THE EFFECT OF DOMESTIC AND OIL REFINERY EFFLUENTS ON MERISTIC AND MORPHOMETRIC CHARACTERISTICS OF THREE CYPRINID FISHES

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PREFACE

The objectives of the present study of population structure of three cyprinid fishes in a stream receiving domestic and oil refinery effluents were to (1) determine the influence of wastes on fish distribution; (2) compare populations among streams to determine the level of morphological divergence; (3) to determine whether wastes influence morphological features, directly or indirectly, in certain fish species.

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CHAPTER I

INTRODUCTION

This study was part of a cooperative study on the effects of oil refinery and domestic effluents on the biota of Skeleton Creek, a permanent stream which originates near Enid, Oklahoma, and flows southeasterly through Garfield, Kingfisher, and Logan Counties.

Studies on fishes were carried out to determine the influence of wastes on distribution, species composition, and morphological characteristics of fish populations in the stream. Distribution and species composition were studied by Phillips (1965) and indicated significant effects of wastes on the distribution of various species in the stream. The present study represents an attempt to determine the influence of wastes on morphological features, directly or indirectly, in certain fish species. Because of availability, ease of handling, presence at sampling stations, and results of bioassay tests, Notropis lutrensis (Baird and Girard), Notropis stramineus (Girard), and Pimephales promelas Rafinesque were chosen.

Wastes may affect morphological characteristics in fish populations by isolating subgroups from one another for periods long enough to permit population divergence, or by directly impinging on development and growth processes to influence body size or shape, and the number of meristic structures.

Several environmental factors have been shown to affect morphological characteristics. Barlow (1961) has summarized the literature dealing with morphological variations in fishes. Almost invariably, the more northern representatives of a species or a genus are larger than those to the south. Northern, slow growing races of a species usually have smaller heads, eyes, maxillaries and fins than their southern counterparts, although opposite effects are not uncommon (Hubbs, 1926). Experiments involving temperature have demonstrated that the number of countable elements are greater in fishes reared at lower temperatures than those reared at higher temperatures. Johnny darters, *Etheostoma nigrum*, reared at cooler temperatures, had more vertebrae than their sibs from higher temperatures (Lagler, *in* Bailey and Gosline, 1955). Higher counts of vertebrae and scales were recorded from *Salmo kamloops* raised at lower temperatures (Mottley, 1934).

In some fishes, temperature-induced changes do not follow a simple pattern of higher counts at low temperatures and lower counts at high temperatures. In salmonid fishes (Schmidt, 1921; Tåning, 1952; Seymour, 1956), the mean vertebral number within a genetic stock was in each instance lowest at some intermediate temperature. Lindsey (1954) found that changes in vertebrae, basal elements of the dorsal fin, segmented rays of the anal fin, and pectoral fin rays were all minimal at an intermediate temperature.

Changes in the salt content of the medium in which fish develop can alter the effect of temperature on meristic characteristics. Heuts (1949) compared differences induced by temperature and salinity in fin-ray numbers of the three-spined stickleback, *Gasterosteus aculeatus*. Two genetic stocks were utilized, one a freshwater race, the other a brackish water race. In one race, the salinity that caused maximum variation in the median fins with temperature changes, coincided with that salinity which produced the minimum variation in the other race, and vice versa. The greater variation in each group occurred at the salinity to which the particular race was best adapted.

Low oxygen tension produces effects parallel to those of low temperature (Hubbs, 1926; Tåning, 1952; Seymour, 1956). Characters that are last to appear in development are more labile (Barlow, 1961).

Martin (1949) demonstrated that body form in the Atlantic salmon (Salmo salar) was influenced by size during relative growth stanzas. The stanzas were found at approximately the eyed-egg stage, hatching, ossification, and sexual maturity. Since body size at the stanzas was an influencing factor on the determination of body parts, it appears that the immediate environment can alter body proportions during a considerable length of time. Rainbow trout (Salmo gairdneri) reared at high temperatures, consequently faster growing fish, had smaller heads than those reared at low temperatures (Martin, 1949). Mottley (1941) introduced the use of covariance procedure in comparing two populations of fishes on the basis of morphometric data. Ichthyologists and fishery biologists have widely used morphometric data in studying races of fish (Lund, 1957). The advantages of using some form of regression analysis when comparing such data, and the disadvantages of using other techniques, have been pointed out by Marr (1955).

Domestic effluents have different effects on fishes, depending on concentration and amount of decomposition. Fishes are resistant to the effects of domestic effluents unless the dissolved oxygen is exhausted from the water for some time. The effects of sewage on fish life varies greatly with the season. During the winter, when the water is cold, fish are more resistant to the effects of pollution (Hubbs, 1933). Sewage may change conditions so that fry are killed, and the dead fry will not ordinarily be seen. The spawn may be prevented from hatching, or the development may be abnormal. Spawning beds may be covered over by deposits of septic sludge in which the eggs cannot hatch. Pollution may kill the animal life on which the fish normally live, thus depriving them of nourishment (Hubbs, 1933).

In a survey of fish distribution in Stillwater Creek, into which 750,000 gallons of domestic effluent were released each day (Moore and Mizelle, 1939), and another survey in 1947 when the stream load was 1,600,000 gallons per day of which 850,000 gallons were untreated (Cross, 1950), a comparison of data indicated that raw sewage had been beneficial to the fish fauna.

Although several studies (Ludzack, Ingram and Ettinger, 1957; Carpenter, 1930; Ellis, 1937; Katz and Gaufin, 1952) all demonstrated the effect of wastes on fish distribution, neither sewage nor industrial effluents have ever been implicated in influencing meristic or morphometric variations in fishes.

This study was designed to investigate the possible effects of refinery and domestic effluents in isolating subpopulations of fishes or in directly modifying fish structures.

CHAPTER II

MATERIALS AND METHODS

Technique of Sampling

Fish collections were made twice each month from June, 1963 through May, 1964 with the exception of one collection in December, 1963, when ice conditions made traveling impossible. Samples were collected with two "Common-Sense" minnow seines: one was 10 feet by 3 1/2 feet with 1/8 inch square mesh; the second was 6 feet by 4 feet with 1/4 inch square mesh.

Collected fish were fixed in 10 percent formalin for four days, washed in water and stored in 50 percent isopropyl alcohol.

Collecting stations were about equidistant apart along Skeleton Creek, with four stations (60, 46, 33 and 15) below the effluent outfalls, and one station (5) 5 miles above the effluent outfalls. Station 2 was on Boggy Creek, 2 miles above the Enid effluent outfalls. Two control stations were selected for comparison, one on Turkey Creek and the other on Otter Creek.

Meristic Characters

Ten meristic characters were studied; and of these, three are reported in this study: numbers of lateral line scales, pectoral fin rays and predorsal scale rows, which conform to the description of

Hubbs and Lagler (1957).

Samples were lumped in three four-month periods to increase the sample size (Table LIII).

An IBM 1410 computer was used to compare fishes collected at one station with those collected at others. The means for seasonal fish samples were compared by use of Students "t" at the 95 percent confidence level. Only significantly different data are listed in the tables.

Morphometric Characters

Seven characteristics were measured with calipers, and weight was determined to the nearest tenth of a gram. Morphometric characters were standard length, body depth, pectoral fin length, and head length were measured according to the description of Hubbs and Lagler (1957). The following measurements were also made: head depth, measured as the distance from dorsum to venter directly behind the eye; nape length, as the distance from anterior origin of dorsal fin to origin of the nape; and body width, measured in front of the dorsal fin origin.

Standard length was used as the independent variable in all comparisons, and all other characters were employed as dependent variables. Seven regressions were determined for the specimens from each station. Homogeneity of regressions was proposed as the null hypothesis and was tested by the appropriate "F" test in an analysis of covariance (Snedecor, 1946). If slopes were judged homogeneous, the intercepts were tested for homogeneity. When the slopes were found heterogeneous, the slopes were tested among stations to determine which populations were different.

When reference is made to significant values, the 99 percent confidence level is implied.

The term "population" is employed to mean "the individuals of a given locality which potentially form a single interbreeding community" (Mayr, Linsley and Usinger, 1946).

CHAPTER III

DESCRIPTION OF AREA

General Description

Skeleton Creek is a permanent stream which originates near Enid, Oklahoma; flows southeasterly through Garfield, Kingfisher, and Logan counties for approximately 75 miles; and empties into the Cimarron River 5 miles north of Guthrie, Oklahoma (Fig. 1). Stream elevation is 1,244 feet at Enid and 910 feet at the mouth, with an average gradient of 6 ft/mi.

Skeleton Creek is a sixth order stream (Horton, 1954). Stream depth varies from a few inches in the riffles to 6 feet in pools.

The exposed rocks in the drainage basin were laid down in the seas of Permian time and are commonly referred to as "Permian Red Beds" (Fitzpatrick, Boatright and Rose, 1930; Galloway, 1948; Galloway, 1960). The Enid groups of this formation are composed of sandstone, shales, and limestones. In narrow areas along the Cimarron River, Skeleton Creek, and Cottonwood Creek, the Permian rocks are mantled with loose loam and Quarternary sand deposits laid down mainly in Pleistocene time (Galloway, 1960).

The climate is continental and is characterized by wide fluctuations in temperature. The sun shines approximately 70 percent of the time. The average frost-free season is from March to October, approximately

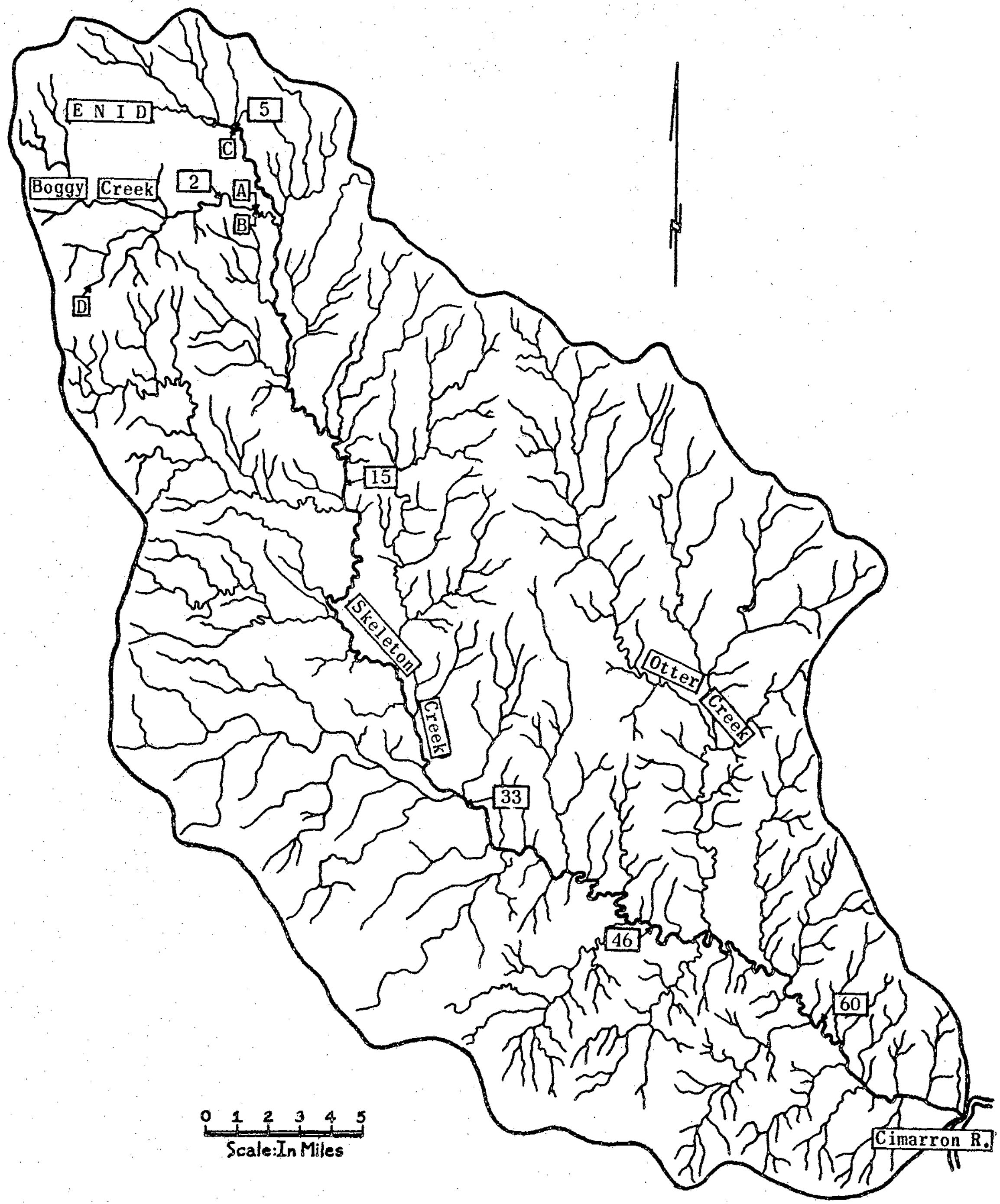

Fig. 1. Skeleton Creek watershed, Garfield, Kingfisher, and Logan Counties, Oklahoma. Stations 15 to 60 are numbered according to distance in miles downstream from the confluence of Skeleton and Boggy Creeks. Station 5 is located five miles upstream from the confluence. Station 2 is located two miles upstream from oil refinery and Enid municipal sewage plant outfalls. A = oil refinery outfall; B = Enid municipal sewage plant outfall; C = state hospital sewage plant outfall; D = military installation sewage plant outfall.

215 days (Fitzpatrick et al., 1939). Mean annual rainfall is between 29 and 30.6 inches; and mean annual temperature is between 59.3 and 61.8 C for the three counties (Fitzpatrick et al., 1939; Galloway, 1960; Fisher et al., 1962).

In Skeleton Creek, stream flow and turbidity exhibited seasonal and longitudinal variations. In general, spring and summer months were periods of high flow and turbidity, whereas during fall and winter reverse conditions prevailed. Longitudinal variation in these conditions was slight in fall and winter and considerable in spring and summer (Wilhm, 1965).

Longitudinal variations in dissolved oxygen concentrations were greater than seasonal fluctuations. Mean oxygen concentrations in spring, summer, and fall were similar; but winter concentration was higher. Oxygen concentrations averaged 3.1 ppm in spring, 3.4 ppm in summer, 4.5 ppm in fall and 7.1 ppm in winter. Oxygen varied from 0.2 ppm 25 miles below effluent outfalls in May to 21.5 ppm 4.4 miles below effluent outfalls in March (Wilhm, 1965).

Variation in water temperature among stations was slight except in upper reaches of the stream and was attributed to sampling station order. Water temperature varied from 0 C in January to 35 C in August. Water temperature at Station 60 ranged from 1.5 C in February to 30 C in August, and at Station 15 from 2.3 C in February to 34 C in August.

Source of Pollution

Both municipal and industrial wastes enter Skeleton Creek (Fig. 1). Approximately 90,000 gal/day of domestic effluent enter the headwaters from holding ponds of North Enid. Two miles below the ponds domestic effluent from the Enid State Hospital enters the creek.

Boggy Creek originates southwest of Enid and receives both municipal and industrial wastes. An air base empties approximately 185,000 gallons of effluent per day 9 miles above the confluence with Skeleton Creek. Boggy Creek flows northeast through Government Springs Park, and domestic sewage from Enid enters approximately 1 mile above its confluence with Skeleton Creek. Over 4 million gallons of sewage is treated each day, and of this amount, approximately 1.5 million gallons is pumped to an oil refinery for use in refining processes. Approximately 720,000 gallons of effluent from the oil refinery leaves holding ponds after a retention period of 27 days. The effluent enters Boggy Creek 300 feet above the Enid sewage treatment plant outfall.

Description of Stations

After a preliminary study of Skeleton Creek from February through May, 1963, six stations were selected. Stations were designated by numbers according to distance in miles from the confluence of Boggy Creek with Skeleton Creek.

Station 60: 60 miles below effluent outfalls or 3 1/2 miles south and 4 3/4 miles west of Mulhall, Logan County, Oklahoma. The bottom was composed of sand, mud, red clay, large rocks and parent material. Water color varied from greenish to brownish-red. Samples were collected from riffles and pools approximately 4 feet in depth. The north and south banks were approximately 30 feet high. The dominant plants on the stream banks were _Ulmus americana_ (American elm), _Celtis occidentalis_ (rough-leafed hackberry), _Quercus macrocarpa_ (bur oak), *Cornus drummondii* (rough-leafed dogwood), *Sorghum halepense* (Johnsongrass), *Chenopodium album* (lambs quarters), and *Erigeron canadensis* (marestail fleabane). The nomenclature of plants is from Waterfall (1962).

Station 46: 46 miles below effluent outfalls or below the bridge on State Highway 74, 3 2/3 miles south of State Highway intersection 74 and 51, Logan County, Oklahoma. The bottom was composed of mud, rock, sand, and gravel. Water color varied from greenish to brownish-red. Samples were collected from riffles and pools approximately 4 feet in depth. The north and south banks were approximately 15 feet high. The dominant plants on the stream banks were *Populus deltoides* (cottonwood), American elm, Johnsongrass, *Desmanthus illinoensis* (Illinois bundle flower), and *Ambrosia trifida* (giant ragweed).

Station 33: 33 miles below effluent outfalls or below the bridge on State Highway 51, 6 miles west of intersection of State Highways 51 and 74, Kingfisher County, Oklahoma. The bottom was composed of mud, sand and parent material. Water color was clear to brownish-red. Samples were collected from running water 6 inches to 3 feet in depth. The east and west banks were approximately 5 feet high. The dominant plants on the stream banks were *Fraximus pennsylvanica* (green ash), *Salix nigra* (black willow), cottonwood, Johnsongrass, giant ragweed, and *Polygonum pennsylvanicum* (smartweed).

Station 15: 15 miles below effluent outfalls or below the bridge 5 1/3 miles west of Douglas, Garfield County, Oklahoma. The bottom was composed of mud, sand, gravel and parent material of red shale underlying riffles. Water color was greenish to brownish-red. Samples were collected from water 6 inches to 2 1/2 feet in depth. The east and west banks were approximately 5 feet high. The dominant plants on the stream banks were cottonwood, giant ragweed, smartweed, and mares-tail fleabane.

Station 2: 1/4 miles east of Thirtieth and Market Avenue, Enid, Garfield County, Oklahoma, below first bridge on U. S. Highway 64 east of Enid, above effluent outfalls. The bottom was composed of sand, gravel, clay and parent material. Water color was clear to brownish-red. Samples were collected from water 6 inches to 3 feet in depth. There was a cultivated field on the east side with the east and west banks approximately 10 feet high. The dominant plants on the stream banks were cottonwood, American elm, Johnsongrass, and Cynodon dactylon (Bermudagrass).

Station 5: Southeast corner of State Hospital north of bridge on Thirtieth Street, Enid, Garfield County, Oklahoma, above effluent out-falls. The bottom was composed of sand, gravel and parent material. Water color was dark brown. Samples were collected from water 1 foot to 3 1/2 feet in depth. The east and west banks were approximately 4 feet high. The dominant plants on the stream banks were Carex gravida (sedge), Artemisia ludoviciana (Louisiana sagewort), smartweed, Mentha spicata (spearmint), and Solidago sp. (goldenrod).

Station T: (Turkey Creek). 4 miles north of Drummond, Garfield County, Oklahoma, on State Highway 132 or below Blue Perry Bridge. The bottom was composed of mud, silt, clay and sand. Water color was dark brown. Samples were collected from water 6 inches to 3 1/2 feet in depth. The north and south banks were approximately 25 feet high.

The dominant plants on the stream banks were cottonwood, black willow, *Carya illinoensis* (pecan), Johnsongrass, Bermudagrass, smartweed, *Xanthium pennsylvanicum* (cocklebur), and *Erigeron strigosus* (daisy fleabane).

Station 0: (Otter Creek). 1 1/2 miles east of Highway junction 74 and 51 underneath bridge on Highway 51, Logan County, Oklahoma. The bottom was composed of mud, silt, and rocks; and the water color was dark brown. Samples were collected from water 1 foot to 4 feet in depth. The east and west banks were approximately 6 feet high. The dominant plants on the stream banks were green ash, Johnsongrass, *Tridens flavus* (purple top), and giant ragweed.

CHAPTER IV

DESCRIPTIONS AND LIFE HISTORIES OF SPECIES STUDIED

Notropis lutrensis (Baird and Girard)

The red shiner, *N. lutrensis*, ranges west of the Mississippi River from South Dakota and Wyoming south to Mexico. It is now established, after bait introduction, in the Lower Colorado River, California, and Arizona (Moore in Blair, et al., 1957). This minnow has a deep, thick body when compared with a closely related form, *Notropis whipplei*, and seems to be a more specialized form. The body depth is contained about three times in standard length. The fin rays are D.8, A.9, $P._1$ 11-16, and the 29-37 scales in the complete lateral line are of usual shape, their exposed heights less than 2.0 times their widths.

Coloration: The breeding males of *N. lutrensis* in Skeleton Creek have the caudal, anal, pectoral, and pelvic fins a deep orange-red, with the outer border clear. The dorsal fin is almost black because of the presence of melanophores on the interradial membranes, although a reddish tinge can be seen. The dorsum is a light olive-green, blending into a steel-blue lateral surface with a white venter. The preopercle has a blue slash with a red slash on opercle and subopercle, followed by a blue slash behind the gill opening and a red slash immediately posteriad. The dorsum of the head is a brilliant red.

White nuptial tubercles cover most of the body. Eye diameter is greater than 1/2 the length from anterior rim of eye to snout tip. The mouth is oblique, with protractile lips.

The female in breeding color may have the caudal and anal fin with light red tinge. The dorsum is olive-green, with a steel gray lateral surface, and white on the venter.

Habits: N. lutrensis is a stream minnow, being especially abundant in swift riffles of rocky streams. It spawns from late May to the middle of August, usually at night (Saksena, 1962). Hatching occurs in approximately 105 hours, when maintained at a temperature of 24.5 C (± 2 C). At the end of 35 days fry were 16.4 mm total length (Saksena, 1962).

Natural foods include algae, insects and crustaceans (Koster, 1957). Cross (1950) found N. lutrensis had fed heavily on Chaoborus during spring and early summer.

Notropis stramineus (Girard)

The sand shiner, N. stramineus, (formerly N. deliciosus) ranges principally from the Rocky Mountains to the Appalachians and from the Great Lakes to Mexico, but apparently is absent on the Gulf Coast east of the Mississippi (Moore in Blair, et al., 1957). The nomenclature of this small minnow is in such a state that it is very difficult to determine which name should be used for this form. Hubbs and Ortenburger (1929) recognized Notropis deliciosus deliciosus from the Red River system and N. deliciosus missuriensis from the Arkansas River system. They pointed out the need for a statistical study to separate these subspecies. The relationship of N. d. deliciosus to N. d. missuriensis, as well as to the subspecies of N. volucellus with which they have been confused, was discussed by Hubbs and Greene (1928).

Clark Hubbs (1954 (1): 72-73) recognized two species in the type series of Moniana deliciosa Girard, 1856. He referred two of eleven specimens to Notropis deliciosus (Girard) and designated one as lectotype which retained the original catalogue number, and the other was recatalogued. The remaining nine specimens were determined by Clark Hubbs to be Notropis volucellus nocomis and recatalogued.

Suttkus (1958) after critical examination and comparisons of the type material with fresh specimens made the following determinations. The lectotype of Moniana deliciosa is not referable to Notropis deliciosus (as known by current workers as Notropis stramineus) but equals Notropis texanus (Girard), 1856. The lectoparatype of Moniana deliciosa is equal to N. v. nocomis. Of the remaining nine specimens, eight are referable to N. v. nocomis and one represents Notropis texanus. Thus no specimen of this type series represents Notropis deliciosus as known currently. The first available name was designated by Cope (1864) as N. stramineus.

According to Suttkus, Notropis stramineus shows little development of a dark lateral band anteriorly; the upper edge of the upper lip only is pigmented and the lower part of upper lip and lower lip are usually immaculate. It rarely has pigment around the anus and has only a few deep seated melanophores along the anal fin. There is a patch of melanophores at the origin of the dorsal, at the posterior base of dorsal and at the base of anterior upper caudal rays.

N. stramineus examined in this study had 7 anal rays, rarely 8; the fin has practically no pigment. The 29-38 scales in the lateral line are of the usual shape, their exposed heights are less than 2.0 times their width. The mid-dorsal stripe is usually prominent, although more prominent before the dorsal fin, and is interrupted in the dorsal fin and does not extend around the dorsal fin base. There is an almost wedge-shaped spot at the dorsal fin origin. The eyes are large, and bulge when viewed from above. The pectoral fins are short, extending slightly over 1/2 the distance to the pelvic fin. The mouth is terminal and has pigment on the upper and lower lips.

Coloration: Dorsally the body is a light olive-green or straw-yellow with a lateral silvery band. The scales are outlined with pigment on the dorsum above the lateral line. Two distinct spots are present, one above and anteriad, the other below and anteriad to each lateral line pore ending on the caudal fin base as two slashes. Most of the fins are quite clear or milky with no interradial pigment present.

Breeding males are straw-colored with the fins almost white. Nuptial tubercles cover the head but are difficult to see without the use of a microscope.

Females are straw-colored with the fins almost white. The pectoral fins appear short when depressed, particularly in females distended with eggs.

Habits: N. stramineus is a minnow of sandy streams, gravel bottom riffles and pools with currents. Spawning starts in May and ends in August. N. stramineus was found under vegetation in the stream at Station 2, which differs from the description by Trautman (1957), who seldom found them among rooted aquatic vegetation. They were surprisingly tolerant to some inorganic pollutants such as mine wastes, provided those pollutants did not cover the sand and gravel (Trautman, 1957). Clemens and Finnell (1956), in a study of a stream polluted with refinery wastes, found that N. lutrensis and P. promelas were present in higher concentrations of effluents than N. stramineus. Irwin (1965) found N. stramineus to be more resistant to oil refinery effluents than N. lutrensis and P. promelas in 24-hour and 96-hour bioassay tests.

Pimephales promelas Rafinesque

The fathead minnow, P. promelas, ranges throughout the Great Plains region of Canada and the United States as well as much of the region east of the Great Plains, from the southern drainage of Hudson Bay and the Maritime Provinces of Canada southward through Ohio and the Cumberland systems to the Tennessee River basins. Apparently being absent on the Atlantic slope and the Gulf states east of the Mississippi River, but present as far west as New Mexico and Chihauhua, Mexico in the south (Moore in Blair, et al., 1957). According to Hubbs and Ortenburger (1929), the Oklahoma form is Pimephales promelas confertus, differing from the more northern races, all referred to at this time as P. p. promelas, in having the lateral line nearly complete, mouth less oblique and nuptial tubercles lacking on the chin.

P. promelas, about 2 inches long, has a robust body, which is heavier anteriad. The body depth is 3.5-4 times in standard length. The head is contained 3.0-3.4 times in standard length. The mouth is small, subterminal and quite oblique in females. The 41-56 scales in the lateral line are the usual shape.

Coloration: Breeding males are rather dark olive-green on the dorsum, with a white venter below the lateral line. The lateral band is indistinct. The dorsal fin has pigmentation along the branched rays, with a lesser amount on the interradial membranes. The caudal fin has an abundance of pigment, with the anal and pelvic fins lacking pigment. The pectoral fins have a concentration of pigment on the anterior edge appearing as a black border. The scales on the dorsal and lateral surfaces are outlined with melanophores.

Females have a yellowish cast, with less pigment in the dorsal fin. The lateral band is more distinct posteriad. Concentration of pigment through the middle of the dorsal fin appears as a black band through the fin. The ventral surface is white from the caudal fin to the chin, being almost devoid of pigment.

Habits: Secondary sex characters develop approximately thirty days before the first eggs are deposited, thus making it easy to distinguish males from females. The eggs are deposited on the underside of objects that lie parallel to the water surface. The male guards the nest and will spawn with several females. According to Markus (1934), the incubation period is approximately 5 days. The fish usually spawns at night. Wynne-Edwards (1933:383) states: ". . . the male was observed stroking the eggs apparently turning them." The young grow rapidly, and according to Markus (1934), reach maturity before the summer is over and spawn. He recorded that approximately 85% of the adults die after spawning. The spawning season is from May to August.

CHAPTER V

POPULATION STRUCTURE AND DISTRIBUTION OF FISHES

N. lutrensis

Variations in structures of fishes may be attributed to two general causal mechanisms, those that have built up over long periods of time and are genetically fixed, and those that are induced by local conditions at a particular time (somatic variations), and are reversible.

Because of the low level of differentiation among subpopulations, and the high variability within samples and among seasons, it was assumed that most of the variations observed were of a somatic nature. Previous workers have shown that characters of the sort studied herein could be influenced by environmental factors such as temperature, salinity, low oxygen tension, and amount and duration of light exposure. It was not possible to systematically determine values for these environmental factors during the periods when young fish would be influenced by them. Thus, there was no way to link variations with specific environmental agents. Likewise, it was not possible to dissociate effects of refinery wastes from those of sewage wastes on the fishes below the effluent outfalls. The following discussion will attempt to identify general factors that might have been responsible for the population structures observed.

Skeleton Creek fishes from above and below the effluent outfalls, and those in Boggy Creek (Station 2) were clearly different from those in Turkey Creek and Otter Creek (Tables IV, V, IX, X, XIV, XV and XLVII). They differed in 66 of 108 possible meristic comparisons, and 46 of 86 possible morphometric comparisons.

Otter Creek fishes were different from those in Turkey Creek (Tables XI, XVI and XLI). They differed in 2 of 9 possible meristic comparisons, and 4 of 7 possible morphometric comparisons.

Fishes from below the effluent outfalls were clearly different from those above (Tables III, VIII, XIII and XLVII). They differed in 36 of 72 possible meristic comparisons, and 29 of 56 possible morphometric comparisons.

Populations at Stations 2 and 5 were significantly different from one another (Tables VI, XI, XVI and XL). They differed in 6 of 9 possible meristic comparisons, and 5 of 7 possible morphometric comparisons.

Three groups or subpopulations could be distinguished in the four stations below effluent outfalls on Skeleton Creek: Stations 15 and 33 appeared generally homogeneous, Station 46 differed from other subpopulations in 22 of 48 possible comparisons, and those at Station 60 differed from the others in 20 of 48 possible comparisons (Tables II, VII, XII, XXXIX and XLVIII).

In summary, seven distinct subpopulations of _N. lutrensis_ were found (Fig. 2). They were located at Stations 60, 46, 33-15, 2, 5, Turkey Creek and Otter Creek. Differences were maintained between subpopulations throughout the year, though some mean counts or measurements varied at one station throughout the seasons. Seasonal variations

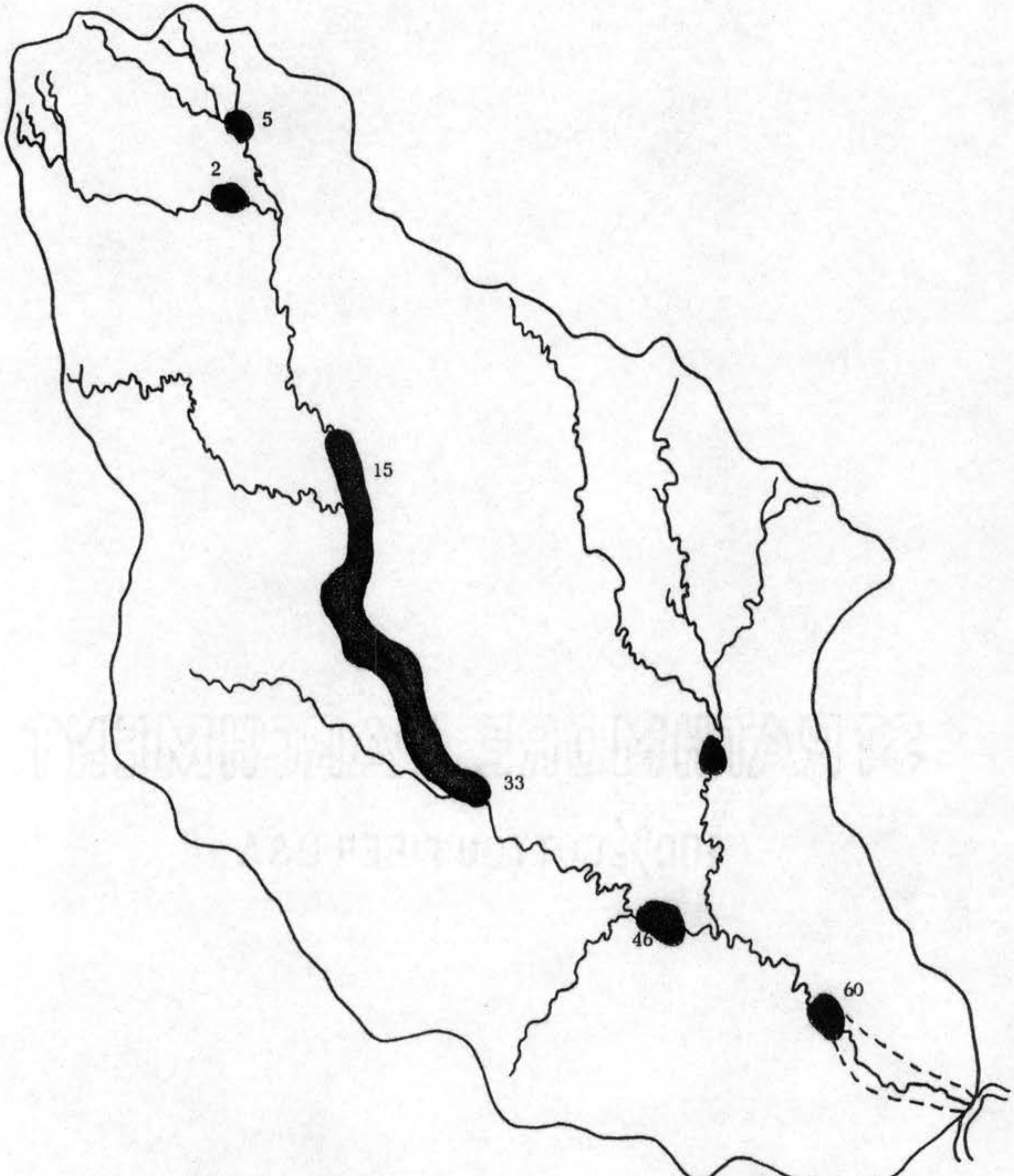

Fig. 2, Local populations of Notropis lutrensis.

probably were due to immigration or emigration of distinct fish schools in the immediate locality.

Populations in Turkey Creek, Otter Creek, Stations 2 and 5 appeared to be relatively stable; and they were present throughout the year.

Populations below effluent outfalls varied sharply (Table LIII) with the season. Baumgardner (1966) has shown that temporary changes in dissolved oxygen, presence of chlorides, and conductivity occurred in the stream after heavy rainfall and could have influenced distribution of subpopulations.

The fact that the populations at Turkey Creek, Otter Creek, Stations 2 and 5 were so distinct suggests that they were permanently or nearly permanently isolated from one another. It is likely that each of these stations contained a resident population influenced only in a minor way, if at all, by migrating river or tributary fishes.

Effluent outfalls apparently formed an impassible barrier which prevented downstream fishes from reaching the headwaters of Skeleton Creek. During floods, however, some upstream fishes may have been washed down below effluent outfalls and contributed to downstream variability. Notemigonus crysoleucas were present at Station 15 after heavy rainfall, but at no other time.

The apparent presence of three distinct subpopulations below effluent outfalls is more difficult to explain. Station 60 is very close to the Cimarron River and the influx of fishes from the river was quite obvious, especially during the spring spawning run. Considerable variability among seasons (Tables II, VII, and XII) also indicate that subgroups from the river moved in and out of the area rather freely. Pollution effects were minimal, and probably of little consequence in determining species composition and abundance throughout most of the year.

Stations 46 to 15, however, showed a different pattern. Phillips (1965) showed that species composition and abundance of fishes (Table LIII) varied markedly with the season, especially at upstream stations. This suggests that effluents were a limiting factor during certain, and perhaps all, seasons.

Baumgardner (1966) found that dissolved oxygen concentration at Station 15 varied diurnally between 1.20 to 5.8 ppm on 28-29 June at 15 to 79 percent saturation, whereas on 28-29 February, dissolved oxygen concentration varied from 9.6 to 15.70 ppm at 72 to 130 percent saturation. At Station 46 dissolved oxygen concentration varied diurnally from 6.05 to 19.55 ppm at 79 to 257 percent saturation on 12-13 August.

Dissolved oxygen may have been a limiting factor during the summer on developing embryos at Station 15. Since the winter dissolved oxygen concentration was high and fishes left the stream, it is likely that other limiting factors were present at this station. Concentration of dissolved oxygen at Station 46 was high, so that it was probably not a limiting factor on developing embryos. However, there was a marked inflow of oil field brines (chlorides 349 ppm) from a large tributary at Station 46.

It appeared that fishes at these stations left the stream during markedly adverse periods, but they were present during the breeding season. Young fishes were captured at all stations during summer and fall, and it is likely that they had undergone early developmental stages in these modified environments. The question of their location in winter cannot be answered directly, since mark and recapture studies were not carried out. However, it seems likely that if large numbers of these fishes moved downstream they would tend to change the sample means at Station 60 toward those of upstream samples earlier in the year. Tables II, VII and XII show that this was definitely not the case since the means did not increase. The capture of some of these fishes in tributaries during the winter also indicates that upstream populations moved into the tributaries rather than downstream during the fall and winter migrations out of the main stream. Thus it appears that populations at Stations 33-15 and 46 were resident populations that moved into adjacent tributaries when the main stream environment became intolerable or offensive. Furthermore, differences between the two populations suggests that the nursery environments differed enough between these two areas to affect early developmental stages in this species. Brine influx at Station 46 may have been responsible for the extreme values for many characteristics found at this station.

N. stramineus

N. stramineus were restricted in their habitat preference. Stations 15, 5 and Otter Creek yielded a total of five specimens in a year. Skeleton Creek fishes below effluent outfalls and those in Boggy Creek were different from those in Turkey Creek (Tables XIX, XX, XXIII, XXIV, XXVII, XXVIII and XLIX). They were different in 22 of 36 possible meristic comparisons, and 11 of 28 possible morphometric comparisons.

Fishes collected below the effluent outfalls were different from those in Boggy Creek (Tables XVIII, XXII, XXVI and L). They were different in 18 of 27 possible meristic comparisons and 12 of 21 possible morphometric comparisons.

In contrasting the three stations below the effluent outfalls in Skeleton Creek, two groups or subpopulations could be distinguished: Stations 46 and 33 appeared to be homogeneous and differed from Station 60 in 15 of 32 possible comparisons (Tables XVII, XXI, XXV, XLII and LI).

Four distinct subpopulations of *N. stramineus* could be distinguished at Stations 60, 46-33, 2 and Turkey Creek (Fig. 3). Differences between subpopulations occurred throughout the year. Mean counts or measurements varied at one station throughout the seasons, probably because of movements of schools in the sampling area.

N. lutrensis are especially abundant in swift riffles of rocky streams but occur in many different types of stream environments, whereas *N. stramineus* are restricted in their habitat preferences and are not found in areas without currents. *N. stramineus* were absent in stations without sand or gravel bottoms.

The absence of *N. stramineus* at Station 5 indicated the presence of limiting factors in the intermittent section of Skeleton Creek. The lack of moving water there during certain seasons could have been limiting. The absence of this species in Otter Creek may have been due to the intermittent nature of the stream, with mud bottom instead of sand and gravel. Absence at Station 15 is difficult to explain, except that the combined concentration of the effluents could have been limiting. Dissolved oxygen concentrations also could have been critical

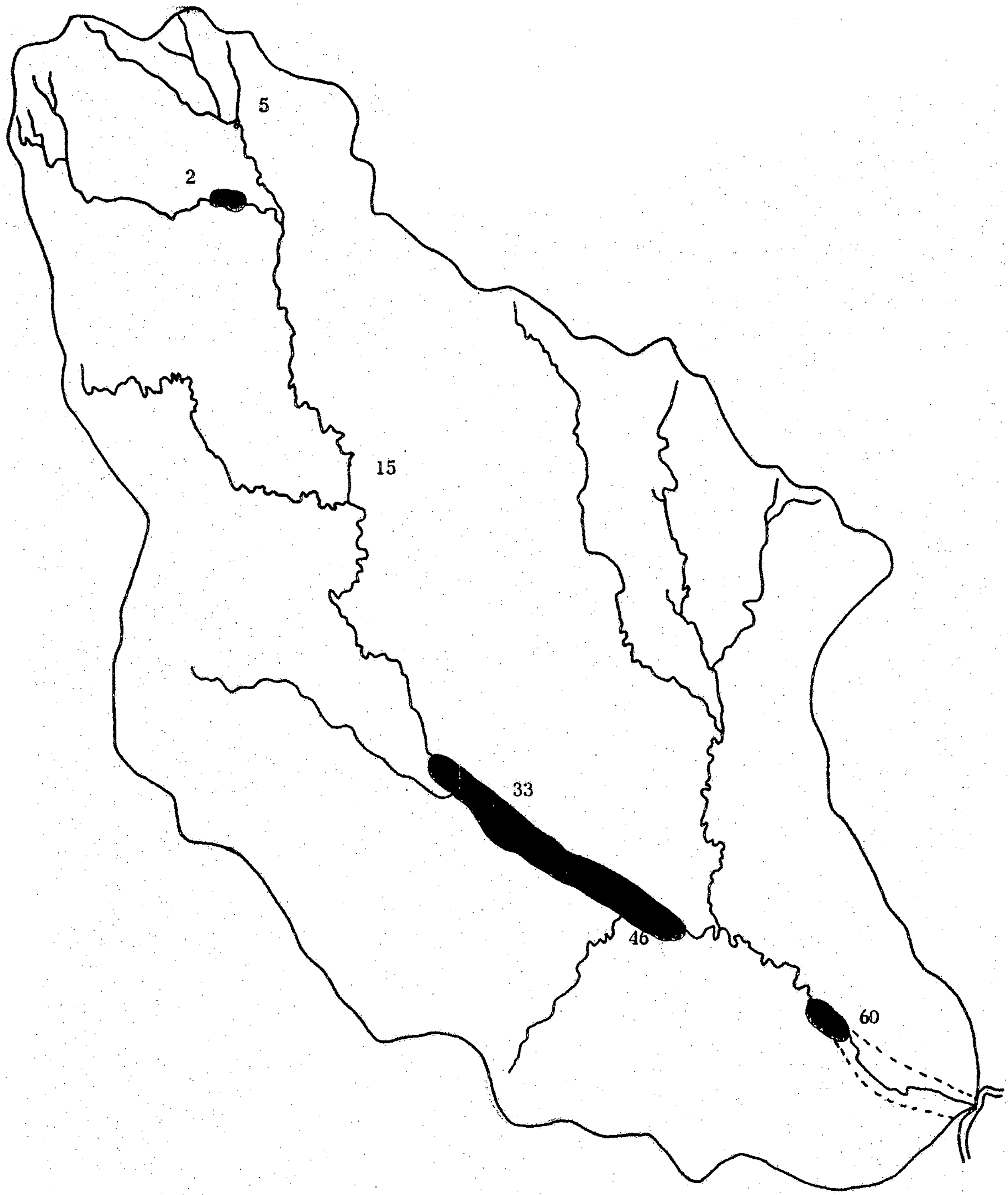

Fig. 3. Local populations of Notropis stramineus.

during the summer months. The moving water, and sand and gravel bottom would appear to satisfy their habitat requirements.

Populations in Turkey Creek and Station 2 appear to have been relatively stable, and they were present there throughout the year.

Populations below the effluent outfalls fluctuated sharply (Table LIII) with seasons. Temporary changes such as heavy rainfall, low dissolved oxygen, shifts in chloride content and conductivity could have been critical to the subpopulations, and caused movement of schools in and out of the stream.

It is likely that these two stations supported resident populations, influenced only in a minor way, if at all, by migrating river or tributary fishes. As in N. lutrensis, it appears that effluent outfalls formed an impassible barrier which prevented downstream fishes from reaching the headwaters of Skeleton Creek. Thus, Turkey Creek and Station 2 were permanently isolated from each other. The presence of only two specimens at Station 5 during this study supported this hypothesis.

The apparent presence of two distinct subpopulations below the effluent outfalls is difficult to explain. Station 60 is very close to the Cimarron River, and the influx of fishes during the spawning run could have supplemented this population, as in N. lutrensis. Considerable variability among seasons also suggests that subgroups from the river moved in and out of the area rather freely (Tables XVII, XXI and XXV).

Stations 46 to 33, however, showed a different pattern. Phillips (1965) showed species composition and abundance of fishes (Table LIII) varied markedly with the seasons, especially at Station 46. It is possible that the influx of oil field brines at Station 46 could have been a limiting factor, and could have helped keep the subpopulations (Stations 60 and 46-33) isolated from each other.

P. promelas

P. promelas also appeared restricted in its habitat preferences. Stations 60, 46, 15, Turkey Creek and Otter Creek failed to yield enough specimens to be utilized in an analysis without biasing the data.

Fishes from Station 33 were different from those at Station 2 (Table LII) in 6 of 16 possible comparisons.

Subpopulations at Stations 2 and 5 differed in 6 of 16 possible comparisons (Tables XXX, XXXVIII and XLV).

In contrasting the four stations below the effluent outfalls in Skeleton Creek, based on small numbers of individuals, it appeared that only one group or subpopulation existed (Tables XXXI, XXXV and XLIV).

In summary, there were three distinct subpopulations of P. promelas represented in the samples studied (Fig. 4). They were located at Stations 60-15, 2 and 5. Although mean counts or measurements at each station varied seasonally, significant differences again were maintained between subpopulations throughout the year.

The absence of this species from Otter Creek suggests the presence of limiting factors in the main body of the stream. However, in a collection in June, 1965, P. promelas was the most abundant species collected in tributaries to Otter Creek. Fish were collected in isolated

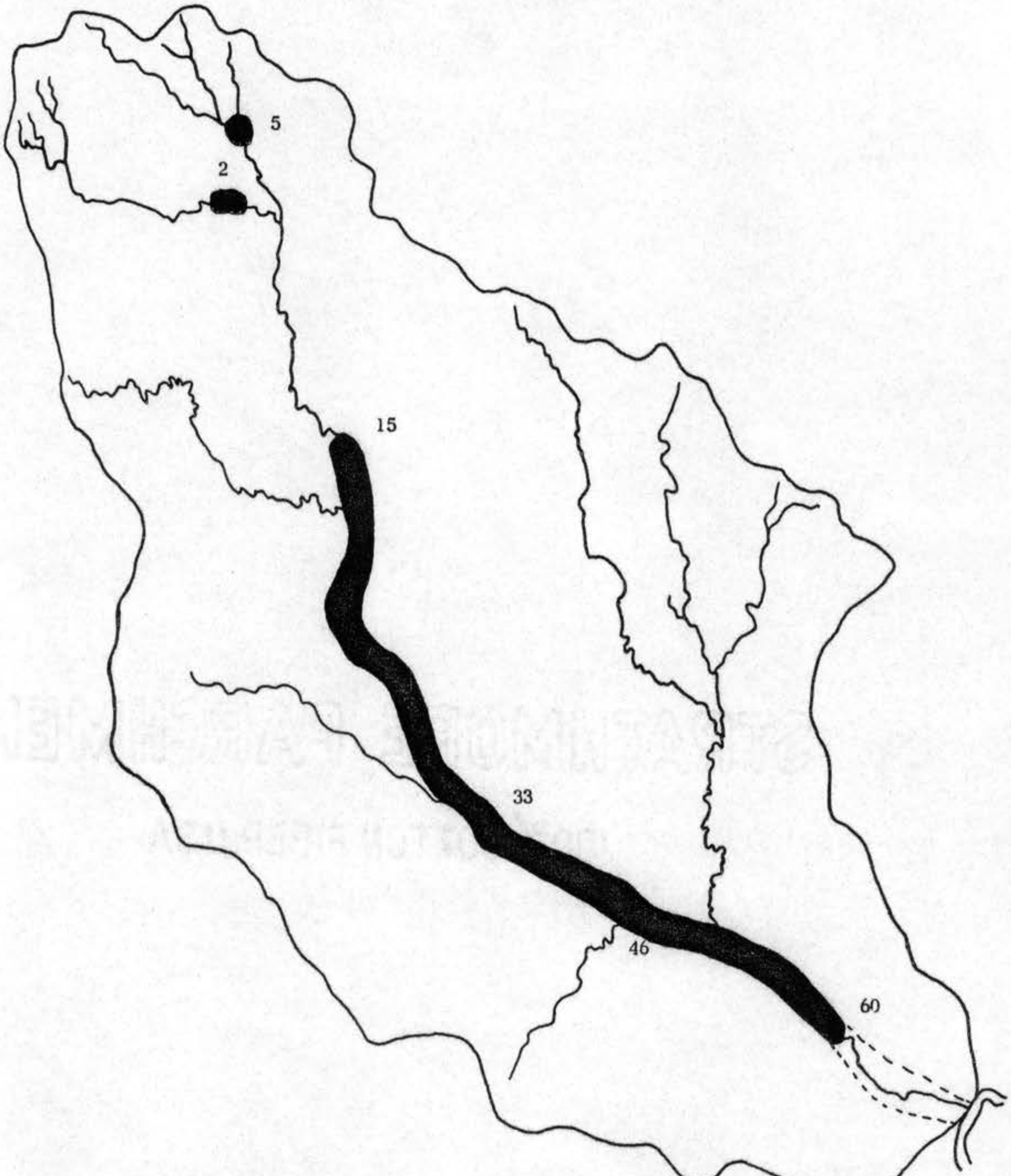

Fig. 4. Local populations of Pimephales promelas.

pools with mud bottoms, which may indicate its preference for this type of habitat. They are common commercial minnows, raised in minnow ponds, and thus do well in quiet waters.

The lack of sufficient numbers of individuals at Stations 60, 46, 15 and Turkey Creek indicates that this species had environmental requirements that were different from those of N. lutrensis and N. stramineus. N. lutrensis and N. stramineus are stream minnows preferring currents and habitats, as previously discussed.

The population at Station 2 appeared to be relatively stable, and they were present throughout the year. Those at Station 5 varied more, yet were completely separated from those at Station 2. The population at Station 5 was probably influenced by migrating schools from small tributaries above this station.

Populations below effluent outfalls varied with the seasons (Table LIII). Variations of conditions in the main stream are believed to have had little effect on this species, particularly because of its preference for small pools in the tributaries. It appears that the currents could have been a critical factor along with the combined effluents. Migrating schools could have been one cause of seasonal variations.

Presence during the spawning season suggests its tolerance to the effluents, and presence of juveniles would indicate that spawning had occurred in the stream. The homogeneity of the population below the effluent outfalls suggests that its movements were unrestricted in Skeleton Creek, or that its tolerance to different concentrations of effluents was greater than N. lutrensis and N. stramineus. Most P. promelas were taken at Station 33 where Wilhm (1965) found fluctuations in dissolved oxygen concentrations most extreme below the effluent outfalls.

The fishes above the effluent outfalls were distinctly different from those below, and bioassay data (Phillips, 1965) suggests that these fishes could not move through the effluent outfalls.

In summary, it appears that influx of effluents can affect species composition, distribution, and abundance of fishes in the stream. These effects were more significant at certain times of the year (Table LIII), but at all times effluents could act as effective barriers isolating upstream populations from downstream populations. Influx of sewage wastes alone produced larger fishes at Station 2. The combination of effluents appeared to act as a noxious (or toxic at times) stimulus, limiting fish types and numbers.

Distinct morphological differences were found in local populations of fishes. Environmental factors such as temperature, dissolved oxygen, salinity and amount and duration of light have been implicated in modifying morphological characteristics of fishes. Since Baumgardner (1966) has shown the effluents modify environmental factors, it is possible that the effluents may have influenced fish structures by indirect means. It is also possible that the effluents themselves may have influenced developmental processes directly. Either or both of these factors may be responsible for the increased variability of Skeleton Creek fishes.

CHAPTER VI

SUMMARY

1. Bimonthly field collections were made from June, 1963 to June, 1964 in an effort to determine population structure in three species of cyprinid fishes.
2. Three streams were sampled; two unpolluted streams served as controls for comparative purposes, while the third received oil refinery and domestic effluents.
3. Meristic and morphometric characteristics were employed to separate groups or subpopulation of fishes.
4. Subpopulations above the effluent outfalls were more stable and probably were not affected by immigrating and emigrating schools.
5. Subpopulations below the effluent outfalls were influenced more by immigrating and emigrating schools of fishes from the Cimarron River and tributaries of the area.
6. Industrial and domestic effluents could have produced variations in the meristic and morphometric characteristics of subpopulations below the effluent outfalls.
7. Emigration of fishes below the effluent outfalls suggested that fishes were less resistant during certain seasons to the effects of effluents or that effluents could have varied in concentration (or toxicity).

8. Domestic effluents appeared to be beneficial in increasing the size of fishes in the absence of refinery effluents.

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A P P E N D I X

TABLE I

SUMMARY OF ALL COMPARISONS AMONG SAMPLES OF ALL SPECIES USED IN THIS STUDY. (+) REPRESENTS SIGNIFICANCE AT NINETY-FIVE PERCENT LEVEL ON MERISTIC CHARACTERS AND NINETY-NINE PERCENT ON MORPHOMETRIC CHARACTERS; (-) REPRESENTS NOT SIGNIFICANT, (0) REPRESENTS NO FISH COLLECTED

Station	Meristic									Morphometric						
	L.L.S.			P_1C.			P.D.R.									
	1	2	3	1	2	3	1	2	3	Wt	NL	HD	BD	BW	P_1L	HL
N. lutrensis																
60-46	-	+	-	+	+	+	+	+	+	+	-	-	-	-	-	-
60-33	-	+	+	-	+	-	+	+	+	+	-	-	-	-	-	-
60-15	-	+	0	-	+	0	+	+	0	-	-	-	-	-	-	+
60- 2	-	+	+	+	-	-	+	+	+	+	+	-	-	-	+	-
60- 5	-	-	+	-	+	-	+	+	+	+	+	+	-	-	+	+
60- T	-	-	-	+	+	+	+	+	+	-	+	-	+	-	-	-
60- 0	+	-	+	+	+	-	+	+	+	+	+	-	+	+	-	-
46-33	-	-	+	+	+	+	-	+	+	+	-	-	-	-	-	-
46-15	+	+	0	+	-	0	-	+	0	+	-	-	-	-	-	+
46- 2	+	-	+	+	+	+	+	-	-	+	+	-	-	-	+	-
46- 5	-	+	+	+	+	+	-	+	-	+	+	+	+	-	+	+
46- T	-	+	-	+	+	+	+	-	-	+	+	-	+	-	-	-
46- 0	-	+	+	+	+	+	+	-	+	+	+	-	+	+	-	-
33-15	+	-	0	-	+	0	-	-	0	-	-	-	-	-	-	-
33- 2	+	-	-	+	+	-	+	+	+	+	+	-	-	-	+	-
33- 5	-	+	-	-	-	-	-	-	+	-	+	-	-	-	+	+
33- T	-	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-

TABLE I (Continued)

Station	Meristic L.L.S. 1	2	3	P_1C. 1	2	3	P.D.R. 1	2	3	Morphometric Wt	NL	HD	BD	BW	P_1L	HL
N. lutrensis																
33- 0	-	+	-	+	+	-	+	+	+	+	+	-	+	+	-	-
15- 2	-	-	0	+	+	0	+	-	0	+	+	-	+	-	+	+
15- 5	-	+	0	-	+	0	-	-	0	-	+	-	-	-	-	-
15- T	+	+	0	+	+	0	+	+	0	+	+	-	-	-	-	+
15- 0	+	+	0	+	+	0	+	+	0	+	+	-	+	+	-	-
2- 5	-	+	-	+	+	+	+	+	-	+	-	+	+	-	+	+
2- T	+	+	+	-	+	+	-	+	-	+	-	-	+	-	+	-
2- 0	+	+	+	-	+	-	-	-	+	+	-	-	+	+	+	+
5- T	-	-	+	+	+	+	+	+	-	+	-	+	-	-	+	+
5- 0	+	-	+	+	+	-	+	+	+	+	-	+	+	+	+	+
T- 0	-	-	-	-	-	+	-	-	+	+	-	-	+	+	-	-
N. stramineus																
60-46	-	+	0	-	+	0	+	+	0	+	-	-	-	+	-	-
60-33	-	+	0	+	+	+	+	+	-	+	-	-	+	+	-	-
60-15	-	0	0	-	0	0	+	0	0	+	+	-	-	-	-	-
60- 2	+	+	+	-	+	+	+	+	+	+	-	+	-	+	+	+
60- 5	-	0	-	-	0	-	-	0	-	-	-	-	-	-	-	-
60- T	+	+	+	-	+	+	+	+	+	+	-	+	+	+	-	+
60- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46-33	-	+	0	-	-	0	+	-	0	-	-	-	-	-	-	-
46-15	-	0	0	-	0	0	-	0	0	+	-	-	-	-	-	-

TABLE I (Continued)

Station	Meristic									Morphometric						
	L.L.S.			P_1C.			P.D.R.									
	1	2	3	1	2	3	1	2	3	Wt	NL	HD	BD	BW	P_1L	HL
N. stramineus																
46- 2	+	-	0	+	-	0	+	-	0	+	-	+	-	-	+	-
46- 5	-	0	0	-	0	0	-	0	0	-	-	-	-	-	-	-
46- T	+	+	0	-	+	0	+	-	0	-	-	+	-	-	+	-
46- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33-15	-	0	0	-	0	0	-	0	0	+	-	-	-	-	-	-
33- 2	-	+	-	+	+	+	+	+	+	+	-	+	+	-	+	-
33- 5	-	0	-	-	0	-	-	0	-	-	-	-	-	-	-	-
33- T	-	-	-	-	+	+	-	-	+	-	-	+	-	-	-	-
33- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15- 2	-	0	0	-	0	0	-	0	0	-	-	-	-	-	-	-
15- 5	-	0	0	-	0	0	-	0	0	-	+	-	+	-	-	-
15- T	-	0	0	-	0	0	-	0	0	+	-	-	-	-	-	-
15- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2- 5	-	0	-	-	0	-	-	0	+	-	-	-	-	-	-	-
2- T	-	+	+	+	+	-	+	+	+	+	-	-	+	-	+	-
2- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5- T	-	0	-	-	0	-	-	0	-	-	-	-	-	-	-	-
5- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. promelas																
60-46	-	-	0	-	+	0	-	-	0	+	-	-	-	-	-	-

TABLE I (Continued)

Station	Meristic									Morphometric						
	L.L.S.			P_1C.			P.D.R.									
	1	2	3	1	2	3	1	2	3	Wt	NL	HD	BD	BW	P_1L	HL
<u>P</u>. <u>promelas</u>																
60-33	-	-	0	-	-	0	+	+	0	+	-	-	-	+	-	-
60-15	-	-	0	-	-	0	+	+	0	+	-	-	-	-	-	-
60- 2	-	+	0	-	-	0	-	-	0	+	-	-	-	-	-	-
60- 5	-	-	0	-	+	0	-	+	0	+	-	-	-	-	-	-
60- T	-	-	0	-	-	0	-	-	0	+	-	-	-	-	-	-
60- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46-33	-	-	0	-	-	0	-	-	0	+	-	-	-	-	-	+
46-15	-	-	0	-	+	0	-	+	0	-	-	-	-	-	-	-
46- 2	-	-	0	-	-	0	-	-	0	-	-	-	-	-	+	+
46- 5	-	-	0	-	-	0	-	-	0	+	-	-	-	-	-	-
46- T	-	-	0	-	+	0	-	-	0	-	-	-	-	-	-	-
46- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33-15	-	-	0	-	+	0	-	+	0	+	-	-	-	-	-	-
33- 2	-	+	-	+	-	-	+	+	-	+	-	+	+	-	-	+
33- 5	-	-	-	-	-	-	-	-	-	+	-	+	-	+	-	+
33- T	-	-	0	-	+	0	-	-	0	-	-	-	-	-	-	-
33- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15- 2	-	+	0	-	+	0	-	+	0	-	-	-	-	-	-	-
15- 5	-	-	0	-	+	0	-	-	0	+	-	-	-	-	-	-
15- T	-	-	0	-	+	0	-	+	0	-	-	-	-	-	-	-
15- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE I (Continued)

Station	Meristic L.L.S. 1	L.L.S. 2	L.L.S. 3	P_1C. 1	P_1C. 2	P_1C. 3	P.D.R. 1	P.D.R. 2	P.D.R. 3	Morphometric Wt	NL	HD	BD	BW	P_1L	HL
<u>P</u>. <u>promelas</u>																
2- 5	-	+	+	-	-	-	-	+	-	+	-	+	-	-	+	-
2- T	-	-	0	-	+	0	-	-	0	-	-	-	-	-	-	-
2- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5- T	-	-	0	-	+	0	-	-	0	-	-	-	-	-	-	-
5- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*L.L.S. equals number of lateral line scales; P_1C equals number of pectoral fin rays; P.D.R. equals number of predorsal scale rows; 1 (April-July), 2(August-November), 3(December-March) equals seasons; Wt. equals weight; N.L. equals nape length; H.D. equals head depth; B.D. equals body depth; B.W. equals body width; P_1L equals pectoral fin length; H.L. equals head length.

TABLE II

<u>N. LUTRENSIS</u>

NUMBER OF LATERAL LINE SCALES, COMPARING
STATIONS 60, 46, 33 AND 15

Station	N	Mean	Station	N	Mean	t
April-July						
46	304	33.67	15	98	34.01	2.6154
33	232	33.66	15	98	34.01	2.4490
August-November						
60	360	33.22	46	284	33.72	5.0340
60	360	33.22	33	331	33.78	5.8860
60	360	33.22	15	90	34.04	5.5312
46	284	33.72	15	90	34.04	2.1023
December-March						
60	49	32.70	33	20	33.85	3.5272
46	45	32.93	33	20	33.85	2.9141

TABLE III

N. LUTRENSIS

NUMBER OF LATERAL LINE SCALES, COMPARING STATIONS 60, 46, 33 AND 15 WITH STATIONS 2 AND 5

Station	N	Mean	Station	N	Mean	t
April-July						
46	304	33.67	2	242	33.91	2.4490
33	232	33.66	2	242	33.91	2.3987
August-November						
60	360	33.22	2	288	33.84	6.1070
46	284	33.72	5	172	33.34	3.1388
33	331	33.78	5	172	33.34	3.7397
15	90	34.04	5	172	33.34	4.2784
December-March						
60	49	32.70	2	146	33.79	5.2022
60	49	32.70	5	109	33.72	4.5635
46	45	32.93	2	146	33.79	4.4547
46	45	32.93	5	109	33.72	3.7953

TABLE IV

N. LUTRENSIS

NUMBER OF LATERAL LINE SCALES, COMPARING STATIONS 60, 46, 33 AND 15 WITH TURKEY CREEK AND OTTER CREEK

Station	N	Mean	Station	N	Mean	t
April-July						
60	263	33.81	O	180	33.48	3.0340
15	98	34.01	T	143	33.61	2.7255
15	98	34.01	O	180	33.48	3.7697
August-November						
46	284	33.72	T	152	33.38	2.8084
46	284	33.72	O	156	33.12	4.8050
33	331	33.78	T	152	33.38	3.3997
33	331	33.78	O	156	33.12	5.4290
15	90	34.04	T	152	33.38	4.0339
15	90	34.04	O	156	33.12	5.5272
December-March						
60	49	32.70	O	105	33.33	2.9216
46	45	32.93	O	105	33.33	2.0033
33	20	33.85	T	180	33.09	2.7447

TABLE V

N. LUTRENSIS

NUMBER OF LATERAL LINE SCALES, COMPARING STATIONS 2 and 5 WITH TURKEY CREEK AND OTTER CREEK

Station	N	Mean	Station	N	Mean	t
April-July						
2	242	33.91	T	143	33.61	2.5138
2	242	33.91	0	180	33.48	3.8506
5	184	33.83	0	180	33.48	2.9700
August-November						
2	288	33.84	T	152	33.38	3.7437
2	288	33.84	0	156	33.12	5.6861
December-March						
2	146	33.79	T	180	33.09	5.8599
2	146	33.79	0	105	33.33	3.6592
5	109	33.72	T	180	33.09	4.4187
5	109	33.72	0	105	33.33	2.6377

TABLE VI

N. LUTRENSIS

NUMBER OF LATERAL LINE SCALES, COMPARING STATION 2 WITH STATION 5

Station	N	Mean	Station	N	Mean	t
August-November						
2	288	33.84	5	172	33.34	4.0692

TABLE VII

N. LUTRENSIS

NUMBER OF PECTORAL FIN RAYS, COMPARING STATIONS 60, 46, 33 AND 15

Station	N	Mean	Station	N	Mean	t
April-July						
60	263	13.70	46	304	13.95	3.4226
46	304	13.95	33	232	13.58	4.8938
46	304	13.95	15	98	13.64	3.0908
August-November						
60	360	13.31	46	284	14.00	9.7319
60	360	13.31	33	331	13.54	3.3866
60	360	13.31	15	90	13.97	6.2367
46	284	14.00	33	331	13.54	4.5527
46	284	14.00	15	90	13.97	6.3672
33	331	13.54	15	90	13.97	4.0288
December-March						
60	49	13.14	46	45	13.91	3.9037
46	45	13.91	33	20	13.25	2.7630

TABLE VIII

N. LUTRENSIS

NUMBER OF PECTORAL FIN RAYS, COMPARING STATIONS 60, 46, 33 AND 15 WITH STATIONS 2 AND 5

Station	N	Mean	Station	N	Mean	t
April-July						
60	263	13.70	2	242	13.38	4.1024
46	304	13.95	2	242	13.38	7.5391
46	304	13.95	5	184	13.58	4.5684
33	232	13.58	2	242	13.38	2.4873
15	98	13.64	2	242	13.38	2.5008
August-November						
60	360	13.31	5	172	13.62	3.7425
46	284	14.00	2	288	13.35	8.4920
46	284	14.00	5	172	13.62	4.3972
33	331	13.54	2	288	13.35	2.5750
15	90	13.97	2	288	13.35	5.6525
15	90	13.97	5	172	13.62	2.9968
December-March						
46	45	13.91	2	146	13.05	5.8877
46	45	13.91	5	109	13.33	3.6827

TABLE IX

N. LUTRENSIS

NUMBER OF PECTORAL FIN RAYS, COMPARING STATIONS 60, 46, 33 AND 15 WITH TURKEY CREEK AND OTTER CREEK

Station	N	Mean	Station	N	Mean	t
April-July						
60	263	13.70	T	143	13.22	5.3344
60	263	13.70	0	180	13.37	3.9325
46	304	13.95	T	143	13.22	8.3039
46	304	13.95	0	180	13.37	7.0999
33	232	13.58	T	143	13.22	3.9099
33	232	13.58	0	180	13.37	2.4374
15	98	13.64	T	143	13.22	3.7093
15	98	13.64	0	180	13.37	2.4891
August-November						
60	360	13.31	T	152	13.04	3.2596
46	284	14.00	T	152	13.04	11.1088
46	284	14.00	0	156	12.92	12.1164
33	331	13.54	T	152	13.04	5.9534
33	331	13.54	0	160	12.92	7.1445
15	90	13.97	T	152	13.04	7.9630
15	90	13.97	0	160	12.92	8.8372
December-March						
60	49	13.14	T	180	12.81	2.0568
46	45	13.91	T	180	12.81	7.4255
46	45	13.91	0	105	13.13	5.1631
33	20	13.25	T	180	12.81	2.1002

TABLE X

N. LUTRENSIS

NUMBER OF PECTORAL FIN RAYS, COMPARING STATIONS 2 AND 5
WITH TURKEY CREEK AND OTTER CREEK

Station	N	Mean	Station	N	Mean	t
April-July						
5	184	13.58	T	143	13.22	3.7288
5	184	13.58	0	180	13.37	2.3097
August-November						
2	288	13.35	T	152	13.04	3.5343
2	288	13.35	0	156	12.92	4.7572
5	172	13.62	T	152	13.04	6.0135
5	172	13.62	0	156	12.92	7.0785
December-March						
2	146	13.05	T	180	12.81	2.6554
5	109	13.33	T	180	12.81	4.8204

TABLE XI

N. LUTRENSIS

NUMBER OF PECTORAL FIN RAYS, COMPARING STATIONS
2 WITH 5 AND TURKEY CREEK WITH OTTER CREEK

Station	N	Mean	Station	N	Mean	t
April-July						
2	242	13.38	5	184	13.58	2.3394
August-November						
2	288	13.35	5	172	13.62	3.0783
December-March						
2	146	13.05	5	109	13.33	2.6663
T	180	12.81	0	105	13.13	3.2565

TABLE XII

N. LUTRENSIS

NUMBER OF PREDORSAL SCALE ROWS, COMPARING STATIONS 60, 46, 33 AND 15

Station	N	Mean	Station	N	Mean	t
April-July						
60	263	13.78	46	304	14.63	10.2858
60	263	13.78	33	232	14.79	11.4447
60	263	13.78	15	98	14.73	8.2290
August-November						
60	360	13.72	46	284	14.55	10.5234
60	360	13.72	33	331	14.98	16.6777
60	360	13.72	15	90	14.80	9.1741
46	284	14.55	33	331	14.98	5.3504
46	284	14.55	15	90	14.80	2.0683
December-March						
60	49	13.49	46	45	14.67	5.0242
60	49	13.49	33	20	15.50	6.8432
46	45	14.67	33	20	15.50	2.9183

TABLE XIII

N. LUTRENSIS

NUMBER OF PREDORSAL SCALE ROWS, COMPARING STATIONS 60, 46, 33 AND 15 WITH STATIONS 2 AND 5

Station	N	Mean	Station	N	Mean	t
April-July						
60	263	13.78	2	242	14.34	6.3455
60	263	13.78	5	184	14.65	9.2388
46	304	14.63	2	242	14.34	3.3903
33	232	14.79	2	242	14.34	4.9465
15	98	14.73	2	242	14.34	3.3157
August-November						
60	360	13.72	2	288	14.60	10.9158
60	360	13.72	5	172	14.98	13.6741
46	284	14.55	5	172	14.98	4.4729
33	331	14.98	2	288	14.60	4.6295
December-March						
60	49	13.49	2	146	14.66	6.1984
60	49	13.49	5	109	14.63	5.6615
33	20	15.50	2	146	14.66	3.3911
33	20	15.50	5	109	14.63	3.3794

TABLE XIV

N. LUTRENSIS

NUMBER OF PREDORSAL SCALE ROWS, COMPARING STATIONS 60, 46, 33 AND 15 WITH TURKEY CREEK AND OTTER CREEK

Station	N	Mean	Station	N	Mean	t
April-July						
60	263	13.78	T	143	14.23	4.4203
60	263	13.78	0	180	14.42	6.7412
46	304	14.63	T	143	14.23	4.0217
46	304	14.63	0	180	14.42	2.2721
33	232	14.79	T	143	14.23	5.3758
33	232	14.79	0	180	14.42	3.7059
15	98	14.73	T	143	14.23	3.9031
15	98	14.73	0	180	14.42	2.5260
August-November						
60	360	13.72	T	152	14.40	7.3797
60	360	13.72	0	156	14.43	7.4506
33	331	14.98	T	152	14.40	6.2079
33	331	14.98	0	156	14.43	5.6973
15	90	14.80	T	152	14.40	3.0787
15	90	14.80	0	156	14.43	2.7993
December-March						
60	49	13.49	T	180	14.58	5.7059
60	49	13.49	0	105	14.02	2.7283
46	45	14.67	0	105	14.02	3.6135
33	20	15.50	T	180	14.58	3.6882
33	20	15.50	0	105	14.02	5.8747

TABLE XV

N. LUTRENSIS

NUMBER OF PREDORSAL SCALE ROWS, COMPARING STATIONS 2 AND 5 WITH TURKEY CREEK AND OTTER CREEK

Station	N	Mean	Station	N	Mean	t
April-July						
5	184	14.65	T	143	14.23	3.8451
5	184	14.65	0	180	14.42	2.2360
August-November						
2	288	14.60	T	152	14.40	2.0497
5	172	14.98	T	152	14.40	5.4057
5	172	14.98	0	156	14.43	4.9995
December-March						
2	146	14.66	0	105	14.02	5.6512
5	109	14.63	0	105	14.02	4.5796

TABLE XVI

N. LUTRENSIS

NUMBER OF PREDORSAL SCALE ROWS, COMPARING STATION 2 WITH 5 AND TURKEY CREEK WITH OTTER CREEK

Station	N	Mean	Station	N	Mean	t
April-July						
2	242	14.34	5	184	14.65	3.2050
August-November						
2	288	14.60	5	172	14.98	3.8946
December-March						
T	180	14.58	0	105	14.02	4.7863

TABLE XVII

N. STRAMINEUS

NUMBER OF LATERAL LINE SCALES, COMPARING STATIONS 60, 46 33 AND 15

Station	N	Mean	Station	N	Mean	t
August-November						
60	35	31.41	46	3	35.67	5.9778
60	35	31.41	33	128	33.84	10.6445
46	3	35.67	33	128	33.84	2.6479

TABLE XVIII

N. STRAMINEUS

NUMBER OF LATERAL LINE SCALES, COMPARING STATIONS 60, 46, 33 AND 15 WITH STATION 2

Station	N	Mean	Station	N	Mean	t
April-July						
60	39	33.67	2	78	34.40	3.0191
46	132	33.77	2	78	34.40	3.5780
August-November						
60	35	31.41	2	170	34.38	13.6010
33	128	33.84	2	170	34.38	3.8998
December-March						
60	145	33.24	2	142	34.23	7.0703

TABLE XIX

N. STRAMINEUS

NUMBER OF LATERAL LINE SCALES, COMPARING STATIONS 60, 46, 33 AND 15 WITH TURKEY CREEK

Station	N	Mean	Station	N	Mean	t
April-July						
60	39	33.67	T	33	34.30	2.1604
46	132	33.77	T	33	34.30	2.2087
August-November						
60	35	31.41	T	125	33.56	9.1293
46	3	35.67	T	125	33.56	3.0425
December-March						
60	145	33.24	T	315	33.78	4.2508

TABLE XX

N. STRAMINEUS

NUMBER OF LATERAL LINE SCALES, COMPARING STATIONS 2 AND 5 WITH TURKEY CREEK

Station	N	Mean	Station	N	Mean	t
August-November						
2	170	34.38	T	125	33.56	5.4641
December-March						
2	142	34.23	T	315	33.78	3.6604

TABLE XXI

N. STRAMINEUS

NUMBER OF PECTORAL FIN RAYS, COMPARING STATIONS 60, 46, 33 AND 15

Station	N	Mean	Station	N	Mean	t
April-July						
60	39	13.64	33	43	14.02	2.0539
August-November						
60	35	12.29	46	3	14.33	3.8599
60	35	12.29	33	128	13.82	9.0371
December-March						
60	145	13.31	33	6	14.00	1.9600

TABLE XXII

N. STRAMINEUS

NUMBER OF PECTORAL FIN RAYS, COMPARING STATIONS 60, 46, 33 AND 15 WITH STATION 2

Station	N	Mean	Station	N	Mean	t
April-July						
46	132	13.77	2	78	13.40	3.0965
33	43	14.02	2	78	13.40	3.9014
August-November						
60	35	12.29	2	170	13.43	6.9152
33	128	13.82	2	170	13.43	3.7978
December-March						
60	145	13.31	2	142	13.03	2.7162
33	6	14.00	2	142	13.03	2.7616

TABLE XXIII

N. STRAMINEUS

NUMBER OF PECTORAL FIN RAYS, COMPARING STATIONS 60, 46, 33 AND 15 WITH TURKEY CREEK

Station	N	Mean	Station	N	Mean	t
August-November						
60	35	12.29	T	125	13.11	4.6949
46	3	14.33	T	125	13.11	2.3720
33	128	13.82	T	125	13.11	6.0280
December-March						
60	145	13.31	T	315	13.40	2.8870
33	6	14.00	T	315	13.40	2.7542

TABLE XXIV

N. STRAMINEUS

NUMBER OF PECTORAL FIN RAYS, COMPARING STATIONS 2 AND 5 WITH TURKEY CREEK

Station	N	Mean	Station	N	Mean	t
April-July						
2	78	13.40	T	125	13.94	3.1080
August-November						
2	142	13.43	T	315	13.11	2.8752

TABLE XXV

N. STRAMINEUS

NUMBER OF PREDORSAL SCALE ROWS, COMPARING STATIONS 60, 46, 33 AND 15

Station	N	Mean	Station	N	Mean	t
April-July						
60	39	12.95	46	132	13.49	2.2927
60	39	12.95	33	43	14.77	6.3690
60	39	12.95	15	3	14.67	2.2214
46	132	13.49	33	43	14.77	5.6409
August-November						
60	35	12.53	46	3	15.67	3.6682
60	35	12.53	33	128	14.46	7.0383

TABLE XXVI

N. STRAMINEUS

NUMBER OF PREDORSAL SCALE ROWS, COMPARING STATIONS 60, 46, 33 AND 15 WITH STATION 2

Station	N	Mean	Station	N	Mean	t
April-July						
60	39	12.95	2	78	15.47	9.9432
46	132	13.49	2	78	15.47	10.7283
33	43	14.77	2	78	15.47	2.8518
August-November						
60	35	12.53	2	170	15.79	12.2092
33	128	14.46	2	170	15.79	7.9964
December-March						
60	145	12.75	2	142	15.94	21.2200
33	6	13.50	2	142	15.94	4.7635

TABLE XXVII

N. STRAMINEUS

NUMBER OF PREDORSAL SCALE ROWS, COMPARING STATIONS 60, 46, 33 AND 15 WITH TURKEY CREEK

Station	N	Mean	Station	N	Mean	t
April-July						
60	39	12.95	T	33	14.52	5.1364
46	132	13.49	T	33	14.52	4.0952
August-November						
60	35	12.53	T	125	14.74	7.8123
December-March						
60	145	12.75	T	315	15.22	18.1104
33	6	13.50	T	315	15.22	3.3837

TABLE XXVIII

N. STRAMINEUS

NUMBER OF PREDORSAL SCALE ROWS, COMPARING STATION 2 WITH STATION 5 AND TURKEY CREEK

Station	N	Mean	Station	N	Mean	t
April-July						
2	78	15.47	T	33	14.52	3.5400
August-November						
2	170	15.79	T	125	14.74	5.8248
December-March						
2	142	15.94	5	1	13.00	2.3840
2	142	15.94	T	315	15.22	5.4551

TABLE XXIX

P. PROMELAS

NUMBER OF LATERAL LINE SCALES, COMPARING STATIONS 60, 46, 33 AND 15 WITH STATIONS 2 AND 5

Station	N	Mean	Station	N	Mean	t
April-July						
60	4	45.60	2	56	47.98	2.0589
33	53	46.81	2	56	47.98	4.2404
15	7	46.76	2	56	47.98	2.0704

TABLE XXX

P. PROMELAS

NUMBER OF LATERAL LINE SCALES, COMPARING STATION 2 WITH STATION 5

Station	N	Mean	Station	N	Mean	t
April-July						
2	56	47.98	5	6	45.63	3.5275
December-March						
2	169	47.56	5	73	45.55	3.5584

TABLE XXXI

P. PROMELAS

NUMBER OF PECTORAL FIN RAYS, COMPARING STATIONS 60, 46, 33 AND 15

Station	N	Mean	Station	N	Mean	t
August-November						
60	5	15.60	46	141	14.25	2.4404
46	4	14.25	15	21	15.43	2.6229
3	141	14.96	15	21	15.43	2.4649

TABLE XXXII

P. PROMELAS

NUMBER OF PECTORAL FIN RAYS, COMPARING STATIONS 60, 46, 33 AND 15 WITH STATIONS 2 AND 5

Station	N	Mean	Station	N	Mean	t
August-November						
60	5	15.60	5	73	14.75	2.0118
15	21	15.43	2	169	14.95	2.5165
15	21	15.43	5	73	14.75	2.4849

TABLE XXXIII

P. PROMELAS

NUMBER OF PECTORAL FIN RAYS, COMPARING STATIONS 60, 46, 33 AND 15 WITH TURKEY CREEK

Station	N	Mean	Station	N	Mean	t
August-November						
46	4	14.25	T	3	16.67	3.8423
33	141	14.96	T	3	16.67	3.5606
15	21	15.43	T	3	16.67	2.4363

TABLE XXXIV

P. PROMELAS

NUMBER OF PECTORAL FIN RAYS, COMPARING STATIONS
2 AND 5 WITH TURKEY CREEK

Station	N	Mean	Station	N	Mean	t
August-November						
2	169	14.95	T	3	16.67	3.5812
5	73	14.75	T	3	16.67	3.7007

TABLE XXXV

P. PROMELAS

NUMBER OF PREDORSAL SCALE ROWS, COMPARING
STATIONS 60, 46, 33 AND 15

Station	N	Mean	Station	N	Mean	t
April-July						
60	4	22.75	33	53	26.13	2.7644
60	4	22.75	15	7	26.14	2.2937
August-November						
60	5	23.00	33	141	26.10	3.4913
60	5	23.00	15	21	27.48	4.6003
46	4	25.00	15	21	27.48	2.3228
33	141	26.10	15	21	27.48	3.0495

TABLE XXXVI

P. PROMELAS

NUMBER OF PREDORSAL SCALE ROWS, COMPARING STATIONS 60, 46, 33 AND 15 WITH STATIONS 2 AND 5

Station	N	Mean	Station	N	Mean	t
April-July						
33	53	26.13	2	56	24.59	3.4080
August-November						
60	5	23.00	5	6	26.31	3.3011
33	141	26.10	2	169	24.51	7.5014
15	21	27.48	2	169	24.51	6.5610

TABLE XXXVII

P. PROMELAS

NUMBER OF PREDORSAL SCALE ROWS, COMPARING STATIONS 60, 46, 33 AND 15 WITH TURKEY CREEK

Station	N	Mean	Station	N	Mean	t
August-November						
15	21	27.48	T	3	25.00	2.0531

TABLE XXXVIII

P. PROMELAS

NUMBER OF PREDORSAL SCALE ROWS, COMPARING STATION 2 WITH STATION 5

Station	N	Mean	Station	N	Mean	t
August-November						
2	169	24.51	5	73	26.31	3.5172

TABLE XXXIX

N. LUTRENSIS

ANALYSIS OF COVARIANCE, COMPARING STATIONS 60, 46, 33 AND 15

Source of Variation	Degrees of Freedom	Reduced Sum of Squares	Mean Squares	F
Weight				
Error	2065	172.13625	.08335	
Stations (adjusted for regression)	3	.64744	.21581	2.58896NS
Sum of stations regressions deviations	2062	165.29715	.08016	
Difference among station regressions	3	6.83910	2.27970	28.43815
Nape Length				
Error	2065	868.27148	.42047	
Stations (adjusted for regression)	3	4.72282	1.57427	3.74407NS
Sum of stations regressions deviations	2062	867.72382	.42081	
Difference among station regressions	3	.54765	.18255	.43380NS
Head Depth				
Error	2065	261.14549	.12646	
Stations (adjusted for regression)	3	29.02466	9.67488	76.50386
Sum of stations regressions deviations	2062	260.34177	.12625	
Difference among station regressions	3	.80372	.26790	2.12193NS
Body Depth				
Error	2065	1521.05610	.73658	
Stations	3	106.17258	35.39086	48.04960
Sum of stations regressions deviations	2062	1517.18640	.73578	
Difference among station regressions	3	3.86970	1.28990	1.75309NS
Body Width				
Error	2065	4540.65108	2.19886	
Stations (adjusted for regression)	3	38.98913	12.99637	5.91049
Sum of stations regression deviations	2062	4520.79810	2.19243	
Difference among station regressions	3	19.85297	6.61765	3.01840NS
Pectoral Fin Length				
Error	2065	610.89432	.29583	
Stations (adjusted for regression)	3	51.50733	17.16911	58.03657
Sum of stations regressions deviations	2062	608.05760	.29488	
Difference among station regressions	3	2.83672	.94557	3.20656NS
Head Length				
Error	2065	474.49929	.22978	
Stations (adjusted for regression)	3	64.30867	21.43622	93.28951
Sum of stations regressions deviations	2062	471.88759	.22884	
Difference among station regressions	3	2.61169	.87056	3.80409

TABLE XL

N. LUTRENSIS

ANALYSIS OF COVARIANCE, COMPARING STATION 2 WITH STATION 5

Source of Variation	Degrees of Freedom	Reduced Sum of Squares	Mean Squares	F
Weight				
Error	1166	164.60165	.14116	
Stations (adjusted for regression)	1	.29286	.29286	2.07466NS
Sum of stations regressions deviations	1165	151.11278	.12971	
Difference among station regressions	1	13.48887	13.48887	103.99252
Nape Length				
Error	1166	385.39596	.33052	
Stations (adjusted for regression)	1	.40792	.40792	1.00054NS
Sum of stations regressions deviations	1165	385.27179	.33070	
Difference among station regressions	1	.12417	.12417	.37547NS
Head Depth				
Error	1166	133.22211	.11425	
Stations (adjusted for regression)	1	41.42890	41.42890	362.61619
Sum of stations regressions deviations	1165	130.59329	.11209	
Difference among station regressions	1	2.62882	2.62882	23.45276
Body Depth				
Error	1166	648.11775	.55585	
Stations (adjusted for regression)	1	53.02425	53.02425	95.39309
Sum of stations regressions deviations	1165	637.53636	.54724	
Difference among station regressions	1	10.64119	10.64119	19.44519
Body Width				
Error	1166	337.92980	.28981	
Stations (adjusted for regression)	1	11.08739	11.08739	38.25744
Sum of stations regressions deviations	1165	337.80046	.28995	
Difference among station regressions	1	.12934	.12934	.44607NS
Pectoral Fin Length				
Error	1166	319.26043	.27380	
Stations (adjusted for regression)	1	1.83249	1.83249	6.69280
Sum of stations regressions deviations	1165	316.37858	.27156	
Difference among station regressions	1	2.88185	2.88185	10.61220
Head Length				
Error	1166	267.57141	.22947	
Stations (adjusted for regression)	1	40.91615	40.91615	178.30718
Sum of stations regressions deviations	1165	252.91807	.21709	
Difference among station regressions	1	14.65334	14.65334	67.49891

TABLE XLI

N. LUTRENSIS

ANALYSIS OF COVARIANCE, COMPARING TURKEY CREEK WITH OTTER CREEK

Source of Variation	Degrees of Freedom	Reduced Sum of Squares	Mean Squares	F
Weight				
Error	977	44.85053	.04590	
Stations (adjusted for regression)	1	2.77746	2.77746	60.50278
Sum of stations regressions deviations	976	43.55002	.04462	
Difference among station regressions	1	1.30050	1.30050	29.14570
Nape Length				
Error	977	264.75340	.27098	
Stations (adjusted for regression)	1	.14777	.14777	.54530NS
Sum of stations regressions deviations	976	264.73683	.27124	
Difference among station regressions	1	.01656	.01656	.06108NS
Head Depth				
Error	977	90.92120	.09306	
Stations (adjusted for regression)	1	.23021	.23021	2.47381NS
Sum of stations regressions deviations	976	90.69914	.09292	
Difference among station regressions	1	.22206	.22206	2.38956NS
Body Depth				
Error	977	348.07695	.35627	
Stations (adjusted for regression)	1	28.47326	28.47326	79.92020
Sum of stations regressions deviations	976	344.60542	.35307	
Difference among station regressions	1	3.47152	3.47152	9.83214
Body Width				
Error	977	306.13883	.31334	
Stations (adjusted for regression)	1	45.85872	45.85872	146.35182
Sum of stations regressions deviations	976	299.26926	.30662	
Difference among station regressions	1	6.86957	6.86957	22.40357
Pectoral Fin Length				
Error	977	1152.74683	1.17988	
Stations (adjusted for regression)	1	1.46371	1.46371	1.24056NS
Sum of stations regressions deviations	976	1149.42129	1.17768	
Difference among station regressions	1	3.32554	3.32554	2.82379NS
Head Length				
Error	977	139.14163	.14241	
Stations (adjusted for regression)	1	.01762	.01762	.12377NS
Sum of stations regressions deviations	976	138.47972	.14188	
Difference among station regressions	1	.66190	.66190	4.66511

TABLE XLII

N. STRAMINEUS

ANALYSIS OF COVARIANCE, COMPARING STATIONS 60, 46, 33 AND 15

Source of Variation	Degrees of Freedom	Reduced Sum of Squares	Mean Squares	F
Weight				
Error	518	8.70105	.01679	
Stations (adjusted for regression)	3	.92902	.30967	18.43583
Sum of stations regressions deviations	515	7.30280	.01418	
Difference among station regressions	3	1.39825	.46608	32.86879
Nape Length				
Error	518	195.62172	.37764	
Stations (adjusted for regression)	3	.48149	.16049	.42499NS
Sum of stations regressions deviations	515	191.90373	.37262	
Difference among station regressions	3	3.71798	1.23932	3.32591NS
Head Depth				
Error	518	38.76474	.07483	
Stations (adjusted for regression)	3	10.51937	3.50645	46.85561
Sum of stations regressions deviations	515	38.45452	.07466	
Difference among station regressions	3	.31022	.10340	1.38487NS
Body Depth				
Error	518	158.33310	.30566	
Stations (adjusted for regression)	3	22.72597	7.57532	24.78330
Sum of stations regressions deviations	515	151.62752	.29442	
Difference among station regressions	3	6.70557	2.23519	7.59178
Body Width				
Error	518	152.97053	.29530	
Stations (adjusted for regression)	3	6.24809	2.08269	7.05259
Sum of stations regressions deviations	515	140.75578	.27331	
Difference among station regressions	3	12.21475	4.07158	14.89719
Pectoral Fin Length				
Error	518	185.46619	.35804	
Stations (adjusted for regression)	3	41.26340	13.75446	38.41570
Sum of stations regressions deviations	515	182.49732	.35436	
Difference among station regressions	3	2.96887	.98962	2.97267NS
Head Length				
Error	518	85.05208	.16419	
Stations (adjusted for regression)	3	30.07489	10.02496	61.05591
Sum of stations regressions deviations	515	83.89363	.16290	
Difference among station regressions	3	1.15844	3.38614	2.37044NS

TABLE XLIII

N. STRAMINEUS

ANALYSIS OF COVARIANCE, COMPARING STATION 2 WITH 5

Source of Variation	Degrees of Freedom	Reduced Sum of Squares	Mean Squares	F
Weight				
Error	388	25.71795	.06628	
Stations (adjusted for regression)	1	8.61533	8.61533	129.98385
Sum of stations regressions deviations	387	25.70411	.06641	
Difference among station regressions	1	.01384	.01384	.20840NS
Nape Length				
Error	388	129.52113	.33381	
Stations (adjusted for regression)	1	1.67795	1.67795	5.02666NS
Sum of stations regressions deviations	387	129.50340	.33467	
Difference among station regressions	1	.01773	.01773	.05297NS
Head Depth				
Error	388	34.38749	.08862	
Stations (adjusted for regression)	1	1.01433	1.01433	11.44583
Sum of stations regressions deviations	387	34.25592	.08851	
Difference among station regressions	1	.13157	.13157	1.48649NS
Body Depth				
Error	388	283.34677	.73027	
Stations (adjusted for regression)	1	1.41134	1.41134	1.93262NS
Sum of stations regressions deviations	387	281.77463	.72807	
Difference among station regressions	1	.57214	.57214	.78580NS
Body Width				
Error	388	169.86293	.43779	
Stations (adjusted for regression)	1	2.20405	2.20405	5.03449NS
Sum of stations regressions deviations	387	169.86284	.43892	
Difference among station regressions	1	.00009	.00009	.00020NS
Pectoral Fin Length				
Error	388	107.29338	.27652	
Stations (adjusted for regression)	1	10.43332	10.43332	33.73079
Sum of stations regressions deviations	387	107.28600	.27722	
Difference among station regressions	1	.00738	.00738	.02662NS
Head Length				
Error	388	78.59480	.20256	
Stations (adjusted for regression)	1	.77226	.77226	3.81250NS
Sum of stations regressions deviations	387	78.59370	.20308	
Difference among station regressions	1	.00110	.00110	.00541NS

TABLE XLIV

P. PROMELAS

ANALYSIS OF COVARIANCE, COMPARING STATIONS 60, 46, 33 AND 15

Source of Variation	Degrees of Freedom	Reduced Sum of Squares	Mean Squares	F
Weight				
Error	271	19.55718	.07216	
Stations (adjusted for regression)	3	.53960	.17986	2.49241NS
Sum of stations regressions deviations	268	16.51729	.06163	
Difference among station regressions	3	3.03989	1.01329	16.44119
Nape Length				
Error	271	313.76202	1.15779	
Stations (adjusted for regression)	3	.52088	.17362	.14996NS
Sum of stations regressions deviations	268	303.98490	1.13427	
Difference among station regressions	3	9.77711	3.25903	2.87324NS
Head Depth				
Error	271	61.36024	.22642	
Stations (adjusted for regression)	3	.53818	.17939	.79230NS
Sum of stations regressions deviations	268	59.39066	.22160	
Difference among station regressions	3	1.96957	.65652	2.96256NS
Body Depth				
Error	271	188.58668	.69589	
Stations (adjusted for regression)	3	12.90015	4.30005	6.17919
Sum of stations regressions deviations	268	187.12799	.69823	
Difference among station regressions	3	1.45869	.48623	.69637NS
Body Width				
Error	271	103.44966	.38173	
Stations (adjusted for regression)	3	.90003	.30001	.78591NS
Sum of stations regressions deviations	268	101.71119	.37951	
Difference among station regressions	3	1.73876	.57958	1.52716NS
Pectoral Fin Length				
Error	271	115.08619	.42467	
Stations (adjusted for regression)	3	3.75136	1.25045	2.94451NS
Sum of stations regressions deviations	268	112.41714	.41946	
Difference among station regressions	3	2.66904	.88968	2.12098NS
Head Length				
Error	271	162.19546	.59850	
Stations (adjusted for regression)	3	1.32916	.44305	.74026NS
Sum of stations regressions deviations	268	155.26123	.57933	
Difference among station regressions	3	6.93423	2.31141	3.98978

TABLE XLV

P. PROMELAS

ANALYSIS OF COVARIANCE, COMPARING STATION 2 WITH STATION 5

Source of Variation	Degrees of Freedom	Reduced Sum of Squares	Mean Squares	F
Weight				
Error	326	85.68234	.26282	
Stations (adjusted for regression)	1	.01598	.01598	.06080NS
Sum of stations regressions deviations	325	66.06285	.20327	
Difference among station regressions	1	19.61940	19.61940	96.51935
Nape Length				
Error	326	175.11398	.53715	
Stations (adjusted for regression)	1	.06651	.06651	.12382NS
Sum of stations regressions deviations	325	174.82784	.53793	
Difference among station regressions	1	.28614	.28614	.53192NS
Head Depth				
Error	326	61.41568	.18839	
Stations (adjusted for regression)	1	2.07959	2.07959	11.03874
Sum of stations regressions deviations	325	58.14066	.17889	
Difference among station regressions	1	3.27502	3.27502	18.30745
Body Depth				
Error	326	195.27694	.59900	
Stations (adjusted for regression)	1	49.45894	49.45894	82.56918
Sum of stations regressions deviations	325	195.03103	.60009	
Difference among station regressions	1	.24591	.24591	.40978NS
Body Width				
Error	326	143.34014	.43969	
Stations (adjusted for regression)	1	6.72456	6.72456	15.29386
Sum of stations regressions deviations	325	142.16105	.43741	
Difference among station regressions	1	1.17909	1.17909	2.69561NS
Pectoral Fin Length				
Error	326	97.89801	.30030	
Stations (adjusted for regression)	1	5.00602	5.00602	16.67006
Sum of stations regressions deviations	325	95.48384	.29379	
Difference among station regressions	1	2.41417	2.41417	8.21733
Head Length				
Error	326	89.67959	.27509	
Stations (adjusted for regression)	1	1.80327	1.80327	6.55520NS
Sum of stations regressions deviations	325	89.37915	.27501	
Difference among station regressions	1	.30044	.30044	1.09246NS

TABLE XLVI

N. LUTRENSIS

COMPARISON OF REGRESSION SLOPES OF STATIONS 60, 46, 33, 15, 2 AND 5 WITH TURKEY CREEK AND OTTER CREEK

Source of Variation	$Slope_1$	$Slope_2$	t
Weight			
	.09774(60)	.08090(O)	6.80982
	.12099(46)	.09475(T)	9.00806
	.12099(46)	.08090(O)	14.33966
	.10725(33)	.09475(T)	4.35808
	.10725(33)	.08090(O)	9.71425
	.10529(15)	.09475(T)	2.86548
	.10529(15)	.08090(O)	8.82639
	.13925(2)	.09475(T)	14.95947
	.13925(2)	.08090(O)	19.41200
	.11121(5)	.09475(T)	5.28440
	.11121(5)	.08090(O)	9.86920
Nape Length			
	.36614(60)	.34475(T)	3.83989
	.36614(60)	.34319(O)	3.72205
	.36975(46)	.34475(T)	3.79617
	.36975(46)	.34319(O)	3.66219
	.36349(33)	.34475(T)	3.01527
	.36349(33)	.34319(O)	2.96944
	.37026(15)	.34475(T)	3.32919
	.37026(15)	.34319(O)	3.35215
Head Depth			
	.14829(33)	.15739(T)	2.58711
	.14203(5)	.15739(T)	4.81322
	.14203(5)	.15167(O)	2.68996
Body Depth			
	.37320(60)	.35170(T)	3.05654
	.37320(60)	.32908(O)	5.92165
	.38454(46)	.35170(T)	3.69908
	.38454(46)	.32908(O)	5.84460
	.37549(33)	.35170(T)	3.10271
	.37549(33)	.32908(O)	5.74518
	.35906(15)	.32908(O)	3.19196
	.38764(2)	.35170(T)	5.41628
	.38764(2)	.32908(O)	8.25508
	.36270(5)	.32908(O)	4.81604

TABLE XLVI (Continued)

Source of Variation	$Slope_1$	$Slope_2$	t
Body Width			
	.21174(60)	.14584(0)	3.18978
	.17684(46)	.14584(0)	4.55803
	.18645(33)	.14584(0)	6.41225
	.17018(15)	.14584(0)	3.24909
	.18249(2)	.14584(0)	6.74217
	.18524(5)	.14584(0)	7.36635
Pectoral Fin Length			
	.16424(2)	.19421(T)	5.61242
	.16424(2)	.21635(0)	4.87163
	.17786(5)	.19421(T)	3.25862
	.17786(5)	.21635(0)	3.33643
Head Length			
	.24219(15)	.26031(T)	3.03906
	.26321(2)	.25043(0)	3.03332
	.23394(5)	.26031(T)	5.89684
	.23394(5)	.25043(0)	3.33829

TABLE XLVII

N. LUTRENSIS

COMPARISONS OF REGRESSION SLOPES OF STATIONS 60, 46, 33 AND 15 WITH STATIONS 2 AND 5

Source of Variation	$Slope_1$	$Slope_2$	t
Weight			
	.09774(60)	.13939(2)	16.73166
	.09774(60)	.11121(5)	5.17245
	.12099(46)	.13929(2)	6.66469
	.12099(46)	.11121(5)	3.37267
	.10725(33)	.13929(2)	11.67621
	.10529(15)	.13929(2)	7.85015
Nape Length			
	.36614(60)	.34906(2)	3.65967
	.36614(60)	.34637(5)	4.16038
	.36979(46)	.34906(2)	3.78580
	.36979(46)	.34637(5)	4.11629
	.36349(33)	.34906(2)	2.75207
	.36349(33)	.34637(5)	3.17537
	.37026(15)	.34906(2)	2.79534
	.37026(15)	.34637(5)	3.18581
Head Depth			
	.15532(60)	.14203(5)	4.66919
	.15543(46)	.14203(5)	4.27547
Body Depth			
	.38454(46)	.36270(5)	2.80928
	.35906(15)	.38764(2)	2.90704
Pectoral Fin Length			
	.18891(60)	.16424(2)	5.61476
	.18891(60)	.17786(5)	2.64482
	.19676(46)	.16424(2)	7.41674
	.19676(46)	.17786(5)	4.76568
	.20116(33)	.16424(2)	7.97864
	.20116(33)	.17786(5)	5.36323
	.18690(15)	.16424(2)	3.20023
Head Length			
	.26136(60)	.23394(5)	7.15455
	.26371(46)	.23394(5)	6.30863
	.25793(33)	.23394(5)	5.61899
	.24219(15)	.26321(2)	3.70651

TABLE XLVIII

N. LUTRENSIS

COMPARISON OF MERISTIC AND MORPHOMETRIC CHARACTERISTICS AMONG STATIONS 60, 46, 33 AND 15; SIXTEEN POSSIBLE DIFFERENCES IN EACH CELL

		Stations			
		60	46	33	15
Stations	60	--	8	7	5
	46	8	--	7	7
	33	7	7	--	2
	15	5	7	2	--

TABLE XLIX

N. STRAMINEUS

COMPARISON OF REGRESSION SLOPES OF STATIONS 60, 46, 33 AND 2 WITH TURKEY CREEK

Source of Variation	$Slope_1$	$Slope_2$	t
Weight			
	.04890(60)	.07830(T)	6.63514
	.11659(2)	.07830(T)	11.64872
Head Depth			
	.10771(60)	.12774(T)	3.14549
	.10290(46)	.12774(T)	3.21609
	.11066(33)	.12774(T)	3.24830
Body Depth			
	.28813(60)	.24006(T)	4.05611
	.28248(2)	.24006(T)	4.34804
Body Width			
	.23501(60)	.15192(T)	5.99885
Pectoral Fin Length			
	.22969(46)	.18046(T)	3.13804
	.13035(2)	.18046(T)	6.88614
Head Length			
	.20598(60)	.24418(T)	4.18429

TABLE L

N. STRAMINEUS

COMPARISON OF REGRESSION SLOPES OF STATIONS 60, 46, 33 AND 15 WITH STATION 2

Source of Variation	$Slope_1$	$Slope_2$	t
Weight			
	.14890(60)	.11659(2)	13.46343
	.07125(46)	.11659(2)	7.22526
	.07299(33)	.11659(2)	12.08747
Head Depth			
	.10771(60)	.12827(2)	3.26544
	.10290(46)	.12827(2)	3.31300
	.11066(33)	.12827(2)	3.50569
Body Depth			
	.23019(33)	.28248(2)	4.12448
Body Width			
	.23501(60)	.17188(2)	4.54740
Pectoral Fin Length			
	.18277(60)	.13035(2)	4.36245
	.22969(46)	.13035(2)	6.59584
	.18105(33)	.13035(2)	5.55145
Head Length			
	.20598(60)	.23665(2)	3.27659

TABLE LI

N. STRAMINEUS

COMPARISON OF MERISTIC AND MORPHOMETRIC CHARACTERISTICS AMONG STATIONS 60, 46, 33 AND 15; SIXTEEN POSSIBLE DIFFERENCES IN EACH CELL

		Stations			
		60	46	33	15
Stations	60	--	6	9	2
	46	6	--	2	1
	33	9	2	--	--
	15	2	1	1	1

TABLE LII

P. PROMELAS

COMPARISON OF MERISTIC AND MORPHOMETRIC CHARACTERISTICS AMONG STATIONS 60, 46, 33 AND 15 WITH STATION 2; SIXTEEN POSSIBLE DIFFERENCES IN EACH CELL

		Station
		2
Stations	60	2
	46	3
	33	6
	15	3

TABLE LIII

SEASONAL VARIATION IN NUMBERS OF SPECIMENS OF EACH DOMINANT SPECIES AND THEIR RANK BASED ON ABUNDANCE (FROM PHILLIPS, 1965)

	Notropis lutrensis											
Stations	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
60	(2)[1] 260	(1) 104	(1) 213	(1) 146	(1) 800	(2) 263	(4) 45	(4) 16	0	(3) 10	(2) 158	(1) 201
46	(1) 292	(1) 113	(1) 50	(1) 280	(1) 479	(2) 355	(1) 64	0	0	(1) 1	(2) 317	(1) 235
33	(1) 93	(1) 50	(3) 188	(1) 335	(1) 576	(1) 257	(1) 22	0	0	0	(1) 35	(1) 73
15	(1) 30	(1) 18	(1) 54	(1) 50	(2) 5	(2) 2	0	0	0	0	0	(2) 50

TABLE LIII (Continued)

					Notropis stramineus							
Stations	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
60	0	(4) 4	0	(5) 1	(5) 1	(4) 47	(1) 171	(2) 40	(2) 1	(2) 52	(4) 20	(3) 15
46	0	(4) 29	(5) 3	(5) 3	0	0	(4) 1	0	0	0	(3) 136	(2) 43
33	(3) 10	(2) 37	(4) 41	(4) 52	(4) 26	(3) 19	(3) 6	0	0	0	(2) 2	(6) 1
15	0	0	0	0	0	0	0	0	0	0	0	(4) 3

TABLE LIII (Continued)

Stations	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
					Pimephales promelas							
60	(4) 3	(3) 12	(4) 7	0	0	0	0	0	0	0	0	0
46	0	(6) 7	(6) 2	0	(5) 1	(4) 2	0	0	0	0	(5) 5	0
33	(2) 25	(3) 35	(2) 202	(3) 47	(3) 29	(4) 9	(5) 1	0	0	0	(3) 1	(5) 9
15	(3) 3	(2) 2	(3) 16	(3) 4	(3) 2	(3) 1	0	0	0	0	(1) 1	(3) 5

[1] Number in parenthesis denotes rank based on relative abundance.

TABLE LIV

ANNUAL NUMBERS AND DISTRIBUTION OF FISHES
(FROM PHILLIPS, 1965)

Species	Stations 60	46	33	15	6	Total	Stations 1	2	5	Total
Dorosoma cepedianum	7	4				11				0
Carpiodes carpio			1			1				0
Cyprinus carpio	6		4			10			1	1
Notemigonus crysoleucas			2	17		19	1	158	16	175
Phenacobius mirabilis	5	8	101			114				0
Notropis percobromus	1,601	1,491	50	7		3,149	2		1	3
Notropis lutrensis	2,216	2,186	1,629	209		6,240	225	2,108	610	2,943
Notropis girardi	110	3				113				0
Notropis stramineus	352	215	194	3		764	199	518	2	719
Hybognathus placita	604	289	79	77		1,049			1	1
Pimephales vigilax			1			1				0
Pimephales promelas	22	17	358	34		431	87	331	66	484

TABLE LIV (Continued)

Species	Stations 60	46	33	15	6	Total	Stations 1	2	5	Total
Campostoma anomalum		3	15			18				0
Ictalurus punctatus	39	6	4			49			1	1
Ictalurus melas			10			10	7	7	78	92
Fundulus kansae		1	29	1		31	1			1
Gambusia affinis	49	118	750	160		1,077	156	303	97	556
Micropterus salmoides						0			23	23
Lepomis cyanellus	2	16	14	16	1	49	46	192	136	374
Lepomis megalotis	20	11	2	1		34	1	2	25	28
Lepomis humilis	29	3	32	2		66	8	28	83	119
Lepomis macrochirus	3	4				7	8	1	119	128
Pomoxis nigromaculatus		1				1			13	13
Pomoxis annularis	1	2				3			9	9
TOTALS	5,066	4,378	3,275	527	1	13,247	741	3,648	1,281	5,670
Total No. of Species	(16)	(18)	(18)	(11)	(1)		(12)	(10)	(17)	

VITA

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