 during this time. Although sampling was also conducted at Station DP when Unit 3 alone was in operation, the numbers of fish

TABLE 4-3. TOTAL NUMBER OF EACH TAXON AND LIFE STAGE COLLECTED FOR SURVIVAL DETERMINATIONS AT INDIAN POINT GENERATING STATION, 1 MAY - 12 JULY 1978

Taxon		Number Collected				
Common Name	Scientific Name	Eggs	Yolk-Sac Larvae	Post Yolk-Sac Larvae	Juveniles	Percent of Total
Herrings	Clupeidae	7	0	1,422	19	32.21
Striped bass	*Morone saxatilis*	175	163	974	23	29.69
Anchovies[(a)]	Engraulidae	(b)	5	910	0	20.35
White perch	*Morone americana*	0	3	377	3	8.52
Rainbow smelt	*Osmerus mordax*	0	43	190	56	6.43
Tessellated darter	*Etheostoma olmstedi*	0	11	34	2	1.04
American eel	*Anquilla rostrata*	0	0	0	26	0.58
Atlantic tomcod	*Microgadus tomcod*	0	0	6	15	0.47
Minnows	Cyprinidae	0	2	13	0	0.33
Silversides	*Menidia* spp.	0	2	6	0	0.18
Yellow perch	*Perca flavescens*	0	4	2	0	0.13
Sunfish	Centrarchidae	0	0	3	0	0.07

(a) Bay anchovies (*Anchoa mitchilli*) are the only engraulids that occur to any appreciable extent within the Hudson River estuary.
(b) Survival determinations were not made for anchovy eggs.

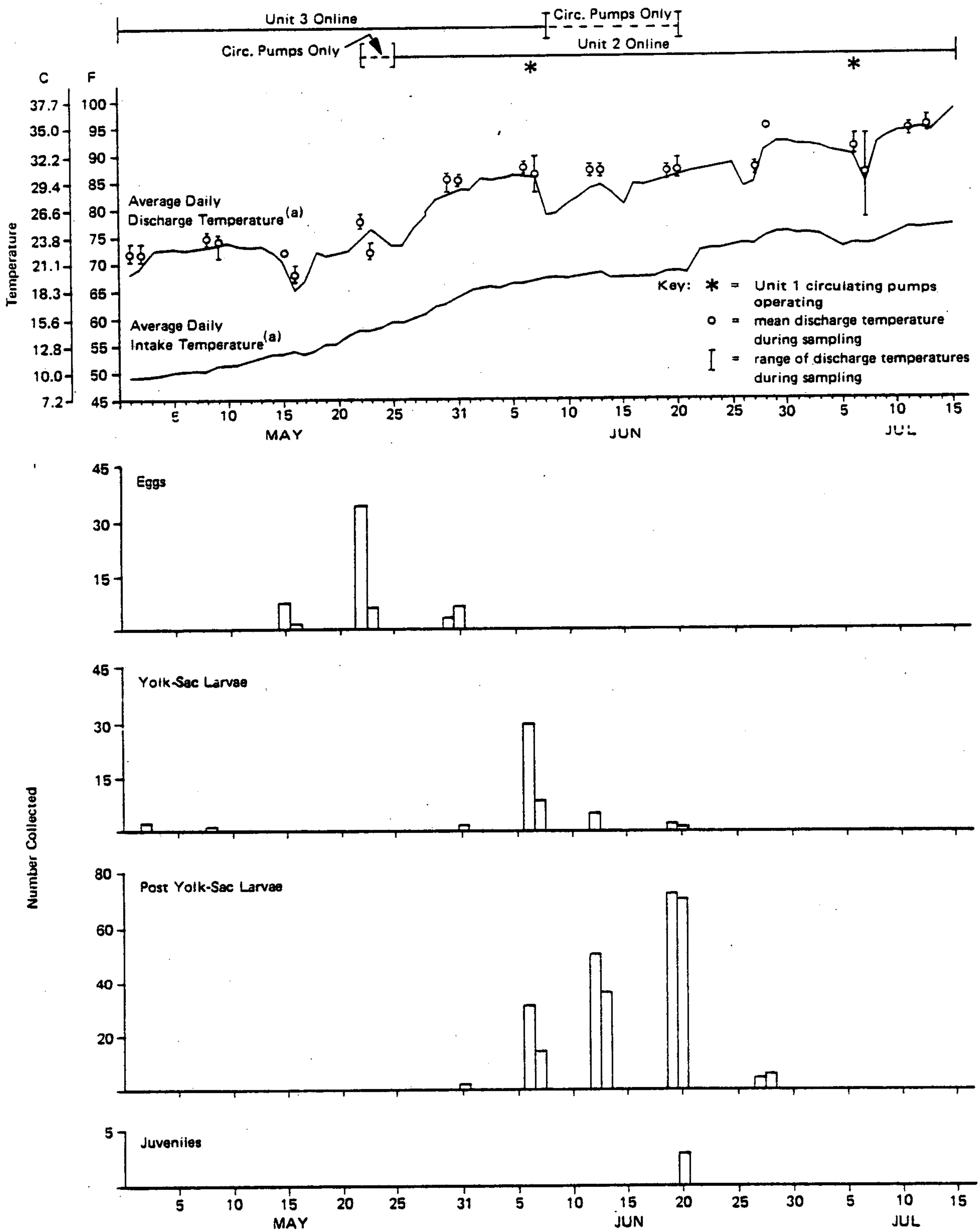

Figure 4-3. Temporal distribution and thermal exposure of striped bass collected at the discharge port sampling station (DP) during the entrainment survival study conducted at the Indian Point Generating Station in 1978.

(a)Source for average daily intake and discharge temperatures was Section 401 Certification data.

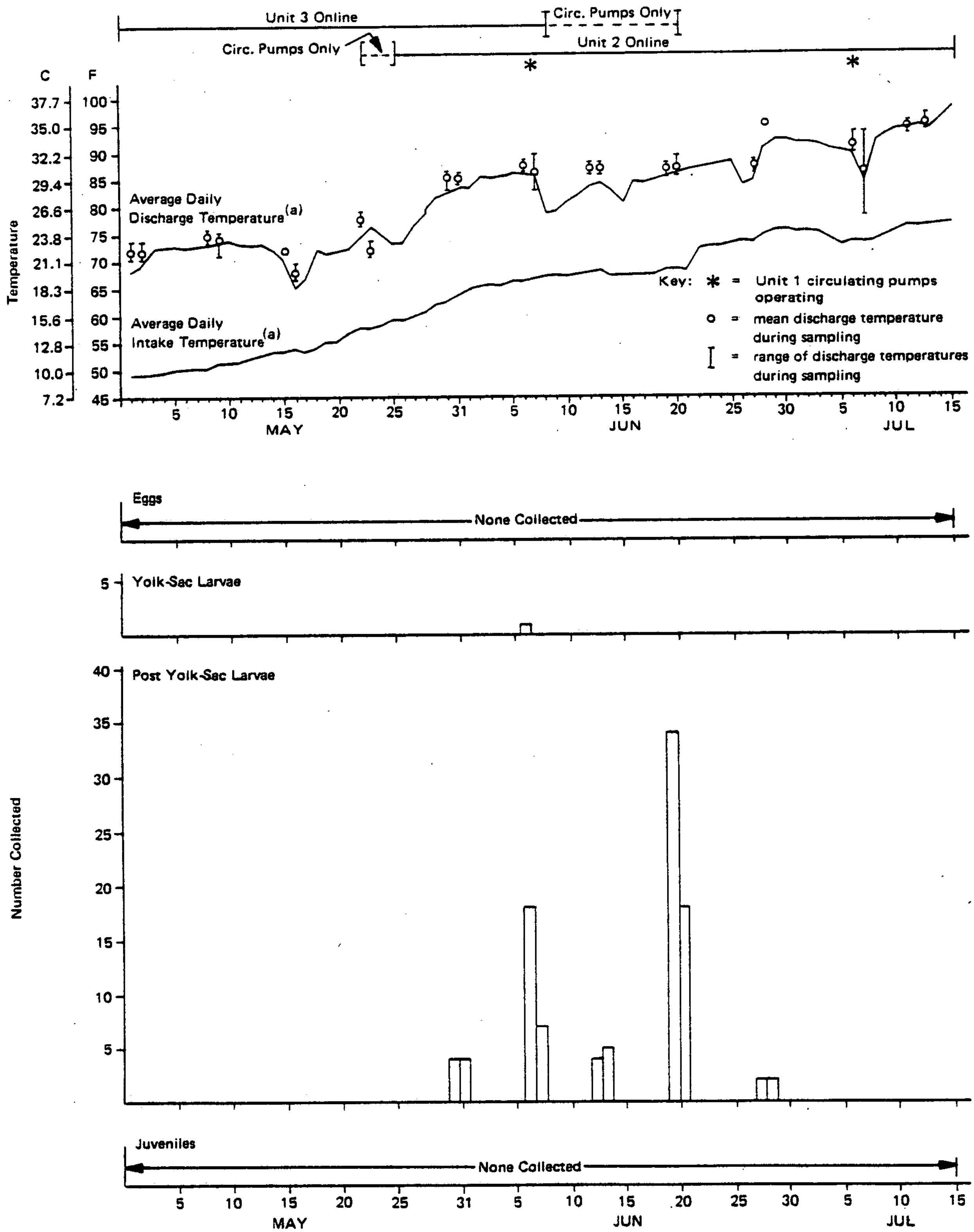

Figure 4-4. Temporal distribution and thermal exposure of white perch collected at the discharge port sampling station (DP) during the entrainment survival study conducted at the Indian Point Generating Station in 1978.

(a)Source for average daily intake and discharge temperatures was Section 401 Certification data.

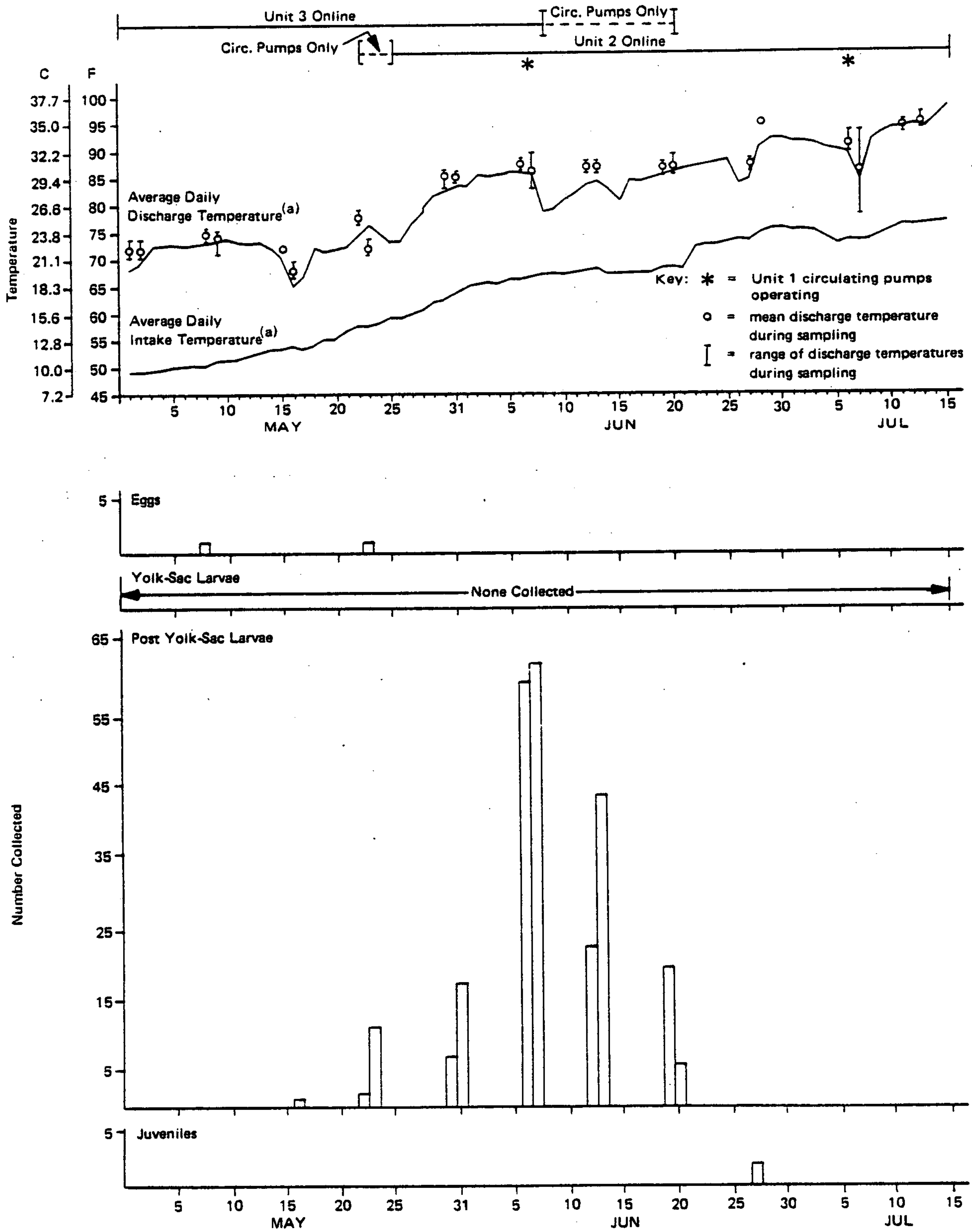

Figure 4-5. Temporal distribution and thermal exposure of clupeids collected at the discharge port sampling station (DP) during the entrainment survival study conducted at the Indian Point Generating Station in 1978.

(a) Source for average daily intake and discharge temperatures was Section 401 Certification data.

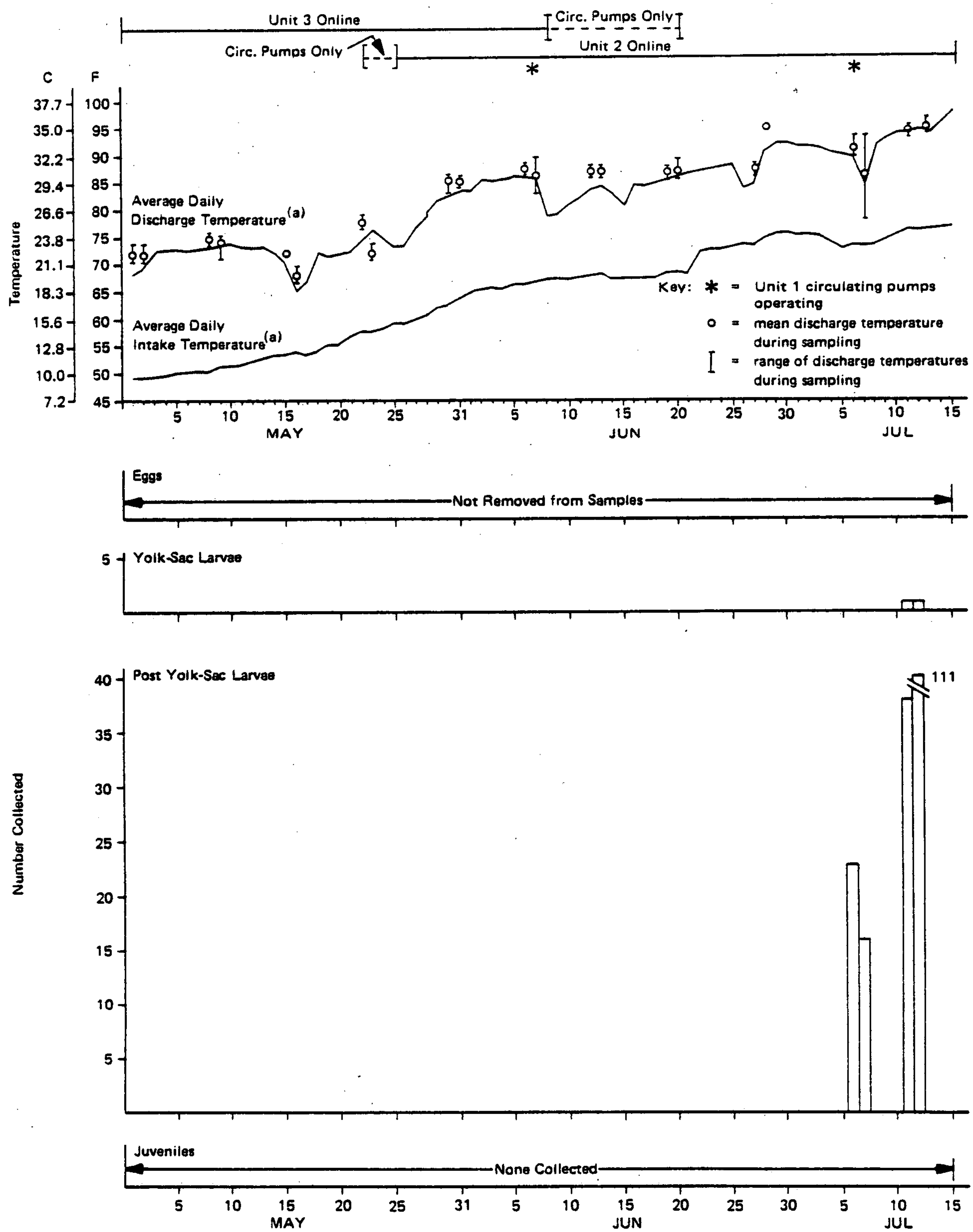

Figure 4-6. Temporal distribution and thermal exposure of engraulids collected at the discharge port sampling station (DP) during the entrainment survival study conducted at the Indian Point Generating Station in 1978.

(a)Source for average daily intake and discharge temperatures was Section 401 Certification data.

TABLE 4-4 LENGTH FREQUENCY DISTRIBUTION BY SAMPLING WEEK FOR STRIPED BASS COLLECTED AT STATIONS I2, I3, D1, D3, AND DP DURING ENTRAINMENT SURVIVAL STUDIES AT THE INDIAN POINT GENERATING STATION, 1978

				Length Invervals (mm)									Range (mm)[a]		
Week of	Number of Fish	Mean Length (mm)	Standard Deviation (mm)	00.0-02.9	03.0-05.9	06.0-08.9	09.0-11.9	12.0-14.9	15.0-17.9	18.0-20.9	21.0-23.9	24.0+	MIN	MED	MAX
Station I2															
30 MAY 78	1	7.0	0.0	0	0	1	0	0	0	0	0	0	7.0	7.0	7.0
6 JUN 78	97	6.4	0.8	0	8	89	0	0	0	0	0	0	5.0	6.0	8.0
12 JUN 78	152	8.9	1.6	0	3	52	91	6	0	0	0	0	4.0	9.0	12.0
19 JUN 78	112	10.8	2.6	0	0	23	46	34	8	1	0	0	6.0	11.0	20.0
27 JUN 78	25	13.7	6.0	0	1	3	8	3	3	4	1	2	5.0	12.0	27.0
6 JUL 78	0	0.0	0.0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
11 JUL 78	4	27.8	9.8	0	0	0	1	0	0	0	0	3	11.0	32.5	35.0
Station I3															
1 MAY 78	3	5.3	0.5	0	2	1	0	0	0	0	0	0	5.0	5.0	6.0
8 MAY 78	1	5.0	0.0	0	1	0	0	0	0	0	0	0	5.0	5.0	5.0
15 MAY 78	1	4.0	0.0	0	1	0	0	0	0	0	0	0	4.0	4.0	4.0
22 MAY 78	0	0.0	0.0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
30 MAY 78	6	6.7	0.5	0	0	6	0	0	0	0	0	0	6.0	7.0	7.0
6 JUN 78	57	6.4	1.1	0	10	45	2	0	0	0	0	0	5.0	6.0	10.0
Station D1															
12 JUN 78	95	9.4	1.8	0	3	25	57	10	0	0	0	0	4.0	9.0	13.0
19 JUN 78	108	10.7	2.2	0	2	18	48	36	4	0	0	0	5.0	11.0	16.0
27 JUN 78	25	12.8	4.5	0	0	2	11	6	1	3	1	1	7.0	11.0	25.0
6 JUL 78	1	36.0	0.0	0	0	0	0	0	0	0	0	1	36.0	36.0	36.0
11 JUL 78	1	10.0	0.0	0	0	0	1	0	0	0	0	0	10.0	10.0	10.0
Station D3															
1 MAY 78	4	5.0	0.0	0	4	0	0	0	0	0	0	0	5.0	5.0	5.0
8 MAY 78	0	0.0	0.0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
15 MAY 78	0	0.0	0.0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
22 MAY 78	0	0.0	0.0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
30 MAY 78	3	6.7	0.5	0	0	3	0	0	0	0	0	0	6.0	7.0	7.0
6 JUN 78	68	6.9	1.1	0	4	57	7	0	0	0	0	0	5.0	7.0	9.0

(a) MIN = shortest length; MED = median length; MAX = greatest length.

Note: Only those weeks when sampling was conducted at a particular station are listed for that station.

TABLE 4-4 (CONT.)

Week of	Number of Fish	Mean Length (mm)	Standard Deviation (mm)	Length Intervals (mm) 00.0-02.9	03.0-05.9	06.0-08.9	09.0-11.9	12.0-14.9	15.0-17.9	18.0-20.9	21.0-23.9	24.0+	Range (mm)[a] MIN	MED	MAX
Station DP															
1 MAY 78	2	5.0	0.0	0	2	0	0	0	0	0	0	0	5.0	5.0	5.0
8 MAY 78	1	6.0	0.0	0	0	1	0	0	0	0	0	0	6.0	6.0	6.0
15 MAY 78	0	0.0	0.0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
22 MAY 78	0	0.0	0.0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
30 MAY 78	2	7.0	0.0	0	0	2	0	0	0	0	0	0	7.0	7.0	7.0
6 JUN 78	84	6.3	1.0	0	20	63	1	0	0	0	0	0	5.0	6.0	9.0
12 JUN 78	86	8.4	1.4	0	2	43	41	0	0	0	0	0	5.0	8.0	11.0
19 JUN 78	124	11.1	2.7	0	2	14	61	33	11	3	0	0	5.0	11.0	18.0
27 JUN 78	9	10.9	2.0	0	0	1	5	3	0	0	0	0	7.0	11.0	14.0
6 JUL 78	0	0.0	0.0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
11 JUL 78	0	0.0	0.0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0

(a) MIN = shortest length; MED = median length; MAX = greatest length.

Note: Only those weeks when sampling was conducted at a particular station are listed for that station.

collected other than striped bass eggs, were too small to determine survival estimates.*

Striped bass and white perch were not abundant during the operation of Unit 3, but sufficient numbers of striped bass yolk-sac larvae and striped bass and white perch post yolk-sac larvae were collected for survival determinations. Initial survival proportions for entrained striped bass yolk-sac and post yolk-sac larvae collected at discharge temperatures less than 30 C did not differ significantly from survival proportions for striped bass larvae collected at the intake (Table 4-5). However, no survival was observed for striped bass yolk-sac and post yolk-sac larvae collected at discharge temperatures greater than 30 C. In addition, 27 percent of the white perch post yolk-sac larvae survived collection at the intake, whereas no white perch yolk-sac or post yolk-sac larvae survived collection at the discharge.

Several striped bass eggs were collected during the operation of Unit 3; however, no striped bass eggs survived collection at either intake or discharge stations (including Station DP). Thus, an entrainment survival determination for striped bass eggs was not possible.

Herring (Clupeidae) post yolk-sac larvae were relatively abundant during 1 May to 7 June. The survival of herring post yolk-sac larvae was significantly lower ($\alpha = 0.05$) at the discharge stations than at the intake station (Table 4-5). No entrained herring larvae were collected alive at discharge temperatures greater than 30 C. Herring eggs did not survive collection at either intake or discharge stations.

4.3.2.2 Survival Proportions During Operation of Both Unit 2 and Unit 3

Both Unit 2 and Unit 3 were in operation only during sampling conducted from 30 May to 7 June. The initial survival of ichthyoplankton entrained during this time was evaluated by determining survival proportions for organisms collected at Stations DP, I2, and I3. Survival results for Unit 2 and Unit 3 intake collections were combined to determine initial intake survival.

Few fish were collected alive at Station DP during two-unit operation (Table 4-6). No survival of entrained striped bass and white perch larvae was observed, although intake survival proportions for striped bass and white perch ranged from 0.20 to 0.35. Survival was observed for herring post yolk-sac larvae collected at discharge temperatures ranging from 28 to 32 C, but the proportion surviving was significantly lower ($\alpha = 0.05$) than that for herring larvae collected at the intake.

4.3.2.3 Survival Proportions During Operation of Unit 2

Unit 2 was in operation from 25 May until the end of the entrainment survival study period (12 July). However, it was not possible to examine the survival of fish entrained through Unit 2 alone until after 7 June, when Unit 3 went

* With the exception of striped bass eggs, only 3 white perch yolk-sac larvae (2 dead initially), 14 clupeid post yolk-sac larvae (all dead initially), and 2 clupeid eggs (both dead) were collected at Station DP prior to 25 May.

TABLE 4-5 MEAN INITIAL AND 96-HOUR SURVIVAL OF ICHTHYOPLANKTON COLLECTED DURING THE ENTRAINMENT SURVIVAL STUDY AT THE INDIAN POINT GENERATING STATION, UNIT 3, 1 MAY - 7 JUNE 1978[a]

			Yolk-Sac Larvae			Post Yolk-Sac Larvae		
			No. of	Proportion Surviving		No. of	Proportion Surviving	
Taxa	Station	Temperature (C)	Organisms	Initial	96-Hour	Organisms	Initial	96-Hour
Striped bass	I3	11.0-21.0[b]	39	0.26±0.07	0.0	24	0.46±0.10	0.17±0.08
	D3	21.0-34.0[b]	39	0.08±0.04*	0.0	36	0.06±0.04*	0.0*
		<30.0	12	0.25±0.12	0.0	9	0.22±0.14	0.0
		30.0-32.9	16	0.0*	--	18	0.0*	--
		>32.9	11	0.0*	--	9	0.0*	--
White perch	I3	19.0-21.0[b]	0	--	--	49	0.27±0.06	0.0
	D3	21.0-34.0[b]	2	0.0	--	35	0.0*	--
		<30.0	1	0.0	--	12	0.0*	--
		30.0-32.9	0	--	--	17	0.0*	--
		>32.9	1	0.0	--	6	0.0	--
Herrings	I3	12.7-16.1[b]	0	--	--	248	0.15±0.02	0.01±0.01
	D3	22.0-34.0[b]	0	--	--	192	0.02±0.01*	0.0
		<30.0	0	--	--	85	0.04±0.02*	0.0
		30.0-32.9	0	--	--	63	0.0*	--
		>32.9	0	--	--	44	0.0*	--

(a) Striped bass and clupeid eggs did not survive collection at either intake or discharge stations. No juveniles were collected when Unit 3 was online.

(b) Entire range of temperatures at which each taxon was collected during 1 May - June 7.

Note: Survival proportions are presented as the mean ±1 Standard Error.

Asterisks (*) indicate that the survival of fish collected at the discharge was significantly lower ($\alpha = 0.05$) than intake survival on the basis of the z-test (one-tailed) of the difference between two proportions.

Dashes (--) indicate data not available.

TABLE 4-6 MEAN INITIAL AND 96-HOUR SURVIVAL OF ICHTHYOPLANKTON COLLECTED DURING THE ENTRAINMENT SURVIVAL STUDY AT THE INDIAN POINT GENERATING STATION, UNIT 2 AND UNIT 3 COMBINED, 30 MAY - 7 JUNE 1978[a]

Taxa	Station[b]	Temperature (C)	Yolk-Sac Larvae			Post Yolk-Sac Larvae		
			No. of Organisms	Proportion Surviving Initial	Proportion Surviving 96-Hour	No. of Organisms	Proportion Surviving Initial	Proportion Surviving 96-Hour
Striped bass	I2 + I3	18.0-21.2[c]	55	0.31±0.06	0.0	108	0.35±0.05	0.05±0.02
	DP	28.0-32.0[c]	39	0.0*	--	46	0.0*	--
		<30.0	7	0.0*	--	13	0.0*	--
		30.0-32.0	32	0.0*	--	33	0.0*	--
White perch	I2 + I3	19.0-21.0[c]	0	--	--	85	0.20±0.04	0.01±0.01
	DP	28.0-32.0[c]	1	0.0	--	33	0.0*	--
		<30.0	0	--	--	10	0.0	--
		30.0-32.0	1	0.0	--	23	0.0*	--
Herrings	I2 + I3	19.0-22.0[c]	0	--	--	460	0.14±0.02	0.01±<0.01
	DP	28.0-32.0[c]	0	--	--	145	0.02±0.01*	--
		<30.0	0	--	--	57	0.04±0.03*	--
		30.0-32.0	0	--	--	88	0.01±0.01*	--

(a) Striped bass eggs did not survive collection at either intake or discharge stations. No juveniles were collected during two unit operation.

(b) Survival results for Unit 2 and Unit 3 intake collections (I2 & I3) were combined for 30 May - 7 June to calculate survival for two unit operation. Discharge survival for two unit operation is represented by collections at DP.

(c) Entire range of temperatures at which each taxon was collected during 30 May - 7 June.

Note: Survival proportions are presented as mean ± 1 standard error ($\alpha = 0.05$).

Asterisks (*) indicate that the survival of fish collected at the discharge was significantly lower ($\alpha = 0.05$) than intake survival on the basis of the z-test (one-tailed) of the difference between two proportions.

Dashes (--) indicate data not available.

off-line and the larval/table collection system at Station D3 was relocated to Station D1. The initial survival of fish entrained through Unit 2 was evaluated by determining survival proportions for ichthyoplankton collected at Stations I2, D1, and DP from 12 June to 12 July.

The majority of ichthyoplankton collected during the entrainment survival study was collected during the operation of Unit 2 alone. During this time, nearly all entrained ichthyoplankton were collected at discharge temperatures greater than 30 C. Although the survival of ichthyoplankton collected at the discharge stations during 12 June to 12 July was lower than the survival of fish collected at the intake, survival proportions for fish collected at both intake and discharge stations were higher than survival proportions for fish collected earlier in the season (Table 4-7). Initial survival proportions determined from collections at Station D1 were similar to initial survival proportions determined from collections at Station DP.

Survival proportions for striped bass collected at the discharge were significantly lower ($\alpha = 0.05$) than survival proportions for striped bass collected at the intake during 12 June to 12 July (Table 4-7). Few striped bass were collected alive at temperatures greater than 33.0 C but a relatively high proportion (with respect to intake survival) were collected alive at discharge temperatures ranging from 30 to 33 C. Survival proportions for striped bass post yolk-sac larvae collected at discharge temperatures ranging from 30 to 33 C were 0.29 (based on 225 fish) and 0.34 (based on 227 fish) at Stations D1 and DP, respectively, compared to a survival proportion of 0.48 (based on 315 fish) at the Unit 2 intake. These survival proportions for striped bass post yolk-sac larvae are in marked contrast to the low survival observed at these temperatures earlier in the sampling season. Survival of striped bass yolk-sac larvae collected at the discharge stations was low (survival proportions ranged from 0.0 to 0.18), although few yolk-sac larvae were collected during 12 June to 12 July. Striped bass juveniles were also collected in low abundance. The survival proportions for juveniles were generally high at both intake (0.85) and discharge stations (0.43 and 1.00 at Stations D1 and DP, respectively, for all temperatures combined).

Survival proportions for white perch collected during 12 June to 12 July were similar to survival proportions for striped bass (Table 4-7). No white perch survived entrainment and collection at discharge temperatures greater than 33 C (based on only 5 fish). Survival proportions for white perch post yolk-sac larvae collected at discharge temperatures ranging from 30 to 33 C were 0.37 (based on 60 fish) and 0.29 (based on 63 fish) at Stations D1 and DP, respectively, compared to a survival proportion of 0.48 (based on 93 fish) at the Unit 2 intake. The survival of white perch post yolk-sac larvae collected at Station D1 was not significantly lower than survival observed at the intake. In contrast, no white perch post yolk-sac larvae were collected alive at the discharge stations earlier in the sampling season. No white perch yolk-sac larvae were collected during 12 June to 12 July. Three juvenile white perch were collected alive at Station D1, but no juvenile white perch were collected at Stations I2 or DP.

Most survival proportions for herring collected at the discharge stations were significantly lower ($\alpha = 0.05$) than survival proportions for herring collected at the intake during the operation of Unit 2 alone (Table 4-7). The

TABLE 4-7 MEAN INITIAL AND 96-HOUR SURVIVAL OF ICHTHYOPLANKTON COLLECTED DURING THE ENTRAINMENT SURVIVAL STUDY AT THE INDIAN POINT GENERATING STATION, UNIT 2, 12 JUNE - 12 JULY 1978[a]

			Yolk-Sac Larvae			Post Yolk-Sac Larvae			Juveniles		
			No. of	Proportion Surviving		No. of	Proportion Surviving		No. of	Proportion Surviving	
Taxa	Station	Temperature (C)	Organisms	Initial	96-Hour	Organisms	Initial	96-Hour	Organisms	Initial	96-Hour
Striped bass	I2	20.7-24.6[b]	4	0.50±0.25	0.25±0.22	315	0.48±0.03	0.22±0.02	13	0.85±0.10	0.77±0.12
	D1	30.0-35.0[b]	11	0.18±0.12	0.0	237	0.28±0.03*	0.14±0.02*	7	0.43±0.19*	0.29±0.17*
		30.0-32.9	11	0.18±0.12	0.0	225	0.29±0.03*	0.14±0.02*	5	0.40±0.22*	0.20±0.18*
		>32.9	0	--	--	12	0.08±0.08*	0.08±0.08	2	0.50±0.35	0.50±0.36
	DP	30.0-35.0[b]	8	0.0*	--	232	0.33±0.03*	0.18±0.02	3	1.0	1.0
		30.0-32.9	8	0.0*	--	227	0.34±0.03*	0.19±0.03	3	1.0	1.0
		>32.9	0	--	--	5	0.0*	--	0	--	--
White perch	I2	19.9-24.0[b]	0	--	--	93	0.48±0.05	0.24±0.04	0	--	--
	D1	31.0-35.0[b]	0	--	--	64	0.34±0.06*	0.14±0.04	3	1.0	1.0
		30.0-32.9	0	--	--	60	0.37±0.06	0.15±0.05	3	1.0	1.0
		>32.9	0	--	--	4	0.0*	--	0	--	--
	DP	30.0-35.0[b]	0	--	--	64	0.28±0.06*	0.06±0.03*	0	--	--
		30.0-32.9	0	--	--	63	0.29±0.06*	0.06±0.03*	0	--	--
		>32.9	0	--	--	1	0.0	--	0	--	--
Herrings	I2	19.9-24.6[b]	0	--	--	338	0.18±0.02	0.0	14	0.29±0.12	0.0
	D1	31.0-35.0[b]	0	--	--	170	0.03±0.01*	0.0	3	0.0	--
		30.0-32.9	0	--	--	155	0.03±0.01*	0.0	1	0.0	--
		>32.9	0	--	--	13	0.08±0.08	0.0	2	0.0	--
	DP	30.0-31.0[b]	0	--	--	92	0.03±0.02*	0.0	2	0.0	--
Anchovies	I2	23.0-25.0[b]	3	0.0	--	500	0.02±0.01	0.0	0	--	--
	D1	28.0-35.0[b]	0	--	--	222	0.0*	--	0	--	--
		<30.0	0	--	--	2	0.0	--	0	--	--
		30.0-32.9	0	--	--	13	0.0	--	0	--	--
		>32.9	0	--	--	207	0.0*	--	0	--	--
	DP	25.0-36.0[b]	2	0.0	--	188	0.0*	--	0	--	--
		<30.0	0	--	--	2	0.0	--	0	--	--
		30.0-32.9	0	--	--	11	0.0	--	0	--	--
		>32.9	2	0.0	--	175	0.0*	--	0	--	--

(a) No eggs were collected during 12 June-12 July.
(b) Entire range of temperatures at which each taxon was collected during 12 June-12 July.

Note: Survival proportions are presented as mean ± 1 Standard Error.
Asterisks (*) indicate that the survival of fish collected at the discharge was significantly lower ($\alpha = 0.05$) than intake survival on the basis of the z-test (one-tailed) of the difference between two proportions.
Dashes (--) indicate data not available.

survival of herring post yolk-sac larvae was similar to survival observed earlier in the sampling season, in spite of the higher discharge temperatures at which herrings were collected during 12 June to 12 July. No juvenile herrings survived collection at the discharge stations, whereas 4 of the 14 juveniles collected at the intake were alive.

Anchovy post yolk-sac larvae were abundant in collections during the last week of sampling. The majority of entrained anchovy larvae were collected at discharge temperatures greater than 33 C. However, few anchovy larvae survived collection at the intake station (2 percent) and no anchovy larvae survived collection at the discharge stations (Table 4-7).

4.3.3 96-Hour Survival

The survival of ichthyoplankton collected alive at the intake and discharge stations was monitored for 96 hours following sample collection. Few fish collected at either intake or discharge stations survived 96 hours, with the exception of striped bass and white perch collected during 12 June to 12 July (Tables 4-5 through 4-7). The 96-hour survival proportions for entrained striped bass and white perch post yolk-sac larvae collected during this period at discharge temperatures less than 33 C were 0.16 (based on 452 fish) for striped bass and 0.11 (based on 123 fish) for white perch (combined 96-hour survival proportions for fish collected at both D1 and DP). The 96-hour survival proportions for striped bass and white perch post yolk-sac larvae collected at the intake during this time were 0.22 and 0.24, respectively. The highest 96-hour survival proportions were observed for striped bass and white perch juveniles (0.20 to 1.00), although the number of juveniles collected was small.

4.3.4 Normalized Latent Survival

Normalized latent survival of fish collected at the discharge was compared to normalized latent survival of fish collected at the intake to determine if mortality resulting from entrainment was manifested beyond the initial survival observation. Latent survival was normalized by calculating survival proportions for each latent effects observation on the basis of the number of live and stunned fish collected. This normalization procedure was applied in order to compare latent survival proportions for fish collected at discharge versus intake stations without including differences in initial survival.

Normalized latent survival comparisons were limited to ichthyoplankton collected from 12 June to 12 July because of the low numbers of live ichthyoplankton collected during the earlier portion of the study period. During this time, only striped bass and white perch post yolk-sac larvae and striped bass juveniles were collected in sufficient abundance to examine latent survival. In most cases, latent survival proportions for fish collected alive at the discharge stations were similar to latent survival proportions for fish collected alive at the intake stations (Table 4-8), indicating that little or no additional mortality as a result of entrainment was manifested beyond the initial survival observation. The latent survival proportions for white perch post yolk-sac larvae collected at Station DP were significantly lower ($\alpha = 0.05$) than latent survival proportions for white perch post yolk-sac larvae collected at Station I2. However, this reduction in latent survival was not observed for white perch post yolk-sac larvae collected at Station D1.

TABLE 4-8 NORMALIZED LATENT SURVIVAL OF ICHTHYOPLANKTON COLLECTED DURING THE ENTRAINMENT SURVIVAL STUDY AT THE INDIAN POINT GENERATING STATION, UNIT 2, 12 JUNE - 12 JULY 1978

Species[a] Life Stage	Station	No. of Organisms Initially Alive	Initial Survival Proportion	Survival Proportions, Time After Collection (Hours): 3	6	12	24	48	72	96
Striped bass PYSL	I2	152	1.0	0.86±0.03	0.72±0.04	0.60±0.04	0.54±0.04	0.49±0.04	0.49±0.04	0.45±0.04
	D1	67	1.0	0.88±0.04	0.76±0.05	0.64±0.06	0.61±0.06	0.51±0.06	0.49±0.06	0.48±0.06
	DP	77	1.0	0.86±0.04	0.70±0.05	0.64±0.05	0.60±0.06	0.57±0.06	0.56±0.06	0.56±0.06
Striped bass Juveniles	I2	11	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.91±0.10
	D1	3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.67±0.27
	DP	3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
White perch PSYL	I2	45	1.0	0.82±0.06	0.73±0.07	0.67±0.07	0.56±0.08	0.53±0.07	0.51±0.07	0.49±0.07
	D1	22	1.0	0.82±0.08	0.59±0.11	0.50±0.11	0.41±0.10	0.41±0.10	0.41±0.10	0.41±0.10
	DP	18	1.0	0.89±0.07	0.67±0.11	0.44±0.12*	0.28±0.11*	0.28±0.11*	0.22±0.10*	0.22±0.10*

(a) The numbers of other ichthyoplankton that survived collection and entrainment during the study were too low for latent survival comparisons between intake and discharge stations.

Note: PYSL = post yolk-sac larvae.

Asterisks (*) indicate that the survival of fish collected at the discharge was significantly lower (α = 0.05) than the intake survival on the basis of the z-test (one-tailed) of the difference between two proportions.

4.3.5 Entrainment Survival Estimates

The survival of ichthyoplankton entrained through the cooling water system of the Indian Point plant was estimated from intake and discharge survival data. The survival proportions for fish collected at the discharge stations reflected mortality resulting from collection stresses and plant entrainment stresses, whereas survival proportions for fish collected at the intake reflected mortality resulting from collection stresses only. Entrainment survival estimates (S_e) were determined by adjusting initial discharge survival proportions to reflect only mortality resulting from plant entrainment (Section 4.2.2). Estimates were calculated for taxa and life stages for which five or more organisms were collected at both the intake and discharge stations.

Survival estimates were generally higher later in the sampling season (12 June to 12 July), when the majority of ichthyoplankton were collected, than during the earlier portion of the sampling season (1 May to 7 June) (Table 4-9). Survival estimates for the two specified sampling periods were calculated based on survival data for intake and discharge stations paired according to unit operation (i.e., I3 versus D3 for 1 May to 23 May, I2 plus I3 versus DP for 30 May to 7 June, and I2 versus D1 plus DP for 12 June to 12 July). Thus, survival estimates for 1 May to 7 June* represent the combined survival during the operation of all units during this time, whereas estimates for 12 June to 12 July represent survival during the operation of Unit 2 alone.

For striped bass and white perch ichthyoplankton, the highest survival estimates were observed during 12 June to 12 July when the majority of white perch and striped bass were collected (Table 4-9). During this time, entrainment survival estimates for white perch and striped bass post yolk-sac larvae ranged from 65 to 67 percent at discharge temperatures of 30 to 32.9 C. No striped bass or white perch were collected at discharge temperatures less than 30 C during the later portion of the study period. The entrainment survival estimate for striped bass juveniles (all temperatures combined) was 71 percent. Although survival estimates for striped bass and white perch collected during 1 May to 7 June were usually low (0 to 7 percent, all temperatures combined), the number of striped bass and white perch collected during this time comprised only 20 percent of the total number of these two species collected during the entire study.

Entrainment survival estimates for herring larvae remained relatively constant throughout the study, in spite of the higher discharge temperatures prevalent during the 12 June to 12 July sampling period (Table 4-9). For all temperatures combined, survival estimates were 13 percent during 1 May to 7 June and 17 percent during 12 June to 12 July. The highest entrainment survival estimate for herring larvae (42 percent) was observed for those collected during 12 June to 12 July at discharge temperatures greater than 32.9 C.

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* In generating survival estimates for the period 1 May to 7 June, survival data collected at Station D3 during 30 May to 7 June were not included because these data represented survival of fish entrained through Unit 3 alone and could not be compared to the combined survival for intake stations I2 and I3.

TABLE 4-9 ENTRAINMENT SURVIVAL ESTIMATES OF ICHTHYOPLANKTON AS A FUNCTION OF TWO SAMPLING INTERVALS AND DISCHARGE TEMPERATURES AT THE INDIAN POINT GENERATING STATION, 1978[a]

		Discharge Temperature Less Than 30.0 C				Discharge Temperatures 30.0-32.9 C				Discharge Temperatures Greater Than 32.9 C				All Temperatures Combined			
		1 May-7Jun[b]		12 Jun-12 Jul[c]		1 May-7 Jun[b]		12 Jun-12 Jul[c]		1 May-7 Jun[b]		12 Jun-12 Jul[c]		1 May-7 Jun[b]		12 Jun-12 Jul[c]	
Taxa	Life Stage	N_d	S_e(%)	N_d	S_e(%)	N_d	S_e(%)	N_d	S_e(%)	N_d	S_e(%)	N_d	S_e(%)	N_d	S_e(%)	N_d	S_e(%)
Striped bass	YSL	15	23	0	--	32	0	19	--	0	--	0	--	47	7	19	--
	PYSL	13	0	0	--	33	0	452	65	0	--	17	12	46	0	469	64
	JUV	0	--	0	--	0	--	8	74	0	--	2	--	0	--	10	71
White perch	PYSL	12	0	0	--	23	0	123	67	0	--	5	0	35	0	128	64
Herring	PYSL	85	18	0	--	88	8	247	15	0	--	13	42	173	13	262	17
Anchovy	PYSL	0	--	4	--	0	--	24	0	0	--	382	0	0	--	410	0

(a) Includes all taxa and life stages for which sufficient data was available to determine a survival estimate.
(b) Entrainment survival estimates were based on collections at I3, D3, and DP during 1 May-23 May and I2, I3, and DP during 30 May-7 June.
(c) Entrainment survival estimates were based on collections at I2, D1, and DP during 12 June-12 July.

Note: Dashes (--) indicate that insufficient data was available to determine a survival estimate (i.e., sample sizes at intake or discharge were less than 5).

N_d indicates number of fish in discharge collections.

S_e(%) indicates entrainment survival (percent).

No anchovy larvae were collected alive at discharge stations during the study, and only 2 percent of the anchovies collected at the intake stations were alive.

Entrainment survival estimates were also calculated on the basis of ichthyoplankton collections for the two sampling intervals combined in order to compare survival estimates with those determined during the 1977 study (Table 4-10). The 1977 survival estimates used for the comparison were based on collections at Stations I2, I3 and DP during the 1977 entrainment survival study (EA 1978a, Table 4-10), and represented survival estimates during 1977 for all units combined.

Entrainment survival estimates determined on the basis of the 1977 survival data were consistently higher than estimates determined on the basis of the 1978 survival data (Table 4-10). For example, the survival estimates for striped bass and white perch post yolk-sac larvae (for combined unit and combined temperature conditions) were 85 and 77 percent, respectively, during 1977, compared to 66 and 71 percent for striped bass and white perch, respectively, during 1978. The lower survival estimates determined on the basis of the 1978 survival data may have resulted from the higher discharge temperatures prevalent throughout most of the 1978 study. Although the 1977 survival estimates were consistently higher within each temperature category, direct comparisons between survival estimates within discharge temperature categories are difficult because of the differences in ichthyoplankton abundance between years. The majority of ichthyoplankton entrained during the 1978 study were collected at discharge temperatures ranging from 30.0 to 32.9 C, whereas few entrained ichthyoplankton (with the exception of anchovy larvae) were collected at discharge temperatures greater than 30.0 C during the 1977 study.

TABLE 4-10 COMPARISON OF ENTRAINMENT SURVIVAL ESTIMATES FOR ICHTHYOPLANKTON COLLECTED IN 1977 TO ENTRAINMENT SURVIVAL ESTIMATES FOR ICHTHYOPLANKTON COLLECTED IN 1978 AT THE INDIAN POINT GENERATING STATION (ALL UNITS COMBINED)[a]

		Discharge Temperatures Less Than 30.0 C				Discharge Temperatures 30.0 to 32.9 C				Discharge Temperatures Greater Than 32.9 C				All Temperatures Combined			
		1977[b]		1978[c]		1977[b]		1978[c]		1977[b]		1978[c]		1977[b]		1978[c]	
Taxa	Life Stage	N_d	S_e(%)	N_d	S_e(%)	N_d	S_e(%)	N_d	S_e(%)	N_d	S_e(%)	N_d	S_e(%)	N_d	S_e(%)	N_d	S_e(%)
Striped bass	YSL	18	63	15	22	1	--	51	13	0	--	0	--	19	67	66	15
	PYSL	221	85	13	0	19	87	485	69	7	93	17	14	247	85	515	66
	JUV	0	--	0	--	0	--	8	74	0	--	2	--	0	--	10	71
White perch	PYSL	32	73	12	0	12	89	146	80	3	--	5	0	47	77	163	71
Herring	PYSL	27	40	85	16	3	--	335	16	0	--	13	50	30	34	433	17
Anchovy	PYSL	0	--	4	--	230	36	24	0	91	18	382	0	321	31	410	0

(a) Includes all taxa and life stages for which sufficient data was available to determine entrainment survival estimates.
(b) Entrainment survival estimates were based on collections at I2, I3, and DP during the 1977 entrainment survival study (from EA 1978a, Table 4-10).
(c) Entrainment survival estimates were based on collections at I3, D3, and DP during 1 May - 25 May, I2, I3 and DP during 30 May - 7 Jun, and I2, D1, and DP during 12 June-12 July (see Table 4-9).

Note: Dashes (--) indicate that insufficient data were available to determine a survival estimate (i.e., sample sizes at intake or discharge were less than 5).

N_d indictes number of fish in discharge collections.

S_e(%) indicates entrainment survival (percent).

CHAPTER 5: PUMP VERSUS STATIONARY NET COMPARABILITY STUDY

5.1 INTRODUCTION

Studies to determine the abundance of ichthyoplankton entrained through the Indian Point Generating Station to date have employed stationary nets (NYU 1973, 1974, 1975, 1976a, 1978). To evaluate pumps as an alternate method of collection, a comparison study was conducted during 1978 to assess the comparability of ichthyoplankton density estimates derived from pump versus stationary net samples. Abundance samples were collected by simultaneously sampling in the discharge canal with a pump and a stationary net. Density estimates determined from the sample data were statistically analyzed to test for differences in abundance of major taxa collected by the two types of sampling gear.

A similar pump-net comparison study was conducted during 1977 (EA 1978a). Results of that study indicated that daily average densities of ichthyoplankton collected were usually similar for both gear types. However, the volume of water sampled by the stationary nets was 13 to 23 times greater than the combined volume sampled by the 3 and 4 in. pumps used during this study (EA 1978a, Table 5-1). As a result, density estimates for the pump samples were based on smaller numbers of fish than those for the net samples. Since the variance associated with density estimates determined for small sample sizes is greater than for large sample sizes, it was difficult to detect differences between gear types for the less abundant taxonomic groups. To increase the volume of water and, consequently, the number of organisms collected in pumped samples, a 6 in. pump was employed during the 1978 study in place of the 3 and 4 in. pumps used in 1977. The larger pump sampled approximately 50 percent of the volume that the stationary net sampled during an equivalent time interval.

5.2 METHODS

Simultaneous 15-minute samples using both a pump and a stationary net were collected at discharge station D1 on a total of six sampling days during June and July 1978. Sampling was conducted simultaneously for equal sampling durations so that each gear sampled a similar ichthyoplankton population. A total of 79 paired samples were collected during the study (Appendix C).

The stationary net sampling apparatus used by New York University Medical Center for entrainment abundance studies (NYU 1975) was used during this study to collect net samples. Two 0.5 m, 571 μ mesh conical plankton nets (1.8 m long) were mounted at the middepth (3 m) sampling position of the net frame (Figures 5-1 and 5-2). At the end of the sampling period, the contents of one of the nets were washed into a removable codend and transferred to an 800 ml container for preservation. The velocity of water entering the net was recorded with a Cushing electromagnetic current meter (Model 612-P) at 2 minute intervals during sampling. The velocity measurements were then converted to volume estimates. Volumes of water sampled with the net during the 15-minute collection period ranged from 87 to 148 m^3 (5,867 to 9,867 liters per minute) (Appendix Table C-1).

Pump samples were obtained using a Marlow 6 in. "Trash Hog" pump. A rigid 6 in. intake pipe was permanently attached to the net sampling structure at

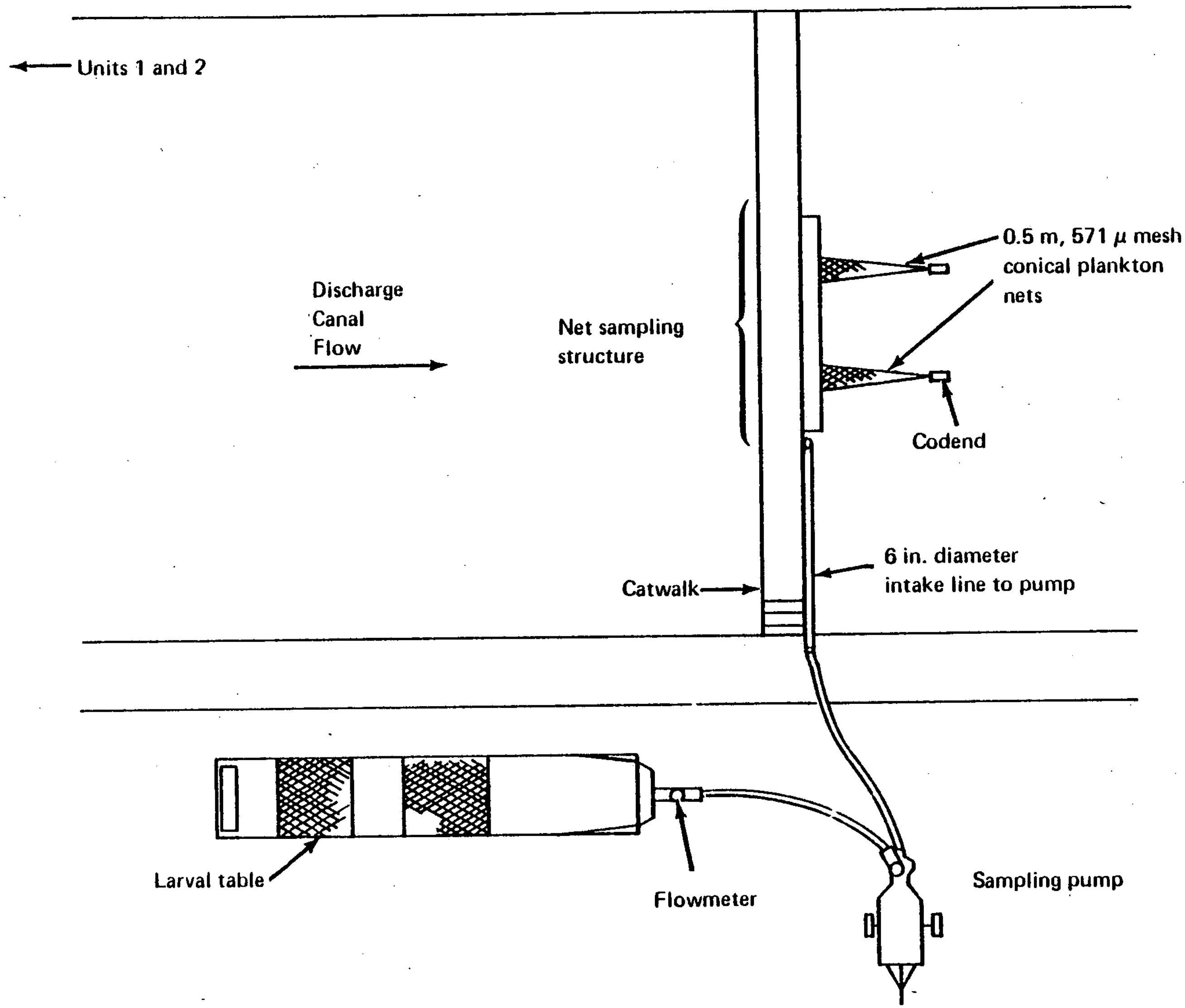

Figure 5-1. Schematic of sampling gear used during the pump-net comparison study (Station D 1), Indian Point Generating Station, 1978.

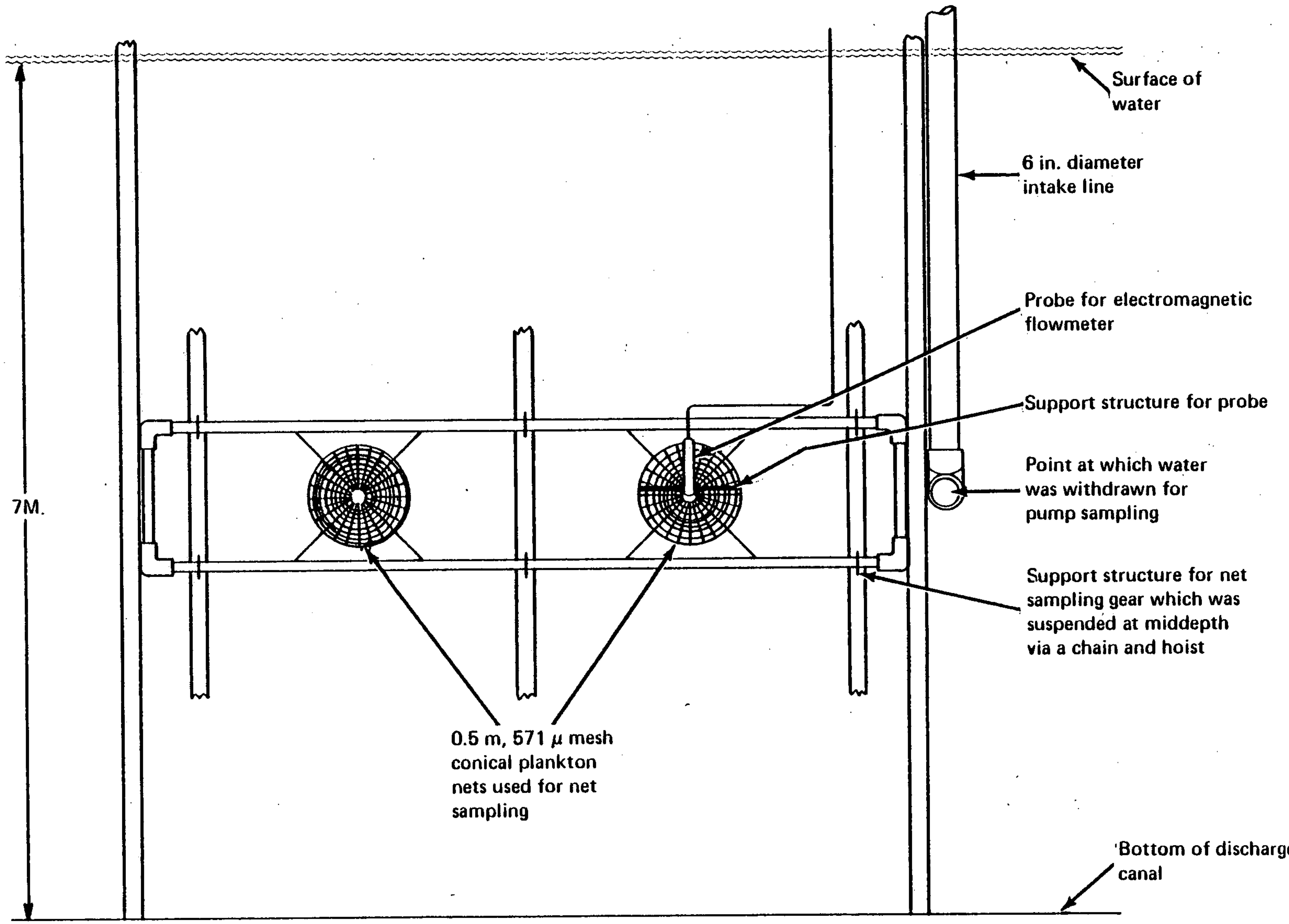

Figure 5-2. Location of net and pump intake pipe used during the pump-net comparison study (Station D 1), Indian Point Generating Station, 1978.

the middepth position (adjacent to the net). An elbow coupling was used to direct the opening of the intake pipe into the current so that the sampling planes of the pump and stationary net were consistent (Figures 5-1 and 5-2). A Sparling "Masterflo" flowmeter was used to measure the volume of water sampled by the pump. The pump was operated at about 1,600 rpm during sampling, representing approximately 70 percent capacity (based on operating specifications at 20 ft [6.1 m] of head). The volumes of water sampled with the pump during the 15-minute collection period ranged from 29.1 to 67.0 m^3 (1,940 to 4,467 liters per minute) (Appendix Table C-1).

Pump samples were concentrated using a standard two-screen (505 μ mesh) larval table modified slightly to accommodate the 6 in. Marlow pump (Figures 4-1 and 5-1). The table was thoroughly rinsed to ensure that all organisms collected were recovered. After concentrating the organisms in the collection box at the rear of the table, the sample was drained into a standard 1 liter codend (similar to codends used with the net) and transferred to an 800 ml container for preservation.

All samples were preserved in 10 percent formalin immediately after collection. Preserved samples were transported to Ecological Analysts' Central Laboratory in Middletown, New York, for identification and enumeration. Ichthyoplankton were identified to either a primary or secondary taxonomic level and classified according to life stage. The primary taxonomic level refers to the lowest taxonomic grouping (usually species) to which routine identifications were made. Specimens that were damaged during collection (to the extent that reliable identification to the primary taxonomic level could not be made) were identified to the lowest taxonomic level possible based on recognizable identification characteristics (secondary taxonomic level). Larvae that could not be classified to a specific life stage or taxonomic group were placed in an "unidentified" life stage or taxonomic category. The category "total ichthyoplankton" was used to apply to all fish classified to a specific life stage, regardless of the taxonomic level to which they were identified.

To compare the collection efficiencies of the two gear types, statistical analyses were conducted for each life stage within the category "total ichthyoplankton" and for all taxa identified to a primary level that were collected in sufficient numbers for analysis. Paired t-tests were used to analyze "total ichthyoplankton" data, whereas data on taxa identified to a primary level were analyzed using a one-way classification analysis of variance (Dixon and Brown 1977). Data were pooled to evaluate gear performance based on paired samples containing an expected frequency of five or more individuals. Pump and net samples were pooled in an identical manner to preserve the paired nature of the experimental design. Pooling was conducted as follows:

1) The number of individuals per unit volume was determined for each sampling day.

2) The minimum volume required to yield an expected count of at least five in a given sample was determined. Five was selected as a pooling criteria because parametric tests are generally more powerful when the expected frequency per cell is five or greater (Fisher 1970).

3) Samples collected within the same sampling day were pooled by adding counts and volumes from sequential samples until the minimum volume was achieved.

After pooling each data set, the data were transformed logarithmically as follows:

$$Y = \text{Log}\left(\frac{\text{count} + 1.0}{\text{volume } (m^3)}\right)$$

This transformation was applied to both the pump and the net data prior to calculating the differences between paired pump and net samples.

The following analysis of variance model was used to analyze taxa identified to a primary level:

$$D_{ij} = U + B_i + e_{ij}$$

where

D_{ij} = the difference between the transformed density values for paired pump and net samples, after pooling (pump minus net)

U = overall gear effect

B_i = effect of gear within each taxon

e_{ij} = random error.

The following hypotheses were tested:

1) H_o (null hypothesis): $U = 0$; H_a (alternative hypothesis: $U \neq 0$ ($\alpha = 0.05$).

2) H_o: $B_1 = B_2 = B_3 = B_i = 0$; H_a: one or more of the B_i's are not equal to the other B_i's or zero ($\alpha = 0.05$).

The first hypothesis was used to determine if the overall mean difference between the density estimates (pump minus net) was significantly different from zero for all taxa collectively. The second hypothesis was used to determine if the difference between the density estimates for individual taxa were significantly different from other taxa or from zero. Rejection of the first null hypothesis would indicate that, averaged over all taxa, there was a significant gear difference. On the other hand, rejection of the second null hypothesis would indicate that the gear difference was not consistent over all taxa.

In cases where the second null hypothesis was rejected, the Student-Newman-Kuels multiple comparison test was used to identify specific taxa that were not collected equally with both gear types. For yolk-sac larvae, however, the range of similar means did not span zero, resulting in an inconclusive assessment of gear performance. In this case, individual t-tests were used to compare each mean with zero, and the alpha level for each test was adjusted to yield an overall alpha level of 0.05 according to the following formula (Kendall and Stuart 1976):

$$1 - (1 - \alpha_i)^m = \alpha_0$$

where

m = number of comparisons

α_i = alpha level of individual test

α_0 = overall alpha level (0.05).

The residuals for the paired t-tests conducted on "total ichthylplankton" life stages and the residuals for the analyses of variance on selected taxa were examined. In all cases, the pooling procedures and log transformations stabilized variances and the residuals were not skewed, thus, yielding acceptable data for parametric analysis.

5.3 RESULTS

5.3.1 Total Ichthyoplankton

A total of 14 ichthyoplankton taxa were collected during the study; 10 taxa were collected in both pump and net samples (Table 5-1). The average densities of "total ichthyoplankton" collected were about 3.0 per cubic meter for pump samples and about 3.3 per cubic meter for net samples. For pump and net samples, respectively, 81.0 and 84.6 percent of the catches were identified as bay anchovy eggs and larvae (70.5 and 72.0 percent, respectively, were identified as bay anchovy eggs alone). Density estimates for total ichthyoplankton and selected taxa collected in each sample are presented in Appendix C.

Results of the pump-net comparison analyses for the "total ichthyoplankton" category (paired t-tests) indicated that the numbers of ichthyoplankton per volume collected by the two gear types were similar. No significant differences (α = 0.05) were found between density estimates determined from pump and net samples for any of the life stages examined, as indicated in the table below.

RESULTS OF PAIRED t-TESTS FOR TOTAL ICHTHYOPLANKTON COLLECTED BY PUMP AND NET SAMPLING GEAR AT THE INDIAN POINT GENERATING STATION, 1978

Life Stage	No. of Pairs	Pump minus Net[a] Mean	Pump minus Net[a] Standard Deviation	t-Statistic	Probability of a Larger t[b]
Egg	35	-0.0108	0.2016	-0.32	P = 0.752
Yolk-sac larvae	20	-0.0797	0.3670	-0.97	P = 0.344
Post yolk-sac larvae	78	-0.0060	0.2535	-0.21	P = 0.835
Juvenile	6	0.0554	0.1801	0.75	P = 0.485

(a) After pooling and logarithmic transformation.
(b) $P \leq 0.05$ is significant.

TABLE 5-1 ICHTHYOPLANKTON COLLECTED DURING THE PUMP-NET COMPARISON STUDY, INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

Taxon[a]	Average Density (No./1,000 m^3)[b]											
	Egg		Yolk-Sac Larvae		Post Yolk-Sac Larvae		Juvenile		Unidentified Life Stage		All Life Stages	
	Pump	Net	Pump	Net	Pump	Net	Pump	Net	Pump	Net	Pump	Net
Primary Taxonomic Level												
Morone saxatilis	4.7	7.5	15.1	53.4	219.7	185.8	1.0	0.8	3.5	3.5	244.0	251.0
Morone americana	3.9	4.1	1.5	1.3	62.2	52.0	0.2	0.1	1.0	0.2	68.8	57.7
Alosa spp.	--	0.1	1.0	0.6	72.3	100.8	0.7	1.1	4.2	1.9	78.2	104.5
Anchoa mitchilli	2,114.0	2,345.5	1.2	5.8	278.2	378.9	--	--	35.8	25.4	2,429.2	2,755.6
Cyprinidae	0.7	--	6.4	3.3	5.7	9.1	0.5	0.1	2.5	1.4	15.8	14.6
Osmerus mordax	--	--	--	--	10.6	6.7	5.7	4.9	0.2	--	16.5	11.8
Etheostoma olmstedi	--	--	8.4	9.8	8.6	4.6	0.2	0.2	0.2	0.1	17.4	14.7
Menidia spp.	--	--	--	--	3.0	2.6	--	--	--	--	3.0	2.6
Fundulus spp.	--	--	--	0.1	0.2	--	--	--	--	--	0.2	0.1
Anguilla rostrata	--	--	--	--	--	--	--	0.4	--	--	--	0.4
Microgadus tomcod	--	--	--	--	--	--	--	0.1	--	--	--	0.1
Centrarchidae	--	--	0.2	0.7	0.7	1.4	--	--	--	--	0.9	2.1
Syngnathus fuscus	--	--	--	--	--	--	0.2	--	--	--	0.2	--
Trinectes maculatus	--	--	--	--	0.2	--	--	--	--	--	0.2	--
Secondary Taxomonic Level												
Morone spp.	--	--	0.7	1.3	24.2	4.6	0.2	--	5.7	3.9	30.8	10.0
Clupeidae	--	--	--	--	10.9	2.6	--	--	1.5	1.5	12.4	4.1
Unidentified	5.7	3.3	0.7	0.9	23.9	8.1	--	--	51.5	16.6	81.8	28.9
Total Ichthyoplankton	2,129.0	2,360.5	35.2	77.2	720.4	757.2	8.7	7.7	106.1	54.5	2,999.4	3,357.1

(a) The primary taxonomic level indicates the lowest taxonomic grouping to which routine identifications were made. The secondary taxonomic level indicates the taxonomic groupings to which ichthyoplankton were identified when classification to the primary level was not possible.

(b) Average Density (No./1,000 m^3) = $\frac{\text{Total No. collected in all samples}}{\text{Total volume sampled}}$

Note: Dashes (--) indicate that no organisms were collected.

5.3.2 Selected Taxa

To examine the performance of the two gear types for specific taxa, an analysis of variance was conducted for each life stage including all taxa with three or more pairs after pooling. The analysis on specific taxa of eggs included bay anchovy, striped bass, and white perch. The analysis on specific taxa of yolk-sac larvae included bay anchovy, striped bass, darter, and Cyprinidae. Seven taxa were included in the analysis on post yolk-sac larvae: bay anchovy, striped bass, white perch, darter, Cyprinidae, Alosa spp., and smelt. Juveniles of specific taxa were not collected frequently enough to examine using analysis of variance.

As observed for total ichthyoplankton, the overall mean differnce between density values determined for each gear type was not significantly different from zero ($\alpha = 0.05$) for any life stage when data for selected taxa were examined using analysis of variance (Tables 5-2, 5-3, and 5-4). For eggs, this trend was consistent for all taxa included in the analysis (Table 5-2), indicating no differences in egg densities collected by the two gear types. However, the analyses of variance on yolk-sac larvae and post yolk-sac larvae indicated a significant difference in densities collected by the two gear types for one or more taxa in each of these groups (Tables 5-3 and 5-4).

In order to determine which yolk-sac larvae taxa were not collected equally by both gear types, the Student-Newman-Kuels test was conducted. This test indicated that the mean differences between the pump and net samples were similar for bay anchovy and striped bass yolk-sac larvae, and for darter and Cyprinidae yolk-sac larvae (Table 5-3); however, it was not possible to discern if the mean difference between the pump and net densities for these four taxa differed from zero because the ranges of similar means did not bracket zero.

Consequently, individual paired t-tests (with the overall alpha level adjusted to account for multiple comparison) were conducted on each yolk-sac larvae taxa to compare the mean difference between pump densities and net densities (pump minus net) with zero. The results of these paired t-tests indicated that the mean density differences between the two gear types were not significantly different from zero for any of the four taxa (overall alpha level of 0.05) (Table 5-3), even though the results of the analysis of variance indicated that at least one taxa was significantly different from the others. A possible explanation for this is that the low number of pairs for bay anchovy, darter, and Cyprinidae yolk-sac larvae (only 3 to 4 pairs for each taxon) may have resulted in a loss of power (ability to detect a true difference) when analyzed individually.

Analysis of variance on post yolk-sac larvae also indicated that the mean differences between densities determined from pump and net samples were significantly different from zero ($\alpha = 0.001$) for one or more taxa (Table 5-4). The Student-Newman-Kuels test indicated that the mean difference between the pump and net densities were similar for all taxa except bay anchovy (Table 5-4). Moreover, the range of similar means (comprising Cyprinidae, Alosa spp., white perch, striped bass, smelt, and darter) bracketed zero; therefore, it was concluded that the mean differences between pump and net densities for these taxa were not significantly different from zero ($\alpha = 0.05$). Thus, density estimates for six taxa of post yolk-sac larvae (striped bass, white perch, darter, Cyprinidae, Alosa spp., and smelt) were comparable for the

TABLE 5-2 RESULTS OF ANALYSIS OF VARIANCE AND THE STUDENT-NEWMAN-KUELS TEST ON EGGS OF SPECIFIC TAXA COLLECTED BY PUMP AND NET SAMPLING GEAR AT THE INDIAN POINT GENERATING STATION, 1978[a]

Results of Analysis of Variance:

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Probability of a Larger F[b]
Mean (U)	0.01744	1	0.01744	0.50	P = 0.486
Taxa (B_i)	0.02278	2	0.01139	0.32	P = 0.726
Error (e_{ij})	1.12469	32	0.03515		

Results of Student-Newman-Kuels Test:

	Bay Anchovy	White Perch	Striped Bass
Pump minus net (mean)	-0.00823	0.04783	0.6430
Number of pairs	28	4	3
Range bar(s) over similar means[c]			

(a) After pooling and logarithmic transformation.
(b) $P \leq 0.05$ is significant.
(c) $\alpha = 0.05$.

TABLE 5-3 RESULTS OF ANALYSIS OF VARIANCE AND THE STUDENT-NEWMAN-KUELS TEST ON YOLK-SAC LARVAE OF SPECIFIC TAXA COLLECTED BY PUMP AND NET SAMPLING GEAR AT THE INDIAN POINT GENERATING STATION, 1978[a]

Results of Analysis of Variance:

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Probability of a Larger F[b]
Mean (U)	0.00061	1	0.00061	0.01	P = 0.941
Taxa (B_i)	2.00189	3	0.66730	6.07	P = 0.003
Error (e_{ij})	2.52833	23	0.10993		

Results of Student-Newman-Kuels Test:

	Bay Anchovy	Striped Bass	Darter	Cyprinidae
Pump minus net (mean)	-0.51631	-0.15423	0.23761	0.40964
Number of pairs	3	16	4	4
Range bar(s) over similar means[c]				

Results of Paired t-tests:

	Bay Anchovy	Striped Bass	Darter	Cyprinidae
t-statistic	-3.5128	-0.4147	1.2636	1.2855
Degrees of freedom	2	15	3	3
Probability of a larger value of t[d]	0.05<P<0.10	P<0.50	0.20<P<0.40	0.20<P<0.40

(a) After pooling and logarithmic transformation.
(b) $P \leq 0.05$ is significant.
(c) $\alpha = 0.05$.
(d) Not adjusted for multiple comparisons.

TABLE 5-4 RESULTS OF ANALYSIS OF VARIANCE AND THE STUDENT-NEWMAN-KUELS TEST ON POST YOLK-SAC LARVAE OF SPECIFIC TAXA COLLECTED BY PUMP AND NET SAMPLING GEAR AT THE INDIAN POINT GENERATING STATION, 1978[a]

Results of Analysis of Variance:

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Probability of a Larger F[b]
Mean (U)	0.20370	1	0.20370	2.62	P = 0.180
Taxa (B_i)	2.48653	6	0.41442	5.33	P < 0.001
Error (e_{ij})	9.40397	121	0.07772		

Results of Student-Newman-Kuels Test:

	Bay Anchovy	Cyprinidae	Alosa spp.	White Perch	Striped Bass	Smelt	Darter
Pump minus net (mean)	-0.20584	-0.10294	-0.03366	0.09781	0.10531	0.23323	0.32021
Number of pairs	28	6	24	30	32	5	3
Range bar(s) over similar means[c]							

(a) After pooling and logarithmic transformation.
(b) $P \leq 0.05$ is significant.
(c) $\alpha = 0.05$.

two gear types, whereas a significantly higher ($\alpha = 0.05$) density of bay anchovy post yolk-sac larvae was collected with the net than with the pump.

5.4 DISCUSSION

The 1978 analyses thus support the results of the 1977 pump-net comparison study which indicated that densities of striped bass, white perch, and clupeid ichthyoplankton were comparable for pump and net samples. Moreover, the higher pump sample volumes and resultantly larger sample sizes collected in 1978 strengthen the statistical basis for these results. Based on the results of both the 1977 and 1978 pump-net comparison studies, it is therefore concluded that the pump and net collection systems tested are equally effective for estimating densities of most ichthyoplankton entrained at the Indian Point plant.

Bay anchovy post yolk-sac larvae were the only ichthyoplankton for which densities were statistically different in pump versus net samples during the 1978 study. A possible explanation for this difference is that bay anchovy early developmental stages are relatively sensitive to collection damage or abrasion to the extent that reliable identification characteristics are obscured. This is indicated by the fact that higher numbers of the "unidentified life stages" category occurred for this species, in both gear, than for any of the other species analyzed (Table 5-1). Consequently, undetectable differences in the densities of various life stages (e.g., post yolk-sac larvae) within the bay anchovy "unidentified life stage" category for the two gear types may have affected differences in densities within the bay anchovy "post yolk-sac larvae" category. In view of the sensitivity of bay anchovy early life stages to gear effects, it is also likely that the higher density of ichthyoplankton within the "unidentified" taxonomic category (Table 5-1), collected by the pump as compared to the net, may have included a proportionally larger number of bay anchovy larvae. This would further account for the statistical difference in the densities of bay anchovy post yolk-sac larvae collected by the pump versus stationary net.

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APPENDIX A

DIRECT RELEASE STUDY,
INDIAN POINT GENERATING STATION, 1978

APPENDIX A: DIRECT RELEASE STUDY

A.1 INTRODUCTION

Hatchery-reared striped bass were released at the intakes of the Indian Point Generating Station and collected at the discharge stations to provide additional information on entrainment survival and to examine the recovery efficiency of the pump/larval table collection systems. The release of large numbers of fish at the intake usually resulted in the collection of more fish at the discharge than normally collected during sampling of wild ichthyoplankton, thus providing larger sample sizes for estimating entrainment survival. Entrainment survival of hatchery-reared striped bass larvae was estimated by comparing survival of fish collected at the discharge with the survival of fish passed through the sampling apparatus only. The recovery efficiency of the pump/larval table collection system was examined by comparing the number of released fish that were recovered at the discharge stations with the predicted recovery based on the number released, the volume of cooling water pumped at the time of the test, and the volume of discharge water sampled.

A.2 METHODS

Direct release experiments were conducted by releasing hatchery-reared striped bass at the intakes to Units 2 and 3 and collecting them at the discharge stations after the released fish had passed through the cooling water system of the power plant. Four experiments using striped bass larvae (1 to 7 days old) were conducted at Unit 3 by releasing fish at the intake of Unit 3 and collecting them at discharge Stations D3 and DP; the majority of larvae used in these experiments were 5 to 7 days old and in a state of transition between yolk-sac and post yolk-sac larval developmental stages. At Unit 2, one experiment with 5-day-old larvae, two experiments with post yolk-sac larvae (16 to 17 days old), and two experiments with early juveniles (40 to 43 days old) were conducted by releasing fish at the intake of Unit 2 and collecting them at discharge stations D1 and DP.

Striped bass used in direct release experiments were obtained from the Con Edison hatchery facility at Verplanck, New York. Larvae (1 to 17 days old) were transported from the hatchery to Indian Point in 45 liter insulated containers (50 x 30 x 30 cm), and were held in these containers for 2 to 5 hours (including transport time) prior to release. Juveniles (40 to 43 days old) were transported from the hatchery in 1,000 liter (100 x 100 x 100 cm) containers and were similarly held 2 to 5 hours prior to release.

Striped bass larvae were released between the trash racks and the circulating pumps. Immediately prior to the release, the larvae were transferred from the transportation containers into a 19 liter (5 gallon) bucket with a 2.5 cm (1 in.) plug in the bottom. The bucket was lowered to the surface of the water and the plug was removed to release the fish. Juvenile striped bass were released in front of the traveling screens after being transferred from the transportation containers to two 324 liter boxes (60 x 90 x 60 cm); they were simultaneously released from the two boxes by removing a 15.2 cm (6 in.) plug near the bottom of each box. The release containers were thoroughly rinsed to remove any remaining fish.

Released striped bass were recovered at the discharge stations by sampling with pump/larval table collection systems according to standard entrainment survival sampling procedures (see Section 4.2). Sampling was initiated 2 to 5 minutes after each release, depending on the predicted transit time through the cooling water system, and was continued for 15 minutes. The 15-minute sampling period exceeded the predicted transit times based on the cooling water flows at the time the experiments were conducted, ensuring that a maximum number of released fish would be recovered. The numbers of live and dead fish recovered at the discharge stations were determined, and the live and stunned fish were maintained at the on-site laboratory for 96 hours to assess latent effects.

Control tests were conducted in conjunction with each direct release experiment to assess the effects of collection stress alone. During each control test, 100 hatchery-reared striped bass larvae were released at the intakes to the pump/larval table collection systems through a piece of 3.8 cm (1.5 in.) vinyl tubing (Figure A-1). An elbow inserted at the end of the tubing was plugged on one end, and larvae were directed into the intake pipe through a 1.90 cm (0.75 in.) hole in the top of the elbow. After transferring the larvae into the vinyl tubing injection system, the tubing was flushed with 10 liters of water. The control organisms were then retrieved from the larval table, after which the live, stunned, and dead striped bass in the sample were enumerated to determine initial collection survival. All control organisms recovered alive or stunned were maintained at the on-site laboratory for 96 hours to assess latent effects.

Entrainment survival of hatchery-reared striped bass was examined by comparing the initial and latent survival of entrained fish with initial and latent survival of the sampling controls. Entrainment survival estimates (S_e) were made according to analytical procedures described in Section 4.2 by substituting sampling control survival for intake survival. The z-test for differences between proportions (one-tailed test) was used to determine if survival observed at the discharge stations was significantly lower than sampling control survival. Differences in latent survival rates between control and experimental fish were examined by calculating survival proportions for each latent effects observation based on the initial number of live and stunned fish.

Prior to each direct release experiment, a population estimate was made to determine the number of fish in the release batch. From 9 to 11 aliquots (11 to 37 ml per aliquot for larvae and 450 ml per aliquot for juveniles) were removed from the transportation container and the number of fish in each aliquot was counted. The total number of fish in the release batch was estimated on the basis of the average density of fish per aliquot and the total volume of water in the transportation container, as follows:

$$\text{total number released} = \left(\frac{\Sigma \text{ number of fish per ml}}{\text{number of aliquots}}\right)(\text{total volume})$$

95 percent confidence limits =

$$\left[\frac{\left(\begin{array}{c}\text{standard deviation of}\\ \text{density estimates}\end{array}\right)(\text{total volume})}{\sqrt{\text{number of aliquots}}}\right]\left[t_{(0.05,\ n-1\ \text{d.f.})}\right]$$

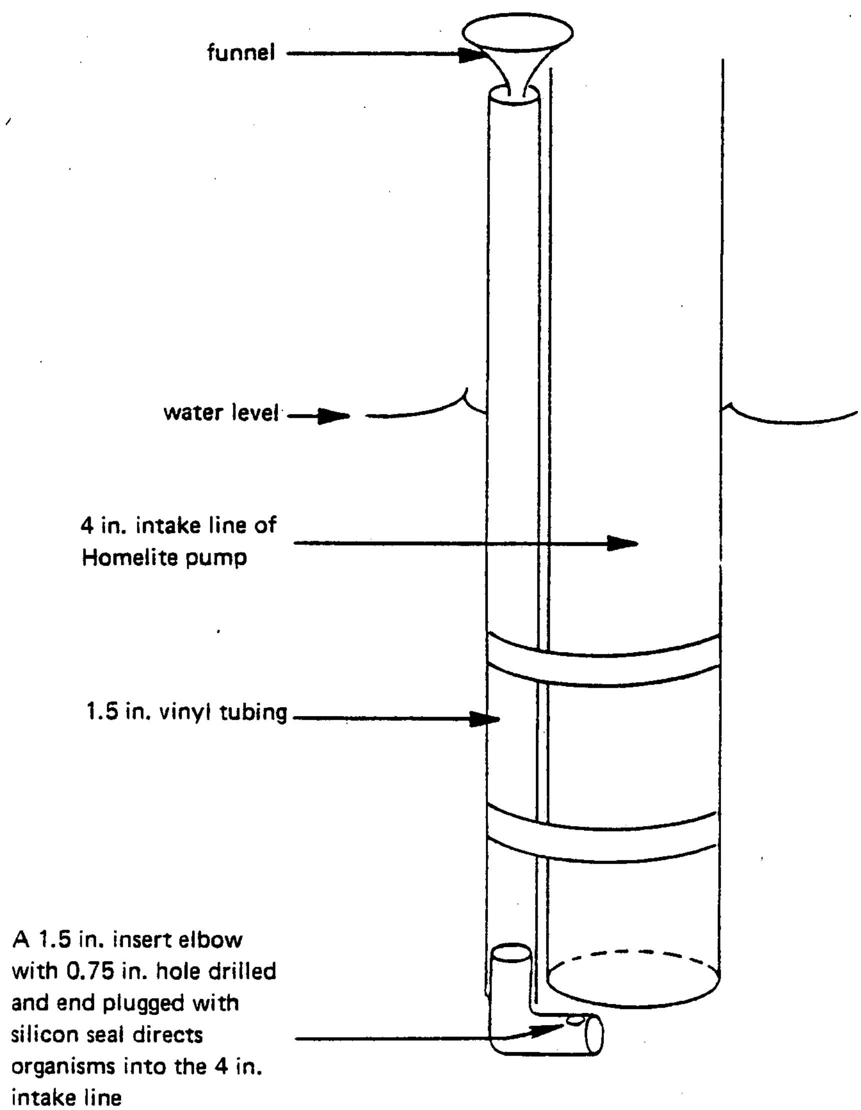

Figure A-1. Vinyl tubing injection system for direct release control experiments conducted at the Indian Point Generating Station, 1978.

The percentage of released fish that were dead at the time of release was also estimated on the basis of the average density of dead larvae determined per aliquot.

Assuming homogeneous mixing, the expected number of fish in discharge collections ($\hat{N_D}$) was calculated as follows:

$$\hat{N_D} = (N_R) \frac{Vs}{Vp}$$

where

$\hat{N_D}$ = expected number of fish recovered
N_R = total number fish released
Vs = volume of discharge water sampled (15 minutes)
Vp = volume of water pumped through the plant (15 minutes).

The 95 percent confidence limits for the expected number of fish recovered were approximated by converting the 95 percent confidence limits determined for the total number released to a proportion of the total number released (95 percent confidence limits of estimated number of fish released/estimated number fish released), and multiplying this proportion by the expected number of fish recovered ($\hat{N_D}$).

To account for wild striped bass ichthyoplankton that may have been present during the direct release experiments, 15-minute samples were collected at each discharge station before and after the direct release experiment. The average number of wild striped bass collected that corresponded to the size class of fish released were used to estimate the number of wild fish in the direct release sample. The actual number of fish recovered at each discharge station was adjusted by subtracting the average number of fish collected in pre- and post-samples to provide more precise estimates of the recovery of released fish.

A.3 RESULTS AND DISCUSSION

A.3.1 Survival

Entrainment survival estimates (S_e) for larvae 1 to 7 days old ranged from 0 to 79 percent, based on three direct releases at Unit 3 and one release at Unit 2 (Tables A-1 and A-2). Initial survival was quite low for experimental (released fish) and control groups, indicating that pretest handling and/or collection stresses rather than entrainment effects were the primary cause of mortality. No initial survival of experimental larvae was observed for one direct release at Unit 3 and the direct release at Unit 2. For the two remaining releases at Unit 3, no survival of experimental fish was observed at Station D3, but some survival was observed for two collections at Station DP (Table A-1). Entrainment survival estimates (S_e) of 79 and 35 percent for Station DP were based on initial survival proportions of 0.11 (two live fish) and 0.06 (one live fish) for experimental larvae and 0.14 and 0.17 for the corresponding controls. Since the number of surviving fish were within the background counts at the time the releases were made, it is possible that the three fish collected alive were wild striped bass larvae. Consequently, the entrainment survival estimates calculated for Station DP may not reflect

TABLE A-1 SURVIVAL OF HATCHERY-REARED STRIPED BASS LARVAE RELEASED DIRECTLY INTO THE INTAKE OF UNIT 3 AT THE INDIAN POINT GENERATING STATION, 1978

Date	Age (Days)	Total Length (mm)	Estimated Percent[a] of Dead Fish in Release	Sampling Station	Temp. (C)	No. Fish Collected	Proportion Alive[b] Initial	24 Hrs	96 Hrs	S_e(%)[c]
24 MAY	1	3.0-4.0	5.2	Control	16	21	0.19 (±0.09)	0.00	0.00	
				DP	23	4	0.00*	--	--	0
4 JUN[d]	6-7	5.5-7.0	6.2	Control	20	35	0.14 (±0.06)	0.09 (±0.05)	0.00	
				D3	31-32	37	0.00*	--	--	0
				DP	31	19	0.11 (±0.07)	0.00*	0.00	79
5 JUN	5	4.5-7.0	7.8	Control	21	6	0.17 (±0.15)	0.00	0.00	
				D3	32	17	0.00	--	--	0
				DP	31	16	0.06 (±0.06)	0.00	0.00	35

(a) Survival estimates were not corrected for the number of dead fish released.
(b) Proportion alive = (number live + number stunned)/total number. Standard errors given in parentheses.

(c) $S_e(\%)$ = initial entrainment survival = $\frac{\text{Initial proportion surviving at discharge}}{\text{Initial proportion surviving sampling control}} \times 100.$

(d) Combination of two direct release experiments.

Note: Asterisk (*) indicates that survival of fish collected at the discharge stations was significantly lower than survival of the sampling control at $\alpha = 0.05$ (one-tailed z-test of differences between two proportions).

Dashes (--) indicate data not available.

TABLE A-2 SURVIVAL OF HATCHERY-REARED STRIPED BASS LARVAE RELEASED DIRECTLY INTO THE INTAKE OF UNIT 2 AT THE INDIAN POINT GENERATING STATION, 1978

Date	Age (Days)	Total Length (mm)	Estimated Percent[a] of Dead Fish in Release	Sampling Station	Temp. (C)	No. Fish Collected	Proportion Alive[b] Initial	24 Hrs	96 Hrs	S_e(%)[c]
5 JUN	5	4.5-7.0	5.7	Control	21	1	0.00	--	--	0
				DP	30	18	0.00	--	--	0
14 JUN[d]	16-17	6.5-9.0	5.4	Control	21-22	173	0.33 (±.001)	0.21 (±0.03)	0.05 (±0.02)	
				D1	30-31.5	126	0.11* (±0.03)	0.07* (±0.02)	0.01* (±0.01)	33[e]
				DP	29-30	59	0.24 (±0.05)	0.17 (±0.05)	0.02 (±0.02)	72
10 JUL[d]	40-43	14-20	8.7	Control	25	146	0.44 (±0.04)	0.32 (±0.04)	0.16 (±0.03)	
				D1	35	25	0.52 (±0.10)	0.52 (±0.10)	0.32 (±0.09)	100
				DP	35	7	0.43 (±0.19)	0.29 (±0.17)	0.29 (±0.17)	98

(a) Survival estimates were not corrected for the number of dead fish released.
(b) Proportion alive = (number live + number stunned)/total number. Standard errors given in parentheses.

(c) $S_e(\%) = \text{initial entrainment survival} = \dfrac{\text{Initial proportion surviving at discharge}}{\text{Initial proportion surviving sampling control}} \times 100.$

(d) Combination of two direct release experiments.
(e) The low survival observed at Station D1 on 14 June may have resulted from failure of the larval table ambient injection system during this test.

Note: Asterisk (*) indicates that survival of fish collected at the discharge stations was significantly lower than survival of the sampling control at $\alpha = 0.05$ (one-tailed z-test of differences between two proportions).

Dashes (--) indicate data not available.

entrainment survival of the released fish. Because of the negligible survival observed for hatchery-reared striped bass (both experimental and control larvae) within the 1 to 7 day age group, these survival results were not conclusive.

Entrainment survival estimates (S_e) for hatchery-reared striped bass post yolk-sac larvae (16 to 17 days old) released near the intake of Unit 2 were 33 and 72 percent for Stations D1 and DP, respectively (Table A-2). The survival estimates for wild striped bass post yolk-sac larvae entrained through Unit 2 at similar temperatures (30.0 to 32.9 C) were 60 and 71 percent at Stations D1 and DP, respectively, based on intake and discharge survival proportions (Table 4-7). Thus, entrainment survival of wild post yolk-sac larvae corresponded closely to entrainment survival of hatchery-reared post yolk-sac larvae at Station DP.

The lower survival of post yolk-sac larvae during direct release experiments at Station D1 (33 percent) likely resulted from failure of the ambient injection system during these tests. Because the ambient injection system was inoperative, the larvae may have been exposed to discharge temperatures of 30 to 31.5 C for up to 60 minutes. The 30-minute TL50 for similarly sized striped bass larvae has been determined to be 33.1 C (EA 1979, Appendix A), indicating that some of the mortality observed at Station D1 may have resulted from thermal stress during collection and sorting.

Entrainment survival of hatchery-reared striped bass juveniles (40 to 43 days old) released near the intake of Unit 2 was estimated to be nearly 100 percent at both discharge stations (Table A-2). In contrast, the survival estimate for wild juvenile striped bass entrained through Unit 2 was 71 percent over the entire sampling season (Table 4-10). However, the survival estimate for wild juveniles was based on only 10 fish, compared to 32 fish collected from the two discharge stations during the direct release experiments. The high survival of juvenile striped bass observed during the direct release study is especially noteworthy because the exposure temperature during entrainment was 35 C, which approaches the maximum exposure temperature that would occur at the Indian Point plant during July.

Survival of hatchery-reared striped bass determined initially to be alive or stunned was monitored for 96 hours following sample collection to examine latent effects due to entrainment. The latent survival of post yolk-sac larvae and early juveniles collected at the discharge stations was equal to or greater than latent survival of control fish (Figures A-2 and A-3). These results indicate that no further effects of entrainment were manifested beyond the initial survival assessment. Latent effects on entrained larvae 1 to 7 days old could not be compared to latent survival of control fish because of the limited number of live fish in both experimental and control groups.

A.3.2 Recovery

The number of striped bass collected at the discharge stations was compared to the number of fish expected to be recovered based on the number released, the volume of cooling water pumped, and the volume of discharge water sampled (Tables A-3 and A-4).

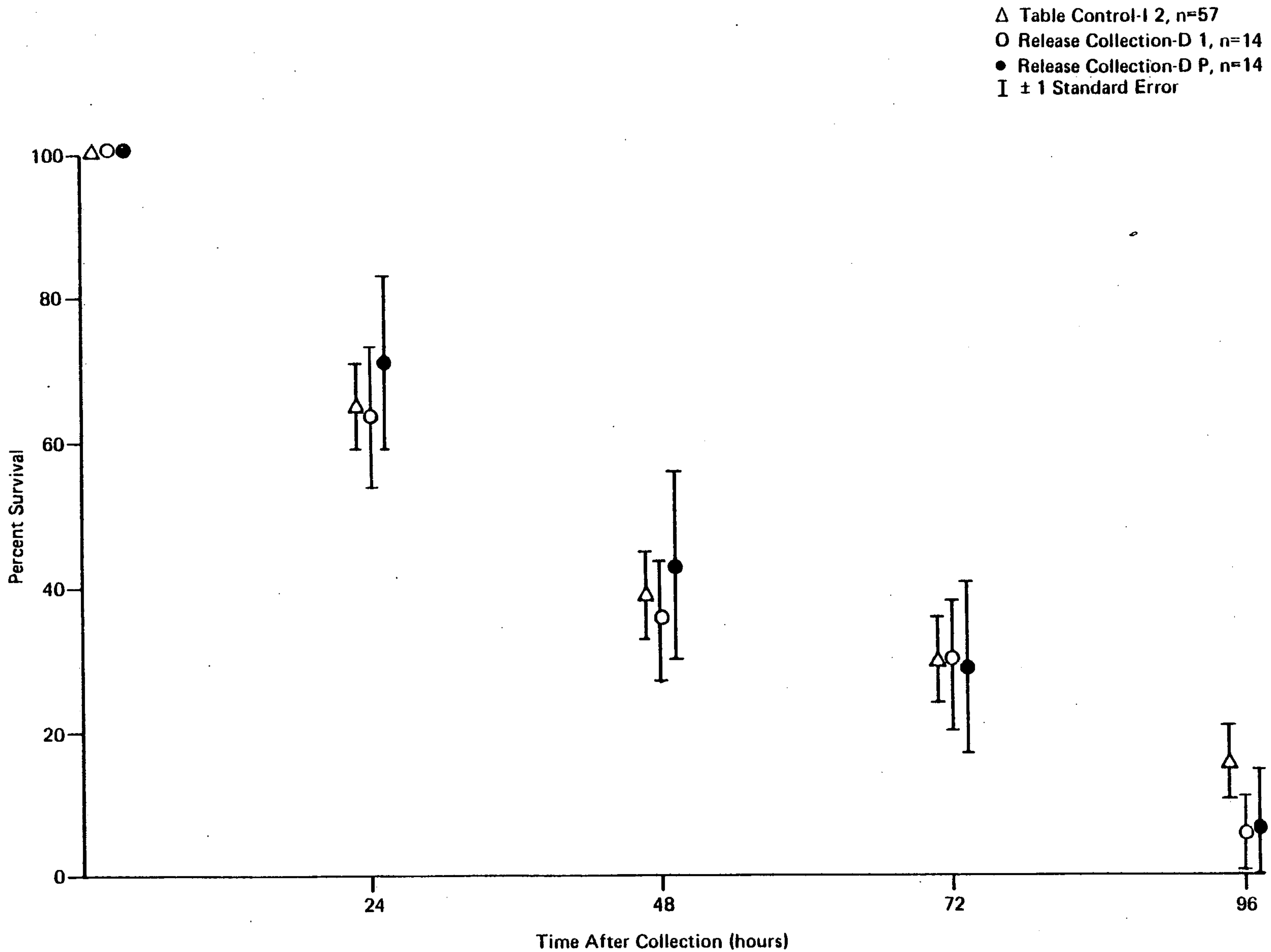

Figure A-2. Latent survival of striped bass post yolk-sac larvae (16 to 17 days old) collected during the direct release study at Indian Point Generating Station Unit 2, 1978.

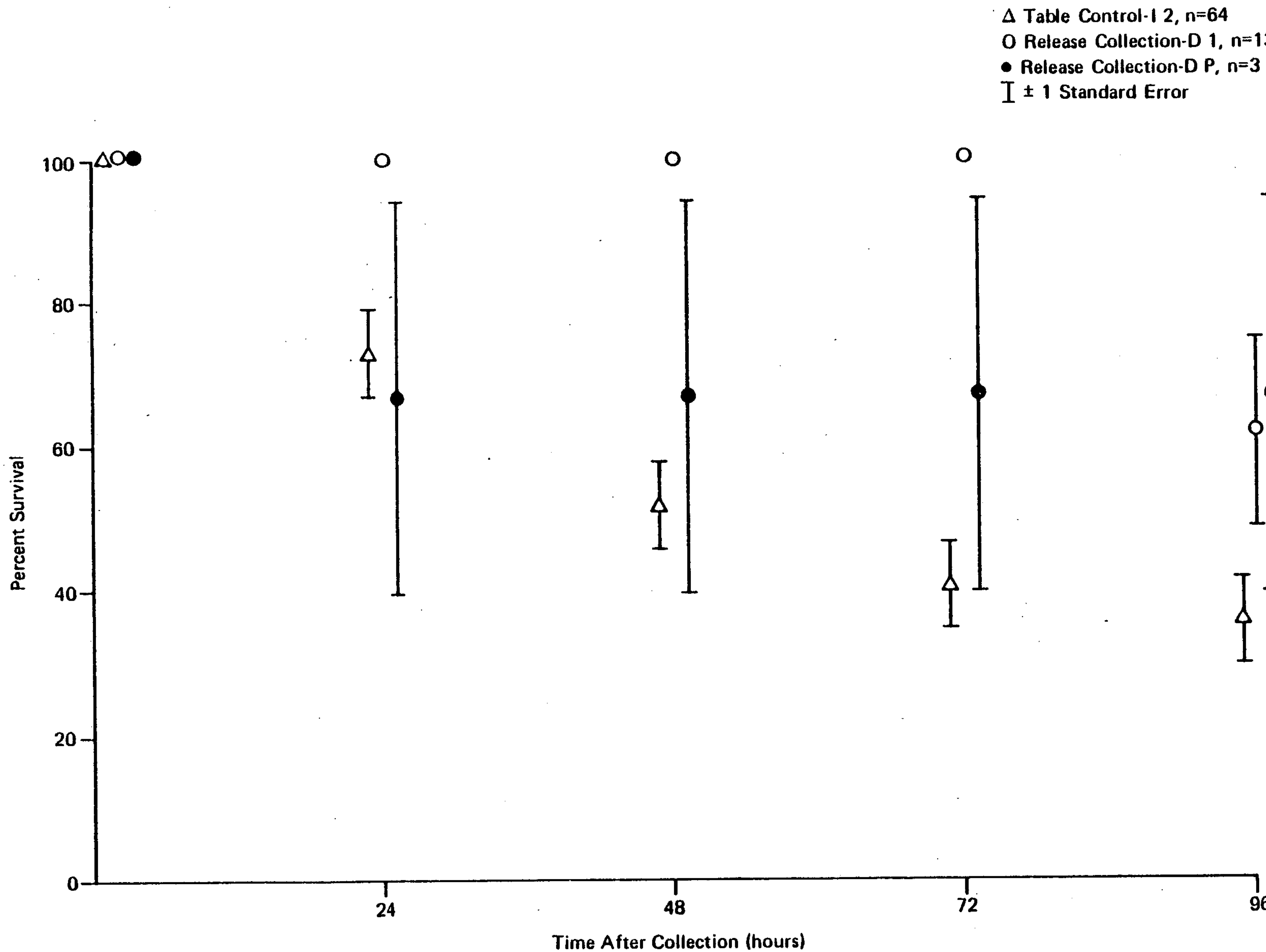

Figure A-3. Latent survival of striped bass juveniles (40 to 43 days old) collected during the direct release study at Indian Point Generating Station Unit 2, 1978.

TABLE A-3 EXPECTED AND ACTUAL NUMBER OF STRIPED BASS RECOVERED AT THE INDIAN POINT GENERATING STATION DISCHARGE FOLLOWING RELEASE AT THE INTAKE OF UNIT 3, 1978

Date	Age (Days)	Total Length (mm)	Sampling Station	Volume Sampled (m^3)	Volume Pumped[a] Through Plant in 15 Minutes (m^3)	Estimated No.[b] Fish Released	Expected No.[b] Fish Recovered	Actual No. Fish Recovered	No. Fish[c] Recovered Corrected For Background Count	Percentage[d] of Expected Number Actually Recovered
24 MAY	1	3.0-4.0	D3	16.2	41,166	106,042	41.7(±8.2)	0	0	0.0
			DP	16.6	83,325	(±20,890)	21.1(±4.2)	4	4	19.0
4 JUN	6-7	5.5-7.0	D3	12.4	41,166	121,201	36.5(±8.4)	18	16.5	45.2
			DP	14.3	91,275	(±27,984)	19.0(±4.4)	5	2.0	10.5
4 JUN	6-7	5.5-7.0	D3	14.4	41,166	125,914	44.0(±8.0)	19	17.5	39.8
			DP	15.3	91,275	(±22,899)	21.1(±3.8)	14	10.5	49.8
5 JUN	5	4.5-7.0	D3	12.6	41,166	52,533	16.1(±4.7)	17	13.5*	83.9
			DP	15.5	91,275	(±15,284)	8.9(±2.6)	16	15.0	168.5

(a) Estimate of through-plant flow based on volumes of cooling water pumped through Unit 3 for Station D3 and volumes pumped through all units for Station DP (from 401 certification data).
(b) The 95 percent confidence limits are given in parentheses.
(c) Actual number of striped bass collected less the mean number of striped bass collected in background samples.
(d) Corrected for background count.

Note: Asterisk (*) indicates that the number of fish recovered were within the 95 percent confidence limits of the expected value.

TABLE A-4 EXPECTED AND ACTUAL NUMBER OF STRIPED BASS RECOVERED AT THE INDIAN POINT GENERATING STATION DISCHARGE FOLLOWING RELEASE AT THE INTAKE OF UNIT 2, 1978

Date	Age (Days)	Total Length (mm)	Sampling Station	Volume Sampled (m^3)	Volume Pumped[a] Through Plant in 15 Minutes (m^3)	Estimated No.[b] Fish Released	Expected No.[b] Fish Recovered	Actual No. Fish Recovered	No. Fish[c] Recovered Corrected For Background Count	Percentage[d] of Expected Number Actually Recovered
5 JUN	5	4.5-7.0	DP	18.3	91,275	66,996 (±23,027)	13.4(±4.6)	18	17.0*	126.9
14 JUN	16-17	6.5-9.0	D1	14.2	58,083	97,745	23.9(±7.8)	50	50.0	209.2
			DP	17.5	68,928	(±32,011)	24.8(±8.9)	22	16.0	64.5
14 JUN	16-17	6.5-9.0	D1	21.6	58,083	119,841	44.6(±12.8)	76	76.0	170.4
			DP	20.7	68,928	(±34,395)	36.0(±10.3)	37	31.0*	86.1
10 JUL	40-43	14-20	D1	14.4	50,478	21,572 (±10,591)	6.2(±3.0)	16	15.5	250.0
10 JUL	40-43	14-20	D1	15.9	50,478	15,918	5.0(±1.5)	9	8.5	170.0
			DP	22.0	51,046	(±4,605)	6.9(±2.0)	7	7.0*	101.4

(a) Estimate of through-plant flow based on volumes of cooling water pumped through Units 1 and 2 for Station D1 and volumes pumped through all units for Station DP (from 401 certification data).
(b) The 95 percent confidence limits are given in parentheses.
(c) Actual numbers of striped bass collected less the mean number of striped bass collected in background samples.
(d) Corrected for background count.

Note: Asterisk (*) indicates that the number of fish recovered were within the 95 percent confidence limits of the expected value.

An average of 52.1 percent of the expected number of larvae (1 to 7 days old) was recovered during the four direct release experiments conducted at Unit 3. The number recovered (after adjusting for background density) was within the 95 percent confidence interval of the expected number for only one collection. In contrast, recovery of hatchery-reared striped bass released at the intake of Unit 3 during the 1977 studies was generally within the predicted confidence limits (EA 1978a, Table A-3). As observed during the 1977 study, recovery at Station DP was usually higher than at Station D3.

The majority of the direct release experiments conducted at Unit 2 generally resulted in the recovery of higher numbers of fish than expected; an average of 146.9 percent of the expected number of fish was recovered at Station D1 during the five Unit 2 direct release experiments. The number recovered (after adjusting for background density) was within the 95 percent confidence interval of the expected number for three of the eight collections. Recovery at Station D1 was consistently higher than at Station DP.

APPENDIX B

SAMPLING GEAR SPECIFICATIONS AND ASSOCIATED SAMPLING CONDITIONS, INDIAN POINT GENERATING STATION ENTRAINMENT SURVIVAL STUDIES, 1978

TABLE B-1 SAMPLING GEAR SPECIFICATIONS AND ASSOCIATED SAMPLING CONDITIONS, INDIAN POINT GENERATING STATION ENTRAINMENT SURVIVAL STUDIES, 1978

	Station									
	I2		I3		D1		D3		DP	
	Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2
Pump type	Two vane, open, nonrecessed impeller, 4-in. Homelite Pump		Two vane, open, nonrecessed impeller, 4-in. Homelite Pump		Two vane, open, nonrecessed impeller, 4-in. Homelite Pump		Two vane, open, nonrecessed impeller, 4-in. Homelite Pump		Two vane, open, nonrecessed impeller, 4-in. Homelite Pump	
Collection device	Pump/Larval Table Collection System		Pump/Larval Table Collection System		Pump/Larval Table Collection System		Pump/Larval Table Collection System		Pump/Larval Table Collection System	
Pump intake diameter	10.2 cm (4 in.)		10.2 cm (4 in.)		10.2 cm (4 in.)		10.2 cm (4 in.)		10.2 cm (4 in.)	
Depth of removal[a]	4.6-5.8 m (15-19 ft)	4.6-5.8 m (15-19 ft)	3.7-4.9 m (12-16 ft)	1.5-2.7 m (5-9 ft)	0.9-1.8 m (3-6 ft)	0.9-1.8 m (3-6 ft)	0.9-1.8 m (3-6 ft)	0.9-1.8 m (3-6 ft)	2.0-2.6 m (6.5-8.5 ft)	2.1-2.7 m (7-9 ft)
Elevation of pump with respect to the water surface	0.6-1.8 m (2-6 ft)	0.6-1.8 m (2-6 ft)	0.9-2.1 m (3-7 ft)	0.9-2.1 m (3-7 ft)	0.6-1.8 m (2-6 ft)	0.6-1.8 m (2-6 ft)	1.2-2.4 m (4-8 ft)	1.2-2.4 m (4-8 ft)	1.2 m (4 ft)	1.2 m (4 ft)
Elevation of collection device with respect to the water surface	4.9-6.1 m (16-20 ft)		3.7-4.9 m (12-16 ft)		5.2-6.4 m (17-21 ft)		4.6-5.8 m (15-19 ft)		4.9-6.1 m (16-20 ft)	
Vacuum at the intake of the pump	11.2 cm of Hg (4.4 in. of Hg)	13.0 cm of Hg (5.1 in. of Hg)	Data not available		18.3 cm of Hg (7.2 in. of Hg)	18.8 cm of Hg (7.4 in. of Hg)	Data not available		10.2 cm of Hg (4.0 in. of Hg)	11.2 cm of Hg (4.4 in. of Hg)
Pump speed (rpm)[b]	1,800-1,900	1,800-2,000	1,700-2,100	1,700-2,000	1,800-1,900	1,800-1,900	1,800-2,000	1,800-2,200[c]	1,800-2,000	1,800-2,000
Pumping rate	350-800 l/min[d] (92-211 gpm)	275-750 l/min (73-198 gpm)	350-750 l/min (92-198 gpm)	400-750 l/min (106-198 gpm)	400-800 l/min (106-211 gpm)	300-825 l/min (79-218 gpm)	400-850 l/min (53-218 gpm)	250-750 l/min (86-211 gpm)	200-825 l/min (53-218 gpm)	325-800 l/min (86-211 gpm)
Duration of sample (min.)	15		15		15		15		15-16	
Volume pumped per sample										
One-pump operation[e]	Not applicable		6.1-10.8 m^3 (1,612-2,853 gal)		Not applicable		Not applicable		7.8-10.0 m^3 (2,061-2,642 gal)	
Two-pump operation	9.7-22.3 m^3 (2,563-5,892 gal)		12.0-22.5 m^3 (3,170-5,944 gal)		10.3-36.4 m^3 (2,721-6,975 gal)		13.1-21.9 m^3 (3,461-5,786 gal)		11.9-23.5 m^3 (3,144-6,209 gal)	
Orientation of tubing relative to water flow	Vertically		Vertically		Horizontally, facing the current		Vertically		Horizontally, facing the current	
Length of tubing from point of removal to the pump	7.6 m (25 ft)	7.6 m (25 ft)	9.1 m (30 ft)	7.6 m (25 ft)	7.6 m (25 ft)	7.6 m (25 ft)	41.1 m (135 ft)	41.1 m (135 ft)	12.2 m (40 ft)	12.2 m (40 ft)
Length of tubing from pump to collection device	22.9 m (75 ft)	49.7 m (163 ft)	10.7 m (35 ft)	7.6 m (25 ft)	12.8 m (42 ft)	12.8 m (42 ft)	7.6 m (25 ft)	7.6 m (25 ft)	18.9 m (62 ft)	21.5 m (70.5 ft)

(a) Depth of removal refers to the measurement from the sample depth to the water surface.
(b) Standard operating procedures require that each pump be checked every 5 minutes and adjusted to 1,800-2,000 rpm. These procedures prevent extended operation outside this range.
(c) This pump operated at 2,200 rpm throughout one sample because of an exceedingly low tide which increased the head and caused loss of suction in the intake hose at standard pump speeds.
(d) As a result of a malfunctioning tachometer, the pumping rate at this pump was 1,000 l/min for a 2-minute period during the collection of one sample.
(e) The normal sampling mode is to have two pumps operating simultaneously. Occasionally, samples were collected with only one pump operating.

APPENDIX C

DATA TABLES FOR THE PUMP-NET COMPARISON STUDY
INDIAN POINT GENERATING STATION, 1978

TABLE C-1 DATES AND TIMES WHICH CORRESPOND TO PUMP-NET RUN NUMBERS AT THE INDIAN POINT GENERATING STATION, 1978[a]

Date	Time	Pump Run Number	Pump Volume Sampled (m^3)	Net Run Number	Net Volume Sampled (m^3)
Sampling Effort					
No. 1					
2 JUN	1751	1	29.5	2	89
2 JUN	1834	3	39.7	4	103
2 JUN	1910	5	30.0	6	108
2 JUN	1952	7	30.7	8	119
2 JUN	2038	9	32.2	10	119
2 JUN	2128	11	31.8	12	123
2 JUN	2206	13	31.0	14	125
2 JUN	2300	15	31.0	16	119
2 JUN	2338	17	29.1	18	124
3 JUN	0016	19	53.4	20	130
3 JUN	0147	23	33.3	24	139
3 JUN	0237	25	33.3	26	138
No. 2					
14 JUN	1838	27	36.0	28	95
14 JUN	1920	29	42.0	30	99
14 JUN	2000	31	45.0	32	101
14 JUN	2105	33	45.0	34	105
14 JUN	2138	35	42.8	36	101
14 JUN	2212	37	46.2	38	109
14 JUN	2305	39	46.6	40	101
14 JUN	2340	41	48.1	42	106
15 JUN	0018	43	43.5	44	105
15 JUN	0104	45	50.0	46	102
15 JUN	0136	47	50.0	48	99
15 JUN	0208	49	50.0	50	101
15 JUN	0242	51	46.6	52	102
15 JUN	0315	53	46.9	54	98
No. 3					
21 JUN	1612	55	55.3	56	100
21 JUN	1756	57	57.9	58	104
21 JUN	1840	59	59.0	60	108
21 JUN	1919	61	58.3	62	102
21 JUN	2000	63	60.6	64	105
21 JUN	2027	65	57.9	66	101
21 JUN	2057	67	56.0	68	99
21 JUN	2130	69	50.0	70	100
21 JUN	2249	71	45.8	72	93
21 JUN	2318	73	48.8	74	93
No. 4					
30 JUN	1634	75	62.1	76	106
30 JUN	1731	77	62.8	78	107
30 JUN	1805	79	63.6	80	104
30 JUN	1838	81	64.3	82	101
30 JUN	1908	83	59.8	84	103
30 JUN	1947	85	63.2	86	105
30 JUN	2018	87	61.7	88	99
30 JUN	2047	89	60.2	90	100
30 JUN	2115	91	49.2	92	97
30 JUN	2227	95	60.6	96	105
30 JUN	2330	97	60.6	98	109
30 JUN	2356	99	61.7	100	105
1 JUL	0023	101	58.3	102	112
1 JUL	0056	103	57.5	104	111
No. 5					
4 JUL	1523	105	51.9	106	110
4 JUL	1556	107	61.3	108	120
4 JUL	1626	109	59.4	110	106
4 JUL	1657	111	67.0	112	108
4 JUL	1728	113	53.7	114	106
4 JUL	1800	115	57.5	116	109
4 JUL	1843	117	48.8	118	108
4 JUL	1908	119	50.0	120	102
4 JUL	1935	121	52.2	122	102
4 JUL	2003	123	52.2	124	97
4 JUL	2028	125	48.8	126	97
4 JUL	2053	127	59.0	128	101
4 JUL	2203	129	51.9	130	90
4 JUL	2227	131	53.4	132	88
4 JUL	2252	133	56.4	134	90
4 JUL	2317	135	53.4	136	97
4 JUL	2347	137	51.9	138	87
5 JUL	0012	139	57.5	140	96
No. 6					
13 JUL	1630	141	55.6	142	108
13 JUL	1705	143	58.3	144	107
13 JUL	1735	145	57.5	146	108
13 JUL	1820	147	60.2	148	115
13 JUL	1848	149	55.6	150	114
13 JUL	1916	151	56.4	152	116
13 JUL	2109	155	56.4	156	131
13 JUL	2221	157	58.7	158	140
13 JUL	2247	159	56.4	160	132
13 JUL	2313	161	55.2	162	126
13 JUL	2340	163	56.0	164	148

(a) Run numbers 21, 22, 93, 94, 153, and 154 were voided because of breakage or spillage of the sample containers.

TABLE C-2 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF EGGS OF ALL FISH SPECIES COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
3	0.0	0	4	38.8	4
5	33.3	1	6	37.0	4
9	31.1	1	10	16.8	2
11	408.8	13	12	260.2	32
13	0.0	0	14	136.0	17
15	32.3	1	16	42.0	5
17	171.9	5	18	0.0	0
19	0.0	0	20	23.1	3
23	0.0	0	24	57.6	8
25	30.0	1	26	36.1	5
29	0.0	0	30	20.2	2
39	42.9	2	40	19.8	2
55	54.2	3	56	100.0	10
57	17.3	1	58	9.6	1
59	33.9	2	60	74.1	8
61	0.0	0	62	29.4	3
105	1,098.3	57	106	1,272.7	140
107	766.7	47	108	641.7	77
109	572.4	34	110	452.8	48
111	403.0	27	112	472.3	51
113	167.6	9	114	301.9	32
115	226.1	13	116	321.1	35
117	471.3	23	118	425.9	46
119	500.0	25	120	382.4	39
121	344.8	18	122	549.0	56
123	287.4	15	124	350.5	34
125	245.9	12	126	237.1	23
127	576.3	34	128	346.5	35

TABLE C-2 (CONT.)

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
129	3,603.1	187	130	3,322.2	299
131	1,254.7	67	132	3,034.1	267
133	3,953.9	223	134	4,855.6	437
135	2,565.6	137	136	2,628.9	255
137	3,834.3	199	138	4,574.7	398
139	6,991.3	402	140	6,760.4	649
141	2,032.4	113	142	1,407.4	152
143	1,818.2	106	144	1,953.3	209
145	11,078.3	637	146	11,027.8	1,191
147	7,292.3	439	148	6,643.5	764
149	10,215.8	568	150	8,956.1	1,021
151	51,914.9	2,928	152	54,689.7	6,344
155	5,762.4	325	156	13,236.6	1,734
157	20,783.6	1,220	158	15,700.0	2,198
159	18,903.6	1,068	160	15,469.7	2,042
161	9,891.3	546	162	8,904.8	1,122
163	3,285.7	184	164	1,540.5	228

TABLE C-3 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF YOLK-SAC LARVAE OF ALL FISH SPECIES COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
1	101.7	3	2	1,550.5	138
3	755.7	30	4	1,563.1	161
5	266.6	8	6	342.6	37
7	293.2	9	8	226.9	27
9	155.4	5	10	168.0	20
11	157.2	5	12	130.0	16
13	96.9	3	14	144.0	18
15	129.1	4	16	75.6	9
17	103.1	3	18	24.2	3
19	18.7	1	20	61.6	8
23	360.4	12	24	295.0	41
25	360.3	12	26	202.8	28
27	0.0	0	28	10.5	1
29	0.0	0	30	10.1	1
31	0.0	0	32	19.8	2
33	22.2	1	34	19.0	2
35	46.7	2	36	19.8	2
37	21.6	1	38	73.3	8
39	86.0	4	40	19.8	2
41	124.8	6	42	47.1	5
43	69.0	3	44	104.7	11
45	40.0	2	46	19.6	2
47	80.0	4	48	111.1	11
49	180.0	9	50	198.0	20
51	64.5	3	52	98.0	10
53	63.9	3	54	41.0	4
57	0.0	0	58	19.2	2
67	0.0	0	68	20.2	2
71	0.0	0	72	21.6	2
73	0.0	0	74	10.8	1
75	0.0	0	76	9.4	1
77	0.0	0	78	18.7	2

TABLE C-3 (CONT.)

Run Number	Pump Density	Pump No. of Organisms	Run Number	Net Density	Net No. of Organisms
79	0.0	0	80	19.2	2
95	49.5	3	96	0.0	0
99	0.0	0	100	9.5	1
101	0.0	0	102	8.9	1
103	17.4	1	104	27.0	3
105	38.6	2	106	0.0	0
107	0.0	0	108	8.3	1
109	0.0	0	110	18.9	2
111	0.0	0	112	18.5	2
117	0.0	0	118	9.3	1
119	0.0	0	120	39.2	4
121	0.0	0	122	19.6	2
123	0.0	0	124	20.6	2
125	0.0	0	126	30.9	3
127	16.9	1	128	39.6	4
129	19.3	1	130	11.1	1
131	0.0	0	132	45.5	4
135	0.0	0	136	10.3	1
139	0.0	0	140	20.8	2
141	0.0	0	142	18.5	2
145	0.0	0	146	18.5	2
147	16.6	1	148	0.0	0
149	0.0	0	150	26.3	3
151	0.0	0	152	77.6	9
159	17.7	1	160	15.2	2
161	0.0	0	162	31.7	4

TABLE C-4 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF POST YOLK-SAC LARVAE OF ALL FISH SPECIES COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
1	508.5	15	2	303.4	27
3	327.5	13	4	359.2	37
5	66.6	2	6	194.5	21
7	358.3	11	8	193.2	23
9	217.4	7	10	218.5	26
11	251.5	8	12	203.4	25
13	677.4	21	14	368.0	46
15	709.7	22	16	285.7	34
17	171.9	5	18	217.8	27
19	243.6	13	20	146.3	19
23	300.3	10	24	223.0	31
25	390.3	13	26	239.1	33
27	916.8	33	28	863.3	82
29	1,618.9	68	30	828.2	82
31	1,288.9	58	32	2,009.9	203
33	866.6	39	34	971.4	102
35	724.3	31	36	1,019.7	103
37	952.4	44	38	926.6	101
39	1,223.2	57	40	1,148.5	116
41	1,601.0	77	42	1,433.9	152
43	1,678.2	73	44	1,380.9	145
45	1,620.0	81	46	686.3	70
47	2,120.0	106	48	2,636.3	261
49	4,340.0	217	50	4,039.5	408
51	3,540.8	165	52	2,607.8	266
53	2,622.6	123	54	1,753.9	171
55	470.2	26	56	480.0	48
57	449.1	26	58	394.2	41

TABLE C-4 (CONT.)

Run Number	Pump Density	Pump No. of Organisms	Run Number	Net Density	Net No. of Organisms
59	457.5	27	60	268.5	29
61	360.3	21	62	215.7	22
63	495.0	30	64	438.1	46
65	466.3	27	66	207.9	21
67	464.4	26	68	373.7	37
69	460.0	23	70	300.0	30
71	916.9	42	72	516.3	48
73	512.4	25	74	376.5	35
75	0.0	0	76	37.7	4
77	79.5	5	78	56.0	6
79	0.0	0	80	28.8	3
81	31.1	2	82	29.7	3
83	100.3	6	84	38.8	4
85	0.0	0	86	19.0	2
87	16.2	1	88	60.6	6
89	132.9	8	90	60.0	6
91	203.3	10	92	134.0	13
95	0.0	0	96	47.6	5
97	99.0	6	98	45.9	5
99	162.0	10	100	38.1	4
101	223.2	13	102	241.0	27
103	347.8	20	104	360.3	40
105	540.1	28	106	491.2	54
107	81.6	5	108	439.9	53
109	437.7	26	110	1,118.7	119
111	700.3	47	112	1,041.6	112
113	297.6	16	114	507.6	54
115	191.4	11	116	430.8	47
117	225.5	11	118	427.8	46
119	340.0	17	120	725.2	74

TABLE C-4 (CONT.)

Run Number	Pump Density	Pump No. of Organisms	Run Number	Net Density	Net No. of Organisms
121	134.1	7	122	715.5	73
123	191.9	10	124	535.6	52
125	389.5	19	126	474.2	46
127	186.3	11	128	346.5	35
129	231.3	12	130	366.6	33
131	131.1	7	132	522.8	46
133	336.9	19	134	166.6	15
135	131.1	7	136	206.2	20
137	250.5	13	138	402.4	35
139	173.9	10	140	104.1	10
141	2,230.2	124	142	3,361.1	363
143	977.7	57	144	1,850.5	198
145	869.6	50	146	675.9	73
147	681.0	41	148	991.3	114
149	413.7	23	150	543.9	62
151	1,241.2	70	152	1,008.6	117
155	992.9	56	156	1,305.3	171
157	1,788.8	105	158	1,799.9	252
159	2,375.9	134	160	2,477.4	327
161	2,934.7	162	162	3,436.5	433
163	2,410.7	135	164	2,000.0	296

TABLE C-5 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF JUVENILES OF ALL FISH SPECIES COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
9	0.0	0	10	8.4	1
11	0.0	0	12	8.1	1
37	0.0	0	38	18.4	2
41	0.0	0	42	9.4	1
43	0.0	0	44	9.5	1
45	20.0	1	46	0.0	0
57	0.0	0	58	9.6	1
59	0.0	0	60	9.3	1
67	53.6	3	68	20.2	2
69	100.0	5	70	50.0	5
71	21.8	1	72	0.0	0
73	20.5	1	74	0.0	0
91	0.0	0	92	10.3	1
95	16.5	1	96	9.5	1
97	49.5	3	98	9.2	1
99	0.0	0	100	38.0	4
101	0.0	0	102	17.8	2
103	17.4	1	104	27.0	3
105	19.3	1	106	0.0	0
107	16.3	1	108	0.0	0
111	0.0	0	112	9.3	1
125	0.0	0	126	10.3	1
127	0.0	0	128	19.8	2
129	0.0	0	130	11.1	1
131	0.0	0	132	22.7	2
135	18.7	1	136	41.2	4
137	57.8	3	138	57.5	5
139	52.2	3	140	52.1	5

TABLE C-5 (CONT.)

Run Number	Pump Density	Pump No. of Organisms	Run Number	Net Density	Net No. of Organisms
141	18.0	1	142	0.0	0
143	0.0	0	144	9.3	1
145	34.8	2	146	27.8	3
147	0.0	0	148	17.4	2
149	71.9	4	150	17.5	2
151	17.7	1	152	25.9	3
155	0.0	0	156	15.3	2
159	0.0	0	160	22.8	3
161	18.1	1	162	0.0	0
163	17.9	1	164	13.6	2

TABLE C-6 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF ALL STRIPED BASS EGGS COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
1	0.0	0	2	11.2	1
3	0.0	0	4	38.8	4
5	33.3	1	6	37.0	4
9	31.1	1	10	16.8	2
11	408.8	13	12	260.2	32
13	0.0	0	14	112.0	14
15	0.0	0	16	33.6	4
17	137.5	4	18	0.0	0
19	0.0	0	20	15.4	2
23	0.0	0	24	7.2	1

TABLE C-7 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF STRIPED BASS YOLK-SAC LARVAE COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
1	101.7	3	2	1,528.1	136
3	654.9	26	4	1,524.3	157
5	166.7	5	6	324.1	35
7	130.3	4	8	168.1	20
9	31.1	1	10	92.4	11
11	125.8	4	12	65.0	8
13	32.3	1	14	104.0	13
15	32.3	1	16	50.4	6
17	0.0	0	18	24.2	3
19	18.7	1	20	23.1	3
23	90.1	3	24	21.6	3
25	0.0	0	26	50.7	7
29	0.0	0	30	10.1	1
31	0.0	0	32	9.9	1
37	0.0	0	38	36.7	4
39	21.5	1	40	9.9	1
41	62.4	3	42	28.3	3
43	23.0	1	44	76.2	8
45	20.0	1	46	19.6	2
47	0.0	0	48	50.5	5
49	60.0	3	50	148.5	15
51	21.5	1	52	9.8	1
53	42.6	2	54	41.0	4
71	0.0	0	72	10.8	1
77	0.0	0	78	18.7	2
79	0.0	0	80	19.2	2
131	0.0	0	132	11.4	1

TABLE C-8 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF STRIPED BASS POST YOLK-SAC LARVAE COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
1	237.3	7	2	56.2	5
3	75.6	3	4	38.8	4
5	33.3	1	6	27.8	3
7	32.6	1	8	8.4	1
9	0.0	0	10	8.4	1
11	0.0	0	12	16.3	2
13	64.5	2	14	32.0	4
15	32.3	1	16	16.8	2
17	34.4	1	18	40.3	5
19	37.5	2	20	15.4	2
23	60.1	2	24	71.9	10
25	30.0	1	26	50.7	7
27	388.9	14	28	242.1	23
29	571.4	24	30	252.5	25
31	288.9	13	32	415.8	42
33	200.0	9	34	104.8	11
35	257.0	11	36	425.7	43
37	519.5	24	38	467.9	51
39	901.3	42	40	742.6	75
41	935.6	45	42	849.1	90
43	1,057.5	46	44	800.0	84
45	1,020.0	51	46	490.2	50
47	1,660.0	83	48	2,232.3	221
49	3,680.0	184	50	3,237.6	327
51	2,596.6	121	52	1,862.7	190
53	2,068.2	97	54	1,528.2	149
55	90.4	5	56	140.0	14
57	17.3	1	58	105.8	11

TABLE C-8 (CONT.)

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
59	33.9	2	60	27.8	3
61	17.2	1	62	19.6	2
63	0.0	0	64	28.6	3
65	51.8	3	66	0.0	0
67	71.4	4	68	131.3	13
69	140.0	7	70	100.0	10
71	655.0	30	72	236.6	22
73	307.4	15	74	258.1	24
75	0.0	0	76	9.4	1
77	31.8	2	78	9.3	1
79	0.0	0	80	9.6	1
81	31.1	2	82	0.0	0
83	16.7	1	84	9.7	1
87	0.0	0	88	20.2	2
89	16.6	1	90	0.0	0
91	20.3	1	92	20.6	2
97	16.5	1	98	9.2	1
99	97.2	6	100	28.6	3
101	34.3	2	102	53.6	6
103	139.1	8	104	117.1	13
105	154.1	8	106	63.6	7
107	0.0	0	108	8.3	1
109	0.0	0	110	9.4	1
117	0.0	0	118	9.3	1
123	19.2	1	124	0.0	0
129	19.3	1	130	0.0	0
131	0.0	0	132	11.4	1
137	38.5	2	138	23.0	2
139	0.0	0	140	10.4	1
151	0.0	0	152	17.2	2
159	0.0	0	160	7.6	1

TABLE C-9 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF WHITE PERCH EGGS COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
19	0.0	0	20	7.7	1
23	0.0	0	24	50.4	7
25	30.0	1	26	21.7	3
29	0.0	0	30	10.1	1
39	42.9	2	40	19.8	2
43	0.0	0	44	9.5	1
47	0.0	0	48	10.1	1
55	54.2	3	56	60.0	6
57	17.3	1	58	9.6	1
59	33.9	2	60	55.6	6
61	0.0	0	62	29.4	3
63	16.5	1	64	0.0	0
65	0.0	0	66	9.9	1
105	0.0	0	106	9.1	1
111	44.8	3	112	9.3	1
135	56.2	3	136	0.0	0
137	0.0	0	138	11.5	1

TABLE C-10 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF WHITE PERCH POST YOLK-SAC LARVAE COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
1	101.7	3	2	89.9	8
3	100.8	4	4	77.7	8
5	33.3	1	6	46.3	5
7	97.7	3	8	50.4	6
9	93.2	3	10	67.2	8
11	62.9	2	12	40.7	5
13	161.3	5	14	72.0	9
15	64.5	2	16	92.4	11
17	34.4	1	18	24.2	3
19	37.5	2	20	15.4	2
23	30.0	1	24	14.4	2
25	120.1	4	26	94.2	13
27	55.6	2	28	21.1	2
29	23.8	1	30	50.5	5
31	66.7	3	32	9.9	1
35	0.0	0	36	9.9	1
37	21.6	1	38	36.7	4
39	0.0	0	40	39.6	4
41	104.0	5	42	150.9	16
43	114.9	5	44	66.7	7
45	20.0	1	46	0.0	0
47	80.0	4	48	40.4	4
49	80.0	4	50	99.0	10
51	64.4	3	52	431.4	44
53	64.0	3	54	71.8	7
55	144.7	8	56	250.0	25
57	259.1	15	58	173.1	18
59	220.3	13	60	129.6	14
61	257.3	15	62	166.7	17
63	313.5	19	64	114.3	12

TABLE C-10 (CONT.)

Run Number	Pump		Run Number	Net	
	Density	No. of Organisms		Density	No. of Organisms
65	276.3	16	66	118.8	12
67	232.1	13	68	101.0	10
69	200.0	10	70	140.0	14
71	131.0	6	72	225.8	21
73	123.0	6	74	96.8	9
75	0.0	0	76	28.3	3
77	31.8	2	78	37.4	4
79	0.0	0	80	19.2	2
81	0.0	0	82	29.7	3
83	83.6	5	84	29.1	3
85	0.0	0	86	9.5	1
87	16.2	1	88	20.2	2
89	99.7	6	90	60.0	6
91	122.0	6	92	103.1	10
95	0.0	0	96	38.1	4
97	49.5	3	98	0.0	0
99	32.4	2	100	0.0	0
101	85.8	5	102	133.9	15
103	139.1	8	104	198.2	22
105	19.3	1	106	127.3	14
107	0.0	0	108	8.3	1
111	0.0	0	112	9.3	1
117	0.0	0	118	9.3	1
119	0.0	0	120	19.6	2
121	57.5	3	122	39.2	4
123	38.3	2	124	10.3	1
127	16.9	1	128	9.9	1
129	0.0	0	130	11.1	1
133	17.7	1	134	0.0	0
137	0.0	0	138	11.5	1
145	17.4	1	146	0.0	0
155	0.0	0	156	7.6	1
161	0.0	0	162	7.9	1
163	17.9	1	164	0.0	0

TABLE C-11 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF *ALOSA* spp. POST YOLK-SAC LARVAE COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
1	33.9	1	2	123.6	11
3	151.1	6	4	194.2	20
5	0.0	0	6	74.1	8
7	65.1	2	8	117.6	14
9	62.1	2	10	126.1	15
11	31.4	1	12	105.7	13
13	387.1	12	14	216.0	27
15	387.1	12	16	134.5	16
17	34.4	1	18	96.8	12
19	131.1	7	20	38.5	5
23	30.0	1	24	36.0	5
25	90.1	3	26	50.7	7
27	416.7	15	28	547.4	52
29	714.3	30	30	494.9	49
31	866.7	39	32	1,564.4	158
33	422.2	19	34	819.0	86
35	327.1	14	36	465.3	47
37	173.2	8	38	293.6	32
39	257.5	12	40	257.4	26
41	332.6	16	42	311.3	33
43	344.8	15	44	371.4	39
45	240.0	12	46	186.3	19
47	140.0	7	48	212.1	21
49	100.0	5	50	297.0	30
51	257.5	12	52	176.5	18
53	85.3	4	54	133.3	13
55	0.0	0	56	40.0	4
57	51.8	3	58	67.3	7
59	118.6	7	60	83.3	9
61	34.3	2	62	29.4	3

TABLE C-11 (CONT.)

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
63	99.0	6	64	276.2	29
65	86.4	5	66	79.2	8
67	107.2	6	68	101.0	10
69	60.0	3	70	40.0	4
71	87.3	4	72	43.1	4
73	0.0	0	74	10.8	1
103	0.0	0	104	9.0	1
119	20.0	1	120	0.0	0

TABLE C-12 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF BAY ANCHOVY EGGS COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
59	0.0	0	60	18.5	2
105	1,098.3	57	106	1,263.6	139
107	766.7	47	108	641.7	77
109	572.4	34	110	443.4	47
111	328.4	22	112	453.7	49
113	167.6	9	114	292.5	31
115	226.1	13	116	321.1	35
117	471.3	23	118	425.9	46
119	480.0	24	120	382.4	39
121	344.8	18	122	549.0	56
123	287.4	15	124	350.5	34
125	245.9	12	126	237.1	23
127	576.3	34	128	346.5	35
129	3,603.1	187	130	3,322.2	299
131	1,254.7	67	132	3,000.0	264
133	3,953.9	223	134	4,800.0	432
135	2,509.4	134	136	2,628.9	255
137	3,834.3	199	138	4,563.2	397
139	6,991.3	402	140	6,760.4	649
141	2,032.4	113	142	1,361.1	147
143	1,818.2	106	144	1,953.3	209
145	11,078.3	637	146	11,027.8	1,191
147	7,076.4	426	148	6,643.5	764
149	10,125.9	563	150	8,956.1	1,021
151	51,914.9	2,928	152	54,689.7	6,344
155	5,709.2	322	156	13,236.6	1,734
157	20,783.6	1,220	158	15,700.0	2,198
159	18,903.6	1,068	160	15,469.7	2,042
161	9,891.3	546	162	8,904.8	1,122
163	3,285.7	184	164	1,540.5	228

TABLE C-13 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF BAY ANCHOVY YOLK-SAC LARVAE COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
105	38.5	2	106	0.0	0
107	0.0	0	108	8.3	1
109	0.0	0	110	18.9	2
111	0.0	0	112	18.5	2
117	0.0	0	118	9.3	1
119	0.0	0	120	39.2	4
121	0.0	0	122	19.6	2
123	0.0	0	124	20.6	2
125	0.0	0	126	30.9	3
127	0.0	0	128	39.6	4
129	19.3	1	130	11.1	1
131	0.0	0	132	34.1	3
139	0.0	0	140	20.8	2
141	0.0	0	142	18.5	2
145	0.0	0	146	18.5	2
147	16.6	1	148	0.0	0
149	0.0	0	150	26.3	3
151	0.0	0	152	77.6	9
159	17.7	1	160	15.2	2
161	0.0	0	162	31.7	4

TABLE C-14 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF BAY ANCHOVY POST YOLK-SAC LARVAE COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
59	0.0	0	60	27.8	3
97	33.0	2	98	18.3	2
105	347.4	18	106	254.8	28
107	81.6	5	108	423.3	51
109	437.7	26	110	1,090.4	116
111	685.4	46	112	1,023.0	110
113	279.0	15	114	507.6	54
115	191.4	11	116	403.3	44
117	225.5	11	118	409.2	44
119	280.0	14	120	666.4	68
121	76.6	4	122	676.3	69
123	115.2	6	124	494.4	48
125	369.0	18	126	453.6	44
127	118.6	7	128	326.7	33
129	192.7	10	130	355.5	32
131	131.1	7	132	488.7	43
133	266.0	15	134	144.4	13
135	112.4	6	136	206.2	20
137	212.0	11	138	264.4	23
139	121.7	7	140	83.3	8
141	2,230.2	124	142	3,361.1	363
143	308.7	18	144	1,850.5	198
145	695.7	40	146	657.4	71
147	614.6	37	148	973.9	112
149	395.7	22	150	517.6	59
151	1,099.3	62	152	991.4	115
155	975.2	55	156	1,282.4	168
157	1,737.7	102	158	1,785.7	250
159	2,340.4	132	160	2,454.6	324
161	2,916.6	161	162	3,365.1	424
163	2,392.8	134	164	1,844.6	273

TABLE C-15 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF CYPRINIDAE YOLK-SAC LARVAE COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
7	32.6	1	8	0.0	0
9	31.1	1	10	8.4	1
19	0.0	0	20	15.4	2
23	60.1	2	24	0.0	0
25	90.1	3	26	0.0	0
33	22.2	1	34	9.5	1
35	46.7	2	36	19.8	2
37	0.0	0	38	18.3	2
39	21.5	1	40	0.0	0
41	62.4	3	42	9.4	1
43	46.0	2	44	9.5	1
47	20.0	1	48	50.5	5
49	60.0	3	50	9.9	1
51	21.5	1	52	68.6	7
53	21.3	1	54	0.0	0
67	0.0	0	68	10.1	1
71	0.0	0	72	10.8	1
73	0.0	0	74	10.8	1
95	33.0	2	96	0.0	0
101	0.0	0	102	8.9	1
103	17.4	1	104	0.0	0
127	16.9	1	128	0.0	0

TABLE C-16 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF CYPRINIDAE POST YOLK-SAC LARVAE COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
13	0.0	0	14	16.0	2
19	0.0	0	20	15.4	2
23	0.0	0	24	7.2	1
25	0.0	0	26	14.5	2
29	0.0	0	30	10.1	1
33	44.4	2	34	28.6	3
35	46.7	2	36	69.3	7
37	0.0	0	38	64.2	7
39	42.9	2	40	49.5	5
41	41.6	2	42	56.6	6
43	0.0	0	44	47.6	5
45	100.0	5	46	0.0	0
47	40.0	2	48	40.4	4
49	100.0	5	50	227.7	23
51	0.0	0	52	39.2	4
53	21.3	1	54	10.3	1
55	18.1	1	56	0.0	0
57	0.0	0	58	9.6	1
63	0.0	0	64	9.5	1
67	17.9	1	68	0.0	0
69	0.0	0	70	10.0	1
73	0.0	0	74	10.8	1

TABLE C-17 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF RAINBOW SMELT POST YOLK-SAC LARVAE COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
1	33.9	1	2	33.7	3
3	0.0	0	4	48.5	5
5	0.0	0	6	27.8	3
7	0.0	0	8	8.4	1
9	0.0	0	10	8.4	1
11	62.9	2	12	0.0	0
13	64.5	2	14	24.0	3
15	193.5	6	16	42.0	5
17	68.7	2	18	32.3	4
19	37.5	2	20	23.1	3
25	30.0	1	26	14.5	2
27	0.0	0	28	21.1	2
29	23.8	1	30	0.0	0
33	0.0	0	34	9.5	1
35	0.0	0	36	19.8	2
37	0.0	0	38	9.2	1
39	21.5	1	40	9.9	1
41	62.4	3	42	9.4	1
43	46.0	2	44	0.0	0
47	20.0	1	48	30.3	3
49	140.0	7	50	39.6	4
51	0.0	0	52	19.6	2
53	42.6	2	54	0.0	0
67	0.0	0	68	40.4	4
69	20.0	1	70	0.0	0
71	21.8	1	72	0.0	0
73	20.5	1	74	0.0	0
87	0.0	0	88	10.1	1
89	16.6	1	90	0.0	0

TABLE C-17 (CONT.)

Run Number	Pump Density	Pump No. of Organisms	Run Number	Net Density	Net No. of Organisms
101	0.0	0	102	8.9	1
103	17.4	1	104	0.0	0
129	19.3	1	130	0.0	0
131	0.0	0	132	22.7	2
133	0.0	0	134	11.1	1
135	18.7	1	136	0.0	0
139	52.2	3	140	10.4	1

TABLE C-18 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF TESSELLATED DARTER YOLK-SAC LARVAE COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
5	33.3	1	6	18.5	2
7	97.7	3	8	33.6	4
9	93.2	3	10	33.6	4
11	31.4	1	12	32.5	4
13	0.0	0	14	8.0	1
17	34.4	1	18	0.0	0
19	0.0	0	20	23.1	3
23	210.2	7	24	259.0	36
25	240.2	8	26	115.9	16
33	0.0	0	34	9.5	1
37	21.6	1	38	18.3	2
39	21.5	1	40	0.0	0
41	0.0	0	42	9.4	1
43	0.0	0	44	19.0	2
45	20.0	1	46	0.0	0
47	40.0	2	48	10.1	1
49	60.0	3	50	39.6	4
51	21.5	1	52	9.8	1
95	16.5	1	96	0.0	0
103	0.0	0	104	9.0	1

TABLE C-19 DENSITY (NUMBER/1,000 m^3) AND NUMBER OF TESSELLATED DARTER POST YOLK-SAC LARVAE COLLECTED DURING PUMP-NET COMPARISON EXPERIMENTS AT THE INDIAN POINT GENERATING STATION, 2 JUNE - 13 JULY 1978

	Pump			Net	
Run Number	Density	No. of Organisms	Run Number	Density	No. of Organisms
5	0.0	0	6	18.5	2
7	162.9	5	8	0.0	0
9	62.1	2	10	8.4	1
11	94.3	3	12	8.1	1
17	0.0	0	18	8.1	1
19	0.0	0	20	7.7	1
23	180.2	6	24	86.3	12
25	60.1	2	26	14.5	2
29	23.8	1	30	0.0	0
31	0.0	0	32	9.9	1
33	22.2	1	34	0.0	0
35	0.0	0	36	9.9	1
37	0.0	0	38	18.3	2
39	0.0	0	40	9.9	1
41	20.8	1	42	9.4	1
43	46.0	2	44	9.5	1
45	100.0	5	46	9.8	1
47	0.0	0	48	40.4	4
49	80.0	4	50	39.6	4
51	42.9	2	52	19.6	2
53	0.0	0	54	10.2	1
67	17.9	1	68	0.0	0

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