To the Graduate Council:

I am submitting herewith a thesis written by C. Michael Swindoll entitled "The Growth, Diet and Distribution of Yellow Perch Fry, *Perca flavescens*, in Lake Itasca, Minnesota." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Zoology.

M. C. Whiteside

M.C. Whiteside, Major Professor

We have read this thesis and recommend its acceptance:

David A. Etnier

Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

THE GROWTH, DIET AND DISTRIBUTION OF YELLOW

PERCH FRY, *Perca flavescens*, IN

LAKE ITASCA, MINNESOTA

A Thesis

Presented for the

Master of Science

Degree

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C. Michael Swindoll

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This thesis is dedicated to the parents of all the yellow perch who gave their lives for this study.

ABSTRACT

The growth, diet, and distribution of yellow perch fry, *Perca flavescens* (Mitchill), were determined from fry collected during the summers of 1978, 1979, and 1980 from Lake Itasca, Minnesota. Yellow perch hatched in the littoral zone at 5.5-6.0 mm total length. Within two weeks all fry had moved into the limnetic zone, where they remained until reaching a length of approximately 25 mm; at this time they moved back into the littoral zone. During the first 40 days after hatching, perch fry grew in length approximately 0.50 mm per day. Growth rates for the remainder of the summer were lower, averaging approximately 0.43 mm per day. Fry first fed at 9-10 mm in length on a diet composed of copepod nauplii, immature copepodids, and rotifers. Various stages of copepods remained the dominant food item until the fry reached 20-24 mm in length, at which time cladocerans became the dominant prey. Larger food items, such as insects and amphipods were important in the diet of fry greater than 30 mm in length.

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I. INTRODUCTION

The yellow perch, *Perca flavescens* (Mitchill), is a common fish in many lakes in the northeastern United States and southern Canada (Scott and Crossman 1973). As a result of the commercial and recreational importance of yellow perch, there is a considerable amount of literature on the growth and production of the adult fish (Carlander 1950; Jobes 1952; Coble 1966; Sheri and Power 1969). Yet, much less is known about the ecology of yellow perch during their first summer (Keast and Webb 1966).

This study was begun in 1978 as part of a comprehensive investigation to determine the effect yellow perch fry predation has on the zooplankton population in Lake Itasca, Minnesota. The objective of my study was to increase the understanding of the general ecology of yellow perch during their first summer. The distribution, diet, and growth of yellow perch fry were determined from fry collected in the spring and summer of 1978, 1979, and 1980.

II. LITERATURE REVIEW

The yellow perch, *Perca flavescens* (Mitchill), is a member of the family Percidae, which includes the walleye, sauger, and the darter. The perch family is one of the largest groups of North American freshwater fishes, characterized by a dorsal fin which is completely divided into a spiny and a separate soft-rayed portion (Pflieger 1975; Eddy and Underhill 1978). While some authorities, (Scott and Crossman 1973), consider *Perca flavescens* to be a subspecies of the Eurasian perch, *Perca fluviatilis* (Linnaeus), others argue that there are sufficient differences between the fish to justify their species status (Thorpe 1977). Together the two species have an almost circumpolar distribution in the freshwaters of the northern hemisphere (Scott and Crossman 1973).

Because of the importance of yellow perch as a game, commercial, and forage fish (Jobes 1952; Tharratt 1959; Tsai and Gibson 1971; Hokanson and Kleiner 1974; Ney and Smith 1975; Smith 1977), it has been widely introduced throughout the United States (Eddy and Underhill 1974). Today the yellow perch occurs in North America from Nova Scotia south to Florida, west to Kansas and Texas, and west of the Rockies in Washington, Oregon and California (Scott and Crossman 1973).

The yellow perch is an adaptable fish as evidenced by its wide distribution. They are found in lakes, backwaters of rivers, streams and brackish and tidal fresh waters (Muncy

1962; Wong 1972; Thorpe 1977). However, this fish is most abundant in the open waters of lakes with moderate vegetation, clear water and bottoms of muck to sand and gravel (Scott and Crossman 1973).

Sexual maturity of male yellow perch usually occurs at an earlier age and at a smaller size than in females (Jobes 1952; Muncy 1962). Male yellow perch usually mature in their second year and females in their third (Thorpe 1977), although males may mature in only one year (Muncy 1962; Scott and Crossman 1973; Thorpe 1977). The size of perch at maturity varies among populations. Muncy (1962) reports males maturing at 11.4 cm total length and females at 17.3 cm while Jobes (1952) found males to mature at 15.2-16.5 cm and females at 20.3-21.6 cm. Females are generally more abundant than males, especially in older age classes (Carlander 1950). Jobes (1952) observed that sexual segregation may occur between April and November, and suggests that differences in the mortality rates during segregation results in fewer males than females.

Spawning normally occurs in April and May, but in some cases has occurred as early as February and as late as July (Muncy 1962; Scott and Crossman 1973). It has been suggested that either photoperiod or temperature is responsible for the onset of spawning (Hergenrader 1969; Thorpe 1977), although little experimentation has been done in this area. Reported spawning temperatures range from 7-14°C (Hergenrader 1969).

In general, spawning starts at a lower temperature and at a later date as latitude increases (Thorpe 1977).

Spawning takes place in the night or early morning (Muncy 1962; Scott and Crossman 1973), however, daytime spawning has been observed (Hergenrader 1969). The males move to the near shore spawning grounds first and generally remain in the shallow spawning area longer than do the females (Muncy 1962; Tsai and Gibson 1971; Scott and Crossman 1973). No visible difference in the color pattern exists between the male and female either before or after spawning (Hergenrader 1969). Although few observations of the spawning ritual have been documented, Harrington (1947) witnessed a gravid female followed closely by a long queue of males. The first males push their snouts against the female's vent, as the female moves about through rooted vegetation and submerged brush and branches (Harrington 1947; Scott and Crossman 1973). The female's tail movements increase rapidly, ending with the expulsion of the egg mass. The pursuing males simultaneously release their milt (Harrington 1947; Hergenrader 1969). After mating, the males continue to produce milt for as long as they remain on the spawning grounds (Muncy 1962).

Eggs are deposited in semi-bouyant, accordion-shaped, gelatinous strands which adhere to surrounding vegetation (Manseuti 1964; Scott and Crossman 1973). Egg masses range from 0.6-2.1 m in length (Sheri and Power 1968) and contain between 2,000 and 109,000 eggs (Thorpe 1977). The number of eggs produced increases with age and size of the female (Sheri and Power 1968; Tsai and Gibson 1971). Within minutes of fertilization, the eggs expand and water harden (Manseuti 1964). Each fertilized egg is surrounded by a distinctive elastic case, and ranges in diameter from 2.26-3.5 mm (Manseuti 1964; Scott and Crossman 1973). Water circulating through pores and a canal in the egg masses provides aeration for the eggs. No parental care is given to the eggs or the young (Scott and Crossman 1973). Clady (1976) reports a high mortality of perch eggs due to physical destruction by high winds.

The descriptive terminology of posthatching fish in recent literature is based on the terminology suggested by Hubbs (1943). Fish (1932) and Mansueti(1964) give detailed descriptions of morphological development of young-of-the-year yellow perch. An embryo is defined as the developmental stages of the fish to the moment of hatching (Hubbs 1943). Yellow perch egg development does not deviate widely from known fish embryology (Mansueti 1964). Incubation time is temperature dependent, and ranges from two days at 18.2 C to as long as 27 days at 8.5 C (Mansueti 1964; Hokanson and Kleiner 1974). Temperatures below 7.3 C result in longer development time with premature hatching and high mortality (Hokanson and Kleiner 1974).

Hubbs (1943) defines larva as the developmental stages between the times of hatching and of transformation into the juvenile or adult-like form. The size of perch larvae at hatching is temperature dependent, with maximal mean lengths at 7.1 -13.1 C and minimal mean lengths at temperature extremes. Total length (TL) varies from 4.7-6.6 mm, averaging 5.5 mm (Mansueti 1964; Hokanson and Kleiner 1974). Prolarva is the developmental stage in which the larva still bears a yolk sac (Hubbs 1943). Yellow perch prolarvae have 18-21 preanal and 16-23 postanal myomeres, with an almost equal preanal and postanal length (Hogue, Wallus and Kay 1976). The pectoral fins are well developed, containing some ray elements (Fish 1932; Mansueti 1964). The dorsal and ventral median fins are relatively undeveloped, being present in the form of a median finfold which is continuous with the caudal fin (Norden 1961). Newly hatched larvae are initially transparent, with the sparsely distributed pigmentation increasing rapidly with later development (Fish 1932; Scott and Crossman 1973). The ovate yolk sac contains a large anteriorly placed oil globule and is usually absorbed by the time the larvae are 7 mm in length (Fish 1932; Mansueti 1964; Hogue et al. 1976). Newly hatched yellow perch larvae must swim to the surface and fill their air bladders before they are able to swim about freely. The ability of larvae to swim to the surface for air is correlated with temperature. Hokanson (1974) showed that perch have increased "swim up" success as temperatures increase. At lower temperatures, larvae may remain inactive until the yolk sac is absorbed (Scott and Crossman 1973).

Postlarva is the stage of development following the absorption of the yolk, when the structure and form of the larvae are strikingly unlike the adult (Hubbs 1943). During postlarval development the fish becomes elongate, the head becomes flattened, and a few teeth develop on the maxillary. Differentiation of the median finfold begins at approximately 11 mm TL. The sequence of fin development is: pectoral, caudal, anal, second dorsal, some spines of the first dorsal, pelvics, and the remaining first dorsal spines (Mansueti 1964). At 20 mm TL the young fish resembles the adult with its distinctive banding pattern, although it may lack the total ray and spine complement of older perch (Fish 1932; Pycha and Smith 1955; Mansueti 1964).

Perch fry in lakes have been reported to mainly inhabit littoral waters (Turner 1920; Fish 1932; Echo 1954; Maloney and Johnson 1957), but have also been reported to inhabit limnetic waters (Fish 1932; Faber 1967; Nobel 1968). It now seems certain that yellow perch fry inhabit both littoral and littoral and limnetic waters at different times during their first summer (Wong 1972; Henderson 1977; Kelso and Ward 1977). Their distribution depends upon the size of the fry (Henderson 1977) and upon physical and morphological factors of the lake such as water currents (Houde 1969). Wong (1972) found that perch fry make vertical migrations during the night while inhabiting limnetic waters.

The diet of yellow perch fry is well documented (Pycha and Smith 1955; Muncy 1962; Siegert 1972; Wong 1972; Clady 1974; Tarby 1974; Lin 1975; Noble 1975; Bulkley, Spykermann and Inmon 1976; Henderson 1977; Hokanson 1977; Thorpe 1977). The food of perch fry varies with the size of the fish, the availability of food items, and with the season (Pycha and Smith 1955; Scott and Crossman 1973). Larval perch have very specific feeding habits, requiring zooplankton of a certain size and abundance. Feeding begins as soon as the larvae are free swimming, rather than after yolk sac absorbtion is complete (Siefert 1972; Henderson 1977; Hokanson 1977). The first foods of perch are copepod nauplii, adult cyclopoids, rotifers, and small cladocerans (Siefert 1972; Bulkley et al. 1976; Henderson 1977; Hokanson 1977). With increasing size, the bulk of the diet shifts to large cladocerans, adult copepods, insect larvae, amphipods, and other benthic organisms (Ney and Smith 1975; Bulkley et al. 1976; Thorpe 1977). Adult yellow perch feed primarily on large insect larvae, decapods, molluscs, and small fishes (Muncy 1962; Keast and Webb 1966; Scott and Crossman 1973.

Annual differences in the food habits of perch fry have been observed (Pycha and Smith 1955; Ney and Smith 1975). Variations in the food used by perch fry suggest different modes of prey selection. Prey abundance and visibility are factors in determining their diets (Pycha and Smith 1955; Ney and Smith 1975; Noble 1975; Bulkley et al. 1976). Perch fry are also size selective, choosing the largest food item compatible with gape width (Wong and Ward 1972).

The feeding periodicity differs between young and adult yellow perch. Henderson (1977) found that limnetic fry feed continuously under natural conditions. Noble (1972) reported that fingerling yellow perch are principally daytime feeders, with feeding maximums between 1200 and 1600 hours. Adult perch actively feed in the morning and evening, with peaks at mid-morning and at dusk (Scott 1955; Keast and Welsh 1968; Thorpe 1977). Feeding activity also varies seasonally, being maximal in midsummer and declining to maintenance levels in early autumn (Thorpe 1977).

The digestion or evacuation rate of young yellow perch is dependent upon the duration of feeding, size of fish, and temperature. Noble (1973) found evacuation time of young yellow perch to be about twice as fast with continuous feeding as compared with sporadic feeding. Evacuation time decreases rapidly with higher temperature and increases with size of fish (Noble 1972). The longer evacuation time of larger fry may reflect the effects of a greater amount of food, a decreasing absorptive surface relative to the total volume of the stomach, and an increase in the length of the digestive tract (Henderson 1977).

Growth of yellow perch fry is well documented (Pycha and Smith 1955; Wong 1972; Lin 1975; Ney and Smith 1975; Noble 1975; Huh, Calbert and Stuiber 1976; Henderson 1977). Growth of fish is influenced by a large variety of factors including temperature, quantity, and quality of food, and population density (Langford and Martin 1940; Coble 1966; Noble 1975; Huh et al. 1976; Thorpe 1977). There is disagreement as to which factors are most influential on yellow perch growth. Jobes (1952) and LeCren (1958) found perch fry growth to be temperature dependent, whereas Huh et al. (1976) in a study comparing the effects of both temperature and photoperiod on perch fry growth, conclude that growth is dependent upon photoperiod and that temperature had little or no effect. Noble (1975) and Ney and Smith (1975) conclude that growth of perch fry is primarily influenced by food availability.

III. DESCRIPTION OF AREA

This study was conducted from the University of Minnesota's Forestry and Biological Station located at Lake Itasca, Minnesota. Lake Itasca is a wishbone-shaped lake in northwestern Minnesota (47 14'N, 95 12'W), located within Lake Itasca State Park (Figure 1). The lake is considered to be the headwaters of the Mississippi River. The basin of the lake was formed by the retreat of glaciers and consists of calcareous drift deposited during the Wisconsin Glaciation (Megard 1968).

Lake Itasca has an area of about 436 ha, with a maximum depth of 14 meters and a mean depth of 5.2 meters (Megard 1968). Approximatly 55% of the lake consists of littoral zone (Cole and Underhill 1965). It is typical of many lakes that occupy the Itasca moraine in this region. The lake is fairly rich, but not polluted; its hypolimnion may become anaerobic in late summer. Cole and Underhill (1965) classify the lake as eutrophic.

The aquatic flora and fauna is characteristic of north-temperate, dimictic lakes. Littoral macrophytes include *Typha*, *Nuphar*, *Nymphaea*, *Scirpus*, *Zizania* and *Potomogeton*. Large mats of the algae *Chara* are common. Dominant phytoplankton include members of Cyanophyta and Chlorophyta (Megard 1968). Lake Itasca has a rich zooplankton fauna that supports a large number and variety of fish. One of the numerically

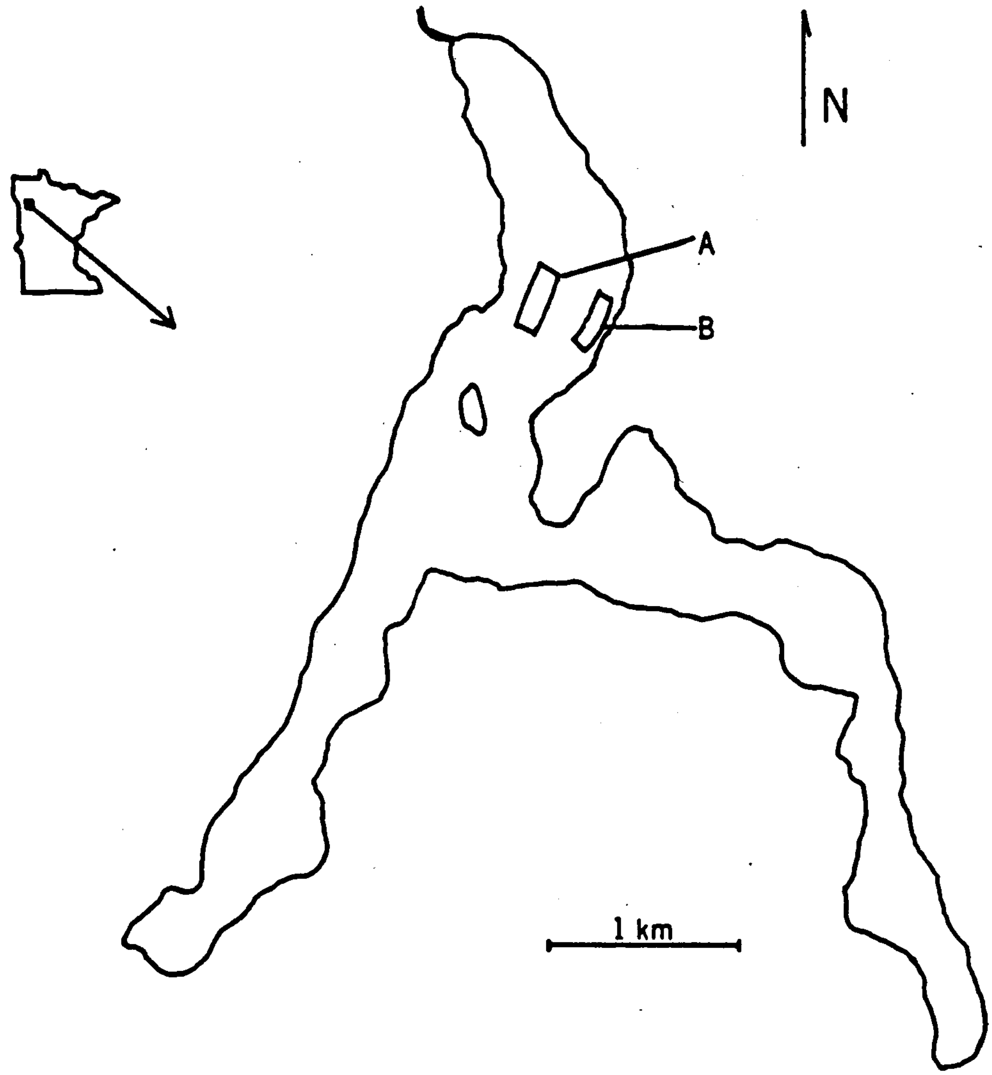

Figure 1. Lake Itasca, Minnesota. 'A' represents the limnetic sampling site and 'B' represents the littoral sampling site.

dominant fish in Itasca is the yellow perch, *Perca flavescens* .

IV. METHODS

Young-of-the-year yellow perch were collected during the spring and summer of 1978, 1979, and 1980 from limnetic and littoral sites in the north arm of Lake Itasca (Figure 1). The 1978 collections were made by M.C. Whiteside and they served primarily as preliminary information for subsequent research. Various methods of collecting were utilized to optimize the catch. In 1978 and 1980 a cone-shaped net with a 64μ mesh and a 1 m diameter was hauled vertically from a depth of 7 meters for limnetic samples. Early in the year, when fry were small, only one haul was required to obtain abundant specimens. As the season progressed, and the fry became larger, repeated tows were needed to collect adequate numbers of fry. Littoral samples were collected with the same 1 m net towed through the surface waters.

In 1979, limnetic fry were first collected with a cone-shaped net with a 706μ mesh and a diameter of 0.5 m hauled vertically from a depth of 7 meters. Hauls were repeated until adequate numbers of fry were collected. As fry grew larger, net avoidance became a problem, therefore a net with a 1800μ mesh and a diameter of 0.5 m was hauled vertically from 7 meters. Later in the season, it was necessary to tow a 1800μ net through the surface waters to collect limnetic and littoral fry.

All samples were taken at dusk (2100 to 2300 hr), when perch fry were abundant near the surface (Henderson 1977). The nets were towed from a pontoon boat equipped with a boom and winch. All fry were immediately preserved in formalin.

All fry used in dietary determinations were collected at dusk from the littoral and limnetic sampling areas (Figure 1). At least 10 fish were examined for each sampling date and location. The entire digestive tract of each fish was removed using a razor blade and dissecting needles and the ingested food organisms were identified with the aid of a binocular dissecting microscope.

Food items found in the digestive tracts were identified and enumerated. Cladocerans were identified to species. Copepods were identified as nauplii, immature copepodids, and calanoids or cyclopoids. The rotifers and protozoans were identified to genera, insects to family, and amphipods and ostracods to order. Food items not identifiable or rarely encountered were grouped together as "other organisms". Whenever fragments of badly digested organisms were encountered only the heads were counted. Organisms were identified with the aid of Pennak (1978) and Ward and Whipple (1959).

Food electivity was determined with Ivlev's (1961) "Electivity Index" using the formula:

$$E = \frac{r - p}{r + p}$$

where E represents the electivity index; r is the relative percentage of any food organism in the stomach of the fish; and p is the relative percentage of the same food organism in the environment. E values may range between -1 and +1, with a negative value indicating avoidance of a food item. Dr. M. C. Whiteside determined the relative occurence of limnetic organisms from samples collected with a plankton net.

Growth was determined from length and weight measurements of perch fry collected during the three-year study. The total length (distance from tip of snout to end of caudal fin) was measured to the nearest 0.1 mm for fry less than 10 mm TL using a binocular dissecting scope fitted with an ocular micrometer. Fry greater than 10 mm TL were measured to the nearest 0.5 mm with a caliper and ruler. The wet weights of fry were determined to the nearest milligram using a Sartorius balance. Preserved fry were blotted dry on paper towels and then placed on a pre-weighed aluminum dish and weighed.

Data on the age, length, weight, and sampling location (littoral or limnetic) was entered into a DEC-10 computer terminal. Data on fry collected in the littoral zone prior to the limntic phase (May 26-June 8, 1979 and May 6-16, 1980) was omitted from littoral growth analysis. Growth is atypical during these dates due to endogenous feeding. In addition, data on fry collected between July 2 and July 11, 1978 and fry collected on June 22, 1979 was omitted from the growth analysis because the smaller size of these fry indicate that they were later cohorts. If the omitted data had been included in the growth analysis , the results of the calculations would not have been representative of the major cohort of perch fry in Lake Itasca.

SAS (Statistical Analysis System) was used on an IBM 360 computer to analyze the data. Regression equations of length-age, weight-age, and length-weight relationships were determined. Student's t-test was used to evaluate the regression coefficients of limnetic and littoral growths within each year. Statistical procedures used were found in Sokal and Rohlf (1969).

V. RESULTS

Distribution

In Lake Itasca, yellow perch begin spawning about one week after "ice-off". Perch began spawning in early May, although during the unusually warm spring of 1980 spawning began in late April. Eggs hatched about 10-20 days after spawning. In 1979 most eggs hatched on May 26 and in 1980 on May 4. Littoral water temperatures at hatching were 11-12° C in 1979 and 18.5-19.5°C in 1980. A general schematic of the distribution of yellow perch fry during their first summer in Lake Itasca is shown in Figure 2.

In 1979, the first fry were collected from the littoral zone on May 26 and had a mean length of 6 mm (Range 5.8-6.2 mm, Table 1, Appendix A). In 1980, the first fry were collected from the littoral zone on May 6 and had a mean length of 5.8 mm (Range 5.7-5.9 mm, Table 2, Appendix A). Perch fry continued to be caught in the littoral zone until 12-13 days after hatching. The last fry collected in the littoral zone before their limnetic phase were collected on June 8 in 1979 with a mean length of 10.9 mm (Range 10.3-11.6 mm, Table 1, Appendix A) and on May 16 in 1980 with a mean length of 8.1 mm (Range 6.5-10.3 mm, Table 2, Appendix A).

The first perch fry were collected in the limnetic zone on June 6 in 1979 with a mean length of 10.1 mm (Range 9.0-11.1 mm, Table 3, Appendix A) and on May 6 in 1980 with

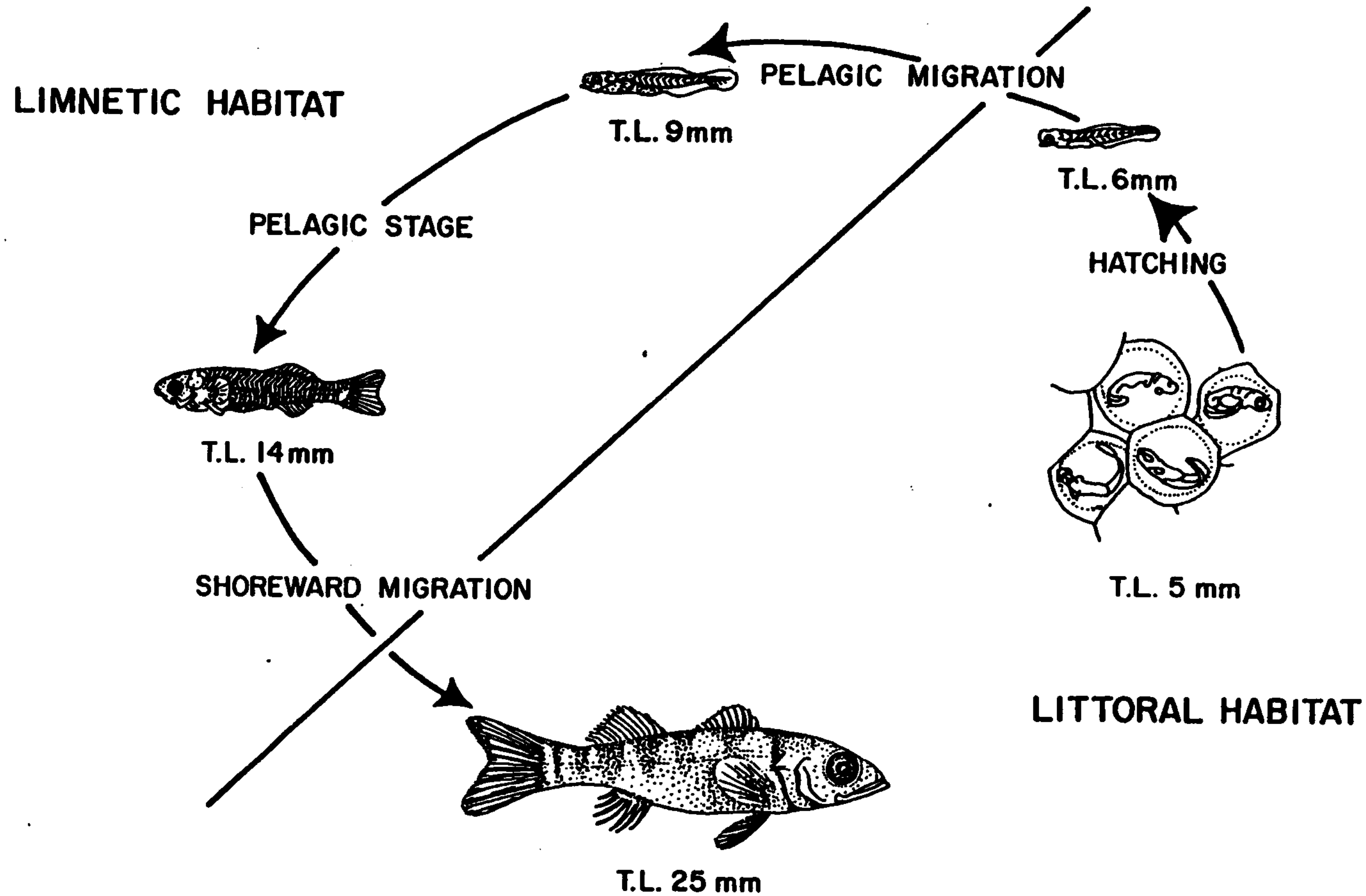

Figure 2. Early life history of Perca flavescens in Lake Itasca, Minnesota.

a mean length of 6.1 mm (Range 5.7-6.4 mm, Table 4, Appendix A). In 1978, the first tows were made on May 29 and the limnetic fry collected had a mean length of 13.7 mm (Range 12.0-15.0 mm, Table 5, Appendix A).

Throughout the limnetic phase, perch fry were most easily caught in the surface waters near dusk (2100-2300 hrs). Once the perch fry began moving into the littoral zone, it became increasingly difficult to collect fry in the limnetic zone. The last perch fry in the limnetic zone were collected on July 11 in 1978 with a mean length of 23.3 mm (Range 22.0-24.5 mm, Table 5, Appendix A), on July 1 in 1979 with a mean length of 23.2 mm (Range 21.0-25.0 mm, Table 3, Appendix A) and on June 20 in 1980 with a mean length of 27.6 mm (Range 25.5-29.0 mm, Table 4, Appendix A).

During midsummer, the fry leave the limnetic zone and return to the littoral zone (Figure 2). Fry were first collected in the littoral zone, after their limnetic phase, on June 21 in 1978 with a mean length of 24.9 mm (Range 21.0-29.5 mm, Table 6, Appendix A), on July 5 in 1979 with a mean length of 23.4 mm (Range 19.0-26.0 mm, Table 1, Appendix A) and on June 17 in 1980 with a mean length of 26.0 mm (Range 24.0-30.0 mm, Table 2, Appendix A). Once the fry moved into the littoral zone, they continued to be caught there for the remainder of the summer.

Feeding

Perch fry begin feeding after they move into the limnetic habitat. The diet of these fry is reflected by the results of stomach analyses show in Tables 7-9, Appendix A. Limnetic fry initially had a diet consisting of nauplii, immature copepodids, adult copepods, and rotifers. Throughout the limnetic phase compepods were a frequent food organism, being found in 93% of the fry examined (Tables 7-9, Appendix A). Cladocera and *Chaoborus* became progressively more important food organisms to limnetic fry. Cladocera were found in 78% and *Chaoborus* in 20% of the limnetic fry examined from 1978, 1979, and 1980 (Tables 7-9, Appendix A).

The diets of the older perch collected in the littoral zone during the three-year study are shown in Tables 10-12, Appendix A. Major food items include copepods and cladocerans and to a lesser extent larger food organisms, such as amphipods, chironomids and ephemeropterans. Cladocerans were found in 91% and copepods in 82% of the littoral fry examined (Tables 10-12, Appendix A). As the littoral fry grew larger, the frequency of larger prey, such as amphipods and insect larvae, increased in their diets (Tables 10-12, Appendix A).

In order to ascertain whether the diets of fry collected in the evening (2100-2300 hrs) were representative of their overall diets, fry were collected over a 24-hour period, June 17-18, 1979. The results of these collections are given in

Table 13, Appendix A. Calanoid copepods were the major food organism, occuring in 83.3% of the stomachs examined (Table 13, Appendix A). Other food organisms included nauplii, cyclopoids, Daphnia, Bosmina and rotifers. The greatest number of food items were found in fry collected at 2300 hrs (Table 13, Appendix A). Fry collected at 1100 and 1500 hrs also contained a relatively large number of food items. The fewest food organisms were found in fry collected at 0300 hrs. The percentage of fry containing each food organisms during the 24-hour period are given in Table 13, Appendix A.

Growth

Growth in length of perch fry was determined from 1423 fry collected in 1978, 1979, and 1980. The mean lengths at each sampling are given in Tables 1-6, Appendix A. The growth in length is best described as sigmoidal for 1979 and 1980 (Figures 3 and 4). Not enough data was collected in 1978 to determine the general slope of the growth curve (Figure 5). Growth in length can be described by the regression equation:

$$L = b + mX$$

where:

L = length (mm)
b = log of the y-intercept
m = log of the slope
X = number of days after hatching

Growth in length during the limnetic phase is described

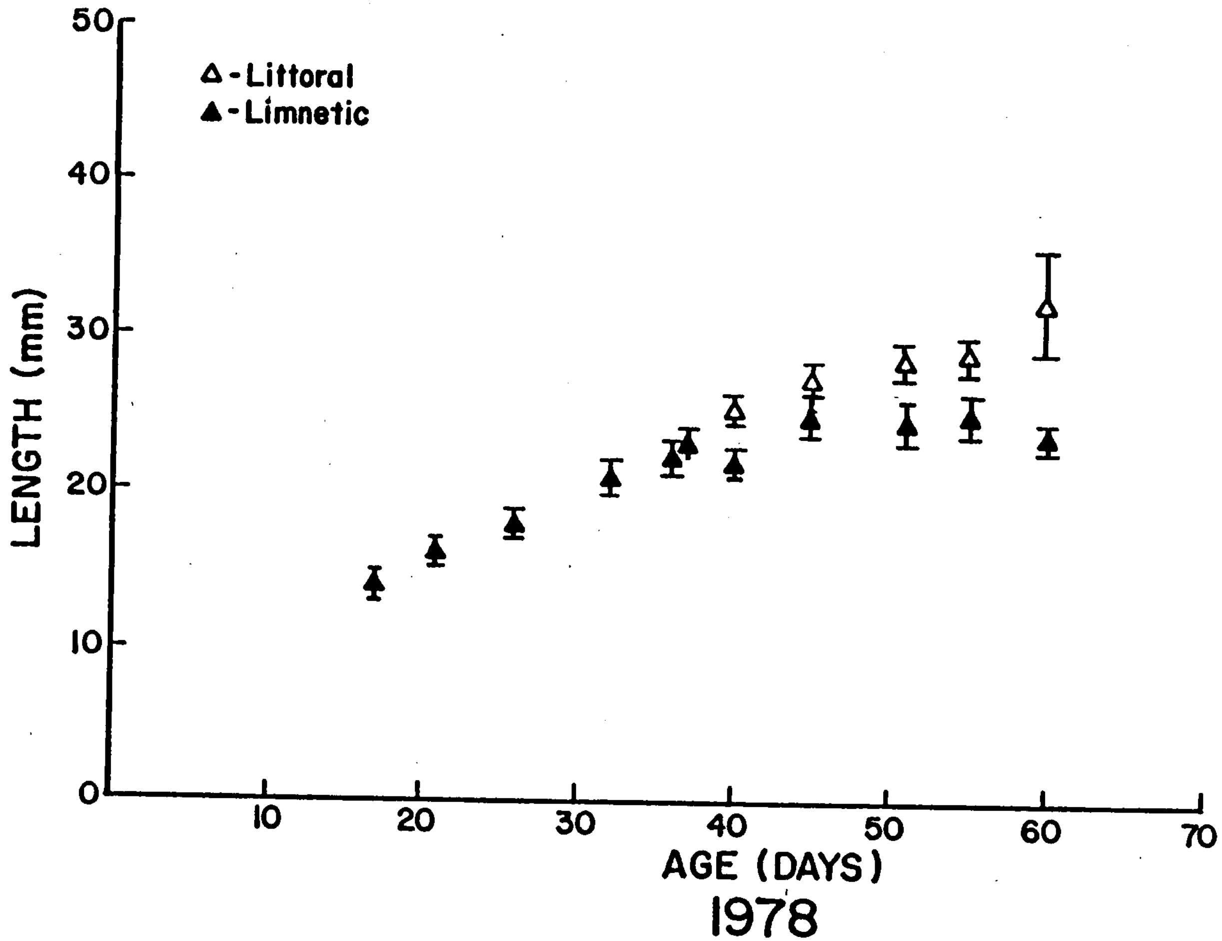

Figure 3. Growth in length of yellow perch fry in Lake Itasca, 1978. Data expressed as means with vertical bars showing standard error.

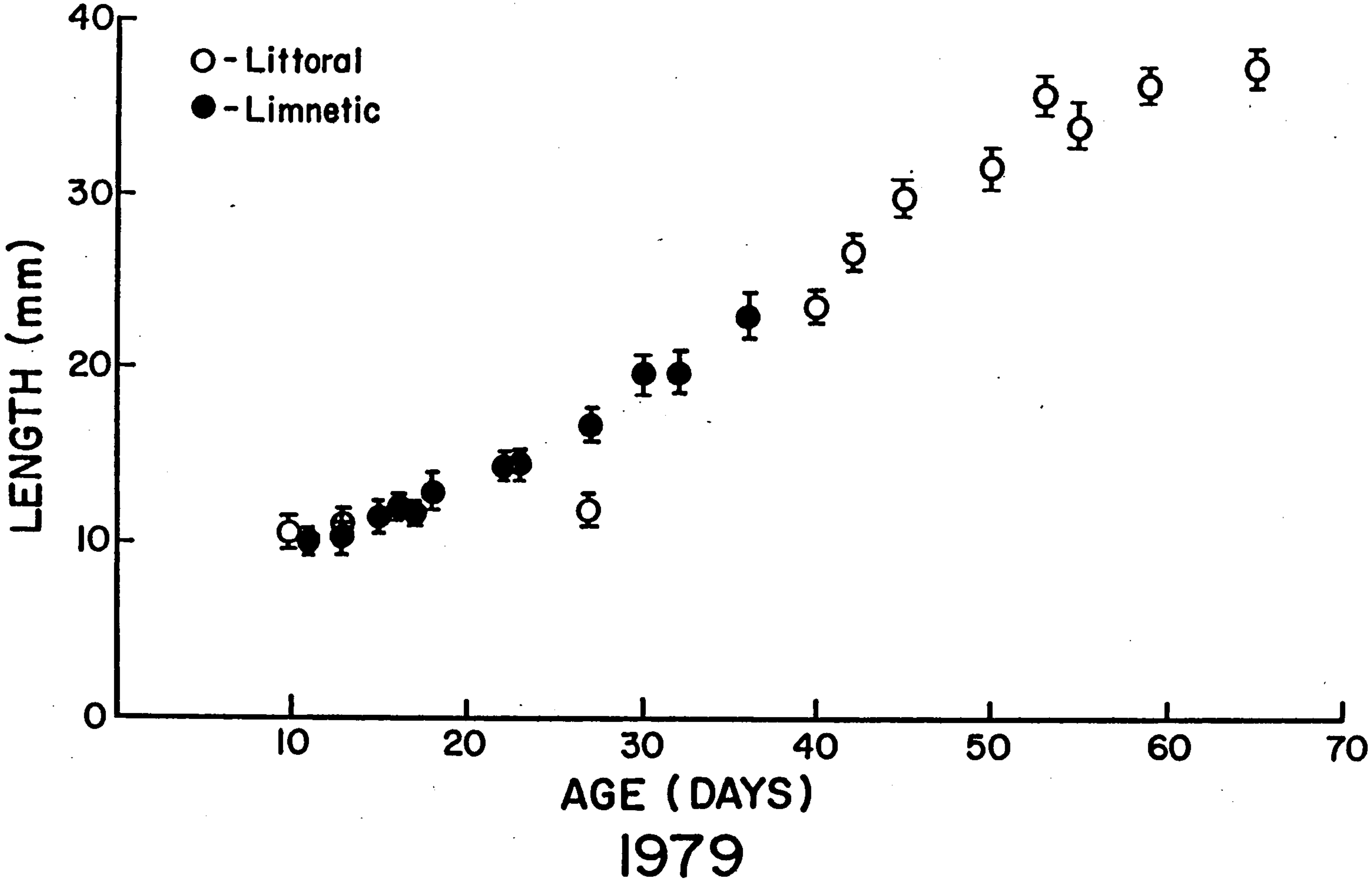

Figure 4. Growth in length of yellow perch fry in Lake Itasca, 1979. Data expressed as means with vertical bars showing standard error.

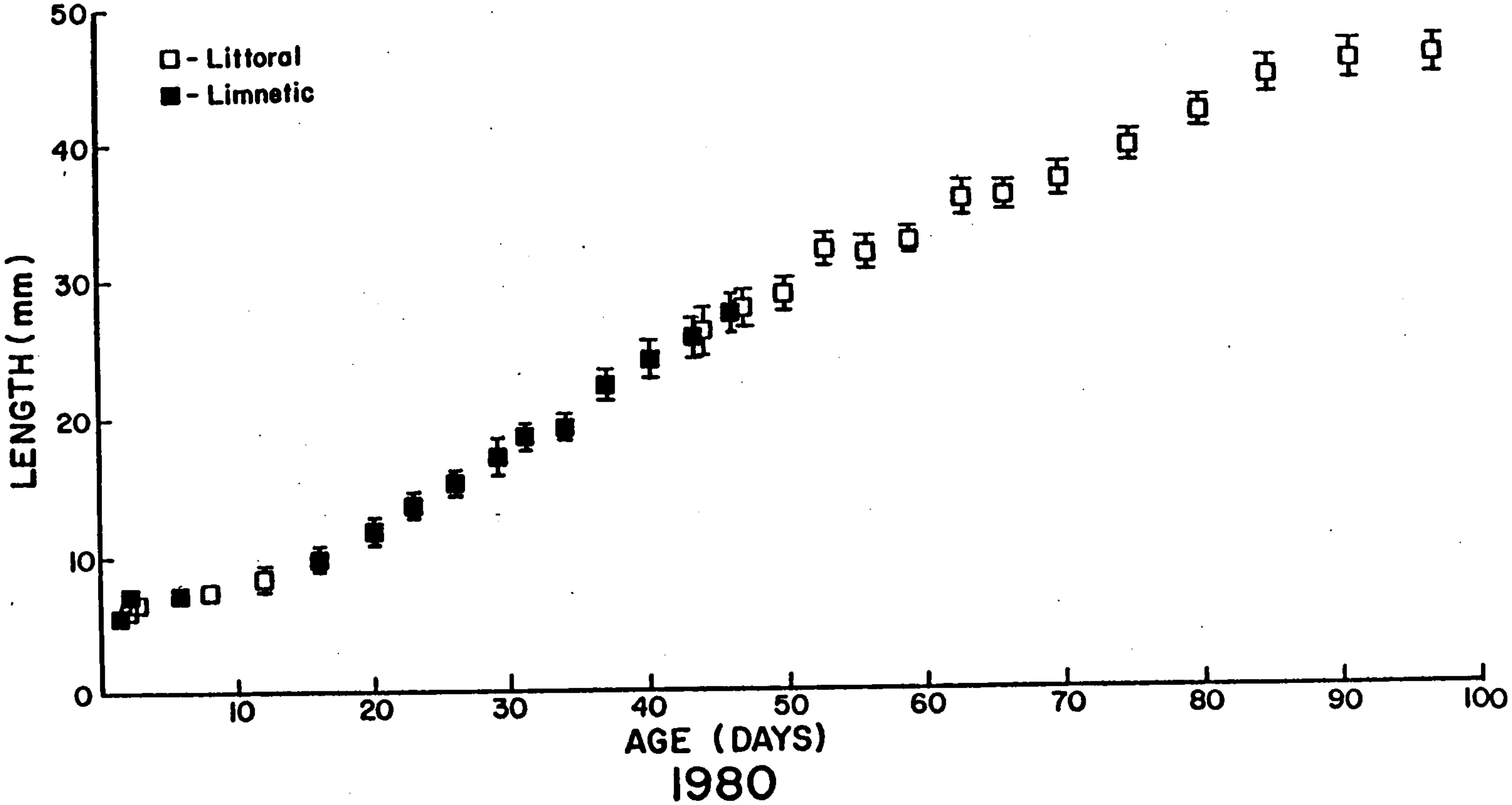

Figure 5. Growth in length of yellow perch fry in Lake Itasca, 1980. Data expressed as means with vertical bars showing standard error.

as:

	for 1978	$\text{Log } L = 1.02 + 0.0088X$	(Figure 6)
	for 1979	$\text{Log } L = 0.84 + 0.0147X$	(Figure 7)
and	for 1980	$\text{Log } L = 0.76 + 0.0154X$	(Figure 8).

Growth in length during the littoral phase using the same formula is:

	for 1978	$\text{Log } L = 1.20 + 0.0047X$	(Figure 6)
	for 1979	$\text{Log } L = 1.14 + 0.0069X$	(Figure 7)
and	for 1980	$\text{Log } L = 1.24 + 0.0046X$	(Figure 8).

T-tests indicate that the regression coefficient describing limnetic and littoral growth in length within a year are not significantly different for 1978, but are signigicantly different for 1979 and 1980 (Table 14, Appendix A). Growth in length of 1978 limnetic and littoral fry is best described by the regression equation:

$$\text{Log } L = 2.03 + 0.0082X.$$

Growth in weight of perch fry was determined from 625 fry collected during the three-year study. These data are given in Tables 15-20, Appendix A and are expressed graphically in Figures 9-11.

Growth in weight can be described by the regression equation:

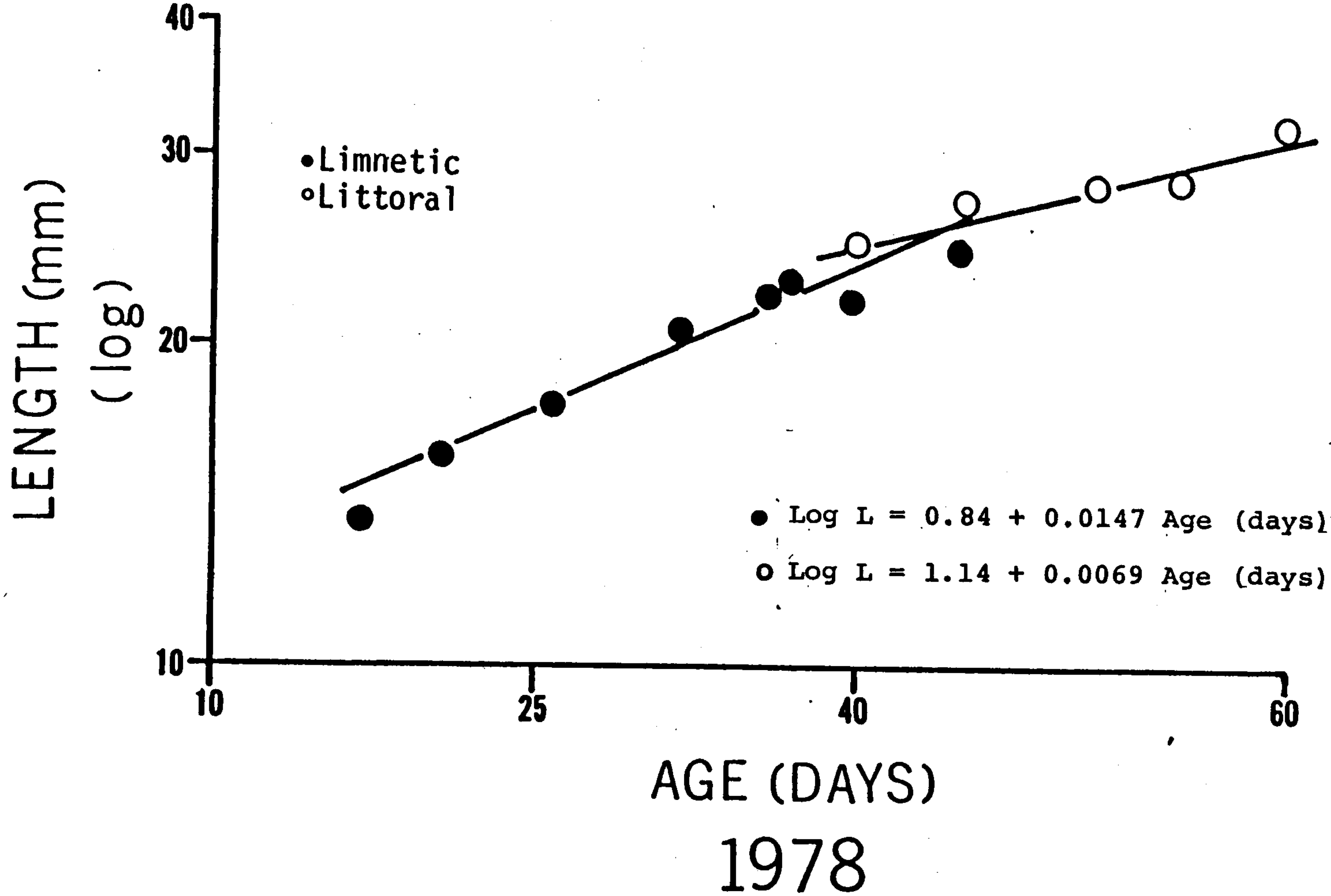

Figure 6. Regressions of growth in length of yellow perch fry collected in littoral and limnetic zones, 1978. Data expressed as means.

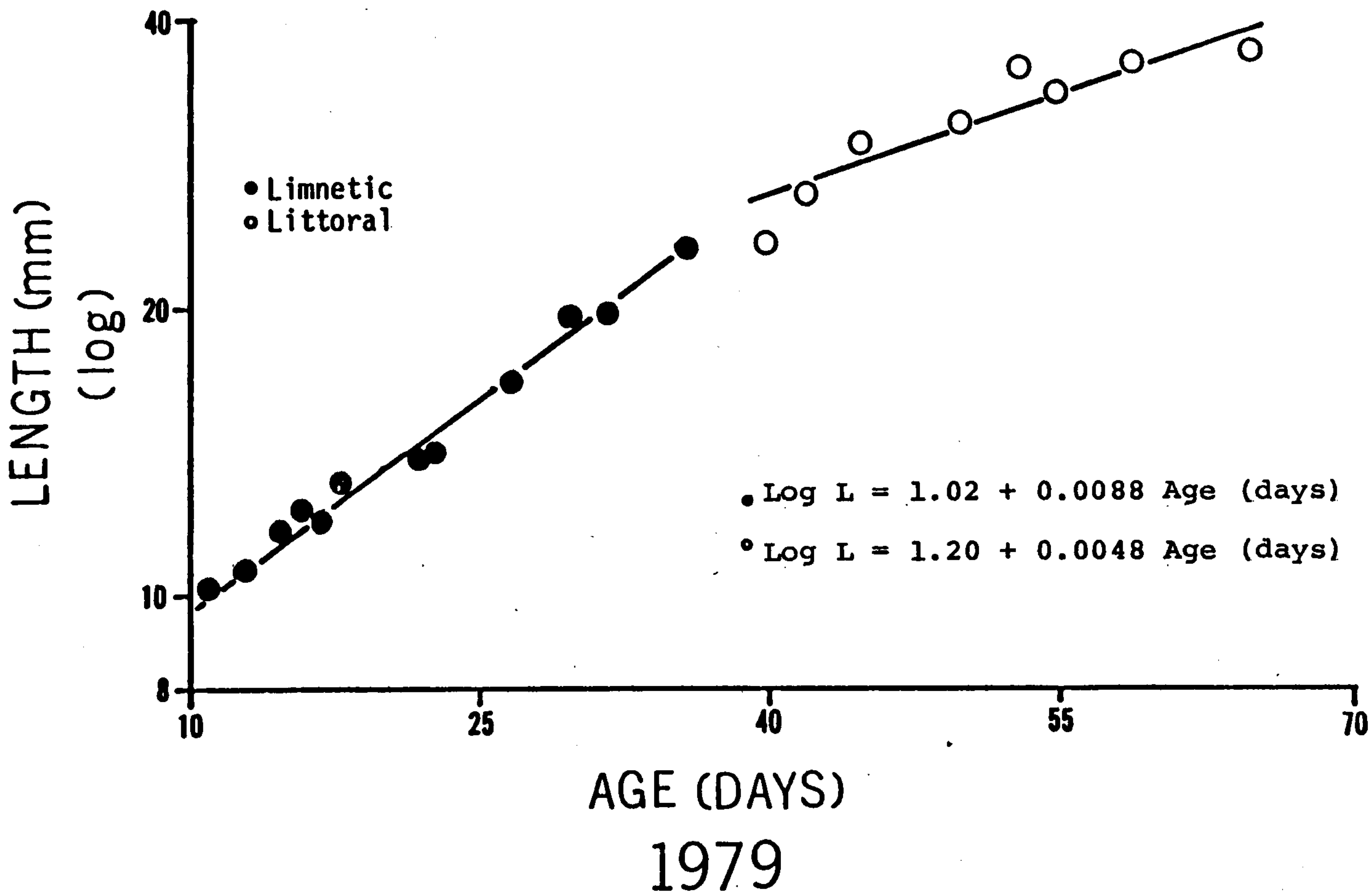

Figure 7. Regressions of growth in length of yellow perch fry collected in littoral and limnetic zones, 1979. Data expressed as means.

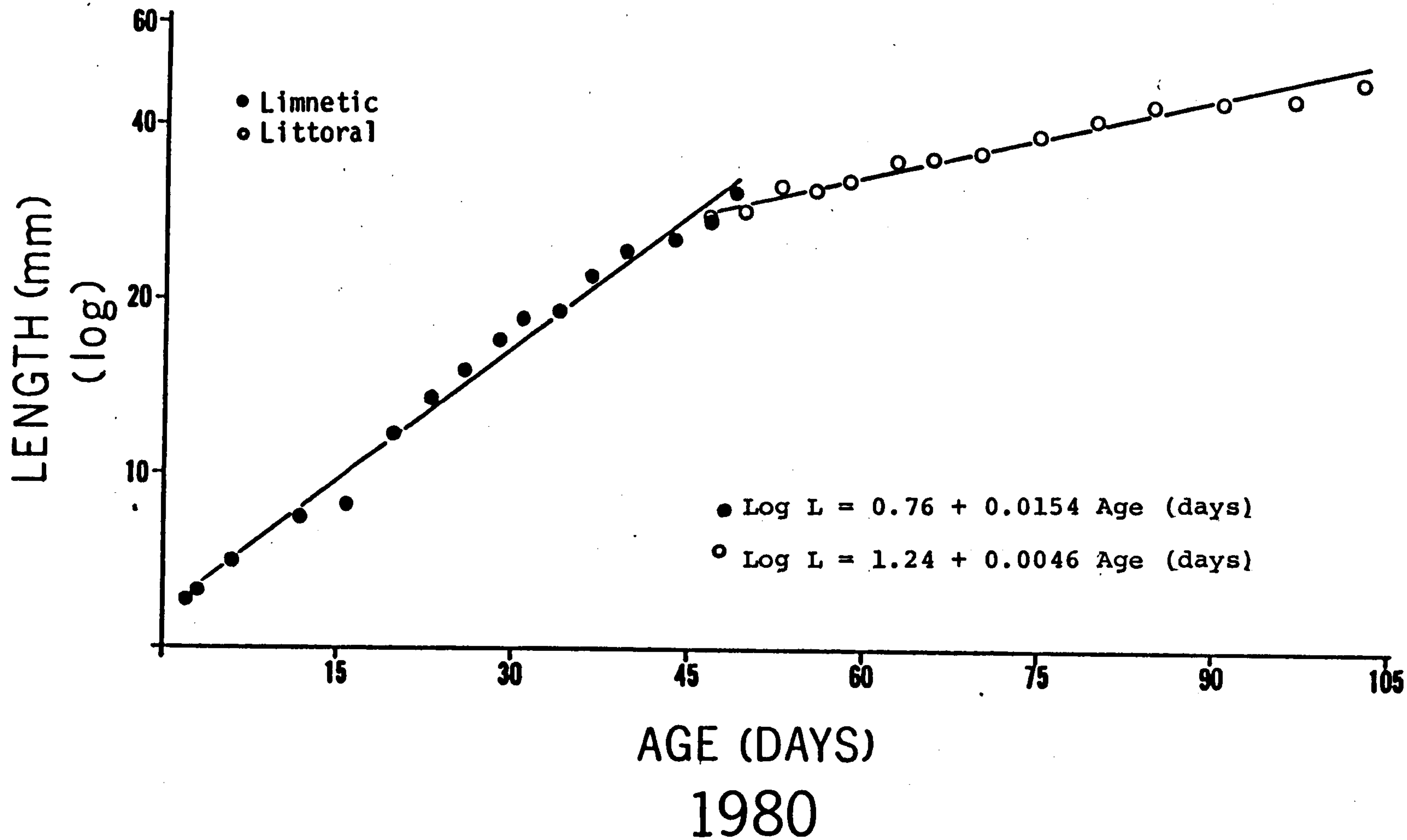

Figure 8. Regressions of growth in length of yellow perch fry collected in littoral and limnetic zones, 1980. Data expressed as means.

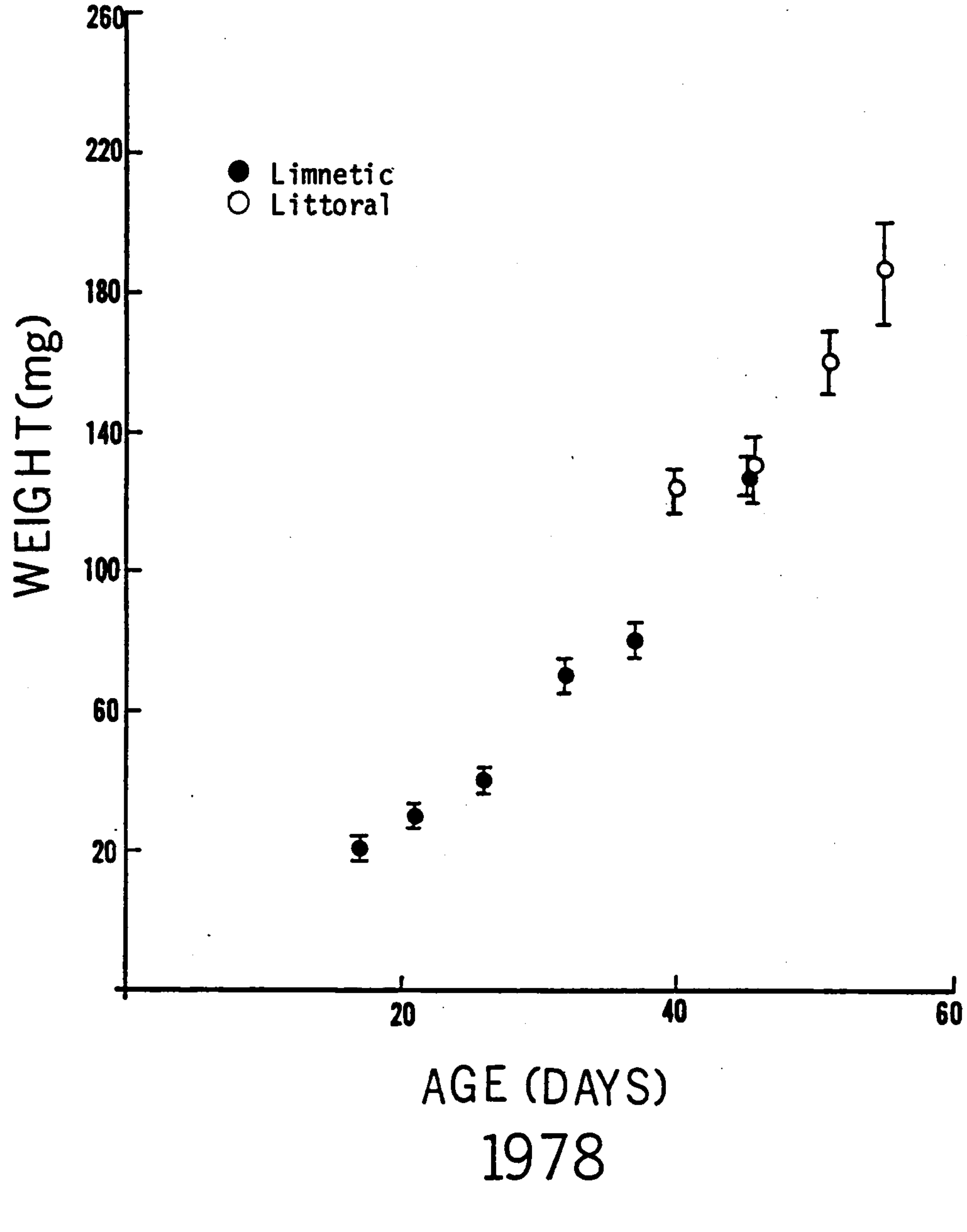

Figure 9. Growth in weight of yellow perch fry in Lake Itasca, 1978. Data expressed as means with vertical bars showing standard error.

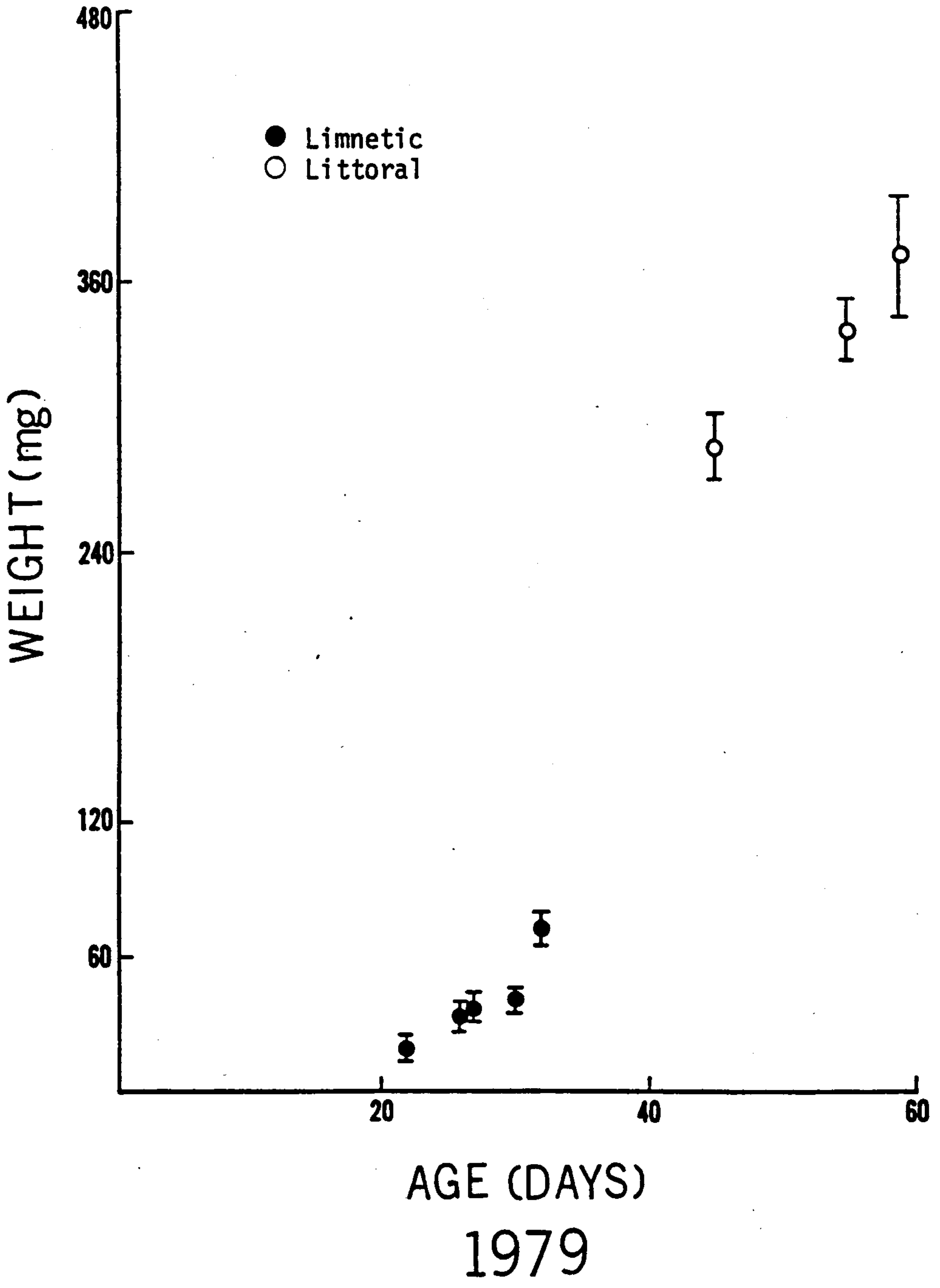

Figure 10. Growth in weight of yellow perch fry in Lake Itasca, 1979. Data expressed as means with vertical bars showing standard error.

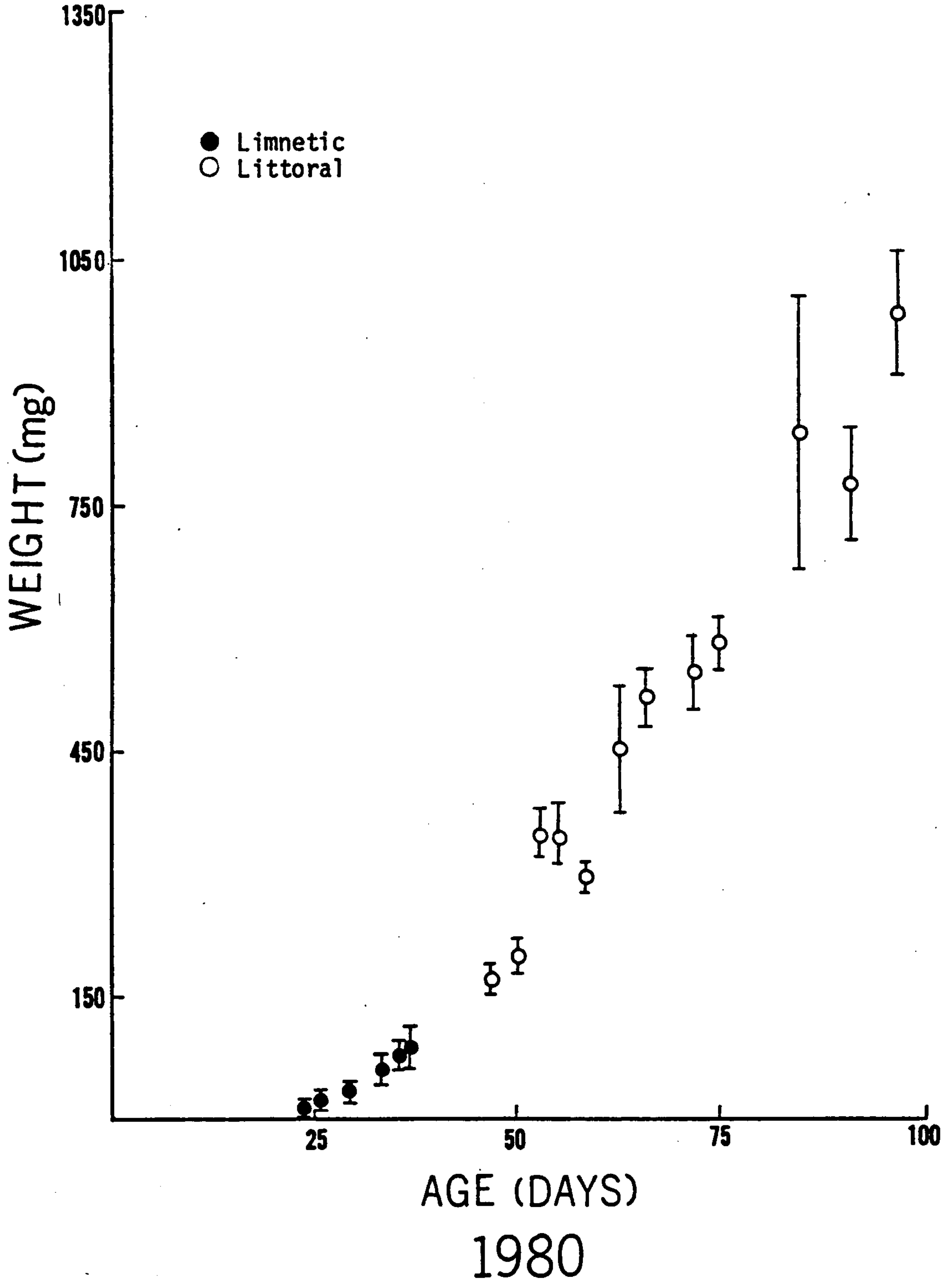

Figure 11. Growth in weight of yellow perch fry in Lake Itasca, 1980. Data expressed as means with vertical bars showing standard error.

$$W = b + mX$$

where:

W = weight (mg)
b = log of the y-intercept
m = log of the slope
X = number of days after hatching

Growth in weight during the limnetic phase is described as:

	for 1978	$\text{Log } W = 0.90 + 0.0268X$	(Figure 12)
	for 1979	$\text{Log } W = 0.07 + 0.0553X$	(Figure 13)
and	for 1980	$\text{Log } W = -0.08 + 0.0543X$	(Figure 14).

Growth in weight during the littoral phase is described as:

	for 1978	$\text{Log } W = 1.63 + 0.0109X$	(Figure 12)
	for 1979	$\text{Log } W = 2.07 + 0.0082X$	(Figure 13)
and	for 1980	$\text{Log } W = 1.74 + 0.0136X$	(Figure 14).

T-tests indicate that the regression coefficient describing limnetic and littoral growth in weight within a year are significantly different for 1979 and 1980 (Table 14, Appendix A). Growth in weight of 1978 limnetic and littoral fry is best described by the regression equation:

$$\text{Log } W = 1.03 + 0.0222X$$

Length-weight relationships for perch fry were deter-

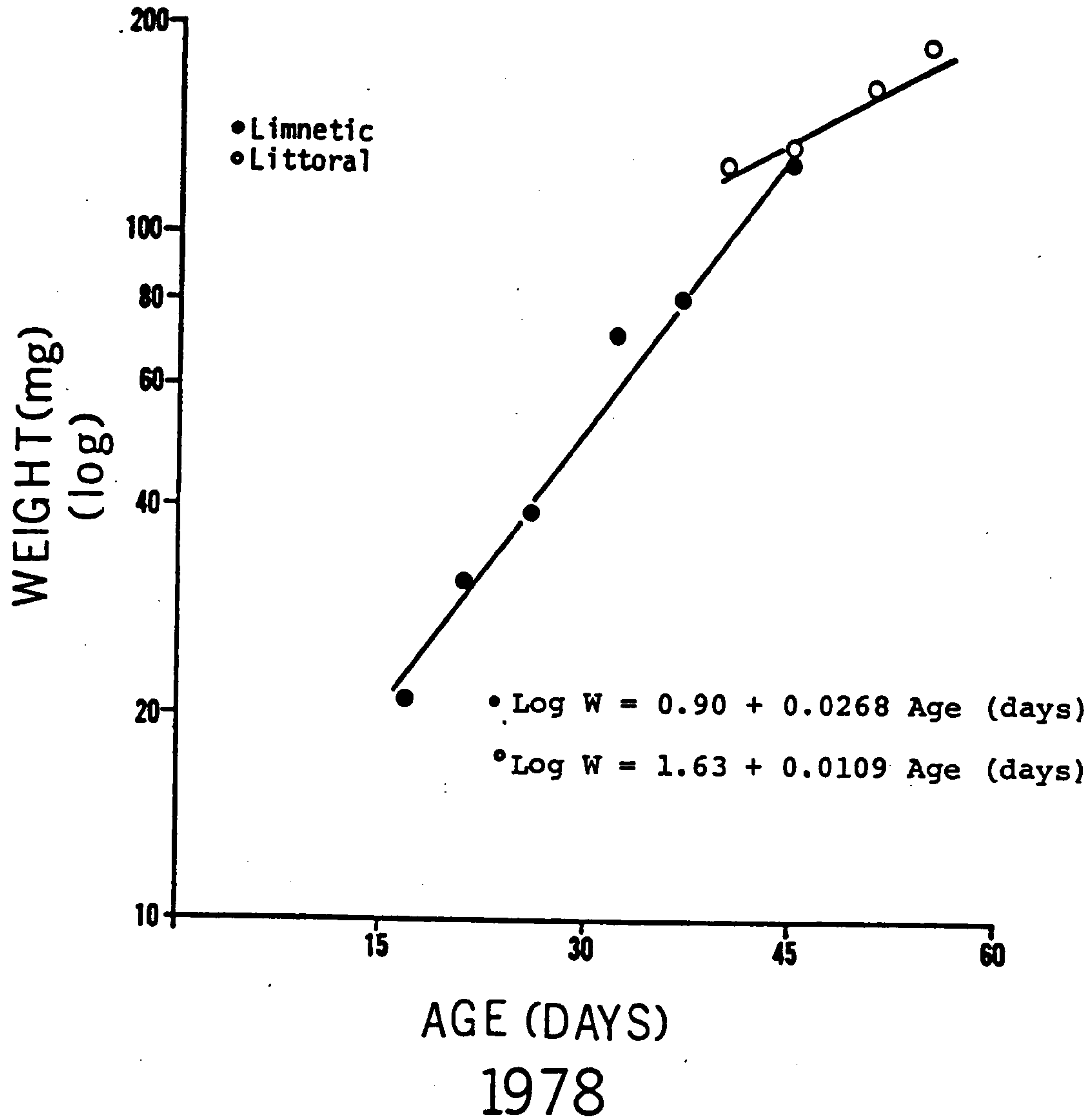

Figure 12. Regressions of growth in weight of yellow perch fry collected in littoral and limnetic zones, 1978. Data expressed as means.

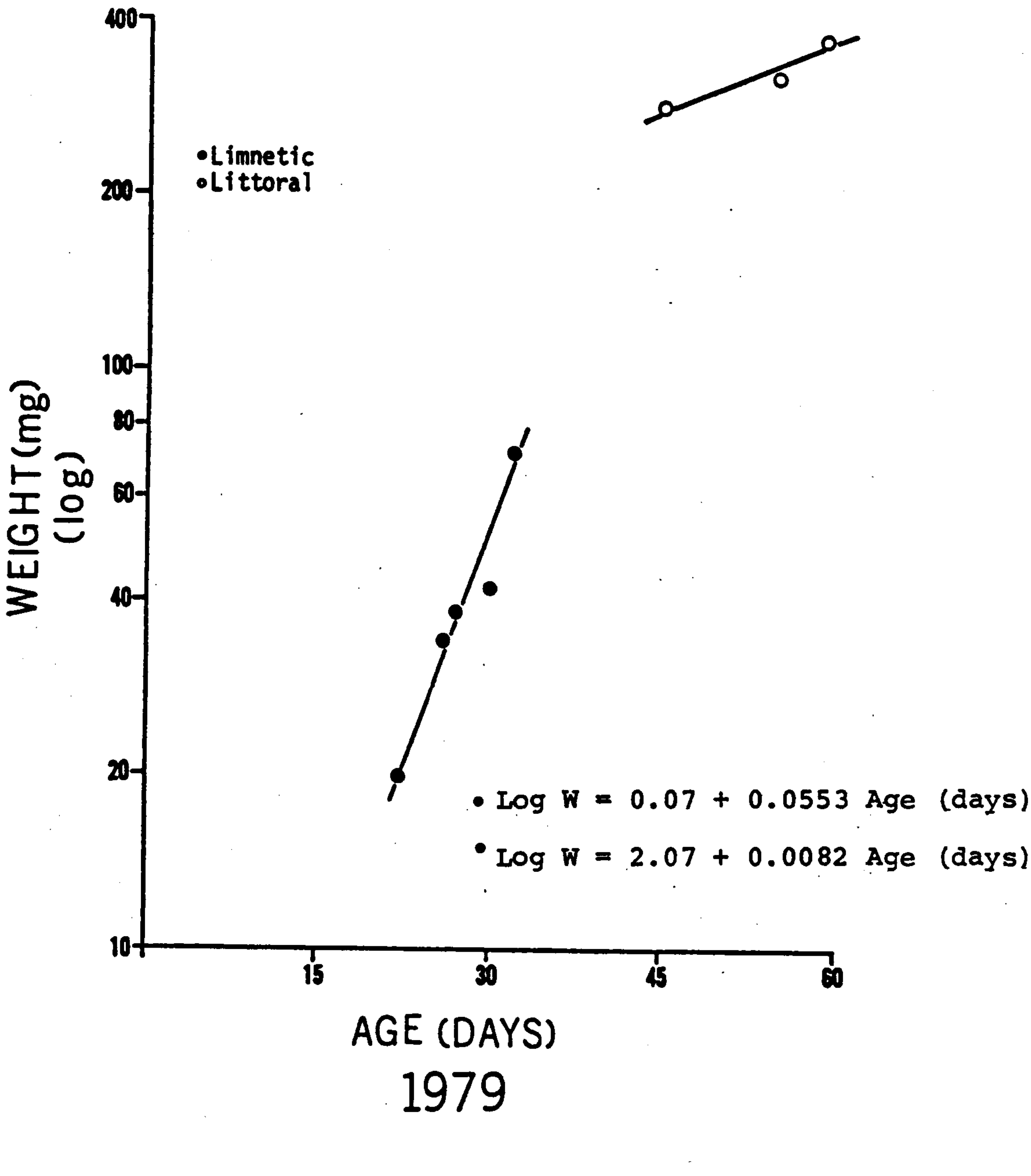

Figure 13. Regressions of growth in weight of yellow perch fry collected in littoral and limnetic zones, 1979. Data expressed as means.

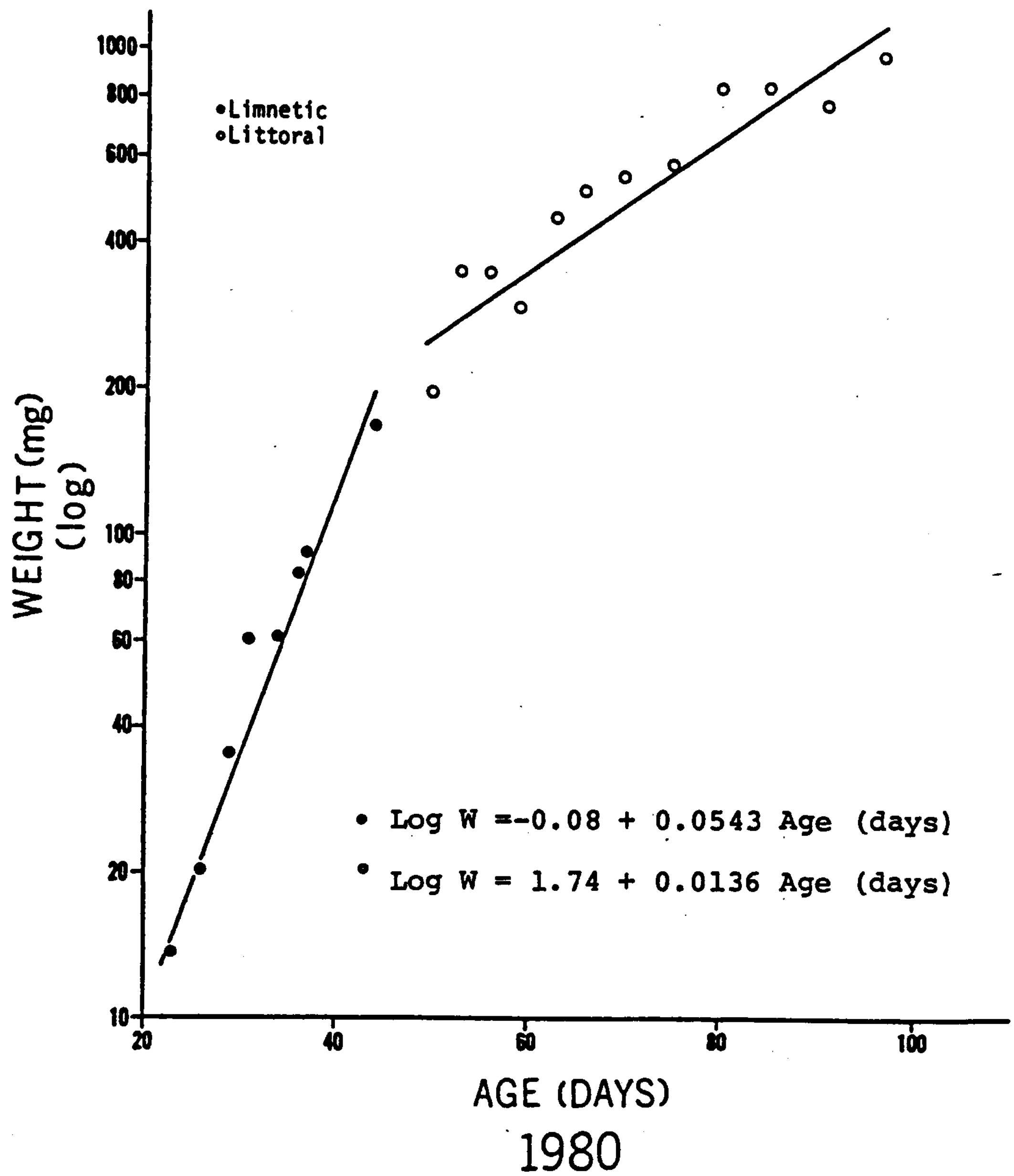

Figure 14. Regressions of growth in weight of yellow perch fry collected in littoral and limnetic zones, 1980. Data expressed as means.

mined from 625 fry collected during the three-year study (Figures 15-17).

Growth can be described by the regression equation:

$$W = b + mL$$

where:

W = weight (mg)
b = log of y-intercept
m = slope
L = length (mm)

Growth during the limnetic phase is described as:

for 1978 Log W = -2.25 + 3.11 Log L (Figure 15)

for 1979 Log W = -3.06 + 3.80 Log L (Figure 16)

and for 1980 Log W = -2.97 + 3.71 Log L (Figure 17).

Growth during the littoral phase is described as:

for 1978 Log W = -2.61 + 3.34 Log L (Figure 15)

for 1979 Log W = -1.17 + 2.43 Log L (Figure 16)

and for 1980 Log W = -2.44 + 3.28 Log L (Figure 17).

T-tests indicate that the regression coefficient describing limnetic and littoral length-weight rate of change within each year are significantly different (Table 14, Appendix A).

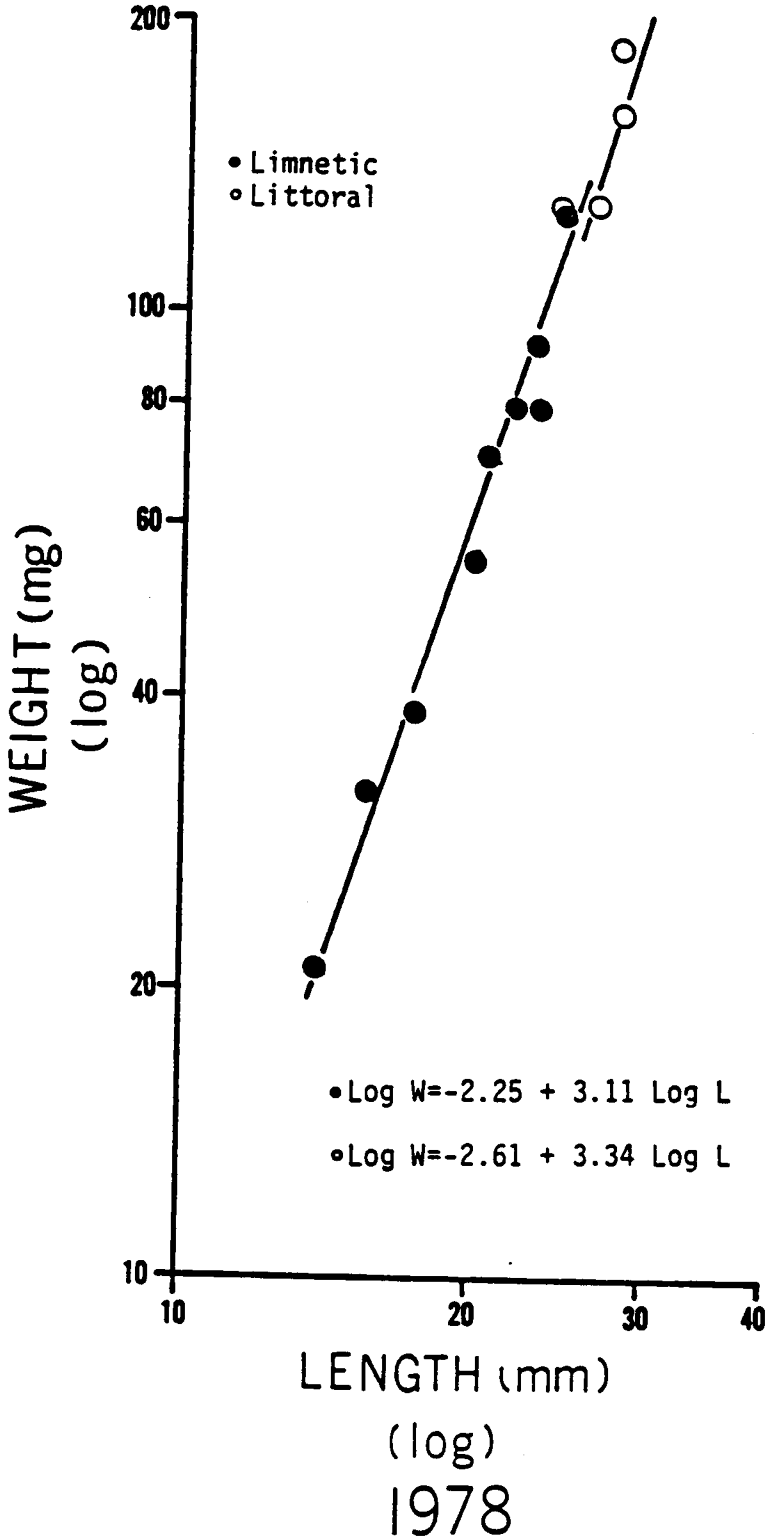

Figure 15. Regressions of length-weight relationship of yellow perch fry in Lake Itasca, 1978. Data expressed as means.

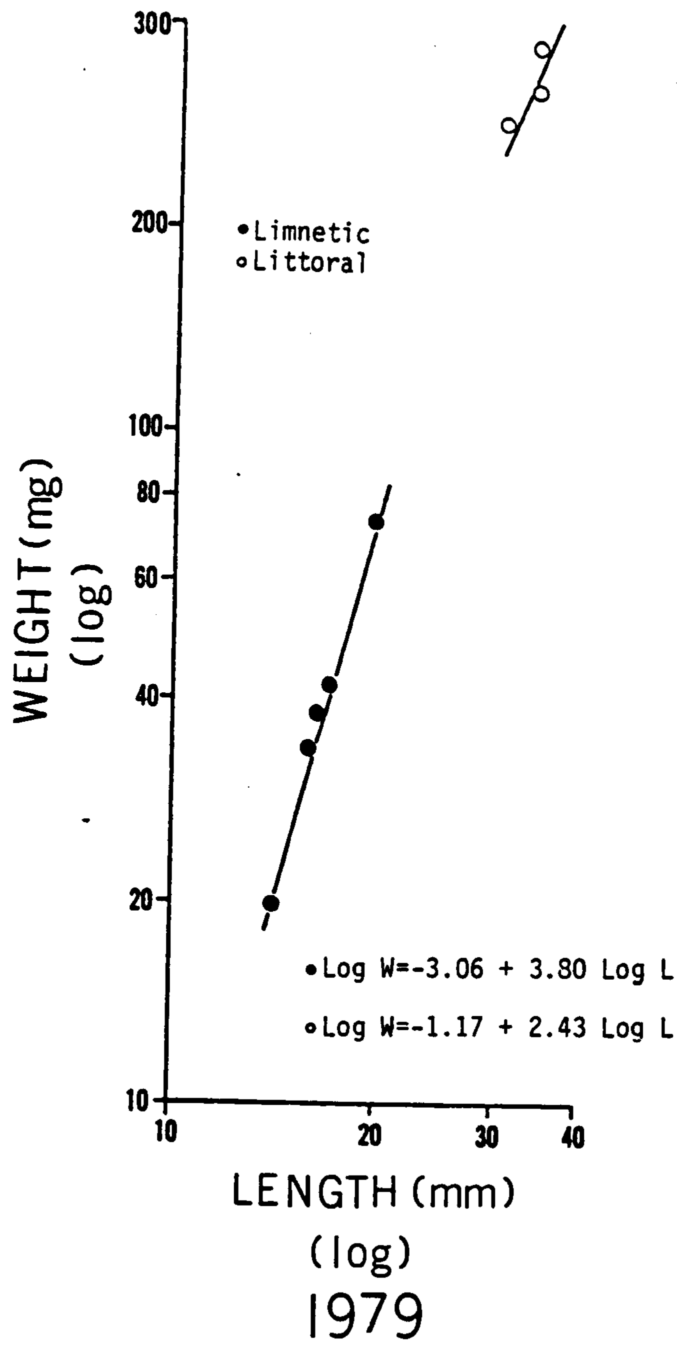

Figure 16. Regressions of length-weight relationship of yellow perch fry in Lake Itasca, 1979. Data expressed as means.

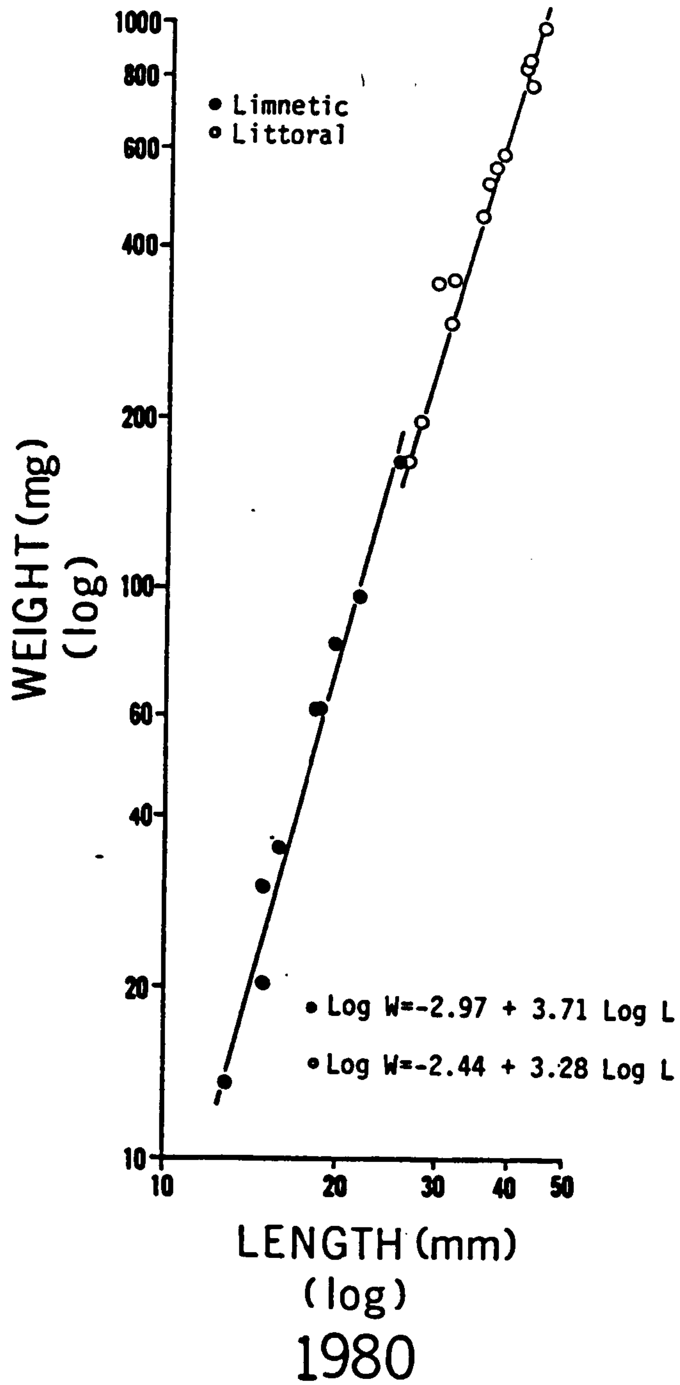

Figure 17. Regressions of length-weight relationship of yellow perch fry in Lake Itasca, 1980. Data expressed as means.

VI. DISCUSSION

Distribution

The distribution of yellow perch fry during their first summer depends upon a variety of factors including the size of the fry and the physical and morphological characteristics of the lake. Yellow perch fry have been reported to mainly inhabit littoral waters (Turner 1920; Fish 1932; Echo 1954; Maloney and Johnson 1957) but have also been reported to inhabit limnetic waters (Fish 1932; Faber 1967). These discrepancies as to the distribution of perch fry are due to differences in sampling methods, varying durations of the studies and possibly to different interpretations as to which areas comprise the littoral and limnetic zones.

In Lake Itasca yellow perch fry inhabit both littoral and limnetic zones at different times during their first summer. The perch fry hatch in shallow littoral waters, and remain there until about two weeks following hatching, after which they move into the limnetic zone. Henderson (1977) found similar movement patterns in West Blue Lake. The length of the perch fry at the time of transition from the littoral to the limnetic zone was variable. In 1979, the first fry collected in the limnetic zone had a mean length of 10.1 mm (Range 9.0-11.1 mm) and in 1980, the fry had a mean length of 6.1 mm (Range 5.7-6.4 mm). Wong (1972) and Henderson (1977) report that the transition from the littoral to the limnetic zone occurs when the fry are 9-10 mm in length. The initial migration of the perch fry may illustrate a dispersion away from the spawning area, which is a common behavior among many aquatic and terrestrial organisms (Faber 1967).

During mid-summer the perch fry abandoned the limnetic zone and returned to the littoral zone. This movement was evident by the reduced catch of fry in the limnetic zone and an increased catch in the littoral zone. The migration occured when the fry were approximately 25 mm in length, ranging from 19.0-30.0 mm over the three-year study (Tables 1,2 and 6, Appendix A). Wong (1972) and Henderson (1977) report the same movement occuring when the fry were almost 30 mm in length. The consistent findings of the West Blue Lake studies (Wong 1972; Henderson 1977) and this study indicate that the early movement from the littoral to limnetic habitat and the mid-summer movement from the limnetic to the littoral habitat are typical of yellow perch fry.

Water temperature has been cited as a possible factor influencing the migration of perch fry from the littoral to limnetic zone (Faber 1967; Wong 1972; Henderson 1977). In Lake Itasca, the movement to the limnetic zone occured when the surface water temperature ranged from 14.4-15.2°C in 1979 and 10.5-12.5°C in 1980 (Appendix B). Wong (1972) and Henderson (1977) report that this migration occured in West Blue Lake when the surface water temperature ranged from 13.0-19.0°C. Because of the wide range in temperature at the time of the limnetic migration, there does not appear to be a strong correlation between water temperature and the perch migration.

It has been postulated that the fry's migrations are an effort to escape predation (Faber 1967; Henderson 1977; Kelso and Ward 1977). This seems a plausible explanation for the newly hatched fry's movement into the limnetic waters since the fry's transparent appearance would make it difficult for potential predators to differentiate the fry from the zooplankton. In addition, there is an abundance of littoral invertebrates and fish which are capable of preying upon the fry, while there are very few limnetic predators that pose a danger to the fry.

In lakes where walleye and yellow perch coexist, walleye and adult perch are the major predators of perch fry (Maloney and Johnson 1955; Forney 1971; Clady 1974; Tarby 1974). During the summer when the lake is stratified, walleye and adult perch inhabit the littoral and sublittoral zones and rarely cross into the limnetic zone (MacLean and Magnuson 1974; Ward and Robinson 1974; Kelso 1976; Ryder 1977). This segregation of walleye and adult perch in the littoral and sublittoral zones would reduce predation upon the perch fry. Tarby (1974) supports this conclusion, noting that predation of perch fry by adult perch did not occur until the fry moved back into the littoral zone.

The movements of perch fry may be an attempt to increase their food supply. Wong and Ward (1972) found that early in life perch fry are limited to small prey because of their mouth gape. The movement of fry into the limnetic zone provides an abundance of small food organisms, such as copepod nauplii, immature copepodids and rotifers (Pittinger 1978). However, this explanation seems unlikely, because, although the average size of zooplankton is smaller in limnetic areas, the absolute abundance of food-sized zooplankton is greatest in the littoral zone (Whiteside, Doolittle personal communication). Thus, the most probable explanation for the initial, offshore migration of perch fry is that they do so to escape predation.

If the fry move into the limnetic zone to escape predation, why should they return to the inshore area? Prior to the fry's inshore migration, there is a decline in number of the limnetic zooplankton population (Whiteside, unpublished data). The fry's migration into the littoral zone could be a response to the lowered limnetic food supply, but, probably more importantly, by moving into the littoral zone the fry increase the size range of potential prey (Pittinger 1978; Whiteside, personal communication). At the time of this migration, the fry have mouth gapes sufficiently large to enable them to prey upon many macroinvertebrates which inhabit the littoral zone. The ability to consume large prey is advantagous because it increases the reward per effort and broadens the size spectrum of potential prey.

There is a 'trade-off' between increased predation of fry in the littoral area versus the limnetic zone and greater food abundace in the littoral habitat. However, the mid-summer shoreward migration occurs when the fry begin developing the characteristic dark vertical bands of adult perch. This banding pattern acts as disruptive coloration among the littoral vegetation, thus making them less conspicuous in this environment. This development,plus their larger size (25 mm), reduces their susceptibility to predation.

Feeding

Zooplankton are the food of many freshwater larval fish, including yellow perch. Perch fry are limited to a specific type and size of prey because of their small mouth gapes and poor swimming ability (Siefert 1972; Wong and Ward 1972). To be a potential food item, the organism must be in the immediate vicinity of the fry, slow enough for the fry to catch, and small enough to be ingested (Siefert 1972; Henderson 1977). Several species of cladocerans, copepods and rotifers meet these prerequisites as food organisms and have been documented as prey of perch fry (Allen 1935; Siefert 1972; Wong 1972; Hokanson 1977).

In Lake Itasca, the initial food organisms of perch fry consisted of the smaller zooplankters: copepod nauplii, immature copepodids, adult copepods and rotifers (Tables 7-9, Appendix A). Thus, copepods form the major portion of their diet in spite of the fact that small cladocera (Bosmina, young Daphnia) could be taken. This is consistent with the findings of other studies of perch fry diets (Turner 1920; Wong 1972; Ward and Robinson 1974; Clady 1977). The various life stages of copepods may be expected to be an important food to fry because of their small size and their conspicious jerky swimming motion (Siefert 1972). Nauplii would be especially vulnerable as prey because they lack the long antennae used by later instars for swimming.

As the mouth gape increased, and as the fry became better swimmers their diets included larger prey; copepods, rotifers, and cladocera were important food organisms (Tables 7-9, Appendix A). Copepods were found in 93% of the limnetic fry examined during the three-year study and composed 48% of the limnetic diet (Tables 7-9, Appendix A). Electivity indices computed from limnetic samples indicate that copepods were taken more frequently by the fry as prey (Table 21 and 22, Appendix A). Cladocera were found in 78% of the limnetic fry examined and composed 35% of the limnetic diet (Tables 7-9, Appendix A). Electivity indices indicate that copepods are preferred over cladocera as prey (Tables 21 and 22, Appendix A). Comita and Schindler (1963) found that copepods have a higher energy content per unit weight than do cladocera. Thus it is advantagous for the fry to select copepods over cladocera. In addition, copepods were numerically more common than cladocera in the limnetic zone (Whiteside, unpublished data).

Rotifers were an important prey to limnetic fry in 1980, being found in over 80% of the fry examined and numerically composing 25% of the diet (Table 9, Appendix A). In 1978 and 1979 rotifers were of minor importance, being found in less than 5% of the fry examined and composing less than 1% of the total diet (Tables 7 and 8, Appendix A). The reason for this differential selectivity of rotifers among years is unclear since information of rotifer abundance is not available.

Once the fry reach a length of 20 mm, *Chaoborus* became part of the limnetic diet (Tables 7-9, Appendix A). This is consistent with the results of other diet studies of perch fry (Wong 1972; Bulkley et al. 1976; Henderson 1977). Perch fry with a length less than 20 mm are unable to use *Chaoborus* or other insect larvae as prey because of their small mouth gape (Wong 1972). For limnetic fry greater than 20 mm in length, *Chaoborus* comprised less than 7% of the diet during the three-year study (Tables 7-9, Appendix A). Although *Chaoborus* comprised a relatively small number of the limnetic organisms eaten, they comprised a large portion of the mass of the diet because of their large size.

Perch fry were collected every four hours over a 24-hour period to establish if the fry consume the same organisms and the same quanity throughout the day. The stomach contents of the limnetic fry indicate that feeding is continuous throughout the day and night and that there is not a significant change in the composition of the organisms eaten (Table 13, Appendix A). The greatest number of food organisms were found in fry collected at 2300 hrs. Wong (1972) found that the feeding maximum of perch fry in West Blue Lake occurred at 2100 hrs.

Furnass (1979) determined that perch fry rely on vision to capture prey. Migrating zooplankton in the epilimnion would be easily seen by fry swimming under them during twilight. This is supported by the occurence of the feeding maximum at 2300 hrs in Lake Itasca and at 2100 hrs in West Blue Lake. Further support of the importance of vision in feeding comes from the fact that the fewest food organisms were found in fry collected during complete darkness (0300 hrs, Table 13, Appendix A). Guma'a(1978a) found that perch fry in Windermere rarely fed between 2400 and 0500 hrs and concluded that this was due to reduced visibility. Other senses, such as olfactory and lateral line systems may be involved in prey detection. However, because of the feeding periodicity of the perch fry it appears that the fry rely predominantly on vision for feeding.

At approximately 25 mm in length the perch fry move into the littoral zone of Lake Itasca (Figure 2,p.19). During this phase copepods and cladocera remain important food organisms in addition to benthic organisms such as amphipods and insect larvae (Tables 10-12, Appendix A).

Cladocera were the most important prey of the littoral fry, being found in 91% of the fry examined and constituting 70% of the total diet (Tables 10-12, Appendix A). Copepods, while remaining a common food organism, were less important to the littoral fry and constituted only 16% of the diet (Tables 10-12, Appendix A). Knapp (1960) and Wong (1972) reported similar findings.

It is unclear why littoral perch fry consumed greater numbers of cladocera than copepods since on many dates the numbers of copepods within the littoral zone were equal to or greater than the number of cladocerans (Doolittle 1981). It is possible that copepods have a greater ability to avoid fry within the littoral zone than do cladocerans or that the habitat of cladocerans renders them more vulnerable to predation than are the copepods. Allan (1976) reports that copepods can achieve a velocity 10-15 times as great as that of cladocerans over short distances and can accomplish rapid changes in direction. While this rapid movement does not appear to help copepods avoid the fry in the limnetic zone, it may be benificial in the littoral zone where vegetation can offer refuge. Prey selection experiments with bluegill fry (Confer and Blades 1974) and perch fry (Furnass 1979) revealed that reaction distances were longer and strike success higher with cladocerans as prey as compared with copepods.

During the littoral phase the perch fry become demersal

(Turner 1920; Thorpe 1977; Hansen and Wahl 1981) and begin to prey upon benthic organisms (Wong 1972, Tables 10-12, Appendix A). Because of the high number of cladocera and copepods in the diet of the fry, benthic organisms such as amphipods and insect larvae do not appear to contribute significantly to the diet (Tables 10-12, Appendix A). However, because of their large biomass, amphipods and insect larvae comprise a substantial portion of the diet. In general, as the fry grow larger, the occurence of these larger benthic organisms in the diet becomes more frequent (Tables 10-12, Appendix A).

Ostracods were plentiful in the littoral zone (Doolittle 1981), yet usually contributed a very small portion of the fry's diet (Tables 10-12, Appendix A). Other studies of the diet of perch fry do not include ostracods as a food organism (Siefert 1972; Noble 1975; Henderson 1977). Pennak (1978) reports that ostracods are only a minor food item in the diet of young fish. The reason for the low predation upon ostracods by perch fry is unknown. Ostracods may be protected from predation because of their habitat selection, by their clam shell-like carapace which may make them undigestible or perhaps they just taste bad.

Due to the wide variety of food organisms consumed (Tables 7-13, Appendix A), yellow perch fry appear to be opportunistic in their feeding habits. The limiting factors to feeding are the size of the fry's mouth gape and the fry's swimming ability. These limiting factors initially restrict the perch fry to a diet of copepod nauplii, copepodids and rotifers. During early development there is a rapid increase in the size of the mouth gape (Wong 1972) which quickly broadens the size spectrum of potential prey. It is advantagous for the fry to consume the largest prey possible, since it provides the greatest reward per effort (Ivlev 1961). Yet, large fry which feed on amphipods and insect larvae continue to include prey of all sizes in their diet (Tables 10-13, Appendix A). This utilization of a wide variety of prey species is of survival value since it insures a continuous abundance of potential prey.

Growth

The growth of larval perch is characterized by two major stanzas (Henderson 1977; Guma'a 1978b; present study). In Lake Itasca, the change from one growth stanza to another takes place approximately 40-45 days after hatching and coincides with the movement of the fry from the limnetic to the littoral zone. During the first growth stanza, the fry undergo a metamorphosis, changing from a transparent fry with undeveloped fins and a poor swimming ability to a juvenile or adult-like perch. During the second growth stanza there is a rapid development of scales, spines and skeletal structure but very little change in external morphology (Pycha and Smith 1955; Henderson 1977).

Statistical comparisons of growth in length and weight of the limnetic and littoral fry indicate that the growth rates were significantly different between the two habitats in 1979 and in 1980 (Table 14, Appendix A). The growth in length between the limnetic and littoral fry in 1978 were found not to be significantly different (Table 14, Appendix A). The co-occurence of several cohorts in 1978 makes the results of the growth analysis questionable due to the difficulty in identifying the individual cohorts.

Growth in length during the first stanza was initially slow, averaging 0.19 mm per day in 1980 (Table 4). This low rate of growth is probably due to endogenous feeding and to the poor swimming ability of the newly hatched fry which makes it difficult to locate and capture prey. The growth in length rapidly accelerates to an average of 0.52 mm per day in 1979 (Table 3, Appendix A) and 0.55 mm per day in 1980 (Table 4, Appendix A) and coincides with the start of intensive feeding of the perch fry. This rapid growth occurs during the fry's limnetic phase and has been well documented (Henderson 1977; Kelso and Ward 1977; Guma'a 1978b). Henderson (1977) found that during the first growth stanza the fry have a 50-60% food conversion efficiency, indicating that over half of the energy consumed by the fry went directly into growth.

Wong and Ward (1972) have clearly shown the importance of rapid growth during the early development of perch fry.

Rapid growth quickly widens the size range of ingestable prey, thereby increasing the abundance of potential prey. This rapid growth in the mouth gape would be particularly important in years of low food abundance.

The second growth stanza coincides with the fry inhabiting the littoral zone. During this stanza there is a decline in the growth rate. Growth in length averaged 0.36 mm per day in 1978, 0.58 mm per day in 1979 and 0.36 mm per day in 1980, and averaged 0.43 mm per day during the three-year study (Tables 1,2 and 6, Appendix A). Growth in weight shows a pattern similiar to growth in length, with higher growth rates occuring during the limnetic phase (Figures 12-14, p.34-36). Other studies have also found a higher growth rate during the limnetic phase than during the littoral phase (Henderson 1977; Kelso and Ward 1977; Guma'a 1978b).

Growth rate depends upon the interrelationship of food (quantity and quality), metabolism and temperature (Brett 1979). In fish, an increase in temperature results in an increased metabolic rate and usually an increase in food consumption. If the energy demand of an increased metabolic rate exceeds the gain from an increased food intake, a reduction in growth rate would result (Brett 1979). In Lake Itasca, the increase in water temperature during summer (Appendix B) results in an overall increase in the metabloic rate of fry. Even though there is an increase in the numbers and size of prey ingested by the littoral fry (Tables 10-12,

Appendix A), there is not enough energy gained, as reflected by the reduced growth rate, to offset the higher metabolic cost. The mid-summer decline of the littoral zooplankton population (Doolittle 1981) appears to be a contributing factor which prohibits the fry from fulfilling their higher energy requirements.

VII. CONCLUSION

Food abundance and predation are likely factors affecting the early life history of yellow perch. Changes in food abundance and predation pressures during the perch's first summer result in changes of habitat, feeding patterns, and growth rates of the perch fry.

Soon after hatching yellow perch fry undertake migrations from the littoral spawning area to the limnetic zone and from the limnetic back to the littoral zone at approximately 40 days old. The initial migration serves to reduce predation of the fry by both invertebrates and fish. After the fry become larger, and develop cryptic coloration, they return to the littoral zone where food is more abundant. These movements do not appear to be triggered by environmental cues and are probably an innate behavior of the growing fry.

Yellow perch fry are opportunistic in their feeding habits, feeding on a wide variety and sizes of food organisms. Initially the fry are limited to a specific type and size of prey because of the fry's small mouth gape and poor swimming ability. During this period the fry inhabit the limnetic zone and feed on copepod nauplii, immature copepodids, adult copepods and rotifers. As the fry's mouth gape increases in size and its swimming ability improves, cladocerans and Chaoborus become food organisms. Once the fry move back into the littoral zone, benthic organisms such as amphipods and insect larvae become included as part of the diet. Yet, the large fry continue to feed on all sizes of prey.

The growth of perch fry is typically characterized by two stanzas which coincide with the habitat of the fry. During the first growth stanza the fry inhabit the limnetic zone. Growth in length is rapid during the limnetic phase, averaging about 0.5 mm per day. This rapid growth is of survival value since it quickly increases the number and size of potential prey. The second growth stanza coincides with the fry inhabiting the littoral zone. Growth in length during the littoral phase averaged about 0.4 mm per day. Growth rates during the littoral stanza are lower than the limnetic stanza, perhaps due to high metabolic cost during the littoral phase.

LIST OF REFERENCES

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Allan, J.D. 1976. Life history patterns in zooplankton. Am. Nat. 110(971):165-180.

Allen, R.K. 1935. The food and migration of the perch Perca fluviatilis L. in Windermere. J. Anim. Ecol. 4:264-273.

Brett, J.R. 1979. Environmental factors and growth. Chapter 10 in Fish Physiology vol.8 Bioenergetics and growth (pp. 599-675) editors W.S. Hoar, D.J. Randall and J.R. Brett. New York, Academic Press. 1979.

Bulkley, R.V., V.L. Spykermann and L. Inmon 1976. Food of the pelagic young of walleye and five cohabiting fish species in Clear Lake, Iowa. Trans. Am. Fish. Soc. 105(1):77-83.

Carlander, K.D. 1950. Growth rate studies of saugers, Stizostedion canadense, and yellow perch, Perca flavescens from Lake of the Woods, Minnesota. Trans. Am. Fish. Soc. 79(1):30-42.

Clady, M.D. 1974. Food habits of yellow perch, smallmouth bass and largemouth bass in two unproductive lakes in northern Michigan. Am. Midl. Nat. 91(2):453-459.

______ 1976. Influence of temperature and wind on the survival of early stages of yellow perch, Perca flavescens. J. Fish. Res. Board Can. 33(9):1887-1893.

Coble, D.W. 1966. Dependence of total annual growth in yellow perch on temperature. J. Fish. Res. Board Can. 23(1):15-20.

Cole, G.A. and J.C. Underhill 1965. The summer standing crop of sublittoral and profundal benthos in Lake Itasca, Minnesota. Limnol. Oceanogr. 10(4):591-597.

Confer, J.L. and P.I. Blades 1974. Omnivorous zooplankton and planktivorous fish. Limnol. Oceanogr. 20(4):571-579.

Doolittle, W. 1981. The nature and cause of the midsummer decline of littoral zooplankton in Lake Itasca, Minnesota. Ph.D. dissertation U. of Tn., Knoxville.

Echo, J.B. 1954. Some ecological relationships between yellow perch and cutthroat trout in Thompson Lakes, Montana. Trans. Am. Fish. Soc. 85(2):239-248.

Eddy, S.F. and J.C. Underhill 1974. Northern Fishes. 3rd. edition. U. of Minn. Press Mpls. 1974. 414pp.

_____ 1978. How to Know the Freshwater Fishes. 3rd edition. Dubuque, Iowa. Wm. C. Brown Co. Publishers. 1978. 215pp.

Faber, D.J. 1967. Limnetic larval fish in northern Wiscosin lakes. J. Fish. Res. Board Can. 24(5):927-937.

Fish, M.P. 1932. Contributions to the early life histories of 62 species of fishes from Lake Erie and its tributary waters. Bull. U.S. Bur. Fish. 47:294-371.

Forney, J.L. 1971. Development of dominant year classes in a yellow perch population. Trans. Am. Fish. Soc. 100(4): 739-749.

Furnass, T.I. 1979. Laboratory experiments on prey selection by perch fry (Perca fluviatilis). Freshwater Biol. 9:33-43.

Guma'a, S.A. 1978a. The food and feeding habits of young perch, Perca fluviatilis in Windermere. Freshwater Biol. 8:177-187.

_____ 1978b. On the early growth of perch, Perca fluviatilis, in Windermere. Freshwater Biol. 8:213-220.

Hansen, M.J. and D.H. Wahl 1981. Selection of small Daphnia pulex by yellow perch fry in Oneida Lake, New York. Trans. Am. Fish. Soc. 110(1):64-71.

Harrington, R.W. Jr. 1947. Observations on the breeding habits of yellow perch. Copeia 1947(3):199-200.

Henderson, M.A. 1977. Growth, mortality, production and feeding of yellow perch fry, Perca fluviatilis flavescens (Mitchill) and their effect on the Daphnia pulicaria Forbes of West Blue Lake. M.S. thesis. Dept. Zoology U. of Manitoba. 1977.

Hergenrader, G.L. 1969. Spawning behavior of Perca flavescens in aquaria. Copeia 1969(4):839-841.

Hogue, J.J.,Jr., R. Wallus and L.K. Kay 1976. Preliminary guide to the identification of larval fishes in the Tennessee River. TVA Tech. note B19. Dec. 1976. TVA Div. Forestry, Fisheries and Wildlife Development. Norris, Tn. 66pp.

Hokanson, K.E.F. 1974. Culture requirements of the early development of the yellow perch. in Perch fingerling production for aquaculture. Proceedings of a Conference held at U. of Wisc. Dec.12, 1977. U. of Wisc. Sea Grant College Program Advisory Report #421. pp.24-39.

_____ 1977. Temperature requirements of some Percids and adaptations to the seasonal temperature cycle. J. Fish. Res. Board Can. 34(10):1524-1550.

Hokanson, K.E.F. and C.F. Kleiner 1974. Effects of constant and rising temperatures on survival and developmental rates of embryonic and larval yellow perch, *Perca flavescens* (Mitchill). in *Early Life History of Fishes*. Proceedings of an Int'l Symposium held at Oban, Scotland May 17-23, 1973. Edited by J.H.S. Blaxter. New York Springer Verlag 1974. 765pp.

Houde, E.D. 1969. Distirbution of larval walleyes and yellow perch in a bay of Oneida Lake and its relation to water currents and zooplankton. N.Y. Fish. Game. J. 16(2):184-205.

Hubbs, C.L. 1943. Terminology of early stages of fishes. Copeia 1943(4):260.

Huh, H.T., H.E. Calbert and D.A. Stuiber 1976. Effects of temperature and light on growth of yellow perch and walleye using formulated feed. Trans. Am. Fish. Soc. 105(2):254-258.

Ivlev, V.S. 1961. *Experimental Ecology of the Feeding of Fishes*. New Haven and London, Yale U. Press. 1961. 302pp.

Jobes, F.W. 1952. Age, growth, and predation of yellow perch in Lake Erie. U.S. Fish. Wildl. Ser. Fish. Bull. 52(70):205-266.

Keast, A. and D. Webb 1966. Mouth and body form relative to feeding ecology in the fish fauna of a small lake, Lake Opinicon, Ontario. J. Fish. Res. Board Can. 23(9): 1845-1875.

Keast, A. and L. Welch 1968. Daily feeding periodicities, food uptake rates, and dietary changes with hour of day of some lake fishes. J. Fish. Res. Board Can. 25(6): 1133-1144.

Kelso J.R. 1976. Diel movement of walleye, *Stizostedion vitreum vitreum*, in West Blue Lake, Manitoba as determined by ultrasonic tracking. J. Fish. Res. Board Can. 33(9):2070-2072.

Kelso, J.R. and F.J. Ward 1977. Unexploited percid populations of West Blue Lake, Manitoba, and their interactions. J. Fish. Res. Board Cna. 34(10):1655-1669.

Knapp, R.J. 1960. Plankton fluctuations in the Lower Red Lake and food utilization by young of the year perch in 1956 and 1957. M.S. thesis. U. of Mn. 185pp.

Langford, R.R. and W.R. Martin 1940. Seasonal variations in stomach contents and rate of growth in a population of yellow perch. Trans. Am. Fish. Soc. 70(3):436-440.

LeCren, E.D. 1958. Observations on the growth of perch (Perca fluviatilis L.) over twenty-two years with special reference to the effects of temperature and changes in population density. J. Animal Ecol. 27:287-334.

Lin Yao-Sung 1975. Food and growth of young yellow perch during the pelagic and demersal stages in Oneida Lake. Ph.D. dissertation. Cornell U. 1975. 96pp.

MacLean, J. and J.J. Magnuson 1977. Species interactions in percid communities. J. Fish. Res. Board Can. 34(10):1941-1951.

Maloney, J.E. and J.H. Johnson 1957. Life histories and interrelationship of walleye and yellow perch. Trans. Am. Fish. Soc. 85(1):191-202.

Mansueti, A.J. 1964. Early development of the yellow perch, Perca flavescens. Cheasapeake Sci. 5:46-66.

Megard, R.O. 1968. Planktonic photosynthesis and the environment of calcium carbonate deposition in lakes. Limnol. Research Center U. of Mn. Interim Report #2. Jan. 1968. 47pp.

Muncy, R.J. 1962. Life history of the yellow perch, Perca flavescens, in estuarine waters of Sevrn River, a tributary of Cheasapeake Bay. Chesapeake Sce. 3:143-159.

Ney, J.J. and L.L. Smith Jr. 1975. First year growth of yellow perch, Perca flavescens, in the Red Lakes, Minnesota. Trans. Am. Fish. Soc. 104(4):718-725.

Noble, R.L. 1968. Mortality rates of pelagic fry of the yellow perch, Perca flavescens (Mitchill) in Oneida Lake, NY, and an anlysis of the sampling problem. Ph.D. dissertation. Cornell U. Ithaca NY 104pp.

_____ 1972. A method of direct estimation of total food consumption with application to young yellow perch. Prog. Fish-Cult. 34:191-194.

_____ 1973. Evacuation rates of young yellow perch, Perca flavescens (Mitchill). Trans. Am. Fish. Soc. 102(4): 759-763.

_____ 1975. Growth of yellow perch (Perca flavescens) in relationship to zooplankton populations. Trans. Am. Fish. Soc. 104(4):731-741.

Norden, C.R. 1961. The identification of larval yellow perch (Perca flavescens) and walleye (Stizostedion vitreum). Copeia 1961(3):282-287.

Pennak, R.W. 1978. Freshwater Invertebrates of the United States. New York, John Wiley and Sons 1978. 803pp.

Pflieger, W.L. 1975. The Fishes of Missouri. Missouri Dept. of Conservation. 1975. 336pp.

Pittinger, C.A. 1978. A comparative analysis of littoral and limnetic microcrustacean communities of Lake Itasca, Minnesota. M.S. thesis. U. of Tn., Knoxville. 73pp.

Pycha, R.L. and L.L. Smith Jr. 1955. Early life history of the yellow perch, Perca flavescens (Mitchill) in the Red Lakes, Minnesota. Trans. Am. Fish. Soc. 84(2):249-260.

Ryder, R.A. 1977. Effects of ambient light variations on behavior of yearling, subadult, and adult walleyes (Stizostedion vitreum vitreum). J. Fish. Res. Board Can. 34(10):1481-1491.

Scott, D.C. 1955. Activity patterns of perch, Perca flavescens, in Rondeau Bay of Lake Erie. Ecology 32(2):320-327.

Scott, W.B. and E.J. Crossman 1973. Freshwater Fishes of Canada. Fish. Res. Board Can. Bull. #184. Ottawa 1973 966pp.

Sheri, A.N. and G. Power 1969. Fecundity of the yellow perch, Perca flavescens, in the Bay of Quinte, Lake Ontario. Can. J. Zool. 47(1):55-58.

Siefert, R.E. 1972. First food of larval perch, white sucker, bluegill, emerald shiner and rainbow smelt. Trans. Am. Fish. Soc. 101(2):219-225.

Smith, L.L. Jr. 1977. Walleye (Stizostedion vitreum vitreum) and yellow perch (Perca flavescens) populations and fisheries of the Red Lakes, Minnesota, 1930-1975. J. Fish. Res. Board Can. 34(10):1774-1783.

Sokal, R.R. and F.J. Rohlf 1969. Biometry. The principles and practice of statistics in biological research. San Francisco. W.H. Freeman and Co. 1969. 776pp.

Tarby, M.J. 1974. Characteristics of yellow perch cannibalism in Oneida Lake and the relation to first year survival. Trans. Am. Fish. Soc. 103(3):462-471.

Tharratt, R.C. 1959. Food of yellow perch, *Perca flavescens* (Mitchill) in Saginaw Bay, Lake Huron. Trans. Am. Fish. Soc. 88(2):330-331.

Thorpe, J.E. 1977. Morphology, physiology, behavior and ecology of *Perca fluviatilis* and *Perca flavescens* (Mitchill). J. Fish. Res. Board Can. 34(10):1504-1514.

Tsai, Chu-Fa and G.R. Gibson Jr. 1971. Fecundity of the yellow perch, *Perca flavescens*, in the Patuxent River, Maryland. Chesapeake Sci. 12(4):270-284.

Turner, C.L. 1920. Distribution, food and associations of young perch in Bass Island region of Lake Erie. Ohio J. Sci. 20:137-152.

Ward, F.J. and C.C. Robinson 1974. A review of research on the limnology of West Blue Lake, Manitoba. J. Fish. Res. Board Can. 31(5):977-1005.

Ward, H.B. and G.C. Whipple 1959. Freshwater Biology. edited by W.T. Edmondson. New York, John Wiley and Sons, Inc. 1959. 1248pp.

Wong, B. 1972. Growth, feeding and distribution of yellow perch fry, *Perca fluviatilis flavescens* (Mitchill), during their first summer in West Blue Lake. M.S. thesis. U. of Manitoba 92pp.

Wong, B. and F.J. Ward 1972. Size selection of *Daphnia pulicaria* by yellow perch fry (*Perca flavescens*) in West Blue Lake, Manitoba. J. Fish. Res. Board Can. 29(12):1761-1764.

APPENDIXES

APPENDIX A. TABLES.

TABLE 1. Mean length (mm) and mean growth in length per day (mm) of perch fry collected in the littoral zone, 1979.

Date	Age (days)	n	$\overline{X}$	Standard Error	Range	mean growth per day
5/26	0	10	6.08	0.0407	5.8-6.2	
6/5	10	8	10.40	0.2420	9.7-11.3	0.43
6/8	13	3	10.86	0.3830	10.3-11.6	0.15
6/22	27	14	11.75	0.2329	10.0-13.0	0.06
7/5	40	5	23.40	0.1166	19.0-26.0	0.90
7/7	42	10	26.60	0.3399	25.0-28.0	1.60
7/10	45	15	29.80	0.3579	28.0-32.0	1.07
7/15	50	11	31.30	0.6444	28.5-36.0	0.30
7/20	55	27	33.85	0.4621	29.5-40.0	0.51
7/24	59	16	36.10	0.5777	30.5-40.0	0.56
7/30	65	10	37.30	0.2999	36.0-39.0	0.20

TABLE 2. Mean length (mm) and mean growth in length per day (mm) of perch fry collected in the littoral zone, 1980.

Date	Age (days)	n	$\overline{X}$	Standard Error	Range	mean growth per day
5/6	2	3	5.80	0.1528	5.6-6.1	
5/7	3	10	6.51	0.0831	6.0-6.7	0.71
5/12	8	20	7.22	0.1242	6.0-8.5	0.18
5/16	12	20	8.07	0.3064	6.5-10.3	0.21
6/17	44	6	26.00	0.8563	24.0-30.0	0.56
6/20	47	16	27.66	0.5278	25.0-32.0	0.55
6/23	50	17	28.76	0.4437	25.0-32.0	0.37
6/26	53	20	31.96	0.4624	28.0-36.5	1.07
6/29	56	17	31.79	0.6155	28.5-40.0	-0.06
7/2	59	17	32.47	0.3941	29.5-35.0	0.23
7/6	63	24	35.21	0.6026	30.0-42.0	0.69
7/9	66	13	35.65	0.5012	33.0-39.5	0.15
7/13	70	16	36.63	0.5410	32.5-43.5	0.25
7/18	75	20	39.10	0.5314	35.5-44.0	0.49
7/23	80	22	41.89	0.4301	39.5-45.0	0.56
7/28	85	16	44.31	0.7744	38.0-48.0	0.48
8/3	91	18	45.28	0.8306	39.5-52.0	0.16
8/9	97	21	45.81	0.7364	41.0-55.0	0.09
8/15	103	30	49.30	0.5490	44.0-57.0	0.58
8/21	109	10	49.55	1.2460	46.0-57.0	0.04

TABLE 3. Mean length (mm) and mean growth in length per day (mm) of perch fry collected in the limnetic zone, 1979.

Date	Age (days)	n	$\bar{X}$	Standard Error	Range	mean growth per day
6/6	11	8	10.10	0.2187	9.0-11.1	
6/8	13	11	10.66	0.3176	8.7-11.9	0.28
6/10	15	7	11.54	0.2964	10.5-11.9	0.44
6/11	16	4	12.27	0.2915	11.8-13.0	0.73
6/12	17	7	11.99	0.1253	11.6-12.4	-0.28
6/13	18	20	13.20	0.2147	12.0-14.6	1.21
6/17	22	61	14.25	0.1156	12.5-17.0	0.26
6/18	23	35	14.38	0.1786	12.0-16.0	0.13
6/22	27	28	16.90	0.2063	15.5-18.5	0.63
6/25	30	13	19.70	0.5180	16.0-22.0	0.93
6/27	32	26	20.00	0.2266	17.0-22.8	0.15
7/1	36	11	23.17	0.3960	21.0-25.0	0.79

TABLE 4. Mean length (mm) and mean growth in length per day (mm) of perch fry collected in the limnetic zone, 1980.

Date	Age (days)	n	$\overline{X}$	Standard Error	Range	mean growth per day
5/6	2	10	6.10	0.0632	5.7-6.4	
5/7	3	15	6.29	0.0796	5.7-6.7	0.19
5/10	6	29	7.12	0.1126	6.0-8.1	0.28
5/16	12	53	8.44	0.1508	6.4-10.7	0.22
5/20	16	37	9.85	0.1536	8.0-11.5	0.35
5/24	20	19	11.74	0.2348	10.5-14.0	0.47
5/27	23	30	13.58	0.1270	12.5-15.0	0.61
5/30	26	18	15.28	0.1948	14.0-17.5	0.57
6/2	29	15	17.20	0.3677	15.0-20.0	0.64
6/4	31	12	18.63	0.2620	17.5-20.0	0.72
6/7	34	35	19.39	0.2511	15.5-22.5	0.25
6/10	37	30	22.20	0.2971	18.5-26.5	0.94
6/13	40	9	24.56	0.6035	22.0-27.0	0.79
6/17	44	12	25.96	0.4057	23.0-29.0	0.35
6/20	47	11	27.64	0.4161	25.5-29.0	0.56

TABLE 5. Mean length (mm) and mean growth in length per day (mm) of perch fry collected in the limnetic zone, 1978.

Date	Age (days)	n	$\bar{X}$	Standard Error	Range	mean growth per day
5/29	17	107	13.73	0.0084	12.0-15.0	
6/2	21	45	15.81	0.0138	13.5-18.0	0.53
6/7	26	46	17.76	0.0204	15.0-21.0	0.40
6/13	32	54	20.82	0.0233	17.0-26.0	0.50
6/17	36	36	22.25	0.0311	16.0-26.0	0.38
6/18	37	175	22.95	0.0111	18.5-27.0	0.60
6/21	40	8	22.0	0.0354	21.0-23.0	-0.03
6/26	45	62	24.63	0.0226	21.5-29.5	0.05
7/2	51	36	24.18	0.0298	21.0-27.5	-0.01
7/6	55	12	24.79	0.0778	22.0-32.0	0.02
7/11	60	4	23.25	0.0576	22.0-24.5	-0.03

TABLE 6. Mean length (mm) and mean growth in length per day (mm) of perch fry collected in the littoral zone, 1978.

Date	Age (days)	n	$\bar{X}$	Standard Error	Range	mean growth per day
6/21	40	31	24.87	0.0313	21.0-29.5	
6/26	45	29	26.76	0.0524	22.0-34.5	0.38
7/2	51	47	28.06	0.0315	22.0-34.0	0.50
7/6	55	23	28.35	0.0528	24.0-33.0	0.08
7/11	60	10	32.00	0.2656	18.5-52.0	0.74

TABLE 7. Stomach contents of _Perca flavescens_ fry inhabiting the Limnetic region 1978
Data expressed as mean number of items per stomach, percent of total food items, and frequency of food item in stomach ($f = \frac{\text{\# of occurences}}{\text{\# of fry examined}} \times 100$)

Date	Age (days)	Size (mm)	n		Bosminidae	Daphmidae	Total Cladocera	Nauplii	Copepodids	Cyclopoids	Calanoids	Total Copepods	Rotifers	Insects	Other Organisms
				#	--	.2	2.0	--	--	70.1	9.1	79.2	--	--	--
5/29	17	13.7	13	%	--	.2	2.4	--	--	86.3	11.2	97.5	--	--	--
				f	--	46.1	54.0	--	--	76.9	76.9	100	--	--	--
				#	--	18.1	20.9	--	--	10.4	3.1	13.5	--	--	--
6/2	21	15.8	10	%	--	52.6	60.7	--	--	30.2	9.0	39.2	--	--	--
				f	--	100	100	--	--	100	100	100	--	--	--
				#	--	21.3	22.2	--	--	16.0	9.4	25.4	--	--	--
6/7	26	17.8	10	%	--	44.7	46.6	--	--	33.6	19.7	25.4	--	--	--
				f	--	100	100	--	--	100	100	100	--	--	--
				#	--	30.6	31.2	--	--	10.6	16.5	27.2	--	--	--
6/13	32	20.8	10	%	--	52.4	53.4	--	--	18.3	28.3	46.6	--	--	--
				f	--	100	100	--	--	100	100	100	--	--	--
				#	--	11.4	11.4	--	--	11.9	8.2	20.1	--	1.3	--
6/17	36	22.3	10	%	--	34.8	34.8	--	--	36.3	25.0	61.3	--	4.0	--
				f	--	80	80	--	--	90	80	90	--	50	--
				#	--	.4	.4	--	--	2.3	14.4	16.7	--	.7	--
6/18	37	22.9	10	%	--	2.2	2.2	--	--	12.9	80.9	93.8	--	3.9	--
				f	--	30	30	--	--	50	100	100	--	40	--

TABLE 7. (continued)

Date	Age (days)	Size (mm)	n		Bosminidae	Daphnidae	Total Cladocera	Nauplii	Copepodids	Cyclopoids	Calanoids	Total Copepods	Rotifers	Insects	Other Organisms
				#	5.3	--	5.3	--	--	5.6	3.3	8.9	--	2.6	--
6/21	40	22.0	8	%	31.6	--	31.6	--	--	33.4	19.7	53.1	--	15.5	--
				f	75	--	75	--	--	75	87.5	87.5	--	37.5	
				#	21.1	--	21.1	--	--	1.2	.6	1.8	--	3.4	--
6/26	45	24.6	10	%	80.2	--	80.2	--	--	4.6	2.3	6.7	--	12.9	--
				f	90	--	90	--	--	30	30	40	--	60	--
				#	8.2	--	8.3	--	--	2.8	9.1	11.8	3.1	3.2	--
7/2	51	24.2	10	%	31.1	--	31.5	--	--	10.6	34.5	45.1	11.7	12.1	--
				f	100	--	100	--	--	90	90	100	60	100	--
				#	79.9	--	79.9	--	--	.5	13.1	13.6	15.2	2.9	--
7/6	55	24.8	10	%	71.6	--	71.6	--	--	.4	11.7	12.1	13.6	2.6	--
				f	100	--	100	--	--	20	100	100	10	90	--
				#	113.8	--	113.8	--	--	2.2	20.8	23.0	51.0	1.5	--
7/11	60	23.3	4	%	60.1	--	60.1	--	--	1.2	10.9	12.1	26.9	.8	--
				f	100	--	100	--	--	50	100	100	100	50	--

TABLE 8. Stomach contents of _Perca flavescens_ fry inhabiting the Limnetic region 1979 Data expressed as mean number of items per stomach, percent of total food items, and frequency of food item in stomach (f= $\frac{\text{\# of occurences}}{\text{\# of fry examined}}$ x 100)

Date	Age (days)	Size (mm)	n		Bosminidae	Daphnidae	Total Cladocera	Nauplii	Copepodids	Cyclopods	Calanoids	Total Copepods	Rotifers	Insects	Other Organisms
				#	--	--	---	.8	1.5	.4	--	2.7	--	--	--
6/6	11	10.1	8	%	--	--	---	26.0	52.2	21.7	--	99.9	--	--	--
				f	--	--	---	37.5	37.5	37.5	--	50	--	--	--
				#	--	--	---	3.6	2.3	--	--	5.9	.5	--	--
6/8	13	10.7	10	%	--	--	---	56.3	35.9	--	--	92.2	7.8	--	--
				f	--	--	---	100	70	--	--	100	20	--	--
				#	.2	--	.2	--	10.7	.2	1.4	12.3	--	--	--
6/13	18	13.2	10	%	1.6	--	1.6	--	85.6	1.6	11.2	98.4	--	--	--
				f	20	--	20	--	100	20	50	100	--	--	--
				#	--	.1	.1	--	--	6.4	8.5	14.9	--	--	--
6/17	22	14.3	10	%	--	.7	.7	--	--	42.7	56.7	99.4	--	--	--
				f	--	10	10	--	--	70	100	100	--	--	--
				#	7.5	.4	7.9	--	--	.9	11.3	13.2	--	--	--
6/21	26	15.8	8	%	37.5	1.9	39.4	--	--	4.4	56.3	60.7	--	--	--
				f	75	25	88	--	--	25	87.5	100	--	--	--
				#	7.5	.6	8.1	--	--	--	10.7	10.7	--	--	--
6/22	27	16.9	10	%	39.9	3.2	43.1	--	--	--	56.9	56.9	--	--	--
				f	90	30	100	--	--	--	100	100	--	--	--

TABLE 8. (continued)

Date	Age (days)	Size (mm)	n		Bosminidae	Daphnidae	Total Cladocera	Nauplii	Copepodids	Cyclopoids	Calanoids	Total Copepods	Rotifers	Insects	Other Organisms
				#	25.8	2.3	28.6	--	.4	2.7	6.0	9.1	.9	--	--
6/25	30	19.7	10	%	66.8	6.0	74.1	--	1.0	7.0	15.5	23.5	2.3	--	--
				f	100	60	100	--	10	30	100	100	10	--	--
				#	53.2	10.6	64.0	--	9.7	10.5	19.1	39.3	1.1	--	--
6/27	32	20.0	10	%	50.9	10.2	61.3	--	9.3	10.1	18.3	37.7	1.1	--	--
				f	100	90	100	--	50	20	70	100	20	--	--
				#	23.5	18.7	42.2	--	2.4	10.1	30.4	42.9	.2	.3	.1
7/1	36	23.2	10	%	27.4	21.8	49.2	--	2.8	11.8	35.5	50.1	.2	.3	.1
				f	100	100	100	--	40	30	50	100	10	20	10

TABLE 9. Stomach contents of Perca flavescens fry inhabiting the Limnetic region 1980. Data expressed as mean number of items per stomach, percent of total food items, and frequency of food item in stomach ($f = \frac{\text{\# of occurences}}{\text{\# of fry examined}} \times 100$).

Date	Age (days)	Size (mm)	n		Bosminidae	Daphnidae	Total Cladocera	Nauplii	Copepodids	Cyclopoids	Calanoids	Total Copepods	Rotifers	Insects	Other Organisms
				#	--	.3	.3	1.6	--	3.8	--	5.4	3.4	--	.1
5/16	12	8.4	13	%	--	3.3	3.3	17.4	--	41.3	--	58.7	37.0	--	1.1
				f	--	15.4	15.4	53.9	--	61.5	--	77	76.9	--	10
				#	.2	--	.2	2.4	--	4.2	--	6.6	7.6	--	.4
5/20	16	9.8	12	%	1.4	--	1.4	16.2	--	28.4	--	44.6	51.4	--	2.7
				f	16.6	--	16.6	66.6	--	75	--	83.3	83.3	--	10
				#	--	--	--	2.4	--	9.4	1.0	12.8	6.3	--	.2
5/24	20	11.7	10	%	--	--	--	12.4	--	48.7	5.2	66.3	32.7	--	1.0
				f	--	--	--	100	--	90	30	100	100	--	10
				#	1.5	1.6	3.3	4.0	--	9.6	--	13.6	11.8	--	.4
5/27	23	13.6	10	%	5.2	5.5	11.4	13.7	--	33.0	--	46.7	40.5	--	1.4
				f	60	80	80	100	--	100	--	100	100	--	10
				#	.7	5.2	6.4	3.6	--	39.4	5.7	48.7	15.5	--	3.1
5/30	26	15.3	10	%	1.0	7.1	8.7	4.9	--	53.4	7.7	66.0	21.0	--	4.2
				f	60	100	100	100	--	100	100	100	100	--	20
				#	.6	3.6	4.5	1.9	--	28.6	12.7	43.2	6.9	.2	.9
6/2	29	17.2	10	%	1.1	6.5	8.1	3.4	--	51.3	22.8	77.5	12.4	.4	1.7
				f	40	100	100	70	--	100	100	100	100	10	10

TABLE 9. (continued)

Date	Age (days)	Size (mm)	n		Bosminidae	Daphnidae	Total Cladocera	Nauplii	Copepodids	Cyclopoids	Calanoids	Total Copepods	Rotifers	Insects	Other Organisms
				#	1.6	4.9	7.3	3.4	--	40.6	7.7	51.7	15.1	--	2.6
6/4	31	18.6	10	%	2.1	6.4	9.5	4.4	--	52.9	10.0	67.3	19.8	--	3.4
				f	80	100	100	100	--	100	100	100	100	--	30
				#	2.2	4.2	6.5	2.6	--	14.5	7.7	24.8	11.7	.8	.3
6/7	34	19.4	10	%	4.9	9.3	14.4	5.7	--	32.0	17.0	54.7	25.8	1.7	.7
				f	60	90	90	90	--	100	100	100	100	10	50
				#	2.7	6.9	9.9	.7	--	10.0	34.3	45.0	3.2	.2	--
6/10	37	22.2	10	%	4.6	11.8	16.9	1.2	--	17.1	58.8	77.1	5.5	.3	--
				f	90	70	90	40	--	100	100	100	50	20	--
				#	5.9	6.1	16.2	8.4	--	8.9	42.9	60.8	67.8	.4	2.4
6/13	40	24.6	9	%	3.8	3.9	10.4	5.5	--	5.7	27.7	38.9	48.6	.3	1.7
				f	100	88.8	100	100	--	100	100	100	100	33.3	77.7
				#	34.0	1.7	37.7	.2	--	8.7	2.8	11.7	4.3	2.4	.3
6/17	44	25.9	10	%	60.3	3.0	66.8	.4	--	15.4	5.0	20.8	7.6	4.3	.5
				f	90	60	90	10	--	90	40	100	50	50	30
				#	3.2	14.1	17.7	--	--	9.5	3.5	13.0	.3	6.1	.2
6/20	47	27.6	10	%	8.6	37.8	47.5	--	--	25.5	9.4	34.9	.8	16.4	.6
				f	70	90	90	--	--	90	60	100	10	80	10

TABLE 10. Stomach contents of *Perca flavescens* fry inhabiting the Littoral region 1978. Data expressed as mean number of items per stomach, percent of total food items, and frequency of food item in stomach (f= # of occurences / # of fry examined x 100).

Date	Age (days)	Size (mm)	n		Bosminidae	Chydoridae	Daphnidae	Total Cladocera	Cyclopoids	Total Copepods	Rotifers	Amphipods	Ostracods	Insects	Other Organisms
				#	9.3	6.7	.2	16.2	11.9	21.5	.2	--	.5	--	--
6/17	36	10.9	10	%	24.2	17.5	.5	42.2	30.9	55.9	.5	--	1.3	--	--
				f	100	90	10	100	90	100	10	--	30	--	--
				#	1.8	.4	.1	2.3	.1	1.8	--	--	--	.2	--
6/18	37	10.7	10	%	41.9	9.3	2.3	53.5	2.3	41.9	--	--	--	4.7	--
				f	60	30	10	70	10	60	--	--	--	10	
				#	3.2	12.3	--	15.5	5.2	5.2	--	.1	.1	4.2	.6
6/21	40	24.9	10	%	12.5	47.9	--	60.4	20.2	20.2	--	.4	.4	16.4	2.4
				f	20	70	--	70	90	90	--	10	10	50	10
				#	1.6	10.4	--	12.0	3.7	3.7	--	--	.4	19.3	1.5
6/26	45	26.7	10	%	4.3	28.2	--	32.5	10.0	10.0	--	--	1.1	52.3	4.1
				f	20	80	--	80	90	90	--	--	40	90	20
				#	.2	21.9	.2	22.3	4.5	5.4	.1	2.3	4.6	12.3	--
7/2	51	28.1	10	%	.4	46.6	.4	47.4	9.6	11.5	.2	4.9	9.8	26.2	--
				f	10	80	10	90	70	80	10	70	80	90	--
				#	.5	6.6	.4	7.5	2.4	20.3	--	.3	4.1	5.4	5.8
7/6	55	28.3	10	%	1.2	15.4	.9	17.5	5.5	46.7	--	.7	9.4	12.5	13.3
				f	50	90	30	100	80	100	--	30	80	80	30

TABLE 10. (continued)

Date	Age (days)	Size (mm)	n		Bosminidae	Chydoridae	Daphnidae	Total Cladocera	Cyclopoids	Total Copepods	Rotifers	Amphipods	Ostracods	Insects	Other Organisms
				#	29.3	9.0	--	38.3	9.9	9.9	--	2.3	.4	11.1	.3
7/11	60	32.0	7	%	47.0	14.4	--	61.4	15.8	15.8	--	3.7	.7	17.9	.4
				f	14.3	100	--	100	71.4	71.4	--	71.4	28.6	85.7	14.3

TABLE 11. Stomach contents of *Perca flavescens* fry inhabiting the Littoral region 1979. Data expressed as mean number of items per stomach, percent of total food items, and frequency of food item in stomach ($f = \frac{\#\text{ of occurences}}{\#\text{ of fry examined}} \times 100$).

Date	Age (days)	Size (mm)	n		Bosminidae	Chydoridae	Daphnidae	Total Cladocera	Cyclopoids	Total Copepods	Rotifers	Amphipods	Ostracods	Insects	Other Organisms
				#	19.4	--	--	19.4	4.9	6.5	1.8	--	--	--	--
6/22	27	11.7	10	%	70.0	--	--	70.0	17.7	23.5	6.5	--	--	--	--
				f	100	--	--	100	60	90	50	--	--	--	--
				#	33.2	--	32.0	65.2	6.6	6.6	--	--	.4	.2	.2
7/5	40	23.4	5	%	45.7	--	44.1	89.9	9.1	9.1	--	--	.6	.3	.3
				f	80	--	80	80	100	100	--	--	40	20	20
				#	8.5	.1	11.1	19.7	8.3	8.3	--	.2	--	.3	.1
7/7	42	26.6	10	%	29.8	.4	39.0	69.2	29.1	29.1	--	.7	--	1.1	.4
				f	40	20	80	90	70	70	--	20	--	30	30
				#	28.5	.1	8.9	37.5	4.4	4.4	1.8	.2	.1	.5	.4
7/10	45	29.8	10	%	63.5	.2	19.9	83.6	9.8	9.8	4.0	.4	.2	1.1	.8
				f	90	10	80	100	90	90	40	30	10	40	20
				#	73.1	3.0	3.8	79.9	32.5	32.5	1.3	.6	--	10.8	.3
7/15	50	31.3	11	%	58.2	2.4	3.0	63.6	25.9	25.9	1.0	.5	--	8.6	.2
				f	81.8	36.4	54.5	90.9	63.6	63.6	27.3	27.3	--	90.9	18.2
				#	28.0	--	.4	28.4	4.9	4.9	8.5	.9	.8	22.9	.3
7/20	55	33.8	10	%	42.0	--	.5	42.5	7.3	7.3	12.7	1.3	1.2	34.3	.4
				f	70	--	20	70	50	50	60	30	30	40	10

TABLE 11. (continued)

Date	Age (days)	Size (mm)	n		Bosminidae	Chydoridae	Daphnidae	Total Cladocera	Cyclopoids	Total Copepods	Rotifers	Amphipods	Ostracods	Insects	Other Organisms
				#	50.7	3.8	.5	55.0	5.9	5.9	43.2	2.3	.2	11.3	.5
7/24	59	36.1	10	%	42.8	3.2	.4	46.4	3.2	3.2	36.5	1.9	.2	9.5	.4
				f	50	50	10	80	50	50	40	70	20	80	30
				#	21.3	2.4	--	23.7	3.0	3.0	--	2.5	15.0	2.8	--
7/30	65	37.3	10	%	45.3	5.1	--	50.4	6.4	6.4	--	5.3	31.9	6.0	--
				f	50	40	--	60	60	60	--	70	50	50	--

TABLE 12. Stomach contents of <u>Perca flavescens</u> fry inhabiting the Littoral region 1980. Data expressed as mean number of items per stomach, percent of total food items, and frequency of food item in stomach ($f = \frac{\#\text{ of occurences}}{\#\text{ of fry examined}} \times 100$).

Date	Age (days)	Size (mm)	n		Bosminidae	Chydoridae	Daphnidae	Total Cladocera	Cyclopoids	Total Copepods	Rotifers	Amphipods	Ostracods	Insects	Other Organisms
				#	---	--	--	---	.1	2.6	1.6	--	--	--	--
5/16	12	8.1	14	%	---	--	--	---	3.4	62.7	37.3	--	--	--	--
				f	---	--	--	---	28.5	64	50	--	--	--	--
				#	10.5	2.3	.8	13.6	6.3	6.5	--	--	1.0	.5	--
6/17	44	26.0	6	%	48.5	10.8	3.9	63.2	29.2	30.0	--	--	4.6	2.3	--
				f	100	66.6	66.6	100	66.6	66.6	--	--	66.6	50	--
				#	11.8	5.4	2.4	19.6	4.2	4.9	2.9	.1	.8	.6	.1
6/20	47	27.7	10	%	40.7	18.6	8.3	67.6	14.5	16.9	10.0	.3	2.8	2.0	.3
				f	90	80	40	100	60	60	60	10	20	30	10
				#	35.1	4.2	.5	39.8	3.3	4.5	1.1	.3	3.6	.6	.2
6/23	50	28.8	10	%	70.1	8.4	1.0	79.5	6.6	9.0	2.2	.6	7.2	1.2	.4
				f	90	80	40	100	70	70	30	30	70	30	20
				#	96.4	12.6	.5	109.5	8.1	8.7	1.7	.3	8.8	.4	.4
6/26	53	31.9	10	%	74.3	9.7	.4	84.4	6.2	6.7	1.3	.2	6.8	.3	.3
				f	100	90	20	100	60	60	60	30	80	40	30
				#	134.8	18.4	.2	153.4	6.7	6.7	19.4	.2	3.0	1.2	.1
6/29	56	31.8	10	%	73.3	10.0	.1	83.4	3.6	3.6	10.5	.1	1.6	.6	.1
				f	100	100	10	100	80	80	100	20	80	60	10

TABLE 12. (continued)

Date	Age (days)	Size (mm)	n		Bosminidae	Chydoridae	Daphnidae	Total Cladocera	Cyclopoids	Total Copepods	Rotifers	Amphipods	Ostracods	Insects	Other Organisms
				#	150.5	8.7	6.4	165.6	55.3	58.9	12.6	.2	1.7	.9	.2
7/2	59	32.5	10	%	62.7	3.7	2.7	69.1	23.0	24.5	5.2	.1	.7	.5	.1
				f	100	90	90	100	100	100	90	10	50	30	20
				#	75.0	7.6	1.2	83.8	17.5	17.6	15.6	.4	6.3	1.9	--
7/6	63	35.2	10	%	59.7	6.1	.7	66.5	13.9	14.0	12.4	.3	5.0	1.5	--
				f	90	90	40	100	100	100	70	20	90	20	--
				#	135.6	4.9	1.8	142.3	18.1	18.1	7.5	1.1	5.1	1.9	.1
7/9	66	35.7	10	%	77.0	2.8	1.0	80.8	10.3	10.3	4.3	.6	2.9	1.1	.1
				f	70	70	70	100	90	90	50	20	90	70	10
				#	79.6	2.1	.1	81.8	14.6	14.6	9.3	.6	3.2	4.2	--
7/13	70	36.6	10	%	70.0	1.9	.1	72.0	12.8	12.8	8.2	.5	2.8	3.7	--
				f	100	60	10	100	90	90	50	40	70	70	--
				#	22.2	.8	10.2	33.2	13.4	17.1	--	1.2	1.8	8.3	.1
7/18	75	39.1	10	%	35.9	1.4	16.5	53.8	21.6	27.6	--	1.9	2.9	13.4	.2
				f	80	20	60	90	90	90	--	40	70	90	10
				#	4.0	--	54.5	58.5	12.8	17.8	--	.8	2.0	1.6	--
7/23	80	41.9	10	%	5.0	--	67.5	72.5	15.9	22.1	--	1.0	2.5	1.9	--
				f	60	--	100	100	100	100	--	50	80	40	--

TABLE 12. (continued)

Date	Age (days)	Size (mm)	n		Bosminidae	Chydoridae	Daphnidae	Total Cladocera	Cyclopoids	Total Copepods	Rotifers	Amphipods	Ostracods	Insects	Other Organisms
				#	60.4	2.9	23.6	86.9	6.3	8.8	--	.9	6.8	8.6	.3
7/28	85	44.3	10	%	53.8	2.6	21.0	77.4	5.6	7.8	--	.8	6.1	7.6	.3
				f	80	30	80	90	80	90	--	40	80	60	20
				#	1.2	--	44.1	45.3	3.4	22.2	--	5.9	19.5	2.9	--
8/3	90	45.3	10	%	1.3	--	46.0	47.3	3.5	23.1	--	6.2	20.4	3.0	--
				f	10	--	70	70	50	70	--	60	50	60	--

TABLE 13. Stomach contents of *Perca flavescens* fry inhabiting the limnetic region, over a 24-hour period, June 17-18, 1979. Data expressed as mean number of items per stomach, percent of total food items, and frequency of food item in stomach ($f = \frac{\text{\# of occurences}}{\text{\# of fry examined}} \times 100$). (Age=22 days, n=10)

Time (hrs)	Mean Size (mm)		Bosminidae	Daphnidae	Total Cladocera	Copepodids	Cyclopoids	Calanoids	Total Copepods	Rotifers
		#	.5	1.0	1.5	1.9	1.5	4.6	8.0	2.7
1500	14.4	%	4.1	8.2	12.3	15.6	12.3	37.7	65.6	14.0
		f	30	40	40	50	20	70	100	50
		#	--	.2	.2	--	.5	4.3	4.8	.3
1900	13.9	%	--	3.8	3.8	--	9.4	81.1	90.5	5.7
		f	--	10	10	--	20	90	100	10
		#	--	.1	.1	--	6.4	8.5	14.9	--
2300	14.3	%	--	3.8	3.8	--	42.7	56.7	99.4	--
		f	--	10	10	--	70	100	100	--
0300	14.8	#	--	--	--	--	--	1.4	1.4	--
0300	14.8	%	--	--	--	--	--	100.0	100.0	--
		f	--	--	--	--	--	60	60	--
		#	.2	--	.2	1.0	.9	3.1	5.0	.6
0700	13.8	%	3.4	--	3.4	17.2	15.5	53.4	86.1	10.3
		f	10	--	10	20	10	80	100	20
		#	.7	.2	.9	--	--	8.5	8.5	1.1
1100	14.8	%	6.7	1.9	8.6	--	--	81.0	81.0	10.5
		f	30	10	30	--	--	100	100	30

TABLE 14. Statistical comparisons (t-test) of littoral versus limnetic regression coefficients. Probability level for all tests = 0.05.

	Calculated t-value
Length-Age	
1978 (n = 459)	t_∞ = 1.15 NS
1979 (n = 314)	t_∞ = 1.97 *
1980 (n = 547)	t_∞ = 3.49 *
Weight-Age	
1978 (n = 335)	t_∞ = 0.95 NS
1979 (n = 93)	t_{68} = 2.41 *
1980 (n = 195)	t_∞ = 1.99 *
Length-Weight	
1978 (n = 335)	t_∞ = 36.43 *
1979 (n = 93)	t_{68} = 153.51 *
1980 (n = 195)	t_∞ = 61.10 *

* Significant

TABLE 15. Mean weight (mg) of perch fry collected in the limnetic zone, 1978.

Date	Age (days)	n	$\bar{X}$	Standard Error	Range
5/29	17	30	21.07	0.97	6.0-32.0
6/2	21	33	31.85	1.54	20.0-50.0
6/7	26	34	40.47	1.67	23.0-64.0
6/13	32	36	71.08	4.18	37.0-150.0
6/18	37	36	80.22	3.73	47.0-135.0
6/26	45	51	127.21	4.49	67.0-208.0

TABLE 16. Mean weight (mg) of perch fry collected in the littoral zone, 1978.

Date	Age (days)	n	$\bar{X}$	Standard Error	Range
6/21	40	18	124.89	6.35	75.0-183.0
6/26	45	18	131.00	8.36	63.0-199.0
7/2	51	41	161.56	8.23	65.0-325.0
7/6	55	12	187.00	17.07	119.0-284.0

TABLE 17. Mean weight (mg) of perch fry collected in the limnetic zone, 1979.

Date	Age (days)	n	$\bar{X}$	Standard Error	Range
6/17	22	29	19.90	0.85	12.0-28.0
6/21	26	8	34.13	3.66	23.0-51.0
6/22	27	8	38.13	2.16	30.0-49.0
6/25	30	4	41.75	2.78	38.0-50.0
6/27	32	16	73.69	4.19	45.0-117.0

TABLE 18. Mean weight (mg) of perch fry collected in the littoral zone, 1979.

Date	Age (days)	n	$\bar{X}$	Stardard Error	Range
7/10	45	5	286.80	17.57	238.0-331.0
7/20	55	17	339.00	13.87	234.0-491.0
7/24	59	6	373.50	34.97	256.0-508.0

TABLE 19. Mean weight (mg) of perch fry collected in the limnetic zone, 1980.

Date	Age (days)	n	$\overline{X}$	Standard Error	Range
5/27	23	20	14.35	0.74	10.0-21.0
5/30	26	8	20.25	2.27	13.0-32.0
6/2	29	5	35.40	4.12	27.0-50.0
6/7	34	23	61.83	4.17	26.0-101.0
6/9	36	8	80.25	5.26	67.0-109.0
6/10	37	17	91.71	5.82	34.0-120.0

TABLE 20. Mean weight (mg) of perch fry collected in the littoral zone, 1980.

Date	Age (days)	n	$\bar{X}$	Standard Error	Range
6/20	47	6	170.17	15.41	133.0-234.0
6/23	50	7	198.43	23.51	130.0-307.0
6/26	53	9	350.22	31.14	265.0-557.0
6/29	56	7	348.00	57.99	276.0-693.0
7/2	59	6	295.83	21.35	238.0-381.0
7/6	63	13	455.38	46.01	296.0-816.0
7/9	66	3	517.67	70.20	443.0-658.0
7/13	70	10	551.5	56.70	318.0-880.0
7/18	75	9	583.56	38.35	422.0-773.0
7/23	80	11	845.73	43.65	594.0-1098.0
7/28	85	5	839.80	182.81	542.0-1558.0
8/3	91	7	775.86	81.10	548.0-1228.0
8/9	97	16	985.44	75.94	678.0-1748.0

TABLE 21. Electivity indices for 1979 limnetic perch fry. (Electivity values were determined using the formula: $E = \frac{r - p}{r + p}$ where E represents the electivity value; r is the relative percentage of any prey in stomach of fry; p is the relative percentage of prey in the lake. Positive E values indicate selection ; negative E values indicate avoidance.)

Date	Organism	p	r	E
6/13	copepodids	41.63	85.6	+0.35
	copepods	5.41	12.8	+0.83
	Bosmina	7.30	1.6	-0.64
6/17	copepods	24.93	99.4	+0.60
	Daphnia	5.09	0.7	-0.88
6/25	copepodids	3.34	1.0	-0.54
	cyclopoids	9.99	7.0	-0.18
	calanoids	14.94	15.5	+0.02
	Bosmina	12.54	66.8	+0.68
	Chydoridae	1.20	1.3	+0.04
	Daphnia	11.33	6.0	-0.31
7/1	copepodids	3.13	2.8	-0.06
	copepods	16.11	47.3	+0.49
	Bosmina	17.53	27.4	+0.22
	Daphnia	9.64	21.8	+0.39
	Chaoborus	1.29	0.2	-0.73

TABLE 22. Electivity indices for 1980 limnetic perch fry. (Electivity values were determined using the formula: $E = \frac{r - p}{r + p}$ where E represents the electivity value; r is the relative percentage of any prey in the stomach of fry; p is the relative percentage of prey in the lake. Positive E values indicate selection; negative E values indicate avoidance.)

Date	Organism	p	r	E
5/16	nauplii	50.28	17.4	-0.49
	cyclopoids	5.12	41.3	+0.78
	Daphnia	8.08	3.3	-.042
5/20	nauplii	58.78	16.2	-0.57
	cyclopoids	13.54	28.2	+0.35
	Bosmina	0.01	1.4	+0.99
6/4	nauplii	57.26	4.4	-0.86
	cyclopoids	10.25	52.9	+0.68
	calanoids	2.26	10.0	+0.63
	Bosmina	1.34	2.1	+0.22
	Chydoridae	0.01	1.0	+0.99
	Daphnia	57.26	4.4	-0.86
	ostracods	0.63	0.9	+0.17
6/16	nauplii	71.19	0.4	-0.99
	cyclopoids	5.67	15.4	+0.46
	calanoids	2.92	5.0	+0.26
	Bosmina	3.69	60.3	+0.88
	Chydoridae	0.59	3.5	+0.71
	Daphnia	1.36	3.0	+0.38
	ostracods	2.92	0.5	-0.62
	Chaoborus	0.97	4.3	+0.63

APPENDIX B. TEMPERATURES

Surface water temperatures of Lake Itasca, 1979.

Date	Temperature (C)	Date	Temperature (C)
5/12	9.5	6/27	21.5-22.0
5/18	10.5	6/30	22.0-23.0
5/23	11.0	7/3	20.0-21.0
5/26	12.0	7/6	21.0-23.0
6/1	15.0	7/9	25.5
6/3	14.4	7/12	25.5
6/8	15.2	7/15	22.0-23.5
6/11	18.0	7/18	23.0-25.5
6/15	23.0	7/24	25.0
6/16	19.5	8/2	24.0-25.5
6/19	18.0-19.0	8/8	24.0-26.0
6/23	18.0-19.5	8/14	18.5-20.5

Surface water temperatures of Lake Itasca, 1980.

Date	Temperature (C)	Date	Temperature (C)
4/23	7.0-8.0	6/3	19.0-20.5
4/25	8.0-9.8	6/6	19.0
4/27	9.7-9.8	6/9	17.0-18.5
4/29	12.8-13.1	6/12	18.5-20.0
5/1	15.5-16.5	6/15	20.0-20.5
5/3	18.0-18.2	6/18	21.0-22.5
5/5	12.0-12.5	6/21	19.0-22.5
5/7	10.5-12.5	6/24	22.0-24.5
5/8	10.5	6/27	21.5-22.5
5/10	11.0-11.2	6/30	18.5-19.5
5/12	10.5-10.8	7/3	20.0-21.5
5/14	12.2-12.5	7/6	21.5-23.0
5/16	13.5-14.0	7/9	22.5-24.0
5/17	13.5-14.5	7/12	23.5-25.0
5/19	15.5-18.2	7/15	25.5-27.0
5/21	17.0	7/18	24.0-25.0
5/22	17.0-17.5	7/21	22.5-24.0
5/23	19.5	7/24	24.0-25.5
5/25	20.0	7/27	22.5-24.0
5/28	22.2-22.4	7/30	22.0-24.0
5/30	20.0-20.5	8/2	21.0-22.0
5/31	19.0-21.0	8/5	20.0-21.0

VITA

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