

Institute of Environmental Medicine

HUDSON RIVER ECOSYSTEM STUDIES

Effects of Entrainment
by the Indian Point Power Plant
on Biota in the Hudson River Estuary

ADDENDA TO: THE 1973 REPORT

I. An Analysis of the Abundance of Four
Life History Stages of Striped Bass (*Morone
saxatilis*) Collected in the Intakes and Discharge
Canal of Indian Point Unit I and in the
Hudson River at Indian Point

II. Larval Striped Bass (*Morone saxatilis*)
Length Frequency Analysis

Docket # 50-247/286
Control # 9394
Date Recvd. 9-7-76
Regulatory Docket File

for

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.
4 Irving Place
New York, New York 10003



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Length Frequency Analysis

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Submitted to

Consolidated Edison Company of New York, Inc.
4 Irving Place
New York, New York 10003

August, 1976

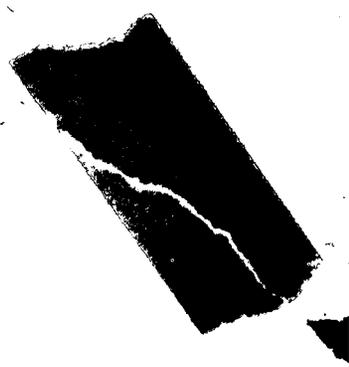
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FOREWORD

The research reported herein is part of a larger study carried out during the calendar year 1973. Analyses of the data contained in this addendum were presented in two separate reports submitted to Consolidated Edison. The first report was entitled, "A Preliminary Analysis of the Abundance of Four Life History Stages of Striped Bass (Morone saxatilis) Collected in the Intakes of Indian Point Unit 1 and in the Hudson River in Front of Indian Point." The second report was entitled, "Larval Striped Bass (Morone saxatilis) Length Frequency Analysis."

This report presents the final results of studies conducted at Indian Point during 1973 using the full complement of available striped bass ichthyoplankton data, which have been analyzed using samples matched by date, time and depth. These procedures were undertaken in order to present data for river and plant comparisons in the proper perspective of time and space.

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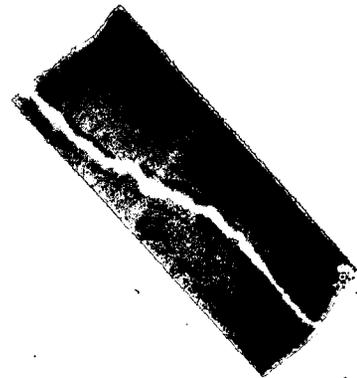
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An Analysis of the Abundance of Four
Life History Stages of Striped Bass (Morone
saxatilis) Collected in the Intakes and Discharge
Canal of Indian Point Unit 1 and in the
Hudson River at Indian Point

INTRODUCTION

The operating schedule for generating Units I and II at the Indian Point nuclear power station did not include power generation from May through August 1973, the time of year during which the eggs and larvae of striped bass and the larvae of white perch, bay anchovy and several transient marine species are common in the vicinity of Indian Point (NYU 1973, 1974; T.I., 1974). For this reason New York University entrainment studies which, in 1971 and 1972 provided data on the thermal/mechanical effects of fish larvae entrainment, were altered in 1973 to focus on the abundance of ichthyoplankton at the Indian Point Station and in nearby river areas rather than on the survival of ichthyoplankton after passage through the cooling water system.

The samples taken in this study were analyzed specifically to provide an estimate of the abundance of striped bass eggs, yolk-sac larvae, larvae and juveniles at four river stations, the intake of Unit I and at three stations in the common discharge from Units I and II.

Methods of Collection

Ichthyoplankton samples were collected simultaneously at three depths (surface, middle, bottom) at each of four river stations (Figure 1). All stations were sampled once every two

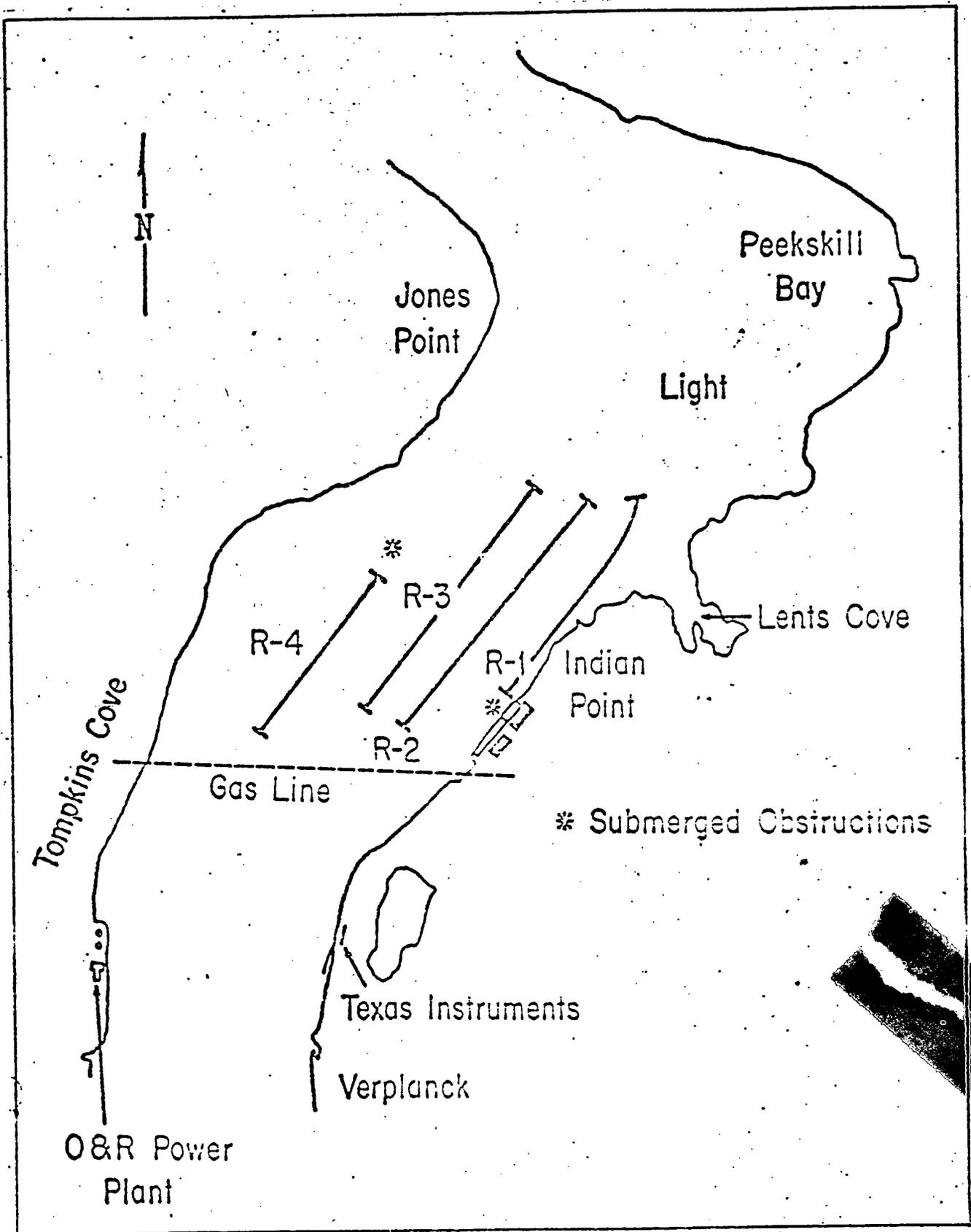


Figure 1 New York University Hudson River sampling stations, 1973.

hours for a 24 hour period once each week from May 29 through July 24. After July 24 samples were collected once every two weeks until the end of the entrainment season. A detailed description of the sampling gear and techniques used may be found in sections 6.1.1, page 120 and 7.1.1, page 206, of New York University's Hudson River Ecosystem Studies, Progress Report for 1973 (N.Y.U., 1974).

In-plant samples were collected from two Unit 1 intake stations (I-1 and I-2) and two discharge canal stations (D-1 and D-2; Figure 2). Replicate samples were collected at each of three depths (surface, middle and bottom) at each station. At Station DP four samples were collected from the area of one of the submerged ports; the data collected from the DP station were not included in the analyses due to an extensive construction program in the area which precluded the acquisition of scheduled samples.

A detailed description of the in-plant sampling methods may be found in section 7.2.2.1.1, page 226 of New York University's Hudson River Ecosystem Studies, Progress Report for 1973 (N.Y.U., 1974). In-plant sampling began on May 8, 1973; sampling in the river was initiated May 29. Samples taken after May 29 were coordinated such that the timing of river and plant samples was coincident on a given date.

Methods of Data Analysis

In the first series of analyses data sets for testing were matched by date: The abundances of life history stages of striped bass collected from the river, intakes, and/or discharge

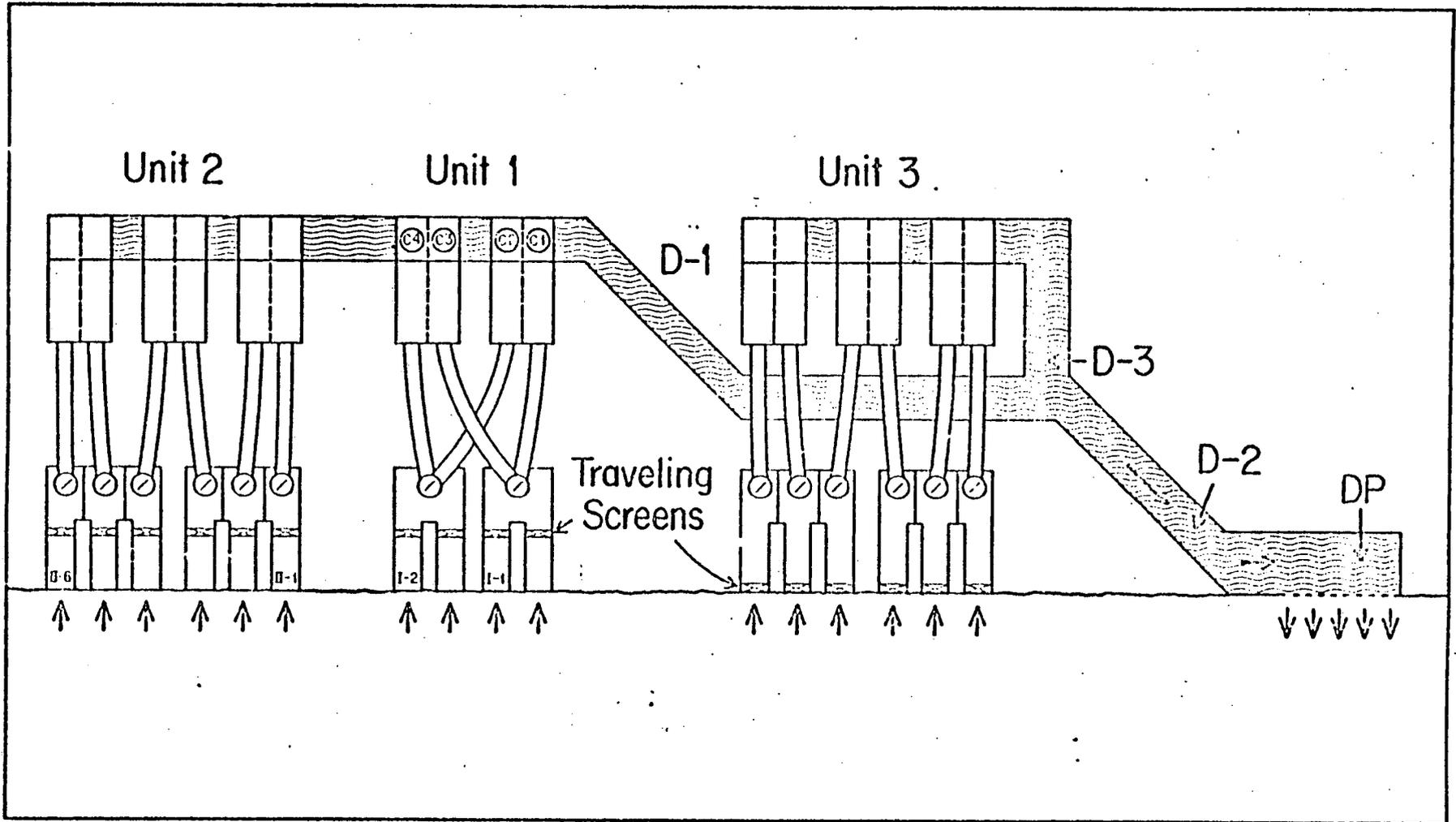


Figure 2. Schematic diagram of Indian Point cooling water system showing locations of sampling stations.

canal stations was compared by date only (Table 1). These comparisons included those dates for which sampling was carried out at more than one location and the life history stage in question was found in any sample on that date. For example, if, on May 29, sampling occurred at the intakes and in the river, and if striped bass eggs were found at either location, the data were included in the analysis.

In the second series of analyses the conditions for inclusion in the analysis were that individual samples were matched by sampling interval (two hour cycle). If on May 29 sampling was accomplished in the river and at the intakes during a two-hour cycle, the data were included. If for some reason time periods did not match, the unmatched sample was removed from the data base before comparisons between stations were made.

The comparisons which have been made are based on calculated abundances (actual catch converted to numbers of organisms per 1000 m³ of water filtered). The formula used to calculate abundances utilized the number of individuals of the life history stage in question that were collected, the water flow-meter reading associated with the tow (or sample) in which the organisms were collected, a correction factor to convert meter readings to volume of water filtered, and the time duration of the sample:

$$\text{number per } 1000 \text{ m}^3 = \frac{N}{RC} \times \frac{1000}{RC}$$

where: N = the number of organisms per species counted in the sample

Table 1. Sampling dates for life history stages.

Life History Stage	Dates
eggs	5-29 through 6-26
Yolk-sac larvae	5-29 through 6-26
larvae	5-29 through 8-21
juveniles	6-12 through 8-21

R = revolutions from the flowmeter

C = factor for the flowmeter converting revolutions to volume.

RIVER SAMPLING

The first step in analyzing river data involved an analysis of flow-meter data to isolate and account for anomalous readings. The frequency-distribution of raw data from flow-meters used during river sampling was tested for goodness of fit to a normal distribution (Kolmogorov-Smirnov Test). The results showed that the distribution of meter readings did not differ from a normal distribution ($\alpha = 0.05$). Some flow-meter data (those from either end of the frequency distribution) were not normally distributed, indicating meter dysfunction during the process of sampling. Dysfunction may have been due to clogging or jamming, gear stripping or any of a variety of other factors. These anomalous values occurred below the 0.005 and 0.995 percentile points of the distribution. It was concluded that meter readings for a river sample falling below the 0.005 percentile of the distribution (1,452 revolutions per sampling interval) and above the 0.995 percentile (34,234 revolutions) should be discarded. Such values were referred to as "outliers" (values lying outside the range of expected ($\alpha = 0.05$) meter readings for the sampling procedure employed).

Meter readings within the normally distributed portion of the curve showed a strong positive correlation with depth. That is, for any given date, time, and station, an estimate to replace an outlier meter reading could be obtained from a linear combination of the meter readings at the remaining depths.

Analysis of the three groups of meter readings (surface, middle and bottom) gave the following corrected meter readings:

Case 1: Bottom meter reading only is an outlier.

$$\text{Bottom} = .922 \times \text{surface meter} + 0.015 \times \text{middle meter reading} - 146.$$

Case 2: Middle meter reading only is an outlier.

$$\text{Middle} = .819 \times \text{surface meter reading} + .009 \times \text{bottom meter reading} + 1346.$$

Case 3: Surface meter reading only is an outlier.

$$\text{Surface} = .515 \times \text{middle} + .337 \times \text{bottom} + 4341.$$

Case 4: Both bottom and middle meter readings are outliers.

$$\begin{aligned} \text{Bottom} &= .934 \times \text{surface} - 126. \\ \text{Middle} &= .827 \times \text{surface} + 1345. \end{aligned}$$

Case 5: Surface and bottom meter readings are outliers.

$$\begin{aligned} \text{Surface} &= .755 \times \text{middle} + 6226. \\ \text{Bottom} &= .711 \times \text{middle} + 5594. \end{aligned}$$

Case 6: Surface and middle meter readings are outliers.

$$\begin{aligned} \text{Surface} &= .591 \times \text{bottom} + 8712. \\ \text{Middle} &= .492 \times \text{bottom} + 8482. \end{aligned}$$

Case 7: All three depths (at any station-date-time combination) are outliers.

$$\begin{aligned} \text{Surface} &= \text{mean value for all surface readings (19,300)}. \\ \text{Middle} &= \text{mean value for all middle readings (17,300)}. \\ \text{Bottom} &= \text{mean value for all bottom readings (17,900)}. \end{aligned}$$

Once the determination of outliers was made and the appropriate substitution accomplished, the river data were analyzed using analysis of variance techniques (ANOVA). The analysis was performed using the numbers of the life history stage in question per unit volume sampled. The concentrations were converted to logarithmic values ($\log_{10} (y + 1)$) for testing in the analysis of variance. This conversion assured compliance with a major assumption of the ANOVA statistic, that the variance of the data was homogeneous (Simpson, Roe and Lewontin, 1960). The analysis of variance of river abundance utilized station, date, depth and time as variables in a nested (hierarchical) design. Depth was considered nested within stations, and time was considered nested within date.

Day versus night comparisons were made. Day was defined as that time period from 0700 hours to 1900 hours. Night was defined as the period from 2100 hours through 0500 hours.

When significant differences ($\alpha = 0.05$) were found with the analysis of variance techniques used, an a posteriori test (Scheffé Test, $\alpha = 0.10$; Scheffé, H., 1959) was used to determine which of the levels of the variable contributing to that difference were significant. For example, if the analysis of variance technique indicated a significant difference among stations for a particular life history stage, the Scheffé Test was used to determine which stations were different.

INTAKE SAMPLING

The methods utilized to analyze the data obtained from samples collected in the Unit 1 intakes and from the discharge stations included analysis of variance and the Scheffé Test. The factors considered in the intake and discharge canal station ANOVA design were the same as those used for the river data.

The confidence intervals on the means given throughout this report are based on the calculated mean and an estimate of the variance given by s^2/n . The distribution of the numbers comprising the mean is not known. It is known that the numbers comprising the mean were not normally distributed nor did they conform to the definitions of contagious or poisson distributions that we have tested (Snedecor and Cochran, 1967). If the distributions of the numbers comprising the mean had conformed to a poisson distribution the sample mean would have been a better estimate of the variance than s^2/n .

The problems associated with sampling at the plant intake were related to the velocity of water entering the sampling gear and the accuracy of the flow-meters at intake velocities. The meters were TSK USA Model 313, mechanical flow-meters; at low water velocities, such as those encountered in the intakes, the frictional resistance offered by the mechanism of this meter probably results in an underestimate of flow per unit time. Frictional resistance may affect estimates of volume filtered at higher velocities also, so that, in effect, there is a tendency to underestimate consistently the volume of water sampled when flow was at extremes. The degree to which the flow estimates are affected by mechanical resistance at higher velocity is less than

that at lower velocities. Underestimating the flow results in a conservatively high estimate of the concentrations of ichthyoplankton in the intake stream.

The data relating to the meter readings for samples collected from the intake and discharge canal were not distributed in a way that made the outlier meter readings readily identifiable. The methods used to identify outliers and the rationale for choosing the methods employed were as follows:

Method I

A meter reading of 500 revolutions or less per sample was operationally defined as the lower cut-off point for rejecting outliers. When a meter reading of 500 or less was encountered, the meter reading was removed from the data base and, in the initial analyses, a mean meter reading calculated for that area (intakes or discharge canal) over all depths was substituted.

Method II

Remove meter readings of less than 500 revolutions and substitute a mean value calculated from readings at each station for each depth.

Method III

Remove meter readings of less than 500 revolutions and substitute a mean value calculated from readings at each station for each depth. After this step was accomplished the ratio of each calculated abundance to the total calculated abundance for each sample and each life history stage was calculated. These ratios were compared to ratios based on the actual numbers collected. Comparisons were made on a sample-by-sample basis for each life history stage collected. In any comparison for which

the ratio based on calculated abundances deviated by more than 5% from the ratio of actual numbers, the meter reading was considered suspect and the mean meter reading for that station and depth was substituted. Table 2 gives an example of how the method of adjusting for outliers works. The hypothetical data base presented in Table 2 represents ten, 50 minute samples from a single depth in one of the intake structures. From an examination of the meter readings the values associated with the 3rd and 10th samples would appear suspect. The fifth column "number/1000m³" shows calculated abundances prior to any adjustments for outlier meter readings. As can be seen, the calculated concentration for sample 10 is unrealistic when compared to the other samples, and represents 71% of the total calculated catch by volume.

The 6th Column shows the calculated number/1000m³ after adjusting for meter readings of less than 500 revolutions. The number/1000m³ for the 10th sample changed from 2750/1000m³ to 151/1000m³.

The column entitled percent contribution to total catch by volume (number/1000m³) shows two samples (3 and 8) for which the percent contribution to total catch by volume equaled or exceeded the percent contribution to total catch in terms of actual numbers by 5% or more. For the 3rd sample the percent contribution to the total catch in number/1000m³ was 22%, while in terms of actual numbers caught the percent contribution was 6%. This large differential occurred as the result of the meter reading of 555 associated with the sample. The meter reading was just

Table 2. Example of adjustment method (hypothetical data) for "outlier" meter readings.

Sample Number	Meter Reading	Actual # Caught	% Contribution to Total Catch (Actual)	Number/1000m ³	Number/1000m ³ After Substituting for Meter Readings of < 500 Revolutions
1	2500	20	23	258	258
2	2450	10	11	132	132
3	555	5	6	294	294
4	2600	4	4	50	50
5	2557	3	3	38	38
6	2650	8	9	98	98
7	2485	7	8	91	91
8	2931	15	17	165	165
9	2326	4	4	56	56
10	125	11	13	2750	151

% Contribution to Total Catch by Volume (#/1000m ³)	Number/1000m ³ After Substituting for Contributions of 5% or Greater	Adjusted % Contribution to Total Catch (#/1000m ³)
19	258	22
10	132	11
22*	68	6
4	50	4
3	38	3
7	98	8
7	91	8
12*	206	18
4	56	5
11	151	13

* Difference between percent contribution based on actual numbers and percent contribution based on #/1000m³ greater than or equal to 5%.

in excess of the 500 revolutions used as the cut-off point for outliers. The last column shows the percent contribution to the total catch (number/1000m³) after adjustment for the deviations of 5% or greater, and, when compared to the 4th column, shows the effect on the 3rd sample.

In this report the results presented for the intakes and discharge canal stations are based on calculated abundances using Method III to identify and adjust for outlier meter readings.

The only data currently available concerning the resistance offered by the nets used in this sampling effort is based on a study made in the discharge canal. Two Kahl Scientific, low friction contact type current meters (no. 232 WA 240) were sampled side by side in the discharge canal at a velocity of between 2.5 and 3 feet/sec for 10, consecutive 5-minute intervals. One meter gave an average velocity estimate approximately 0.2 ft/sec higher than the second. One meter was then placed inside a standard intake sampling net with a cod end. The second meter remained mounted without a net. Seventeen consecutive 5-minute readings were made for both meters without removing them from the water between readings. The analysis of these readings, made after adjusting for the previously determined difference due to meter differences or position differences, indicated that the velocity calculated from the meter within the net was less than the velocity calculated for the meter with no

net by 14%. This was attributed to the resistance offered by the net. The velocities at which these comparisons were made were between 2.5 and 3 feet/sec, and the calculated cross sectional velocity of the intakes for the operational conditions of the plant was 0.5 feet/sec. At these lower velocities the resistance offered by the nets may differ.

In an attempt to determine the most realistic number of revolutions that may be utilized as a lower limit in identifying inaccurate meter readings, we have taken some preliminary measurements of velocities in the two intake forebays. The measurements were made in May of 1974 during a time period when Unit I was not generating electricity and the circulator pumps operated at a reduced level, similar to that which existed during the 1973 sampling program.

In one set of experiments a TSK USA 303 current meter of the type utilized in the 1973 program was mounted in one of the intake sampling rigs next to a Kahl Scientific Instrument Corporation, low friction-type current meter, no. 232 WA 240. The Kahl Scientific Instrument Corporation meter is also a mechanical meter but it has a lower velocity threshold at which revolutions are first recorded.

In intake sampling station #2 (I-2), 40 simultaneous recordings were made over all depths for varying sampling times.

Based on the results of these comparisons the mean velocity and 95% confidence interval calculated using meter readings from the TSK meter was 0.53 ± 0.07 ft/sec. The mean velocity and 95% confidence interval calculated with meter readings from the Kahl current meter was 0.48 ± 0.04 ft/sec.

In intake sampling station #1 (I-1) the same comparison was made based on 33 simultaneous recordings. Based on the results of these comparisons the mean velocity and 95% confidence interval calculated from meter readings from the TSK meter was 0.89 ± 0.09 ft/sec while the mean velocity and 95% confidence interval calculated from readings from the Kahl current meter was 0.84 ± 0.05 ft/sec. These measurements made with two different instruments indicate a mean velocity equal to or greater than the calculated 0.5 ft/sec.

These values were however recorded under one set of tidal conditions. To further explore the velocity profiles in the Unit 1 intakes we installed, during the same period of approximately 7 days in May of 1974, three General Oceanics Film Recording Current Meters, Model 2010 in the Unit 1 intake forebay (I-1). The three meters were attached to a taut line suspended from the top of the forebay at depths of 2, 10, and 18 feet. The sounded depth of the forebay at the time of meter placement (low tide) was 20 feet. The meters were set to record at a rate of approximately once every 5 minutes.

After the meters were retrieved and the film was developed 2329 frames were read for the surface, 2145 frames from the mid-depth, and 1699 frames from the bottom depth. The differences

in the numbers of frames read for each meter were due to the differences in the rates at which recordings were made by each meter.

The data were analyzed by averaging the individual readings obtained from each meter over half-hour intervals. For the surface meter there were 7 readings per half-hour interval, for mid-depth 6 readings, and for bottom depth 5 readings. The data were also analyzed according to tidal stage (flood or ebb). The results of these analyses are presented in Figures 3 and 4.

Figure 3 gives the mean intake velocity and 95% confidence interval for each depth and for the flood or ebb tidal stages. As can be seen from these analyses the tidal stage (flood or ebb) had no significant effect on the intake velocity recorded. Figure 4 shows the mean velocity and 95% confidence interval recorded over all tidal stages. These data indicate the velocities recorded by these methods were lower at the surface, while the mid and bottom depths did not differ. In each case the mean velocities recorded were between 0.5 and 0.7 ft/sec.

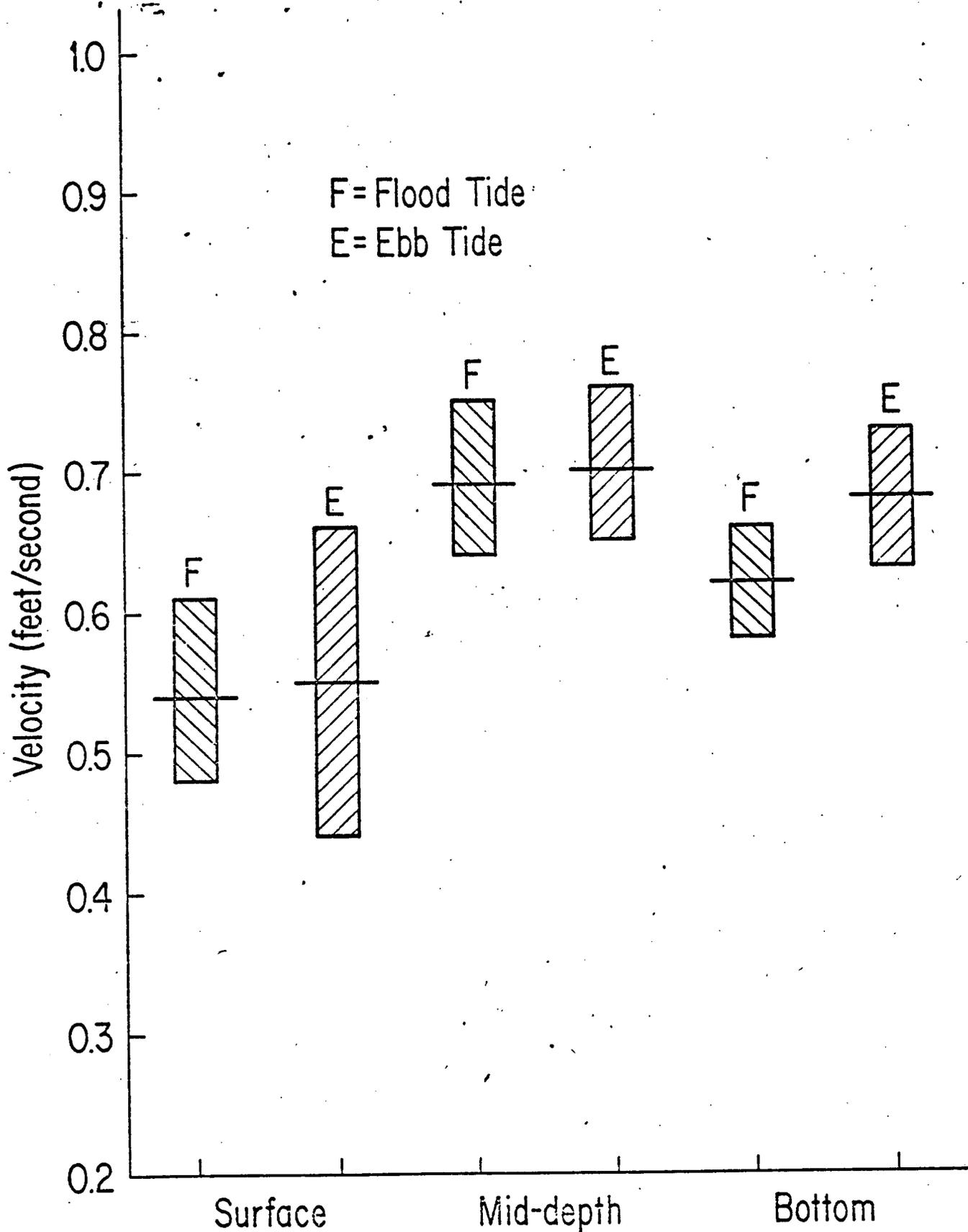


Figure 3. Mean intake velocity and 95% confidence interval for each depth and for the flood or ebb tidal stages at Indian Point.

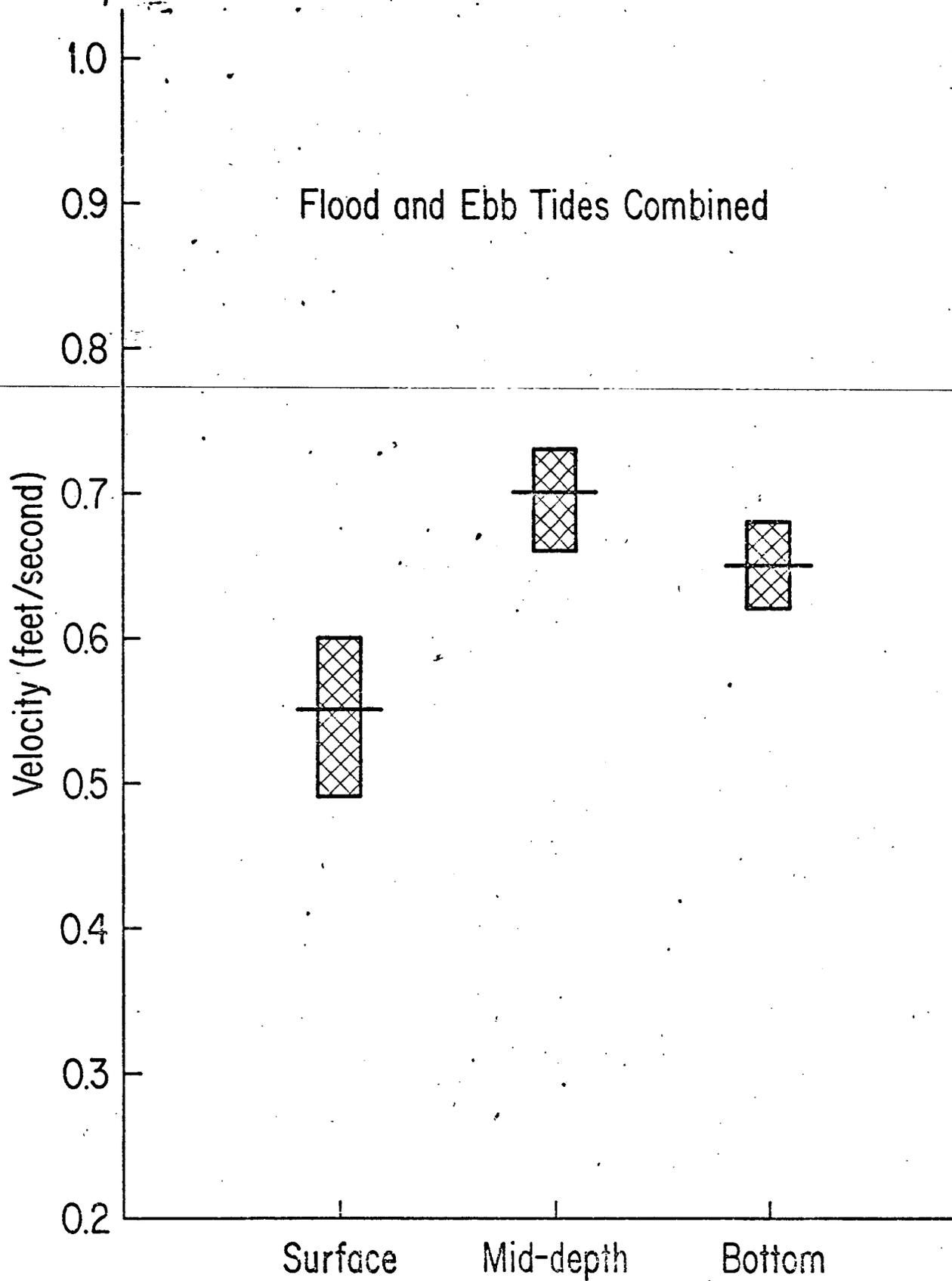


Figure 4. Mean velocity and 95% confidence interval recorded over all tidal stages at Indian Point.

RESULTS

I. Abundance of striped bass life-history stages from samples matched by date and station.

A. Temporal occurrence of developmental stages.

With the exception of intake samples collected during the daytime hours striped bass larvae were the most abundant life-history stage collected during 1973 (Table 3). Eggs and yolk-sac larvae were both present in samples from May 29 through June 26. Larvae were present from May 29 through July 24. Juveniles were recorded in samples from June 12 through August 21 (Table 3), but were not present in samples taken after that date.

B. Diel distribution of developmental stages among sampling locations.

Diel differences in abundance for earlier developmental stages (eggs, yolk-sac larvae) collected in the river were apparent only for yolk-sac larvae (Table 4) whose daytime abundance exceeded nighttime abundance by a factor of more than three. Eggs were more abundant in intake and discharge samples during the daytime than during the night by a factor of approximately 2 (Table 3).

Later developmental stages (larvae and juveniles), with the exception of juveniles from river stations, showed a greater abundance during the nighttime at all stations (Table 4).

A posteriori tests for discrimination of statistical differences among stations between day and night showed the early stages (eggs and yolk-sac larvae) were present in greatest abundance at the plant intakes during the daytime (Table 5) and that the greater abundance applied in all cases except day-

Table 3. Mean abundances, for day and night collections, in number/1000m³ and 95% confidence intervals, for four life history stages of striped bass. Samples were collected over time periods shown. N given beneath means indicate number of samples examined.

	River		Intakes		Discharge	
	Day	Night	Day	Night	Day	Night
Eggs	13±6	7±5	83±11	40±8	14±2	5±1
5/29-6/26	n=356	n=240	n=272	n=273	n=376	n=273
YSL	21±6	6±2	16±2	16±4	8±1	7±2
5/29-6/26	n=356	n=240	n=272	n=273	n=376	n=273
Larvae	141±23	182±35	40±3	122±26	85±10	127±19
5/29-7/24	n=561	n=383	n=463	n=485	n=662	n=476
Juveniles	1±1	1±1	1±0	31±6	11±4	38±6
6/12-8/21	n=289	n=203	n=340	n=384	n=545	n=377

Table 4. Differences between day and night abundances in log (catch + 1) of four life history stages of striped bass. Samples were collected over time periods shown.

	River	Intakes	Discharge
Eggs 5/29-6/26	none	D>N	D>N
YSL 5/29-6/26	D>N	none	none
Larvae 5/29-7/24	N>D	N>D	N>D
Juveniles 6/12-8/21	none	N>D	N>D

N = night

D = day

> = greater than

Table 5. Results of a posteriori test for discrimination of station differences during daytime and nighttime sampling at Indian Point. Stations included over a continuous line are not statistically different.

	DAY			NIGHT		
Eggs	<u>D</u>	<u>R</u>	<u>I</u>	<u>D</u>	<u>R</u>	<u>I</u>
YSL	<u>D</u>	<u>R</u>	<u>I</u>	<u>R</u>	<u>D</u>	<u>I</u>
Larvae	<u>I</u>	<u>D</u>	<u>R</u>	<u>I</u>	<u>D</u>	<u>R</u>
Juveniles	<u>R</u>	<u>I</u>	<u>D</u>	<u>R</u>	<u>I</u>	<u>D</u>

D = Discharge

R = River

I = Intake

time samples of yolk-sac larvae. The trend of abundance among stations for the two stages was identical in day samples (Table 5), but during night samples the trend between river and discharge was reversed.

Overall larval abundance was greatest in the river during both day and night. The fewest larvae were taken in intake samples. During the daytime, intake larval abundance was significantly less than in the discharge (Table 5).

C. Depth distribution by sampling location.

1. River

The distribution of developmental stages among depths reflected the increased motility of developing striped bass with age and suggested a tendency toward upward vertical migration during the nighttime hours. Calculated mean abundances for eggs showed greater numbers in bottom samples during the daytime (Table 6) and no definable trend toward greater abundance at any specific depth during the night (Table 7). The variability of the data, however, prevented statistical discrimination of any differences in distribution between day and night river samples (Tables 8 and 9).

Yolk-sac larvae, and larvae taken in daytime collections were clearly concentrated in the middle and bottom strata (Tables 6 and 8), whereas juvenile fish were most abundant in bottom waters during the daytime (Tables 6 and 8). Yolk-sac larvae and juveniles were not concentrated at specific depths

Table 6. Mean abundance and 95% confidence intervals by depth, for daytime collections in number/100m³, Determinations made for four life history stages of striped bass collected over the time periods shown. N given beneath means indicate number of samples examined. Note that confidence limits for are indential for depths in a given location since the confidence limit was calculated directly from the ANOVA table, and rounded to the nearest integer.

	Day								
	S	River		Intake			Discharge		
		M	B	S	M	B	S	M	B
Eggs 5/29-6/26	1±10 n=118	16±10 n=119	23±10 n=119	29±19 n=90	72±19 n=91	148±19 n=91	19±3 n=125	11±3 n=125	10±3 n=126
YSL 5/29-6/26	2±11 n=118	27±11 n=119	33±11 n=119	10±4 n=90	21±4 n=91	19±4 n=91	9±2 n=125	9±2 n=125	5±2 n=126
Larvae 5/29-7/24	1±40 n=189	229±41 n=183	197±40 n=189	13±6 n=152	49±5 n=157	59±5 n=154	16±18 n=223	85±18 n=221	154±18 n=218
Juveniles 6/12-8/21	0±1 n=99	1±1 n=92	3±1 n=98	0±1 n=111	2±1 n=116	2±1 n=113	1±7 n=184	9±7 n=182	24±7 n=179

S = surface

M = middle

B = bottom

Table 7. Mean abundance and 95% confidence intervals, by depth, for nighttime collections in numbers/1000m³. Determinations made for four life history stages of striped bass collected over the time periods shown. N given beneath means indicate number of samples examined.

	Nighttime								
	S	River M	B	S	Intake M	B	S	Discharge M	B
Eggs 5/29-6/26	1±8 n=80	11±8 n=80	9±8 n=80	41±13 n=91	31±13 n=91	47±13 n=91	10±2 n=93	4±2 n=90	3±2 n=90
YSL 5/29-6/26	3±4 n=80	5±4 n=80	10±4 n=80	18±7 n=91	20±7 n=91	8±7 n=91	10±3 n=93	7±3 n=90	5±3 n=90
Larvae 5/29-7/24	129±60 n=128	201±60 n=128	215±61 n=127	84±44 n=163	206±44 n=162	77±44 n=160	106±33 n=169	144±34 n=157	134±35 n=150
Juveniles 6/12-8/21	0±1 n=68	3±1 n=68	2±1 n=67	17±11 n=129	62±11 n=129	14±11 n=126	18±10 n=137	42±11 n=125	55±11 n=115

S = surface

M = middle

B = bottom

Table 8. Differences in daytime abundance among depths, in log (catch + 1) as determined for four life history stages of striped bass. Samples were collected over time periods shown.

Daytime

	River	Intakes	Discharge
Eggs 5/29-6/26	none	M>S B>S B>M	S>M S>B
YSL 5/29-6/26	M>S B>S	M>S B>S	S>B M>B
Larvae 5/29-7/24	M>S B>S	M>S B>S B>M	M>S B>S B>M
Juveniles 6/12-8/24	B>S B>M	M>S B>S	M>S B>S B>M

S = surface

M = middle

B = bottom

> = greater than

Table 9. Differences in nighttime abundance among depth, in log (catch + 1) as determined for four life history stages of striped bass. Samples were collected over time periods shown.

	Nighttime		
	River	Intakes	Discharge
Eggs 5/29-6/26	none	none	S>M S>B
YSL 5/29-6/26	none	M>B	none
Larvae 6/29-7/24	M>S B>S	M>S M>B	M>S
Juveniles 6/12-8/21	none	M>S M>B	M>S B>S

S = surface

M = middle

B = bottom

> = greater than

at night; larvae retained the same distribution relative to depth during the night as during the day (Tables 7 and 9).

2. Intake Stations

Daytime samples yielded a greater number of striped bass developmental stages in mid-depth and bottom samples than in surface samples (Tables 6 and 8). Nighttime sampling at the intake stations showed uniform distribution of eggs (Tables 7 and 9) and a greater abundance of yolk-sac larvae, larvae and juveniles in mid-water samples (Tables 7 and 9).

The depth distribution in discharge samples showed interesting results considering the thorough mixing applied to the cooling water during plant passage. Most eggs collected appeared in the surface samples (Tables 6-9). Yolk-sac larvae were more abundant in surface and mid-water samples during the day (Tables 6 and 8) but were uniformly distributed among depths at night (Tables 7 and 9). Later developmental stages (larvae and juveniles) were more abundant in bottom waters during the day (Tables 6 and 8) and in mid and bottom waters at night (Tables 7 and 9). Examination of depth abundance shows eggs and yolk-sac larvae in daytime discharge samples had a different depth-distribution than in the river and intakes, being more abundant in discharge surface waters than at river and intake stations. Larvae and juveniles retained the same, or similar, depth distribution in discharge samples as in river and intake samples. Except for eggs at discharge stations, nighttime sampling yielded more homogeneous distribution among all stations; however, the mid-water concentration of most developmental stages (Table 9),

particularly larvae and juveniles, was retained in nighttime discharge collections.

D. Distribution with sampling areas.

Analysis of data from individual stations (depth pooled for each station; Tables 10 and 11) suggested that station-to-station differences were due, at least in part, to the age of the population sampled. Except for the single instance wherein egg abundance at intake station I-2 was greater than I-1, the abundance of eggs and yolk-sac larvae within each segment of the sampling matrix (i.e. river, intake, discharge) was similar (Tables 12 and 13). Larval stages showed variable intra-segmental differences between daytime and nighttime collections (Tables 12 and 13); river stations differed among one another during the day but were similar at night. Station D-1 had more larvae than D-2 during the day and night, but intake stations differed only at night. A similarly variable pattern occurred for juveniles within segments between day and night, although the data were so few as to render the results less than representative (Tables 10 and 11).

II. Abundance of striped bass life-history stages from samples matched by date, station and time-of-collection.

A. Intake and River Stations

Imposition of the time-coincident criterion on samples for comparison resulted in an increase in the frequency of statistically significant differences between samples at all levels of comparison (compare, e.g. Tables 12 and 13 above with Table 16).

Table 10. Mean abundance and 95% confidence intervals, by station, for daytime collections. Abundances given as mean number/1000m³ of four life history stages of striped bass. Samples were collected over time periods shown. N given beneath each mean represents number of samples examined.

	Daytime							
	River				Intakes		Discharge	
	R-1	R-2	R-3	R-4	I-1	I-2	D-1	D-2
Eggs 5/29-6/26	12±12 n=90	17±12 n=90	10±12 n=89	14±12 n=87	77±13 n=185	97±20 n=87	14±2 n=189	13±2 n=187
YSL 5/29-6/26	14±12 n=90	21±12 n=90	20±12 n=89	28±13 n=87	18±3 n=185	13±4 n=87	8±1 n=189	7±1 n=187
Larvae 5/29-7/24	79±47 n=141	164±47 n=142	129±47 n=141	194±47 n=137	41±4 n=337	38±6 n=126	105±15 n=326	65±14 n=336
Juveniles 6/12-8/21	1±1 n=72	2±1 n=73	2±1 n=73	1±1 n=71	1±1 n=260	1±1 n=80	15±6 n=268	7±6 n=277

Table 11. Mean abundance and 95% confidence intervals, by station, for nighttime collections. Abundances given as mean number/1000m³ of four life history stages of striped bass. Samples were collected over time periods shown. N given beneath each mean represents number of samples examined.

	Nighttime							
	R-1	River R-2	R-3	R-4	Intakes I-1 I-2		Discharge D-1 D-2	
Eggs 5/29-6/26	8±9 n=60	1±9 n=60	10±9 n=60	10±9 n=60	40±10 n=148	40±11 n=125	6±2 n=137	5±2 n=136
YSL 5/29-6/26	4±4 n=60	8±4 n=60	5±4 n=60	7±4 n=60	18±6 n=148	12±6 n=125	8±2 n=137	6±2 n=136
Larvae 5/29-7/24	139±70 n=96	198±70 n=95	193±70 n=96	197±70 n=96	141±34 n=266	100±38 n=219	188±28 n=226	73±27 n=250
Juveniles 6/12-8/21	3±1 n=51	0±1 n=50	2±1 n=51	0±1 n=51	39±8 n=213	21±9 n=171	56±9 n=177	21±8 n=200

Table 12. Differences in daytime abundance among stations in log (catch + 1) as determined for four life history stages of striped bass. Samples were collected over time periods shown.

	Daytime		
	River	Intakes	Discharge
Eggs 5/29-6/26	none	I-2>I-1	none
YSL 5/29-6/26	none	none	none
Larvae 5/29-7/24	R-2>R-1 R-4>R-1	none	D-1>D-2
Juveniles 6/12-8/21	none	none	D-1>D-2

> = greater than

Table 13. Differences in nighttime abundance among stations in log (catch + 1) as determined for four life history stages of striped bass. Samples were collected over time periods shown.

	Nighttime		
	River	Intakes	Discharge
Eggs 5/29-6/26	none	none	none
YSL 5/29-6/26	none	none	none
Larvae 5/29-6/26	none	I-1>I-2	D-1>D-2
Juveniles 5/29-6/26	R-1>R-4	I-1>I-2	D-1>D-2

> = greater than

Eggs were more abundant during the day than during the night at both intake stations (Table 4, 14, 15) and were present in consistently greater abundances at Station I-1 than at I-2. Egg abundances at night were similar for both intake stations (Table 16).

Yolk-sac larvae, larvae and juveniles were either equally abundant between day and night, or more abundant at night (Table 4). Except for juvenile fish which were caught in very ~~low numbers during the daytime~~, abundances of all stages older than the egg were greater at I-1 than I-2 (Table 16). Numerical differences for calculated abundances at the two intake stations were relatively small (less than a factor of 1.5 in all but one case); however, the very small confidence limits associated with time-matched samples enabled a fine discrimination of differences (Tables 14 and 15).

Comparisons between pooled river samples and samples for individual intake stations (Tables 17 and 18) yielded consistent results for eggs and yolk-sac larvae; egg abundance was greater at intakes than in river samples. Yolk-sac larvae were present in river and intake samples in approximately the same concentrations during the night and day, although yolk-sac larvae were more abundant at station I-1 than at I-2 (Tables 16, 19, 20). Larvae were more abundant in the river than at I-1 in the daytime (Table 19) and more abundant in the river than at I-2 at night (Table 20). Juveniles were present in numbers too low for meaningful comparison during the daytime hours (Tables 17 and 18) but were more abundant in the intakes than the river stations at night (Tables 19 and 20).

Table 14. Mean abundance and 95% confidence intervals calculated for intake stations I-1 and I-2. Samples used in calculations were collected during daytime sampling and were matched by station, date and time. Abundances given in terms of number of the various life history stages of striped bass/1000m³. Samples were collected over time periods shown. N given beneath the mean represents the number of samples examined.

	Day	
	I-1	I-2
Eggs 5/8-6/12	138±21 n=177	102±21 n=177
YSL 5/8-6/19	18±3 n=189	13±3 n=189
Larvae 5/15-7/24	33±4 n=205	23±4 n=205
Juveniles 6/12-8/7	1±1 n=52	1±1 n=52

Table 15. Mean abundance and 95% confidence intervals calculated for intake stations I-1 and I-2. Samples used in calculations were collected during nighttime sampling and were matched by station, date and time. Abundances given in terms of number of the various life history stages of striped bass/1000m³. Samples were collected over time periods shown. N given beneath the mean represents the number of samples examined.

Nighttime

	I-1	I-2
Eggs 5/8-6/12	101±15 n=154	80±15 n=154
YSL 5/8-6/19	23±5 n=177	15±5 n=177
Larvae 5/15-7/24	118±31 n=275	78±31 n=275
Juveniles 6/12-8/7	44±10 n=169	21±10 n=169

Table 16. Comparison of abundances of the various life history stages of striped bass found in matched samples collected at intake stations I-1 and I-2.

	Day	Night
Eggs 5/8-6/12	I-1>I-2	none
YSL 5/8-6/19	I-1>I-2	I-1>I-2
Larvae 5/15-7/24	I-1>I-2	I-1>I-2
Juveniles 6/12-8/7	none	I-1>I-2

> = greater than

Table 17. Mean abundance and 95% confidence intervals for samples collected during the day and night from the river stations and intake station I-1. Samples matched by station, date and time. N given beneath each mean represents the number of samples examined.

	River		I-1	
	Day	Night	Day	Night
Eggs 5/29-6/12	26±12 n=176	14±9 n=120	153±29 n=90	66±19 n=59
YSL 5/29-6/26	20±6 n=344	6±2 n=240	17±3 n=174	10±6 n=118
Larvae 5/29-7/24	134±23 n=549	182±35 n=383	44±3 n=314	167±43 n=224
Juveniles 6/12-8/21	1±1 n=289	1±1 n=203	1±1 n=242	41±12 n=201

Table 18. Mean abundance and 95% confidence intervals for samples collected during the day and night from river stations and intake station I-2. Samples matched by station, date, and time. N given beneath each mean represents the number of samples examined. N beneath each mean represents number of samples examined.

	River		I-2	
	Day	Night	Day	Night
Eggs 5/29-6/12	32±15 n=141	16±10 n=108	120±22 n=70	39±26 n=54
YSL 5/29-6/26	31±13 n=177	5±2 n=204	13±3 n=87	1±1 n=100
Larvae 5/29-7/24	47±10 n=236	163±23 n=323	40±8 n=120	114±42 n=188
Juveniles 6/12-8/21	1±1 n=71	1±1 n=167	1±1 n=74	21±3 n=164

Table 19. Comparison of abundances based on matched samples collected from the river and intake stations I-1.

	Day	Night
Eggs 5/29-6/12	I-1>R	I-1>R
YSL 5/29-6/26	none	none
Larvae 5/29-7/24	R>I-1	none
Juveniles 6/12-8/21	none	I-1>R

> = greater than

Table 20. Comparison of abundances based on matched samples collected from the river and intake station I-2.

	Day	Night
Eggs 5/29-6/12	I-2>R	I-2>R
YSL 6/29-6/26	none	none
Larvae 5/29-7/24	none	R>I-2
Juveniles 6/12-8/21	none	I-2>R

DISCUSSION

The 1973 year-class of Hudson River striped bass first appeared in late April and early May at upriver stations (Kingston-Catskill; T.I., 1975). The first indications of spawning in the vicinity of Indian Point were detected between 6 and 12 May (LMS, 1974a, b; T.I., 1975; NYU, 1974). The single peak of spawning activity in 1973 which occurred between 13 and 19 May, 1973 (T.I., 1975) had two loci; the Hyde Park/Kingston area (~~River miles 82-92~~) and between Indian Point and Storm King Mountain (RM 42-60; T.I., 1975). This report constitutes an analysis of abundance and distribution of 1973 year class striped bass at Indian Point from 29 May through 21 August, a time interval which did not include the majority of spawning in that area, but did include those dates identified by New York University (1974), Texas Instruments (1975) and LMS Engineers (1974a, b) as the period of peak abundance for yolk-sac larvae, larval and juveniles striped bass of the 1973 year class.

The developmental stage collected in greatest numbers at the Indian Point Power Plant and at nearby river stations was the larval stage, operationally defined as that stage from the time of yolk-sac absorption (\sim 5 days after hatching) until approximately one inch (25.4 mm) in length. Yolk-sac larvae were collected in fewest numbers and comprised the least abundant life-history stage on a catch-per-unit-effort basis.

River collections of striped bass eggs showed a homogeneous depth distribution, fully consistent with the behavior of a particle of slightly less than neutral buoyancy (Albrecht, 1964)

in a fully mixed estuarine system (Abood, 1974; Pritchard, 1955). The homogeneous depth-distribution of striped bass eggs was apparent during the day as well as during the night; however, the egg stage was no more abundant during the daytime than during the night in the river. Given the relatively short stage duration of the striped bass eggs at temperatures experienced in the Hudson River during late May ($\sim 14-16^{\circ}\text{C}$; stage duration 1.5-2 days), analysis of the embryonic development of eggs collected on a given date may shed considerable light on the temporal aspects of striped bass spawning. These analyses were not conducted in 1973.

Striped bass eggs were found to be more abundant in the Indian Point intake samples than in the river and discharge samples. Eggs were more abundant in the bottom samples during the daytime and homogeneously distributed throughout the water column at night. Samples taken at both intake stations showed a greater abundance of eggs than in the river, although the catch per unit effort at I-1 was greater than at Unit 2.

The differences in egg abundances between river and intake samples lead to more than one conclusion. One may conclude that eggs are more abundant at the plant intake than elsewhere in the river, or one may conclude that flow conditions at the plant intake lead to a selective concentration of eggs at the intakes.

Alternatively, one may conclude that the intake stations are sampling more efficiently than the towed nets in the river. To justify this conclusion, one must assume that intake stations are sampling portions of a water mass not sampled by towed

nets: one in which eggs may be more abundant than elsewhere.

Results from samples taken in 1973 in the vicinity of Indian Point (NYU, 1974) and in the vicinity of the Lovett and Bowline generating stations (LMS, 1974b) indicate no horizontal differences in river larvae abundance. The abundance of larvae at the Lovett Plant intake (LMS, 1974b) exceeded those at LMS' "Lovett West" station (immediately in front of the intake). Sufficient differences exist between the two plants to hypothesize that similar "concentrating" phenomena would not occur at the Lovett and Indian Point stations. However, the sampling devices employed at the two stations, though not identical, share the characteristic of fixed placement in the cooling water flow and the possibility of sampling strata not sampled by towed nets. For example, due to the constraint of variable depth and uneven bottom contours, a towed net cannot sample practically closer than within one to two feet of the bottom. To do otherwise results in damaged gear and lost samples. The bottom layers which are sampled at the plant are not sampled well by a net towed in the river. It is essential, therefore, that efficient sampling of the bottom stratum in the river be carried out, particularly within a few inches of the mud-water interface, to make better estimates of the impact of power stations on the striped bass egg stage.

Fewest eggs were collected in the discharge samples; those eggs collected in the discharge were most abundant in the surface waters despite the mixing applied to the cooling water supply during passage through the plant. Due to the location of

the intake sampling stations in the intake forebay, one would assume that the concentration of eggs in the discharge would be equivalent to that in the intake providing no removal or destruction of eggs occurred during plant passage, and providing the sampling gear at both locations is equally efficient in capturing and retaining eggs.

Intake and discharge sampling gear identical to that used at Indian Point in 1973 has been tested for retention efficiency of egg and larval stages at the Con Edison experimental flume in Holden, Massachusetts. These tests showed that net-retention of eggs at velocities encountered in the intakes and discharge canals was similar. No tests have been conducted to determine sampling efficiency of the net; however, discharge sampling in 1973 included two stations (D-1, D-2, Figure 2) which showed no differences in egg abundance between them, indicating a consistency of sampling efficiency in the discharge and, by association and similarity of technique, with the intake.

The differences in egg abundance between river and intakes may be an artifact associated with sampling technique and that the intake sampling nets are more efficient in sampling the egg stage due to their fixed position in the cooling water flow and access to water strata not sampled by towed nets.

Yolk-sac larvae were more abundant in daytime river samples than at night. During the daytime the yolk-sac stage was most abundant in bottom and mid-depth strata but was homogeneously distributed at night suggesting a nocturnal upward migration at night. The abundance of yolk-sac larvae was similar among river

stations during the day and night.

Plant intake stations, although sampling from a homogeneous population, showed differences in abundance between I-1 and I-2, station I-1 being consistently greater than I-2. This is probably due to the fact that intake samples were simultaneous. The smaller variance component in intake samples (generally less than 50% of the mean) allowed discrimination of statistical differences between stations at levels of numerical difference which if used in comparing intake vs river, would indicate a homogeneous distribution.

Yolk-sac larvae were more abundant in the intakes than in the discharge canal during the day and night. For precisely the same reasons cited above for the egg stage we conclude that the decreased abundance of yolk-sac larvae is not due to disruption and destruction of the organism during plant passage.

Striped bass larvae were collected in greatest abundance during the nighttime and showed sufficient variation in depth-distribution between the day and night to be considered as a species which undertakes a substantial vertical migration from deeper waters during the daytime to mid-depth and surface waters at night.

The abundance of larvae in river samples was greater than at either the plant intakes or in the plant discharge canal. In the discharge canal the abundance of larvae decreased from D-1 to D-2 (i.e. in a downstream direction) but remained greater than the intake abundance of the same life-history stage.

The inconsistencies in mass balance observed between the intakes and discharge canal stations may be due to several factors. A decreased abundance in the discharge canal as compared to the intakes may be explained by a "destruction factor" on the part of the power plant accounting for the differences observed. It is more difficult to accept an increased abundance in the discharge canal when compared to the intakes.

During the study period covered by this report intake samples were collected from two of four Unit 1 intake forebays. In addition, for most of the study period various of the six Unit 2 circulators were operational. Therefore, at times samples were being collected from 2 of 10 potential sampling stations. When comparisons are made between the two sampling stations utilized, statistically significant differences in abundances of various of the life history stages were detected. With a potential of 10 intake sampling stations all pumping water to a common discharge canal, one might easily account for the observed differences in mass balance since the density of organisms may differ among intake stations. While statistical differences were detected between the intake stations for some of the life history stages it is also important to consider whether or not differences such as 118 ± 31 compared to 78 ± 31 , found to be statistically significant (Table 15, larvae) are, in fact, of practical significance in terms of the overall analyses.

Another hypothesis which can be proposed to account for the differences in mass balance observed between the intakes and discharge canal is one of differential avoidance of the sampling gear between the two sampling regions.

Juvenile striped bass showed differences in distribution by station, depth and time of day. Whether these data are of significance in an evaluation of power plant impact on the Hudson River bass population remains an important question. The quantities of juveniles collected at all stations are well below the levels of abundance one would expect, even after imposing rates of natural mortality on the population (see e.g. Lawler, 1974; LMS, 1975). Recent fisheries survey data from ~~Texas Instruments (1974, 1975)~~ as well as population studies (Raney, 1952; Merriman, 1941) indicate that prior to and during the metamorphosis of striped bass from a larval (i.e. embryonic) organism to the juvenile form there is expressed a preference for shoal areas. While shoal areas are abundant in the lower Hudson, river morphology is such that the immediate vicinity of Indian Point contains none. Thus, assuming the "shoaling" preference of striped bass, one would be forced to accept an immigration from the plant area of juvenile life-history stages which, simultaneously, would reduce the statistical validity of conclusions drawn from the available data, and the likelihood of significant numbers of juveniles being affected by the plant.

The results and conclusions contained in this report, based upon a single season's sampling of striped bass life history stages, cannot provide an estimate of real or potential impact of the Indian Point Power Station on Hudson River striped bass. The information herein, by inclusion in models designed to provide such estimates, serve to increase the data base required for more refined model estimates.

Some aspects of striped bass life-history may be stated which affect the procedures employed in estimating power plant impact:

1. The periodicity of striped bass reproductive events.

Natural history data indicate that the reproductive behavior of striped bass is a phenomenon controlled by environmental cues, such as temperature, photo-period and tidal phenomena. The spawning act, never observed in Hudson River bass, would appear to be confined in time and space, often being concentrated at one or two loci on the river (T.I., 1975) and often producing large quantities of eggs of a narrow agespread.

This periodicity results in the patchy distribution of striped-bass early life-history stages in the river, a distribution capable of yielding samples on an hour-by-hour basis which vary from 0 eggs or yolk-sac larvae one hour to more than 1000/1000m³ the next.

2. Vertical distribution of striped bass developmental stages.

The available data on striped bass egg and yolk-sac larval distributions in the river and at power plant intakes demonstrates clearly that intake sampling, especially of eggs, is more productive on the basis of catch per unit effort, than river sampling. Interestingly, river collections by different workers

in nearby sections of the river often yield data which agree quite well with one another. Intake data, however rarely agree well, on a sample-by-sample basis, with river collections (NYU, 1974; LMS, 1974a). Intake data represent an estimate of egg abundance essentially unobtainable by towed nets, due primarily to the fixed geometry of the intake structure and the necessity for towed nets to sample no closer to the bottom than 1-2 feet. Recent data relevant to this point were obtained by New York University personnel in Sterling Lake, Orange County, New York. In an attempt to define precisely the distance above the mud-water interface at which river sampling year sampled, divers observed and photographed ichthyoplankton gear in normal field operation. Bottom nets were observed to fish approximately two feet from the bottom, and maintained precisely at the calculated altitude and pitch for proper sampling. Sled mounted gear (T.I., 1974, 1975) fished within 12 inches of the bottom, as defined by the rigid structure of the sampling sled.

Part II

Larval Striped Bass (Morone saxatilis)
Length Frequency AnalysisNew York University
October, 1974

During the 1973 striped bass entrainment season at Consolidated Edison's Indian Point generating facility on the Hudson River, New York University undertook an intensive near-field and in-plant sampling program. The details concerning sampling procedure and station locations are presented in sections 7.1 and 7.2 of New York Universities progress report for 1973 entitled, "Effects of Entrainment by the Indian Point Power Plant on Biota in the Hudson River Estuary".

As a part of the overall analysis of the data collected for this program the total length of each larval stage of striped bass collected was determined. Some specimens, too badly damaged or bent to accurately measure were not analyzed. Measurements were made to the nearest millimeter for each specimen analyzed. Measurements of larvae of approximately 10 mm or less were made using an ocular micrometer while those larvae of approximately 10 mm or larger were measured using metric rules. The larvae collected from the three major collection regions (river, intakes, and discharge canal) were measured separately.

A total of 64,806 measurements were made. Of these 14,104 were for specimens collected from the river; 8,683 were from the intakes; and 42,019 were from the discharge canal. The specimens measured from the river samples were collected between May 29 and July 24, 1973. The specimens measured from the intake and discharge canal samples were collected between May 15, and July 24, 1973.

The data relating to these length measurements are summarized in Table 23. The largest larval specimens collected from the river and intake samples were 43 mm in total length. The largest specimen collected from the discharge canal was 40 mm in total length. However, the numbers of the larger larvae collected from any region was small. Data on the length distribution of striped bass impinged on Indian Point units 1,2, and 3 intake screens indicate that during July and August of 1973 the smallest impinged striped bass were 40 mm and less in total length (Texas Instruments, Inc., 1974). These data indicate an overlap in length of the smaller impinged and larger entrained striped bass.

For those dates between 6/5 and 7/3 there were at least 100 larvae measured from each of the three regions. During this time period the modal length based on the percent of the totals of striped bass collected from the intake and discharge canal respectively, were essentially similar, while the modal length based on the percent of the total striped bass from the river was 1-3 mm smaller than modes for the intake and discharge collections for 4 of the 5 collection dates.

In the 1971-72 New York University Progress Report we reported that during 1972 the mean length of striped bass larvae collected from the intakes was 9.5 mm based on measurements of 253 specimens. The mean length of striped bass larvae collected from the intakes during the 1973 sampling season was 9.3 mm. We also reported that during 1972 that the mean length of striped bass larvae collected from the discharge canal was 10.4 mm, based on the measurements of 152 specimens. The mean total length of

Table 21

LARVAL STRIPED BASS LENGTH FREQUENCY

Date	RIVER				INTAKES				DISCHARGE			
	Mean (mm)	Mode* (mm)	Range (mm)	N**	Mean (mm)	Mode* (mm)	Range (mm)	N**	Mean (mm)	Mode* (mm)	Range (mm)	N**
5/15	-	-	-	-	4	4	2,7	456	4	4	2,6	165
5/22	-	-	-	-	5	6	3,7	31	6	5	2,18	74
5/29	7	7	2,10	177	4	3	3,10	33	5	6	2,8	17
6/5	5	5	2,8	403	4	4	2,8	731	4	4	2,10	1302
6/12	6	6	2,10	6277	6	7	2,8	855	7	7	2,13	1246
6/10	7	6	3,13	4802	8	8	3,20	2380	9	8,9	3,18	12741
6/26	8	8	4,17	2152	11	10	3,21	3622	11	10	3,25	22735
7/3	9	7	5,22	219	14	10	6,25	323	13	11,12	5,29	2499
7/10	15	10	8,30	45	21	25	7,34	145	17	10,11	5,37	862
7/17	11	10	6,28	18	17	11	7,41	69	14	12	7,38	332
7/24	28	34	10,43	11	25	33	10,43	38	15	12	7,40	46

* Mode of distribution based on percent of total catch for each date.

** The sample sizes given for each sample region should not be interpreted as a reflection of abundance because of variations in effort between regions.

larvae collected from the discharge canal during 1973 was 10.2 mm.

In addition, we reported that during the 1972 sampling season the longest striped bass collected in the intake and discharge canal samples was 10 mm in total length. The longest striped bass collected in river plankton collections in 1972 was 20 mm. As stated previously the longest striped bass larvae collected from the river and intake samples in 1973 was 43 mm in total length.

Since the same collection equipment was used during both 1972 and 1973 the occurrence of the larger fish in 1973 samples would appear to reflect their presence at Indian Point in 1973 in contrast to their absence in 1972.

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