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FINAL REPORT

RESEARCH AND SURVEYS

FEDERAL AID GRANT NO. F-50-R

FISH RESEARCH FOR OKLAHOMA WATERS

PROJECT NO. 7

THE INFLUENCE OF TEMPORAL AND ENVIRONMENTAL VARIABLES ON THE EFFECTIVENESS OF ELECTROFISHING PROCEDURES FOR SAMPLING FLATHEAD CATFISH

MAY 1, 1995 through MAY 31, 1998

FINAL REPORT

State: Oklahoma Grant Number: F-50-R

Grant Title: Fish Research for Oklahoma Waters

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Project Title: The influence of temporal and environmental variables on the effectiveness of electrofishing procedures for sampling flathead catfish.

Period Covered: From: May 1, 1995 To: May 31, 1998

ABSTRACT

Fisheries personnel with the Oklahoma Department of Wildlife Conservation began using electrofishing in 1991, as part of it's Standardized Sampling Procedures, to assess flathead catfish populations in reservoirs. While this type of sampling is highly effective, it is not clear how temporal and environmental factors such as season, time of sampling, water temperature, water depth, and differing habitat types might affect sampling efficiency. Electrofishing was conducted twice monthly from June-October 1995 on Lake Ponca and from May-October 1996 on Fort Gibson Reservoir. Relationships among catch data and concurrent temporal and environmental data were determined by multiple regression analysis. Models were generated for *O/f* (numbers of individuals observed per 3 min electrofishing), *C/f* (numbers of individuals netted per 3 min electrofishing), C/f_H (numbers of individuals ≥510 mm total length netted per 3 min electrofishing), and C/f_R (numbers of individuals <200 mm total length netted per 3 min electrofishing) which were statistically significant. Sampling was most effective over areas where bank inclines are moderate to steep and bottom substrates are composed of riprap or natural rock or where submerged structure is evident. Sampling was less effective during the later portions of the study period and as water temperatures

decreased.

Flathead catfish sampling is also labor intensive because of the perceived need for a chase boat to facilitate the capture of stunned individuals. During summer 1997, electrofishing was compared with and without a chase boat on three Oklahoma reservoirs to assess the benefit of using a chase boat while conducting flathead catfish electrofishing surveys. No significant differences were detected between the two methods when comparing mean O/f, mean C/f, mean C/f_H, or mean C/f_R. It is recommend that chase boats no longer be used while sampling for flathead catfish in reservoirs.

REPORT CONTENT

I. Need:

Interest and concerns regarding Oklahoma's flathead catfish (*Pylodictis olivaris)* sport fisheries have steadily increased in recent years (Summers 1986). Sampling of flathead catfish in Oklahoma reservoirs has traditionally been limited to incidental catches in standardized gill-net sets (Erickson 1978). However, resulting catch rates were typically low or nil. In recent years, electrofishing boats have been used effectively to collect flathead catfish (Weeks and Combs 1981; Gilliland 1988). The Oklahoma Department of Wildlife Conservation (ODWC) began using electrofishing in 1991 to assess flathead catfish populations in reservoirs. While electrofishing was extremely effective in sampling flatheads, it was not clear how temporal and environmental factors such as time of sampling, water temperature, water depth, and differing habitat types might affect sampling efficiency. This study helped refine current electrofishing techniques for flathead catfish so its effectiveness can be maximized by fisheries managers.

Flathead catfish electrofishing is also fairly labor intensive because of the need for a chase boat. Additionally, his study evaluated alternate electrofishing procedures which would preclude the need for a chase boat while still enabling fisheries workers to effectively monitor Oklahoma's reservoir flathead catfish populations.

II. Background:

Electrofishing is the method currently used to sample flathead catfish in Oklahoma reservoirs (Oklahoma's Standardized Sampling Procedures, F-44-D, Project 5). Current electrofishing procedures include sampling during summer months (June, July, or August) after water temperatures reach 16 °C. Sampling locations include typical flathead catfish habitat (rocky points, riprap, log piles, undercut banks, and timbered creek channels). The majority of flathead catfish sampling in Oklahoma takes place during June (77%). However, flathead catfish appear to be more susceptible to electrofishing during July - October (Quinn 1988), and this may be temperature related. While electrofishing is ineffective for sampling flathead catfish at temperatures below 16 °C, increases in effectiveness can usually be correlated with increases in water temperatures above 16 °C (Morris and Novak 1968; Gilliland 1988).

Other environmental variables affecting flathead catfish abundance include structure and depth. Flathead catfish are usually structurally oriented (Hart and Summerfelt 1974; Coon and Dames 1991), and can be particularly abundant in riprap habitat (Layher and Boles 1979, 1980; Cunningham, 1995). However, the effects of other habitat types on flathead catfish abundance have not been documented. While water depth is an important environmental variable affecting flathead catfish abundance in rivers (Coon and Dames 1991), its effect on reservoir populations is unknown.

Current standardized flatfish catfish sampling procedures also call for the use of a chase boat to facilitate capture of stunned individuals. Generally, stunned flathead catfish surface within 45 s after sampling is initiated and remain on the surface for 60-90 s (Hale et al. 1987; Gilliland 1988; Cunningham 1995). Capture of stunned individuals is difficult when several fish surface over a wide area, which necessitates the use of a chase boat. Typically, 50-60% of stunned individuals are actually captured and the majority of these are taken by personnel in the chase boat. Captured individuals are usually enumerated, measured and weighed for calculation of catch rates, length-frequency histograms, and relative weights. While numbers of individuals observed but not captured is also recorded, these data are not used to determine catch rates of flathead catfish. Preliminary analysis indicates that catch data are less variable when observed but not captured data are included in catch rate calculations.

These data could be collected without a chase boat. However, the number of flathead catfish available for collection of length and weight data might be greatly reduced.

III. Project Objectives:

To estimate the influence, if any, of time of sampling, water temperature, water depth, substrate type and aquatic habitat on flathead catfish electrofishing catch rate and population structure from May through September samples collected biweekly and to determine if CPUE and length-frequency data collected using flathead catfish electrofishing procedures without a chase boat are comparable to sampling with a chase boat.

IV. Approach:

Study Sites

Lake Ponca impounds Turkey and Little Turkey Creeks, 8.1 km east of Ponca City in Kay County, Oklahoma. Lake Ponca was impounded in 1935 and covers 340 ha. It has a mean depth of 4.3 m, a maximum depth of 15 m, a shoreline development ratio of 3.9, and a water exchange rate of 0.5. The lake is moderately turbid with mid-summer secchi disk readings averaging 70 cm; turbidity is primarily from plankton.. Sport species include flathead catfish, largemouth bass *Micropterus salmoides*, white bass *Morone chrysops*, white crappie *Pomoxis annularis*, channel catfish *Ictaluris punctatus*, and striped bass x white bass hybrids *Morone saxatilis* x *M. chrysops*. Major forage species include gizzard shad, *Dorosoma cepedianum*, and bluegill, *Lepomis macrochirus*

Fort Gibson Reservoir is the lower of three reservoirs located along the Grand (Neosho) River in northeastern Oklahoma. This 8,053 ha impoundment, located 19.3 km northeast of Mukogee, is bordered by Wagoner County to the west and Cherokee County to the east; the upper reaches extend into southern Mayes County. Fort Gibson is a U.S. Army Corps of Engineers reservoir impounded in 1953 for hydropower, flood control, water supply, and recreational purposes. It also stores water, in conjunction with four other eastern Oklahoma reservoirs, during periods of high flow to assure adequate water for year-round operation of the McClellan-Kerr Arkansas River Navigation System. Fort Gibson Reservoir has a mean

depth of 6 m, a maximum depth of 23.3 m, and a water exchange rate of 16.3. The lake is moderately turbid with mid-summer secchi disk readings averaging 79 cm; turbidity is primarily from plankton and sediment. Sport species include flathead catfish, largemouth bass, white bass, white crappie, black crappie *Pomoxis nigromaculatus*, blue catfish *Ictalurus furcatus*, and channel catfish. Major forage species include gizzard shad and bluegill.

Hudson Reservoir is the middle of three reservoirs located along the Grand (Neosho) River in northeastern Oklahoma. 5 km northwest of Locust Grove, Mayes County. Hudson is a 4,411 ha Grand River Dam Authority reservoir impounded in 1964 for hydropower, flood control, water supply, and recreational purposes. It also stores water, in conjunction with four other eastern Oklahoma reservoirs, during periods of high flow to assure adequate water for year-round operation of the McClellan-Kerr Arkansas River Navigation System. Hudson Reservoir has a mean depth of 5.6 m, a maximum depth of 19.5 m, and a water exchange rate of 34.6. The lake is moderately turbid with mid-summer secchi disk readings averaging 98 cm; turbidity is primarily from plankton and sediment. Sport species include flathead catfish, largemouth bass. white bass, crappie, and blue and channel catfish. Major forage species include gizzard shad and bluegill.

Robert S. Kerr Reservoir is located along the Arkansas River in east-central Oklahoma, 10 km south of Sallisaw: the reservoir lies in portions of Mukogee, Leflore, Sequoyah, and Haskell Counties. Robert S. Kerr is a 17,010 ha U.S. Army Corps of Engineers reservoir impounded in 1970 for hydropower. flood control, water supply, and recreational purposes. It also an important component of the McClellan-Kerr Arkansas River Navigation System. Robert S. Kerr Reservoir has a mean depth of 4 m, a maximum depth of 16 m, and a water exchange rate of 34.6. The lake is moderately turbid with mid-summer secchi disk readings averaging 73 cm; turbidity is primarily from plankton and sediment. Major forage species include gizzard shad and bluegill. Sport species include flathead catfish, largemouth bass, white bass, crappie, and blue and channel catfish.

Temporal and Environmental Evaluation

Electrofishing Sampling: Lake Ponca and Fort Gibson Reservoir were electrofished for flathead catfish during daylight hours twice monthly. Sampling was conducted on Lake

Ponca Reservoir from June through October 1995 and on Fort Gibson Reservoir from May through October 1996. Sampling was conducted at 20 sites per reservoir and, in habitat thought to harbor flathead catfish, such as rocky points, riprap, and steep undercut banks (Hale et al. 1987). An electrofishing boat outfitted with a Smith-Root GPP 5.0(Smith-Root, Inc., Vancouver, Washington[1]) set at low DC pulse rates (7.5-30 pulses/s) was held stationary 2-10 m offshore (Gilliland 1988; Quinn 1988; Cunningham 1995) for 3 min at each site. A second boat was used to locate and net surfacing flathead catfish. The number of flathead catfish observed and the number and total lengths and weights of flathead catfish netted were recorded.

Catch rates were expressed as the number of individuals netted plus those observed but not netted at each site per 3 min of electrofishing (O/f) and as the number of individuals netted at each site per 3 min of electrofishing (C/f). In addition to monitoring overall population density, objectives of ODWC sampling procedures for flathead catfish were also to monitor numbers of harvestable-sized individuals (Oklahoma has a 510-mm statewide minimum length limit on flathead catfish) and recruitment to age 1. Thus, catch rates were also expressed as the number of individuals 510 mm long or greater (C/f_H) and less than 200 mm long (C/f_R) netted per 3 min. The 200-mm ceiling was used for the first length interval because age-1 flathead catfish are typically 160-200 mm long in Oklahoma (Jenkins 1952; Weeks and Combs 1981).

Environmental Sampling: Conductivity (μS), depth (m), secchi disk visibility (cm), and water temperature (°C) were collected in conjunction with electrofishing sampling. At the beginning of the study, each site was categorized by presence or absence of obvious submerged structure, type of substrate, and degree of bank incline. Substrate was categorized as either riprap, natural rock, or other substrate types. Bank incline was categorized as either steep (>45°), moderate (10-45°), or flat (<10°). Because the data describing submerged timber, substrate, and bank incline were categorical rather than numeric, indicator variables were used to describe these variables. A summary of these variables and their numeric values

[1]Does not imply endorsement of this product by the ODWC

is included in Table 1.

Multiple regression procedures were used to generate a model for each reservoir describing the effects of temporal and environmental variables on catch rate differences for each catch statistic. Temporal data were included in the analysis by converting the month and day each sample was collected to Julian day. The lowest mean square error value was used as the criterion for choosing the best model (Montgomery and Peck 1982). Standardized partial regression coefficients were used to determine the importance of the environmental variables (Montgomery and Peck 1982; Zar 1984). Residual analyzes were performed on the models to test for normality, linearity, and homogeneity of variance. The models was also tested for multicollinearity (Montgomery and Peck 1982; Zar 1984). The data were $Log_{10}(Y+1)$ transformed because results of the residual analysis indicated that the variance was not homogenous for any of the models. Statistical significance was assessed at the $P = 0.05$ level for this and all subsequent statistical analysis.

Population Characteristics:

Sexual maturity was determined in the field for each flathead catfish by examination of the upper lobe of the caudal fin (Minckley and Deacon 1959). Immature flathead catfish have a light-colored patch at the tip of the upper lobe of the caudal fin which is lost as the fish matures. Those individuals identified as mature were then sexed in the field by examination of the genital region (Johnson 1950; Turner and Summerfelt 1971; Weeks and Combs 1981). Males have a distinct, posteriorly directed genital papilla with a small urogenital opening at its tip. The genital papilla of the female is more recessed and less distinct than the male. The urogenital opening of the female is larger, appearing as a longitudinal slit.

Chase Boat Evaluation

Electrofishing Sampling: Fort Gibson, Hudson, and Robert S. Kerr reservoirs were electrofished for flathead catfish during daylight hours in June 1997. Sampling was conducted at 20 sites per reservoir and selected in habitat thought to harbor flathead catfish, such as rocky points, riprap, and steep undercut banks (Hale et al. 1987). An electrofishing boat outfitted with a Smith-Root GPP 5.0 set at low DC pulse rates (7.5-30 pulses/s) was held stationary 2-10 m offshore (Gilliland 1988; Quinn 1988; Cunningham 1995). Two 3 min

samples were collected at each site. During one of the samples, a second boat was used to locate and net surfacing flathead catfish; during the other sample, surfacing flathead catfish were located and netted by personnel in the electrofishing boat. The sampling method used first at each site was randomly selected and was followed about 1 week later with the other method. One week was deemed sufficient to eliminate bias introduced by repeated shocking (Cross and Stott 1975).

The number of flathead catfish observed and the number and total lengths of flathead catfish netted were recorded. Catch rates were expressed as O/f, C/f, C/f_H, and C/f_R. Wilcoxon's signed-rank test was used to test if the two methods provided equivalent estimates of the four catch statistics listed above.

V. Results

Temporal and Environmental Evaluation

Environmental Sampling: Conductivity trends for both reservoirs were similar and, except for a drastic decline on Lake Ponca during October, remained fairly stable during the duration of my study (Figure 1). Secchi disk visibility trends were variable for both reservoirs, and showed no distinct seasonal trends. Secchi disk visibility was lowest on Lake Ponca during June and July, but then increased and remained fairly stable for the remainder of the study. Conversely, secchi disk visibility on Fort Gibson Reservoir was highest from May through July. Sampling was conducted at fairly constant water depths for both reservoirs, although slightly deeper water was sampled on Fort Gibson. Water temperature trends for both reservoirs were similar and were typically highest from July through September.

Electrofishing Sampling: Mean O/fs, C/fs, and C/f_Rs for Lake Ponca were fairly constant from June through the first half of September (Figure 2). However, catch rates decreased during the latter half of September and further decreased during October. Mean C/f_Hs for Lake Ponca were low or nil throughout the study. Mean O/fs, C/fs, and C/f_Hs for Fort Gibson Reservoir were greatest in May, declined through June and into July, and then remained fairly constant with some fluctuations from July through October (Figure 2). Mean C/f_Rs for

Fort Gibson Reservoir were low or nil throughout the study.

The multiple-regression models describing O/f, C/f, C/f_H, and C/f_R for Lake Ponca Reservoir accounted for 40%, 31%, 6%, and 11% of the variance for each catch statistic, respectively. All models were significant ($P \leq 0.01$) (Table 2). Julian day was included in all of the models as a negative variable, while secchi disk visibility and water temperature were included in at least one of the models as positive variables. All of the indicator variables contrasting bank incline (indicator variables 1-3) were included in at least one of the models as positive variables, indicating a general increase in electrofishing effectiveness as slopes became steeper. Similarly, all of the indicator variables contrasting bottom substrate (indicator variables 4-6) were included in at least one of the models as positive variables, indicating an increase in electrofishing effectiveness at sites with riprap substrate. The indicator variable contrasting the presence or absence of flooded structure (indicator variable 7) was included in the model describing O/f as a negative variable, indicating an increase in electrofishing effectiveness at those sites with flooded structure. Standardized partial regression coefficients indicated that Julian day and indicator variables 5 and 6 were the most important variables affecting flathead catfish electrofishing effectiveness on Lake Ponca .

The multiple-regression models describing O/f, C/f, C/f_H, and C/f_R for Fort Gibson Reservoir accounted for 33%, 35%, 28%, and 9% of the variance for each catch statistic, respectively. All models were significant ($P<0.01$) (Table 2). Julian day and water temperature were included in all of the models except the one for C/f_R as a negative variable, while water depth was included in the model for C/f as a positive variable. Secchi disk visibility was included in the model for C/f_H as a negative variable but was included as a positive variable in the model for C/f_R. The indicator variable contrasting moderate and steep slopes (indicator variable 2) was included in two of the models as a negative variable, while the indicator variable contrasting flat and steep slopes (indicator variable 3) was included in three of the models as a positive variable. These results together indicate a general increase in electrofishing effectiveness from sites with flat slopes, to sites with steep slopes, and finally to sites with moderate slopes. Two of the indicator variables contrasting bottom substrate (indicator variables 5 and 6) were included in at least two of the models as positive

variables, indicating an increase in electrofishing effectiveness at sites with riprap substrate. However, the indicator variable contrasting other substrate types with riprap was included as negative variable in the model describing C/f_H, indicating electrofishing for flathead catfish $\geq$508 mm was more effective over other substrate types. The indicator variable contrasting the presence or absence of flooded structure (indicator variable 7) was included in the model describing *O/f* as a negative variable, indicating an increase in electrofishing effectiveness at those sites with flooded structure. Standardized partial regression coefficients indicated that Julian day and indicator variables 3 and 6 were the most important variables affecting flathead catfish electrofishing effectiveness on Fort Gibson Reservoir.

Population Characteristics: Young/adult ratios for both reservoirs were similar, but the values for Lake Ponca were much higher (Figure 3). In general, young/adult ratios were generally lower from May through July and higher from August through October. Ratios of females to males were highly variable for both reservoirs. In general, males were more prevalent than females, but no distinct seasonal trends were evident (Figure 4).

Chase Boat Evaluation

Electrofishing Sampling: Mean *O/f*s for sampling with and without a chase boat were 5.5 and 5.15, 2.8 and 3.55, and 4.8 and 4.75 for Fort Gibson, Hudson, and Robert S. Kerr Reservoirs (Figure 5), respectively, and did not differ significantly. Mean *C/f*s for sampling with and without a chase boat were 3.05 and 3, 1.25 and 1.85, and 2.65 and 2.5 for Fort Gibson, Hudson, and Robert S. Kerr Reservoirs, respectively, and did not differ significantly. Mean C/f_Hs for sampling with and without a chase boat were 1.95 and 1.4, 0.75 and 0.9, and 1.15 and 0.85 for Fort Gibson, Hudson, and Robert S. Kerr Reservoirs, respectively, and did not differ significantly. Mean C/f_Rs for sampling with and without a chase boat were 0.15 and 0.15 and 0.55 and 0.6 for Fort Gibson and Robert S. Kerr Reservoirs, respectively, and did not differ significantly. Mean C/f_Rs for both types of sampling on Hudson Reservoir were nil.

VI. Discussion

Temporal and Environmental Evaluation

Julian day was included in seven of the eight models describing flathead catfish catch

rates as a negative variable, indicating catch rates were highest during the early part of my study period. Although flathead catfish move into near-shore areas during late-spring months as water temperatures warm (Turner and Summerfelt 1973; Layher and Boles 1979), they often prefer deeper, cooler waters during summer months (Weller 1996). Perhaps this behavior explains the decrease in flathead catfish catch rates. These findings contradict those of Quinn (1988), who found catch rates for flathead catfish to peak in September and October. However, Quinn attributed at least some of the increases in observed catch rates to improvements in electrofishing equipment and techniques.

Flathead catfish are usually structurally oriented (Hart and Summerfelt 1974; Coon and Dames 1991), and are particularly attracted to riprap habitat where they often spawn and are attracted to forage fish (Layher and Boles 1979, 1980; Cunningham 1995; Weller 1996). In general, the models indicated that sites with other substrates were the least productive in terms of catch rates. Furthermore, sites with riprap substrate were more productive in a majority of the models when contrasted with the other sites. The exception was C/f_H for Fort Gibson Reservoir, where sites with other substrates were the most productive. Two of the models also included the variable contrasting the presence or absence of underwater structure.

Steep banks seem to attract flathead catfish, especially during spawning (Fontaine 1944). In general, the models indicated that sites with flat bank inclines were the least productive in terms of catch rates. Furthermore, sites with steep banks were more productive in a majority of the models when contrasted with the other sites. The exceptions were O/f and C/f_R for Fort Gibson Reservoir, where sites with moderate bank inclines were the most productive.

Secchi disk visibility was included in four of the models. However, partial regression coefficients indicated that this variable was relatively unimportant to the models. Mean bi-monthly values ranged from 68-92 cm for Lake Ponca and 40-105 cm for Fort Gibson Reservoir. However, it is doubtful that these variations in secchi disk visibility would effect catch rates. Electrofishing catch rates for flathead catfish collected on several Oklahoma reservoirs from 1991-1996 were compared with corresponding secchi disk visibility readings

representing a range of values. No significant correlations existed (ODWC unpublished data), indicating that secchi disk values at the ranges collected on Lake Ponca and Fort Gibson Reservoir have little or no effect on electrofishing catch rates for flathead catfish.

Water temperature was included in four of the models, *O/f* for Lake Ponca and *O/f*, *C/f*, and C/f_H for Fort Gibson. The *O/f* model for Lake Ponca indicated that catch rates increased as water temperature increased. Mean bi-monthly water temperature for Lake Ponca ranged from 23-30 °C from June and into September. However, water temperatures declined below 20 °C between the two September sampling dates along with a corresponding decrease in catch rates. This sudden decrease in both water temperatures and *O/f* probably accounts for the significance of this variable to the model. Conversely, the models for Fort Gibson Reservoir indicated that catch rates decreased as water temperature increased. Mean bi-monthly water temperature for Fort Gibson Reservoir ranged from 22-29 °C over the entire 1996 study period. Catch rates for Fort Gibson Reservoir steadily declined during this same period. Several studies have indicated that electrofishing for flathead catfish is less effective at water temperatures of 16-20 °C (Morris and Novak 1968; Gilliland 1988; Quinn 1988) and ineffective at temperatures <16 °C (Weeks and Combs 1981). These results would suggest that, although sampling at temperatures > 16 °C is effective, maximum sampling effectiveness can only be maintained at temperatures >20 °C. However, as water temperatures continue to rise, catch rates will decline because flathead catfish eventually move into cooler, deeper waters after spawning (Weller 1996).

Flathead catfish typically spawn in late spring when water temperatures are 24-27 °C (Turner and Summerfelt 1971). Prior to spawning, males typically move to inshore areas where cover is prevalent (Fontaine 1944;Turner and Summerfelt 1971; Layher and Boles 1979). After spawning, females leave the males to defend the nest and young (Carlander 1969). This behavior may explain why male flathead catfish were more prevalent in near-shore areas.

Chase Boat Evaluation

Several studies have concluded that using a chase boat greatly facilitates the capture of stunned flathead catfish (Gilliland 1988; Quinn 1988). The results of this study do not

support these conclusions. No significant differences were found in any of the catch statistics when sampling with a chase boat was compared with sampling without a chase boat.

VII. Recommendations

Based on these results, effectiveness of sampling flathead catfish seems to be related to pre-spawning migrations of individuals into near-shore areas followed by post-spawn migrations to deeper areas as water temperatures increase. This suggests that this pre-spawning period (late May) is a better time to sample flathead catfish than later months (June-October). Flathead catfish can still be sampled effectively during the post-spawning period. However, catch rates will probably be lower, and fewer sexually mature females will be captured. These results also suggest that sampling effectiveness is related to habitat. Sampling sites should be located in areas of reservoirs where bank inclines are moderate to steep and bottom substrates are composed of riprap or natural rock or where submerged structure is evident. Finally, it is proposed that chase boats no longer be used while conducting flathead catfish electrofishing surveys.

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IX. Date: May 31, 1998

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Table 1. Summary of indicator variables used to describe the differences in flathead catfish electrofishing effectiveness due to bank incline (flat vs. moderate, moderate vs. steep, and flat vs. steep), bottom substrate (other substrate types vs. natural rock, natural rock vs. riprap, and other substrate types vs. riprap), or presence or absence of flooded structure characterizing each sampling site. Numeric values for the indicator variables are also included.

	bank incline			bottom substrate			flooded structure
Habitat Characteristics	Indicator Variable 1	Indicator Variable 2	Indicator Variable 3	Indicator Variable 4	Indicator Variable 5	Indicator Variable 6	Indicator Variable 7
bank incline							
flat	-1	0	-1	-	-	-	-
moderate	1	-1	0	-	-	-	-
steep	0	1	1	-	-	-	-
bottom substrate							
other types	-	-	-	-1	0	-1	-
natural rock	-	-	-	1	-1	0	-
riprap	-	-	-	0	1	1	-
flooded timber							
presence	-	-	-	-	-	-	-1
absence	-	-	-	-	-	-	1

Table 2. Multiple-regression models describing flathead catfish electrofishing effectiveness (O/f, number of individuals observed per 3 min of electrofishing; C/f, number of individuals collected per 3 min of electrofishing; C/f_H, number of harvestable sized individuals [≥510 mm] collected per 3 min of electrofishing; and C/f_R, number of age-1 individuals [<200 mm] collected per 3 min of electrofishing on Lake Ponca Reservoir, 1995 and Fort Gibson Reservoir, 1996. The model variable abbreviations are: I1 = indicator variable 1; I2 = indicator variable 2; I3 = indicator variable 3; I4 = indicator variable 4; I5 = indicator variable 5; I6 = indicator variable 6; I7 = indicator variable 7; JD = Julian day; WD = water depth (m); WT = water temperature (°C); and SD = secchi disk visibility (cm). Partial regression coefficients b'_1, b'_2, b'_3, b'_4, b'_5, b'_6, and b'_7 refer to the first, second, third, fourth, fifth, sixth, and seventh variable terms, respectively.

	partial regression coefficients								
model	b'_1	b'_2	b'_3	b'_4	b'_5	b'_6	b'_7	R^2	P
Lake Ponca									
Log10(O/f+1) = 0.5820+0.1252(I6)-0.0024(JD)+0.0788(I3)+0.0020(SE)+0.0088(WT)+0.0350(I5)-0.0612(I7)	0.29	0.29	0.17	0.15	0.12	0.10	0.09	0.40	<0.01
Log10(C/f+1) = 0.6817+0.1300(I5)-0.0021(JD)+0.1043(I3)+0.0738(I4)+0.0022(SE)	0.38	0.27	0.24	0.21	0.17	-	-	0.31	<0.01
Log10(C/f_H+1) = 0.2053-0.0007(JD)+0.0217(I5)+0.0268(I1)	0.19	0.14	0.11	-	-	-	-	0.06	0.01
Log10(C/f_R+1) = 0.3214-0.0010(JD)+0.0346(I2)+0.0333(I6)	0.21	0.16	0.14	-	-	-	-	0.11	<0.01
Fort Gibson									
Log10(O/f+1) = 2.0663+0.3200(I3)-0.0039(JD)+0.1697(I5)-0.0947(I2)-0.0333(WT)-0.0689(I7)	0.61	0.46	0.27	0.23	0.22	0.14	-	0.33	<0.01
Log10(C/f+1) = 1.9352-0.0038(JD)-0.0335(WT)+0.1245(I6)+0.0866(I3)+0.0779(I5)+0.0102(WD)	0.51	0.26	0.20	0.19	0.14	0.10	-	0.35	<0.01
Log10(C/f_H+1) = 1.4631-0.0032(JD)+0.1174(I3)-0.0221(WT)-0.0014(SE)-0.0538(I6)	0.50	0.31	0.20	0.11	0.10	-	-	0.28	<0.01
Log10(C/f_R+1) = -0.0065+0.0260(I6)-0.0140(I2)+0.0004(SE)	0.21	0.20	0.12	-	-	-	-	0.09	<0.01

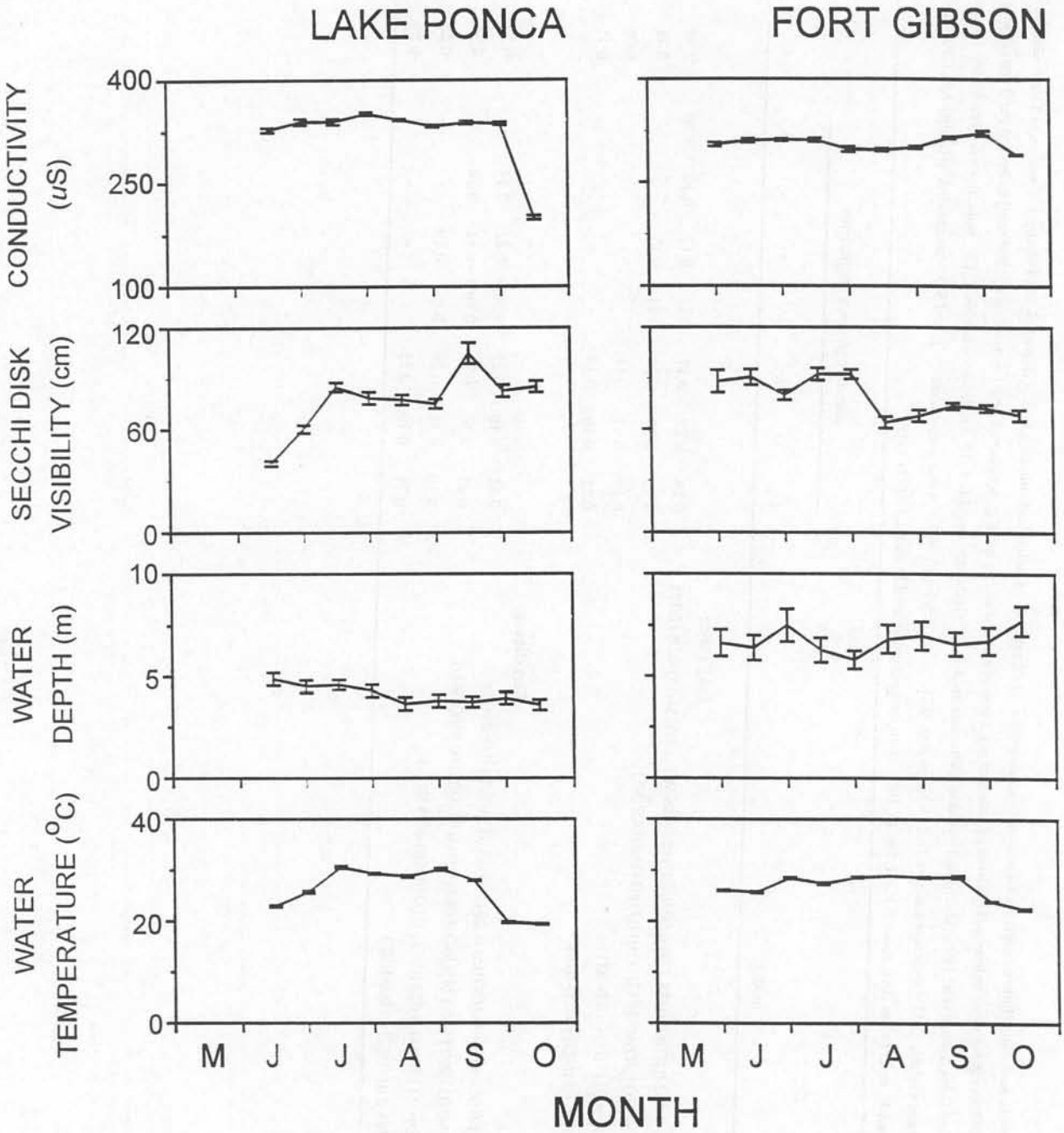

Figure 1. Mean bi-monthly conductivity (uS), secchi disk visibility (cm), water depth (m), and water temperature (°C) measurements for Lake Ponca, June-October 1995, and Fort Gibson Reservoir, May-October 1996. Error bars represent one standard error.

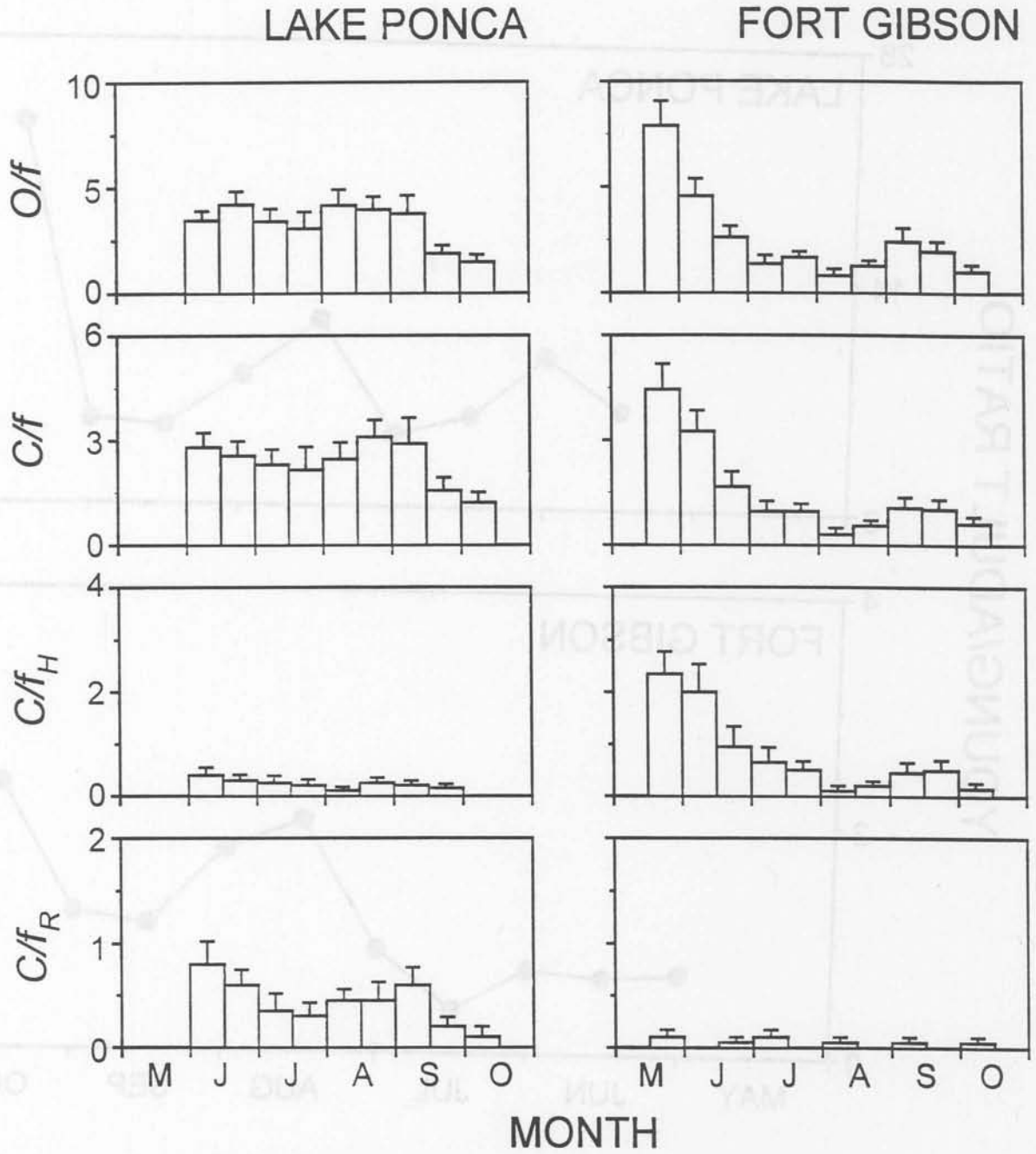

Figure 2. Mean catch rates for flathead catfish collected with electrofishing from Lake Ponca, June-October 1995 and Fort Gibson Reservoir, May-October 1996 in Oklahoma. Catch rates are expressed as mean number of individuals observed per 3 min of electrofishing (*O/f*), mean number of individuals collected per 3 min of electrofishing (*C/f*), mean number of harvestable sized (≥510 mm) individuals collected per 3 min of electrofishing (C/f_H), and mean number of age-1 (<200 mm) individuals collected per 3 min electrofishing (C/f_R). Error bars represent one standard error.

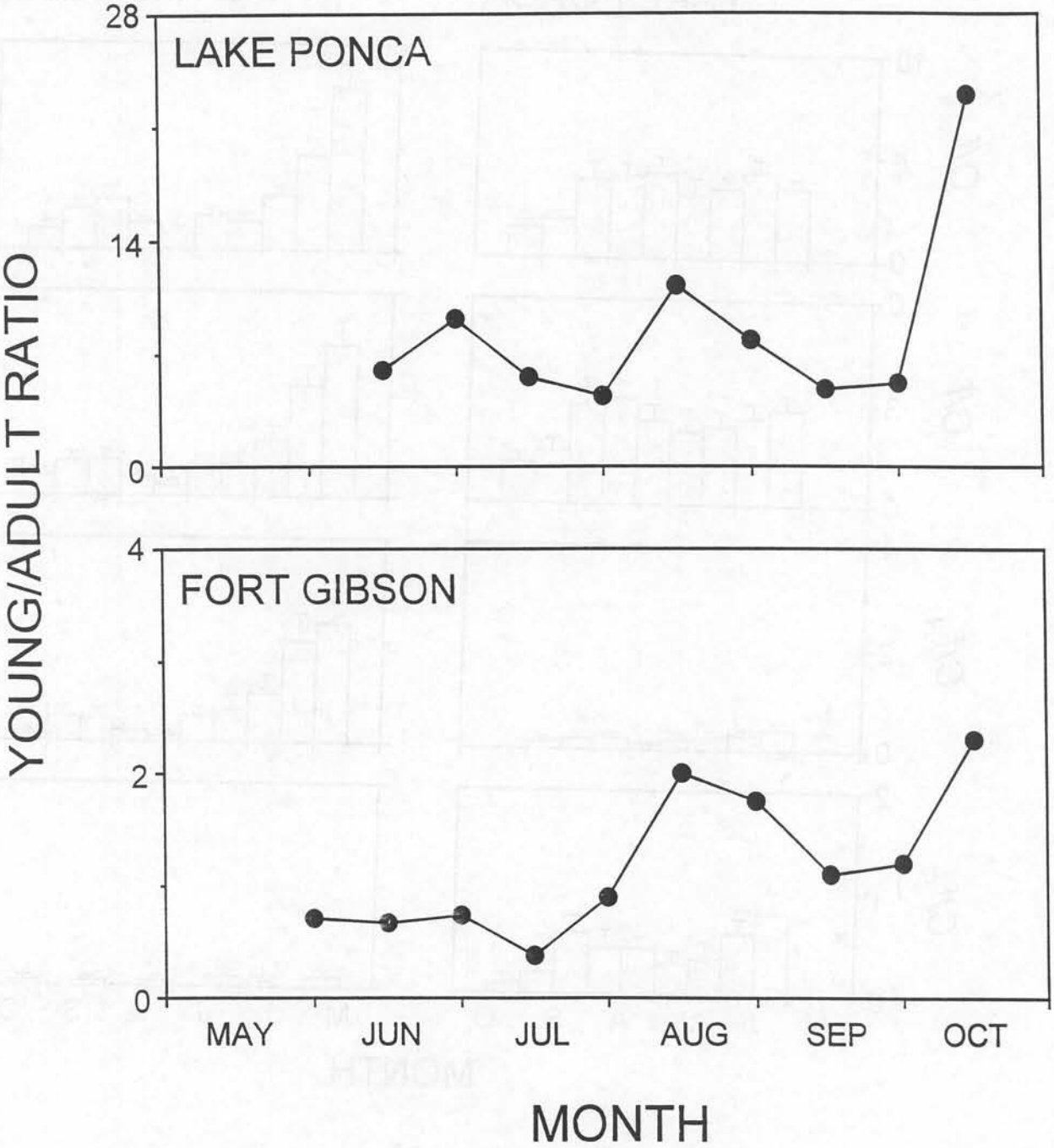

Figure 3. Young/adult ratios of flathead catfish collected by electrofishing from Lake Ponca, June-October 1995 and Fort Gibson Reservoir, May-October 1996 in Oklahoma.

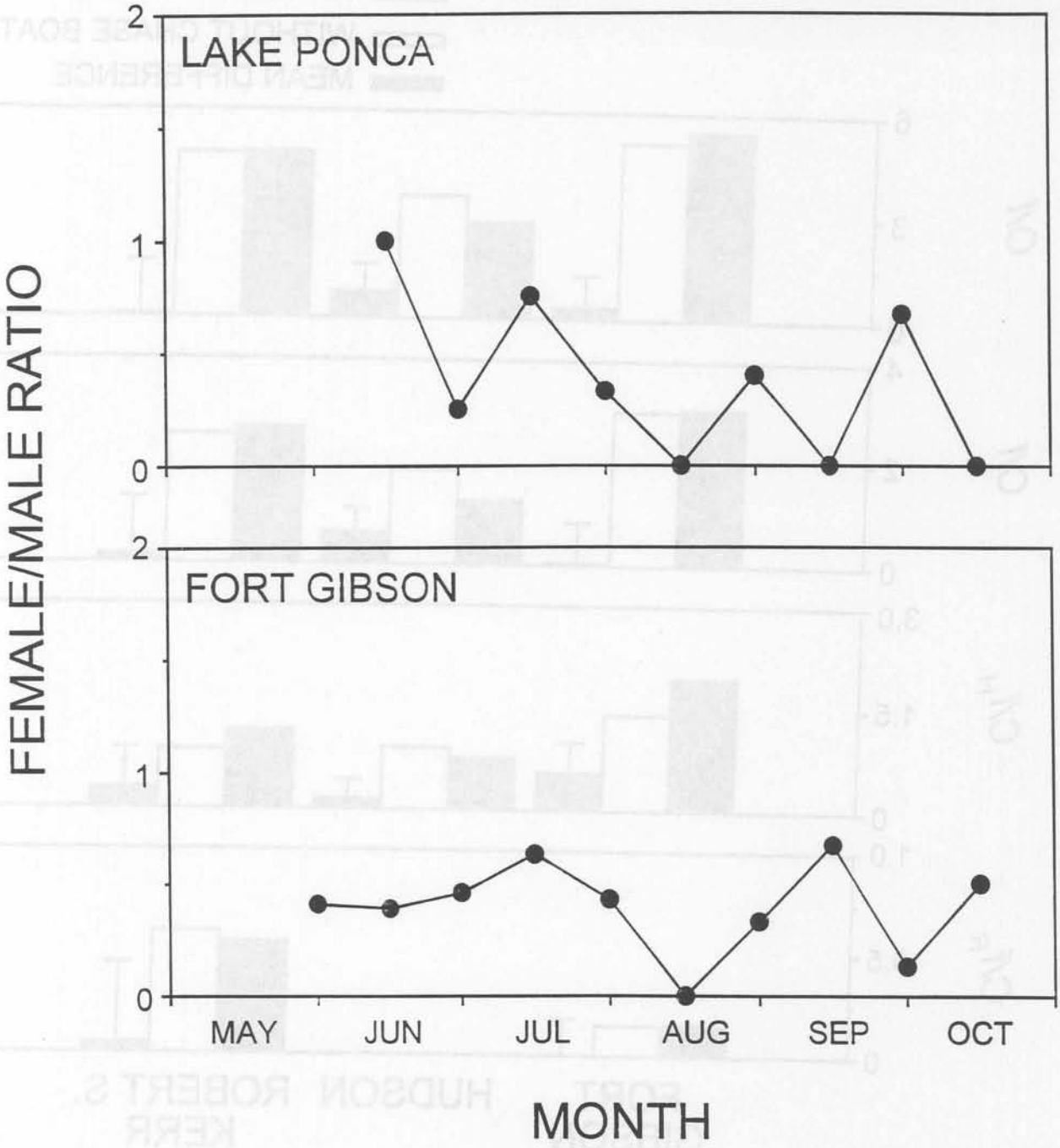

Figure 4. Female/male ratios of adult flathead catfish collected by electrofishing from Lake Ponca, June-October 1995 and Fort Gibson Reservoir, May-October 1996, in Oklahoma.

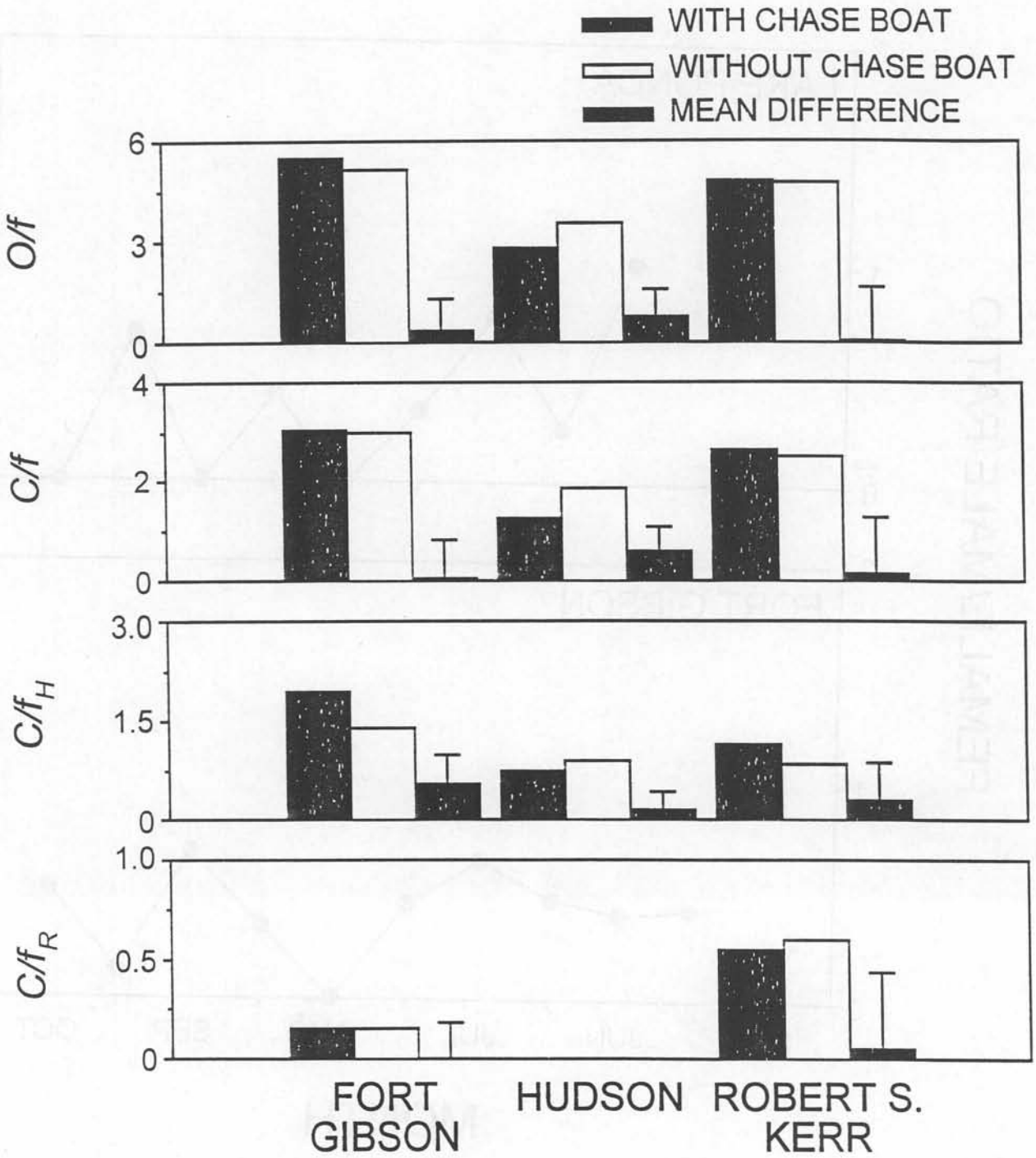

Figure 5. Mean electrofishing catch rates and differences in the means for flathead catfish collected with and without a chase boat from Fort Gibson, Hudson, and Robert S. Kerr Reservoirs, June 1997. Catch rates are expressed as mean number of individuals observed per 3 min of electrofishing (*O/f*), mean number of individuals collected per 3 min of electrofishing (*C/f*), mean number of harvestable sized (≥510 mm) individuals collected per 3 min of electrofishing (C/f_H), and mean number of age-1 (<200 mm) individuals collected per 3 min of electrofishing (C/f_R). Error bars represent one standard error.

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