RELATIONSHIP OF INTERVAL BETWEEN LIFTS AND THE CATCH OF TEN-FOOT WISCONSIN-TYPE TRAP NETS

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ABSTRACT

A study to determine the relationship of the interval of time between lifts and the catch of ten-foot Wisconsin-type trap nets was included as a segment of an investigation designed to determine the potential of utilizing trap nets as a commercial fishing device in warmwater reservoirs.

Data obtained from the catch of 170 trap net lifts, which varied in interval of time between lifts from one to seven days, indicate that with an increase in the interval of time between lifts, the total catch increased while the catch per net day decreased. A logarithmic curve $Y = 73.866 + 235.229 \log X$, where Y equals total catch in pounds and X equals the interval of time between lifts in days, appears to best describe this relationship.

The species composition of the catch also changed significantly as the interval of time between lifts increased. This change was the result of a decreasing percentage of gizzard and threadfin shad in the catch as the interval increased.

It has been shown that stationary gear such as gill or trammel nets are most efficient when tended daily. Operating in this manner requires less time to tend the gear due to the smaller catch. In addition, mortality of the catch increases substantially with an increase in the interval of time between lifts. Trap net catches differ in that the time required to tend this gear varies only slightly with an increase in the size of catch and the mortality of fish in the crib does not appear to increase significantly with an increase in the interval of time between lifts.

It is therefore possible to increase the total catch of a commercial fishing operation by increasing the number of trap nets and tending each one less frequently. The most efficient operation, considering the conditions under which this study was conducted, would have been to set 30 nets and lift each net every 3 days.

INTRODUCTION

A thorough understanding of the influence of various intervals of time between lifts upon the catch of a specific type of fishing gear is essential in the establishment of an efficient commercial fishery utilizing that type of gear. Various aspects of this relationship between catch of stationary types of fishing gear and the interval of time between lifts have been investigated in other areas. Van Oosten (1935) was the first to show that the catch of gill and trap nets did not increase in direct proportion to the interval of time between lifts. Hansen (1949) and Patriarche (1968) investigated the escapement of certain species of fish from fyke and small trap nets respectively to illustrate how this affected total catch and certain other population parameters. Kennedy (1951) investigated the relationship between catch of gill nets and the interval of time between lifts and determined that commercial fishermen would profit most by tending their gear daily.

A study was therefore designed to obtain data on these parameters while conducting an investigation to evaluate the potential of trap nets as a commercial fishing device in TVA reservoirs. Handling procedures and gear descrip-

[1]Field work for this investigation was conducted while the author was an employee of the Tennessee Valley Authority.

tions of the 10-foot, Wisconsin-type trap net used in this study have been presented by Grinstead (1968). Trap nets were fished primarily in Wheeler Reservoir, Alabama, but data were also taken on catches made in Kentucky, Pickwick, Wilson, Guntersville, and Watts Bar reservoirs in Kentucky, Tennessee, and Alabama. The study period extended from September 1965 to June 1967.

METHOD AND MATERIAL

Trap nets were set at a particular location for periods that extended from 5 to 49 days. During these periods lifts were made according to the following schedule so each net would sample all intervals from one to seven days in a four-week period. When possible, all nets were lifted on the same day.

First week — Monday only
Second week — Monday and Tuesday
Third week — Monday and Wednesday
Fourth week — Monday and Thursday

The catch was sorted into game and commercial fish. Species of game fish were noted and their total weight recorded. During the early phase of the investigation (September 1965 through June 1966) measurements on commercial fish consisted of combined weight, number of individuals, and total length of the minimum and maximum individual of each species. These, along with the data collected later, were utilized in the compilation of total catch per interval of time between lifts. Later in the investigation (July 1966 through June 1967) the commercial fish were first sorted by species and then into categories termed industrial and marketable. Only these data were used in the evaluation of the species composition of the catch and the industrial-marketable ratio, as they relate to the interval of time between lifts.

Marketable fish were those commonly sold in local fish markets for human consumption. This group included all catfish, regardless of size, and buffalo, carp, carpsucker, freshwater drum, and paddlefish with a total length greater than 11 inches. Fish of these species less than 11 inches and all other non-game species regardless of size were classed as industrial fish. Measurements taken on the catch during this period included the combined weight and number of each species in each category, as well as the total length of the smallest and largest fish of each species in each category. Weights in pounds were used as the measurement of the total catch and in calculations of species compositions.

DISCUSSION

As was previously noted, gill nets have proven to be most efficient when tended daily and gill nets left untended for longer periods require more time and effort to clean and reset. This additional time is a function of an increased number of fish entangled in the net. Since, the time required to tend the gear is proportional to the number of fish in the catch, the average catch per day decreases with an increase in the interval between lifts, and mortality of the catch increases with longer intervals, there is no advantage to extending the interval of time between lifts. Such is not the case with trap nets. Although the catch per net day did decrease with longer intervals between lifts of trap nets, the time required to tend the gear and the percentage of mortality remained almost constant with the increased intervals. The time and effort required to lift and position a trap net alongside the vessel was found to be completely independent of the size of the catch. More effort was required to dip and transfer fish from net to boat with larger catches, but the time required to perform the task varied only slightly. This is to say that a 600-pound catch could be removed from a net in approximately the same amount of time as a 100-pound catch. These conditions prevailed for intervals of time that extended to 7 days and with catches as large as 842 pounds.

Data from 170 trap net lifts, in which 32,880.9 pounds of fish were taken, were utilized in this investigation. The number of lifts, mean catch, and standard deviation for each interval of time between lifts, from one to seven days, are presented in Table 1. The relationship of total catch and interval of time between lifts, utilizing these data, appears to be best described as the logarithmic curve $Y = 73.866 + 235.229 \log X$, where Y equals total catch in pounds and X equals interval of time between lifts in days. A calculated value of 34.20, distributed as F, with 1 and 168 degrees of freedom, indicates a regression coefficient significantly different from zero. This relationship indicates that the efficiency of trap nets decreases, by a specific percentage, as the interval of time between lifts increases. The total catch per lift increased with an increase in the interval of time between lifts, from a low of 73.87 pounds per lift with an interval of one day, to a high of 272.66 pounds per lift with an interval of seven days. The daily increase in size of catch decreased so that the catch per net day ranged from a high of 73.87 pounds per net day with an interval of one day, to a low of 38.95 pounds per net day with an interval of seven days.

The large values for two standard deviations listed in Table 1 are thought to be a result of the differences in behavior and distributional patterns of the various species of fish rather than a difference in efficiency of the gear or operational procedures. A few unproportionally large catches in each interval tended to drastically increase the variance of the catch. However, since the distributions of the catch values for all intervals are similar, it is believed that the calculated curve is a valid description of the relationship between catch and interval of time between lifts but the calculated catch rates should be regarded as a minimum estimate in a determination of the potential catch of this gear.

The species compositions and catches of industrial and marketable commercial fish harvested with each interval of time between lifts are presented in Tables 2 and 3. The ratios of industrial to marketable commercial fish were analyzed to determine the influence of the interval of time between lifts on the catch of fish grouped into these categories. The percentage of industrial and marketable fish harvested utilizing intervals between lifts that ranged from 1 to 7 days are illustrated in Figure 2. These data indicated that as the interval of time between lifts increases the percentage of industrial fish decreased with a corresponding increase in the percentage of marketable fish.

Kendall's *Tau* coefficient as described by Ghent (1963) was used to establish the significance of this change. The ranks of the percentages of industrial fish for each interval were compared to the interval between lifts in Table 4. These values ranged from a high of 56.9 percent at the one-day intervals to a low of 29.7 percent at the six day interval. A significant relative correlation ($P = .05$) was obtained, which indicated a smaller percentage of the catch was made up of industrial fish as the interval of time between lifts increased.

Those data presented in Tables 2 and 3 were also used to determine if the species composition of the catch remained similar for the various intervals of time between lifts. A 5 x 7 contingency table was used to measure the significance of this change. The various species of fish were grouped arbitrarily into five groups to obtain an expected value of 3.5 in each cell of the contingency table (Table 5). This method of "pooling" has been discussed by Houser and Ghent (1964). A significant difference ($P = .0005$) was observed, with the largest contribution to the total chi-square resulting from the catch of gizzard and threadfin shad. These data indicate that the species composition of the catch varied significantly with an increase in the interval of time between lifts.

Differences in the species composition of commercial fish, excluding gizzard and threadfin shad, for each interval were then tested for significance in Table 6. It was necessary to "pool" the three species of catfish with the "others" group in Table 5 to obtain an expected value of 3.5 in all cells. The non-significant differences in these data indicate that the catch of gizzard and threadfin shad was primarily responsible for differences in the species composition as it related to intervals between lifts. The catch of gizzard and threadfin shad decreased with an increased interval.

Since all shad were classified as industrial fish, this group probably accounted for the observed difference in the industrial-marketable ratio. Excluding shad, the percentage rank of industrial fish for each interval does not correlate with days between lifts (Table 7).

These data indicate that a change in the time interval between lifts results in changes in total catch, species composition, and industrial-marketable ratio. The differences in the species composition and the industrial-marketable ratio, were found to result from the catch of gizzard and threadfin shad. Approximately the same number of shad were harvested regardless of the intervals between lifts. Why these fish were taken at a different rate than the other commercial fish is unknown, but possible explanations are a higher mortality due to predation in the crib or a higher rate of escapement.

CONCLUSION

These data illustrate that the variation in catch as it relates to interval of time between lifts should be regarded as a major parameter and should be given careful consideration when attempting to establish a trap net commercial fishery. The species of fish most desired in the commercial fishery will regulate to some extent how these data are to be analyzed. For example, a shorter interval of time between lifts would certainly be recommended if the primary species desired were gizzard or threadfin shad. These decisions must be independently established for each particular commercial fishing operation and are mentioned here only to illustrate the importance of the analysis.

The relationship of the total catch of all species and the interval between lifts is probably the most significant analysis that should be considered. The importance of this relationship can best be illustrated by accepting the theory that the amount of time required to lift and remove the catch of a trap net is independent of the size of the catch and that 10 trap nets can be tended by one crew in a normal work day. If a total of 10 nets were used by this crew, each net would be lifted every day to produce an expected daily catch of 10 times the calculated catch of a net left untended for an interval of one day, i.e., 10 x 73.9 = 739 pounds per day. With an inventory of 20 nets, each net would be lifted every other day to produce an estimated catch equal to 10 times the catch calculated for a two day interval, or (10 x 144.7) 1447 pounds per day. The largest expected daily catch would result with an inventory of 70 nets. Each net would be lifted only once a week to produce a catch of (10 x 272.7) 2727 pounds per day. This increased catch would be obtained with the same crew, vessel, equipment, dockage, and shore facilities. However, as the number of nets were increased, a substantial investment in additional gear and a greater cost of processing the larger catch would result in an increase in both the operational and fixed expenditures. The time required to set, pull, and repair the additional gear would also increase the operational cost. The physical problem of the larger area required to set a larger number of nets and the greater distances that would be required to travel to and from the nets would decrease the number of nets which could be tended in a day.

As a result of these conditions and the large number of variables influencing the trap net catch, it is not now possible to accurately predict the number of trap nets that should be operated in particular warmwater reservoirs to obtain the largest profit. However, considering conditions under which this study was conducted, an inventory of 30 trap nets, of which 10 are to be lifted each day, appears to have the potential of being the most efficient operation. An operation utilizing this number of nets would definitely be more efficient and profitable than one in which the minimum number of trap nets was used to enable daily lifts, as would be recommended for most types of conventional commercial fishing gear.

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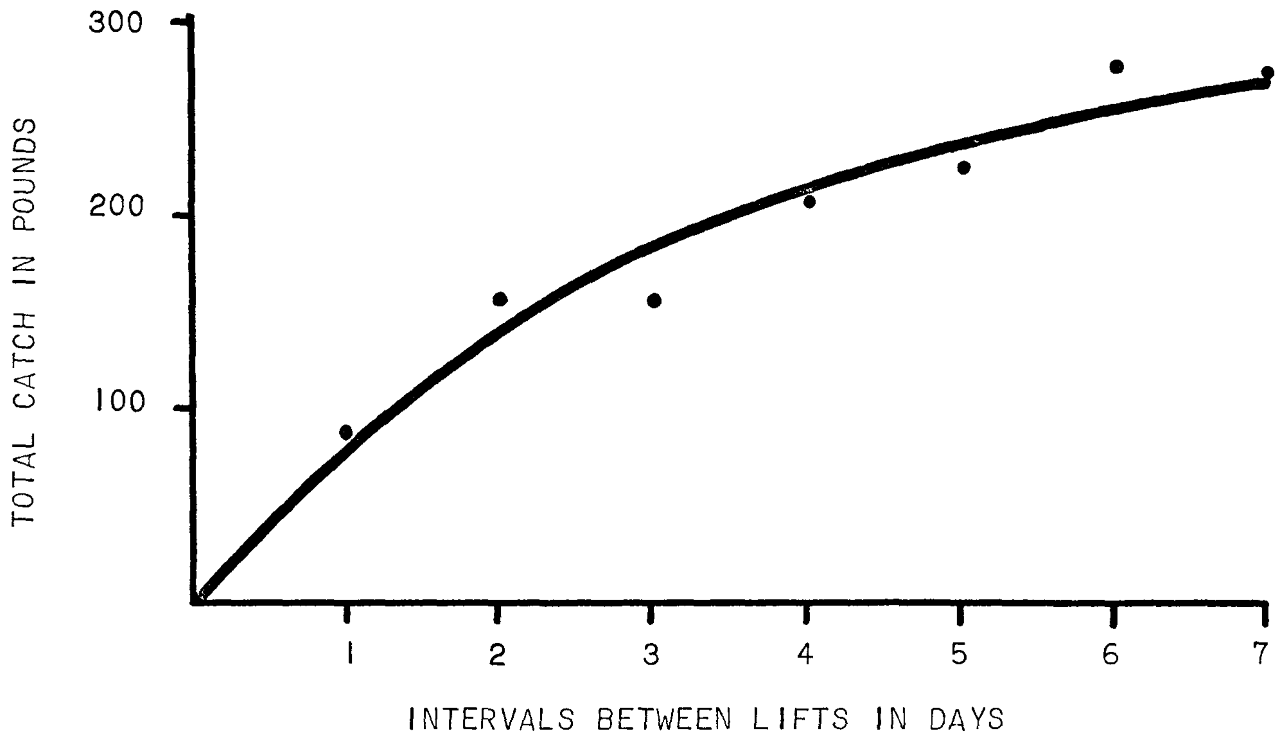

FIGURE 1. The relationship between the total catch and the interval between lifts presented by the mean catch per interval and the calculated catch curve of $Y = 73.866 + 235.229 \log X$.

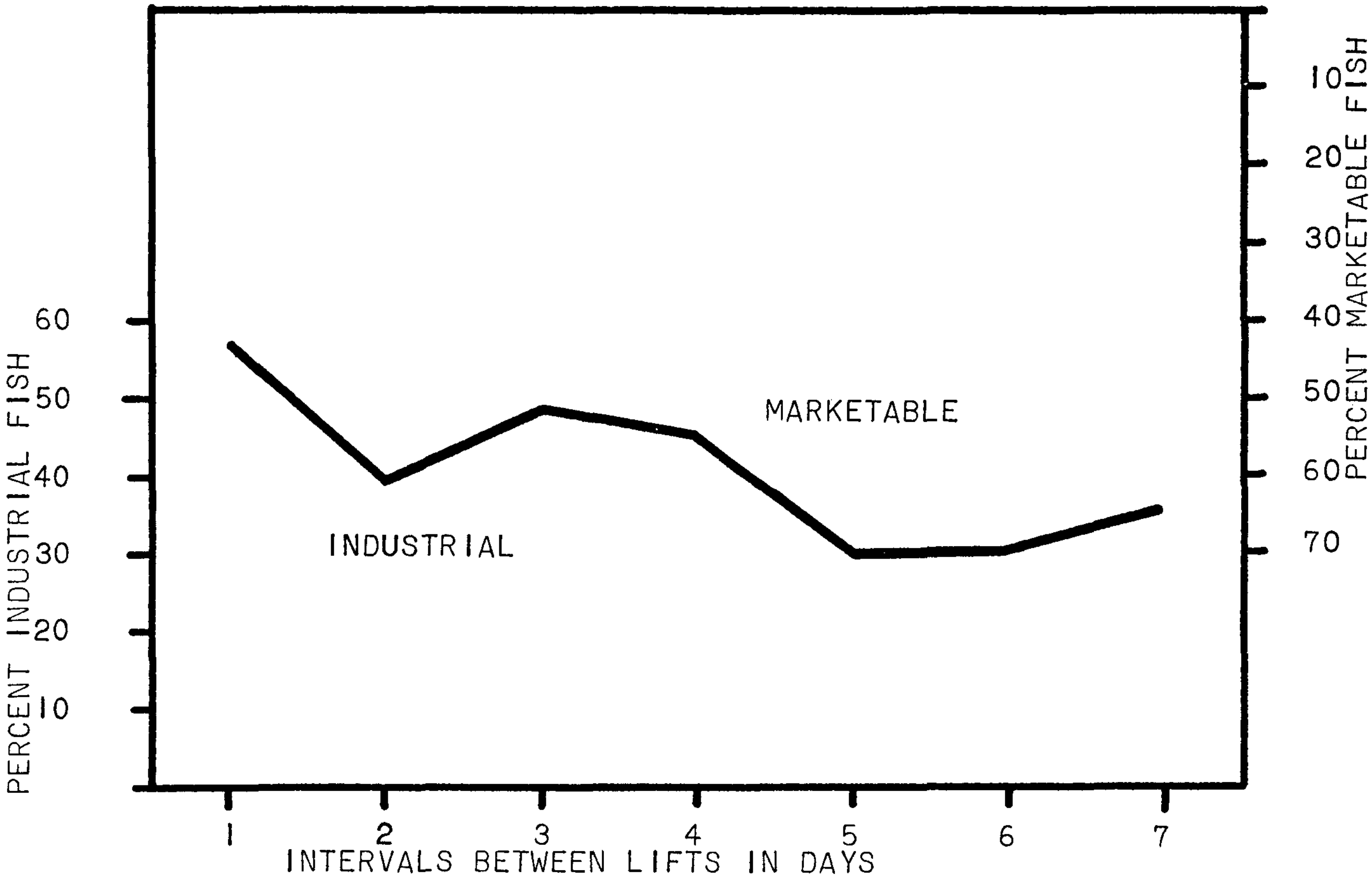

FIGURE 2. Percentage of Industrial and Marketable fish taken from catches with intervals of time between lifts that ranged from 1 to 7 days.

Table 1. The relationship between the total catch of fish and the interval of time between lifts.

Interval of time between lifts (days)	Number of lifts	Mean catch (pounds)	Two standard deviations	Calculated catch $Y = 73.866 + 235.229 \log X$
1	26	86.04	167.48	73.87
2	29	158.25	224.40	144.67
3	21	155.78	270.36	186.09
4	25	208.85	254.92	215.50
5	30	225.61	232.42	238.29
6	18	277.64	454.46	255.28
7	21	276.00	392.04	272.66

Table 2. Industrial-commercial fish harvested with different intervals of time between lifts. Percentages are calculated from the combined catch of industrial and marketable fish. The total percentage for each interval represents the percentage of industrial fish in the combined catch.

Species	Intervals													
	1-Day		2-Day		3-Day		4-Day		5-Day		6-Day		7-Day	
	wt.	%	wt.	%	wt.	%	wt.	%	wt.	%	wt.	%	wt.	%
Carp	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--
Smallmouth buffalo	6.3	1.2	10.8	0.6	48.6	2.4	9.0	0.3	21.2	0.6	2.4	0.1	64.8	1.9
Bigmouth buffalo	0.0	--	0.0	--	0.0	--	1.5	0.0	0.0	--	0.0	--	0.0	--
Drum	38.1	7.4	316.8	16.5	587.2	28.6	763.2	26.7	685.2	20.0	290.2	8.1	779.4	22.4
Shad[1]	239.5	46.5	337.6	17.6	282.9	13.8	470.5	16.4	254.7	7.4	654.6	18.3	310.3	8.9
Channel catfish	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--
Blue catfish	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--
Flathead catfish	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--
Redhorse[2]	0.0	--	8.2	0.4	8.3	0.4	0.0	--	9.7	0.3	17.4	0.5	2.2	0.1
Spotted sucker	0.0	--	3.5	0.2	0.0	--	1.8	0.0	0.0	--	5.6	0.2	2.1	0.1
River carpsucker	0.0	--	5.6	0.3	0.0	--	0.0	--	0.0	--	3.4	0.1	2.2	0.1
Mooneye	0.9	0.2	9.0	0.5	20.6	1.0	27.3	1.0	20.1	0.6	5.9	0.2	33.0	0.9
Skipjack herring	8.0	1.6	49.5	2.6	29.0	1.4	26.4	1.0	35.7	1.0	77.3	2.2	36.9	1.0
Paddlefish	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--
Gar[3]	0.0	--	0.0	--	2.5	0.1	0.0	--	0.0	--	0.0	--	3.1	0.1
Blue sucker	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	6.8	0.2	0.0	--
Total	292.8	56.9	741.0	38.6	979.1	47.7	1299.7	45.4	1026.6	29.9	1063.6	29.8	1234.0	35.5

1. Gizzard and threadfin shad.
2. Golden, black, shorthead, silver, and northern redhorse.
3. Shortnose and spotted gar.

Table 3. Marketable commercial fish harvested with different intervals of time between lifts. Percentages are calculated from the combined catch of industrial and marketable fish. The total percentage for each interval represents the percentage of marketable fish in the combined catch.

Species	Intervals													
	1-Day		2-Day		3-Day		4-Day		5-Day		6-Day		7-Day	
	wt.	%	wt.	%	wt.	%	wt.	%	wt.	%	wt.	%	wt.	%
Carp	5.7	1.1	22.3	1.2	6.2	0.3	24.1	0.8	8.6	0.3	73.9	2.1	292.5	8.4
Smallmouth buffalo	120.6	23.4	566.1	29.5	608.8	29.7	826.6	28.9	1223.4	35.7	1239.1	34.7	805.9	23.2
Bigmouth buffalo	13.7	2.7	12.3	0.6	18.5	0.9	65.9	2.3	54.1	1.6	111.0	3.1	465.9	13.4
Drum	41.5	8.1	463.0	24.2	173.7	8.5	223.7	7.8	617.0	18.0	614.3	17.2	315.2	9.1
Shad[1]	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--
Channel catfish	18.0	3.5	15.3	0.8	61.1	3.0	30.7	1.1	163.6	4.8	30.3	0.8	78.2	2.3
Blue catfish	3.7	0.7	13.9	0.7	30.5	1.5	19.1	0.7	34.0	1.0	5.9	0.2	64.5	1.8
Flathead catfish	17.6	3.4	57.8	3.0	165.6	8.1	329.6	11.6	199.2	5.8	234.5	6.6	112.0	3.2
Redhorse[2]	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--
Spotted sucker	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--
River carpsucker	1.2	0.2	12.6	0.7	7.5	0.4	38.2	1.3	61.4	1.8	89.9	2.5	36.4	1.0
Mooneye	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--
Skipjack herring	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--
Paddlefish	0.0	--	11.5	0.6	0.0	--	3.8	0.1	42.7	1.2	112.3	3.1	75.7	2.2
Gar[3]	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--
Blue sucker	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--	0.0	--
Total	222.0	43.1	1174.8	61.4	1701.9	52.3	1561.7	54.6	2404.0	70.1	2511.2	70.2	2246.3	64.5

1. Gizzard and threadfin shad.
2. Golden, black, shorthead, silver, and northern redhorse.
3. Shortnose and spotted gar.

Table 4. Comparison of catch per lift of industrial and marketable commercial fish harvested with various intervals of time between lifts.

Interval in days	Industrial fish	Marketable fish	Total catch	Percent industrial fish	Rank of percent	P	Q
1	24.4	18.6	43.0	56.9	7	0	6
2	52.9	83.9	136.8	38.7	4	2	3
3	69.9	76.7	146.6	47.7	6	0	4
4	81.2	97.6	178.8	45.4	5	0	3
5	54.0	126.5	180.5	29.9	2	1	1
6	76.0	179.4	255.4	29.7	1	1	0
7	72.7	132.1	204.8	35.4	3	0	0
						4	17

Kendall's *Tau* coefficient = -.619; rank correlation S score = -13; variance of S = 44.33; significance of *Tau* equivalent to normal deviate = -1.95; p = .05.

Table 5. A comparison of the species composition of commercial fish harvested with various intervals.

Species		Interval Between Lifts in Days							Sum
		1	2	3	4	5	6	7	
Freshwater drum	Catch/lift	6.6	55.7	54.4	61.7	68.5	64.6	89.2	400.7
	Expected	15.0	47.9	51.2	62.5	63.2	89.3	71.6	
	Chi-square	4.7	1.3	0.2	0.0	0.5	6.8	4.3	
Smallmouth buffalo	Catch/lift	10.6	41.2	47.0	52.2	65.5	88.7	64.9	370.1
	Expected	13.9	44.2	47.3	57.8	58.3	82.5	66.1	
	Chi-square	0.8	0.2	0.0	0.5	0.9	0.5	0.0	
Shad[1]	Catch/lift	20.0	24.1	20.2	29.4	13.4	46.8	18.3	172.2
	Expected	6.5	20.6	22.0	26.9	27.1	38.4	30.8	
	Chi-square	28.3	0.6	0.2	0.2	6.9	1.8	5.1	
Catfish[2]	Catch/lift	3.3	6.2	18.4	23.7	20.9	19.3	15.0	106.8
	Expected	4.0	12.8	13.7	16.7	16.8	23.8	19.1	
	Chi-square	0.1	3.4	1.6	3.0	1.0	0.8	0.9	
Others[3]	Catch/lift	2.5	0.6	6.6	11.8	12.2	36.0	17.4	96.1
	Expected	3.6	11.5	12.3	15.0	15.1	21.4	17.2	
	Chi-square	0.6	0.3	2.6	0.7	0.6	9.9	0.0	
Total catch/lift		43.0	136.8	146.6	178.8	180.5	255.4	204.8	1145.9

1. Gizzard and threadfin shad.
2. Flathead, channel, and blue catfish.
3. *Bigmouth buffalo, paddlefish, skipjack herring, river carpsucker, mooneye, carp, golden redhorse, black redhorse, shorthead redhorse, silver redhorse, northern redhorse,* spotted sucker, shortnose gar, and spotted gar.

Table 6. A comparison of commercial fish — excluding gizzard and threadfin shad — harvested with various intervals between lifts.

Species		Interval Between Lifts in Days							Sum
		1	2	3	4	5	6	7	
Freshwater drum	Observed	6.6	55.7	54.4	61.7	68.5	64.6	89.2	400.7
	Expected	9.5	46.4	52.0	61.5	68.8	85.8	76.8	
	Chi-square	0.885	1.864	0.111	0.001	0.001	5.238	2.002	
Smallmouth buffalo	Observed	10.6	41.2	47.0	52.2	65.5	88.7	64.9	370.1
	Expected	8.7	42.8	48.0	56.8	63.5	79.3	70.9	
	Chi-square	0.415	0.060	0.021	0.373	0.063	1.114	0.508	
Others[1]	Observed	5.8	15.8	25.0	35.5	33.1	55.3	32.4	202.9
	Expected	4.8	23.5	26.3	31.1	34.8	43.5	38.9	
	Chi-square	0.208	2.523	0.064	0.623	0.083	3.201	1.086	
Total catch per lift excluding shad[2]		23.0	112.7	126.4	149.4	167.1	208.6	186.5	973.7

Total chi-square, 12 d.f., = 20.44 .10 p .05

1. Flathead, channel, and blue catfish; bigmouth buffalo; paddlefish; skipjack herring, river carpsucker, mooneye, carp; golden redhorse; black redhorse; shorthead redhorse; silver redhorse; northern redhorse; spotted sucker; shortnose gar; and spotted gar.
2. Gizzard and threadfin shad.

Table 7. Comparison of catch per lift of industrial and marketable commercial fish — excluding shad — harvested with various intervals of time between lifts.

Interval in days	Industrial fish (exc. shad)	Marketable fish	Total catch	Percent industrial fish	Rank of percent	P	Q
1	4.4	18.6	23.0	19.2	2	5	1
2	28.8	83.9	112.7	25.6	4	3	2
3	49.7	76.7	126.4	39.4	7	0	4
4	51.8	97.6	149.4	34.7	6	0	3
5	40.6	126.5	167.1	24.3	3	1	1
6	29.2	179.4	208.6	14.0	1	1	0
7	54.4	132.1	186.5	29.1	5	0	1
						10	12

Kendall's *Tau* coefficient = -.048; rank correlation S score = -2; variance of S = 44.33; significance of *Tau* equivalent to normal deviate = .30; p = .76.