DISTRIBUTION AND FOOD HABITS OF SEVERAL SPECIES OF FISH

IN POOL 19, MISSISSIPPI RIVER

by

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Signatures have been redacted for privacy

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INTRODUCTION

On July 1, 1966, a study was begun on the fish and bottom fauna populations of a section of Mississippi River Pool 19 at Fort Madison, Iowa. The primary objective of the project was to define the distribution of bottom fauna and its utilization by fish. The project was financed by the U.S. Bureau of Sport Fisheries and Wildlife and the Iowa Cooperative Fishery Unit, and directed by Drs. Kenneth D. Carlander and Robert J. Muncy, Iowa State University. The bottom fauna investigations were conducted by William F. Gale, Ph. D. candidate, assisted by Wayne Herndon, an undergraduate student from the University of Southern Illinois. David J. Jude and Richard G. Ranthum, candidates for the Master of Science degree, collected data on fish and their feeding habits and divided the analysis for separate theses. This thesis includes data on the following species: shovelnose sturgeon Scaphirynchus platorynchus, paddlefish Polyodon spathula, longnose gar Lepisosteus osseus, shortnose gar Lepisosteus platostomus, bowfin Amia calva, northern pike Esox lucius, American eel Anguilla rostrata, white bass Roccus chrysops, yellow bass Roccus mississippiensis, warmouth Chaenobryttus gulosus, pumpkinseed Lepomis gibbosus, bluegill Lepomis macrochirus, largemouth bass Micropterus salmoides, white crappie Pomoxis annularis, black crappie Pomoxis nigromaculatus, yellow perch Perca flavescens, sauger Stizostedion canadense, walleye Stizostedion vitreum vitreum, and freshwater drum Aplodinotus grunniens.

The desirability of such a study became apparent when dredging operations by the Army Corps of Engineers were proposed to provide a navigation channel for barge traffic from the main river channel to the Port Lee industrial complex developing along the Mississippi River southwest of Fort Madison (Figure 1). A further 6-mile extension of the dredge channel to Montrose, Iowa, is also being considered.

Pool 19 is a 47-mile stretch of the Mississippi River extending from the lock and dam at Burlington, Iowa, to the lock and dam at Keokuk, Iowa. The dam at Keokuk was constructed in 1913 to generate electric power (Carlander, 1954). Impoundment increased the surface area from 36 to 60 square miles at low water stage. With impoundment, fluctuations in surface area between low and high water decreased from 18 square miles to 4 square miles. In the Fort Madison vicinity, the pool consists primarily of a shallow expanse of water from 1 to 2 miles in width and, except for the main river channel and certain dredged areas and "guts", is less than 9 feet deep. Therefore, it seemed likely that dredging operations and subsequent barge traffic might have an appreciable impact on the ecology and the fish and wildlife resources in the area.

The commercial catch of fish from Pool 19 averaged over one million pounds per year from 1953-64 (Nord, 1967). Only 6 species of this study were reported in the 1965 and 1966 catch (Table 1). A more extensive summary of the Pool 19 commercial fishery can be found in Hoopes (1959). An important sport fishery also exists (Nord, 1967). Angler counts averaged approximately one thousand shore fishermen and three thousand boat fishermen annually (1959-63). A catch rate of 2.35 fish per angler interviewed (1956-57) and an annual sport catch of 4 pounds per acre for Iowa and 2 pounds per acre for Illinois (1956-58) were recorded. Several of the fish species investigated were important in the sport catch. Freshwater drum were the most frequently creeled fish and made up 47.5 percent of the total

Figure 1. Map of Pool 19, Mississippi River indicating location of the study area (Insert map gives location of Pool 19 in Iowa)

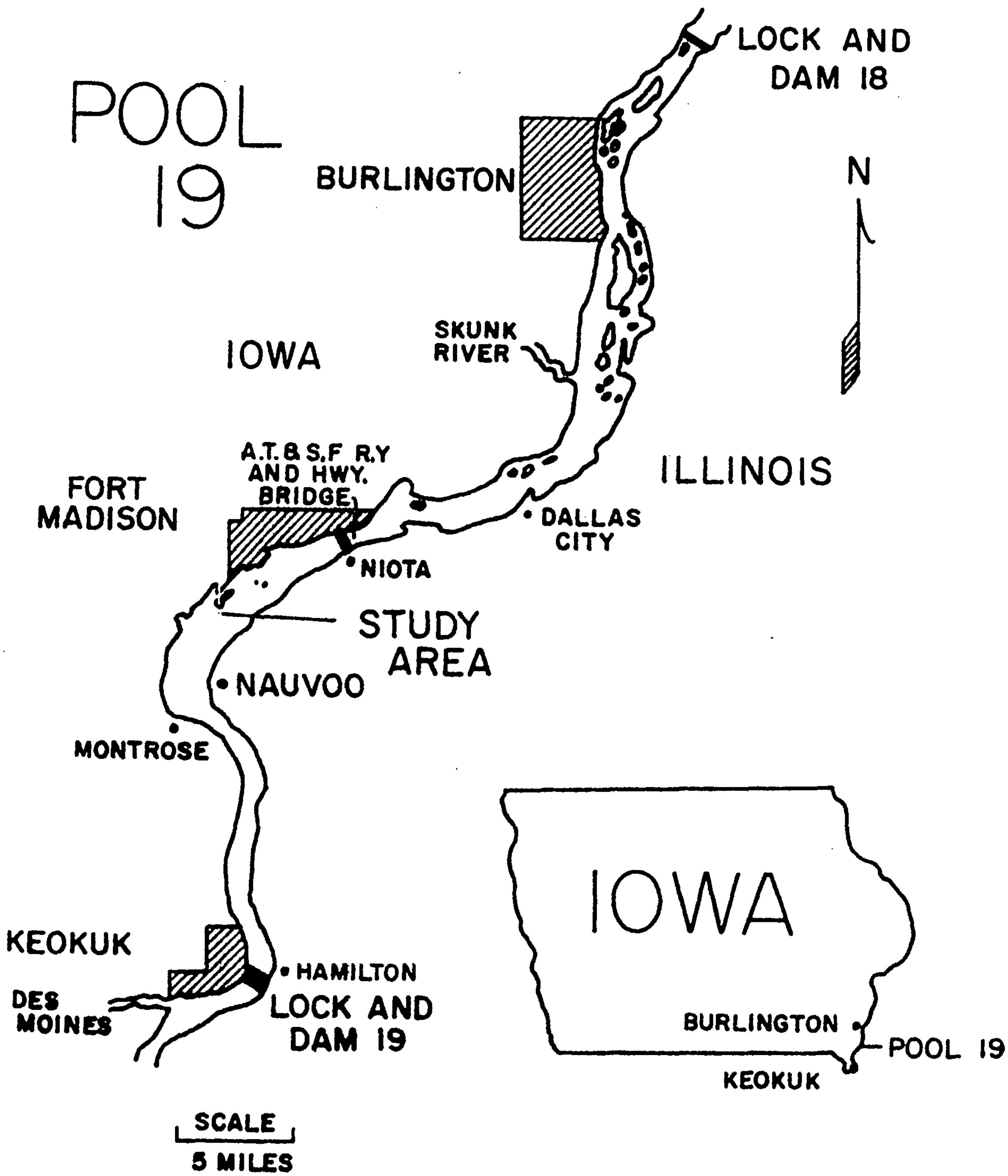

POOL
19
LOCK AND
DAM 18
BURLINGTON
N
IOWA
SKUNK
RIVER
ILLINOIS
A.T.& S.F. R.Y
AND HWY.
BRIDGE
FORT
MADISON
DALLAS
CITY
NIOTA
STUDY
AREA
NAUVOO
MONTROSE
KEOKUK
HAMILTON
DES
MOINES
LOCK AND
DAM 19
SCALE
5 MILES
IOWA
BURLINGTON
POOL 19
KEOKUK

Table 1. Total commercial catch and value of certain fishes from Pool 19, Mississippi River, 1965[a]-1966[b]

Species	Pounds 1965	Pounds 1966	Approximate value 1965	Approximate value 1966
Freshwater drum	75,550	142,763	$6,044	$9,993
Sturgeon	634	2,817	152	563
Paddlefish	23,237	18,468	2,788	2,308
Gar	1,088	480	44	14
Bowfin	283	823	14	25
American eel	3	-	-	-

[a]Upper Mississippi River Conservation Committee. 1967

[b]Upper Mississippi River Conservation Committee. 1968

number of fish taken by angling. Sauger ranked 3rd, crappies 4th, white bass 5th, bluegills and other less common centrarchids 7th, yellow perch 8th, walleye 10th, largemouth bass 12th, sturgeon 14th, and American eel 15th. Pool 19 also has one of the largest spring and fall concentrations of diving ducks on the Mississippi flyway with 5.9 to 10.7 million duck-days of use during each migration 1966-68 (Douglas Thompson, Iowa State University, personal communication).

MATERIALS AND METHODS

The area selected for study was an 11-mile section of river from 1 mile above the Atchison, Topeka, and Santa Fe Railroad bridge at Fort Madison, Iowa, to 1 mile below Nauvoo, Illinois (Figure 2). This was part of a 25-mile lower stretch of Pool 19 which averages over 1 mile in width. Stations were set up along lines or transects and marked with stakes or anchored floats. Some transects traversed the river roughly at right angles to the main current flow to include a maximum amount of variation in habitat factors. Others were located in areas with unique habitats: sloughs, beds of various types of aquatic vegetation, dredged or relatively deep-water areas apart from the main channel, and the water cooling pool and outlet of a fertilizer plant. Transects were established above, in, and below the proposed dredging area to aid in future evaluation of dredging activities (Figures 2-5). In general, the number of stations on a given transect increased with observable variation in the habitat.

A pilot survey of the fish population was undertaken from July 14 through August 2, 1966, with gill nets and electro-shocking gear. The purpose of this phase of the work was to obtain data on the number of fish species and their abundance in various locations. The standard experimental gill net (125 feet in length, 6 feet deep, and consisting of five 25-foot sections of 0.75 inch, 1.00 inch, 1.25 inch, 1.50 inch, and 2.00 inch mesh size bar measure) was selected as the primary sampling gear. Such nets are the most effective gear for collecting many species and show little size selection for walleyes, yellow perch, yellow bass, or white bass 4.5 inches long and larger. Since gill nets are dependent on fish

Figure 2. Map of Pool 19 study area showing sections above, in, and below proposed dredging site and the transects used in sampling fish (adapted from U.S. Army Corps of Engineers Map)

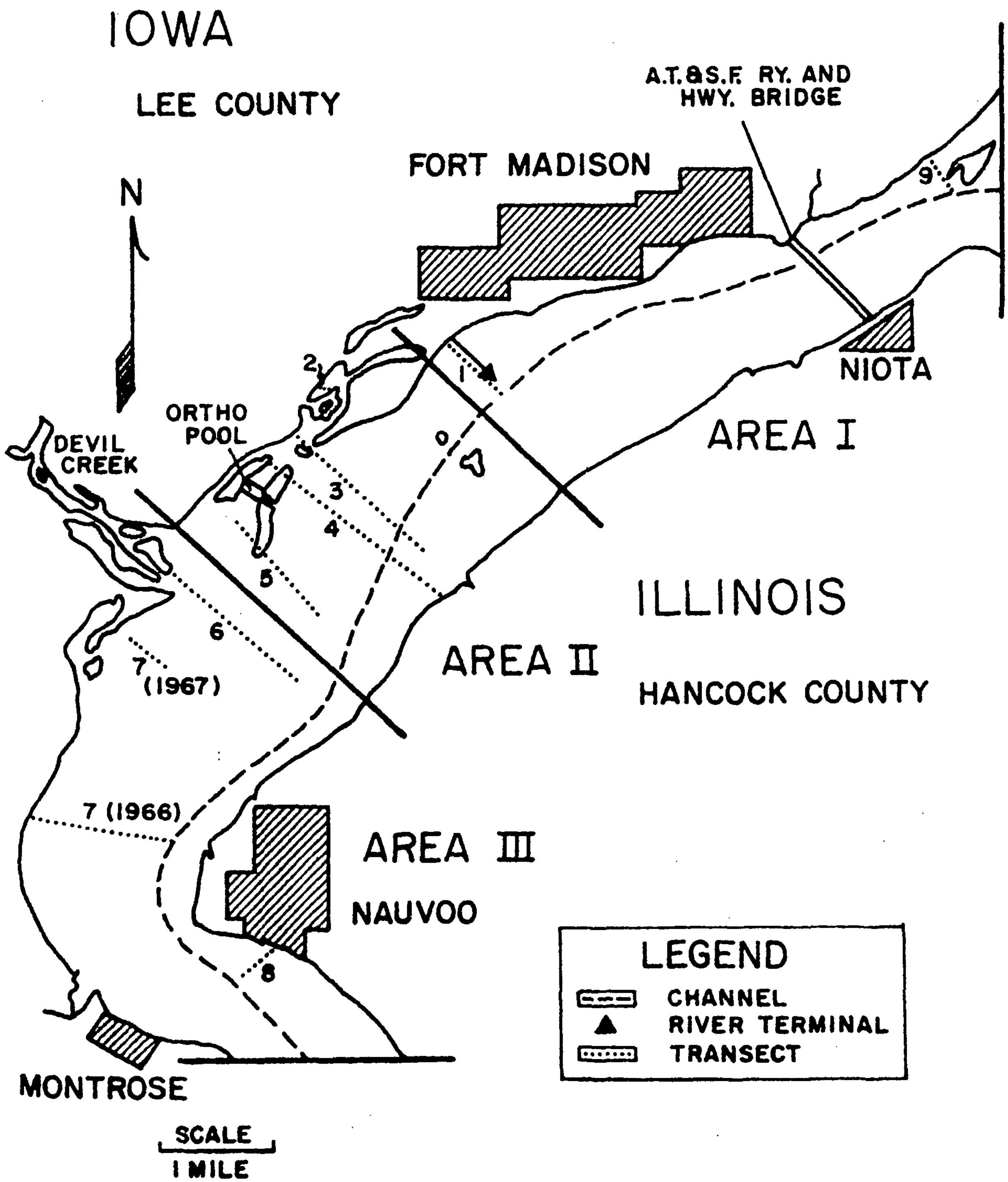

IOWA
LEE COUNTY
A.T.&S.F. RY. AND
HWY. BRIDGE
FORT MADISON
N
NIOTA
ORTHO
POOL
DEVIL
CREEK
AREA I
ILLINOIS
AREA II
HANCOCK COUNTY
7 (1967)
7 (1966)
AREA III
NAUVOO
LEGEND
CHANNEL
RIVER TERMINAL
TRANSECT
MONTROSE
SCALE
1 MILE

Figure 3. Upper portion of Pool 19 study area showing transects and sampling stations (adapted from U.S. Army Corps of Engineers Map, 1965)

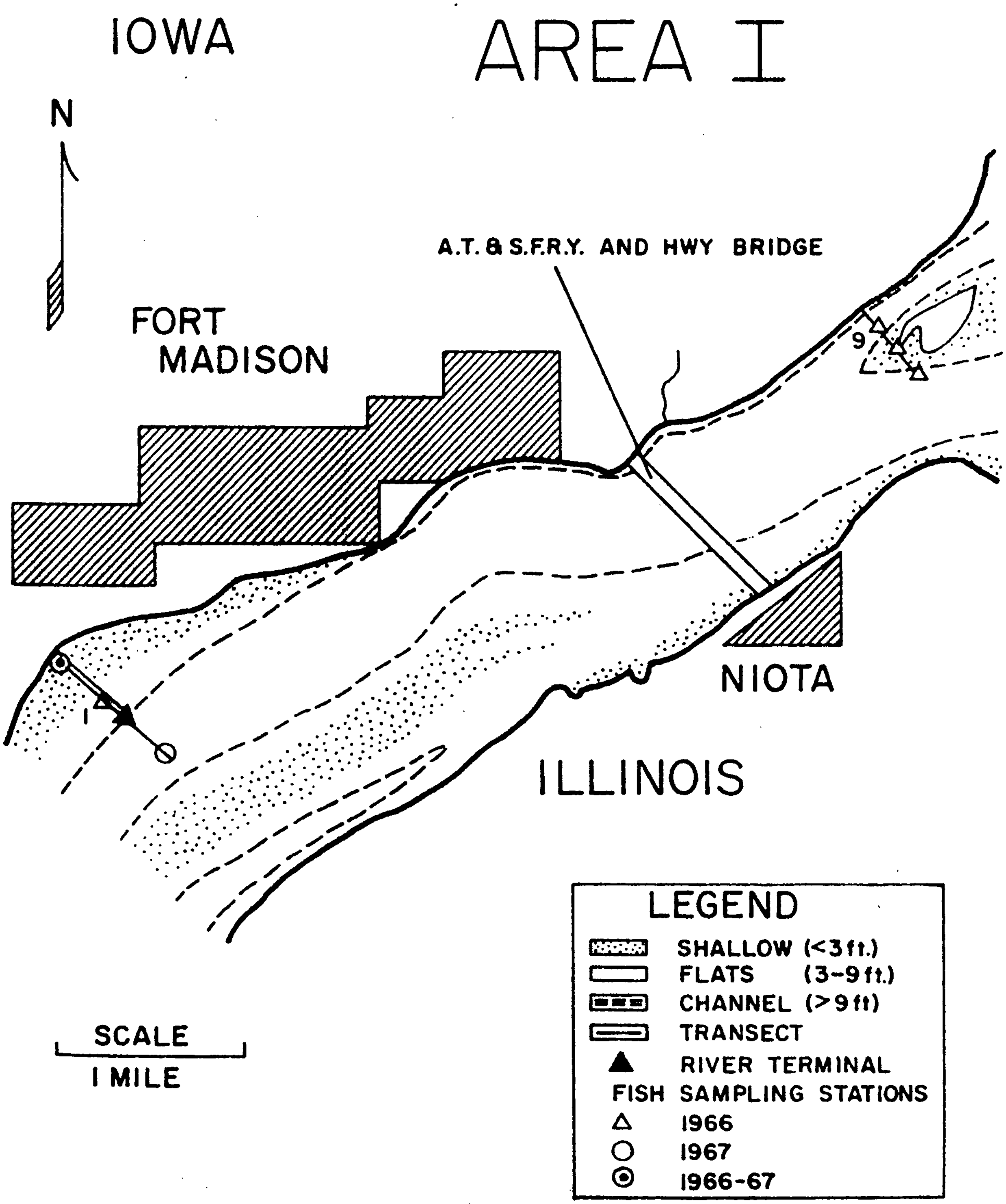

IOWA
AREA I
N
A.T. & S.F.R.Y. AND HWY BRIDGE
FORT
MADISON
9
1
NIOTA
ILLINOIS
LEGEND
SHALLOW (<3 ft.)
FLATS (3-9 ft.)
CHANNEL (>9 ft)
TRANSECT
RIVER TERMINAL
FISH SAMPLING STATIONS
1966
1967
1966-67
SCALE
1 MILE

Figure 4. Middle portion of Pool 19 study area showing transects, sampling stations, and proposed dredging site (adapted from U.S. Army Corps of Engineers Map, 1965)

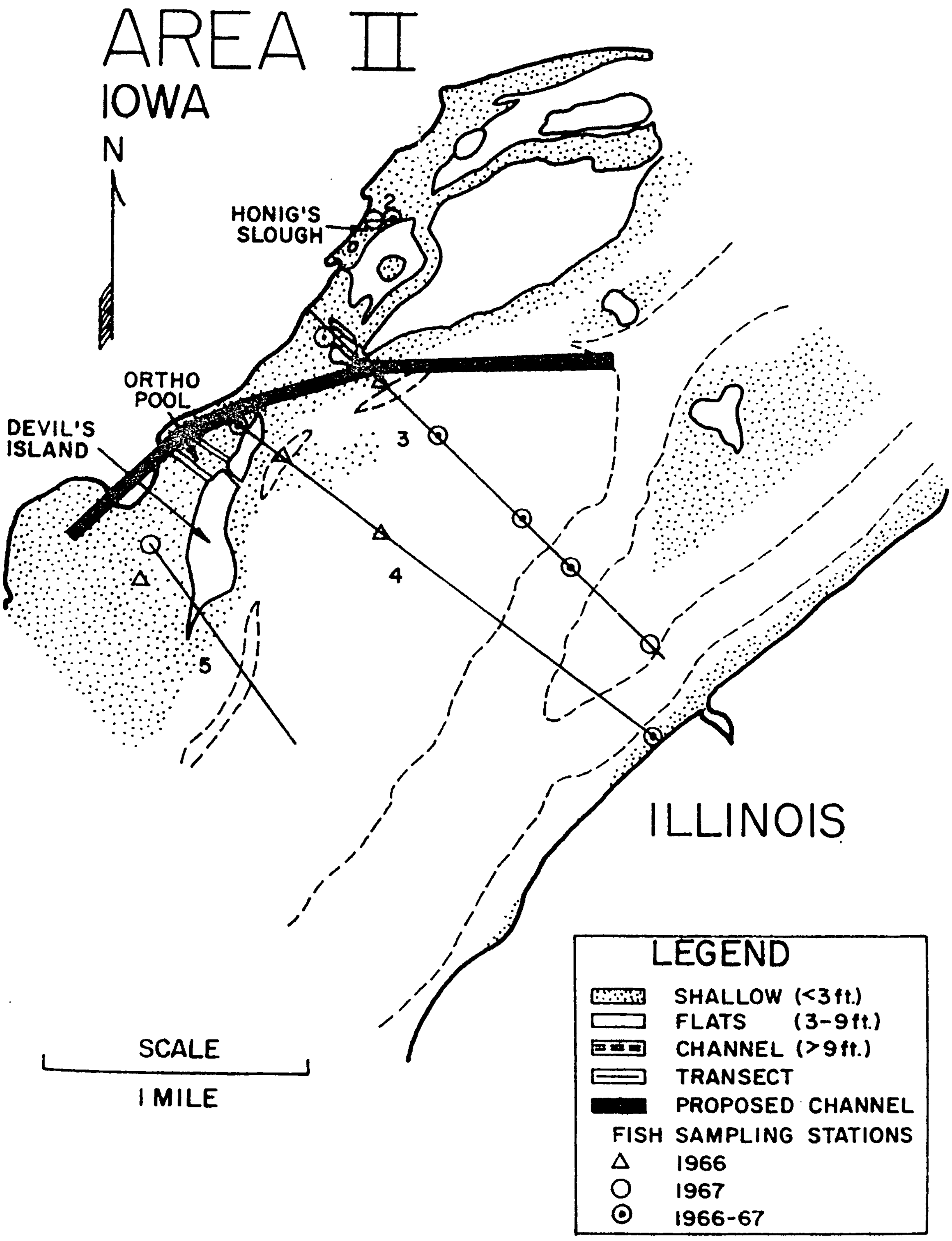
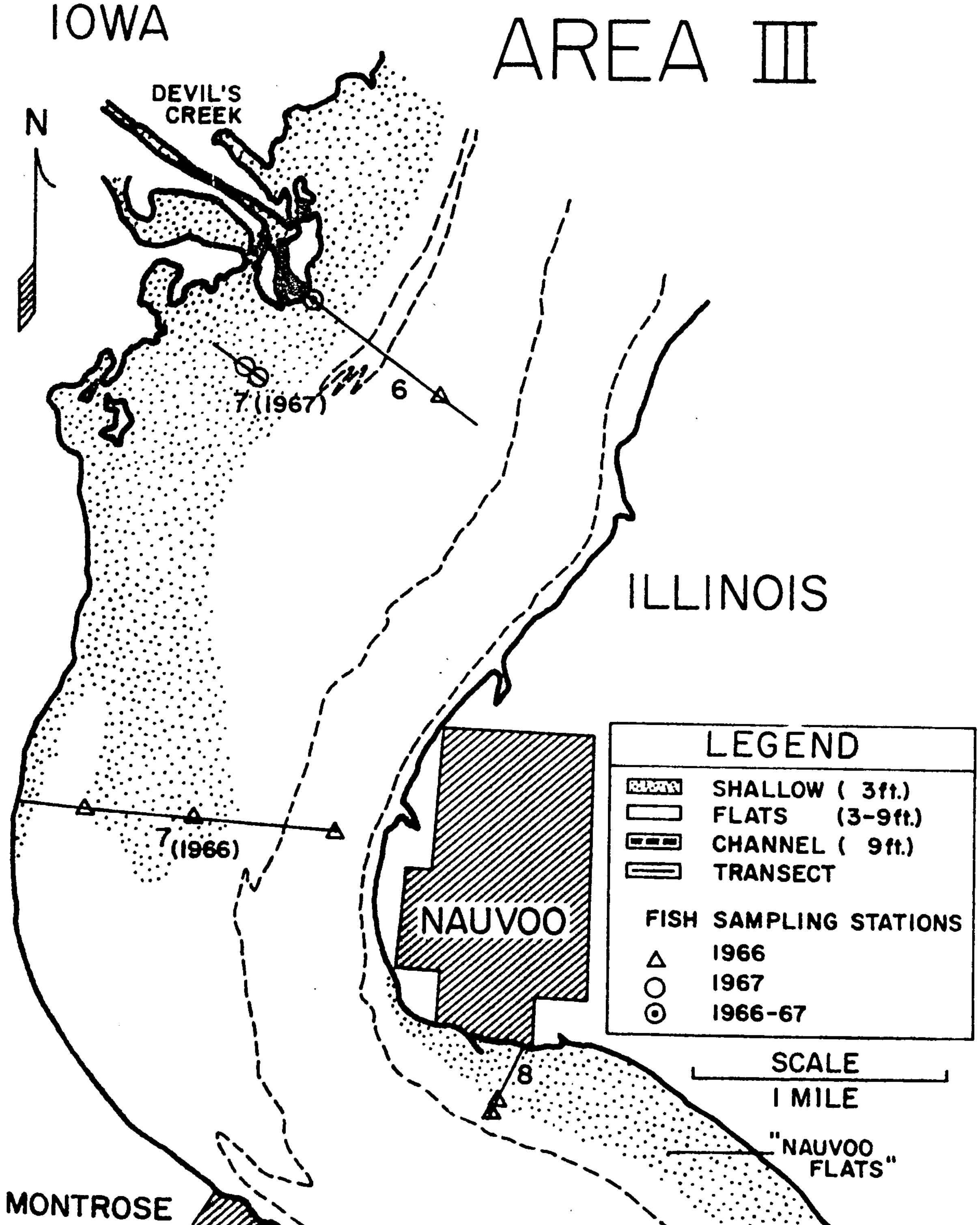

AREA II
IOWA
N
HONIG'S SLOUGH
2
1
ORTHO POOL
DEVIL'S ISLAND
3
4
5
ILLINOIS
LEGEND
SHALLOW (<3 ft.)
FLATS (3-9 ft.)
CHANNEL (>9 ft.)
TRANSECT
PROPOSED CHANNEL
FISH SAMPLING STATIONS
1966
1967
1966-67
SCALE
1 MILE

Figure 5. Lower portion of Pool 19 study area showing transects and sampling stations (adapted from U.S. Army Corps of Engineers Map, 1965)


IOWA
AREA III
DEVIL'S CREEK
N
7 (1967)
6
ILLINOIS
LEGEND
SHALLOW (3ft.)
FLATS (3-9ft.)
CHANNEL (9ft.)
TRANSECT
FISH SAMPLING STATIONS
1966
1967
1966-67
7 (1966)
NAUVOO
8
SCALE
I MILE
"NAUVOO FLATS"
MONTROSE

movement for operation, catch per effort data are a function of activity as well as abundance, and characteristic activity cycles can be noted for different species (Carlander, 1953). Habitat preference may be observed through variations in catch rates in different habitats (Carlander and Cleary, 1949). Particular advantages of the experimental gill net in this study were its effectiveness in nearly all habitats, high portability, ease in handling by two workers, and capability in taking a fairly large sample of a wide variety of fish species and sizes in a short time. It also constitutes a fairly standard unit of effort. Like any sampling gear, gill nets have certain disadvantages. They are more selective for some species than for others. Largemouth bass, crappies, and sunfish may avoid gill nets (Carlander, 1953). Fish may be able to see gill nets better during daylight hours than at night (Carlander and Cleary, 1949) and avoid them, biasing daytime catch rates downward or making nocturnally active species more susceptible and, therefore, apparently more abundant than they actually are relative to diurnal species. As turbidity increases, this effect could be expected to diminish. Some species may be able to recognize and avoid gill nets better than others even at the same time of day. The behaviorial characteristics and body structure of some species may also influence their vulnerability to gill netting. Efficiency may vary with water velocity and depth. Slack nets in shallow water or areas without current may be more efficient than taut ones in deep water or strong currents (Sieh and Parsons, 1950). Therefore, catch rates in deeper open water areas of the river may be lower relative to those in shallow water locations even when fish are equally abundant. Debris in the netting such as aquatic vegetation may influence its visibility to fish and efficiency. Periods of low fish activity, seasonal or diurnal, may make adequate samples difficult to obtain at such times.

Water temperature was important in determining the length of time a net could be usefully set. During summer months when water temperatures were fairly high, digestion and decomposition of samples in the nets proved to be critical factors. A period of 2 hours was selected as the best compromise between obtaining adequate samples and satisfactory specimens for the data needed. By limiting net sets to short time intervals, more precise information concerning diurnal changes in fish movements could also be obtained. In general, more species and total numbers of specimens were taken in samples near shore in shallow water than in the deeper areas of the open river, and catches were larger during the hours of darkness than in daylight. This information was necessary in setting up adequate and workable sampling schedules.

The first extensive experimental gill net sample was taken during the period August 3 through 31, 1966, from 24 stations on 9 transects (Table 2, Figures 3-5). Sampling covered a 24-hour period at each of the stations. To form a workable schedule, sampling was divided into two 12-hour periods: 8 AM to 8 PM and 8 PM to 8 AM. All stations were sampled first over one 12-hour period and then the other. The nets were set for 2 hours, picked up and the fish removed, and then re-set at the same location 2 hours later. In this way, three such sets were made at each station during a 12-hour sampling period. The 2-hour interval between sets was necessary to allow time for travel between stations, processing specimens, and recording data. Size of catch, distance between stations, and weather conditions were factors determining the number of nets which could be handled effectively on a

Table 2. Description of stations in Pool 19, Mississippi River, 1966

Transect station[a]		Depth (feet)	General depth category[b]
T1	S1	1	shallow
T1	S2	5.5-7	flat
T2	S1	1.5-2	shallow
T2	S2	0.5-1	shallow
T3	S1	1	shallow
T3	S2	5.5-9.5	drop-off
T3	S3	3	flat
T3	S4	6	flat
T3	S5	18	channel
T4	S1	1-3	shallow
T4	S2	4-14	drop-off
T4	S3	4-5	flat
T4	S4	3-8	flat
T5	S1	0.5-1	shallow
T6	S1	1	shallow
T6	S2	7-8	flat
T7	S1	1.5-3	shallow
T7	S2	3	flat
T7	S3	18-22	channel
T8	S1	1	shallow
T8	S2	4-19	drop-off
T9	S1	17-19	channel
T9	S2	0.5-1	shallow
T9	S3	21-24	channel

[a]Locations are shown on Figures 3-5.

[b]Bottom types were generally soft in shallow area except for hard sand at T6 S1. Sediments contained considerable organics in vegetated area, particularly in sloughs. Flat, drop-off, and channel sediments were generally firmer than those at shallow stations and in some areas consisted of a sand and mud mixture.

[c]Current velocity measured at normal river stage. (general commercial harbor map, Mississippi River, Fort Madison, Iowa. Corps of Engineers, U.S. Army)

[d]Distance of 0 yards means set from the shoreline and at a right angle to it out into the river.

Velocity of current (fps)[c]	Vegetation		Distance from nearest shore (yards)[d]
	Density	Type	
0.7	absent		0
0.8	absent		450
0	light	Ceratophyllum Potamogeton	40
0	heavy	Ceratophyllum Potamogeton	35
0	light	Potamogeton	80
1.0	absent		75
1.2	absent		800
1.0	absent		1,050
1.7	absent		1,200
0	absent		20
0.7	absent		150
0.9	absent		1,000
1.0	absent		150
0	light	Ceratophyllum Potamogeton Lotus	300
0.2	absent		30
0.9	absent		1,000
0.4	heavy	Potamogeton	300
0.6	absent		1,300
1.7	absent		2,000
0.2	absent		600
1.0	absent		660
1.6	absent		30
0.1	light	Potamogeton	200
1.7	absent		300

given day, and as many nets were set as was feasible during a 12-hour period.

Sampling during fall and winter of 1966 and spring of 1967 was necessarily restricted by course requirements. Gill nets were set for longer times to get the maximum number of fish. The detrimental effects of longer sets on specimens were not appreciable because lower water temperatures decreased digestion and decomposition rates. Data were restricted to species abundance and food habits of the fish taken at the few stations sampled. Gill net samples were collected during October 14-15, November 16-23, December 17-20, 1966; and March 23 and May 4-10, 1967. Trammel nets were used occasionally during these sampling periods. Electro-shocking samples were taken during May 4-10, 1967.

Two extensive 24-hour gill net samples similar to the August, 1966, sample were taken during the summer of 1967; one June 25-July 10 and the second August 18-30. Certain modifications were made in the sampling technique to incorporate improvements in methods over the 1966 sample. Sampling stations were reduced from 24 to 17 to enable two 24-hour samples to be taken at each station. Some of the stations farthest from the main access point were eliminated and others added nearer the proposed dredging site. Duplication of sampling in certain habitats was reduced and new stations set up in areas where differences which were not previously recognized seemed likely (Table 3, Figures 3-5). Miscellaneous fish sampling was conducted prior to the first 24-hour sampling during the period June 6-24, 1967, by means of trotlines, hoop nets, trammel nets, and electroshocking. Fish samples were taken from the fertilizer plant cooling pool

Table 3. Description of stations in Pool 19, Mississippi River, 1967 (see footnotes on Table 2)

Transect station	Depth (feet)	General depth category	Velocity of current (fps)	Vegetation		Distance from nearest shore (yards)
				Density	Type	
T1 S1	1-1.5	shallow	0.7	absent		0
T1 S3	18-21	channel	1.7	absent		1,200
T2 S1	1.5	shallow	0	light	_Ceratophyllum_ _Potamogeton_	20
T2 S2	1	shallow	0	heavy	_Ceratophyllum_ _Potamogeton_	30
T3 S1	1	shallow	0	light	_Potamogeton_	80
T3 S2	0-4.5	flat	0.2	absent		0
T3 S3	3	flat	1.2	absent		900
T3 S4	5	flat	1.0	absent		1,200
T3 S5	18-19	channel	1.7	absent		700
T3 S6	8-9	flat	1.3	absent		600
T4 S1	4.5-5	flat	0	absent		60
T4 S3	3	flat	0.9	absent		200
T4 S4	2.5-5	flat	1.0	absent		150
T5 S1	1	shallow	0	light	_Potamogeton_ _Lotus_	300
T6 S1	0.5	shallow	0.2	absent		40
T7 S1	1	shallow	0.3	absent		600
T7 S2	1	shallow	0.3	heavy	_Potamogeton_	650

and outlet at various times during 1966 and 1967 with electro-shocking gear and gill and trammel nets.

Lengths and weights were recorded for nearly all fish specimens. Scale and stomach samples and sex determinations required more time. A random method of subsampling different sizes of certain species became necessary when numbers were large. Total length was measured to the nearest 0.1 of an inch and the weight to the nearest gram with fish up to 500 grams. Larger fish were weighed to the nearest ounce. Scales were collected for age determinations from all species taken except shovelnose sturgeon, paddlefish, shortnose and longnose gar, and American eel. Time limitations did not permit an age and growth analysis to be included in this study.

There were two problems in species recognition. In the summer of 1966, there was a failure to distinguish properly between black and white crappies; therefore, the specimens collected had to be analyzed on a generic basis. Several adult gar were captured with definite head spotting and dark pigment on the paired fins and undersides indicating that they might be spotted gar, but most of the specimens collected were not preserved for later detailed examination. Scale counts on one preserved specimen with these characteristics indicated it was a shortnose gar rather than a spotted gar. Further investigations in this area would seem worthwhile.

Only food in the stomach of fish was examined in this study. This has been the procedure in most previous food habit studies, although other methods have been used (Kutkuhn, 1954). The fish involved in this study all had fairly well defined stomachs, and it was felt that food in the stomach region would be the least digested portion in the alimentary tract and, therefore, give the most accurate description of food habits. Analyzing the contents of lower portions probably would not have yielded enough additional information to be worthwhile. Stomach contents were preserved in 10 percent formaldehyde for later examination to facilitate maximum data collection. In 1966 fish stomachs were removed, tied off at both ends, and injected with formalin to insure preservation of the contents. They were then individually labeled with identifying plastic tape and stored in large jars also containing formalin. In 1967 the food material from a given stomach was emptied into a jar of appropriate size with an identifying plastic tape label and enough formalin to cover the contents. Borgeson (1966) described a similar procedure. This method insures more complete preservation of the food items and eliminates time lost in tying off, injecting, unwrapping, and cutting open stomachs which have been hardened by formalin. If tied-off stomachs are over-injected, they tend to squirt out their contents upon rupture, resulting in possible loss of food items and a hazard to the investigator's eyes. If under-injected, the stomachs contract into heavy folds trapping food items which may be consequently missed or difficult to obtain intact for examination.

In the laboratory analysis, food material was removed from the stomach or container and excess formalin was drained off. The contents were then covered with ethanol and/or water in one-half of a Petri dish with a grid arrangement on the bottom to facilitate counting operations. Contents were examined through a binocular microscope. All recognizable material was identified and its volume measured by a liquid displacement method. A count of food items of each type observed was made when feasible. Food items were separated according to type and the excess moisture absorbed on dry paper toweling. Each component was placed in a round bottom glass tube of known volume and ethanol added to fill it to the calibration line on the tube. The food volume measurement was then taken as the difference between the tube volume and amount of liquid necessary to fill the calibrated tube as noted from burette readings. For convenience, three sizes of such tubes were calibrated for use on stomachs containing varying amounts of food. Accuracy of readings necessarily decreased with increasing tube size although the percent error could be assumed fairly constant. In cases where fish contained sufficiently large amounts of food, a 100-ml graduate cylinder cut off to 60 ml and filled with an adequate amount of liquid to cover the sample was used in volume determinations. Measurements were made by placing the food in the tube so that it was submerged and recording the liquid displacement. The most likely sources of error in determining food volumes by the above method are failure to have a consistent moisture content in the samples at the time determinations are made and cases where the volumes being measured are so small that they approach the precision limits of the measurement technique.

Other investigators have used a number of methods of collecting fish specimens and preserving and analyzing their stomach contents. Kutkuhn (1954) gives a rather extensive review of those used in earlier food habits studies. Lagler (1956) discusses the relative merits and shortcomings of various approaches to food habit study: gravimetric, volumetric, numerical, frequency of occurrence, estimated percentage by bulk, and restoration of original properties of food items methods. Volume or weight of food items and their frequency of occurrence in the specimens were two of the more popular analyses, and they were adopted in this study. Wenke (1965), Hoopes (1959), Kutkuhn (1954), and others used different methods of estimating volumes of various food components rather than actually measuring them as was done here. While theirs were considerably faster techniques, it was felt that errors involved in estimation, particularly variation likely to exist between different investigators, justified the more accurate and time-consuming procedure used here. Borgeson (1966) described a rapid and simple method of stomach analysis by combining the stomach contents of all specimens in a given size class taken over a given time period. By combining the food items from several fish in this manner, small volumes of organisms in individual stomachs become of sufficient volumetric magnitude to enable more accurate measurement. This becomes increasingly important when dealing with small fish and correspondingly small food items. The two chief disadvantages of this method are that frequency of occurrence determinations are not possible, and size and time groups cannot be separated once they are established by combining stomach contents.

ECOLOGICAL DISTRIBUTION OF THE FISH

In the species summaries, two main areas are considered: distribution and food habits. A general survey of the distribution of the fish may be helpful before considering the species separately.

The species may be classed according to numbers obtained with all types of gear as follows:

1) between 300 and 600 individuals-- sauger and shortnose gar,

2) from 100 to 200 specimens-- white bass, black crappie, bluegill, and yellow perch,

3) from about 40 to 80 fish-- bowfin, largemouth bass, white crappie, and freshwater drum,

4) about 20 fish-- longnose gar, pumpkinseed, and walleye,

5) less than 10 specimens-- shovelnose sturgeon, paddlefish, northern pike, American eel, yellow bass, and warmouth.

The catches per 100 gill net hours (Figure 6) are a better measure of abundance than the total numbers taken, since the fishing effort was not equal in each habitat.

1) most frequently caught, nearly 26 fish per unit effort-- sauger,

2) about half the above-- shortnose gar,

3) from 7.5 to 10 fish per unit effort-- black crappie, yellow perch, and bluegill,

4) about 4.5 fish per unit effort-- white bass,

5) having fairly low catch frequency, 1.5 to 3 fish per unit effort-- largemouth bass, white crappie, bowfin, and freshwater drum,

6) infrequent, 1 or fewer fish per unit effort-- walleye, pumpkin-

Figure 6a. Numbers of each species caught per 100 experimental gill net hours, by depth classifications and combined, 1966 and 1967, in Pool 19, Mississippi River. Figures with bars denote numbers of fish; figures at bottom, hours of gill net effort

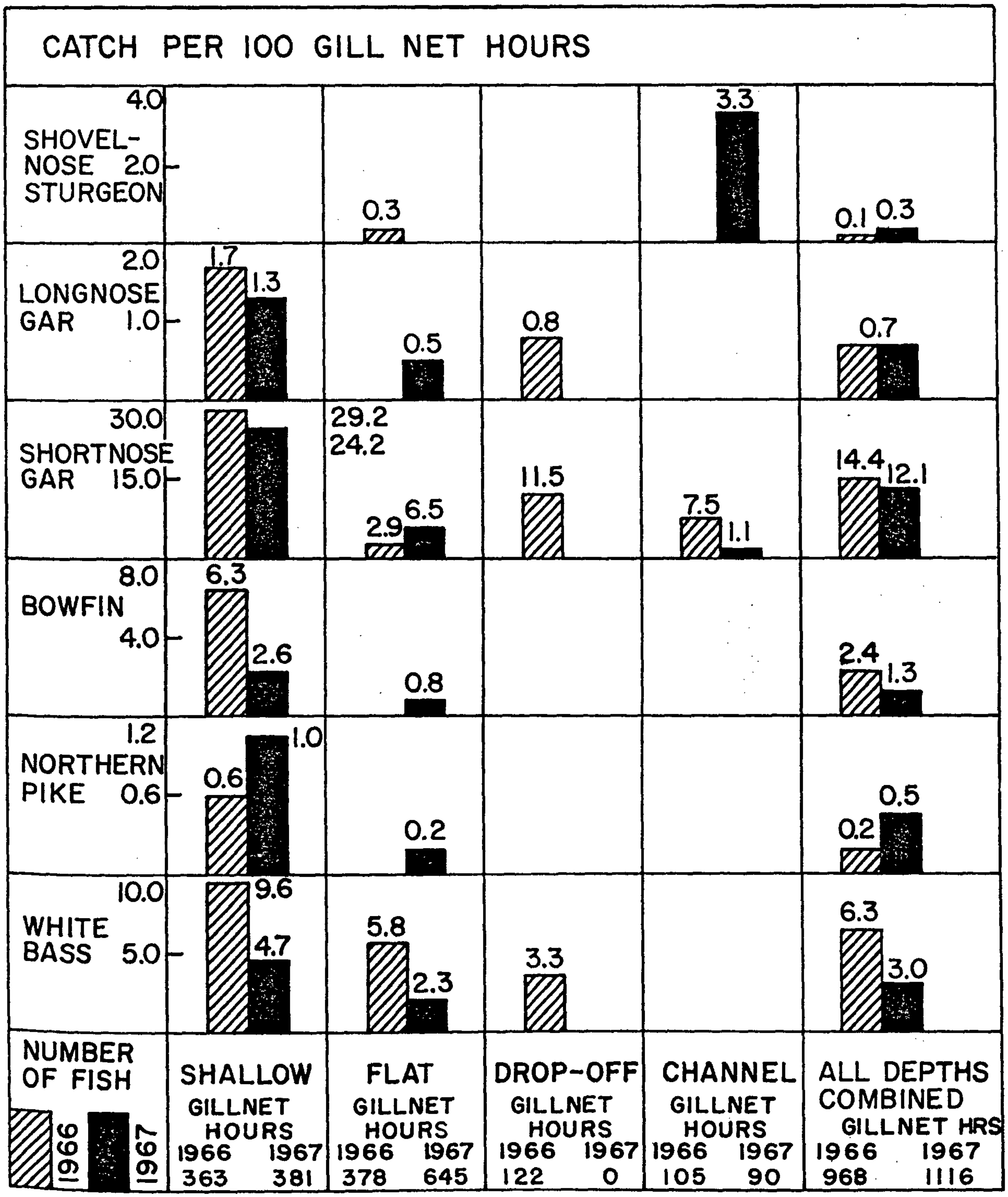

CATCH PER 100 GILL NET HOURS
SHOVEL-NOSE STURGEON
4.0
2.0
3.3
0.3
0.1 0.3
LONGNOSE GAR
2.0
1.0
1.7
1.3
0.5
0.8
0.7
SHORTNOSE GAR
30.0
15.0
29.2
24.2
2.9 6.5
11.5
7.5 1.1
14.4 12.1
BOWFIN
8.0
4.0
6.3
2.6
0.8
2.4 1.3
NORTHERN PIKE
1.2
0.6
0.6
1.0
0.2
0.2 0.5
WHITE BASS
10.0
5.0
9.6
4.7
5.8
2.3
3.3
6.3
3.0
NUMBER OF FISH
1966 1967
SHALLOW GILLNET HOURS 1966 1967 363 381
FLAT GILLNET HOURS 1966 1967 378 645
DROP-OFF GILLNET HOURS 1966 1967 122 0
CHANNEL GILLNET HOURS 1966 1967 105 90
ALL DEPTHS COMBINED GILLNET HRS 1966 1967 968 1116

Figure 6b. Numbers of each species caught per 100 experimental gill net hours, by depth classifications and combined, 1966 and 1967, in Pool 19, Mississippi River. Figures with bars denote numbers of fish; figures at bottom, hours of gill net effort

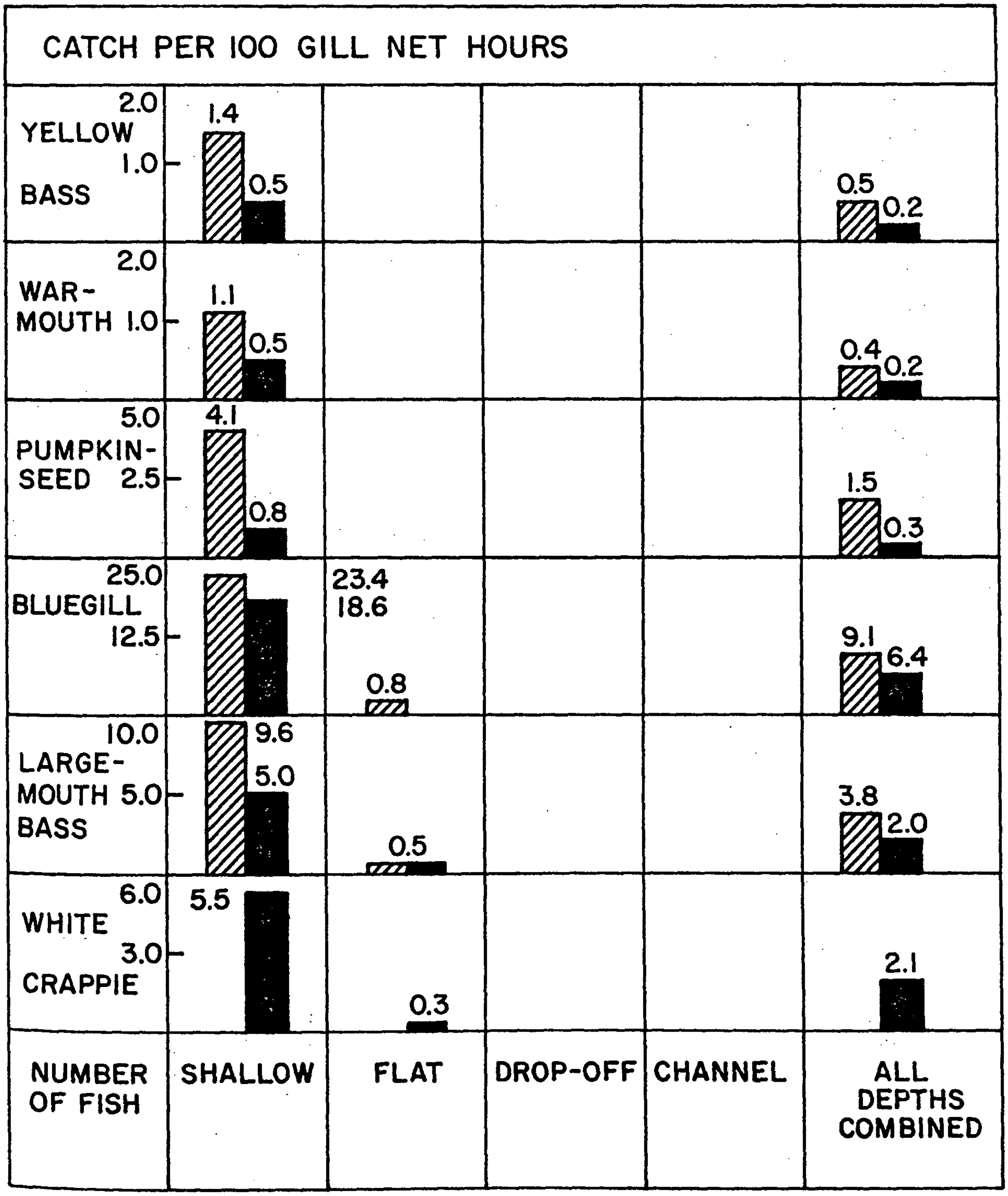
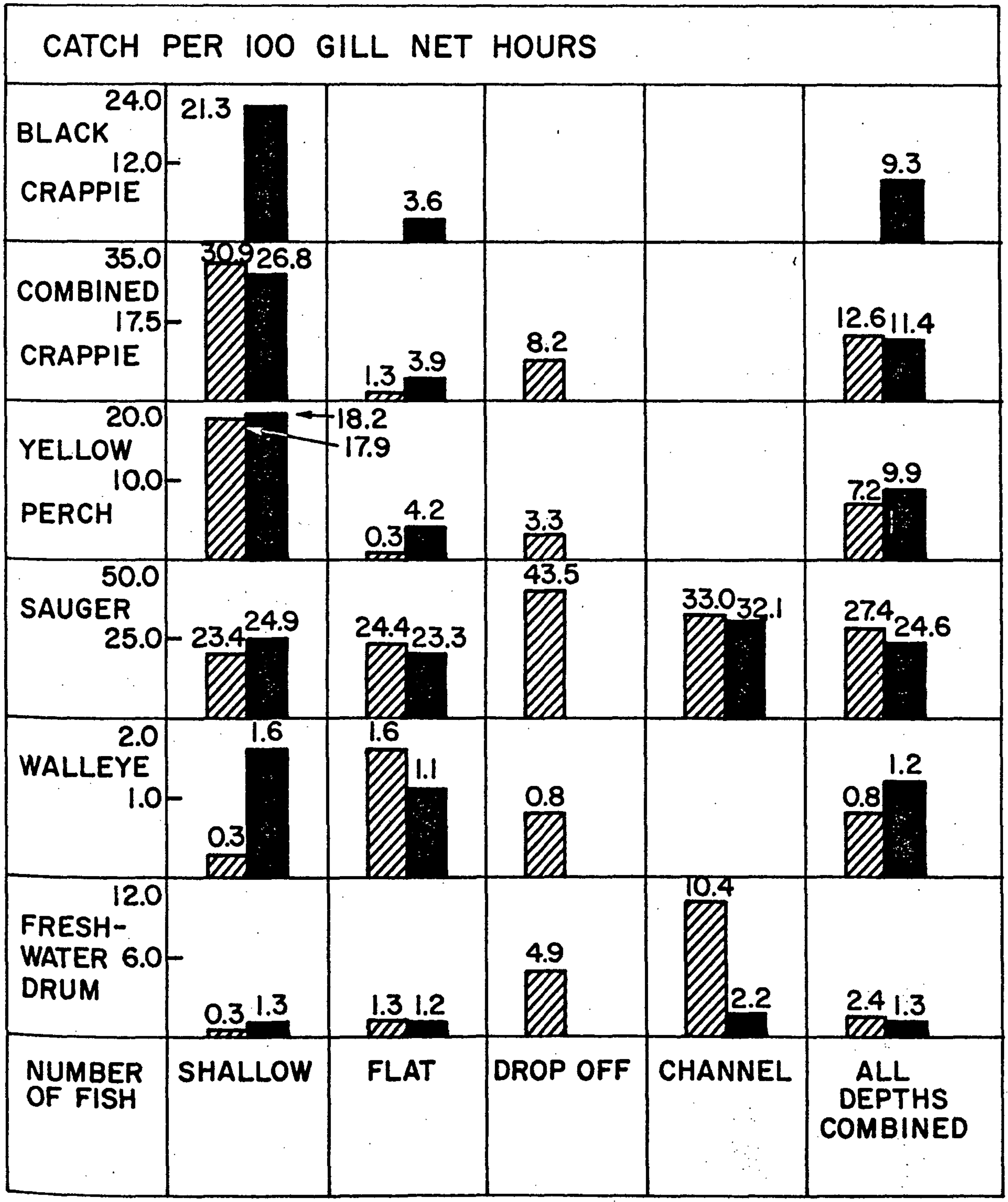

CATCH PER 100 GILL NET HOURS
2.0
YELLOW
1.0
BASS
1.4
0.5
0.5
0.2
2.0
WAR-
MOUTH 1.0
1.1
0.5
0.4
0.2
5.0
PUMPKIN-
SEED 2.5
4.1
0.8
1.5
0.3
25.0
BLUEGILL
12.5
23.4
18.6
0.8
9.1
6.4
10.0
LARGE-
MOUTH 5.0
BASS
9.6
5.0
0.5
3.8
2.0
6.0
WHITE
3.0
CRAPPIE
5.5
0.3
2.1
NUMBER OF FISH
SHALLOW
FLAT
DROP-OFF
CHANNEL
ALL DEPTHS COMBINED

Figure 6c. Numbers of each species caught per 100 experimental gill net hours, by depth classifications and combined, 1966 and 1967, in Pool 19, Mississippi River. Figures with bars denote numbers of fish; figures at bottom, hours of gill net effort


CATCH PER 100 GILL NET HOURS
24.0
BLACK
12.0
CRAPPIE
21.3
3.6
9.3
35.0
COMBINED
17.5
CRAPPIE
30.9
26.8
1.3
3.9
8.2
12.6
11.4
20.0
YELLOW
10.0
PERCH
18.2
17.9
0.3
4.2
3.3
7.2
9.9
50.0
SAUGER
25.0
23.4
24.9
24.4
23.3
43.5
33.0
32.1
27.4
24.6
2.0
WALLEYE
1.0
0.3
1.6
1.6
1.1
0.8
0.8
1.2
12.0
FRESH-
WATER 6.0
DRUM
0.3
1.3
1.3
1.2
4.9
10.4
2.2
2.4
1.3
NUMBER
OF FISH
SHALLOW
FLAT
DROP OFF
CHANNEL
ALL
DEPTHS
COMBINED

seed, longnose gar, warmouth, yellow bass, northern pike, shovelnose sturgeon, and paddlefish. (Paddlefish were not included in Figure 6 due to their low catch rate; only one specimen was gill netted.)

Habitats were defined by water depth: 1) shallow -- less than 3 feet deep, 2) flat -- between 3 and 9 feet deep, 3) channel -- over 9 feet deep, and 4) drop-off -- a rapid transition between flat and channel depths. The shallow areas were sometimes subdivided on the absence or presence and density of vegetation. A shallow weedy slough (transect 2), largely isolated from the river proper, and the water cooling pool of an Ortho chemical plant and its outlet were also considered separately in some tables.

Species occurrence with relation to water depth (Figure 6) is described by the following groups:

1) taken only in shallow areas-- yellow bass, warmouth, and pumpkinseed,

2) taken predominately at shallow and occasionally at flat stations, listed in order of decreasing catch rate in shallow relative to flat areas-- bluegill, white crappie, largemouth bass, bowfin, northern pike, and black crappie,

3) taken in shallow, flat, and drop-off areas, a) but most commonly in shallow, listed in order of decreasing catch rate in the latter relative to deeper locations-- yellow perch, longnose gar, white bass, b) and about equally in each-- walleye,

4) taken in all depth categories, but a) most frequently at shallow stations-- shortnose gar, b) most frequently in drop-off and channel, listed in order of decreasing catch rate in shallow and flat relative to above-- sauger and freshwater drum,

5) taken only in flat and channel-- shovelnose sturgeon and paddlefish.

For those species found to some extent in shallow water, the following ratios of catch rates in vegetated areas to those in non-vegetated areas were observed for 1966-67 data combined:

1) appearing in vegetated areas only-- pumpkinseed,

2) consistently appearing more frequently at vegetated stations than at non-vegetated ones-- bluegill (28.5) and bowfin (24.0),

3) less difference but with a consistently higher catch rate in vegetation compared to open water-- yellow perch (11.9), largemouth bass (6.0), white crappie (4.1), warmouth (3.7), and black crappie (3.1),

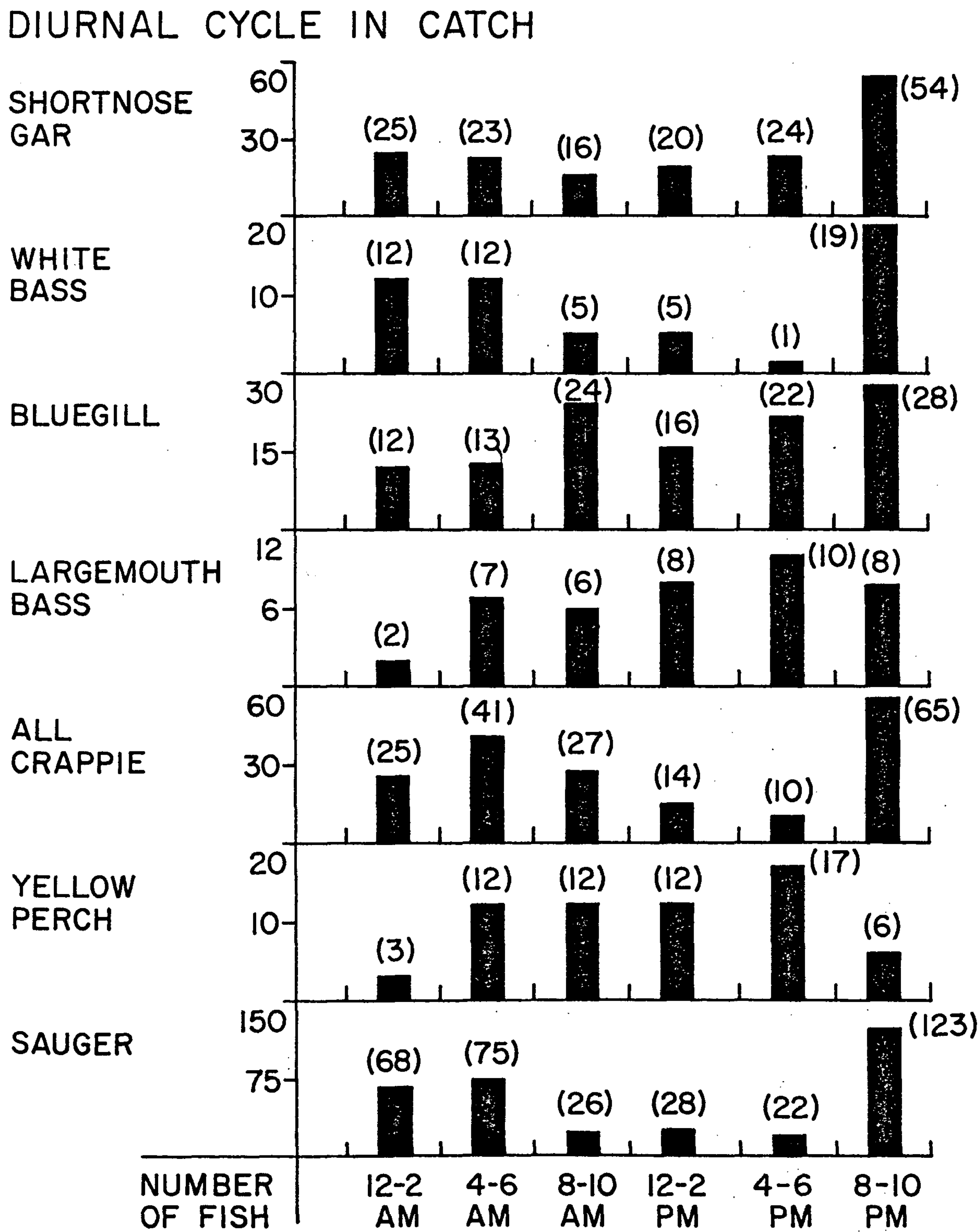
4) having catch rates higher in vegetated areas one year and non-vegetated the next, or equal in both areas in a given year-- yellow bass (1.8), shortnose gar (1.3), northern pike (0.8), white bass (0.7), longnose gar (0.6), and freshwater drum (0.4),

5) showing consistently lower catch rates at vegetated stations compared to non-vegetated ones-- sauger (0.2), and walleye (0.1).

Since fish must be active before they are susceptible to gill net capture, the 24-hour gill net samples provided data showing at what time of day each species was most active (Figure 7). Only species taken frequently are included in the graph, but comments on other species are given in the species summaries.

Most species showed greatest activity at night. Starting with the greatest degree of night activity and decreasing were: walleye, white bass, sauger, longnose gar, black crappie, freshwater drum, shortnose gar, bowfin, and white crappie. Pumpkinseed were the most strongly diurnal, fol-

Figure 7. Gill net catch of fish by species at various times of day during August, 1966, and June through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote numbers of fish. Each two-hour period represents 116 gill-net hours


DIURNAL CYCLE IN CATCH
SHORTNOSE GAR
60
30
(25) (23) (16) (20) (24) (54)
WHITE BASS
20
10
(12) (12) (5) (5) (1) (19)
BLUEGILL
30
15
(12) (13) (24) (16) (22) (28)
LARGEMOUTH BASS
12
6
(2) (7) (6) (8) (10) (8)
ALL CRAPPIE
60
30
(25) (41) (27) (14) (10) (65)
YELLOW PERCH
20
10
(3) (12) (12) (12) (17) (6)
SAUGER
150
75
(68) (75) (26) (28) (22) (123)
NUMBER OF FISH
12-2 AM
4-6 AM
8-10 AM
12-2 PM
4-6 PM
8-10 PM

lowed by the yellow perch, largemouth bass, and bluegill. Data for warmouth, northern pike, shovelnose sturgeon, paddlefish, and yellow bass were too inconclusive to indicate definite activity trends.

FOOD HABITS ANALYSIS

The following approaches were used to describe the food habits of the fish:

1) an overall summary based on all the stomach contents examined for each species over the entire study period. This was done by calculating the percent of the total food volume contributed by each type of food item. The percent occurrence value for each food item was calculated by dividing the number of fish which contained a certain food item by the number of fish with identifiable food contents and multiplying by 100.

2) a summary of food utilization by fish at different sizes. Specimens were grouped in inch classes when these represented adequate samples. In some cases, two or more inch groups were combined to make comparisons more meaningful. In general, sample size was most adequate for inch groups near the median and decreased with increasing and decreasing fish size.

3) monthly variations in food. A large majority of the samples were taken in July and August, with other months sampled less intensively or not at all.

4) variations in the food habits in different locations. Sampling stations providing similar fish habitat were grouped in an attempt to find major trends. The habitats included in these groups varied with the fish being considered. Stations were placed in separate groups wherever important differences in the stomach contents of fish collected at them were evident. Where such variations between stations were absent, data were combined to form categories.

It should be noted at this point that the numbers of fish involved in presenting the data were sometimes small (shovelnose sturgeon, paddlefish, yellow bass, warmouth, and pumpkinseed) or that a large percentage of the stomachs were empty (longnose gar, northern pike, walleye). Where specimen numbers were small, tabular presentation of the data was omitted. Even for those fish where a fairly large sample was obtained, the numbers in certain categories became quite small when size, month, or habitat was being considered.

DISTRIBUTION AND FOOD HABITS BY SPECIES

Shovelnose Sturgeon

Only four shovelnose sturgeon were obtained in this study, ranging from 16.2 to 25.0 inches (average, 21.4 inches). Three were taken in the river channel, and the smallest was caught in the flat area (Figure 6). Two of three sturgeon sampled in August were taken at night, the other in early afternoon. The largest specimen was taken in late November at an unknown time of day.

Potamyia flava caddisfly larvae made up over 88 percent of the total food volume and were found in all specimens examined. The largest and smallest sturgeon contained *Hexagenia* mayfly naiads which amounted to 10 percent of the total food volume. Chironomid and ceratopogonid larvae were present in small amounts in fish sampled in August.

In 74 shovelnose sturgeon examined from Pool 19 by Hoopes (1959), caddisflies contributed 75 percent of the total food volume, 68 percent of which was *P. flava* larvae. *Hexagenia* naiads were next in importance (17 percent). The food of a 26.6-inch shovelnose sturgeon taken from Pool 19 in early April consisted almost entirely of *Hexagenia* naiads, with caddisfly (*P. flava*) and chironomid larvae present only in small volumes (Wenke, 1965). Barnickol and Starrett (1951) also report that several shovelnose sturgeon from the Mississippi River contained *Hexagenia* naiads. Forbes and Richardson (1920) found small numbers of caddisfly larvae and *Hexagenia* naiads in two fish taken in Illinois, and similar observations were made on 12 sturgeon from Lake Pepin, Wisconsin (Pearse, 1921).

Paddlefish

The only paddlefish examined were a 27.6-inch specimen from the flat area and 28.2-inch fish from the channel, both samples in early May. Zooplankton made up practically the entire food volume of these fish. The stomach of the larger specimen contained only a small amount of food which was too digested to allow further identification of the zooplankton. A single chironomid larvae was also present. The smaller paddlefish contained a large volume of food, and nearly all the zooplankters were copepods, plus a few cladocerans. Two Hexagenia naiads and ceratopogonid larvae were also present, plus a small amount of vegetation.

Hoopes (1959) secured a sizable sample of 64 paddlefish from Pool 19 commercial fishermen with representative specimens from all seasons of the year. The fish ranged from the size taken in this study to specimens nearly twice as long. All were caught in about 10 feet of water. He found Hexagenia naiads were the most important food item, making up nearly half the total food volume. They were utilized most from winter through early summer and were largely replaced by zooplankton (copepods and cladocerans) and algae from late summer through fall. Wenke (1965) examined four paddlefish in another Pool 19 food habits study. Two slightly larger than those studied here contained over 90 percent Hexagenia naiads by volume in early April. In July one fish had eaten only a small amount of vegetation, and another contained zooplankton. Some earlier workers (Kofoid, 1900; Imms, 1904; and Stockard, 1907) were of the opinion that paddlefish fed almost entirely on crustacean zooplankton. Coker (1923, 1930) also believed paddlefish were essentially zooplankton and phytoplankton feeders, although he observed that five fish taken from April through August contained mostly naiads of mayflies and dragonflies and caddisfly larvae. Forbes (1888a and 1888b), Wagner (1908), Alexander (1915), Forbes and Richardson (1920), and Pearse (1921) also reported paddlefish feeding on zooplankton and insects, particularly *Hexagenia*.

Longnose Gar

The 17 longnose gar ranged from 14.1 to 31.9 inches in length (average, 19.3 inches). They appeared mostly in shallow areas with only four specimens taken in over 3 feet of water and none in the channel (Figure 6). The shallow water catch rate was about five times that of the deeper areas. One of six gar sampled in 1966 was taken at a vegetated station; four of five in 1967 came from vegetated areas. The overall catch rate per 100 gill net hours was 1.5 fish for non-vegetated stations and 1.1 for vegetated ones. Gill nets caught 9 longnose gar during the night compared to 3 in daylight hours.

The 11 specimens containing food were taken in July and August and were entirely piscivorous. The stomach contents of three gar were too digested to further identify the forage fish eaten, but it was evident that each contained a single fish, one of which was about 3 inches in length. The most important forage fish was gizzard shad, Dorosoma cepedianum. Five longnose gar contained only this species. The numbers of shad per stomach ranged from 2 to 20 and their sizes from 0.2 to 5.0 inches. Minnows from 0.2 to 1.5 inches in length were the only food items in two gar; three were found in one fish and seven in the other. One longnose gar contained three gizzard shad 2 to 3 inches in length and a 1-inch largemouth bass.

Wenke (1965) found very similar food habits in nine longnose gar taken in July and August in Pool 19. Nearly half the specimens did not contain identifiable food items. The others had fed exclusively on fish, mostly gizzard shad. However, two gar taken in June contained only insects, suggesting that an exclusively piscivorous diet may be characteristic of mid- and late-summer, with insects of importance in the spring and early summer months. Unfortunately the only longnose gar I collected in the spring had an empty stomach. Forbes and Richardson (1920) reported that longnose gar feed heavily on fish. Young gar first feed on entomostracans, but fish were observed in a gar 1.25 inches long. Lagler and Hubbs (1940) found 99 percent of the food of longnose gar was fish, mainly yellow perch, bullheads, minnows, and various centrarchids. Small numbers of crayfish and naiads of damselflies and mayflies were observed. Half of 136 specimens examined were empty.

Shortnose Gar

Shortnose gar were caught in all depth classifications but appeared predominately in shallow water areas (Figure 6). The catch per 100 gill net hours was 30.2 in the vegetated areas compared to 17.0 in the non-vegetated ones in 1966, but in 1967 the figures were 25.4 and 25.0. Shortnose gar were about equally active throughout the day and night, except for a peak period 8 to 10 PM when they were caught about twice as frequently as during any of the other two-hour intervals in the 24-hour sampling period (Figure 7).

The stomach contents of 181 shortnose gar averaging 19.7 inches in length and ranging from 8.4 inches to 28.2 inches were examined. Gar stomachs often contained either little or no food or very large volumes; 40 percent of those examined here were empty (Table 4). Of 109 specimens containing food, both fish and mayflies (*Hexagenia*) appeared in about half the gar examined. They were the only food items of major importance, each making up approximately half of the total food volume. *Hexagenia* naiads were considerably more important than the adults as a food item. Several other food organisms were found in small amounts in small numbers of specimens, including various immature insects, crustaceans, and other invertebrates. There were no obvious differences in food habits of gar of different sizes over the size range sampled here. The less common food items most likely appeared only in the gar of intermediate size, not because the largest and smallest fish were not feeding on them, but because the larger sample of medium-sized fish increased the probability of unusual items appearing there.

Table 4. Percent volume and occurrence of food items[a] in shortnose gar, combined and by months

Food Items	Combined Vol.	Combined Occ.	May Vol.	May Occ.	June Vol.	June Occ.	July Vol.	July Occ.	August Vol.	August Occ.
Fish	45.84	51.4	83	16	2	17	12	47	99	100
Hexagenia										
naiads	38.82	48.6	17	84	98	89	88	59	-	5
adults	14.85	20.2	0	0	-	22	-	47	0	0
Crayfish	0.32	0.9	0	0	0	0	0	0	-	2
Vegetation	0.04	2.7	0	0	-	11	0	0	-	5
Leeches	0.03	1.8	0	0	-	6	-	3	0	0
Potamyia	0.03	1.8	0	0	0	0	0	0	-	5
Hyallela	0.01	0.9	-	5	0	0	0	0	0	0
Oecetis	0.01	1.8	0	0	-	11	0	0	0	0
Corixids	-	1.8	0	0	0	0	-	3	-	2
Chironomids	-	0.3	0	0	-	6	-	6	0	0
Other[b]	-	2.7	-	5	0	0	-	3	-	2
Unidentified	0.05	0.9	-	5	0	0	0	0	1	2
Number with food		109		19		18		32		40
Number empty		72		12		4		13		43

[a]All insects are immature forms except corixids and adult Hexagenia.

[b]Other: caenid and baetid mayflies, stoneflies, snails.

Fish dominated the gar diet in May and August and were of some importance in July; Hexagenia were the main food in June and July and were of lesser importance in May (Figure 8, Table 4). Differences in food habits in different river habitats were also evident (Figure 9). Fish were the only food item of importance in gar from the channel and Ortho pool and made up nearly the entire food volume of those from slough areas, although Hexagenia naiads were found in small amounts in a few fish from this area. Shortnose gar fed on Hexagenia most extensively in the shallow non-vegetated areas of the river, with a corresponding reduction in the amount of fish eaten. Hexagenia were slightly less important in the shallow vegetated areas but still made up over half the total food volume. Here the adult form was somewhat more important than the naiads. In the flat and drop-off habitats, fish were the dominant food item, although Hexagenia naiads and to a somewhat lesser extent Hexagenia adults still formed an appreciable part of the food volume.

In specimens containing recognizable fish, gizzard shad were the most frequently occurring species of forage fish. They were the only kind of fish found in 16 gar. One gar contained gizzard shad and unidentifiable fish; another, bowfin and bluegill, as well as gizzard shad. Shad found in gar stomachs ranged from 1.5 inches to 5.0 inches in length. The number of fish per stomach was one to four in most cases but reached as high as eight. The next most commonly eaten fish were small centrarchids (bluegills and/or crappies) found in three of the gar examined. They ranged in length from 0.5 inches to 1.2 inches, with 2 to 12 individuals per stomach. Three gar contained only single channel catfish, another a bullhead of undetermined species, and a third one 1.8-inch channel catfish and a 0.8-

Figure 8. Percent volume of food items in shortnose gar stomachs, by months from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size

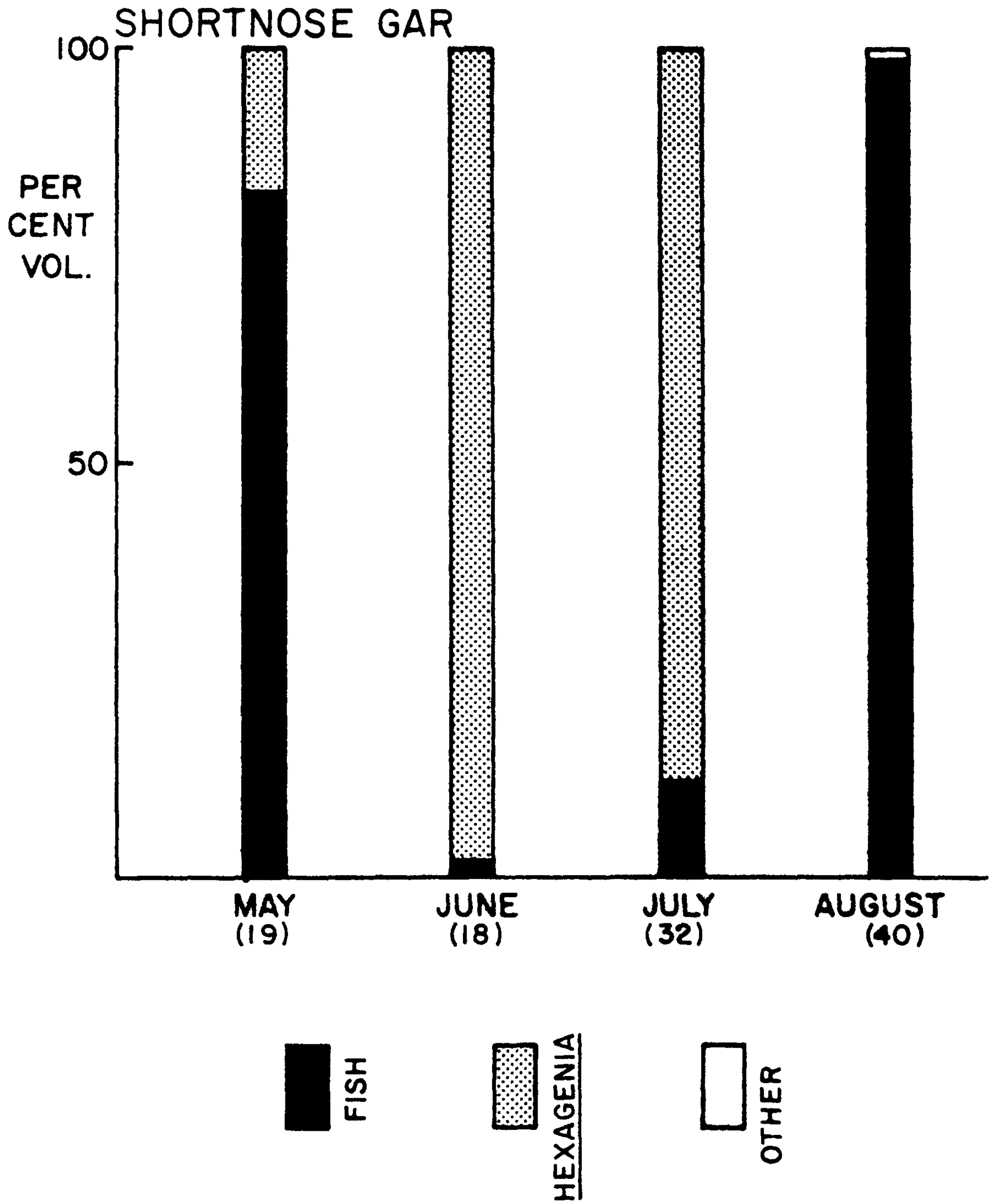
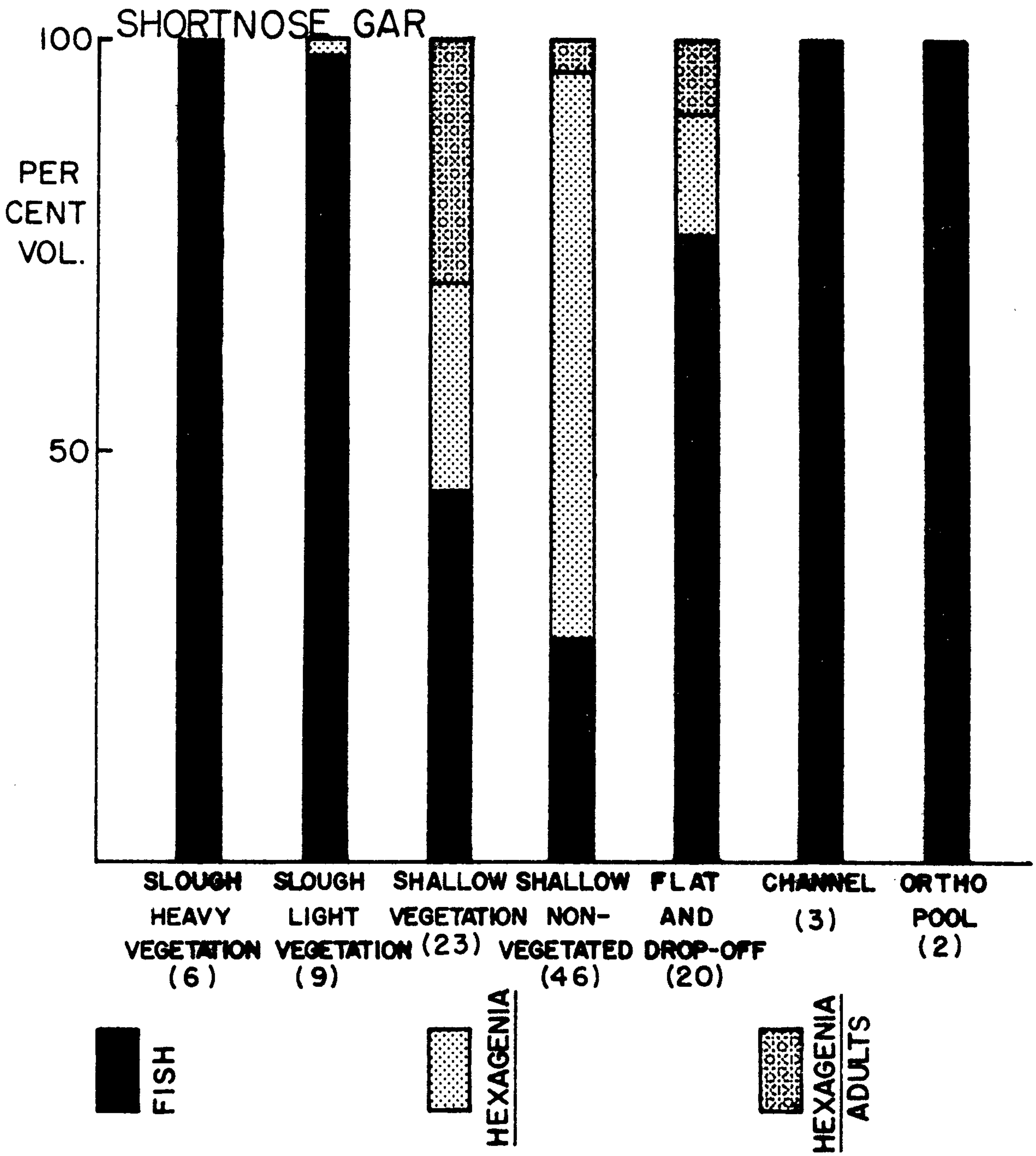

SHORTNOSE GAR
100
50
PER CENT VOL.
MAY (19)
JUNE (18)
JULY (32)
AUGUST (40)
FISH
HEXAGENIA
OTHER

Figure 9. Percent volume of food items in shortnose gar stomachs in various habitats from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size


SHORTNOSE GAR
100
50
PER CENT VOL.
SLOUGH HEAVY VEGETATION (6)
SLOUGH LIGHT VEGETATION (9)
SHALLOW VEGETATION (23)
SHALLOW NON-VEGETATED (46)
FLAT AND DROP-OFF (20)
CHANNEL (3)
ORTHO POOL (2)
FISH
HEXAGENIA
HEXAGENIA ADULTS

inch unidentified fish. Another gar had three fish which were either buffalo or carpsuckers in its stomach. Two gar had eaten minnows: a 5.0-inch golden shiner and a 1.2-inch minnow of undetermined species.

Wenke (1965) examined the stomach contents of 18 shortnose gar and found one-third of them empty and several others containing little food, agreeing closely with the results of this study and others (e.g. Hunt, 1960). Wenke found both fish and Hexagenia to be of less significance than they were in this study, largely due to the much greater utilization of caddisflies in his sample.

Other studies of shortnose gar food habits generally agree that fish is the main food item, although various types and amounts of insects are frequently found. Coker (1930) found insects in specimens collected from the lower Pool 19 vicinity. Beetles were important in a Mississippi study (Hildebrand and Towers, 1927), and grasshoppers were noted in Florida (Holloway, 1954). Insects made up an appreciable part of the diet of shortnose gar in an Indiana pond (Lagler, Obrecht, and Harry, 1942). Corixids were most important, and mayfly naiads and adults were also eaten. Insects were not observed in some other studies of shortnose gar food habits (Scott, 1938; Parker, 1939; Potter, 1923 and 1927).

Bowfin

Except for 5 specimens caught in the flats, all bowfin were taken from shallow water stations (Figure 6). All but one of the gill net samples were captured at locations with aquatic vegetation. Bowfin showed about an equal amount of movement during all two-hour sampling periods except for a peak between 4 and 6 AM.

The stomachs of 39 bowfin ranging from 13.4 to 25.2 inches in length (average, 17.4 inches) were analyzed (Table 5). Slightly less than half the fish examined had empty stomachs. In the 21 bowfin with identifiable stomach contents, fish were the most important food item, making up over half the total volume. Crayfish (27 percent) and dragonfly naiads (13 percent) were the only other foods of major volume. Immature chironomids (3 percent) and Hexagenia naiads (1 percent) appeared in minor amounts, and corixids occurred in 14 percent of the samples but made up only 0.02 percent of the total volume.

Fish made up 45 percent or more of the food of all size groups examined and were more important in bowfin over 16 inches long than in smaller ones (Table 5). No trends in importance with size could be determined for crayfish. Dragonfly naiads were about as important as fish to bowfin less than 15 inches long but made up only 2 percent of the diet of specimens 15.0 to 19.9 inches long.

Bowfin containing identifiable food items were obtained May through August (Figure 10). Three specimens taken in November and December were empty. Crayfish were a significant part of the food in the shallows but not in the slough (Table 6).

Table 5. Percent volume and occurrence of food items[a] in bowfin, combined and by size groups (lengths in inches)

Food Items	Combined Vol.	Combined Occ.	13.0-14.9 Vol.	13.0-14.9 Occ.	15.0-15.9 Vol.	15.0-15.9 Occ.	16.0-19.9 Vol.	16.0-19.9 Occ.	20.0-24.9 Vol.	20.0-24.9 Occ.
Fish	53.58	76.2	45	80	45	72	69	60	68	100
Crayfish	26.58	19.0	4	20	52	14	3	20	32	25
Dragonfly	13.06	14.3	47	40	0	0	6	20	0	0
Chironomids	3.47	33.3	-	60	-	28	18	40	0	0
Hexagenia	1.21	9.5	0	0	3	28	0	0	0	0
Snails	0.66	9.5	0	0	-	14	3	20	0	0
Leeches	0.23	9.5	0	0	0	0	1	40	0	0
Damselfly	0.13	9.5	-	40	0	0	0	0	0	0
Vegetation	0.09	4.8	0	0	0	0	0	0	0	0
Oecetis	0.04	4.8	-	20	0	0	0	0	0	0
Caddisfly adults	0.04	4.8	-	20	0	0	0	0	0	0
Corixids	0.02	14.3	-	20	-	28	0	0	0	0
Caenids and baetids	-	4.8	-	20	0	0	0	0	0	0
Unidentified	0.79	9.5	4	40	0	0	0	0	0	0
Number with food		21		5		7		5		4
Number empty		18		3		7		2		6

[a]All insects are immature forms except corixids and caddisfly adults.

Figure 10. Percent volume of food items in bowfin stomachs by months from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size

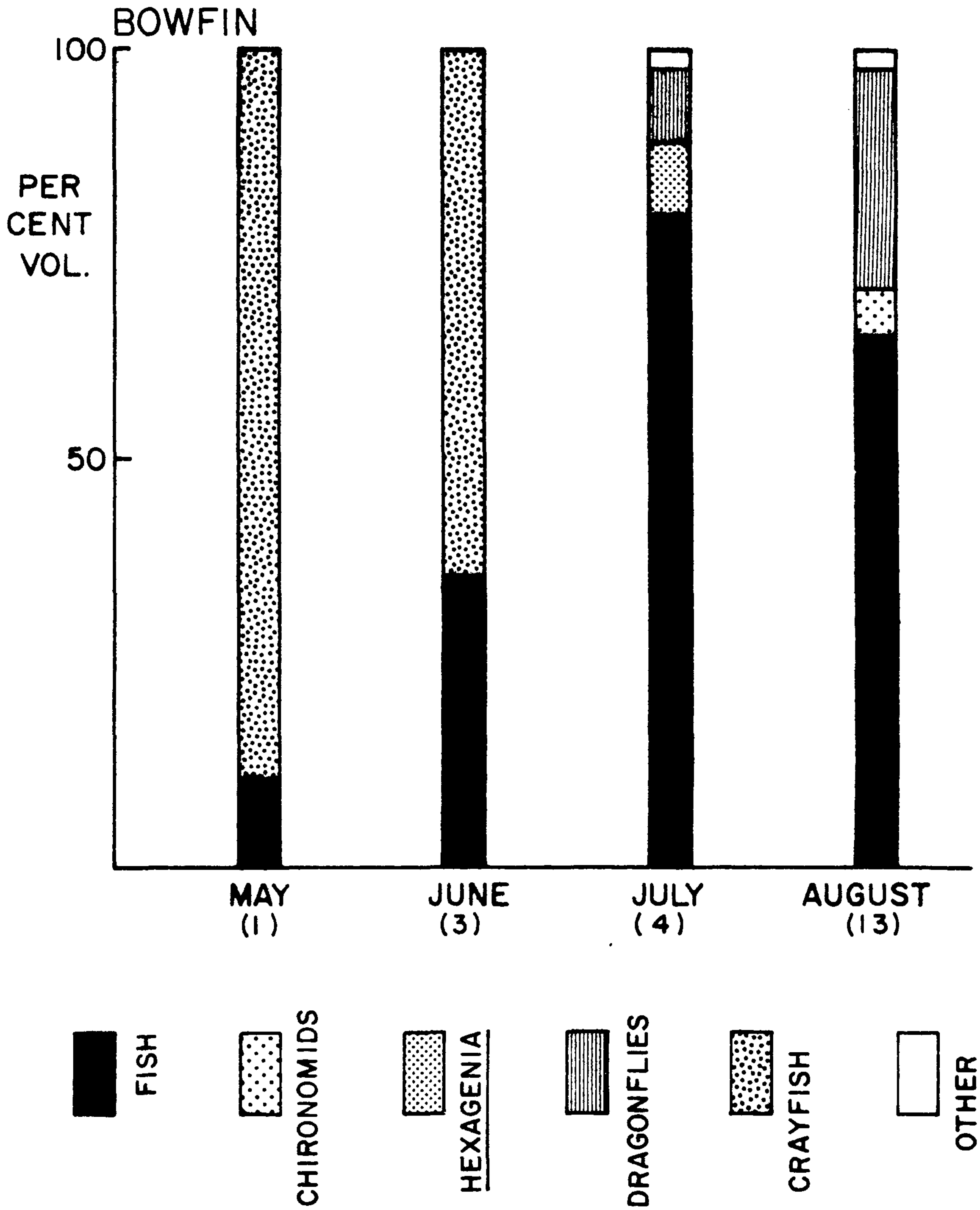

BOWFIN
100
50
PER CENT VOL.
MAY (1)
JUNE (3)
JULY (4)
AUGUST (13)
FISH
CHIRONOMIDS
HEXAGENIA
DRAGONFLIES
CRAYFISH
OTHER

Table 6. Percent volume and occurrence of food items[a] in bowfin by habitats[b]

Food Items	Slough Heavy Vegetation Vol.	Occ.	Slough Light Vegetation Vol.	Occ.	Shallow Vegetated Vol.	Occ.	Shallow Non-Vegetated Vol.	Occ.	Flat Vol.	Occ.
Fish	97	86	21	75	56	100	31	60	-	-
Crayfish	0	0	0	0	20	33	64	60	0	0
Dragonfly	0	0	65	25	7	33	3	20	0	0
Chironomids	3	29	14	50	-	67	0	0	-	100
Hexagenia	0	0	0	0	3	33	0	0	92	100
Snails	0	0	0	0	0	0	1	20	8	100
Leeches	-	14	-	25	0	0	0	0	0	0
Damselfly	0	0	0	0	1	33	-	20	0	0
Vegetation	0	0	0	0	0	0	-	20	0	0
Oecetis	0	0	0	0	1	33	0	0	0	0
Caddisfly adults	0	0	0	0	1	33	0	0	0	0
Corixids	-	14	0	0	-	33	0	0	-	100
Caenid and baetids	0	0	-	25	0	0	0	0	0	0
Unidentified	0	0	0	0	11	33	-	20	0	0
Number with food		7		4		3		5		1
Number empty		7		4		2		1		2

[a]All insects are immature forms except corixids and caddisfly adults.

[b]A single specimen from Ortho Outlet contained only fish remains.

Four bowfin contained centrarchids (bluegills and/or crappies) ranging in size from 0.5 inches to 2.0 inches. The numbers per stomach varied between 4 and 37. A 1.2-inch bullhead and five centrarchids ranging from 0.5 to 1.0 inches were found in the stomach of one bowfin, and another contained a gizzard shad and a bullhead. Small bluegills, crappies, and bullheads associated with shallow weedy areas seemed to be the fish utilized most extensively by bowfin also found in this habitat.

Wenke (1965) obtained two bowfin from a backwater area of Pool 19 in March, but both specimens had empty stomachs. Forbes (1888) analyzed the food habits of 21 bowfin from various locations in Illinois. He observed the main food items were crustaceans, mostly crayfish and also a few cladocerans; fish, recognizable individuals included buffalo and minnows; and mollusks, primarily fingernail clams. Insects accounted for only 2% of the total food volume, with chironomid larvae and mayfly naiads observed in a few specimens. Bowfin less than 18 inches long fed mainly on insects in a Mississippi sample (Hildebrand and Towers, 1927). Corixids, dragonfly naiads, and aquatic beetles were eaten most often. In two Michigan studies (Lagler and Hubbs, 1940 and Lagler and Applegate, 1942) the bowfin diet was made up almost entirely of fish (about 80 percent) and crayfish (14 to 18 percent).

Northern Pike

Seven northern pike ranging from 17.4 to 24.3 inches (average, 20.9 inches) appeared in the samples. Except for a 19.5-inch pike taken in the flats, all came from shallow water (Figure 6) and were caught with about equal frequency in vegetated and non-vegetated areas. Threinen et al. (1966) described the preferred habitat of northern pike as shallow weedy areas. Only three had food in their stomachs, in each case a single fish, 4 to 6 inches in length. Gizzard shad were present in two fish taken in August and November, respectively, and a bluegill in one sampled in May. According to Threinen et al. (1966) pike are most active during daylight hours. Studies of northern pike activity in Clear Lake, Iowa, (Carlander, 1953) and Lake of the Woods, Minnesota, (Carlander, 1942 and Carlander and Cleary, 1949) gave the same conclusion.

American Eel

A 33.5-inch American eel taken in a basket trap of a commercial fisherman was the only one obtained during the study. It was caught in the channel in late August and had no food in its stomach. Hoopes (1959) in his Pool 19 study found one eel with a full stomach containing three small clams and a large number of *Hexagenia* naiads, and Wenke (1965) found two crayfish in a 26.6-inch eel and a heptageniid mayfly naiad in a 10.6-inch eel. Rimsky-Korsakoff (1930) found 17 eels taken in New York feeding mostly on fish, with chironomid larvae also observed. Mayfly naiads and adults made up over half the food of 20 eels from the Delaware River in New York (Bishop, 1936).

White Bass

White bass appeared twice as frequently in gill net sets in shallow water as in the flat and drop-off areas and not at all in the channel (Figure 6).

The catch per 100 gill net hours was 8.1 white bass in vegetated areas compared to 6.5 in non-vegetated areas in 1966 but only 1.1 to 8.9 in 1967. Bailey and Harrison (1945) reported Clear Lake white bass preferred open water or areas with sparse vegetation, with both young and adults avoiding dense weeds and soft bottom.

White bass were considerably more active at night than during the daylight hours, with the highest catch rate from 8 to 10 PM (Figure 7). Similar observations were made (Carlander, 1953) on Clear Lake, Iowa, white bass. White bass prefer deeper waters during the daylight hours and move into shallow nearshore areas in the evening and at daybreak (Sigler, 1943; Bailey and Harrison, 1945).

The food habits of 109 white bass ranging in length from 2.3 to 15.3 inches and averaging 7.7 inches were examined (Table 7). Of 80 specimens containing food, fish made up over half the total volume, the only other major items being Hexagenia naiads and adults (18 percent) and corixids (17 percent). Minor items included cladocerans, immature chironomids, and larvae of Potamyia flava caddisflies.

Fish were not eaten by white bass less than 6 inches in length, while corixids were utilized by all size ranges (Table 7). Hexagenia naiads were not found in fish smaller than 5 inches, and the adults appeared in only three fish 10.0 to 10.9 inches. Only fish 3.0 to 4.9 inches in length had eaten significant amounts of small crustaceans and damselfly naiads. Imma-

Table 7. Percent volume and occurrence of food items[a] in white bass, combined and by size groups (lengths in inches)

Food Items	Combined Vol.	Combined Occ.	2.0-3.9 Vol.	2.0-3.9 Occ.	4.0-5.9 Vol.	4.0-5.9 Occ.	6.0-8.9 Vol.	6.0-8.9 Occ.	9.0-15.9 Vol.	9.0-15.9 Occ.
Fish	57.16	40.0	0	0	0	0	73	56	53	58
Corixids	17.25	38.8	8	50	10	33	18	34	17	46
<u>Hexagenia</u>										
naiads	11.19	20.0	0	0	10	6	5	16	16	35
adults	6.64	3.8	0	0	0	0	0	0	12	12
Cladocerans	3.26	10.0	90	75	44	28	0	0	0	0
Chironomids	1.32	28.8	0	0	26	61	-	25	-	19
<u>Potamyia</u>	0.92	12.5	0	0	0	0	2	34	-	4
Dragonfly	0.46	1.2	0	0	0	0	0	0	1	4
Damselfly	0.20	3.8	0	0	3	17	-	6	0	0
<u>Leptodera</u>	0.15	8.8	2	75	3	22	0	0	0	0
<u>Hyallela</u>	0.06	5.0	0	0	2	22	0	0	0	0
<u>Stenonema</u>	0.01	2.5	0	0	0	0	-	6	-	8
Caenids and baetids	-	7.5	-	50	-	11	-	6	0	0
Other[b]	0.68	12.0	0	0	-	11	1	19	1	8
Unidentified	0.74	6.2	0	0	2	6	1	9	-	4
Number with food		80		4		18		32		26
Number empty		29		0		9		11		9

[a]All insects are immature forms except corixids and adult <u>Hexagenia</u>.

[b]Other: Snails, Leeches, Vegetation, <u>Oecetis</u> larvae, Water mites, Ceratopogonid larvae, Caddisfly adults.

ture chironomids made up a major part of the stomach contents only in white bass 4.0 to 5.9 inches in length, although they occurred in most sizes sampled. A number of other investigators found small white bass fed primarily on crustaceans and insects (Ewers, 1933; Ewers and Boesel, 1935; Harlan and Speaker, 1956; Forney and Taylor, 1963).

Fish were important food only in July and August (Figure 11). Hexagenia naiads were the most important food item of white bass May through July, with peak utilization in June. They also comprised the entire food volume of two fish taken in October. Bailey and Harrison (1945) found large mayfly naiads formed 75 percent of the food of Clear Lake white bass during April. Corixids were eaten June through December but formed a major part (24 percent) of the diet only during August. Cladocerans were observed in the greatest amounts in August and also appeared in December samples indicating their possible importance to small white bass throughout the year. Immature chironomids were found in white bass stomachs throughout the sampling period but were of the greatest importance in May, November, and December. Potamyia larvae were most important in July and appeared in lesser amounts in August.

The types of food eaten and their relative importance also varied with fish from different habitats (Figure 12). A single specimen from a lightly vegetated slough location contained only fish. In the shallow vegetated areas of the river proper, corixids made up the bulk of the food, followed by fish and a small amount of chironomid larvae and pupae. White bass in the shallow areas lacking vegetation ate roughly equal amounts of fish, corixids, Hexagenia naiads, and Hexagenia adults. In the flat and drop-off locations, fish were the dominant food, followed in importance by cladocer-

Figure 11. Percent volume of food items in white bass stomachs by months from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size

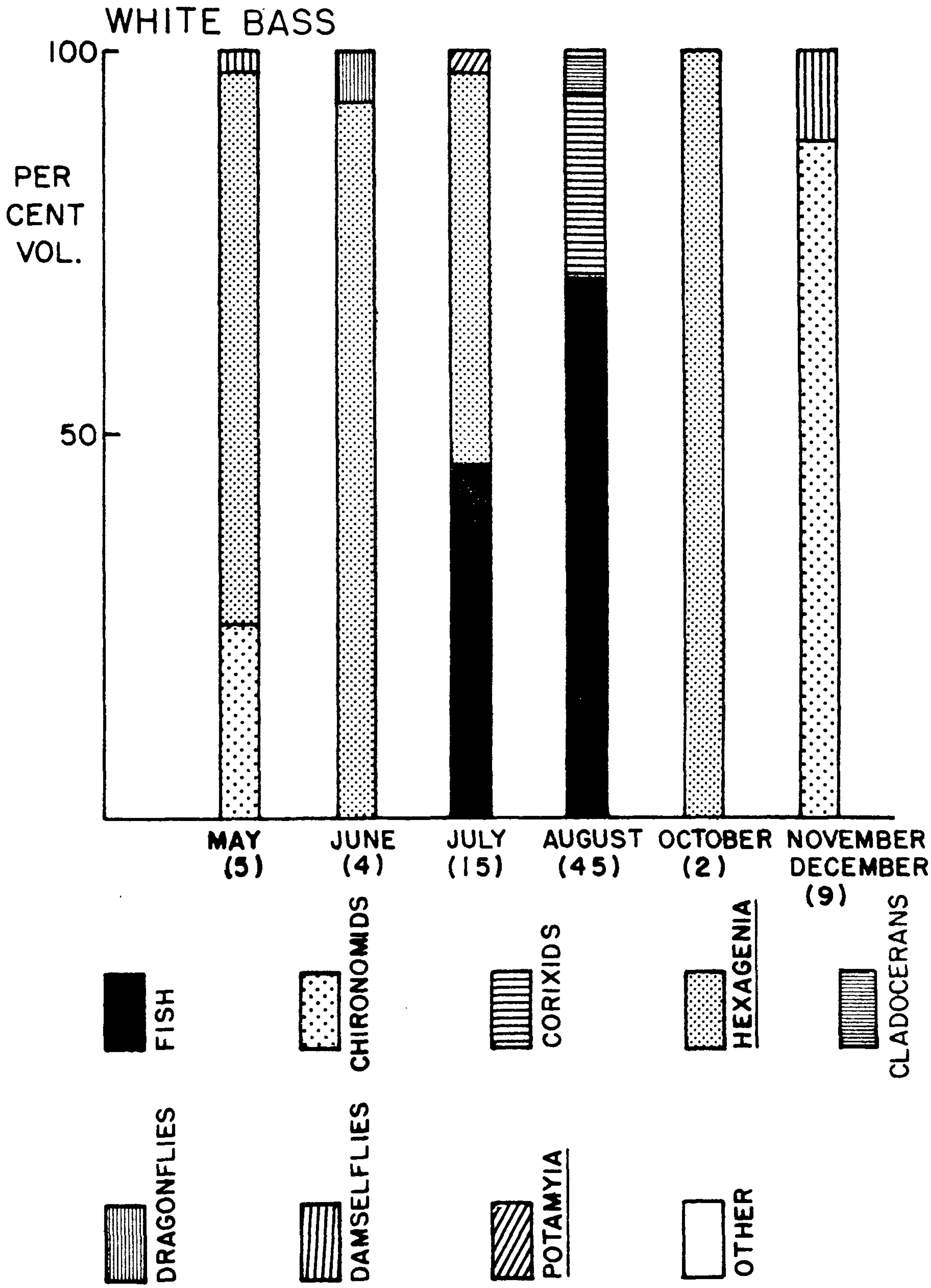
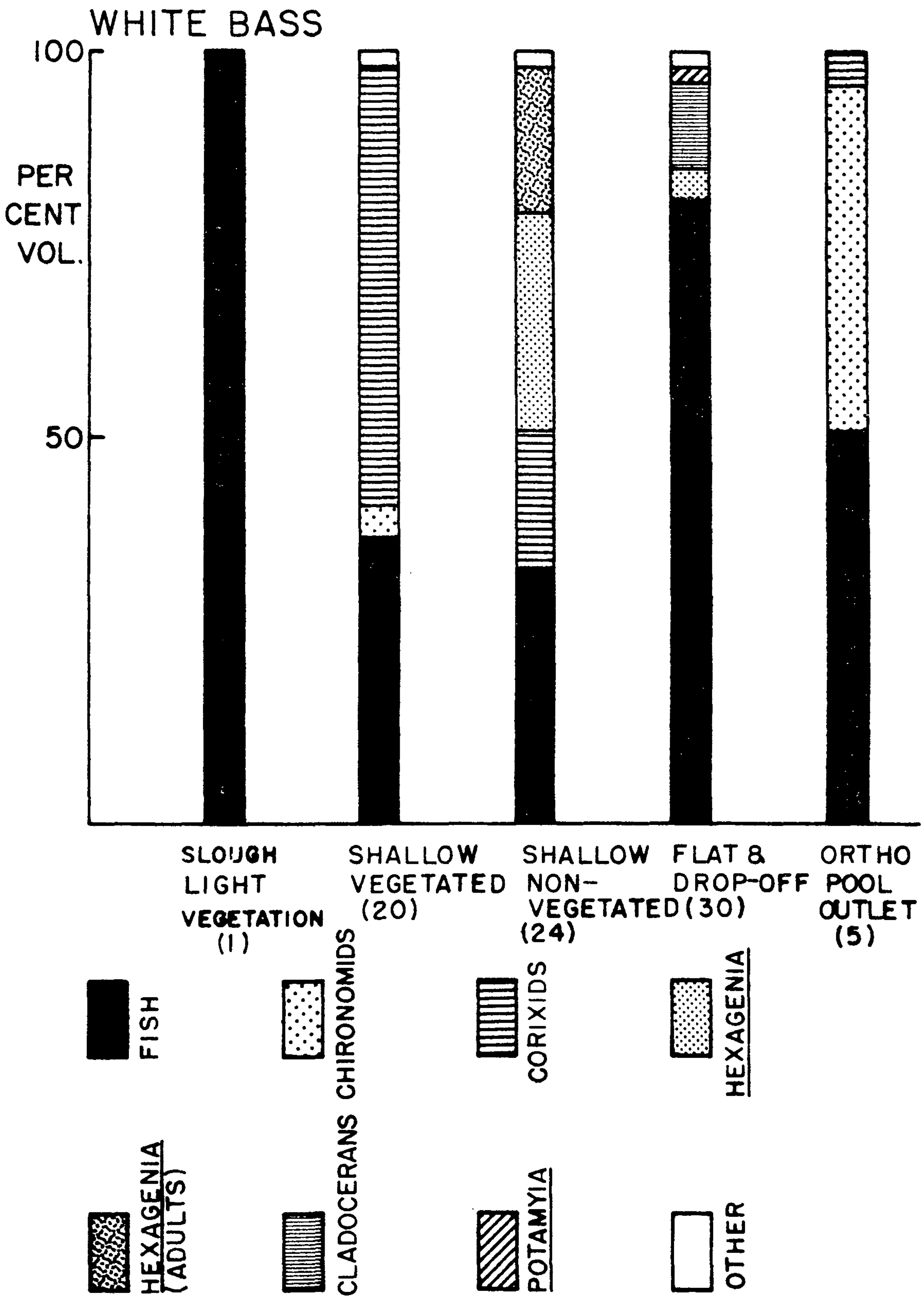

WHITE BASS
100
50
PER
CENT
VOL.
MAY (5)
JUNE (4)
JULY (15)
AUGUST (45)
OCTOBER (2)
NOVEMBER DECEMBER (9)
FISH
CHIRONOMIDS
CORIXIDS
HEXAGENIA
CLADOCERANS
DRAGONFLIES
DAMSELFLIES
POTAMYIA
OTHER

Figure 12. Percent volume of food items in white bass stomachs in various habitats from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size


WHITE BASS
100
PER CENT VOL.
50
SLOUGH LIGHT VEGETATION (1)
SHALLOW VEGETATED (20)
SHALLOW NON-VEGETATED (24)
FLAT & DROP-OFF (30)
ORTHO POOL OUTLET (5)
FISH
CHIRONOMIDS
CORIXIDS
HEXAGENIA
HEXAGENIA (ADULTS)
CLADOCERANS
POTAMYIA
OTHER

ans and small amounts of Hexagenia naiads and Potamyia larvae. In a small sample from the outlet of a chemical plant cooling pool, fish made up about half the food volume and immature chironomids slightly less with corixids accounting for the remainder. The high value for chironomids was due to the large amount of this food item in the stomach of one small fish taken in December.

Gizzard shad were the most frequently occurring recognizable forage fish in white bass. They were the only fish found in seven specimens and were also present with a 1.5-inch bowfin and four unidentifiable fish in another white bass. One to five shad 1 to 3 inches in length were found per stomach. In five white bass, small drum were the fish eaten. In most cases, one or two were present, but one white bass had 16 drum in its stomach, all less than 1 inch long. The largest drum observed in a white bass stomach was 2.8 inches in length and was the only food item present. One white bass contained 48 bluegills, 0.5 to 1.2 inches in length. Jenkins and Elkin (1957) found white bass in Oklahoma did well in large reservoirs which also contained gizzard shad. Richardson and Rutledge (1961) and Tatum (1961) reached similar conclusions in South Carolina. Lamb (1951) found white bass ate mainly shad, minnows, and few game fish. Toole (1952) gave gizzard shad as the most important food of white bass. Young bass in Lake Texoma fed primarily on gizzard shad June through October (Bonn, 1953). Other fish were eaten occasionally, but no cannibalism was observed. In Iowa, Bailey and Harrison (1945) also found no cannibalism in Clear Lake white bass, where their preferred food was black bullheads. The primary food of white bass was panfish in Spirit Lake and yellow perch in Storm

Lake (Sigler, 1943; 1949a; and 1949b). Carp, black crappies, walleyes, and bluegills were also eaten in Spirit Lake.

Hoopes (1959) collected 56 white bass from Pool 19 within the size range sampled here but averaging slightly larger. The results of his samples April through July agree closely with those for the same period in this study, with *Hexagenia* naiads the dominant item throughout the period and adults becoming prevalent coincident with emergences in July. *Potamyia* larvae were also important in July.

The considerable importance of fish in the white bass diet in August agrees well with the present findings but continued prevalence of *Hexagenia* naiads and the absence of corixids does not. This discrepancy may be due to differences in the part of August in which the samples were taken and in location of sampling sites. The true nature of white bass food habits during October is probably somewhere between a diet composed entirely of fish as found by Hoopes and one with *Hexagenia* naiads as the only important item as the present study would indicate. Inadequate sample size is most likely the source of these contrasting results. Hoopes found gizzard shad to be the main food of white bass in November, while the only food items of importance in November-December samples of the present study were immature chironomids and damselfly naiads. The small size of the white bass in the latter case probably best explains the preponderance of insects and lack of fish.

Wenke (1965) found Pool 19 white bass eating several food organism also observed in this study including naiads of *Hexagenia*, caenid, and baetid mayflies, *P. flava* caddisfly larvae, gizzard shad, and cladocerans. *Hexagenia* mayflies and caddisflies were of similar importance in both studies. Wenke found that the diet of white bass from the pool in general differed from those taken from the lock areas and tailwaters. On the whole, his studies indicated less utilization of forage fish. However, he did find that fish constituted one-third of the food volume in 21 small white bass (length range, 1.3 to 8.2 inches; average, 3.2 inches) taken July through November. I found no fish in 22 white bass from 2.3 to 5.6 inches (average, 4.6 inches) collected from May through December.

Bailey and Harrison (1945) found adult white bass fed entirely on forage fish when these were available. Various types of insects, primarily mayflies and dipterans, and small crustaceans (Hyallela) appeared in the diet when forage fish became scarce. Sigler (1949a) found fish, insects, and crayfish were the main foods of Storm Lake white bass. Two-thirds of the food volume was fish, and the only important invertebrates were mayflies (15 percent) and crayfish (17 percent). In Spirit Lake (Sigler, 1949b) the diet was primarily fish, but here crayfish were a very minor item while small crustaceans were heavily fed upon. Lamb (1951) lists insects as one of the main white bass foods. Ewers (1933) and Ewers and Boesel (1935) found zooplankton (mostly copepods and cladocerans) were the most important food of small white bass. Fish were most important in larger specimens, but these also fed heavily on small crustaceans. The most important insects were corixids and chironomids. McNaught and Hasler (1961) found the dominant food of adult white bass in Lake Mendota, Wisconsin, was the cladoceran, Daphnia.

Yellow Bass

All yellow bass were caught in shallow areas (Figure 6), appearing twice as frequently in those with aquatic vegetation as in open water. Bailey and Harrison (1945) give open water or sparse vegetation as the preferred habitat of yellow bass. Most of these specimens were taken between 4 PM and 6 PM, with three from midnight to 6 AM. Sieh and Parsons (1950) found yellow bass in Clear Lake, Iowa, most active at night, with peak movement during the periods 8 to 10 PM and 4 to 6 AM. In the same lake, Carlander and Cleary (1949) found no yellow bass in shallow water during daylight hours, and Carlander (1953) includes yellow bass among the primarily nocturnal fish, giving 8 to 10 PM as the time of greatest movement. Kutkuhn (1954) found the greatest amount of food in adult bass stomachs between 2 AM and 8 AM, indicating they feed most actively in the late night and early morning hours. However, young-of-the-year yellow bass had the highest percentage of empty stomachs between midnight and 4 AM, indicating they may feed most actively during daylight hours.

The stomachs of eight yellow bass ranging from 5.2 to 9.0 inches (average, 7.1 inches) were examined. Corixids made up over half the total food volume, with fish next in importance (Table 8). Small crustaceans were the only other food item of appreciable volume. Hyallela were the most important of these, followed by cladocerans. Larvae of chironomids and caddisflies appeared frequently in the stomachs but contributed little volume. It is difficult to determine when differences in food habits are due to fish size with so small a sample, but it was observed that only yellow bass over 7 inches long contained fish, and only those smaller than 8 inches had eaten small crustaceans. Insect utilization appeared to be gen-

Table 8. Percent volume and occurrence of food items[a] in yellow bass, combined and by size groups (lengths in inches)

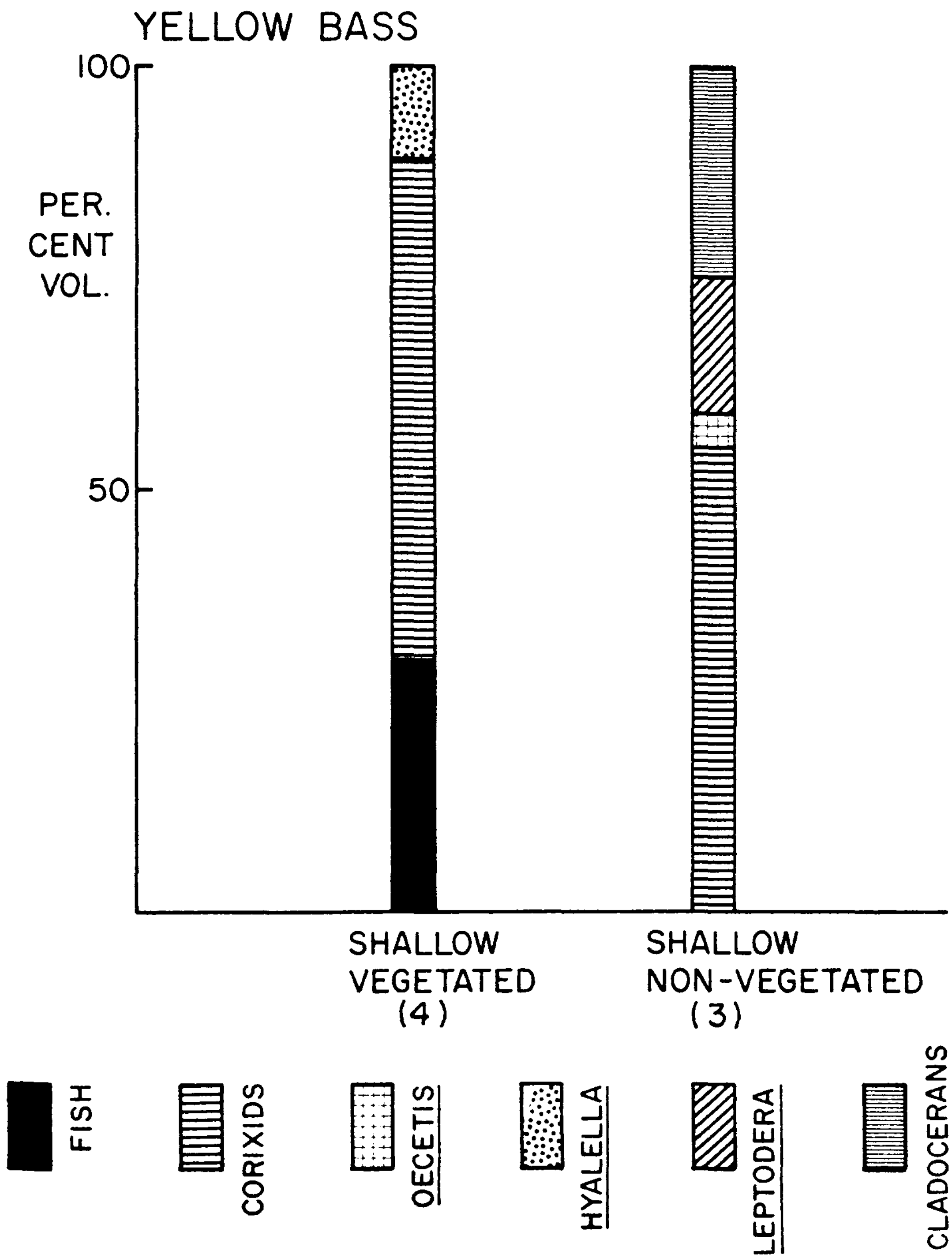
Food Items	Combined Vol.	Combined Occ.	5.0-5.9 Vol.	5.0-5.9 Occ.	6.0-6.9 Vol.	6.0-6.9 Occ.	7.0-7.9 Vol.	7.0-7.9 Occ.	8.0-9.9 Vol.	8.0-9.9 Occ.
Corixids	58.35	85.7	63	100	71	100	76	50	8	100
Fish	25.90	28.6	0	0	0	0	7	50	92	50
Hyallela	9.83	28.6	-	100	0	0	17	50	0	0
Cladocerans	4.68	14.3	0	0	27	50	0	0	0	0
Hexagenia	0.78	28.6	31	100	0	0	0	0	0	0
Oecetis	0.47	57.1	6	100	2	50	0	0	-	50
Chironomids	-	71.4	-	100	0	0	-	100	-	100
Number with food		7		1		2		2		2
Number empty		1		1		0		0		0

[a]All insects are immature forms except corixids.

erally greater in the smaller fish. The forage fish in the two yellow bass containing them were not identified. All specimens containing food were taken in August except a single fish containing Hyallela and immature chironomids sampled in May. The one yellow bass examined in December was empty. Fish were an important food item only in vegetated areas and zooplankton only in non-vegetated ones (Figure 13).

Hoopes (1959) examined two yellow bass 8.0 and 8.5 inches long taken from Pool 19 in late November. The single specimen containing food had eaten Hexagenia naiads, plus a few corixids and chironomid larvae. Wenke (1965) also was able to obtain only two yellow bass from Pool 19, both with empty stomachs. In adult yellow bass from North Twin Lake, Iowa, (Kutkuhn,

Figure 13. Percent volume of food items in yellow bass stomachs in various habitats from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size. *Leptodera* is separated from other cladocerans in these data


YELLOW BASS
100
50
PER. CENT VOL.
SHALLOW VEGETATED (4)
SHALLOW NON-VEGETATED (3)
FISH
CORIXIDS
OECETIS
HYALELLA
LEPTODERA
CLADOCERANS

1954) fish made up the greatest food volume. Chironomids and *Chaoborus* were also important, while caddisflies and mayflies occurred only in small amounts. The chief food of yearling yellow bass was immature chironomids, followed closely by mayfly naiads of the genera *Hexagenia* and *Caenis*. Copepods and chironomids were the main foods of young-of-the-year yellow bass. Although Bailey and Harrison (1945) found yellow bass less piscivorous than white bass in Clear Lake, invertebrate foods were of importance only when forage fish were scarce. Damselflies, dragonflies, chironomids, and *Hyallela* were most extensively utilized at such times. Small game and panfish were eaten much more frequently than minnows, with small yellow bass and yellow perch most important. Bluegills and black crappies were apparently utilized to a lesser extent because they preferred areas of dense aquatic vegetation which adult yellow bass avoided. Forbes (1878, 1880) found mayflies to be an important food of yellow bass in Illinois.

Warmouth

Only six warmouth were obtained, and they ranged in size from 5.3 to 6.8 inches (average, 6.2 inches). All specimens were taken in August from shallow water areas (Figure 6), mostly in vegetated locations. Half the fish were caught between noon and 2 PM, the other three between 4 and 6 AM. The preferred habitat of warmouth has been described as shallow water with soft, often muddy bottom and dense aquatic vegetation or other cover (Larimore, 1957; Lewis and English, 1949; and Hubbell, 1966b). Larimore found this especially true of the fish smaller than 5 inches, while larger ones spent most of the time in deeper water. The most important food item was *Oecetis* sp. larvae, contributing over half the total food volume (Table 9). Fish were the only other food of major volume (34 percent). Corixids (2 percent) and damselfly naiads (3 percent) were the most significant minor foods. Insects dominated the diet of specimens less than 6 inches in length and fish that of those larger than 6.0 inches. Warmouth from the vegetated slough habitat fed mainly on fish while those from the shallow river areas contained only insects (Figure 14). Three warmouth contained one to three forage fish per stomach, including an unidentified minnow and a small bluegill or crappie.

Larimore (1957) in a study of warmouth populations of two ponds in Illinois found a wide variety of food organisms commonly present in the stomach contents including crayfish, amphipods, dipterans, damselflies, caddisflies, mayflies, ostracods, and cladocerans. The bulk of the food was made up of crayfish, fish, dragonflies, caddisflies, and mayflies, listed in order of decreasing volume. Crayfish were also the most important food of warmouth in Reelfoot Lake, Tennessee, (Rice, 1941). Fish and cray-

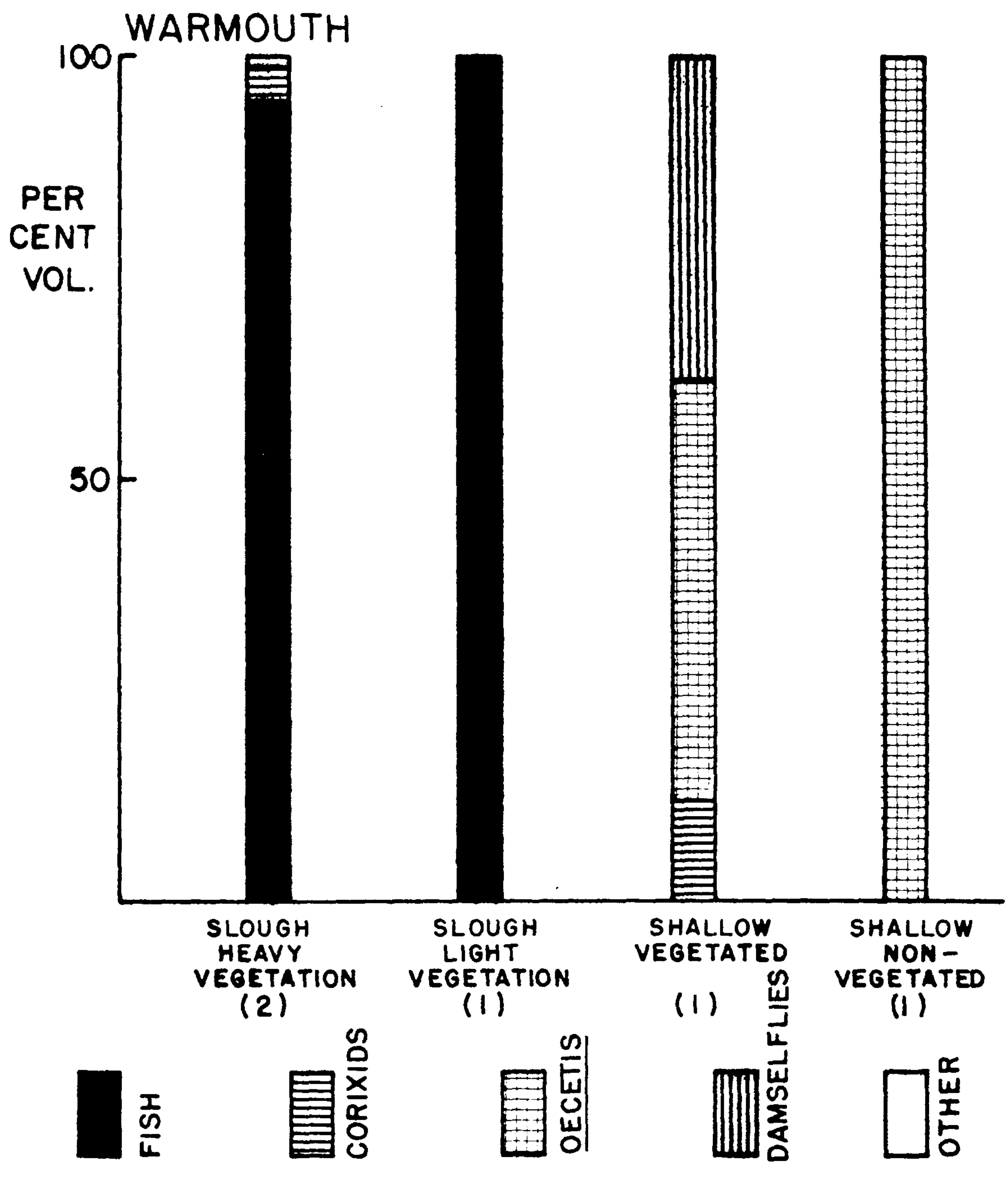
Table 9. Percent volume and occurrence of food items in warmouth, combined and by size groups (lengths in inches)[a]

Food Items	Combined Vol.	Combined Occ.	5.0-5.9 Vol.	5.0-5.9 Occ.	6.0-6.9 Vol.	6.0-6.9 Occ.
Oecetis larvae	52.97	40.0	75	66	0	0
Fish	34.05	60.0	8	33	96	100
Damselfly naiads	3.24	20.0	5	33	0	0
Corixids	2.16	60.0	2	66	4	50
Coleopteran adults	0.54	20.0	0	0	-	50
Immature chironomids	-	20.0	-	33	0	0
Coleopteran larvae	-	20.0	-	33	0	0
Unidentified	7.03	20.0	10	33	0	0
Number with food		5		3		2

[a]A 7-inch fish was empty.

fish made up the greatest volume of food in warmouth in an Iowa reservoir (Lewis and English, 1949). Snails, leeches, dragonfly naiads, and several unidentified insects were also observed. Hubbell (1966b) reports warmouth fry first feed on protozoans and bacteria, with insects, snails, zooplankton, and other small crustaceans becoming increasingly important with increasing fish size. The adults were more piscivorous than other sunfishes, often feeding to large extent on small fish.

Figure 14. Percent volume of food items in warmouth stomachs in various habitats from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size



WARMOUTH
100
50
PER CENT VOL.
SLOUGH HEAVY VEGETATION (2)
SLOUGH LIGHT VEGETATION (1)
SHALLOW VEGETATED (1)
SHALLOW NON-VEGETATED (1)
FISH
CORIXIDS
OECETIS
DAMSELFLIES
OTHER

Pumpkinseed

All the pumpkinseeds were obtained from shallow vegetated areas of the river (Figure 6). The preferred habitat of pumpkinseeds is weed beds in slow or non-flowing water (Hubbell, 1966a). Bailey and Harrison (1945) and Trautman (1957) state the pumpkinseeds generally inhabit larger and denser masses of aquatic vegetation than bluegills and are less of a deep, open water fish. Pumpkinseeds were taken during all sampling periods except 4 to 6 AM and were apparently most active from 8 to 10 AM and 4 to 6 PM. Carlander (1953) also found them active during the day and inactive at night.

Food habits of 15 pumpkinseeds, 3.5 to 6.8 inches in length (average, 5.5 inches), were determined (Table 10). Mollusks made up the bulk of the food, with snails the most important food item followed by fingernail clams. Immature chironomids ranked third, and leeches, dragonfly naiads, and _Occetis_ larvae were found in lesser but appreciable amounts. Baetid naiads were found fairly often in the stomachs but contributed little to the food volume. One specimen was sampled in May; the rest in August. The pumpkinseed taken in May contained a small amount of _Hyalella_ which did not appear in the August fish. However, the bulk of its food was immature chironomids, which were also an important food item in August. Only pumpkinseeds over 5 inches long ate fingernail clams, leeches, and dragonfly naiads. Chironomids were eaten most heavily by the small pumpkinseeds and decreased in importance as specimens increased in size. Caenid and baetid naiads were utilized in significant amounts only by the small fish. All sizes of pumpkinseeds sampled ate snails and _Oecetis_ caddisflies to about the same degree. The most apparent food habit variation with different habitats was

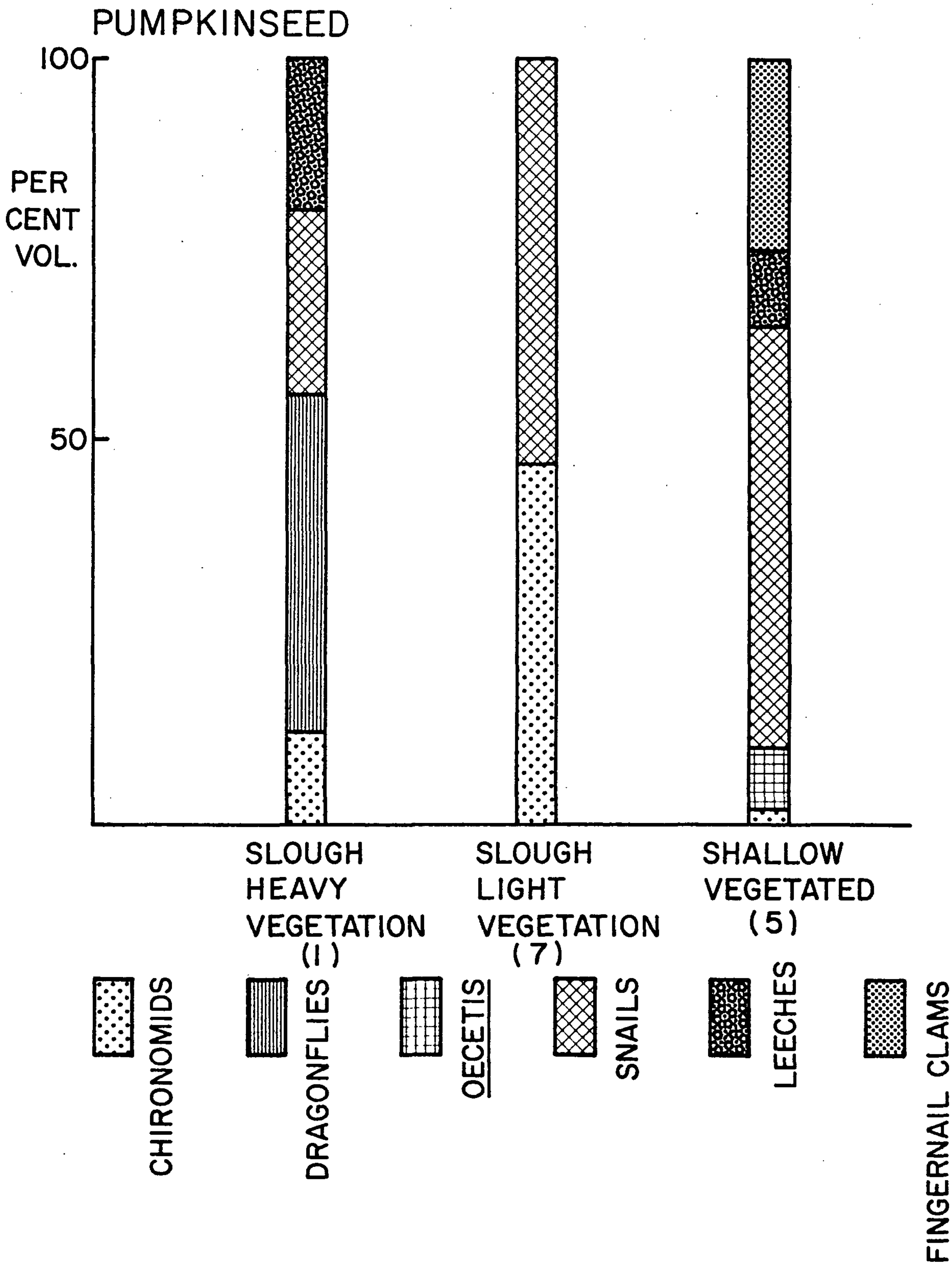
Table 10. Percent volume and occurrence of food items in pumpkinseed, combined and by size groups (lengths in inches)

Food Items	Combined Vol.	Combined Occ.	3.0-4.9 Vol.	3.0-4.9 Occ.	5.0-5.9 Vol.	5.0-5.9 Occ.	6.0-6.9 Vol.	6.0-6.9 Occ.
Snails	43.48	78.6	46	67	40	83	58	100
Fingernail clams	25.12	21.4	0	0	6	17	22	25
Immature Chironomids	14.49	92.3	38	67	28	100	5	100
Leeches	7.25	7.1	0	0	6	17	11	25
Dragonfly naiads	5.31	7.1	0	0	14	17	0	0
Oecetis larvae	4.11	42.9	8	33	6	33	4	50
Caenids and baetids	0.24	21.4	8	67	-	17	0	0
Hyallela	-	7.1	0	0	-	17	0	0
Ceratopogonid larvae	-	7.1	0	0	0	0	-	25
Corixids	-	7.1	0	0	0	0	-	25
Number with food		13		3		6		4
Number empty		2		0		2		0

the presence of fingernail clams and *Oecetis* caddisfly larvae only in fish from the river proper and dragonfly naiads only in those from the slough area (Figure 15).

Trautman (1957) gives aquatic insects, small mollusks, and crustaceans as the chief foods of pumpkinseeds and adds that large specimens will eat small fish including their own young. Kimsey and Bell (1956) in a Honey Lake, California, study found mayflies to be the dominant food, followed by cladocerans and dipterans.

Figure 15. Percent volume of food items in pumpkinseed stomachs in various habitats from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size


PUMPKINSEED
100
50
PER
CENT
VOL.
SLOUGH
HEAVY
VEGETATION
(1)
SLOUGH
LIGHT
VEGETATION
(7)
SHALLOW
VEGETATED
(5)
CHIRONOMIDS
DRAGONFLIES
OECETIS
SNAILS
LEECHES
FINGERNAIL CLAMS

Bluegill

Almost all bluegills were caught in vegetated shallow water areas (Figure 6). Bailey and Harrison (1945) also found bluegills preferred weedy areas in Iowa waters. Whitmore, et al. (1960) states bluegills are most abundant in water with little or no flow. They prefer protected areas of clear quiet water with scattered weed beds and sand, gravel, or muck bottom according to Hubbs and Lagler (1958) and Trautman (1957). These descriptions nearly typify the slough areas which produced over 60 percent of the bluegills sampled in the present study. However, Emig (1966b) reports bluegills have done well in some large fluctuating reservoirs lacking rooted vegetation in California.

Bluegills were most active from 4 to 10 PM and 8 to 10 AM with the largest numbers taken between 8 and 10 PM (Figure 7). A considerable amount of activity was observed at all other sampling hours as well. Carlander (1953) found bluegills active during daylight hours and inactive at night. Pool 19 bluegills are only slightly more diurnal than nocturnal, with a considerable amount of movement at night, particularly the early evening hours.

Food habits of bluegills were determined from 130 stomachs containing foods out of 142 fish sampled, 3.3 to 8.2 inches in length (average, 5.9 inches).

Bluegills consumed a wide range of food items (Table 11), the main ones being chironomid larvae and pupae, aquatic vegetation, caddisfly larvae (*Oecetis* sp.), snails, and water boatmen (22 to 10 percent volume). Damselfly adults and naiads, *Hexagenia* mayfly naiads, and fingernail clams were the main minor foods (5 to 2 percent volume). Small mayfly naiads and

Table 11. Percent volume and occurrence of food items[a] in bluegill, combined and by size groups (lengths in inches)

Food Items	Combined Vol.	Combined Occ.	3.0-3.9 Vol.	3.0-3.9 Occ.	4.0-4.9 Vol.	4.0-4.9 Occ.	5.0-5.9 Vol.	5.0-5.9 Occ.	6.0-6.9 Vol.	6.0-6.9 Occ.	7.0-8.9 Vol.	7.0-8.9 Occ.
Chironomids	22.0	81.4	57	75	44	86	29	82	18	82	20	84
Vegetation	14.3	25.4	0	0	2	14	7	10	15	39	25	42
Oecetis	13.5	27.7	6	12	7	43	24	35	8	12	16	21
Snails	9.7	40.8	2	25	1	36	7	42	15	45	7	37
Corixids	9.7	53.1	10	50	4	21	7	45	12	61	11	74
Fish	0.5	2.3	0	0	0	0	0	0	1	2	-	5
Damselfly naiads	3.5	40.8	17	50	4	43	4	42	4	35	3	47
Damselfly adults	5.0	4.6	0	0	0	0	8	15	5	8	3	16
Hexagenia	3.2	0.8	0	0	0	0	0	0	-	2	0	0
Fingernail clams	2.1	4.6	0	0	7	14	0	0	3	6	2	5
Caenids and baetids	1.8	43.8	6	50	16	64	2	55	1	29	-	37
Hyallela	1.2	24.6	2	12	-	14	2	25	-	27	3	32
Leeches	0.8	2.3	0	0	0	0	-	2	0	0	2	11
Cladocerans	0.7	7.7	-	12	4	29	2	8	-	4	0	0
Pleidae	0.2	11.5	0	0	-	14	-	15	-	10	-	16
Ceratopogonid	0.1	12.3	-	12	-	14	-	5	-	12	-	21
Other	-	19.1	-	12	-	7	-	25	-	20	-	21
Unidentified	11.2	21.5	-	-	11	29	8	15	18	24	8	26
Number with food		130		8		14		40		49		19
Number empty		12		1		3		3		3		2

[a]All insects are immature forms except corixids and damselfly adults.

[b]Other: crickets, water mites, ostracods, ants, leafhoppers, chrysomelid beetles, cranefly, _Stenonema_, coleopteran, _Chaoborus_, _Potamyia_, dragonfly larvae and naiads, caddisfly, and chironomid adults.

Hyalella frequently occurred in bluegill stomachs but in volumes less than 2 percent.

Chironomids were an important food of all sizes sampled but declined in significance with increasing bluegill size. Vegetation, however, became more important as bluegills increased in size. Damselfly naiads made up a considerable part of the diet of bluegills less than 4 inches long but were of minor and about equal importance in all other sizes. Caenid and baetid mayflies appeared to be most important to bluegills under 5 inches, while snails and damselfly adults were most important in larger ones.

Although most of the bluegills were taken during July and August (over 80 percent of those sampled), smaller samples from other months indicate some seasonal trends in food habits (Figure 16). Immature chironomids were eaten throughout the sampling period, making up the dominant part of the spring and fall diet and a sizable amount of the food volume in July and August. However, in June they were found only in negligible volumes. Leeches and *Hyalella* were of some importance in spring. During summer, a variety of foods were utilized. Bluegills fed heavily on aquatic vegetation during June and July. Corixids and *Oecetis* caddisflies were important only during June and August and snails and damselfly naiads, July and August. *Hexagenia* naiads and fingernail clams appeared in significant amounts only during June.

Chironomids were found in stomachs of bluegills from all habitats sampled but were most important in vegetated areas of sloughs and the river itself and in a chemical plant cooling pool and outlet (Figure 17). Vegetation was found only in bluegills taken at vegetated sampling stations and was utilized to the greatest extent where the weeds were the most dense.

Figure 16. Percent volume of food items in bluegill stomachs by months from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size

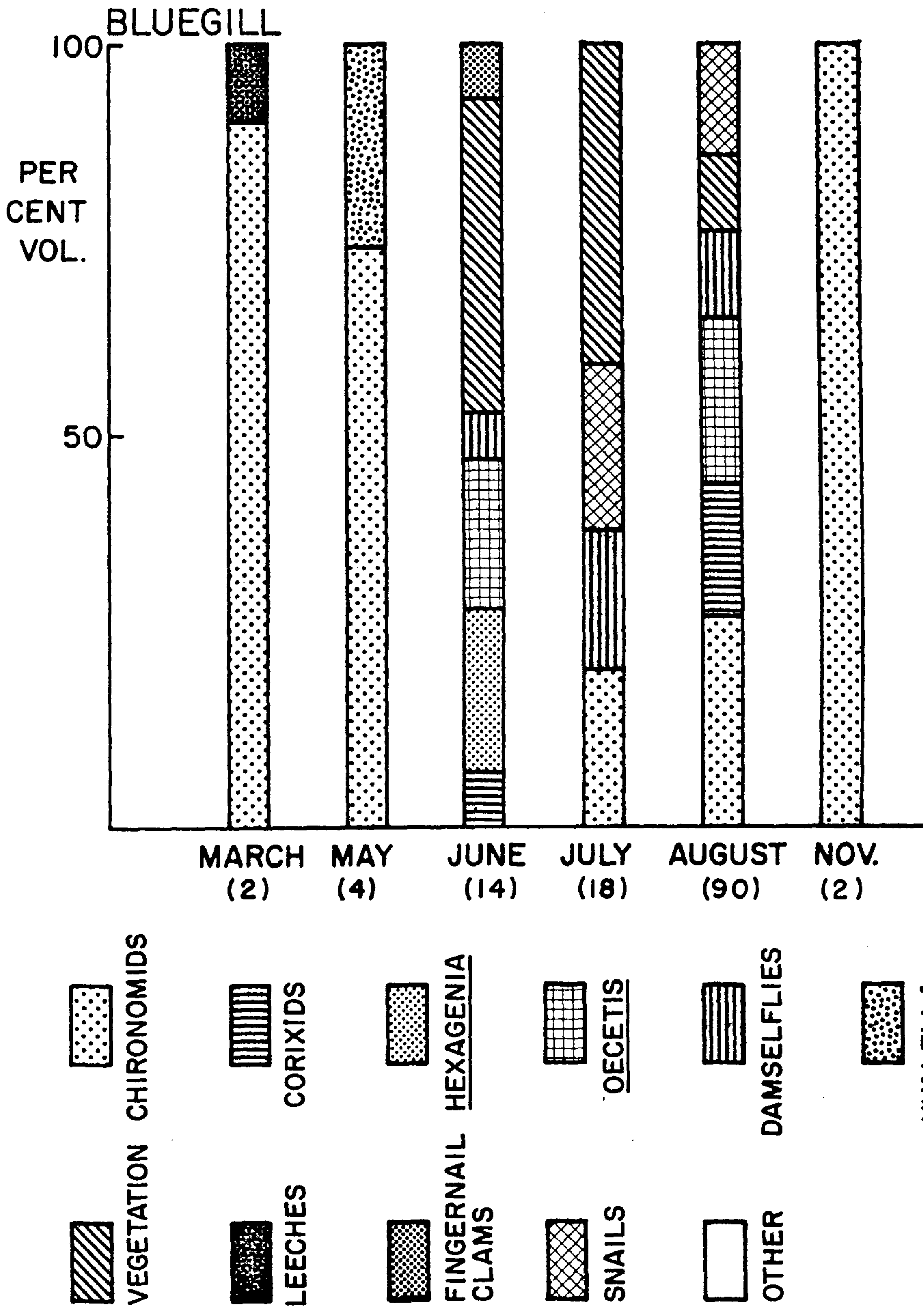
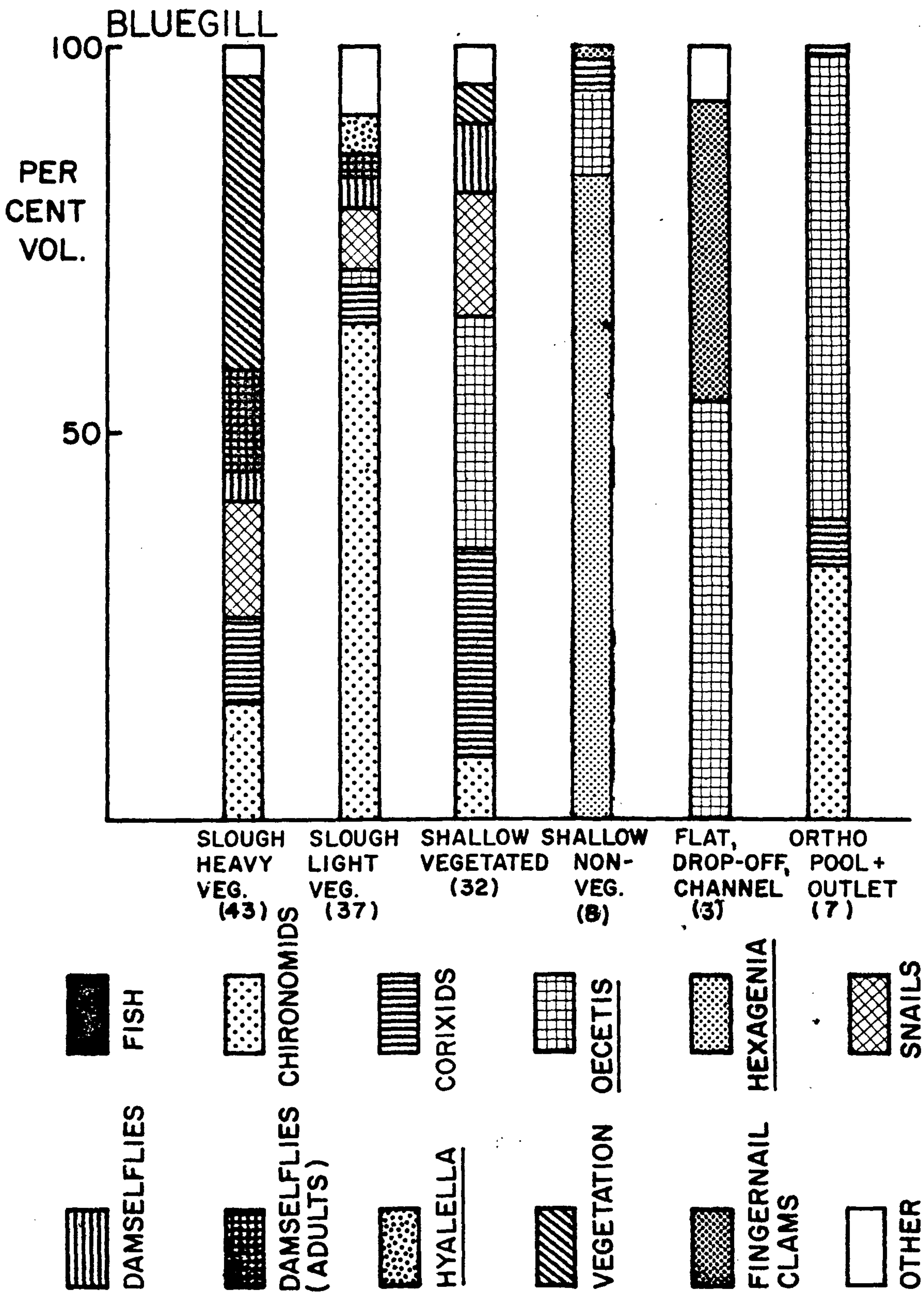

BLUEGILL
100
50
PER CENT VOL.
MARCH (2)
MAY (4)
JUNE (14)
JULY (18)
AUGUST (90)
NOV. (2)
CHIRONOMIDS
CORIXIDS
HEXAGENIA
OECETIS
DAMSELFLIES
HYALELLA
VEGETATION
LEECHES
FINGERNAIL CLAMS
SNAILS
OTHER

Figure 17. Percent volume of food items in bluegill stomachs in various habitats from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size


BLUEGILL
100
50
PER CENT VOL.
SLOUGH HEAVY VEG. (43)
SLOUGH LIGHT VEG. (37)
SHALLOW VEGETATED (32)
SHALLOW NON-VEG. (8)
FLAT, DROP-OFF, CHANNEL (3)
ORTHO POOL + OUTLET (7)
FISH
CHIRONOMIDS
CORIXIDS
OECETIS
HEXAGENIA
SNAILS
DAMSELFLIES
DAMSELFLIES (ADULTS)
HYALELLA
VEGETATION
FINGERNAIL CLAMS
OTHER

Only bluegills from vegetated habitat were found feeding on snails and damselfly naiads. Corixids were most important at vegetated stations and Oecetis caddisfly larvae in areas outside the slough. Damselfly adults and Hyalella were important only in fish from the slough habitat. Hexagenia naiads made up a large part of the food of one specimen from a non-vegetated shallow station. Fingernail clams were important only in deep open-water areas. Fish were found in the stomach contents of two bluegills from the slough and included a small gizzard shad.

Wenke (1965) examined the stomachs of 24 bluegills from Pool 19. Chironomids were again the most important food by volume, and Hyalella and Hexagenia mayflies were of considerably greater importance than in this study, each making up nearly as much of the total food volume as chironomids. Vegetation, snails, and corixids were not mentioned as major food items. Wenke felt that chironomids and small crustaceans (amphipods, cladocerans, copepods, and ostracods) were important foods in small bluegills and that Hexagenia mayflies might have been of greater significance if the size of the fish sampled had been greater. However, Leonard (1940) stated that mayflies decreased in importance as bluegills increased in size in a Michigan lake. Hankinson, Needham, and Davis (1908) observed bluegills utilizing caddisflies and mayflies in another Michigan lake, while an Ohio study (Ewers and Boesel, 1935) failed to find any in the stomach contents of small bluegills. The main dependence of bluegills on insects and invertebrates and their utilization of a variety of foods of this sort is shown in many studies (DiCostanzo, 1957; McCormick, 1940; Rice, 1941; Huish, 1958; Emig, 1966b; Leonard, 1940; Scidmore and Woods, 1960; Ball, 1948;

Harlan and Speaker, 1956; Lux and Smith, 1960; Dill, 1944; Beland, 1954; and Goodson, 1965).

Largemouth Bass

Largemouth bass samples included 99 specimens ranging from 5.1 to 16.0 inches in length (average, 9.9 inches). Except for a few fish caught in flat depth, all were taken in shallow areas with aquatic vegetation strongly preferred (Figure 6). Bailey and Harrison (1945) also give weedy areas as the preferred habitat of largemouth bass. Trautman (1957) describes large-mouth bass habitat as non-flowing water of low turbidity with a soft muck bottom supporting a growth of aquatic vegetation. These environmental characteristics typify the sampling stations which produced most of the specimens in this study. Weedy backwaters of rivers are listed as one of the favorite habitats of largemouth bass in the Great Lakes region (Hubbs and Lagler, 1958). Caine (1949) mentions the importance of vegetation or other cover to largemouth bass. Emig (1966a), however, states that large-mouth bass have been able to survive well in some fluctuating California reservoirs lacking rooted aquatic plant. Largemouth bass were taken most frequently between 4 and 6 PM and least often between midnight and 2 AM but appeared fairly active during all times of the day (Figure 7). Movement was generally greater in daylight hours than those of darkness.

Fish were by far the dominant food in the 73 bass containing identifi-able items, with dragonfly naiads and crayfish the only other organisms contributing appreciable volumes to the diet (Table 12). Corixids, chiron-omids, and damselflies occurred with some frequency in the stomachs but contributed little volume.

Forage fish were by far the dominant food of all size groups of bass analyzed (over 70 percent of the food volume) with the exception of the 8-inch group where they were replaced to a considerable extent by large

Table 12. Percent volume and occurrence of food items[a] in largemouth bass, combined and by size groups (lengths in inches)

Food Items	Combined Vol.	Combined Occ.	5.0-7.9 Vol.	5.0-7.9 Occ.	8.0-8.9 Vol.	8.0-8.9 Occ.	9.0-9.9 Vol.	9.0-9.9 Occ.	10.0-10.9 Vol.	10.0-10.9 Occ.	11.0-15.9 Vol.	11.0-15.9 Occ.
Fish	71.46	71.2	81	69	17	45	84	79	71	80	89	86
Dragonfly	21.00	12.3	0	0	83	30	13	28	27	10	0	0
Crayfish	5.41	6.8	0	0	0	0	-	14	0	0	10	29
Corixids	0.80	28.8	8	15	-	45	3	36	-	30	-	7
Crickets	0.44	1.4	0	0	0	0	0	0	0	0	-	7
Leeches	0.41	4.1	2	8	0	0	0	0	0	0	1	14
Damselfly adults	0.32	2.7	7	8	-	5	0	0	2	10	0	0
Damselfly	0.07	4.1	1	15	0	0	-	14	0	0	0	0
Vegetation	0.07	1.4	0	0	-	5	0	0	0	0	0	0
Chironomids	0.03	8.2	-	15	-	5	-	14	-	10	0	0
Hexagenia	-	1.4	0	0	0	0	0	0	-	10	0	0
Terrestrial insects	-	1.4	0	0	0	0	0	0	0	0	-	7
Hyallela	-	2.7	-	8	-	5	0	0	0	0	0	0
Number with food		73		13		20		14		10		16
Number empty		26		1		7		9		1		8

[a]All insects are immature forms except corixids, damselfly adults, crickets, and other terrestrial insects.

amounts of dragonfly naiads (Table 12). Corixids, damselfly naiads and adults, and leeches made their greatest contribution to the diet of bass less than 8 inches long. Dragonfly naiads were a food of considerable importance to bass 8.0 to 10.9 inches long. Crayfish were important only in bass over 11 inches long. Other investigators have found largemouth bass fry fed principally on small planktonic crustaceans such as Cyclops and Daphnia, switching to insects as they increase in size (Ewers and Boesel, 1935; Emig, 1966a; McCammon, 1957; Kimsey et al., 1957). As adults, fish are always the main food, supplemented to a varying extent by such diverse foods as worms of various sorts, clams, frogs, crayfish, snails, and large insects (Goodson, 1965; Seaburg and Moyle, 1964; McCammon, 1957; Forbes and Richardson, 1920; Nelson and Hasler, 1941; Dendy, 1946; Kutkuhn, 1954; McCormick, 1940; Moffett, 1943; and Lynch et al., 1953).

Fish were a major food item throughout the sampling period but made their greatest contribution to the total volume during the spring and fall (Figure 18). Dragonfly naiads were fed upon heavily during the summer, particularly during July. This probably explains the reduced importance of fish during this period. Crayfish and leeches were most important in spring, corixids and winged insects in the summer, and chironomids in fall. Largemouth bass fed on fish in appreciable amounts in all habitat types sampled but to the greatest extent in the shallow vegetated and flat areas and in the fertilizer plant outlet (Figure 19). Dragonfly naiads were eaten in large amounts in the slough only. Crayfish and leeches were both utilized in non-vegetated areas and flats; crayfish were also found in bass from the chemical plant outlet. Corixids were found in specimens from all habitats in small amounts.

Figure 18. Percent volume of food items in largemouth bass stomachs by months from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size

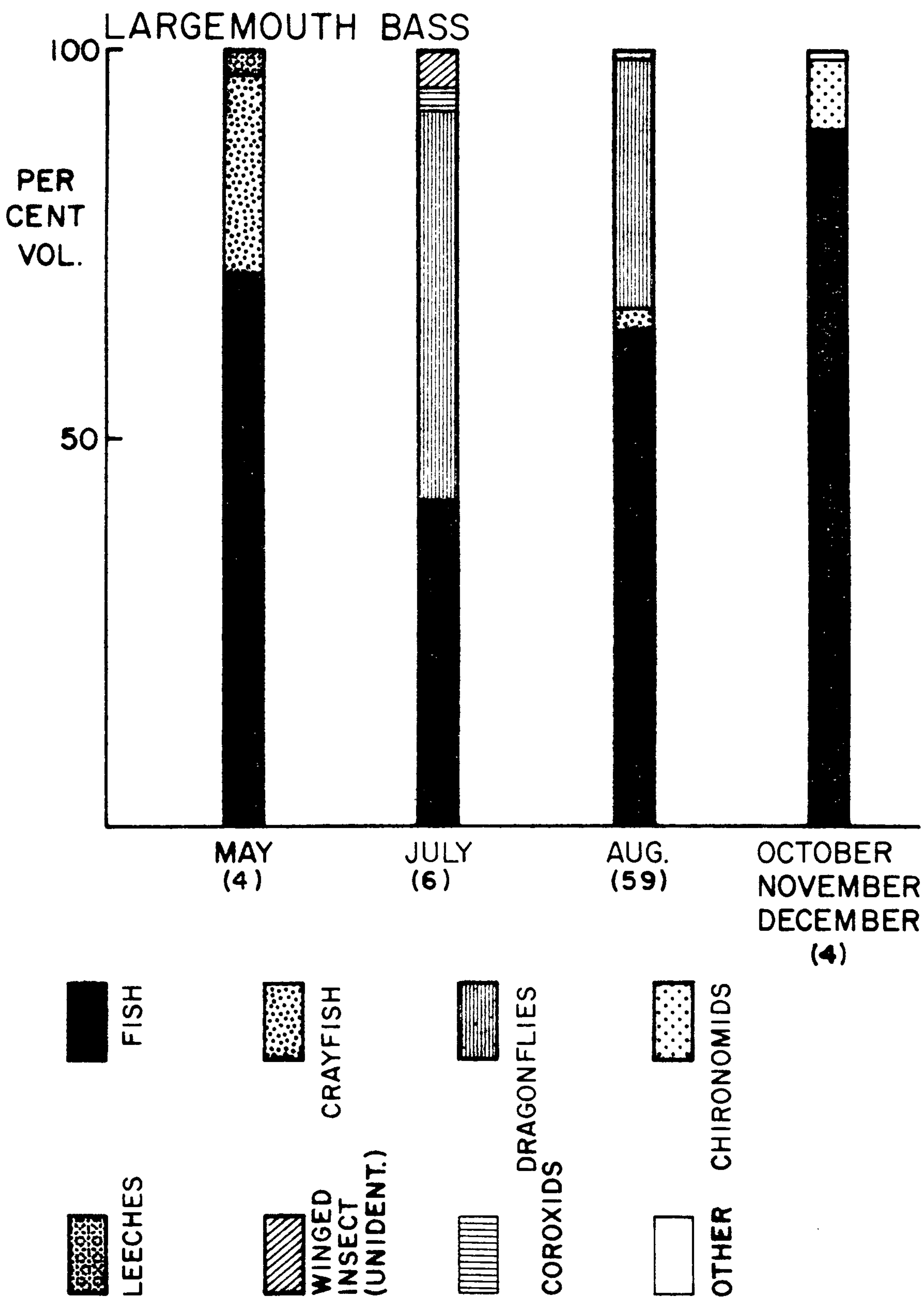
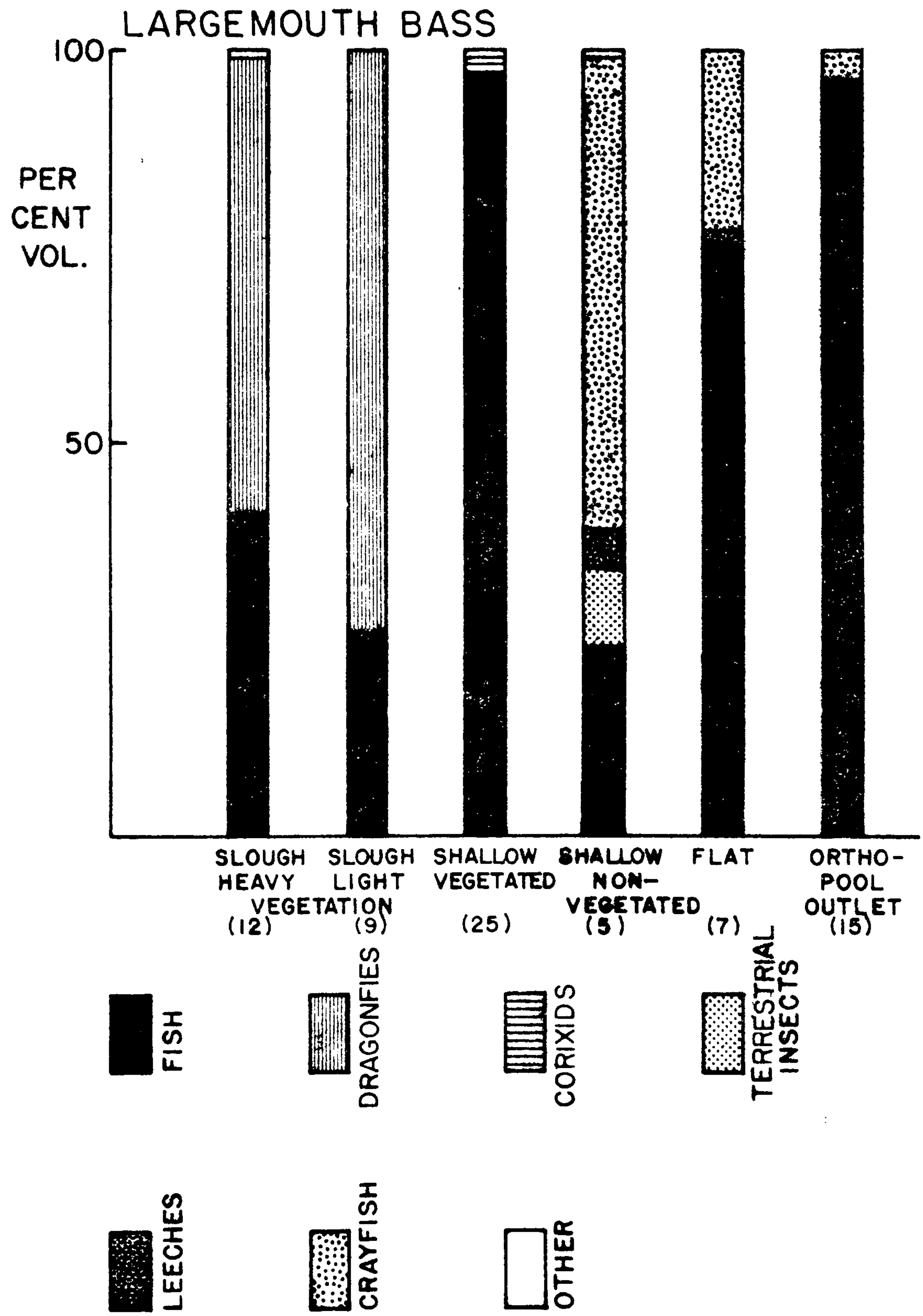

LARGEMOUTH BASS
100
50
PER
CENT
VOL.
MAY
(4)
JULY
(6)
AUG.
(59)
OCTOBER
NOVEMBER
DECEMBER
(4)
FISH
CRAYFISH
DRAGONFLIES
CHIRONOMIDS
LEECHES
WINGED
INSECT
(UNIDENT.)
COROXIDS
OTHER

Figure 19. Percent volume of food items in largemouth bass stomachs in various habitats from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size


LARGEMOUTH BASS
100
50
PER CENT VOL.
SLOUGH HEAVY
SLOUGH LIGHT
VEGETATION
(12)
(9)
SHALLOW VEGETATED
(25)
SHALLOW NON-VEGETATED
(5)
FLAT
(7)
ORTHO-POOL OUTLET
(15)
FISH
DRAGONFIES
CORIXIDS
TERRESTRIAL INSECTS
LEECHES
CRAYFISH
OTHER

In 25 of the 52 largemouth bass containing fish, the stomach contents were so completely digested, the type of forage fish could not be recognized. Bennett (1962) states the digestion rate of largemouth bass is slow below 65 degrees F. and increased rapidly between 65 degrees and 90 degrees F. Most of the samples were collected when water temperatures were above 75 degrees F. One or two unidentifiable fish were present in most of these stomachs, with some containing as many as five. They ranged from 0.5 to 1.3 inches in length. From one to five gizzard shad 1.0 to 3.5 inches long were found per stomach in 13 bass. Schneidermeyer and Lewis (1956) also found largemouth bass utilizing gizzard shad. Six bass examined here contained minnows 0.5 to 1.5 inches long in numbers ranging from 1 to 30 per stomach. White bass 2.0 to 3.0 inches in length were found in four specimens, one or two per stomach. From one to three bullheads were eaten by three of the bass. One of the bullheads was 3.0 inches long. Three bass contained one or two bluegills in their respective stomachs. One bluegill was 1.2 inches long. The following forage fish were noted in individual bass: one crappie 2.2 inches long, five bluegills and/or crappies 0.5 to 1.2 inches long, one largemouth bass 3.5 inches long, and one channel catfish. Gizzard shad were found in combination with minnows, bullheads, largemouth bass, and bluegills respectively in individual bass stomachs. Unrecognizable forage fish were often found in stomachs containing identifiable ones.

Lewis et al. (1961) studied the food preferences of largemouth bass in tanks and found golden shiners, bluegills, and green sunfish ranked as the first three. Black bullheads and white crappies were eaten less often. Tadpoles, small bullfrogs, and crayfish showed variable utilization. Apparently the tanks affected the vulnerability of the food organisms involved, for in a later study using ponds (Lewis and Helms, 1964), tadpoles were eaten most, with crayfish, green sunfish, and black bullheads next in importance. Bluegills and golden shiners were not important foods in the ponds. Size preference tests were run in aquaria with green sunfish as the forage species. Larger bass were found to prefer larger sunfish. Lawrence (1957) found that largemouth bass readily eat forage fish whose maximum body depth equals bass mouth width, swallowing them headfirst. Competition for food between largemouth bass and other species have been studied. Larimore (1957) found that while largemouth bass and warmouth have similar food habits, warmouth feed on the bottom in shallow water near shore whereas bass prefer deeper open water. Bennett (1962) states bass and bluegill compete for insects when fish and crayfish are not available for the bass, but bass prefer the adult forms and bluegills, the larvae.

Wenke (1965) obtained only 14 largemouth bass in his fish samples from Pool 19. Stomachs with unidentifiable fish or no food were also common in his study. Fish were the dominant food item, although insects and crustaceans were also observed. A crayfish was found in one large bass taken in November. Damselfly naiads, chironomids, and Hyalella appeared in small amounts. Although Wenke found only one dragonfly naiad in the bass he sampled, they were second only to fish in total food volume in this study. The most likely explanation for this difference is that Wenke did not sample the slough areas, which was the only place where bass fed extensively on dragonfly naiads in this study. It is significant that nearly 30 percent of the bass examined here came from slough areas. Corixids were described as a food item of considerable importance in Wenke's study, making up as high as 97 percent of the food volume of one specimen. Although corixids were found in nearly 30 percent of the bass in this study, they contributed less than 1 percent of the total food volume. This difference is probably related to the generally smaller size of the bass in Wenke's samples, nine of which were smaller than the average length of those in this study. Unfortunately, the size of the bass which fed almost entirely on corixids is not given by Wenke. Wenke suggests the absence of mayflies and caddisflies in the bass stomachs he examined may be because none of his fish were collected earlier than August. However, no caddisfly larvae and only one Hexagenia naiad were found in 10 bass containing identifiable food collected in May and July during this study. Pearse (1918, 1921) found 15 to 20 percent of the summer food of largemouth bass in some Wisconsin lakes was mayflies. Turner and Kraatz (1921) and Ewers and Boesel (1935) found mayflies were an important food of small bass in Ohio.

Hoopes (1959) obtained only three largemouth bass in his Pool 19 study, ranging from 8.5 to 13.0 inches. One in April contained a stonefly naiad, another in November had eaten a tadpole, and the third in October was empty.

Black and White Crappies, 1966

An unfortunate failure to correctly discriminate between white and black crappies during the 1966 summer collection made it necessary to analyze this first sample of 88 fish from the generic standpoint (Pomoxis sp.). These crappies were taken from mid-July through August and ranged from 3.7 to 11.6 inches (average, 7.4 inches) in length. They were most frequently taken in shallow-water areas and considerably less often at drop-off stations (Figure 6). Only a few specimens were caught on the flats and none in the channel. In the shallow areas, vegetated stations had a catch rate slightly over three times that of open water sampling sites. Activity was the highest during the 8 to 10 PM sampling period, after which it fell off to about half the peak level and persisted there from midnight to 10 AM. By noon it dropped to the lowest level and remained there up to 6 PM. In general, crappies were more nocturnal than diurnal during this sampling period. Carlander (1953) could find no clear relationship between crappie movements and time of day.

Fish were the dominant food of these crappies, making up nearly two-thirds of the total food volume (Table 13). Goodson (1966a) states that quantity and quality of food was the most important factor limiting growth and population size in both species of crappies in California reservoirs. All stunted populations were found associated with a lack of forage fish.

The only other recognizable items of appreciable volume in the present study were immature chironomids and corixids, each of about equal importance. Although both appeared in the stomach contents more frequently than fish, their combined volumes were less than one-seventh of the total food volume. Goodson (1966a) found that in California reservoirs chironomids

Table 13. Percent volume and occurrence of food items[a] in black and white crappie - 1966, combined and by size groups (lengths in inches)

Food Items	Combined Vol.	Combined Occ.	3.0-4.9 Vol.	3.0-4.9 Occ.	5.0-6.9 Vol.	5.0-6.9 Occ.	7.0-7.9 Vol.	7.0-7.9 Occ.	8.0-8.9 Vol.	8.0-8.9 Occ.	9.0-11.9 Vol.	9.0-11.9 Occ.
Fish	66.46	59.8	0	0	16	17	57	56	72	62	86	62
Chironomids	7.87	66.8	19	82	23	67	14	72	4	57	3	69
Corixids	5.93	59.8	31	82	19	61	6	78	6	48	1	46
Leeches	1.92	8.5	0	0	4	6	2	6	3	31	-	8
Hexagenia												
naiads	0.98	11.0	4	9	-	11	2	22	1	14	0	0
adults	1.39	2.4	0	0	0	0	6	6	0	0	0	0
Cladocerans	1.68	8.5	32	36	9	11	-	6	0	0	0	0
Potamyia	1.08	26.8	0	0	2	33	2	28	1	43	1	15
Chaoborus	0.84	18.3	10	9	3	28	-	17	-	14	1	8
Dragonfly	0.37	11.0	0	0	2	6	0	0	0	0	1	15
Damselfly	0.22	12.3	2	27	-	17	-	17	-	14	-	15
Caenids and baetids	0.14	29.6	-	18	1	28	-	28	-	31	-	15
Ceratopogonid	0.14	22.0	1	9	-	28	-	28	-	10	-	23
Hyallela	0.04	23.2	1	27	-	28	-	17	-	10	-	8
Stenonema	0.04	7.3	0	0	-	11	-	11	-	10	0	0
Other[b]	1.27	18.3	-	9	5	22	1	33	1	19	0	0
Unidentified	9.63	30.5	0	0	16	28	11	45	11	43	7	23
Number with food		81		11		18		18		21		13
Number empty		7		1		0		3		3		0

[a]All insects are immature forms except corixids and *Hexagenia* adults.

[b]Other: crickets, crayfish, pleidae, leafhoppers, damselfly and caddisfly adults, and riffle beetle and other coleopteran larvae.

were the most important food item of crappies only where other foods were not available.

Larvae of Chaoborus, Potamyia caddisflies, and ceratopogonids, naiads of baetid and caenid mayflies, and Hyalella were found in 18 to 30 percent of the stomachs examined but contributed little to the overall volume. Amphipods ranked third in food volume importance in a California study of both species of crappies (Goodson, 1966a). Harlan and Speaker (1956) and Sigler (1959) found both species of crappies fed principally on crustaceans, insects, and fish.

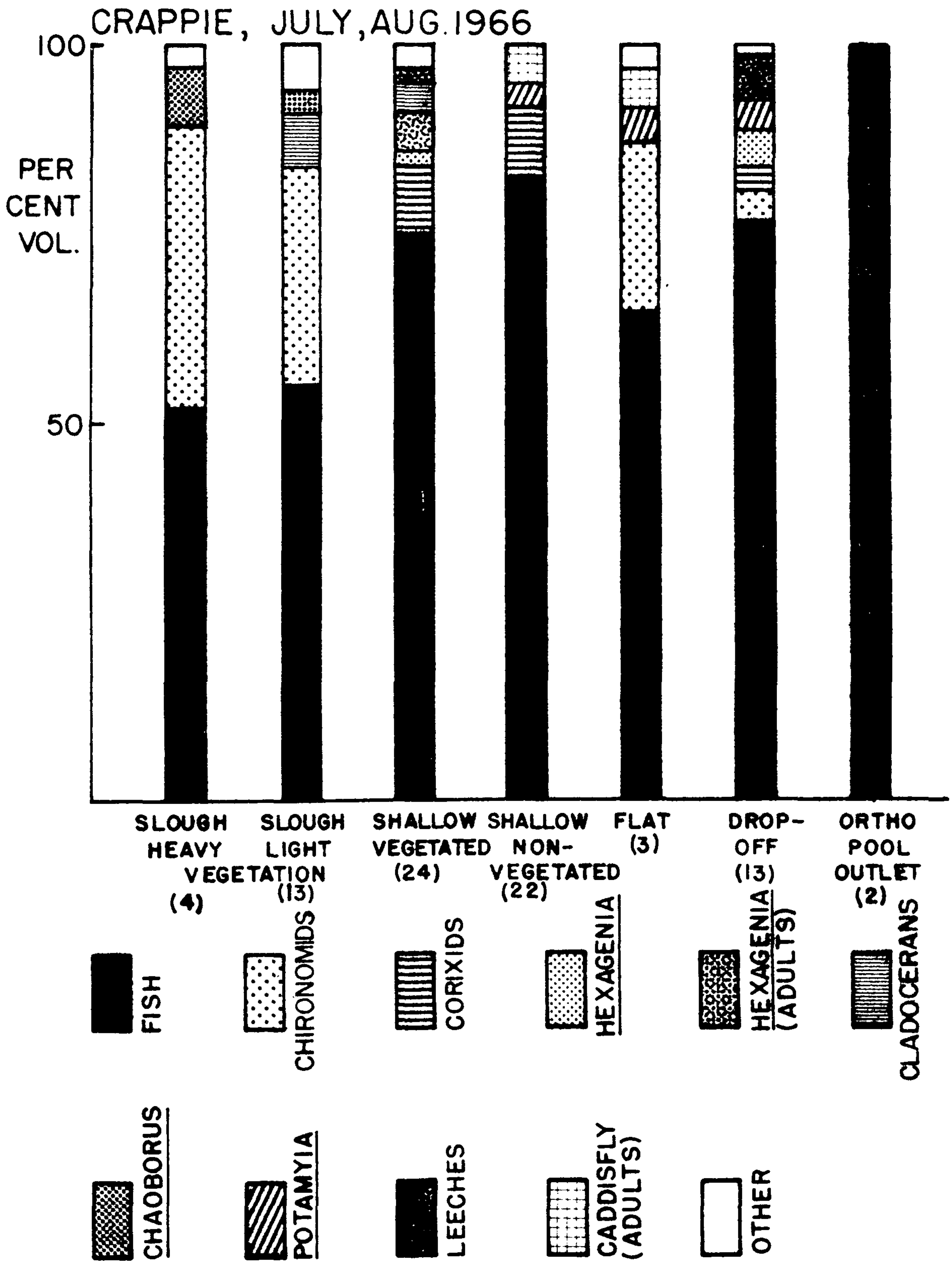
Size analysis found forage fish did not appear in the diet of crappies less than 5 inches long and increased in importance with increasing crappie size in those larger than 5 inches (Table 13). Chironomids and corixids were eaten by all sizes sampled. Chironomids were an important item in crappies from 3.0 to 7.9 inches and a minor one in larger ones. Corixids were most important in 3.0- to 5.9-inch fish. Small crustaceans and Chaoborus larvae were important in crappies 3.0 to 4.9 inches. No definite size trends were evident in the utilization of naiads of Hexagenia mayflies and dragonflies, larvae of Potamyia caddisflies, or leeches. Harlan and Speaker (1956) and Sigler (1959) state that young crappies first feed on zooplankton and then turn to small aquatic insects. Fish are most important in larger crappies but are utilized by 2- to 3-inch specimens.

Fish were the most important food of crappies taken in July, making up nearly a third of the food volume. Hexagenia naiads and adults were next in importance, followed by corixids, chironomids, and leeches. In August fish became much more dominant in the diet. Hexagenia were no longer important and chironomids, corixids, and leeches all declined somewhat in volume.

Fish made up more than half the food volume of crappies from all habitats sampled (Figure 20). They were the only food found in specimens from the chemical plant outlet. In the flat and slough areas, fish consumption was reduced and apparently partly replaced by chironomids. Chironomids were also utilized to a lesser extent in drop-off areas. Corixids made their most significant contributions to the crappie diet in fish from shallow and drop-off areas. Appreciable amounts of Chaoborus larvae were eaten only by fish from the slough habitat; cladocerans, in vegetated areas of the slough and river. Hexagenia naiads and leeches were found in crappies taken in the shallow vegetated and drop-off habitats, while the adults appeared only in fish from shallow vegetated stations. Potamyia larvae and adult caddisflies were eaten only by fish taken at non-vegetated stations.

Of the crappies collected during July and August, 1966, 34 had fish in their stomach contents. In 20 of these, the forage fish were largely digested and not identified. One to two fish were present per stomach and ranged from 1 to 2 inches in length. Small centrarchids, bluegills and/or crappies were found in the stomachs of eight of the crappies. Most of the centrarchids eaten were 0.5 to 1.5 inches in length, but one crappie contained a 3.0-inch bluegill. The number per stomach varied from 1 to 17 fish. Gizzard shad were found in five crappie stomachs and ranged in length from 1 to 2 inches. One or two shad were present per stomach. One crappie contained a 2.0-inch freshwater drum and another both a contrarchid and a gizzard shad 1.5 inches in length.

Figure 20. Percent volume of food items in black and white crappie stomachs in various habitats from July-August, 1966, in Pool 19, Mississippi River. Figures in parentheses denote sample size



CRAPPIE, JULY, AUG. 1966
100
50
PER CENT VOL.
SLOUGH HEAVY VEGETATION (4)
SLOUGH LIGHT VEGETATION (13)
SHALLOW VEGETATED (24)
SHALLOW NON-VEGETATED (22)
FLAT (3)
DROP-OFF (13)
ORTHO POOL OUTLET (2)
FISH
CHIRONOMIDS
CORIXIDS
HEXAGENIA
HEXAGENIA (ADULTS)
CLADOCERANS
CHAOBORUS
POTAMYIA
LEECHES
CADDISFLY (ADULTS)
OTHER

White Crappie

A sample of 28 white crappies was obtained from November, 1966, through August, 1967. They ranged from 4.7 to 11.3 inches in length, averaging 8.2 inches. Shallow areas were strongly preferred, with only two specimens appearing in flat areas and none in the channel (Figure 6). Hubbs and Lagler (1958) state that white crappies are more common in silty water than in clear water, and Bailey and Harrison (1945) feel they prefer a silty river environment.

Although the catch rates indicate white crappies are more restricted to shallow water areas than black crappies, the small sample of white crappies obtained makes the importance of this comparison doubtful. White crappies also had a catch rate in vegetated areas four times that of open water stations. White crappies were more nocturnal than diurnal, with activity peaks between 8 PM and 10 PM and 4 AM and 6 AM. There was a rapid decline in movement between the evening and morning peak and a more gradual one between the morning and evening. Hansen (1951) reports the catch of white crappies in hoop nets twice as high at night as during the day and the gill net catch 1.5 times as high.

All specimens contained food. Fish were the most important food item, followed closely by chironomids (Table 14). _Hexagenia_ mayfly naiads and adults were the only other food of major volume. Corixids and _Hyallela_ appeared in fairly large numbers of the specimens but contributed little volume. Food habits studies in California reservoirs found forage fish varied from first to third in importance in the diet of white crappies (Goodson, 1966a). In Rock River, Illinois (Hansen, 1951), fish were a greater part of the diet than in my study. Some investigators found may-

Table 14. Percent volume and occurrence of food items[a] in white crappie, combined and by size groups (lengths in inches)

Food Items	Combined Vol.	Combined Occ.	4.0-5.9 Vol.	4.0-5.9 Occ.	6.0-7.9 Vol.	6.0-7.9 Occ.	8.0-8.9 Vol.	8.0-8.9 Occ.	9.0-9.9 Vol.	9.0-9.9 Occ.	10.0-11.9 Vol.	10.0-11.9 Occ.
Fish	43.07	57.1	90	75	86	67	42	67	37	56	14	67
Chironomids	36.67	60.6	3	25	-	67	32	67	46	67	6	67
Hexagenia												
naiads	9.71	17.9	0	0	0	0	-	33	9	33	72	33
adults	2.68	10.7	0	0	0	0	0	0	4	22	0	0
Cladocerans	1.96	10.7	0	0	0	0	15	33	-	11	0	0
Corixids	1.93	50.0	4	50	11	83	4	67	-	22	5	33
Hyallela	1.41	25.0	-	25	0	0	3	50	2	22	-	33
Leeches	0.98	3.6	0	0	0	0	0	0	1	11	0	0
Damselfly	0.65	14.3	0	0	1	17	0	0	1	33	0	0
Caenids and baetids	0.16	14.3	3	25	-	17	-	17	-	11	2	33
Stenonema	0.10	7.1	0	0	0	0	-	17	-	11	1	33
Potamyia	0.03	10.7	0	0	-	17	-	17	-	11	0	0
Ceratopogonid	0.03	14.3	-	25	-	17	0	0	-	22	0	0
Leptodera	-	3.6	0	0	0	0	0	0	-	11	0	0
Chaoborus	-	14.3	0	0	0	0	-	33	-	11	-	33
Riffle beetle	-	3.6	-	25	0	0	0	0	0	0	0	0
Unidentified	0.62	7.1	0	0	2	17	4	17	0	0	0	0
Number with food		28										

[a]All insects are immature forms except corixids and *Hexagenia* adults.

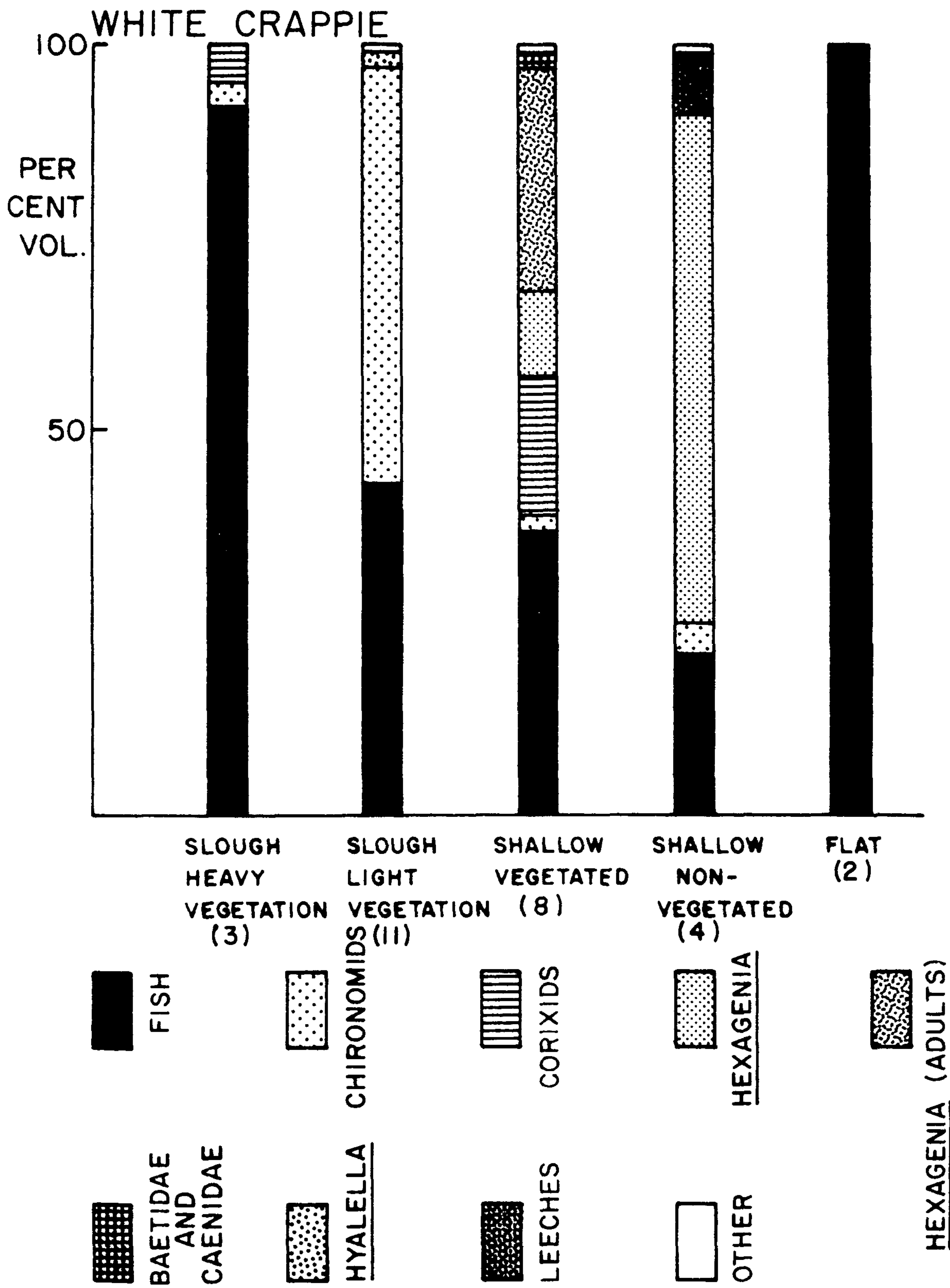
flies (especially Hexagenia) quite an important dietary item (Sibley, 1929; Forbes and Richardson, 1920; and Johnson, 1929).

Contrary to the usual pattern of food habit differences with size, the smaller crappies fed almost entirely on fish but also ate small amounts of immature insects (Table 14). Larger crappies still fed to an appreciable but lesser extent on fish but showed a strong dependence on insects. Ewers (1933) and Ewers and Boesel (1935) found small white crappies (0.6 to 2.4 inches long) feeding primarily on zooplankton (cladocerans and copepods), plus small amounts of immature chironomids.

One white crappie sampled in March contained only immature chironomids (97 percent) and a small amount of Hyalella, and another taken in May had eaten fish and a few immature chironomids (trace volume). A June sample found one specimen containing half naiad and half adult Hexagenia, and another fish held only two corixids. Hexagenia were the predominant food in 7 white crappies taken in July (76 percent volume), followed by fish (24 percent). Except for 5 percent corixids, fish made up the entire food volume of 12 crappies sampled in August. Hexagenia naiads reappeared as an important food (48 percent volume) in five white crappies taken in November and December. Cladocerans and fish ranked next (about 20 percent each) and a small amount (4 percent) of Hyalella was also found.

Fish made up the entire food of two white crappies from the flat area. Except for a small amount of chironomids and corixids, fish was the diet of three specimens from the heavily vegetated slough station (Figure 21). However, at the other slough location with less weeds, immature chironomids were more important than fish. Insects also exceeded fish in food volume in shallow vegetated river areas, but here Hexagenia and corixids were the

Figure 21. Percent volume of food items in white crappie stomachs in various habitats from November, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size


WHITE CRAPPIE
100
50
PER CENT VOL.
SLOUGH HEAVY VEGETATION (3)
SLOUGH LIGHT VEGETATION (11)
SHALLOW VEGETATED (8)
SHALLOW NON-VEGETATED (4)
FLAT (2)
FISH
CHIRONOMIDS
CORIXIDS
HEXAGENIA
HEXAGENIA (ADULTS)
BAETIDAE AND CAENIDAE
HYALELLA
LEECHES
OTHER

main types eaten. At shallow stations lacking vegetation, Hexagenia predominated (66 percent volume), followed by fish (20 percent) and leeches (10 percent). Corixids showed up in important volumes only in fish from the shallow vegetated river.

Forage fish 0.5 to 2.0 inches long were found in the stomachs of 17 white crappies and were often not identified due to the state of digestion. Five crappies contained two or three gizzard shad each, another a bluegill or crappie, and four minnows were found in a third specimen.

Wenke (1965) found Hexagenia naiads and adults made up over half the food of an earlier sample of 28 white crappies from Pool 19. A February sample of three fish contained mostly fish and a few corixids, and three more taken in June and November fed mainly on mayflies, including Hexagenia. Hexagenia were the dominant food in July and August samples. Smaller crappies than those examined in the present study fed mainly on Hexagenia naiads and small crustaceans, and larger ones ate mostly fish and both adults and naiads of Hexagenia. A possible reason for the larger amount of Hexagenia and smaller amount of fish in Wenke's samples is that they may have been taken generally earlier than mine were when Hexagenia utilization was high during emergence periods.

Hoopes (1959) obtained a larger sample (83 specimens) of larger white crappies (none under 6 inches) in his Pool 19 study. Hexagenia was the main food in April and July samples. Fish were important in April, August, and October. Chironomids were of some importance in April and Potamyia caddisflies in July and October.

Black Crappie

A sample of 98 black crappies was taken from November, 1966, through August, 1967. They ranged from 4.2 to 9.9 inches in length (average, 7.5 inches). Shallow water areas were strongly preferred by this species, with a much lower catch rate in flat regions and none taken in the channel (Figure 6). In shallow water, stations with aquatic vegetation had a catch rate over three times that of open water sites. Bailey and Harrison (1945) describe the preferred habitat of black crappies as clear weedy areas. Black crappies were most active between 8 and 10 PM and 4 and 6 AM, with catch rates dropping to about half the peak levels for the periods midnight to 2 AM and 8 to 10 AM. The lowest rate of activity occurred between noon and 6 PM. In general, black crappies were more nocturnal than diurnal. Hansen (1951) reports catches of black crappies with hoop nets were eight times higher at night than during daylight hours, and the gill net catch was almost three times higher. Possible explanations of the larger night catches were reduced net visibility, inshore feeding movement, and a general increase in activity with darkness.

All but four crappie contained food, with fish the most important item, followed very closely by *Hexagenia* mayfly naiads and adults (Table 15). Of more frequent occurrence but considerably smaller volume than the above were immature chironomids, the only other food item of major significance (14 percent volume). Corixids and small crustaceans often appeared in the stomachs but contributed only small volumes (2 to 3 percent). Larvae of *Chaoborus* and ceratopogonids, and naiads of damselflies and small mayflies also were found in large numbers of crappies but combined made up less than 2 percent of the total food volume. A number of investigators

Table 15. Percent volume and occurrence of food items[a] in black crappie, combined and by size groups (lengths in inches)

Food Items	Combined Vol.	Combined Occ.	4.0-5.9 Vol.	4.0-5.9 Occ.	6.0-6.9 Vol.	6.0-6.9 Occ.	7.0-7.9 Vol.	7.0-7.9 Occ.	8.0-8.9 Vol.	8.0-8.9 Occ.	9.0-9.9 Vol.	9.0-9.9 Occ.
Fish	37.33	39.4	38	30	34	40	48	39	29	33	33	50
Hexagenia												
naiads	28.64	33.0	1	20	41	40	13	14	42	46	36	42
adults	5.44	9.6	0	0	0	0	0	0	13	25	9	25
Chironomids	13.66	72.4	40	60	16	80	16	79	10	71	7	67
Corixids	3.23	66.0	2	10	1	45	4	79	4	79	2	58
Cladocerans	3.10	13.8	1	10	-	5	6	18	-	17	5	8
Hyallela	2.40	41.5	7	70	-	35	3	50	-	38	5	25
Damselfly	1.20	23.4	4	40	-	20	3	36	-	12	-	25
Dragonfly	0.67	4.3	0	0	0	0	-	4	-	4	2	8
Ceratopogonid	0.48	35.1	-	30	-	50	1	46	-	25	-	16
Leeches	0.38	3.2	0	0	0	0	-	4	0	0	1	16
Caddisfly adults	0.37	4.3	0	0	0	0	-	11	0	0	-	8
Caenids and baetids	0.16	21.3	1	30	-	15	1	29	-	21	-	8
Potamyia	0.15	2.1	0	0	0	0	-	7	0	0	-	16
Stonefly	0.11	5.3	0	0	-	10	-	7	-	4	0	0
Chaoborus	0.10	13.8	0	0	-	25	-	14	-	12	-	8
Other[b]	0.10	16.0	-	-	-	10	-	18	-	17	-	33
Unidentified	2.48	14.9	6	20	8	30	5	14	2	4	-	-
Number with food		94		10		20		28		24		12
Number empty		4		0		1		2		1		0

[a]All insects are immature forms except corixids and *Hexagenia* adults.

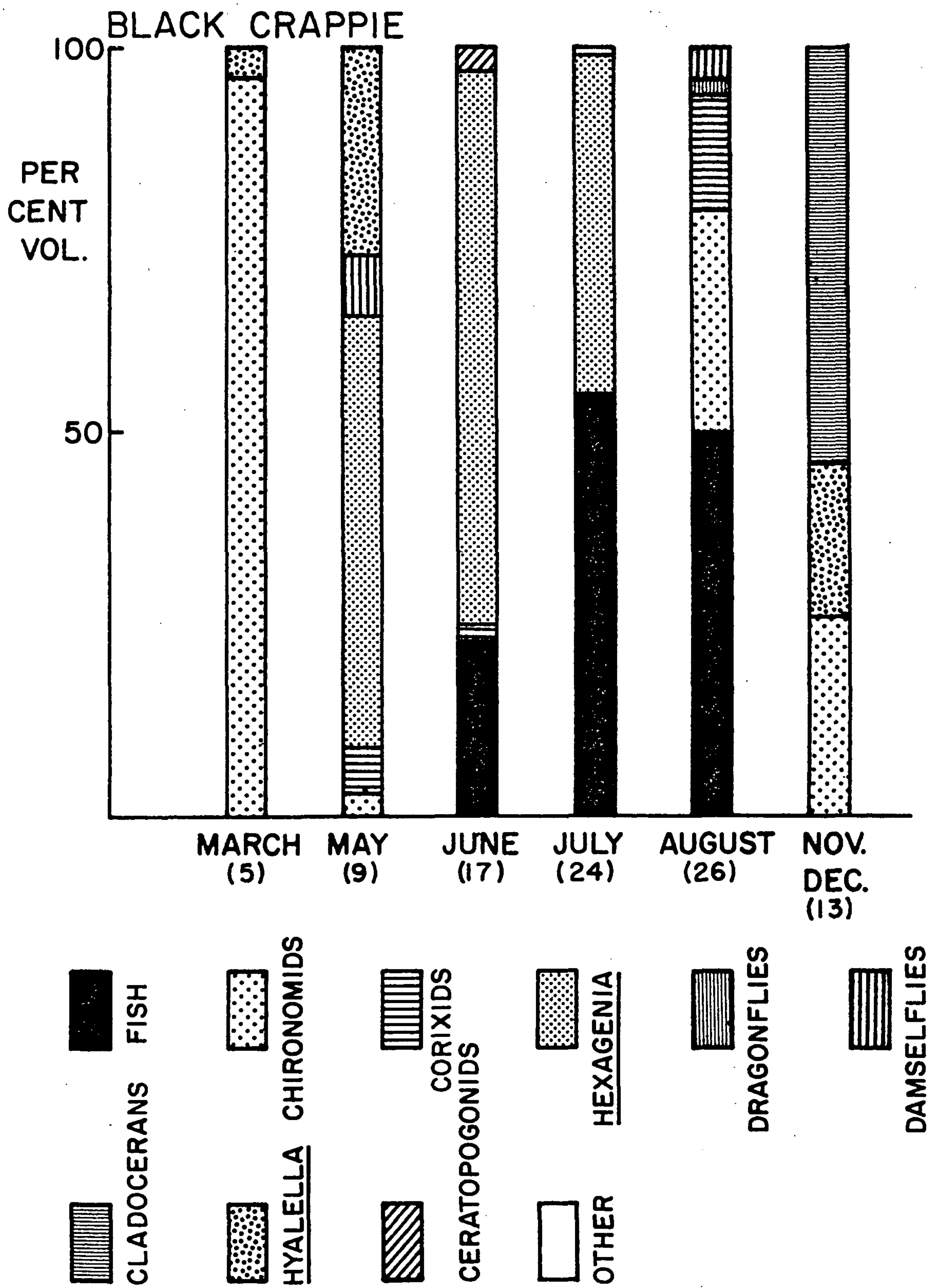
[b]Other: pleidae, water mites, ants, *Stenonema* naiads, chironomid adults, and cranefly, riffle beetle, *Oecetis* and other coleopteran larvae.

are in general agreement that the main food items of black crappies include aquatic insects, small crustaceans, and fish of some type (Forbes, 1878; 1888b; Pearse, 1919; Wilson, 1920; Forbes and Richardson, 1920; De Ryke, 1922; Kuhne, 1939; Kutkuhn, 1954; Bailey and Harrison, 1945; Goodson, 1966a; McCormick, 1940; Huish, 1958; Hansen, 1951). The relative importance of these food items varies considerably, probably due to differences in availability with location and time of year (Lagler and Ricker, 1942; Eddy and Surber, 1947; Johnson, 1945; Ewers, 1933; Dendy, 1946; Pearse, 1919; and Hunt, 1953).

The size of black crappies had no apparent effect on the relative importance of fish, corixids, ceratopogonid larvae, Hyalella, cladocerans, caenid and baetid mayflies, or damselflies in the diet (Table 15). Chironomids were eaten to the greatest extent by crappies less than 6 inches long. Hexagenia adults were most important in crappies over 8 inches long. Hexagenia naiads were found in all sizes of black crappies sampled but were not of significant volume in fish less than 6 inches long.

Seasonal analysis found fish an important summer food of black crappies, particularly in July and August (Figure 22). Hexagenia mayflies made up from 44 to 72 percent of the food May through July, with peak utilization in June. In March samples, chironomids made up nearly the entire food volume but declined to a very small percentage of the diet in May. They reappeared in sizable amounts in August and November and December specimens. Hyalella made up the remainder of the black crappie diet in March and were a considerable food item in May. They were not important during the summer months, then reappeared in significant amounts in November and December. Corixids were utilized to the greatest extent in August and were eaten in

Figure 22. Percent volume of food items in black crappie stomachs by months from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size


BLACK CRAPPIE
100
50
PER CENT VOL.
MARCH (5)
MAY (9)
JUNE (17)
JULY (24)
AUGUST (26)
NOV. DEC. (13)
FISH
CHIRONOMIDS
CORIXIDS
HEXAGENIA
DRAGONFLIES
DAMSELFLIES
CLADOCERANS
HYALELLA
CERATOPOGONIDS
OTHER

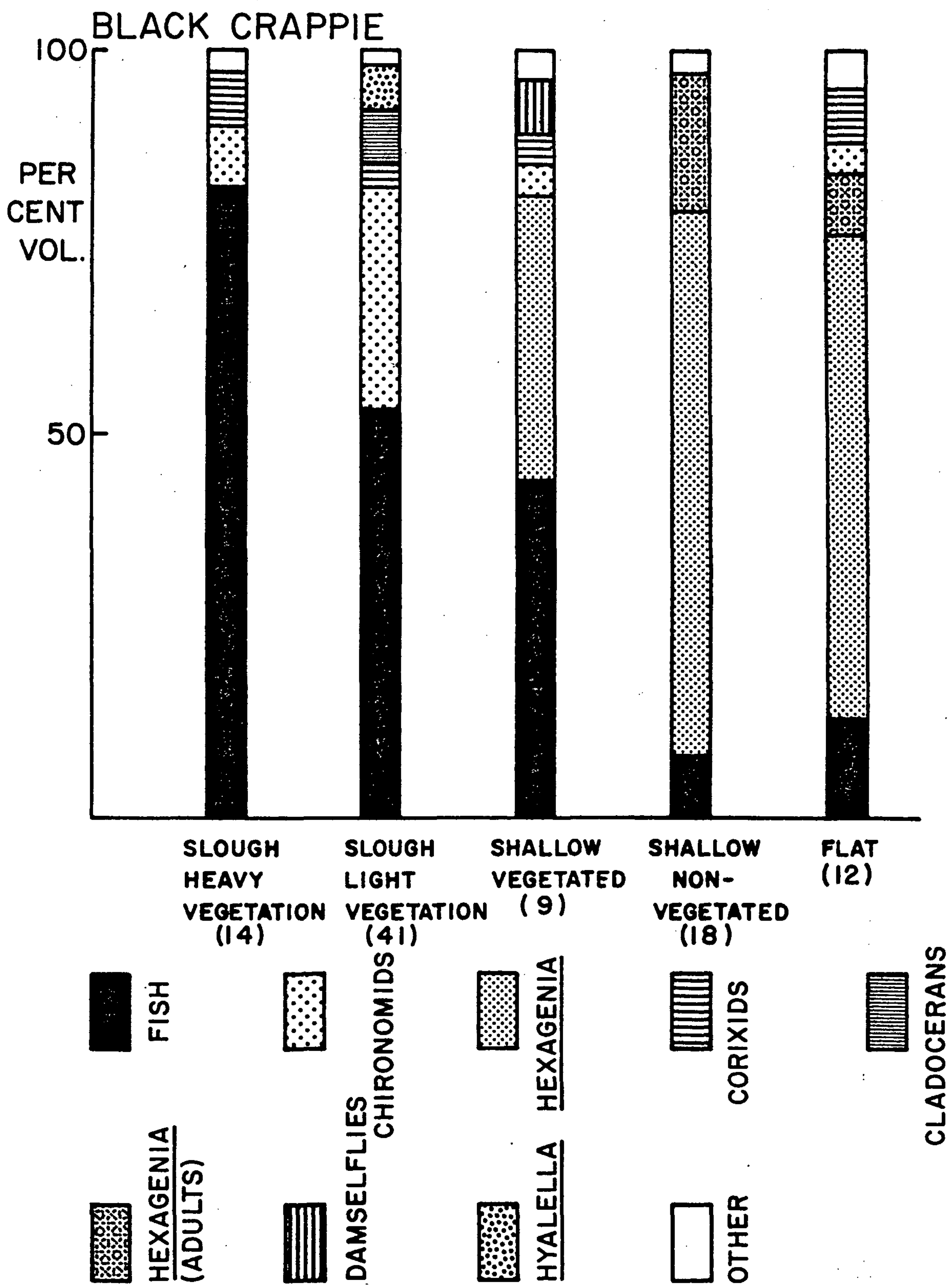
small amounts in May and June. In November and December samples, cladocerans made up most of the food volume but were not found in the stomachs during other sampling months. Dendy (1946) concluded aquatic insects (mainly chironomids and chaoborines) and plankton (mainly Leptodera) are the main foods of adult black crappie in spring and early summer in Norris Reservoir, Tennessee. In late summer and fall, they changed to a diet consisting mainly of young fish.

Fish were the most important food item in the vegetated habitat of the slough and shallow river areas (Figure 23). Hexagenia mayflies were utilized to major extent in the shallow and flat categories. Adult Hexagenia were found only in black crappies taken at open water stations. Black crappies fed most heavily on chironomids at the slough stations, although they were found in noticeable volumes in fish from the shallow vegetated and flat areas as well.

In 21 of the 36 black crappies containing fish, the stomach contents were too completely digested to allow identification of the fish eaten. The unidentified forage fish ranged in size from tiny fry to fish 1 inch in length. Most crappies contained one to three fish, although there were as many as 20 in a case where very small fish were eaten. Gizzard shad were the most frequently occurring recognizable fish eaten. Six crappies contained gizzard shad only, and another had eaten both shad and one small bullhead. The numbers per stomach ranged from 1 to 47 shad, and over half of these crappies contained over 10 forage fish.

Hansen (1951) states that crappies in Illinois often fed heavily on gizzard shad. The second most numerous forage fish were small centrarchids, mostly bluegills, ranging from 0.5 to 1.5 inches long. The numbers

Figure 23. Percent volume of food items in black crappie stomachs in various habitats from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size


BLACK CRAPPIE
100
50
PER
CENT
VOL.
SLOUGH
HEAVY
VEGETATION
(14)
SLOUGH
LIGHT
VEGETATION
(41)
SHALLOW
VEGETATED
(9)
SHALLOW
NON-
VEGETATED
(18)
FLAT
(12)
FISH
CHIRONOMIDS
HEXAGENIA
CORIXIDS
CLADOCERANS
HEXAGENIA (ADULTS)
DAMSELFLIES
HYALELLA
OTHER

per stomach varied from 1 to 31, and they were found in five of the crappies examined. One crappie contained two minnows, 1.0 to 1.5 inches in length, plus an unrecognizable 1.0-inch fish. Another had one bullhead and two unidentified fish in its stomach, and a third had eaten one small drum.

Wenke (1965) reported Hexagenia naiads and fish as the main food of 11 crappies taken in the upper part of Pool 19 during the months of March, June, August, and November. In the lower part of Pool 19, June through August, the main foods again were Hexagenia naiads and fish, plus entomostracans and immature chironomids. Wenke attributes the presence of the last two organisms in the diet to the smaller size of the crappies in the second sample. Caddisflies were an important food item of five crappies taken in the tailwaters. Changes in the availability of different types of food organisms in this markedly changed environment seems the best explanation of the above. In all his samples, Wenke found fish and chironomids considerably less important as a food item than they were in this study.

Hoopes (1959) obtained only four black crappies in his Pool 19 food habits study. He described three of these as having little food in their stomachs, most of which was Hexagenia naiads with a few corixids also present. The fourth contained an unidentified fish.

Yellow Perch

Yellow perch were taken primarily in shallow water where the catch rate was about six times that of the flat and drop-off areas (Figure 6). None appeared in channel nets. In shallow water, vegetated areas seemed strongly preferred with a catch rate nearly 12 times that of open water stations. Perch appeared to be considerably more active during the day than at night (Figure 7). Movement was lowest from midnight to 2 AM, after which it increased rapidly and persisted at a fairly high level from 4 AM to 2 PM and peaked between 4 PM and 6 PM. This was followed by a rapid decline to a low level by 8 PM to 10 PM. Carlander (1942, 1953) found the same diurnal behavior in yellow perch in Lake of the Woods, Minnesota, and Clear Lake, Iowa. Carlander and Cleary (1949) state that perch in these lakes showed more movement in the afternoon than in the morning, which agrees closely with this study. Sieh and Parsons (1950) found perch showed no night activity but placed peak movement between 6 and 8 AM.

Stomachs of 109 yellow perch ranging from 4.9 to 10.7 inches in length (average, 8.2 inches) were examined and 82 contained identifiable food. Immature chironomids were the most important food item, followed by fish and *Hexagenia* naiads which were of approximately equal volume (Table 16). Minor items together contributing less than one-sixth of the food volume included naiads of dragonflies and damselflies, larvae of *Oecetis* and *Potamyia* caddisflies, corixids, and cladocerans. Some trends in food habits related to size of perch seemed evident. Chironomids, while of considerable importance in all sizes, showed a definite decline in utilization with increasing fish size. Forage fish showed the opposite relationship, becoming most important in the diet of the largest perch. Similarly, *Hexa-*

Table 16. Percent volume and occurrence of food items[a] in yellow perch, combined and by size groups (lengths in inches)

Food Items	Combined		4.0-7.9		8.0-8.9		9.0-10.9	
	Vol.	Occ.	Vol.	Occ.	Vol.	Occ.	Vol.	Occ.
Chironomids	41.06	65.9	72	76	35	68	23	40
Fish	20.38	16.0	4	9	11	12	54	33
Hexagenia	18.28	14.8	2	3	28	24	15	20
Dragonfly	4.90	12.3	3	15	9	15	0	0
Oecetis	4.29	24.7	3	24	8	21	3	20
Corixids	2.50	12.3	2	9	4	12	-	20
Cladocerans	2.10	11.1	3	12	1	9	4	13
Potamyia	1.32	2.5	-	3	3	3	0	0
Damselfly	1.29	24.7	4	36	1	18	-	7
Clams	0.79	2.5	-	3	1	3	0	0
Caenids and baetids	0.74	21.0	2	30	-	21	0	0
Leeches	0.22	4.9	-	3	-	3	1	13
Coleopterans	0.18	6.2	-	12	-	3	0	0
Hyallela	0.11	4.9	-	9	-	9	-	20
Snails	0.07	3.7	-	6	-	3	0	0
Ceratopogonid	-	6.2	-	6	-	9	0	0
Leafhoppers	-	1.2	0	0	-	3	0	0
Copepods	-	1.2	0	0	0	0	-	7
Unidentified	1.73	8.6	5	9	-	6	-	7
Number with food		82		33		34		15
Number empty		27		12		8		7

[a]All insects are immature forms except corixids and leafhoppers.

genia naiads first became important in perch 8 inches and longer. Odonate naiads and corixids appeared in noticeable amounts in the small and medium perch but were not observed in the largest specimens. Other food organisms failed to show any apparent patterns of utilization determined by perch size.

Chironomids were important in spring and from late summer to early winter (Figure 24). They made up the entire diet in March samples, then declined to about half the total food volume in May and disappeared entirely in June and July. They reappeared at about the May level in August, increasing only slightly by November and again made up the entire diet by December. Forage fish were important only during the summer months, appearing in small amounts in June, increasing to nearly half the food volume in July, and dropping back to a low level in August. In May Hexagenia naiads showed up as a minor item and rapidly increased to the dominant food in June and July, after which they disappeared from the diet. Dragonfly naiads appeared in the greatest amounts in July and August. Potamyia larvae were of considerable importance in May and cladocerans in November.

Chironomids were important only in slough areas and were utilized to a much greater extent at the lightly vegetated station than the one with dense weeds (Figure 25). Fish, on the other hand, were much more important at the latter station. They were also found in stomachs of perch from all the other habitats but in rather minor amounts. Outside the slough, specimens from the flat areas fed most heavily on fish. Forage fish were of much less importance in shallow non-vegetated areas and were little used in the shallow weedy areas. The dominant food at the non-slough stations was Hexagenia naiads, and they contributed half or more of the food volume in

Figure 24. Percent volume of food items in yellow perch stomachs by months from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size

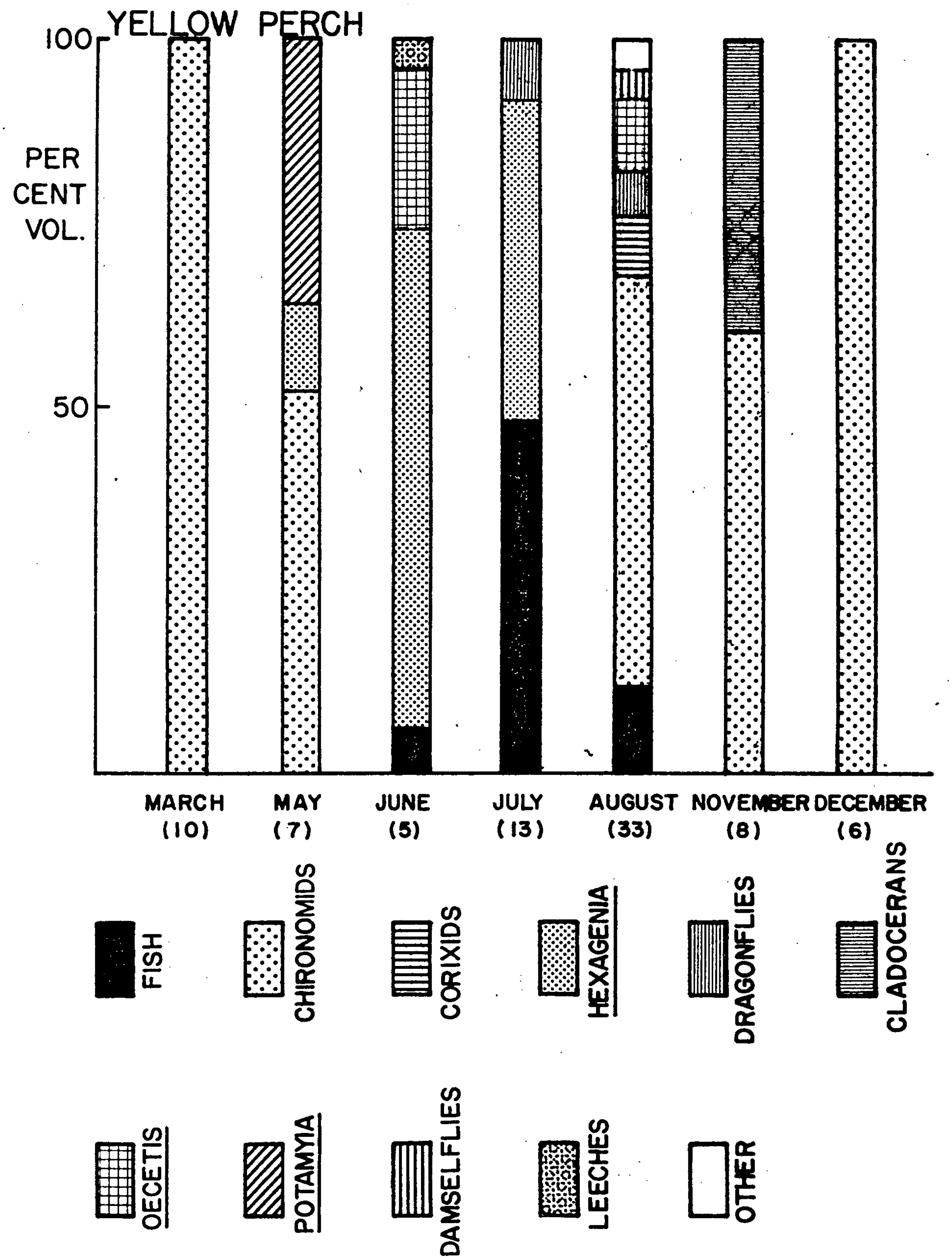
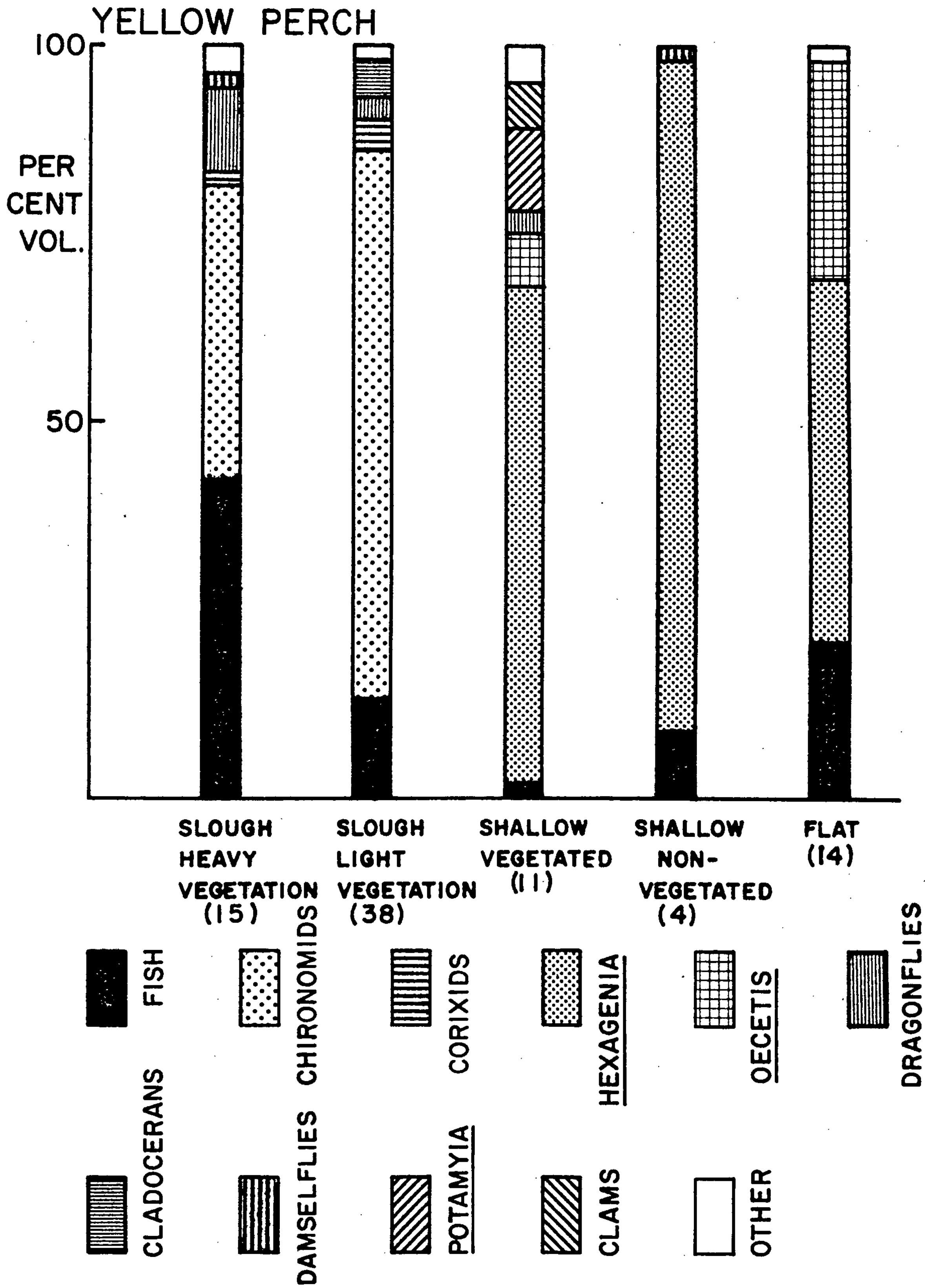

YELLOW PERCH
100
50
PER CENT VOL.
MARCH (10)
MAY (7)
JUNE (5)
JULY (13)
AUGUST (33)
NOVEMBER (8)
DECEMBER (6)
FISH
CHIRONOMIDS
CORIXIDS
HEXAGENIA
DRAGONFLIES
CLADOCERANS
OECETIS
POTAMYIA
DAMSELFLIES
LEECHES
OTHER

Figure 25. Percent volume of food items in yellow perch stomachs in various habitats from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size


YELLOW PERCH
100
50
PER CENT VOL.
SLOUGH HEAVY VEGETATION (15)
SLOUGH LIGHT VEGETATION (38)
SHALLOW VEGETATED (11)
SHALLOW NON-VEGETATED (4)
FLAT (14)
FISH
CHIRONOMIDS
CORIXIDS
HEXAGENIA
OECETIS
DRAGONFLIES
CLADOCERANS
DAMSELFLIES
POTAMYIA
CLAMS
OTHER

all these habitats. Next in importance were Oecetis larvae which were fed upon fairly heavily in flat areas and in small amounts in shallow vegetated ones. Dragonfly naiads showed up in fish from all vegetated habitats and were of greatest significance in the densely vegetated slough.

In 8 of the 14 yellow perch containing forage fish, the stomach contents were too completely digested for identification. Most of these forage fish were about 0.5 inch long. The majority of these perch contained single fish, but certain specimens held as many as four. Two perch had eaten 1 or 2 centrarchids about 0.5 inch long, apparently small crappies or bluegills. From 2 to 18 gizzard shad, 0.5 to 1.5 inches long, were found per stomach in 3 perch. Another specimen held 1 small drum.

Neither Hoopes (1959) nor Wenke (1965) examined yellow perch in their Pool 19 food habits studies. Kutkuhn (1954) analyzed the stomachs of 62 young and 639 yearling and adult perch from a dredged Iowa lake. Food was found in 73 percent of the young fish and 37 percent of the yearlings and adults. Almost the entire diet of adult perch was forage fish. Sub-adult perch from about 1.5 to 5.0 inches long fed heavily on insects. Cladocerans, copepods, and other entomostracan zooplankters dominated the perch diet from the time they first began to feed until insects begin to replace them at about 1.5 inches. They still occurred frequently in stomachs of perch up to 3 inches long but in decreasing volume. Availability seemed to determine the important type of forage fish. One year young yellow bass predominated; the next, small gizzard shad were most important.

Bailey and Harrison (1945) examined the food habits of 15 adult yellow perch taken from Clear Lake in the fall and found over half the food volume consisted of insects, mostly chironomids and odonate naiads. Small fish including yellow perch, bluegills, and minnows were about half as important as insects. *Hyallela* were a common food but contributed little volume. Coots (1966) found the major foods of yellow perch in the Klamath River in California were small crustaceans, mollusks (especially small snails), larvae and nymphs of aquatic insects, and fish. In Lake of the Wood, (Carlander, 1942), zooplankton was an important food of small perch but was found only occasionally in the larger specimens. Perch under 4 inches fed most often on *Hyallela*, earthworms, algae, copepods, chironomids, hydroptilid caddisflies, and mayflies. Fish (minnows and perch) and mayflies were the most common food of perch between 4 and 6 inches long. Perch over 6 inches fed on crayfish and mayflies to the greatest extent.

Sauger

The catch rate of sauger was high in all depth categories but greatest in the drop-off and channel locations indicating this species prefers deeper open water (Figure 6). Carlander (1942) found Lake of the Wood saugers showed the same habitat preference. In shallow areas, non-vegetated habitat had a catch rate over four times that of vegetated locations. Sauger were strongly nocturnal, with 3.5 times as many taken at night as during daylight hours (Figure 7). Carlander (1942) and Carlander and Cleary (1949) made similar observations.

Food habits of 371 sauger were determined. The specimens ranged from 6.7 to 18.7 inches in length (average, 12.6 inches), and 215 contained food items. Almost the entire food volume of sauger consisted of fish (Table 17). Hexagenia naiads were the only other food frequently found in the stomach contents and accounted for less than 3 percent of the food volume. There were no apparent differences in food habits with size over the range studied. Hexagenia naiads made their contribution to the diet May through July and were not present in significant amounts August through December (Figure 26). Hexagenia naiads were eaten in flat and shallow areas and were most important in the non-vegetated shallows (Figure 27). Small volumes of leeches were found in fish from shallow stations with and without aquatic vegetation.

Gizzard shad, 0.8 to 4.5 inches long, were found in 49 sauger and were the most common forage fish. Most stomachs contained 1 to 4 shad, but as many as 32 were found in a single fish. Channel catfish, 1.2 to 7.0 inches in length, were eaten by 26 sauger. Most of the catfish were about 2 inches long, and 1 to 3 were found per stomach. Freshwater drum were pre-

Table 17. Percent volume and occurrence of food items in sauger

Food Items	Vol.	Occ.
Fish	96.48	87.9
Hexagenia naiads	2.96	22.3
Leeches	0.42	4.7
Crayfish	0.06	0.5
Vegetation	0.04	1.4
Potamyia larvae	0.03	0.9
Stonefly naiads	0.01	0.9
Damselfly naiads	-	0.9
Hyallela	-	0.5
Immature chironomids	-	0.5
Number with food		215
Number empty		156

sent in 14 sauger and ranged from 0.8 to 4.0 inches long, with 1 to 4 per stomach. Eight sauger contained a single bullhead each; five, 1 or 2 minnows each; and two, 3 to 8 crappies and/or bluegills each. One sauger contained a yellow perch, another a 3-inch warmouth, and a third a 4-inch white bass. The following combinations of types of forage fish were observed in individual stomachs: six sauger held freshwater drum and channel catfish, and one each contained freshwater drum and gizzard shad, minnows and channel catfish, and bullheads and gizzard shad. Forage fish unrecognizable due to the state of digestion were often present with recognizable ones. Fish were also the major food of saugers from Pool 19 exam-

Figure 26. Percent volume of food items in sauger stomachs by months from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size

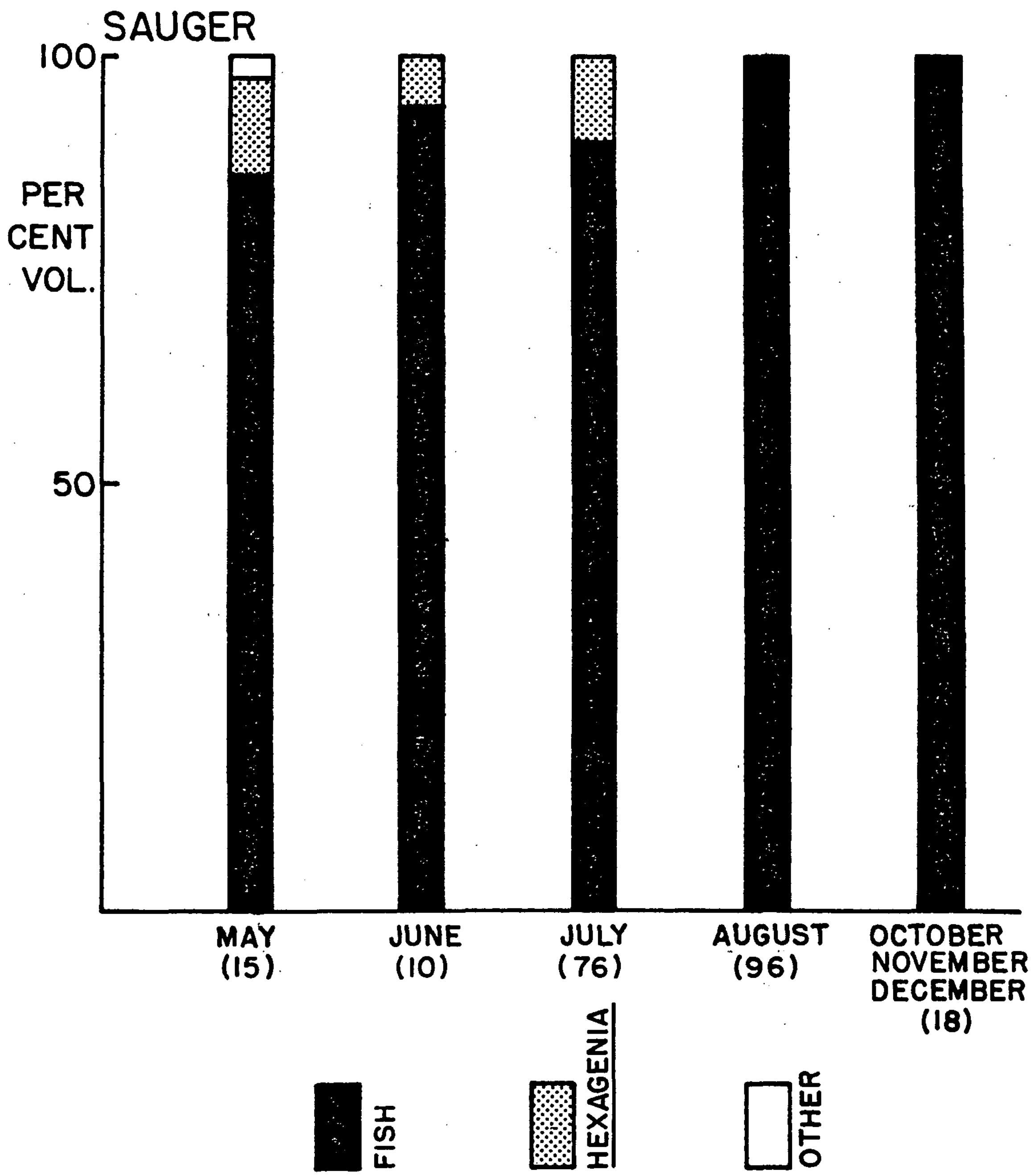
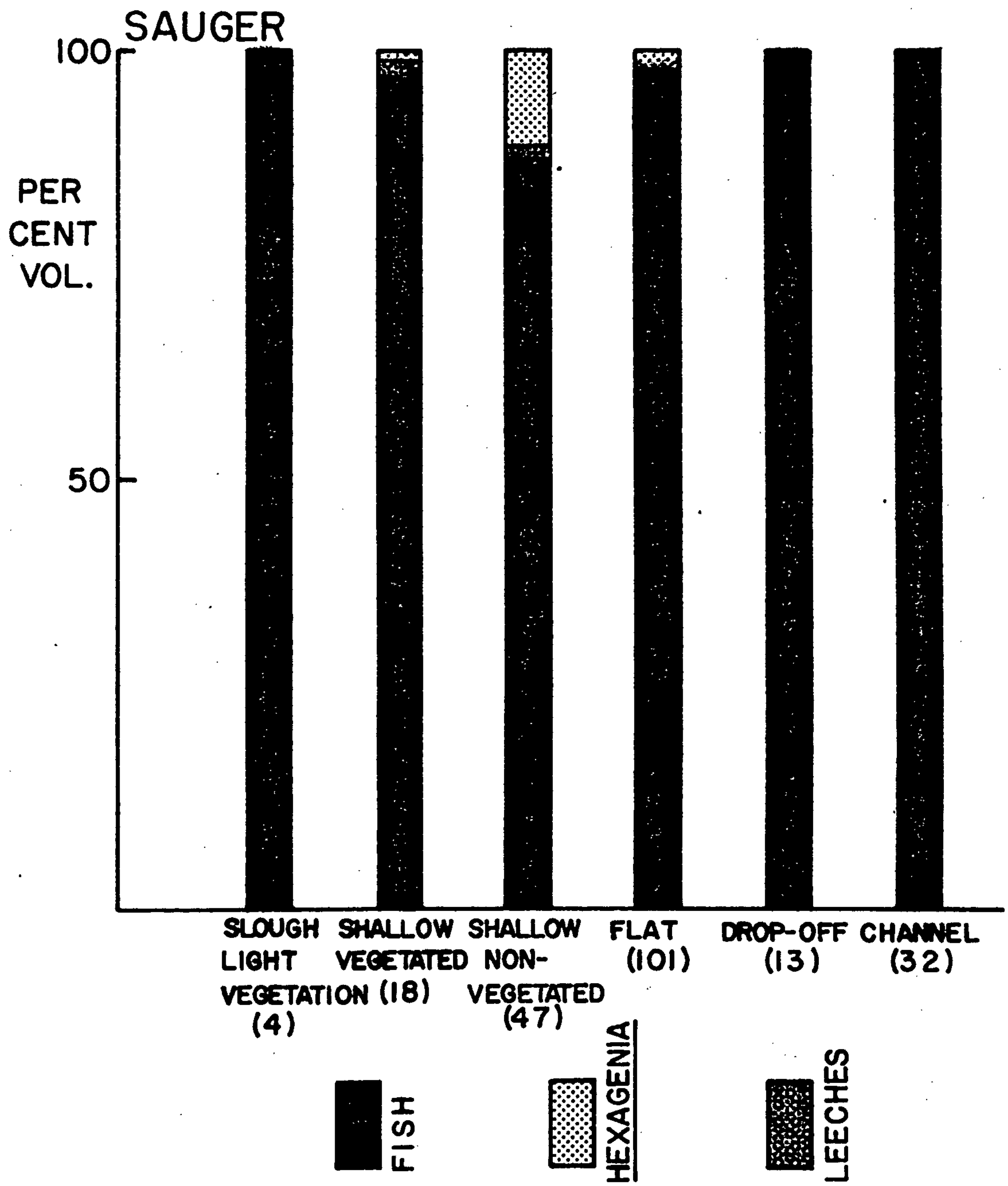

SAUGER
100
50
PER
CENT
VOL.
MAY
(15)
JUNE
(10)
JULY
(76)
AUGUST
(96)
OCTOBER
NOVEMBER
DECEMBER
(18)
FISH
HEXAGENIA
OTHER

Figure 27. Percent volume of food items in sauger stomachs in various habitats from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size



SAUGER
100
50
PER CENT VOL.
SLOUGH LIGHT VEGETATION (4)
SHALLOW VEGETATED (18)
SHALLOW NON-VEGETATED (47)
FLAT (101)
DROP-OFF (13)
CHANNEL (32)
FISH
HEXAGENIA
LEECHES

ined by Hoopes (1959) and Wenke (1965) and of saugers above 4 inches long in other waters (Carlander, 1942; Bajkov, 1930; Neave, 1932; Sibley, 1929; Priegel, 1963; Pearse, 1921; and Dendy, 1946).

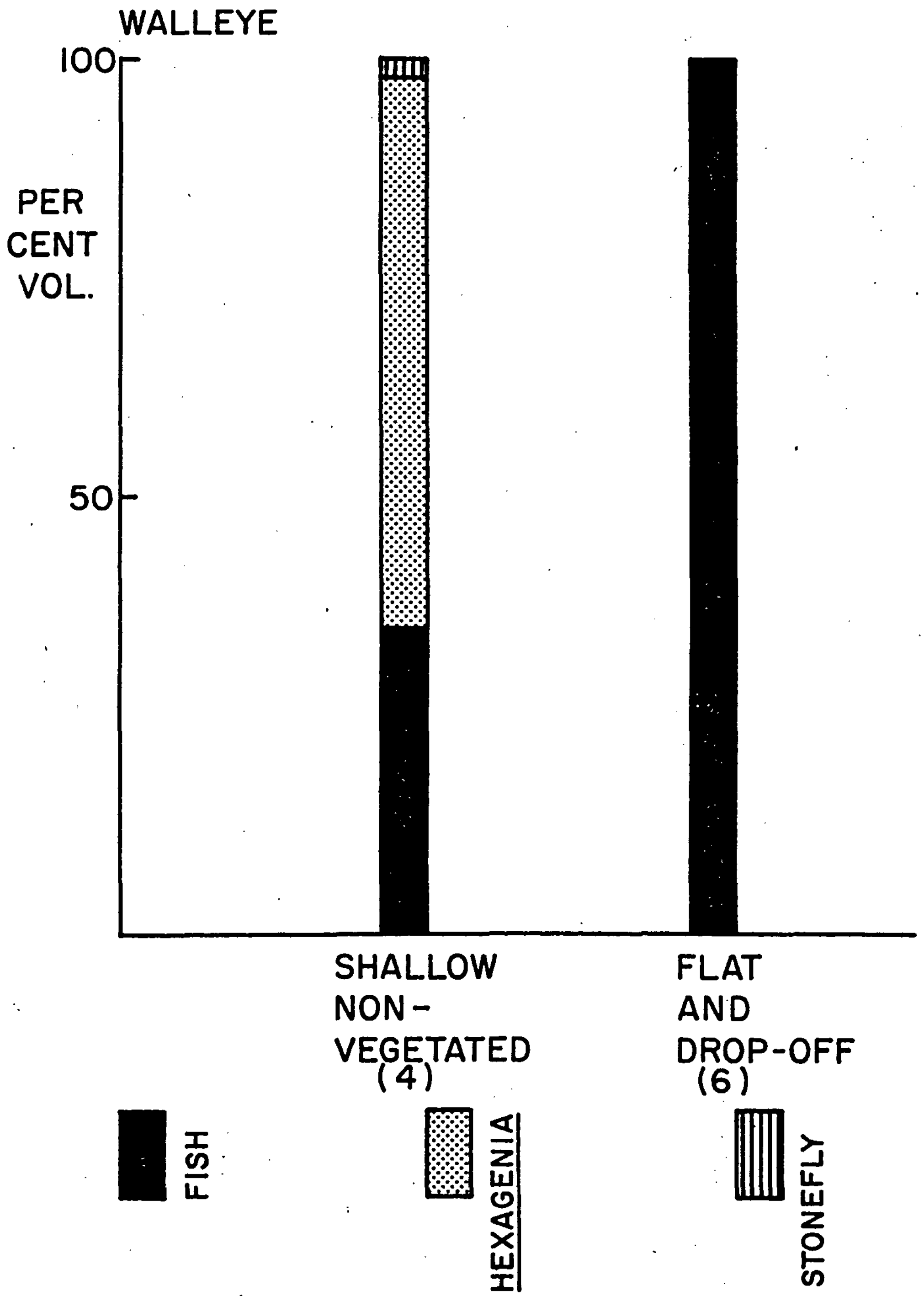
Walleye

The walleye catch rate was about the same in shallow, flat, and drop-off areas over the entire sampling period but varied considerably between years. It was highest in the flat in 1966 and in the shallow water in 1967 (Figure 6). The catch at shallow non-vegetated stations was nine times that found at vegetated ones. Though walleyes appear to prefer open water, none were taken in channel depths. They were distinctly nocturnal, with over four times as many taken at night as during the day. Similar dominance of nocturnal over daylight catches have been reported for walleye (Carlander, 1942, 1953; Carlander and Cleary, 1949; and Sieh and Parsons, 1950).

Stomachs of 20 walleyes 10.4 to 20.1 inches in length (average, 13.9 inches) were examined. Fish were found in nine and made up nearly the entire food volume. The only walleye collected in May had fed mostly on *Hexagenia* and was the only specimen that had not eaten fish. Two other walleyes had eaten a few *Hexagenia*, one in July and the other in November. The May specimen had also eaten a few stonefly naiads and chironomid larvae. Caddisfly adults, an unidentified terrestrial insect, and fish were eaten by the one walleye taken in June. All insects eaten were found in fish from shallow non-vegetated stations, and in flat and drop-off areas, forage fish were the sole food item observed (Figure 28). One to five of these forage fish appeared per stomach, including gizzard shad up to 5 inches long in five walleyes. One specimen contained four mooneyes 1.5 to 2.5 inches long.

Wenke (1965) examined 20 walleyes in his Pool 19 study, but only four of these were empty. His samples included specimens ranging from fish much

Figure 28. Percent volume of food items in walleye stomachs in various habitats from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size


WALLEYE
100
50
PER
CENT
VOL.
SHALLOW
NON-
VEGETATED
(4)
FLAT
AND
DROP-OFF
(6)
FISH
HEXAGENIA
STONEFLY

smaller than those in this study to a comparable maximum size. Fish were the dominant food with gizzard shad, minnows, freshwater drum, and one ictalurid observed. Minor items included mayfly naiads, caddisfly adults, immature chironomids, cladocerans, and *Hyalella*. Even the six smallest specimens (1.6 to 2.4 inches) fed on fish, five of them exclusively. *Hexagenia* naiads were considerably less important in Wenke's study than in this one, with only a single naiad observed in his walleye stomachs.

Hoopes (1959) collected five walleyes from Pool 19 ranging in size from 13.0 to 21.0 inches (average, 17.4 inches). Single fish taken in May, July, and October had empty stomachs. An August and November specimen both had fed on mooneyes.

The food of walleyes in Pool 19 is similar to that reported elsewhere (Carlander, 1942; Dendy, 1946; Eschmeyer, 1950; Bailey and Harrison, 1945; and Kutkuhn, 1954).

Freshwater Drum

The catch rate of freshwater drum was highest in the channel and progressively declined in the drop-off, flat, and shallow areas (Figure 6). Shallow open water stations had an overall catch rate over twice as great as those with aquatic vegetation, but two of the six specimens taken in shallow water were caught at vegetated stations. Drum appeared to be predominantly nocturnal, with nearly three times as many taken at night as during the day. There were two activity peaks, the largest between 8 PM and 10 PM and a smaller one between 4 AM and 6 AM. The smallest amount of movement occurred between midnight and 2 AM and 8 AM and 10 AM.

Of 59 freshwater drum, 36 had food in their stomachs. The specimens ranged from 2.2 to 17.9 inches in length (average, 9.5 inches). The most important food item was leeches which were found in nearly half the specimens examined and made up close to half the food volume (Table 18). Fish were next contributing about one-fourth the food volume. The only other food of considerable importance was caddisfly larvae (*Oecetis* and *Potamyia*) which were about half as important as fish. Immature chironomids were found in over one-third of the drum but made up less than 0.5 percent of the food volume. Some differences in food habits were found in drum of different sizes. Leeches made their greatest contribution in fish 11 inches long and larger but were also found in specimens less than 6 inches in length, the smallest size group. *Potamyia* were of large importance only in the fish less than 6 inches although they appeared in minor amounts in all the larger size groups. *Hexagenia* naiads were found in appreciable amounts only in drum less than 12 inches long and were most important in those less than 11 inches. Drum 6 inches long and larger fed on forage

Table 18. Percent volume and occurrence of food items in freshwater drum, combined and by size groups (lengths in inches)

Food Items	Combined Vol.	Combined Occ.	3.0-5.9 Vol.	3.0-5.9 Occ.	6.0-10.9 Vol.	6.0-10.9 Occ.	11.0-11.9 Vol.	11.0-11.9 Occ.	12.0-15.9 Vol.	12.0-15.9 Occ.
Leeches	41.19	44.4	7	12	0	0	40	91	50	62
Fish	27.02	16.7	0	0	36	33	43	18	3	12
Hexagenia naiads	10.21	22.2	27	12	52	11	3	36	-	25
Oecetis larvae	9.35	30.1	17	50	0	0	11	27	11	65
Clams	4.36	2.8	0	0	0	0	0	0	14	12
Potamyia larvae	3.46	27.8	47	12	4	33	1	27	1	37
Immature chironomids	0.45	85.8	1	50	3	33	-	36	-	25
Snails	0.18	5.6	0	0	0	0	0	0	1	25
Caddisfly adults	0.10	5.6	-	12	0	0	-	9	0	0
Corixids	0.05	5.6	0	0	-	22	0	0	0	0
Stanonema naiads	0.05	5.6	0	0	0	0	-	18	0	0
Hyallela	0.05	2.8	1	12	0	0	0	0	0	0
Caenids and baetids	-	5.6	-	12	0	0	-	9	0	0
Unidentified	3.51	16.7	0	0	5	11	2	36	20	25
Number with food		36		8		9		11		8
Number empty (including two 2-inch fish)		23		3		8		4		6

fish, and forage fish were most important in specimens between 6 and 12 inches long. Immature chironomids decreased in frequency of occurrence with increasing drum size and made up 1 percent or more of the diet only in fish less than 11 inches long.

Seasonal analysis found leeches made up between one-third and one-half the food volume during the sampling period, May through August (Figure 29). Over half the food volume in May was chironomids and in June, Hexagenia naiads. Fish appeared in the diet in July when they made up one-fifth of the food volume and increased to over one-third in August. Oecetis caddisflies were the most important food items in July but declined considerably by August. Two small drum (4.3 and 4.5 inches) were seined in December, and each contained an immature chironomid.

Fish made up all or nearly all the food volume of fish from shallow vegetated, drop-off, and Ortho pool outlet sampling stations but were a minor item in the channel (Figure 30). Leeches made up over half the food of drum from shallow non-vegetated, flat, and channel locations. Oecetis caddisflies were eaten to the greatest extent in shallow non-vegetated areas and were also minor items in the flat and channel areas. Potamyia larvae were found in the greatest relative amounts in drum from the channel and to a somewhat lesser extent in those from drop-off areas. Hexagenia naiads were present in the largest amounts in fish from flat areas and also showed up in minor amounts in the shallow non-vegetated ones.

From one to three unidentified forage fish were found in three stomachs. One drum contained six minnows, apparently bigmouth shiners. Another had eaten a small drum, and a third specimen held a channel catfish about 0.8 inches long.

Wenke (1965) found only 48 of 98 freshwater drum from Pool 19 contained food. The high percentage of empty stomachs was partly attributed to 22 fish taken in November, December, February, and March which contained no food. Wenke felt his data and those of Moen (1955) and Hoopes (1959)

Figure 29. Percent volume of food items in freshwater drum stomachs by months from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size

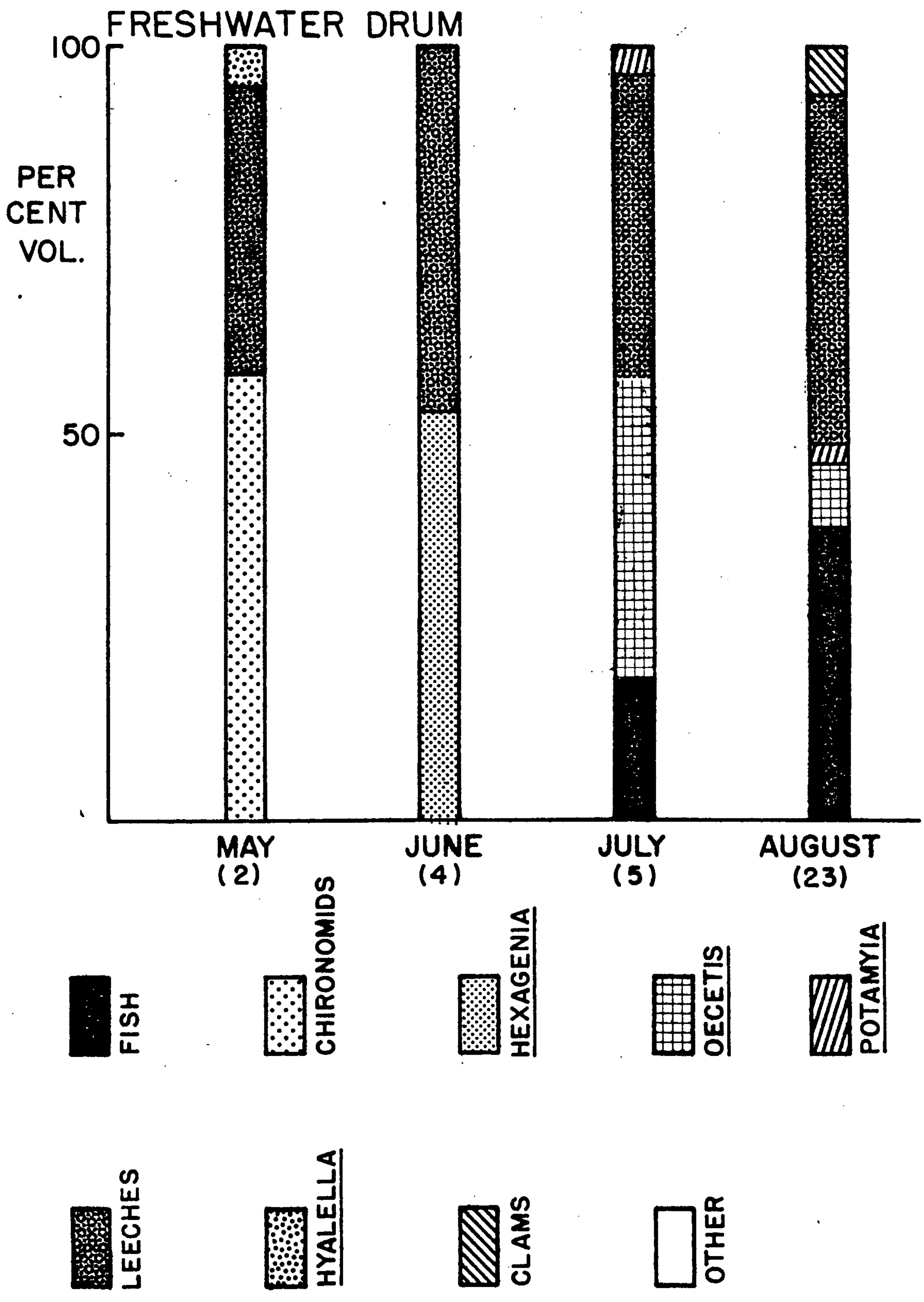
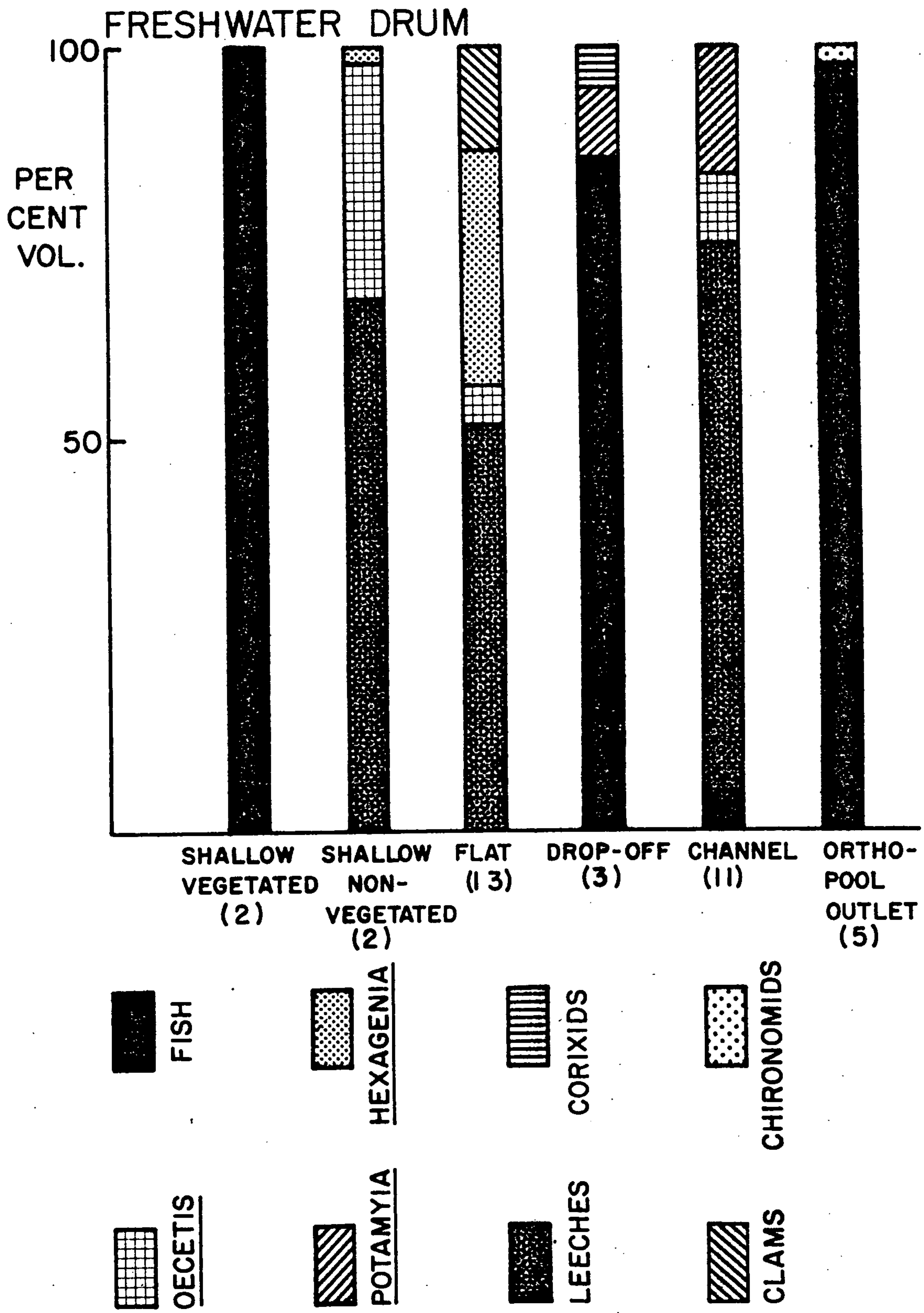

FRESHWATER DRUM
100
50
PER CENT VOL.
MAY (2)
JUNE (4)
JULY (5)
AUGUST (23)
FISH
CHIRONOMIDS
HEXAGENIA
OECETIS
POTAMYIA
LEECHES
HYALELLA
CLAMS
OTHER

Figure 30. Percent volume of food items in freshwater drum stomachs in various habitats from July, 1966, through August, 1967, in Pool 19, Mississippi River. Figures in parentheses denote sample size


FRESHWATER DRUM
100
50
PER CENT VOL.
SHALLOW VEGETATED (2)
SHALLOW NON-VEGETATED (2)
FLAT (13)
DROP-OFF (3)
CHANNEL (11)
ORTHO-POOL OUTLET (5)
FISH
HEXAGENIA
CORIXIDS
CHIRONOMIDS
OECETIS
POTAMYIA
LEECHES
CLAMS

indicate drum feed little or not at all during these months. In Wenke's study, Hexagenia naiads were the most important food in all collecting areas. Chironomids were utilized to a considerably greater extent by Wenke's specimens than in this study. Wenke thought the increased importance of caddisflies and decreased significance of Hexagenia naiads in his study as compared to Hoopes (1959) were due to differences in sampling locations (lower pool vs. upper pool) and the larger average size of Hoopes' specimens.

Hoopes (1959) examined 33 drum containing food. Most of these were over 12 inches long. Three-fourths of the food of all specimens was Hexagenia naiads, a level of utilization much higher than that found in Wenke's or the present study. The rest of the food volume was made up of coleopteran larvae and odonate naiads (not observed here), fish, and snails.

Priegel (1967) examined the food habits of 672 adult drum from Lake Winnebago, Wisconsin. Chironomids were the dominant food item in fish sampled during April, July, and October. Leeches were second in importance and ranged from negligible amounts to over 10 percent of the diet. Their occurrence in the stomachs more than doubled between April and October. Drum from another nearby lake fed almost entirely on chironomids. Drum under 1.6 inches long fed chiefly on Cyclops zooplankters.

Dendy (1946) found drum in Norris Reservoir, Tennessee, fed mainly on planktonic crustaceans and small insect larvae as small sub-adults and switched to a diet of clams and fish as they grew larger. Though fish were more important than insects or crustaceans in the larger drum, mollusks were apparently preferred and made up almost the entire diet where they were available. Small drum (average length, 1.4 inches) fed almost exclusively on small crustaceans including copepods, cladocerans, ostracods, and amphipods (Ewers, 1933). With increasing size, entomostracans decreased in importance, insects became a major food, and fish appeared in small amounts. Daiber (1952) in another study of drum food habits in western Lake Erie found Hexagenia naiads made up almost half the diet of young-of-the-year drum and nearly 80 percent in adults and concluded that Hexagenia were one of the most important foods of drum of all sizes.

DISCUSSION OF FOOD HABITS

The most important foods on a volume basis, for each species, are summarized in Figure 31 for quick comparison. The main foods may be classed as fish, insects, crustaceans, mollusks, and leeches.

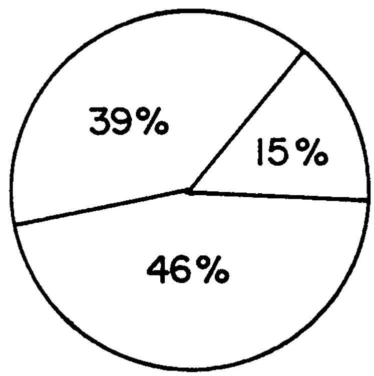
Forage fish were the food important to the greatest number of species, occurring in all but three of the fish containing food. They ranked first in the diet of half those analyzed, making up over one-third of the food volume in longnose gar, bowfin, northern pike, white bass, largemouth bass, white crappie, black crappie, sauger, and walleye. Forage fish were the only food found in northern pike and longnose gar, and the second most important food of shortnose gar, yellow bass, warmouth, yellow perch, and freshwater drum (46 to 20 percent volume). A small amount of fish was also found in two bluegill stomachs (less than 1 percent). The preponderance of predatory fish in this study was partly because of the way in which the species were divided for analysis. Forage fish were much less important in the species studied by Jude (1968).

Approximately one-third (22 percent by volume) of the forage fish in stomachs were not identified. It was assumed that these represented the partially digested remains of the same type of fish as were identifiable, and only identified forage fish were analyzed to evaluate the importance of the various types eaten (Table 19). About half of these were gizzard shad, which made up 56 percent of the total volume of identified fish. Bluegills and crappies were next in importance (28 percent by numbers, 13 percent by volume), followed by channel catfish (11 percent volume) and freshwater drum (6 percent volume), both 5 percent by numbers. Minnows were 12 per-

Figure 31a. Percent volume of food items in various fish species from July, 1966, through August, 1967, in Pool 19, Mississippi River

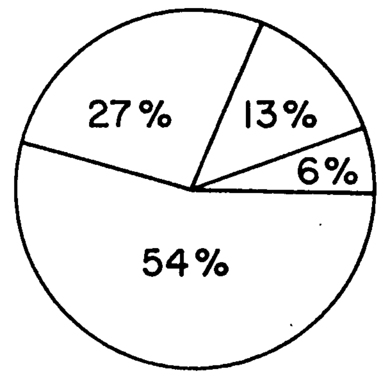
MAJOR FOOD ITEMS - PER CENT VOLUME

SHORTNOSE GAR



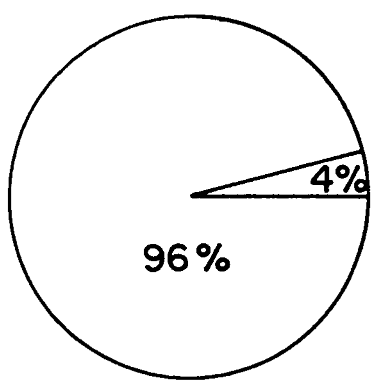
46% - FISH
39% - <u>HEXAGENIA</u> NAIADS
15% - <u>HEXAGENIA</u> ADULTS

BOWFIN



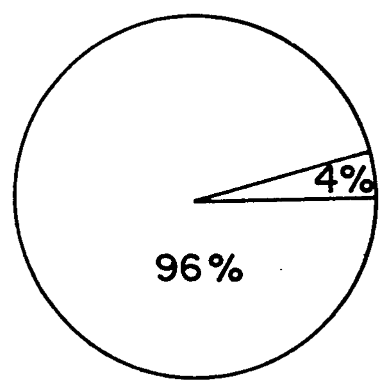
54% - FISH
27% - CRAYFISH
13% - DRAGONFLY NAIADS
6% - OTHER

SAUGER



96% - FISH
4% - OTHER - veg .14
crayfish .16
leeches .42
other insects

WALLEYE

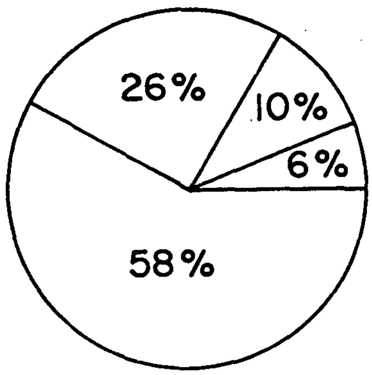


96% - FISH
4% - OTHER - insects.

Figure 31b. Percent volume of food items in various fish species from July, 1966, through August, 1967, in Pool 19, Mississippi River

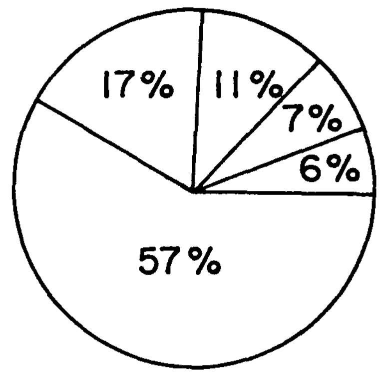
MAJOR FOOD ITEMS - PER CENT VOLUME

YELLOW BASS



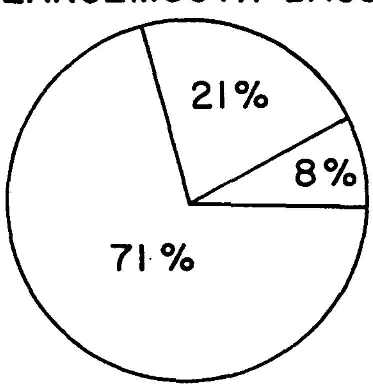
58% - CORIXIDS
26% - FISH
10% - HYALELLA
6% - OTHER

WHITE BASS



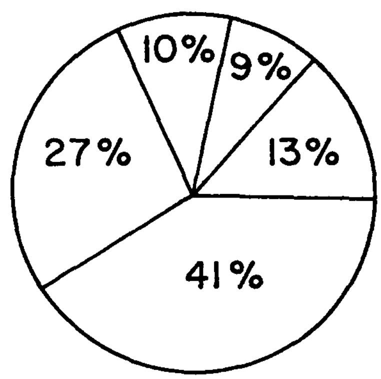
57% - FISH
17% - CORIXIDS
11% - HEXAGENIA NAIADS
7% - HEXAGENIA ADULTS
6% - OTHER

LARGEMOUTH BASS



71% - FISH
21% - DRAGONFLY NAIADS
8% - OTHER - insects
crayfish 5.4
veg .17

FRESHWATER DRUM

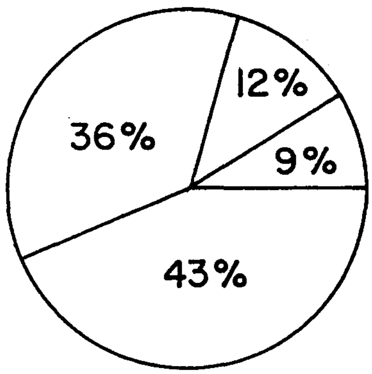


41% - LEECHES
27% - FISH
10% - HEXAGENIA NAIADS
9% - OECETIS LARVAE
15% - OTHER -

Figure 31c. Percent volume of food items in various fish species from July, 1966, through August, 1967, in Pool 19, Mississippi River

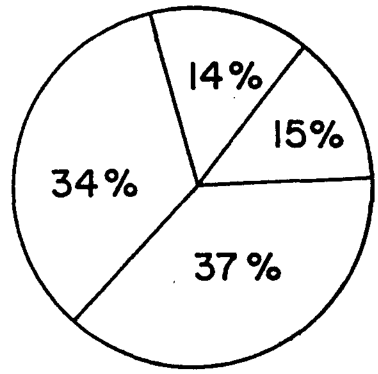
MAJOR FOOD ITEMS - PER CENT VOLUME

WHITE CRAPPIE



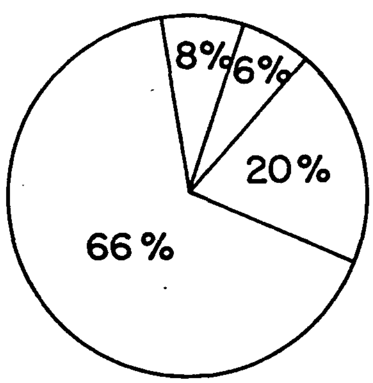
43% - FISH
36% - CHIRONOMIDS
12% - <u>HEXAGENIA</u>
9% - OTHER

BLACK CRAPPIE



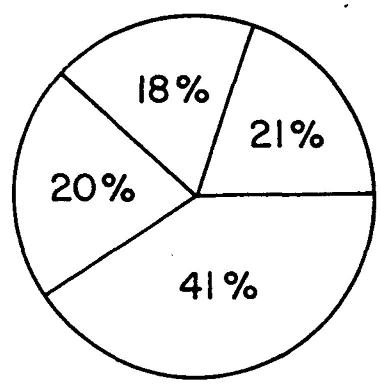
37% - FISH
34% - <u>HEXAGENIA</u>
14% - CHIRONOMIDS
15% - OTHER

COMBINED CRAPPIE (1966)



66% - FISH
8% - CHIRONOMIDS
6% - CORIXIDS
20% - OTHER

YELLOW PERCH

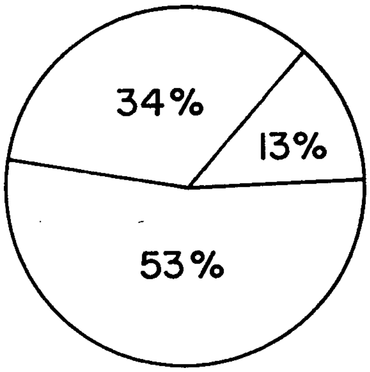


41% - CHIRONOMIDS
20% - FISH
18% - <u>HEXAGENIA</u> NAIADS
21% - OTHER

Figure 31d. Percent volume of food items in various fish species from July, 1966, through August, 1967, in Pool 19, Mississippi River

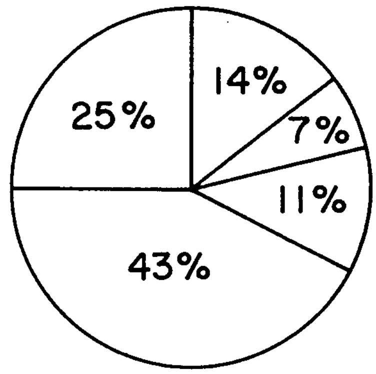
MAJOR FOOD ITEMS - PER CENT VOLUME

WARMOUTH



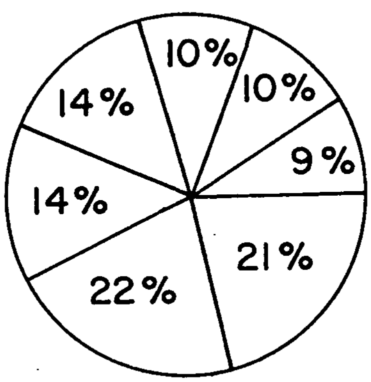
53% - *OECETIS* LARVAE
34% - FISH
13% - OTHER

PUMPKINSEED



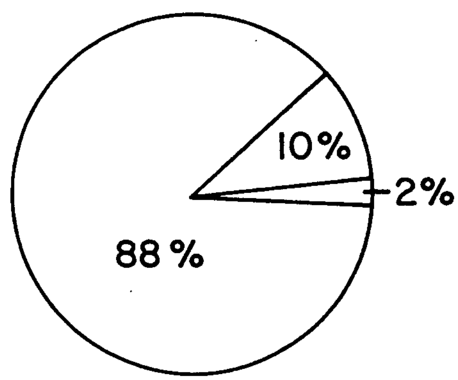
43% - SNAILS
25% - FINGERNAIL CLAMS
14% - CHIRONOMIDS
7% - LEECHES
11% - OTHER

BLUEGILL



22% - CHIRONOMIDS
14% - VEGETATION
14% - *OECETIS* LARVAE
10% - SNAILS
10% - CORIXIDS
9% - DAMSELFLIES
21% - OTHER

SHOVELNOSE STURGEON



88% - *POTAMYIA* LARVAE
10% - *HEXAGENIA* NAIADS
2% - OTHER

Table 19. Percent by number and volume contributed by certain forage fish to the fish portion of the diet of several piscivorous species

	Prey													
	Gizzard shad		Channel catfish		Bluegill, crappie		Minnows		Bullheads		Drum		Other	
Predator[a]	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.[b]
Longnose gar	80	96.4	0	0	0	0	18	3.0	0	0	0	0	2	0.6
Shortnose gar	63	67.7	5	13.9	23	4.2	3	3.2	1	-	0	0	5	11.0
Bowfin	1	1.7	0	0	97	94.4	0	0	0	0	0	0	0	0
Northern pike	67	66.6	0	0	33	33.4	0	0	0	0	0	0	0	0
White bass	19	34.0	0	0	55	31.7	0	0	0	0	25	32.2	1	2.1
Warmouth	0	0	0	0	50	64.5	50	35.5	0	0	0	0	0	0
Largemouth bass	22	28.4	1	7.4	9	31.4	59	8.7	4	3.7	0	0	5	20.4
Crappie	58	63.7	0	0	38	30.8	3	1.8	1	1.2	-	2.5	0	0
Yellow perch	88	96.2	0	0	9	3.0	0	0	0	0	3	0.8	0	0
Sauger	58	51.3	19	18.2	5	3.1	4	2.7	1	1.1	10	13.1	3	10.5
Freshwater drum	0	0	12	3.8	0	0	76	92.6	0	0	12	3.6	0	0

[a]The only forage fish recognized in bluegill and walleye were gizzard shad.

[b]Other: buffalo and/or carpsuckers, white bass, largemouth bass, yellow perch, warmouth, and mooneyes.

cent of the forage fish examined but only 3.5 percent of their volume. The above forage fish combined represented over 96 percent of the identified forage fish found in stomachs and 90 percent of their volume.

Bowfin, white bass, yellow bass, warmouth, and yellow perch utilized forage fish more as the size of the predator increased, but such a trend was not evident in the other species, at least over the size range studied. Forage fish utilization was usually greater in August than other months, with July second. Fish of a suitable size as food are probably more abundant in these months.

Insects ranked second in overall fish utilization, appearing in appreciable volumes in all but three of the species. They made up over half the food volume of shovelnose sturgeon, shortnose gar, yellow bass, warmouth, bluegill, and black and white crappie. White bass, pumpkinseed, freshwater drum, largemouth bass, and bowfin also ate considerable amounts of insects (38 to 13 percent by volume). Sauger and walleye ate minor amounts of insects (4 percent by volume).

The most extensively utilized insect food was Hexagenia mayflies. They made up most of the diet of shortnose gar, ranked second in food importance in shovelnose sturgeon, paddlefish, white bass, black crappie, sauger, and walleye, and third in white crappie, yellow perch, and freshwater drum. Hexagenia contributed 10 to 46 percent of the food volume of all the above fish except paddlefish, sauger, and walleye, where they made up less than 3 percent. Hexagenia naiads were also eaten in minor amounts by bowfin, yellow bass, bluegill, and largemouth bass (3 percent or less). Hexagenia were heavily utilized from May through July, with a peak in late June and early July coincident with the period of greatest emergence. They were mostly in fish taken in shallow and flat areas and were particularly important in specimens from shallow non-vegetated stations.

Chironomids ranked second in insect food volume; they were the most important food of bluegill and yellow perch and second in white crappie, contributing from 22 to 41 percent of the respective food volumes. Pumpkinseeds and black crappies contained 14 percent chironomids and shovelnose sturgeon 2 percent. They were the third ranking food in these species. Paddlefish, shortnose gar, bowfin, white bass, yellow bass, warmouth, largemouth bass, walleye, and freshwater drum all ate chironomids in minor amounts (3 percent or less by volume). Chironomids were generally eaten over the entire size range of crappies, white bass, pumpkinseed, bluegill, freshwater drum, and yellow perch but decreased in importance with increasing fish size. They appeared in all but the largest bowfin and in largemouth bass under 11 inches. Chironomid utilization was greatest in March, followed by fall and early winter, May, and August. Bluegills were the only fish found eating considerable amounts of chironomids in July.

No other insect foods were important to more than three species of fish. *Oecetis* caddisflies were the most important food of warmouth (53 percent), ranked third in bluegills (14 percent), and fourth in freshwater drum (9 percent). They also made up 4 percent or less of the food volume of shortnose gar, bowfin, white bass, yellow bass, pumpkinseed, black crappie, and yellow perch. *Oecetis* caddisflies were important June through August. *Potamyia* caddisflies dominated the diet of shovelnose sturgeon (88 percent) but were not an important food of any other species. However, *Potamyia* larvae were found in minor amounts (3 percent or less) in shortnose gar, white bass, bluegill, white crappie, black crappie, yellow perch, sauger, and freshwater drum.

Odonate naiads were important to four species, mostly in July and August. Dragonflies ranked second in the diet of largemouth bass (21 percent), third in bowfin (13 percent), and were eaten in minor amounts (5 percent or less) by white bass, pumpkinseed, bluegill, black crappie, and yellow perch. Damselflies were the third ranking food of warmouth (3 percent) and fifth of bluegills (8 percent). They also occurred in minor amounts (1 percent or less by volume) in bowfin, white bass, largemouth bass, black crappie, white crappie, yellow perch, and sauger.

Corixids made up most of the food volume of yellow bass (58 percent), were third in importance in white bass (17 percent), and fourth in bluegills (10 percent). They were a minor food (3 percent or less by volume) of shortnose gar, bowfin, warmouth, pumpkinseed, largemouth bass, black crappie, white crappie, yellow perch, and freshwater drum.

Several kinds of immature insects of small size were eaten by a sizable number of fish species but were never of important food volume. Ceratopogonid larvae appeared in shovelnose sturgeon, paddlefish, white bass, pumpkinseed, bluegill, white crappie, black crappie, and yellow perch in amounts of less than 1 percent total food volume. Caenid and baetid mayflies made up less than 2 percent of the food eaten by shortnose gar, bowfin, white bass, pumpkinseed, bluegill, white crappie, black crappie, and yellow perch. White bass, bluegill, black crappie, white crappie, and freshwater drum ate less than 1 percent <u>Stenonema</u> mayflies. Stoneflies were eaten by shortnose gar, black crappie, sauger, and walleye, and <u>Chao-</u>

borus larvae by black crappie, white crappie, and bluegills in amounts less than 1 percent of the diet.

Crustaceans were eaten by half the fish species but made up over 10 percent of the food volume only in paddlefish, bowfin, and yellow bass. Crustaceans were 2 to 5 percent of the food of white bass, bluegills, largemouth bass, black and white crappie, and yellow perch. Small crustaceans ranked high in importance in two species; copepods made up practically all the food of paddlefish (99 percent), and *Hyallela* were third in food volume in yellow bass (10 percent). Zooplankton was eaten to a small extent (5 percent or less by volume) by white bass, yellow bass, bluegill, black crappie, white crappie, and yellow perch. *Hyalella* were a minor food (2 percent volume or less) of shortnose gar, white bass, pumpkinseed, bluegill, largemouth bass, black crappie, white crappie, yellow perch, sauger, and freshwater drum. Crayfish were found in the stomachs of four species. They were second in food volume importance in bowfin (26 percent), third in largemouth bass (5 percent), and minor in shortnose gar and sauger (less than 1 percent). Crayfish were eaten to the greatest extent in May and June and *Hyalella* and zooplankton in May and November.

Mollusks were an important food of pumpkinseed and bluegill (over 10 percent volume) and minor one in bowfin, yellow perch, and freshwater drum, (1 to 5 percent volume). Snails were first (43 percent volume) and fingernail clams second (25 percent volume) in the pumpkinseed diet. Snails also ranked fourth (10 percent volume) in bluegill, mostly in those over 5 inches. Shortnose gar, bowfin, white bass, yellow perch, and freshwater drum ate less than 1 percent snails by volume. Bluegills ate 2 percent fingernail clams, and large clams made up 4 percent of the freshwater drum and 1 percent of the yellow perch diet.

Leeches were the most important food of freshwater drum (41 percent volume) and a minor one of pumpkinseed, bluegill, and white crappie (7 to 1 percent volume). They were also eaten in amounts less than 1 percent by sauger, shortnose gar, bowfin, white bass, largemouth bass, black crappie, and yellow perch.

Vegetation appeared to be an important food only in bluegills (14 percent) and was probably incidentally ingested in paddlefish, shortnose gar, bowfin, white bass, largemouth bass, and sauger, where it made up less than 1 percent of the food volume.

FOOD UTILIZATION IN VARIOUS HABITATS

It is obvious that most food organisms are eaten by several species of fish and that there may possibly be competition between species for certain foods. Diagrams have been prepared for each habitat to give some suggestions of the possible competition (Figures 32 to 39). Since the species of fish studied by Jude (1968) also inhabit the same environments and eat many of the same foods, only part of the competition and interrelationships are suggested in these diagrams. The solid lines in the diagrams indicate food items which made up 5 percent or more of the food volume of a given species in a particular habitat. The dotted lines indicate food items which contributed less than 5 percent of the food volume but were found in at least 10 percent of the stomach samples of a given species from that habitat. Food items which were not taken to these levels are not included in the diagrams.

The channel (Figure 32) represents a relatively simple community compared to the others diagrammed. The freshwater drum is the only species which utilizes a wide variety of foods. The only bluegill taken from the channel was a 7-inch specimen caught by angling in August.

The drop-off area is also relatively simple (Figure 33), although it includes more species of fish and greater overlap in the usage of various food categories.

The flat area includes so many species of fish and food items that it was necessary to use two diagrams (Figures 34a,b). While the walleye, sauger, and longnose gar fed mostly or entirely on fish and the shortnose gar

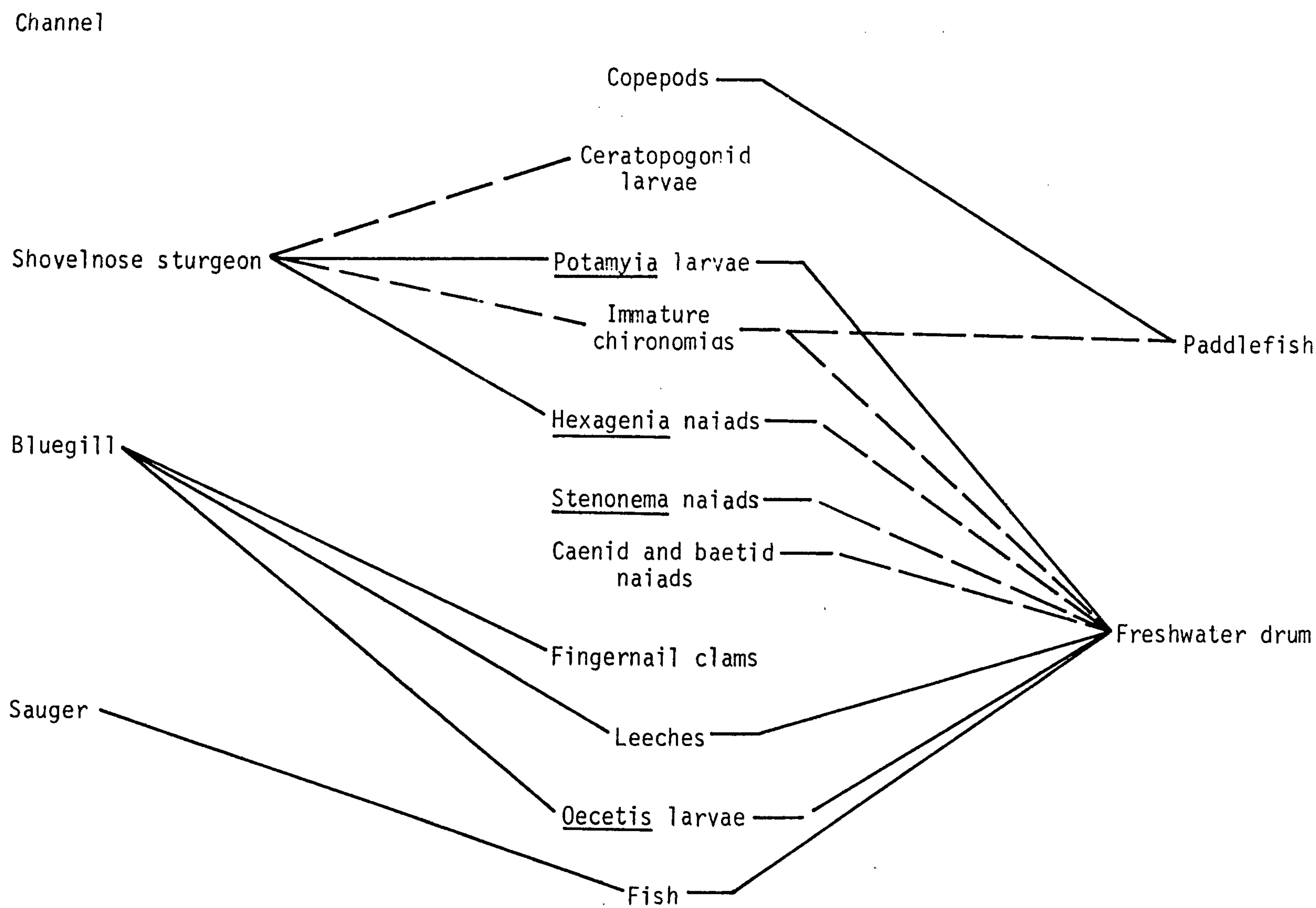


Figure 32. Food items eaten by fish taken at channel stations from July, 1966, through August, 1967, in Pool 19, Mississippi River. Solid lines indicate items of 5 percent or greater volume, dotted lines less than 5 percent volume but 10 percent or greater occurrence

Figure 33. Food items eaten by fish taken at drop-off stations from July, 1966, through August, 1967, in Pool 19, Mississippi River. Solid lines indicate items of 5 percent or greater volume, dotted lines less than 5 percent volume but 10 percent or greater occurrence

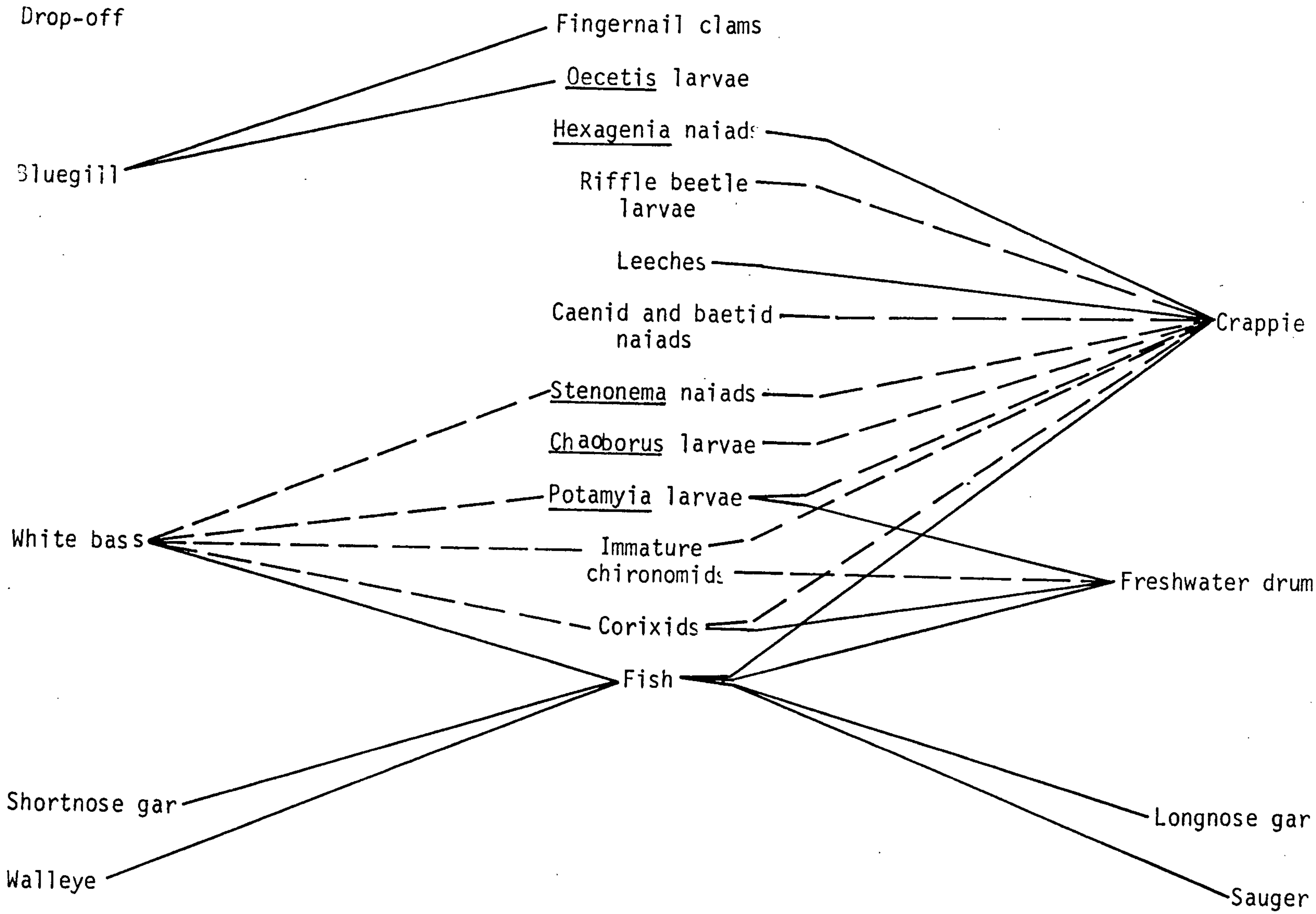

Drop-off
Fingernail clams
Oecetis larvae
Hexagenia naiads
Riffle beetle larvae
Leeches
Caenid and baetid naiads
Stenonema naiads
Chaoborus larvae
Potamyia larvae
Immature chironomids
Corixids
Fish
Bluegill
White bass
Shortnose gar
Walleye
Crappie
Freshwater drum
Longnose gar
Sauger

Figure 34a. Food items eaten by fish taken at flat stations from July, 1966, through August, 1967, in Pool 19, Mississippi River. Solid lines indicate items of 5 percent or greater volume, dotted lines less than 5 percent volume but 10 percent or greater occurrence

Flat

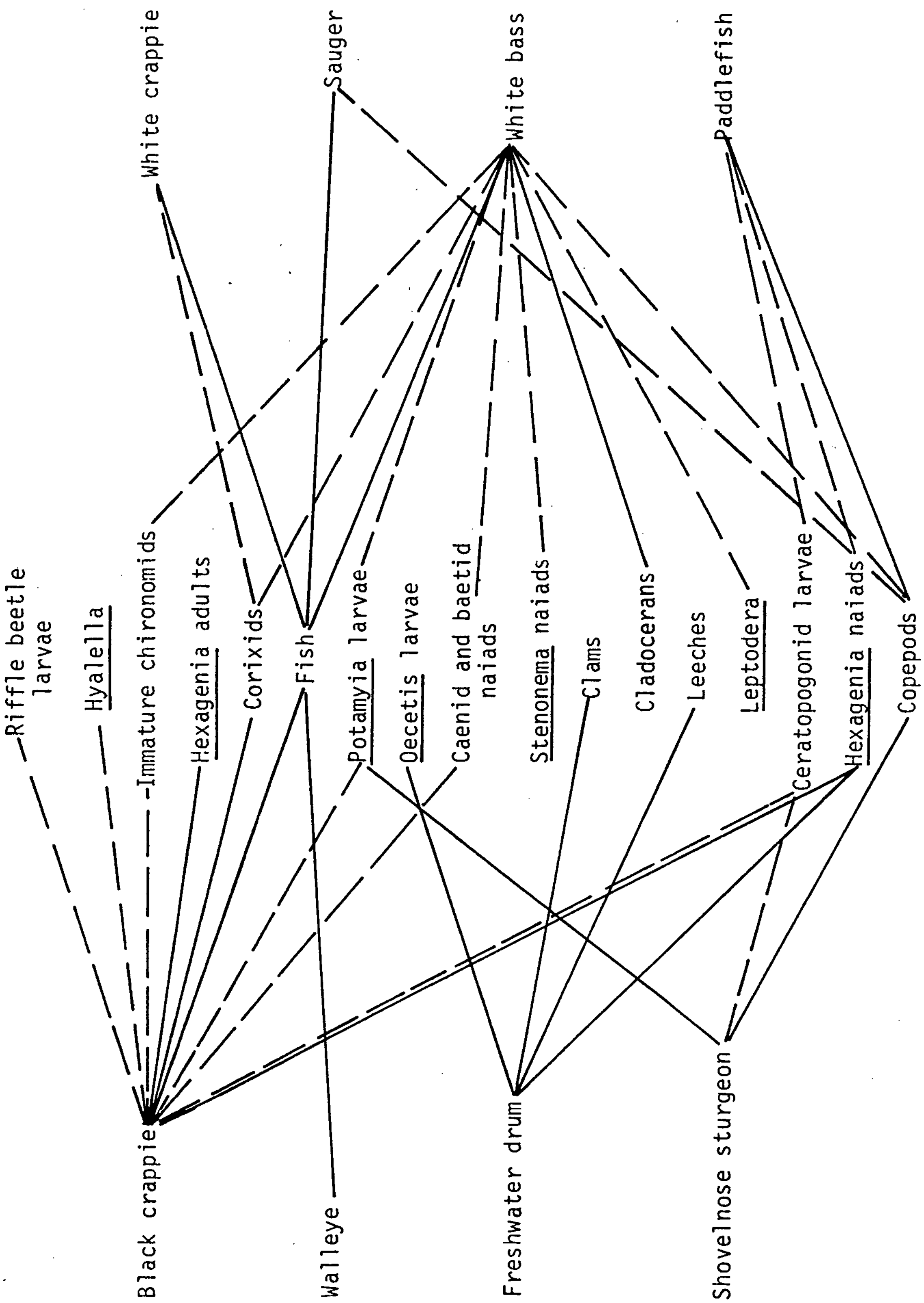

Black crappie
Walleye
Freshwater drum
Shovelnose sturgeon
Riffle beetle larvae
Hyalella
Immature chironomids
Hexagenia adults
Corixids
Fish
Potamyia larvae
Oecetis larvae
Caenid and baetid naiads
Stenonema naiads
Clams
Cladocerans
Leeches
Leptodera
Ceratopogonid larvae
Hexagenia naiads
Copepods
White crappie
Sauger
White bass
Paddlefish

Figure 34b. Food items eaten by fish taken at flat stations from July, 1966, through August, 1967, in Pool 19, Mississippi River. Solid lines indicate items of 5 percent or greater volume, dotted lines less than 5 percent volume but 10 percent or greater occurrence

Flat

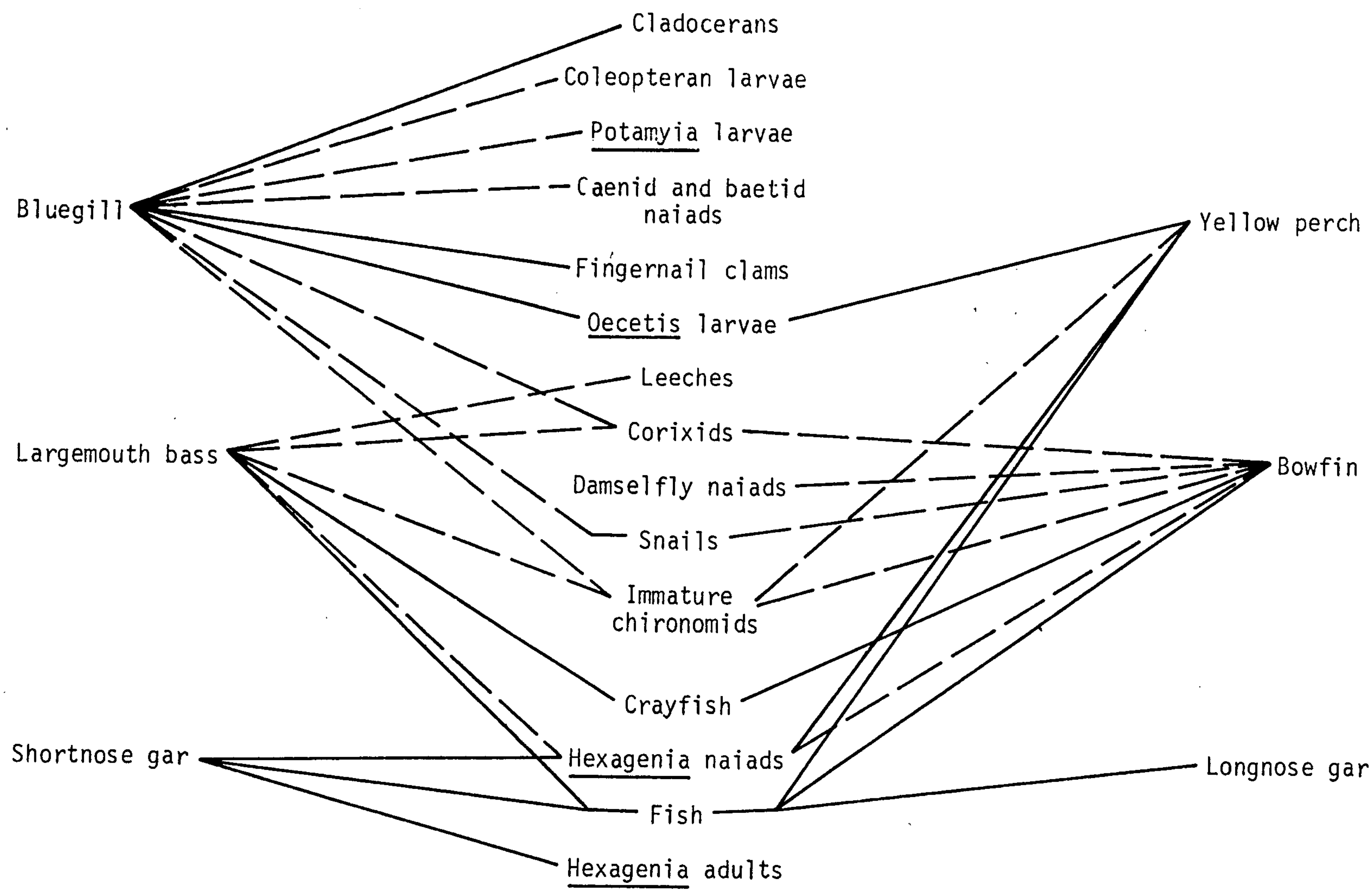
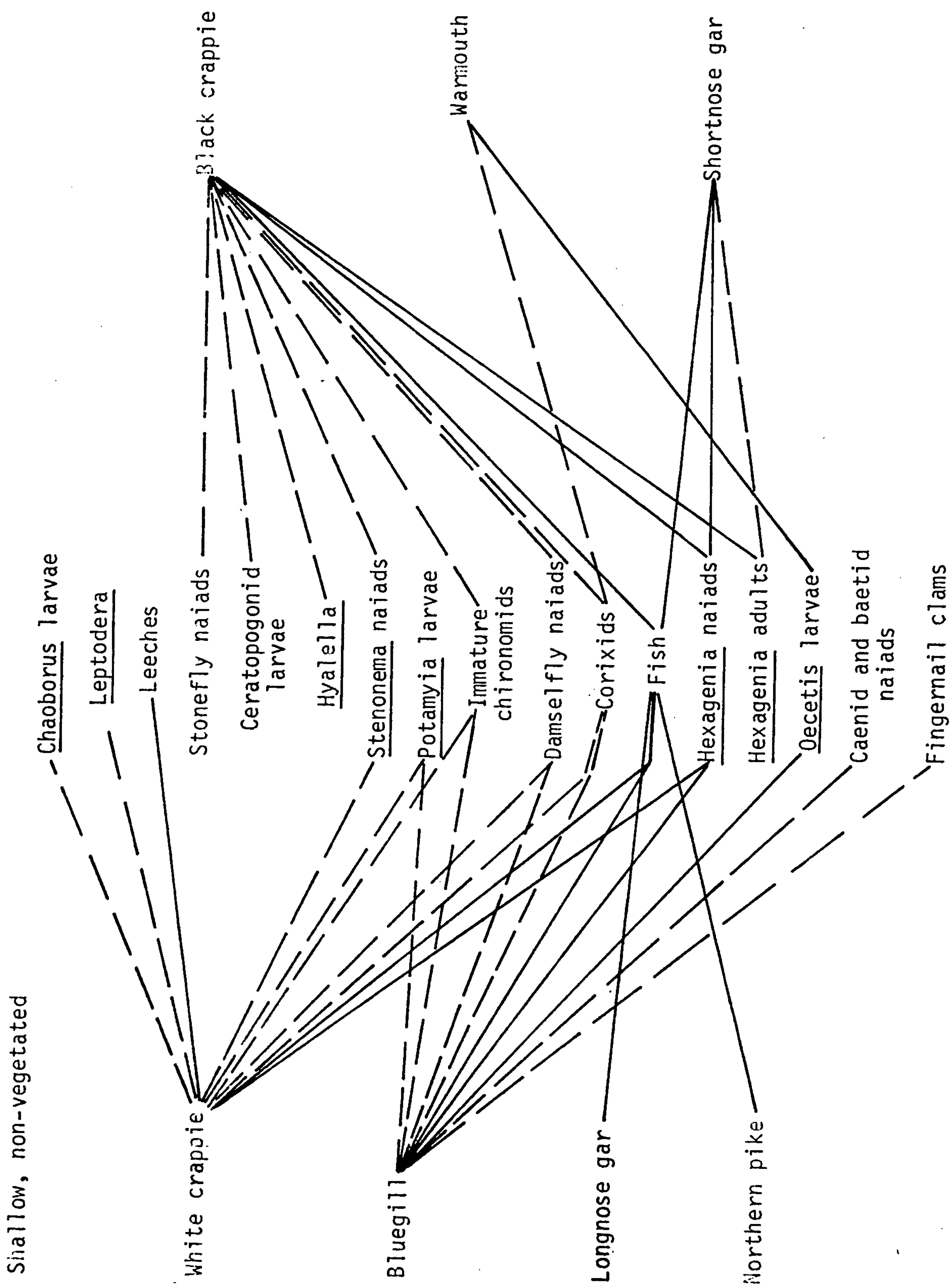

Bluegill
Largemouth bass
Shortnose gar
Cladocerans
Coleopteran larvae
Potamyia larvae
Caenid and baetid naiads
Fingernail clams
Oecetis larvae
Leeches
Corixids
Damselfly naiads
Snails
Immature chironomids
Crayfish
Hexagenia naiads
Fish
Hexagenia adults
Yellow perch
Bowfin
Longnose gar

Figure 35a. Food items eaten by fish taken at shallow non-vegetated stations from July, 1966, through August, 1967, in Pool 19, Mississippi River. Solid lines indicate items of 5 percent or greater volume, dotted lines less than 5 percent volume but 10 percent or greater occurrence



Shallow, non-vegetated
White crappie
Bluegill
Longnose gar
Northern pike
Chaoborus larvae
Leptodera
Leeches
Stonefly naiads
Ceratopogonid larvae
Hyalella
Stenonema naiads
Potamyia larvae
Immature chironomids
Damselfly naiads
Corixids
Fish
Hexagenia naiads
Hexagenia adults
Oecetis larvae
Caenid and baetid naiads
Fingernail clams
Black crappie
Warmouth
Shortnose gar

Figure 35b. Food items eaten by fish taken at shallow non-vegetated stations from July, 1966, through August, 1967, in Pool 19, Mississippi River. Solid lines indicate items of 5 percent or greater volume, dotted lines less than 5 percent volume but 10 percent or greater occurrence

Shallow, non-vegetated

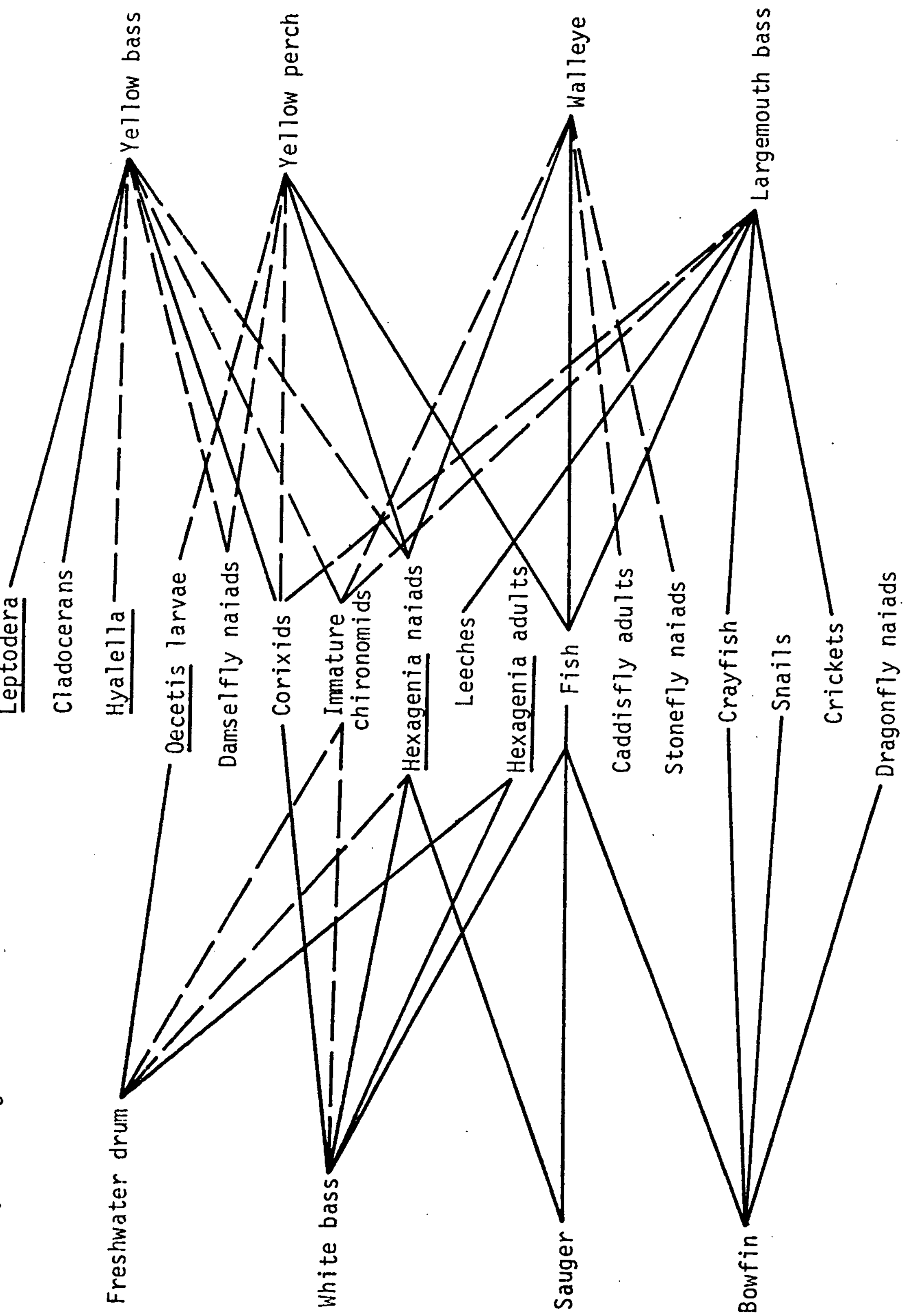
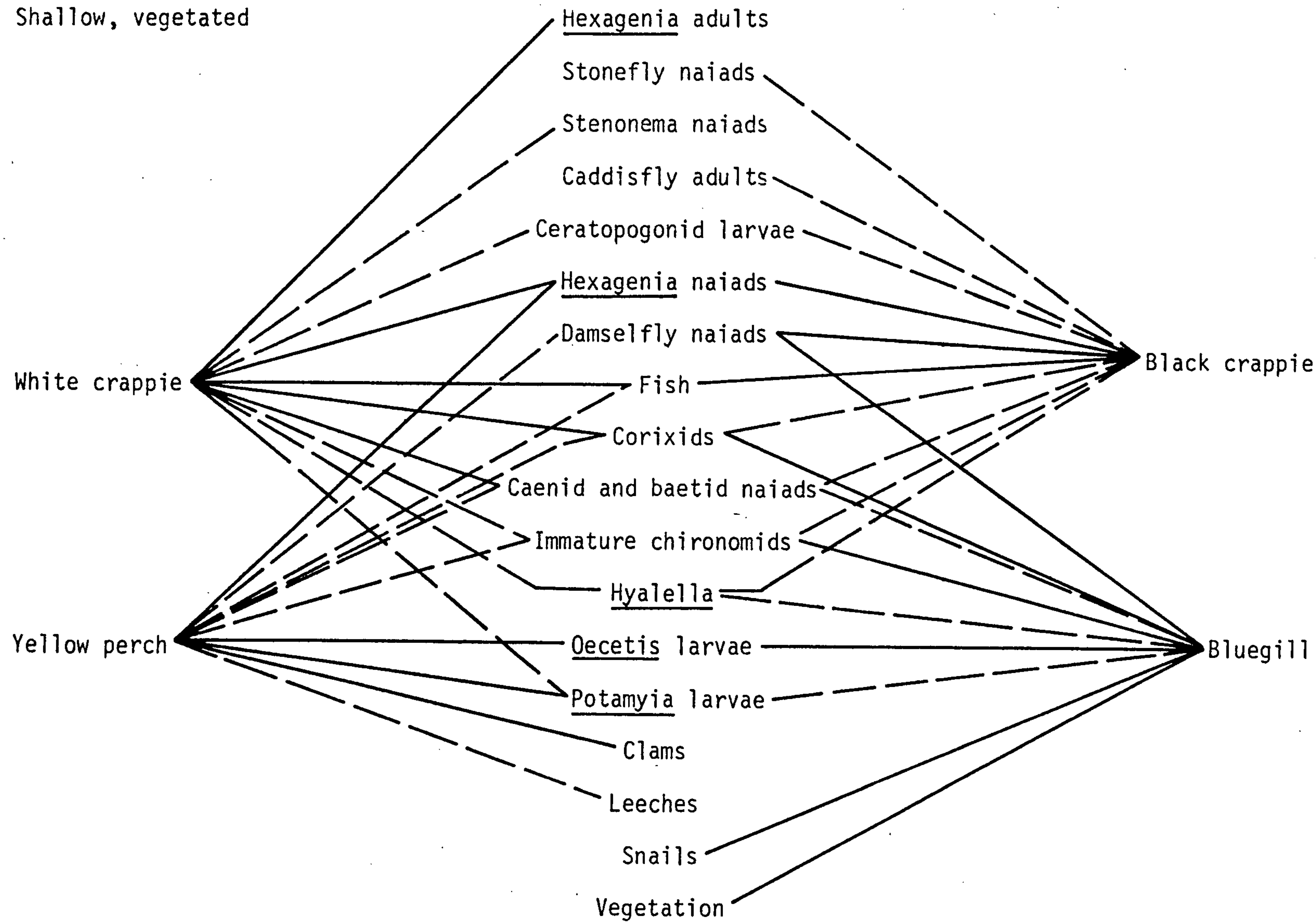


Figure 36a. Food items eaten by fish taken at shallow vegetated stations from July, 1966, through August, 1967, in Pool 19, Mississippi River. Solid lines indicate items of 5 percent or greater volume, dotted lines less than 5 percent volume but 10 percent or greater occurrence


Shallow, vegetated
White crappie
Yellow perch
Black crappie
Bluegill
Hexagenia adults
Stonefly naiads
Stenonema naiads
Caddisfly adults
Ceratopogonid larvae
Hexagenia naiads
Damselfly naiads
Fish
Corixids
Caenid and baetid naiads
Immature chironomids
Hyalella
Oecetis larvae
Potamyia larvae
Clams
Leeches
Snails
Vegetation

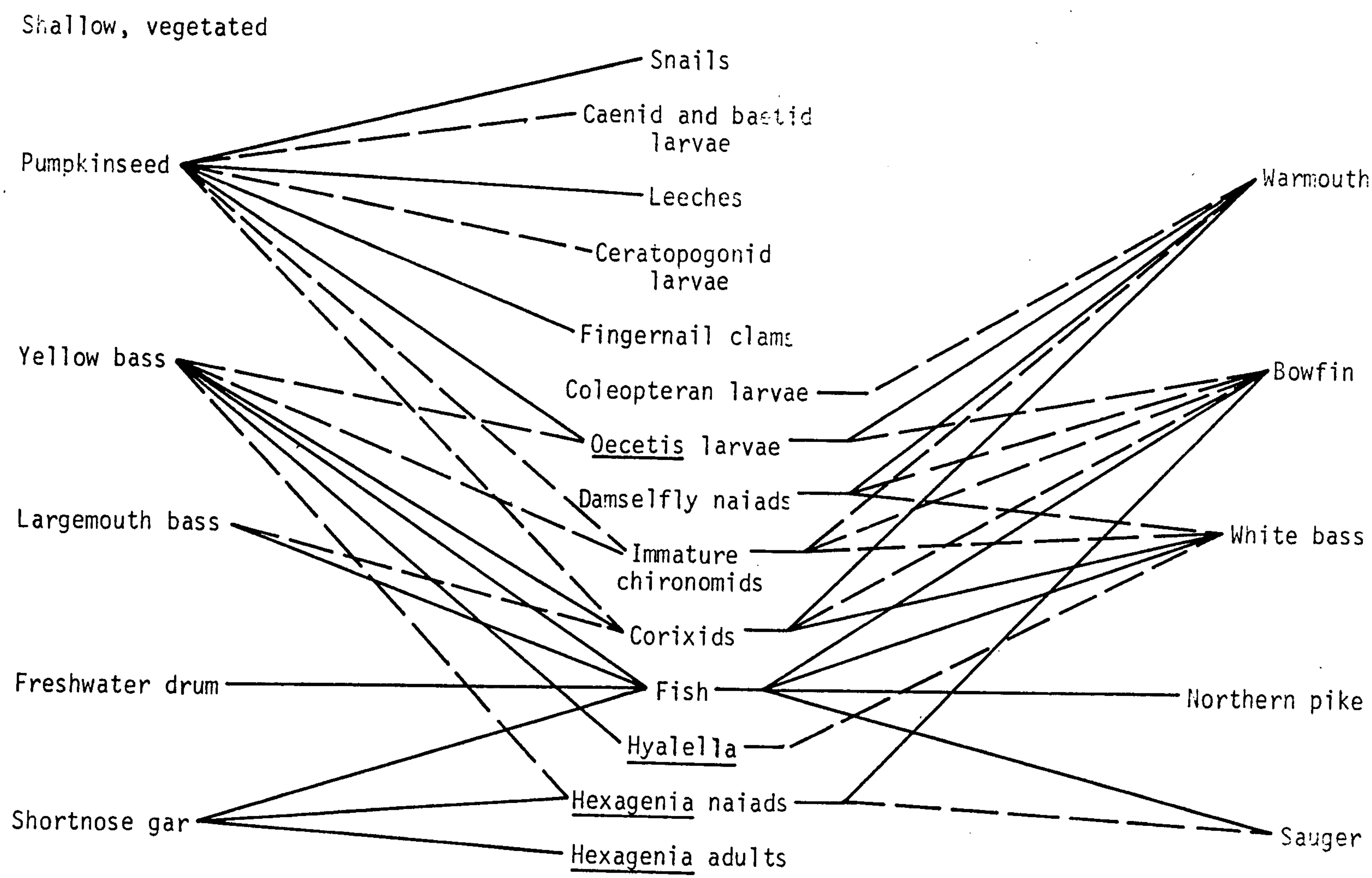


Figure 36b. Food items eaten by fish taken at shallow vegetated stations from July, 1966, through August, 1967, in Pool 19, Mississippi River. Solid lines indicate items of 5 percent or greater volume, dotted lines less than 5 percent volume but 10 percent or greater occurrence

Slough, light vegetation

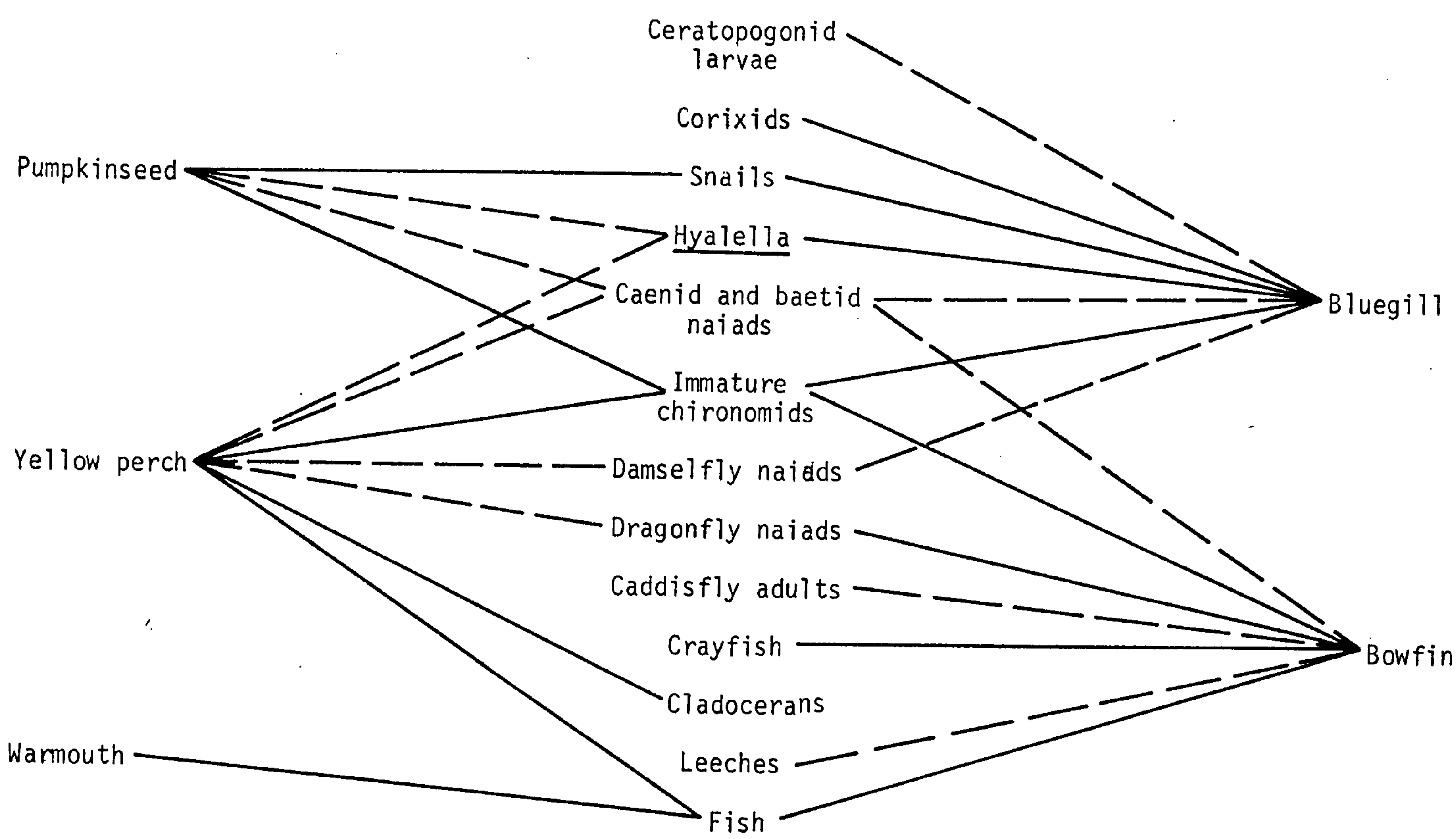


Figure 37a. Food items eaten by fish taken at lightly vegetated slough stations from July, 1966, through August, 1967, in Pool 19, Mississippi River. Solid lines indicate items of 5 percent or greater volume, dotted lines less than 5 percent volume but 10 percent or greater occurrence

Figure 37b. Food items eaten by fish taken at lightly vegetated slough stations from July, 1966, through August, 1967, in Pool 19, Mississippi River. Solid lines indicate items of 5 percent or greater volume, dotted lines less than 5 percent volume but 10 percent or greater occurrence

Slough, light vegetation

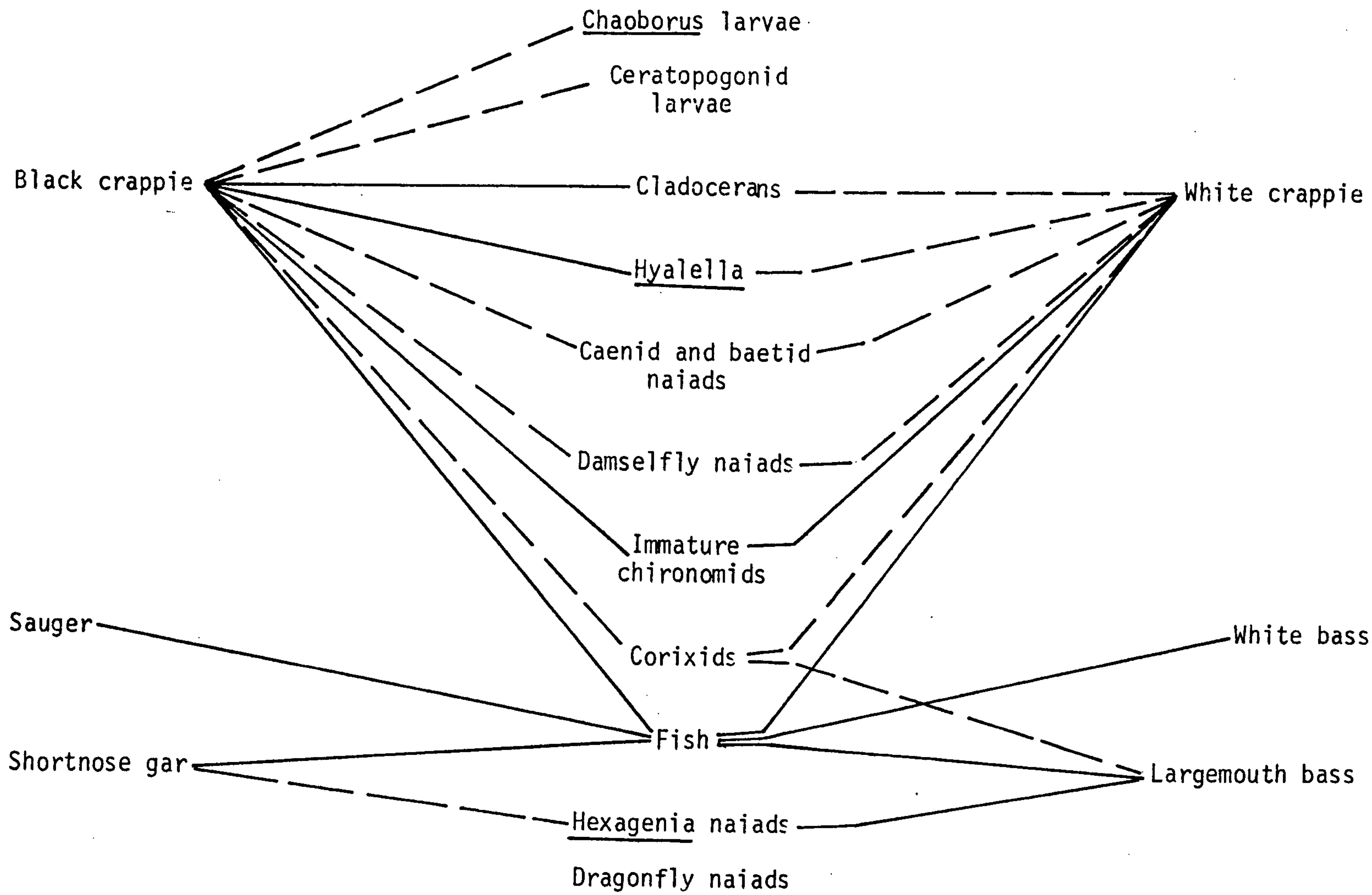
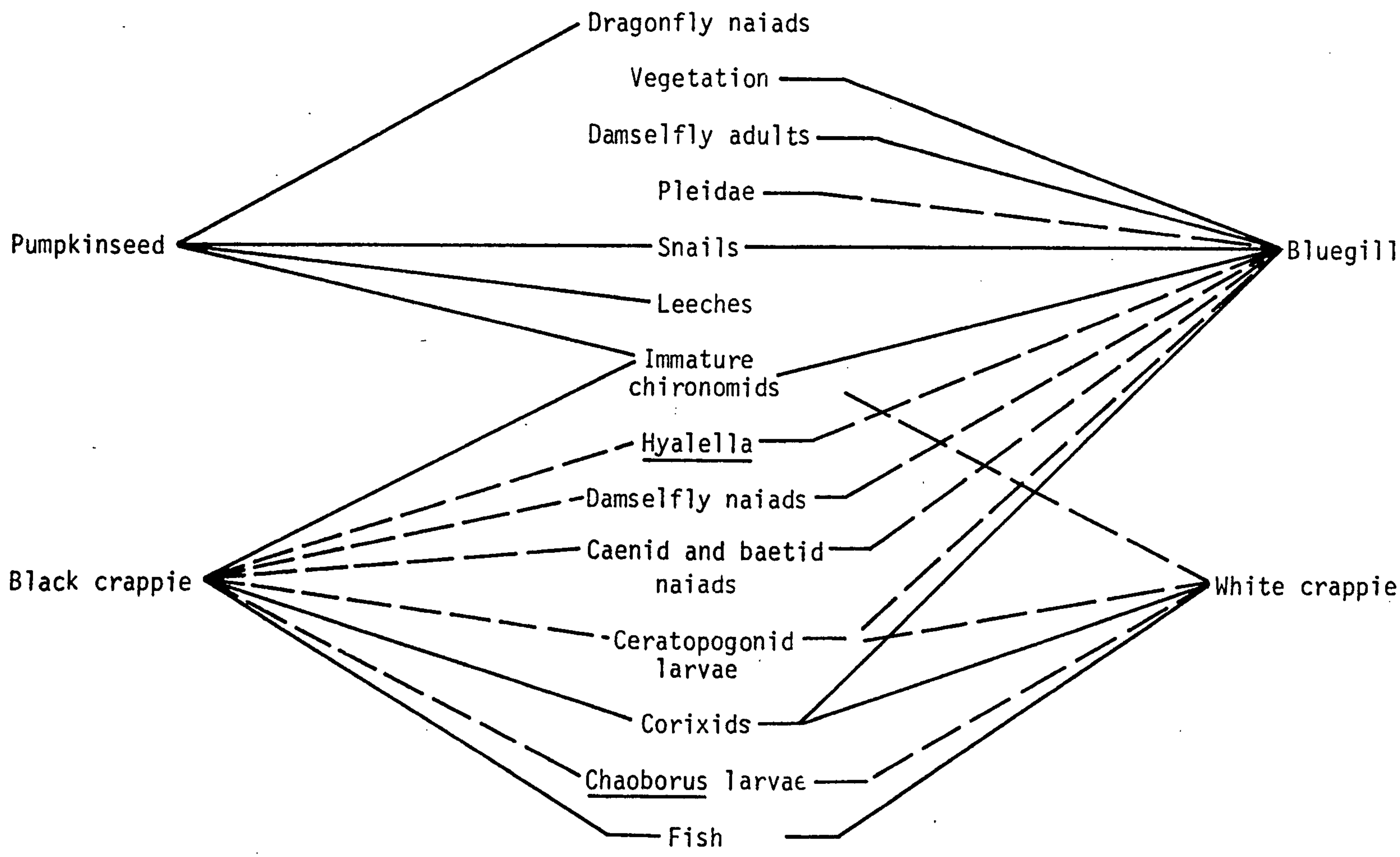


Figure 38a. Food items eaten by fish taken at heavily vegetated slough stations from July, 1966, through August, 1967, in Pool 19, Mississippi River. Solid lines indicate items of 5 percent or greater volume, dotted lines less than 5 percent volume but 10 percent or greater occurrence

Slough, heavy vegetation



Slough, heavy vegetation

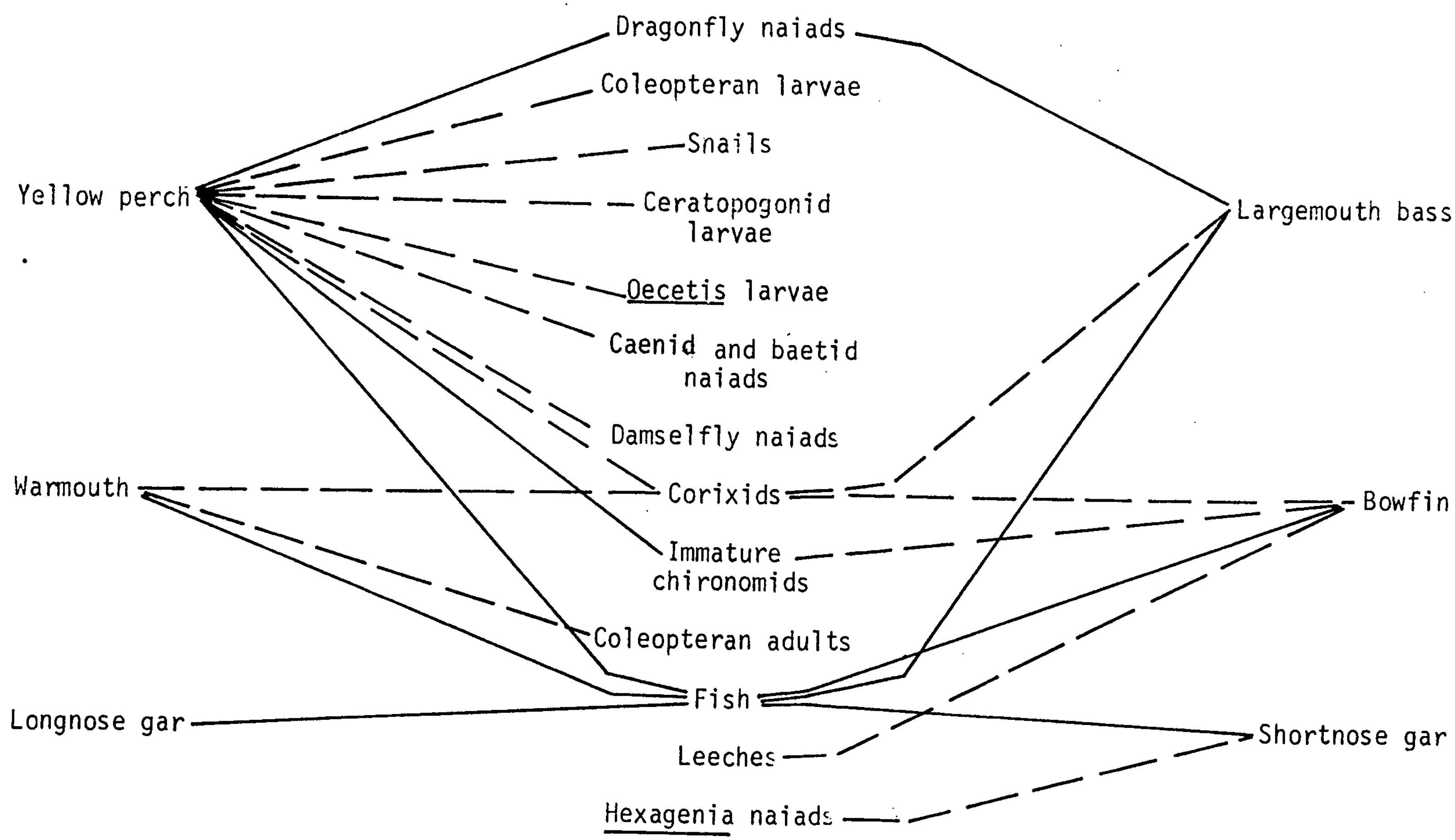


Figure 38b. Food items eaten by fish taken at heavily vegetated slough stations from July, 1966, through August, 1967, in Pool 19, Mississippi River. Solid lines indicate items of 5 percent or greater volume, dotted lines less than 5 percent volume but 10 percent or greater occurrence

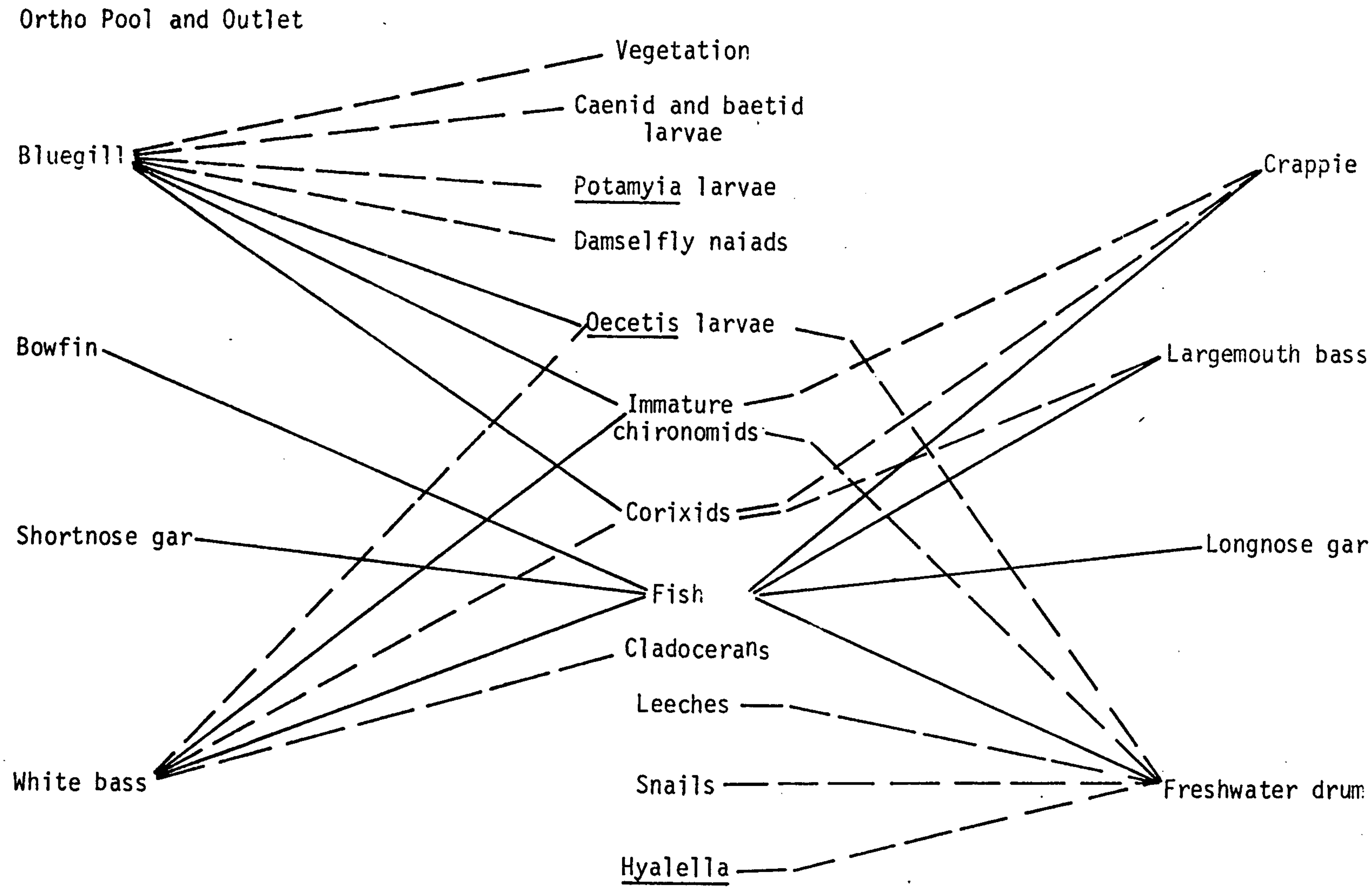


Figure 39. Food items eaten by fish taken at Ortho pool and outlet stations from July, 1966, through August, 1967, in Pool 19, Mississippi River. Solid lines indicate items of 5 percent or greater volume, dotted lines less than 5 percent volume but 10 percent or greater occurrence

on fish and *Hexagenia*, the other species utilize a wide variety of food organisms, and most food categories are eaten by several species of fish.

Two diagrams are also needed for the shallow non-vegetated habitat (Figure 35a,b), the shallow vegetated habitat (Figure 36a,b), the slough lightly-vegetated habitat (Figure 37a,b), and the slough heavily vegetated (Figure 38a,b). The Ortho pool and outlet is a somewhat less complicated food web (Figure 39). The numbers of fish species and the numbers of food organism categories were about the same for vegetated and non-vegetated shallow areas.

POSSIBLE EFFECTS OF DREDGING

Most of the species studied here were primarily associated with shallow water habitats and fed on food organisms available in these areas. Information concerning the distribution and abundance of some organisms utilized as fish food in the study area can be found in a concurrently conducted bottom fauna study (Gale, 1969). Additional investigations may be necessary to gain this sort of information on other food organisms, such as small forage fish and zooplankton. Identification and measurement of factors limiting the fish population such as inter- or intraspecific competition was not within the scope of the data collected. While positive evaluation of dredging effects is dependent on future investigations, some general predictions can be made on the basis of these findings. Species likely to be adversely affected to some extent by disruption and destruction of their preferred habitat and associated food items would include bowfin, northern pike, yellow bass, warmouth, pumpkinseed, bluegill, largemouth bass, black and white crappies, and to a somewhat lesser extent longnose and shortnose gar, white bass, and yellow perch. On the basis of depth preference and food habits data alone, those species least likely to be detrimentally affected by dredging operations would appear to be paddlefish, shovelnose sturgeon, sauger, walleye, and freshwater drum. They were generally found in deeper open water and drop-off areas where they are able to obtain their preferred foods. One aspect not thoroughly investigated was the possibility that shallow areas may be of some importance to young of deeper water species. As previously mentioned, electro-shocking samples in shallow habitats were limited in scope.

Small freshwater drum and white bass were found in both shallow and deep water by using electrofishing gear in the former and trawling in the latter areas. Sampling with small mesh seines or wire traps also may give additional information in this area.

SUMMARY

1. The main objective of this investigation was to secure information useful in evaluating the impact of proposed dredging on the fish population in the study area. Similar studies of fish distribution and food habits both before and after dredging seemed a logical approach to achieving this end. The data presented here, plus those of a companion study (Jude, 1968), are intended to fulfill the first segment of this program.

2. This portion of the study includes data on distribution and food habits of 19 species. Sauger and shortnose gar were the most readily obtained species. The next most abundant group included white bass, black crappie, bluegill, and yellow perch and moderate numbers of bowfin, largemouth bass, white crappie, and freshwater drum were also taken. Small samples of longnose gar, pumpkinseed, and walleye were obtained. Several species were caught so infrequently that the data were practically incidental: shovelnose sturgeon, paddlefish, northern pike, American eel, yellow bass, and warmouth. Since experimental gill nets were the main sampling gear, the above rankings are the result of abundance and gill net susceptibility.

3. Bowfin, northern pike, yellow bass, and all the centrarchids were closely associated with shallow water and seldom or never appeared elsewhere. The gars, white bass, and yellow perch were found to some extent in deeper areas but still preferred shallow habitats. Shovelnose sturgeon, sauger, and freshwater drum apparently prefer drop-off and channel habitats. Walleye showed no depth preference, and paddlefish samples were inadequate to draw conclusions. Bowfin, yellow perch, and the centrarchids showed a close association with the aquatic vegetation in shallow water and

sauger and walleye with open water areas. No clean preference was shown by the gars, northern pike, white and yellow bass, or freshwater drum.

4. Predominantly nocturnal species included walleye, white bass, sauger, longnose gar, black crappie, freshwater drum, shortnose gar, bowfin, and white crappie. Pumpkinseed, yellow perch, largemouth bass, and bluegill were chiefly diurnal.

5. Longnose gar, shortnose gar, bowfin, northern pike, white bass, yellow bass, warmouth, largemouth bass, white crappie, black crappie, yellow perch, sauger, walleye, and drum all ate considerable amounts of fish. Shovelnose sturgeon, shortnose gar, white bass, black crappie, white crappie, yellow perch, and freshwater drum fed heavily on Hexagenia. Chironomids were important to pumpkinseed, bluegill, white crappie, black crappie, yellow perch; Potamyia to shovelnose sturgeon and Oecetis to pumpkinseed, bluegill, and drum; corixids to white and yellow bass and bluegill; and dragonflies to bowfin and largemouth bass. Pumpkinseed and bluegill ate large amounts of snails. The following foods were important to single species: copepods to paddlefish, crayfish to bowfin, fingernail clams to pumpkinseed, vegetation to bluegill, and leeches to freshwater drum.

6. Fish increased in importance with increasing predator size in bowfin, white bass, yellow bass, warmouth, and yellow perch. Chironomids declined in importance as crappies, white bass, pumpkinseed, bluegill, freshwater drum, and yellow perch increased in size.

7. Forage fish and dragonfly utilization was highest in July and August and Hexagenia utilization, May through July. Chironomids, Hyalella, and

zooplankton were eaten most in the spring and fall and Oecetis through the summer.

8. The shallow river and flat habitats were most complex, yielding the largest numbers of species and varieties of food organisms eaten by them. The slough locations ranked next, followed by the drop-off and Ortho pool and outlet sites. The channel produced the fewest fish species and kinds of food organisms. There were no appreciable differences in complexity between vegetated and non-vegetated areas.

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IOWA PRODUCTION TESTING LETTER

Cooperative Extension Service
IOWA STATE UNIVERSITY
Ames, Iowa 50010

March, 1969

SIRE SUMMARY ISSUE

Basil R. Eastwood

This newsletter contains the official U.S.D.A. summaries of over 300 sires. Included is the latest information (thru 1/69) on every summarized sire made available to Iowa dairymen by the six A. I. organizations serving the state. These sires are either currently available, or have been available sometime during the past eight months. Their current availability status is listed with the summary information. Although the status codes are generally correct as of February 1, 1969, it is advisable to check with your local technician regarding semen availability.

Sires are listed in one further issue of this newsletter after they are removed from service by the A. I. organization.

Index List of Sires -- A double listing of all sires is again provided in this issue. The "Index of Sires in This Issue" may be found on pages 4, 5 and 6. This Index is in order by sire code number within association.

Each sire summary is assigned a line number to assist in finding that summary. You will note that the Index tells you on what line that sire's summary may be found.

Sire Summary Section -- The summaries are divided into two groups. Those having a 60% or higher repeatability of summary are ranked in order of their predicted difference for milk, with their rank on fat also shown. Sires having a repeatability of summary less than 60% are listed in order of registration number.

Regardless of the level of Repeatability, the best estimate of each sire's true transmitting ability is his Predicted Difference. The Repeatability tells how accurate this Predicted Difference is as an estimate of that sire's true transmitting ability.

There is nothing sacred about the 60% Repeatability level. However, the ranking of sires according to their Predicted Difference for milk and fat is limited to those sires having a 60% + Repeatability since we are reasonably sure the Predicted Difference is a good estimate of their true transmitting ability.

There are many good sires among those with Repeatabilities of less than 60%. Although the Predicted Difference of these sires is not as accurately estimated due to fewer daughters in fewer herds, these sires are a better gamble than those at the lower end of the ranking.

Distribution of Sires by Stud, Breed, and Level of Repeatability

	Ayr.	Guern.	Holst.	Jers.	B.S.	M.S.	
ABS	4	8	46	9	3	2	72
Carnation	5	3	16	4	3	2	33
Curtiss	4	10	37	7	4	2	64
Midwest Breeders	-	10	34	4	4	1	53
Minn Valley	4	10	44	4	1	2	65
Tri-State	1	7	16	5	5	1	35
Repeat. 60% +	9	22	84	7	6	-	128
Repeat. under 60%	9	26	109	26	14	10	194
Total	18	48	193	33	20	10	322

Prepared by Extension Dairymen:
James R. Dunham, Basil R. Eastwood, Donald E. Voelker, and Ray E. Whitmore

INDEX OF SIRES IN THIS ISSUE

SIRE CODE	NAME	REG. NO.	REPEAT-ABILITY	PRED. DIFF. MILK	PRED. DIFF. FAT	LINE NO.
1	2	3	4	5	6	7

1 SIRE CODE - The identification number assigned to the sire by the A.I. association. The sires are listed in order by this number in the "Index of Sires".

2 SIRE NAME - The registered name of the sire.

3 REGISTRATION NUMBER - The identification number assigned to the sire by the breed association.

4 REPEATABILITY - A percentage figure which shows the accuracy or reliability of the summary. The repeatability ranges from about 14% for summaries based on five daughters in one herd to 99% for those based on many daughters in many herds.

5 6 PREDICTED DIFFERENCE for MILK and FAT - A measure of the sire's ability to transmit production of milk and fat to his daughters. The predicted difference may be positive or negative depending on whether the sires' daughters produced better or poorer than other sires' daughters producing under those same conditions.

7 LINE NUMBER - The line on which this sire's complete summary may be found in this newsletter. The line number has nothing to do with the sire's ability, but merely aids in finding that sire among the summaries listed in this issue.

SIRE SUMMARIES

LINE NO.	SIRE	SIRE CODE	ASSOC	STA-TUS	DAUGHTERS OF SIRE: HDS	DAUS.	REC/DAU.	MILK	%	FAT	% INC	ADJUSTED HDMATE AV.: MILK	FAT	REPEAT OF SUM.	PREDICTED DIFFERENCE: MILK	FAT	RANK ON FAT
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

1 LINE NUMBER - The sire summaries in this issue are numbered consecutively. The line number assists in locating the complete summary of any sire when the "Index of Sires" is used.

2 SIRE NAME - The registered name of the sire.

3 SIRE CODE - The identification number assigned to the sire by the A.I. association.

4 ASSOCIATION - The artificial insemination association providing service to the sire. The associations having sires listed in this newsletter are:

A B S - American Breeders Service, Inc. DeForest, Wis. 53532

CARN. - Carnation Farms Breeding Serv. Hiawatha, Iowa 52233

CURT. - Curtiss Breeding Service, Inc. Cary, Ill. 60013

MID.B.- Midwest Breeders, Inc. Shawano, Wis. 54166

MIN.V.- Minn. Valley Breeders Assn. New Prague, Minn. 56071

TRI-S.- Tri State Breeders Coop. Westby, Wis. 54667

5 STATUS - The current availability of semen from the sire. The codes used are as follows:
- A - Sire is AVAILABLE on a regular basis.
- P - Sire is available via semen PURCHASED from another association.
- N - Sire is NOT AVAILABLE.

It is advisable to check further with your local A.I. technician regarding availability since this is constantly changing and may vary somewhat from technician to technician within an association.

6 HERDS - The number of herds in which daughters are located.

7 DAUGHTERS - The number of daughters included in the summary.

8 RECORDS PER DAUGHTER - The average number of records per daughter.

9 10 11 DAUGHTER AVERAGE MILK, %, and FAT - The average lactation production of the daughters standardized to a 305 day, twice-a-day milking, mature equivalent basis.

12 PERCENT INCOMPLETE - The percent of daughters that died or were sold for slaughter during their first lactation. This is blank if first lactations are not available on at least 50% of the daughters.

13 14 ADJUSTED HERDMATE AVERAGE MILK and FAT - The average 305-2x-M.E. lactation production of the herdmates, adjusted for the average number of herdmates per daughter.

15 REPEATABILITY OF SUMMARY - A percentage figure which shows the accuracy or reliability of the summary. The repeatability ranges from about 14% for summaries based on five daughters in one herd to 99% for those based on many daughters in many herds.

16 17 PREDICTED DIFFERENCE FOR MILK AND FAT - A measure of the sire's ability to transmit production of milk and fat to his daughters. The predicted difference may be positive or negative depending on whether the sire's daughters produced better or poorer than other sires' daughters producing under those same conditions.

18 RANK ON FAT - Since the sires having a repeatability of summary of 60% or more are ranked on predicted difference for milk, their rank on predicted difference for fat is also shown.