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LIFE HISTORY OF CARP IN THE LAKE WINNEBAGO SYSTEM, WISCONSIN

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ABSTRACT

Carp (Cyprinus carpio Linnaeus) life history information was compiled from observations and collections made on Lakes Winnebago, Butte des Morts, Poygan, and Winneconne. Previously, lack of information on carp populations and ecology in these lakes has limited the development of management strategies for this species.

Methods and techniques are discussed for sampling of eggs, young-of-the-year, and adult carp. Adult carp were aged from cross-sections of the dorsal spine because of undefinitive annuli on scales and opercles.

Carp spawned in shallow vegetated habitats. The adhesive eggs hatched in 3-4 days, and the 5-mm larvae immediately became demersal. After about 3 days, the yolk sacs were absorbed and fry became mobile. Throughout their first summer, carp were found in vegetated cover.

Ranges in size distribution of age 0 carp indicated that extended spawning seasons were favorable to young-of-the-year recruitment. Young carp ate predominantly copepods, dipterans, and cladocerans; they ate almost no plant material. The mean female gonadosomatic index was 16.2%. Carp growth in all 4 lakes was better than average compared to other waters, and males and females commonly reached age XV. Female carp had greater longevity, slightly better growth, and higher condition factors than males.

INTRODUCTION

Carp (Cyprinus carpio Linnaeus) were first stocked in Wisconsin waters in the early 1880's (Frey 1940; Mraz and Cooper 1957). Since that time carp have been common in Lake Winnebago and Lake Butte des Morts in east central Wisconsin (Otis and Weber 1982). However, the lack of any specific information on carp populations and their ecology in these lakes has limited the development of management strategies.

A study was initiated in 1974 to obtain information on: (1) the commercial harvest in the Lake Winnebago system; (2) methods and techniques for sampling eggs, young-of-the-year, and adults; (3) primary spawning habitat; (4) reproductive biology; (5) habitat preferences of young-of-the-year and adults; (6) age and growth of young-of-the-year and adults; (7) food habits of young-of-the-year, (8) length-weight-condition relationships of adults; and (9) seasonal movement and homing tendencies of adults.

Seasonal movement and homing of carp determined by conventional tagging and radio telemetry were described in a separate publication (Otis and Weber 1982) with references to commercial harvest, sampling methodology, and habitat preferences of adults. This paper deals with life history information not covered in that report.

STUDY AREA

Lake Winnebago has an area of 137,708 acres with a maximum depth of 21.0 ft and average depth of 15.5 ft. The lake is roughly rectangular in shape: 28.0 miles long and 10.5 miles wide at its widest point (Fig. 1). The smaller upriver lakes are Poygan (14,102 acres), Winneconne (4,507 acres) and Butte des Morts (9,234 acres). These smaller lakes have maximum depths, located in the river channels, of 11.0 ft. or less

MATERIALS and METHODS

Egg and Young-of-the-Year Collection

The location of spawning areas was verified by egg collection. Carp eggs were collected throughout the study area (Fig. 1) in 1974, 1975, and 1976, with wire mesh (1/21 inch) baskets and conventional garden rakes. A rectangular basket (15 x 16 x 6 inches with angled front and mounted on a pole handle) was pushed across flat bottoms or shaken through vegetation. Rakes collected aquatic vegetation to which the highly adhesive eggs were attached.

Incubation and hatching of larval carp were described from observations made on eggs collected in Lake Poygan in 1974 and reared in a 5-gallon glass aquarium.

Young-of-the-year carp were collected between July and September of 1974-1976 with wire mesh baskets, fine mesh (1/8-1/16 inch) dip nets, 25-ft seine

(1/4-inch stretch mesh), 1-ft fyke nets (1/8-inch mesh) and a 150-300 volt direct current portable shocking unit of the type normally used in stream sampling. Young carp between 10-53 mm were readily captured by making random plunges into dense vegetation with fine mesh dip nets and the screened egg sampling basket. When the average size exceeded 40 mm, the electroshocking unit was more effective.

All young-of-the-year carp captured from 1974-76 were measured (to the nearest mm) to develop seasonal growth curves. Only young-of-the-year carp from 1974 were weighed (to the nearest gram).

Food habits were determined from 227 young-of-the-year collected from Lakes Winnebago, Butte des Morts, and Poygan from 5 July-8 August 1974, and from Lakes Butte des Morts and Poygan during 12-15 July 1976. Food items were counted and identified, at least to order, under a dissecting microscope (7 to 30X). Contents from the upper esophagus to the end of the lower intestine were identified using taxonomic keys by Pennak (1953), Eddy and Hodson (1969), Usinger (1973), and Hilsenhoff (1975).

Sampling Adult Carp

Adult carp were collected on Lakes Butte des Morts and Winnebago in late fall 1975, 1977, and 1979 with a 240-volt alternating current boomshocker unit. Fish were measured in the field to the nearest 0.1 inch (total length) and weighed to the nearest 0.01 lb. In 1975 and 1977, fish were then killed and sexed by inspection of the gonads, whereas in 1979 fish were sedated and sexed by examination of the urogenital opening as described by Heinrich (1934). Those carp from 1979 that could not be sexed by external characteristics were killed and examined internally.

Scales were taken from 1,686 fish in October 1975. Scales were removed from a point midway between the lateral line and the fourth anterior dorsal ray, pressed on cellulose acetate slides and read on a scale projector (44X). Opercle bones were taken from 917 of the carp as a supplemental criteria for age. Opercles were frozen for storage and later thawed and cleaned (McConnell 1952). Opercles were placed in a small screen basket and emersed in boiling water for 15 minutes to loosen the tissue. Tissue was removed with a scissors and scalpel, then each opercle was placed in a 50% bleach solution for five minutes, rinsed with tap water, scrubbed with a nylon abrasive pad, rinsed again, and dried.

It was not possible to make adequate age determinations from either 1,686 scales or 917 opercle bones taken in the 1975 Lake Butte des Morts sample because of extreme difficulty in locating definitive annuli. Age and growth determinations in this study were made from dorsal spines collected from Lake Butte des Morts on 10-14 October 1977 (1,000 samples) and 20-27 September 1979 (190 samples), and from Lake Winnebago on 3 October 1979 (144 samples).

Since the fish in the 1977 collections were killed, spines were removed with a knife by cutting the flesh at the spine's base, bending the spine anteriorly, and cutting at the basal articulation. In 1979, spines from live fish were taken by cutting 2-4 mm below the tip of the first soft dorsal flap with a 20-25 tooth/inch hacksaw blade. Spines were placed in scale envelopes with a file number, and pertinent data was recorded for each individual.

Age and growth were back calculated from the dorsal spines of 838 Lake Butte des Morts carp in 1977, and 270 Lake Butte des Morts and Lake Winnebago carp in 1979. Cross-sections of air-dried dorsal spines (Fig. 2) were made by securing each spine in a small bench vise and cutting thin sections from the base of the spine with a jeweler's saw (Wichers 1976). Spine sections were placed on a glass slide with a drop of mineral oil and examined on a scale projector (44X). Measurements of annuli for back calculations were made to the outer edge of each opaque, dark band (Fig. 2). An additional year was not attributed to the spine edge, even though annual growth was nearly complete in fall-sampled carp.

Lengths and weights from 2,914 carp from 1975, 1977, and 1979 were used in length-weight-condition comparisons. Unless specified, fish were grouped into 1/2 inch total length intervals. Condition, reflecting relative robustness, was expressed as:

$$C = \frac{W \times 100,000}{L^3}$$

where W=weight in lb and L=total length in inches.

Ovaries were collected from 976 mature female carp from Lake Butte des Morts--719 in October 1975 and 257 in October 1977. Ovaries which were free of external adipose tissue on the ovarian membranes were weighed to the nearest 0.01 lb in the field.

RESULTS and DISCUSSION

Spawning Habitats

Carp do not appear to select specific spawning habitat. In general, however, they prefer shallow (0.5 to 4.0 ft) vegetated areas (Jester 1974; Sigler 1958). Frey (1940) observed carp in Madison, Wisconsin lakes spawning on *Cladophora*, a filamentous green algae, in shallow water no deeper than the carp bodies. He also observed carp eggs on sago pondweed (*Potamogeton ceratophyllum pectinatus*) and coontail (*Ceratophyllum demersum*). Common marsh plants used by spawning carp in Lake St. Lawrence, Ontario (Swee and McCrimmon 1966) included coontail, sago pondweed, water moss (*Fontinalis*), bladderwort (*Utricularia*), water milfoil (*Myriophyllum*), and needle rush (*Eleocharis*).

The adaptability of carp to various spawning habitats was evident by the use of the different vegetative substrates in the different lakes in this study. In Lake Poygan in 1974, spawning was associated with sago pondweed. During early July, carp eggs were found in the scattered sago beds adjacent to shore in depths of 1.5 to 2.0 ft on firm, sandy substrates. Spawning carp and eggs were not found in the peripheral marsh areas in what appeared to be more optimum habitat--protected shallow areas with dense coontail, elodea (*Anacharis* sp.), and water milfoil in soft muck bottoms.

In contrast to the Lake Poygan observations, spawning activity in Lake Butte des Morts in 1974 appeared to be confined to peripheral marsh areas with cattail (*Typha* sp.) marsh edge over coontail in 0.5 to 1.0 ft of water at the shoreline over soft muck bottom. The sago beds in Lake Butte des Morts showed no evidence of carp spawning activity or eggs in 1974.

Major carp spawning areas are Supple Marsh at the south end of Lake Winnebago, Sunset Bay and the Fox River inlet on Lake Butte des Morts, and the Wolf River inlet to Lake Poygan (Fig. 1). Other spawning areas were located in all the lakes and rivers, but they lacked strong, consistent activity in 1972-80 observations. Movement and habitat preferences of adults in this system are described in a separate publication (Otis and Weber 1982).

Hatching and Fry Behavior

Carp eggs from Lake Poygan were incubated in the laboratory at 73-74 F. The adhesive eggs were collected with sago pondweed from an active spawning site and were assigned an incubation increment of 1 day. The eggs were "eyed" on the 2nd day and all were hatched on the 3rd day following collection. English (1952) found that carp eggs "eye" in 24 hours at 71 F and hatch in less than 96 hours.

Immediately after hatching, larval carp became demersal, dropping from the vegetation to the bottom. At that time they were about 5 mm in length. Larval carp were 3 mm at hatching in Utah lakes (Sigler 1958) and 5.0 to 5.5 mm at hatching in Canadian waters (McCrimmon 1968). The larvae remained on the bottom until yolk sacs were absorbed on the 3rd day after hatching. At this time fry became extremely mobile, moving from the bottom into the vegetation cover. Results from three years of field sampling indicated that this early association with vegetated habitat continues throughout their first summer.

Habitat of Young

Many authors have described the association of young-of-the-year carp with shallow, vegetated habitat (Frey 1940; English 1952; Sigler 1958; Swee and McCrimmon 1966; McCrimmon 1968; Wichers 1976).

In early summer, young-of-the-year carp in this study were generally found at the shoreline in shallow water (0.5 to 1.0 ft) with muck bottom and dense growths of coontail. Most areas were at least partially protected from excessive wind and wave action. The water was usually crystal clear and would not normally be suspected of harboring young carp. In late summer, water levels were lower in coontail beds still inhabited by young carp. The water was only 3-6 inches deep and covered with dense mats of floating, filamentous green algae.

The habitat locations were important for determining the extent of the annual hatch. Previously, we have used fine mesh nets, which are generally surface-towed in pelagic areas free of weeds. Although this extensive sampling has captured many larval species, larval carp have never been found in these open waters. Sampling away from vegetation will probably not capture larval carp except in a stream channel where recruitment is from an upstream site.

Growth of Young

Growth in total length of young-of-the-year carp from 1974-76 samples is shown in Figure 3. Mean young-of-the-year growth was near that observed in other waters; it was lower than growth from Clear Lake, Iowa (English 1952) and was higher than growth from Lake St. Lawrence, Ontario (McCrimmon 1968). Although mean lengths indicated a strong linear relationship with sampling date ($r=0.97$), the ranges in length were often dramatic and indicated an extended carp spawning season (Frey 1940; McCrimmon 1968). This was the case during field sampling, when on 24 July 1974, fertilized carp eggs and 2.6-inch fingerlings from the same year class were collected in the same area. The variation in size ranges observed later in the summer indicated that extended carp spawning was favorable to young-of-the-year recruitment.

Growth in weight of young-of-the-year carp from 1974 samples is shown in Tables 1, 2, and 3. Young-of-the-year carp weights were not recorded for 1975 and 1976 samples. T-tests on total mean weights by 10-mm length groups indicated that growth in weight was similar between the lakes ($P<0.99$). Most young-of-the-year carp were captured in Lake Butte des Morts (Table 2) followed by Lake Poygan (Table 3) and Lake Winnebago (Table 1).

Catch per unit of effort and mortality of young-of-the-year carp could not be estimated over their first summer due to sampling gear variability. Tables 1, 2, and 3 tend to show declining catch over the summer since 64% of young-of-the-year carp captured in 1974 were less than 50 mm total length and were primarily sampled in July. Dip nets and the portable direct current shocking unit (stream shocker) were more effective in capturing young-of-the-year carp in shallow vegetated habitat than were the seine or the boomshocker (electroshocking boat).

Food Habits of Young Carp

The food habits of 277 young-of-the-year carp from Lake Winnebago and the upriver lakes in 1974 and 1976 are shown in Table 4. Food items did not appear to change appreciably throughout the summer.

By total numbers, copepods were the dominant food item, followed by dipterans and cladocerans. Although no attempt was made to determine volumes or weights of these three major food items, the chironomids were the largest prey, and would constitute the bulk of the diet. Frey (1940) found that food of young Wisconsin carp in their first two seasons consists mainly of plankton, crustacea, and dipteran larvae. The lack of plant material in young-of-the-year carp stomachs confirmed previous observations that young carp eat predominantly animal material (Sigler 1958, Struthers 1929).

Ovary Weight Relationships

Figures 4 and 5 show that a highly correlated, linear relationship exists between ovary weight and the total length and total body weight of Lake Butte des Morts carp (sampled in the fall of 1975 and 1977). Total length by half-inch group, ranged between 16.5 and 35.9 inches and averaged 26.0 inches (Table 5). Mean body weight, to the nearest 0.01 lb, ranged from 2.63 to 25.50 lb and averaged 11.14 lb (Table 5). Mean ovary weight, to the nearest 0.01 lb, ranged from 0.22 to 4.37 lb and averaged 1.88 lb. The gonadosomatic index, expressed as percent ovary to body weight, ranged from 7.1 to 19.2% with a mean of 16.2%. Frey (1940) estimated that ovaries averaged 14-15% of the body weight in larger, mature carp from Madison, Wisconsin lakes.

Age and Growth of Adults

Scales and opercles traditionally have been used and reported in the literature as reliable criteria for aging carp in North American waters. As noted previously, we were unable to determine age from either of the structures because of extreme difficulty in locating definitive annuli by methods cited in the literature.

Frey (1940) was unable to age carp scales from Lake Mendota, Wisconsin, but he was successful with scales from other area lakes and rivers. The scale method was used with satisfactory results by Clifford (1973) in Ocean Lake, Wyoming, and by Walburg and Nelson (1966) in Lewis and Clark Lake, South Dakota. Walburg and Nelson (1966) found incongruities in the structure of carp opercle bones. Jester (1974) found carp scales and opercle bones suitable for valid age determination and growth computation in Elephant Butte Lake, New Mexico.

Many authors (McConnell 1952; Rehder 1959; Sigler 1958) that tried carp scales and opercle bones found that opercles provided the best results because scales after ages III-IV were difficult to age, opercles were simpler to work with, and there were fewer variations in opercle bone/body length relationships. We found that carp scales after age VIII were very difficult to age, and that carp opercles, when cleaned and held up to both reflected and transmitted light (English 1952), displayed no annuli. Opercles were then stained using separate solutions of oil, ionol, alizarin red dye, neutral red dye, bismark brown dye and fluorescein dye, and then X-rayed. However, results were also negative. Growth characteristics and physiology in eutrophic waters may be contributing to some differential densities or irregularities that obscure the annuli.

We aged carp using cross sections of the dorsal spine. This was the best method of aging carp in Pathfinder Reservoir, Wyoming, after scales and opercles were tried and rejected (Wichers 1976). Wichers (1976) provided evidence for validation of the fin spine method of aging described by Boyko (1940), who found collection and preparation time similar to other methods, with reduced reading time and increased accuracy. We found, as did Wichers (1976), that spine removal did not seriously injure the fish. For these reasons, dorsal fin spines were taken in 1977 and 1979 samples for age and growth determinations in this study.

The relationship between total length in inches (Y) and radius of dorsal spine cross section in mm (X) (Fig. 6) is:

$$Y=3.2367 + 4.3423 X \quad (r=0.99)$$

There was not a significant difference ($P<0.99$) between growth in carp from Lake Butte des Morts and Lake Winnebago, so data were combined and separated only by sex (Figs. 7 and 8; Tables 6 and 7). Growth of carp from this study area was better than average compared to other North American waters (Carlander 1969). Both male and female carp in this area commonly reached age XV, with one Lake Butte des Morts female reaching age XX. McCrimmon (1968) suggested that the life span for carp in North American waters seldom would exceed 20 years.

Most rapid carp growth in length was attained in the second year before gradually declining with age (English 1952; Sigler 1958; Walburg and Nelson 1966). Female carp were found to live longer than males and displayed slightly better growth. Frey (1940) found similar growth between male and female Wisconsin carp in their first two years, but thereafter females grew more rapidly. Sigler (1958) found male carp in Utah to be slightly longer and heavier than females, while others (Rehder 1959; Jester 1974) noted that females lived longer, but found no difference in growth rates between males and females.

Table 8 shows length, weight, and condition of female and male carp from 1975, 1977, and 1979 samples in Lakes Butte des Morts and Winnebago. Sex ratios contained slightly more males than females in the fall samples. Carp sex ratios were about even in Madison, Wisconsin waters (Frey 1940).

Condition of mature carp (Table 8) did not appear to change with increases in length and weight according to Rehder (1959). Average coefficients of condition in Clear Lake, Iowa, tended to decrease with an increase in the age and size of carp (English 1952). Wichers (1976) found that carp condition in Pathfinder Reservoir, Wyoming, increased with age, assuming it was due to gonad development. Carp condition factors from Lakes Butte des Morts and Winnebago displayed consistent similarities by length and weight, but when compared by sex, females showed higher condition than males (Table 8).

MANAGEMENT CONSIDERATIONS

In the course of this study, two items were unanticipated and, thus, are noteworthy to anyone engaged in future carp research or management studies. These include: 1) difficulty in capturing age 0 carp in the often restrictive habitats encountered; and 2) aging adult carp by conventional scale or opercle methods.

Approximately 3 days post-hatching, after fry move from bottom substrates up into dense vegetation and until they are about 40 mm, carp can be captured by making random plunges with wire mesh baskets (1/21 inch) or fine mesh dip nets (1/16 - 1/8 inch). The fry are found by carefully picking through the clumps of sample vegetation. When the average size of the young carp exceeds 40 mm, dip net avoidance becomes evident and a shocking unit should be employed. When habitats of carp were comprised of dense vegetation over shallow (<1 ft.) water and a soft muck bottom, access could only be gained with a portable shocker unit mounted in a shallow draft boat which can be push-poled (skiff style) through a sampling zone. Due to the often restrictive nature of these types of habitats, conventional sampling gear such as seines, traps, and large boomshockers were unsuccessful.

Because scales and opercles were not satisfactory for aging carp from this area, dorsal spines were selected as the next most practical alternative. We found that dorsal spines were: 1) easier to age than scales or opercles; 2) more accurate for determining age; 3) not injurious to the carp; and 4) similar to other methods in amount of time spent, both in field collection and lab processing/reading. We would, therefore, recommend the dorsal spine method for aging carp.

TABLE 1. Mean growth in weight of young-of-the-year carp in Lake Winnebago, 24 July-13 September 1974.*

Total Length (mm)	24 July**		21 Aug		3, 13 Sep		Total	
	No. Fish	Mean Weight	No. Fish	Mean Weight	No. Fish	Mean Weight	No. Fish	Mean Weight
20- 29	2	0.38					2	0.38
30- 39	11	0.68					11	0.68
40- 49	14	1.42	2	1.88			16	1.48
50- 59	5	2.72	1	2.68			6	2.71
60- 69	1	5.08	8	4.46			9	4.53
70- 79			9	6.60			9	6.60
80- 89			10	9.88			10	9.88
90- 99			7	13.80	1	15.23	8	13.98
100-109			3	19.86	2	20.78	5	20.23
110-119					1	24.13	1	24.13
Total	33		40		4		77	
Average		1.42		8.91		20.23		6.29

*Weight in grams.
**Gear used in collecting samples was : dipnets on 24 July, stream shocker on 21 August, and 30-ft seine on 3, 13 September.

TABLE 2. Mean growth in weight of young-of-the-year carp in Lake Buttes des Morts, 5 July-5 September 1974.*

Total Length (mm)	5, 8, 18 Jul** No. Fish	Mean Weight	7, 22 Aug No. Fish	Mean Weight	4, 5 Sep No. Fish	Mean Weight	Total No. Fish	Mean Weight
10- 19	64	0.07					64	0.07
20- 29	166	0.19					166	0.19
30- 39	40	0.61	2	1.00			42	0.63
40- 49	31	1.49	64	1.46			95	1.47
50- 59	3	2.40	62	2.60			65	2.59
60- 69			37	4.33			37	4.33
70- 79			12	7.22			12	7.22
80- 89			13	10.24			13	10.24
90- 99			4	14.96			4	14.96
100-109			5	19.50	3	20.91	8	20.03
110-119					3	23.75	3	23.75
120-129			3	28.39	3	29.17	6	28.78
130-139					1	50.20	1	50.20
140-149			1	49.59			1	49.59
Total	304		203		10		517	
Average		0.37		4.58		27.17		2.54

*Weight in grams.
**Gear used in collecting samples was: dipnets on 5, 8, 18 July, stream shocker on 7, 22 August, and 30-ft seine on 4, 5 September.

TABLE 3. Mean growth in weight of young-of-the-year carp in Lake Poygan, 10 July-10 September 1974.*

Total Length (mm)	10, 26 Jul** No. Fish	Mean Weight	14, 15 Aug[a] No. Fish	Mean Weight	9, 10 Sep No. Fish	Mean Weight	Total No. Fish	Mean Weight
10- 19	5	0.97	1	0.07			6	0.07
20- 29	18	0.27	1	0.39			19	0.28
30- 39	17	0.63					17	0.63
40- 49			2	1.55			2	1.55
50- 59	1	2.77	11	2.39			12	2.63
60- 69			11	4.32			11	4.32
70- 79			12	6.81	1	7.16	13	6.92
80- 89			5	8.70			5	8.70
90- 99			4	15.27			4	15.27
100-109			1	17.00	2	19.75	3	18.83
110-119			1	25.72	2	26.53	3	26.26
120-129					1	25.13	1	25.13
Total	41		49		6		95	
Average		0.47		6.31		20.95		4.72

*Weight in grams.
**Gear used in collecting samples was: dipnets on 10, 26 July, stream shocker on 14, 15 August, and 30-ft seine on 9, 10 September.
[a]Includes 7 fish from Lake Winneconne, taken 15 August 1974.

TABLE 4. Food habits of 277 young-of-the-year carp from Lakes Winnebago, Butte des Morts, and Poygan shown as number of each item for all stomachs containing food.*

Food Item	Sampling Dates, 1974									Sampling Dates, 1976		
	Jul 5	Jul 8	Jul 10, 14-15,22	Jul 17	Jul 18	Jul 24	Jul 26	Aug 7	Aug 8	Jul 12	Jul 13	Jul 15
CRUSTACEA												
Cladocera												
Bosmina		10	3	6	2		2	2		36	106	12
Camptocercus			5						3			
Ceriodaphnia							1			14	6	11
Chydorus	19		45		16	2	17	13		61		254
Daphnia		47	14		1			7		4	2	5
Diaphanosoma			1		42	5	1	5				
Eurycercus	4	1	7			5	365		4	8	4	116
Sida			6				1					
Unknown				1								
Copepoda												
Cyclops	159	63	5	152	312	66	518	122	8			2
Cyclops Copepodid	8	6	9				15			41	130	333
Diaptomus					1		1	1				
Amphipoda												
Hyalella				1	8	8	4	1	1	1		
Rotatoria			347	8								
Ostracoda	5	2	1	14	1	5	68	4	3		2	1
INSECTA												
Diptera												
Chironomidae												
Larvae	53	481	23	76	217	69	369	221	9	87	43	27
Pupae							2					
Coleoptera	9	16					2	6				
Ephemeroptera								5				
Hemiptera	4	1				1	5	1				1
Odonata	3				2							
Trichoptera					1	13						
OTHER												
Hydracarina		1	1		2		3				3	6
Nematoda										1		
Unidentified (remains)	2				1	2		17			2	
Algae			4	34								
Duckweed	3											
Diatoms			5									
Stomachs With Food	24	25	17	11	25	22	25	25	2	19	23	42
Stomachs Empty	1	0	7	1	0	3	0	0	0	2	2	1
Carp Length Range (mm)	17-34	13-28	5-7	18-28	22-52	27-66	15-54	38-76	42-51	13-21	10-65	10-61

* Methods of capture in 1974 were DC stream shocker, bobbinet seine, and fine mesh dip net; in 1976 the method was fine mesh dip net.

TABLE 5. Mean body weight and mean ovary weight by total length group for 790 mature female carp in Lake Butte des Morts, in the fall of 1975 and 1977.

Total Length	Total No. Fish	Mean Body Weight (lb)	Mean Ovary Weight (lb)	Gonadosomatic Index (%)
16.5 - 16.9	1	2.63	0.22	8.4
17.0 - 17.4	2	2.59	0.23	8.9
17.5 - 17.9	3	3.06	0.25	8.2
18.0 - 18.4	7	3.27	0.51	15.6
18.5 - 18.9	6	3.60	0.43	11.9
19.0 - 19.4	9	3.65	0.26	7.1
19.5 - 19.9	19	4.02	0.61	15.2
20.0 - 20.4	19	4.32	0.63	14.6
20.5 - 20.9	28	4.56	0.63	13.8
21.0 - 21.4	31	5.03	0.94	18.7
21.5 - 21.9	29	5.45	0.92	16.9
22.0 - 22.4	46	5.61	1.06	18.9
22.5 - 22.9	35	6.43	1.17	18.2
23.0 - 23.4	33	6.68	1.17	17.5
23.5 - 23.9	33	7.22	1.28	17.7
24.0 - 24.4	36	7.66	1.40	18.3
24.5 - 24.9	35	7.91	1.37	17.3
25.0 - 25.4	41	8.73	1.63	18.7
25.5 - 25.9	42	9.01	1.52	16.9
26.0 - 26.4	37	9.80	1.78	18.2
26.5 - 26.9	33	10.31	1.82	17.7
27.0 - 27.4	36	10.93	1.95	17.8
27.5 - 27.9	33	11.78	2.19	18.6
28.0 - 28.4	36	12.37	2.25	18.2
28.5 - 28.9	29	13.00	2.33	17.9
29.0 - 29.4	22	13.63	2.39	17.5
29.5 - 29.9	23	15.00	2.78	18.5
30.0 - 30.4	26	15.23	2.77	18.2
30.5 - 30.9	9	16.45	3.15	19.1
31.0 - 31.4	13	16.64	2.92	17.5
31.5 - 31.9	12	17.83	2.94	16.5
32.0 - 32.4	5	18.45	3.33	18.0
32.5 - 32.9	12	20.59	3.46	16.8
33.0 - 33.4	3	21.56	4.14	19.2
34.0 - 34.4	2	22.50	3.97	17.6
34.5 - 34.9	2	20.95	3.00	14.3
35.0 - 35.4	1	29.50	4.37	14.8
35.5 - 35.9	1	25.50	3.69	14.5
(16.5-35.9) Unweighted $\bar{x}$		11.14	1.88	16.2

TABLE 6. Back-calculated lengths from dorsal spines of 519 male carp in Lakes Butte des Morts and Winnebago, in the fall of 1977 and 1979.

Year Class	Total Length at Annulus (inches)																
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII
1978	8.8																
1977	7.6	15.8															
1976	6.9	13.5	18.4														
1975	7.7	16.0	18.0	19.9													
1974	7.0	14.8	18.6	19.7	21.1												
1973	8.3	15.0	18.3	20.0	21.3	22.4											
1972	8.6	15.4	17.2	19.0	20.2	22.1	23.0										
1971	7.7	15.7	18.3	20.3	21.4	22.4	23.8	24.6									
1970	6.9	15.1	18.0	19.8	21.0	22.1	23.0	23.9	24.6								
1969	7.8	15.6	18.3	19.9	21.1	22.0	23.0	23.8	24.7	25.3							
1968	7.2	15.1	18.1	20.1	21.4	22.5	23.4	24.2	25.0	26.6	27.2						
1967	6.9	15.2	18.3	20.1	21.3	22.4	23.3	24.1	24.8	25.5	26.2	26.7					
1966	6.7	15.0	17.9	19.3	20.3	21.3	22.2	22.9	23.6	24.3	24.9	25.3	25.7				
1965	6.8	15.1	17.8	19.5	20.5	21.5	22.4	23.2	23.9	24.5	25.1	25.7	26.9	27.4			
1964	6.3	14.0	17.0	18.3	19.3	20.3	21.3	22.1	22.8	23.4	24.1	24.7	25.3	26.9	27.6		
1963	5.9	13.8	16.4	18.1	19.1	20.2	21.2	22.1	22.8	23.5	24.1	24.7	25.3	25.9	27.5	28.0	
1962	5.6	12.9	16.3	18.1	19.3	20.2	21.1	22.0	22.8	23.4	24.0	24.6	25.2	25.7	26.1		
1961	5.2	13.5	17.4	18.9	19.7	20.6	21.5	22.1	23.0	23.4	23.9	24.5	25.0	25.4	26.0	26.7	
1960	4.2	15.3	18.8	20.7	21.3	21.9	22.4	22.8	23.2	23.8	24.7	25.7	26.3	27.2	27.6	28.0	28.4
Unweighted Mean	7.0	14.8	17.8	19.5	20.6	21.6	22.4	23.2	23.7	24.4	24.9	25.2	25.7	26.4	27.0	27.6	28.4
Weighted Mean	7.1	15.0	17.8	19.5	20.6	21.6	22.6	23.2	23.7	24.2	24.7	25.2	25.4	26.1	26.9	27.8	28.4

TABLE 7. Back-calculated lengths from dorsal spines of 589 female carp in Lakes Butte des Morts and Winnebago, in the fall of 1977 and 1979.

Year Class	Total Length at Annulus (inches)																			
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX
1977	7.1	15.9																		
1976	8.9	18.1	22.1																	
1975	7.1	15.2	19.3	21.7																
1974	8.7	15.5	17.6	22.7	23.8															
1973	8.7	15.3	19.1	21.4	22.3	23.6														
1972	8.8	15.3	18.7	20.5	22.0	23.7	24.7													
1971	8.5	15.5	19.1	21.1	22.2	23.6	24.8	25.8												
1970	8.2	15.7	19.3	21.6	23.0	24.2	25.3	25.5	26.3											
1969	7.5	14.9	18.7	20.7	22.2	23.5	24.6	25.4	26.5	27.1										
1968	8.3	16.9	20.5	22.4	23.7	24.9	26.0	26.9	27.8	28.9	29.6									
1967	7.9	16.2	19.7	21.8	23.1	24.2	25.2	26.0	26.7	27.5	28.9	29.5								
1966	8.3	15.7	18.8	20.5	21.7	22.8	23.8	24.5	25.3	26.0	26.6	26.9	27.4							
1965	8.3	15.6	18.8	20.7	21.9	23.0	23.9	24.7	25.5	26.1	26.8	27.4	28.0	28.3						
1964	8.0	15.3	18.5	20.4	21.7	22.9	24.0	24.9	25.7	26.4	27.0	27.7	28.3	28.4	28.8					
1963	7.6	15.2	18.4	20.4	21.6	22.8	24.0	24.8	25.5	26.2	26.9	27.5	28.1	28.6	33.0	33.4				
1962	6.4	15.0	18.6	20.6	22.0	23.3	24.4	25.4	26.3	27.0	27.7	28.3	28.7	29.4	29.9	30.4	30.8			
1961	8.5	16.1	19.2	21.0	22.0	23.0	24.1	25.3	26.0	27.0	27.5	28.2	28.7	29.2	29.7	30.2	29.2	29.8		
1959	7.3	15.0	18.5	21.1	23.0	24.2	25.8	26.8	27.8	28.4	29.7	30.3	30.9	31.6	32.5	33.5	34.1	34.8		
1958	6.3	13.5	16.9	17.7	18.1	18.8	19.8	20.3	20.7	21.5	22.0	22.6	24.1	26.8	27.4	27.9	29.3	30.6	31.9	
1957	6.5	14.2	17.1	18.7	20.5	21.9	23.2	24.6	25.4	25.6	26.2	26.8	27.2	27.6	28.2	28.6	29.0	29.4	29.7	30.1
Unweighted Mean	7.8	15.5	18.9	20.8	22.0	23.2	24.2	25.1	25.8	26.5	27.2	27.5	27.9	28.7	29.9	30.7	30.5	31.2	30.8	30.1
Weighted Mean	8.2	15.6	18.9	21.0	22.3	23.5	24.6	25.1	25.9	26.5	27.1	27.7	28.2	28.7	29.8	30.5	30.6	31.2	30.8	30.1

TABLE 8. Length range, average empirical weight, and condition factors for adult female and male carp in Lakes Butte des Morts and Winnebago, in the fall of 1975, 1977, and 1979.

Length Range	Females No.	Females Weight	Females Condition	Males No.	Males Weight	Males Condition
16.5 - 16.9	2	2.56	55.1	3	2.58	55.3
17.0 - 17.4	2	2.59	51.3	5	2.68	54.3
17.5 - 17.9	4	3.00	53.9	9	2.73	49.3
18.0 - 18.4	9	3.24	53.8	13	3.33	51.3
18.5 - 18.9	8	3.66	56.1	18	3.18	48.5
19.0 - 19.4	9	3.65	51.9	26	3.63	50.8
19.5 - 19.9	22	3.96	51.5	43	3.70	48.7
20.0 - 20.4	27	4.32	52.3	53	3.95	47.8
20.5 - 20.9	37	4.57	51.4	60	4.38	49.3
21.0 - 21.4	36	4.90	51.6	55	4.68	48.9
21.5 - 21.9	44	5.58	54.6	62	5.02	48.1
22.0 - 22.4	66	5.72	53.0	102	5.38	49.1
22.5 - 22.9	57	6.44	54.9	116	5.69	48.7
23.0 - 23.4	73	6.93	54.3	122	6.09	48.7
23.5 - 23.9	67	7.23	54.1	120	6.41	48.3
24.0 - 24.4	77	7.62	54.6	101	6.96	49.1
24.5 - 24.9	76	8.12	54.1	114	7.39	48.6
25.0 - 25.4	77	8.76	54.6	117	7.62	45.0
25.5 - 25.9	72	9.06	53.3	102	8.08	47.2
26.0 - 26.4	67	9.81	54.5	96	8.80	48.8
26.5 - 26.9	80	10.19	53.5	78	8.98	47.7
27.0 - 27.4	69	10.92	54.2	59	9.87	49.0
27.5 - 27.9	49	11.84	55.9	39	10.28	48.5
28.0 - 28.4	60	12.51	56.9	26	10.91	48.6
28.5 - 28.9	43	13.08	55.1	19	11.50	48.5
29.0 - 29.4	36	13.84	54.3	14	11.94	47.8
29.5 - 29.9	39	14.99	57.3	2	12.08	45.9
30.0 - 30.4	41	15.87	57.7			
30.5 - 30.9	24	16.56	57.2	1	14.91	52.5
31.0 - 31.4	20	16.78	55.1			
31.5 - 31.9	21	17.74	55.6			
32.0 - 32.4	7	18.73	56.2			
32.5 - 32.9	15	20.52	58.6			
33.0 - 33.4	3	21.56	59.0			
Total Fish	1,339			1,575		
Weighted Mean		9.44	54.5		6.75	48.4
Unweighted Mean		9.61	54.6		6.88	49.1

* Weight in pounds (lb).

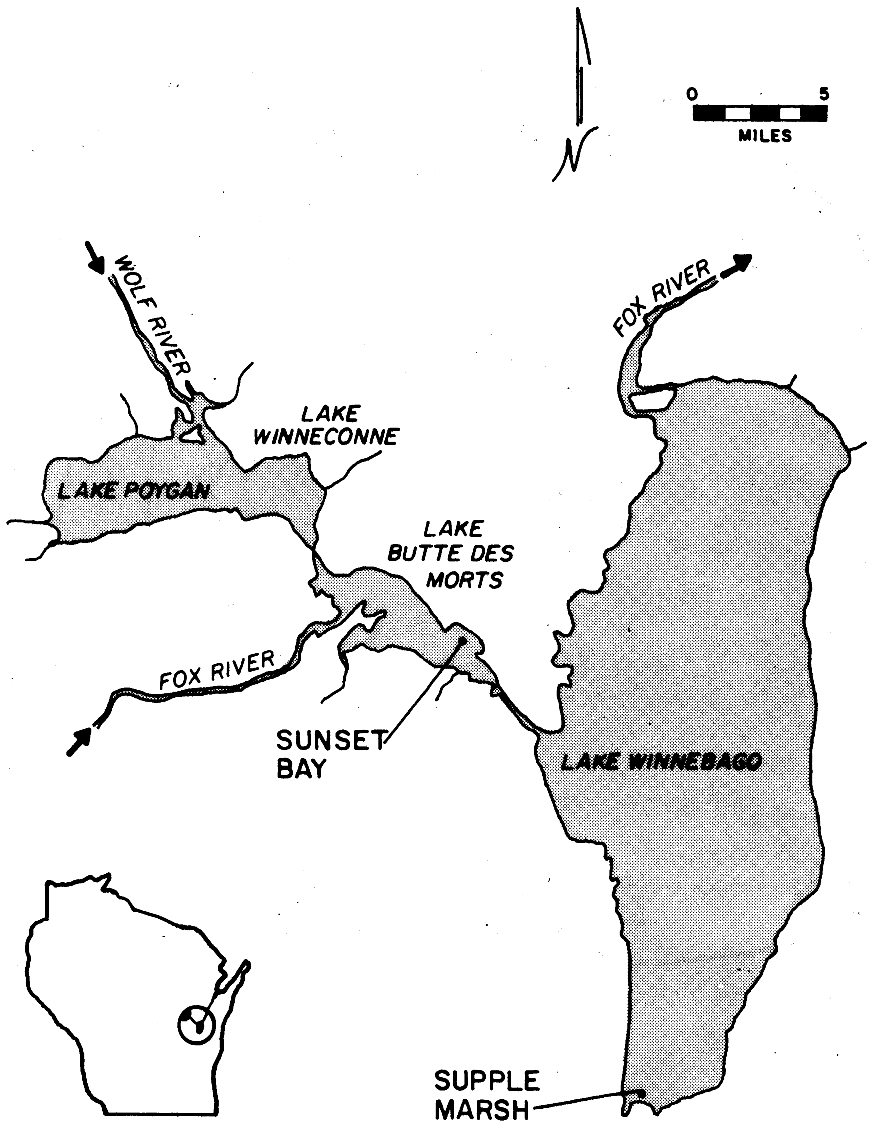

FIGURE 1. Lakes and rivers in the 166,000-acre study area.

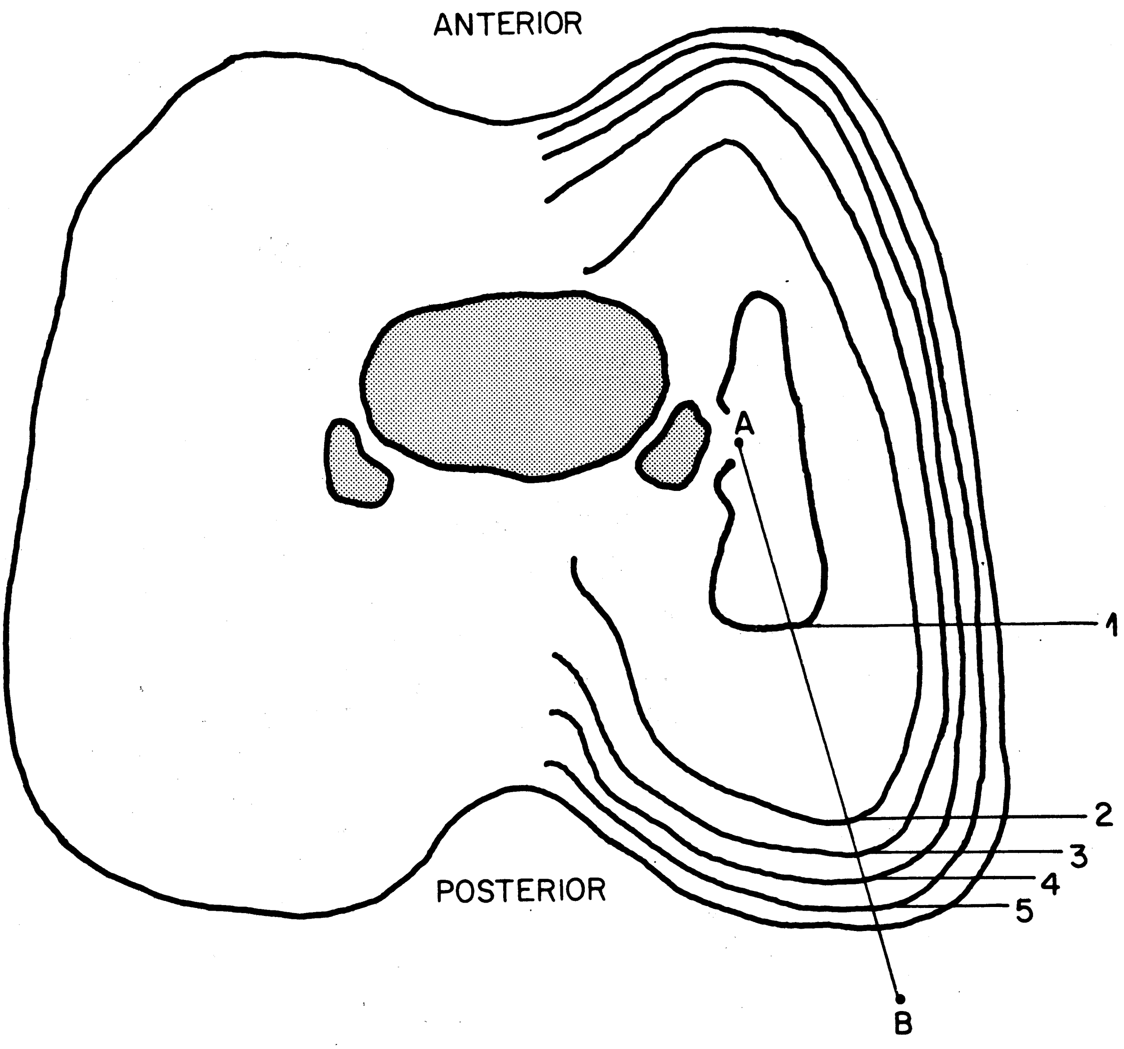

FIGURE 2. Diagrammatic view of dorsal spine cross-section from age V+ carp, showing line AB along which back-calculated measurements were taken. Shaded areas are canals for nerves, blood vessels, and tendons. (Spine sections are bilaterally symmetrical; only one side is shown with annuli for illustration.)

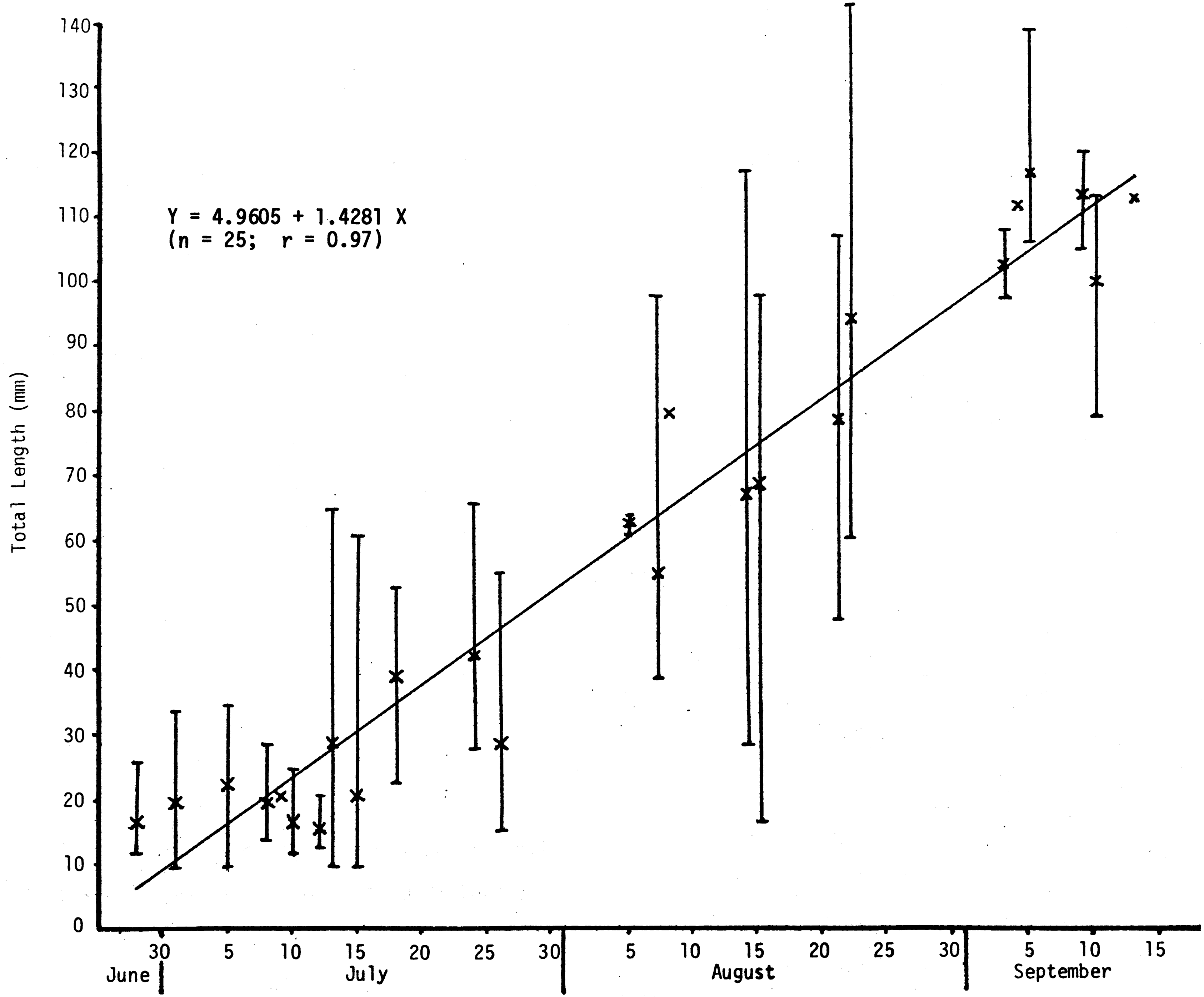

FIGURE 3. Mean growth (x) and range in total length for 823 young-of-the-year carp from Lakes Winnebago, Butte des Morts, and Poygan, combined. Regression line fitted from the 25 mean growth points from 5 July - 13 September 1974 (n=690), 1 July - 8 August 1975 (n=41), 28 June - 15 July 1976 (n=92).

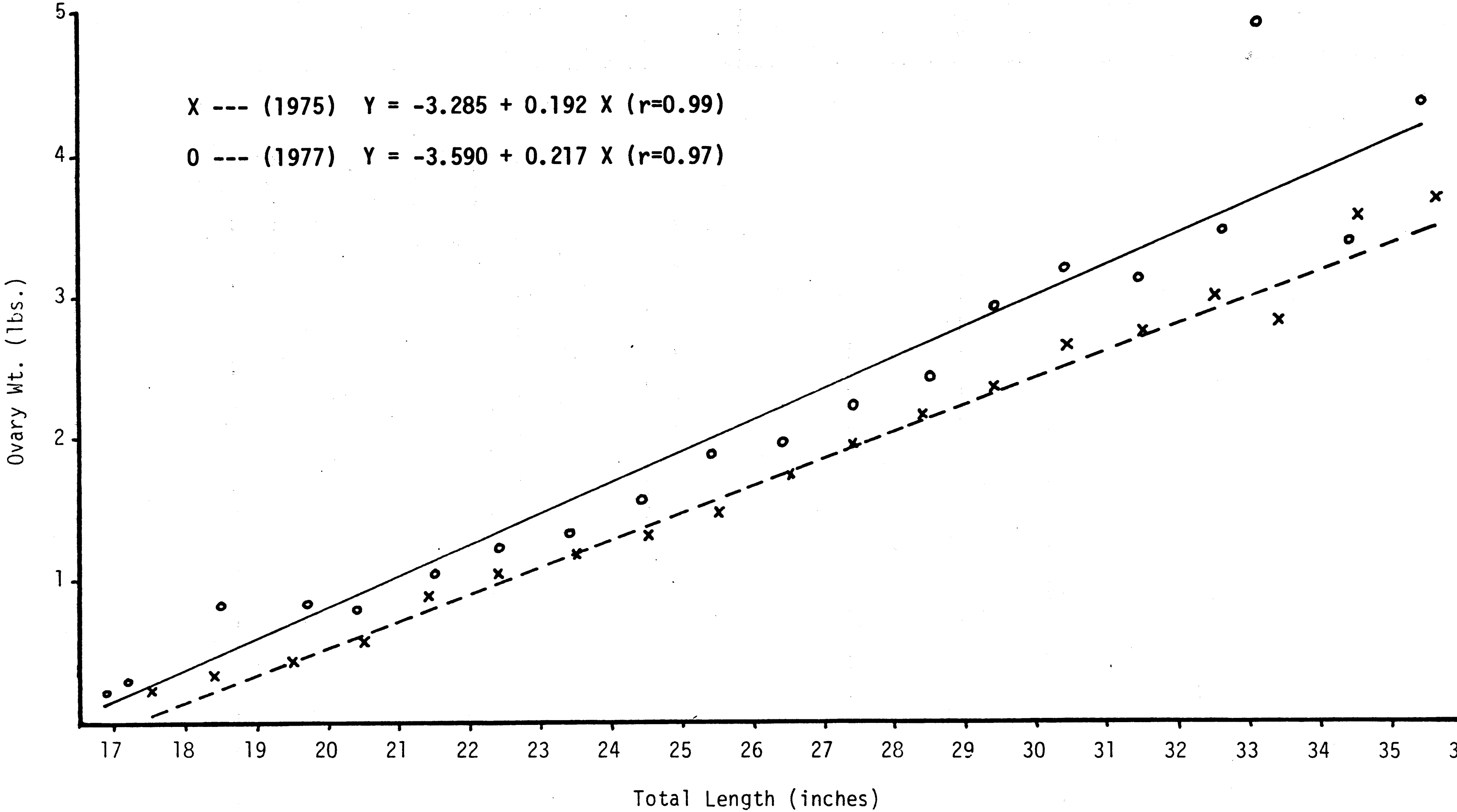

FIGURE 4. Relationship between mean total lengths and mean ovary weights by 1-inch length intervals for 976 mature female carp from Lake Butte des Morts (719 in October 1975 and 257 in October 1977).

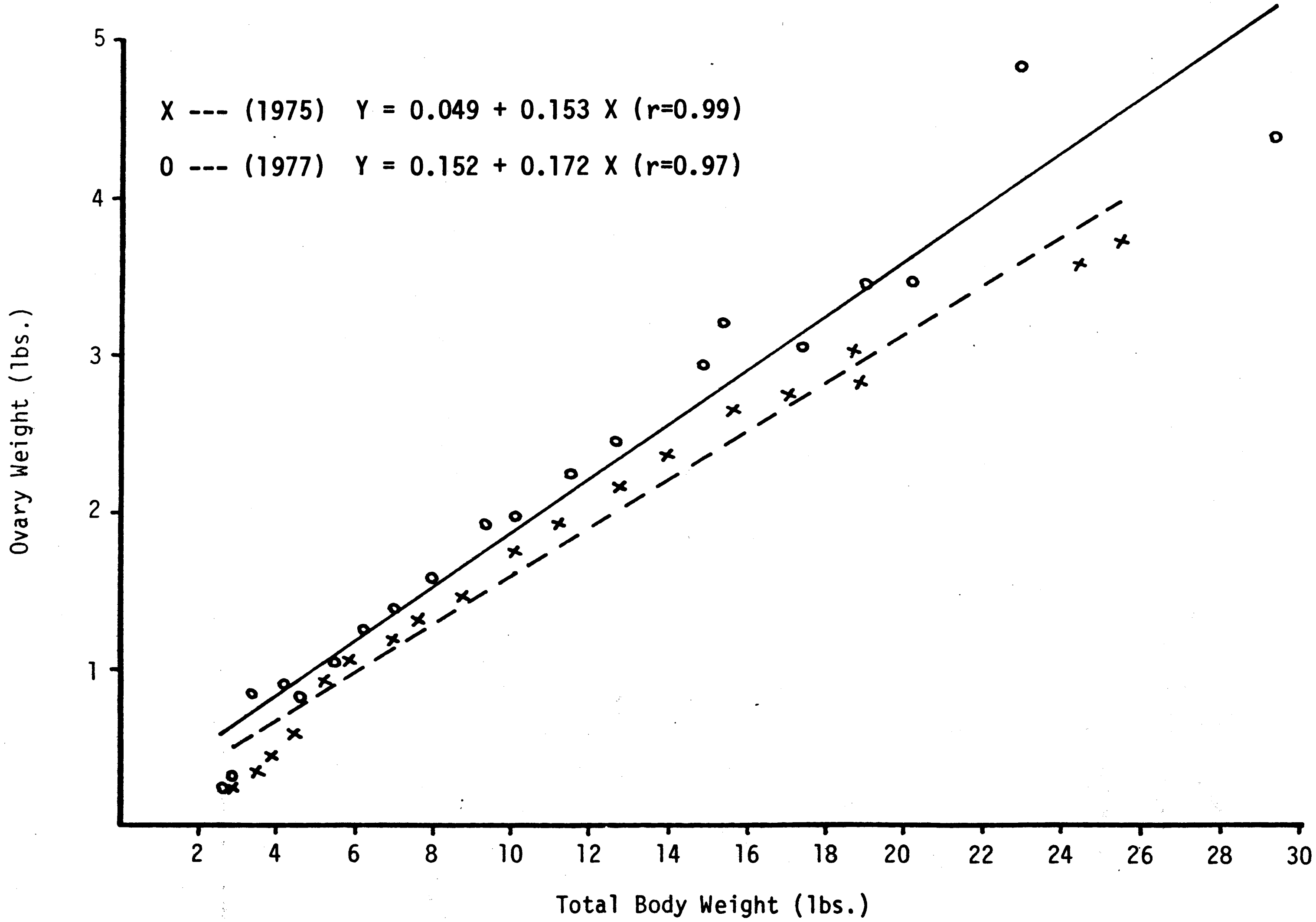

FIGURE 5. Relationship between mean total body weights and mean ovary weights by 1-inch length intervals for 976 mature female carp from Lake Butte des Morts (719 in October 1975 and 257 in October 1977).

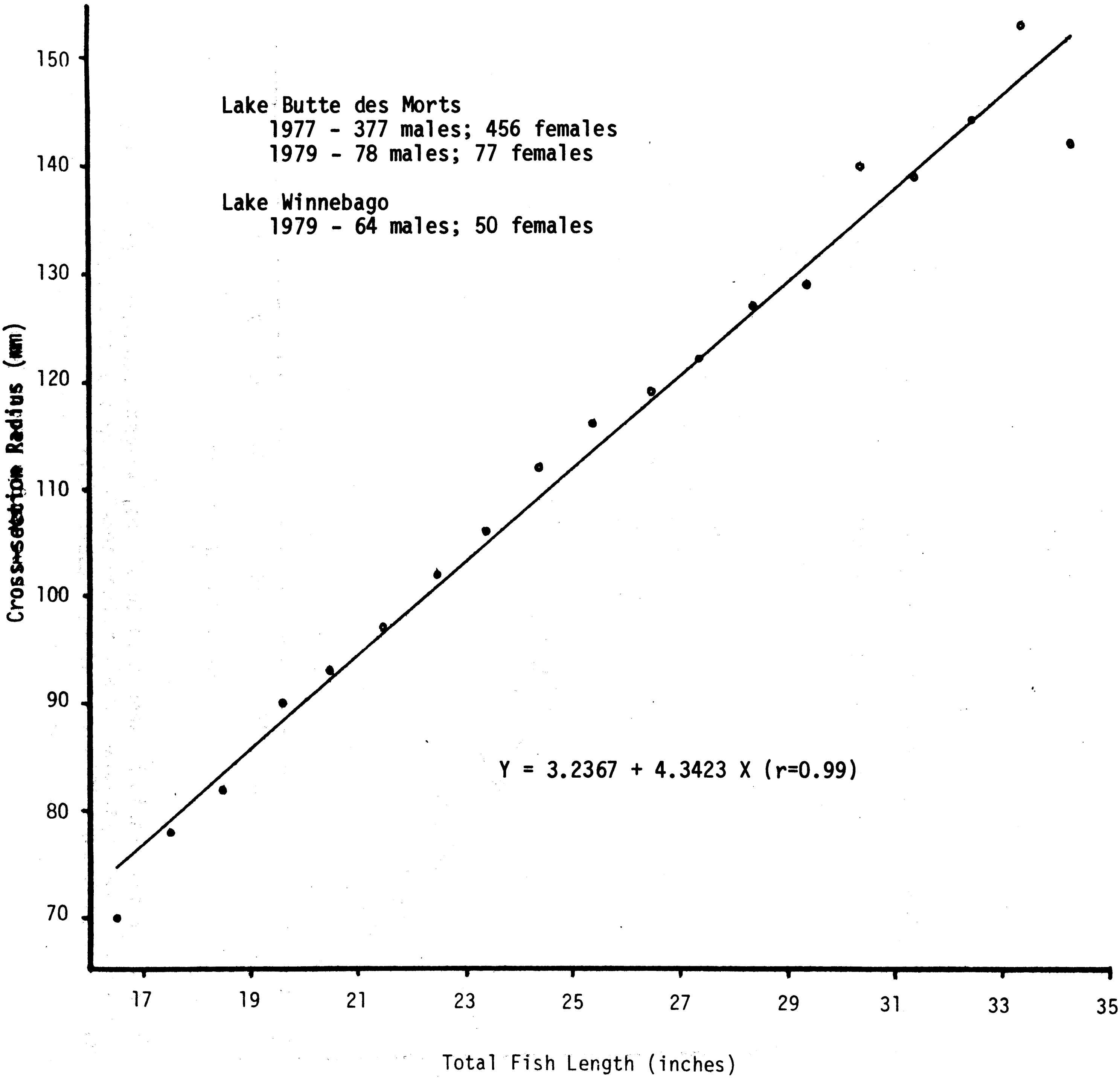

FIGURE 6. Relationship between total fish length and radius of dorsal spine cross section for 1,102 male and female carp. Data points derived from 1-inch total fish length means.

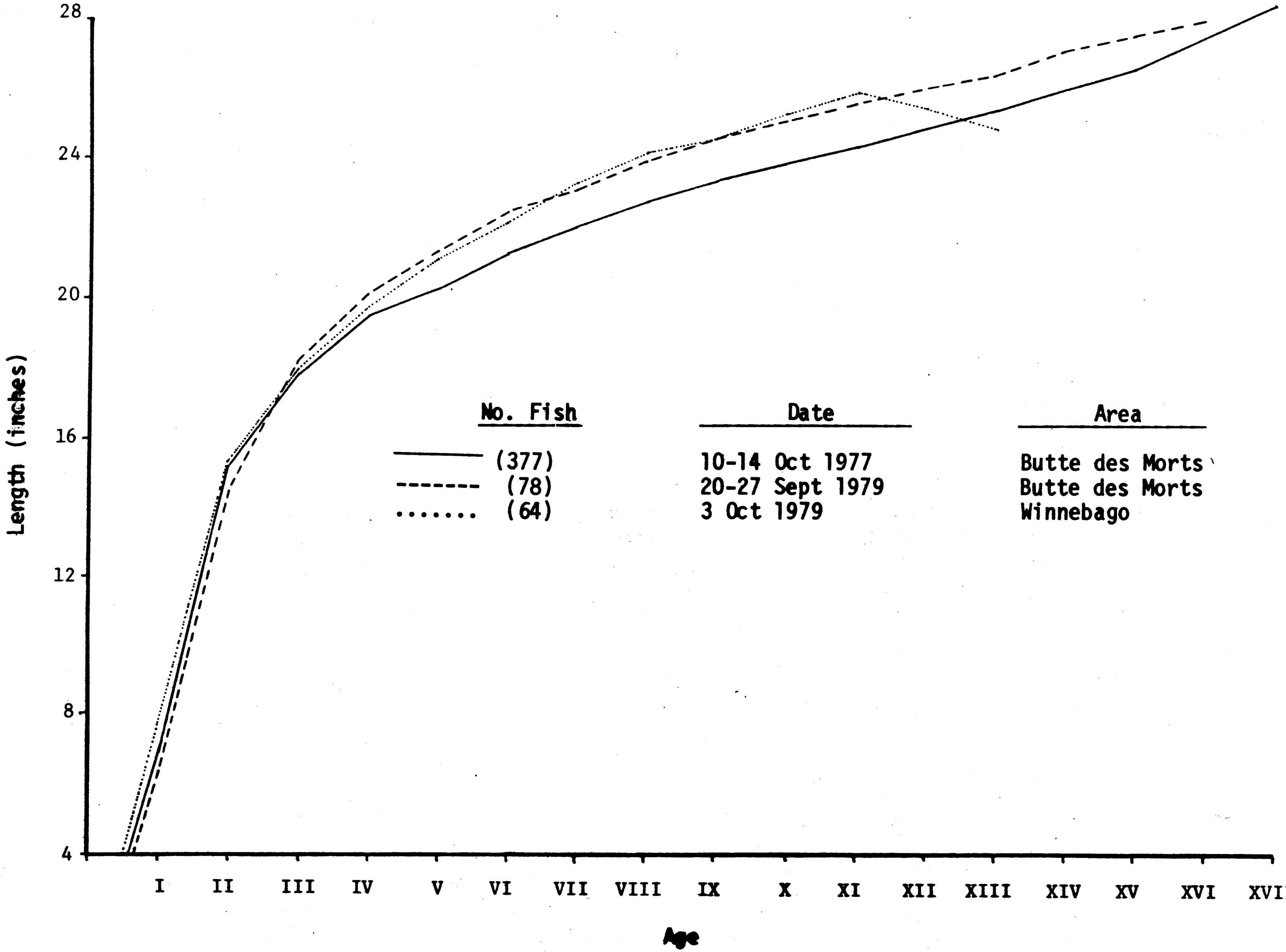

FIGURE 7. Weighted means of back-calculated lengths from dorsal spines for 519 male carp from Lakes Butte des Morts and Winnebago, 1977-79.

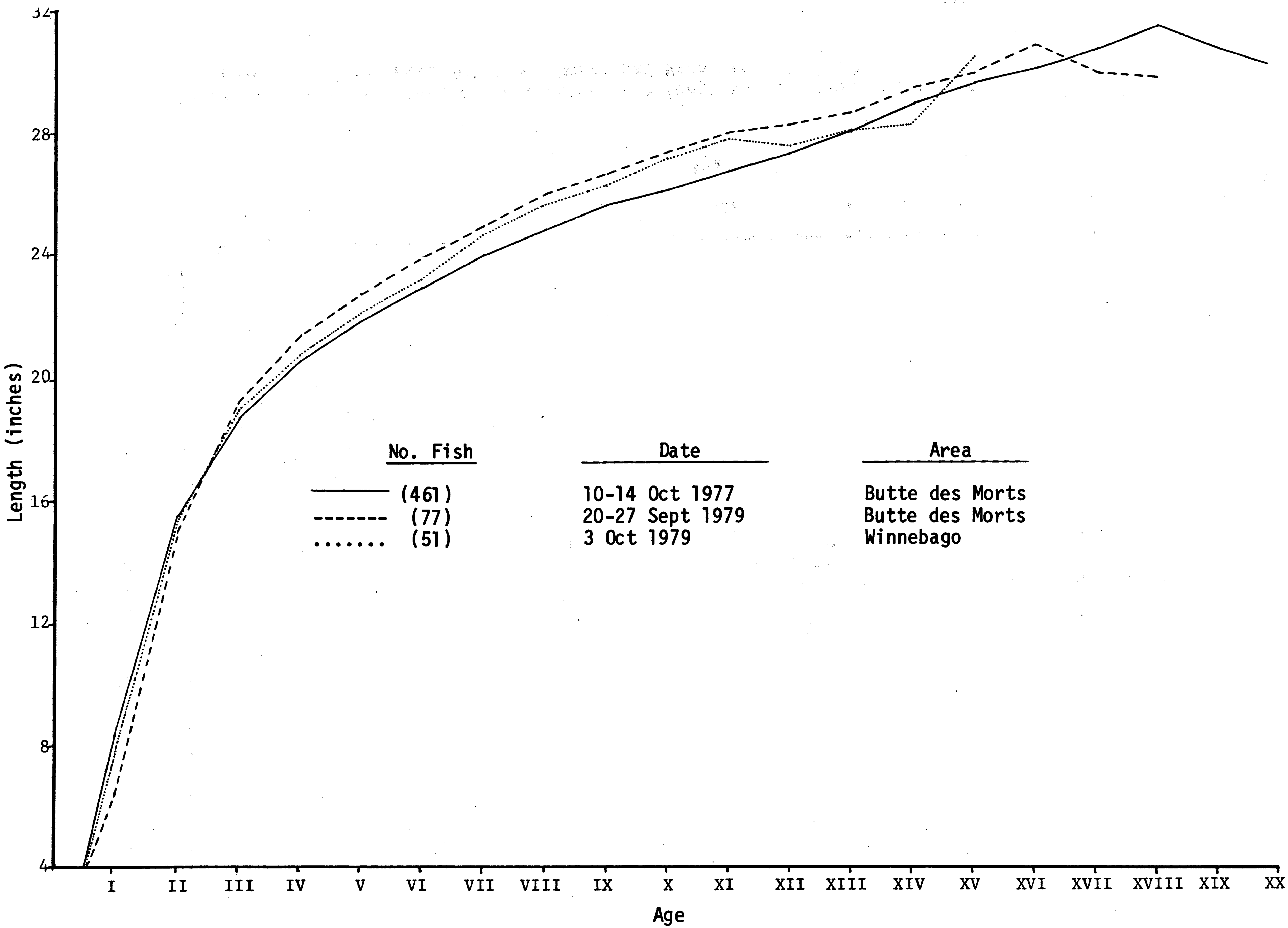

FIGURE 8. Weighted means of back-calculated lengths from dorsal spines for 589 female carp from Lakes Butte des Morts and Winnebago, 1977-79.

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