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Study No. J-15, Job No. 1. A review of the literature on crappies in small impoundments

Arvil Ming, Principal Investigator

Abstract

Fifty papers were reviewed on crappies with special reference to their ecology and success in impoundments of 250 acres and smaller.

A trend prevalent throughout the literature is that both species of crappies tend to become "stunted" or overpopulated, creating huge populations of fish that usually remain smaller than 8 inches in length and that suppress the reproduction and growth of other species present. This characteristic seems to become more pronounced, sooner in small lakes and ponds.

Stunting of crappies appears to be caused primarily by the lack of a suitable forage fish of the preferred size. Stunting did not appear to be a result of crowding or heredity.

Space or size of the impoundment was also suggested by several authors to be an important factor that may cause crappie to overpopulate. Inter-specific and intraspecific competition were listed by some authors as the reason for stunting, while still other authors felt that water fluctuation in a reservoir was a factor that causes stunting among a crappie population.

White crappies appear to become dominant over black crappies when they occur together. The usual pattern is an abundance cycle with white crappies being abundant for a few years, then black crappies becoming abundant. After this oscillating period, one or the other species becomes dominant; white crappies in turbid waters, the blacks in clear water.

A few significant differences between the two species were listed in

the literature. Black crappies seem to tolerate cooler waters, are associated with beds of aquatic vegetation, tolerate waters with pH values less than 7.0, and tend to feed more at night. White crappies can tolerate more turbid waters, are found in open areas of the lake, tolerate waters with pH values over 7.0; and tend to feed more during daylight hours.

Black crappies were listed by most authors as being more desirable, mainly because they did not seem to overpopulate as much as white crappie and appeared to grow at slightly faster rates.

Some evidence was presented of natural die-offs of complete year-classes of crappies. Reasons given ranged from "poor summer condition" to "natural mortality of old fish following the spawning period".

According to the literature, growth rates are sometimes erratic, and the scales are generally hard to read. False annuli may be present on a large portion of the scales.

Crappies generally do not live long. Most reports list 4 years to be the average life span with a few individuals always present that attain the age of 8 years.

There was no mention of hybrid crappies in the literature reviewed.

Gizzard shad or threadfin shad appeared to provide the best forage and to be the most desired food for crappies.

Although large crappies feed primarily on fish, they apparently have the ability to switch to other food items when forage fish becomes scarce.

Most authors concluded that crappies compete with largemouth bass and usually become dominant over bass. In the cases listed, the resulting crappie population was usually stunted. This dominance appeared to be linked with overharvest of the bass by fishermen. A few authors felt that the presence of crappies had no measureable effect on largemouth bass crops.

Study No. I-15, Job No. 1. A review of the literature on crappies in small impoundments.

Arvil Ming, Principal Investigator

Introduction

The objective of this job is to review the literature on crappies with special reference to their ecology and success in impoundments of 250 acres and smaller.

Crappies have not been stocked in public fishing lakes operated by the Department of Conservation. We do not stock them in other small impoundments and reservoirs and recommend to owners of private waters that they not be stocked. This policy apparently originated from early experience with stunted populations of crappies in ponds and small reservoirs. No organized study of this problem has ever been made in the state. We know, however, of some small reservoirs which have provided good crappie fishing for many years. There are constant requests from fishermen for crappies in our public fishing lakes and recently crappies have begun to appear in the catch from several lakes (Paho, Pony Express, Little Dixie, Binder). There are numerous questions for which a manager of a lake containing crappies would want answers. What contributions will they make to the fishery? Will they compete with other desirable sport species, especially largemouth bass? Will they over-populate and become stunted? How can they be collected? Where and when do they spawn? What environmental factors affect their populations? What are their food habits, growth rates, reproductive rates, survival, diseases, mortalities, and standing crops? To answer these questions, basic life histories of crappies in all situations will need to be reviewed to provide background data for crappie populations in general. A special effort will be made to review the factors that cause crappies to over-populate and stunt in some waters but not in others. Another area of particular interest is the interspecific competition between black and white crappies since both species occur in most of the Missouri public fishing lakes. Collecting methods and gear are also of interest here because crappies are difficult to collect with methods presently used.

When applicable, catch rates, growth rates, reproductive rates and condition factors will be included.

Papers being reviewed will be searched for particular references of interest and will not be summarized in their entirety.

Annotated Selected Bibliography

Bartholomew, J. P. 1966. The effects of Threadfin Shad on White Crappie Growth in Isabella Reservoir, Kern County, California. Cal. Dept. Fish and Game, Inland Fish. Ad. Rept. 66-6: 11.

Threadfin shad were stocked in Isabella Reservoir (11,400 acres) in 1961 and 1962 to provide forage for a stunted population of white crappies. White crappie growth increased after the introduction of shad, especially for fish in their second and third years. Crappie growth seemed to be independent of annual water volume fluctuations. Shad remains were found in at least some of the stomachs during each sampling trip, including the spring samples, indicating a substantial winter carry over of shad.

Bennett, G. W. 1944. The effect of species combinations on fish production. Trans. 9th N.A. Wildlife Conf.: 184-190.

Crappies tend to produce a dominant brood or year class, that, from the year of its origin controls the survival of young of all species within a lake, until a sudden natural die-off so reduces its numbers as to allow the survival of another large year class. These dominant broods appearing every 3 to 5 years, require 2 or 3 years to reach useful size, and furnish good fishing for only one or two seasons out of four or five.

Crappies are apparently successful when competing with bass through limiting the survival of the young bass, while the young crappies in some way escape serious predation. Only in lakes where fishing pressure is heavy are bass able to compete successfully.

Bennett, G. W. 1945. Overfishing in a small artificial lake. Ill. Nat. Hist. Survey Bull. 23(3): 373-406.

A creel census on Onized Lake, a 2-acre Illinois pond showed that black crappies were practically eliminated by 4 years of heavy fishing (about 1500 hours per acre per year). Netting and final processing showed that the crappies had been reduced from over 200 to 22, only 7 of which were of catchable size. No crappies older than four summers were taken.

Bennett, G. W. 1962. Management of artificial lakes and ponds. Reinhold Publishing Corp., Chapman and Hall Ltd. London: 283 pp.

Wing nets used in Lake Senachwine, Illinois indicated a crappie-dominated fish cycle, wherein a dominant brood of crappies curtailed the survival of its own young and those of other species until this brood was decimated by natural mortality. Then another dominant brood was produced and the cycle was repeated. The cycle shifted between high numbers of black crappies with low numbers of white crappies and bluegills, and moderate numbers of white crappies and bluegills, and moderate numbers of black crappies.

There are several records of the disappearance of relatively strong year classes of white crappies during the summer months where the only evidence of their death was the fact that they suddenly disappeared from wing net catches and never again reappeared. Crappies often are in their poorest condition in the summer, and many apparently fail to recover.

Barris, W. E. 1956. Studies of the age, growth, and food of known-age young-of-year black crappie and of stunted and fast-growing black and white crappies of some Oklahoma lakes. Ph. D. Thesis, Okla. State Univ., 85 pp. (Unpublished).

Oklahoma impoundments were studied to determine the differences between the fast-growing populations of crappies in new lakes and the populations of stunted crappies in older lakes. The kind and amount of food available are considered the chief causal factors.

Crappies in new lakes had made relatively rapid growth and their large populations consisted of only a few age groups; Crappies in older lakes and ponds, 13 to 25 years old, were overpopulated and stunted. Stunted white crappies had proportionally faster growth of scales than of fish length, exhibited body-scale relationships that were curvilinear, had low coefficients of condition, and a resistance to shrinkage from fixation. Faster-growing crappies contained larger volumes of fish as food, mostly gizzard shad and minnows, whereas the slower-growing crappies contained smaller volumes of fish, mostly centrarchids.

White crappies from the "new lakes" were 8 to 11 inches in length during their second year of life, whereas, white crappies from the "old lakes" were 4.7 to 5.4 inches in length at the end of their second year of life.

Studies of carnivorous young-of-the-year black crappies 2.5 to 13.5 weeks of age showed that scales developed as tiny platelets in the "key-scale area" when the fish were about 0.9 inches in length and that the body-scale relationship was approximately linear (intercept 0.7 inches). Coefficients of condition of young-of-year black crappies were found to increase with age and length until the fish were about six weeks old and 1.4 inches long. Thereafter, the coefficients of condition were not significantly different for longer or older fish.

Large numbers of 5- to 7-inch crappies were found in stunted populations. It is at this size that white crappies begin to feed almost exclusively on fish. Thus, the evidence indicates that slow growth of crappies in the older lakes is caused by a shortage of forage fish for crappies less than 7 inches in length.

Generally the author has compared food habits and growth rates of crappies between small impoundments where the dominant forage fishes are centrarchids and newly-impounded reservoirs where the principal forage is shad. Many factors in addition to food habits are involved and the inference that stunted crappies occur as a result of feeding on centrarchids is not valid.

Carter, E. R. 1953. Growth rates of the white crappie, Pomoxis annularis, in Kentucky Lake. K. Dept. of Fish and Wildlife Resources, Fish. Bull. 12: 8

Rotenone samples in this 260,000-acre shallow impoundment suggested that white crappies comprised only a small proportion of the population, but eight types of commercial gear showed that this species comprised 40 per cent of the weight of over 13,000 pounds of fish taken.

Forty-seven per cent of the crappies were in their third summer, with no individuals over five years of age. Crappies in the fishermen's creel ranged between 12.5 to 12.9 inches total length. Average calculated lengths for 925 white crappies for Age Groups I, II, III, IV, and V were 4.6, 7.9, 10.4, 11.9 and 12.8 inches total length, respectively. These growth rates were considered high.

Sex ratios among 826 individuals indicated 335 females for each 100 males. Males matured earlier at smaller sizes than females.

Crowding of crappies was of little or no significance.

Carter, J. P. 1963. Experimental crappie removal. K. Dept. Fish and Wildlife, Completion Rept. F-21-R: 18.

A study was conducted to determine the effectiveness of gill nets and hoop nets for crappie removal in Dewey Reservoir.

Netting success was poor, only 1,374 crappies were harvested; 4.04 per net day. White crappies comprised 33.7 per cent of the fish taken in gill nets, bluegills dominated the hoop net harvest, 49.3 per cent.

Charles, J. R. 1967. The Dewey Lake (Reservoir) fishery during the first seventeen years of impoundment. K. Dept. of Fish and Wildlife Resources, Fish. Bull. 47: 63.

At Dewey Lake (1,100 acres) data collected from the spring, 1964 to 1966 showed that crappies and sunfishes together comprised between 93 and 95 per cent of all fish caught each year.

Attempting to thin out the gizzard shad and white crappie populations in Dewey Lake, the lake level, was lowered rapidly from 650 feet to 625 feet. Results of the rapid drawdown were quite satisfactory. In a second drawdown the lake was lowered 25 feet in 5-foot increments. This drawdown did not achieve the desired results, since shad were nearly as abundant the following year.

Post-drawdown population studies showed that the principal piscivorous species drawn through the dam were intermediate-size black and white crappies. White crappies outnumbered the blacks about two to one. It was hoped that the drawdown would thin out the intermediate size classes resulting in better growth of the crappies remaining in the lake.

Childers, W. and H. H. Shoemaker. 1953. Time of feeding of the black crappie and the white crappie. Trans. Ill. Acad. of Sci. 46: 227-230.

Black crappies and white crappies held in tanks were offered 10 minnows at four time intervals; dark, daylight, dawn and dusk.

The period of greatest feeding intensity for both species was at dusk, though the rate of feeding was somewhat greater for black crappies than for the whites. The rate of feeding at dawn was much less than at dusk for both species. The rate at dawn was much less than at dusk for both species. The rate at night dropped to about half of that at dawn for both species, and the rate during the day for the whites was about eight times that of the blacks.

Black crappies were somewhat more active than white crappies during the night and dusk periods while whites are more active during the dawn period.

The differences in feeding activity of white and black crappies appeared to be very similar to the differences in catches of day and night hoopnet sets. The periods of feeding activity for white crappies corresponded to the period of greatest oxygen consumption.

Cleary, R. E. and T. E. Moen. 1957. The effect of mechanical reduction on the growth of the crappie in Backbone Lake. Ia. Quart. Biol. Rept. 9(4): 13-19.

In an effort to increase the average size of the crappies a removal program by netting was instigated on shallow, 125-acre Backbone Lake. A total of 26 pounds per acre of crappies were removed in a 2-year period. In addition, 15 pounds per acre of suckers and carp were removed.

In samples taken from the removed crappie, 80 per cent of the 1956 group were in the 7-8 inch class, and in 1957 only 50 per cent were in this length class; however, a greater per cent of the 1957 fish were less than 7 inches than were the 1956 fish.

The species ratio, black to white crappies, though always dominated by the white crappie, varied as much as 60 per cent in three sampling periods.

Scale analyses determined that both species of crappie increased in growth after intra-specific competition was lessened by a netting removal. This was especially apparent in the younger age classes. A year after the first removal, the growth increments of the white crappie increased an average of 70 per cent for all ages (range, 12 - 24 per cent). Eighteen months after the first removal the increment of the different age classes of fish were still larger than the original but not as spectacular as the 12-month sample.

The average weights per crappie at each removal was: May, 1956, 0.16 pound; May 1957, 0.19 pound; and October, 1957, 0.15 pound.

The average "K" factors of the May, 1956 sample of the black and white crappies were 3.05 and 3.15 respectively; in May 1957, they were 4.84 and 4.41.

Growth increments for black crappie were very erratic and in some age groups the growth prior to mechanical thinning was greater than after.

Crawley, H. D. 1954. Causes of stunting of crappie (Pomoxis nigromaculatus and Pomoxis annularis) in Oklahoma lakes. Ph. D. Thesis, Okla. State Univ., 92 pp. (unpublished).

The rate of food eaten in relation to rate of growth of black and white crappies was studied from three Oklahoma lakes that varied from 2 to 215 acres in size, to learn if food acquired was the dominate factor influencing growth.

Stunting of crappies in the lakes studied was not noticeable until after the first year of life. After stunting occurred, retarded growth continued until the crappies reached a length of approximately 6 inches. Stunted crappies from one of the lakes studied contained a greater volume of food per pound of body weight than did crappie from other lakes in which growth was better. A difference in diet was shown between stunted crappies and those in which growth was more satisfactory. Evidence seems to show that the quality of the diet rather than the quantity was responsible for gorwth made. There seems to be no reason for stunting in crappies in the lakes studied on the basis of volume of food eaten. However, there was considerable differences in the kinds of food eaten and hence ~~probably differences~~ in nutritive value. The differences in rate of growth for the different age groups appeared to be the result of the availability of useable food and its nutritive value and not the result of either crowding or heredity.

Ercole, J. A. 1968. Investigation of factors limiting population growth of crappie. Ariz. Game and Fish Dept., Proj. F-14-R-2, Work Plan 1, Job 1: 1-12.

This study was initiated to determine the cause of the apparent decline of black crappies in Roosevelt Lake, a 17,015 acre impoundment in Arizona.

Analysis of nearly 220 crappie stomachs collected throughout the year indicated that threadfin shad was the most heavily-used food. The major components in the diet of male crappies during the spawning season were Bosmina, tendipédidae, and other planktonic organisms. At this time of year males consumed twice as much Bosmina but only 1/8 as much shad as the female.

About 90 per cent of nests found by SCUBA diving were closely associated with submerged brush and areas of submerged Bermuda grass. Nests were found in water ranging from 4 to 18 feet in depth but most nests were found at a depth of 12 feet. Male crappies began clearing nest sites when surface water temperature approached 64 - 68° F. These temperatures are usually reached near the last week of March to the first week of April. Spawning activity peaked in April and extended into May. No spawning crappies were found after May 17.

Carp were observed preying on crappie eggs. The author surmised that possibly reduced predation on the carp population due to the introduction of threadfin shad may have caused an expansion of the carp population to a point that they may have served as a population depressant by preying on crappie eggs during poor spawning years. He suggested that fluctuating water levels caused poor spawning conditions for crappies.

Ercole, J. A. 1969. Investigation of factors limiting population growth of crappie. Ariz. Game and Fish Dept., Proj. F-14-R-3, Work Plan 1, Job 1: 1-12.

Black crappies less than 3.5 inches in length consumed a significant quantity of largemouth bass fry as well as shad (63 per cent of total volume for largemouth bass fry).

Adult crappies appeared to forage mostly at night or in early morning.

Male crappies formed a depression of 6 to 8 inches in diameter in gravel. Ninety per cent of the crappie nests found were in relatively shallow water at the base of submerged brush. Water depth ranged from four to fourteen feet, with an average of nine.

Fluctuating water levels may be one of the more important factors influencing population levels of crappie.

Carp predation on crappie nests was found to be less serious than suspected. Underwater observations revealed carp in crappie spawning areas but few crappie eggs were found in carp stomachs and protected nests had no more eggs than unprotected ones. Doubtless carp do consume crappie eggs but it is not known to what degree such predation affects population levels.

Age Group I crappies averaged about 8.3 inches, Age Group II, 10.2

inches, and Age Group III 12.2 inches. Generally, crappies were found to more than double their weight each year during the first three years, and to increase their length by 2.4 to 3.1 inches annually during the same period. Large numbers of crappies were attracted to two areas where overhanging bluffs afforded shade during much of the afternoon and dense brush covered the bottom. Few crappies were found in these areas during early morning (6:00 to 8:00 a.m.) hours but those few that were collected in the morning always had full stomachs. Apparently crappies used this area as a home ground and made daily migrations to their feeding areas.

Goodson, L. F. 1965. Diets of four warmwater game fishes in a fluctuating steepsided California reservoir. Cal. Fish and Game 51(4): 259-269.

The diet of black crappies in a 5,970 acre impoundment was similar to that of largemouth bass but crappies ate more arthropods in the March-to-June period. During this period, 6.0- to 9.9-inch crappies consumed large quantities of midge larvae, cladocerans, and copepods which together totaled over 45 per cent of the diet. Golden shiners were the most important single item in the diet with threadfin shad again important. The results may be biased, since fishing pressure for crappies was extremely heavy at this time and golden shiners were used extensively for bait. During the remainder of the year, threadfin shad dominated the diet constituting 57 per cent numerically and 93 per cent volumetrically of the total diet. Largemouth bass were also eaten. A few chironomid larvae were eaten but they became less important as the year progressed. The author felt that threadfin shad do not provide adequate forage for yearling crappies in areas where shad have a single, short spawning period.

Goodson, L. F. 1966. Crappie. In: Inland Fisheries Management. Cal. Dept. Fish and Game: 312-332.

Crappies may be underutilized by anglers. Liberalized angling regulations such as no closed season and no limits could help correct this situation as well as increase recreational opportunity.

In general, both crappies are most readily caught during the spring, but there is no indication of any significant seasonal catchability between species. However, night fishing can increase the catch of black and white crappies. At Lake Havasu in February, 1958, 1,009 day anglers caught only 311 black crappies, while 314 night anglers took 1,569 crappies.

Crappies frequently overpopulate waters and become stunted. Some fishery workers think this is because crappie populations are frequently dominated by a single year class. At any rate, it makes consideration of ecological factors influencing growth and population size particularly important.

In 1951, white crappies were planted in four reservoirs. By 1959 white crappies in two of the reservoirs had overpopulated. Over 80 per cent of the sport fish in both waters were crappies under 8 inches long. Wahlford Reservoir, a 220-acre reservoir in southern California initially maintained good crappie fishing but the population is now stunted. Unauthorized introduction of black crappies into four southern California lakes ranging from 2,600 acres to 22 acres have resulted in severely stunted populations. One of these reservoirs has had a stunted population of black crappies since the early 1940's.

Every California water containing a stunted crappie population has one thing in common, a paucity of small forage fish. In waters where slow growing crappie populations exist, a forage fish such as threadfin shad should be introduced with due regard to all implications of such an introduction. Information available for five reservoirs that had histories of stunted crappie populations indicated increased crappie growth rates and population size after threadfin shad were introduced. Black or white crappies and threadfin shad should be planted only in lakes or reservoirs containing extensive deep, open areas that contain cover in the form of aquatic plants, submerged trees, or brush. Cover appears to be more a necessity than an enhancement for a crappie fishery.

Extensive spring die-offs of adult crappies have occurred in several areas throughout the State. In 1964 large numbers of dead crappies were reported from 3 reservoirs. An estimated 21,000 white crappies (8- to 11-inch) died at one reservoir. Although the cause of these deaths has not been determined, they may represent natural mortality of old fish during and following spawning period. Extreme water drawdown also appears to be detrimental to some crappie populations. Extremely low water levels were recorded in three reservoirs prior to the development of stunted crappie populations in each.

Of the California waters that contain both crappies, the black predominates in the clear waters while the white crappie is the only survivor in turbid reservoirs. Black crappies appear to tolerate cooler water. The relationship between black crappie and aquatic plants listed in other states does not seem to hold in California waters. In three reservoirs where there is a paucity of aquatic plants, black crappie predominate. These waters are clear, however, and turbidity may be a more important factor. Crappies in California generally follow a trend of black crappies predominating in waters with pH values less than 7.0 and white crappies dominating in waters with pH values over 7.0.

Crappie scales are evidently difficult to interpret. White and black crappie scales collected in 1963 from Pine Flat Lake could not be read. California crappies that have been aged grew more slowly than those in most out-of-state waters. This is particularly true at older ages.

Generally, crappies are considered predators which compete more with largemouth bass and smallmouth bass than with other panfish.

Grinstead, B. G. 1969. The vertical distribution of the white crappie in the Buncombe Creek arm of Lake Texoma. Okla. Fish. Res. Lab., Bull. 3: 37.

White crappies over 10 inches total length occurred at an average depth greater than did the smaller fish, but the smaller white crappies were taken in open water more commonly than near the shoreline while the large white crappies were more commonly taken near the shoreline.

The mean depth of capture of white crappies was deepest (25.79 feet) during the month of January and nearest the surface (16.91 feet) in April. In general the fish were distributed from the surface to the bottom more or less evenly during the fall (September, October, and November); were concentrated near the bottom in winter (December, January, and February); were nearer the surface and more widely distributed during the spring (March, April and May); and were found in a deeper distribution during the summer (June, July, and August).

Returns of tagged white crappies indicated that some individuals in the population move considerable distances (one individual was found to have moved a minimum distance of 22.8 miles) but the majority tend to remain in a somewhat limited area (73.1 per cent were recaptured within two miles of the release point).

There were no indications from data collected in this study of water temperature affecting the distributional patterns. However, white crappies did appear to be influenced by light penetration. Generally, they occurred at a greater depth when the turbidity was low and nearer the surface as turbidity increased.

Grinstead, B. G. No date. A report on Lake Humphreys fishery survey. Okla. Wildlife Consv. Dept.: 15.

Black and white crappies sampled in a heavily timbered, 880-acre, impoundment in Oklahoma were found to maintain growth comparable to the State average for this species (7.8 inches in three years). However, few large white crappies were observed during the survey with only 17 per cent of the recorded fish above the harvestable size of 8.0 inches. Only 2 per cent of the white crappies were larger than 10.0 inches.

Growth of black crappies for the first year class was above the state average but the growth fell off the second year. They exhibited faster growth than white crappies but their estimated population was somewhat lower. These data indicated a poor crappie fishery.

Hall, G. E., R. M. Jenkins, and J. C. Finnell. 1954. The influence of environmental conditions upon the growth of white crappie and black crappie in Oklahoma waters. Okla. Fish. Res. Lab., Rept. 40: 56.

Scales from 560 white crappies from 130 bodies of water and 2,406 black crappies from 83 bodies of water, captured by various means during the period 1946 - 1953, were employed in determing average rates of growth of these species under various environmental conditions in Oklahoma.

Of the total numbers of fish, 97 per cent of the white crappies and 98 per cent of the black crappies were less than five years old.

White crappies averaged 2.9 inches in total length at the end of the first year of life and during successive years averaged 5.9, 7.8, 9.8, 11.9, 13.2, 14.2, and 15.0 inches. Black crappies averaged 3.1 inches at the end of their first year of life, and at the ends of the next six succeeding years averaged 6.3, 8.2, 9.9, 11.6, 13.5, and 15.2 inches.

At equal lengths black crappies are slightly heavier than white crappies.

Time of annulus formation of white crappies appears to be from the middle of April to the first of May. Annulus formation was later in older crappies.

White crappies grew faster in ponds and small lakes after the first three years of life than in large lakes, whereas black crappies grew fastest in large reservoirs. Both species grew slowest in turbid lakes of the 110- to 500-acre class. Black crappies grew much faster in lakes with no white crappies, but the latter grew better where black crappies were present.

Other environmental factors, including age and turbidity of water, appeared to influence rate of growth of both species more than the water area. Growth rates were much faster in waters impounded less than four years than in older waters. The majority of poor-growing crappie populations were found in turbid waters, which drained postoak-blackjack forest watersheds. Above average growth occurred in all clear lakes over 1,000 surface acres, and in small ponds and lakes with very limited crappie populations.

Black crappies appeared to prefer clear-water habitats, since 82 per cent of the samples of this fish came from clear waters. White crappies were found more widely distributed in both clear and turbid waters, although better growth rates were attained in clear waters.

Satisfactory crappie fishing was dependent on proper environmental conditions - relatively clear, deep waters, and aggregating points such as brush shelters, submerged trees, and rocky bluffs, and an adequate forage fish food supply. Crappies must reach a length of 8 inches in three years, and 10 inches in four years, to provide good fishing. Crappie thinning operations must be used to raise the growth rate if they tend to remain below sizes desirable to fishermen.

Intraspecific competition probably contributes more to crappie stunting than does competition from other species.

Black crappies were less prone to overpopulate small lakes.

No creel limits should be imposed on crappie populations.

Hansen, D. F. 1951. Biology of the white crappie in Illinois. Ill. Nat. History Surv. Bull. 25(4): 209-265.

White crappies generally outnumber black crappies in artificial lakes of all sizes, although black crappies tended to be more common in the deep glacial lakes of northeastern Illinois. In the bottomland lakes preponderance of one species over the other varies from lake to lake.

White crappies required 2 to 3 years to reach sexual maturity. The smallest ripe female observed in Illinois measured 5.6 inches total length. Dark breeding coloration was found in most males of breeding size from April to June and was seen in one female. Ripe females (with mature eggs) were found in Illinois as early as May 6 and as late as July 13; ripe males as early as May 16 and as late as June 24. The height of the Illinois spawning season was probably late May or early June. It appeared that only a portion of the eggs in ripe females were laid and that perhaps a considerable number of unlaid eggs were absorbed.

Crappies seemed to show a preference for depositing their eggs on plant material, but they did not require aquatic plants for that purpose.

Hoop-net samples showed a predominance of males among young white crappies, a predominance of females among older white crappies. They showed a temporary scarcity of males in late spring and early summer. In year-round hoop-net catches, the poorest catches were made in the summer. Fishermen caught white crappies principally from March 1 to June 1.

Lymphocystis, the most common disease observed in white crappies, was found in 19.5 per cent of the white crappies in one locality.

Annual rings on the scales of white crappies were not invariably formed at the rate of one ring for each year of life and they were not formed at exactly the same time of year.

Size classes of white crappies caught in hoop-nets fluctuated strongly from year to year. Large sizes were abundant only in alternate years. Disappearance of large sizes is believed to have been due to summer mortality.

Crappie broods were generally short lived and were usually not conspicuous in net catches beyond the second or third year of life. One brood disappeared completely at age three; another brood at age four.

Annulus formation ranged from early May to late August.

Only small differences in growth rates of males and females were found among white crappies.

Hooper, A. D. and J. H. Crance. 1960. Use of rotenone in restoring balance to overcrowded fish populations in Alabama Lakes. Trans. Am. Fish. Soc. 89(4): 351-357.

Overcrowded crappie populations that either survived rotenone or were introduced by sportsmen have occurred in five of Alabama's 18 State-owned, public-fishing lakes ranging between 32 and 80 acres in size.

The year after treating one of these lakes with a series of six marginal poisonings, an overcrowded crappie population developed, apparently because a high proportion of fish (289 pounds per acre) was removed by angling. A second series of five marginal poisonings brought the lake into balance. Unfortunately, fishermen had introduced black crappies the following spring which caused low sunfish reproduction and insufficient food for young bass. An additional series of seven marginal poisonings was attempted but killed none of the 4- and 5-inch crappies which were in deep water at the time. However, seining the following year indicated the fish population had returned to balance. This may have been brought about by predation on intermediate-sized sunfish and crappies by bass. The balanced condition lasted for two years but seining then indicated the lake was again over-populated with crappies and harvest by anglers decreased abruptly.

A similar problem occurred on another unbalanced lake which had also been stocked with crappies by uninformed sportsmen. Again, marginal poisoning failed to kill enough crappies to restore a balanced population.

Crappies apparently augment crowding in bass, bluegill, redear sunfish populations and cause management problems that cannot be readily corrected by partial poisoning.

Jackson, S. W., Jr. 1956. Rotenone survey of Black Hollow on Lower Spavinaw Lake, November, 1953. Proc. Okla. Acad. Sci. 35: 10-14.

A 1,637 acre reservoir in Oklahoma was drawn down 8 feet during the winter of 1951 - 52, raised back to normal in the spring of 1952, and again lowered in 1953 for a more prolonged period.

During a rotenone sample in mid-November the white crappie recovery was much less than anticipated, evidently because they had moved to deeper water.

White crappie growth was fair in 1951, good in 1952, but then practically ceased during 1953, suggesting that the prolonged drawdown caused poor crappie growth. Calculated total lengths in inches at the end of year for 27 white crappies were 2.0, 7.0 and 8.0 for age groups I, II and III respectively.

Jenkins, R. M. 1955. The effect of gizzard shad on the fish population of a small Oklahoma lake. Trans. Am. Fish Soc. 85: 58-74.

Estimates of the standing crop of crappies were collected from two small Oklahoma lakes (29 and 16 acres). One lake contained a large population of gizzard shad, the other had no shad.

It was believed that gizzard shad had a depressing effect upon the growth and condition of crappies, but that they promoted the existence of larger numbers of these fishes. Although fast growth rendered shad unavailable as forage after the first summer of life, the large number of 2- to 6-year-olds evidently competed directly with other species for food.

A relationship between shad and white crappies was indicated by the large population of the latter species in the lake containing shad verses small numbers of crappies in the lake without shad.

Black crappies produced more catchable-size individuals and were in better condition in both lakes than white crappies, and should provide the better fishing in small lakes with proper habitat conditions.

Jenkins, R. M. 1955. Expansion of the crappie population in Ardmore City Lake following a drastic reduction in numbers. Proc. Okla. Acad. of Sci. 36: 70-76.

An estimated 27 black crappies and 23 white crappies remained in a 184-acre Oklahoma Lake following rotenone treatment in September, 1953. Their approximate potential combined production in 1954 was an estimated 390,000 offspring. Population estimates indicated that 136,000 black crappies and 64,000 white crappies were in the lake after one complete year of growth.

The combined estimated population of 200,000 crappies produced by a population of only 50 adults demonstrates the fecundity of these two species, and emphatically underlines the inanity of stocking crappies in lakes where they are already present.

Jenkins, R. M. 1958. The standing crop of fish in Oklahoma ponds. Proc. Okla. Acad. Sci. 38: 158-172.

A total of 42 ponds treated with rotenone were used in the study. They varied in size from 0.16 to 9.51 acres, averaging 2.05 acres. Most were clear (less than 2.5 ppm turbidity).

The average standing crop of white and black crappies combined was 63 pounds per acre, ranging from a trace to 222 pounds per acre.

The average standing crop for white crappies was 72 pounds per acre with a maximum of 205 pounds per acre. Eleven pounds per acre or 15 per cent of the total number of white crappies collected were of a harvestable size (a minimum weight of 0.25 pounds). They represented 21 per cent of the total standing crop and occurred in 43 per cent of the ponds sampled.

The average standing crop for black crappies was 23 pounds per acre with a maximum of 69 pounds per acre. Seven pounds per acre or 30 per cent of the total number of black crappies collected were of a harvestable size. They represented 6 per cent of the total standing crop and occurred in 38 per cent of the 42 ponds sampled.

White crappies tended to become overcrowded and to grow slowly. Black crappies seemed to be slightly more desirable than white crappies but neither were recommended for ponds.

The presence of crappies had no measureable effect on largemouth bass crops. A decrease in black crappies in the presence of white crappies, and no appreciable effect of black bullheads on crappies were also noted.

White crappies were represented by an adequate number of harvestable-size fish in only 2 ponds out of 18, and black crappies in only 3 out of 16. They are not, therefore, desirable species for waters under 10 acres in size, and their introduction into ponds should be discouraged.

Kemmerer, A. J. 1967. Investigation of factors limiting population growth of crappie. Ariz. Game and Fish Dept., Proj. F-14-R-1, Work Plan 1, Job 1: 20.

Electrofishing, fyke nets, trammel nets, gill nets, rotenone, and hook and line methods were used to sample crappies during 1966, 1967 in Roosevelt Lake, Arizona. No crappies were collected with gill nets or rotenone. The most crappie ever taken in one fyke net was three even after baiting, attaching lights, making both shallow and deep sets, and changing lengths of lead. Best catches were obtained in fyke nets with 100 foot leads set on sandy or rocky bottoms, at depths less than 10 feet with the lead tied to shore. Trammel nets were only partially successful. Electrofishing with a 220 volt A.C. generator was one of the best methods used, however, more crappies were taken by angling than by any other method. Few crappies were collected during the summer.

All crappies collected were black although white crappies were considered abundant from 1958 to 1960.

Aging and back calculations using the scale method indicated that scales taken from below the lateral line expressed a better relationship of anterior scale radius to fish size than scales from above the lateral line. False annuli, determined by non-continuous cutting over around the scale, appeared on a large number of scales.

Average calculated total lengths at each annulus of 79 black crappies collected in November for age groups I, II, III and IV were 8.6, 10.8, 13.7 and 14.9 inches total length, respectively. Small crappies less than 4 inches total length seen in December indicated that fish previously assigned to age group I must be two or more years old.

The diet of 100 crappies indicated that threadfin shad were the most important food item and apparently smaller shad were being selected.

Chironomidae larva and pupae were the second most important food. The data was insufficient to substantiate previous authors suggestions that crappie may shift from a fish to an insect diet during the breeding season.

Spawning in 1966 was over by May. Enlargement of gonads began in late summer and fish were ripe by February. Data suggested that males were ready to spawn before the females.

LaFaunce, D. A. 1960. Comparison of some aspects of white crappie, Pomoxis annularis, and black crappie, Pomoxis nigromaculatus, life histories. Cal. Dept. Fish and Game, Inland Fish. Ad. Rept. 60-9: 13.

Black crappies supported a good springtime fishery at Lake Havasu (25,000-acres), but produced little fishing at other times of the year. Fishing was concentrated at night.

In general, white crappies grew faster than black crappies and attained a greater size. However, the maximum size attained by the two species is almost the same. The California record for each species is four pounds. The world's record white crappie listed in Field and Stream weighed 5 pounds, 3 ounces, while the world's record black crappie weighed an even 5 pounds.

Stunted populations of both species were common in California. Black crappies in a 1,900 acre reservoir attained a mean length of only 6.6 inches after four growing seasons. White crappies in an 1,800 acre reservoir were 7.4 inches in length at the end of three years. This growth was not rapid enough to produce adequate numbers of desirable-sized fish for the angler. Except for Clear Lake (45,118 acres) where black crappies had excellent growth, and Lake Havasu where crappie growth was adequate, most California crappies show growth below the desirable rate of 8 inches in three years, and 10 inches in four years.

At Big Bear Lake (2,600-acres), prior to rotenoning in 1956, a large stunted population of black crappies existed despite a harvest higher than the catch of 80,000 trout. After a chemical treatment, rainbow trout grew as much in one month as they had previously grown in an entire season. Lack of an adequate supply of small forage fish undoubtedly contributed to the stunting.

Crappies generally do not live long. Black crappies of age group 5 were the oldest collected at Clear Lake and Lake Havasu.

When spawning, white crappies appeared to be more secretive than black crappies and apparently spawn in deeper water.

High production of eggs probably contributes to the problem of crappie stunting. The numbers of eggs per unit of body weight is reported to be higher for crappies than for other centrarchids.

The evidence for competition between crappies and other species is rather vague. Largemouth bass declined in East Park Reservoir (1,800 acres) after white crappies were introduced and crappie growth has been slow in this widely fluctuating reservoir. A heavy dieoff of large bass was observed after the reservoir was drawn down to a very small volume in 1958. The crappies perhaps were better able to adjust to the environment than the bass. A stunted population of black crappies existed in highly fluctuating Salt Springs Valley Reservoir, where the bass population was relatively low. On the other hand, a good largemouth bass fishery existed in Lake Havasu, in the presence of an apparently large black crappie population. The presence of a large population of threadfin shad, probably reduced the competition between bass and crappies.

The temperature requirements for the two species were about the same.

Apparent seasonal differences in the catch may be due more to climate and its effect on the angler than any response of the fish to differences.

It was evident that without proper environmental conditions, such as cover and an abundant forage fish supply, neither species of crappies will produce a desirable fishery. In addition, it was necessary that both species be heavily cropped.

Many of the assumed differences between black crappies and white crappies are subjective rather than objective. There are more similarities than differences between the two species. The major differences seemed to be the white crappie's greater tolerance of turbid waters and a tendency for them to become dominant over black crappie despite somewhat inconclusive evidence of greater egg production by black crappies. There is evidence that crappies often become the dominant carnivore in reservoirs.

Lambou, V. W. 1958. Growth rate of young-of-the-year largemouth bass, black crappie, and white crappie in some Louisiana lakes. Proc. La. Acad. Sci. 21: 63-69.

Regression analysis of growth rates for young-of-the-year black and white crappies showed that black crappies grew .009 ± .003 inches per day and white crappies grew .009 ± .005 inches per day. No further increase in length could be demonstrated after October. Young black and white crappies probably reach 3 inches total length during their first growing season.

Lea, R. N. 1967. Observations on the food habits of adult black crappie in a California Lake. Ichthyolica/Aquarium J., 39(2): 93-94.

The stomach contents of 31 adult black crappies measuring between 6.1 and 10.2 inches total length and collected during late March and early April showed that 95 per cent by weight of all food taken was composed of Entomostraca (_Daphnia_ sp., 90 per cent; _Diaptomus_, 5 per cent) and occurred in 21 out of 24 full stomachs. Chironomid pupae, the only insect found in the stomachs, composed 4.3 per cent of the total stomach contents by weight and was found in 17 stomachs. Chironomid larvae composed 0.1 per cent of the total stomach content mass by weight, and the amphipod Hyalella azteca composed 0.2 per cent of the total weight. Plant material found in 4 stomachs was probably ingested inadvertently. These data may be significant in that other food-habit studies of black crappies, made in their native range, indicate a similar preference for entomostraca and immature insects.

Mathur, D. and T. W. Robbins. 1971. Food Habits and Feeding Chronology of young White Crappie, Pomoxis annularis Rafinesque, in Conowingo Reservoir. Trans. Am. Fish. Soc. 100(2): 307-311.

In Conowingo Reservoir (9,000 acres) most of the food consumed by young white crappies over one 24-hour period was eaten during daylight hours, mainly during the morning and early afternoon. The maximum number of organisms occurred during mid-afternoon. Daphnia spp. and Cyclops spp. were the most important food items. The consumption of these items changed significantly over the 24-hour period of study. It was estimated that the food items eaten by young white crappies passed through the stomach in 14 to 17 hours.

Seasonal food studies inciated that Daphnia spp. were important in the diet in June through October. Cyclops spp. were important in September through April. Chironomid larvae and pupae were most eaten in April and May, Bosmina sp., Leptodora sp., Alona sp., Diaptomus sp., amphipods, mayfly nymphs, and algae were also eaten seasonally in small quantities. The diet was more varied in late fall, winter, and early spring months than in the summer. Feeding activity was highest in May through October.

McConnell, W. J. and J. H. Gerdes. 1964. Threadfin shad, Dorosoma petenense, as food of yearling centrarchids. Cal. Fish. and Game, 50(3): 170-175.

During a 3-year study, stomachs of 100 black crappies between 3.5

inches and 7.9 inches total length revealed that occurrence of threadfin shad never exceeded 13 per cent per stomach. Although important in total volume of food consumed, shad were out-ranked by arthropods in the diets of both centrarchids in 1960 and 1961. In volume, threadfin shad averaged 17 per cent of the crappies diet during these years. Arthropods, mainly cladocerans and insects, made up the remainder of the diet. Rapid growth of threadfin shad after one short spawning period in late spring was postulated as a probable reason for their infrequent use as food by yearling crappies. Failure of the shad to produce a year-class in 1961 was also important.

Morgan, G. D. 1951. A comparative study of the spawning periods of the bluegills, Lepomis macrochirus, the black crappie, Pomoxis nigromaculatus (LeSever), and the white crappie, Pomoxis annularis (Rafinesque), of Buckeye Lake, Ohio. Jour. Sci. Lab. Denison Univ. 42, (art. 11-14): 112-118.

The spawning period for crappies can be determined by calculating a ratio obtained by dividing the weight of the ovaries into the body weight and then plotting the ratio on graph paper.

Black crappies began to spawn during late March and early April, and ended between June 1 and 5. Water temperatures during this time period varied from 40° F. in May to 60° F. in June.

Development of the ovaries in black crappies took place during the fall, and fish were ready to spawn early in the year with little further development.

White crappies began to spawn in late March and continued until July 20. Water temperatures varied between 40° F. in March to 80° F. in July. Generally, white crappies spawned later than black crappies. Development of the gonads in white crappies took place in the fall as in the black crappie.

Morgan, G. D. 1954. The life history of the white crappie (Pomoxis annularis) of Buckeye Lake, Ohio. Jour. Sci. Lab. Denison Univ. 43 (Art. 6, 7, 8): 113-144.

White crappies did not mature until they were two years old and some did not mature until they were three years old. The smallest ripe female observed in Buckeye Lake was 5.9 inches total length.

They spawned from later April to July, but the height of the spawning period was May and early June. The nests might by made on mud, sand, clay, gravel, or in vegetation.

The number of eggs produced varied from 1,908 in fishes 5.9 inches total length to 325,677 in fishes 13 inches total length. The incubation period varied between 24 and 27.5 hours at temperatures of 70° to 74° Fahrenheit. At hatching they were poorly developed and were capable of very little movement. The head was still attached to the yolk sac. The egg membrane at hatching dissolved into an elastic sticky mass to which the young larvae became stuck head on. The length of the larvae at hatching varied from 1.215 mm. to 1.98 mm. At 14 days the larvae measured 6 millimeters.

Annulus formation might occur from March to September. Young fishes appeared to form annuli early in the summer while older fishes formed annuli later in the summer.

Average yearly growth of both male and female was about the same. However, during the sixth and seventh years females grew faster than males.

The predominant food of white crappies 3 inches and smaller was gizzard shad, followed by midge pupae and Cladocera. During March, Copepods and Cladocera made up 100 per cent of the food in the stomachs. During May food consisted of Cladocera, midge pupae, and shad respectively. During June and July the number of midge pupae and Cladocera decreased. In August 89 per cent of the food eaten was Cladocera.

There was a close relationship between the creel census and net catches which indicated that white crappies were most active during March, April, May, June, September and October. During July and August when water temperatures ranged between 70 - 87° F., the creel census and test net catches were low and represented the most inactive periods of the summer. Net catches indicated the crappies were most active between 5:00 p.m. and 5:00 a.m.

Neal, R. A. 1963. Black and white crappies in Clear Lake, 1950-1961. Iowa St. Jour. of Sci., 37(4): 425-445.

Catches of crappies in 3,643-acre Clear Lake indicated a shift in populations from one predominantly black, from 1948 - 56, to one predominantly white in 1961.

Crappies made up approximately 28 per cent of the fish taken by anglers in the shallow eutrophic lake.

Gill nets were the main source of crappies over the entire period. The shocker and small seines took a higher percentage of adult black crappies. Experimental gill nets and the trawl appeared selective toward white crappies. Net catches indicated that black crappies preferred the shallow weedy areas while white crappies were more abundant in the open areas of the lake.

White crappie scales were read more easily than black crappie scales partly because the white crappies were not as old and partly because the annuli on black crappie scales were crowded and indistinct. Annulus formation by white crappies occurred as early as June 9, although some specimens had not yet formed an annulus by June 23. Annulus formation by black crappies occurred for one individual on June 6. Body-scale regressions indicated intercepts of 1.6 inches for white crappies and 1.7 inches for black crappies. There was little evidence of dominant year classes as is sometime the case with crappies. Population changes of other species of fish in the lake did not seem to be related to the crappie changes. Growth data on black crappies gave some indication of Lee's phenomenon but the white crappie data did not. In general, the periods of poor white crappie growth were periods of good black crappie growth and vice versa. No correlation could be demonstrated between mean air temperature, April to October, and the annual growth of black or white crappies as indicated by the Hile indexes, or between mean water levels and crappie growth.

Average white crappie condition factors varied little between years and did not show any apparent trends. Average black crappie condition factors showed a steady decline from 1951 to 1960 although they were heavier for their length than white crappies. An increase in the average condition factor of both black and white crappies that occurred between 1960 and 1961 may be related to an increase in the level of the lake of approximately 8 inches during the winter of 1960-61. Condition factors for white crappies dropped during late June through mid-July and a similar drop was found among black crappies during July though not as conclusive as in white crappies.

Low water levels appeared to cause higher turbidity levels which favored white crappie abundance. There was a good general relationship between periods of clear water and black crappie abundance. White crappie populations in Clear Lake seemed to replace the black crappies, in general, as the turbidity increased. Although turbidity is an important factor in feeding, food habits of the two crappie species appeared to be similar in Clear Lake. Turbidity may also have some effect on the spawning success of one or both species of crappies, but no obvious differences in spawning habits of crappies in Clear Lake were noted except that black crappies preferred shallower waters with much vegetation.

Nelson, W. R., R. E. Siefert, and D. V. Swedberg. 1967. Studies of the early life history of reservoir fishes. In: Reservoir Fishery Resources Symposium. Res. Comm. Southern Div., Am. Fish. Soc.: 374-385.

Back-calculation from length frequencies of young-of-the-year white crappies indicated that spawning occurred from mid-May to mid-July. White crappie eggs were adhesive and become attached to the nest bottom, to surrounding objects such as twigs and vegetation, and to each other. Minute particles of silt readily adhered to the egg wall but tolerance limits of eggs to foreign material are not known. Turbidity levels in excess of 350 ppm might cause significant mortalities.

Incubation periods ranged from 2 to 4 days, with shorter incubation occurring at warmer temperatures. After hatching, larvae remained in the nest for 2 - 4 days. Larvae were 4.1 to 4.6 mm long when they left the nest and no schooling of free-swimming fry was observed.

When white crappies reached a total length of 2.0 to 2.4 inches they left shallow waters and moved to deeper areas.

Stomach contents of young-of-the-year white crappies from 0.4 to 3.9 inches were compared with plankton abundance. Bottom fauna organisms were unimportant food items. Common zooplankton in the diet included Daphnia, Cyclops, Diaptomus, and Leptodora. Cyclops were selected most by fish up 1.2 inches long but became unimportant as growth progressed. The other three general increased in importance with fish growth; the order of priority was Daphnia, Diaptomus, and Leptodora.

Roach, L. S. and I. M. Evans. 1948. Growth of game and panfish in Ohio. Crappies. Ohio Div. of Consv., Fish Mgt. Rept., 3: 29.

Although crappies are a favored spring fish of many anglers, they are believed by some fish technicans to be competitors to other desirable species, particularly the black bass. Their spawning period is apparently restricted, but their production rate seems to be high and the rate of survival very great. Consequently, many lakes contain large populations of fish of retarded or slow growth, too small to be in great demand by fishermen.

Crappies in several Ohio lakes have shown a pronounced cyclic tendency. High numbers of white crappies generally coincided with low numbers of black crappies or vice versa. This occurred in spite of any apparent change in lake ecology or other measured factors. The situation was especially noticeable in small or medium-size lakes.

Average white crappie growth in liberalized fishing waters was consistently below the state average and was very erratic. Growth rates of white crappies in small lakes was even more erratic than in the liberalized fishing lakes but was usually above the state average. Lakes of medium size showed the best and most consistent rate of growth.

It seemed that white crappie growth was good where gizzard shad was numerous.

Schoffman, R. J. 1965. Age and rate of growth of the white crappie in Reelfoot Lake, Tennessee, for 1959 and 1964. Rept. Reelfoot Lake Biol. Sta. 24: 6-8.

The study of age and growth of white crappies in Reelfoot Lake, Tennessee, has extended over 25 years. The maximum growth rate was reached in 1948 followed by a slow decrease to the time of the present study. During this period changes in fishing regulations resulted in a decrease in the growth rate and an increase in the population. At the present time Reelfoot Lake is over populated with white crappies. Since the prohibition of commercial fishing, sportsmen have been catching more small white crappies each year.

The appearance of age group II in 1959 with its increase to 46 per cent of the specimens taken in 1964 showed that an overpopulation exists.

The author felt that the restriction of white crappie fishing to sport fishing was of no value unless there was a depletion of fish due to biological causes. Since this was not the case, he felt the restriction unnecessary. In 1950 he stated that, because of over population, sport fishing would not exist within 6 years if commercial fishing were stopped. This prediction of 1950 has become a reality in 1964.

Seaburg, K. G. and J. B. Moyle. 1964. Feeding habits, digestive rates, and growth of some Minnesota warmwater fishes. Trans. Am. Fish. Soc. 93(3): 269-285.

During 1956, information on food and feeding habits of black crappies was obtained from Maple Lake (875 acres) and Grove Lake (373 acres). Crappie were more abundant in Grove than in Maple.

In 1958 a population estimate in Grove Lake indicated there were 67 black crappies per acre over 7 inches in length; about eight times the angling catch of 8.8 per acre. It seems likely, therefore, that angling harvest was not great enough to appreciably affect growth rates and the average size of fish taken.

Growth increments between annulus formation and August 1 was 1.5 inches for Maple Lake and 1.0 for Grove. This growth difference was related to volume of food found in the stomachs. The younger and faster growing fish from Maple Lake contained more than twice as much food as the older and slower growing fish from the denser population of Grove Lake.

In Maple Lake the amount of food in crappie stomachs was related to the size of the fish with greater volumes of food present in larger-size fish. However, the increase in stomach volume was not directly proportionate to the increase in the weight of the fish. In Grove Lake the relationship between stomach volumes and fish length was not as marked, possibly due to greater competition for insect food items in the denser panfish population. Here, apparently, the larger fish were more pressed for food than the smaller fish.

Insect items in the stomachs consisted of Chaoborus, and Chironomus which were frequent in the stomachs after July 1. Fish remains consisted of bass, 25 per cent; sunfish and crappies, 33 per cent; and perch, 17 per cent. In Maple Lake, perch, bass, and minnows were found in crappie stomachs but in lesser amounts than in Grove Lake.

Insects were important in the diet of crappies in early summer but toward mid-summer more fish were consumed. Crustacea were utilized mostly in early and late summer. Small fish made up an important part of the diet of larger crappies.

The abundance and distribution of various organisms indicated that the bluegills and crappies may at times have been feeding at different depths and therefore were not actively competing for food.

The average volume of food in crappie stomachs decreased from morning to afternoon in Grove Lake. Although it appears that the crappies had fed primarily in the early morning hours, they are also known to be evening feeders in these lakes. It is generally recognized by fishermen that crappies bite most readily in early morning and at dusk.

Siefert, 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.

Males exhibited territorial behavior, swept the spawning sites and cared for eggs and prolarvae. A well-defined nest depression was not constructed. No substrate preference for nesting was apparent, but fish appeared to select areas near objects or bottom vegetation. Polygamy and multiple spawnings by an individual fish occurred. Up to 50 spawning acts were observed during one spawning run and the longest lasted 145 minutes. Each act lasted from 2 to 5 seconds with most lasting 4. Intervals between spawning acts ranged from 1/2 to 20 minutes. The periods of egg incubation ranged from 42 to 103 hours and most rapid hatching occurred at warmer temperatures. Highest egg mortality with correspondingly longer incubation periods occurred in nests when water temperatures were lowest. The average time between start of hatching and departure of broods from the nests was 95 hours.

Larvae absorbed the yolk sac when 4.5 to 4.6 mm long. Nauplii were the most important food item of larvae at the initiation of active feeding. As fish attained a size of 6.0 to 7.9 mm, a sharp increase in selection of Cyclops occurred, and Daphnia became a significant food item of fish 10.0 to 13.9 mm long. Observations suggest that low temperatures before and during the spawning season may affect year-class strength.

Spawning may be influenced more by photoperiod than by temperature.

Siefert, R. E. 1969. Biology of the White Crappie in Lewis and Clark Lake Bur. Sport Fish. and Wildl. Tech. Paper 22: 16.

White crappie, *Pomoxis annularis* (Rafinesque), in Lewis and Clark Lake spawned from May 27 to July 1, 1966; peak in spawning was from June 14 to 24. Little or no successful reproduction has occurred in the open areas of the reservoir since 1962, but reproduction has occurred in most protected areas. Length range of young-of-the-year reached a maximum (0.6 to 3.5 inches) during the last two weeks of August, and by late autumn fish up to 4.1 inches were captured. Zooplankton were the total diet of early stage larvae (0.2 to 0.6 inches long) and the most important food of larger young-of-the-year. Young fish fed mainly during daylight hours. Preferred diet of age I and older fish was zooplankton followed by insects, especially *Hexagenia*. White crappie growth after the first season of life appears related to the population density of *Hexagenia*.

Siefert, R. E. 1969. Characteristics for separation of white and black crappie larvae. Trans. Am. Fish. Soc., 98(2): 326-328.

White crappies were slightly longer (minimum total length 2.56 mm) than black crappies (minimum total length 2.32 mm) at hatching.

Reliable characteristics for distinguishing between white and black crappies longer than five millimeters were given as follows:

Total Length (mm)	Characteristics	White crappie	Black crappie
5.00 - 6.49	Postanal myomeres	19 or less	21 or more
6.00 - 16.00	Total myomeres	30, or less often 31	32
Greater than 16.00	Dorsal spiny rays	5 - 6	7

Postanal myomeres include all myomeres posterior to an imaginary vertical line drawn through the body at the posterior end of the anus. No distinguishing characteristics were found to separate the species at lengths less than 5 mm.

Spall, R. D. and R. C. Summerfelt. 1969. Host-parasite relations of certain endoparasitic helminths of the channel catfish and white crappie in an Oklahoma reservoir. Bull. Wildl. Disease Assoc. 5: 48-67.

Changes relating to age in white crappies were limited to the occurrence of *Posthodiplostomum minimum* where multiple generations of metacercariae

accumulate in older fish. These metacercariae occurred in significantly higher numbers in males. Otherwise the occurrence of parasitism did not differ significantly between the sexes. Observations on the pattern of seasonal variation in prevalence and degree of infection of Posthodiplostomum minimum in white crappies suggests that it may contribute to summer mortality of its host.

Stroud, R. H. 1948. Growth of the basses and black crappie in Norris Reservoir, Tennessee. Jour. Tenn. Acad. Sci., 23(1): 31-99.

A total of 698 black crappies were used in the age and growth study.

Black crappies averaged 2.5 inches at the end of the first year of life. They averaged 9.2, 11.5, 12.7, and 13.7 inches, successively, at the ends of the next four years of life.

Young crappies were readily sampled in moderately deep water.

The young tended to attain most of their season's growth in spring and early summer. Adults tended to grow at diminished rates in mid-summer, and more rapidly in spring and in late summer and early fall.

Swingle, H. S. and E. V. Smith. 1940. Experiments on the stocking of fish ponds. Trans. 5th N. A. Wildl. Conf.: 267-276.

When white crappies were stocked as a carnivorous fish with bluegills, both species became overpopulated. Evidently crappies did not exert enough pressure on the bluegills to prevent overpopulation and were not cannibalistic enough to prevent their own overpopulation.

Swingle, H. S. 1952. Farm pond investigations in Alabama. Jour. Wildl. Mgt. 16(3): 243-249.

Both species of crappie can be used as a supplemental species for the bass - bluegill stocking combination. Since small crappies (less than 4

sunnies) compete with bluegills, they are of doubtful value in small, shallow ponds.

Surber, E. W. 1949. Results of varying the ratio of largemouth black bass and bluegills in the stocking of experimental farm ponds. Trans. Am. Fish. Soc., 77: 141-151.

White crappies were stocked with bass and bluegills in two fertilized ponds (0.38 and 0.29 acres). The stocking rate used was 50 largemouth bass, 700 bluegill, and 300 white crappies per acre. Over a year later the ponds were drained. The crappies did not grow well and did not produce more harvestable fish than did a similar stocking of bass and bluegill.

Thompson, W. H., H. C. Ward, and J. F. McArthur. 1951. The age and growth of white crappie, Pomoxis annularis (Rafinesque) from four small Oklahoma lakes. Proc. Okla. Acad. Sci. 30 (1949): 94-101.

In Oklahoma, new artificial lakes have a period of unusually good crappie angling three or four years after impoundment which is followed by and indefinite period during which crappies of large sizes tend to disappear from the creel except for a week or so during the early spring. Smaller crappies may still be caught but most are not desirable to fishermen. Average calculated standard lengths for 201 white crappies at the end of the year from four 200-acre lakes for age groups I, II, III, IV, V and VI were 2.8, 4.3, 5.3, 6.1, 7.7, and 11.7 inches, respectively. These growth rates were considered slow. Average condition factors (K) for four lakes were 2.41, 2.40, 2.48 and 0.85. Since growth in length of some of these fish at end of the first two years of life had been more rapid than the average for the four lakes combined and because they still had a low condition factor (K) it was suggested that these fish had lost a substantial amount of weight. This phenomenon has been observed in other Oklahoma waters.

White crappies tended to dominate black crappies and in general seemed to be better adapted to Oklahoma waters than black crappies.

Viosca, P., Jr. 1952. Growth rates of black basses and crappie in an impoundment of northwestern Louisiana. Trans. Am. Fish. Soc., 82: 255-264.

Largemouth bass and black crappie populations were in best condition when their respective populations were at a minimum. In this deep basin, these two species were not in serious competition because their food selection was from a different size range. Bass foraged principally in the upper 10 feet of water, whereas crappies foraged mostly in the lower 10 feet.

A small number of fish-eaters developed among the crappies, producing two distinct size groups of the same age class. A sample of the smaller size class, the midge-eaters, averaged 1.2 ounces and had a mean condition factor of 46, whereas the larger but less numerous size class, the fish-eaters, averaged 6.9 ounces and had a mean condition factor of 64.

Whiteside, B. G. 1962. Biology of the white crappie, Pomoxis annularis in Lake Texoma, Oklahoma. M.S. Thesis, Okla. State Univ., 35 pp. (Unpublished).

Sexual maturity was reached in the second or third year of life and was probably correlated with size of the fish.

Dark breeding coloration in the males began to appear in the middle of March, reached a maximum intensity during the period of late March to early May and began to disappear by the end of May. By the end of June the males and females again looked alike.

Mature eggs varied in size from 0.82 to 0.92 mm (average 0.89) in diameter. Many fish were taken with partially spent ovaries containing both mature and immature eggs, indicating that only part of the eggs were laid in a single spawning act.

Shad and unidentified fish remains were the main food items in the stomachs during July through January. Dipterans, mayfly naiads, copepods and cladocerans were major food items during February through May. In June, shad and unidentified fish remains again were the most common food items.

Wilson, C., Jr. 1950. Age and Growth of the White Crappie in Lake Texoma, Oklahoma. Proc. Okla. Acad. Sci., 31 (1949): 28-38.

The age and growth of the white crappies in Lake Texoma, Oklahoma was studied using 868 fish collected in 1949.

Although net selectivity is important in evaluation of white crappie collections, it does not prevent adequate sampling.

The ratio of male to female white crappies taken was 9:11.

False annuli, although present, did not prevent age determination.

No significant difference was found in average calculated lengths or weights for each year of life between males and females.

Calculated growth to the end of each year of life indicated that white crappies grew to an average length of 3.8 inches the first year of life, 5.6 inches the second year, 7.3 inches the third year, 8.9 inches the fourth year, and 10.0 inches the fifth year.

Witt, A., Jr. 1952. Age and growth of the white crappie in Missouri. Ph. D. Thesis from Univ. of Missouri, 213 pp. (Unpublished)

This age and growth study of the white crappie was based on 3,515 specimens from the five major impoundments in Missouri. The number of specimens used from each of the impoundments were: 1,977 from the Niangua Arm of the Lake of the Ozarks, 522 from Lake Wappapello, 387 from Lake Taneycomo, 408 from Clearwater Lake, and 221 from Norfork Lake.

The length frequency distributions of the age groups of white crappies for each monthly collection showed that: (a) length frequency distributions could serve as a fairly reliable index of age for the first three age groups, especially if collections are made in the spring and fall. (b) the progressive growth of year classes during the three years of collecting could be followed as well as the monthly growth of age groups during the growing season.

Summary

Only six publications were found that specifically or in general discussed crappie populations in lakes of around 250 acres. Most data that dealt with crappie populations were collected on either small ponds (1 to 20 acres) or medium to large reservoirs (in excess of 1,000 acres). Other papers that presented data from medium-size lakes in the 200 - 250-acre category dealt with fish populations in general and mentioned crappie interactions only in a cursory way. Many of the reports summarized here dealt with crappies in large reservoirs, but they are included because they seem to contain the majority of the available life history data on crappies.

One trend that is mentioned throughout the literature is that crappie populations tend to become stunted. Stunted crappie situations have been reported from Alabama, California, Kentucky, Iowa, Ohio, Oklahoma and Tennessee. The usual trend for crappies stocked in a new lake is best described by Thompson, et al. (1951) when he stated "in Oklahoma, new artificial lakes have a period of unusually good crappie angling three or four years after impoundment which is followed by an indefinite period during which crappie of large sizes tend to disappear from the creel except for a week or so during the early spring. Smaller crappie may still be caught but most are not desirable to fishermen."

Goodson (1966) reported crappies frequently overpopulate in California waters and become stunted. He listed several lakes and reservoirs that contained stunted crappie, some having such populations for over 20 years duration. One 220-acre reservoir that initially maintained good crappie fishing now has a stunted population. Hooper and Crance (1960), in reporting on overcrowded fish populations in Alabama lakes, found that crappies had contributed to this condition in 3 of 5 lakes.

Apparently, both species of crappies tend to overpopulate. LaFaunce (1960), reported stunted populations of both species were common, both in California and elsewhere. Black crappies in a 1,900-acre reservoir only attained a mean length of 6.6 inches after four growing seasons. White crappies in a 1,800 acre reservoir were 7.4 inches in length at the end of three years.

It appears that when large populations of crappies are below 8 inches in length, they are considered stunted. This length evidently represents a size that is not desired by fishermen. Hall, et al. (1954) stated that crappies must reach a length of 8 inches in three years, and 10 inches in four years, to provide good fishing. Most states have set size limits of 8-inches for crappies which would seem to compound the problem of over-population. It seems reasonable to accept Hall's criteria for good fishing to decide if a crappie population is out of balance.

Many proposals have been made as to why crappies are prone to over-populate, the most common being over-production of young with a corresponding lack of small forage fish. Bennett, (1944) felt that stunting of crappies was caused by a shortage of forage fish for crappie less than seven inches in length. LaFaunce (1960) reported that a lack of an adequate supply of small forage fish undoubtedly caused crappies to stunt. Goodson (1966) mentioned that all California waters containing stunted crappie populations has one thing in common - a paucity of small forage fish.

paucity

Stunting of crappies is not noticeable until after the first year of life (Crawley, 1954). Evidence seems to show that the quality of the diet rather than the quantity was responsible for growth made. He could find no reason for stunting of crappies on the basis of volume of food eaten. Stunted crappies contained greater food volumes per pound of body weight than crappies from lakes in which growth was better. The differences in rate of growth between fast-growing and stunted crappies appeared to be the result of the availability of useable food and its nutritive value and not the result of either crowding or heredity.

Space, or size of impoundment also appears to be a factor that causes crappies to overpopulate. Roach and Evans (1948), in Ohio, reported that average growth of white crappies from large lakes was consistently greater than the state average, but growth in small and medium-size lakes was more erratic. Swingle (1952) did not recommend crappies be stocked in small, shallow ponds with bass and bluegill. Jenkins (1958) recommended that crappies not be stocked in ponds. Most stunted crappie populations listed by Goodson (1966) were from small lakes and reservoirs while all balanced populations he listed occurred in large reservoirs. LaFaunce (1960), mentioned that crappies are not considered good pond fish but usually did better in large bodies of water. However, Hall, et al. (1954) stated that environmental factors other than size of the water appeared to influence the growth rate of both species. They also felt it was highly probable that intraspectific competition contributes more to crappie stunting than does competition from other species. Some fishery workers think crappies became stunted because they frequently produce a single large year-class that dominates the entire fish population, crappies as well as other fish species (Goodson, 1966).

Interspecific competition also affects crappie populations. Swingle (1940) found that when white crappies were stocked as a carnivorous fish with bluegills, both species became overpopulated. Evidently, crappies did not exert enough predation on the bluegills to prevent overpopulation and were not cannibalistic enough to prevent their own overpopulation. He also felt that small crappies compete with bluegills. Surber (1949) found that two fertilized ponds stocked with largemouth bass, bluegills, and white crappies did not produce more harvestable fish than did a similar stocking of only bass and bluegills, nor did the crappies grow well. Crappies were found to augment crowding in bluegill - redear sunfish populations and cause management problems that cannot be readily corrected by partial poisoning (Hooper and Crance, 1960).

Schoffman (1965) has recorded a steady decrease in length and weight of white crappies in Reelfoot Lake, Tennessee since 1941, apparently as a result of a reduced harvest by sport and commercial fishermen. In the early years, various creel limits on crappies were imposed but a restricted commercial harvest was allowed. In later years, the creel limits were gradually lifted but the commercial harvest was gradually restricted and finally abolished in 1955. At the present time the lake is overpopulated with white crappie. California recommends that liberalized angling regulations such as no closed seasons, no limits, and night fishing would help keep crappies from overpopulating (Goodson, 1966). LaFaunce (1960) also felt that both crappie species should be heavily cropped to produce good fishing. Both authors mentioned that night fishing was found to greatly increase the catch of black and white crappies. In California, Goodson (1966) felt that low summer temperatures (in mountain lakes) resulted in a short growing season and might be instrumental in causing overpopulation of crappies. Hall et al. (1954) felt that satisfactory crappie fishing was dependent on proper environmental conditions - relatively clear, deep waters, aggregating points such as brush shelters, submerged trees, and rocky bluffs, and an adequate forage fish food supply.

High production of eggs contributes to the problem of crappie stunting. The numbers of eggs per unit of body weight is reported to be higher for crappies than for other centrarchids (LaFrance 1960). Comparable fecundity figures for the two species are limited and evidence is inconclusive as to which species is more prolific, although Goodson (1966) believes that black crappies are. An example of the high reproductive rate of crappies is presented by Jenkins (1955). He found an estimated population of 200,500 crappies had been produced from only 50 adults during one reproductive season.

The literature shows that because of the high fecundity of crappies and their ability to shift to other food chains, they apparently tend to control whole fish populations. However, Neal (1963) stated that population changes of other species of fish did not seem to be related to the crappie changes. It seems since crappies are generally prone to overpopulate, especially under conditions of inadequate forage of the right size, that this in itself would tend to limit reproduction, survival, and growth of other fish species.

Most papers from 1950 to late 1960 dealt with interspecific competition between the two crappie species rather than crappie competition with other fishes. White and black crappie populations evidently show a pronounced cyclic tendency. Roach and Evans (1948) in several Ohio lakes found that an upswing in abundance of white crappies generally coincided with a downswing of black crappies or vice versa. This seemed to occur in spite of any apparent changes in lake ecology or other measured factors. This situation was especially noticeable in small or medium-sized lakes. Bennett (1962) quoting data taken earlier, discussed a crappie cycle that seemed to alternate approximately every 4 years. High numbers of white crappies alternated with high numbers of black crappies.

Several other papers showed a complete dominance of white crappies over black crappies when they were found together. Thompson, et al. (1951) stated that white crappies tended to dominate black crappies and in general seemed to be better adapted to Oklahoma waters than black crappies. Jenkins, (1958), found a decrease in black crappies in the presence of white crappie. Neal (1963), recorded a shift in the composition of the crappie population from one predominantly black (1948 to 1956) to one predominantly white in 1961. During this study, he found that black crappies preferred the shallow weedy areas whereas white crappies were more abundant in the open areas of the lake. He also concluded that white crappies seemed to replace black crappies as turbidity levels increased. Goodson (1966) reported that the relationship between black crappies and aquatic plants as listed in other states does not seem to hold in California waters. Hansen, (1951), found that although the white crappie generally outnumbered the black in artificial lakes of all sizes in Illinois, the black crappie tended to be more common in deep glacial lakes. In California where all crappies present have been introduced, the black predominated in clear waters while the white crappie was the only survivor in the turbid reservoirs (Goodson, 1966). Black crappies apparently also tolerate cooler water and predominate in waters with pH values less than 7.0. White crappies predominate in waters with pH values over 7.0. A reverse of the trend of white crappies replacing black crappies was recorded in Arizona in a clear brushy impoundment (Kemmerer, 1967) where only blacks were present but earlier studies indicated that white crappies were abundant.

Black crappies appeared to be the most desired species as long as turbidity levels remained low and aquatic plant growth was abundant. Roach and Evans (1948), reported that black crappies showed the best and most consistent growth rates in medium-size lakes. Hall et. al., (1954) stated that, generally, at equal lengths black crappies were slightly heavier than white crappies. They were less prone to overpopulate small lakes and they appeared to prefer clear-water habitats. In 1955, Jenkins found that black crappies produced more catchable-size individuals and were in better condition than white crappies in two small lakes, one with large numbers of sha present, the other with no shad. Jenkins, (1958), in calculating ave age standing crops of white and black crappies in Oklahoma ponds, felt that black cranpie seemed to be slightly more desirable than white crappie.

Water level fluctuations have been mentioned by several authors as a factor that effect crappie populations. Jackson, (1956) found that a prolonged drawdown of a 1,637-acre reservoir was not conductive to desirable crappie growth in Oklahoma. In Iowa, low water levels appeared to cause higher turbidity levels which favored white crappie abundance (Neal, 1963). Goodson (1966) listed three reservoirs in California that had developed stunted crappie populations after extremely low water levels. Fluctuating water levels caused poor spawning conditions for black crappies in Arizona and were listed as one of the more important factors influencing population levels of crappies (Ercole, 1968 and 1969). However, Bartholomew (1966) felt that crappie growth seemed to be independent of annual water volume fluctuations.

There is some evidence of natural die-offs of complete year-classes of crappies that may be caused by old age or from poor summer condition from which they fail to recover (Bennett, 1962). Goodson (1966) reported extensive spring die-offs of adult crappies in several areas in California. An estimated 21,000 white crappies (8- to 11-inch) died at one reservoir. Although the cause of these deaths was not determined, it was suggested that it may have been natural mortality of old fish during and following the spawning period. Spall and ...erfelt (1969) suggested that infections of an endoparasitic helminth, Posthodiplostomum minimum, may contribute to summer mortality of white crappie.

Crappie fishing is known to be seasonal with high catches usually occurring only in the spring. Hansen, (1951), reported that fishermen caught white crappies principally from March 1 to June 1 in Illinois. Goodson, (1966) stated that generally both species of crappie were most readily caught during the spring in California. LaFaunce, (1960), found that black crappies supported a good springtime fishery at Lake Havasu, California (25,000-acres) but produce little fishing at other times of the year. However, he felt that apparent seasonal differences in the catch might be due more to climate and its effect on the angler than to any response of the fish.

Only one case of over-harvest of crappies by fishermen was found in the literature. Bennett (1945) reported that only 22 black crappies remained in a 2-acre pond after 4 years of intensive fishing. Only seven crappies were large enough to interest fishermen. Apparently crappies are difficult for fishermen to over-harvest or they can recover quickly through high reproduction and survival.

Seaburg and Moyle (1964) felt that the angling harvest for black crappies in a 373-acre lake in Minnesota was not great enough to appreciably affect growth rates and the average size of crappies taken.

In Iowa, Cleary (1957) determined that both species of crappie increased in growth after intraspecific competition was lessened by removal of part of the population by netting. Carter (1963), while attempting to use hoop nets and gill nets to remove crappies from 1,000-acre Dewey Lake in Kentucky, found the total harvest to be below that considered necessary to significantly reduce competition within the population. In the same lake, Charles (1967), used a series of drawdowns in the hope of thinning out intermediate-size crappies. He found that the principal fish species below the dam were small crappies.

Crappies generally do not live long. Most reports list 4 years to be the average life span with a few individuals present that attain 8 years of age.

Crappie scales are sometimes hard to read. Hansen (1951) found that annual rings on white crappie scales are not invariably formed at the rate of one per year and are not formed at exactly the same time of year. Some specimens failed to grow at all during two different years. Kemmerer (1967) found that false annuli appeared on a large number of scales. White crappie scales are more easily read than black crappie scales (Neal, 1963). Viosca (1952), found that two distinct size groups of black crappies developed in the same age class (young-of-year), caused by some crappies becoming fish-eaters while the majority fed on midges.

Annulus formation, as reported by most authors, usually occurred from May to early June. Hansen (1951) in Illinois found that annulus formation occurred from early May to late August. Morgan (1954) found annulus formation in white crappies to last from March to September with young fishes forming annuli earlier than the older crappies.

Stroud (1948) reported that young black crappies tended to attain most of their season's growth in spring and early summer while the adults tended to grow at diminished rates in mid-summer and more rapidly in spring, late summer, and early fall.

Hansen (1951) noted only small differences in growth rates between male and female white crappies. No significant difference was found in average calculated length for each year of life or in calculated weights between male and female white crappies (Wilson, 1950). Witt (1952) noted a differential growth rate between sexes of white crappies, attributal to sexual development of the female but this difference was small and did not necessitate treating the sexes separately.

Witt, (1952) found that monthly length-frequency distributions of white crappies could be used as a fairly reliable index of age for the first three age groups, especially if collections were made in the spring and fall and the progressive growth of year classes could be followed.

There was no mention of hybrid crappies in the literature reviewed.

Gizzard or threadfin shad appear to provide the best forage and the most desired food for crappies. Bartholomew (1966) found that white crappie growth increased after the introduction of threadfin shad, especially for crappies in their second and third years of growth. However, these high growth rates occurred in the presence of a substantial winter carry over of threadfin which would not occur in Missouri. Roach and Evans (1948) reported that white crappie growth was good where gizzard shad were numerous. The introduction of threadfin shad in California increased crappie growth rates and population sizes after histories of stunted crappies in five reservoirs (Goodson, 1966). However, Goodson (1965) indicated that threadfin shad did not provide adequate forage for yearling centrarchids (including crappies) in areas where shad have a single, short spawning period.

Gizzard shad and threadfin shad also cause problems of their own due to their high reproductive capabilities. Because gizzard shad attain a size that makes them unavailable to most predators, they tend to overpopulate and may end up surpressing the predator species for which they were originally stocked. Jenkins (1955) found that gizzard shad had a depressing effect upon the growth and condition of crappies but that they promoted larger numbers of crappies. Some relationship between shad white crappies was indicated by a large population of the latter species in a lake containing shad, versus small numbers of white crappies in a lake without shad. Rapid growth of threadfin shad after one short spawning period in late spring was postulated by McConnell and Gerdes (1964) as a probable reason for their infrequent use as food by yearling black crappies. Failure of the shad to produce a year-class in 1961 was also important.

There may be a feeding difference between crappie species. Apparently, black crappies are more active than white crappies during the night and dusk periods while whites are more active during the dawn period (Childers and Shoemaker, 1953). The feeding activity of both species was more intense at dawn and dusk. The most striking difference between black and white crappie feeding time was during the dam when the whites fed about 8 times as much as the blacks, though this was also the period of lowest feeding intensity for the white crappies. This might explain why white crappies become dominant over black crappies in turbid waters. Low light intensity could allow some feeding activity for sight feeders during daylight hours only but little chance for nighttime feeding. Ercole (1969) also found evidence that most of the foraging by black crappies was done at night or in early morning. Siefert (1969) noted that young white crappies fed mainly during daylight hours, primarily on zooplankton.

Although large crappies feed primarily on fish, they apparently have the ability to switch to other item when forage fish become scarce. This probably enhances their survival even in the face of overpopulation and decreased growth. Lea, (1967) found that black crappies measuring between 6.1 and 10.2 inches total length showed a preference for entomostraca and immature insects. Siefert (1969) noted the preferred diet of Age I and older white crappies was zooplankton, followed by insect material, especially Hexagenia. White crappie growth after the first season of life appeared related to the population density of Hexagenia. Other studies found that adult crappies utilize insects periodically, mainly in spring and early summer.

Although LaFaunce (1960) concluded that the introduction of white crappies into a California reservoir should have little effect upon the largemouth bass fishery, evidence in the literature suggest there may be competition between the two species. Bennett, (1944) felt that crappies compete with bass by limiting survival of the young bass, while the young crappies in some way escape serious predation. Hooper and Crance (1960) found that an unauthorized introduction of black crappies into a balanced lake had caused sunfish reproduction to cease and insufficient food for young bass. This corresponded with the removal of large numbers of fish by angling. LaFaunce (1960) discussed a decline in largemouth bass in a 1,800-acre reservoir after white crappies were introduced. In California, crappies are generally considered predators which compete more with largemouth bass than with other panfish (Goodson, 1966). In 1965, Goodson reported that crappies had fed on largemouth bass. Seaburg and Moyle (1964) found, in a 373-acre lake without shad that black crappie stomachs contained 33 per cent sunfish and crappies, 25 per cent largemouth bass, and 17 per cent yellow perch. Ercole, 1969, reported that crappies less than 3.5 inches in length consumed a significant quantity of largemouth bass fry (63 per cent of the total food volume). In 1969 he found that, for crappies less than 3.9 inches in length, bass fry rather than threadfin shad were the most important food. On the other hand Jenkins (1958) felt that the presence of crappies had no measurable effect on largemouth bass crops. Viosca (1952) found that in a deep lake, largemouth bass and black crappies were not in serious competition because their food selection was from different levels. Bass foraged in the upper 10 feet and crappies in the lower 10 feet.

Discussion

Pony Express Lake meets practically all the requirements for good crappie fishing listed by Hall et al. (1954), i.e. relatively clear deep waters'.

aggregating points such as brush shelters, submerged trees, and rocky bluffs, and an adequate fish food supply. There are no rocky bluffs, but there are areas where the shoreline is steep and submerged trees are present in these steep areas. The main problem will be an adequate fish food supply. It appears that only shad, either threadfin or gizzard, can provide this forage supply. However, careful consideration should be made before shad are stocked. This could place the crappies and largemouth bass in direct competition for shad, probably to the detriment of the bass, and take predatory pressure off the bluegill population. Bluegills would then become a problem and cause stunting of the remaining fish population. Gizzard shad grow quickly to a size not useful to either bass or crappies and tend to have overpopulation problems of their own. Threadfin shad do not grow to such a large size and would probably provide better forage. However, in Missouri public use area lakes, they will winter kill and may be difficult to establish each year. The addition of shad may also upset the food chain of the bluegill and cause stunting of this species.

The literature suggests that interspecific competition between black and white crappie will probably occur in Pony Express, and their numbers will probably cycle back and forth until one or the other species becomes dominant. If Pony Express remains clear and aquatic vegetation remains abundant, the black crappie will probably become dominant. If the lake becomes turbid for an extended period (one growing season), white crappie will probably predominant and may stunt.

Based on the evidence in the literature, crappies stand a good chance of disrupting the present fish populations in our public use area lakes. However, a sustained crappie fishery could develop if fishing pressure remains high, and large numbers of bass are present to control the numbers of crappie. The length limit on bass at Pony Express Lake is presently causing