AN ABSTRACT OF THE THESIS OF

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Title: Growth of Channel Catfish in Two Farm Ponds in the Kansas Flint Hills

Abstract approved: Robert F Clarke

A study was undertaken to determine the growth of channel catfish, Ictalurus punctatus, in two farm ponds in the Flint Hills region of Kansas. One pond had an existing channel catfish population while the other did not. Nineteen fish were captured from the first pond (Bell's Pond) and pectoral spines were removed for analysis. The length of each fish was recorded for each year of its life. Average sizes were: Age I yr, 9.17 cm; age II yrs, 20.68 cm; age III yrs, 29.36 cm; age IV yrs, 33.63 cm; age V yrs, 39.21 cm; age VI yrs, 45.35 cm; age VII yrs, 47.77 cm. In the spring of 1982, 250 fish, averaging 12.52 cm in length, were placed in the second pond (Gladfelter Pond) which did not have an existing catfish population. Twenty-eight of the stocked fish were captured during the spring and summer of 1983. These averaged 24.83 cm in length and 109.9 g in mass. Turbidity readings were taken for both ponds in early March, 1983. The pond with the previously existing catfish population had a turbidity reading of 64.7 ppm, whereas the other pond had a reading of 53.0 ppm. It was concluded that the turbidity levels in the two ponds had no marked influence on the growth of the channel catfish. The length-weight relationship (WR) values were low for the channel catfish in both ponds. The average WR for fish from Bell's Pond was 73.9 and average for fish from Gladfelter Pond was 79.95. No definite conclusion was reached concerning the reason for the low WR values.

GROWTH OF CHANNEL CATFISH IN TWO FARM PONDS IN THE KANSAS FLINT HILLS

A Thesis
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the Division of Biological Sciences
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In Partial Fulfillment
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Master of Science

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INTRODUCTION

The purpose of this study was to determine the age and growth rates of channel catfish, *Ictalurus punctatus* (Rafinesque), in two different small impoundments and to derive pertinent judgments from the value obtained as to the growth of the fish and the suitability for growth in the two impoundments. Special focus was placed on the turbidity of the two impoundments, since turbidity has been shown to influence growth of channel catfish (Davis, 1959; Buck, 1956).

This study was initiated in November, 1981, with fish collection starting in September, 1982. The study extended into August, 1983, at which time adequate samples were collected from both study sites.

The channel catfish is native to the Great Plains region of Canada, Hudson Bay drainage, St. Lawrence River, Great Lakes, Mississippi Valley, and streams tributary to the Gulf of Mexico (Davis, 1959). The fish has been widely introduced since the 1880's and now occurs in most rivers in the United States (Moore, in Blair et al, 1957). The channel catfish is native to all the major river systems in Kansas (Cross and Collins, 1974); and Doze (1925) stated that by 1925 it had become more numerous in the southwestern part of the state than it was in the 1880's.

Schoumacher and Ackerman (1967) classified the channel catfish as the most important game fish in most of our inland waters, and of major importance as a commercial fish in the Mississippi and Missouri Rivers.

Simco and Cross (1966) stated that the increased number of farm ponds in Kansas has stimulated a growing interest in raising channel catfish for sport, food, and profit. They also gave six advantages of channel catfish as pond fish:

(1) Channel catfish are native, well known to Kansas anglers, and

are highly popular both as sport and table fish.

(2) They are tolerant of varied environmental conditions, including turbid water. Buck (1956) has shown that turbid water is not conducive to good growth and reproduction of bluegill and bass but that catfish do well in both clear and muddy water.

(3) Channel catfish attain large size; the record for the species exceeds 60 pounds. Occasionally, catfish weighing 25 pounds or more are caught from lakes in Kansas, and farm ponds have been known to produce channel catfish as heavy as 17 pounds. Although such large fish are unusual, they indicate the great capacity for growth that is an important attribute of any sport fish. At normal rates of stocking, channel catfish attain a desirable size early in life; therefore, they are available for capture by anglers during a large part of their life-span.

(4) Channel catfish are omnivorous and opportunistic in their feeding habits (Davis, 1959). Consequently, they readily use supplemental feeds introduced in ponds, making it possible to increase pond-production greatly.

(5) Natural reproduction of channel catfish in ponds is not usually excessive (Marzolf, 1957; Davis, 1959). Thus, knowledge of the approximate number of channel catfish in a pond is possible, and there is little likelihood of stunted growth due to over-population.

(6) Fingerling channel catfish for stocking-purposes are available from state, federal, and several private hatcheries.

When fish are stocked into a pond, or if they are being raised for commercial purposes, it is desirable to know the rate of growth of the fish. A knowledge of the age and rate of growth is extremely useful in management. Lagler (1956) stated that age and growth work has its practical applications in dealing with the following problems.

(1) At what age does a fish attain sexual maturity? How long must it be held to reach breeding age? How long will a fresh stock of young reproduce?

(2) At what age will a given species reach catchable size? This is important for fishery regulations.

(3) Determination of the age reached in a given environment may help to discover environmental unsuitabilities.

(4) A comparison of the rate of fish growth in different bodies of water may partly identify good or bad environmental conditions

and point the way for future action.

(5) Relation of age and growth in any body of water to a regional average, as in (4), is a measure of environmental suitability for the species in question.

(6) A partial test of attempts of environmental improvement is afforded by the effect of the changes made on growth rate.

(7) Age and growth studies show that stocking is an appropriate followup measure (subsidiary of point [6]).

(8) Continuing studies of age and growth in particular bodies of water will show the normal flucuations from year to year and over periods of years necessary for the proper interpretations of deviations which single samples may show from a regional average.

DESCRIPTION OF STUDY AREAS

Gladfelter Pond

Gladfelter Pond is a man-made impoundment located on the F. B. and Rena Ross Natural History Reservation approximately 22.5 km northwest of Emporia, Kansas. The early history of the Ross Natural History Reservation and descriptions of its vegetation and topography have been reported by Hartman (1960), Wilson (1963), and Spencer (1980).

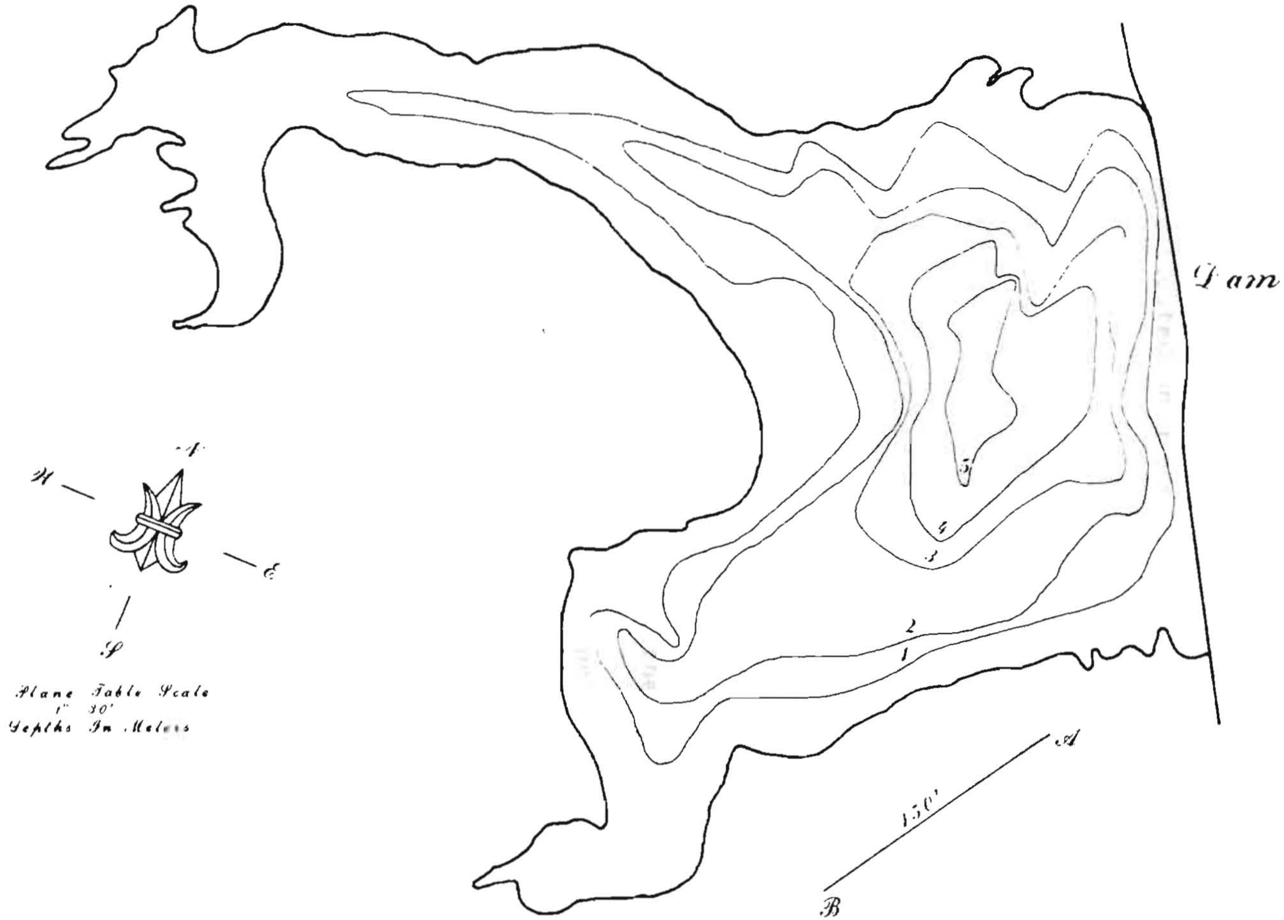
The pond's watershed was approximately 32.3 ha consisting almost entirely of grassland, with few trees and no land under cultivation (Jones, 1977). There had been little use of the grassland or pond by livestock and, consequently, little, if any, livestock waste had been deposited in or washed into the pond. This, coupled with no wading by livestock, helps to control turbidity problems in most ponds.

Initial maximum depth of Gladfelter Pond was 6.1 m (Griffith, 1961). The Emporia State University Limnology class found the maximum depth to be slightly over 5 m in June, 1968 (Fig. 1). Jones (1977) described Gladfelter Pond as having a surface area of 1.0 ha spillway level. He also stated that the pond was relatively turbid, with the euphotic zone rarely exceeding 1.6 m in depth.

The fish in Gladfelter Pond were killed by the use of rotenone in the fall of 1980. It was believed that all fish in the pond were killed at that time.

Green sunfish (*Lepomis cyanellus* Rafinesque) were observed in the pond in 1981. Their presence can possibly be explained by the fact that water flowed around the spillway in the summer of 1981, thus allowing green sunfish to swim upstream and establish a population. Approximately five pounds of fathead minnows (*Pimephales promelas* Rafinesque) were

Figure 1. Topographic map of Gladfelter Pond showing depth in meters (1-5).



Gladfelter Pond, R.N.H.R.
Limnology Class
June 1968

placed in the pond on April 28, 1981. Glass Shrimp (*Palaemonetes kadiadensis*) were also introduced into the pond at that time.

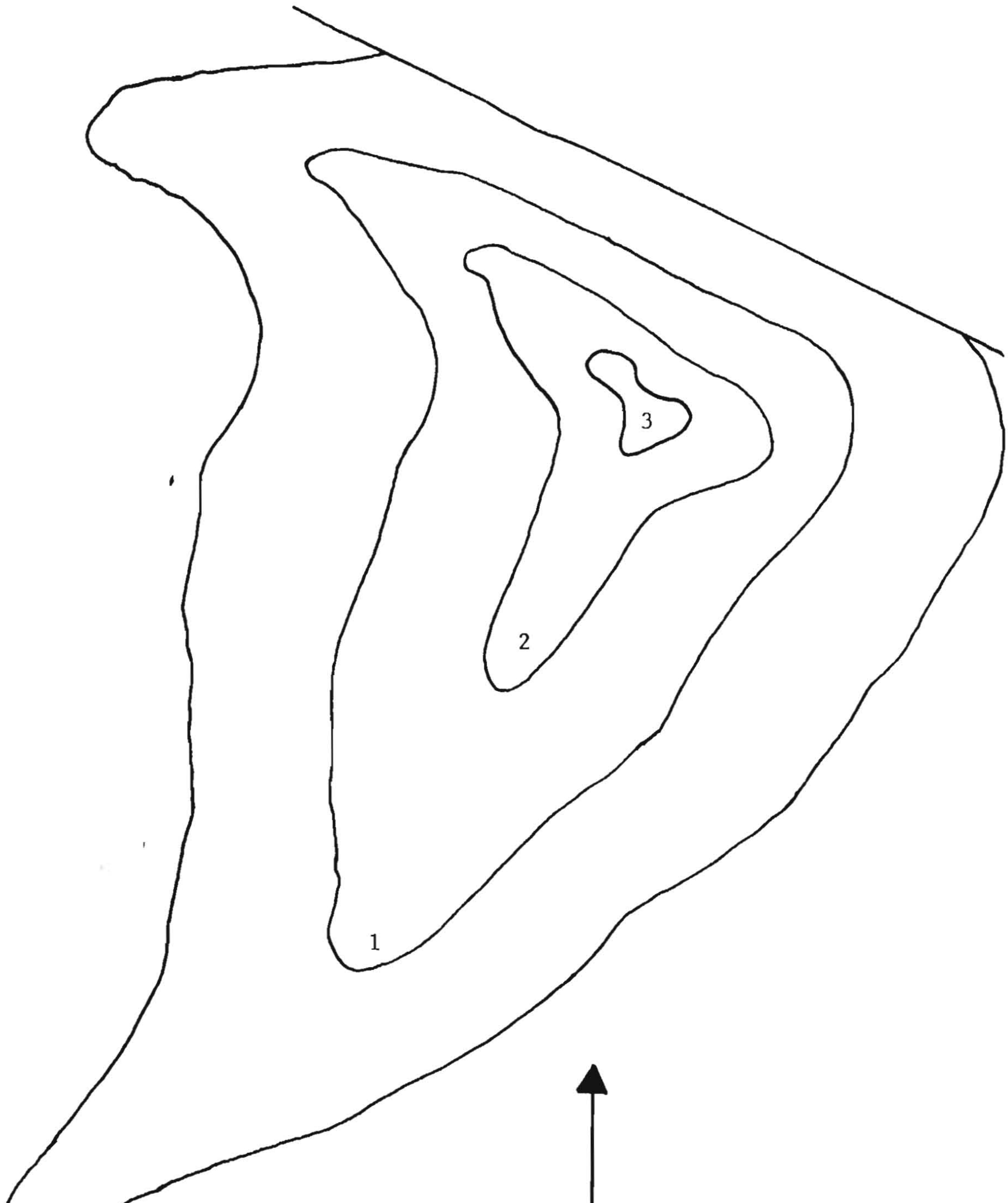
Bell's Pond

The second pond, Bell's Pond (Fig. 2), used in the study, located approximately 24.5 km southwest of Emporia, is also a man-made impoundment. It is located on property owned by Jane Bell of rural Cottonwood Falls, Kansas.

Surface area of the pond was approximately 0.5 ha. Maximum depth was slightly greater than three m (Fig. 2) when the pond was full to spillway level. The watershed consisted of pastureland with few trees and no cultivated land. It was used by cattle from mid-May to early fall annually and serves as a major water source for the cattle. Because of this use, there appeared to be a slight turbidity problem.

After being drained and rebuilt, the pond was restocked in 1977 by Kansas Fish and Game Commission personnel. Species stocked were channel catfish, bluegill sunfish (*Lepomis macrochirus*), and large-mouth bass (*Micropterus salmoides*) (Bell, 1983).

Figure 2. Topographic map of Bell's Pond showing depth in meters (1-3).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METHODS AND MATERIALS

Description of the Species

Channel catfish can be distinguished from all other catfish in Kansas, except blue catfish (Icatalurus furcatus) by their forked caudal fin; the caudal fin of all other catfish is either square or rounded (Davis, 1959). The channel catfish is generally slender, pale, and steely blue with a few dark spots scattered over its sides. Young fish less than four inches long, and large, old fish often lack spots (Cross and Collins, 1975). The anal fin of channel catfish is rounded and contains 24-29 supporting rays.

When growth is rapid, sexual maturity may be reached by channel catfish at three years of age, but may take four or five years in areas where growth is slow (Cross and Collins, 1975). In Kansas, channel catfish spawn from late May through July and perhaps later, with the peak in June and July (Doze, 1925; Brown, 1942; and Marzolf, 1957). Optimum spawning temperature for channel catfish is 80 degrees Fahrenheit (Clemens and Sneed, 1957).

It has been observed by several investigators that the food habits of channel catfish change as they increase in size. Mathur (1971), found that the stomachs of young channel catfish in Pennsylvania contained 68 to 76 % zooplankton by weight. Devaraj (1976) found zooplankton was second to dipterans in volume of stomach content in young catfish (47-100 mm). Bailey and Harrison (1948), while studying food habits of channel catfish gathered from the Des Moines River, Iowa, found that stomachs of fish less than 100 mm in length contained 98 % insects by volume. Davis (1959) also found the food of channel catfish less than four inches long to be insects, primarily larval forms of midges, black flies, mayflies, and caddis flies.

Bailey and Harrison (1948) reported that channel catfish four to 12 inches long continue to utilize insects, but as the fish grew larger, insects of larger size (mayflies and caddis flies) were eaten more often than midges and blackflies. They indicated that fish greater than 12 inches in length began to utilize fish as part of their diet. Busbee (1948) found some fish in the stomach of 11 inch long catfish, but fish did not become a major part of the diet until the channel catfish reached 15 inches in length. Jerald (1970) noted that channel catfish in Lake Carl Blackwell, Oklahoma, became progressively more dependent on a diet of fish at a length of about 300 mm (11.8 inches). In a limited study in Louisiana, Perry (1969) indicated that a change in food from invertebrates to fish occurred when the fish reach a length of 376 mm (14.8 inches).

Channel catfish have a highly diversified diet that includes _Hexegenia_, _Chaoborus punctipennis_ (Savitz, 1975); immature Plecoptera, Diptera, clams, snails, (Hoopes, 1960); Odonata (dragonfly nymphs), Coleoptera adults, Sphaeriidae (mussels), crayfish, detritus (sticks, leaves, acorns, algae, and roots), (Lewis, 1972); salamander larvae, tadpoles, (Tiemeier and Elder, 1957); and various forms of forage fish (Dendy, 1946; Swingle, 1954).

Stocking of Fish in Gladfelter Pond

Two hundred and fifty channel catfish were placed in Gladfelter Pond on May 15, 1982. The fish were purchased from Oren Windle, a commercial fish producer, from Neosho Rapids, Kansas.

When measured at the time of stocking, a sample of 50 fish ranged from 10.5 cm to 15.5 cm in total length (Table 1). The average ($\bar{x}$) total length of the 50 fish was 12.52 cm. The fifty fish were weighed in groups

Table 1. Lengths and mass of channel catfish stocked in Gladfelter Pond.

Length (cm)	Mass/10 Fish (Grams)	Average Mass Per Fish (Grams)
13.5		
14.2		
11.9		
10.8		
14.0		
12.8		
12.3		
12.6		
12.8		
11.2	180.0	13.0
13.7		
12.2		
14.5		
11.2		
12.4		
11.9		
12.0		
11.5		
11.7		
12.6	160.0	16.0
13.2		
15.5		
11.6		
11.6		
11.4		
13.8		
12.9		
11.3		
11.6		
11.4	175.0	17.5
14.8		
12.8		
13.6		
12.2		
15.0		
11.7		
11.2		
11.7		
12.5		
13.4	197.0	19.7

Table 1. (Continued)

Length (cm)	Mass/10 Fish (Grams)	Average Mass Per Fish (Grams)
14.4		
13.4		
10.5		
11.2		
14.2		
13.2		
11.4		
12.2		
11.0		
11.5	155.0	15.5
$\bar{x}$ 12.52 (4.93 in.)		17.34

of ten at the time of stocking. The total group mass was then divided by ten to give the average mass per fish: $\bar{x}$ for the fifty fish was 17.34 g (Table 1).

Collection of Fish from Gladfelter Pond

Fish remained in the pond for approximately one year before sampling began. Collecting the fish was somewhat difficult and several different collecting methods were employed before an adequate sample was obtained.

The first attempt to obtain fish for the sample was made by setting six, wire fish traps. The traps were baited with a variety of items ranging from dead fish to liver. No fish was captured using the devices. A series of one inch and one and a half inch bar mesh gill nets was the next sampling method employed. A total of 150 feet of net was used each of seven nights. This method produced only four fish, so it was discontinued because of the little success in relation to effort spent, then a 100 foot long, 0.25 inch mesh seine was used. One additional fish was collected. The next method involved setting a series of three trotlines containing 25 hooks each. These were left in the pond for three nights and one fish was captured. The next two methods, neither of which proved to be successful, involved use of a backpack electro-fishing unit and two modified fyke nets. The entire shoreline was worked with the shocker but only fathead minnows and green sunfish were recovered. The fyke nets were left for eight days and nights. They were baited with cut-up shad but failed to capture specimens.

It should be noted that the water temperature, as well as the air temperature, remained quite cool during all of the efforts mentioned. Nets were run several days when there was snow cover on the ground. This may explain in part the lack of success, because channel catfish movement is reduced during cold weather.

The next attempt to collect fish was on July 9, 1983, using fishing poles equipped with small hooks baited with liver. This method was successful and a suitable sample was captured within a few hours during that evening and the next morning. A list of the fish caught, their sizes, capture method, and date caught is given in Table 2.

Collection of Fish from Bell's Pond

The primary fish collecting method used at Bell's Pond was trotlines. They were set several nights before catching enough fish for the study. The primary bait was liver. Only one fish was taken by a method other than trotlines; it was taken with a fishing pole and line. Table 3 lists the data for Bell's Pond.

Growth Determination in Gladfelter Pond

In May, 1982, 250 channel catfish, four to six inches in length, were purchased from a commercial fish producer. Fifty were measured and weighed before being placed in Gladfelter Pond (Table 1). An average size was determined for the stocked fish.

After approximately one year, a sample of the channel catfish population was captured from Gladfelter Pond. These fish were measured and weighed. Mean length and mass were determined (Table 2).

Average mean size for the fish when stocked was subtracted from the average size of the fish after one year's growth. The calculated value represented the average growth in length for the one year period.

Sectioning of Spines

Determination of age and growth by the sectioning of a pectoral spine was necessary for fish taken from Bell's Pond. Perry (1967) stated that age and growth determinations for catfish have long been based upon

Table 2. Channel Catfish recovered from Gladfelter Pond.

Date Caught	Capture Method	Length in mm	Mass in Grams	WR
2/27/83	gill net	227	76	77.5
2/27/83	gill net	218	72	83.7
2/27/83	gill net	210	62	81.4
2/28/83	gill net	215	70	85.1
3/03/83	100' seine	210	70	91.9
3/13/83	trot line	300	250	103.2
7/09/83	angling	251	110	80.9
7/09/83	angling	205	117	72.2
7/09/83	angling	230	86	83.9
7/09/83	angling	268	123	73.2
7/09/83	angling	270	172	99.9
7/09/83	angling	236	90	80.9
7/09/83	angling	266	118	71.9
7/09/83	angling	245	135	73.9
7/09/83	angling	275	143	78.3
7/09/83	angling	251	98	72.1
7/09/83	angling	247	92	71.3
7/10/83	angling	268	140	83.3
7/10/83	angling	262	139	89.0
7/10/83	angling	265	115	72.7
7/10/83	angling	269	123	72.3
7/10/83	angling	254	101	71.5
7/10/83	angling	263	144	91.1
7/10/83	angling	241	89	74.7
7/10/83	angling	269	128	75.2
7/10/83	angling	250	105	78.3
7/10/83	angling	261	117	75.9
7/10/83	angling	229	74	73.3
	Mean	248.3	109.9	79.95

$$WR = \frac{\text{Mass of Fish}}{\text{Standardized Mass}} \times 100$$

Table 3. Length, mass, and weight-relationship values for Channel Catfish taken from Bell's Pond.

	Length (cm)	Mass (G)	WR
	42.4	510	68.5
	42.5	475	63.3
	43.5	600	74.2
	45.3	670	72.3
	45.8	620	64.9
	46.3	680	68.7
	46.6	630	62.3
	46.9	760	73.6
	48.1	910	81.8
	48.6	850	73.4
	49.2	907	75.3
	50.4	1210	92.9
	50.6	1120	84.8
	43.8	640	77.4
	45.7	625	65.9
	47.5	800	74.4
	48.5	780	67.8
	49.7	924	74.2
	51.4	1230	88.5
Mean	44.6	750.4	73.9

counts of the annular rings on cross sections cut from the pectoral spine.

Spines were collected as described by Sneed (1951) by grasping the spine with a pair of pliers (Fig. 3), pressing the spine flat against the body (Fig. 4), and rotating it counter-clockwise until it was completely dislocated (Fig. 5 and Fig. 6). Sometimes it was necessary to cut muscles surrounding the spine on larger fish. All extraneous flesh was removed and spines were placed in envelopes labeled with pertinent data. No special treatment or preservation was needed since the spines were free of all tissue except a thin layer of skin (Fig. 7).

The spines were sectioned through the basal groove, distal to the articulating portion of the spine, as described by DeRoth (1965) (Fig. 8). The sections were cut using a Dremel moto-tool mounted on a manual microtome. Sections were made as thin as possible. When they were too thick, they were rubbed on fine carborundum paper until they were translucent.

The sections were then placed in 70 % alcohol to help produce a higher degree of differentation between translucent and opaque zones (Perry, 1967). The spines remained in the 70 % alcohol bath until they could be examined.

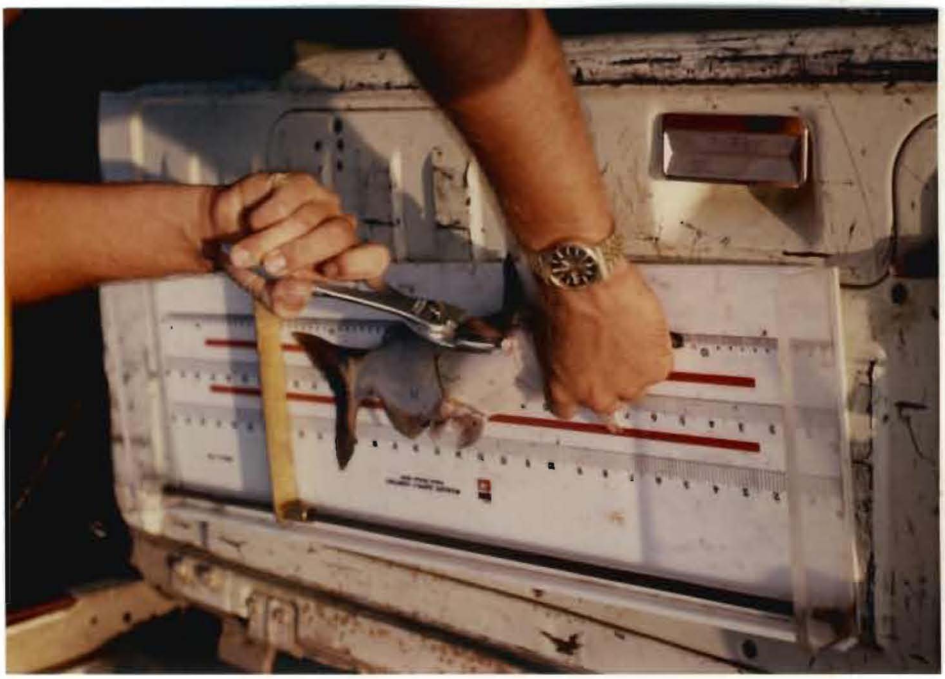
A Bausch and Lomb projection scope was used for spine analysis. Zones of growth appeared as translucent rings (annuli) alternating with opaque bands. Rings were regarded as annuli when they were distinct and appeared in all fields of the dissection. Marzolf (1955) described a false annulus as being incomplete or indistinct. He also stated that there was no question concerning the number or identity of winter and summer growth zones. This fact, coupled with the low incidence of false rings on the spines, indicated that growth marks of the spines were

Figure 3. Grasping of spine with pliers.

Figure 4. Pressing and rotation of the spine.

Figure 5. Dislocation of the spine.

Figure 6. Fish and spine after removal.



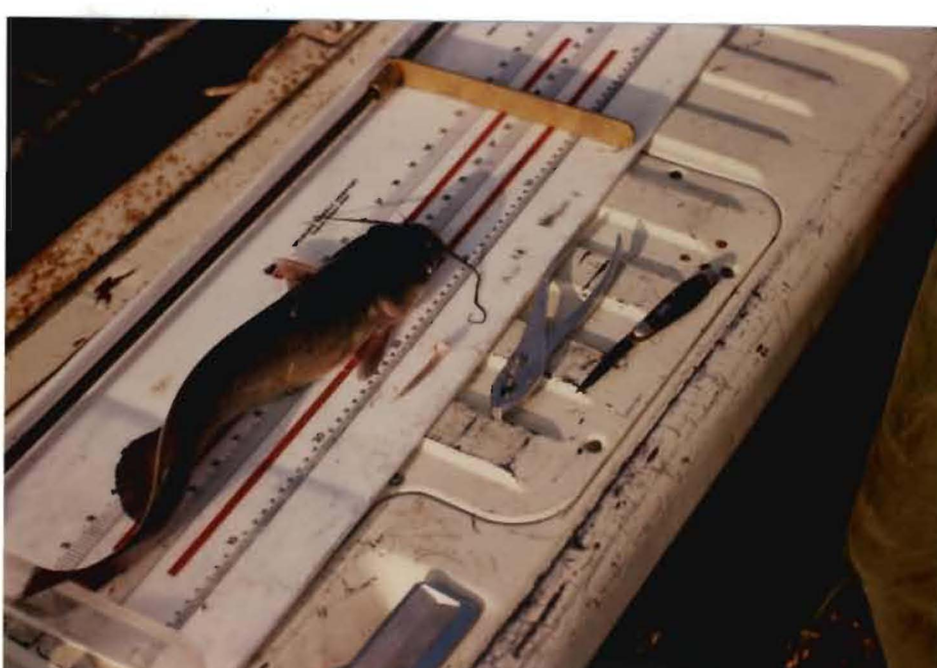


Figure 7. Spine removed and cleaned.


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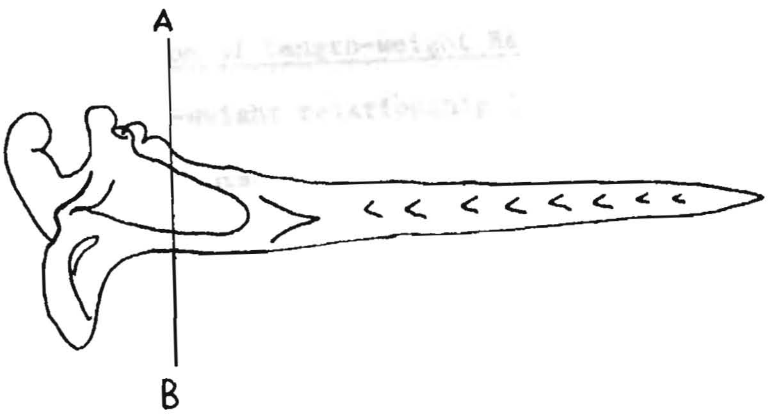
Figure 8. Spine showing line AB of dissection so age and growth could be determined.


A
B

reliable for indicating age of channel catfish. Measurements were taken on a projected image from the center of the spine to the outer edge. Additional measurements from the center to each successive ring representing a year of growth were also recorded.

The measurements were used to determine the length of the fish at different years of its life. The following formula was used to find the length of the fish at the appropriate years of growth (Davis, 1959):

$$\frac{\text{diameter of spine}}{\text{length of fish}} = \frac{\text{diameter of annulus x}}{\text{length of fish at year x}},$$

Determination of Length-weight Relationship

Length-weight relationship (WR) values were found by using a list of standard weights for channel catfish (Missouri Cooperative Fishery Research Unit, 1976). The weight of each catfish taken from Bell's Pond and Gladfelter Pond was divided by the corresponding value taken from the table of standard weights. This value was then multiplied by one hundred to give the final WR value for each fish. Table 2 and Table 3 list the WR values for the fish taken from Gladfelter Pond and Bell's Pond respectively.

Determination of Turbidity

Turbidity values were found by following the procedures described in Colorimetric Procedures and Chemical Lists for Water and Wastewater Analysis. A Bausch and Lomb Spectronic 20 set at 450 nm and one inch test tubes with a pond water sample were used for assessment. Turbidity values found for water taken from Gladfelter Pond and Bell's Pond are given in Table 4 and Table 5.

Determination of Standing Crop in Gladfelter Pond

In April, 1982, Gladfelter Pond was seined with a 20 foot long, 1/8 inch mesh seine. Seining was restricted to portions of the pond containing water approximately one meter or less in depth. The area which was

Table 4. Percent transmittance and parts per million for water from Gladfelter Pond, March 1, 1983.

	Percent Trans.		Parts per million
First tube	86		47
Second tube	81		59
Third tube	83		54
		Mean	53

Table 5. Percent transmittance and parts per million for water from Bell's Pond, March 3, 1983

	Percent Trans.		Parts per million
First tube	76		71
Second tube	81		59
Third tube	79		64
		Mean	64.7

seinable corresponds to the area shallower than the one meter contour line in Figure 1. Four species: green sunfish, fathead minnows, glass shrimp, and crayfish (Orconectes nais) were collected.

Eleven seine hauls were made, primarily in the 0-1 m contour, covering approximately 286.5 m^2 of surface area. Standing crop was estimated for the pond by calculating the number of individuals that would be in 4000 m^2 (1 acre). The standing crop was calculated on the assumption that the number of individuals found in the 286.5 m^2 area was representative of an entire acre. Standing crop estimated in this case was an estimate principally of the shallow water contour and may not be representative of the entire pond.

One problem encountered was the inability to seine the entire pond to make estimates of the complete pond rather than only the margins. Also, organisms may have been avoiding the seine, so that all the individuals in the sample area were not collected. Another consideration is that some organisms may have passed through the seine rather than being captured. (Seine was a selective device.)

The purpose of seining was to obtain a population estimation of the four species present prior to stocking of channel catfish.

RESULTS AND DISCUSSION

It was determined by spine connection analysis that fish length from Bell's Pond at respective ages (Table 6) were: age I, 9.17 cm (3.6 inches); age II, 20.68 cm (8.14 inches); age III, 29.36 cm (11.56 inches); age IV, 33.63 cm (13.24 inches); age V, 39.21 cm (15.44 inches); age VI, 45.38 cm (17.87 inches); and age VII, 47.77 cm (18.81 inches).

Several other studies have been conducted on the relationship between habitat and mean fish length. Klaasen and Townsend (1973) listed several such studies from various states in the United States (Table 7). Lengths recorded in this study are comparable to lengths Davis (1959) found for 1,567 fish from the state of Kansas (Table 7). Davis took fish from a variety of different habitat types (large lakes, ponds, and streams), so this comparison is not as valid as if his data were for fish lengths from Kansas farm ponds (Tiemeier, 1966). The average lengths found by Tiemeier (Table 8) are slightly larger at early ages through age V, but at age VI and VII, the reverse is true for fish from Bell's Pond.

Lopinot's (1968) data indicate that channel catfish grew faster in Illinois than in Kansas. His values were age I, 16.26 cm; age II, 24.38 cm; age III, 32.00 cm; age IV, 36.32 cm; age V, 42.42 cm; age VI, 46.99 cm, and age VII, 53.34 cm. These fish were also taken from ponds, so the comparison to this study is valid.

Additional data were collected by Finnel and Jenkins (1954) in Oklahoma waters. They found that channel catfish in Oklahoma ponds grow at a rate similar to Kansas channel catfish. Average sizes of fish from 24 ponds are as follows: age I, 10.92 cm; age II, 21.84 cm; age III, 30.99 cm; age IV, 37.34 cm; age V, 37.34 cm; age VI, 42.16 cm, and age VII, 43.69 cm.

Table 6. Length of fish in centimeters at various ages taken from Bell's Pond.

Fish (Total Length)	I	II	III	IV	V	VI	VII
42.4	7.95	19.43	27.38	31.80	37.10	42.40	
42.5	9.53	21.25	27.11	32.24	36.64	42.50	
43.5	7.84	19.97	27.81	31.38	37.08	43.50	
45.3	8.30	18.12	26.42	30.95	38.50	45.30	
45.8	9.99	19.15	26.65	31.64	38.31	45.80	
46.3	10.68	21.37	29.38	33.83	39.18	46.30	
46.6	9.64	20.09	31.33	34.55	40.17	46.60	
46.9	7.28	20.22	29.92	37.20	42.05	46.90	
48.1	9.31	20.17	32.58	37.24	43.45	48.10	
48.6	9.00	19.80	27.90	33.30	39.19	48.60	
49.2	12.10	24.20	33.88	37.10	42.75	49.20	
50.4	10.08	21.00	29.40	35.28	42.84	50.40	
50.6	9.98	20.74	29.73	36.18	43.24	50.60	
47.5	8.06	25.87	33.50	34.70	39.02	41.99	41.99
43.8	6.65	16.43	24.64	27.77	33.34	40.28	43.80
45.7	8.06	20.74	28.80	32.26	37.25	41.86	45.70
48.5	8.85	19.82	26.20	30.09	37.53	43.90	48.50
49.7	9.78	21.43	31.85	34.64	38.12	43.89	49.70
51.4	11.24	23.16	33.44	36.80	39.24	44.19	51.40
Mean	9.17	20.68	29.36	33.63	39.21	45.38	47.77

Table 7. Calculated total lengths (mm) of Channel Catfish at different ages from selected states of Central U.S.

LOCATION	I	II	III	IV	V	VI	VII
Kentucky Lake, Tenn. (Condor and Hoffarth, 1962)	*109	170	221	262	307	363	424
All Impounded Waters, Kans. (Davis, 1959)	* 94	211	257	297	323	361	429
Grand Lake, Okla. (Sneed, 1951)	77	144	210	269	333	401	456
5 Turbid Lakes, Okla. (Carlander, 1969)	76	152	213	262	310	358	421
Tuttle Creek Res., Kans. (Klaasen and Townsend, 1973)	60	145	201	257	301	344	394
Kanopolis Res., Kans. (Davis, 1959)	* --	160	203	241	272	320	292
Smoky Hill River, Kansas (Klaasen and Eisler, 1970)	34	120	174	209	240	298	336
Lake of the Ozarks, Mo. (Marzolf, 1955)	53	117	168	206	241	269	295

* Converted to mm from inches
Klaasen and Townsend, 1973

Table 8. Length of Channel Catfish in Kansas farm ponds.

	0	I	II	III	IV	V	VI	VII
Maximum	127.0	299.7	497.8	566.4	746.8	543.6	622.3	640.1
Minimum	61.0	147.3	221.0	249.0	259.1	264.2	281.9	287.0
Average	119.4	231.1	307.3	368.3	401.3	429.3	452.1	414.0
No. Ponds	(10)	(19)	(20)	(20)	(14)	(14)	(11)	(4)

Converted to mm from inches.

From Eiemeier, 1966.

Buck (1956) and Finnel and Jenkins (1954) stated that channel catfish grow faster in clear water than in turbid water.

Buck (1956) defined turbid water as that which had an average turbidity of 100 ppm or greater. He also stated that water having turbidity readings of 25 to 100 ppm had intermediate turbidities and water with values less than 25 ppm was considered clear. Tiemeier and Moorman (1957) classified Flint Hills (Kansas) ponds as being clear if the average of summer turbidity readings was 40 ppm or less and turbid if the readings were 101 ppm or above.

Turbidity values were measured for both Gladfelter Pond and Bell's Pond in March, 1983, (Tables 4 and 5). Turbidity readings for Bell's Pond ranged from 50 ppm to 71 ppm in three samples measured, with the average reading of 64.7 ppm. Readings for Gladfelter Pond were only slightly lower, with a range of 47 to 59 ppm and an average of 53 ppm. This would make the turbidities of the two ponds fall in the intermediate turbidity levels as defined by both Buck (1956) and Tiemeier and Moorman (1957). Jones (1977) stated that Gladfelter Pond was relatively turbid, with the euphotic zone rarely exceeding 1.6 m in depth.

It should be noted that samples for turbidity readings were taken in March. This is the time of year when ponds are clearest due to lack of run-off. Bell's Pond would be clearer this time of year because of lack of cattle watering in it. Cattle are only in the pasture from mid-May to early fall. Tiemeier (1966) stated that turbidity levels are highest from May through September because of increased precipitation rates as well as an increase in grazing and wading in the ponds by cattle. This would pertain to Gladfelter Pond in only one aspect since no cattle use the pond.

Turbidity levels in the two ponds probably verge on the 100 ppm level during the high turbidity months, if indeed they did not actually exceed it.

Perez (1970) found turbidity in Gladfelter Pond to be 123 ppm in October of that year. This was the highest turbidity value found, with the lowest being 30 ppm in February.

Schneberger and Jewell (1928), studying factors affecting pond fish production in Kansas, observed that, other factors being equal, fish production in ponds was directly related to clearness of the water when turbidities exceeded 100 ppm, but that other factors become more influential at lesser turbidities.

Since the turbidities in Gladfelter Pond and Bell's Pond reach the 100 ppm level during the growing period for the channel catfish, it is possible that turbidity levels were high enough to be a factor in growth achieved by fish in the two ponds according to the standards of Schneberger and Jewel (1928). The degree to which the fish were affected cannot easily be measured since there was no great difference between the growth achieved in the two ponds (Tables 2 and 3) and there was not a decisive difference from the sizes found in various other studies in Kansas and surrounding states.

Finnel and Jenkins (1954) stated that within each of the year classes turbidity appeared to retard channel catfish growth to a marked degree. Since there was no marked difference between the growth of fish in this study and growth of channel catfish in previous studies, it is concluded that even though it reaches a level at which it could be a factor in growth, turbidity was not an influential factor in the growth of channel catfish in Gladfelter Pond or Bell's Pond.

Another factor which can influence growth of channel catfish in ponds is whether or not there is natural reproduction taking place (Finnel and Jenkins, 1954). They found that ponds having natural reproduction produced slower growing channel catfish. This is probably due to the increased population in the pond; thus increased competition for available food.

Since no fish were found in Bell's Pond that were not from the original stocking, this would not be a problem. It is assumed that successful natural reproduction was not taking place. The fish in Gladfelter Pond had not reached a size capable of reproduction, so this problem does not apply to Gladfelter Pond at the present, but may in the future.

Lengths of fish taken from Gladfelter Pond and Bell's Pond are similar to fish lengths from other impoundments. However, the length-weight relationship is not good for fish from either pond. The length-weight relationship (WR) values (Tables 2 and 3) are much less than fish in ideal condition. Fish in ideal condition should have WR values that approach 100. The 100 value is representative of 100 percent of the standard weight for that length.

The fish from Bell's Pond had an average WR value of 73.9 and fish from Gladfelter Pond had an average WR of 79.95. These values are not close to the 100 value which is indicative of fish in ideal condition. It is not possible to know the exact reason for poor condition of fish from these ponds using the data secured in the study.

Gladfelter Pond had an abundance of forage food in it as indicated by the standing crop survey made prior to stocking of the channel catfish (Table 9). It is possible that the fish were not large enough to utilize available food sources. Busbee (1948) found that fish did not

Table 9. Estimated standing crop of Gladfelter Pond in April, 1982.

Type of organism	No. Collected	Estimated standing crop (No./Acre)
Orconectes nais	36	510
Pimephales promelas	662	9390
Lepomis cyanellus	155	2198
Palaemontes kadiakensis	94	1333

become a major part of channel catfish diets until the fish reached a length of fifteen inches. This could explain why the small channel catfish were not using the abundant supply of fathead minnows and green sunfish. A large number of glass shrimp, crayfish and frogs was also available to help enhance their diet. It has been documented that channel catfish under 100 mm in length have a diet consisting primarily of insects and zooplankton (Bailey and Harrison, 1948; Davis, 1959). There appeared to be a sufficiency of insects and zooplankton in the pond, so this should not have been a limiting factor. The fish were large enough (mean 248.3 mm) to utilize larger organisms by the time of collection.

There does not seem to be an explanation for the poor condition of the channel catfish unless the small catfish were in direct competition with the large green sunfish population for the available food.

No analysis was made on Bell's Pond to identify food that was available to the channel catfish there. Because of this, no definite conclusions are drawn as to why the fish were in such poor condition. It is known that bluegill and largemouth bass were placed in the pond at the time of stocking, so there should have been a source of food established by the reproduction of bluegill in the pond.

SUMMARY

A growth study of channel catfish was conducted in two ponds, Bell's and Gladfelter, in the Flint Hills of Kansas. One pond had an existing channel catfish population; the other pond was stocked with fish 4-6 inches in length. Pectoral spine cross-sections of fish from the existing population were analyzed to determine the length of the fish at each year of their life. A sample of the stocked fish was captured after one year to determine their growth. The size of the fish in Bell's Pond was age I, 9.17 cm; age II, 20.68 cm; age III, 29.36cm; age IV, 33.63 cm; age V, 39.21 cm; age VI, 45.35 cm; age VII, 47.77 cm. The fish recovered from Gladfelter Pond averaged 24.83 cm after one year. Using the Student *t* test, it was determined that there was no significant difference at the .05 confidence level between the size of the fish in Gladfelter Pond and Bell's Pond at both age I and age II.

Turbidity was determined for each pond. Bell's Pond had a turbidity of 64.7 ppm and the Gladfelter Pond had a turbidity of 53 ppm in March of 1983. It was concluded that the turbidity did not influence the growth of the channel catfish, since there was no marked difference from the growth of fish in other impoundments, as reported by several other biologists.

Length-weight relationship (WR) values were low for both ponds, with Gladfelter fish having an average of 79.95 and Bell's having an average WR of 73.9. No conclusion was made as to the reason why the fish were not in good condition because there seemed to be sufficient forage available.

LITERATURE CITED

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Bailey, R.M., and H.M. Harrison, Jr. 1948. Food habits of the southern channel catfish (Ictalurus lacustris punctatus) in the Des Moines River, Iowa. Trans. Amer. Fish. Soc., 75:110-138.

Bell, J. 1983. Personal Communication. Cottonwood Falls, Kansas.

Blair, A.P., W.F. Blair, P. Brodkorb, F.R. Cagle, and G.A. Moore. 1957. Vertebrates of the United States. McGraw-Hill, New York. 819 pp.

Brown, L. 1942. Propagation of the spotted channel catfish (Ictalurus lacustrus punctatus). Trans. Kansas Acad. Sci., 45:311-314.

Buck, D.H. 1956. Effects of Turbidity on Fish and Fishing. Oklahoma Fish. Res. Lab., Report No. 56, 62 pp.

Busbee, R.L. 1948. Piscivorous activities of the channel catfish. Prog. Fish. Cult., 30(1):32-34.

Carlander, K.D. 1969. Handbook of Freshwater Fishery Biology. Vol. One. Iowa State Univ. Press, Ames, Iowa. 752 pp.

Carrillo, B.A. 1977. Primary productivity in Gladfelter Pond. M.S. Thesis, Emporia State University, Emporia, Kansas. 46 pp.

Clemens, H.P., and K.E. Sneed. 1957. The Spawning behavior of the channel catfish (Ictalurus punctatus). U.S. Fish and Wildlife Service, A Special Scientific Report Fisheries No. 219, 2 preliminary 11 + 11 pp.

Condor, J.R., and R. Hoffarth. 1962. Growth of channel catfish, Ictalurus punctatus, and Blue Catfish, Ictalurus furcatus, in Kentucky Lake Portion of the Tennessee River in Tennessee. Proceedings of the 16th Annual Conf. S.E. Assoc. of Game and Fish Comm., 16:348-354.

Cross, F.B., and J.T. Collins. 1975. Fishes in Kansas, Univ. of Kansas Mus. Nat. Hist., Lawrence, Kansas. 189 pp.

Davis, J. 1959. Management of Channel Catfish in Kansas. Univ. Kansas Mus. Nat. Hist. Misc. Publ. No. 21. 56 pp.

Dendy, J.S. 1946. Food of several species of fish, Norris Reservoir, Tennessee. Rep. Reelfoot Lake Biol. Stn. 10:105-127.

DeRoth, G.C. 1965. Age and growth studies of channel catfish in western Lake Erie. Jour. Wildl. Mgt., 29(2):280-286.

Devaraj, K.V. 1976. On the food of channel catfish stocked in farm ponds. Aquaculture, 7(1):27-32.

Doze, J.B. 1925. The barbed trout of Kansas. Trans. Amer. Fish. Soc., 55:167-183.

Finnel, J.C., and R.M. Jenkins. 1954. Growth of channel catfish in Oklahoma waters: 1954 revision. Oklahoma Fish. Res. Lab. Rept. 41:ii + 1-37.

Griffith, S.J. 1961. The Physical and Chemical Characteristics and Occurrence of Fauna in a New Impoundment. Unpubl. M.S. Thesis. Kansas State Teachers College. Emporia, Kansas. 64 pp.

Hach Chemical Company. 1970. Colormetric Procedures and Chemical Lists for Water and Wastewater Analysis. 4th edition. Ames, Iowa. 103 pp.

Hartman, E.L. 1960. The F.B. and Rena G. Ross Natural History Reservation. Emporia State Research Studies, 8(4):5-39.

Hoopes, D.T. 1960. Utilization of mayflies and caddisflies by some Mississippi River Fishes. Trans. Amer. Fish. Soc., 89:32-34.

Jerald, A., Jr. 1970. Fecundity, Food Habits, Age and Growth, Length-weight Relationships, and Condition of Channel Catfish, Ictalurus punctatus (Rafinesque), in a 3300 Acre Turbid Oklahoma Reservoir. M.S. Thesis, Oklahoma State University, Stillwater, Oklahoma. 78 pp.

Jones. R.L. 1977. Planktonic and benthic metabolism in Gladfelter Pond. Unpubl. M.S. Thesis, Emporia, Kansas State College, Emporia, Kansas. 38 pp.

Klaasen, H.E. and M.K. Eisler. 1970. Age and growth of channel catfish in the Smoky Hill River of western Kansas. Trans. Kansas Acad. Sci., 73(4):439-445.

____________, and A.H. Townsend. 1973. Age and growth of channel catfish in Tuttle Creek Reservoir, Kansas. Trans. Kansas Acad. Sci., 76(3):248-253.

Lagler, K.F. 1956. Freshwater Fishery Biology. Second edition. Wm. C. Brown Company Publishers. Dubuque, Iowa. 421 pp.

Lewis, G.E. 1972. Summer food of channel catfish in a West Virginia flood control reservoir. Prog. Fish-Cult. 38(4):177-178.

Lopinot, A.C. 1968. Pond fish and fishing in Illinois. Fishery Bulletin No. 5. Illinois Dept. of Cons. Div. of Fish. Springfield, IL. 1-64 pp.

Marzolf, R.C. 1955. Use of pectoral spines and vertebra for determining age and rate of growth of the channel catfish. Jour. Wildl. Mgt., 19:243-249.

____________. 1957. The reproduction of channel catfish in Missouri ponds. Jour. Wildl. Mgt., 21:22-28.

Mathur, D. 1971. Food habits and feeding chronology of channel catfish, Icatalurus punctatus (Rafinesque), in Conowingo Reservoir. Proc. 24th Annu. Conf. Southeast Assoc. Game Fish Comm. 377-386 pp.

Missouri Cooperative Fishery Research Unit, USDI. 1976. University of Missouri, Columbia, Missouri.

Perry, W.G., Jr. 1967. An improved method of sectioning catfish spines for age and growth studies. Prog. Fish-Cult. 29(1):12.

______________. 1969. Food habits of blue and channel catfish collected from a brackish-water habitat. Prog. Fish-Cult. 31(1):47-50.

Perez, G.R. 1970. A comparative study of some physicochemical and biological characteristics of Gladfelter Pond. 1969-70. Unpubl. Research Report, Kansas State Teachers College, Emporia, Kansas.

Savitz, J. 1975. Specific growth rates of channel catfish (Ictalurus punctatus) in ponds. Trans. Illinois State Acad. Sci. 68(4):364-368.

Schneberger, E., and M.E. Jewell. 1928. Factors affecting pond fish production, Kansas Forestry, Fish and Game Comm. Bull. No. 9:5-14.

Schoumacher, R., and G. Ackerman. 1967. Comparative age and growth of channel catfish from some eastern Iowa rivers. Proc. Iowa Acad. Sci. 72:248-253.

Simco, B.A., and F.B. Cross. 1966. Factors affecting growth and production of channel catfish, Ictalurus lacustrus punctatus. Trans. Am. Fish. Soc. 80:174-183.

Sneed, K.E. 1951. A method for calculating the growth of channel catfish, Ictalurus lacustrus punctatus. Tran. Am. Fish. Soc. 80:174-183.

Spencer. D.L. 1980. Ross Natural History Reservation: The First Twenty Years, 1959-1979. Emporia St. Res. St. 64 pp.

Swingle, H.S. 1954. Fish populations in Alabama rivers and impoundments. Trans. Am. Fish. Soc., 83:47-57.

Tiemeier, O.W. 1966. Kansas farm ponds agricultural experimental station. Kansas State University of Agriculture and Applied Science. Manhattan, Kansas. Kansas Bulletin 488. pp. 1-64.

______________, and J.B. Elder. 1957. Limnology of Flint Hills Ponds for 1956 and preliminary report on growth studies of fish. Trans. Kansas Acad. Sci. 60(4):379-392.

______________, and R.B. Moorman. 1957. Limnological observations on some Flint Hills Farm Ponds. Trans. Kansas Acad. Sci. 60(2):167-173.

Wilson, J.S. 1963. Flowering plants of the Ross Natural History Reservation, Lyon and Chase Counties, Kansas. Emporia State Research Studies. 11(4):5-91.