7-1982

Some Variations in Distribution of Fishes in Large Mainstream Reservoirs Associated with Artificial Cover

Digital Object Identifier: https://doi.org/10.13023/kwrri.rr.135

Donald W. Johnson
University of Kentucky

Elizabeth M. Choinski
University of Kentucky

Research Report No. 135

SOME VARIATIONS IN DISTRIBUTION OF FISHES IN LARGE MAINSTREAM RESERVOIRS ASSOCIATED WITH ARTIFICIAL COVER

By

Donald W. Johnson
Principal Investigator

Elizabeth M. Choinski
Graduate Assistant

Project Number: A-080-KY (Completion Report)

Agreement Numbers: 14-34-0001-0119 (FY 1980)
14-34-0001-1119 (FY 1981)

Period of Project: October 1979 - July 1982

University of Kentucky
Water Resources Research Institute
Lexington, Kentucky

The work upon which this report is based was supported in part by funds provided by the Office of Water Research and Technology, United States Department of the Interior, Washington, D.C. as authorized by the Water Research and Development Act of 1978. Public Law 95-467.

July 1982

DISCLAIMER

Contents of this report do not necessarily reflect the views and policies of the Office of Water Research and Technology, United States Department of the Interior, Washington, D.C., nor does mention of trade names or commercial products constitute their endorsement or recommendation for use by the U.S. Government.

Abstract

The influence of artificial cover (brush piles) on fish populations in Kentucky Lake and Lake Barkley was studied. Mature and larval fishes were collected from deep and shallow sites with and without cover in a bay of each lake. Highest densities of mature crappie, bass, and sauger were found adjacent to deep attractors, while larval crappie and minnows were most concentrated at shallow brush piles. Shad (both adult and larvae) were not congregated at attractor sites. Information gathered supports the continuation of artificial cover installation and water level management procedures which will provide high and stable levels through spring spawning and early development periods.

Descriptors: Fish Populations*; Fish Establishment; Fish Behavior; Fish Harvest; Fish Migration; Fish Farming.

Identifiers: Artificial Cover; Fish Attractors.

Acknowledgements

This project was initiated with the assistance of TVA, utilizing the collaborative support of the Land Between the Lakes (Golden Pond, KY) fisheries biologist, Dr. Tom Forsythe, the loan of larval collecting equipment from TVA's Norris group, the orientation of project personnel and assistance in identifying questionable larvae by James Baker and the TVA larval fish group (Division of Natural Resource Operations, Norris, TN), and the installation of three of the attractors evaluated.

Charles Bronte, Larry Kips, Ed Schnautz and many others helped in both the field and laboratory. Dr. Ken Fairbanks (Math Department, Murray State University, KY) provided valued assistance in statistical analysis and computer programming. Fishermen provided discussions and assistance, especially in the mark-recapture effort.

This project was funded by the Kentucky Water Resource Research Institute, project number A-080-KY, and field and laboratory work completed using facilities at Hancock Biological Station on Kentucky Lake.

Dr. Donald W. Johnson, Principal Investigator, is now at the Institute of Oceanography and Fisheries at Split, Yugoslavia. Ms. Elizabeth M. Choinski is at the Lake Texoma Biological Station, Oklahoma.

Table of Contents

List of Tables

List of Figures

Chapter I. Introduction--Objectives/Background

Sportfishing for black bass and crappie is a major industry in the Tennessee Valley region. Variations in sportfish production and fisherman success has a serious economic impact in many communities in Western Kentucky. Shorelines with an absence of flooded vegetation and water level management which has not considered fisheries needs may have resulted in degradation of these fisheries. Fluctuating water levels, lack of near shore vegetation, and the resulting instability of shoreline substrate have eliminated much of the crappie and bass cover in Kentucky and Barkley Lakes. A program to develop artificial cover (fish attractors) has been initiated in both lakes, although quantification of the effects of this introduced cover on standing crop, species composition, size distribution, growth and reproductive success is in most cases lacking.

The objectives of this project were to quantify the impact of introduced littoral cover on (1) the aggregation of fishes (community structure-species composition and relative abundance), especially white crappie and largemouth bass, and (2) the reproductive success of these fishes. In addition the relative effect of (3) different introduced materials (brush vs. tires), (4) depth of placement (shallow vs. deep), and (5) ambient temperatures and dissolved oxygen concentrations on attractor utilization were examined. These results will contribute to a management plan for the water level fluctuation zone of Kentucky and Barkley Lakes that will enhance the sport fishery without negating other water management objectives.

Water management programs on mainstream reservoirs have mainly dealt with problems of irrigation, navigation, power generation, and flood and mosquitoe control. The effect of these programs on fisheries has received little attention.

If techniques for management of reservoir fluctuation zones are shown to enhance production of sport fishes, TVA and the U.S. Army Corps of Engineers will consider manipulating water levels for sportfish production. The effects of available cover, water levels and fluctuation on spawning conditions, reproductive success and recruitment of sport fishes must be quantified in order to make appropriate management recommendations.

The structure and size of fish populations are known to be greatly affected by fluctuating water levels and the presence of vegetative cover (Seifert 1968; Beckman and Elrod 1971; Walburg 1972; Storck, Dufford and Clement 1978). Reproduction (Wood, 1951; Nelson 1968; Vogale and Rainwater 1975), growth (Kramer and Smith 1960; Johnson and Andrew 1974; Zweicker, Summerfelt and Johnson 1974), species composition (Kindschi, Hoyt and Overman 1979; Krause and Van Den Avyle 1979), and year class formation (Wilbur 1978) may be influenced by artificial cover.

Spawning success of largemouth bass may be dependent on water depth and may be greatly increased with the presence of flooded vegetation (Hunsaker and Crawford 1964; Hansen 1965). The use of flooded vegetation in shallow water as spawning sites for white crappie has also been noted (Hansen 1943; Hansen 1951). Lake levels below average have been correlated with slower growth of yearling crappie and young-of-the-year largemouth bass due to reduction in littoral invertebrates resulting from the absence of littoral vegetation (Henan, Campbell and Redmond 1969). Detrimental effects of low or fluctuating water levels during the spawning season have been shown for other sport, forage, and commercial fishes (Shields 1957; Franklin and Smith 1963). Relative species abundance and species composition may also be altered by manipulating water levels (Hulsey 1957; Parsons 1957).

It has been generally accepted that fish attractors have been effective at concentrating fish and improving harvest. The 1978 Reservoir Committee (Southern Division, American Fisheries Society) rotenone project in Crooked Creek Bay, Barkley Lake, Kentucky compared standing crop, species distribution and size distribution of fish near attractors and open water areas. This research gives a more complete understanding of the effects of fish attractors on the community and facilitates the development of a management program for optimizing sportfish production utilizing controlled water level manipulations and fish attractors.

Chapter II. Research Procedures

Installations of artificial cover in two bays were chosen for study. Barnett Bay is an inlet along the eastern shore of Kentucky Lake (275 km long impoundment of the Tennessee River) at TRM 41. Crooked Creek Bay is located on the western shore of Lake Barkley at CRM 59. Lake Barkley is a 189 km long impoundment of the Cumberland River. Four sampling areas were located in Barnett Bay, two with brush attractors, and two, the controls, without. One of the attractor areas (SA) and one of the control areas (SC) were located in 1.5-2.0 m of water at summer pool (109 m above mean sea level) while the other attractor area (DA) and control area (DC) were located in 4.0-5.0 m of water (Figure 1). Four sites in Crooked Creek Bay (Fig. 2) met the same requirements as those in Barnett Bay. In the first phase of the study a tire attractor in Crooked Creek Bay was compared to a brush deep attractor (DA).

Studies in 1979-80 (June-June) concentrated on the relative abundance and distribution of mature fishes, while those in 1980-81 focused on larval fishes. Mature fishes were sampled by gill and trammel nets, as well as electrofishing. Larval fishes were sampled by push nets and traps. Experimental gill nets were 2 m depth with 10 m panels of mesh sizes 1.3, 1.9, 2.5, 3.8, 5.1, and 6.4 cm. The trammel net was 91 x 1.8 m with 3.8 cm inner mesh and 15 cm outer mesh. Electrofishing efforts utilized a Coffelt VVP-10 mounted in a 6 m john boat. Paired push nets for larval fish sampling were 1.5 m long with a 0.25 m^2 mouth and 0.5 mm mesh; all collections with these nets were made from the surface to 0.5 in depth. Organisms were concentrated into PVC collecting buckets attached to the cod end of the nets. A digital flow meter was suspended in the throat of one net to determine the volume of water filtered during each sampling. Three-minute collections were made from either side of the foredeck of a 5 m john boat (equipped with a metal mounting frame) at a velocity of 0.5-1.0 m/sec. Samples were washed from the nets and collecting buckets into jars and fixed in 5% formalin. Larval fishes were sorted using a dissecting microscope and identified to the lowest taxon possible using keys by Hogue et al. (1976) and Seifert (1969). Mr. James Baker (Division of Natural Resources Operations, TVA, Norris, TN) identified larvae and eggs beyond the expertise of project personnel. Numbers in each taxon were calculated as fish/100 m^3 of water. Plexiglass larval traps were set with and without lights both day and night at each site. The traps were rectangular boxes, open on one end. Wings were fitted into the open end to make a funnel which directed fish into the trap. Their construction is described by Bagenal and Braum (IN Bagenal 1978). Some traps were equipped with 6v batteries and light bulbs for night sets. The bulbs were able to burn for 6 to 8 hours. The traps were used as a means of obtaining qualitative data concerning the presence of age-0 fish which were too small to collect with nets. Mature fishes were identified to species with size and location of capture recorded for each. In 1979-80 black bass and crappie longer than 25 cm and in good condition were marked with coded Floy (F67) spaghetti tags and returned to the water. Age and growth rates were determined for white crappie and large-mouth bass collected by electrofishing in 1981. The body:scale relationship was determined by the least squares method using standard regression techniques (Sokal and Rohlf 1973). Growth rates were determined using a modified Lea's formula (Bagenal and Tesch IN Bagenal 1978):

$$l_n - a = S_n/S\ (l-a)$$

where: l_n = length of fish at formation of annulus n

l = length when fish was sampled

S_n = radius of annulus n at length l_n

S = total scale radius

a = constant derived from body:scale relationship

Water temperature and dissolved oxygen profiles were monitored at all sampling sites throughout the study.

Preliminary comparisons of densities for each taxon among the sites in each bay were made using three-way analysis of variance (ANOVA) with interactions (Kleinbaum and Kupper 1978). The factors involved were date, depth (shallow or deep), and presence or absence of attractors. A general ANOVA table was computed, the model sum of squares was partitioned into sums of squares for the three main effects: date, depth, and type, and depth with type, and for one three-way interaction: date with depth with type. The three-way interaction was considered first in each ANOVA: If it was close to being significant ($P < 0.10$) then the mean densities of each site were compared using a protected least significant difference procedure (LSD):

$$LSD = t_{\alpha/2,\nu} \sqrt{MSE\ (1/n_i + 1/n_j)}$$

where ν = degrees of freedom from error mean square

$t_{\alpha/2}$ = critical value from Students T distribution

MSE = error mean square

n_i = sample size of ith mean sample

n_j = sample size of jth mean sample

To compare two population means ($H_o: \mu_i = \mu_j$) the difference between their respective sample means was compared to the LSD value. All comparisons were made at $\alpha = 0.05$. In the case of three-way interactions the emphasis was placed on looking for trends in the data through time. Isolated differences between sites were not considered meaningful information in themselves, since the large number of comparisons may well have resulted in a few erroneous differences.

If the three-way interaction was not significant, then the two-way interaction between depth and type was considered. If it was significant ($P < 0.05$) a protected LSD was performed to compare the means of the four sites, at different depths, for all the dates combined. If the depth with type interaction was not significant then the other two-way interactions were examined and treated in the same manner. If no interactions were significant, the main effects of type and depth were examined. Date alone was not considered since variations from one date to another would most likely be the result of changes in spawning intensity. Since the data were counts, which typically follow a Poisson probability distribution, all statistics were performed on $\log_{10}$ transformed data. The ANOVA procedures were performed using Statistical Analysis System (SAS) computer programs.

Instantaneous growth rates (B_1) and instantaneous total mortality (Z) were computed for sport fish from all sites using methods described by Cada and Hergenrader (1980) and Ricker (1975). Length categories of 0.5 mm increments, instead of individual total lengths, were used in the following analyses (for example, fish in the 4.3 to 4.7 mm range were included in the 4.5 mm length category). Catch curves were obtained by plotting the natural logarithms of the total number in each length category. The catch curves were used to determine if the entire catch could be used in the analyses or if it would have to be truncated because of poorly represented size classes. By plotting the abundance of each length category through time, average growth rate estimates were obtained. The mean date of each distribution represented the date the average individual reached that length category. To derive the growth estimates, regressions were performed on each plot of length against date. The regression equation was of the following form:

$$L = B_o r^{B_1 t}$$

where L = length in mm
t = age in days
e = base of the natural logarithms
B_o and B_1 are constants

Using this equation, the age of each length group was determined. The natural logarithm of the frequency of each length group was plotted versus age. Regressions were then performed on each of these plots. The resulting slopes were the instantaneous total mortality rates (Z). Z values and growth rates of larval sport fish were compared between sites using the Hollander parallelism test (Hollander and Wolfe 1973) at $\alpha = 0.05$. This test determines if two regression lines are parallel; it is distribution free and eliminates correlation effects through time. Regression analyses were performed using Statistical Analyses Systems computer programs.

Chapter III. Results and Discussion

Mature Fish Distribution

Relative Abundance

August 1979 sampling found twice as many species at introduced cover as in control areas. Brush attractors congregated four times more white crappie than control areas, and twice the number found at tire attractors. Blue catfish were more concentrated at tire than brush attractors. Skipjack herring and spotted sucker were also more common at attractor sites, while drum dominated the control areas where catfishes were the only sport fish collected. Deep attractors had five to eight times more crappie than control areas, while shallow attractors had two times more than control areas. Black bass and sauger were four to five times more abundant at deep attractor sites, although three to five times more numerous at shallow attractors than control sites (personal communication, L. D. Kips). This information supported the decision of TVA and the State to proceed with the installation of more brush attractors in both shallow and deep sites.

In winter gill netting between October 1979 and March 1980 no sport fish were collected at the shallow control area in Crooked Creek after December when total numbers sampled also declined (Figs. 3 and 8). In November and December most sport fish collected were sauger (Table 1). The installation of artificial cover in deeper sites over rocky bottoms should provide additional high quality winter sport fishing, especially for sauger.

The unavailability of sport fishes in winter may have resulted from their decreased movement and/or the absence of forage fishes in sampling areas. From November to December water temperatures dropped from 8 to 6°C in Crooked Creek Bay and 13 to 7°C in Barnett Bay; these temperature drops produced threadfin shad "kills" (Fig. 3). The elimination of nearshore forage could explain the absence of crappie and sauger from attractor sites in January.

Fish numbers were highly correlated with water temperatures. Between October and December 1979 water temperature in Crooked Creek Bay fell from 17° to 6°C while catch decreased from 40 to <1 fish/m of gill net set. As water temperature rose during April 1980 there was a corresponding increase in catch. Sport fishes were not collected at shallow control sites between January and April and catches at shallow attractors were reduced (Fig. 4b). Sauger numbers peaked during mid-December in Barnett Bay, were absent in February and March, and increased to another peak in April. This trend in sauger numbers paralleled the abundance of forage fishes.

Numbers of crappie peaked in October-November and May, although the spawning "run" to shallow habitat was interrupted by several days of unusually cold temperatures in 1980. These low temperatures appeared to inhibit spawning and females sampled were resorbing their eggs. Although bass were never found in large numbers they were more numerous in October than any other month.

In the spring of 1979 196 crappie and 26 largemouth bass were tagged in Crooked Creek Bay; 8% of the crappie and 19% of the bass were caught and returned by fishermen. Most (80%) remained at the site of their initial capture and tagging, although some had moved from 3.2 to 16.1 km. This lack of movement and high catch rate supports the potential of installed artificial cover to hold sport fish populations and to contribute to fishing success.

Species Composition

Evaluation of the influence of artificial cover (brush attractors) on distribution by comparing total numbers of mature fish captured at each collecting site with experimental gill nets is misleading as a result of the influence of a school of forage fishes (especially clupeids--shad) comprising several hundred individuals compared to several sport fishes. For instance, in December 1979 collections at Barnett Bay, 3X more sport fish were collected at the shallow attractor site (SA) than at the shallow or deep control (SC or DC). Many more total fish were collected at the control sites, a function of shad catches (Table 1, Fig. 3). The consideration of fishes other than clupeids (Fig. 3) or the ratio of sport fishes to total catch (Fig. 4) more accurately reflect the impact of the added cover. Examination of the relative abundance of the dominant species from the experimental gill net catch (Table 1) shows no evidence of a relationship between numbers of shad, carp, catfishes, or yellow bass and brush cover, while suggesting that a positive correlation may exist for spotted sucker, sauger, crappie, black bass, and sunfishes. The attraction of schools of forage fishes in control areas to feeding predaceous sport fishes may produce catches which underestimate the importance of the introduced cover to these sport fishes, but the consistently higher percentage of sport fish at attractor sites is perhaps the best indicator of their value (Fig. 4).

Age and Growth

This study did not determine the influence of artificial cover on growth of mature crappie and bass, but their growth was determined to compare favorably with populations in other regional waters (Tables 2 and 3). The body:scale relationship for white crappie in Barnett Bay was L = 107.86 + 0.515 (r^2 = 0.48), those from Crooked Creek Bay L = 42.79 + 0.925 (r^2 = 0.98) which was similar to that determined for this population by Gasser and Johnson (1979).

Growth of crappie in Crooked Creek Bay has been shown to be superior to other Lake Barkley bays and subimpoundments (Gasser and Johnson, 1979). The body:scale relationship for largemouth bass from Barnett Bay was L = 28.11 + 2.055 (r^2 = 0.98). Studies of the influence of water level fluctuation on largemouth bass growth have shown a positive correlation with high water levels (Stroud 1948; 1949; Mayhew, 1967; Zweiacker et al. 1974). Although the analyses were not completed it is supposed that the introduction of artificial cover (brush attractors) would have similar effects.

Dissolved Oxygen Stratification--a complicating factor.

Temperature and dissolved oxygen monitoring at collecting sites found that stratification existed in Crooked Creek Bay from mid-July through the late summer (Fig. 5). During that period, dissolved oxygen in bottom waters was too low to support sport fish populations and were sometimes anoxic. This information indicated that some artificial cover had been installed in inappropriate locations and that proposed sites should be monitored prior to installation to obtain maximum benefit to the fisheries. Other bays monitored, including Vickers and Savells near Crooked Creek Bay, did not stratify and the availability of dissolved oxygen would not restrict the utilization of installed artificial cover in those bays.

Larval Fish Distribution

In conjunction with studies of adult populations of fish attractors, larval fish populations were examined to see if there were any differences in species composition and relative numbers of crappie, bass, and other larvae at brush attractors and controls.

Relative Abundance of Young-of-the-Year

Densities of white crappie, sunfish, clupeids, and minnows collected at all sites were plotted on a $\log_{10}$ scale (Fig. 6-12) throughout the sampling period (24 April to 14 July 1981). Dissolved oxygen and temperature information from each sampling date are shown in Figs. 13-16.

White crappie were collected from 24 April to 18 June at water temperatures ranging from 17 to 27°C. It was apparent from the high initial densities in Crooked Creek Bay that spawning had begun there before the first sampling occurred (Fig. 7). These observations agreed with those of other authors. Overmann et al.

(1980) first collected white crappie larvae in Rough River Lake, Kentucky, when water temperature reached 17°C. In South Dakota, white crappie spawned between 16 and 20°C during a 20-29-day period (Seifert 1968).

Densities of white crappie larvae from Barnett Bay showed a significant two-way interaction between depth and substrate type. The LSD test indicated there was no difference in mean densities between deep attractor and deep control sites. There was a significantly higher average density at shallow attractors than shallow controls (Fig. 6). This suggested that more adult white crappie were utilizing the SA area for spawning sites and/or more young crappie were surviving in these areas. No significant interactions were seen in Crooked Creek Bay. Depth, the main effect, was a highly significant factor ($P < 0.001$). Comparison of the overall means from deep and shallow sites showed that there were significantly more crappie in the shallow water than the deep water. In Crooked Creek Bay, both shallow sites (attractor and control) had abundant natural brushy vegetation along the shoreline, which was inundated during the sampling period. Since the artificial cover made up only a small portion of all the available cover at SA, the available natural cover can explain the similar results at SA and SC. This may also explain the higher larval densities in Crooked Creek Bay when compared to Barnett Bay. These results emphasize both the importance of installing artificial cover and water level management to the enhancement of crappie reproductive success.

Maximum densities observed in this study, 631/100 m^3, were much greater than the 147/100 m^3 observed by Overmann (1979) in Rough River Lake. He also observed only one spawning peak whereas two were observed in each lake during this study. These differences may reflect lake size, community structure, or different population cycles. They also support maintaining a maximum quanity of flooded vegetation and submerged cover during the spring months to maximize young-of-the-year production.

The importance of vegetation and cover in the life cycle of white crappie have been known for many years. White crappie usually spawn under overhanging banks or on flat or sloping banks at depths of 20 to 97 cm (Hansen 1943; 1965; Mitzner 1973; Seifert 1968). Nelson et al. (1968) noted that spawning occurred mostly in the protected bays and shallow island areas of a reservoir. In Lake Rathbun, Iowa, abundance of yearling crappie was positively related to floodwater storage (Mitzner 1981). Eggs are deposited on almost any type of vegetation including tree roots, grasses and filamentous algae; deposition of eggs occurs at depths up to 6 m and often in very turbid waters (Hansen 1943; Seifert 1968; Mitzner 1972; Carlander 1977). Since white crappie do not migrate until they reach the juvenile stage (Nelson et al. 1968), it was assumed that most of the larvae were captured near their nests.

The average densities of sunfish at all sites in Barnett Bay and Crooked Creek Bay are presented in Figures 8 and 9 respectively. Highly significant three-way interactions occurred in each bay. Apparently much of the variation in density was caused by temporal changes, especially in Crooked Creek Bay where very few significant density differences among sites were noted. These sets of data are particularly difficult to interpret because the available taxonomic keys did not distinguish species of the genus Lepomis. Therefore, it was not known what species, or even how many species were present. Bluegill sunfish (L. macrochirus), longear sunfish (L. megalotis) and green sunfish (L. cyanellus) are the most common sunfish in the lakes. All prefer to spawn in water less than 3 m deep (Carlander 1977). The first appearance of sunfish in the samples was probably green sunfish or other species which spawn at lower temperatures than bluegill or longear (17 to 27 C and 21 to 28 C respectively). Although bluegill nests are found near littoral vegetation, the longear generally spawns in brush free areas (Boyer and Vogele 1968; Kitchell et al. 1974; Carlander 1977). These data probably reflected these kinds of interactions. Even so, it was apparent in Barnett Bay that the shallow attractors were concentrating some species of sunfish. It is probable that bluegill, a desirable panfish, are utilizing the attractors for spawning sites. In both bays there were significantly more sunfish in the shallow areas, the same areas negatively affected by water level drawdowns.

The mean densities of the Clupeidae collected at all sites in Barnett Bay and Crooked Creek Bay are shown in Figure 10 and 11, respectively. Highly significant ($P < 0.001$) three-way interactions occurred in both bays. The determining factor in these interactions was date. Results of comparisons between attractor and control sites were highly variable and did not reveal any trends. Once again, the species involved were unknown. The possibilities include the skipjack herring, the gizzard shad, and the threadfin shad. The spatial and temporal distribution of young gizzard shad and threadfin shad were studied in Beaver Reservoir, Arkansas. Their spawning periods overlapped greatly. Gizzard shad spawned from early April to mid-June while threadfin shad spawned from early May to early July (Netsch et al. 1971). These spawning dates corresponded with the dates that shad larvae first appeared in this study. Location (near shore or in channel) did not have a significant effect on density for either species in Beaver Reservoir. Likewise, no differences between deep and shallow or attractor and control sites were found in Lake Barkley or Kentucky Lake.

Average densities of all Cyprinidae from Barnett Bay and Crooked Creek Bay are depicted in Figures 12 and 13. A significantly higher mean density occurred at SA in Barnett Bay than any other site. In Crooked Creek Bay there were significantly more cyprinids at shallow than deep sites. Again these differences might be caused by different species compositions at different sites and on different dates. In both bays, the shallow areas were apparently important nursery areas for whatever species were present.

Early in the year larvae of *Morone* sp. and *Stizostedion* sp. were collected at attractor sites in Barnett Bay and Crooked Creek Bay respectively. Of the remaining larvae and eggs, the brook silverside (*Labidesthes sicculus*) and the freshwater drum (*Aplodinotus grunniens*) were the most frequently encountered. The silversides were mostly collected at shallow sites. In Barnett Bay, silversides appeared only in mid-June, whereas in Crooked Creek Bay, they occurred at low frequencies from mid-May to the end of the sampling period. Silversides generally attached their eggs to rocks, stumps, or vegetation in shallow water. Their low frequency of occurrence was probably related to their intolerance of the high turbidity of the reservoirs (Clay 1975). The eggs and larvae of the drum were mostly found at the deeper sites, as would be expected of this pelagic spawning species. In Barnett Bay, larvae and eggs of the drum were observed sporadically throughout the study with peaks occurring in early May and again in early and late June. In Crooked Creek Bay, drum were observed at very low frequencies in mid-June. Darters (Percidae) of undetermined genus were collected only from shallow sites during the first four weeks of the sampling period in Barnett Bay. In Crooked Creek Bay two specimens were observed from shallow sites on the first sampling date.

The plexiglass traps were not effective at capturing larval forms of any species. All specimens were taken from night set traps in the shallow attractor areas. In Barnett Bay two minnow were collected with lighted traps set on 7 May and seven *Lepomis* spp. were collected from an unlighted trap set on 9 June. In Crooked Creek Bay, three shad and one white crappie were captured with a lighted trap set on 16 May. These taxa were well represented in the net samples. Kindschi (1979), in Rough River Lake, collected large numbers of shad and *Lepomis* spp. larvae only in lighted traps but collected no larvae in unlighted traps.

Growth Rates of Larval White Crappie

White crappie were the only sport fish larvae collected in large enough numbers for growth analyses. Instantaneous growth estimates were used because only a limited portion of the population was sampled. Thus estimates of growth were obtained only for the larval stages during the summer months.

All regressions of growth analysis were significant ($P < 0.05$) for fish of Barnett Bay while only one was significant for fish from Crooked Creek Bay (Tables 6 and 7). The intensity and duration of the spawn best explained the difference between bays. Crappie underwent two spawns during the sampling period (Figs. 6 and 7). Another spawn may have occurred in either bay prior to sampling. Judging by the width and height of the density peaks, spawning periods in Barnett Bay were of shorter duration and did not produce as many larvae as those in Crooked Creek Bay. This resulted in higher densities of smaller larvae in Crooked Creek Bay for a longer period of time. Using the lengths of these fish through time to determine growth rates showed no growth occurring as reflected in the regressions. Nelson et al. (1968) found that satisfactory growth rates could not be calculated for yearling crappie because white crappie have extended spawning periods resulting in multi-modal length frequency distributions. No methods are presently available which accurately split modal groups. Growth rates formulated using lengths are frequently slower than actual rates (Nelson et al. 1968). Broods from different spawns become mixed because of individual differences in growth, mortality and migration of larger individuals. In the Rough River Lake study, only one spawning peak was observed for white crappie and a growth rate of 1.43 mm/week was calculated for the first eight weeks of the spawning period (Overmann et al. 1980). Since this calculation was based on a single spawn, it is probable a more reliable estimate than the estimates produced in this study (Tables 6 and 7). No significant differences in growth were found between attractor and control sites.

Mortality Rates of Larval White Crappie

Since significant growth rates are required for their computation, instantaneous mortality rates of larval crappie were only computed for fish from Barnett Bay (Table 8). The Hollander parallelism test revealed a significantly lower mortality rate for DA fish than DC fish. No significant difference was detected between SA and SC mortality estimates. As in the case of growth estimates, the accuracy of mortality estimates probably was reduced because of multiple spawning. No mortality rate estimates for young-of-the-year white crappie were found in the literature.

To increase survival of a species, the periods of highest mortality for that species must be identified. Dahlberg (1979) pointed out that few published reports provide the data needed to determine relative mortality among the different stages in the early development of fish (i.e., egg, prolarva, postlarva). Once the stage with the highest mortality is identified, management steps can be taken to help increase survival during that period.

Chapter IV. Conclusions

The effect of submerged vegetation on the distribution of both young-of-the-year and mature sport fish in Kentucky Lake and Lake Barkley has been demonstrated. Mature fish are attracted to this cover and some species utilize it for spawning substrate and shelter for young-of-the-year. The positive value of submerged vegetation in managing sportfish populations can be obtained by installation of brush-pile attractors and in some cases by water level management. Black bass, crappie, sauger and sunfish populations are all critical to the recreation industry in the Tennessee Valley and have been enhanced by management strategies which increase submerged vegetation cover.

Installation of natural materials (brush attractors) is more effective in aggregating sportfishes than industrial products (tires). Depth of the cover is an important factor with that installed in less than 2 m of water (summer pool) with greater impact on reproductive success and that in more than 4 m most important in aggregating mature sport fish to improve fishing success. Installation of deep cover must be preceded by dissolved oxygen and temperature monitoring at proposed sites to avoid the potential for negative effects resulting from stratification and anoxic conditions at the "attractor."

Winter harvest of sauger, crappie, and bass may be improved through the aggregating effect of introduced cover in deeper (>4 m) waters. Tagging studies indicated that most bass and crappie do not move far from winter to spring spawning substrate and summer cover. Increased installation of deep cover might provide staging areas for subsequent movement inshore to adjacent littoral zones managed to improve reproductive success through water level management or installation of shallow artificial cover (brush piles).

While there was no evidence that mature cyprinids (carp and minnows) were attracted to installed cover their larvae were most abundant at shallow attractor sites where they may provide an important forage contribution for growing sport fishes. The importance of these sites to young sunfish might provide an available source of forage for the more valued sport fishes, as well as improving recruitment into the "panfish" fishery.

Larval fish distribution clearly demonstrated that the installation of suitable cover in reservoir littoral zones and/or maintenance of high, stable water levels flooding natural vegetation during periods of spawning and development are management techniques which enhance reproductive success and survival of sportfish populations.

The completion of this study has provided information which should assist the U. S. Army Corps of Engineers, the Tennessee Valley Administration, state and local organizations concerned with sportfish management in enhancing these fisheries. Of equal importance might be the public education component gained directly by students who participated in the project and secondarily by citizens who observed the work on the lake shores and television and thereby became aware of the nature of fish movement and growth and the critical importance of cover to their productivity.

Nomenclature

common names	scientific names
black bass	*Micropterus* spp.
largemouth bass	*M. salmoides*
catfish	Ictaluridae
blue catfish	*Ictalurus furcatus*
clupeids	Clupeidae
threadfin shad	*Dorosoma petenense*
gizzard shad	*D. cepedianum*
skip-jack herring	*Alosa chrysochloris*
crappie	*Pomoxis* spp.
white crappie	*P. annularis*
minnows (cyprinids)	Cyprinidae
sauger	*Stizostedion canadense*
spotted sucker	*Mintrema melanops*
sunfish	*Lepomis* spp.
yellow bass	*Morone mississippiensis*

References

Bagenal, T. and E. Braum. 1978. Eggs and early life history. IN Bagenal, T. (ed.). Methods for Assessment of Fish Production in Fresh Water. Blackwell Scientific Publications. Oxford. 365 pp.

_________, and F. W. Tesch. 1978. Age and growth. IN Bagenal, T. (ed.). Methods for Assessment of Fish Production in Fresh Waters. Blackwell Scientific Publications. Oxford. 365 pp.

Beckman, L. G. and J. H. Elrod. 1971. Apparent abundance and distribution of young of the year fishes in Lake Oahe, 1965-1969. Reservoir Fisheries and Limnology, Special Pub. No. 8, 1971 of the Am. Fish. Soc.

Benson, N. G. 1976. Water management and fish production in Missouri River main stem reservoirs. IN Osborne, J. F. and C. H. Allman (eds.). Proc. of the Symposium and Specialty Conf. on Instream Flow Needs, Vol. II. Am. Fish. Soc. 675 pp.

Boyer, R. L. and L. E. Vogele. 1969. Longear sunfish. U. S. Bur. Sport Fish and Wildl. Resour. Pub. 77: 76-78.

Cada, G. F. and G. L. Hergenrader. 1980. Natural mortality rates of freshwater drum larvae in the Missouri River. Trans. Am. Fish. Soc. 109: 479-483.

Carlander, K. 1977. Handbook of Freshwater Fishery Biology. Vol. II. Iowa State Univ. Press. 431 pp.

Clay, W. G. 1975. The Fishes of Kentucky. Kentucky Dept. of Fish and Wildl. Resour. 416 pp.

Dahlberg, M. D. 1979. A review of survival rates of fish eggs and larvae in relation to impact assessment. Marine Fisheries Review 41: 1-12.

Elliott, G. V. 1976. Diel activity and feeding activity of schooled largemouth bass fry. Trans. Am. Fish. Soc. 105: 624-627.

Franklin, D. R. and L. L. Smith. 1963. Early life history of northern pike with special reference to factors influencing numerical strength of year classes. Trans. Am. Fish. Soc. 92: 91-110.

Gasser, K. W. and D. W. Johnson. 1980. Growth variation in selected fishes of Lake Barkley and adjoining Land Between the Lakes subimpoundments. Proc. Conf. S. E. Assoc. Fish and Wildl. Agencies 33: 723-737.

Hansen, D. F. 1965. Further observations on nesting of the white crappie, Pomoxis annularis. Trans. Am. Fish. Soc. 94: 182-184.

__________. 1951. Biology of the white crappie in Illinois. Ill. Nat. Hist. Bull. 25: 211-264.

__________. 1943. On nesting of the white crappie, Pomoxis annularis. Copeia 1943: 259-260.

Heman, M. L., R. S. Campbell, and L. C. Redmond. 1969. Manipulation of fish populations through reservoir drawdown. Trans. Am. Fish. Soc. 98: 292-304.

Hollander, M. and D. A. Wolfe. 1973. Nonparametric statistical methods. John Wiley and Sons, New York.

Hulsey, A. G. 1957. Effects of a fall and winter drawdown on a flood control lake. Proc. S.E. Assoc. Game and Fish Comm. 10: 285-289.

Hunsaker, D. and R. W. Crawford. 1964. Preferential spawning behavior of the largemouth bass, Micropterus salmoides. Copeia 1964: 240-241.

Johnson, J. N., and A. K. Andrew. 1974. Growth of white crappie and channel catfish in relation to mean annual water level of Lake Carl Blackwell, Oklahoma. Proc. S.E. Assoc. Game and Fish Comm. 27: 767-776.

Kindschi, G. A., R. D. Hoyt, and G. J. Overmann. 1979. Some aspects of the ecology of larval fishes in Rough River Lake, Kentucky. Proceedings of the Third Symposium on Larval Fish. Western Kentucky University.

Kindschi, G. A. 1979. Some aspects of the ecology of larval fishes in Rough River Lake, Kentucky. M. S. Thesis, Western Kentucky Univ., Bowling Green. Mimeo. 86 pp.

Kitchell, J. F., J. F. Koonie, R. V. ONeill, H. H. Shugart, J. J. Magnusen and R. S. Booth. 1974. Model of fish biomass dynamics. Trans. Am. Fish. Soc. 103: 786-798.

Kleinbaum, D. G. and L. L. Kupper. 1978. Applied Regression Analysis and Other Multivariable Methods. Duxbury Press, North Scituate, Massachusetts. 556 pp.

Kramer, R. H. and L. L. Smith, Jr. 1960. First year growth of the largemouth bass, Micropterus salmoides (Lacepede), and some related ecological factors. Trans. Am. Fish. Soc. 89(2): 222-233.

Krause, R. A. and M. H. Van Den Avyle. 1979. Temporal and spatial variations in abundance and species composition of larval fishes in Center Hill Reservoir, Tennessee. Proceedings of the Third Symposium on Larval Fish. Western Kentucky Univ.

Mayhew, J. 1967. Comparative growth of four species of fish in three different types of Iowa artificial lakes. Proc. Iowa Acad. Sci. 72: 224-229.

Mitzner, L. 1981. Influence of floodwater storage on abundance of juvenile crappie and subsequent harvest at Lake Rathbun, Iowa. North Am. J. Fish. Mgmt. 1: 46-50.

__________. 1972. Some vital statistics of the crappie population in Coralville Reservoir with an evaluation of management. Iowa Fish. Res. Tech. Ser. 72: 1-35.

Nelson, W. R. 1968. Reproduction and early life history of sauger, Stizostedion canadense, in Lewis and Clark Lake. Trans. Am. Fish. Soc. 97: 159-162.

__________, R. E. Seifert and D. V. Swedberg. 1968. Studies of the early life history of reservoir fishes. Reservoir Fishery Resources Symposium.

Overmann, G. J. 1979. The early life history of the white and black crappie in Rough River Lake, Kentucky. M. S. Thesis, Western Kentucky University, Kentucky.

________, R. D. Hoyt, and G. A. Kindschi. 1980. The larvâl life history of the crappies (Pomoxis spp.). Trans. KY. Acad. Sci. 41: 1-15.

Parsons, J. W. 1957. Fishery management and possibilities on large southeastern reservoirs. Trans. Am. Fish. Soc. 87: 333-335.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 382 pp.

Seifert, R. E. 1968. Reproductive behavior, incubation and mortality of eggs, and postlarval food selection in the white crappie. Trans. Am. Fish. Soc. 97(3): 252-259.

________. 1968. Biology of the white crappie in Lewis and Clark Lake. Tech. Pap. No. 22 of U. S. Dept. of the Interior, Fish and Wildl. Serv. 16 pp.

Sokal, R. R. and F. J. Rohlf. 1973. Introduction to Biostatistics. W. H. Freeman and Company, San Francisco. 368 pp.

Shields, J. T. 1957. Experimental control of carp reproduction through water drawdowns in Fort Randall Reservoir, South Dakota. Trans. Am. Fish. Soc. 87:23-33.

Storck, T. W., D. W. Dufford, and K. T. Clement. 1978. The distribution of limnetic fish larvae in a flood control reservoir in central Illinois. Trans. Am. Fish. Soc. 107(3): 419-424.

Stroud, R. H. 1949. Rate of growth and condition of game and pan fish in Cherokee and Douglas Reservoirs, Tennessee and Hiwassee Reservoir, North Carolina. J. Tenn. Acad. Sci. 24: 60-74.

________. 1948. Growth of basses and black crappie in Norris Reservoir, Tennessee. J. Tenn. Acad. Sci. 23: 31-100.

Vogele, L. E. and W. C. Rainwater. 1975. Use of brush shelters as cover by spawning black basses in Bull Shoals Reservoir. Trans. Am. Fish. Soc. 104: 264-269.

Walburg, C. H. 1972. Some factors associated with fluctuations in year class strength of sauger in Lewis and Clark Lake, South Dakota. Trans. Am. Fish. Soc. 101: 311-316.

Wilbur, R. L. 1978. Two types of fish attractors compared in Lake Tohopekaliga, Florida. Trans. Am. Fish. Soc. 107: 689-695.

Wood, R. 1951. The significance of managed water levels in developing the fisheries of large impoundments. J. Tenn. Acad. Sci. 26: 214-235.

Zweiacker, P. L., R. C. Summerfelt and J. N. Johnson. 1972. Largemouth bass growth in relationship to annual variations in mean pool elevations in Lake Carl Blackwell, Oklahoma. Proc. S. E. Assoc. Game and Fish. Comm. 26: 530-540.

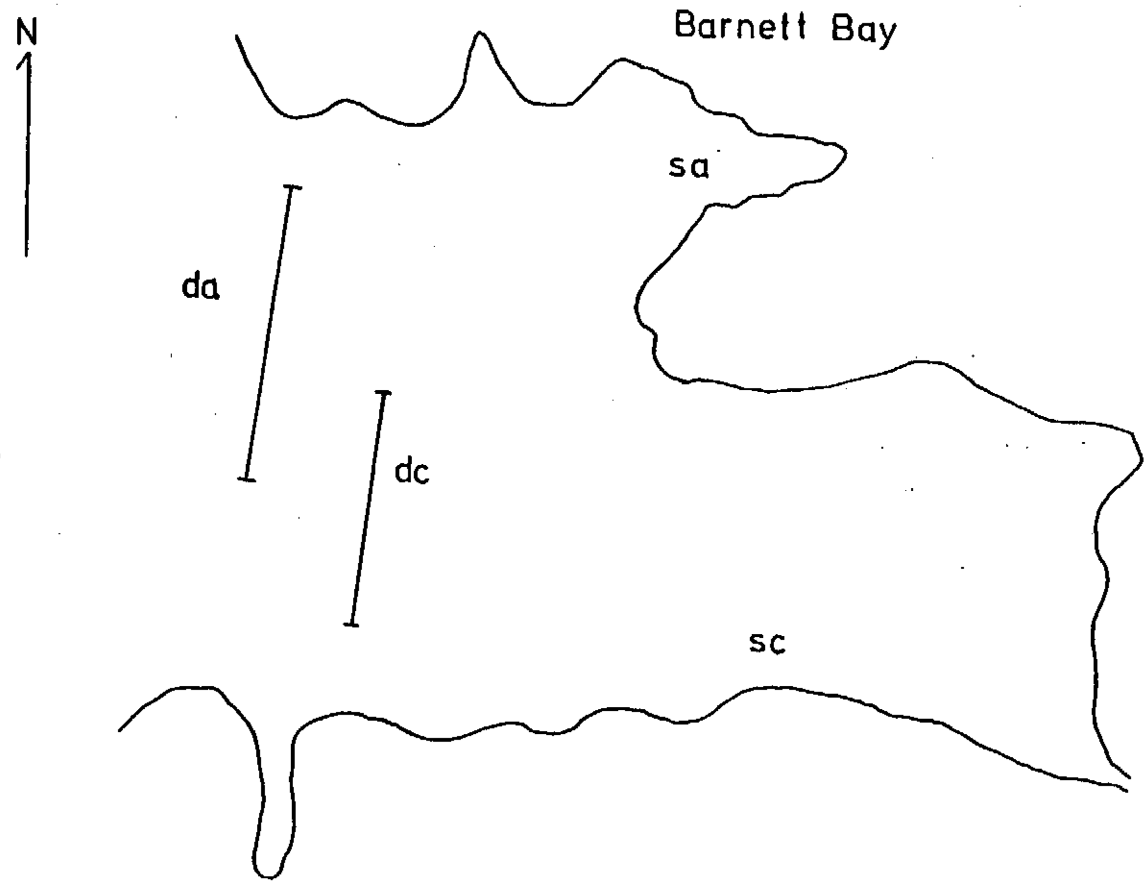

Figure 1: Map of Barnett Bay showing locations of sampling sites. SA is shallow attractor, SC is shallow control, DA is deep attractor, DC is deep control.

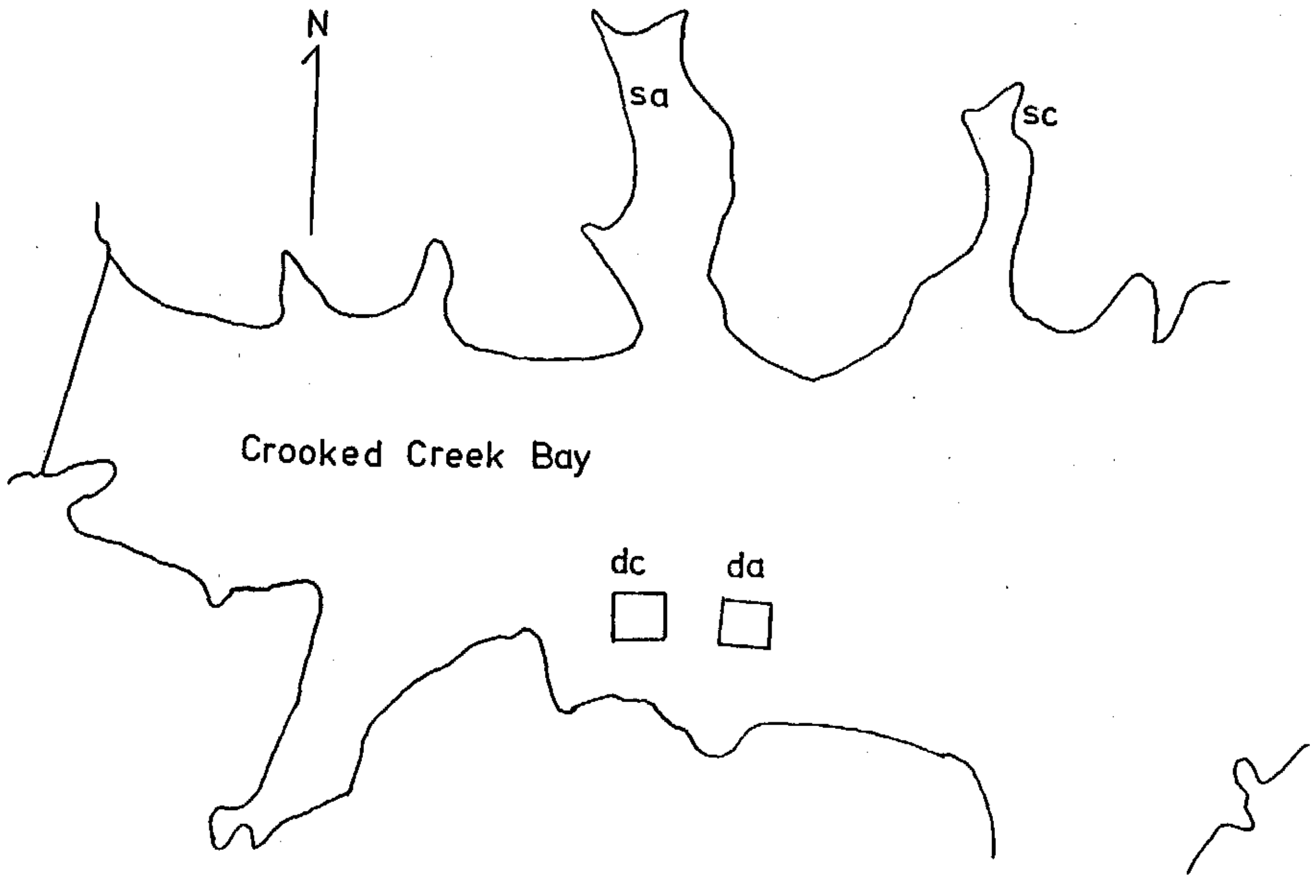

Figure 2: Map of Crooked Creek Bay showing locations of sampling sites. SA is shallow attractor, SC is shallow control, DA is deep attractor, DC is deep control.

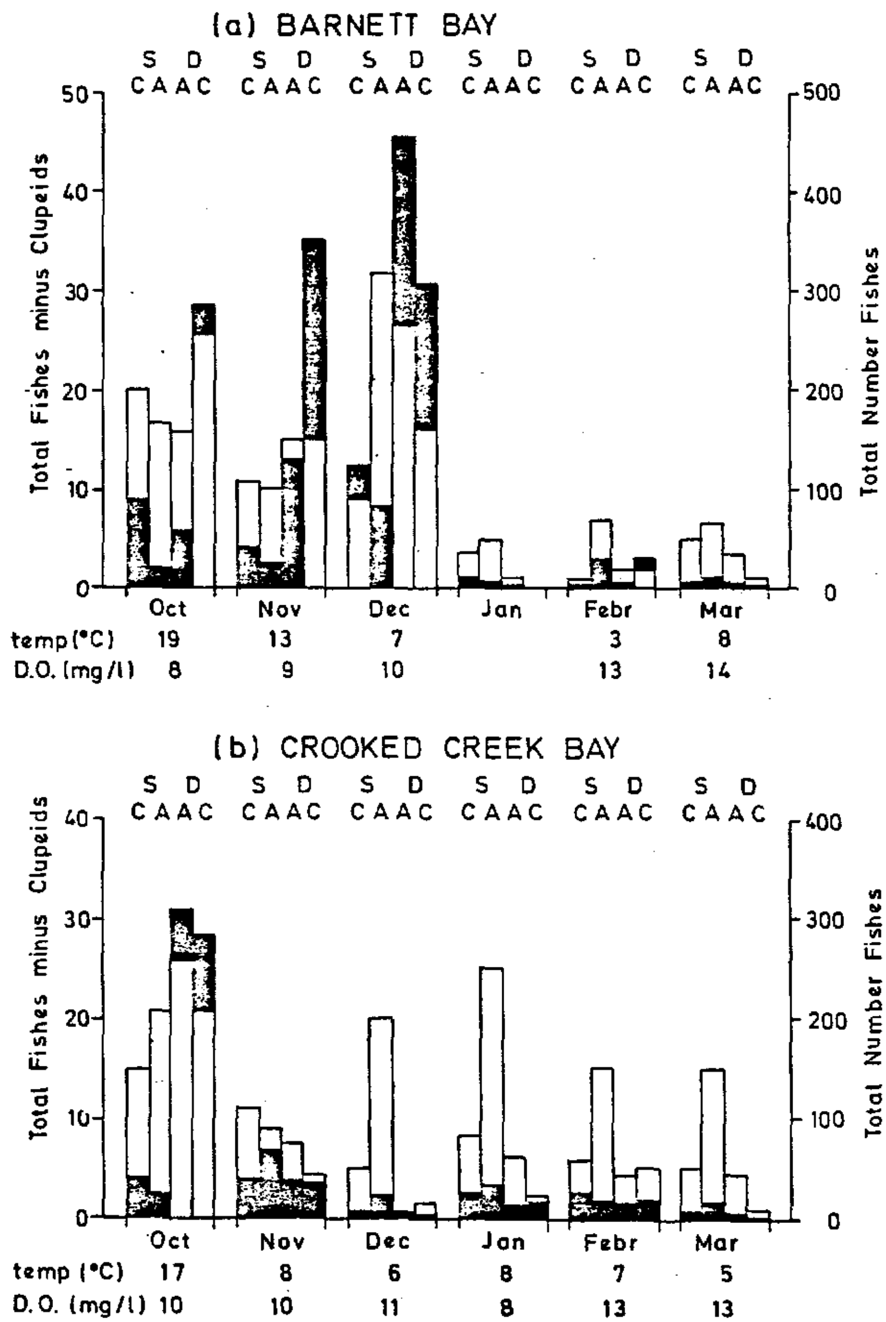

Figure 3. Experimental gill netting catch at collecting sites in Kentucky Lake (Barnett Bay) and Lake Barkley (Crooked Creek Bay) from October 1979 to March 1980. Solid bar represents total number of fish caught; shaded bar represents numbers of fishes other than clupeids.

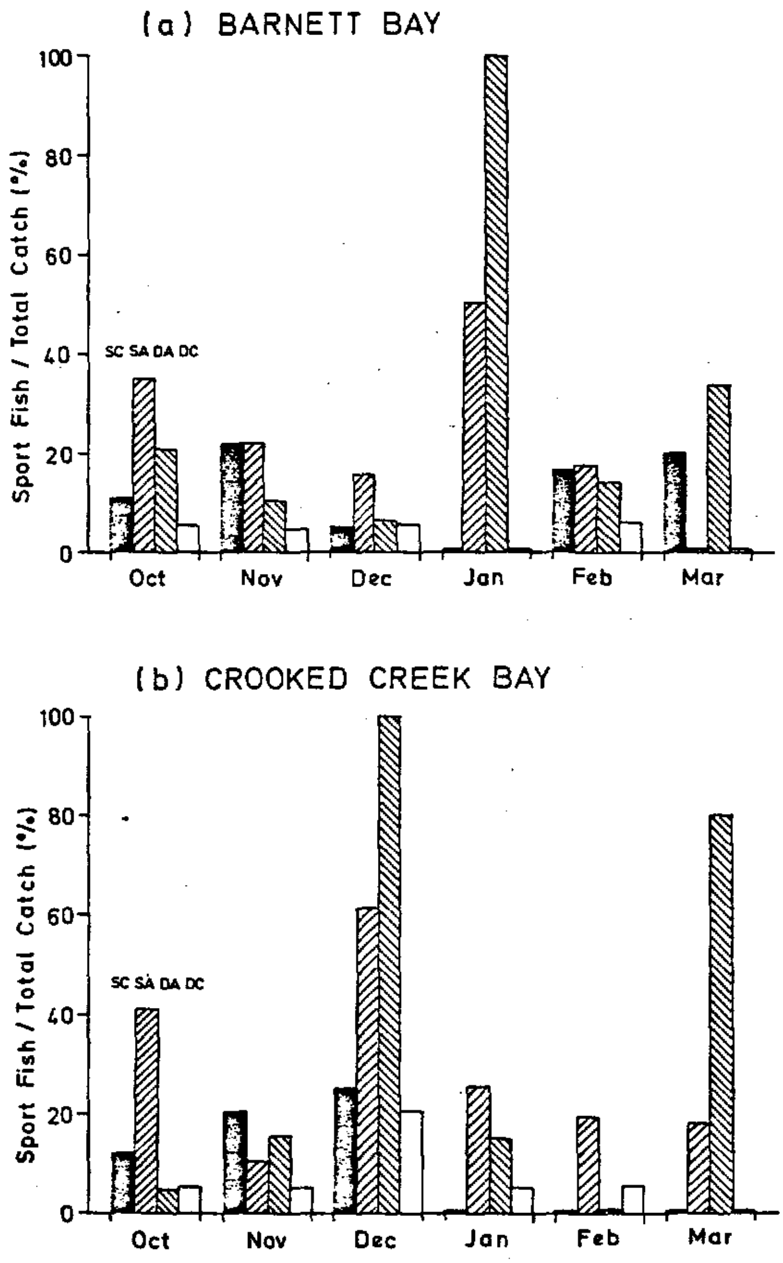

Figure 4. The relationship (%) of sport fish numbers to total catch from experimental gill netting at each collecting site on Kentucky Lake (a) Barnett Bay and Lake Barkley (b) Crooked Creek Bay from October 1979 through March 1980.

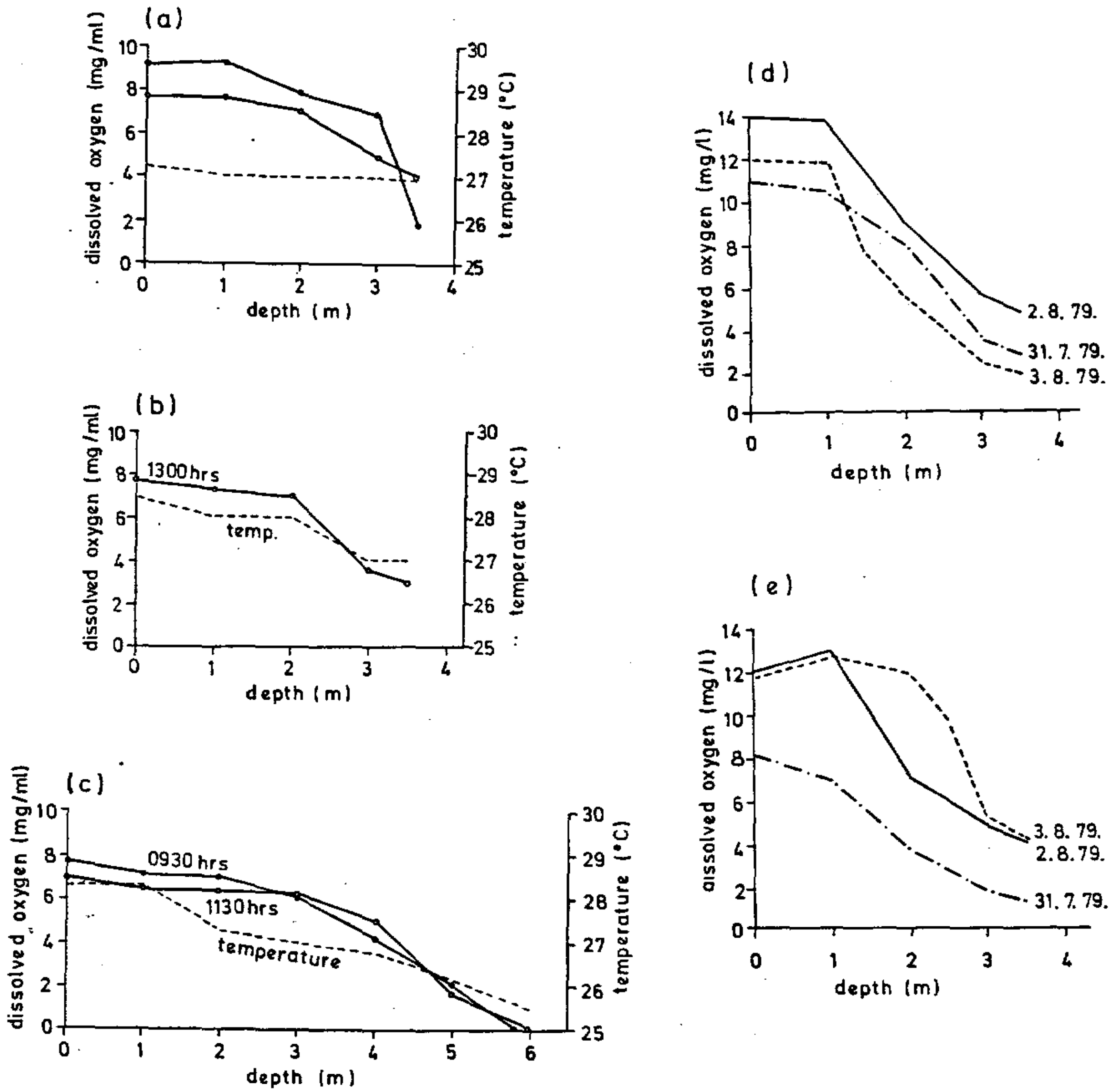

Figure 5. Summer 1979 dissolved oxygen and temperature profiles in Crooked Creek Bay (a) near the mid-bay deep attractor site (18-19 July), (b) open water near the head of the bay (18 July), (c) open water at the mouth of the bay--near the old road bed (18-19 July), (d) mid-bay deep attractor site (31 July-August 3), and (e) open water near the head of the bay (31 July-August 3).

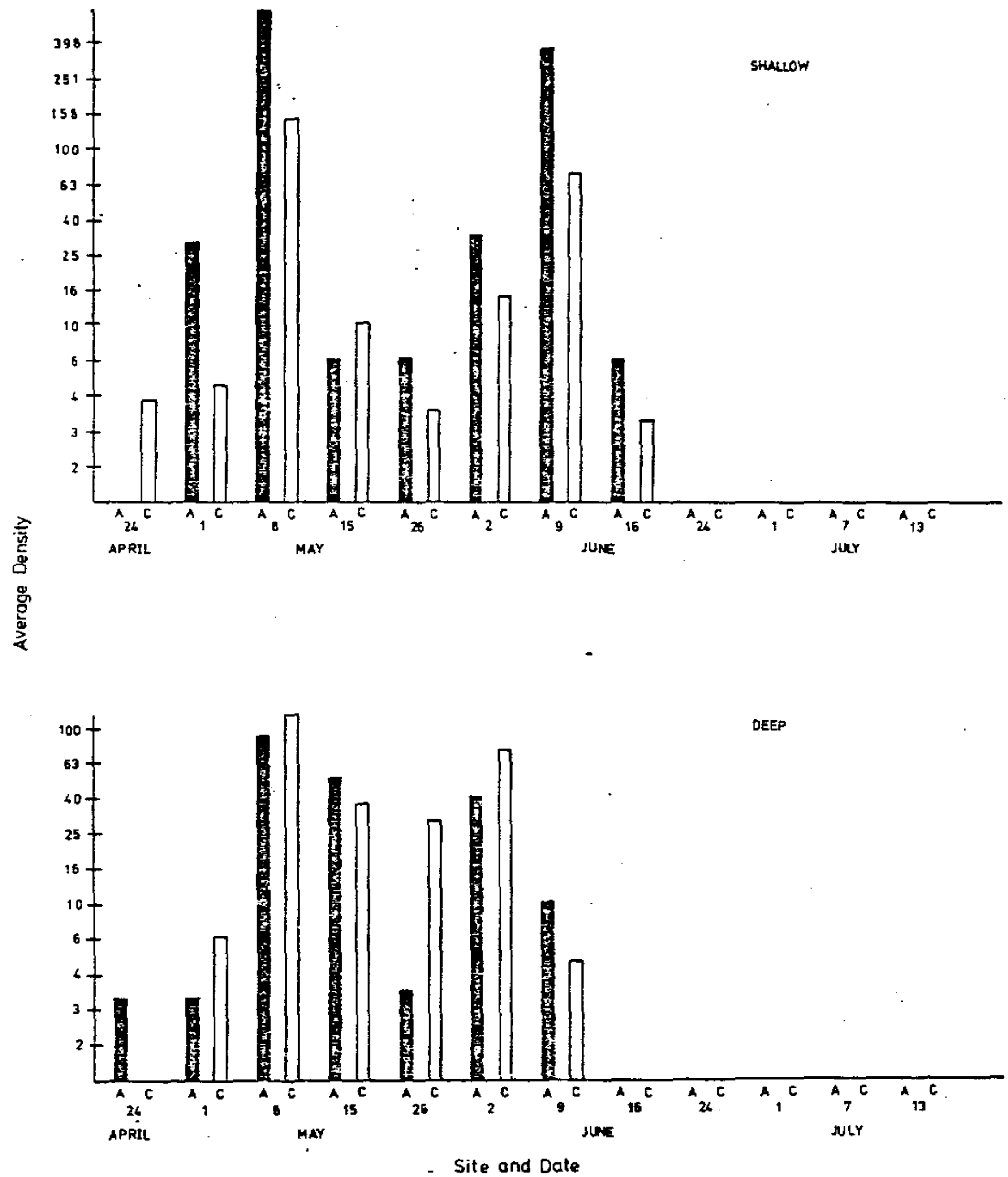

Figure 6: Average density of white crappie (<u>Pomoxis annularis</u>) larvae throughout the sampling period at all sites in Barnett Bay, plotted on a $\log_{10}$ scale. A is attractor, C is control.

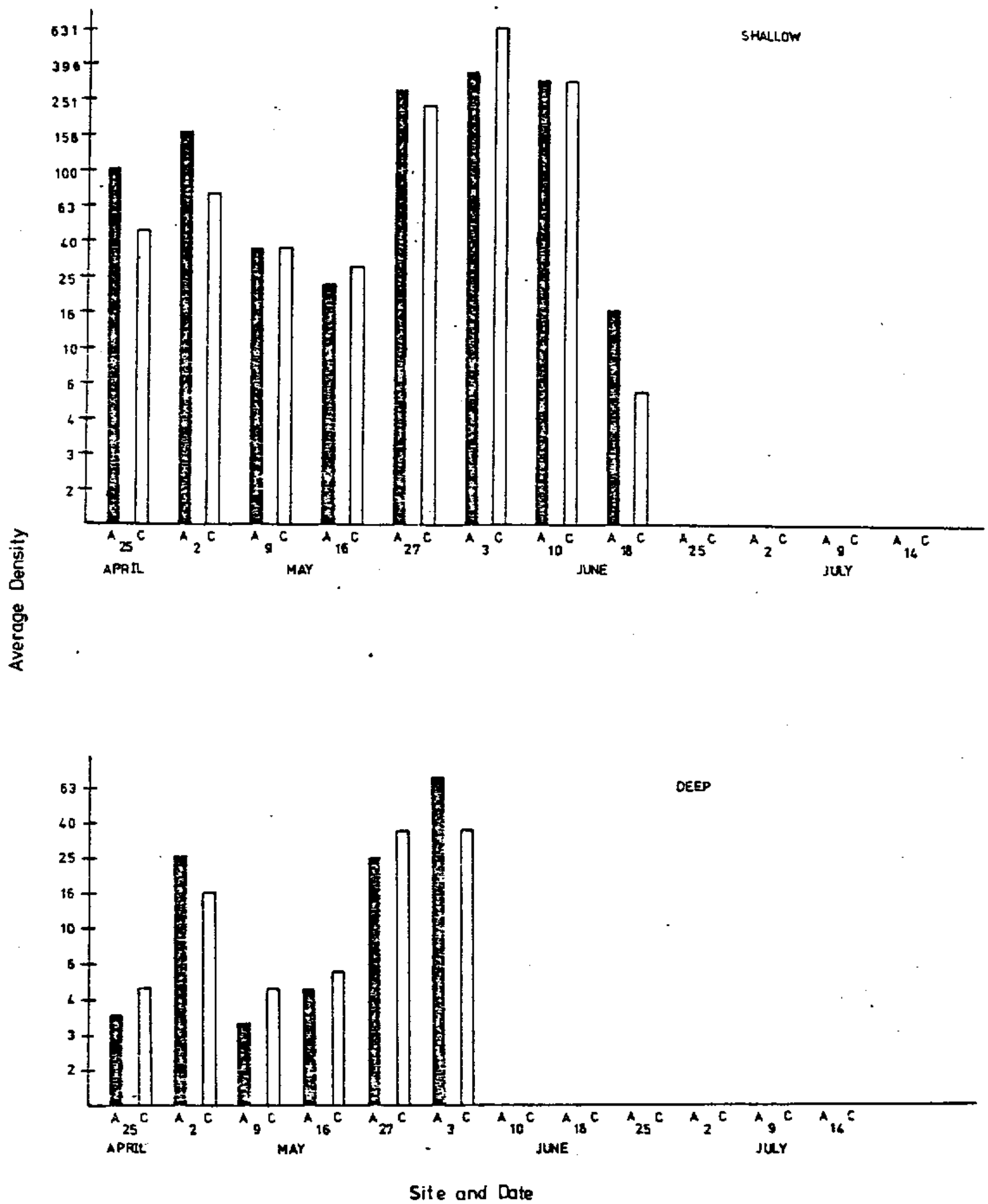

Figure 7: Average density of white crappie (Pomoxis annularis) larvae throughout the sampling period at all sites in Crooked Creek Bay, plotted on a $\log_{10}$ scale. A is attractor, C is control.

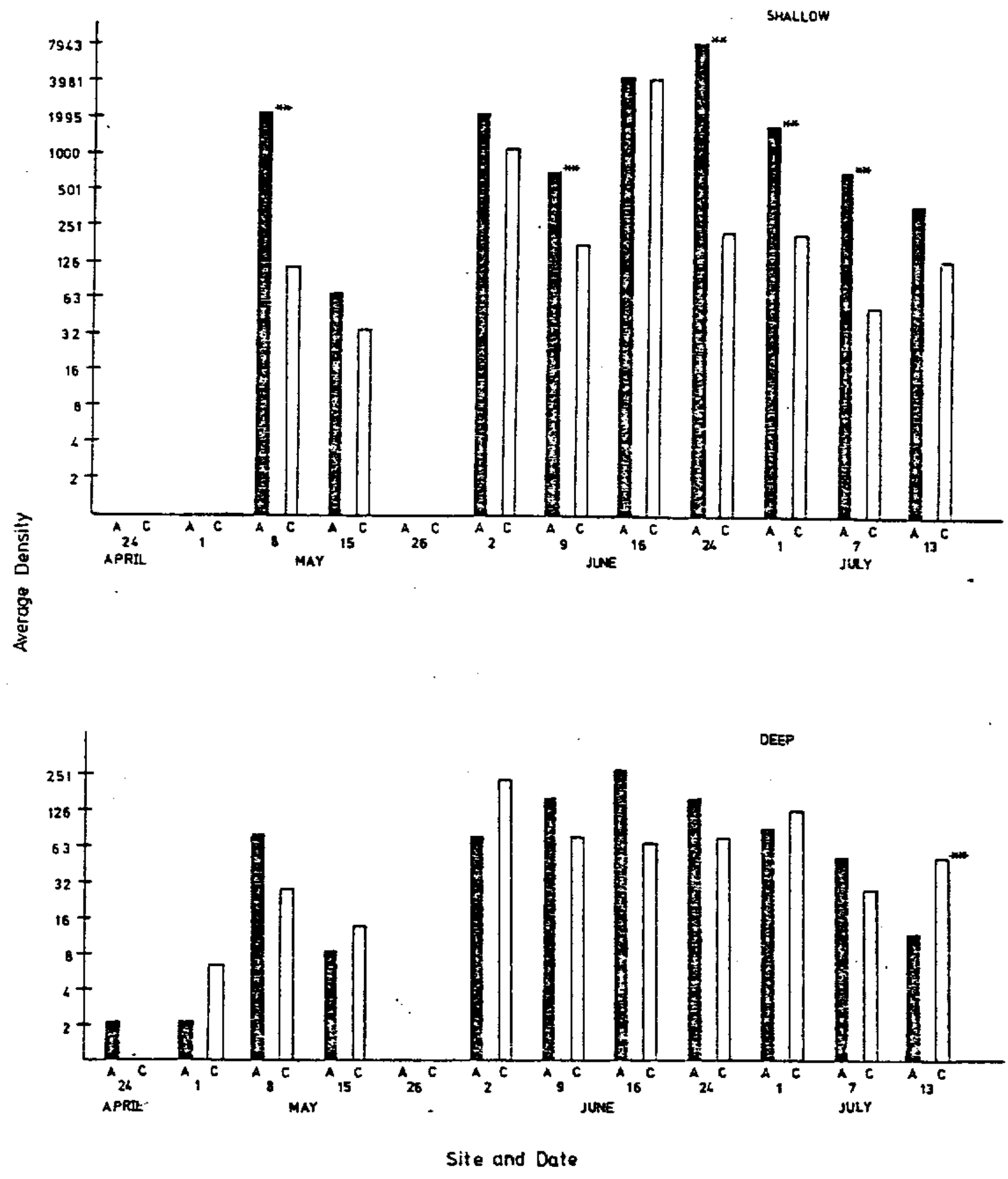

Figure 8: Average density of sunfish (Lepomis spp.) larvae throughout the sampling period at all sites in Barnett Bay, plotted on a $\log_{10}$ scale. A is attractor, C is control.

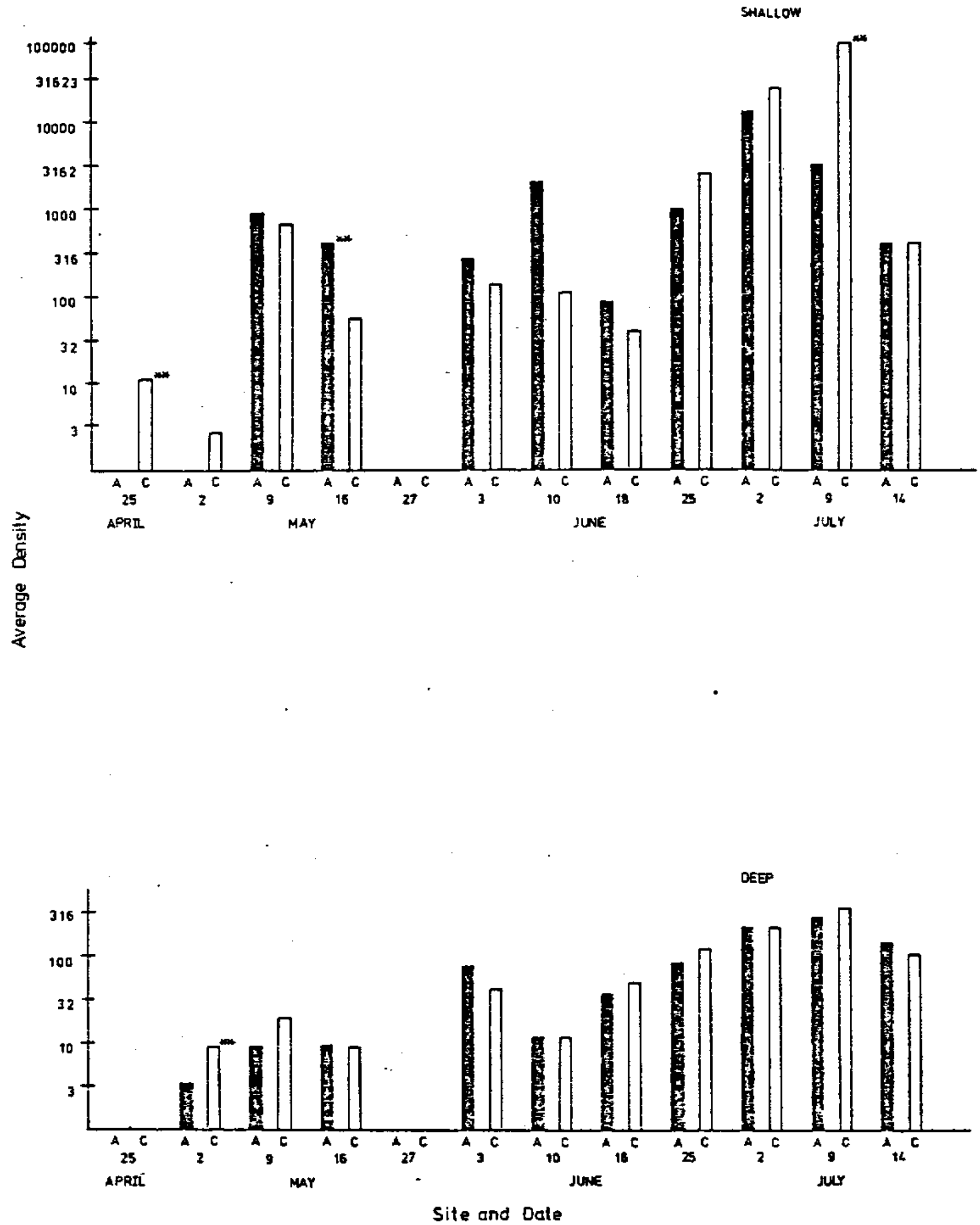

Figure 9: Average density of sunfish (<u>Lepomis</u> <u>spp</u>.) larvae throughout the sampling period at all sites in Crooked Creek Bay, plotted on a $\log_{10}$ scale. A is attractor, C is control.

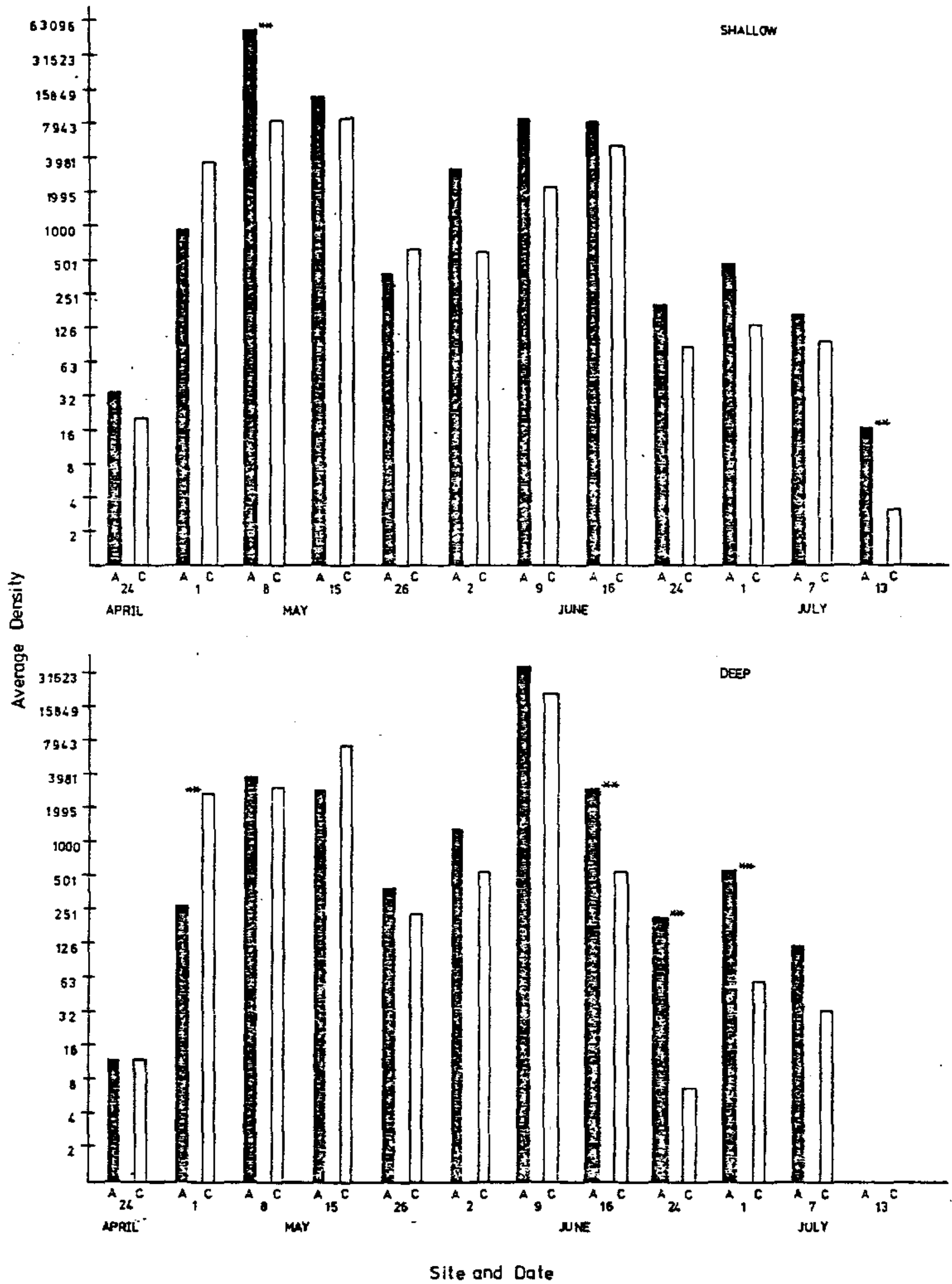

Figure 10. Average density of shad (Clupeidae) larvae throughout the sampling period at all sites in Barnett Bay, plotted on a $\log_{10}$ scale. A is attractor, C is control.

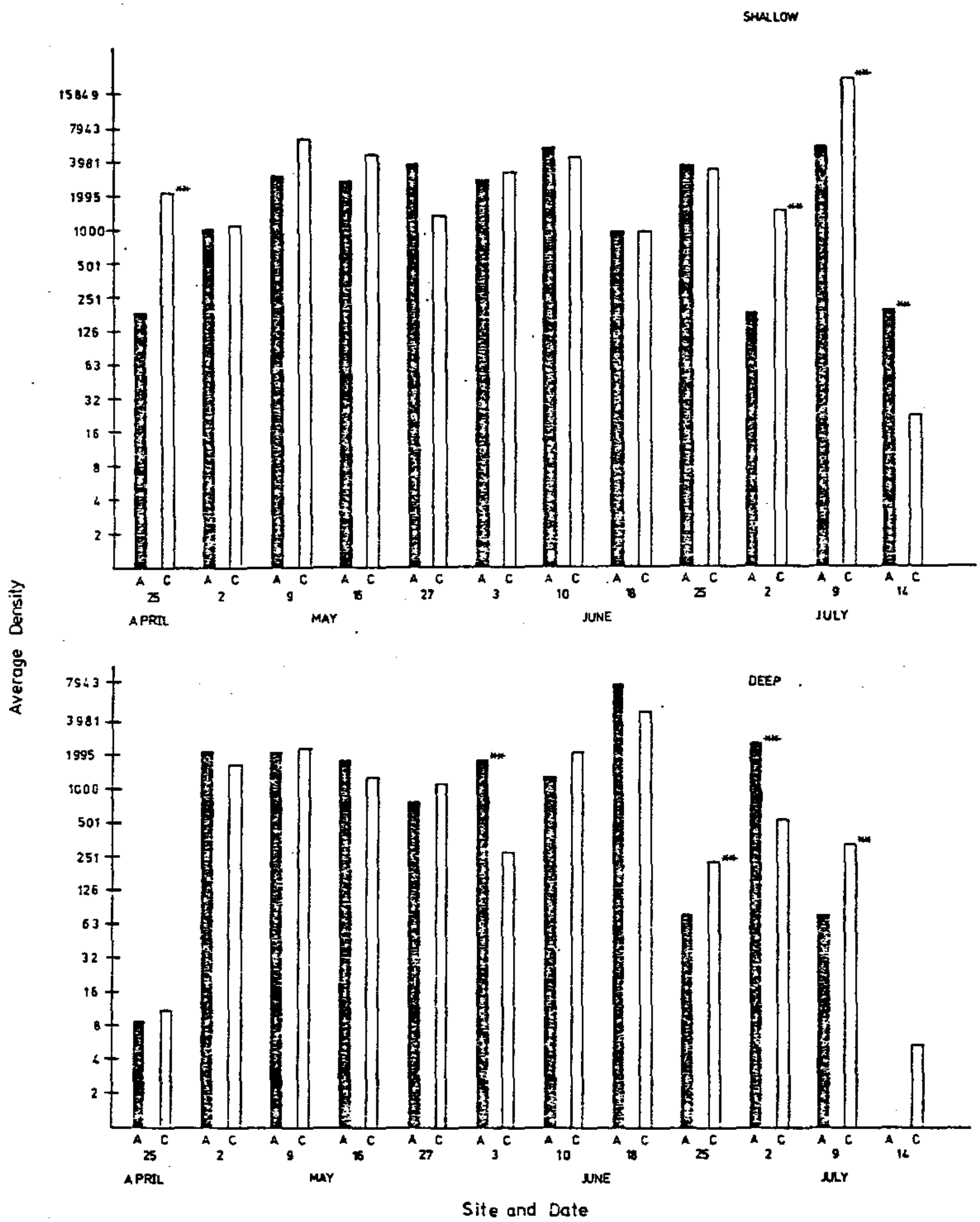

Figure 11. Average density of shad (Clupeidae) larvae throughout the sampling period at all sites in Crooked Creek Bay, plotted on a $\log_{10}$ scale. A is attractor, C is control.

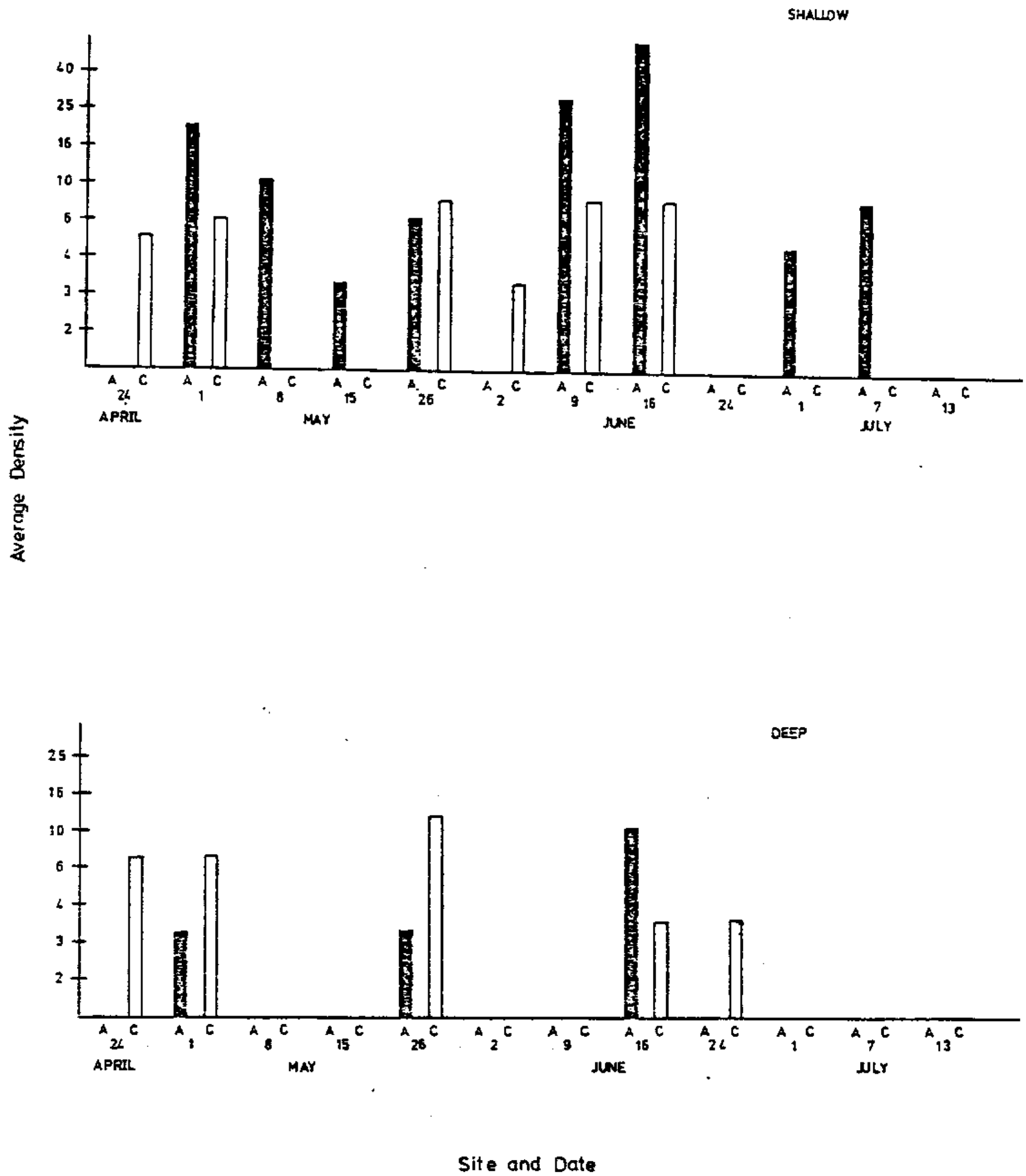

Figure12: Average density of minnow (Cyprinidae) larvae throughout the sampling period at all sites in Barnett Bay, plotted on a $\log_{10}$ scale. A is attractor, C is control.

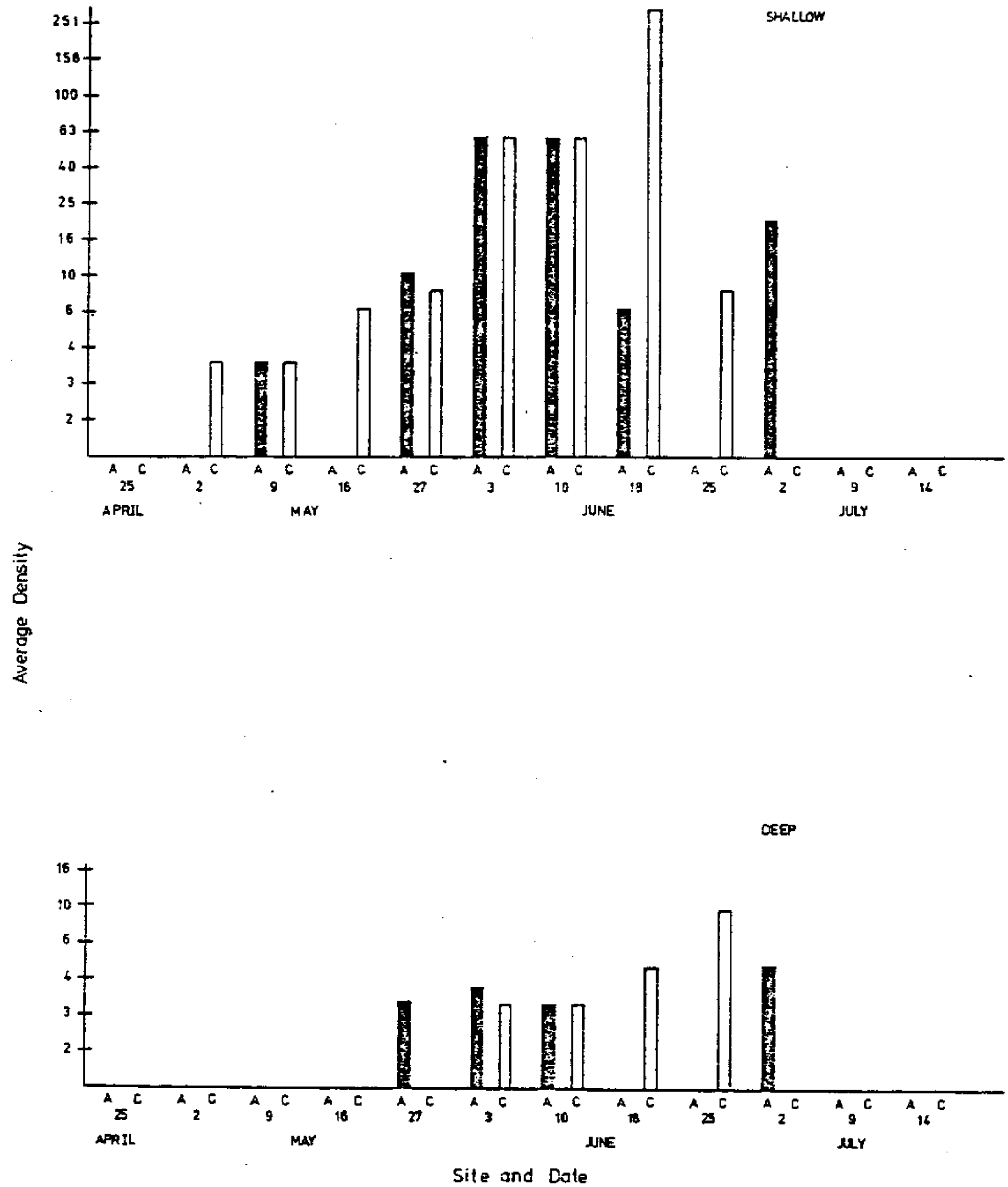

Figure 13: Average density of minnow (Cyprinidae) larvae throughout the sampling period at all sites in Crooked Creek Bay, plotted on a $\log_{10}$ scale. A is attractor, C is control.

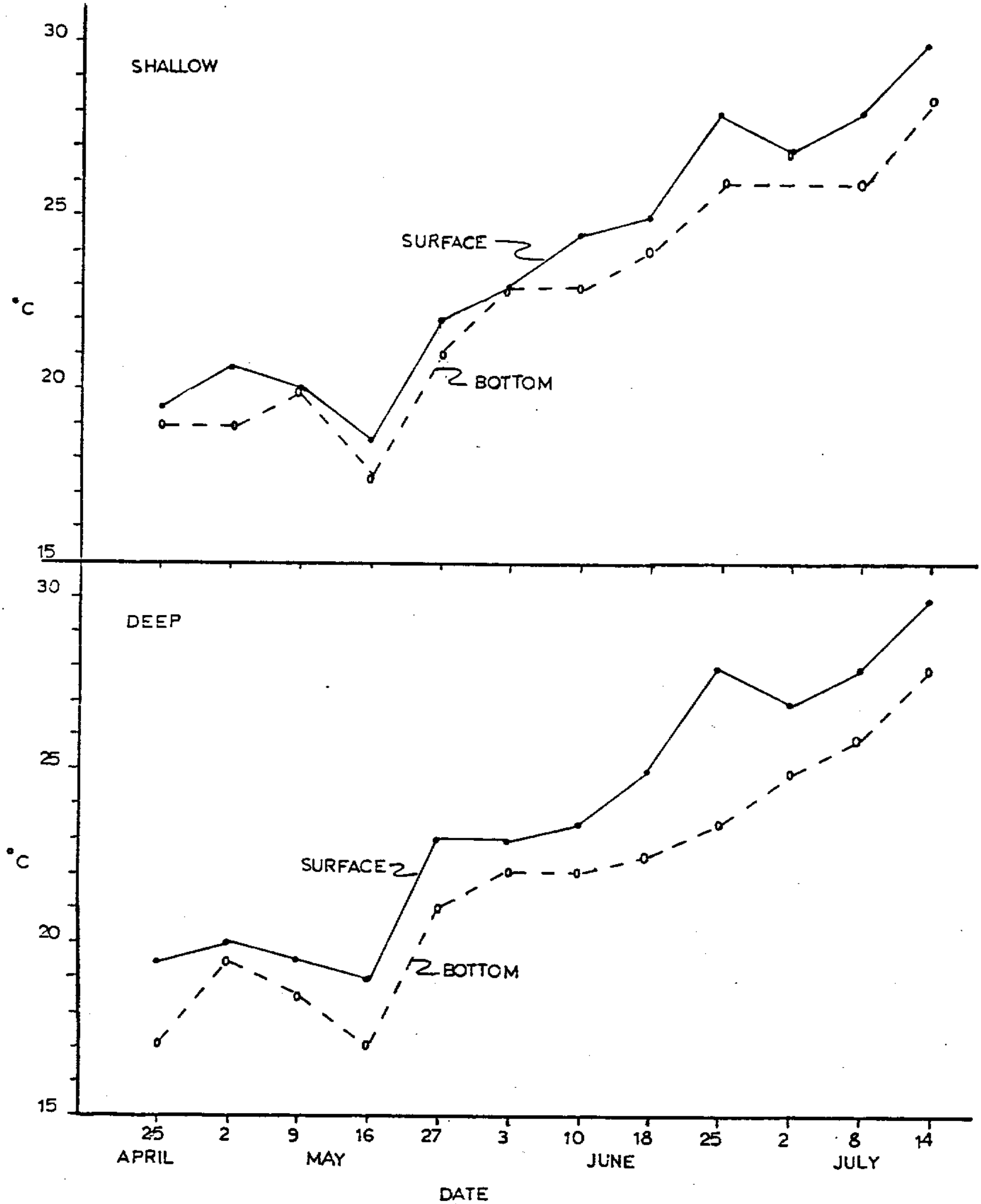

Figure 14: Water temperature (C) throughout the sampling period in Barnett Bay.

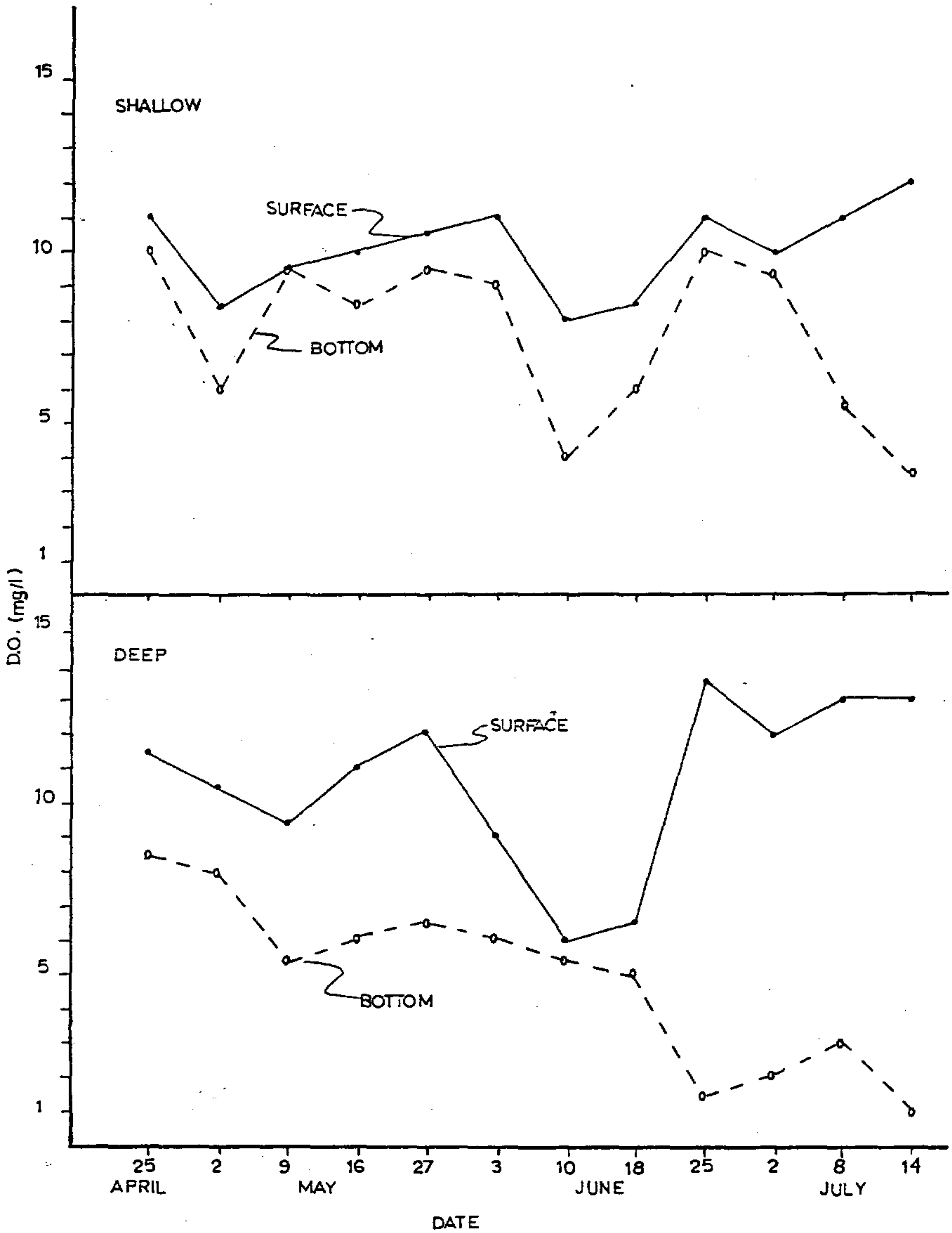

Figure 15: Dissolved oxygen (mg/l) throughout the sampling period in Barnett Bay.

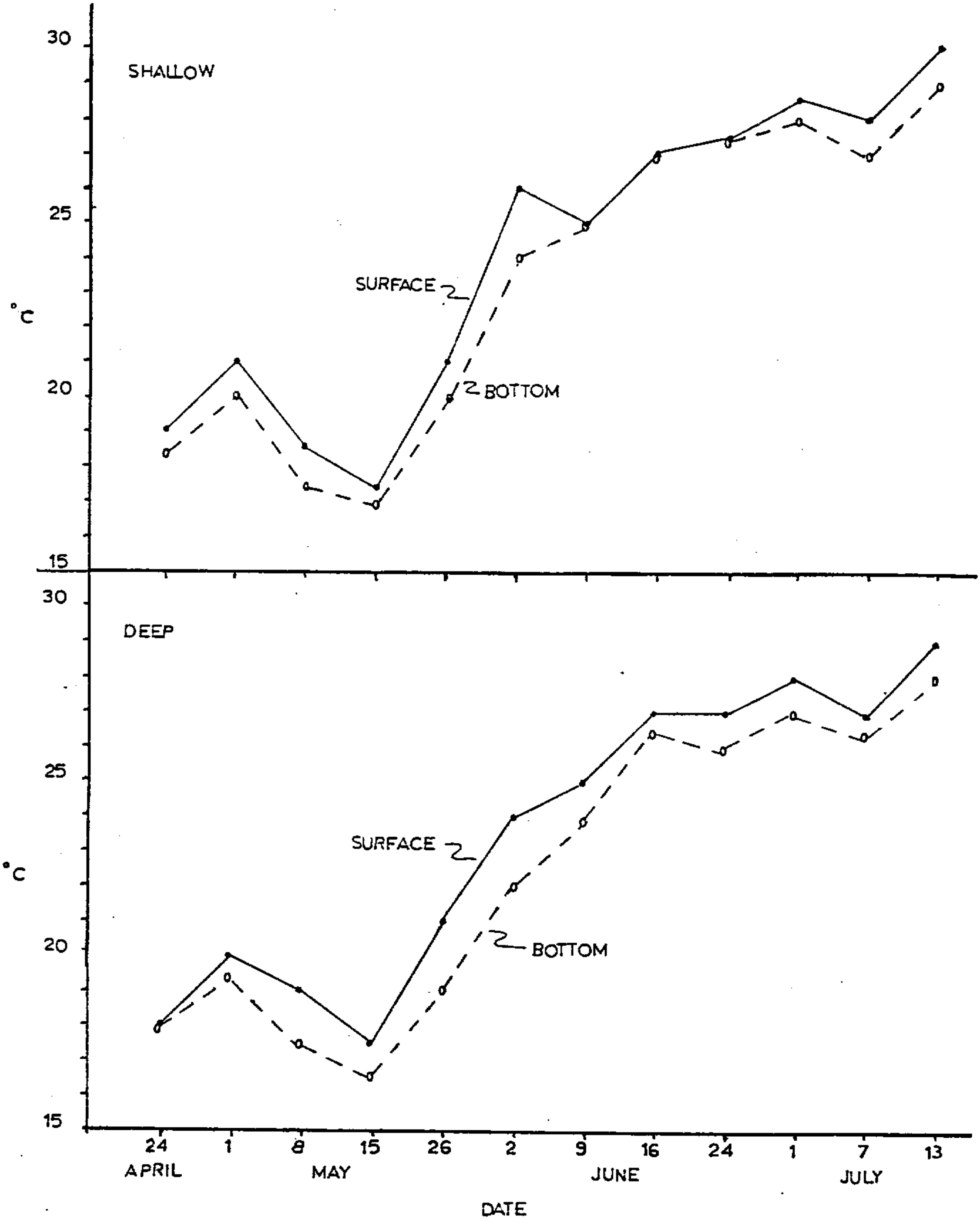

Figure 16: Water temperature (C) throughout the sampling period in Crooked Creek Bay.

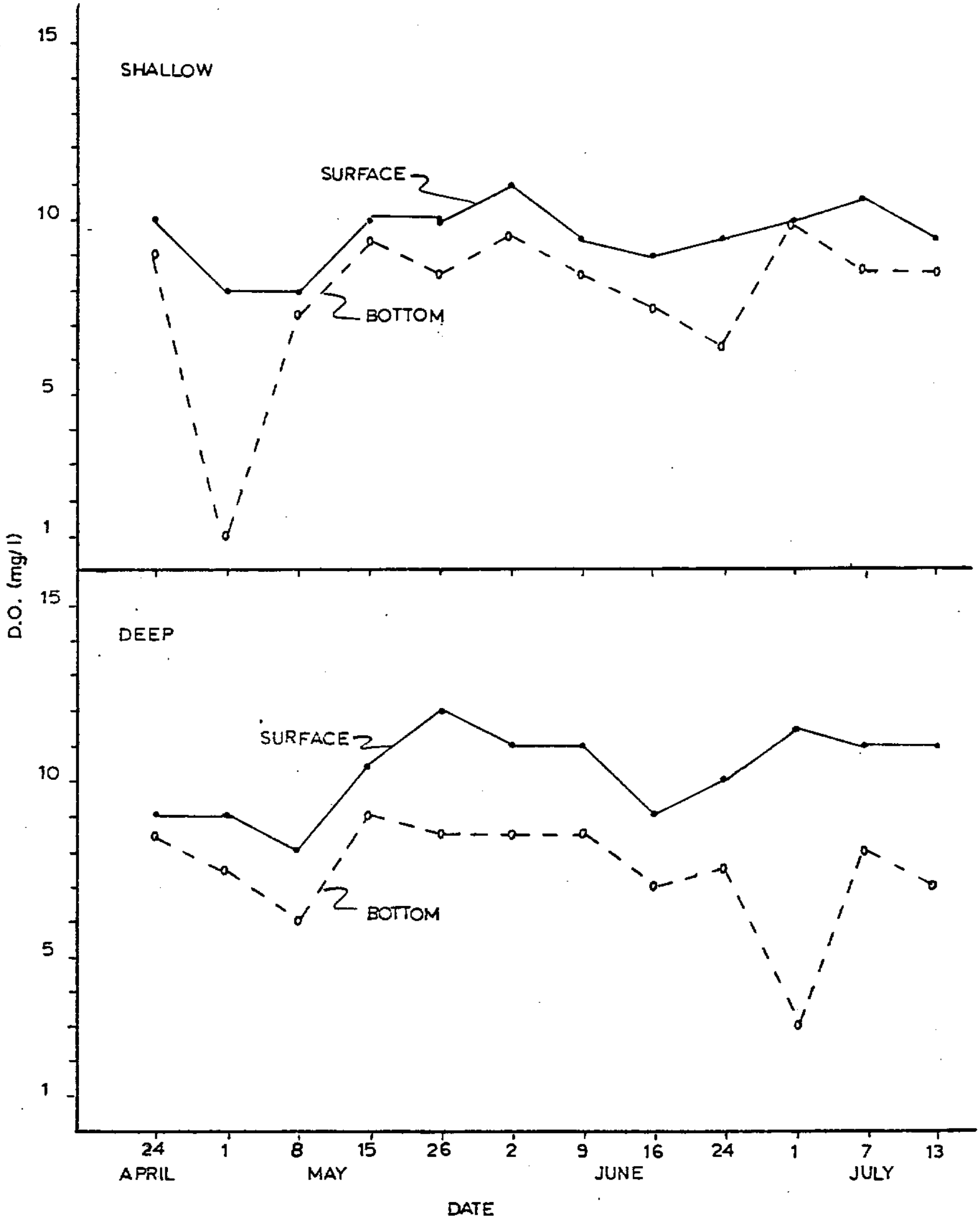

Figure 17: Dissolved oxygen (mg/l) throughout the sampling period in Crooked Creek Bay.

Table 1. Dominant species from experimental gill net catch from Kentucky Lake (Barnett Bay) and Lake Barkley (Crooked Creek Bay) from October 1979 through March 1980. Four sites were sampled in each bay: shallow control (SC), shallow attractor (SA), deep attractor (DA), and deep control (DC). (See Appendix 1 for total catch data.)

	October				November				December				January				February				March			
	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC
(a) Barnett Bay																								
D. petenense	2	1	13	153	18	12	106	310	89	37	397	277	0	0	0	0	3	1	0	0	0	0	0	0
D. cepedianum	69	1	26	100	4	0	10	23	22	12	21	7	5	1	0	0	1	24	5	26	0	0	0	0
Cyprinus carpio	1	0	0	0	1	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	1	0	1
M. melanops	2	10	0	0	1	1	2	0	2	14	0	1	2	1	0	0	0	1	1	0	0	3	0	0
Ictalurus spp.	1	0	6	16	5	0	2	10	3	1	10	10	0	0	0	0	0	0	0	0	1	0	0	0
M. mississippiensis	3	0	0	0	0	0	0	1	1	3	0	0	0	0	0	0	0	3	0	2	0	0	1	0
Micropterus spp.	2	1	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0
Lepomis spp.	3	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	2	0	0	0	0	0	0
Pomoxis spp.	1	1	3	2	1	1	4	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
S. canadense	0	1	2	1	2	4	6	1	3	9	14	4	0	1	1	0	0	0	0	0	0	0	0	0
% sport fish (% total catch)	11	35	21	5	22	22	10	4	5	16	6	5	0	50	100	0	17	18	14	7	20	0	33	0
(b) Crooked Creek Bay																								
D. petenense	0	0	0	182	29	50	0	0	0	1	0	0	15	1	0	0	23	2	0	3	4	2	0	0
D. cepedianum	19	2	283	77	3	8	30	33	3	0	0	3	0	8	7	14	3	4	14	14	0	0	1	1

Table 1 (concluded).

	October				November				December				January				February				March			
	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC
C. carpio	4	0	2	1	0	1	1	1	0	2	0	0	0	1	0	0	1	0	0	0	2	0	0	1
M. melanops	5	9	0	0	0	1	0	0	2	1	0	0	2	3	2	0	4	8	4	2	1	6	0	0
Ictalurus spp.	3	3	7	11	4	3	1	1	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0
M. mississippiensis	0	0	6	5	2	2	0	0	0	1	0	1	0	5	0	0	0	0	0	0	0	3	0	0
Micropterus spp.	0	1	0	0	0	0	3	0	0	2	0	0	0	1	0	0	0	1	0	0	0	0	2	0
Lepomis spp.	0	0	0	0	0	0	0	0	0	7	0	0	0	2	0	0	0	1	0	0	0	0	0	0
Pomoxis spp.	0	1	2	0	3	2	2	0	2	3	0	0	0	1	2	0	0	2	0	0	0	0	2	0
S. canadense	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
% sport fish (% total catch)	12	41	5	6	21	10	16	5	25	62	100	20	0	26	15	6	0	19	0	5	0	18	80	0

Table 2: Instantaneous growth rates of larval white crappie (Pomoxis annularis) at each sampling site in Barnett Bay. L is total length in mm, t is age in days.

DEEP ATTRACTOR

$$L = .3761e^{.4819t} \qquad (r^2 = .63)$$

DEEP CONTROL

$$L = .2453e^{.5593t} \qquad (r^2 = .76)$$

SHALLOW ATTRACTOR

$$L = .1236e^{.6795t} \qquad (r^2 = .88)$$

SHALLOW CONTROL

$$L = .3747e^{.4938t} \qquad (r^2 = .83)$$

Table 3: Instantaneous growth rates of larval white crappie (*Pomoxis annularis*) at each sampling site in Crooked Creek Bay. L is total length in mm, t is age in days.

Site	Equation	r^2
DEEP ATTRACTOR	$L = 1.3974e^{.2692t}$	$(r^2 = .20)$
DEEP CONTROL	$L = 2.7776e^{.1361t}$	$(r^2 = .04)$
SHALLOW ATTRACTOR	$L = .3749e^{.5097t}$	$(r^2 = .74)$
SHALLOW CONTROL	$L = 39.3698e^{.3843t}$	$(r^2 = .05)$

Table 4: Instantaneous mortality rates of larval white crappie (*Pomoxis annularis*) at each sampling site in Barnett Bay. N is the frequency of occurrence, t is the age in days.

DEEP ATTRACTOR

$$N = 22136e^{-1.5038t} \qquad (r^2 = .82)$$

DEEP CONTROL

$$N = 80331e^{-2.1203t} \qquad (r^2 = .91)$$

SHALLOW ATTRACTOR

$$N = 69e^{-.5616t} \qquad (r^2 = .10)$$

SHALLOW CONTROL

$$N = 282e^{-.8193t} \qquad (r^2 = .20)$$

Table 5: Comparison of white crappie growth in Crooked Creek Bay with growth in other regional water bodies (from Carlander 1977).

		Calculated total length (and increments) in mm at each annulus					
LOCATION	N	1	2	3	4	5	
Tennessee reservoirs	+	53 (53)	196 (43)	254 (58)	-	-	
Cumberland Lake, KY	531	79 (79)	157 (78)	231 (74)	-	-	
Crooked Creek Bay, KY	9	83 (83)	148 (65)	238 (45)	-	-	(present study)
Eastern res., TN	4462+	64 (64)	173 (109)	239 (66)	284 (45)	-	
Herrington Lake, KY	+	76 (76)	190 (114)	251 (61)	279 (28)	-	
Kentucky Lake, KY	925	117 (117)	201 (84)	264 (63)	302 (38)	325 (23)	

Table 6: Comparison of largemouth bass growth in Barnett Bay with growth reported from other regional water bodies (from Carlander 1977).

LOCATION	N		Calculated total length and increments in mm at each annulus								
			1	2	3	4	5	6	7	8	9
White Oak L., TN	92		102	236	330	406	429	-	-	-	-
		incr.	102	134	96	76	23	-	-	-	-
N. Fork and Floyd's R., TN	182		104	188	259	320	394	404	-	-	-
		incr.	104	84	71	61	74	10	-	-	-
Kentucky L., KY	33		109	213	300	371	437	-	-	-	-
		incr.	109	104	87	71	66	-	-	-	-
Barnett Bay, KY*	11		118	274	358	426	510	-	-	-	-
		incr.	118	156	82	88	84	-	-	-	-
Eastern Res., TN	345		119	254	343	411	452	498	569	635	-
		incr.	119	135	89	48	41	46	71	66	
Center Hill Res., TN	1		127	254	432	457	483	521	533	546	559
		incr.	127	127	178	25	26	38	12	13	13

* present study

Appendix 1. Experimental gill netting catch at collecting sites in Kentucky Lake (Barnett Bay) and Lake Barkley (Crooked Creek Bay) from October 1979 to March 1980. Four sites were collected in each bay: shallow control (SC), shallow attractor (SA), deep attractor (DA), and deep Control (DC).

	October								November							
	Barnett Bay				Crooked Creek Bay				Barnett Bay				Crooked Creek Bay			
	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC
Clupeidae																
Dorosoma petenense	2	1	13	153	0	0	0	182	18	12	106	310	29	50	0	0
D. cepedianum	69	1	26	100	19	2	283	77	4	0	10	23	3	8	30	33
Alosa chrysochloris	0	0	2	1	6	4	0	2	7	5	1	4	0	0	1	0
Hiodonidae																
Hiodon alosoides	1	0	1	0					0	2	0	0				
H. tirgisus													1	0	0	0
Cyprinidae																
Cyprinus carpio	1	0	0	0	4	0	2	1	1	0	0	0	0	1	1	1
Notemigonus crysoleucas	4	1	0	0												
Hybopsis storeriana	2	0	0	6					0	0	0	1				
Catostomidae																
Ictiobus bubalus					0	1	8	4								
Carpiodes carpio	0	2	0	0					0	0	0	1				
Mintrema melanops	2	10	0	0	5	9	0	0	1	1	2	0	0	1	0	0
Ictaluridae																
Ictalurus punctatus	1	0	0	4	1	2	6	8					3	1	1	1
I. furcatus	0	0	6	12	1	0	0	3	5	0	2	10	1	2	0	0
I. sp.					1	1	1	0								

Appendix 1 (continued).

	October								November							
	Barnett Bay				Crooked Creek Bay				Barnett Bay				Crooked Creek Bay			
	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC
Serranidae																
Morone mississippiensis	3	0	0	0	0	0	6	5	0	0	0	1	2	2	0	0
M. chrysops					2	4	1	0	0	0	1	1	0	0	0	1
Centrarchidae																
Micropterus salmoides	1	1	0	0									0	0	2	0
M. punctulatus	1	0	1	1	0	1	0	0	0	1	0	0	0	0	1	0
Lepomis megalotis	3	1	0	0					1	0	0	0				
Pomoxis nigromaculatus	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0
P. annularis	1	1	3	2	0	1	1	0	1	0	4	0	3	2	1	0
Percidae																
Stizostedion canadense	0	1	2	1	0	2	0	0	2	4	6	1				
Percina caprodes	0	0	0	0									1	0	0	0
Sciaenidae																
Aplodinotus grunniens	0	0	3	0	1	0	0	0	0	1	0	0	0	0	0	1
Total minus Clupeidae	20	17	16	26	15	21	26	21	11	10	15	15	11	9	7	4
Family Groups	8	6	8	6	6	6	6	5	6	6	6	6	6	6	4	5
Species	15	13	12	11	9	10	9	8	9	8	8	9	8	8	8	5
Fishes	91	19	57	280	40	27	309	282	40	27	132	352	43	67	38	37

Appendix 1 (continued).

	December								January							
	Barnett Bay				Crooked Creek Bay				Barnett Bay				Crooked Creek Bay			
	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC
Clupeidae																
Dorosoma petenense	89	37	397	277	0	1	0	0					15	1	0	0
D. cepedianum	22	12	21	7	3	0	0	3	5	1	0	0	0	8	7	14
Alosa chrysochloris	8	1	7	4												
Cyprinidae																
Cyprinus carpio	0	4	0	0	0	2	0	0					0	1	0	0
Notemigonus crysolencas					1	4	0	0	1	1	0	0	6	12	0	0
Hybopsis storeriana	0	0	1	1									0	0	0	1
Catostomidae																
Ictiobus bubalus																
Carpiodes carpio	0	1	0	0	0	0	0	1					0	0	2	0
Mintrema melanops	2	14	0	1	2	1	0	0	2	1	0	0	2	3	2	0
Ictaluridae																
Ictalurus punctatus	0	1	1	1	0	0	1	0					0	0	0	1
I. furcatus	3	0	9	9												
Serranidae																
Morone mississippiensis	1	3	0	0	0	1	0	1					0	5	0	0
Centrarchidae																
Micropterus salmoides					0	2	0	0	0	1	0	0	0	1	0	0
Lepomis megalotis					0	2	0	0	0	1	0	0				
L. maorochirus					0	5	0	0					0	2	0	0
Pomoxis nigromaculatus					0	1	0	0					0	0	1	0
P. annularis	0	0	2	0	2	2	0	0					0	1	1	0

Appendix 1 (continued).

	December								January							
	Barnett Bay				Crooked Creek Bay				Barnett Bay				Crooked Creek Bay			
	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC
Percidae																
Stizostedion canadense	3	9	14	4					0	1	1	0				
Total minus Clupeidae	9	32	27	16	5	20	1	2	3	5	1	0	8	25	6	2
Family Groups	5	6	5	5	4	5	1	3	3	5	1	0	3	5	3	3
Species	7	9	8	8	4	10	1	3	3	6	1	0	3	9	5	3
Fishes	128	82	452	304	8	21	1	5	8	6	1	0	23	34	13	16

Appendix 1 (continued).

	February								March							
	Barnett Bay				Crooked Creek Bay				Barnett Bay				Crooked Creek Bay			
	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC
Lepisostidae																
Lepisosteus oculatus	0	1	0	0												
Clupeidae																
Dorosoma petenense	3	1	0	0	23	2	0	3					4	2	0	0
D. cepedianum	1	24	5	26	3 4	14	14						0	0	1	1
Alosa chrysochloris	1	0	0	0												
Hiodonidae																
Hiodon tirgisus									0	1	0	0				
Cyprinidae																
Cyprinus carpio					1	0	0	0	0	1	0	1	2	0	0	1
Notemigonus crysoleucas					1	3	0	0					2	6	0	0
Hybopsis storeriana									0	0	1	0				
Catostomidae																
Carpiodes carpio					0	0	0	1								
Mintrema melanops	0	1	1	0	4	8	4	2	0	3	0	0	1	6	0	0
Ictaluridae																
Ictalurus punctatus					0	0	0	1	1	0	0	0				
Serranidae																
Morone mississippiensis	0	3	0	2					0	0	1	0	0	3	0	0

Appendix 1 (concluded).

	February								March							
	Barnett Bay				Crooked Creek Bay				Barnett Bay				Crooked Creek Bay			
	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC	SC	SA	DA	DC
Centrarchidae																
Micropterus salmoides	0	1	1	0	0	1	0	0					0	0	1	0
M. punctulatus													0	0	1	0
Lepomis megalotis	1	0	0	0												
L. macrochirus	0	1	0	0	0	1	0	0								
L. microlophus	0	1	0	0												
Pomoxis annularis					0	2	0	0					0	0	2	0
Percidae																
Percina caprodes									4	2	0	0				
Sciaenidae																
Aplodinotus grunniens					0	0	0	1	0	0	1	0				
Total minus Clupeidae	1	8	2	2	6	15	4	5	5	7	3	1	5	15	4	1
Family Groups	2	5	3	2	3	4	2	4	2	4	3	1	3	4	3	2
Species	4	8	3	2	5	7	2	6	2	4	3	1	4	4	4	2
Fishes	6	33	7	28	32	21	18	22	5	7	3	1	9	17	5	2