

JOB COMPLETION REPORT

As required by

FEDERAL AID IN FISHERIES RESTORATION ACT

TEXAS

Federal Aid Project No. F-5-R-8

Fisheries Investigations and Surveys of the Waters of Region 1-B

Job No. E-3 Experimental Attraction and Repulsion
of Fish Populations as a Means of Fishery Management

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ABSTRACT

Much of the work planned for this job was not completed. Favorable circumstances permitted opportune developmental work to be done, and resulted in virtually all of seven months of the eleven month period being spent in the completion of that management work. A search of the available literature on this subject was continued, and laboratory experimentation to determine the specific reaction to induced flow and aeration of four of the problematic species was completed. Intensive sampling of fish populations in five lakes provided background data. This data will be used later when sampling of the populations can provide evidence of the degree of attraction exerted by flow entering reservoirs. It is recommended that the scope of this job be reduced, and more time allocated to its requirements.

JOB COMPLETION REPORT

State of Texas

Project No. F-5-R-8

Name: Fisheries Investigations and Surveys
of the Waters of Region 1-B

Job No. E-3

Title: Experimental Attraction and Repulsion
of Fish Populations as a Means of
Fishery Management

Period Covered: April 1, 1960 - March 1, 1961

Objectives:

To determine if certain natural or man-made phenomena may be used to concentrate, by attraction or repulsion, specific fish populations, or an aggregate of several populations of fish, into small rather than large areas within bodies of water so that control measures may be used to bring about effective management of the fishery resource.

In Region 3-B of Texas, gizzard shad (Dorosoma cepedianum), river carpsuckers (Carpionoxenus carpio), carp (Cyprinus carpio), white crappie (Pomoxis annularis), bluegill (Lepomis macrochirus), green sunfish (Lepomis cyanellus), white bass (Ambloplites chrysops), channel catfish (Ictalurus punctatus), and bullheads (Ictalurus sp.) are species that are most often involved in management problems. For that reason, these fish will be the species for which means of attraction or repulsion will be sought.

It was recommended that the following basic or kinds of conditions be tested either separately or in combination in the manner appearing to be most suitable and logical. This work should be done in the future, either within Region 3-B or in other regions of the state, as the coordinators for the state may direct or as the prevailing circumstances may indicate as desirable.

1. Physical Movements of Water

a. Currents and Stream Flow

- (1) Natural stream flow from run-off and other flow of a sporadic nature.
- (2) Springs and movements of water from seepage or ground waters.
- (3) Water movements induced or created by man-made devices.

b. Thermal Movements of Water

- (1) Movements of water resulting from a difference in density, convection currents.

c. Movements of Water Resulting From the Movements of Air

(1) Waves

(2) Drift and tides or rises from atmospheric force (Seiche and similar currents)

2. Physical Properties of Water as a Force of Attraction or Repulsion

a. Temperature; ie, amount of heat in water (not to be confused with movement of water resulting from temperature)

b. Dissolved gasses, primarily oxygen and carbon dioxide. However, nitrogen and possibly other gasses may be tested.

c. Suspended and dissolved matter (inert matter and naturally occurring dissolved chemical compounds, such as salts, etc.)

3. Chemicals

In conjunction with water movements resulting from the above forces and/or independent of those forces, procedures should include a future effort to ascertain if a chemical means of attraction can be found.

4. Mechanical Devices

Mechanical means of luring or congregating fish as a control are virtually limitless, and are already known to be selective in some instances.

5. Specific Limitations for Segment's Work

It was known when the preceding outline was prepared that other necessary work would restrict testing under this project to a few devices or conditions. The preceding outline was to illustrate some of the directions in which investigation might logically be made. This was done to demonstrate the overall coverage that might be required before positive data could be obtained, and also to provide a basis for the delegation of specific categories of experimentation, if the coordinators for the state should deem a statewide effort desirable. Selection of specific procedures, to be completed by personnel of this region, were made on a basis of how the work could be carried out with the facilities available and in conjunction with the other work. How information and data obtained might be utilized in secondary objectives also influenced selection.

Procedures:

The procedures approved were not completed during the period because extensive developmental work was done in order to take advantage of favorable circumstances. The amount of that work was much greater than could be anticipated at the time of planning. Seven of eleven months covered under this project were required in completing developmental work at ten reservoirs within the region.

Detailed Explanation of Why Job Requirements Were Not Completed

When planning for this project in January 1960, it could not be anticipated that it would be practical later in that year to undertake extensive developmental work. This was especially true for the spring and summer to follow. Partially because of this lack of knowledge and also because living fish of the required species could be more easily obtained for the tests when hatchery ponds were being drained, most testing for attraction and repulsion was allocated to that period. A great quantity of developmental work was considered unlikely for several reasons:

1. The drought had broken and most reservoirs needing chemical treatments were near spillway capacity.
2. Other reservoirs were the municipal water supply and the effect of some chemicals on drinking water was not accurately known.
3. Responsible authorities were reluctant to meet federal aid requirements.
4. Where vegetation control was to be done, the mild winter had not resulted in the usual kill-back of emergent vegetation. The burning of this plant residue was regarded as being necessary before chemical control work could be performed later in that spring.

However, in May 1960, reversals in policy by municipal authorities provided compliance with requirements for federal aid. Application and approval for the control of excessive plants in Lake Nasworthy permitted that work to be done. Later in May, reversal of city policy permitted planning for eradication of fish life in Lake Sweetwater. As described in the completion report for Project No. F-15-D-3, Job No. 15a7, the control of bulrushes and other emergents proved to be much more difficult than was expected. Log jams and a recession of the lake level retarded or interfered with access to the plants. As a result, the work at Lake Nasworthy required almost all of June and July. In the last week of July, reconnaissance work at Lake Ascarate revealed that the reservoir was dominated by undesirable fish. Since that 43-surface-acre lake is the only public water in El Paso County, it was decided to institute corrective management immediately. Eradication of fish in that lake was accomplished in August, and was followed by other developmental work to eliminate or control the submerged vegetation. That work was not entirely finished when it was necessary that Lake Sweetwater be treated so that a supply of game fish for restocking would be available from hatcheries at an opportune time. The treatment of Lake Sweetwater was completed in mid-September. The remainder of September and October were spent in finishing vegetation control work, in testing the treated waters so that restocking could be completed, and in arranging for the closing of those waters to fishing. At Lake Ascarate it had been necessary to treat the lake with toxephene to assure a complete fish kill after emulsifiable rotenone had obviously failed in that effort. In December 1960, an extensive fish re-kill indicated that the residual toxicant had been inadvertently reintroduced into the lake's waters. Subsequently, the fishes previously restocked were probably eradicated. Considerable effort and time was required to determine when the lake's water would again permit fish life, and to secure fish for restocking so that an entire fishing season would not be lost. The total work for development during the 11-month period included preparing and submitting plans and job completion reports for six jobs that were large enough to be included under the statewide program,

the planning of lesser jobs covered under the S-1 completion report, and other supervisory work. Virtually all of 7 of the total 11-month period were required for completion of these duties. The occurrence of the bulk of this work during the period when work on Job No. E-3 was planned prevented the completion of scheduled experimentation.

1. Laboratory Procedures

a. A search of the literature was continued. Twenty-seven chemical companies were contacted in an attempt to select chemicals and substances that would be suitable for testing.

b. Simulated Flow An attempt was made to set up experimental procedures exactly as was originally outlined in the job description. However, a lack of materials at the time when they were needed and failure to secure a sufficient number of the individuals of the nine species to be tested restricted this type experimentation to the following work:

(1) Six metal tanks were placed in the workshop adjacent to the laboratory. The tanks were 30 inches wide, 36 inches deep and 12 feet long. Each tank was equipped with a 2-inch pipe fitting for draining the tank and was supplied with water from a tap. The bottom of each tank was trisected by orange-colored lines, and these sections were designated by letters "A", "B" and "C".

(2) Tanks were filled with approximately 24 inches of water, and were maintained near that level during experimentation. Mirrors were placed above the tanks and attached to the building rafters permitting observers to view the distribution pattern of the fish unobtrusively. After the apparatus was set up, the particular species of fish to be tested were placed in the tanks and permitted to become acclimated for a period of not less than two days.

(3) To obtain data that might indicate bias in interpretation of statistics (primarily that resulting from diurnal or nocturnal movement of fishes), counts were recorded to establish any normal pattern of distribution of fish in the tanks. Night counts were made by instantaneously turning on strong lights. These counts were made hourly and were taken for 12 hours of each day for not less than two days. The counts were recorded by quarters. Opposite quarters were arbitrarily selected as the order in which counts were taken. First counts were started in the afternoon at 1 p. m., and hourly counts continued until 7 p. m. The second series recorded counts from 1 a. m. until 7 a. m., the third period was from 7 p. m. until 1 a. m., and the fourth from 7 a. m. until 1 p. m. This procedure was continued for four days. The tendency of the tested species to respond to normally occurring visual and auditory stimuli was noted, and is taken into account in analysing statistical data.

(4) After the fourth day, a flow was induced into two tanks by means of a pump. The remaining tanks were used as controls. Identical counts to those previously described were recorded for the particular species of fish being tested. Counts were taken for three days.

(5) Following experimentation with water current as the attracting or repelling force, aeration supplied by an air compressor and released through plastic tubes in the end of the vats marked "C" was tested in near identical manner for each group of fish.

(6) When testing of these devices and conditions was completed for a particular species, the water was changed and another species of fish was immediately placed in the vats and testing resumed. It was impossible to effect an exact control of water temperature, but reasonable efforts were made to maintain uniformity. Temperature variation was recorded. Other uncontrolled variables, due to imperfect testing conditions, were a lack of control on turbidity and directness and amount of sunlight entering tanks. Microscopic organisms were produced in direct relationship to the amount and the directness of sunlight entering the water. As a result, turbidity could not be accurately controlled. In specific instances, where it was believed justifiable, additional counts were made to provide supporting data to more accurately establish the degree of attraction or repulsion on a particular species by a particular force. Counts were made to establish the relationship of the movement of largemouth bass (Micropterus salmoides) and channel catfish resulting directly from the movement of aeration from one end of a tank to the opposite end. Other counts were made to ascertain the effect of auditory stimuli when light was removed, and to obtain some idea of the repulsive effect of visual stimuli. Bits of cotton soaked with extremely diluted concentrations of asafetida were placed in one end of the test tanks. This was done after other testing had been completed, and the effect on the distribution of fish recorded. The testing of groups of fish made up of several species was planned, and that work was done immediately following the testing of separate species. However, that work overlaps and extends into the period covered by Project No. F-5-R-9, and will be reported in that completion report. It was decided to begin testing by using a single species rather than attempting the approved testing of a population made up of several species. This was done so that individual response of the various species might be recorded and considered as a separate reaction. The method also offers the possibility of determining to some extent the interspecific influence exerted by one species on another when the fish are reacting to a common stimuli. The described testing was done in January and February 1961, and during that period, four species were successfully tested. A fifth test resulted in failure. The species included in the tests were river carpsuckers, carp, largemouth bass and channel catfish. The testing failure occurred when an attempt was made to conduct an identical series of tests using gizzard shad. Reliable data could not be obtained because too many of those fish died.

The specified procedures that were approved but were either modified or not completed for the reasons previously stated include painted lines substituted for use in designating areas rather than using an apparatus that would instantly divide the tanks into three separate and equal parts. This was done so that any undue influence such an apparatus might exhibit could be accounted for later when the combined species tests were made. Since testing was for only a single species at a time, item 5, dealing with the statistical method to be used in treating data from a combination of species, can not be used. Also omitted were procedures that involved use of a combination of two or more forces or devices, which were postponed for completion the following segment.

2. Field Procedures

a. Work Done

(1) Systematic and intensive sampling of the fish populations within various areas of Lake Nasworthy was done to add to existing data that attempts to establish a normal distribution of species within the lake for different times of

the year. Exact duplication of previous sampling was impossible because lake level fluctuations prevented such work. Rapid expansion of some of the fish populations is regarded as being prohibitive in obtaining any reasonable estimate of the existing quantity of fish per unit volume of water.

(2) Suitable locations for the semi-permanent traps planned were selected, but circumstances did not permit construction of these devices.

(3) Systematic sampling of fish populations was performed within several reservoirs where conditions that are to be tested exist. Included were Lake Colorado City, Lake Balmorhea, Oak Creek Reservoir, Lake Walk and Devil's Lake. The purpose of this work was to provide background data to be used when considering the effectiveness of attraction of flow on the various species of fish.

b. Work Planned But Not Completed for the Reasons Previously Set Forth

(1) Testing mechanical devices in the field.

(2) Work planned for Red Bluff Reservoir and the associated irrigation system intended to determine attraction or repulsion of various species as resulting from variation in salinity.

(3) Experimentation to determine if attraction or repulsion is exerted on particular species of fish by silt and other inert matter.

Results:

Laboratory Work

Search of Literature A search of the literature was continued. Replies to letters of inquiry and examination of literature available indicated that the following substances probably offer, in potential, means of chemical or physical attraction of fish.

a. Natural Substances of Organic Derivation

1. Tissue and Body fluids from various species of fish including sharks, carp, shad, eels, pike, goldfish, piranhas, rays, octopus, barracuda, salmon, sturgeon, cod, herrings, many species of minnows, and others.

2. Tissue and body fluids from various crustacea, mollusca and insects.

3. Excretions of micro-plankton.

4. Urine and naturally produced scents from mammals and some birds.

5. Natural vegetative products and derived compounds, such as asafetida, several species of the plant genus Derris, extract from green walnuts, pine resins, alfalfa, cotton seed, wheat, flour, anise, corn, maize, clover, peppers, and others.

6. Modified and derived organic substances that are changed by processing, such as chlorinated hydrocarbons that number in the thousands, other organic insecticides, and modified petroleum by-products.

b. Inorganic Chemicals

1. Caustic substances, such as acrolin, various salts and compounds of metallic base.
2. Compounds, such as chlorine and copper acetate, that have specific repellent properties.
3. Dyes, such as the nigrosine group.

Experimentation in Flow and Aeration The data obtained through experimentation is recorded in Tables 1 through 16. Those results are not now meaningful because a basis is not provided for reliable conclusion. The information may and should be useful in the future, after the required supplemental procedures are completed and the needed data obtained. Because of this, the following deficiencies and limitations of the work completed are pointed out:

a. The apparatus and facilities that were available when the experiments were set up did not provide adequate means for eliminating or controlling several variables that were, as a result, unmeasurable. Sunlight entered the enclosure where the vats were housed from the east, south and west only. Because of the required position of the vats and the differences in the sizes and location of the illuminating openings, an entirely different quantity and concentration of sunlight affected each vat. As a result, water temperatures and turbidity were significantly affected.

b. The difficulty in obtaining suitable fish to be used in testing resulted in a lack of uniformity of individuals within the species being tested. Size was inconsistent and age unknown for all species except largemouth bass and channel catfish.

c. Because of limited space, the required size of the containing vats restricted the number of fish that could be used in the experiments. It is felt that some of the fish recorded in the "B" section were there as a result of crowding in one of the vat's extremities rather than from choice.

d. As has been previously stated, the choice to use marked lines rather than apparatus that actually separated the vats into compartments was motivated by a desire to remove any influence that such a device would have on the fish. However, the necessary method of counting fish was subject to human error. The person recording the counts recorded only the number of fish in two sections and the number of fish in the third section was obtained by subtracting the sum of those counted from the total number of fish known to be in the vat. In doing the work in that manner, it was often necessary to arbitrarily and instantly decide where a particular fish should be included. Turbidity also made counts difficult.

Field Work

As stated in the procedures, the systematic sampling of fish populations within five lakes was done to provide background data for future use when attraction of flow on the various species of fish present was to be considered. These data are not meaningful without additional data that determines the degree of attraction exerted. That data will have to be obtained during future work. Tables 17 through 21 show the results of netting.

Recommendations:

It is recommended that the scope of this work be reduced, and more time allocated to its completion.

Prepared by Lawrence S. Campbell
Project Leader

Approved by Marion Toole
Coordinator

Date January 25, 1962

Table 1. Recorded distribution of largemouth bass during daylight (Composite of two counts)

Vat Number: Subdivisions: Fish Contained:	1			2			3			4			5			6		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
	21	21	21	21	21	21	21	21	21	20	20	20	20	20	20	20	20	20
Forenoon Counts																		
7 a.m.	17	3	1	16	5	0	19	2	0	17	2	1	19	1	0	18	2	0
8 a.m.	14	4	3	16	5	0	18	1	2	16	4	0	18	2	0	18	2	0
9 a.m.	14	2	5	12	8	1	16	3	2	12	8	0	12	6	2	16	4	0
10 a.m.	11	5	5	16	5	0	12	8	1	14	7	0	11	6	3	16	1	3
11 a.m.	3	7	1	14	5	2	13	6	2	11	6	3	14	5	1	14	4	2
12 a.m.	12	8	1	8	7	6	14	5	2	8	6	6	8	6	6	12	8	0
Afternoon Counts																		
1 p.m.	10	8	3	8	8	5	8	9	4	10	3	7	8	7	5	12	7	1
2 p.m.	10	6	5	12	6	3	12	6	3	10	3	7	7	5	8	11	9	0
3 p.m.	10	6	5	12	8	1	9	11	1	7	7	6	8	6	6	8	9	3
4 p.m.	0	1	20	6	6	8	8	8	5	6	8	6	6	8	6	8	4	8
5 p.m.	2	0	19	6	1	14	5	6	10	8	4	9	4	4	12	6	6	8
6 p.m.	2	0	19	6	1	14	4	10	7	8	2	11	4	4	12	6	4	10
7 p.m.	6	6	9	5	3	12	4	6	11	6	10	5	5	6	10	6	2	12

Table 2. Recorded distribution of largemouth bass during night (Composite of two counts)

Vat Number: Subdivisions: Fish Contained:	1			2			3			4			5			6		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
	21	21	21	21	21	21	21	21	21	20	20	20	20	20	20	20	20	20
	Evening Counts																	
7 p.m.	6	6	9	5	3	12	4	10	11	6	10	5	5	6	10	6	2	12
8 p.m.	6	6	9	2	2	17	4	1	16	10	0	10	9	0	11	0	0	20
9 p.m.	8	6	7	0	1	20	3	0	18	12	0	8	9	0	11	0	0	20
10 p.m.	10	0	11	0	1	20	3	0	18	12	0	8	9	0	11	0	1	19
11 p.m.	10	1	10	0	1	20	0	0	21	12	0	8	9	0	11	0	1	19
12 p.m.	10	1	10	0	1	20	0	0	21	14	0	6	9	1	10	0	1	19
	Early Morning Counts																	
1 a.m.	8	0	13	0	2	19	0	0	21	20	0	0	16	0	4	0	4	16
2 a.m.	8	0	13	0	2	19	4	0	17	20	0	0	18	0	2	0	4	16
3 a.m.	9	0	12	0	2	19	6	0	15	20	0	0	18	0	2	0	4	16
4 a.m.	9	0	12	0	2	19	2	2	17	20	0	0	18	0	2	0	4	16
5 a.m.	9	0	12	0	2	19	13	0	8	20	0	0	18	0	2	0	6	14
6 a.m.	14	3	4	1	12	8	16	3	2	16	4	0	19	1	0	10	6	4
7 a.m.	17	3	1	16	5	0	19	2	0	17	2	1	19	1	0	18	2	0

Table 3. Response of largemouth bass to induced flow (Composite of two counts)

Vat Number: Subdivisions: Fish Contained: Conditions:	1			2			3			4			5			6		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
	Flow Induced																	
7 a.m.*	16	4	4	19	3	0	12	0	4	0	0	16	3	4	9	16	0	0
8 a.m.	8	6	10	2	0	22	16	0	0	16	0	0	0	10	6	16	0	0
9 a.m.	12	8	4	2	0	22	14	2	0	13	0	3	11	0	5	16	0	0
10 a.m.	14	8	2	2	0	22	13	2	1	9	1	6	14	2	0	14	2	0
11 a.m.**	14	8	2	8	10	6	13	2	1	11	1	4	8	8	0	8	8	0
12 a.m.	14	8	2	9	6	9	10	4	2	8	8	0	8	8	0	7	6	3
1 p.m.	14	8	2	7	0	17	10	4	2	8	8	0	8	8	0	7	6	3
Afternoon Counts																		
1 p.m.	14	8	2	7	0	17	10	4	2	8	8	0	8	8	0	7	6	3
2 p.m.	4	4	16	2	0	22	6	0	10	6	10	0	8	0	8	4	0	12
3 p.m.**	4	4	16	4	0	20	4	0	12	2	10	4	8	1	7	4	0	12
4 p.m.	2	8	14	2	8	14	4	0	12	2	0	14	6	1	9	0	0	16
5 p.m.*	0	0	24	0	1	23	0	4	12	4	0	12	2	6	8	0	0	16
6 p.m.	0	0	24	0	1	23	0	2	14	1	4	11	2	6	8	0	4	12
7 p.m.	0	0	24	0	1	23	0	2	14	1	4	11	4	8	4	0	4	12

* -Flow started
** -Flow discontinued

Table 4. Response of largemouth bass to induced aeration (Composite of two counts)

Vat Number: Subdivision: Fish Contained: Conditions:	1			2			3			4		
	A	B	C	A	B	C	A	B	C	A	B	C
	21			21			21			16		
	Aeration Added			Aeration Added			Control			Control		
	Forenoon Counts											
7 a.m.	12	6	3	14	0	7	18	2	1	16	0	5
8 a.m.*	0	16	5	1	9	11	18	3	0	16	0	5
9 a.m.**	0	8	13	4	0	17	20	1	0	12	9	0
10 a.m.	6	12	3	12	4	5	16	5	0	14	7	0
11 a.m.***	6	15	0	10	8	3	12	8	1	14	6	1
12 a.m.	8	8	5	9	8	4	10	10	1	8	5	8
1 p.m.	8	8	5	6	1	14	6	3	12	8	5	8

* -Aeration started in "C"

** - Aeration switched to "A"

***-Aeration stopped

Table 5. Recorded distribution of channel catfish in daylight (Composite of two counts)

Vat Number: Subdivisions: Fish Contained:	1			2			3			4			5			6		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
7 a.m.	3	3	6	0	1	11	3	6	3	6	3	3	3	5	4	5	5	2
8 a.m.	3	4	5	2	0	9	6	4	2	7	2	3	6	4	2	5	5	2
9 a.m.	2	2	8	5	3	4	8	2	2	4	0	8	6	4	2	8	3	1
10 a.m.	2	3	7	6	4	2	8	3	1	6	1	5	3	6	3	8	4	0
11 a.m.	10	0	1	6	4	2	9	3	0	4	4	4	7	3	2	9	3	0
12 a.m.	11	0	1	8	4	0	9	1	2	2	6	4	7	4	1	10	2	0
1 p.m.	6	0	6	8	3	1	8	4	0	6	5	1	8	2	2	10	2	0
Forenoon Counts																		
1 p.m.	6	0	6	8	3	1	8	4	0	6	5	1	8	2	2	10	2	0
2 p.m.	4	4	4	2	6	4	6	5	1	5	7	0	10	1	1	8	4	0
3 p.m.	4	6	2	8	3	1	8	3	1	6	6	0	10	1	1	8	2	2
4 p.m.	6	4	2	9	3	0	9	2	1	4	6	2	11	0	1	10	1	1
5 p.m.	5	3	4	12	0	0	9	2	1	8	2	2	8	3	1	11	1	0
6 p.m.	8	4	0	11	1	0	8	4	0	6	4	2	8	3	1	11	0	1
7 p.m.	7	5	0	10	2	0	8	3	1	10	1	1	8	4	0	9	3	0
Afternoon Counts																		

Table 6. Recorded distribution of channel catfish at night (Composite of two counts)

Vat Number:	1			2			3			4			5			6		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Fish Contained:	12			12			12			12			12			12		
7 p.m.	3	5	4	6	4	2	4	2	6	3	5	4	8	0	4	6	2	4
8 p.m.	5	1	6	6	3	4	4	6	2	4	6	2	3	4	5	4	5	3
9 p.m.	4	2	6	3	6	3	2	8	2	7	2	3	6	0	6	5	2	5
10 p.m.	4	3	5	0	4	8	6	2	4	9	1	2	2	3	7	4	6	2
11 p.m.	4	4	4	2	2	8	7	0	5	1	5	6	1	7	3	3	7	1
12 p.m.	8	2	2	7	3	2	7	2	3	7	0	5	4	0	8	7	1	3
1 a.m.	8	2	2	6	5	1	5	6	1	8	2	2	5	5	2	1	9	2
Evening Counts																		
1 a.m.	8	2	2	6	5	1	5	6	1	8	2	2	5	5	2	1	9	2
2 a.m.	4	2	6	3	5	4	7	2	3	3	6	3	3	4	5	1	4	7
3 a.m.	3	4	5	7	1	4	6	5	1	6	0	6	6	0	6	6	2	4
4 a.m.	6	2	4	2	4	6	8	3	1	9	2	1	2	7	3	8	1	3
5 a.m.	6	3	3	6	3	3	3	7	1	4	1	6	8	0	4	8	2	2
6 a.m.	5	6	1	5	2	5	0	8	4	6	2	3	9	1	2	4	2	6
7 a.m.	4	6	2	1	4	7	4	4	4	6	1	4	9	1	2	6	0	6

Table 7. Response of channel catfish to induced flow (Composite of two counts)

Vat Number:	1			2			3			4			5			6					
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C			
Fish Contained:	12			12			12			12			12			12					
Conditions:	Flow Induced			Flow Induced			Flow Induced			Flow Induced			Flow Induced			Flow Induced					
	Forenoon Counts																				
7 a.m.*	6	0	6	4	6	2	5	0	7	6	2	4	6	2	4	5	7	0	4	6	2
8 a.m.	0	0	12	0	0	12	4	2	6	6	5	1	6	5	1	6	5	1	5	6	1
9 a.m.	0	0	12	0	0	12	3	2	7	4	6	2	8	1	3	5	6	1	5	6	1
10 a.m.	1	0	11	0	0	12	4	4	4	6	0	6	8	3	1	6	4	2	6	4	2
11 a.m.	1	1	10	1	1	10	2	4	6	3	6	3	3	7	2	6	4	2	6	4	2
12 a.m.**	0	0	12	0	2	10	2	5	5	7	3	2	5	3	4	7	3	2	7	3	2
1 p.m.	3	2	7	2	2	8	6	3	3	8	3	1	8	2	2	7	3	2	7	3	2
	Afternoon Counts																				
1 p.m.	3	2	7	4	0	8	7	4	1	6	4	2	6	1	5	8	3	1	8	3	1
2 p.m.	6	0	6	6	2	4	3	3	6	4	6	2	6	4	2	8	3	1	8	3	1
3 p.m.*	4	3	5	6	2	4	5	5	2	4	2	6	3	3	6	7	3	2	7	3	2
4 p.m.	2	0	10	3	1	8	8	1	3	7	2	3	11	0	1	6	5	1	6	5	1
5 p.m.	1	0	11	0	1	11	8	3	1	6	3	3	12	0	0	6	5	1	6	5	1
6 p.m.	1	1	10	0	0	12	2	5	5	6	5	1	1	7	4	6	5	1	6	5	1
7 p.m.	1	0	11	0	0	12	8	4	0	6	4	2	4	6	2	6	5	1	6	5	1

* -Flow started
 **-Flow discontinued

Table 8. Response of channel catfish to induced aeration (Composite of two counts)

Vat Number: Subdivision: Fish Contained: Conditions:	1			2			3			4		
	A	B	C	A	B	C	A	B	C	A	B	C
	12			12			12			12		
	Aeration Added			Aeration Added			Control			Control		
7 a.m.*	6	4	2	7	4	1	5	3	4	8	1	3
8 a.m.	2	2	8	0	1	11	3	3	6	3	4	5
9 a.m.	0	2	10	0	1	11	1	8	3	6	3	2
10 a.m.	1	0	11	1	0	11	7	0	5	9	2	1
11 a.m.**	4	0	8	2	0	10	6	1	5	3	3	6
12 a.m.	6	0	6	4	6	2	5	4	3	7	3	2
1 p.m.	6	0	6	4	6	2	6	3	3	8	2	2

Forenoon Counts

* - Aeration added to "C"

** - Aeration stopped

Table 9. Recorded distribution of river carsuckers in daylight (Composite of two counts)

Vat Number: Subdivisions: Fish Contained:	1			2			3			4			5			6		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
	14	14	14	14	14	14	12	12	12	12	12	12	12	12	12	12	12	12
7 a.m.	4	3	7	6	1	7	5	3	4	2	4	6	4	2	6	5	3	4
8 a.m.	5	4	5	6	4	4	6	3	3	1	5	6	2	2	8	1	0	7
9 a.m.	3	5	6	8	0	6	3	6	3	1	6	5	5	1	6	4	2	6
10 a.m.	7	3	4	5	2	7	6	3	3	4	2	6	3	1	8	3	3	6
11 a.m.	2	4	8	5	5	4	7	5	0	4	4	4	3	5	4	7	4	1
12 a.m.	6	2	6	6	3	5	7	5	0	4	3	5	6	2	4	7	3	2
1 p.m.	6	1	7	6	5	3	3	5	4	5	3	4	6	2	4	7	3	2
Forenoon Counts																		
1 p.m.	6	1	7	6	5	3	3	5	4	5	3	4	6	2	4	7	3	2
2 p.m.	4	7	3	2	8	4	7	1	4	5	1	6	4	4	4	1	7	4
3 p.m.	5	2	7	2	6	6	8	2	2	7	1	4	2	4	6	2	5	5
4 p.m.	8	0	6	7	5	2	4	2	6	3	8	1	5	3	4	5	3	4
5 p.m.	8	1	5	6	2	6	7	3	2	4	0	8	2	1	9	4	1	7
6 p.m.	4	3	7	6	4	4	6	2	4	5	5	2	3	4	5	7	2	3
7 p.m.	6	3	5	5	7	2	5	2	5	2	5	5	6	2	4	3	5	4
Afternoon Counts																		

Table 10. Recorded distribution of river carpsuckers at night (Composite of two counts)

Vat Number: Subdivision: Fish Contained:	1			2			3			4			5			6		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
	14	14	14	14	14	14	12	12	12	12	12	12	12	12	12	12	12	12
7 p.m.	6	8	0	5	8	1	2	4	6	1	5	6	2	2	8	6	2	4
8 p.m.	5	8	1	6	2	6	5	3	4	3	4	5	6	4	2	4	6	2
9 p. m.	7	4	3	1	11	2	7	1	4	6	3	3	6	0	6	2	8	3
10 p.m.	2	5	7	9	0	5	3	5	4	2	7	3	3	5	4	3	3	6
11 p.m.	2	10	2	12	0	3	4	5	3	4	2	6	5	3	4	3	3	6
12 p.m.	6	4	4	6	2	6	1	8	3	4	6	2	5	4	3	6	4	2
1 a.m.	6	7	1	5	2	7	6	4	2	1	7	4	2	5	5	7	1	4
- 18 -																		
	Morning Counts																	
1 a.m.	6	7	1	5	2	7	6	4	2	1	7	4	2	5	5	7	1	4
2 a.m.	5	5	4	4	6	4	2	5	5	3	2	7	3	5	4	2	8	2
3 a.m.	8	3	3	3	9	2	2	4	6	3	6	3	3	5	4	5	2	5
4 a.m.	1	8	5	2	5	7	3	2	7	6	4	2	1	9	2	3	5	4
5 a.m.	3	3	8	7	1	6	5	4	3	8	3	1	2	8	2	4	4	4
6 a.m.	2	6	6	8	6	0	1	8	3	2	9	1	1	8	3	4	4	4
7 a.m.	7	1	6	3	3	8	7	3	2	1	6	5	4	4	4	2	7	3

Table 11. Response of river carsuckers to induced flow (Composite of two counts)

Vat Number:	1			2			3			4			5			6		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Subdivision:	14			14			12			12			12			12		
Fish Contained:	Flow Induced			Flow Induced			Control			Control			Control			Control		
Conditions:	Flow Induced	Control																
7 a.m.*	7	4	3	6	6	2	6	2	4	4	5	3	7	3	2	5	1	6
8 a.m.	6	3	5	4	5	5	6	4	2	4	5	3	5	5	2	4	1	7
9 a.m.	6	4	4	3	8	3	4	3	5	5	1	6	1	7	6	3	3	6
10 a.m.**	5	7	2	7	5	2	4	5	3	2	4	6	6	1	5	7	3	2
11 a.m.	7	6	1	7	6	1	4	2	6	3	5	4	2	6	3	5	5	2
12 a.m.	6	2	6	5	3	6	3	7	2	5	6	1	4	6	2	5	5	2
1 p.m.	6	2	6	5	3	6	4	6	2	6	6	1	2	4	6	4	0	8
Forenoon Counts																		
1 p.m.	6	2	6	5	3	6	4	6	2	6	6	1	2	4	6	4	0	8
2 p.m.*	4	5	5	5	5	4	3	2	7	4	3	5	5	2	5	4	0	8
3 p.m.	3	6	5	4	6	4	2	5	5	4	4	4	3	5	4	5	3	4
4 p.m.	8	2	4	7	1	6	6	5	1	4	3	5	6	3	3	6	3	3
5 p.m.	9	2	3	6	5	3	4	4	4	6	3	3	2	5	5	2	3	7
6 p.m.	9	2	3	2	9	3	6	2	4	6	2	4	7	3	2	4	6	2
7 p.m.	2	5	7	5	5	4	5	2	5	6	2	4	1	4	7	4	0	9

Table 12. Response of river carpsucker to induced aeration (Composite of two counts)

Vat Number:	1			2			3			4		
	A	B	C	A	B	C	A	B	C	A	B	C
Subdivision:												
Fish Contained:	14			14			12			12		
Conditions:	Aeration Added			Aeration Added			Control			Control		
	Forenoon Counts											
7 a.m.	6	6	2	5	7	2	2	4	6	3	1	8
8 a.m.*	4	0	10	1	2	11	2	5	5	3	1	8
9 a.m.	7	1	6	3	5	6	2	5	5	3	6	3
10 a.m.**	3	8	3	4	5	6	3	4	5	6	3	3
11 a.m.	2	11	1	5	5	4	4	5	3	7	2	3
12 a.m.***	5	1	8	3	3	8	4	4	4	8	4	0
1 p.m.	4	1	9	3	5	6	5	4	3	8	3	1

* -Aeration added to "C"
 ** -Aeration stopped
 ***-Aeration started in "C"

Table 13. Recorded distribution of carp in daylight (Composite of two counts)

Vat Number Subdivision: Fish Contained	1			2			3			4			5			6		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
7 a.m.	7	2	5	5	4	5	6	2	4	7	3	4	5	6	3	4	5	4
8 a.m.	6	2	6	6	5	3	4	3	7	6	4	4	5	3	6	6	4	2
9 a.m.	8	4	2	6	2	6	7	4	3	8	3	3	9	3	2	3	5	4
10 a.m.	9	3	2	8	4	2	7	5	2	10	1	3	9	3	2	3	1	8
11 a.m.	8	2	4	7	5	2	3	9	2	9	2	3	6	4	4	8	3	1
12 a.m.	8	4	2	7	3	4	6	6	2	10	1	3	2	11	1	9	1	2
1 p.m.	4	6	4	6	6	2	5	5	4	10	1	3	1	12	1	10	1	1
Forenoon Counts																		
1 p.m.	4	6	4	6	6	2	5	5	4	10	1	3	1	12	1	10	1	1
2 p.m.	5	6	3	7	2	5	5	6	3	7	3	4	1	10	3	8	3	1
3 p.m.	6	1	7	4	5	5	4	7	3	3	9	2	4	6	4	7	2	3
4 p.m.	6	3	5	4	4	6	4	5	5	6	7	1	5	4	5	6	4	2
5 p.m.	2	5	7	2	4	8	3	7	4	6	2	6	2	7	5	5	5	2
6 p.m.	2	4	8	2	4	8	6	6	2	2	9	3	3	6	5	6	6	0
7 p.m.	4	2	8	4	2	8	2	10	2	5	8	1	3	6	5	7	3	2
Afternoon Counts																		

100
100
100
100

Table 16. Response of carp to induced aeration (Composite of two counts)

Vat Number: Subdivisions: Fish Contained: Conditions:	1			2			3			4		
	A	B	C	A	B	C	A	B	C	A	B	C
	14			14			14			14		
	Aeration Added			Aeration Added			Control			Control		
	Forenoon Counts											
7 a.m.*	6	6	4	4	7	3	4	8	2	6	6	2
8 a.m.	4	6	6	5	3	6	6	6	2	5	6	3
9 a.m.	2	6	8	2	5	7	5	7	2	7	7	0
10 a.m.**	4	5	6	4	4	6	4	4	6	3	5	6
11 a.m.	2	6	6	5	6	3	4	5	5	8	4	2
12 a.m.***	3	3	8	7	2	5	4	3	7	2	7	5
1 p.m.	3	3	8	3	4	7	6	2	6	4	3	7

* -Aeration added to "C"
 ** - Aeration stopped
 ***-Aeration started in "C"

Table 17. Results of 39 netting collections obtained from Lake Nasworthy from April 1, 1960, to February 28, 1961

Species	Number	Per Cent by Number	Total Weight Lb.	Oz.	Average Weight Lb.	Oz.	Per Cent by Weight	Average K
Longnose gar	4	.38	4	4	1	1.0	.25	.47
Gizzard shad	257	24.45	32	2	0	2.0	1.90	1.68
River carpsucker	499	47.48	1,287	11	2	9.0	75.58	2.48
Carp	86	8.18	107	8	1	4.0	6.35	2.34
Channel catfish	48	4.57	99	0	2	1.0	5.85	No lengths*
Flathead catfish	11	1.04	50	14	4	10.0	3.01	1.62
White bass	49	4.67	42	14	0	14.0	2.53	2.24
Largemouth bass	16	1.52	34	0	2	2.0	2.01	2.25
Bluegill sunfish	2	.19	0	4	0	2.0	.02	3.54
White crappie	76	7.23	38	0	0	8.0	2.25	2.46
Freshwater drum	<u>3</u>	<u>.29</u>	<u>4</u>	<u>4</u>	<u>1</u>	<u>6.7</u>	<u>.25</u>	<u>1.85</u>
Totals	1,051	100.00	1,691	13			100.00	

*Fish retained for use in laboratory experiments

Table 18. Results of eight netting collections obtained from Oak Creek Reservoir from April 1, 1960, to February 28, 1961

Species	Number	Per Cent by Number	Total Weight Lb.	Total Weight Oz.	Average Weight Lb.	Average Weight Oz.	Per Cent by Weight	Average K
River carpsucker	76	13.99	135	5	1	12.5	30.85	2.46
Golden shiner	1	.19	-	3	-	3.0	.05	1.89
Carp	36	6.63	153	10	4	4.3	35.03	2.30
Channel catfish	37	6.81	50	12	1	5.9	11.57	1.36
Black bullheads	12	2.21	3	4	-	4.3	.74	2.02
White bass	45	8.29	55	4	1	3.6	12.60	2.07
Largemouth bass	6	1.10	2	8	-	6.7	.57	1.89
Yellowbelly sunfish	1	.19	-	4	-	4.0	.06	2.35
Redear sunfish	4	.73	-	15	-	3.8	.22	2.96
Bluegill sunfish	170	31.31	17	11	-	1.7	4.03	2.82
White crappie	<u>155</u>	<u>28.55</u>	<u>18</u>	<u>12</u>	<u>-</u>	<u>1.9</u>	<u>4.28</u>	<u>2.15</u>
Totals	543	100.00	438	8			100.00	

Table 19. Results of 12 netting collections from Lake Colorado City from April 1, 1960, to February 28, 1961

Species	Number	Per Cent		Total Weight		Average Weight		Per Cent by Weight	Average K
		by Number	by Number	Lb	Oz	Lb	Oz		
Gizzard shad	6	5.76	1	2	3.0		.91	1.63	
River carpsucker	42	40.39	53	8	4.4		43.56	2.24	
Channel catfish	19	18.27	36	3	14.5		29.47	1.75	
Flathead catfish	1	.96	1	9	9.0		1.27	1.58	
Largemouth bass	4	3.85	17	1	4.3		13.89	2.74	
White crappie	<u>32</u>	<u>30.77</u>	<u>13</u>	<u>6</u>	<u>6.7</u>		<u>10.90</u>	2.83	
Totals	104	100.00	122	13			100.00		

Table 20. Results of eight netting collections obtained from Devil's Lake from April 1, 1960, to February 28, 1961

<u>Species</u>	<u>Number</u>	<u>Per Cent by Number</u>
Spotted gar	1	.61
Longnose gar	2	1.21
Gizzard shad	51	30.91
Texas gray redbhorse	4	2.42
River carpsucker	30	18.17
Carp	2	1.21
Channel catfish	29	17.58
Flathead catfish	2	1.21
White bass	4	2.43
Largemouth bass	4	2.43
Warmouth bass	3	1.82
Green sunfish	1	.61
Bluegill sunfish	7	4.21
White crappie	22	13.33
Freshwater drum	<u>3</u>	<u>1.82</u>
Totals	165	100.00

Weights and K factors not taken because fish are to be used in laboratory experiments.

Table 21. Results of eight netting collections obtained from Lake Walk from April 1, 1960, to February 28, 1961

<u>Species</u>	<u>Number</u>	<u>Per Cent by Number</u>
Spotted gar	1	.58
Longnose gar	4	2.31
Gizzard shad	40	23.12
Gray redbhorse	19	10.98
River carpsucker	43	24.86
Golden shiner	2	1.17
Channel catfish	37	21.38
White bass	15	8.67
Largemouth bass	4	2.31
Warmouth bass	1	.58
Black crappie	6	3.46
Freshwater drum	<u>1</u>	<u>.58</u>
Totals	173	100.00

Weights and K factors not taken because fish are to be used in laboratory experiments.

