CHARACTERISTICS OF FISH POPULATIONS IN UPPER MISSISSIPPI RIVER BACKWATER AREAS

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ABSTRACT

Standing crops of fish and their fluctuations from year to year, age and size class structure of the populations, and growth rates of the common species present in three backwater areas of the upper Mississippi River were determined during the period 1947-52 under the auspices of the Upper Mississippi River Conservation Committee.

Standing crops as estimated from six collections following rotenone treatment of blocked-off areas ranged from 39 to 605 and averaged 248 pounds per acre.

Weight composition by species groups varied greatly among four collections made in one study area but was characterized by the following percentages: (1) Rough fish - 38 (2) Non-game predaceous species - 27 (3) Panfish - 13 (4) Game fish - 12 (5) Catfish - 11, and (6) Forage fish - 1. Among the same four collections, the average composition in pounds per acre was: (1) Rough fish - 112 (2) Non-game predaceous species - 77 (3) Panfish - 36 (4) Game fish - 29 (5) Catfish - 30, and (6) Forage fish - 2.

Very few fish over 5 years of age were found and most of the game fish and panfish were less than 3 years old.

Growth rates of most species were greater than most of those described in other waters of the north central States and in downstream areas of the Mississippi River.

Limited data on environmental factors are presented. Differences in standing crop and species composition could not be related to changes in the water level.

INTRODUCTION

Numerous attempts to remove fish populations in order to determine the productivity and population structure of various landlocked waters have been made, but most were conducted where populations were abnormal and consequently the findings were not typical of normal conditions (Solman, 50[1]). Many of them were only partially successful because recoveries of fish were incomplete. Until the research program of the Tennessee Valley Authority was initiated, little attention had been given to detailed studies of warm-water fish populations of backwater areas in rivers and impoundments. Surber (52, 54) studied the fish populations in some upper Mississippi River sloughs before installation of navigation dams; many of the conditions he described still exist. Meehean (32) attempted to show the

1/ Underscored figures in parentheses refer to list of references beginning on page 50.

relation of scale structure to the life history of the bluegill in some upper Mississippi River sloughs. Tarzwell (57, 58) and Eschmeyer (19), employing a technique similar to that used in these studies, obtained information on fish populations in restricted areas of TVA reservoirs.

The studies discussed here were initiated primarily to evaluate the standing fish populations of representative backwater areas created by the navigation dams on the upper Mississippi River. At normal pool levels these areas are connected with the main and side channels and form an important part of the total fish-producing waters.

Collection of data on fish populations in the backwaters has been an integral part of a broad fishery investigation carried on by the Upper Mississippi River Conservation Committee[2/] since its beginning. Under auspices of this organization the populations of seven backwater areas in the upper river were studied. The present discussion is limited to three areas in the Minnesota-Wisconsin section of the river: Miller Lake, area A, and area B. Collections were made by means of toxicants in Miller Lake in August 1957, in area A in July 1948, and in area B in July 1948, August 1949 and 1951, and September 1952. The objectives of the study were to determine (1) fish productivity, (2) fluctuations in the populations from year to year, (3) population structure, (4) rate of growth of the common species present, and (5) effects of navigation-pool drawdowns on the fish populations of these backwater areas.

Description of the backwater areas

Miller Lake:--Miller Lake[3/], a backwater area in pool 8 of the upper Mississippi River lock and dam system, is located approximately 2 miles below the interstate bridge at La Crosse, Wisconsin, on the Wisconsin side of the river (fig. 1). On August 15, 1947, the date of fish collection, it covered an area of 11.9 acres[4/]. The water level at the pool-control point approximately 1 mile below La Crosse was 630.97 feet (elevation above mean sea level). The normal level at this gauge is 631.00 feet.

Two outlets connect the lake indirectly with the main channel. One, appriximately 70 feet wide and 5 feet deep, empties into a large running slough. The other, approximately 15 feet wide, drains into a shallow ditch that has no appreciable current at normal pool level. There is a single inlet less than 3 feet in maximum width which is very shallow and choked with weeds. The amount of water entering the backwater from this source is negligible. Silt deposited periodically during high water stages forms the bottom.

A heavy growth of coontail, Ceratophyllum demersum, was on the periphery of the lake and in the bays at the time of poisoning. The water temperature 1 foot below the surface was 80°F. and the turbidity was 320 ppm as measured with a U.S. Geological Survey standard platinum needle scale.

Areas A and B:--Areas A and B lie west of Fountain City, Wisconsin, in pool number 5-A (fig. 2). The main channel of the river

2/ The Upper Mississippi River Conservation Committee was organized in 1943. It is composed of representatives from Minnesota, Wisconsin, Iowa, Illinois, Missouri, the U.S. Fish and Wildlife Service, and the U.S. Corps of Engineers. The primary purpose of the Committee is to conduct biological and economic studies concerning fish and wildlife of the upper Mississippi River.

3/ Descriptive information and raw data pertaining to Miller Lake are from a preliminary report (unpublished) prepared by D.W. Kelley and John Greenbank, parts of which appeared in the Fourth Progress Report of the Technical Committee for Fisheries of the Upper Mississippi River Conservation Committee, January 27, 1948.

4/ Original determinations of areas of Miller Lake, area A and area B, and of area B in 1951 were made from plane-table maps. Acreages of area B for the years 1949 and 1952 are estimates based on the original maps.

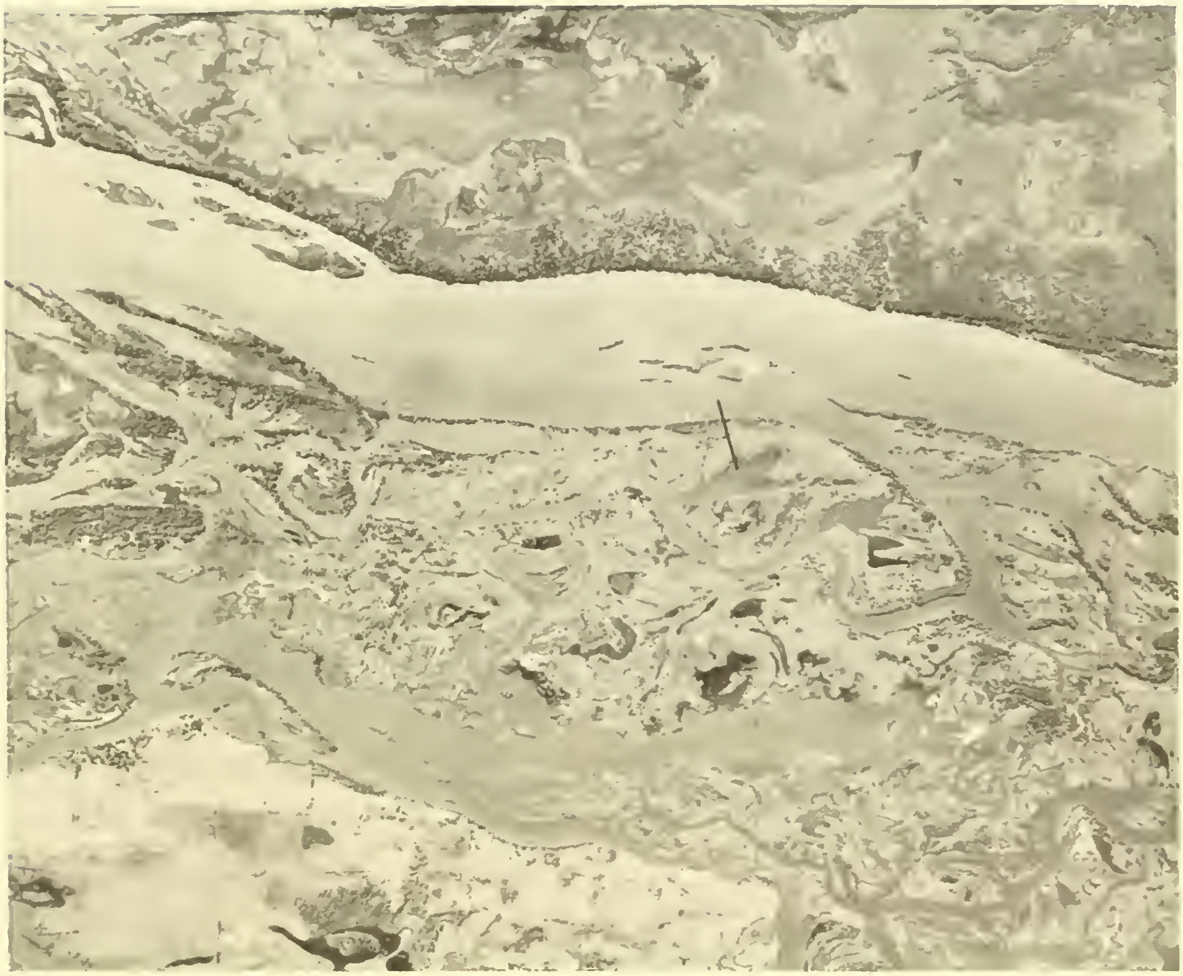

Figure 1:--Mississippi River approximately 2 miles south of La Crosse, Wisconsin. Miller Lake is indicated by a line near the center of the photograph (aerial photo taken July [illegible]).

follows the east bank of the valley proper at this location. West of the main channel the broad river bottoms are dissected by lesser meandering channels and it is in this region that the two sampling areas are located. Normal level of the pool at the U. S. Corps of Engineers Fountain City boatyard gauge is 650.50 feet.

Area A covered 1.35 acres on July 6, 1948. It had a maximum depth of 4.5 feet and an average depth of 2.4 feet with a water level of 650.61 feet at the Fountain City gauge. The bottom was silt and except for a heavy stand of Sagittaria sp. at the closed end of the backwater, aquatic vegetation was sparse.

Area B covered 3.36 acres on July 7, 1948 (fig. 3). It had a maximum depth of 9 feet and an average depth of 5.5 feet when the water level at the Fountain City gauge was 650.65. The silt bottom supported a more diversified and abundant stand of aquatic vegetation than was found in area A. Sagittaria sp. predominated, Potamogeton natans was abundant, and there was a scattering of Vallianeria sp. and Nymphaea tuberosa.

Water temperature and turbidity were not determined in areas A and B on these dates but maximum air temperature at Winona, Minnesota, 6 miles downstream, on both dates was 96 F. The water in both cases was clear enough to permit the bottom to be seen to depths of approximately 3 feet.

Figure 2:--Mississippi River in vicinity of Fountain City, Wisconsin. Areas A and B are indicated by letters. Direction of river flow in this photograph is from bottom to top (aerial photograph taken July 31, 1951).

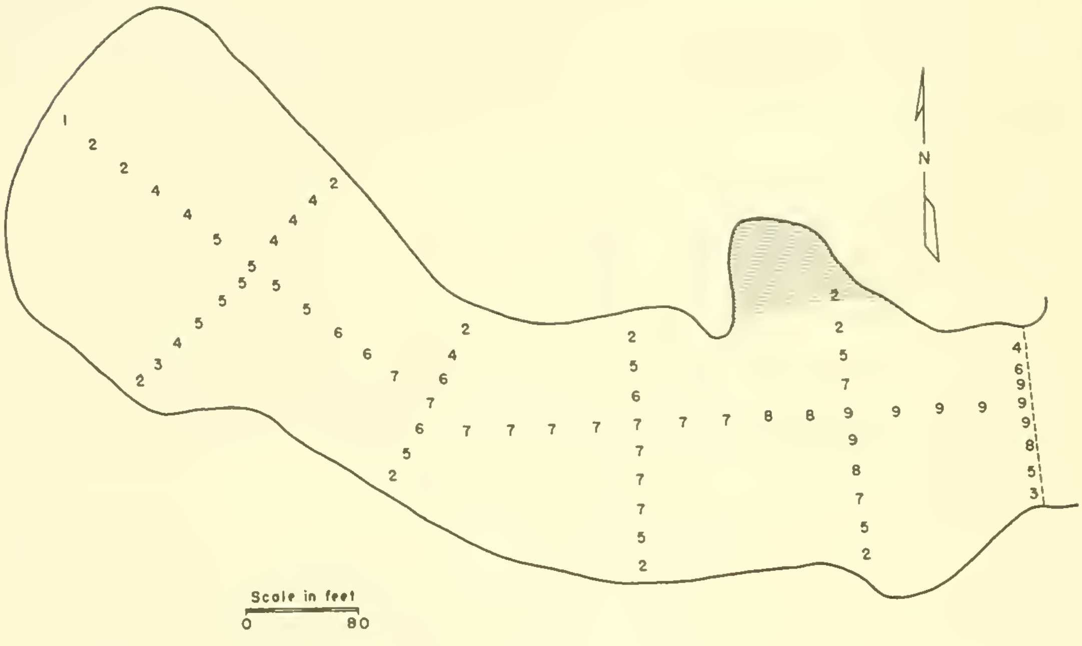

Figure 3:--Outline map of area B in 1948. The shaded area indicates the extent of sand deposition noted in 1951.

On August 3, 1949, the water level at the gauge stood at 649.65, 1.00 feet lower than on the date of the previous operation. This change reduced the size of area B to approximately 3 acres, the maximum depth to 8.0 feet, and the average depth to 4.0 feet. Neither water temperature nor turbidity was determined. The water was clear enough to permit the bottom to be seen over a major portion of the area.

On August 14, 1951, the water level stood at 650.18, 0.53 feet above that of August 3, 1949, and 0.47 feet below that of July 7, 1948. Deposition of sand had filled one small bay and, together with the lower water level, had reduced the area to 3.1 acres. The maximum depth was 7.5 feet and the average depth approximated 4 feet. Surface water temperature at noon was 73° F. and the silt bottom was visible to a depth of approximately 2 feet. Aquatic vegetation, identified by John Moyle of the Minnesota Department of Conservation was much more abundant than in July, 1948. The following species were present: mud plantain (Heteranthera dubia), coontail (Ceratophyllum demersum), western waterweed (Anacharis occidentalis), arrowhead (Sagittaria sp.), sago pondweed (Potamogeton pectinatus), duckweeds (Lemna minor, Spirodela polyrhiza), wild celery (Vallisneria americana), white waterlily (Nymphaea tuberosa), and river pondweed (Potamogeton nodosus). Coontail was the most abundant species, followed by western waterweed and mud plantain. Arrowhead was abundant only at the closed end of the area.

On September 17, 1952, the water level was 649.90 feet, 0.28 feet below that of August 14, 1951, 0.25 feet above that of August 3, 1949, and 0.75 feet below that of July 7, 1948. On the basis of previous plane table compatations, the size of area B was estimated to be approximately 3.0 acres. The maximum and average depths were 7.5 and approximately 4 feet, respectively. Surface-water temperature at noon was 65° F. Bottom, turbidity, and vegetation were similar to those existing on the date of the preceding operation, August 14, 1951.

METHODS AND MATERIALS

Toxicant application

The methods of applying the fish toxicant followed in each of the six operations were nearly identical. A 0.75-inch (stretch measure) mesh seine was installed across the open end of each area and the toxicant was then distributed. The seine was laid out early in the morning in 1948 and 1949, in mid-afternoon on the day prior to poisoning in 1951, and at noon in 1952. The corresponding time for the Miller Lake operation in 1947 is unknown. Diluted toxicant was poured over the side of moving boats powered by outboard motors. During application the areas were repeatedly traversed. Dispersion of the poison in weedbeds and shallow portions was accomplished with hand scoops or portable hand-operated pumps. Powdered derris root warranted 5 percent rotenone (4.5 percent in Miller Lake) was used in the first four operations and emulsified rotenone was applied to area B in 1951 and 1952. The concentration of toxicant in all cases was 0.50-0.75 ppm.

Fish collection

During the 3 days following application of the toxicant in areas A and B, as many fish as possible were picked up and the small numbers of those remaining were estimated. In Miller Lake an attempt was made to collect all fish except forage species, some young-of-the-year largemouth bass, some yellow perch, and lesser sunfishes and bluegills, under 3.5 inches in length. The estimated members of observed unrecovered fish, primarily of age group 0, in all operations except area B, 1952, were assigned a total weight on the basis of those actually recovered and weighed. In area B the 1952 collection of forage fish and young-of-the-year specimens was considered to be of little utility because a large quantity of small fish was taken by gulls and terns.

In all operations total length of fish (length from anterior tip of snout to the extreme end of the caudal fin with the lobes compressed) was recorded to the nearest 0.1 inch and weight to the nearest 0.05 pound. General scale samples were taken from areas of the bodies of the various species in accordance with Smith (48). Only length and weight determinations were made of the bowfin, northern longnose gar, shortnose gar, channel catfish, flathead catfish, bullheads, and paddlefish.

Up to 100 scale samples per species were taken in Miller Lake. Additional length measurements, up to approximately 500 for one species, were recorded for the most abundantly represented species. The remaining fish were counted and weighed in bulk. Total number and total weight of all forage fish were estimated. Total lengths and weights were recorded for all fish from area A and from area B in 1948, 1951, and 1952 except young-of-the-year specimens and forage fish for which only numbers and bulk weight were noted. Up to 50 scale samples were collected from each species of importance except as indicated above. In area B, during the 1949 operation, 50 scale samples were taken from most species and an additional 50 length measurements were made if enough fish were available. The remaining fish were counted and weighed collectively by species.

In addition to the fish collected, the numbers of unrecovered small specimens of some species were estimated and assigned a total weight on the basis of recovered samples in the respective size classes.

WEIGHT AND SPECIES COMPOSITION OF THE FISH POPULATIONS

In an analysis of a fishery the determination of the capability of a water to produce fish is of primary importance. The term "fish production" has been employed in the literature to convey two different meanings: 1) the surplus of fish available for harvest in any period, and 2) the total fish population present at any one time. In this study the term is used in the latter sense only. Fish production, or standing crop, is considered here in terms of pounds of fish per acre with discussions of size and age-group composition presented in a later section. The list of fish species in table 1 is complete for the 1948 and 1949 collections in area B but omits the "forage fish" group in the other studies.

The broad nature of the present studies suggested the grouping of all species under six classifications (predators, game fish, panfish, catfish, rough fish, and forage fish) following the precedent established by the Technical Committee for Fisheries of the Upper Mississippi River Conservation Committee in its preliminary reports on other backwater populations (Upper Mississippi River Conservation Committee, 63, 64). Barnickol and Starrett (3) employed grouping of a similar type but pointed out certain inadequacies of the arrangement.

Reliability of estimates

Consideration was given to the efficiency of the toxicant application and fish collection in area B during 1951. Sixteen fin-clipped fish with a minimum length of approximately 6 inches and representing eight species were released prior to application of the toxicant. In addition, one spotted sucker was placed in a wire cage and lowered to the bottom at the deepest point in the area. A 0.25-inch-mesh seine 8 feet wide and 35 feet long was weighted on both the lead and float lines and laid flat on the bottom in the deepest water. On the day following the poisoning a 250-foot experimental gill net and a 1-inch bar mesh frame net with a 50-foot lead were set in the enclosed area.

The condition of the spotted sucker in the cage 3 hours after application of the poison had been completed indicated that death had occurred soon after the toxicant was placed in the water. All of the 16 marked fish were recovered and neither the gill net nor the frame net caught any fish. Only two trout-perch and two small gizzard shad were found in the seine which had been spread on the bottom. Minnows and young-of-the-year crappies placed in a wire cage 56 hours after application of the toxicant showed immediate signs of distress and most of them died within 15 minutes. While individual checks on the efficiency of the toxicant application and fish collection were not conclusive because their scope was limited, as a group they indicated a complete kill and a recovery of fish approaching 100 percent by weight. Although no checks of this nature were made in the other studies, the procedures were similar and therefore it is probable that comparable efficiency was attained except in Miller Lake.

At Miller Lake the poisoning was preceded by netting, seining, and fin-clipping operations to check the relative efficiency of nets used in test netting operations. These activities were

Table 1:--Fish species taken from Miller Lake (1947), Area A (1948), and Area B (1948, 1949, 1951, and 1952).

Species	Miller Lake	Area A	Area B 1948	1949	1951	1952
PREDATORS						
Shortnose gar -- *Lepisosteus platostomus* Rafinesque		X	X	X		
Northern longnose gar -- *Lepisosteus osseus oxyurus* Rafinesque		X	X	X	X	X
Bowfin -- *Amia calva* Linnaeus	X	X	X	X	X	X
GAME FISH						
Northern pike -- *Esox lucius* Linnaeus	X	X	X	X	X	X
Northern largemouth bass -- *Micropterus salmoides salmoides* (Lacepede)	X	X	X	X	X	X
Sauger -- *Stizostedion canadense* (Smith)	X	X	X	X	X	X
Walleye -- *Stizostedion vitreum vitreum* (Mitchill)	X		X	X	X	X
PANFISH						
White bass -- *Morone chrysops* (Rafinesque)		X	X	X		X
Green sunfish -- *Lepomis cyanellus* Rafinesque				X	X	X
Pumpkinseed -- *Lepomis gibbosus* (Linnaeus)	X		X	X	X	X
Northern bluegill -- *Lepomis macrochirus macrochirus* Rafinesque	X	X	X	X	X	X
Orangespotted sunfish -- *Lepomis humilis* (Girard)	X	X	X	X	X	X
Northern rock bass -- *Ambloplites rupestris rupestris* (Rafinesque)			X		X	
White crappie -- *Pomoxis annularis* Rafinesque	X	X	X	X	X	X
Black crappie -- *Pomoxis nigromaculatus* (LeSueur)	X	X	X	X	X	X
Yellow perch -- *Perca flavescens* (Mitchill)	X		X	X	X	X

Table 1 (continued)

Species	Miller Lake	Area A	Area B 1948	1949	1951	1952
CATFISH						
Channel catfish -- *Ictalurus lacustris lacustris* (Walbaum) ...	X	X	X	X	X	X
Northern brown bullhead -- *Ameiurus nebulosus nebulosus* (LeSueur) ...	X					
Northern black bullhead -- *Ameiurus melas melas* (Rafinesque)		X	X	X	X	X
Yellow bullhead -- *Ameiurus natalis* (LeSueur)	X					
Flathead catfish -- *Pilodictis olivaris* (Rafinesque)			X			X
ROUGH FISH						
Paddlefish -- *Polyodon spathula* (Walbaum)						X
Mooneye -- *Hiodon tergisus* LeSueur .						X
Bigmouth buffalo -- *Ictiobus cyprinellus* (Valenciennes)		X	X	X		
Smallmouth buffalo -- *Ictiobus bubalus* (Rafinesque)	X			X		
Northern river carpsucker -- *Carpiodes carpio carpio* (Rafinesque) .		X	X		X	X
Northern redhorse -- *Moxostoma aureolum* (LeSueur)		X	X	X	X	
Spotted sucker -- *Minytrema melanops* (Rafinesque)	X		X	X	X	X
Carp -- *Cyprinus carpio* Linnaeus ...	X	X	X	X	X	X
Freshwater drum -- *Aplodinotus grunniens* Rafinesque		X	X	X	X	X
FORAGE FISH						
Cyprinidae						
Western golden shiner -- *Notemigonus crysoleucas auratus* (Rafinesque)	X		X	X	X	X
Pugnose minnow -- *Opsopoeodus emiliae* Ray			X	X		
Lake Emerald shiner -- *Notropis atherinoides acutus* (Lapham)1/			X			
Northern weed shiner - *Notropis roseus richardsoni* Hubbs and Greene			X	X		

1/ Not listed by Bailey (1951).

Table 1 (concluded)

Species	Miller Lake	Area A	Area B 1948	Area B 1949	Area B 1951	Area B 1952
FORAGE FISH (continued)						
Cyprinidae						
Spottail shiner -- *Notropis hudsonius* (Clinton)			X	X		
Spotfin shiner -- *Notropis spilopterus* (Cope)			X	X		
Northern mimic shiner -- *Notropis volucellus volucellus* (Cope) .				X		
Bullhead minnow -- *Pimephales perspicuus* (Girard)				X		
Bluntnose minnow -- *Pimephales notatus* (Rafinesque)			X			
Northern fathead minnow -- *Pimephales promelas promelas* Rafinesque		X	X			
Gizzard shad -- *Dorosoma cepedianum* (LeSueur)	X	X	X	X	X	X
Tadpole madtom -- *Schilbeodes mollis* (Hermann)	X	X	X	X	X	X
Trout-perch -- *Percopsis omiscomaycus* (Walbaum)			X		X	X
Western pirate-perch -- *Aphredoderus sayanus gibbosus* LeSueur					X	
Northern brook silversides -- *Labidesthes sicculus sicculus* (Cope)			X	X		
Northern logperch -- *Percina caprodes semifasciata* (DeKay) ...		X	X	X		
Central Johnny darter -- *Etheostoma nigrum nigrum* Rafinesque			X	X	X	
Mud darter -- *Etheostoma asprigenis* (Forbes)		X	X	X		
Iowa darter -- *Etheostoma exile* (Girard)				X		

conducted within a 10-day period prior to installation of the block seine. Only 15.9 percent of the marked fish were recovered following application of the toxicant on August 16. Known netting mortality partially accounted for the low recovery of fin-clipped fish but in view of the evidence presented above for area B in 1951, it is likely that the activity preceding installation of the block seine was responsible for the egress of many fish. Since the value of these data is directly related to the extent of fish recovery, the use of the Miller Lake material here is limited.

Standing crops

Miller Lake:--At the time of collection the fish population of Miller Lake, exclusive of forage fish, was composed of 17 species (Table 1). Only three species in the forage-fish group were identified although others were present. On the basis of both recovered[5] and estimated numbers and weights, Miller Lake produced 3,798 fish and 153.8 pounds per acre (Table 2).

5/ The words "recover", "collect", etc. and their derivatives as subsequently employed refer to the total of fish actually recovered and estimated.

Table 2:--Standing crop of fish in Miller Lake, August 15, 1957, expressed as number and pounds per acre of various species.

Species	Number: Number per acre	Number: Percentage of total number	Weight: Pounds per acre	Weight: Percentage of total weight
Predators				
Bowfin	6.1	0.2	9.5	6.2
	6.1	0.2	9.5	6.2
Game fish				
Largemouth bass	194.6	5.1	9.9	6.4
Northern pike	26.3	0.7	16.9	11.0
Sauger	1.6	---	0.4	0.3
Walleye	1.4	---	0.4	0.2
	223.9	5.9	27.6	17.9
Panfish				
White bass	0.1	---	---	---
Bluegill	1,216.1	32.0	63.8	41.5
Black crappie	40.8	1.1	4.1	2.7
White crappie	3.8	0.1	0.8	0.5
Yellow perch	468.3	12.3	6.6	4.3
Miscellaneous contrarchids 1/	42.0	1.1	1.7	1.1
	1,771.2	46.6	77.0	50.1
Catfish				
Northern brown bullhead	5.8	0.2	2.8	1.8
Yellow bullhead	4.4	0.1	2.0	1.3
Channel catfish	0.5	---	1.2	0.8
	10.7	0.3	6.0	3.9
Forage fish				
Gizzard shad	1,260.5	33.2	25.2	16.4
Minnows	188.0	4.4	1.2	0.8
Madtom	336.1	8.8	1.7	1.1
	1,764.7	46.5	28.1	18.3
Rough fish				
Smallmouth buffalo	0.1	---	---	---
Carp	0.2	---	0.1	0.1
Spotted sucker	21.4	0.6	5.5	3.6
	21.7	0.6	5.6	3.7
GRAND TOTAL	3,798.3	---	153.8	---

1/ Includes orangespotted sunfish and pumpkinseed.

Table 3:-Standing crop of fish in area A, July 6, 1948, expressed as number and pounds per acre of various species.

Species	Number: Number per acre	Number: Percentage of total number	Weight: Pounds per acre	Weight: Percentage of total weight
Predators				
Bowfin	3.0	0.2	12.1	30.8
Northern longnose gar	0.7	---	0.1	0.4
Shortnose gar	23.7	1.5	4.9	12.4
	27.4	1.7	17.1	43.6
Game fish				
Largemouth bass	3.7	0.2	0.4	1.1
Northern pike	0.7	---	---	---
Sauger	10.4	0.6	0.7	1.9
	14.8	0.8	1.1	3.0
Panfish				
White bass	77.0	4.8	0.1	0.4
Bluegill	94.8	5.9	2.1	5.3
Black crappie	33.3	2.1	2.8	7.1
White crappie	26.7	1.6	4.0	10.2
Miscellaneous centrarchids 1/	290.4	18.0	0.9	2.3
	522.2	32.3	9.9	25.3
Catfish				
Northern black bullhead	0.7	---	---	---
Channel catfish	2.2	0.1	4.7	12.0
	2.9	0.1	4.7	12.0
Forage fish				
Gizzard shad	182.2	11.3	0.9	2.3
Minnows	170.4	10.5	0.4	0.9
Miscellaneous	26.7	1.6	---	---
	379.3	23.4	1.3	3.2
Rough fish				
Bigmouth buffalo	0.7	---	0.2	0.6
Carp	647.4	40.0	1.7	4.3
Northern river carpsucker	0.7	---	---	---
Northern redhorse	0.7	---	0.1	0.2
Freshwater drum	20.7	1.3	3.0	7.7
	670.2	41.5	5.0	12.8
GRAND TOTAL	1,617.0	---	39.1	---

1/ Includes orangespotted sunfish and undetermined young-of-the-year Centrarchidae.

Table [illegible].--Standing crop of fish in area B, July 7, 19[illegible], expressed as number and pounds per acre of various species.

Species	Number: Number per acre	Number: Percentage of total number	Weight: Pounds per acre	Weight: Percentage of total weight
Predators				
Bowfin	8.3	0.2	33.1	15.2
Northern longnose gar	0.9	---	0.3	0.1
Shortnose gar	9.8	0.3	1.9	0.9
	19.0	0.5	35.3	16.2
Game fish				
Largemouth bass	147.0	4.3	0.8	0.4
Northern pike	4.8	0.1	21.8	10.0
Sauger	9.2	0.3	1.6	0.7
Walleye	2.7	0.1	0.6	0.3
	163.7	4.8	24.8	11.4
Panfish				
White bass	472.0	13.8	1.3	0.6
Bluegill	191.1	5.6	4.0	1.8
Black crappie	636.9	18.7	4.0	1.8
White crappie	64.9	1.9	6.2	2.8
Yellow perch	95.5	2.8	0.3	0.2
Miscellaneous centrarchids[1]	45.8	1.3	0.4	0.2
	1,506.3	44.2	16.2	7.4
Catfish				
Northern black bullhead	0.3	---	---	---
Channel catfish	13.7	0.4	18.3	8.4
Flathead catfish	0.6	---	2.9	1.3
	14.6	0.4	21.2	9.7
Forage fish				
Gizzard shad	451.2	13.3	1.5	0.7
Minnows	776.7	22.6	1.7	0.7
Miscellaneous[2]	83.6	2.5	0.2	0.1
	1,311.5	38.5	3.4	1.5
Rough fish				
Bigmouth buffalo	40.2	1.2	5.7	2.6
Carp	324.4	9.5	98.2	45.3
Northern river carpsucker	3.0	0.1	1.3	0.6
Northern redhorse	7.1	0.2	0.5	0.2
Freshwater drum	5.7	0.2	4.6	2.1
Spotted sucker	11.9	0.3	5.8	2.6
	392.3	11.5	116.1	53.4
GRAND TOTAL	3,410.4	---	217.0	---

2/ Includes madtom, trout-perch, darters, and silversides.

Table 5:--Standing crop of fish in area B, August 3, 1949, expressed as number and pounds per acre of various species.

Species	Number per acre	Percentage of total number	Pounds per acre	Percentage of total weight
Predators				
Bowfin	22.7	0.6	84.3	13.9
Northern longnose gar	8.0	0.2	6.4	1.1
Shortnose gar	19.7	0.4	26.7	4.4
	50.4	1.2	117.4	19.4
Game fish				
Largemouth bass	292.7	7.2	9.2	1.5
Northern pike	6.0	0.1	13.3	2.2
Sauger	6.3	0.2	1.7	0.3
Walleye	3.7	0.1	6.1	1.0
	308.7	7.6	30.3	5.0
Panfish				
White bass	4.0	0.1	1.9	0.3
Bluegill	1,333.0	32.8	12.0	2.0
Black crappie	399.3	9.8	22.6	3.7
White crappie	269.3	6.6	9.0	1.5
Yellow perch	185.7	4.6	0.9	0.1
Miscellaneous centrarchids 1/	175.7	4.3	0.3	---
	2,367.0	58.2	46.5	7.6
Catfish				
Northern black bullhead	1.0	---	0.3	---
Channel catfish	13.3	0.3	37.7	6.3
	14.3	0.3	38.0	6.3
Forage fish				
Gizzard shad	336.3	8.3	156.8	25.9
Minnows	796.0	19.6	1.0	0.2
Miscellaneous 2/	67.2	1.5	0.1	---
	1,195.0	29.4	157.9	26.1
Rough fish				
Bigmouth buffalo	6.3	0.2	7.9	1.3
Smallmouth buffalo	2.7	0.1	2.4	0.4
Carp	69.7	1.7	165.0	27.3
Northern redhorse	0.3	---	0.8	0.1
Freshwater drum	8.7	0.2	9.5	1.6
Spotted sucker	37.7	0.9	29.2	4.8
	125.4	3.1	214.8	35.5
GRAND TOTAL	4,060.7	---	604.9	---

1/ Includes orangespotted sunfish, green sunfish, and pumpkinseed.

2/ Includes madtom, darters, and brook silversides.

Table 6:--Standing crop of fish in area B, August 14, 1951, expressed as number and pounds per acre of various species.

Species	Number: Number per acre	Number: Percentage of total number	Weight: Pounds per acre	Weight: Percentage of total weight
Predators				
Bowfin	17.1	1.3	63.9	31.6
Longnose gar	3.2	0.3	0.2	0.1
	20.3	1.6	64.1	31.7
Game fish				
Largemouth bass	141.0	11.2	9.7	4.8
Northern pike	24.5	1.9	24.4	12.0
Sauger	3.5	0.3	0.6	0.3
Walleye	27.1	2.1	3.6	1.8
	196.1	15.5	38.3	18.9
Panfish				
Bluegill	66.1	5.2	6.9	3.4
Black crappie	286.5	22.7	12.8	6.3
White crappie	55.5	4.4	14.0	7.0
Yellow perch	76.8	6.1	1.3	0.6
Miscellaneous centrarchids 1/	70.6	5.6	0.9	0.4
	555.5	44.1	35.9	17.7
Catfish				
Northern black bullhead	0.3	---	---	---
Channel catfish	10.3	0.8	19.3	9.6
	10.6	0.8	19.3	9.6
Forage fish				
Gizzard shad	60.0	4.8	0.7	0.3
Minnows	324.2	25.7	0.6	0.2
Miscellaneous 2/	63.5	5.0	0.1	---
	447.7	35.5	1.4	0.5
Rough fish				
Carp	0.3	---	1.4	0.7
Northern river carpsucker	3.5	0.3	3.6	1.8
Northern redhorse	0.3	---	0.9	0.4
Freshwater drum	1.3	0.1	1.5	0.7
Spotted sucker	24.8	2.0	36.1	17.9
	30.3	2.4	43.5	21.5
GRAND TOTAL	1,260.5	---	202.4	---

1/ Includes orangespotted sunfish, green sunfish, pumpkinseeds, and rock bass.

2/ Includes madtom, darters, trout-perch, pirateperch, and brook silversides.

Table 7:--Standing crop of fish in area B, September 17, 1952, expressed as pounds per acre of various species.

Species	Pounds per acre	Percentage of total weight
Predators		
Bowfin	90.7	33.3
Northern longnose gar	0.3	0.1
	91.0	33.4
Game fish		
Largemouth bass	0.9	0.3
Northern pike	15.6	5.7
Sauger	2.2	0.8
Walleye	5.4	2.0
	24.1	8.8
Panfish		
White bass	2.8	1.0
Bluegill	0.9	0.3
Black crappie	21.5	7.9
White crappie	17.8	6.5
Yellow perch	0.5	0.2
	43.5	15.9
Catfish		
Northern black bullhead	0.1	---
Channel catfish	36.1	13.2
Flathead catfish	3.5	1.3
	39.7	14.6
Forage fish		
Gizzard shad	0.7	0.2
	0.7	0.2
Rough fish		
Carp	29.6	10.9
Northern river carpsucker	0.6	0.2
Freshwater drum	20.3	7.4
Mooneye	0.4	0.1
Paddlefish	5.4	2.0
Spotted sucker	17.4	6.4
	73.7	27.0
GRAND TOTAL	272.6	---

Area 2.--The fish population of area 2 was comprised of [illegible] identified species (Table [illegible]) and several which were unidentified. A total of [illegible] fish weighing [illegible] pounds or [illegible] fish and [illegible] pounds per acre was recovered (Table [illegible]). Rapid deterioration of minnows and small panfish prevented estimation of unrecovered specimens but this residue affected the total numbers very slightly and had practically no effect on the total weight.

The predator, game fish, panfish, catfish, forage fish, and rough fish groups accounted for [illegible], [illegible], [illegible], [illegible], [illegible], and [illegible] percent, respectively, of the total weight of all fish collected. The species which were the most important on the basis of weight were the bowfin, sauger, white crappie, channel catfish, gizzard shad, and freshwater drum, respectively.

Area 3.--In 1948 and 1949, collections in area 3 included [illegible] and [illegible] species, respectively. No efforts were made to identify all species in 1951 and 1952. The standing crops in terms of pounds per acre were [illegible], [illegible], [illegible], and [illegible] in 1948, 1949, 1951, and 1952, respectively (Tables [illegible]).

In all four years the bowfin, northern pike, channel catfish, and gizzard shad were the most important species of their respective groups on the basis of weight. The black and white crappies alternated between years as the most abundant species in the panfish group, and in the rough fish group the weight contribution of the common sucker exceeded that of carp only in 1951.

Variations in the standing crops in area 3 will be presented more fully in the section on [illegible].

Fluctuations in standing crops in area 3

Annual variations in standing crops of backwater areas were anticipated at the beginning of the study. To determine the nature of the fluctuations, population estimates were made for area 3 in the summers of 1948, 1949, 1951, and 1952. These four estimates varied from [illegible] to [illegible] pounds per acre with an average of [illegible] pounds. The percentage composition of the population by species groups also varied considerably.

Percentage composition.--The percentage composition by weight of the species groups varied considerably in the different years (Table [illegible], Fig. [illegible]). On the average, predators contributed [illegible] percent; game fish, [illegible] percent; panfish, [illegible] percent; catfish, [illegible] percent; forage fish, [illegible] percent; and rough fish, [illegible] percent. These percentages are skewed in favor of the forage-fish group because there was a preponderance of adult[1] gizzard shad in 1949. In that year this group made up [illegible] percent of the total while the average of the other three years was only [illegible] percent. When the adult gizzard shad taken in 1949 were excluded, the average contributions of the various groups were: predators, [illegible] percent; game fish, [illegible] percent; panfish, [illegible] percent; catfish, [illegible] percent; forage fish, [illegible] percent; and rough fish, [illegible] percent. This average composition is believed to be more valid for comparisons than that incorporating the 1949 adult gizzard shad.

Weight per acre.--The average standing crops by species groups in the four population estimates expressed as pounds per acre were: predators, [illegible] pounds; game fish, [illegible] pounds; panfish, [illegible] pounds; catfish, [illegible] pounds; forage fish, [illegible] pounds; and rough fish, [illegible] pounds (Table [illegible], Fig. [illegible]). The average weight of the forage fish is heavily influenced by the large proportion of adult gizzard shad in 1949. Deletion of the weight of this species from the 1949 data results in a total standing crop of [illegible] pounds per acre for that estimate, and reduces the average standing crop of forage fish for all years to [illegible] pounds per acre. It is suggested that

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1/ Refers to gizzard shad larger than young-of-the-year size, regardless of state of maturity, which could readily be separated on the basis of length frequency.

[illegible]

Table [illegible].--[illegible]

Date	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Total
[illegible]							
Percentage total weight	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Pounds per acre	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							
Percentage total weight	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Pounds per acre	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Percentage total weight	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Pounds per acre	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							
Percentage total weight	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Pounds per acre	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							
Percentage total weight	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Pounds per acre	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average:							
Percentage total weight	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Pounds per acre	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Adjusted average:							
Percentage total weight	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Pounds per acre	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

1/ Figures are rounded to the nearest whole number.

2/ [illegible]

3/ Less than [illegible] percent.

4/ [illegible]

5/ Based on collected specimens only.

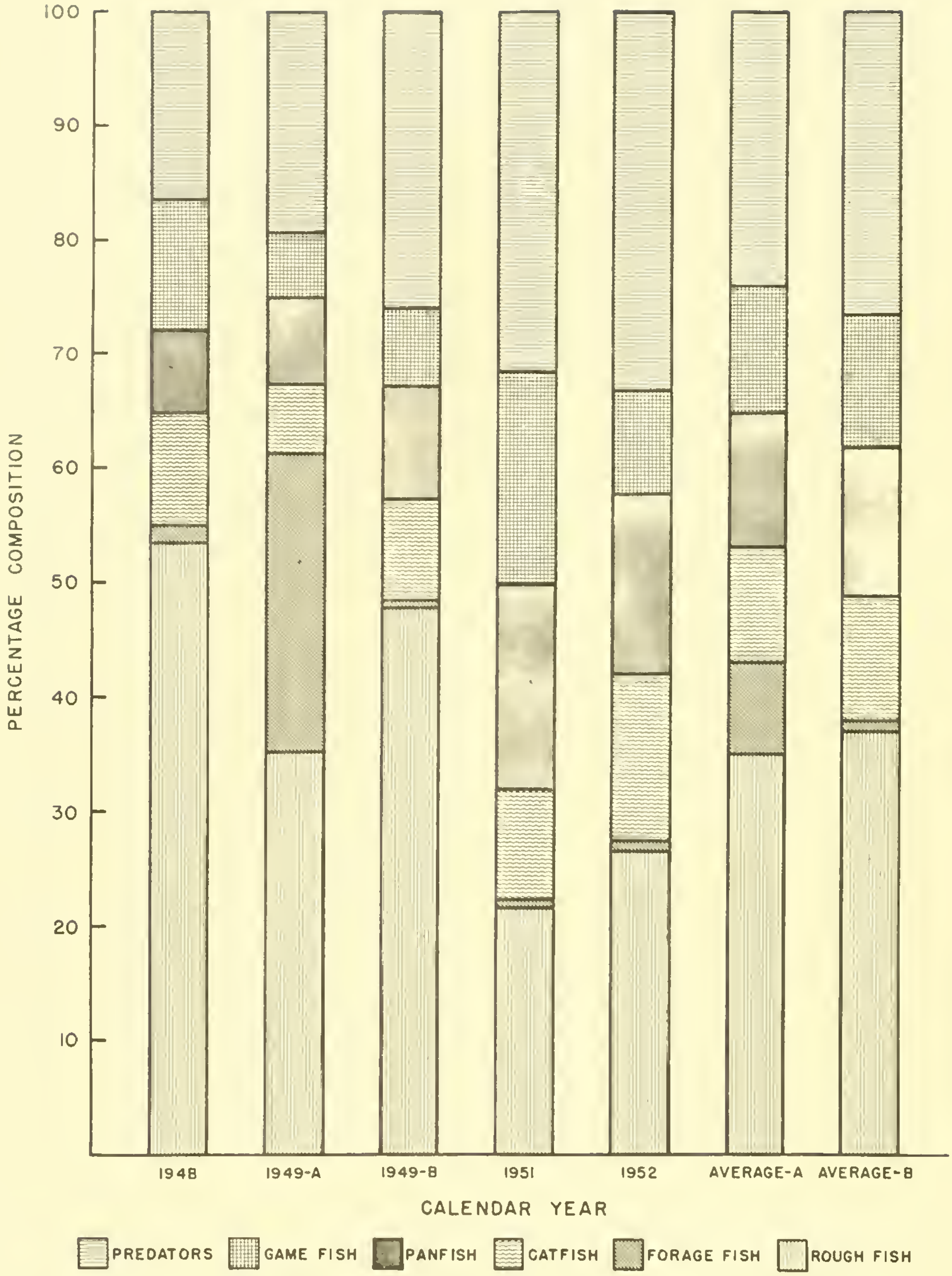

Figure 4:--Percentage composition by weight of the various species groups in the standing crops of area B in 1948, 1949, 1951, and 1952. The 1949-A and average-A columns include gizzard shad collected in 1949. The 1949-B and Average-B columns represent the adjusted percentage composition when adult gizzard shad are excluded.

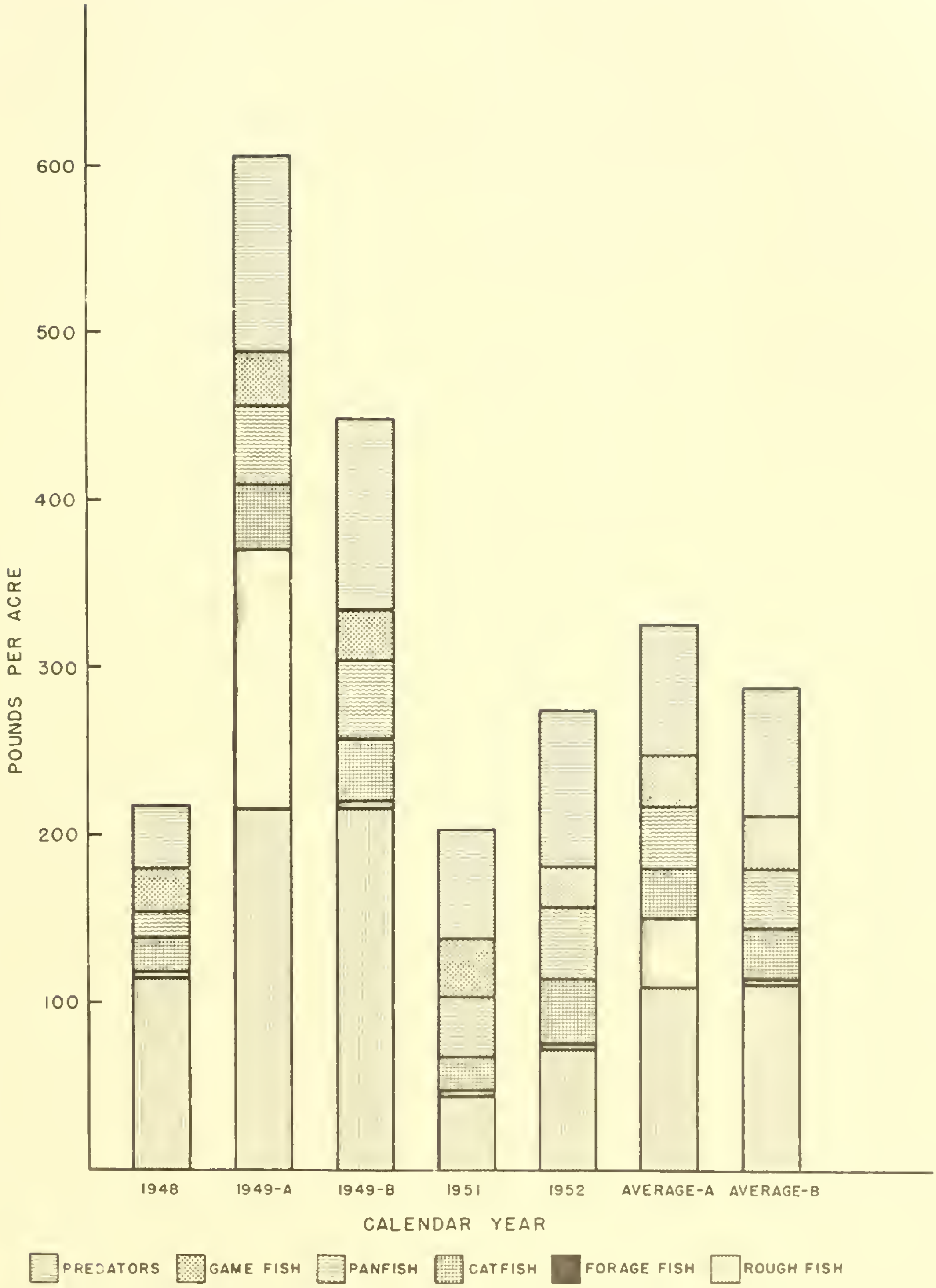

Figure 5:--Standing crops of fish in area B in 1948, 1949, 1951, and 1952 expressed as pounds per acre of the various species groups. The 1949-A and Average-A columns include adult gizzard shad collected in 1949. The 1949-B and Average-B columns represent the adjusted standing crops when adult gizzard shad are excluded.

Table [illegible]:--Standing crops of species groups from northern and southern sections of the upper Mississippi River backwaters expressed as pounds per acre.

Water	Pounds per acre						
	Predators	Game fish	Pan-fish	Cat-fish	Forage fish	Rough fish	Total
Area A	17.1	1.1	9.9	4.7	1.3	5.0	39.1
Area B 1/	77.0	29.0	36.0	30.0	41.0	112.0	324.0
Miller Lake	9.5	27.6	77.0	6.0	28.1	5.6	153.8
Oquawka No. 1	5.1	2.7	10.5	59.8	81.2	210.5	390.6 2/
Oquawka No. 2	3.5	11.1	56.3	19.4	408.4	195.9	694.6
Savanna No. 1	17.7	2.2	24.2	22.1	1.2	103.9	171.4
Savanna No. 2	16.7	14.1	47.4	26.9	12.4	305.4	422.8

1/ Average of 4 years; figures are rounded to nearest pound.

2/ Includes 20.7 pounds per acre listed as "Miscellaneous".

Comparison with other waters

Valid comparison of standing crops may be difficult for several reasons: there may be different methods of procuring population data, e.g., poisoning and mark-recovery (Carlander, 12); there is a lack of estimates from representative waters (Solman, 50); the number of samples is insufficient; and some authors do not present data in a form from which comparable elements may be extracted. Swingle and Smith (56) pointed out that the weight of fish which can be produced in a particular water varies with the species and therefore that when productivity is compared, the same species must be used to secure the most accurate results. This approach to comparison is employed here by species groups rather than with individual species.

Mississippi River backwaters

Information on standing crops was obtained under the auspices of the Upper Mississippi River Conservation Committee from two backwater areas near Savanna, Illinois (Upper Mississippi River Conservation Committee (63) and two near Oquawka, Illinois (Upper Mississippi River Conservation Committee, (64) (Table 9).

These estimates suggest that standing crops in the southern section are larger and have greater rough fish and smaller predator and game-fish components than those in the northern section of the upper river. While the percentage of panfish was much lower in the southern backwaters, the actual mean standing crop of this group approximated that of the area B average. As was the case in area B in 1949, the gizzard shad strongly influenced the total productivity in the two Oquawka areas. Deletion of the contribution of this single species in all cases reduces the difference between the two sections in average standing crops of all other species combined. With this omission the average standing crops of the northern and southern sections were approximately 225 and 294 pounds per acre, respectively. The mean production of area B alone without adult gizzard shad would approximate 285 pounds per acre, which would reduce the variation to insignificance.

Inland waters of adjacent States

Thompson (59) noted that, in contrast to the 500 pounds of fish per acre in most Illinois waters, the carrying capacity of northern Wisconsin and Michigan waters was about 50 pounds per acre or less, and that the intermediate regions with more fertile soils than the northern regions show intermediate poundages. This generalization is strengthened by the information presented in table 10, which tends to show that the average total standing crops are greater in more southerly regions. The major differences, however, are reflected primarily in the abundance of fish in the rough-fish group.

Game-fish production in area B exceeded that reported for northern Wisconsin, northern and southern Minnesota, and Iowa but was similar to that shown for southern Wisconsin and Illinois. The average standing crop of panfish in area B was similar to that found in northern waters, but less than that found in lakes further south.

The mean production of the combined panfish and game-fish groups was higher in area B than in lakes of the north and slightly greater than that reported for Iowa, central Illinois and Illinois River floodplain lakes. It was less than the average standing crops of those species in southern Minnesota, southern Wisconsin, and in three Illinois lakes.

SIZE AND AGE-GROUP COMPOSITION OF POPULATION IN AREA B, 1948-1949

The total standing crop of a water area is an index of its biological productivity, but the potential harvestable crop will depend on the size and age structure of the population. A description of this structure in area B at the time of fish removal in 1948 and 1949 is presented below. Age-frequency distribution in the various samples was determined by aging a number of fish within certain size ranges and then assigning ages to measured fish in these ranges on the basis of percentage composition of various size classes. Since there was only a small amount of overlap between the intervals, a reasonably accurate estimate of age composition of the entire population was obtained.

SIZE AND AGE STRUCTURE

Predators

Bowfin:--In the 1948 collection there were 28 bowfin. Of that number, 27 varied from 21.0 to 25.9 inches in length (Table 11). In 1949, 65 specimens were recovered, of which 62 ranged from 17.0 to 24.9 inches in an uninterrupted 1-inch interval sequence. Forty of the latter group fell within the 21.0- to 23.9-inch interval. The 1948 sample did not indicate the presence of a strong size class which appeared in the 1949 collection as a group of larger fish. The scarcity of fish under approximately 17 inches in both years and in 1951 and 1952, as well, suggests that young and juveniles of this species do not generally inhabit backwater areas of this type in summer.

Shortnose gar:--Twenty-one specimens of shortnose gar under 8.0 inches in length (presumably of age group 0) and 12 between 15.0 and 25.9 inches were collected in 1948. In 1949 only 2 fish of the former size were recovered while 57 between 17.0 and 25.0 inches were collected.

Longnose gar:--The three specimens collected in 1948 were all in the 18.0-18.9-inch interval. Two size groups, 9.0-11.9 inches and 19.0-23.9 inches, were present in the 1949 collection of 34 fish.

Game fish

Largemouth bass:--Young-of-the-year of largemouth bass were abundant in both years. In 1948 only two and three specimens of age groups I and II, respectively, were recovered. In the following year 24 and 10 fish of those respective age groups and 3 of age group III were taken (Table 12).

Northern pike:--Aging of scale samples with a high degree of certainty was not possible for northern pike so age groups cannot be defined. The numbers of specimens recovered in 1948 and 1949 were 16 and 15, respectively (Table 11). The smallest fish in 1948 were in the 22.0-22.9-inch size class, and the largest exceeded 36 inches in length. In 1949, 13 of the 15 fish ranged from 14.0 to 20.9 inches in length and the largest was less than 30 inches.

Table 10:--Average standing crops, in total and by certain species groups, of inland waters of States adjacent to the upper Mississippi River and of Area B.

Location	Number of waters	Average pounds per acre: Panfish	Game fish	Rough fish	Total 1/	Reference
Northern Minnesota	5 2/3/	39	17	2	60	Peterson (40)
Northern Wisconsin	3 3/	31	4	103	139	O'Donnell (39)
Area B	4	36	29	112	324	Present study
Southern Minnesota	44 4/	64	12	283	375	Moyle, Kuehn and Burrows (34a)
Southern Minnesota	68 5/	70	17	13	110	Moyle, Kuehn and Burrows (34a)
Southern Wisconsin	3 3/	169	25	237	442	Juday, (24); Threinen and Helm, (61); Mraz and Threinen (36)
Iowa	2 3/	48	10	690	778	Speaker, (51); Carlander, (11)
Illinois	3 3/	97	33	172	363	Thompson and Bennett (60); Bennett (6, 7)
Central Illinois	9	60 6/	--	--	600	Thompson (59)
Illinois 7/	--	50-55 6/	--	--	400-500	Thompson (59)

1/ Includes predator, catfish, and forage-fish groups, if present.
2/ Littoral areas only.
3/ Data from sources cited averaged by present authors.
4/ Littoral areas only; includes lakes with 40 pounds or more of rough fish per acre.
5/ Littoral areas only; includes lakes with less than 40 pounds of rough fish per acre.
6/ Game fish and panfish combined.
7/ Floodplain lakes in Illinois River valley.

Table 11:--Length-frequency distribution of northern pike, channel catfish, bowfin, bigmouth buffalo, shortnose gar, longnose gar, and gizzard shad recovered from area B in 1948 and 1949.

Size range (total length in inches)	Species							
	Northern pike		Channel catfish		Bowfin		Bigmouth buffalo	
	1948	1949	1948	1949	1948	1949	1948	1949
8.0- 8.9			1					
9.0- 9.9			1					3
10.0-10.9							4	2
11.0-11.9			1					4
12.0-12.9			2					7
13.0-13.9			3		1			
14.0-14.9		2	3			3	2	
15.0-15.9		1	4	2		1	2	
16.0-16.9		1	5	1				
17.0-17.9		4	5	5		1	1	
18.0-18.9		3	7	6		4		1
19.0-19.9		1	7	6		3	1	
20.0-20.9		1		7		6		1
21.0-21.9			1	6	5	11		
22.0-22.9	5			3	10	11		
23.0-23.9				3	7	18		
24.0-24.9		1		1	2	2		
25.0-25.9	2	1			3	3		
26.0-26.9	4					1		
27.0-27.9	1							
28.0-28.9	1	2						
29.0-29.9		1						
30.0-30.9	1							
31.0-31.9								
32.0-32.9	1							
36.0-36.9	1							
Total	16	18	40 1/	40	28	64 2/	10 3/	18 4/

1/ Does not include six specimens not measured.
2/ Does not include four fish not measured.
3/ Does not include 125 fish less than 8.0 inches in length.
4/ Does not include one specimen less than 8.0 inches in length.

Table 11 (continued)

Size range (total length in inches)	Species				
	Shortnose gar		Longnose gar		Gizzard shad
	1948	1949	1948	1949	1949
8.0- 8.9					
9.0- 9.9				1	
10.0-10.9				2	
11.0-11.9				1	351
12.0-12.9					281
13.0-13.9					14
14.0-14.9					42
15.0-15.9	1				28
16.0-16.9	1				
17.0-17.9	6	1			
18.0-18.9		7	3		
19.0-19.9	2	3		1	
20.0-20.9		5		3	
21.0-21.9		6		4	
22.0-22.9		12		3	
23.0-23.9	1	10		3	
24.0-24.9		5		4	
25.0-25.9	1	8			
26.0-26.9				1	
27.0-27.9					
28.0-28.9				1	
29.0-29.9					
30.0-30.9					
31.0-31.9					
32.0-32.9					
33.0-33.9					
34.0-34.9					
35.0-35.9					
36.0-36.9					
Total	12 5/	57 6/	3	24	716 7/

5/ Does not include 21 specimens less than 8.0 inches in length.
6/ Does not include two fish less than 8.0 inches in length.
7/ Based on length frequency in measured sample; does not include 293 specimens less than 8.0 inches in length.

Table 12:--The age, length at capture, and number of largemouth bass recovered from area [illegible] in 1948 and 1949.

Age group	Year class	Number of fish aged	Estimated total number in age group	Percentage of total number	Total length (inches)	
					Range	Average
			1948			
0	1948	7	489	99.0	---	---
I	1947	2	2	0.4	6.4- 8.2	7.3
II	1946	3	3	0.6	10.3-11.0	10.6
Total		12	494	---	---	---
			1949			
0	1949	0	841	96.0	---	---
I	1948	19	24	2.6	6.4- 9.1	7.4
II	1947	10	10	1.1	11.5-12.9	12.0
III	1946	3	3	0.3	13.4-15.3	14.4
Total		32	878	---	---	---

Table 13:--The age, length at capture, and number of saugers recovered from area [illegible] in 1948 and 1949.

Age group	Year class	Number of fish aged	Estimated total number in age group	Percentage of total number	Total length (inches)	
					Range	Average
			1948			
0	1948	2	8	25.8	---	---
I	1947	10	10	32.3	6.4- 7.8	7.1
II	1946	7	7	22.6	9.5-11.1	10.0
III	1945	5	5	16.1	11.9-13.3	12.7
IV	1944	1	1	3.2	---	14.5
Total		25	31	---	---	---
			1949			
0	1949	0	0	---	---	---
I	1948	7	7	36.8	6.2- 8.6	7.3
II	1947	10	10	52.6	9.4-11.8	10.9
III	1946	2	2	10.5	13.7-14.4	14.1
Total		19	19	---	---	---

Table 14.--The age, length at capture, and number of bluegills recovered from area B in 1948 and 1949.

Age group	Year class	Number of fish aged	Estimated total number in age group	Percentage of total number	Total length (inches) Range	Average
			1948			
0	1948	8	399	62.1	---	---
I	1947	39	183	28.6	2.5-4.4	3.8
II	1946	50	55	8.6	4.9-6.6	5.7
III	1945	4	4	0.6	6.1-7.2	6.7
IV	1944	1	1	0.2	---	9.3
Total		102	642	---	---	---
			1949			
0	1949	0	3,103	77.6	---	---
I	1948	17	862	21.6	4.0-5.0	4.5
II	1947	29	29	0.7	5.3-7.2	6.3
III	1946	4	4	0.1	6.7-8.6	7.6
IV	1945	1	1	---	---	9.0
Total		51	3,999	---	---	---

Sauger:--Five age groups of saugers were represented in the 1948 collection of 31 fish (Table 13). Age groups I, II, and III accounted for 32.3, 22.6, and 16.1 percent, respectively, of the total number. Excluding age group 0, the specimens ranged from 6.4 to 14.5 inches in length. In 1949 there were no young-of-the-year among the 19 fish recovered and the oldest specimen was of age group III. The 1947 year class was represented by a like number of fish in both years.

Walleye:--Of nine fish recovered in 1948, eight were of age group 0 and one was of age group V. The 1949 collection of 11 fish was not aged, but six varied from 3.8 to 7.5 inches and five from 17.2 to 22.2 inches in length.

Panfish

Bluegill:--Age groups 0-IV were present in both years (Table 14). In the 2 years age groups III and IV were represented by four and one specimens, respectively. The difference in numbers of young-of-the-year fish recovered in the two years (399 in 1948; 3,103 in 1949) is probably more apparent than real, since the 1949 collection was made approximately 1 month later in the year and the water was lower and clearer than in 1948. This assumption is supported by the fact that more than twice as many specimens of the 1948 year class were recovered in 1949 as 1-year-olds than were taken in the previous season as young-of-the-year. Age group II was more strongly represented in 1948 than in the following year. The largest fish in 1948 and 1949 were 9.3 and 9.0 inches in length, respectively.

Black crappie:--More black crappies of age group I were collected in 1948 than in 1949 but representatives of age group II were much more abundant in the latter year than in the former Table 15). The appearance of this strong 1947 year class in 1949 as age group II could not have been predicted on the basis of recovery data of 1948 when the fish were of age group I. The limited occurrence of fish of the 1945 year class in 1948 is repeated in the 1949 collection. Only four specimens of the 1944 year class were taken in 1948 but nine appeared in the collection a year later. This apparent strength of year class is not shown in the data for any other panfish species in either 1948 or 1949. A sharp decline in representation of older age groups was evident in both years. The largest fish from the combined collection was 12.8 inches in length.

Table 15:--The age, length at capture, and number of black crappies recovered from area P in 1948 and 1949.

Age group	Year class	Number of fish aged	Estimated total number in age group	Percentage of total number	Total length (inches)	
					Range	Average
			1948			
0	1948	10	2,056	96.0	---	---
I	1947	27	52	2.4	4.6- 5.8	5.2
II	1946	23	24	1.1	6.0- 8.8	7.4
III	1945	4	4	0.2	9.0-10.4	9.6
IV	1944	3	4	0.3	10.3-11.7	11.1
Total		67	2,140	---	---	---
			1949			
0	1949	0	941	78.5	---	---
I	1948	12	36	3.1	[illegible].4- 6.6	5.6
II	1947	11	196	16.4	7.2- 8.8	8.3
III	1946	14	14	1.2	9.0-10.2	9.8
IV	1945	2	2	0.2	10.9-11.2	11.1
V	1944	9	9	0.8	11.5-12.8	12.2
Total		48	1,198	---	---	---

White crappie:--In 1948 the age-group composition of the white crappie was characterized by the relatively high number of age group III fish and by the scarcity of young-of-the-year fish (Table 16). The latter deficiency cannot be explained on the basis of poor recovery since a large sample of fingerling crappies was collected and closely examined to separate the two species. Age groups I through III were well represented but only one specimen of age group IV was recovered. The corresponding numbers for 1949 were quite different. Age group 0 was well represented in that year but fish of age group II and over were relatively scarce. The apparent weakness of the 1948 year class indicated by the 1948 collection was not borne out by the 1949 results. In the latter collection the 1948 year class (age group I) was strongly represented. The largest fish in the combined collections was 12.8 inches in length.

White bass:--Natural reproduction of white bass was very successful in 1948 but only one specimen of age group 0 was collected in 1949 (Table 17). This scarcity in the latter year may be indicative of a tendency of white bass to move out of backwater areas with advancing size. Evidence of natural reproduction was also lacking in the 1951 and 1952 samples collected later in the year than that of 1948 and fish of older age groups were not prominent in any of the four

Table 16:--The age, length at capture, and number of white crappies recovered from area B in 1948 and 1949.

Age group	Year class	Number of fish aged	Estimated total number in age group	Percentage of total number	Total length (inches)	
					Range	Average
			1948			
0	1948	6	85	39.5	---	---
I	1947	28	73	33.5	4.6- 6.8	5.4
II	1946	36	36	16.5	6.5- 8.2	7.9
III	1945	22	22	10.1	9.3-10.7	9.9
IV	1944	1	1	0.5	---	10.9
Total		93	218			
			1949			
0	1949	0	655	81.1	---	---
I	1948	29	129	16.0	5.1- 8.0	6.8
II	1947	4	9	1.1	8.5- 9.4	8.9
III	1946	9	9	1.1	10.0-11.2	10.7
IV	1945	5	5	0.6	11.2-12.8	11.8
V	1944	1	1	0.1	---	12.2
Total		48	808			

collections. Age groups I and II were represented by only one fish each in 1948, and in 1949 by nine and one fish, respectively. One individual of age group III was found in 1949.

Yellow perch:--Age groups 0, I, and II of yellow perch were present in 1948 but only young-of-the-year and fish of age group I were found in 1949 (Table 17). These recoveries, together with those of 1951 and 1952, suggest that adult yellow perch were either not abundant in the vicinity or that they do not frequent the habitat type studied during the summer months. The largest fish in the combined collections was 7.4 inches in length.

Catfish

Channel catfish:--Forty of the 46 channel catfish recovered in 1948 ranged from 8.0 to 21.9 inches in length (Table 11). Within this measured sample 24 fish were in the 16.0-19.9-inch size range. In 1949 the size spread of the 40 specimens collected was 15.0 to 24.9 inches and 25 of these fell within the 18.0-21.9-inch interval. No attempt was made to determine the ages of the channel catfish.

Flathead catfish:--Two flathead catfish with total lengths of 21.2 and 21.4 inches were recovered in 1948. None were observed in 1949.

Table 17:--The age, length at capture, and number of white bass and yellow perch recovered from area B in 1948 and 1949.

Age group	Year class	Number of fish aged	Estimated total number in age group	Percentage of total number	Total length (inches)	
					Range	Average
			White bass, 1948			
0	1948	3	1,584	99.9	---	---
I	1947	1	1	0.1	---	7.1
II	1946	1	1	0.1	---	12.5
Total		5	1,586	---	---	---
			White bass, 1949			
0	1949	1	1	8.3	---	3.9
I	1948	9	9	75.0	8.6-9.8	9.3
II	1947	1	1	8.3	---	12.9
III	1946	1	1	8.3	---	14.3
Total		12	12	---	---	---
			Yellow perch, 1948			
0	1948	8	309	96.3	---	---
I	1947	11	11	3.4	4.1-5.4	4.8
II	1946	1	1	0.3	---	7.4
Total		20	321	---	---	---
			Yellow perch, 1949			
0	1949	2	521	93.5	2.6-2.8	2.7
I	1948	15	36	6.5	4.4-6.4	5.3
Total		17	557	---	---	---

Black bullhead:--One black bullhead 5.6 inches in length was collected in 1948. In 1949 three fish ranging from 7.2 to 9.1 inches were recovered.

Forage fish

Gizzard shad:--In 1948 adult gizzard shad were very rare but in 1949 large fish predominated. Of the 1,009 collected in the latter year, 716 ranged from 11.0 to 15.9 inches in length (Table 11). This difference represents the most extreme variation in size-class structure between the two samples of any one species where the fish were present in appreciable numbers during both years.

Rough fish

Carp:--Since difficulty was experienced in aging carp beyond the second year of life, the age distributions indicated below should be considered as approximations. Seven age groups were represented in the 1948 sample which ranged up to 30.4 inches in length (Table 18). Almost 94 percent of the collection was of age group 0. Specimens of age group III comprised a distinct mode, suggesting the occurrence of a strong 1945 year class. Scale samples were not taken in 1949.

Spotted sucker:--Age groups I, II, III, V, and VI of the spotted sucker were represented in the 1948 collection of 40 fish (Table 19). Age groups I (1947 year class) and V (1943 year class) constituted 75.0 and 17.5 percent, respectively, of the total number. The 1944 year class was missing and the 1946 year class was represented by only one fish. In the 1949 collection of 113 fish, the 1947 year class again was predominant with 45.1 percent of the total. The 1946 year class, of which only one was recovered in 1948, accounted for 15.0 percent of the 1949 collection. Two specimens of the 1944 year class were taken. The 1943 year class was still present (one specimen). It is apparent that the 1948 sample gave little indication of the real year-class strength, with the exception of the 1947 hatch.

Freshwater drum:--The 19 freshwater drum taken in the 1948 collection were distributed through age groups 0 to VI (Table 20). Age groups I through VII were present in 1949 (26 fish) with a distinct mode in the distribution represented by the 1947 year class (57.7 percent). This strength of year class was not evident in the 1948 data.

Northern river carpsucker:--Six northern river carpsuckers, Carpiodes carpio carpio (Rafinesque), of age group 0, three of age group I and one of age group VI comprised the entire 1948 collection (Table 18).

Northern redhorse:--Of the 24 northern redhorse, Moxostoma aureolum (LeSueur), recovered in 1948 all but one were of age group 0. The single fish belonged to the 1943 year class (age group V) and measured 17.1 inches in length (Table 18).

Bigmouth buffalo:--The 1948 collection of bigmouth buffalo included 125 fish less than 8.0 inches in length and 10 that ranged between 10.0 and 19.9 inches (Table 11). In the 1949 collection of 19 fish one was less than 8.0 inches in length, 16 ranged between 9.0 and 12.9, and two measured 18.9 and 20.8 inches. Difficulty encountered in identifying annuli prevented assignment of individuals to age groups.

Smallmouth buffalo:--Eight smallmouth buffalo, Ictiobus bubalus (Rafinesque), recovered in 1949 ranged between 9.4 and 14.1 inches and all were of age group I. None was observed in 1948.

Comparison with other Mississippi River areas

Surber (54) found that the important fishes in the Mississippi River sloughs of the Trempealeau, Wisconsin-Winona, Minnesota area which were isolated at low water were the black crappie, bluegill, pumpkinseed, black bullhead, brown bullhead, and yellow perch. The northern pike, bowfin, and largemouth bass were the principal carnivorous species but they were present in relatively lower numbers. The populations in area B were similar but the pumpkinseed, bullheads, and yellow perch were less important.

Table 18:--The age, length at capture, and number of carp, northern carpsuckers, and northern redhorse recovered from area B in 1948.

Age group	Year class	Number of fish aged	Estimated total number in age group	Percentage of total number	Total length (inches)	
					Range	Average
			Carp			
0	1948	10	1,023	93.9	---	---
I	1947	12	12	1.1	10.5-14.4	12.0
II	1946	7	7	0.6	15.6-18.2	17.0
III	1945	22	29	2.6	18.4-22.9	20.9
IV	1944	9	13	1.2	20.9-24.9	22.3
V	1943	4	5	0.5	25.0-28.0	26.7
?	?	1	1	0.1	---	30.4
Total		65	1,090	---	---	---
			Northern carpsucker			
0	1948	0	6	60.0	---	---
I	1947	3	3	30.0	7.2-8.5	7.9
VI	1942	1	1	10.0	---	20.8
Total		4	10	---	---	---
			Northern redhorse			
0	1948	0	23	95.8	---	---
V	1943	1	1	4.2	---	17.1
Total		1	24	---	---	---

Table 19:--The age, length at capture, and number of spotted suckers recovered from area B in 1948 and 1949.

Age group	Year class	Number of fish aged	Estimated total number in age group	Percentage of total number	Total length (inches)	
					Range	Average
			1948			
0	1948	0	---	---	---	---
I	1947	24	30	75.0	4.7-6.4	5.4
II	1946	1	1	2.5	---	10.1
III	1945	1	1	2.5	---	13.5
IV	1944	0	0	0.0	---	---
V	1943	6	7	17.5	15.6-17.5	16.8
VI	1942	1	1	2.5	---	17.4
Total		33	40	---	---	---
			1949			
0	1949	0	0	---	---	---
I	1948	14	38	33.6	6.7-8.4	7.7
II	1947	30	51	45.1	11.3-13.2	12.2
III	1946	3	17	15.0	14.6-15.4	15.0
IV	1945	2	4	3.5	15.7-16.6	16.2
V	1944	2	2	1.8	16.4-16.8	16.6
VI	1943	1	1	0.9	---	16.5
Total		52	113	---	---	---

Table 20:-- Age, length at capture, and number of freshwater drum recovered from area B in 1948 and 1949.

Age group	Year class	Number of fish aged	Estimated total number in age group	Percentage of total number	Total length (inches)	
					Range	Average
			1948			
0	1948	2	7	36.8	---	---
I	1947	2	2	10.5	---	7.6
II	1946	3	3	15.8	11.0-11.9	11.5
III	1945	1	1	5.3	---	14.2
IV	1944	2	2	10.5	15.2-16.0	15.6
V	1943	3	3	15.8	16.7-17.2	17.0
VI	1942	1	1	5.3	---	17.9
Total		14	19	---	---	---
			1949			
0	1949	0	0	---	---	---
I	1948	4	4	15.4	8.2-10.4	9.4
II	1947	15	15	57.7	10.8-13.0	11.9
III	1946	1	1	3.8	---	15.0
IV	1945	2	2	7.7	15.3-16.7	16.0
V	1944	2	2	7.7	18.2-18.4	18.2
VI	1943	1	1	3.8	---	17.9
VII	1942	1	1	3.8	---	19.9
Total		26	26	---	---	---

Of the species represented in area B, only the largemouth bass, bluegill, black crappie, and white crappie were present in sufficient numbers and sizes to warrant comparison of population structure with those in other sections of the river. In the following comparisons, emphasis is placed on longevity of life since the limited collections and the variable methods by which other populations were sampled make other comparisons of doubtful value.

Largemouth bass

The oldest largemouth bass in the combined collections of area B was of age group III. The oldest fish taken in the Illinois-Missouri section of the river was of age group V (Upper Mississippi River Conservation Committee, 62).

Bluegill

The combined 1948 and 1949 collections from area B included only one bluegill of age group IV and only four of age group III. Kelley (25) found the oldest fish collected from the Mississippi River in the vicinity of La Crosse, Wisconsin in the latter half of May to be of age group V. A gradual decline in representation of older fish was apparent as netting progressed and by September age groups IV and V had disappeared from the catch. He ruled out migration as a factor and ascribed the decline primarily to natural mortality. Meehean (32) found no bluegills beyond age group III in Mississippi River sloughs of the Trempealeau area. The oldest fish netted in the Illinois-Missouri waters of the Mississippi River were 5 years of age (Upper Mississippi River Conservation Committee, 62).

Black crappie

The oldest black crappies in the 1948 and 1949 collections from area B were of age groups IV and V, respectively. Kelley (25) noted a decline in trap-net catches of 4- and 5-year-old fish from May to September and concluded the principal cause to be natural mortality. The oldest specimen collected in the Illinois-Missouri waters of the river was of age group VI (Upper Mississippi River Conservation Committee, 62).

White crappie

In area B in 1948 the oldest white crappie was of age group IV (one specimen), and in 1949, one fish of age group V was collected. Kelley (25) noted that by September, very few 4- and 5-year-old fish were being caught in the La Crosse area and again attributed the loss primarily to natural mortality. The oldest fish taken in the Illinois-Missouri section of the river was of age group VI (Upper Mississippi River Conservation Committee, 62).

General consideration of age structure

Data presented in this section suggest that these species in the upper Mississippi River backwaters are generally short-lived. Results of an investigation in several similar areas near La Crosse in 1948 tend to substantiate this hypothesis (Kelley, 25). Few fish of the species studied at La Crosse and in the present investigation were found to be greater than 5 years of age. This age structure is in contrast to much of the published data which show a tendency in many waters of the north central States for populations of the species considered to be longer-lived.

GROWTH RATES OF FISH

Butler and Smith (8) and Appelget and Smith (1) reported on growth of the freshwater drum and the channel catfish in the upper Mississippi River, respectively. Eddy and Carlander (15) presented limited growth-rate data on the white bass and spotted sucker from the Mississippi River and a general summary of the growth rates of several species from the Illinois-Missouri waters of the river was reported by the Upper Mississippi River Conservation Committee (62). Because the number of scale samples taken from each species was relatively small, no attempts have been made to validate the scale method for the present collections. Adequate validation of the method for some of the species included here has not yet been presented but successful employment of the scale method of aging and growth analysis by various investigators is considered to be an adequate basis for its acceptance in the present case. Eddy and Carlander (15) presented general growth summaries for all species herein studied except the orange-spotted sunfish, *Lepomis humilis* (Girard). Smith and Moe (49) and Moyle (34) also reported such summary data for all species considered here except the white crappie, spotted sucker, orangespotted sunfish, bigmouth buffalo, and smallmouth buffalo.

A rectilinear relationship between total body length and length of the anterior scale radius was used for all growth calculation. The values of the correction for length at time of scale formation, where used (Table 21), were taken from various sources except for carp. Following the method of Butler and Smith (8) for examination of scale pocket formation, the average total length at time of scale formation (in the area of the body from which samples were taken) of carp was found to be 0.9 inches.

Table 21:--Values of correction for length at time of scale formation in the various species used in growth calculations.

Species	Correction Total length in inches
Largemouth bass	0.8
White bass	[illegible].0
Bluegill	0.86
Bigmouth buffalo	[illegible]
Smallmouth buffalo	[illegible].0
Carp	0.9
Black crappie	0.[illegible]
White crappie	0.[illegible]
Freshwater drum	[illegible]
Yellow perch	[illegible]
Sauger	[illegible]
Spotted sucker	[illegible]
Orangespotted sunfish	0.[illegible]

Back calculations of length at various annuli were made by the use of manila tagboard strips marked from the projected scale image and a straightline nomograph (Carlander and Smith, 13). Two scales from each sample were read to minimize the influence of variability of the scales. Size of the samples and incomplete sex data did not permit separate calculations for each sex.

References in this section to the number of year classes or age groups present exclude young-of-the-year (age group 0).

Miller lake

Growth-rate calculations were made for eight species from Miller Lake (Table 22). For each of these species the difference in numerical representation of the 1944 and 1945 year classes (age groups III and II) was extensive. Because so few specimens of the former year class were present, significant figures for most species are limited to age groups I and II. In general, very poor growth was shown for all species in 1945. Since that year class strongly affects the weighted calculations due to its strong representation in the samples compared to other year classes, the resulting data are not considered to be representative of the general growth picture for the area. Butler and Smith (8) found similar conditions in the 1945 year class of the freshwater drum.

22:--Grand average calculated total lengths in inches at time of annulus formation of various species, sexes combined, from Miller Lake, August 15, 1947.

Species	Number in sample by year class				Total number	Annulus			
	1943	1944	1945	1946		I	II	III	IV
Largemouth bass			27	38	65	3.2	6.0		
Bluegill		1	83	17	101	1.6	3.8	6.9	
Black crappie		1	44	44	89	2.0	4.4	8.1	
White crappie	1	1	16	12	30	1.9	4.7	8.0	9.1
Yellow perch	1	5	35	68	109	2.8	5.7	8.9	10.5
Northern pike		1	21	38	60	8.9	15.7	20.8	
Sauger			7	7	14	4.5	8.8		
Spotted sucker		5	36	35	76	1.9	6.7	11.7	

Areas A and B

The growth-rate calculations for various species from areas A and B have been combined where an increase in the size of the sample of poorly represented year classes would result. It is assumed that fish from both areas represent the same population because: 1) there is agreement in the growth-rate calculations among well-represented year classes of certain species; 2) both areas open upon the same unobstructed channel during low water stages; and 3) at high water levels both are virtually contiguous and offer an opportunity for random distribution of fish over the entire area. Robert Sharp[7]

7/Personal communication, December 14, 1951.

demonstrated that fish will move into flooded areas during high water stages. He eradicated fish from a rearing pond at the U.S. Fishery Station, Guttenberg, Iowa, which had been dry in the fall of 1950 but from which 124 pounds of fish per acre were obtained after recession of the flood water in the spring of 1951. Fish had access to the pond for approximately 2 weeks, during which time 16 identified species had moved into the area. Random movement of several species into and out of a Mississippi River backwater area has also been reported (Upper Mississippi River Conservation Committee, 64). Surber (54) related similar activity in Mississippi River sloughs to changes in water level.

Bluegill:--The growth of bluegills was determined from 169 fish collected from area A, and area B, 1948 and 1949. Although this sample was larger than that of any other species examined, the oldest age group was in its fifth season of growth (age group IV) and was represented by only two specimens. The average calculated total lengths at the end of each year of life of the four age groups present were 2.0, 4.4, 6.4, and 8.4 inches, respectively (Table 23).

The bluegills collected in areas A and B grew much faster than those from waters in various localities listed in table 24. The average calculated total lengths of age groups III and IV exceeded the average total lengths at capture for the corresponding age groups of the bluegill in 17 southern Wisconsin lakes (Mackenthum, 30) and were larger than the Michigan average total lengths at capture for the same two age groups (Beckman, 4).

Black crappie:--Growth rate of the black crappie collected in area A, and area B in 1948 and 1949 was calculated from 132 scale samples. Since the five year classes found in these areas were all well represented, we believe the average growth calculated from this collection more truly represents actual conditions than those determined for other species. At the end of each of the first five growing seasons, the black crappie averaged 2.7, 5.7, 8.5, 10.3, and 11.4 inches, respectively, in total length (Table 25).

With two exceptions, the growth of the black crappie in the Fountain City backwater areas was generally faster than that cited in several waters in various localities (Table 26). After the third growing season, average calculated growth in areas A and B was greater than the Michigan (Beckman, 1949) and southern Wisconsin (Mackenthun, 29) average total lengths at capture for corresponding age groups.

Table 23.--Grand average calculated total lengths in inches at time of annulus formation of the bluegill, sexes combined, from area A, 1948, and area B, 1948 and 1949.

Year class	Year of capture	Age group	Number of specimens	Area of capture	Annulus I	Annulus II	Annulus III	Annulus IV
1948	1949	I	17	B	2.6			
1947	1948	I	8	A	2.2			
	1948	I	39	B	2.2			
	1949	II	29	B	2.0	4.7		
1946	1948	II	14	A	1.7	3.9		
	1948	II	50	B	1.9	4.3		
	1949	III	[illegible]	B	1.8	4.3	6.6	
1945	1948	III	2	A	1.5	3.9	6.1	
	1948	III	[illegible]	B	1.6	4.0	5.9	
	1949	IV	1	B	2.7	4.9	7.2	8.3
1944	1948	IV	1	B	2.2	5.1	7.5	.5
Grand average calculated length					2.0	[illegible]	6.4	8.4
Number of fish			169		169	105	12	2

Table 24.--[illegible]

Locality	Reference	I	II	III	IV
[illegible]	Present study	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

1/ [illegible]
2/ [illegible] from graph.

Table [illegible].--Grand average calculated total lengths in inches at time of annulus formation of the black crappie, sexes combined, from [illegible].

Year class	Year of capture	Age group	Number of specimens	Area of capture	Annulus I	II	III	IV	V
1948	1949	I	12	B	3.1				
1947	1948	I	23	A	2.8				
	1948	I	27	B	2.8				
	1949	II	11	B	2.7	[illegible]			
1946	1948	II	[illegible]	A	2.9	[illegible]			
	1948	II	23	B	[illegible]	[illegible]			
	1949	III	[illegible]	B	[illegible]	5.8	7.0		
1945	1948	III	[illegible]	B	[illegible]	[illegible]	[illegible]		
	1949	IV	2	B	2.9	[illegible]	[illegible]	10.[illegible]	
1944	1949	IV	3	B	2.5	[illegible]	[illegible]	10.2	
	1949	V	9	B	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Grand average calculated length					2.7	[illegible]	[illegible]	[illegible]	[illegible]
Number of fish			132		132	[illegible]	[illegible]	[illegible]	[illegible]

Table [illegible].--Calculated total lengths in inches at various annuli of the black crappie from different localities.

Locality	Reference	Annulus I	II	III	IV	V
[illegible]	Present study	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
Iowa, East Lake	Lewis [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Indiana, Foots Pond	Ricker and Lagler [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Roach and Evans [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table [illegible].--Grand average calculated total lengths in inches at time of annulus formation of the white crappie, sexes combined, from [illegible], area B, 1948 and 1949.

Year class	Year of capture	Age group	Number of specimens	Area of capture	Annulus I	II	III	IV	V
1948	1949	I	29	B	3.0				
1947	1948	I	1[illegible]	A	2.7				
	1948	I	2[illegible]	B	2.7				
	1949	II	[illegible]	B	3.1	6.[illegible]			
1946	1948	II	12	A	2.[illegible]	[illegible]			
	1948	II	36	B	[illegible].3	5.9			
	1949	III	6	B	[illegible].5	[illegible]	[illegible]		
1945	1948	III	[illegible]	A	[illegible]	[illegible]	[illegible]		
	1948	III	22	B	[illegible]	[illegible]	[illegible]		
	1949	IV	5	B	[illegible]	[illegible]	[illegible]	[illegible]	
1944	1948	IV	[illegible]	B	2.3	[illegible]	[illegible]	[illegible]	
	1949	V	1	B	2.3	[illegible]	[illegible]	[illegible]	[illegible]
Grand average calculated length					2.6	6.0	9.[illegible]	10.9	11.[illegible]
Number of fish			165		165	[illegible]	[illegible]	[illegible]	1

Table [illegible].--Calculated total lengths in inches at various annuli of the white crappie from different localities.

Locality	Reference	Annulus I	II	III	IV	V
[illegible]	Present study	[illegible]	[illegible]	[illegible]	10.9	11.[illegible]
Iowa, Red Haw Lake	Lewis (1950a)	[illegible]	7.[illegible]	[illegible]	[illegible]	[illegible]
Minnesota average	[illegible] (19[illegible])	[illegible]	5.5	[illegible]	[illegible]	10.[illegible]
Indiana, Foots Pond	Ricker and Lagler (19[illegible])	[illegible]	5.8	8.6	10.[illegible]	11.5
Ohio average	Roach and Evans (19[illegible])[1]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Iowa, Clear Lake	Erickson (1952)	[illegible]	5.[illegible]	7.[illegible]		
Iowa, East Lake	Lewis (1950a)	[illegible]	5.[illegible]	[illegible]	[illegible]	[illegible]
Iowa, Lake Ahquabi	Hennemuth (1955)	[illegible]	[illegible]	[illegible]	[illegible]	

1/ Estimated from graph.

White crappie:--Growth-rate calculations were made from 165 scale samples from the white crappie from area A, and area B, 1948 and 1949. Five age groups were represented but only one fish of age group V was present. The generally poor growth in 1945, previously referred to, is most clearly demonstrated in these calculations, although it is also evident in those for the bluegill and black crappie. The average calculated total lengths at the end of each of the first five growing seasons were 2.6, 6.0, 9.1, 10.9, and 11.7 inches (Table 27).

The growth of the white crappie in areas A and B was generally faster than that shown for other waters in table 28. Average total lengths at capture of age groups IV and V approximated those of Lake Decatur, Illinois, which Hansen (20) considered to represent average or slightly better than average growth for the State.

Largemouth bass:--Growth rate was determined from the scales of 32 fish collected during the 1949 poisoning of area B. Only three age groups were represented in the entire population. Grand average calculated total lengths at the time of annulus formation for age groups I, II, and III were 4.0, 9.6, and 12.8 inches, respectively (Table 29).

Table [illegible].--Grand average calculated total lengths in inches at time of annulus formation of several species, sexes combined, from the combined area A, 194?, and area B, 1948 and 1949, collections (number of specimens shown in parentheses).

Species	Total number of specimens	Annulus I	II	III	IV	V	VI	VII
Largemouth bass	32	4.0(32)	9.6(13)	12.8(3)				
Sauger	42	4.9(42)	9.0(25)	11.9(8)	13.6(1)			
Carp	54	7.7(54)	14.8(42)	19.1(35)	22.1(13)	25.8(4)		
Freshwater drum	37	5.0(37)	9.6(31)	12.5(13)	14.8(11)	16.[illegible](7)	17.5(3)	19.3(1)
White bass	11	5.7(11)	10.7(2)	13.4(1)				

The growth of the largemouth bass in these areas was considerably more rapid than the Wisconsin average (Bennett, 5), the Minnesota average, and that in three Iowa lakes (Lewis, 27; Ruhr, 45). It was also faster than the rate shown by this species in southern Wisconsin waters (Bennett, 5) and in Sportsmens Lake, Illinois (Thompson and Bennett, 60). Bennett (6) reported a faster growth rate in Onized Lake, Illinois. The average total lengths at capture exceeded those of the corresponding age groups in the Michigan average (Beckman, 4).

Sauger:--Calculation of growth rate was made from 42 scale samples collected in area B in 1948 and 1949. Total lengths at the end of each of the first four growing seasons were 4.9, 9.0, 11.9, and 13.6 inches, respectively (Table 29).

The growth of saugers in area B was much faster than that in Lake of the Woods, Minnesota (Carlander, 9) and was also well above the Minnesota average. It closely approximated that in Lake Erie (Van Oosten, 67).

Carp:--Growth calculations were made from the scales of 54 carp taken in area B in 1948. Difficulty was encountered in the interpretation of the various apparent annuli on the scales from fish over 2 years of age and 12 scale samples of the original 66 in the collection were discarded. A similar problem was reported by English (17) and the Upper Mississippi River Conservation Committee (62). Average calculated total lengths at the end of each of the first five growing seasons were 7.7, 14.8, 19.1, 22.1, and 25.8 inches, respectively (Table 29).

The growth rate of carp approximated that of the Minnesota average. English (17) reported a faster growth of carp in Clear Lake, Iowa.

Spotted sucker:--Growth was calculated from a collection of 85 scale samples taken in area B in 1948 and 1949. Six age groups were present but age group VI was represented by only one fish in each of the 2 years. The average calculated total lengths at the end of each of the first six growing seasons were 2.4, 8.0, 11.2, 13.8, 15.6, and 16.3 inches respectively (Table 30).

Table 30:--Grand average calculated total lengths in inches at time of annulus formation of the spotted sucker, sexes combined, from area B, 1948 and 1949.

Year class	Year of capture	Age group	Number of specimens	Annulus I	II	III	IV	V	VI
1948	1949	I	14	3.3					
1947	1948	I	24	2.5					
	1949	II	30	2.2	8.7				
1946	1948	II	1	1.3	7.1				
	1949	III	1	1.9	7.3	12.8			
1945	1948	III	1	2.2	7.4	12.3			
	1949	IV	2	2.4	7.3	11.7	14.6		
1944	1949	V	2	1.7	5.4	9.7	12.9	15.3	
1943	1948	V	6	2.0	6.9	10.9	14.0	15.9	
	1949	VI	1	2.3	5.8	9.5	12.5	14.1	15.6
1942	1948	VI	1	2.0	7.1	10.9	13.8	15.7	16.9
Grand average calculated length				2.4	8.0	11.2	13.8	15.6	16.3
Number of fish			85	85	47	16	12	10	2

Freshwater drum:--Growth calculations were made from a collection of 37 fish from area B in 1948 and 1949. Seven age groups were present but age group VII was represented by only one specimen. The average calculated total lengths for age groups I-VII were 5.0, 9.6, 12.5, 14.8, 16.5, 17.5, and 19.2 inches, respectively (Table 29). These determinations exceeded both those reported by Van Oosten (66) for Lake Erie and by Kuehn (26) as the average for three Minnesota lakes.

White bass:--The growth rate of the white bass was determined from a collection of 11 scale samples. Three year classes were represented but only one fish of each of the two older age groups was included. Calculated total lengths for age groups I, II, and III were 5.7, 10.7, and 13.4 inches, respectively (Table 29). This growth exceeded the Minnesota average and that in Lake Erie (Van Oosten, 67), and approximated that in Clear, Storm, and Spirit lakes, Iowa (Lewis, 28; Sigler, 46, 47).

Yellow perch:--All but one of 27 yellow perch collected in area B in 1948 and 1949 were of age group I, the single exception being of age group II. The average calculated total lengths of age groups I and II were 2.6 and 6.1 inches, respectively.

Bigmouth buffalo:--The average calculated total length of age group I, based on a collection of 16 fish of that age group from area B in 1949, was 5.1 inches. Annuli could not be identified on scales of two larger specimens collected at the same time.

Smallmouth buffalo:--Eight smallmouth buffalo were collected in area B in 1949. All were of age group I and the average calculated total length at time of annulus formation was 5.8 inches.

Orangespotted sunfish:--Of 18 fish collected from area A, all but one were of age group I, the lone exception being of age group II. The average calculated total lengths of age groups I and II were 1.1 and 2.6 inches, respectively.

Comparison of growth in areas A and B and Illinois waters of the Mississippi River

General growth-rate information for several species in the Illinois-Missouri waters of the Mississippi River were reported by the Upper Mississippi River Conservation Committee (62). Data for six species taken from this report, together with a summary of findings of the present study, are shown in table 31. Since the growth figures for the lower section of the river appeared in a brief tabular form with no details concerning the manner of calculation, a precise comparison is not possible. In addition, growth of certain species was based on average total lengths at capture for which the dates are unknown.

The growth of both the black and white crappies in areas A and B was faster than that for these species in the Illinois-Missouri waters of the Mississippi River. Reliability of this

Table 31:--Growth rates of six species in areas A and B and Illinois-Missouri waters of the Mississippi River expressed as total lengths in inches. Except where indicated, calculated lengths are shown.

Species	Number of specimens	Annulus I	II	III	IV	V
Largemouth bass						
Areas A and B	32	4.0	9.6	12.8		
Illinois-Missouri	119	4.4	8.6	11.1	12.9	14.2
Bluegill						
Areas A and B	169	2.0	4.4	6.4	8.4	
Illinois-Missouri	105	3.0	5.3	6.6	7.3	7.8
Black crappie						
Areas A and B	132	2.7	5.7	8.5	10.3	11.4
Areas A and1/	64	5.1	7.4	9.6	11.1	
Areas A and2/	48	5.6	8.3	9.8	11.1	12.2
Illinois-Missouri3/	142	---	5.7	7.6	8.6	9.6
White crappie						
Areas A and B	165	2.6	6.0	9.1	10.9	11.7
Areas A and B1/	117	5.4	7.9	9.7	10.9	
Areas A and B2/	48	6.8	8.9	10.7	11.8	12.2
Illinois-Missouri3/	220	5.3	7.2	8.4	9.8	10.2
Freshwater drum						
Areas A and B	37	5.0	9.6	12.5	14.8	16.5
Areas A and B1/	11	7.6	11.5	14.2	15.6	17.0
Areas A and B2/	26	9.4	11.9	15 0	16.0	18.2
Illinois-Missouri3/	303	5.5	8.9	11.2	12.5	14.3
Sauger						
Areas A and B	42	4.9	9.0	11.9	13.6	
Illinois-Missouri	44	5.3	10.8	10.8	14.5	

1/ Average lengths at time of capture, July 6-7, 1948.

2/ Average lengths at time of capture, August 3, 1949.

3/ Average lengths at time of capture, 1944 (no dates given).

conclusion is enhanced by the availability of comparatively large samples from both regions and by demonstration of greater average calculated lengths of age groups III, IV, and V of fish from areas A and B than of average lengths at capture of fish in corresponding age groups from the Illinois-Missouri section. Growth of the white crappie in the Fountain City backwaters also exceeded that reported by Hansen (20) at three stations in the Illinois-Iowa waters of the Mississippi River. Of the two species, the white crappie grew faster in both the Fountain City area and the Illinois-Missouri-Iowa section (Barnickol and Starrett, 3).

The freshwater drum also exhibited faster growth in areas A and B than it did in the Illinois-Missouri section of the river. Reasonable agreement between the growth data in the present study and those of Butler and Smith (8) tends to support this conclusion. Average calculated lengths of advanced age groups of fish from the Fountain City areas exceeded the average lengths at capture of corresponding age groups in the lower part of the river.

On the basis of annual length increments and on calculated lengths of the oldest age group common to samples from both sections of the river, growth of the bluegill and largemouth bass appeared to be faster in the Fountain City areas when it is compared to that in Illinois-Missouri waters; however, because collections of older-age fish of both species were limited, this evidence is considered to be weak.

Growth of the sauger appeared to be slower in areas A and B than in the lower section of the river.

Appelget and Smith (1) reported a growth rate of the channel catfish in Iowa-Wisconsin waters which apparently was slower than that in the Illinois-Missouri section (Upper Mississippi River Conservation Committee, 62). Barnickol and Starrett (3) reported the growth of this species to be faster in the Illinois-Missouri section than in Illinois-Iowa waters of the river.

The foregoing comparisons tend to confirm the ratings given by Hatner (41) concerning water quality in relation to fish production in the upper Mississippi River. He found that in comparison with waters producing good fish fauna, the Mississippi River would be rated good in the upper section and only fair in the lower section. However, recent findings, which indicate faster growth of the channel catfish and sauger in the lower section than in the upper portion, demonstrate that the fish species themselves must be given primary consideration in any evaluation of fish-growth potential of a water.

General consideration of growth

Without exception the growth rate of each species examined in the present study exceeded[8/] those previously cited as averages of two or more waters in Minnesota, Wisconsin, southern Wisconsin, Illinois, Michigan, northern Indiana, and Ohio. The growth of certain species also exceeded or approximated that reported for individual waters in Illinois, Indiana, Iowa, and Minnesota, with the following exceptions: 1) carp in Clear Lake, Iowa; 2) largemouth bass in Onized Lake, Illinois; and 3) black crappies in Onized Lake, Illinois, and Red Haw Lake, Iowa. It is evident, considering the geographic region and the latitude, that the growth of the fish species studied from areas A and B was comparatively fast.

FACTORS INFLUENCING PRODUCTIVITY AND POPULATION DEVELOPMENT

Detailed investigation of conditions which influence fish production was not attempted in the present study. The rather limited data from other areas, however, which compare environmental factors with standing crops of fish justify a short discussion of observed conditions and related data from other sources. Among the elements most likely to affect population levels are water and soil fertility, food availability, species composition, and water-level fluctuation.

8/Average total lengths of the younger age groups were less than those shown from other studies in certain cases but those of the older age groups were consistently greater in the present study.

Water and soil fertility

Water fertility.--It is generally recognized that fertility of surface water is primarily dependent upon fertility of the watershed from which it drains. A major share of the 47 percent of Minnesota land classed as good to excellent for general agricultural production (Engene and Pond 16) lies in the upper Mississippi River drainage. It includes much of the Clarion-Webster soil association which is unsurpassed by any other in the State for corn production (McMiller, 31). It might then be expected that the water which drains from this region would also be fertile. Water analyses 9/ were run on samples collected in area B and vicinity on October 3, 1955 and July 24, 1956 and in the main channel at La Crosse, Wisconsin on September 10, 1956 (Table 32). Concentrations of total phosphorus in and near area B ranged from 0.091 to 0.114 ppm and those of total nitrogen from 0.69 to 1.43 ppm. The average phosphorus-nitrogen ratios in water samples collected October 3, 1955 and July 24, 1956 were 1:8.2 and 1:10.9, respectively. Total alkalinity ranged from 100.0 to 115.0 ppm among the combined samples from area B and vicinity.

Moyle (33) reported that total alkalinity and total phosphorus appear to be the most valuable indices of lake productivity in Minnesota waters. Lakes with a total alkalinity of 91 ppm or more were classed as high in both fish and plant productivity. Those with a total phosphorus content (unfiltered samples) of 0.051 to 0.10 and 0.11 to 0.20 were rated good and very good, respectively, in terms of phosphorus fertility. Moyle found the average fish yields from hard water ponds with total phosphorus exceeding 0.05 ppm to be highest when total nitrogen ranged from 0.51 ppm to 1.0 ppm although nitrogen appears to be only occasionally a limiting factor in the productivity of Minnesota waters.

9/ Analyses were run at the laboratory of the Minnesota Department of Conservation, Bureau of Research and Planning, St. Paul, Minnesota.

The basic components generally associated with fertility were found in the present study to equal or exceed those values described above which are indicative of heavy fish production and it is concluded that chemical fertility of the upper Mississippi River is high and capable in that regard of supporting a fish population at a proportionate level.

Bottom soils.--The importance of bottom soils in fish culture in Europe is described by Neess (38) in his review of numerous papers. The bottom soil in area B was a silty clay in texture and had a organic content of 7.49 percent (Table 33). The soils of both the side channel adjacent to area B and the main channel were of a coarser texture and contained less organic material.

In a series of Minnesota walleye rearing ponds, Dobie (14) found higher fish production in ponds with fine-textured soils than in those with the bottom composed of coarse material. Wood (68) concluded that the availability of essential plant nutrients in the bottom soils is one of the two most important factors affecting the productivity of impoundments.

The pressure of fine-textured soil with a higher organic content than that associated with the coarser soils of the adjacent lotic environments suggests that the backwater areas in the upper Mississippi River represent a major component of the entire fish-producing habitat.

Food availability

That fish production is directly related to the abundance of food in plankton or macroinvertebrate form has often been suggested.

Surber (54) found an abundance of phytoplankton and rotifers in samples from upper Mississippi River sloughs. He reported Cyclops, chironomid larvae, and ostracods to be the "animal staples" in these waters.

Comparison of bottom fauna and epifauna production in 1929-30 with that in 1953 in three sloughs located approximately 20 miles below Fountain City was reported by the Upper Mississippi River Conservation Committee (65) (Table 34). In the 1953 samples, copepods,

Table 32:--Results of chemical analyses run on water samples collected in area B and vicinity on October 3, 1955 and July 24, 1956 and in the main channel at La Crosse, Wisconsin on September 10, 1956. All values are expressed in parts per million.

Location	Sulfates	Total phosphorus	Chlorides	Ammonia	Organic nitrogen	Total nitrogen	Total alkalinity
			Area B and vicinity, October 3, 1955				
Area B, surface	16.0	0.095	4.0	0.12	0.66	0.82	102.5
Area B, 4-foot depth	18.0	0.120	4.2	0.18	0.59	0.69	102.5
Side channel, surface	19.0	0.091	[illegible].0	0.15	0.86	0.98	103.8
Main channel, surface	16.0	0.105	4.4	0.20	0.51	0.86	100.0
Main channel, 6-foot depth	17.0	0.098	4.0	0.18	0.44	0.83	101.3
			Area B and vicinity, July 24, 1956				
Area B, surface	66.0	0.114	6.0	0.00	0.96	1.21	115.0
Area B, 4-foot depth	71.5	0.109	6.3	0.00	1.11	1.[illegible]3	113.8
Main channel, surface	66.0	0.116	6.0	0.00	1.00	1.07	115.0
			La Crosse, Wisconsin, September 10, 1956				
Main channel, surface	26.0	0.174	8.1	0.03	0.75	0.79	127.5

Table 33:--Texture and organic material content of bottom soils of area B, the adjacent side channel, and the main channel collected October 3, 1955.1/

Location	Texture	Percentage of organic material
Area B	Silty clay	7.49
Side channel	Coarse loamy sand	2.64
Main channel	Coarse sand	0.74

1/ Analyses were run at the laboratory of the Minnesota Department of Conservation, Bureau of Research and Planning, St. Paul, Minnesota.

Table 11.--Production of bottom fauna and epifauna of three Mississippi River sloughs near Trempealeau, Wisconsin during the spring periods of 1929 and 1930 and on May 26, 1953, expressed as average number of organisms per square meter.[1/]

Organisms	Gibbs Slough		Goose Pond		Franks Bay	
	1929-30	1953	1929-30	1953	1929-30	1953
Bryozoa	11	290	53	36	---	51
Turbellaria	5	9,188[2/]	3	9,602[2/]	---	---
Nematoda	730	1,451	503	517	333	1,709
Oligochaeta	1,773	8,565	1,992	1,838	1,377	2,311
Hirudinea	57	---	130	7	---	---
Gastropoda and Pelecypoda	3,301	173	991	112	1,162	55
Acarina	69	11	21	2	227	---
Amphipoda	11	140	36	116	213	65
Copepoda	1,111	13,008	15,606	12,555	11,005	36,107
Cladocera	786	3,398	7,710	903	1,386	35,293
Ostracoda	50,490	3,111	1,120	1,290	10,564	1,129
Plecoptera	---	11	---	---	---	11
Ephemeroptera	291	1,237	118	5,256	303	3,269
Odonata	79	---	---	---	23	---
Coleoptera	771	---	189	35	106	23
Diptera	1,073	980	2,993	1,838	1,870	835
Trichoptera	226	---	57	22	63	---
Hemiptera	9	11	1	---	---	11

1/ Adapted from Upper Mississippi River Conservation Committee (15). Original data submitted by Eugene W. Surber.

2/ Composed entirely of an organism tentatively identified as a turbellarian.

almost entirely of the genus Cyclops, numerically ranged from [illegible] to [illegible] per square meter and cladocerans from 801 to 35,[illegible] per square meter. The most important genera in the latter group were Canthocamptus and Eurycercus. Mayflies, primarily of the genus Hexagenia, numbered 1,[illegible] to 5,[illegible] per square meter. Between the two sampling periods analysis of the data indicates: 1) a great increase in burrowing mayflies, 2) an increase in the genera Cyclops and Canthocamptus, 3) a sharp decrease in ostracods, and 4) an appearance of an unidentified organism not observed in the first survey.22/ An abundance of mayflies was noted in area B in 1948.

Sauber (53) found bottom fauna production consistently higher (for the same strata) (with one exception) in studies of upper Mississippi River sloughs than that reported by Muttkowski (37) and Juday (31) in Lake Mendota and Green Lake, Wisconsin, respectively. Lake Mendota is known to be a heavy producer of fish and it can be inferred from this and other information presented above that food production in the upper Mississippi River backwaters attains a level capable of supporting a large fish population.

Species composition

The adjusted average percentage composition of the fish populations by species groups in area B during the 4 years was: 1) predators 27, 2) game fish 11, 3) panfish 13, 4) catfish 11, 5) forage fish 3, and 6) rough fish 35 percent (Table 9). In accordance with the groupings by Carlander (1955), those species with short, intermediate, and long food chains would compose approximately 38, 13, and 49 percent, respectively, of the average standing crop in area B.

Species with short food chains have been shown to produce greater standing crops than predacious fish with long food chains (Carlander 11). Thompson (59) suggested that the high carrying capacity of Illinois lakes, populated only by carp, buffalo, and other non-predacious species was due to the short food chain of these species. He reported areas containing these species in combination with game and panfish and those having only game and panfish to have proportionately lower carrying capacities.

It was shown previously that standing crops of fish tend to be greater in backwaters of the lower section of the river than in those of the upper section (Table 12). Species with short food chains comprised 61 to 87 percent by weight (average of 73 percent) of the total standing crops of four backwaters studied in the southern section (Upper Mississippi River Conservation Committee, 63, 64) as compared to an adjusted average of 38 percent for area B. With such a large percentage of the population comprised of fish with short food chains, the backwaters of the southern section can be expected to produce larger standing crops than those of the northern part. Considering this difference in species composition, the average total standing crop of area B compares very favorably with crops in the lower section of the river.

Water-level Fluctuations

Water-level changes affect fish populations in several ways but limitations of applicable data permit discussion only of those effects concerned with movement of fish.

Fish movement into and out of backwater bays and sloughs in response to water-level fluctuations has been reported by several workers. A standing crop of 150 pounds of fish per acre was present in a Wheeler Reservoir (Tennessee) slough in June after spring high waters had receded (Cadwell 12). After a rise in water level flooded this area for a 40-day period in July, a second evaluation showed a standing crop of approximately 140 pounds per acre. The percentage composition by weight of gizzard shad, buffalo, and largemouth bass was appreciably greater than in the earlier determination. Carp entered in large numbers but did not represent as large a portion of the total weight as in the first case. The largemouth bass was found to be one of the first species to enter the backwater area when the water rises and among the first to leave when it recedes.

22/ Not shown in the analysis table (Table 7) except that part "Remaining organisms."

Information of a similar nature was provided by Robert Sharp[11] concerning movement of fish into a previously dry rearing pond near the Mississippi River at the National Fish Hatchery, Guttenberg, Iowa. Fish had access to the pond after a rise in water level for approximately 2 weeks, during which period 1,240.2 pounds (124 pounds per acre) of fish had entered the area, as shown by subsequent eradication (Table 35). The species comprising the greatest weight were carp, bowfin, buffalo, black crappie, and shortnose gar, in that order. Largemouth bass and black bullheads were also prominent.

Falling water levels during the winter were accompanied by a definite movement out of backwater areas in pools 8 and 9 by carp, northern pike, crappies, spotted sucker, and bowfin (Upper Mississippi River Conservation Committee, 63). Movement of these fish was intensified by a sharp drop in the water stage. Conversely, nets set under the ice to block completely the outlet of a backwater lake near La Crosse, Wisconsin, demonstrated only random movement during a 43-day period when only minor water-level fluctuations occurred (Upper Mississippi River Conservation Committee, 64).

The catch of gill nets set in and just outside area B approximately 1 week after the 1948 investigation provides further evidence of fish movement into backwater areas from another source (Table 36). This movement cannot be correlated with changes in water level, but it does suggest that backwaters which become de-populated through drawdown or winter-kill are apt to be invaded as soon as suitable conditions are re-established.

Comparison of water levels (Table 37) with population estimates in area B in 1948, 1949, 1951, and 1952 fails to show any relation between water-level fluctuation and standing crop. The greatest short-term changes in level were between 6 PM July 31 and 7 AM August 1, 1949 and between 7 AM and 6 PM August 1, 1949 when a rise of 1.03 feet and a drop of 0.8 feet, respectively, occurred. The highest standing crop was found in the August 3, 1949 operation. In view of previously cited data the sharp rise in water level might account for a large influx of fish, but conversely the more rapid drop (though not as extensive) immediately following would expectedly have initiated egress. Of the 4 years, levels in 1948 prior to poisoning were the most stable, yet production of rough fish, the group purportedly most influenced by water-level change, was second only to that of 1949, while the standing crop of panfish, the group probably least affected, was the lowest of the four estimates.

SUMMARY AND CONCLUSIONS

The objectives of this study were to determine the productivity of and the fluctuations in the populations from year to year, the population structure, and the rate of growth of the common fish species present in backwater areas of the upper Mississippi River. Some of these questions have been more adequately answered than others.

1. Estimates of total fish populations of three upper Mississippi River backwater areas, area A and area B near Fountain City, and Miller Lake near La Crosse, Wisconsin, were obtained between 1947 and 1952 by application of a fish toxicant. Standing crops in one of these areas were determined in 4 different years.

2. Standing crops of fish in the six individual estimates ranged from 39.1 to 604.9 pounds per acre and averaged 248.4 pounds per acre. Deletion of the weight contributed by adult gizzard shad present in only one of the collections reduced the average weight per acre to approximately 225 pounds. This figure is considered to be more indicative of the average population.

3. Standing crops in the backwater treated on four occasions (area B) ranged from 202.4 to 604.9 pounds per acre and averaged 324.2

[11] Personal communication.

Table 35:-- Species composition of fish recovered from a previously dry rearing pond at the U. S. Fishery Station, Guttenberg, Iowa, after recession of high water, May 8, 1951 -- expressed as total numbers and weights and as pounds per acre.

Species	Number	Weight		
		Total number of pounds	Pounds per acre	Percentage of total weight
Predators				
Bowfin	106	298.0	29.8	
Shortnose gar	26	26.0	2.6	
	132	324.0	32.4	26.1
Game fish				
Largemouth bass ...	23	16.0	1.6	
Northern pike	3	1.0	0.1	
Sauger	1	0.5	0.05	
Walleye	3	1.0	0.1	
	30	18.5	1.85	1.5
Panfish				
White bass	2	0.7	0.07	
Bluegill	28	5.0	0.5	
Black crappie	154	40.0	4.0	
Yellow perch	21	3.0	0.3	
	205	48.7	4.87	3.9
Catfish				
Black bullhead	81	19.0	1.9	
	81	19.0	1.9	1.5
Forage fish				
Golden shiner	26	4.0	0.4	
	26	4.0	0.4	0.3
Rough fish				
Buffalo1/	63	269.0	26.9	
Carp	170	545.0	54.5	
Carpsucker1/	22	9.0	0.9	
Spotted sucker	3	3.0	0.3	
	258	826.0	82.6	66.6
GRAND TOTAL	732	1,240.2	124.0	

1/ Species not shown in original data.

Table 36:--Catch of gill nets[1/] lifted within and 50 feet outside of Area B on July 17-18, 1948.

Species	Number	Size range (inches)
Largemouth bass	1	7.2
Sauger	1	12.2
Black crappie	3	5.4 - 5.7
White crappie	2	6.3 - 12.4
White bass	2	8.6 - 9.0
Channel catfish	2	12.3 - 13.3
Mooneye	1	10.3
Carp	10	11.6 - 13.2
Spotted sucker	1	17.0
Northern redhorse	4	10.1 - 18.8

1/ One 2-inch bar mesh and one 4-inch bar mesh net lifted on 2 consecutive days.

Table 37:-- Water-level readings at Fountain City, Wisconsin for 5 days prior to, and for the dates of, eradication of fish in area B in 1948, 1949, 1951, and 1952.[1/]

Days prior to poisoning	1948		1949		1951		1952	
	7 a.m.	6 p.m.	7 a.m.	6 p.m.	7 a.m.	6 p.m.	7 a.m.	6 p.m.
5	650.72	650.65	650.15	650.33	650.51	650.41	649.74	649.66
4	50.64	50.64	50.03	49.72	50.35	50.42	49.58	49.55
3	50.62	50.62	49.95	49.32	50.29	50.18	49.68	49.72
2	50.62	50.62	50.35	49.55	50.08	49.90	49.81	49.88
1	50.61	50.63	49.69	49.70	49.74	49.95	49.83	49.85
0	50.65		49.65		50.18		49.90	

1/ Data provided by the U. S. Corps of Engineers, St. Paul District.

pounds per acre. Deletion of the adult gizzard shad reduced the average weight per acre to approximately 285 pounds. This figure also is considered to be more indicative of the average population of area B.

4. To facilitate evaluation of the population data the various species were arranged in the following groups: predators, game fish, panfish, catfish, forage fish, and rough fish.

5. On the basis of adjusted average weight per acre of 285 pounds, the mean percentage composition of the various species groups in area B was predators, 27; game fish, 12; panfish, 13; catfish, 11; forage fish, 1; and rough fish, 38. On the same basis, average composition in pounds per acre was: predators, 77; game fish, 29; panfish, 36; catfish, 30; forage fish, 2; and rough fish, 112.

6. Average standing crops of the three northern backwaters and of area B alone were less than the mean weight per acre of four backwater areas in the southern section of the river but the predator and game fish components were greater in the upper section.

7. The average standing crop of areas A and B and Miller Lake exceeded that of inland waters to the north, approximated that of waters in the same general latitude, and was less than the mean crop of inland waters to the south.

8. The preponderance of species with long food chains suggests that total standing crops with the existing species composition are comparatively high for the latitude.

9. Production of game fish in area B tended to exceed that in most waters of the north-central States where comparison was made. Weight per acre of panfish in the same area tended to approximate that in northern inland waters but was much less than that in waters to the south.

10. The most prominent species in the backwaters in each of the species groups were: 1) predators -- bowfin; 2) game fish -- northern pike and largemouth bass; 3) panfish -- bluegill, black crappie, white crappie; 4) catfish -- channel catfish; 5) forage fish -- gizzard shad; and 6) rough fish -- carp, spotted sucker, and freshwater drum.

11. Weight composition by species groups in area B varied greatly from year to year. The most stable component of the populations was the catfish group while the rough fish group was the most variable.

12. Very few fish over 5 years of age were found in the four collections from which fish were aged. The great majority of game fish and panfish were less than 3 years old.

13. Growth rates of most species were faster than those of the same species in almost all waters of the north-central States where a comparison was made, including the Illinois-Missouri section of the river.

14. Results of water analyses indicated that chemical fertility of the upper Mississippi River is high when compared to that of other waters producing heavy crops of fish.

15. Bottom soils of the backwater areas have a higher organic content (7.49 percent) than those of adjacent running channels (2.64 percent) and also a finer texture.

16. Composition of the bottom fauna in the backwaters of the upper Mississippi River has changed since the navigational locks and dams were installed but production per unit area compares favorably with that observed before installation of those structures.

17. Differences in standing crops in area B during the 4 years could not be related to changes in water level.

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