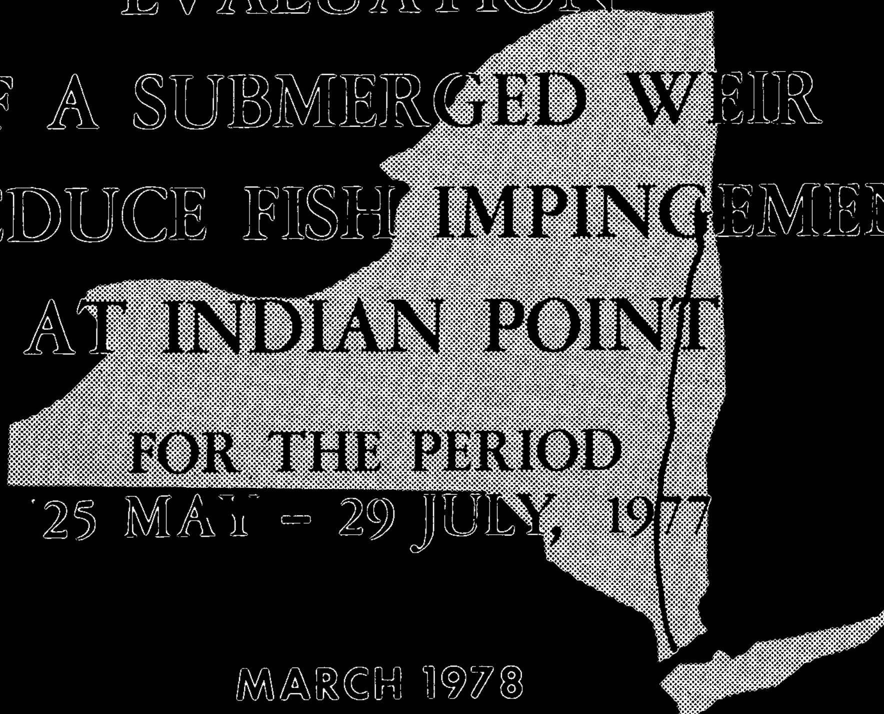
EVALUATION OF A SUBMERGED WEIR TO REDUCE FISH IMPINGEMENT AT INDIAN POINT

FOR THE PERIOD 25 MAY – 29 JULY, 1977



MARCH 1978

Prepared for

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New York, New York 10003

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SECTION I
INTRODUCTION

Impingement of fish at power plant intakes is often an unavoidable consequence of withdrawals of large volumes of water from cooling water sources. Frequently, the magnitude of the impingement problem can be reduced by careful design of intake structures and judicious selection of intake location (USEPA, 1973). Installation of various diversionary devices functioning as physical barriers or by influencing fish behavior has been found to further reduce impingement under certain conditions. Techniques have also been developed which allow fish to be recovered from intake screens and returned to the water source unharmed (TI, 1974; Stone and Webster, 1975; White and Brehmer, 1976; Tomljanovich, Heuer and Voigtlander, 1977).

Means of minimizing the number of fish killed by impingement at the Indian Point nuclear generating station have been sought since shortly after Unit 1 began operation in 1962. The techniques employed and an evaluation of their merits have been reported by Consolidated Edison (1973) and summarized by the United States Nuclear Regulatory Commission (1975). In spite of efforts which have included modifications of screen design and location, modifications of depth and velocity of water withdrawal, reduction of flow volume during periods when water temperature is less than 4.4°C and installation of air curtains, impingement has continued to be a source of concern.

Restricting water withdrawal to selected zones of the water column has been suggested as a means of reducing impingement rates at power plants where fish particularly subject to impingement are found to be concentrated at a specific depth (Long, 1968; Fairbanks, Collings and Sides, 1971; Stone and Webster, 1975). Results of impingement monitoring programs conducted at Indian Point have indicated that certain demersal fish, particularly the Atlantic tomcod *(Microgadus tomcod)*, contribute heavily to the total number of fish killed annually by impingement (TI, 1974; 1975; 1976). It appeared that impingement of these and other fishes found on or near the bottom might be reduced by restricting the withdrawal of cooling water to the upper strata of the Hudson River.

In order to test this hypothesis, submerged weirs, which limited cooling water withdrawal from directly in front of the intakes to the upper strata of the water column, were installed at Unit 1 and their effects on impingement were monitored during a two-month period in 1977.

SECTION II
METHODS AND MATERIALS

A. INDIAN POINT NUCLEAR PLANT

The Indian Point plant is located on the east bank of the Hudson River estuary at river kilometer (km) 68 (RM 42.5) near Peekskill, New York. The plant (Figure II-1) consists of three nuclear reactors (Units 1, 2, and 3) and associated apparatus for power generation and water circulation. The respective licensed generating capabilities for Units 1*, 2, and 3 are 265 Mw (electric), 873 Mw (electric), and 1033 Mw (electric). All three units have a combined water pumping capacity of 7790 m^3/min (2,058,000 gpm). Unit 1 has two 530 m^3/min (140,000 gpm) circulating pumps, each drawing water through two intake bays. Three service pumps with a combined capacity of 72 m^3/min (19,000 gpm) draw water from each circulator forebay. Units 2 and 3 each have six circulator pumps with individual capacities of 530 m^3/min (140,000 gpm) which draw water from separate intake bays. Both Units 2 and 3 have service water pumps with a total unit capacity of 114 m^3/min (30,000 gpm) which draw through separate service water bays located in the middle of the intake structure for each unit. Units 1 and 2 have fixed screens at the entrance to the intake bays and vertical traveling screens at the back of the bays immediately in front of the pumps. Unit 3 has only vertical traveling screens at the back of the intake bays (Figure II-1). All screens are constructed of 9.5 mm (0.375 in.) square mesh.

B. STUDY DESIGN

The effects of bottom weirs on fish impingement at the Indian Point intakes were investigated at Unit 1 from 25 May through 29 July 1977 by comparing the numbers and kinds of fish impinged on days when weirs were in place with those impinged when fixed screens were in place. Unit 1 was suitable for this study since it was off line and intake structures and circulator flows could be manipulated without influencing power generation of the Indian Point station.

*Unit 1 is presently not operational for commercial power production.

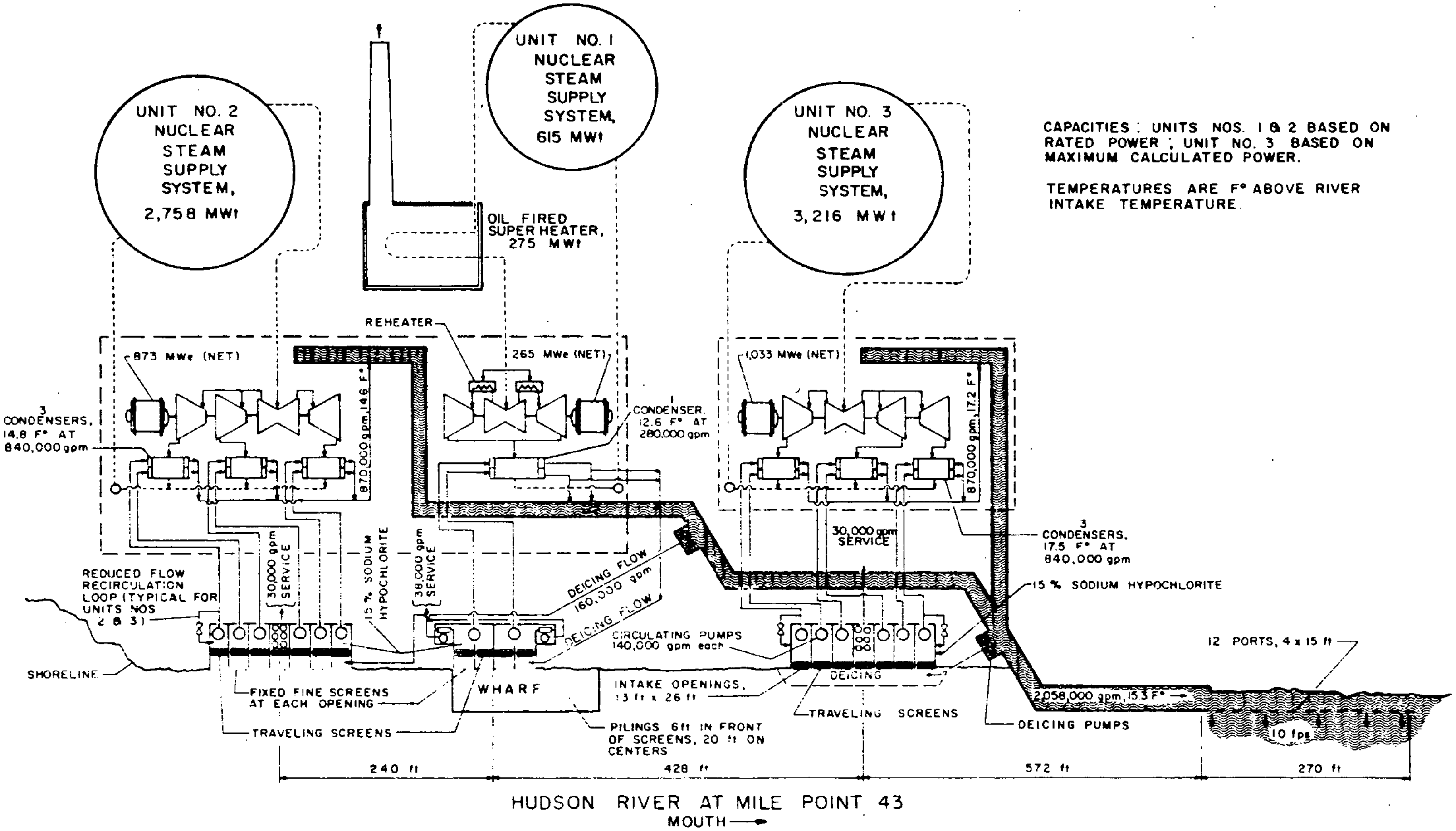

Figure II-1. Indian Point Plant Layout. (Courtesy of Consolidated Edison Company of New York)

Weirs designed and constructed by Consolidated Edison were installed at the entrances to two of the four intake forebays at Unit 1 (forebays 13 and 14) (Figure II-2). During normal operation, these positions had been occupied by fixed screens which completely covered each forebay entrance. Weirs were constructed on fixed screen frames measuring 7.9 m (26 ft) high and 3.5 m (11.5 ft) wide. All screen sections were removed from the frames and the lower half of each frame (3.9 m [13 ft]) was covered with sheet metal. Each frame with an attached weir was constructed so that it could be lowered into position at the forebay entrance and raised completely from the water with a crane. When lowered into the water, the weir restricted intake flows to the upper half of the forebay entrance (Figure II-3).

Fixed screens of 9.5 mm (0.375 in.) mesh were similarly rigged in slots approximately 2 m (6 ft) behind the weirs in forebays 13 and 14 (Figure II-2). When the fixed screens were in the down position, they completely blocked the passage of screenable organisms and debris.

Tests of weir efficiency in reducing impingement were conducted in a series of 6-day cycles. For the first 3 days of a cycle, impingement of fish on the fixed screens was monitored. The fixed screens were lowered into place after the weirs had been raised and blocked into position above the water. On each day of this 3-day period, fixed screens were raised from the water and washed at about 1030. Fish and debris accumulated since the previous wash were dislodged by washing with a high pressure hose. Material freed from the fixed screens in this fashion was carried by the intake flow to the back of the forebays where it was collected from traveling screens. Following the washing procedure on each of the first two days, the fixed screens were again lowered into position. At the end of the collection procedure on the third day, the fixed screens were blocked in the up position and the weirs lowered into position in front of them. On each of the next 3 days (days 4, 5, and 6 of the cycle), the traveling screens were rotated at about 1030 and fish and debris that had accumulated were collected as before. Materials collected represented those carried through the upper uncovered half of the weir frames and through the forebay.

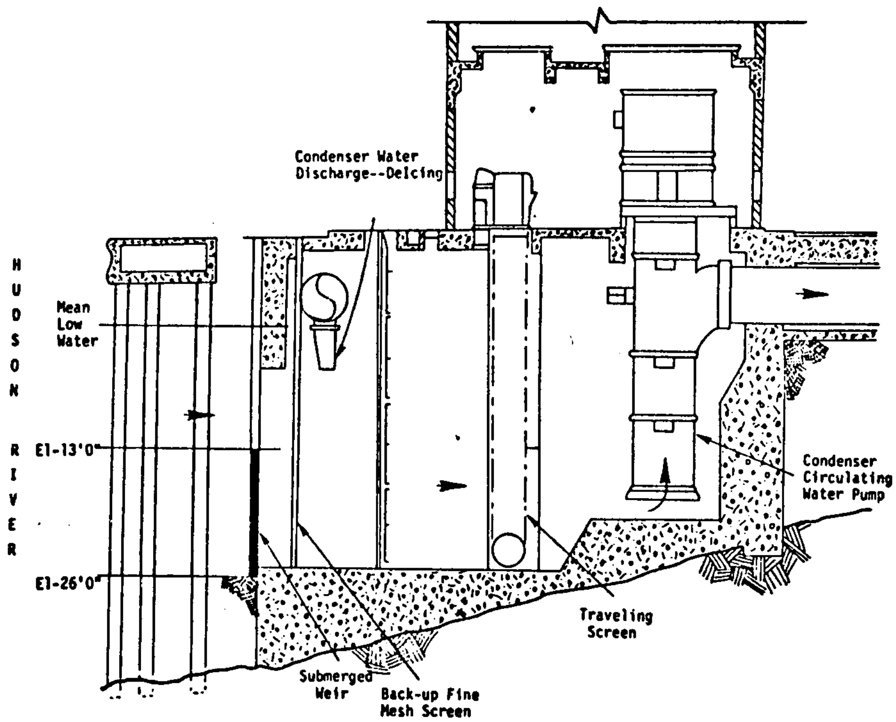

Figure II-2. Cross Section of Unit 1 Forebay with Submerged Weir and Back-up Fine Mesh Screen

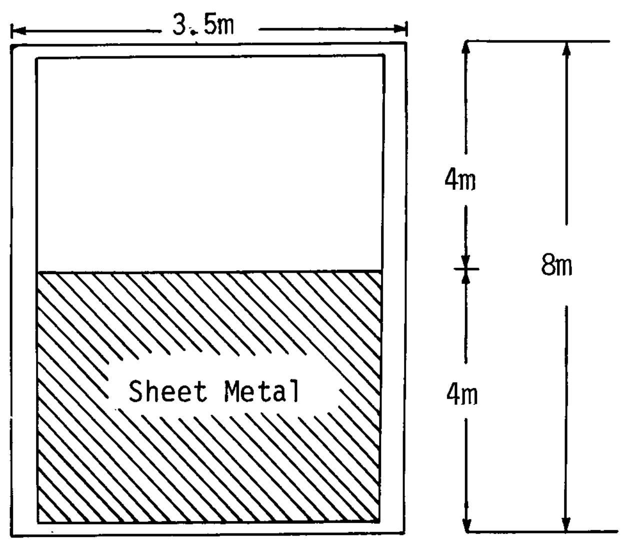

Figure II-3. Details of Submerged Weir Construction

After completing the collection from the traveling screens on the 6th day (3rd day with the weir in place), the weirs were raised from the water and blocked, and the fixed screens were again lowered. This sequence of 3 days of operation with fixed screens in place followed by 3 days with the weirs in place was followed over a 66-day period and was designed to provide collection data for 33 days in each mode (i.e., screen-in and weir-in). However, sampling problems encountered on 6 and 7 June when the screens were in place resulted in only 31 days from which data were suitable for analysis for the screen-in mode.

Following collection of fish and debris from the traveling screens, fish were separated from debris and returned to the laboratory for identification and enumeration. Fish from intakes 13 and 14 were combined during the collection process. All the fish that were collected were counted. Since the single circulating pump drawing water through intakes 13 and 14 was operated continuously at 80% of capacity (maximum flow is 530 m^3min), flow volumes were assumed to be approximately the same for all days. Therefore, daily fish counts were compared directly rather than first calculating impingement rates, i.e., number of fish collected/volume of flow.

Total counts and counts of each species collected during the days on which the weirs were in place were compared with similar counts made on days when the fixed screens were in place using a 2-tailed Mann-Whitney U-test at an alpha level of 0.05. The null hypothesis (H_0) tested was that the number of fish impinged with the weirs in place did not differ from the number impinged with the fixed screens in place. The alternative to the null hypothesis is that impingement may be decreased with the weirs in place.

SECTION III
RESULTS

A total of 17,210 fish were collected from the traveling screens at intakes 13 and 14 on 64 test days; 7340 (222.4/day) were collected on 33 days of weir operation and 9870 (318.4/day) on 31 days of fixed screen operation (Table III-1 and Appendix A). Of 26 species identified, 17 were collected during both operating modes; 8 species occurred only in collections made with the weirs in place, and 1 species occurred only while the fixed screens were in place (Table III-1). None of the species which occurred during only one operating mode was represented by more than two individuals. In addition to the 26 species identified, small numbers of very young centrarchids, clupeids, and larvae of the genus *Morone* were collected, but could not be identified to species (Table III-1).

Collections from both operating modes were dominated by Atlantic tomcod; they made up 47% of the fish collected with the weirs in place and 49% of the collections with the screens in place. Atlantic tomcod, bay anchovy *(Anchoa mitchilli)*, white perch *(Morone americana)*, and bluefish *(Pomatomus saltatrix)* accounted for more than 80% of all the fish collected during both operating modes. Other species occurred in limited numbers and individually comprised less than 2% of the total collections.

Although the total number of fish collected (9870) and the average number collected daily (318.4) were greater during screen-in operation than during the weir-in mode (total collection 7340; average daily collection 222.4), the difference in average daily collection was not statistically significant at an α level of 0.05 (Table III-2). Of the 17 species collected during both modes of operation, nine were collected at a greater daily rate during screen-in operation and seven at a greater rate during the weir-in mode. Most species differences were small and none was significant (α = 0.05). The only significant difference encountered was a greater daily catch of unidentified clupeids from collections made with the weir in place (Table III-2).

Most of the differences in total fish collected and average daily rates for all species between the two operating modes can be attributed to the lower numbers of Atlantic tomcod, bay anchovy, and bluefish which were collected during the weir-in operation. The magnitude of the difference in total numbers of fish collected between the two operating modes was less than 100 for all other species except the white perch. More white perch were collected during weir-in operation (Table III-1), but the difference was not significant (Table III-2). Although more striped bass were collected during the weir-in operating mode, the total in both cases was small (29 during weir-in mode; 17 during screen-in mode).

Table III-1

Taxon List of Fish Collected during Submerged Weir Study (Total number, percent of total and mean daily catch are listed for species in each mode of operation)

		Weir Operation (33 days)			Fixed Screen Operation (31 days)		
		No.	%	$\bar{X}$	No.	%	$\bar{X}$
Atlantic tomcod	*Microgadus tomcod*	3456	47	104.73	4880	49	157.42
Bay anchovy	*Anchoa mitchilli*	1115	15	33.79	1780	18	57.42
White perch	*Morone americana*	825	11	25.00	641	6	20.68
Bluefish	*Pomatomus saltatrix*	754	10	22.85	1399	14	45.13
Rainbow smelt	*Osmerus mordax*	407	6	12.33	468	5	15.10
Alewife	*Alosa pseudoharengus*	288	4	8.73	363	4	11.71
Blueback herring	*Alosa aestivalis*	184	3	5.58	136	1	4.39
American eel	*Anquilla rostrata*	84	1	2.55	55	1	1.77
American shad	*Alosa sapidissima*	50	1	1.52	49	<1	1.58
Atlantic menhaden	*Brevoortia tyrannus*	33	<1	1.00	10	<1	0.32
Striped bass	*Morone saxatilis*	29	<1	0.88	17	<1	0.55
Pumpkinseed	*Lepomis gibbosus*	20	<1	0.61	20	<1	0.65
Redbreast sunfish	*Lepomis auritus*	7	<1	0.21	1	<1	0.03
White catfish	*Ictalurus catus*	5	<1	0.15	7	<1	0.23
Spottail shiner	*Notropis hudsonius*	5	<1	0.15	4	<1	0.13
Hogchoker	*Trinectes maculatus*	3	<1	0.09	6	<1	0.19
Rough silverside	*Membras martinica*	2	<1	0.06	0	0	0
Yellow perch	*Perca flavescens*	2	<1	0.06	0	0	0
Banded killifish	*Fundulus diaphanus*	1	<1	0.03	1	<1	0.03
Atlantic needlefish	*Strongylura marina*	1	<1	0.03	0	0	0
Golden shiner	*Notemigonus crysoleucas*	1	<1	0.03	0	0	0
Goldfish	*Carassius auratus*	1	<1	0.03	0	0	0
Northern hogsucker	*Hypentelium nigricans*	1	<1	0.03	0	0	0
Spot	*Leiostomus chrysops*	1	<1	0.03	0	0	0
Winter flounder	*Pseudopleuronectes americanus*	1	<1	0.03	0	0	0
Tidewater silverside	*Menidia beryllina*	0	0	0	1	<1	0.03
Clupeid unidentified		63	<1	1.91	22	<1	0.71
Morone larvae		2	<1	0.06	6	<1	0.19
Centrarchid unidentified		0	0	0	2	<1	0.06
Total		7340	100	222.42	9870	100	318.40

Table III-2

Results* of Two-tailed Mann-Whitney U-Tests
Comparing Number of Fish Collected Daily from Traveling Screens
at Indian Point Unit 1 during Periods of Weir and Fixed Screen Operation

Species	P**	Species	P**
Atlantic tomcod	0.0872	Hogchoker	0.5754
Bay anchovy	0.7872	Rough silverside	0.1676
White perch	0.3844	Yellow perch	0.9602
Bluefish	0.2302	Banded killifish	0.9602
Rainbow smelt	0.5486	Atlantic needlefish	0.3320
Alewife	0.4902	Golden shiner	0.3320
Blueback herring	0.1868	Goldfish	0.3320
Americal eel	0.3472	Northern hogsucker	0.3320
American shad	0.7490	Spot	0.3320
Atlantic menhaden	0.1010	Winter flounder	0.3320
Striped bass	0.0818	Tidewater silverside	0.3030
Pumpkinseed	0.9680	Clupeid unidentified	0.0090
Redbreast sunfish	0.1836	*Morone* larvae	0.5552
White catfish	0.6242	Centrarchid unidentified	0.1416
Spottail shiner	0.7948	All taxa	0.0970

*The Null hypothesis tested is that daily collections during periods of weir operation did not differ from collections during periods of fixed screen operation.

**P is the probability of error in rejecting the Null hypothesis; i.e., the likelihood that the observed difference is due to chance.

SECTION IV
DISCUSSION

The results of this study suggest that the installation of weirs does not significantly influence impingement at Indian Point Unit 1 under the conditions which prevailed during these tests. However, numerous biological, environmental, and plant-related variables are thought to interact to influence impingement of fishes. Because these tests were conducted during a restricted portion of a single year, the extent to which these results may be applicable to other sets of environmental conditions is uncertain. For many of the species which contribute most heavily to impingement collections at Indian Point, the test period did not coincide with the peak annual impingement period. Whether the distributions, behavioral patterns, and physiological responses to differing environmental circumstances which occur at periods of peak impingement would result in impingement being influenced in the same way by the weirs at those times as during the test period is unknown.

The weirs, which restrict intake flow from directly in front of the intakes to the upper strata of the water column, might be expected to be most effective in reducing impingement of species (such as the Atlantic tomcod and hogchoker [*Trinectes maculatus*]) which are concentrated on or near the bottom. There was, in fact, a somewhat lesser daily rate of Atlantic tomcod impingement during periods of weir operation, although the difference was not statistically significant. Hogchokers were not impinged in great enough numbers under either mode to allow any conclusions to be drawn. However, earlier studies of the vertical distribution of impinged fish on the fixed screens at Indian Point Unit 2 indicated that all species examined, including the demersal Atlantic tomcod and hogchoker, were impinged in greater numbers on the upper portions of the screens (TI, 1975). The reasons for this are unknown. Possible explanations include greater jeopardy for those individuals straying into the upper strata where water approaches the screens at greater velocity, or the presence of vertical eddies in the vicinity of the intakes displacing the fish upwardly as they approach the screens. During the present study, water flow patterns in front of and lateral to the weir were unknown. It is possible that upward currents were created some distance in front of the weir, thereby extending the area from which demersal fish would be exposed to impingement.

White perch are impinged in greatest numbers during the winter and early spring (TI, 1974; 1975; 1976). During these times, they are thought to be inactive and concentrated near the bottom in offshore areas of the middle and lower estuary (TI, 1974). Under these conditions, the possibility exists that weirs may effectively reduce the exposure of white perch to impingement. However, the present study was conducted during a portion of the year in which white perch are active and concentrated in more inshore areas; perhaps as a consequence of the seasonal movement of white perch inshore and into the upper strata where exposure is greater, the weir did not effectively reduce white perch impingement during the spring and summer.

Also to be considered is the relationship which exists among swimming capacity (i.e., speed and endurance), water velocity approaching the intake, and impingement. Because water velocity at the intakes is directly related to pumping volume and inversely related to cross-sectional areas of the intake (TI, 1974), the reduction of the intake area by approximately 50% (Figure II-3) by the installation of the weirs would be expected to result in an approximate two-fold increase in water velocity as it entered the forebays. Therefore, intake water velocity would be increased from approximately 0.7 ft/sec which occurs at 100% pumping capacity with the fixed screens in place (TI, 1974) to a velocity of approximately 1.5 ft/sec. Although velocity would again decline during passage through the forebays to the traveling screens at the rear, fish drawn past the weirs may have difficulty avoiding impingement on the traveling screens or escaping from the forebays. Previous studies at Indian Point have shown that as intake water velocities increased beyond 1 ft/sec, impingement increased (TI, 1974). Therefore, installation of weirs at the forebay entrances may be expected to increase impingement of those species inhabiting strata where increased velocity near the forebay entrance may occur.

Species in the mid- and upper-water strata near Indian Point during the study period which are most likely to be affected by the increased velocity near the forebay entrance include bluefish, rainbow smelt *(Osmerus mordax)*, bay anchovy, and four species of clupeids. The impingement of bluefish, rainbow smelt, bay anchovy, and alewife was somewhat reduced during the weir-in mode, but these differences were not statistically significant. Although greater numbers of Atlantic menhaden, American shad, blueback herring, and unidentified clupeids (mostly young-of-the-year blueback herring and alewife) were impinged during the weir-in-mode, only the increase in impingement of unidentified clupeids was statistically significant.

Typically, peak impingement of most of the clupeids occurs in late summer and fall as downstream migration takes place (TI, 1974; 1975; 1976). It is unknown whether behavioral patterns at that time would make them more vulnerable to the increased intake water velocity induced by the weirs than they were during the spring and early summer test period.

Typically, few striped bass are impinged at Indian Point and this was the case during the present study. Although more were impinged during periods of weir operation, the difference in daily rate was not significant. However, increasing intake water velocity by the construction of a weir may have a greater effect on striped bass impingement during other time periods. Increased intake water velocity may be particularly important during the early spring when fish are dispersing from offshore overwintering areas, and swimming capacity may be reduced by low temperatures.

Studies of the swimming capacity of fishes have demonstrated that although differences exist among species, swimming capacity typically declines with temperature (TI, 1974; Rulifson and Huish, 1975). Partly because of findings of this nature, intake flow at all Indian Point units is reduced to 60% of capacity when river temperatures decline to 4.4°C (40°F) or below in accordance with requirements of the New York State Department of Environmental Conservation (TI, 1975). Flow reduction to 60% of capacity at Unit 1 results in intake water velocities of approximately 0.3 ft/sec

(Consolidated Edison, 1973). Operation with weirs in place during this period of reduced flow may be counterproductive in that intake water velocity may be increased at the forebay entrance to near those velocities existing at 100% flow, i.e., 0.7 ft/sec. It is possible that any advantage gained by reducing the volume of water withdrawn from near the bottom will be negated by increased intake water velocity.

Conclusions to be drawn from this study on the effects of weirs on impingement at Indian Point must be tentative and limited. It is not possible to extrapolate results from a two-month study period to the rest of the year on the basis of data now available. More information on factors influencing the impingement of various species is needed. Empirical studies, particularly during periods of peak impingement, are needed before conclusions can be drawn as to the efficacy of the weirs in reducing annual impingement. Further data are especially important for those species typically impinged in large numbers (white perch, Atlantic tomcod, bay anchovy, and blueback herring) and for those considered to be of greatest importance (striped bass, Atlantic tomcod, and white perch). It could prove to be that weirs would be most effective if used only during certain portions of the year rather than continuously. Further studies on the effects of weir design on current patterns and flow near the intake would be useful and information from such studies may allow modification of present weir design to optimize those characteristics most likely to result in reduced impingement.

SECTION V

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APPENDIX A

IMPINGEMENT DATA COLLECTED AT INDIAN POINT UNIT 1
DURING THE COURSE OF WEIR STUDY, 25 MAY - 29 JULY 1977

Table A-1

Numbers of Fish Collected during Submerged Weir Study at Indian Point Unit 1 Forebays 13 and 14, 25 May - 29 July 1977

Screen In / Weir In	5/25-5/26-5/27			5/28-5/29-5/30			5/31-6/1-6/2			6/3-6/4-6/5			6/6-6/7-6/8		
Atlantic tomcod	49	32	7	2	1	1	35	97	206	23	7	6	NS*	NS	139
Bay anchovy		1		2		2	13	12	4	3	1	10	NS	NS	8
Bluefish								3	19	7		5	NS	NS	72
White perch	22	16	9	16	16	12	28	21	20	30	30	29	NS	NS	47
Rainbow smelt	17	4	14	21	7	8	21	23	27	43	50	28	NS	NS	46
Alewife			2	2	5		1	1	3	4	3		NS	NS	1
Blueback herring	3					4	6	15	5	10	7	4	NS	NS	7
American eel	1		1	12			3	2		1	2	1	NS	NS	3
American shad													NS	NS	
Clupeid unidentified													NS	NS	
Striped bass	1							1					NS	NS	1
Atlantic menhaden													NS	NS	
Pumpkinseed	3	2			2	1							NS	NS	1
White catfish			1	1					1	1			NS	NS	
Hogchoker	1	2			1		1	2					NS	NS	
Spottail shiner		1				1		1			1		NS	NS	
Morone larvae													NS	NS	
Redbreast sunfish													NS	NS	
Banded killifish													NS	NS	
Centrarchid unidentified		1											NS	NS	1
Rough silverside						1							NS	NS	
Yellow perch		1											NS	NS	
Atlantic needlefish													NS	NS	
Golden shiner													NS	NS	
Goldfish													NS	NS	
Northern hogsucker					1								NS	NS	
Spot													NS	NS	
Tidewater silverside								1					NS	NS	
Winter flounder													NS	NS	
Total	97	60	34	56	33	30	108	179	285	123	100	83			326

Screen In / Weir In	6/9-6/10-6/11			6/12-6/13-6/14			6/15-6/16-6/17			6/18-6/19-6/20			6/21-6/22-6/23			6/24-6/25-6/26		
Atlantic tomcod	137	29	13	4	3		5	1	6	2	425	82	26	17	22	165	297	190
Bay anchovy	11	16	21	10	17	11	14	18	9	3	9	89	23	30	26	4	20	128
Bluefish	20	23	14	41	38	21	26	20	25	15	7	64	29	75	74	41	147	226
White perch	68	42	42	37	35	15	47	37	36	25	17	32	32	39	56	30	47	23
Rainbow smelt	17	12	3	6	1	1	12	25	15	17	35	102	29	49	30	38	41	52
Alewife	2		2	1			1		1	2	5	1	3	1	7	1	3	1
Blueback herring	11	7	4	4	3	1	3	6	3		2	2	2	10	1		3	4
American eel	3	2	1	1		2	3	2	3	2	2	3	3	4	10	3	3	
American shad	1	1										2						
Clupeid unidentified																		
Striped bass	5	1											1	1	2		1	
Atlantic menhaden	4	7	4	1			1	3			2		1	1	3	1	1	
Pumpkinseed	2	1	1	1								2			1	1		1
White catfish						2										1		
Hogchoker	1																	
Spottail shiner			1														1	
Morone larvae																		
Redbreast sunfish																		1
Banded killifish	1																	
Centrarchid unidentified																		
Rough silverside								1										
Yellow perch																		
Atlantic needlefish																		
Golden shiner													1					
Goldfish			1															
Northern hogsucker																		
Spot																		
Tidewater silverside																		
Winter flounder																		
Total	283	141	107	106	97	53	112	113	98	66	504	379	150	227	232	285	564	626

*NS=Not Sampled

Screen In / Weir In	6/27-6/28-6/29			6/30-7/1-7/2			7/3-7/4-7/5			7/6-7/7-7/8			7/9-7/10-7/11		
Atlantic tomcod	63	63	18	88	158	141	88	59	136	91	93	66	236	215	108
Bay anchovy	16	13	11	48	20	38	17	11	23	20	41	15	31	88	59
Bluefish	13	27	17	100	103	138	42	36	46	34	70	19	47	102	44
White perch	33	28	8	27	32	27	37	31	31	17	16	10	20	19	13
Rainbow smelt	5	15	3	13	4	2	8	6	6	1		2	4	4	
Alewife	2					1	1	1			4	6	15	19	17
Blueback herring	4	6		3	7	10	4	2	3		4	2	1	4	2
American eel	4	1	1	3	2	2	3	1	1	2	1	1		3	2
American shad											6		6	8	
Clupeid unidentified							2	4	10	13			3	5	3
Striped bass	1		2	1			2		1		1			1	1
Atlantic menhaden	1	1		2		1			2				2		
Pumpkinseed			3				1		1	1		1		2	
White catfish		1													
Hogchoker															
Spottail shiner							1								
Morone larvae															
Redbreast sunfish													4		
Banded killifish															
Centrarchid unidentified															
Rough silverside															
Yellow perch															
Atlantic needlefish															
Golden shiner															
Goldfish															
Northern hogsucker															
Spot															
Tidewater silverside															
Winter flounder															
Total	142	155	63	285	326	360	206	151	260	179	236	122	369	470	249

Screen In / Weir In	7/12-7/13-7/14			7/15-7/16-7/17			7/18-7/19-7/20			7/21-7/22-7/23			7/24-7/25-7/26			7/27-7/28-7/29		
Atlantic tomcod	39	43	30	101	38	81	398	266	877	796	271	332	279	172	406	96	190	269
Bay anchovy	352	99	20	51	52	43	54	58	70	70	29	48	320	205	91	81	98	188
Bluefish	84	89	16	12	18	8	19	8	7	1	1	9	7	6	5	1	7	5
White perch	12	9	6	9	6	7	10	7	9	16	5	8	5	10	20	3	6	13
Rainbow smelt		1								2	2	1				1		1
Alewife	15	18		10	10	9	18	21	29	27	8	23	133	65	31	22	25	68
Blueback herring	2	2		2	3	3		7	3	7	4	26	28	5	8	13	12	16
American eel	4	4	2	5	3	1	1	2	1	1	2	4	2		2	1	3	1
American shad	3	2		1	2	2	2	1	7	5	1	1	8	14	4	2	9	11
Clupeid unidentified				5		4	8			6		1		1		1	4	15
Striped bass					1	1	1			1		3	2	1	7	3		2
Atlantic menhaden	1	1							1		1	1						1
Pumpkinseed	1	1		1			3		1			1	1		1	1	1	1
White catfish		1		1					1		1							
Hogchoker																	1	
Spottail shiner															1			1
Morone larvae							2			1			3	1				
Redbreast sunfish											1						1	
Banded killifish							1											
Centrarchid unidentified																		
Rough silverside																		
Yellow perch																	1	
Atlantic needlefish																		1
Golden shiner																		
Goldfish																		
Northern hogsucker																		
Spot												1						
Tidewater silverside																		
Winter flounder				1														
Total	512	270	74	199	134	160	517	370	1008	933	326	459	788	480	576	225	358	593

A-1

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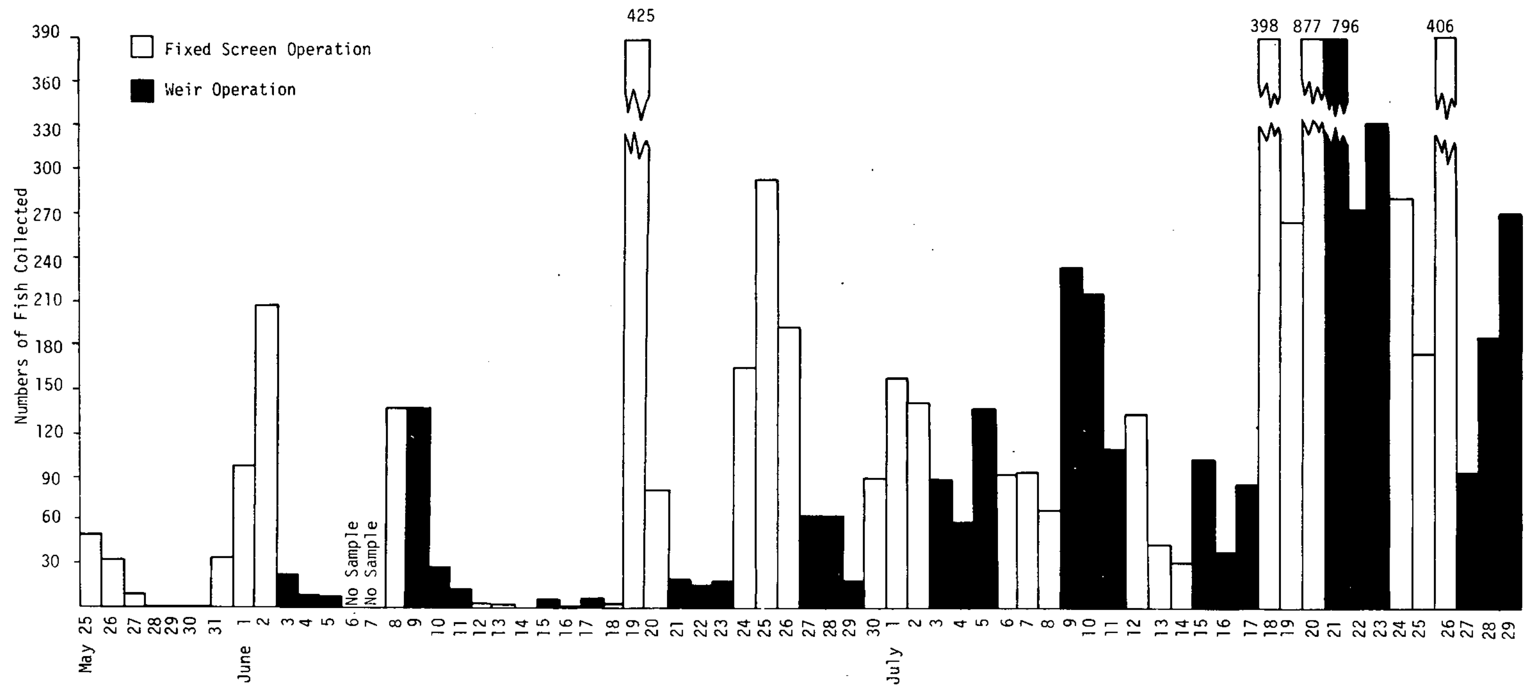

Figure A-1. Numbers of Atlantic Tomcod Collected at Indian Point Unit 1 (forebays 13 and 14) during Periods of Weir and Fixed Screen Operation

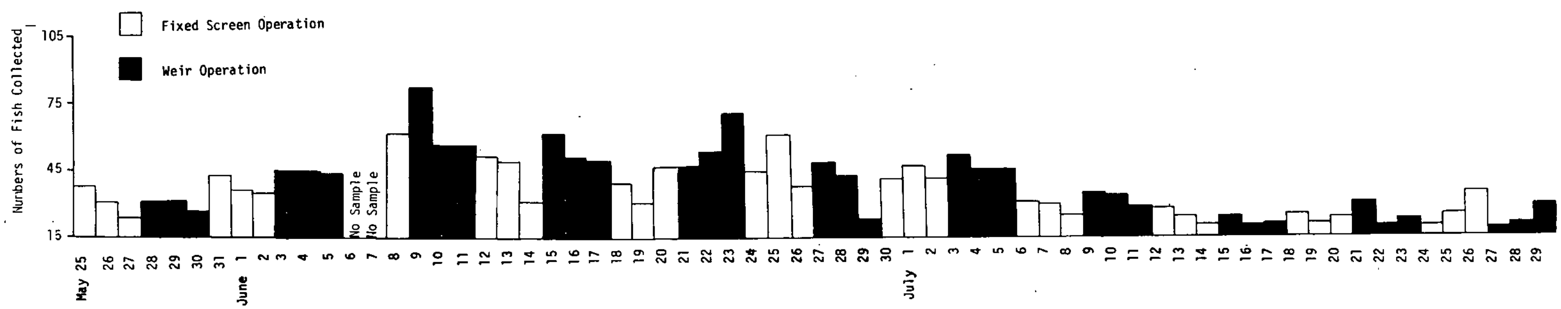

Figure A-2. Numbers of White Perch Collected at Indian Point Unit 1 (forebays 13 and 14) during Periods of Weir and Fixed Screen Operation

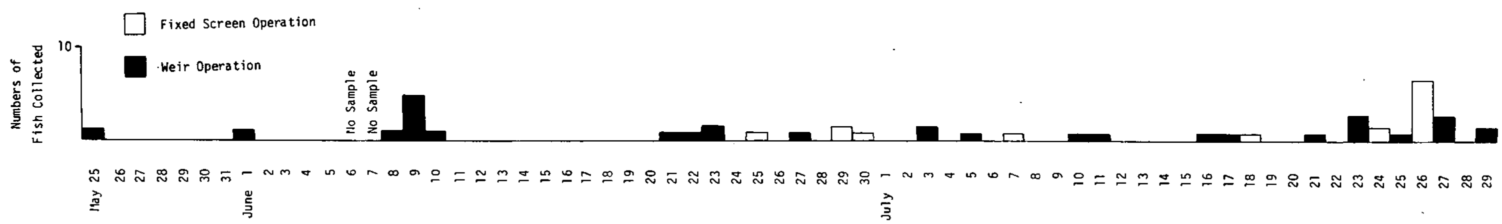

Figure A-3. Numbers of Striped Bass Collected at Indian Point (forebays 13 and 14) during Periods of Weir and Fixed Screen Operation

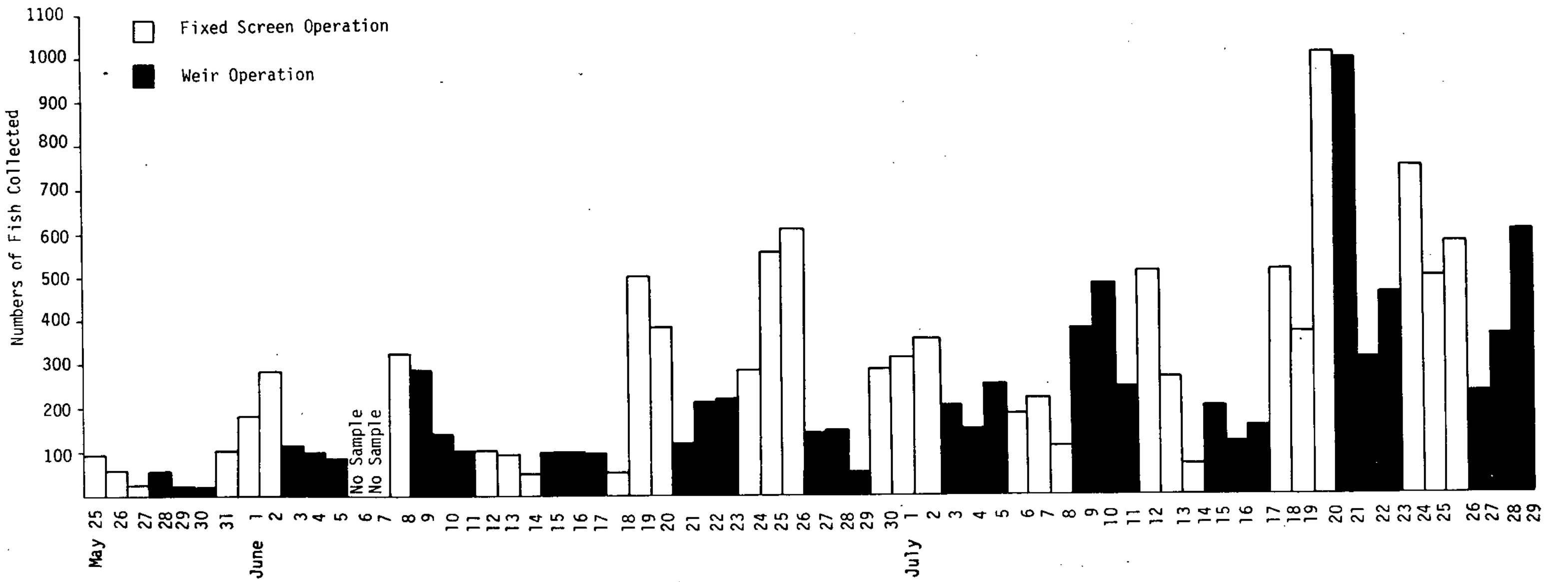

Figure A-4. Total Numbers of Fish Collected at Indian Point Unit 1 (forebays 13 and 14) during Periods of Weir and Fixed Screen Operation