PrairieIslandNPEm Resource

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Sent: Wednesday, December 03, 2008 1:06 PM
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Cc: Holthaus, James J.; Eckholt, Gene F.; Kuhl, Brent A
Subject: List of Industry Peers and NSP 1986 Impingement Study
Attachments: 120308_nsp_1986_Impinge.pdf

Greetings Nate!

Attached you will find our NSP 1986 Impingement Study, pulled from the full NSP 1986 Prairie Island Nuclear Generating Plant (PINGP) Annual Environmental Monitoring Report. This is a public document; however please note this is only the Impingement Survival Study, which is one section of the full report. The change in sampling method is described on pages 190 and 203.

Listed below are the full names of industry peers that attended the PINGP Environmental Audit August 17-21, 2008:

Richard Gallagher
Ed Keating, he attended very briefly
Henry Day
Nancy Ranek
Herb Giorgio
Virginia Holt
Sharon Merciel

Please feel fee to contact me or James Holthaus, Environmental Project Manager (james.holthaus@xenuclear.com 651-388-1121 ext 7268) with any questions or concerns.

Thank you,

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PRAIRIE ISLAND NUCLEAR GENERATING PLANT
ENVIRONMENTAL MONITORING PROGRAM
1985 ANNUAL REPORT

FINE MESH VERTICAL TRAVELING SCREENS IMPINGEMENT SURVIVAL STUDY

Prepared for
Northern States Power Company
Minneapolis, Minnesota

by
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INTRODUCTION

Studies to assess the effectiveness of fine mesh (0.5mm) vertical traveling screens in reducing entrainment impacts on fishes in the vicinity of PINGP were begun in 1984 following construction of a new plant intake and screenhouse in 1983. The fine mesh screens, which are used from mid-April through August, rotate continuously and are equipped with fish-lift buckets to enhance survival of impinged fish. Each of the eight screens' rotation is variable between three and twenty feet per minute, depending upon differential pressure across the screen.

Each ten-foot wide screen has a fish and a debris removal spray system. The fish removal system consists of a low pressure (10psi) internal front side spray. Debris is removed from the backside of the screen by a 50psi interior spray system. Fish collected on the fine mesh screens are washed off the front side of the screen into a trough on the screenhouse operating deck. Flow in the trough is returned to the Mississippi River downstream of the plant intake or can be diverted into fish collection tanks in the environmental laboratory.

Studies conducted in 1984 concluded that the fish removal spray system was more than 98 percent efficient in removing fish from the front side of the screen and that laboratory personnel could effectively separate unstained organisms from debris. This year, studies were continued to determine the number and species composition of fish and eggs collected by the screens, initial and latent survival of fish collected, and establish differences between day and night fish densities.

METHODS AND MATERIALS

SAMPLE COLLECTION

Sample collection commenced on April 15, 1985 and continued through August 28, 1985. Samples were collected on Monday, Wednesday, and Friday of each week by diverting 25 percent of the screen wash water into collection tanks in the basement of the environmental lab. Wash water flows by gravity from the screen wash trough, into a drop structure, and through an 18-inch diameter pipe into the environmental lab basement. Screen wash water was channeled from the 18-inch pipe through a larval collection tank manufactured by Lawler, Matusky, and Skelly Engineers (Figure 1). The collection tank filters approximately 200 gallons of screen wash water per minute through 0.5 mm mesh nylon screen material. Filtered water was returned to the circulating water system via a 12-inch diameter drain pipe.

Samples collected during 1984 had extremely large numbers of juvenile fish, particularly channel catfish. These numbers were thought to be overestimates of actual impingement due to design problems in the fish collection system. Prior to sampling in 1985 a metal box was constructed inside the adult tank which allowed the water in the tank to be siphoned rapidly from the tank. This allowed the 18 inch pipe from the screenhouse to be thoroughly flushed prior to sampling. It was hypothesized that in 1984, juvenile and possibly large postlarvae were not being flushed from the pipe due to low velocity. The new method of siphoning water from the tank in 1985 allowed for higher velocity in the pipe which should remove any accumulation of juvenile and large postlarvae life stages and provide a more accurate impingement estimate.

Three types of samples were collected, depending on the type of data desired. Sample types included abundance, initial survival, and latent survival. During sample collection, physical parameters measured included collection time and duration, screen speed, number of screens sampled, flow through the larval tank in gallons per minute, river stage, water temperature, and plant blowdown.

Following a designated sampling duration (three minutes to 15 minutes), all fish and any debris were gently washed into the two collection baskets located in the collection area of the tank (Figure 2). These baskets were then removed from the tank, the contents transferred to four liter beakers, and transported to the fish handling and sorting area for further processing.

INITIAL SURVIVAL SAMPLES

These samples were collected at night or early morning to determine night density of fish and eggs and initial survival of fish impinged on the fine mesh traveling screens (Figure 3). These samples underwent a "first and "second" sort. The first sort was designed to remove live and dead fish, with emphasis placed on removing all live fish in a time efficient manner. The second sort was designed to assure removal of all remaining fish and eggs. All fish, eggs, and debris in the sample containers were transferred to glass baking dishes and sorted over a light table. During the first sort, fish were separated from debris and placed in vials labeled "live" or "dead", based on the presence or absence of movement, respectively. These fish were preserved in five percent buffered formalin solution and retained for identification.

During periods of excessive debris loading subsamples were sorted. During the early portion of the study, a subsample large enough to yield 100 fish (live and dead combined) was sorted, but as debris loading and sort time continued to increase, it became apparent fish were dying as a result of being entangled with debris in the sample containers. To avoid possible bias, sorting was terminated when this condition occurred, regardless of the number of fish collected. Subsample and total sample volumes were recorded for calculating density and impingement estimates.

After completion of the first sort, the entire sample was preserved in 10 percent buffered formalin solution containing rose bengal stain and resorted after the stain had an opportunity to penetrate any remaining fish and eggs. Fish from the second sort were included with the "initial dead" from the first sort.

ABUNDANCE SAMPLES

Abundance samples were collected during mid morning to estimate day density of fish eggs impinged on the fine mesh traveling screens (Figure 4). After the sample was collected, all fish, eggs, and debris were preserved in 10 percent buffered formalin solution containing rose bengal stain. The sample was sorted after the stain had an opportunity to penetrate all organisms. All fish and eggs were removed and placed in a labeled vial containing five percent buffered formalin solution and retained for identification. Collection duration on abundance samples varied from less than one minute to approximately 15 minutes, depending on debris loading and fish density.

LATENT SURVIVAL SAMPLES

These samples were collected to determine the latent survival of fish impinged on the fine mesh traveling screens (Figure 5). Samples were collected during early morning, after the initial survival sample was completed. Collection duration was restricted to a period less than 20 minutes to minimize sampling stress; time varied depending on debris loading and fish density.

After the sample was collected, aliquots were placed in Pyrex baking dishes and sorted over a light table. Only live fish were removed and placed in 250 ml wide mouth jars containing filtered river water. A maximum of six larvae and/or early juveniles were placed in each jar; larger juveniles and small adults were held in six-gallon aquaria containing filtered river water. Jars and aquaria were kept in acrylic plastic water baths receiving a constant supply of river water. This allowed fish to be maintained at ambient temperatures throughout the holding period. Larger fish held in aquaria were aerated; small larvae held in jars were not. No feeding schedule was implemented for fish held during the latent holding period.

Fish held for latent survival estimates were held for 48 hours and checked after three hours, six hours; every 12, 24, 36 and 48 hours. This is a change from 1984 when fish were held for 96 hours and checked more frequently (Eberley, et al. 1985). At each observation time, the appropriate jar was placed on the light table, the number of live and dead fish recorded on a data sheet, and any dead fish removed. Dead fish were placed in labeled vials, preserved, and retained for identification. This procedure was repeated for each jar and any aquaria containing fish. Following the 48-hour check, all remaining live fish were preserved and retained for identification.

Due to the cannibalistic and/or predatory nature of some species, there were occasions when the previously recorded number of live fish were not present at the time of observation. Any missing fish were recorded as "dead", of unknown species and life stage.

DATA ANALYSIS METHODS

Fish and Egg Density

Fish and egg density was calculated on a day and night basis using data from abundance and initial survival samples, respectively. Using a combination of sample duration, plant blowdown, and identification data, density values were calculated as numbers of fish or eggs per 100 cubic meters of water. Values were initially calculated by individual species and life stage for each date; then expanded to day and night densities of all taxa and life stages combined for each date. A students t-test was performed to test for significance between day and night density of all taxa and life stages combined.

Survival Estimates

Initial survival of fish impinged on the fine mesh traveling screens was calculated by totaling the number of live fish and dividing by the number of live plus dead fish of each species and life stage in each initial sample. Initial survival was calculated for each sample collected and as a weighted yearly average.

Latent survival of impinged fish was calculated by dividing the number of live and dead fish collected in each latent sample. Overall survival was calculated by multiplying initial times latent survival.

Impingement Estimates

Estimates of the number of fish and fish eggs impinged on the fine mesh traveling screens were calculated by averaging data from the initial survival and abundance samples. These values were expanded to weekly and yearly impingement estimates. When only initial or abundance data were available for a given day, impingement estimates were based on that sample.

Annual survival estimates were calculated using weighted weekly averages rather than simply averaging overall survival values. This eliminates the bias of samples having very few fish with extremely high or low survival.

Identification Methodology

All fish and eggs collected were identified to the lowest practical taxon by life stage and developmental phase. Life stages included egg, larvae, juvenile, and adult. Terminology and criteria are similar to those described by Auer (1982). The larval stage was divided into two developmental phases, prolarvae and postlarvae, which correspond to Auer's terms yolk-sac larvae and larvae.

Terminology and criteria:

Prolarvae (Yolk-sac larvae) - Phase of development from moment of hatching to complete absorption of yolk.

Postlarvae (Larvae) - Phase of development from complete absorption of yolk to development of the full compliment of adult fin rays and absorption of finfold.

Juveniles - Phase of development from complete fin ray development and finfold absorption to sexual maturity.

Based on above criteria, a postlarval phase does not occur in channel catfish[1/], flathead catfish, bullheads, and madtoms.

All fish eggs removed from samples were enumerated, but only freshwater drum eggs were identified. Others were recorded as "unidentified fish eggs". No differentiation was made between live and dead eggs. Egg data were included only in density and total impingement estimates.

Total lengths (millimeters) of representative specimens were recorded to establish length ranges for developmental phases of each taxon. Representative specimens of taxonomic levels identified during this study were verified by D.E. Snyder, Larval Fish Laboratory, Colorado State University.

Identification aids included published and unpublished literature, recent manuals (Auer, 1982 and Holland, 1983), reference specimens from previous studies, and stereo-zoom microscopes with bright field/dark field bases and polarizing filters.

1/Test refers to fish by common name. Common and scientific names are listed in Appendix A.

Results

A total of 163 samples consisting of more than 40,000 individual fish and eggs was collected and identified in 1985. Table 1 shows the number of each sample type collected and the number of organisms identified per sample type. Sampling in 1984 demonstrated that the traveling screens front spray fish removal system was extremely (>98%) efficient in removing fish from the front side of the traveling screens. For this reason, no backwash samples were collected in 1985. Forty-eight taxa/life stage combinations were identified from the 1985 samples. Table 2 lists representative total length ranges for 44 taxa/life stage combinations collected in 1984 and 1985.

Organism Densities

Densities ranged from less than 0.01 to more than 100 organisms per 100 cubic meters of water sampled in April and May, respectively (Figure 6). Comparison of day and night densities revealed that, on the average, day densities were higher than night densities but the two were not significantly different (Table 3).

Initial Latent, and Overall Survival

Initial, latent, and overall survival estimates for all taxa/life stage combinations collected in the initial and latent survival samples are presented in Table 4. No overall survival estimates were calculated for those taxa/life stage combinations not collected in both initial and latent samples. For those calculated, overall survival is the unweighted product of initial and latent survival sample estimates. As in 1984, initial, latent, and overall survival estimates each ranged from zero to 100 percent, both extremes represented by taxa/life stage combinations for which very few organisms were collected.

For initial samples, 12 taxa/life stage combinations represented by at least 100 individuals had an average survival estimate of 40.1 percent. For these 12 taxa/life stage combinations, initial survival ranged from one percent for cyprinid prolarvae to 96.9 percent for channel catfish juveniles. For all taxa/ life stages combined, initial survival averaged 21.6 percent.

Using the same arbitrary 100 individual criteria for latent samples, ten taxa/life stage combinations averaged 65.4 percent survival. Latent survival ranged from 10.5 percent (freshwater drum prolarvae) to 95.7 percent (catostomid prolarvae) for these same taxa/life stage combinations. For all taxa/life stages combined, latent survival averaged 70.3 percent.

Overall survival averaged 15.2 percent for all taxa/life stage combinations. For the taxa/life stage combinations discussed above, overall survival ranged from zero percent for gizzard shad postlarvae to 89.9 percent for channel catfish juveniles and averaged 31.8 percent. By lifestage, juvenile overall survival was highest averaging 60.7 percent and postlarvae was lowest at 13.4 percent. Overall prolarvae survival averaged 30.6 percent.

Latent Mortality

Table 5 summarizes the results of the 51 latent survival samples collected in 1985. The table shows the number of fish that died at prescribed intervals following collection and the number that survived after being held for 48 hours. Mortality was highest during the first three hours following collection and nearly 84 percent of all mortality occurred in the first 24 hours.

Figure 7 shows the percentage of mortality occurring at each observation time by lifestage for all taxa/life stage combinations combined. Pro-and postlarvae mortality approached 50 percent only three hours after collection, then rapidly declined. For juveniles, mortality was more constant throughout the holding period. Juvenile mortality peaked at 24 hours after collection.

Estimated Impingement

The estimated number and percentage composition of all taxa/lifestage combinations impinged between April 15 and August 28, 1985 is presented in Table 6. More than 17 million eggs and nearly 25 million fish were estimated to have been impinged on the PINGP vertical traveling screens during 1985. Freshwater drum prolarvae, juvenile channel catfish, and cyprinid post larvae comprised 64 percent of all fish impinged. Other taxa/life stage combinations representing more than one percent of the total impingement were carp pro-and postlarvae, catostomid prolarvae, cyprinid prolarvae, freshwater drum postlarvae, and gizzard shad postlarvae. Freshwater drum eggs represented more than 95 percent of all eggs collected and more than 40 percent of all taxa/life stage combinations estimated to have been impinged. Walleye and sauger were collected in very small numbers and collectively represented one-tenth of one percent of all taxa/life stage combinations estimated to have been impinged during 1985.

Freshwater drum prolarvae estimated impingement peaked in late June and July (Figure 8) nearly three weeks after their egg impingement had peaked. Walleye and sauger prolarvae estimated impingement distributions depicted in Figure 9, each appear to be trimodal. Although the estimated numbers impinged are low, the reasons for these types of distributions are unclear. Walleye postlarvae were not represented in samples used to estimate impingement (initial and abundance) and sauger postlarvae were collected for only a two-week period. Weekly estimated impingement rates for white bass and gizzard shad, two other species of interest at PINGP, are shown in Figures 10 and 11, respectively.

Estimated Annual Impingement Survival

Table 7 presents the estimated number and percentage of fish which survived impingement on the PINGP fine mesh vertical traveling screens. Annual percentage survival estimates were computed by dividing the sum of the weekly estimated number of fish surviving after 48 hours by the sum of the estimated weekly number of fish impinged; the resultant estimated survival percentages are therefore, different than the overall survival estimates presented in Table 4, which are the product of initial and latent survival estimates. No annual survival estimates could be calculated for those taxa/life stage combinations not represented in both initial and latent samples for at least one week.

Annual estimated survival percentages ranged from zero to 100 percent. Five taxa/life stage combinations had no estimated survival (cyprinid prolarvae, gizzard shad pro-and postlarvae, percid juvenile, and sauger postlarvae) while all tadpole madtom juveniles were estimated to have survived impingement. For all taxa/life stage combinations for which estimates could be made, average annual impingement survival was estimated to be 23.14

percent. Of the 27 taxa/life combinations represented by sufficient data, seven had estimated survival rates in excess of 50 percent, while 12 had less than 10 percent. By life stage, juvenile was highest (49.91 percent) and postlarvae lowest (16.22 percent) with prolarvae in between at 30.54 percent.

Discussion

Past studies conducted at PINGP (NUS, 1976; Eberley et al., 1985) and other entrainment studies (Hesse et al 1982) have indicated that larval fish densities tend to be higher during hours of darkness than during daylight hours. We collected our initial and latent samples at night or early morning to try maximizing data collection on taxa/life stage combinations expected to occur in low numbers or be present in samples for short periods of time. Day and night densities were averaged when calculating total estimated impingement. An average should present a more realistic estimate of the number of fish collected than either day or night density data alone.

In contrast to 1984 data, 1985 densities were on the average, higher during the day, although day and night densities were not significantly different. Density differences may reflect dominance by one species in the larval drift. In 1984, densities were significantly higher at night when channel catfish, a nocturnal species, dominated (>65 percent) the overall catch. In 1985, freshwater drum, probably a diurnal species, dominated (>30 percent) the larval fish collected. Density differences may be as much due to species composition as the time of day of collection.

Survival was generally lower in 1985 than in 1984. In 1984, initial and overall survival 50.1 and 32.1 percent, respectively, was more than twice that of 1985 (21.6 and 15.2 percent, respectively). Latent survival averaged 64.0 percent in 1984 and 70.3 percent in 1985. The averages may be deceiving however, due to the large influence of channel catfish in 1984 and freshwater drum in 1985. To examine similarities in survival data for the two years, Table 8 lists initial, latent, and overall survival data for all taxa/life stage combinations for which at least 100 individuals were collected in either 1984 or 1985 for each survival category (initial, latent, and overall). While the 100 individuals per category per year is acknowledged as being arbitrary, it does provide a criterion for comparison. While no definitive statements can be made regarding each taxa/ life stage combination, the data does present a two-year survival range for each taxa/life stage combination. Generally, it can be stated that all life stages of channel catfish exhibit relatively high survival. Further, Table 8 reveals those taxa/ life stage combinations exhibiting low (ie <10 percent for both years) overall survival, namely, gizzard shad postlarvae, freshwater drum prolarvae and white bass postlarvae. Additional years data collection will be needed to verify the survival status of other taxa/life stage combinations.

By life stage, juvenile overall survival was highest in both 1984 and 1985, averaging 57.4 and 60.7 percent, respectively; postlarvae survival was lowest, 17.5 and 13.4 percent respectively. Prolarvae survival was intermediate in both years averaging 24.8 percent in 1984 and 30.6 percent in 1985.

In 1984, latent survival samples were held for 96 hours. It was noted however, that mortality unexpectedly began rising dramatically for postlarvae and juveniles after 48 hours. This condition was thought to be due to factors not related to impingement stress so samples were held for only 48 hours in 1985 (Table 5, Figure 7). Table 9 compares mortality by observation time for all taxa/life stage combinations combined for 1984 and 1985. In both years, more than 70 percent of the overall mortality occurred within 24 hours following collection. Other similarities between the years were that initially, juvenile mortality was quite low, with prolarval mortality high, and postlarval mortality between the two. In both years, the highest mortality for all life stages occurred within three hours following collection.

Estimated 1985 impingement was an order of magnitude less than the nearly 500 million organisms estimated to have been impinged in 1984. We feel this is primarily due to changes in sampling equipment design (see Methods and Materials, Sample Collection section). This hypothesis is supported by the fact that juveniles comprised less than eight percent of the estimated 1985 impingement compared with more than 70 percent in 1984. We suspect that the siphon and subsequent flushing the 18 inch pipe in 1985 removed juvenile fish that had accumulated in the pipe prior to sampling. The 1985 estimated impingement is also of the same order of magnitude as the 1975 entrainment estimate (61 million) at PINGP calculated by NUS (1976). We feel the 1985 estimate is a more realistic approximation of the number of organisms which would have passed through PINGP in the absence of the fine mesh vertical traveling screens than was the 1984 estimate.

Estimated 1985 impingement survival (23.14 percent) was considerably lower than the 1984 estimate (42.1 percent). A large part of this discrepancy is due to the fact that channel catfish juveniles, which exhibited a relatively high survival rate, (47.6 percent) dominated the 1984 impingement estimate while in 1985, impingement was dominated by feshwater drum prolarvae which experienced very low survival (0.59 percent). For the two years, impingement survival estimates by lifestage are similar (58.9 and 49.91 percent for juveniles, 22.8 and 30.54 percent for prolarvae and 12.0 and 16.22 percent for postlarvae in 1984 and 1985, respectively).

LITERATURE CITED

Auer, N.A. (ed.). 1982. Identification of larval fish of the Great Lakes basin with emphasis on the Lake Michigan drainage. Great Lakes Fishery, Commission, Ann Arbor, Michigan. Special Pub. 82-3: 744 pp.

Eberley, L.W. 1984. Vertical Traveling Screens Survival Study In: Prairie Island Nuclear Generating Plant Environmental Monitoring Program 1983 Annual Report. Northern States Power Company, Minneapolis, MN.

Eberley, L.W., G.M. Kuhl, and K. N. Mueller 1985. Fine Mesh Vertical Traveling Screens Impingement Survival Study. In: Prairie Island Nuclear Generating Plant Environmental Monitoring Program 1984 Annual Report. Northern States Power Company, Minneapolis, Mn.

Hesse, L.W., G.L. Hergenrader, H.S. Lewis, S.D. Reetz, and A.B. Schlesinger (eds.). 1982. The Middle Missouri River. The Missouri River Study Group, Norfolk, Nebraska. 301 pp.

Holland, L.E. and M.L. Huston (ed.). 1983. A compilation of available literature on the larvae of fishes common to the upper Mississippi River. Prepared for U.S. Army Corps of Engineers, Rock Island, IL. 364 pp.

NUS 1976. Section 316(b) Demonstration for the Prairie Island Nuclear Generating Plant on the Mississippi River near Red Wing, Minnesota. NUS Corp. Pittsburgh, PA.

Robins, C.R., R.M. Bailey, C.E. Bond, J.R. Brooker, E.A. Lachner, R.N. Lea, and W. B. Scott, 1980. A list of Common and Scientific Names of Fishes from the United States and Canada. American Fisheries Society. Special Publication No. 12, Bethesda, Md.

LITERATURE CITED (Continued)

Tin, H.T. 1982. Family Ictaluridae, Bullhead Catfishes. In: N.A. Auer (ed.) 1982. Identification of Larval Fishes of the Great Lakes Basin with Emphasis on the Lake Michigan Drainage. Great Lakes Fishery Commission, Ann Arbor, Michigan. Special Publ. 82-3: 744 pp.

Appendix A. Common and Scientific Names of Fish Collected from the Fine Mesh Vertical Traveling Screens Impingement Survival Study (After Robins, et al 1980)

Common Name	Scientific Name
Bullhead spp.	*Ictalurus* spp.
Burbot	*Lota lota*
Carp	*Cyprinus carpio*
Channel catfish	*Ictalurus punctatus*
Flathead catfish	*Pylodictus olivarus*
Freshwater drum	*Aplodinotus grunniens*
Gar spp.	*Lepisosteus* spp.
Gizzard shad	*Dorosoma cepedianum*
Largemouth bass	*Micropterus salmoides*
Mooneye	*Hiodon tergisus*
Rock bass	*Ambloplites rupestris*
Sauger	*Stizostedion canadense*
Trout perch	*Percopsis omiscomaycus*
Tadpole madtom	*Noturus gyrinus*
White bass	*Morone chrysops*
Walleye	*Stizostedion vitreum vitreum*

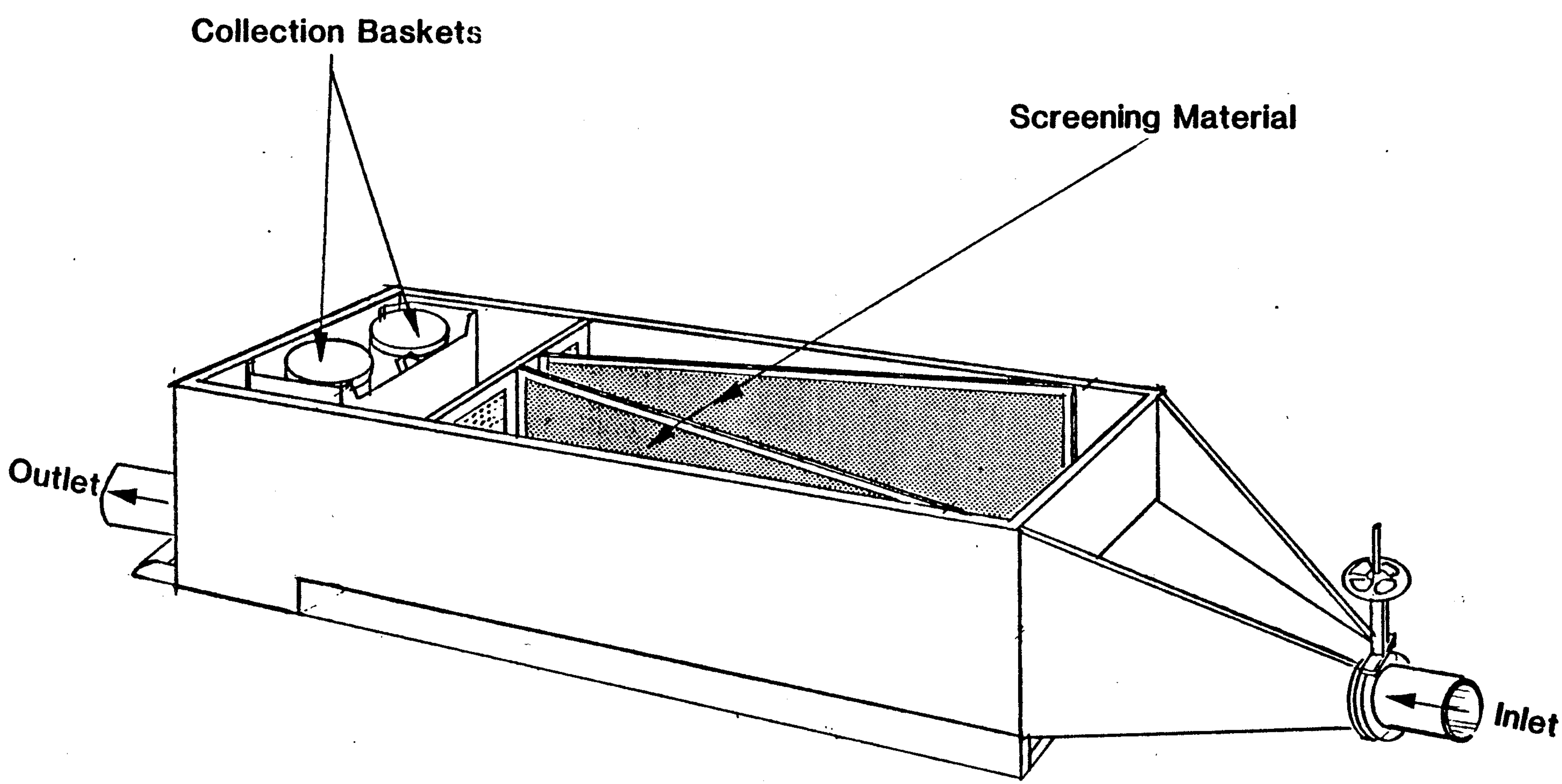


FIGURE 1. Larval Fish Collection Tank

Figure 2. Collection Basket.

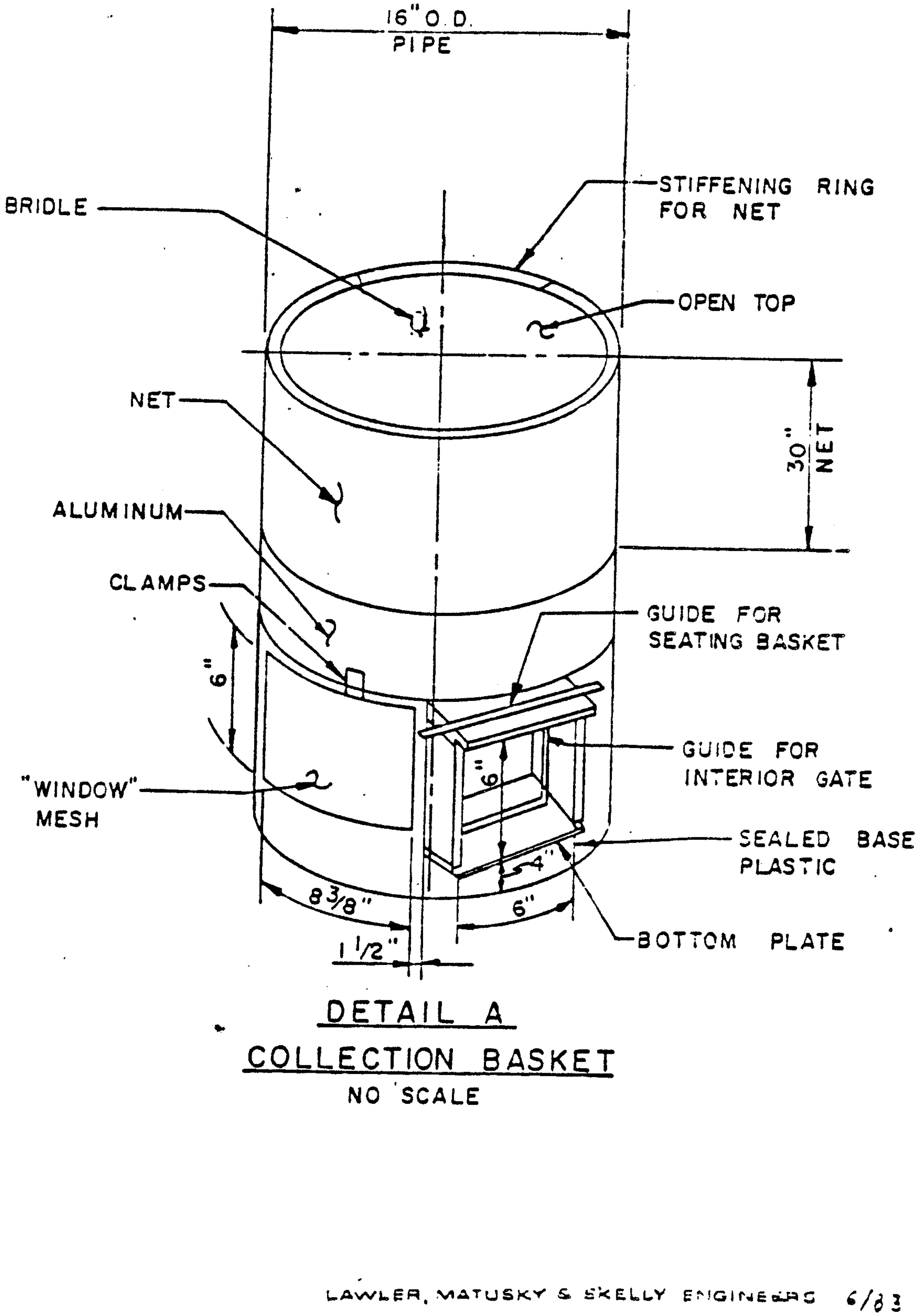
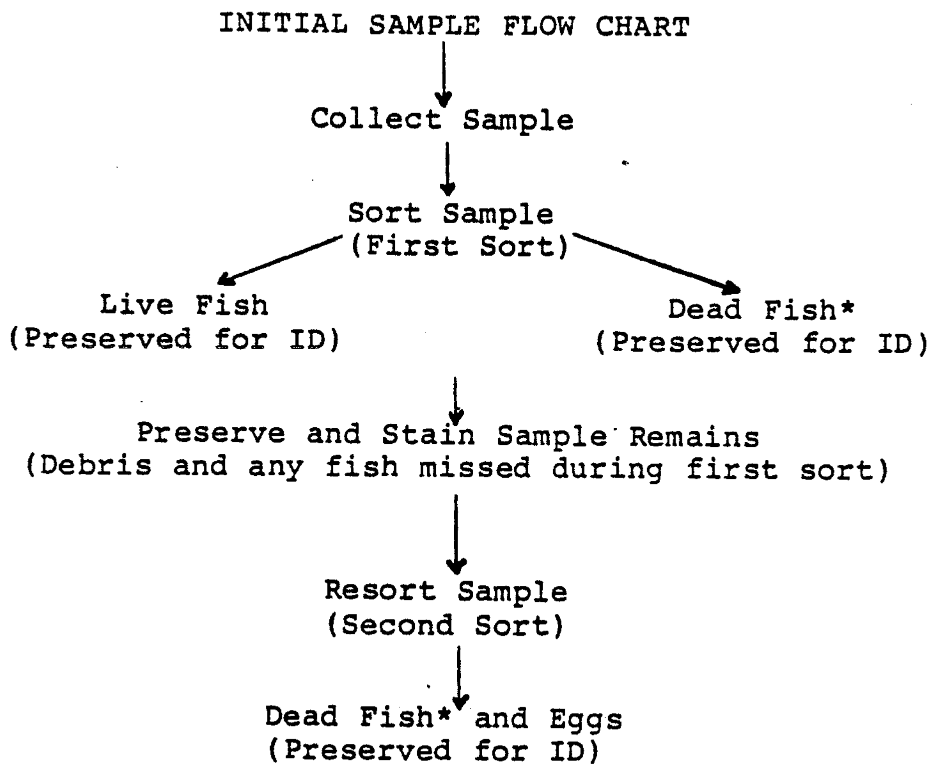


Figure 3.



ad fish from first and second sort combined to yield "Initial Dead"

Figure 4.

ABUNDANCE SAMPLE FLOW CHART

Collect Sample

↓

Preserve and Stain Entire Sample

↓

Sort Sample

↓

Remove Fish and Eggs

↓

Preserve for Identification

Figure 5.

LATENT SURVIVAL FLOW CHART

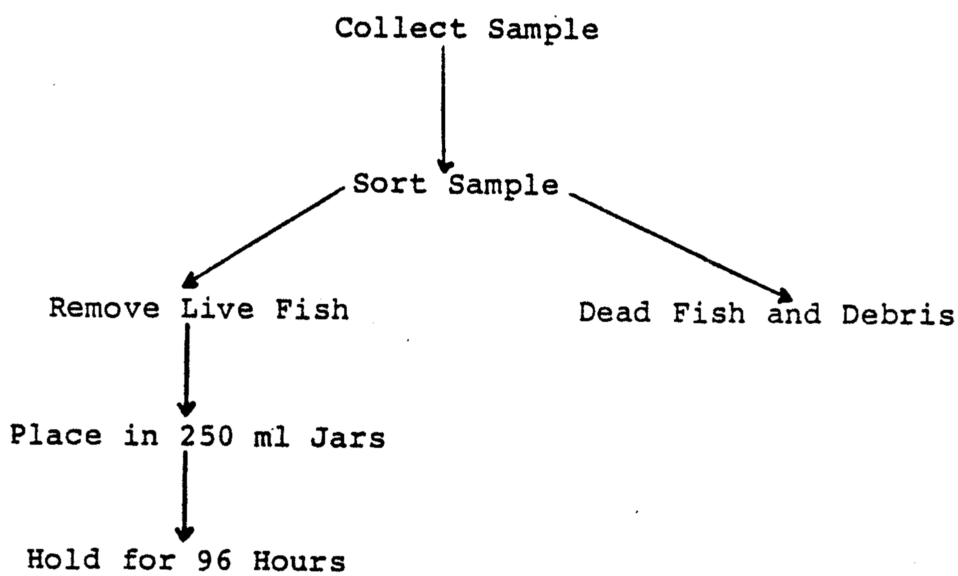


FIGURE 6

COMPARISON OF DAY AND NIGHT DENSITY FISH AND EGGS COLLECTED DURING 1985

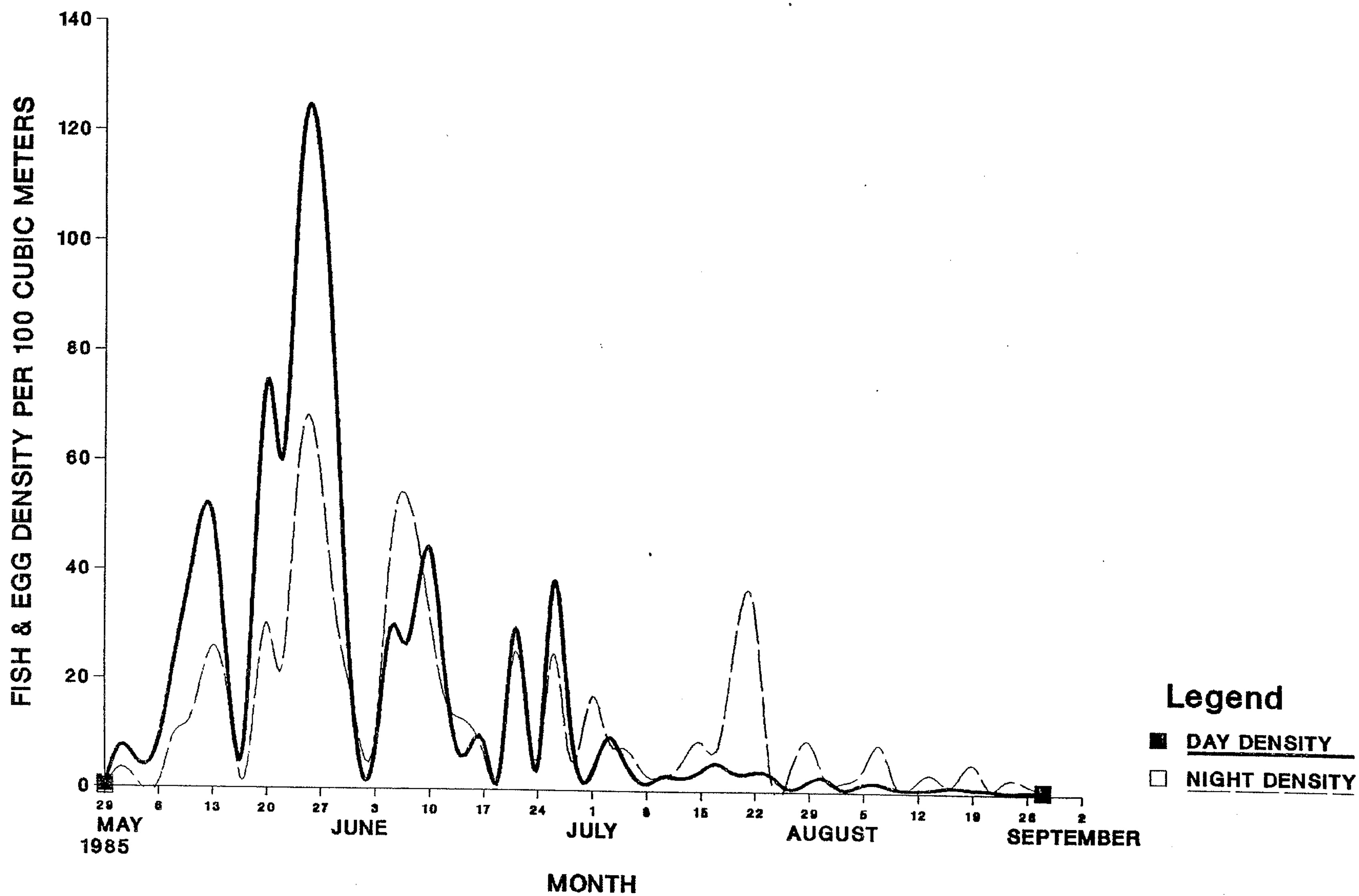
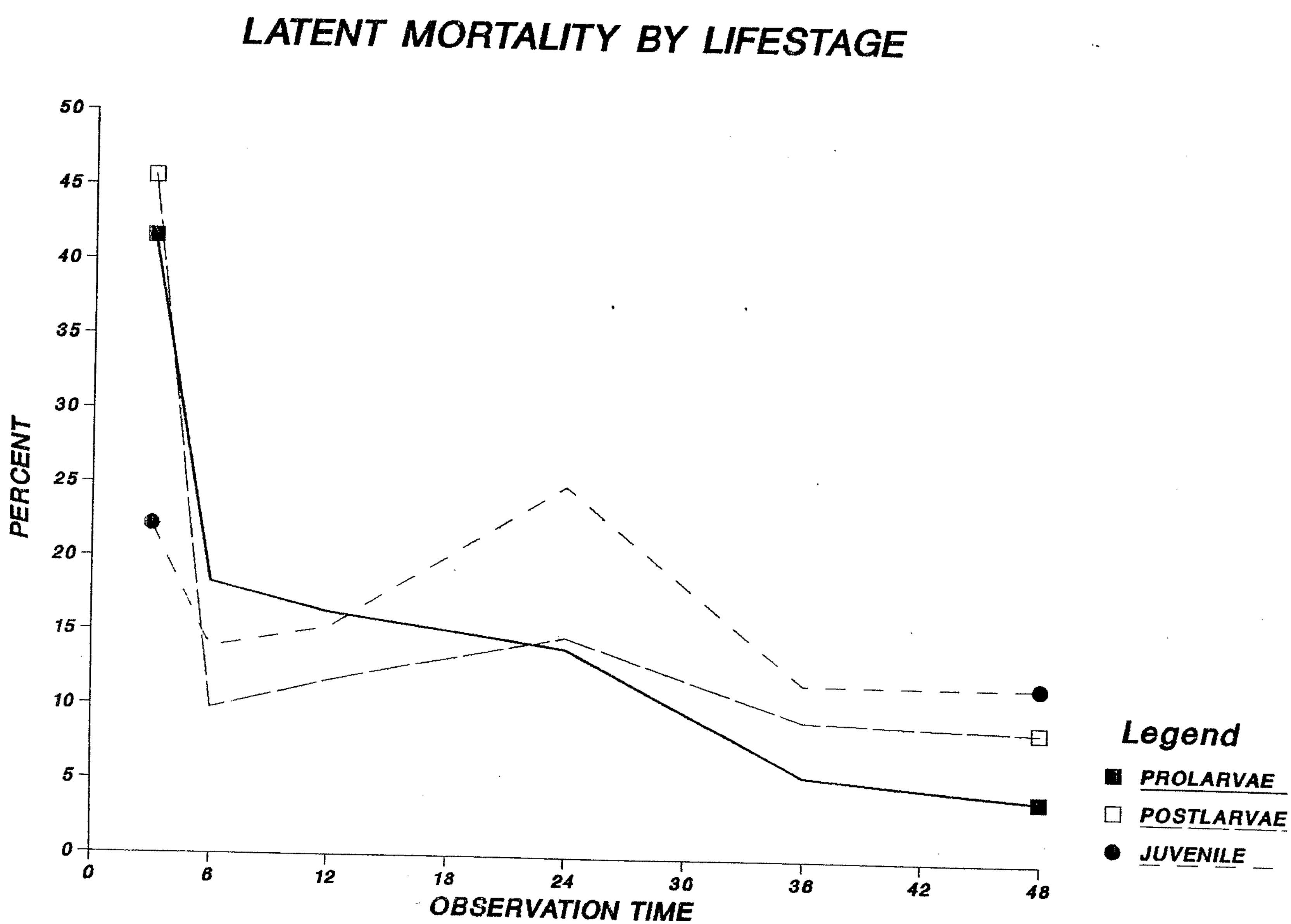


FIGURE 7



LATENT MORTALITY BY LIFESTAGE
PERCENT
0
5
10
15
20
25
30
35
40
45
50
OBSERVATION TIME
0
6
12
18
24
30
36
42
48
Legend
PROLARVAE
POSTLARVAE
JUVENILE

FIGURE 8

WEEKLY ESTIMATED FRESHWATER DRUM IMPINGED DURING 1985

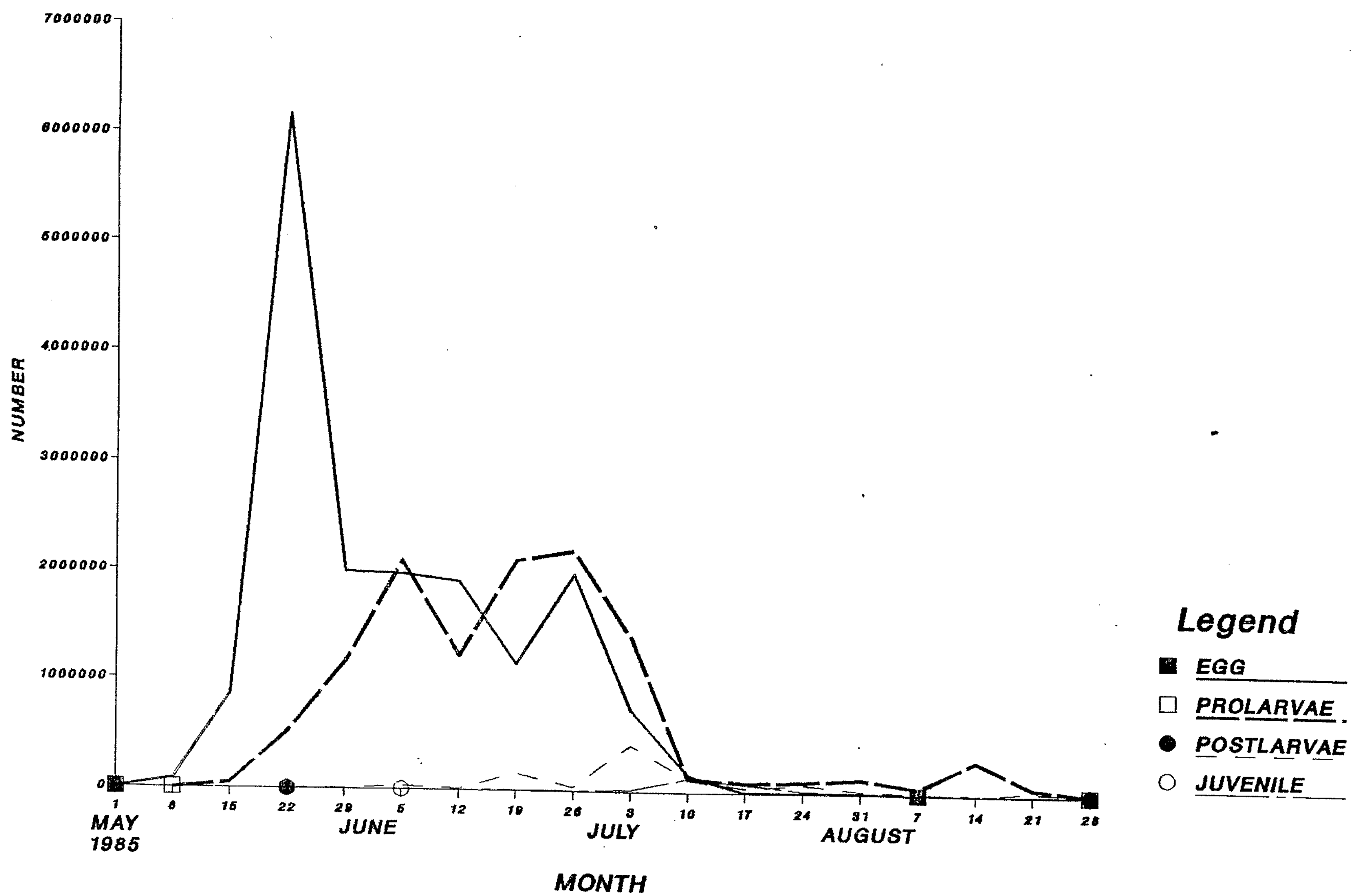


FIGURE 9

DAILY ESTIMATED NUMBER OF WALLEYE AND SAUGER IMPINGED DURING 1985

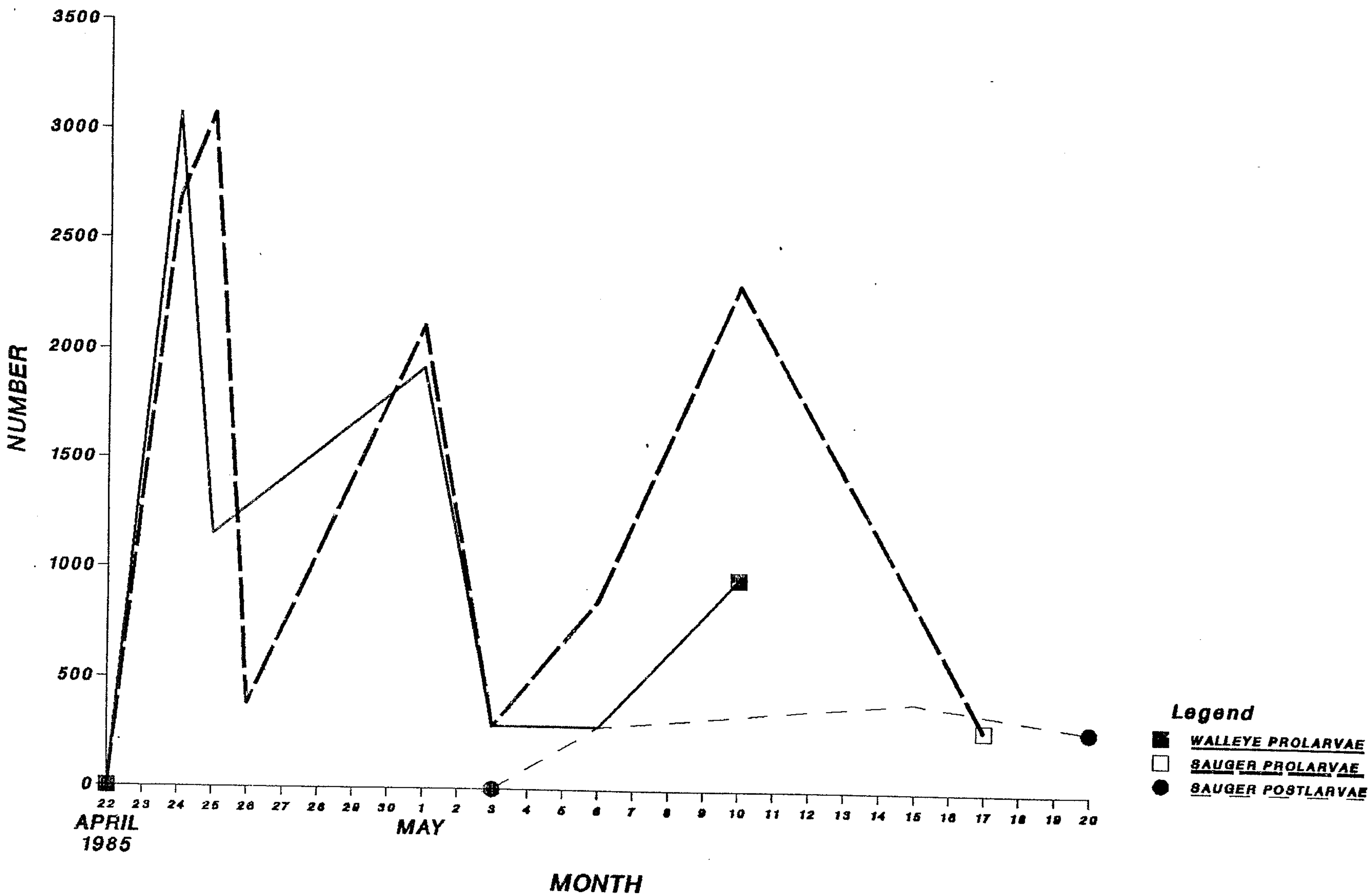


FIGURE 10

WEEKLY ESTIMATED WHITE BASS IMPINGED DURING 1985

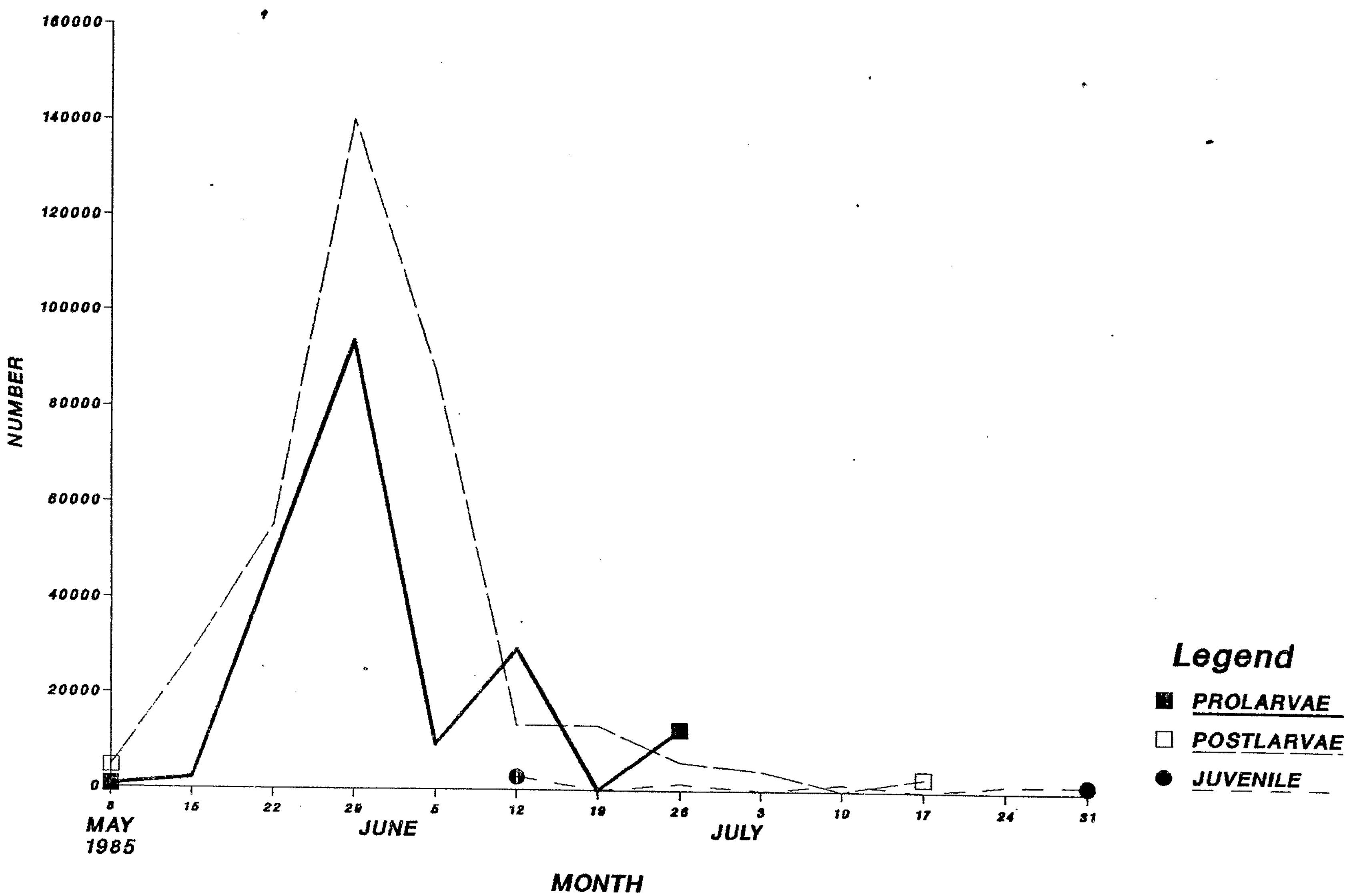


FIGURE 11

WEEKLY ESTIMATED GIZZARD SHAD IMPINGED DURING 1985

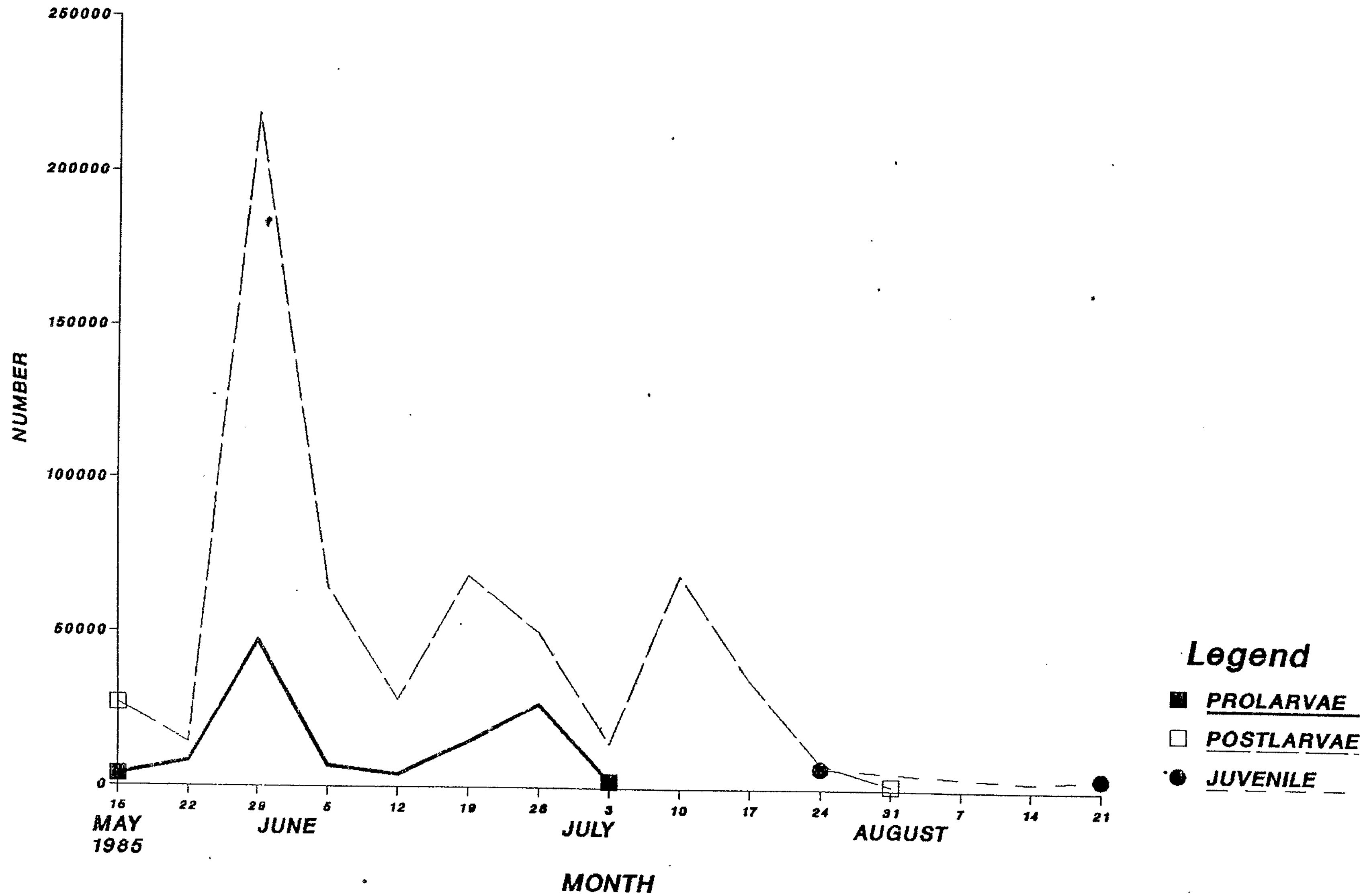


Table 1. Number of samples and organisms collected by sample type in 1985.

SAMPLE TYPE	NUMBER	NO. OF FISH	NO. OF EGGS
Abundance	60	8745	11858
Initial Survival	52	11106	5738
Latent Survival	51	3847	0
TOTAL	163	23698	17596

Table 2. Representative total length ranges (mm) for 44 taxa/life stage combinations collected in the 1984-5 fine mesh impingement survival study.

	Pro.	Post.	Juv.
Channel catfish	11.0 - 18.0	N/A	15.0 - 38.0
Walleye	5.6 - 9.2	-	21.5 - 87.0
Sauger	5.1 - 8.2	8.2 - 14.6	-
Lepomis spp.	4.8 - 6.2	5.3 - 7.4	16.7 - 66.0
Pomoxis spp.	4.6 - 5.7	5.2 - 14.7	17.0 - 75.0
White bass	3.9 - 4.2	5.0 - 12.5	15.0 - 56.0
Rock bass	-	7.3 - 12.1	14.0 - 32.0
Trout perch	6.3 - 6.6	9.0 - 12.8	13.0 - 43.0
Mooneye	8.3 - 12.6	13.0 - 15.0	-
Burbot	4.7 - 5.3	-	-
Carp	4.9 - 7.6	7.5 - 18.5	23.0 - 52.0
Cyprinids	4.4 - 6.2	5.8 - 17.0	14.0 - 36.0
Catostomids	4.6 - 13.2	8.6 - 22.5	20.0 - 37.0
Freshwater drum	3.4 - 7.5	8.0 - 13.5	14.0 - 51.0
Flathead catfish	16.5 - 17.8	N/A	19.0 - 34.0
Tadpole madtom	10.8 - 11.8	N/A	14.5 - 21.0
Gizzard shad	3.7 - 5.6	7.3 - 14.6	19.0 - 42.0
Bullhead spp.	-	N/A	16.0 - 23.0

Table 3. Day vs. night densiity for all taxa/lifestage combinations expressed as number of organisms per 100m3 of water

DATE	DAY DENSITY	NIGHT DENSITY
April 19	0.05	--
22	0.15	--
23	0.06	--
25	1.67	--
26	0.17	--
29	0.47	0.08
May 01	7.59	3.46
03	5.08	1.40
06	8.92	1.00
08	23.77	9.93
10	38.89	12.57
13	49.82	26.00
15	21.14	16.81
17	7.87	1.43
20	74.66	30.29
22	60.70	22.18
24	108.20	58.78
29	66.51	31.06
31	17.62	16.50
June 03	7.58	9.90
05	29.67	45.42
07	26.60	53.48
10	44.07	31.87
12	20.88	16.43
14	6.02	13.07
17	8.71	6.26
19	2.58	3.40
21	29.38	25.28
24	4.63	5.71
26	37.90	25.09
28	14.58	6.64
July 01	3.37	17.36
03	9.74	9.19
05	5.75	7.89
08	1.29	2.64
10	2.68	2.66
12	2.38	4.16
15	3.72	9.00
17	5.13	7.45
19	3.49	4.68
22	--	32.30
24	2.99	2.64
26	0.71	1.47
29	--	8.92
31	2.50	2.32
August 02	0.61	1.62
05	1.58	4.28
07	--	8.68
09	0.84	1.66
12	0.57	2.29
14	0.86	3.15
16	1.14	1.14
19	0.88	5.30
21	0.70	0.98
23	0.39	2.23
26	0.45	1.60
28	0.42	0.61
AVERAGE	14.15	11.93

Table 4. Initial, latent, and overall survival by taxa and lifestage.

Taxa	Lifestage	Initial Survival No. Dead	Initial Survival No. Live	Initial Survival Percent Live	Latent Survival No. Dead	Latent Survival No. Live	Latent Survival Percent Live	Overall Survival Percent Live
Gar spp	postlarvae	1	0	0.0	0	0	-	-
Gizzard shad	prolarvae	72	0	0.0	0	0	-	-
Gizzard shad	postlarvae	207	13	5.9	23	0	0.0	0.0
Gizzard shad	juvenile	5	6	54.5	5	0	0.0	0.0
Mooneye	prolarvae	3	3	50.0	2	2	50.0	25.0
Mooneye	postlarvae	0	0	-	0	1	100.0	-
Carp	prolarvae	166	250	60.1	26	198	88.4	53.1
Carp	postlarvae	87	74	46.0	37	312	89.4	41.1
Carp	juvenile	0	2	100.0	0	2	100.0	100.0
Cyprinidae	prolarvae	205	2	1.0	1	2	66.7	0.6
Cyprinidae	postlarvae	774	90	10.4	109	119	52.2	5.4
Cyprinidae	juvenile	58	72	55.4	28	54	65.9	36.5
Cyprinidae	adult	0	1	100.0	0	5	100.0	100.0
Catostomidae	prolarvae	175	437	71.4	25	550	95.7	68.3
Catostomidae	postlarvae	47	63	57.3	21	255	92.4	52.9
Catostomidae	juvenile	0	0	-	0	2	100.0	-
Channel catfish	prolarvae	2	64	97.0	1	9	90.0	87.3
Channel catfish	juvenile	25	786	96.9	62	800	92.8	89.9
Tadpole madtom	prolarvae	0	1	100.0	0	0	-	-
Tadpole madtom	juvenile	0	9	100.0	0	3	100.0	100.0
Flathead catfish	juvenile	1	18	94.7	2	9	81.8	77.5
Trout-perch	juvenile	1	6	85.7	6	12	66.7	57.1
White bass	prolaravae	52	0	0.0	0	0	-	-
White bass	postlarvae	150	53	26.1	153	42	21.5	5.6
White bass	juvenile	0	3	100.0	1	2	66.7	66.7
Rock bass	postlarvae	0	1	100.0	0	0	-	-
Largemouth bass	postlarvae	0	0	-	1	0	0.0	-

Table 4. (Continued)

Taxa	Lifestage	Initial Survival No. Dead	Initial Survival No. Live	Initial Survival Percent Live	Latent Survival No. Dead	Latent Survival No. Live	Latent Survival Percent Live	Overall Survival Percent Live
Lepomis spp.	prolarvae	19	0	0.0	0	0	-	-
Lepomis spp.	postlarvae	66	8	10.8	9	2	18.2	2.0
Lepomis spp.	juvenile	2	9	81.8	2	18	90.0	73.6
Pomoxis spp.	prolarvae	56	0	0.0	0	0	-	-
Pomoxis spp.	postlarvae	72	4	5.3	5	11	68.8	3.6
Pomoxis spp.	juvenile	0	6	100.0	3	3	50.0	50.0
Centrarchidae	prolarvae	1	0	0.0	0	0	-	-
Sauger	postlarvae	1	1	50.0	1	0	0.0	0.0
Walleye	prolarvae	4	0	0.0	1	1	50.0	0.0
Stizostedion spp.	prolarvae	1	0	0.0	0	0	-	-
Percidae	prolarvae	24	5	17.2	3	4	57.1	9.9
Percidae	postlarvae	26	5	16.1	29	11	27.5	4.4
Percidae	juvenile	2	5	71.4	3	3	50.0	35.7
Freshwater drum	prolarvae	6092	210	3.3	297	35	10.5	0.4
Freshwater drum	postlarvae	151	137	47.6	235	159	40.4	19.2
Freshwater drum	juvenile	41	56	57.7	32	77	70.6	40.8
Unidentified larvae		0	0	-	1	0	0.0	-
Unidentified larvae	egg	3	0	0.0	0	0	-	-
Unidentified larvae	prolarvae	50	0	0.0	0	0	-	-
Unidentified larvae	postlarvae	1	0	0.0	0	0	-	-
Unidentified larvae	unidentified	66	0	0.0	17	1	5.6	0.0
TOTAL		8709	2400	21.6	1140	2704	70.3	15.2

Table 5. Time of mortality by taxa and lifestage.

Taxa	Lifestage	3	6	12	24	36	48 Dead	48 Live	Total
Carp	juvenile	0	0	0	0	0	0	0	2
Carp	postlarvae	9	3	3	4	11	8	312	349
Carp	prolarvae	11	0	0	6	8	1	198	224
Catostomidae	juvenile	0	0	0	0	0	2	2	2
Catostomidae	postlarvae	9	0	0	3	1	8	255	276
Catostomidae	prolarvae	3	0	1	8	6	7	550	575
Channel catfish	juvenile	4	8	9	20	8	13	800	862
Channel catfish	prolarvae	0	0	0	1	0	0	9	10
Cyprinidae	adult	0	0	0	0	0	0	5	5
Cyprinidae	juvenile	13	3	1	4	6	1	54	82
Cyprinidae	postlarvae	82	7	0	5	7	8	119	227
Cyprinidae	prolarvae	0	0	0	1	0	0	2	3
Flathead catfish	juvenile	1	0	1	0	0	0	9	11
Freshwater drum	juvenile	6	7	7	7	2	3	77	109
Freshwater drum	postlarvae	114	31	39	25	15	11	159	394
Freshwater drum	prolarvae	133	64	57	33	5	5	35	332
Gizzard shad	juvenile	4	1	0	0	0	0	0	5
Gizzard shad	postlarvae	18	2	2	1	0	0	0	23
Lepomis spp.	juvenile	1	0	0	1	0	0	18	20
Lepomis spp.	postlarvae	5	0	0	1	0	3	2	11
Largemouth bass	postlarvae	1	0	0	0	0	0	0	1
Mooneye	postlarvae	0	0	0	0	0	0	1	1
Mooneye	prolarvae	1	0	0	1	0	0	2	4
Percidae	juvenile	0	0	0	2	1	0	3	6
Percidae	postlarvae	13	5	7	2	1	1	11	40
Percidae	prolarvae	0	1	0	0	1	1	4	7
Pomoxis spp.	Juvenile	2	0	0	1	0	0	3	6
Pomoxis spp.	postlarvae	5	0	0	0	0	0	11	16
Sauger	postlarvae	0	1	0	0	0	0	0	1
Trout-perch	juvenile	0	1	4	1	0	0	12	18
Tadpole madtom	juvenile	0	0	0	0	0	0	3	3
Unidentified	unidentified	2	4	3	3	1	4	1	18
White bass	juvenile	1	0	0	0	0	0	2	3
White bass	postlarvae	28	12	23	51	23	16	42	195
Walleye	prolarvae	0	0	0	0	0	1	1	2
Total		466	150	156	181	96	91	2704	3844

Table 6. Estimated number and percent composition of fish and eggs impinged during 1985.

TAXA	LIFE STAGE	ESTIMATED NO. IMPINGED	PERCENT COMPOSITION
Bullhead spp.	juvenile	2688	0.01
Burbot	postlarvae	448	<0.01
Carp	juvenile	5376	0.01
Carp	postlarvae	534752	1.26
Carp	prolarvae	1503104	3.54
Catostomidae	postlarvae	201576	0.47
Catostomidae	prolarvae	1748970	4.12
Channel Catfish	juvenile	2459504	5.79
Channel Catfish	prolarvae	266112	0.63
Centrarchidae	postlarvae	2688	0.01
Centrarchidae	prolarvae	448	<0.01
Cyprinidae	adult	2688	0.01
Cyprinidae	juvenile	207712	0.49
Cyprinidae	postlarvae	2080416	4.90
Cyprinidae	prolarvae	651264	1.53
Flathead Catfish	juvenile	32256	0.08
Freshwater Drum	egg	17010668	40.04
Freshwater Drum	juvenile	278976	0.66
Freshwater Drum	postlarvae	984880	2.32
Freshwater Drum	prolarvae	11609536	27.32
Gar spp.	postlarvae	2688	0.01
Gizzard Shad	juvenile	22848	0.05
Gizzard Shad	postlarvae	598800	1.41
Gizzard Shad	prolarvae	114032	0.27
Lepomis spp.	juvenile	33600	0.08
Lepomis spp.	postlarvae	237216	0.56
Lepomis spp.	prolarvae	58688	0.14
Mooneye	prolarvae	17024	0.04
Percidae	juvenile	15072	0.04
Percidae	postlarvae	66832	0.16
Percidae	prolarvae	69063	0.16
Pomoxis spp.	postlarvae	250699	0.59
Pomoxis spp.	prolarvae	84896	0.20
Rock Bass	postlarvae	4928	0.01
Rock Bass	prolarvae	1344	<0.01
Sauger	postlarvae	3011	0.01
Sauger	prolarvae	25626	0.06
Stizostedion spp.	prolarvae	2573	0.01
Trout Perch	juvenile	14112	0.03
Tadpole Madtom	juvenile	16128	0.04
Tadpole Madtom	prolarvae	1344	<0.01
Unidentified	egg	524093	1.23
Unidentified	postlarvae	2016	<0.01
Unidentified	prolarvae	88243	0.21
Unidentified	unidentified	120816	0.28
White Bass	juvenile	8064	0.02
White Bass	postlarvae	355585	0.84
White Bass	prolarvae	149648	0.35
Walleye	prolarvae	13978	0.03
TOTAL		42487029	

Table 7. Estimated annual impingement and estimated number and percentage of fish surviving impingement by taxa/lifes

TAXA	LIFESTAGE	ESTIMATED IMPINGEMENT	ANNUAL SURVIVAL	PERCENT SURVIVAL
Carp	postlarvae	534752	224429	41.97
Carp	prolarvae	1503104	741821	49.35
Catostomidae	postlarvae	201576	119493	59.28
Catostomidae	prolarvae	1748970	1213628	69.39
Channel Catfish	juvenile	2459504	2261449	91.95
Channel Catfish	prolarvae	266112	256460	96.37
Cyprinidae	juvenile	207712	80001	38.52
Cyprinidae	postlarvae	2080416	174252	8.38
Cyprinidae	prolarvae	651264	0	0.00
Flathead Catfish	juvenile	32256	14112	43.75
Freshwater Drum	juvenile	278976	106259	38.09
Freshwater Drum	postlarvae	984880	239232	24.29
Freshwater Drum	prolarvae	11609536	68726	0.59
Gizzard Shad	juvenile	22848	0	0.00
Gizzard Shad	postlarvae	598800	0	0.00
Lepomis spp.	juvenile	33600	18000	53.57
Lepomis spp.	postlarvae	237216	22889	9.65
Mooneye	prolarvae	17024	3064	18.00
Percidae	juvenile	15072	0	0.00
Percidae	postlarvae	66832	6340	9.49
Percidae	prolarvae	69063	7332	10.62
Pomoxis spp.	postlarvae	250669	3345	1.33
Sauger	postlarvae	3011	0	0.00
Trout Perch	juvenile	14112	11760	83.33
Tadpole Madtom	juvenile	16128	16128	100.00
White Bass	postlarvae	355585	27582	7.76
Walleye	prolarvae	13978	0	0.00
TOTAL		24272996	5616302	
AVERAGE SURVIVAL				23.14

Table 8. Comparison of 1984 and 1985 initial, latent, and overall survival percentages for taxa/lifestage combinations represented by at least 100 individuals in either year.

TAXA	LIFESTAGE	INITIAL SURVIVAL 1984	INITIAL SURVIVAL 1985	LATENT SURVIVAL 1984	LATENT SURVIVAL 1985	OVERALL SURVIVAL 1984	OVERALL SURVIVAL 1985
Gizzard Shad	postlarvae	8.7(104)a	5.9(228)	b		0.0(120)	0.0(243)
Carp	prolarvae	35.8(530)	60.1(411)	57.4(162)	88.4(224)	20.4(692)	53.1(635)
Carp	postlarvae	60.0(55)	46.0(161)	55.2(319)	89.4(349)	33.1(374)	41.1(510)
Cyprinidae	prolarvae	1.0(207)	2.1(95)	c		0.6(210)	0.0(108)
Cyprinidae	postlarvae	15.8(461)	10.4(864)	66.3(196)	52.2(228)	10.5(657)	5.4(1092)
Cyprinidae	juvenile	84.2(952)	55.4(160)	77.3(1007)	65.9(82)	65.1(1959)	36.5(242)
Catostomidae	prolarvae	49.1(1118)	71.4(612)	68.7(843)	95.7(575)	33.7(1961)	68.3(1187)
Catostomidae	postlarvae	40.3(72)	57.3(110)	85.3(468)	92.4(276)	34.3(540)	52.9(386)
Channel Catfish	prolarvae	67.2(235)	97.0(66)	d		49.5(254)	87.3(76)
Channel Catfish	juvenile	64.4(6976)	96.9(811)	75.9(1876)	92.8(862)	48.9(8852)	89.9(1673)
White Bass	postlarvae	4.1(490)	26.1(203)	5.2(191)	21.5(195)	0.2(681)	5.6(398)
Walleye	prolarvae	42.4(243	0.0(4)	78.9(573)	50.0(2)	33.4(816)	0.0(6)
Freshwater Drum	prolarvae	4.8(1560)	3.3(6302)	23.5(204)	10.5(332)	1.1(1764)	0.4(6634)
Freshwater Drum	postlarvae	44.7(103)	47.6(288)	20.3(429)	40.4(394)	9.1(532)	19.2(682)
Freshwater Drum	juvenile	90.4(104)	57.7(97)	49.1(169)	70.6(109)	44.4(273)	19.2(682)
Unidentified Larvae	unidentified	e		3.3(123)	5.6(18)	0.0(151)	0.0(84)

a = Sample size (n) in parentheses.

b-e = less than 100 individuals collected in either year.

Table 9. Percent mortality by observation time for all taxa/lifestage combinations collected in 1984 and 1985.

	OBSERVATION TIME (Hours After Collection)					
	3	6	12	24	36	48
1984	26.9	15.3	12.8	16.7	14.3	14.0
1985	40.9	13.2	13.7	15.9	8.4	8.0