# Growth and Movement of Fish in the Vicinity of a Thermal Discharge

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*Abstract*

This paper summarizes 2 years of study on the growth and movement of fish in three areas above, next to and below a thermal effluent into the White River at Petersburg, Indiana. The Indianapolis Power and Light Company (IPALCO) electric-generating plant operated a single 220 Megawatt (MW) unit in 1969, which caused an average temperature elevation of less than 1° Fahrenheit. In 1970 a second unit of 420 MW was put into operation which caused an average temperature elevation of 3°F. With both units operating, the Plants normal output is about 640 MW. It has a temperature change of 20°F and a rate of flow of about 675 cubic feet per second. Maximum discharge temperatures reached over 100°F and cooled gradually downstream.

Mark and recapture data showed a majority of the centrarchids to remain in the same areas as originally captured and to move away from the heated water less than towards it. Catch-per-hour electrofishing data also showed the number of centrarchids decreased in the heated water while the number of other species (more thermally tolerant) increased in the heated water.

Using the scale method, age and growth characteristics of 328 longear sunfish (*Lepomis megalotis*), 56 green sunfish (*Lepomis cyanellus*), 361 bluegill (*Lepomis macrochirus*), 489 spotted bass (*Micropterus punctulatus*), 194 white crappie (*Pomoxis annularis*), and 47 black crappie (*Pomoxis nigromaculatus*) were studied. Length-weight relationships were also tabulated for 2,158 gizzard shad (*Dorosoma cepedianium*). All fish were collected from May 1969 to November 1970.

No significant differences could be determined in the growth rates from separate areas, thus the data were combined to be presented as growth dynamics in this area of the White River. A comparison of the growth rates of these seven species with the same species studied in other areas in the Midwest showed that the White River specimens grow neither extremely slow nor extremely fast but rather fit within the range of established growth rates for the region.

In each species studied, the majority of the specimens fit into the II, III and IV-year age classes, with fewer fish in the age classes above IV. Although fewer specimens fit into the age O and I-year classes, this was attributed to collecting gear selectivity and not to a reduction in the numbers of these age specimens in the area.

## Introduction

From May 1969 to November 1970 a study was conducted to determine the effect of a thermal effluent from the Indianapolis Power and Light Company (IPALCO) electric-generating plant on the growth and movement of fish in the White River near Petersburg, Indiana (3, 5, 16). The Plant operated a single 220 MW unit in 1969 which caused an average temperature elevation of less than 1°F. In 1970 a second unit of 420 MW was put into operation which caused an average temperature elevation of 3°F. With both units operating, the Plant's normal output is about 640 MW. It has a $\Delta$ T of 20°F and a rate of flow of about 675 cu ft/sec. This paper presents information related to the growth and movement of various species of fish as related to the heated effluent which reached temperatures over 100°F during the summer months in the discharge area and cooled as it moved down-river.

## Description of the Study Area

The study area consisted of three river sections: Section A (above the Plant), Section B (mixing section) and Section C (below the Plant) covering 2,400, 3,200 and 6,700 feet, respectively, and 25, 33 and 69 surface acres, respectively. An additional section designated Relocated Lick Creek (RLC) which is a ditch containing little water except during periods of high river water, was also studied. Sections A, B and C averaged 450 feet wide and were fairly homogeneous with mostly wooded shorelines dotted with fallen trees, overhanging branches and submerged logs. The depth normally ranged from 4 to 14 feet with sluggish midstream currents of 1 to 3 ft/sec. The bottom consists of mud, sand, silt, washed gravel and hard clay. The water level fluctuates about 30 feet during flood conditions and is usually turbid with Secchi disc readings of less than 1 to 2 feet. The White River in this area is typical of midwestern rivers which drain agricultural bottom land. The sections are not identical with respect to depths, currents, bottoms and other habitat requirements of fishes.

## Methods

All fish were captured by means of a 600-v d-c, battery-operated electro-fisher. Most of the collecting was done along the shores of each section in water ranging in depth from 6 inches to 4 feet, except in RLC where the entire section was always shocked.

A shocking run was conducted by boat about 10 feet from shore up or downstream at idling speed. Each run was timed and all fish captured were marked with acrylic polymer dye and an accessory fin clip (2) and returned to the mid-point of each section. A particular combination of fin and dye color was sufficient to identify a recaptured fish as to date and section of its original capture. A scale sample was taken from the caudal peduncle of each fish to be used in calculation of age and growth, and all fish were measured to the nearest 0.5 cm and weighed to the nearest gram for calculation of condition factors. All age and growth analyses were performed by standard fisheries techniques as described in detail by Ricker (18) and Benda (3).

## Results and Discussion

As a group, the centrarchids studied were shown to remain for extended periods in the section of the river where captured and released. Less movement was shown away from the heated water than towards it. Table 1 shows the number of fish marked and recaptured in each section in each year and where the fish were recaptured in relation to where they were first captured. The majority of the fish were recaptured in the same section they were originally captured and marked indicating restricted movements of centrarchids such as Gerking (8, 9) found. The spotted bass, bluegill and white crappie showed more movement toward the heated water than the longear sunfish which showed greater movement away from the heated water. It was determined that as temperatures increased in the discharge area to over 100°F all species abandoned this area as their tolerances were reached.

TABLE 1. *Number of fish marked and recaptured and the per cent of recaptured fish which were retaken in the same section (PRS), retaken moving toward the heated section (PRT), and retaken moving away from the heated section (PRA) for both years.*

| Species and Section | 1969 Number Marked | 1969 Number Recapt. | 1969-70 % PRS | 1969-70 % PRT | 1969-70 % PRA | 1970 Number Marked | 1970 Number Recapt. |
|---|---|---|---|---|---|---|---|
| Longear sunfish | | | | | | | |
| Section A | 61 | 19 | 98 | 2 | | 70 | 8 |
| Section B | 103 | 45 | 87 | | 13 | 53 | 5 |
| Section C | 95 | 6 | 71 | | 29 | 56 | 1 |
| Spotted bass | | | | | | | |
| Section A | 76 | 21 | 94 | 6 | | 126 | 21 |
| Section B | 75 | 36 | 82 | | 18 | 148 | 45 |
| Section C | 57 | 1 | 69 | 25 | 6 | 107 | 5 |
| Bluegill | | | | | | | |
| Section A | 81 | 10 | 70 | 30 | | 141 | 11 |
| Section B | 48 | 7 | 81 | | 29 | 77 | 18 |
| Section C | 73 | 2 | 100 | | | 70 | 6 |
| White crappie | | | | | | | |
| Section A | 48 | 2 | 75 | 25 | | 64 | 5 |
| Section B | 32 | 1 | 100 | | | 33 | 3 |
| Section C | 47 | 2 | 100 | | | 12 | 1 |
| [1]Other species | 790 | 12 | 72 | 17 | 11 | 1604 | 23 |

[1] Includes carp, carpsucker species, gizzard shad, white bass, largemouth bass, and shortnose gar.

Electrofishing catch data based on time in Table 2 shows that Section B, except for June 1970, had a higher rate for fish captured per hour than Section A and except for September 1970 than Section C. Gammon (7) found that although there were losses in numbers of certain species of fish (centrarchids), other more thermally-tolerant species (carp, *Cyprinus carpio*, longnose gar, *Lepisosteus osseus*, shortnose gar, *Lepisosteus platostomus*, carpsuckers, *Carpiodes* sp., etc.) moved into the heated area and the standing crops either remained the same or increased.

Fish of all species left the river during flood conditions and sought the quieter waters of Relocated Lick Creek (RLC). This can be seen in Table 2 when collecting was done in RLC. This was evidenced only during flood conditions especially in June 1970 when 172.6 fish per hour were collected. Overall the movement of fish was temperature dependent and as temperatures increased and tolerances were exceeded, all fish eventually abandoned the heated water and moved into cooler water areas.

Table 3 shows the body length-magnified scale radius relationship for six species of fish, while Table 4 shows the back calculated mean total lengths for the 1,475 fish by species. A comparison of the growth rates of the six species of centrarchids studied in the White River with the same species studied in other areas of the Midwest shows that the White River species grows neither extremely slow nor extremely fast, but rather falls within the range of established growth rates (1, 4, 6, 10 thru 15, 17, 19).

TABLE 2. *Catch of fish per hour by electro-fishing in Sections A, B, C, and RLC during June, July, August, September, October and November for 1969 and 1970.*

| Month-Year | Section | Total Fish | Total Shocking Time | Ave. No. Fish/Hour |
|---|---|---|---|---|
| 1969 | | | | |
| August | A | 245 | 10.7 | 23.6 |
| | B | 348 | 13.2 | 26.1 |
| | RLC | 188 | 3.6 | 54.8 |
| September | A | 380 | 12.8 | 20.2 |
| | B | 478 | 12.8 | 33.0 |
| October | C | 516 | 7.7 | 67.4 |
| | RLC | 30 | 0.4 | 71.1 |
| November | A | 28 | 1.5 | 18.6 |
| | B | 58 | 1.7 | 33.6 |
| 1970 | | | | |
| June | A | 577 | 13.6 | 42.1 |
| | B | 416 | 11.3 | 36.7 |
| | RLC | 214 | 1.5 | 172.6 |
| July | A | 187 | 5.5 | 33.3 |
| | B | 309 | 6.1 | 50.6 |
| | C | 202 | 4.0 | 50.5 |
| August | A | 384 | 8.9 | 43.1 |
| | B | 445 | 9.4 | 47.3 |
| September | A | 60 | 2.4 | 25.0 |
| | B | 50 | 1.5 | 33.3 |
| | C | 339 | 10.1 | 35.3 |

In each species studied the majority of the fish fit into the II, III and IV-year age classes with fewer fish in the age classes above these, which compares favorably to the other above-mentioned studies. The lack of numerous age class 0 and I fish was attributed to collecting gear selectivity rather than to lack of fish in these groups.

TABLE 3. *The relationship between magnified scale radius (SC) in mm and total length (TL) in mm: (CF indicates the correction factor); (r indicates the regression coefficient).*

| Species | Number | Body-scale Relationship | CF | r |
|---|---|---|---|---|
| Longear sunfish | 328 | SC = —2.0155 + 0.3536 TL | —11.2939[1] | .925 |
| Spotted bass | 489 | SC = —1.8768 + 0.2609 TL | 7.1251 | .971 |
| White crappie | 194 | SC = —2.6827 + 0.3223 TL | 8.2908 | .945 |
| Bluegill | 361 | SC = —2.5202 + 0.3792 TL | 6.5004 | .951 |
| Black crappie | 47 | SC = 5.5445 + 0.2925 TL | —21.5293[1] | .912 |
| Green sunfish | 56 | SC = 0.807 + 0.2882 TL | — 4.4811[1] | .845 |

[1] Indicates a linear intercept of 0.00 was assumed due to the regression line intercept being a negative value.

Table 5 shows the mean condition factors for 1969 and 1970 divided up into length intervals for four of the species studied. Mean condition factors for 1970 for longear sunfish, bluegill, spotted bass and white crappie showed the fish to be in better condition (heavier at most length intervals) than those collected in 1969. This was attributed to increased silt in the river due to more frequent flood conditions in 1969 than 1970 thus limiting feeding time for these piscivorous fish.

TABLE 4. *Calculated mean total length, mean weight, and total length increments of fish from the White River.*

| Age Class | Number of Fish | Mean Total Length (mm) | Total Length Increment (mm) | Mean Weight (gms) |
|---|---|---|---|---|
| | | 328 Longear Sunfish | | |
| 0 | 16 | 61.3 | 61.3 | 28.9 |
| I | 33 | 81.9 | 20.6 | 47.6 |
| II | 51 | 109.2 | 27.3 | 87.2 |
| III | 188 | 128.2 | 19.0 | 94.5 |
| IV | 25 | 140.2 | 12.3 | 102.3 |
| V | 13 | 148.8 | 8.3 | 123.6 |
| VI | 2 | 152.5 | 3.4 | 142.7 |
| | | 489 Spotted Bass | | |
| 0 | 137 | 75.5 | 75.5 | 33.3 |
| I | 93 | 102.1 | 26.6 | 38.7 |
| II | 48 | 153.1 | 51.0 | 66.3 |
| III | 139 | 194.5 | 41.4 | 113.8 |
| IV | 46 | 245.5 | 51.0 | 178.1 |
| V | 18 | 263.1 | 17.6 | 231.3 |
| VI | 8 | 270.4 | 7.3 | 351.3 |
| | | 194 White Crappie | | |
| 0 | 1 | 68.5 | 68.5 | 22.4 |
| I | 29 | 101.6 | 33.1 | 33.9 |
| II | 78 | 159.1 | 57.5 | 52.9 |
| III | 73 | 201.3 | 42.2 | 102.8 |
| IV | 8 | 244.4 | 43.1 | 165.3 |
| V | 4 | 250.0 | 5.6 | 262.5 |
| | | 361 Bluegill | | |
| 0 | 23 | 62.0 | 62.0 | 23.7 |
| I | 62 | 77.2 | 15.2 | 35.8 |
| II | 106 | 106.0 | 28.8 | 47.6 |
| III | 142 | 134.5 | 28.5 | 75.3 |
| IV | 16 | 168.3 | 33.8 | 108.5 |
| V | 7 | 182.1 | 13.8 | 148.3 |
| VI | 5 | 186.0 | 3.9 | 186.7 |
| | | 47 Black Crappie | | |
| I | 6 | 70.2 | 70.2 | 20.2 |
| II | 21 | 149.5 | 79.3 | 53.6 |
| III | 14 | 178.6 | 29.1 | 68.6 |
| IV | 6 | 188.9 | 10.3 | 136.2 |
| | | 56 Green Sunfish | | |
| 0 | 8 | 72.4 | 72.4 | 25.5 |
| I | 33 | 77.3 | 4.9 | 34.6 |
| II | 14 | 95.8 | 18.5 | 44.3 |
| III | 1 | 135.6 | 40.0 | 61.7 |

TABLE 5. *Mean condition factors for length groups of Centrarchids for 1969 and 1970.*

| Length Group (mm) | Longear Sunfish | | Bluegill | | Spotted Bass | | White Crappie | |
|---|---|---|---|---|---|---|---|---|
| | 1969 | 1970 | 1969 | 1970 | 1969 | 1970 | 1969 | 1970 |
| 55 | — | — | — | — | — | 8.1 | — | — |
| 75 | 5.1 | 6.6 | — | — | — | — | — | — |
| 85 | 3.5 | 5.5 | 3.5 | 5.6 | 3.5 | 5.4 | — | — |
| 95 | 3.4 | 5.0 | 3.0 | 4.3 | — | — | — | — |
| 105 | 3.0 | 3.9 | 2.8 | 3.9 | — | — | — | — |
| 115 | 3.1 | 3.8 | 2.7 | 3.2 | 2.2 | 2.9 | 2.1 | 1.5 |
| 125 | 2.9 | 3.6 | 2.2 | 3.3 | — | — | — | — |
| 135 | 2.9 | 3.5 | 2.7 | 3.0 | — | — | — | — |
| 145 | 2.8 | 3.1 | 2.2 | 3.0 | 1.5 | 2.4 | 1.4 | 1.7 |
| 155 | 2.8 | 3.2 | 2.5 | 2.9 | — | — | — | — |
| 165 | 2.6 | 3.3 | 2.2 | 2.8 | — | — | — | — |
| 175 | — | — | 2.5 | 2.8 | 1.3 | 1.9 | 1.4 | 1.5 |
| 185 | — | — | — | 2.9 | — | — | — | — |
| 205 | — | — | — | — | 1.4 | 1.7 | 1.4 | 1.6 |
| 235 | — | — | — | — | 1.3 | 1.5 | 1.4 | 1.5 |
| 265 | — | — | — | — | 1.3 | 1.4 | 1.4 | 1.5 |
| 295 | — | — | — | — | 1.3 | 1.3 | — | — |

A comparison of the length-weight distributions of 2,158 gizzard shad collected with those from the study by Lagler and Applegate (4) showed the majority of the fish were in age classes II, III, IV and V, based on their length intervals. The comparison of weight-length data showed most of the fish were in weight groups below 260 g.

Overall the seven species of fish studied displayed average growth rates when compared to other areas indicating normal growth of these fish in this section of the White River. Their growth does not seem to be affected by the thermal discharge either beneficially or detrimentally.

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