AN EVALUATION OF THE RAINBOW TROUT-WARMWATER SPECIES FISHERY IN PARKER CANYON LAKE

by

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ABSTRACT

The sport fishery of Parker Canyon Lake was studied from October 24, 1973 through November 1, 1974. Emphasis was placed on the biology and harvest of the stocked rainbow trout and their compatibility to the warmwater species of channel catfish, largemouth bass, green sunfish and bluegill.

The first of five monthly stockings of eight to ten inch rainbow trout began on November 6, 1973. After stocking, the rainbow trout dispersed to the littoral areas around the lake. Rainbow trout fed primarily on zooplankton during the winter (Dec.-Feb.) and on midge pupae or larvae during the spring (March-May). Growth was good and condition factors were comparable to rainbow trout in the lake before the introduction of warmwater species. By the end of April, 90 to 95% of all the rainbow trout had been harvested from the lake. Rainbow trout could have survived through the summer stratification period because of adequate water quality in the thermocline. The littoral plant beds provided the warmwater species with food, cover and spawning sites throughout the year. Crayfish was the primary food for most of the warmwater species during the year. Although food and habitat overlap occurred between rainbow trout and warmwater species it did not adversely affect the fish and the fishery of Parker Canyon Lake was biologically compatible.

INTRODUCTION

Parker Canyon Lake originally was planned to be a coldwater fishery impoundment because it is located at an elevation of 1636 meters and water temperatures presumably would stay within ranges to sustain rainbow trout on a year round basis. Fingerling rainbow trout (*Salmo gairdneri* Richardson) were first stocked in November, 1963 (Glucksman, 1965). Since then the introduction of other fish species has made the history of the lake rather precarious.

In 1965, channel catfish were stocked by the Arizona Game and Fish Department and, in addition, green sunfish (*Lepomis cyanellus*), bluegill (*L. macrochirus*) and largemouth bass (*Micropterus salmoides*) were introduced surreptitiously.

The fingerling trout introductions, although fairly successful at first, were not very successful after the surreptitious introduction of the largemouth bass. The bass apparently preyed upon the young trout rather extensively because some plants never showed up in the angler's creel. To complicate matters, Glucksman (1965) found that the lake thermally stratified and water in the epilimnion was warmer than expected and the hypolimnion became oxygen deficient.

The bass reproduced successfully, and in 1971, threadfin shad (Dorosoma petenense) were stocked as a forage fish for the bass. The Arizona Game and Fish Department after 1970, changed to stocking only eight to ten inch rainbow trout during the winter. Thus, within eight years, the original sport fishery of rainbow trout only was altered to the fisheries of stocked rainbow trout (8-10"), stocked channel catfish and centrarchids, largemouth bass, green sunfish and bluegill.

With the various species of fish that now inhabit Parker Canyon Lake, there has been much concern by fishery managers that an overlap exists in the ecological requirements of these fish, primarily for food and space. Saiki (1973) reconfirmed Glucksman's data on thermal stratification and further indicated that the temperature and oxygen regimes from May until November may not be suitable for trout.

To date a good evaluation of the success of this stocked rainbow trout fishery has not been made. It is not known how many of the rainbow trout are harvested by fisherman or how long it takes them to do it.

During the last 10 to 15 years there has been an increasingly larger demand for water based recreation, especially fishing (Davis, 1967). Parker Canyon Lake receives a part of this larger demand. The question still remains, "Is a warmwater fishery and a coldwater fishery compatible and biologically feasible?" If it is, then it would be possible to provide more fishing days per year and make better utilization of the lake. However, if certain interrelationships between the various species which occur are detrimental, then alterations in the current management practices might be advisable.

The purpose of this investigation was to: (1) study the biological aspects of food, cover and distribution of the stocked rainbow trout, largemouth bass, bluegills and channel catfish; (2) evaluate the interrelationships of all fish and the food chain and (3) determine the success of the rainbow trout fishery in regard to harvest and water quality.

DESCRIPTION OF THE STUDY AREA

Parker Canyon Lake is located in Santa Cruz and Cochise counties, in southeastern Arizona, at an elevation of 1636 meters. It is approximately 56 kilometers east of Nogales, Arizona and 10 kilometers north of the U. S. - Mexico border.

Oak-juniper woodland is the dominant watershed vegetation in the lake vicinity. Manzanita and Mexican pinon become more abundant in the higher and more exposed areas around the lake. Climate varies from a mean temperature of 10° C with a mean precipitation of 20 cm during the October to April period to a mean temperature of 20° C with a mean precipitation of 30 cm during the May to September period (Bergersen, 1969 and Glucksman, 1956).

Parker Canyon Lake is a warm monomictic impoundment with an L-shaped basin (Figure 1). There is intermittent inflow into the lake from Parker, Collins and Meritt Canyons. The rooted aquatic plant water milfoil, *Myriophyllum exalbescens*, is very abundant along the lake shore with annual die-offs occurring in late fall and winter. Additional information on the physical and limnological description of the lake has been given by Glucksman (1965), Bergersen (1969), and Saiki (1973).

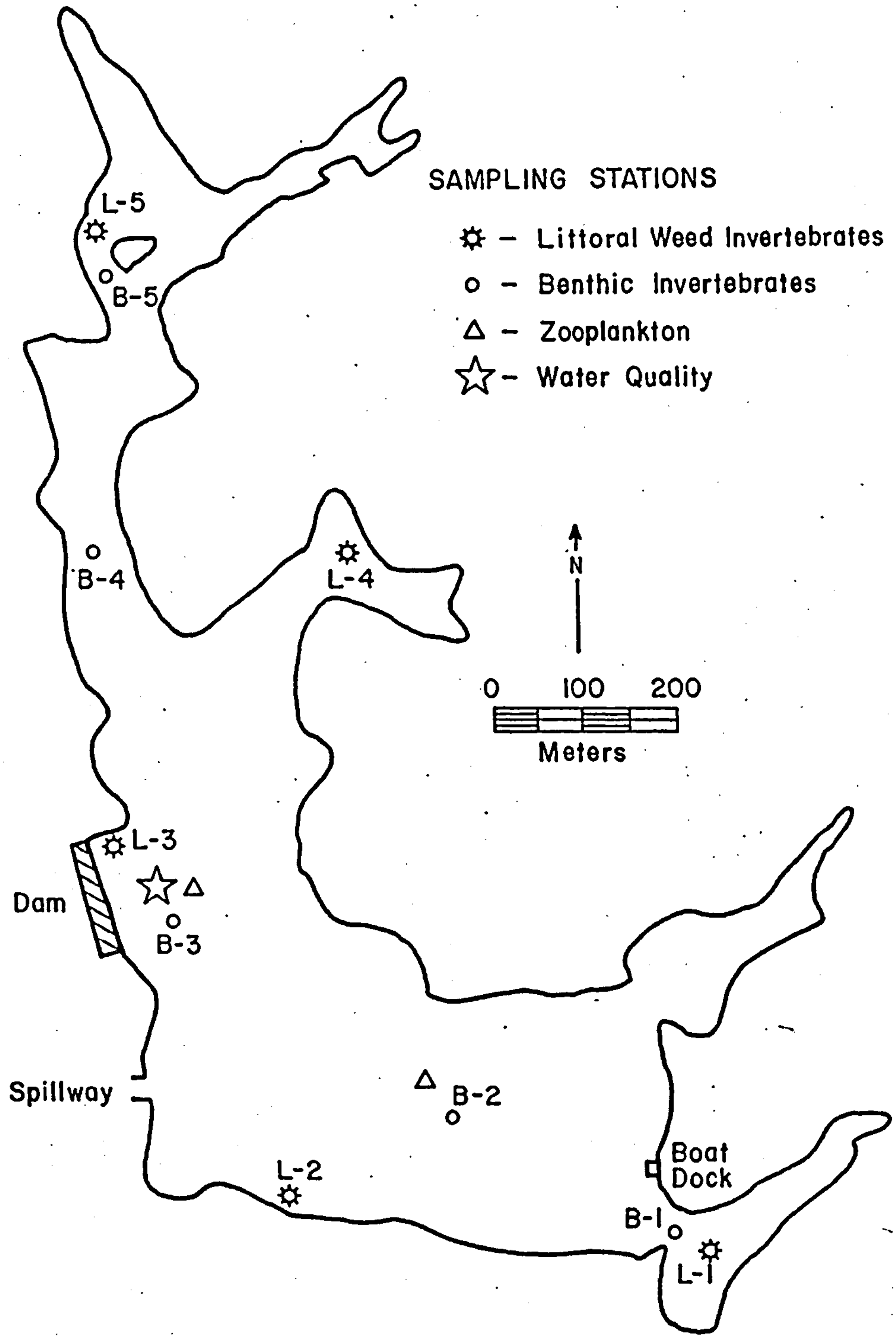

Figure 1. Map of study area and locations of sampling stations.

METHODS AND MATERIALS

The methods and materials used for this study were selected on the basis of the type of data they would produce and the time available for collection of data. Methods were usually designed by previous investigators, although some modifications were needed when methods proved to be inadequate.

Period and Grouping of Samples

Collections began October 24, 1973 and terminated November 1, 1974. The seasonal groups were arbitrarily chosen as the following:

1. Fall: September through November
2. Winter: December through February
3. Spring: March through May
4. Summer: June through August

Physico-chemical Water Quality

Only one water quality station was established, approximately 50 meters east of the dam (Figure 1), because of extensive data from previous studies by Saiki (1973) and Ziebell (1973). Samples were collected at this location monthy. Dissolved oxygen (mg/l) and temperature (°C) were sampled with a portable YSI model 54 oxygen-temperature meter at one meter intervals to obtain vertical water quality profiles of the lake. Lake level, to the nearest 0.1 meter, was recorded from a water gauge by the spillway whenever water quality was collected.

Forage Invertebrate Collections

Benthos, littoral plant invertebrates and net zooplankton and phytoplankton were collected on a monthly basis at the stations indicated in Figure 1. Benthic invertebrates were sampled at depths ranging from 2 to 15 meters with an Ekman dredge and sieved through #30 mesh screen. Samples were placed in jars and refrigerated until examined in the lab. One liter of littoral plants was sampled at each station by using a #16 mesh dip-net and making upward sweeping motions through the two meter deep littoral plant bed. The samples were then placed in jars and preserved in 10% formalin for subsequent laboratory analysis. All invertebrates were separated by the sugar flotation method of Anderson (1959) and classified to family by using keys in Pennak (1953) and Usinger (1956).

Net zooplankton and phytoplankton were collected with the Clarke-bumpus sampler using a #10 mesh net. A cross section was sampled by starting the tows (approximately 200 meters in length) at the surface, sloping to within one meter of the bottom and then sloping back to the surface. Samples were placed in jars and preserved in 10% formalin.

The quantity of water sampled was recorded so that an estimate of standing crop of plankton could be expressed in ml of plankton per cubic meter of water.

Fish Collections

Fish were collected monthly by gillnetting and seasonally by electrofishing. Four experimental gillnets, each containing five sections with mesh sizes ranging from ½ to 2½", were placed along the shore two to three meters outside the littoral plant beds in two meters of water. Three sets of vertical gillnets, each containing a complete vertical section of 1, 1½ and 2" netting, were placed in open water, encompassing the total vertical profile of the lake. All gillnets were placed in the water just before dusk and were raised again by 9 o'clock the next morning. Electrofishing was done at selected sites which were representative of all habitats found in the lake.

Food Habits

All fish stomachs were removed and preserved with 10% formalin in the field. Stomach contents, from the posterior portion of the esophagus to the pyloric sphincter, were examined. Identification of contents was made using keys in Pennak (1953), Usinger (1956) and Eddy (1969). The relative importance of foods was determined volumetrically (Lagler, 1956), and only stomachs containing food were considered.

Growth and Condition

All fish were weighed and measured alive in the field. Standard and total lengths were measured to the nearest 0.1 cm on a standard measuring board. Weights were determined to the nearest 2 g on a Hanson model 1460 scale.

The coefficient of condition (K), was determined by using the formula shown in Bennett (1971),

$$K = \frac{100 \text{ X Weight}}{\text{Length}^3}$$

with length as standard length in cm and weight in grams. Individual condition factors were averaged into a monthly condition factor for each plant of rainbow trout.

Growth of the rainbow trout was determined by averaging the standard lengths and weights for every plant during each month.

Tagging, Stocking and Tag Returns

Rainbow trout were tagged at Page Springs Hatchery, one day prior to stocking, by personnel of The Arizona Game and Fish Department. The fish were anesthetized with MS 222 and sterilized color-coded streamer tags described by Dell (1968) were inserted between the pterygiophore bones beside the dorsal fin. The fish were then transported to Parker Canyon Lake in an oxygenated and refrigerated hatchery truck according to the schedule in Table 1.

Table 1. Stockings and returns of rainbow trout planted by tag color-group.

Color Group	Date Stocked	Number Stocked	Total tags[a] Returned
Orange	11-6-73	3600	977 (27)
Green	12-6-73	3200	842 (26)
Yellow	1-9-74	3200	711 (22)
Pink	2-12-74	2700	625 (23)
Blue	3-20-74	2300	404 (18)
Total		15000	3561 (24)

[a] ( ) = percent returned.

Brochures were distributed to fishermen explaining the scope of the study and the importance of returning the tags to boxes located at the boat dock and store. Also, an article explaining these same points appeared in a local newspaper, the Tucson Daily Citizen, and signs were posted around the lake reminding fishermen to return their trout tags. Tags were then picked up on a monthly basis from the designated areas.

RESULTS

Salient ecological factors which played an important role in the sport fishery of Parker Canyon Lake are emphasized to show interrelationships between rainbow trout and warmwater species in an over-all picture of the fishery.

Physico-chemical Water Quality

Destratification of temperautre and dissolved oxygen occurred during November (Figure 2). Water temperautres cooled to between 6 and 8° C throughout the water column by January, and dissolved oxygen ranged from 8 mg/l on the bottom to 10 mg/l at the surface. A more pronounced difference in dissolved oxygen and temperature patterns was noted by March, and stratification occurred at 10 meters during April. The thermocline gradually moved toward the surface during the spring and early summer months and became established at 6 to 7 meters during July. Water in the hypolimnion was devoid of oxygen from July through September. The thermocline remained oxygenated with at least 3 mg/l dissolved oxygen and water temperatures remained below 21° C. Epilomnion waters during the summer months reached a temperature of 25° C, with dissolved oxygen concentrations greater

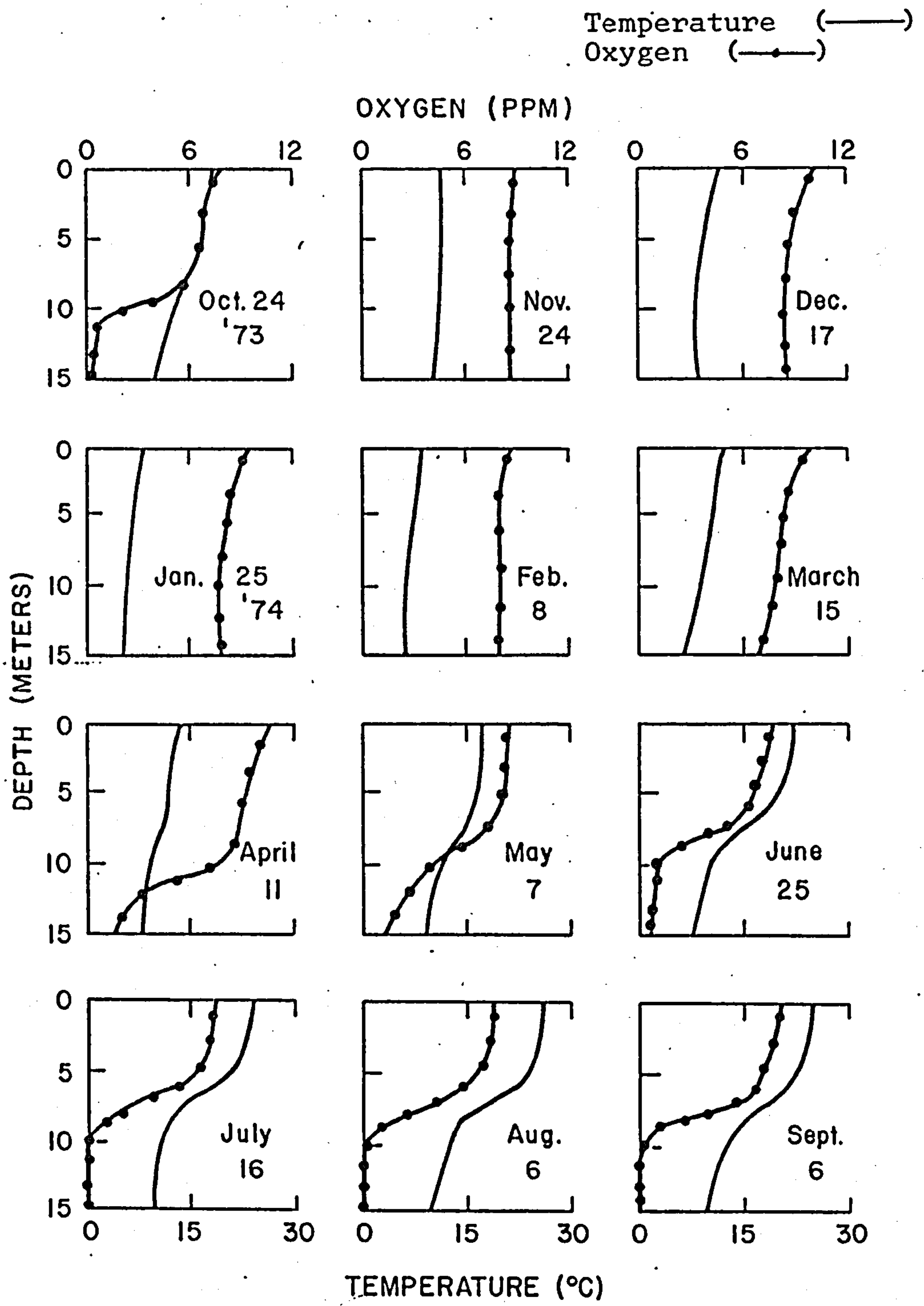

Figure 2. Monthly temperature and dissolved oxygen profiles.

than 6 mg/l. The cooling of the upper water column began in October which lead to the destratification in November.

Water level decreased steadily from a high point of -2.4 meters below the spillway in October to a low of -3.8 meters by June. The level then increased slightly in July, August and September to -3.5 meters, but fell to -3.7 meters by November, 1974.

Fish Distribution

During the winter and spring most of the rainbow trout were caught in the upper 2 meters of the water column (Figures 3 and 4). However, during the winter 93% of the rainbow trout were captured near shore, while during the spring 66% were caught in open water. The only other depth concentration of rainbow trout occurred at 8 to 10 meters during the spring. Rainbow trout at no time were captured below 10 meters and were not found at all in the upper 2 meters of the lake during the summer.

Warmwater species had a wider vertical distribution in the spring and summer compared to fall and winter. Warmwater species also were captured in greater numbers during the spring and summer, than in fall and winter. They appeared only in the top 10 meters of the lake, with the exception of one channel catfish caught at 12 to 14 meters during the spring.

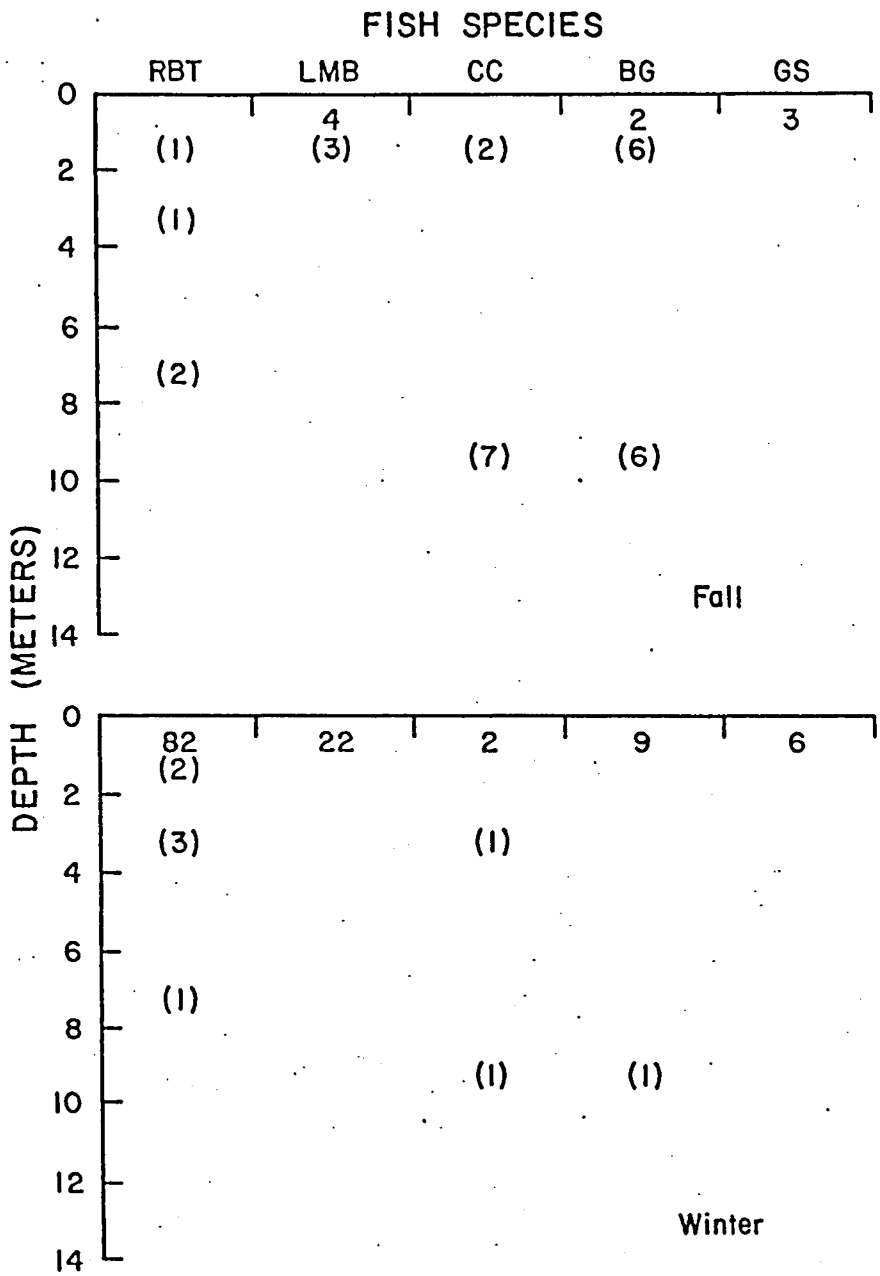

Figure 3. Fall and winter vertical distribution of the total fish captured by gillnetting and electrofishing in shoreline areas and in open water. --Rainbow trout = (RBT), largemouth bass = (LMB), channel catfish = (CC), bluegill = (BG), green sunfish = (GS), ( ) designates open water.

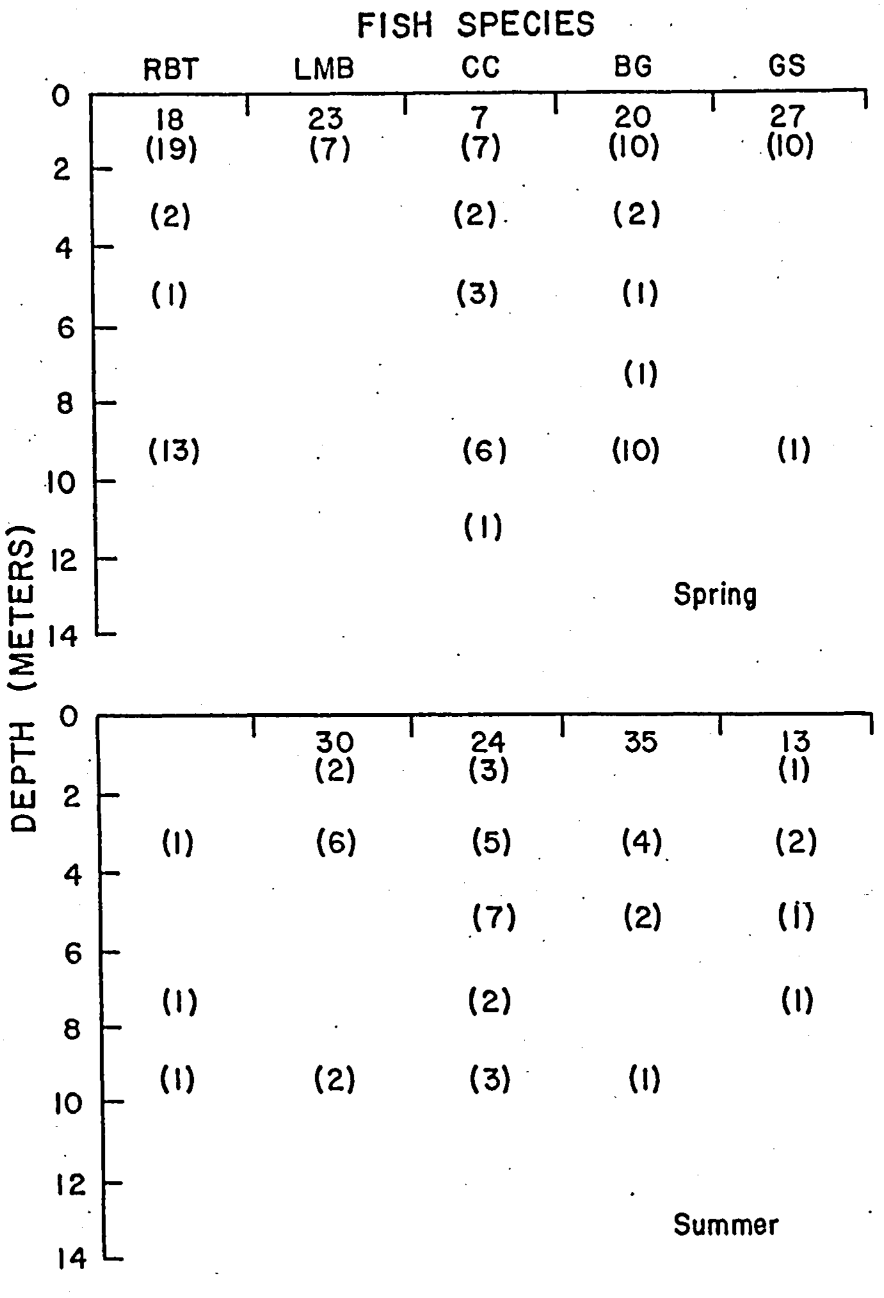

Figure 4. Spring and summer vertical distribution of the total fish captured by gillnetting and electrofishing in shoreline areas and in open water. -- Rainbow trout = (RBT), largemouth bass = (LMB), channel catfish = (CC), bluegill = (BG), green sunfish = (GS), ( ) designates open water.

Green sunfish and largemouth bass almost exclusively inhabited the shoreline areas in water less than two meters deep. Channel catfish and bluegill although captured in similar areas as green sunfish and largemouth bass, were found to a greater extent in the deeper (2-10 meters) and more open waters of the lake.

Available Fish Forage Invertebrates

Results from benthic sample stations were divided into those less than five meters (B-1 and B-5) and those greater than five meters (B-2, B-3 and B-4). Midges (Chironomidae), were the most abundant organisms throughout the year at the shallow-water stations, with per cent composition ranging from 62 to 94% (Figure 5). Additionally, midges were the most abundant insects during the winter and spring at the deep-water stations (Figure 6). Aquatic earthworms (Oligachaeta) and phantom midges (Culicidae) were most abundant during the summer and fall at the deep-water stations, comprising 81 to 90% of the benthic invertebrates, in addition to being secondarily abundant during the remainder of the year. Fewer organisms were found at the deepest station (B-3), at a depth of 15 meters (Appendix C), during the summer stratification than any other time of the year.

Littoral plant invertebrates were also found in two basic groups, those in water inflow areas (L-1 and L-5) and those in non-inflow areas (L-2, L-3 and L-4). More families

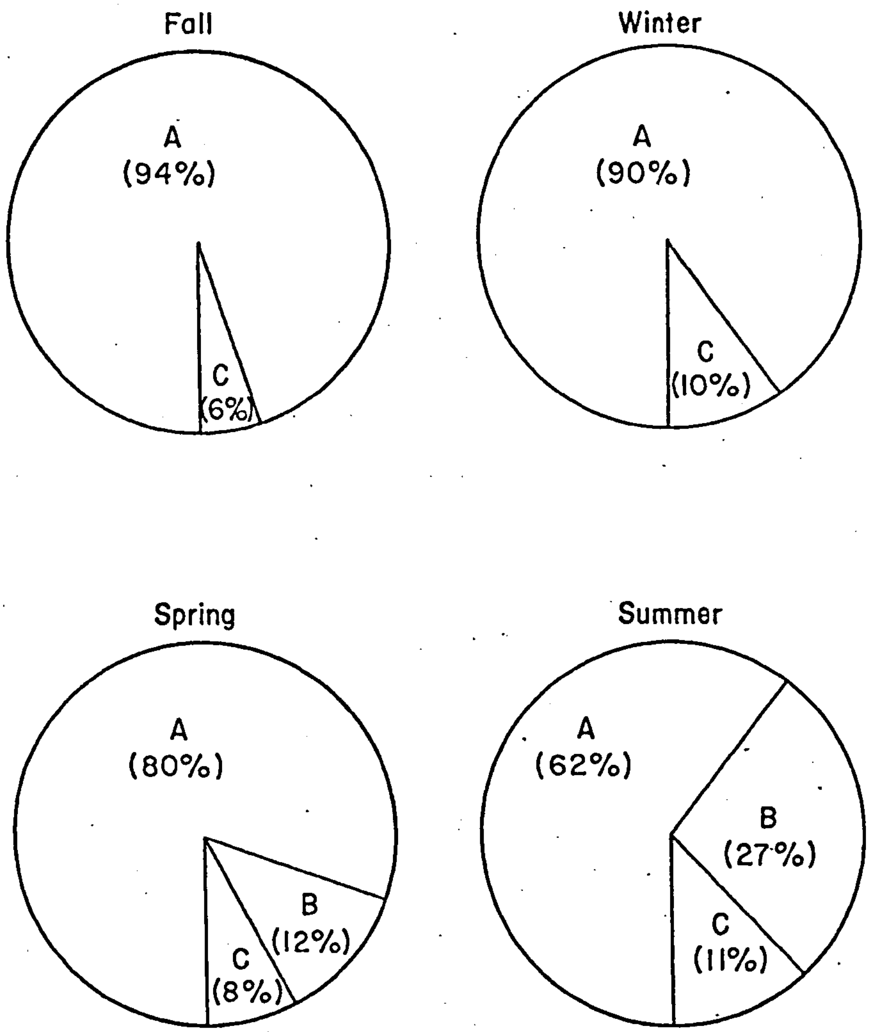

Figure 5. Seasonal per cent composition of benthos at stations less than five meters deep. -- A = chrionomidae, B = ceratopogonidae, C = other, 1 ml = 12 chironomidae, 1 ml = 25 ceratopogonidae.

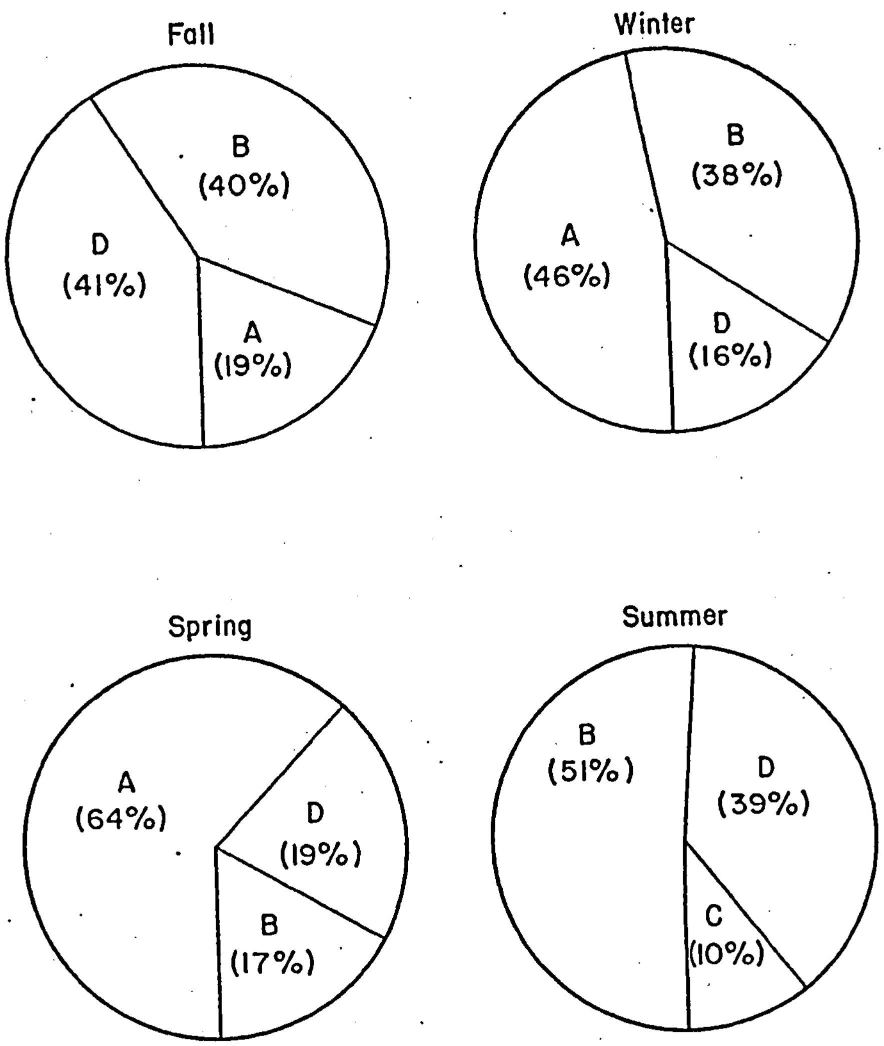

Figure 6. Seasonal per cent composition of benthos at stations greater than five meters deep. -- A = chironomidae, B = oligachaeta, C = other, D = culicidae, 1 ml = 12 chironomidae, 1 ml = 24 culicidae, 1 ml = 10 oligachaeta.

of organisms occurred at the non-inflow stations than at the inflow stations. The organisms found only at non-inflow stations were phantom midges, sideswimmers (Gammaridae), aquatic earthworms and planaria (Planaridae), (Tables 2 and 3). The mayfly (Baetidae), damselfly (Coenagrionidae) and dragonfly (Libellulidae) nymphs along with midges, pouch (Physidae) and orb (Planorbidae) snails were present throughout the year in all areas.

Net zooplankton and phytoplankton samples showed peak standing crops of 72.7 ml/meter^3 during April in area B-2 and 34.5 ml/meter^3 during March in area B-3 (Figure 7). Smaller peaks (17.6-28.0 ml/meter^3) were observed during December in both areas and an additional plateau (12.5-12.7 ml/meter^3) occurred during May and June in area B-3.

Bosmina longirostris was the most abundant species of zooplankton present in the lake from November, 1973 until April, 1974 with *Daphnia ambigua* and *Chydorus sphaericus* of secondary abundance. The high peaks of standing crop in March and April, corresponded with the appearance of *Daphnia galeata mendotae* as the major species with *Bosmina longirostris* dropping to second in abundance. This pattern continued until July when numbers of zooplankton dropped and remained low until the end of the study.

Table 2. Seasonal littoral weed invertebrates in inflow areas, stations L-1 and L-5.

Invertebrate Classification	Appearance[a] Fall	Winter	Spring	Summer
Family Baetidae (Mayfly nymphs)	P	P	P	P
Family Coenagrionidae (Damselfly nymphs)	P	P	P	P
Family Libellulidae (Dragonfly nymphs)	P	P	P	P
Family Ceratopogonidae (Biting midges)	P	A	A	P
Family Chironomidae (Midges)	P	P	P	P
Order Diptera (Adult)	A	P	A	P
Orconectes causeyi (Crayfish)	P	P	P	P
Family Physidae (Pouch snails)	P	P	P	P
Family Planorbidae (Orb Snails)	P	P	P	P

[a] A = absent, P = present.

Table 3. Seasonal littoral weed invertebrates in non-inflow areas, stations L-2, L-3 and L-4.

Invertebrate Classification	Appearance[a]			
	Fall	Winter	Spring	Summer
Family Baetidae (Mayfly nymphs)	P	P	P	P
Family Coenagrionidae (Damselfly nymphs)	P	P	P	P
Family Libellulidae (Dragonfly nymphs)	A	P	P	A
Family Culicidae (Phantom midges)	P	P	A	A
Family Gammaridae (Sideswimmers)	P	P	P	P
Family Ceratopogonidae (Biting Midges)	P	A	A	P
Class Oligachaeta (Aquatic earthworms)	A	A	A	P
Family Chironomidae (Midges)	P	P	P	P
Family Planariidae (Planaria)	P	A	A	A
Order Diptera (Adult)	A	P	A	P
Orconectes causeyi (Crayfish)	A	P	P	P
Family Physidae (Pouch snails)	P	P	P	P
Family Planorbidae (Orb snails)	P	P	P	P

[a] A = absent, P = present.

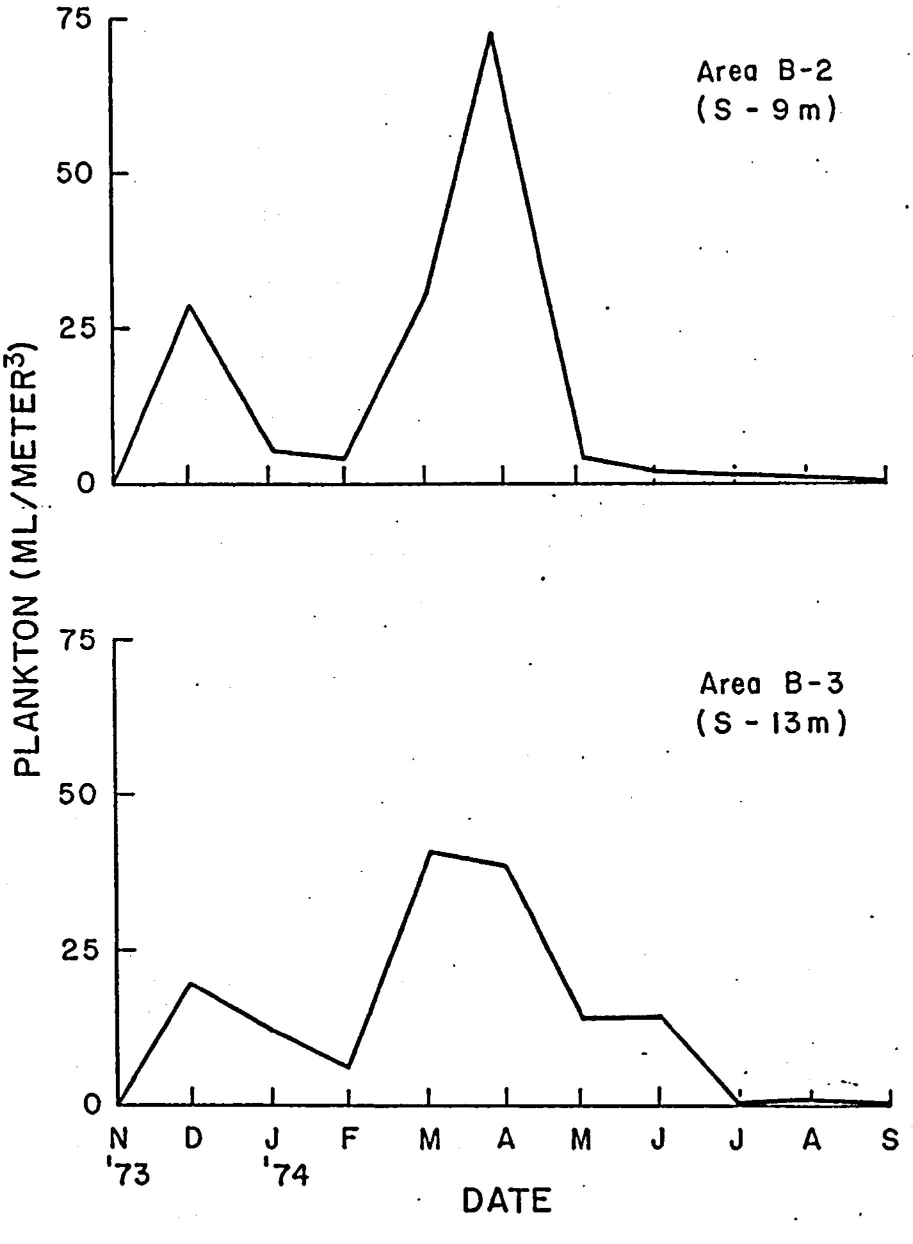

Figure 7. Monthly standing crops of net zooplankton and phytoplankton.

Food Habits

A total of 187 warmwater fish stomachs and 118 rainbow trout stomachs were examined for determination of food habits. Stomachs examined from warmwater species were from various size fish older than young-of-the-year.

Rainbow trout food habits varied seasonally. Threadfin shad was their primary food during the fall (Table 4). Cladocera were the primary forage and fish remains or midge pupae and larvae were secondary during the winter. Midge pupae and larvae were the two major foods during the spring (Table 5). Summer food analysis of rainbow trout was limited to one fish which had plants in its stomach.

Bluegills also showed seasonal variations in food habits. Cladocera were their primary food and snails their secondary food during the winter. Midge pupae or larvae were the major foods during the spring. Crayfish, *Orconectes causeyi*, was the primary food and plants the secondary food in the summer. No samples of bluegill or any warmwater species were taken during the fall for stomach analysis.

The remaining warmwater species showed a heavy dependence on crayfish throughout the year. Crayfish was their primary food in all seasons, except channel catfish primarily ate plants during the winter. Green sunfish secondarily used snails in winter, midge pupae during spring and snails during the summer. Largemouth bass ate fish in some capacity as a secondary food source in all seasons and consumed a few

Table 4. Primary and secondary foods of fish during fall (Sept.-Nov.) and winter (Dec.-Feb.).[a]

Fish Species and Trout Stocking Dates	Fall		Winter	
	Primary	Secondary	Primary	Secondary
Trout-Orange (11-6-73)	Threadfin shad	Midge pupae	Cladocera	Fish remains
Trout-green (12-6-73)	Threadfin shad	Midge pupae	Cladocera	Midge pupae
Trout-yellow (1-9-74)	*	*	Cladocera	Midge pupae
Bluegill	*	*	Cladocera	Snails
Green sunfish	*	*	Crayfish	Snails
Largemouth bass	*	*	Crayfish	Rainbow trout
Channel catfish	*	*	Algae	Crayfish

[a] * = No fish caught during this period.

Table 5. Primary and secondary foods of fish during spring (March-May) and summer (June-August).[a]

Fish Species and Trout Stocking Dates	Spring		Summer	
	Primary	Secondary	Primary	Secondary
Trout-Orange (11-6-73)	Midge larvae	Midge pupae	*	*
Trout-Green (12-6-73)	Midge pupae	Midge larvae	*	*
Trout-Yellow (1-9-74)	Midge pupae	Plant	*	*
Trout-Pink (2-12-74)	Midge pupae	Midge larvae	*	*
Trout-Blue (3-20-74)	Midge pupae	Midge larvae	Plant	*
Bluegill	Midge pupae	Midge larvae	Crayfish	Plant
Green sunfish	Crayfish	Midge pupae	Crayfish	Plant
Largemouth bass	Crayfish	Fish Remains	Crayfish	Threadfin shad
Channel catfish	Crayfish	Midge pupae	Crayfish	Plant

[a] * = No fish caught during this period.

rainbow trout during the winter. The diet of channel catfish in addition to being primarily dependent on crayfish for food, secondarily used midge pupae during the spring and plants during the summer.

Average volumes of food in stomachs of rainbow trout increased gradually from the winter to summer (0.8 ml/stomach to 2.1 ml/stomach). Bluegill, green sunfish and largemouth bass had relatively constant volumes of food in their stomachs. Channel catfish averaged 0.6 ml of food in their stomachs in winter which increased to 8.6 ml of food per stomach during the summer.

Growth and Condition of Rainbow Trout

Rainbow trout in all color-groups increased in length and weight with increasing residency in the lake (Figure 8). Rainbow trout-orange, which were stocked first and were captured consistently until May, had a mean standard length increase from 18.6 to 26.8 cm and a mean weight increase from 118 to 320 g. The largest rainbow trout captured was from the green color-group and was netted in November, 1974, after eleven months in the lake. It had grown to a standard length of 29.9 cm and weighed 602 g.

Condition factors (K) varied during the study from 1.43 to 2.39 (Figure 9). All color-groups showed their lowest condition factors (1.43-1.70) during either March or

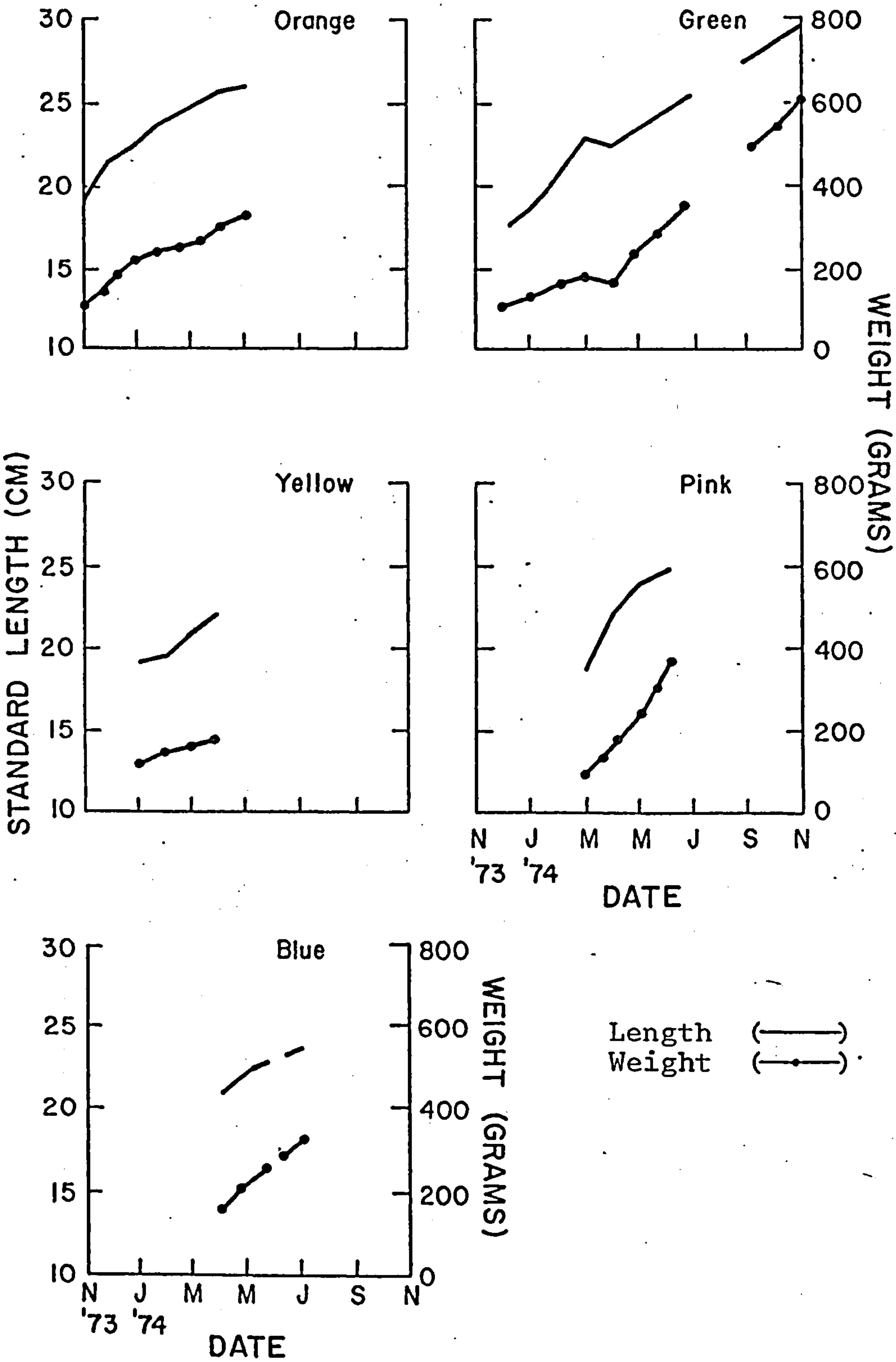

Figure 8. Monthly growth of rainbow trout.

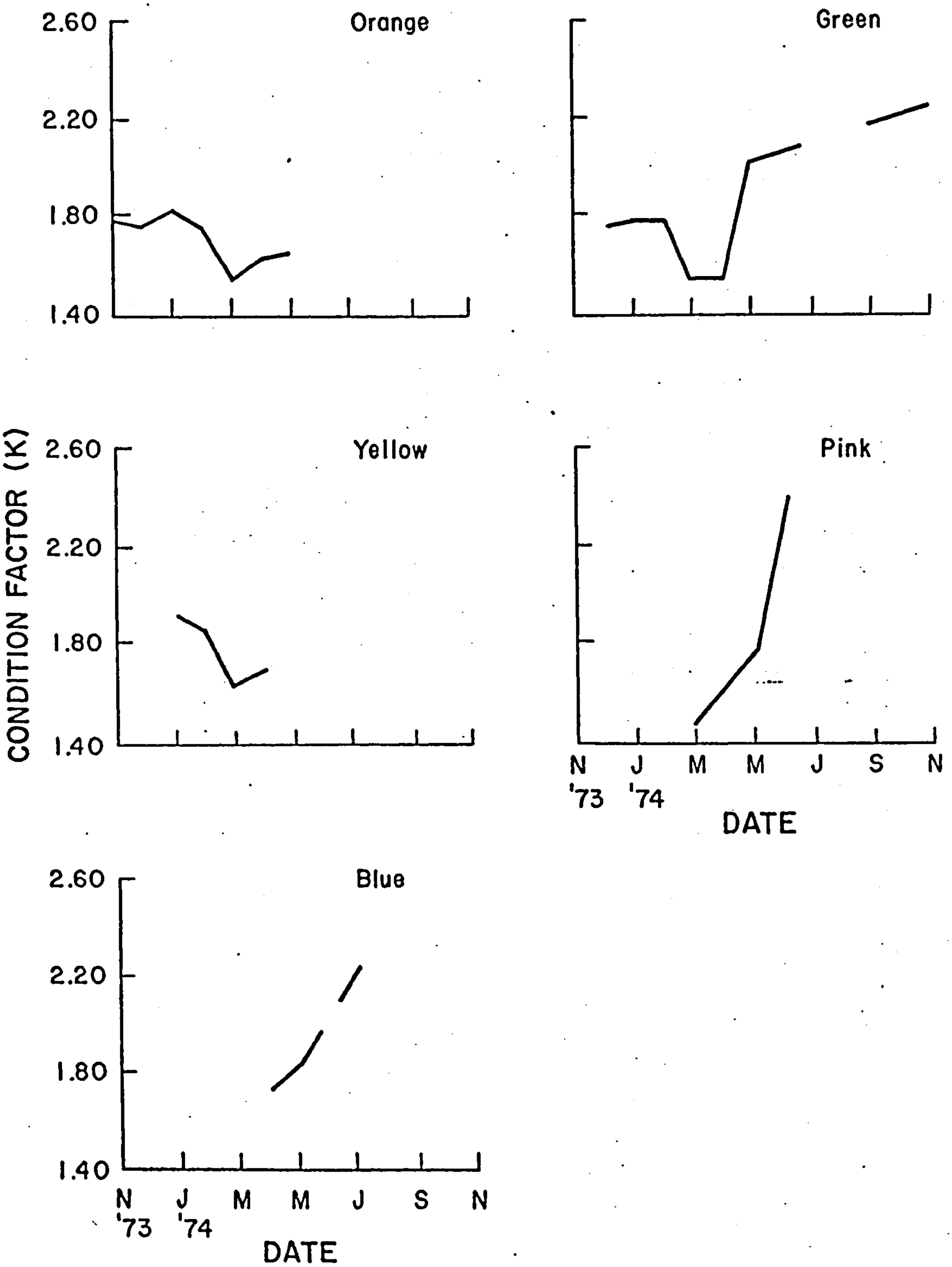

Figure 9. Monthly condition factors of rainbow trout.

April. Condition factors decreased into this two month period and increased afterwards.

Harvest of Rainbow Trout

Fifteen thousand rainbow trout were tagged and stocked and of these, 24% or 3,561 tags were recovered (Table 1). Tag returns from these plants of rainbow trout showed initial peaks within two or three days, which then tapered off in the following weeks (Figure 10). The yellow color-group appeared for the shortest time (January-April) and the orange color-group appeared in every month from November, 1973 until May, 1974. The orange color-group showed an additional peak of tag returns during February, which was not exhibited by an other color-group.

Total tag returns for all rainbow trout showed two peaks, the first in December and the second in February (Figure 11). The period after the February peak showed a steady decline in tag returns until they became non-existent by June.

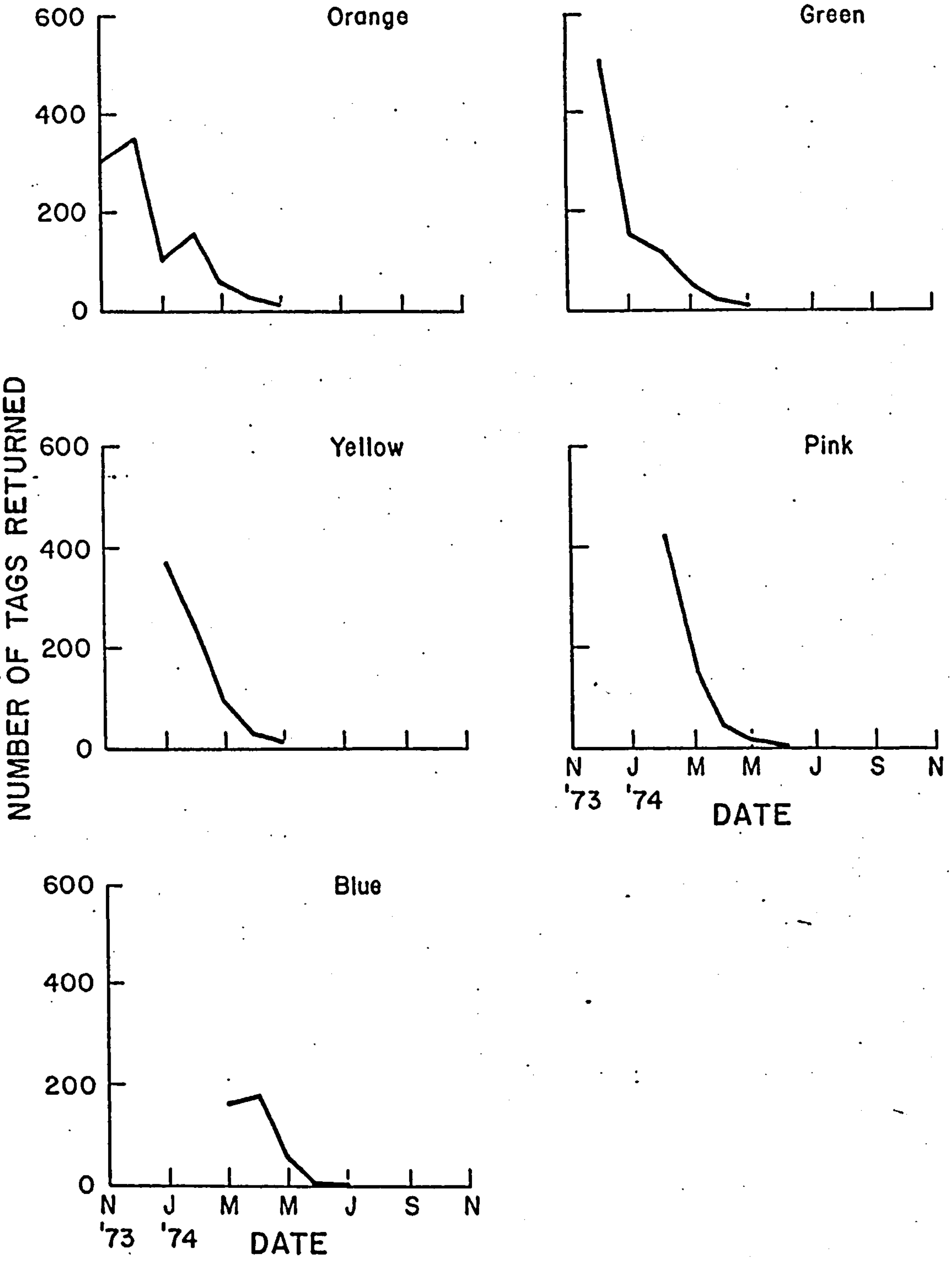

Figure 10. Monthly color-coded tag returns from fishermen.

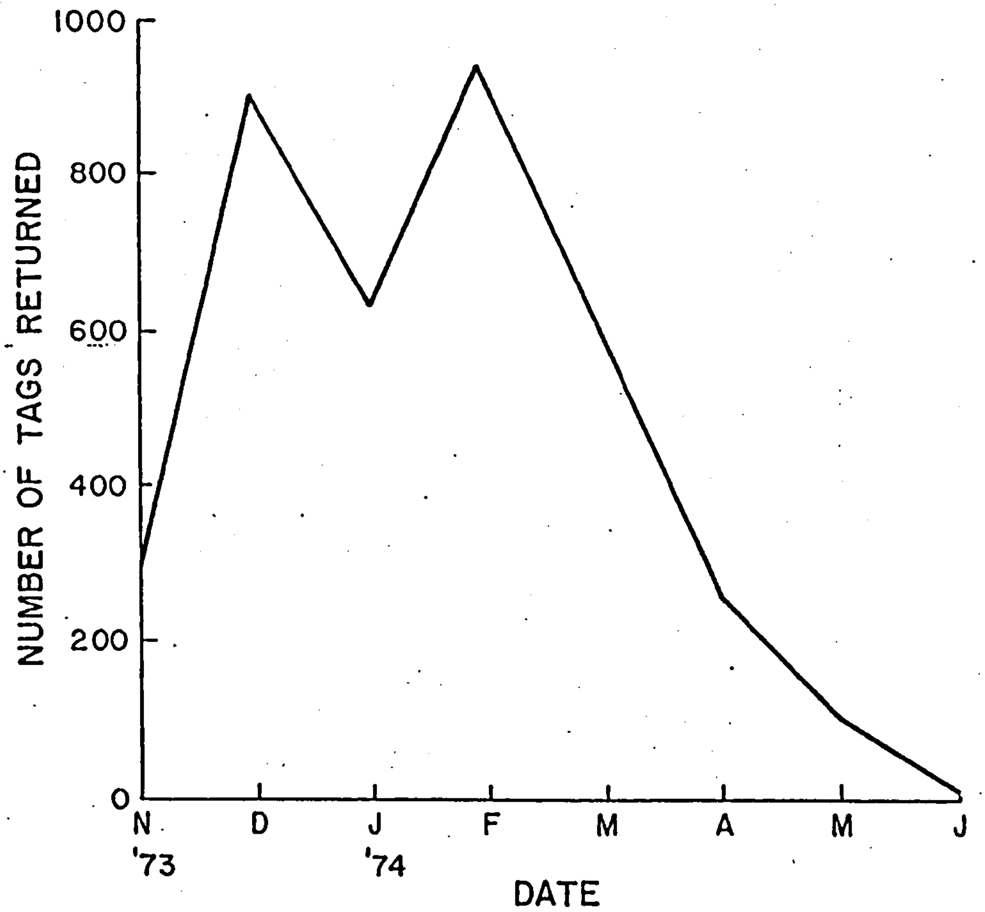

Figure 11. Total monthly tag returns from fishermen.

DISCUSSION

The sport fishery of Parker Canyon Lake consists of three components, stocked rainbow trout, stocked channel catfish and centrarchids (largemouth bass, green sunfish and bluegill). Stocking of rainbow trout on a yearly basis is necessary because there is no natural reproduction. The majority of these fish are harvested each year; and, of those which are not harvested, few survive through the summer months. Although channel catfish do survive year round, continued stockings are essential due to negligible evidence of natural reproduction. The remaining warmwater species do reproduce naturally in the lake and maintain population from year to year.

Components of Fishery

Rainbow Trout

Rainbow trout were first stocked on November 6, 1973. The stocking, however, need not have been delayed until November. The minimum water quality needed for rainbow trout survival was found by Kirland and Bowling (1966) and Raustron (1972) to be at least 3 mg/l dissolved oxygen and a water temperature of 21° C or less. This study showed that the water quality in October, with water temperatures of 13-17°C and dissolved oxygen concentration of 5-8 mg/l, made the top 10 meters of the lake suitable for rainbow trout inhabitation. This suggests that rainbow trout could have been stocked in the lake earlier.

Rainbow trout dispersed throughout the lake soon after stocking. Individuals of the green color-group were captured within 10 days at the opposite end of the lake from where they were stocked. Raustron (1972) had similar findings with Coleman Kamloops trout in Lake Berryessa, California. His dispersal data indicated that the fish moved to the limnetic zone. Rainbow trout in this study, however, dispersed to the protective cover of the water milfoil near shore as indicated by the high percent (93%) of rainbow trout captured in these areas during the winter months (December-February). During the spring months (March-May) rainbow trout moved out of the littoral plant beds. This movement was evident in the lower percentage (34%) of rainbow trout captured near shore during the spring months. Rainbow trout distribution during this study showed that they inhabited the water above 10 meters, although water quality conditions were not always limiting below this depth. Though rainbow trout utilized food organisms similar to those found below 10 meters, avoidance of the deep water was related to the food organisms' low numerical abundance (Appendix C).

Distribution data of rainbow trout during the summer was very limited because only three fish were captured. Glucksman (1965) found that, when water of low oxygen content or high temperatures was all that was available, the vertical distribution of rainbow trout showed no preference for one unfavorable stratum over another. Horak and Tanner (1964) found rainbow trout to prefer water temperatures of 19 to 21° C in Horsetooth Reservoir, Colorado. Capture of rainbow trout in waters warmer than this in Parker Canyon Lake can be accounted for by acclimation (Garside and Tait, 1958) or temporary excursions.

During this study, a high percentage of "garbage type" remains (rocks, sticks and rubber bands) were found in rainbow trout stomachs. These items were not considered in the analysis of food habits. Warmwater species did not have such materials in their stomachs. According to Ware (1971) stocked rainbow trout needed four days of feeding experience before they would attack novel prey. These data, then, suggests that a short time period (5 to 10 days) is needed for the stocked rainbow trout to gain experience in feeding on natural foods.

Food habits of rainbow trout shifted twice during the study. The primary food during the winter, Cladocera, was replaced by midge pupae and larvae during the spring. This shift to midge pupae and larvae, which were numerically abundant throughout the year, occurred at a time when the standing crops of net zooplankton and phytoplankton were at their highest levels. The second dietary shift occurred during the fall when the primary food was threadfin shad. Calhoun (1966) points out that rainbow trout require larger sized food sources as the fish increase in size. The two shifts then, apparently, were related to the larger size of each new food source, that met the increased food requirements of the rainbow trout, and not to the numerical availability of the food sources.

Growth of Parker Canyon Lake rainbow trout was comparable to growth of rainbow trout in other lakes (Calhoun, 1966), even with the streamer tags which can retard growth according to Carline and Brynildson (1972). This growth was also found to be similar to growth in northern lakes where the main growing season is during the summer. Neither the location of the lake, the season of the year, nor the presence of tags adversely affected the growth of the rainbow trout.

During the spring months of March and April, low condition factors were noted in the rainbow trout. This corresponded with their first dietary shift and their movement to the limnetic areas of the lake. Also, a peak of tag returns occurred during this time indicating that a large number of rainbow trout were present in the lake. These data suggest that a large number of rainbow trout were moving to new areas of the lake and eating different food items during this period (March-April) and that these changes adversely affected their condition factors.

Channel Catfish

Ferguson (1958) stated that channel catfish prefer water temperatures of approximately 27° C. Avoidance of low dissolved oxygen concentrations (less than 3 mg/l) has been reported by Moss and Scott (1961). Reduced activity, because of cool water temperatures (6 to 9° C), was noted during the winter. Channel catfish during this period were difficult to capture by electrofishing and gillnetting, presumably because they moved to deeper water and were relatively inactive. In the warmer months (April-October), they showed renewed activity and also a preference for the warmest stratum of water (upper 2 meters) near the shore. Ziebell (1973) also found this preference and suggested that it was due to water temperature. However, data from this study suggest that this preference was due not only to water temperature but also to the availability of the channel catfishes' primary food, crayfish, in the littoral plant beds.

Channel catfish, unlike the other warmwater species, had less food volume in their stomachs during the winter than in the spring and summer. Algae was the primary food source in winter rather than the crayfish, their primary food during the spring and summer. Dean (1969) reported that fewer crayfish are available during the winter because of burrowing. Warmer water temperatures (April-October) not only increased the activity of the channel catfish and the food volume in their stomachs but also induced more crayfish to come out of their burrows and therefore become more available. After this occurred, channel catfish again returned to crayfish as their primary food. This suggests that the use of crayfish as a food by channel catfish was related to the numerical abundance of the crayfish and the activity of the channel catfish.

Centrarchids

The centrarchids, largemouth bass, green sunfish and bluegill, comprised another important segment of the warmwater fishery. Water temperatures and dissolved oxygen requirements of all three centrarchids are essentially the same. Ferguson (1958) stated that centrarchids preferred water temperatures of approximately 25° C. Whitmore, Warren and Doudoroff (1970) found that centrarchids showed an avoidance reaction to water containing less than 4.5 mg/l dissolved oxygen. Distributional data showed that the centrarchids preferred the shallow shoreline areas throughout the year. Water quality data indicated that the warmest temperatures and the highest dissolved oxygens were always found in the top two meters of the lake. This suggests that the centrarchids sought out the warmest and best oxgyenated water, even though other water might have been available in which they could have survived. The preference for shoreline areas was also probably related to the availability of food, cover and spawning sites.

During the summer centrarchids were limited to the top seven meters of the lake because water below this depth was devoid of oxygen. Coupling this limitation of distribution with the lowered water level and reduced inhabitable volume during this study, certain management implications may be foreseen. Increased predations due to overcrowding may occur (Ziebell, 1969) and even interruption of growth may result because of lack of food (Mayhew, 1963). No evidence of these management problems was found during this study but may become important during future years.

The centrarchids primarily used crayfish for food from winter through summer (except for bluegills during winter and spring). This utilization of crayfish for food by centrarchids was related to the crayfish's numerical abundance (Ricker, 1952) and its use of the littoral plant beds where centrarchids were concentrated. The bluegill's dietary shift away from crayfish during the winter and spring was probably related to a lack of this food source as most of the smaller crayfish burrow during the cooler months and the new hatch does not occur until late May or early June

(Dean, 1969). This suggests that during the winter and spring crayfish are either unavailable or too large for predation by bluegills which could account for their dietary shift to other food sources.

Low fish forage production in Parker Canyon Lake was found by Bergersen (1969). Data from this study showed that although centrarchids were present throughout the year in the littoral plant beds, they used only small amounts of other food organisms (mayflys, dragonflys, etc.) which were found in the area in addition to crayfish. This points out that there was a numerical relationship between the food organisms available and what was eaten by centrarchids. The use of crayfish as a primary food by the centrarchids in future years will most likely continue if crayfish populations remain at current levels.

Interrelationships and Implications

There were three main questions that instigated this study. 1. Do stocked rainbow trout have a biologically adverse effect on the warmwater fish and vice versa? 2. Can rainbow trout survive during the warmer summer months? 3. How fast and how many of the stocked rainbow trout are harvested by fishermen? These questions were answered.

The data indicated that there was little food overlap between rainbow trout and warmwater species even though they occupied similar habitats during the winter. The food overlap occurred between rainbow trout and bluegills in the winter, when their common food was Cladocera; and in the spring, when their common food was midge pupae and larvae. Rainbow trout food habits during these two seasons were similar before the introduction of the warmwater species in 1965 (Glucksman, 1965). Condition factors of the rainbow trout in 1964 ranged from 1.65 to 2.10 and those in this study ranged from 1.43 to 2.39. These factors were nearly comparable and equal to or better than those listed in Carlander (1969). This suggests that even though rainbow trout and warmwater species occupied similar areas, and ate, to a limited extent, similar foods; the overlaps did not adversely affect the fish and the situation was biologically compatible.

Two incidences of predation by largemouth bass upon recently stocked rainbow trout occurred during the winter. This predation occurred mainly because the recently stocked rainbow trout were apparently unfamiliar with their surroundings and were vulnerable to the bass. After the rainbow trout became accustomed to their environment this predation ceased.. Thus, predation by largemouth bass on rainbow trout appeared minimal.

Rainbow trout survival during the warmer summer months was possible because the water in the thermocline at a depth of six to seven meters had at least 3.0 mg/l of dissolved oxygen and temperatures were 21.0° C or less. Eight rainbow trout from previous years' stockings, which had survived through the summer, were captured during the study. This indicated that a few of the stocked rainbow trout survived through the summer stratification period. The favorable water quality conditions during this study would have allowed many of the remaining stocked rainbow trout to survive until fall. However, other studies which have been conducted at Parker Canyon Lake (Saiki, 1973; Ziebell, 1973) point out that these minimum conditions were not present every year. This suggests that the stocked rainbow trout should be harvested before summer stratification commences, because their survival during the summer is questionable.

Harvest of the stocked rainbow trout showed peaks within two to three days after each stocking and then tapered off markedly in the next two to three weeks. Thus, the majority of any color-group of rainbow trout was harvested before the next monthly stocking. The data also suggest that few rainbow trout remained in the lake after April. An estimated 90 to 95% of the rainbow trout were harvested by this time. This estimate was based on the total number of tags returned (24%) plus an estimate of those rainbow trout caught but whose tags were not returned (70%). The data on tags not returned was based on reports from two check stations set up near the lake on January 19 and February 23, 1974, by personnel of the Arizona Game and Fish Department.

Additionally, less than 50 tags were returned after April, and only three rainbow trout were captured by gillnetting and electrofishing during the summer. Thus, each stocking was removed quickly from the lake and the majority (90 to 95%) of the 15,000 rainbow trout stocked were harvested.

Creel census data (G. Ginnelly, Arizona Game and Fish) showed that very few warmwater fish were caught during the time rainbow trout were being planted and harvested. Food volumes in stomachs of centrarchids showed little change during the year. Centrarchids also occupied areas near shore which were readily accessible to angling by fishermen. This suggests that either the centrarchids were uncatchable; fishermen did not know how to fish for them during the cooler months; or fishermen preferred fishing for the easiest catch, rainbow trout.

Even though the stocked rainbow trout-warmwater fishery looked biologically compatible, it may not be economically feasible. Rainbow trout which are stocked must be of sufficient size to avoid predation by largemouth bass (Keith and Barkley, 1970; Baker and Mathis, 1967) and also be of acceptable size so that fishermen will harvest them before summer stratification. Thus, the Arizona Game and Fish Department, to stock rainbow trout of this size (greater than 8"), must absorb an ever increasing cost. This increased cost to raise rainbow trout to this size is because of higher prices for food, labor, transportation, etc. However, if the Department would reduce stockings to the coldest months of the year (December-February), costs could be reduced. The fewer number of stockings would mean a substantial monetary savings. Fishermen would be forced to fish for warm-water species for an additional two to three months, but stockings during the coolest months would continue the year round fishing at Parker Canyon Lake.

CONCLUSION

Although there was some food and habitat overlap between the rainbow trout and warmwater species in Parker Canyon Lake, they are biologically compatible. Water quality of at least 3 mg/l dissolved oxygen and 21° C temperature or less was available at a depth of six to seven meters throughout the summer. This water quality is not available every summer and it is not advisable to rely on rainbow trout survival year round. Stockings of rainbow trout should be limited to the coldest months, November through March, to be safe. Stockings of rainbow trout were quickly harvested and 90 to 95% of the trout were harvested by the end of April.

Stockings of rainbow trout in the cooler months provides more fish for the anglers and better use of the lake for recreational fishing. However, the continuation of stocking rainbow trout into Parker Canyon Lake may not be economically feasible in the future. The increased costs which Arizona Game and Fish Department must pay to rear the rainbow trout may bring this about. A possible solution may be to reduce the number of stockings to the coldest months, December through February, of the year. This may stimulate anglers to fish for warmwater species later in the fall and earlier in the spring, and thus maintain year round fishing in Parker Canyon Lake.

APPENDIX A

SEASONAL COMPOSITION OF BENTHOS

AT STATION B-1[a]

Invertebrate Classification	Season			
	Fall	Winter	Spring	Summer
Family Chironomidae	1048 (94)	3029 (91)	2684 (75)	445 (45)
Class Oligachaeta	43 (4)	144 (4)	172 (5)	43 (4)
Family Culicidae	14 (1)	29 (1)	-	14 (2)
Family Baetidae	14 (1)	-	-	-
Family Coenagrionidae	-	-	72 (3)	-
Family Ceratopogonidae	-	159 (4)	617 (17)	459 (46)
Class Ostracoda	-	-	-	29 (3)

[a] Represented as number/meter^3 and ( ) per cent of total.

APPENDIX B

SEASONAL COMPOSITION OF BENTHOS

AT STATION B-2[a]

Invertebrate Classification	Season			
	Fall	Winter	Spring	Summer
Family Chironomidae	14 (1)	689 (34)	1163 (62)	144 (9)
Class Oligachaeta	1507 (70)	947 (46)	545 (30)	1249 (78)
Family Culicidae	617 (29)	401 (20)	86 (5)	187 (12)

[a] Represented as number/meter^3 and ( ) per cent of total.

APPENDIX C

SEASONAL COMPOSITION OF BENTHOS

AT STATION B-3[a]

Invertebrate Classification	Season			
	Fall	Winter	Spring	Summer
Family Chironomidae	28 (22)	344 (34)	631 (53)	-
Class Oligachaeta	43 (33)	502 (50)	230 (20)	201 (58)
Family Culicidae	57 (45)	158 (16)	316 (27)	144 (42)

a Represented as number/meter^3 and ( ) per cent of total.

APPENDIX D

SEASONAL COMPOSITION OF BENTHOS AT STATION B-4[a]

Invertebrate Classification	Season			
	Fall	Winter	Spring	Summer
Family Chironomidae	299 (35)	2024 (71)	1708 (73)	28 (18)
Class Oligachaeta	100 (16)	488 (17)	43 (2)	29 (18)
Family Culicidae	316 (49)	359 (12)	588 (25)	100 (64)

[a] Represented as number/meter^3 and ( ) per cent of total.

APPENDIX E

SEASONAL COMPOSITION OF BENTHOS

AT STATION B-5[a]

Invertebrate Classification	Season Fall	Winter	Spring	Summer
Family Chironomidae	1794 (94)	3387 (87)	2842 (85)	1765 (77)
Class Oligachaeta	57 (3)	359 (9)	57 (2)	287 (13)
Family Culicidae	-	14 (1)	172 (5)	-
Family Baetidae	29 (1)	-	-	-
Family Coenagrionidae	14 (1)	-	-	-
Family Ceratopogonidae	29 (1)	129 (3)	215 (7)	172 (8)
Class Ostracoda	-	-	-	57 (2)
<u>Orconectes causeyi</u>	-	-	14 (1)	-

[a] Represented as number/meter^3 and ( ) per cent of total.

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