STATE Texas

PROJECT NO. F-7-R-1, Job B-4

PERIOD June 15, 1953 - May 31, 1954

FILE

JOB COMPLETION REPORT

by

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TITLE

Laboratory and statistical analysis of materials and data collected in the field.

OBJECTIVES

1. To determine the following data from laboratory examination of field collected specimens:

   a. Growth rate of the species present.

   b. Food habits.

   c. Sexual development and spawning success.

   d. Comparative physical condition (coefficient of condition).

2. To determine population estimates and trends from field data.

TECHNIQUES

1. Attempts were made to determine the growth rates of the more important species of fishes by correlation of length and weight with age determination from scale readings.

2. Preserved stomachs of predatory species, when they contained food, were examined in the laboratory.

3. Sexual development and spawning success, spawning seasons and the reproductive potential (egg counts) were determined in the field and laboratory.

4. The coefficients of condition were computed in the laboratory for all specimens collected, after the formula presented by Carlander (Fresh Water Fisheries Biology.)

5. Analysis of relative abundance of species is based on field-taken gill net collections supplemented by rotenone samples and appropriate mathematical treatment.

6. Pathological conditions that might affect future population trends were diagnosed and recorded whenever discovered in the field.

FINDINGS

The findings under this job are so varied and unrelated that they are best discussed under the following separate headings:

1. Age determinations from scale readings.
2. Food habits of predatory species.
3. Reproduction.
4. Coefficients of condition.
5. Relative abundance of species.
6. Pathological conditions.

The headings apply, in each case, only to the three lakes studied during the past project period, in Region B-1, northcentral Texas. Details on the lakes, their ecology and fish populations are discussed in completion reports for Jobs B-1, B-2 and B-3.

AGE DETERMINATION

In the field, samples of scales of every specimen taken in gill nets were saved for laboratory examination. Suitable equipment and materials for reading scales were borrowed from Midwestern University.

It was originally suggested in our project proposals that doubt existed as to the validity of annuli on scales in determining the age of fishes from this latitude.

After many hours of study we summarize our findings as follows:

1. Many scales present apparent annuli that seem logical as age rings in consideration of the length and weight of the fishes from which the scales were removed.
2. Scale markings are usually duplicated on most scales from any individual fish.
3. For every specimen with logical "annuli", there is at least one specimen of the same species that gives ridiculous age readings.
4. The bulk of the specimens examined do not present scale markings recognizable as valid annuli.

We are forced to conclude that annuli on the scales of fishes from this region, if valid for age determinations at all, will require far more time and detailed study than we can spare for them. In this region, winters are mild and the lakes rarely freeze. Insect and plant life is available throughout the year. It is possible that scale marks reflect violent ecological conditions such as drouth, excessive salanity or sudden floods rather than regular yearly growth stages.

We do feel, however, that scale markings may show, or at least indicate in a general way, age of the specimens. If the "ridiculous" specimens are discarded and the doubtful specimens read as best they can be determined, the results are in fair agreement with what we would judge from size and weight. Nevertheless we have no confidence in the results and would rather depend on length and weight as age indicators.

FOOD HABITS OF PREDACIOUS SPECIES

The stomachs of all predacious fishes were examined in the field. Those stomachs that contained food were removed, labeled and preserved in 10% formalin. In the laboratory these stomachs were opened and examined, under a microscope, when necessary. Only those food items that could be identified with reasonable centainty were recorded. The differences in the forage fish species in the three lakes and diversity of food items found, makes it impossible to present the data obtained in a uniform way.

Lepisosteus osseus. (Absent from Lake Kemp) The single specimen (and only gar of any species taken) from Lake Kickapoo contained a gizzard shad (Dorosome cepedianum) 140 mm. in standard length. Three specimens from Lake Diversion held four small white bass (Morone chrysops) 65, 67, 85 and 90 mm. in standard length and an adult bluegill (Lepomis macrochirus) 127 mm. in standard length. The latter fish would scarcely fit in the stretched mouth of the dead gar.

Lepisosteus productus. (Absent from Lake Kickapoo.)

No stomachs with identifiable food remains were taken in either Lake Kemp or Lake Diversion.

Lepisosteus platostomus. (Absent from Lake Kickapoo). Four specimens from Lake Kemp held food, as follows: 1 gizzard shad, ca. 150 mm., 2 white bass, 155 and ca 150 mm.; 1 small drum (Aplodinotus grunniens), ca. 185 mm. in standard length. One specimen from Lake Diversion held a white bass about 75 mm. in standard length.

Hiodon alosoides. The single specimen taken in the course of the study (from Lake Diversion) held a short-horned grasshopper with tegmina 42 mm. in length.

Ictalurus punctatus. The channel catfish is present in all three lakes but is most numerous in Lake Kickapoo. A total of 66 stomachs containing identifiable food items were examined.

Plant material occurred in nine stomachs. Two stomachs contained only a felt-like mass of green algae and mud; one contained algae, mud and about 100 midge larvae. Three stomachs contained nothing but wheat grains and hulls; one contained wheat and insects. This material presumably came from "baited fishing holes," probably baited to attract crappie. One stomach contained, in addition to other food, a single large grain of corn. Another contained a small amount of plant fiber, possibly grass fiber, in addition to other food.

Earthworm was detected in a single stomach; possibly it represented bait. A crayfish was found in one stomach and several isopods (pillbugs) in another. One stomach held two spiders, another held three spiders, and one held a large scorpion.

One large catfish had eaten a small bird of the finch type; possibly an English sparrow (Passer domesticus). It is possible that this was bait; probably it was carrion.

Bait (chicken heads, bird or mammal intestine) and trash (dragonfly droppings, mud, gravel, bologna sausage rind, etc.) was present in 13 stomachs. The mud and gravel appeared to have been eaten accidentally.

The bulk of the food items identified consisted of insects and fish. The popular notion that catfish will eat "almost anything" is well borne out by our investigations. Nevertheless some astonishing facts were discovered, especially with regard to the insects eaten. The bulk of the insects was land insects; many were flightless types. Individual fish showed great selectivity. In the same nets catfish were taken with only insects in their stomachs; others with only fish; others yet with both fish and insects. In general the smaller fish took insects and the larger ones were pisciverous.

TABLE 1. FREQUENCIES OF OCCURRENCE AND NUMBERS OF INSECTS, IDENTIFIED TO FAMILY, FROM STOMACHS OF 37 CHANNEL CATFISHES, ICTALURUS PUNCTATUS.

Food Item	Frequency of occurrence	Total Number identified
Mayfly nymphs (Ephemeroptera)	1	7
Mayfly adults (Ephemeroptera)	3	10
Grasshoppers (Locustidae)	23	286
Crickets (Cyrillidae)	1	1
Earwigs (Dermoptera)	1	1
Termites (Isoptera)	1	1
Water Boatmen (Corixidae)	1	1
Backswimmers (Notonectidae)	3	209
Assassin Bugs (Reduviidae)	5	9
Damsel Bugs (Nabidae) (?)	1	17
Plant Bugs (Miridae)	3	17
Chinch Bug (Lygaeidae)	2	12
Squash Bugs (Coreidae)	2	6
Stink Bugs (Pentatomidae	11	140
Leaf Hoppers (Cicadellidae)	12	3333
Green Lacewings (Neuroptera)	2	10
Ant-lion Larvae (Neuroptera)	1	11
Gall Wasps (Cynipoidea)	2	2
Velvet Ants (Mutillidae)	2	2
Digger Wasps (Scoliidae)	1	1
Ants (Formicoidae)	4	13
Tiger Beetles (Cicindelidae)	4	4
Ground Beetles (Carabidae)	12	1175
Diving Beetles (Dytiscidae)	1	3
Whirligigs (Gyrinidae)	1	1
Click Beetles (Elatridae)	1	2
Metalic Wood Borers (Buprestidae)	2	2
Ladybugs (Coccinellidae)	3	4
Darkling Beetles (Tenebrionidae)	2	2
Scarabs (Scarabeidae)	2	5
Leaf Beetles (Chrysomelidae)	6	15
Weevils (Curculionidae)	1	3
Moths (Lepidoptera)	2	7
Angelwing Butterflies (Nymphalidae)	1	7
Mosquitos (Culicidae)	1	100
Midge Larvae (Chironomidae)	1	113

TABLE 11. FREQUENCIES OF OCCURRENCE AND NUMBERS OF FISHES FROM STOMACHS OF 22 CHANNEL CATFISH, ICTALURUS PUNCTATUS

Food Item	Frequency of Occurrence	Total Number Identified
Gizzard shad (Dorosoma cepedianum)	15	18
Carpsucker (Carpiodes carpio)	1	1
Minnow (Notropis lutrensis)	1	1
White bass (Morone chrysops)	1	1
Crappie (Pomoxis annularis)	4	4
Drum (Aplodinotus grunniens)	4	5

Some catfish, both large and small, preferred insects of a given size. Some stomachs contained only relatively large insects such as grasshoppers and beetles. Others had eaten hundreds of tiny species, like leafhoppers. Some fish seemed to prefer insects of a green or greenish color. When the stomachs of these fish were opened, the food mass had a distinctly greenish color, coming from numerous different insects of different families and orders but all or mostly greenish in color.

Most, perhaps all, of the land insects eaten must have been taken from the surface of the water. Many were blown into the water by wind. That the catfish took the insects from the surface is well shown by the presence in 12 stomachs of dragonfly droppings. These small, dark balls of chiton puzzled us for some time until it was learned that dragonflys deficate in midair. Comparison of known dragonfly droppings with the mysterious balls of chiton from catfish stomachs made identification certain. It also suggests that the surface feeding catfish feed by smell rather than by sight, on material resting on the surface film of the water.

Rises in lake level following rains are reflected in the stomach contents of catfish. Following lake rises, the numbers of flightless and rarely flying insects in the diet of fish increases. The greatest numbers of carabid beetles were found after heavy rains. The catfish with 11 ant-lion larvae in its stomach was taken after a rain.

Surprising also is the nature of some of the insects eaten. Insects such as velvet ants and assassin bugs can inflict painful stings or bites. These forms may have been taken while dead. Some odorous forms, such as tenebrionid beetles and stink bugs are eaten. Indeed, one species of large stink bug (Nazare viridula) was often eaten and constitutes most of the stink bugs eaten. It is noteworthy that blister beetles, known to be extremely poisonous, at least to man, were absent from catfish stomachs though they are common on the vegetation about the lake and must often have fallen into the water.

In general, however, a distinct preference is noted for grasshoppers, true bugs (especially stink bugs and leaf hoppers) and beetles (especially greenish carabids.)

Some seasonal variation in insect diet was noted. Grasshoppers were most common in the fall of the year. Mayflies were eaten only in the summer. However, the diet of small catfish consists of insects, even in midwinter. Stomachs taken in January and February, following periods of sub-freezing weather, contained nothing but insect remains. Most of the winter-taken insects were leaf hoppers and backswimmers.

Only channel catfish of three-pound weight, or over, fed exclusively on fish. Some smaller catfish had eaten both fish and insects. Apparently small catfish eat fish when they catch them, but only larger and older catfish are adept at capturing fish. Most of the fish eaten were quite small but only one was a "forage fish" Young gizzard shad, drum and crappie made up the bulk of the fish food. The food habits of the larger, pisciverous catfish is quite similar to the food habits of the other predacious fishes.

Pilodictus olivaris. Only five filled stomachs were obtained from flathead catfish. These large catfish seem to be entirely pisciverous. One had eaten 2 Dorosoma cepedianum and a Notropis lutrensis; another had eaten one Pomoxis annularis; one had eaten ten shad (Dorosoma cepedianum), some of moderately large size; one had eaten 3 Dorosoma cepedianum; and one had eaten a drum (Aplodinotus grunniens).

Morone chrysops. We obtained 73 white bass that contained identifiable food in their stomachs. Of these, 27 were young specimens captured while feeding on enormous hatches of sub-imago and adult mayflies of the genus Hexagenia. Another specimen held ten nymphs of a mayfly, probably Hexagenia. Another held, in addition to a small fish, a nymph of a dragonfly. A total of 45 specimens had eaten fish, mostly small, as follows:

TABLE 111. FREQUENCIES OF OCCURRENCES AND NUMBERS OF FISHES EATEN BY WHITE BASS (MORONE CHRYSOPS), BASED ON 45 STOMACHS.

Food Item	Frequency of occurrence	Total Number identified
Dorosoma cepedianum	24	27
Notropis lutrensis	3	4
Notropis venustus	1	1
Pimephales vigilax	1	1
Lepomis (megalotis ?)	2	2
Aplodinotus grunniens	14	17

Micropterus salmoides. A total of 32 stomachs of black bass, with identifiable food was examined. Of these, 17 were of small fish, taken in seine hauls during an enormous hatch of the mayfly, Hexagenia. The 17 stomachs were crammed with sub-imago and adult mayflies and nothing else. The remaining 15 stomachs contained fish, as follows:

TABLE 1V. FREQUENCIES OF OCCURRENCE AND NUMBERS OF FISHES EATEN BY BLACK BASS (MICROPTERUS SALMOIDES), BASED ON 15 STOMACHS.

Food Item	Frequency of Occurrence	Total Number Identified
Dorosoma cepedianum	10	13
Notropis lutrensis	2	2
Aplodinotus grunniens	3	5

Pomoxis annularis. Crappie are present in all three lakes but are especially abundant in Lake Kickapoo. We obtained 63 stomachs that held identifiable food items. Of these, six stomachs were of fishes taken in areas where the mayfly, Hexagenia, was swarming. The stomachs of these 6 fish were crammed with the remains of the insect. The total food items identified are as follow:

TABLE V. FREQUENCIES OF OCCURRENCE AND NUMBERS OF FOOD ITEMS EATEN BY CRAPPIE, POMOXIS ANNULARIS, BASED ON 63 STOMACHS.

Food Item	Frequency of Occurence	Total Number Identified
Dorosoma cepedianum	37	44
Notropis lutrensis	13	14
Pimephales vigilax	1	1
Aplodinotus grunniens	6	6
Grass Shrimp (Palemanotes)	2	2
Mayflies (Pentagenia)	1	1
Mayflies (Hexagenia)	11	443

Aplodinotus grunniens. Only two drum with food in their stomachs were obtained. One of these held a shad (Dorosoma cepedianum). The other held a shad (Dorosoma cepedianum) and a much smaller drum. Apparently the species is cannibalistic.

CONCLUSIONS. Except for the insects, so important to the catfish, and the occasional hatches of mayflies, the important food items for the game fishes of the lakes seem to be shad and small drum. The so-called forage fishes, in spite of their great abundance, are of only nominal value.

REPRODUCTION

All fishes taken in gill nets, and most specimens taken by other means were opened in the field and the stages of sexual development were recorded. Sheer bulk of the material precluded detailed description of developmental stages while the number of individuals making observations and their differences in judging finer stages of development, made it impossible to record more than the most basic data. Therefore femal gonads were classed into only three groups: (1) ripe - with large or relatively large eggs, ready to be laid or nearly ready, (2) - immature - eggs small or inconspicuous and obviously not ready to be laid and (3) spent - with ovaries from which eggs had recently been expelled. Male gonads were judged in a similar fashion, on the basis of the size of the testes.

Ripe ovaries were preserved and the eggs counted only during the later stages of the project. We regret that this was not begun sooner for checking of the literature discloses little data as to the numbers of eggs laid by some of the species of fishes most common to our waters. Ovaries containing large eggs were carefully weighed on a chemical balance, to the nearest tenth of a gram. A small portion of the ovary, approximately one gram, was then snipped free and weighed on an extremely accurate balance to the nearest ten milligrams. The eggs in this small portion were counted and the total eggs thus estimated.

Times of spawning and spawning success we found extremely difficult to determine, at least in an accurate and comparable way. The data on this aspect of the problem is generalized from the number and date of findings of spent ovaries,

fry and young fish taken in minnow seines, and fry found in the stomachs of the predatory species. In this connection we have utilized some field notes from waters other than the three lakes studied in detail but located within a few miles of these lakes.

The varied nature of the information obtained makes it impossible to present it in tabular form but brief summaries for each species are offered herewith:

Lepisosteus osseus - A female weighing 1,600 grams contained 40,992 eggs. One gar only about three inches in length was taken in backwater near Lake Diversion on June 21, 1953 but no small specimens were taken in any of the lakes studied. Individuals with ripe ovaries were taken throughout the year and we do not believe gars in the lakes studied laid any eggs during the project period.

Lepisosteus platostomus - No egg counts available. As is true of the longnosed gar, the shortnosed gar apparently did not breed during the project period. Females with ripe ovaries were taken during the entire year and no young gars were taken in the lakes.

Lepisosteus productus - A female weighing 902 grams contained 77,572 eggs and another weighing 966 grams, contained 71,048 eggs. Ripe females were taken through the project period and we found no evidence of breeding in the lakes studied.

Dorosoma cepedianum - No egg counts available. Heaviest spawn came about June 15, 1953. After this date hundreds of small shad were taken in seine hauls, but such small shad were notably scarce in Lake Diversion. In the food of predators also we found shad rare in Lake Diversion but abundant in Lake Kemp and Lake Kickapoo. After the major spawn, in June, spawning continued throughout the period at a reduced rate. However, even in January 1954, nets set under the ice of Lake Kemp took numerous shad about 30 mm. in standard length and obviously only days of age.

Ictiobus cyprinellus - No egg counts or spawning data available. One specimen about three inches in total length was taken on June 16, 1954.

Ictiobus bubalus - Egg counts are as follows: fish of 950 grams weight, 67,100 eggs, 1,875 grams, 94,770 eggs; 2,490 grams, 147,136 eggs; 2,650 grams, 182,120 eggs; 2,775 grams, 199,209 eggs; 1,375 grams, 157,544 eggs. Ripe females and fry were taken throughout theyear. Ovaries with large eggs were recorded during every month of the project period.

Carpiodes carpio - Egg counts from two females: fish of 650 grams, 192,640 eggs; 950 grams, 111,110 eggs. Ripe females and fry were taken throughout the year. Fry live in dense schools in shallow, muddy water until approximately three inches in length. Fry taken during all months of the project period. This species definitely spawns in the lakes rather than in streams entering the lakes. Spawning highly successful in all three lakes.

Cyprinus carpio - Egg counts of three females are as follows: fish of 205 grams (possibly one year old), 13,610 eggs; fish of 2,250 grams, 198,068 eggs; fish of 1,820 grams, 379,840 eggs. Breeding appears to be restricted to mid - June, at least in 1953. Fry appear in streams and backwaters of lakes for several weeks, until about four inches in total length. None encountered thereafter until fish of approximately eight inches are taken in gill nets in the following March. Spawning moderately successful in all three lakes.

Ictalurus punctatus - Egg counts of two females are as follows: fish of 2,300 grams, 11,228 eggs; fish of 2,650 grams, 11,041 eggs. Heaviest spawn seems to occur in September and October but occasional ripe females are taken through the year. Fry are rarely taken in seines but fish 6 to 8 inches in length and thought to be about a year old are taken in gill nets. Spawning highly successful in Lake Kickapoo, moderately so in Lake Diversion and very poor in Lake Kemp.

Pilodictus olivaris - one female weighing 3,050 grams contained 10,218 eggs. No fry and few even moderately small individuals were taken.

Morone chrysops - No egg counts are available from lakes studies. Gill nets, seines and hook-and-line fishing show spawn highly successful in Lake Diversion, but poor in Lakes Kemp and Kickapoo.

Micropterus salmoides - Egg counts are as follow: Fish of 2,300 grams, 95,816 eggs; 2,460 grams, 73,260 eggs ; 3,300 grams, 137,720 eggs. Seining checks show the reproduction of this species in Lake Diversion to be highly satisfactory. Nearly every seine haul in the shallows revealed numerous small black bass. Reproduction in Lake Kemp and Lake Kickapoo, on the other hand, was very poor during the project period.

Pomoxis annularis - Egg counts are as follows: fish of 24 grams, 4,520 eggs; 102 grams, 7,140 eggs; 120 grams, 8,880 eggs, 129 grams, 9,420 eggs; 388 grams, 15,148 eggs. An abundance of small crappie were taken in Lake Kickapoo during every month of the year and females with ripe ovaries were taken during most months. The heaviest spawn occurs in June and July, however. Spawning during the project period was highly successful in Lake Kickapoo and moderately so in Lake Kemp and Lake Diversion.

Aplodinotus grunniens - Egg counts are as follows: fish of 236 grams, 9,020 eggs; 475 grams, 9,900 eggs; 525 grams, 10,680 eggs; 236 grams, 10,740 eggs; 760 grams, 12,800 eggs; 540 grams, 13,120 eggs. Data here is contradictory. Ripe females were taken only in May and June but small fish, less than two inches in length were taken in all months of the year. We believe that some females, at least, breed during all months although the major spawn takes place in late May and early June. Spawning highly successful in all three lakes but especially so in Lake Diversion.

COEFFICIENTS OF CONDITION

The coefficients of condition, or "K" factors, have been worked out separately for each lake. Statistical treatment showed distinct differences in the average "K" factors for males and females. Separation by seasonal samples indicated some increase in the "K" factors in fall and early winter but, in most instances, the differences were not significant, probably because such separation reduced the samples so greatly. Contrary to expectation, no correlation between age and "K" factors was discovered except in the case of black bass and crappie. In black bass, the "K" factor increases rapidly in large fish. In very small crappie, the "K" was larger than for mature specimens.

Because of the possible comparisons and statistical treatments that might be desired by other workers (we have used standard deviations and the standard error of the mean in our own work) we have presented in the following tables a brief summary of our actual findings:

TABLE VI. DISTRIBUTION OF "K" FACTORS FOR FISHES FROM LAKE KEMP

Lepisosteus productus

Factors	.5	.6	.7	.8	.9	1.0	1.1	1.2
Males	1	6	3	2	-	-	1	1
Females	5	8	8	2	-	-	-	-

Lepisosteus platostomus

Factors	.5	.6	.7
Males	1	-	-
Females	-	1	1

Dorosoma cepedianum

Factors	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3
Males	1	1	5	13	22	14	13	6	2	2	1
Females	1	2	11	16	25	33	27	17	4	4	2

Carpiodes carpio

Factors	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
Males	-	2	1	4	8	17	26	36	42	33	39	8	7	5	2
Females	1	2	1	6	9	14	18	21	30	41	30	20	3	6	2

Cyprinus carpio

Factors	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9
Males	2	2	5	1	5	6	5	2	-	-	1
Females	-	2	-	3	5	4	9	2	3	1	-

Ictalurus punctatus

Factors	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2
Males	-	5	3	2	1	4	1	-	-	-
Females	1	6	4	4	3	-	1	2	-	1

TABLE VI. DISTRIBUTIONS OF "K" FACTORS FOR FISHES FROM LAKE KEMP (cont'd)

Morone chrysops

Factors	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
Males	2	3	6	5	5	6	4	2	4
Females	1	9	9	5	3	9	4	1	-

Pomoxis annularis

Factors	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1
Males	1	1	3	9	8	8	6	7	2	3
Females	1	5	7	13	12	9	8	1	2	1

Aplodinotus grunniens*

Factors	2.0	2.1	2.2	2.3	2.4	2.5	2.6
Males	1	1	2	1	-	1	1

* - No comparable females available.

Micropterus salmoides

"K" factors for males - - 2.2, 2.5, 2.6, 4.4

"K" factors for females - 2.4, 2.4, 2.5, 2.5, 2.7, 2.9, 3.0, 3.2, 3.2, 3.2, 3.4

Of the males, fish from 252 grams to 652 grams had "K" factors less than 2.7; one large specimen (2700 grams) had a "K" factor of 4.4

Of the females, fish weighing less than 1,000 grams had "K" factors of less than 3.0, with the exception of a specimen of 907 grams (K of 3.2). Fish weighing more than 1,000 grams had "K" factors of more than 3.0, except for a specimen of 1,175 grams (K of 2.9). In general, in black bass weighing more than two pounds, the "K" factor increased with weight. In fish weighing less than two pounds, the "K" factor was not correlated with body weight.

TABLE VII. DISTRIBUTION OF "K" FACTORS FOR FISHES FROM LAKE DIVERSION.

Lepisosteus osseus

Factors	.2	.3	.4	.5
Males	4	20	8	
Females	10	17	11	3

Lepisosteus platostomus

Factors	.3	.4	.5	.6
Males	1		1	1
Females	1		1	

Lepisosteus productus

Factors	.5	.6	.7	.8	.9	1.0
Males		1				1
Females	2	1	1			

Dorosoma cepedianum

Factors	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
Males		5	5	8	22	56	59	42	8	9	2	1
Females	2	1	6	12	23	59	57	33	16	3	7	

Ictiobus bubalus

Factors	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6
Males	1	2	9	9	11	19	27	7	27	1	10		4
Females		1	2	3	3	10	5	3	11		3	1	3

Carpiodes carpio

Factors	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3
Males	2	9	18	17	33	35	21	12	10	4	6	2
Females	3	9	7	13	16	18	14	6	10	9	6	2

TABLE VII. DISTRIBUTION OF "K" FACTORS FOR FISHES FROM LAKE DIVERSION

Cyprinus carpio

Factors	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2
Males		2	1		4	1	3	2	2	5	1	1
Females	1		1	1	2	2	3	2	3	1	4	

Ictalurus punctatus

Factors	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
Males					3	4	3	2	2	
Females	2		2	3	5	7	4			1

Morone chrysops

Factors	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2
Males	2	4	10	11	15	25	12	16	7	5			
Females	3	3	11	9	11	21	15	15	5	5	2	1	2

Micropterus salmoides

Factors	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1
Males			1	1	3	1	1	1	1		1		
Females	2		1	1	5	2	8	5	3	2		1	2

Pomoxis annularis

Factors	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3
Males	1			3	8	6	14	7	6	1	1	1
Females	1	1	7	8	7	6	11	6	5	2	2	

Aplodinotus grunniens

Factors	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
Males			1	4	5	2	2	1		1	1
Females	1			6	6	3	7	4	1	1	1

TABLE VIII. DISTRIBUTION OF "K" FACTORS FOR FISHES FROM LAKE KICKAPOO.

Dorosoma cepedianum

Factors	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6
Males			2	1	1	1	2	2	2	1		
Females	1	1	2	1	9	2	4		1	1	1	2

Ictiobus cyprinellus

Factors	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3
Males	1			1	1	1		2	1
Females		1		1		1			

Ictiobus bubalus

Factors	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4
Males	1	4	1	2	1	4	2	1						1		
Females	1	2		3		1		3		2		1		1		1

Carpiodes carpio

Factors	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4
Males	1	2	4	7	4	18	22	26	16	13	19	7	8	3	3
Females				4	4	15	16	18	22	20	13	10	3	4	1

Cyprinus carpio

Factors	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3
Males	7	8	4	5	3	5	3	1	3			
Females		1	7	4	5	5	2	2	1	1		2

Ictalurus punctatus

Factors	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2
Males		2	5	15	19	20	7	4	1	1		2
Females	2	1	5	6	8	15	17	6	1			1

TABLE VIII. DISTRIBUTION OF "K" FACTORS FOR FISHES FROM LAKE KICKAPOO.

Pilodictus olivaris

Factors	1.3	1.4	1.5	1.6	1.7	1.8	1.9
Males			2		1	3	2
Females	1				3		1

Morone chrysops

Factors	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1
Males		2	1	3	2	6	3	9	8	2	
Females	2	3	4	3	4	4	2	7	7	3	1

Micropterus salmoides

Factors	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9
Males	3	1	1			1			1	1	2	2	1	1	
Females	1	1				1	1	5		1		1		1	1

Pomoxis annularis

Factors	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4
Males	5	5	18	21	25	29	35	43	39	38	30	12	6	11	
Females	7	9	12	16	18	26	24	42	35	25	22	11	8	4	2

Aplodinotus grunniens

Factors	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8
Males		2	2		5	8	7	6	5	4	2	3	
Females	1	2		1	4	7	3	5	4		1	2	1

ANALYSIS OF RELATIVE ABUNDANCE OF SPECIES

In determining the relative abundance of species in the lakes studied, we have relied most heavily on our gill net records. The nets were set at six stations in each lake. Each of these stations was designed to sample varied ecological niches of the lakes as well as to show geographic and seasonal distribution of fishes in the lakes. Each station was worked for two days and two nights at periods three to four weeks apart, as weather conditions permitted. (See Completion Reports, Jobs B-1, B-2 and B-3.)

Very little difference is apparent in the total catches of the stations of each lake, over the period of the study. Considerable variation between the stations during any day is usually found. This may reflect geographic seasonal variations in the lake, or more likely, simply reflects the erratic, wandering, distribution of the "school" fishes such as gizzard shad, river carpsucker, etc. Some stations were consistently more productive of fishes than other stations but the relative abundance of species at each station is surprisingly uniform. In consequence we judge that fish distribution is qualitatively, quite uniform in each lake.

Our stations were designed to sample the parts of the lakes near their heads (river mouths) and foots (dams) as well as sites between these points. In Lake Kemp and Lake Diversion a "midlake station" was maintained, far out from shore. Comparison of records of each station indicates that, though certain small areas are favored feeding places, the fish distribution over a period of several months is relatively uniform. Deep water seems no more productive than shallow water except for white bass, (Morone chrysops).

Although we have relied most heavily on our gill net records in determining the species ratios, we realize that gill nets do have inherent weaknesses for this purpose. They are selective in that certain species, perhaps because of their habits, rarely enter the nets.

In an effort to determine the relative efficiency of our gill nets, we blocked off with floating and sinking nets a moderately large area of each lake and killed all fishes within the restricted areas with rotenone. The nets prevented fishes from outside the area entering the test area, and prevented dead and dying fish within the test area from escaping.

This method is non-selective and indicates the species of fishes for which our nets do not give a reliable count. It also gives a check on the reliability of the more sedentary fish species as taken in nets. The principal weakness of the method, however, is that it gives the count of individuals and species within the test area at the time of testing only. The number of "school" fishes obtained by such methods is not comparable to the gill net figures.

Taken in conjunction, however, the two methods give moderately uniform figures as to the relative populations and each points out the major faults of the other.

In general we found that the gill nets gave no idea of the true numbers of the drum (Aplodinotus grunniens) in the lakes. In general the rotenone samples failed to give a true picture of the numbers of "school" fish such as gizzard shad (Dorosoma cepedianum) and smallmouth buffalo (Ictiobus bubalus) and perhaps others. In computing the total numbers of drum in each lake we have relied on the rotenone samples. In computing the total number of fishes of ALL kinds in each lake, we have also relied on the rotenone samples. In computing the total numbers of EACH

kind of fishes in each lake we have relied on the ratios obtained in gill nets.

Total fish population was obtained in two ways: total fish of the "large and important" class killed per surface area in sample plot times surface area of lake and total fishes of the "large and important" class killed per volume of water in the test plot time volume of the lake. Gill net records strongly indicate that surface area rather than volume gives the best results.

Counts were made only of fishes large enough to be taken in gill nets. On this basis, fish per surface acre and fish per acre ft. give the following results: Lake Diversion, 413 and 83; Lake Kemp, 329 and 66; Lake Kickapoo, 316 and 40. The figures for fish per surface acre seem to be quite comparable and agree with our own observations as to lake productivity.

As to actual sampling, our efforts in Lake Diversion were the most successful and there we were able to utilize a relatively large sampling area. Our work in Lake Kemp coincided with a sudden rise in lake level and perhaps for this reason, our catch of gizzard shad was excessive. Lake Kickapoo provided the poorest sampling area. Because this lake is the source of drinking water for the City of Wichita Falls, we were forced to operate in a relatively small area consisting of a long, narrow, bay with much submerged vegetation. As a result of the protected water sampled the catch of carp and catfish was excessive. Inasmuch as all samples were from shallow waters, white bass are poorly represented in all samples.

Results of samplings and interpretation are given graphically in the following tables:

TABLE IX. COMPARISON OF RESULTS OF GILL NET AND ROTENONE SAMPLING OF LARGE AND IMPORTANT SPECIES FROM LAKE KEMP, LESS APLODINOTUS GRUNNIENS

Species	Rotenone Total	Rotenone Percent	Net Total	Net Percent
Lepisosteus platostomus	2	.1	2	.2
Lepisosteus productus	7	.5	40	4.0
Dorosoma cepedianum	1,255	89.1	222	22.2
Carpiodes carpio	99	7.0	428	42.9
Cyprinus carpio	21	1.6	61	6.2
Ictalurus punctatus	10	.7	39	3.9
Morone chrysops	2	.1	79	7.9
Micropterus salmoides	2	.1	15	1.5
Pomoxis annularis	11	.8	111	11.2
TOTAL	1,409	100	997	100

TABLE X. NUMBERS OF DRUM TAKEN IN GILL NETS IN LAKE KEMP AS COMPARED WITH THOSE TAKEN IN ROTENONE SAMPLE

	Total Fishes Taken	Total Drum Taken	Percent Drum Taken
Rotenone	1,808	399	22.07
Gill nets	1,005	8	.71

TABLE XI. ESTIMATE OF TOTAL FISHES IN LAKE KEMP, BASED ON TEST PLOT

	Area	Total fishes Based on Surface Area	Volume	Total Fishes Based on Water Volume
Test Plot	5.5 acres	1,808	27.5 acre ft.	1,808
Lake Kemp	22,800 acres	7,495,044	560,000 acre ft.	36,820,000

TABLE XII. ESTIMATED RELATIVE ABUNDANCE OF FISHES IN LAKE KEMP.

	Percent	Estimated by Surface Area	Estimated by Water Volume
Lepisosteus platostomus	.2	14,899	73,640
Lepisosteus productus	3.1	232,345	1,141,420
Dorosoma cepedianum	17.3	1,296,635	6,369,860
Carpiodes carpio	33.4	2,503,330	12,297,880
Cyprinus carpio	4.8	359,760	1,777,360
Ictalurus punctatus	3.0	244,850	1,104,600
Morone chrysops	6.2	464,690	2,282,840
Micropterus salmoides	1.2	89,394	441,840
Pomoxis annularis	8.7	652,065	3,203,340
Aplodinotus grunniens*	22.1	1,656,395	8,137,220

* - Percentage based on rotenone sample; others based on gill net samples.

TABLE XIII. COMPARISON OF RESULTS OF GILL NET AND ROTENONE SAMPLING OF LARGE AND IMPORTANT SPECIES FROM LAKE DIVERSION, LESS *APLODINOTUS GRUNNIENS*

	Rotenone Total	Rotenone Percent	Net Total	Net Percent
Lepisosteus osseus	65	4.2	73	5.1
Lepisosteus productus	8	.5	6	.4
Lepisosteus platostomus	6	.3	5	.3
Dorosoma cepedianum	802	52.2	443	30.9
Ictiobus bubalus	137	8.9	185	12.9
Carpiodes carpio	153	10.0	287	20.0
Cyprinus carpio	45	2.9	42	2.9
Ictalurus punctatus	69	5.0	38	2.7
Morone chrysops	69	5.0	206	14.4
Micropterus salmoides	35	2.3	41	2.9
Pomoxis annularis	146	9.5	107	7.5
TOTAL	1,535	100.8	1,433	100.0

TABLE XIV. NUMBERS OF DRUM TAKEN IN GILL NETS AS COMPARED WITH THOSE TAKEN IN ROTENONE SAMPLE

	Total fishes Taken	Total drum Taken	Percent Drum Taken
Rotenone	4,136	2,601	62.88
Gill Nets	1,482	49	3.0

TABLE XV. ESTIMATE OF TOTAL FISH IN LAKE DIVERSION, BASED ON TEST PLOT

	Area	Total Fishes Based On Surface Area	Volume	Total Fishes Based On Water Volume
Test Plot	10 Acres	4,136	50 acre ft.	4,136
Lake Diversion	3,000 Acres	1,240,800	40,000 acre ft.	3,308,800

TABLE XVI. ESTIMATED RELATIVE ABUNDANCE OF FISHES IN LAKE DIVERSION

Species	Percent	Estimated by Surface Area	Estimated by Water Volume
Lepisosteus osseus	1.9	25,579	63,871
Lepisosteus productus	.2	2,486	6,618
Lepisosteus platostomus	.1	1,241	3,309
Dorosoma cepedianum	11.5	142,715	381,135
Ictiobus bubalus	4.8	59,568	158,832
Carpiodes carpio	7.4	91,834	244,966
Cyprinus carpio	1.1	13,651	36 399
Ictalurus punctatus	1.0	12,408	33,088
Morone chrysops	5.3	65,773	175,377
Micropterus salmoides	1.1	13,651	36,399
Pomoxis annularis	2.8	34,748	92,652
Aplodinotus grunniens*	62.9	780,589	2,081,361

* - Percentage based on rotenone sample; others based on gill net samples.

TABLE XVII. COMPARISON OF RESULTS OF GILL NET AND ROTENONE SAMPLING OF LARGE AND IMPORTANT SPECIES FROM LAKE KICKAPOO, LESS *APLODINOTUS GRUNNIENS*

	Rotenone Total	Rotenone Percent	Net Total	Net Percent
Dorosoma cepedianum	103	18.3	40	3.0
Ictiobus cyprinellus	11	2.0	9	.7
Ictiobus bubalus	9	1.6	33	2.5
Carpiodes carpio	74	13.2	292	21.8
Cyprinus carpio	91	16.2	71	5.2
Ictalurus punctatus	174	30.9	141	10.3
Pilodictus olivaris	1	.2	13	1.0
Amieurus melas	7	1.2	1	.1
Morone chrysops	2	.4	81	6.1
Micropterus salmoides	13	2.3	27	2.1
Pomoxis annularis	77	13.7	628	46.3
TOTAL	562	100	1,336	99.1

TABLE XVIII. NUMBERS OF DRUM TAKEN IN GILL NETS AS COMPARED WITH THOSE TAKEN IN ROTENONE SAMPLING

	Total Fishes Taken	Total Drum Taken	Percent Drum Taken
Rotenone	632	70	11.08
Gill nets	1,413	77	5.45

TABLE XIX. ESTIMATE OF TOTAL FISHES IN LAKE KICKAPOO BASED ON TEST PLOT

	Area	Total Fishes Based on Surface Area	Volume	Total Fishes Based on Water Volume
Test Plot	2 acres	632	16 acre ft.	632
Lake Kickapoo	6,200 acres	1,592,200	105,000 ac. ft.	4,134,375

TABLE XX. ESTIMATED RELATIVE ABUNDANCE OF FISHES IN LAKE KICKAPOO

Species	Percent	Estimated by Surface Area	Estimated by Water Volume
Dorosoma cepedianum	2.7	42,989	111,629
Ictiobus cyprinellus	.6	9,553	24,806
Ictiobus bubalus	2.2	35,024	90,948
Carpiodes carpio	19.4	309,848	801,996
Cyprinus carpio	4.6	73,232	190,164
Ictalurus punctatus	9.2	146,464	380,328
Pilodictus olivaris	.9	14,330	37,210
Amieurus melas	.1	1,592	4,134
Morone chrysops	5.4	85,968	223,236
Micropterus salmoides	1.9	30,252	78,554
Pomoxis annularis	41.2	655,904	1,703,208
Aplodinotus grunniens*	11.1	176,712	458,874

* - Aplodinotus figure based on rotenone sample; others based on gill nets.

PATHOLOGICAL CONDITIONS

All fishes taken in the course of the present investigations were examined for evidences of disease or other abnormalities. Entire specimens or diseased tissues were preserved in 10% formalin. Diseased tissues were dehydrated in a graded series of alcohols, imbedded in paraffin, sectioned in a microtome, stained, and examined microscopically. Parasites were identified and the identifications were checked by authorities in the specific field covered.

The fungus, Saprolegnea parasitica, is common in the waters of all three lakes. It rarely attacks healthy fishes, however, and the only live fish parasitized by this species was a minnow that had escaped from a hook. The fungus had spread from the hook wound posteriorly over the body. Two dead drum and a dead carpsucker possessed patches of fungus of this genus on their bodies. The fishes may have died of other causes. In all three cases it appeared that the quantity of Saprolegnia was too small to cause death. The fungus may have been a post mortem infection of the saprophytic Saprolegnia invadens.

A second, and more common, fungus disease was found in Lake Diversion. This form has not yet been identified. It causes large, white, crust-like balls to form on the tails and fins of crappie but was not seen on other fishes. Several infections were seen and others were reported. The largest ball of fungus noted measured 15 mm. in diameter. Stained slides of this parasite are now available.

The internal parasites not ordinarily seen by fishermen were not studied but internal parasites free in the coelomic cavity, easily seen by fishermen when their catches are cleaned, were studied. The presence of such parasites results in the loss of some edible fish, discarded as "wormy." A serious offender in this respect is the nematode worm, Contracaecum spiculigerum. This worm was found once in a gar and never in other rough fishes, but was found in all game species from all three lakes. It was especially abundant in catfish. More than 50 specimens were found in each of several flathead catfish from Lake Kickapoo and more than twenty worms were found in several large black bass from Lake Kemp and Lake Kickapoo. The worms are prominent and disgusting but are not a parasite of man. Their primary stages are spent in water birds, such as ducks and gulls. Species of fishes infected include: Lepisosteus osseus (only once); Ictalurus punctatus, Pilodictus olivaris, Amieurus melas (in the only specimen taken); Morone chrysops Micropterus salmoides, Lepomis macrochirus, Pomoxis annularis and Aplodinotus grunniens.

Another nematode worm, Eustrongylides sp. is an occasional intracoelomic parasite of minnows. Two specimens of Notropis lutrensis from LakeDiversion had their bodies greatly swollen and deformed. On opening the fishes, their coelomic cavities were found to be bulged and distorted by a single specimen each of this worm. Other minnows with similar body swellings were noted but not opened.

Parasitic copepods (Argulus) are rare in the lakes investigated, and only once were found in Lake Kemp. There, in one area near Lake Kemp dam, one minnow Notropis lutrensis, in approximately every fifty was parasitized. The parasites could easily be seen on the living fishes. They were not found elsewhere nor were they again found in minnows from the locality where they were seen earlier.

The gizzard shad (Dorosoma cepedianum) from Lake Diversion seems susceptible to a disease, the nature of which was not discovered. It seems to be an ossification of the mucous covering of the head. The entire anterior part of the

body is sometimes covered with a whitish crust and the eyes are often covered and the fish blinded. The disease seems to strike only fishes of moderately large or healthy size (one pound or more). It seems to have no particular affect on the health of the infected fish. These plankton eaters apparently do not need to see in order to eat. No cellular structure could be detected when the covering material was stained. The material gave the typical brown reaction of mucin when treated with sudan brown.

Accidental blinding of bottom-dwelling species seems to be rather common. One carpsucker was taken that was blind in both eyes; two carpsuckers and one smallmouth buffalo were blind in one eye; one flathead catfish was blind in both eyes; one channel catfish was blind in both eyes; nine channel catfish were blind in one eye. In all cases recorded, the wounds were old and had long been healed; in some instances there remained scarcely a scar to mark the place where the eye had been. The blinded and partially blinded fishes seemed, on the whole, to be slightly less plump than normal fishes but were otherwise healthy.

One extreme abnormality in smallmouth buffalo from Lake Kickapoo was noted. This fish measured only eleven inches in length but was seven and one-half inches in height and proportionately wide and heavy. It had approximately the shape of an inflated football. It appeared to be otherwise healthy and no scars or evidence of old wounds were noted.

SUMMARY

Determination of age of fishes from north-central Texas is not reliable, at best, and may be impossible. The so-called forage fishes seem to be of relatively little value to predacious fishes which feed more extensively on the young of the gizzard shad and the drum. Channel catfish weighing less than three pounds feed extensively on insects throughout the year. True bugs (Hemiptera), grasshoppers and carabid beetles form most of the food items taken. Egg counts and observations on spawning seasons and spawning success are given for the species concerned. Coefficients of condition ("K" factors) are presented for all specimens taken in gill nets. Relative abundance of species, based on both gill nets and rotenone samples, is computed for each lake on the basis of surface area and water volume. Pathological conditions encountered in fishes in the area are described.