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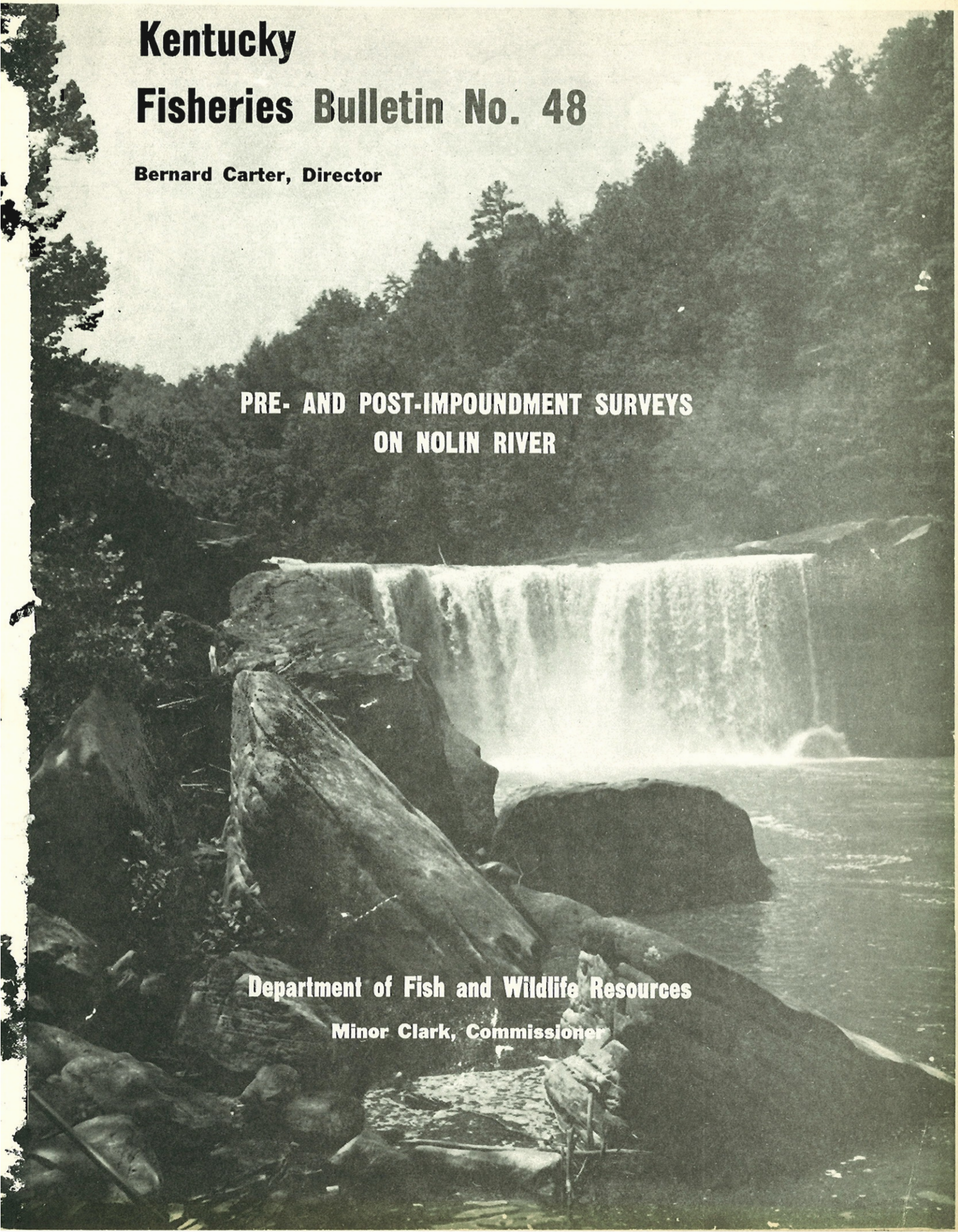
Bernard Carter, Director



## PRE- AND POST-IMPOUNDMENT SURVEYS ON NOLIN RIVER

Department of Fish and Wildlife Resources

Minor Clark, Commissioner

# PRE- AND POST-IMPOUNDMENT SURVEYS

# ON NOLIN RIVER

*By*

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*ABSTRACT*

*Investigations were conducted on Nolin River during a two year period preceding impoundment, and on Nolin Reservoir the first four years of impoundment to determine and evaluate changes in the fish population composition, fishing intensity, creel composition, and fishing success. Monthly water quality studies were performed on the reservoir in 1965 and 1966.*

*Thermal stratification was evident by May both years and a metalimnion persisted throughout the reservoir until late September. In June, oxygen depletion occurred throughout the hypolimnion and lower limit of the metalimnion in the upper two-thirds of the reservoir.*

*Total alkalinity values generally ranged from 80 ppm in late winter to 140 ppm in June. During the summer, concentrations within the metalimnion of the lower two-thirds of the reservoir were generally greater than concentrations either above or below this level.*

*Fish population compositions were determined by sampling with an emulsifiable rotenone formulation at a concentration of 0.5 ppm to 1.0 ppm on the river, and a concentration of 1.0 ppm on the reservoir.*

*Sixty-one species of fishes were recorded from three areas before impoundment and 29 of these were absent from the reservoir studies. The stoneroller was the most abundant species prior to impoundment. After impoundment the samples were numerically dominated by carp (19.4 per cent) and spotted bass (19.0 per cent) in 1963, bluegill (71.2 per cent) in 1964, threadfin shad (80.6 per cent) in 1965, and gizzard shad (71.3 per cent) in 1966. The first year of impoundment the relative abundance of cyprinids decreased 27.4 per cent while centrarchids increased 63.8 per cent. Gizzard shad were collected in the river but were not represented in the reservoir studies until the third year of impoundment; this species may have been precluded from the original fish population of the reservoir by early winter impoundment.*

*The fish population biomass after impoundment fluctuated from 157 pounds per acre in 1963, to 138 pounds per acre in 1964, to 180 pounds per acre in 1965. Carp comprised 47.0 per cent and 53.8 per cent of the biomass respectively the first two years of impoundment and threadfin shad comprised 42.9 per cent the third year. Centrarchids comprised 30.6 per cent, 35.7 per cent and 25.6 per cent respectively the first three years of impoundment.*

*Creel surveys were based on a stratified sampling schedule and the fishing effort was estimated by the mean-count method. The fishing effort increased from an average of 10,260 man-hours before impoundment to 25,336 man-hours (11.5 man-hours per acre), the first year of impoundment. The second year of impoundment the fishing effort was estimated at 39,083 man-hours (16.4 man-hours per acre) and the third year it increased to 58,700 man-hours (31.3 man-hours per acre). The average rate of harvest ranged from 0.16 fish per hour to 0.17 fish per hour before impoundment and from 0.55 fish per hour to 1.13 fish per hour after impoundment. In 1959 the harvest was numerically dominated by black basses (47.9 per cent) and in 1960 it was chiefly comprised of catfishes (29.4 per cent), black basses (26.0 per cent), and sunfishes (24.0 per cent). After impoundment the harvest was numerically dominated by carp (69.7 per cent) in 1963, sunfishes (54.1 per cent) in 1964, and crappies (58.5 per cent) in 1965.*

*The estimated annual harvest increased from an average of 2,337 pounds before impoundment to 10,641 pounds (4.8 pounds per acre), the first year of impoundment. The second year of impoundment the harvest was estimated at 7,035 pounds (2.8 pounds per acre), and the third year it increased to 31.9 pounds per acre.*

## INTRODUCTION

This is the final report for a portion of a project initiated in 1959 to study the pre- and post-impoundment fish populations and sport fishery of selected Kentucky streams to be impounded by the U. S. Army Corps of Engineers. The study was financed in part by the U. S. Bureau of Sport Fisheries and Wildlife under the auspices of the Dingell-Johnson program, Federal Aid in Fisheries. From 1959 through August of 1964 the project leader was Mr. William R. Turner*. From September 1964 until the completion date in October 1966, the writer served as project leader. Nolin Reservoir was one of the four reservoirs under study during the period.

The scientific objectives of this study were to determine pre- and post-impoundment fish population compositions; changes in fishing intensity and fishing success; success of stocking various species of fish in reservoirs; and water quality of the reservoir.

## ACKNOWLEDGEMENTS

The following conservation officers of the Kentucky Department of Fish and Wildlife Resources, Law Enforcement Division, served as creel clerks and assisted during fish population studies: Al Davidson, James Harrod, Charles Moody, James Stewart and Kenneth Merideth.

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* U. S. Bureau of Commercial Fisheries, Beaufort, North Carolina.

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Bernard T. Carter, Director of Fisheries, provided helpful criticism throughout the study and edited the manuscript.

## DESCRIPTION OF STUDY AREA

Nolin River is one of the major tributaries of the Green River and encompasses a drainage area of 727 square miles, 703 square miles of which are above the reservoir (U. S. Department of the Interior, 1960). Approximately 95 per cent of the drainage area is located in the Pennyroyal physiographic region while the remaining five per cent is whthin the Western Coal Field region. The Pennyroyal region is characterized by karst topography with underlying formations of limestone, some sandstone, shale and chert, while the underlying formations of the Western Coal Field region are primarily sandstone, shale and some limestone. The topography ranges from gently rolling in the upper reaches, to hilly in the middle section, to precipitous in the lower section. Upland soils are mostly Westmoreland and Muskingum associations derived from acid siltstones, sandstones and shales. Approximately half the watershed is cropland and pastureland while the remaining half is in timber. The stream extended a distance of 122 miles prior to impoundment and the reservoir impounds approximately 39 miles of stream at summer pool. The stream gradient averages 1.5 feet per mile along the lower 30 miles and 2.7 feet per mile for the next 50 miles upstream. In the extreme headwaters the gradient is comparatively steep, averaging 25 feet per mile.

Nolin Dam was constructed at mile 7.8 on the river and the reservoir was impounded in early 1963. The dam is a rock fill structure with an earth core. The spillway is uncontrolled and is cut through rock.

The outlet works is constructed of reinforced concrete conduit with two outlet systems. The standard low level discharge gates are supplemented by a pair of discharge structures known as bypasses. Each bypass consists of a vertical chamber with multi-level inlets and a discharge valve at the bottom. The inlets are four feet square, located on the upstream side of the control tower, and paired at each elevation. There are six inlets at three elevations; invert elevations 497.7, 484.3 and 471.3 msl.

During the study period, the normal operational schedule for Nolin Reservoir was as follows: summer pool (515 msl) was scheduled for early May and maintained through August; drawdown began in early September and flood control or minimum pool was reached by December 1. Flood waters were impounded as necessary, regardless of season. At summer pool the surface acreage of the reservoir is 5,800 acres and the total volume is 170,000 acre-feet.

## METHODS

### Fish Population Sampling

The locations of study areas on Nolin River were to some degree determined by accessibility but an effort was made to sample each section of stream where major habitat changes occurred: one area in the headwaters, one in the area to be impounded, and one in the future tailwater.

The Nolin River study areas were sampled with 5% emulsifiable rotenone. After computing the stream flow and blocking off the study area with small mesh nets, the toxicant was diluted and applied to the upper end of the area at a concentration of 0.5 ppm to 1.0 ppm; the time of application depended upon the time required for the toxicant to reach the lower end of the study area. Detoxification was accomplished by the addition of potassium permanganate at a concentration equivalent to twice the strength of rotenone, in the lower end of the study area. Easily-identified fishes were processed in the

field, while small specimens including minnows, darters, and other small fishes were preserved in formalin and subsequently identified in the laboratory.

The Nolin Reservoir study areas were also located to provide samples from each section of the lake. These areas were restricted to coves or portions of coves which could be isolated from the main body of the reservoir with three-quarter-inch-mesh block nets which measured 300 feet in length and 20 feet in depth. These nets were usually set soon after dawn and then the area was treated with emulsifiable rotenone at a concentration of 1.0 ppm (0.05 ppm actual rotenone). The rotenone was applied by means of a venturi-type boat bailer where the study areas did not exceed 10 feet in maximum depth. In deeper areas, a pressure tank and weighted hose or the mud-ball method, (powdered cubé) was used to assure penetration of the thermocline. Fish were picked up over a 60-hour period following application of the rotenone.

Creel Surveys

Creel surveys were conducted by Departmental conservation officers (subsequently referred to as creel clerks) who made direct contacts with fishermen on predetermined days. Survey schedules were designed to provide a stratified sample representative of each day of the week. This was accomplished by basing the survey on a 12-hour day (7:00 a.m. to 7:00 p.m.), dividing each day of the week into three 4-hour periods, 7-11, 11-3, 3-7, and sampling each period an equal number of times throughout the survey period. This method provided samples for 21 complete days or three days for each day of the week during the survey period 1 April through 31 October.

During the pre-impoundment survey the creel clerks contacted fishermen by driving to designated check points; after impoundment fishermen were contacted by boating over a designated area. The creel clerks made fisherman counts as well as interviews and the counts were used to compute the fishing

pressure. This method was described by Lambou in 1961:

$$f = c\bar{x}$$

where f = number of man-hours of fishing
c = number of hours in the population
$\bar{x}$ = mean number of fishermen per count.

Fisherman count methods used during the pre-impoundment survey were distinctly different from those made on the reservoir. During the pre-impoundment survey the creel clerk counted fishermen as he progressed with the interviews whereas on the reservoir the counts were made as quickly as possible by cruising the survey area, either before or after interviewing.

The creel clerks interviewed as many fishermen as possible during the survey period and obtained information on the amount of time fished, the number and species of fish harvested, the average length of each species, the method used and the species preference of the fishermen. After the average rate of harvest and the average weight of fishes had been determined (the weight of fishes in the creel was obtained from fish population study data), an estimate of the total harvest was made by multiplying the rate of harvest by the total fishing effort.

Water Quality

Monthly physico-chemical analyses were made on the reservoir during 1965 and 1966. Samples were collected at mid-channel at three separate areas: Area I, 20.8 miles upstream from the dam, near Wax; Area II, 11.7 miles upstream from the dam, near the mouth of Conoloway Creek; and Area III, 1000 feet above the dam.

Temperature measurements were made with a telethermometer at five-foot depth intervals from surface to bottom and recorded in Fahrenheit.

Water collected for chemical analyses was taken with a Kemmerer sampler at 10-foot depth intervals. Dissolved oxygen was determined by the Modified Winkler Method and total alkalinity determinations (expressed as $CaCO_3$) were

made using methyl-orange-xylene cyanol as an indicator and titrating with N/50 sulfuric acid.

## PHYSICAL AND CHEMICAL CHARACTERISTICS

Pre-impoundment discharge records for Nolin River show an average flow of 786 cfs with extremes ranging from no flow during the summers of most years to a maximum of 22,000 cfs in January 1937, U. S. Geological Survey, 1962. Limited water quality studies performed the summer preceding impoundment (Whitney, 1963), revealed that the alkalinity, composed exclusively of bicarbonates, ranged from 120 ppm to 188 ppm. The pH was well within the alkaline range and varied from 7.6 - 9.2.

The reservoir was impounded in February of 1963, but never attained summer pool capacity (170,000 acre-feet) during the first two years of impoundment. Instead, the volume ranged from 85,000 acre-feet in 1963 to 130,000 acre-feet in 1964. During the third and fourth years of impoundment seasonal pool was reached in May as scheduled.

Since a study was in progress which involved the manipulation of temperatures in the Nolin tailwater (Carter, 1967), discharges during the seasonal pool periods of both 1965 and 1966 were primarily made through the upper bypass inlets. Only occasional (5 days in 1965, and 21 days in 1966) gate level discharges were made during April through August. Throughout the remainder of both years discharges were made from either or both levels.

Minimum surface temperatures (41°), were recorded in February of both years. Surface temperatures generally reached 50° by late March, 60° by late April, and 75° by late May. Maximum surface temperatures were reached in July (81° in 1965, and 85° in 1966), of both years.

Dissolved oxygen and temperature profiles during May, August, and December of 1965 and 1966 are depicted in Figures 1 and 2. Thermal stratification

Figure 1. Dissolved oxygen and temperature profiles at mid-lake during periods of early stratification, late summer stagnation, and winter circulation - 1965.

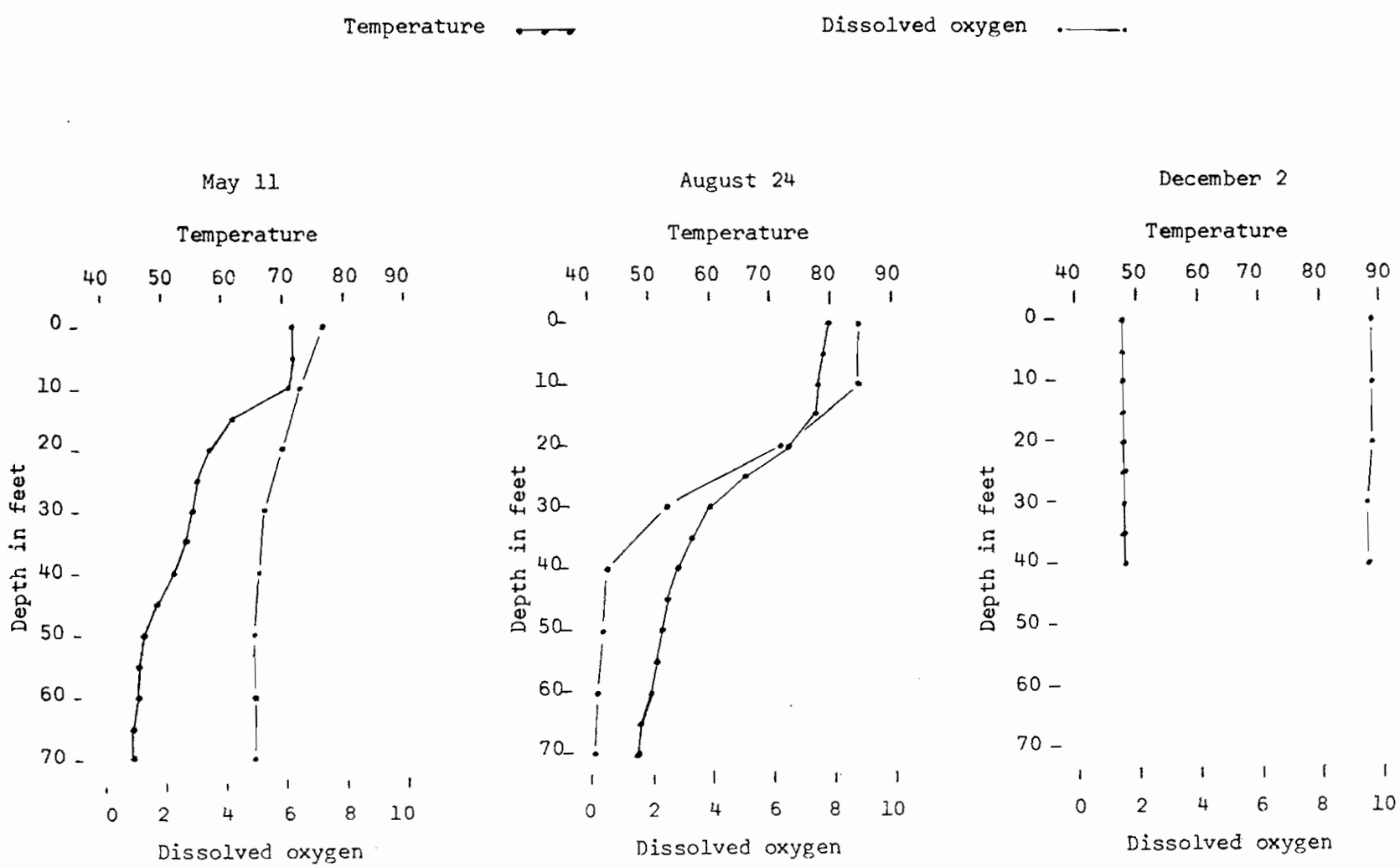
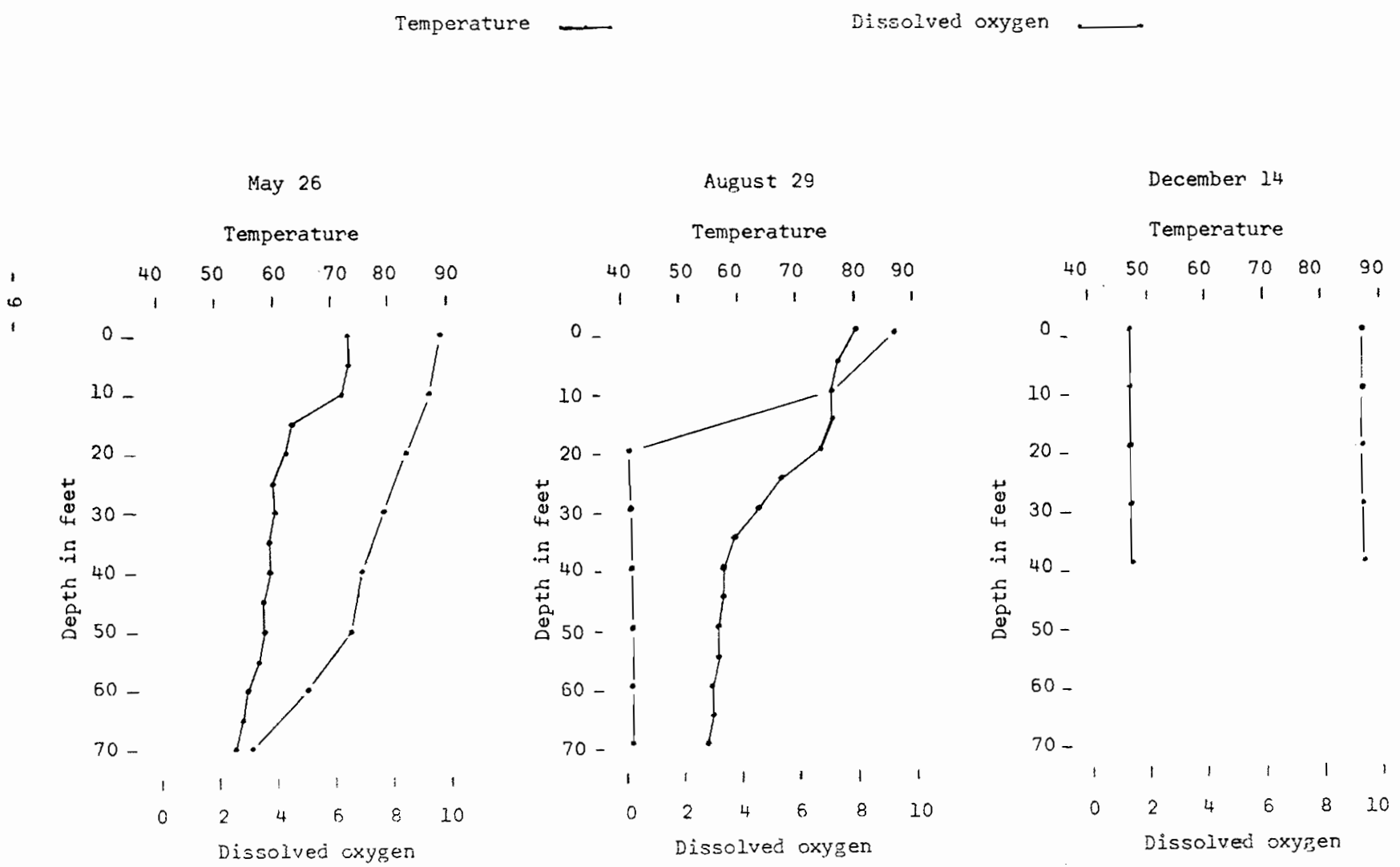


Figure 2. Dissolved oxygen and temperature profiles at mid-lake during periods of early stratification, late summer stagnation, and winter circulation - 1966.



became evident by the middle of May both years when the metalimnion was positioned at the 10 to 20 feet depth. At mid-lake, the temperature gradient within the metalimnion was 10° while the surface to bottom differential was 21°. In May, the epilimnion, metalimnion and hypolimnion each comprised about one-third the total volume of the reservoir.

During the period June through August of 1965, the metalimnion progressively descended in depth and its volume decreased. By late August it was located at the 15 to 33 foot depth and constituted about 30 per cent of the volume. In 1966, the upper limit of the metalimnion remained at the 10 foot depth through July while the lower limit progressively descended with a resultant increase in volume. However, by late August of 1966, the metalimnion had further descended to the 20 to 35 foot depth and decreased in volume.

Temperature gradients were greatest in late July when the surface to bottom differential was as much as 34° and the gradient within the metalimnion was 22°.

Fall drawdown began during the second week of September both years and by the last week of the month stratification was completely disrupted in the upper two-thirds of the reservoir. Surface water temperatures had cooled to 70° by September, and the maximum surface to bottom gradient was 15°. By the middle of October the thermocline was completely disrupted throughout the reservoir, but homothermy was not evident until early December.

Dissolved oxygen concentrations at the surface were maximal (11 to 12 ppm) in February and ranged from 8.4 ppm to 10.2 ppm during the spring and summer.

Oxygen depletion in the metalimnion occurred in the upper two-thirds of the reservoir in June, but was not detected near the dam until July. By late August depletion in the lower limit of the metalimnion was acute throughout the reservoir and dissolved oxygen concentrations near the dam ranged from

0.3 ppm in the lower limit, to 8.4 ppm in the upper limit; at the head of the reservoir the range was a trace to 0.4 ppm. Oxygen depletion in the hypolimnion was acute in the upper two-thirds of the reservoir in early June of 1965, and throughout the entire reservoir in late June of 1966. By late August of both years concentrations ranged from a trace to 0.3 ppm.

Dissolved oxygen concentrations below the dam were adequate year round. Concentrations ranged from 7.5 ppm in October to 10.5 ppm in May.

Concentrations of total alkalinity (expressed as $CaCO_3$) varied considerably with depth, area location, and reservoir volume. Concentrations at a given depth were generally greatest at the head of the lake while values at mid-lake and near the dam were similar. During the period June through August, maximum concentrations were often found within the thermocline in the lower two-thirds of the reservoir, while at the head of the lake concentrations generally increased with depth throughout the year. Maximum values for the year coincided with attainment of summer pool level. Concentrations ranged from a minimum of 81 ppm to a maximum of 150 ppm during the period.

## FISHES OF THE DRAINAGE

Pre-impoundment fish population sampling was limited due to the occurrence of high water at the time studies were conducted. Although several attempts were made, only three studies were completed (encompassing 3.5 surface acres), and only one of these (Station II) was considered a successful quantitative study. For this reason pre-impoundment populations are described and compared with post-impoundment populations only on the basis of relative abundance.

Sixty-one species of fishes representing 11 families were recorded before impoundment and eight additional species, including two non-indigenous forms

which were introduced, were collected after impoundment, Table 1. The total pre-impoundment sample from all three stations numbered 1235 fishes. Cyprinids were dominant in the sample from Stations I and II while the freshwater drum *Aplodinotus grunniens* Rafinesque, was the most abundant at Station III. The total number of species collected increased from the headwaters downstream, but the greatest number was recorded at the middle station.

Station I

This station was located at mile 41.6 on the stream near the mouth of Bacon Creek.

Cyprinids comprised 54.1 per cent of the collection from this station. The bigeye chub *Hybopsis amblops* (Rafinesque), bluntnose minnow *Pimephales notatus* (Rafinesque), rosyface shiner *Notropis rubellus* (Agassiz), and stoneroller *Campostoma anomalum* (Rafinesque) were the dominant species. Catostomids ranked second and the most abundant were northern hogsucker *Hypentilium nigricans* (Lesueur), golden redhorse *Moxostoma erythrurum* (Rafinesque), and shorthead redhorse *Moxostoma breviceps* (Cope). Of the four species of centrarchids recorded at this station, spotted bass *Micropterus punctulatus* (Rafinesque) dominated. They were followed in order of decreasing abundance by rock bass *Ambloplites rupestris* (Rafinesque), smallmouth bass *Micropterus dolomieui* Lacepede, and longear sunfish *Lepomis megalotis* (Rafinesque). Five species recorded at this station were not collected in the lower reaches. These were grass pickerel *Esox americanus vermiculatus* Lesueur, rosefin shiner *Notropis ardens* (Cope), stargazing minnow *Phenacobius uranops* Cope, rosyface shiner, and white sucker *Catostomus commersoni* (Lacepede).

Table 1. The relative abundance or percentage composition of the fish population of the Nolin River in 1959 and the Nolin Reservoir during the first four years of impoundment.

| Species | Nolin River Stations | | | Nolin Reservoir | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | 1963 | 1964 | 1965 | 1966 |
| (Sample area in acres) | 1.0 | 1.0 | 1.5 | 5.0 | 5.8 | 6.4 | 2.7 |
| **Petromyzontidae** | | | | | | | |
| **Brook lamprey - *Lampetra* sp. | | | | tr. | | | |
| **Lepisostidae** | | | | | | | |
| Longnose gar - *Lepisosteus osseus* (Linnaeus) | | 0.1 | 0.3 | 0.1 | | | tr. |
| **Clupeidae** | | | | | | | |
| Gizzard shad - *Dorosoma cepedianum* (Lesueur) | | | 0.2 | | | 0.1 | 71.3 |
| **Threadfin shad - *Dorosoma petenense* (Gunther) | | | | | 0.1 | 80.6 | |
| Total | | | 0.2 | | 0.1 | 80.7 | 71.3 |
| **Hiodontidae** | | | | | | | |
| *Goldeye - *Hiodon alosoides* (Rafinesque) | | | 0.7 | | | | |
| *Mooneye - *Hiodon tergisus* Lesueur | | | 0.1 | | | | |
| Total | | | 0.8 | | | | |
| **Esocidae** | | | | | | | |
| Grass pickerel - *Esox americanus vermiculatus* Lesueur | 0.1 | | | 0.4 | | tr. | |
| **Cyprinidae** | | | | | | | |
| Stoneroller - *Campostoma anomalum* (Rafinesque) | 7.6 | 56.0 | | 0.1 | | | 0.1 |
| Goldfish - *Carassius auratus* (Linnaeus) | | | 0.1 | | | 0.1 | 0.1 |
| Carp - *Cyprinus carpio* Linnaeus | | | 0.2 | 19.4 | 7.8 | 1.0 | 1.0 |

Table 1. (continued)

| Species | Nolin River Stations | | | Nolin Reservoir | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | 1963 | 1964 | 1965 | 1966 |
| (Sample area in acres) | 1.0 | 1.0 | 1.5 | 5.0 | 5.8 | 6.4 | 2.7 |
| **Cyprinidae (continued)** | | | | | | | |
| *Bigeye chub - *Hybopsis amblops* (Rafinesque) | 13.4 | 1.1 | | | | | |
| *Streamline chub - *Hybopsis dissimilis* (Kirtland) | 0.1 | | | | | | |
| *Silver chub - *Hybopsis storeriana* (Kirtland) | | | 0.4 | | | | |
| *Rosefin shiner - *Notropis ardens* (Cope) | 2.3 | | | | | | |
| Emerald shiner - *Notropis atherinoides* Rafinesque | | 0.3 | 4.7 | | tr. | | tr. |
| *Ghost shiner - *Notropis buchanani* Meek | | | 10.9 | | | | |
| Common shiner - *Notropis cornutus* (Mitchill) | 0.4 | 0.9 | | tr. | tr. | | |
| Silver shiner - *Notropis photogenis* (Cope) | 2.3 | 1.7 | 0.3 | | tr. | | |
| *Rosyface shiner - *Notropis rubellus* (Agassiz) | 8.8 | | | | | | |
| Spotfin shiner - *Notropis spilopterus* (Cope) | 4.6 | 1.1 | 0.7 | tr. | tr. | | |
| *Mimic shiner - *Notropis volucellus* (Cope) | 4.0 | 1.7 | | | | | |
| *Steelcolor shiner - *Notropis whipplei* (Girard) | | 0.1 | | | | | |
| *Stargazing minnow - *Phenacobius uranops* Cope | 0.2 | | | | | | |
| Bluntnose minnow - *Pimephales notatus* (Rafinesque) | 10.4 | 1.0 | 1.6 | 0.1 | tr. | | |
| *Bullhead minnow - *Pimephases vigilax* (Baird and Girard) | | 0.4 | 3.4 | | | | |
| Creek chub - *Semotilus atromaculatus* (Mitchill) | | 0.1 | | tr. | | | |
| Total | 54.1 | 64.4 | 22.3 | 19.6 | 7.8 | 1.1 | 1.2 |
| **Catostomidae** | | | | | | | |
| *White sucker - *Catostomus commersoni* (Lacepede) | 0.1 | | | | | | |
| Northern hogsucker - *Hypentelium nigricans* (Lesueur) | 8.1 | 0.7 | | 0.2 | tr. | tr. | |
| Spotted sucker - *Minytrema melanops* (Rafinesque) | | | 2.3 | 0.1 | 0.1 | tr. | |
| **Silver redhorse - *Moxostoma anisurum* (Rafinesque) | | | | | | tr. | 0.2 |
| Shorthead redhorse - *Moxostoma breviceps* (Cope) | 2.0 | | 1.8 | tr. | tr. | | |
| Golden redhorse - *Moxostoma erythrurum* (Rafinesque) | 7.6 | 0.4 | 4.0 | 0.2 | 0.3 | 0.1 | |
| Total | 17.8 | 1.1 | 8.1 | 0.5 | 0.4 | 0.1 | 0.2 |

Table 1. (continued)

| Species | Nolin River Stations | | | Nolin Reservoir | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | 1963 | 1964 | 1965 | 1966 |
| (Sample area in acres) | 1.0 | 1.0 | 1.5 | 5.0 | 5.8 | 6.4 | 2.7 |
| **Ictaluridae** | | | | | | | |
| **Black bullhead - *Ictalurus melas* (Rafinesque | | | | 2.4 | 0.5 | tr. | tr. |
| **Yellow bullhead - *Ictalurus natalis* (Lesueur) | | | | tr. | tr. | 0.1 | |
| Channel catfish - *Ictalurus punctatus* (Rafinesque) | 8.8 | 2.6 | 11.7 | 0.7 | 0.2 | 0.1 | 0.1 |
| *Mountain madtom - *Noturus eleutherus* Jordan | 1.5 | 0.1 | | | | | |
| *Slender madtom - *Noturus exilis* Nelson | | 1.6 | | | | | |
| Brindled madtom - *Noturus miurus* Jordan | 1.1 | 2.5 | 4.1 | 3.4 | 0.1 | tr. | |
| *Freckled madtom - *Noturus nocturnus* Jordan and Gilbert | | | 0.3 | | | | |
| Flathead catfish - *Pylodictis olivaris* (Rafinesque) | 0.8 | 0.8 | 4.1 | 0.8 | 0.1 | tr. | tr. |
| Total | 12.2 | 7.6 | 20.2 | 7.3 | 0.9 | 0.2 | 0.1 |
| **Cyprinodontidae** | | | | | | | |
| **Blackstripe topminnow - *Fundulus notatus* (Rafinesque) | | | | | | tr. | |
| **Centrarchidae** | | | | | | | |
| Rock bass - *Ambloplites rupestris* (Rafinesque) | 1.2 | 0.3 | | 0.8 | 0.1 | tr. | |
| Warmouth - *Chaenobryttus gulosus* (Cuvier) | | | 0.2 | 3.9 | 1.3 | 0.8 | 0.5 |
| Green sunfish - *Lepomis cyanellus* Rafinesque | | 0.1 | | 1.0 | 0.2 | tr. | tr. |
| *Orangespotted sunfish - *Lepomis humilus* (Girard) | | | 0.2 | | | | |
| Bluegill - *Lepomis macrochirus* Rafinesque | | | 0.3 | 16.0 | 71.2 | 10.7 | 6.6 |
| Longear sunfish - *Lepomis megalotis* (Rafinesque) | 0.4 | 0.6 | 3.7 | 6.6 | 13.4 | 1.6 | 1.4 |
| Smallmouth bass - *Micropterus dolomieui* Lacepede | 1.1 | | 0.8 | 0.1 | tr. | | |
| Spotted bass - *Micropterus punctulatus* (Rafinesque) | 1.6 | 1.0 | 1.5 | 19.0 | 1.3 | 1.8 | 1.7 |
| **Largemouth bass - *Micropterus salmoides* (Lacepede) | | | | 16.0 | 0.6 | 0.5 | 14.9 |
| White crappie - *Pomoxis annularis* Rafinesque | | | 2.6 | 6.0 | 2.4 | tr. | 0.8 |
| Black crappie - *Pomoxis nigromaculatus* (Lesueur) | | | 1.1 | | tr. | tr. | tr. |
| Total | 4.3 | 2.0 | 10.4 | 69.4 | 90.5 | 15.4 | 25.9 |

Table 1. (continued)

| Species | Nolin River Stations | | | Nolin Reservoir | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | 1963 | 1964 | 1965 | 1966 |
| (Sample area in acres) | 1.0 | 1.0 | 1.5 | 5.0 | 5.8 | 6.4 | 2.7 |
| **Percidae** | | | | | | | |
| Greenside darter - *Etheostoma blennioides* Rafinesque | 2.4 | 0.3 | | 0.1 | | tr. | tr. |
| Rainbow darter - *Etheostoma caeruleum* Storer | 0.2 | 0.9 | | tr. | tr. | | |
| Fantail darter - *Etheostoma flabellare* Rafinesque | | 1.3 | | tr. | | | |
| *Stripetail darter - *Etheostoma kennicotti* (Putnam) | | 0.6 | | | | | |
| Johnny darter - *Etheostoma nigrum* Rafinesque | | 0.1 | | | | tr. | |
| *Barcheek darter - *Etheostoma obeyense* Kirsch | 0.1 | | | | | | |
| *Etheostoma* sp. | 0.3 | | | | | | |
| *Spottail darter - *Etheostoma squamiceps* Jordan | 0.1 | | | | | | |
| *Speckled darter - *Etheostoma stigmaeum* (Jordan) | | 0.1 | | | | | |
| Logperch - *Percina caprodes* (Rafinesque) | | 0.7 | | 0.1 | 0.1 | 0.4 | 0.1 |
| Blackside darter - *Percina maculata* (Girard) | 0.4 | 0.6 | 0.2 | 0.2 | | tr. | tr. |
| *Slenderhead darter - *Percina phoxacephala* (Nelson) | 2.3 | 4.5 | 0.4 | | | | |
| Dusky darter - *Percina sciera* (Swain) | | 0.1 | | 0.5 | | | |
| *Sauger - *Stizostedion canadense* (Smith) | | 0.1 | 0.4 | | | | |
| Total | 5.8 | 9.3 | 1.0 | 0.9 | 0.1 | 0.4 | 0.1 |
| **Sciaenidae** | | | | | | | |
| *Freshwater drum - *Aplodinotus grunniens* Rafinesque | | 0.1 | 36.6 | | | | |
| **Cottidae** | | | | | | | |
| *Banded sculpin - *Cottus carolinae* (Gill) | 5.4 | 0.6 | | | | | |
| **Atherinidae** | | | | | | | |
| **Brook silverside - *Labidesthes sicculus* (Cope) | | | | 0.3 | 0.2 | 0.1 | 0.3 |
| Total number species | 32 | 36 | 33 | 34 | 29 | 28 | 22 |

* Indicates species recorded only before impoundment.
** Indicates species recorded only after impoundment.

Station II

This station was located at mile 18.2 on the stream near the settlement of Dickys Mills.

Sixty-four per cent of the fishes collected at Station II were cyprinids. The stoneroller was the most abundant, comprising 54 per cent of the sample. The percentage composition of percids (mainly darters) was greater here (9.3 per cent), than at either Station I or III. Seven species of fishes collected at this station were not recorded at the other two stations. These included the steelcolor shiner *Notropis whipplei* (Girard), creek chub *Semotolis atromaculatus* (Mitchill), slender madtom *Noturus exilis* Nelson, green sunfish *Lepomis cyanellus* Rafinesque, fantail darter *Etheostoma flabellare* Rafinesque, stripetail darter *Etheostoma kennicotti* (Putnam), and Johnny darter *Etheostoma nigrum* Rafinesque.

Station III

This station was located at mile 7.0 on the stream immediately below the dam site and was characteristically a backwater area.

A large collection of freshwater drum dominated the sample and eight other species characteristic of the larger river were also recorded. Included among the latter were the longnose gar *Lepisosteus osseus* (Linnaeus), gizzard shad *Dorosoma cepedianum* (Lesueur), goldeye *Hiodon alosoides* (Rafinesque), mooneye *Hiodon tergisus* Lesueur, goldfish *Carassius auratus* (Linnaeus), carp *Cyprinus carpio* Linnaeus, and silver chub *Hybopsis storeriana* (Kirtland). The percentage composition of centrarchids was greatest (10.4 per cent) at this station and five species recorded here were not collected in the upper reaches of the stream; they were warmouth *Chaenobryttus gulosus* (Cuvier), orangespotted sunfish *Lepomis humilus* (Girard), bluegill *Lepomis macrochirus* Rafinesque, white crappie *Pomoxis annularis* Rafinesque, and black crappie *Pomoxis nigromaculatus* (Lesueur).

## Changes in the Composition after Impoundment

Changes in the fish population composition after impoundment were substantial and significant fluctuations continued to occur during the first four years of impoundment.

Twenty-nine species of fishes recorded before impoundment were not collected in the reservoir. Although six species which were native to the drainage were recorded only after impoundment, only three, yellow bullhead *Ictalurus natalis* (Lesueur), black bullhead *Ictalurus melas* (Rafinesque), and brook silverside *Labidesthes sicculus* (Cope), substantially increased in abundance, Table 1.

## Petromyzontidae

This family was represented only after impoundment by one specimen of brook lamprey, *Lampetra* sp.

## Lepisostidae

Longnose gar was the only representative of this family. While this species was considered scarce in the mid-section of the river and common in the lower section, only four specimens were collected during cove sampling.

The longnose gar was apparently more abundant in the reservoir than the cove samples indicated, however, since it was common among the fishes collected during a gill-netting study in 1965 (Anderson, personal communication).

## Clupeidae

Gizzard shad were recorded at Station III prior to impoundment, but did not appear in the reservoir studies until the third year of impoundment. However, this species became well established the fourth year of impoundment and constituted 71.3 per cent of the aggregate sample.

Turner (1963), theorized that this species had been precluded from the reservoir as it was from Buckhorn Reservoir (Middle Fork of Kentucky River).

He postulated that the reason for their absence in both reservoirs was a direct result of late winter impoundment which preceded their migratory "run" in late spring. Since gizzard shad have yet to be found in Buckhorn Reservoir since impoundment in 1961 (Charles 1967), and only 42 specimens were recorded during extensive sampling on Nolin Reservoir in 1965, (a total of 8 areas encompassing 6.2 surface acres were sampled), their belated appearance in the latter reservoir does not invalidate this theory.

Threadfin shad *Dorosoma petenense* (Gunther), obtained from Lake Cumberland, Kentucky, were introduced in the spring of 1964 and by 1965 this species had become the most abundant fish in the reservoir, comprising 80.6 per cent of the sample. This excellent forage species suffered drastic reductions the following winter, however, and none were recorded in 1966.

Hiodontidae

The mooneye and goldeye were recorded at Station III before impoundment, but never have been collected in the reservoir.

Esocidae

Although only two grass pickerel were recorded prior to impoundment, post-impoundment studies during 1963 revealed this species must have been more abundant than was realized. This species declined in abundance after the first year of impoundment, however.

Although the Ohio muskellunge *Esox masquinongy ohioensis* Kirtland, is known to inhabit the Green River drainage, none were recorded before or after impoundment.

Cyprinidae

The relative abundance of cyprinids decreased substantially after impoundment. Nineteen species of cyprinids were recorded prior to impoundment, but

only nine species were found in the reservoir. The bigeye chub and bluntnose minnow were the dominant species in the river while carp was the most abundant species in the reservoir. Carp became the most abundant fish during the first year of impoundment, but decreased in abundance the following three years. Carp reproduction was very light after the first year of impoundment.

Ictaluridae

The relative abundance of ictalurids decreased after impoundment. The channel catfish *Ictalurus punctatus* (Rafinesque), was the most abundant species in the river while the black bullhead numerically dominated during the first year of impoundment. Neither the black bullhead nor the yellow bullhead were recorded before impoundment. Although the black bullhead increased numerically in 1963, they gradually decreased in abundance the following three years. Of the four species of madtom collected in the river, only the brindled madtom *Noturus miurus* Jordan, was recorded in the reservoir.

Centrarchidae

Ten species of centrarchids were recorded during the pre-impoundment studies and each of these, excluding the orangespotted sunfish, were subsequently collected in the reservoir. Largemouth bass *Micropterus salmoides* (Lacepede), were never recorded in the river but 160,000 were stocked as fry in the reservoir in 1963. Spotted bass remained the most abundant of the black basses during the first three years of impoundment, however. The relative abundance of smallmouth bass decreased after impoundment and no reproduction of this species was observed after the first year of impoundment. Aside from the exceptions noted above, plus slight decreases in the relative abundance of rock bass and black crappie, the abundance of all other centrarchids increased after impoundment. While the post-impoundment studies indicated that bluegill achieved the greatest increase among the species in this family (bluegill

comprised 71.2 per cent of the total sample in 1964), there was also a substantial increase in crappies as evidenced by the creel surveys.

Percidae

The relative abundance of percids decreased after impoundment. This family was represented by thirteen species of darters and the sauger *Stizostedion canadense* (Smith), before impoundment and seven species of darters were recorded in the reservoir. The logperch *Percina caprodes* (Rafinesque), was the only species in this family which increased numerically after impoundment. Although sauger were recorded in each of the lower stations on the river this species was not recorded in the reservoir.

Sciaenidae

Freshwater drum were abundant in the pre-impoundment study at Station III, but were not recorded in the reservoir.

Cottidae

The banded sculpin *Cottus carolinae* (Gill), was recorded only in the headwaters of the river and has never been collected in the reservoir.

Atherinidae

Although the brook silverside was never recorded in Nolin River, this excellent forage species became well established the first year of impoundment and increased numerically during the following three years.

## FISH POPULATION BIOMASS

The one quantitative study performed on Nolin River in 1959 yielded 30 pounds of fish per acre. This estimate is below the average productivity determined for other rivers in Kentucky (averages for Rough River, Middle Fork of the Kentucky River, and Barren River were 40, 47, and 108 pounds per

acre respectively), and the actual value probably approximated that of Rough River which is situated in the same physiographic region and drainage.

After impoundment the fish population biomass fluctuated from 157 pounds per acre in 1963, to 138 pounds per acre in 1964, to 180 pounds per acre in 1965, Table 3.

Table 3. The total weight of fishes per acre collected on Nolin Reservoir during the first three years of impoundment. Weight per acre is followed by percent of total weight in parentheses.

| Study year | 1963 | | 1964 | | 1965 | |
|---|---|---|---|---|---|---|
| Surface area sampled | 5.00 | | 5.76 | | 6.37 | |
| Petromyzontidae | tr. | ( tr.) | | | | |
| Lepisostidae | 0.15 | ( 0.09) | | | | |
| Clupeidae | | | 0.11 | ( 0.07) | 77.65 | (42.93) |
| Esocidae | 0.88 | ( 0.57) | | | 0.05 | ( 0.03) |
| Cyprinidae | 75.44 | (48.04) | 74.53 | (53.84) | 41.34 | (22.43) |
| Catostomidae | 2.12 | ( 1.35) | 4.94 | ( 3.55) | 8.30 | ( 4.59) |
| Ictaluridae | 29.98 | (19.09) | 9.37 | ( 6.77) | 6.76 | ( 3.73) |
| Cyprinodontidae | | | | | tr. | ( tr.) |
| Centrarchidae | 48.13 | (30.64) | 49.43 | (35.72) | 46.35 | (25.62) |
| Percidae | 0.33 | ( 0.21) | 0.03 | ( 0.02) | 0.42 | ( 0.23) |
| Atherinidae | 0.02 | ( 0.01) | 0.03 | ( 0.03) | 0.02 | ( 0.01) |
| TOTAL | 157.05 | (100.00) | 138.44 | (100.00) | 180.89 | (100.00) |

The decrease shown between 1963 and 1964 was not attributed to an actual fluctuation in the biomass but was ascribable to a distorted sample. The 1963 estimate was inflated by a large group of ictalurids from a single study area and this resulted in an apparent decrease the following year. Fluctuations in the biomass between 1963 and 1964 may have been further obscured by

a 50 per cent increase in reservoir volume the latter year. What affect an increase of this magnitude may have had on the validity of the 1964 productivity estimate for comparative purposes is open to question, but it seems reasonable to assume that an actual increase occurred that year since the biomass of most families, excluding ictaluridae, was essentially unchanged.

Fluctuations in the biomass of clupeids and cyprinids accounted for the major changes which occurred in 1965.

Carp was the dominant species the first two years of impoundment while threadfin shad dominated the third year. Carp comprised 47.0, 53.8, and 23.2 per cent of the weight respectively the first three years while threadfin shad comprised 0.07 per cent in 1964 and 42.9 per cent in 1965.

Centrarchids ranked second in importance all three years. They constituted 30.6 per cent in 1963, 35.7 per cent in 1964 and 25.6 per cent in 1965. Game fishes, including three species of black bass and white crappie, contributed 24.4, 13.0, and 12.0 per cent of the biomass respectively the first three years. Intermediate-sized game fishes dominated each year. Black bass reproduction was substantial the first year of impoundment, but was never as large the two years following. Crappie reproduction was evident the first year of impoundment and increased each successive year. Panfishes, chiefly bluegill and longear sunfish, constituted 7.0, 22.7, and 13.7 per cent of the biomass respectively, the first three years of impoundment. Panfish reproduction was greatest the second year of impoundment.

The biomass of catostomids increased each year after impoundment and in 1965 they constituted 4.6 per cent of the total weight.

The percentage by weight of harvestable-sized fishes ($A_t$ value) decreased from 21.7 in 1963, to 12.3 in 1964, and was 12.6 in 1965. The decrease between 1963 and 1964 is attributed to the distorted sample previously mentioned, as the $A_t$ value of most fishes except catfish increased from 1963 to 1965.

## THE SPORT FISHERY

Pre-impoundment creel surveys were conducted in 1959 and 1960. Surveys were also made on the reservoir the first three years of impoundment but none of these included its entire surface area. The survey areas respectively comprised 67, 55, and 36 per cent of the total area of the reservoir and included approximately 2,211 surface acres in 1963, 2,430 surface acres in 1964, and 1,872 surface acres in 1965. Each of the surveys was made in the lower reservoir.

The fishing effort increased from an average of 10,260 man-hours before impoundment to 25,336 man-hours the first year of impoundment. The second year of impoundment the effort was estimated at 39,083 man-hours, and the third year it increased to 58,700 man-hours, despite a 31 per cent reduction in size of the survey area. On a per acre basis, the fishing intensity was 11.5, 16.4, and 31.3 man-hours per acre respectively, the first three years of impoundment, Table 4.

Table 4. Fishing effort and success as determined by creel surveys on Nolin River and the lower section of Nolin Reservoir.

| | Pre-impoundment | | Post-impoundment | | |
|---|---|---|---|---|---|
| | 1959 | 1960 | 1963 | 1964 | 1965 |
| Survey period (days) | 214 | 214 | 214 | 214 | 214 |
| Stream miles | 57 | 48 | 31 | 31 | 24 |
| Fishing effort: | | | | | |
| total man-hours | 13,270 | 7,250 | 25,336 | 39,083 | 58,700 |
| man-hours/acre | | | 11.5 | 16.4 | 31.3 |
| Total harvest: | | | | | |
| fish/mile | 37 | 28 | 924.0 | 676.0 | 2494.7 |
| fish/acre | | | 12.9 | 16.4 | 32.0 |
| pounds/mile | 75 | 19 | 343.2 | 226.9 | 831.6 |
| pounds/acre | | | 4.8 | 2.9 | 10.7 |
| Rate of harvest: | | | | | |
| fish/hour | 0.16 | 0.17 | 1.13 | 0.55 | 1.02 |
| pounds/hour | 0.32 | 0.37 | 0.42 | 0.18 | 0.34 |

The average rate of harvest on Nolin River was slightly below that determined for three other Kentucky streams (Barren River, Middle Fork, and Russell Fork), and ranged from 0.16 fish per hour (0.32 pound per hour) in 1959 to 0.17 fish per hour (0.37 pound per hour) in 1960. The rate of harvest improved after impoundment. On the reservoir, fishermen averaged 1.13 fish per hour in 1963; 0.55 fish per hour in 1964; and 1.02 fish per hour in 1965.

The average weight of fish harvested from the river was greater than the average weight of fish harvested from the reservoir. Prior to impoundment the average weight ranged from 0.70 pound to 1.20 pounds, whereas after impoundment the average weight ranged from 0.37 pound in 1963, to 0.33 pound in 1964 and 1965.

Changes in the creel composition and fluctuations in the total harvest were substantial both before and after impoundment, Table 5. The pre-impoundment creel of 1959 was numerically dominated by black basses, whereas in 1960, the relative abundance of black basses, catfishes and panfishes was approximately the same. Three species of fishes represented in the creel before impoundment, rock bass, suckers, and freshwater drum, did not appear in the reservoir surveys. Conversely, the only species harvested from the reservoir that were not recorded prior to impoundment were crappies.

The first year of impoundment carp became the dominant fish in the creel. Although this species comprised 69.7 per cent of the harvest that year their numbers were drastically reduced thereafter and by the third year of impoundment they comprised only 5.7 per cent of the harvest. Panfishes dominated numerically the second year of impoundment and crappies were most abundant the third year. Crappies did not appear in the creel until the second year of impoundment, but by the third year they constituted 58.5 per cent of the harvest.

The weight composition of the creel was dominated by black basses and catfishes before impoundment. The first year of impoundment black basses accounted for 51.5 per cent of the harvest weight and carp comprised 40.9 per cent. These two species continued to dominate the harvest weight the second year, when each species comprised about 38 per cent of the total harvest. The third year of impoundment crappies comprised 56.0 per cent of the total weight and black basses ranked second at 27.1 per cent.

The estimated harvest on Nolin River was 2,123 fishes (4,246 pounds) in 1959 and 606 fishes (429 pounds) in 1960. After impoundment the estimated harvest increased to 28,630 fishes (10,641 pounds) the first year of impoundment; 21,496 fishes (7,035 pounds) the second year, and 59,874 fishes (19,958 pounds) the third year.

Fisherman intent or species preference was determined during the second and third years of impoundment. Some shifting of angler preference was noted during the period but black basses and crappies were the most sought after species both years, Table 6. These two groups of fishermen were among the least successful of the anglers surveyed, however. Black bass fishermen averaged only 0.08 bass per hour in 1964 and 0.16 bass per hour in 1965. Crappie fishermen were more successful — they averaged 0.46 and 1.21 crappies per hour during the period. Anglers specifying sunfishes were the most successful both years. They averaged 2.11 and 1.66 sunfishes per hour. Fishermen who stated they had no species preference accounted for six per cent of the anglers surveyed in 1964 and eight per cent in 1965. This group was also very successful as they averaged 1.35 and 1.42 fish per hour in 1964 and 1965, respectively.

The majority of the fishermen interviewed on the reservoir were residents. The first three years of impoundment (1963-1965) this group comprised 99.4, 98.5, and 98.2 per cent, respectively, of the total number of fishermen.

Table 5. The estimated sport fishing harvest from Nolin River before and after impoundment.

Numerical Composition of the Harvest

| Species | Pre-impoundment | | | | Post-impoundment | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1959 | | 1960 | | 1963 | | 1964 | | 1965 | |
| | No. | % | No. | % | No. | % | No. | % | No. | % |
| Black basses | 1,017 | 47.9 | 158 | 26.0 | 5,153 | 18.0 | 1,999 | 9.3 | 4,551 | 7.6 |
| Crappies | - | - | - | - | - | - | 2,085 | 9.7 | 35,026 | 58.5 |
| Catfishes | 244 | 11.5 | 178 | 29.4 | 286 | 1.0 | 473 | 2.2 | 479 | 0.8 |
| Rock bass | 42 | 2.1 | - | - | - | - | - | - | - | - |
| Other sunfishes | 244 | 11.5 | 146 | 24.0 | 3,235 | 11.3 | 11,629 | 54.1 | 16,405 | 27.4 |
| Carp | 22 | 1.0 | - | - | 19,956 | 69.7 | 5,310 | 24.7 | 3,413 | 5.7 |
| Suckers | 156 | 7.3 | 87 | 14.4 | - | - | - | - | - | - |
| Drum | 398 | 18.7 | 37 | 6.2 | - | - | - | - | - | - |
| TOTAL | 2,123 | 100.0 | 606 | 100.0 | 28,630 | 100.0 | 21,496 | 100.0 | 59,874 | 100.0 |

Weight Composition of the Harvest

| | Wt. | % | Wt. | % | Wt. | % | Wt. | % | Wt. | % |
|---|---|---|---|---|---|---|---|---|---|---|
| Black basses | 2,165 | 51.0 | 148 | 34.4 | 5,480 | 51.5 | 2,716 | 38.6 | 5,409 | 27.1 |
| Crappies | - | - | - | - | - | - | 471 | 6.7 | 11,176 | 56.0 |
| Catfishes | 824 | 19.4 | 177 | 41.3 | 500 | 4.7 | 77 | 1.1 | 439 | 2.2 |
| Rock bass | 30 | 0.7 | - | - | - | - | - | - | - | - |
| Other sunfishes | 48 | 1.1 | 27 | 6.3 | 309 | 2.9 | 1,048 | 14.9 | 1,377 | 6.9 |
| Carp | 42 | 1.0 | - | - | 4,352 | 40.9 | 2,723 | 38.7 | 1,557 | 7.8 |
| Suckers | 225 | 5.3 | 59 | 13.8 | - | - | - | - | - | - |
| Drum | 912 | 21.5 | 18 | 4.2 | - | - | - | - | - | - |
| TOTAL | 4,246 | 100.0 | 429 | 100.0 | 10,641 | 100.0 | 7,035 | 100.0 | 19,958 | 100.0 |

Table 6. Fisherman intent or species preference and success of surveyed anglers on Nolin Reservoir during 1964 and 1965.

| Species sought | % of total fishermen | | Success* No./hour | | Wt./hour | |
|---|---|---|---|---|---|---|
| | 1964 | 1965 | 1964 | 1965 | 1964 | 1965 |
| Black basses | 39 | 32 | 0.08 | 0.16 | 0.11 | 0.20 |
| Crappies | 11 | 40 | 0.46 | 1.21 | 0.09 | 0.41 |
| Catfishes | 4 | 2 | 0.61 | 0.03 | 0.26 | 0.02 |
| Sunfishes | 10 | 16 | 2.11 | 1.66 | 0.32 | 0.15 |
| Carp | 10 | 2 | 1.33 | 1.02 | 0.54 | 0.40 |
| No preference | 6 | 8 | 1.35 | 1.42 | 0.68 | 0.37 |

* Species which may have been harvested along with those specified are not included.

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