

BULLETIN

of the

ILLINOIS NATURAL HISTORY SURVEY

HARLOW B. MILLS, *Chief*

Efficiency and Selectivity
of Commercial
Fishing Devices
Used on the Mississippi River

WILLIAM C. STARRETT

PAUL G. BARNICKOL



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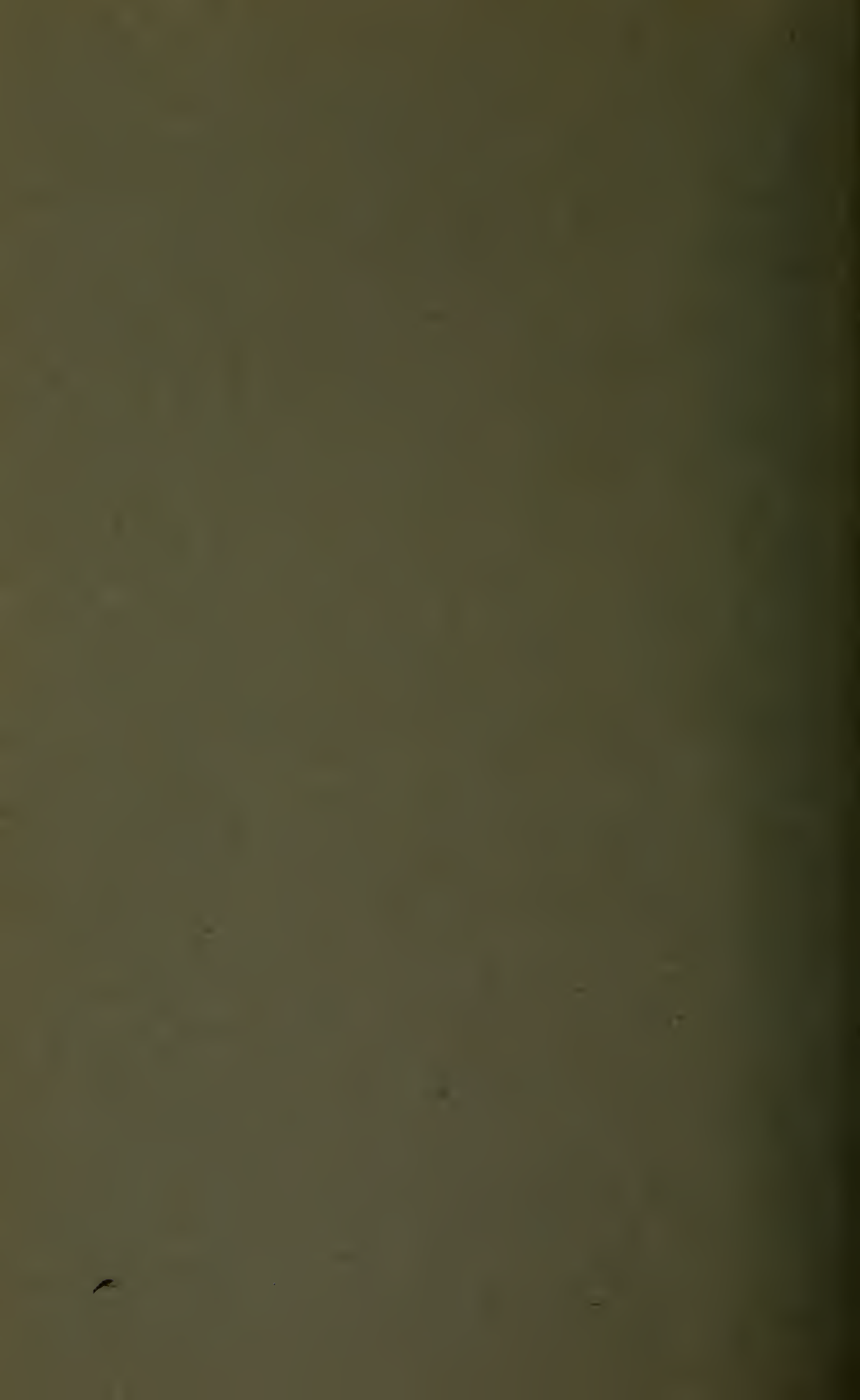
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NATURAL HISTORY SURVEY DIVISION
HARLOW B. MILLS, *Chief*

Volume 26

BULLETIN

Article 4

Efficiency and Selectivity of
Commercial Fishing Devices
Used on the Mississippi River

WILLIAM C. STARRETT
PAUL G. BARNICKOL



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URBANA, ILLINOIS

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This paper is a contribution from the Section of Aquatic Biology.

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Cleaning fish in a commercial fish market at Dallas City, Illinois, on the Mississippi River.

Efficiency and Selectivity of

Commercial Fishing Devices

*Used on the Mississippi River**

WILLIAM C. STARRETT†

PAUL G. BARNICKOL‡

IN 1944 and 1946, a fishery survey was made of the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, under the auspices of the Technical Committee for Fisheries, a subgroup of the Upper Mississippi River Conservation Committee. Collections of fish were made with various types of fishing devices at 31 field stations. Based largely on these collections, a report relative to the status of commercial and sport fishing in the Caruthersville-Dubuque section of the river was written and published (Barnickol & Starrett 1951).

The present paper is a statistical analysis of the catch data relative to the efficiency and selectivity of the various commercial fishing devices used during the survey. It is believed that such an analysis could be of value to persons interested in the management of the river's commercial fishery. At the present time, law enforcement is the chief form of fish management practiced in the Caruthersville-Dubuque section of the river.

The fishery survey was financed by the Illinois Department of Conservation, the Illinois Natural History Survey, the Iowa Conservation Commission, and the Missouri Conservation Commission. The Illinois Natural History Survey's laboratory boat, the *Anax*, was used as field headquarters.

The writers are indebted to Dr. George W. Bennett of the Illinois Natural History Survey for suggestions and encour-

agement in the preparation of this paper and to Dr. Robert Touchberry of the University of Illinois for technical advice in the statistical treatment of the data. The following persons, at the time associated with the Illinois Natural History Survey, aided in the collection of data: Mr. Daniel Avery, Mr. Leonard Durham, Dr. B. Vincent Hall, Dr. Donald F. Hansen, Mr. Don W. Kelley, Mr. Jacob Lemm, Dr. Hurst H. Shoemaker, and Dr. David H. Thompson. Mr. James S. Ayars of the Illinois Natural History Survey edited the manuscript. Many other persons contributed directly in making this investigation possible through their administrative assistance, notably Dr. Harlow B. Mills, present Chief, and the late Dr. Theodore H. Frison, former Chief, of the Illinois Natural History Survey; Dr. G. B. Herndon of the Missouri Conservation Commission; Mr. Sam A. Parr of the Illinois Department of Conservation; and Mr. Everett B. Speaker and the late William E. Albert of the Iowa Conservation Commission. Photographs other than that for fig. 10 were taken by Natural History Survey staff photographers William E. Clark and Charles L. Scott and by the senior author of this paper.

Materials and Methods

In 1944, fish collections were made at 19 field stations on the Mississippi River between Caruthersville, Missouri, and Warsaw, Illinois, and, in 1946, at 12 field stations on the river between Burlington, Iowa, and Dubuque, Iowa, fig. 1. Table 1 contains a list of the field stations, inclusive dates of fishing operations at each

* The investigation on which this paper is based was conducted under the auspices of the Technical Committee for Fisheries of the Upper Mississippi River Conservation Committee.

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station, pool numbers, and the distances of stations from Dubuque.

The survey covered 306 miles of the Mississippi below the mouth of the Missouri River and 383 miles above this point. The lower section extended from the

mouth of the Missouri River to Caruthersville and is referred to in this paper as the MR-C section. The upper section extended from Dubuque to the mouth of the Missouri River and is designated as the D-MR section.

In both years of the survey, a key station was established for checking seasonal differences in catches. In 1944, Grafton was the key station and, in 1946, Andalusia. Three sampling periods were spent at each of these stations.

In the fall of 1944, trammel net experiments were conducted at Quincy and at Grafton, Illinois. The data from these experiments are treated separately in this paper.

When, in this paper, reference is made to mesh size of nets and seines, the size of the mesh in inches is indicated; for example, a 1-inch-mesh wing net refers to a wing net having mesh of 1-inch square measure. Square measure mesh size is used throughout this publication. The approximate stretch measure of the webbing can be calculated by multiplying the square measure by two.

The following fishing devices, some of which could not in 1944 or 1946 be used legally by commercial fishermen, were tested by the survey party:

Trammel nets, length of each 80, 100, or 150 yards (mesh of inner net $1\frac{1}{2}$, $1\frac{3}{4}$, 2, or 3 inches), depth 5 or 6 feet

Seines, length of each 100, 150, or 200 yards (mesh 1 inch), depth 10 feet

Hoop nets (mesh 1 inch, hoop diameters $3\frac{1}{2}$ or 4 feet; mesh $2\frac{1}{2}$ inches, hoop diameters 4 or $4\frac{1}{2}$ feet; mesh 3 inches, hoop diameters 4 or $4\frac{1}{2}$ feet)

Wing nets with and without leads (mesh 1 inch, hoop diameters $2\frac{1}{2}$ to $4\frac{1}{2}$ feet; mesh $1\frac{1}{2}$ inches, hoop diameter 3 feet; mesh $2\frac{1}{2}$ inches, hoop diameters $3\frac{1}{2}$ and $4\frac{1}{2}$ feet)

Trap nets (mesh $1\frac{1}{4}$ inches)

Basket traps (opening $1\frac{1}{2}$ inches)

Trot lines

The number of each of the various kinds of fish caught and the total lengths of the individuals and their weights, as well as the dates and hours of setting and raising gear, were recorded separately for each type of fishing device (except trot lines) and each mesh size of net (except trammel net) and seine used. The data

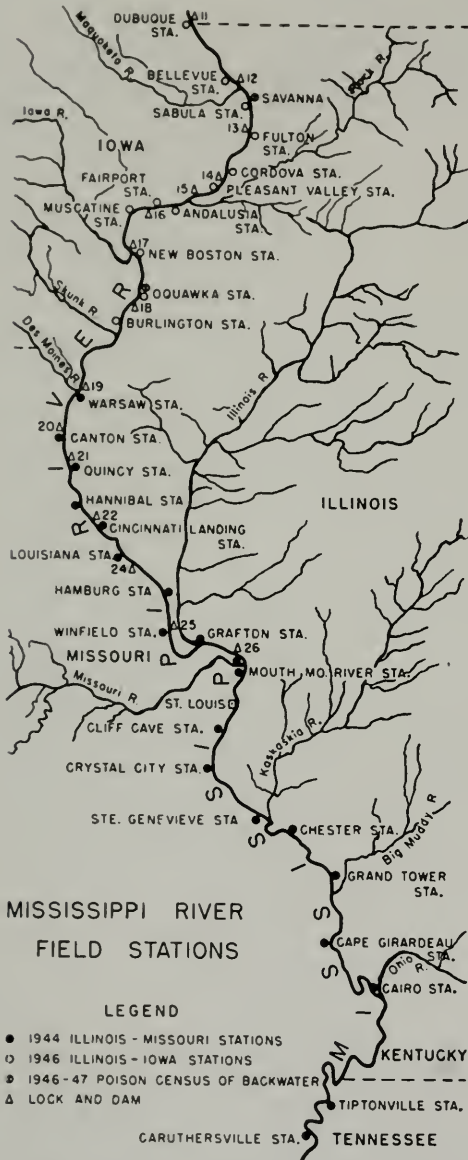


Fig. 1.—The Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa; shown is the location of field sampling stations used during the fisheries survey of 1944 and 1946. The river distance between Caruthersville and Dubuque is 689 miles.

from trot line sets were too meager for valid analysis. The hoop diameters of wing nets and hoop nets were not considered in this study, and catches made in these nets were not separated on the basis of hoop size.

The common and scientific names of fish caught are listed in table 2.

Characteristics of Area

The Mississippi River in the MR-C section is more turbid and swifter than in the D-MR section. The MR-C section is free of locks and dams, whereas the D-MR section is canalized by a series of 14 locks and dams maintained for navigation.

Detailed descriptions of the physical and fish-faunal characteristics of the Caruthersville-Dubuque section of the Mississippi River and the field stations established during the 2-year survey are contained in the earlier report prepared by Barnickol & Starrett (1951).

In test-net collections, sport fishes were present in greater numbers in the D-MR section of the river than in the MR-C section. In the MR-C collections, small-mouth buffalos and black buffalos were more abundant than bigmouth buffalos. Bigmouth buffalos were more common in the D-MR collections than in the MR-C collections. Blue catfish were found upstream as far as Lock and Dam No. 19 at Keokuk, Iowa. Fish of this species were taken in greater numbers in the Mississippi River below the mouth of the Missouri than above. Flathead catfish were common in both sections of the Mississippi. In 1944, more channel catfish were in test-net collections between Warsaw and the mouth of the Missouri River than in collections from the MR-C section.

Commercial Fishing Activities

At the time of the survey, commercial fishing was conducted along much of the Mississippi River between Caruthersville and Dubuque. According to Starrett & Parr (1951:6), in 1950 there were 248 residents of Illinois who worked either part or full time as professional commercial fishermen on the Mississippi. These

Table 1.—Stations at which fish collections were made in 1944 and 1946 fisheries survey of the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, inclusive dates for each collection, and location of each station.

STATION	INCLUSIVE DATES	MILES BELOW DUBUQUE STATION	POOL No.
1944			
Caruthersville, Mo.....	April 6-12	689	—
Tiptonville, Tenn.....	April 15-May 10	665	—
Cairo, Ill.....	May 18-24	573	—
Cape Girardeau, Mo.....	May 26-31	529	—
Grand Tower, Ill.....	June 2-9	499	—
Chester, Ill.....	June 11-15	468	—
Ste. Genevieve, Mo.....	June 18-24	454	—
Crystal City, Mo.....	June 25-30	429	—
Cliff Cave, Mo.....	July 2-8	412	—
Mouth of Missouri River, Mo.....	July 10-15	383	—
Grafton, Ill.....	March 22-30	358	26
Grafton, Ill.....	July 17-25	358	26
Grafton, Ill.....	Sept. 22-27	358	26
Grafton, Ill. (Experimental)	Oct. 25-29	358	26
Winfield, Mo.....	July 27-Aug. 2	337	26, 25
Hamburg, Ill.....	Aug. 3-9	320	25
Louisiana, Mo.....	Aug. 12-17	295	24
Cincinnati Landing, Ill.....	Aug. 19-23	281	24
Hannibal, Mo.....	Aug. 25-30	267	22
Quincy, Ill.....	Sept. 2-6	256	22
Quincy, Ill. (Experimental)...	Oct. 31-Nov. 13	256	22
Canton, Mo.....	Sept. 8-13	236	21
Warsaw, Ill.....	Sept. 14-19	218	20
1946			
Burlington, Iowa	April 10-22	178	19
Oquawka, Ill....	April 24-May 5	159	18
New Boston, Ill..	May 7-18	143	18
Muscataine, Iowa	May 19-30	134	17
Fairport, Iowa...	June 2-13	118	16
Andalusia, Ill....	April 1-7	103	16
Andalusia, Ill....	June 18-26	103	16
Andalusia, Ill....	Sept. 15-24	103	16
Pleasant Valley, Iowa.....	June 28-July 9	87	15
Cordova, Ill.....	July 11-22	75	14
Fulton, Ill.....	July 24-Aug. 4	57	14
Sabula, Iowa.....	Aug. 6-17	44	13
Bellevue, Iowa...	Aug. 19-30	17	12
Dubuque, Iowa...	Sept. 1-12	0	12

Table 2.—Accepted common, scientific, and local names of fishes occurring in Mississippi River test-net or other fisheries survey collections made between Caruthersville, Missouri, and Dubuque, Iowa, 1944 and 1946.*

ACCEPTED COMMON NAME	SCIENTIFIC NAME	LOCAL NAME
Shovelnose sturgeon.....	<i>Scaphirhynchus platyrhynchus</i> (Rafinesque) ..	Hackleback, switchtail, sand sturgeon
Paddlefish.....	<i>Polyodon spathula</i> (Walbaum).....	Spoonbill cat, spoony
Longnose gar.....	<i>Lepisosteus osseus</i> (Linnaeus).....	Garpiki, billfish, billy gar
Shortnose gar.....	<i>Lepisosteus platostomus</i> Rafinesque.....	Duckbill gar
Alligator gar.....	<i>Lepisosteus spatula</i> Lacépède.....	Mississippi alligator gar
Bowfin.....	<i>Amia calva</i> Linnaeus.....	Dogfish, grindle, cypress trout, mudfish
Mooneye.....	<i>Hiodon tergisus</i> Le Sueur.....	Toothed herring, white shad
Goldeye.....	<i>Amphiodon alosoides</i> Rafinesque.....	Mooneye
Skipjack.....	<i>Pomolobus chrysochloris</i> Rafinesque.....	Golden shad, river herring, blue herring
Gizzard shad.....	<i>Dorosoma cepedianum</i> (Le Sueur).....	Hickory shad
American eel.....	<i>Anguilla bostoniensis</i> (Le Sueur).....	Freshwater eel
Blue sucker.....	<i>Cycleptus elongatus</i> (Le Sueur).....	Missouri sucker, bluefish, blackhorse, gourdseed sucker
Bigmouth buffalo.....	<i>Megastomatobus cyprinella</i> (Valenciennes) ..	Redmouth buffalo, stubnose buffalo, roundhead buffalo, brown buffalo, goarhead, bullhead buffalo, bullmouth buffalo, bullnose buffalo, slough buffalo, trumpet buffalo
Black buffalo.....	<i>Ictiobus niger</i> (Rafinesque).....	Mongrel buffalo, hugler, rooter, reefer, round buffalo, sheepshead buffalo, blue buffalo
Smallmouth buffalo.....	<i>Ictiobus bubalus</i> (Rafinesque).....	Razorback buffalo, roach-back buffalo, humpback buffalo, channel buffalo, liner buffalo, quillback buffalo
Quillback carpsucker.....	<i>Carpiodes cyprinus</i> (Le Sueur).....	Silver carp, carpsucker, cold-water carp, quillback
River carpsucker.....	<i>Carpiodes carpio</i> (Rafinesque).....	Silver carp, carpsucker
Highfin carpsucker.....	<i>Carpiodes velifer</i> (Rafinesque).....	Silver carp, river carp, carpsucker, highfin sucker
White sucker.....	<i>Catostomus commersonnii</i> (Lacépède).....	Common sucker, fine-scaled sucker
Spotted sucker.....	<i>Minytrema melanops</i> (Rafinesque).....	Striped sucker
Silver redhorse.....	<i>Moxostoma anisurum</i> (Rafinesque).....	Silver mullet
Northern redhorse.....	<i>Moxostoma aureolum</i> (Le Sueur).....	Des Moines plunger, mullet, common redhorse
Carp.....	<i>Cyprinus carpio</i> Linnaeus.....	German carp, European carp
Golden shiner.....	<i>Notemigonus crysoleucas</i> (Mitchill).....	American bream, roach
Channel catfish.....	<i>Ictalurus lacustris</i> (Walbaum).....	Fiddler, catfish, channel cat, spotted cat
Blue catfish.....	<i>Ictalurus furcatus</i> (Le Sueur).....	Fulton cat, Mississippi cat, chucklehead cat, coal boater
Yellow bullhead.....	<i>Ameiurus natalis</i> (Le Sueur).....	Yellow-bellied cat, greaser
Brown bullhead.....	<i>Ameiurus nebulosus</i> (Le Sueur).....	Speckled bullhead
Black bullhead.....	<i>Ameiurus melas</i> (Rafinesque).....	Bullhead
Flathead catfish.....	<i>Pilodictis olivaris</i> (Rafinesque).....	Hoosier, goujon, shovelnose cat, mudcat, yellow cat, Johnny cat, Morgan cat, flat belly
Northern pike.....	<i>Esox lucius</i> Linnaeus.....	Pickrel, great northern pike, northern pike
Grass pickerel.....	<i>Esox vermiculatus</i> Le Sueur.....	Little pickerel, grass pike, mud pickerel

Table 2.—Concluded

ACCEPTED COMMON NAME	SCIENTIFIC NAME	LOCAL NAME
Yellow walleye.....	<i>Stizostedion vitreum vitreum</i> (Mitchill).....	Walleye, yellow pikeperch, jack, jack salmon
Sauger.....	<i>Stizostedion canadense</i> (Smith).....	Sandpike, jack salmon
Smallmouth bass.....	<i>Micropterus dolomieu</i> Lacépède.....	Smallmouth, smallmouth black bass
Spotted bass.....	<i>Micropterus punctulatus</i> (Rafinesque).....	Kentucky bass, spotted black bass
Largemouth bass.....	<i>Micropterus salmoides</i> (Lacépède).....	Black bass, bigmouth bass, line side, green bass, green trout, largemouth black bass
Green sunfish.....	<i>Lepomis cyanellus</i> Rafinesque.....	Black perch
Orangespotted sunfish....	<i>Lepomis humilis</i> (Girard).....	
Bluegill.....	<i>Lepomis macrochirus</i> Rafinesque.....	Bream, sunfish
Warmouth.....	<i>Chaenobryttus coronarius</i> (Bartram).....	Goggle-eye, warmouth bass
Flier.....	<i>Centrarchus macropterus</i> (Lacépède).....	Round sunfish, longfinned sunfish, round bass
White crappie.....	<i>Pomoxis annularis</i> Rafinesque.....	Crappie, newlight
Black crappie.....	<i>Pomoxis nigro-maculatus</i> (Le Sueur).....	Calico bass, strawberry bass
White bass.....	<i>Lepibema chrysops</i> (Rafinesque).....	Silver bass, striped bass, streaker
Yellow bass.....	<i>Morone interrupta</i> Gill.....	Streaker, barfish
Freshwater drum.....	<i>Aplodinotus grunniens</i> Rafinesque.....	White perch, perch, sheepshead, gaspergou, grunting perch, croaker

* Because of the pressure of field work, most of the fish handled in the test-net collections could be classified only to species. Some, however, could be classified further, and the following subspecies are believed to have been represented in the sampling: *Lepisosteus osseus oxyurus* Rafinesque, northern longnose gar; *Carpiodes carpio carpio* (Rafinesque), northern carpsucker; *Catostomus commersonnii commersonnii* (Lacépède), white sucker; *Notemigonus crysoleucas auratus* (Rafinesque), western golden shiner; *Ictalurus furcatus furcatus* (Valenciennes), blue catfish; *Ameiurus natalis natalis* (Le Sueur), northern yellow bullhead; *Ameiurus nebulosus marmoratus* (Holbrook), brown bullhead; *Ameiurus melas melas* (Rafinesque), northern black bullhead; *Stizostedion canadense canadense* (Smith), eastern sauger; *Micropterus dolomieu dolomieu* Lacépède, northern smallmouth bass; *Micropterus punctulatus punctulatus* (Rafinesque), northern spotted bass; *Lepomis macrochirus macrochirus* Rafinesque, common bluegill. The spotted gar, *Lepisosteus productus* Cope, if present, was not separated from the shortnose gar. Accepted common and scientific names in the table are from Special Bulletin No. 1 of the American Fisheries Society (1948) or from amendments accepted by the Society (Bailey 1952, 1953); most subspecific names in the footnote are from Hubbs & Lagler (1947).

fishermen reported having caught in that year 2,788,073 pounds of fish valued in the rough at \$297,045.23 (Starrett & Parr 1951:7, 10). During 1950, according to the Upper Mississippi River Conservation Committee (1952:35, 37) report, 590 licensed commercial fishermen of Missouri caught 330,488 pounds of fish from the Mississippi River. This same report lists the total Iowa catch from the Mississippi at 839.211 pounds. The Iowa catch was made by 2,200 licensed commercial fishermen. The Iowa report includes data on fishing activities above and below Dubuque.

The most important commercial fishes included in the figures above were carp, black buffalo, smallmouth buffalo, bigmouth buffalo, channel catfish, flathead catfish, blue catfish, freshwater drum, paddlefish, and shovelnose sturgeon.

Hoop nets, seines, basket traps, tram-

mel nets, and trot lines were the principal types of commercial fishing devices employed by these fishermen.

Terminology for Commercial Fishing Devices

The vernacular names of commercial fishing devices used on the Mississippi River are often quite confusing. In an attempt to correct this situation, members of the Upper Mississippi River Conservation Committee (1946:9) defined and classified the commercial fishing devices used on the upper part of the river.

The committee separated the various fishing devices into broad classifications based on the methods by which the devices capture fish. The four principal methods of capture are angling, encompassment, entrapment, and entanglement. Each method is treated separately in the

succeeding sections. The terminology recommended by the committee for commercial fishing devices is used in this paper.

Angling Devices

Angling refers to the capture of fish with either single or multiple hooks attached to a line.

Jugs or Floats (Single Hook).—Some fishermen on the Mississippi River use jugs or floats with a hook and bait attached to each, fig. 2. The jugs or floats are floated downstream and are often very effective in taking large catfishes, blue and flathead. These fishing devices provide sport as well as meat, especially when a 25- or 30-pound catfish takes the bait.

Trot Lines (Multiple Hooks).—Trot lines and throw lines are multiple-hook fishing devices common on the Mississippi. Throw lines are favorites among

sport fishermen, but they are seldom used by commercial fishermen. Trot lines are of some importance as commercial tackle, fig. 3. They are fished mainly for catfishes in the Caruthersville-Dubuque section and to a lesser extent for carp, bullheads, and freshwater drums.

In 1947, 2.8 per cent of the reported Illinois commercial catch from the Mississippi was taken with trot lines, also known as set lines (Upper Mississippi River Conservation Committee 1948, third section:19). In this same year, 10.4 per cent of the reported Missouri commercial catch from the Mississippi was taken on trot lines (set lines). At the time of the survey, regulations relative to the number of hooks that a fisherman might use varied among the states.

A trot line consists of a heavy cord to which are tied, at intervals of 2 to 3 feet, short drop lines, to each of which is tied a single hook. The ends of the cord



Fig. 2.—Rigging up floats on the Mississippi River for blue catfish. Float fishing, or jug fishing, is more popular on the Mississippi below the mouth of the Missouri River than above.

are secured to stumps or other supports. Each drop line may be a foot or more in length; the length depends upon the depth at which fishing is to be done. Live minnows or small fish (young carp are preferred by many fishermen), cut fish of various kinds, crayfish, spoiled clam meat, and grasshoppers are the common baits used on trot lines for catfish. Dough-balls or corn are the usual baits for carp.

The length of trot lines and number of hooks used seem to vary with the accessibility of bait, number of men to run the lines, and fishing conditions. Evermann (1899:292) reported that he had learned of a trot line 12 miles long in Louisiana. In the Caruthersville-Dubuque section of the Mississippi, the lines seldom exceed 3,000 yards.

During the survey, only a few trot line sets were made. The search for live bait would have consumed more time than could be allotted to one phase of the test-fishing research program. An investigation devoted solely to studying trot line catches in the Caruthersville-Dubuque area would be of value in managing the fishery.

Encompassment Devices

Seines are the only type of encompassment tackle of importance to commercial fishermen in the Caruthersville-Dubuque section of the Mississippi River, fig. 4. Dip nets, another type, are used by hundreds of sport fishermen along this river, but are of little importance as commercial tackle.

Most of the commercial seining in the Caruthersville-Dubuque section of the river is done with short seines. The seines commonly used there are 200 yards in length. In some parts of the river, longer seines are used. A short seine can be operated by two or three men, whereas a longer seine requires more men for efficient operation. The owner of a large seine should be in a position to handle large catches and sell them in distant markets. The operator of a small seine usually can sell his catch locally.

Prior to making a seine haul, a commercial fisherman usually cruises near his selected "seine hauls" or water areas he knows that have bottoms clean enough for seining. If he believes fish are using the

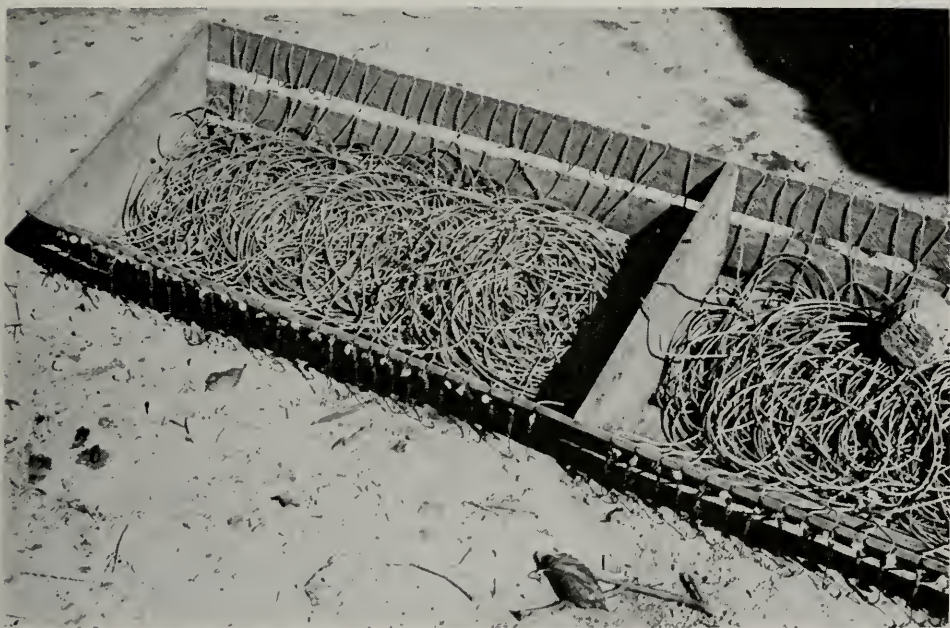


Fig. 3.—Trot lines used by commercial fishermen. On the Mississippi River, trot lines are used chiefly for catfishes. Usually the hooks and lines are secured in a homemade box as shown above.

area, he makes preparations to lay out the seine. A seine haul of 200 or 300 yards can usually be completed within a couple of hours. Handling a big catch in a large seine may require several days.

The survey crew made 25 seine hauls in the Mississippi River between Winfield, Missouri, and Cordova, Illinois. These hauls were made with 100-, 150-, and 200-yard seines of 1-inch square mesh. Time and personnel limited the seining operations to one mesh size.

A summary of the survey seine hauls is given in table 3. Commercial and predatory fishes represented 89.3 per cent of the total weight of all fishes taken with the seine. Sport fishes occurred regularly in the hauls; they represented 11.7 per cent of the total numbers and 3.3 per cent of the total weight of fish in the seine hauls.

Crappies made up 82.1 per cent of the number of sport fishes. Only insignificant numbers of other sport species were taken in the seines.

A seine is an efficient fishing device when operated by experienced commercial fishermen. Commercial seines are of larger mesh sizes than the seines employed in the survey. Fishermen generally try to use seines selectively by making hauls in waters they believe are being used by species they desire. The commercial hauls usually are made for carp, buffalofishes, freshwater drums, and paddlefish. However, fishermen using commercial seines frequently catch only a few carp and buffalofishes in a haul and many gizzard shads and gars.

The seine is an important commercial fishing device on the Mississippi River

Table 3.—Composition of catches made with 1-inch-mesh 100-yard, 150-yard, and 200-yard seines in fisheries survey of the Mississippi River between Winfield, Missouri, and Cordova, Illinois, 1944 and 1946.

KIND OF FISH	NUMBER OF FISH TAKEN	PER CENT OF TOTAL NUMBER TAKEN	WEIGHT, POUNDS	PER CENT OF TOTAL WEIGHT
COMMERCIAL				
Carp.....	96	6.5	221.54	16.8
Bigmouth buffalo.....	16	1.1	26.63	2.0
Smallmouth buffalo.....	50	3.4	25.16	1.9
Black buffalo.....	1	0.1	5.93	0.4
Paddlefish.....	51	3.4	139.80	10.6
Channel catfish.....	121	8.2	48.56	3.7
Blue catfish.....	27	1.8	17.04	1.3
Flathead catfish.....	1	0.1	0.19	—
Carp suckers.....	148	10.0	96.05	7.3
Suckers.....	1	0.1	1.68	0.1
Freshwater drum.....	88	6.0	29.78	2.2
Subtotal.....	600	40.7	612.36	46.3
SPORT				
White crappie.....	114	7.8	24.96	1.9
Black crappie.....	28	1.9	5.16	0.4
Bluegill.....	2	0.1	0.24	—
Yellow walleye.....	2	0.1	1.99	0.1
Sauger.....	6	0.4	5.16	0.4
White bass.....	16	1.1	5.02	0.4
Yellow bass.....	5	0.3	0.83	0.1
Subtotal.....	173	11.7	43.36	3.3
PREDATORY				
Shortnose gar.....	391	26.6	416.06	31.5
Longnose gar.....	71	4.8	134.73	10.2
Bowfin.....	6	0.4	17.93	1.3
Subtotal.....	468	31.8	568.72	43.0
FORAGE				
Gizzard shad.....	181	12.3	85.06	6.4
Mooneye, goldeye.....	51	3.5	12.58	1.0
Subtotal.....	232	15.8	97.64	7.4
Total.....	1,473	100.0	1,322.08	100.0



Fig. 4.—Commercial fishermen shipping a seine after completing a haul.

throughout the year. In the D-MR section, large hauls of carp and buffalofishes often are taken from under the ice during the winter months. The seine enables some fishermen in both the D-MR and the MR-C sections of the river to take paddlefish, carp, buffalofishes, and freshwater drums during periods when few fish are being caught in other devices.

Entrapment Devices

Entrapment devices used in some or all parts of the Caruthersville-Dubuque area of the Mississippi River at the time of the survey included basket traps, hoop nets, wing nets, and trap nets.

Basket traps are constructed of wooden slats and have flexible, wooden throats, fig. 5. Fishermen usually bait these traps with old cheese scrapings and often in the spring they put a live gravid female catfish in each trap to serve as a decoy for unsuspecting males. Basket traps are set

in current and are fished in water ranging from 4 to 15 feet in depth. A weight is secured to the tail line of each basket trap to anchor it in place. Some fishermen fish two basket traps or a basket trap and a hoop net by joining the tail lines.

The basket trap is an important fishing device for commercial fishermen of Illinois and Iowa who fish the Mississippi. The state of Missouri does not permit the use of this device. In 1950, Illinois commercial fishermen of the Mississippi River took 52.3 per cent of their reported catfish catch in basket traps (Starrett & Parr 1951:5).

The local terminology often applied to hoop nets, wing nets, and trap nets can be quite confusing. In one area, a hoop net, fig. 6, may be called a buffalo net, in another a fyke net, and in still another a fiddler net. Hoop nets are defined by the Upper Mississippi River Conservation Committee (1946:13) as a "group of devices" "constructed of vegetable fiber net-

ting without fore bay, leads, or wings." The group "includes hoop net, bait net, buffalo net, fiddler net, and *fyke net*." The main differences in the local terminology among these nets result from dif-

ferences in mesh size and hoop diameter. The fine-mesh nets with small hoops are used for catfish, and the nets with large hoops and large meshes are fished for buffalo-fishes and carp.



Fig. 5.—A Mississippi River commercial fisherman removing a catfish from a basket trap. In the upper tub is cheese bait.

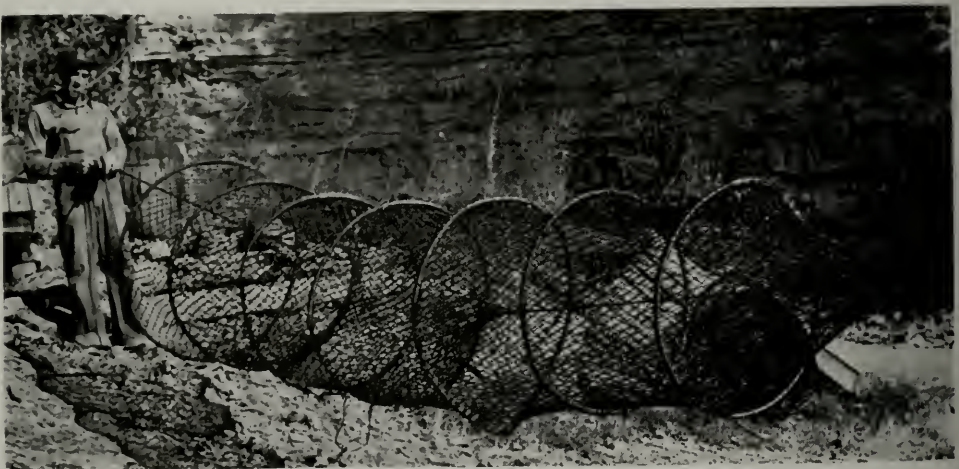


Fig. 6.—A hoop net stretched to show the construction of the net. The hoop net does not have wings.

Hoop nets are fished in the currents of rivers and in depths that cover the nets entirely. Often these nets are baited with cheese scrapings and other wastes purchased from cheese manufacturers, fig. 7. Frequently they are fished in 15 or more feet of water. Each of these nets is anchored by a wire cable or rope attached to

a weight, a stake, or a basket trap. The fisherman setting the net takes a mental fix of his location by noting several landmarks. The following day he checks his bearings and locates the approximate place his net was set the previous day. He drags the bottom with a grappling hook until he strikes the net cable, fig. 8. He then re-



Fig. 7.—A commercial fisherman baiting a hoop net with cheese. This fisherman demonstrates a common method of fishing for catfish on the Mississippi River.



Fig. 8.—Searching the bottom of the Mississippi River with a grappling hook for a hoop net and basket trap set. Experienced fishermen quickly locate and retrieve their deep-water sets with a grappling hook.



Fig. 9.—Commercial wing net sets. Wing nets are particularly effective for carp and buffalo-fishes.

trieves the net and removes the fish from the net.

Hoop nets of 1-, $2\frac{1}{2}$ -, and 3-inch mesh were used in the survey. The 3-inch-mesh nets were fished only at the Du-buque station.

The wing net, fig. 9, is identical in construction to the hoop net insofar as the net proper is concerned. Attached to the first hoop of the wing net are two pieces of netting called wings, which give the net its name. The wings are set at about 45 degree angles to the main axis of the net

and are secured in position with poles. The wing net is fished either with or without a lead, a piece of netting extending outward from the first hoop and continuing the main axis of the net. It is fished in sloughs, backwaters, and sluggish sections of rivers; also in shallower water than the hoop net. It is held in position by poles. On the Illinois River, the wing net is the net most commonly used by fishermen, whereas on the Mississippi the hoop net is the one most generally fished. The wing net is not popular among com-

mercial fishermen who operate on the Mississippi River.

Wing nets with and without leads were used in the 1944 survey. In 1946, all wing nets were fished without leads. The meshes used in this study were 1 inch, 1½ inches, and 2½ inches. The 1½-inch-mesh wing nets were used only in 1944. The catch data for the 2½-inch-mesh wing nets fished with leads have been combined with the catch data for these nets fished without leads.

About 70 per cent of the commercial fish catch reported from the Illinois section and 59 per cent of that reported from the Missouri section of the Mississippi River for 1947 were taken in hoop nets (Upper Mississippi River Conservation Committee 1948, third section:19). The reports do not differentiate between hoop nets and wing nets; however, the wing net catch comprised only a small fraction of the total annual yield.

The trap net is quite similar to the wing net in construction and operation, fig. 10. It differs from the wing net in that it has a double rectangular wooden frame in front of the first hoop. It is staked out in the same fashion as the wing net. It may be fished either with or without a lead. During the survey, trap nets were fished at only three stations. The mesh used was 1¼ inches. The nets were fished in localities identical to those fished with wing nets.

Analyzing Entrapment Catch Data.—In the Mississippi River survey, entrapment devices were tested more than any of the other devices.

The unit of measurement usually employed in analyzing net catch data is the net-day, and the efficiency of a fishing device is measured by the number of fish and/or the number of pounds of fish it catches per net-day. One net fished for 24 hours is termed one net-day. In this investigation, the number of net-days fished (or trap-days in the case of basket traps) was recorded for each entrapment device.

In some instances, when the catch per net-day of a certain species of fish in one type of net is compared with the catch of this same species in another type of net, the difference is obviously significant. In other instances, it may not be clear as to

whether the catch difference is significant, unless the data are tested statistically. In this study, tests for significance of differences in the efficiency of various entrapment devices were made by using the chi-square method of analysis (Snedecor 1946:16). The chi-square was computed from the following formula:

$$\chi^2 = \frac{(X_1 - m_1)^2}{m_1} + \frac{(X_2 - m_2)^2}{m_2}$$

X_1 and X_2 are the actual catches in numbers of commercial-sized fish and m_1 and m_2 are the expected catches. The expected catch for each net of the two nets being compared is that part of the actual total catch of the two nets which is directly proportional to the total number of net-days fished by the net. In table 4 are given catch data on commercial-sized carp, as presented in table 12, and below the table an equation that tests whether there is a significant difference in catch of commercial-sized carp (15 inches or more total length) between 1-inch-mesh wing nets (without leads) and 1½-inch-mesh wing nets (most without leads*) at the 0.05 level with 1 degree of freedom.

The value 21.09 indicates statistically that at the 0.05 level the catch of commercial-sized carp is significantly greater in the 1½-inch-mesh wing net than in the 1-inch-mesh wing net. A chi-square value of 3.841 or more is considered significant at the 0.05 level with 1 degree of freedom. The fish samples were taken at the same stations and the nets were fished simultaneously, thereby eliminating station and seasonal differences with respect to species. However, at each station various habitats were netted, and as a result probably different segments of the population at each station were sampled. This pattern of netting in no way affects the analysis, since the information sought was, in many cases, for the purpose of giving a comparison of efficiency and selectivity of two nets designed for different habitats. For example, the hoop net usually is fished in deeper water than is the wing net and is always fished in the current; the wing net usually is fished in quiet water. Habitat differences of flowing and quiet water are discernible in the catch data, table 5. In the backwater areas and sloughs of the

* Of 156.10 net-days. 8.84 net-days were with leads.

Table 4.—Data (from table 12) on catches of wing nets of two different mesh sizes used in fisheries survey of the Caruthersville-Dubuque section of the Mississippi River, 1944, the data selected and presented to allow comparison of the efficiency of the two mesh sizes in taking carp of commercial sizes.

NET	NUMBER OF NET-DAYS	PER CENT OF TOTAL NUMBER OF NET-DAYS	NUMBER OF COMMERCIAL- SIZED CARP CAUGHT	NUMBER OF COMMERCIAL- SIZED CARP IN EXPECTED CATCH
1-inch-mesh.....	508.12	76	413	461.32
1½-inch-mesh.....	156.10	24	194	145.68
<i>Total</i>	<i>664.22</i>	<i>100</i>	<i>607</i>	<i>607.00</i>

The following equation is based on the chi-square (χ^2) formula on page 337.

$$\chi^2 = \frac{(413 - 461.32)^2}{461.32} + \frac{(194 - 145.68)^2}{145.68} = 5.06 + 16.03 = 21.09$$



Fig. 10.—Trap net. This net is used by some fishermen who operate on the Mississippi River. Photo courtesy of Dr. John Moyle, Division of Game and Fish, Minnesota Department of Conservation, St. Paul.

upper Mississippi, there is usually a more abundant population of sport fishes than in the river channel.

In figs. 11 and 12, the total catches for all species of fish taken with entrapment devices are presented graphically. Species composition differences between the two sections of the river sampled in 1944 and 1946 account for most of the catch differences reflected in the graphs for the 2 years of test-netting. Differences between 1944 and 1946 in the number of sport fish taken per net-day are apparent in the graphs. The data in table 5 are not suited for detailed analysis, since fishing with the different types of gear was not in all cases done simultaneously.

In order to have some standard for comparing the efficiency and selectivity of the various entrapment devices, it was desirable to select a device that was fished at all the stations. The only entrapment device that met this requirement was the

1-inch-mesh wing net without a lead. In the following catch analyses, the data for the 1-inch-mesh wing net without a lead are used from only those stations at which one or more of the other devices were fished.

The analyses concern largely the catches of the nine most important commercial and sport fishes occurring in the Caruthersville-Dubuque section of the river: carp, bigmouth buffalo, smallmouth buffalo, freshwater drum, channel catfish, flathead catfish, black crappie, white crappie, and bluegill.

In tests for significant differences in numbers of a species caught by various entrapment devices, only fish of commercial or desirable sizes were included. The following minimum total lengths were used: 15 inches for carp, buffalofishes, and channel catfish; 10 inches for freshwater drum; 18 inches for flathead catfish; 8 inches for crappies; 7 inches for bluegill.

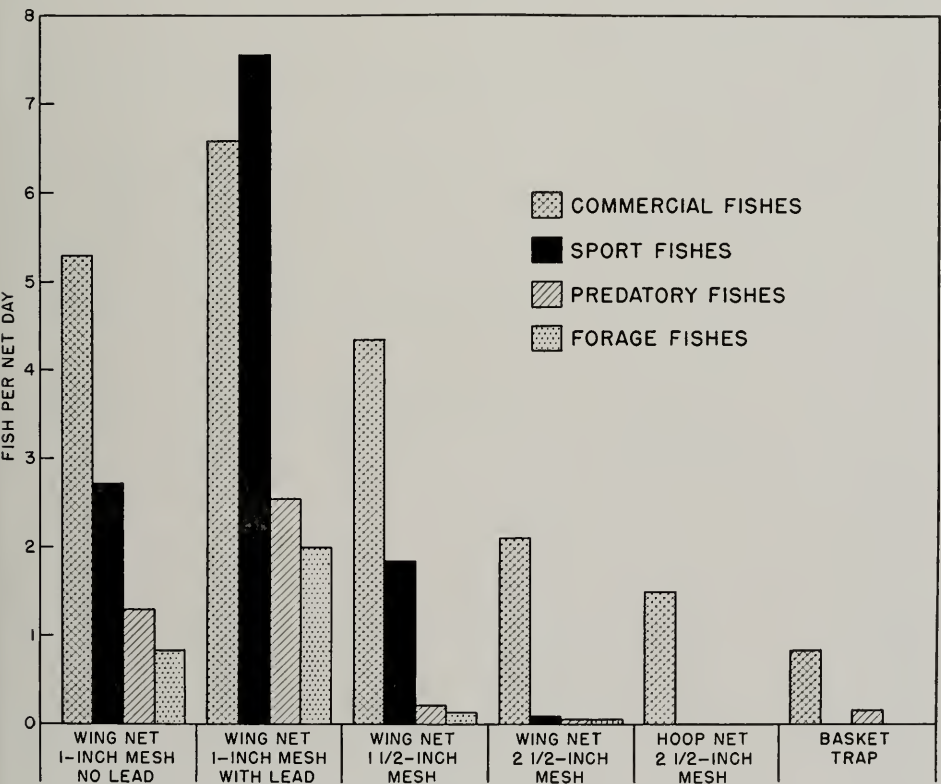


Fig. 11.—The number of fish, all sizes, taken per net-day in entrapment devices fished in the Mississippi River between Caruthersville and Warsaw in 1944.

Table 5.—Number of fish taken per net-day in the various entrapment devices used in fisheries survey of the Caruthersville-Dubuque section of the Mississippi River, 1944 and 1946. Nets fished with leads are so designated, except in the case of some 2½-inch-mesh wing nets; catch data for 2½-inch-mesh wing nets fished with leads in 1944 have been combined with data for such nets fished without leads.

KIND OF FISH	CARUTHERSVILLE-WARSAW SECTION, 1944					BURLINGTON-DUBUQUE SECTION, 1946					
	1-Inch-Mesh Wing Nets (632.37) Net-Days	1-Inch-Mesh Wing Nets (175.40) Net-Days	1½-Inch-Mesh Wing Nets (156.10) Net-Days	2½-Inch-Mesh Wing Nets (377.63) Net-Days	2½-Inch-Mesh Hoop Nets (186.81) Net-Days	1-Inch-Mesh Wing Nets (855.86) Net-Days	1-Inch-Mesh Hoop Nets (105.97) Net-Days	2½-Inch-Mesh Wing Nets (421.75) Net-Days	2½-Inch-Mesh Hoop Nets (730.42) Net-Days	3-Inch-Mesh Hoop Nets (35.00) Net-Days	1½-Inch-Mesh Trap Nets (50.53) Net-Days
COMMERCIAL											
Shovelnose sturgeon.....	—	—	—	—	—	—	—	—	tr.*	—	—
Paddlefish.....	tr.*	0.08	—	—	—	—	—	—	—	—	—
American eel.....	0.05	0.03	—	—	—	0.02	—	—	—	—	0.04
Blue sucker.....	—	—	—	—	—	—	—	—	tr.*	—	—
Suckers, redhorses.....	0.01	0.05	—	tr.*	0.01	0.09	—	0.01	0.02	0.03	0.30
Bigmouth buffalo.....	0.03	0.20	0.03	0.07	0.04	0.04	—	0.11	0.07	0.14	—
Black buffalo.....	0.02	0.06	0.02	0.17	0.02	0.01	—	0.02	0.01	0.03	—
Smallmouth buffalo.....	0.27	0.64	0.19	0.14	0.34	0.32	0.06	0.12	0.12	0.37	0.06
Carp suckers.....	0.85	0.75	0.59	0.21	0.12	0.97	0.11	0.41	0.34	0.09	0.28
Carp.....	1.50	2.16	2.28	1.14	0.44	0.35	0.08	0.41	0.21	0.42	0.93
Channel catfish.....	0.48	0.31	0.06	0.02	0.01	1.09	0.59	0.01	tr.*	—	0.20
Blue catfish.....	0.22	0.31	0.01	0.01	0.01	—	—	—	—	—	—
Yellow bullhead.....	0.03	0.04	—	—	—	0.01	—	—	—	—	—
Brown bullhead.....	tr.*	0.01	—	—	—	—	—	—	—	—	—
Black bullhead.....	0.21	0.50	0.07	—	—	0.07	0.06	—	—	—	—
Flathead catfish.....	0.61	0.50	0.51	0.07	0.12	0.21	0.42	0.01	0.08	0.03	0.04
Freshwater drum.....	0.99	0.95	0.58	0.27	0.35	0.74	0.61	0.11	0.21	0.11	1.13
Subtotal.....	5.27	6.59	4.34	2.10	1.48	3.92	1.93	1.21	1.06	1.22	2.98
SPORT											
Pike.....	—	—	—	—	—	0.04	—	—	—	—	—
Grass pickerel.....	—	0.01	—	—	—	0.01	—	tr.*	tr.*	0.03	0.02
Yellow walleye.....	—	—	0.01	—	—	0.07	0.01	—	—	—	0.14
Sauger.....	0.07	0.06	0.03	—	—	tr.*	0.01	—	—	—	—
Spotted bass.....	—	—	—	—	—	tr.*	—	tr.*	—	—	—
Largemouth bass.....	0.11	0.27	0.09	0.01	tr.*	tr.*	—	—	—	—	—
Green sunfish.....	0.01	0.01	—	—	—	tr.*	—	—	—	—	—

Bluegill.....	0.23	2.29	0.19	—	—	0.33	0.02	—	—	—	—	0.18
Warmouth.....	0.02	0.24	0.01	—	—	0.01	—	—	—	—	—	—
Pier.....	—	0.01	—	—	—	—	—	—	—	—	—	—
White crappie.....	0.93	1.04	0.53	0.02	—	2.94	0.13	0.01	tr.*	—	—	0.63
Black crappie.....	1.11	3.45	0.81	0.02	—	1.57	0.09	0.01	tr.*	—	0.03	0.26
White bass.....	0.22	0.17	0.18	0.01	—	0.16	—	—	—	—	—	0.26
Yellow bass.....	tr.*	0.01	0.01	—	—	0.28	—	—	—	—	—	0.28
Subtotal.....	2.70	7.56	1.86	0.06	—	5.43	0.25	0.02	tr.*	—	0.06	1.77
PREDATORY												
Longnose gar.....	0.19	0.11	0.03	—	tr.*	0.03	0.01	tr.*	tr.*	—	—	0.04
Shortnose gar.....	0.99	1.88	0.08	0.01	—	0.15	0.10	tr.*	—	—	—	0.08
Alligator gar.....	0.01	0.43	0.01	—	—	—	—	—	—	—	—	—
Bowfin.....	0.10	0.14	0.08	0.02	—	0.13	—	tr.*	tr.*	—	—	0.02
Subtotal.....	1.29	2.56	0.20	0.03	tr.*	0.31	0.11	tr.*	tr.*	—	—	0.14
FORAGE												
Mooneye, goldeye.....	0.04	0.26	0.03	tr.*	—	0.26	0.08	—	tr.*	—	—	—
Skipjack.....	tr.*	0.03	—	—	—	—	—	—	—	—	—	—
Gizzard shad.....	0.78	1.70	0.10	0.03	tr.*	0.23	—	—	tr.*	—	—	—
Golden shiner.....	tr.*	0.01	—	—	—	—	—	—	tr.*	—	—	—
Subtotal.....	0.82	2.00	0.13	0.03	tr.*	0.49	0.08	—	tr.*	—	—	—
Total.....	10.08	18.71	6.53	2.22	1.48	10.15	2.37	1.23	1.06	—	1.28	4.89

* tr. (trace) indicates that the species was taken but that the take averaged less than 0.01 fish per net-day.

In comparing the efficiency and selectivity of the various entrapment devices, it was necessary to consider the average size of the fish taken, as well as the number of commercial-sized or desirable-sized fish caught. A small-mesh net might take as many fish of commercial species as a large-mesh net; however, the catch of the

small-mesh net might be largely of fish under commercial size. The large-mesh net taking only a few fish under commercial size would be a more efficient net to the fisherman since it would require less time for the handling and releasing of small fish.

The mean of the total lengths of indi-

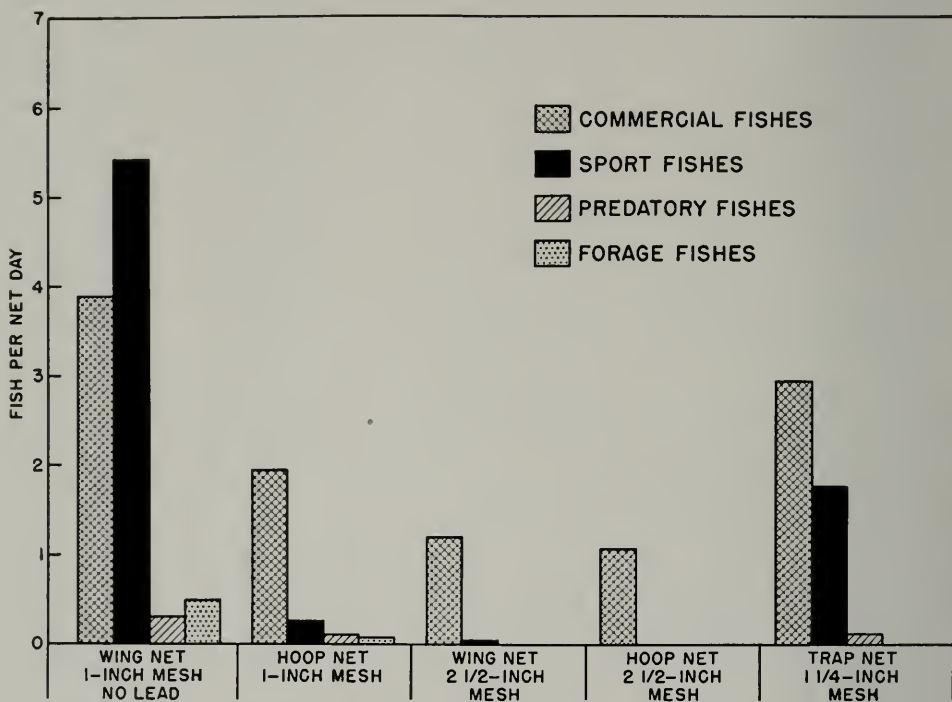


Fig. 12.—The number of fish, all sizes, taken per net-day in entrapment devices fished in the Mississippi River between Burlington and Dubuque in 1946.

Table 6.—Data (from table 13) on catches of wing nets of two different mesh sizes used in fisheries survey of the Caruthersville-Dubuque section of the Mississippi River, 1944, the data selected and presented to allow comparison of the sizes of carp taken by the two mesh sizes.

NET	MEAN TOTAL LENGTH (\bar{x}), INCHES	NUMBER OF CARP (n)	STANDARD DEVIATION (s)
1-inch-mesh.....	14.47	886	3.34
1½-inch-mesh.....	14.96	356	2.37

The following equations are based on the t-test for significance and the degrees of freedom (d.f.) formulas on page 344.

$$t = \frac{14.96 - 14.47}{\sqrt{\frac{(2.37)^2}{356} + \frac{(3.34)^2}{886}}} = \frac{0.49}{\sqrt{0.2839}} = 2.908$$

$$\text{d.f.} = \sqrt{356 \cdot 886} - 1 = 561.6 \text{ or } 562 - 1 = 561$$

Table 7.—Composition of catches made in 74 basket trap sets in fisheries survey of the Mississippi River between Cape Girardeau and Louisiana, Missouri, 1944.

KIND OF FISH	NUMBER OF FISH TAKEN	PER CENT OF TOTAL NUMBER TAKEN	WEIGHT IN POUNDS	PER CENT OF TOTAL WEIGHT
COMMERCIAL				
Carp.....	2	2.7	2.52	4.0
Blue catfish.....	18	24.7	8.70	13.9
Channel catfish.....	32	43.8	32.24	51.7
Flathead catfish.....	9	12.3	12.98	20.8
Freshwater drum.....	1	1.4	0.75	1.2
PREDATORY				
Shortnose gar.....	11	15.1	5.25	8.4
<i>Total</i>	73	100.0	62.44	100.0

Table 8.—Composition of catches of commercial-sized or desirable-sized fish taken in basket traps and in 1-inch-mesh wing nets without leads in fisheries survey of the Mississippi River between Cape Girardeau and Louisiana, Missouri, 1944.

KIND OF FISH	BASKET TRAPS (74.0 NET-DAYS)			1-INCH-MESH WING NETS WITHOUT LEADS (236.5 NET-DAYS)			CHI-SQUARE VALUE
	Pounds per Net-Day	Number	Number per Net-Day	Pounds per Net-Day	Number	Number per Net-Day	
Carp.....	—	0	—	—	229	0.97	—
Bigmouth buffalo.....	—	0	—	—	4	0.02	—
Smallmouth buffalo.....	—	0	—	—	12	0.05	—
Freshwater drum.....	0.01	1	0.01	0.53	171	0.72	51.71*
Channel catfish.....	0.34	16	0.22	0.26	31	0.13	2.60
Flathead catfish.....	0.09	2	0.03	1.93	99	0.42	26.85*
Bluegill.....	—	0	—	—	21	0.09	—
White crappie.....	—	0	—	—	187	0.79	—
Black crappie.....	—	0	—	—	249	1.05	—

* Denotes a significant difference, in numbers of commercial-sized or desirable-sized fish taken, between basket traps and 1-inch-mesh wing nets at 0.05 level with 1 degree of freedom.

viduals of each species taken in each type of net was computed from measurements of all the fish of that species taken in that type of net. The actual total length of each individual was converted to the nearest one-half inch. The mean of the total lengths and the standard deviation of length of the individuals of a species taken in a particular type of net indicates approximately the size of fish that can be expected in future catches of that net. The presence or absence of dominant year-classes of the various species would be expected to change the species composition and the mean of the total lengths of individuals in the catches from year to year. However, such changes would probably not materially affect the basic differences

in efficiency and selectivity of the devices discussed here.

Frequently the differences in the means of the total lengths of fish taken by two types of nets were not apparent. To determine whether the sizes of the individuals of a species taken in one type of net were significantly different from the sizes of the individuals of that species taken in another type of net, a statistical test was desirable. The t-test, derived from a Snedecor (1946:81) formula adapted to groups with different numbers of individuals, appeared to be a satisfactory test for significance of size differences of fish taken in two types of nets. The formula used in computing the t-test for significance is as follows:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{(s_1)^2}{n_1} + \frac{(s_2)^2}{n_2}}}$$

\bar{X}_1 and \bar{X}_2 are the mean total lengths of the fish; n_1 and n_2 represent the numbers of individuals, all sizes, of the species taken in the gear; and s_1 and s_2 represent the standard deviation. The degrees of freedom were determined by using the geometric mean:

$$d.f. = \sqrt{n_1 \cdot n_2} - 1$$

From actual net data, table 13, an example is given below table 6 to test if a significant difference exists between the size of carp taken in 1-inch-mesh wing nets and the size of those taken in the 1½-inch-mesh wing nets.

The t-test below table 6 shows that, at the 0.05 level and with 561 degrees of freedom, there is a significant difference in size between the carp taken in the 1½-inch-mesh wing nets and those taken in the 1-inch-mesh wing nets. The 1½-inch-mesh wing nets, on the basis of this test, catch carp which are significantly larger than those taken in the 1-inch-mesh wing nets.

Catches With Basket Traps.—Not a great deal of fishing was done with basket traps during the survey; however, 74 sets were made in the spring and early summer months of 1944. In these sets, the catch was dominated by catfish, table 7. Of a total of 73 fish taken with basket traps, 80.8 per cent were catfish. Channel catfish made up 54.2 per cent of the number and 59.8 per cent of the weight of the catfish catch.

The shortnose gar, the only other fish taken in numbers with basket traps, amounted to 15.1 per cent of the number of fish taken with these traps. No sport fish was taken in the basket traps set by the survey party. However, the writers have observed a few crappies taken in baited basket traps set in one of the bottomland lakes of the Illinois River.

A comparison of the catches of 1-inch-mesh wing nets with catches of basket traps may be made by referring to tables 8 and 9. Fishing was done at the same stations. The channel catfish was the only species of fish taken in greater numbers per net-day in basket traps than in 1-inch-mesh wing nets; the difference was not significant. The catch of flathead catfish was much greater in 1-inch-mesh wing nets than in basket traps. The difference

Table 9.—Size ranges and means of the total lengths of fish taken in basket traps and in 1-inch-mesh wing nets without leads in fisheries survey of the Mississippi River between Cape Girardeau and Louisiana, Missouri, 1944.

KIND OF FISH	BASKET TRAPS					1-INCH-MESH WING NETS WITHOUT LEADS					DEGREES OF FREEDOM	t VALUE
	Per Cent Commercial or Desirable Sizes	Number Taken, All Sizes	Mean of Total Lengths, Inches	Size Range, Inches	Standard Deviation	Per Cent Commercial or Desirable Sizes	Number Taken, All Sizes	Mean of Total Lengths, Inches	Size Range, Inches	Standard Deviation		
Carp.....	—	2	—	—	—	—	631	—	—	—	—	—
Bigmouth buffalo.	—	0	—	—	—	—	7	—	—	—	—	—
Smallmouth buffalo.....	—	0	—	—	—	—	0	—	—	—	—	—
Freshwater drum.	—	1	—	—	—	—	377	—	—	—	—	—
Channel catfish...	50.0	32	14.16	5.1-19.4	3.64	53.4	58	15.0	2.8-24.5	4.10	42	1.001
Flathead catfish..	22.2	9	14.83	8.1-21.6	3.88	39.0	254	17.23	9.4-29.0	4.50	47	1.813
Bluegill.....	—	0	—	—	—	—	77	—	—	—	—	—
White crappie....	—	0	—	—	—	—	366	—	—	—	—	—
Black crappie....	—	0	—	—	—	—	365	—	—	—	—	—

* Denotes a significant difference, in sizes of fish taken, between basket traps and 1-inch-mesh wing nets at 0.05 level for degrees of freedom indicated.

in size between channel catfish and flat-head catfish taken in 1-inch-mesh wing nets and these same kinds of fish taken in basket traps was not significant.

The basket trap is considered by commercial fishermen of the upper Mississippi as an efficient device for catching catfish. It provides the fisherman with a device that usually does not take sport fish and that can catch channel catfish as effi-

ciently as does the 1-inch-mesh wing net, which is illegal for use in the upper Mississippi. The basket trap was found to be one of the most selective fishing devices tested on the river.

Catches With Wing Nets.—The catches made with wing nets during the survey tend to indicate that commercial fishermen of the upper Mississippi might well increase their catches by using these

Table 10.—Composition of catches of commercial-sized or desirable-sized fish taken in 1-inch-mesh wing nets with leads and in 1-inch-mesh wing nets without leads in fisheries survey of the Mississippi River between Caruthersville and Hannibal, Missouri, 1944.

KIND OF FISH	1-INCH-MESH WING NETS WITH LEADS (175.40 NET-DAYS)			1-INCH-MESH WING NETS WITHOUT LEADS (330.51 NET-DAYS)			CHI- SQUARE VALUE
	Pounds per Net-Day	Number	Number per Net-Day	Pounds per Net-Day	Number	Number per Net-Day	
Carp.....	2.29	152	0.87	2.10	255	0.77	0.99
Bigmouth buffalo..	0.26	15	0.09	0.04	3	0.01	18.48*
Smallmouth buffalo..	0.41	11	0.06	0.09	7	0.02	5.40*
Freshwater drum....	0.26	61	0.35	0.34	146	0.44	2.78
Channel catfish.....	0.11	13	0.07	0.21	35	0.11	1.32
Flathead catfish.....	0.75	33	0.19	0.99	68	0.21	0.24
Bluegill.....	—	175	1.00	—	42	0.13	198.74*
White crappie.....	—	107	0.61	—	138	0.42	8.11*
Black crappie.....	—	410	2.34	—	285	0.86	175.86*

* Denotes a significant difference, in numbers of commercial-sized or desirable-sized fish taken, between the two types of nets at 0.05 level with 1 degree of freedom.

Table 11.—Size ranges and means of the total lengths of fish taken in 1-inch-mesh wing nets with leads and in 1-inch-mesh wing nets without leads in fisheries survey of the Mississippi River between Caruthersville and Hannibal, Missouri, 1944.

KIND OF FISH	1-INCH-MESH WING NETS WITH LEADS					1-INCH-MESH WING NETS WITHOUT LEADS					DEGREES OF FREEDOM	t VALUE
	Per Cent Com- mercial or Desir- able Sizes	Number Taken, All Sizes	Mean of Total Lengths, Inches	Size Range, Inches	Standard Deviation	Per Cent Com- mercial or Desir- able Sizes	Number Taken, All Sizes	Mean of Total Lengths, Inches	Size Range, Inches	Standard Deviation		
Carp.....	40.2	378	13.99	5.2-25.6	3.47	40.7	627	14.03	5.2-30.7	3.40	486	0.174
Bigmouth buffalo..	42.9	35	14.09	7.0-22.3	3.49	33.3	9	14.72	10.0-21.6	3.99	170	0.433
Smallmouth buf- falo.....	9.7	113	10.58	4.8-22.6	4.05	11.1	72	11.11	5.6-20.9	3.34	890	0.968
Freshwater drum..	36.5	167	8.85	4.1-15.1	2.59	35.5	411	8.97	3.8-16.4	2.28	2610	0.522
Channel catfish...	23.6	55	12.19	6.4-19.6	3.25	27.8	126	12.08	2.5-24.5	4.38	820	0.188
Flathead catfish..	37.5	88	16.81	8.4-36.2	4.18	34.3	198	16.04	7.0-41.2	4.85	1311	0.367
Bluegill.....	43.6	401	6.49	3.9- 8.3	0.81	42.4	99	6.59	4.3- 8.2	0.76	1981	0.156
White crappie....	59.8	182	8.04	4.0-12.7	1.89	52.5	263	7.76	4.6-15.2	1.38	2181	0.707
Black crappie....	67.8	605	7.86	4.4-11.5	3.09	66.1	431	8.27	4.5-12.0	1.17	5102	0.975*

* Denotes a significant difference, in sizes of fish taken, between the two types of nets at 0.05 level for degrees of freedom indicated.

nets more. Wing nets are particularly adapted to fishing backwater and slough areas. In the canalized section of the upper Mississippi, there are now more slough and backwater areas than in years previous to the construction of dams. In periods of low water, when the current is too sluggish for hoop nets, wing nets can be used to advantage.

In that part of the survey made in 1944, several 1-inch-mesh wing nets were fished with leads and others were

fished without leads. In table 10 are listed, for each of nine species, the numbers of commercial fish of commercial sizes and sport fish of desirable or usable sizes caught in these nets. The catch per net-day of buffalofishes of commercial sizes was somewhat greater and the catch of crappies and bluegills of desirable sizes was much greater in the nets with leads than in the nets without leads. With respect to each of the other species of fish listed, the difference between the catch

Table 12.—Composition of catches of commercial-sized or desirable-sized fish taken in 1½-inch-mesh wing nets (most without leads) and in 1-inch-mesh wing nets (without leads) in fisheries survey of the Mississippi River between Grand Tower and Warsaw, Illinois, 1944.

KIND OF FISH	1½-INCH-MESH WING NETS (156.10 NET-DAYS)			1-INCH-MESH WING NETS (508.12 NET-DAYS)			CHI-SQUARE VALUE
	Pounds per Net-Day	Number	Number per Net-Day	Pounds per Net-Day	Number	Number per Net-Day	
Carp.....	3.09	194	1.24	2.18	413	0.81	21.09*
Bigmouth buffalo...	0.09	3	0.02	0.04	6	0.01	0.43
Smallmouth buffalo...	—	0	—	0.08	13	0.03	—
Freshwater drum....	0.38	72	0.46	0.39	255	0.50	0.71
Channel catfish.....	0.08	6	0.04	0.20	59	0.12	7.78*
Flathead catfish.....	1.05	40	0.26	0.78	86	0.17	4.14*
Bluegill.....	—	12	0.08	—	49	0.10	0.63
White crappie.....	—	51	0.32	—	319	0.63	21.17*
Black crappie.....	—	66	0.42	—	496	0.98	46.29*

* Denotes a significant difference, in numbers of commercial-sized or desirable-sized fish taken, between the two types of nets at 0.05 level with 1 degree of freedom.

Table 13.—Size ranges and means of the total lengths of fish taken in 1½-inch-mesh wing nets (most without leads) and in 1-inch-mesh wing nets (without leads) in fisheries survey of the Mississippi River between Grand Tower and Warsaw, Illinois, 1944.

KIND OF FISH	1½-INCH-MESH WING NETS					1-INCH-MESH WING NETS					DEGREES OF FREEDOM	t VALUE
	Per Cent Com- mercial or Desir- able Sizes	Number Taken, All Sizes	Mean of Total Lengths, Inches	Size Range, Inches	Standard Deviation	Per Cent Com- mercial or Desir- able Sizes	Number Taken, All Sizes	Mean of Total Lengths, Inches	Size Range, Inches	Standard Deviation		
Carp.....	54.5	356	14.96	7.0-22.7	2.37	46.6	886	14.47	5.2-30.7	3.34	561	2.908*
Bigmouth buffalo...	75.0	4	16.88	12.6-22.3	4.45	46.2	13	14.92	10.0-21.6	2.88	6	0.829
Smallmouth buffalo.....	0.0	29	10.47	7.7-14.0	1.78	7.8	166	11.36	5.6-28.0	2.83	68	2.242*
Freshwater drum.....	80.0	90	11.23	6.6-16.8	1.93	43.4	588	9.45	3.8-16.4	2.28	229	7.954*
Channel catfish....	60.0	10	16.20	11.1-21.1	3.20	24.0	246	12.85	2.8-24.5	3.33	49	3.240*
Flathead catfish....	50.6	79	18.38	12.3-31.0	3.71	29.5	292	16.28	7.0-41.2	4.38	151	4.287*
Bluegill.....	40.0	30	6.57	5.6- 8.0	0.63	33.1	148	6.43	4.2- 8.2	0.79	66	1.058
White crappie....	61.4	83	8.39	5.7-12.4	1.50	54.9	581	7.94	4.6-15.2	1.46	219	2.564*
Black crappie.....	52.4	126	8.08	6.1-10.9	1.07	70.9	700	8.43	4.5-12.0	1.25	296	3.293*

* Denotes a significant difference, in sizes of fish taken, between the two types of nets at 0.05 level for degrees of freedom indicated.

rate of the nets with leads and that of the nets without leads was not great enough to be statistically significant.

Data from the survey indicate that 1-inch-mesh wing nets with leads were the most efficient entrapment gear used for crappies and bluegills. That small-mesh wing nets were effective during the survey in taking sport fishes is shown in table 5. With or without leads, 1-inch-mesh wing nets were effective in catching pred-

The species composition of the 1944 catches in the 1-inch-mesh wing nets (without leads) and that of the 1½-inch-mesh wing nets were quite similar, fig. 11 and table 5. The catch per net-day of the 1½-inch-mesh nets, however, was less than that of the 1-inch-mesh nets. The increased mesh size of one-half inch tended to reduce the take of small fish.

The wing nets of 1½-inch-mesh took, per net-day, fewer sport fishes of all sizes,

Table 14.—Catches of entrapment devices used in fisheries survey of the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, 1944 and 1946. For each device is given the percentage of the catch represented by each of the various classes of fish: commercial, sport, predatory, and forage.

TYPE OF FISH	BASKET TRAPS, 1944	1¼-INCH-MESH TRAP NETS, 1946	1-INCH-MESH WING NETS WITHOUT LEADS, 1944	1-INCH-MESH WING NETS WITHOUT LEADS, 1946	1-INCH-MESH WING NETS WITH LEADS, 1944	1½-INCH-MESH WING NETS, 1944	2½-INCH-MESH WING NETS, 1944	2½-INCH-MESH WING NETS, 1946	1-INCH-MESH HOOP NETS, 1946	2½-INCH-MESH HOOP NETS, 1944	2½-INCH-MESH HOOP NETS, 1946	3-INCH-MESH HOOP NETS, 1946
Commercial..	84.9	61.0	52.3	38.6	35.2	66.5	94.8	97.3	81.6	98.8	98.8	95.6
Sport.....	0.0	36.2	26.8	53.4	40.4	28.5	2.4	1.9	10.4	0.4	0.8	4.4
Predatory...	15.1	2.8	12.8	3.2	13.7	3.1	1.1	0.8	4.8	0.4	0.0	0.0
Forage.....	0.0	0.0	8.1	4.8	10.7	1.9	1.7	0.0	3.2	0.4	0.4	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

ator and forage fishes, particularly gars and gizzard shads, table 5.

In table 11 are listed, for each of nine species, the mean of the total lengths of individual fish and the size range of fish caught in 1944 in the 1-inch-mesh wing nets with leads and in similar nets without leads. The mean of the total lengths of black crappies caught in the nets without leads was slightly, but significantly, larger than that of black crappies caught in the nets with leads. With respect to each of the other species of fish, the difference between the mean of the total lengths of fish caught in the nets with leads and that of fish caught in the nets without leads was not great enough to be statistically significant.

Larger catches, per net-day, of carp-suckers were made with the small-mesh nets than with any of the other entrapment devices tested. The species of carp-suckers were considered together because of difficulty in separating them in the field.

Most 1½-inch-mesh wing nets used in test-netting were fished without leads.

table 5, significantly fewer crappies of usable sizes, and significantly fewer channel catfish of commercial sizes, but significantly more carp and flathead catfish of commercial sizes, than did the nets of 1-inch mesh, table 12. The numbers of bigmouth buffalos caught were too small to permit valid comparisons to be made between the two mesh sizes. No small-mouth buffalo of commercial size was caught in the 1½-inch-mesh nets. The catches, per net-day, of freshwater drums and bluegills were about the same in the nets of 1-inch mesh as in those of the larger mesh.

The mean of the total lengths of the carp caught in nets of each of the mesh sizes was about 15 inches, table 13.

As indicated by the mean of the total lengths of individuals of each species, the sizes of freshwater drums, channel catfish, flathead catfish, and white crappies were greater in catches of 1½-inch-mesh wing nets than in catches of the nets of smaller mesh, table 13. The mean length of black crappies was greater in the nets

of 1-inch mesh than in the nets of larger mesh. The writers are unable to explain why the mean length for one species of crappie was greater in nets of 1-inch mesh and the mean length for the other species was greater in the nets of larger mesh.

In the nets of 1-inch mesh, 24.0 per cent of the channel catfish and 29.5 per cent of the flathead catfish were of commercial sizes; in the nets of 1½-inch mesh, 60.0 per cent of the channel catfish

and 50.6 per cent of the flathead catfish were of commercial sizes, table 13. The number of commercial-sized fish per net-day was greater for the channel catfish in the nets of 1-inch mesh and for the flathead catfish in the nets of 1½-inch mesh, table 12.

The 2½-inch mesh was the largest mesh tested in wing nets. The 2 years of test fishing indicate that very few sport fishes are taken in nets of this mesh size,

Table 15.—Composition of catches of commercial-sized or desirable-sized fish taken in 2½-inch-mesh wing nets and in 1-inch-mesh wing nets, both types without leads, in fisheries survey of the Mississippi River between Burlington and Dubuque, Iowa, 1946.

KIND OF FISH	2½-INCH-MESH WING NETS (421.75 NET-DAYS)			1-INCH-MESH WING NETS (855.86 NET-DAYS)			CHI-SQUARE VALUE
	Pounds per Net-Day	Number	Number per Net-Day	Pounds per Net-Day	Number	Number per Net-Day	
Carp.....	1.76	172	0.41	1.10	238	0.28	14.86*
Bigmouth buffalo.....	0.31	44	0.10	0.04	13	0.02	50.35*
Smallmouth buffalo.....	0.21	35	0.08	0.04	16	0.02	29.28*
Freshwater drum.....	0.22	47	0.11	0.23	210	0.25	25.16*
Channel catfish.....	0.01	1	0.002	0.10	53	0.06	23.70*
Flathead catfish.....	0.11	4	0.009	0.27	42	0.05	12.29*
Bluegill.....	—	0	—	—	97	0.11	—
White crappie.....	—	6	0.01	—	1,228	1.43	590.01*
Black crappie.....	—	2	0.005	—	560	0.65	270.87*

* Denotes a significant difference, in numbers of commercial-sized or desirable-sized fish caught, between the two types of nets at 0.05 level with 1 degree of freedom.

Table 16.—Size ranges and means of the total lengths of fish taken in 2½-inch-mesh wing nets and in 1-inch-mesh wing nets, both types without leads, in fisheries survey of the Mississippi River between Burlington and Dubuque, Iowa, 1946.

KIND OF FISH	2½-INCH-MESH WING NETS					1-INCH-MESH WING NETS					DEGREES OF FREEDOM	t VALUE
	Per Cent Com- mercial or Desir- able Sizes	Number Taken, All Sizes	Mean of Total Lengths, Inches	Size Range, Inches	Standard Deviation	Per Cent Com- mercial or Desir- able Sizes	Number Taken, All Sizes	Mean of Total Lengths, Inches	Size Range, Inches	Standard Deviation		
Carp.....	100.0	172	20.28	15.4-31.8	2.83	78.5	303	17.55	4.7-30.0	4.85	227	7.747*
Bigmouth buffalo.....	97.8	45	17.14	13.8-20.1	1.52	39.4	33	13.48	4.5-19.6	3.67	38	5.399*
Smallmouth buffalo.....	68.6	51	15.74	12.4-26.0	2.30	5.8	277	9.21	4.1-18.4	3.46	118	17.036*
Freshwater drum.....	100.0	47	15.40	11.4-18.8	1.41	33.2	632	8.79	4.0-18.6	2.93	171	27.961*
Channel catfish.....	50.0	2	14.25	5.7-23.0	12.37	5.7	936	9.44	2.7-30.1	2.21	42	0.550
Flathead catfish.....	100.0	4	28.75	18.8-37.0	7.15	23.5	179	15.39	5.6-37.6	5.30	26	3.714
Bluegill.....	—	0	—	—	—	34.4	282	5.99	3.0-8.4	1.33	—	—
White crappie.....	100.0	6	10.42	8.6-13.0	1.85	48.8	2,514	7.36	2.9-13.2	2.30	122	4.045*
Black crappie.....	100.0	2	10.50	9.1-12.2	2.21	41.7	1,343	7.03	3.0-14.0	2.14	51	2.220*

* Denotes a significant difference, in sizes of fish taken, between the two types of nets at 0.05 level for degrees of freedom indicated.

Table 17.—Composition of catches of commercial-sized or desirable-sized fish taken in 1-inch-mesh hoop nets and 1-inch-mesh wing nets, both types without leads, in fisheries survey of the Mississippi River between Burlington and Dubuque, Iowa, 1946.

KIND OF FISH	1-INCH-MESH HOOP NETS (105.97 NET-DAYS)			1-INCH-MESH WING NETS (855.86 NET-DAYS)			CHI-SQUARE VALUE
	Pounds per Net-Day	Number	Number per Net-Day	Pounds per Net-Day	Number	Number per Net-Day	
Carp.....	0.48	9	0.08	1.10	238	0.28	13.65*
Bigmouth buffalo..	—	0	—	0.04	13	0.02	—
Smallmouth buffalo..	—	0	—	0.04	16	0.02	—
Freshwater drum....	0.34	32	0.30	0.23	210	0.25	1.22
Channel catfish.....	0.10	8	0.08	0.10	53	0.06	0.28
Flathead catfish.....	0.16	5	0.05	0.27	42	0.05	0.06
Bluegill.....	—	1	0.009	—	97	0.11	9.97*
White crappie.....	—	9	0.13	—	1,228	1.43	133.34*
Black crappie.....	—	6	0.06	—	560	0.65	57.12*

* Denotes a significant difference, in numbers of commercial-sized or desirable-sized fish taken, between the two types of nets at 0.05 level with 1 degree of freedom.

Table 18.—Size ranges and means of the total lengths of fish taken in 1-inch-mesh hoop nets and in 1-inch-mesh wing nets, both types without leads, in fisheries survey of the Mississippi River between Burlington and Dubuque, Iowa, 1946.

KIND OF FISH	1-INCH-MESH HOOP NETS					1-INCH-MESH WING NETS					DEGREES OF FREEDOM	t VALUE
	Per Cent Commercial or Desirable Sizes	Number Taken, All Sizes	Mean of Total Lengths, Inches	Size Range, Inches	Standard Deviation	Per Cent Commercial or Desirable Sizes	Number Taken, All Sizes	Mean of Total Lengths, Inches	Size Range, Inches	Standard Deviation		
Carp.....	100.0	9	21.83	17.2-26.0	2.97	78.5	303	17.55	4.7-30.0	4.85	51	4.162*
Bigmouth buffalo.....	—	0	—	—	—	39.4	33	13.48	4.5-19.6	3.67	—	—
Smallmouth buffalo.....	0.0	6	11.75	9.0-13.9	2.09	5.8	277	9.21	4.1-18.4	3.46	40	2.892*
Freshwater drum	49.2	65	10.03	4.9-17.7	3.74	33.2	632	8.79	4.0-18.6	2.93	202	2.593*
Channel catfish..	12.9	62	9.15	3.5-18.5	3.62	5.7	936	9.44	2.7-30.1	2.21	240	0.623
Flathead catfish..	11.4	44	13.20	4.4-21.0	4.46	23.5	179	15.39	5.6-37.6	5.30	88	2.807*
Bluegill.....	50.0	2	6.00	5.0-6.8	1.41	34.4	282	5.99	3.0-8.4	1.33	23	0.010
White crappie...	64.3	14	7.54	4.7-12.4	2.21	48.8	514	7.36	2.9-13.2	2.30	187	0.304
Black crappie...	66.7	9	7.83	4.3-9.7	2.02	41.7	1,343	7.03	3.0-14.0	2.14	109	1.183

* Denotes a significant difference, in sizes of fish taken, between the two types of nets at 0.05 level for degrees of freedom indicated.

figs. 11 and 12. Of the total number of fishes taken with the 2½-inch-mesh wing nets, sport fishes comprised only 2.4 per cent in 1944 and 1.9 per cent in 1946, table 14. The number of sport fishes per net-day taken with 2½-inch-mesh wing nets amounted to 0.06 fish in 1944 and 0.02 fish in 1946, table 5. Crappies comprised most of the sport fish catch. The eight crappies taken in the 2½-inch-mesh wing nets in 1946 were all of desirable or

usable sizes; of the more than 3,800 crappies taken in the 1-inch-mesh wing nets (without leads) in the same year, less than 50 per cent were of usable sizes, table 16.

Very few predatory and forage fishes, per net-day, were taken in the 2½-inch-mesh wing nets, table 5. The catch in these nets consisted largely of carp, buffalo-fishes, carpsuckers, and freshwater drums. Thompson (1925:431) states that

carp avoid small-mesh nets and traps, but that they are taken readily in large-mesh nets. He writes, "Channel cat and bull-heads seem to go most readily into small-mesh nets and basket traps, probably because, being largely nocturnal and hiding during the day, they go into the nets for concealment."

In 1946 test fishing, all of the 172 carp taken in the 2½-inch-mesh wing nets

were of commercial sizes, table 16. At the stations at which the 2½-inch-mesh wing nets were fished, only 78.5 per cent of the 303 carp taken in 1-inch-mesh wing nets were of commercial sizes. The catch of commercial-sized carp in the 2½-inch-mesh wing nets amounted to 1.76 pounds per net-day and in the 1-inch-mesh nets to 1.10 pounds per net-day, table 15.

The data indicate that the 1-inch-mesh

Table 19.—Composition of catches of commercial-sized or desirable-sized fish taken in 2½-inch-mesh hoop nets and in 1-inch-mesh wing nets, both types without leads, in fisheries survey of the Mississippi River between Burlington and Dubuque, Iowa, 1946.

KIND OF FISH	2½-INCH-MESH HOOP NETS (730.42 NET-DAYS)			1-INCH-MESH WING NETS (855.86 NET-DAYS)			CHI-SQUARE VALUE
	Pounds per Net-Day	Number	Number per Net-Day	Pounds per Net-Day	Number	Number per Net-Day	
Carp.....	1.10	150	0.21	1.10	238	0.28	8.42*
Bigmouth buffalo...	0.19	45	0.06	0.04	13	0.02	23.30*
Smallmouth buffalo...	0.19	59	0.08	0.04	16	0.02	32.22*
Freshwater drum....	0.34	152	0.21	0.23	210	0.25	2.35
Channel catfish.....	0.01	2	0.003	0.10	53	0.06	39.74*
Flathead catfish.....	0.84	58	0.08	0.27	42	0.05	5.80*
Bluegill.....	—	0	—	—	97	0.11	—
White crappie.....	—	3	0.004	—	1,228	1.43	1,037.54*
Black crappie.....	—	1	0.001	—	560	0.65	474.19*

* Denotes a significant difference, in numbers of commercial-sized or desirable-sized fish taken, between the two types of nets at 0.05 level with 1 degree of freedom.

Table 20.—Size ranges and means of the total lengths of fish taken in 2½-inch-mesh hoop nets and in 1-inch-mesh wing nets, both types without leads, in fisheries survey of the Mississippi River between Burlington and Dubuque, Iowa, 1946.

KIND OF FISH	2½-INCH-MESH HOOP NETS					1-INCH-MESH WING NETS					DEGREES OF FREEDOM	t VALUE
	Per Cent Com- mercial or Desir- able Sizes	Number Taken, All Sizes	Mean of Total Lengths, Inches	Size Range, Inches	Standard Deviation	Per Cent Com- mercial or Desir- able Sizes	Number Taken, All Sizes	Mean of Total Lengths, Inches	Size Range, Inches	Standard Deviation		
Carp.....	99.3	151	21.28	14.6-31.6	3.31	78.5	303	17.55	4.7-30.0	4.85	213	9.623*
Bigmouth buf- falo.....	84.9	53	16.84	13.2-22.9	2.07	39.4	33	13.48	4.5-19.6	3.67	41	4.804*
Smallmouth buffalo.....	66.3	89	15.35	10.0-20.0	1.97	5.8	277	9.21	4.1-18.4	3.46	156	20.842*
Freshwater drum	100.0	152	14.66	11.5-18.9	1.39	33.2	632	8.79	4.0-18.6	2.93	309	36.190*
Channel catfish..	66.6	3	17.67	6.6-21.9	9.03	5.7	936	9.44	2.7-30.1	2.21	52	1.578
Flathead catfish..	95.1	61	26.19	11.8-39.5	6.33	23.5	179	15.39	5.6-37.6	5.30	104	11.972*
Bluegill.....	—	0	—	—	—	34.4	282	5.99	3.0-8.4	1.33	—	—
White crappie....	100.0	3	10.83	10.6-11.3	0.29	48.8	2,514	7.36	2.9-13.2	2.30	86	20.448*
Black crappie....	50.0	2	8.25	7.7-8.8	1.06	41.7	1,343	7.03	3.0-14.0	2.14	51	1.625

* Denotes a significant difference, in sizes of fish taken, between the two types of nets at 0.05 level for degrees of freedom indicated.

wing nets are much more efficient in taking catfishes than are the $2\frac{1}{2}$ -inch-mesh wing nets, table 15. In 1946, only 4 flat-head catfish were taken in the $2\frac{1}{2}$ -inch-mesh wing nets and 179 (42 of them of commercial sizes, table 15) in the 1-inch-mesh wing nets, table 16. The fish of this species in the $2\frac{1}{2}$ -inch-mesh wing net collections ranged in total length from 18.8 to 37.0 inches, and in the 1-inch-mesh wing net collections from 5.6 to 37.6 inches.

More commercial-sized buffalofishes per net-day were caught in the $2\frac{1}{2}$ -inch-mesh wing nets than in the 1-inch-mesh wing nets, table 15. In the $2\frac{1}{2}$ -inch-mesh wing net catches, 97.8 per cent of the bigmouth buffalos and 68.6 per cent of the smallmouth buffalos were of commercial sizes, table 16. In the 1-inch-mesh wing net sets, only 39.4 per cent of the bigmouth buffalos and 5.8 per cent of the smallmouth buffalos were of commercial sizes.

More freshwater drums of commercial sizes were caught per net-day in the 1-inch-mesh wing nets than in the $2\frac{1}{2}$ -inch-mesh wing nets, table 15. On a pounds-per-net-day basis of commercial-sized drums, the catches of the two types of net were almost identical. All of the freshwater drums taken in the $2\frac{1}{2}$ -inch-mesh wing nets were of commercial sizes, whereas only 33.2 per cent of these fish taken in the 1-inch-mesh wing nets were of these sizes, table 16. The test-net figures indicate that a fisherman using $2\frac{1}{2}$ -inch-mesh wing nets will handle fewer undersized freshwater drums than one using nets of a smaller mesh size.

As indicated in preceding paragraphs, the efficiency and selectivity of wing nets of the mesh sizes used in the survey varied with species and sizes of fish. The small-mesh (1-inch) wing nets were more selective for crappies, bluegills, and catfishes than the $2\frac{1}{2}$ -inch-mesh nets, table 15. The $2\frac{1}{2}$ -inch-mesh nets were more efficient than the small-mesh (1-inch) nets in taking commercial-sized carp and buffalofishes, table 15.

Catches With Hoop Nets.—In the 1946 test fishing, sport fishes comprised 53.4 per cent of the entire catch with 1-inch-mesh wing nets (without leads), whereas they comprised only 10.4 per cent

of the catch with 1-inch-mesh hoop nets, table 14. No attempt was made to fish hoop nets and wing nets of the same mesh in the same habitat to determine if the absence or presence of the wings influenced the catch.

In tables 17 and 18 are listed comparative data on nine species of fish caught in the 1946 test fishing in 1-inch-mesh hoop nets and 1-inch-mesh wing nets (without leads) used at the same stations, although not necessarily in similar habitats.

The numbers, per net-day, of commercial-sized carp and usable-sized bluegills and crappies caught in the wing nets were significantly greater than the numbers, per net-day, of these fish caught in hoop nets, table 17. The numbers, per net-day, of commercial-sized freshwater drums and catfishes did not differ greatly between the two nets. The weights, per net-day, of commercial-sized carp and flathead catfish were greater in the wing net catch, and the weight, per net-day, of commercial-sized freshwater drums was greater in the hoop net catch.

No buffalofish of commercial size was taken in the 1-inch-mesh hoop net sets. The catch of these fishes in the 1-inch-mesh wing nets was small.

The mean of the total lengths for each of three species, carp, smallmouth buffalo, and freshwater drum, was significantly greater for individuals taken in the 1-inch-mesh hoop nets than for those taken in the wing nets of the same mesh, table 18. The mean of the total lengths for flathead catfish was greater for individuals taken in the wing nets. The small number of carp (nine) taken in the hoop nets casts doubt on the value of the test for fish of this species. The mean of the total lengths for bluegills and for crappies was approximately the same for individuals taken in hoop nets as for those taken in wing nets.

In tables 19 and 20 are listed comparative data on nine species of fish taken in the 1946 test fishing in $2\frac{1}{2}$ -inch-mesh hoop nets and 1-inch-mesh wing nets (without leads) fished at the same stations, but in most cases in different habitats.

The number of commercial-sized buffalofishes taken, per net-day, was much greater in the $2\frac{1}{2}$ -inch-mesh hoop nets than in the small-mesh wing nets, table

19. The 2½-inch-mesh hoop nets were less efficient in taking commercial-sized bigmouth buffalos than were the 2½-inch-mesh wing nets, table 21. The catch per net-day of smallmouth buffalos in the 2½-inch-mesh hoop nets was identical with that in the 2½-inch-mesh wing nets.

Freshwater drums often frequent waters too deep and swift for wing nets. However, such waters are usually suitable for hoop net fishing. Perhaps that is why

in 1946 the weights and numbers, per net-day, of commercial-sized drums were higher in the 2½-inch-mesh hoop net catch than in the 2½-inch-mesh wing net catch, table 21. The mean of the total lengths for drums caught in 1946 in 2½-inch-mesh wing nets was greater than for drums caught in the 2½-inch-mesh hoop nets, table 22.

The test-net survey data indicate that the 2½-inch-mesh hoop nets are not effi-

Table 21.—Composition of catches of commercial-sized or desirable-sized fish taken in 2½-inch-mesh wing nets and in 2½-inch-mesh hoop nets, both types without leads, in fisheries survey of the Mississippi River between Burlington and Dubuque, Iowa, 1946.

KIND OF FISH	2½-INCH-MESH WING NETS (421.75 NET-DAYS)			2½-INCH-MESH HOOP NETS (730.42 NET-DAYS)			CHI-SQUARE VALUE
	Pounds per Net-Day	Number	Number per Net-Day	Pounds per Net-Day	Number	Number per Net-Day	
Carp.....	1.76	172	0.41	1.10	150	0.21	37.22*
Bigmouth buffalo...	0.31	44	0.10	0.19	45	0.06	5.91*
Smallmouth buffalo...	0.21	35	0.08	0.19	59	0.08	0.002
Freshwater drum....	0.22	47	0.11	0.34	152	0.21	15.29*
Channel catfish.....	0.01	1	0.002	0.01	2	0.003	0.014
Flathead catfish.....	0.11	4	0.009	0.84	58	0.08	24.82*
Bluegill.....	—	0	—	—	0	—	—
White crappie.....	—	6	0.01	—	3	0.004	3.40
Black crappie.....	—	2	0.005	—	1	0.001	1.13

* Denotes a significant difference, in numbers of commercial-sized or desirable-sized fish taken, between the two types of nets at 0.05 level with 1 degree of freedom.

Table 22.—Size ranges and means of the total lengths of fish taken in 2½-inch-mesh hoop nets and in 2½-inch-mesh wing nets, both types without leads, in fisheries survey of the Mississippi River between Burlington and Dubuque, Iowa, 1946.

KIND OF FISH	2½-INCH-MESH WING NETS					2½-INCH-MESH HOOP NETS					DEGREES OF FREEDOM	t VALUE
	Per Cent Com- mercial or Desir- able Sizes	Number Taken, All Sizes	Mean of Total Lengths, Inches	Size Range, Inches	Standard Deviation	Per Cent Com- mercial or Desir- able Sizes	Number Taken, All Sizes	Mean of Total Lengths, Inches	Size Range, Inches	Standard Deviation		
Carp.....	100.0	172	20.28	15.4-31.8	2.83	99.3	151	21.28	14.6-31.6	3.31	160	2.897*
Bigmouth buf- falo.....	97.8	45	17.14	13.8-20.1	1.52	84.9	53	16.84	13.2-22.9	2.07	48	0.825
Smallmouth buffalo.....	68.6	51	15.74	12.4-26.0	2.30	66.3	89	15.35	10.0-20.0	1.97	66	1.016
Freshwater drum	100.0	47	15.40	11.4-18.8	1.41	100.0	152	14.66	11.5-18.9	1.39	84	3.156*
Channel catfish..	50.0	2	14.25	5.7-23.0	12.37	66.6	3	17.67	6.6-21.9	9.03	1	0.336
Flathead catfish..	100.0	4	28.75	18.8-37.0	7.15	95.1	58	26.19	11.8-39.5	6.33	14	0.698
Bluegill.....	—	0	—	—	—	—	0	—	—	—	—	—
White crappie....	100.0	6	10.42	8.6-13.0	1.85	100.0	3	10.83	10.6-11.3	0.29	6	0.531
Black crappie....	100.0	2	10.50	9.1-12.2	2.21	50.0	2	8.25	7.7- 8.8	1.06	1	1.299

* Denotes a significant difference, in sizes of fish taken, between the two types of nets at 0.05 level for degrees of freedom indicated.

cient devices for catching channel catfish, table 5. However, these large-mesh nets were found to be the most efficient devices tested for taking commercial-sized nets did not take as many sport fishes per net-day as the 1-inch-mesh wing nets, tables 5 and 23; however, they took more than the nets of 2½-inch-mesh. The trap

Table 23.—Composition of catches of commercial-sized or desirable-sized fish taken in 1¼-inch-mesh trap nets (with leads) and in 1-inch-mesh wing nets (without leads) in fisheries survey of the Mississippi River between Andalusia, Illinois, and Dubuque, Iowa, 1946.

KIND OF FISH	1¼-INCH-MESH TRAP NET (50.53 NET-DAYS)			1-INCH-MESH WING NET (200.50 NET-DAYS)			CHI-SQUARE VALUE
	Pounds per Net-Day	Number	Number per Net-Day	Pounds per Net-Day	Number	Number per Net-Day	
Carp.....	2.78	37	0.73	0.96	43	0.21	34.45*
Bigmouth buffalo ..	—	0	—	—	0	—	—
Smallmouth buffalo ..	—	0	—	—	2	0.01	—
Freshwater drum....	0.29	14	0.28	0.26	56	0.28	0.00
Channel catfish.....	0.05	2	0.04	0.04	5	0.02	0.32
Flathead catfish.....	—	0	—	0.15	9	0.05	—
Bluegill.....	—	2	0.04	—	21	0.10	1.84
White crappie.....	—	20	0.40	—	131	0.65	4.31*
Black crappie.....	—	6	0.12	—	137	0.68	22.32*

* Denotes a significant difference, in numbers of commercial-sized or desirable-sized fish taken, between the two types of nets at 0.05 level with 1 degree of freedom.

flathead catfish. Of the flatheads taken with these nets in 1946, 95.1 per cent were 18 inches or more in total length, table 20. In the 1-inch-mesh wing net collections of 1946, only 23.5 per cent were 18 inches or more in total length. The mean of the total lengths of flatheads taken in 1946 in the 2½-inch-mesh hoop nets was 26.19 inches, table 20, as compared with 15.39 inches in the 1-inch mesh wing nets and 13.20 inches in the 1-inch-mesh hoop nets, table 18. In the 1946 test-netting, the mean of the total lengths for the 58 flatheads taken in the 2½-inch-mesh hoop nets was about the same as the mean for the 4 flatheads in the 2½-inch-mesh wing net collections, table 22.

The catch of sport fishes in the 2½-inch-mesh hoop nets amounted to less than 0.01 fish per net-day in 1946, table 5. In this same year, the catch of sport fishes was 5.43 fish per net-day in the 1-inch-mesh wing net collections.

Catches With Trap Nets.—Trap nets were fished at only three stations for a total of 50.53 net-days. The nets were all of 1¼-inch mesh. As indicated by fig. 12, the catch with these nets included both commercial and sport fishes. These

net sets made during this investigation were too few in number to give any conclusive evidence regarding usage of these nets on the Mississippi.

Entanglement Device

The trammel net is the only entanglement device that was used in the survey. This device is composed of three separate nets secured to a single top and a single bottom line. The two exterior nets (for purposes of explanation called here left-exterior and right-exterior) are made of heavy twine and have a mesh size of 8 to 10 inches. The inner net is a small-mesh gill net loosely sandwiched between the two large-mesh outer nets, fig. 13.

A fish swimming into a trammel net from the left side passes freely through the left-exterior net and strikes the loosely hung inner net with enough force to carry a portion of the inner net with it through a mesh opening of the right-exterior net. The inner net, passing through a mesh of the right-exterior net, forms a pocket in which the fish is enclosed. Similarly, a fish approaching the trammel net from the right side passes through the right-exterior net and becomes trapped in a pocket



Fig. 13.—View of a trammel net, showing the two exterior large-mesh nets and the inner small-mesh net.

formed when the inner net is carried through a mesh opening of the left-exterior net. The fish is held in the pocket until released by a fisherman, fig. 14.

Trammel nets can be fished in all types of habitats found on the Mississippi. The method by which the trammel net is fished differs with habitat. If a backwater or quiet stretch of the river is to be fished, the net is set, fig. 15. If the river channel is to be fished, the net is floated or drifted downstream.

Trammel net sets and floats were made during the survey at some of the field stations in the D-MR section of the river. A summary of the trammel net fishing data is presented in table 24. Except for data collected from experimental trammel netting at Grafton in October, 1944, and at Quincy in November of the same year, the data relative to catches made in trammel nets of various lengths and mesh sizes were combined. Data from the ex-

perimental trammel netting at Grafton and at Quincy were not included in the previous report on the survey (Barnickol & Starrett 1951).

In 1947, trammel nets accounted for 25.1 per cent of the commercial catch from the Missouri section of the river and 14.5 per cent from the Illinois section (Upper Mississippi River Conservation Committee 1948, third section:19).

Catches With Set Trammel Nets.—The set method of trammel netting is the one most generally used by commercial fishermen of the upper Mississippi River. When this method is used, the net is set around a school of fish. Sometimes it is laid out in a zigzag or spiral fashion. Frequently the shore line is used as a backstop for the net. After the net has been set around the fish, a disturbance in the water is created with plungers, fig. 16. Usually the trapped fish become excited and, when they attempt to escape

by swimming toward the deep water, they hit the net.

The trammel net can be fished selectively for commercial species by a fisherman familiar with the habits of these fishes. Carp and buffalofishes tend to school in large numbers when spawning or feeding. These fishes ripple the surface of the water or stir up the bottom, revealing their presence to the commercial fisherman searching for signs of fish activity. If the fisherman believes there are quite a few fish of a desired species present, he proceeds to set his trammel net around them. On three occasions, selective netting for one or two commercial species was done by the survey crew. The catches made in these sets are listed in table 25. Carp and buffalofishes dominated these catches. No sport fish was taken in these sets. Trammel net catches taken by commercial fishermen and examined by the

writers have been found to contain largely carp and buffalofishes.

Commercial fishes, most of them carp and buffalofishes, dominated the 116 test sets made in 1944 and 1946 with trammel nets, table 26. The trammel net seems to be a very inefficient method for taking catfish. Only three channel catfish and two flathead catfish were netted in the 116 sets.

Bowfins and gars were caught regularly in the sets. These fishes are sold commercially in some areas along the river.

More than 90 per cent of the carp, big-mouth buffalos, and freshwater drums taken in 73 sets of trammel nets in 1946 were of commercial sizes, table 27.

Sport fishermen have long believed and argued that the trammel net is a destroyer of sport fishes. Their belief probably has been influential in outlawing the use of the trammel net in most midwestern wa-



Fig. 14.—A pocketed fish in a trammel net. The inner net forming the pocket around the fish hangs over the cord of one of the exterior nets.



Fig. 15.—Fishermen setting a trammel net around a school of carp on the Mississippi.

ters. Sport fishes amounted to 17.3 per cent of the catches in trammel nets set at the various stations tested along the river in 1944 and 1946, including the late fall, 1944, experimental catches at Grafton, table 26. The majority of the river sets were made with a net having a 1½-inch-

or 2-inch-mesh inner net and usually were not made in sites indicating the presence of carp or buffalofishes. Many of the sets were made in areas that appeared especially favorable for sport fishes. In the 116 sets made with trammel nets of various mesh sizes, only 7 bass (*Micro-*

Table 24.—Summary of trammel net sets and floats made in the Mississippi River by the fisheries survey party between Grafton, Illinois, and Dubuque, Iowa, 1944 and 1946.*

YEAR	TRAMMEL NET SETS					TRAMMEL NET FLOATS				
	Number of Sets	Length of Net, Yards	Mesh Size, Inches†	Number of Fish Caught	Pounds of Fish Caught	Number of Floats	Length of Net, Yards	Mesh Size, Inches†	Number of Fish Caught	Pounds of Fish Caught
1944.....	16	100	1½, 2	109	192.08	5	100	1½, 2	6	10.23
1944 (<i>Grafton Experimental</i>).....	27	150‡	1½, 2, 3	247	336.54	0	—	—	—	—
1944 (<i>Quincy Experimental</i>).....	0	—	—	—	—	33	100‡	1½, 2	197	250.50
1946.....	73	100-200	1½, 1¾, 2	961	2,572.41	70	80-100	1½, 1¾, 2	361	591.24
Total.....	116	—	—	1,317	3,101.03	108	—	—	564	851.97

* Does not include all the sets and floats made by the survey party; certain sets and floats were omitted because of discrepancies in methods of fishing.
† Inner net.
‡ Each mesh size was represented by a 50-yard length of net.

Table 25.—Examples of trammel net sets in which catches of the fisheries survey party were dominated by a single species of fish, Mississippi River, 1946.

KIND OF FISH	BURLINGTON, IOWA APRIL 17, 1946 (ONE SET)		MUSCATINE, IOWA MAY 28, 1946 (TWO SETS)	
	Number	Pounds	Number	Pounds
Carp.....	0	0.00	149	527.79
Bigmouth buffalo.....	31	88.21	1	3.50
Smallmouth buffalo.....	1	2.10	7	10.39
Carp suckers.....	0	0.00	2	2.60
Freshwater drum.....	0	0.00	7	9.62
Total.....	32	90.31	166	553.90



Fig. 16.—A commercial fisherman using a plunger to create a disturbance in the water in an effort to drive fish into his trammel net.

Table 26.—Composition of catches of trammel net sets and trammel net floats made in the Mississippi River by the fisheries survey party between Grafton, Illinois, and Dubuque, Iowa, 1944 and 1946. Included are catches of the experimental sets made at Grafton and of the experimental floats made at Quincy in the fall of 1944 and all other sets and floats except a few that were omitted because of discrepancies in methods of fishing.

KIND OF FISH	TRAMMEL NET SETS (116)				TRAMMEL NET FLOATS (108)			
	Number of Fish	Per Cent of Total Number	Weight, Pounds	Per Cent of Total Weight	Number of Fish	Per Cent of Total Number	Weight, Pounds	Per Cent of Total Weight
COMMERCIAL								
Shovelnose sturgeon.....	0	0.0	0.00	0.0	383	67.9	473.38	55.5
Carp.....	584	44.3	1,986.54	64.1	28	4.9	135.21	15.9
Bigmouth buffalo.....	135	10.3	376.63	12.1	0	0.0	0.00	0.0
Black buffalo.....	10	0.8	23.76	0.8	0	0.0	0.00	0.0
Smallmouth buffalo.....	32	2.4	45.42	1.5	2	0.4	3.94	0.5
Bullheads.....	14	1.1	11.68	0.4	0	0.0	0.00	0.0
Channel catfish.....	3	0.2	8.37	0.3	2	0.4	10.42	1.2
Flathead catfish.....	2	0.1	4.45	0.1	7	1.2	11.32	1.3
Suckers and redhorses...	4	0.3	7.56	0.2	7	1.2	15.55	1.8
Carp suckers.....	67	5.1	84.89	2.7	14	2.5	16.80	2.0
Freshwater drum.....	50	3.8	63.74	2.1	96	17.0	109.83	12.9
Subtotal.....	901	68.4	2,613.04	84.3	539	95.5	776.45	91.1
SPORT								
Largemouth bass.....	1	0.1	0.87	tr.*	0	0.0	0.00	0.0
Spotted bass.....	6	0.5	6.50	0.2	0	0.0	0.00	0.0
Black crappie.....	117	8.9	61.35	2.0	0	0.0	0.00	0.0
White crappie.....	76	5.8	43.04	1.4	0	0.0	0.00	0.0
Bluegill.....	20	1.5	8.35	0.3	0	0.0	0.00	0.0
Warmouth.....	2	0.1	0.98	tr.*	0	0.0	0.00	0.0
Sauger.....	1	0.1	1.52	0.1	5	0.9	8.54	1.0
Northern pike.....	1	0.1	3.49	0.1	0	0.0	0.00	0.0
White bass.....	2	0.1	3.45	0.1	0	0.0	0.00	0.0
Yellow bass.....	2	0.1	0.87	tr.*	0	0.0	0.00	0.0
Subtotal.....	228	17.3	130.42	4.2	5	0.9	8.54	1.0
PREDATORY								
Longnose gar.....	5	0.4	12.85	0.4	14	2.5	57.49	6.8
Shortnose gar.....	94	7.1	140.98	4.6	5	0.9	8.66	1.0
Bowfin.....	51	3.9	171.41	5.5	0	0.0	0.00	0.0
Subtotal.....	150	11.4	325.24	10.5	19	3.4	66.15	7.8
FORAGE								
Gizzard shad.....	35	2.7	30.33	0.9	0	0.0	0.00	0.0
Goldeye.....	3	0.2	2.00	0.1	1	0.2	0.83	0.1
Subtotal.....	38	2.9	32.33	1.0	1	0.2	0.83	0.1
Total.....	1,317	100.0	3,101.03	100.0	564	100.0	851.97	100.0

* tr. (trace) indicates that the species was taken but that the take averaged less than 0.1 per cent of total weight.

Table 27.—Summary of catches of three important commercial fishes in 73 trammel net sets made in the fisheries survey of the upper Mississippi River, 1946.

KIND OF FISH	NUMBER OF FISH, ALL SIZES	NUMBER OF FISH OF COMMERCIAL SIZES	NUMBER OF FISH OF COMMERCIAL SIZES PER SET	PER CENT COMMERCIAL SIZES	MEAN OF TOTAL LENGTHS, INCHES	RANGE OF TOTAL LENGTHS, INCHES
Carp.....	537	491	6.73	91.4	16.5	10.6-31.6
Bigmouth buffalo.....	116	107	1.47	92.2	17.1	10.2-20.8
Freshwater drum.....	49	46	0.63	93.9	13.5	7.7-17.4

terus spp.) and 20 bluegills were caught. Crappies amounted to 84.6 per cent of the 228 sport fishes taken in the 116 sets.

Experimental Sets at Grafton.—During the regular test-netting program, no specific test was made of the efficiency

of various mesh sizes of the inner net in the taking of sport fishes, as well as commercial and other species.

The experimental trammel net was composed of three 50-yard lengths sewed together to form one net 150 yards in

Table 28.—Summary of the catches of fish taken in 27 sets made with a 150-yard experimental trammel net in three bottomland lakes (Flat, Silver, and Royal) near Grafton, Illinois, October, 1944. Figures in parentheses indicate the numbers of fish gilled.

KIND OF FISH	1½-INCH-MESH NET		2-INCH-MESH NET		3-INCH-MESH NET	
	Number Caught	Per Cent Gilled	Number Caught	Per Cent Gilled	Number Caught	Per Cent Gilled
COMMERCIAL						
Channel catfish .	0 (0)	0.0	2 (0)	0.0	0 (0)	0.0
Black bullhead .	12 (1)	8.3	0 (0)	0.0	0 (0)	0.0
Brown bullhead .	0 (0)	0.0	1 (0)	0.0	0 (0)	0.0
Carp	1 (0)	0.0	6 (2)	33.3	1 (0)	0.0
Smallmouth buffalo	5 (1)	20.0	3 (0)	0.0	1 (0)	0.0
Bigmouth buffalo	0 (0)	0.0	13 (5)	38.5	5 (1)	20.0
Black buffalo	2 (0)	0.0	3 (1)	33.3	1 (0)	0.0
Carp suckers	3 (0)	0.0	4 (0)	0.0	0 (0)	0.0
Subtotal	23 (2)	—	32 (8)	—	8 (1)	—
Average	—	8.7	—	25.0	—	12.5
SPORT						
Largemouth bass	1 (0)	0.0	0 (0)	0.0	0 (0)	0.0
Spotted bass	5 (2)	40.0	1 (1)	100.0	0 (0)	0.0
White crappie	8 (0)	0.0	6 (0)	0.0	1 (0)	0.0
Black crappie	53 (8)	15.1	13 (4)	30.8	1 (0)	0.0
Bluegill	4 (1)	25.0	0 (0)	0.0	0 (0)	0.0
Warmouth	1 (1)	100.0	0 (0)	0.0	0 (0)	0.0
Yellow bass	2 (0)	0.0	0 (0)	0.0	0 (0)	0.0
Subtotal	74 (12)	—	20 (5)	—	2 (0)	—
Average	—	16.2	—	25.0	—	0.0
PREDATORY						
Shortnose gar	46 (7)	15.2	2 (0)	0.0	0 (0)	0.0
Longnose gar	2 (1)	50.0	0 (0)	0.0	0 (0)	0.0
Bowfin	11 (0)	0.0	6 (0)	0.0	0 (0)	0.0
Subtotal	59 (8)	—	8 (0)	—	0 (0)	—
Average	—	13.6	—	0.0	—	0.0
FORAGE						
Gizzard shad	8 (3)	37.5	11 (1)	9.1	0 (0)	0.0
Goldeye	1 (0)	0.0	0 (0)	0.0	1 (0)	0.0
Subtotal	9 (3)	—	11 (1)	—	1 (0)	—
Average	—	33.3	—	9.1	—	0.0
Total	165 (25)	—	71 (14)	—	11 (1)	—
Average	—	15.2	—	19.7	—	9.1

and selectivity of various mesh sizes of the inner net. However, such a test was conducted in late October, 1944, in a series of 27 sets made with a 150-yard experimental trammel net in several bottomland lakes near Grafton, Illinois. As these lakes were known to have high populations of sport fishes, particularly crappies, they appeared to be especially suited for testing the efficiency and selectivity of va-

rious mesh sizes of the inner net in the taking of sport fishes, as well as commercial and other species. The experimental trammel net was composed of three 50-yard lengths sewed together to form one net 150 yards in length. The mesh size of the inner net of the first section, or length, was 1½ inches, of the second 2 inches, and of the third 3 inches. This experimental net permitted the sampling of a site with three mesh sizes in one set. Each 50-yard section of netting is assumed to have had an equal chance to catch fish and, on the basis of this assumption, the following analysis has been made.

The catch of commercial species in the 27 experimental sets was low, since no effort was made to search out such species.

In the 27 sets, 247 fish were caught, table 28. The section with the 1½-inch-mesh inner net caught 165 fish, or 66.8 per cent of the number of fish taken; the section with the 2-inch-mesh inner net took 71 fish, or 28.7 per cent of the total; and the section with the 3-inch-mesh inner net took only 11 fish, or 4.5 per cent of the total.

Of the 165 fish taken in the section with the 1½-inch-mesh inner net, 44.8 per cent were sport fishes, 35.8 per cent were garfishes and bowfins, and 13.9 per cent were commercial species. Crappies comprised 82.4 per cent of the number of sport fishes taken in the section with the 1½-inch-mesh inner net. Of the remaining 17.6 per cent of the sport fishes, six were bass (*Micropterus* spp.), four were bluegills, two were yellow bass, and one was a warmouth. Bullheads were the principal commercial fishes taken in the section with the 1½-inch-mesh inner net. Seven buffalofishes, one carp, and three carpsuckers formed the remainder of the commercial catch.

Commercial species, principally buffalofishes and carp, made up 45.1 per cent of the number of fish caught in the section of the experimental trammel net with 2-inch-mesh inner net. In this section of the net, sport fishes comprised 28.2 per cent of the catch; crappies comprised 95.0 per cent of the number of sport fishes. The section with the 1½-inch-mesh inner net caught 3.7 times as many sport fishes as did the section with the 2-inch-mesh inner net. Only 2 garfishes were taken in the section with the 2-inch-mesh inner net and 48 in the section with the 1½-inch-mesh inner net.

Of the 11 fish caught in the section with the 3-inch-mesh inner net, 72.7 per cent were commercial species. This section of the net caught but 2 sport fishes.

Of the three mesh sizes used in the experimental trammel net, the 2-inch size appeared to be by far the best for commercial fishing. The section of the net having an inner net of this mesh size had the highest catch of commercial species, it had few garfishes, and it had a catch of

sport fishes that was low when it is considered that the net was fished in waters known to contain a high population of these fishes, table 28. If sport fishes of larger sizes had been abundant in the waters fished, perhaps the catch of these fishes would have been much higher in this section of the net. The section with the 3-inch-mesh inner net would probably have taken a high catch of large commercial species if fished in a habitat being used by such fishes. This section of the net took very few sport fishes of the sizes then present in the Grafton waters.

In conjunction with the trammel netting experiment at Grafton, 12 net-days of fishing were done with 1-inch-mesh wing nets. Ninety-one bluegills were taken in these wing nets; they ranged in size from 3.8 to 7.6 inches total length. The mean of the total lengths of these bluegills was 5.7 inches. The four bluegills taken in that section of the experimental trammel net having a 1½-inch-mesh inner net ranged from 7.0 to 7.2 inches in length. Evidently most of the bluegills present in the Grafton waters in the fall of 1944 were too small to be taken in the 1½-inch-mesh net. If bluegills of 7 inches and longer had been extremely abundant, the catch in the experimental trammel net probably would have been higher. The mean of the total lengths of bluegills taken in the Mississippi River during the 2-year survey with all types of fishing devices was between 6.1 and 6.5 inches. In the 116 trammel net sets made during the survey, only 20 bluegills were caught, table 26. On the basis of the above discussion, it appears that trammel nets having inner nets with meshes of 1½ inches or larger are quite inefficient in taking bluegills in the Caruthersville-Dubuque section of the Mississippi.

In the 12 net-days of fishing with wing nets at Grafton, 285 crappies were taken. These fish ranged in total length from 4.4 to 11.4 inches; the mean of their total lengths was 7.6 inches. Crappies caught in the section of the experimental net having an inner net of 1½-inch mesh ranged in total length from 7.4 to 12.2 inches; the mean of their total lengths was 9.3 inches. Crappies taken in the section having an inner net of 2-inch mesh ranged

lengths of 2.9 to 11.2 inches. The mean of the total lengths was 10.8 inches. The two crappies taken in the section having an inner net of 3-inch mesh were each more than 11 inches in total length. The mean of the total lengths of white crappies taken at the various stations in the 2 years of test-netting with various commercial devices was between 7.5 and 8.0 inches, and of black crappies between 7.1 and 8.4 inches. As was the case with the bluegills, most of the crappies were too small to be taken in the trammel nets having meshes of $1\frac{1}{2}$ inches or larger. How much the crappie population of the Caruthersville-Dubuque section of the Mississippi fluctuates from year to year in abundance of individuals of different size or age groups is not known; however, the differences in individual lengths between the 1944 and the 1946 samples from the river were not great (Barnickol & Starrett 1951:317).

It was shown by test-netting that, although trammel nets will catch sport fishes, if a mesh of 2 inches or larger size is used, the catch of these fishes is nominal, even when the nets are fished in waters having a high population of crappies and such other common sport fishes as are found in the Caruthersville-Dubuque section of the Mississippi River.

Gilling Experiment With Set Trammel Net.—Some critics of the trammel net have claimed that the net not only captures large numbers of sport fishes, but that sport fishes are killed in the net by gilling. Gilling occurs when a fish strikes the inner fine-mesh net and forces its head through the netting far enough to allow the net twine to become lodged beneath one or both gill covers. The gills may be injured while the fish is trying to escape or while a fisherman is dislodging the fish from the netting. Release of a gilled fish requires of the fisherman more time and patience than does release of a pocketed fish. Pocketed fish are seldom injured in the net.

In the trammel net experiment at Grafton in October, 1944, a record was kept of the section of the net in which each fish was caught, as well as whether the fish was pocketed or gilled in the net. The number and per cent of fishes that were gilled are listed by species and size

in table 25. Gilling was relatively greater among the buffalofishes than among any of the other commercial species. The high percentage of gilled buffalofishes might be due to the terrific force with which these fishes hit a trammel net. A fisherman trying to hold buffalofishes alive for a period of time in a crib or holding pond might experience a higher mortality among the gilled fish than among the pocketed fish.

Persons who have fished gill nets know that the sunfishes, including the crappies, the bluegill, and the basses (*Micropterus* spp.), are ordinarily a difficult group to take in large numbers in these nets, whereas the perches and similarly shaped fish are taken readily in them. A low percentage of gilling was recorded for the crappies in the section of the trammel net having a $1\frac{1}{2}$ -inch-mesh inner net, table 28. Of 61 crappies taken in this net, only 8 were gilled. These gilled fish ranged in total length from 8.2 to 10.2 inches, and the mean of their total lengths was 8.8 inches. The crappies that were pocketed ranged in length from 7.4 to 12.2 inches, and the mean of their total lengths was 9.4 inches. Although the mean of the total lengths for the pocketed crappies was higher than that for gilled fish, some of the pocketed fish were smaller than any of the gilled fish.

The percentage of gilled crappies in the section of the experimental net with the 2-inch mesh was higher than in the section with the $1\frac{1}{2}$ -inch mesh; however, there were twice as many gilled crappies in the section with the $1\frac{1}{2}$ -inch mesh as in the section with the 2-inch mesh. No sport fish was gilled in that section of the net with the 3-inch mesh.

Catches With Floated Trammel Net.—Current and a clean river bottom are requirements for fishing with a trammel net that is to be floated or drifted. The floats on the net must be of such buoyancy and the weights of such weight as to hold the narrow axis of the net in a nearly vertical position. The fisherman lays his net in an area of the channel he desires to fish and lets the current carry the net downstream over a clean sand or gravel bottom.

In the D-MR section of the Mississippi

River, fishing with the trammel net floated is limited mainly to the upper ends of the pools where there is enough current to drift the net.

The float method of fishing with the trammel net is limited not only in use but in the kinds of fishes it takes. The shovelnose sturgeon, or hackleback, is the principal species taken by the float method. It may be noted in table 26 and fig. 17 that this species of sturgeon was not taken in the survey collections made with set trammel nets. The trammel net float was the only method by which the survey crew was able to take shovelnose sturgeons in numbers. The only shovelnose sturgeon taken by the survey party with other gear or methods of fishing was a single speci-

men in a hoop net at the New Boston station. However, in the MR-C section of the river, sturgeons are taken on trot lines by commercial fishermen.

Trammel net floating is an important method available to commercial fishermen interested in fishing for shovelnose sturgeons. This method of fishing makes it possible to harvest a fish crop that might otherwise be lost to man. The freshwater drum was the only other species taken by the float method in large enough numbers to be of importance to commercial fishermen.

Sport fishes are seldom taken in the Mississippi River by the float method. In 108 floats, only 5 sport fishes were taken, of which all were saugers, table 26.

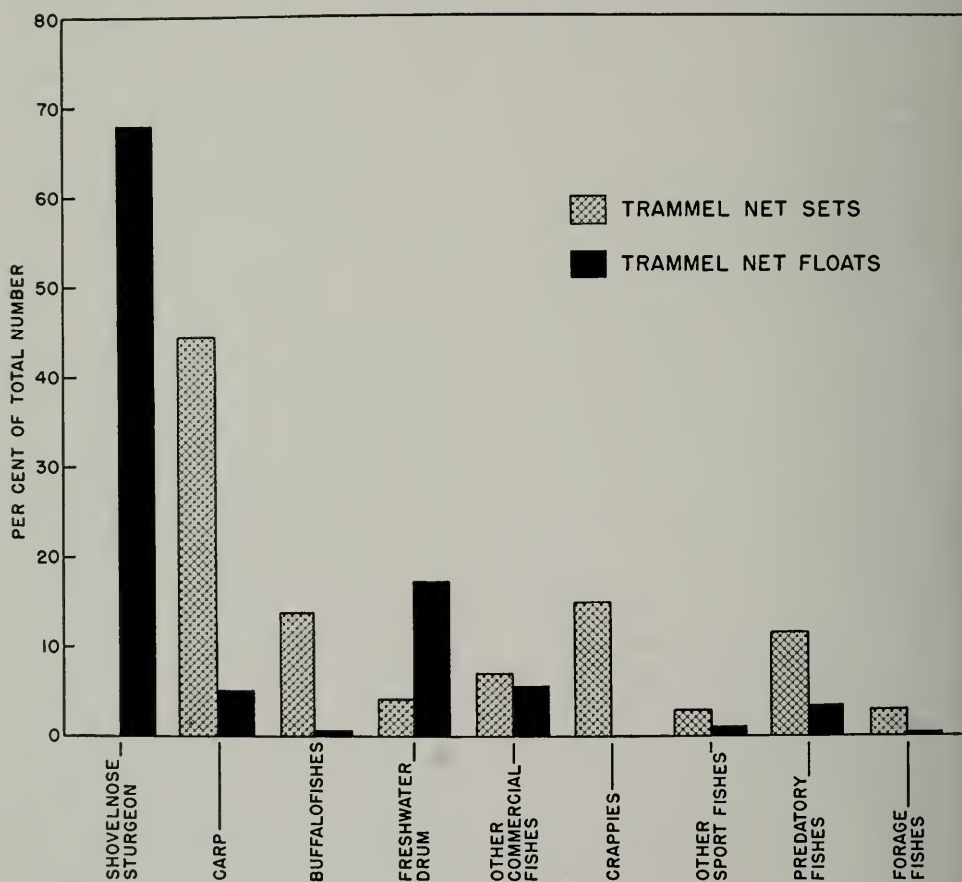


Fig. 17.—The relative numbers of commercial, sport, predator, and forage species of fish taken in trammel net sets and in trammel net floats on the Mississippi River between Grafton, Illinois, and Dubuque, Iowa, in 1944 and 1946. The graph is based on the total number of fish taken by each of the two methods of fishing, table 26.

Experimental Floats at Quincy.—

An experiment with trammel net floats was conducted in the Mississippi River near Quincy, Illinois, in early November of 1944. The experimental net used was 100 yards in length and consisted of two sections, one 50-yard section with a 1½-inch-mesh inner net and the other 50-yard section with 2-inch-mesh inner net. The two sections were sewed together to form one continuous net.

In 33 floats, 197 fish were taken, table 29. The catches from these floats are included also in table 26. Shovelnose sturgeons comprised 51.3 per cent and freshwater drums 30.5 per cent of the number of fish in these catches. Other commercial fishes amounted to only 6.6 per cent of the number of individuals in these catches. Garfishes amounted to 8.6 per cent.

Five saugers were the only sport fishes taken in the 33 experimental floats. These fish were taken in the section of the net

with the 1½-inch-mesh inner net. The float method of trammel netting, as demonstrated by the 33 experimental floats and the other 75 floats made during the 2-year survey, presents no problem relative to sport fishes.

The section of the experimental net with the 1½-inch-mesh inner net took 3.8 times as many shovelnose sturgeons as the section with the 2-inch-mesh inner net. The sturgeons taken in the 1½-inch mesh were smaller than those taken in the 2-inch mesh. The mean of the fork lengths* of shovelnose sturgeons was 25.5 inches for those taken in the 1½-inch mesh, and 26.8 inches for those taken in the 2-inch mesh. One 8.4-inch shovelnose sturgeon was taken in the 1½-inch mesh; the remainder taken in this mesh ranged from 22.5 to 31.2 inches fork length. In the section of the net with 2-inch mesh, the sturgeons caught ranged in fork length

* Fork length is the measurement from the tip of the snout to the base of the caudal filament.

Table 29.—Summary of the catches of fish taken in 33 floats with a 100-yard experimental trammel net (50 yards with 1½-inch-mesh inner net and 50 yards with 2-inch-mesh inner net) in the Mississippi River near Quincy, Illinois, November, 1944. Figures in parentheses indicate the numbers of fish gilled.

KIND OF FISH	1½-INCH-MESH NET		2-INCH-MESH NET	
	Number Caught	Per Cent Gilled	Number Caught	Per Cent Gilled
COMMERCIAL				
Flathead catfish.....	4 (0)	0.0	1 (0)	0.0
Channel catfish.....	1 (0)	0.0	0 (0)	0.0
Carp.....	0 (0)	0.0	1 (0)	0.0
Freshwater drum.....	37 (1)	2.7	23 (1)	4.3
Smallmouth buffalo.....	0 (0)	0.0	1 (0)	0.0
Shovelnose sturgeon.....	80 (3)	3.8	21 (1)	4.8
Carp suckers.....	2 (0)	0.0	0 (0)	0.0
Blue sucker.....	2 (0)	0.0	1 (0)	0.0
Subtotal.....	126 (4)	—	48 (2)	—
Average.....	—	3.2	—	4.2
SPORT				
Sauger.....	5 (0)	0.0	0 (0)	0.0
Subtotal.....	5 (0)	—	0 (0)	—
Average.....	—	0.0	—	0.0
PREDATORY				
Shortnose gar.....	4 (1)	25.0	1 (1)	100.0
Longnose gar.....	7 (1)	14.3	5 (0)	—
Subtotal.....	11 (2)	—	6 (1)	—
Average.....	—	18.2	—	16.7
FORAGE				
Goldeye.....	1 (0)	0.0	0 (0)	0.0
Subtotal.....	1 (0)	—	0 (0)	—
Average.....	—	0.0	—	0.0
Total.....	143 (6)	—	54 (3)	—
Average.....	—	4.2	—	5.6

from 23.0 to 30.6 inches. Of the sturgeons taken in this section of the net, 76.2 per cent were of commercial sizes (25 inches or more fork length); of those sturgeons taken in the section with 1½-inch mesh, 61.2 per cent were of commercial sizes.

The number and percentages of the fishes that were gilled in the experimental floats are listed in table 29. None of the five saugers taken during the experiment was gilled. In the section with the 1½-inch-mesh inner net, 4.2 per cent of the fish were gilled; in the section with the 2-inch-mesh inner net, 5.6 per cent were gilled.

Discussion

During the past 50 years, there have been increasing numbers of sport fishermen in Illinois and other states. Many of these fishermen view with suspicion the operations of commercial fishermen. Some even believe that commercial fishermen have been responsible for the decline of sport fish populations in certain localities. Their beliefs probably have developed as a result of hearsay, casual contact with the commercial fish industry, and lack of realization that many environmental changes have taken place in the past century and that some of these have had an effect on the fishery of the Mississippi River and other waters.

The effect of commercial fishing devices of illegal mesh size on certain sport fishes was demonstrated by Bennett (1948:411) in his study at Fork Lake, a small artificial lake of 1.38 acres stocked with bluegills and largemouth bass. After nearly 3½ years of being cropped heavily with small-mesh wing nets, Fork Lake still contained a large population of fish. If it was not possible in a 1.38-acre lake to reduce a sport fish population to a low level by concentrated effort with commercial gear of a mesh smaller than legal size, then it certainly does not appear logical that commercial fishermen, using nets of legal-size mesh, could remove enough sport fishes from the Mississippi River to affect the sport fishery, even if it were lawful to keep the sport fish taken in commercial devices.

It was demonstrated in the survey of

1944 and 1946 reported here that commercial fishing devices can be fished on a selective basis. Of the fishing devices tested in the survey, basket traps and floated trammel nets were found to be the ones most selective for commercial species. Other devices were found to be quite selective when fished for a particular species of fish. The type of fishing device, the mesh size, and the fishing site influenced the species composition of the catch.

Missouri statutes no longer specify minimum size limits for any commercial fish, except catfish. Illinois and Iowa still have minimum size limits on certain commercial species. Analysis of data from the Mississippi River survey of 1944 and 1946 indicates that, where minimum size limits of commercial fish are necessary, sizes of fish caught can be controlled by using nets of certain mesh sizes. The use of mesh size as a means of controlling the size of fish in the commercial catches reduces the labor of complying with the law by eliminating the necessity for measuring the fish in the catches.

Practices and policies of fish management for the Caruthersville-Dubuque section of the Mississippi River should not eliminate either sport fishing or commercial fishing. Prohibitive measures aimed at either kind of fishing affect the best use of the fishery. Too frequently, laws governing this dynamic river fishery tend to be static and thereby defeat their original purpose to benefit the fishery. Laws established to aid in the management of the river fishery should not be adopted with an attitude of permanency. These laws should be changed whenever scientific findings indicate they are no longer useful.

Summary

1. Data on fishing with various types of commercial fishing devices were collected during a fish survey of the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, in 1944 and 1946. Particular emphasis was placed on determining the selectivity and effectiveness of the commercial fishing devices of various mesh sizes used on the river.

2. During the survey, the following types of commercial fishing devices were used: seines, trammel nets, basket traps,

wing nets, hoop nets, trap nets, and trot lines.

3. Twenty-five seine hauls were made by the survey crew with 1-inch-mesh seines of 100-, 150-, and 200-yard lengths. Carp, buffalofishes, channel catfish, paddlefish, carpsuckers, and freshwater drum were the principal commercial species taken with seines. Shortnose gar was the principal predatory fish, gizzard shad the principal forage fish, and white crappie the principal sport fish. Sport fishes amounted to 11.7 per cent by number and 3.3 per cent by weight of the total catch with seines. Crappies comprised 82.1 per cent of the number of sport fishes taken with seines.

4. Of the fish taken in the survey with basket traps, 80.8 per cent were catfishes, 15.1 per cent were shortnose gars. No sport fish was taken in the basket traps.

5. One-inch-mesh wing nets with leads were found to be more efficient in taking crappies, bluegills, and buffalofishes than were nets of the same mesh fished without leads.

6. The number of commercial-sized channel catfish caught per net-day was larger in the 1-inch-mesh wing nets than in wing nets of larger mesh sizes.

7. The number of commercial-sized carp and buffalofishes caught per net-day was larger in the nets of large mesh sizes than in the nets of 1-inch mesh.

8. The efficiency of wing nets in taking sport fishes decreased as mesh size increased.

9. Wing nets took more sport fishes per net-day than did hoop nets.

10. The catch of freshwater drums of commercial sizes was larger per net-day

in the 2½-inch-mesh hoop nets than in the 2½-inch-mesh wing nets. The catch of buffalofishes of commercial sizes was slightly larger in the 2½-inch-mesh wing nets than in the 2½-inch-mesh hoop nets. The 2½-inch-mesh hoop nets were the most effective entrapment devices used for flathead catfish of commercial sizes.

11. Three trammel net sets were made on a selective basis for carp and buffalofishes. Trammel nets having an inner net of 1½-inch mesh took a larger number of sport fishes than did trammel nets having inner nets with mesh sizes of 2 or 3 inches.

12. Trammel net float fishing was found to be selective for shovelnose sturgeons and freshwater drums. Only five sport fishes were taken by this method of trammel netting.

13. In 27 experimental trammel net sets at Grafton, 15.2 per cent of the fish taken in the section with an inner net of 1½-inch mesh were gilled; 19.7 per cent taken in the section with an inner net of 2-inch mesh, and 9.1 per cent taken in the section with an inner net of 3-inch mesh were gilled. No white crappie was gilled. In the section with the 1½-inch-mesh inner net, 15.1 per cent of the black crappies were gilled; in the section with the 2-inch-mesh net, 30.8 per cent of the black crappies were gilled. Of commercial species taken, buffalofishes had the greatest tendency to become gilled.

14. In 33 experimental trammel net floats made at Quincy, 4.2 per cent of the fish taken in the section of the net with a 1½-inch-mesh inner net were gilled; 5.6 per cent in the section with a 2-inch-mesh inner net were gilled.

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