IOWA CONSERVATION COMMISSION

FISHERIES SECTION

COMMERCIAL FISHERIES INVESTIGATIONS

PROJECT COMPLETION REPORT

Project No. 2-255-R: Paddlefish Investigations

Period Covered: 1 April, 1975 - 30 September, 1978

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PROJECT COMPLETION REPORT

RESEARCH SEGMENT

STATE: Iowa

NAME: Paddlefish Investigations

PROJECT NO.: 2-255-R

SEGMENTS NOS.: 1-3

PERIOD COVERED: 1 April, 1975 through 30 September, 1978

ABSTRACT

Mississippi River paddlefish investigations were initiated to determine exploitation, characterize the harvest and obtain basic life history information necessary for management of the species. Over 3,000 paddlefish were examined during the study. One thousand, five hundred sixty-two were tagged and released in Pool 13. Four hundred fifty were tagged and released in other pools bordering Iowa. Estimated numerical population size was 10,807. Movement to and from the tailwater area was measured through stochastic inference and estimated to be 10-80% of the pool population. Seasonal vulnerability was related to temperature, turbidity, and discharge. Temperature accounted for 46% of the variation in catch per effort. Discharge and turbidity were significantly intra-class correlated (P < .01). Mean size of fish in the sport harvest declined 150 mm (5.9 in) and 2.33 kg (5.1 lbs). Age frequency distributions were constructed from jaw samples removed from 603 fish. Survival over the study period, sexes combined, was 63%. Recommendations for management related to existing and projected survival and exploitation rates are included.

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INTRODUCTION

Paddlefish are indigenous to Iowa and are found throughout the Mississippi and Missouri Rivers and the lower reaches of the Cedar, Des Moines, and Iowa Rivers. Formerly considered abundant throughout much of the Mississippi River Valley (Pflieger, 1975) and in some Gulf Coast drainages (Carlson and Bonislawsky, personal communication) its range has since diminished. Relict populations in the Great Lakes and Iowa natural lakes have been eliminated and viable sport and/or commercial fisheries remain prominant only within the impounded tributary rivers of the Tennessee River system, the upper portions of the Mississippi and Missouri Rivers, and the Arkansas River system. Commercial harvests from the upper Mississippi River, indicate significantly larger catches in downstream pools (unpublished Iowa commercial fishery statistics).

Regulations governing paddlefish harvest on the upper Mississippi and Missouri Rivers differ considerably between states (Appendix Tables 1 and 2). Wisconsin has placed the species on a precautionary "watch" status in their portion of the river and prohibit harvest. Paddlefish have been long considered both a sport-fish and commercial food-fish in Iowa and Illinois. Until recently, sport fishing regulations were quite restrictive and harvest was almost exclusively by commercial methods. Illinois legalized snagging in November, 1973, as a method for taking paddlefish. One year later Iowa adopted similar regulations. Legalization of snagging had the potential of increasing total harvest over the already established unrestricted commercial exploitation.

Since exploitation, harvest potential and the compatability of this species to fit into both a sport and commercial fishery was unknown, it was imperative that an investigation of these parameters be conducted. Delineation of these parameters would allow for proper management of the species.

Investigations were initiated on 1 April, 1975, in cooperation with the National Marine Fisheries Service and the Iowa Conservation Commission. Sampling terminated on 30 September, 1978.

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[1]Funds for this study were provided by the Commercial Fisheries Research and Development Act (PL88-309), Project 2-255-R, National Marine Fisheries Service and the Iowa Conservation Commission.

DESCRIPTION OF POOL 13 AND THE UPPER MISSISSIPPI RIVER

The Mississippi River is comprised of an intricate network of diverse aquatic habitats, ranging from inter-connected river lakes and ponds (Hutchinson, 1957) to the swift nagivation channel and extensive pool and tailwater area adjacent to locks and dams. From Caruthersville, Missouri, to the Chain of Rocks at St. Louis, there are no locks and dams. From this point upstream to the St. Anthony Falls Upper Harbor Project at Minneapolis, Minnesota, the river contains 28 locks and dams, maintained by the U. S. Army Corp of Engineers in conjuntion with the operation of the 2.74 m (9 ft) channel navigation project. Prior to construction of navigation dams, a 1.8 m (6 ft) navigation channel was maintained via construction of hundreds of rock and brush "wing dams". Wing dams extend perpendicular from shore and constrict the flow of the river. As an additional measure to divert water into the navigable portion of the river, major side channel exits were blocked by rock and brush "closing dams". Both types of structures were submerged by waters impounded by navigation dams. Numerous banks were stabilized from the natural processes of erosion and deposition by riprap.

Upper regions of navigation pools often contain physical features similar to those observed prior to dam construction. The lower portions of pools, however, exhibit the profound effect of impoundment caused by dam operation. The navigation channel is identified by markers, buoys, and islands of dredge spoil.

The present impounded river contains several distinctly different fish habitats. These have been identified and chronicled by the Upper Mississippi River Conservation Committee (UMRCC) Fish Technical Committee (FTS). This classification system (Appendix A) separates aquatic habitats into seven categories: tailwaters, main channel, main channel border, side channel, slough, and lake and pond.

Over 15% of the aquatic habitat in the 502.5 km (312.3 mi) segment of river bordering Iowa is found within Pool 13. It is the third largest pool completely bordered by Iowa, encompassing some 10,918 ha (26,967 ac) extended over 55 km (34.2 mi). The pool controlling point, established as elevation 177.6 m (583.0 ft) above sea level (flat pool), is located at Lock and Dam 13.

Riverbed deposits, exclusive of regulatory works, are primarily sand with lesser amounts of clay and silt and with small amounts of gravel and boulders. Alluvial floodplain deposits are primarily silt and clay soils .6-6.1 m (2-20 ft) deep overlying sand deposits. Four small rivers and eight minor streams discharge into Pool 13. Suspended sediments in these streams adds to the bed load of the Mississippi River.

At Lock and Dam 12, the upper extreme of Pool 13, the Mississippi River drains an area of 213,334 km^2 (82,400 mi^2) and has a mean daily flow of 1,262 m^3/s (44,600 cfs) (U.S. Army Corps of Engineers, 1974).

CAPTURE, HANDLING, AND TAGGING OF PADDLEFISH

Paddlefish were captured by snagging in the tailwaters of Lock and Dam 12. Snagging equipment consisted of standard heavyweight sport fishing tackle. A lead sinker was attached to the end of 11 kg (25 lb) test line. Two number 8/0 treble hooks were attached approximately 0.5 and 2.0 m (1.5 and 6.0 ft) above the sinker. Sinker weight varied from 85-230 g (3-8 oz), depending upon river conditions. Lines were fished by jigging while trolling perpendicular to the current. Snagging effort was confined to an area 30-150 m (100-300 yds) below the dam.

Additional fish were captured during the early phases of this study by drifting 30.4 x 1.8 m; 12.7 cm bar mesh (100 x 6 ft; 5 in bar mesh) nylon gill nets on the surface, in areas known to be inhabited by paddlefish. Netting occurred in two areas, 11.3 and 12.9 km (7 and 8 mi) downstream from the tailwaters. Netting at other locations, including the tailwaters, was also attempted but found to be unsuccessful. Drift netting proved undesirable as a collection method because of the lack of control of the number paddlefish captured at any one time. In one instance, 13 fish were entangled in a single drift. As a result, the last fish processed after removal was under sufficient handling stress as to lessen survival. Snagging was also found to be less size selective than gill nets.

Captured fish were measured for fork length (FL), total length (TL) and body length (BL) and weighed. Body length was an additional measurement added to the study in 1978 and refers to that distance from the anterior edge of the eye to the fork of the tail. Observations concerning severity and location of hook wounds, number of lampreys present, presence of old and new lamprey wounds, scars and other abnormalities or impairments were recorded (Appendix Tables 3 and 4). Part of the anal fin was excised as an aid in evaluating tag loss.

Jaws were removed from 604 fish for age determination. Samples were taken in navigation Pools 9, 11, 12, 13, 16, 17, 18 and 19 (Table 1). Sources of specimens included sport fishermen, commercial markets, individual commercial fishermen

Table 1. Source and location of paddlefish used for age determination, 1975-1978.

	POOL	COMMER-CIAL	SPORT	EXPERI-MENTAL	TOTAL
1975	9	1			1
	13	15	2	46	63
	16	81			81
	17	7			7
TOTAL		104	2	46	152
1976	12	4			4
	13	8	91	42	141
	16	30			30
TOTAL		42	91	42	175
1977	13	2	12	1	15
	18	102			102
TOTAL		104	12	1	117
1978	11		3		3
	13	18	70		88
	17	36			36
	18	8			8
	19	25			25
TOTAL		87	73	0	160
Combined	9	1			1
	11		3		3
	12	4			4
	13	43	175	89	307
	16	111			111
	17	43			43
	18	110			110
	19	25			25
TOTAL		337	178	89	604

and experimental fishing. All available fish representing a single source of location were sampled to reduce bias associated with selective sampling. Concomitant information included fork length, total length (body length in 1978), weight, sex, and maturity.

Methods used in age assessment were similar to those described by Adams (1942) using sectioned dentary bones. A thin vertical section was removed from the jaw lateral to the medial symphasis. Sections were magnified 60X for aging; however, no attempt was made to measure annualar increments for back-calculating growth. Sexes were analyzed separately for each year and all years combined.

Two yellow FD68B Floy anchor tags having a 3 cm (1.2 in) shank and a 5 cm (3.0 in) spaghetti were inserted into the dorsal surface of the rostrum at approximately a 45 degree angle using a modified FD68 Dennison gun. Tags were serially numbered and affixed with the identification "IA CONS COMM". Captured fish were examined, tagged and released within two minutes of landing.

Postage-paid postcards requesting pertinent information were distributed to commercial fishermen, wholesale fish markets and landings, and bait and tackle shops in the area. Fishermen observed snagging were also provided with cards. Public awareness of the study and the importance of reporting tags was further promulgated through extensive media contact.

ABUNDANCE OF THE POPULATION

Estimation of paddlefish population abundance was necessary for understanding basic changes in numerical population size, composition and as a basis for proper management of the species. To accomplish this objective, indirect methods of estimation were employed in combination. This facilitates error reduction and allows adequate adjustment for seasonal aggregation and dispersal behavior patterns exhibited by the population.

ESTIMATES OF NUMERICAL POPULATION SIZE

Mark and recapture data from a continuous marking experiment extending over 40 months were used for purposes of obtaining numerical estimates. The use of serially numbered tags provided flexibility in the treatment of data.

Rickers (1975) modification of Chapmans (1951) version of an adjusted Petersen estimate,

$$N = \frac{(M + 1)\ (C + 1)}{R + 1}$$

where $\hat{N}$ = estimated number of fish in the population,
M = number of fish marked and released,
C = number of fish in the recapture sample,
R = number of recaptured marked fish,

was used as the estimator. This estimate is interpreted to be for the entire pool and estimates the numerical size of the population at the time of marking. To obtain an unbiased estimate of the population size (Robson and Regier, 1964) only those time intervals in which MC was greater than $4\hat{N}$ and the number of recaptures where 3 or more were used. The probability of statistical bias in this case is < 2% (Robson and Regier in Ricker 1968) and is of no practical significance. Nine sampling intervals met these criteria. Of these, the February/ March, 1976; February/March, 1977, interval was most reliable because it allowed for the maximum dispersion of marked fish within the population. Since the observed ratio of M to $\hat{N}$ was < .01, fiducial limits were calculable in a Poisson distribution.

The paddlefish population estimate in Pool 13 during February and March, 1976 was $\hat{N}$ = 10,807 with 95% confidence intervals of 4,411 to 27,018. The other, statistically unbiased, time intervals yielded more restricted fiducial limits but were not considered to be the best population estimate because the interval from marking to recapture was inadequate for uniform dispersion of marked fish.

TIME SPECIFIC ABUNDANCE INDICIES

Catch per unit effort (c/f) was defined as the number of paddlefish caught and landed in each pole hour of effort for all fishing effort expended by experimental snagging (Table 2) and as the number of paddlefish captured per gill net drift (Table 2). Catch per effort allowed assessment of changes in seasonal density and vulnerability to capture. One thousand seven hundred-nine pole hours of snagging resulted in the capture of 2,055 paddlefish larger than 40 cm (15.7) FL. Sixty-five fish were captured in 33 drifts. Highest c/f of paddlefish was attained during late fall and winter, November-March (Figure 1 and Appendix Table 5). Low c/f values for paddlefish were common during spring and summer months. High c/f values may be attributed to aggregate behavior and the subsequent increase in vulnerability. Inconsistent changes in c/f values within and between summer months suggests frequent mass movement in relationship to the tailwater area. In addition to paddlefish, 285 fish representing 16 species were also snagged during experimental fishing (Table 3). Sixty-one percent were channel catfish of which 72% were snagged in a single four month period.

NUMERICAL ESTIMATE OF TIME SPECIFIC ABUNDANCE

The magnitude of movement and its effects on population

Table 2. Catch per effort for paddlefish captured by snagging in the tailwaters of Lock and Dam 12 and by drifting entanglement gear in Pool 13, 1975-1978.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1975													
Pole hours of effort			21	65	11	36	65	53	41	62	41	18	41
Fish captured			10	64	2	26	37	61	10	61	55	60	39
Catch per effort			.47	.98	.18	.72	.56	1.15	.24	.98	1.34	3.33	.99
Number of drifts					2	7	3		2				3.5
Fish captured					27	35	0		2				16
Catch per effort					13.50	5.00	0		1.00				4.88
1976													
Pole hours of effort	21	18	24	11	72	32	46	88	31	36	28	19	36
Fish captured	68	70	86	7	24	69	45	25	27	57	53	54	49
Catch per effort	3.23	3.88	3.58	.63	.33	2.15	.97	.28	.87	1.58	1.89	2.84	1.85
Number of drifts				8	8				3				6
Fish captured				0	1				0				.33
Catch per effort				0	.12				0				.04
1977													
Pole hours of effort	10	13	75	39	44	31	126	133	75	38	70	27	57
Fish captured	10	56	371	26	52	50	45	51	32	55	58	56	72
Catch per effort	1.00	4.30	4.94	.66	1.18	1.61	.35	.38	.42	1.44	.82	2.07	1.60
1978													
Pole hours of effort	25	IC[1]	117	44	NS[2]	3							47
Fish captured	71	IC	118	32	NS	1							56
Catch per effort	2.84	IC	1.00	.72	NS	.33							1.22

[1]Ice cover.

[2]Not sampled.

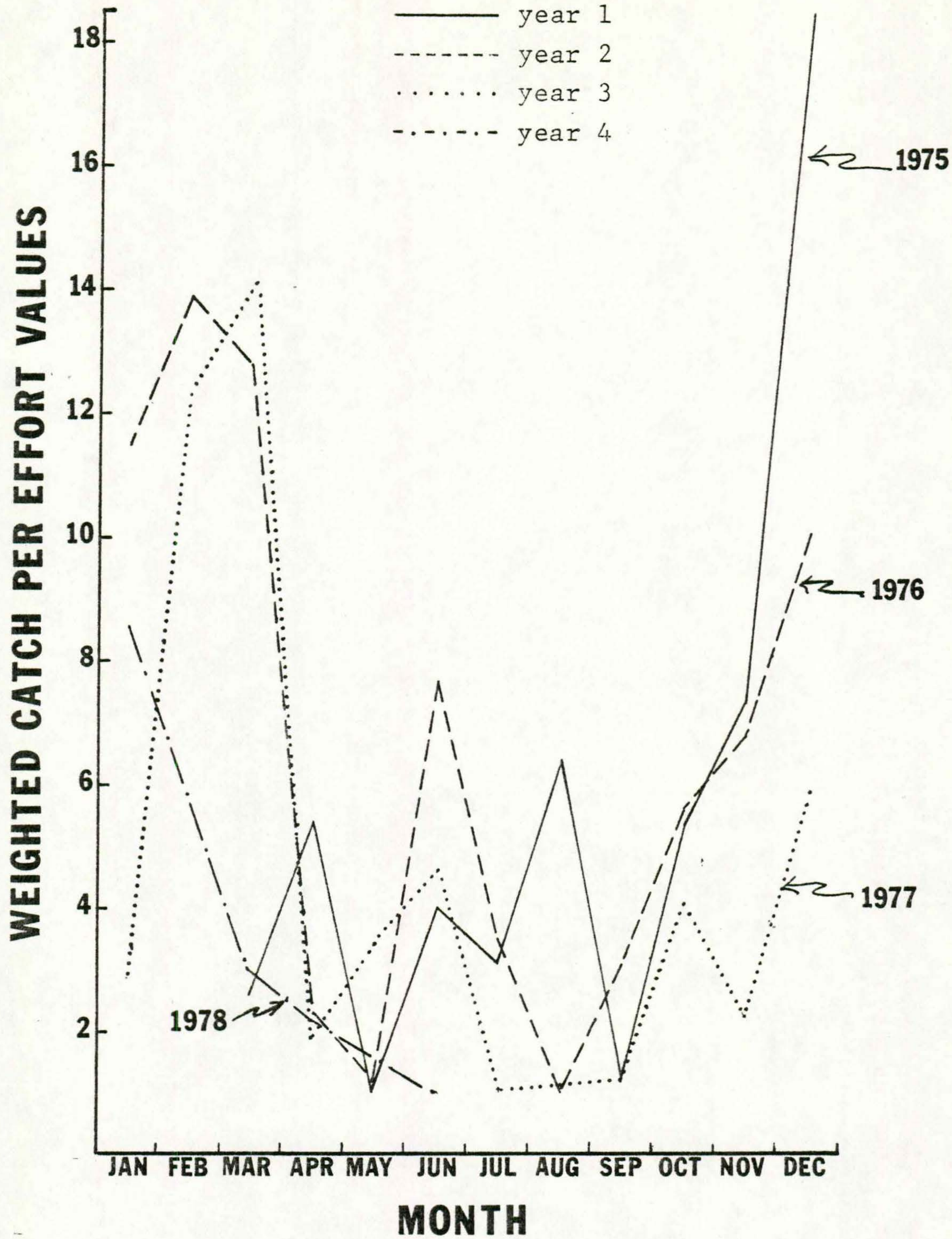

Figure 1. Weighted catch per effort values, by month, for paddlefish captured by snagging in the tailwaters of Lock and Dam 12, 1975-1978.

Table 3. Fish, other than paddlefish, snagged while experimental fishing during 1975-1978.

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Channel catfish	9		4	5	12	3	7	29	46	9	24	25	173
River redhorse				3	1								4
Sauger				1		1	1				1		4
Flathead catfish				1	5		5	5	2				18
Walleyed pike				3	2								5
Smallmouth buffalo				1	2	4	3	5	2	2	4		23
River shiner					1								1
Mooneye	1		2	1	2	8	4			1	1	2	22
White bass						1							1
Freshwater drum				1	2	2	4	2	1				12
Quillback carpsucker			1		1		2						4
Carp							1						1
Shovelnose sturgeon					3			2	1	1			7
Long nosed gar						1		2					3
Gizzard shad					1	2	1			3			7
TOTALS	10		7	16	32	22	28	45	52	16	30	27	285

density within specific time intervals was estimated by the stochastic model of Seber (1965) and Jolly (1965). This estimator is most appropriate in this case not because of its treatment of variable survival rates but rather because it allows for treatment of fluctuations in density inherent in populations which exhibit aggregation and dispersal behavior patterns such as those exhibited by paddlefish. Newly marked fish and fish examined for marks and recaptures were displayed in a 40 x 40 sampling array period using the following notation:

TIME	FISH NEWLY MARKED	FISH EXAMINED FOR MARKS	RECAPTURES OF FISH MARKED AT TIME 1	TIME 2	TIME 3	TIME 4	TOTAL	K
1	M_1	---	---	---	---	---	---	
2	M_2	C_2	R_{12}	---	---	---	M_2	$K_2=R_{13}+R_{14}+R_1$
3	M_3	C_3	R_{13}	R_{23}	---	---	M_3	$K_3=R_{14}+R_{1n}+R_{24}+R_{2n}$
4	M_4	C_4	R_{14}	R_{24}	R_{34}	---	M_4	$K_4=R_{1n}+R_{2n}+R_{3n}$
$:_n$	M_n	C_n	R_{1n}	R_{2n}	R_{3n}	R_{4n}	M_n	
TOTAL	---	---	R_1	R_2	R_3	R_n		

Estimates were derived from expressions (5.17) and (5.18) of Ricker (1975). There is no general formula for estimating variance in Seber-Jolly estimates. Using the estimates in which the observed number of recaptures, R or M, were 4 or larger, indicates that during one month time intervals, 10-80% of the pool population may be found in the tailwater area. Estimates from this procedure ranged from 1,175-8,873.

RELATIONSHIP OF CATCH PER EFFORT TO ENVIRONMENTAL VARIABLES.

Temperature, turbidity, and river discharge (Figures 2 and 3) were tested for their relationship to catch per effort. Discharge data were provided by G. E. Johnson, Chief of Hydraulics, U.S. Army Corp of Engineers, Rock Island District. All parameters (Appendix Tables 6 and 7) were tested for normality and subsequently transformed to $\log_e x$.

The independent variables were tested for intra-class correlation. Discharge and turbidity were significantly ($P < .01$) intra-class correlated (Table 4).

Catch per effort was then regressed on temperature, turbidity, and discharge and all combinations of the independent variables. Regressions were formated as simple

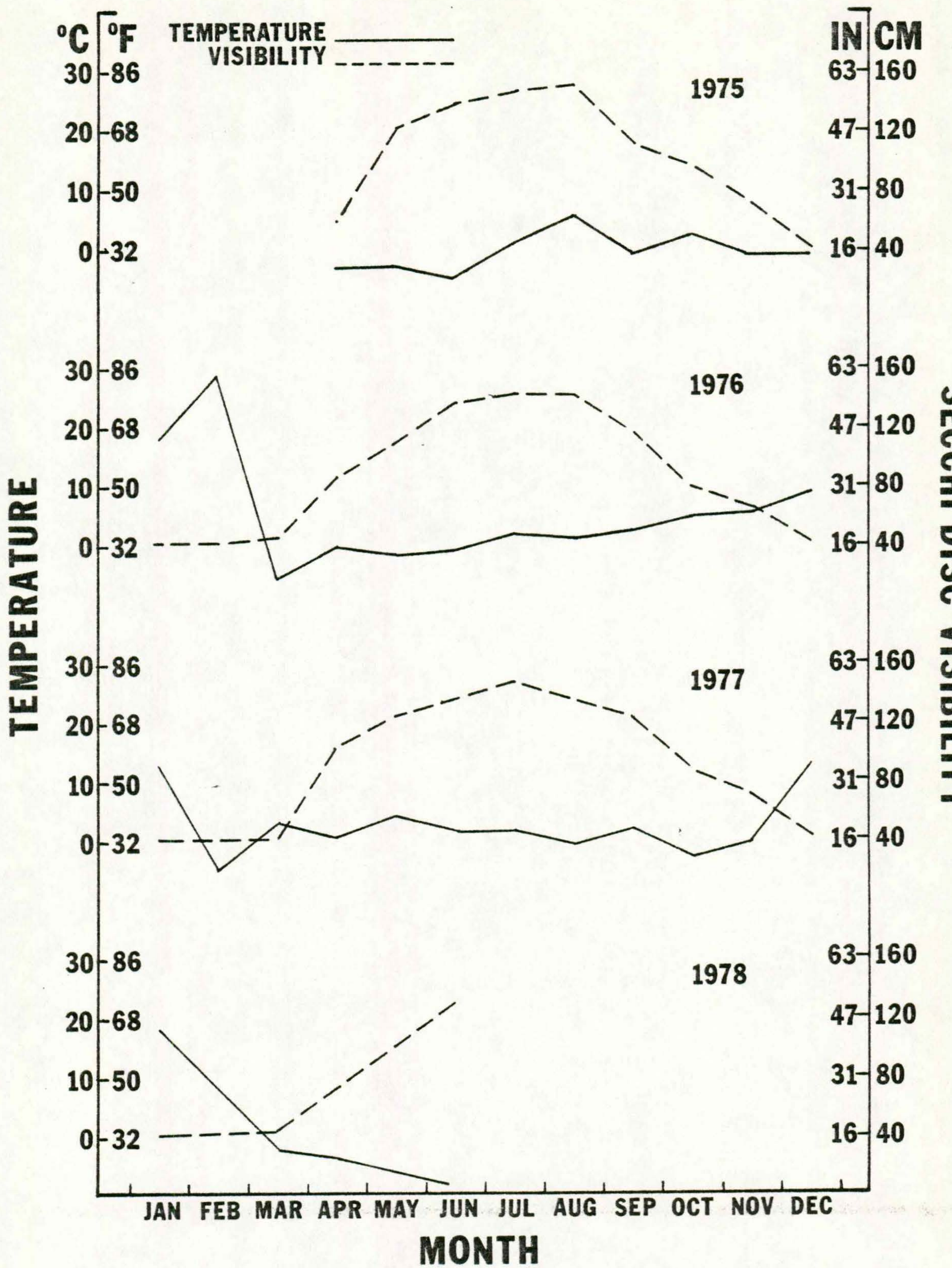

Figure 2. Secchi disc visibility and temperature in the tail-waters of Lock and Dam 12, 1975-1978. Monthly values are means of sample measurements.

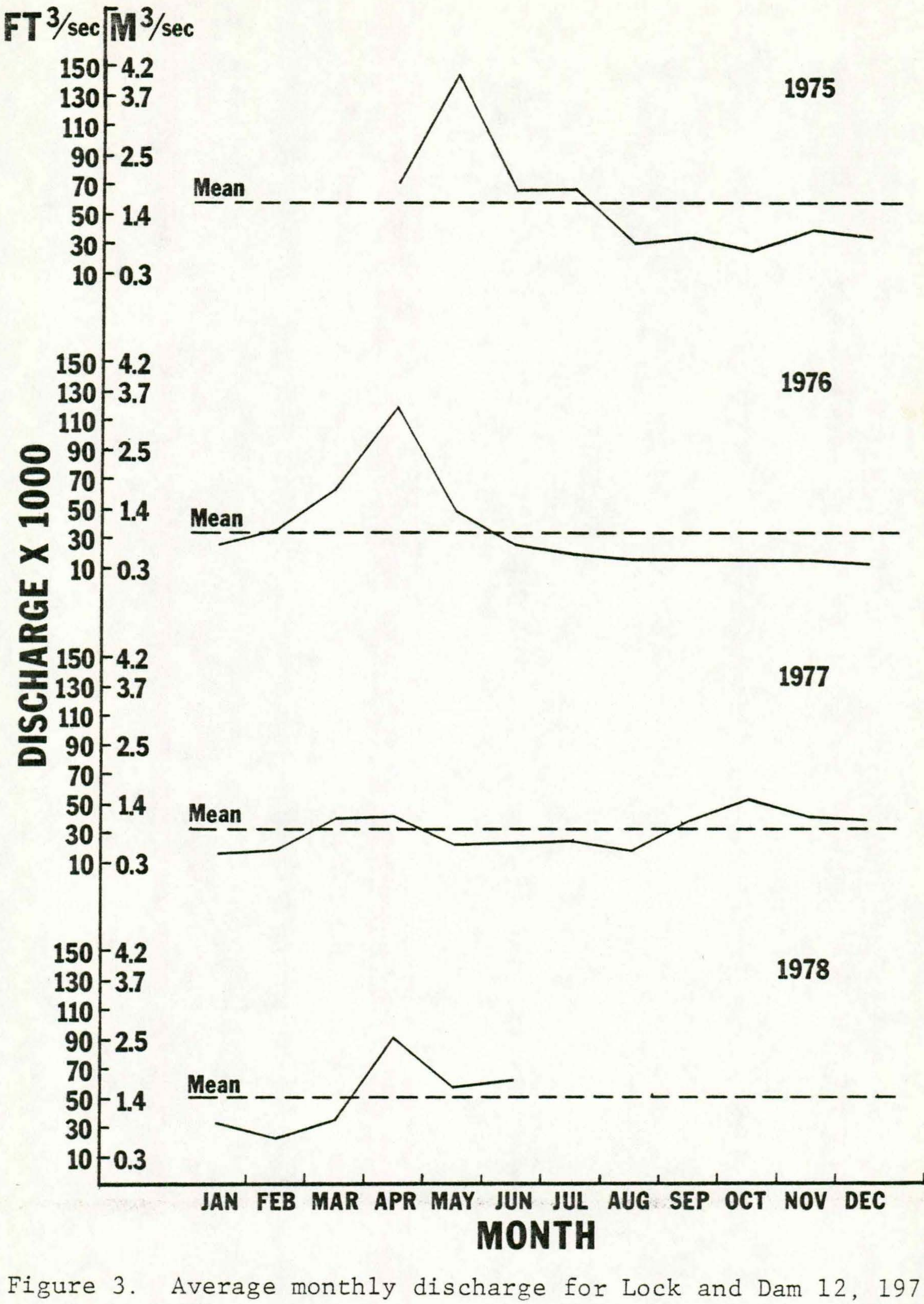

Figure 3. Average monthly discharge for Lock and Dam 12, 1975-1978.

Table 4. Simple product moment intra-class correlation between environmental variables.

	TEMPERATURE	TURBIDITY	DISCHARGE
Temperature	1.00		
Turbidity	.30	1.00	
Discharge	.06	- .45[1]	1.00

[1]Significant at the 99% level

Table 6. Estimates of annual exploitation rate of paddlefish in Pool 13, separated by method of exploitation and fish size, 1975-1978. Estimates based upon actual number of tag returns.

YEAR	METHOD OF EXPLOITATION	EXPLOITATION	EXPLOITATION RATE SEPARATED BY SIZE	
			$<$ 900 mm ($<$ 35 in)	$\leq$ 900 mm ($\leq$ 35 in)
1975	Sport	.04	.02	.06
	Commercial	.02	.02	.02
	Combined	.06	.04	.08
1976	Sport	.06	.03	.08
	Commercial	.01	.00	.01
	Combined	.07	.03	.09
1977	Sport	.07	.05	.09
	Commercial	.01	.02	.01
	Combined	.08	.06	.10
1978	Sport	.03	.03	.04
	Commercial	.01	.00	.00
	Combined	.04	.02	.04
MEAN	Sport	.05	.03	.06
	Commercial	.01	.01	.01
	Combined	.06	.00	.07

Table 7. Estimates of monthly exploitation rates of paddlefish in Pool 13, 1975-1978.

YEAR	METHOD OF EXPLOITATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1975	Sport				.0208		.0151	.0109	.0363			.0120	
	Commercial						.0075	.0218	.0090				
	Combined				.0208		.0226	.0327	.0453			.0120	
1976	Sport		.0165	.0206	.0018		.0228	.0076	.0029	.0042	.0026	.0024	
	Commercial		.0020	.0056			.0081				.0013		
	Combined		.0185	.0262	.0018		.0309	.0076	.0029	.0042	.0039	.0024	
1977	Sport		.0021	.0589	.0070	.0038	.0054	.0026		.0008	.0039	.0007	.0036
	Commercial		.0076		.0040		.0009		.0025				.0014
	Combined		.0097	.0589	.0110	.0038	.0063	.0026	.0025	.0008	.0039	.0007	.0050
1978	Sport	.0042		.0204	.0064	.0006	.0019	.0006					
	Commercial	.0007			.0038	.0006			.0006				
	Combined	.0049		.0204	.0102	.0012	.0019	.0006	.0006				

voluntary tag returns (Table 8) in relation to number of fish marked and released. Exploitation was calculated from the equation,

$$\mu = \frac{R}{M}$$

where μ = exploitation rate,
R = number of tag returns or number of recaptured marked fish,
M = number of marked fish released into the population.

An estimate of the tag loss rate was obtained from the ratio of tag retentions among recovered fish which were both tagged and fin clipped. There was no incidence of both tags being lost until 1977. During 1977 and 1978 estimated tag loss was 2.9% and 2%, respectively. Over the entire study observed tag loss was less than 2%. Approximately 24% of the anal fin was excised. It is therefore unlikely that this procedure would alter individual fish behavior.

The fraction of fishermen returning tags was estimated by the simple linear relationships of total mortality on fishing mortality. The reciprocal of the regression slope (1/b) provided an estimate of the percent of tags returned from tagged fish which were caught (Youngs, 1974). Over the three year period (1975-1977) 46% of the sport fishermen returned tags from tagged fish which they caught. Sixteen percent of the commercial fishermen returned tags from tagged fish which they caught. Tags from larger fish were more likely to be returned than tags from smaller fish, 57% as compared to 37%.

Using these estimates, the number of reported tag returns were proportionately expanded and these values substituted into the equation for calculating exploitation rates to provide a more realistic estimate of the exploitation in Pool 13 (Table 9). Values obtained in this manner were 7-14% for sport fishing, 4-12% for commercial fishing and 11-22% combined.

Annual catch reports submitted by commercial fishermen was another method of estimating commercial exploitation. Mean weight observed in the catch during each year was divided into the reported total harvest for that same year. This quotient was divided by the estimated numerical population size, therefore providing an estimate of exploitation (Table 9). Mean values for annual commercial exploitation varied by $< 1\%$.

Exploitation rates in pools other than Pool 13 were similar to the empirical estimates for Pool 13 (Table 10). The mean of the values for 9 pools was 5%. Exploitation decreased in downstream pools.

CHARACTERISTICS OF THE REPORTED AND SIMULATED HARVEST

Bias of harvest characteristics was minimized by comparing

Table 8. Paddlefish tag returns separated by month and source, 1975-1978.

SOURCE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Sport	6	10	99	19	5	25	11	10	4	7	7	5	208
Experimental	19	6	55	7	1	3	4	2	5	8	13	13	136
Commercial	1	8	3	10	1	7	4	6		1		2	43
Found dead					1	1							2
TOTALS	26	24	157	36	8	36	19	18	9	16	20	20	389

Table 10. Estimates of paddlefish exploitation in nine pools during 1975-1978.

POOL	EXPLOITATION SPORT	COMMERCIAL	COMBINED
10	0	.06	.06
11	.04	.04	.08
12	.02	.06	.08
14	.02	0	.02
16	.04	.04	.08
17	.06	.04	.10
18	.02	0	.02
19	0	0	0
20	0	.02	.02
MEAN	.02	.03	.05

Table 11. Mean length and weight at time of tagging, estimated age and mean time at large separated by source of paddlefish which were tagged and recaptured in Pool 13, 1975-1978.

	SPORT, N[1] = 202					COMMERCIAL, N[1] = 36					SIMULATED, N[1] = 137				
YEAR	SAMPLE SIZE	LG mm (in)	WT kg (lbs)	ESTIMATED AGE	TIME AT LARGE	SAMPLE SIZE	LG mm (in)	WT kg (lbs)	ESTIMATED AGE	TIME AT LARGE	SAMPLE SIZE	LG mm (in)	WT kg (lbs)	ESTIMATED AGE	TIME AT LARGE
1975	16	1,065 (41.9)	7.79 (17.2)	8	52	6	918 (36.1)	4.68 (10.3)	6	80	9	994 (39.1)	6.24 (13.8)	7	109
1976	45	1,026 (40.4)	6.44 (14.2)	7	166	7	900 (39.0)	5.38 (11.9)	7	146	20	989 (38.9)	5.96 (13.1)	7	177
1977	91	949 (37.4)	5.55 (12.2)	7	162	17	816 (32.1)	3.07 (6.8)	4	192	65	869 (34.2)	4.51 (9.9)	6	200
1978	50	915 (36.0)	5.46 (12.0)	6	179	6	978 (38.5)	6.13 (13.5)	7	280	42	922 (36.3)	5.13 (11.3)	6	215
GRAND MEAN		975	5.90	7	140		901	4.40	6	180		931	5.01	6	195

[1]Total sample size.

Table 12. Mean length and weight, by age class, of paddlefish examined in conjunction with life history investigations, 1975-1978.

AGE	SAMPLE SIZE	RANGE FORK LENGTH (mm/in)	MEAN (mm/in)	STANDARD DEVIATION (mm/in)	WEIGHT (kg/lb)	MEAN (kg/lb)	STANDARD DEVIATION (kg/lb)
1	4	438 - 551 / 17.2 - 21.7	498.3 / 19.6	48.9 / 1.9	.25 - .63 / .30 - 1.39	.47 / 1.04	.16 / .35
2	11	476 - 622 / 18.7 - 24.5	542.7 / 21.4	44.2 / 1.74	.30 - .93 / .66 - 2.05	.58 / 1.28	.19 / .41
3	111	597 - 838 / 23.5 - 33.0	740.7 / 29.2	53.5 / 2.1	.73 - 2.59 / 1.61 - 5.71	1.75 / 3.86	.42 / .93
4	95	723 - 889 / 28.4 - 35.0	828.5 / 32.6	28.6 / 1.1	1.79 - 3.63 / 3.95 - 8.00	2.62 / 5.78	.37 / .81
5	131	831 - 958 / 32.7 - 37.7	897.3 / 35.3	28.4 / 1.1	2.45 - 5.07 / 5.40 - 11.18	3.51 / 7.74	.52 / 1.14
6	46	889 - 1041 / 35.0 - 41.0	970.0 / 38.2	30.9 / 1.2	3.78 - 5.55 / 8.33 - 12.24	4.64 / 10.23	.42 / .93
7	68	889 - 1086 / 35.0 - 42.8	1014.1 / 39.9	37.2 / 1.5	3.17 - 6.88 / 7.00 - 15.17	5.81 / 11.42	.82 / 1.82
8	40	1016 - 1282 / 40.0 - 50.5	1086.1 / 42.8	44.5 / 1.75	4.53 - 9.82 / 9.99 - 21.65	7.38 / 16.27	.91 / 2.00
9	16	1035 - 1257 / 40.7 - 49.5	1149.8 / 45.3	60.6 / 2.39	7.10 - 11.58 / 15.65 - 25.53	8.90 / 19.62	1.15 / 2.53
10	12	1111 - 1264 / 43.7 - 49.8	1180.4 / 46.47	44.7 / 1.76	7.88 - 14.50 / 17.37 - 31.97	10.25 / 22.60	1.53 / 3.37
11	7	1130 - 1282 / 44.5 - 50.5	1201.6 / 47.3	39.3 / 1.55	11.20 - 13.20 / 24.69 - 29.10	12.34 / 27.21	.78 / 1.71
12	5	1181 - 1295 / 46.5 - 51.0	1246.8 / 49.1	59.7 / 2.4	12.10 - 20.15 / 26.68 - 44.42	14.64 / 32.28	3.19 / 7.02
13	3	1263 - 1295 / 49.7 - 51.0	1284.3 / 50.6	18.5 / .73	16.95 - 17.65 / 37.37 - 38.91	18.3 / 40.34	1.59 / 3.50
14	4	1327 - 1365 / 52.2 - 53.7	1350.8 / 53.2	16.7 / .66	14.50 - 15.47 / 31.97 - 34.11	15.04 / 33.16	.49 / 1.09
15	2	1390 - 1397 / 54.7 - 55.0	1397.5 / 54.9	5.0 / .2	19.45 - 21.25 / 42.88 - 46.85	20.35 / 44.86	1.27 / 2.81
16	4	1359 - 1447 / 53.5 - 57.0	1403.0 / 55.2	36.3 / 1.4	17.20 - 21.15 / 37.92 - 46.63	19.23 / 42.39	1.63 / 3.59
17	2	1435 - 1441 / 56.5 - 56.7	1438.0 / 56.6	4.2 / .16	21.65 - 21.80 / 47.73 - 48.06	21.72 / 47.88	.11 / .23
18	4	1391 - 1562 / 54.8 - 61.5	1485.6 / 58.5	76.2 / 3.0	20.30 - 24.80 / 44.75 - 54.67	22.86 / 50.40	1.89 / 4.17

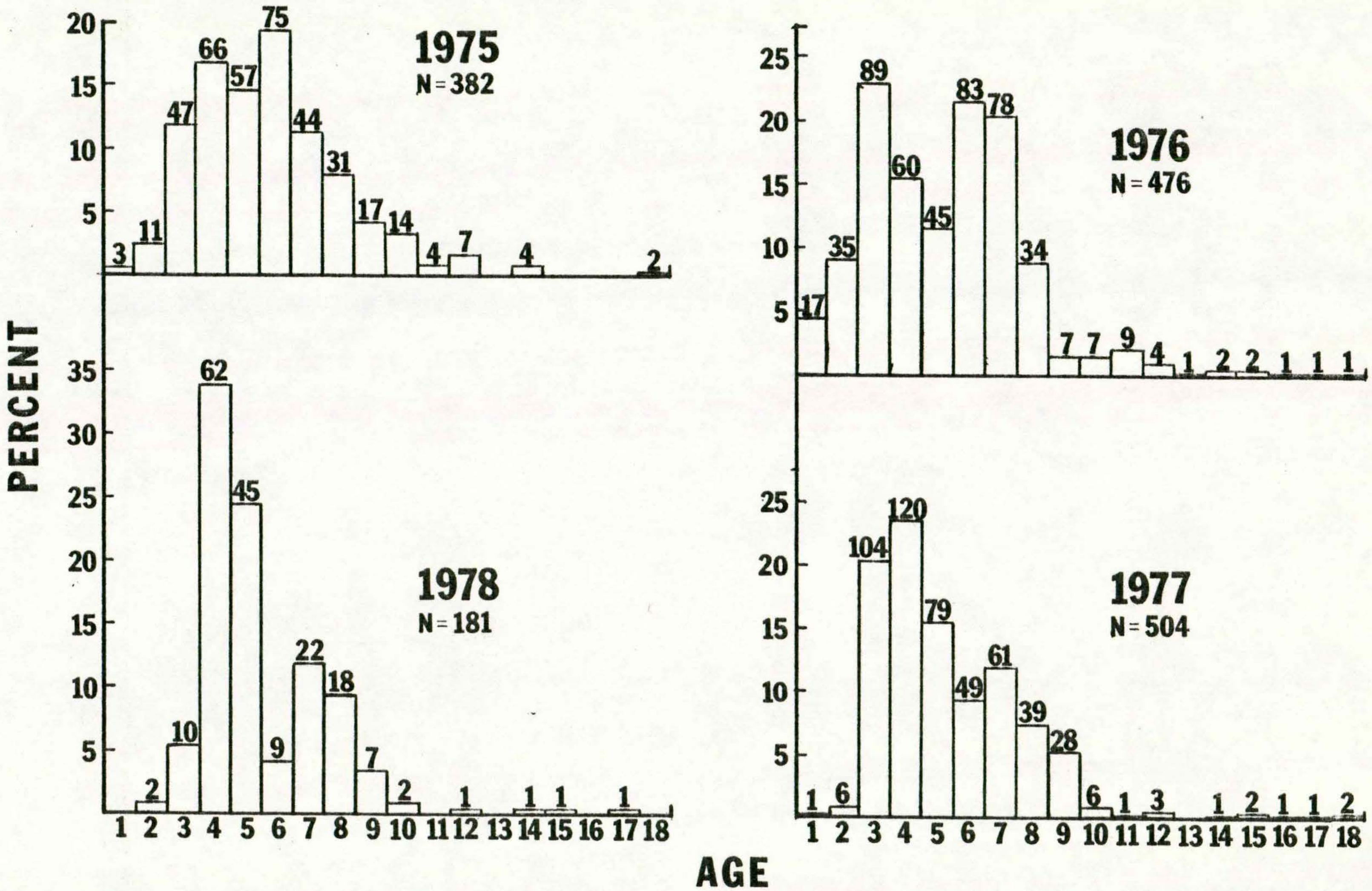

Figure 4. Age frequency distributions of paddlefsih tagged in the tailwaters of Lock and Dam 12, 1975-1978. Number of fish per age class is shown above bars.

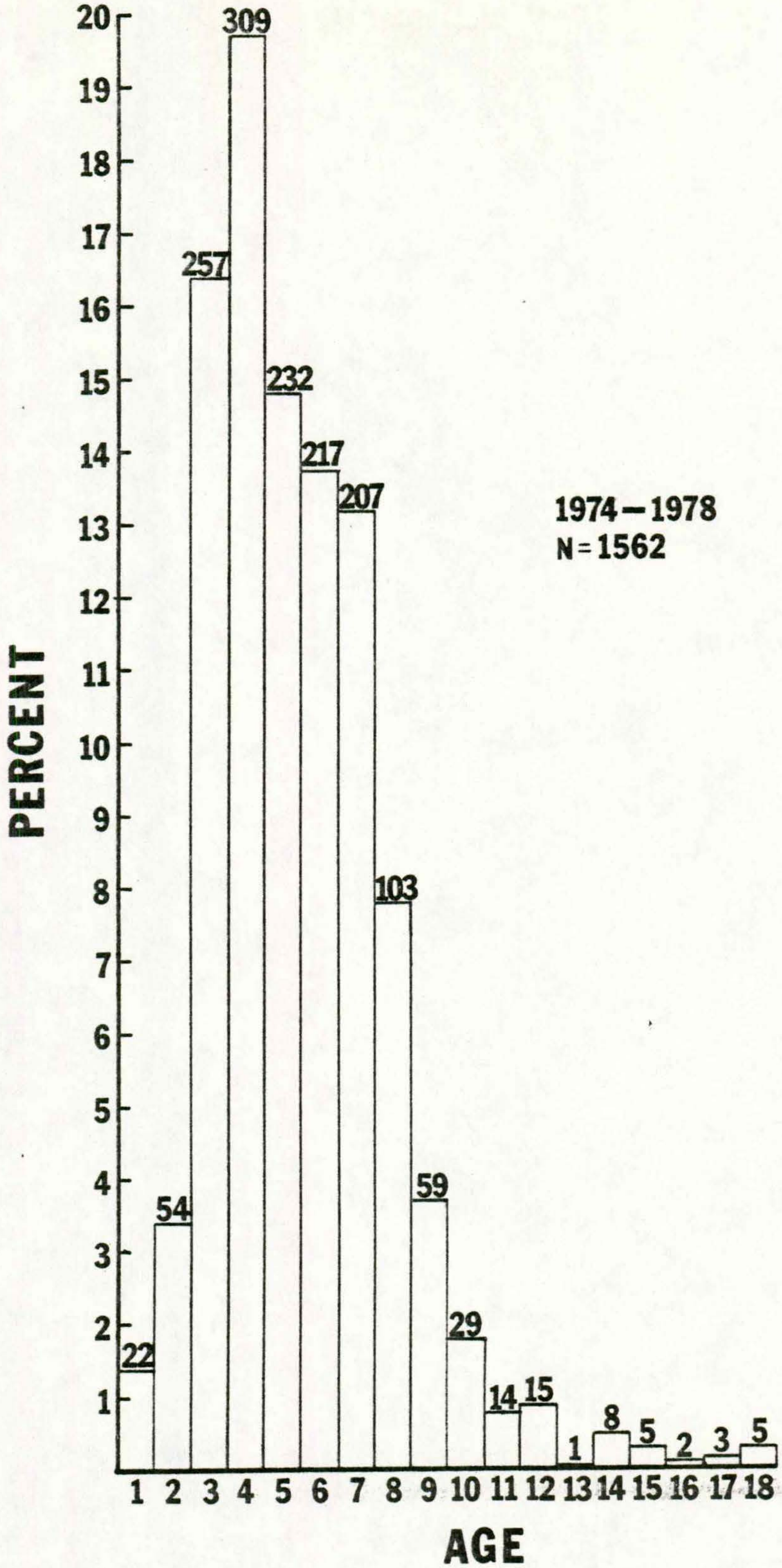

Figure 5. Age frequency distribution of all paddlefish tagged in the tailwaters of Lock and Dam 12, 1974-1978. Number of fish per age class is shown above bars.

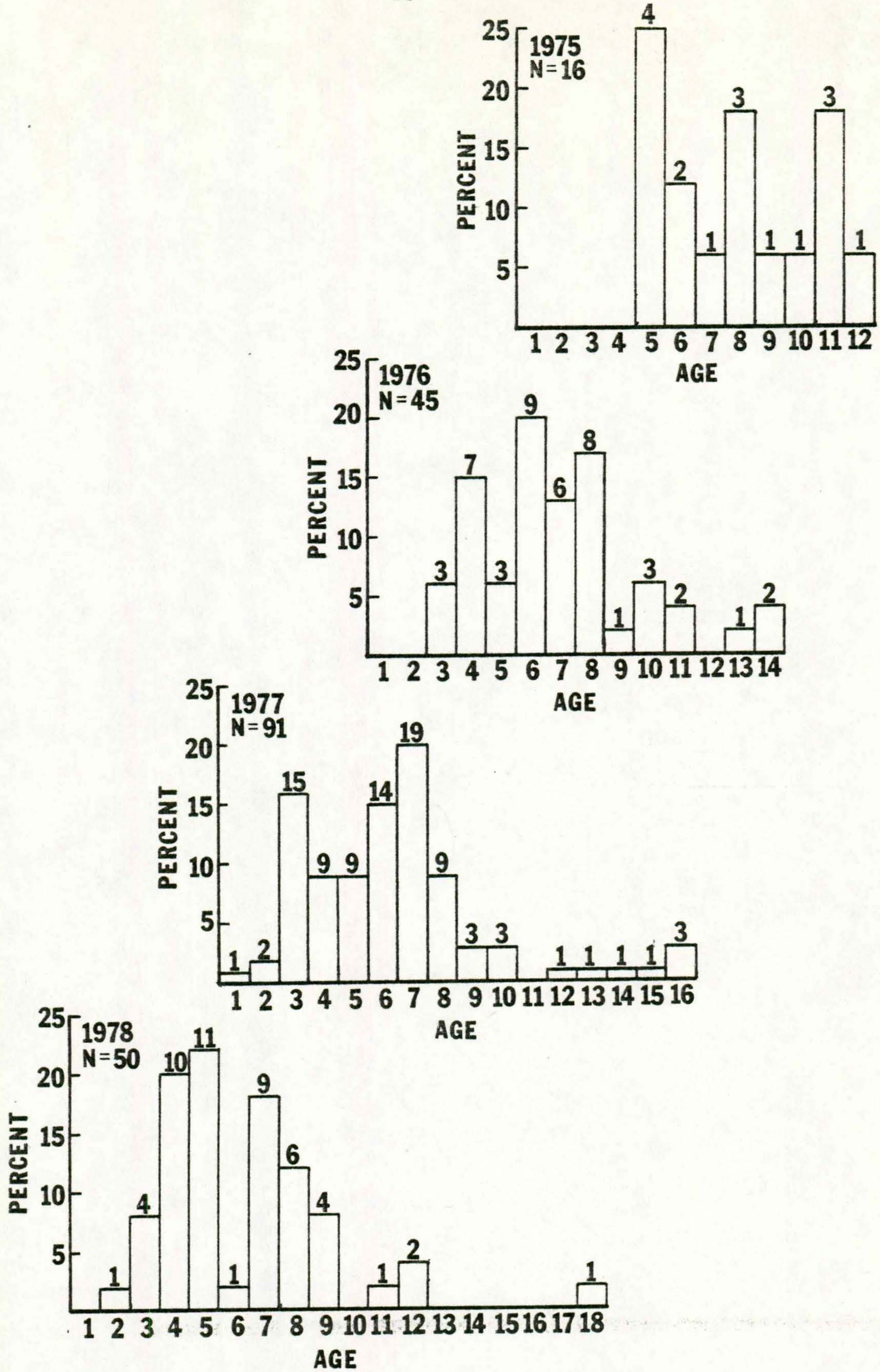

Figure 6. Age frequency distributions of sport harvested paddlefish in the tailwaters of Lock and Dam 12, 1975-1978. Numbers of fish per age class is shown above bars.

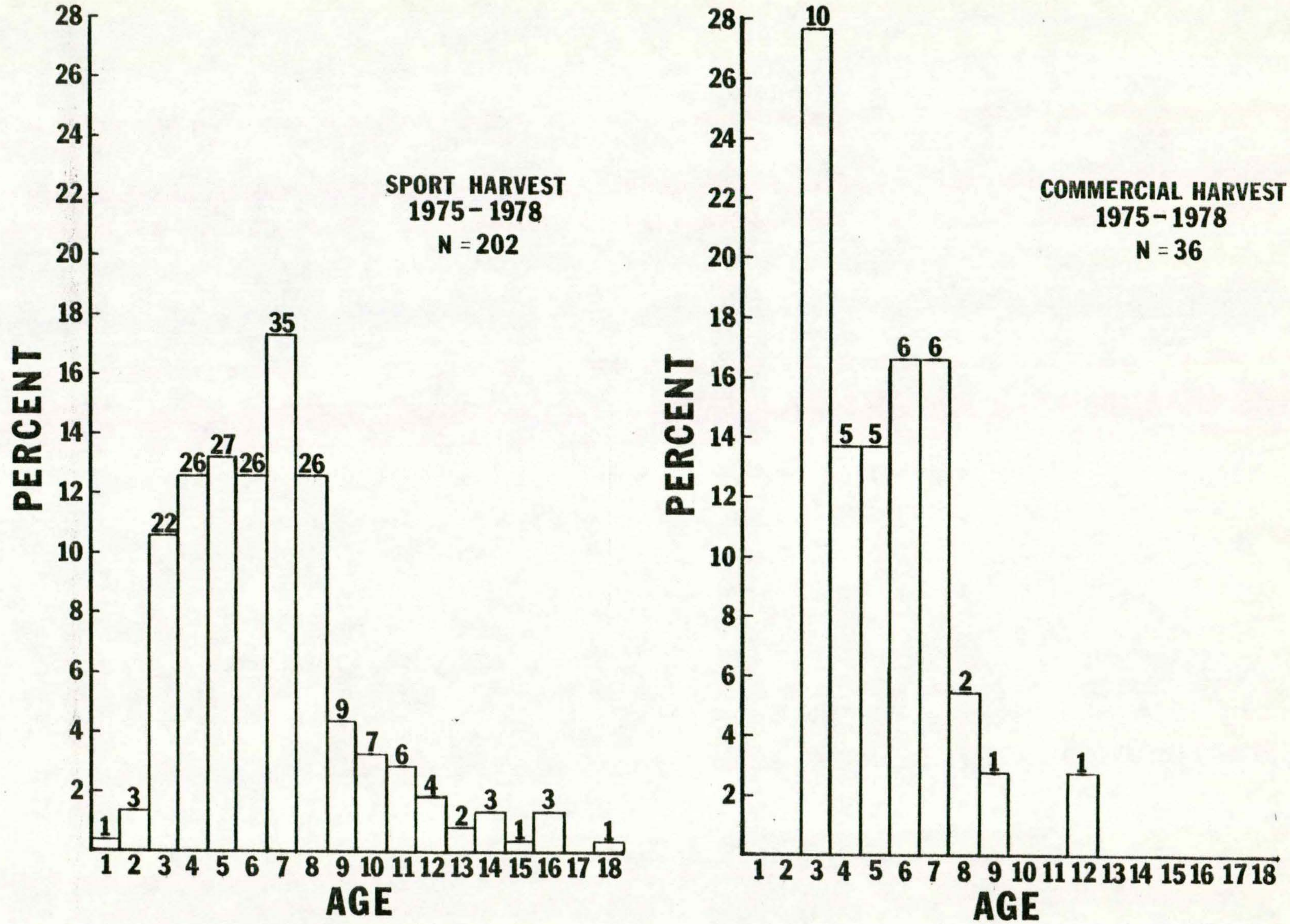

Figure 7. Age frequency distribution for all sport and commercially harvested paddlefish in the tailwaters of Lock and Dam 12, 1975-1978. Number of fish per age class is shown above bars.

The unique minimum-variance unbiased estimator of survival developed by Chapman and Robson (1960) and described by Everhart (1975) was appropriate. The equation is as follows:

$$\hat{S} = \frac{T}{n + T - 1}$$

where $\hat{S}$ = survival estimate

f_x = frequency of a coded age in a distribution

x = coded age; 0, 1, 2 $\cdots$k

$$T = \sum_{x=o}^{k} x\, f_x$$

and $$n = \sum_{x=o}^{k} f_x$$

Of particular importance to this calculation is the age of full recruitment and vulnerability to the fishery (N_o). The estimates of N_o were tested and refined through a Chi-square comparison of Chapman-Robson and Heincke survival estimates.

The later estimator:

$$\hat{S} = \frac{\Sigma N - N_o}{\Sigma N}$$

where $\hat{S}$ = survival estimate

ΣN = the sum of all age frequencies in the sample

and N_o = the frequency of the first fully recruited age, was used only to refine the estimates of N_o in the Chapman-Robson estimate. The equation:

$$\chi^2 = \frac{(\text{Chapman and Robston est.-Heincke est.})}{T(T-1)\ (\Sigma N-1)/\Sigma N(\Sigma N+T-1)^2(\Sigma N+T-2)}$$

with all symbols as previously defined was used for the Chi-square comparison.

Variance of the Chapman-Robson estimator was estimated from the equation:

$$\hat{V}(\hat{S}) = \hat{S}\ (\hat{S} - \frac{T-1}{\Sigma N + T-2})$$

where all symbols are as previously defined. Standard error was computed by the usual procedure.

Survival estimated in this manner ranged from .60 to .81

for females and from .53 to .75 for males (Table 13). Estimates from pooled age distributions were .73 and .59 for females and males, respectively. Survival estimates for the population ranged from .56 to .78; with the pooled estimate, sexes combined over years, equal to .70 (Table 14).

CALCULATED FROM ASSIGNED AGE DISTRIBTUIONS OF TAGGED FISH

A corresponding set of survival estimates were computed using assigned ages for tagged fish. This was necessary because populations of fish from which we collected our samples for life history analyses may have been subject to size selection pressures by sport and commercial fishermen prior to being sampled. The sample size more than doubled (1,562 as compared to 603) by using tagged fish. Length, weight, aged jawbones, ranges in length and weight and corresponding means, and regression analyses of these growth parameters were used in assigning age. Estimators were as previously defined.

Survival estimates utilizing age distributions constructed in this manner ranged from .60 to .67 (Table 14). The survival estimate from the pooled age distribution was .66; the mean over 4 years was .63.

LENGTH-LENGTH RELATIONSHIPS

The relationship of fork length and body length to total length was examined through the simple linear regression function (Snedecor and Cochran, 1967):

$$\hat{Y} = b_0 + b_1 X + E$$

where $\hat{Y}$ = predicted total length of the fish,

X = observed length, either fork length or body length,

and E = random residuals resulting from fitting the regression line.

Fork length to total length for the population (Figure 8) was best described by the least squares equation:

$$\hat{Y} = 120 + .955 \text{ FL}.$$

Members of the paddlefish work group (Unkenholz, personal communications) have proposed body length as the routine length measurement for paddlefish since 1976. Ruelle and Hudson (1977) have formally proposed this procedure as an outgrowth of their Missouri River studies. Body length to total length relationships (Figures 9 and 10) are best

Table 13. Survival estimates for male and female paddlefish in the Mississippi River with special emphasis on Pool 13, 1975-1978.

	HEINCKE SURVIVAL ESTIMATE	CHAPMAN-ROBSON SURVIVAL ESTIMATE	STANDARD ERROR OF CHAPMAN-ROBSON ESTIMATE	AGE OF FULL RECRUITMENT TO THE POPULATION
FEMALE				
1975	.65	.60	.04	3
1976	.86	.78	.02	4
1977	.78	.81	.02	3
1978	.70	.67	.03	4
MEAN	.75	.71	.03	4
COMBINED				
1975-1978	.76	.73	.02	4
MALE				
1975	.60	.53	.04	3
1976	.83	.75	.02	3
1977	.71	.72	.03	3
1978	.75	.63	.04	4
MEAN	.72	.66	.03	
COMBINED				
1975-1978	.56	.59	.02	3

Table 14. Survival estimates and standard error of estimates for paddlefish in the Mississippi River with special emphasis on Pool 13, 1975-1978.

	SURVIVAL ESTIMATES USING AGED JAWBONES FROM LIFE HISTORY FISH		SURVIVAL ESTIMATES USING ASSIGNED AGES FOR TAGGED FISH	
	CHAPMAN-ROBSON SURVIVAL ESTIMATE	STANDARD ERROR OF CHAPMAN-ROBSON ESTIMATE	CHAPMAN-ROBSON SURVIVAL ESTIMATE	STANDARD ERROR OF CHAPMAN-ROBSON POPULATION
1975	.56	.03	.63	.09
1976	.78	.02	.60	.02
1977	.68	.02	.67	.01
1978	.64	.02	.63	.02
MEAN	.67	.02	.63	.04
COMBINED 1975-1978	.70	.01	.66	.01

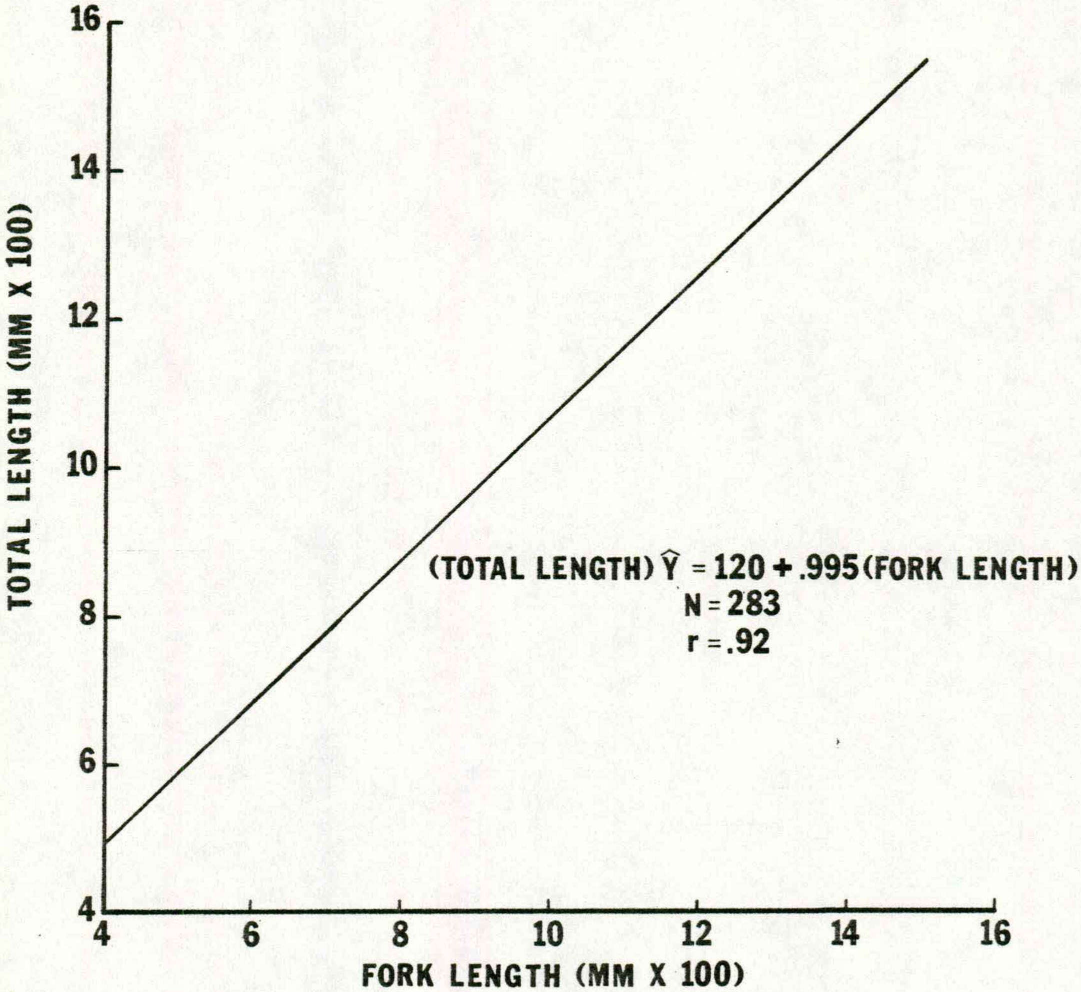

Figure 8. Simple linear regression total length on fork length for paddlefish, sexes combined, in the upper Mississippi River.

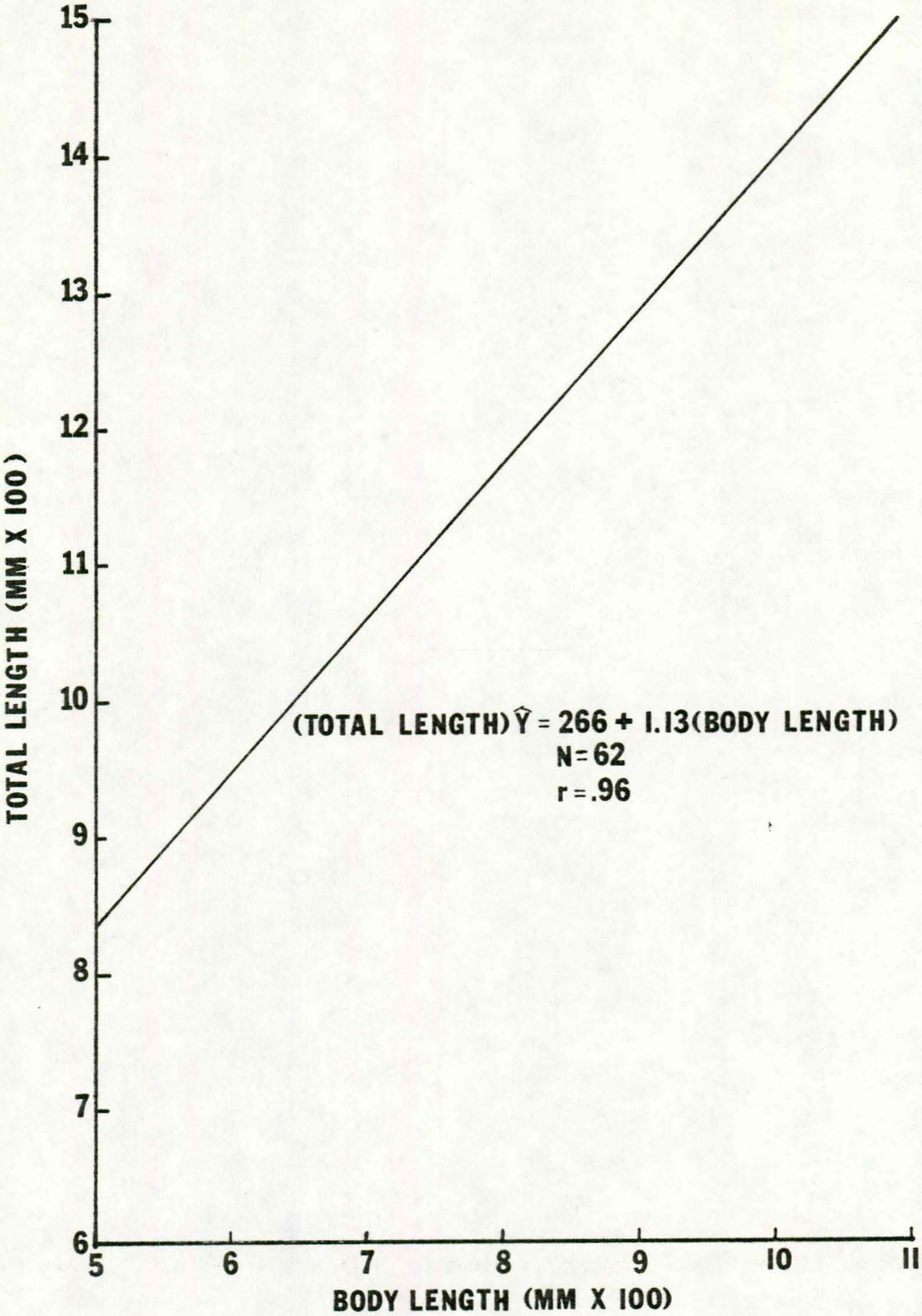

Figure 9. Simple linear regression of total length on body length for female paddlefish in the upper Mississippi River.

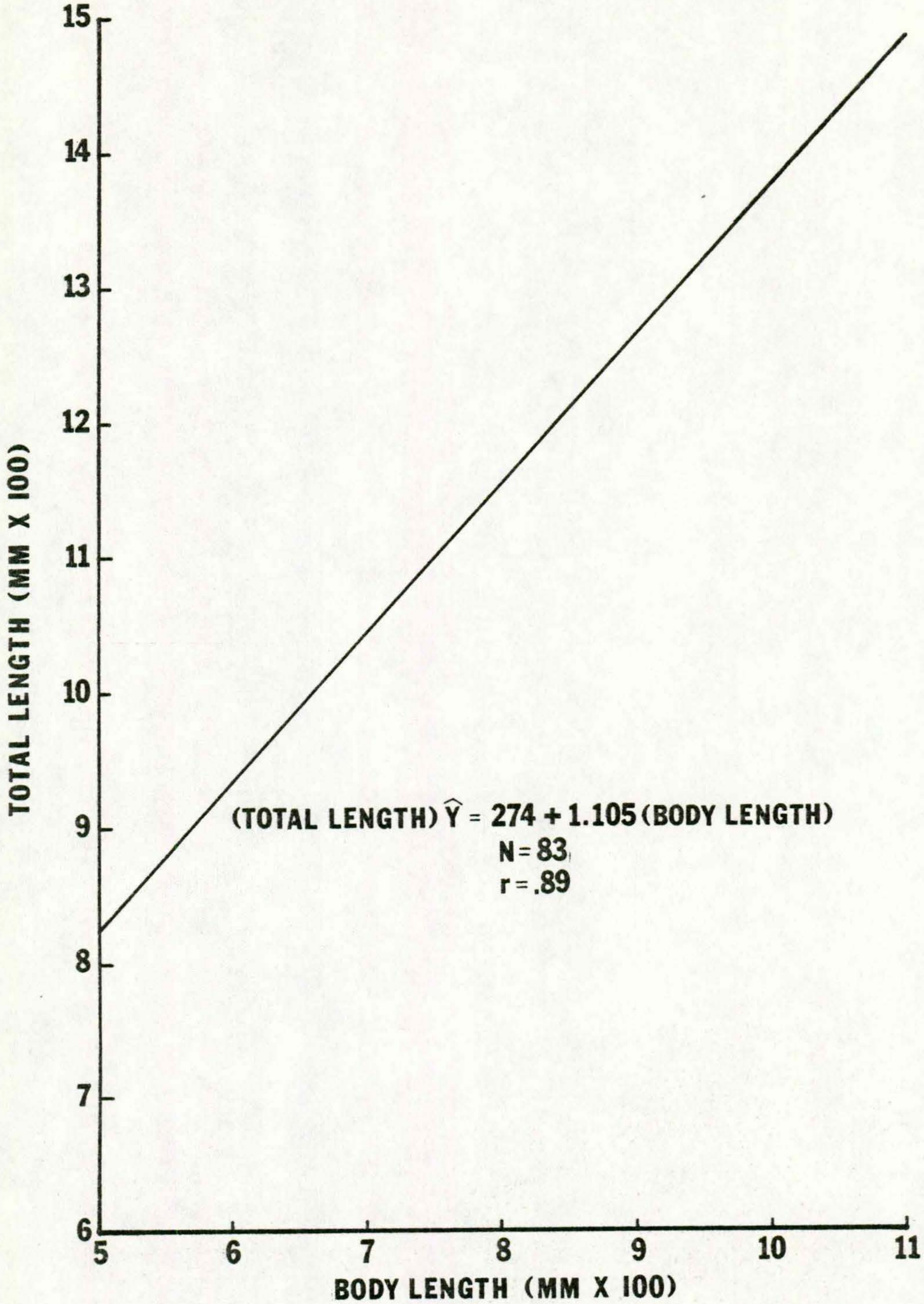

Figure 10. Simple linear regression of total length on body length for male paddlefish in the upper Mississippi River.

demonstrated by the equations:

$$\hat{Y} = 266 + 1.134\ BL$$

for females 831-11,524 mm (32.7-60.0 in) in total length, and

$$\hat{Y} = 274 + 1.105\ BL$$

for males 635-1,301 mm (25.0-51.2 in) in total length. When sexes were combined the predictive equation (Figure 11) for converting body length to total length was,

$$\hat{Y} - 225 + 1.198\ BL$$

Predictive equations were tested for differences in relationships through analysis of covariance. There were no sigificant differences ($P < .05$) between the regression lines and therefore the more general formula for sexes combined is appropriate.

WEIGHT-LENGTH RELATIONSHIPS

Weight-length relationships were demonstrated by sex and for the population by the transformed linear regression model:

$$\log_{10} \text{weight} = b_0 + b_1 \log_{10} \text{fork length}$$

where all components are as previously defined. Predicted values of weight from fork length for the population (Figure 12) best described by the equation:

$$\log_{10} W = -6.999 + 3.658 \log_{10} FL$$

Standard error of the slope (S_b) is ± .07.

Weight-length relationships for males ages 1-4 and 5-10 and females ages 1-4, 5-10, and 11-18 were best described by the following equations:

$\log_{10} W = -6.75 + 3.38 \log_{10} FL$; males, age 1-4,

$\log_{10} W = -8.03 + 3.92 \log_{10} FL$: males, age 5-10

$\log_{10} W = -6.44 + 3.38 \log_{10} FL$: females, age 1-4,

$\log_{10} W = -7.10 + 3.60 \log_{10} FL$; females, age 1-10,

$\log_{10} W = -3.71 + 2.54 \log_{10} FL$; females, age 11-18.

The slopes of these regression lines were tested in a t-distribution (95% confidence interval) for similarities. Similar weight-length relationships were demonstrated for females

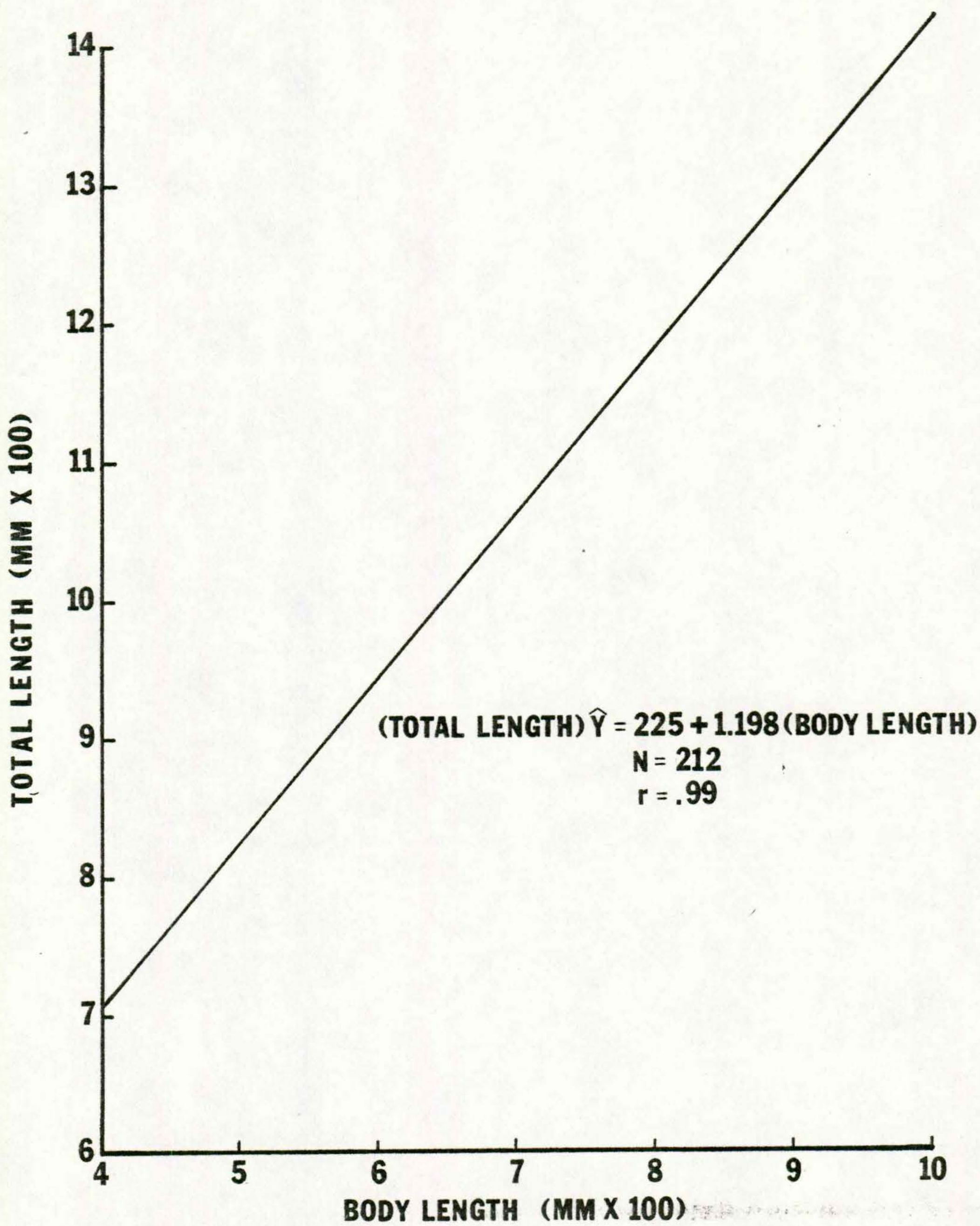

Figure 11. Simple linear regression of total length on body length for paddlefish, sexes combined, in the upper Mississippi River.

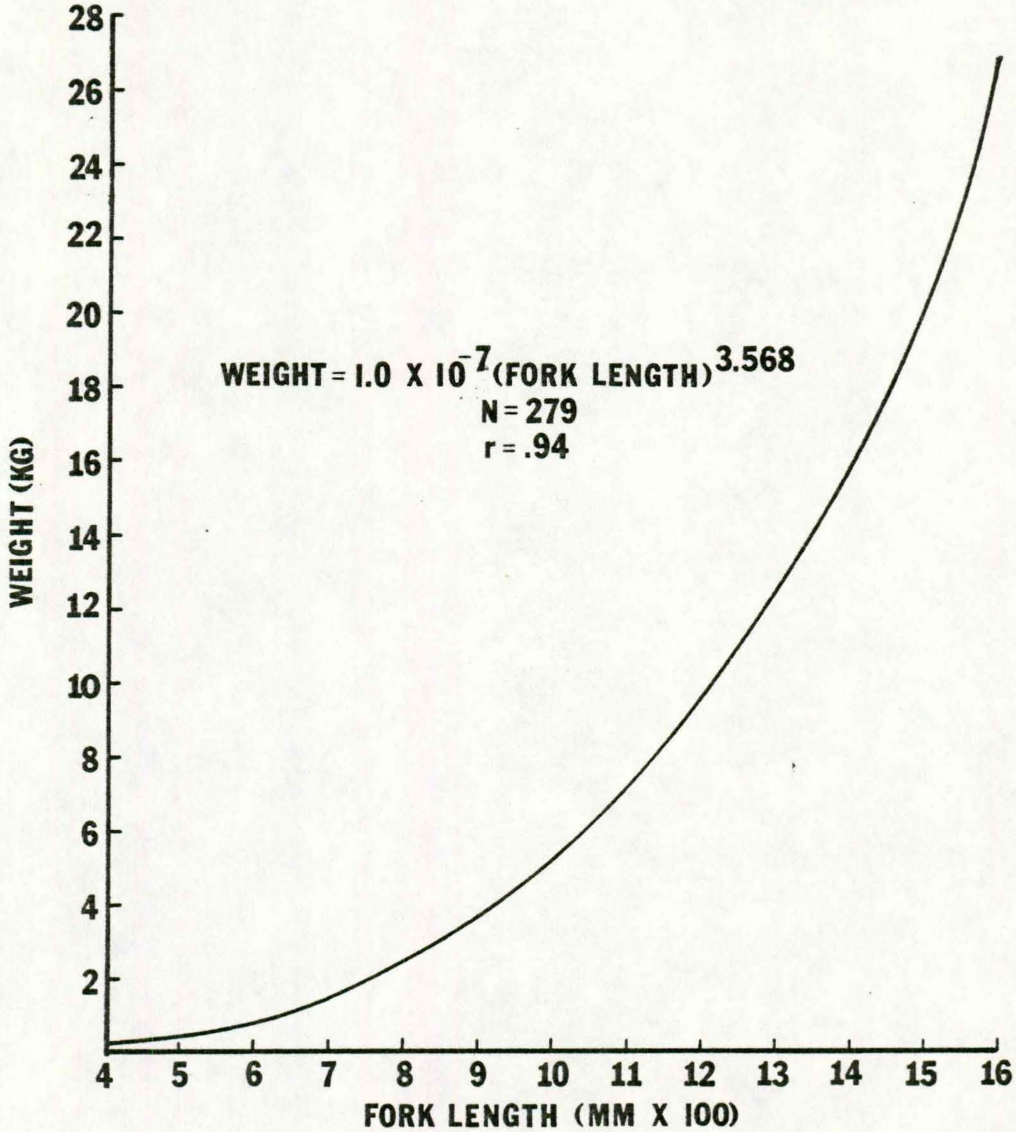

Figure 12. Regression of weight on fork length for paddlefish, all sexes and ages combined, in the upper Mississippi River.

ages 1-10 and males, ages 1-4. Mature males and mature females did not show similar relationships.

AGE AT MATURITY AND FECUNDITY

Six hundred three fish were examined for sexual maturity and egg development. Superficial appearance of gonads at various stages of development was similar to sturgeon (Helms, 1976). Immature males gonads consisted of a longitudinal body of fatty tissue with testicular tissue appearing as a narrow creamy-yellow band extending the length of the dorsal surface. At maturity, the dorsal band enlarges, forming a homogenous convoluted organ several times larger than the associated fatty tissue. Gonads of immature females were similar in size to those of males. They differed by being markedly laminated with no creamy-yellow band on the dorsal surface. Early developmental stages were obscure until eggs appeared. When eggs are present, stage of development is described by egg size and color.

Three hundred fifteen males and 218 females were examined for maturity (Table 15). All males age 3 or younger were immature and all males age 9 or older were mature. All females age 5 or younger were immature and all females age 12 or older were mature. Overlap and trends within overlap were as expected (Table 15).

Egg development was noted in adult females and fecundity determined when practical. Ovaries from fish used in these estimations were measured for volume and 25 ml randomly removed subsamples were preserved in 10% formalin for later enumeration. Expansion of the data was by the usual procedure.

Fecundity data were collected from fish in Pools 12, 13, and 18 during 1976, 1977, and 1978. Eleven fish ranging in size from 1,187 mm (46.7) in) and 14.0 kg (30.8 lbs) to 1,562 mm (61.5 in) and 23.5 kg (51.7 lbs) were examined (Table 16). Total estimated ova ranged from 148,782 to 506,516. Mean egg production was 16,840 ova/kg (7,654 ova/lb) of fish with a standard deviation of ± 4,933 ova/kg (± 2,242 ova/lb).

Simple and multiple linear regression equations for predicting numbers of ova from fork length and total body weight were (Figure 13):

$$\text{Ova } (\hat{y}) = -965{,}363 + 938.4 \text{ FL}$$

$$\text{Ova } (\hat{y}) = -192{,}799 + 27{,}779 \, W_g t$$

$$\text{Ova } (\hat{y}) = -473{,}544 + 307 \text{ FL} + 20{,}257 \, W_g t$$

Sixty-three percent of the variation in numbers of ova was explained by body measurements.

Table 15. Age at maturity for male and female paddlefish in the upper Mississippi River.

AGE	MALE		FEMALE	
	IMMATURE	MATURE	IMMATURE	MATURE
1	4			
2	10		1	
3	69		47	
4	45	3	57	
5	64	16	58	
6	7	19	29	1
7	5	35	31	1
8	2	17	19	3
9		9	4	3
10		5	4	4
11		3	2	2
12		1		4
13				3
14				4
15				2
16		1		3
17				2
18				4
SUBTOTAL	206	109	252	36
TOTAL	315		288	

Table 16. Estimates of fecundity for paddlefish in the upper Mississippi River.

YEAR	POOL	ESTIMATED AGE	FORK LENGTH (mm)	FORK LENGTH (in)	WEIGHT (kg)	WEIGHT (lb)	ESTIMATED NUMBER OF EGGS	FECUNDITY (kg)	FECUNDITY (lb)
1976	13	18	1,391	54.7	20.30	44.66	506,516	24,951	11,341
	13	12	1,295	51.0	12.90	28.38	241,916	18,753	8,524
	12	14	1,327	52.2	15.47	34.03	345,208	22,314	10,144
1977	18	12	1,187	46.7	14.00	30.80	148,782	10,627	4,830
	18	13	1,295	51.0	17.20	37.84	220,970	12,847	5,839
	13	17	1,453	56.5	21.65	47.63	362,401	16,739	7,608
	13	18	1,562	61.5	23.50	51.70	430,146	18,304	8,320
	13	12	1,460	57.5	22.85	50.27	505,571	22,125	10,057
1978	13	10	1,295	51.0	17.65	38.83	241,514	13,683	6,219
	13	10	1,352	53.2	15.45	33.99	156,515	10,130	4,604
	13	11	1,390	54.7	19.45	42.79	287,250	14,768	6,713

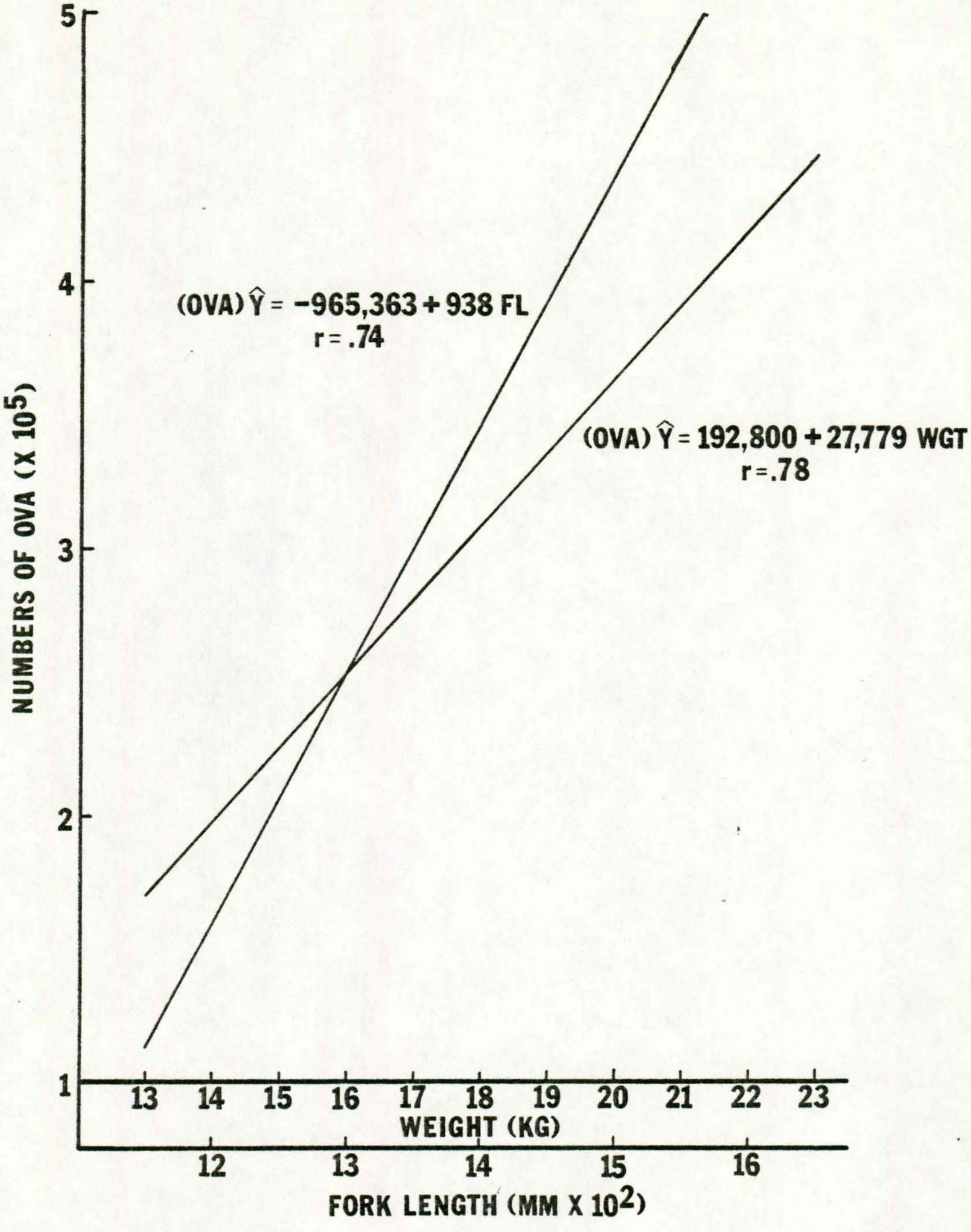

Figure 13. Linear regression of estimated number of ova on fork length and total body weight for paddlefish in the upper Mississippi River, 1976-1978.

LOCAL AND INTERPOOL MOVEMENT

Observations of localized movement of 15 fish were indirectly examined utilizing a variety of similar methods, each involving the attachment of a float to a fish and the subsequent chronicling of location at 15 minute time intervals. Numerous problems were encountered and success minimal. The technique included attachment of a good quality balloon, slightly inflated, to the anterior base of the dorsal fin by a small hook and 30.4 m (100 ft) of 3.6 kg (8 lb) test monofilament line. Only fish greater than 5 kg (11 lbs) were used and observations were only made on calm days. Observations were separated according to fish size. Three general behavior patterns were observed, one of which is certainly related to the method of observation. Small fish (Figure 14) 794-857 mm (31.2-33.7 in) were affected by the increase in resistence which the attached balloon created and attempted to seek protection from the current behind islands or regulatory works. Medium sized fish 927-978 mm (36.5-38.5 in) and larger fish 1,080-1,251 mm (42.5-49.2 in) inhabited the area 30.4-91.4 m (100-300 ft) below the dam and moved in a conterclockwise direction. The larger fish appeared to wander or probe a larger area but still maintained the counterclockwise directional movement (Figure 14).

Interpool movement was recorded from tag returns. Time at large, direction of movement, physical characteristics of the fish and main channel distance from point of release to area of recapture were recorded. Of the 18 fish for which inter-pool movement could be identified, 78% moved downstream. Mean distances from point of release to point of recapture for fish which moved in this direction were 88.1 km ± 1.7 (5.48 mi ± 1.1), 99.7 km ± 63.3 (62.0 mi ± 39.3), and 81.1 km ± 31.0 (50.4 mi ± 19.2) for 1976, 1977, and 1978, respectively. Mean upstream movement from all years was 82.8 km ± 78.9 (51.5 mi ± 49.0). Mean downstream movement from all years was 92.7 km ± 49.6 (57.6 mi ± 30.8) (Table 17).

HARVEST STATISTICS AND PYRAMID OF VALUES

Harvest statistics were obtained from National Marine Fisheries Service (NMFS) records, UMRCC Annual Reports and unpublished Iowa Conservation Commission catch records. A survey of value changes associated with the various steps in processing was conducted by interviewing commercial fishermen and market operators. Values thus obtained were applied to weight changes resulting from various processing procedures to assess monetary gain.

HISTORICAL AND CURRENT HARVEST STATISTICS

Historically, the five states bordering the upper

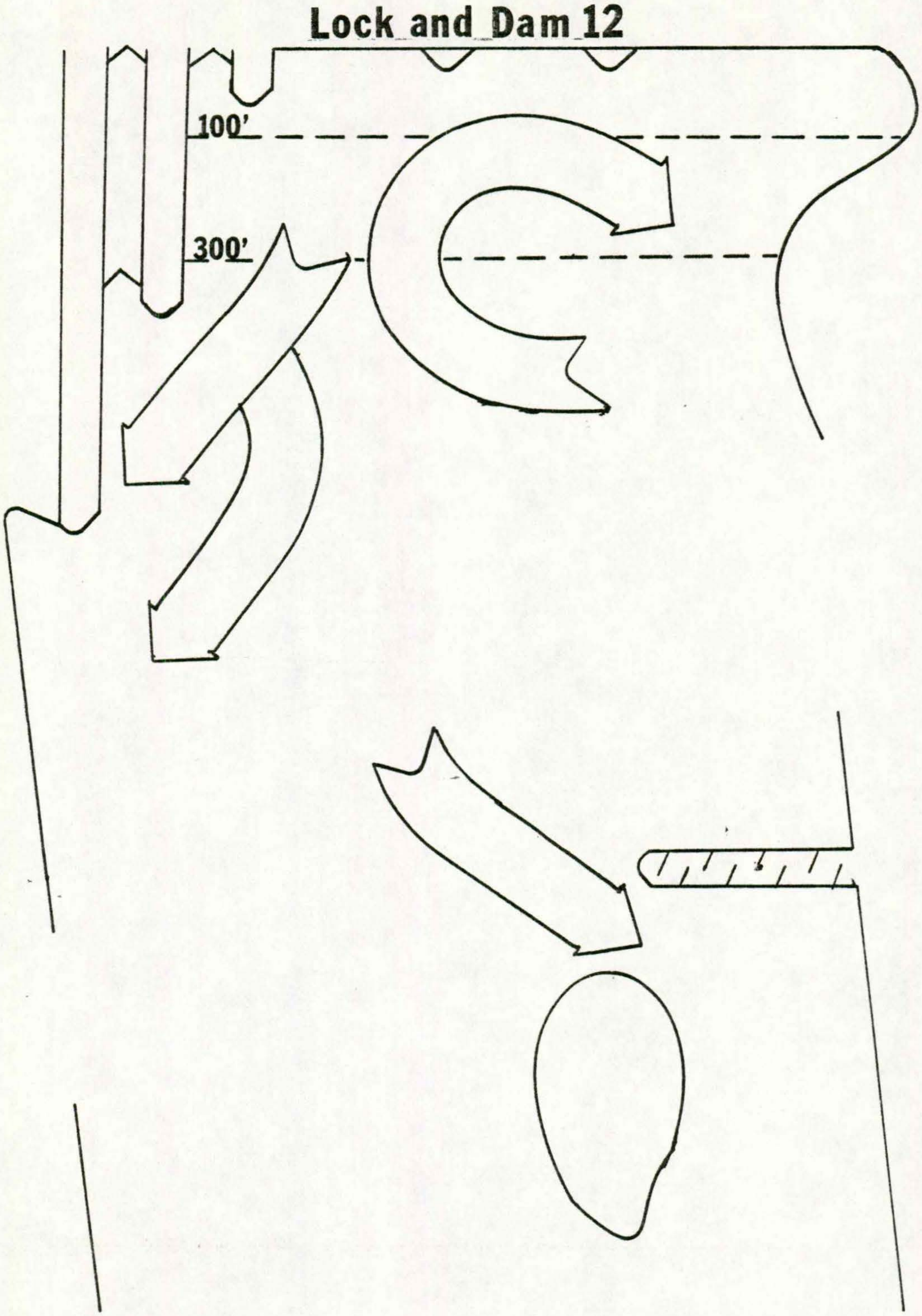

Figure 14. Observations of localized movement patterns of paddlefish > 794 mm (31 in) in the tailwaters of Lock and Dam 12.

Table 17. Interpool movement of tagged paddlefish, 1976-1978.

CONTROL NUMBER	DIRECTION	POOL OF ORIGIN	POOL OF RECOVERY	DISTANCE TRAVELED KILO-METERS	MILES	DAYS AT LARGE
1976						
44	downstream	13	14	86.9	54	310
85[1]	upstream	13	12	5.6	3.5	133
95	downstream	13	14	89.3	55.5	389
1977						
114	downstream	13	14	58.7	36.5	431
142[1]	downstream	12	13	5.6	3.5	395
183	downstream	13	14	80.5	50	142
223	downstream	13	14	70.6	43.9	166
224	downstream	13	14	70.6	43.9	502
239	downstream	13	17	187.5	116.5	114
277	downstream	13	16	162	100.7	394
278	downstream	13	16	162	100.7	640
1978						
361	downstream	13	14	54.7	34	724
382	downstream	13	14	100.6	62.5	101
385	downstream	13	16	114.3	71	1078
387	upstream	13	12	42.6	26.5	265
389	downstream	13	14	54.7	34	78
390	upstream	13	11	95.7	59.5	270
391	upstream	13	9	187.4	116.5	392

[1]This fish moved upstream in 1976 and returned to Pool 13 in 1977.

Mississippi River have permitted commercial paddlefish harvest. Minnesota and Wisconsin, however, reported moderate harvest compared to Illinois, Iowa, and Missouri (Table 18) and removed paddlefish from their commercial species lists prior to the construction of navigation regulatory works in the 1930's. During this early period, the latter three states each reported large catches. After construction of the dams, Missouri experienced a sharp decline in harvest (Purkett, 1961); Iowa and Illinois maintained a high rate of harvest until the late 1950's. Harvest after 1959 was comparatively low, particularly in Illinois. Although the cause of this change is not well documented, it was probably related to dam construction. Pooling the river no doubt destroyed major spawning grounds. Continued production through the 1950's in Iowa and Illinois probably resulted from increased survival and growth of fish spawned prior to impoundment.

If harvest is assumed to be a measure of production, current production appears to be sufficient to sustain the population.

Mean harvest in Iowa from 1960-1970 was 10,864 kg (23,952 lbs) with downstream pools producing more than upstream pools (Table 17). The 15 year mean from 1960-1974 was 8.161 kg (17,993 lbs). A substantial increase in harvest was reported between 1975 and 1977. In all cases, the standard deviation approaches the mean, indicating substantial fluctuations in harvest. Mean hearvest in Pool 9 was 199 kg (438 lbs), while mean harvest in Pool 19 was 2,200 kg (4,850 lbs) (Table 19).

Paddlefish values and harvest have increased since 1960 (Table 20). Price per pound remained relatively constant at 11-12¢ through 1970, with a low of 9¢ in 1964, but increased to 15¢ in 1972 where it stabilized through 1976. Mean price per pound in 1977 was 19¢. Coupled with a trend toward consistantly higher harvest in recent years, total annual value to Iowa fishermen is now approaching $10,000 which represents less than 2% of the value of the commercial fishery and about 1% of the total weight of commercial fish harvested.

MARKETING INTERVIEWS AND WEIGHT LOSS IN PROCESSING

Most of the commercially harvested paddlefish from the upper Mississippi River are consumed locally or by the individual fishermen who catches them. Demand is moderate to low except for the area around Camanche, Iowa, and a few select outlets near Davenport, Moline, Rock Island, and Bettendorf. These last outlets cater to a rather individualized consumer and are not representative of the entire retail outlet. Nearly all fish are prepared for retail sales by smoking.

A survey of 91 fishermen and market operations was

Table 18. Commercial catch of paddlefish from the Mississippi River, by state, for the years 1894-1977. Estimates are rounded to the nearest whole number in thousands.

	ILLINOIS		IOWA		MINNESOTA		MISSOURI		WISCONSIN	
YEAR	kg	lbs	kg	lbs	kg	lbs	kg	lbs	kg	lbs
1894	53	117	20	45	6	13	20	45	7	16
1899	67	148	9	21			48	107		
1922	37	81	22	49			7	16	13	29
1931	10	23	4	9			17	37		
1950	19	42					2	5		
1954	30	65	3	6			4	8		
1955	56	123	3	6			2	4		
1956	82	181	3	6			2	5		
1957	48	107	12	27			1	3		
1958	110	243	11	24			3	7		
1959	32	71	9	19			4	9		
1960	13	29	5	11			4	8		
1961	14	32	4	9			3	7		
1962	10	23	4	9			4	10		
1963	27	59	1	3			1	3		
1964	34	74	9	21			1	3		
1965	27	60	3	6			1	3		
1966	22	49	10	23			1	3		
1967	1	2	4	10						
1968	39	86	10	23			4	9		
1969	27	60	9	19			3	7		
1970	40	89	18	39			4	9		
1971			8	18			6	13		
1972	33	72	14	32			4	10		
1973	32	70	10	23			6	13		
1974	4	10	12	27			3	7		
1975			15	33						
1976			26	58						
1977			31	69						

Table 19. Commercial harvest of paddlefish, by pool, from the Mississippi River, 1960-1977.

YEAR	POOLS 9	10	11	12	13	14	15	16	17	18	19	POOLS COMBINED
Standard deviation	± 422	±3,022	± 541	±1,891	±3,409	±3,534	±1,276	±3,108	±2,843	±2,823	±4,924	±17,786
18-year average	438	2,155	347	1,516	2,399	2,792	920	2,521	3,846	2,232	4,840	23,952
1977	583	3,109	1,562	469	13,341	10,800	2,493	3,509	10,153	5,480	17,927	69,426
1976	967	12,435	1,538	546	5,215	13,121	3,582	2,544	9,909	4,034	3,652	48,543
1975	1,133	4,673	1,332	2,439	6,299	2,516	3,650	2,830	3,516	406	4,477	33,271
15-year average	347	1,172	121	1,589	1,182	1,588	456	2,366	3,044	2,018	4,083	17,993
1974	1,483	5,366	138	2,872	5,582	3,610	1,081	1,127	1,478	595	3,414	26,746
1973	490	1,291	171	7,360	3,079	1,355	1,647	2,640	1,876	1,083	2,144	23,136
1972	120	3,000	602	4,290	1,787	3,451	2,447	6,839	4,585	2,275	3,609	32,005
1971	100	748		1,163	761	1,469	15	5,648	3,101		4,923	17,928
1970	201	1,485	103	1,232	2,990	1,816	151	12,117	3,986	10,877	4,280	39,238
1969	317	2,672	57	2,066	545	1,812	218	1,238	7,432	344	2,667	19,368
1968	756	842	292	1,372	181	2,446	678	505	3,284	66	12,144	22,566
1967	20	1,165	183	726	1,253	1,680	149	586	3,064	40	717	9,583
1966	436	306	20		93	3,253	23	2,781	5,272	4,249	6,673	23,105
1965	627	100	78		265	850	43	172	1,149	2,202	326	5,630
1964	225	750	109	36	417	117		1,400	3,391	94	13,914	20,443
1963	316		65	9				16	310	232	2,191	3,139
1962					157	30		177	240	5,000	3,111	8,715
1961	8	801		2,257	578	804			2,675	1,125	50	8,298
1960	105	55		447	641	1,134	384	249	3,811	2,093	1,078	9,997

Table 20. Commercial value of paddlefish to Iowa fishermen.

YEAR	HARVEST IN LBS	PRICE PER LB	TOTAL COMMER-CIAL VALUE
18-year average	23,952	.13	$ 3,348
1977	69,426	.19	13,191
1976	58,543	.15	8,781
1975	33,271	.15	4,991
15-year average	17,993	.12	2,220
1974	26,746	.15	4,012
1973	23,136	.15	3,470
1972	23,005	.15	4,801
1971	17,928	.13	2,331
1970	39,238	.11	4,316
1969	19,368	.11	2,130
1968	22,566	.11	2,482
1967	9,583	.11	1,054
1966	23,105	.12	2,773
1965	5,630	.11	619
1964	20,443	.09	1,840
1963	3,139	.10	314
1962	8,715	.12	1,046
1961	8,298	.11	913
1960	9,997	.12	1,200

conducted (Appendix B) to determine monetary gain as fish were processed and subsequently sold. These values were then applied to our estimates of weight loss in processing to assess the cost effectiveness of various processing steps.

Samples of fish, representative of a range of sizes, were processed as if being prepared for sale (Table 21). Fish were dressed for smoking by removing the head and tail, eviscerating and trimming a portion of the abdominal region. Large fish were steaked in 7.6 cm (3 in) chunks while smaller specimens were split lengthwise or left whole. Initial lengths and weights were compared with finished lengths and weights after dressing and smoking. After preparation, a subsample was further tested to determine the percentage of edible product. Identity of individual fish was maintained.

Results were analyzed by fish size. Size ranged from .25 kg (.5 lb) to 19.55 kg (43.1 lb). Ninety-eight fish were dressed, 78 were smoked and 69 were examined to determine the edible fraction.

Dressed paddlefish averaged 41% of whole weight, but large fish yielded more than small ones (Table 21). Fish less than 1 kg (2.2 lbs) dressed to 37%. When smoked, paddlefish yielded 25% of their whole weight, with smaller fish yielding less than larger fish. This difference was due to dressing as loss from dressed to smoked product was consistent for all sizes examined. Only a small portion of the smoked product was inedible.

Wholesale price in the round was accurately described through our commercial catch statistics, fluctuating from 8-20¢ per pound with the average near 15¢ per pound. If the fishermen sold his product in a dressed condition, the price ranged from 30-65¢ per pound. The quantity of product would decrease to about 41% (Table 21) of the original weight. Originally worth $15 per 100 lbs., the product increased to a worth of $19.48 per 100 lbs., an increase in value received of $4.48 for the initial 100 lbs. If the seller markets his product in a smoked condition, only 25% of the original whole weight will remain; however, smoked paddlefish are sold for 50¢ to $1.75 per pound and the original product is now worth $28.12, an increase in value received of $13.12 for the initial 100 lbs.

Paddlefish are, for the most part, rather inconsequential to most commercial operations and no strong sentiments concerning this market were expressed. Most fishermen and all but one market operator feel they can catch or buy enough fish to fulfill the needs of their customers and that their outlets can handle only what is being brought in. The majority of fishermen stated that discharge and time of year affected catch and that there wasn't sufficient demand to warrant the time it takes to catch paddlefish. No market operator and

Table 21. Weight loss of paddlefish during commercial food-fish processing, expressed as percent of whole weight.

	WEIGHT (kg)	SAMPLE SIZE (n)	MEAN	STANDARD DEVIATION
Dressed	< 1	12	37.2	± 2.47
	1-1.9	14	41.2	± 2.64
	2-2.9	25	41.2	± 2.31
	3-3.9	20	42.3	± 3.16
	4-4.9	12	43.6	± 3.29
	> 4.9	16	43.5	± 4.08
Combined		98	41.4	± 3.95
Smoked	< 1	4	18.8	± 2.74
	1-1.9	12	26.2	± 4.55
	2-2.9	20	25.0	± 3.92
	3-3.9	17	25.0	± 4.66
	4-4.9	11	27.0	± 4.34
	> 4.9	14	26.8	± 4.55
Combined		78	25.4	± 4.54
Edible	< 1	4	14.1	± 3.66
	1-1.9	8	21.0	± 3.88
	2-2.9	18	21.0	± 3.03
	3-3.9	17	20.5	± 3.37
	4-4.9	10	22.1	± 5.07
	> 4.9	11	20.5	± 4.63
Combined		68	20.6	± 4.17

only 4 fishermen felt that snagging had affected their fishing or harvest. These 4 fishermen all fish near Bellevue, the area of greatest snagging intensity, and 3 of the 4 fish as close to the dam as they are (900 ft) legally allowed.

DISCUSSION AND IMPLICATIONS

Stated objectives of Mississippi River Paddlefish Investigations were (1) determination of existing exploitation rates, (2) characterization of the harvest and (3) the acquisition of basic life history information necessary to the management of the species. These objectives were delineated within the more general goals of complete species management and estimation of harvest potential. In pursuit of these goals, and to accomplish these objectives, paddlefish populations and physical environmental parameters were investigated continually over 40 months.

Estimation of paddlefish population abundance was necessary for understanding basic changes in numerical population size, composition and as a basis for proper management of the species. Mark and recapture data were used in a variety of indirect methods, employed in combination, to estimate the numerical population size. The best estimate in Pool 13 was $\hat{N} = 10,807$. Confidence intervals of 4,411-27,018 were obtained from a Poisson distribution. Mass bidirectional movement was observed, measured through stochastic inference and related to seasonal vulnerability and environmental variables by regression analyses. Temperature was the most important factor, explaining 46% of the variation in catch per effort. Discharge and turbidity were significantly intra-class correlated ($P < .01$) with discharge the important regulating element. Ten to 80% of the pool population is found within the tailwater area at any one time.

In addition to paddlefish, 285 other fish, representing 16 species, were also snagged during the simulated harvest. Sixty-one percent were channel catfish, of which 72% were snagged in a single four month period. There are no detrimental effects to any fish populations whose members may be snagged incidental to the paddlefish sport fishery.

The probability that a paddlefish would succumb via the fishery during the study period, was 6% when estimated from tag returns. Rates were refined and catagorized independently for each year and all years combined. Exploitation was more accurately described when the proportion of tags returned from captured fish was estimated. These analyses showed that tags from larger fish were more likely to be returned than those from smaller fish. Sport fishermen returned proportionately more tags than commercial fishermen. Sport fishermen unquestionably selected larger fish. Exploitation calculated from the proportionate expansion of tag returns was 7-14% for sport fishing, 4-12% for commercial fishing and 11-22% combined. The mean exploitation rate from all fishing sources over the study period was 18% when calculated in this manner. Exploitation rates in pools other than Pool 13 were similar to the empirical estimates for Pool 13. Exploitation of this magnitude is not excessive. Neither sport fishing or commercial fishing is adversely effected by one another. There would be a 4-7% increase in survival if either sport or commercial fishing were eliminated. A significant impact upon the survival rate of the population could only be achieved by eliminating all methods of exploitation. Under present conditions, sport and commercial fisheries are compatible.

Characteristics of the sport catch changed during the study. Mean paddlefish size decreased by 150 mm (5.9 in); 2.33 kg (5.1 lbs) and there was a systematic shift towards younger fish. There was a concurrent decrease in the frequency of larger fish in the simulated harvest. Small sample size precluded analyses of this sort for the commercial catch. The reduction in frequency of occurrence of larger fish in the catch is not unusual for populations which have not been previously exploited or which have been exploited in a nonselective manner.

Survival rate differed by sex. Estimates were 74% and 59% for females and males, respectively. While sexual differentiation of this type is common among fishes, I am unable to explain why the larger fish, which I assume are females, are exploited at such a substantially higher rate and yet show pronounced advantage in survival over males. It may be that the only significant component of mortality affecting females is from fishing, i.e., there is a depensatory effect upon natural mortality when fishing mortality increases; however, it seems unlikely that the effect would be this pronounced. The mean survival estimate over the study period using constructed age distributions was 63%.

Assessment of survival and exploitation for paddlefish populations is difficult because stock and recruitment relationships are undefined and the effects of size selection and reduction in spawning stock survival may not be recognized for 2-3 years and may not be measurable for much longer. If we assume constant natural mortality and a static ratio of fishing mortality on total mortality; then predictions of survival given changing exploitation rates are workable. For instance, if sport fishermen were allowed to harvest an additional 10% when present exploitation is 11% and survival is 63%, the new survival rate would decrease to 55%. Setting an arbitrary lower limit of 50% for survival would allow for an increase in exploitation of 15%. Conversely, elimination of either sport or commercial fishing would increase survival approximately 4-7%. If fishing was eliminated the estimated survival rate would be 77%. If the exploitation of larger fish was brought into balance with the exploitation of the population and they were harvested at a rate more in keeping with their relative abundance, survival would increase to about 65%. The weakness of this type of analysis is that predictions are based upon the presumption of constant recruitment. Depensatory effects on recruitment are not manifested in the calculations. Similar observations as to when exploitation becomes excessive (Purkett, 1963) have been made for populations in the Osage River and for the fishery at Intake, Montana (Rehwinkel, 1978). These investigations did not deal with sample populations of this magnitude nor did they address the subjects of abundance, exploitation and survival as completely as this one has.

Providing the 50% arbitrary lower limit for survival is accepted, indications are that we are managing the fishery through a two fish limit in such a way as to adequately allow for fluctuations in angling pressure and exploitation. To eliminate the potential problem arising from the size selection of larger fish and subsequent reduction of the spawning stock, the present catch limit would be revised to include a "no sorting" provision. Illinois should be encouraged and assisted in the strict enforcement of their established no sorting rule. Implementation of this management tool would help insure continuence of the fishery without concern over exploitation.

The greatest threat to the population may be habitat alteration and deterioration. Presently, the U.S. Army Corp of Engineers is rebuilding wing dams along all the Mississippi River. We have observed behavior patterns of individual fish, when water temperatures were approaching 16° C (61° F) and discharge approximated 700 m^3/s (24,300 ft^3s), which were similar to those described by Purkett (1961) for spawning fish. Fish observed behaving in this manner inhabited the top or the end of wing dams located near river mile 555.3. Wing dams in this area have eroded to fist sized cobble, suitable for paddlefish spawning (Unkenholz, personal communication). With the rebuilding of wing dams this potential source of spawning habitat may be lost and recruitment diminished. A need still exists for an 18 month telemetry study of adult female paddlefish behavior to define spawning grounds or sites. The delineation of spawning grounds through telemetry investigations would provide the last descriptive component to a complete species management program.

Assessment of this fishery should be accomplished during 1981. A sample of three to five hundred fish should be meaured, and released during the period of peak concentration in the tailwater area of Lock and Dam 12. A creel census of this area should be initiated for one open water season. At the end of this period a recapture sample should be taken. From this information survival, abundance, exploitation and the age of full recruitment to the fishery may be determined. Comparison of this information with that obtained during the present study will indicate the status of the fishery.

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A P P E N D I X

APPENDIX A

UMRCC HABITAT CLASSIFICATION CATEGORIES

TAILWATERS

Includes areas immediately below dams which are affected by the passage of waters through gates of the dam and out of locks. These areas change in size according to water stage, and the arbitrary lower boundary for fishery purposes has been set at a distance of 0.80 km (0.50 mi) below the dams.

MAIN CHANNEL

Includes only the portion of the river through which large commercial craft can operate. It is defined by combinations of contraction devices (wing dams), river banks, islands, buoys and other markers. It has a minimum depth of 2.74 m (9 ft) and a minimum width of 121.6 m (400 ft).

MAIN CHANNEL BORDER

The zone between the 2.74 m (9 ft) channel and the main river bank, islands, or submerged definitions of the old main river channel. It includes all areas in which wing dams occur along the main channel.

SIDE CHANNELS

Includes all departures from the main channel border in which there is current during normal river stage.

RIVER LAKES AND PONDS

This classification along with slough replaces the old term "back waters". River lakes and ponds in general are open expanses of water with little or no current. Several types of lakes occur along the Mississippi. These are: lakes of formation due to the fluviatile dams, lakes of mature flood plains and lakes due to behavior of higher organisms. Ponds differ from lakes only by size.

SLOUGHS

This category includes all of the remaining aquatic habitat found in the river. Sloughs often border on the "lake or pond" category on the one side and on the "side channel" category on the other. They have no current at normal water stage, muck bottoms, and an abundance of submerged and emergent aquatic vegetation.

APPENDIX B

PADDLEFISH STUDIES

Marketing Interview Form

NAME AND ADDRESS:

____

____

____

TYPE OF BUSINESS: ______________

POOL OR AREA: ______________

DATE OF CONTACT: ______________

ANNUAL REPORTED VOLUME FOR YEARS

1972: ________ 1975: ________

1973: ________ 1976: ________

1974: ________ 1977: ________

ESTIMATED ANNUAL VOLUMES:

________ (whole) ________ (dressed) ________ (smoked)

EGGS: ________ VALUE: ________

STAGE IN PROCESSING

	WHOLE	DRESSED	SMOKED
AVERAGE PRICE PAID			
SOURCE (s) BY %			
AVERAGE WHOLE-SALE PRICE			
BUYER (s) BY %			
AVERAGE RE-TAIL PRICE			
BUYER (s) BY%			

Questions (answer on back of sheet):

1. Can you catch (buy) enough paddlefish to fulfill needs of your customers?
2. What volume can your outlets handle?
3. What limits your volume of harvest (trade)?
4. Has snagging affected your fishing (business) and how?
5. List other comments.

Appendix Table 1. Paddlefish harvest regulations[1] in the Mississippi River.

	MINNESOTA	WISCONSIN	IOWA	ILLINOIS	MISSOURI	ARKANSAS
LEGALIZED SNAGGING	no	no	yes	yes	yes	yes
Creel limit	NA[2]	NA	2	2	2	no limit
Sorting allowed	NA	NA	yes	yes	yes	yes
Size limit	NA	NA	none	none	none	none
Season	NA	NA	continuous	continuous	continuous	continuous
Area	NA	NA	100 ft. from dam on Missouri and Mississippi Rivers; to first dam on Upper Iowa and Des Moines Rivers	With 100-900 ft. of dams	100 ft. from dams	100 yds. from dam
EQUIPMENT RESTRICTIONS						
Lines	NA	NA	2	1	3 (more than 3, must be tagged)	1
Line Size	NA	NA	NR[3]	NR	NR	NR
Hooks per line	NA	NA	2	2	33	NR
Hook size	NA	NA	NR	1/2 in. from tip of barb to shank	NR	NR
COMMERCIAL FISHERY	no	no	yes	yes	yes	yes
Restrictions on the commercial fishery	NA	NA	2 in. bar mesh for trammel nets; 3 3/4 in. bar mesh for gill nets	no	no	32 in. minimum size limit; 3 in. bar mesh for trammel and gill nets; Oct. 1-April 30; restricted lakes and Ozark area.

[1]These regulations are subject to change and interpretation. For complete information contact your local Fish and Game Agency.

[2]Not applicable.

[3]No restrictions.

Appendix Table 2. Paddlefish harvest regulations[1] in the Missouri River, exclusive of Iowa.

	MONTANA	NORTH DAKOTA	SOUTH DAKOTA	NEBRASKA	KANSAS	OKLAHOMA
LEGALIZED SNAGGING	yes	yes	yes	yes	yes	yes
Creel limit	1	2	Mo. R. 1; S.D.-Neb. border 2	2	1	5
Sorting Allowed	yes	no	no; no	no	unknown	yes
Size limit	none	none	none	none	none	none
Season	continuous	May 6-Sep 9	contin-uous; Sep 1-Apr 30	Gavens Point, Oct 1-Apr 30; elsewhere, Nov 1-Mar 31	Mar 20-May 20	continuous
Area	statewide	Missouri River west of US 85 bridge to Montana and portion of Yellowstone River	Missouri River	Missouri River	Neosho and Marais-descygnes River	statewide 1000 ft below all reservoirs except Wister and Ft. Gibson
EQUIPMENT RESTRICTIONS						
Lines	1	NR[2]	2	2	2	NR
Line size	NR	NR	NR	NR	NR	NR
Hooks per line	NR	1	3	2	2 single hooks or 1 treble hook	NR
Hook size	NR	NR	NR	NR	treble hook size 1-12	NR
COMMERCIAL FISHERY	no	yes	no	no	yes Missouri River and back channels	yes Only on Grand, Ft. Gibson, Eufaula and Dologah Reservoirs
Restrictions on the commercial fishery	NA[3]	Contract; can keep only dead fish. Also agree to keep away from large paddlefish congregations	Contract; must release all fish alive and keep and turn in all dead fish		2 in. bar mesh for trammel nets and seines; no electrical equipment	

[1]These regulations are subject to change and interpretation. For complete information contact your local Fish and Game Agency.
[2]No restrictions.
[3]Not applicable.

Appendix Table 3. Number of paddlefish per month with open and closed lamprey wounds, old scars, prop injuries, hood wounds and lampreys attached, 1975-1976. Percentage of sample subtended.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1975													
Sample size				48	28	56	37	51	12	50	50	50	382
No wounds				8 (.17)	4 (.14)	7 (.13)	2 (.05)	7 (.14)	1 (.08)	6 (.12)	8 (.16)	12 (.24)	55 (.14)
Closed wounds				27 (.56)	22 (.79)	45 (.80)	34 (.92)	41 (.80)	11 (.92)	44 (.88)	42 (.84)	38 (.76)	304 (.80)
Open wounds				13 (.27)	14 (.50)	36 (.64)	20 (.54)	34 (.67)	4 (.33)	38 (.76)	24 (.48)	24 (.48)	207 (.54)
Prop injuries				0	0	0	0	0	0	0	0	0	0
Hook wounds				0	0	1 (.02)	1 (.03)	0	0	2 (.04)	1 (.02)	0	5 (.01)
Lamprey attached				3 (.06)	13 (.46)	30 (.54)	12 (.32)	19 (.37)	3 (.25)	13 (.26)	10 (.20)	7 (.14)	110 (.29)

Table 3 continued--Number of paddlefish per month with open and closed lamprey wounds, old scars, prop injuries, hook wounds and lampreys attached, 1975-1976. Percentage of sample subtended.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1976													
Sample size	50	50	50	7	25	50	43	25	26	50	50	50	476
No wounds	11 (.22)	11 (.22)	12 (.24)	1 (.14)	8 (.32)	2 (.04)	5 (.12)	3 (.12)	0	2 (.04)	5 (.10)	7 (.14)	67 (.14)
Closed wounds	39 (.78)	39 (.78)	37 (.74)	6 (.86)	15 (.60)	48 (.96)	35 (.81)	21 (.84)	25 (.96)	46 (.92)	44 (.88)	38 (.76)	393 (.83)
Open wounds	29 (.58)	24 (.48)	24 (.48)	4 (.57)	6 (.24)	34 (.68)	33 (.77)	15 (.60)	23 (.88)	36 (.72)	33 (.66)	31 (.62)	292 (.61)
Prop injuries	0	0	0	0	0	0	0	0	0	1 (.02)	0	0	1 (.02)
Hook wounds	4 (.08)	5 (.10)	3 (.06)	0	4 (.16)	3 (.06)	2 (.50)	3 (.12)	1 (.04)	2 (.04)	3 (.06)	1 (.02)	31 (.07)
Lamprey attached	3 (.06)	3 (.06)	0	0	6 (.24)	25 (.50)	17 (.40)	11 (.44)	13 (.50)	17 (.34)	15 (.30)	9 (.18)	19 (.25)

Appendix Table 4. Number of paddlefish per month with open and closed lamprey wounds, old scars, prop injuries, hook wounds and lampreys attached, 1977-1978. Percentage of sample subtended.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977													
Sample size	9	50	50	25	50	50	42	50	28	50	50	50	504
No wounds	1 (.11)	2 (.04)	6 (.12)	5 (.20)	7 (.14)	12 (.24)	5 (.12)	4 (.08)	2 (.07)	4 (.08)	5 (.10)	4 (.08)	57 (.11)
Closed wounds	8 (.89)	46 (.92)	42 (.84)	18 (.72)	36 (.72)	37 (.74)	36 (.86)	46 (.92)	26 (.93)	45 (.90)	44 (.88)	46 (.92)	430 (.85)
Open wounds	6 (.67)	33 (.66)	25 (.50)	11 (.44)	33 (.66)	32 (.64)	19 (.45)	24 (.48)	6 (.21)	8 (.16)	14 (.28)	7 (.14)	218 (.43)
Prop injuries	0	1 (.02)	1 (.02)	0	1 (.02)	0	0	0	0	0	3 (.06)	1 (.02)	7 (.01)
Hook wounds	2 (.22)	3 (.06)	3 (.06)	3 (.12)	6 (.12)	4 (.08)	2 (.05)	2 (.04)	0	2 (.04)	0	3 (.06)	30 (.06)
Lamprey attached	3 (.33)	5 (.10)	5 (.10)	2 (.08)	25 (.50)	25 (.50)	13 (.31)	17 (.34)	2 (.07)	2 (.04)	4 (.08)	1 (.02)	104 (.21)

Table 4 continued--Number of paddlefish per month with open and closed lamprey wounds, old scars, prop injuries, hook wounds and lampreys attached, 1977-1978. Percentage of sample subtended.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL
<u>1978</u>													
Sample size	56	0	97	27	0	1							181
No wounds	2 (.04)	0	14 (.14)	0	0	1 (1.00)							17 (.09)
Closed wounds	54 (.96)	0	80 (.82)	27 (.27)	0	0							161 (.89)
Open wounds	14 (.25)	0	12 (.12)	8 (.30)	0	0							34 (.19)
Prop wounds	1 (.02)	0	3 (.03)	0	0	0							4 (.02)
Hook wounds	6 (.11)	0	5 (.05)	2 (.07)	0	0							13 (.07)
Lamprey attached	6 (.11)	0	5 (.05)	0	0	0							11 (.06)

Appendix Table 5. Weighted values of catch per pole hour of effort for paddlefish captured by snagging in the tailwaters of Lock and Dam 12, 1975-1978.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	STANDARD DEVIATION
1975	0	0	2.6	5.4	1.0	4.0	3.1	6.4	1.3	5.4	7.4	18.5	5.5	± 5.0
1976	11.5	13.9	12.8	2.3	1.2	7.7	3.5	1.0	3.1	5.6	6.8	10.1	6.6	± 4.6
1977	2.9	12.3	14.1	1.9	3.4	4.6	1.0	1.1	1.2	4.1	2.3	5.9	4.6	± 4.3
1978	8.6	IC[1]	3.0	2.2	NS[2]	1.0	2.5						3.7	± 3.3
MEAN	7.6	13.1	8.1	3.0	1.9	4.3	2.5	2.8	1.9	5.0	5.5	11.5		
STANDARD DEVIATION	± 4.4	± 1.1	± 6.2	± 1.6	± 1.3	± 2.7	± 1.1	± 3.1	± 1.1	± .8	± 2.8	± 6.4		

[1]Ice cover.

[2]Not sampled.

Appendix Table 6. Secchi disc visibility and temperature in the tailwaters of Lock and Dam 12, 1975-1978. Values are means of monthly sample measurements.

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1975	Temperature	°C				5.0	20.0	24.4	26.7	27.2	17.8	13.9	7.8	0
		(°F)				(41)	(68)	(76)	(80)	(82)	(64)	(57)	(46)	(32)
	Visibility	cm				28	28	20	43	61	36	48	36	36
		(in)				(11)	(11)	(8)	(17)	(24)	(14)	(19)	(14)	(14)
1976	Temperature	°C	0	0	1.1	11.1	17.2	23.9	25.6	25.0	18.9	9.4	6.1	0
		(°F)	(32)	(32)	(34)	(52)	(63)	(75)	(78)	(77)	(66)	(49)	(43)	(32)
	Visibility	cm	112	157	18	38	33	36	46	43	48	58	61	74
		(in)	(44)	(62)	(7)	(15)	(13)	(14)	(18)	(17)	(19)	(23)	(24)	(29)
1977	Temperature	°C	0	0	0	15.6	21.1	23.9	26.7	23.3	20.6	11.7	7.8	0
		(°F)	(32)	(32)	(32)	(60)	(70)	(75)	(80)	(74)	(69)	(53)	(46)	(32)
	Visibility	cm	91	20	51	41	56	46	46	36	46	28	38	91
		(in)	(36)	(8)	(20)	(16)	(22)	(18)	(18)	(14)	(18)	(11)	(15)	(36)
1978	Temperature	°C	0		.06	8.3		22.2						
		(°F)	(32)		(33)	(47)		(72)						
	Visibility	cm	112		30	25		6						
		(in)	(44)		(12)	(10)		(2.5)						

Appendix Table 7. Mean monthly discharge (X 1000) from Lock and Dam 12, April, 1975-June, 1978.

	1975		1976		1977		1978	
	m^3/s	(ft^3/s)	m^3/s	(ft^3/s)	m^3/s	(ft^3/s)	m^3/s	(ft^3/s)
January			.8	(26.8)	.4	(14.5)	.9	(32.4)
February			1.0	(36.5)	.5	(18.0)	.7	(24.1)
March			1.9	(65.4)	1.0	(37.0)	1.0	(34.9)
April	2.0	(72.4)	3.4	(119.0)	1.2	(41.2)	2.6	(92.5)
May	4.1	(145.8)	1.4	(49.5)	.7	(24.3)	1.7	(58.8)
June	1.9	(68.6)	.7	(26.0)	.7	(25.7)	1.8	(63.2)
July	1.9	(68.3)	.5	(19.3)	.7	(26.2)		
August	.9	(32.9)	.5	(16.1)	.5	(18.6)		
September	1.0	(35.8)	.4	(13.8)	1.1	(38.8)		
October	.8	(26.7	.4	(14.7)	1.5	(52.7)		
November	1.2	(42.9)	.4	(15.4)	1.1	(40.4)		
December	1.0	(36.2)	.4	(12.8)	1.0	(35.5)		
Mean	1.6	(58.8)	1.0	(34.6)	.9	(31.1)	1.5	(51.0)

Appendix Table 8. Age and length frequency distribution of male paddlefish, 1975.

CLASS RANGE[1] (cm)	(in)	SAMPLE SIZE	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
40- 44	16-17.9	0																		
45- 49	18-19.9	1	1																	
50- 54	20-21.9	1	1																	
55- 59	22-23.9	1	1																	
60- 64	24-25.9	0																		
65- 69	26-27.9	1			1															
70- 74	28-29.9	8			8															
75- 79	30-31.9	16			15	1														
80- 84	32-33.9	21			6	15														
85- 89	34-35.9	10				5	5													
90- 94	36-37.9	13					11	2												
95- 99	38-39.9	3						2	1											
100-104	40-41.9	0																		
105-109	42-43.9	2							1		1									
110-114	44-45.9	1									1									
115-119	46-47.9	0																		
120-124	48-49.9	0																		
125-129	50-51.9	0																		
130-134	52-53.9	0																		
135-139	54-55.9	0																		
140-144	56-57.0	0																		
145-149	58-59.9	0																		
150-154	60-61.9	0																		
155-159	62-63.9	0																		
Damaged Rostrum		3			1	2														
TOTALS			3	0	31	23	16	4	2	0	2	0	0	0	0	0	0	0	0	0

[1]Fork length.

Appendix Table 9. Age and length frequency distribution of male paddlefish, 1976.

CLASS RANGE[1] (cm)	(in)	SAMPLE SIZE	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
40- 44	16-17.9	1	1																	
45- 49	18-19.9	2		2																
50- 54	20-21.9	4		4																
55- 59	22-23.9	4		3	1															
60- 64	24-25.9	4		1	3															
65- 69	26-27.9	4			4															
70- 74	28-29.9	2			2															
75- 79	30-31.9	4			3	1														
80- 84	32-33.9	2			1	1														
85- 89	34-35.9	16					14	1	1											
90- 94	36-37.9	9				1	5	1	2											
95- 99	38-39.9	17						8	9											
100-104	40-41.9	14						1	11	2										
105-109	42-43.9	3								3										
110-114	44-45.9	2										2								
115-119	46-47.9	1											1							
120-124	48-49.9	0																		
125-129	50-51.9	0																		
130-134	52-53.9	0																		
135-139	54-55.9	1																1		
140-144	56-57.9	0																		
145-149	58-59.9	0																		
150-154	60-61.9	0																		
155-159	62-63.9	0																		
Damaged Rostrum		2							1			1								
TOTALS		92	1	10	14	3	19	11	24	5	0	3	1	0	0	0	0	1	0	0

[1]Fork length.

Appendix Table 10. Age and length frequency distributions of male paddlefish, 1977.

CLASS RANGE[1] (cm)	(in)	SAMPLE SIZE	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
40- 44	16-17.9	0																		
45- 49	18-19.9	0																		
50- 54	20-21.9	0																		
55- 59	22-23.9	0																		
60- 64	24-25.9	2			2															
65- 69	26-27.9	5			5															
70- 74	28-29.9	6			6															
75- 79	30-31.9	2			2															
80- 84	32-33.9	1					1													
85- 89	34-35.9	4				2	2													
90- 94	36-37.9	8					8													
95- 99	38-39.9	9					1	4	4											
100-104	40-41.9	4							2	1	1									
105-109	42-43.9	4								3	1									
110-114	44-45.9	1										1								
115-119	46-47.9	2											1	1						
120-124	48-49.9	1											1							
125-129	50-51.9	0																		
130-134	52-53.9	0																		
135-139	54-55.9	0																		
140-144	56-57.9	0																		
145-149	58-59.9	0																		
150-154	60-61.9	0																		
155-159	62-63.9	0																		
Damaged Rostrum		3						3												
TOTALS		52	0	0	15	2	12	7	6	4	2	1	2	1	0	0	0	0	0	0

[1]Fork length.

Appendix Table 11. Age and length frequency distributions of male paddlefish, 1978.

CLASS RANGE[1] (cm)	(in)	SAMPLE SIZE	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
40- 44	16-17.9	0																		
45- 49	18-19.9	0																		
50- 54	20-21.9	0																		
55- 59	22-23.9	0																		
60- 64	24-25.9	0																		
65- 69	26-27.9	0																		
70- 74	28-29.9	0																		
75- 79	30-31.9	7			6	1														
80- 84	32-33.9	18			2	15	1													
85- 89	34-35.9	22				2	20													
90- 94	36-37.9	11					11													
95- 99	38-39.9	5						4	1											
100-104	40-41.9	4							4											
105-109	42-43.9	10							3	7										
110-114	44-45.9	7								3	4									
115-119	46-47.9	1										1								
120-124	48-49.9	1									1									
125-129	50-51.9	0																		
130-134	52-53.9	0																		
135-139	54-55.9	0																		
140-144	56-57.9	0																		
145-149	58-59.9	0																		
150-154	60-61.9	0																		
155-159	62-63.9	0																		
Damaged Rostrum		4			1	2	1													
TOTALS		90	0	0	9	20	33	4	8	10	5	1	0	0	0	0	0	0	0	0

[1]Fork length.

Appendix Table 12. Age and length frequency distribution of male paddlefish, 1975-1978.

CLASS RANGE[1] (cm)	(in)	SAMPLE SIZE	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
40- 44	16-17.9	1	1																	
45- 49	18-19.9	3	1	2																
50- 54	20-21.9	5	1	4																
55- 59	22-23.9	5	1	3	1															
60- 64	24-25.9	6		1	5															
65- 69	26-27.9	10			10															
70- 74	28-29.9	16			16															
75- 79	30-31.9	29			26	3														
80- 84	32-33.9	42			9	31	2													
85- 89	34-35.9	51				9	41	1	1											
90- 94	36-37.9	41				1	35	3	2											
95- 99	38-39.9	34					1	18	15											
100-104	40-41.9	22						1	17	3	1									
105-109	42-43.9	19							4	13	2									
110-114	44-45.9	11								3	5	3								
115-119	46-47.9	4										1	2	1						
120-124	48-49.9	2									1		1							
125-129	50-51.9	0																		
130-134	52-53.9	0																		
135-139	54-55.9	1																1		
140-144	56-57.9	0																		
145-149	58-59.9	0																		
150-154	60-61.9	0																		
155-159	62-63.9	0																		
Damaged Rostrum		12			2	4	1	3	1			1								
TOTALS		315	4	10	69	48	80	26	40	19	9	5	3	1	0	0	0	1	0	0

[1]Fork length.

Appendix Table 13. Age and length frequency distribution of female paddlefish, 1975.

CLASS RANGE[1] (cm)	(in)	SAMPLE SIZE	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
40- 44	16-17.9	0																		
45- 49	18.19.9	0																		
50- 54	20-21.9	0																		
55- 59	22-23.9	0																		
60- 64	24-25.9	0																		
65- 69	26-27.9	1			1															
70- 74	28-29.9	6			6															
75- 79	30-31.9	15			13	2														
80- 84	32-33.9	20			4	15	1													
85- 89	34-35.9	7				5	2													
90- 94	36-37.9	7					6	1												
95- 99	38-39.9	3						2	1											
100-104	40-41.9	3						1	2											
105-109	42-43.9	3							1	2										
110-114	44-45.9	1								1										
115-119	46-47.9	1										1								
120-124	48-49.9	0																		
125-129	50-51.9	0																		
130-134	52-53.9	0																		
135-139	54-55.9	1														1				
140-144	56-57.9	0																		
145-149	58-59.9	0																		
150-154	60-61.9	0																		
155-159	62-63.9	0																		
Damaged Rostrum		3			1	1	1													
TOTALS		71	0	0	25	23	10	4	4	3	0	1	0	0	0	1	0	0	0	0

[1]Fork length.

Appendix Table 14. Age and length frequency distributions of female paddlefish, 1976.

CLASS RANGE[1] (cm)	(in)	SAMPLE SIZE	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
40- 44	16-17.9	0																		
45- 49	18-19.9	0																		
50- 54	20-21.9	0																		
55- 29	22-23.9	0																		
60- 64	24-25.9	1			1															
65- 69	26-27.9	2			2															
70- 74	28-29.9	2			1	1														
75- 79	30-31.9	2				2														
80- 84	32-33.9	6				6														
85- 89	34-35.9	6				2	4													
90- 94	36-37.9	9					7	2												
95- 99	38-39.9	11						8	3											
100-104	40-41.9	12						3	8	1										
105-109	42-43.9	7							5	2										
110-114	44-45.9	4								2	1	1								
115-119	46-47.9	2									1	1								
120-124	48-49.9	1									1									
125-129	50-51.9	7								1	2	2		2						
130-134	52-53.9	2												1		1				
135-139	54-55.9	2														1				1
140-144	56-57.9	2																1	1	
145-149	58-59.9	0																		
150-154	60-61.9	1																		1
155-159	62-63.9	0																		
Damaged Rostrum		3		1			1													
TOTALS		82	0	1	4	11	12	13	16	6	5	4	0	3	1	2	0	1	1	2

[1]Fork length.

Appendix Table 15. Age and length frequency distributions of female paddlefish, 1977.

CLASS RANGE[1] (cm)	(in)	SAMPLE SIZE	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
40- 44	16-17.9	0																		
45- 49	18.19.9	0																		
50- 54	20-21.9	0																		
55- 59	22-23.9	0																		
60- 64	24-25.9	2			2															
65- 69	26-27.9	6			6															
70- 74	28-29.9	5			5															
75- 79	30-31.9	1			1															
80- 84	32-33.9	0																		
85- 89	34-35.9	5				2	3													
90- 94	36-37.9	7					7													
95- 99	38-39.9	8					1	5	2											
100-104	40-41.9	5							4	1										
105-109	42-43.9	6							1	5										
110-114	44-45.9	2								2										
115-119	46-47.9	5									2	2		1						
120-124	48-49.9	2											2							
125-129	50-51.9	1													1					
130-134	52-53.9	0																		
135-139	54-55.9	2															1	1		
140-144	56-57.9	1																	1	
145-149	58-59.9	1																		1
150-154	60-61.9	0																		
155-159	62-63.9	1																		1
Damaged Rostrum		5				1		4												
TOTALS		65	0	0	14	3	11	9	7	8	2	2	2	1	1	0	1	1	1	2

[1]Fork length

Appendix Table 16. Age and length frequency distributions of female paddlefish, 1978.

CLASS RANGE[1] (cm)	(in)	SAMPLE SIZE	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
40- 44	16-17.9	0																		
45- 49	18-19.9	0																		
50- 54	20-21.9	0																		
55- 59	22-23.9	0																		
60- 64	24-25.9	0																		
65- 69	26-27.9	0																		
70- 74	28-29.9	0																		
75- 79	30-31.9	3			1	2														
80- 84	32-33.9	11			2	8	1													
85- 89	34-35.9	24				7	17													
90- 94	36-37.9	6					6													
95- 99	38-39.9	3						3												
100-104	40-41.9	4						1	3											
105-109	42-43.9	3							1	2										
110-114	44-45.9	1								1										
115-119	46-47.9	2								1			1							
120-124	48-49.9	1										1								
125-129	50-51.9	2											1		1					
130-134	52-53.9	0																		
135-139	54-55.9	2														1	1			
140-144	56-57.9	1																1		
145-149	58-59.9	0																		
150-154	60-61.9	0																		
155-159	62-63.9	0																		
Damaged Rostrum		7			1	3	1		1	1										
TOTALS		70	0	0	4	20	25	4	5	5	0	1	2	0	1	1	1	1	0	0

[1]Fork length

Appendix Table 17. Age and length frequency distributions of female paddlefish, 1975-1978.

CLASS RANGE[1] (cm)	(in)	SAMPLE SIZE	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
40- 44	16-17.9	0																		
45- 49	18-19.9	0																		
50- 54	20-21.9	0																		
55- 59	22-23.9	0																		
60- 64	24-25.9	3			3															
65- 69	26-27.9	9			9															
70- 74	28-29.9	13			12	1														
75- 79	30-31.9	21			15	6														
80- 84	32-33.9	37			6	29	2													
85- 89	34-35.9	42				16	26	1												
90- 94	36-37.9	29					26	4												
95- 99	38-39.9	25					1	17	6											
100-104	40-41.9	24						4	17	2										
105-109	42-43.9	19							8	11										
110-114	44-45.9	8								6	1	1								
115-119	46-47.9	10								1	3	4	1	1						
120-124	48-49.9	4									1	1	2							
125-129	50-51.9	10								1	2	2	1	2	2					
130-134	52-53.9	2												1		1				
135-139	54-55.9	7														3	2	1		1
140-144	56-57.9	4																2	2	
145-149	58-59.9	1																		1
150-154	60-61.9	1																		1
155-159	62-63.9	1																		1
Damaged Rostrum		18		1	2	5	3	4	1	1					1					
TOTALS		288	0	1	47	57	58	30	32	22	7	8	4	4	3	4	2	3	2	4

[1]Fork length.

Appendix Table 18. Length frequency and constructed age frequency distributions for paddlefish tagged in the tailwaters of Lock and Dam 12, 1975.

CLASS RANGE[1] (cm)	(in)	SAMPLE SIZE	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
40- 44	16-17.9	0																		
45- 49	18-19.9	2	1	1																
50- 54	20-21.9	10	2	8																
55- 59	22=23.9	2		1	1															
60- 64	24-25.9	3		1	2															
65- 69	26-27.9	2			2															
70- 74	28-29.9	13			12	1														
75- 79	30-31.9	31			17	13	1													
80- 84	32-33.9	46			6	34	6													
85- 89	34-35.9	41				19	21	1												
90- 94	36-37.9	45					23	19	3											
95- 99	38-39.9	62					4	39	19											
100-104	40-41.9	40						14	18	7	1									
105-109	42-43.9	23							4	14	5									
110-114	44-45.9	17								7	6	4								
115-119	46-47.9	7								2	3	1	1							
120-124	48-49.9	14									2	6	3	3						
125-129	50-51.9	4										3		1						
130-134	52-53.9	3												2		1				
135-139	54-55.9	1														1				
140-144	56-57.9	3														2				1
145-149	58-59.9	1																		1
150-154	60-61.9	0																		
155-159	62.63.9	0																		
Damaged Rostrum		11			5	1	2	2		1										
Length not available		1			1															
TOTALS		382	3	11	46	68	57	75	44	31	17	14	4	6	0	4	0	0	0	2

[1] Fork length.

Appendix Table 19. Length frequency and constructed age frequency distributions for paddlefish tagged in the tailwaters of Lock and Dam 12, 1976.

CLASS RANGE[1] (cm)	(in)	SAMPLE SIZE	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
40- 44	16-17.9	1	1																	
45- 49	18-19.9	12	12																	
50- 54	20-21.8	17	3	14																
55- 59	23-23.9	20		19	1															
60- 64	24-25.9	13		2	11															
65- 69	26-27.9	23			23															
70- 74	28-29.9	28			28															
75- 79	30-31.9	26			20	6														
80- 84	32-33.9	36			1	32	3													
85- 89	34-35.9	41				20	19	2												
90- 94	36-37.9	53					26	25	2											
95- 99	38-39.9	69						41	28											
100-104	40-41.9	50						10	35	5										
105-109	42-43.9	26							4	21	1									
110-114	44-45.9	13								7	6									
115-119	46-47.9	4										3	1							
120-124	48-49.9	9										2	3	4						
125-129	50-51.9	1												1						
130-134	52-53.9	5												2	1	2				
135-139	54-55.9	2															2			
140-144	56-57.9	2																1		1
145-149	58-59.9	1																	1	
150-154	60-61.9	0																		
155-159	62-63.9	0																		
Damaged Rostrum		22	1		3	1		5	9	1		2								
Length not available		2				1	1													
TOTALS		476	17	35	87	60	49	83	78	34	7	7	4	7	1	2	2	1	1	1

[1] Fork length.

Appendix Table 20. Length frequency and constructed age frequency distributions for paddlefish tagged in the tailwaters of Lock and Dam 12, 1977.

CLASS RANGE[1] (cm)	(in)	SAMPLE SIZE	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
40- 44	16-17.9	0																		
45- 49	18-19.9	0																		
50- 54	20-21.9	1	1																	
55- 59	22-23.9	2		2																
60- 64	24-25.9	2		1	1															
65- 69	26-27.9	21			20	1														
70- 74	28-29.9	45			40	5														
75- 79	30-31.9	64			35	29														
80- 85	32-33.9	71			4	60	7													
85- 89	34-35.9	66				26	39	1												
90- 94	36-37.9	48					30	17	1											
95- 99	38-39.9	34						23	11											
100-104	40-41.9	44						5	31	7	1									
105-109	42-43.9	46							10	26	10									
110-114	44-45.9	18								5	13									
115-119	46-47.9	8								1	3	4								
120-124	48-49.9	5									1	2	1	1						
125-129	50-51.9	1												1						
130-134	52-53.9	2												1		1				
135-139	54-55.9	1																1		
140-144	56-57.9	1																		1
145-149	58-59.9	3															1		1	1
150-154	60-61.9	1															1			
155-159	62-63.9	0																		
Damaged Rostrum		20		1	4	2	3	2	8											
Length not available																				
TOTALS		504	1	4	104	123	79	48	61	39	28	6	1	3	0	1	2	1	1	2

[1]Fork length.

Appendix Table 21. Length frequency and constructed age frequency distributions for paddlefish tagged in the tailwaters of Lock and Dam 12, 1978.

CLASS RANGE[1] (cm)	(in)	SAMPLE SIZE	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
40- 44	16-17.9	0																		
45- 49	18-19.9	0																		
50- 54	20-21.9	0																		
55- 59	22-23.9	0																		
60- 64	24-25.9	1		1																
65- 69	26-27.9	2		1	1															
70- 74	28-29.9	2			2															
75- 79	30-31.9	6			5	1														
80- 84	32-33.9	33			1	32														
85- 89	34-35.9	50				25	25													
90- 94	36-37.9	21				2	18	1												
95- 99	38-39.9	7					1	3	3											
100-104	40-41.9	15						3	12											
105-109	42-43.9	19							4	15										
110-114	44-45.9	6								2	4									
115-119	46-47.9	3									3									
120-124	48-49.9	1										1								
125-129	50-51.9	0																		
130-134	52-53.9	1														1				
135-139	54-55.9	1															1			
140-144	56-57.9	0																		
145-149	58-59.9	1																	1	
150-154	60-61.9	0																		
155-159	62-63.9	0																		
Damaged Rostrum		11			1	1	1	2	3	2		1								
Length not available		1				1														
TOTALS		181	0	2	10	62	45	9	22	19	7	2	0	0	0	1	1	0	1	0

[1]Fork length.

Appendix Table 22. Length frequency and constructed age frequency distributions for paddlefish tagged in the tailwaters of Lock and Dam 12, 1975-1978.

CLASS RANGE[1] (cm)	(in)	SAMPLE SIZE	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
40- 44	16-17.9	1	1																	
45- 49	18-19.9	14	13	1																
50- 54	20-21.9	28	6	22																
55- 59	22-23.9	24		22	2															
60- 64	24-25.9	19		5	14															
65- 69	26-27.9	48		1	46	1														
70- 74	28-29.9	88			82	6														
75- 79	30-31.9	127			77	49	1													
80- 84	32-33.9	186			12	158	16													
85- 89	34-35.9	198				90	104	4												
90- 94	36-37,9	167				2	97	62	6											
95- 99	38-39.9	172					5	106	61											
100-104	40-41.9	149						32	96	19	2									
105-109	42-43.9	114							22	76	16									
110-114	44-45.9	54								21	29	4								
115-119	46-47.9	22								3	9	8	2							
120-124	48-49.9	29									3	11	7	8						
125-129	50-51.9	6										3		3						
130-134	52-53.9	11												5	1	5				
135-139	54-55.9	5														1	3	1		
140-144	56-57.9	6														2		1		3
145-149	58-59.9	6															1		3	2
150-154	60-61.9	1															1			
155-159	62-63.9	0																		
Damaged Rostrum		64	1	1	13	5	6	11	20	4		3								
Length not available		4		1		2	1													
TOTALS		1,543	21	53	246	314	229	215	205	123	59	29	9	16	1	8	5	2	3	5

[1]Fork length.

Appendix Table 23. Length frequency distributions of sport and commercial harvested paddlefish, 1975-1978. Length is at time of tagging.

CLASS RANGE[1] (cm)	(in)	1975 SPORT	1975 COMM.	1976 SPORT	1976 COMM.	1977 SPORT	1977 COMM.	1978 SPORT	1978 COMM	TOTAL SPORT	TOTAL COMM.
45- 49	18-19.9					1				1	
50- 54	20-21.9							1		1	
55- 59	22-23.9					2		1		3	
60- 64	24-25.9					2	1	1		3	1
65- 69	26-27.9					3	3	1		4	3
70- 74	28-29.9		1			7	2			7	3
75- 79	30-31.9			3		6	4	3	1	12	5
80- 84	32-33.9		2	5		5	1	5	1	15	4
85- 89	34-35.9	3		4	3	6	1	10	2	23	6
90- 94	36-37.9	1		1		11	1	6		19	1
95- 99	38-39.9	2	1	8	3	13	1	3	2	26	7
100-104	40-41.9	2	1	6	1	11	3	6		25	5
105-109	42-43.9	1		6	1	9		7		23	1
110-114	44-45.9	2	1	1		2		1		6	1
115-119	46-47.9	4		2		5		2		13	
120-124	48-49.9	1		1		1		2		5	
125-129	50-51.9			2	1			1		3	1
130-134	52-53.9			1		3				4	
135-139	54-55.9			1						1	
140-144	56-57.9			2				1		3	
145-149	58-59.9					2				2	
150-154	60-61.9								1		1
155-159	62-63.9					1				1	
TOTALS	SPORT	16		43		90		51		200	
TOTALS	COMMERCIAL		6		9		17		7		39

[1]Fork length.

Appendix Table 25. Age frequency distributions of sport harvested paddlefish at the tailwaters of Lock and Dam 12, 1975-1978.

YEAR	SAMPLE SIZE	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1975	16					4	2	1	3	1	1	3	1						
1976	45			3	7	3	9	6	8	1	3	2		1	2				
1977	91	1	2	15	9	9	14	19	9	3	3		1	1	1	1	3		
1978	50		1	4	10	11	1	9	6	4		1	2						1
TOTALS	202	1	3	22	26	27	26	35	26	9	7	6	4	2	3	1	3		1

Appendix Table 24. Age frequency distributions of commercially harvested paddlefish in Pool 13, 1975-1978.

YEAR	SAMPLE SIZE	AGE 1	2	3	4	5	6	7	8	9	10	11	12
1975	6			1	1	1	1	1		1			
1976	7				1	1	2		2				1
1977	17			9	1	1	1	5					
1978	6				2	2	2						
TOTALS	36			10	5	5	6	6	2	1			1