29348
Intake
R5-WI-J.P. Pulliam

NALCO ENVIRONMENTAL SCIENCES
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NALCO CHEMICAL COMPANY

REPORT TO

WISCONSIN PUBLIC SERVICE CORPORATION
GREEN BAY, WISCONSIN

J. P. PULLIAM POWER PLANT
GREEN BAY, WISCONSIN

# 316(b) DEMONSTRATION

# ENVIRONMENTAL EFFECTS OF EXISTING COOLING WATER INTAKE STRUCTURES

PREPARED AND SUBMITTED
BY
NALCO ENVIRONMENTAL SCIENCES

1976

Report approved by: B. G. Johnson

B. G. Johnson, Ph.D.
General Manager

# PREFACE

The overall supervision of the 316(b) Demonstration was the responsibility of Dr. B. G. Johnson, General Manager, NALCO Environmental Sciences, and Dr. J. A. DeMarte and Dr. B. J. Cox, Project Coordinators. Mr. A. L. Restaino and Mr. J. Rice shared Project Leader responsibilities for the impingement and entrainment studies. The preparation of the 316(b) Demonstration was the responsibility of Mr. J. Rice, Environmental Physiology Section.

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Mr. T. P. Meinz, Wisconsin Public Service Corporation

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## I. Introduction

Section 316(b) of Public Law 92-500 and Section 147.02(b), Wisconsin Statutes require that the location, design, construction and capacity of cooling water intake structures reflect the "best technology available for minimizing adverse environmental impact." As required by Wisconsin Pollution Discharge Elimination System Permit (WPDES) WI-0000965, a one-year study was undertaken to determine the environmental impact of the present J. P. Pulliam Power Plant cooling water intake structures.

This report is intended to provide data concerning present intake effects. Data were collected with the aim of evaluating intake effects on all life stages of fish and describing peripheral factors which may directly influence results. Frequent periodic sampling of adult and juvenile fish removed from the cooling water by the trash rack/traveling screen barrier system allowed the estimation of the total number of fish removed and some of their characteristics such as size and weight. During the period of reproductive activity in the area of the Plant quantitative sampling for fish eggs, larvae and small juveniles not removed by the barrier systems was conducted. Results allowed the estimation of total numbers of eggs, larvae and juveniles which passed through the Plant.

Ancillary data concerning the physical plant, its routine operations, intake and discharge characteristics, and condenser cleaning and deicing procedures were collected.

This report presents a summary of J. P. Pulliam Power Plant operations focused on the intake systems through which cooling water is drawn and effects on fish inhabiting the water used.

## II. Present Intake Structures

The J. P. Pulliam Power Plant is located at the southern end of Green Bay at the confluence of the Fox River in the city of Green Bay, Wisconsin (Figure 1). It is a coal-fired facility consisting of eight generating units with a total gross output of 392.5 MWe (Table 1). The Plant is classified as an intermediate load range facility. Units 7 and 8 are base loaded and the Plant as a whole is load following. The Plant is thus in operation every hour of every day but generation rates are highly variable.

A generalized summary of Plant output during this study is presented in Table 2. Hourly generation rates on two different dates varied from 82 to 319 MWH. The lowest rates generally occurred between midnight and 6 a.m., the highest between 6 p.m. and 7 p.m. Another lower peak in generation occurred between 10 a.m. and noon.

Plans for future use of J. P. Pulliam Plant show a slight rise and then decline in hours of operation per year (Table 3). By the year 1985, a reduction of 9891 MW hours of operation is predicted to have taken place (approximately 41%). A concomitant reduction in the cooling water requirements of the Plant is expected.

Condenser cooling at J. P. Pulliam Plant is accomplished by once-through cooling water flow. Two sources of cooling water were developed. The initial (north) intake structure was located on Green Bay and, as requirements increased, an additional Green Bay (north) intake was added, and finally an intake drawing water from the Fox River (south intake)(Figures 1 and 3).

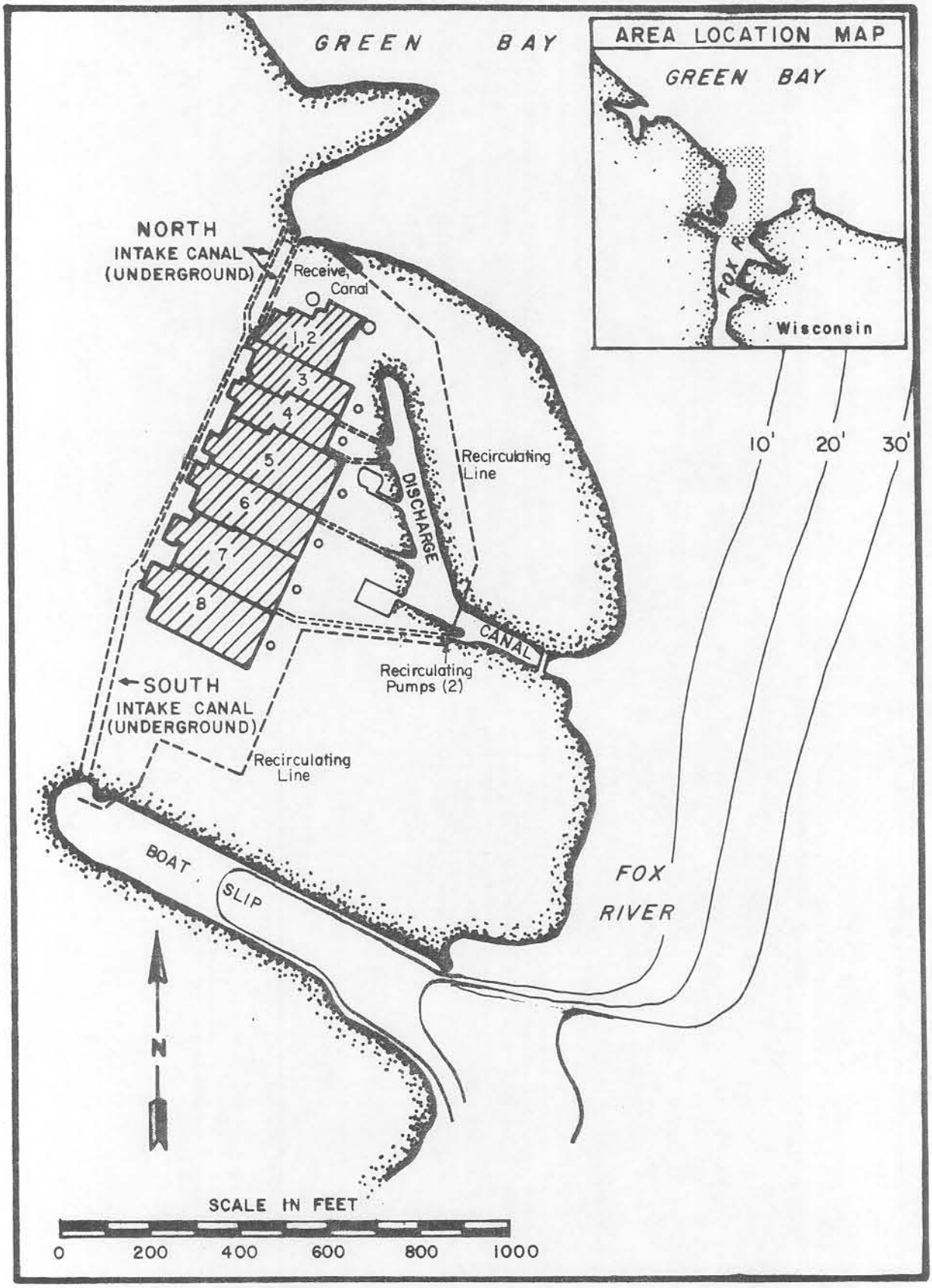



Figure 1. Diagram of Pulliam Power Plant, Green Bay, Wisconsin.

Table 1. Nameplate capacities (MWe) and rated flows ($m^3$/min) of Units 1 through 8, Pulliam Power Plant.

| Unit Number | Nameplate Capacity (MWe) | Cooling Water ($m^3$/min) | Service Water ($m^3$/min) | Ash Sluice ($m^3$/min) |
|---|---|---|---|---|
| 1 | 10 | 49 | - | - |
| 2 | 10 | 49 | - | - |
| 3 | 30 | 136 | 8 | - |
| 4 | 30 | 128 | 8 | 9 |
| 5 | 50 | 203 | 8 | - |
| 6 | 62.5 | 288 | 8 | 9 |
| 7 | 75 | 246 | 4 | 9 |
| 8 | 125 | 375 | 5 | 11 |
| TOTAL | 392.5 | 1474<br>49<br>38 | 49 | 38 |

1561

Table 2. Hourly Generation (MWH) at Pulliam Plant on February 2 and February 7, 1976.[a]

| Hour | Hourly Generation | |
|---|---|---|
| | Feb. 2, 1976[b] | Feb. 7, 1976[c] |
| 0100 | 95 | 162 |
| 0200 | 88 | 161 |
| 0300 | 82 | 166 |
| 0400 | 84 | 137 |
| 0500 | 89 | 106 |
| 0600 | 115 | 103 |
| 0700 | 177 | 174 |
| 0800 | 252 | 222 |
| 0900 | 297 | 228 |
| 1000 | 305 | 240 |
| 1100 | 303 | 246 |
| 1200 | 299 | 250 |
| 1300 | 305 | 218 |
| 1400 | 286 | 194 |
| 1500 | 275 | 168 |
| 1600 | 285 | 165 |
| 1700 | 297 | 212 |
| 1800 | 308 | 261 |
| 1900 | 319 | 261 |
| 2000 | 307 | 208 |
| 2100 | 284 | 181 |
| 2200 | 183 | 128 |
| 2300 | 111 | 95 |
| 2400 | 82 | 107 |

[a] Wisconsin Public Service Corporation.
[b] Units 1 through 4 offline. Units 5 through 8 online part or all of day.
[c] Only Units 6 through 8 online.

Table 3. Predicted hours of unit operation for Pulliam Power Plant, 1976 through 1985.[a]

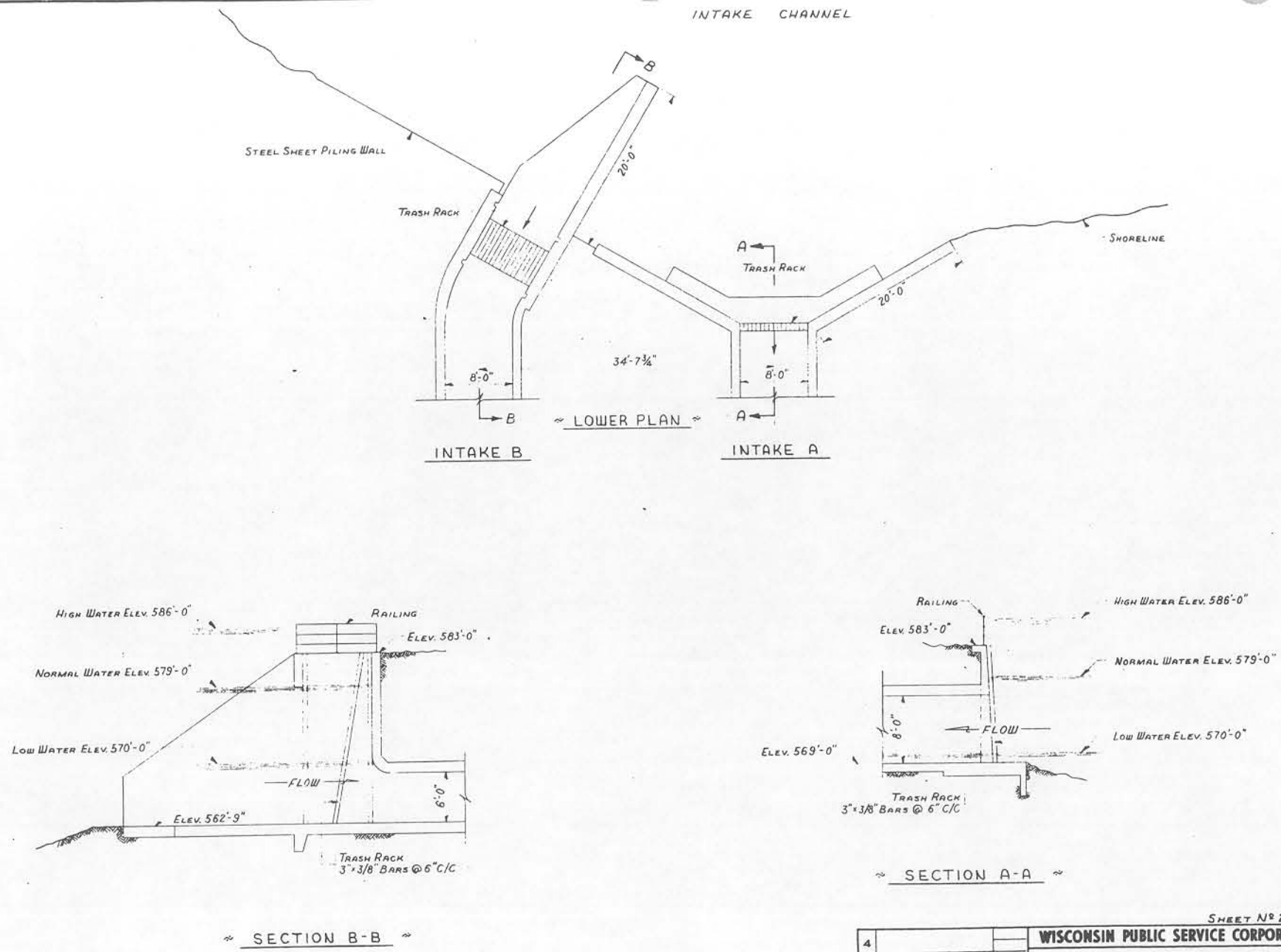
| Unit/ Year | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 |
|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 6719 | 7119 | 6919 | 6177 | 7507 | 6775 | 6127 | 6335 | 4778 | 5715 |
| 7 | 6014 | 6223 | 5556 | 5946 | 6515 | 5126 | 4572 | 4318 | 4010 | 4442 |
| 6 | 4051 | 4123 | 4148 | 3906 | 4784 | 3921 | 3303 | 2547 | 1342 | 2233 |
| 5 | 3695 | 3813 | 3888 | 3593 | 4246 | 3039 | 2388 | 1416 | 671 | 1056 |
| 4 | 1358 | 2204 | 1701 | 1539 | 2069 | 992 | 771 | 419 | 230 | 379 |
| 3 | 2216 | 2986 | 2403 | 1994 | 2386 | 1393 | 983 | 648 | 292 | 436 |
| 2 & 1 | 173 | 326 | 303 | 194 | 263 | 184 | 146 | 73 | 39 | 74 |
| | | | Totals | 23349 | 27770 | 21430 | 18290 | 11756 | 11362 | 14335 |

[a] Wisconsin Public Service Corporation.

At the present time, condenser cooling water is drawn from both north and south intakes. The north intakes are located on the shoreline of Green Bay and the south at the end of the coal boat slip, which in effect creates an intake canal off the Fox River. After condenser passage, cooling water is discharged into a discharge canal (Figure 1) which in turn discharges into the Fox River. Discharges for higher numbered units are paired (i.e., 7 and 8 share a common discharge structure).

The two north intakes draw surface water from Green Bay (within the 10 ft depth contour, at normal water elevation) (Figure 1). The Fox River and discharge water may also enter these intakes at times depending on flow rate and weather. The structures are cribs housing a 6 ft diameter (Intake A) or 8 ft diameter (Intake B) intake pipe, trash rack and trash rack cleaning rake. The trash racks are standard vertical bar systems with 6 inch openings between bars (Figure 2). The area immersed at normal water level is 8 ft wide by 10 ft (Intake A) or 18 ft (Intake B) high (total area 216 sq ft). The south intake is a combined crib for two 9 ft diameter pipes with 8 inch c/c trash racks of the same design as the other intakes. The combined trash rack area at normal water level is 360 $ft^2$ (Figure 3). Each intake is also equipped with an air bubble screen to deter fish from entering the intake. The air bubble screen is operated continuously from April through October.

The distribution of cooling water to various condensers is a result of the addition of units to the original Plant (Figure 4).




SHEET Nº 2 of 7

| NO. | DESCRIPTION | APP'D |
|---|---|---|
| 4 | | |
| 3 | | |
| 2 | | |
| 1 | | |

TABLE OF REVISIONS

Figure 2.

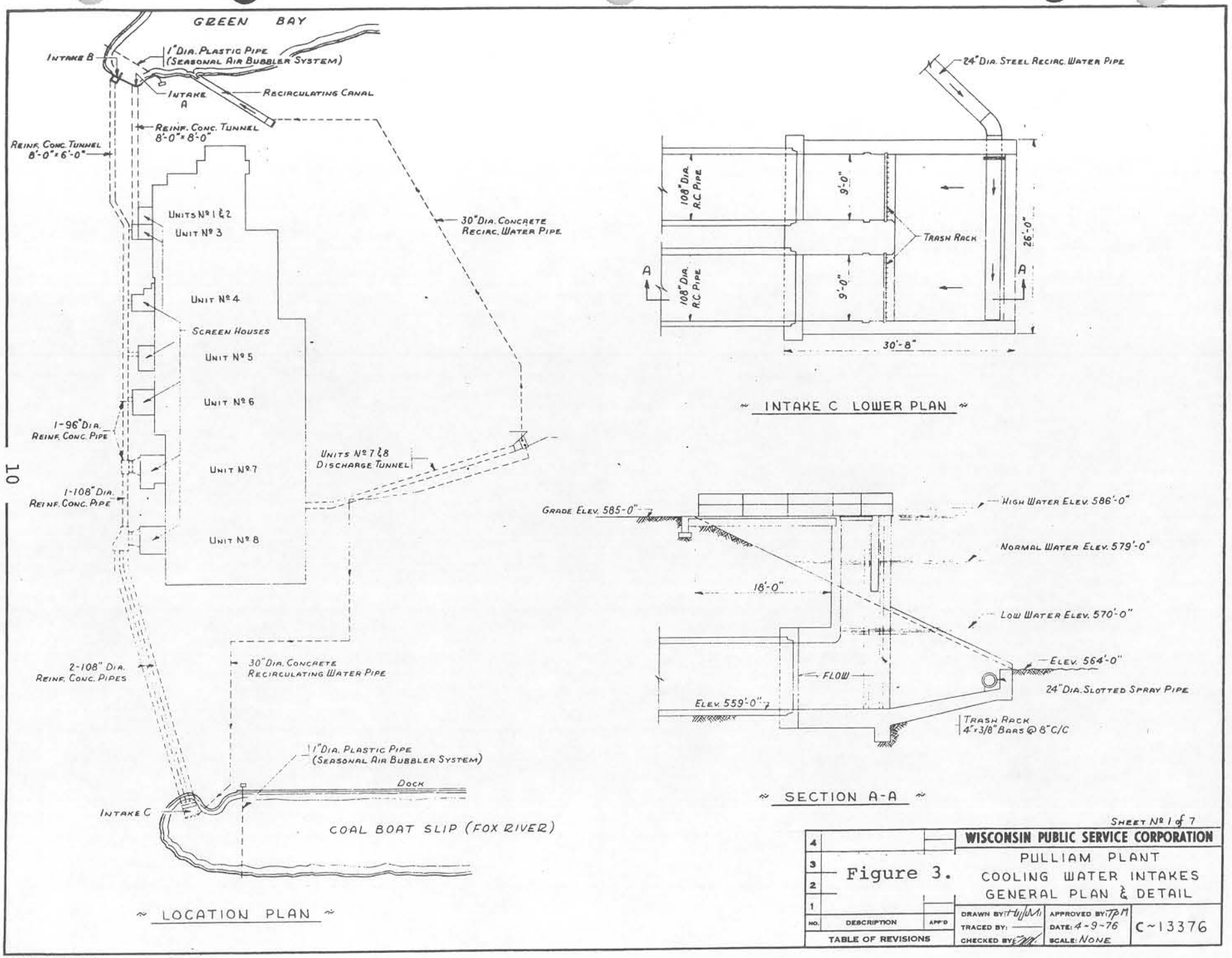
**WISCONSIN PUBLIC SERVICE CORPORATION**

PULLIAM PLANT
COOLING WATER INTAKES
INTAKES A & B DETAIL

DRAWN BY: HWM
TRACED BY:
CHECKED BY: EW
APPROVED BY: TPM
DATE: 4-9-76
SCALE: NONE

C-13377

DESIGN PRODUCTS CO.—1018


GREEN BAY
INTAKE B
1" DIA. PLASTIC PIPE (SEASONAL AIR BUBBLER SYSTEM)
INTAKE A
RECIRCULATING CANAL
REINF. CONC. TUNNEL 8'-0" x 8'-0"
REINF. CONC. TUNNEL 8'-0" x 6'-0"
UNITS Nº 1 & 2
UNIT Nº 3
UNIT Nº 4
SCREEN HOUSES
UNIT Nº 5
UNIT Nº 6
UNIT Nº 7
UNIT Nº 8
30" DIA. CONCRETE RECIRC. WATER PIPE
1-96" DIA. REINF. CONC. PIPE
1-108" DIA. REINF. CONC. PIPE
UNITS Nº 7 & 8 DISCHARGE TUNNEL
2-108" DIA. REINF. CONC. PIPES
30" DIA. CONCRETE RECIRCULATING WATER PIPE
1" DIA. PLASTIC PIPE (SEASONAL AIR BUBBLER SYSTEM)
DOCK
INTAKE C
COAL BOAT SLIP (FOX RIVER)
LOCATION PLAN
24" DIA. STEEL RECIRC. WATER PIPE
108" DIA. R.C. PIPE
9'-0"
TRASH RACK
26'-0"
A
30'-8"
INTAKE C LOWER PLAN
GRADE ELEV. 585-0"
HIGH WATER ELEV. 586'-0"
NORMAL WATER ELEV. 579'-0"
18'-0"
LOW WATER ELEV. 570'-0"
ELEV. 564'-0"
FLOW
24" DIA. SLOTTED SPRAY PIPE
ELEV. 559'-0"
TRASH RACK 4" x 3/8" BARS @ 8" C/C
SECTION A-A
SHEET Nº 1 of 7
WISCONSIN PUBLIC SERVICE CORPORATION
PULLIAM PLANT
COOLING WATER INTAKES
GENERAL PLAN & DETAIL
Figure 3.
NO. DESCRIPTION APP'D
TABLE OF REVISIONS
DRAWN BY:
TRACED BY:
CHECKED BY:
APPROVED BY: TPM
DATE: 4-9-76
SCALE: NONE
C-13376
DESIGN PRODUCTS CO.-1015

All units receive water from a manifold type system drawing water from the north and the south intakes. In general Units 7 and 8 draw water from the Fox River. A screen house consisting of a small forebay, 3 inch c/c trash rack and traveling screens serves each unit (Figure 4). Traveling screens are the conventional vertical type with 3/8 inch square wire mesh. The dimensions of each screen house are shown in Figures 5 through 9. The traveling screens are normally operated for 15 minutes duration four times per shift whenever the unit they serve is on line.

The total (maximum) water flow through the Plant with all operable pumps on is approximately 1561 $m^3$/min, 94% of which is cooling water (Table 1, Figure 4). The mean observed flow on entrainment sampling days (1600, 2400, 0800 hr one day per week, April through August) was considerably less than this, approximately 923 $m^3$/min. Winter flows could be expected to be approximately half this or 400 $m^3$/min. Since the Plant is load following, the flows are somewhat unpredictable and fluctuate daily. Currents created at the intakes are thus highly variable also. Velocities were measured using a General Oceanics 2031/2035 Direct Reading Meter. They were found to vary from 0 to 180 cm/sec depending on time of year and Plant output. Current velocities at each of the intakes were first measured at maximum flow, all pumps operating. Current velocities in front of the intake pipes at maximum flow (1561 $m^3$/min) were 180 cm/sec in the intake for Units 1, 2 and 3 and 170 cm/sec in both other intakes. There are eddies in every intake, and a reverse flow of 20 to 30 cm/sec was detected near the surface in each intake.

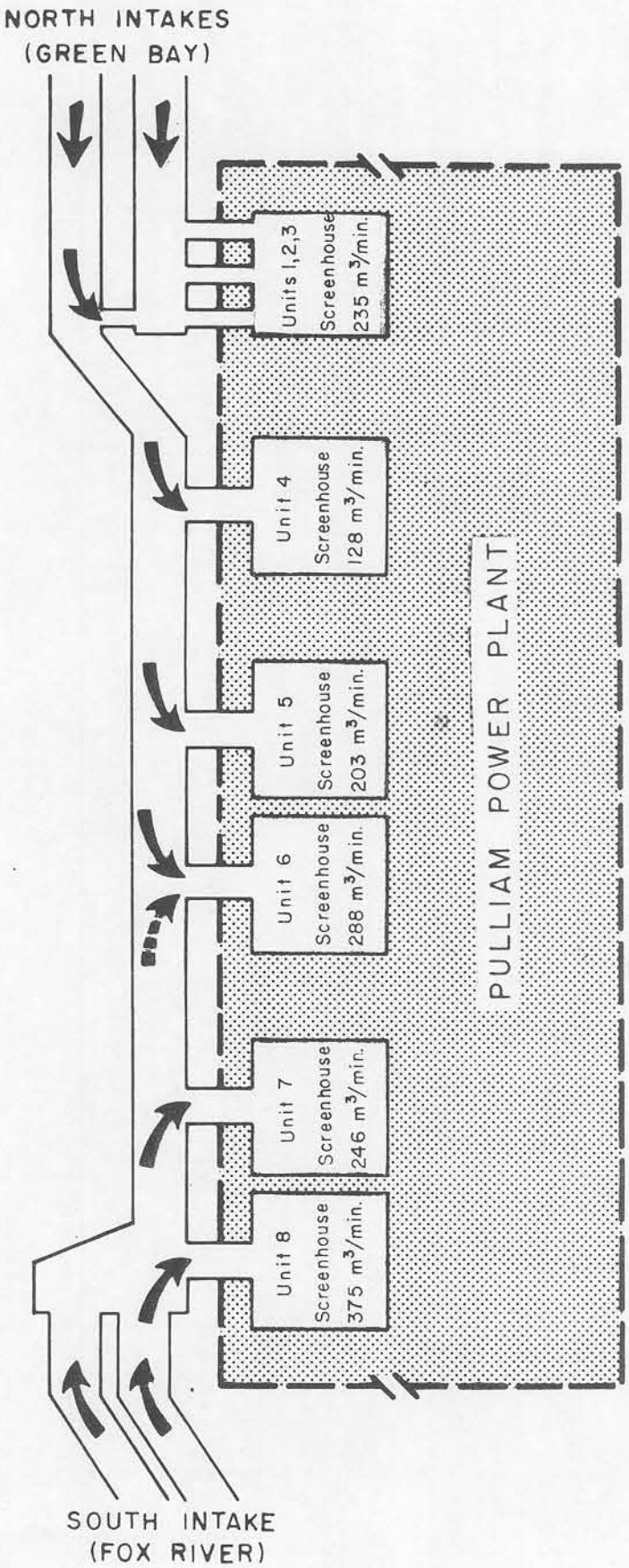
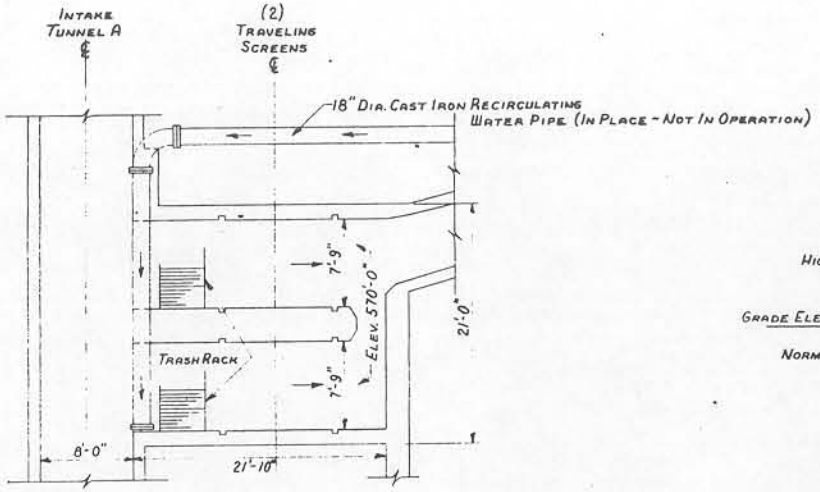
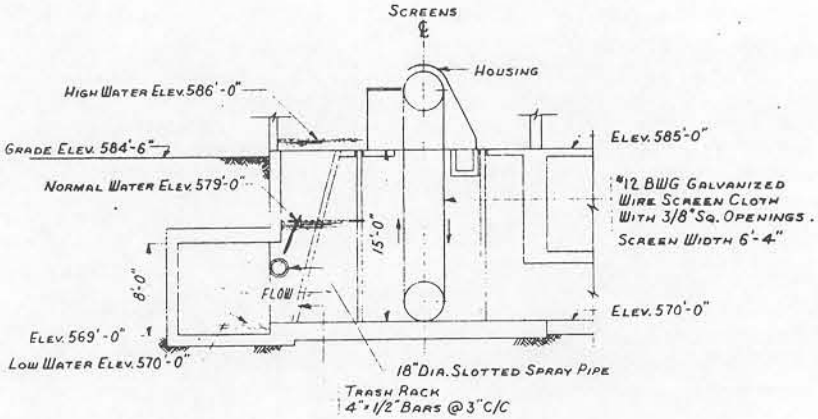



Figure 4. Schematic diagram of water flow in Pulliam Power Plant intakes.




~ SCREENHOUSE LOWER PLAN ~




~ SCREEN ELEVATION ~

Figure 5.

SHEET Nº 3 of 7

**WISCONSIN PUBLIC SERVICE CORPORATION**

PULLIAM PLANT
UNITS Nº 1 & 2
SCREEN HOUSE DETAIL

| NO. | DESCRIPTION | APP'D |
|---|---|---|
| 4 | | |
| 3 | | |
| 2 | | |
| 1 | | |

TABLE OF REVISIONS

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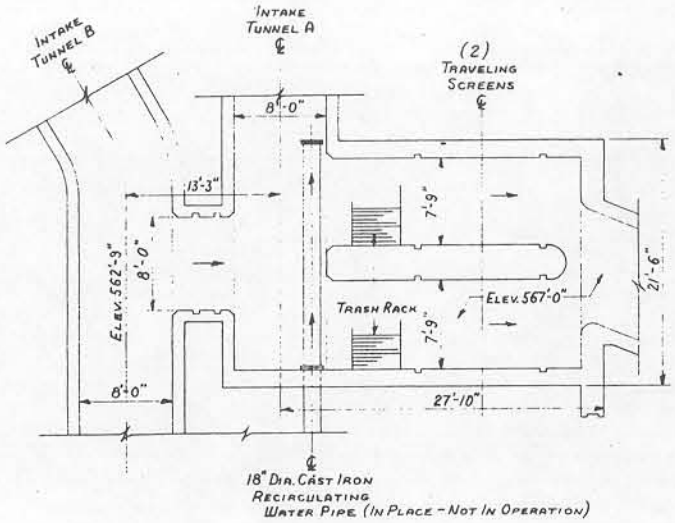
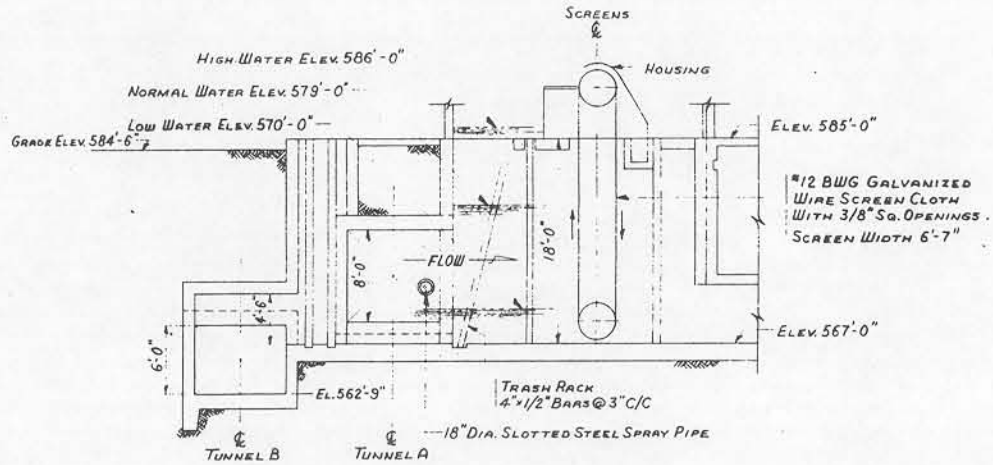
TRACED BY:
CHECKED BY:
APPROVED BY: TPM
DATE: 4-9-76
SCALE: NONE

C-13378

DESIGN PRODUCTS CO.—1018




SCREENHOUSE LOWER PLAN




SCREEN ELEVATION

SHEET Nº 4 of 7

| NO. | DESCRIPTION | APP'D |
|---|---|---|
| 4 | | |
| 3 | | |
| 2 | | |
| 1 | | |

TABLE OF REVISIONS

Figure 6.

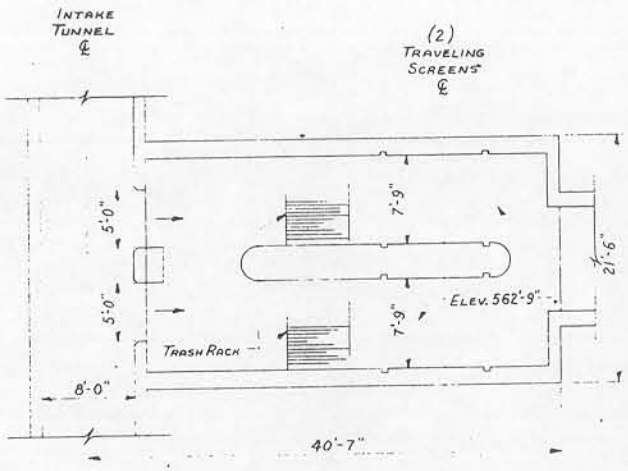
**WISCONSIN PUBLIC SERVICE CORPORATION**

PULLIAM PLANT
UNIT Nº 3
SCREEN HOUSE DETAIL

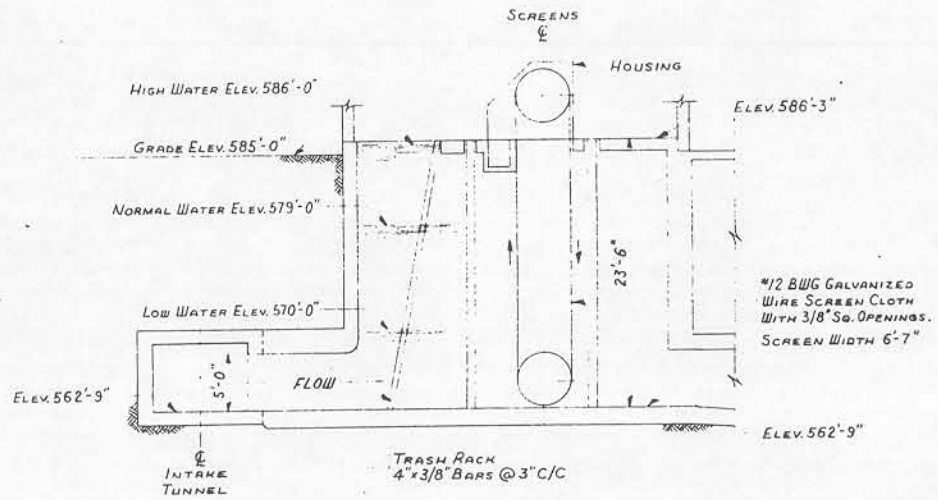
DRAWN BY: [illegible] APPROVED BY: TPM
TRACED BY: DATE: 4-9-76
CHECKED BY: [illegible] SCALE: NONE

C-13379

DESIGN PRODUCTS CO.—1019



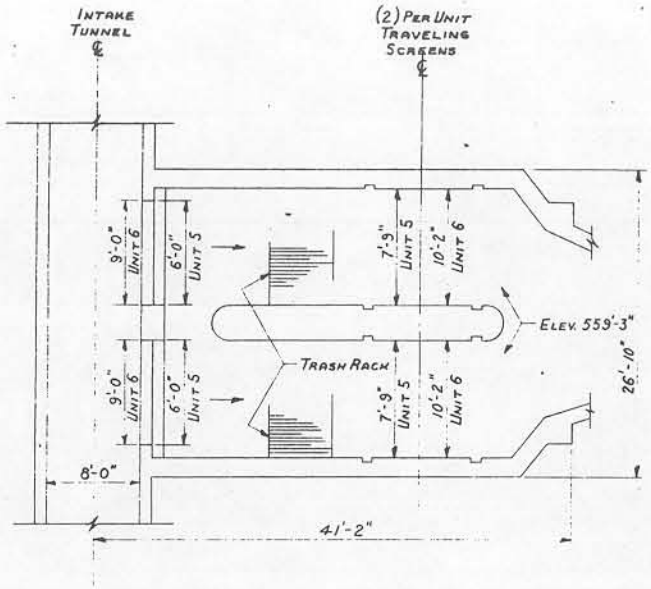

~ SCREENHOUSE LOWER PLAN ~



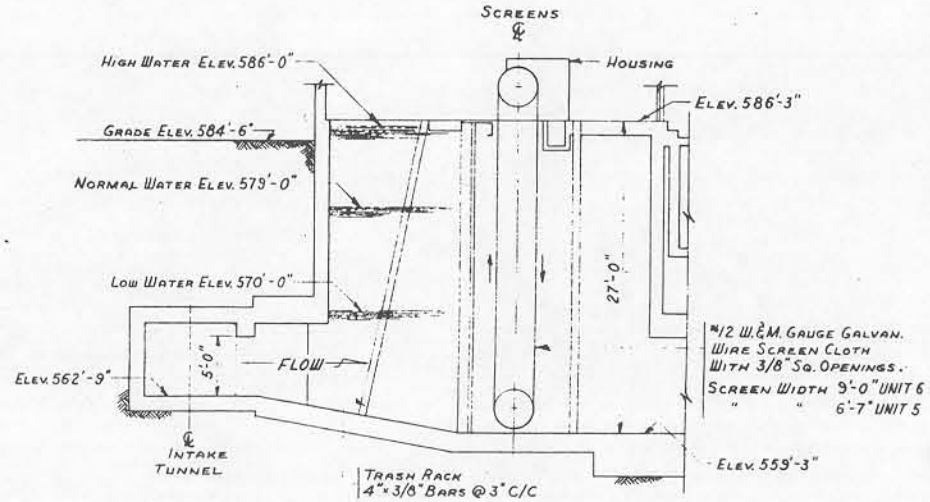

~ SCREEN ELEVATION ~

SHEET Nº 5 of 7

| | | | |
|---|---|---|---|
| 4 | | | WISCONSIN PUBLIC SERVICE CORPORATION |
| 3 | | | PULLIAM PLANT |
| 2 | Figure 7. | | UNIT Nº 4 |
| 1 | | | SCREEN HOUSE DETAIL |
| NO. | DESCRIPTION | APP'D | DRAWN BY: [illegible] APPROVED BY: TPM |
| | TABLE OF REVISIONS | | TRACED BY: DATE: 4-9-76 C~13380 |
| | | | CHECKED BY: [illegible] SCALE: NONE |




~ SCREENHOUSE LOWER PLAN ~



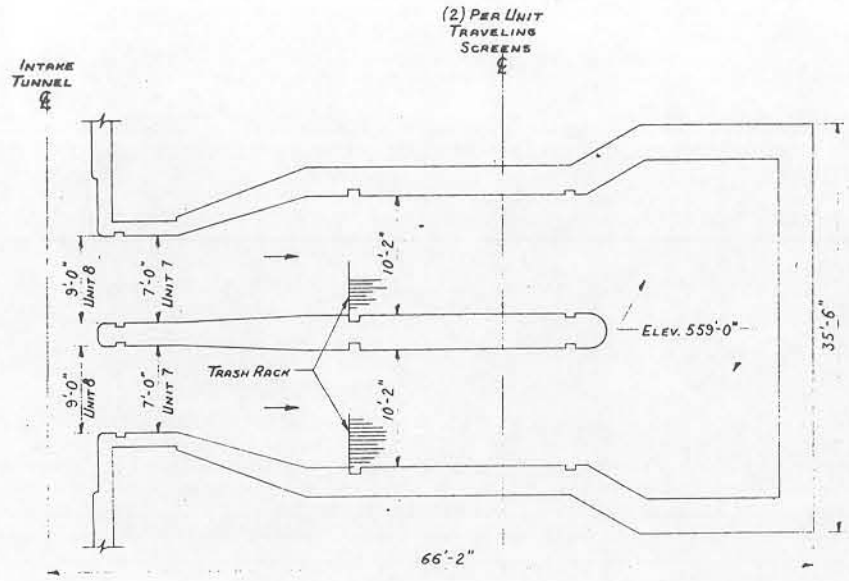

~ SCREEN ELEVATION ~

NOTE:
VIEWS ARE TYPICAL FOR UNITS 5 & 6 ~ EXCEPT AS NOTED.

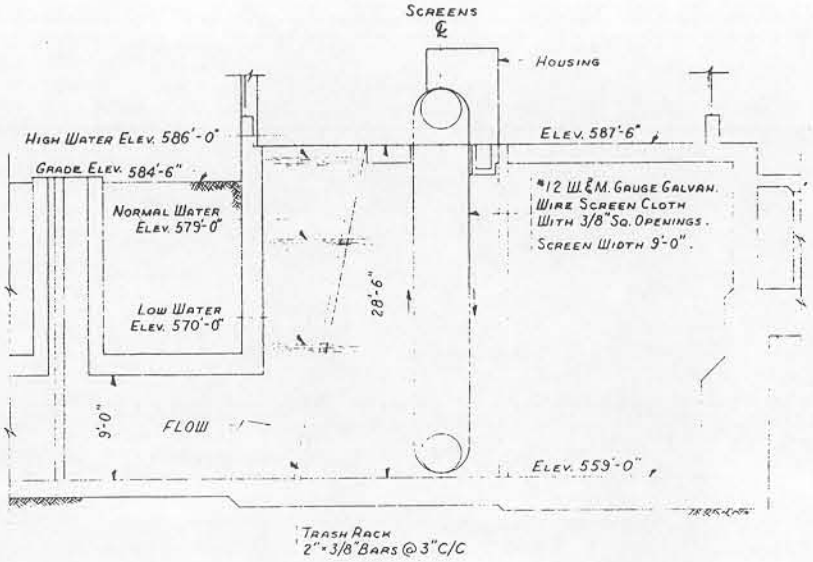
SHEET Nº 6 of 7

| | | | |
|---|---|---|---|
| 4 | | | WISCONSIN PUBLIC SERVICE CORPORATION |
| 3 | Figure 8. | | PULLIAM PLANT |
| 2 | | | UNITS Nº 5 & 6 |
| 1 | | | SCREEN HOUSE DETAIL |
| NO. | DESCRIPTION | APP'D | DRAWN BY: HJM / APPROVED BY: TPM / TRACED BY: / DATE: 4-9-76 / CHECKED BY: / SCALE: NONE / C-13381 |
| | TABLE OF REVISIONS | | |

DESIGN PRODUCTS CO.—1012




~ SCREENHOUSE + LOWER PLAN ~




~ SCREEN ELEVATION ~

NOTE:
VIEWS ARE TYPICAL FOR UNITS 7 & 8 → EXCEPT AS NOTED.

SHEET Nº 7 of 7

| | | | |
|---|---|---|---|
| 4 | | | WISCONSIN PUBLIC SERVICE CORPORATION |
| 3 | Figure 9. | | PULLIAM PLANT |
| 2 | | | UNITS Nº 7 & 8 |
| 1 | | | SCREEN HOUSE DETAIL |
| NO. | DESCRIPTION | APP'D | DRAWN BY: HJM / TRACED BY: — / CHECKED BY: — / APPROVED BY: TPM / DATE: 4-9-76 / SCALE: NONE / C-13382 |
| | TABLE OF REVISIONS | | |

DESIGN PRODUCTS CO.—1018

Minimum flow through the Plant on December 3, 1975, probably representing maximum flow under winter conditions, was approximately 732 $m^3$/min. Units 1 through 3 were off line; velocity in the intake for these units was 0 cm/sec. The current velocities in front of the intake pipes at both other intakes were 110 cm/sec. Again, eddies of 10 to 30 cm/sec were found in the water near the surface.

The deicing system at Pulliam consists of two pumps of 56.8 $m^3$/min capacity located in the Units 7 and 8 discharge and appropriate piping (Figure 1). Discharge water is piped from one pump to the deicing canal adjacent to the north intakes and from the other to the face of the south intake. Operation is intermittent, depending on anchor ice. The intakes are visually checked frequently and, if anchor ice is present, the pumps are turned on.

Condenser cleaning is by chlorination. Chlorine is added to the intake water prior to condenser passage. The chlorinators are automatically operated for 20 min every 4 hr each day when the unit is operating. The average concentrations of chlorine on the inlet side of the condenser are 0.75 mg/l for Units 1 through 6 and 1.0 mg/l for Units 7 and 8. The average concentration is 0.90 mg/l. Chlorine concentrations in the discharge would be minute. The reason for this is that chlorination is not simultaneous on all units, but staggered. On a day at random, April 10 at 0800, chlorine in Unit 5 discharge would be diluted by the discharges of Units 6, 7 and 8 in the discharge canal. Chlorine levels should be very low.

## III. Sampling Data

### A. Adult and Juvenile Fish

Adult and juvenile fish impinged in the J. P. Pulliam Power Plant traveling screens were monitored by trained Plant personnel. Detailed sampling methods, equipment and copies of Eddy (1969), Hubbs and Lagler (1970) and Morris et al (1974) were provided by NALCO ES biologists. Supervisory checks of impingement monitoring activities were made and help with identification of unknown fish was also provided by NALCO ES biologists.

Impingement sampling was conducted every fourth day from April 1, 1975 through March 31, 1976. At the beginning of each sampling period the traveling screens were washed and fish discarded. The screens were then operated manually by personnel on each shift for twenty-four hours and all fish retained for the count. One hundred percent of the operating intake volume was sampled.

Impinged fish were washed from the screens into a discharge sluice and collected using a basket made from traveling screen wire which was inserted in the sluice prior to screen washing.

Fish collected were identified to species (usually sport fish) or family (suckers, bullheads, shiners), measured to the nearest centimeter total length and weighed to the nearest five gram increment. Up to forty fish of each species were weighed and measured. If greater numbers were collected, their total weight was recorded and the total number estimated using the mean weight of individually weighed fish.

Impingement data were summarized by NALCO ES biologists. Summary tables including total number and total weight collected per species and sampling date were prepared. Monthly total numbers and weights collected were used to estimate the total number and weight actually impinged using the formula:

$$\text{Estimated Total Number Or Weight} = \text{Total Number Or Weight Collected} \times \frac{\text{Number of Days In Month}}{\text{Number of Sample Days}}$$

When sufficient numbers of fish per species were collected monthly, length frequency distributions were prepared. Plant operating data for impingement sampling periods were extracted from hourly computer summaries of Plant operations supplied by Wisconsin Public Service Corporation. These data included average flow at rated pump capacities in $m^3$/min and intake and discharge temperatures in degrees Centigrade. A record of screen rotations since the last sampling period was maintained.

Fish impingement sampling results are summarized in Tables 4 through 15. Data per species include total number and weight (kg) per day and monthly total. Means and ranges of total lengths were calculated monthly.

Some grouping of species occurred. The group shiners (Table 4) included mainly spottail and emerald shiners but could also contain common and golden shiners and fathead minnows. Bullheads (Table 4) were generally the locally abundant black bullheads, but yellow and brown bullheads and stonecats were also found in the area. The vast majority of the suckers collected were white suckers, but longnose suckers and silver and shorthead redhorses may also have been included.

Table 4. Summary of plant operating and fish impingement data collected at Pulliam Power Plant, April, 1975.

| | | 4/4 | 4/8 | 4/12 | 4/16 | 4/20 | 4.24 | 4/28 | Monthly Total | Total Length(cm) Range | Total Length(cm) Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | | | | | | | | | | | |
| Average flow ($m^3$/min) | | 794.8 | 558.4 | 284.1 | 487.7 | 375.0 | 579.4 | 897.0 | | | |
| Intake temperature (°C) | | 0- 1 | 0- 2 | 3- 5 | 4- 6 | 4- 5 | 5- 7 | 6- 9 | | | |
| Discharge temperature (°C) | | 5-12 | 7-12 | 8-14 | 11-14 | 10-12 | 11-17 | 12-19 | | | |
| Number of times screens operated since last sample | | - | - | - | - | - | - | - | | | |
| Species | | | | | | | | | | | |
| Rainbow smelt | Number | 0 | 0 | 0 | 0 | 1304 | 0 | 0 | 1304 | 14-19 | 17 |
| | Weight (Kg) | | | | | 49.120 | | | 49.120 | | |
| Yellow perch | Number | 2 | 1 | 8 | 14 | 455 | 133 | 188 | 801 | 5-25 | 16.8 |
| | Weight (Kg) | 0.084 | 0.254 | 0.452 | 0.739 | 25.842 | 10.051 | 15.231 | 52.648 | | |
| Shiner | Number | 0 | 0 | 0 | 0 | 392 | 0 | 237 | 629 | 7.5-15.2 | 11.8 |
| | Weight (Kg) | | | | | 4.255 | | 4.882 | 9.137 | | |
| Bullhead | Number | 0 | 0 | 1 | 11 | 88 | 27 | 66 | 193 | 6-29 | 16.5 |
| | Weight (Kg) | | | 0.028 | 0.807 | 4.395 | 2.870 | 2.752 | 10.852 | | |
| Northern pike | Number | 0 | 2 | 2 | 20 | 10 | 2 | 24 | 60 | 30-74 | 52.3 |
| | Weight (Kg) | | 1.807 | 0.847 | 24.784 | 10.640 | 2.620 | 25.260 | 65.958 | | |
| Sucker | Number | 2 | 4 | 1 | 2 | 2 | 7 | 4 | 22 | 6-45 | 32.1 |
| | Weight (Kg) | 0.734 | 1.129 | 0.424 | 1.725 | 0.800 | 1.760 | 1.600 | 8.172 | | |
| Carp | Number | 2 | 0 | 0 | 2 | 3 | 3 | 1 | 11 | 32-47 | 39.4 |
| | Weight (Kg) | 1.186 | | | 1.850 | 1.990 | 3.100 | 0.690 | 8.816 | | |

Table 4. (continued)

| | | 4/4 | 4/8 | 4/12 | 4/16 | 4/20 | 4/24 | 4/28 | Monthly Total | Total Length(cm) Range | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Burbot | Number | 0 | 0 | 0 | 0 | 1 | 1 | 4 | 6 | 23-43 | 32.6 |
| | Weight (Kg) | | | | | 0.300 | 0.100 | 3.006 | 1.406 | | |
| Crappie (Black) | Number | 0 | 0 | 1 | 0 | 2 | 0 | 3 | 6 | 15.2-24 | 18.9 |
| | Weight (Kg) | | | 0.085 | | 0.360 | | 0.163 | 0.608 | | |
| Walleye | Number | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 4 | 20-31 | 23.3 |
| | Weight (Kg) | | | | | 0.075 | | 0.593 | 0.668 | | |
| Mudminnow | Number | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 3 | 10 | 10 |
| | Weight (Kg) | | | | | 0.030 | | | 0.030 | | |
| Round whitefish | Number | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 16-18.9 | 17.5 |
| | Weight (Kg) | | | | | | | 0.105 | 0.105 | | |
| White bass | Number | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 25 | 25 |
| | Weight (Kg) | | | | 0.200 | | | | 0.200 | | |
| Rainbow trout | Number | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 54 | 54 |
| | Weight (Kg) | | | | | 1.850 | | | 1.850 | | |
| Freshwater drum | Number | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 15 | 15 |
| | Weight (Kg) | | | | | 0.030 | | | 0.030 | | |
| Lamprey | Number | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 32.4 | 32.4 |
| | Weight (Kg) | | | | | 0.040 | | | 0.040 | | |

Table 5. Summary of plant operating and fish impingement data collected at Pulliam Power Plant, May 1975.

| | | 5/2 | 5/6 | 5/10 | 5/14 | 5/18 | 5/22 | 5/26 | 5/30 | Monthly Total | Total Length(cm) Range | Total Length(cm) Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | | | | | | | | | | | | |
| Average flow ($m^3$/min) | | 661.5 | 477.3 | 318.2 | 740.2 | 694.8 | 1065.0 | 415.2 | 652.0 | | | |
| Intake temperature (°C) | | 6- 8 | 8-10 | 11-13 | 11-14 | 14-16 | 19-23 | 18-21 | 18-19 | | | |
| Discharge temperature (°C) | | 12-16 | 15-20 | 17-20 | 17-22 | 20-24 | 24-30 | 22-26 | 24-28 | | | |
| Number of times screens operated since last sample | | - | - | - | - | - | - | - | - | | | |
| Species | | | | | | | | | | | | |
| Alewife | Number | 0 | 0 | 0 | 0 | 0 | 14 | 395 | 1334 | 1743 | 5-21 | 18.0 |
| | Weight (Kg) | | | | | | 0.509 | 20.900 | 39.641 | 61.050 | | |
| Yellow perch | Number | 127 | 240 | 84 | 202 | 123 | 108 | 438 | 364 | 1686 | 5-28 | 17.0 |
| | Weight (Kg) | 10.700 | 14.300 | 5.009 | 17.817 | 9.077 | 5.000 | 31.800 | 17.945 | 111.648 | | |
| Shiner | Number | 0 | 74 | 92 | 12 | 86 | 29 | 376 | 37 | 706 | 2.5-16 | 9.6 |
| | Weight (Kg) | | 0.600 | 1.151 | 0.189 | 0.900 | 0.415 | 4.700 | 0.388 | 8.343 | | |
| Bullhead | Number | 10 | 27 | 15 | 14 | 8 | 15 | 110 | 20 | 219 | 5-28 | 18.4 |
| | Weight (Kg) | 1.870 | 3.555 | 0.600 | 1.395 | 1.615 | 2.954 | 8.400 | 2.433 | 22.822 | | |
| Rainbow smelt | Number | 21 | 9 | 7 | 4 | 3 | 1 | 0 | 0 | 45 | 9-20 | 14.9 |
| | Weight (Kg) | 0.397 | 0.356 | 0.192 | 0.036 | 0.028 | 0.109 | | | 1.058 | | |
| Sucker | Number | 1 | 0 | 0 | 4 | 6 | 4 | 3 | 2 | 20 | 23-49 | 36.6 |
| | Weight (Kg) | 0.560 | | | 3.560 | 7.334 | 2.885 | 0.610 | 1.050 | 15.999 | | |
| Carp | Number | 1 | 3 | 1 | 1 | 0 | 1 | 2 | 2 | 11 | 12-47 | 29.3 |
| | Weight (Kg) | 1.750 | 1.755 | 0.600 | 1.600 | | 0.105 | 0.175 | 0.160 | 6.145 | | |

Table 5. (continued)

| | | 5/2 | 5/6 | 5/10 | 5/14 | 5/18 | 5/22 | 5/26 | 5/30 | Monthly Total | Total Length(cm) Range | Total Length(cm) Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Northern pike | Number | 4 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 7 | 30-57 | 44.4 |
| | Weight (Kg) | 4.050 | 0.550 | | | | | 1.000 | 0.245 | 5.845 | | |
| Walleye | Number | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 3 | 5 | 19-37 | 25.9 |
| | Weight (Kg) | | 0.060 | | | | 0.420 | | 0.255 | 0.735 | | |
| Burbot | Number | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 1 | 5 | 7-49 | 34.0 |
| | Weight (Kg) | | 0.020 | | 4.300 | | | | 0.180 | 4.500 | | |
| White bass | Number | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 3 | 23-26 | 24.7 |
| | Weight (Kg) | | | 0.250 | | | | | 0.395 | 0.645 | | |
| Crappie | Number | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 20 | 20 |
| | Weight (Kg) | | 0.105 | | | | | | | 0.105 | | |

Table 6. Summary of plant operating and fish impingement data collected at Pulliam Power Plant, June 1975.

| | | 6/3 | 6/7 | 6/11 | 6/15 | 6/19 | 6/23 | 6/29 | Monthly Total | Total Length(cm) Range | Total Length(cm) Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | | | | | | | | | | | |
| Average flow ($m^3$/min) | | 795.0 | 246.2 | 544.7 | 375.0 | 1193.1 | 1003.9 | 1244.9 | | | |
| Intake temperature (°C) | | 17-18 | 16-19 | 18-19 | 16-19 | 17-21 | 21-25 | 20-25 | | | |
| Discharge temperature (°C) | | 24-27 | 22-26 | 26-30 | 22-25 | 22-27 | 27-32 | 26-32 | | | |
| Number of times screens operated since last sample | | 106 | 141 | 164 | 170 | 168 | 199 | 256 | | | |
| Species | | | | | | | | | | | |
| Alewife | Number | 1211 | 1092 | 8355 | 5171 | 13339 | 20990 | 12182 | 62340 | 16-22.4 | 18.6 |
| | Weight (Kg) | 47.216 | 41.087 | 340.500 | 197.944 | 562.960 | 995.622 | 522.554 | 270.883 | | |
| Yellow perch | Number | 230 | 15 | 32 | 14 | 8 | 4 | 3 | 306 | 10-25 | 17.9 |
| | Weight (Kg) | 15.300 | 1.130 | 2.840 | 1.045 | 0.505 | 0.375 | 0.225 | 21.420 | | |
| Bullhead | Number | 21 | 0 | 8 | 16 | 9 | 0 | 9 | 63 | 9-27 | 19.4 |
| | Weight (Kg) | 1.817 | 0 | 1.095 | 2.570 | 1.790 | 0 | 1.070 | 8.342 | | |
| Bullhead (Black) | Number | 0 | 8 | 0 | 0 | 0 | 8 | 0 | 16 | 14.4-23.09 | 18.8 |
| | Weight (Kg) | 0 | 0.845 | 0 | 0 | 0 | 0.755 | 0 | 1.600 | | |
| Walleye | Number | 2 | 1 | 6 | 1 | 1 | 0 | 4 | 15 | 18-33 | 23.9 |
| | Weight (Kg) | 0.110 | 0.100 | 0.625 | 0.105 | 0.210 | 0 | 0.630 | 1.780 | | |
| Shiner | Number | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 6-12.5 | 10.3 |
| | Weight (Kg) | 0.014 | 0 | 0 | 0 | 0 | 0 | 0 | 0.014 | | |
| Carp | Number | 1 | 1 | 0 | 2 | 0 | 0 | 1 | 5 | 15-53.3 | 27.2 |
| | Weight (Kg) | 1.362 | 0.050 | 0 | 0.170 | 0 | 0 | 0.110 | 1.692 | | |

Table 6. (continued)

| | | 6/3 | 6/7 | 6/11 | 6/15 | 6/19 | 6/23 | 6/29 | Monthly Total | Total Length(cm) Range | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Troutperch | Number | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 5 | 13-14 | 13.4 |
| | Weight (Kg) | 0 | 0 | 0 | 0.075 | 0 | 0 | 0 | 0.075 | | |
| Northern pike | Number | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 3 | 23-70 | 44.3 |
| | Weight (Kg) | 0 | 0 | 1.500 | 0 | 0 | 0 | 0.575 | 2.075 | | |
| Sucker | Number | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 46.2 | 46.2 |
| | Weight (Kg) | 0.454 | 0 | 0 | 0 | 0 | 0 | 0 | 0.454 | | |
| White bass | Number | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 24 | 24 |
| | Weight (Kg) | 0 | 0.165 | 0 | 0 | 0 | 0 | 0 | 0.165 | | |
| Crappie | Number | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 26 | 26 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0 | 0.230 | 0.230 | | |

Table 7. Summary of plant operating and fish impingement data collected at Pulliam Power Plant, July 1975.

| Date | | 7/1 | 7/5 | 7/9 | 7/13 | 7/17 | 7/21 | 7/25 | 7/28 | Monthly Total | Total Length (cm) Range | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | | | | | | | | | | | | |
| Average Flow ($m^3$/min) | | 1362.2 | 528.1 | 1165.4 | 554.5 | 1403.7 | 1008.7 | 870.3 | 1180.9 | | | |
| Intake Temperature (°C) | | 23-26 | 21-24 | 23-25 | 19-22 | 20-24 | 22-25 | 19-24 | 16-20 | | | |
| Discharge Temperature (°C) | | 30-32 | 28-34 | 28-32 | 25-30 | 25-30 | 28-32 | 26-30 | 20-26 | | | |
| Number of times screen operated since last sample | | 258 | 222 | 224 | 176 | 180 | 214 | 224 | 138 | | | |
| Species | | | | | | | | | | | | |
| Alewife | Number | 8442 | 8031 | 5032 | 1457 | 4256 | 3745 | 510 | 2450 | 33923 | 14-225 | 18.5 |
| | Weight (Kg) | 549.340 | 323.248 | 481.694 | 64.468 | 140.740 | 149.366 | 19.930 | 112.138 | 1804.924 | | |
| Bullhead (Black) | Number | 9 | 8 | 90 | 117 | 19 | 48 | 6 | 10 | 307 | 12.5-31 | 19.9 |
| | Weight (Kg) | 2.017 | 0.915 | 9.080 | 9.534 | 2.830 | 2.270 | 0.850 | 1.122 | 28.618 | | |
| Yellow perch | Number | 0 | 9 | 6 | 14 | 4 | 15 | 10 | 5 | 63 | 13.7-25 | 18.0 |
| | Weight (Kg) | 0 | 1.167 | 0.650 | 1.115 | 0.375 | 1.042 | 1.800 | 0.445 | 5.594 | | |
| Burbot | Number | 0 | 2 | 1 | 0 | 0 | 0 | 2 | 2 | 7 | 25-49.5 | 33.8 |
| | Weight (Kg) | 0 | 0.325 | | 0 | 0 | 0 | 0.445 | 1.190 | 2.310 | | |
| Northern pike | Number | 1 | 0 | 3 | 1 | 1 | 0 | 0 | 0 | 6 | 37-53.3 | 43.5 |
| | Weight (Kg) | 0.896 | 0 | 1.605 | 0.908 | 1.000 | 0 | 0 | 0 | 4.409 | | |
| Crappie (Black) | Number | 0 | 0 | 6 | 0 | 0 | 4 | 0 | 0 | 10 | 16-26 | 22.0 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0.720 | 0 | 0 | 1.650 | | |
| Shiner (Spottail, Golden) | Number | 0 | 0 | 0 | 0 | 2 | 8 | 0 | 0 | 10 | 9-24.9 | 14.8 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0.015 | 0.690 | 0 | 0 | 0.705 | | |
| Carp | Number | 0 | 0 | 2 | 0 | 3 | 0 | 0 | 0 | 5 | 10-44 | 30.2 |
| | Weight (Kg) | 0 | 0 | 1.210 | 0 | 0.450 | 0 | 0 | 0 | 1.660 | | |
| Walleye | Number | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 22-25 | 23.7 |
| | Weight (Kg) | 0 | 0.495 | 0 | 0 | 0 | 0 | 0 | 0 | 0.495 | | |
| Sucker | Number | 0 | 3 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 25-43 | 34.0 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0 | 1.340 | 0 | 1.340 | | |
| White bass | Number | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 16.7 | 16.7 |
| | Weight (Kg) | 0 | 0 | 0 | 0.060 | 0 | 0 | 0 | 0 | 0.060 | | |
| Gar | Number | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 55.5 | 55.5 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0.400 | 0 | 0 | 0.400 | | |
| Rainbow trout | Number | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 27.5 | 27.5 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.210 | 0.210 | | |

Table 8. Summary of plant operating and fish impingement data collected at Pulliam Power Plant, August 1975.

| Date | | 8/2 | 8/6 | 8/10 | 8/14 | 8/18 | 8/22 | 8/26 | 8/30 | Monthly Total | Total Length (cm) Range | Total Length (cm) Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | | | | | | | | | | | | |
| Average Flow ($m^3$/min) | | 681.2 | 602.3 | 342.8 | 833.3 | 736.1 | 709.7 | 511.8 | 534.1 | | | |
| Intake Temperature (°C) | | 15-18 | 18-21 | 17-19 | 20-22 | 20-21 | 19-21 | 19-22 | 18-19 | | | |
| Discharge Temperature (°C) | | 19-24 | 24-29 | 24-26 | 26-30 | 25-30 | 24-29 | 25-27 | 23-26 | | | |
| Number of times screens operated since last sample | | 274 | 176 | 162 | 212 | 160 | 130 | 118 | 168 | | | |
| Species | | | | | | | | | | | | |
| Alewife | Number | 5530 | 7653 | 780 | 2999 | 1173 | 495 | 1478 | 12 | 20120 | 13.1-20.9 | 18.2 |
| | Weight (Kg) | 192.496 | 325.518 | 35.866 | 110.776 | 45.854 | 24.516 | 69.916 | 0.505 | 805.447 | | |
| Bullhead (Black) | Number | 11 | 15 | 0 | 18 | 11 | 0 | 27 | 358 | 440 | 7-28 | 17.4 |
| | Weight (Kg) | 0.725 | 1.785 | 0 | 2.355 | 0.806 | 0 | 1.526 | 29.510 | 36.707 | | |
| Yellow perch | Number | 17 | 15 | 7 | 17 | 28 | 5 | 19 | 12 | 121 | 13.9-25 | 18.8 |
| | Weight (Kg) | 1.430 | 1.280 | 1.275 | 1.275 | 1.755 | 0.575 | 1.500 | 0.285 | 8.595 | | |
| Burbot | Number | 4 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 8 | 23-49 | 32.5 |
| | Weight (Kg) | 0.975 | 0.225 | 0 | 0.590 | 0 | 0 | 0 | 0 | 1.790 | | |
| Sucker | Number | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 5 | 18-30.7 | 27.3 |
| | Weight (Kg) | 0 | 0 | 0 | 1.245 | 0 | 0 | 0 | 0 | 1.245 | | |
| Carp | Number | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 25-39 | 31.0 |
| | Weight (Kg) | 1.100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.100 | | |
| Northern pike | Number | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 21-61 | 47.3 |
| | Weight (Kg) | 0 | 0.550 | 0 | 0 | 1.589 | 0 | 0 | 0 | 2.139 | | |
| Walleye | Number | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 24-30 | 27.0 |
| | Weight (Kg) | 0 | 0.105 | 0 | 0 | 0 | 0.275 | 0 | 0 | 0.380 | | |
| Crappie | Number | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 22 | 22.0 |
| | Weight (Kg) | 0 | 0 | 0 | 0.200 | 0 | 0 | 0 | 0 | 0.200 | | |
| Freshwater drum | Number | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 37 | 37.0 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0.625 | 0 | 0 | 0 | 0.625 | | |
| Bowfin | Number | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 35.5 | 35.5 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0 | 0.290 | 0 | 0.290 | | |
| Coho salmon | Number | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 14 | 14.0 |
| | Weight (Kg) | 0 | 0.020 | 0 | 0 | 0 | 0 | 0 | 0 | 0.020 | | |

Table 9. Summary of plant operating and fish impingement data collected at Pulliam Power Plant, September 1975.

| Date | | 9/3 | 9/7 | 9/11 | 9/15 | 9/19 | 9/23 | 9/26 | Monthly Total | Total Length (cm) Range | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | | | | | | | | | | | |
| Average Flow ($m^3$/min) | | 675.6 | 375.9 | 969.5 | 874.9 | 1004.7 | 721.8 | 365.7 | | | |
| Intake Temperature (°C) | | 19 | 16-20 | 16-19 | 15-18 | 15-19 | 12-16 | 11-14 | | | |
| Discharge Temperature (°C) | | 23-28 | 24-26 | 22-26 | 20-25 | 21-27 | 20-25 | 17-22 | | | |
| Number of times screens operated since last sample | | 144 | 206 | 222 | 143 | 296 | 178 | 252 | | | |
| Species | | | | | | | | | | | |
| Alewife | Number | 37 | 105 | 252 | 243 | 293 | 233 | 15 | 1178 | 7.5-21 | 16.9 |
| | Weight (Kg) | 0.264 | 3.632 | 16.798 | 5.903 | 10.896 | 9.193 | 0.335 | 47.021 | | |
| Bullhead (Black) | Number | 47 | 77 | 539 | 372 | 13 | 16 | 15 | 1079 | 5-27 | 13.3 |
| | Weight (Kg) | 1.531 | 1.800 | 9.988 | 12.258 | 1.155 | 2.552 | 0.212 | 29.496 | | |
| Yellow perch | Number | 15 | 48 | 12 | 52 | 26 | 153 | 26 | 332 | 6-22.5 | 14.9 |
| | Weight (Kg) | 0.875 | 0.550 | 1.988 | 1.135 | 2.490 | 2.156 | 0.240 | 9.434 | | |
| Carp | Number | 0 | 52 | 0 | 56 | 8 | 7 | 5 | 128 | 6-21 | 12.4 |
| | Weight (Kg) | 0 | 0.435 | 0 | 0.454 | 0.435 | 0.518 | 0.055 | 1.897 | | |
| Walleye | Number | 0 | 5 | 0 | 0 | 1 | 3 | 0 | 9 | 8.5-21 | 16.9 |
| | Weight (Kg) | 0 | 0.048 | 0 | 0 | 0.075 | 0.265 | 0 | 0.388 | | |
| Bluegill | Number | 0 | 2 | 0 | 5 | 0 | 0 | 2 | 9 | 4-8 | 5.3 |
| | Weight (Kg) | 0 | 0.008 | 0 | 0.008 | 0 | 0 | 0.004 | 0.020 | | |
| White bass | Number | 0 | 1 | 0 | 4 | 1 | 0 | 1 | 7 | 13-25 | 22.0 |
| | Weight (Kg) | 0 | 0.205 | 0 | 0.390 | 0.150 | 0 | 0.120 | 0.865 | | |
| Shiner (Spottail) | Number | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 6 | 7-8 | 7.3 |
| | Weight (Kg) | 0 | 0.031 | 0 | 0 | 0 | 0 | 0 | 0.031 | | |
| Crappie | Number | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 5 | 7-10 | 8.3 |
| | Weight (Kg) | 0 | 0.038 | 0 | 0 | 0 | 0 | 0 | 0.038 | | |
| Burbot | Number | 0 | 2 | 0 | 3 | 0 | 0 | 0 | 5 | 12-20 | 14.9 |
| | Weight (Kg) | 0 | 0.030 | 0 | 0.075 | 0 | 0 | 0 | 0.105 | | |
| Sucker | Number | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 40 | 40.0 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0.040 | 0 | 0.040 | | |

Table 10. Summary of plant operating and fish impingement data collected at Pulliam Power Plant, October 1975.

| Date | | 10/1 | 10/5 | 10/9 | 10/13 | 10/17 | 10/21 | 10/25 | 10/29 | Monthly Total | Total Length (cm) Range | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | | | | | | | | | | | | |
| Average Flow ($m^3$/min) | | 435.7 | 406.7 | 744.8 | 627.9 | 687.0 | 831.4 | 686.7 | 949.3 | | | |
| Intake Temperature (°C) | | 11.6-13.2 | 11.0-12.6 | 12.6-14.8 | 9.9-13.2 | 9.9-13.2 | 8.8-11.0 | 9.4-12.6 | 9.4-12.6 | | | |
| Discharge Temperature (°C) | | 17.0-22.0 | 16.5-22.6 | 17.0-23.6 | 17.6-22.0 | 17.6-22.0 | 16.0-20.9 | 16.5-20.9 | 14.3-20.9 | | | |
| Number of times screens operated since last sample | | 188 | 148 | 296 | 134 | 276 | 174 | 288 | 236 | | | |
| Species | | | | | | | | | | | | |
| Yellow Perch | Number | 23 | 253 | 3830 | 4419 | 2202 | 589 | 2897 | 885 | 15098 | 8-22 | 10.9 |
| | Weight (Kg) | 0.224 | 5.270 | 3.800 | 46.524 | 21.792 | 5.448 | 39.952 | 14.827 | 137.837 | | |
| Bullhead | Number | 0 | 113 | 9 | 448 | 1 | 597 | 1518 | 46 | 2732 | 5-31 | 13.1 |
| | Weight (Kg) | 0 | 2.708 | 0.762 | 7.053 | 0.110 | 3.178 | 35.866 | 1.135 | 50.812 | | |
| Alewife | Number | 20 | 69 | 0 | 623 | 0 | 0 | 199 | 7 | 918 | 5-22 | 14.9 |
| | Weight (Kg) | 1.350 | 3.250 | 0 | 15.696 | 0 | 0 | 2.305 | 0.125 | 22.726 | | |
| Shiner | Number | 0 | 4 | 0 | 1 | 0 | 0 | 67 | 0 | 72 | 6-18.5 | 13.3 |
| | Weight (Kg) | 0 | 0.085 | 0 | 0.025 | 0 | 0 | 0.438 | 0 | 0.548 | | |
| Sucker | Number | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 0 | 28 | 13-18 | 15.8 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0 | 1.135 | 0 | 1.135 | | |
| Burbot | Number | 0 | 5 | 0 | 4 | 0 | 0 | 13 | 2 | 24 | 15.5-56 | 26.3 |
| | Weight (Kg) | 0 | 2.417 | 0 | 0.485 | 0 | 0 | 0.660 | 0.385 | 0.385 | | |
| Carp | Number | 0 | 14 | 0 | 0 | 0 | 0 | 7 | 0 | 21 | 9-22 | 12.8 |
| | Weight (Kg) | 0 | 0.856 | 0 | 0 | 0 | 0 | 0.123 | 0 | 0.979 | | |
| White Bass | Number | 0 | 5 | 0 | 5 | 0 | 0 | 0 | 0 | 10 | 10-24 | 14.9 |
| | Weight (Kg) | 0 | 0.355 | 0 | 0.325 | 0 | 0 | 0 | 0 | 0.680 | | |
| Freshwater Drum | Number | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 8 | 8-13 | 10.6 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0 | 0.120 | 0 | 0.120 | | |
| Walleye | Number | 0 | 0 | 3 | 3 | 0 | 0 | 1 | 0 | 7 | 16-35 | 23.0 |
| | Weight (Kg) | 0 | 0 | 0.695 | 0.665 | 0 | 0 | 0.080 | 0 | 1.440 | | |
| Northern Pike | Number | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 50 | 50.0 |
| | Weight (Kg) | 0 | 0 | 0 | 0.750 | 0 | 0 | 0 | 0 | 0.750 | | |
| Rainbow Smelt | Number | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 18.5 | 18.5 |
| | Weight (Kg) | 0 | 0 | 0 | 0.032 | 0 | 0 | 0 | 0 | 0.032 | | |

Table 11. Summary of plant operating and fish impingement data collected at Pulliam Power Plant, November 1975.

| Date | | 11/2 | 11/6 | 11/10 | 11/14 | 11/18 | 11/22 | 11/26 | 11/30 | Monthly Total | Total Length (cm) Range | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | | | | | | | | | | | | |
| Average Flow ($m^3$/min) | | 609.1 | 628.3 | 492.3 | 542.63 | 400.6 | 313.5 | 481.8 | 310.6 | | | |
| Intake Temperature (°C) | | 7.2-8.2 | 8.8-10.4 | 8.2-12.1 | 2.8-7.7 | 4.4-5.5 | 2.2-5.0 | 0-2.8 | -1.1-1.1 | | | |
| Discharge Temperature (°C) | | 13.2-16.0 | 14.8-19.8 | 14.8-19.2 | 8.8-16.5 | 10.4-17.0 | 8.2-12.6 | 7.2-12.6 | 5.5-8.2 | | | |
| Number of times screen operated since last sample | | 316 | 300 | 174 | 136 | 114 | 168 | 238 | 140 | | | |
| Species | | | | | | | | | | | | |
| Yellow Perch | Number | 1649 | 1208 | 1437 | 552 | 300 | 466 | 214 | 987 | 6813 | 8-20 | 11.7 |
| | Weight (Kg) | 21.376 | 15.436 | 20.884 | 5.221 | 4.540 | 13.393 | 7.151 | 14.301 | 102.302 | | |
| Bullhead | Number | 234 | 308 | 603 | 5 | 90 | 523 | 15 | 391 | 2169 | 6-28.5 | 13.2 |
| | Weight (Kg) | 11.577 | 4.767 | 11.350 | 0.665 | 0.408 | 8.967 | 1.285 | 22.246 | 61.765 | | |
| Alewife | Number | 0 | 6831 | 3 | 0 | 0 | 0 | 0 | 68 | 6902 | 10-18 | 14.8 |
| | Weight (Kg) | 0 | 18.160 | 0.055 | 0 | 0 | 0 | 0 | 1.135 | 19.350 | | |
| White Bass | Number | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 7 | 13 | 10-20 | 14.3 |
| | Weight (Kg) | 0 | 0 | 0.165 | 0 | 0 | 0 | 0 | 0.115 | 0.280 | | |
| Sucker | Number | 0 | 0 | 4 | 0 | 0 | 4 | 0 | 4 | 12 | 14-25 | 16.9 |
| | Weight (Kg) | 0 | 0 | 0.370 | 0 | 0 | 0.143 | 0 | 0.205 | 0.718 | | |
| Burbot | Number | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 3 | 8 | 16-51 | 25.1 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0.192 | 0 | 1.460 | 1.652 | | |
| Carp | Number | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 6 | 10-13 | 11.6 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.148 | 0.148 | | |
| Northern Pike | Number | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 3 | 37-68 | 50.8 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0.915 | 0 | 3.260 | 4.175 | | |
| Channel catfish | Number | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 21 | 21.0 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.080 | 0.080 | | |
| Gar | Number | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 51 | 51.0 |
| | Weight (Kg) | 0 | 0 | 0.450 | 0 | 0 | 0 | 0 | 0 | 0.450 | | |

Table 12. Summary of plant operating and fish impingement data collected at Pulliam Power Plant, December 1975.

| Date | | 12/7 | 12/12 | 12/16 | 12/20 | 12/24 | 12/28 | Monthly Total | Total Length (cm) Range | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | | | | | | | | | | |
| Average Flow ($m^3$/min) | | 342.6 | 591.3 | 533.1 | 364.6 | 388.6 | 213.1 | | | |
| Intake Temperature (°C) | | -0.6-0.6 | 0-0.6 | 0-2.8 | -0.6-0 | -1.6-0.6 | -1.6-0.6 | | | |
| Discharge Temperature (°C) | | 4.4-9.9 | 6.1-14.3 | 7.2-14.3 | 5.0-12.6 | 5.0-11.6 | 3.8-7.7 | | | |
| Number of times screen operated since last sample | | 132 | 210 | 156 | 202 | 152 | 86 | | | |
| Species | | | | | | | | | | |
| Yellow perch | Number | 124 | 234 | 74 | 15 | 15 | 99 | 561 | 9.0-19.0 | 11.4 |
| | Weight (Kg) | 1.929 | 2.156 | 1.702 | 0.296 | 0.296 | 0.794 | 7.173 | | |
| Gizzard shad | Number | 547 | 0 | 13 | 0 | 0 | 0 | 560 | 8.0-16.0 | 11.7 |
| | Weight (Kg) | 6.129 | 0 | 0.361 | 0 | 0 | 0 | 6.490 | | |
| Bullhead | Number | 39 | 7 | 25 | 18 | 11 | 78 | 177 | 5.0-26.0 | 14.1 |
| | Weight (Kg) | 0.794 | 0.347 | 1.883 | 0.175 | 0.235 | 4.086 | 7.520 | | |
| Freshwater drum | Number | 0 | 4 | 0 | 4 | 0 | 6 | 14 | 9.0-15.0 | 12.9 |
| | Weight (Kg) | 0 | 0.055 | 0 | 0.100 | 0 | 0.125 | 0.280 | | |
| Mooneye | Number | 0 | 8 | 0 | 0 | 0 | 0 | 8 | 12.0-17.0 | 15.0 |
| | Weight (Kg) | 0 | 0.155 | 0 | 0 | 0 | 0 | 0.155 | | |
| White bass | Number | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 9.5-12.0 | 11.1 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0.095 | 0.095 | | |
| Alewife | Number | 0 | 0 | 0 | 4 | 0 | 0 | 4 | 10.0-16.0 | 54.0 |
| | Weight (Kg) | 0 | 0 | 0 | 0.040 | 0 | 0 | 0.040 | | |
| Rainbow smelt | Number | 0 | 0 | 3 | 0 | 0 | 0 | 3 | 20.0-21.0 | 20.3 |
| | Weight (Kg) | 0 | 0 | 0.127 | 0 | 0 | 0 | 0.127 | | |
| Crappie (Black) | Number | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 20.0 | 20.0 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0.115 | 0 | 0.115 | | |



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Table 13. Summary of plant operating and fish impingement data collected at Pulliam Power Plant, January 1976.

| Date | | 1/1 | 1/5 | 1/9 | 1/13 | 1/18 | 1/21 | 1/25 | 1/29 | Monthly Total | Total Length (cm) Range | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | | | | | | | | | | | | |
| Average Flow ($m^3$/min) | | 187.5 | 591.3 | 607.4 | 532.4 | 336.4 | 581.6 | 310.6 | 461.9 | | | |
| Intake Temperature (°C) | | 0-0 | -0.6-3.3 | -0.6-1.6 | -1.1-0.6 | -0.6-2.2 | -0.6-1.1 | -0.6-0 | -0.6-1.6 | | | |
| Discharge Temperature (°C) | | 8.8-19.8 | 5.5-15.4 | 5.5-14.8 | 5.0-13.8 | 6.0-13.8 | 6.0-13.2 | 5.5-9.4 | 6.0-16.0 | | | |
| Number of times screen operated since last sample | | 158 | 156 | 256 | 158 | 250 | 182 | 200 | 148 | | | |
| Species | | | | | | | | | | | | |
| Yellow Perch | Number | 23 | 234 | 154 | 18 | 73 | 76 | 98 | 529 | 1205 | 9.0-14.0 | 11.1 |
| | Weight (Kg) | 0.359 | 2.270 | 1.248 | 0.185 | 0.454 | 0.456 | 0.681 | 4.994 | 10.647 | | |
| Bullhead | Number | 3 | 23 | 7 | 15 | 7 | 10 | 7 | 0 | 72 | 9.0-25.0 | 20.6 |
| | Weight (Kg) | 0.085 | 0.359 | 0.125 | 0.401 | 0.225 | 0.270 | 0.083 | 0 | 1.548 | | |
| Freshwater Drum | Number | 0 | 3 | 5 | 2 | 8 | 0 | 0 | 0 | 18 | 10.0-17.0 | 12.6 |
| | Weight (Kg) | 0 | 0.055 | 0.050 | 0.030 | 0.119 | 0 | 0 | 0 | 0.254 | | |
| White Bass | Number | 0 | 4 | 0 | 3 | 0 | 0 | 0 | 0 | 7 | 11.0-13.0 | 9.6 |
| | Weight (Kg) | 0 | 0.069 | 0 | 0.040 | 0 | 0 | 0 | 0 | 0.109 | | |
| Sucker | Number | 0 | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 5 | 16.0-17.0 | 16.2 |
| | Weight (Kg) | 0 | 0 | 0.020 | 0.135 | 0 | 0 | 0 | 0 | 0.155 | | |
| Burbot | Number | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 18.0 | 18.0 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0.030 | 0 | 0 | 0 | 0.030 | | |

Table 14. Summary of plant operating and fish impingement data collected at Pulliam Power Plant, February 1976.

| Date | | 2/2 | 2/6 | 2/10 | 2/14 | 2/18 | 2/22 | 2/26 | Monthly Total | Total Length (cm) Range | Total Length (cm) Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | | | | | | | | | | | |
| Average Flow ($m^3$/min) | | 480.3 | 526.5 | 358.6 | 412.4 | 603.4 | 310.6 | 526.4 | | | |
| Intake Temperature (°C) | | -1.1-0.6 | -0.6-1.1 | -0.6-0.6 | -2.2-1.1 | -1.1-0.6 | -2.2-(-)1.6 | 1.1-2.2 | | | |
| Discharge Temperature (°C) | | 5.0-12.6 | 6.6-14.3 | 5.0-12.1 | 5.5-12.1 | 4.4-12.1 | 3.8-8.8 | 4.4-10.4 | | | |
| Number of times screen operated since last sample | | 124 | 168 | 100 | 76 | 236 | 208 | 268 | | | |
| Species | | | | | | | | | | | |
| Yellow perch | Number | 248 | 74 | 91 | 129 | 24 | 25 | 33 | 624 | 8.0-20.0 | 11.2 |
| | Weight (Kg) | 2.724 | 0.451 | 0.655 | 1.959 | 0.374 | 0.498 | 0.341 | 7.002 | | |
| Bullhead | Number | 28 | 26 | 18 | 28 | 10 | 10 | 11 | 131 | 6.0-26.0 | 9.4 |
| | Weight (Kg) | 0.454 | 0.221 | 0.131 | 0.546 | 0.081 | 0.072 | 0.072 | 1.577 | | |
| Freshwater drum | Number | 8 | 10 | 1 | 9 | 0 | 0 | 0 | 28 | 10.0-18.0 | 13.1 |
| | Weight (Kg) | 0.114 | 0.156 | 0.016 | 0.193 | 0 | 0 | 0 | 0.479 | | |
| White bass | Number | 10 | 0 | 1 | 0 | 0 | 1 | 0 | 12 | 10.0-20.0 | 13.4 |
| | Weight (Kg) | 0.150 | 0 | 0.048 | 0 | 0 | 0.030 | 0 | 0.228 | | |
| Carp | Number | 1 | 0 | 3 | 0 | 5 | 0 | 0 | 9 | 10.0-12.0 | 10.9 |
| | Weight (Kg) | 0.026 | 0 | 0.057 | 0 | 0.056 | 0 | 0 | 0.139 | | |
| Burbot | Number | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 22.0-50.0 | 32.0 |
| | Weight (Kg) | 0.077 | 0 | 0 | 0 | 0 | 1.362 | 0 | 1.439 | | |
| Grappie (Black) | Number | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 3 | 20.0-22.0 | 21.0 |
| | Weight (Kg) | 0 | 0 | 0.414 | 0 | 0 | 0 | 0 | 0.414 | | |
| Shiner (Emerald, Spottail) | Number | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 6.0-8.5 | 7.3 |
| | Weight (Kg) | 0 | 0 | 0.038 | 0 | 0 | 0.003 | 0 | 0.041 | | |
| Sucker | Number | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 16.0 | 16.0 |
| | Weight (Kg) | 0 | 0 | 0.038 | 0 | 0 | 0 | 0 | 0.038 | | |



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Table 15. Summary of plant operating and fish impingement data collected at Pulliam Power Plant, March 1976.

| Date | | 3/1 | 3/5 | 3/9 | 3/13 | 3/17 | 3/22 | Monthly Total | Total Length (cm) Range | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | | | | | | | | | | |
| Average Flow ($m^3$/min) | | 601.4 | 624.2 | 607.4 | 567.3 | 623.6 | 628.4 | | | |
| Intake Temperature (°C) | | 0.6-2.2 | 0-1.6 | 0.6-2.2 | 1.1-3.3 | 2.2-3.8 | 0.6-3.3 | | | |
| Discharge Temperature (°C) | | 3.8-13.2 | 3.8-11.6 | 3.8-13.8 | 6.6-13.2 | 7.2-12.1 | 4.4-12.6 | | | |
| Number of times screen operated since last sample | | 188 | 236 | 206 | 280 | 238 | 234 | | | |
| Species | | | | | | | | | | |
| Yellow perch | Number | 113 | 40 | 11 | 26 | 11 | 1001 | 1210 | 8.0-21.6 | 11.2 |
| | Weight (Kg) | 1.176 | 0.485 | 0.142 | 0.419 | 0.119 | 16.309 | 18.788 | | |
| Bullhead | Number | 30 | 15 | 7 | 10 | 9 | 9 | 80 | 7.0-21.0 | 10.6 |
| | Weight (Kg) | 0.486 | 0.176 | 0.129 | 0.105 | 0.084 | 0.189 | 1.169 | | |
| Shiner (Emerald Spottail) | Number | 5 | 0 | 0 | 2 | 0 | 3 | 10 | 6.0-10.9 | 7.7 |
| | Weight (Kg) | 0.013 | 0 | 0 | 0.020 | 0 | 0.020 | 0.053 | | |
| Troutperch | Number | 0 | 0 | 0 | 0 | 0 | 8 | 8 | 9.4-13.5 | 11.6 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0.138 | 0.138 | | |
| Sucker (White) | Number | 0 | 0 | 3 | 0 | 0 | 4 | 7 | 14.0-19.0 | 15.6 |
| | Weight (Kg) | 0 | 0 | 0.116 | 0 | 0 | 0.175 | 0.291 | | |
| Freshwater drum | Number | 3 | 4 | 0 | 0 | 0 | 0 | 7 | 10.0-13.5 | 12.0 |
| | Weight (Kg) | 0.055 | 0.058 | 0 | 0 | 0 | 0 | 0.113 | | |
| Burbot | Number | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 19.0-47.3 | 28.9 |
| | Weight (Kg) | 1.448 | 0 | 0 | 0 | 0 | 0 | 1.448 | | |
| White bass | Number | 2 | 0 | 0 | 1 | 0 | 0 | 3 | 12.8-14.5 | 13.6 |
| | Weight (Kg) | 0.047 | 0 | 0 | 0.034 | 0 | 0 | 0.081 | | |
| Crappie (Black) | Number | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 21.0-23.0 | 22.0 |
| | Weight (Kg) | 0.288 | 0 | 0 | 0 | 0 | 0 | 0.288 | | |
| Longnose sucker | Number | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 16.0-17.0 | 16.5 |
| | Weight (Kg) | 0.078 | 0 | 0 | 0 | 0 | 0 | 0.078 | | |
| Northern pike | Number | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 38.0 | 38.0 |
| | Weight (Kg) | 0.301 | 0 | 0 | 0 | 0 | 0 | 0.301 | | |
| Walleye | Number | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 20.0 | 20.0 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0.056 | 0.056 | | |
| Channel catfish | Number | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 18.7 | 18.7 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0.048 | 0.048 | | |



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B. Eggs and Larvae

Sampling for entrained fish eggs, larvae and juveniles was conducted weekly from April 1 through August 31, 1975. Samples were taken in the common discharges for Units 7 and 8 and Units 5 and 6. Discharges were selected for sampling for two reasons: 1) to eliminate possible intake vertical and horizontal stratification, and 2) to sample in a strong current to decrease net avoidance.

The common discharge for Units 7 and 8 was chosen as representative of the water drawn from the Fox River (south) intake. The discharge for Units 5 and 6 was chosen as strongly representative of the water from the Green Bay (north) intake. Water from both intakes at times probably mixes in Units 5 and 6 but usually only Units 5 through 8 were operating. Discharges for Units 3 and 4 were sampled on occasion but the current was insufficient to deploy the nets; samples were thus not considered representative. For the purpose of analysis, it was presumed that all water flowing through Units 7 and 8 came from the Fox River and water flowing through Units 5 and 6 came from Green Bay. When only Units 7 and 8 were operating, all water was presumed to originate from the south intake.

Entrainment samples consisted of quadruple replicates (two nets set twice) taken at 1600, 2400 and 0800 during one 24-hour period. Number 0 mesh (526 μ aperture) Nitex cone plankton nets with one-meter barrel collars were used. Each net was equipped with a General Oceanics Number 2030 digital flow meter centered in the net opening. The total number of cubic meters

sampled per net set was computed using the appropriate formula. A target number of $\cong$50 $m^3$/replicate was chosen but the actual number varied with sampling conditions.

Fish eggs, larvae and debris were field sorted using a fluorescent lighted macroscope and eggs and larvae were preserved in 10% formalin for laboratory analysis. Eggs were counted and measured to the nearest 1/10 millimeter using a Bausch & Lomb Stereo Zoom 7 microscope fitted with an ocular micrometer. If eggs were too numerous to count, a subsample was taken and the total number estimated. Eggs were tentatively identified to species. The large variety of species available in both Green Bay and the Fox River made absolute identification impossible.

Larvae were measured to the nearest 0.1 mm, identified to species or infrequently to genera or family using Fish (1932), Mansueti and Hardy (1967), Norden (1961), various single-species references and NALCO ES reference collections from lake and river systems. Juveniles were separated from larvae when young fish attained full adult fin ray counts (Mansueti and Hardy 1967). This system is somewhat arbitrary but is only intended to give an indication of the relative age and size of animals entrained. All larvae and juveniles of each species can be lumped as young-of-year.

Plant operating data collected on entrainment sampling days included intake and discharge temperatures (°C), flow through each unit ($m^3$/min) and percent of total Plant capacity at the time each sample was taken. Intake and discharge temperatures were

taken concurrently to sampling using a YSI Telethermometer. Intake temperatures, pumps operating and rated capacities and percent total turbine capacity were provided by Wisconsin Public Service Corporation.

Monthly summary tables of Plant operating conditions and egg and larval total numbers and concentrations by water source were prepared. Observed densities of eggs by diameter range and of larvae by species were calculated per sampling day and a monthly mean computed. The estimated total number of entrained eggs and larvae was calculated using the formula:

$$\text{Total Entrained} = \text{Mean Monthly Density } (No/m^3) \times \text{Mean Observed Flow } (m^3/min) \times \frac{1440 \text{ Min}}{\text{Day}} \times \text{Days In Month}$$

The average volume of water sampled per net set over the entire sampling period was 58 to 62 $m^3$ (Table 16). The average number of cubic meters passing through the nets per day was approximately 12 times this number (4 replicates, 3 times per day). This would be approximately 540 $m^3$ of Green Bay water and 1092 $m^3$ of Fox River water in April. Limiting factors in the maximum number of cubic meters sampled were first the flow rate in the discharge and second the volume of zooplankton, phytoplankton and detritus collected per net set. Ranges in volumes sampled stem mainly from variations in discharge flow during the sampling period (high flow during the day, low flow at night) rather than differences between replicates.

The total numbers of eggs and larvae collected per replicate, day and month are summarized in Tables 17 through 21.

Table 16. Mean and range (difference between largest and smallest) number of cubic meters per replicate sampled at Pulliam Power Plant, April through August 1975.

| Month | Green Bay Water | | Fox River Water | |
|---|---|---|---|---|
| | Mean | Range | Mean | Range |
| April | 70 | ±17 | 91 | ±23 |
| May | 55 | ±21 | 55 | ±13.5 |
| June | 57 | ± 6 | 49 | ±10 |
| July | 56 | ±14.5 | 60 | ±11 |
| August | 54 | ±17.5 | 54 | ±12.5 |
| Entire Sampling Period | 58 | ±15 | 62 | ±28 |



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Table 17. Summary of entrainment sampling data collected at Pulliam Power Plant, April 1975.

| Date | Time | Replicate | Discharge for Units | Eggs Number | Eggs Number/m3 | Larvae Number | Larvae Number/m3 | Discharge for Units | Eggs Number | Eggs Number/m3 | Larvae Number | Larvae Number/m3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apr 2 | 1600 | A | 3 & 4 | 0 | 0.000 | 0 | 0.000 | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | 2400 | A | 3 & 4 | 0 | 0.000 | 0 | 0.000 | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| Apr 3 | 0800 | A | 3 & 4 | 0 | 0.000 | 0 | 0.000 | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | Mean | | | 0.0 | 0.000 | 0.0 | 0.000 | | 0.0 | 0.000 | 0.0 | 0.000 |
| Apr 9 | 1600 | A | 5 & 6 | 0 | 0.000 | 0 | 0.000 | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 4 | 0.057 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 7 | 0.093 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | 2400 | A | 5 & 6 | | Off Line | | | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | | | | | | 0 | 0.000 | 0 | 0.000 |
| | | C | | | | | | | 0 | 0.000 | 0 | 0.000 |
| | | D | | | | | | | 0 | 0.000 | 0 | 0.000 |
| Apr 10 | 0800 | A | 5 & 6 | 11 | 0.151 | 0 | 0.000 | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | 4 | 0.038 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 1 | 0.014 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 20 | 0.028 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | Mean | | | 3.375 | 0.044 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| Apr 16 | 1600 | A | 5 & 6 | 12 | 0.115 | 0 | 0.000 | 7 & 8 | 1 | 0.009 | 0 | 0.000 |
| | | B | | 11 | 0.105 | 0 | 0.000 | | 1 | 0.010 | 0 | 0.000 |
| | | C | | 13 | 0.174 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 14 | 0.035 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | 2400 | A | 5 & 6 | | Off Line | | | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | | | | | | 0 | 0.000 | 0 | 0.000 |
| | | C | | | | | | | 0 | 0.000 | 0 | 0.000 |
| | | D | | | | | | | 0 | 0.000 | 0 | 0.000 |



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Table 17. (continued)

| Date | Time | Replicate | Discharge for Units | Eggs Number | Eggs Number/m3 | Larvae Number | Larvae Number/m3 | Discharge for Units | Eggs Number | Eggs Number/m3 | Larvae Number | Larvae Number/m3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apr 17 | 0800 | A | 5 & 6 | 14 | 0.168 | 0 | 0.000 | 7 & 8 | 2 | 0.018 | 0 | 0.000 |
| | | B | | 19 | 0.184 | 0 | 0.000 | | 4 | 0.030 | 0 | 0.000 |
| | | C | | 20 | 0.175 | 0 | 0.000 | | 3 | 0.023 | 0 | 0.000 |
| | | D | | 12 | 0.114 | 0 | 0.000 | | 2 | 0.025 | 0 | 0.000 |
| | Mean | | | 13.1 | 0.134 | 0 | 0.000 | | 1.6 | 0.010 | 0 | 0.000 |
| Apr 23 | 1600 | A | 5 & 6 | 2 | 0.046 | 0 | 0.000 | 7 & 8 | 2 | 0.037 | 0 | 0.000 |
| | | B | | 1 | 0.014 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 1 | 0.025 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 1 | 0.010 | 0 | 0.000 | | 3 | 0.035 | 0 | 0.000 |
| | 2400 | A | 5 & 6 | | Off Line | | | 7 & 8 | 4 | 0.077 | 0 | 0.000 |
| | | B | | | | | | | 0 | 0.000 | 0 | 0.000 |
| | | C | | | | | | | 2 | 0.039 | 0 | 0.000 |
| | | D | | | | | | | 0 | 0.000 | 0 | 0.000 |
| | 0800 | A | 5 & 6 | 7 | 0.161 | 0 | 0.000 | 7 & 8 | 8 | 0.103 | 0 | 0.000 |
| | | B | | 3 | 0.080 | 0 | 0.000 | | 1 | 0.015 | 0 | 0.000 |
| | | C | | 2 | 0.057 | 0 | 0.000 | | 1 | 0.013 | 0 | 0.000 |
| | | D | | 2 | 0.071 | 0 | 0.000 | | 2 | 0.025 | 0 | 0.000 |
| | Mean | | | 2.4 | 0.059 | 0 | 0.000 | | 1.9 | 0.028 | 0 | 0.000 |
| Apr 30 | 1600 | A | 5 & 6 | 20 | 0.667 | 0 | 0.000 | 7 & 8 | 15 | 0.243 | 0 | 0.000 |
| | | B | | 16 | 0.415 | 1 | 0.026 | | 22 | 0.465 | 0 | 0.000 |
| | | C | | 30 | 0.668 | 0 | 0.000 | | 14 | 0.285 | 0 | 0.000 |
| | | D | | 18 | 0.540 | 0 | 0.000 | | 21 | 0.460 | 0 | 0.000 |
| | 2400 | A | 5 & 6 | 2 | 0.035 | 0 | 0.000 | 7 & 8 | 3 | 0.067 | 0 | 0.000 |
| | | B | | 3 | 0.099 | 0 | 0.000 | | 1 | 0.014 | 0 | 0.000 |
| | | C | | 2 | 0.034 | 0 | 0.000 | | 2 | 0.038 | 0 | 0.000 |
| | | D | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| May 1 | 0800 | A | 5 & 6 | 2 | 0.040 | 0 | 0.000 | 7 & 8 | 1 | 0.016 | 0 | 0.000 |
| | | B | | 1 | 0.023 | 0 | 0.000 | | 1 | 0.025 | 0 | 0.000 |
| | | C | | 2 | 0.037 | 0 | 0.000 | | 1 | 0.016 | 0 | 0.000 |
| | | D | | 1 | 0.017 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | Mean | | | 8.1 | 0.215 | 0.8 | 0.002 | | 6.8 | 0.136 | 0.0 | 0.000 |
| | | Grand Total (April) | | 250 | | 1 | | | 115 | | 0 | |
| | | Grand Mean (April) | | | 0.094 | | <0.001 | | | 0.037 | | 0.000 |



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Table 18. Summary of entrainment sampling data collected at Pulliam Power Plant, May 1975.

| Date | Time | Replicate | Discharge for Units | Eggs Number | Eggs Number/m³ | Larvae Number | Larvae Number/m³ | Discharge for Units | Eggs Number | Eggs Number/m³ | Larvae Number | Larvae Number/m³ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May 7 | 1600 | A | 5 & 6 | 0 | 0.000 | 0 | 0.000 | 7 & 8 | 0 | 0.000 | 1 | 0.020 |
| | | B | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 1 | 0.017 |
| | | C | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 1 | 0.014 |
| | | D | | 17 | 0.390 | 0 | 0.000 | | 0 | 0.000 | 1 | 0.019 |
| | 2400 | A | 5 & 6 | | Off Line | | | 7 & 8 | 5 | 0.062 | 0 | 0.000 |
| | | B | | | | | | | 0 | 0.000 | 0 | 0.000 |
| | | C | | | | | | | 2 | 0.027 | 0 | 0.000 |
| | | D | | | | | | | 0 | 0.000 | 0 | 0.000 |
| May 8 | 0800 | A | 5 & 6 | 0 | 0.000 | 0 | 0.000 | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | 1 | 0.010 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 0 | 0.000 | 0 | 0.000 | | 1 | 0.012 | 2 | 0.024 |
| | | D | | 1 | 0.016 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | Mean | | | 2.4 | 0.051 | 0.0 | 0.000 | | 0.7 | 0.008 | 0.5 | 0.008 |
| May 14 | 1600 | A | 5 & 6 | 0 | 0.000 | 0 | 0.000 | 7 & 8 | 1 | 0.023 | 0 | 0.000 |
| | | B | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | 2400 | A | 5 & 6 | 0 | 0.000 | 0 | 0.000 | 7 & 8 | 2 | 0.054 | 1 | 0.027 |
| | | B | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 0 | 0.000 | 0 | 0.000 | | 1 | 0.024 | 1 | 0.024 |
| | | D | | 0 | 0.000 | 0 | 0.000 | | 1 | 0.022 | 1 | 0.022 |
| May 15 | 0800 | A | 5 & 6 | 0 | 0.000 | 0 | 0.000 | 7 & 8 | 1 | 0.024 | 0 | 0.000 |
| | | B | | 0 | 0.000 | 0 | 0.000 | | 2 | 0.046 | 0 | 0.000 |
| | | C | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | Mean | | | 0.0 | 0.000 | 0.0 | 0.000 | | 0.7 | 0.016 | 0.3 | 0.006 |
| May 21 | | A | 5 & 6 | 1 | 0.014 | 2 | 0.029 | 7 & 8 | 3 | 0.049 | 1 | 0.016 |
| | | B | | 2 | 0.029 | 6 | 0.087 | | 3 | 0.049 | 4 | 0.066 |
| | | C | | 1 | 0.022 | 5 | 0.106 | | 1 | 0.017 | 0 | 0.000 |
| | | D | | 0 | 0.000 | 2 | 0.042 | | 0 | 0.000 | 2 | 0.033 |
| | 2400 | A | 5 & 6 | 2 | 0.026 | 0 | 0.000 | 7 & 8 | 1 | 0.014 | 1 | 0.014 |
| | | B | | 0 | 0.000 | 3 | 0.038 | | 0 | 0.000 | 2 | 0.028 |
| | | C | | 0 | 0.000 | 6 | 0.090 | | 0 | 0.000 | 3 | 0.120 |
| | | D | | 0 | 0.000 | 9 | 0.135 | | 0 | 0.000 | 0 | 0.000 |



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Table 18. (continued)

| Date | Time | Replicate | Discharge for Units | Eggs Number | Eggs Number/m$^3$ | Larvae Number | Larvae Number/m$^3$ | Discharge for Units | Eggs Number | Eggs Number/m$^3$ | Larvae Number | Larvae Number/m$^3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May 22 | 0800 | A | 5 & 6 | 1 | 0.025 | 12 | 0.306 | 7 & 8 | 0 | 0.000 | 2 | 0.034 |
| | | B | | 0 | 0.000 | 5 | 0.128 | | 0 | 0.000 | 6 | 0.103 |
| | | C | | 0 | 0.000 | 5 | 0.155 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 0 | 0.000 | 1 | 0.031 | | 0 | 0.000 | 0 | 0.000 |
| | Mean | | | 0.6 | 0.010 | 4.7 | 0.096 | | 0.7 | 0.011 | 1.8 | 0.035 |
| May 28 | 1600 | A | 5 & 6 | 0 | 0.000 | 1 | 0.020 | 7 & 8 | 0 | 0.000 | 2 | 0.042 |
| | | B | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 1 | 0.021 |
| | | C | | 0 | 0.000 | 1 | 0.022 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 0 | 0.000 | 1 | 0.022 | | 0 | 0.000 | 2 | 0.047 |
| | 2400 | A | 5 & 6 | | Off Line | | | 7 & 8 | 0 | 0.000 | 10 | 0.223 |
| | | B | | | | | | | 0 | 0.000 | 15 | 0.335 |
| | | C | | | | | | | 0 | 0.000 | 16 | 0.330 |
| | | D | | | | | | | 0 | 0.000 | 24 | 0.496 |
| May 29 | 0800 | A | 5 & 6 | 1 | 0.027 | 0 | 0.163 | 7 & 8 | 0 | 0.000 | 10 | 0.221 |
| | | B | | 0 | 0.000 | 8 | 0.217 | | 0 | 0.000 | 8 | 0.177 |
| | | C | | 0 | 0.000 | 10 | 0.213 | | 0 | 0.000 | 12 | 0.241 |
| | | D | | 0 | 0.000 | 8 | 0.170 | | 0 | 0.000 | 16 | 0.321 |
| | Mean | | | 0.1 | 0.003 | 4.4 | 0.103 | | 0 | 0.000 | 9.7 | 0.204 |
| | | Grand Total (May) | | 27 | | 91 | | | 24 | | 146 | |
| | | Grand Mean (May) | | 0.7 | 0.016 | 2.3 | 0.050 | | 0.50 | 0.009 | 3.0 | 0.063 |



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Table 19. Summary of entrainment sampling data collected at Pulliam Power Plant, June 1975.

| Date | Time | Replicate | Discharge for Units | Eggs Number | Eggs Number/m$^3$ | Larvae Number | Larvae Number/m$^3$ | Discharge for Units | Eggs Number | Eggs Number/m$^3$ | Larvae Number | Larvae Number/m$^3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jun 4 | 1600 | A | 5 & 6 | 10 | 0.152 | 7 | 0.106 | 7 & 8 | 0 | 0.000 | 3 | 0.051 |
| | | B | | 12 | 0.182 | 4 | 0.061 | | 0 | 0.000 | 2 | 0.034 |
| | | C | | 6 | 0.106 | 0 | 0.000 | | 0 | 0.000 | 2 | 0.032 |
| | | D | | 20 | 0.352 | 6 | 0.088 | | 0 | 0.000 | 0 | 0.000 |
| | 2400 | A | 5 & 6 | 0 | 0.000 | 3 | 0.051 | 7 & 8 | 0 | 0.000 | 1 | 0.020 |
| | | B | | 0 | 0.000 | 0 | 0.000 | | 0. | 0.000 | 0 | 0.000 |
| | | C | | 0 | 0.000 | 5 | 0.088 | | 0 | 0.000 | 1 | 0.015 |
| | | D | | 0 | 0.000 | 2 | 0.035 | | 0 | 0.000 | 5 | 0.076 |
| Jun 5 | 0800 | A | 5 & 6 | 0 | 0.000 | 12 | 0.200 | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | 4 | 0.066 | 1 | 0.016 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 7 | 0.115 | 7 | 0.115 | | 0 | 0.000 | 2 | 0.003 |
| | | D | | 20 | 0.330 | 16 | 0.263 | | 0 | 0.000 | 0 | 0.000 |
| | Mean | | | 6.6 | 0.109 | 5.3 | 0.085 | | 0.0 | 0.000 | 1.3 | 0.019 |
| Jun 11 | 1600 | A | 5 & 6 | 325 | 5.336 | 0 | 0.000 | 7 & 8 | 265 | 4.522 | 0 | 0.000 |
| | | B | | 293 | 4.810 | 0 | 0.000 | | 392 | 6.689 | 0 | 0.000 |
| | | C | | 472 | 7.790 | 0 | 0.000 | | 475 | 7.915 | 0 | 0.000 |
| | | D | | 348 | 5.744 | 0 | 0.000 | | 472 | 7.865 | 0 | 0.000 |
| | 2400 | A | 5 & 6 | | Off Line | | | 7 & 8 | 572 | 10.343 | 0 | 0.000 |
| | | B | | | | | | | 387 | 6.998 | 0 | 0.000 |
| | | C | | | | | | | 501 | 9.193 | 0 | 0.000 |
| | | D | | | | | | | 599 | 10.991 | 0 | 0.000 |
| Jun 12 | 0800 | A | 5 & 6 | 729 | 12.350 | 1 | 0.017 | 7 & 8 | 187 | 3.274 | 0 | 0.000 |
| | | B | | 872 | 14.780 | 2 | 0.034 | | 482 | 8.439 | 0 | 0.000 |
| | | C | | 523 | 7.791 | 0 | 0.000 | | 369 | 6.059 | 0 | 0.000 |
| | | D | | 486 | 7.240 | 1 | 0.015 | | 273 | 4.482 | 0 | 0.000 |
| | Mean | | | 506.0 | 8.230 | 0.5 | 0.008 | | 414.5 | 7.033 | 0.0 | 0.000 |
| Jun 18 | 1600 | A | 5 & 6 | 4 | 0.070 | 1 | 0.018 | 7 & 8 | 0 | 0.000 | 1 | 0.020 |
| | | B | | 1 | 0.018 | 10 | 0.176 | | 0 | 0.000 | 1 | 0.020 |
| | | C | | 1 | 0.018 | 6 | 0.106 | | 0 | 0.000 | 1 | 0.021 |
| | | D | | 6 | 0.106 | 6 | 0.106 | | 0 | 0.000 | 0 | 0.000 |
| | 2400 | A | 5 & 6 | 0 | 0.000 | 17 | 0.251 | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | 0 | 0.000 | 5 | 0.074 | | 0 | 0.000 | 1 | 0.038 |
| | | C | | 0 | 0.000 | 4 | 0.068 | | 0 | 0.000 | 1 | 0.036 |
| | | D | | 3 | 0.051 | 5 | 0.084 | | 0 | 0.000 | 1 | 0.036 |

Table 19. (continued)

| Date | Time | Replicate | Discharge for Units | Eggs Number | Eggs Number/m$^3$ | Larvae Number | Larvae Number/m$^3$ | Discharge for Units | Eggs Number | Eggs Number/m$^3$ | Larvae Number | Larvae Number/m$^3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jun 19 | 0800 | A | 5 & 6 | 25 | 0.466 | 2 | 0.037 | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | 37 | 0.689 | 2 | 0.037 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 52 | 0.928 | 3 | 0.053 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 51 | 0.910 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | Mean | | | 15.0 | 0.271 | 5.1 | 0.084 | | 0.0 | 0.000 | 0.5 | 0.014 |
| Jun 25 | 1600 | A | 5 & 6 | 31 | 0.555 | 4 | 0.071 | 7 & 8 | 2765 | 96.746 | 15 | 0.525 |
| | | B | | 26 | 0.466 | 2 | 0.036 | | 3215 | 112.491 | 20 | 0.700 |
| | | C | | 18 | 0.326 | 5 | 0.090 | | 1872 | 56.182 | 19 | 0.570 |
| | | D | | 32 | 0.580 | 8 | 0.145 | | 1507 | 45.228 | 12 | 0.360 |
| | 2400 | A | 5 & 6 | 20 | 0.501 | 4 | 0.100 | 7 & 8 | 873 | 28.089 | 3 | 0.096 |
| | | B | | 32 | 0.802 | 2 | 0.050 | | 1041 | 33.494 | 6 | 0.193 |
| | | C | | 28 | 0.641 | 3 | 0.069 | | 635 | 18.825 | 5 | 0.148 |
| | | D | | 18 | 0.412 | 2 | 0.046 | | 727 | 21.554 | 7 | 0.208 |
| Jun 26 | 0800 | A | 5 & 6 | 58 | 1.219 | 0 | 0.000 | 7 & 8 | 425 | 9.388 | 0 | 0.000 |
| | | B | | 40 | 0.841 | 0 | 0.000 | | 287 | 6.340 | 1 | 0.022 |
| | | C | | 22 | 0.457 | 0 | 0.000 | | 303 | 4.915 | 0 | 0.000 |
| | | D | | 62 | 1.290 | 0 | 0.000 | | 386 | 6.261 | 0 | 0.000 |
| | Mean | | | 32.3 | 0.641 | 2.5 | 0.056 | | 1169.7 | 36.626 | 9.2 | 0.219 |
| | | Grand Total (June) | | 4694 | | 157 | | | 19010 | | 110 | |
| | | Grand Mean (June) | | 139.9 | 2.313 | 3.6 | 0.058 | | 396.0 | 10.915 | 2.29 | 0.063 |



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Table 20. Summary of entrainment sampling data collected at Pulliam Power Plant, July 1975.

| Date | Time | Replicate | Discharge for Units | Eggs Number | Eggs Number/m$^3$ | Larvae Number | Larvae Number/m$^3$ | Discharge for Units | Eggs Number | Eggs Number/m$^3$ | Larvae Number | Larvae Number/m$^3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7/2/75 | 1600 | A | 5 & 6 | 2 | 0.028 | 0 | 0.000 | 7 & 8 | 22 | 0.322 | 0 | 0.000 |
| | | B | | 2 | 0.037 | 0 | 0.000 | | 13 | 0.252 | 0 | 0.000 |
| | | C | | 3 | 0.059 | 0 | 0.000 | | 24 | 0.380 | 1 | 0.016 |
| | | D | | 4 | 0.069 | 0 | 0.000 | | 48 | 0.751 | 0 | 0.000 |
| | 2400 | A | 5 & 6 | 752 | 14.051 | 3 | 0.056 | 7 & 8 | 12 | 0.227 | 10 | 0.189 |
| | | B | | 552 | 8.464 | 2 | 0.031 | | 8 | 0.123 | 12 | 0.184 |
| | | C | | 720 | 14.557 | 4 | 0.081 | | 6 | 0.078 | 12 | 0.155 |
| | | D | | 3084 | 57.270 | 4 | 0.074 | | 10 | 0.130 | 17 | 0.220 |
| 7/3/75 | 0800 | A | 5 & 6 | 25 | 0.357 | 1 | 0.014 | 7 & 8 | 114 | 0.152 | 1 | 0.013 |
| | | B | | 18 | 0.309 | 1 | 0.017 | | 97 | 0.149 | 1 | 0.015 |
| | | C | | 11 | 0.265 | 0 | 0.000 | | 128 | 0.168 | 1 | 0.013 |
| | | D | | 25 | 0.414 | 0 | 0.000 | | 105 | 0.168 | 0 | 0.000 |
| | MEAN | | | 433.2 | 7.990 | 1.3 | 0.023 | | 48.9 | 0.242 | 4.6 | 0.067 |
| 7/9/75 | 1600 | A | 5 & 6 | 345 | 6.855 | 3 | 0.060 | 7 & 8 | 20 | 0.391 | 0 | 0.000 |
| | | B | | 431 | 10.035 | 5 | 0.116 | | 30 | 0.534 | 1 | 0.018 |
| | | C | | 410 | 7.370 | 6 | 0.108 | | 42 | 0.661 | 2 | 0.031 |
| | | D | | 520 | 8.890 | 4 | 0.068 | | 19 | 0.256 | 1 | 0.013 |
| | 2400 | A | 5 & 6 | | OFF LINE | | | 7 & 8 | 20 | 0.358 | 4 | 0.072 |
| | | B | | | | | | | 18 | 0.315 | 3 | 0.052 |
| | | C | | | | | | | 5 | 0.089 | 8 | 0.143 |
| | | D | | | | | | | 21 | 0.503 | 4 | 0.065 |
| 7/10/75 | 0800 | A | 5 & 6 | 675 | 13.892 | 3 | 0.062 | 7 & 8 | 27 | 0.460 | 1 | 0.017 |
| | | B | | 721 | 13.387 | 5 | 0.092 | | 40 | 0.726 | 0 | 0.000 |
| | | C | | 536 | 11.189 | 1 | 0.021 | | 21 | 0.398 | 0 | 0.000 |
| | | D | | 421 | 8.386 | 2 | 0.040 | | 53 | 0.903 | 0 | 0.000 |
| | MEAN | | | 507.4 | 8.329 | 3.6 | 0.071 | | 26.3 | 0.466 | 2.0 | 0.034 |
| 7/16/75 | 1600 | A | 5 & 6 | 1 | 0.025 | 1 | 0.025 | 7 & 8 | 1 | 0.018 | 2 | 0.036 |
| | | B | | 6 | 0.131 | 0 | 0.000 | | 0 | 0.000 | 1 | 0.017 |
| | | C | | 6 | 0.106 | 2 | 0.035 | | 0 | 0.000 | 5 | 0.103 |
| | | D | | 8 | 0.121 | 0 | 0.000 | | 1 | 0.015 | 2 | 0.030 |
| | 2400 | A | 5 & 6 | | OFF LINE | | | 7 & 8 | 2 | 0.032 | 9 | 0.143 |
| | | B | | | | | | | 4 | 0.079 | 3 | 0.059 |
| | | C | | | | | | | 3 | 0.040 | 1 | 0.013 |
| | | D | | | | | | | 0 | 0.000 | 3 | 0.049 |



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Table 20. (continued)

| Date | Time | Replicate | Discharge for Units | Eggs Number | Eggs Number/m$^3$ | Larvae Number | Larvae Number/m$^3$ | Discharge for Units | Eggs Number | Eggs Number/m$^3$ | Larvae Number | Larvae Number/m$^3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7/17/75 | 0800 | A | 5 & 6 | 21 | 0.499 | 0 | 0.000 | 7 & 8 | 10 | 0.211 | 0 | 0.000 |
| | | B | | 12 | 0.122 | 1 | 0.010 | | 2 | 0.042 | 0 | 0.000 |
| | | C | | 27 | 0.537 | 0 | 0.000 | | 3 | 0.042 | 0 | 0.000 |
| | | D | | 52 | 0.728 | 1 | 0.014 | | 0 | 0.000 | 0 | 0.000 |
| | MEAN | | | 16.6 | 0.284 | 0.6 | 0.011 | | 2.2 | 0.040 | 2.2 | 0.038 |
| 7/23/75 | 1600 | A | 5 & 6 | 5 | 0.094 | 0 | 0.000 | 7 & 8 | 2 | 0.033 | 0 | 0.000 |
| | | B | | 3 | 0.056 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 4 | 0.082 | 0 | 0.000 | | 2 | 0.029 | 0 | 0.000 |
| | | D | | 1 | 0.016 | 0 | 0.000 | | 2 | 0.029 | 0 | 0.000 |
| | 2400 | A | 5 & 6 | 2 | 0.038 | 0 | 0.000 | 7 & 8 | 4 | 0.073 | 0 | 0.000 |
| | | B | | 1 | 0.014 | 0 | 0.000 | | 2 | 0.036 | 0 | 0.000 |
| | | C | | 5 | 0.079 | 0 | 0.000 | | 8 | 0.117 | 0 | 0.000 |
| | | D | | 6 | 0.095 | 0 | 0.000 | | 7 | 0.103 | 0 | 0.000 |
| 7/24/75 | 0800 | A | 5 & 6 | 96 | 1.853 | 0 | 0.000 | 7 & 8 | 8 | 0.148 | 0 | 0.000 |
| | | B | | 64 | 1.236 | 0 | 0.000 | | 30 | 0.554 | 0 | 0.000 |
| | | C | | 149 | 2.181 | 0 | 0.000 | | 12 | 0.226 | 0 | 0.000 |
| | | D | | 116 | 1.698 | 0 | 0.000 | | 8 | 0.151 | 0 | 0.000 |
| | MEAN | | | 37.7 | 0.620 | 0 | 0.000 | | 7.1 | 0.125 | 0 | 0.000 |
| 7/30/75 | 1600 | A | 5 & 6 | 2 | 0.028 | 0 | 0.000 | 7 & 8 | 1 | 0.015 | 1 | 0.015 |
| | | B | | 2 | 0.041 | 0 | 0.000 | | 2 | 0.030 | 0 | 0.000 |
| | | C | | 2 | 0.043 | 0 | 0.000 | | 1 | 0.014 | 0 | 0.000 |
| | | D | | 1 | 0.018 | 0 | 0.000 | | 1 | 0.015 | 0 | 0.000 |
| | 2400 | A | 5 & 6 | 0 | 0.000 | 0 | 0.000 | 7 & 8 | 5 | 0.114 | 0 | 0.000 |
| | | B | | 0 | 0.000 | 0 | 0.000 | | 1 | 0.019 | 0 | 0.000 |
| | | C | | 0 | 0.000 | 1 | 0.019 | | 1 | 0.018 | 0 | 0.000 |
| | | D | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| 7/31/75 | 0800 | A | 5 & 6 | 4 | 0.051 | 0 | 0.000 | 7 & 8 | 2 | 0.038 | 0 | 0.000 |
| | | B | | 6 | 0.107 | 0 | 0.000 | | 5 | 0.094 | 2 | 0.038 |
| | | C | | 8 | 0.132 | 1 | 0.017 | | 2 | 0.034 | 0 | 0.000 |
| | | D | | 5 | 0.088 | 0 | 0.000 | | 3 | 0.059 | 0 | 0.000 |
| | MEAN | | | 2.5 | 0.042 | 0.2 | 0.003 | | 2.0 | 0.038 | 0.3 | 0.004 |
| | GRAND TOTAL (July) | | | 9872 | - | 51 | - | | 1048 | - | 108 | - |
| | GRAND MEAN (July) | | | 199.5 | 3.453 | 1.0 | 0.022 | | 17.3 | 0.182 | 1.8 | 0.029 |



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Table 21. Summary of entrainment sampling data collected at Pulliam Power Plant, August 1975.

| Date | Time | Replicate | Discharge for Units | Eggs Number | Eggs Number/m³ | Larvae Number | Larvae Number/m³ | Discharge for Units | Eggs Number | Eggs Number/m³ | Larvae Number | Larvae Number/m³ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/6/75 | 1600 | A | 5 & 6 | 0 | 0.000 | 0 | 0.000 | 7 & 8 | 0 | 0.000 | 1 | 0.020 |
| | | B | | 0 | 0.000 | 0 | 0.000 | | 1 | 0.015 | 0 | 0.000 |
| | | C | | 0 | 0.000 | 1 | 0.026 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 1 | 0.015 | 0 | 0.000 | | 1 | 0.018 | 0 | 0.000 |
| | 2400 | A | 5 & 6 | | OFF LINE | | | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | | | | | | 0 | 0.000 | 0 | 0.000 |
| | | C | | | | | | | 2 | 0.030 | 2 | 0.030 |
| | | D | | | | | | | 0 | 0.000 | 0 | 0.000 |
| 8/7/75 | 0800 | A | 5 & 6 | 0 | 0.000 | 0 | 0.000 | 7 & 8 | 1 | 0.020 | 0 | 0.000 |
| | | B | | 1 | 0.019 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 3 | 0.053 | 0 | 0.000 | | 3 | 0.053 | 1 | 0.018 |
| | | D | | 2 | 0.040 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | MEAN | | | 0.9 | 0.016 | 0.1 | 0.003 | | 0.7 | 0.011 | 0.3 | 0.006 |
| 8/13/75 | 1600 | A | 5 & 6 | 1 | 0.019 | 0 | 0.000 | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | 2400 | A | 5 & 6 | | OFF LINE | | | 7 & 8 | 2 | 0.041 | 0 | 0.000 |
| | | B | | | | | | | 1 | 0.018 | 0 | 0.000 |
| | | C | | | | | | | 2 | 0.035 | 0 | 0.000 |
| | | D | | | | | | | 1 | 0.017 | 0 | 0.000 |
| 8/14/75 | 0800 | A | 5 & 6 | 0 | 0.000 | 0 | 0.000 | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | MEAN | | | 0.1 | 0.002 | 0 | 0.000 | | 0.5 | 0.009 | 0 | 0.000 |



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Table 21 (continued)

| Date | Time | Replicate | Discharge for Units | Eggs Number | Eggs Number/m³ | Larvae Number | Larvae Number/m³ | Discharge for Units | Eggs Number | Eggs Number/m³ | Larvae Number | Larvae Number/m³ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/20/75 | 1600 | A | 5 & 6 | 1 | 0.019 | 0 | 0.000 | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | 1 | 0.018 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 2 | 0.031 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | 2400 | A | 5 & 6 | | OFF LINE | | | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | | | | | | 0 | 0.000 | 0 | 0.000 |
| | | C | | | | | | | 0 | 0.000 | 0 | 0.000 |
| | | D | | | | | | | 0 | 0.000 | 0 | 0.000 |
| 8/21/75 | 0800 | A | 5 & 6 | 0 | 0.000 | 0 | 0.000 | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | MEAN | | | 0.5 | 0.009 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| 8/27/75 | 1600 | A | 5 & 6 | 0 | 0.000 | 0 | 0.000 | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | 2400 | A | 5 & 6 | | OFF LINE | | | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | | | | | | 0 | 0.000 | 0 | 0.000 |
| | | C | | | | | | | 0 | 0.000 | 0 | 0.000 |
| | | D | | | | | | | 0 | 0.000 | 0 | 0.000 |
| | 0800 | A | 5 & 6 | 0 | 0.000 | 0 | 0.000 | 7 & 8 | 0 | 0.000 | 0 | 0.000 |
| | | B | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | C | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | | D | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | MEAN | | | 0 | 0.000 | 0 | 0.000 | | 0 | 0.000 | 0 | 0.000 |
| | GRAND TOTAL (August) | | | 12 | - | 1 | - | | 14 | - | 4 | - |
| | GRAND MEAN (August) | | | 0.4 | 0.007 | >0.1 | 0.001 | | 0.3 | 0.005 | 0.1 | 0.001 |



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The total numbers of eggs and larvae collected were zero in early April, reached their peaks in July and decreased to zero in late August.

Plant operating data collected concomitantly with entrainment sampling are summarized in Tables 22 through 26. Data include intake and discharge temperatures, flow through the plant from each water source and total percent of Plant turbine capacity.

Eggs collected at the J. P. Pulliam Power Plant could not be positively identified to species due to the number of species with overlapping spawning times and egg diameters. Tentative identifications were based on comparison of literature researched data with the time of year, water temperatures (Tables 22 through 26) and measured diameters of the eggs collected. Egg diameter frequencies for each month were prepared and literature extraced egg diameters for various species were added when appropriate (Figures 10 through 14). Early spawners shown in Figure 10 include rainbow smelt, northern pike or white sucker and an unidentifiable intermediate group. The 1.4 to 2.1 mm egg diameter group in May indicated the beginning of carp spawning (Figure 11); others in Figure 11 were not identified. Diameter frequency distributions for June (Figure 12) were thought to indicate alewife and possibly Notropis spp. spawning in the 0.6 to 1.3 mm egg diameter range and carp spawning in the 1.4 to 2.1 mm egg diameter range. Continued spawning of alewives and possibly Notropis was indicated during July and August (Figures 13 and 14).

Table 22. Summary of plant operating conditions collected during entrainment sampling at Pulliam Power Plant, April 1975.

| Date | Time | Discharge for Units | Temperature (°C) Intake | Temperature (°C) Discharge | Total Flow Presumed Bay Water ($m^3$/min) | Discharge for Units | Temperature (°C) Intake | Temperature (°C) Discharge | Total Flow Presumed River Water ($m^3$/min) | % Plant Turbine Capacity |
|---|---|---|---|---|---|---|---|---|---|---|
| Apr 2 | 1600 | 3&4 | 0.5 | 8.0 | 366.3 | 7&8 | 0.0 | 12.5 | 393.4 | 87 |
| | 2400 | 3&4 | 0.5 | 8.0 | 312.1 | 7&8 | 0.0 | 12.5 | 394.5 | 64 |
| Apr 3 | 0800 | 3&4 | 0.5 | 8.0 | 425.8 | 7&8 | 0.5 | 12.5 | 394.5 | 91 |
| | Mean | | 0.5 | 8.0 | 368.1 | | 0.2 | 12.5 | 394.1 | 81 |
| Apr 9 | 1600 | 5&6 | 3.0 | 6.0 | 253.8 | 7&8 | 4.0 | 10.0 | 394.5 | 45 |
| | 2400 | 5&6 | Off Line | | 0.0 | 7&8 | 4.0 | 8.0 | 402.1 | 20 |
| Apr 10 | 0800 | 5&6 | 2.0 | 7.0 | 253.8 | 7&8 | 3.0 | 11.0 | 394.5 | 53 |
| | Mean | | 2.5 | 6.5 | 169.2 | | 3.7 | 9.7 | 397.0 | 39 |
| Apr 16 | 1600 | 5&6 | 3.0 | 6.0 | 125.0 | 7&8 | 4.5 | 14.5 | 394.5 | 43 |
| | 2400 | 5&6 | Off Line | | 0.0 | 7&8 | 4.5 | 12.5 | 405.9 | 22 |
| Apr 17 | 0800 | 5&6 | 4.0 | 9.0 | 125.0 | 7&8 | 4.0 | 15.0 | 383.9 | 57 |
| | Mean | | 3.5 | 7.5 | 83.3 | | 4.3 | 14.0 | 394.8 | 41 |
| Apr 23 | 1600 | 5&6 | 9.5 | 17.0 | 181.8 | 7&8 | 7.0 | 14.0 | 394.5 | 54 |
| | 2400 | 5&6 | Off Line | | 0.0 | 7&8 | 6.0 | 13.0 | 402.1 | 20 |
| Apr 24 | 0800 | 5&6 | 8.0 | 11.5 | 253.8 | 7&8 | 7.0 | 15.0 | 393.9 | 55 |
| | Mean | | 8.8 | 14.3 | 145.2 | | 6.7 | 14.0 | 396.8 | 43 |
| Apr 30 | 1600 | 5&6 | 10.0 | 15.5 | 676.5 | 7&8 | 5.5 | 17.0 | 394.5 | 92 |
| | 2400 | 5&6 | 10.0 | 15.5 | 439.4 | 7&8 | 5.5 | 17.0 | 394.5 | 62 |
| May 1 | 0800 | 5&6 | 9.5 | 13.5 | 604.5 | 7&8 | 5.0 | 16.5 | 394.5 | 86 |
| | Mean | | 9.8 | 14.8 | 573.5 | | 5.3 | 16.8 | 394.5 | 80 |
| | Grand Mean (April) | | | | 267.9 | | | | 395.4 | 57 |



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Table 23. Summary of plant operating conditions collected during entrainment sampling at Pulliam Power Plant, May 1975.

| Date | Time | Discharge for Units | Temperature (°C) Intake | Temperature (°C) Discharge | Total Flow Presumed Bay Water ($m^3$/min) | Discharge for Units | Temperature (°C) Intake | Temperature (°C) Discharge | Total Flow Presumed River Water ($m^3$/min) | % Plant Turbine Capacity |
|---|---|---|---|---|---|---|---|---|---|---|
| May 7 | 1600 | 5&6 | 14.5 | 19.0 | 530.3 | 7&8 | 11.0 | 21.0 | 337.7 | 84 |
| | 2400 | 5&6 | Off Line | | 0.0 | 7&8 | 10.5 | 18.5 | 371.8 | 25 |
| May 8 | 0800 | 5&6 | 13.0 | 18.0 | 208.3 | 7&8 | 11.0 | 20.5 | 337.7 | 56 |
| | Mean | | 13.8 | 18.5 | 246.2 | | 10.8 | 20.0 | 349.1 | 55 |
| May 14 | 1600 | 5&6 | 14.0 | 21.5 | 431.8 | 7&8 | 10.5 | 22.0 | 394.5 | 71 |
| | 2400 | 5&6 | 12.0 | 17.0 | 242.4 | 7&8 | 10.0 | 21.0 | 237.7 | 23 |
| May 15 | 0800 | 5&6 | 12.0 | 21.0 | 375.0 | 7&8 | 10.5 | 21.5 | 237.7 | 62 |
| | Mean | | 12.7 | 19.8 | 349.7 | | 10.3 | 21.5 | 290.1 | 52 |
| May 21 | 1600 | 5&6 | 20.0 | 26.0 | 492.0 | 7&8 | 21.0 | 29.0 | 547.9 | 65 |
| | 2400 | 5&6 | 23.0 | 25.5 | 231.8 | 7&8 | 21.0 | 27.0 | 421.0 | 47 |
| May 22 | 0800 | 5&6 | 24.0 | 27.0 | 594.3 | 7&8 | 21.0 | 27.0 | 542.6 | 75 |
| | Mean | | 22.3 | 26.2 | 439.4 | | 21.0 | 27.7 | 503.8 | 62 |
| May 28 | 1600 | 5&6 | 19.5 | 24.5 | 515.5 | 7&8 | 18.5 | 25.0 | 489.2 | 54 |
| | 2400 | 5&6 | Off Line | | 0.0 | 7&8 | 18.0 | 25.0 | 493.8 | 26 |
| May 29 | 0800 | 5&6 | 19.0 | 25.0 | 270.8 | 7&8 | 18.0 | 26.5 | 489.2 | 55 |
| | Mean | | 19.3 | 24.8 | 262.1 | | 18.3 | 25.5 | 490.7 | 45 |
| | Grand Mean (May) | | | | 324.4 | | | | 418.1 | 54 |



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Table 24. Summary of plant operating conditions collected during entrainment sampling at Pulliam Power Plant, June 1975.

| Date | Time | Discharge for Units | Temperature (°C) Intake | Temperature (°C) Discharge | Total Flow Presumed Bay Water ($m^3$/min) | Discharge for Units | Temperature (°C) Intake | Temperature (°C) Discharge | Total Flow Presumed River Water ($m^3$/min) | % Turbine Capacity |
|---|---|---|---|---|---|---|---|---|---|---|
| Jun 4 | 1600 | 5&6 | 22.0 | 25.0 | 306.8 | 7&8 | 20.5 | 27.0 | 417.2 | 63 |
| | 2400 | 5&6 | 20.5 | 23.0 | 344.7 | 7&8 | 18.5 | 23.0 | 489.2 | 25 |
| Jun 5 | 0800 | 5&6 | 21.5 | 25.0 | 344.7 | 7&8 | 20.0 | 27.0 | 489.2 | 65 |
| | Mean | | 21.3 | 24.3 | 332.1 | | 19.7 | 25.7 | 465.2 | 51 |
| Jun 11 | 1600 | 5&6 | 19.5 | 26.0 | 303.0 | 7&8 | 19.0 | 30.0 | 417.2 | 63 |
| | 2400 | 5&6 | Off Line | | 0.0 | 7&8 | 19.5 | 31.0 | 432.4 | 29 |
| Jun 12 | 0800 | 5&6 | 20.0 | 27.0 | 506.1 | 7&8 | 19.5 | 30.5 | 417.2 | 76 |
| | Mean | | 19.8 | 26.5 | 269.7 | | 19.3 | 30.5 | 422.3 | 56 |
| Jun 18 | 1600 | 5&6 | 21.0 | 23.0 | 303.0 | 7&8 | 20.0 | 25.5 | 640.7 | 54 |
| | 2400 | 5&6 | 20.0 | 23.0 | 189.4 | 7&8 | 19.0 | 24.0 | 394.5 | 27 |
| Jun 19 | 0800 | 5&6 | 18.5 | 24.0 | 628.8 | 7&8 | 19.0 | 22.0 | 489.2 | 85 |
| | Mean | | 19.8 | 23.3 | 373.7 | | 19.3 | 23.8 | 508.1 | 55 |
| Jun 25 | 1600 | 5&6 | 22.0 | 31.5 | 945.5 | 7&8 | 20.5 | 31.0 | 640.7 | 83 |
| | 2400 | 5&6 | | | 306.8 | 7&8 | 20.5 | 32.0 | 417.2 | 31 |
| Jun 26 | 0800 | 5&6 | 21.0 | 31.0 | 774.2 | 7&8 | 20.0 | 32.5 | 640.7 | 87 |
| | Mean | | 21.5 | 31.3 | 675.5 | | 20.3 | 31.8 | 566.2 | 67 |
| | Grand Mean (June) | | | | 412.8 | | | | 490.5 | 57 |



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Table 25. Summary of plant operating conditions collected during entrainment sampling at Pulliam Power Plant, July 1975.

| Date | Time | Discharge for Units | Temperature (°C) Intake | Temperature (°C) Discharge | Total Flow Presumed Bay Water ($m^3$/min) | Discharge for Units | Temperature (°C) Intake | Temperature (°C) Discharge | Total Flow Presumed River Water ($m^3$/min) | % Plant Turbine Capacity |
|---|---|---|---|---|---|---|---|---|---|---|
| Jul 2 | 1600 | 3 | 24.0 | 28.0 | 899.2 | 7 & 8 | 26.0 | 31.5 | 640.7 | 93 |
| | 2400 | 3 | 22.0 | 28.0 | 517.4 | 7 & 8 | 24.0 | 30.0 | 640.7 | 61 |
| Jul 3 | 0800 | 3 | 24.0 | 29.0 | 682.6 | 7 & 8 | 25.5 | 30.5 | 640.7 | 81 |
| | MEAN | | 23.3 | 28.3 | 699.7 | | 25.2 | 30.7 | 640.7 | 78 |
| Jul 9 | 1600 | 5 & 6 | 23.5 | 30.5 | 494.7 | 7 & 8 | 22.0 | 31.0 | 640.7 | 65 |
| | 2400 | 5 & 6 | OFF LINE | | 0.0 | 7 & 8 | 22.0 | 31.5 | 649.7 | 23 |
| Jul 10 | 0800 | 5 & 6 | 23.0 | 29.0 | 521.2 | 7 & 8 | 22.5 | 31.5 | 630.1 | 58 |
| | MEAN | | 23.3 | 29.8 | 338.6 | | 22.2 | 31.3 | 640.2 | 49 |
| Jul 16 | 1600 | 5 & 6 | 26.0 | 30.0 | 511.7 | 7 & 8 | 24.0 | 29.5 | 640.7 | 73 |
| | 2400 | 5 & 6 | OFF LINE | | 0.0 | 7 & 8 | 23.0 | 29.0 | 947.5 | 36 |
| Jul 17 | 0800 | 5 & 6 | 27.0 | 29.0 | 711.7 | 7 & 8 | 23.0 | 29.0 | 630.1 | 86 |
| | MEAN | | 26.5 | 29.5 | 407.8 | | 23.3 | 29.2 | 739.4 | 65 |
| Jul 23 | 1600 | 5 & 6 | 24.0 | 29.0 | 606.1 | 7 & 8 | 25.5 | 30.0 | 640.7 | 78 |
| | 2400 | 5 & 6 | 24.0 | 27.5 | 100.8 | 7 & 8 | 25.0 | 30.0 | 634.8 | 27 |
| Jul 24 | 0800 | 5 & 6 | 24.5 | 29.5 | 637.9 | 7 & 8 | 25.0 | 30.5 | 630.1 | 66 |
| | MEAN | | 24.2 | 28.7 | 448.3 | | 25.2 | 30.2 | 635.2 | 57 |
| Jul 30 | 1600 | 5 & 6 | 19.5 | - | 608.3 | 7 & 8 | 16.0 | - | 640.2 | 86 |
| | 2400 | 5 & 6 | 15.5 | - | 250.0 | 7 & 8 | 15.5 | - | 588.1 | 33 |
| Jul 31 | 0800 | 5 & 6 | 19.0 | - | 566.7 | 7 & 8 | 19.0 | - | 630.1 | 77 |
| | MEAN | | 18.0 | - | 475.0 | | 16.8 | - | 619.5 | 65 |
| | GRAND MEAN (July) | | | | 473.9 | | | | 655.0 | 63 |



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Table 26. Summary of plant operating conditions collected during entrainment sampling at Pulliam Power Plant, August 1975.

| Date | Time | Discharge for Units | Temperature (°C) Intake | Temperature (°C) Discharge | Total Flow Presumed Bay Water ($m^3$/min) | Discharge for Units | Temperature (°C) Intake | Temperature (°C) Discharge | Total Flow Presumed River Water ($m^3$/min) | % Plant Turbine Capacity |
|---|---|---|---|---|---|---|---|---|---|---|
| Aug 6 | 1600 | 5 & 6 | 21.0 | 25.0 | 303.0 | 7 & 8 | 25.5 | 31.0 | 640.7 | 52 |
| | 2400 | 5 & 6 | OFF LINE | | 0.0 | 7 & 8 | 25.0 | 28.0 | 640.7 | 30 |
| Aug 7 | 0800 | 5 & 6 | 21.5 | 25.5 | 128.8 | 7 & 8 | 23.0 | 26.5 | 640.7 | 44 |
| | MEAN | | 21.3 | 25.3 | 143.9 | | 24.5 | 28.5 | 640.7 | 42 |
| Aug 13 | 1600 | 5 & 6 | 22.0 | 29.0 | 778.0 | 7 & 8 | 20.5 | 30.0 | 602.8 | 84 |
| | 2400 | 5 & 6 | OFF LINE | | 0 | 7 & 8 | 20.0 | 29.0 | 602.8 | 22 |
| Aug 14 | 0800 | 5 & 6 | 22.5 | 29.0 | 147.7 | 7 & 8 | 20.5 | 31.0 | 602.8 | 38 |
| | MEAN | | 22.3 | 29.0 | 308.6 | | 20.3 | 30.0 | 602.8 | 48 |
| Aug 20 | 1600 | 5 & 6 | 22.5 | 26.5 | 128.8 | 7 & 8 | 19.5 | 27.5 | 389.2 | 39 |
| | 2400 | 5 & 6 | OFF LINE | | 0.0 | 7 & 8 | 19.0 | 28.0 | 399.1 | 26 |
| Aug 21 | 0800 | 5 & 6 | 22.0 | 27.0 | 128.8 | 7 & 8 | 19.0 | 27.5 | 393.9 | 43 |
| | MEAN | | 22.3 | 26.8 | 85.9 | | 19.2 | 27.7 | 394.1 | 36 |
| Aug 27 | 1600 | 5 & 6 | 21.5 | 25.0 | 147.7 | 7 & 8 | 23.5 | 27.0 | 388.6 | 30 |
| | 2400 | 5 & 6 | OFF LINE | | 0.0 | 7 & 8 | 23.0 | 27.5 | 383.9 | 25 |
| Aug 28 | 0800 | 5 & 6 | 21.5 | 23.5 | 261.4 | 7 & 8 | 22.0 | 25.0 | 383.9 | 33 |
| | MEAN | | 21.5 | 24.3 | 136.4 | | 22.8 | 26.5 | 385.5 | 29 |
| | Grand Mean (August) | | | | 168.7 | | | | 505.8 | 39 |



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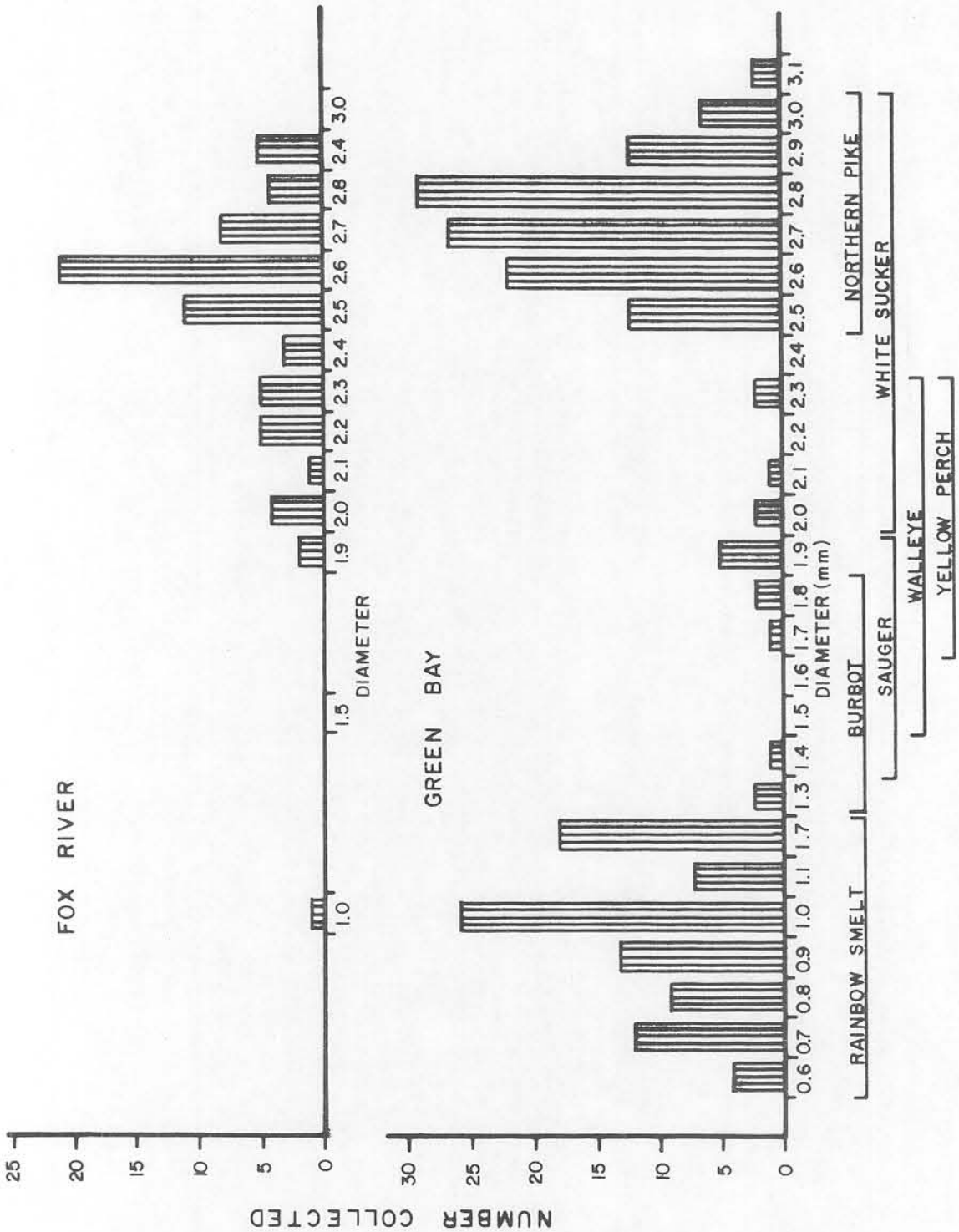


Figure 10. Diameter-frequency distribution of eggs collected from Fox River and Green Bay water at Pulliam Power Plant, April 1975.

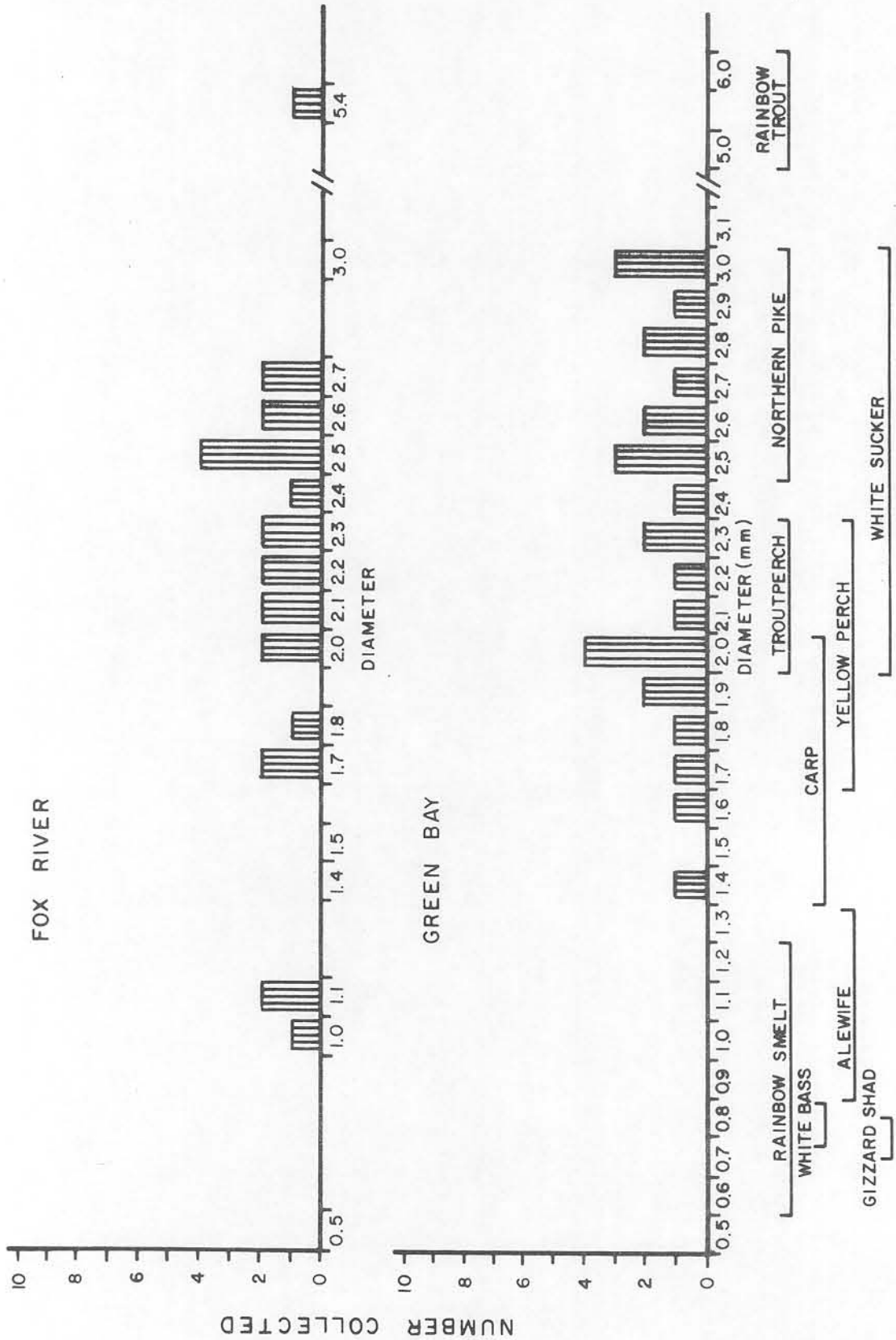


Figure 11. Diameter-frequency distribution of eggs collected from Fox River and Green Bay water at Pulliam Power Plant, May 1975.

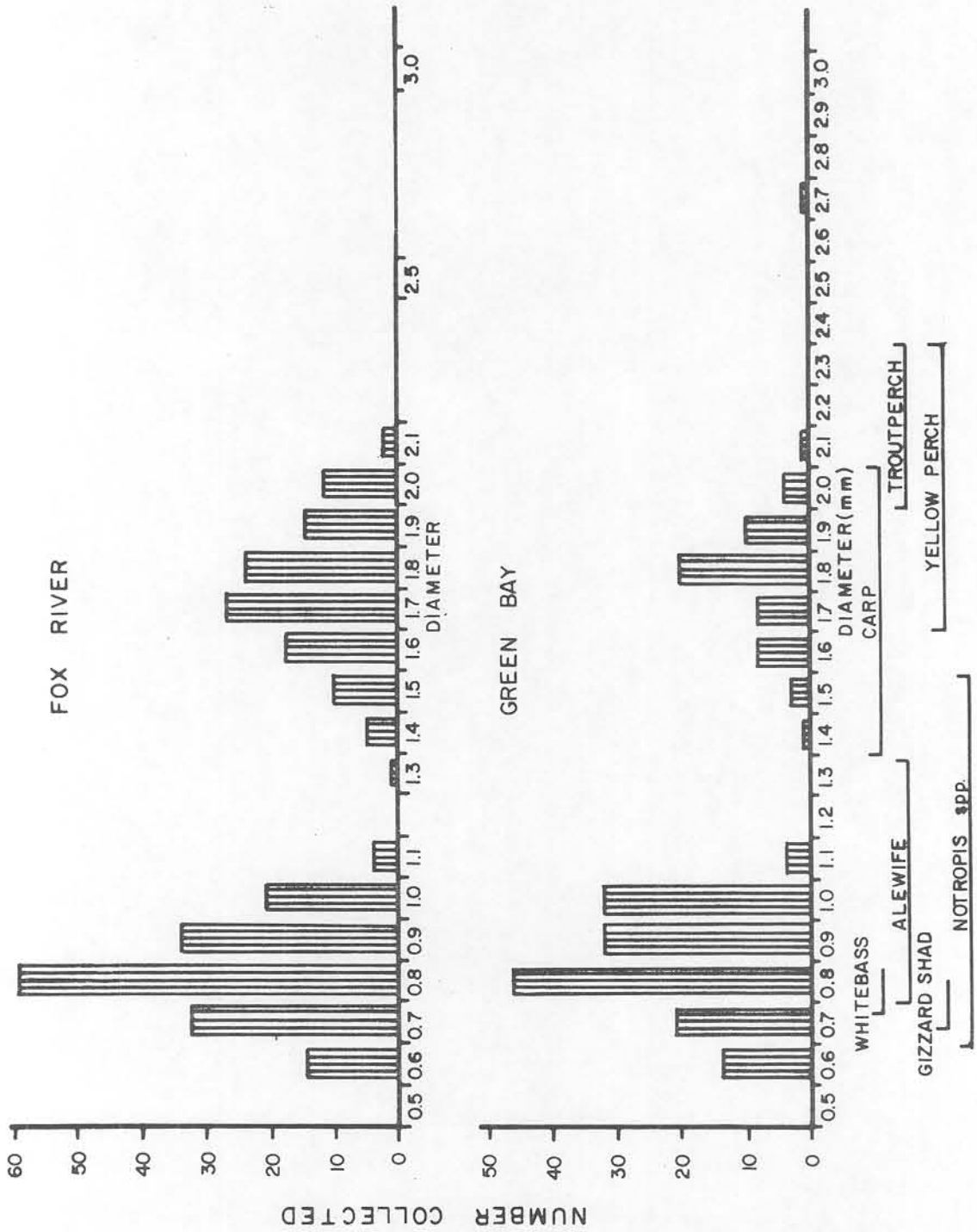


Figure 12. Diameter-frequency distribution of eggs collected From Fox River and Green Bay water at Pulliam Power Plant, June 1975.

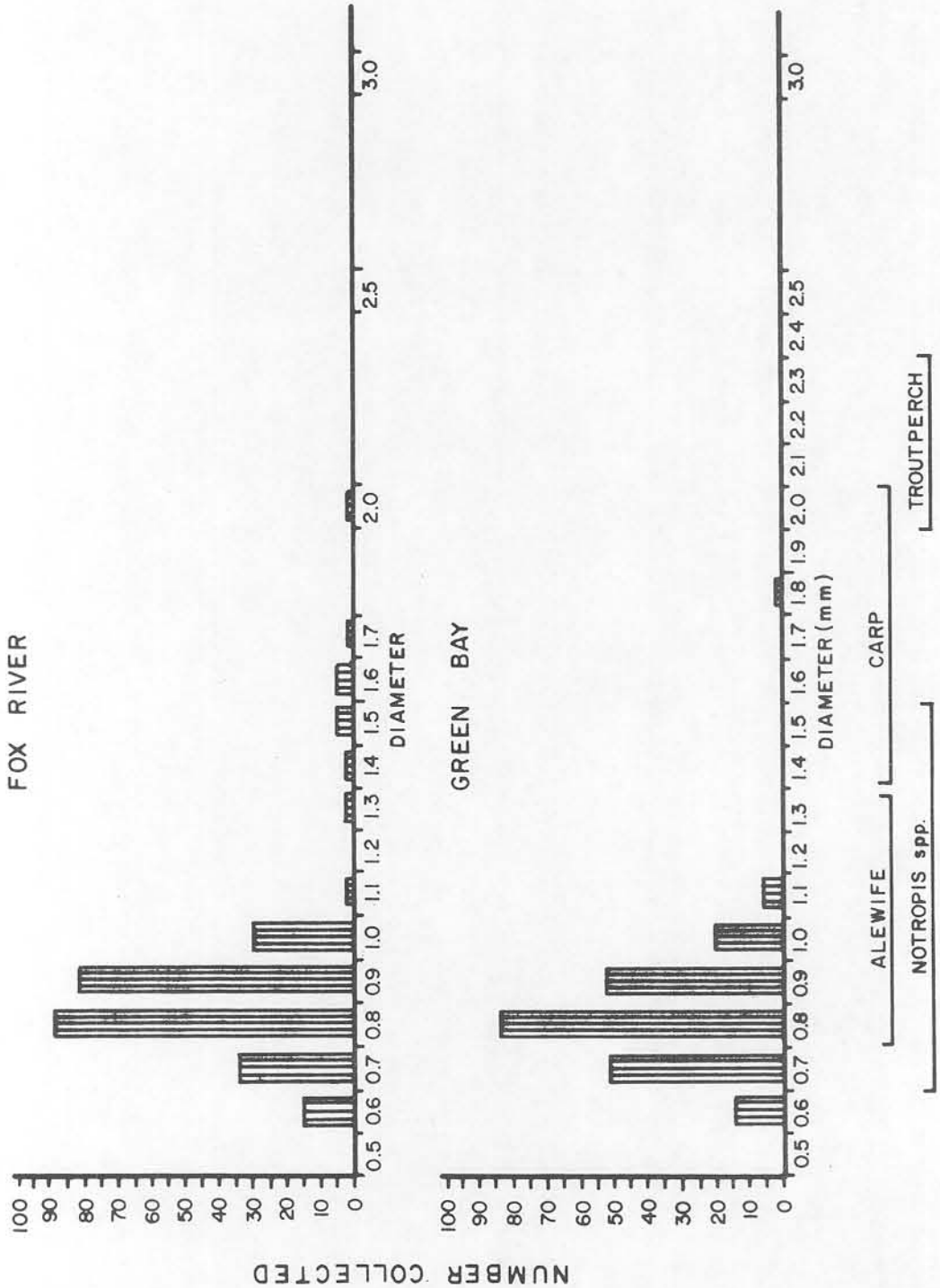


Figure 13. Diameter-frequency distribution of eggs collected from Fox River and Green Bay water at Pulliam Power Plant, July 1975.

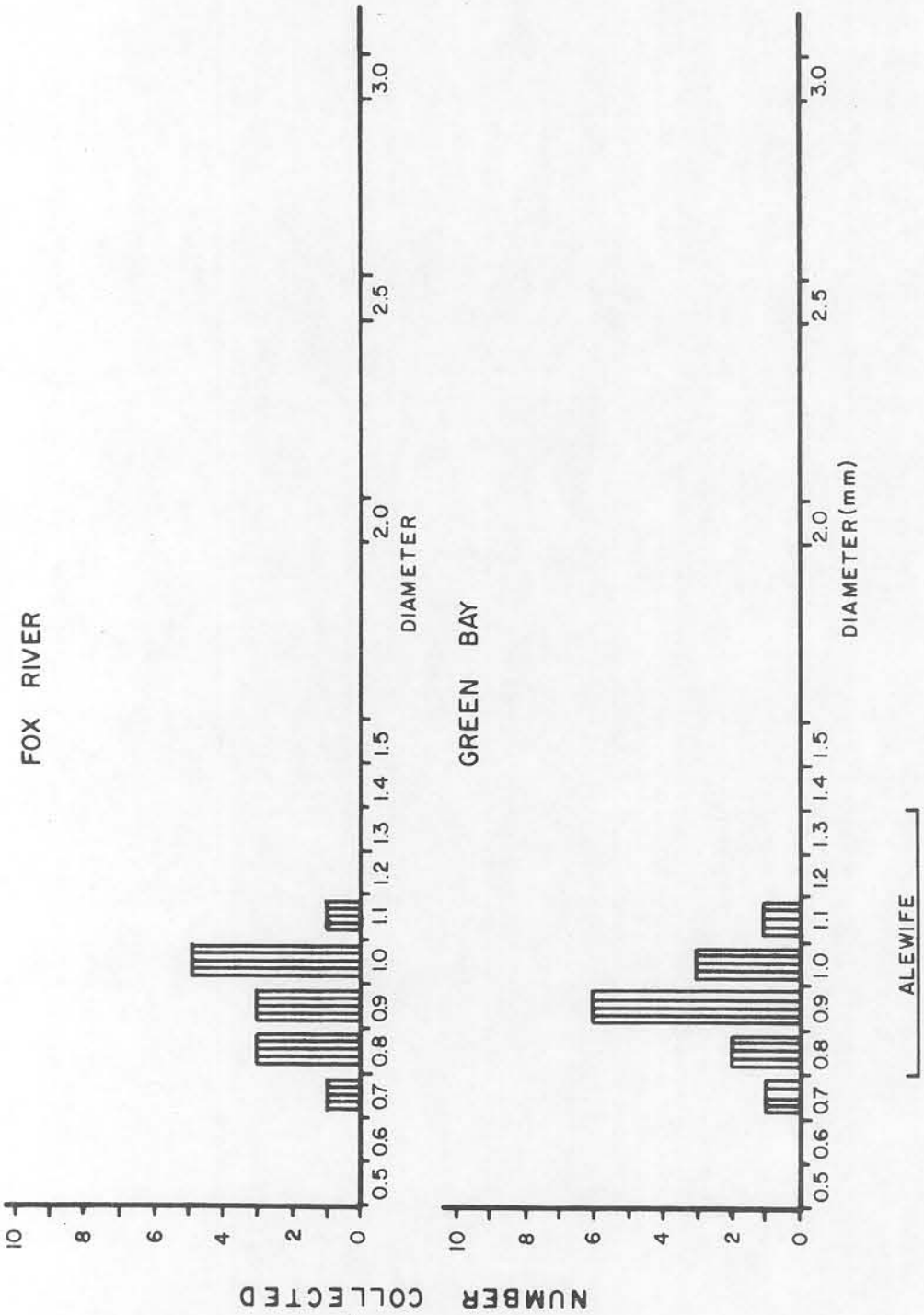


Figure 14. Diameter-frequency distribution of eggs collected from Fox River and Green Bay water at Pulliam Power Plant, August 1975.

Eggs collected were grouped by naturally occurring diameter ranges indicated in Figures 10 through 14 and larvae were identified to the lowest positive taxon. Daily and monthly mean concentrations were computed (Tables 27 athrough 36). Larvae and juveniles were separated only to indicate the relative age of the fish. Only larvae were found through June (Tables 31 and 32). The appearance of juvenile carp, drum, smelt and shad in July (Tables 33 and 34) indicated that these species spawned earlier and some growth had occurred.

The collection of both larvae and juveniles of a single species indicated spawning in the Plant area. The collection of eggs of the same probably species added strength to the assumption of spawning near the Plant. Species which spawned near the Plant include rainbow smelt, alewife, yellow perch, carp and freshwater drum.

C. Additional Data

Green Bay is the most eutrophic and commercially productive portion of Lake Michigan, averaging fifty percent of the annual commercial fish catch for the lake (Wells and McLain 1973). It is divided into a deep northern end which supports cold water species and a shallow southern end characterized by warm water species (Epstein et al. 1974).

The Fox River is a highly eutrophic river draining Lake Winnebago to Green Bay. In addition to the indigenous population of pollution tolerant organisms any of the 76 species of Lake Winnebago (Priegel 1967) could be encountered in the river.

Table 27. Total numbers and mean concentrations of eggs, larvae, and juvenile fish collected in presumed Fox River water at Pulliam Power Plant, April 1975.

| Date | 4/2 | | 4/9 | | 4/16 | | 4/23 | | 4/30 | | April | | Diameter or Total Length (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Number/$m^3$ | Number | Number/$m^3$ | Number | Number/$m^3$ | Number | Number/$m^3$ | Number | Number/$m^3$ | Total Number | Mean Number/$m^3$ | Mean | Range |
| Eggs | | | | | | | | | | | | | | |
| 0.6-1.3mm | 0 | 0.000 | 0 | 0.000 | 1 | 0.001 | 0 | 0.000 | 0 | 0.000 | 1 | >0.001 | | |
| 1.4-2.1mm | 0 | 0.000 | 0 | 0.000 | 10 | 0.007 | 2 | 0.002 | 0 | 0.000 | 12 | 0.002 | | |
| 2.2-3.1mm | 0 | 0.000 | 0 | 0.000 | 2 | 0.001 | 19 | 0.023 | 81 | 0.148 | 102 | 0.034 | | |



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Table 28. Total numbers and mean concentrations of eggs, larvae, and juvenile fish collected in presumed Green Bay water at Pulliam Power Plant, April 1975.

| Date | 4/2 | | 4/9 | | 4/16 | | 4/23 | | 4/30 | | April | | Total Length (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Number/m$^3$ | Number | Number/m$^3$ | Number | Number/m$^3$ | Number | Number/m$^3$ | Number | Number/m$^3$ | Total Number | Mean Number/m$^3$ | Mean | Range |
| Larvae | | | | | | | | | | | | | | |
| Burbot | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 1 | 0.002 | 1 | >0.001 | 4.8 | - |
| Eggs | | | | | | | | | | | | | | |
| 0.6-1.3mm | 0 | 0.000 | 0 | 0.000 | 65 | 0.081 | 0 | 0.000 | 82 | 0.130 | 147 | 0.042 | | |
| 1.4-2.1mm | 0 | 0.000 | 0 | 0.000 | 11 | 0.014 | 0 | 0.000 | 0 | 0.000 | 11 | 0.003 | | |
| 2.2-3.1mm | 0 | 0.000 | 27 | 0.042 | 41 | 0.051 | 19 | 0.054 | 15 | 0.024 | 102 | 0.034 | | |



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Table 29. Total numbers and mean concentrations of eggs, larvae, and juvenile fish collected in presumed Fox River water at Pulliam Power Plant, May 1975.

| Date | 5/7 | | 5/14 | | 5/21 | | 5/28 | | May | | Total Length | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Number/m$^3$ | Number | Number/m$^3$ | Number | Number/m$^3$ | Number | Number/m$^3$ | Total Number | Mean Number/m$^3$ | Mean | Range |
| Larvae | | | | | | | | | | | | |
| Burbot | 6 | 0.011 | 3 | 0.005 | 9 | 0.013 | 27 | 0.048 | 45 | 0.019 | 8.8 | 4.8-16.4 |
| Yellow Perch | 0 | 0.000 | 0 | 0.000 | 10 | 0.014 | 28 | 0.050 | 38 | 0.016 | 10.6 | 6.1-15.0 |
| Carp | 0 | 0.000 | 0 | 0.000 | 2 | 0.003 | 60 | 0.108 | 62 | 0.028 | 6.2 | 5.2- 9.2 |
| *Stizostedeon* sp | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 1 | 0.002 | 1 | 0.001 | 5.8 | - |
| Eggs | | | | | | | | | | | | |
| 0.6-1.3mm | 0 | 0.000 | 3 | 0.005 | 0 | 0.000 | 0 | 0.000 | 3 | 0.001 | | |
| 1.4-2.1mm | 1 | 0.001 | 3 | 0.005 | 3 | 0.004 | 0 | 0.000 | 7 | 0.003 | | |
| 2.2-3.1mm | 6 | 0.007 | 2 | 0.004 | 5 | 0.010 | 0 | 0.000 | 13 | 0.005 | | |
| 5.4mm | 1 | 0.001 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 1 | <0.001 | | |



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Table 30. Total numbers and mean concentrations of eggs, larvae, and juvenile fish collected in presumed Green Bay water and Pulliam Power Plant, May 1975.

| Date | 5/7 | | 5/14 | | 5/21 | | 5/28 | | May | | Total Length | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Number/$m^3$ | Number | Number/$m^3$ | Number | Number/$m^3$ | Number | Number/$m^3$ | Total Number | Mean Number/$m^3$ | Mean | Range |
| Larvae | | | | | | | | | | | | |
| Burbot | 0 | 0.000 | 0 | 0.000 | 10 | 0.015 | 2 | 0.006 | 12 | 0.005 | 9.6 | 8.2-10.7 |
| Yellow Perch | 0 | 0.000 | 0 | 0.000 | 25 | 0.038 | 11 | 0.030 | 36 | 0.017 | 8.7 | 6.4-12.0 |
| Carp | 0 | 0.000 | 0 | 0.000 | 21 | 0.031 | 22 | 0.061 | 43 | 0.023 | 6.2 | 5.2- 7.5 |
| Eggs | | | | | | | | | | | | |
| 0.6-1.3mm | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | | |
| 1.4-2.1mm | 6 | 0.011 | 0 | 0.000 | 5 | 0.008 | 0 | 0.000 | 11 | 0.005 | | |
| 2.2-3.1mm | 13 | 0.024 | 0 | 0.000 | 2 | 0.003 | 1 | 0.003 | 16 | 0.008 | | |



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Table 31. Total numbers and mean concentrations of eggs, larvae, and juvenile fish collected in presumed Fox River water at Pulliam Power Plant, June 1975.

| Date | 6/4 | | 6/11 | | 6/18 | | 6/25 | | June | | Total Length | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Number/$m^3$ | Number | Number/$m^3$ | Number | Number/$m^3$ | Number | Number/$m^3$ | Total Number | Mean Number/$m^3$ | Mean | Range |
| Larvae | | | | | | | | | | | | |
| Yellow Perch | 1 | 0.001 | 0 | 0.000 | 0 | 0.000 | 3 | 0.006 | 4 | 0.002 | 13.0 | - |
| White Bass | 5 | 0.007 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 5 | 0.002 | 8.3 | 4.4-13.0 |
| Freshwater Drum | 4 | 0.006 | 0 | 0.000 | 5 | 0.012 | 7 | 0.015 | 16 | 0.008 | 6.9 | 4.8- 8.8 |
| Carp | 4 | 0.005 | 0 | 0.000 | 1 | 0.002 | 78 | 0.117 | 83 | 0.031 | 6.9 | 5.9- 7.8 |
| Burbot | 1 | 0.001 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 1 | >0.001 | 20.4 | - |
| Catastomidae | 1 | 0.001 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 1 | >0.001 | 21.5 | - |
| Eggs | | | | | | | | | | | | |
| 0.6-1.3mm | 0 | 0.000 | 4870 | 6.882 | 0 | 0.000 | 13995 | 29.942 | 18865 | 9.206 | | |
| 1.4-2.1mm | 0 | 0.000 | 104 | 0.147 | 0 | 0.000 | 41 | 0.088 | 145 | 0.059 | | |
| 2.2-3.1mm | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | | |



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Table 32. Total numbers and mean concentrations of eggs, larvae, and juvenile fish collected in presumed Green Bay water at Pulliam Power Plant, June 1975.

| Date | 6/4 | | 6/11 | | 6/18 | | 6/25 | | June | | Total Length (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Number/$m^3$ | Number | Number/$m^3$ | Number | Number/$m^3$ | Number | Number/$m^3$ | Total Number | Mean Number/$m^3$ | Mean | Range |
| Larvae | | | | | | | | | | | | |
| Yellow Perch | 3 | 0.004 | 0 | 0.000 | 0 | 0.000 | 1 | 0.002 | 4 | 0.002 | 12.7 | 6.8-17.3 |
| White Bass | 17 | 0.024 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 17 | 0.006 | 4.5 | 4.1- 4.9 |
| Freshwater Drum | 32 | 0.045 | 0 | 0.000 | 55 | 0.079 | 2 | 0.003 | 89 | 0.032 | 5.2 | 4.9- 9.2 |
| Carp | 6 | 0.008 | 4 | 0.008 | 5 | 0.007 | 27 | 0.047 | 42 | 0.018 | 7.0 | 6.2-10.6 |
| White Sucker | 1 | 0.001 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 1 | <0.001 | 26.3 | - |
| Troutperch | 0 | 0.000 | 0 | 0.000 | 1 | 0.001 | 0 | 0.000 | 1 | <0.001 | 25.0 | - |
| Unidentified | 3 | 0.014 | 0 | 0.000 | 0 | 0,000 | 0 | 0.000 | 3 | 0.004 | - | - |
| Eggs | | | | | | | | | | | | |
| 0.6-1.3mm | 36 | 0.050 | 3920 | 7.916 | 180 | 0.257 | 381 | 0.656 | 4517 | 2.220 | | |
| 1.4-2.1mm | 43 | 0.060 | 128 | 0.258 | 0 | 0.000 | 5 | 0.009 | 176 | 0.082 | | |
| 2.2-3.1mm | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 1 | 0.002 | 1 | <0.001 | | |



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Table 33. Total numbers and mean concentrations of eggs, larvae, and juvenile fish collected in presumed Fox River water at Pulliam Power Plant, July 1975.

| Date | 7/2 | | 7/9 | | 7/16 | | 7/23 | | 7/30 | | July | | Total Length (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Number/m³ | Number | Number/m³ | Number | Number/m³ | Number | Number/m³ | Number | Number/m³ | Total Number | Mean Number/m³ | Mean | Range |
| **Larvae & Juveniles** | | | | | | | | | | | | | | |
| Carp | | | | | | | | | | | | | | |
| Larvae | 42 | 0.053 | 24 | 0.034 | 22 | 0.019 | 0 | 0.000 | 2 | 0.003 | 90 | 0.022 | 6.8 | 4.8- 9.5 |
| Juvenile | 0 | 0.000 | 0 | 0.000 | 1 | 0.001 | 0 | 0.000 | 0 | 0.000 | 1 | >0.001 | 19.0 | - |
| Alewife | | | | | | | | | | | | | | |
| Larvae | 12 | 0.015 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 12 | 0.003 | 4.8 | 4.0- [illegible] |
| Freshwater Drum | | | | | | | | | | | | | | |
| Larvae | 1 | 0.001 | 0 | 0.000 | 2 | 0.002 | 0 | 0.000 | 0 | 0.000 | 3 | 0.001 | 8.3 | 4.8-11.0 |
| Juvenile | 0 | 0.000 | 0 | 0.000 | 1 | 0.001 | 0 | 0.000 | 0 | 0.000 | 1 | >0.001 | 48.0 | - |
| Troutperch | | | | | | | | | | | | | | |
| Juvenile | 0 | 0.000 | 0 | 0.000 | 3 | 0.004 | 0 | 0.000 | 0 | 0.000 | 3 | 0.001 | 41.7 | 40.0-45.0 |
| Gizzard Shad | | | | | | | | | | | | | | |
| Juvenile | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 1 | 0.001 | 0 | 0.000 | 1 | >0.001 | 21.0 | - |
| Unidentified | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 1 | 0.001 | 1 | >0.001 | - | - |
| **Eggs** | | | | | | | | | | | | | | |
| 0.6-1.3mm | 587 | 0.736 | 326 | 0.465 | 26 | 0.038 | 85 | 0.118 | 24 | 0.034 | 1048 | 0.278 | | |
| 1.4-2.1mm | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | | |
| 2.2-3.1mm | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | | |



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Table 34. Total numbers and mean concentrations of eggs, larvae, and juvenile fish collected in presumed Green Bay water at Pulliam Power Plant, July 1975.

| Date | 7/2 | | 7/9 | | 7/16 | | 7/23 | | 7/30 | | July | | Total Length (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Number/m³ | Number | Number/m³ | Number | Number/m³ | Number | Number/m³ | Number | Number/m³ | Total Number | Mean Number/m³ | Mean | Range |
| Larvae & Juveniles | | | | | | | | | | | | | | |
| Spottail Shiner | | | | | | | | | | | | | | |
| Juvenile | 1 | 0.001 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 1 | <0.001 | 29.0 | - |
| Gizzard Shad | | | | | | | | | | | | | | |
| Larvae | 1 | 0.001 | 4 | 0.010 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 5 | 0.002 | 10.9 | 8.6-12.8 |
| Juvenile | 0 | 0.000 | 8 | 0.020 | 2 | 0.004 | 3 | 0.004 | 0 | 0.000 | | | 21.5 | 17.5-26.5 |
| Carp | | | | | | | | | | | | | | |
| Larvae | 12 | 0.017 | 25 | 0.061 | 2 | 0.004 | 0 | 0.000 | 0 | 0.000 | 39 | 0.016 | 6.8 | 4.8- 8.8 |
| Juvenile | 1 | 0.001 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 1 | <0.001 | 24.0 | - |
| Freshwater Drum | | | | | | | | | | | | | | |
| Larvae | 0 | 0.000 | 0 | 0.000 | 1 | 0.002 | 0 | 0.000 | 0 | 0.000 | 1 | <0.001 | 12.5 | - |
| Rainbow Smelt | | | | | | | | | | | | | | |
| Larvae | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 1 | 0.001 | 1 | <0.001 | 19.0 | - |
| Juvenile | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 2 | 0.003 | 2 | 0.001 | 26.5 | 24.0-24.0 |
| Alewife | | | | | | | | | | | | | | |
| Larvae | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 1 | 0.001 | 1 | <0.001 | 10.8 | - |
| Eggs | | | | | | | | | | | | | | |
| 0.6-1.3mm | 5197 | 7.556 | 4046 | 9.917 | 133 | 0.280 | 451 | 0.654 | 30 | 0.044 | 9856 | 3.690 | | |
| 1.4-2.1mm | 2 | 0.003 | 13 | 0.032 | 0 | 0.000 | 1 | 0.001 | 0 | 0.000 | 16 | 0.007 | | |
| 2.2-3.1mm | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | | |



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Table 35. Total numbers and mean concentrations of eggs, larvae, and juvenile fish collected in presumed Fox River water at Pulliam Power Plant, August 1975.

| Species | Date | 8/6 | | 8/13 | | 8/20 | | 8/27 | | August | | Diameter or Total Length (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Number | Number/$m^3$ | Number | Number/$m^3$ | Number | Number/$m^3$ | Number | Number/$m^3$ | Total Number | Mean Number/$m^3$ | Mean | Range |
| Larvae & Juveniles | | | | | | | | | | | | | |
| Rainbow Smelt | | | | | | | | | | | | | |
| Juvenile | | 1 | 0.001 | 0 | 0.000 | 0 | 0.000 | 1 | 0.002 | 2 | 0.001 | 30.0 | 27.0-33.0 |
| Notropis sp. | | | | | | | | | | | | | |
| Larvae | | 1 | 0.001 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 1 | >0.001 | 14.1 | – |
| Eggs | | | | | | | | | | | | | |
| 0.6-1.3mm | | 8 | 0.012 | 6 | 0.009 | 0 | 0.000 | 0 | 0.000 | 14 | 0.005 | | |
| 1.4-2.1mm | | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | | |
| 2.2-3.1mm | | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | | |



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Table 36. Total numbers and mean concentrations of eggs, larvae, and juvenile fish collected in presumed Green Bay water at Pulliam Power Plant, August 1975.

| Species \ Date | 8/6 | | 8/13 | | 8/20 | | 8/29 | | August | | Total Length (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Number/m | Number | Number/m | Number | Number/m | Number | Number/m | Total Number | Mean Number/m$^3$ | Mean | Range |
| Juveniles | | | | | | | | | | | | |
| Rainbow Smelt | | | | | | | | | | | | |
| Juvenile | 1 | 0.002 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 1 | >0.001 | 30.0 | - |
| *Notropis* sp. | | | | | | | | | | | | |
| Juveniles | 2 | 0.004 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 2 | 0.001 | 30.0 | 29.0-31.0 |
| Bluegill Sunfish | | | | | | | | | | | | |
| Juvenile | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 2 | 0.004 | 2 | 0.001 | 56.0 | - |
| Black Bullhead | | | | | | | | | | | | |
| Juvenile | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 1 | 0.002 | 1 | >0.001 | 41.5 | 39.0-42.0 |
| Eggs | | | | | | | | | | | | |
| 0.6-1.3mm | 7 | 0.013 | 1 | 0.002 | 4 | 0.011 | 0 | 0.000 | 12 | 0.007 | | |
| 1.4-2.1mm | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | | |
| 2.2-3.1mm | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | | |



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Kernen (1974) studied fish populations in Green Bay and the Fox River and Robinson (1976) studied fish populations in the area of J. P. Pulliam Power Plant. A combined species list is presented in Table 37. Those species making up a significant percentage of catches in the river or bay are marked with an "A", abundant. These species include alewives, carp, white suckers, black bullheads, burbot, white bass and yellow perch. These same species are commercially exploited in the area (Table 39) and cited by Lloyd (1966) as representative.

Commercial catches reflect demand as well as abundance, not population levels directly, but are useful in indicating important species. Commercially important species in which Wisconsin catches contribute 50 percent or more to the Lake Michigan total include: alewife, carp, suckers, whitefish and yellow perch. Several other species are caught almost exclusively in Green Bay. These include: northern pike, bullheads, burbot, lake herring, freshwater drum, white bass and walleyes (Table 38).

Commercial fishery statistics for Wisconsin District 1 or southern Green Bay are shown in Table 39. These data emphasize the predominance of warm water species including alewives, carp, suckers, northern pike and yellow perch in southern Green Bay. Cold water species such as chubs, herring and lake trout comprise small percentages of landings.

No species listed as endangered by the Wisconsin Department of Natural Resources (1975) were found by Robinson (1976) or Kernan (1974). The longer sunfish listed as "changing status" was reported by Kernan (1974).

Table 37. Fishes of Green Bay and the Fox River in the vicinity of Green Bay, Wisconsin.[a]

| Common Name | Scientific Name | Occurrence | |
|---|---|---|---|
| | | Fox River | Green Bay |
| Lake Sturgeon | *Acipenser fulvescens* | X | X |
| Longnose Gar | *Lepisosteus osseus* | - | X |
| Shortnose Gar | *Lepisosteus platosomus* | X | - |
| Bowfin | *Amia calva* | X | X |
| Alewife | *Alosa pseudoharengus* | A[b] | A |
| Gizzard Shad | *Dorosoma cepedianum* | X[c] | X |
| Mooneye | *Hiodon tergisus* | X | - |
| Rainbow Trout | *Salmo gairdneri* | X | X |
| Brown Trout | *Salmo trutta* | X | X |
| Brook Trout | *Salvelinus fontinalis* | X | - |
| Lake Trout | *Salvelinus namaycush* | - | X |
| Coho Salmon | *Oncorynchus kisutch* | X | X |
| Chinook Salmon | *Oncorynchus tshawytscha* | X | X |
| Rainbow Smelt | *Osmerus mordax* | X | X |
| Northern Pike | *Esox lucius* | X | X |
| Muskellunge | *Esox masguinongy* | X | - |
| Carp | *Cyprinus carpio* | A | A |
| Spottail Shiner | *Notropis hudsonius* | X | X |
| Emerald Shiner | *Notropis atherinoides* | X | X |
| Common Shiner | *Notropis cornutus* | - | X |
| Golden Shiner | *Notemigonus crysoleucas* | - | X |
| Fathead Minnow | *Pimephales promelas* | - | X |
| Quillback | *Caproides cyprinus* | X | - |
| White Sucker | *Catostomus commersoni* | A | A |
| Longnose Sucker | *Catostomus catostomus* | - | X |
| Bigmouth Buffalo | *Ictiobus cyprinellus* | X | - |
| Shorthead Redhorse | *Moxostoma macrolepidotum* | X | X |
| Silver Redhorse | *Moxostoma anisurum* | X | - |
| Channel Catfish | *Ictalurus punctatus* | X | X |
| Black Bullhead | *Ictalurus melas* | A | A |
| Brown Bullhead | *Ictalurus nebulosus* | X | X |
| Yellow Bullhead | *Ictalurus natalis* | X | X |
| Stonecat | *Noturus flavus* | X | - |

Table 37. (continued)

| Common Name | Scientific Name | Occurrence | |
|---|---|---|---|
| | | Fox River | Green Bay |
| Troutperch | Percopsis omiscomaycus | X | X |
| Burbot | Lota lota | X | A |
| Brook Stickleback | Culaea inconstans | X | - |
| White bass | Morone chrysops | A | A |
| Largemouth bass | Micropterus salmoides | X | X |
| Smallmouth bass | Micropterus dolomieui | X | X |
| Bluegill | Lepomis macrochirus | X | X |
| Pumpkinseed | Lepomis gibbosus | X | X |
| Green Sunfish | Lepomis cyanellus | X | - |
| Longear Sunfish | Lepomis megalotis | X | - |
| Rock Bass | Ambloplites rupestris | X | X |
| Black Crappie | Pomoxis nigromaculatus | X | X |
| White Crappie | Pomoxis annularis | X | - |
| Yellow Perch | Perca flavescens | X | A |
| Walleye | Stizostedeon vitreum | X | X |
| Sauger | Stizostedeon canadense | X | X |
| Log Perch | Percina caprodes | X | - |
| Johnny Darter | Etheostoma nigrum | X | - |
| Freshwater Drum | Aplodinotus grunniens | X | X |

[a] Adapted from Robinson 1976, Kernen 1974.
[b] A indicates abundant species contributing a significant percentage to catches in studies of the lake or river.
[c] Present in collections.
[-] Not collected.

Table 38. Wisconsin and total Lake Michigan Commercial Fisheries Landings (Pounds), 1973.[a]

| Species | Wisconsin | Lake Michigan |
|---|---|---|
| Alewives | 31,298,200 | 36,552,300 |
| Bullheads | 33,100 | 33,200 |
| Burbot | 113,700 | 156,800 |
| Carp | 3,207,900 | 3,211,000 |
| Catfish | 100 | 200 |
| Chubs | 1,861,000 | 4,461,300 |
| Lake Herring | 3,100 | 3,100 |
| Lake Trout | - | 42,200 |
| Pike or Pickerel | 31,300 | 31,300 |
| Salmon, Coho | - | 500 |
| Freshwater Drum | 2,600 | 2,600 |
| Smelt | 163,100 | 881,700 |
| Suckers | 449,500 | 709,600 |
| White Bass | 3,900 | 3,900 |
| Yellow Perch | 308,500 | 749,500 |
| Walleye | 3,700 | 3,700 |

[a] NOAA 1975.

Table 39. Total commercial landings (pounds) in Wisconsin and southern Green Bay (statistical district 1), 1974.[a]

| Species | Southern Green Bay | Total Wisconsin |
|---|---|---|
| Alewives | 20,094,473 | 39,725,524 |
| Bullheads | 33,257 | 33,257 |
| Burbot | 119,426 | 205,826 |
| Carp | 3,047,770 | 3,243,845 |
| Catfish | 1,742 | 1,742 |
| Chubs | 3,950 | 1,235,248 |
| Lake Herring | 851 | 6,112 |
| Lake Trout | 860 | 23,347 |
| Northern Pike | 22,705 | 22,705 |
| Freshwater Drum | 1,941 | 1,941 |
| Smelt | 77,465 | 336,483 |
| Suckers | 226,012 | 311,700 |
| Walleye | 5,733 | 5,795 |
| White Bass | 3,815 | 3,815 |
| Whitefish | 137,963 | 1,174,208 |
| Menominee | 2 | 9,437 |
| Yellow Perch | 786,609 | 834,942 |

[a] From data supplied by U.S.D.I., Great Lakes Fishery Laboratory.

A comparison of the flow in the Fox River with flow through the J. P. Pulliam Power Plant shows that 2.8% to 19.2% of the river flow traverses the condensers (Table 40). The mean for the five-month period is approximately 9.4%. These percentages are of most importance during periods of peak entrainment. During June 1975 the largest number of eggs and larvae were entrained in Fox River water. The percentage of the river withdrawn was approximately 5.2%.

Table 40. Comparison of mean flows in the Fox River near Wrightstown, Wisconsin and through Units 7&8, Pulliam Power Plant, April through August 1975.

| Month | Fox River Wrightstown, Wis. ($m^3$/min) | Units 7&8 Pulliam Power Plant ($m^3$/min) | % Units 7&8 / Fox River |
|---|---|---|---|
| April | 10,472.9 | 395.4 | 3.8 |
| May | 14,818.9 | 418.1 | 2.8 |
| June | 9,360.9 | 490.5 | 5.2 |
| July | 3,418.9 | 655.0 | 19.2 |
| August | 3,121.4 | 505.8 | 16.2 |

## IV. Analysis of Effect of Intake

### A. Adult and Juvenile Fish

An estimated total number of 675,714 fish weighing an estimated 15829 kg was impinged at the J.P. Pulliam Power Plant from April 1975 through March 1976 (Table 41). In order of numerical rank, species contributing 1% or more to the total number were: alewife, 76.1%; yellow perch, 16.8%; and bullheads, 4.5%. Other species were considered numerically incidental. Species contributing 1% or more by weight were: alewife, 74.5%; yellow perch, 12.4%; bullheads, 6.6%; rainbow smelt, 1.4%; and northern pike, 2.3%. Combined, these five species constituted 97.4% of the numerical total and 97.2% of the total by weight.

Although alewives dominated impinged fish collections, they were not impinged throughout the year (Figure 15). Their occurrence in impingement samples followed their seasonal migrations inshore for spawning in May and June followed by gradual offshore migration by adults as water temperatures rise (NALCO ES 1975). The numbers and weights of alewives collected reflected their relative abundance. Thus the Plant is a non-selective collection point, and impingement rates of alewives peaked in June and generally declined thereafter. It was also in June that the first eggs tentatively identified as alewife were entrained (Figure 15). Larvae were collected during July. Alewives apparently spawned in the area of the J.P. Pulliam Power Plant June, July, and August.

Length frequency distributions of impinged alewives reflected the occurrence of various lifestages of the species (Figure 18). From May through August the impinged fish were almost

Table 41. Estimated total numbers and weights of fish impinged at Pulliam Power Plant, April 1975 through March 1976.

| | | Number of Fish Impinged/Month | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Total | % |
| Alewife | Number | 0 | 6.754 | 267.189 | 131.452 | 77.965 | 5.049 | 0 | 25.882 | 21 | 0 | 0 | 0 | 514.312 | 76.1 |
| | Weight (Kg) | 0 | 236.569 | 1161.005 | 6994.080 | 3121.107 | 201.532 | 0 | 72.563 | 0.207 | 0 | 0 | 0 | 11787.063 | 74.5 |
| Yellow perch | Number | 3.433 | 6.533 | 1.312 | 244 | <169 | 1.423 | 58.505 | 25.594 | 2899 | 4669 | 2496 | 6252 | 113484 | 16.8 |
| | Weight (Kg) | 225.650 | 432.636 | 91.806 | 21.677 | 33.306 | 40.434 | 534.119 | 303.633 | 37.063 | 41.257 | 28.008 | 97.078 | 1966.677 | 12.4 |
| Shiner (Emerald & Spottail) | Number | 2.696 | 2.736 | 34 | 39 | 0 | 26 | 279 | 0 | 0 | 0 | 8 | 50 | 5868 | 0.9 |
| | Weight (Kg) | 39.161 | 32.329 | 0.060 | 2.732 | 0 | 0.133 | 2.124 | 0 | 0 | 0 | 0.032 | 0.274 | 76.845 | 0.5 |
| Bullhead (Black) | Number | 827 | 849 | 339 | 1.190 | 1.705 | 4.625 | 10.587 | 8.134 | 915 | 274 | 524 | 413 | 30382 | 4.5 |
| | Weight (Kg) | 46.512 | 88.435 | 42.612 | 110.985 | 142.240 | 126.420 | 196.897 | 231.619 | 38.856 | 5.999 | 6.308 | 6.040 | 1042.923 | 6.6 |
| Sucker (White Longnose) | Number | 94 | 78 | 4 | 8 | 19 | 4 | 109 | 45 | 0 | 19 | 4 | 47 | 431 | 0.1 |
| | Weight (Kg) | 35.025 | 61.996 | 1.946 | 5.193 | 4.824 | 0.171 | 4.398 | 2.693 | 0 | 0.601 | 0.152 | 1.907 | 118.906 | 0.8 |
| Carp | Number | 47 | 43 | 21 | 19 | 12 | 548 | 81 | 23 | 0 | 0 | 36 | 0 | 830 | 0.1 |
| | Weight (Kg) | 37.785 | 23.812 | 7.252 | 6.433 | 4.263 | 8.131 | 3.794 | 0.555 | 0 | 0 | 0.556 | 0 | 92.581 | 0.6 |
| Rainbow smelt | Number | 5.589 | 174 | 0 | 0 | 0 | 0 | 4 | 0 | 16 | 0 | 0 | 0 | 5783 | 0.9 |
| | Weight (Kg) | 210.528 | 4.100 | 0 | 0 | 0 | 0 | 0.124 | 0 | .651 | 0 | 0 | 0 | 251.403 | 1.4 |
| Walleye | Number | 17 | 19 | 64 | 12 | 0 | 39 | 27 | 0 | 0 | 0 | 0 | 5 | 183 | <0.1 |
| | Weight (Kg) | 2.863 | 2.848 | 7.629 | 1.918 | 0 | 1.663 | 5.580 | 0 | 0 | 0 | 0 | 0.289 | 22.790 | 0.1 |
| Burbot | Number | 26 | 19 | 0 | 27 | 31 | 21 | 99 | 30 | 0 | 4 | 12 | 16 | 285 | <0.1 |
| | Weight (Kg) | 6.026 | 17.438 | 0 | 8.951 | 6.936 | 0.450 | 1.492 | 6.195 | 0 | 0.116 | 5.756 | 7.482 | 60.842 | 0.4 |
| Northern pike | Number | 257 | 27 | 13 | 23 | 12 | 0 | 4 | 11 | 0 | 0 | 0 | 5 | 352 | 0.1 |
| | Weight (Kg) | 282.696 | 22.649 | 8.893 | 17.084 | 8.289 | 0 | 2.906 | 15.656 | 0 | 0 | 0 | 1.555 | 359.728 | 2.3 |
| Crappie (Black) | Number | 26 | 4 | 4 | 39 | 8 | 21 | 0 | 0 | 5 | 0 | 12 | 11 | 130 | <0.1 |
| | Weight (Kg) | 2.606 | 0.407 | 0.230 | 6.394 | 1.473 | 0.163 | 0 | 0 | 0.594 | 0 | 1.656 | 1.488 | 15.011 | 0.1 |
| Freshwater drum | Number | 4 | 0 | 0 | 0 | 4 | 0 | 31 | 0 | 72 | 70 | 112 | 36 | 329 | 0.1 |
| | Weight (Kg) | 0.129 | 0 | 0 | 0 | 0.775 | 0 | 0.465 | 0 | 1.448 | 0.984 | 1.916 | 0.584 | 6.301 | <0.1 |
| White bass | Number | 4 | 12 | 4 | 4 | 0 | 30 | 39 | 49 | 26 | 27 | 48 | 16 | 259 | <0.1 |
| | Weight (Kg) | 0.857 | 2.500 | 0.707 | 0.233 | 0 | 3.707 | 2.635 | 1.050 | 0.491 | 0.422 | 0.912 | 0.419 | 13.933 | 0.1 |
| Troutperch | Number | 0 | 0 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 41 | 62 | <0.1 |
| | Weight (Kg) | 0 | 0 | 0.321 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.713 | 1.034 | <0.1 |
| Round whitefish | Number | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | <0.1 |
| | Weight (Kg) | 0.450 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.450 | <0.1 |
| Mudminnow | Number | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | <0.1 |
| | Weight (Kg) | 0.129 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.129 | <0.1 |
| Channel catfish | Number | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 5 | 9 | <0.1 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.300 | 0 | 0 | 0 | 0.248 | 0.548 | <0.1 |
| Rainbow trout | Number | 4 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | <0.1 |
| | Weight (Kg) | 7.927 | 0 | 0 | 0.814 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8.741 | 0.1 |



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Table 41. (continued)

| | | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gar | Number | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 8 | <0.1 |
| | Weight (Kg) | 0 | 0 | 0 | 1,550 | 0 | 0 | 0 | 1.688 | 0 | 0 | 0 | 0 | 3.238 | <0.1 |
| Bowfin | Number | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | <0.1 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 1.127 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.127 | <0.1 |
| Coho salmon | Number | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | <0.1 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0.078 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.078 | <0.1 |
| Bluegill | Number | 0 | 0 | 0 | 0 | 0 | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | <0.1 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0.086 | | 0 | 0 | 0 | 0 | 0 | 0.086 | <0.1 |
| Mooneye | Number | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 41 | 0 | 0 | 0 | 41 | <0.1 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .801 | 0 | 0 | 0 | .801 | <0.1 |
| Gizzard shad | Number | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2894 | 0 | 0 | 0 | 2894 | 0.4 |
| | Weight (Kg) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33.534 | 0 | 0 | 0 | 33.534 | 0.2 |
| Total | Number | 13.046 | 17.248 | 269005 | 133065 | 79933 | 11820 | 69765 | 59731 | 6889 | 5063 | 3252 | 6897 | 675714 | |
| | Weight (Kg) | 898.344 | 925.719 | 1322.461 | 7178.044 | 3324.418 | 382.890 | 754.534 | 715.952 | 113.645 | 49.379 | 45.296 | 118.077 | 15828.769 | |
| | Number | 1.9 | 2.6 | 39.8 | 19.7 | 11.8 | 1.7 | 10.3 | 8.8 | 1.0 | 0.7 | 0.5 | 1.0 | | |
| | Weight (Kg) | 5.7 | 5.8 | 8.4 | 45.3 | 21.0 | 2.4 | 4.8 | 4.5 | 0.7 | 0.3 | 0.3 | 0.7 | | |



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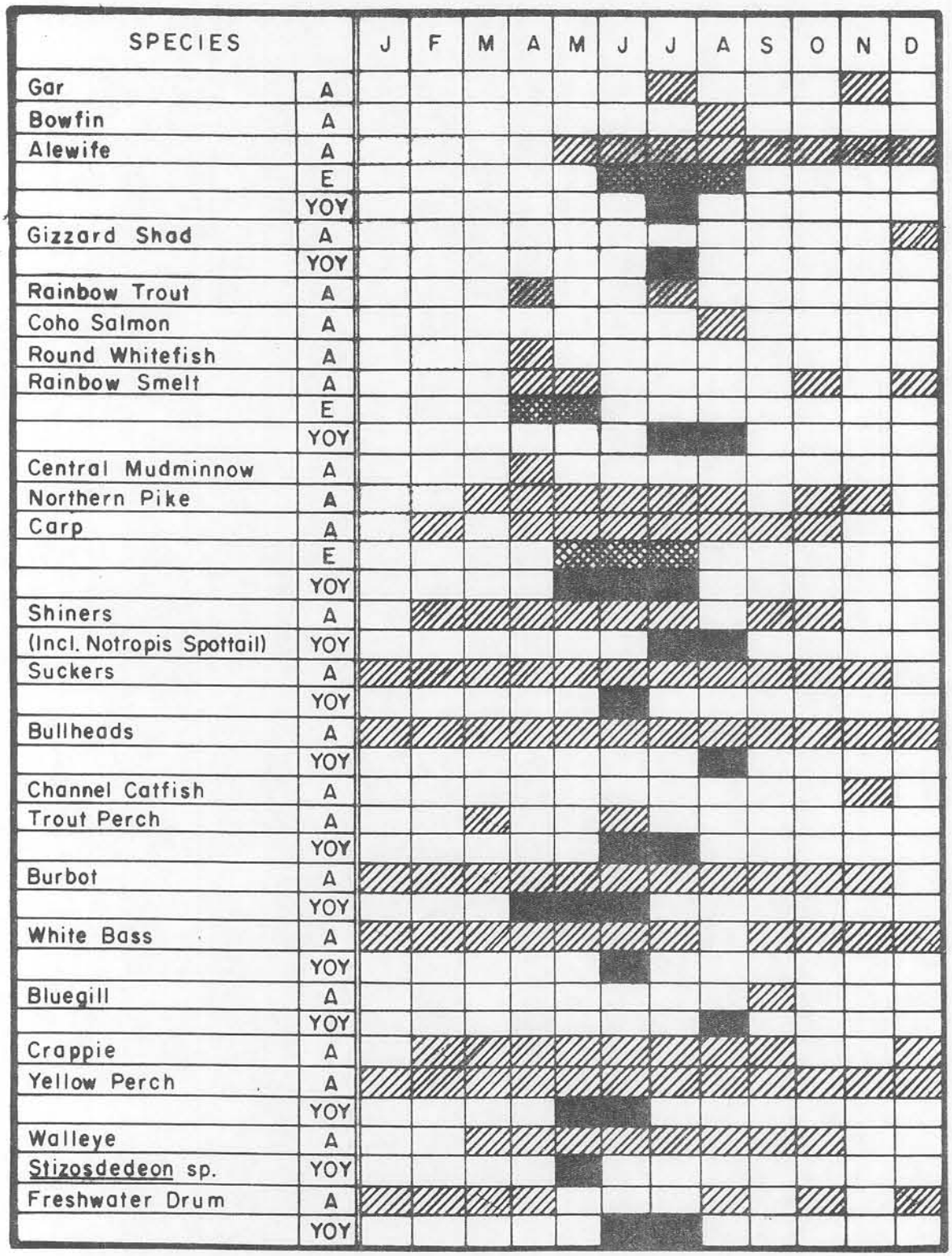


LIFESTAGES:

A = Adult E = Eggs YOY = Young Of Year

Figure 15. Seasonal occurrence of impinged adult and juvenile and entrained eggs and larval fish at Pulliam Power Plant, April 1975 through March, 1976.

exclusively adults with a modal total length of 18-19 cm. Juvenile fish appeared for the first time in September. During October and November fish of all sizes were impinged, but in low numbers, and no dominant size group was seen.

Yellow perch was the second most important species numerically and by weight. Adult and juvenile perch were impinged during every month (Figure 15). No eggs identifiable as yellow perch were collected, perhaps because they are spawned in gelatinous strings attached to the bottom. Larvae were collected in May and June, indicating spawning in April or May.

The numbers of yellow perch collected in impingement samples varied from 63 in July to 15098 (estimated from total weight) in October (Tables 4-15, Figure 16). The curve in Figure 16 is essentially unimodal with the peak occurring in October and November. Length frequency distributions of impinged perch show all sizes from 5 to 28 cm (Figure 19). From April through August the modal length was in the 17 to 19 cm (adult) range. In August the first juveniles, apparently young-of-year, appeared in small percentages. The percentage of juveniles continued to increase through March 1976 while percentages of older, larger fish steadily decreased. The reason was that adults moved offshore while younger perch inhabited shallower water during the summer (Wisconsin Department of Natural Resources 1959).

If the length frequencies were treated as a continuous cycle the obvious interpretation was that juvenile perch spend their first and/or second winter in shallow water near the J.P. Pulliam Power Plant and that older fish appeared inshore in April

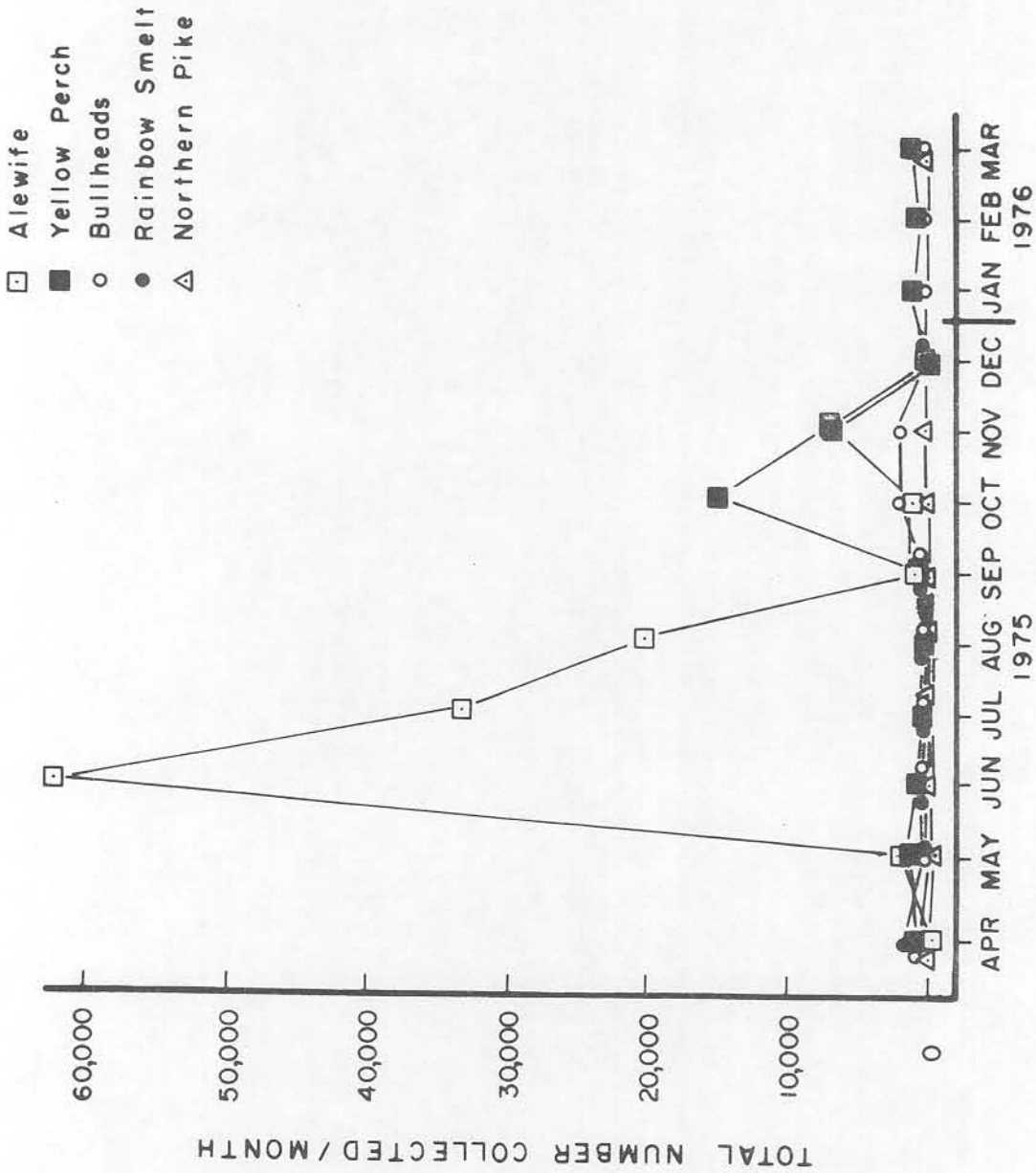


Figure 16. Total numbers of five species of fish collected from the traveling screens at Pulliam Power Plant, April 1975 through March 1976.

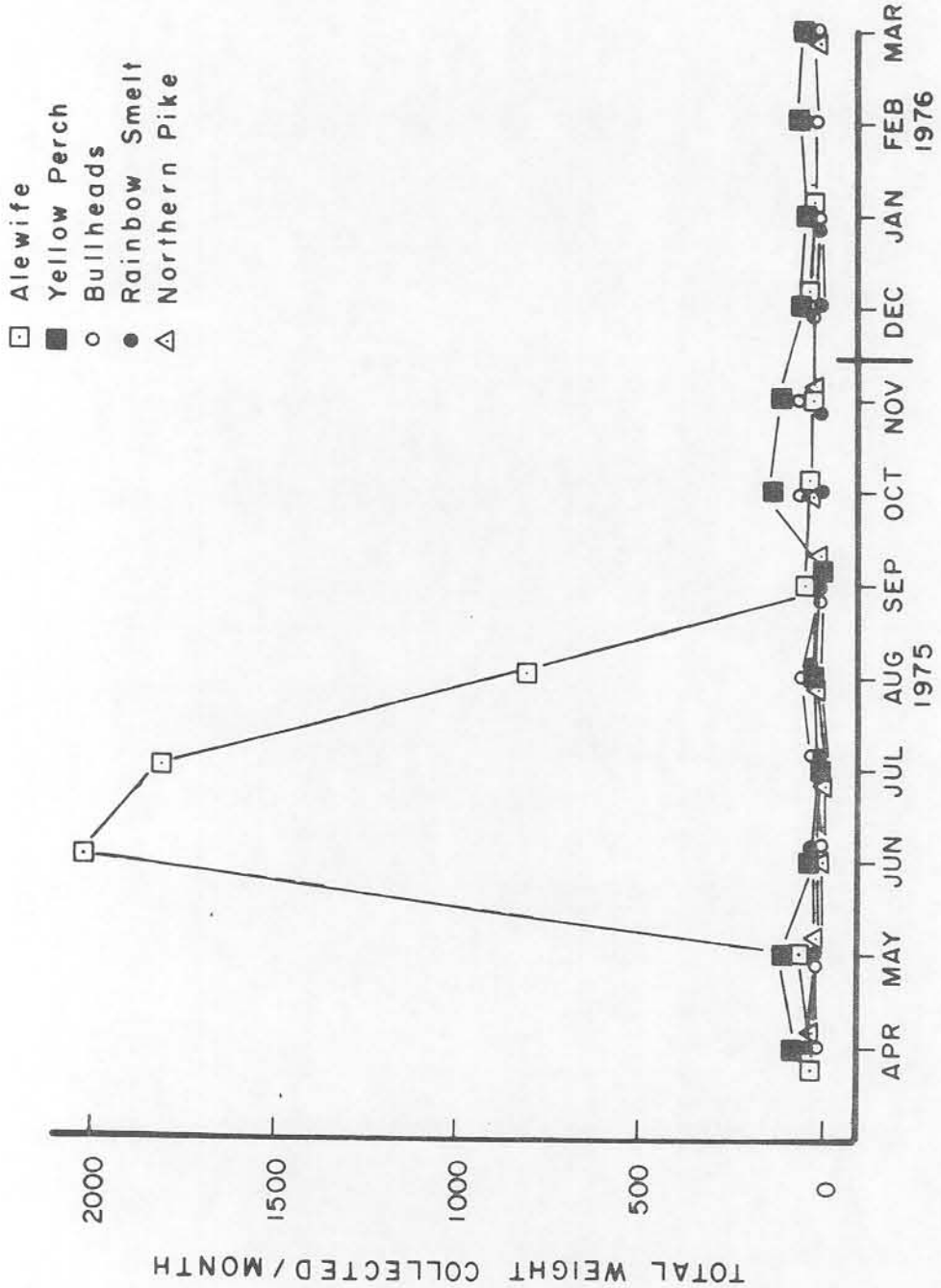


Figure 17. Total weights (Kg) of five species of fish collected from the traveling screens at Pulliam Power Plant, April 1975 through March 1976.

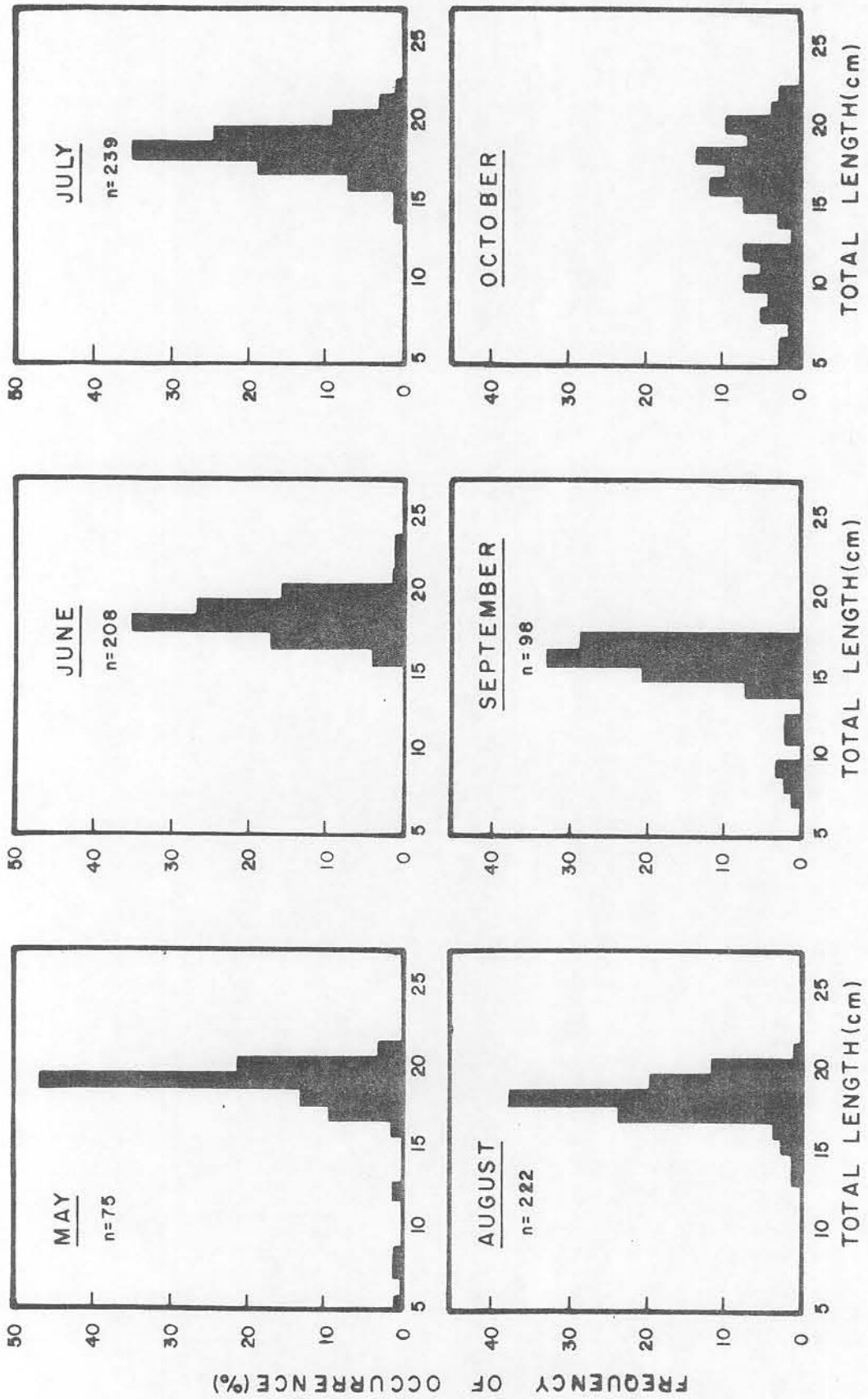


Figure 18. Length-frequency distributions of adult and juvenile alewives impinged at Pulliam Power Plant, May through November, 1975.

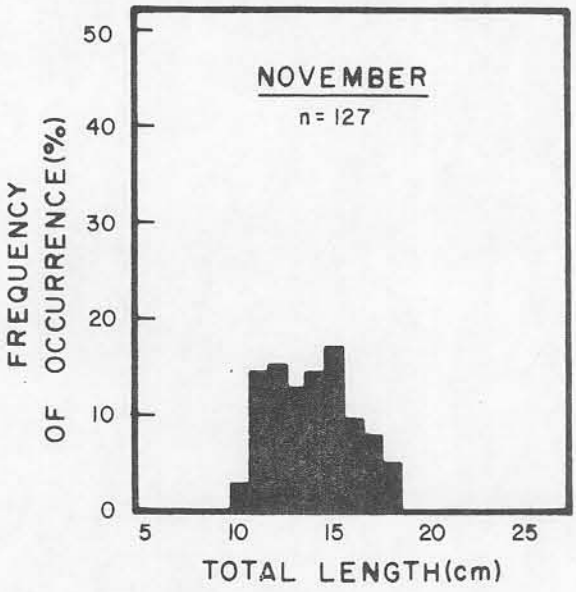


Figure 18. (continued)

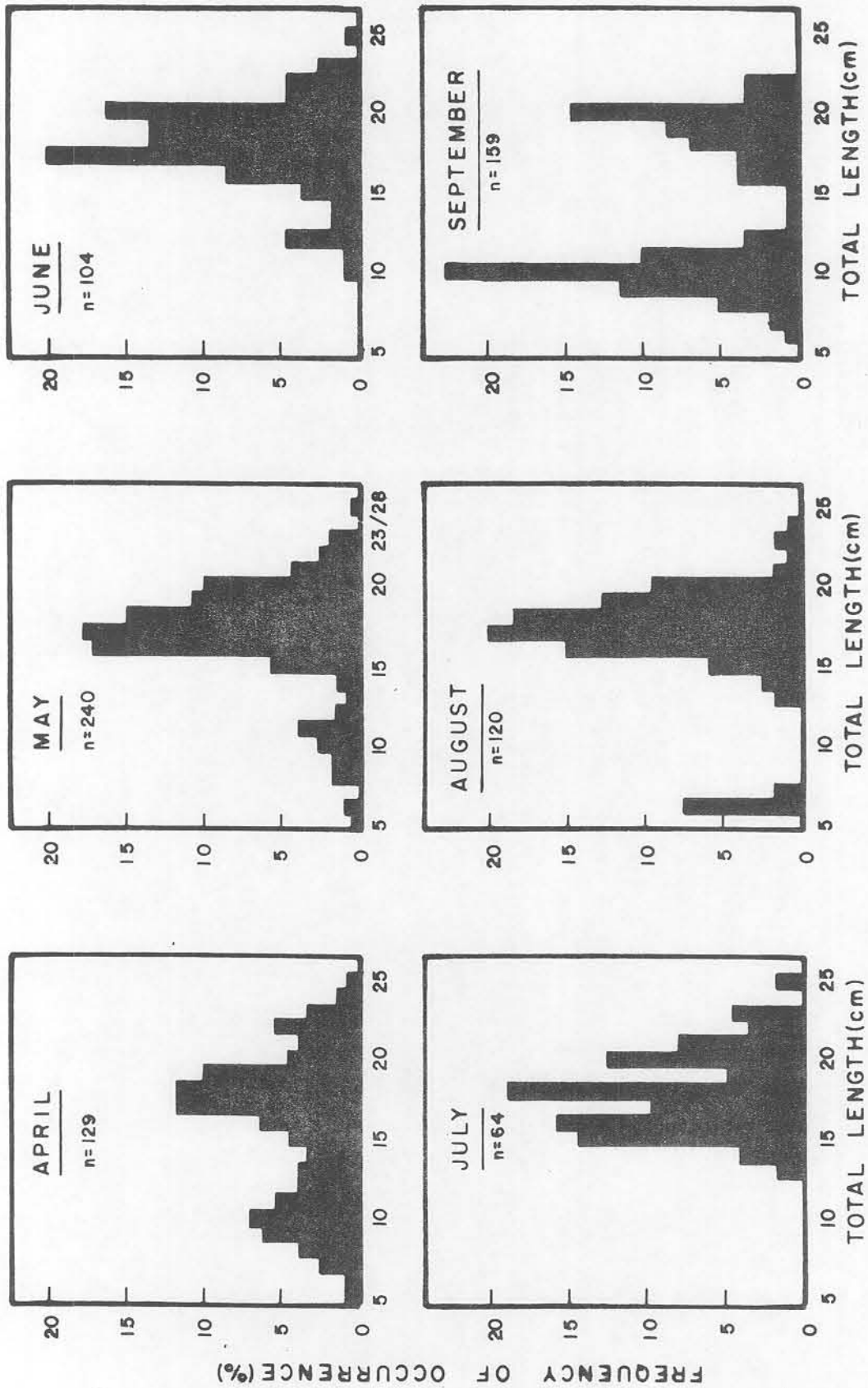


Figure 19. Length-frequency distributions of adult and juvenile yellow perch impinged at Pulliam Power Plant, April 1975 through March 1976.

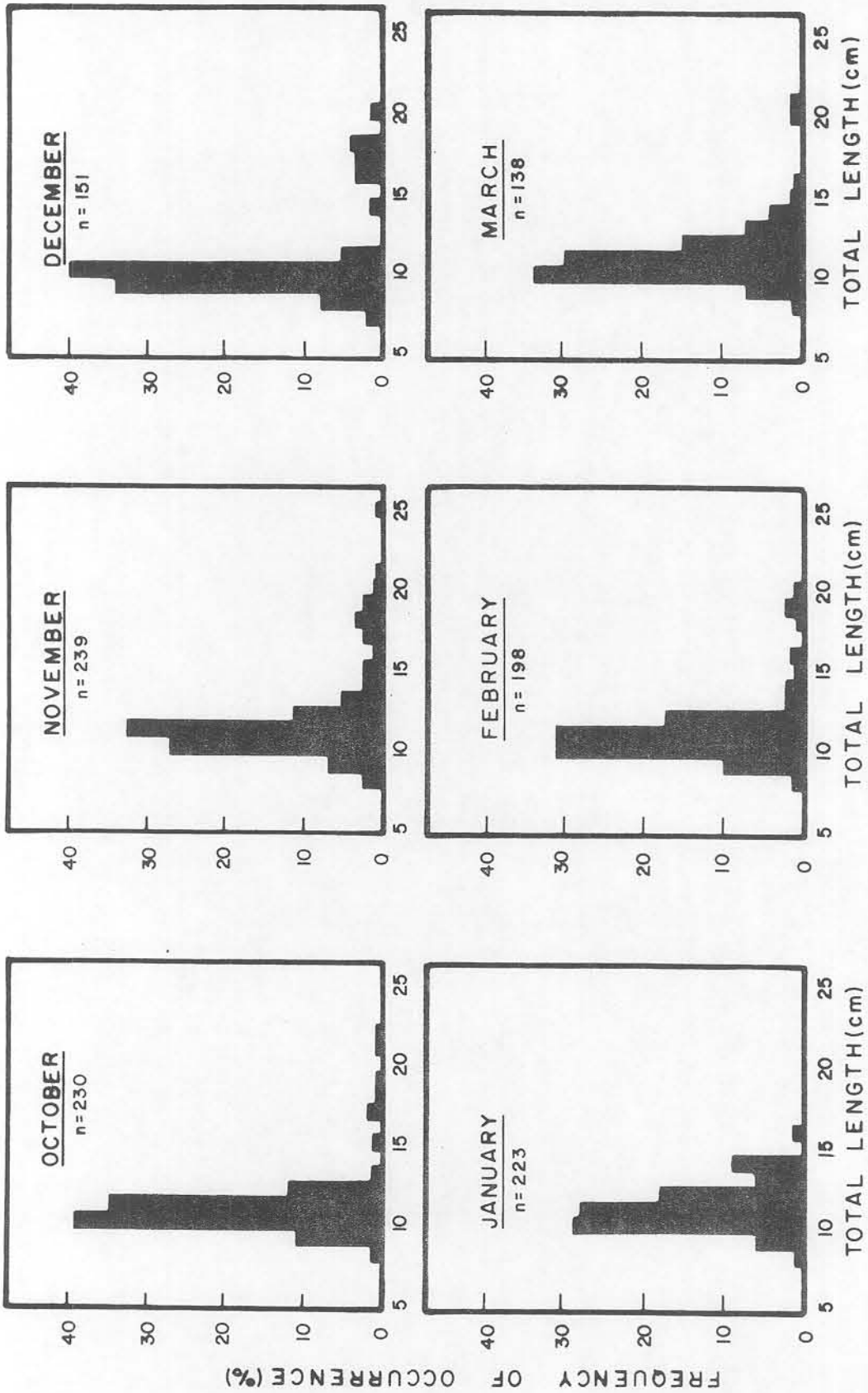


Figure 19. (continued)

for spawning and gradually moved offshore as the water warmed. Peak impingement occurred in October and November among the young fish with a modal length of 10 to 11 cm (Figures 16, 19). According to age and growth data from the Wisconsin Department of Natural Resources (1959) these fish belonged to age group I; other data indicated they were age group II (Brazortal 1975). The 1975 year class may have been large enough to be impinged during the winter of 1975/1976.

Bullheads, the third species of importance both numerically and by weight, were not identified to species but were probably black bullheads (Table 37). Bullheads were impinged throughout the year, (Figure 15) but always at relatively low numbers (Figure 16) and total weights (Figure 17). No data indicated that spawning was expected due to their spawning habits (guarded nests, schooling guarded young, Scott & Crossman, 1973). In fact, only one juvenile bullhead was observed in entrainment samples in August (Figure 15) even though there was a large resident population.

All lengths of bullheads from juvenile to adult were impinged (Figure 20). The presence of adults in impingement samples each month strongly implied a large resident population in the immediate vicinity of the Plant. Juveniles appeared in large percentages in September and dominated impingement results through the winter. Peak impingement rates occurred in October and November (Table 41), when the major size class impinged were juveniles in the 7-9 cm class. Although growth of juvenile black bullheads is highly variable, these fish probably belonged to age group 0 (in

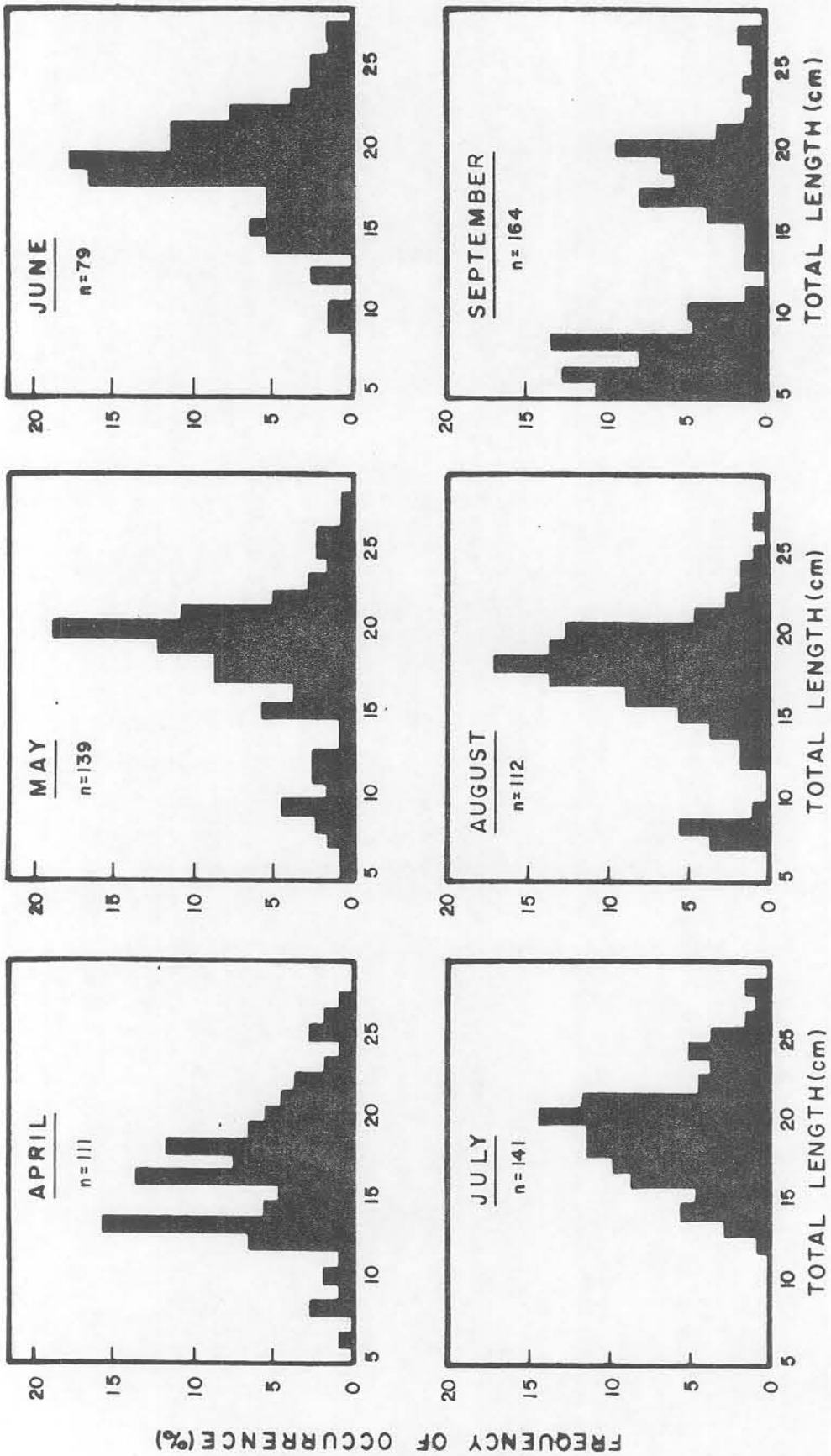


Figure 20. Length-frequency distributions of adult and juvenile bullheads impinged at Pulliam Power Plant, April 1975 through March 1976.

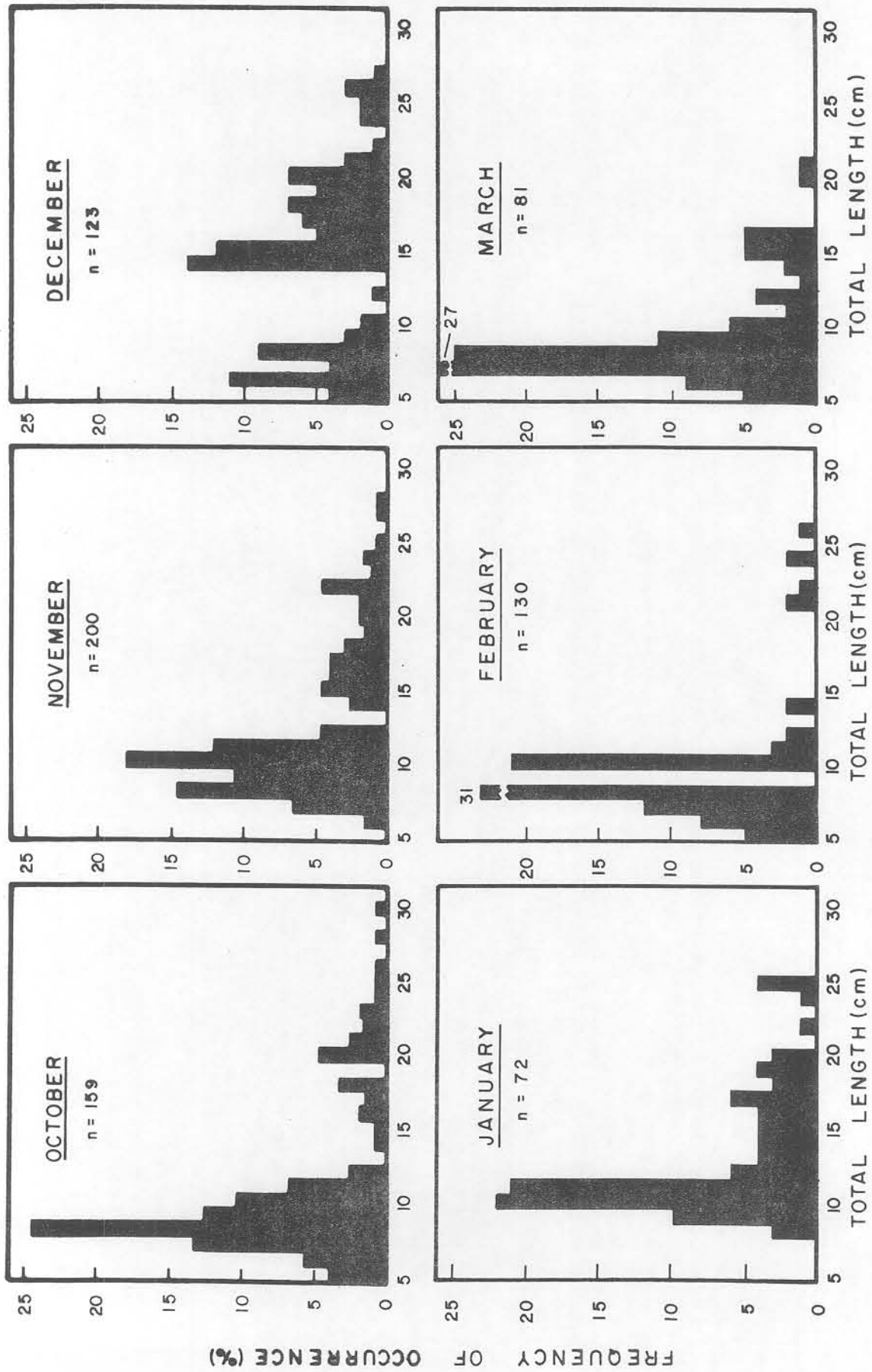


Figure 20. (continued)

the fall) and I (in the spring) (Carlander, 1950).

Rainbow smelt, although not important numerically, contributed a small percentage by weight (Table 41). This was entirely due to their nearshore migration for spawning in April. Ninety eight percent of all smelt impinged were taken during this month. Smelt were impinged sporadically (Figure 15) and at very low rates (Figure 16) during the remainder of the year.

Northern pike were impinged during 8 months of the sampling period (Figure 15). The numbers and weight impinged were low throughout the study (Figures 16, 17). Low numbers negated length-frequency distribution calculations, but review of data presented in Tables 4 through 15 indicated fish that averaged 0.75 to 1.25 kg (1.5 to 2.5 lbs). Eggs collected in the 2.5-3.0 mm diameter range (Figures 10,11) probably were northern pike. No larvae or juveniles were collected.

There were no Green Bay population estimates for the five species discussed with which to make comparison. Three of the five (alewife, perch, and bullhead) are also known to be abundant in the vicinity of J.P. Pulliam Power Plant (Table 37) therefore impingement rates would be relatively high. As previously stated, smelt entered because of their spawning pulse and northern pike because they were relatively heavy and omnipresent.

The numbers of fish collected in a field study were comparable to impingement rates during most months. Data obtained from Robinson's (1976) study were compared with J.P. Pulliam Power Plant impingement rates in Table 42. Differences occurred for bullheads in August and bullheads and perch in November. These

Table 42. Total numbers of fish collected by gill net, electroshocking, and seine per sampling trip and average daily impingement rate at Pulliam Power Plant. Data for September and November for gill net, electroshocking and seine were collected in 1974, impingement in 1975.

| | April (75) | | | | June (75) | | | |
|---|---|---|---|---|---|---|---|---|
| | Gill Net | Elect. | Seine | Imping. | Gill Net | Elect. | Seine | Imping. |
| Alewife | 0 | 0 | 0 | 0 | 1037 | 100 | 1 | 8,906 |
| Northern pike | 9 | 0 | 0 | 9 | 14 | 0 | 0 | 0,5 |
| Carp | 6 | 42 | 0 | 2 | 85 | 50 | 0 | 1 |
| Shiners | 1 | 11 | 1 | 90 | 0 | 3 | 1 | 1 |
| Bullheads | 1 | 0* | 0 | 27 | 6 | 1* | 1 | 11 |
| Yellow perch | 35 | 0 | 0 | 114 | 58 | 3 | 0 | 44 |

* Not suseptible to collection by this method.



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Table 42. (continued)

| | August (75) | | | | September (74) (75) | | | |
|---|---|---|---|---|---|---|---|---|
| | Gill Net | Elect. | Seine | Imping. | Gill Net | Elect. | Seine | Imping. |
| Alewife | 152 | 6 | 0 | 3502 | 841 | 13 | 0 | 168 |
| Northern pike | 3 | 0 | 0 | 0.3 | 5 | 0 | 0 | 0 |
| Carp | 23 | 13 | 29 | 0.3 | 100 | 36 | 61 | 18 |
| Shiners | 0 | 0 | 13 | 1 | 10 | 2 | 13 | 1.0 |
| Bullheads | 37 | 7* | 6 | 568 | 123 | 0* | 2 | 154 |
| Yellow perch | 63 | 1 | 0 | 46 | 47 | 7 | 0 | 47 |



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Table 42. (continued)

| | November (74) | | | |
|---|---|---|---|---|
| | Gill Net | Elect. | Seine | Imping. (75) |
| Alewife | 17 | 0 | 0 | 963 |
| Northern pike | 27 | 0 | 0 | 0.4 |
| Carp | 14 | 28 | 0 | 0.8 |
| Shiners | 2 | 0 | 0 | 0 |
| Bullheads | 35 | 0 | 0 | 271 |
| Yellow perch | 29 | 0 | 0 | 852 |



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differences may have occurred because one year had elapsed between studies, however, were probably due to size differences. Due to the small size of perch impinged, they would not readily be gill netted and not easily seined. Also in November electroshocking was not as effective due to low water temperatures. It did not appear that impingement of fish at J.P. Pulliam Power Plant was different than catch rates in the field study.

The next best comparator was commerical landings, which were not indicative of actual populations but demonstrated removal of some species other than at the J.P. Pulliam Power Plant. The most recent commercial statistics (1974) were compared with impingement results (Table 43). Estimated impingement ranged from 0.01% of commercial landings for carp to 6.90% for bullheads (excluding the round whitefish). If the patently false assumption that commercial landings were the same each day throughout the year, in the worst case (bullheads) commercial fishermen would remove from Green Bay in 25 days poundage equal to the entire year's impingement at Pulliam. An equivalent poundage of perch would be removed in two days, alewives in half a day.

When the commercial landings for the entire lake were considered, the percentage for alewives were 0.07%, yellow perch 0.6%, and for smelt 0.05% (Table 44). The percentage for bullheads and northern pike did not change since they were caught exclusively in Green Bay. Because of this fact commercial landings were probably poor indicators of whole lake populations.

Estimated total numbers impinged at the J.P. Pulliam Power Plant did not constitute a large enough percentage of

Table 43. Comparison of commercial catches in southern Green Bay in 1974 with estimated total impingement at Pulliam Power Plant, 1975-1976. All data are in pounds.

| Species | Commercial Landings | Estimated Total Impinged | % Impinged/Commercial |
|---|---|---|---|
| Alewife | 20,094,473 | 25,932 | 0.13 |
| Yellow perch | 786,609 | 4,327 | 0.55 |
| Bullheads | 33,257 | 2,294 | 6.90 |
| Northern pike | 22,705 | 791 | 3.58 |
| Smelt | 77,465 | 474 | 0.61 |
| Sucker | 226,012 | 262 | 0.12 |
| Carp | 3,047,770 | 204 | 0.01 |
| Burbot | 119,426 | 134 | 0.11 |
| Walleye | 5,733 | 50 | 0.87 |
| White Bass | 3,815 | 31 | 0.81 |
| Freshwater drum | 1,941 | 14 | 0.72 |
| Round whitefish | 2 | 1 | 50.00 |

Table 44. Comparison of 1973 Commercial catches in Lake Michigan with estimated total impingement at Pulliam Power Plant 1975-1976. All data are in pounds.

| Species | Commercial Landings | Estimated Total Impinged | % Impinged Commercial |
|---|---|---|---|
| Alewife | 36,552,300 | 25,932 | 0.07 |
| Yellow Perch | 749,500 | 4,327 | 0.60 |
| Bullheads | 33,200 | 2,294 | 6.90 |
| Smelt | 881,700 | 474 | 0.05 |
| Pike or Pickerel | 31,300 | 791 | 2.53 |

commercial landings by weight to cause concern. It was not possible to compare numbers of fish impinged to any other data. It should be remembered, however, that many of the fish were juveniles. These young fish have very high natural mortality rates, and the number impinged cannot be considered as adults. Mortality rates were not available for young fish but it can be conjectured that if these numbers could be converted to adults, natural mortality would make the numbers considerably smaller.

B. Eggs

An estimated 325.8 x $10^6$ eggs were entrained at the J.P. Pulliam Power Plant from April through August 1976 (Table 45). Daily and monthly numbers collected and numbers per cubic meter were presented previously. As seen in Table 44, 98.7% of the eggs entrained were in the 0.6-1.3 mm range. An additional 0.9% were in the 1.4-2.1 mm range. During June an estimated total of 237.4 x $10^6$ eggs or approximately 73% of the total were entrained. Thus of major interest was eggs in the diameter range of 0.6-1.3 mm in June.

These eggs were tentatively identified as alewife, with possible Notropis mixed in. Also, the eggs of 0.6-1.3 mm in April were identified as smelt and the 1.4-2.0 mm in June as carp (Section III. B.). Assuming that all eggs in these size ranges during these months to be from carp, smelt and alewife, even though interspecies mixing probably occurred, total numbers of eggs per species entrained, were calculated (Table 46).

Division of the total number of entrained eggs by average fecundity per female for each species yielded the number of

Table 45. Estimated total number of fish eggs entrained at Pulliam Power Plant, April through August 1975.

| | Presumed Water Source | Month | | | | | Total Number x $10^3$ | % |
|---|---|---|---|---|---|---|---|---|
| | | Apr | May | Jun | Jul | Aug | | |
| Mean Observed Flow $m^3$/min | Green Bay | 267.9 | 324.4 | 412.8 | 473.9 | 168.7 | 1,647.7 | 40 |
| | Fox River | 395.4 | 418.1 | 490.5 | 655.0 | 505.8 | 2,464.8 | 60 |
| 0.6-1.3 mm | Green Bay | 486.1 | 0 | 39,624.5 | 78,061.6 | 52.7 | 118,224.9 | 98.7 |
| | Fox River | 3.4 | 18.6 | 195,074.5 | 8,128.5 | 112.9 | 203,337.9 | |
| 1.4-2.1 mm | Green Bay | 34.7 | 72.4 | 1,462.3 | 148.1 | 0 | 1,717.5 | 0.9 |
| | Fox River | 34.1 | 56.0 | 1,250.2 | 0 | 0 | 1,340.0 | |
| 2.2-3.1 mm | Green Bay | 393.5 | 115.8 | 8.9 | 0 | 0 | 518.2 | 0.4 |
| | Fox River | 580.8 | 93.3 | 0 | 0 | 0 | 674.1 | |
| 5.4 mm | Green Bay | 0 | 0 | 0 | 0 | 0 | 0 | >0.1 |
| | Fox River | 0 | 18.6 | 0 | 0 | 0 | 18.6 | |
| TOTAL | | | | | | | 325,831.2 | 100.0 |



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Table 46. Total numbers of alewife, rainbow smelt, and carp eggs entrained at Pulliam Power Plant and average fecundity of each species.

| Species | Estimated Total Eggs Entrained | Average Fecundity | Number of Females of Average Fecundity |
|---|---|---|---|
| Alewife | 321,054,700 | 13,000[1] | 24,000 |
| Carp | 2,712,500 | 900,000[2] | 3 |
| Rainbow Smelt | 489,500 | 22,500[1] | 22 |

[1] Otto (1975)

[2] Mean from Swee & McCrimman (1966)

Table 47. Estimated total number of larval and juvenile fish entrained at Pulliam Power Plant, April through August 1975.

| Species | Presumed Water Source | Month | | | | | Total Number x $10^3$ | % of Total Per Species |
|---|---|---|---|---|---|---|---|---|
| | | Apr | May | Jun | Jul | Aug | | |
| Carp | | | | | | | | |
| Larvae | Green Bay | 0 | 333.1 | 321.0 | 338.5 | 0 | 992.6 | 50.2 |
| | Fox River | 0 | 522.6 | 656.9 | 643.3 | 0 | 1,822.8 | |
| Juveniles | Green Bay | 0 | 0 | 0 | 4.2 | 0 | 4.2 | |
| | Fox River | 0 | 0 | 0 | 5.8 | 0 | 5.8 | |
| Yellow Perch | | | | | | | | |
| Larvae | Green Bay | 0 | 246.2 | 356.7 | 0 | 0 | 602.9 | 16.8 |
| | Fox River | 0 | 298.6 | 42.4 | 0 | 0 | 341.0 | |
| Freshwater Drum | | | | | | | | |
| Larvae | Green Bay | 0 | 0 | 570.6 | 8.5 | 0 | 579.1 | 13.9 |
| | Fox River | 0 | 0 | 169.5 | 29.2 | 0 | 198.7 | |
| Juveniles | Green Bay | 0 | 0 | 0 | 0 | 0 | 0 | |
| | Fox River | 0 | 0 | 0 | 5.8 | 0 | 5.8 | |
| Burbot | | | | | | | | |
| Larvae | Green Bay | 4.6 | 72.4 | 0 | 0 | 0 | 77.0 | 7.7 |
| | Fox River | 0 | 354.6 | 4.2 | 0 | 0 | 358.8 | |
| Gizzard Shad | | | | | | | | |
| Larvae | Green Bay | 0 | 0 | 0 | 42.3 | 0 | 42.3 | 3.0 |
| | Fox River | 0 | 0 | 0 | 0 | 0 | 0 | |
| Juveniles | Green Bay | 0 | 0 | 0 | 118.4 | 0 | 118.4 | |
| | Fox River | 0 | 0 | 0 | 5.8 | 0 | 5.8 | |
| White Bass | | | | | | | | |
| Larvae | Green Bay | 0 | 0 | 107.0 | 0 | 0 | 107.0 | 2.7 |
| | Fox River | 0 | 0 | 42.4 | 0 | 0 | 42.4 | |
| Alewife | | | | | | | | |
| Larvae | Green Bay | 0 | 0 | 0 | 21.2 | 0 | 21.2 | 1.9 |
| | Fox River | 0 | 0 | 0 | 87.7 | 0 | 87.7 | |
| Rainbow Smelt | | | | | | | | |
| Larvae | Green Bay | 0 | 0 | 0 | 4.2 | 0 | 4.2 | 0.9 |
| | Fox River | 0 | 0 | 0 | 0 | 0 | 0 | |
| Juveniles | Green Bay | 0 | 0 | 0 | 21.2 | 3.8 | 25.0 | |
| | Fox River | 0 | 0 | 0 | 0 | 22.6 | 22.6 | |



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Table 47. (continued)

| Species | Presumed Water Source | Month Apr | May | Jun | Jul | Aug | Total Number x $10^3$ | % of Total Per Species |
|---|---|---|---|---|---|---|---|---|
| Troutperch | | | | | | | | |
| Larvae | Green Bay | 0 | 0 | 3.6 | 0 | 0 | 3.6 | 0.6 |
| | Fox River | 0 | 0 | 0 | 0 | 0 | 0 | |
| Juveniles | Green Bay | 0 | 0 | 0 | 0 | 0 | 0 | |
| | Fox River | 0 | 0 | 0 | 29.2 | 0 | 29.2 | |
| Stizostedeon sp. | | | | | | | | |
| Larvae | Green Bay | 0 | 0 | 0 | 0 | 0 | 0 | 0.3 |
| | Fox River | 0 | 18.6 | 0 | 0 | 0 | 18.6 | |
| Notropis sp. | | | | | | | | |
| Juveniles | Green Bay | 0 | 0 | 0 | 0 | 7.5 | 7.5 | 0.2 |
| | Fox River | 0 | 0 | 0 | 0 | 5.6 | 5.6 | |
| Bluegill | | | | | | | | |
| Juveniles | Green Bay | 0 | 0 | 0 | 0 | 7.5 | 7.5 | 0.1 |
| | Fox River | 0 | 0 | 0 | 0 | 0 | 0 | |
| Spottail Shiner | | | | | | | | |
| Juveniles | Green Bay | 0 | 0 | 0 | 4.2 | 0 | 4.2 | <0.1 |
| | Fox River | 0 | 0 | 0 | 0 | 0 | 0 | |
| Catastomidae | | | | | | | | |
| Larvae | Green Bay | 0 | 0 | 0 | 0 | 0 | 0 | <0.1 |
| | Fox River | 0 | 0 | 4.2 | 0 | 0 | 4.2 | |
| White Sucker | | | | | | | | |
| Larvae | Green Bay | 0 | 0 | 3.6 | 0 | 0 | 3.6 | <0.1 |
| | Fox River | 0 | 0 | 0 | 0 | 0 | 0 | |
| Black Bullhead | | | | | | | | |
| Juvenile | Green Bay | 0 | 0 | 0 | 0 | 3.8 | 3.8 | <0.1 |
| | Fox River | 0 | 0 | 0 | 0 | 0 | 0 | |
| Unidentified | Green Bay | 0 | 0 | 71.3 | 0 | 0 | 71.3 | 1.4 |
| | Fox River | 0 | 0 | 0 | 5.8 | 0 | 5.8 | |
| TOTAL | | 4.6 | 1,846.1 | 2,353.4 | 1,375.3 | 50.6 | 5,630.1 | 99.7 |



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spawning females whose eggs were entrained. No further consideration of carp or rainbow smelt was necessary. The total for alewives was approximately 24,000 females. This number was probably low as alewives cannibalize their own eggs and several other species prey on them as well (Edsall, 1964). The 24,000 females equalled approximately 10% of the number of alewives impinged in June (Table 41). Allowing for a 3/1 sex ratio (mean from Limnetics, 1976) 24,000 would be 12% of the 200,391 females impinged during that month.

C. Larvae

An estimated total of $5.6 \times 10^6$ larval and juvenile fish were entrained at the J.P. Pulliam Power Plant from April through August, 1975 (Table 47). Of the total aproximately 50.2% were carp, 16.8% yellow perch, 13.9% freshwater drum, and 7.7% burbot. These four species constituted 87% of the total. Daily numbers collected and mean numbers/$m^3$ were presented in Tables 27-36; seasonal distribution in Figure 15.

Larvae were collected during each month (Table 46). A single species was collected in April, four in May, seven in both June and July, and four in August. The number of larvae entrained was lowest in April, reached a peak in June, then decreased through August. Those species contributing a significant percentage to the total were collected over an extended period (2 or more months). Carp, the dominant species in entrainment samples, was collected from May through July.

Length-frequency distributions for the entire sampling period were calculated for those species collected in sufficient

numbers (Figure 21). Low numbers collected necessitated distributions covering the entire year. Results varied with species. The modal length of entrained carp and drum larvae was 5 - 6 mm (mainly prolarvae). In the freshwater drum this effect was due to a very large percentage of the total being collected during a very short period (Table 32). Carp were, however, collected in approximately equal numbers during May, June, and July. Figure 21 shows that larval carp were only collected when newly hatched; few older fish were collected, as shown in Table 46 by the collection of low numbers of juvenile only in July. Whether this was due to high mortality rates or the fact that older larvae and juveniles were more motile and thus not entrained was not known. Yellow perch larvae over a large size range were collected during both May and June. Why larger sized perch were collected but not carp was unknown.

D. Other Conditions

As stated in Section II, future plans for J.P. Pulliam Power Plant indicate a reduction of approximately 41% total hours of operation by the year 1985. Because circulating water pumps are generally not run when a unit is not in operation, a proportional reduction in water consumption will result. The effect of this reduction in water consumption could vary depending on whether the reduction takes place during one month or is "across the board". It is assumed that the reduction will be evenly distributed throughout the year and a proportional reduction in entrained eggs and larvae will result. Impingement, however, is related more closely to the local abundance of fish near the

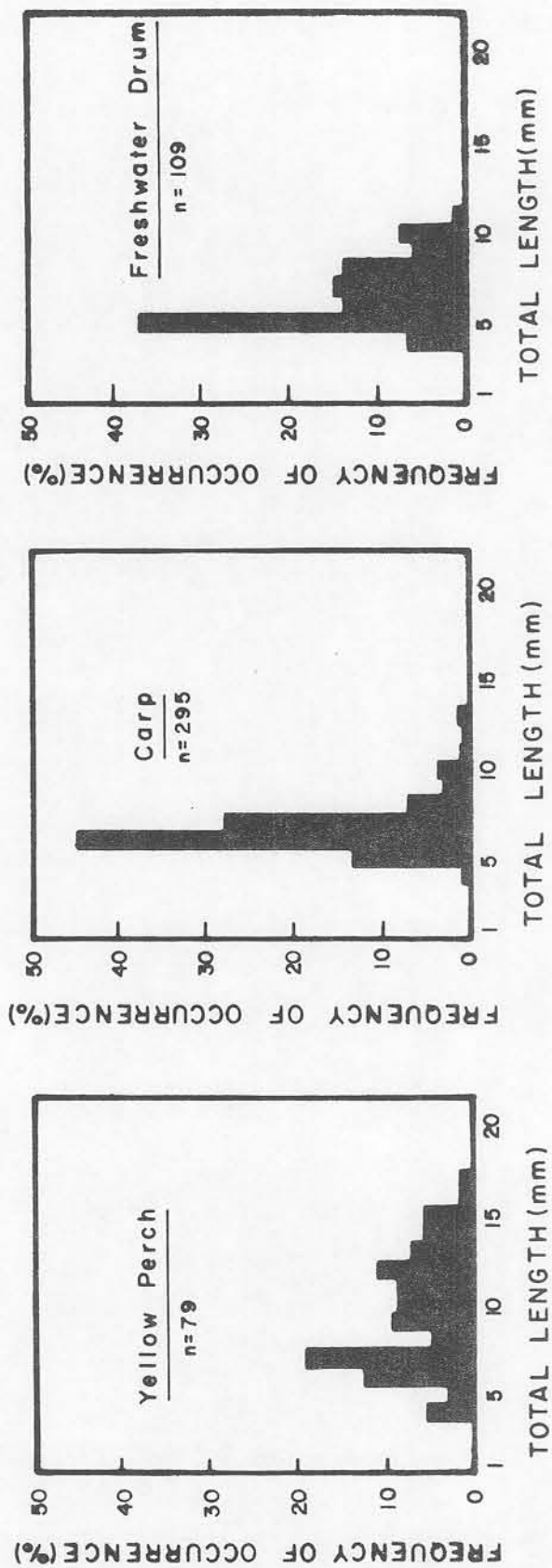


Figure 21. Length-frequency distributions of larval yellow perch, carp, and freshwater drum collected at Pulliam Power Power Plant, April through August, 1976.

intake than to flow through the Plant (Otto and Kitchel, 1974). Therefore, although some alleviation of impingement is expected, the observed reduction in impingement rates may not be related directly to hours of operation.

The percentage of Fox River flow traversing the Plant is another factor. As previously stated an average of 9.4% of the river flow is used. If eggs and larvae are evenly distributed in the river, an average of 9.4% would be exposed to the Plant. During May, June, and July, when entrainment of larvae was highest, 2.8%, 5.2% and 19.2% of the larvae in the river would have been affected.

## V. Conclusion

Adult and juvenile fish of twenty species and three families were impinged at the J. P. Pulliam Power Plant from April 1975 through March 1976. The estimated total number of fish impinged was approximately 676,000 fish weighing approximately 15000 kg. The numerical composition of the impinged fish was 76.1% alewives, 16.8% yellow perch, 4.5% bullheads and 2.6% incidental species. Species composition by weight was 74.5% alewiwife, 12.4% yellow perch, 6.6% bullhead, 2.3% northern pike, 1.4% rainbow smelt and 2.8% other species combined. Comparisons of the estimated total weights of the five major fish species impinged with available commercial landings in southern Green Bay showed impingements to equal 0.13% to 6.90% of commercial landings. Comparisons with lakewide commercial landings yielded 0.05% to 6.90% of commercial landings.

An estimated 325.8 x $10^6$ eggs were entrained in the cooling water at the J. P. Pulliam Power Plant from April through August 1975. The number of eggs entrained was equivalent to the number of eggs released by 22 carp, 3 rainbow smelt and 24000 alewives of average fecundity. Twenty-four thousand female alewives were found to equal 1.2% of the female alewives impinged during the month of peak impingement.

An estimated total of approximately 5.6 x $10^6$ larvae and juveniles were entrained at the J. P. Pulliam Power Plant from April through August 1975. Of the total, approximately 50.2% were carp, 16.8% yellow perch, 13.9% freshwater drum and 7.7% burbot.

Based upon a comparison of the data collected to the available indicators of resident fish populations, there is no apparent

significant impact on the fish population of Green Bay. Based on the data presented, "the location, design, construction and capacity of cooling intake structures" apparently reflect "the best technology available 'under the described conditions' for minimizing adverse environmental impact." Data concerning future plans for plant operation indicate a lessened impact in the future.

The sampling program was adequate to allow evaluation of intake effects at J. P. Pulliam Power Plant. Impingement sampling was very intensive (25% of the entire year). At the rate of once each four days per 24 hours, small changes in impingement rates could be detected and short duration spawning pulses, such as seen with smelt, were not missed. Methods were adequate to estimate the numbers and total weights of each species impinged, and a simple extrapolation of one day of sampling to three days with no sampling led to reasonably accurate estimates of total impingement.

Entrainment sampling was scheduled such that it started before the known or reported spawning periods of fishes in the area (with zero eggs and larvae), bracketed periods of peak outlined egg and occurrence and ended after the spawning periods (again with zero eggs and larvae). Sampling was intended to provide estimates of mean concentrations of eggs and/or larvae at 0800 hr, 1600 hr and 0400 hr to determine daily distribution. Number of replicates (4) was chosen as practical to collect and field sort in one day. Extrapolation of mean egg and larval densities to total numbers entrained was the most tenuous operation performed. It was, however, the only known method of estimating total numbers and represents the state of the art at this time.

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