#21
NPC-38014

POINT BEACH NUCLEAR 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-0000957

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-0000957 required (Special Condition J.1) a one-year intake monitoring study to determine the environmental impact of the Point Beach Nuclear 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

The Point Beach Nuclear Plant (PBNP) is situated about 90 miles north of Milwaukee on the western margin of Lake Michigan. The plant consists of two units, each consisting of a pressurized water nuclear reactor and a tandem compound, four flow exhaust turbine generator with a rated output of 497 MWe. Water for condenser cooling is withdrawn from Lake Michigan and returned to the lake via two discharge flumes, each 228 feet in length.

The Point Beach Nuclear Plant intake system and related features of plant operation are described in this section.

A. INTAKE DESCRIPTION

Cooling water for both units is withdrawn through an emergent intake crib located 1750 feet offshore in about 22 feet of water (Figure I-1). The structure consists of two annular rings of 12 inch structural steel "H" piles driven to a minimum depth of 23 feet below lake bed and reinforced with steel tie beams. The annulus is filled with individually placed limestone blocks having two approximately parallel surfaces and weighing between 3 and 12 tons. The structure has an outside diameter of 110 feet, an inside diameter of 60 feet, and a top elevation of 8 feet above standard water level. Water enters the structure through the void spaces between the stone and through 38 concrete-encased, 30 inch diameter, corrugated, galvanized steel pipes. The pipes are located around the periphery of the structure approximately 5 feet above the lake bed. The outer end of the pipes are covered with 1-3/16 inch by 2 inch galvanized bar grating to prevent fish or debris from entering the structure. Water flows from the intake structure to the pumphouse forebay through two 14 foot diameter, corrugated, galvanized, structural plate pipes buried to a minimum depth of 3 feet below the lake bed (Figure I-2). Flow through either pipe can be reversed during winter operation to recirculate warm condenser discharge water to the intake to prevent freezing in the system. Inside the intake crib, a steel divider wall 50 feet long is provided between the intake pipes to assure that most warm, recirculated water flows to the outside of the crib for ice melting. A 4 foot gap between the end of the divider wall and the inner crib face provides some warm water recirculation to the pumphouse.

At the pumphouse, the 14 foot diameter intake pipes terminate at the intake chamber (Figure I-3). From these the water passes through the inlet valves and into the forebay area. Water depth in the forebay is approximately 28 feet.

Water flow is spread throughout the forebay by a concrete baffle wall located in front of the inlet valves. The intake water then passes through vertical bar racks consisting of 3/8 inch by 4 inch bars, spaced with 2-1/4 inch gaps. One 59 foot wide rack is provided for each unit. Water then flows through the eight travelling water screens (3/8-inch square mesh) in the pumphouse, each of which is approximately 11 feet wide (Figure I-4). The screen wash (80 psi) is filtered through a collection basket with 3 inch square openings, and returned to the lake via a 24 inch diameter steel pipe with an outlet in the Unit 2 discharge flume, approximately 80 feet from the collection basket.

B. LOCATION

Figure I-5 shows the bathymetry in the vicinity of the PBNP intake. Depth at the intake crib is approximately 22-24 feet. Other bathymetry surveys (Limnetics, 1974, 1975, 1976) have indicated that the lake bed configuration in the intake area is stable.

C. ENVIRONMENTAL FEATURES

Bar gratings on crib intake pipes as well as the stone construction of the crib provide a partial barrier to fish penetration and subsequent entrapment. The intake crib was designed for minimal face velocities. Because the crib extends above water level, vertical intake velocities are avoided. Fish are more susceptible to vertical velocities than to horizontal velocities (EPA, 1973).

D. DEICING PROCEDURE

Deicing is performed by reversing flow in one of the intake pipes to return warm discharge water to the intake crib. This is done by throttling the discharge valve between the seal pit and discharge flume, enabling part or all of the cooling water discharge of one unit to be redirected to the crib. The other intake pipe then supplies the water to both units. Deicing is normally conducted as required over the period of mid-December to March.

Maximum recirculation flow to the intake crib is approximately 200,000 gpm. During January and February, 1976, average return flow to the crib was approximately 165,000 gpm. Average ΔT between the intake and discharge was 29°F, with a maximum of 34°F. During the deicing period, ambient Lake Michigan water temperature is about 33°F. Highest intake temperature recorded during the January-February 1976 period was 60°F, indicating that the maximum theoretical increase in intake temperature due to deicing was 27°F. Average influent temperature was 46°F, giving a routine temperature increase of 13°F. It should be noted that recirculated water does not discharge

directly to the lake but only through the intake crib.

E. USE OF BIOCIDES

No biocide is used for condenser cleaning at Point Beach.

F. PLANT OPERATION

PBNP operates primarily as a base-load facility with both units generating at or near maximum capacity except for scheduled maintenance shutdown and refueling. The 1975 capacity for PBNP was 69.3% for Unit 1 and 87.9% for Unit 2.

From March or April until November, the plant usually operates on four circulating water pumps, with a maximum design flow of about 750,000 gpm. During the remainder of the year, two pumps are used for a design flow rate of about 430,000 gpm. The eight travelling screens were operated intermittently with a minimum rinsing three times a day, or once every eight hour shift. The duration of each rinse is one half hour. Rinsing is performed more often when debris may accumulate. Typically, this occurs following spring and, to a lesser degree, fall storms. Silt and debris accumulation during those times is significant, and may necessitate continuous rinsing while the lake is turbulent, in the extreme case.

It is anticipated that during 1976 the screen controls will be programmed to initiate a rinse cycle on a predetermined pressure drop across a screen, in addition to the once per shift rinse now performed. This change in screen operation will have no foreseeable effect on fish impingement.

Operation of PBNP is not expected to change significantly in the future.

G. INTAKE VELOCITY

Table I-1 presents calculated velocities in the intake pipes and in voids between rocks in the intake crib. These velocities do not occur outside the pipes or voids but could occur at the crib face immediately in front of the void. Measured velocities within 5 feet of the crib face were 0.06 to 0.7 fps and averaged 0.36 fps (Limnetics, 1974). The higher velocities at a distance of 5 feet generally occurred in front of intake pipes.

Table I-5. Calculated velocities through the PBNP intake crib and at the vertical travelling screens.

Number of Pumps	Intake Crib El.+2.5	Intake Crib El. 0.0	Intake Crib El.-4.5	Travelling Screens El.+2.5	Travelling Screens El.0.0	Travelling Screens El.-4.
2 (ice-melt)	1.8	2.0	2.4	0.44	0.48	0.56
4 (normal)	2.2	2.4	2.8	0.74	0.79	0.94

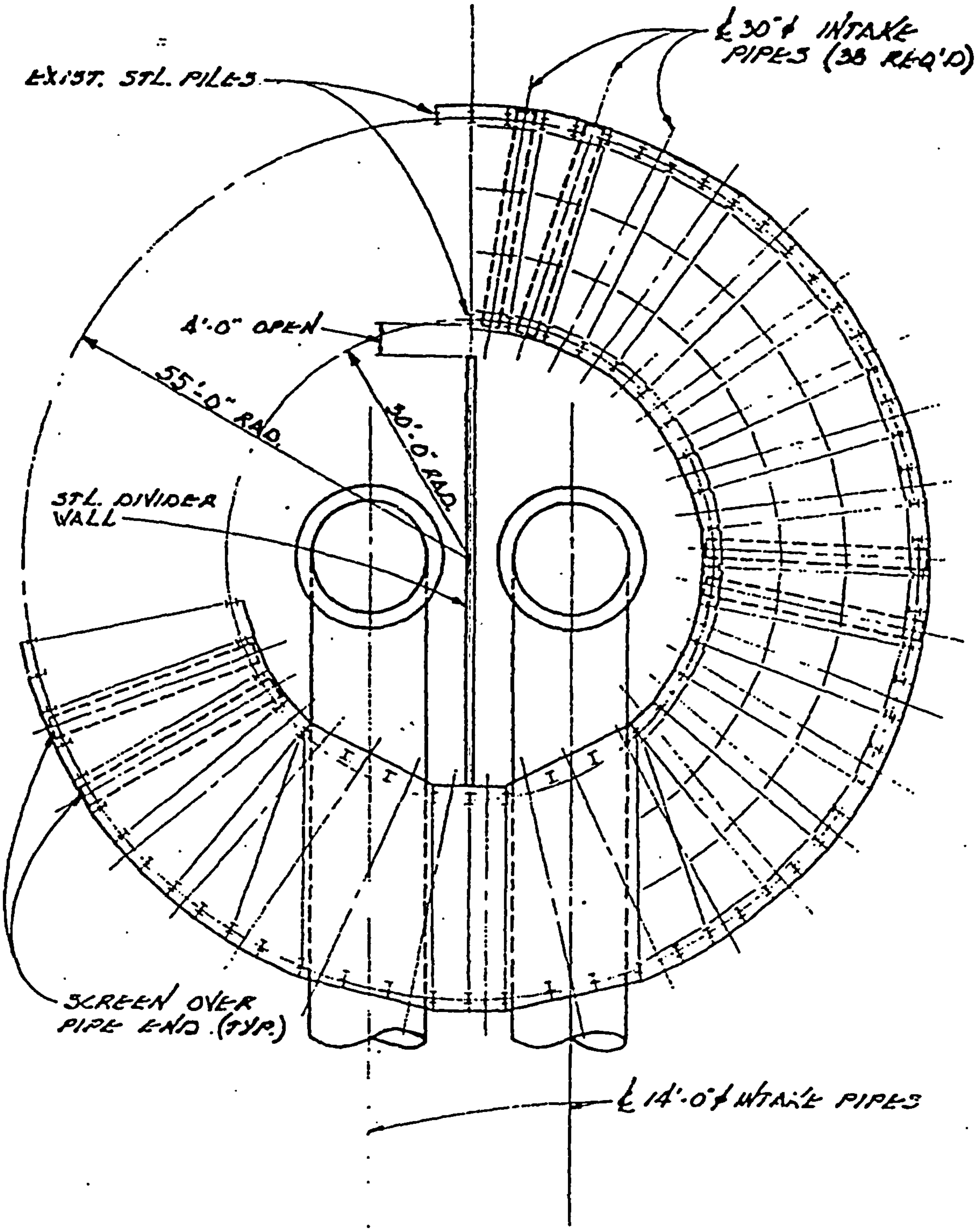

FIGURE I-1: PLAN OF INTAKE CRIB

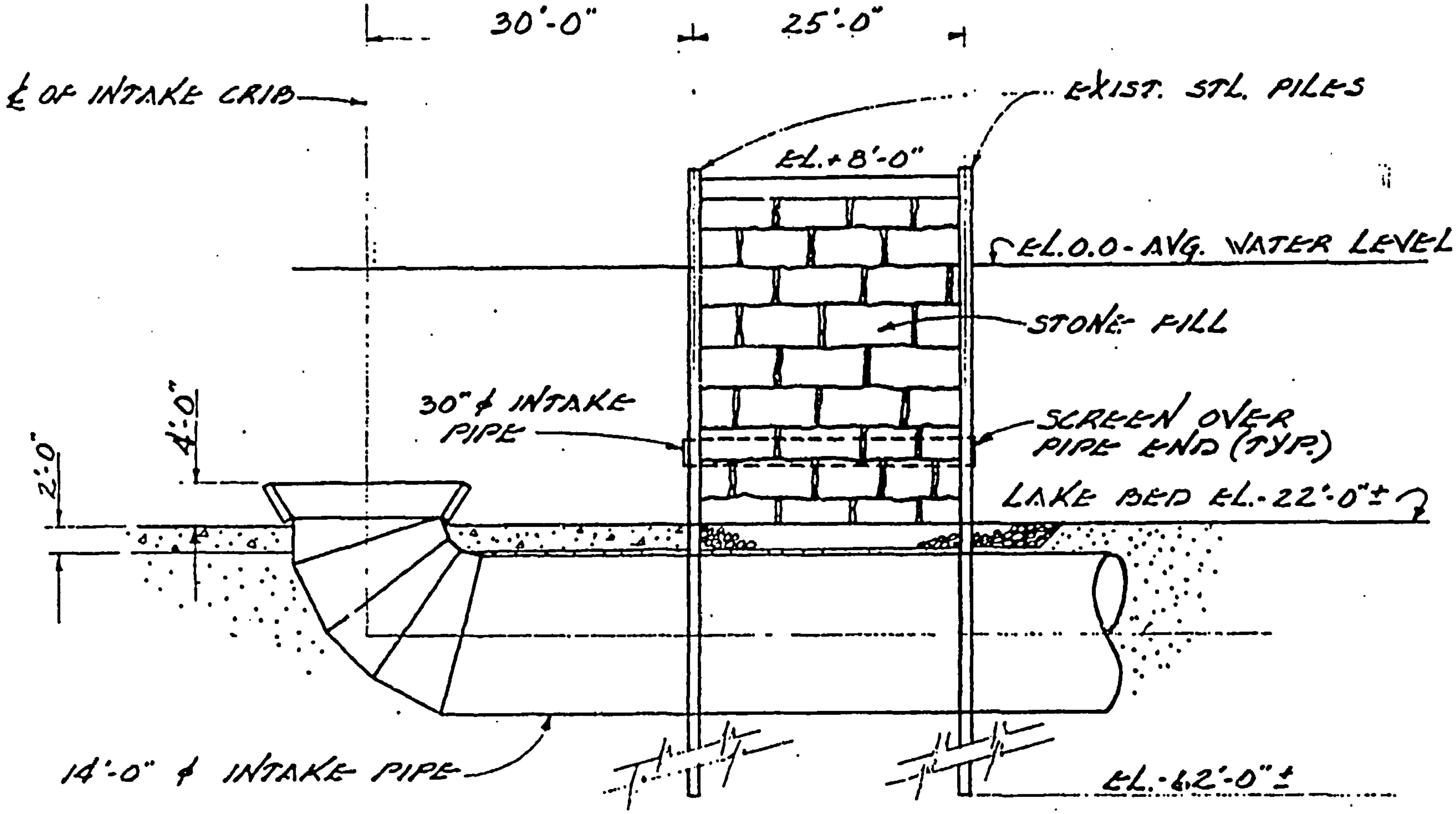

FIGURE I-2. CROSS SECT. THRU INTAKE CRIB

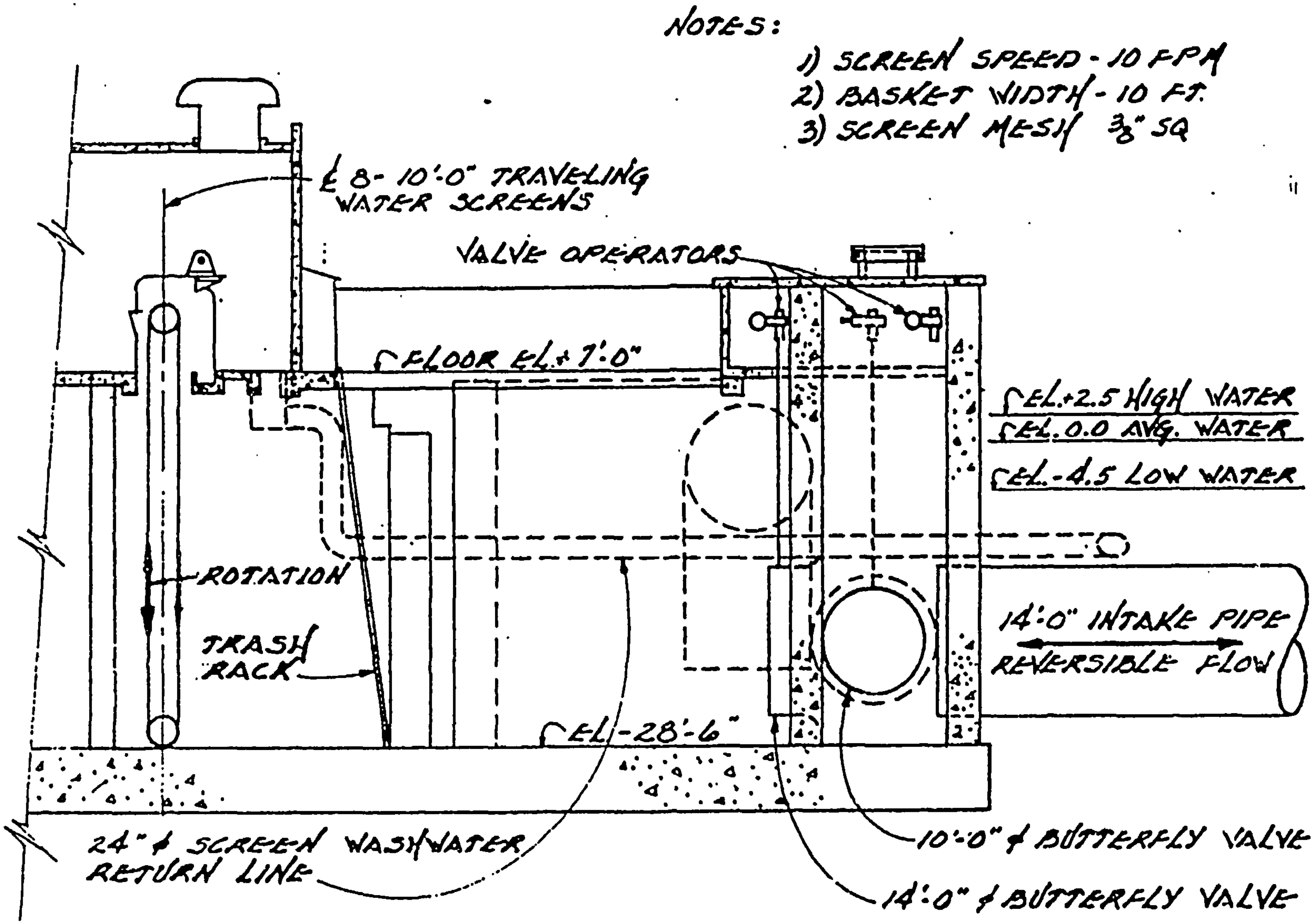

FIGURE I-3. CROSS SECT. THRU TRAVELING WATER SCREENS & FOREBAY

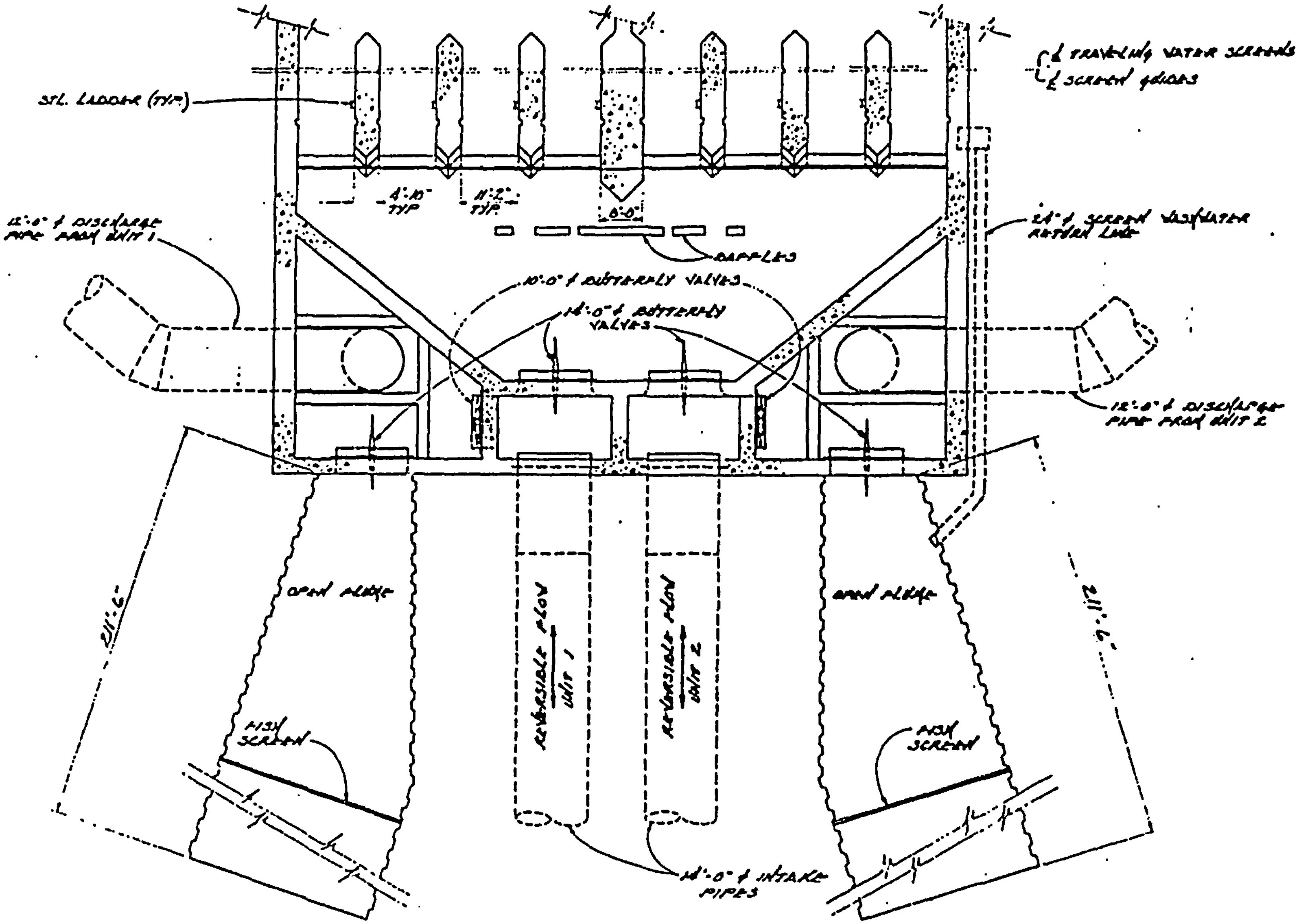

FIGURE I-4: PLAN OF PUMPHOUSE

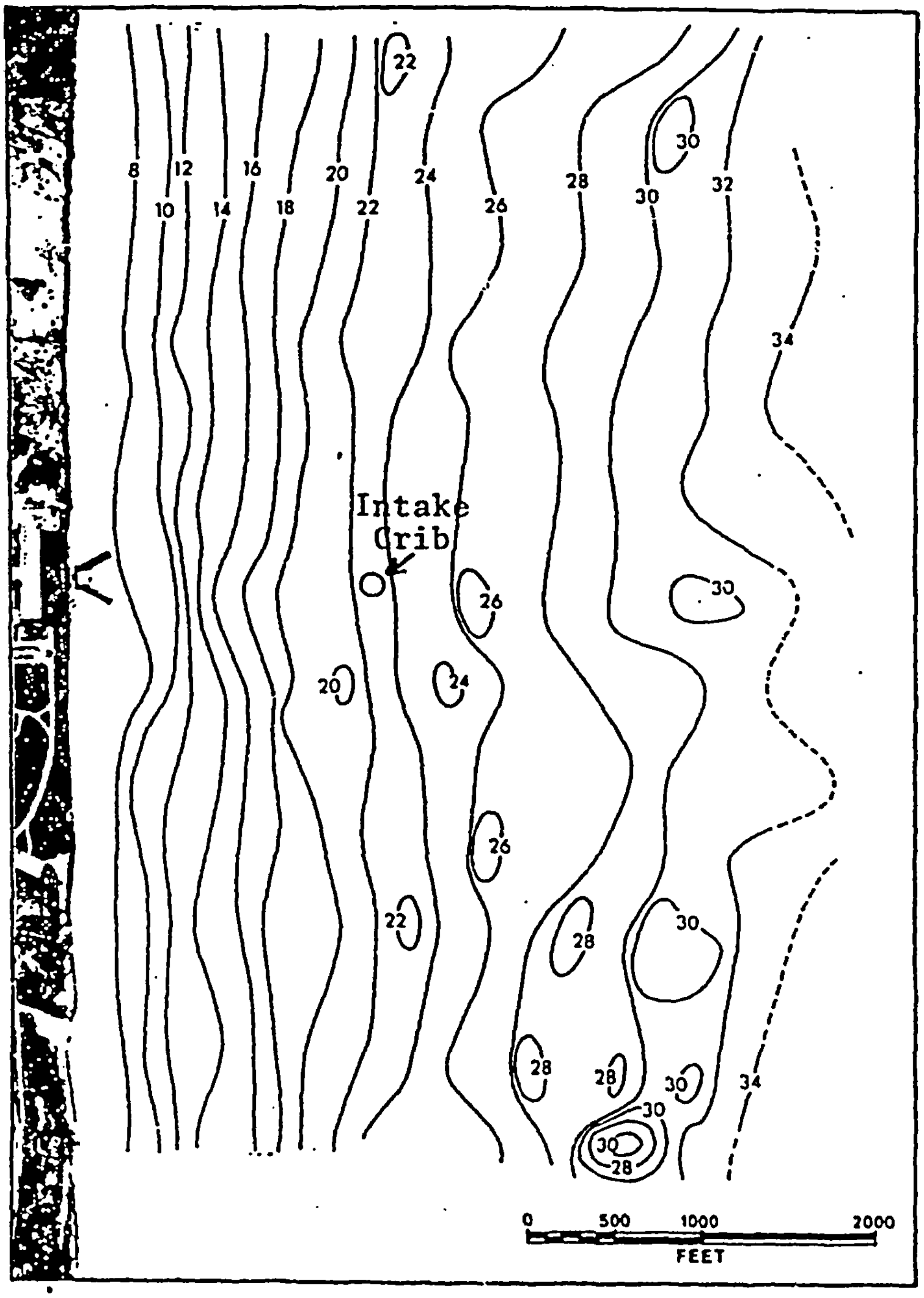

Figure 1-5 Bathymetry in the vicinity of the Point Beach Nuclear Plant, corrected to low water datum, for 26 September, 1975.

II. SAMPLING DATA

The intake monitoring program at Point Beach Nuclear 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 monitoring was scheduled to be performed for 24 hours every fourth day of plant operation during the period March 1, 1975 - February 29, 1976. This schedule was met with few exceptions. On a few occasions, rescheduling of personnel necessitated fifth-day collection compensated by sampling on the third day following. Only three sampling periods were missed, due to clogging of screens with debris and ice. A total of 88 impingement collections were made.

SAMPLING METHODS

The eight vertical travelling screens at PBNP are rotated as debris load requires. At a minimum, all screens are operated concurrently for a period of 30 minutes every 8 hours. Debris (including fish) is washed from the backside of the screens into a common debris return trough. Impinged fish and debris were collected in a large (30" x 30" x 30") 3/8 inch square mesh basket placed in the sluiceway beyond the screens (Figure II-1). The basket filled the sluiceway so that all fish in the washwater were collected. Following screen rotation, the basket was lifted from the sluiceway and fish were removed.

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 forebay were observed during the sampling program, dead fish were never found there; the gaps between bars in the racks permitted passage of all entrapped 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. Generally, 100% of plant volume was sampled on each date. Each collection included at least three screen runs, the normal number per day. Variations in volume sampled occurred as a function of when the screens were run: the elapsed time from first to third run did not always total 1,440 minutes.

A total of 313,151 impinged fish, representing more than 25 species, were collected during the monitoring program. Of these, 265,516 (84.79%) were alewife and 43,238 (13.81%) were smelt. Salmonids (trout and salmon) totaled 94 fish (0.03%). The remaining 1.4% was comprised principally of forage species such as slimy sculpin and ninespine stickleback. No threatened or endangered species were collected. Of the sixteen coregonids, three were not preserved for final identification and were labeled "cisco". From their size, it is likely that these individuals were lake herring or lake whitefish.

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 forty-nine dates.

SAMPLING METHODS

Entrainment sampling was performed with KENCO models 32N1 and 139 submersible pumps situated at 20% and 80% of water depth immediately ahead of the second travelling screen in Unit 2. Water was pumped via rigid plastic hose (2 inch id.) through plankton nets of 333 micron mesh suspended at pumphouse floor level (Figure II-2). Material sampled was drained into a plastic container attached to the plankton net.

Although pumps were rated at greater than 100 gpm, sampling accommodations required maintenance of a high (15-20 ft.) dynamic head. Resultant pump flow ranged from 60-80 gpm. The

Department of Natural Resources staff inspected and approved this sampling arrangement at Point Beach (letter from D. Heiser to J. Ney, June 17, 1975).

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. Initial and final daily calibrations showed close agreement. 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 differentiated 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 49 sampling dates. Included are fish-larvae, fish eggs, Pontoporeia affinis, and Mysis relicta. More than 35,400 cubic meters of water (9.3 million gallons) were sampled.

A total of 91 fish larvae were collected. These included 57 smelt, 17 alewife, 15 sculpin, and 2 longnose suckers. Only alewife fertilized eggs were collected, totaling 203. Pontoporeia and Mysis totaled 595 and 406, respectively.

C. OTHER DATA

Data on the occurrence and abundance of fish larvae and eggs in the nearshore Point Beach area was collected on eleven dates between May and October. Sampling was performed in the vicinity of the intake crib and 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, and at the surface, 3 meters and 6 meters along the 5 and 9-meter contours, respectively. This design resulted in 6 tows per depth

contour, 12 tows per area. Volume of water sampled by the nets were 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 foot 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 288 larvae were collected, including 34 smelt and 233 alewife. More than two thirds of the larvae were taken at the reference area, largely as a result of the capture of 157 alewife on July 15. On other dates, good agreement was obtained between sampling areas. Lake survey relative abundance was generally higher than in entrainment collections, indicating either that larvae are not entrained in proportion to their abundance or that a disparity existed in sampling efficiencies.

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Point Beach Nuclear 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
3-4	100.8%	Lake Trout	1	0.05	-	4.5	-	-	-	-	1
		Lake Whitefish	1	1.75	-	17.3	-	-	-	-	1
		Rainbow Trout	1	6.50	-	23.0	-	-	1	-	-
3-8	99.3%	No Fish	-	-	-	-	-	-	-	-	-
3-12	102.0%	No Fish	-	-	-	-	-	-	-	-	-
3-16	100.0%	No Fish	-	-	-	-	-	-	-	-	-
3-20	85.4%	Smelt	14	0.08	5.3-8.3	6.7	2	3	3	5	1
3-24	100.0%	Brook Trout	1	2.20	-	16.5	-	-	1	-	-
		Lake Trout	1	5.60	-	26.8	-	-	1	-	-
		Tiger Trout	1	2.00	-	17.0	-	-	-	-	1
3-28	100.0%	No Fish	-	-	-	-	-	-	-	-	-
4-1	108.0%	No Fish	-	-	-	-	-	-	-	-	-
4-5	100.0%	Ninespine Stickleback	6	0.05	2.3-3.1	2.7	-	-	1	-	5
		Other Cislo	1	1.70	-	17.0	-	-	1	-	-
		Smelt	46	0.11	5.1-9.0	6.8	11	31	3	-	1
		Slimy Sculpin	12	0.05	2.0-2.8	2.3	-	-	-	-	12
4-9		Ninespine Stickleback	13	0.05	2.3-3.1	2.9	-	-	-	-	13
		Other Cisco	1	0.90	-	15.0	-	-	-	-	1
		Smelt	46	0.09	2.5-9.5	6.2	5	32	1	-	8
		Yellow Perch	14	0.38	8.3-10.5	9.1	-	-	9	5	-
4-13	100.0%	Ninespine Stickleback	3	0.05	2.0-2.8	2.4	-	-	-	-	3
		Slimy Sculpin	15	0.05	1.8-3.6	2.5	-	-	-	1	14
		Smelt	9	0.09	3.3-8.0	5.7	1	6	-	-	2

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Point Beach Nuclear 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.
4-18	100.0%	Brook Trout	1	0.50	-	11.1	-	-	-	-	1
		Deepwater Sculpin	1	0.05	-	2.1	-	1	-	-	-
		Lake Chub	1	0.13	-	7.4	-	1	-	-	-
		Lake Trout	5	0.06	4.9-6.0	5.4	-	-	-	-	5
		Ninespine Stickleback	1	0.05	-	2.8	-	-	-	1	-
		Slimy Sculpin	8	0.05	2.0-2.9	2.6	-	-	1	1	6
		Smelt	136	0.10	1.8-9.9	7.0	50	44	6	28	8
		Yellow Perch	1	0.50	-	11.7	-	-	-	-	1
4-22	100.0%	Black Bullhead	1	0.15	-	5.7	-	-	-	-	1
		Lake Trout	1	0.10	-	6.3	-	-	-	-	1
		Ninespine Stickleback	3	0.05	2.5-2.6	2.6	-	-	-	-	3
		Slimy Sculpin	6	0.05	2.4-3.2	2.8	-	-	-	-	6
		Smelt	11	0.10	6.0-8.8	7.0	6	3	-	-	2
4-26	100.0%	Alewife	6	0.09	7.0-7.9	7.5	-	-	2	4	-
		Lake Trout	2	6.10	25.0-28.5	26.7	-	-	-	2	-
		Ninespine Stickleback	4	0.05	2.3-3.3	2.8	-	-	-	3	1
		Rainbow Trout	1	2.10	-	17.5	-	-	1	-	-
		Slimy Sculpin	50	0.05	2.0-3.0	2.5	10	10	8	11	11
		Smelt	6	0.07	4.7-8.0	6.3	2	1	-	3	-
		Unident. Minnow sp.	1	0.05	-	3.5	-	-	-	-	1
4-30	100.0%	Alewife	1	0.10	-	7.4	-	-	-	1	-
		Ninespine Stickleback	2	0.05	3.0-3.1	3.0	-	-	-	2	-
		Slimy Sculpin	9	0.05	2.2-3.3	2.9	2	-	2	4	1
		Smelt	2	0.05	2.6-3.5	3.0	-	-	-	-	2
		Spottail Shiner	1	0.10	-	7.0	-	-	-	1	-
		Tiger Trout	1	1.50	-	15.2	-	-	1	-	-
		Yellow Perch	1	0.40	-	9.3	-	-	1	-	-

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Point Beach Nuclear 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.
5-4	120.8%	Alewife	2	0.13	6.2-7.5	6.8	-	-	-	1	1
		Unident. Bullhead sp.	1	0.18	-	6.7	-	-	-	-	1
		Ninespine Stickleback	3	0.05	2.5-3.0	2.8	-	-	1	1	1
		Slimy Sculpin	7	0.05	2.0-2.8	2.4	-	1	2	3	1
		Smelt	2	0.05	2.0-2.0	2.0	-	-	-	-	2
5-8	68.8%	Alewife	12	0.15	3.0-8.0	7.1	-	-	3	5	4
		Brown Trout	1	0.60	-	11.5	-	-	-	-	1
		Ninespine Stickleback	4	0.05	2.5-3.1	2.8	-	-	-	3	1
		Cisco sp.	1	1.50	-	16.0	-	-	-	-	1
		Slimy Sculpin	7	0.05	2.0-3.0	2.7	-	4	-	3	-
		Smelt	1	0.05	-	3.7	-	-	-	1	-
5-12	100.0%	Alewife	55	0.11	2.4-8.2	6.5	-	1	20	26	8
		Brown Trout	1	0.18	-	6.5	-	-	-	-	1
		Lake Trout	2	4.12	5.2-29.5	17.3	-	-	-	-	2
		Ninespine Stickleback	8	0.05	2.0-3.0	2.7	-	1	2	3	2
		Slimy Sculpin	6	0.05	1.6-3.0	2.3	-	3	-	-	3
		Smelt	11	0.05	2.5-6.8	4.5	-	-	4	1	6
		White Sucker	1	1.50	-	15.1	-	-	-	1	-
		Yellow Perch	1	0.50	-	9.5	-	-	-	1	-
5-16	107.1%	Alewife	140	0.07	3.0-8.5	4.9	-	-	47	41	52
		Ninespine Stickleback	4	0.05	2.5-3.2	2.8	-	1	2	1	-
		Slimy Sculpin	8	0.05	1.5-2.8	2.3	-	4	-	3	1
		Smelt	6	0.05	2.1-7.0	4.3	-	-	1	2	3
		Yellow Perch	1	0.25	-	9.4	-	-	1	-	-

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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.
5-20	100.0%	Alewife	4,880	0.06	2.6-8.5	5.5	-	-	2,537	2,147	196
		Bluegill Sunfish	1	0.05	-	4.0	-	-	-	-	1
		Ninespine Stickleback	6	0.05	2.5-3.2	2.8	-	-	1	3	2
		Slimy Sculpin	19	0.05	1.2-2.8	2.3	2	2	2	-	13
		Smelt	67	0.09	1.0-9.8	5.0	-	1	29	13	24
5-24	87.6%	Alewife	7,764	0.09	4.7-8.2	7.2	-	-	3,416	4,347	1
		Lake Trout	2	4.37	5.6-29.5	17.5	-	-	-	1	1
		Longnose Dace	1	0.10	-	6.5	1	-	-	-	-
		Ninespine Stickleback	12	0.05	2.3-3.2	2.8	2	6	2	2	-
		Rainbow Trout	1	5.25	-	23.0	-	-	1	-	-
		Slimy Sculpin	26	0.05	1.3-3.0	2.4	9	1	5	9	2
		Smelt	62	0.06	2.9-9.8	6.5	19	8	24	8	3
5-28	96.8%	Alewife	6,259	0.07	2.5-8.0	7.5	-	-	1,877	2,753	1,629
		Coho Salmon	1	0.05	-	5.5	-	-	-	-	1
		Ninespine Stickleback	16	0.05	2.4-3.0	2.7	-	10	3	3	-
		Slimy Sculpin	10	0.05	1.5-2.8	2.4	-	1	2	4	3
		Smelt	26	0.06	2.5-8.6	6.2	10	1	4	9	2
6-1	100.0%	Alewife	12,424	0.06	3.1-8.5	7.0	248	-	4,472	6,957	747
		Lake Club	1	0.10	-	7.8	-	1	-	-	-
		Longnose Dace	1	0.05	-	4.0	-	-	-	1	-
		Ninespine Stickleback	2	0.05	2.5-2.7	2.6	-	1	-	1	-
		Rainbow Trout	1	0.13	-	8.4	-	-	-	-	1
		Slimy Sculpin	12	0.05	2.3-3.3	2.7	-	-	4	6	2
		Smelt	29	0.06	1.8-7.8	5.6	6	-	18	1	4

Table II.1. Summary of Fish Impingement Data,
March 1975-February 1976 at Point Beach Nuclear Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches)		Breeding State				
							Ripe		Unripe		
					Range	Mean	Male	Female	Male	Female	Imm.
6-5	100.0%	Alewife	4,808	0.07	4.1-8.5	7.5	-	-	1,346	3,269	193
		Coho Salmon	1	1.20	-	15.6	-	-	-	-	1
		Ninespine Stickleback	2	0.05	2.4-3.0	2.7	-	2	-	-	-
		Slimy Sculpin	8	0.05	1.8-2.6	2.4	1	-	1	4	2
		Smelt	21	0.05	2.6-7.2	4.7	1	-	5	4	11
6-9	100.0%	Alewife	9,613	0.07	4.4-8.6	7.0	-	-	3,076	6,536	1
		Fathead Minnow	1	0.05	-	2.8	1	-	-	-	-
		Lake Trout	2	10.30	29.6-30.0	29.8	-	-	1	-	1
		Ninespine Stickleback	6	0.05	2.2-3.2	2.7	-	2	1	3	-
		Slimy Sculpin	12	0.05	2.0-2.9	2.5	-	-	4	8	-
		Smelt	37	0.06	2.3-8.5	5.4	6	-	18	4	9
6-13	100.0%	Alewife	26,598	0.06	4.8-8.4	7.1	3,617	7,181	904	-	14,896
		Bloater	1	0.20	-	6.6	-	1	-	-	-
		Ninespine Stickleback	4	0.05	2.9-3.1	3.0	-	-	2	2	-
		Slimy Sculpin	8	0.05	1.5-3.1	2.3	-	-	1	1	6
		Smelt	16	0.06	1.9-9.6	3.8	-	1	3	-	12
6-17	100.0%	Alewife	29,099	0.08	4.8-8.5	7.0	1,338	3,480	12,046	11,651	584
		Coho Salmon	1	0.05	-	5.2	-	-	-	-	1
		Lake Trout	1	4.97	-	25.3	-	-	-	1	-
		Ninespine Stickleback	18	0.05	2.4-3.1	2.8	-	9	1	7	1
		Slimy Sculpin	38	0.05	1.5-2.9	2.4	6	-	10	16	6
		Smelt	284	0.04	2.3-9.7	6.0	56	62	46	23	97
		Yellow Perch	1	0.75	-	11.0	-	-	1	-	-

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Point Beach Nuclear 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.
6-21	100.0%	Alewife	3,425	0.08	3.2-8.4	7.0	-	1,972	273	1,109	71
		Lake Trout	1	13.75	-	31.0	-	-	1	-	-
		Ninespine Stickleback	4	0.05	2.6-3.0	2.8	-	2	-	2	-
		Rainbow Trout	1	3.90	-	18.3	-	-	1	-	-
		Slimy Sculpin	7	0.05	1.5-2.7	2.2	-	-	3	3	1
		Smelt	72	0.06	2.1-8.7	5.1	4	4	18	8	38
		Trout Perch	1	0.05	-	3.2	-	1	-	-	-
		White Sucker	1	0.65	-	13.3	-	-	-	1	-
		Yellow Perch	1	0.75	-	12.2	-	-	1	-	-
6-25	100.0%	Alewife	23,712	0.07	3.1-8.6	7.3	2,835	6,639	9,494	2,845	1,899
		Lake Trout	1	1.30	-	15.5	-	-	1	-	-
		Ninespine Stickleback	3	0.05	2.9-3.0	3.0	-	3	-	-	-
		Slimy Sculpin	7	0.05	1.4-3.1	2.3	-	-	1	2	4
		Smelt	58	0.06	3.4-9.0	6.1	7	-	21	17	13
		Trout Perch	1	0.05	-	4.7	-	1	-	-	-
7-4	100.0%	Alewife	39,096	0.08	4.6-8.3	7.2	781	19,704	7,037	11,572	2
		Ninespine Stickleback	3	0.05	2.8-3.1	2.9	-	2	-	-	1
		Slimy Sculpin	2	0.05	2.3-2.5	2.4	-	-	-	2	-
		Smelt	7	0.07	2.5-7.8	5.7	-	-	2	3	2
7-7	100.0%	Alewife	13,219	0.08	4.6-8.0	7.0	4,320	5,842	-	3,146	1
		Ninespine Stickleback	1	0.05	-	2.5	-	-	1	-	-
		Slimy Sculpin	2	0.05	2.3-2.5	2.4	-	-	1	1	-
		Smelt	8	0.05	2.5-6.8	4.2	-	-	3	-	5

Table II.1. Summary of Fish Impingement Data,
March 1975-February 1976 at Point Beach Nuclear 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.
7-11	100.0%	Alewife	2,355	0.07	2.1-8.5	7.2	655	237	474	893	96
		Brook Stickleback	1	0.05	-	2.3	-	-	-	-	1
		Brook Trout	1	3.63	-	18.3	-	-	-	-	1
		Brown Trout	1	0.60	-	11.1	-	-	-	-	1
		Longnose Dace	3	0.05	3.6-4.6	4.2	-	2	-	-	1
		Ninespine Stickleback	3	0.05	2.4-3.0	2.8	-	1	-	2	-
		Rainbow Trout	1	4.63	-	22.8	-	1	-	-	-
		Slimy Sculpin	36	0.05	1.5-3.1	2.5	3	-	16	9	8
		Smelt	264	0.01	2.3-6.7	2.8	-	-	-	5	259
		Unidentified	1	0.05	-	3.5	-	-	-	-	1
		Yellow Perch	4	0.61	9.0-12.5	10.4	-	-	1	1	2
7-15	100.0%	Alewife	1,284	0.08	3.0-8.3	7.0	587	283	80	332	2
		Longnose Dace	1	0.07	-	5.0	-	1	-	-	-
		Longnose Sucker	1	1.00	-	16.7	-	-	-	1	-
		Ninespine Stickleback	1	0.05	-	2.7	-	1	-	-	-
		Slimy Sculpin	7	0.05	1.7-3.0	2.2	-	-	1	1	5
		Smelt	7	0.37	2.1-5.5	3.2	-	-	-	-	7
		White Sucker	3	0.83	11.0-31.5	19.8	-	-	1	2	-
		Yellow Perch	4	0.44	8.1-11.1	9.3	-	-	1	3	-
7-19	100.0%	Alewife	5,420	0.05	2.3-8.2	6.8	535	102	873	1,956	1,954
		Bloater	4	0.11	3.0-7.0	5.3	-	-	-	2	2
		Longnose Dace	1	0.05	-	3.7	-	-	-	-	1
		Ninespine Stickleback	3	0.05	1.6-3.0	2.4	-	2	-	-	1
		Slimy Sculpin	70	0.05	1.5-3.2	2.4	11	-	16	10	33
		Smelt	1,868	0.01	2.3-7.7	3.0	-	-	37	37	1,794
		Trout Perch	3	0.05	4.3-4.5	4.4	-	2	-	-	1
		White Sucker	2	0.36	9.8-12.0	10.9	-	-	-	2	-
		Yellow Perch	1	0.38	-	9.6	-	-	1	-	-

Table II.1. Summary of Fish Impingement Data,
March 1975-February 1976 at Point Beach Nuclear 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.
7-23	100.0%	Alewife	14,735	0.08	3.1-7.2	6.4	2,121	5,599	2,298	1,768	2,949
		Black Bullhead	1	0.25	-	8.4	-	-	1	-	-
		Lake Trout	1	8.20	-	30.2	-	-	-	-	1
		Ninespine Stickleback	5	0.05	1.7-2.5	2.1	-	2	1	1	1
		Slimy Sculpin	4	0.05	2.3-2.8	2.5	-	4	-	-	-
		Smelt	32	0.05	1.7-5.7	2.3	-	-	2	-	30
7-27	100.0%	Alewife	5,280	0.08	3.2-8.3	7.5	727	2,217	645	1,478	213
		Brown Trout	1	8.70	-	25.0	-	-	1	-	-
		Ninespine Stickleback	2	0.05	2.9-2.9	2.9	-	1	-	1	-
		Slimy Sculpin	15	0.05	1.6-3.0	2.2	-	2	1	2	10
		Smelt	61	0.05	2.3-6.5	3.1	-	-	2	-	59
		Yellow Perch	1	0.26	-	8.8	-	-	-	-	1
7-31	100.0%	Alewife	8,616	0.07	3.0-8.3	7.2	2,644	1,375	881	3,914	2
		Brown Trout	1	3.50	-	18.2	-	-	-	1	-
		Lake Chub	1	0.09	-	8.0	-	1	-	-	-
		Lake Trout	1	9.00	-	27.0	-	-	-	-	1
		Ninespine Stickleback	1	0.05	-	3.2	-	1	-	-	-
		Slimy Sculpin	9	0.05	2.1-3.1	2.6	1	1	-	2	5
		Smelt	13	0.05	2.3-5.3	3.4	-	-	-	-	13
		Yellow Perch	1	0.13	-	8.6	-	-	1	-	-
8-4	100.0%	Alewife	15,762	0.08	5.1-8.4	7.0	3,114	3,032	983	8,631	2
		Brook Trout	1	0.20	-	7.4	-	-	-	1	-
		Rainbow Trout	2	6.06	21.0-21.4	21.2	-	-	1	1	-
		Slimy Sculpin	4	0.05	1.7-2.7	2.4	-	-	1	2	1
		Smelt	16	0.05	2.5-6.6	3.8	-	-	-	5	11

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Point Beach Nuclear 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.
8-8	100.0%	Alewife	1,013	0.06	3.2-7.5	7.0	-	18	222	164	609
		Lake Trout	1	7.80	-	27.3	-	-	-	1	-
		Longnose Dace	1	0.05	-	4.3	-	-	-	-	1
		Rainbow Trout	2	7.15	20.5-24.0	22.2	-	-	-	2	-
		Slimy Sculpin	4	0.05	1.4-2.9	1.9	-	-	-	-	4
		Smelt	3	0.05	3.1-5.9	4.1	-	-	1	-	2
		Yellow Perch	1	0.50	-	10.1	-	-	-	-	1
8-12	100.0%	Alewife	430	0.06	3.0-8.2	7.0	111	8	77	206	28
		Ninespine Stickleback	1	0.05	-	3.0	-	1	-	-	-
		Slimy Sculpin	8	0.05	1.5-2.7	2.4	-	-	2	3	3
		Smelt	4	0.05	2.3-6.9	3.8	-	-	1	-	3
8-16	100.0%	Alewife	540	0.06	3.6-7.6	7.0	12	32	300	108	88
		Lake Chub	1	0.08	-	6.3	-	-	-	-	1
		Lake Trout	1	8.50	-	29.0	-	1	-	-	-
		Ninespine Stickleback	2	0.05	-	3.0	-	-	-	-	2
		Slimy Sculpin	1	0.05	-	3.1	-	-	1	-	-
		Smelt	6	0.05	3.0-6.2	4.8	-	-	1	-	5
		White Sucker	1	0.15	-	11.5	-	-	1	-	-
8-20	100.0%	Alewife	359	0.06	5.1-8.2	7.1	27	20	144	166	2
		Lake Chub	4	0.06	5.6-7.4	6.8	-	-	1	3	-
		Ninespine Stickleback	1	0.05	-	2.1	-	-	-	-	1
		Rainbow Trout	1	0.20	-	8.6	-	-	-	-	1
		Slimy Sculpin	8	0.05	1.7-3.2	2.4	-	-	1	4	3
		Smelt	22	0.05	2.3-7.3	3.0	-	-	-	1	21
		White Sucker	1	2.05	-	19.1	-	-	-	1	-

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Point Beach Nuclear 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.
8-24	100.0%	Alewife	591	0.06	4.9-8.5	7.0	-	-	390	200	1
		Black Bullhead	1	0.24	-	7.1	-	-	-	1	-
		Lake Chub	3	0.08	6.1-7.6	6.7	-	-	-	3	-
		Slimy Sculpin	7	0.05	1.6-3.0	2.0	-	-	2	-	5
		Smelt	170	0.01	1.6-3.6	3.0	-	-	-	-	170
		Yellow Perch	1	0.80	-	11.4	-	-	1	-	-
8-28	100.0%	Alewife	1,400	0.07	3.4-8.0	7.0	25	-	618	727	30
		Bloater	1	0.13	-	8.2	-	-	-	-	1
		Bluegill Sunfish	1	0.05	-	1.6	-	-	-	-	1
		Brook Trout	1	0.35	-	9.0	-	-	-	-	1
		Carp	1	0.05	-	2.3	-	-	-	-	1
		Lake Chub	1	0.05	-	6.4	-	-	-	1	-
		Northern Pike	1	0.06	-	7.2	-	-	-	-	1
		Slimy Sculpin	12	0.05	1.7-2.8	2.3	-	-	2	-	10
		Smelt	1,578	0.01	3.0-3.5	3.0	-	-	1	6	1,571
		Spottail Shiner	1	0.05	-	2.4	-	-	-	-	1
		White Sucker	2	1.00	13.5-14.0	13.7	-	-	-	2	-
		Yellow Perch	6	0.38	8.3-10.9	9.5	-	-	1	4	1
9-1	100.0%	Alewife	199	0.06	1.4-8.0	7.0	-	4	83	79	33
		Black Bullhead	4	0.09	2.4-7.5	3.7	-	-	-	-	4
		Carp	3	0.05	2.2-2.8	2.5	-	-	-	-	3
		Lake Chub	3	0.11	7.1-7.7	7.4	-	-	-	3	-
		Lake Trout	1	0.05	-	5.8	-	-	-	-	1
		Longnose Sucker	1	2.05	-	18.7	-	-	-	1	-
		Rainbow Trout	1	0.38	-	9.9	-	-	-	-	1
		Slimy Sculpin	18	0.05	1.6-2.8	2.3	-	-	-	1	17
		Smelt	513	0.01	1.5-6.3	3.2	-	-	20	-	493
		White Sucker	2	1.00	11.0-14.5	12.7	-	-	1	1	-
		Yellow Perch	3	0.59	9.2-12.0	10.4	-	-	-	3	-

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Point Beach Nuclear 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.
9-5	100.0%	Alewife	140	0.06	1.7-8.2	7.0	2	-	39	58	41
		Black Bullhead	1	0.05	-	4.4	-	-	-	-	1
		Bluegill Sunfish	1	0.05	-	1.6	-	-	-	-	1
		Carp	1	0.05	-	4.0	-	-	-	-	1
		Gizzard Shad	3	0.05	2.8-4.3	3.7	-	-	-	-	3
		Longnose Dace	1	0.05	-	3.5	-	-	-	-	1
		Ninespine Stickleback	1	0.05	-	3.0	-	-	-	-	1
		Slimy Sculpin	11	0.05	1.5-2.7	2.2	-	-	-	-	11
		Smelt	267	0.01	2.5-7.3	3.0	-	-	-	5	262
		Spottail Shiner	1	0.08	-	6.1	-	-	-	-	1
		White Sucker	5	0.78	6.0-14.9	11.7	-	-	-	-	5
		Yellow Perch	4	0.49	8.9-10.7	9.8	-	-	-	1	3
9-9	100.0%	Alewife	143	0.06	3.3-9.5	7.0	-	-	34	34	75
		Bluegill Sunfish	4	0.06	1.5-4.2	2.3	-	-	-	-	4
		Brown Trout	1	10.40	-	25.0	-	1	-	-	-
		Carp	1	0.05	-	2.5	-	-	-	-	1
		Lake Chub	4	0.14	5.6-6.2	5.9	-	-	-	1	3
		Lake Trout	1	5.60	-	27.5	-	-	1	-	-
		Longnose Dace	4	0.06	3.6-4.9	4.2	-	-	-	1	3
		Slimy Sculpin	15	0.05	1.8-2.5	2.1	-	-	-	-	15
		Smelt	100	0.01	1.8-4.6	3.0	-	-	-	-	100
		White Sucker	2	0.62	10.5-14.2	12.3	-	-	-	1	1
		Yellow Perch	3	0.57	9.6-10.5	10.1	-	-	1	-	2

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Point Beach Nuclear Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches)		Breeding State				
							Ripe		Unripe		Imm.
					Range	Mean	Male	Female	Male	Female	
9-13	95.1%	Alewife	109	0.05	1.7-8.4	6.5	2	-	13	21	73
		Black Bullhead	2	0.07	2.0-6.8	4.4	-	-	-	-	2
		Bluegill Sunfish	5	0.05	1.7-2.0	1.8	-	-	-	-	5
		Carp	1	0.05	-	2.8	-	-	-	-	1
		Channel Catfish	1	0.05	-	1.8	-	-	-	-	1
		Coho Salmon	1	0.20	-	9.0	-	-	-	-	1
		Emerald Shiner	4	0.05	2.5-3.2	3.0	-	-	-	-	4
		Gizzard Shad	1	0.05	-	2.7	-	-	-	-	1
		Lake Chub	3	0.07	2.5-6.5	5.0	-	1	-	-	2
		Lake Trout	1	11.50	-	31.0	-	1	-	-	-
		Longnose Dace	2	0.05	4.4-5.8	5.1	-	-	-	1	1
		Slimy Sculpin	8	0.05	1.9-2.9	2.4	-	-	-	-	8
		Smelt	350	0.01	2.4-7.2	3.4	-	-	76	-	274
9-17	100.0%	Alewife	270	0.05	1.8-8.6	6.8	-	-	35	35	200
		Black Bullhead	2	0.05	2.6-2.7	2.6	-	-	-	-	2
		Bluegill Sunfish	20	0.05	1.5-2.3	1.8	-	-	-	-	20
		Carp	3	0.05	2.6-3.0	2.8	-	-	-	-	3
		Gizzard Shad	9	0.06	2.8-5.4	4.2	-	-	-	-	9
		Lake Chub	4	0.13	6.7-7.3	7.0	-	-	-	4	-
		Ninespine Stickleback	1	0.05	-	2.7	-	-	-	-	1
		Slimy Sculpin	13	0.05	1.7-2.8	2.4	-	-	-	-	13
		Smelt	368	0.01	2.6-7.4	3.5	-	-	-	-	368
		Spottail Shiner	1	0.05	-	4.6	-	-	-	-	1
		White Sucker	1	1.40	-	14.3	-	-	-	-	1
9-21	89.9%	Alewife	481	0.04	1.8-8.2	4.3	-	-	28	28	425
		Black Bullhead	1	0.50	-	9.1	-	-	1	-	-
		Bluegill Sunfish	1	0.05	-	1.7	-	-	-	-	1
		Gizzard Shad	17	0.05	2.9-5.0	3.4	-	-	-	1	16
		Longnose Dace	1	0.05	-	3.8	-	-	-	-	1
		Slimy Sculpin	11	0.05	1.6-2.7	2.3	-	-	-	-	11
		Smelt	203	0.01	2.7-7.4	3.0	-	-	-	-	203

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Point Beach Nuclear Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches)		Breeding State				
							Ripe		Unripe		Imm.
					Range	Mean	Male	Female	Male	Female	
9-25	97.9%	Alewife	395	0.06	2.3-7.9	6.7	-	-	102	47	246
		Black Bullhead	1	0.40	-	8.5	-	-	1	-	-
		Bluegill Sunfish	12	0.05	1.5-2.1	1.8	-	-	-	-	12
		Brown Trout	1	1.25	-	13.0	-	-	1	-	-
		Lake Chub	2	0.05	5.6-6.0	5.8	-	-	-	1	1
		Longnose Dace	2	0.05	4.1-4.2	4.1	-	-	-	1	1
		Slimy Sculpin	29	0.05	1.4-3.0	2.3	-	-	-	-	29
		Smelt	166	0.01	2.9-7.1	3.5	-	-	-	-	166
		Trout Perch	1	0.05	-	4.3	-	-	-	-	1
9-29	100.0%	Alewife	56	0.06	1.7-8.2	4.7	-	-	5	9	42
		Black Bullhead	1	0.35	-	9.3	-	-	-	-	1
		Bluegill Sunfish	2	0.05	1.6-2.2	1.9	-	-	-	-	2
		Gizzard Shad	5	0.05	3.6-4.6	4.0	-	-	-	-	5
		Lake Chub	1	0.07	-	7.2	-	-	-	1	-
		Lake Trout	1	9.00	-	30.1	-	-	1	-	-
		Slimy Sculpin	5	0.05	2.0-2.6	2.3	-	-	-	-	5
		Smelt	7	0.05	2.8-6.5	4.0	-	-	-	-	7
10-3	100.0%	Alewife	25	0.08	1.9-7.6	6.0	-	-	5	3	17
		Bluegill Sunfish	1	0.05	-	1.7	-	-	-	-	1
		Lake Trout	1	7.60	-	28.7	-	-	-	1	-
		Slimy Sculpin	5	0.05	1.5-2.4	2.0	-	-	-	-	5
		Smelt	10	0.05	3.1-9.1	4.4	-	-	-	-	10
		Whitefish	1	0.10	-	6.3	-	-	1	-	-

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Point Beach Nuclear 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.
10-7	100.0%	Alewife	100	0.03	1.3-8.2	4.4	-	-	1	5	94
		Black Bullhead	1	0.50	-	9.5	-	-	-	-	1
		Bluegill Sunfish	8	0.05	1.6-2.3	1.9	-	-	-	-	8
		Gizzard Shad	6	0.11	3.5-7.9	5.7	-	-	-	-	6
		Lake Trout	1	7.40	-	29.3	-	-	-	-	1
		Longnose Dace	1	0.05	-	5.0	-	-	-	-	1
		Ninespine Stickleback	3	0.05	1.9-2.7	2.2	-	-	-	-	3
		Slimy Sculpin	27	0.05	1.7-2.8	2.4	-	-	-	-	27
		Smelt	500	0.01	2.8-6.2	3.4	-	-	-	-	500
		White Sucker	2	1.45	15.0-16.5	15.7	-	-	2	-	-
		Yellow Perch	1	0.30	-	8.9	-	-	-	-	1
10-11	100.0%	Alewife	137	0.04	2.1-9.9	5.4	-	-	49	30	58
		Black Bullhead	1	0.13	-	6.8	-	-	-	1	-
		Bluegill Sunfish	1	0.05	-	1.8	-	-	-	-	1
		Gizzard Shad	9	0.08	4.2-7.5	6.1	-	-	1	-	8
		Ninespine Stickleback	1	0.05	-	2.6	-	-	-	-	1
		Slimy Sculpin	12	0.05	1.8-2.9	2.3	-	-	-	-	12
		Smelt	10	0.05	1.7-3.6	2.7	-	-	-	-	10
		Yellow Perch	1	0.65	-	10.5	-	-	1	-	-
10-15	100.0%	Alewife	24	0.07	2.5-7.7	6.4	-	-	5	3	16
		Bluegill Sunfish	1	0.05	-	1.7	-	-	-	-	1
		Brown Trout	1	5.90	-	23.6	1	-	-	-	-
		Gizzard Shad	4	0.17	6.6-7.7	7.1	-	-	3	-	1
		Slimy Sculpin	3	0.05	2.0-2.5	2.3	-	-	-	-	3
		Smelt	1	0.05	-	3.2	-	-	-	-	1

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Point Beach Nuclear Power Plant

Date	% Volume Sampled	Species	Number	Mean Weight (lbs.)	Length (inches)		Breeding State				
							Ripe		Unripe		Imm.
					Range	Mean	Male	Female	Male	Female	
10-7	100.0%	Alewife	100	0.03	1.3-8.2	4.4	-	-	1	5	94
		Black Bullhead	1	0.50	-	9.5	-	-	-	-	1
		Bluegill Sunfish	8	0.05	1.6-2.3	1.9	-	-	-	-	8
		Gizzard Shad	6	0.11	3.5-7.9	5.7	-	-	-	-	6
		Lake Trout	1	7.40	-	29.3	-	-	-	-	1
		Longnose Dace	1	0.05	-	5.0	-	-	-	-	1
		Ninespine Sticklebach	3	0.05	1.9-2.7	2.2	-	-	-	-	3
		Slimy Sculpin	27	0.05	1.7-2.8	2.4	-	-	-	-	27
		Smelt	500	0.01	2.8-6.2	3.4	-	-	-	-	500
		White Sucker	2	1.45	15.0-16.5	15.7	-	-	2	-	-
		Yellow Perch	1	0.30	-	8.9	-	-	-	-	1
10-11	100.0%	Alewife	137	0.04	2.1-9.9	5.4	-	-	49	30	58
		Black Bullhead	1	0.13	-	6.8	-	-	-	1	-
		Bluegill Sunfish	1	0.05	-	1.8	-	-	-	-	1
		Gizzard Shad	9	0.08	4.2-7.5	6.1	-	-	1	-	8
		Ninespine Stickleback	1	0.05	-	2.6	-	-	-	-	1
		Slimy Sculpin	12	0.05	1.8-2.9	2.3	-	-	-	-	12
		Smelt	10	0.05	1.7-3.6	2.7	-	-	-	-	10
		Yellow Perch	1	0.65	-	10.5	-	-	1	-	-
10-15	100.0%	Alewife	24	0.07	2.5-7.7	6.4	-	-	5	3	16
		Bluegill Sunfish	1	0.05	-	1.7	-	-	-	-	1
		Brown Trout	1	5.90	-	23.6	1	-	-	-	-
		Gizzard Shad	4	0.17	6.6-7.7	7.1	-	-	3	-	1
		Slimy Sculpin	3	0.05	2.0-2.5	2.3	-	-	-	-	3
		Smelt	1	0.05	-	3.2	-	-	-	-	1

Table II.1. Summary of Fish Impingement Data,
March 1975-February 1976 at Point Beach Nuclear 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.
10-19	100.0%	Alewife	908	0.01	2.0-7.5	2.8	-	-	36	-	872
		Black Bullhead	1	0.05	-	2.6	-	-	-	-	1
		Bloater	1	0.05	-	7.9	-	1	-	-	-
		Bluegill Sunfish	6	0.05	1.6-2.3	1.9	-	-	-	-	6
		Brown Trout	1	6.00	-	23.2	-	-	1	-	-
		Gizzard Shad	19	0.16	4.8-8.5	6.9	-	-	9	1	9
		Lake Trout	1	11.90	-	31.5	1	-	-	-	-
		Longnose Dace	1	0.05	-	3.4	-	-	-	-	1
		Rainbow Trout	1	5.80	-	20.8	-	-	1	-	-
		Slimy Sculpin	82	0.05	1.5-3.4	2.5	-	-	-	-	82
		Smelt	236	0.01	2.2-6.3	3.8	-	-	-	-	236
		Yellow Perch	1	0.05	-	3.7	-	-	-	-	1
10-23	100.0%	Alewife	2,230	0.01	2.3-6.9	3.0	-	-	-	-	2,230
		Black Bullhead	2	0.05	2.6-2.9	2.7	-	-	-	-	2
		Bluegill Sunfish	4	0.05	1.8-1.9	1.8	-	-	-	-	4
		Emerald Shiner	1	0.05	-	3.3	-	-	-	-	1
		Gizzard Shad	2	0.07	2.9-6.8	4.9	-	-	-	-	2
		Lake Trout	1	5.40	-	26.7	-	-	-	1	-
		Longnose Dace	1	0.05	-	4.1	-	-	-	-	1
		Ninespine Stickleback	1	0.05	-	3.1	-	-	-	-	1
		Slimy Sculpin	43	0.05	1.9-3.5	2.6	-	-	-	-	43
		Smelt	273	0.01	2.7-6.0	3.5	-	-	-	-	273

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Point Beach Nuclear 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.
10-27	100.0%	Alewife	5,037	0.01	1.6-7.8	3.0	-	-	-	-	5,037
		Bluegill Sunfish	18	0.05	1.2-2.2	1.8	-	-	-	-	18
		Brown Trout	1	7.60	-	24.3	-	1	-	-	-
		Carp	2	0.05	2.5-3.2	2.8	-	-	-	-	2
		Gizzard Shad	14	0.09	2.6-7.8	5.0	-	-	-	-	14
		Salmonid sp.	1	0.05	-	8.6	-	-	-	-	1
		Lake Chub	1	0.05	-	7.1	-	1	-	-	-
		Lake Trout	1	8.10	-	28.8	-	1	-	-	-
		Largemouth Bass	1	0.05	-	3.5	-	-	-	-	1
		Longnose Dace	1	0.05	-	3.8	-	-	-	-	1
		Mudminnow	1	0.05	-	3.6	-	-	-	-	1
		Ninespine Stickleback	3	0.05	2.1-2.2	2.2	-	-	-	-	3
		Slimy Sculpin	204	0.02	1.7-3.4	1.8	-	-	-	-	204
		Smelt	22,253	0.01	2.5-7.2	3.5	-	-	-	-	22,253
		Trout Perch	2	0.05	3.3-3.9	3.6	-	-	-	-	2
10-31	100.0%	Alewife	1,300	0.02	2.0-7.7	3.2	-	-	-	-	1,300
		Bloater	1	0.05	-	6.3	-	-	-	-	1
		Bluegill Sunfish	8	0.05	1.2-2.1	1.7	-	-	-	-	8
		Brown Trout	3	4.07	20.0-23.0	21.1	1	2	-	-	-
		Gizzard Shad	354	0.01	1.2-7.9	2.5	-	-	-	-	354
		Lake Chub	2	0.05	-	6.0	-	-	-	1	1
		Lake Trout	1	11.20	-	31.7	1	-	-	-	-
		Longnose Dace	1	0.05	-	3.7	-	-	-	-	1
		Ninespine Stickleback	3	0.05	2.3-2.9	2.7	-	-	-	-	3
		Slimy Sculpin	68	0.02	1.1-3.3	1.9	-	-	-	-	68
		Smelt	8,624	0.01	2.0-7.0	3.8	-	-	-	-	8,624
		Trout Perch	8	0.05	2.7-5.3	4.0	-	-	-	-	8
		White Sucker	1	0.05	-	3.4	-	-	-	-	1
		Yellow Perch	6	0.05	3.6-4.7	4.2	-	-	-	-	6

Table II.1. Summary of Fish Impingement Data,
March 1975-February 1976 at Point Beach Nuclear 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.
11-4	100.0%	Alewife	900	0.01	1.9-7.2	3.0	-	-	-	-	900
		Black Bullhead	2	0.12	2.4-6.8	4.6	-	-	-	-	2
		Bluegill Sunfish	3	0.05	1.6-2.0	1.8	-	-	-	-	3
		Brown Trout	2	0.64	22.2-24.8	23.5	2	-	-	-	-
		Gizzard Shad	31	0.07	2.6-6.7	4.7	-	-	-	-	31
		Lake Chub	1	0.15	-	6.6	-	-	-	-	1
		Lake Trout	2	4.12	5.0-30.8	17.9	-	-	1	-	1
		Ninespine Stickleback	1	0.05	-	2.7	-	-	-	-	1
		Slimy Sculpin	54	0.02	1.9-2.9	1.2	-	-	-	-	54
		Smelt	314	0.02	2.3-8.5	4.0	-	-	-	-	314
		Spottail Shiner	2	0.05	2.7-2.8	2.7	-	-	-	-	2
11-8	101.0%	Alewife	450	0.01	2.0-6.3	2.7	-	-	-	-	450
		Bluegill Sunfish	4	0.05	1.6-1.9	1.8	-	-	-	-	4
		Gizzard Shad	2	0.07	4.3-5.8	5.0	-	-	-	-	2
		Lake Chub	1	0.15	-	7.2	-	1	-	-	-
		Slimy Sculpin	60	0.02	1.8-3.0	1.1	-	-	-	-	60
		Smelt	333	0.01	1.8-7.3	3.3	-	-	-	-	333
		Spottail Shiner	1	0.05	-	2.5	-	-	-	-	1
11-12	100.0%	Alewife	11,273	0.01	2.3-7.0	2.9	-	-	-	-	11,273
		Bluegill Sunfish	7	0.05	1.7-4.2	2.3	-	-	-	-	7
		Gizzard Shad	3	0.05	5.0-5.4	5.1	-	-	-	-	3
		Lake Trout	1	4.30	-	23.3	-	-	1	-	-
		Lake Whitefish	2	0.90	5.1-19.0	12.0	-	-	-	-	2
		Ninespine Stickleback	2	0.05	2.9-3.0	2.9	-	-	-	-	2
		Slimy Sculpin	97	0.02	1.3-3.4	1.8	-	-	-	-	97
		Smelt	745	0.01	1.5-6.9	3.3	-	-	-	-	745
		Spottail Shiner	1	0.05	-	2.8	-	-	-	-	1
		Unidentified Salmonid	1	0.50	-	11.0	-	-	-	-	1
		Yellow Perch	1	0.05	-	4.2	1	-	-	-	-

Table II.1. Summary of Fish Impingement Data,
March 1975-February 1976 at Point Beach Nuclear 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
11-16	99.3%	Alewife	2,493	0.01	2.2-7.6	2.5	-	-	-	-	2,493
		Bluegill Sunfish	3	0.05	1.7-1.9	1.8	-	-	-	-	3
		Brook Trout	1	1.50	-	15.4	-	-	-	-	1
		Emerald Shiner	1	0.05	-	2.9	-	-	-	-	1
		Gizzard Shad	8	0.06	2.4-7.1	4.3	-	-	1	1	6
		Lake Chub	2	0.10	6.2-6.6	6.4	-	-	-	2	-
		Ninespine Stickleback	2	0.05	-	2.8	-	-	-	-	2
		Slimy Sculpin	209	0.01	1.7-3.0	1.9	-	-	-	-	209
		Smelt	614	0.01	1.5-6.7	3.5	-	-	2	-	612
		Spottail Shiner	2	0.05	2.7-3.4	3.0	-	-	-	-	2
11-24	96.5%	Alewife	56	0.03	2.0-7.0	1.9	-	-	-	-	56
		Bluegill Sunfish	2	0.05	1.7-1.8	1.7	-	-	-	-	2
		Gizzard Shad	18	0.05	1.9-7.2	4.2	-	-	1	-	17
		Lake Chub	1	0.10	-	6.7	-	1	-	-	-
		Lake Trout	1	7.10	-	27.7	-	-	-	1	-
		Slimy Sculpin	72	0.02	1.8-3.3	2.0	-	-	-	-	72
		Smelt	47	0.03	1.6-6.6	1.7	-	-	-	-	47
		Yellow Perch	1	0.05	-	3.5	-	-	-	-	1
11-28	102.0%	Alewife	5	0.06	1.9-6.0	3.3	-	-	-	-	5
		Gizzard Shad	5	0.05	2.5-6.5	5.3	-	-	-	-	5
		Ninespine Stickleback	4	0.05	2.5-2.9	2.7	-	-	-	-	4
		Slimy Sculpin	60	0.02	1.9-3.1	2.0	-	-	-	-	60
		Smelt	26	0.02	2.1-6.4	3.4	-	-	-	-	26

Table II.1. Summary of Fish Impingement Data,
March 1975-February 1976 at Point Beach Nuclear 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.
12-2	111.8%	Alewife	1	0.10	-	6.1	-	-	-	-	1
		Bluegill Sunfish	6	0.05	1.5-1.7	1.6	-	-	-	-	6
		Emerald Shiner	1	0.05	-	2.9	-	-	-	-	1
		Gizzard Shad	20	0.07	2.1-7.8	4.0	-	-	1	-	19
		Ninespine Stickleback	8	0.05	2.4-3.2	2.8	-	-	-	-	8
		Slimy Sculpin	79	0.02	1.3-3.1	2.0	-	-	-	-	79
		Smelt	150	0.01	1.8-8.2	3.4	-	-	12	12	126
		Spottail Shiner	1	0.05	-	2.7	-	-	-	-	1
12-6	100.0%	Bluegill Sunfish	10	0.05	1.6-2.0	1.8	-	-	-	-	10
		Carp	2	0.05	-	2.8	-	-	-	-	2
		Gizzard Shad	5	0.05	2.4-5.3	3.5	-	-	-	-	5
		Lake Chub	2	0.05	6.5-7.1	6.8	-	-	-	2	-
		Lake Trout	1	8.6	-	29.8	-	-	-	1	-
		Longnose Dace	1	0.05	-	3.3	-	-	-	-	1
		Ninespine Stickleback	7	0.05	2.5-3.1	2.9	-	-	-	-	7
		Rainbow Trout	1	1.50	-	14.7	-	-	1	-	-
		Round Whitefish	1	0.05	-	4.3	-	-	-	-	1
		Slimy Sculpin	76	0.02	1.9-3.0	2.8	-	-	-	-	76
		Smelt	115	0.01	1.7-7.5	3.2	-	-	9	9	97
		Trout Perch	1	0.05	-	3.5	-	-	-	-	1
		Yellow Perch	3	0.05	2.3-4.4	3.4	-	-	-	-	3

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Point Beach Nuclear 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.
12-10	100.0%	Bluegill Sunfish	11	0.05	1.5-2.0	1.7	-	-	-	-	11
		Brown Trout	2	2.00	11.0-20.9	15.9	-	-	-	2	-
		Carp	3	0.05	2.5-2.8	2.6	-	-	-	-	3
		Gizzard Shad	2	0.10	2.7-7.8	5.2	-	-	-	-	2
		Ninespine Stickleback	5	0.05	2.3-3.0	2.7	-	-	-	-	5
		Slimy Sculpin	143	0.01	1.5-3.6	1.7	-	-	-	-	143
		Smelt	125	0.01	1.6-6.8	3.4	-	-	2	4	119
		Spottail Shiner	1	0.05	-	2.7	-	-	-	-	1
		Trout Perch	3	0.05	3.2-3.9	3.6	-	-	-	-	3
		White Sucker	1	1.90	-	16.8	-	-	-	1	-
		Yellow Perch	1	0.05	-	4.5	-	-	-	-	1
12-14	101.7%	Bluegill Sunfish	2	0.05	1.8-2.0	1.9	-	-	-	-	2
		Gizzard Shad	1	0.05	-	5.5	-	-	-	-	1
		Lake Trout	1	0.30	-	9.8	-	-	-	-	1
		Longnose Dace	2	0.05	3.2-3.6	3.4	-	-	-	-	2
		Ninespine Stickleback	4	0.05	2.5-2.9	2.6	-	-	-	-	4
		Slimy Sculpin	94	0.02	1.4-3.7	1.2	-	-	-	-	94
		Smelt	69	0.03	1.8-5.7	2.7	-	-	1	3	65
12-18	100.0%	Alewife	1	0.05	-	2.9	-	-	-	-	1
		Gizzard Shad	7	0.07	3.5-7.1	5.1	-	-	-	-	7
		Lake Chub	3	0.10	6.2-7.5	6.8	-	1	-	2	-
		Lake Trout	2	2.25	7.5-25.5	16.5	-	-	-	1	1
		Lake Whitefish	1	3.00	-	20.3	-	-	-	-	1
		Longnose Dace	2	0.05	3.0-4.5	3.7	-	-	-	-	2
		Ninespine Stickleback	3	0.05	2.5-3.1	2.8	-	-	-	-	3
		Slimy Sculpin	322	0.01	1.9-3.5	2.5	-	-	-	-	322
		Smelt	300	0.01	1.7-6.1	2.3	-	-	17	-	283
		Spottail Shiner	2	0.05	-	2.8	-	-	-	-	2

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Point Beach Nuclear 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.
12-22-75	102.1%	Slimy Sculpin	13	0.05	1.7-2.7	2.1	-	-	-	-	13
		Smelt	15	0.05	2.0-2.5	2.2	-	-	-	-	15
		Unident. Salmonid sp.	1	0.10	-	7.0	-	-	-	-	1
12-26-75	100.0%	Alewife	1	0.10	-	6.1	-	-	-	-	1
		Black Bullhead	1	0.10	-	5.3	-	-	-	-	1
		Gizzard Shad	4	0.24	4.2-11.8	7.5	-	-	2	-	2
		Ninespine Stickleback	1	0.05	-	2.4	-	-	-	-	1
		Slimy Sculpin	67	0.02	1.1-3.0	2.0	-	-	-	-	67
		Smelt	98	0.01	1.7-3.2	2.3	-	-	-	-	98
12-30-75	88.2%	Gizzard Shad	1	0.12	-	7.0	-	-	-	-	1
		Lake Trout	1	0.05	-	5.6	-	-	-	-	1
		Slimy Sculpin	8	0.05	1.6-2.4	2.0	-	-	1	-	7
		Smelt	2	0.05	1.8-2.1	1.9	-	-	-	-	2
1-3-76	89.9%	Bluegill	1	0.05	-	2.0	-	-	-	-	1
		Gizzard Shad	1	0.05	-	6.5	-	-	-	-	1
		Lake Trout	1	7.25	-	28.3	-	-	1	-	-
		Slimy Sculpin	19	0.05	1.8-2.9	2.3	-	-	3	4	12
		Smelt	5	0.00	1.8-2.3	2.1	-	-	-	-	5
1-7-76	97.2%	Black Bullhead	3	0.13	2.4-7.7	4.2	-	-	-	1	2
		Carp	1	0.05	-	2.1	-	-	-	-	1
		Gizzard Shad	7	0.14	5.1-8.0	7.0	-	-	1	2	4
		Lake Trout	1	9.30	-	30.3	-	-	-	1	-
		Ninespine Stickleback	1	0.05	-	2.7	-	-	-	-	1
		Rainbow Trout	2	1.10	9.7-15.8	12.7	1	-	-	-	1
		Slimy Sculpin	77	0.03	1.3-3.1	1.5	-	1	18	16	42
		Smelt	221	0.01	1.5-3.5	2.5	-	-	-	-	221

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Point Beach Nuclear 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.
1-11	100.0%	Black Bullhead	6	0.06	2.1-5.2	3.2	-	-	-	-	6
		Bluegill Sunfish	4	0.05	1.5-2.1	1.8	-	-	-	-	4
		Brown Trout	1	2.30	-	16.8	-	-	1	-	-
		Gizzard Shad	17	0.16	5.7-7.6	6.8	-	-	6	5	6
		Lake Trout	1	0.40	-	10.2	-	-	1	-	-
		Ninespine Stickleback	3	0.05	1.6-2.8	2.3	-	-	-	-	3
		Slimy Sculpin	125	0.05	1.2-3.2	2.4	-	-	42	34	49
		Smelt	225	0.01	1.5-4.9	2.0	-	-	-	-	225
1-19	100.0%	Black Bullhead	1	0.05	-	2.6	-	-	-	-	1
		Brown Trout	1	4.40	-	23.2	-	-	-	1	-
		Carp	1	0.05	-	4.7	-	-	-	-	1
		Gizzard Shad	2	0.30	6.5-11.4	8.9	-	-	1	-	1
		Lake Trout	2	2.95	10.7-26.1	18.4	-	-	1	-	1
		Ninespine Stickleback	4	0.05	1.6-2.7	2.3	-	-	-	-	4
		Slimy Sculpin	50	0.05	1.2-3.0	2.2	-	2	9	11	28
		Smelt	371	0.01	1.4-6.2	2.1	-	-	7	22	342
		Spottail Shiner	4	0.05	2.9-4.3	3.6	-	-	-	2	2
		Trout Perch	1	0.05	-	3.6	-	1	-	-	-
		Yellow Perch	1	0.50	-	10.7	-	-	-	-	1
1-23	100.0%	Alewife	2	0.05	5.2-5.3	5.2	-	-	-	-	2
		Black Bullhead	1	0.20	-	7.2	-	-	-	-	1
		Deepwater Sculpin	1	0.05	-	4.1	-	-	-	1	-
		Ninespine Stickleback	1	0.05	-	2.6	-	-	-	-	1
		Slimy Sculpin	30	0.05	1.3-3.0	2.3	-	-	6	6	18
		Smelt	280	0.01	1.6-6.4	2.0	-	11	-	-	269
		Spottail Shiner	1	0.05	-	3.7	-	-	-	-	1

Table II.1. Summary of Fish Impingement Data, March 1975-February 1976 at Point Beach Nuclear 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.
1-27	100.0%	Alewife	1	0.10	-	6.5	-	-	-	-	1
		Rainbow Trout	1	0.40	-	10.1	-	-	1	-	-
		Slimy Sculpin	11	0.05	1.8-2.8	2.4	-	-	3	3	5
		Smelt	14	0.05	1.7-5.3	2.4	-	-	1	1	12
		White Sucker	1	1.20	-	14.2	-	-	-	1	-
1-31	100.0%	Alewife	1	0.10	-	7.7	-	-	-	-	1
		Black Bullhead	1	0.20	-	7.3	-	-	-	-	1
		Lake Trout	1	6.00	-	27.2	-	-	-	1	-
		Ninespine Stickleback	1	0.05	-	2.8	-	-	-	-	1
		Slimy Sculpin	4	0.09	2.1-2.6	2.4	-	-	-	-	4
		Smelt	23	0.05	1.5-8.1	2.3	-	-	1	-	22
2-4	100.0%	Lake Trout	1	6.7	-	25.5	-	-	-	-	1
		Slimy Sculpin	15	0.05	1.5-2.5	2.1	-	1	1	5	8
		Smelt	15	0.05	1.8-6.6	2.6	-	-	2	-	13
2-8	100.0%	Black Bullhead	1	0.20	-	7.0	-	-	-	1	-
		Slimy Sculpin	6	0.05	2.1-2.3	2.2	-	1	1	2	2
		Smelt	27	0.03	1.6-3.2	1.3	-	-	-	-	27
2-12	100.0%	Slimy Sculpin	11	0.05	1.5-3.0	2.5	-	4	2	3	2
		Smelt	26	0.05	1.6-5.7	2.2	-	1	-	-	25
2-16	100.0%	Black Bullhead	1	0.05	-	2.3	-	-	-	-	1
		Longnose Dace	1	0.05	-	4.0	-	-	-	-	1
		Ninespine Stickleback	1	0.05	-	3.2	-	-	-	1	-
		Slimy Sculpin	45	0.05	1.9-3.6	2.5	-	8	15	16	6
		Smelt	125	0.05	1.6-5.4	2.2	-	-	-	2	123

Table II.1. Summary of Fish Impingement Data,
March 1975-February 1976 at Point Beach Nuclear 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.
2-20	100.0%	Ninespine Stickleback	1	0.05	-	2.9	-	-	-	-	1
		Slimy Sculpin	9	0.05	2.1-2.8	2.4	-	-	2	4	3
		Smelt	11	0.05	1.6-6.3	2.4	-	-	1	-	10
2-24	100.0%	Ninespine Stickleback	2	0.05	2.5-3.0	2.7	-	-	1	-	1
		Slimy Sculpin	104	0.05	1.7-3.3	2.5	8	39	37	14	6
		Smelt	117	0.01	1.5-8.8	2.2	-	-	7	13	97
		Yellow Perch	1	0.60	-	10.7	1	-	-	-	-
2-28	100.0%	Ninespine Stickleback	1	0.05	-	2.5	-	-	-	-	1
		Slimy Sculpin	49	0.05	2.2-3.1	2.6	1	11	22	13	2
		Smelt	19	0.05	1.7-6.1	3.1	-	1	3	1	14

Table II.2. Summary of Entrainment Sampling Data, April-October, 1975 for Point Beach Nuclear 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
4-18	582.3	0.014	None	-	-	None	-	-	8	13.74	27	46.37
4-26	742.4	0.018	None	-	-	None	-	-	10	13.47	4	5.39
4-30	755.4	0.018	None	-	-	None	-	-	6	7.94	2	2.65
5-4	704.6	0.017	None	-	-	None	-	-	11	15.61	6	8.52
5-8	793.7	0.019	None	-	-	None	-	-	4	5.04	0	-
5-12	764.5	0.018	None	-	-	None	-	-	9	11.77	3	3.92
5-16	775.0	0.018	None	-	-	None	-	-	5	6.45	1	1.29
5-20	780.0	0.019	Longnose Sucker	1	1.28	None	-	-	0	-	0	-
5-24	743.2	0.018	Longnose Sucker	1	1.35	None	-	-	0	-	3	4.04
5-28	760.4	0.018	None	-	-	None	-	-	4	5.26	8	10.52
6-1	775.9	0.018	None	-	-	None	-	-	0	-	0	-
6-5	781.6	0.019	None	-	-	None	-	-	12	15.35	2	2.56
6-9	812.0	0.019	None	-	-	None	-	-	25	30.79	1	1.23
6-13	731.3	0.017	None	-	-	None	-	-	4	5.47	1	1.37
6-17	763.4	0.018	None	-	-	None	-	-	1	1.31	2	2.62

Table II.2. Summary of Entrainment Sampling Data, April-October, 1975 for Point Beach Nuclear Power Plant.

Date	Volume Sampled (meters^3)	Percent of Intake Volume	Fish Larvae Species	Fish Larvae No.	Fish Larvae No./m^3 x 1000	Fish Eggs Species	Fish Eggs No.	Fish Eggs No./m^3 x 1000	Invertebrates: Pontoporeia No.	Invertebrates: Pontoporeia No./m^3 x 1000	Invertebrates: Mysis No.	Invertebrates: Mysis No./m^3 x 1000
6-21	847.4	0.020	None	-	-	Alewife	15	17.70	10	11.80	3	3.54
6-25	809.9	0.019	None	-	-	Alewife	6	7.41	0	-	0	-
6-29	774.8	0.018	None	-	-	None	-	-	0	-	0	-
7-3	697.1	0.017	None	-	-	None	-	-	0	-	0	-
7-7	682.0	0.016	Alewife Sculpin	1 3	1.47 4.40	Alewife	10	14.66	26	38.12	6	8.80
7-11	814.3	0.019	Sculpin	4	4.91	None	-	-	28	34.39	0	-
7-15	740.5	0.018	None	-	-	None	-	-	20	27.00	0	-
7-19	727.7	0.017	None	-	-	None	-	-	33	45.35	7	9.62
7-23	719.7	0.017	Sculpin	1	1.39	Alewife	101	140.34	26	36.13	68	94.48
7-27	590.5	0.014	None	-	-	None	-	-	38	64.35	17	28.79
7-31	786.2	0.019	Sculpin	1	1.27	None	-	-	14	17.81	90	114.47
8-4	856.7	0.020	Alewife Sculpin Smelt	1 5 1	1.17 5.84 1.17	None	-	-	15	17.51	104	121.40
8-8	737.8	0.018	Smelt	21	28.46	None	-	-	95	128.76	39	52.86
8-12	834.7	0.039	Smelt	1	1.20	None	-	-	17	23.14	1	1.20

Table II.2. Summary of Entrainment Sampling Data, April-October, 1975 for Point Beach Nuclear 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
8-16	732.0	0.028	Slimy Sculpin	1	1.37	Alewife	70	95.63	24	32.79	3	4.10
8-20	717.6	0.017	Alewife Smelt	5 2	6.97 2.79	Alewife	1	1.39	28	39.02	0	-
8-24	718.3	0.017	Alewife Smelt	2 2	2.78 2.78	None	-	-	11	15.31	0	-
8-28	738.6	0.018	Smelt	3	4.06	None	-	-	4	5.42	0	-
9-1	725.3	0.017	Alewife Smelt	1 2	1.38 2.76	None	-	-	13	17.29	0	-
9-5	776.1	0.018	Alewife Smelt	2 1	2.58 1.29	None	-	-	10	12.88	0	-
9-9	786.8	0.019	Alewife Smelt	2 3	2.54 3.81	None	-	-	6	7.63	0	-
9-13	746.0	0.018	None	-	-	None	-	-	10	13.40	0	-
9-17	763.6	0.018	Alewife Smelt	2 2	2.62 2.62	None	-	-	4	5.24	1	1.31
9-21	748.8	0.018	Smelt	2	2.67	None	-	-	1	1.34	4	5.34
9-25	782.1	0.019	Smelt	1	1.28	None	-	-	1	1.28	0	-
9-29	761.1	0.018	Alewife	1	1.31	None	-	-	1	1.31	1	1.31

Table II.2. Summary of Entrainment Sampling Data, April-October, 1975 for Point Beach Nuclear 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
10-3	749.8	0.018	Smelt	1	1.33	None	-	-	33	44.01	0	-
10-7	753.6	0.018	None	-	-	None	-	-	3	3.98	1	1.33
10-11	723.5	0.017	Smelt	1	1.38	None	-	-	3	4.15	1	1.38
10-15	729.9	0.017	None	-	-	None	-	-	0	-	0	-
10-19	734.7	0.018	None	-	-	None	-	-	1	1.36	0	-
10-23	751.3	0.018	Smelt	4	5.32	None	-	-	0	-	0	-
10-27	729.2	0.017	None	-	-	None	-	-	4	5.49	0	-
10-31	667.4	0.016	Smelt	10	14.98	None	-	-	17	25.47	0	-

Table II-3. Summary of Lake Survey Sampling Data May-October, 1975 for Point Beach Area

Date	Area	Volume Sampled (meters^3)	Fish Larvae			Volume Sampled (meters^3)	Fish Eggs	
			Species	No.	No./m^3 x 1000		Species	No.
5-8	Reference	49.7	Smelt	6	120.7	1.5	None	-
	Intake	65.6	Smelt	9	137.2	1.5	Smelt	6
6-5	Reference	48.1	Smelt	5	104.0	1.4	None	-
	Intake	38.9	Smelt	1	25.7	1.4	None	-
6-25	Reference	45.9	Yellow Perch	1	21.8	1.4	None	-
			Sucker	1	21.8			
	Intake	51.5	Smelt	4	77.7	1.4	Alewife	11
			Alewife	3	58.2			
7-3	Reference	87.8	Alewife	4	45.6	1.4	Alewife	9
	Intake	92.1	Alewife	26	282.3	1.4	None	-
			Cyprinid	6	65.1			
			Sculpin	2	21.7			
			Unidentified	1	10.9			

Table II-3. Summary of Lake Survey Sampling Data May-October, 1975 for Point Beach Area

Date	Area	Volume Sampled (meters³)	Fish Larvae Species	Fish Larvae No.	Fish Larvae No./m³ x 1000	Volume Sampled (meters³)	Fish Eggs Species	Fish Eggs No.
7-15	Reference	65.7	Alewife	157	2,389.6	1.4	Alewife	6
			Sculpin	7	106.5			
			Stickleback	1	15.2			
	Intake	43.5	Alewife	6	137.9	1.4	None	-
			Sculpin	3	69.0			
			Smelt	1	23.0			
			Stickleback	1	23.0			
7-31	Reference	24.6	Alewife	1	40.6	1.4	Alewife	40
			Sculpin	2	91.3			
			Smelt	1	40.6			
	Intake	25.5	Sculpin	4	156.9	1.4	None	-
			Smelt	7	274.5			
8-12	Reference	56.6	Sculpin	1	17.7	1.4	None	-
	Intake	43.9	Alewife	1	22.8	1.4	None	-

Table II-3. Summary of Lake Survey Sampling Data May-October, 1975 for Point Beach Area

Date	Area	Volume Sampled (meters^3)	Fish Larvae			Volume Sampled (meters^3)	Fish Eggs	
			Species	No.	No./m^3 x 1000		Species	No.
9-5	Reference	67.4	Alewife	1	14.8	1.4	None	-
	Intake	70.7	Alewife	1	14.1	1.4	None	-
			Sculpin	1	14.1			
9-9	Reference	57.7	Alewife	12	208.0	1.4	None	-
	Intake	58.2	Alewife	11	189.0	1.4	None	-
9-29	Reference	64.6	None	-	-	1.4	None	-
	Intake	49.5	None	-	-	1.4	None	-
10-7	Reference	39.9	None	-	-	1.4	None	-
	Intake	54.8	None	-	-	1.4	None	-

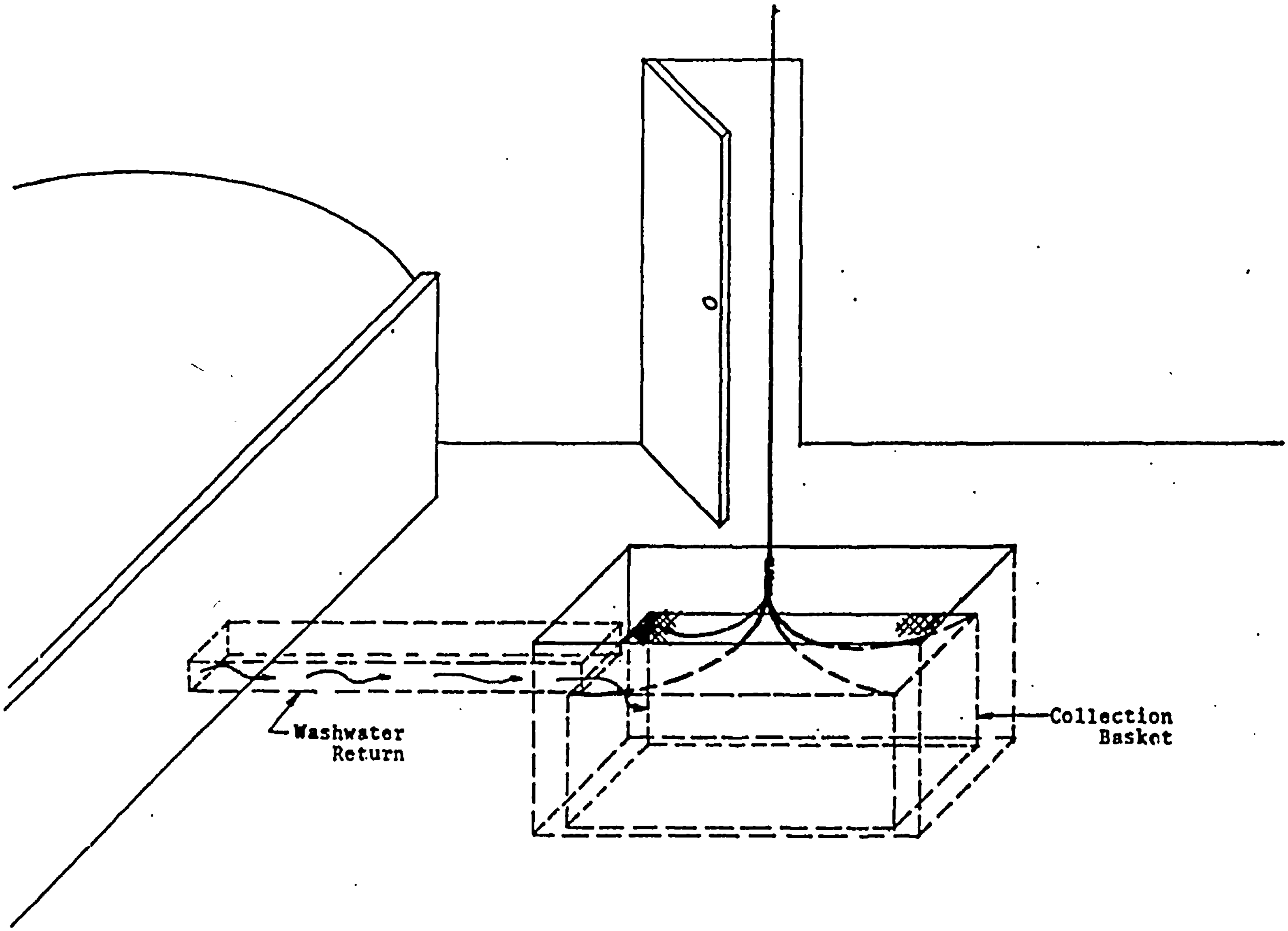

FIGURE II-1: IMPINGEMENT COLLECTION AT POINT BEACH NUCLEAR PLANT

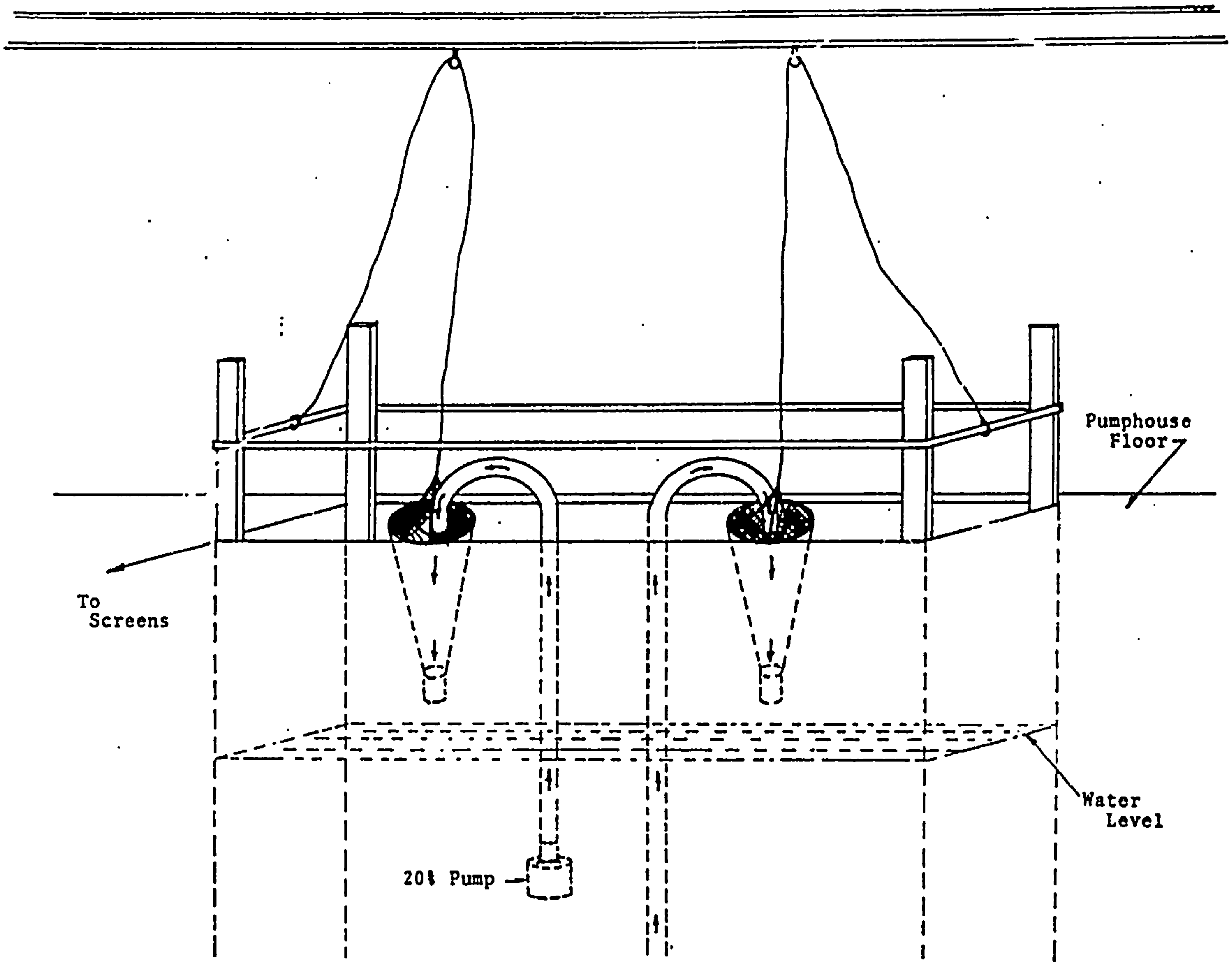

FIGURE II-2: ENTRAINMENT SAMPLING SYSTEM AT POINT BEACH POWER PLANT

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 Point Beach Nuclear Plant:

SEASONAL VARIATIONS

Number and weight distributions of alewife and smelt in the impingement catch over the monitoring year are graphed in Figures III-1 and III-2. Alewife and smelt were selected because they comprised the bulk (98% by number) of the catch. Other species, including trout and salmon, occurred in insufficient numbers to merit graphical presentation.

Figures III-1 illustrates the seasonal variation in numbers for the entire daily collections of smelt and alewife.

Alewife were virtually absent from the impingement catch from December through April. Numbers rose dramatically to 5000-8000/day in late May. Through June, numbers increased to the peak for the year on July 3 of 39,000 fish. In August through October, alewife numbers dropped to an average of a few hundred a day. Secondary peaks in the alewife catch occurred in late October and November. These were composed principally of yearling fish while the summer peak resulted from collection of adults.

Although smelt were present in low numbers in the impingement catch in all months, three-quarters of the yearly total were taken in October. These were primarily yearling fish. The spring smelt spawning run was not reflected in impingement statistics.

The fall peaks in alewife numbers did not appear on the graph of weight variation (Figure III-2), illustrating the small average size of fish in the October and November collections. Weight of alewife impinged reflected variations in

numbers during the summer period. The highest impingement weight (3,245 lbs.) coincided with the peak number which occurred on July 3. Highest smelt weight (209 lbs.) also agreed with numbers, occurring on October 27.

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 PBNP 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 or weight per 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 large confidence intervals. This carried over in the annual estimate, despite the much greater number of data points. 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 stipulated that monthly and annual impingement estimates should be made.

For purposes of assessment, the mean estimate will be used since the confidence intervals are irrelevant. 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 1,056,724 fish weighing 96,903 pounds were impinged at Point Beach during the sampling year. Alewife comprised 83.9% of the projected catch by number and 95.3% by weight. Smelt were estimated to account for 15.3% and 2.2% by number and weight, respectively. Trout were only 0.04% of the projected total number and 1.7% by weight. The other four categories combined represented 0.2% of the estimated total number.

LENGTH FREQUENCY

Cumulative length-frequency distribution was determined for critical 30-day periods for alewife and smelt. Results are as follows:

Alewife

On the seven June sampling days, 41% of the yearly alewife impingement occurred. Length ranged from 3.0-8.9 inches. Ninety-five percent of the alewife were >5.0 inches in total length (Figure III-3), confirming that the majority of fish were adults.

Smelt

Seventy-six percent of the smelt catch occurred on the seven sampling dates between October 27 and November 24. Length ranged from 1.5-8.4 inches. Ninety-three percent of the fish were less than 5.0 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.

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, however, 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 or more 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 influ-

ence 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 the exponent of length. For most species which have been tested, 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-3 describes sustained swimming speeds of midwestern fishes at various temperatures. It indicates that the smallest fish swim at 3+ body length/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 to 3 times body length of the fish would provide adequate protection. This review of the available literature indicates that these values may be conservative and can't 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.

IMPINGEMENT MORTALITY

Although no study of impingement mortality at PBNP has been made, it can be assumed to be high. Screens are normally operated 1/2 hour per 8-hour shift. Fish can be impinged for more than 7 hours before removal. In addition, WPDES permit requirements include maintenance of a wire collection basket of 3-inch square mesh in the washwater sluiceway. Although the purpose of the basket is to collect debris, all large fish, as well as many small specimens, are trapped in this basket. It is likely that some fish are returned through the basket alive, but no quantitative estimate can be made.

IMPINGEMENT IMPACT

To assess its impact, it will be assumed that impingement mortality at PBNP is complete, recognizing that actual mortality is something less than total. 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 886,000 alewife weighing about 92,400 pounds were impinged during the monitoring year. Ninety percent of these fish were taken in May through August 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 PBNP 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 PBNP represents 0.003% of the estimated alewife population by number and weight, and 0.009% of the minimal annual mortality. Clearly, impingement at PBNP has a negligible impact on the alewife population.

Smelt

The estimated smelt impingement for the monitoring year was 161,400 fish totaling 2,145 pounds. The number-to-weight ratio and the length-distribution data indicate that the majority of the smelt were immature, probably yearling 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 1/10 of a pound, providing a numerical estimate of more than 300 million individuals. Using these numbers, projected

PBNP annual impingement represents 0.05% and 0.007% 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 452 trout and 16 salmon. 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). Using this application factor at PBNP and assuming that all impinged fish die, approximately 56 salmonids would be lost to the creel. This represents 0.013% of the 1974 Wisconsin catch. It is recognized that the 12% return figure may not be completely valid for the Point Beach situation since some fish may be entrapped because they are diseased or enfeebled. However, this exercise is included to put some perspective on the situation. Alternative intake costs (Section V) could be weighed against loss of satisfied angler-days or of dollars generated by fishermen. Obviously, such an analysis would show that loss of trout and salmon is inconsequential. The PBNP discharge area is a favorite fishing location, and about 2,000 salmonids were caught in 1973 from the WEPCo-sponsored fishing platform located over the Unit 1 discharge (Spigarelli and Thommes, 1974).

Game and Food Fishes

Game and food fish impingement was estimated at 979 (190 lbs.) for the monitoring year. The catch consisted primarily of yellow perch and incidental warm-water species (bluegills, sunfish, 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 several whitefish and bloaters. 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 209 (126 lbs.). The catch consisted of white and long-nose suckers, and carp. Although none of the species are highly valued, a commercial fishery exists in Lake Michigan for the 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 PBNP is insignificant rel-

ative to commercial exploitation and can exert no effect on the populations.

Forage Fishes

Forage species consisted primarily of sculpins, ninespine sticklebacks, and gizzard shad. Estimated annual impingement totaled 7,285 (336 lbs.) for this group. All of the resident forage 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 pounds 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 Point Beach Nuclear Plant. The following discussion examines seasonal variations in entrainment as well as its estimated magnitude, concluding with an assessment of the environmental impact of PBNP entrainment:

SEASONAL VARIATIONS

Fish larvae were collected on 24 of the 49 sampling dates in total numbers ranging from 1 to 21. Fertilized fish eggs were taken on only 6 of the dates. Due to the low numbers of both eggs and larvae, graphical presentation of variation with time was not warranted.

Of the 91 larvae collected, only two (longnose sucker) were collected April through June. Larvae of smelt, alewife, and/or sculpin were present in very low numbers in most July-September collections. Smelt young-of-year were taken on 4 of 8 sampling dates in October.

Alewife eggs, taken on two dates each in June, July, and August, were the only eggs collected. The wide time spread is indicative of the lengthy summer spawning period for the species.

Pontoporeia affinis was present in all but eight samples. Highest numbers were found in July and August. Mysis

relicta was found in low numbers in more than half the samples, with peak numbers in late July and early August.

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 two larvae and no eggs were found from "other" species.

It is estimated that 2,082,525 fish larvae were entrained during the April-October period. Of these, 20% were alewife, 61% smelt, and 17% were sculpin. Highest monthly estimates for larvae entrainment were for August, September, and October.

Of the 4,661,410 fish eggs estimated to be entrained, all were alewife. Approximately 14 million *Pontoporeia* and 10 million *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 did not correspond well with occurrence in lake survey samples. Lake survey collections generally revealed higher relative densities than entrainment samples at both sampling areas. This may re-

sult from avoidance of the immediate intake area by larvae or from a disparity in sampling efficiencies. With regard to the former, intake velocities within a few feet of the crib are sufficiently low to permit escape of most free swimming larvae; avoidance is clearly possible. A similar phenomenon was reported for larval alewife at the Zion (Illinois) Nuclear Plant (Nalco, 1975). In this instance plankton nets were used for both lake survey and entrainment collections. Sampling efficiency may also differ. The entrainment pumps were located at 20% and 80% of depth in an area of high turbulence. Velocity through the pump orifice (5-6 fps) was too high to permit avoidance. Larvae should have been rather homogeneously distributed at the entrainment sampling site and should have been subject to collection at a rate equal to their overall density. However, lake survey collection with towed plankton nets over two depth contours and several different depths should also produce reliable estimates of density. It seems likely that larvae avoid the intake crib. Shortly after hatching, larvae are capable of some directed movement, both horizontally and vertically.

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 were about 10 billion age I alewife in Lake Michigan in 1972. First-year mortality of larvae is undoubtedly in excess of 90%. The above-cited authors note annual mortality of 40%-70% for older, established age groups. Thus, if it can be assumed that the 1971 year class is typical, larval alewife production in Lake Michigan is at least 100 billion fish. Entrainment at PBNP appears to involve no more than 0.0004% of Lake Michigan alewife larvae and can't be construed to exert an impact on the population of this prolific species.

Similarly for smelt, it has been estimated that there were more than 30 million pounds of age I+ smelt in Lake Michigan in 1974 (Limnetics, 1976). If these fish are assumed to average 10 to the pound, then there were 300 million 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 were age I.

At a first-year mortality rate of 90%, 600 million larvae would have to be generated each year to maintain the population if the 1974 population is typical. PBNP entrains about 0.2% 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 must at least be regional in nature. They are found throughout Lake Michigan, being more common beyond the littoral area (Wells, 1968). It has been tentatively estimated that there are 2-4 million pounds of sculpins beyond the larvae stage 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 undoubltedly suffer substantial mortality. While it is not possible to realistically quantify the local sculpin population, the abundance of sculpin in Lake Michigan makes it extremely doubtful that entrainment at PBNP has more than a minimal effect on the population.

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

Eggs

The 4.7 million alewife eggs entrained represent the production of about 425 gravid females (Norden, 1967). Removal of eggs at this magnitude can't 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 affini·* and *Mysis relicta* are bottom-oriented species which are most ·bundant beyond the littoral zone. Even within the 30-foot contour, numbers are often extremely high. Limnetics (1974) found an average of .10 *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, 1975b). Populations have been found to increase with depth to concentrations of 35 million per/acre (Powers and Alley, 1967). *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 are vulnerable to entrainment at PBNP.

C. VARIATIONS IN INTAKE EFFECT

Variations in intake effects over the next several years are more likely to result from changes in the highly un-

stable ecosystem than from changes in either plant operation or in lake level. It is expected that Point Beach Nuclear Plant will continue to operate in its present mode for the foreseeable future (Section I). Changes in lake level will not have much effect on fish entrapment because velocity within a few feet of the crib will not change markedly with lake level differences.

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

TROUT

Rainbow Trout	Tiger Trout
Atlantic Salmon	Brook Trout
Brown Trout	Lake Trout

SALMON

Chinook Salmon	Coho Salmon

GAME AND FOOD FISHES

Channel Catfish	Largemouth Bass
Black Bullhead	Northern Pike
Lake Whitefish	Bloater
Round Whitefish	Yellow Perch
Bluegill Sunfish	

ROUGH FISHES

Carp	Longnose Sucker
White Sucker	

FORAGE FISHES

Trout Perch	Emerald Shiner
9-Spine Stickleback	Brook Stickleback
Deepwater Sculpin	Gizzard Shad
Slimy Sculpin	Mud Minnow
Longnose Dace	Fathead Minnow
Lake Chub	Other Minnow
Spottail Shiner	

Table III-1. Monthly and Annual Estimates (number) of Total Impingement at Point Beach Nuclear Plant

riod	Species or Group	Ninety Percent Confidence Interval		
		Minimum	Mean	Maximum
1975 March	Smelt	-	80	460
	Alewife	-	None	-
	Trout	-	30	136
	Salmon	-	None	-
	Game & Food Fishes	-	3	18
	Rough Fishes	-	None	-
	Forage Fishes	-	None	-
	Total	-	113	471
April	Smelt	-	832	2,998
	Alewife	-	22	116
	Trout	-	35	125
	Salmon	-	None	-
	Game & Food Fishes	-	75	376
	Rough Fishes	-	None	-
	Forage Fishes	-	493	1,216
	Total	-	1,457	3,662
May	Smelt	-	768	2,438
	Alewife	-	83,408	287,735
	Trout	-	35	99
	Salmon	-	4	25
	Game & Food Fishes	-	26	54
	Rough Fishes	-	4	25
	Forage Fishes	-	615	1,272
	Total	-	84,860	291,211
June	Smelt	-	2,387	7,856
	Alewife	-	464,807	1,033,508
	Trout	-	36	96
	Salmon	-	8	31
	Game & Food Fishes	-	15	49
	Rough Fishes	-	8	44
	Forage Fishes	-	608	1,533
	Total	-	467,869	1,039,208

Table III-1. Monthly and Annual Estimates (number) of Total Impingement at Point Beach Nuclear Plant

riod	Species or Group	Ninety Percent Confidence Interval		
		Minimum	Mean	Maximum
July	Smelt	-	8,734	46,583
	Alewife	-	348,463	1,063,983
	Trout	-	27	80
	Salmon	-	None	-
	Game & Food Fishes	-	58	158
	Rough Fishes	-	23	100
	Forage Fishes	-	676	2,184
	Total	-	371,981	1,064,588
August	Smelt	-	7,285	39,393
	Alewife	-	83,443	393,856
	Trout	-	38	92
	Salmon	-	None	-
	Game & Food Fishes	-	44	211
	Rough Fishes	-	25	95
	Forage Fishes	-	278	568
	Total	-	91,113	398,616
September	Smelt	-	7,447	16,723
	Alewife	-	6,727	15,123
	Trout	-	26	60
	Salmon	-	4	23
	Game & Food Fishes	-	210	567
	Rough Fishes	-	90	224
	Forage Fishes	254	690	1,126
	Total	1,857	15,194	28,531
October	Smelt	-	122,962	587,214
	Alewife	-	37,777	138,755
	Trout	-	0	118
	Salmon	-	4	23
	Game & Food Fishes	-	244	699
	Rough Fishes	-	19	63
	Forage Fishes	-	3,419	12,193
	Total		164,425	725,897

Table III-1. Monthly and Annual Estimates (number) of Total Impingement at Point Beach Nuclear Plant

Period	Species or Group	Ninety Percent Confidence Interval Minimum	Mean	Maximum
November	Smelt	-	12,758	25,914
	Alewife	-	63,588	284,299
	Trout	-	46	99
	Salmon	-	None	-
	Game & Food Fishes	-	116	266
	Rough Fishes	-	8	44
	Forage Fishes	-	728	1,782
	Total	-	77,244	307,499
December	Smelt	-	5,756	16,107
	Alewife	-	13	43
	Trout	-	34	63
	Salmon	-	None	-
	Game & Food Fishes	-	132	395
	Rough Fishes	-	21	91
	Forage Fishes		330	785
	Total		6,286	16,883
1976 January	Smelt	-	6,283	16,173
	Alewife	-	16	50
	Trout	-	55	123
	Salmon	-	None	-
	Game & Food Fishes	-	32	119
	Rough Fishes	-	13	37
	Forage Fishes	-	192	554
	Total	-	6,591	16,864
February	Smelt	-	2,510	5,045
	Alewife	-	None	-
	Trout	-	4	25
	Salmon	-	None	-
	Game & Food Fishes	-	4	25
	Rough Fishes	-	None	-
	Forage Fishes		35	98
	Total		2,553	7,480

Table III-1. Monthly and Annual Estimates (number) of Total Impingement at Point Beach Nuclear Plant

riod	Species or Group	Ninety Percent Confidence Interval Minimum	Mean	Maximum
March, 1975 - February 1976	Smelt	-	161,389	375,369
	Alewife	648,884	886,394	1,123,904
	Trout	-	452	1,344
	Salmon	-	16	125
	Game & Food Fishes	-	979	3,597
	Rough Fishes	-	209	938
	Forage Fishes	-	7,285	32,341
	Total	503,602	1,056,724	1,609,846

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 Point Beach Nuclear Plant

Period	Species or Group	Ninety Percent Confidence Interval		
		Minimum	Mean	Maximum
March	Smelt	-	6.7	38.8
	Alewife	-	None	-
	Trout	-	126.0	608.4
	Salmon	-	None	-
	Game & Food Fishes	-	5.7	32.7
	Rough Fishes	-	None	-
	Forage Fishes	-	None	-
	Total	-	138.4	617.8
April	Smelt	-	80.5	290.4
	Alewife	-	2.0	10.1
	Trout	-	53.3	281.1
	Salmon	-	None	-
	Game & Food Fishes	-	36.4	160.6
	Rough Fishes	-	None	-
	Forage Fishes	-	25.1	60.6
	Total	-	197.3	509.7
May	Smelt	-	55.3	192.2
	Alewife	-	6319.4	22870.0
	Trout	-	124.4	402.4
	Salmon	-	0.2	1.2
	Game & Food Fishes	-	11.0	40.1
	Rough Fishes	-	6.5	37.7
	Forage Fishes	-	31.0	64.7
	Total	-	6547.9	23536.9
June	Smelt	-	116.3	338.2
	Alewife	-	32901.5	74076.6
	Trout	-	246.4	920.4
	Salmon	-	5.2	28.8
	Game & Food Fishes	-	9.6	35.8
	Rough Fishes	-	5.0	28.6
	Forage Fishes	-	30.6	76.7
	Total	-	33314.6	74316.0

Table III-2. Monthly and Annual Estimates (weight in lbs.) of Total Impingement at Point Beach Nuclear Plant

Period	Species or Group	Ninety Percent Confidence Interval Minimum	Mean	Maximum
July	Smelt	-	117.5	474.8
	Alewife	-	64605.5	279591.9
	Trout	-	147.8	372.6
	Salmon	-	None	-
	Game & Food Fishes	-	20.9	69.0
	Rough Fishes	-	16.3	82.2
	Forage Fishes	-	34.0	109.2
	Total	-	64942.0	279616.7
August	Smelt	-	86.8	418.1
	Alewife	-	6334.7	31452.4
	Trout	-	186.3	619.7
	Salmon	-	None	-
	Game & Food Fishes	-	15.4	60.2
	Rough Fishes	-	22.2	85.6
	Forage Fishes	-	14.6	29.2
	Total	-	6660.0	31846.5
September	Smelt	-	82.2	171.1
	Alewife	-	354.4	743.4
	Trout	-	143.2	462.2
	Salmon	-	0.7	4.5
	Game & Food Fishes	-	29.2	76.8
	Rough Fishes	-	57.7	168.7
	Forage Fishes	12.9	38.9	64.9
	Total	339.6	706.3	1073.0
October	Smelt	-	1235.9	5871.9
	Alewife	-	463.3	1459.2
	Trout	-	346.5	807.1
	Salmon	-	.2	1.2
	Game & Food Fishes	-	18.0	51.3
	Rough Fishes	-	11.7	68.1
	Forage Fishes	-	96.1	242.3
	Total	-	2171.7	8072.9

Table III-2. Monthly and Annual Estimates (weight in lbs.) of Total Impingement at Point Beach Nuclear Plant

Period	Species or Group	Ninety Percent Confidence Interval Minimum	Mean	Maximum
November	Smelt	-	174.6	285.5
	Alewife	-	647.9	2839.2
	Trout	-	156.6	376.3
	Salmon	-	None	-
	Game & Food Fishes	-	12.9	53.4
	Rough Fishes	-	4.0	22.2
	Forage Fishes	-	33.9	73.2
	Total	-	1029.9	3254.0
December	Smelt	-	87.8	186.1
	Alewife	-	1.1	4.1
	Trout	-	31.8	128.4
	Salmon	-	None	-
	Game & Food Fishes	-	19.3	81.9
	Rough Fishes	-	7.5	43.2
	Forage Fishes	-	24.4	59.8
	Total	-	171.9	430.0
January	Smelt	-	125.4	280.9
	Alewife	-	1.2	3.4
	Trout	-	137.1	432.0
	Salmon	-	None	-
	Game & Food Fishes	-	3.4	12.3
	Rough Fishes	-	5.2	28.0
	Forage Fishes	-	21.9	74.9
	Total	-	294.2	729.7
February	Smelt	-	103.7	281.7
	Alewife	-	None	-
	Trout	-	29.4	169.2
	Salmon	-	None	-
	Game & Food Fishes	-	2.6	15.1
	Rough Fishes	-	None	-
	Forage Fishes	-	1.8	5.4
	Total	-	137.5	343.6

Table III-2. Monthly and Annual Estimates (weight in lbs.) of Total Impingement at Point Beach Nuclear Plant

Period	Species or Group	Ninety Percent Confidence Interval		
		Minimum	Mean	Maximum
March, 1975 thru February, 1976	Smelt	-	2144.8	14215.8
	Alewife	-	92389.9	685502.5
	Trout	-	1711.2	5977.6
	Salmon	-	5.1	66.9
	Game & Food Fishes	-	190.0	778.9
	Rough Fishes	-	126.0	639.2
	Forage Fishes	-	336.0	951.4
	Total	-	96903.0	694483.2

Table III-3. Monthly and Annual Estimates of Total Entrainment for Point Beach Nuclear Plant

Period	Life Form	Estimated Number Entrained
April - May 1975	Larvae	
	Alewife	None
	Sculpin	None
	Smelt	None
	Other	59,833
	Total	59,833
	Eggs	None
	Pontoporeia	1,713,140
	Mysis	1,998,840
June	Larvae	None
	Eggs	
	Alewife	293,060
	Sculpin	None
	Smelt	None
	Other	None
	Total	293,060
	Pontoporeia	1,031,180
	Mysis	175,331

Table III-3. Monthly and Annual Estimates of Total Entrainment for Point Beach Nuclear Plant

Period	Life Form	Estimated Number Entrained
July	Larvae	
	Alewife	23,772
	Sculpin	208,843
	Smelt	None
	Other	None
	Total	232,615
	Eggs	
	Alewife	2,638,730
	Sculpin	None
	Smelt	None
	Other	None
	Total	2,638,730
	Pontoporeia	4,224,030
	Mysis	4,677,850

Table III-3. Monthly and Annual Estimates of Total Entrainment for Point Beach Nuclear Plant

Period	Life Form	Estimated Number Entrained
August	Larvae	
	Alewife	188,128
	Sculpin	119,092
	Smelt	616,163
	Other	None
	Total	923,383
	Eggs	
	Alewife	1,442,980
	Sculpin	None
	Smelt	None
	Other	None
	Total	1,442,980
	Pontoporeia	4,052,080
	Mysis	2,909,720
September	Larvae	
	Alewife	168,456
	Sculpin	None
	Smelt	230,362
	Other	None
	Total	398,818
	Eggs	None
	Pontoporeia	1,127,890
	Mysis	145,571

Table III-3. Monthly and Annual Estimates of Total Entrainment for Point Beach Nuclear Plant

Period	Life Form	Estimated Number Entrained
October	Larvae	
	Alewife	None
	Sculpin	None
	Smelt	346,321
	Other	None
	Total	346,321
	Eggs	None
	Pontoporeia	1,305,450
	Mysis	65,057
April thru October, 1975	Larvae	
	Alewife	416,311
	Sculpin	349,517
	Smelt	1,272,080
	Other	44,617
	Total	2,082,525
	Eggs	
	Alewife	4,661,410
	Sculpin	None
	Smelt	None
	Other	None
	Total	4,661,410
	Pontoporeia	13,851,400
	Mysis	10,180,200

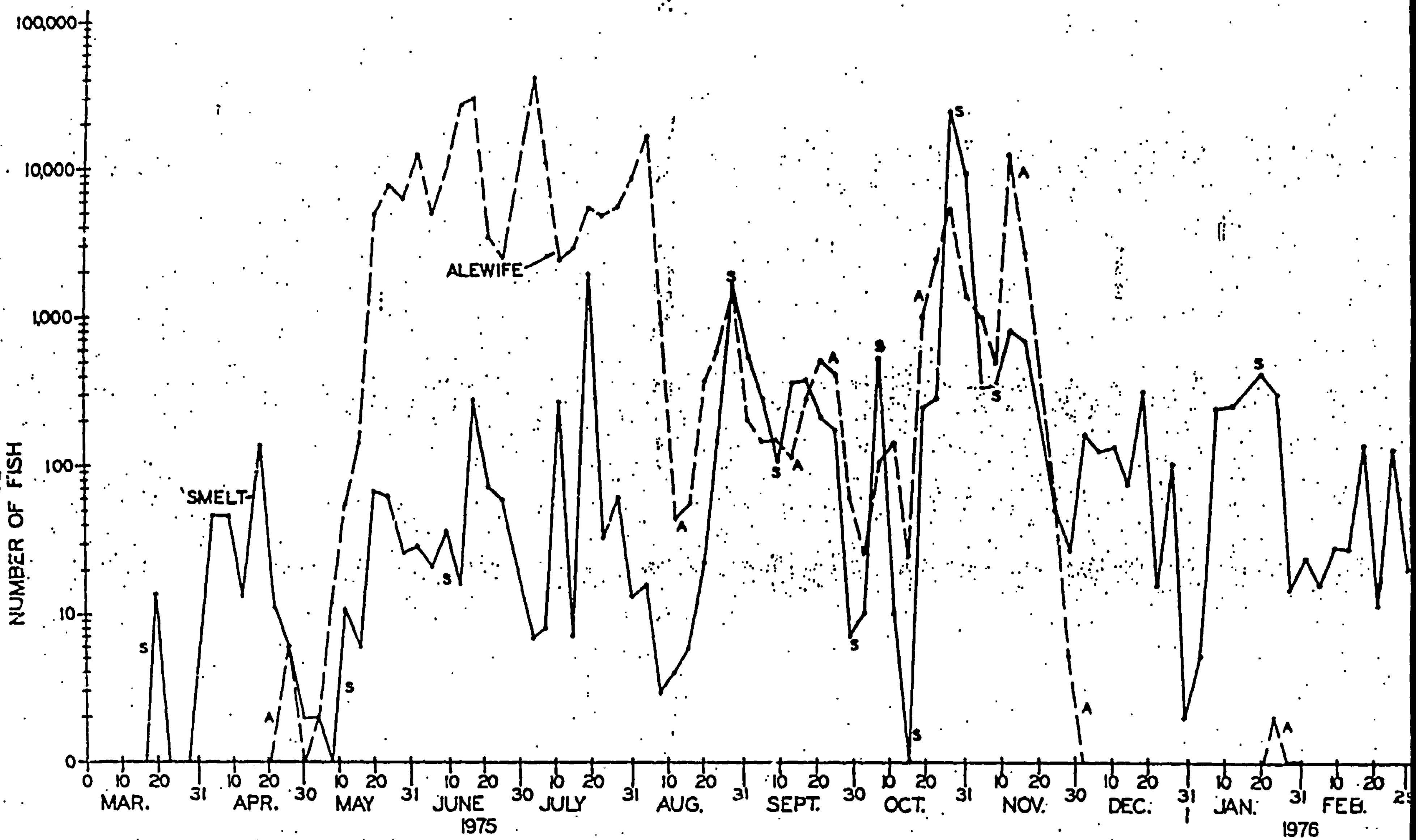

FIGURE III-1: SEASONAL VARIATION IN NUMBER OF ALEWIFE AND SMELT COLLECTED FROM THE POINT BEACH NUCLEAR PLANT TRAVELING SCREENS, MARCH 1975 - FEBRUARY 1976

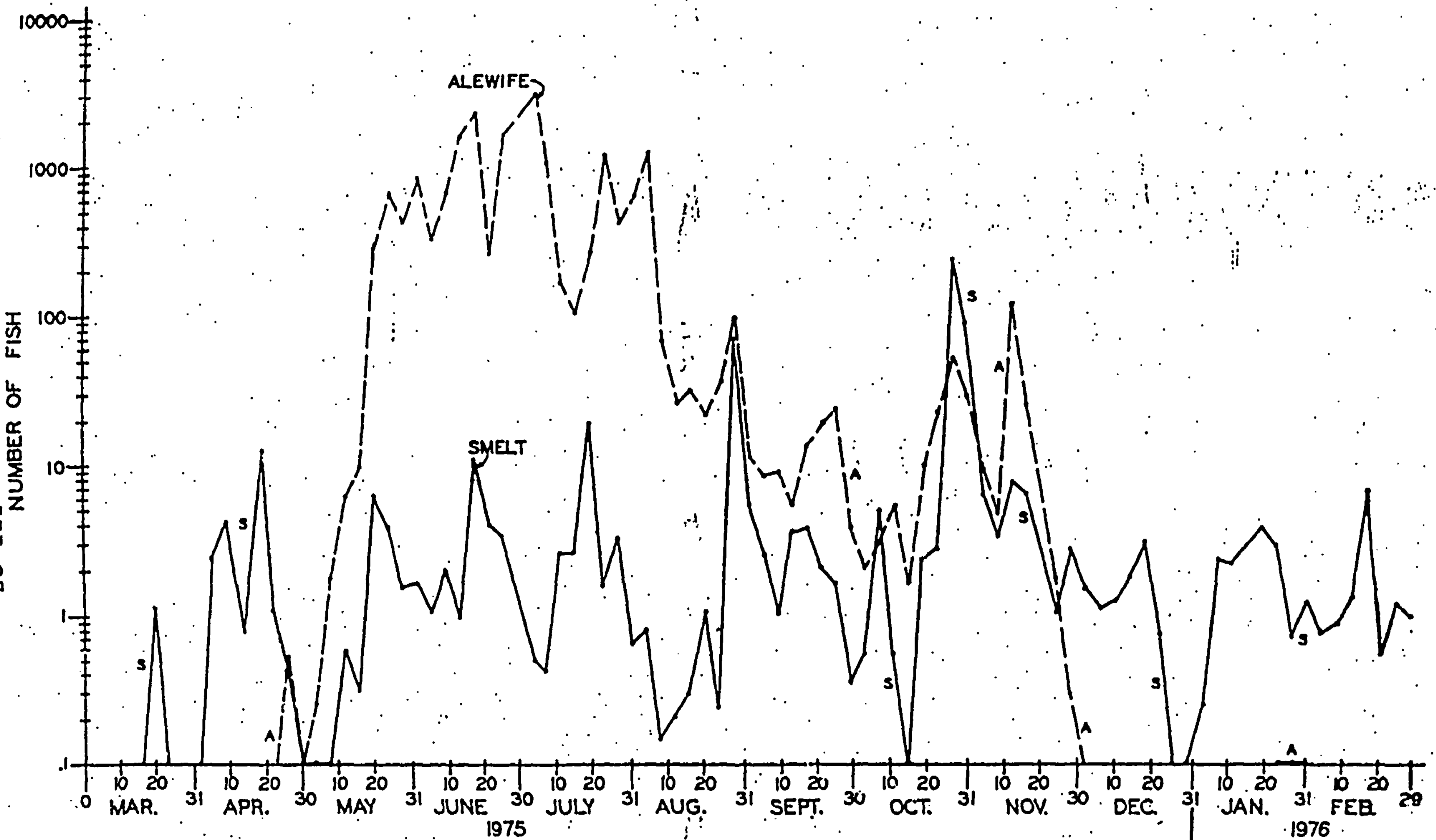

FIGURE III-2: SEASONAL VARIATION IN WEIGHT OF ALEWIFE AND SMELT COLLECTED FROM THE POINT BEACH NUCLEAR PLANT TRAVELING SCREENS, MARCH, 1975 - FEBRUARY, 1976

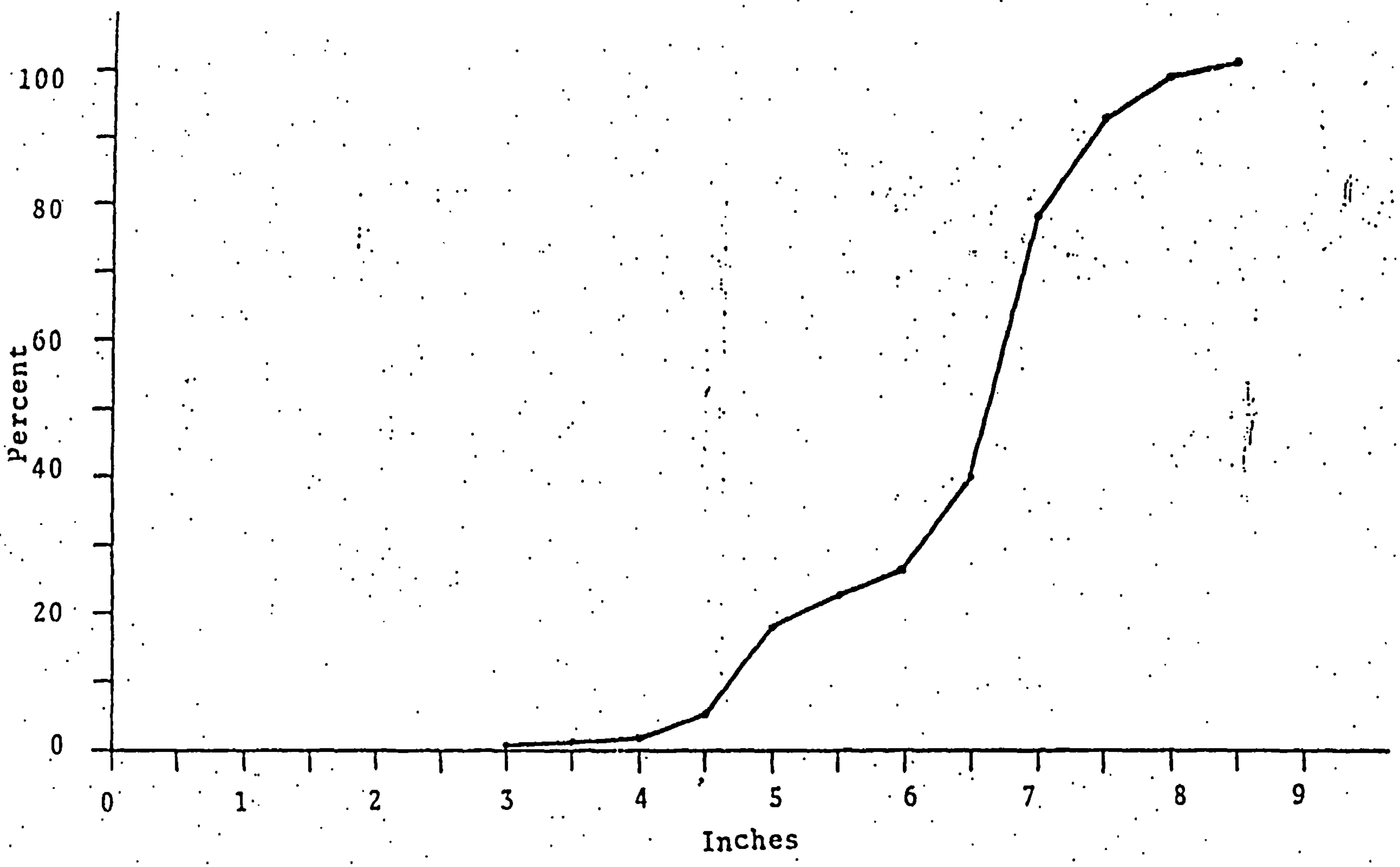

Figure III-3. Cumulative length frequency of alewife collected from the Point Beach Nuclear Plant travelling screens, during June, 1975.

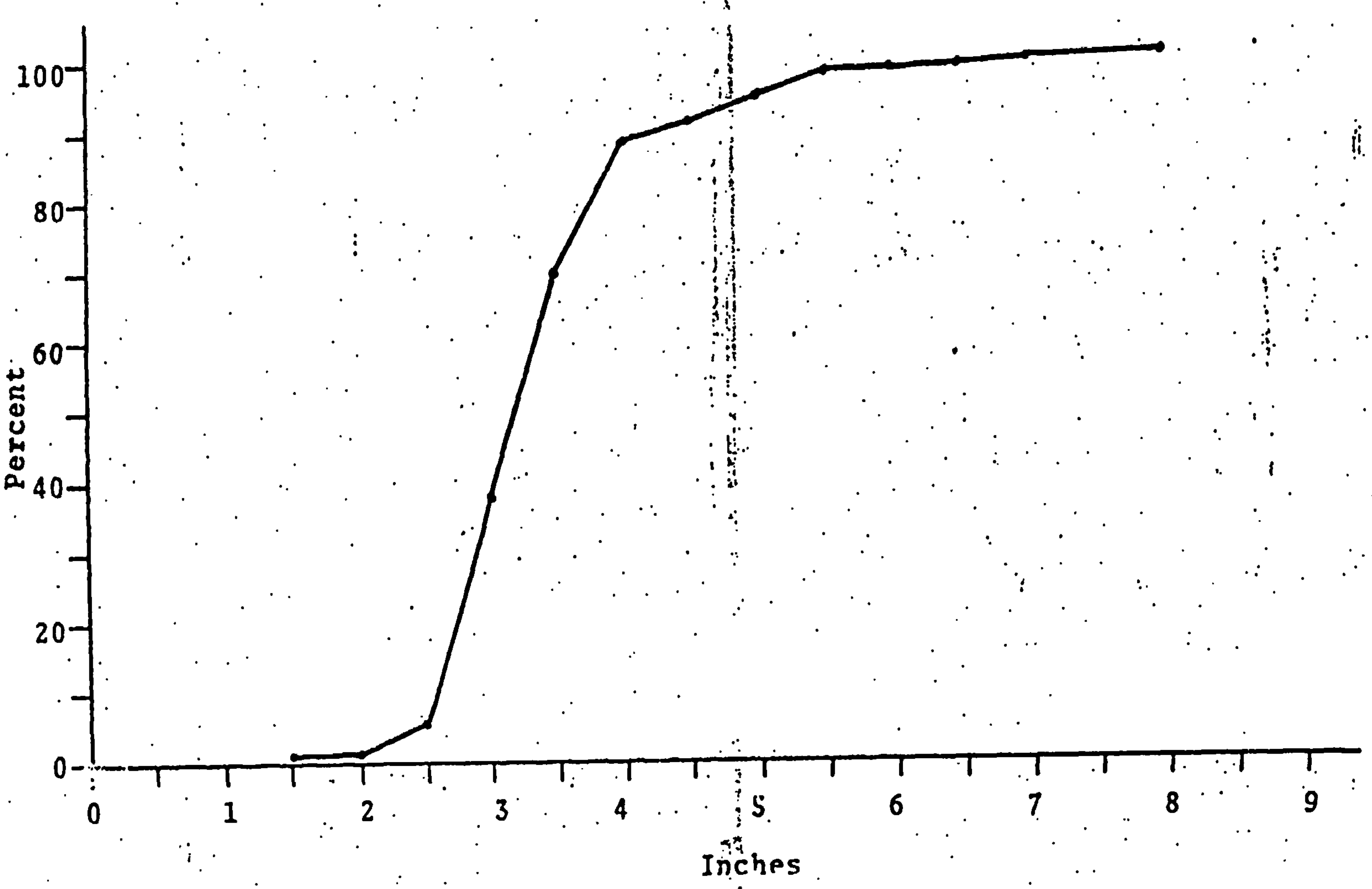

Figure III-4. Cumulative length frequency of smelt collected from the Point Beach travelling screens between October 27 and November 24, 1975.

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. Sampling approximately 150 gallons of water per minute for 24 continuous hours every fourth day 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 not likely.

The fact that lake survey results showed higher larval densities than entrainment collections might indicate that the pumps did not obtain representative samples and that icthyoplankton density in the samples did not equal icthyoplankton density in the cooling water. Alternately, it might indicate that larvae avoid the immediate intake area. The latter possibility seems more likely, since entrainment sampling was performed at two depths in a turbulent area and larvae are physically capable of avoidance.

Impingement collection was of sufficient frequency to monitor about one-fourth 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 could probably 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 egg and larvae numbers and smelt 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 is very unlikely that entrainment at PBNP has a discernible impact on the population. Entrainment of Pontoporeia affinis and Mysis relicta was not high in compari-

son 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 Point Beach Nuclear Plant is minimal.

Although a diverse number of fish species were collected from the Point Beach travelling screens, most were captured in such low numbers that impact was obviously insignificant. Alewife and smelt accounted for approximately 98% of the estimated annual impingement by weight. The magnitude of alewife and smelt impingement is so miniscule relative to the size of the populations of these species that impact on the populations must be considered negligible. In addition, it is thought that 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 PBNP represents less than one-tenth of one percent of the annual Wisconsin sport catch from Lake Michigan. A cost benefit analysis would certainly show that application of remedial technology to alleviate salmonid impingement is not warranted.

Other species were impinged at PBNP in very low numbers relative to their abundance in the lake. Impact was negligible.

On the basis of the one-year monitoring study, it is apparent that entrapment of adult and juvenile fish, icthyoplankton, and benthic macroinvertebrates in the cooling water intake system of Point Beach Nuclear Plant effects at most a very local and minor reduction in abundance of these organisms. The impact on the environment must be considered to be minimal and insignificant.

V. ALTERNATIVE INTAKE TECHNOLOGY

Guidelines for this report, as developed by the Wisconsin 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. We therefore conclude that no alternative technology is required.

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." 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 Technical Committee (LMCWITC, 1973).

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

A. SYSTEM DESIGN ALTERNATIVES

The design of power plant circulating water systems includes several options for reducing fish mortality in the system. These generally fall into the category of either 1) preventing fish from entering the system, 2) allowing escape after the fish have entered the system, or 3) returning them to the lake unharmed after impingement on the travelling water screens.

PREVENTION OF INITIAL ENTRY INTO THE SYSTEM

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 entrapment of true planktonic organisms (EPA, 1973).

The present intake system at Point Beach Nuclear 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 of 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 from the shoreline. Each is considered below:

Shoreline Location

A shoreline intake at PBNP would consist of lakeward jetties to protect a dredged area leading to the travelling screens. Such an embayment could prove attractive to fish. Fish might also be attracted if the intake was not sufficiently removed from the area of the thermal discharge. This type of water inlet system appears to afford no real potential for reducing impingement and may well increase it.

However, the problem of fish attraction might be reduced by utilizing a shoreline intake enclosed in a rubble mound intake pond. To achieve a maximum velocity of 0.5 fps through the rubble, the walls would have to encompass approximately 6.5 acres of the lake. Interstices in the rubble would permit entrance by relatively large fish. A pond of this type services Lakeside Power Plant on Lake Michigan. This plant operates on an intermittent load follow basis. 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.

The Point Beach plant operates continuously, normally withdrawing cooling water at maximum pumping rate. Fish which penetrated an intake pond might become impinged. While the rubble would serve as a partial barrier to fish movement and would prevent some fish from being inadvertently carried into the intake system, the pond area might prove attractive to fish which frequented the thermal discharges if the pond was located near the rubble mound. Due to these uncertainties, it is not possible to confidently predict that installation of an intake pond would reduce impingement.

Offshore Location

The present PBNP water intake consists of an emergent rock-filled crib located 1750 feet offshore in 22 to 24 feet of water. Water enters through a series of 30 inch diameter pipes located approximately 5 feet above the lake floor as well as through interstices in the rocks. The openings of the pipes are covered with 2" x 1-3/16" iron bar grid which should prohibit

penetration of fish greater than 8 to 12 inches long. Larger fish must enter through voids in the rocks. The two 14 foot diameter conduits from the intake crib experience maximum water velocities of 5-6 fps. Once a fish emigrates from the crib into one of these conduits, it is very unlikely that it could escape.

The intake point could be moved further offshore by extending the buried conduits leading to the plant and constructing a new crib. Benefits, in terms of reduction of fish entrapment, are not significant. Observations indicate that fish, including salmonids, are often abundant well beyond the thirty-foot depth contour on the western shore of Lake Michigan. It is unlikely that fish abundance in the vicinity of the present intake is greatly influenced by its proximity to the thermal discharges. Surface temperatures at the intake crib are restricted to less than 3°C above ambient more than 80 percent of the time, and subsurface thermal addition is even less (Limnetics, Inc., 1976). There is no apparent advantage to moving the intake point further offshore.

Approach Channel

Location of PBNP on the Lake Michigan shoreline does not permit construction of an inland approach channel. This type of water inlet is considered to have high entrapment potential because fish are attracted to the area and unwilling or unable to escape the velocities at the debris screens (EPA, 1973, LMCWITC, 1973).

B. DESIGN ALTERNATIVES

Although the intake location is important in affecting the number of fish ultimately impinged in the system, there are no locations in the nearshore region of Lake Michigan which will not be frequented by fish at various times. Given an intake location, however, further design refinements are available to prevent fish from entering an intake system. These generally involve either diversion devices, screening systems, or atypical intake designs to preclude entry.

DIVERSION DEVICES

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 devices 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. In addition, they would be difficult to maintain around the open-water intake crib.

SCREENING SYSTEMS

Screening systems are used to prevent fish larger than a given size from entering the intake water system. At Point Beach, the stone crib is designed to make it difficult for fish to negotiate the intersticies of the rocks. In addition, there are metal grates over the 30 inch diameter feeder pipes to prevent entrance of fish longer than about 8-12 inches.

An alternative to the existing system would be to install a chain link fence, or grate, around the entire crib. This would prevent fish larger than the screen opening from passing ghrough the crib. Ice buildup would limit its functionality to the ice-free months. The grid would have to be large enough to prevent clogging, and this would limit the grid design size to a minimum of about 1 inch square openings.

ALTERNATIVE DESIGN CONCEPTS

Alternative design concepts other than a stone crib are used for some intakes, and these have the ability for excellent fish protection. However, there is none that would be adaptable for use at Point Beach. Filter bed or radial collector well designs are generally practical only for plants with low water volume requirements, and they may be susceptible to clogging. Neither of these could provide an adequate water supply for the Point Beach plant (EPA, 1973). Perforated pipe screen intake systems would also be highly effective in fish entry into the circulating water system, but it would not be adaptable to an ice protection system. Therefore, it is not a reliable design for the Great Lakes where frazil ice may accumulate and cause clogging.

C. ESCAPE MECHANISM ALTERNATIVES

Fish which do encounter intake systems still enjoy some potential for escape. Feasibility of escape is dependent on the type of intake system, the season, and the size and species of fish. Shoreline or approach channel intakes can be designed to offer escape potential up to the debris screens through inclusion of lateral trash racks, bypass systems, louvers, and other devices to redirect fish. Offshore intakes are generally enclosed systems which afford little or no opportunity for escape after entrance.

At Point Beach, escape is unlikely once fish have entered the intake crib, since they would have to renegotiate either the crib pipes or the interstices in the rocks, linear distances of 25 feet. Fish which encounter the intake crib can escape entrapment if intake velocity is less than the animal's maximum swimming speed. Tests have indicated that velocities <.5-1.0 fps permit escape of various fishes >2 inches total length even at cold temperatures (Section III). Current measurements made within 5 feet of the outer edge of the PBNP intake crib indicate velocities of 0.06-0.70 fps at maximum pumping rate (WEPCo, 1975). Highest values were recorded near the surface and below 11 feet in depth. Average velocity was 0.36 fps. Calculated velocities in the crib annulus are 1.8-2.8 fps. Although not vertically uniform, intake velocity in close proximity to the crib is sufficiently low to permit escape of most fishes.

The only other area of the intake system from which escape might be made possible is the forebay. Although water flow in the forebay is extremely turbulent, it is conceivable that crowding devices could be implanted to guide fish to a holding area where they could be removed by elevator basket or pumps and returned via a conduit to the lake. This alternative would require extensive modification of the forebay area with uncertain effectiveness for fish removal. Further, it would be difficult to return the fish in good condition. Modifications to permit forebay escape do not appear to offer a feasible alternative relative to their costs and uncertain effectiveness.

D. <u>RETURN OF IMPINGED FISH</u>

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.

The PBNP vertical travelling screens are rotated for 30 minutes every 8 hours (unless debris load requires further operation) at 10 fps. Fish and debris are removed from the screen by a washwater spray at 80 psig. Fish and debris enter the washwater sluiceway which empties through a collection basket. Washwater then flows 80 feet through a return pipe which empties in the Unit 2 discharge flume. The Point Beach WPDES permit requires use of a collection basket of no more than 3 inch square mesh to remove debris (including fish). This stipulation effectively prohibits return of larger fish. Small fish are discharged into the flume, experiencing an average of about 15-20°F temperature increase.

The screening system could be modified to be more

conducive to return of viable fish if 1) the screens operated continuously 2) low pressure, high-volume washwater spray could be used and 3) fish could be more favorably returned. Continuous screen operation appears feasible, but additional maintenance/replacement costs would accrue. High washwater pressure is necessary to remove the moss-like debris typical of Lake Michigan. Ice buildup in the winter often extends several hundred feet lakeward from shore. A return pipe would have to extend at least 300 feet to empty beyond this shore ice. Assuming that continuous screen operation would release fish unharmed, passage through a collection basket and a long lake return conduit might well induce mortality.

Doubts about the effectiveness of the return system undermine the feasibility of other screen modifications and alternatives. Included here is an addition to the present vertical travelling screens to include baskets or troughs at intervals along their faces. Fish would not be truly impinged but would be lifted from the water in the basket and dumped into a return channel on the backside of the screens.

An alternative system which might reduce impingement effects is the inclined screen. 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 downstream 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. This type of inclined screen is still experimental, is sensitive to even slight water level fluctuations, and is considerably more expensive to install than the conventional vertical travelling screen (EPA, 1973). Installation at PBNP would be virtually impossible.

E. 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 would require major changes in the cooling water pumps, circulating water system, and turbine 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* (EPA, 1973) and is not considered further in this report.

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. However, it would result in increased ΔT of the circulating water discharge.

No substantial reductions in condenser cooling water flow can be achieved without corresponding capacity limitations. It would be possible, for example, to utilize only one pump per unit on a year-round basis rather than two pumps per unit during the eight warmer months. This action would reduce cooling water flow by 40 percent during those eight months. The capacity of the plant would be reduced a minimum of 16 MWe during the peak summer load period, and the temperature of the cooling water discharge would increase approximately 10°F. The capacity loss would cost $700,000-$1,000,000 per year to replace with power from other sources. Eventually, new generating capacity would be required to replace the lost 16 MWe. Current construction costs to provide 16 MWe range from $2,200,000 for combustion turbines to approximately $8,800,000 for nuclear generation.

If entrapment is determined to represent a significant impact, it is uncertain that a 40% reduction in flow would alleviate it. The obvious environmental and economic costs render capacity reduction an unfeasible method of minimizing fish entrapment.

F. SUMMARY: FEASIBLE ALTERNATIVES

Determination of the feasibility of alternatives to the present intake system at Point Beach Nuclear Plant sould 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

None of the alternative intake locations appears to have definite potential for minimizing fish entrapment. A rubble mound intake pond with shoreline intake would result in inlet velocities (through the rubble) of less

than 0.5 fps. However, fish could penetrate the rubble in the same way that they enter the present intake crib since velocities are comparable. Because the rubble mound would extend over more area than the crib, opportunity for encounter would increase. If the pond was located in the area of the warm water discharge, seasonal attraction of some fishes could ultimately result in greater impingement.

There is no reason to expect that moving the present water inlet further offshore would decrease fish encounters.

DESIGN

The only modification which could curtail entrapment impact is placement of a screen around the perimeter of the intake crib. Use of the screen would be limited to ice-free months, and would not be effective for fish smaller than about 8-1/2 inches long.

Alterations to permit escape of entrapped fish or to release impinged fish undamaged are subject to grave uncertainties concerning fish behavior and performance of the fish return system.

CAPACITY

Capacity of cooling water flow could not be reduced without substantially affecting plant efficiency and capability. The anticipated benefits of capacity reduction versus the cost of reducing plant capability preclude its further discussion.

G. COSTS OF FEASIBLE ALTERNATIVES

Placement of a screen grating around the entire PBNP intake is the only feasible alternative/modification to the present intake in that it appears to possess the potential for reducing entrapment impact and is capable of installation and reliable operation. The costs of implementation of the screen are considered below:

CONSTRUCTION

Construction of the screen would require fabrication of frames that fit between the H-piles on the outside of the crib. The frames would be structural steel sections with chain link fence fabric mounted on them. The fabric would be galvanized steel of either 9 or 13 ga., with 1 inch square openings. The frames would slide into channel slots that would be added to the H-piles. It would be necessary to fabricate special frame sections for a diver to install around the 30 inch feeder pipes.

Cost of purchase, fabrication, and initial installation would be approximately $170,000. Annual installation and removal of the screens for the winter, maintenance, and cleaning would be approximately $17,000.

SCHEDULE

Design of the screen system could be achieved in four months. Fabrication would require four months and construction about two months. Since construction of the frames would require a tug and barge-mounted crane, it would be performed in late summer or fall when the weather conditions on the lake are most favorable.

EFFECTS ON PLANT OPERATION

No effects on plant operation of construction or operation of the screens would be anticipated. However, accumulation of debris and/or periphyton on the chain link fabric could conceivably limit intake flow. Experience at Point Beach and other Lake Michigan plants indicate this is a remote possibility.

ENVIRONMENTAL EFFECTS

Construction effects should be negligible since the construction would consist of modification to the existing structure. As noted above, it is unlikely that periphytic growth on the screen would reach nuisance proportions. The major impact of the net could result from the gilling of small fishes in the screen mesh where it overlies an opening. However, the fence mesh is much heavier than standard nylon gill net, and fish should be able to avoid gilling and entanglement.

VI. LITERATURE CITED

Edsall, T.A., Brown, E.H. Jr., Yocum, T.G., and R.S.C. Wolcott, Jr. 1974. Utilization of alewifes by coho salmon in Lake Michigan. U.S. Fish and Wild. Ser. Great Lakes Fishery Laboratory, Ann Arbor, Michigan. 15 p.

Griffiths, J.S. and P.F. Alderdice. 1972. Effects of acclimation and acute temperature experience on the swimming speed of juvenile coho salmon. J. Fish. Res. Bd. Canada, Vol. 29(3):251-264.

Houde, E.D. 1969. Sustained swimming ability of larvae of walleye (Stizostedion vitreum vitreum) and yellow perch (Perca flavescens). J. Fish. Res. Bd. Canada, Vol. 26(6):1647-1660.

Jones, D.R., Kiceniuk, J.W., and O.S. Banford. 1974. Evaluation of the swimming performance of several fish species from the Mackenzie River. J. Fish. Res. Bd. Canada, Vol. 34(10):1641-1647.

Kutty, M.N., and R.L. Saunders. 1973. Swimming performance of young Atlantic salmon (Salmo salar) as affected by reduced ambient oxygen concentration. J. Fish. Res. Bd. Canada, Vol. 30(2):223-227.

Lake Michigan Cooling Water Intake Technical Committee. 1973. Lake Michigan intake report on the best technology available. 45 p.

Lake Michigan Cooling Water Studies Panel. 1975. A statement of concerns and suggested ecological research. 382 p.

Limnetics, Inc. 1974. An environmental study of the ecological effects of the thermal discharges from Point Beach, Oak Creek, and Lakeside Power Plant on Lake Michigan. Pp. 7.0-223 to 7.0-226. Report to Wisconsin Electric Power Company.

Limnetics, Inc. 1976. Review of the literature on Lake Michigan fish. Report to Lake Michigan Utilities Study Group. 388 p.

Nalco Environmental Sciences. 1975. Compilation of special reports on the effects of Zion Station operation on the biota in southwestern Lake Michigan. Report to Commonwealth Edison Company.

Norden, C.R. 1967. Age, growth, and fecundity of the alewife *Alosa pseudoharengus* (Wilson) in Lake Michigan. Trans. Amer. Fish. Soc., 96:387-393.

Oseid, D., and L.L. Smith, Jr. 1972. Swimming endurance and resistance to copper and malathion of bluegills treated by long-term exposure to sublethal levels of hydrogen sulfide. Amer. Fish. Soc. Trans., Vol. 101(4):620-625.

Otto, R.G. 1974. Temperature effects on fish. Laboratory studies IBT No. 64309862. Industrial Biotest Laboratories, Inc. Report to Commonwealth Edison Company. 69 p.

Power, C.F. and W.P. Alley. 1967. Some preliminary observations on the depth distribution of macrobenthos in Lake Michigan. Great Lakes Res. Div., Univ. of Michigan, Spec. Rept. No. 30.

Reynolds, J.B. and G.M. DeGraeve. 1972. Seasonal population characteristics of the oppossum shrimp, *Mysis relicta*, in southeastern Lake Michigan, 1970-71. Proc. 15th Conf. on Great Lakes Res.

Schiewe, M.H. 1974. Influence of dissolved atmospheric gas on swimming performance of juvenile chinook salmon. Amer. Fish. Soc. Trans., Vol. 103(4):717-721.

Spigarelli, S.A. and M.M. Thommes. 1974. Sport fishing survey at the Point Beach Nuclear Plant during 1973. Argonne National Laboratory, Report ANL-8060(III):142-149.

United States Environmental Protection Agency. 1973. Development document for proposed best technology available for minimizing adverse environmental impact of cooling water intake structures. 175 p.

Wells, L. 1968. Seasonal depth distribution of fish in southeastern Lake Michigan. U.S. Dept. Int. Fish. Bull., 67(1):1-15.

Wells, L. and A.L. McLain. 1973. Lake Michigan: man's effect on native fish stocks and other biota. Great Lakes Fishery Commission, Tech. Rept. No. 20. 55 p.

Wisconsin Electric Power Company. 1975. Point Beach Nuclear Plant demonstration for thermal standard variance.

Wissing, T.E. and A.D. Hasler. 1971. Effects of swimming activity and food intake on the respiration of young-of-the-year white bass, *Morone chrysops*. Amer. Fish. Soc. Trans. Vol. 100(3):537-543.