EVALUATION OF A WIRE FISH TRAP AS A COMMERCIAL FISHING DEVICE IN LARGE IMPOUNDMENTS

By A. LEON KIRKLAND
Georgia Game and Fish Commission
Atlanta, Georgia

ABSTRACT

A modified wire fish trap is evaluated as a commercial fishing device for reservoirs.

Details of construction and costs of the wire trap is presented along with a description of fishing methods.

The wire trap was tested in three reservoirs with fish populations of varying ages to determine: (1) Efficiency of the trap in taking game species. (2) Efficiency of the trap for taking commercial species. (3) Size classes of commercial fish taken. (4) Extent of use of the wire trap by commercial fishermen.

The results of these investigations were compared to similar data for widely accepted mesh sizes of gill, trammel and hoop nets to determine the relative acceptability of the wire trap for commercial use in freshwater impoundments.

INTRODUCTION

Development and evaluation of commercial fishing devices that can adequately harvest the large numbers of available fish in our streams and reservoirs is one of the more pressing problems in fish management. The conventional types of commercial fishing gear now in use fail to utilize these fishery resources satisfactorily. This need for new, more efficient commercial fishing gear led to the present evaluation of the wire fish trap for commercial use in large impoundments.

Several workers have reported on similar wire traps tested under various ecological conditions. Cobb (1954) found wire traps to be successful in reducing overpopulated bluegills in farm ponds. Likewise Carter (1954) on Kentucky Lake and Davis and Posey (1957) working in Louisiana lakes and streams found a similar wire trap to be highly successful for taking game and panfish species. These wire traps caught too high a percentage of game species, however, to be considered for legal commercial fishing gear. The Georgia Wire Trap, as it will be called to distinguish this trap from other similar traps, was adopted by the State of Georgia as a result of the evaluation work by May (1955) on warm water streams in Georgia. May found the trap most efficient for taking commercial species with the least percentage of game fish of any of the five devices tested. These devices included four wire traps and a hoop net.

The Georgia Wire Trap differed from the other traps in that a swinging door was placed on the second throat. This door must be pushed forward before the fish can enter. Once the fish is inside, the trap door closes preventing escape of the fish. Evidently the difference in behavior of commercial species cause them to push through the trap door while very few game fish will do so.

The present problem was set up to evaluate the wire trap in large impoundments. Since fish populations of streams and reservoirs differ so greatly, application of management techniques developed on one habitat may result in unsatisfactory results under different conditions. As an example, the population of the stream where the original work by May was performed contained less than 3 percent game species, while the three reservoirs under consideration contained from 33 to 55 percent game species. The higher game fish percentages in reservoirs necessitates further investigation to determine if the trap would be beneficial under these conditions.

Populations of commercial species in reservoirs and streams also vary in species composition and standing crop. May (1954, p. 3) recorded 729.0 pounds/A. of commercial species in the streams where the wire trap was originally tested. This is compared to an average of 30.0 pounds/A. of commercial species in the three reservoirs studied. Whether the wire trap would be efficient as a commercial fishing device under these conditions of low pound-

age of commercial fish populations, remained to be demonstrated. The size class of fish taken in the trap from reservoir populations is also important from both a biological and commercial aspect. Successful commercial gear must take a wide size range of fish with a high percentage of the fish within a readily marketable size.

Biologically the trap should take the size of commercial fish that would result in the most benefit to sport or game species.

The final and most difficult problem of evaluation is to determine if the wire trap could harvest a large enough percentage of commercial species to benefit sport fishing. The answer to these questions would determine if the wire fish trap would be a desirable tool for reservoir management.

METHODS AND MATERIALS

Three impoundments with considerable variation in physical and biological conditions were selected to test each of these four factors. The physical and biological data for each of the reservoirs in the study is included in the appendix.

The data presented were collected primarily from commercial catches, since it was desirable to evaluate the wire trap under normal conditions of commercial fishing. The remaining data were from traps fished by project personnel.

The traps were usually fished by one of two methods. The first by securing the basket to a wire that was either tied to a bush or root near shore; or to an anchor that may be any distance from shore. The second method was to tie a main wire across a cove or anchor it in open water and tie short dropper wires with traps at intervals along the main wire. This method allowed several baskets to be "run" in a short period of time and was the most efficient of the two methods. In either case a special drag generally was required to locate the wire when the baskets were fished.

The length of time between the time of set and time of lift varied from one to four days. With heavy catches, traps were run at more frequent intervals than when catches were light.

All traps were baited with cottonseed meal cake each time they were "run". Approximately two pounds of bait was required at each setting.

CONSTRUCTION OF THE TRAP

The trap was constructed of inch-mesh, double dipped, galvanized poultry wire. The trap is cylindrical in shape with a diameter of approximately 23 inches and a length of 60 inches. Approximately 19 inches of the bottom of the trap is flattened so it will rest in an upright position. The trap has two throats. The first is located at the front of the cylinder, and the second approximately 17 inches to the rear of the first. Two ⅜" cables are installed as supporting hoops at the front of each throat. The opening in the front throat is cylindrical with a circumference of 18 to 20 inches. The opening in the rear throat is 7 inches square and is reinforced with No. 9 wire. The top of the opening is tilted one inch from vertical toward the front of the trap. The second opening is fitted with a trap door 8 inches square attached at the top by pig rings. A second door is installed in the top rear of the trap for baiting and removing fish. Dipping the traps in tar every six months increases the life of the trap two to three hundred percent. A tarred trap under average use will last two to three years. Catch efficiency was apparently equal between tarred and untarred fish traps.

The average cost of the traps including construction and labor was about $4.70 each.

TABLE I

MATERIALS AND COST TO CONSTRUCT 50 WIRE FISH TRAPS

Number	*Materials*	*Cost*
2 rolls	Double-dipped, galvanized, chicken wire, 5′ x 150′ x 1″ mesh	$ 53.00
2½ rolls	Double-dipped, galvanized, chicken wire, 2′ x 150′ x 1″ mesh	31.25
2½ cases	Pig rings	7.50
600 feet	#9 galvanized smooth wire	6.00
900 feet	⅜" aluminum high tension wire (free from Elec. Coop.)	
100 gallons	Best grade road tar (free from county)	
Labor		137.50

With a life of two to three years the cost per year of use will run from $2.35 to $1.57 a year. This is very low compared to the cost of other commercial gear.

EFFICIENCY IN TAKING GAME SPECIES

Commercial fishing gear for use by the general public must necessarily harvest a small percentage of game species. This is essential both from a biological and a public relations standpoint. Tables II, III and IV give the catch per unit of effort of game species for the three impoundments studied. A study of the catch per unit of effort shows that the wire trap is very inefficient in taking game species. Even without regulations prohibiting commercial fishermen from retaining game species once they are caught, it is doubtful if most reservoir game fish populations could be damaged by commercial trap fishing. Traps also have the advantage over most other commercial gear in that there is very little mortality of fish taken from the traps (Carter, 1954). With an enforced regulation requiring commercial fishermen to release game species the damage to game fish would be negligible. A comparison of the catch per unit of effort of game species with the population study material (see appendix) shows very close agreement for the three impoundments studied.

TABLE II

CATCH PER UNIT OF EFFORT—GAME SPECIES

CLARK HILL RESERVOIR—1959, MEAN VALUE FOR 2,079 TRAY DAYS OF FISHING

NUMBERS GIVEN AS NUMBER PER TRAP DAY, WEIGHT AS LBS. PER TRAP DAY

Largemouth Bass		*Crappie**		*Bream*		*Basket Day Total*	
Number	*Weight*	*Number*	*Weight*	*Number*	*Weight*	*Number*	*Weight*
.001	.003	.022	.010	.035	.003	.058	.016

* Black and White Crappie.

TABLE III

CATCH PER UNIT OF EFFORT—GAME SPECIES *

ALLATOONA RESERVOIR—1960, MEAN VALUE FOR 683 TRAP DAYS OF FISHING

NUMBERS GIVEN AS NUMBER PER TRAP DAY, WEIGHT AS LBS. PER TRAP DAY

Spotted Bass		*Black Crappie*		*Basket Day Total*	
Number	*Weight*	*Number*	*Weight*	*Number*	*Weight*
.016	.031	.016	.004	.032	.035

* Bream Omitted.

TABLE IV

CATCH PER UNIT OF EFFORT—GAME SPECIES

LAKE LANIER—1959, MEAN VALUE FOR 1,965 TRAP DAYS OF FISHING

NUMBERS GIVEN AS NUMBER PER TRAP DAY, WEIGHT AS LBS. PER TRAP DAY

Largemouth Bass		*Black Crappie*		*Bream*		*Basket Day Total*	
Number	*Weight*	*Number*	*Weight*	*Number*	*Weight*	*Number*	*Weight*
.001	.001	.030	.002	.046	.005	.077	.008

A comparison of new commercial fishing devices with older, accepted types of gear is highly desirable in establishing the relative merits of the new gear. However, before such a comparison can be made a common basis must be established for comparison of the fish populations where the two types of gear are fished. The literature contains considerable information on the efficiency of the various types of gear in use, however, there are few publications with basic information on the fish populations from which the netting data were derived. Davis and Posey (1957) have a comprehensive evaluation of the efficiency of the various types of commercial gear along with population study material from rotenone samples (Table V).

TABLE V

FISH POPULATION DATA FOR RESERVOIRS WHERE COMMERCIAL FISHING GEAR WAS EVALUATED, GEORGIA AND LOUISIANA

Species	Combined Fish Pop. of 13 La. Lakes* M.L.A.	% Wt.	Allatoona Resv., Ga.† M.L.A.	% Wt.	Clark Hill Resv., Ga.‡ M.L.A.	% Wt.	Lanier Resv., Ga.† M.L.A.	% Wt.
Largemouth Bass	10.19	4	3.34	4	6.06	7	4.88	6
Spotted Bass	0.54	T	2.80	4	. . .	..	. . .	..
White Bass	0.09	T	0.09	T	. . .	..	. . .	..
Yellow Bass	1.60	1	. . .	..	. . .	..	. . .	..
Black Crappie	2.63	1	2.98	4	1.09	1	9.61	11
White Crappie	0.96	T	. . .	..	0.28	1	. . .	..
Chain Pickerel	0.13	T	. . .	..	. . .	..	. . .	..
Bluegill	12.00	5	17.83	24	14.91	18	19.72	23
Redbreast Sunfish	. . .	..	0.55	1	. . .	..	3.15	4
Longear Sunfish	1.64	1	. . .	..	. . .	..	. . .	..
Orangespotted Sunfish	0.38	T	. . .	..	. . .	..	. . .	..
Redear Sunfish	5.95	3	0.07	T	. . .	..	. . .	..
Spotted Sunfish	0.14	T	. . .	..	. . .	..	. . .	..
Green Sunfish	0.04	T	. . .	..	0.87	1	5.87	7
Pumpkinseed Sunfish	. . .	..	. . .	..	0.72	1	. . .	..
Warmouth	2.20	1	0.25	T	1.87	2	0.60	1
Yellow Perch	. . .	..	. . .	..	1.00	1	2.92	3
American Eel	0.16	T	. . .	..	. . .	..	. . .	..
Carp	0.73	T	42.84	57	3.59	4	30.41	35
Drum	12.79	5	. . .	..	. . .	..	. . .	..
Paddlefish	0.72	T	. . .	..	. . .	..	. . .	..
Buffalo fishes	7.50	3	. . .	..	. . .	..	. . .	..
Suckers	0.86	T	0.34	1	0.78	1	. . .	..
Lake Chubsucker	0.04	T	. . .	..	. . .	..	. . .	..
River Carpsucker	0.03	T	. . .	..	. . .	..	. . .	..
Striped Mullet	0.07	T	. . .	..	. . .	..	. . .	..
Brown Bullhead	. . .	..	0.06	T	1.12	1	3.73	4
Yellow Bullhead	0.43	T	. . .	..	. . .	..	0.71	1
Flat Bullhead	. . .	..	. . .	..	0.75	1	. . .	..
Black Bullhead	0.13	T	. . .	..	. . .	..	. . .	..
Channel Catfish	9.16	4	1.62	2	3.78	5	. . .	..
Blue Catfish	0.10	T	. . .	..	. . .	..	. . .	..
Flathead Catfish	0.57	T	. . .	**	. . .	..	. . .	..
White Catfish	. . .	..	. . .	..	. . .	..	0.43	1
Alligator Gar	0.24	T	. . .	..	. . .	..	. . .	..
Longnose Gar	5.17	2	. . .	..	0.06	T	. . .	..
Shortnose Gar	1.99	1	. . .	..	. . .	..	. . .	..
Spotted Gar	18.83	8	. . .	..	. . .	..	. . .	..
Bowfins	0.86	T	. . .	..	. . .	..	. . .	..
Gizzard Shad	97.56	41	. . .	..	44.84	55	. . .	..
Threadfin Shad	41.78	18	0.38	1	0.46	1	2.22	3
River Herring	0.03	T	. . .	..	. . .	..	. . .	..
Madtoms	T	T	. . .	..	0.09	T	0.14	T
Miscellaneous	0.26	T	1.94	3	0.09	T	1.37	1
TOTAL	238.50	..	75.09	..	82.36	..	86.26	..
Game Species	38.49 lbs., 16%		27.91 lbs., 37%		26.80 lbs., 33%		46.75 lbs., 55%	
Food Species	60.30 lbs., 25%		44.80 lbs., 60%		10.08 lbs., 12%		35.78 lbs., 41%	
Forage Species	139.63 lbs., 59%		2.32 lbs., 3%		45.48 lbs., 55%		3.73 lbs., 4%	

ABBREVIATIONS: M.L.A.—Mean Pounds Per Acre. % Wt—Percent by Weight.

* Taken from Davis and Posey, 1957, La. Wildlife & Fisheries Commission, pp. 85-99. Transformation of original data; the author accepts responsibility for any errors.

† For complete population data see appendix.

‡ One 2-acre cove sample with block-off net, May 10-13, 1960. Surface temp., 68 degrees.

There are recognized inaccuracies in rotenone sampling that are widely known and need not be elaborated on here. However, for the type of comparison de-

sired, the inaccuracies should not affect results significantly. Population study methods for all areas included block-off or retaining nets using 1 p.p.m. rotenone.

The nets selected for comparison with the wire traps were gill nets (3″ mesh), trammel nets (3″ mesh, and hoop nets (2″ mesh). These nets are the ones most commonly used in commercial fishing. The mesh sizes were the same as those recommended by Davis and Posey (1957) as a result of their investigations on catch of commercial species with various mesh sizes.

The following generalizations are apparent from a comparison of catch per unit of effort with nets (Table VI) and wire traps (Tables II, III and IV) considering the availability of different species in the population.

TABLE VI

CATCH PER UNIT OF EFFORT—GAME SPECIES

DAVIS AND POSEY (1957) GIVEN AS NUMBERS AND POUNDS PER NET-DAY

	LM Bass		*Sp. Bass*		*White Bass*		*Crappie*		*Bream*		*Total*	
Type of Gear	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Trammel Net	.03	.15	0	0	.01	.01	0	0	.02	.02	.06	.18
Gill Net	.03	.14	0	0	0	0	.16	.30	.02	.02	.21	.46
Hoop Net	0	0	.01	.01	.01	.01	.05	.05	T	T	.07	.07

Trammel and Gill Nets using 3-inch mesh, and Hoop Nets with 2-inch mesh.

It is immediately apparent that gill nets, hoop nets, and trammel nets took a much greater total catch per unit of effort by weight of game species than wire traps. An analysis of the effectiveness of different types of gear for taking individual game species follows:

Largemouth Bass: The catch per unit of effort of this species in numbers and weight was much higher for gill and trammel nets compared to traps. Hoop nets did not catch as many largemouth bass as wire traps.

Spotted Bass: This species was taken in greater numbers and weight in traps than in the other gear considered.

White Bass: White Bass were taken in greater numbers in trammel and hoop nets and with equal low success in gill nets and wire traps.

Crappie: Crappie were taken in greater numbers and weight in gill and hoop nets and in less number and weight in trammel nets. Wire traps took more crappie than trammel nets and much less than gill or hoop nets.

Bream: Bream were taken in greater numbers in all instances with wire traps than any of the other types of gear.

The percentage composition of the catch in wire traps is important in analyzing the relationship between the catch of game, commercial, and forage species. The percentage composition of the catch for the three impoundments studied is given in Tables VII, VIII, and IX.

TABLE VII

SPECIES COMPOSITION OF TRAP CATCHES

CLARK HILL RESV.—1959, 2,079 TRAP-DAYS OF FISHING GIVEN AS % BY WT.

Bass	*Crappie*	*Bream*	*Bullhead*	*Chan. Catfish*	*W. Catfish*	*Carp*
1.1%	3.9%	1.2%	15.8%	45.5%	11.9%	20.3%

TABLE VIII

SPECIES COMPOSITION OF TRAP CATCHES

ALLATOONA RESV.—1960, 683 TRAP-DAYS OF FISHING GIVEN AS % BY WEIGHT

Sp. Bass	*Bl. Crappie*	*Channel Catfish*	*Carp*	*Flathead Catfish*	*Suckers*
.9%	.1%	28.4%	69.7%	.7%	.2%

TABLE IX

SPECIES COMPOSITION OF TRAP CATCHES

LAKE LANIER RESV.—1959-60, 1,965 TRAP-DAYS OF FISHING GIVEN BY % OF WT.

LM Bass	*Black Crappie*	*Bream*	*Bullhead*	*Carp*
.2%	.5%	.9%	21.6%	76.4%

The percentage composition is a partial measure of selectivity of the gear. If any species is taken in the traps in a greater or lesser percentage than it occurs in the population, then the gear is either negatively or positively selective for that particular species. However, there is an interaction between species with a highly positive selectivity causing a negative shift to other species in the catch, and vice versa. The percentage composition by weight of the catch in wire traps is important in analyzing the relationship between the catch of game, food and forage species (Tables VII, VIII and IX). These values are an indication of whether a particular type of gear is doing more damage to game species than can be offset by the benefits derived from commercial fishing. This comparison is particularly valid for trap catches since they take only game and commercial species to the exclusion of forage species.

Catches from Clark Hill Reservoir showed the highest percentage catch of game fish for the three lakes studied. This resulted from a high percentage of game species coupled with a low percentage of commercial species in the population (Table V). On the other hand, the catch per unit of effort for Clark Hill was no higher than those for the other two reservoirs. The percentage composition of game species was well within acceptable limits even if the assumption is made that game fish will not be released once they are caught.

It is almost impossible to draw a valid conclusion by the comparison of the percentage composition of any one species with the same species using different types of gear for the reasons of interaction discussed above. However, by dividing the population study data of Table V into game, food and forage species,

Figure 1. Typical two-day catch with a legal wire trap, taken from Allatoona Reservoir during the month of October.

and doing likewise with the catch of the different types of gear, valuable information can be derived.

TABLE X

COMPARISON OF PERCENTAGE COMPOSITION OF CATCH (BY WEIGHT)

	Wire Traps			*Gill Nets**	*Trm. Nets**	*Hp. Nets†*
	Clark Hill	*Allatoona*	*Lanier*	*Louisiana*	*Louisiana*	*Louisiana*
Game Species	6.2%	1.0%	1.6%	9.0%	9.9%	10.9%
Food Species	93.5	99.0	98.0	87.0	90.1	80.8
Forage Species	0	0	0	4.0	0	8.2

* 3-inch mesh. † 2-inch mesh.

There is a higher percentage of game species in all reservoirs where the wire trap was tested than for the Louisiana lakes where the other gear was evaluated. Under these conditions the wire trap will nevertheless take a much smaller percentage of game species than any other type of gear tested.

Tables XI, XII and XIII give the distribution of sampling effort in time for the data given in Tables II through IV and VII through IX.

Table 11

Distribution of Sampling Effort In Time
Clark Hill Reservoir - 1959, 2,079 Trap-days. Fishing,Given as Trap-days per Month.

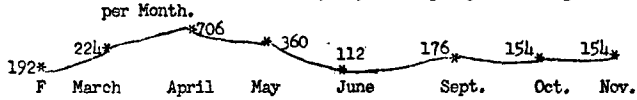


Table 12

Distribution of Sampling Effort in Time
Allatoona Reservoir - 1960, 683 Trap-days of Fishing, Given as Trap-days per Month.

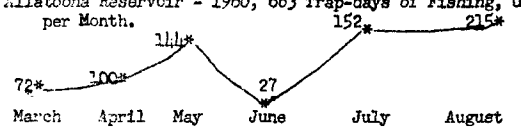
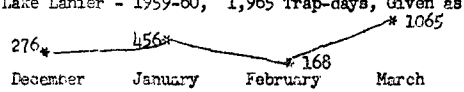


Table 13

Distribution of Sampling Effort in Time
Lake Lanier - 1959-60, 1,965 Trap-days, Given as Trap-days per Month.



EFFICIENCY OF THE WIRE TRAP AS A COMMERCIAL FISHING DEVICE

In determining the acceptability of a commercial fishing device from a biological and commercial standpoint there are numerous considerations that must be evaluated. These are:

1. The cost of the unit of gear.
2. The ease with which the gear is constructed and/or maintained.
3. The cost of operation of the gear.
4. The mortality of fish captured as a result of the gear used.
5. The catch per unit of effort of the available commercial species in the population.
6. The number of units of gear than can be operated at one time.
7. The size range of fish taken in relation to commercial and biological desirability.

The cost of the wire trap has been shown to be very low (Table I), with the average cost per year of use being approximately $2.35. Many potential com-

mercial fishermen either cannot afford to or will not purchase equipment even at the low price given for the wire trap. These same potential fishermen will, however, construct and maintain their own gear if no special skills or hard-to-get materials are required. The wire trap meets these specifications as evidenced by material requirements listed previously. Construction details are relatively simple as well.

The cost of cottonseed meal cake or some similar bait material is the most expensive item in wire trap fishing. The traps should be baited each time they are fished with one to two pounds of cottonseed meal cake costing approximately 6 cents per pound. Without using bait in reservoir trap fishing, the catch efficiency is very low.

The number of units of gear that can be operated is an important factor in determining the success of commercial fishing. With wire traps, using dropper wires from a main line, it is possible for one man to fish sixty to eighty baskets a day. Unlike the entangling nets, removal of fish from the wire trap takes only a matter of minutes. Under most conditions traps are not "run" for two or three days after the previous "run". As long as these traps are in water where there is sufficient oxygen the fish suffer very little from being entrapped. Using a two or three day interval of fishing one operator could fish 120 to 180 traps. Markets generally available in Georgia, tend to limit the operator's number of traps more than insufficient fishing time.

Mortality of fish caught in the traps is very low as stated previously. With adequate holding facilities fish from traps, unlike entangling nets, may be held alive until an opportune time for disposal. This is of considerable importance to operators who depend on the sale of live fish to local markets.

The catch per unit of fishing effort as much as any other factor determines if a type of gear will be satisfactory for commercial fishing. The catch per unit of effort of commercial or food species is given for the three impoundments by months in Tables XIV through XVI.

TABLE XIV

CATCH PER UNIT OF EFFORT, COMMERCIAL SPECIES, CLARK HILL RESERVOIR, 1959
NUMBERS EXPRESSED AS NO. PER TRAP-DAY, WEIGHTS AS LBS. PER TRAP-DAY

Basket-Day		*Bullheads*		*Channel Catfish*		*White Catfish*		*Carp*		*Total*	
Fished	*Month*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
192	Feb.	.18	.05	..	..	..	..	.04	.11	.22	.16
224	Mar.	.02	.01	.04	.01	.01	T	..	..	.07	.02
706	April	.13	.07	.26	.07	.03	.01	.03	.09	.45	.24
361	May	.07	.05	.34	.15	.16	.08	T	.01	.57	.29
112	June	.06	.05	.13	.03	.19	.05	..	..	.38	.13
176	Sept.	.06	.03	1.18	.41	.06	.03	.02	.06	1.32	.53
154	Oct.	.21	.09	1.14	.38	.18	.05	.09	.09	1.62	.61
154	Nov.	.01	T	.06	.02	.05	.03	.01	.01	.13	.06
T.2079	Mean Value	.10	.04	.35	.12	.07	.03	.02	.05	.54	.24

TABLE XV

CATCH PER UNIT OF EFFORT, COMMERCIAL SPECIES, LAKE LANIER, 1959
NUMBERS EXPRESSED AS NO. PER TRAP-DAY, WEIGHTS AS LBS. PER TRAP-DAY

Basket-Day		*Bullheads* *		*Carp*		*Total*	
Fished	*Month*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
184	Feb.	.23	.06	.32	.49	.55	.55
144	Mar.	.67	.25	.19	.29	.86	.54
211	April	2.56	.78	1.23	2.13	3.79	2.91
288	May	5.80	1.74	4.09	7.08	9.89	8.82
384	June	4.00	1.20	4.15	7.18	8.15	8.38
268	July	6.02	1.81	1.47	2.48	7.49	4.29
145	Aug.	5.23	1.52	.75	.99	5.98	2.51
276	Dec.	.73	.12	.63	.72	1.36	.84
T.1900	Mean Value	3.40	1.01	2.00	3.36	5.40	4.37

* Brown and Yellow Bullhead.

TABLE XVI

CATCH PER UNIT OF EFFORT, COMMERCIAL SPECIES, LAKE ALLATOONA, 1960
NUMBERS EXPRESSED AS NO. PER TRAP-DAY, WEIGHTS AS LBS. PER TRAP-DAY

Basket-Days		*Flathead Catfish*		*Suckers*		*Channel Catfish*		*Carp*		*Total*	
Fished	*Month*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
72	Mar.	..	..	.03	.03	.44	.23	.67	.76	1.14	.93
100	April	..	..	.01	.02	.75	.40	.98	1.12	1.74	1.54
108	May	..	..	..	..	1.02	.46	3.00	3.37	4.02	3.83
63	June	..	..	.02	.02	1.13	.63	2.68	3.36	3.83	4.01
128	July	..	..	..	..	3.63	1.99	2.41	2.80	6.04	4.79
212	Aug.	.02	.08	..	..	3.55	1.21	2.01	2.43	5.58	3.72
T. 683	Mean Value	.01	.02	.01	.01	2.20	.96	2.04	2.37	4.25	3.36

The catch is broken down by month so it will be possible to determine the efficiency of the traps by selectively fishing the more productive months. A comparison of the catch per unit of effort data with population study material shows good agreement in most instances. In cases where agreement is lacking the population study material rather than trap data is probably biased.

The catch of commercial species from gill, trammel and hoop nets in Louisiana, Davis and Posey (1957) is given in Table XVII for comparison with the wire trap data. Only species common to both sections are given.

TABLE XVII

CATCH PER UNIT OF EFFORT, COMMERCIAL SPECIES, LOUISIANA
DAVIS AND POSEY, 1957, GIVEN AS NUMBER AND POUNDS PER NET-DAY

	Carp		*Suckers*		*Bullhead*		*Chan. Catfish*		*Flathead Cat.*	
Type of Gear	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Gill Net (3" mesh)	.02	.14	.00	.00	.04	.10	.04	.20	.01	.06
Tram. Net (3" mesh)	.03	.13	.01	.06	.00	.00	.00	.00	.01	.08
Hoop Net (2" mesh)	.01	.01	T	T	.00	.00	T	T	.01	.01

Using the population study material as a basis the following statements may be made in regard to the catch per unit of effort of wire traps compared to the three types of nets.

Carp and Suckers: There is very little difference in the number of carp and suckers captured in wire traps and the three types of nets. However, the larger size fish from net catches causes the weight per net-day to be higher for gill and trammel nets.

Bullheads: Gill nets take a comparable weight of bullheads but a smaller number than wire traps. Wire traps take a greater number and weight of bullheads than either hoop or trammel nets.

Channel Catfish: Wire traps take a much larger number and weight of channel cat than either of the three types of nets.

Flathead Catfish: Wire traps and nets take a comparable quantity of flathead catfish.

Total Catch: Although the population of commercial species varies considerably between the reservoirs studied, the wire trap harvests a greater percentage of the available commercial weight than any of the three types of nets under consideration.

SIZE CLASSES OF COMMERCIAL SPECIES FROM TRAPS

The size of fish taken with a particular type of gear is of importance from both a commercial and a biological standpoint. If commercial fishermen are to operate at a profit, the fish caught must be of a size in demand on the market. From a biological viewpoint the gear should ideally remove a wide range of sizes, with a tendency toward smaller sizes in order to remove commercial species before they complete with game species. Removal of small fish would also be advantageous where populations are overcrowded and slow growing. Swingle (1957) found that restaurants preferred to buy red catfish varying from .2 to .5 pound each. Fish that would run .7 to 1.0 pound were considered

too large. This breakdown would probably hold true for most species of catfish. The most desirable size of carp and suckers probably range from 1 to 5 pounds. Buffalo and possibly other species are desirable at even larger sizes. Table XVIII shows the length frequency measurements for commercial species taken from traps in the reservoirs studied. The approximate lengths for the specified acceptable weight range discussed previously would be as follows: For bullheads, 8 through 11 inches; channel catfish, 9 through 13 inches; white catfish, 8 through 11 inches; carp, 13 through 22 inches; and for suckers, 13 through 25 inches.

TABLE XVIII

LENGTH FREQUENCIES IN TOTAL LENGTH OF COMMERCIAL SPECIES FROM TRAPS CLARK HILL, LANIER, AND ALLATOONA RESERVOIRS, 1959-1960

Inch Group *	*Bullheads*	*Carp*	*Chan. Catfish*	*White Cat.*
6	62	..	..	..
7	407	..	1	7
8	544	1	100	32
9	307	1	218	35
10	97	1	172	30
11	43	16	141	31
12	17	39	26	9
13	11	110	20	3
14	5	210	15	2
15	..	177	2	..
16	..	97	2	..
17	..	33	..	..
18	..	16	1	..
19	..	1	..	..
20	..	3	1	..
TOTALS	1,493	705	699	149
	$\bar{X} = 8.17$	$\bar{X} = 14.43$	$\bar{X} = 10.10$	$\bar{X} = 9.64$

* Measurements used are 6.0-6.9—6 inches; 7.0-7.9—7 inches, etc.

A comparison of the length frequency measurements from wire traps with the most desirable commercial size shows 66% of the bullheads to be in the most desirable range. Of the remaining bullheads 2% were oversize and 31% were too small. Eighty-three percent of the channel catfish were in the most desirable range, with 14% undersize and 3% too large. White catfish showed 86% in the desirable range with 9% too large and 5% were smaller than is desirable. Carp were 92% within the desirable commercial size with only 8% below the minimum length stated.

From a marketing viewpoint, it would be difficult to improve on the size range of fish taken. Any increase or decrease in mesh size of the trap would probably result in a smaller percentage of the fish in a size that is most in demand with the highest price.

Biologically the trap is shown to be efficient in removing commercial species over a wide range of sizes. A comparison of the length frequencies from the wire trap with that of population study material shows the trap to be effective in removing the full size range of bullheads, white catfish and carp in the populations. However, the dimensions of the trap will necessarily limit the size of carp that can be taken as the individuals within the population became larger. Channel catfish are rarely taken after they reach sixteen inches in length. This is the approximate size at which the channel catfish begins to feed primarily on small fish. This shift in food habits could result in fewer of the larger individuals being taken in traps. The ability of the wire trap to harvest the smaller size classes of commercial species is advantageous in areas where overpopulations and slow growth of these species occur.

The only comparative statement regarding the size class of fish taken in wire traps and the recommended mesh sizes of hoop, gill and trammel nets is to say that almost all catfish taken in the latter type of gear is above the most desirable commercial size range as I have described it. Carp and suckers taken in

the nets are in the upper limits of the desirable commercial size. The possibility that only the larger fish were available in the populations where the other nets were fished is ruled out by the fact that the smaller mesh nets operated in these impoundments did take smaller fish.

EXTENT OF USE OF TRAPS BY COMMERCIAL FISHERMEN

One of the most reliable tests of whether a type of gear is successful for commercial fishing is the extent of use of the gear by commercial fishermen. Table XIX gives the number of traps licensed for use in each of the reservoirs.

TABLE XIX

LICENSED TRAPS FOR THE PERIOD MARCH 31, 1959-MARCH 31, 1960

Clark Hill	*Lanier*	*Allatoona*
365	519	54

The license for the traps cost $1.10 for each trap fished, regardless of the number of traps the fisherman is using.

Gill nets (3″ mesh), trammel nets (2″ mesh), hoop nets (2″ mesh), and fyke nets (2″ mesh), are also legal for commercial fresh-water fishing in Georgia. The license for commercial net fishermen costs $10.00 and permits the holder to fish as many nets as he desires. As a comparison to the wire trap there are only 50 commercial nets being fished in Clark Hill, Lanier, and Allatoona. According to these figures wire traps receive much wider use than nets in these impoundments.

EFFECTIVENESS IN REDUCTION OF NON-GAME SPECIES

In addition to establishing the wire trap as an efficient commercial fishing device, studies are presently under way to determine if the wire trap would be effective as a management tool in reducing populations of non-game species in reservoirs. Such a reduction would be valuable in eliminating competition with species sought by the sport fishermen. The evaluation of this problem in reservoirs necessitates either the collection of records on the total pounds removed from a reservoir by traps or an alternate method of establishing the effect on the population by population sampling. Tagging of large numbers of non-game species and thereby determining percentage removal by tag returns is also possible. All of these methods are in use at present on the three reservoirs reported on. Data from these projects are not complete and will be reported in a later publication.

CONCLUSIONS

On the basis of results from this investigation under the conditions outlined, the following conclusions are apparent:

1. The wire trap was low in cost and easy to construct and maintain.
2. The wire trap removed a very low percentage of game species and was not detrimental to sport fishing.
3. The wire trap was an efficient commercial fishing device.
4. The wire trap took a desirable size class of fish from both the biological and commercial standpoint.
5. The wire trap in combination with gill, trammel, and hoop nets as fresh water commercial fishing gear, demonstrated a diversity of desirable characteristics which neither possessed alone.

BIBLIOGRAPHY

1. Davis, James and Lloyd Posey, Jr. 1957. Relative Selectivity of Freshwater Commercial Fishing Devices Used in Louisiana. Louisiana Wildlife and Fisheries Commission, 27 pp.
2. ————————. 1957. Supplement to Relative Selectivity of Freshwater Commercial Fishing Devices Used in Louisiana. Louisiana Wildlife and Fisheries Commission, 144 pp.
3. May, Otho, Jr. 1954. Experiments with Commercial Fishing Traps in the Oconee, Ocmulgee and Altamaha Rivers in Georgia. Georgia Game and Fish Commission, 11 pp.

4. Carter, Ellis R. 1954. An Evaluation of Nine Types of Commercial Fishing Gear in Kentucky Lake. Proc. of the Southeastern Association of Game and Fish Commissioners, pp. 44-52.
5. Swingle, H. S. 1957. Commercial Production of Red Cats (Speckled Bullheads) in Ponds. Proc. Southeastern Association Game and Fish Commissioners, pp. 156-160.
6. Cobb, Eugene S. 1954. The Use of Fish Traps in the Management of Farm Ponds. Journal of the Tennessee Academy of Science, Vol. 1, Jan., 1954, pp. 45-54.
7. Surber, Eugene W. 1959. Standard Methods of Reporting Fish Population Data for Reservoirs. Annual Report, Reservoir Committee, Southern Division American Fisheries Society, 19 pp.

APPENDIX I

Physical Description, Fish Population, and Creel Census Statistics, Clark Hill Reservoir, Georgia

Physical Data

Location: Savannah River between the states of Georgia and South Carolina, Latitude 33.7°, Longitude 82.5°
Date Reservoir Filled: May 1953
Length: 39 miles
Shoreline: 1,200 miles
Area: 70,000 acres at top of Power Pool
Maximum Depth: 150 feet
Normal Fluctuation: 25 feet

Biological Data

Rotenone Sample of Fish Population. Two, 2-acre cove samples with Block-off net ⅜" mesh May 10-13, 1960, 1 p.p.m. 5% Rotenone, Surface Temp. 68-71°. Data reported according to Surber (1959) given as mean number and pounds per acre.

Group A: Predatory Game Fish

Species	*Fingerling*		*Intermediate*		*Harvestable*		*Total*	
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Largemouth Bass	2.25	.05	4	.51	9.5	8.90	15.15	9.46
Black Crappie	6	.12	6	.45	5	1.18	17	1.75
White Crappie	2	.05	3	.26	6	1.50	11	1.81

Group B: Non-Predatory Game Fish

Species	*Fingerling*		*Intermediate*		*Harvestable*		*Total*	
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Bluegill	942	3.96	550	8.07	17	1.26	1,509	13.29
Green Sunfish	19	.19	25	.83	..	...	44	1.02
Warmouth	58	.26	72	1.14	4	.53	134	1.93
Pumpkinseed	9	.06	20	.38	..	...	29	.44
Yellow Perch	38	.31	24	.26	..	...	62	.57

Group C: Non-Predatory Food Fish

Species	*Fingerling*		*Intermediate*		*Harvestable*		*Total*	
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Spotted Sucker	..	..	..	..	0.25	.39	0.25	.39
Carp	..	..	..	..	6.0	15.22	6.0	15.22
Brown Bullhead	0.50	.02	..	..	0.50	.55	1.0	.57
Flat Bullhead	..	..	0.50	.09	...	...	0.50	.09

Group D: Predatory Food Fish

Species	*Fingerling*		*Intermediate*		*Harvestable*		*Total*	
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Channel Catfish	..	..	1	.23	1	1.82	2	2.05
White Catfish	..	..	0.25	.14	..	...	0.25	.14
Longnose Gar	..	..	0.50	.09	..	...	0.50	.09

GROUP E: FORAGE FISH

Species	*Fingerling*		*Intermediate*		*Harvestable*		*Total*	
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Gizzard Shad	..	..	75	28.08	..	..	75	28.08
Threadfin Shad	35	.31	13	.29	..	..	48	.60
Mad Toms	13	.15	..	..	..	..	13	.15
Misc. Minnows	3	T	2	.05	0.50	.05	5.50	.10

Group	*Total*	*Number*	*Weight*
Group A:	Total	33	13.02
Group B:	Total	1,778	17.25
Group C:	Total	7.75	16.27
Group D:	Total	2.75	2.28
Group E:	Total	141.50	28.93

Creel Census Summary

Survey by boat of complete and incomplete fishing trips.

$$\text{Catch/Hr.} = \frac{\text{Catch of Any Species}}{\text{Total Hrs. Fished}}$$

7,210 fisherman contacts (March 1–November 30, 1959)

ANNUAL AVERAGE CATCH PER HOUR

Largemouth Bass	.156 Fish/Hr.
Crappie	.236 Fish/Hr.
Bream	.097 Fish/Hr.
Catfish	.026 Fish/Hr.
White Bass	.002 Fish/Hr.
"Other"	.004 Fish/Hr.
Fishing Pressure	6.17 Hrs./A.

HARVEST

Largemouth Bass	.96 Fish/A.
Crappie	1.46 Fish/A.
Bream	.60 Fish/A.
Catfish	.16 Fish/A.
White Bass	.01 Fish/A.
"Other"	.02 Fish/A.

AVERAGE WEIGHT

Largemouth Bass	2.0 Lbs.
Crappie	.81 Lbs.

APPENDIX II

Physical Description, Fish Population, and Creel Census Statistics, Allatoona Reservoir, Georgia

Physical Data

Location: Etowah River, Northwest Georgia
Latitude 34.1°, Longitude 85.3°
Date Reservoir Filled: 1950
Length of Reservoir: 20 miles
Length of Shoreline: 180 miles
Area: 10,550 acres
Maximum Depth: 120 feet
Normal Fluctuation: Approximately 25 feet

Biological Data

Rotenone samples of fish population. Two, 2-acre cove samples Block-off net ⅜" mesh May 17-19, 1960, 1 p.p.m. 5% Rotenone, Surface Temp. 66-68°. Data according to Surber (1959) given as mean number and pounds per acre.

Group A: Predatory Game Fish

Species	*Fingerling*		*Intermediate*		*Harvestable*		*Total*	
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Largemouth Bass	..	..	..	..	1.5	3.35	1.5	3.35
Spotted Bass	47	.22	13	1.46	3.0	1.12	63.00	2.80
Black Crappie	13	.09	35	1.86	.05	.78	48.05	2.73

Group B: Non-Predatory Game Fish

Species	*Fingerling*		*Intermediate*		*Harvestable*		*Total*	
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Bluegill	8	.10	451	6.75	138	11.4	597	17.89
Redbreast	..	..	3	.02	7	.54	10	.56
Warmouth	5	T	6	.11	1	.14	12	.25
Red Ear	..	..	.02	T	.50	.08	.52	.08

Group C: Non-Predatory Food Fish

Species	*Fingerling*		*Intermediate*		*Harvestable*		*Total*	
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Spotted Sucker	..	..	.25	.11	.25	.24	.50	.35
Carp	..	..	45	36.39	25.00	6.46	.50	42.85
Brown Bullhead	..	..	..	..	.25	.05	.25	.05

Group D: Predatory Food Fish

Species	*Fingerling*		*Intermediate*		*Harvestable*		*Total*	
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Channel Catfish	..	..	4	.59	3	1.04	5	1.63

Group E: Forage Fish

Species	*Fingerling*		*Intermediate*		*Harvestable*		*Total*	
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Threadfin Shad	..	..	9	.38	..	..	9	.38
Goldfish	..	..	..	..	2	1.55	2	1.55
Misc. Minnow	2	T	10	.26	22	..	34	.26
Log Perch	..	..	9	.16	..	..	9	.16

Group	*Total*	*Number*	*Weight*
Group A:	Total	112.10	8.88
Group B:	Total	671.00	18.78
Group C:	Total	50.75	43.25
Group D:	Total	5.00	1.63
Group E:	Total	54.00	2.35

Creel Census Summary

Survey by boat of complete and incomplete fishing trips.

$$\text{Catch/Hr.} = \frac{\text{Catch of Any Species}}{\text{Total Hrs. Fished}}$$

2,790 fishermen checks (March 1–November 30, 1959)

ANNUAL AVERAGE CATCH PER HOUR

Bass *	.050	Fish/Hr.
Black Crappie (daytime)	.268	Fish/Hr.
(night)	1.717	Fish/Hr.
Bream	.059	Fish/Hr.
Catfish	.026	Fish/Hr.
White Bass	.002	Fish/Hr.
"Other"	.005	Fish/Hr.
Fishing Pressure (daytime)	11.93	Hrs./A.
(night)	1.76	Hrs./A.

HARVEST

Bass	.60	Fish/A.
Black Crappie (daytime)	3.20	Fish/A.
(night)	3.01	Fish/A.
Bream	.70	Fish/A.
Catfish	.31	Fish/A.
White Bass	.02	Fish/A.
"Other"	.06	Fish/A.

AVERAGE WEIGHT

Bass	1.38	Lbs.
Crappie	.40	Lbs.

* 97% Spotted Bass *Micropterus punctulatus.*

APPENDIX III

Physical Description, Fish Population, and Creel Census Statistics, Lanier Reservoir, Georgia

Physical Data

Location: Chattahoochee River, North Central Georgia
Latitude 32.2°, Longtitude 84.0°
Date Filled: 1958
Length of Reservoir: 54 miles
Length of Shoreline: 540 miles
Area: 38,000 acres
Maximum Depth: 151 feet
Normal Fluctuation: 10 feet

Biological Data

Rotenone Sample of fish population. Two, 2-acre cove samples. Block-off net ⅜" mesh May 31-June 3, 1960, 1 p.p.m. 5% Rotenone, Surface Temp. 76°. Data according to Surber (1959), given as mean numbers, and pounds per acre.

Group A: Predatory Game Fish

Species	*Fingerling*		*Intermediate*		*Harvestable*		*Total*	
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Largemouth Bass	5	.14	3	.37	4	4.38	12	4.89
Black Crappie	4	.50	68	4.55	22	5.00	94	10.05

Group B: Non-Predatory Game Fish

Species	*Fingerling*		*Intermediate*		*Harvestable*		*Total*	
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Bluegill	30	.22	294	.38	175	11.62	499	12.22
Redbreast	..	..	10	.38	42	2.87	52	3.25
Green Sunfish	91	1.09	259	6.80	..	..	350	7.89
Warmouth	4	.06	20	.53	0.25	.02	24.25	.61
Yellow Perch	1	.05	.50	.06	2	.61	3.50	.72

Group C: Non-Predatory Food Fish

Species	*Fingerling*		*Intermediate*		*Harvestable*		*Total*	
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Carp	..	..	23	22.18	6	8.24	29	30.42
Speckled Bullhead	19	T	..	.06	18	3.75	37	3.75
Yellow Bullhead	1	.05	.50	.06	2	.61	3.50	.72

Group D: Predatory Food Fish

Species	*Fingerling*		*Intermediate*		*Harvestable*		*Total*	
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
White Catfish	..	..	.50	.15	.65	.72	1.15	.87

Group E: Forage Fish

Species	*Fingerling*		*Intermediate*		*Harvestable*		*Total*	
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Threadfin Shad	10	.14	50	2.09	..	..	60	2.23
Madtoms	6	.19	.25	.02	..	..	6.25	.21
Misc. Minnow	..	..	9	.48	4	.88	13.00	1.36

Group	*Total*	*Number*	*Weight*
Group A:	Total	106	14.94
Group B:	Total	928.75	24.69
Group C:	Total	69.50	34.88
Group D:	Total	1.15	.87
Group E:	Total	79.29	3.80

Creel Census Summary

Survey by boat of complete and incomplete fishing trips.

$$\text{Catch/Hr.} = \frac{\text{Catch of Any Species}}{\text{Total Hrs. Fished}}$$

2,959 fisherman checks (March 1–November 30, 1959)

ANNUAL AVERAGE CATCH PER HOUR

Bass	.058 Fish/Hr.
Crappie	.390 Fish/Hr.
Bream	.404 Fish/Hr.
Catfish	.355 Fish/Hr.
"Other"	.018 Fish/Hr.

HARVEST

Bass	.18 Fish/A.
Crappie	1.24 Fish/A.
Bream	1.28 Fish/A.
Catfish	1.14 Fish/A.
"Other"	.06 Fish/A.

AVERAGE WEIGHT

Crappie	6 Oz.
Bass	2.6 Lbs.
Fishing Pressure	3.19 M/H/A.

A STUDY OF THE COMPARATIVE USE OF DIFFERENT SPECIES OF FISH IN THE TOXICITY BIOASSAY OF PETROLEUM REFINERY EFFLUENT *

By NEIL H. DOUGLAS

Aquatic Biology Laboratory, Department of Zoology
Oklahoma State University
Stillwater, Oklahoma

ABSTRACT

Fish have been used as test animals in pollution abatement programs since the inception of bioassay research. Many kinds of fish have been used in the bioassay tests. The kinds used at times have been selected merely on availability factors and not necessarily on a basis of adaptation of the fish to bioassay tests. This paper presents a comparison of four different species of fish used as test animals in a series of toxicity bioassays of petroleum refinery effluents.

INTRODUCTION

Toxicity bioassays were made during 1958 to determine the differences in the resistance of four species of fish to pertoleum refinery effluents. The four species were chosen because they were easily obtained and they were used previously for bioassay in the Southwest by other workers.

To compare the resistance of one species to the other three it was necessary to use dilutions of effluents whose toxic strengths would neither kill all specimens nor permit all to live. Comparisons of the relative resistance of the four species to petroleum refinery effluents were made.

One of the purposes of the study was to determine if one of the species was more resistant or susceptible to refinery effluents than were the others. At no time were the effluents chemically tested to reveal the components. A determination of the toxicity of refinery effluents to biotic life was not an objective.

Another purpose was to compare the behaviors of the four species regarding their habitats, ease of capture, adjustment to laboratory confinement and reactions in test solutions.

* Contribution No. 293 from the Department of Zoology. Oklahoma State University.