PI Island 316(b) Document

TABLE 6.4-1

CALCULATION OF LOSS OF ADULT FISH DUE TO ENTRAINMENT OF EGGS, LARVAE AND JUVENILES AT PINGP IN 1975. (Sheet 1 of 2)

	Number Entrained	Fecundity[a]	Survival Egg to Larva	Larvae Produced by One Female	Survival Larvae to Adult	Number of Adults Lost	Economic Classification[c]
Dorosoma cepedianum	10,370,000	1,560,000	0.005	7,800	0.0003	3,111	F
Coregonus clupeaformis	4,000	178,000	0.005	900	0.002	8	C
Hiodon tergisus	1,221,000	60,000	0.005	300	0.007	8,547	C,S
Esox lucius	4,000	981,000	0.005	4,900	0.0004	2	S
Cyprinus carpio	3,257,000	7,360,000	0.005	36,800	0.00006	195	C
Notropis atherinoides	15,961,000	2,900[b]	0.005	15	0.13	2,075,000	F
Cyprinidae	1,575,000	2,900[b]	0.005	15	0.13	204,700	F
Carpiodes spp	4,598,000	619,200	0.005	3,100	0.0006	2,759	C
Catostomus commersoni	13,000	954,000	0.005	4,800	0.0004	5	C
Ictiobus spp	6,617,000	1,610,000	0.005	8,000	0.0002	1,323	C
Moxostoma spp	36,000	135,000	0.005	680	0.003	108	C
Ictalurus punctatus	325,000	214,800	0.75	160,000	0.00001	3	C
Noturus gyrinus	3,000	200	0.75	150	0.01	30	F
Pylodictis olivaris	16,000	108,300	0.75	500	0.004	64	C
Percopsis omiscomaycus	25,000	1,400	0.005	7	0.3	7,500	F
Morone chrysops	7,297,000	3,390,000	0.005	17,000	0.0001	730	S
Ambloplites rupestris	5,000	63,000	0.75	300	0.007	35	S
Lepomis gibbosus	122,000	16,425	0.75	12,000	0.0002	24	S
L. macrochirus	742,000	97,000	0.75	73,000	0.00003	22	S
Pomoxis spp	480,000	462,200	0.75	35,000	0.00006	29	S
Etheostoma nigrum	67,000	1,600	0.75	1,200	0.002	134	F
Perca flavescens	102,000	436,800	0.03	13,100	0.0001	10	S
Percina caprodes	88,000	6,000	0.005	30	0.07	6,160	F
P. shumardi	1,711,000	1,200[2]	0.005	6	0.3	513,300	F
Stizostedion canadense	1,881,000	159,500	0.005	800	0.003	5,643	S
S. vitreum	319,000	2,257,000	0.005	11,300	0.0002	64	S
Percidae	956,000	477,000	0.005	2,400	0.0008	765	
Aplodinotus grunniens							
Eggs	7,484,000	1,300,000	0.005	6,500	0.0003	11	
Larvae & Juveniles	3,408,000	-	-	-	-	1,022	
Unidentifiable Larvae	403,000	-	-	-	-	-	

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Prairie Island 316(b) Entrainment Data

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TABLE 6.4-1 (Sheet 2 of 2)

	Number Entrained	Fecundity[a]	Survival Egg to Larva	Larvae Produced by One Female	Survival Larvae to Adult	Number of Adult Lost	Economic Classification[c]
Unidentifiable eggs	887,000	–	–	–	–	–	
Unidentified Larvae	39,000	–	–	–	–	–	
Total Eggs	8,371,000				Total	2,831,304	
Total Larvae & Juveniles	61,645,000				Forage	2,809,9[illegible]	
					Sport/Commercial	21,339	

[a]Fecundity information obtained from Scott and Crossman (1973); Wrenn (1968); Swee and McCrimmon (1966); Bodola (1955); Daiber (1953); Winn (1958); Wolfert (1969); Ulrey, Risk and Scott (1968)

[b]Average of fecundities of several similar species.

[c]F = Forage; C = Commercial; S = Sport.

TABLE 6.5-1

NUMBERS OF MAJOR FISH SPECIES IMPINGED AT PINGP, ESTIMATES OF STANDING CROP BASED ON TRAWL SURVEY, SPORT CATCHES, AND ESTIMATES OF SPORT FISH POPULATIONS

	Total impinged[b]		Trawl survey[c]		Tag and recapture[d]	
	1974	1975	Plant area 33.4 ha	North Lake 438 ha	Peterson	Schnabel
Gizzard shad[a]	136,667	70,506	2,252	270,684		
Channel catfish	637	6,223	2,669	4,818	22,720	
White bass	1,367	2,712	2,190	60,006	173,910	155,335
Crappies	1,704	2,030	417	154,176		
Drum	3,143	3,789	66,220	58,692		
Walleye	5	--	250	2,190	162,721	123,512
Sauger	13	--	417	1,752	609,809	228,784
Sauger/walleye	87	197	667	3,942	772,530	352,296

[a] Six million estimated for Sturgeon Lake (Andersen 1975)

[b] Section 5.2

[c] Section 4.5, 1974 - 1975.

[d] Section 4.5, Sturgeon Lake to Lake Pepin, 1974 and 1975.

PRAIRIE ISLAND NUCLEAR GENERATING PLANT

ENVIRONMENTAL MONITORING PROGRAM

1984 ANNUAL REPORT

ECOLOGICAL STUDIES

IMPINGEMENT OF FISHES AND OTHER ORGANISMS ON THE PRAIRIE ISLAND PLANT COOLING WATER INTAKE TRAVELING SCREENS

by

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Northern States Power Company

IMPINGEMENT OF FISHES AND OTHER ORGANISMS ON THE PRAIRIE ISLAND PLANT COOLING WATER INTAKE TRAVELING SCREENS

INTRODUCTION

There are presently two complete screening facilities operating at the Prairie Island plant. The old, or original, traveling screens and screenhouse were designed to prevent debris, fish, and other organisms from entering the plant via the cooling water intake. The new screenhouse and screens, completed in 1983, were designed and located to exclude fish from the warm circulating water system. Location of both systems are shown in Figure 1. Monitoring of fish and other organisms impinged on the old traveling screens has been conducted annually since the plant became operational in 1973 and was continued during 1984. The first full year of data was collected in 1974. Impingement and survival of fish at the new screening facility were also studied during 1984, and reported separately in the section, Fine Mesh Vertical Traveling Screen Survival Study, of this volume.

As in previous years, impingement data were collected every other week. The terms "every other week", "biweekly", and "alternate weeks" are used interchangeably in reference to sampling frequency. Biweekly and seasonal impingement rates, and length distribution are presented in this report. Predominant taxa, percent composition, and estimated annual total of fish collected in 1984 are presented and compared with previous years. A summary of non-fish organisms such as crayfish, turtles, clams, and small mammals is included.

METHODS

Impingement sampling was conducted every other week during 1984, beginning with the first two weeks, (weeks ending January 6 and 13), and ending with the last week (week ending December 28).

Plant helpers removed fish from the trash baskets at approximately 8:00 a.m. Monday, Wednesday, and Friday each week, but delivered fish to the lab only every other week. Alternate week sampling periods included seven days ending on Friday. Annual impingement loss was estimated by multiplying actual numbers of fish collected by two. Observations were made during weeks not sampled to assure no extraordinary losses occurred. Such losses would be included in addition to the estimated total from scheduled sampling. Exceptions were made to the sampling schedule when holidays coincided with collection dates, in which case sampling was done the following day.

Debris and organisms were separated, fish were taxonomically enumerated, and non-fish organisms were recorded. Procedures for counting and estimating numbers of fish have been described in previous annual reports. Total length in millimeters (mm) was recorded in 20 mm increments for all fish in measurable condition when the number per taxa or taxonomic group was less than 50. When a sample contained more than 50 young-of-the-year (yy)[1] and adults per taxa, 50 of each were measured. The remaining fish were recorded as unmeasured, unmeasured yy, and/or unmeasured adults. Fish removed from the bar rack were included in impingement data.

Several species were combined into taxonomic groups for reporting impingement losses. Members of the family Cyprinidae, with the exception of carp[2] and silver chub, were recorded as "shiner species". Groups at genus level were used when similarity of

[1]Young-of-the-year (yy) refers to fish less than one year of age after hatching.

[2]Text refers to fish by common name. Common and scientific names are presented in the Appendix.

species and deterioration of specimens prevented positive identification. Specimens deteriorated beyond recognition were listed as "fish skeletons".

RESULTS

The 1984 estimated annual impingement loss totaled 210,590 fish, including specimens from 13 taxonomic families (see Appendix). Of the estimated loss, nearly 204,000 were gizzard shad, representing 96.8 percent of the total. Only one species of shad occurs in the study area, hence gizzard shad will be referred to as shad. Other predominant taxa, in decreasing order of abundance, included freshwater drum (1.4 percent), channel catfish, bluegill, shiner/minnow species, white bass, and crappie species (ranging from 0.1 to 0.5 percent). All other taxa combined represented 0.3 percent of the total number of fish impinged. Actual numbers of other gamefish included one largemouth bass, six sauger, and eight walleye. Table 1 provides a comparison of 1984 predominant taxa, other taxa combined, and annual total, to those for 1983, and to the range and mean for 1974 through 1983.

Chlorination of the cooling water system was conducted August 25, 1984. Fish killed were collected and reported separately to the MDNR. Impingement sampling was continued as scheduled following chlorination, and reduced impingement rates were evident.

Weekly impingement data for all taxa collected in 1984 are presented in Table 2. Based on the 27 weeks sampled, weekly loss averaged 7,900 fish, with a range of 0 to 45,831 fish per week. Peak impingement occurred in January (Figure 2). Shad predominated the January peak. Ninety-three percent of annual impingement occurred between January 1 and February 10, at which time 99 percent of the fish collected were shad. Over 95 percent of all shad collected during 1984 were taken at that time. Impingement decreased after mid-February and remained low with

minor peaks occurring in June and November. Channel catfish (191), carp (45), and shiner/minnow spp. (945) collected during the week ending June 16 dominated the increased impingement rate seen in June. Impingement of all predominant taxa increased in November. Freshwater drum (708) and shad (1,133) collected November 2 accounted for the majority of fish creating the November peak. Impingement of white bass, bluegill, and crappie spp. was minimal throughout the year, but appeared in the samples most frequently during the three peak periods.

A seasonal summary of 1984 impingement is presented in Table 3. Percent of each taxa collected per season is included. Four percent of the annual total was collected in fall (Oct-Dec) and 95 percent during winter (Jan-Mar). The majority of shad, white bass, and bluegill were collected during winter. Freshwater drum, crappie spp., and shiner/minnow spp. appeared most frequently in fall.

Length frequency distribution for all taxa is presented in Table 4, and for predominant species in Figures 3 through 8. Nearly 100 percent of the shad collected in 1984 were recorded as young-of-the-year (yy). Shad less than 200 mm, and recorded as yy, represented 1983 and 1984 year classes. Most of these fish were collected in January and February prior to 1984 spawning, and must be considered from the 1983 year class. Fish collected from the bar rack were combined with those from the trash baskets and included in length frequency data.

Clams were the predominant non-fish organisms collected (Table 5). All clam species were combined for reporting, and included Paper Pondshells, Floaters, Fragile Paper Shells, Fawn's Foot, Asiatic Clam (Corbicula), and unidentified clams. The diversity of non-fish organisms was reduced from 1983. Only one turtle species, the spiny softshell, was collected. One bat was the only small mammal, and there were no birds. Surviving aquatic organisms were released.

DISCUSSION

All taxa impinged during 1984 have been collected and reported in previous years, although the number of species was reduced from 1983.

More shad, bluegill, and shiner/minnow spp. were impinged in 1984 than 1983. All predominant taxa, except shad, exhibited lower than average impingement during 1984. The number of freshwater drum was most dramatically reduced from 41,390 in 1983 to 2,944. Fewer white bass and crappie spp. were collected than in any previous year. Channel catfish impingement was approximately one-third that of 1983, and of the ten-year average. The total of all other taxa combined (574 fish) was also lower than any previous year.

It appears there may have been several plant-induced factors, as well as natural effects, influencing fish impingement during 1984. The emergency by-pass gates of the new screenhouse were open from July, 1983 through February 15, 1984, allowing unscreened water and fish to enter the circulating water system. Unit 1 was off line from December 2, 1983 to January 3, 1984. Increased water appropriation and water temperature fluctuaions, associated with return of the unit to service, coincide with peak fish impingement in January. See the Water Temperature and Flow sections of this volume and of the 1983 Annual Report for specific outage dates, flow data, and temperatures. Above average impingement, predominately shad, occurred in January and early February (Figure 9). Nearly 100 percent of the shad taken in 1984 were recorded as yy, but the majority were actually of the 1983 year class collected prior to closing of the by-pass gates in mid-February. Impingement of fish other than shad, after February 15, was much lower than the average of previous years (Figure 10), indicating the new screenhouse may be effective in preventing fish from entering the circulating water system.

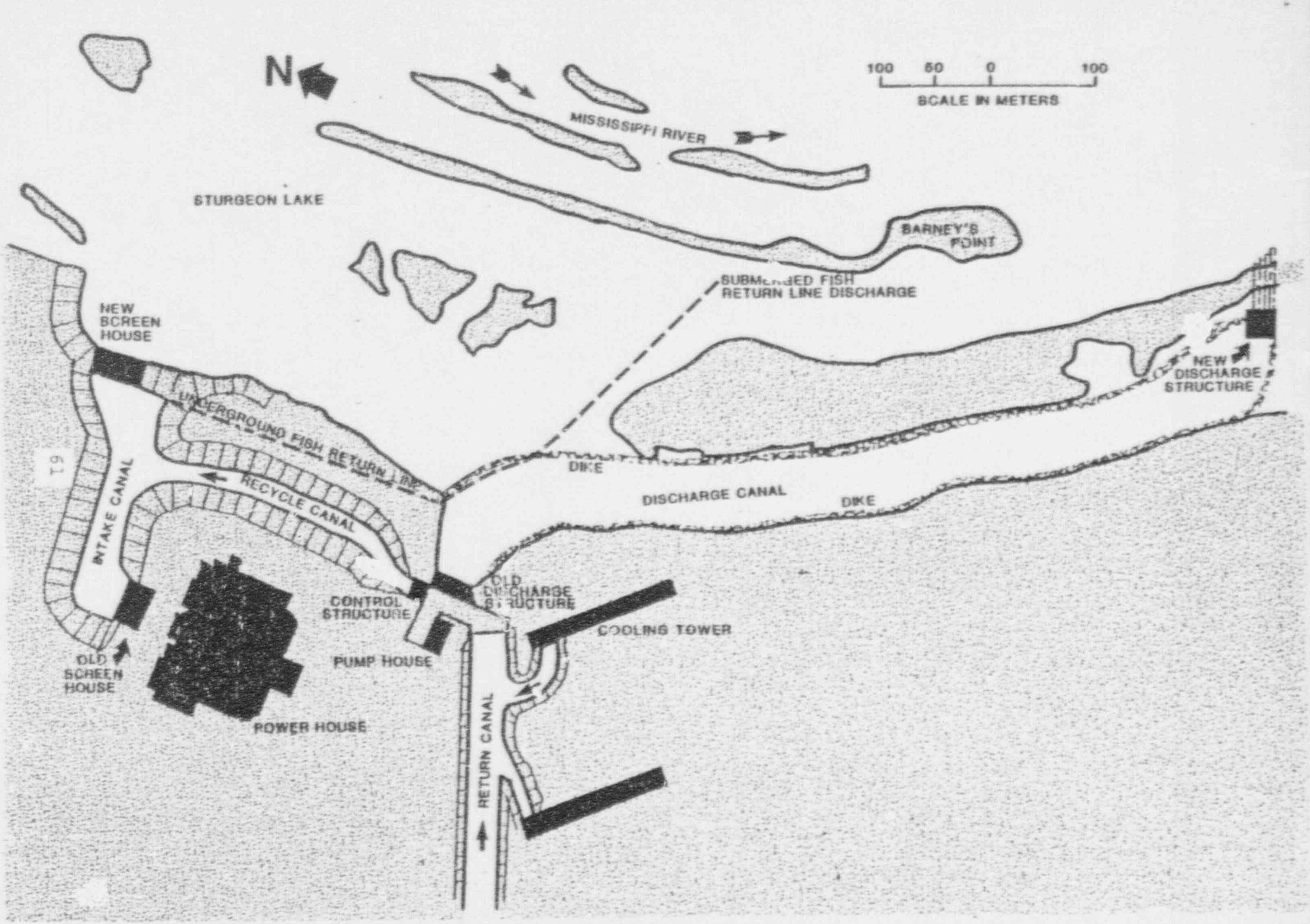
Impingement was slightly above average in mid-June, affecting primarily channel catfish, carp, and shiner/minnow species. This may be attributed to increased water appropriation and high river flow which occurred in June (Table 3, Water Temperature and Flow section).

Fall impingement was greatly reduced from previous years, but an increase did occur in October and November (Figures 9 and 10). The minor peak may be indicative of the annual die-off historically affecting yy fish in the fall. Review of the data indicated the majority of freshwater drum and shad, collected in October and November, were less than 160 mm total length and were of the 1984 year class. Also occurring at that time were intermittent plant outages of Unit 1 (Oct 2-Nov 7) and Unit 2 (Sept 4-Oct 12). Fluctuations in water temperature and increased appropriation, associated with resumed service of the units, may have had as much effect on impingement as the fall die-off. Lower than average fall impingement may be attributed to closure of the by-pass gates in February, and a reduced fish population in the canal following chlorination in August.

<u>SUMMARY</u>

Estimated annual impingement nearly equalled that of 1983 and was higher than the average of the previous ten years. Shad comprised nearly 97 percent of the total. The majority of impingement, primarily shad of the 1983 year class, occurred prior to closing the by-pass gates of the new screenhouse in mid-February. Numbers of freshwater drum and white bass were most dramatically reduced. Over the years, highest impingement has occurred in the fall, primarily affecting yy fish. During 1984, impingement peaked in February and was greatly reduced thereafter. Reduced fall impingement in 1984 may be attributed to closure of the by-pass gates preventing fish from entering the canal and reduction of the canal's fish population during chlorination in August.

Figure 1.



N
100 50 0 100
SCALE IN METERS
MISSISSIPPI RIVER
STURGEON LAKE
BARNEY'S POINT
SUBMERGED FISH RETURN LINE DISCHARGE
NEW SCREEN HOUSE
UNDERGROUND FISH RETURN LINE
RECYCLE CANAL
INTAKE CANAL
DIKE
DISCHARGE CANAL
DIKE
NEW DISCHARGE STRUCTURE
OLD DISCHARGE STRUCTURE
CONTROL STRUCTURE
COOLING TOWER
PUMP HOUSE
OLD SCREEN HOUSE
POWER HOUSE
RETURN CANAL

FIGURE 2

NUMBERS OF FISH COLLECTED PER WEEK
FROM THE PRAIRIE ISLAND PLANT TRASH BASKETS
DURING 1984

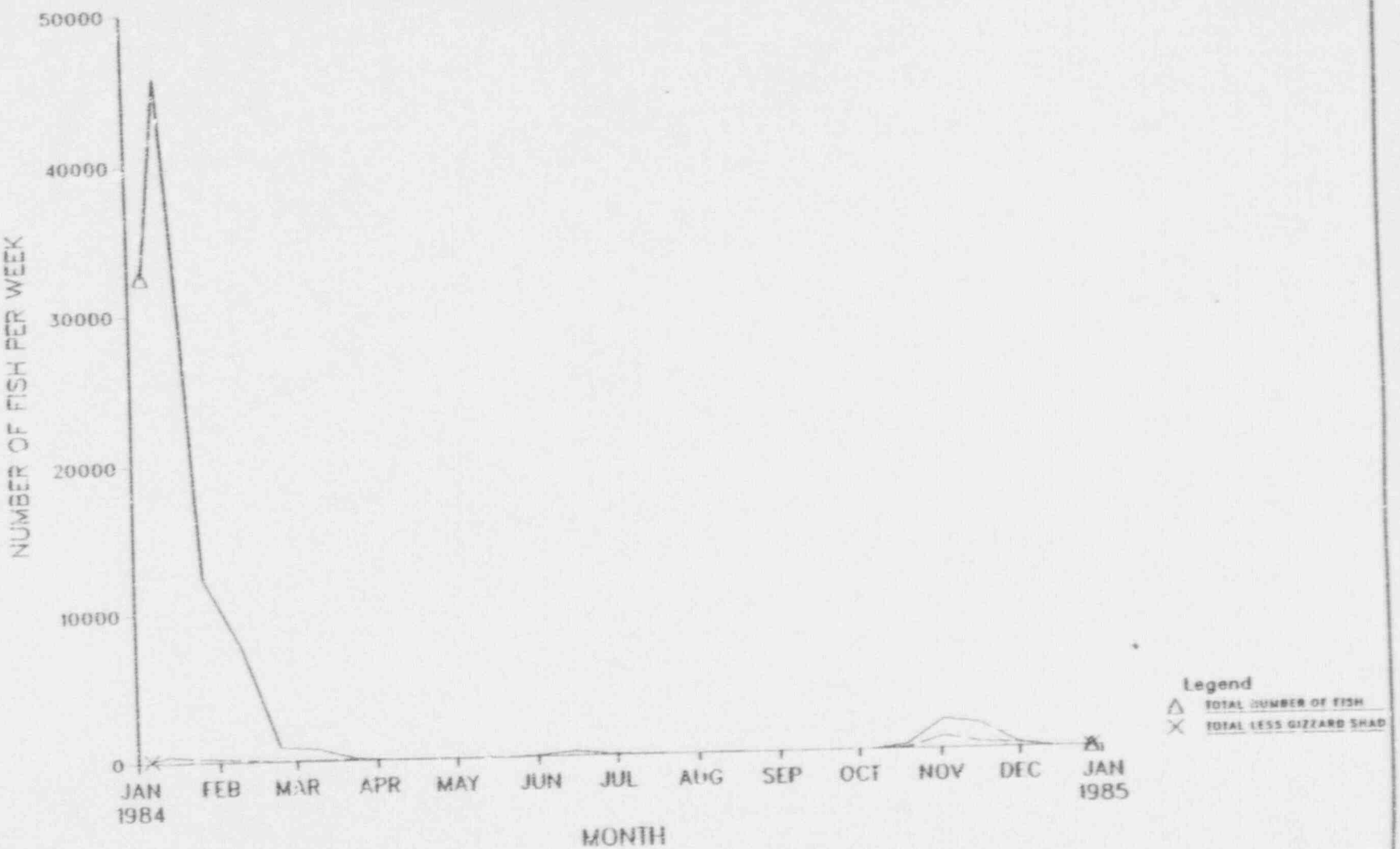


FIGURE 3

LENGTH FREQUENCY OF GIZZARD SHAD IMPINGED DURING 1984

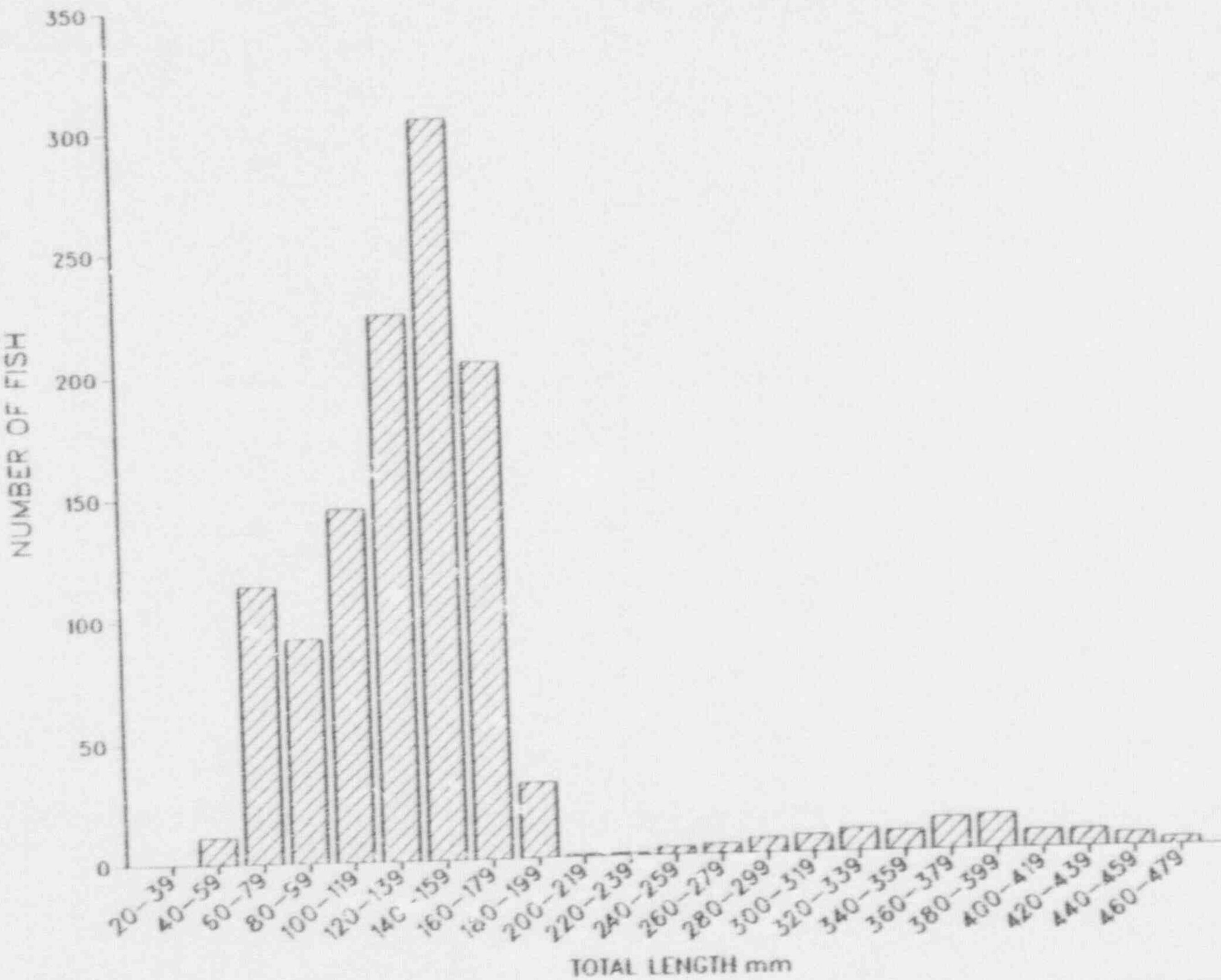


FIGURE 4

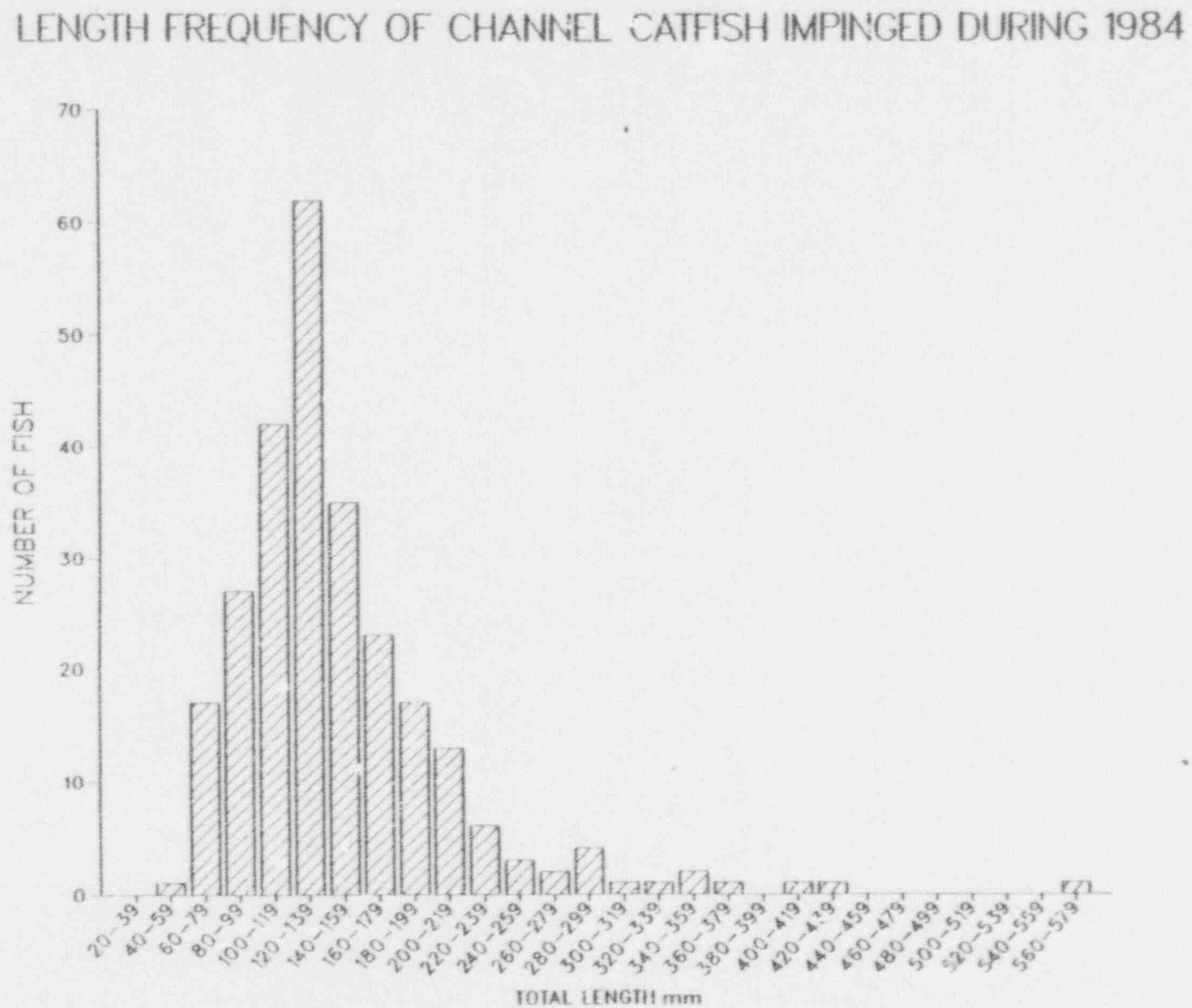

LENGTH FREQUENCY OF CHANNEL CATFISH IMPINGED DURING 1984
NUMBER OF FISH
70
60
50
40
30
20
10
0
20-39
40-59
60-79
80-99
100-119
120-139
140-159
160-179
180-199
200-219
220-239
240-259
260-279
280-299
300-319
320-339
340-359
360-379
380-399
400-419
420-439
440-459
460-479
480-499
500-519
520-539
540-559
560-579
TOTAL LENGTH mm

FIGURE 5

LENGTH FREQUENCY OF WHITE BASS IMPINGED DURING 1984

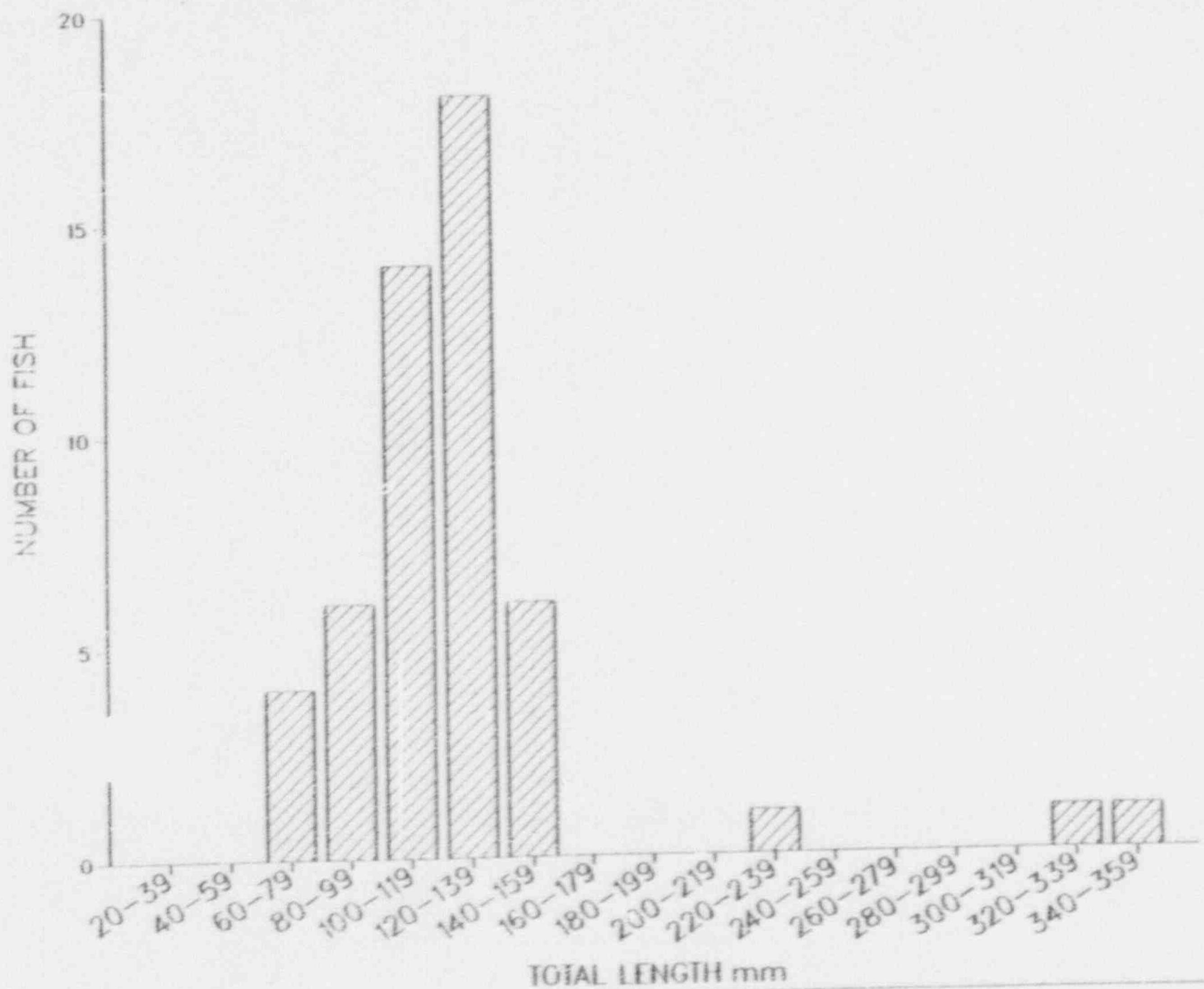


FIGURE 6

LENGTH FREQUENCY OF BLUEGILL IMPINGED DURING 1984

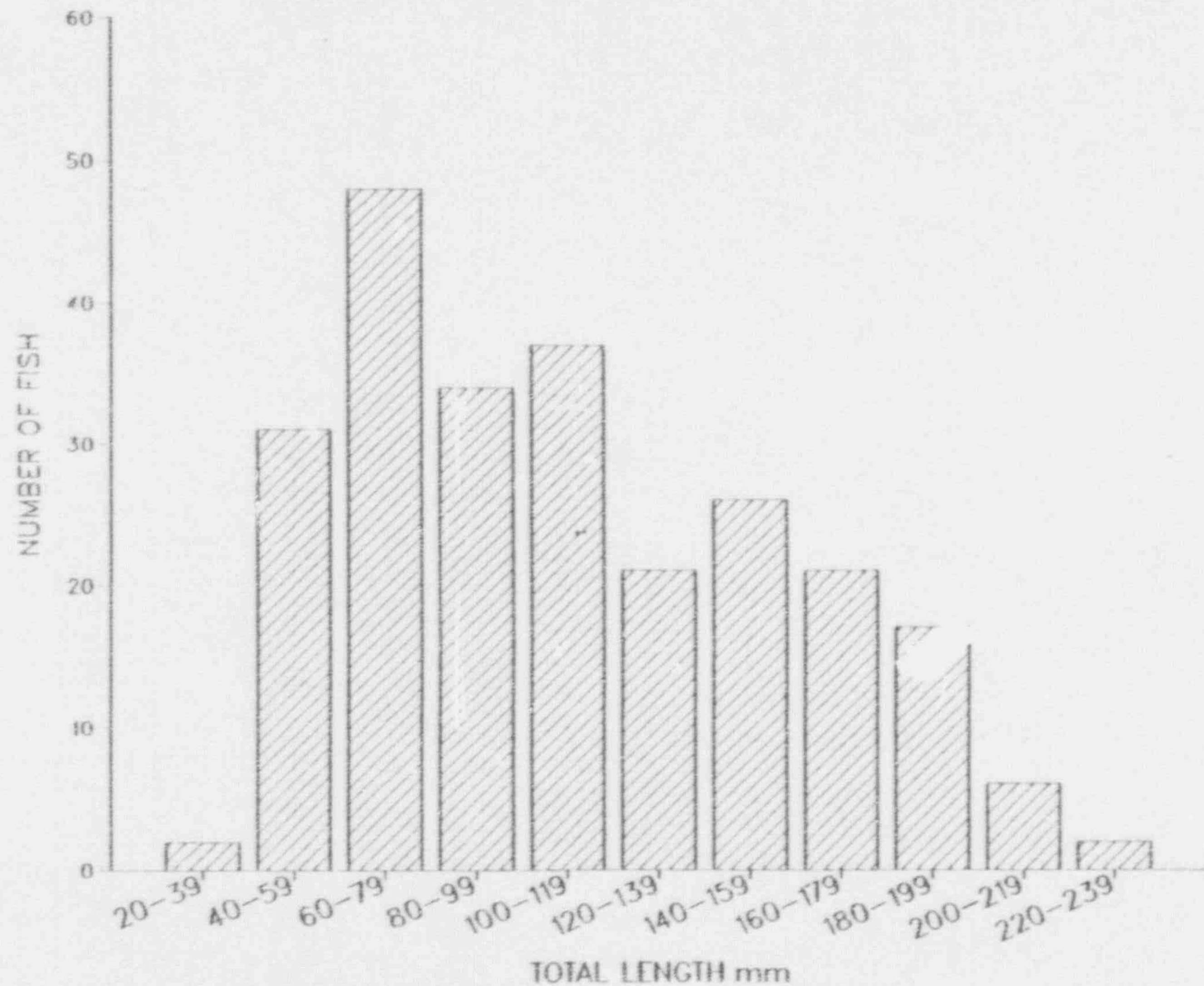


FIGURE 7

LENGTH FREQUENCY OF CRAPPIE SPP. IMPINGED DURING 1984

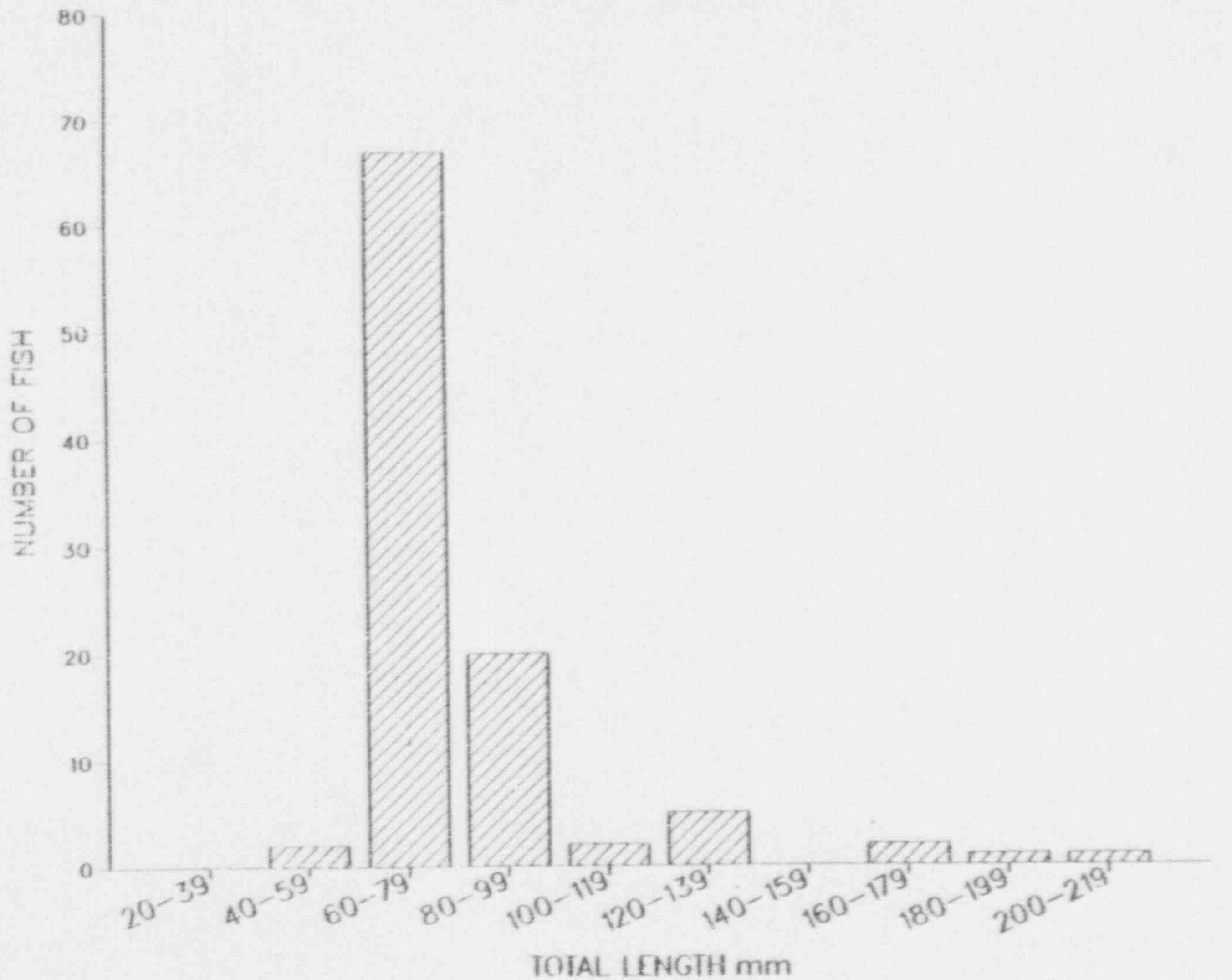
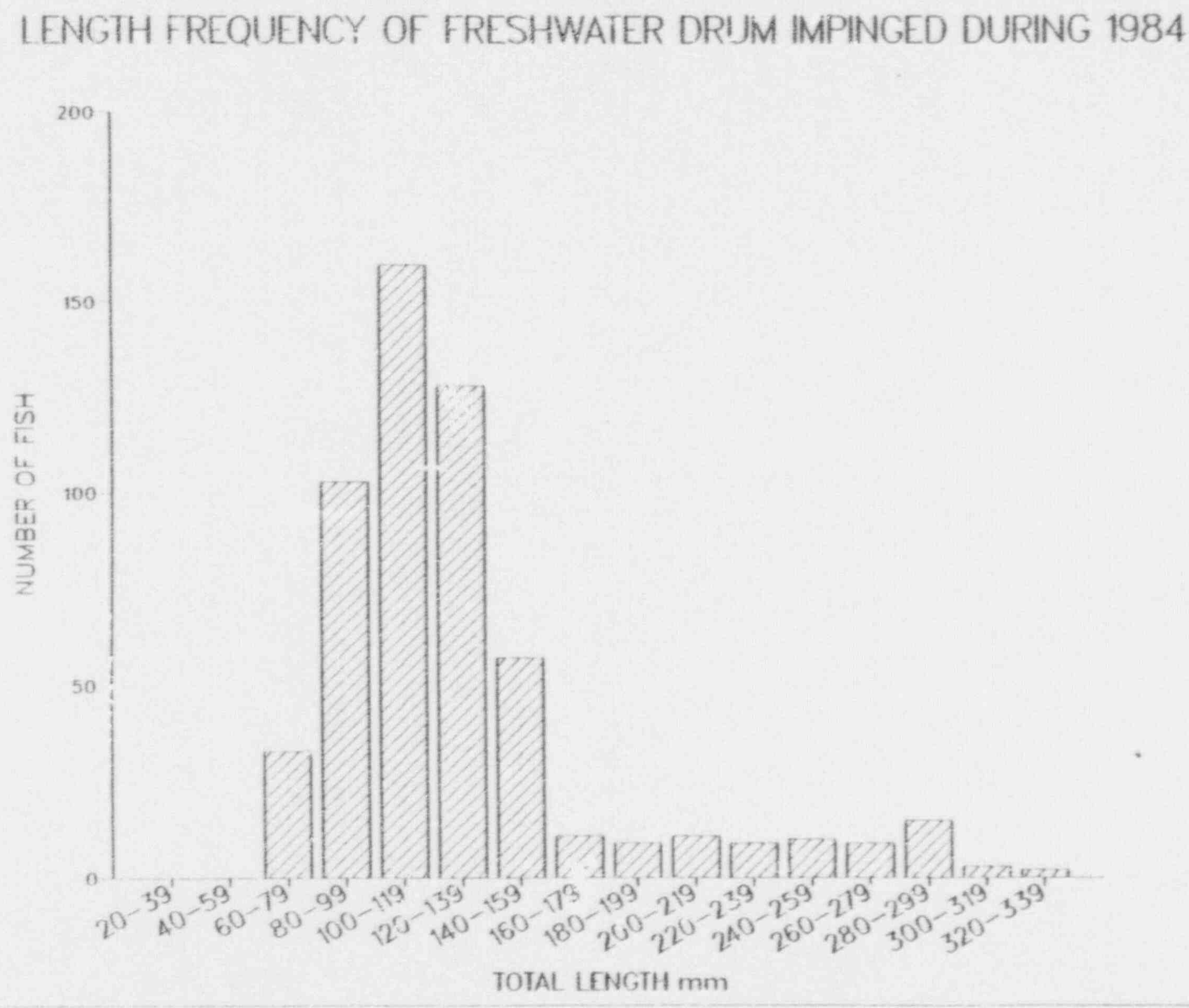
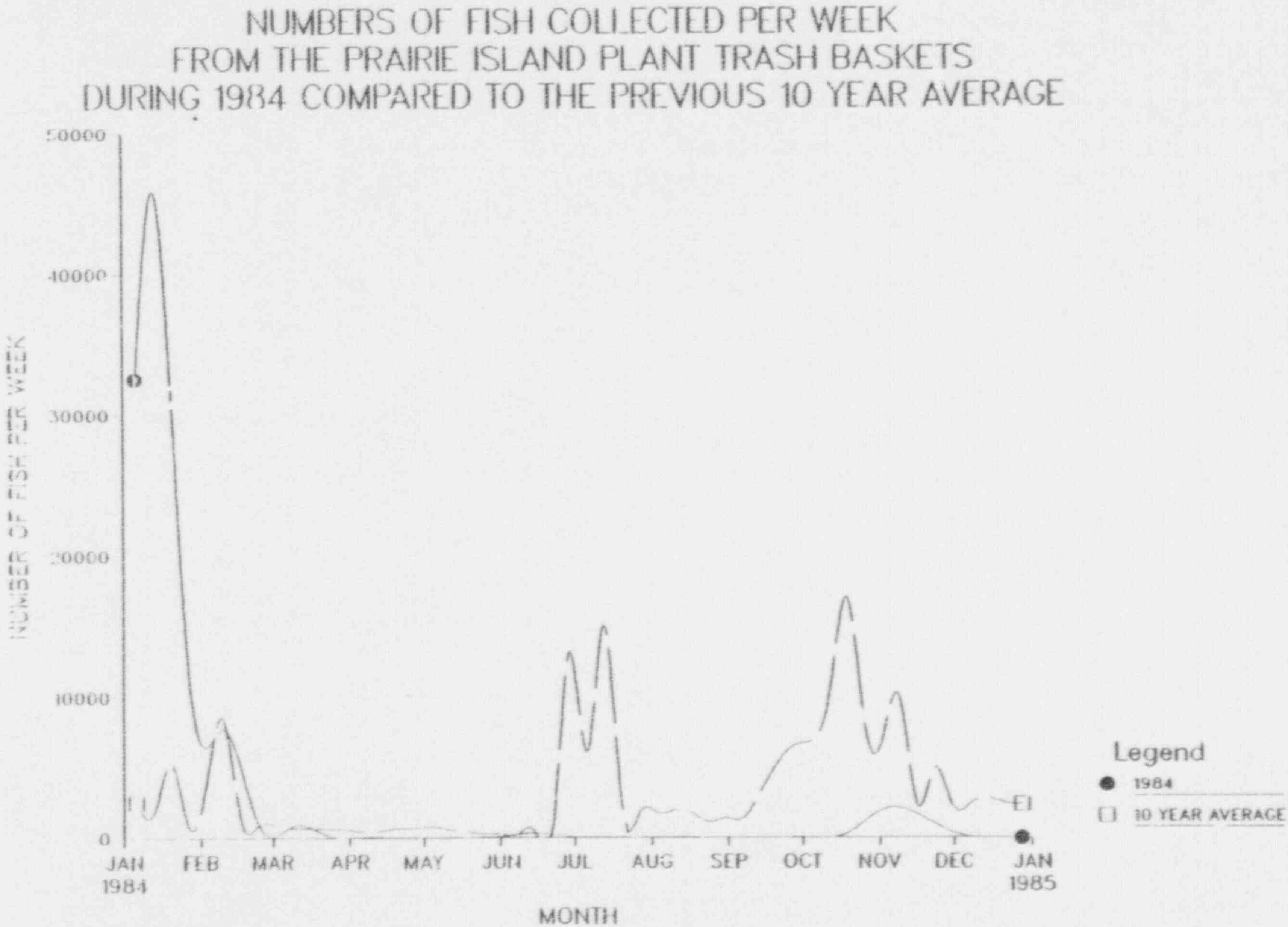


FIGURE 8



LENGTH FREQUENCY OF FRESHWATER DRUM IMPINGED DURING 1984
NUMBER OF FISH
200
150
100
50
0
20-39
40-59
60-79
80-99
100-119
120-139
140-159
160-179
180-199
200-219
220-239
240-259
260-279
280-299
300-319
320-339
TOTAL LENGTH mm

FIGURE 9



NUMBERS OF FISH COLLECTED PER WEEK
FROM THE PRAIRIE ISLAND PLANT TRASH BASKETS
DURING 1984 COMPARED TO THE PREVIOUS 10 YEAR AVERAGE
NUMBER OF FISH PER WEEK
50000
40000
30000
20000
10000
0
JAN 1984
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN 1985
MONTH
Legend
1984
10 YEAR AVERAGE

FIGURE 10

NUMBERS OF FISH LESS GIZZARD SHAD COLLECTED EVERY WEEK FROM THE PRAIRIE ISLAND PLANT TRASH BASKETS DURING 1984 COMPARED TO THE AVERAGE OF THE PREVIOUS 10 YEARS

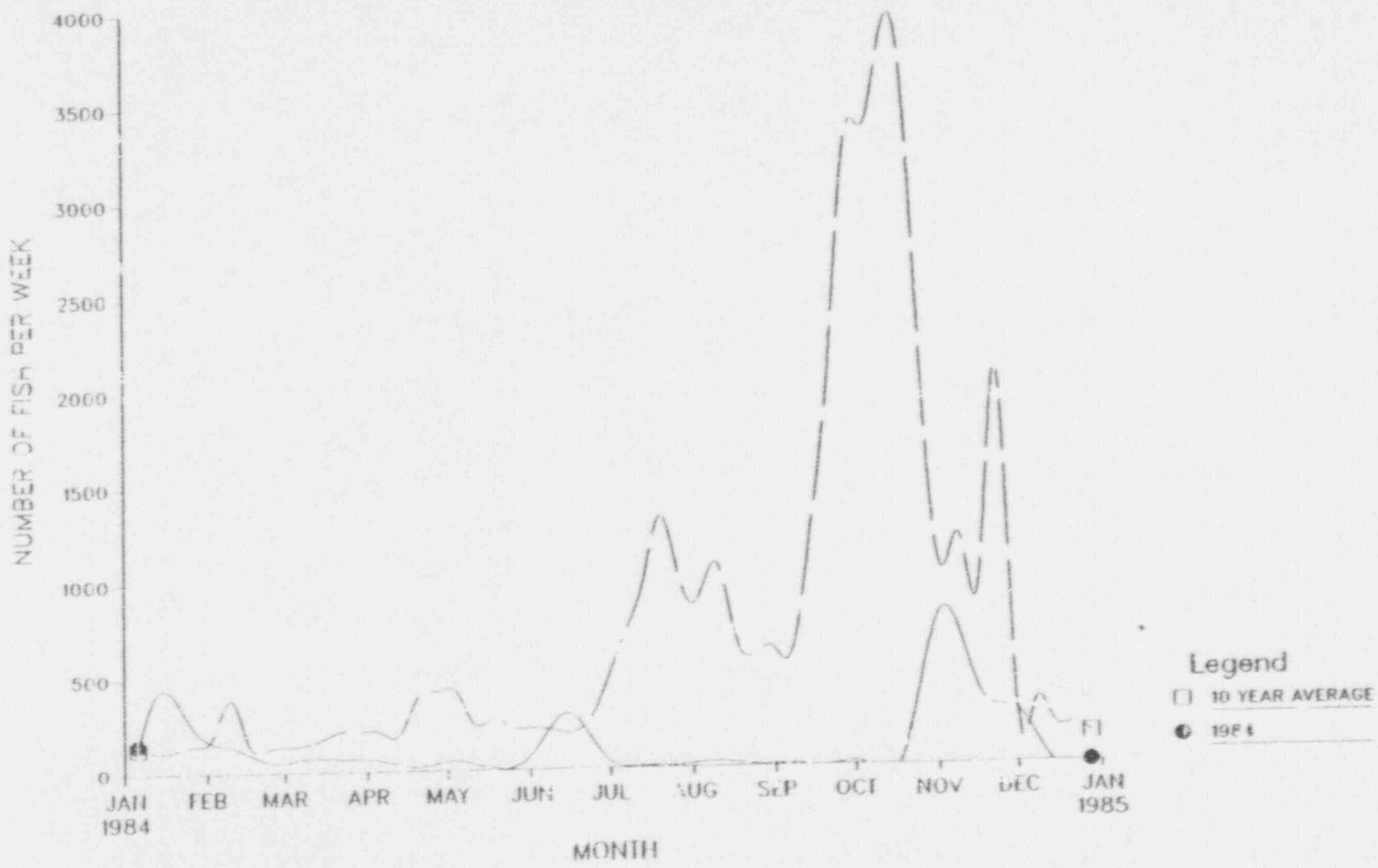


Table 1. Estimated Numbers and Percent Composition of Predominant Taxa Impinged at Prairie Island in 1984, 1983, and Ranges, Means, and Percent Composition for 1974 Through 1983.

	Number/Percent Composition			
	1984 Estimated	1983 Estimated	1974-83 Range	1974-83 Mean/% Comp
Gizzard shad	203,956 96.8	171,972 77.3	9,381-456,949	130,539 77.0
Freshwater drum	2,944 1.4	41,390 18.6	2,248- 74,422	22,346 13.2
Channel catfish	1,014 0.5	3,458 1.6	502 - 8,457	3,366 2.0
Bluegill	880 0.4	708 0.3	242 - 2,317	797 0.5
Shiner/minnow spp.	730 0.3	262 0.1	186 - 5,580	1,127 0.7
White bass	274 0.1	1,312 0.6	1,014- 44,638	6,874 4.1
Crappie spp.	218 0.1	2,390 1.1	357 - 6,852	2,268 1.3
Estimated total of predominant taxa	210,016 99.7	221,492 99.6	23,597-553,306	167,317 98.7
Other Taxa Combined	574 0.3	986 0.4	747 - 6,908	2,271 1.3
Estimated Annual Total	210,590	222,478	24,967-554,590	169,588

Table 2.

JANUARY 25, 1985

NUMBER OF FISH COLLECTED "EVERY OTHER WEEK" FROM THE TRASH BASKETS AT THE PRAIRIE ISLAND PLANT DURING 1984.

SAMPLE WEEK ENDING

TAXA	01/06	01/13	01/27	02/10	02/24	03/09	03/23	04/06	04/20	05/04	05/18	06/01
Silver lamprey	0	0	0	0	0	0	0	0	0	0	1	0
Longnose gar	0	0	0	0	0	0	0	0	0	0	0	0
Gizzard shad	32363	45412	12109	7605	905	746	93	1	5	3	2	9
Carp	0	0	0	0	0	0	1	1	0	7	1	12
Silver chub	0	0	0	0	0	0	4	0	0	1	0	0
Minnow species	0	0	0	0	0	2	0	1	0	3	0	4
Shiner species	0	0	2	0	9	17	7	0	0	12	0	4
Carpsucker species	0	0	0	0	0	0	1	4	0	1	0	0
Smallmouth buffalo	0	0	0	0	0	0	0	2	0	0	0	0
Bigmouth buffalo	0	0	0	0	0	0	0	0	0	5	0	0
Shorthead redhorse	0	4	0	3	0	1	0	0	0	0	0	0
Bullhead species	0	0	0	0	0	0	1	0	0	0	0	0
Channel catfish	38	72	22	14	0	14	6	13	6	2	0	22
Flathead catfish	0	0	0	0	0	0	0	0	0	0	0	3
Trout-perch	0	0	3	0	0	0	0	0	0	0	0	0
Burbot	0	0	2	0	1	0	0	5	0	0	0	0
White bass	38	4	48	4	2	0	1	0	2	0	0	0
Rock bass	0	0	0	0	0	0	3	1	0	0	0	0
Green sunfish	0	0	2	0	0	1	2	2	0	0	0	1
Bluegill	38	100	33	33	13	24	97	7	2	0	0	1
Largemouth bass	0	5	0	0	0	0	0	0	0	0	0	0
Crappie species	0	0	0	4	0	2	0	4	0	0	0	0
Sauger	0	0	3	3	0	1	1	1	0	0	0	0
Walleye	0	4	0	0	0	0	1	5	0	0	0	1
Freshwater drum	38	229	101	76	14	10	14	23	10	25	7	26
Fish skeletons	0	0	0	0	2	0	0	0	0	0	0	0
Buffalo species	0	6	9	0	0	0	0	4	0	0	0	0
Central mudminnow	0	0	0	0	0	0	0	0	0	0	0	9
TOTAL	32515	45831	12341	7746	962	838	187	57	25	53	11	83
TOTAL LESS GIZZARD SHAD	152	419	232	141	57	72	47	56	20	50	9	74

Table 2. (Continued)

JANUARY 25, 1985

NUMBER OF FISH COLLECTED "EVERY OTHER WEEK" FROM THE TRASH BASKETS AT THE PRAIRIE ISLAND PLANT DURING 1984.

SAMPLE WEEK ENDING

TAXA	06/15	06/29	07/13	07/27	08/10	08/24	09/07	09/21	10/05	10/19	11/02	11/16
Silver lamprey	0	0	0	0	0	0	0	0	0	0	0	0
Longnose gar	0	0	0	0	0	0	0	0	0	0	0	2
Gizzard shad	10	19	8	2	2	2	1	0	0	218	1193	1258
Carp	45	18	4	2	1	1	5	0	0	0	1	0
Silver chub	0	0	0	0	0	0	0	0	0	0	0	3
Minnow species	7	1	0	0	2	0	0	0	0	0	1	68
Shiner species	38	19	4	3	2	0	5	0	0	5	12	28
Carpsucker species	0	0	0	0	0	0	0	0	0	0	6	2
Smallmouth buffalo	0	0	0	0	0	0	0	0	0	3	0	0
Bigmouth buffalo	0	0	0	0	0	0	0	0	0	0	0	0
Shorthead redhorse	0	0	0	0	0	0	0	0	0	0	3	0
Bullhead species	0	0	0	0	0	0	0	0	0	0	18	16
Channel catfish	191	16	0	2	10	4	0	0	0	7	3	5
Flathead catfish	4	3	0	0	1	1	0	0	0	0	0	4
Trout-perch	0	0	0	0	5	0	0	0	0	0	6	8
Burbot	0	0	0	0	0	0	0	0	0	0	0	9
White bass	0	0	0	0	7	0	0	0	0	0	14	13
Rock bass	0	0	0	0	0	0	0	0	0	0	0	0
Green sunfish	0	0	0	0	0	0	0	0	0	0	4	19
Bluegill	4	1	2	2	1	0	0	0	0	4	30	36
Largemouth bass	0	0	0	0	0	0	0	0	0	0	0	1
Crappie species	0	0	0	0	0	0	0	0	0	7	28	63
Sauger	0	0	0	0	0	0	0	0	0	0	0	0
Walleye	0	0	0	0	0	0	0	0	0	0	0	0
Freshwater drum	0	0	0	0	2	1	2	0	0	37	708	97
Fish skeletons	2	1	0	0	3	0	4	0	0	0	0	0
Buffalo species	0	0	0	0	0	1	0	0	0	4	0	0
Central mudminnow	0	1	0	0	0	0	0	0	0	0	0	0
TOTAL	301	79	18	12	31	10	12	0	0	278	1950	1647
TOTAL LESS GIZZARD SHAD	291	60	10	9	29	8	11	0	0	49	617	389

Table 2. (Continued)

JANUARY 25, 1985

NUMBER OF FISH COLLECTED "EVERY OTHER WEEK" FROM THE TRASH BASKETS AT THE PRAIRIE ISLAND PLANT DURING 1984.

TAXA	11/30	12/14	12/28	"EVERY OTHER WEEK" TOTALS
	SAMPLE WEEK ENDING			
Silver lamprey	0	0	0	1
Longnose gar	0	0	0	2
Gizzard shad	54	0	0	101978
Carp	2	0	0	95
Silver chub	0	0	0	1
Minnow species	42	0	0	131
Shiner species	85	0	0	234
Carpsucker species	0	0	0	14
Smallmouth buffalo	0	0	0	2
Bigmouth buffalo	0	0	0	5
Shorthead redhorse	0	0	0	18
Bullhead species	0	0	0	29
Channel catfish	52	0	0	507
Flathead catfish	0	0	0	16
Trout-perch	1	0	0	9
Burbot	0	0	0	3
White bass	8	0	0	137
Rock bass	0	0	0	1
Green sunfish	40	0	0	70
Bluegill	22	0	0	440
Largemouth bass	0	0	0	1
Crappie species	16	0	0	109
Sauger	0	0	0	6
Walleye	0	0	0	8
Freshwater drum	22	0	0	1472
Fish skeletons	0	0	0	12
Buffalo species	0	0	0	1
Central mudminnow	0	0	0	1
TOTAL	338	0	0	105295
TOTAL LESS GIZZARD SHAD	284	0	0	3317

Table 3.

SEASONAL COMPARISON OF NUMBERS AND OF FISH TAXA IMPINGED "EVERY OTHER WEEK" AT PRAIRIE ISLAND

TAXA	WINTER JANUARY - MARCH NUMBER	% OF TOTAL	SPRING APRIL - JUNE NUMBER	% OF TOTAL	SUMMER JULY - SEPTEMBER NUMBER	% OF TOTAL	FALL OCTOBER - DECEMBER NUMBER	% OF TOTAL
Silver lamprey	3	6.0	1	100.0	0	0.0	0	0.0
Longnose gar	0	0.0	0	0.0	0	0.0	2	100.0
Gizzard shad	99250	97.3	49	0.0	16	0.0	2463	2.4
Carp	1	1.1	78	_2.1	13	13.7	3	3.2
Silver chub	0	0.0	1	100.0	0	0.0	0	0.0
Minnow species	2	1.5	16	12.2	2	1.5	111	84.7
Shiner species	30	12.8	73	31.2	9	3.8	122	52.1
Carpsucker species	1	7.1	5	35.7	0	0.0	8	57.1
Smallmouth buffalo	0	0.0	2	100.0	0	0.0	0	0.0
Bigmouth buffalo	0	0.0	5	100.0	0	0.0	0	0.0
Shorthead redhorse	10	100.0	0	0.0	0	0.0	0	0.0
Bullhead species	1	3.4	0	0.0	0	0.0	28	96.6
Channel catfish	174	34.3	250	49.3	16	3.2	67	13.2
Flathead catfish	0	0.0	10	62.5	2	12.5	4	25.0
Trout-perch	0	0.0	0	0.0	0	0.0	9	100.0
Burbot	3	100.0	0	0.0	0	0.0	0	0.0
White bass	93	67.9	2	1.5	7	5.1	35	25.5
Rock bass	0	0.0	1	100.0	0	0.0	0	0.0
Green sunfish	13	18.6	3	4.3	0	0.0	54	77.1
Bluegill	278	63.2	15	3.4	5	1.1	142	32.3
Largemouth bass	0	0.0	0	0.0	0	0.0	1	100.0
Crappie species	8	7.3	1	0.9	0	0.0	100	91.7
Sauger	5	83.3	1	16.7	0	0.0	0	0.0
Walleye	7	87.5	1	12.5	0	0.0	0	0.0
Freshwater drum	512	34.8	91	6.2	5	0.3	864	58.7
Fish skeletons	2	16.7	3	25.0	7	58.3	0	0.0
Buffalo species	0	0.0	0	0.0	1	100.0	0	0.0
Central mudminnow	0	0.0	1	100.0	0	0.0	0	0.0
TOTAL	100390	95.3	609	0.6	83	0.1	4213	4.0
TOTAL LESS GIZZARD SHAD	1140	34.4	560	16.9	67	2.0	1550	46.7

Table 4.

JANUARY 28, 1985

LENGTH FREQUENCY AND NUMBERS OF FISH LOST DUE TO IMPINGEMENT AT THE PRAIRIE ISLAND PLANT
TABULATED FROM COLLECTIONS MADE EVERY OTHER WEEK

TOTAL LENGTH (MM)	Silver Lamprey	Longnose Gar	Gizzard Shad	Carp	Silver Chub	Minnow Species	Shiner Species	Carpsucker Species
0-19	0	0	0	0	0	0	0	0
20-39	0	0	0	0	0	0	1	0
40-59	0	0	11	0	0	5	23	0
60-79	0	0	114	15	0	36	68	0
80-99	0	0	92	26	0	86	43	5
100-119	0	0	145	22	0	1	4	0
120-139	0	0	224	10	0	0	1	0
140-159	0	0	304	4	0	0	0	1
160-179	0	0	204	3	0	0	1	3
180-199	0	0	37	4	0	0	0	2
200-219	0	0	1	1	0	0	0	0
220-239	0	0	1	1	0	0	0	0
240-259	0	0	3	1	0	0	0	0
260-279	1	0	4	0	0	0	0	0
280-299	0	0	6	1	0	0	0	0
300-319	0	1	7	0	0	0	0	0
320-339	0	0	9	0	0	0	0	0
340-359	0	1	8	1	0	0	0	0
360-379	0	0	13	1	0	0	0	0
380-399	0	0	14	1	0	0	0	0
400-419	0	0	7	0	0	0	0	0
420-439	0	0	7	2	0	0	0	0
440-459	0	0	5	1	0	0	0	0
460-479	0	0	3	0	0	0	0	0
480-499	0	0	0	0	0	0	0	0
500-519	0	0	0	0	0	0	0	0
520-539	0	0	0	0	0	0	0	0
540-559	0	0	0	0	0	0	0	0
560-579	0	0	0	0	0	0	0	0
580-599	0	0	0	0	0	0	0	0
600-619	0	0	0	0	0	0	0	0
620-639	0	0	0	0	0	0	0	0
640-659	0	0	0	0	0	0	0	0
660-679	0	0	0	1	0	0	0	0
680-699	0	0	0	0	0	0	0	0
700-	0	0	0	0	0	0	0	0
TOTAL MEASURED	1	2	1219	90	0	128	181	11
UNMEASURED	0	0	0	3	0	3	52	2
UNM. YY	0	0	100722	1	0	0	0	0
UNM. ADULT	0	0	37	1	1	0	1	1
TOTAL	1	2	101978	95	1	131	234	14

Table 4. (Continued)

JANUARY 28, 1985

LENGTH FREQUENCY AND NUMBERS OF FISH LOST DUE TO IMPINGEMENT AT THE PRAIRIE ISLAND PLANT
TABULATED FROM COLLECTIONS MADE EVERY OTHER WEEK

TOTAL LENGTH (MM)	Smallmouth Buffalo	Bigmouth Buffalo	Shorthead Redhorse	Bullhead Species	Channel Catfish	Flathead Catfish	Trout-perch	Burbot
0-19	0	0	0	0	0	0	0	0
20-39	0	0	0	0	0	0	0	0
40-59	0	1	0	9	1	0	0	0
60-79	0	3	0	10	17	4	1	0
80-99	0	1	0	2	27	4	6	0
100-119	0	0	0	0	42	3	2	0
120-139	0	0	0	0	62	0	0	0
140-159	1	0	0	0	35	2	0	0
160-179	0	0	0	0	23	0	0	0
180-199	0	0	0	1	17	1	0	0
200-219	1	0	0	0	13	1	0	0
220-239	0	0	0	0	6	0	0	0
240-259	0	0	0	0	3	0	0	0
260-279	0	0	0	0	2	0	0	0
280-299	0	0	0	0	4	0	0	0
300-319	0	0	0	0	1	0	0	1
320-339	0	0	1	0	1	0	0	1
340-359	0	0	1	0	2	0	0	0
360-379	0	0	0	0	1	0	0	0
380-399	0	0	0	0	0	0	0	0
400-419	0	0	0	0	1	0	0	0
420-439	0	0	1	0	1	0	0	0
440-459	0	0	0	0	0	0	0	0
460-479	0	0	0	0	0	0	0	0
480-499	0	0	0	0	0	0	0	0
500-519	0	0	0	0	0	0	0	0
520-539	0	0	0	0	0	0	0	0
540-559	0	0	0	0	0	0	0	0
560-579	0	0	0	0	1	0	0	0
580-599	0	0	0	0	0	0	0	0
600-619	0	0	0	0	0	0	0	0
620-639	0	0	0	0	0	0	0	0
640-659	0	0	0	0	0	0	0	0
660-679	0	0	0	0	0	0	0	0
680-699	0	0	0	0	0	0	0	0
700-	0	0	0	0	0	0	0	0
TOTAL MEASURED	2	5	3	22	260	16	9	2
UNMEASURED	0	0	0	7	214	0	0	0
UNM. YY	0	0	0	0	29	0	0	0
UNM. ADULT	0	0	7	0	4	0	0	1
TOTAL	2	5	10	29	507	16	9	3

Table 4. (Continued)

JANUARY 28, 1985

LENGTH FREQUENCY AND N[illegible]MBERS OF FISH LOST DUE TO IMPINGEMENT AT THE PRAIRIE ISLAND PLANT
[illegible]ULATED FROM COLLECTIONS MADE EVERY OTHER WEEK

TOTAL LENGTH (MM)	White Bass	Rock Bass	Green Sunfish	Bluegill	Largemouth Bass	Crappie Species	Sauger	Walleye
0-19	0	0	0	0	0	0	0	0
20-39	0	0	0	2	0	0	0	0
40-59	0	0	9	31	0	2	0	0
60-79	4	0	11	48	0	67	0	0
80-99	6	0	29	34	0	26	0	0
100-119	14	0	9	37	1	2	0	0
120-139	18	0	5	29	0	5	0	0
140-159	6	0	4	26	0	0	0	0
160-179	0	1	0	21	0	2	0	0
180-199	0	0	1	17	0	1	0	0
200-219	0	0	0	4	0	1	0	0
220-239	1	0	0	2	0	0	0	0
240-259	0	0	0	0	0	0	0	0
260-279	0	0	0	0	0	0	0	0
280-299	0	0	0	0	0	0	0	0
300-319	0	0	0	0	0	0	0	0
320-339	1	0	0	0	0	0	0	0
340-359	1	0	0	0	0	0	0	0
360-379	0	0	0	0	0	0	1	0
380-399	0	0	0	0	0	0	0	1
400-419	0	0	0	0	0	0	1	1
420-439	0	0	0	0	0	0	1	0
440-459	0	0	0	0	0	0	1	0
460-479	0	0	0	0	0	0	0	0
480-499	0	0	0	0	0	0	0	0
500-519	0	0	0	0	0	0	0	0
520-539	0	0	0	0	0	0	0	0
540-559	0	0	0	0	0	0	0	0
560-579	0	0	0	0	0	0	0	0
580-599	0	0	0	0	0	0	0	0
600-619	0	0	0	0	0	0	0	1
620-639	0	0	0	0	0	0	0	0
640-659	0	0	0	0	0	0	0	0
660-679	0	0	0	0	0	0	0	0
680-699	0	0	0	0	0	0	0	0
700-	0	0	0	0	0	0	0	0
TOTAL MEASURED	51	1	68	[illegible]63	1	108	4	3
UNMEASURED	0	0	1	174	0	0	0	0
UNM. YY	81	0	1	4	0	9	0	0
UNM. ADULT	5	0	0	9	0	0	2	5
TOTAL	137	1	70	440	1	109	6	8

Table 4. (Continued)

JANUARY 28, 1985

LENGTH FREQUENCY AND NUMBERS OF FISH LOST DUE TO IMPINGEMENT AT THE PRAIRIE ISLAND PLANT
TABULATED FROM COLLECTIONS MADE EVERY OTHER WEEK

TOTAL LENGTH (MM)	Freshwater Drum	Fish Skeletons	Buffalo Species	Central Mudminnow
0-19	0	0	0	0
20-39	0	0	0	0
40-59	0	0	0	0
60-79	33	0	0	1
80-99	103	0	1	0
100-119	140	0	0	0
120-139	128	0	0	0
140-159	57	0	0	0
160-179	11	0	0	0
180-199	9	0	0	0
200-219	11	0	0	0
220-239	9	0	0	0
240-259	10	0	0	0
260-279	9	0	0	0
280-299	15	0	0	0
300-319	3	0	0	0
320-339	2	0	0	0
340-359	0	0	0	0
360-379	0	0	0	0
380-399	0	0	0	0
400-419	0	0	0	0
420-439	0	0	0	0
440-459	0	0	0	0
460-479	0	0	0	0
480-499	0	0	0	0
500-519	0	0	0	0
520-539	0	0	0	0
540-559	0	0	0	0
560-579	0	0	0	0
580-599	0	0	0	0
600-619	0	0	0	0
620-639	0	0	0	0
640-659	0	0	0	0
660-679	0	0	0	0
680-699	0	0	0	
700-	0	0	0	0
TOTAL MEASURED	560	0	1	1
UNMEASURED	8	12	0	0
UNM. YY	853	0	0	0
UNM. ADULT	51	0	0	0
TOTAL	147[illegible]	12	1	1

Table 5. Non-fish Organisms Collected "Every Other Week" from the Prairie Island Plant Trash Baskets during 1984.

ORGANISMS	TOTAL
Spiny softshell turtles	22
Clams	185*
Crayfish	24
Mudpuppy	7
Leopard frog	3
Toad	1
Bat	1
"Every other week" Total	243

*Clams include - Fawns foot, corbicula, paper pond shells, floaters, fragile paper shells, and unidentified clams.

Appendix Common and Scientific Names of Fish Impinged at the Prairie Island Plant during 1984 (After Bailey et al. 1970)

Common Name	Scientific Name
Silver lamprey	*I. unicuspis*
Longnose gar	*Lepisosteus osseus*
Gizzard shad	*Dorosoma cepedianum*
Central mudminnow	*Umbra limi*
Carp	*Cyprinus carpio*
Minnow and shiner species	Family Cyprinidae
Silver chub	*Hybopsis storeriana*
Carpsucker species	Genus *Carpiodes*
Smallmouth buffalo	*Ictiobus bubalus*
Bigmouth buffalo	*I. cyprinellus*
Shorthead redhorse	*M. macrolepidotum*
Redhorse species	Genus *Moxostoma*
Bullhead species	Genus *Ictalurus*
Channel catfish	*Ictalurus punctatus*
Flathead catfish	*Pylodictus olivaris*
Trout-perch	*Percopsis omiscomaycus*
Burbot	*Lota lota*
White bass	*Morone chrysops*
Rock bass	*Ambloplites rupestris*
Green sunfish	*Lepomis cyanellus*
Bluegill	*L. macrochirus*
Largemouth bass	*M. salmoides*
Crappie species	Genus *Pomoxis*
Sauger	*Stizostedion canadense*
Walleye	*S. vitreum*
Freshwater drum	*Aplodinotus grunniens*

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
ENVIRONMENTAL MONITORING PROGRAM
1988 ANNUAL REPORT

FINE MESH VERTICAL TRAVELING SCREENS IMPINGEMENT SURVIVAL STUDY

Prepared for
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Minneapolis, Minnesota

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INTRODUCTION

Studies to assess the effectiveness of fine mesh (0.5 mm) vertical traveling screens in reducing entrainment impacts on fishes in the vicinity of PINGP were begun in 1984; 1988 represented the fifth year of the study. This report will provide a summary of the five years' data and program modifications anticipated during 1989.

The extreme low flow conditions during 1988 resulted in a very large plankton community in the vicinity of PINGP. Samples collected throughout much of the summer were characterized by large amounts of zooplankton and phytoplankton; it was visually apparent that mortality was greatly increased as a result of fish being confined with the mass of material in the samples. In addition, sorting time increased dramatically, which resulted in increased mortality of fish in these samples. As a result, sampling was suspended from June 22 to July 8, 1988.

Due to conditions outlined above, it was apparent that survivorship data generated would not be representative of impingement survivorship but would be affected by mortality incurred during sampling. NSP discussed this issue with the Minnesota Pollution Control Agency and it was mutually agreed that this data would not provide useful information for assessing the effectiveness of the fine mesh screens at PINGP. Therefore, this report will not include initial survivorship data or latent survivorship data. Initial samples were sorted and specimens identified; these data were used for estimating fish and egg density only.

METHODS AND MATERIAL

SAMPLE COLLECTION

Sample collection commenced on April 8, 1988 and continued through August 31, 1988. Samples were collected on Monday, Wednesday, and Friday of each week throughout the season by diverting 25 percent (2 out of the 8 screens) 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 screen wash water through 0.5 mm mesh nylon screen material. Filtered water was returned to the circulating water system via a 12-inch diameter drain pipe.

The screen wash trough was manually cleaned prior to sample collection on each date of the 1988 sample season, to reduce accumulated debris and fish in the fish return and sampling systems.

Three types of samples were collected to provide various data desired. Sample types included abundance, initial survival, and latent survival. During sample collection, physical parameters were recorded including collection time and duration, screen speed, number of screens sampled, river stage, and water temperature. Volume of river water filtered by the intake screens was obtained from the PINGP monthly thermal effluent report.

Following a designated sampling duration, all fish and any debris were rinsed into 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. All samples were collected with the traveling screens in the "automatic" mode

at a rotation speed ranging from three to ten feet per minute.

As discussed in the Introduction, effects of 1988 flow conditions resulted in changes to the larval survivorship program. Methods for initial survival samples will be presented in this report since data from these samples were used for density estimates; data were not used to generate survivorship estimates.

INITIAL SURVIVAL SAMPLES

These samples were collected during early morning prior to daylight 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. Fish were separated from debris and placed in vials labeled "live" or "dead", based on the presence or absence of movement. The second sort was designed to assure removal of all remaining fish and eggs. All fish and eggs were preserved in five percent buffered formalin solution and retained for identification. Sorting efficiency was maximized by pouring only portions of the sample at a time into glass baking dishes placed on light tables, providing light from below.

After completion of the first sort, the entire sample was preserved in 10 percent formalin solution, buffered with calcium carbonate, and containing rose bengal stain. The sample was resorted after the stain had an opportunity to penetrate any remaining fish and eggs, with maximum uptake of stain requiring approximately 24 hours. Fish from the second sort were included with the "initial dead" from the first sort.

During periods of excessive debris loading subsamples were sorted. Percent of total sample sorted was recorded for calculating density and impingement estimates. During 1988, a 50 percent split was performed on nine initial samples, five of which required a further 1/4 split, resulting in 1/8 of each total sample for identification.

ABUNDANCE SAMPLES

Abundance samples were collected during early to midmorning to estimate day density of fish and 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 (minimum of 24 hours). 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 5 to 15 minutes, depending on fish density and the amount of zooplankton, insects, and detritus in the drift. Heavy debris loading necessitated subsampling for abundance estimates on fourteen collection dates. On eight of the dates, 50 percent of the sample was sorted. Further splits were required on six dates, resulting in 1/4, 1/8, and 1/16 of the total sample for sorting, on 3, 2, and 1 sample dates, respectively.

LATENT SURVIVAL SAMPLES

Sampling methodology for determination of latent mortality (Figure 5) was consistent with previous years as described by Kuhl and Mueller (1987). Methodology will not be described here because survivorship data will not be presented in this report.

DATA ANALYSIS METHODS

Fish and Egg Density

Fish and egg densities were 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 taxa and life stage for each date; then expanded to day and night densities of all taxa and life stages combined for each date. A student's t-test was performed to test for significance between day and night density of all taxa and life stages combined.

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.

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 these 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 refine length ranges as established in previous years, for developmental phases of each taxon.

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

[1]/Test refers to fish by common name after Robins, et al 1980.

RESULTS

A total of 108 samples was collected during 1988 (Table 1). These samples were collected from April 8 through August 31, 1988 and provided data for approximately 35,000 fish and 8,000 eggs representing 43 taxa/lifestage combinations. Representative total length ranges for 46 taxa/lifestage combinations collected at PINGP from 1984 through 1988 are presented in Table 2.

ORGANISM DENSITY

Organism density estimates ranged from zero to more than 280 organisms per 100 cubic meters of river water for 45 paired day/night samples collected from May 2 through August 31, 1988 (Table 3). Mean day and night density for the 45 paired estimates was 20.36 and 26.86 organisms per 100 cubic meters of river water, respectively. Night organism density was significantly higher than day estimates ($p < 0.05$).

ESTIMATED IMPINGEMENT

The estimated number and percent composition of all taxa/lifestage combinations collected between April 8 and August 31, 1988 are presented in Table 4. More than 12 million eggs and 54 million fish were estimated to be impinged on the PINGP vertical traveling screens during 1988. Freshwater drum prolarvae comprised 42.6 percent of the total, followed by freshwater drum eggs and Cyprinidae postlarvae with 14.5 percent and 11.6 percent of the total, respectively. All lifestages combined for freshwater drum and cyprinidae comprised 84.7 percent of the total estimated impingement during 1988. The game species walleye and sauger (all life stages combined) comprised less than 0.04 percent of the total estimated impingement.

Figure 6 depicts daily estimated walleye impingement during 1988; walleye were collected from May 2 through May 11. Daily estimated sauger impingement is presented in Figure 7, this species being present in samples collected from May 2 through May 20. Weekly impingement estimates for freshwater drum, white bass, and gizzard shad are presented in Figures 8 through 10, respectively.

1984-1988 SUMMARY

Since survival estimates were not calculated during 1988, the data summarizing this portion of the study is identical to that provided in 1987 (Kuhl and Mueller, 1987). Initial, latent, and overall survival data for all taxa/lifestage combinations collected from 1984 through 1987 for which overall survival estimates could be calculated are presented in Table 5. Taxa/lifestage combinations represented by few individuals do not allow for adequate characterization of survival, however, only seven of the 33 taxa/lifestage combinations are represented by fewer than 100 individuals. Fifteen of these same 33 taxonomic groups are represented by more than 1,000 individuals each. Table 6 summarizes these data into overall survival by subjectively grouping taxa/lifestage combinations into survival ranges; 0-10, 11-30, 31-50, and >50 percent overall survival. It is apparent that overall, prolarvae and postlarvae exhibit lower survival while juveniles exhibit highest survival. Catostomidae, channel catfish, and walleye exhibit relatively high survival for the lifestages collected. Freshwater drum, gizzard shad, and white bass exhibit relatively poor survival for all life stages collected, with the possible exception of freshwater drum juveniles.

Table 7 summarizes survival information collected from 1984 through 1987 for all taxa/lifestage combinations by sample type. Survival data collected during 1987 was the lowest for

all categories except latent survival of prolarvae. Data from 1984 exhibited the highest survival estimates for all lifestages in initial, latent and overall estimates, due to the large numbers of channel catfish collected in 1984. The low survival of prolarvae and postlarvae in initial samples collected during 1987 resulted in low overall survival estimates for the year. As suggested in 1987 and as was obvious in 1988, excessive debris can affect and quite possibly control initial survival estimates. This is compounded in samples where large numbers of fish also occur, increasing sorting time and thereby increasing mortality.

Figures 11 through 14 indicate the percent contribution to total impingement and corresponding overall survival estimates for the four dominant taxa/lifestage combinations collected from 1984 through 1987. During 1984 (Figure 11) three of the four predominant taxa/lifestage combinations (75.1% of total estimated impingement) exhibited overall survival estimates greater than 47 percent. This was due to large numbers of channel catfish prolarvae and juveniles as well as large numbers of cyprinidae juveniles. These taxa/lifestage combinations were mainly responsible for the 1984 overall survival estimate of 42.1 percent.

During 1985 (Figure 12) freshwater drum prolarvae and cyprinidae postlarvae comprised 32.2 percent of the total estimated impingement but their respective overall survival estimates were 0.6 percent and 8.4 percent. Channel catfish juveniles and carp prolarvae comprised 9.4 percent of total estimated impingement with survival estimates of 91.9 and 49.4 percent, respectively. These four taxa/lifestage combinations were in large part responsible for the 1985 overall survival estimate of 23.1 percent.

Figure 13 depicts two taxa/lifestage combinations, carp prolarvae and catostomidae prolarvae, with overall survival

estimates of 29.3 and 29.8 percent, respectively. The remaining two dominant taxa/lifestage combinations, freshwater drum prolarvae and gizzard shad postlarvae, exhibited very low overall survival estimates of 0.3 percent and zero percent, respectively. The corresponding overall survival estimate for all taxa/lifestage combinations in 1986 was 16.1 percent.

During 1987 (Figure 14) the four predominant taxa/lifestage combinations each exhibited survival estimates of less than three percent, while they cumulatively were responsible for 64.8 percent of total impingement estimates. These four taxonomic groups were clearly responsible for the low overall survival estimate of 2.88 percent.

From the four years of survival information collected at PINGP, it has become clear that overall survival estimates ranging from 2.8 percent to 42.1 percent, are controlled by the survival of a rather small number of taxa/lifestage combinations, but these groups can represent a large portion of the total impingement estimates. During years when strong year classes of species exhibiting poor survival are present (e.g. freshwater drum), the overall survival estimates for that year are low. If a taxa/lifestage combination exhibiting relatively high survival (e.g. channel catfish juveniles) is one of the dominant groups, it will be reflected in overall survival.

With the exception of channel catfish, forage and nongame species were represented as predominant taxa/lifestage combinations impinged from 1984-1988. Estimated impingement of walleye and sauger for 1984-1988 has been a minor fraction of the total. Percent of total estimated impingement for all lifestage combinations of walleye, sauger, and Stizostedion spp. was as follows: 1984, 0.07%; 1985, 0.11%; 1986, 0.18%; 1987, 0.13%; and 1988, 0.03%. Estimated white bass impingement for all lifestages combined has been less than 2.5

percent during each of the five years of this study.

During 1988 it became apparent that sampling induced mortality could have a pronounced impact on initial survival estimates. Therefore, the larval survivorship study will be adapted, beginning in 1989, to address this concern, by introducing test fish into the sample collection system.

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.

Kuhl, G.M. and K. N. Mueller, 1988 Fine Mesh Vertical Traveling Screens Impingement Survival Study. In: Prairie Island Nuclear Generating Plant Environmental Monitoring Program 1987Annual Report. Northern States Power Company Minneapolis, MN.

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.

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.

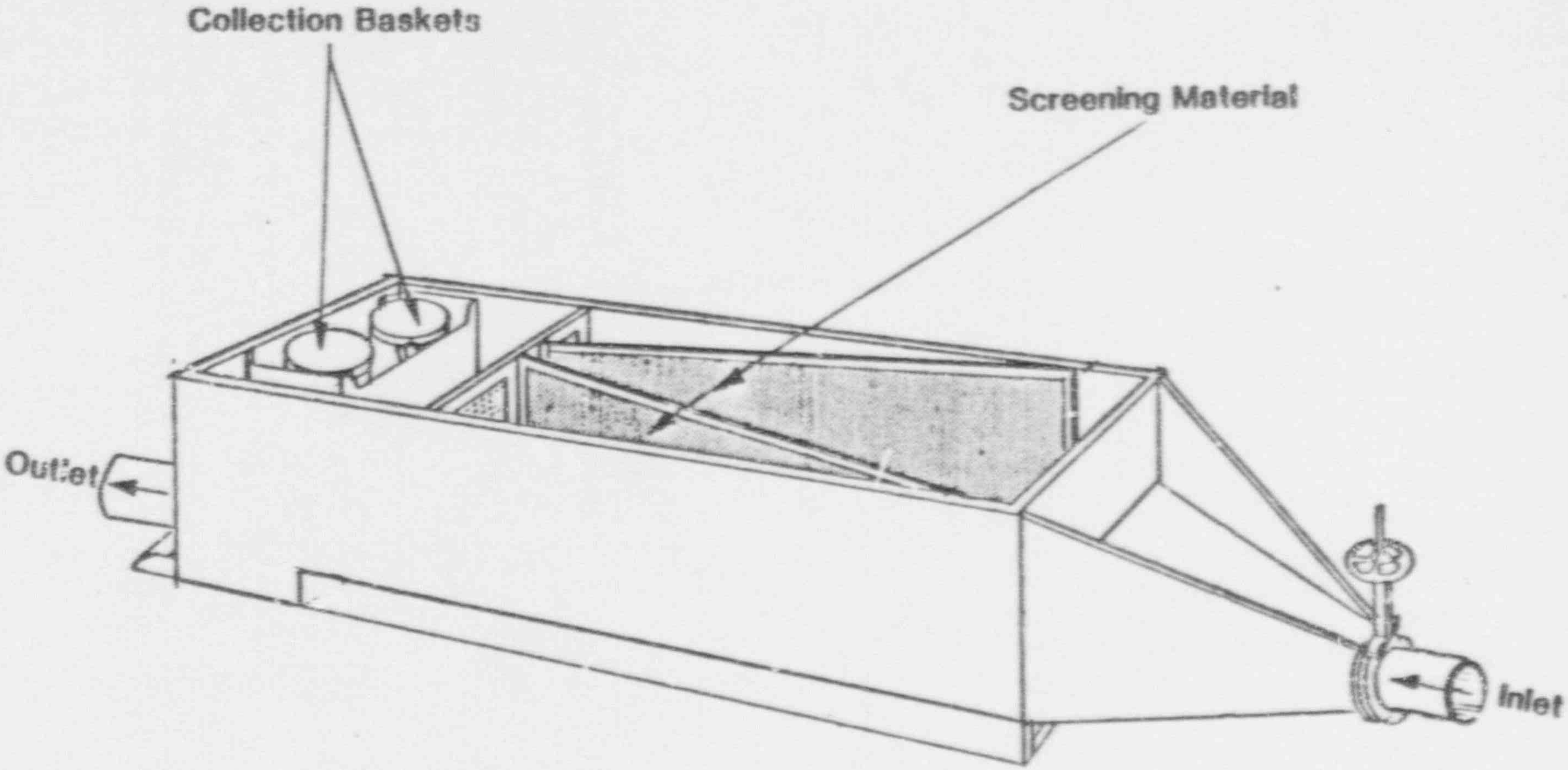
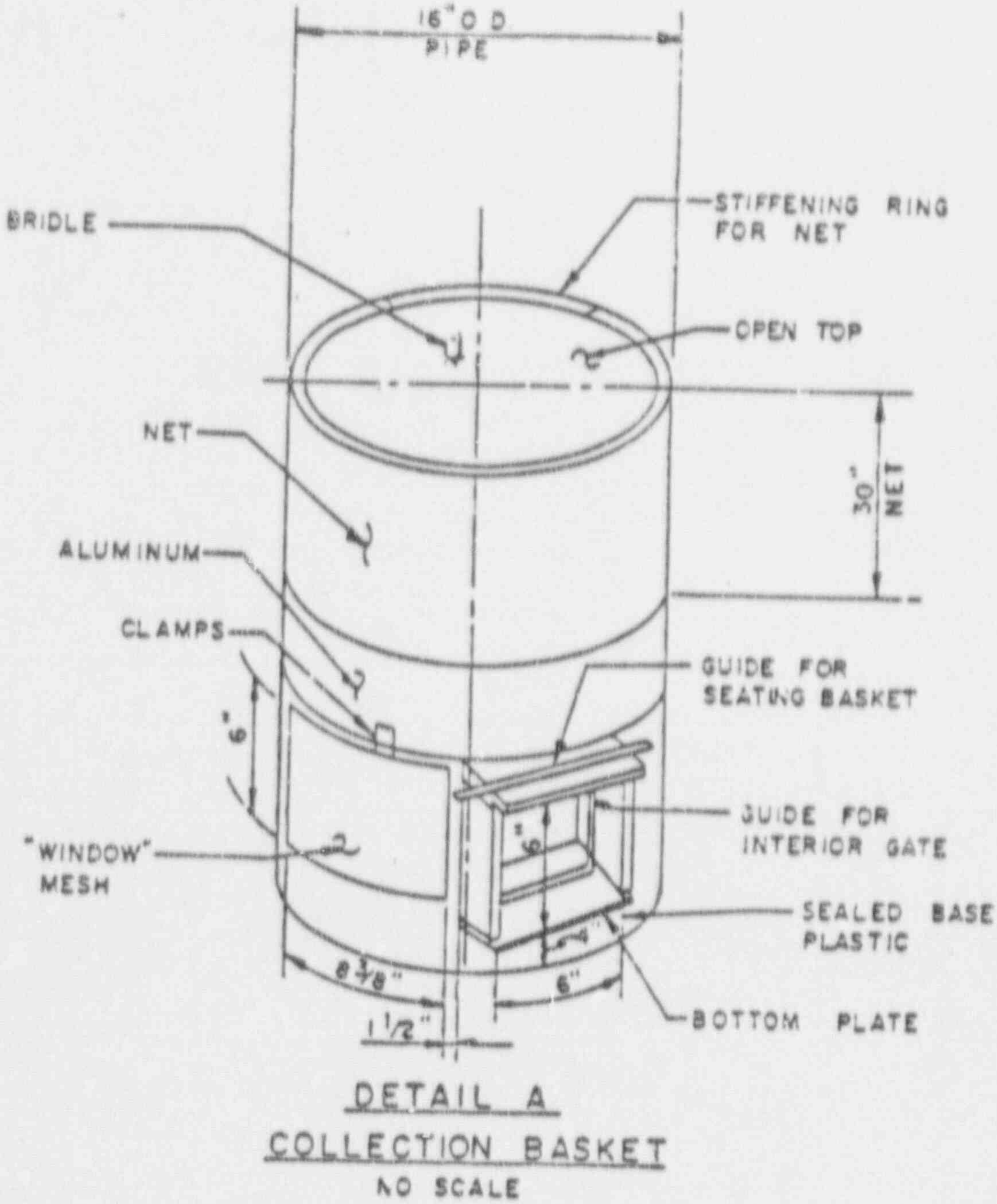


FIGURE 1. Larval Fish Collection Tank

Figure 2. Collection Basket.



LAWLER, MATUSKY & SKELLY ENGINEERS 6/83

Figure 3.

INITIAL SAMPLE FLOW CHART

Collect Sample

Sort Sample
(First Sort)

Live Fish
(Preserved for ID)

Dead Fish*
(Preserved for ID)

Preserve and Stain Sample Remains
(Debris and any fish missed during first sort)

Resort Sample
(Second Sort)

Dead Fish* and Eggs
(Preserved for ID)

*Dead 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

↓

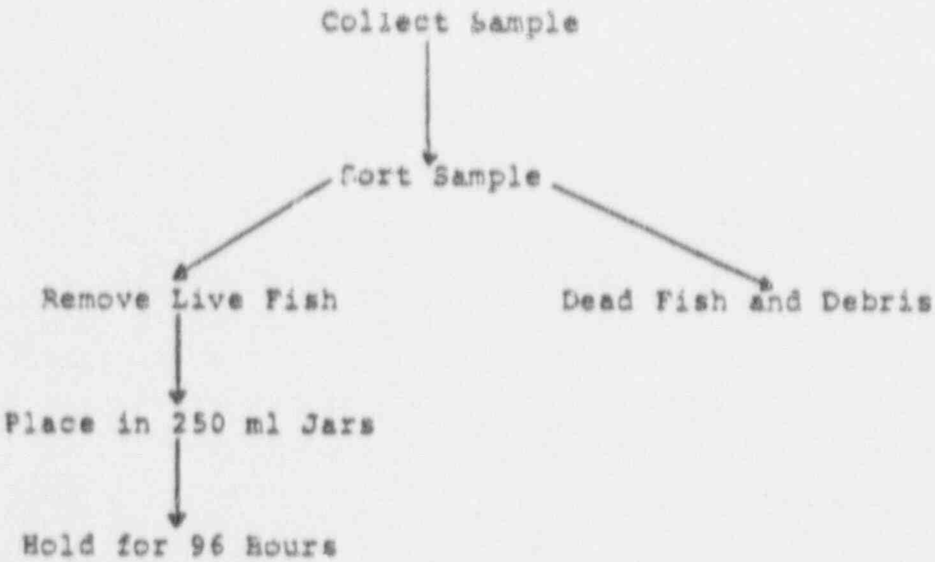
Remove Fish and Eggs

↓

Preserve for Identification

Figure 5.

LATENT SURVIVAL FLOW CHART



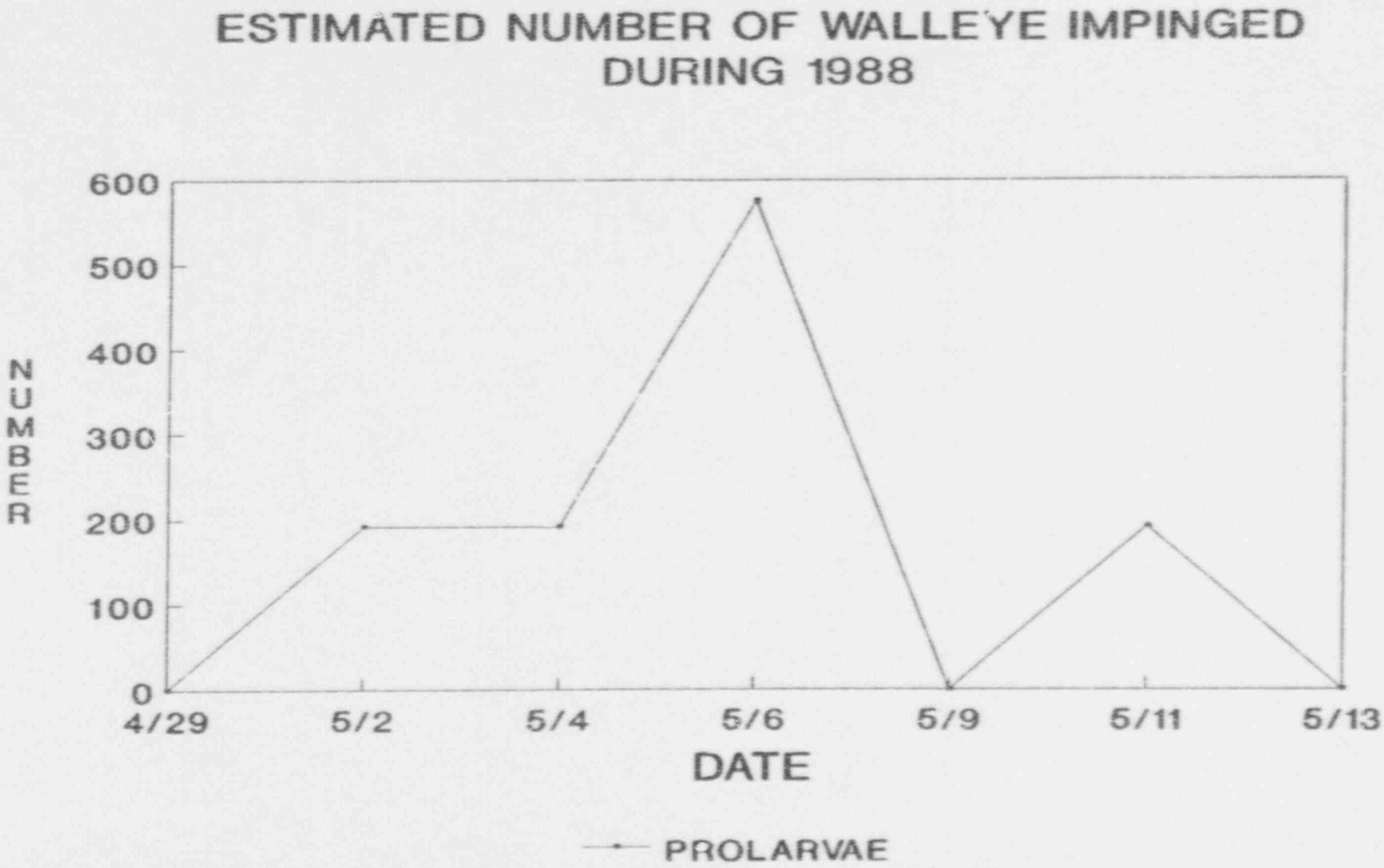

ESTIMATED NUMBER OF WALLEYE IMPINGED
DURING 1988
NUMBER
600
500
400
300
200
100
0
4/29
5/2
5/4
5/6
5/9
5/11
5/13
DATE
PROLARVAE

FIGURE 6

ESTIMATED NUMBER OF SAUGER IMPINGED DURING 1988

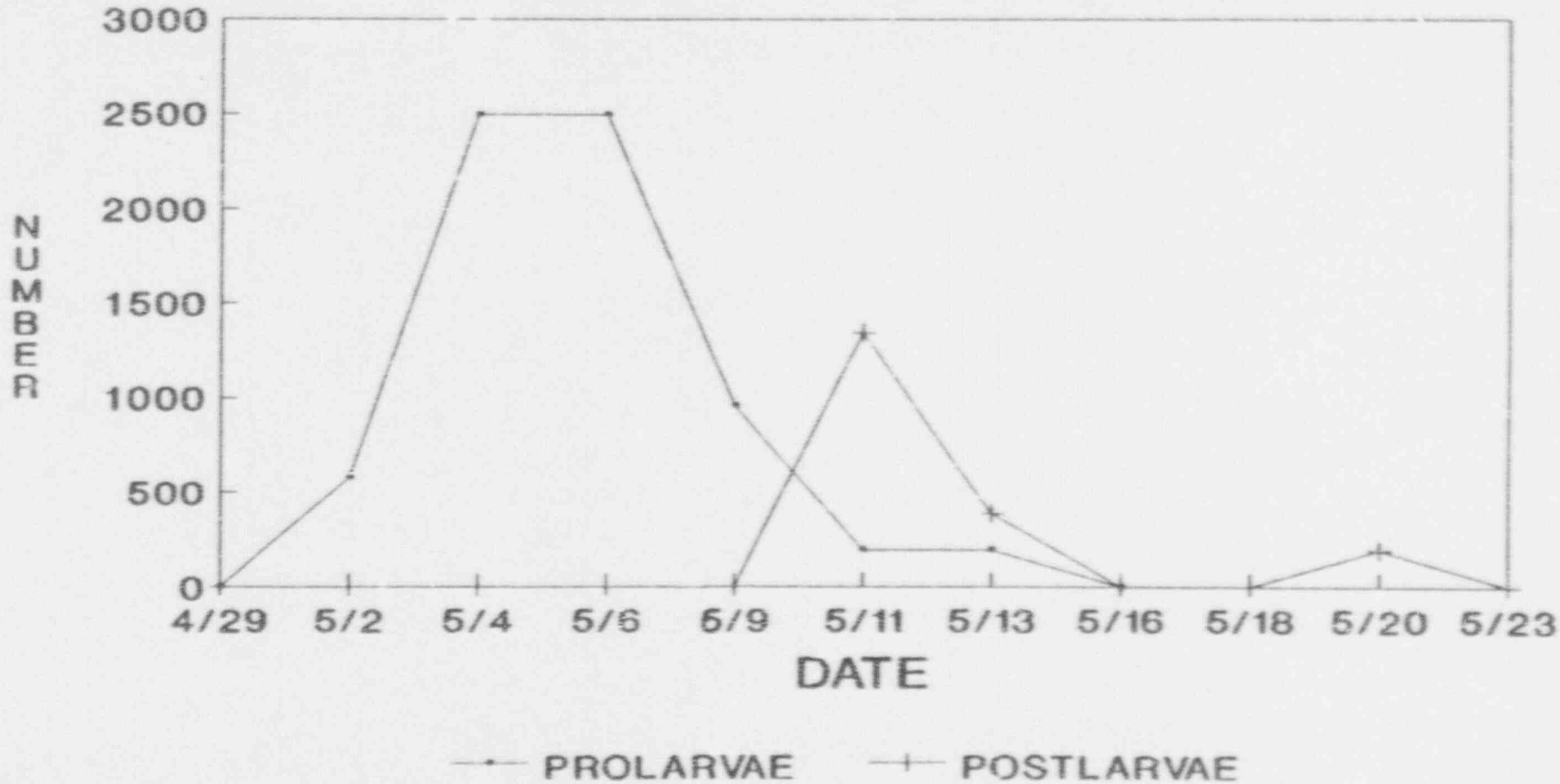


FIGURE 7

WEEKLY ESTIMATED FRESHWATER DRUM IMPINGED DURING 1988

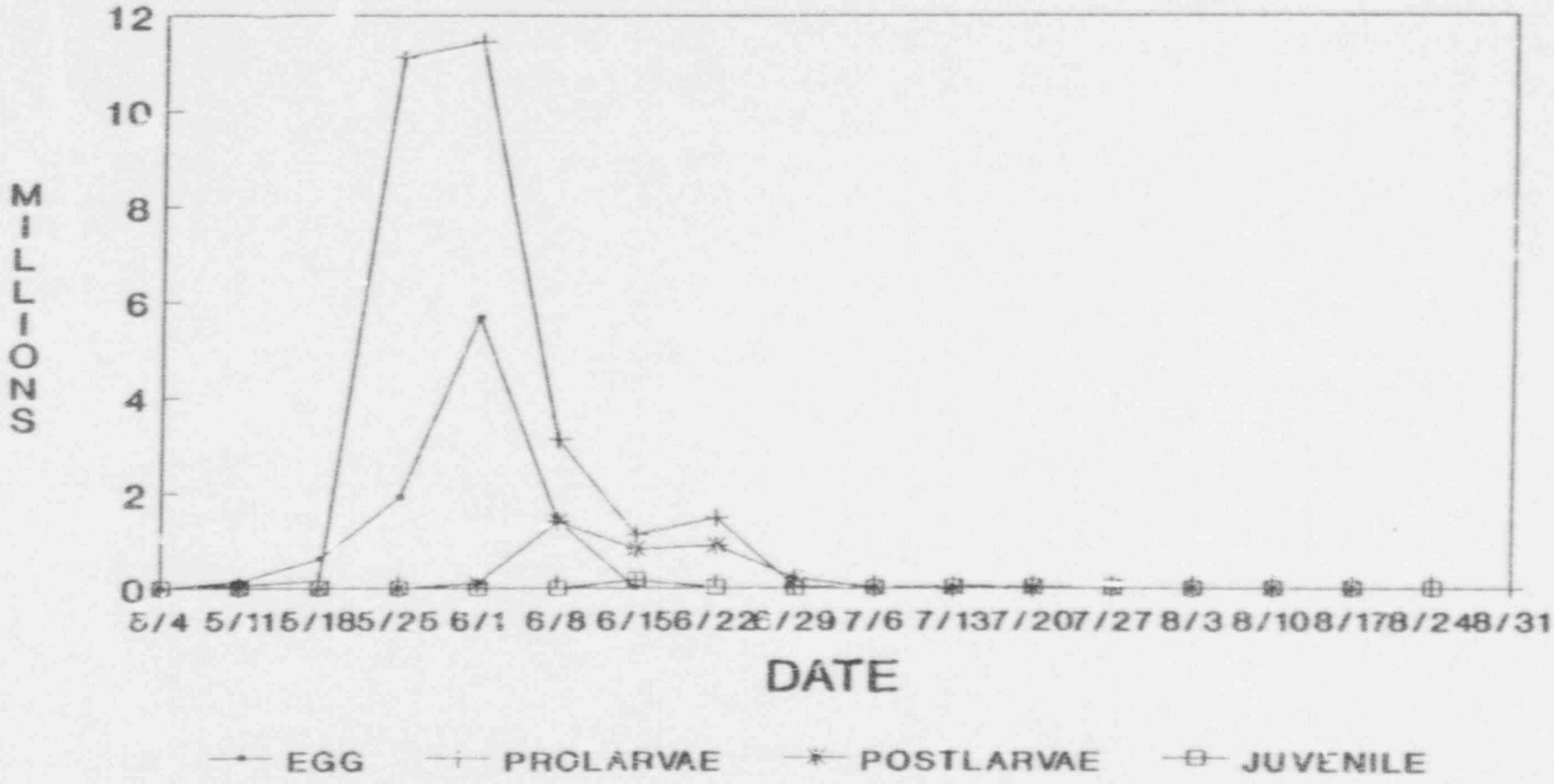


FIGURE 8

WEEKLY ESTIMATED NUMBER OF WHITE BASS IMPINGED DURING 1988

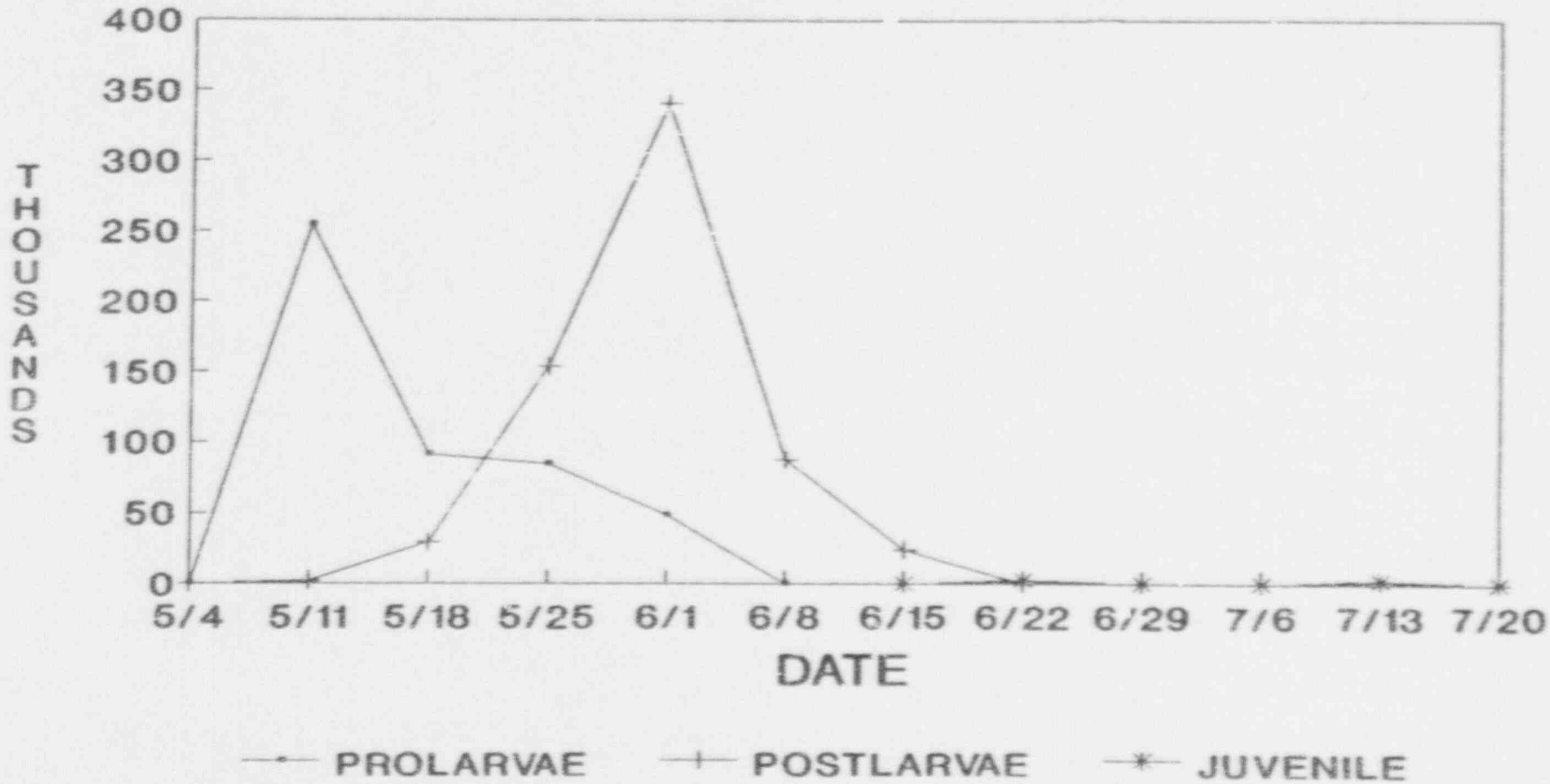


FIGURE 9

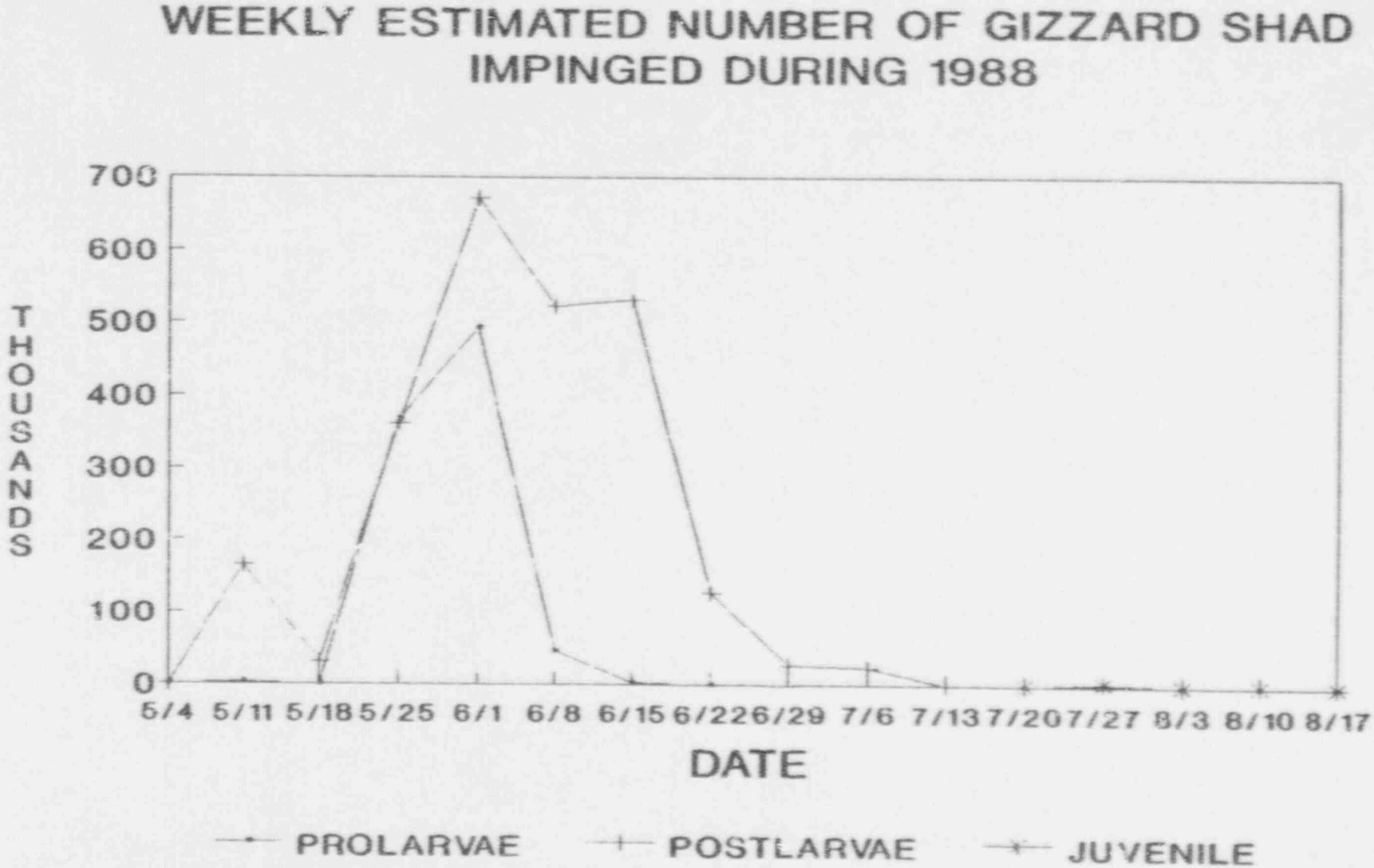

WEEKLY ESTIMATED NUMBER OF GIZZARD SHAD
IMPINGED DURING 1988
THOUSANDS
700
600
500
400
300
200
100
0
5/4 5/11 5/18 5/25 6/1 6/8 6/15 6/22 6/29 7/6 7/13 7/20 7/27 8/3 8/10 8/17
DATE
PROLARVAE
POSTLARVAE
JUVENILE

FIGURE 10

Percent Contribution and Survival of Dominant Fish Species in 1984

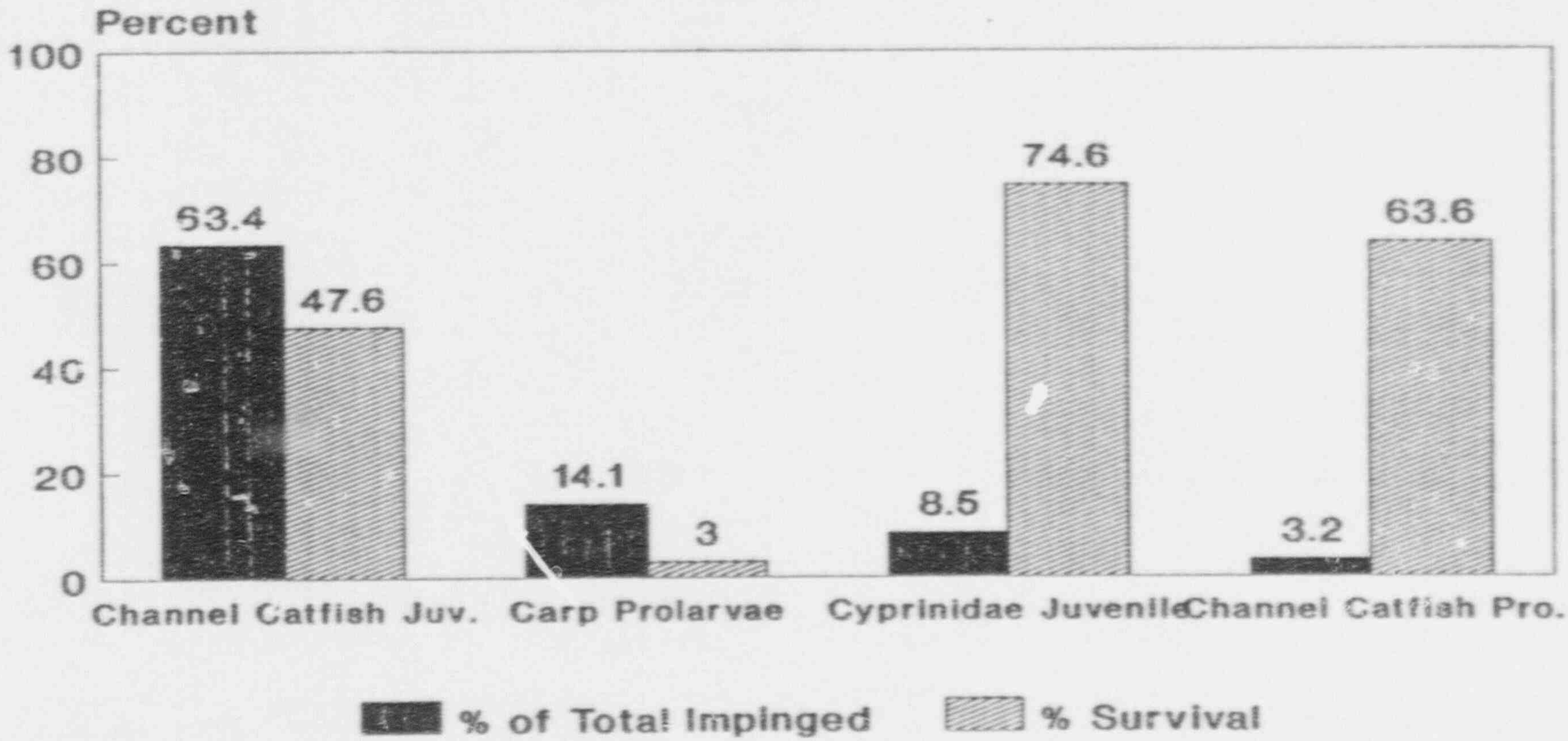


Figure 11

Percent Contribution and Survival of Dominant Fish Species in 1985

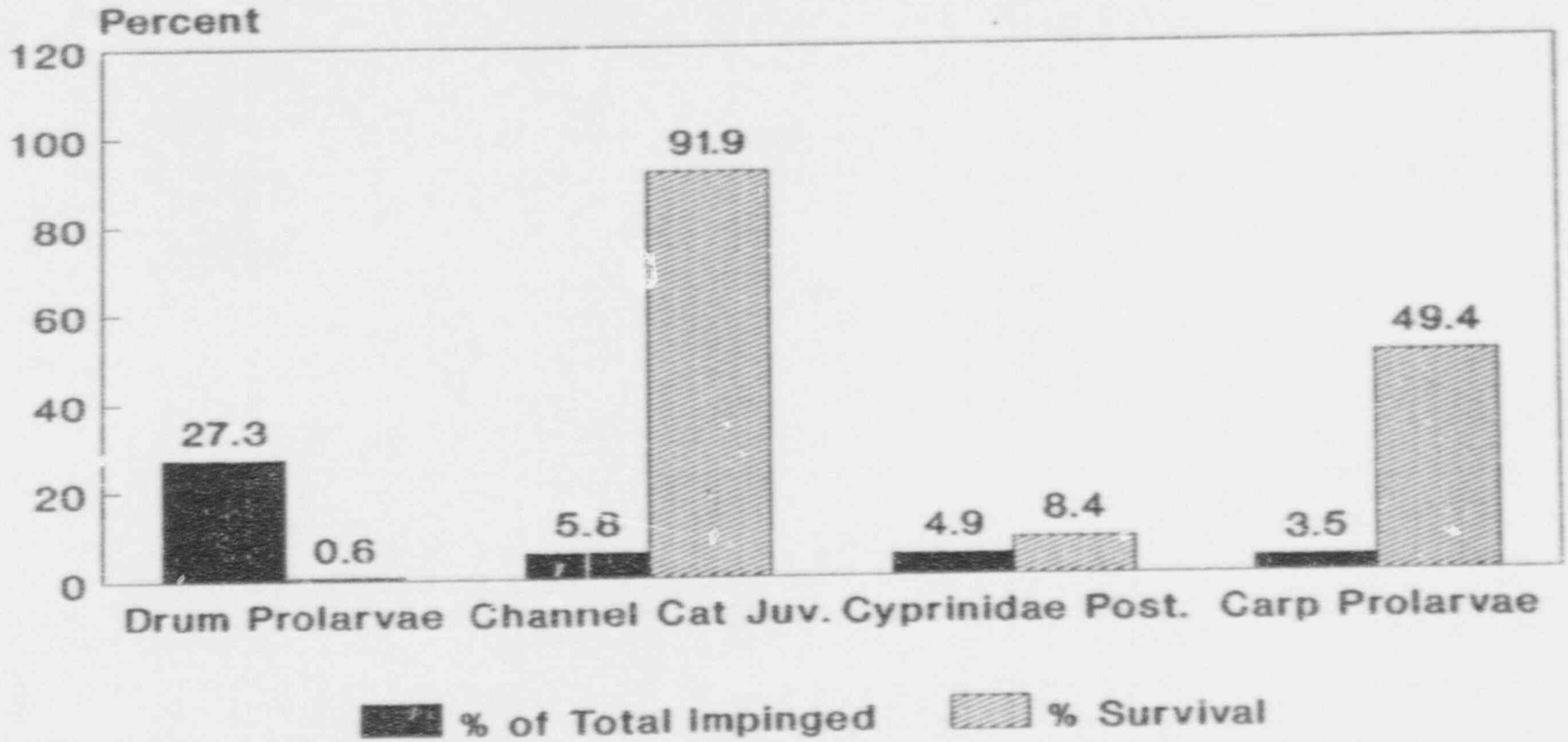


Figure 12

Percent Contribution and Survival of Dominant Fish Species in 1986

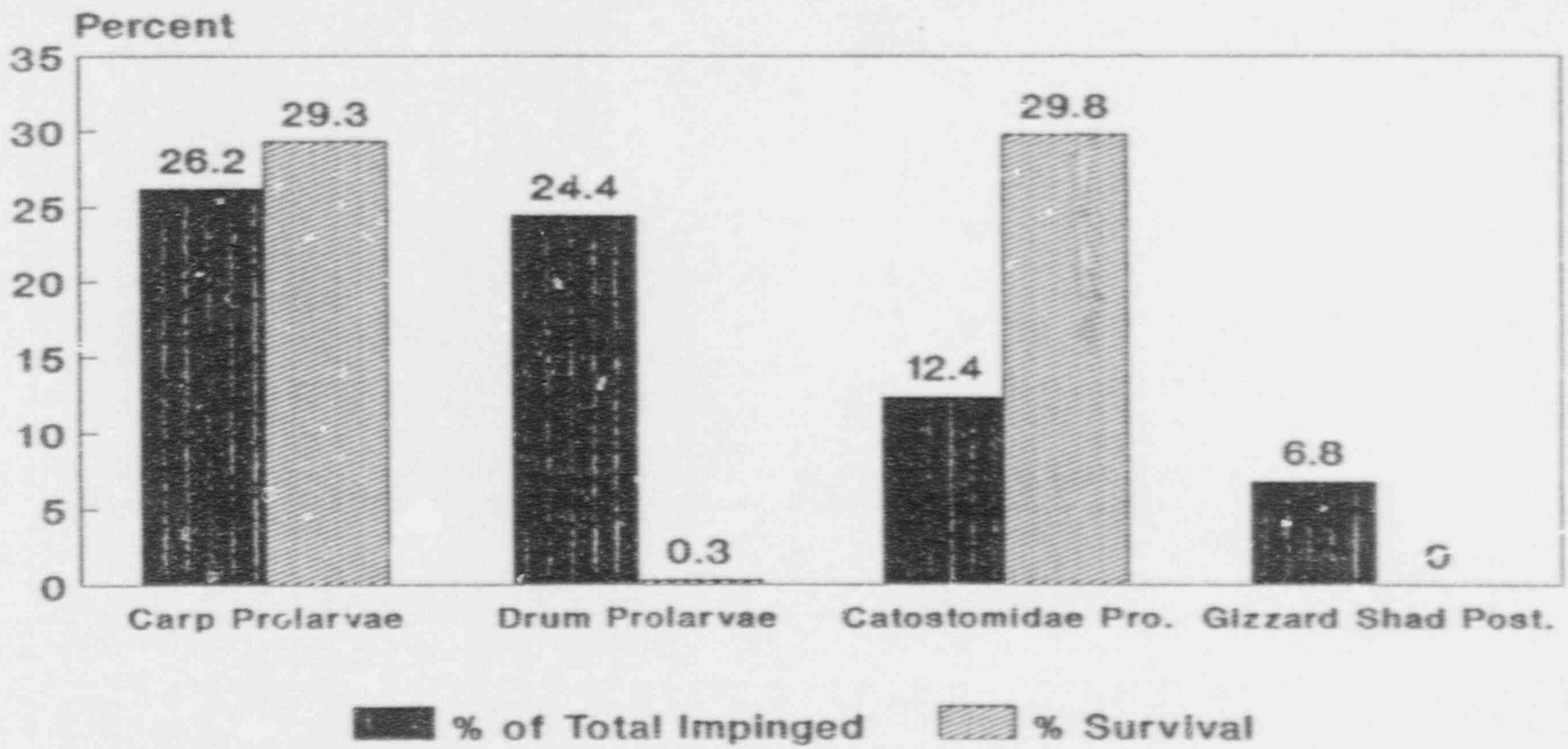


Figure 13

Percent Contribution and Survival of Dominant Fish Species in 1987

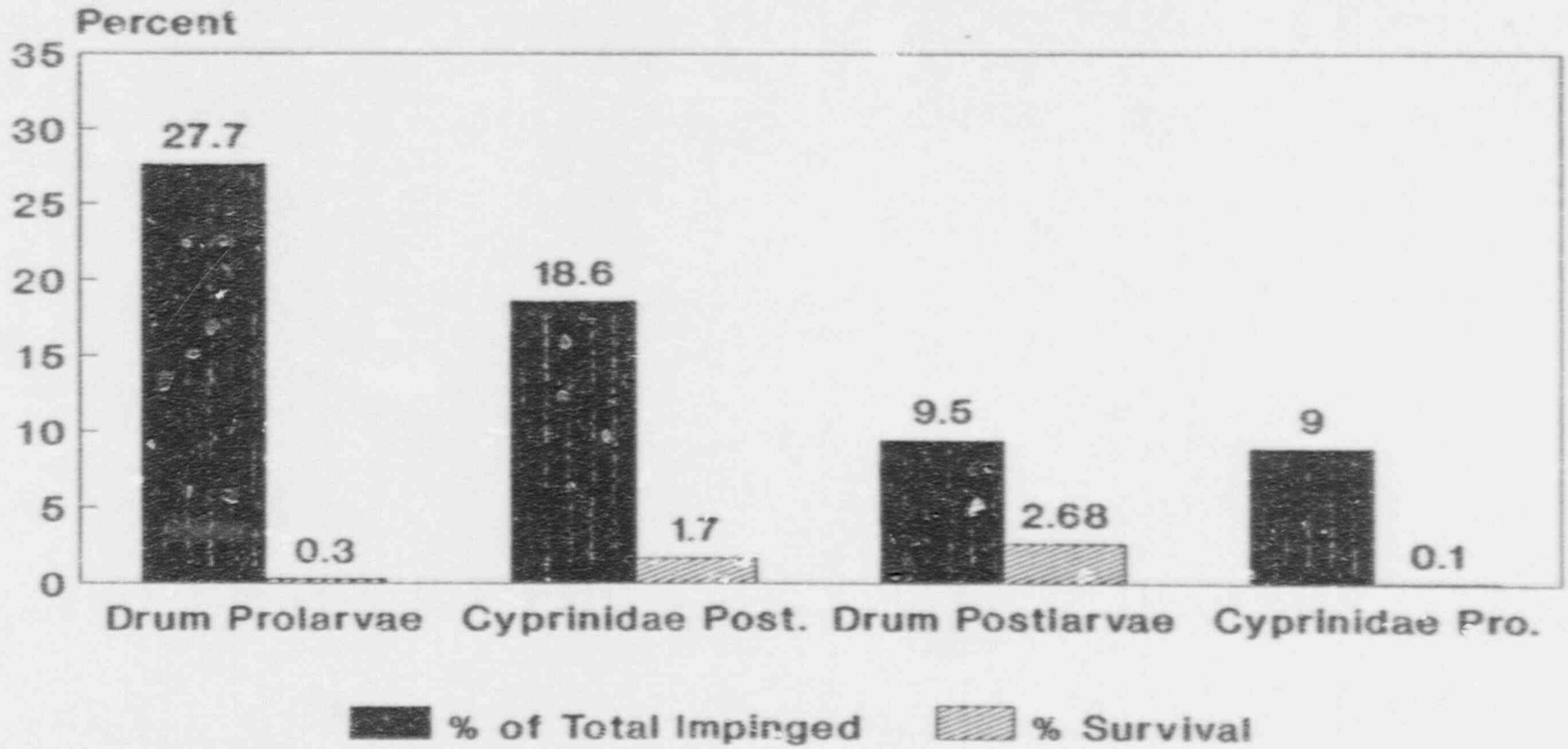


Figure 14

TABLE 1. NUMBER OF SAMPLES AND ORGANISMS COLLECTED BY SAMPLE TYPE IN 1988

SAMPLE TYPE	NUMBER OF SAMPLES	NUMBER OF FISH	NUMBER OF EGGS
Abundance	[illegible]	13,844	3,304
Initial Survival	46	20,845	4,573
TOTAL	108	34,689	7,877

TABLE 2. REPRESENTATIVE TOTAL LENGTH RANGES (mm) FOR 46 TAXA/LIFE STAGE COMBINATIONS COLLECTED IN THE 1984-88 FINE MESH FISH IMPINGEMENT STUDY

	Pro.	Post.	Juv.
Channel catfish	11.0 - 18.0	N/A	15.0 - 51.0
Walleye	5.6 - 10.[illegible]	9.8 - 19.8	21.5 - 87.0
Sauger	5.1 - 10.6	8.[illegible] - 14.6	-
Lepomis spp.	4.3 - 6.2	4.2 - 13.5	14.2 - 66.0
Pomoxis spp.	4.2 - 5.7	4.1 - 15.6	16.4 - 75.0
White bass	3.6 - 6.5	4.2 - 17.0	1[illegible].0 - 57.0
Rock bass	7.1 - 7.1	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 - 19.3	13.0 - 15.0	-
Burbot	3.8 - 7.6	-	84.0 - 84.0
Carp	4.8 - 8.5	5.9 - 18.5	19.7 - 59.0
Cyprinids	3.1 - 6.2	5.0 - 17.0	12.9 - 60.0
Catostomids	4.4 - 13.7	6.9 - 22.5	19.4 - 37.0
Freshwater drum	3.3 - 9.5	6.2 - 14.3	12.5 - 53.0
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	3.6 - [illegible].6	5.5 - 21.7	19.0 - 50.0
Bullhead spp.	-	N/A	16.0 - 24.0

TABLE 3. DAY VS. NIGHT DENSITY FOR ALL TAXA/LIFESTAGE COMBINATIONS EXPRESSED AS NUMBER OF ORGANISMS PER [illegible]00 CUBIC METERS OF WATER FOR 1988

DATE		DAY DENSITY	NIGHT DENSITY
May	2	0.000	0.219
	4	0.321	0.268
	6	0.369	0.263
	9	3.986	0.727
	11	8.294	7.610
	13	3.610	18.376
	16	18.363	0.032
	18	8.094	9.451
	20	6.243	5.083
	23	23.517	19.640
	25	104.508	36.435
	27	287.780	261.620
June	1	91.945	236.724
	3	223.849	30.870
	6	19.319	285.606
	8	10.620	76.816
	10	5.744	75.239
	13	2.949	17.800
	15	12.452	47.263
	17	4.944	22.922
	20	3.371	14.776
	22	37.755	.
	24	1.777	.
	27	9.888	.
	29	3.146	.
July	1	3.024	.
	6	3.688	.
	8	1.531	4.137
	11	6.917	4.626
	13	6.874	2.263
	15	4.717	2.986
	18	7.205	1.471
	20	4.993	1.678
	22	1.116	1.453
	25	2.769	1.255
	27	2.964	1.406
	29	2.464	2.295
August	1	1.074	1.264
	3	1.095	1.137
	5	5.138	6.211
	8	2.272	0.736
	10	5.461	0.993
	12	8.560	1.328
	15	1.345	0.807
	17	1.117	0.538
	19	6.296	1.255
	22	0.547	0.668
	24	0.698	1.922
	26	0.313	0.049
	29	0.480	0.517
	31	0.072	0.144
Mean		20.362	26.864

TABLE 4. ESTIMATED NUMBER AND PERCENT COMPOSITION OF FISH AND EGGS IMPINGED DURING 1988

TAXA	LIFE STAGE	ESTIMATED NO. IMPINGED	PERCENT COMPOSITION
Burbot	Postlarvae	3,136	0.005
Burbot	Prolarvae	19,936	0.030
Carp	Postlarvae	552,608	0.822
Carp	Prolarvae	536,032	0.798
Catostomidae	Juvenile	1,344	0.002
Catostomidae	Postlarvae	15,232	0.023
Catostomidae	Prolarvae	145,600	0.217
Centrarchidae	Postlarvae	8,736	0.013
Centrarchidae	Prolarvae	9,408	0.014
Channel catfish	Juvenile	110,656	0.165
Channel catfish	Prolarvae	18,816	0.028
Coregonus spp.	Postlarvae	448	0.001
Cyprinidae	Adult	315,840	0.470
Cyprinidae	Juvenile	6,028,512	8.973
Cyprinidae	Postlarvae	7,789,600	11.594
Cyprinidae	Prolarvae	525,504	0.782
Flathead catfish	Juvenile	2,688	0.004
Freshwater drum	Egg	9,782,976	14.561
Freshwater drum	Juvenile	331,968	0.494
Freshwater drum	Postlarvae	3,525,984	5.248
Freshwater drum	Prolarvae	28,620,928	42.599
Gizzard shad	Juvenile	5,376	0.008
Gizzard shad	Postlarvae	2,464,448	3.668
Gizzard shad	Prolarvae	913,024	1.359
Lepomis spp.	Juvenile	77,952	0.116
Lepomis spp.	Postlarvae	857,472	1.276
Lepomis spp.	Prolarvae	370,944	0.552
Mooneye	Prolarvae	448	0.001
Percidae	Juvenile	4,032	0.006
Percidae	Postlarvae	17,472	0.026
Percidae	Prolarvae	41,440	0.062
Pomoxis spp.	Postlarvae	61,824	0.092
Pomoxis spp.	Prolarvae	2,912	0.004
Sauger	Postlarvae	4,480	0.007
Sauger	Prolarvae	16,128	0.024
Tadpole madtom	Prolarvae	1,344	0.002
Walleye	Prolarvae	2,688	0.004
White bass	Juvenile	5,376	0.008
White bass	Postlarvae	637,952	0.950
White bass	Prolarvae	478,912	0.713
Unidentified	Egg	2,438,464	3.629
Unidentified	Postlarvae	5,376	0.008
Unidentified	Prolarvae	433,216	0.645
	TOTAL	67,187,232	100

TABLE 5. INITIAL, LATENT AND OVERALL SURVIVAL
BY TAXA AND LIFESTAGE FOR 1984-1987

SPECIES NAME	LIFESTAGE	INITIAL SURVIVAL DEAD	INITIAL SURVIVAL LIVE	INITIAL SURVIVAL % LIVE	LATENT SURVIVAL DEAD	LATENT SURVIVAL LIVE	LATENT SURVIVAL % LIVE	OVERALL SURVIVAL % LIVE
Gizzard shad	Postlarvae	2899	23	0.8	55	1	1.8	<0.1
Gizzard shad	Juvenile	17	8	32.0	13	1	7.1	2.3
Mooneye	Prolarvae	39	12	23.5	25	4	13.8	3.2
Carp	Prolarvae	1778	881	33.1	182	458	71.6	23.7
Carp	Postlarvae	1570	296	15.9	331	1638	83.2	13.2
Carp	Juvenile	4	95	96.0	40	112	73.7	70.7
Cyprinidae	Prolarvae	2622	8	0.3	17	10	37.0	0.1
Cyprinidae	Postlarvae	13690	391	2.8	276	339	55.1	1.5
Cyprinidae	Juvenile	454	1306	74.2	719	1179	62.1	46.1
Cyprinidae	Adult	0	8	100.0	13	8	38.1	38.1
Catostomidae	Prolarvae	935	1088	53.8	301	1296	81.2	43.6
Catostomidae	Postlarvae	146	103	41.4	107	687	86.5	35.8
Catostomidae	Juvenile	9	25	73.5	7	50	87.7	64.5
Channel catfish	Prolarvae	81	224	73.4	6	24	80.0	58.8
Channel catfish	Juvenile	2535	5765	69.5	556	2653	82.7	57.4
Trout-perch	Juvenile	3	34	91.9	35	58	62.4	57.3
White bass	Prolarvae	76	0	0.0	8	0	0.0	0.0
White bass	Postlarvae	1227	155	11.2	513	122	19.2	2.2
White bass	Juvenile	26	67	72.0	90	67	42.7	30.7
Lepomis spp.	Postlarvae	215	10	4.4	23	7	23.3	1.0
Lepomis spp.	Juvenile	13	52	80.0	14	80	85.1	68.1
Pomoxis spp.	Postlarvae	177	9	4.8	17	18	51.4	2.5
Pomoxis spp.	Juvenile	2	30	93.8	36	52	59.1	55.4
Sauger	Prolarvae	51	17	25.0	14	40	74.1	18.5
Sauger	Postlarvae	44	17	27.9	10	9	47.4	13.2
Walleye	Prolarvae	15	104	87.4	123	456	78.8	68.8
Walleye	Postlarvae	0	2	100.0	3	15	83.3	83.3
Percidae	Prolarvae	362	33	8.4	24	34	58.6	4.9
Percidae	Postlarvae	273	38	12.2	167	42	20.1	2.5
Percidae	Juvenile	19	40	67.8	26	90	77.6	52.6
Freshwater drum	Prolarvae	20134	414	2.0	751	159	17.5	0.4
Freshwater drum	Postlarvae	3340	693	17.2	1145	447	28.1	4.8
Freshwater drum	Juvenile	190	433	69.5	420	401	48.8	33.9

TABLE 6. OVERALL SURVIVAL BY TAXA/LIFESTAGE FOR 1984-1987

PERCENTAGE OVERALL SURVIVAL	TAXA		
	PROLARVAE	POSTLARVAE	JUVENILE
0 - 10	Freshwater drum Percidae White bass Cyprinidae Mooneye	Percidae Pomoxis spp. Lepomis spp. White bass Cyprinidae Gizzard shad Freshwater drum	Gizzard shad
11 - 30	Sauger Carp	Sauger Carp	White bass
31 - 50	Catostomidae	Catostomidae	Freshwater drum Cyprinidae
> 51	Channel catfish Walleye	Walleye	Percidae Pomoxis spp. Lepomis spp. Trout-perch Channel catfish Catostomidae Carp

TABLE 7. PERCENTAGE SURVIVAL FOR ALL SAMPLES AND LIFESTAGES BY YEAR

	1984	1985	1986	1987
INITIAL SURVIVAL				
Prolarvae	26.9	12.3	7.3	2.7
Postlarvae	15.6	22.1	8.0	4.4
Juvenile	67.9	87.9	89.7	66.1
All lifestages	50.1	21.6	12.8	6.1
LATENT SURVIVAL				
Prolarvae	64.4	69.2	43.7	62.5
Postlarvae	47.5	59.4	67.2	46.7
Juvenile	74.2	87.2	69.2	26.9
All lifestages	64.0	70.3	64.4	38.2
OVERALL SURVIVAL				
Prolarvae	24.8	30.6	17.2	1.8
Postlarvae	17.5	13.4	4.4	1.7
Juvenile	57.4	60.7	48.0	26.1
All lifestages	32.1	15.2	8.3	2.7

PRAIRIE ISLAND NUCLEAR GENERATING PLANT

ENVIRONMENTAL MONITORING PROGRAM

1985 ANNUAL REPORT

PRAIRIE ISLAND NUCLEAR GEN PLT

ATTACHMENT 4

WALLEYE/SAUGER REPRODUCTION STUDY

by

Charles A Donkers

Environmental and Regulatory Activities Department

Northern States Power Company

WALLEYE/SAUGER REPRODUCTION STUDY

INTRODUCTION

A requirement of the National Pollutant Discharge Elimination System (NPDES) permit for Prairie Island Nuclear Generating Plant (PINGP) is to evaluate spawning success of walleye and sauger as related to chill period and open cycle operation.

Large numbers of walleye and sauger reside in the portion of the Mississippi River immediately below Lock and Dam 3 (approximately six-tenths of a kilometer downstream from PINGP), which serves as a congregation area for walleye and sauger during winter months. During this period, ambient water temperatures and duration of exposure to these temperatures may affect gonad maturation of walleye and sauger. Because open cycle operation raises water temperatures below Lock and Dam 3, a monitoring program was set up to evaluate gonad maturation of female walleye and sauger. Background data were collected from 1981 through 1983, so comparisons could be made between the mode of winter operation used prior to 1983 and open cycle winter operation. PINGP ceased using cooling towers during winter months in December of 1983.

Walleye and sauger are annual spawners with synchronous oocyte growth during fall and winter. Laboratory studies indicate that maturation depends upon low water temperature during this period and occurs when water temperature drops below 12 degrees centigrade (Hokanson 1977).

MATERIALS AND METHODS

Walleye and sauger are collected below Lock and Dam 3 when mature females are close to spawning condition (approximately the first part of April), which corresponds to an ambient river temperature of approximately nine degrees Centigrade. Specimens

are obtained using a pulsed, direct current electrofisher (described in the PINGP Fisheries Population Study) equipped for night shocking, or they are obtained from Lake City MDNR personnel who use an alternating current electrofisher.

Sex, maturity, total length, and weight were recorded for all fish collected. Scale samples were taken for age analysis, and ovaries from mature females were removed and weighed to the nearest gram.

Gonad-to-body weight ratios and age were calculated for individuals from which ovaries had been removed. Gonad weight versus total weight were plotted and regression equations calculated.

RESULTS

Eighteen walleye and ten sauger were collected in three days of electrofishing during 1984. Regression lines for gonad weight versus total weight were calculated for both species. The regression equation for walleye was:

$$GWT = -122 + 0.246\ wt\ (r\text{-square} = 0.969)$$

The regression equation for sauger was:

$$GWT = -32 + 0.222\ wt\ (r\text{-square} = 0.969)$$

Regression lines for preoperational and operational data were calculated for each day five or more walleye/sauger were collected. Equations are listed in Table 1 and illustrated in Figure 1.

DISCUSSION

The objective of this study was to assess impacts on walleye/sauger reproductive success due to PINGP open cycle operation. Three years of preoperational and two years of operational fecundity data have been collected.

Gonad versus total weight regression equations were used to compare preoperational with operational eras. Palmquist (1983) determined gonad versus total weight displays a stronger relationship than gonad weight versus total length. It is assumed reduced reproductive success (impaired egg maturation) is indicated by a decrease in gonad weight for a given size fish. This is synonymous to a decrease in the regression line slope.

The relative contribution of eggs to total body weight increases as spawning time approaches. Prior to spawning, walleye eggs may account for 27 percent of the total weight. It is difficult to capture females at identical developmental stages each year. Data should therefore consist of several collection days, either within one year or between several years, to account for various degrees of egg development.

In the past a student's t-test was used to compare results; however, standard statistical methods should not be applied to non-normal distributions. Both walleye and sauger spawning populations are skewed and bounded at the younger ages, making them non-normal. For statistical verification, a non-parametric method must be employed. Also required is greater precision in selecting and identifying a specific developmental stage; or collecting an even distribution of developmental stages.

Preoperational data for walleye consists of 46 fish collected in 7 days; operational data consists of 28 fish collected in 4 days. Regression analysis is presented in Table 1. Strict interpolation of the regression analysis (the lower the slope

the greater the impairment to egg maturation) should not be performed due to experimental design and natural variances. Differences exhibited in regression slopes is thought to be primarily caused by collecting fish of various stages of egg development. Due to the uncertainties in developmental stages collected, reliable statistics are nonexistent. .However, the large overlap in preoperational and operational data presented in Figure 1 strongly suggests no impairment of egg development.

From 1981 to 1983, 24 sauger were collected, 20 of which were collected in one day. It is impossible to collect further preoperational data, however with the accruement of two years of operational data an assessment can be made. Figure 2 strongly suggests no change in reproductive capabilities between pre and operational era's. Statistical verification cannot be performed for the same reasons as were given for walleye.

Continuation of this study will be of little benefit. Presently, the data does not support the hypothesis of reproductive impairment for either walleye or sauger. In fact a strict interpretation of the high slopes presented in Table 1 for walleye (4/17/84) and sauger (4/22/85) contradicts a decline in reproductive success (Donkers 1984). Since egg development is an annual occurrence, no lag-time to impact is expected. A continuation of this study, as is, would therefore be unlikely to show reproductive impairment in the future. Additional data would only show the natural range as reflected from regression analysis. Presently two years of operational data indicate no impairment, a third year, if a lower slope were calculated could probably be explained by experimental design or natural variation.

SUMMARY

Eighteen walleye and ten sauger were collected in 1985 to evaluate spawning success. Neither sauger or walleye females show any decline in gonad development due to present winter operating conditions at the PINGP. Reproductive impairment in future years is unlikely due to to the nature of reproduction. Continuation of this study will not support the hypothesis of reproductive impairment due to open cycle operation at PINGP. Discontinuation of this study is therefore recommended.

LITERATURE CITED

Hokanson, K.E.F. 1977. Temperature Requirements of Some Percids and Adaptations to the Seasonal Temperature Cycle. J. Fish/ Res. Board Can. 34: 15241550.

Palmquist, P.R. 19(3. Walleye/Sauger Reproduction Study. In: Prairie Island Nuclear Generating Plant Environmental Monitoring and Ecological Studies Program, 1983 Annual Report Prepared for Northern States Power Company, Minneapolis, Mn.

Donkers, C.A. 1984. Walleye/Sauger Reproduction Study. In: Prairie Island Nuclear Generating Plant Environmental Monitoring and Ecological Studies Program, 1984 Annual Report Prepared for Northern States Power Company, Minneapolis, Mn.

Table 1. Gonad Weight Versus Total Weight Regression Equations for Walleye and Sauger

Walleye:

April 7, 1981	Gwt = -105 + .252 wt (N = 19, r-sq = .996)
April 11, 1983	Gwt = -200 + .267 wt (N = 12, r-sq = .968)
April 20, 1983	Gwt = -26 + .206 wt (N = 8, r-sq = .960)
April 17, 1984	Gwt = -198 + .285 wt (N = 10, r-sq = .944)
April 15, 1985	Gwt = -150 + .260 wt (N = 9, r-sq = .956)
April 17, 1985	Gwt = -87 + .230 wt (N = 9, r-sq = .915)

Sauger:

April 26, 1983	Gwt = -21 + .182 wt (N = 16, r-sq = .947)
April 19, 1984	Gwt = -15 + .181 wt (N = 20, r-sq = .951)
April 22, 1985	Gwt = -32 + .222 wt (N = 10, r-sq = .969)

Figure 1

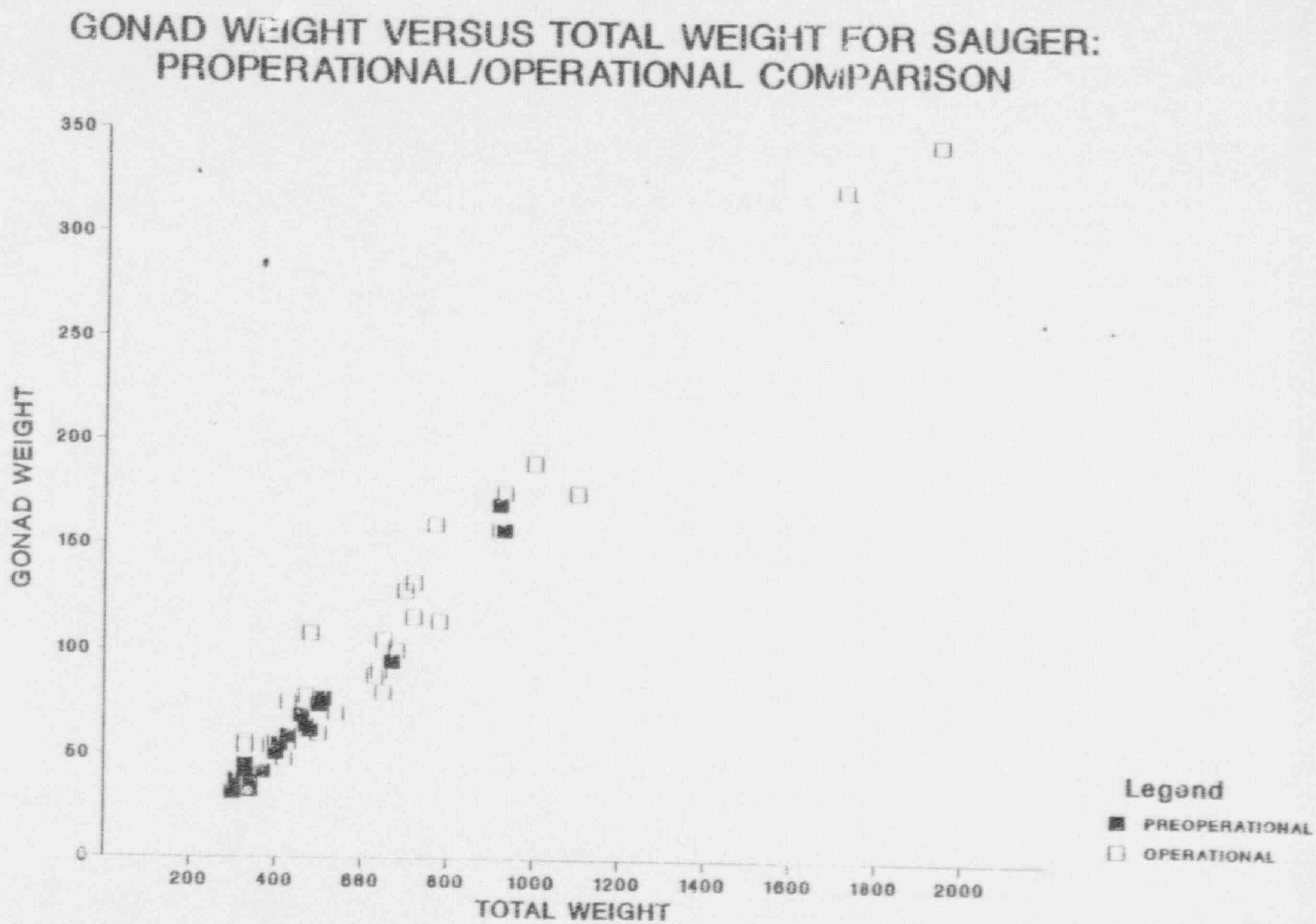
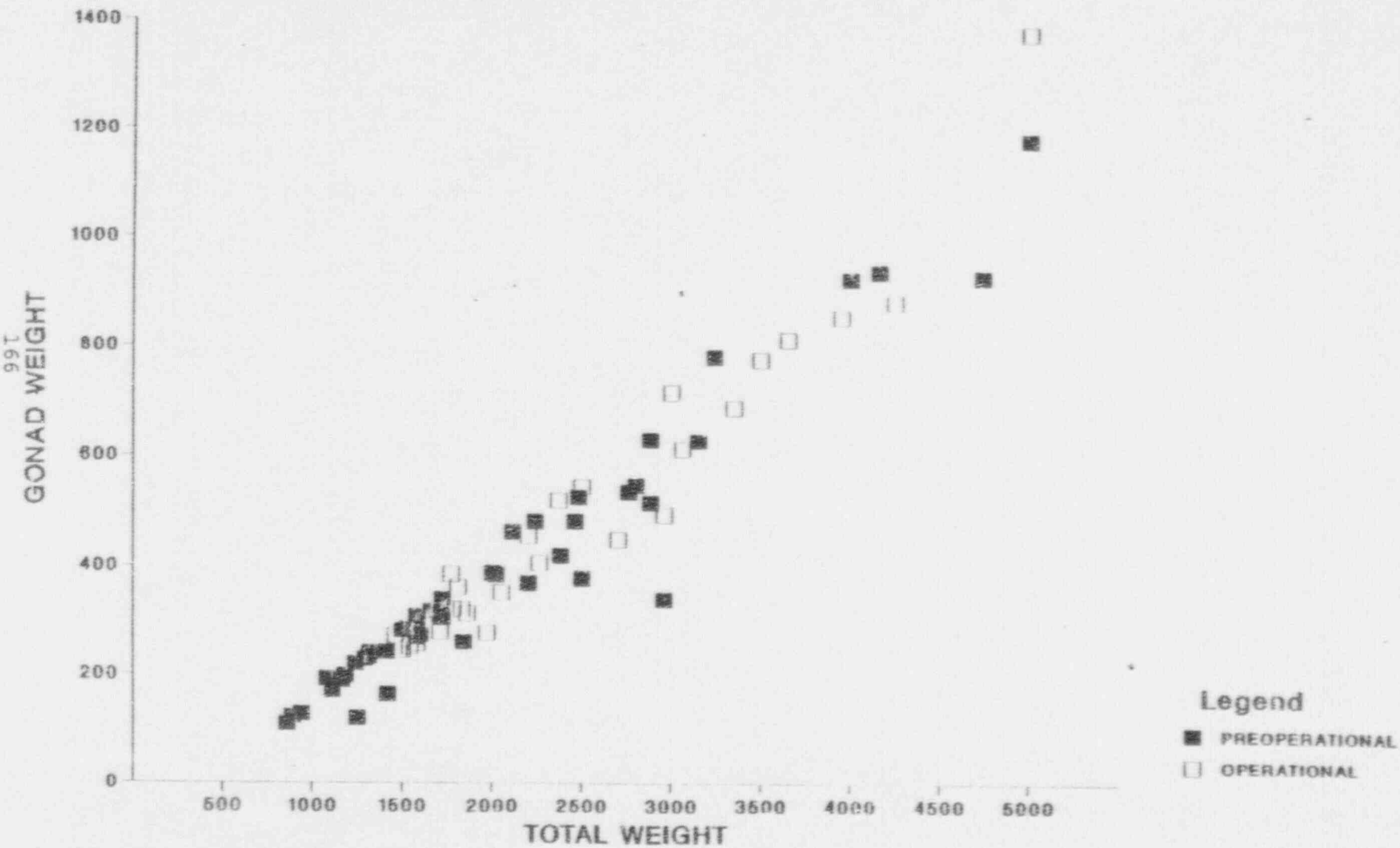

GONAD WEIGHT VERSUS TOTAL WEIGHT FOR SAUGER:
PROPERATIONAL/OPERATIONAL COMPARISON
350
300
250
200
150
100
50
0
GONAD WEIGHT
200
400
600
800
1000
1200
1400
1600
1800
2000
TOTAL WEIGHT
Legend
PREOPERATIONAL
OPERATIONAL

Figure 1 (Continued)

GONAD WEIGHT VERSUS TOTAL WEIGHT FOR WALLEYE: PREOPERATIONAL/OPERATIONAL COMPARISON



PRAIRIE ISLAND NUCLEAR GENERATING PLANT
ENVIRONMENTAL MONITORING PROGRAM
1987 ANNUAL REPORT

1987 PROGRESS REPORT ON THE PRAIRIE ISLAND CREEL SURVEY

by

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Northern States Power Company

1987 PROGRESS REPORT AND SUMMARY ON THE PRAIRIE ISLAND CREEL SURVEY

INTRODUCTION

Northern States Power Company (NSP) began conducting a winter creel survey on the Mississippi River in 1981. The study was designed to assess any impact on area fishing caused by a modification of the cooling water system at Prairie Island Nuclear Generating Plant (PINGP). There was concern that increased thermal discharge during plant operation without cooling towers would result in ice-free conditions at boat ramps immediately below Lock and Dam #3. The potential thus existed for over-harvesting sportfish due to increased accessibility during the winter months. December through February were the months most apt to be affected since accessibility has not been a limiting factor during the months of March and April.

This report presents creel data collected in the 1986-1987 season and attempts to summarize all available winter creel survey data on the PINGP study area.

MATERIALS AND METHODS

Study Area

The study area consisted of a section of the Mississippi River and its backwaters stretching from the PINGP intake (river mile 790) to the head of Lake Pepin (river mile 785.5). The area covered 1267 hectares of water and included the Wisconsin channel and associated backwaters along 12.5 miles of navigational channel. The study area is illustrated in Figure 1.

Open water fishing was done primarily by boat and took place in the ice-free areas downstream of Lock and Dam #3. The extent of open water varied during periods of weather extremes, as did the accessibility of some boat launches. As a general rule, the main channel could be expected to stay open from the PINGP discharge to the city of Red Wing. Ice fishing activities were also monitored at three frozen bays in the study area.

Survey Design

A nonuniform probability survey was conducted from December 6, 1986 through May 1, 1987. NSP has conducted this survey since the fall of 1981. This survey was patterned after a creel survey conducted by the Minnesota Department of Natural Resources (MDNR) Lake City Area Fisheries personnel on Pool 4 of the Mississippi River from 1977-1981. In a probability survey, sampling effort is distributed in proportion to the expected use by anglers. Probability of use, using previous years' data, is determined for the station, time of day, and day of the week. These probabilities are then used for scheduling daily sampling effort and for calculating estimated fishing pressure.

Saturday, Sunday and two randomly chosen weekdays were sampled each week. Paired weekdays were used for the clerk's convenience. The probabilities used to determine which weekdays were sampled are listed in Table 1. Day of the week probabilities used in calculations were based on the number of fishing trips expected to be completed each day (Table 2).

Sampling days were divided into two consecutive four-hour sample periods. Generally, travel time between sites was

split equally between the two stations. Each sample period was spent at one access point where the creel clerk counted and interviewed anglers as they completed their fishing trips. A completed trip was recorded when an angling party discontinued fishing and returned to the access for longer than 15 minutes. Data recorded from each interviewed party included number of anglers, start and end time, number of each species kept, their size and number of fish released. The following information was totaled for each four-hour sample period: number of completed fishing trips, number of interviewed fishing trips and number of hours spent fishing.

The probabilities used to schedule clerk starting times and used in time-of-day calculations are listed in Tables 3 and 4, respectively. These probabilities were based on the time of day that fishing trips were likely to be completed. They were adjusted to reflect different angler usage according to changes in daylight hours.

Between sample periods, all access points were visited and the number of parked cars recorded. Distribution of cars was used to determine scheduling and calculating probabilities for the following year.

Seven access points were sampled below Lock and Dam #3: Evert's Resort, Barb's Resort, River's Edge, Upper Red Wing Harbor (Bay Point Park), Levee Park, Colvill Park and Goose Lake. Probabilities assigned to each station were based on expected use by anglers and reflected changes in accessibility due to ice conditions (Tables 5 and 6).

Calculations

Fishing Pressure:

Estimated fishing pressure (in man trips) for the

probability survey was calculated using angler count data from each four-hour sample period as follows: Station, time and day probabilities were determined on the basis of probable use by anglers (Watson and Hawkinson 1979). Probabilities were changed to reflect changes in fishing pressure (Tables 2, 4 and 6). Man-trips may be converted to man-hours using the following equation:

$$\text{Eq 1.}\quad \text{Weekly estimated man-hours} = \text{Weekly estimated man trips} \times \frac{\text{Total man-hours fished by interviewed anglers}}{\text{Total number of interviewed man-trips}}$$

For each month, weekly man-hour estimates were summed, then divided by the total number of estimates to give a mean weekly estimate. A monthly estimate of man-hours was then calculated as:

$$\text{Eq 2.}\quad \text{Monthly estimated man-hours} = \text{Mean weekly estimated man-hours} \times \text{Number of weeks in month}$$

Fishing Success and Harvest:

Fishing success for the probability survey was described using the overall catch rate. This was defined as:

$$\text{Eq 3.}\quad \text{Overall catch rate (fish/man-hour)} = \frac{\text{No. of fish kept by interviewed anglers}}{\text{Man-hours spent fishing by interviewed anglers}}$$

The harvest was calculated using the formula:

$$\text{Eq 4.}\quad \text{Est. harvest} = \text{Est. No. of man-hours} \times \frac{\text{No. of fish kept}}{\text{No. of interviewed man-hours}}$$

RESULTS

Fishing Pressure

Overall estimated fishing pressure for the five month survey period was the highest ever recorded at 152,715 hours. Open water angling was predominant and accounted for 141,342 hours, approximately 93 percent of total fishing time (Table

8 and 9). In the previous four years open water percentages have ranged from 80-96 percent, averaging 89 percent. Typically, April pressure has been derived entirely from open water sources, while December, January, February and March monthly total acquire data from both open water and ice anglers. The unseasonably warm winter, the second warmest on record, provided unlimited access to boating, while thin ice conditions restricted ice fishing at some survey points.

The greatest overall monthly fishing pressure occurred in March with 85,870 hours of open water fishing. April was second highest with 40,600 hours. March figures have typically reflected a month popular for open water fishing with some additional pressure from ice angling. Due to scheduling probabilities during the 1986-1987 season, an insufficient number of ice angler interviews were conducted prohibiting the estimation of ice angling pressure.

Open water pressure for the months of March and April combined was 126,470 hours, a figure almost three times the estimated March-April pressure in 1985 (Figure 2). Of all winter survey months, these two have historically shown the greatest fluctuation while comprising the largest fraction of the season's angling pressure (Figure 3 and 4).

Fishing Success

Overall catch rates are expressed as fish kept per man-hour of fishing. Open water catch rates consist of a combination of boat and bank fishing, data collected from shoreline anglers were minimal. Walleye and sauger occupied the greatest portion of the open water angler's creel, supplemented by white bass, crappies, northern pike and catfish. A walleye catch rate of 0.070 fish per man-hour was calculated for both December and January; December

sauger success was rated at 0.351/man-hour (Table 10). These early winter catch rates were the highest for the five-month season, a trend which has been consistent since the full-winter survey began in 1981.

March-April catch rates for walleye and sauger were significantly higher than the 6 year average ($p = 0.05$ $n = 6$), demonstrating the most successful spring fishing in many years. The walleye catch rate of 0.063 was exceeded only once in the past 14 years (1978), and sauger catch rates greater than 1987's 0.238 have not been recorded in nine years (Figure 6). These catch rates are considerably lower than the 1968-1976 values determined by a roving census clerk methodology.

Average winter catch rates for walleye had formerly been between 32 and 45 percent of average sauger catch rates. In 1987, walleye success was only 28 percent of that for sauger, due to an overall greater increase in sauger catch rates.

Average winter ice fishing catch rates for crappies and northern pike were 0.056 and 0.015 fish/man-hour, respectively. These figures were down from 1986 but fall within previously established ranges.

Harvest

A total of 5,944 fish were tabulated during the 1987 survey, bringing the estimated harvest to 46,814 (Tables 7 and 8). Open water angling produced 8,894 walleyes and 32,575 sauger, nearly 89 percent of the total winter harvest (Figure 5). From 1982-86, these two species comprised from 66-81 percent (mean 76 percent) of the total. An estimated 2,723 white bass were also harvested.

The March-April harvest of sauger was calculated at 30,084 fish, a drastic increase over the 1986 figure of 3,220 (Figure 6). Walleyes caught during this period numbered 8,056, the second highest spring catch ever recorded. Similar to pressure, the season's harvest is predominated by March and April. Figure 7 illustrates March and April comprise 92 percent of the winter walleye and sauger harvest.

Only 912 fish were estimated to be caught through the ice. This is a figure similar to harvests in 1982 and 1985, but low compared to the five-year mean of 1,843 fish.

Length-Weight Relationships

In March of 1987, 114 walleyes and 224 sauger were weighed and measured. From a length-weight regression analysis, the slopes for walleye and sauger were determined to be 3.440 and 3.653, respectively. As shown in Table 13, the regression slopes for both populations have been above 3.0 in five out of six years, and show no pattern in their fluctuation. Walleye and sauger regression analyses are given in Figures 7 and 8.

DISCUSSION

As suggested by equation 4, harvest is a function of fishing pressure and catch rate. Because anglers rely on word-of-mouth for news of fish activity, catch rates can also influence fishing pressure. In effect, good fishing promotes more fishing. We believe weather is an important factor affecting pressure and harvest. As an example, the open water season of 1986-87 was a period of record high pressure, increased catch rates and high harvest. An extremely warm winter provided open access to the river.

Precipitation from rain and melted snow totaled only 2.66 inches. River levels remained low and with little snowmelt run-off, "normal" spring high water levels never occurred. The average April, 1987, river stage in Red Wing was 4.22, nearly 8.5 feet lower than in 1986. These factors resulted in a season of warmer air temperatures, reduced turbidity and less dispersion of staging and spawning fish. In contrast, the spring of 1986 was characterized by rainstorms and a ten-year flood. Since pressure from March and April accounts for an average of 83 percent of the 1986-87 open water season, the conditions during this period had a pronounced affect on the year's data. Wind, high water levels, rain and snowstorms are common and may influence fishing pressure and numbers harvested.

The months most likely to be affected by PINGP operation without cooling towers, December and January, have consistently exhibited the highest catch rates. This may be due to an insufficient number of anglers interviewed (avg. number of monthly interviews 1981-1987, Dec-Jan n= 60, Feb-Apr n=876) or due to a bias in the quality of angler. In spite of these high catch rates, estimated harvest is dwarfed by the harvest occurring in March and April due to differences in pressure.

Using additional MDNR creel survey data on pool #4 permits a (year review of March-April fishing pressure, catch rate and harvest, (Figures 2, 5 and 7). In a 1982 MDNR report for NSP, Gustafson stated both summer and winter sauger harvests were down and attributed this to smaller year classes in the late 1970's. Lonkers (1984) associated fluctuations in sauger harvests to a younger population structure. Difficulties arise in the interpretation of the available data due to different methodologies used. A roving creel census was used from 1968-1976 (Thorn 1984) while a probability access based survey has been employed

from 1977 to the present. Due to the high variability of external factors, winter creel survey data is probably best analyzed in conjunction with other year-round studies.

A catch analysis by length-weight regression gives an independent evaluation of the well-being of Mississippi River walleye and sauger stocks. Regression analyses for the last six years are shown in Table 13. All fish were sampled prior to peak spawning periods and are of the same approximate age as indicated by similar mean lengths. Lagler (1956) states a well-conditioned fish population will have a length-weight regression slope greater than or equal to 3.0. A change in slope is hypothesized if the population is being over-exploited. This is observed when anglers begin to keep smaller and poorer conditioned fish to fill their creel. Walleye regression slopes have been very consistent and indicate a well-conditioned population is being harvested. Regression analyses for sauger length-weight show more variability, but exhibit no trend. No declining trend in condition factors has been observed since PINGP winter cooling tower operation was discontinued in 1984.

Due to the low priority of ice fishing; ice angling interviews occupy 13 percent of the clerk's interview time, very little can be deduced from data collected on ice anglers. Ice fishing pressure does not appear to correlate with weather histories, and patterns of catch rate and harvest are erratic for the two most sought after species, crappies and northern pike.

CONCLUSION

A winter creel survey was conducted near PINGP; fishing pressure, catch rate, and harvest were monitored for seven years. Open water anglers were responsible for 92 percent

of the total fishing pressure surveyed. Seventy-eight percent of the winter harvest was comprised of walleye and sauger. The highest catch rates for these species were recorded in December and January, however; the majority were harvested in March and April. Length-weight regression analyses show both walleye and sauger stocks to be well-conditioned.

There has been no increase in December through February open water fishing since the discontinuation of winter cooling tower operation in 1984. This study was conducted on the premise that walleye and sauger populations could be over exploited by open water anglers due to increased accessibility. This projection has not been supported with the three years of data collected since the change in plant operation.

REFERENCES

Cochran, W.G. 1963. Sampling techniques, 2nd ed. John Wiley and Sons, Inc., New York.

Donkers, C.A., D.J. Orr and K..N. Mueller. 1984. 1983 progress report on the Prairie Island creel survey. Page 151-210 in Prairie Island Nuclear Generating Plant Environmental Monitoring Program 1983 Annual Report, Northern States Power Co., Minneapolis, MN.

Donkers, C.A. 1985. 1984 progress report on the Prairie Island creel survey. Pages 145-194 in Prairie Island Nuclear Generating Plant Environmental Monitoring Program 1984 Annual Report, Northern States Power Co., Minneapolis, MN.

Donkers, C.A. 1987. 1986 progress report on the Prairie Island creel survey. Pages 93-124 in Prairie Island Nuclear Generating Plant Environmental Monitoring Program 1986 Annual Report, Northern States Power Co., Minneapolis, MN.

Geis, J.L. (1979) unpublished. Estimate of Fishing Pressure and Harvest Below Lock and Dam 3 from December through February if the Area is Ice Free All Winter.

Geis, J.L. and S.P. Gustafson. 1977. Progress report on the Prairie Island creel survey March 6-November 21, 1976. Pages 2.5.3-1 - 2.5.3-60 in Prairie Island Nuclear Generating Plant Environmental Monitoring Program 1976 Annual Report, Vol. II. Northern States Power Co., Minneapolis, MN.

Gustafson, S.P. and P.J. Diedrich. 1976. Progress report on the Prairie Island creel survey March 1-November 23,

REFERENCES (continued)

1975. Pages 1.5.3-1 - 2.5.3-35 in Prairie Island Nuclear Generating Plant Environmental Monitoring Program 1975 Annual Report, Vol. II. Northern States Power Co., Minneapolis, MN.

Gustafson, S.P., H.L. Fierstine and J.L. Geis. 1978. Progress report on the Prairie Island creel survey February 23-November 22, 1977. Pages 2.5-1 - 2.5-67 in Prairie Island Nuclear Generating Plant Environmental Monitoring Program 1977 Annual Report, Vol. II. Northern States Power Co., Minneapolis, MN.

Gustafson, S.P. and J.L. Geis. 1980. Progress report on the Prairie Island creel survey May 1-November 18, 1979. Pages 2.5-1 - 2.5-61 in Prairie Island Nuclear Generating Plant Environmental Monitoring Program 1979 Annual Report, Vol. II. Northern States Power Co., Minneapolis, MN.

Gustafson, S.P., C.J. Bublitz and G.M. Clymer. 1981. 1980 progress report on the Prairie Island creel survey May 1-November 23, 1980. Pages 2.4-1 - 2.4-63 in Prairie Island Nuclear Generating Plant Environmental Monitoring Program 1980 Annual Report, Vol. II. Northern States Power Company, Minneapolis, MN.

Gustafson, S.P. and C.J. Bublitz. 1982. 1981 progress report on the Prairie Island creel survey. Pages 197-250 in Prairie Island Nuclear Generating Plant Environmental Monitoring Program 1981 Annual Report, Northern States Power Company Minneapolis, MN.

Gustafson, S.P. 1983. 1982 progress report on the Prairie Island creel survey. Pages 149-226 in Prairie Island

REFERENCES (continued)

Nuclear Generating Plant Environmental Monitoring Program 1982 Annual Report, Northern States Power Co., Minneapolis, MN.

Haroldson, B.S., C.A. Donkers and R. Binder. 1986. 1985 progress report on the Prairie Island creel survey. Pages 93-124 in Prairie Island Nuclear Generating Plant Environmental Monitoring Program 1986 Annual Report, Northern States Power Co., Minneapolis, MN.

Hawkinson, B.W. 1974. Progress report on the Prairie Island creel survey May 10-November 5, 1973. Pages C-5.59 - C-5.85 in Prairie Island Nuclear Generating Plant Environmental Monitoring Program 1973 Annual Report, Vol. I. Northern States Power Co., Minneapolis, MN.

Naplin, R.L. and S.P Gustafson. 1975. 1974 progress report on the Prairie Island creel survey. Page 717-753 in Prairie Island Nuclear Generating Plant Environmental Monitoring Program 1974 Annual Report, Vol. II. Northern States Power Co., Minneapolis, MN.

Sternberg, R.B. 1974. Assessment of continuous walleye-sauger fishing at Lock and Dams 3 and 4 of the Mississippi River, 1968-74. Minnesota Department of Natural Resources, Division of Fish and Wildlife Investigational Report No. 332.

Watson, L.D. and B.W. Hawkinson. 1979. A recreational use survey of Pool 5 Upper Mississippi River January 1 to December 31, 1978. Minnesota Department of Natural Resources, Division of Fish and Wildlife, Section of Fisheries, Investigational Report No. 362.

Figure 1 Prairie Island creel survey study area

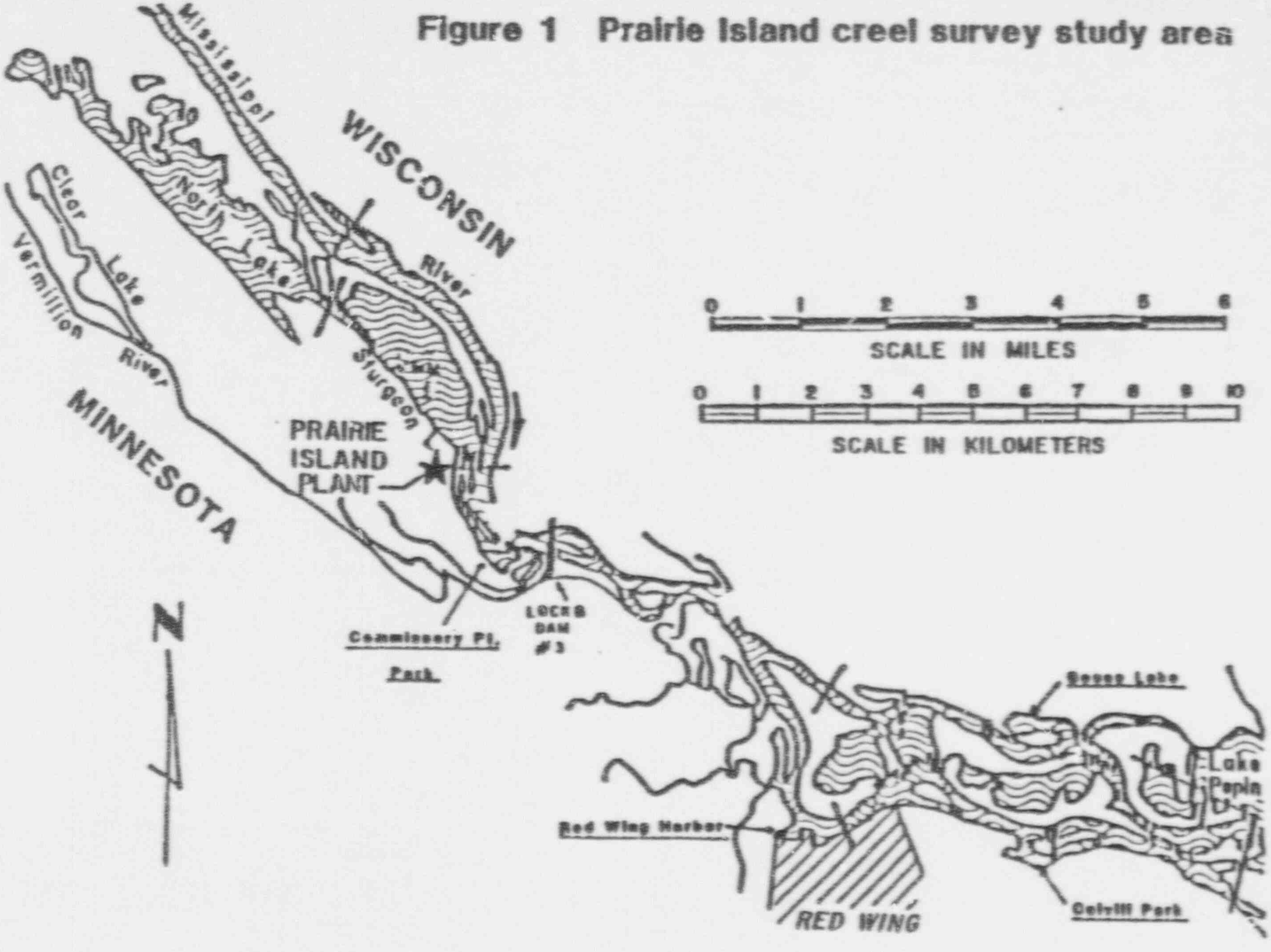


Figure 2 ESTIMATED OPEN WATER FISHING PRESSURE MARCH and APRIL, 1968-1987

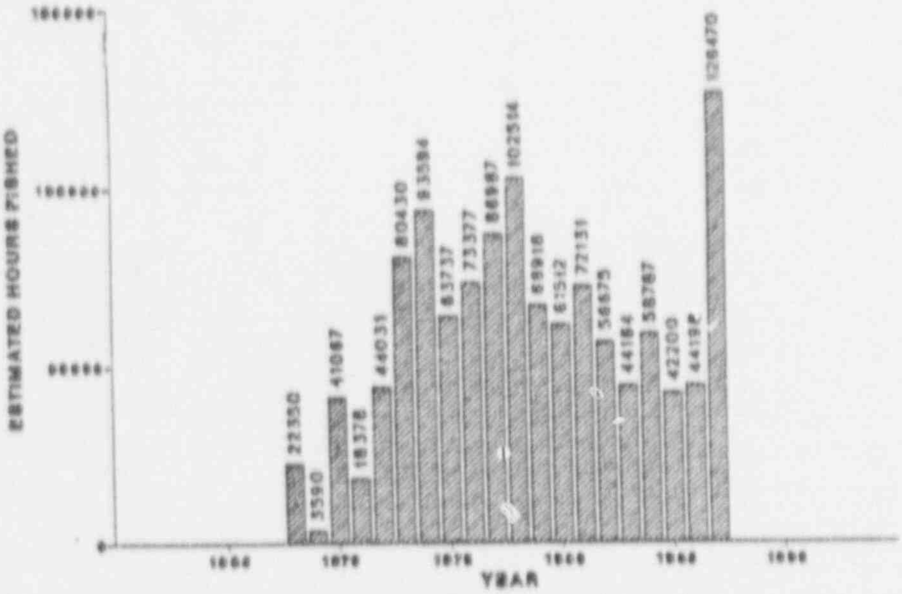


Figure 3 ESTIMATED OPEN WATER FISHING PRESSURE DEC-FEB and MAR-APR, 1981-1987

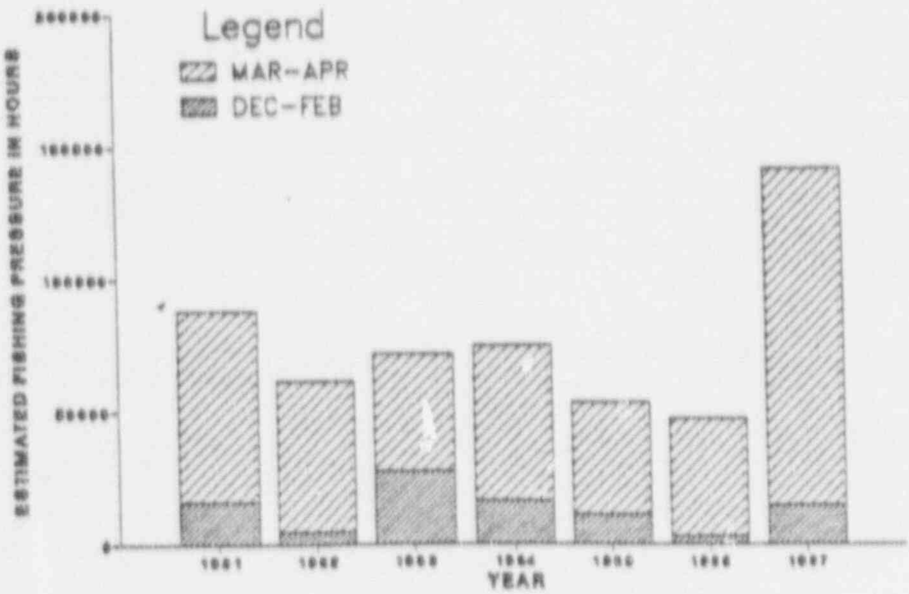


Figure 4
DISTRIBUTION OF ESTIMATED FISHING PRESSURE IN THE PINGP VICINITY, 1982 – 1987

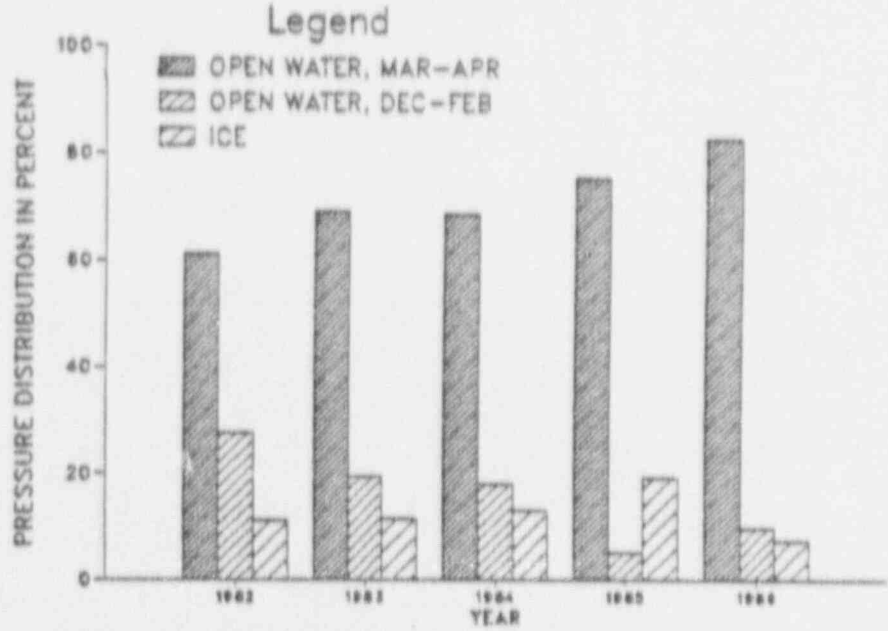


Figure 5
DISTRIBUTION OF ESTIMATED HARVEST IN THE PINGP VICINITY, 1982–1986, WALLEYE AND SAUGER COMBINED

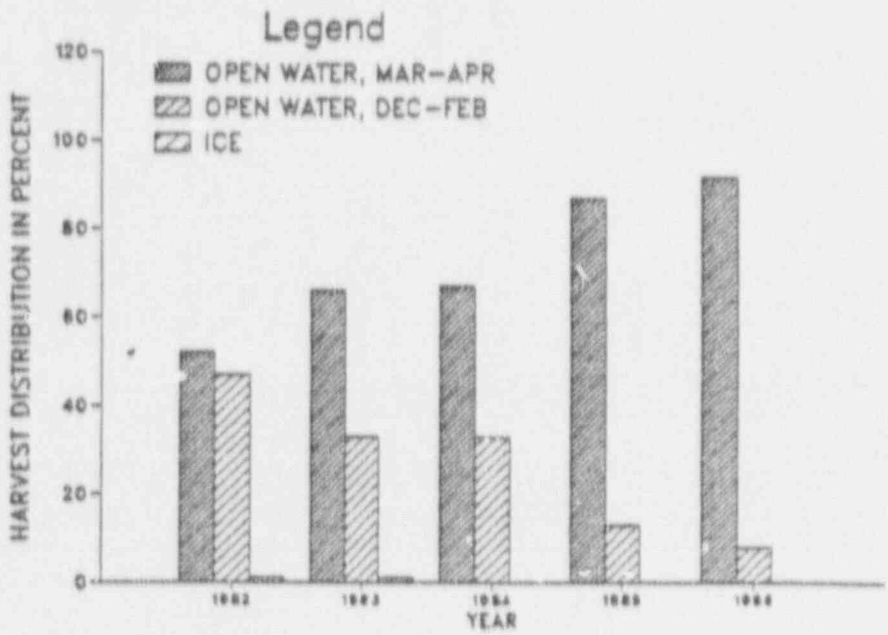
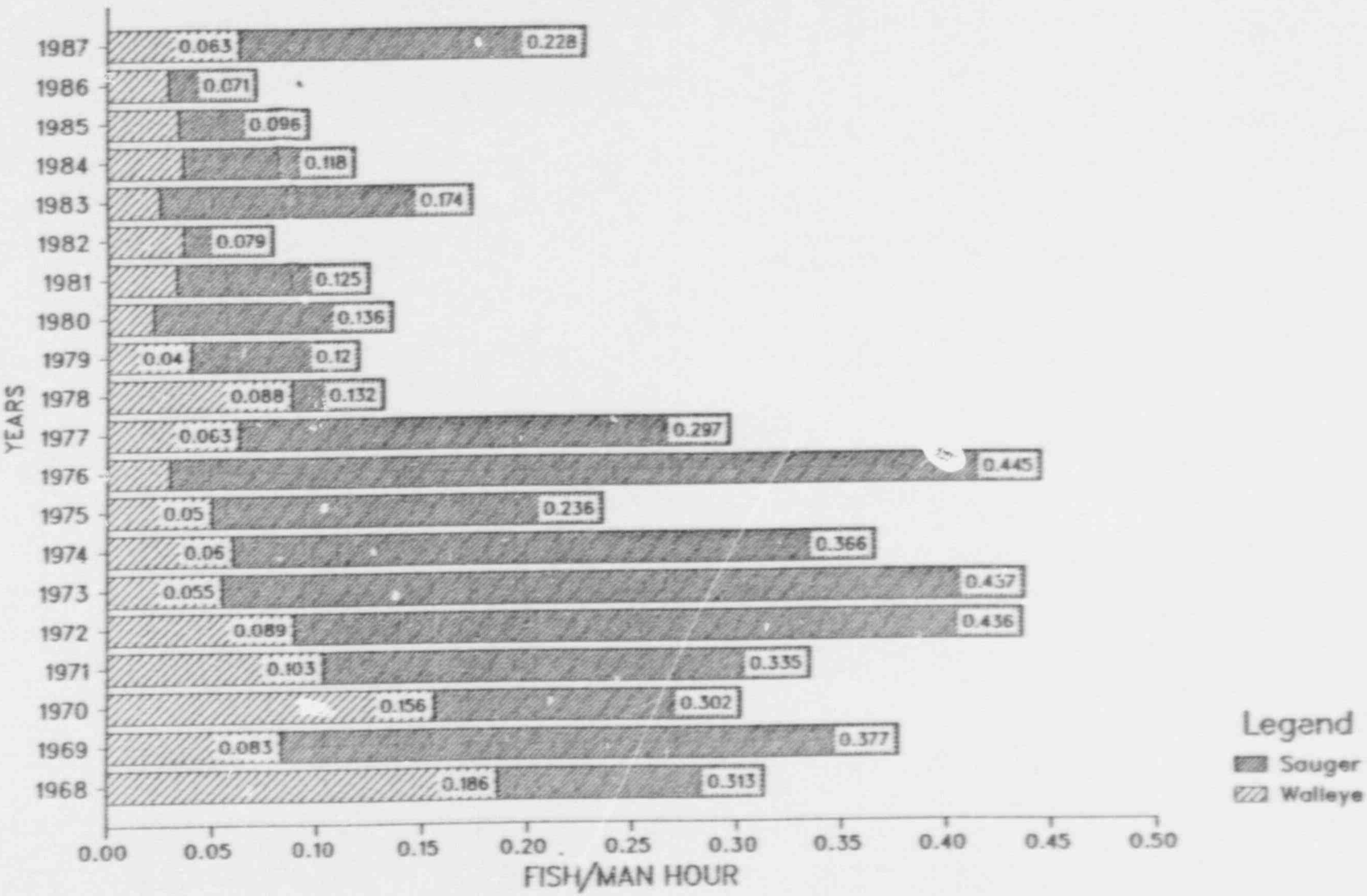


FIGURE 6

Overall catch rates for sauger and walleye during March and April in the vicinity of PINGP, 1968 through 1986 (boat and bank anglers combined).



Note: Data for years 1968 – 1982 was obtained Gustafson (1982)

Figure 7

WALLEYE LENGTH-WEIGHT REGRESSION ANALYSIS

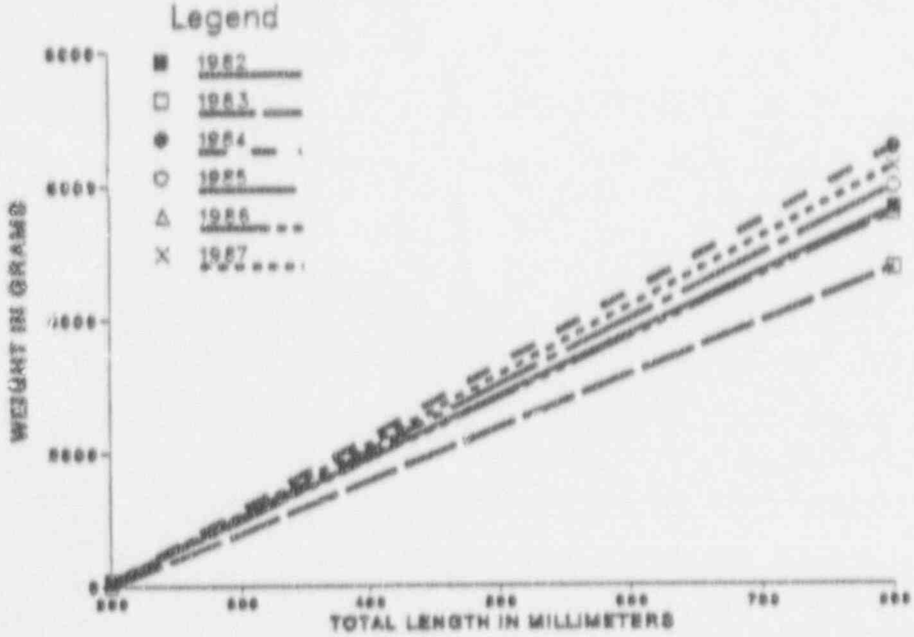


Figure 8

SAUGER LENGTH-WEIGHT REGRESSION ANALYSIS

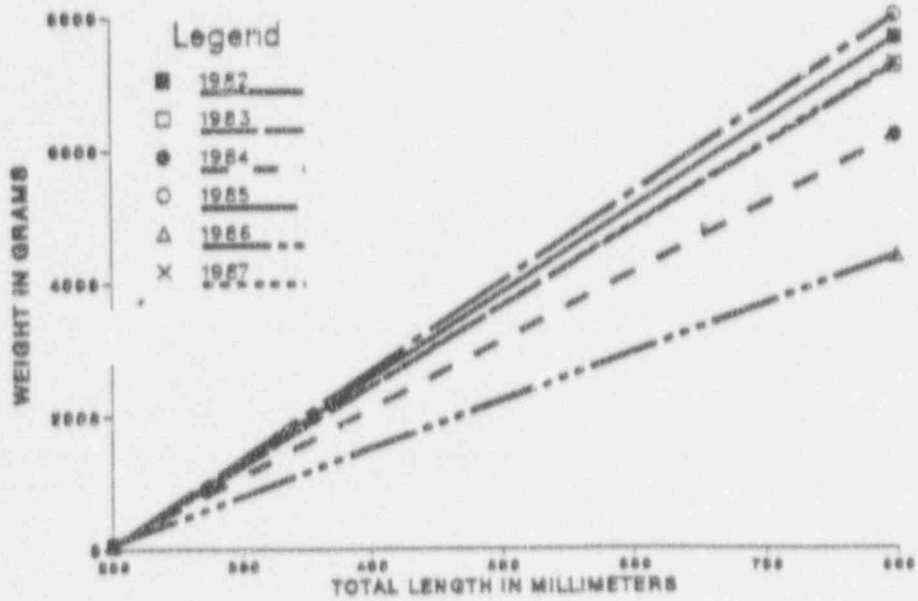


Table 1. Day of week probabilities used to schedule the access point creel survey on the Mississippi River and connecting waters near the Prairie Island Nuclear Generating Plant, Red Wing, Minnesota, December, 1986-April, 1987.*

Weekdays	Probability (%)	Random Number Range
Mon-Tue	20	00-19
Tue-Wed	20	20-39
Wed-Thur	20	40-59
Thur-Fri	20	60-79
Mon-Fri	20	80-99

Table 2. Day of week probabilities used in calculations for the access point creel survey on the Mississippi River and connecting waters near the Prairie Island Nuclear Generating Plant, Red Wing, Minnesota, December, 1986-April, 1987.*

Day	December	January-April
Saturday	30	30
Sunday	30	30
Monday	12	10
Tuesday	07	07
Wednesday	07	07
Thursday	07	07
Friday	07	09

*All numbers expressed in percent

Table 3. Starting time probabilities used to schedule the access point creel survey on the Mississippi River and connecting waters near the Prairie Island Nuclear Generating Plant, Red Wing, Minnesota, December, 1986 - April, 1987.*

Starting Time	December Probability	December Random Number Range	January Probability	January Random Number Range	February Probability	February Random Number Range	March-April Probability	March-April Random Number Range
0800	0	-	19	00-18	0	-	15	00-14
0900	15	00-14	43	19-61	05	00-04	19	15-33
1000	85	15-99	38	62-99	95	05-99	21	34-54
1100	0	-	0	-	0	-	23	55-77
1200	0	-	0	-	0	-	22	78-99

*All numbers expressed in percent

Table 4. Time probabilities used in calculations for the access point creel survey on the Mississippi River and connecting waters near the Prairie Island Nuclear Generating Plant, Red Wing, Minnesota, December, 1986-April, 1987.*

Time	December	January	February	March-April
0800-1200	15	25	-	13
0900-1300	25	31	27	20
1000-1400	30	38	41	25
1100-1500	-	-	-	37
1200-1600	47	54	-	40
1300-1700	60	61	59	47
1400-1800	68	56	57	54
1500-1900	-	-	-	57
1600-2000	-	-	-	47

*All numbers expressed in percent

Table 5. Station probabilities used to schedule the access point creel survey on the Mississippi River and connecting waters near the Prairie Island Nuclear Generating Plant, Red Wing, Minnesota, December, 1986 - April, 1987.*

Stations	Open Water Only	Open Water & Ice Edgewater Open	Open Water & Ice Edgewater Frozen	Ice Only December-January	Ice Only February	Open Water & Ice Edgewater Frozen	Open Water & Ice RW Harbor Frozen	Open Water Only
Evert's Resort	67	50	56	-	-	60	34	18
Barb's Resort						14	09	06
Edgewater	33	23	-	-	-	08	50	27
Red Wing Harbor	-	09	20	36	72	13	03	35
Colvill Park	-	08	02	-	-	-	-	10
Goose Lake	-	10	22	64	28	04	03	-
Levee	-	-	-	-	-	-	-	03

Table 6. Station probabilities used in calculations for the access point creel survey on the Mississippi River and connecting waters near the Prairie Island Nuclear Generating Plant, Red Wing, Minnesota, December, 1986 - April, 1987.*

Stations	Open Water Only	Open Water & Ice Edgewater Open	Open Water & Ice Edgewater Frozen	Ice Only December-January	Ice Only February	Open Water & Ice Edgewater Frozen	Open Water & Ice RW Harbor Frozen	Open Water Only
Evert's Resort	67	68	1	-	-	73	37	18
Barb's Resort						17	10	06
Edgewater	33	32	-	-	-	10	53	27
Red Wing Harbor	-	35	45	36	72	76	50	36
Colvill Park	-	30	05	-	-	-	-	10
Goose Lake	-	35	50	64	28	24	50	-
Levee	-	-	-	-	-	-	-	03

*All numbers expressed in percent

TABLE 7. ACTUAL FISH HARVEST (WINTER CREEL 1986-1987)

	DEC		JAN		FEB		MAR	APR	
	BOAT	ICE	BOAT	ICE	BOAT	ICE	BOAT	BOAT	TOTAL
INT. ANGLERS	78	82	66	62	562	13	1676	897	3436
HOURS FISHED	330.75	285.5	345.25	290.5	2947.7	57	9965.5	5312	19534.2
WALLEYE	23	0	24	0	152	1	660	310	1170
SAUGER	116	0	86	0	370	0	2905	661	4138
CRAPPIE	0	44	0	4	3	0	101	61	213
WB	0	0	0	0	16	0	7	341	364
NP	4	0	0	3	14	2	20	16	59
TOTAL	143	44	110	7	555	3	3693	1389	5944

TABLE 8. ESTIMATED HARVEST AND PRESSURE
OPEN WATER AND ICE ANGLERS (1986-1987)

	DEC	JAN	FEB	MAR	APR	TOTAL
EST HOURS	6524	6538	13183	85870	40690	152715
WALLEYE	136	103	617	5687	2369	8912
SAUGER	686	371	1435	25032	5052	32575
CRAPPIES	703	70	12	870	466	2121
WHITE BASS	0	0	57	60	2606	2723
N. PIKE	24	50	115	172	122	483
TOTAL	1549	594	2236	31822	10615	46815

TABLE 9. ESTIMATED HARVEST AND PRESSURE FOR BOAT ANGLERS (1986 - 1987)

	DEC	JAN	FEB	MAR	APR	TOTAL
EST HOURS	1956	1488	11428	85870	40600	141342
WALLEYE	136	103	[illegible]	5687	2369	8884
SAUGER	686	371	1435	25032	5052	32575
CRAPPIE	0	0	12	870	466	1348
WB	0	0	57	60	2606	2723
NP	24	0	54	172	122	372
TOTAL	846	474	2147	31822	10615	45903

TABLE 10. CATCH RATES FOR BOAT AND ICE ANGLERS (1986 - 1987)

	DEC		JAN		FEB		MAR	APR	AVG	
	BOAT	ICE	BOAT	ICE	BOAT	ICE	BOAT	BOAT	BOAT	ICE
WALLEYE	0.070	0.000	0.070	0.000	0.052	0.017	0.066	0.058	0.063	0.006
SAUGER	0.351	0.000	0.249	0.000	0.126	0.000	0.292	0.124	0.228	0.000
CRAPPIE	0.000	0.154	0.000	0.014	0.001	0.000	0.010	0.011	0.005	0.056
WB	0.000	0.000	0.000	0.000	0.005	0.000	0.001	0.064	0.014	0.000
NP	0.012	0.000	0.000	0.010	0.005	0.035	0.002	0.003	0.004	0.015
TOTAL	0.432	0.154	0.319	0.024	0.188	0.052	0.371	0.261	0.314	0.077

TABLE 11. ESTIMATED HARVEST BY SPECIES PER YEAR. BOAT AND ICE FISHING COMBINED

YEAR	1982	1983	1984	1985	1986	1987
ESTIMATED HOURS	63727	80624	85024	61603	58591	152715
N. PIKE	142	138	55	262	462	483
CHANEL CATFISH	8	27	19	48	74	-
WHITE BASS	1384	448	1311	1274	492	2723
CRAPPIES	753	3368	2547	816	1583	2121
SUAGER	5684	15022	10653	6199	3622	32575
WALLEYE	2580	2976	3345	2354	1561	8912
TOTAL	10551	21979	17930	10953	7794	55718

TABLE 12. ESTIMATED HARVEST BY SPECIES PER YEAR. BOAT FISHING ONLY

YEAR	1982	1983	1984	1985	1986	1987
ESTIMATED HOURS	61744	72222	75233	53482	47295	141342
N. PIKE	75	8	9	165	139	372
CHANEL CATFISH	8	27	19	48	74	-
WHITE BASS	1378	419	871	1274	492	1348
CRAPPIES	21	52	106	53	39	272*
SUAGER	5684	14933	10653	6183	3622	32575
WALLEYE	2537	2976	3277	2354	1561	8884
TOTAL	9703	18415	14935	10077	5927	141342

TABLE 13. LENGTH-WEIGHT REGRESSION ANALYSIS FOR WALLEYE AND SAUGER.

WALLEYE

		r2	N	mean Wt	mean L
1982	log Wt = 3.215*log L-5.581	0.98	64	1108	449
1983	log Wt = 2.759*log L-4.333	0.84	64	1103	453
1984	log Wt = 3.238*log L-5.583	0.94	135	986	420
1985	log Wt = 3.248*log L-5.653	0.97	51	1113	458
1986	log Wt = 3.213*log L-5.581	0.95	71	1185	469
1987	log Wt = 3.440*log L-6.189	0.92	114	1346	484

SAUGER

		r2	N	mean Wt	mean L
1982	log Wt = 3.621*log L-6.627	0.94	58	521	362
1983	log Wt = 3.525*log L-6.373	0.79	169	451	349
1984	log Wt = 3.164*log L-5.393	0.84	196	645	381
1985	log Wt = 3.682*log L-6.786	0.93	95	736	408
1986	log Wt = 2.877*log L-4.710	0.71	73	793	436
1987	log Wt = 3.653*log L-6.743	0.93	224	666	403