PORT WASHINGTON POWER PLANT

FINAL REPORT

W.P.D.E.S.

INTAKE MONITORING STUDIES

WISCONSIN ELECTRIC POWER COMPANY

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PORT WASHINGTON POWER PLANT

FINAL REPORT

ON

INTAKE MONITORING STUDIES

PERFORMED BY

WISCONSIN ELECTRIC POWER COMPANY

IN FULFILLMENT OF CONDITIONS OF

WISCONSIN POLLUTION DISCHARGE ELIMINATION SYSTEM

PERMIT NUMBER WI-0000922

June 1, 1976

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INTRODUCTION

Section 147.02(6) of the Wisconsin Statutes provides that any permit issued by the Department shall require that "the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact". Wisconsin Pollution Discharge Elimination System (WPDES) permit WI-0000922 required (Special Condition H.1) a one-year intake monitoring study to determine the environmental impact of the Port Washington Power Plant's cooling water intake system. This report describes the results of that study, which was conducted during the period, March 1, 1975 - February 29, 1976.

Both the study and this report were developed with Department of Natural Resources guidance. The plan of study was approved by the Department on February 5, 1975 (letter from P. P. Didier to N. A. Ricci). This report was prepared using the Department's February 1976 document "Guidance for Preparation of a Final Report on the Environmental Effects of Existing Cooling Water Intake Structures". Deviations from this guidance document were made when necessary to conform to study design and the nature of the study data.

I PRESENT INTAKE SYSTEM

Port Washington Power Plant (PWPP) is situated on the shore of Lake Michigan in the city of Port Washington. The plant and its coal dock form the southern boundary of Port Washington Harbor (Figure I-1). Water for condenser cooling is withdrawn from Lake Michigan and the heated effluent is discharged to Port Washington Harbor. Part of the discharge can be directed to the intake area to prevent icing. The intake system and related features of plant operation are described below.

A INTAKE DESCRIPTION

Water is withdrawn from Lake Michigan via an approach channel which extends lakeward a distance of approximately 1200 feet, parallel to the south boundary of the coal dock (Figures I-1, 2 & 3). The channel is approximately 75 feet wide and 12 feet deep at its origin. The recirculation channel extends 300 feet from shore, parallel and adjacent to the intake channel. At the mouth of the recirculation channel, the intake system is reduced to 60 by 9-1/2 feet. Near the trash racks, the intake channel depth increases to 20 feet, but steel sheet piling reduce the width to 40 feet.

At the mouth of the approach channel, a vertical steel bar trash rack prevents large debris from entering the intake tunnel (Figure I-4). The steel bars are one inch wide with 5.5 inch gaps and extend to the bottom of the tunnel inlet.

The intake tunnel is a rectangular concrete conduit, 10 feet wide and 12 feet high (Figures I-5). The tunnel runs approximately 350 feet under plant grounds expanding to a width of 65 feet to form a common chamber ahead of the vertical travelling debris screens.

The screen chamber contains six identical vertical travelling screens (Figures I-6 and 7). Screens are 8.5 feet wide and are built of 3/8 inch-square wire mesh. Debris is removed by high pressure (100 psig) wash at the upstream sides of the screens. Debris and washwater are carried to the adjoining discharge tunnel via a single sluiceway (2 by 2 feet). Distance from screens to discharge in the harbor is 240 feet.

B. LOCATION

Figure I-8 illustrates the bottom contours of the nearshore region of Lake Michigan in relation to the present

intake (U.S. Dept. of Commerce, 1971). Bathymetry is characterized by a gentle lakeward bottom slope of about 1.1 per cent (11 feet vertical in 1000 feet horizontal). Contours are relatively uniform in the Port Washington area, and irregular bottom configurations are not evident

C. ENVIRONMENTAL FEATURES

Screen and washwater operation may function to return a substantial portion of impinged fish unharmed. Continuous screen rotation reduces impingement time to a minute, and the total time from initial impingement to discharge to Port Washington Harbor is less than 1.5 minutes. Fish are held out of water a maximum of 30 seconds during the impingement process. Effectiveness of the screen-wash system in returning viable fish is discussed in Section III.

D DEICING PROCEDURE

Deicing is performed by recirculating heated effluent to the approach channel (Figure I-2). The 300 foot recirculation line runs parallel to the approach channel for its entire length. It is separated from the approach channel by steel pilings. Approximately 20-40% of the cooling water is so directed to prevent buildup of ice in the approach channel and formation of frazzle ice on the trash racks and travelling debris screens. Recirculation occurs when ambient lake temperatures are below 40°F, generally encompassing the period December to April. At these times, reciculation for deicing is performed continuously during plant operation. For January, 1976 average recirculation flow was 111.4 mgd with a maximum of 181.6 mgd. Average ΔT between intake and deicing discharge was 7.7°F.

E. USE OF BIOCIDES

Powdered calcium hypochlorite is sequentially aspirated into the suction side of the circulating water pumps of each of the five units. Fifteen pounds of this biocide is added for each unit during a single chlorination At PWPP, chlorination is usually performed one day per week, except during summer periods of high intake temperature when the frequency of chlorination is increased to twice a week. Chlorination takes 5-10 minutes per unit, encompassing a total period of 1/2-1 1/2 hours.

F. PLANT OPERATION

Port Washington Power Plant is a coal-fired

steam electric generating facility, consisting of five boiler-turbine units, each rated at 80 MW. PWPP was constructed for base-load operation in the 1930's, but for the last decade has functioned as an intermediate load range plant. The typical weekday generating schedule is characterized by low load (0-80 MW) from midnight until 5 a.m., followed by intermediate to high load (150-350 MW) from 5 a.m. to 10 p.m., after which load is reduced to less than 50 MW, increasing to 150 MW for the mid-day period. The 1975 capacity factor for PWPP was 40.07%.

Two circulating water pumps, each with a capacity of 55,000 gpm, are associated with each of the five units. Maximum cooling water volume is 550,000 gpm (792 mgd). The number of pumps in operation varies over the plant operating day as well as on a seasonal basis. Less volume is required in the winter because ambient water temperature is lower and the cooling capacity is higher.

Five of the travelling screens are rotated and rinsed continuously at 10 feet per minute, with the sixth screen used as a standby reserve. One screen functions to remove debris for each condenser unit.

There are no plans to substantially modify the mode of operation of the Port Washington Power Plant in the foreseeable future.

G. CURRENT VELOCITY

Table I-1 lists calculated velocities at the trash rack intake and at the travelling screens as functions of water level and pumping rates. Trash rack velocities range between 0.5 and 1.5 feet per second (fps) over midlevel pumping rates. Velocities at the travelling screens are 30-40% lower than at the trash racks.

TABLE I-1. Calculated Velocities at Trash Racks and Traveling Water Screens - Port Washington Power Plant

Number of Pumps Operating	Flow GPM	Velocity at Trash Rack			Velocity at Traveling Screens		
		Low Water El-4.5 FPS	Ave. Level El-0.0 FPS	High Water El-2.5 FPS	Low Water El-4.5 FPS	Ave. Level El-0.0 FPS	High Water El-2.5 FPS
1	55,000	0.23	0.18	0.16	0.15	0.12	0.10
2	110,000	0.46	0.36	0.32	0.30	0.24	0.20
3	165,000	0.69	0.54	0.48	0.45	0.36	0.30
4	220,000	0.92	0.72	0.64	0.60	0.48	0.40
5	275,000	1.15	0.90	0.80	0.75	0.60	0.50
6	330,000	1.38	1.08	0.96	0.90	0.72	0.60
7	385,000	1.61	1.26	1.12	1.05	0.84	0.70
8	440,000	1.84	1.44	1.28	1.20	0.96	0.80
9	495,000	2.07	1.62	1.44	1.35	1.08	0.90
10	550,000	2.30	1.80	1.60	1.50	1.20	1.00

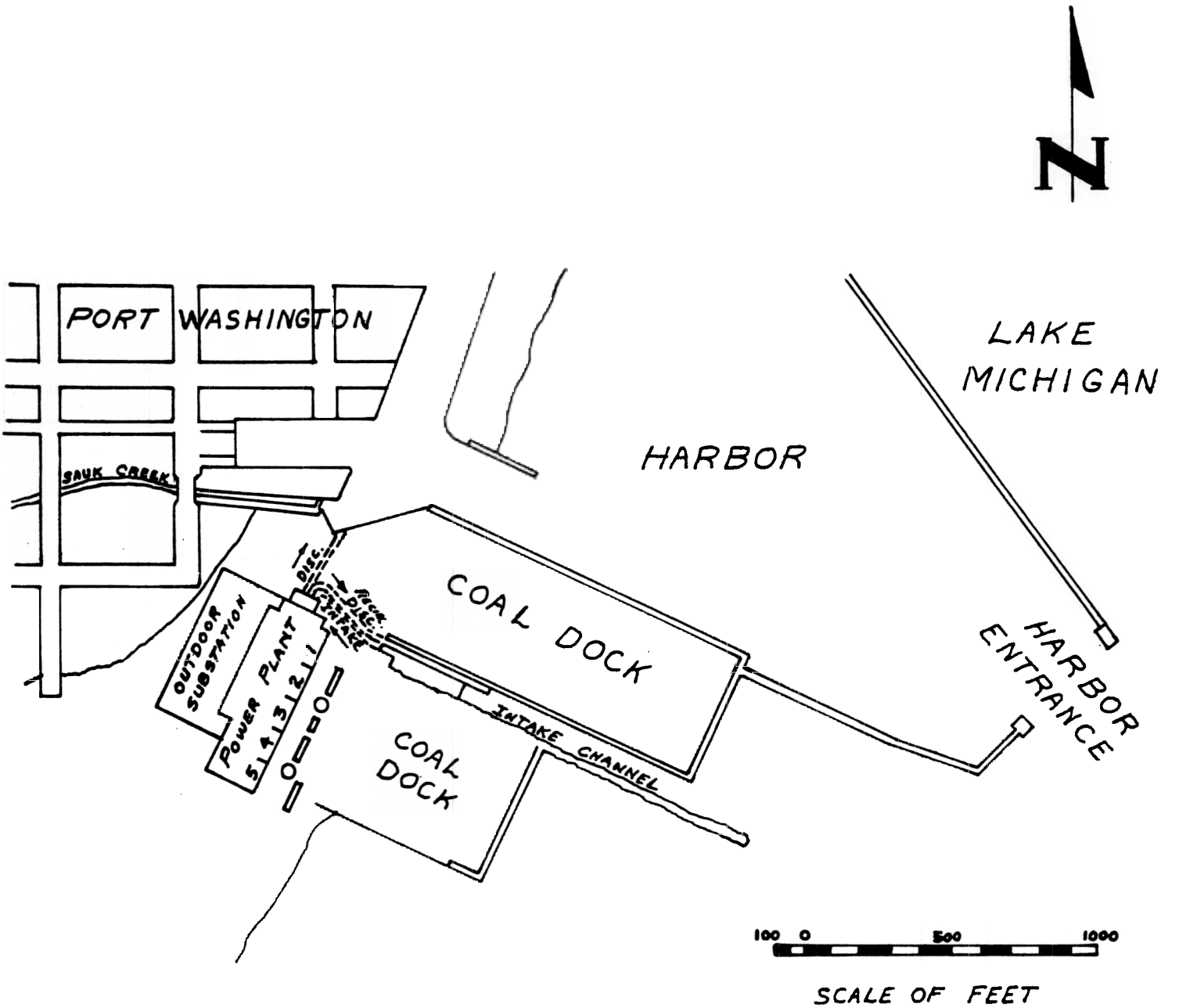

Figure 1-1. Port Washington Power Plant

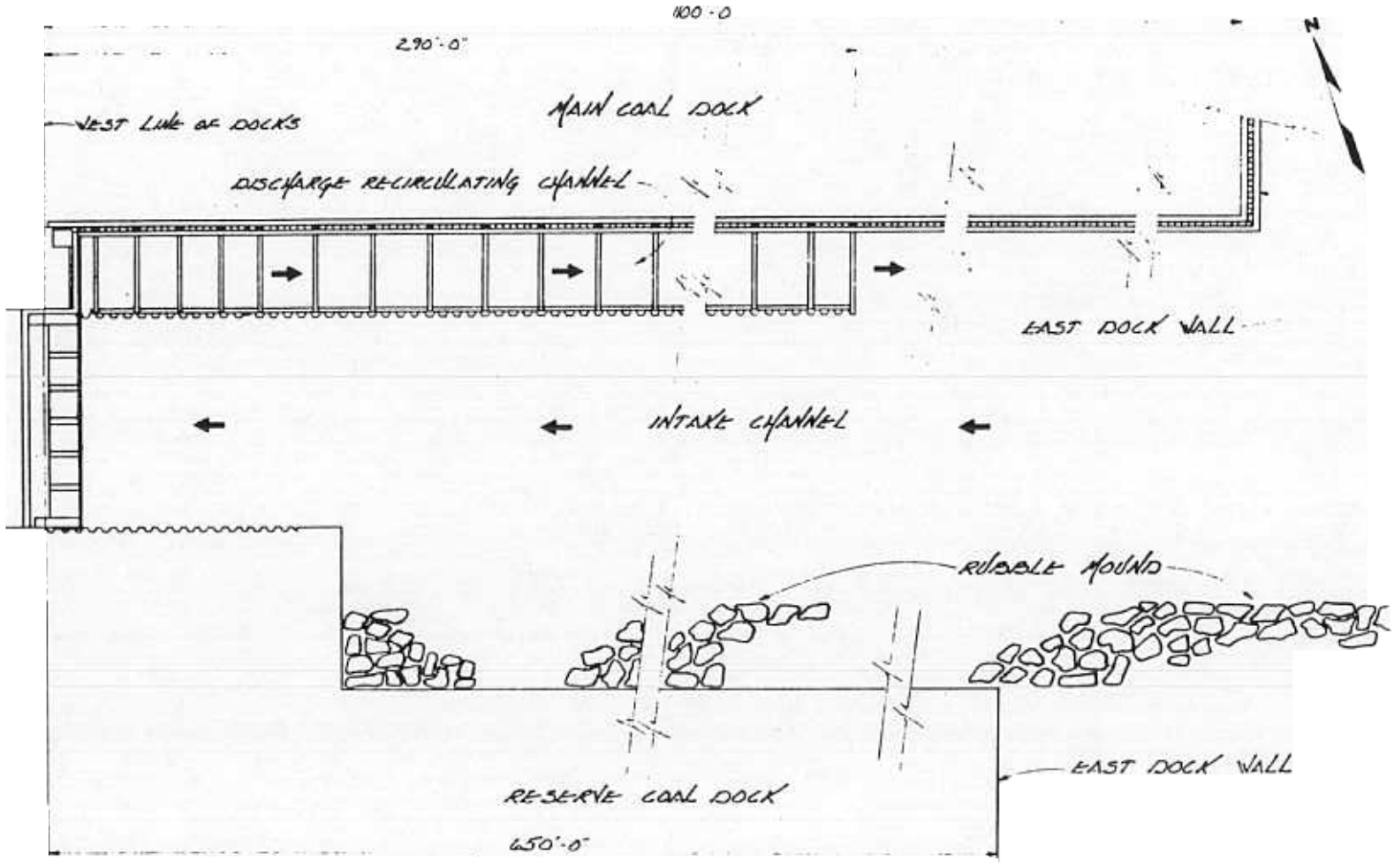

FIGURE I-2: PLAN OF INTAKE CHANNEL AREA

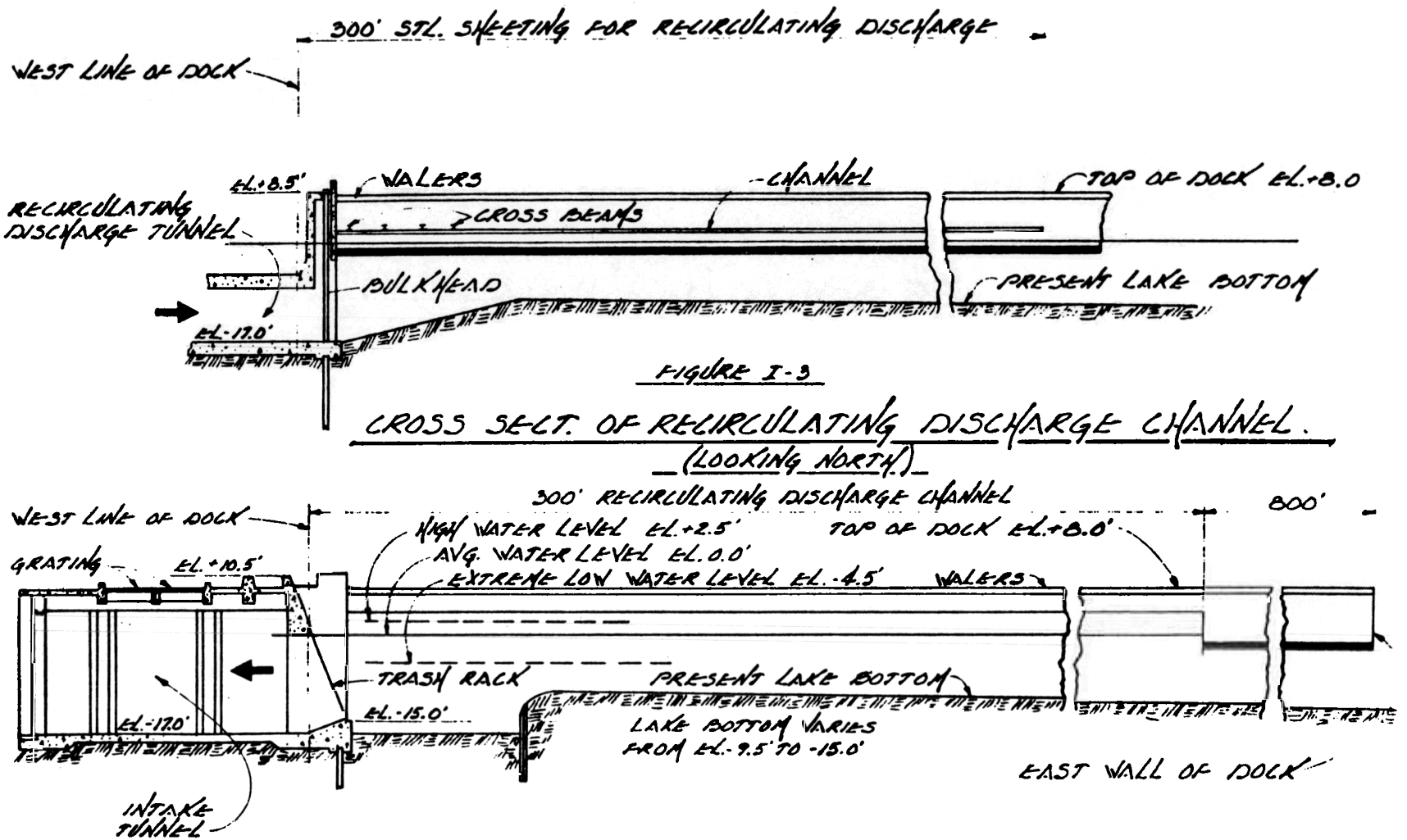

FIGURE I-3. CROSS SECT. OF INTAKE TUNNEL & CHANNEL

(LOOKING NORTH)

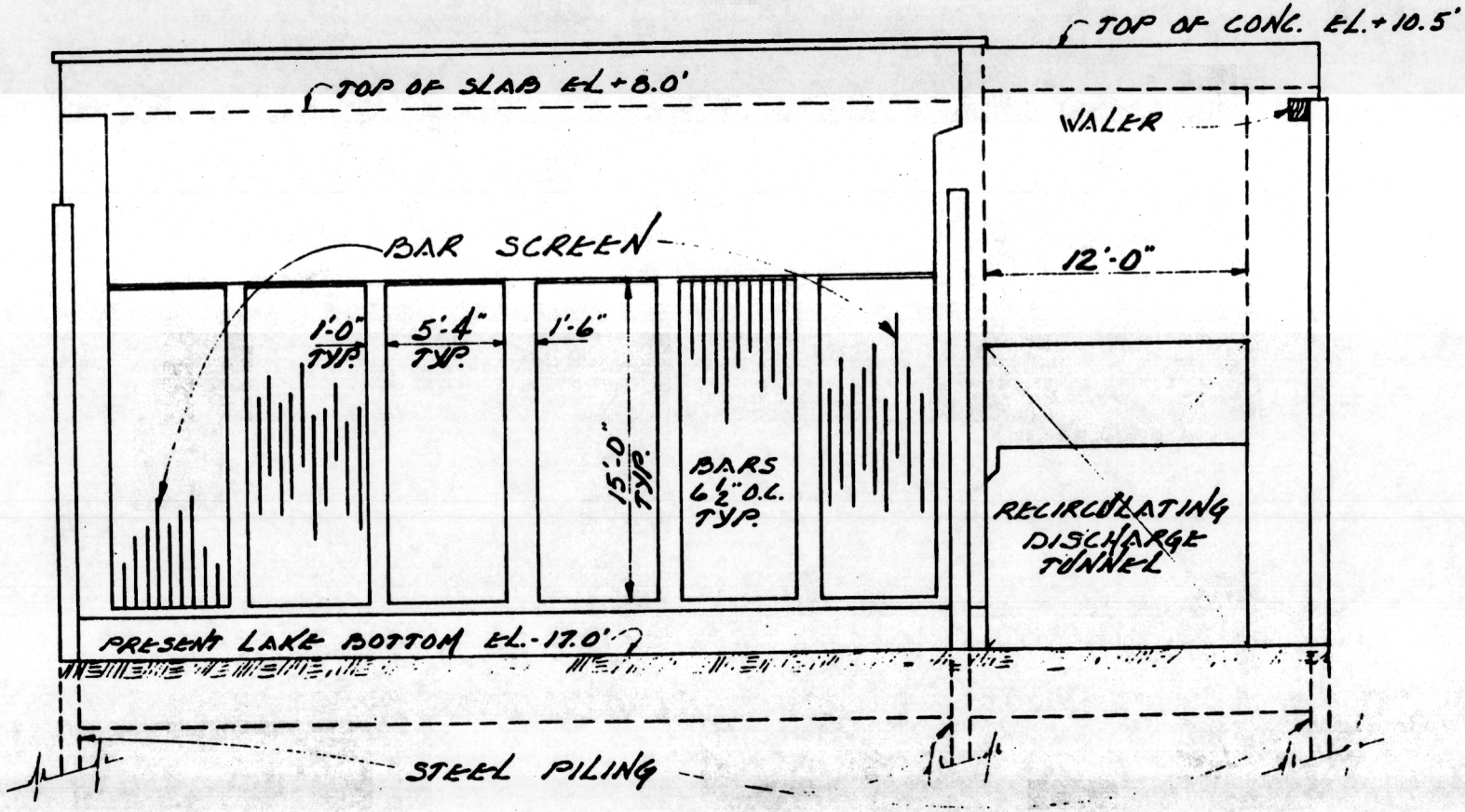

FIGURE I-4. ELEV. OF INTAKE TUNNEL AT BAR SCREEN

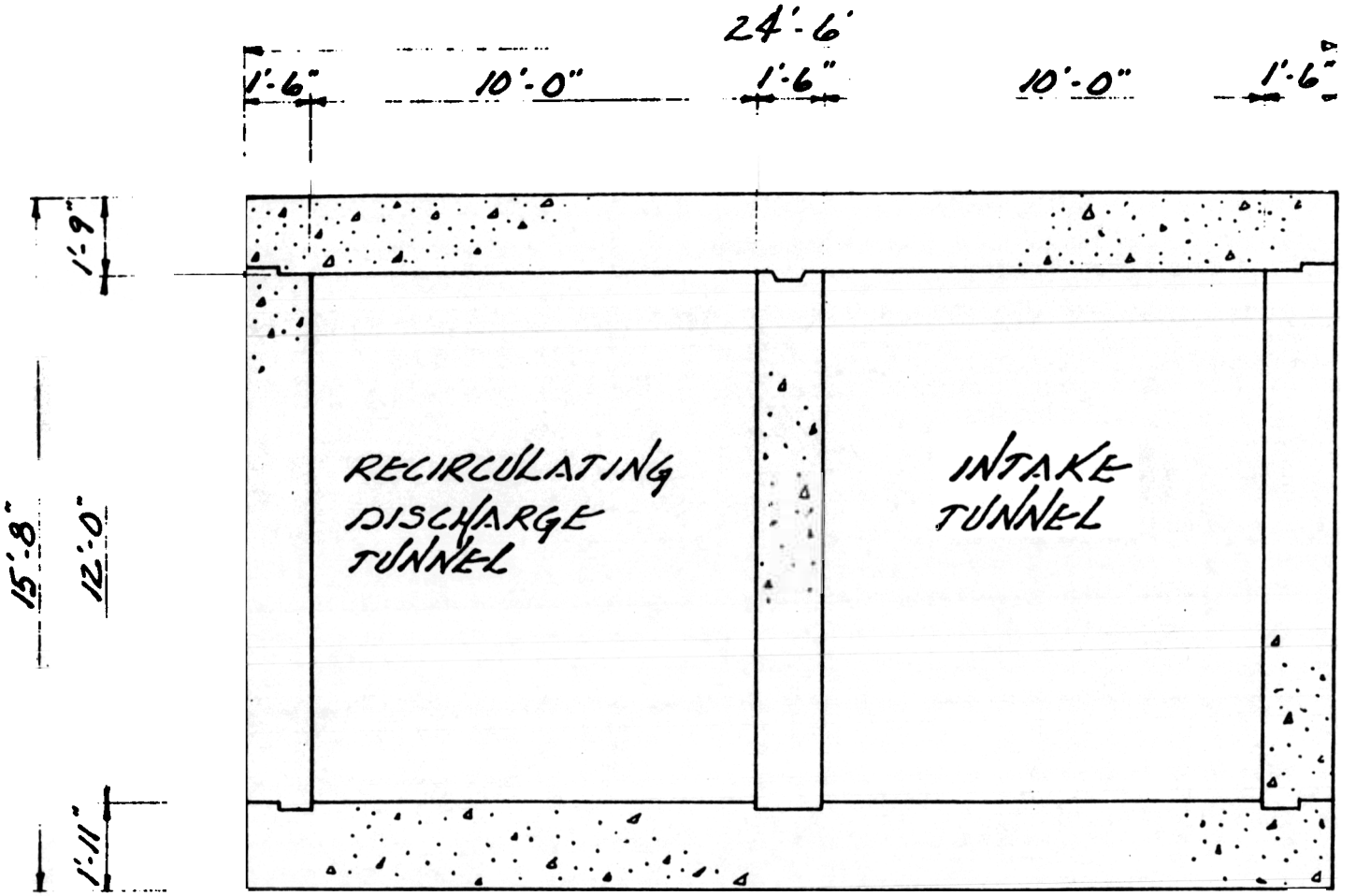

FIGURE I-5. TYP. CROSS SECT. THROUGH TUNNELS

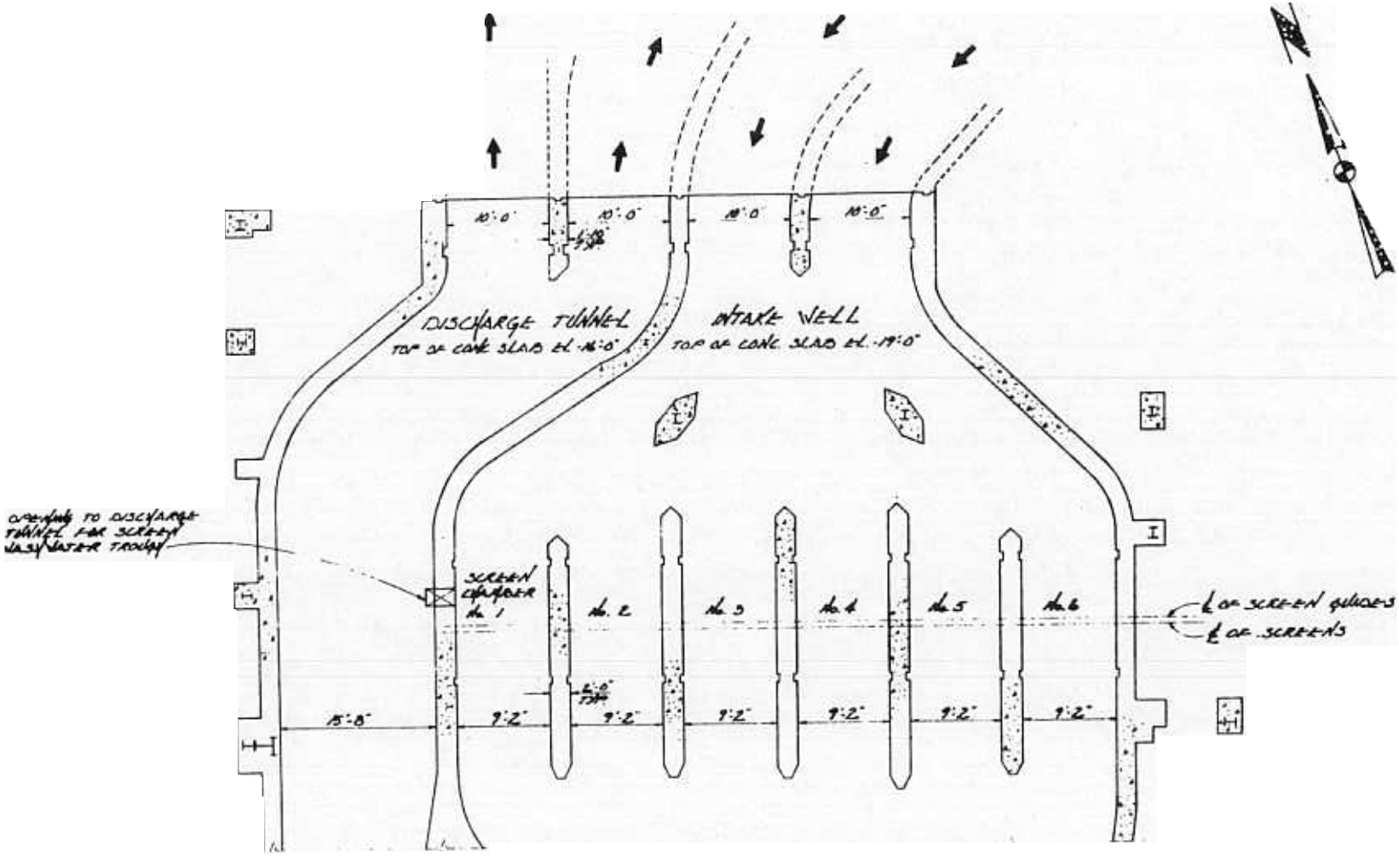

FIGURE I-6. PLAN OF TUNNELS & INTAKE WELL AT SCREEN CHAMBER

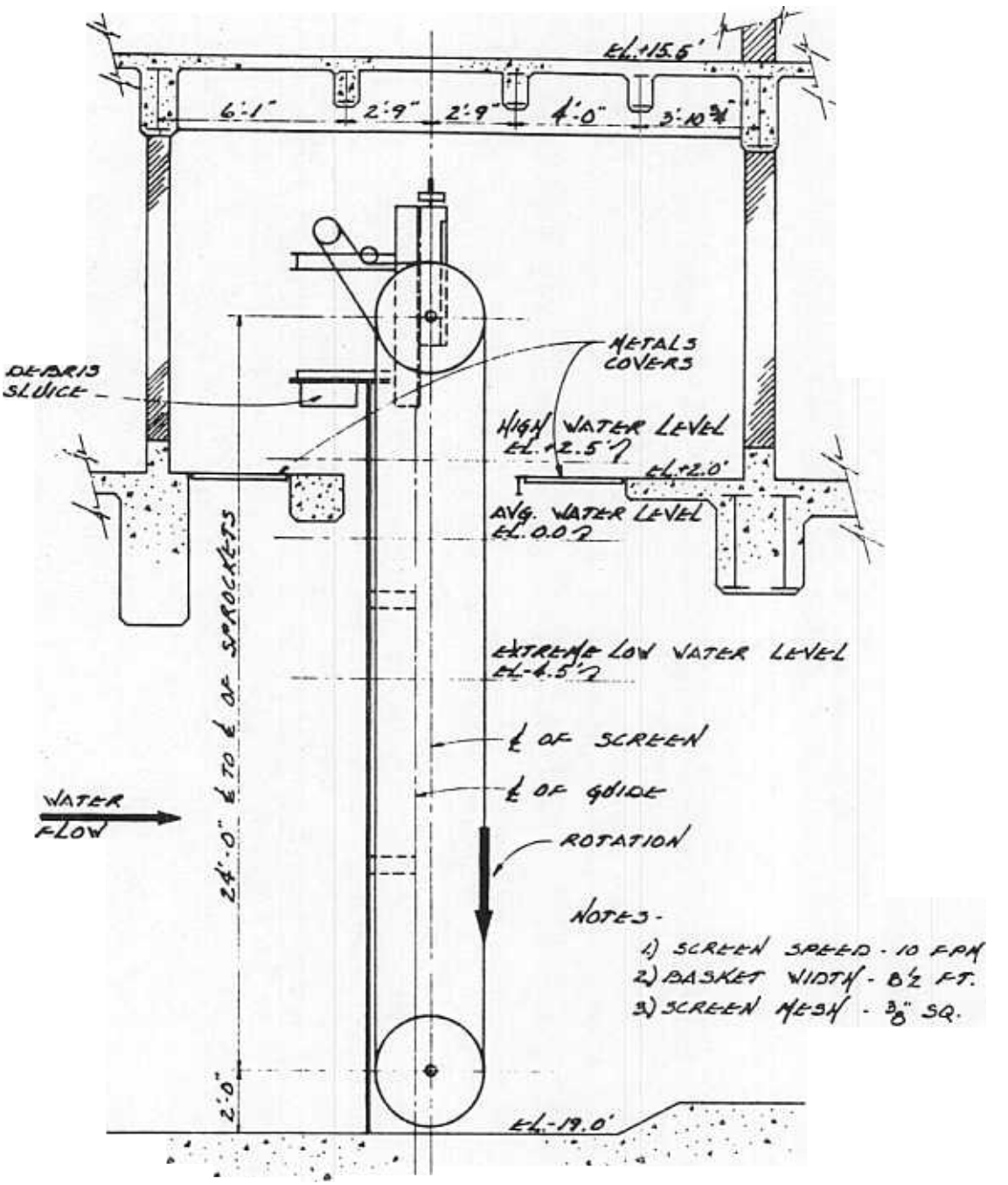

FIGURE I-7. CROSS SECT. OF TRAVELING WATER SCREEN

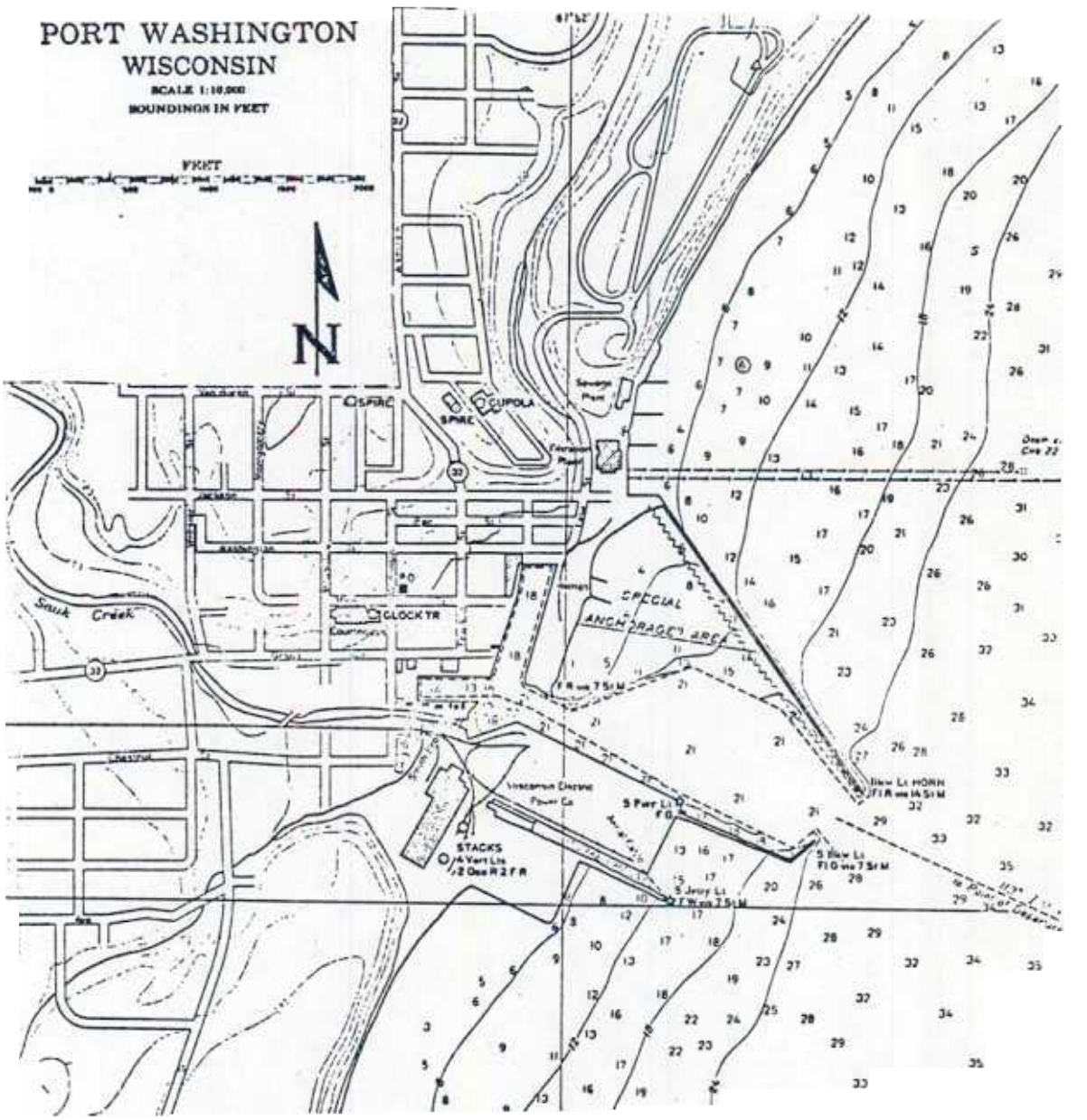

Figure I-8. Contour map of Lake Michigan in the vicinity of Port Washington Power Plant.

II. SAMPLING DATA

The intake monitoring program at Port Washington Power Plant was conducted in accord with the Scope of Work approved by the Wisconsin Department of Natural Resources (letter from P. P. Didier to N. A. Ricci, February 5, 1975).

A. ADULT AND JUVENILE FISH (IMPINGEMENT)

Impingement monitoring was scheduled to be performed one operating day ($\leq$ 24 hrs.) every week during the period March 1, 1975 - February 29, 1976. This schedule was met with one exception; debris load prevented sampling in the first week of January. A total of 51 impingement collections were made.

SAMPLING METHODS

The vertical travelling screens at PWPP are rotated continuously. Debris (including fish) is washed from the front of the screens into a debris return trough. Impinged fish and debris were collected in a large basket of 3/8 inch square mesh placed in the sluiceway beyond the screens (Figure II-1). The basket filled the sluiceway so that all fish in the wash-water could be collected. The basket was frequently inspected and fish removed for tabulation. Occasionally the basket was lifted from the sluiceway to remove debris. Time of basket removal and replacement was always recorded, so that total sampling time/day could be determined.

All fish were collected and identified by trained WEPCo Environmental Department personnel. Identification to species was confirmed by Dr. John J. Ney, WEPCo fisheries biologist. Infrequently, decomposition prevented complete identification. Total length (to the nearest 0.1 inch) and weight (to the nearest .05 lb.) were recorded. Fish were also eviscerated to determine breeding condition. Sexual state was recorded as ripe (running) male or female, unripe male or female, or if gonads could not be identified, as immature. All individuals were processed in the above manner, except for smelt and alewife when total number of those species exceeded 100. In those instances, a random sample of 100 fish was subjected to individual analysis. The total weight for the species was divided by the weight of the sample to obtain an estimate of total number.

Although the trash racks in the approach channel were observed during the sampling program, dead fish were never found there; gaps in the racks permitted passage of even large fish.

IMPINGEMENT DATA

Table II-1 lists impingement data for each sampling date. Included for each species are number, range and mean total length, mean weight, and sex and breeding conditions. Percent of daily cooling water volume which was sampled is also included. Between 48.6 and 100 percent of plant volume was sampled on each date, with the average between 80% and 90%. Variations occurred as functions of debris loading and the need to remove the collection basket for cleaning.

A total of 411,434 impinged fish representing more than 40 species were collected during the monitoring program. Of these, 392,432 (95.38%) were alewife and 13,979 (3.40%) were smelt. Trout and salmon totaled 921 (0.22%). The remaining one percent was divided among indigenous species such as sculpin (0.10%) and ninespine stickleback (0.14%) and warm-water species including centrarchids, cyprinids, etc. Only three coregonids were captured--a bloater and two lake whitefish. No threatened or endangered species were encountered.

B. EGGS AND LARVAE (ENTRAINMENT)

Entrainment sampling for fish eggs and larvae was performed concurrently with impingement collection during the period April 15 - October 31, 1975. The macroinvertebrates, *Mysis relicta* and *Pontoporeia affinis*, were also collected. Entrainment collections were made on twenty-eight dates.

SAMPLING METHODS

Entrainment collections were made with two Kenco Model 32N1 submersible pumps. The pumps were suspended from a bridge at 20% and at 80% of water depth at midstream in the approach channel, approximately 250 feet ahead of the trash rack. This site was chosen for entrainment sampling because it provided the closest point to the travelling screens where pumps could be installed. Current velocity at this site was greater than 1 fps, indicating that all icthyoplankton passing this point were entrained and would enter the plant.

Each pump routinely produced flows between 140 and 170 gpm. Water was pumped through rigid plastic hose (2 inch I.D.) into plankton nets (1 meter diameter, 333 micron mesh)

suspended from the bridge. Approximately the lower third of each net was immersed in the approach channel. Sampled material drained down the net into a collection container at the base of the net. (Figure II-2).

Nets were periodically inspected for clogging and container contents were routinely transferred at approximately eight-hour intervals to sample jars containing 10% formalin. Time of start and stop of pumps was recorded so that total operating time per sampling day could be obtained. Pumps were calibrated prior to and at the conclusion of the sampling day. Calibration involved determining the time to fill a 55-gallon barrel. The mean flow from the two calibrations was multiplied by total sample time to obtain total daily sample volume for each pump.

Samples were analyzed for fish eggs, fish larvae, and macroinvertebrates by Dr. C. R. Norden, University of Wisconsin-Milwaukee icthyologist. Dr. Norden was able to differentiate fertilized eggs from those which had not been fertilized. Only the former are included in this report.

ENTRAINMENT DATA

Table II-2 lists entrainment data for each of the twenty-eight sampling dates. Included are fish larvae, fish eggs, *Pontoporeia affinis* and *Mysis relicta*. More than 43,000 cubic meters of water (11.5 million gallons) were sampled.

A total of 87 fish larvae were collected. These included 31 alewife, 28 smelt, 21 sculpin, and 4 ninespine stickleback. One individual each of lake herring, burbot, and yellow perch were taken. No larvae were collected after September 22.

Fertilized fish eggs were limited to alewife (431), smelt (18), and sculpin (5). No eggs were collected after August 5. *Pontoporeia* and *Mysis* totaled 704 and 70, respectively

C. OTHER DATA

Data on the occurrence and abundance of fish larvae and eggs in the nearshore Port Washington area was collected on thirteen bi-weekly dates between May and October. Sampling was performed at both the intake area and at a reference site one mile to the north.

SAMPLING METHODS

In each area, fish larvae were collected with a 333 micron mesh, 1.5 meter diameter plankton net towed along the 5 and 9 meter contours. Duplicate 5-minute tows were made at the surface, 2 meters, and 4 meters along the 5-meter contour, and at the surface, 3 meters, and 6 meters along the 9-meter contour. This design resulted in 6 tows per depth contour, 12 tows per area. Volume of water sampled by the nets was measured using a current meter suspended in the mouth of the plankton net. This provided a quantitative measurement (number/meter^3) of abundance. Larvae were collected at night to minimize net avoidance.

Fish eggs were collected by duplicate 5-minute bottom samples at 18 and 30 feet in both areas. Collections were made with a diaphragm pump (30-50 gpm) and attached 2-inch diameter rigid plastic hose. Water was pumped into a 333 micron mesh plankton net, and organisms were removed from the net's collection container. Egg sampling was not quantitative, but did demonstrate local occurrence of reproduction.

All egg and larvae samples were placed in 10% formalin and sent to Dr. Norden for analysis.

RESULTS

Table II-3 summarizes the lake survey results. A total of 391 larvae were collected, all before September 22. Ninety-four smelt, 286 alewife, 9 sculpin, 1 perch, and 1 stickleback larvae were taken. The smelt peak on June 10 was not reflected in the entrainment statistics for the same date. The majority (265) of the alewife were captured at the reference area on July 1. Only two alewife were found in the entrainment collection for that date. Overall, approximately ten times as many larvae were captured in the reference area as were taken adjacent to the intake, indicating that the intake area south of the harbor may not be a preferred area for reproduction or may be avoided by larvae. The absolute number of larvae captured in lake survey as well as the density was considerably higher than observed in the entrainment collections.

Fish eggs were found twice at the reference area and twice at the intake sampling area. In both areas, alewife eggs were found in abundance on July 1. Three alewife eggs were found at the intake sampling area on July 16, and three sculpin eggs were taken at the reference area on August 25.

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
3-3	92.3	Alewife	3	0.07	4.0-7.1	5.1			-	1	2
		Brown Trout	10	0.36	6.5-16.3	8.4			1	-	9
		Deepwater Sculpin	4	0.05	3.4-3.5	3.4			2	1	-
		Gizzard Shad	5	0.05	3.3-5.1	4.2			-	1	4
		Goldfish	1	1.50	-	12.5			-	1	-
		Ninespine Stickleback	1	0.05	-	2.9			-	-	-
		Rainbow Trout	4	3.15	10.3-26.5	19.0			-	1	1
		Slimy Sculpin	4	0.05	3.0-3.8	3.3			2	1	1
		Smelt	10	0.06	3.4-7.4	5.1			4	2	3
3-10	93.0	Brook Trout	1	0.81		12.8			-	1	-
		Brown Trout	1	0.10		6.9			-	-	1
		Gizzard Shad	5	0.05	4.0-4.6	4.3			-	5	-
		Rainbow Trout	8	4.41	10.0-27.5	21.2			1		2
		Slimy Sculpin	5	0.05	1.5-3.8	3.1			4		1
		Smelt	6	0.07	2.3-7.3	5.4			1	2	2
		Spottail Shiner	2	0.05	2.8-4.1	3.4			1		1
3-18	93.4	Brown Trout	17	0.29	6.5-14.6	8.2				1	16
		Emerald Shiner	2	0.05	2.8-3.3	3.0				1	1
		Gizzard Shad	4	0.09	4.5-7.0	5.7				1	3
		Rainbow Trout	7	2.54	10.6-23.9	17.1				1	2
		Slimy Sculpin	6	0.05	2.6-3.8	3.2					2
		Smelt	4	0.06	2.7-6.3	3.8					3
		White Sucker	1	0.70		12.0					-

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
3-26	81.1	Alewife	4	0.06	3.2-7.2	4.8	-	1	1	-	2
		Black Bullhead	1	0.05	-	1.9	-	-	-	-	1
		Bluegill Sunfish	8	0.05	1.2-4.0	2.5	-	-	-	-	8
		Brook Stickleback	5	0.05	2.2-2.7	2.4	-	-	-	-	5
		Brown Trout	64	0.21	5.2-12.7	7.5	-	1	-	1	62
		Bullhead Sp.	7	0.05	2.1-6.0	3.5	-	-	-	-	7
		Emerald Shiner	11	0.05	1.4-3.4	2.5	-	-	1	1	9
		Gizzard Shad	26	0.09	3.8-9.0	5.3	2	1	3	5	15
		Longnose Dace	3	0.05	2.6-3.7	3.2	-	-	-	-	3
		Longnose Sucker	4	0.05	2.5-3.4	3.0	-	-	1	-	3
		Ninespine Stickleback	13	0.05	2.3-3.0	2.6	-	-	-	-	13
		Rainbow Trout	5	2.97	7.8-24.0	17.1	1	1	-	1	2
		Rock Bass	1	0.05	-	1.6	-	-	-	-	1
		Sculpin Sp.	1	0.05	-	3.0	-	-	-	-	1
		Shiner Sp.	3	0.05	2.0-2.8	2.4	-	-	-	-	3
		Shorthead Redhorse	2	0.40	5.5-8.7	7.1	-	-	1	-	1
		Slimy Sculpin	19	0.05	1.8-4.5	3.2	1	3	4	4	7
		Smelt	236	0.06	1.6-9.3	4.7	26	34	20	27	129
		Spottail Shiner	9	0.05	1.5-4.0	2.6	-	-	-	1	8
		Trout Perch	1	0.05	-	4.7	-	-	-	1	-
		Unidentified Fish	6	0.05	2.6-3.6	3.0	-	-	-	-	6
		White Sucker	1	0.05	-	2.5	-	-	-	-	1
		Yellow Perch	3	0.20	2.5-8.8	5.6	1	-	-	-	2
4-2	79.3	Alewife	20	0.11	2.8-8.0	5.5	-	1	2	7	10
		Black Bullhead	2	0.05	2.7-3.0	2.8	-	-	-	-	2
		Black Crappie	1	0.50	-	5.4	-	-	-	-	1
		Brook Stickleback	1	0.05	-	2.3	-	-	-	-	1
		Brown Trout	74	0.28	5.1-18.0	8.0	-	-	3	2	69
		Carp	1	1.85	-	15.6	-	-	1	-	-
		Deepwater Sculpin	1	0.05	-	2.0	-	-	-	-	1
		Emerald Shiner	8	0.05	2.3-3.5	2.9	-	-	-	1	7
		Gizzard Shad	21	0.10	3.0-12.0	5.3	-	-	1	7	13

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
4-2	Cont'd	Goldfish	2	0.57	8.0-8.8	8.4	-	-	1	-	1
		Green Sunfish	1	0.05	-	4.2	-	-	-	-	1
		Lake Trout	1	0.05	-	5.6	-	-	-	-	1
		Longnose Dace	6	0.05	2.5-4.7	3.7	-	1	-	2	3
		Longnose Sucker	5	0.05	2.8-4.0	3.5	-	-	-	1	4
		Ninespine Stickleback	93	0.05	2.0-3.1	2.5	1	-	14	12	66
		Northern Pike	4	0.52	4.4-18.3	10.9	-	-	1	-	3
		Rainbow Trout	9	2.35	8.0-22.5	16.3	3	2	-	-	4
		Rock Bass	1	0.05	-	1.8	-	-	-	-	1
		Slimy Sculpin	32	0.05	1.6-4.5	2.9	2	3	5	4	18
		Smelt	874	0.03	2.0-10.0	3.7	40	47	114	101	572
		Spottail Shiner	3	0.05	1.9-2.5	2.2	-	-	-	-	3
		Unidentified Fish	10	0.05	1.5-3.8	2.4	-	-	-	-	10
		White Sucker	3	1.68	8.2-20.0	14.0	-	-	2	1	-
		Yellow Perch	8	0.08	2.3-7.8	4.0	-	1	1	1	5
4-7	94.3	Alewife	16	0.08	4.3-8.1	6.5	1	4	3	3	5
		Brook Stickleback	2	0.05	2.0-2.2	2.1	-	-	-	1	1
		Brook Trout	2	0.13	7.7-8.0	7.8	-	-	1	1	-
		Brown Trout	17	0.45	6.7-17.2	8.9	-	-	2	-	15
		Emerald Shiner	6	0.05	2.3-3.4	3.0	-	-	-	1	5
		Fathead Minnow	1	0.05	-	2.5	-	-	-	-	1
		Gizzard Shad	13	0.11	3.7-12.0	5.3	-	-	3	1	9
		Goldfish	1	0.80	-	9.3	-	-	-	1	-
		Lake Trout	4	0.05	4.8-5.5	5.2	-	-	-	-	4
		Longnose Dace	2	0.05	3.7-4.2	3.9	1	-	-	-	1
		Mudminnow	1	0.05	-	3.0	-	-	-	-	1
		Ninespine Stickleback	14	0.05	2.1-3.0	2.5	-	-	2	5	7
		Rock Bass	2	0.05	1.5-1.7	1.6	-	-	-	-	2
		Slimy Sculpin	10	0.05	2.1-3.7	2.7	-	-	2	3	5
		Smelt	159	0.06	1.6-9.4	4.0	20	27	5	4	103
		Spottail Shiner	2	0.05	3.0-3.6	3.3	2	-	-	-	-
		White Sucker	1	0.05	-	2.7	-	-	-	-	1

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
4-15	91.4	Brown Bullhead	1	0.05	-	3.1	-	-	-	-	1
		Brown Trout	8	0.15	6.2-8.4	7.6	-	-	-	-	8
		Emerald Shiner	2	0.05	2.5-4.2	3.3	-	-	-	-	2
		Gizzard Shad	3	0.05	3.0-5.5	4.5	-	-	-	1	2
		Goldfish	1	0.38	-	7.8	-	-	1	-	-
		Johnny Darter	1	0.05	-	1.3	-	-	-	-	1
		Lake Trout	1	0.05	-	5.4	-	-	-	-	1
		Mudminnow	1	0.05	-	3.1	-	-	-	-	1
		Ninespine Stickleback	18	0.05	2.1-3.2	2.7	-	-	-	4	14
		Northern Pike	1	0.50	-	13.3	1	-	-	-	-
		Rainbow Trout	3	1.35	5.4-21.0	10.8	-	1	-	-	2
		Slimy Sculpin	3	0.05	3.0-3.6	3.4	-	-	1	1	1
		Smelt	30	0.07	2.4-9.0	5.5	8	8	2	4	8
		Spottail Shiner	2	0.05	3.0-3.3	3.1	-	-	-	-	2
4-23	78.1	Alewife	255	0.09	3.4-8.5	7.3	3	9	83	137	23
		Brook Trout	3	0.12	5.8-8.0	6.9	-	-	1	-	2
		Brown Trout	15	0.30	6.7-16.0	8.3	-	-	2	-	13
		Emerald Shiner	3	0.05	2.8-3.6	3.3	-	-	-	-	3
		Gizzard Shad	2	0.22	5.8-10.5	8.1	-	-	1	-	1
		Goldfish	2	0.42	6.7-8.8	7.7	-	-	2	-	-
		Lake Chub	1	0.15	-	7.5	-	1	-	-	-
		Longnose Dace	1	0.05	-	2.8	-	-	-	-	1
		Mudminnow	1	0.05	-	5.0	-	-	-	-	1
		Ninespine Stickleback	27	0.05	2.1-3.4	2.5	-	-	2	2	23
		Northern Pike	1	0.25	-	9.8	-	-	-	-	1
		Rainbow Trout	2	5.70	20.9-26.0	23.4	-	1	-	1	-
		Shorthead Redhorse	1	0.05	-	3.2	-	-	-	-	1
		Slimy Sculpin	17	0.05	1.6-3.7	3.0	1	1	2	3	10
		Smelt	146	0.06	1.8-9.0	4.1	18	23	2	2	101
		Sunfish Sp.	1	0.05	-	1.7	-	-	-	-	1
		Yellow Perch	1	0.50	-	10.6	-	1	-	-	-

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
4-28	68.4	Alewife	2,033	0.09	3.0-8.2	7.5	-	-	650	935	448
		Brook Trout	1	0.10	-	7.9	-	-	-	1	-
		Brown Trout	32	0.28	6.4-17.5	8.2	-	-	-	2	30
		Bullhead Sp.	3	0.05	2.1-4.0	3.3	-	-	-	-	3
		Carp	1	15.20	-	30.3	-	-	-	1	-
		Gizzard Shad	16	0.19	4.2-11.2	6.8	-	-	2	9	5
		Goldfish	1	0.25	-	5.3	-	-	1	-	-
		Largemouth Bass	1	0.20	-	8.0	-	-	-	-	1
		Longnose Dace	14	0.05	2.0-4.6	3.6	-	3	1	3	7
		Longnose Sucker	1	0.05	-	2.5	-	-	-	-	1
		Ninespine Stickleback	24	0.05	2.0-3.0	2.5	-	-	5	5	14
		Rainbow Trout	1	4.30	-	22.5	-	1	-	-	-
		Slimy Sculpin	23	0.05	1.6-3.9	2.9	2	7	3	2	9
		Smelt	350	0.06	1.6-9.1	4.0	33	49	7	7	254
		Unidentified Fish	4	0.09	2.3-10.5	4.8	-	2	-	-	2
		White Sucker	4	0.60	4.2-13.5	9.7	1	-	2	-	1
		Yellow Perch	2	0.57	9.9-11.0	10.4	-	-	-	2	-
5-5	93.3	Alewife	2,566	0.07	2.4-8.1	6.9	1	-	861	1,163	541
		Brown Trout	14	0.28	5.2-13.3	8.5	-	-	1	-	13
		Emerald Shiner	1	0.05	-	2.5	-	-	-	-	1
		Gizzard Shad	3	0.05	4.5-5.0	4.8	-	-	-	1	2
		Green Sunfish	1	0.05	-	3.3	-	-	-	-	1
		Longnose Dace	2	0.05	3.5-4.0	3.7	-	-	-	-	2
		Ninespine Stickleback	82	0.05	1.9-3.4	2.6	-	5	7	29	41
		Rainbow Trout	4	4.57	6.6-31.0	22.5	-	1	-	2	1
		Slimy Sculpin	17	0.05	2.0-3.7	2.8	-	3	4	7	3
		Smelt	17	0.06	3.0-7.0	5.0	3	4	-	3	7
		Spottail Shiner	1	0.05	-	4.2	-	-	-	1	-
		White Sucker	2	0.97	3.0-17.3	10.1	-	-	1	-	1
		Yellow Perch	1	0.40	-	9.5	-	-	-	1	-

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
5/13	97.2	Alewife	959	0.07	2.6-8.6	7.0	77	115	190	345	232
		Black Crappie	1	0.25	-	7.7	-	-	1	-	-
		Brook Trout	2	0.11	6.8-7.9	7.3	-	-	-	1	1
		Brown Trout	9	0.21	6.0-9.1	8.0	-	-	-	-	9
		Chinook Salmon	1	0.95	-	13.8	-	-	-	-	1
		Emerald Shiner	2	0.05	3.1-4.3	3.7	-	-	1	-	1
		Gizzard Shad	4	0.27	5.1-11.4	8.0	-	-	1	1	2
		Goldfish	1	0.50	-	8.0	-	-	1	-	-
		Green Sunfish	1	0.05	-	3.2	-	-	-	-	1
		Longnose Dace	12	0.05	3.1-5.5	3.9	-	1	4	5	2
		Ninespine Stickleback	118	0.05	1.8-3.2	2.5	-	18	37	47	16
		Rainbow Trout	4	4.82	7.1-31.5	21.2	-	1	-	2	1
		Slimy Sculpin	14	0.05	1.5-4.6	2.9	1	6	1	5	1
		Smelt	41	0.07	3.0-9.7	5.9	20	3	7	5	6
		Spottail Shiner	1	0.05	-	2.7	-	-	1	-	-
		Tiger Trout	1	0.05	-	8.8	-	-	-	-	1
		White Sucker	1	2.18	-	18.5	-	-	-	1	-
		Yellow Perch	1	0.70	-	11.7	-	-	-	1	-
5/21	70.7	Alewife	63,240	0.05	3.4-8.3	7.0	6,235	-	30,443	25,295	1,267
		Brown Trout	9	0.82	7.0-21.8	9.5	-	-	1	-	8
		Chinook Salmon	3	3.25	9.4-29.2	17.3	-	-	2	-	1
		Gizzard Shad	2	0.41	10.0-10.5	10.2	-	-	2	-	-
		Goldfish	1	0.40	-	6.7	-	-	1	-	-
		Longnose Dace	8	0.05	3.2-5.9	3.9	1	-	3	3	1
		Ninespine Stickleback	121	0.05	1.7-3.9	2.5	-	59	49	7	6
		Rainbow Trout	3	1.14	7.4-22.5	12.5	-	-	1	1	1
		Slimy Sculpin	8	0.05	2.6-3.9	3.1	-	2	3	-	3
		Smelt	376	0.05	2.8-9.3	4.0	75	15	104	37	145
		Spottail Shiner	3	0.05	3.6-4.2	3.9	-	-	1	-	2
		White Sucker	2	0.52	8.6-14.5	11.5	-	1	-	-	1

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
5/29	90.3	Alewife	31,248	0.07	2.7-8.2	7.0	-	-	12,499	15,623	3,126
		Brown Trout	6	0.22	5.7-8.6	8.0	-	-	1	-	5
		Chinook Salmon	30	0.07	2.4-12.1	3.4	-	-	-	-	30
		Emerald Shiner	1	0.05	-	3.5	-	-	-	1	-
		Lake Chub	13	0.13	5.4-7.8	6.6	6	6	-	1	-
		Longnose Dace	22	0.05	3.0-5.1	3.9	-	4	11	6	1
		Ninespine Stickleback	152	0.05	1.4-3.7	2.5	20	91	23	2	16
		Rainbow Trout	5	1.57	7.4-22.0	13.8	-	2	1	-	2
		Sculpin sp.	1	0.05	-	3.4	-	1	-	-	-
		Slimy Sculpin	4	0.05	2.9-3.5	3.1	2	2	-	-	-
		Smelt	283	0.08	5.4-8.7	7.0	80	5	157	39	2
		Spottail Shiner	10	0.06	3.1-5.1	4.0	-	1	4	5	-
		Unid. Fish	1	0.10	-	6.1	-	1	-	-	-
		White Sucker	5	1.96	7.0-20.0	15.1	1	-	1	2	1
		Yellow Perch	1	0.10	-	5.2	-	-	1	-	-
6/2	94.2	Alewife	15,944	0.06	3.9-8.7	7.1	-	-	7,015	8,928	1
		Brook Trout	1	0.20	-	8.5	-	-	-	-	1
		Brown Trout	2	0.22	7.8-8.1	7.9	-	-	-	-	2
		Lake Chub	1	0.10	-	6.5	-	-	-	1	-
		Longnose Dace	10	0.07	3.2-7.6	4.5	-	-	7	3	-
		Ninespine Stickleback	44	0.05	2.1-3.2	2.6	1	33	7	3	-
		Northern Pike	1	6.90	-	33.2	-	-	-	1	-
		Rainbow Trout	2	2.94	14.8-22.3	18.5	-	-	1	1	-
		Slimy Sculpin	4	0.05	2.1-3.0	2.6	-	-	-	3	1
		Smelt	75	0.08	4.2-9.0	6.8	27	3	34	5	6
6/10	88.3	Alewife	12,250	0.07	4.6-8.3	7.0	232	734	4,422	6,614	248
		Chinook Salmon	2	0.05	2.9-3.4	3.1	-	-	-	-	2
		Coho Salmon	1	0.20	-	9.9	-	-	-	-	1
		Gizzard Shad	1	0.42	-	10.7	-	-	1	-	-
		Ninespine Stickleback	13	0.05	2.4-3.2	2.7	3	8	-	1	1
		Slimy Sculpin	4	0.05	3.4-3.7	3.6	-	-	3	-	1

Table II.1. Summary of Fish Impingement Data,
March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Breeding State: Ripe Female	Breeding State: Unripe Male	Breeding State: Unripe Female	Imm.
6-10 (cont'd)		Smelt	152	0.06	3.5-8.6	6.2	16	5	70	8	53
		Trout Perch	1	0.05	-	5.1	1	-	-	-	-
		Yellow Perch	1	0.07	-	10.2	-	1	-	-	-
6-19	76.6	Alewife	100,424	0.05	2.7-8.2	6.7	30,127	16,068	2,008	8,034	44,187
		Brown Trout	3	2.13	9.0-19.8	13.2	-	-	-	1	2
		Carp	3	8.57	25.2-26.7	26.1	-	-	1	2	-
		Chinook Salmon	42	0.12	2.9-21.0	4.0	-	-	-	1	41
		Coho Salmon	7	0.81	5.1-8.5	6.9	-	-	-	-	7
		Gizzard Shad	1	0.30	-	9.5	-	-	-	1	-
		Goldfish	1	0.06	-	8.2	-	-	1	-	-
		Lake Chub	1	0.13	-	7.3	-	1	-	-	-
		Longnose Dace	1	0.05	-	3.1	1	-	-	-	-
		Ninespine Stickleback	12	0.05	2.2-3.0	2.7	1	10	1	-	-
		Slimy Sculpin	1	0.05	-	2.2	-	-	-	-	1
		Smelt	222	0.04	2.2-9.7	6.1	-	-	119	-	103
		Trout Perch	5	0.06	3.2-5.9	4.6	2	3	-	-	-
		Yellow Perch	1	0.20	-	10.2	-	-	1	-	-
6-26	65.8	Alewife	56,275	0.07	2.8-9.5	7.2	16,781	14,541	6,854	6,843	11,256
		Brown Trout	1	0.20	-	7.8	-	-	-	-	1
		Carp	12	7.24	18.0-27.2	24.2	9	2	-	-	1
		Chinook Salmon	18	0.05	2.9-5.2	3.8	-	-	-	-	18
		Coho Salmon	1	0.05	-	6.7	-	-	-	-	1
		Fathead Minnow	1	0.05	-	2.1	-	-	-	-	1
		Gizzard Shad	2	0.21	5.7-10.2	7.9	-	1	1	-	-
		Lake Chub	8	0.11	4.4-7.9	6.1	1	4	-	3	-
		Longnose Dace	79	0.05	2.6-5.1	3.9	19	49	8	2	1
		Ninespine Stickleback	21	0.05	2.0-3.0	2.6	-	20	1	-	-
		Northern Pike	1	2.80	-	25.0	-	-	1	-	-

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
6-26 (cont'd)		Rainbow Trout	1	3.60	-	22.3	-	1	-	-	-
		Sculpin sp.	1	0.05	-	3.2	-	-	-	-	1
		Slimy Sculpin	4	0.05	3.0-4.2	3.5	-	-	-	3	1
		Smelt	88	0.05	2.7-8.9	4.5	1	1	5	1	80
		Spottail Shiner	5	0.05	2.8-4.3	3.5	-	3	-	-	2
		Trout Perch	9	0.06	3.2-5.5	4.0	3	6	-	-	-
		White Sucker	4	1.66	15.5-16.2	15.9	1	-	2	1	-
		Yellow Perch	2	0.06	5.1-6.6	5.8	-	-	-	-	2
7-1	86.5	Alewife	28,461	0.02	2.0-7.7	3.5	569	2,276	2,276	2,276	21,064
		Black Crappie	1	0.35	-	8.0	-	-	1	-	-
		Brown Trout	2	2.50	7.1-19.0	13.0	-	-	1	-	1
		Chinook Salmon	8	0.06	3.5-4.7	4.1	-	-	-	-	8
		Coho Salmon	7	0.10	5.0-8.7	6.0	-	-	-	1	6
		Lake Chub	7	0.14	5.9-7.9	7.0	1	1	-	5	-
		Lake Whitefish	1	1.80	-	17.2	-	-	-	1	-
		Longnose Dace	60	0.05	2.9-5.7	4.0	7	47	-	2	4
		Longnose Sucker	1	1.70	-	17.0	-	-	1	-	-
		Ninespine Stickleback	7	0.05	2.0-3.9	2.9	-	2	1	2	2
		Slimy Sculpin	3	0.05	3.2-3.5	3.4	1	1	1	-	-
		Smelt	962	0.01	3.2-8.5	4.7	-	-	76	39	847
		Spottail Shiner	1	0.05	-	3.0	-	-	1	-	-
		Trout Perch	2	0.05	4.0	4.0	1	1	-	-	-
		White Sucker	3	1.50	10.0-18.8	14.4	-	-	2	1	-
		Yellow Perch	2	0.40	8.9-10.2	9.5	-	-	2	-	-
7-8	78.2	Alewife	17,634	0.06	3.5-8.0	7.0	4,951	7,713	1,396	1,809	1,765
		Brown Trout	1	0.35	-	10.0	-	-	-	-	1
		Coho Salmon	22	0.07	3.8-9.0	5.6	-	-	-	-	22
		Emerald Shiner	1	0.05	-	3.4	-	-	-	1	-
		Fathead Minnow	1	0.05	-	2.1	-	-	-	-	1

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
7-8 (cont'd)		Green Sunfish	2	0.07	3.9-4.2	4.0	1	-	1	-	-
		Lake Chub	2	0.12	6.3-6.5	6.4	-	-	1	1	-
		Longnose Dace	37	0.05	3.2-5.2	4.2	7	28	-	1	1
		Ninespine Stickleback	9	0.05	2.6-3.9	3.0	-	5	-	1	3
		Rainbow Trout	2	4.87	7.8-30.5	19.1	1	-	-	-	1
		Slimy Sculpin	13	0.05	2.0-3.6	3.1	2	-	3	2	6
		Smelt	677	0.01	3.3-7.4	4.3	-	-	5	5	667
		Spottail Shiner	1	0.05	-	3.1	-	-	-	-	1
		Trout Perch	2	0.05	4.3-5.2	4.7	1	1	-	-	-
		White Sucker	2	2.30	18.2-18.5	18.3	-	-	-	2	-
		Yellow Perch	4	0.19	5.1-9.2	7.3	1	1	-	-	2
7-16	84.5	Alewife	9,523	0.07	2.7-8.6	7.1	1,514	2,475	1,342	2,285	1,907
		Chinook Salmon	18	0.05	3.9-5.3	4.3	-	-	-	-	18
		Coho Salmon	5	0.13	4.7-8.2	6.4	-	-	-	-	5
		Goldfish	2	0.65	8.7-9.7	9.2	2	-	-	-	-
		Lake Chub	3	0.12	6.8-7.4	7.2	-	1	-	2	-
		Longnose Dace	24	0.05	3.1-5.0	4.0	5	12	-	2	5
		Ninespine Stickleback	4	0.05	2.3-3.1	2.7	-	2	-	-	2
		Slimy Sculpin	6	0.05	1.8-3.6	3.1	-	-	2	-	4
		Smelt	242	0.01	2.5-8.5	4.0	-	-	19	14	209
		Spottail Shiner	2	0.05	3.3-3.7	3.5	-	- 2	-	-	-
		Yellow Perch	1	0.05	-	5.0	-	-	-	-	1

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
7-21	92.6	Alewife	13,423	0.05	2.8-8.1	7.3	-	-	2,953	5,100	5,370
		Brook Trout	1	0.30	-	9.2	-	-	-	-	1
		Brown Trout	3	2.68	7.9-24.5	13.5	-	1	-	1	1
		Chinook Salmon	16	0.06	4.0-5.9	4.7	-	-	-	-	16
		Coho Salmon	3	0.08	5.0-7.1	5.7	-	-	-	-	3
		Lake Chub	1	0.15	-	7.6	-	1	-	-	-
		Ninespine Stickleback	8	0.05	2.2-3.0	2.7	-	6	1	-	1
		Rainbow Trout	1	0.15	-	7.0	-	-	-	-	1
		Shiner sp.	1	0.05	-	3.1	-	-	-	-	1
		Slimy Sculpin	9	0.05	2.3-4.0	3.3	-	2	1	4	2
		Smelt	204	0.02	2.4-8.3	3.8	-	-	20	28	156
		Trout Perch	3	0.07	4.3-5.4	4.9	3	-	-	-	-
		White Sucker	1	1.30	-	15.5	-	1	-	-	-
		Yellow Perch	2	0.15	6.1-7.4	6.7	-	1	1	-	-
7-29	79.2	Alewife	19,639	0.05	3.0-8.3	7.0	2,686	2,356	4,776	7,462	2,359
		Brown Trout	3	0.53	9.0-11.5	10.0	-	-	2	-	1
		Chinook Salmon	5	0.06	4.7-5.8	5.1	-	-	-	-	5
		Coho Salmon	9	0.07	2.8-8.5	5.2	-	1	-	-	8
		Lake Chub	10	0.10	5.0-7.9	6.1	-	-	1	5	4
		Longnose Dace	11	0.05	2.7-4.5	3.8	3	3	1	3	1
		Ninespine Stickleback	14	0.05	2.2-2.9	2.6	-	4	3	3	4
		Slimy Sculpin	5	0.05	2.7-3.0	2.8	-	-	2	2	1
		Smelt	605	0.02	2.3-9.9	3.6	-	-	24	48	533
		Spottail Shiner	3	0.05	2.8-3.8	3.3	1	1	1	-	-
		Trout Perch	5	0.05	3.0-5.0	4.3	-	4	-	1	-
		White Sucker	1	2.00	-	19.2	-	-	-	1	-
		Yellow Perch	1	0.06	-	5.0	-	-	-	-	1

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Breeding State: Ripe Female	Breeding State: Unripe Male	Breeding State: Unripe Female	Imm.
8/5	94.2	Alewife	2,715	0.08	2.8-8.1	6.8	399	1,086	469	488	273
		Bluegill Sunfish	1	0.05	-	3.7	-	-	-	-	1
		Chinook Salmon	4	0.09	4.1-9.7	5.7	-	-	-	-	4
		Coho Salmon	8	0.13	4.8-9.6	6.7	-	-	-	-	8
		Juvenile Pacific Salmon	17	0.05	4.6-5.6	5.0	-	-	-	-	17
		Lake Chub	1	0.10	-	4.8	-	-	-	1	-
		Ninespine Stickleback	6	0.05	2.2-2.7	2.4	-	2	2	-	2
		Rainbow Trout	1	0.20	-	7.8	-	-	-	-	1
		Slimy Sculpin	3	0.05	2.9-3.5	3.2	-	-	1	1	1
		Smelt	672	0.01	2.4-7.0	3.3	38	-	52	38	544
		Trout Perch	3	0.05	3.1-4.4	3.6	1	2	-	-	0
		White Sucker	3	0.32	10.5-11.6	11.1	-	-	2	1	-
		Yellow Perch	2	0.15	5.6-7.8	6.7	-	-	1	-	1
8/14	76.1	Alewife	1,629	0.07	3.1-8.2	7.0	31	325	359	554	360
		Brown Trout	4	4.61	7.8-25.7	18.2	-	-	2	1	1
		Chinook Salmon	9	0.10	4.9-11.7	7.1	-	-	-	-	9
		Coho Salmon	1	0.15	-	7.5	-	-	-	-	1
		Green Sunfish	2	0.05	3.6-4.0	3.8	-	-	-	-	2
		Juvenile Pacific Salmon	3	0.10	5.1-8.4	6.7	-	-	-	-	3
		Lake Chub	27	0.07	3.2-7.3	5.4	-	-	3	11	13
		Longnose Dace	6	0.05	4.1-4.9	4.5	-	1	-	4	-
		Ninespine Stickleback	5	0.05	2.3-2.7	2.5	-	1	1	-	3
		Rainbow Trout	3	0.25	7.6-9.4	8.4	-	-	-	-	3
		Slimy Sculpin	10	0.05	2.6-4.0	3.2	-	-	3	4	3
		Smelt	1,225	0.01	2.3-5.7	3.9	-	-	-	-	1,225
		Spottail Shiner	4	0.05	2.6-4.2	3.6	-	1	-	-	3
		Trout Perch	9	0.05	3.6-5.0	4.2	2	6	-	1	-
		White Sucker	11	0.27	4.5-12.1	8.6	-	-	3	2	6
		Yellow Perch	3	0.12	3.5-8.7	5.3	1	-	-	-	2

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
8/21	88.3	Alewife	561	0.07	2.8-8.1	7.0	-	5	246	274	36
		Brown Trout	3	3.37	9.5-23.1	17.7	1	-	1	-	1
		Green Sunfish	2	0.05	4.0-4.7	4.3	-	-	-	-	2
		Juvenile Pacific Salmon	2	0.05	5.3-5.6	5.4	-	-	-	-	2
		Lake Chub	1	0.10	-	7.0	-	-	-	1	-
		Longnose Dace	2	0.05	4.3-4.4	4.3	-	-	-	2	-
		Ninespine Stickleback	2	0.05	2.4-2.7	2.5	-	-	-	1	1
		Slimy Sculpin	2	0.05	3.3-3.8	3.5	-	-	2	-	-
		Smelt	766	0.01	2.2-4.5	3.1	-	-	-	-	766
		Trout Perch	1	0.05	-	4.1	-	-	-	-	1
		White Sucker	1	1.40	-	8.5	-	-	1	-	-
8/25	96.5	Alewife	1,251	0.07	3.2-8.2	7.0	27	25	522	475	202
		Black Crappie	1	0.20	-	7.8	-	-	-	-	1
		Brown Trout	1	9.00	-	24.5	-	-	1	-	-
		Coho Salmon	1	0.35	-	10.5	-	-	-	-	1
		Emerald Shiner	2	0.05	3.5-3.8	3.6	-	-	-	1	1
		Juvenile Pacific Salmon	1	0.10	-	5.9	-	-	-	-	1
		Longnose Dace	2	0.05	3.3-3.5	3.4	-	1	-	-	1
		Ninespine Stickleback	1	0.05	-	2.5	-	-	-	-	1
		Rock Bass	1	0.05	-	3.2	-	-	-	-	1
		Slimy Sculpin	2	0.05	1.7-3.0	2.3	-	-	-	1	1
		Smelt	344	0.01	2.7-8.8	3.3	-	-	-	13	331
		Spottail Shiner	1	0.05	-	2.5	-	-	-	-	1
		White Sucker	1	0.07	-	12.1	-	-	1	-	-

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
9-2	91.9	Alewife	188	0.06	2.2-8.2	6.9	-	-	37	78	73
		Brown Trout	2	5.50	20.4-23.7	22.0	-	-	2	-	-
		Carp	4	0.05	2.2-3.7	3.0	-	-	-	-	4
		Chinook Salmon	1	0.50	-	11.0	-	-	1	-	-
		Coho Salmon	1	0.62	-	12.4	-	-	-	1	-
		Gizzard Shad	6	0.06	3.5-5.9	4.5	-	-	-	-	6
		Goldfish	2	0.05	4.2-4.5	4.3	-	-	-	-	2
		Longnose Dace	2	0.05	3.7-4.3	4.0	-	-	-	1	1
		Rainbow Trout	4	5.17	13.2-25.9	21.6	1	-	3	-	-
		Slimy Sculpin	5	0.05	2.5-3.6	3.1	-	-	1	2	2
		Smelt	101	0.05	2.1-7.7	4.1	-	1	7	8	85
		Spottail Shiner	1	0.05	-	2.4	-	-	-	-	1
		Trout Perch	2	0.05	3.2-5.1	4.1	-	1	-	1	-
		White Sucker	2	1.05	9.8-15.9	12.8	-	-	1	1	-
		Yellow Perch	1	0.40	-	9.8	-	-	-	-	1
9-10	78.7	Alewife	532	0.06	2.7-8.7	6.5	-	-	127	85	320
		Bloater	1	0.05	-	3.2	-	-	-	-	1
		Bluegill Sunfish	1	0.05	-	3.8	-	-	-	-	1
		Brook Trout	1	2.20	-	17.2	-	1	-	-	-
		Brown Trout	9	5.08	9.7-25.8	19.9	1	3	2	1	2
		Carp	13	0.05	2.1-4.0	2.9	-	-	-	-	13
		Coho Salmon	1	0.70	-	12.8	-	-	1	-	-
		Emerald Shiner	1	0.05	-	4.4	-	-	-	-	1
		Gizzard Shad	5	0.06	3.8-5.0	4.4	-	-	-	-	5
		Juvenile Pacific Salmon	1	0.15	-	7.4	-	-	-	-	1
		Longnose Dace	15	0.05	2.6-4.6	4.0	-	1	6	6	2
		Ninespine Stickleback	5	0.05	2.0-2.4	2.2	-	-	-	-	5
		Rainbow Trout	9	3.84	5.4-27.7	17.1	-	-	2	4	3
		Shiner sp.	2	0.05	3.1-4.1	3.6	-	-	1	1	-
		Slimy Sculpin	9	0.05	2.4-3.7	3.2	-	-	3	4	2
		Smelt	3,683	0.01	2.4-7.4	3.0	-	-	-	-	3,683
		Trout Perch	3	0.05	3.5-4.7	4.0	-	2	-	-	1
		White Sucker	2	1.10	11.4-15.2	13.3	-	-	-	2	-

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
9-15	68.8	Alewife	160	0.05	1.7-8.0	6.7	-	-	15	38	107
		Black Bullhead	1	0.05	-	3.6	-	-	-	-	1
		Bloater	1	0.05	-	3.2	-	-	-	-	1
		Bluegill Sunfish	1	0.10	-	4.9	-	-	-	-	1
		Brown Trout	10	7.07	21.4-27.0	23.4	5	-	2	3	-
		Carp	2	0.05	2.5-3.5	3.0	-	-	-	-	2
		Coho Salmon	2	4.17	4.7-25.7	15.2	-	-	1	-	1
		Emerald Shiner	1	0.05	-	2.3	-	-	-	-	1
		Gizzard Shad	9	0.05	2.3-4.2	3.1	-	-	-	-	9
		Green Sunfish	1	0.10	-	4.6	-	-	-	-	1
		Longnose Dace	9	0.05	3.2-4.0	3.6	-	-	-	1	8
		Ninespine Stickleback	1	0.05	-	3.0	-	-	-	-	1
		Rainbow Trout	3	7.78	22.3-25.2	24.1	-	1	-	2	-
		Slimy Sculpin	12	0.05	1.1-3.5	2.4	-	-	-	-	12
		Smelt	833	0.01	2.6-6.3	3.2	-	-	-	-	833
		Yellow Perch	1	1.40	-	13.2	-	-	-	1	-
9-22	98.5	Alewife	308	0.01	2.5-6.9	3.1	-	-	-	-	308
		Atlantic Salmon	1	9.00	-	25.5	-	-	-	1	-
		Carp	1	0.05	-	3.0	-	-	-	-	1
		Emerald Shiner	1	0.05	-	3.7	-	-	1	-	-
		Gizzard Shad	10	0.05	3.2-5.2	4.0	-	-	-	-	10
		Juvenile Pacific Salmon	1	0.10	-	6.6	-	-	-	-	1
		Longnose Dace	2	0.05	4.1-4.5	4.3	-	1	-	1	-
		Slimy Sculpin	1	0.05	-	2.6	-	-	-	-	1
		Smelt	20	0.05	3.1-7.3	4.4	-	-	-	-	20
		Spottail Shiner	3	0.05	2.7-4.0	3.5	-	-	2	-	1
		White Sucker	3	0.27	7.5-9.7	8.9	-	-	1	-	2

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
9-30	93.3	Alewife	232	0.02	2.0-8.2	2.8	-	-	10	14	208
		Black Crappie	1	0.05	-	2.4	-	-	-	-	1
		Brown Trout	14	5.69	15.1-28.4	22.1	6	2	1	5	-
		Chinook Salmon	1	6.80	-	25.1	-	-	-	1	-
		Emerald Shiner	1	0.05	-	3.3	-	-	-	-	1
		Gizzard Shad	93	0.05	2.7-7.1	4.4	-	-	-	1	92
		Lake Trout	7	6.32	26.8-28.5	28.0	1	-	1	5	-
		Longnose Dace	2	0.05	4.2-5.0	4.6	-	-	-	2	-
		Rainbow Trout	2	7.50	23.0-27.1	25.0	-	-	-	2	-
		Shiner sp.	1	0.05	-	3.7	-	-	-	-	1
		Slimy Sculpin	4	0.05	2.2-3.6	2.9	-	-	-	-	4
		Smelt	12	0.05	2.3-6.2	3.9	-	-	-	-	12
		Spottail Shiner	1	0.05	-	4.1	-	-	-	-	1
		White Crappie	1	0.20	-	7.5	-	-	-	-	1
		White Sucker	1	1.80	-	15.3	-	-	-	1	-
10-8	96.9	Alewife	603	0.01	2.2-8.0	2.8	-	-	2	-	601
		Brown Trout	19	6.32	14.8-26.1	22.7	16	1	-	2	-
		Coho Salmon	2	7.45	25.9-26.5	26.2	-	2	-	-	-
		Deepwater Sculpin	1	0.05	-	3.7	-	-	-	1	-
		Emerald Shiner	1	0.05	-	3.8	-	1	-	-	-
		Gizzard Shad	90	0.16	2.9-7.7	6.4	-	2	54	1	33
		Lake Trout	22	7.41	25.5-31.2	27.5	6	2	2	11	1
		Ninespine Stickleback	2	0.05	2.2-2.7	2.4	-	-	-	-	2
		Rainbow Trout	2	4.60	14.2-26.1	20.1	-	-	2	-	-
		Shiner sp.	1	0.05	-	3.5	-	-	-	-	1
		Shorthead Redhorse	1	0.05	-	3.3	-	-	-	-	1
		Slimy Sculpin	1	0.05	-	2.2	-	-	-	-	1
		Smelt	38	0.05	2.9-7.4	4.1	-	-	4	-	34
		White Sucker	5	0.75	5.8-14.6	11.1	-	-	4	-	1

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
10-13	81.9	Alewife	7,112	0.01	1.8-3.7	2.6					7,112
		Brown Trout	9	4.83	19.9-24.2	21.7	6		2	1	-
		Coho Salmon	1	1.00	-	13.2			1		-
		Emerald Shiner	1	0.05	-	2.8			-		1
		Gizzard Shad	35	0.05	3.4-7.1	5.0			2		33
		Lake Trout	2	6.80	26.5-28.1	27.3		2			-
		Largemouth Bass	1	0.70	-	11.1					1
		Rainbow Trout	1	0.10	-	5.7	1				-
		Shorthead Redhorse	1	0.05	-	2.3					1
10-20	88.3	Alewife	21	0.05	1.9-7.0	3.2			1	1	19
		Brown Trout	5	5.60	14.1-25.2	21.1	2	1	-	2	-
		Chinook Salmon	3	4.07	12.8-24.9	19.6	1		-	1	1
		Gizzard Shad	129	0.09	2.9-7.7	5.4	-		16	9	104
		Lake Trout	40	8.02	19.8-33.5	28.2	11	29	-		
		Longnose Dace	2	0.05	3.0-3.6	3.3	-		-		2
		Rainbow Trout	6	1.50	6.4-21.4	11.2	-		2	2	2
		Slimy Sculpin	2	0.05	2.8-3.5	3.1	-		2		
		Smelt	6	0.06	2.2-8.1	4.1	-		1		5
		Yellow Perch	1	0.17		6.5	-				1

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
10/28	89.2	Alewife	627	0.01	1.9-7.5	2.7	-	-	50	12	565
		Brown Trout	6	4.41	6.3-26.0	19.5	1	4	-	-	1
		Chinook Salmon	1	4.10	-	21.4	1	-	-	-	-
		Coho Salmon	2	5.45	12.9-26.8	19.8	-	1	-	-	1
		Emerald Shiner	1	0.05	-	3.3	-	-	1	-	-
		Gizzard Shad	108	0.07	3.1-7.4	5.1	-	-	6	12	90
		Lake Trout	1	3.70	-	23.9	-	-	1	-	-
		Longnose Dace	1	0.05	-	3.7	-	-	1	-	-
		Rainbow Trout	5	2.98	7.4-23.1	17.6	2	1	1	-	1
		Slimy Sculpin	5	0.05	1.6-3.1	2.3	-	-	-	1	4
		Smelt	24	0.06	2.4-7.8	4.1	-	-	1	-	23
		White Sucker	2	0.37	2.5-11.7	7.1	-	-	-	-	2
11/5	97.9	Alewife	30	0.05	1.3-7.5	2.7	-	-	2	1	27
		Brown Trout	4	3.00	7.0-23.4	15.5	1	1	-	-	2
		Coho Salmon	1	8.00	-	28.2	-	1	-	-	-
		Gizzard Shad	905	0.06	3.0-8.1	5.3	-	-	-	-	905
		Juvenile Pacific Salmon	1	0.20	-	8.0	-	-	-	-	1
		Lake Trout	1	9.30	-	31.1	-	1	-	-	-
		Longnose Dace	1	0.05	-	3.4	-	-	1	-	-
		Rainbow Trout	1	5.90	-	23.7	-	-	-	1	-
		Slimy Sculpin	1	0.05	-	3.5	-	-	1	-	-
		Smelt	4	0.07	4.1-7.2	5.6	-	-	2	-	2

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
11/13	86.3	Alewife	611	0.05	2.1-7.8	2.7			36	36	539
		Black Crappie	1	0.05	-	3.8			-	-	1
		Black Bullhead	1	0.05	-	1.7			-	-	1
		Brown Trout	2	1.27	6.9-15.2	11.0			1	-	1
		Emerald Shiner	1	0.05	-	3.3			-	-	1
		Gizzard Shad	30	0.09	3.2-12.8	4.5			1	1	28
		Green Sunfish	1	0.05	-	1.5				-	1
		Ninespine Stickleback	6	0.05	2.0-3.1	2.2				-	6
		Pumpkinseed Sunfish	1	0.05	-	1.9				-	1
		Rainbow Trout	6	3.21	6.5-26.2	15.6		1		2	3
		Shiner sp.	1	0.05	-	3.4					1
		Slimy Sculpin	15	0.05	1.5-4.1	2.5			1		14
		Smelt	74	0.06	1.8-8.9	4.0			6	2	66
		Spottail Shiner	1	0.05	-	2.0					1
		Yellow Perch	2	0.05	4.0-4.3	4.1					2
11/17	85.2	Alewife	1,012	0.05	2.0-7.6	2.9			-	20	992
		Brown Trout	1	0.25	-	7.0			-	-	1
		Gizzard Shad	9	0.36	3.5-15.7	7.4			1	1	7
		Lake Trout	1	9.50	-	30.8			-	1	-
		Lake Whitefish	1	0.10	-	7.1			-		1
		Rainbow Trout	6	3.83	7.5-24.9	19.0	1	2	-	1	2
		Slimy Sculpin	13	0.05	1.6-3.4	2.1			-		13
		Smelt	52	0.07	3.0-10.0	5.2			11	9	32

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
11/25	90.9	Alewife	488	0.05	2.0-7.1	2.7	-	-	-	-	488
		Black Crappie	1	0.05	-	2.4	-	-	-	-	1
		Brook Stickleback	3	0.05	2.5-2.6	2.5	-	1	1	-	1
		Brown Trout	2	0.15	6.0-7.4	6.7	-	-	-	-	2
		Gizzard Shad	12	0.05	2.8-5.5	3.5	-	-	-	-	12
		Lake Trout	1	7.95	-	28.9	1	-	-	-	-
		Longnose Dace	1	0.05	-	3.5	-	-	-	-	1
		Ninespine Stickleback	1	0.05	-	2.6	-	-	-	-	1
		Rainbow Trout	3	0.87	7.1-19.5	11.4	-	-	1	-	2
		Slimy Sculpin	32	0.05	1.5-3.7	2.4	2	1	1	-	28
		Smelt	114	0.05	1.4-7.7	3.6	-	-	27	22	65
		Trout Perch	1	0.05	-	4.3	-	-	-	1	-
		Yellow Perch	2	0.21	2.1-8.2	5.1	-	-	1	-	1
12/3	48.57	Alewife	171	0.05	2.0-3.5	2.7	-	-	-	-	171
		Brook Stickleback	1	0.05	-	2.5	-	-	-	-	1
		Brown Trout	2	1.15	7.9-15.7	11.8	-	-	-	-	2
		Emerald Shiner	1	0.05	-	1.2	-	-	-	-	1
		Gizzard Shad	8	0.07	2.6-7.5	4.8	-	-	-	-	8
		Goldfish	2	0.60	7.4-8.6	8.0	-	-	-	2	-
		Lake Trout	1	7.80	-	30.1	-	-	1	-	-
		Longnose Dace	2	0.05	3.2-3.4	3.3	-	-	-	-	2
		Rainbow Trout	8	1.99	7.0-27.3	12.1	1	1	-	-	6
		Shiner sp.	1	0.05	-	4.1	-	-	-	-	1
		Slimy Sculpin	15	0.05	1.9-3.5	2.7	-	-	-	-	15
		Smelt	18	0.06	1.9-8.5	4.5	-	-	5	1	12
		White Sucker	1	0.05	-	2.8	-	-	-	-	1

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Breeding State: Ripe Female	Breeding State: Unripe Male	Breeding State: Unripe Female	Imm.
12/8	89.3	Alewife	146	0.05	2.1-7.4	2.9	-	-	-	2	144
		Brook Stickleback	1	0.05	-	2.6	-	-	-	1	-
		Brown Trout	3	2.58	6.9-25.6	13.6	-	1	-	-	2
		Gizzard Shad	46	0.06	2.8-7.1	4.4	-	-	3	1	42
		Lake Whitefish	1	3.20	-	19.0	-	-	-	1	-
		Ninespine Stickleback	2	0.05	2.5-3.9	3.2	-	-	-	-	2
		Northern Pike	1	0.30	-	11.1	-	-	-	-	1
		Rainbow Trout	2	0.20	10.1-22.3	16.2	-	-	1	-	1
		Slimy Sculpin	17	0.05	1.6-4.0	2.5	-	-	3	-	14
		Smelt	147	0.05	1.8-8.9	5.3	-	-	44	29	74
12/16	68.8	Alewife	15	0.05	2.1-3.1	2.5	-	-	-	-	15
		Brown Trout	6	1.08	6.3-24.4	10.4	-	-	-	1	5
		Gizzard Shad	22	0.06	3.1-7.5	4.3	-	-	1	-	21
		Ninespine Stickleback	1	0.05	-	2.7	-	-	-	1	-
		Rainbow Trout	1	3.00	-	19.0	-	-	-	-	1
		Slimy Sculpin	5	0.05	1.5-3.3	2.9	-	-	-	-	5
		Smelt	96	0.06	1.7-9.3	4.0	-	-	11	14	71
		Yellow Perch	1	0.05	-	2.4	-	-	-	-	1

Table II.1. Summary of Fish Impingement Data,
March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
12/23	100	Alewife	9	0.05	2.6-3.6	3.0	-	-	-	-	9
		Brown Trout	2	0.08	-	7.3	-	-	-	-	2
		Burbot	1	2.50	-	20.5	-	-	1	-	-
		Gizzard Shad	4	0.05	3.0-4.7	4.1	-	-	-	-	4
		Ninespine Stickleback	1	0.05	-	2.5	-	-	-	-	1
		Rainbow Trout	2	2.05	6.8-21.0	13.9	-	1	-	-	1
		Slimy Sculpin	12	0.05	1.7-4.0	3.0	-	-	6	-	6
		Smelt	78	0.06	2.0-8.5	5.1	-	-	19	22	37
		Yellow Perch	1	0.05	-	2.3	-	-	-	-	1
12/29	89.2	Brown Trout	1	4.75	-	22.3	-	-	-	1	-
		Juvenile Pacific Salmon	1	0.20	-	8.0	-	-	-	-	1
		Ninespine Stickleback	1	0.05	-	2.9	-	-	-	-	1
		Rainbow Trout	1	3.80	-	22.1	1	-	-	-	-
		Slimy Sculpin	2	0.05	2.1-3.5	2.8	-	-	-	1	1
		Smelt	10	0.06	2.6-7.1	4.8	-	1	2	2	5

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
1-8	69.1	Alewife	5	0.05	2.5-3.5	3.0	-	-	-	-	5
		Black Bullhead	1	0.05	-	2.0	-	-	-	-	1
		Gizzard Shad	1	0.05	-	4.0	-	-	-	-	1
		Rainbow Trout	2	0.15	7.8-8.1	7.9	-	-	-	-	2
		Slimy Sculpin	17	0.05	1.6-4.2	2.6	-	-	1	1	15
		Smelt	18	0.06	2.4-8.0	4.2	1	-	-	4	13
1-20	77.5	Alewife	21	0.05	2.3-7.6	3.3	-	-	-	1	20
		Brown Trout	4	0.53	6.2-13.6	9.8	-	-	1	-	3
		Emerald Shiner	1	0.05	-	3.6	-	-	-	-	1
		Gizzard Shad	1	0.05	-	5.3	-	-	-	-	1
		Lake Trout	1	0.40	-	10.1	-	-	1	-	-
		Ninespine Stickleback	3	0.05	2.0-2.9	2.6	-	-	1	-	2
		Rainbow Trout	4	4.24	8.7-26.3	19.9	1	1	1	-	1
		Slimy Sculpin	13	0.05	1.0-4.0	2.5	1	-	3	1	8
		Smelt	20	0.05	1.8-7.0	4.4	-	2	1	4	13
1-28	72.0	Alewife	1	0.05	-	2.5	-	-	-	-	1
		Emerald Shiner	1	0.05	-	4.2	-	-	1	-	-
		Ninespine Stickleback	1	0.05	-	2.8	-	-	-	-	1
		Shiner sp.	1	0.05	-	3.5	-	-	-	-	1
		Slimy Sculpin	6	0.05	1.5-3.5	6	-	-	-	2	4
		Smelt	2	0.05	1.9-6.5	4.2	-	-	1	-	1
		Spottail Shiner	1	0.05	-	2.5	-	-	-	-	1
2-2	87.97	Brown Trout	2	1.11	11.5-15.8	13.6	-	-	1	-	1
		Rainbow Trout	5	4.11	7.5-25.0	17.8	1	1	1	-	2
		Slimy Sculpin	4	0.05	1.9-3.4	2.5	-	-	-	-	4
		Smelt	9	0.08	2.3-8.5	5.3	-	1	2	2	4
		Yellow Perch	1	0.20	-	7.5	-	-	-	1	-

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Port Washington Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches) Range	Length (inches) Mean	Breeding State: Ripe Male	Ripe Female	Unripe Male	Unripe Female	Imm.
2-12	73.8	Alewife	8	0.05	2.3-4.3	3.4	-	-	-	-	8
		Gizzard Shad	3	0.05	3.5-4.7	4.1	-	-	-	-	3
		Rainbow Trout	4	2.48	8.1-22.6	15.2	2	-	-	-	2
		Slimy Sculpin	1	0.05	-	3.6	-	-	1	-	-
		Smelt	14	0.05	2.9-7.6	4.6	-	-	6	-	8
2-17	74.2	Alewife	45	0.05	2.1-4.0	3.1	-	-	-	-	45
		Brown Trout	1	0.17	-	7.8	-	-	-	-	1
		Gizzard Shad	6	0.29	4.7-14.7	7.0	-	-	-	2	4
		Ninespine Stickleback	2	0.10	2.1-2.7	2.4	-	-	-	-	2
		Rainbow Trout	1	0.15	-	8.0	-	-	-	-	1
		Shiner sp.	1	0.05	-	3.1	-	-	-	1	-
		Slimy Sculpin	3	0.05	1.0-3.2	2.0	-	-	-	-	3
		Smelt	2	0.05	4.0-7.8	5.9	-	-	1	-	1
2-25	98.5	Alewife	8	0.05	2.4-3.8	3.1	-	-	-	-	8
		Black Crappie	1	0.05	-	3.2	-	-	-	-	1
		Brook Trout	1	0.10	-	6.8	-	-	-	-	1
		Brown Trout	1	1.15	-	13.3	-	-	-	-	1
		Gizzard Shad	5	0.05	3.9-4.9	4.4	1	-	-	-	4
		Longnose Dace	1	0.05	-	2.7	-	-	-	-	1
		Ninespine Stickleback	3	0.05	2.3-2.8	2.5	-	-	-	-	3
		Rainbow Trout	3	2.25	14.5-24.5	20.6	1	1	1	-	-
		Rock Bass	1	0.20	-	6.2	-	-	-	-	1
		Salmonid sp.	1	0.20	-	7.5	-	-	-	-	1
		Shorthead Redhorse	2	0.05	4.3-5.2	4.7	1	-	1	-	-
		Slimy Sculpin	7	0.05	2.1-4.3	3.1	-	1	1	1	4
		Smelt	46	0.06	1.8-9.0	4.2	2	7	7	3	27
		Spottail Shiner	1	0.05	-	2.2	-	-	-	-	1

Table II.2. Summary of Entrainment Sampling Data, April-October, 1975 for Port Washington Power Plant.

Date	Volume Sampled (meters^3)	Percent of Intake Volume	Fish Larvae			Fish Eggs			Invertebrates			
									Pontoporeia		Mysis	
			Species	No.	No./m^3 x 1000	Species	No.	No./m^3 x 1000	No.	No./m^3 x 1000	No.	No./m^3 x 1000
4-15	1516.9	0.300	Lake Herring Slimy Sculpin	1 9	0.66 5.93	None			10	6.59	4	2.64
4-23	1534.2	0.180	None	-		None			113	73.65	7	4.56
4-28	1426.6	0.092	Sculpin Burbot		0.70 0.70	None			225	157.72	12	8.41
5-5	1855.8	0.150	None			Smelt	3	1.62	32	17.24	3	1.62
5-13	1555.6	0.120	None			Smelt	6	3.86	32	20.57	5	3.21
5-21	1562.4	0.082	None			Smelt	9	5.76	8	5.12	4	2.56
5-29	1710.0	0.097	None			None			16	9.36	4	2.34
6-2	1628.9	0.120	None			None			17	10.44	0	
6-10	1606.0	0.130	None			None			14	8.72		2.49
6-19	1626.0	0.075	None			None			0			1.23
6-26	1619.7	0.059	None			None			6	3.70		
7-1	2049.6	0.075	Alewife Spoonhead Sculpin Yellow Perch		0.98 0.49 0.49	Alewife Sculpin	90 5	43.91 2.44	7	3.42		
7-8	1014.0	0.043	None			Alewife	111	109.47	0			

Table II.2. Summary of Entrainment Sampling Data, April-October, 1975 for Port Washington Power Plant.

Date	Volume Sampled (meters^3)	Percent of Intake Volume	Fish Larvae			Fish Eggs			Invertebrates			
									Pontoporeia		Mysis	
			Species	No.	No./m^3 x 1000	Species	No.	No./m^3 x 1000	No.	No./m^3 x 1000	No.	No./m^3 x 1000
7-16	1967.6	0.080	Alewife	1	0.51	Alewife	225	114.35	10	5.08	1	0.51
			Slimy Sculpin	1	0.51							
			Smelt	1	0.51							
7-21	1746.1	0.079	Slimy Sculpin	2	1.15	None			6	3.44	0	
7-29	1655.1	0.074	Ninespine Stickleback	2	1.21	None			21	12.69	0	
			Slimy Sculpin	3	1.81							
			Smelt	1	0.6							
8-5	1645.1	0.083	Fourhorned Sculpin	1	0.61	Alewife		04	45	27.35	24	14.59
			Ninespine Stickleback	2	1.23							
			Slimy Sculpin	1	0.61							
			Smelt	7	4.26							
8-14	1623.2	0.057	Alewife	1	0.62	None			4	2.46	0	
			Slimy Sculpin	1	0.62							
8-21	1632.6	0.099	Alewife	1	0.61	None			41	25.11	0	
8-25	1633.9	0.091	Slimy Sculpin	1	0.61	None			26	15.91	0	
9-2	1483.7	0.080	Alewife	15	10.11	None			18	12.13	0	
			Smelt	11	7.41							
9-10	743.4	0.033	Alewife		1.35	None			22	29.59	0	
			Smelt		6.73							

Table II.2. Summary of Entrainment Sampling Data, April-October, 1975 for Port Washington Power Plant.

Date	Volume Sampled (meters^3)	Percent of Intake Volume	Fish Larvae			Fish Eggs			Invertebrates			
									Pontoporeia		Mysis	
			Species	No.	No./m^3 x 1000	Species	No.	No./m^3 x 1000	No.	No./m^3 x 1000	No.	No./m^3 x 1000
9-15	1629.7	0.077	Alewife Smelt	10 2	6.14 1.23	None			14	8.59	0	
9-22	1613.5	0.095	Smelt		0.62	None			2	1.24	0	
9-30	1574.9	0.075	None			None			0		0	
10-13	1626.6	0.065	None			None			1	0.61	0	
10-20	789.3	0.038	None			None			0		0	
10-28	1627.7	0.080	None			None				4.30	0	

Table II.3. Summary of Lake Survey Icthyoplankton
May-October, 1975 for Port Washington Area

Date	Area	Volume Sampled (meters^3)	Fish Larvae Species	Fish Larvae No.	Fish Larvae No./m^3 x 1000	Volume Sampled (meters^3)	Fish Eggs Species	Fish Eggs No.
5-5	Reference	21.3	None	-		1.4	None	
	Intake	57.7	None	-		1.4	None	
5-22	Reference	47.0	Smelt	1	21.3	1.9	None	
	Intake	44.0	None	-	-	1.9	None	
6-10	Reference	95.8	Smelt	75	782.9	1.4	None	
	Intake	78.0	Smelt	15	192.3	1.4	None	
6-19	Reference	94.9	Alewife	10	101.1	1.4	None	-
	Intake	88.0	Alewife	1	11.4	1.4	None	-
			Smelt	1	11.4			
7-1	Reference	62.7	Alewife	265	4,226.5	1.2	Alewife	434
			Sculpin	2	31.9			
	Intake	75.9	Yellow Perch	1	15.9			
			None	-	-	1.2	Alewife	180
7-16	Reference	34.5	Alewife	1	29.0	1.4	None	
	Intake	27.2	Alewife	3	110.3	1.4	Alewife	3
7-29	Reference	38.0	Alewife	1	26.3	1.4	None	
	Intake	32.2	Sculpin	5	155.3	1.4	None	
			Smelt	1	31.1			

Table II.3. Summary of Lake Survey Icthyoplankton May-October, 1975 for Port Washington Area

Date	Area	Volume Sampled (meters^3)	Fish Larvae Species	Fish Larvae No.	Fish Larvae No./m^3 X 1000	Volume Sampled (meters^3)	Fish Eggs Species	Fish Eggs No.
8-14	Reference	62.6	None	-		1.4	None	
	Intake	48.9	Ninespine Stickleback	1	20.4	1.4	None	
			Sculpin	2	40.9			
8-25	Reference	63.8	Alewife	2	12.5	1.4	Sculpin	3
			Smelt	1	6.2			
	Intake	59.7	None	-	-	1.4	None	
9-15	Reference	111.7	None	-	-	1.4	None	-
	Intake	76.6	Alewife	3	13.9	1.4	None	-
9-22	Reference	69.2	None			1.4	None	
	Intake	52.6	None			1.4	None	
10-8	Reference	50.5	None			1.4	None	
	Intake	52.3	None			1.4	None	
10-20	Reference	67.0	None			1.4	None	
	Intake	61.0	None			1.4	None	

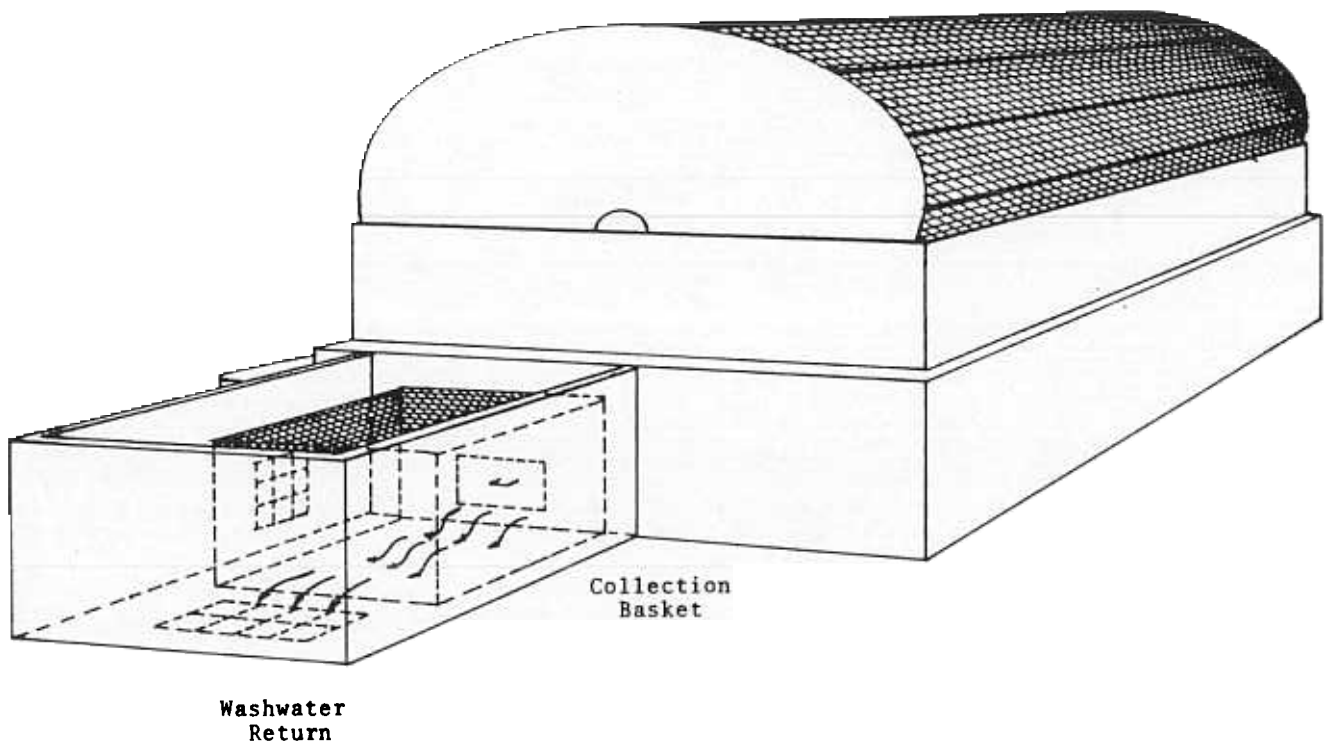

FIGURE II-1: IMPINGEMENT COLLECTION AT PORT WASHINGTON POWER PLANT

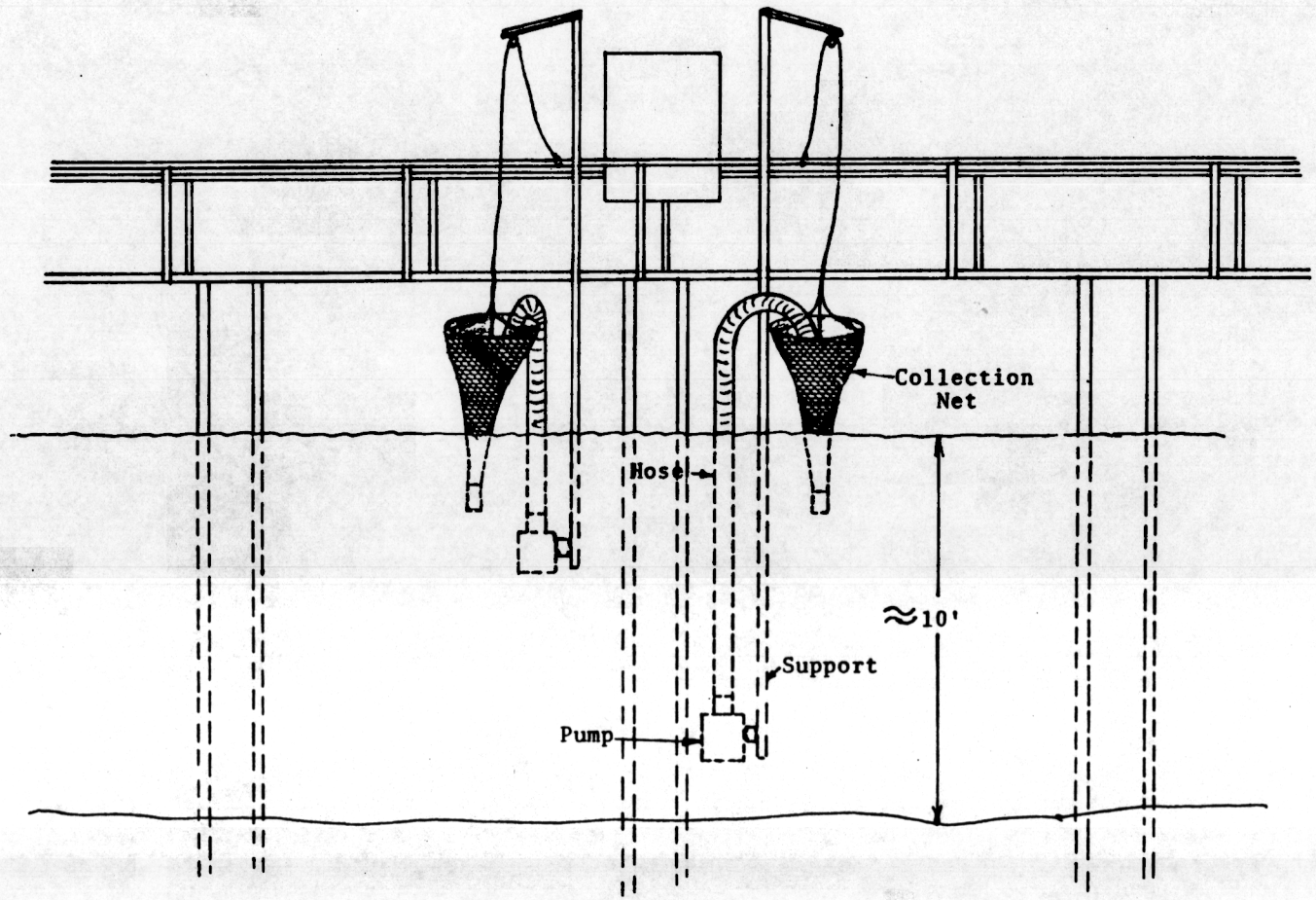

FIGURE II-2: ENTRAINMENT SAMPLING IN PORT WASHINGTON POWER PLANT APPROACH CHANNEL

III. ANALYSIS OF INTAKE EFFECTS

In this section, the environmental impacts of impingement and entrainment are assessed, in accord with DNR guidelines, to the degree that available biological information permits.

A. ANALYSIS OF IMPINGEMENT DATA

Data on adult and juvenile fish impingement,as obtained in the monitoring program was,processed to facilitate discussion of seasonal and size variations and to project total impingement. The following discussion examines these aspects as well as swimming speed and mortality information, and concludes with an assessment of the overall impact of impingement at Port Washington Power Plant:

SEASONAL VARIATIONS

Number and weight distributions of key components of the impingement catch over the monitoring year are graphed in Figures III-1 to III-4. These include total fish, alewife, smelt, and salmonids (collectively, all salmon and trout). Alewife and smelt were selected because they comprised the bulk of the catch. Salmonids were chosen because of their recreational importance. Other species occurred in insufficient numbers or were judged to be of insignificant importance to merit graphical presentation.

Figures III-1 and III-4 illustrate the seasonal variation in numbers and weight for the entire daily collection. The major numerical peak in May and June was almost exclusively a function of alewife impingement, as were the lesser autumn peaks. The minor March peak was the result of smelt impingement. The summer peak in total weight was comprised almost entirely of alewife, but the minor October peaks resulted from salmonid impingement.

Alewife impingement increased steadily from early March through June, becoming minimal by December (Figures III-2 and III-3). Variations reflected characteristic seasonal onshore-offshore movements as well as the spawning/die-off phenomena of early summer.

Smelt numbers rose dramatically in April from less than ten to several hundred per day coincident with the advent of the spawning season (Figure III-2). Numbers fluctuated through September between one hundred and several thousand per day. Fall and winter numbers were generally below 100/day. On a weight basis, peak smelt impingement occurred in April and

May, reflecting the preponderance of spawning adults (Figure III-3).

Salmonid numbers always totaled less than 100/day, with peaks in March, June, and October (Figure III-1). The heaviest catches by weight occurred in October, as a result of impingement of adults during their reproductive periods (Figure III-4). Earlier peaks were largely composed of freshly stocked trout (March) and salmon (June).

ESTIMATED TOTAL IMPINGEMENT

Total monthly and yearly impingement was projected from the impingement data. Numerical and weight estimates were made for alewife, smelt, various groups of fish species, and total fish (Tables III-1 and III-2).

The groups comprising all other species impinged at PWPP were: trout, salmon, game and food fishes, rough fishes and forage fishes. Composition of these groups is provided in Table III-1a. These groupings were made in an attempt to condense the data along functional and exploitative lines to provide better estimates.

Estimates were made by transforming the basic data from each sampling day to number/cooling water volume, (e.g., 3.2 salmon/million gallons). For each category, one such data point was produced each sampling day. For the period, data points were averaged and 90% confidence intervals were produced. These were multiplied by total plant flow to obtain the mean estimate as well as the range.

Inherent variation among days resulted in extremely large standard deviations. This was compensated somewhat in the annual estimate, because of the much greater number of data points. However, within-year variations in impingement are naturally greater than within-month variations, balancing much of the advantage of the increase in data points. Better estimates could probably have been made on a seasonal basis, adjusting time periods to the characteristic seasonal changes in inshore abundance. However, DNR guidelines for this report called for monthly and annual estimates.

For purposes of assessment, the mean estimate will be used exclusively since the confidence intervals are generally irrelevant. Exceptions occurred for alewife and total fish in periods when numbers were high. Mean estimates appear to have validity, in that their ratio to actual impingement statistics is similar to the ratio of plant operating to sampling time per period.

It is estimated that a total of 2,040,472 fish weighing 115,986 pounds were impinged at Port Washington during the sampling year. Alewife comprised 95.4% of the catch by number and 88.6% by weight. Smelt accounted for 3.6% and 1.7% by number and weight, respectively. Trout were only .02% of the total number but accounted for 7.5% by weight. The other four categories each had both numbers and weight below 1% of the total.

LENGTH FREQUENCY

Cumulative length-frequency distribution was determined for critical 30-day periods for alewife, smelt, and salmonids (trout and salmon). Results are as follows:

Alewife

On the five sampling days between May 21 and June 19, 58% of the yearly alewife impingement occurred. Length ranged from 2.5-8.9 inches. More than 59% of the alewife were between 6.5 and 7.9 inches in total length (Figure III-5), confirming that the majority of fish were adults.

Smelt

43% of the smelt catch occurred on five sampling dates between August 14 and September 10. Length ranged from 2.0-8.9 inches. 97% of the fish were less than 5.5 inches long, with the median 3.0-3.4 inches (Figure III-6). This indicates that most of these fish were yearlings, unlike the spring impingement which included spawning adults.

Salmonids

The spring (March 18-April 15) and fall (September 30-October 28) impingement collections of trout and salmon were examined (Figure III-7). They represented 23% and 16% of the year's catch respectively. 87% of the spring catch was under 10 inches in total length. This catch consisted primarily of freshly-stocked brown trout. The fall catch was virtually a diametric opposite, consisting of 84% of fish over 20 inches in total length. The collection consisted principally of lake, brown, and rainbow trout in breeding condition.

FISH SWIMMING SPEEDS VS. TOTAL LENGTH

Entrapment of fish in an intake can be, to some degree, a function of intake velocity. Velocities which exceed the escape speeds of certain fish will result in entrapment of those fish when they encounter the intake. It is logical to assume that reduction of intake velocity might, in some instances, be a promising means to decrease fish entrapment. It is not, how-

ever, a panacea for entrapment problems, as witnessed by impingement statistics for larger, viable fish which can obviously escape the intake system.

To determine a "safe" intake velocity, it is necessary to first know the swimming speeds of the fishes to be protected. The approach of this brief review is conservatively directed toward minimal safe intake velocities. To that end, it concentrates on examining the swimming speed total-length relationship for juvenile fishes which represent the smaller size classes which might be impinged. Also, the discussion is limited to sustained swimming speeds, i.e.,rates which can be maintained for 30+ minutes. Fish are capable of "burst" speeds for periods of a few seconds which may be 50% higher than their sustained speeds (Otto, 1974) and which may be adequate to allow escape when the sustained speed level would not.

Although variables such as oxygen concentration (Schiewe, 1974; Kutty and Saunders, 1973), feeding (Wissing and Hasler, 1971), and pollutants (Smith and Oseid, 1972) can influence fish swimming speed, the basic factor for any species is size, followed by water temperature.

The relationship of fish length to swimming ability can be expressed as $V=KL^n$ where V=speed, L=total length, K is a constant and ^{n} is about 0.5, indicating that swimming performance varies approximately according to the square root of body length (Griffiths and Alderice, 1972; Jones et al, 1974). Absolute swimming speed increases with body length, but relative swimming speed (body lengths/time) decreases.

The second variable which has a profound influence on swimming speed in any given species is water temperature. In general, fish will swim faster at higher temperatures, up to a critical level beyond which performance decreases (Otto, 1974). Fish enjoy lowest escape potential at small size and during the coldest months.

Table III-2a describes sustained swimming speeds of midwestern fishes at various temperatures. It indicates that the smallest fish swim at 3+ body lengths/sec, even at low temperatures. An intake velocity of 0.5-1.0 fps appears to be satisfactory to protect even the smallest impingeable fish.

The U.S. Environmental Protection Agency (1973) suggested that approach velocities lower than 0.8-1.1 fps might be required to protect against impingement of certain species of fish. The Lake Michigan Cooling Water Intake Technical Committee (1973) observed that some studies showed intake velocities of 0.5 fps or 2-3 times body length of the fish would provide adequate protection.

This brief review of the available literature indicates that these values may be conservative and can not be applied as a general requirement. Any attempt to minimize entrapment by reducing velocity should be predicated on an assessment of the problem, based on the species, size, and seasonal variation in impingement statistics.

The length-frequency distributions of fish impinged at Port Washington, for example, indicate the seasonal variability. Even though large (>20 inches) salmonids are capable of escaping the intake velocities of 1-2 fps, they are impinged in numbers during the autumn breeding season. Lower intake velocities would probably not reduce their impingement.

IMPINGEMENT MORTALITY

A study was initiated in late October to determine mortality due to impingement on the PWPP travelling screens. Salmonids captured in the collection basket were immediately transferred to an adjacent 100 gallon flow-through holding tank. Fish which had fungus or old wounds were not included, but fish with fresh wounds which might have been inflicted during impingement were retained. Fish were observed during the following collection period, 2-9 days later, and survival was noted.

Forty-two salmonids, consisting of 15 rainbow trout, 22 brown trout, 2 brook trout, 1 tiger trout, 1 lake trout, and 1 chinook salmon were held. Fish ranged from 6-26 inches in total length averaging 13 inches. Thirty-four (81 percent) survived the holding period and were released. When it is considered that some fish might become impinged because they are diseased and feeble, this study shows that salmonid impingement mortality is very low.

However, mortality suffered from the entire entrapment process might be higher. Additional stress might be experienced in discharge to the harbor and exposure to elevated (7°-16°F) temperature. Wisconsin Electric proposed to tag impinged salmonids and release them into the washwater return system - the normal post-impingement experience. Wisconsin Electric requested of the DNR Bureau of Fish Management a technical review of the scope of work and DNR involvement in the tagging study (letter from J. Ney to J. Addis, February 17, 1976). Although Mr. Addis sought a formal response from the Bureau, none was made and the study was abandoned as a consequence. However, the results of the impingement mortality study are supported by the fact that dead or distressed salmonids or other fish are rarely observed in the harbor. Dead alewife are found in the harbor during the summer die-off period, but they are also found along the entire western shore. The

discharge is adjacent to a Wisconsin Electric-sponsored fishing pier which enjoys great popularity. Mortality problems should be evidenced in this area, but this is not the case.

In summary, while absolute, quantitative proof is lacking, the evidence indicates that impingement mortality at Port Washington Power Plant may not be severe. Certainly, the assumption of complete mortality is not warranted.

IMPINGEMENT IMPACT

It is impossible to provide an accurate quantitative assessment of impingement effects without knowledge of mortality. If mortality is nil, PWPP impingement may function merely to displace fish from the lake to the harbor where they are more accessible to fishermen. To facilitate this exercise, it will be assumed that impingement mortality at PWPP is complete, recognizing that the evidence indicates otherwise. The assessment will be made for the species and groupings utilized to make estimates of total impingement with the exception that trout and salmon, which represent a unique situation, will be considered together as salmonids.

Alewife

It was estimated that 1,960,000 alewife, weighing about 103,000 pounds, were impinged during the monitoring year. Ninety-five percent of these fish were taken in May, June, and July coincident with the spawning period and the annual die-off. The size distribution indicates that most of these fish were adults. Many of the impinged alewife were decomposed, although it was not possible to assess the ambient mortality rate. However, it should be remembered that dead and dying alewife frequently clogged municipal, industrial, and utility intakes during the great die-offs of 1966 and 1967. Although the die-offs have not reached that magnitude since, they still occur, creating a shoreline nuisance. It is conceivable that most of the alewife impinged at PWPP are actually victims of this die-off.

The seasonal onshore-offshore movements of alewife have been well-documented. The species is pelagic and considered to form a single interbreeding population in the lake. Biomass of alewife in Lake Michigan was estimated to exceed 3.2 billion pounds (Edsall et al., 1974). Conservatively assuming ten individuals to the pound, there are more than 30 billion alewife in the lake. Annual mortality estimates of 40%-70% per age class were made by the previously cited authors, indicating that well in excess of 10 billion alewife die annually. Impingement at PWPP represents 0.006% of the estimated alewife population by number, 0.003% by weight, and 0.02% of the minimal annual mortality. Clearly, impingement at PWPP

has a negligible impact on the alewife population.

Smelt

The estimated smelt impingement for the monitoring year was 72,800 fish totaling 1,920 pounds. The number -to-weight ratio and the length-distribution data indicate that the majority of the smelt were immature, probably yearling or young-of-year fish. Like the alewife, the smelt is pelagic, and localized populations have not been defined. Total lake biomass of smelt was estimated to be in excess of 30 million pounds in 1974 (Limnetics, 1976). The average adult fish weighs something less than one-tenth of a pound, providing a numerical estimate of more than 300 million individuals. Using these numbers, PWPP impingement represents 0.02% and 0.006% of the lake number and biomass, respectively. Removal of this fraction of smelt would have no impact on the lake population.

Salmonids

Estimates for the monitoring year projected the impingement of 4,234 trout and 1,210 salmon weighing 8,713 lbs. and 526 lbs., respectively. This would appear to indicate that the average trout was of catchable (>1 lb.) size while the average salmon was not. The length-frequency distribution was actually bi-modal, consisting principally of small,freshly-stocked and large mature fish. During March through May, 274 trout (mostly brown trout) less than 10 inches total length were collected, 40% of the actual trout catch for the year. Salmon collected from the screens totaled 241 for the study. During the May-September period, 225 salmon were collected, 193 of which were less than 10 inches total length. Most of these fish were freshly planted chinook salmon, probably emigrating from a planting of 50,000 fish in Sauk Creek (J. Addis, personal communication). Fifty-four percent of the total salmonid impingement collection for the year resulted from impingement of newly-stocked fish in spring and summer. It would appear that impingement of these fish can be decreased by changing stocking practices. Indeed, this plan has been implemented for the trout species. Through the cooperation of the DNR, these fish were stocked in the spring of 1976, several miles north of the former site in Port Washington Harbor. The chinook salmon stocking program, however, is being continued in Sauk Creek to establish return of spawning adults to this site. The impingement monitoring program is being continued through the spring of 1976. Preliminary results indicate a marked decrease in impingement of small trout but renewed impingement of the juvenile chinook salmon. It is hoped that some total estimate of impingement of this species can be made, so that the percentage of stocked fish which are impinged can be determined. The 1975 figures provide rough estimate of impingement as

approximately 2% of the 50,000 chinook stocked in Sauk Creek. The overall return of stocked chinook salmon to the angler is approximately 7% (Limnetics, 1976). This would indicate that the impingement of juveniles removed perhaps 70 chinook from the anglers' creels in 1976.

The ultimate assessment of impingement impact on salmonids must be made on a socio-economic basis. Salmonids are maintained in Lake Michigan as an artifical population, a recreational resource worth more than $70 million/year (Lake Michigan Cooling Water Studies Panel Report, 1975). In 1974, Wisconsin stocked over 3.4 million trout and salmon in Lake Michigan, and its anglers caught 414,000, a return of almost 12% (Limnetics, 1976). Applying this application factor at PWPP and assuming that all impinged fish die, approximately 653 salmonids would be lost to the creel. This represents 0.16% of the 1974 Wisconsin catch and would appear to be inconsequential. It is recognized that the 12% return figure may not be valid for the Port Washington situation in which freshly stocked fish with low return probability are impinged with mature fish which may have a better chance of being harvested. However, this exercise is included to put some perspective on the situation. Alternative intake costs could be weighed against loss of satisfied angler-days or of dollars generated by fishermen. This is the only legitimate means to assess impact of salmonid impingement. The impact, in a strict ecological sense, is minimal.

Game and Food Fishes

Game and food fish impingement was estimated at 669 (199 lbs.) for the monitoring year. The catch consisted primarily of yellow perch and incidental warm-water species (centrarchids, bullheads, etc.). The latter probably entered the lake from nearby tributary streams. In addition to the yellow perch, the only other true Lake Michigan residents collected were two lake whitefish and one bloater. No species in this category was impinged in numbers which suggest any impact on populations, local or lakewide.

Rough Fishes

The yearly impingement estimate for rough fishes totaled 756 (969 lbs.). The catch consisted primarily of white and longnose suckers, with some carp and goldfish. Although none of the species are highly valued, a commercial fishery exists in Lake Michigan for the first three. In 1974, Wisconsin landings totaled 311,000 lbs. and 3.2 million lbs. for suckers (both species) and carp, respectively. The projected loss at PWPP is insignificant relative to commercial exploitation and can exert no effect on the populations.

Forage Fishes

Forage species included sculpins and ninespine sticklebacks, and to a lesser degree, trout perch, longnose dace, lake chub, emerald and spottail shiners, and gizzard shad, as well as several incidental species associated with warm-water systems. Estimated annual impingement totaled 14,728 (930 lbs.) for this group. All of the resident species are seasonally abundant in the nearshore zone of southern Lake Michigan. With the exception of sculpins, no attempts have been made to quantify local or lakewide abundance of these species. It has been conservatively estimated that the 1974 biomass of juvenile and adult sculpins totaled 3.74 million lbs. in Lake Michigan (Limnetics, 1976). Although some forage species, such as the emerald shiner,may have suffered from competition with alewife (Wells and McLain, 1973), the various forage species appear to remain sufficiently abundant so that impingement of this magnitude represents no danger to the maintenance of local populations.

B. ANALYSIS OF ENTRAINMENT DATA

Numbers of fish eggs, fish larvae, and the two benthic macroinvertebrate species collected in entrainment sampling were used to project total monthly and annual entrainment at Port Washington Power Plant. The following discussion examines seasonal variations in entrainment as well as its estimated magnitude, concluding with an assessment of the environmental impact of PWPP entrainment;

SEASONAL VARIATIONS

Fish larvae were collected on 14 of the 28 sampling dates in total numbers ranging from 1 to 15. Fertilized fish eggs were taken on only 7 of the dates. Due to the low numbers of both eggs and larvae, graphical presentation of variation with time was not warranted.

Of the 87 larvae collected, 12 were taken during April but none were present in May and June samples. Larvae of smelt, alewife, and sculpin were present in very low numbers in most July and August collections. Larvae numbers peaked in early September, but no larvae were collected in October samples.

Smelt eggs were found on three consecutive dates in May, indicative of the brief spawning period of the species. Alewife eggs were collected in high (90-225) numbers in the first three July samples, probably coinciding with the peak in reproductive activity. Five alewife eggs were also taken on August 5. The only other fish eggs collected were five sculpin eggs collected on July 1.

Pontoporeia affinis was present in all but four samples. Highest numbers were found in April. *Mysis relicta* was found in lower numbers in April and May samples, but on only three dates following that period. The seasonal variation in entrainment of benthic macroinvertebrates probably reflects their preference for lower temperatures, both species being generally more abundant in the cooler, deeper waters of Lake Michigan.

ESTIMATED TOTAL ENTRAINMENT

Estimates of total entrainment were made for the periods April 15-May 31, and for the months of June, July, August, September, and October as well as the entire April-October sampling period. The sum of monthly estimates approximates, but does not equal,the April-October estimate because of the relatively few data points in the former. Estimates were made for the several categories by multiplying the mean number of organisms/sample volume for the period by the total plant flow for the period. For estimation, fish eggs and larvae categories were confined to smelt, alewife, sculpin, and "other". Only seven larvae and no eggs were found from "other" species.

It is estimated that 875,350 fish larvae were entrained during the April-October period. Of these, 44% were alewife, 34% smelt,and 16% were sculpin. The majority of the larvae (actually juveniles) were entrained in September, before leaving the nearshore zone.

Of the 3,675,357 fish eggs estimated to be entrained, 97% were alewife and 3% were smelt. Smelt eggs were found in May and alewife eggs were confined almost entirely to July.

Approximately 5 million *Pontoporeia* and 400,000 *Mysis* were estimated to have been entrained during the monitoring period.

ENTRAINMENT IMPACT

In this discussion, it will be assumed that icthyoplankton and invertebrates which are entrained and experience condenser passage suffer complete mortality. Evidence, although limited, indicates that this is not the case. Sucker eggs which have undergone condenser passage have been shown to have higher viability than controls (Limnetics, 1974). Other studies with eggs and larvae have revealed that these life stages can withstand the temperature differential associated with condenser passage. However, to make a valid estimate of mortality, it would be necessary to obtain icthyoplankton at the discharge and hold the organisms for at least several days

under conditions (including availability of food organisms) which simulate the natural environment. The scope of that task was clearly beyond the limits of this study.

Larvae

Larval occurrence in entrainment samples corresponded closely with occurrence in lake survey samples, but density did not. Alewife, smelt ,and sculpin larvae were generally found at higher concentrations in the lake survey samples, particularly in the reference area. This may indicate either larval avoidance of the immediate intake area or initial depletion of numbers via entrainment,but without replacement.

Quantitative assessments of entrainment can be made if the appropriate biological data is available. Using this approach for alewife, length-weight (Limnetics, 1974) and biomass information (Edsall, et al., 1974) indicate that there are about 10 billion age I alewife in Lake Michigan. First-year mortality is undoubtedly in excess of 90%. It can be assumed that larval alewife production in Lake Michigan is at least 100 billion fish. Entrainment at PWPP appears to involve no more than 0.0004% of Lake Michigan alewife larvae and can not be construed to exert an impact on the population of this prolific species.

Similarly for smelt, it has been estimated that there are more than 30 million pounds of age I+ smelt in the lake. Information is not available on the biomass or number in a given age class. It can conservatively be assumed that at least 20% or 60 million smelt are age I. At a first-year mortality rate of 90%, 600 million larvae would have to be generated each year to maintain the population. The PWPP entrains about 0.05% of this number.

The foregoing exercises make conservative assumptions and should be considered as worst-case examples. Their validity rests on the fact that both species are pelagic and must be considered to have lakewide populations.

This is not the case for the slimy and other sculpins, which were also estimated to be entrained in some number. Adult sculpin are bottom-oriented fish which are relatively sedentary. Larvae, however, are planktonic and are captured in the water column (Section II), indicating that populations are probably at least regional in nature. They are found throughout Lake Michigan, being more common beyond the littoral zone (Wells, 1968). It has been tentatively estimated that there are 2-4 million pounds of sculpins beyond the larvae state in Lake Michigan (Limnetics, 1976). Length-weight information (Limnetics, 1974) indicates that they probably average about

50 to the pound. Although sculpin fecundity is relatively low, larvae are subjected to the open water environment and undoubtedly suffer substantial mortality. While it is not possible to realistically quantify the sculpin population, the abundance of sculpin in Lake Michigan makes it extremely doubtful that entrainment at PWPP has more than a very local effect on the population.

Other larval species are apparently entrained at PWPP in very low numbers, and it is likely that impact is negligible.

Eggs

The 3.5 million alewife eggs entrained represent the production of about 330 gravid females (Norden, 1967). Similarly the 122,500 smelt eggs could be produced by only 6 fish (Nalco, 1975a). These were the only eggs collected.

Removal of eggs at this magnitude can not be considered to exert an impact on alewife or smelt populations. All Lake Michigan species (except the sheepshead) have demersal eggs which would not be subject to entrainment in large numbers.

Invertebrates

Both *Pontoporeia affinis* and *Mysis relicta* are bottom-oriented species which are most abundant beyond the littoral zone. Even within the 30-foot contour, numbers are often extremely high. Limnetics (1974) found an average of 740 *Pontoporeia* per square meter at the 24-foot depth at Point Beach, almost 3 million/acre. Densities of *Pontoporeia* of 18 million/acre have been reported near Zion, Illinois (Nalco, 1975). Although quantification has not been performed in the Port Washington area, it appears likely that PWPP entrains an insignificant percentage of the *Pontoporeia* in the vicinity. *Mysis* densities in the littoral region are generally lower, but rise with distance from shore (Reynolds and DeGraeve, 1972). Like *Pontoporeia*, *Mysis* is a benthic creature; and it is unlikely, because of its depth and distribution, that more than a minute fraction of the local *Mysis* population would be vulnerable to entrainment at PWPP.

C VARIATIONS IN INTAKE EFFECT

Variations in intake effects over the next several years are more likely to result from changes in the highly unstable ecosystem than from changes in either plant operation or in lake level. It is expected that Port Washington Power Plant will continue to operate in its present mode for the foreseeable future (Section I). Changes in lake level will affect fish entrapment inasmuch as entrapment is a function of intake velocity rather than volume.

TABLE III-1a. Species comprising groups in Tables III-1 and III-2

TROUT	
Rainbow Trout	Tiger Trout
Atlantic Salmon	Brook Trout
Brown Trout	Juvenile Trout
Lake Trout	
SALMON	
Chinook Salmon	Juvenile Pacific Salmon
Coho Salmon	
GAME AND FOOD FISHES	
Channel Catfish	Pumpkinseed Sunfish
Black Bullhead	Green Sunfish
Brown Bullhead	Black Crappie
Yellow Bullhead	White Crappie
Lake Whitefish	Rock Bass
Bloater	Largemouth Bass
Yellow Perch	Northern Pike
Bluegill Sunfish	
ROUGH FISHES	
Carp	Shorthead Redhorse
Goldfish	Longnose Sucker
Burbot	White Sucker
FORAGE FISHES	
Trout Perch	Emerald Shiner
9-Spine Stickleback	Other Shiner
Brook Stickleback	Gizzard Shad
Deepwater Sculpin	Mud Minnow
Slimy Sculpin	Johnny Darter
Other Sculpin	Creek Chub
Longnose Dace	Fathead Minnow
Lake Chub	Other Minnow
Spottail Shiner	

Table III-1. Monthly and Annual Estimates (number) of Total Impingement at Port Washington Power Plant

Period	Species or Group	Ninety Percent Confidence Interval		
		Minimum	Mean	Maximum
1975 March	Smelt	-	1,571	8,051
	Alewife	-	43	127
	Trout	-	841	2,403
	Salmon	-	None	-
	Game & Food Fishes	-	132	669
	Rough Fishes	-	60	215
	Forage Fishes	-	858	3,023
	Total		3,505	14,345
April	Smelt	-	6,143	17,240
	Alewife	-	8,838	37,901
	Trout	-	782	1,671
	Salmon	-	None	-
	Game & Food Fishes	-	127	314
	Rough Fishes	-	105	247
	Forage Fishes	72	1,741	3,411
	Total		17,736	50,125
May	Smelt	-	3,372	10,485
	Alewife	283,840	446,654	639,468
	Trout	-	330	671
	Salmon	-	161	758
	Game & Food Fishes	-	31	77
	Rough Fishes	-	58	129
	Forage Fishes	1,634	3,274	4,914
	Total	255,300	453,880	652,460
June	Smelt	-	3,906	8,830
	Alewife	145,330	1,101,745	2,058,160
	Trout	-	73	236
	Salmon	-	397	1,454
	Game & Food Fishes	9	39	69
	Rough Fishes		95	359
	Forage Fishes		1,447	3,702
	Total	150,425	1,107,702	2,065,019

Table III-1. Monthly and Annual Estimates (number) of Total Impingement at Port Washington Power Plant

Period	Species or Group	Ninety Percent Confidence Interval		
		Minimum	Mean	Maximum
July	Smelt		12,478	26,718
	Alewife	104,154	417,223	730,292
	Trout	-	64	141
	Salmon	235	448	660
	Game & Food Fishes		60	155
	Rough Fishes		46	97
	Forage Fishes	234	1,184	2,134
	Total	105,041	431,503	757,966
August	Smelt		18,421	39,570
	Alewife		34,614	73,088
	Trout		72	210
	Salmon		253	900
	Game & Food Fishes		64	136
	Rough Fishes		84	290
	Forage Fishes		488	1,576
	Total	17,600	53,996	90,392
Septembe	Smelt	-	18,291	84,666
	Alewife	-	5,960	12,070
	Trout	-	254	648
	Salmon	9	33	57
	Game & Food Fishes	-	32	80
	Rough Fishes	-	130	372
	Forage Fishes	-	858	2,462
	Total		25,558	97,081
October	Smelt		378	1,093
	Alewife		45,086	214,286
	Trout		649	1,709
	Salmon		51	106
	Game & Food Fishes		11	32
	Rough Fishes		48	158
	Forage Fishes		2,124	4,492
	Total		48,347	262,442

Table III-1. Monthly and Annual Estimates (number) of Total Impingement at Port Washington Power Plant

Period	Species or Group	Ninety Percent Confidence Interval		
		Minimum	Mean	Maximum
November	Smelt		1,903	5,239
	Alewife	3,746	19,084	34,422
	Trout	112	182	252
	Salmon	-	13	65
	Game & Food Fishes	-	50	123
	Rough Fishes	-	None	
	Forage Fishes	-	441	1,439
	Total	9,602	21,673	33,744
December	Smelt	-	1,854	4,886
	Alewife	-	1,462	5,062
	Trout	-	135	278
	Salmon	-	6	30
	Game & Food Fishes	-	19	53
	Rough Fishes	-	17	69
	Forage Fishes	-	402	1,338
	Total		3,895	10,257
1976 January	Smelt	-	656	1,707
	Alewife	-	228	1,004
	Trout	-	92	385
	Salmon	-	None	-
	Game & Food Fishes	-	None	-
	Rough Fishes	-	None	-
	Forage Fishes	-	91	260
	Total		1,067	2,991
February	Smelt		566	1,980
	Alewife		391	2,291
	Trout		121	256
	Salmon		None	
	Game & Food Fishes		13	38
	Rough Fishes		13	68
	Forage Fishes		143	274
	Total		1,247	3,059

Table III-1. Monthly and Annual Estimates (number) of Total Impingement at Port Washington Power Plant

Period	Species or Group	Ninety Percent Confidence Interval		
		Minimum	Mean	Maximum
March, 1975	Smelt	-	72,814	303,918
	Alewife	1,237,444	1,946,061	2,654,678
	Trout	-	4,234	113,767
February, 1976	Salmon	-	1,210	5,043
	Game & Food Fishes	-	669	2,554
	Rough Fishes	-	756	2,260
	Forage Fishes	-	14,728	42,294
	Total	1,252,212	2,040,472	2,828,732

TABLE III.-2a. Sustained swimming speeds of some midwestern fishes

Species	Length (inches)	Water Temp. (°C)	Max. Speed (fps)	Body Lengths/ second	Source
Smelt	6.0*	5°	1.12	2.2	Otto, 1974
		15°	1.31	2.6	
Lake Trout	6.6*	5°	0.82	1.5	Otto, 1974
		15°	0.98	1.8	
Yellow Perch	0.6	-	0.17	3.4	Houde, 1969
	5.0*	10°	0.55	1.3	Otto, 1974
		20°	0.85	2.0	
Bluegill	1.3		0.74	6.8	Oseid & Smith,1972
Rainbow Trout	4.3*	10°	1.02	2.8	Otto, 1974
		20°	1.34	3.7	
	12.9	-	3.54	3.3	Jones, et al, 1974
Coho Salmon	3-4	5°	0.8-1.0	3.0	Griffiths & Alderdice, 1972
		20°	1.2-2.0	5-6	

*Total length derived from standard length.

Table III-2. Monthly and Annual Estimates (weight in lbs.) of Total Impingement at Port Washington Power Plant

Period	Species or Group	Ninety Percent Confidence Interval Minimum	Mean	Maximum
1975 March	Smelt	-	98.8	506.8
	Alewife	-	2.7	6.0
	Trout	91	759.0	1,427.0
	Salmon	-	None	-
	Game & Food Fishes	-	9.3	47.1
	Rough Fishes	1.7	23.7	45.7
	Forage Fishes	-	50.4	183.8
	Total	155.1	943.9	1,732.7
April	Smelt	-	268.7	539.1
	Alewife	-	805.0	3,418.7
	Trout	158.9	405.5	969.9
	Salmon	-	None	-
	Game & Food Fishes	-	27.8	64.9
	Rough Fishes	-	101.0	354.2
	Forage Fishes	18.1	104.2	190.3
	Total		1,712.2	4,830.7
May	Smelt	-	215.9	666.2
	Alewife	-	25,762.7	26,428.9
	Trout	-	380.1	926.8
	Salmon	100.8	59.0	218.8
	Game & Food Fishes	-	8.4	26.5
	Rough Fishes	-	83.6	250.6
	Forage Fishes	75.6	178.4	281.2
	Total		26,688.1	89,136.0
June	Smelt	-	225.7	529.6
	Alewife	-	58,716.6	134,744.9
	Trout	-	114.3	303.6
	Salmon	-	69.2	333.2
	Game & Food Fishes	-	79.0	361.5
	Rough Fishes	-	570.5	2,094.1
	Forage Fishes	-	84.2	199.0
	Total		59,859.5	136,605.9

Table III-2. Monthly and Annual Estimates (weight in lbs.) of Total Impingement at Port Washington Power Plant

Period	Species or Group	Ninety Percent Confidence Interval Minimum	Mean	Maximum
July	Smelt		174.3	387.6
	Alewife	-	18,918.4	30,878.4
	Trout	-	119.2	298.0
	Salmon	18.9	30.7	42.5
	Game & Food Fishes	-	17.3	65.5
	Rough Fishes	-	70.2	165.8
	Forage Fishes	-	67.1	121.9
	Total		19,397.2	31,454.5
August	Smelt		194.7	392.9
	Alewife		2,568.2	5,921.4
	Trout		247.6	682.7
	Salmon		23.0	74.2
	Game & Food Fishes		5.2	13.4
	Rough Fishes		32.4	93.7
	Forage Fishes		27.6	92.8
	Total		3,098.7	6,081.7
September	Smelt		209.3	841.6
	Alewife		243.1	731.1
	Trout		1,453.5	3,705.4
	Salmon		69.1	228.3
	Game & Food Fishes		9.3	34.2
	Rough Fishes		38.0	85.2
	Forage Fishes		44.0	126.3
	Total		2,066.3	4,782.5
October	Smelt		20.5	56.9
	Alewife		459.2	2,136.6
	Trout		4,127.8	12,477.2
	Salmon		272.0	692.4
	Game & Food Fishes		4.7	18.7
	Rough Fish		24.4	105.3
	Forage Fish		202.9	484.2
	Total		5,111.5	12,934.5

Table III-2. Monthly and Annual Estimates (weight in lbs.) of Total Impingement at Port Washington Power Plant

Period	Species or Group	Ninety Percent Confidence Interval Minimum	Mean	Maximum
November	Smelt	-	107.6	279.9
	Alewife	78.7	1,013.1	1,947.5
	Trout	-	624.9	1,281.2
	Salmon	-	52.3	265.6
	Game & Food Fishes	-	4.7	11.9
	Rough Fishes	-	None	-
	Forage Fishes	-	46.7	139.9
	Total	279.6	1,849.3	3,419.0
December	Smelt		100.7	257.3
	Alewife		73.1	253.1
	Trout		279.8	607.7
	Salmon		1.1	6.0
	Game & Food Fishes		16.1	88.7
	Rough Fishes		18.3	74.2
	Forage Fishes		23.4	77.8
	Total	3.2	512.5	1,021.8
1976 January	Smelt	-	35.7	95.7
	Alewife	-	11.8	52.7
	Trout	-	166.6	914.5
	Salmon	-	None	-
	Game & Food Fishes	-	None	
	Rough Fishes	-	None	-
	Forage Fishes	-	4.6	13.0
	Total		218.7	1,110.5
February	Smelt		32.0	111.0
	Alewife		19.5	74.5
	Trout		257.4	799.5
	Salmon		None	-
	Game & Food Fishes		2.6	7.6
	Rough Fishes		0.7	3.4
	Forage Fishes		16.5	64.0
	Total		328.7	791.9

Table III-2. Monthly and Annual Estimates (weight in lbs.) of Total Impingement at Port Washington Power Plant

Period	Species or Group	Ninety Percent Confidence Interval		
		Minimum	Mean	Maximum
March, 1975 - February, 1976	Smelt		1,920	5,607
	Alewife		102,730	493,173
	Trout		8,713	33,359
	Salmon		526	2,192
	Game & Food Fishes		199	906
	Rough Fishes		969	5,471
	Forage Fishes		930	2,609
	Total		115,986	510,329

Table III-3. Monthly and Annual Estimates of Total Entrainment for Port Washington Power Plant

Period	Life Form	Estimated Number Entrained
April-May	Larvae	
	Alewife	None
	Sculpin	55,909
	Smelt	None
	Other	11,131
	Total	67,040
	Eggs	
	Alewife	None
	Sculpin	None
	Smelt	97,749
	Other	None
	Total	97,749
	Pontoporeia	2,412,300
	Mysis	159,814
	Larvae	None
	Eggs	None
	Pontoporeia	283,969
	Mysis	46,254
	Larvae	
	Alewife	16,980
	Sculpin	43,042
	Smelt	11,791
	Other	19,460
	Total	91,273

Table III-3. Monthly and Annual Estimates of Total Entrainment for Port Washington Power Plant

Period	Life Form	Estimated Number Entrained
July (cont'd)	Eggs	
	Alewife	3,711,680
	Sculpin	None
	Smelt	None
	Other	None
	Total	3,711,680
	Pontoporeia	271,111
	Mysis	5,896
August	Larvae	
	Alewife	17,559
	Sculpin	34,768
	Smelt	60,639
	Other	17,159
	Total	130,125
	Eggs	
	Alewife	43,314
	Sculpin	None
	Smelt	None
	Other	None
	Total	43,314
	Pontoporeia	1,089,350
	Mysis	225,233
September	Larvae	
	Alewife	244,820
	Sculpin	9,825
	Smelt	169,318
	Other	None
	Total	423,963

Table III-3. Monthly and Annual Estimates of Total Entrainment for Port Washington Power Plant

Period	Life Form	Estimated Number Entrained
September (cont'd)	Eggs	None
	Pontoporeia	359,985
	Mysis	9,826
October	Larvae	None
	Eggs	None
	Pontoporeia	122,973
	Mysis	None
April-October	Larvae	
	Alewife	384,158
	Smelt	300,765
	Sculpin	143,276
	Other	47,151
	Total	875,350
	Eggs	
	Alewife	3,552,870
	Smelt	122,487
	Sculpin	None
	Other	None
	Total	3,675,357
	Pontoporeia	4,902,880
	Mysis	393,320

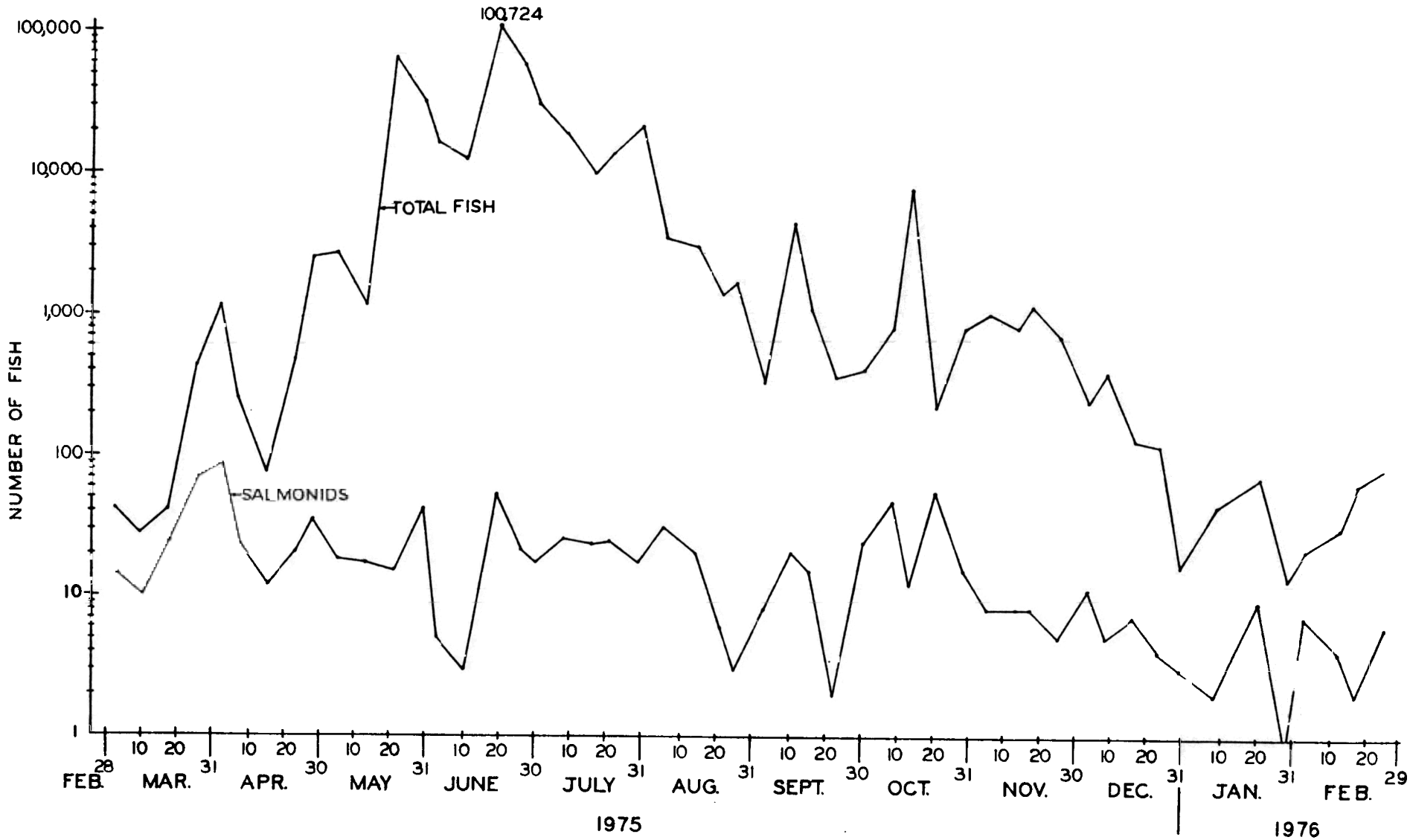

FIGURE III-1: SEASONAL VARIATIONS IN NUMBER OF ALL FISH AND SALMONIDS

COLLECTED FROM THE TRAVELING SCREENS AT PORT WASHINGTON POWER PLANT

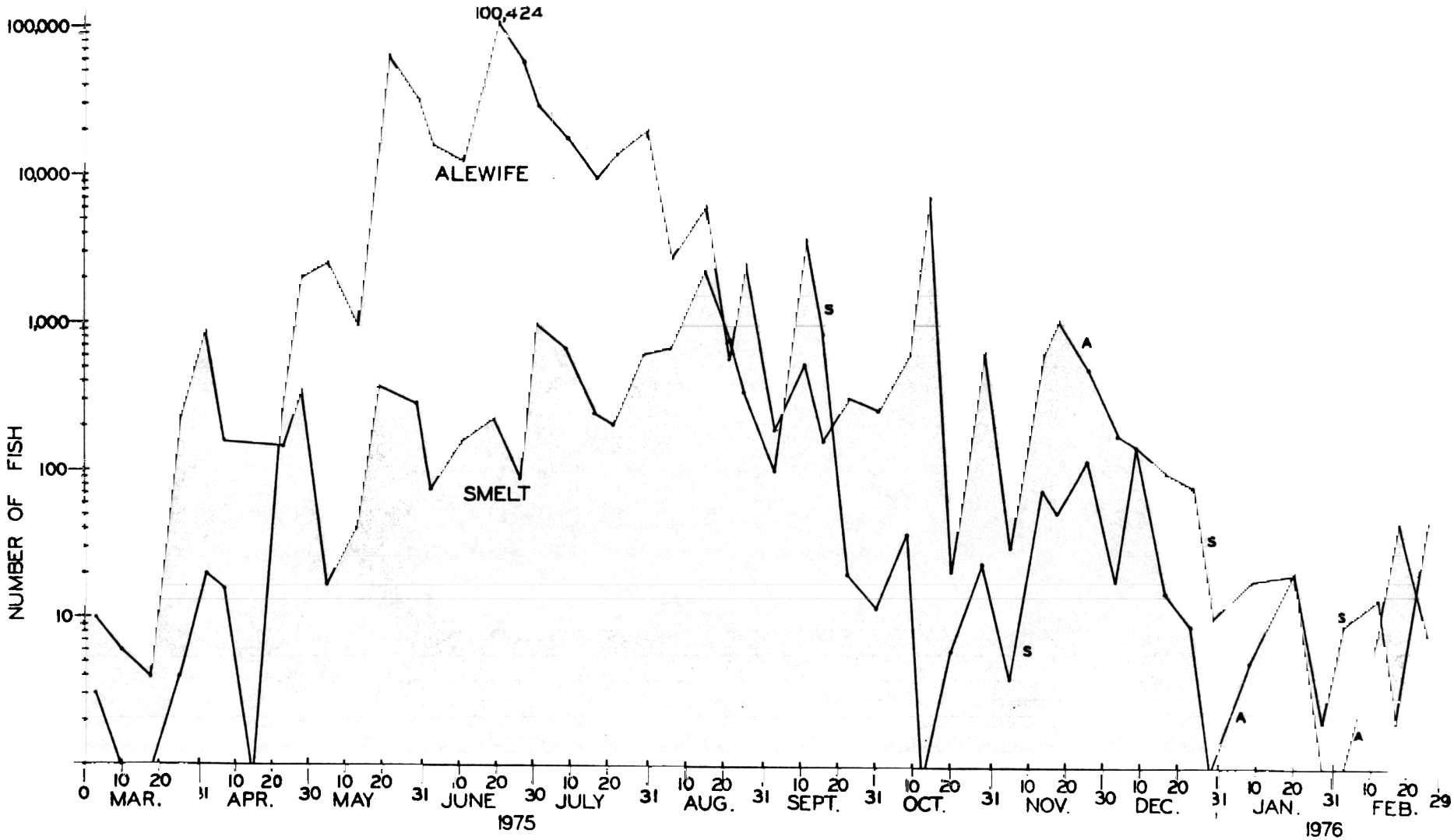

FIGURE III-2: SEASONAL VARIATION IN NUMBER OF SMELT AND ALEWIFE COLLECTED FROM THE TRAVELING SCREENS AT PORT WASHINGTON POWER PLANT

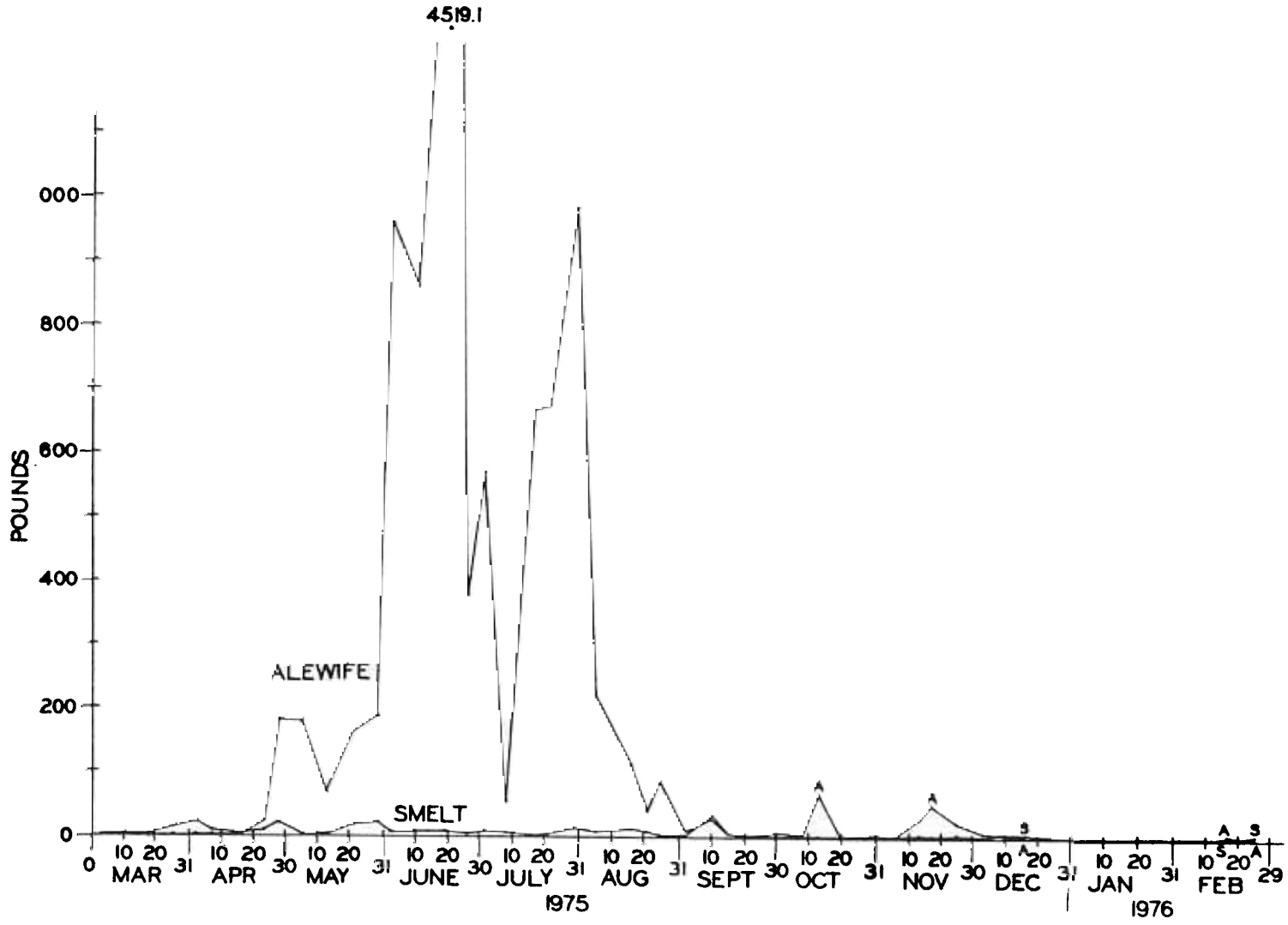

FIGURE III-3: SEASONAL WEIGHT DISTRIBUTION OF SMELT AND ALEWIFE

COLLECTIONS FROM THE PORT WASHINGTON TRAVELING SCREENS

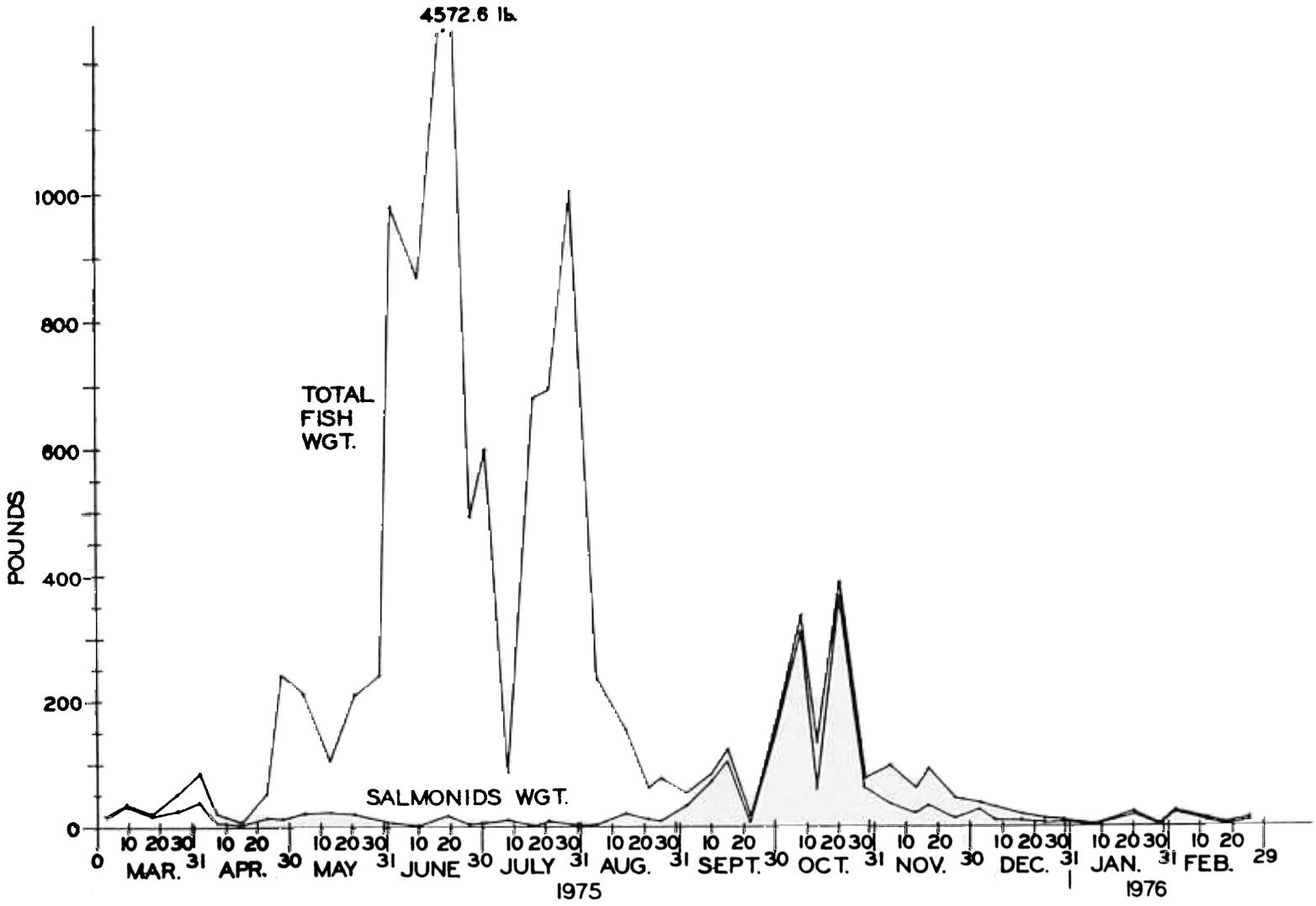

FIGURE III-4: SEASONAL WEIGHT DISTRIBUTION FOR TOTAL FISH AND SALMONIDS

COLLECTED FROM THE TRAVELING SCREENS AT PORT WASHINGTON POWER PLANT

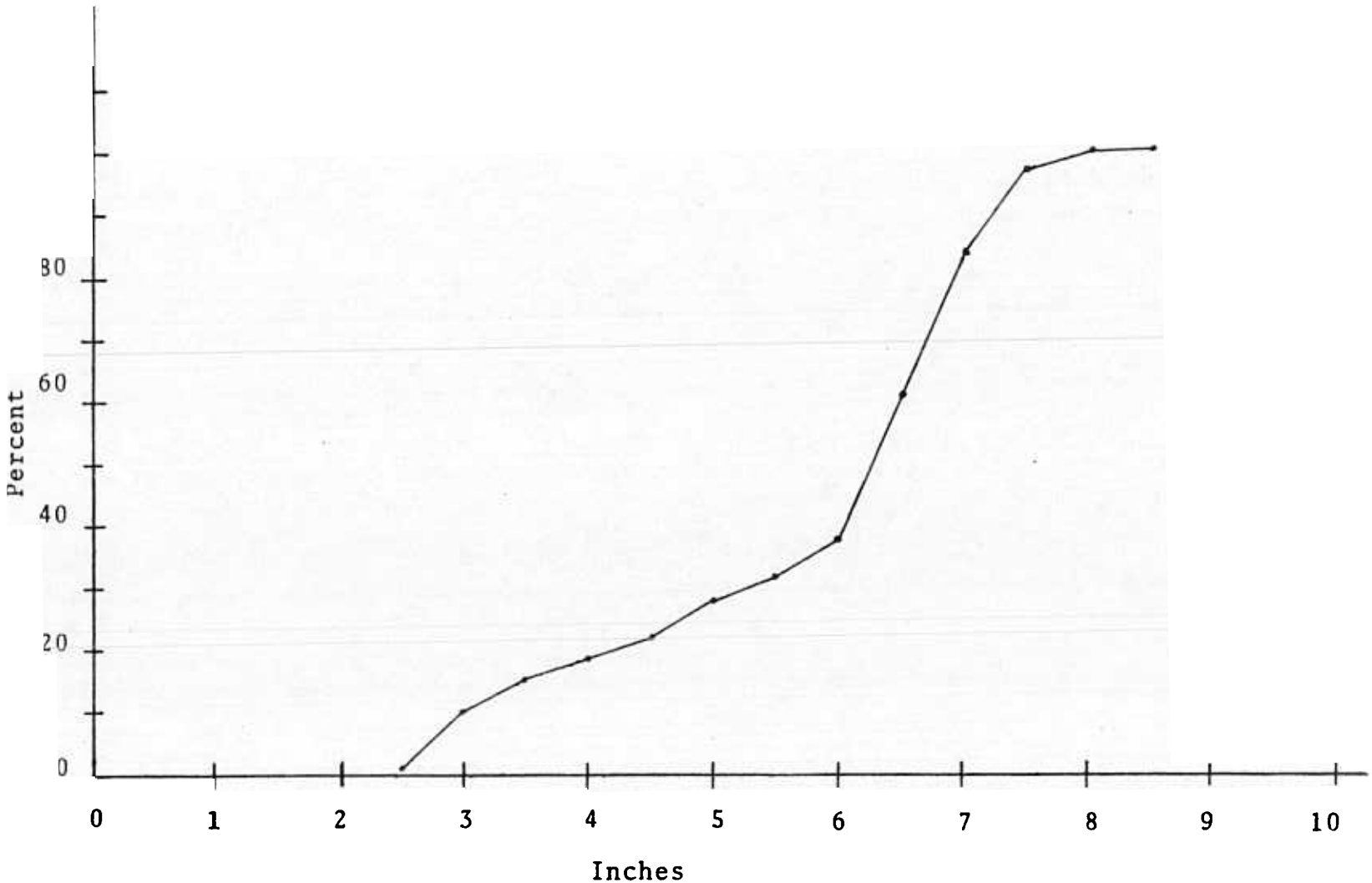

Figure III-5. Cumulative length-frequency distribution of alewife collected from the travelling screens at Port Washington Power Plant May 21-June 19, 1975

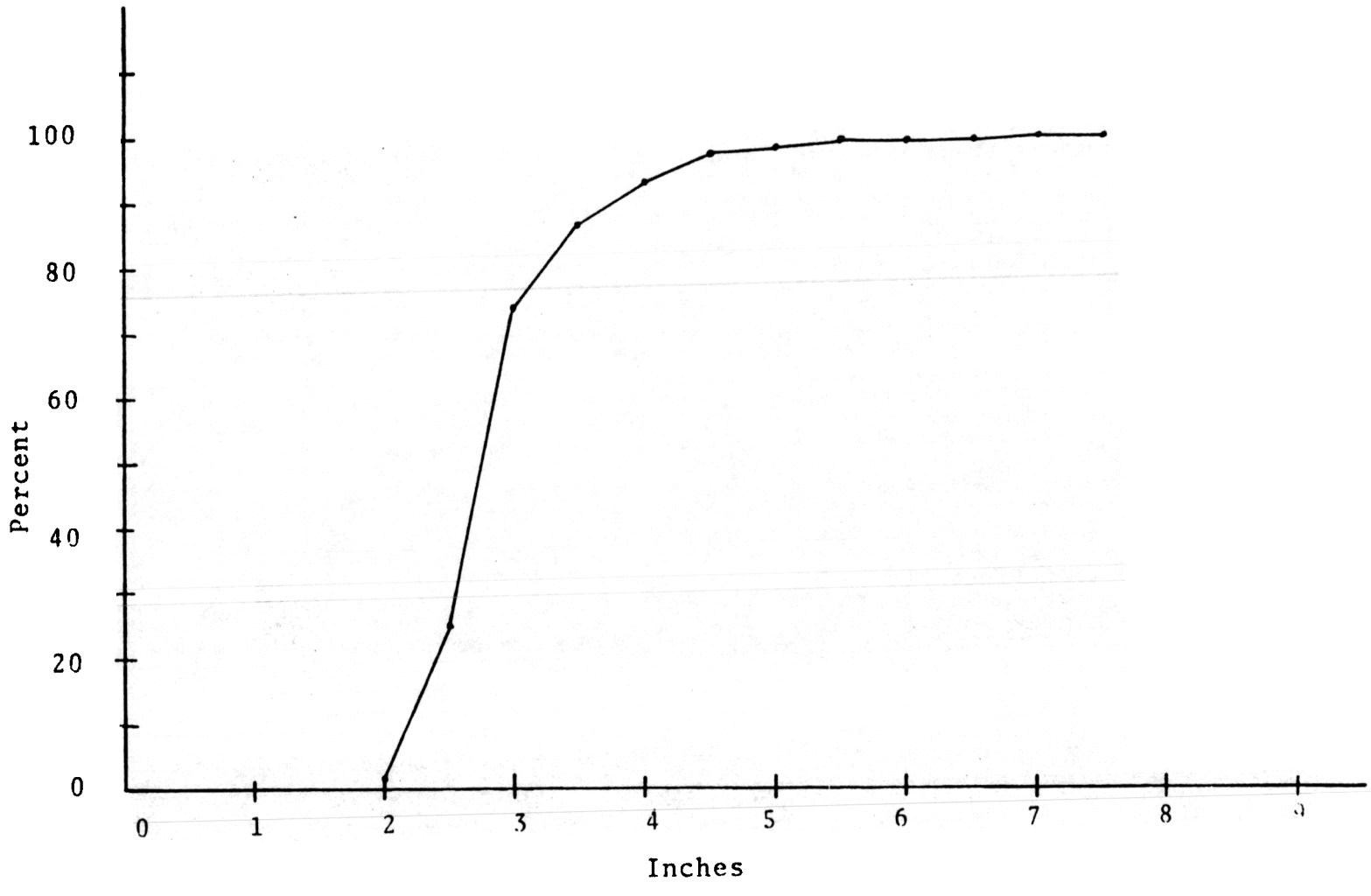

Figure III-6. Cumulative Length-frequency Distribution of Smelt Collected from the Travelling Screens at Port Washington Power Plant, August 14 - September 10, 1973.

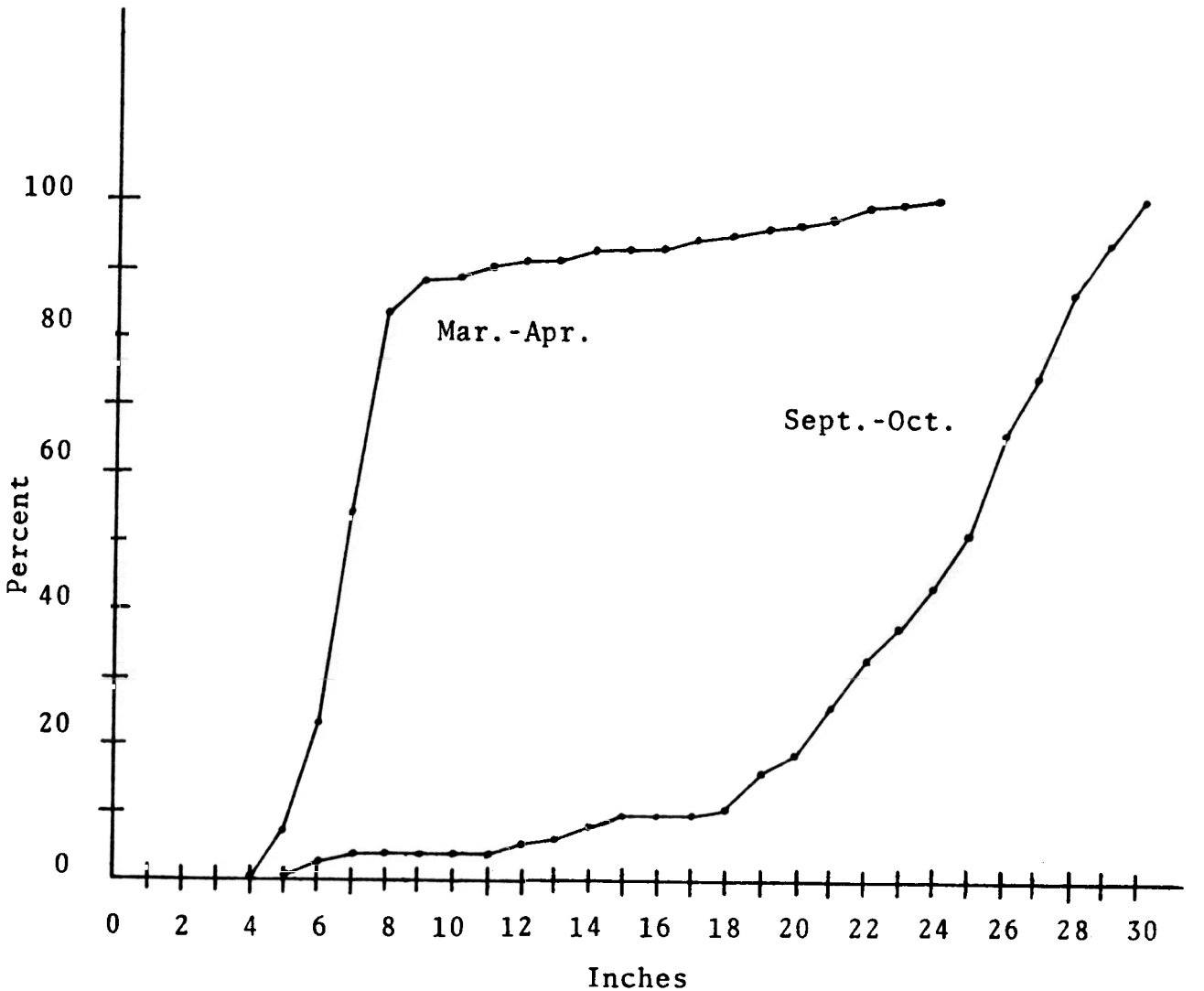

Figure III-7. Cumulative length-frequency distribution of salmonids collected from the travelling screens at Port Washington Power Plant March 18-April 15 and September 30-October 28, 1975

IV. CONCLUSION

A. ADEQUACY OF THE MONITORING PROGRAM

The monitoring program was of sufficient scope to obtain useful estimates of the magnitude of entrainment and entrapment. There were no real problems with either type of collection, nor were there techniques which could be substantially improved. Lake survey results agreed well with entrainment results in terms of the appearance of organisms. Sampling approximately 300 gallons of water per minute for 24 continuous hours per week should be sufficient to indicate the magnitude of entrainment, unless nearshore icthyoplankton abundance consists of one or a few very dramatic and short term peaks, e.g.,if 50% of annual entrainment occurs in one day. Studies of larvae distribution and seasonal abundance indicate that this is a remote possibility.

Impingement collections were of sufficient frequency to monitor about one-sixth of the total annual cooling water use. Sampling of this intensity should provide accurate total estimates. Confidence intervals generated in the estimation procedure were, however, too large in most instances to be useful. This might be corrected by making seasonal rather than monthly estimates (Section III). The actual estimates appear to be sound inasmuch as they have approximately the same ratio to actual counts as does plant operating time to sampling time.

B. ENVIRONMENTAL IMPACT OF THE INTAKE SYSTEM

Entrainment of icthyoplankton was confined principally to alewife, smelt, and sculpin. Alewife and smelt eggs and larvae numbers were minute relative to the reproductive potential of these prolific, early-maturing species. Sculpin, though less prolific, are also extremely abundant in Lake Michigan; and it appears doubtful that entrainment at PWPP has any discernible impact on the population.

Entrainment of *Pontoporeia affinis* and *Mysis relicta* was not high in comparison with reports of offshore abundance. Although these epibenthic invertebrates frequent the nearshore area, they are found at much higher densities near the bottom, in deeper water.

In summary, entrainment impact at the Port Washington Power Plant appears to be negligible.

Although a diverse number of fish species were collected from the Port Washington travelling screens, most were captured in such low numbers that impact was obviously nil. Alewife and smelt and the salmonid species accounted for approximately 98% of the estimated annual impingement by weight. The magnitude of alewife and smelt impingement is so small,relative to the size of the populations of these species,that impact on the populations must be considered negligible. In addition, many of the alewife are dead before they enter the plant.

Impingement of trout and salmon can not be evaluated in a strict ecological sense, since these species are artificially maintained as a recreational resource. Useful evaluation of impact on salmonids should be made on a socio-economic basis. In terms of potential loss to fishermen, impingement of salmonids at PWPP probably represents much less than one per cent of the annual Wisconsin sport catch from Lake Michigan. Whether this potential loss warrants application of remedial technology should be determined on a cost-benefit basis.

Finally, it should be noted that evidence indicates that impingement survival at PWPP may be high, and that any assessment of impact based on complete mortality may be unduly conservative.

V. ALTERNATIVE INTAKE TECHNOLOGY

Guidelines for this report, as developed by the Department of Natural Resources (DNR), include discussion of alternative intake locations, designs, capacities, and construction techniques. This section contains that discussion. However, it must be noted that application, as contrasted with the discussion, of remedial technology is contingent on evidence of adverse environmental impact of present intake facilities. The intensive monitoring program, presented in preceding sections of this report, demonstrates that the existing intake facilities have minimal adverse environmental impact on all components of Lake Michigan fish populations *per se*. The potential loss of salmonids through impingement is a socioeconomic phenomenon more than an ecological one. Modification of the existing intake system to alleviate salmonid impingement can only be justified if real losses are of a magnitude to provide a satisfactory cost/benefit ratio relative to the feasible alternatives.

The following discussion is based, to a large extent, on information contained in U.S.E.P.A.'s (1973) "Development Document for Proposed Best Technology Available for Minimizing Adverse Environmental Impact of Cooling Water Intake Structures". This document shall hereafter be cited as "EPA, 1973". A second source of useful information was the (1973) "Lake Michigan Intakes: Report on the Best Technology Available" by the Lake Michigan Cooling Water Intake Structure Technical Commitee. This report shall hereafter be cited as "LMCWISTC, 1973".

For purposes of this discussion, "intake" shall include the entire intake facility from the actual inlet structure (point of water entrance) to and including debris removal devices.

A. LOCATION

Location of the water inlet structure in an area of low biological activity and significance is the most obvious way to minimize entrapment of organisms and is virtually the only way to assure low entrainment of true planktonic organisms.

The present intake channel configuration at Port Washington Power Plant is located in an area frequented by nektonic fishes, but results of the biological monitoring program indicate that icthyoplankton are limited primarily to smelt, alewife, and sculpin and are not entrained in excessive numbers relative to their abundance. The following discussion on alternative inlet locations will focus on methods to reduce impingement potential.

There are three basic orientations for inlet structures: shoreline, offshore, and as an approach channel extending inland from the shoreline. Each is considered below:

SHORELINE LOCATION

The PWPP approach channel could be modified to become essentially a shoreline intake by a) moving the trash bars to the end of the channel or b) constructing a rubble-walled intake pond extending from the channel mouth. Success of the first alternative is partially dependent on low velocity through the trash rack. If the present intake channel was uniformly dredged to the maximum possible depth of 17 feet, velocity through the trash rack would be 1.5 fps, well in excess of the recommended 0.5 fps velocity for fish escape (EPA, 1973). This type of modification does not actually increase impingement potential, trapping fish between the trash rack and the travelling screen.

A rubble-mound intake pond could be constructed from the east end of the south rubble mound to utilize the north rubble mound, which extends beyond the coal dock, as a fourth side. To achieve a maximum velocity of 0.5 fps through the rubble, the walls would have to extend 600 feet and encompass approximately 4 acres of the lake. It should be noted that interstices in the rubble would permit entrance by relatively large fish. A pond of this type services Lakeside Power Plant on Lake Michigan. Although fish impingement is very low at this plant, gill-netting surveys in the pond revealed the presence of large (12+ inch total length) fish, principally carp and salmonids. It appears that these fish enter the pond periodically, since numbers captured and removed remained similar in consecutive surveys. The fact that these large fish are seldom impinged may result from the intermittent nature of plant operation.

Although fish can penetrate it, a rubble-mound pond should provide a barrier to free movement. Construction of a rubble-mound intake pond at Port Washington should serve to reduce the abundance of fish in the immediate intake area. In addition, small fish which frequent the vicinity would not be inadvertently carried into the intake system.

OFFSHORE LOCATION

A number of Lake Michigan power plant and municipal inlets have been constructed offshore at depths of 18-30 feet. The inlets generally consist either of an emergent intake crib or a submerged structure rising several feet above the

lake bottom. Buried conduits carry water from the inlet structure to the plant.

Emergent cribs draw water through crib material, pipes in the crib wall, or both. An emergent crib located in the vicinity of Port Washington Harbor would pose a potential navigational hazard to recreational boating and commercial shipping. The area is used intensively by pleasure craft and coal and oil carriers frequently docked in the harbor.

Submerged intakes generally consist of a basement structure overlaid by an open area for water intake and topped by a velocity cap. Fish are not responsive to vertical currents, but are able to avoid horizontal changes in velocity. The velocity cap prevents vertical entrapment

Both types of intake cribs can be equipped with trash racks over orifices. However, these racks will permit passage of large fish since bars must be spaced at wide intervals to prevent frequent clogging.

An offshore intake might reduce impingement at Port Washington if it could be placed in an area of lower fish concentration. To achieve a trash rack velocity of 0.5 fps, a submerged intake with 5 foot vertical gap would require a structure 120 feet in diameter at PWPP. With a 2 foot vertical gap, diameter would approach 400 feet. Observations indicate that fish, including salmonids, are often abundant well beyond the thirty-foot depth contour on the western shore of Lake Michigan. The inlet area at an offshore intake which fish could enter to become entrapped would be 2 to 3 times as large as with the present system. Installation of a submerged offshore intake would not minimize entrapment at PWPP.

APPROACH CHANNEL

The approach channel intake, such as is used at PWPP, is considered to have generally high entrapment potential because fish tend to be attracted to the area and are unable or unwilling to escape the flow to the debris screens. This situation might be alleviated in a number of ways while retaining the approach channel configuration. Trash racks at the mouth, reduced velocity, diversion devices, and bypass systems may reduce impingement. These alternatives are discussed in the appropriate parts of this section.

B. DESIGN

Design aspects of inlet structures were described in the preceding section because location and design of inlets are functionally related. This section discusses design considerations for the remainder of the intake system. The components described include diversion devices, screening systems, and return facilities.

Steam electric generating stations employ a variety of mechanisms to prevent debris from clogging condenser tubes. Inanimate debris is necessarily removed by physical screening devices. Fish, however, may be "screened" prior to this point by devices which prevent them from becoming entrapped. Impact of the intake system on entrapped nektonic fishes can be minimized by providing for escape from contact with the physical screening system or by design of that system to return fish unharmed following impingement.

PREVENTION OF ENTRAPMENT

Location of the water inlet is of prime importance in minimizing entrapment potential. However, there are no locations in the nearshore region of Lake Michigan which will not be frequented by fish at various times. Certain non-conventional intakes have been developed which can totally prevent entrapment. These intakes rely on filtering water through an overlying medium (such as sand or stone) or draw water directly from an aquifer. The filter intakes require very large areas of substrate and are subject to clogging. They are generally practical only for plants with low circulating flow. Intakes which derive cooling water from underlying aquifers are subject to similar limitations. Neither the filter nor the aquifer-type intake would provide a sufficient and reliable supply of cooling water for Port Washington Power Plant.

Several means of diverting fish from contact with debris screens have been devised. Two physical diversion devices which employ changes in flow direction may be effective in reducing impingement. The velocity cap, described in conjunction with offshore inlets, prevents vertical entrapment of fishes. A second type of diverter consists of louvers, each placed at an angle of 90° to the direction of flow. The angle of inclination of the louver barrier is 10° to 15° to the angle of flow. Fish orient themselves perpendicular to the barrier and are carried along its face to a bypass system. Ratio of bypass to channel velocities should be 1.2-1.5:1. Diversion efficiency is dependent on velocity and fish size (actually, swimming capacity). Design aspects such as bypass ratios, velocities, louver angles, spacings, guide walls, etc. may be varied on a

site-specific basis to increase efficiency. The louver diverter has potential application for intakes with strong uni-directional flow, as experienced in rivers and some approach channels. This system is still experimental, and complete evaluation of the effectiveness of louver diverters has not been made. Disadvantages, in addition to costs, are that efficiency is impeded by heavy debris loads and changes in flow velocity. The PWPP approach channel suffers occasionally heavy loads of suspended vegetation. The plant operating schedule is highly variable which is in variations in pumping rates and, therefore, in approach channel velocities. An additional consideration associated with the louver diverter is development of an effective bypass system. A channel could be excavated to return the fish to the lake on the southern edge of the PWPP peninsula. Whether these fish would then disperse, concentrate in the area, or perhaps return to the approach channel cannot be predicted. In view of its unproved effectiveness and performance limitations, the louver diverter cannot be considered as a feasible modification to the PWPP intake system.

A second category of diversion devices relies on fish behavior or reaction patterns rather than on physical barriers to prevent impingement. Included here are electric, sound and light screens, and air bubbler systems. These contrivances are designed to produce negative stimuli to repel fish. Effectiveness is related to fish swimming ability, which is itself dependent on size and water temperature; behavioral barriers are less successful for smaller fish and during colder seasons. Avoidance is also species dependent and may vary within a species by life stage. For any fish, reception of a higher priority stimulus will negate response to the behavioral system. Appearance of a predator, food organisms, or reproductive cues might elicit an undesired response. Because of these factors, behavioral systems have not been consistently effective. However, each of these systems could readily be installed in the PWPP intake channel, and this fact warrants assessment of their potential effectiveness.

Electric screens utilize current pulses to repel fish. They are effective at diverting fish moving upstream, but may actually increase entrapment of fish moving with the current; electric screens would not be effective in the PWPP approach channel. Both light and south barriers have been tested at power plants with inconsistent results. Species react differently to a given wavelength or frequency, and there is evidence that acclimation might occur. Response of fishes to light or sound is not sufficiently well understood that reliable avoidance systems can be constructed which utilize these stimuli. Air bubble screens, extending from bottom to surface, have had inconclusive results in reducing entrapment. Since installation of this system in

the approach channel of the Pulliam Power Plant (Green Bay, Wisconsin) in 1968, no shutdowns resulting from intake clogging by alewives have occurred. However, clogging of Lake Michigan intakes by alewives has occurred rarely since the 1966-67 die-offs experienced by that species. The air bubble screen system employed at the Indian Point Plant on the Hudson River has not markedly reduced impingement. In addition, no assessment of the effectiveness of the air bubble screen in repelling salmonids or other larger fish has been made. For these reasons, it can't be considered to be a feasible alternative for PWPP.

ESCAPE FROM INTAKE SYSTEMS

If fish can't be prevented from entering an intake system, methods should be considered which will permit their escape. Feasibility of escape is dependent on the type of intake system, the season, and the size and species of fish. Offshore intakes afford little opportunity for escape after initial entrapment. Shoreline intakes can be designed to include escape potential up to the debris screens. In addition, certain types of screening systems themselves include escape technology.

The simplest means of providing escape potential is maintenance of low, uniform velocities at the water inlet and at all points in the system at which escape remains feasible. Maintenance of low, uniform inlet velocity is also effective in minimizing initial entrapment. Tests have indicated that velocities <0.5 fps permit escape of various fishes, >2 inches total length, even in cold winter months (Section III). The escape area is effectively limited to the approach channel. At maximum pumping rate, calculated velocities in the PWPP approach channel range from 1.2 fps at the mouth of the approach channel to about 2.5 fps midway to the trash racks.

In general, fish can escape a velocity of 2-3x their body length. Assuming that this relationship is valid at PWPP, fish over 8-10 inches total length should be able to emigrate from all points in the approach channel. During the course of the one-year monitoring program, 13,337 fish over 8 inches total length were collected after impingement, 3.2 percent of the total collection. Many of these fish were extremely viable. It is logical to assume that greater escape potential will reduce impingement. The approach channel velocity could be reduced by increasing the volume of the intake channel or reducing flow capacity. The latter possibility is considered in a following section. Increasing channel depth to a uniform 17 feet would reduce the maximum velocity to 2 fps, permitting fishes over 5 inches

total length to escape. Because of the variables associated with fish behavior, no prediction of impingement reduction can be associated with this modification.

For shoreline intakes, installation of lateral trash racks between the conventional trash rack and the debris screens affords a means of escape after initial penetration of the intake system. Fish can more easily move laterally than reverse directions to swim against the current. The only other device which could be installed at PWPP to provide escape potential is the bypass channel.

The feasibility of utilizing a bypass channel to redirect fish from the approach channel to the lake has been discussed in conjunction with the louver diverter.

The bypass may be used with other diversion or screening devices to prevent entrapment or following entrapment to prevent impingement. In the latter instance, fish are concentrated in an area ahead of the debris screens, then transferred back to the water body by pumps, elevators, etc. There is no such area, e.g. forebay, where fish may be concentrated at PWPP; and the system is not amenable to this type of modification. Channels to divert and bypass fish around physical structures are most effective in a riverine situations in which the fish can be reintroduced to a current which will continue to carry them downstream, away from the intake structures. At PWPP, a bypass channel would only return fish to the lake where they could again become entrapped. Since a bypass channel would have to maintain a velocity greater than that through the diversion/screen system, the overall approach channel velocity would have to be higher than at present. This may function to increase entrapment. Installation of a bypass channel at PWPP has the potential to reduce impingement; but in view of the uncertainties of fish behavior, it can not be predicted that this modification would be successful. This limitation also applied to fish return technology, discussed in a following section.

Several types of screening systems permit escape after contact. The horizontal travelling screen is similar in configuration to the louver diverter and elicits a similar directional response from fish. Fish encountering the horizontal travelling screen move along its face to a bypass channel. Although some fish may be impinged, they will not be removed from the water, but will be released into the bypass channel. This screening system has the same limitations for PWPP as does the louver diverter as well as several operational drawbacks. Variations in flow and high debris load severely limit performance. Due to necessarily high rotational speed, the system is not reliable; and debris and bed load tend to jam its lower tracks. These deficiencies cause frequent maintenance shut-

downs necessitating the use of a redundant screening system. The chief advantage of the horizontal travelling screen over the louver diverter is that the size of fish which can be bypassed is limited only by screen mesh dimensions. The horizontal travelling screen is still in the experimental stage. Until operational drawbacks can be remedied, this system can not be considered a feasible alternative to present intake devices.

The open setting screen is suspended from a platform so that it is surrounded on all sides by water. Water enters the screen from both sides and exits via a pipe to the condensers. Fish are not confronted by a barrier, but are free to pass around the screen. This design is also experimental and has inherent problems of clogging. It is operationally inferior to conventional screening systems. Its most effective application appears to be for rivers where fish can continue past rather than milling about a dead end channel, as would be the case at PWPP.

Drum screens can be mounted on horizontal or vertical axes, and either type could be located in the approach channel at PWPP. If a series of vertical axis drum screens were installed, a bypass channel would be required to remove debris and fish. The chief advantage of this system is that impinged fish would remain in the water until bypassed. The vertical drum screen has not yet been proven to be an effective and reliable screening device; and it appears to offer no advantage over the louver diverter and horizontal travelling screens, which have been previously discussed. The horizontal axis drum screen is designed to resolve with its upper surface just below the water surface. Fish can be passed over the top of the screen to a downstream collection trough. However, debris removal is inefficient and the screens can become clogged; this screening device is not a feasible alternative for PWPP.

RETURN OF IMPINGED FISH

A third approach to resolving entrapment problems via intake technology design concentrates on minimizing the effects of impingement rather than its magnitude. Debris screening systems can be designed to return fish unharmed to the water body. Indeed, there is evidence that the present system at PWPP does return fish in good condition.

To minimize impingement effects, travelling screens can be run continuously so that fish are not held against the screens for long periods. The PWPP vertical travelling screens rotate continuously at 10 fpm. Fish are held out of water for a maximum of 30 seconds, then washed from the screens with a spray of 100 psi. Fish and debris enter the washwater sluiceway which combines with the circulating water return for discharge to Port Washington Harbor. Distance from screens to discharge point is 240 feet. Velocity

in the tunnel is 10 fps at maximum flow, resulting in a return time of 24 seconds after removal from the travelling screens. Average ΔT°F experienced is approximately 7°F (the maximum ΔT is 16°F which occurs at low ambient water temperatures; maximum recorded discharge temperature was 76°F in August).

During the course of the monitoring program, it was observed that most of the fish collected from the screens were viable. A study was initiated in November to determine if fish actually survived impingement. During the weekly sampling day, 4-8 fish, principally salmonids, were removed from the collection basket and placed in an adjacent 100 gallon nalgene holding tank. Intake water was circulated through the tank at 3-5 gpm. Fish were held for four days (96 hours), with mortality recorded at the end of the period. Results indicate that 81 percent of salmonids survived the impingement experience. It was not determined if the return system caused additional mortality. The ΔT of 7-16°F should not be sufficient to induce thermal shock in Lake Michigan fishes (Otto, 1974), but may be an additive stress. The harbor discharge is adjacent to a fishing pier provided by the Company. The pier is used intensively in all seasons, and very good catches of salmonids are realized. Dead or distressed salmonids are seldom observed in this area or anywhere in the harbor. Most dead fish in the harbor are alewives, which are found along the entire Lake Michigan shoreline in the summer months. If the PWPP intake system caused extensive mortality, it should be evidenced in the harbor. The results of the survival study and these observations indicate that the present PWPP intake syseem does return healthly fish. Modification which might further reduce impingement damage include a return system directly to the lake, high volume, low velocity screen wash, and lift buckets on the vertical travelling screens. Alternatives to the present screening system which might have a similar effect also exist. Modifications and/or alternatives to the present screen return system are considered below. It is not possible to confidently assess their attributes.

A washwater system could be designed to return fish directly to Lake Michigan. This would operate much like the bypass channel discussed earlier, except that a tunnel would be built to empty into the lake on the south side of the PWPP peninsula. Such a return system would have controlled velocity and would include no thermal input, thereby reducing potential post-impingement stress. However, the behavior of the fish upon return is unpredictable. As negative considerations, they might return to the intake channel for reimpingement, serve as a localized source of food for predators, or be driven against the shore in heavy seas. A lake return conduit can not be viewed as a certain benefit.

The use of high volume, low velocity screen wash would reduce damage from high pressure jets of water. Present washwater pressure could be reduced by increasing the volume. However, volume is not an acceptable substitute for pressure in the removal of the moss-like debris typical of Lake Michigan.

Another possible modification to the existing system consists of the addition of baskets or troughs at intervals along the screens. Fish would be lifted from the water in the basket and be dumped into a return channel on the back-side of the screens. While baskets can be designed to handle juvenile fish, they may not be practicable for adult salmonids and the other large fish which are commonly impinged at PWPP.

Alternative screening systems which might reduce impingement effects include inclined screens. Vertical travelling screens inclined in the downstream direction serve to provide better support, so that fewer fish fall off the screens on their ascent. A similar but more sophisticated system consists of fixed inclined screens with extreme down-stream angles. The rear portion of the screen is bent horizontally over a fish collection trough. A continuous chain conveyor system of brushes is used to remove debris and herd fish up the screen into the trough. In this system, fish are never truly impinged, since they remain in water the entire time. This type of inclined screen is still experimental, is sensitive to even slight water level fluc-tuations, and is considerably more expensive to install than the conventional vertical travelling screen.

C. CAPACITY

The most drastic means of minimizing adverse environmental impact of cooling water intake structures is through reduction of cooling water flow. Change in capacity of flow generally requires expensive redesign of not only the intake system, but also the pumps, boilers and condenser operations. In the most extreme case, a closed cycle cooling system could be installed to reduce intake capacity more than 90%. Closed cycle cooling does not relate to intake structures *per se* and is not a proper consideration for this report (EPA, 1973).

Less extreme measures of reducing cooling water volume have been examined. Reduction in volume could reduce entrapment in the intake system to the degree that this phenomenon is a function of cooling water use, and also by accompanying decrease in intake velocity.

No substantial reductions in condenser cooling water flow can be achieved without corresponding capacity limitations. Since it is physically impossible to install significantly more condenser surface at PWPP, reduction in cooling water flow could only be achieved by reducing condenser steam flow or by increasing condenser back pressure. Either modification would result in lowered generating capability and decreased equipment efficiency ratings.

It would be possible, for example, to utilize only one pump per unit on a year-round basis. This action would reduce cooling water flow by 34 percent during those months when ambient lake temperature exceeds 50°F. However, costs in lost generation would be between $100,000-$200,000 per month. Further flow reduction could be achieved by even more expensive design modifications. If entrapment is determined to be having a significant impact, it is unlikely that a 34% reduction in flow would alleviate it. Velocity at the trash racks under maximum pumping rates would still approximate 1.2 fps.

D. SUMMARY: FEASIBLE ALTERNATIVES

Determination of the feasibility of alternatives to the present intake system at Port Washington Power Plant should be based on the following criteria:

1) potential for minimizing adverse environmental impact

2) physical capability for implementation

3) reliability of operation

4) financial and environmental costs

The first three criteria have been applied in this discussion. Costs of alternatives which meet these criteria will be considered in the next section. Alternatives which may meet non-cost criteria include:

LOCATION

Entrapment statistics for the Lakeside Power Plant indicate that installation of a rubble-mound intake pond should result in reduced impingement. This type of intake can be designed with flow-through velocities <.5 fps. The rubble should also act as a partial physical barrier to fish penetration.

The rubble-mound pond could be retrofitted to the present PWPP system without substantial in-plant modification.

However, its installation would require considerable construction activity in Lake Michigan, necessitating approval by state and federal regulatory agencies.

Experience at Lakeside indicates that this type of intake could perform reliably and would require little maintenance. It is possible, however, that excessive amounts of ice could pile up on the rubble during stormy lake conditions.

DESIGN

Modifications which promise to curtail entrapment while performing in reliable fashion relative to plant operation are few. The physical limitations of the PWPP configuration eliminate most diversion, escape, and return modifications from consideration. The majority of technological alternatives which have been advanced are experimental and applicable only for new intake systems now under design. Feasible modifications to existing systems are not generally available. There is, for example, no generally viable alternative to the vertical travelling screen for debris removal (EPA, 1973).

The preceding discussion has confirmed the paucity of feasible alternatives. With regard to prevention technology no system conforms to the feasible criteria in that it would be reliable, could readily be installed, and promises to effectively reduce entrapment.

Escape technology which could be applied at PWPP is fraught with uncertainties relative to fish behavior. The most promising design changes consist of modification to the present screen and return system. Use of baskets on the screen might reduce physical damage in impingement. Similarly, direct return of fish to Lake Michigan would prevent additional stress which may result from the present discharge combination with the circulating water to Port Washington Harbor.

CAPACITY

Capacity of cooling water flow cannot be reduced without substantially affecting plant efficiency. The anticipated benefits of capacity reduction do not warrant its further discussion.

E. COSTS OF FEASIBLE ALTERNATIVES

Only two alternatives appear to possess the potential for reducing entrapment impact at PWPP and are capable of installation and reliable operation. These are the rubble-

mound intake pond and modification of the existing debris screening and return system and a washwater return. The costs of implementation of these alternatives - in time and money as well as on plant operation and the environment itself - are considered here.

RUBBLE MOUND POND

The pond would be formed by construction of a rubble mound between the existing north and south rubble extensions to enclose an area of approximately 4 acres (Figure V-1).

Construction

Construction of the stone mound would involve two primary activities; limited dredging in the area of deposition and placement of the stones. Both activities would be accomplished from a barge. All dredged spoil would be transferred to shore for disposal at a landfill site. Estimated (1976) costs to complete the rubble mound are in excess of $925,000. In addition, recurrent maintenance expenditures are anticipated.

Schedule

Final design of the rubble mound would require 3 months. After completion of final design, it is estimated that 12 months would be required to obtain necessary permits from the Army Corps of Engineers. Approximately 3 months would be needed to obtain a contractor. Construction itself would take 6 months, but an additional four months would have to be allocated for scheduling around severe weather conditions. Total schedule for installation of the rubble mound is therefore estimated to be over two years.

Effects on Plant Operation

No effects on plant operation are anticipated, except that bottom debris released during dredging would impair screen efficiency.

Environmental Effects

Effects of construction on the aquatic biota would be very local and transitory and would not have any observable effects on communities in the general Port Washington

inshore region. Principal construction effects would result from dredging - removal of substrate and increased turbidity. Substrate removal would directly affect the sedimentary benthic community, consisting of invertebrate animals. The sand substrate in the construction area does not support either perphytic or macrophyte growth. Benthic invertebrates would be removed from approximately 4 acres, but recolonization should follow completion of the mound. Increased turbidity would result in fish avoidance and reduced phytoplankton productivity and zooplankton abundance. None of these effects could be considered to have an adverse impact on the populations of the area.

The rubble mound pond would eventually support a biota which may differ in some respects from that characteristic of the adjacent inshore waters. Observation of similar ponds indicates that the pond assemblage would not constitute a local nuisance nor a threat to the indigenous Lake Michigan community.

SCREEN/RETURN MODIFICATIONS

The existing vertical travelling screens could be fitted with Ristroph-type buckets to lift fish from the intake without actual impingement (Figure V-2). Buckets, consisting of troughs which contain several inches of water, deposit fish in an elevated return sluice on the backside of the screens. The sluice could be directed to join the circulating water discharge (to PW Harbor) as in the present system or to discharge directly to Lake Michigan.

Construction

Construction would entail a complete rebuilding of the present debris screening and return system. Addition of fish buckets would increase screen weight and size, necessitating installation of larger motors and structural changes to provide adequate operation room.

The estimated (1976) cost to retrofit the existing six travelling screens plus one set of replacement baskets is $330,000. Structural modifications to the building to accommodate the rebuilt screens is estimated at $190,000. Between $75,000 and $140,000 will have to be expended to construct a separate fish return sluice, depending upon final discharge point. These figures do not include costs accruing from plant shutdown and lost generation during the construction period.

Schedule

Final design of the screen/return modification would require six months. It is estimated that after completion of final design, five months would be required to achieve contract placement, fabrication of screen parts, and construction of the fish return system. Approximately six months would be required for structural modifications and screen placement with an additional month allocated for final system modifications. Realistically, three months should be added to this schedule to accommodate possible late deliveries of material, construction problems, and plant operating requirements. A schedule for implementation of the modified system is estimated to require a total of 21 months.

Effects on Plant Operation

Construction and retrofit activities would have to be performed on one or two screens at a time to permit continued plant operation.

However, even this working arrangement would result in some reduction of plant output during the entire period of retrofitting (7-10 months). During this time, the entire plant would be subjected to emergency shutdowns resulting from inadequate facilities to handle heavy debris loads. Such shutdowns could affect life-of-plant equipment, causing increased maintenance and/or replacement expenses.

The modified screen system would reduce net screen free area, operate at higher speed, and require more wash water. These features promote higher maintenance and operational costs which cannot now be estimated.

Environmental Effects

The only adverse environmental effect which could be expected is increased impingement mortality during construction. The concentration of entire plant flow through a reduced number of operation screens would increase velocity through the screens, resulting in increased abrasion to impinged fish.

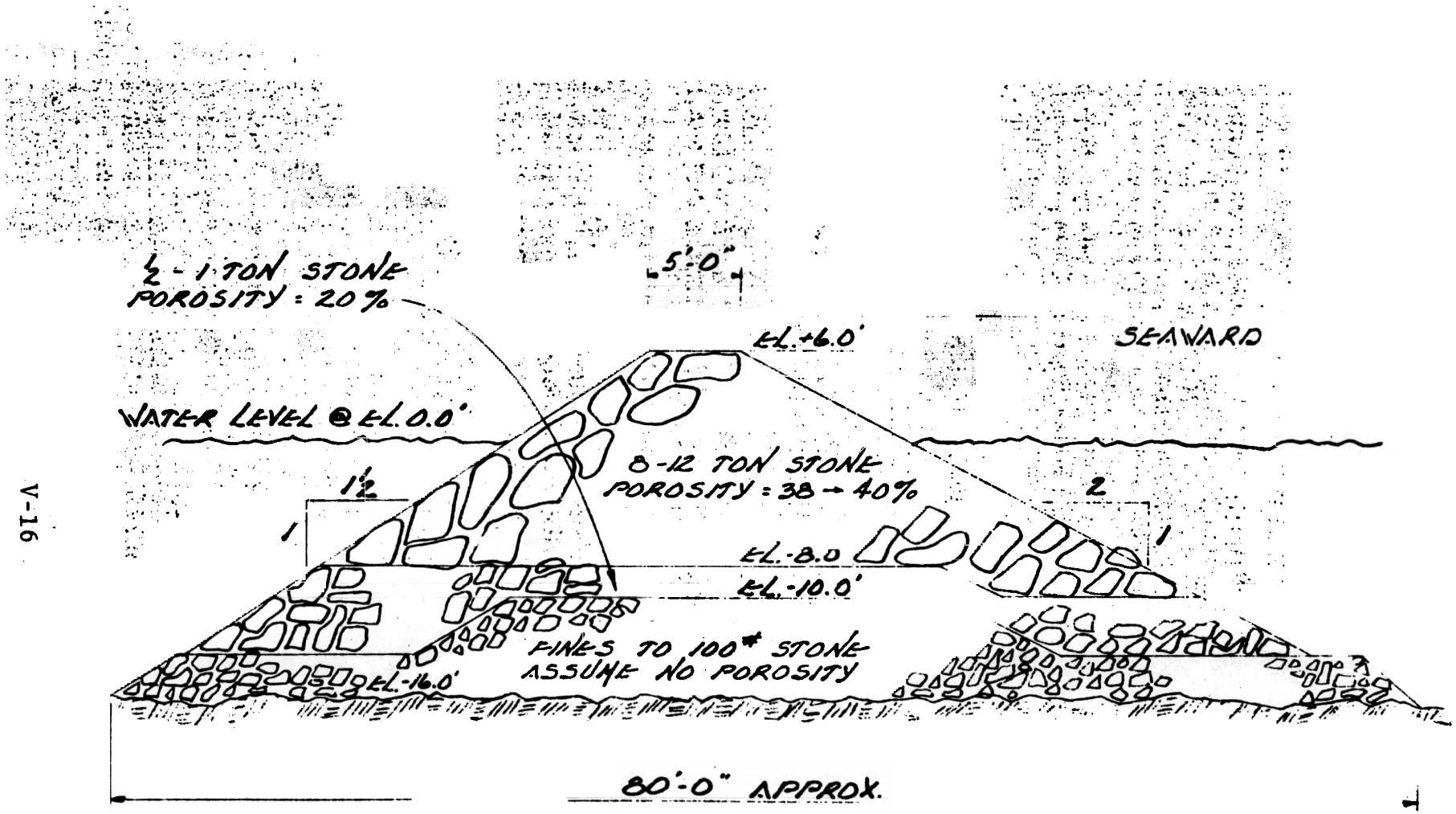

FIGURE V-1. TYP. CROSS SECT. THRU RUBBLE MOUND

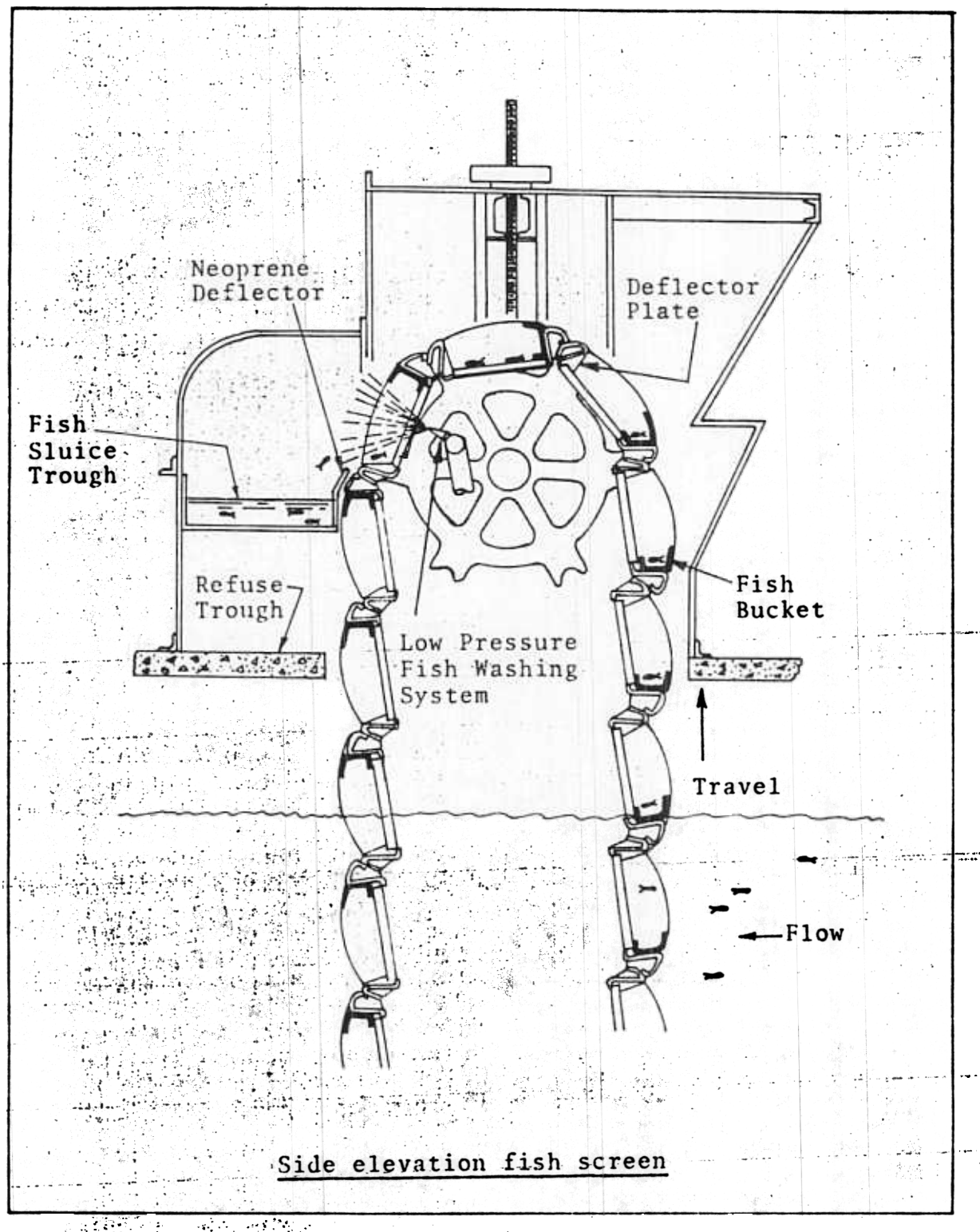

Figure V-2. Fish bucket modification to vertical travelling screens.

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