RETURN TO REACTOR DOCKET FILES

ENVIRO

Docket # 50-237/286
Control # 7817700065
Date 9-21-78 of Document
REGULATORY DOCKET FILE

INITIAL AND EXTENDED SURVIVAL OF FISH COLLECTED FROM A FINE MESH CONTINUOUSLY OPERATING TRAVELING SCREEN AT THE INDIAN POINT GENERATING STATION

FOR THE PERIOD
15 JUNE - 22 DECEMBER 1977

SEPTEMBER 1978

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

Jointly financed
by
Consolidated Edison Company of New York, Inc.
Orange and Rockland Utilities, Inc.
Central Hudson Gas and Electric Corporation
Power Authority of the State of New York

Prepared by
TEXAS INSTRUMENTS INCORPORATED
Science Services Division
P.O. Box 5621
Dallas, Texas 75222

TABLE OF CONTENTS

ILLUSTRATIONS

TABLES

1. Introduction

Cooling water withdrawal by power plants usually results in entrainment and impingement of aquatic biota. Several techniques have been developed in recent years to reduce the numbers of impinged organisms or to return impinged organisms to the water unharmed. Several of these techniques have been tested at the Indian Point generating station since 1962 (Con Edison 1973).

Recent studies by the Virginia Electric and Power Company (VEPCO), and the Tennessee Valley Authority (TVA) tested the effectiveness of two new techniques designed to reduce impingement and entrainment. VEPCO developed a traveling screen system that combined modified conventional traveling screens with a sluiceway system that transported impinged fish back to the river and greatly increased survival (White and Brehmer 1976). TVA studies tested the feasibility of using fine mesh screening to reduce entrainment (Tomljanovich et al. 1977). These concepts were combined for this study, conducted by Texas Instruments (TI), to evaluate a continuously operating fine mesh traveling screen.

In early 1977 the continuously operating fine mesh screen was installed at Indian Point Unit No. 1. In June 1977, Ecological Analysts, Inc. (1977) tested the effectiveness of this screen for reducing entrainment and conducted survival studies on early life stages of impinged fish. Results indicated that most smaller larvae (less than 15 mm) would still pass through the fine mesh screen. Survival of striped bass larvae which were impinged was estimated to be 60 percent. Texas Instruments subsequently conducted preliminary studies to test the system design and investigate the initial and extended survival of juvenile and older fish recovered from the continuously operated traveling fine mesh screen at Unit No. 1. Striped bass, white perch, Atlantic tomcod, alewife, blueback herring, American shad, and bay anchovy were the species of primary interest, but species collected coincidentally were also held for survival studies. This report describes the results of those studies conducted from 15 June through 22 December 1977.

2. Methods and Materials

2.1. Description of the Indian Point Generating Station

Unit No. 1 is one of three nuclear reactors making up the Indian Point Generating Station located on the Hudson River (RM 42) near Peekskill, New York, approximately 67 km above the Battery in New York City. Unit No. 1 has a net generating capacity of 265 MW(e), but has not been utilized for commercial power production since 1974. It has two 530 m^3/min (140,000 gpm) circulating pumps, each drawing water through two intake bays. There is a fixed screen at the entrance and a vertical traveling screen at the back of each intake bay (Figure 1).

2.2. Description of the Traveling Screen

Modifications were made to the conventional traveling screen at one intake bay (No. 11) for testing purposes. Each screen panel was fitted with a 2.5 mm fine mesh nylon screen and horizontal trough 10.2 cm (4 in.) wide by 3 m (10 ft) long that retained about two inches of water as the screen was rotated. The collection sluice was constructed of plywood lined with fiberglass and extended the entire width of the traveling screen (Figure 3). The screen panels were washed by two spray cleaning systems; one inside the rotating screen pointing out toward the collection sluice and another located outside and above the screen pointing down toward the collection sluice (Figure 2). These spray nozzles extended the full width of the traveling screen. A third nozzle was located at the end of the sluiceway to supplement the amount of water in the sluice. An additional high pressure wash, located below the sluice, removed debris from the screen.

White and Brehmer (1976) explain the operating principles for the fine mesh continuously operating traveling screen. Fish impinged on the face of a traveling screen panel remain there until the panel clears the air-water interface whereupon they drop into the screen trough and remain

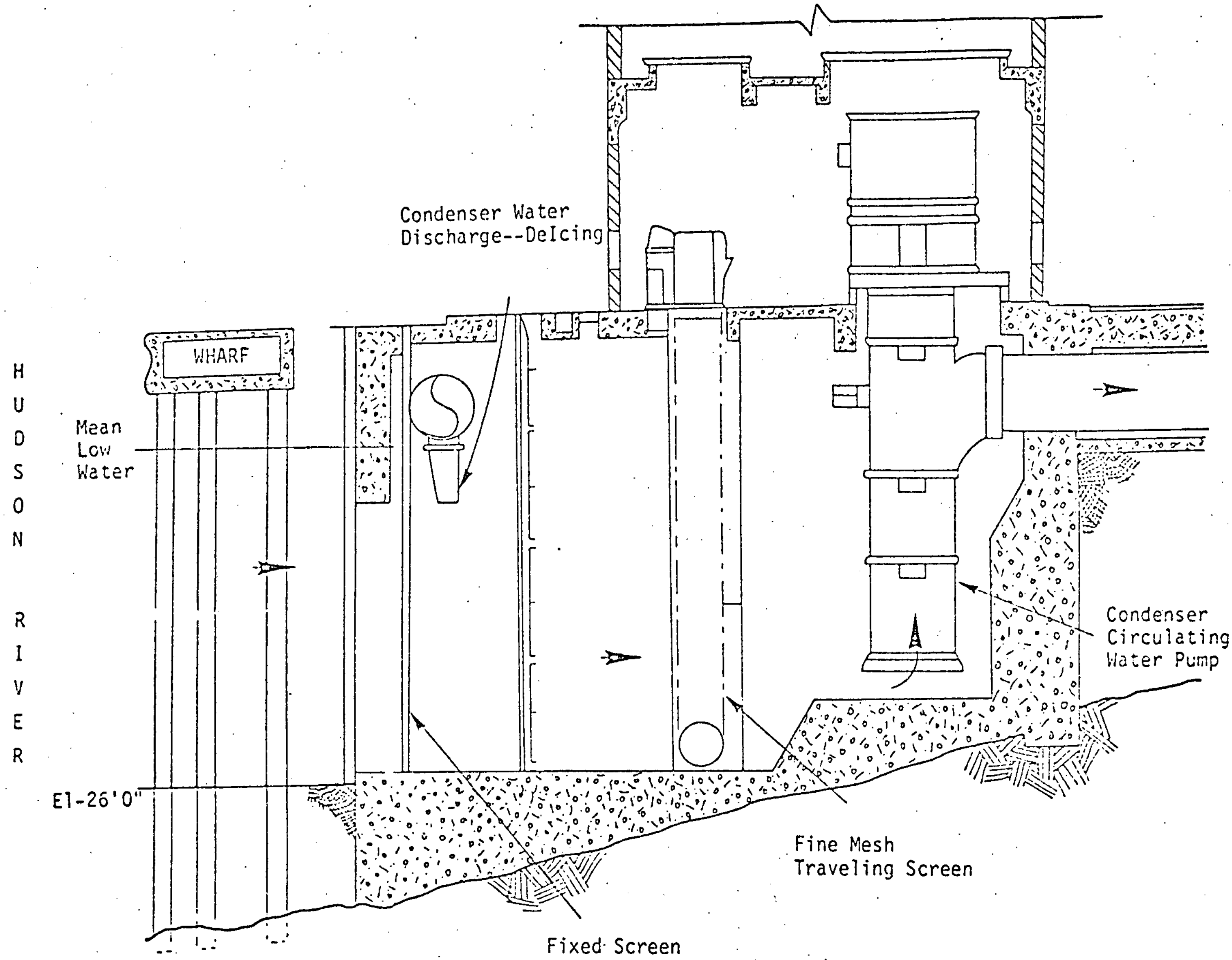

Figure 1. Cross Section of Intake Structure at Indian Point Unit No. 1

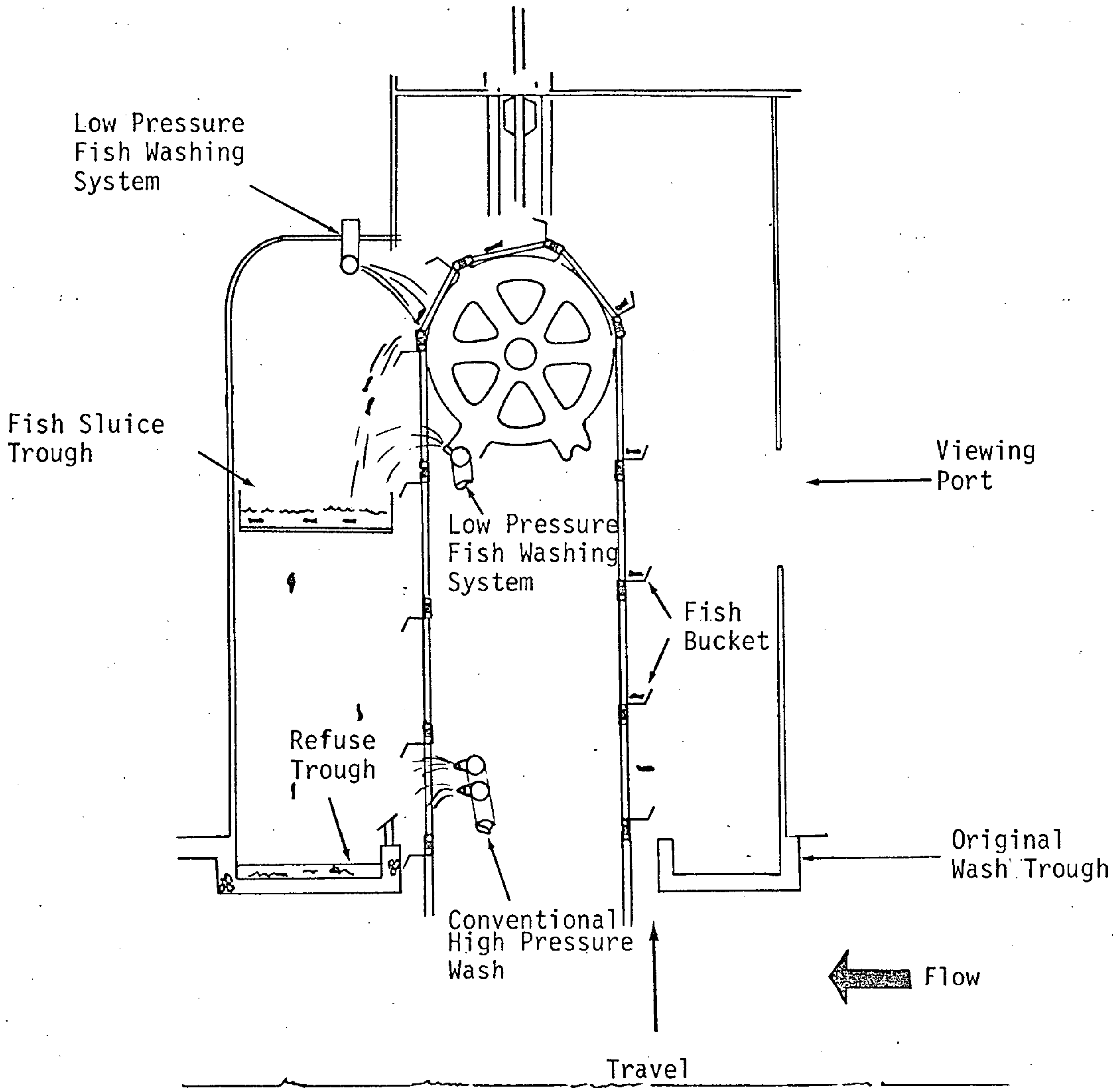

Figure 2. Schematic Diagram of a Fine Mesh Continuously Operating Traveling Screen. (Modified from Figure 2, White and Brehmer, 1976).

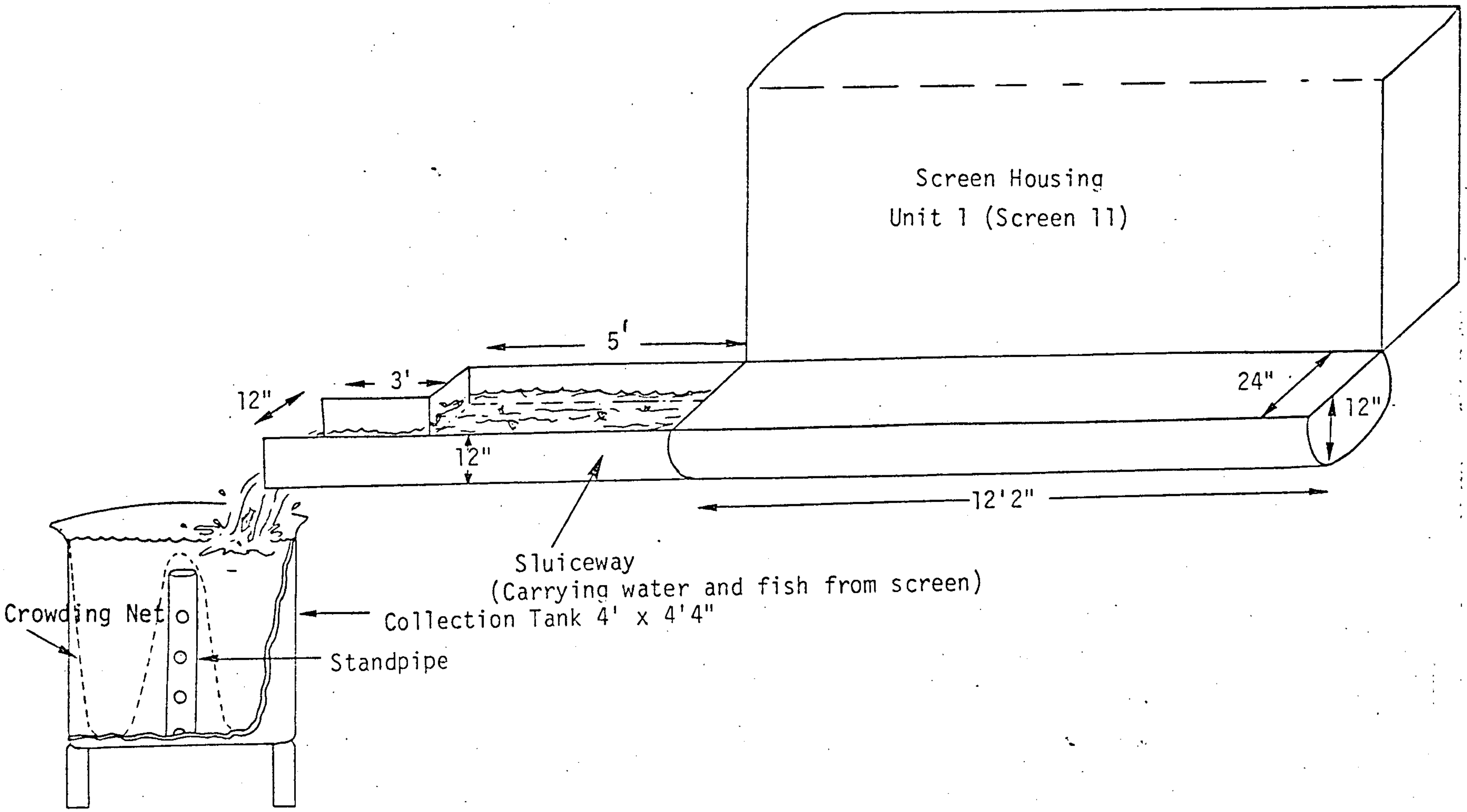

Figure 3. Collection Device and Collection Tank Used to Collect Fish from Fine Mesh Traveling Screen at Indian Point Unit No. 1

there as the screen travels vertically upwards. As the panel passes over the top sprocket the fish slide down the side of the panel and are washed into the sluice (Figure 2). In this study, organisms washed down the sluice could be diverted to one of three places: 1. the Hudson River, 2. a collecting tank for impingeable sized fish (Figure 3), or 3. a collecting device for entrainable sized organisms.

Intake flow was 100% of circulator capacity for the single June test, and 78% of maximum for the remaining sixteen tests. Percent of maximum flow changed because of plant operational requirements. Intake velocities were estimated to be approximately .2 m/sec at 100% flow and .15 m/sec at 78% flow based on data from previous studies (TI 1974). The screen traveled at a rate of 3.1 m/min. It took approximately 2.5 minutes for the screen trough to travel from the water surface to the point where the fish were washed into the sluiceway (assuming tidal height at mean sea level).

2.3. Testing Procedures

During testing periods the fixed screen at forebay No. 11 was lifted and held up with blocks, and the fine mesh traveling screen was rotated and washed continuously. All screen washings were diverted to a 1672 liter (441 gallon) fiberglass collection tank. During collection periods, fish were carefully removed from the collection tank with small buckets and placed in 121 liter (32 gallon) barrels for transport to the laboratory. Transit time was approximately 10 minutes. Dead fish were counted and numbers of live fish were estimated and recorded at the time of removal from the collection tank. Fish were considered to be dead if there was no spontaneous body or opercular movement and the fish failed to respond to probing.

Once in the laboratory, fish were placed in either a series of interconnected 184 liter (49 gallon) aquaria, or in a 191 liter (51 gallon) wooden trough. The fish were divided evenly among the holding facilities with no more than 50 fish per aquarium or trough. Fish were checked at 0, 12, 36, 60 and 84 hours, and all dead fish were removed and counted at the end of each interval. After 84 hours, tests were terminated and the remaining live fish counted. For these preliminary studies no controls were used to evaluate mortality related to handling and holding.

Wash water, collection tank water, and holding tank water were pumped from an area of the river directly in front of Unit No. 1. Unfiltered river water flowed continuously through the holding tanks so that water chemistry closely resembled that of ambient river water.

2.4. Analyses

Initial survival and survival after each time interval were calculated for striped bass, white perch, Atlantic tomcod, blueback herring, bay anchovy, alewife, and American shad in each test. Pooled estimates were calculated for initial survival and extended survival at each time interval for each of these species by summing numbers of fish held and numbers surviving to the end of each interval from all tests. For each of the other species impinged in sufficient numbers for testing, initial survival and survival after 84 hours of holding were calculated. Initial survival (S_I) was calculated as:

$$S_I = \frac{N_A}{N_c} \times 100$$

where

N_A = number of individuals of a species recovered alive after a screen washing; and

N_c = total number of that species collected

Extended survival (S_E) was calculated as:

$$S_E = \frac{N_x}{N_A} \times 100$$

where

N_X = number of individuals of a species alive at the end of each period (0, 12, 36, 60, and 84 hours); and

N_A = number of individuals of that species alive after screen washing.

For species of primary interest which were represented by multiple age classes or were collected over several months, contingency tables were constructed and the G-test (Sokal and Rohlf 1969) was applied to test for differences (α = .05) in survival among months and between age groups.

3. Results and Discussion

Seventeen tests were conducted from 15 June to 22 December, with one occurring in June, four in September, two in October, five in November and five in December. The numbers and species of fish collected during each test varied with changes in seasonal abundance. A total of 3505 fish representing 21 species was collected; 80 unidentified clupeids and 5 unidentified centrarchids were also collected. Bay anchovy, blueback herring, and white perch accounted for the majority of the fish collected. The length of the collection period varied from 0.5 to 5.0 hours, with a mean of 1.4 hours. The initial survival for all species was 41%, and survival after 84 hours was 24% for all species. Detailed results for each of the major species are given in the following paragraphs.

3.1. Striped Bass (*Morone saxatilis*)

Thirteen young-of-the-year (YOY) striped bass were collected. Initial survival and survival after 84 hours were relatively high for all tests, with pooled estimates of 85% and 88%, respectively (Table 1). These results were similar to those reported by Ecological Analysts (1977), wherein 100% of the juvenile striped bass (mean length = 19 mm) survived collection and 88% survived for 96 hours. White and Brehmer (1976) reported 100% survival of striped bass held for 15 minutes after collection from continuously washed modified traveling screens. Survival in both these

Table 1

Initital and Extended Survival of Young-of-the-Year Striped Bass Impinged on Continuously Operating Fine Mesh Traveling Screen at Indian Point in 1977

Test Date	Screen Wash Duration (Hrs)	Number Collected	Initial Survival (%)	Extended Survival (%) 0 Hrs	12 Hrs	36 Hrs	60 Hrs	84 Hrs
9/12	1.25	3	100	100	100	100	100	100
10/5	1.00	1	100	100	100	100	100	100
10/25*	0.50	1	100	-	-	-	-	-
11/1*	0.25	1	100	-	-	-	-	-
11/3	0.50	1	100	100	100	100	100	100
11/15	2.00	1	100	100	100	100	100	100
12/13*	1.50	1	100	-	-	-	-	-
12/15	5.00	3	33	100	100	100	100	100
12/21	0.50	1	100	100	0	-	-	-
Total	-	13						
Pooled estimate			85	100	88	88	88	88

*No extended survival tests conducted

tests was higher than that of striped bass collected from continuously operated conventional traveling screens at Indian Point Unit No. 3 in February, March, and April 1973. At that time 0% survival was reported after 96 hours (TI 1974). Kerr (1953) reported immediate survival of 9.9% for striped bass recovered from continuously operated conventional traveling screens.

3.2. White Perch (<u>Morone americana</u>)

A total of 228 young-of-the-year and 37 yearling and older white perch were collected. Initial survival and survival after 84 hours were 45% and 57%, respectively, for YOY, and 41% and 40%, respectively, for yearling and older white perch (Tables 2 and 3). Survival was not affected by age and/or holding duration ($0.975>p>0.90$ for the age x time x survival test of independence [Table 4]). Highest mortality occurred between 12 and 36 hours for both YOY and yearling and older white perch. Initial and extended survival of young-of-the-year white perch were both significantly higher ($p<0.005$) in November than in December (Table 5). December survival was low because of the exceptionally low survival during the December 15 test. This low survival may have been due to high spray wash pressures (technician's observation) and a relatively long collection period of five hours. When the December 15 test is excluded, no statistically significant differences exist between months, and survival becomes 89% (initial) and 78% (extended) for YOY, and 61% (initial) and 43% (extended) for yearling and older white perch.

White and Brehmer (1976) reported survival of white perch collected from modified traveling screens and held for 15 minutes to be 99.4%. The studies done in 1973 at Indian Point Unit No. 3 with white perch collected from a conventional traveling screen system resulted in survival after 96 hours of 8.4% (TI 1974).

Table 2

Initial and Extended Survival of Young-of-the-Year White Perch Impinged on Continuously Operating Fine Mesh Traveling Screen at Indian Point in 1977

Test Date	Screen Wash Duration (Hrs)	Number Collected	Initial Survival (%)	Extended Survival (%) 0 Hrs	12 Hrs	36 Hrs	60 Hrs	84 Hrs
10/5	1.00	8	100	100	100	100	100	100
10/25*	0.50	6	100	-	-	-	-	-
11/1*	0.25	1	100	-	-	-	-	-
11/3	0.50	10	100	100	100	100	100	100
11/8	0.50	10	100	100	100	100	100	90
11/17	2.00	7	71	100	100	100	100	100
12/13	1.50	16	69	100	NC	64	64	45
12/15	5.00	164	27	100	100	51	40	33
12/16	1.50	1	100	100	100	100	100	100
12/21	0.50	2	100	100	100	50	50	50
12/22	0.75	3	100	100	100	0	-	-
Total	-	228						
Pooled estimate			45	100	100	68	63	57

NC = Not checked

*No extended survival tests conducted

Table 3

Initial and Extended Survival of Yearling and Older White Perch Impinged on Continuously Operating Fine Mesh Traveling Screen at Indian Point in 1977

Test Date	Screen Wash Duration (Hrs)	Number Collected	Initial Survival (%)	Extended Survival (%)				
				0 Hrs	12 Hrs	36 Hrs	60 Hrs	84 Hrs
6/15	1.00	1	0	-	-	-	-	-
11/3	0.50	1	100	100	100	100	100	100
12/13	1.50	15	67	100	NC	80	80	50
12/15	5.00	14	0	-	-	-	-	-
12/16	1.50	5	60	100	100	0	-	-
12/22	0.75	1	100	100	100	0	-	-
Total	-	37						
Pooled estimate			41	100	100	60	60	40

NC = Not checked

Table 4

Initial and Extended Survival of Impinged Young-of-the-Year and Yearling and Older White Perch for All Tests Combined. G-Test Showed that Survival Was Not Affected by Age or Holding Duration (0.975 > p > 0.90)

Age	Holding Duration	Survival Alive	Survival Dead	Survival %
Young-of-the-Year	Initial	102	126	45
	Extended	54	41	57
Yearling & Older	Initial	15	22	41
	Extended	6	9	40

Table 5

Initial and Extended Survival of Impinged Young-of-the-Year White Perch Collected in November and December, 1977. G-Test Showed that Survival Was Affected by Month (p <.005)

Month	Holding Duration	Survival Alive	Survival Dead	Survival %
Nov	Initial	26	2	93
	Extended	24	1	96
Dec	Initial	62	124	33
	Extended	22	40	36

3.3. Atlantic Tomcod (Microgadus tomcod)

A total of eighty (78 YOY, 2 yearling and older) Atlantic tomcod were collected in all tests. Initial survival and survival after 84 hours were 92% and 62%, respectively (Table 6), and were similar to survival percentages of 100% and 67% reported by Ecological Analysts Inc. (1977). A comparison of survival between June and December showed that December survival (initial and extended) was significantly higher ($p<0.005$) than June survival (Table 7), although results from June were derived from a single test. This may be related to the reported preference of Atlantic tomcod for cooler water temperatures (Bigelow and Schroeder 1953). The 1973 study at Indian Point Unit No. 3 (conventional traveling screen) resulted in extended survival of 67% for Atlantic tomcod.

3.4. Blueback Herring (Alosa aestivalis)

Of the 480 blueback herring collected, 479 were young-of-the-year, while only one was older. Initial survival and survival after 84 hours were 93% and 25% respectively (Table 8). Survival declined steadily over the 84 hour period. White and Brehmer (1976) reported survival of 90% for blueback herring held 15 minutes after collection from a modified continuously operating screen.

3.5. Bay Anchovy (Anchoa mitchilli)

Bay anchovy comprised the greatest portion of the fish collected, and consisted of 2415 young-of-the-year and 65 adults. Survival for both age classes was low, initial survival and survival after 84 hours were 25% and 4%, respectively, for young-of-the-year, and 55% and 24%, respectively, for yearling and older fish (Table 9 and 10). Most young-of-the-year that survived impingement died shortly after collection and only 20% were still alive after 12 hours (Table 7). Survival of adult bay anchovies was significantly higher ($p>0.005$) than young-of-the-year survival (Table 11). This finding is consistent with those of other studies (Hanson et al. 1977), which reported that mortality from impingement often

Table 6

Initial and Extended Survival of Young-of-the-Year and Yearling and Older Atlantic Tomcod Impinged on Continuously Operating Fine Mesh Traveling Screen at Indian Point in 1977

Age Class	Test Date	Screen Wash Duration (Hrs)	Number Collected	Initial Survival (%)	Extended Survival (%) 0 Hrs	12 Hrs	36 Hrs	60 Hrs	84 Hrs
Young-of-the-Year	6/15	1.00	37	84	100	94	87	NC	19
	9/12	1.25	1	100	100	100	100	100	100
	12/13	1.50	3	100	100	NC	67	67	67
	12/16	1.50	1	100	100	100	100	100	100
	12/21	0.50	31	100	100	97	97	97	97
	12/22	0.75	5	100	100	100	100	100	100
	Total		78						
	Pooled estimate			92	100	96	92	92	62
Yearling & Older	9/12*	1.25	1	100	-	-	-	-	-
	12/16	1.50	1	100	100	100	100	100	100
	Total	-	2						
	Pooled estimate			100	100	100	100	100	100

NC = Not checked
*No extended survival tests conducted

Table 7

Initial and Extended Survival of Young-of-the-Year Atlantic Tomcod in June and December, 1977. G-Test Indicated that Survival Was Affected By Month ($p < 0.005$)

Month	Holding Duration	Survival Alive	Dead	%
Jun	Initial	31	6	84
	Extended	6	25	19
Dec	Initial	40	0	100
	Extended	38	2	95

Table 8

Initial and Extended Survival of Young-of-the-Year and Yearling and Older Blueback Herring Impinged on Continuously Operating Fine Mesh Traveling Screen at Indian Point in 1977

Age Class	Test Date	Screen Wash Duration (Hrs)	Number Collected	Initial Survival (%)	Extended Survival (%) 0 Hrs	12 Hrs	36 Hrs	60 Hrs	84 Hrs
Young-of-the-Year	9/12	1.25	11	82	100*	100	50	0	-
	10/25	0.50	152	100	100**	53	38	29	13
	11/1	0.25	40	85	100	2	2	2	2
	11/3	0.50	158	96	100	66	35	22	16
	11/8	0.50	28	100	100	68	54	50	36
	11/15***	2.00	12	100	-	-	-	-	-
	11/17	2.00	78	73	86	NC	82	81	81
	Total	-	479						
	Pooled estimate			93	98	61	42	34	25
Yearling & Older	9/12	1.25	1	100	100	100	0	-	-

NC = Not Checked

*4 fish held for extended survival tests

**100 fish held for extended survival tests

***No extended survival tests conducted

Table 9

Initial and Extended Survival of Young-of-the-Year Bay Anchovy Impinged on Continuously Operating Fine Mesh Traveling Screen at Indian Point in 1977

Test Date	Screen Wash Duration (Hrs)	Number Collected	Initial Survival (%)	Extended Survival (%) 0 Hrs	12 Hrs	36 Hrs	60 Hrs	84 Hrs
9/8	1.00	334	34	91	6	1	0	0
9/12	1.25	330	67	88*	53	20	9	0
9/21	1.80	166	71	92	52	26	20	15
9/26	2.50	986	9	49	0	-	-	-
10/5	1.00	597	11	38	5	5	5	0
10/25	0.50	1	0	-	-	-	-	-
11/3	0.50	1	0	-	-	-	-	-
Total	-	2415						
Pooled estimate			25	76	26	11	8	4

*85 fish held for extended survival tests

Table 10

Initial and Extended Survival of Yearling and Older Bay Anchovy Impinged on Continuously Operating Fine Mesh Traveling Screen at Indian Point in 1977

Test Date	Screen Wash Duration (Hrs)	Number Collected	Initial Survival (%)	Extended Survival (%) 0 Hrs	12 Hrs	36 Hrs	60 Hrs	84 Hrs
6/15	1.00	8	62	100	60	20	20	20
9/8	1.00	3	0	-	-	-	-	-
9/12	1.25	7	86	100*	100	67	67	33
9/21	1.80	23	91	100	86	57	43	29
9/26	2.50	15	13	100	100	100	0	-
10/5	1.00	9	22	100	50	50	50	0
Total	-	65						
Pooled estimate			55	100	82	55	39	24

*3 fish held for extended survival tests

Table 11

Initial and Extended Survival of Impinged Young-of-the-Year and Adult Bay Anchovy for All Tests Combined. G-Test Indicated That Survival Was Affected by Age ($p < .005$)

Age	Holding Duration	Survival		
		Alive	Dead	%
Young-of-the-Year	Initial	600	1815	25
	Extended	18	446	4
Adult	Initial	36	29	55
	Extended	8	25	24

decreases as fish size increases. White and Brehmer (1976) reported 82% survival of bay anchovies held 15 minutes after collection. This was below the average of 93.3% for all species in that study.

3.6. Alewife (Alosa pseudoharengus) and American Shad (Alosa sapidissima)

A total of 102 young-of-the-year alewife and 4 young-of-the-year shad were collected during all tests. As expected, survival of each species was similar to that of blueback herring, with high initial survival but relatively low extended survivals. Initial and extended survival were 69% and 9%, respectively, for alewife, and 100% and 0%, respectively, for American shad (Tables 12 and 13). Relatively high survival of alewife (90%) and American shad (93%) 15 minutes after collection from modified, continuously washed traveling screens was reported previously (White and Brehmer 1976).

3.7. Other Species

Although data were limited for other species, the results indicated that these fishes could be divided into two groups. One group (Table 14) totaling 47 individuals representing 9 species showed high survival. With the exception of weakfish, all species in this group showed 100% initial and extended survival. The 1973 Indian Point tests with white catfish (conventional screens), the most abundant species in this group, resulted in high survival also (87.7% after 96 hours). The species in the second group (Table 15) totaling 115 individuals representing 5 species showed either poor initial survival, poor extended survival, or both.

3.8. General Discussion

Post-impingement survival of fish is a function of several factors including species, age, size, season, spray wash pressure, intake velocity, and many other variables. Although results from this study show that size and season affect survival, differences in survival were primarily

Table 12

Initial and Extended Survival of Young-of-the-Year Alewife
Impinged on Continuously Operating Fine Mesh Traveling Screen
at Indian Point in 1977

Test Date	Screen Wash Duration (Hrs)	Number Collected	Initial Survival (%)	Extended Survival (%) 0 Hrs	12 Hrs	36 Hrs	60 Hrs	84 Hrs
9/8	1.00	5	40	100	50	50	0	-
9/21	1.80	16	88	93	93	93	86	14
9/26	2.50	23	30	100	71	71	0	-
10/5	1.00	21	62	77	54	54	54	0
10/25	0.50	27	100	100	70	41	15	11
11/1	0.25	4	50	100	0	-	-	-
11/3	0.50	2	100	100	50	0	-	-
11/17	2.00	4	75	67	NC	33	33	33
Total	-	102						
Pooled estimate			69	93	69	54	34	9

NC = Not checked

Table 13

Initial and Extended Survival of Young-of-the-Year American Shad
Impinged on Continuously Operating Fine Mesh Traveling Screen
at Indian Point in 1977

Test Date	Screen Wash Duration (Hrs)	Number Collected	Initial Survival (%)	Extended Survival (%) 0 Hrs	12 Hrs	36 Hrs	60 Hrs	84 Hrs
10/25	0.50	2	100	100	100	50	0	-
11/1	0.25	1	100	100	100	100	100	0
11/3*	0.50	1	100	-	-	-	-	-
Total	-	4						
Pooled estimate			100	100	100	67	33	0

*No extended survival tests conducted

Table 14

Initial and Extended Survival for Other Species with Relatively High Survival After Impingement on Continuously Operating Fine Mesh Traveling Screen at Indian Point in 1977.

Species	Numbers Collected All Tests	Life Stage*	Initial Survival (%)	Extended Tests No. Tested	Extended Tests Survival (% at 84 hr)
Hogchoker	4	1	100	2	100
American Eel	4	2	100	2	100
Banded Killifish	1	1	100	**	**
White Catfish	29	1	100	29	100
Spottail Shiner	2	1	100	2	100
Centrarchids	5	1	100	5	80
Sea Lamprey	1	1	100	1	100
Largemouth Bass	1	1	100	1	100
Yellow Perch	1	1	100	1	100
Weakfish	3	1	67	1	100
Total	47			44	
Pooled estimate			98		98

*Life Stage 1 = Young-of-the-Year
2 = Yearling and Older
**No extended survival tests conducted

Table 15

Initial and Extended Survival for Other Speces with Relatively Low Survival After Impingement on Continuously Operating Fine Mesh Traveling Screen at Indian Point in 1977.

Species	Numbers Collected All Tests	Life Stage*	Initial Survival (%)	Extended Tests No. Tested	Extended Tests Survival (% at 84 hr)
Bluefish	4	1	100	4	0
Rainbow Smelt	4	2	25	**	**
Rainbow Smelt	20	1	10	2	0
Northern Pipefish	1	1	0	**	**
Menhaden	1	1	100	**	**
Gizzard Shad	5	2	100	5	0
Unidentified Clupeids	80	1	51	**	**
Total	115			11	(For Species Tested)
Pooled estimate			47		0

*Life Stage 1 = Young-of-the-Year
2 = Yearling and Older

**No extended survival tests conducted

a function of species. This is shown on several occasions where differences in survival among species occurred within a single test.

The differences seemed to follow three general patterns. One pattern, demonstrated by the clupeids, consisted of high initial survival but low extended survival. A second pattern, demonstrated by the bay anchovy and rainbow smelt, consisted of low initial and low extended survival. The third pattern, demonstrated by the Atlantic tomcod, white perch, and striped bass, consisted of high initial and high extended survival.

The mechanisms causing these differences in survival are unknown, but it is likely that species with soft fin rays and soft bodies such as blueback herring, bay anchovy, and rainbow smelt are more susceptible to physical damage. Hanson (1977) speculated that impingement mortalities may also result from partial descaling. Scale loss destroys the protective body covering and upsets normal osmoregulatory processes (Black and Tredwell 1966), and increases susceptibility to pathogens. The clupeids (American shad, blueback herring, alewife) have scales which are readily lost (Hanson 1977) and such loss of scales was apparent when handling those species during these tests.

Because of the preliminary nature of this study, the effectiveness of the continuously operating fine mesh traveling screen has not been fully evaluated. Further studies incorporating controls for survival testing, regulation of spray wash pressures, collection efficiency tests, sampling during peak impingement periods for all important species, and better holding facilities, will provide more conclusive results. However, some general conclusions can be drawn from the existing data. It should be emphasized that the overall initial survival (41%) and extended survival (24%) reported in this study were greatly influenced by the low survival of the bay anchovy. When bay anchovies were excluded overall initial survival increased to 74% and extended survival to 37%. Overall survival during this study was lower than the average survival of 93.3% that

White and Brehmer (1976) reported, but the survival during this study was higher for striped bass, white perch, and white catfish than for these species collected from a conventional traveling screen at Indian Point Unit No. 3 in 1973.

Survival estimates of white perch, striped bass, and Atlantic tomcod collected from continuously operating conventional traveling screens at three Hudson River power plants (Bowline, Roseton, and Danskammer generating stations) were within the same range as survival estimates reported in the present study for these three species (King et al. 1977). The survival of three species which were common to all six studies is listed in Table 16. The results of studies done at the Bowline, Roseton, and Danskammer plants of post-impingement survival have indicated that stress associated with collection, transport, and holding contributes to the mortality reported (King et al. 1977). In the present study no control tests were conducted to provide data with which to adjust for mortality resulting from these stresses. Therefore extended survival may be underestimated in the present study.

Differences in study design account for some of the differences in survival reported. White and Brehmer`s studies at the VEPCO plant were more extensive than the present study; the study spanned an eighteen month period, with 10 impingement samples taken each week. Collection time was five minutes, but fish were held for only 15 minutes in a large 64,300 liter (17,000 gal.) fiberglass tank. No extended survival tests were conducted. The studies at the Danskammer, Bowline, and Roseton generating plants were conducted over a five to seven month period. Sampling was done at varying intervals, and the results are based on large sample size. Collection time was 15-30 minutes and fish were held for extended survival tests. Attempts were made to distinguish survival differences due to screen operational mode, and spray wash pressure. Survival tests were conducted so that affects of impingement alone on survival could be determined. Results were not reported for species other than white perch, striped bass, and Atlantic tomcod. The 1973 study done at

Table 16

Initial and Extended Survival of Three Species from Six Separate Studies (ND = NO DATA)

Species	Indian Point Unit No. 3 1973 Study (TI)* (All Ages)	1977 Indian Point Fine Mesh Study (TI)** (Young-of-the-year)	1976 VEPCO Study (White & Brehmer)† (All Ages)	1976-77 Roseton Study (King et al)‡ (Young-of-the-year)	1976-77 Danskammer Study (King et al)‡ (Young-of-the-Year)	1976-77 Bowline Study (King et al)‡ (Young-of-the-year)
White Perch						
Initial	ND	45%	99%	79-98%	82-88%	80-97%
Extended	8%	57%	ND	6-51%	29-43%	21-56%
Striped Bass						
Initial	ND	85%	100%	ND	ND	90-95%
Extended	0	88%	ND	ND	ND	32-62%
Atlantic Tomcod						
Initial	ND	92%	ND	96%	89%	ND
Extended	67%	63%	ND	79%	82%	ND

$$\text{*Survival} = \frac{\text{Total number alive after 96 hours}}{\text{Total number alive after collection}} \times 100$$

$$\text{**Survival} = \frac{\text{Total number alive after 34 hours}}{\text{Total number alive after collection}} \times 100$$

$$\text{†Survival} = \frac{\text{Total Number alive after 15 minutes}}{\text{Total number collected}} \times 100$$

$$\text{‡Survival} = \frac{\text{Total number alive after 96-108 hrs}}{\text{Total number collected}} \times 100$$

Indian Point Unit No. 3 was less extensive than either of these two studies and the present study. Only four tests on four species over a short period of time (late winter to early spring) were completed. The duration of the collection period was four hours and fish were held for 96 hours in 16,185 liter (4281 gal.) pools. Spray wash pressures were not reported but were most likely higher than those used in the VEPCO study.

The difference in study design makes direct comparisons of survival among studies difficult. However, the results of the present study indicate that a fine mesh continuously operating traveling screen can increase survival of impinged fish compared to survival after impingement on conventionally operated traveling screens. This is consistent with the results of other studies done with continuously operating traveling screens, and indicates that continuous operation of the traveling screen is the key factor in increasing survival. The extent of success of the continuously operating traveling screen at Indian Point then, will depend on the ability to make improvements in other operational parameters (e.g. sluiceway design, spray wash pressure, etc.). These improvements will refine the present system, build on the concept of continuous screen operation, and ultimately increase survival of impinged fish.

Literature Cited

Bigelow, H.B. and W.G. Schroeder. 1953. Fishes of the Gulf of Maine. USFWS Fish. Bull. 53(74):1-577

Black, E.C. and S.J. Tredwell. 1967. Effect of a partial loss of scales and mucous on carbohydrate metabolism in rainbow trout (Salmo gairdneri). Jour. Fish. Res. Bd. of Canada 24:5.

Consolidated Edison Company of New York, Inc. 1973. The biological effects of fish impingement on the intake screens at Indian Point. In: Environmental Report, Indian Point Unit No. 3. Vol 3, App BB.

Ecological Analysts, Inc. 1977. Preliminary investigations into the use of a continuously operating fine mesh traveling screen to reduce ichthyoplankton entrainment at Indian Point Generating Station. Report to Consolidated Edison Company of New York, Inc.

Hanson, C.H., J.R. White, and H.W. Li. 1977. Entrapment and impingement of fishes by power plant cooling-water intakes: An overview. Marine Fisheries Review, 39:10 pp. 7-17.

Kerr, J. 1953. Studies on fish preservation at the Contra Costa steam plant of the Pacific Gas and Electric Co. Calif. Dept. Fish & Game, Fish. Bull 92.

King, L.R., J.B. Hutchinson, Jr., and T.G. Huggins. 1977. Impingement survival studies on white perch, striped bass, and Atlantic tomcod at three Hudson River power plants. (Draft paper)

Sokal, R.R., and F.J. Rohlf. 1969. Biometry. W.H. Freeman & Co., San Francisco.

Texas Instruments Incorporated. 1974. Indian Point impingement study report for the period 15 June 1972 through 31 December 1973. Report to Consolidated Edison Company of New York, Inc.

Tomljanovich, D.A., J.H. Heuer, and C.W. Voigtlander. 1977. Investigations on the protection of fish larvae at water intake using fine-mesh screening. Tennessee Valley Authority Technical Note No. B22.

White, J.C., and M.L. Brehmer. 1976. Eighteen month evaluation of the Ristroph traveling screen. Proc. Third National Workshop on Entrainment and Impingement. Ecological Analysts, Inc. pp. 367-381.

Science Services Division

21

TEXAS INSTRUMENTS

INCORPORATED

13500 NORTH CENTRAL EXPRESSWAY
POST OFFICE BOX 225621 • DALLAS, TEXAS 75265