THE INFLUENCE OF VARIOUS FACTORS ON THE CATCH OF OTTER TRAWLS IN A WARMWATER RESERVOIR [1]

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ABSTRACT

The first phase of a study to determine the potential of otter trawls as commercial fishing gear in the warmwater reservoir was investigated. The research was conducted on Wheeler Reservoir, Alabama, during September, October and December, 1967. Two 37-foot and two 45-foot otter trawls constructed from three designs were investigated utilizing a systematic sampling schedule in which direction, speed and duration of tow, and length of warp were randomly selected. Two areas of Wheeler Reservoir, an expanse of open water in the main body and two smaller areas in the Elk River arm, were designated as study sites and were sampled at all hours of the day. A total of 232 tows which harvested 5259 pounds of fish were made with the research vessel DAKWA. Of this catch, 237 pounds or 4.5 percent were classified as game fish. The commercial catch was comprised primarily of gizzard and threadfin shad.

The 37-foot, semi-balloon trawl was the most efficient during the investigation. The greatest deviation in catch resulted from tows made in the two different areas of the reservoir. Although other variables, such as time of day and duration of tow appeared to have an influence on catch, these were minor when compared to the influence of the distribution patterns of the fish. It was concluded that an otter trawl fishery would be feasible only when large concentrations of fish could be found in or attracted to areas that were physically suited for trawling.

INTRODUCTION

Commercial fishery investigations currently being conducted by the Tennessee Valley Authority includes the life history aspects of some of the more important commercial fish, seasonal catch records of the existing fishery, ways and means of attracting fish to designated areas, and the development of more efficient harvest methods. Previous segments of these studies have been presented by Wrenn (1968) and by Grinstead (1968).

The particular study reported here was designed to establish the expected species composition of catch, to develop handling procedures, and to select a suitable size and design of otter trawl for the research vessel DAKWA. This is the first in a series of studies to determine the potential of this gear in an expanded commercial fishery of a warmwater reservoir.

A history of the commercial fishery industry in TVA reservoirs may be obtained from papers by Bryan and Tarzwell (1941), Tarzwell (1944), and Bryan and White (1958). Information on the fish population of those areas of Wheeler Reservoir sampled in this study is available in an inventory report by Tennessee Valley Authority and Alabama Department of Conservation (1961).

METHODS AND MATERIALS

Field investigations were conducted on Wheeler Reservoir during one week periods of September, October, and December of 1967. During these times the research vessel DAKWA was operated 24 hours a day by

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three crews. This 35-foot, steel-hulled vessel was powered by a 160 h.p. diesel engine. The work deck was fitted with two gin poles, which also functioned as davits for the aft-blocks, a double spool winch which was powered by the main engine, a stern roller, and a mast and boom.

Double warps of 5/16 inch wire rope were used to tow the gear. Nets were hauled with the winch until the otter boards approached the aft-blocks. The boards were then secured to the davits and detached from the warp by means of a "G" snap. An idler line which by-passed the aft-block was used to connect the trawl legs to the warp. Pressure was applied at the winch to release the drag of the net on the otter boards and davits. The otter boards were then disconnected from the trawl legs by another "G" snap. The trawl was hauled aboard over the stern roller by spooling the trawl legs on to the winch. The vessel remained under power until the wings of the trawl approached the forward blocks and the entire length of the foot-rope was aboard the vessel. The vessel was then stopped and the remaining portion of the trawl and catch were hauled aboard by hand. It was necessary to utilize the boom winch to bring the net aboard with some of the larger catches.

A single set of otter boards were used with all trawls. These boards were of conventional design with dimensions of 30 by 60 inches. Iron rod brackets were used to attach the otter boards to the warp in such a manner that the towing point was located one inch below the horizontal center line and 22.5 inches back of the forward edge. Trawl legs were attached to the back of the boards in positions 45 inches back of the forward edge. A steel runner and five vertical support members were constructed of ¼ inch steel plate.

Four types of otter trawls were tested. The description of these nets follows the terminology recommended by Bullis (1951). All mesh sizes are given in stretch measure. Nylon webbing was used throughout all nets.

(A) A 37-foot, four-seam, semi-balloon trawl was constructed of four-inch number 12 thread in the wings, dogears and square; 3-inch number 12 thread in the body; and 2-inch number 15 thread in the intermediate and cod end. The foot-rope was 49 feet.

(B) A 37-foot, two seam, trawl was constructed of 5-inch number 15 thread in the wings, dogears, and square; 3½-inch number 15 thread in the body; and 2-inch number 24 thread in the cod end. The foot-rope was 48 feet.

(C) A 45-foot, fast taper, two seam trawl was constructed of 6-inch number 24 thread in the wings, dogears, and square; 4-inch number 24 thread in the body; and 1¾-inch number 36 thread in the cod end. The foot-rope was 62 feet.

(D) A 45-foot, two seam trawl was constructed of 5-inch number 15 thread in the wings, dogears, and square; 3½-inch number 15 thread in the body; and 2-inch number 24 thread in the cod end. The foot-rope was 57 feet.

Handling procedures which were thought to influence catch were categorized into two groups. Those variables that could be selected independently from other operations, such as speed, duration and direction of tow, and the warp length were divided into increments that were thought to be applicable to reservoir conditions. Before a cruise these increments were selected for each tow by utilizing a table of random numbers.

Increments of the variables, location, time of day, and size and design of the trawl were selected by a stratified sampling method.

The catch was first sorted into game and commercial fish. The species of game fish were noted and the total weight of the combined species were recorded. Commercial fish were sorted by species, and then categorized as industrial or marketable. Marketable fish were those commonly sold in local fish markets for human consumption. This group includes the larger carp; river carpsucker; freshwater drum; paddlefish;

smallmouth and bigmouth buffalo; channel, blue, and flathead catfish. Fish of these species less than 11 inches in length and all other commercial fish, regardless of size were recorded as industrial fish. Measurements taken on the commercial species included the combined weight and number in each category of each species. Total lengths of the largest and smallest individual in each category were also recorded. No attempt was made to separate the catch of gizzard and threadfin shad. Throughout the text they have been referred to only as shad. Weight, in pounds, was used as the measurement of total catch and in calculations of species composition. Common names of fishes are those recommended by the American Fisheries Society, (1960).

VARIABLES INFLUENCING THE CATCH OF OTTER TRAWLS

During this investigation the mean catch for all otter trawls was 22.7 pounds per haul and 1.8 pounds per minute of tow, (Table 1). Of the four trawls tested, the 37-foot semi-balloon trawl was the most efficient, harvesting 32.7 pounds per haul or 2.67 pounds per minute of tow. The 37- and 45-foot, two-seam, trawls had smaller catches of 23.1 and 18.3 pounds per haul. The 45-foot fast taper trawl was the least efficient, harvesting only 4.0 pounds per haul. This net also differed in the percentage of game fish in the catch. The 45-foot fast taper net took 14.6 percent game fish, whereas the percentages in the 37-foot semi-balloon, 37-foot two seam and 45-foot two seam were 3.6, 4.1 and 5.7 percent, respectively. The 37-foot two seam trawl harvested only 6.0 percent marketable fish, whereas the 37-foot semi-balloon, 45-foot fast taper, and the 45-foot two seam took 11.8, 10.7 and 11.9 percent, respectively.

The two areas sampled in Wheeler Reservoir were an open-water station in the main body of the reservoir and two shoreline stations in the Elk River arm. The open-water station which was located at Tennessee River Mile 285, directly above the mouth of Elk River, was well suited physically for trawling. The area was approximately four square miles, and the bottom was relatively flat and free of obstructions. The bottom type was silt that was fluid to a depth of approximately four feet. The depth of water varied from 25 to 30 feet. The two stations in the Elk River arm, associated with the shoreline, had a number of obstructions throughout the area and a wider variety of bottom types. The first station was located four miles upstream from the mouth of Elk River on the left bank. This station had a relatively flat bottom and had apparently been a field before the inundation of the reservoir. The depth of water varied from 15 to 25 feet. The other station was approximately five miles upstream on the right bank. This station was within the river channel and had a depth of 25 to 30 feet.

Tows made in the open-water station harvested 246.0 pounds of fish in 66 hauls, for a mean catch of 3.73 pounds. The largest catch made in the area was 17.9 pounds. Numerous hauls were made in which no fish were taken. Tows made in the Elk River stations averaged 30.2 pounds for 166 hauls. The largest catch was 549.1 pounds. There appeared to be no difference in the catch from the two stations in the Elk River arm.

The data (Figure 1) indicate that otter trawls were more efficient when towed at night. The largest mean catch per haul (27.9 pounds) was taken with tow made from 0100 to 0659 (military time), while tows made between 1300 and 1859 resulted in the lowest mean catch (19.91 pounds).

Data presented in Table 2 indicate tows of longer duration have a larger mean catch per haul, but tows of shorter duration have a larger mean catch per minute of tow. During this investigation duration of tows varied from 4 to 22 minutes. The mean catch per haul varied from a low of 13.1 pounds, with durations of tow between 4.0 and 5.9 minutes; to a high of 31.0 pounds, with durations of tow between 20.0 and 21.9 minutes. The largest mean catch per minute (2.92 pounds) was made

TABLE 1. Catch by weight in pounds of different otter trawls towed in Wheeler Reservoir, 1967.

	Commercial Fish						
	Indust.	Market	Combined	Game Fish	Total Catch	Number of Hauls	Duration of Hauls in Min.
37-foot, Semi-balloon Catch	2101.8	294.0	2395.8	89.2	2485.0	76	931
% of total	84.6	11.8	96.4	3.6			
Mean catch/haul	27.66	3.87	31.53	1.17	32.70		
Mean catch/min.	2.26	.31	2.57	.10	2.67		
37-foot, Two seam Catch	1017.5	68.1	1085.6	46.2	1131.8	49	634
% of total	89.9	6.0	95.9	4.1			
Mean catch/haul	20.77	1.39	22.16	.94	23.10		
Mean catch/min.	1.60	.11	1.71	.07	1.78		
45-foot, Fast taper Catch	65.7	9.4	75.1	12.9	88.0	22	241
% of total	74.7	10.7	85.4	14.6			
Mean catch/haul	2.99	.42	3.41	.59	4.00		
Mean catch/min.	.27	.04	.31	.05	.37		
45-foot, Two seam Catch	1280.2	185.7	1465.9	88.5	1554.4	85	1085
% of total	82.4	11.9	94.3	5.7			
Mean catch/haul	15.06	2.18	17.25	1.04	18.29		
Mean catch/min.	1.18	.17	1.35	.08	1.43		
All Trawls Catch	4465.2	557.2	5022.4	236.8	5259.2	232	2891
% of total	84.9	10.6	95.5	4.5			
Mean catch/haul	19.25	2.40	21.65	1.02	22.67		
Mean catch/min.	1.55	.19	1.74	.08	1.82		

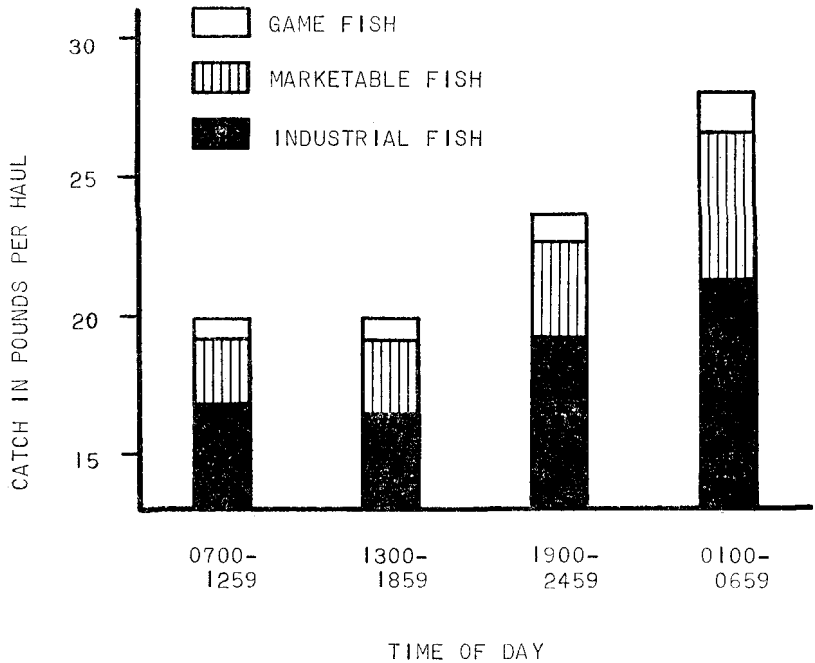

FIGURE 1. Mean catch of otter trawls towed at different times of the day in Wheeler Reservoir, 1967.

with tows which had durations between 10.0 and 11.9 minutes, while the next highest catch (2.72 pounds) was with durations between 4.0 and 5.9 minutes. The smallest catch per minute of tow was 1.02 pounds taken with tows of 18.0 to 19.9 minutes duration.

The relationship of catch and the duration of tow between 4 and 22 minutes are presented in Figure 2. Since there was a significant difference in the catch from the two areas of the reservoir, calculations were made from data collected at the stations in the Elk River arm. The relationship of catch per haul to duration of tow can be described as $Y = 9.904 + 1.206\ X$, where Y equals the catch per haul in pounds and X equals the duration of tow in minutes. The correlation coefficient, $r = 203$, indicates a significant correlation of X and Y ($.025 > p > .01$). The catch per minute decreased with an increase in the duration of tow as $Y = 2.99 - .071\ X$, where Y equals the catch per minute in pounds and X equals the duration of tow in minutes. However, the correlation coefficient $r = -.129$, indicates a non-significant correlation at the .05 level ($p \cong .10$).

Speed of tow was measured as revolutions per minute of the main engine. This measure can be used only as an indication of the effect of speed of tow upon the catch, since it will be pertinent only to the particular vessel and gear used in this investigation. However, these data do show that speed of tow had an important influence on the size of catch and should therefore be critically established with each operation.

In this investigation, the range of RPM was 1000 to 1800 with intervals of 100 RPM used to establish the relationship between catch and speed of tow. Generally, the catch increased from 13.7 pounds at 1000 RPM to a peak of 44.7 at 1400 RPM, then declined to the lower level at 1600 RPM (Table 3).

TABLE 2. Catch by weight in pounds of otter trawls with durations of tows between four and twenty-two minutes.

Duration in Minutes		Commercial Fish			Game Fish	Total Catch	Number of Hauls	Duration of Hauls in Min.
		Indust.	Market	Combined				
4.0- 5.9	Sum	63.2	4.0	67.2	.8	68.0	5	25
	X/Haul	12.64	.80	13.44	.16	13.60		
	X/Min.	2.53	.16	2.69	.03	2.72		
6.0- 7.9	Sum	209.0	78.4	287.4	7.8	295.2	19	125
	X/Haul	11.0	4.13	15.13	.41	15.54		
	X/Min.	1.67	.63	2.30	.06	2.36		
8.0- 9.9	Sum	452.4	76.0	529.0	17.7	546.7	33	274
	X/Haul	13.70	2.32	16.03	.54	16.57		
	X/Min.	1.65	.28	1.93	.06	1.99		
10.0-11.9	Sum	1188.2	138.1	1326.3	55.9	1382.2	47	474
	X/Haul	25.28	2.94	28.22	1.19	29.41		
	X/Min.	2.51	.29	2.80	.12	2.92		
12.0-13.9	Sum	659.5	142.0	801.5	33.0	834.5	38	469
	X/Haul	17.36	3.74	21.09	.87	21.96		
	X/Min.	1.41	.30	1.71	.07	1.78		
14.0-15.9	Sum	640.7	159.6	800.3	45.1	845.4	36	526
	X/Haul	17.80	4.43	22.23	1.25	23.48		
	X/Min.	1.22	.30	1.52	.09	1.61		
16.0-17.9	Sum	202.4	48.8	251.2	9.5	260.7	14	226
	X/Haul	14.45	3.49	17.94	.68	18.62		
	X/Min.	.90	.22	1.11	.04	1.15		
18.0-19.9	Sum	221.0	73.2	294.2	19.5	313.7	17	307
	X/Haul	13.00	4.31	17.31	1.15	18.45		
	X/Min.	.72	.24	.96	.06	1.02		
20.0-21.9	Sum	585.8	79.5	665.3	47.5	712.8	23	465
	X/Haul	25.47	3.46	28.93	2.07	30.99		
	X/Min.	1.26	.17	1.43	.10	1.53		

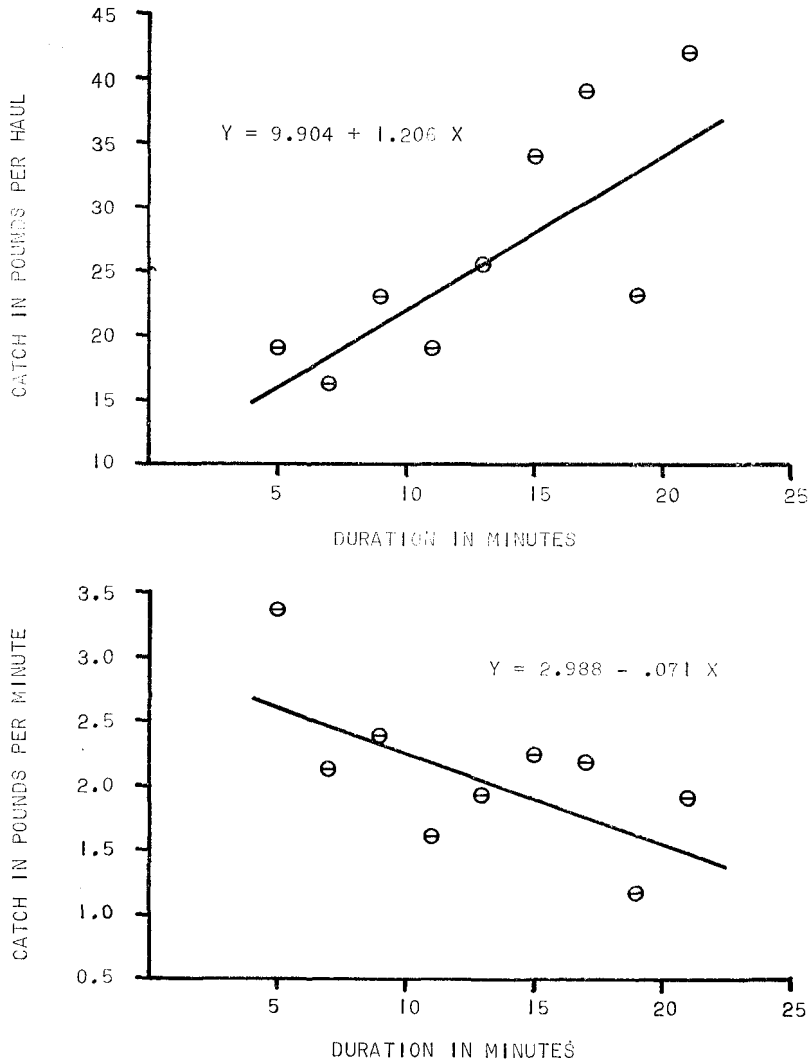

FIGURE 2. Relationship of catch and duration of tow of otter trawls.

Warp lengths from 75 to 175 feet were tested at 25-foot intervals. The length of warp instead of a warp-depth ratio was used in the analysis of these data because of the relative shallow nature of the study sites. Depth of water ranged from 15 to 30 feet. The largest mean catch (38.9 pounds) was made with tows that used a 75-foot warp. The mean catch decreased to 18.0 pounds per haul with a warp of 175 feet (Figure 3).

The effect of direction of tow, in relation to current, was tested. Utilizing all data, the mean catch per haul of tows made upstream was 20.8 pounds, while the mean catch of downstream tows was 24.7 pounds. To determine if there was a significant difference in upstream and downstream tows, data on hauls made only in the Elk River arm were used

TABLE 3. Catch by weight in pounds of otter trawls towed at various speeds as measured by revolutions per minute.

RPM		COMMERCIAL FISH Indust.	Market.	Combined	GAME FISH	TOTAL CATCH	Number of Hauls	Duration of Hauls in Min.
1000	Sum	77.2	18.8	96.0	13.8	109.8	8	119
	X/Haul	9.65	2.35	12.00	1.73	13.73		
1100	Sum	767.5	192.3	959.8	44.4	1004.2	36	520
	X/Haul	21.32	5.34	26.66	1.23	27.89		
1200	Sum	418.1	66.1	484.2	28.4	512.6	28	413
	X/Haul	14.93	2.36	17.29	1.01	18.31		
1300	Sum	576.6	134.9	711.5	35.9	747.4	27	362
	X/Haul	21.36	5.00	26.35	1.33	27.68		
1400	Sum	944.8	109.0	1053.8	19.4	1073.2	24	279
	X/Haul	39.37	4.54	43.91	.81	44.72		
1500	Sum	651.2	102.0	753.2	39.9	793.1	38	429
	X/Haul	17.13	2.68	19.82	1.05	20.87		
1600	Sum	258.8	47.2	306.0	14.4	320.4	23	254
	X/Haul	11.25	2.05	13.30	.63	13.93		
1700	Sum	309.3	98.5	407.8	11.7	419.5	29	280
	X/Haul	10.67	3.40	14.06	.40	14.46		
1800	Sum	218.7	31.4	250.1	28.9	279.0	19	235
	X/Haul	11.51	1.65	13.16	1.52	14.68		

to reduce the variance of the sample. These means were calculated as 34.9 pounds for downstream tows and 26.3 pounds for upstream tows. These means are not significantly different at the .05 level ($t = .955$ with 164 d.f. $= .20 > p > .10$), so we assumed that the direction of tow did not effect the catch.

SPECIES COMPOSITION OF CATCH

Of the 5259.2 pounds of fish harvested with otter trawls, 236.8 pounds (4.5 percent) were classified as game fish. The species of game fish were: white crappie, yellow bass, white bass, bluegill, redear and sauger. Although catch of individual game species were not recorded, white crappie, yellow bass, and white bass were the most common. The percentages of game fish taken during the three cruises were 6.9, 4.7, and 3.0 in September, October, and December, respectively.

The combined catch of gizzard and threadfin shad made up 76.9 percent of the commercial fish. Other commercial species which were significant in the catch were channel catfish (8.5 percent), freshwater drum (8.4 percent), smallmouth buffalo (2.0 percent), spotted sucker (1.5 percent) and paddlefish (1.1 percent). Of the other species, only carp accounted for more than 1.0 percent of the commercial fish catch dur-

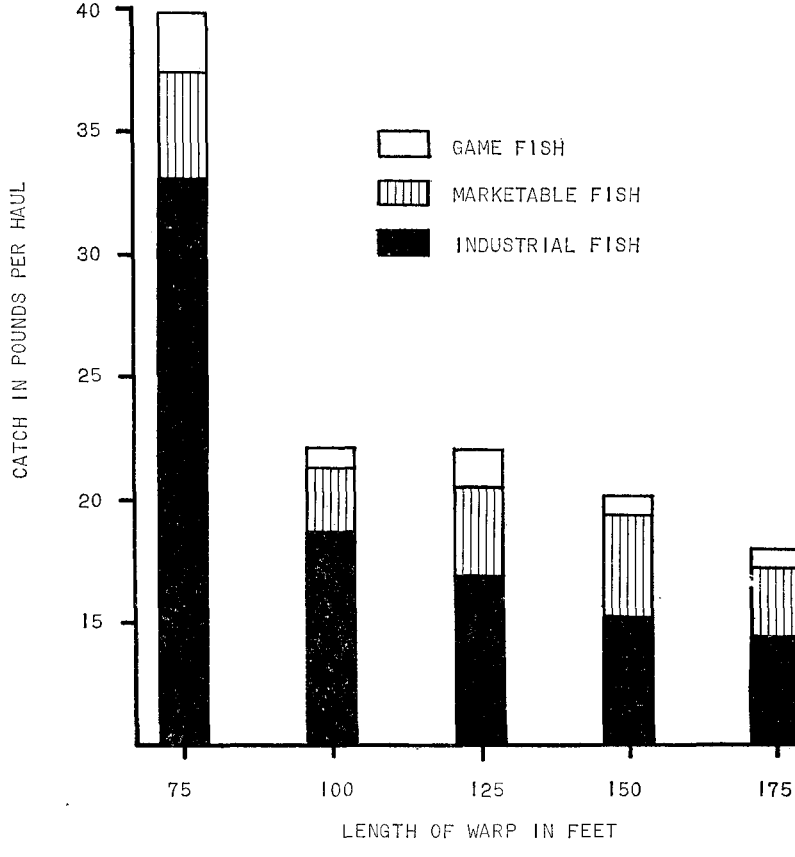

FIGURE 3. Mean catch of otter trawls utilizing various lengths of warp.

ing any particular cruise. However, carp represented only 0.4 percent of the total commercial fish catch for all cruises (Table 4).

The catch of industrial and marketable fish taken during this investigation are presented in Table 5. These data indicate industrial fish account for 88.9 percent of the commercial fish. Although shad, which are classified exclusively as industrial fish, made up 86.5 percent of this group, the catch of the remaining industrial species still outweighed the catch of marketable fish, 601.6 to 557.2 pounds. Catfish (channel, blue and flathead), accounted for 62.5 percent of marketable catch.

CONCLUSION

Under ideal conditions, such as towing the 37-foot semi-balloon trawl in the Elk River stations from 0100 to 0659 hours, with a warp of 75 feet, and at a speed of 1400 RPM, the mean catch would be expected to be higher than any recorded during the investigation. However, the narrow range in catch which resulted from the different increments of each variable indicates this expected increase would not be substantial. More of an effect is expected to result from differences in the fish distribution. This was indicatd by the significant difference in the catch taken from the two areas of the reservoir. However, distributional patterns of fish within the sample sites and the reasons for high concentrations of fish at these sites only at particular times were not studied. However, the occurrence of such concentrations have been demonstrated. A catch of 549 pounds was made in the Elk River arm during the night of December 12, 1967. Tows made directly before and after this haul harvested 43.7 and 28.2 pounds, respectively. Since the handling procedures were similar in the three tows it must be assumed that some unmeasured variable was responsible for this larger catch.

The next phase of the otter trawl investigation will therefore use the handling procedures and trawls we found best suited in this study to develop methods of locating the larger concentrations of fish and to establish the reasons for these concentrations. At this time it appears that a reservoir otter trawl fishery will be feasible only when these large concentrations of a desired fish can be located in or attached to areas that are physically suited for trawling.

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TABLE 4. Species composition, by weight in pounds, of fish taken with otter trawls in Wheeler Reservoir, 1967.

Species	September							
	Pounds	Percent	Pounds	Percent	Pounds	Percent	Pounds	Percent
Carp	10.5	1.1	5.9	.3	4.0	.2	20.4	.4
Smallmouth buffalo	9.5	1.0	41.4	1.9	51.6	2.7	102.5	2.0
Bigmouth buffalo	. . .	. .	3.0	.1	5.0	.3	8.0	.2
Freshwater drum	86.3	8.8	192.1	8.9	143.4	7.6	421.8	8.4
Shad [1]	677.6	69.1	1763.5	81.9	1422.5	75.3	3863.6	76.9
Channel catfish	154.7	15.8	106.5	4.9	168.2	8.9	429.4	8.5
Blue catfish	3.9	.4	4.7	.2	1.5	.1	10.1	.2
Flathead catfish	3.1	.3	10.0	.5	2.5	.1	15.6	.3
Golden redhorse	. . .	. . .	2.8	.1	. .	. .	2.8	.1
Spotted sucker	2.0	.2	10.7	.5	63.2	3.3	75.9	1.5
River carpsucker	5.1	.5	1.2	.1	6.2	.3	12.5	.2
Mooneye	1.7	.2	0.4	t	0.9	t	3.0	.1
Skipjack herring	1.3	.1	. . .	. .	. .	. .	1.3	t
Paddlefish	24.4	2.4	10.2	.5	18.6	1.0	53.2	1.1
Longnose gar	. . .	. . .	. . .	. .	1.9	.1	1.9	t
Golden shiner	.2	t	.2	t	. .	. .	.4	t
Percent	. . . .	99.9		99.9		99.9		99.9
Commercial fish	980.3	93.1	2152.6	95.3	1889.5	97.0	5022.4	95.5
Game fish [2]	72.1	6.9	106.8	4.7	57.9	3.0	236.8	4.5
Total	1052.4	. . .	2259.4		1947.4		5259.2	

1 Gizzard and threadfin shad.
2 White crappie, yellow bass, white bass, bluegill, redear and sauger.
t = Less than .05.

TABLE 5. Catch of industrial and marketable fish by weight in pounds of fish taken with otter trawls in Wheeler Reservoir, 1967.

Species	September		October		December		Total	
	Indust.	Market.	Indust.	Market.	Indust.	Market.	Indust.	Market.
Carp	1.2	9.3	5.9	...	0.8	3.2	7.9	12.5
Smallmouth buffalo	...	9.5	15.8	25.6	7.3	44.3	23.1	79.4
Bigmouth buffalo	...	...	...	3.0	0.1	4.9	0.1	7.9
Freshwater drum	83.7	2.6	167.2	24.9	127.3	16.1	378.2	43.6
Shad [1]	677.6	...	1763.5	...	1422.5	...	3863.6	...
Channel catfish	37.0	117.7	23.1	83.4	42.6	125.6	102.7	326.7
Blue catfish	2.0	1.9	1.3	3.4	1.0	0.5	4.3	5.8
Flathead catfish	...	3.1	...	10.0	...	2.5	...	15.6
Golden redhorse	...	...	2.8	...	...	...	2.8	...
Spotted sucker	2.0	...	10.7	...	63.2	...	75.9	...
River carpsucker	...	5.1	...	1.2	...	6.2	...	12.5
Mooneye	1.7	...	0.4	...	0.9	...	3.0	...
Skipjack herring	1.3	...	...	...	...	...	1.3	...
Paddlefish	...	24.4	...	10.2	...	18.6	...	53.2
Longnose gar	...	...	...	...	1.9	...	1.9	...
Golden shiner	0.2	...	0.2	...	...	...	0.4	...
Total	806.7	173.6	1990.9	161.7	1667.6	221.9	4465.2	557.2

[1] Gizzard and threadfin shad.