University of Louisville
Potamological Institute

Technical Report No. 9

ORSANCO - UNIVERSITY OF LOUISVILLE SURVEILLANCE STUDY OF THE OHIO RIVER, 1960 - 61 FINAL REPORT

By
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UNIVERSITY OF LOUISVILLE

THE POTAMOLOGICAL INSTITUTE

3005 UPPER RIVER ROAD

LOUISVILLE 7, KENTUCKY

Dr. Edward J. Cleary
Executive Director
Ohio River Valley Water
Sanitation Commission
414 Walnut Street
Cincinnati 2, Ohio

Dear Dr. Cleary:

Attached herewith the final report of the ORSANCO-University of Louisville Surveillance Study of the Ohio River.

The Potamological Institute finds no greater satisfaction than that which comes from serving the Ohio River Valley Water Sanitation Commission in the Commission's efforts to maintain a healthy and health-giving condition of the Ohio River. It is my hope that the data contained in this report, and those in other reports to which this is a sequel, will be useful in attaining this objective.

Respectfully submitted,

William M. Clay

William M. Clay
Executive Director

WMC:bd

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SYNOPSIS

1. The Aquatic Life Surveillance Project covered the period from July 1, 1960 to June 30, 1961.
2. Fish were collected from eight U. S. Navigation Lock chambers by use of Pronoxfish for population and species composition studies.
3. Limnological investigations were carried out on seven regions of the river.
4. Field Personnel included John C. Williams, Ichthyologist, Joseph E. Hanegan, Limnologist and C. Fred Bryan, Technician. The project was under the direction of William M. Clay.
5. All necessary equipment and supplies were obtained as needed during the project.
6. Physical, chemical and biological data were obtained in order to survey the condition of the river at selected points from Dashields Dam at Mile 13.3 to the Saline River at Mile 867.9.

INTRODUCTION

A major purpose of this investigation was to determine the location and nature of possible persistent sources of pollution in the Ohio River and in the lower portions of some of its tributaries. Other objectives were to obtain physical and chemical data on the water and to continue a survey of the fish fauna which was begun in an earlier ORSANCO - University of Louisville Project. The field work was done in the period from July 21, 1960, through August 21, 1960.

Limnological studies and surveillance for pollution were carried out in seven regions of the river as noted below. In, or immediately adjacent to each of these regions except one, a fish population sample was made by rotenone in a navigation lock chamber. In one region (Region VI) fish were collected in each of two lock chambers. The sites of the fish collections are called stations in the account which follows.

Region I: The Ohio River from Dashields Dam at Mile 13.3 to Dam 7 at Mile 36.4. Station 1: Montgomery Dam, Industry, Pennsylvania, at Mile 31.7.

Region II: The Ohio River from immediately above Wheeling, West Virginia, at Mile 90.3 to Dam 14 at Mile 113.7. Station 2: Lock 13, McMechan, West Virginia, at Mile 96.1.

Region III: The Ohio River from the Guyandot River at Mile 305.0 to immediately above Dam 30 at Mile 339.5. Station 3: Lock 29, Cattlettsburg, Kentucky, at Mile 319.9.

Region IV: The Ohio River from Mile 351.0 to immediately above Dam 31 at mile 359.2. Station 4: Lock 31, Kirksville, Kentucky, at Mile 359.3.

Region V: The Ohio River 500 yards above the Licking River at Mile 470.0 to Mile 495.7 below Tanner's Creek. Station 5: Lock 37, Cleves, Ohio, at Mile 483.2.

Region VI: The Ohio River at Mile 581.0 above Eighteen-mile Creek to Mile 630.5, one-half mile below the Salt River. Station 6 - A: McAlpine Lock, Louisville, Kentucky, at Mile 607.0: Station 6-B: Lock 43, New Boston, Indiana, at Mile 633.2.

Region VII: The Ohio River from Mile 828.0 above Mount Vernon, Illinois, to Mile 867.9, one-half mile below the Saline River, Illinois. Station 7: Lock 49, Uniontown, Kentucky, at Mile 845.0.

All major tributaries entering the Ohio River between the limits of these seven regions were also investigated. The intensity of study of each tributary depended upon its degree of pollution as determined by tests run near the mouth. If these tests indicated the tributary could possibly be a major source of pollution, further sampling was continued upstream, generally to a point where navigation became impossible. Tributaries of the Ohio River that were intensely sampled are: the Kanawha River, the Licking River, Tanner's Creek and Wheeling Creek.

Part I Limnological Investigations

Since a large area (170 linear miles of the Ohio River and over 100 miles of tributary streams) had to be investigated in a short time, the specific observations in the field were largely determined by conditions confronting the investigators at the time of measurement. Rather detailed notes on the visual impression made by any given area were kept. Also, any or all of the following tests were run, as needed.

1. Temperature: The temperature of the water one foot below the surface was determined with a Centigrade thermometer.
2. Dissolved Oxygen: The Alsterberg modification of the Winkler method was employed exclusively.
3. Copper and Iron: Copper was determined by use of the cuprethol method. Iron was assayed by the bipyridine test.
4. Nitrates and Phosphates: Phosphates were measured by use of the stannous-chloride-molybdate test. A Bausch and Lomb Spectronic 20 colorimeter was employed in measuring nitrates, phosphates, copper and iron.
5. Hydrogen ion concentration: pH was determined by use of a battery operated Beckman pocket pH meter.

RESULTS

Region I

The area of the Ohio River below Dashields Dam at Mile 13.3 to Dam 7 at Mile 36.4 was studied on July 21-22, 1960. The results of physical and chemical tests made in this region are shown in Table I. The water in the Ohio River immediately below Dashields Dam had a high dissolved oxygen content (13.7 mg./l.), a relatively low pH (6.3), and a slightly positive test for iron (0.16 mg./l.), and was relatively clear. By the time the river flows beneath the bridge at Economy (Mile 16.8), contributions have been made to it by a small tributary, Sewickley Creek (Mile 15.4), and by large effluents from the heavily industrialized Jones and Laughlin Steel Company (Miles 16.4-19.6.).

Sewickley Creek was rich in oxygen (14.2 mg./l.) slightly below a riffle area, and was alkaline in nature (pH 9.1). This creek was of unpleasant appearance. It's water was murky gray and gave off an odor characteristic of sewage-laden streams. Two dead bullheads were found slightly below the mouth of the stream.

The first major effluent from Jones and Laughlin was just above a tin-plating plant at Mile 16.4. Water from this effluent was alkaline (pH 10.1) and quite warm (47° C.). The iron content was 0.48 mg./l. A short distance below this effluent a second effluent contributed a deep yellow substance to the Ohio River. This yellow cast was maintained for over 100 yards downstream. The pH of this effluent was 3.4; the temperature a warm 40° C. Copper and iron values were very high here, being 0.72 mg./l. and 10.3 mg./l. respectively. The third major effluent from Jones and Laughlin (about Mile 19.0) had a rust-brown color. This effluent current was approximately 4 ft./sec. at the surface. The rust-brown color was maintained for 100 yards offshore. The pH of this water was an acid 3.4. Copper was maximally concentrated here (1.65 mg./l.); iron was also quite high (9.7 mg./l.). The fourth major effluent emanating from Jones and Laughlin was found at about Mile 19.6. A water sample from the Ohio River was taken 50 yards below this outlet just above Crow Island. The water temperature at this point was significantly higher than the mainstream (35° C vs 27° C). Dissolved oxygen was quite low here (4.8 mg./l.). This decrease was probably due to chemical demand, since the only other possible oxygen demand was Sewickley Creek water which was already shown to be high in O_2. The surface of the water inside of Crow Island was characteristically slick and oily for one-half mile or more downstream. Also, the outflow from Sewickley Creek could not be expected to contribute much to the flow inside of Crow Island since it is on the opposite side of the river. This entire area was also characterized by a great amount of air pollution. Although only four major effluents were assayed, 12 other major effluents and 14 minor ones were found within 500 feet above the fourth major effluent just discussed.

The Ohio River at Economy Bridge (Mile 16.8) had a lower oxygen concentration (7.5 mg./l.). Iron measured 0.4 mg./l, and the hydrogen ion concentration was slightly on the acid side (pH 6.1). The shoreline was very black from industrial deposits and continued to be so for several miles downstream.

Legionville Run (Mile 18.8) and the majority of the Jones and Laughlin effluents mentioned above are the only significant contributors to the Ohio River between the Economy Bridge and the Beaver River. Legionville Run was a slightly alkaline (pH 9.4), moderately flowing stream, somewhat brown in color and with a surface film of oil. This stream was well oxygenated (10. 3 mg./l.). The iron content of this stream near the mouth was a high 1.86 mg./l. It would be difficult to say whether this was or was not from a backwater accumulation from the Ohio River, however.

The Ohio River a mile and a half above the Beaver River (Mile 24.0) had a markedly reduced dissolved oxygen content (5.0 mg./l.), a slightly increased pH (6.8) and a considerable increase in iron content (1.10 mg./l.)

when compared to the station beneath the Economy Bridge.

From Mile 24.0 to Mile 29.5, the Beaver River constituted the only obvious possible source of major pollution. The Beaver River which enters the Ohio River at Mile 25.5 was a turbid stream with a low dissolved oxygen content (4.1 mg./l.). Copper and iron, if present, were negligible. The low oxygen content did not have a lasting effect on the Ohio River, since the dissolved oxygen content in the Ohio River was on the increase at a point just below the Beaver River (Mile 25.7). Recalling that the dissolved oxygen at Mile 24.0 was 5.0 mg./l., at Mile 25.7 it was 9.5 mg./l. despite the Beaver River's contribution of water low in oxygen. A possible interpretation of this phenomenon is that although oxygen is low at the mouth of the Beaver River, the river is in the recovery phase there. Water continuing on into the Ohio presumably does not make a significant oxygen demand on the Ohio River, although it may somewhat depress the rate of recovery.

In addition to the increased oxygen there was an increase in iron content, from 1.10 mg./l. at Mile 24.0 to 1.32 mg./l. At Mile 25.7 the pH remained at 6.8.

By Mile 29.5 just above Raccoon Creek, the dissolved oxygen concentration had recovered to 10.2 mg./l., pH had been depressed to 6.0, and no positive test for iron was obtained.

Raccoon Creek and effluents from the Koppers Company enter the Ohio River between Mile 29.5 and Montgomery Dam (Mile 31.7). Raccoon Creek (Mile 29.7) was typified by a very satisfactory dissolved oxygen concentration (14.2 mg./l.), a low pH (4.8), and a modest iron content (0.79mg./l.), as determined from samples taken about one mile above the mouth. At the mouth, the dissolved oxygen content was decreased to 9.7 mg./l., and the pH had increased to 5.4, possibly as a result of the effluent described below.

A chalky-white coloration extended from an effluent near the mouth all of the way across the stream, and on upstream for 100 yards. This effluent was slightly acid (pH 6.6) and did not contain iron or copper. It did produce a strong, sickening odor, however.

A rather large concealed effluent extended underwater from the shore bordering Koppers Company immediately above Raccoon Creek to 20 yards out into the Ohio River. The ebullient nature of the surface at this point indicated a strong flow.

Another chalky white discharge (pH 6.4) was seen to emanate from a very large outflow into the Ohio River a short distance below Raccoon Creek. A strong odor similar to that described for the effluent in the mouth of Raccoon Creek was also noticed. The turbulence produced by this effluent was so great that it was difficult to hold the boat into the current. Iron and copper tests were again negative.

The dissolved oxygen at Montgomery Dam (Mile 31.7) was 10.2 mg./l. the same value as was reported for Mile 29.5. The pH was slightly depressed, from 6.3 to 6.0. The presence of iron and copper was not revealed. The water temperature was slightly lowered from 28° C to 26° C, perhaps due to the influence of Raccoon Creek which has a water temperature of 17° C.

Two other possible sources of pollution were observed below Montgomery Dam. One very rapid effluent at Crucible Steel (Mile 36.3) gave forth quite acidic water (pH 3.7) devoid of iron and copper, but emitting a strong phenolic odor. An outflow at Midland just below Crucible Steel (Mile 36.4) emanated a characteristically sewage laden effluent marked by an accumulation of scavenger fish.

Phosphates in Region I varied from 0.1 mg./l. at Dashields Dam to a maximum of 0.3 mg./l. at the Economy Bridge. Minimum nitrogen values were also seen at Dashields Dam (0.6 mg./l.) with a maximum at Mile 24.0 (0.9 mg./l.). Sewickley Creek had relatively high phosphate and nitrate values, of 1.0 and 2.1 respectively.

In summary, Region I is probably the most highly polluted region studied. Most of this pollution was of an industrial nature. Jones and Laughlin Steel Company and the Koppers Corporation seem to be the major offenders. In general, the water quality in this region of the Ohio was bad, and was characteristically acidic, was oily in consistency, and contained large quantities of suspended materials.

TABLE I. Physical-Chemical Measurements in Region I

Location	Mile Point	Dissolved Oxygen (mg./l.)	pH	Water Temp. (°C)	Copper mg/l.	Iron mg/l.
Below Dashields Dam	13.3	13.7	6.3	28	0	.16
Sewickley Creek	15.4	14.2	9.1	23	0	0
Economy Bridge	16.8	7.5	6.1	27	0	.41
Jones & Laughlin *Effluent	16.4	——	10.1	47	0	.48
* "	to	——	3.4	40	0.72	10.3
* "	19.6	——	3.8	——	1.65	9.7
Jones & Laughlin Inside Crow Island		4.8	6.4	35	0	0
Legionville Run	18.8	10.3	9.4	——	0	1.86
Ohio River	24.0	5.0	6.8	28	0	1.10
Mouth of Beaver River	25.5	4.1	6.8	26	0	0
Bridge below Beaver River	25.7	9.5	6.8	28	0	1.32
Ohio River above Raccoon Creek	29.5	10.2	6.0	28	0	0
Raccoon Creek	29.7	14.2	4.8	17	0	0
Mouth of Raccoon Creek	29.7	9.7	5.4	28	0	0
*Effluent at Koppers Corp.	29.8	——	6.4	——	0	0
Montogomery Dam	31.7	10.2	6.3	26	0	0
*Crucible Steel	36.3	——	3.7	——	0	0
*Midland Sewer	36.4	12.5	6.4	——	0	0

*Effluents

Region II

The limnological condition of the Ohio River from Mile 90.3, near Wheeling to Dam 14 at Mile 113.7, was examined on July 24 and 25, 1961.

The Ohio River above Wheeling Creek was well oxygenated 12.3 mg./l.), did not contain any detectable copper or iron, and was slightly acidic (pH 6.4). Water from the mouth of Wheeling Creek (Mile 90.7) had comparable values of oxygen (10.7 mg./l.), copper and iron (absent) and a pH of 6.3. The condition of the Ohio River below Wheeling Creek was little altered, insofar as could be determined. At Mile 91.1 the dissolved oxygen present was 13.7 mg./l., pH was 6.1, no copper was present and only a trace of iron (0.16 mg./l.) was recorded. These results are surprising since considerable evidence of extensive pollution in Wheeling Creek was obtained.

A very large fish kill was apparent near the mouth of Wheeling Creek. Oscillatoria was present in great quantities. The creek had a persistent odor of stagnation. Dead fish were seen for 1/4 mile upstream to an unnavigable riffle area. A heavy yellowish effluent and with the odor of raw sewage was seen at this point. This effluent had a pH of 5.5 and contained no copper or iron. Oxygen varied little in the creek. At a point above the riffle area 10.5 mg./l. were recorded, 11.0 mg./l. just below the riffle, and 10.7 mg./l. at the mouth. How much of this was due to decomposition of the biota, and how much was due to sewage decomposition was not determined.

The Ohio River from below Wheeling Creek to McMechen Dam (Mile 96.2) was relatively free of external sources of pollution. Dissolved oxygen was maintained at a satisfactory 11.5 mg./l. A noticeable decrease in pH to 5.4 was recorded, however.

Below McMehen Dam, dissolved oxygen unaccountably decreased to 8.6 and the pH increased to 6.6. A small concentration of iron (0.20 mg./l.) was also seen to be present.

A heavy effluent was observed on the West Virginia shore at Mile 104.0. This effluent had an odor similar to that of benzine and was orange in color. A Beckman Industrial pH Meter was installed at this site and read 6.2. This water contained 0.80 mg/l of copper and no iron.

Captina Creek contributed its very red outflow to the Ohio River at Mile 109.7. This creek had a barren shore line due to the runoff from slag heaps along the shore. Rust colored deposits were observed along the banks. Dissolved oxygen was high (13.3 mg/l) at a point one mile upstream. No copper was detected. Iron varied from 0.20 mg/l to 0.14 mg/l.

A conspicuous feature of the north shore of the Ohio River below Captina Creek is the total absence of vegetation. Slag heaps continue along this bank for one mile. A highly acidic effluent (pH 3.6) was discharged into the river at Mile 110.7 from the Powhatan Mining Company. This water contained 1.50 mg/l of copper and 2.20 mg/l of iron.

Nevertheless, by the time Dam 14 (Mile 113.7) was reached, no copper and little iron (0.14 mg/l) was measured in the Ohio River. Dissolved oxygen continued to be a high 15.2 mg/l.

Phosphates and nitrates were minimal at Mile 113.7, being 0.2 and 1.0 mg/l respectively. Highest values in Region II were recorded at Mile 113.7. Here PO_4's registered 0.3 mg/l and NO_3's measured 1.8 mg/l.

In summary, Region II can be characterized as follows: Dissolved oxygen was always adequate and usually quite high. In general, water entering this area was slightly acidic (pH 6.4) and left it the same way (pH 6.6). The sources of pollution are somewhat limited in number, but may be quite extensive in effect. Wheeling Creek certainly should be investigated further. The effect of industrial effluents from the Powhatan Mining Company and at Mile 104.0 should also be assayed.

TABLE II. Physical-Chemical Measurements in Region II

Location	Mile Point	Dissolved Oxygen (mg./l.)	pH	Water Temp. (°C)	Copper mg./l.	Iron mg./l.
Ohio River above Wheeling Creek	90.3	12.3	6.4	31	0	0
1/4 mile above Wheeling Creek	90.7	10.5	——	—	0	0
*Effluent in Wheeling Creek	90.7	——	5.5	—	0	0
Mouth of Wheeling Creek	90.7	10.7	6.3	—	0	0
Ohio River below Wheeling Creek	91.1	13.7	6.1	—	0	.16
Above Dam 13	96.0	11.5	5.4	27	0	0
Below Dam 13	96.2	8.6	6.6	29	0	0.20
*Effluent on W. Va. Shore	104.0	——	6.2	—	.80	0
Mouth of Captina Creek	109.7	——	6.8	—	0	0.20
1 mile up Captina Creek	109.7	13.2	6.4	26.5	0	.14
*Powhatan Mining Co.	110.7	——	3.6	——	1.50	2.20
Above Dam 14	113.7	15.2	6.6	33	0	0.14

*Effluents

Region III

The Ohio River from Guyandot (Mile 305.0) to Lock 30 at Mile 339.4 received the outflow from three major tributaries and the effluents from several large industries.

At Guyandot, the dissolved oxygen content of the river was 11.8 mg/l, the pH was 7.5, no copper was recorded, and only a trace of iron was detected (0.08 mg/l). The Guyandot River (Mile 305.4) entered the Ohio also with a high dissolved oxygen concentration (10.8 mg/l), but was considerably more alkaline (pH 9.2) than was the Ohio. Also, the iron content (0.76 mg/l) of the Guyandot was considerably higher at the time of measurement. It seems likely that the Standard Ultramarine Company on the Guyandot River was responsible for this difference in iron. The effluent emanating from this company was very high in copper (2.26 mg/l) and iron (1.56 mg/l). In the presence of the investigators, this effluent was seen to change from a deep blue color to a red and finally purple color. The pH of the effluent water was a strongly acid 3.8. Upon leaving the Guyandot, the boat propeller stirred up the bottom of the river sufficiently to show that the bottom was covered with this dye.

That the Guyandot River might contribute significantly to the pollution of the Ohio River is indicated by the results of chemical tests above Dam 28 (Mile 311.7). Although the oxygen and pH values recorded here are little changed from those determined at Guyandot, a remarkable increase in the iron content of the river was measured. Iron increased from 0.08 to 1.56 mg/l. The only observable source of such an increase was the Guyandot River, and more specifically, the Standard Ultramarine Company.

Between Dam 28 at Mile 311.7 and Dam 29 at Mile 320.0, the Levisa Fork of the Big Sandy River and effluents from the Nitrogen Division of Allied Chemical were the sole contributors to the Ohio River. The Levisa Fork did not seem to be polluted. Oxygen was 10.7 mg./l., and the pH was 7.8. Copper and iron were not detected. The Nitrogen Division of Allied Chemical at Mile 318.5 emitted an effluent which was slightly alkaline (9.2), and contained 0.76 mg./l. of iron. This effluent coursed over a spillway about 12 feet wide and certainly contributed a great total discharge. That this flow might significantly affect the Ohio River seems apparent if one considers that the nitrate and phosphate levels in the river reached a maximum of 2.0 and 0.6 respectively at Dam 29, 1.5 miles downstream. Also, dissolved oxygen declined to 8.6 mg./l. at Dam 29. This may be contrasted with the value of 11.5 mg./l. recorded at Dam 28.

Between Dam 29 and Lock 30, five major effluents and one major tributary were sampled. Three of these effluents are especially noteworthy. The effluent from the Barrett Division of Allied Chemical Company had a pH of 3.6 and contained 2.80 mg./l. of iron. A blue dye was present in the effluent from ARMCO (Mile 324.6). This water had a pH of 2.4, the lowest recorded in the region, and contained 6.64 mg./l. of copper and 8.50 mg./l. of iron, the highest values recorded in the region. A second effluent from ARMCO at Mile 324.8 also was blue in color, and was acidic (pH 3.8). No copper was detected in this effluent, however. Iron measured 2.50 mg./l.

The Little Sandy River seemed to be reasonably free of any pollution and should not be considered as a threat to the quality of the Ohio River Water.

Above Lock and Dam 30 at Mile 339.4, oxygen was maintained at a high level (11.1 mg./l.), the pH was 7.8 and the iron content was somewhat higher than that recorded at Dam 29. This increase in iron was likely due to the heavy industrialization in this area.

In summary, the only significant sources of pollution seen in region three were the Standard Ultramarine Company, Allied Chemical (Nitrogen Division), the Barrett Division of Allied Chemical, and ARMCO Steel. Municipal pollution was not detected in this region.

TABLE III. Physical-Chemical Measurements in Region III

Location	Mile Point	Dissolved Oxygen mg/l.	pH	Water Temp. (°C)	Copper mg/l.	Iron mg/l.
Ohio River at Guyandot River	305.0	11.8	7.5	29	0	.08
Mouth of Guyandot River	305.4	10.8	9.2	—	0	.76
*Standard Ultramarine in Guyandot River	305.4	—	3.8	—	2.26	1.56
Above Dam 28	311.7	11.5	7.6	29	0	1.66
Mouth of Big Sandy River	317.0	10.7	7.8	27.5	0	0
*Nitrogen Div. of Allied Chemical	318.5	—	9.2	—	0	.76
Above Dam 29	320.0	8.6	8.0	28	0	.25
*Semet - Solvay Div. of Allied Chemical	320.3	—	7.4	—	0	.58
*Barrett Division Allied Chemical	324.5	—	3.6	41	0	2.80
*Armco Steel	324.6	—	2.4	—	6.64	8.50
* "	324.8	—	3.8	38.5	0	2.50
* "	324.8	—	7.1	—	0	0
Little Sandy River	336.3	10.2	—	26	0	.20
Above Lock 30	339.4	11.1	7.8	28	0	.41

*Effluents

Region IV

This zone of the Ohio River from Detroit Steel at Mile 351.4 to Dam 31 at Mile 359.2 was sampled rather cursorily on two different days.

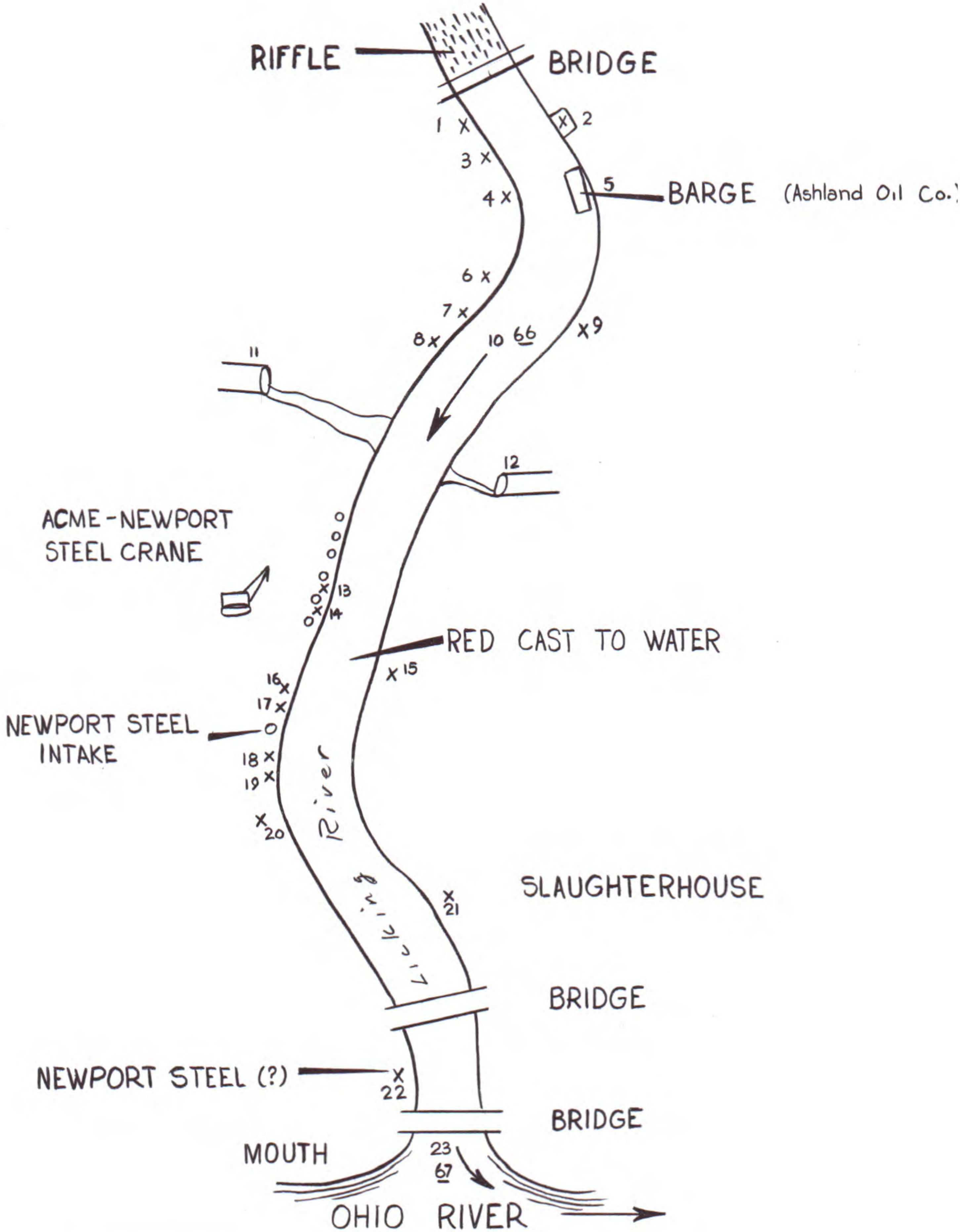
Mr. William Klein of ORSANCO assisted in the survey of the Detroit Steel area on August 5, 1960. Chemical tests run at the Potamological Institute revealed that 0.31 mg./l. of iron was present in the Ohio River at Mile 351.7. No copper or iron values were registered for two effluents at Detroit Steel. The river water was covered by a scum of coal dust and oil throughout the area.

The Ohio River and the Scioto River were studied August 6, 1960. Four and one-half inches of rain fell the previous night so that the data probably do not represent normal conditions. The Ohio River above the Scioto (Mile 356.4) had a dissolved oxygen content of 6.2 mg./l. Photometric assay indicated 0.48 mg./l. of iron were present. The Scioto River enters the Ohio River at Mile 356.6. The dissolved oxygen content at this sampling station was 7.9 mg./l. Neither copper nor iron were detected. The Ohio River above Dam 31 (Mile 359.2) was also low in dissolved oxygen (5.7 mg./l.). Some iron was still present (0.20 mg./l.) and no copper was indicated. The pH in the Ohio River became alkaline in Region IV, varying from 7.6 above Dam 31 to 7.9 at Mile 356.4.

It is believed that the low oxygen values were related to the heavy rainfall of the previous night. The presence of iron in the region could be industrial in orgin, but no supporting evidence was obtained.

TABLE IV. Physical-Chemical Measurements in Region IV

Location	Mile Point	Dissolved Oxygen mg/l.	pH	Water Temp. (°C)	Copper mg/l.	Iron mg/l.
Detroit Steel Effluent	351.4	—	—	—	0	0
Detroit Steel Effluent	351.5	—	—	—	0	0
Ohio River below Detroit Steel	351.7	—	—	—	0	0.31
Ohio River above Scioto River	356.4	6.2	7.9	31	0	0.48
Mouth of Scioto River	356.6	7.9	8.0	25.6	0	0
Above Dam 31	359.2	5.7	7.6	30	0	0.20



Map I. Sketch of lower portion of Licking River, with locations of stations.

Region V

From just above the Licking River (Mile 466.0) to Mile 495.7 below Tanner's Creek the Ohio River receives six tributaries of consequence. The Licking River, the first of these tributaries, is especially noteworthy and was studied quite extensively. Since the Licking enters the Ohio River near the beginning of Region V, and thus may be presumed to exert any effect it might have on the Ohio River before downstream stations were studied, it will be taken up now.

Twenty-three stations are located on the accompanying sketch of the Licking River. These stations extend from a riffle area, approximately three miles upstream, to the rivers confluence with the Ohio. Various landmarks are located on (Map I).

Four small effluent pipes were seen just below the riffle area mentioned above. Three of these were issuing forth a small trickle (Stations 1, 3, 4,) and the fourth (Station 2), although large, was inoperative. As the investigation party moved downstream, an Ashland Oil Company barge (Station 5) was seen to be moored on the left bank. Mr. Klein took a picture of the barge which showed open hoses hanging over the water. An oil slick was observed along the banks beginning at this point. The slick continued on past Station 17, where a picture was taken which showed oil on a willow tree which was hanging in the water. Station 15 was a small effluent on the left bank which gave a grey discoloration to the water.

Stations 16-20 were located on or at Newport Steel property. A very heavy effluent of what appeared to be wash water entered the Licking at Station 16. The pH of a water sample taken here was 8.6. No copper or iron were present. Submerged effluents were found at Stations 18 and 19, both of which had a pH of 8.6. The extent of flow could not be ascertained. Another very large effluent was located at Station 20. Visually, it appeared to be very similar to that at Station 16. Chemical tests corroborated this similarity. The pH was 8.6 and no copper or iron was detected.

A slaughter house on Theodore Greaves property was contaminating the river with bloody water at Station 21. The outflow here was considerable and from the condition of the shoreline it was apparent that this pollution had been continuing for some time.

Two effluents, probably from Newport Steel, entered the Licking near its mouth at Station 22. One of these, a few feet up the bank, had a greenish-blue color. A sample of this water showed that it was slightly acid (pH 6.4), lacked copper, but contained 0.71 mg./l. of iron. The second effluent was 50 feet up the bank and gave forth a yellowish outflow.

Effluents 6,7, and 8 emitted a small trickle of cool (17.3°C) alkaline water (pH 11.6 - 11.8). These effluents were devoid of copper and iron. On the left bank, across from stations 6, 7, and 8, a large effluent pipe gave forth a relatively small amount of sewage (Station 9).

A chemical water sample was taken in the middle of the stream slightly below the point (Station 10) and chemical tests indicated that the river water was slightly alkaline (pH 8.4), was free of copper, and possessed a trace of iron (0.14 mg./l.).

A very large effluent emanated from pipes in a wooded area 100 feet from the shoreline. This water was very acid (pH 2.1) and was quite warm

(46° C). Station 12 was a large effluent pipe which gave forth a small trickle.

Stations 13 and 14 were located between 40-foot tall pilings at Newport Steel. A small trickle emanated from a pipe at Station 13. A great volume of what appeared to be wash water issued from a large pipe at Station 14. No samples were taken here.

The river water along the left bank between Stations 12 and 15 had a reddish cast. The source of this discoloration could not be determined. It probably resulted from the release of industrial wastes into the river at some earlier time.

The dissolved oxygen at the mouth of the Licking was 10.0 mg/l, certainly more than adequate for the sustenance of aquatic life. The pH was depressed from 8.4 at Station 10 to 7.7 at the mouth (Station 23). No copper or iron was detected at the mouth.

In summary, it appears that there is ample opportunity for pollution to occur along the three mile stretch of the Licking River which was studied. The types of possible pollution here were varied. Barge washing, industrial outflows, municipal sewage and slaughterhouse wastes were being discharged into the river at the time of this study. In addition, it was obvious that the total capacity for pollution here was not being realized. Many of the discharge pipes were 3 to 8 feet in diameter and were either not in operation or emitted only a trickle of fluid wastes. Should all of these come into full play at once, the total effect on the river could be quite significant.

The Ohio River above the mouth of the Licking River was rich in dissolved oxygen (11.7 mg./l.) and was significantly more alkaline (pH 7.5) than it had been at Dam 31 (pH 5.7). No copper and only 0.10 mg./l. of iron were present. The union of the Licking River with the Ohio River did not significantly alter these values. Below the Licking River (Mile 470.3), dissolved oxygen was sustained at a high 11.6 mg./l., the pH was elevated very slightly to 7.6, no copper was indicated, and iron was maintained at 0.14 mg./l.

The only major contributor to the Ohio River between Mile 470.3 and 472.5 was oxygen-poor (0.6 mg./l.) Mill Creek. Except for the difference in oxygen, all other chemical tests gave quantities similar to those for the Ohio at the point of junction. That Mill Creek could be exerting a substantial effect on the Ohio can be seen from the fact that the dissolved oxygen in the Ohio dropped from 11.6 mg./l. above Mill Creek to 11.0 mg./l. below Mill Creek (Mile 472.7) and finally to 9.6 mg./l. above Dam 37 (Mile 483.0). Iron increased to 0.45 mg./l. below Mill Creek but was undetected at Dam 37. It is suggested that the increase in iron could be due to a residual content in the river which arose from some previous discharge of iron-rich waters from Mill Creek.

Parenthetically, it should be mentioned that a barge at Queen City Harbor was being washed free of sulfur-contaminated water (pH 7.8). The only other possible source of pollution between Mill Creek and Dam 37 was a large municipal outfall on the left bank serving many municipalities. The discharge from this outfall did not appear especially noteworthy.

Between Dam 37 (Mile 483.0) and the Ohio River below Tanner's Creek (Mile 495.7), Muddy Creek, the Great Miami River, Second Creek and Tanner's Creek contribute their outflows. Muddy Creek was obviously polluted. The stream abruptly turned white 100 yards from its mouth. This creek had the odor of latex. At this point a heavy municipal discharge of untreated sewage entered, if visual evidence is admitted. The research party could not determine the source of the white pollutant since further navigation was barred by a riffle area. Dissolved oxygen measured 8.6 mg/l., the pH was 8.0. Iron registered 0.91 mg/l. Copper was not present in detectable amounts.

Evidently the outflow from Muddy Creek elevated the iron content of the Ohio River from 0 to 0.69 mg/l. If determinations at Mile 488.2 are correct. Dissolved oxygen increased to 10.6 mg/l. (recovery from Mill Creek effect) and the pH was maintained at 7.5. Again, no copper was present.

A sample obtained from the Great Miami River, 1/4 mile upstream from a railroad bridge crossing the river, did not show anything untoward. Values for dissolved oxygen 10.0 mg/l., pH 7.8, and copper 0 mg/l. paralleled those for the Ohio River in this area. Iron registered somewhat lower, 0.22 mg/l. One heavy effluent of clear water was located 400 yards up the Great Miami River on the right bank. Although this water was warm (41° C) and slightly alkaline (pH 8.3), the absence of copper and the modest iron content (0.20 mg/l.) were not of a magnitude to cause concern.

Second Creek (Mile 493.3) seemed to be polluted near its mouth. The stream was clear, however, about 100 yards above the mouth. The quantity of iron seemed to be quite high (1.10 mg/l.) at this site. The lack of any real evidence for pollution leads one to believe that a good proportion of the iron found in the tributaries in Region V might be endemic and not of industrial orgin. The flow from Second Creek was not very great and should not be of much concern with regard to the state of the Ohio River.

Tanner's Creek (Mile 494.7) was undoubtedly one of the most heavily polluted streams encountered during the course of this study. As the research team went upstream, the water became progressivley more noxious. A white line of residue persisted along the shore. The water gradually turned quite brown. A heavy fish kill was noted. This kill included the following species: Pimephales notatus, Aplodinotus grunniens, Ictalurus punctatus, Dorosoma cepedianum and Notropis atherinoides. The state of some of the fish suggested that they died at least 72 hours previous to their discovery. Dissolved oxygen was uniformly low in the creek. 1.1 mg/l. was recorded 150 yards from the mouth and 1.3 mg/l. was determined 1 1/2 miles from the mouth. Iron was higher (1.20 mg/l.) upstream than it was near the mouth (0.10 mg/l.). The source of this pollution could not be determined by boat. The only effluent seen was near the mouth and could not be responsible for its poor condition. This effluent had a pH of 9.2. The outflow was clear and devoid of copper and iron. The pH of the stream was a constant 7.1 throughout its length.

After the Ohio River received Tanner's Creek contribution, the oxygen in the river fell from 10.6 mg/l. at Mile 488.2 to 8.1 mg/l. at Mile 495.7. The pH of the river was depressed slightly from 7.5 to 7.4. Iron decreased from 0.69 mg/l. to 0.16 mg/l.

Numerous other possible sources of pollution were observed in Region V, but because of their seeming inconsequential nature they were not studied at length and they are merely listed below with brief remarks on their condition.

Municipal discharge above Dam 37 on Kentucky shore: Small, clear flow

Monsanto barge (Mile 484.2): Hoses well-capped

Ohio River Company: Coal barges, no evidence of pollution

Raymond City Coal and Transport Co.: Eleven barges, no pollution

Small run, Kentucky shore (Mile 486.3): Clear

Gulf Oil (Mile 468.8): Hoses well-capped

American Bituminous and Asphalt (Mile 490): Hoses well-capped

Dark Hollow Run: Clear

Cincinnati Gas & Electric Company: One clear effluent

Peoples Coal Company: Nothing

Lawrenceburg, Indiana: No effluents operating

Indiana-Michigan Electric Company: One large clear effluent

Mile 493.6 Gravel Plant: Muddy wash water

Taylor Creek: Small flow of clear water

Garrison Creek: Small flow; some raw sewage

Sandy Run: Water clear

Potato Creek: Dry

Loders Creek: Small flow of clear water

In summary, pollution along the Ohio River proper seems to be minimal for Region V. The tributaries here cannot be easily dismissed. Evidence has been cited that seems to indicate that the Licking River, Mill Creek, Muddy Creek and especially Tanner's Creek are polluted. Often the precise source of this pollution could not be determined, since the research party was limited in its search by the navigability of these tributary streams. In general, the Ohio River contained adequate amounts of dissolved oxygen throughout its length. Mill Creek and Tanner's Creek did cause a moderate oxygen sag in the river, however. At the time of this study, the river was high due to a heavy rain the previous day. During low water periods, it is quite possible that this oxygen sag could be more marked and even serious due to the diminished dilution of tributary outflows. No copper was recorded for the Ohio or its tributaries. Iron values were relatively high, but this need not indicate pollution. Even relatively clear streams had a substantial amount of iron in them suggesting a goodly amount of iron is endemic to the region.

TABLE V. Physical-Chemical Measurements in Region V

Station	Mile Point	Dissolved Oxygen (mg/l)	pH	Water Temp. (°C)	Copper mg/l	Iron mg/l
Ohio River	446.0	11.7	7.5	27.7	0	0.10
Mouth of Licking River	470.1	10.0	7.7	27.7	0	0
Ohio River	470.3	11.6	7.6	27.7	0	0.14
Mouth of Mill Creek	472.5	0.6	7.4	23	0	0.14
Ohio River below Mill Creek	472.7	11.0	7.4	27.7	0	0.45
Queen City Harbor	473.0	——	7.8	——	0	0
Ohio River	483.0	9.6	7.6	27	0	0
Mouth Muddy Creek	484.1	8.6	8.0	——	0	0.91
Ohio River	488.2	10.6	7.5	27	0	0.69
Great Miami River 1/4 mile upstream	491.0	10.0	7.8	24.5	0	0.22
Effluent, 400 yards from mouth of Great Miami River	491.0	——	8.3	40.5	0	0.20
Second Creek	493.3	——	7.9	20.5	0	1.10
Tanner's Creek 150 yards upstream	494.7	1.1	7.1	27	0	0.10
Tanner's Creek 1 1/2 miles up-stream	494.7	1.3	7.1	27	0	1.20
Effluent near mouth of Tanner's Creek	495.7	——	9.2	22.2	0	0
Ohio River	495.7	8.1	7.4	26.7	0	0.16

Maximum NO_3 1.4 PO_4 1.0

Minimum NO_4 1.3 PO_4 0.6

Region VI

The Ohio River from Mile 581.0 to Mile 630.3 was studied August 20-23 1960. Five tributaries were included: Eighteen-Mile Creek, Fourteen-Mile Creek, Harrod's Creek, Goose Creek and the Salt River. Only one industry (American Synthetic Rubber) seemed to warrant further study.

The dissolved oxygen values recorded for six stations on the Ohio River proper ranged from a maximum of 12.5 mg./l. at Mile 581.0 to a minimum of 8.4 mg./l. at Mile 596.5, just below Harrod's Creek. The five tributaries studied also had adequate dissolved oxygen, with values ranging from 7.4 mg./l. (Goose Creek) to 13.5 mg./l. (Fourteen-Mile Creek).

In general, the tributary streams in this region were somewhat more alkaline than the Ohio River. Except for Fourteen-Mile Creek (pH 7.4), all tributaries had a pH of at least 8.0. As a result, the river increased in alkalinity from 7.8 at Mile 581.0 to 8.1 at Mile 630.3.

No copper was detected anywhere in this region. Small amounts of iron (0.16 to 0.55 mg./l.) were recorded for every tributary and station on the Ohio River except just below Salt River (Mile 630.3).

The only glaring source of pollution discovered in this area was American Synthetic Rubber. Three large latex-ladened effluent pipes discharged a heavy volume of foamy brown water into the Ohio River. The odor of this discharge was sickeningly sweet. A bottom sample taken 25 yards out from this site yielded nothing but solidified latex. No copper or iron were present in this effluent. The pH was 6.4.

Other than American Synthetic Rubber, all industries in this region seemed to be safeguarding against pollution of the river. Effluents and barges belonging to the following industries were investigated and found to be free from defilement unless otherwise indicated.*

*Editor's Note: At various times in the past large masses of foam, seemingly due to the presence of a detergent, have been observed in the Ohio River at short distances below Dam 41 (McAlpine Dam) and not far from the site of the Colgate-Palmolive Plant on the north shore. This condition was not apparent at the time of the Surveillance Study.

INDUSTRY	REMARKS
1. Shell Oil Company	None
2. National Oil Company	Leaky gasoline barge, hoses well capped
3. American Compressed Steel	None
4. American Bitumuls and Asphalt	None
5. International Salt	One trickling effluent
6. E. T. Slider Company	None
7. Sinclair Oil Company	None
8. Nugent Sand Company	None
9. Louisville Refineries	One submerged pipe
10. Gulf Oil Company	None
11. Aetna Oil Company	One line not capped; oil on bank
12. Standard Oil Company	All lines capped except one
13. Union Carbide Company	One clear effluent
14. Paddy Run Power Plant	None
15. Triangle Refineries	None
16. Sunoco Oil Company	None
17. Stauffer Chemical Company	None
18. Cane Run Power Plant	Large clear effluent
19. Mile 620 (unidentified)	Oil lines open

In summary, Region VI is notable for its relatively good conditions. One major industry seems to be polluting the water. Beargrass Creek was not studied since it is being separately investigated. This creek may constitute a source of pollution. Other than this, this region is uniformly high in dissolved oxygen and is characterized by being richly endowed with clean and often strikingly beautiful tributaries.

TABLE VI - Chemical-Physical Measurements in Region VI

Station	Mile Point	Dissolved Oxygen (mg/l.)	pH	Water Temp. (°C)	Copper mg/l.	Iron mg/l.
Ohio River above 18-Mile Creek	581.0	12.5	7.8	26	0	0.20
Mouth of 18-Mile Creek	580.8	10.2	8.5	27	0	0.22
Mouth of 14-Mile Creek	589.3	13.5	7.4	27.7	0	0.22
500 yards up Harrod's Creek	595.8	8.1	8.0	26	0	0.55
Ohio River	596.5	8.4	8.0	26	0	0.16
500 Yards up Goose Creek	596.9	7.4	8.0	26	0	0.50
Ohio River	610.0	11.6	7.6	26.7	—	—
Effluent at American Synthetic Rubber	613.4	—	6.4	—	0	0
Ohio River	620.0	11.6	7.6	26.7	0	0.48
Ohio River above Salt River	629.5	10.3	8.0	26.7	0	0.41
Mouth of Salt River	629.8	13.4	8.6	28.2	—	—
Ohio River below Salt River	630.3	10.3	8.1	26	0	0

Maximum NO_3 2.2 PO_4 1.1

Minimum NO_3 1.2 PO_4 0.6

Region VII

Miles 828.0 to 867.0 mark the limits of Region VII. This region is almost free of any industrialization or other possible sources of pollution. Except for Highland Creek, the river and its tributaries are very rich in dissolved oxygen (13.6 - 22.4 mg/l.). Highland Creek had 4.5 mg/l. dissolved oxygen 1/4 mile from the mouth, and 5.4 mg/l. at the mouth. The Ohio River continued to become more alkaline in this region, the pH varying from 8.2 to 8.6. No copper was recorded. Small amounts of iron were detected in the Wabash River (0.45 mg/l.). This perhaps accounts for the appearance of iron in the Ohio River in the region of the Wabash (0.22 mg/l.) and its increase to 0.31 mg/l. just below the Saline River.

Lost Creek differed from other tributaries in the region in that the water was muddy-red, probably a product of the strip-mining in the area.

In general, there was no evidence of pollution in this area of the Ohio River, either from upstream contamination of the Ohio or from tributaries and industries in the area.

TABLE VII - Physical-Chemical Measurements in Region VII

Station	Mile Point	Dissolved Oxygen mg/l.	pH	Water Temp. (°C)	Copper mg/l.	Iron mg/l.
Ohio River	828.0	13.2	8.2	22.2	0	0
Mouth of Highland Creek	841.8	5.4	7.3	24.5	0	0
1/4 Mile up Highland Creek	841.8	4.5	——	——	——	——
Mouth of Lost Creek	843.0	22.4	8.0	25.6	0	0
Ohio River	844.0	14.5	8.6	31	0	0
Ohio River above Wabash River	847.5	15.1	8.6	28.2	0	0.22
Mouth of Wabash River	848.0	14.4	8.2	27	0	0.16
Ohio River above Saline River	865.8	14.1	8.6	28.2	0	0.22
Mouth of Saline River	867.4	20.9	8.6	29.5	0	0.45
Ohio River below Saline River	867.9	15.3	8.2	31	0	0.31

The Kanawha River

The Kanawha River was investigated from Charleston, West Virginia to the point where it enters the Ohio River at Point Pleasant, on July 26, 1960.

Description of the Stations

Station 1: Samples were acquired in the center of the river at a point about 100 yards downstream from its confluence with the Elk River. Both sides of the river are heavily urbanized. The water is brownish in color. Oxygen 8.5 p.p.m., 9:15 a.m., pH 7.1.

Station 2: Below Charleston the river is divided into two streams by a long island. The eastern-most branch is not subjected to heavy industrialization. The western-most branch received the discharge from about 30 to 40 major effluent pipes emanating from property inhabited by two major chemical plants. One of these plants is on the island and the other is on the western bank of the Kanawha. About 15 to 20 dead carp, bullheads and suckers were seen floating at the surface of the water in this stream. Chemical odors were so intense that it was difficult to take samples without becoming nauseated. The odors were sickeningly sweet and were detectable all the way to the Ohio. That the effluvium emanates from the water is demonstrated by the fact that even those plankton samples taken near the mouth of the Kanawha effused the odor two days after being preserved in formaldehyde. A scum of various reds, whites and yellows covers the water in the polluted stream until it joins its sister stream at the south end of the island.

Station 3: This station is at the first highway bridge below Charleston at about Mile 52. No effluents were seen below the island. The chemical odors are still intense. The water is still brownish in color. Dissolved oxygen is 2.4 p.p.m. Minor raw sewage effluent 100 yards below bridge 9:55 a.m., pH 6.7.

Station 4: Mile 50 east bank across from chemical plant. Pile of sulfur extends to water's edge.

Station 5: Chemical plant on west bank at Mile 50. Constructing new large effluent pipe. Sickening sweet odor, smelled like oil of citronella; three major effluents, the last effluent giving foamy water across to opposite shore; 1/4 mile above Criss and Sharer Concrete Company.

Station 6: 10.25 a.m. Second bridge below Charleston; Mile 46; oxygen 0.7 p.p.m. pH 7.0.

Station 7: American Viscose: Mile 42.5. Very strong odor (burnt hair); four major effluents.

Station 8: 10.56 a.m. Mile 40.7. Odor still prevalent. pH 6.6.

Station 9: 11.40 a.m. Mile 32.9. Odor still strong; no chemical plants or municipal effluents since Mile 42.5 Water becoming greenish brown. pH 7.1.

Station 10: 12.25 a.m. Mile 25. No effluents since last station; odor weakening though detectable. Oxygen 2.9 p.p.m. pH 7.1; oxygenation should have occurred at dam. Odor picked up at Mile 23; same as at chemical plants.

Station 11: 1.05 p.m. Mile 17.5. Odor strong. pH 7.2.

Station 12: 1:40 p.m. Mile 10, water quite green now; odor still detectable; pH 7.2.

Station 13: Mile 2.5 Water had been very green for the last 10-15 miles. Oxygen 11.0 p.p.m. pH 7.1.

Station 14: Ohio River above the mouth of the Kanawha. Oxygen 17.2. pH 7.2. 2:40 p.m.

Remarks: No fishermen, or shore birds were seen the entire length of the Kanawha. Only one fish was seen to jump and that was near the mouth. People in the area say that the Kanawha has not been fished for years.

TABLE VIII. Physical-Chemical Measurements for the Kanawha River from Elk River to the Ohio River

Station Number	Dissolved Oxygen	pH	Fe.	Cu.	Station Description
1	8.5	7.1	0.45	0	Kanawha River 100 yds. below Elk River
2	——	6.9	0.71	0	Between Island and Shore
3	2.4	6.7	0.69	0	1st Highway Bridge
4	——	——	——	—	Mile 50
5	——	——	——	—	Chemical Plant at Mile 50
6	0.7	7.0	0.38	0	American Viscose at Mile 42.5
7	——	——	——	—	Mile 40.7
8	——	6.6	0.91	0	Mile 32.9
9	——	7.1	0.35	0	Mile 25
10	2.9	7.1	0.45	0	Mile 17.5
11	——	7.2	0.58	0	Mile 10
12	——	7.2	0.41	0	Mile 5
13	11.0	7.1	0.69	0	Mile 2.5
14	17.2	7.2	0.31	0	Ohio River above Mouth of Kanawha River

11 Chemical Samples
6 Oxygen Determinations
11 pH Determinations

Part II
ICHTHYOLOGICAL INVESTIGATIONS

Field Methods and Materials

Fish were collected from lock chambers by applying Pronoxfish, a rotenone compound manufactured by the S. B. Penick Company of Chicago, Illinois. Five gallons were applied to each of the lock chambers at Montgomery Dam, Industry, Pennsylvania and Lock 41, at Louisville, Kentucky. These locks are 56 feet by 360 feet and have an area of approximately 0.45 acres. The remaining locks are 110 feet by 660 feet with an area of approximately 1.67 acres each. Ten gallons of Pronoxfish was used in each of these larger locks. In all locks the approximate concentration was 1 p. p.m.

The compound was diluted about 3:1 with water and then distributed evenly in the upper two-thirds of the lock chamber. Currents due to leakage and other factors distributed the Pronofish to the lower one-third. As the fish rose to the surface, they were picked up by dip nets, and those less than 50 centimeters in length were preserved in 10% formalin and returned to the Potamological Institute, Louisville, Kentucky. All fish in excess of 50 centimeters were weighed, measured and discarded at the site at which they were taken.

Total length was determined in centimeters (cm.) by use of a fish measuring board. Weights were recorded in grams. Fish over 50 cm. were weighed by a suspension scale. Fish under 50 cm. were weighed with one of the following types of scale: Chatillion suspension scale, Ohaus analytical balance, or Mettler electronic balance. All <u>Ictalurus punctatus</u> under 15 cm. were sorted into classes of 1-cm. interval. Those of each size class were weighed collectively and the mean weight of the specimens in the group was then calculated. The same method was used for Aplodinotus grunniens under 9 cm. Whenever large numbers of Notropis atherinoides and N. volucellus were taken, all specimens of each species were weighed collectively, and their mean weight was determined.

Representative samples of the fish obtained during this study are presently in the museum of The Potamological Institute. These are being retained for future investigations on their food habits, relationships, life histories, etc.

Results

Fish Collections

Seven collections of fishes were made in U. S. Navigation Lock Chambers by use of Pronoxfish within a six weeks period beginning July 20, 1960, and ending August 19, 1960. One additional collection was made in connection with filming of the movie "Beargrass Creek" on September 22, 1960, at Lock 43, at New Boston, Indiana. All lock chambers studied are listed in the introduction.

A total of 29 species of fishes representing 10 families were taken during the study. (Table XIV). The most abundant fish in numbers was Notropis atherinoides which accounted for almost half (48.7%) the total number taken. Aplodinotus grunniens and Ictalurus punctatus were the next two most abundant species with 20.3% and 12.3% respectively (Table XVI).

Ictalurus punctatus accounted for 54% of the total weight of all fishes taken, and Aplodinotus grunniens and Ictalurus melas accounted for 19% and 12% respectively (Table XVII).

Only three species were taken in every area studied. These were *Notropis atherinoides*, *Hybopis storeriana*, and *Ictalurus punctatus*. Some species were fairly scarce in the collections. Table XV shows the numbers of individuals of each species sampled.

No more than fourteen and no fewer than eight species were taken at any one station. Total numbers of individual fishes ranged from 243 at Station III to 4,219 at Station II. Total weight in grams ranged from 15,296 at Station I to 59,375 in Station V. Altogether, 10,827 fish weighing 257,446 grams were collected during this study (Table XV).

Total numbers, weights and their percentages for each species have been calculated for each area (Tables XVI and XVII).

Ictalurus punctatus and *Aplodinotus grunniens* occurred in sufficient abundance at most stations to permit reasonably valid determinations of the length-weight relationships of each species. In order to compare variation in "condition" of fish of a given species in the various areas, the theoretical weight for various lengths was calculated. The chosen lengths are 9 cm., 24 cm., and 39 cm., for *Aplodinotus grunniens* and 10, 20, 30, 40, and 50 cm. for *Ictalurus punctatus*.

The reason for employing the theoretical (calculated) weight rather than the actual weight is simply because there are too few specimens of precisely the same lengths from the different areas. The practice is conventional.

The length-weight relationship is given by the following equation:

$$W = AL^n$$

Where:

W = Weight

A = Weight of a fish of unit length (1 cm.)

L = Length

n = Exponential increase in weight for any given length.

For any given length of fish, the theoretical weight can be calculated most easily by putting the equation in logarithmic form as follows:

$$\text{Log } W = A + n\ (\text{Log } L)$$

The results of these calculations are shown in Tables IX and X, and are discussed in the following section.

DISCUSSION

II. Species Composition

A. Relative Abundance

Species composition of Station I was unusual in that a wide variety of minnows appeared here and nowhere else. Some fishes considered common in the river, such as Dorosoma cepedianum, the gizzard shad, Ictalurus punctatus, the channel catfish, and Cyprinus carpio, the carp, were scarce in this sample. In general, the sample was dominated by the various minnows and by Ictalurus melas, the black bullhead. There was a relative paucity of carnivorous fishes in this area, a fact which may account for the large variety and numbers of minnows. It is significant that the black bullhead, a fish tolerant to low dissolved oxygen, is abundant in the highly industrialized area. Except for a single carp, large fishes which are exclusively bottom feeders were absent from the sample.

In Station II, Notropis atherinoides, the emerald shiner, reached its maximum numbers. Several other members of the genus that were taken at Station I were not taken in this sample. Ictalurus melas continued to be relatively high in numbers and Ictalurus punctatus first appeared in significant numbers.

Station III exhibited a marked change in species composition as compared to Stations I and II. Numbers of Notropis atherinoides dropped sharply and Pimephales notatus and Notropis volucellus were not found. Hybopsis storeriana, the silver chub, was the only minnow more abundant here than in Stations I and II. No Ictalurus melas were taken at this station or at any other station downstream while numbers of Ictalurus punctatus increased markedly. The inability of the channel catfish to thrive in upstream areas diminishes the competition for Ictalurus melas, and probably accounts for the large populations of the latter in upstream areas. Once conditions become suitable for I. punctatus, I. melas has difficulty competing and thus becomes scarce.

Two species of game fishes, Micropterus salmoides, the largemouth black bass, and Lepomis megalotis, the longear sunfish, and one member of the family Percidae, Percina caprodes, the log perch, appeared for the first time. These species are notably intolerant of heavily polluted water. Aplodinotus grunniens, the freshwater drum, also appeared in the collections for the first time. The fact that it is a bottom feeder would indicate an increase in the benthos.

Station IV was characterized by the continued abundance of Ictalurus punctatus. Aplodinotus grunniens increased in numbers over Station III. The percentage of minnows in this sample was considerably reduced. Fish were less abundant here than in other collections.

In Station V, an increase in the numbers of minnows was noted. The relative abundance of Ictalurus punctatus was very high, while the numbers of Aplodinotus grunniens decreased somewhat. This sample may not be representative inasmuch as an exceptionally heavy rainstorm occurred the night preceding the lock study and caused a sudden rise in the river. All wickets were thrown during the night and open river was run for a period of time. This may possibly have affected the composition of species in the lock chamber.

Station VII, the nest area downstream, had many young of the year of various species, an indication of good reproduction. Aplodinotus grunniens and Dorosoma cepedianum, together comprising approximately 87% of the total sample, were the most abundant fishes present.

This would indicate high productivity in both plankton and benthos. In general, the species composition here indicated water relatively free of industrial pollution.

Station VIII was worked fairly late in the season (September 22, 1960). This may account for some of the variations in species composition of the sample. Also, the complete pickup of fishes was halted before it was completed in order to permit the lockage of a towboat. The occurrence of *Stizostedion canadense*, the sauger, in this sample is indicative of comparatively clean water.

Station VI had the greatest variety of species, a condition associated with a high quality of water. *Ictalurus furcatus*, the blue catfish, which is highly intolerant of polluted waters, was found in abundance here. Pollution had not diminished the number of suitable habitants in this area, and the less strigent requirements for existence permitted a greater number of species to be present.

In summary, it is shown in Table XV that the upstream areas are inhabited by fishes more tolerant to industrial and municipal wastes. Samples from further downstream contain the more gamefishes and other fishes intolerant to pollution, an indication of less pollution.

B. Relative Weights

Biological productivity, rather than water quality, is indicated by relative total poundage from different areas. In particular, one may be interested in the potential poundage of commercial and game fishes which may be produced by a given body of water.

Cyprinus carpio, the carp, Ictalurus punctatus, the channel catfish, Ictalurus furcatus, the blue catfish and Aplodinotus grunniens, the fresh-water drum, are of commercial importance, and the minnows and shad must also be considered since they are the most abundant forage fishes.

Consideration of the data in Table XVI indicated that Regions III through VIII may be regarded as potential commercial and sports fishing areas, even though at the present time fish from some localities in this zone are not satisfactorily palatable.

II. Length-Weight Relationships.

A. Aplodinotus grunniens

From a study of the length-weight relationships for Aplodinotus grunniens (Table IX) and ponderal index (Table XIII), it is apparent that this fish grows best in Region VIII, well in Regions IV and V, and slowest in Region VII.

B. Ictalurus punctatus

In contrast to Aplodinotus grunniens, Region VII as well as VIII seem to be well suited for the growth of Ictalurus punctatus. Regions III and IV are the least suited for growth and weight accumulation.

In five of the areas, the small fish exibited a growth rate definitely different from the large ones. Region VI was especially poor for the growth of younger Ictalurus punctatus. This fact could indicate this area is deficient in the food, probably bottom organisms, that these small fish utilize.

SUMMARY

This study was made to determine possible persistant sources of pollution and to continue the studies of physical, chemical and biological aspects of the Ohio River.

Fish were collected at eight U. S. Navigation Lock chambers and limnological investigations were carried out on seven regions of the Ohio River and its tributaries.

Specifically, this investigation demonstrated that the Ohio River is characterized by heavy industrial pollution from Dashields Dam at Mile 13.3 to Dam 14 at Mile 113.7. This is indicated by the species composition of the fish fauna, the "condition" of fish in this area, specific limnological tests and by visual evidence. As investigations proceeded downstream, a gradual improvement in water quality and less pollution was noted. Pollution in these downstream areas did exist but was confined to local areas and evidently was not of sufficient degree to prevent recovery of river conditions. The extent to which such localized pollution depressed the recovery of the river cannot be known until the conditions of the heavily polluted areas upstream are considerably improved.

Limnological and biological evidence indicated that the following tributaries of the Ohio River were heavily polluted: Kanawha River, Wheeling Creek, Tanner's Creek, Licking River, Mill Creek at Cincinnati, and the Guyandot River. The Kanawha River is especially noteworthy in that it contributes a great volume of water to the Ohio River and is the most extremely polluted body of water studied during the investigation.

Municipal pollution does exist at various places in the Ohio River but it must be considered to be relatively insignificant in contrast with the great amount of industrial pollution present.

Conditions in the river are relatively good in downstream areas due to the "clean-up" program and according to oral communication with local citizens and lock personnel, conditions are improving throughout the length of the Ohio River.

TABLE IX - Length-Weight relationships of *Aplodinotus grunniens*

The relationship of weight to length may be expressed by the equation $W = AL^n$, where W = weight in grams, a is a constant which is the theroretical weight at unit length, L is length in centimeters, and n is a calculated exponent. The determined values of this equation areas III to VIII inclusive are as follows:

Station III	$W = 0.015\ L^{2.95}$	
Station IV	$W = 0.017\ L^{2.95}$	
Station V	$W = 0.010\ L^{3.12}$	
Station VI	(a) $W = 0.0064\ L^{2.05}$	(b) $0.00069\ L^{3.22}$
Station VII	$W = 0.016\ L^{2.86}$	
Station VIII	(a) $W = 0.0196\ L^{1.84}$	(b) $= .0060\ L^{3.29}$
	(a) under 10 cm.	(b) over 10 cm.

Representative Lengths cm.	Regions					
	III	IV	V	VI	VII	VIII
9	9.8	11.0	7.4	5.8	8.5	11.6
24	177	200	218	196	141	20.6
39	740	842	910	930	575	1020

TABLE X Length-Weight relationships of *Ictalurus punctatus*

Equations of length-weight relationship of this species were determined for each of the seven areas at which it was found in adequate numbers. Station I had one specimen. In five instances, length-weight relationships were determined for two different length groups. The smaller of the groups is given by equation A; the larger by equation B. The break-point represents the length in centimeters below which equation A will apply and above which equation B will apply. On those where no break-point is only a single regression line, determined by inspection, was required by the plotted logarithmic values of the weights and lengths of the measured specimens.

STATION	FORMULA A	BREAK POINT	FORMULA B
II	$W = 0.096L^{3.00}$		
III	$W = 0.096L^{1.27}$	5.6 cm.	$W = 0.011\ L^{2.93}$
IV	$W = 0.033L^{2.51}$	18.0 cm.	$W = 0.0057L^{3.08}$
V	$W = 0.013L^{2.92}$		
VI	$W = 0.033L^{2.08}$	10.0 cm.	$W = 0.0052L^{3.16}$
VII	$W = 0.015L^{2.84}$	19.0 cm.	$W = 0.0014L^{3.61}$
VIII	$W = 0.019L^{2.67}$	14.0 cm.	$W = 0.0029L^{3.38}$

TABLE XI. Theoretical calculated weight in grams, of *Ictalurus punctatus* of five representative lengths, from Stations II to VIII.

Representative Lengths (cm.)	Stations II	III	IV	V	VI	VII	VIII
10	9.6	9.9	10.7	11.0	7.6	10.4	9.1
20	77	71	57	83	68	72	72
30	259	240	209	275	251	311	283
40	614	537	490	616	603	878	752
50	1200	1047	1000	1202	1259	1965	1593

TABLE XII. Ponderal index of *Ictalurus punctatus*. $K = \frac{W + 10^2}{L^3}$

Stations	Length (cm.)				
	10	20	30	40	50
II	0.96	0.96	0.96	0.96	0.96
III	0.99	0.89	0.89	0.84	0.84
IV	1.07	0.71	0.77	0.77	0.80
V	1.10	1.04	1.02	0.96	0.96
VI	0.76	0.85	0.93	0.94	1.01
VII	1.04	0.90	1.15	1.37	1.57
VIII	0.91	0.90	1.05	1.17	1.27

TABLE XIII. Ponderal index of Aplodinotus grunniens

Stations	Length (cm.)		
	9	24	39
III	1.34	1.28	1.25
IV	1.51	1.45	1.42
V	1.01	1.57	1.53
VI	0.80	1.42	1.57
VII	1.17	1.02	0.97
VIII	1.59	1.49	1.72

Table XIV

List of fishes, by scientific and common names, and grouped by families, taken from the Ohio River during this study.

Lepisosteidae		
	Lepisosteus osseus	longnose gar
Clupeidae		
	Alosa chrysochloris	skipjack herring
	Dorosoma cepedianum	gizzard shad
Hiodontidae		
	Hiodon alosoides	goldeye
Catostomidae		
	Carpiodes carpio	river carpsucker
	Carpiodes cyprinus	quillback
	Ictiobus cyprinellus	bigmouth buffalo
Cyprinidae		
	Campostoma anomalum	stoneroller minnow
	Cyprinus carpio	carp
	Hybopsis storeriana	silver chub
	Notropis atherinoides	emerald shiner
	Notropis photogenis	
	Notropis spilopterus	spotfin shiner
	Notropis stramineus	sand shiner
	Notropis volucellus	mimic shiner
	Pinephales notatus	bluntnose minnow
Ictaluridae		
	Ictalurus furcatus	blue catfish
	Ictalurus melas	black bullhead
	Ictalurus nebulosus	brown bullhead
	Ictalurus punctatus	channel catfish
	Pylodictis olivaris	mud cat
Anguillidae		
	Anguilla rostrata	american eel
Centrarchidae		
	Lepomis gibbosus	pumpkinseed
	Lepomis megalotis	longear sunfish
	Micropterus salmoides	largemouth bass
	Pomoxis annularis	white crappie
Percidae		
	Percina caprodes	log perch
	Stizostedion canadense	sauger
Sciaenidae		
	Aplodinotus grunniens	freshwater drum

Table XV. The total number of specimens and their total and mean individual weights, by species, of fishes taken from the Ohio River.

Scientific Name	Number of Individuals	Weight (grams)	Mean Weight
Lepisosteus osseus	2	6.0	3.0
Alosa chrysochloris	11	2,366.9	215.2
Dorosoma cepedianum	546	6,581.3	12.1
Hiodon alosoides	5	2,047.0	409.4
Carpiodes carpio	34	8,481.9	249.5
Carpiodes cyprinus	1	83.0	83.0
Ictiobus cyprinellus	3	4,743.0	1,581.0
Campostoma anomalum	1	5.0	5.0
Cyprinus carpio	17	9,545.3	561.6
Hybopsis storeriana	206	1,737.6	8.4
Notropis atherinoides	5,267	6,402.5	1.2
Notropis photogenis	7	6.2	0.9
Notropis spilopterus	3	12.5	4.2
Notropis stramineus	4	9.3	2.3
Notropis volucellus	417	330.1	0.8
Pimephales notatus	10	21.5	2.2
Ictalurus furcatus	194	8,031.1	41.4
Ictalurus melas	729	30,249.0	41.5
Ictalurus nebulosus	1	198.0	198.0
Ictalurus punctatus	1,079	126,509.4	117.2
Pylodictis olivaris	81	3,913.3	48.3
Anguilla rostrata	1	29.2	29.2
Lepomis gibbosus	1	15.0	15.0
Lepomis megalotis	3	51.1	17.0
Micropterus salmoides	1	203.0	203.0
Pomoxis annularis	1	97.0	97.0
Percina caprodes	2	21.0	10.5
Stizostedion canadense	3	1,003.0	334.3
Aplodinotus grunniens	2,197	44,747.0	20.4
Totals	10,827	257,446.2	23.8

TABLE XVI

Total Number and Percentages of Total Numbers of Species by Region

Species	I No.	I %	II No.	II %	III No.	III %	IV No.	IV %
	REGIONS							
Lepisosteus osseus								
Alosa chrysochloris					1	0.9	8	73.0
Dorosoma cepedianum	1	0.2	1	.02			14	2.6
Hiodon alosoides								
Carpiodes carpio			1	2.9			6	17.6
Carpiodes cyprinus								
Ictiobus cyprinellus								
Campostoma anomalum								
Cyprinus carpio	1	5.9						
Hybopsis storeriana	6	2.9	9	4.4	34	16.5	3	1.5
Notropis atherinoides	1,293	24.5	3,719	70.6	2	0.0	8	0.2
Notropis photogenis	7	100.0						
Notropis spilopterus	3	100.0						
Notropis stramineus	4	100.0						
Notropis volucellus	377	90.4	40	9.6				
Pimephales notatus	8	80.0	2	20.0				
Ictalurus furcatus								
Ictalurus melas	307	42.1	422	57.9				
Ictalurus nebulosus								
Ictalurus punctatus	1	0.1	25	2.3	237	21.4	103	9.2
Pylodictis olivaris					5	6.2	4	4.9
Anguilla rostrata								
Lepomis gibbosus	1	100.0						
Lepomis megalotis					1	33.3		
Micropterus salmoides					1	100.0		
Pomoxis annularis								
Percina caprodes					2	100.0		
Stizostedion canadense								
Aplodinotus grunniens					41	1.9	97	4.4
No. Species	12		8		9		8	
No. Individuals	2,009		4,219		324		243	
Per cent of total number		18.5		38.9		3.0		2.2

TABLE XVI
(continued)
Total Number and Percentages of Total Numbers of Species by Region

Species	REGIONS V No.	V %	VI No.	VI %	VII No.	VII %	VIII No.	VIII %
Lepisosteus osseus	2	100.0						
Alosa chrysochloris	1	9.0					1	9.0
Dorosoma cepedianum	9	1.6	16	2.9	493	90.3	12	2.3
Hiodon alosoides			1	20.0	4	80.0		
Carpiodes carpio	4	11.8	15	44.1	7	20.6	1	2.9
Carpiodes cyprinus			1	100.0				
Ictiobus cyprinellus			3	100.0				
Campostoma anomalum	1	100.0						
Cyprinus carpio	4	23.5	3	17.6	5	29.4	4	23.5
Hybopsis storeriana	39	18.9	15	7.3	84	40.8	16	7.8
Notropis atherinoides	195	3.7	6	0.1	40	0.8	4	0.1
Notropis photogenis								
Notropis spilopterus								
Notropis stramineus								
Notropis volucellus								
Pimephales notatus								
Ictalurus furcatus			182	93.8	3	1.5	9	4.6
Ictalurus melas								
Ictalurus nebulosus					1			
Ictalurus punctatus	285	23.3	298	26.9	82	7.4	103	9.3
Pylodictis olivaris	8	9.9	49	60.5	12	14.8	3	3.7
Anguilla rostrata			1	100.0				
Lepomis gibbosus								
Lepomis megalotis	1	33.3			1	33.3		
Micropterus salmoides								
Pomoxis annularis			1	100.0				
Percina caprodes								
Stizostedion canadense							3	100.0
Aplodinotus grunniens	57	2.6	280	12.7	1,564	71.2	158	7.2
No. Species	12		14		12		11	
No. Individuals	579		843		2,296		314	
Per cent of total number		5.3		8.0		21.2		2.9

TABLE XVII

Weight in grams and per cent of total weight by species for each area

	AREAS							
	I		II		III		IV	
Species	W/gr	%	W/gr	%	W/gr	%	W/gr	%
Lepisosteus osseus								
Alosa chrysochloris					164.0	6.9	2,030.0	85.8
Dorosoma cepedianum	56.0	0.9	88.0	1.3			2,081.0	31.6
Hiodon alosoides								
Carpiodes carpio			436.0	5.1			2,750.0	32.4
Carpiodes cyprinus								
Campostoma anomalum								
Ictiobus cyprinellus								
Cyprinus carpio	492.0	5.2						
Hybopsis storeriana	26.1	1.2	81.6	4.7	596.8	34.3	28.5	1.6
Notropis atherinoides	1,737.0	27.1	3,635.0	56.8	7.5	0.1	18.5	0.3
Notropis photogenis	6.2	100.0						
Notropis spilopterus	12.5	100.0						
Notropis stramineus	9.3	100.0						
Notropis volucellus	299.3	90.7	30.8	9.3				
Pimephales notatus	17.1	79.5	4.4	20.5				
Ictalurus furcatus								
Ictalurus melas	12,422.0	41.1	17,827.0	58.9				
Ictalurus nebulosus								
Ictalurus punctatus	184.0	0.1	4,850.0	3.8	11,203.5	8.9	17,210.1	13.6
Pylodictis olivaris					8.5	0.2	385.6	9.6
Anguilla rostrata								
Lepomis gibbosus	15.0	100.0						
Lepomis megalotis					8.0	15.7		
Micropterus salmoides					203.0	100.0		
Pomoxis annularis								
Percina caprodes					21.0	100.0		
Stizostedion canadense								
Aplodinotus grunniens					4,138.1	9.2	17,942.2	40.1
Total Weights	15,276.5		26,952.8		16,350.4		42,445.9	
Fraction of Total Weight	.059		.105		.064		.165	

TABLE XVII
(Continued)
Weight in grams and per cent of total weight by species for each area

	AREAS							
	V		VI		VII		VIII	
Species	W/gr	%	W/gr	%	W/gr	%	W/gr	%
Lepisosteus osseus	6.0	100.0						
Alosa chrychloris	136.0	5.7					36.9	1.6
Dorosoma cepedianum	1,074.0	16.3	2,190.0	33.3	969.9	14.7	122.4	1.9
Hiodon alosoides			576.0	28.1	1,471.0	71.9		
Carpiodes carpio	1,296.0	15.3	3,411.0	40.2	358.7	4.2	230.2	2.7
Carpiodes cyprinus			83.0	100.0				
Ictiobus cyprinellus			4,723.0	100.0				
Campostoma anomalum	5.0	100.0						
Cyprinus carpio	894.4	9.4	2,922.0	30.6	1,273.0	13.3	3,962.8	13.3
Hybopsis storeriana	490.5	28.2	29.3	1.7	304.6	17.5	180.2	10.4
Notropis atherinoides	864.5	13.5	22.5	0.4	93.7	1.5	23.8	0.4
Notropis photogenis								
Notropis spilopterus								
Notropis stramineus								
Notropis volucellus								
Pimephales notatus								
Ictalurus furcatus			7,462.5	92.9	220.0	2.8	346.6	4.3
Ictalurus melas								
Ictalurus nebulosus					198.0	100.0		
Ictalurus punctatus	49,948.0	39.5	23,494.0	18.6	10,864.0	8.6	8.755.8	6.9
Pylodictis olivaris	1,509.5	38.6	1,062.8	27.2	416.3	10.6	530.6	13.5
Anguilla rostrata			29.2	100.0				
Lepomis gibbosus								
Lepomis megalotis	26.0	50.9			17.1	33.5		
Micropterus salmoides								
Pomoxis annularis			97.0	100.0				
Percina caprodes								
Stizostedion canadense							1,003.0	100.0
Aplodinotus grunniens	3,125.0	7.0	8,233.0	18.4	4,828.2	10.8	6,480.0	14.5
Total Weights	59,375.0		54,335.3		21,016.5		21,673.8	
Fraction of Total Weight	.231		.211		.082		.084	

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