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Feeding Periodicity of Yellow Perch, *Perca flavescens*, (Mitchill), in Southwestern Lake Michigan

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FEEDING PERIODICITY OF YELLOW PERCH, Perca flavescens,
(Mitchill), IN SOUTHWESTERN LAKE MICHIGAN

by

Ronald J. Abrant

A Thesis Submitted to the Faculty of the Graduate School
of Loyola University of Chicago in Partial Fulfillment
of the Requirements for the Degree of
Master of Science

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VITA

The author, Ronald Joseph Abrant, is the son of Walter J. Abrant and Josephine (Shubat) Abrant. He was born on June 21, 1955, in Chicago, Illinois.

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INTRODUCTION

Throughout the past century the yellow perch (Perca flavescens) has been an important species in both commercial and sport fisheries in the Great Lakes (Wells and McLain, 1973; Wells, 1977; Scott, 1981; Kraft, 1982). Throughout its range the diet of perch changes with the availability of prey. Perch are opportunistic predators adapted to a diet of small, live animals and will take whatever food is available (Hermann, 1964). Even within the Great Lakes the major prey species varies considerably. Pontoporeia, Daphnia, crayfish, immature insects, and fish have all been identified as the primary food for adult perch (Fisk, 1953; Tharratt, 1957; Brazo, 1973; and Schaefer, 1973).

Besides geographical differences, seasonal changes in the diet are expected as the availability of different prey changes. Some prey may be present at all times but others migrate to a preferred depth or temperature of water where they are no longer vulnerable to predation. Insects may be abundant for a very limited time only during a hatch. Fish and crayfish may grow too large and are vulnerable only within a certain size range.

Diel differences in diet are expected due to the diel changes in prey activity. Crayfish are important in the diet of perch in Illinois waters of Lake Michigan, and they

show considerable differences in diel activity (Janssen and Quinn, 1985; Quinn, 1987). In lakes with high predator densities, the crayfish population remains inactive and concealed during daylight, (Hazlett et al., 1979; Collins et al., 1983), and exhibits a high degree of activity and low shelter occupancy at night (Stein and Magnuson, 1976).

I studied seasonal and diel changes in feeding activity of yellow perch in an effort to determine some of the factors that may affect seasonal and diel differences in feeding. My results revealed a feeding pattern with a peak after dawn, continued feeding all day, evidence of an evening peak, and some foraging during night.

MATERIALS AND METHODS

Collections were made on Lake Michigan on seven dates from 12 June through 10 September, 1984. A 2.5 cm bar monofilament gill net, measuring 1.5 meters by 90 meters, was fished on the bottom. All sets were conducted in approximately 8 meters of water located due east of Howard Street in Evanston, Illinois (42° 01' N lat, 87° 34' W long). The times of net sets were pre-sunset, post-sunset, pre-sunrise, and post-sunrise. The length of time the net was in the water varied with the abundance of perch and ranged from 10 minutes to 5 hours (Table 1).

After removing all the fish from the net, I immediately opened the stomach and removed the contents. Stomach contents were preserved in 10% formalin on site and prey identified later in the lab. The total length (TL) of each fish was measured and the sex determined. Temperature and light profiles were made at the site.

To determine a rate of digestion for the various prey ingested, yellow perch were captured alive in hoop nets set in shallow water (2 to 4 meters) to minimize stress from pressure differential upon hauling them to the surface. Twenty-four fish were kept alive in 1200 liter holding tanks and fed at maintenance level on a diet of live minnows. SCUBA divers collected 70 O. propinquus and O. virilis (13-37 mm carapace length) from the study site. Only crayfish

were used to determine feeding periodicity because they are the primary prey. For each of the five digestion states ten fish were fed a single crayfish. The temperature was kept between 18 - 20° C. I retrieved the food at separate 2, 4, 6, 8, and 10 hour intervals after ingestion by inserting a tube into the mouth and palpating the fish.

I defined the five digestion states as follows:

1. No visible sign of degradation, integument firm, original pigmentation, abdomen firm and resilient. (time less than 2 hrs)
2. Carapace still firm and resilient, abdomen firm but pliable, joints in exoskeleton begin to separate, tissue separates from exoskeleton, color lighter, begins to show light mottled pattern. (time 2 to 4 hrs)
3. Carapace fragile, easily pliable and mottled with enlarged holes, abdomen soft and easily separates at joints, faded coloration. (time 4 to 6 hrs)
4. Entire body soft and fragmented at joints, integument tears easily, tissue fibers separate easily, color bleached out, heavily mottled carapace. (time 6 to 8 hrs)
5. Body fragments mushy, amorphous, color bleached out. (time 8 to 10 hrs)

From these categories a digestion state (1 - 5) for each crayfish recovered from field collected perch was determined. The digestion states were treated as numerical estimates of relative digestion for statistical analysis.

RESULTS

Seasonal Variation in Prey

I collected 745 yellow perch on seven dates between 12 June and 10 September, 1984. The lowest percentage of perch with prey occurred in the first sample when spawning had not yet been completed and the majority of male perch stomachs were empty. Percentages for female perch were higher than that for males (62% ♀, 21% ♂) on that date and similar to the values found throughout the rest of the study. However, the percentage of perch (excluding the males from the first sample date) with detectable material in the stomach showed no significant seasonal change (chi-square = 5.61, 6 dF, $p > 0.25$) (Figure 1).

There was a seasonal change in the prey species consumed by yellow perch. The greatest number of species occurred on 12 June when fish, snails, amphipod and annelid species reached maximum numbers and, together with crayfish and insects, represented 14 total species (Table 2). Fewer species were consumed in later samples with a minimum of six species in the 26 August sample.

Crayfish (Orconectes propinquus and O. virilis) were the most important food item and made up 49.5% of the total number of organisms found in stomach analysis over the entire sample period. The percent of total organisms (% TO) (Figure 2) represented by crayfish increased significantly

from early summer samples to late summer when the diet consisted almost entirely of crayfish. The percent frequency of occurrence:

$$100 * \frac{(\text{the number of fish with a particular prey item})}{(\text{the total number of fish})},$$

(Figure 1) complements the data for (% TO) very well. Again crayfish were the dominant prey. The percentage of perch feeding on crayfish, initially low (28% on 12 June), more than tripled in late summer (87% on 26 August). Except for the lower values obtained in the first and last sample periods, most of the perch (51 to 87%) in each sample fed on crayfish, and every fish with food during the 8 August sample fed on crayfish. The mean number of crayfish consumed per fish increased from 0.46 on 12 June to 2.5 on 26 August (Figure 3). There was also a significant increase in the relative abundance of O. virilis compared to O. propinquus in September (chi-square = 22.26, 6 dF, p = 0.001) (Figure 4).

The crayfish species inhabiting the study area vary considerably in size. Yellow perch consumed crayfish ranging in size from young of the year, measuring approximately 4 mm, to the largest adult specimen with a carapace length of 28 mm. However, crayfish collected by divers measured 15 - 40 mm. Perch size was only a minor factor in the selection of crayfish prey since less than 4.4% of the variance is explained by size ($r^2 = 0.0437$, $N =$

342). This was, however, significant at $p < 0.0001$). Figure 5 indicates that the largest crayfish were consumed by the smallest (TL) perch.

Length distributions of the crayfish in perch stomachs were compared to diver collected populations. I chose the intersection of these two subsets to represent the crayfish vulnerable to both divers and fish. The ratio of O. propinquus to O. virilis measuring 15 - 28 mm recovered from the gut was not different from that in the 15 - 28 mm range in a random sample collected with SCUBA (chi-square = 0.0001, 1 dF, $p = 0.99$). Crayfish with a carapace length in the size range of 16 - 20 mm were taken in greater frequency (56%) than other lengths.

Fish in the diet ranked second behind crayfish (Figure 1). Fish were the only taxonomic group other than crayfish present on every date throughout the study despite the temporally sporadic occurrence of individual species. Eight species of fish were identified (Table 2). Mottled sculpin (Cottus bairdi) occurred consistently in every sample throughout the study but showed greater relative abundance early in the summer. The frequency of occurrence of juvenile yellow perch, approximately 25 - 40 mm TL, was less than 4 percent in each of the first six samples, but increased dramatically at summer's end (chi-square = 312.29, 6dF, $p < 0.001$). They were the most abundant prey item on 9 September (Figure 6). The greatest mean number of perch

consumed was 1.29 on 9 September (Figure 3). Each other fish species represented less than 2% TO or 1% FO.

Insects comprised 22.85% TO, but the occurrence of caddis flies (Athripsodes), sometimes as many as 40 per fish, resulted in insects representing nearly half of the total organisms in the 28 June and 11 July samples (Figure 2). Mayflies (Stenonema) and midges (Chironomus) each made up less than 2% TO of the samples. The mean number of insects consumed per date also indicated some variation (Figure 3). The mean values increased slightly, then peaked on 11 July due to perch feeding on Athripsodes.

The remaining prey (Table 2) included three snail genera (Gyraulus, Amnicola and Physa), aquatic earthworms and leeches early in the summer, incidental numbers of amphipods (Gammarus), and various non-food items, such as bits of gravel, coal or slag presumably eaten accidentally whilst picking bottom prey.

Diel Periodicity of Foraging Behavior

Yellow perch were actively foraging throughout a 24 hour day as evidenced by the presence of crayfish in digestion state 1 in every period (Figure 7). Data from the periods of pre-sunset, post-sunset, pre-sunrise and post-sunrise, indicated a increase in the percent of category 1 prey before sunset and at dawn. At those times, 45% of the prey was less than 2 hours old (Figure 7).

A two-factor ANOVA, (dependent variable = digestion state; independent variables = date, period, and interaction of date * period) indicated that period and date had a significant effect on feeding (Period $F = 3.49$, $p < 0.02$, 3, 684 dF; Date $F = 4.47$, $p < 0.001$, 6, 684 dF; Date * Period $F = 1.73$, $p < 0.05$, 17, 684 dF). Newman-Keuls test, comparing the means of digestion states, showed the following:

$P < 0.01$	$P < 0.05$
Pre-sunrise Post-sunset ^A Post-sunrise ^B Pre-sunset	Pre-sunrise Post-sunset ^A Post-sunrise ^B Pre-sunset ^C

Despite morning and evening peaks, perch fed throughout the night, as evidenced by live crayfish in stomach samples, and were caught at 1:30 a.m. by angling with live minnows.

The studies conducted with perch in captivity revealed similar patterns of behavior. The 24 yellow perch captured in hoop nets and maintained in holding tanks exhibited foraging behavior, activity levels, and pigmentation fluctuations in response to varying light intensities. The fish were less active at night and displayed a coloration of obvious darker and intensified vertical bars with green interspaces. When live food was introduced into the environment during low light conditions, the fish readily chased and captured the prey. No attempt was made to measure the frequency of foraging behavior within the

previously defined time intervals in the controlled environment except to determine if the fish would be able to locate and take prey under the varying intensities of light.

DISCUSSION

Variation in Prey

The primary prey of yellow perch vary considerably within its geographic range throughout the U. S. In a study conducted by Brazo (1973) off Ludington, Michigan, Pontoporeia affinis was the most significant food item eaten by 135 - 235 mm TL perch, while the diet of fish larger than 235 mm consisted mainly of crayfish and sculpins. Immature insects, primarily chironomid and Hexagenia, were the most important food from Saginaw Bay (Tharratt, 1957), and slimy sculpins (Cottus cognatus) and alewives dominated samples taken off Milwaukee, Wisconsin (Schaefer, 1973). Numerous authors have reported Entomostraca (Daphnia) being most prominent, as the primary or exclusive food for adult perch in several inland lakes (Fisk, 1953). The large variation in prey species indicates that availability, rather than a preference, was the controlling factor in prey consumed. The lake bottom off Chicago has substantial crayfish populations (J. Quinn, 1987) but off Milwaukee, which is also rocky, crayfish are absent. Therefore, the great abundance of crayfish on the rocky substrate in southwestern Lake Michigan correlates to its appearance as the most important prey.

The seasonal variation in the diet of perch in this study also correlates with availability. The September

sample indicated a reduction of crayfish in the diet with a vast increase in the utilization of young-of-the-year (YOY) perch. Spawning was finished before 28 June and YOY perch are frequently seen in harbors and along beaches during July and August but disappear in September. This is consistent with reports from Jude et al. (1975) where YOY yellow perch first appeared in July in beach seines at sizes of about 25 mm. Greatest mortality of young perch occurs between August and the following May, and is a direct result of the shift to a demersal stage in open water (Forney, 1971; Tarby, 1974). Offshore dispersal of YOY yellow perch in late summer has also been noted for populations in Lake Erie (Wells, 1968) and Lake Mendota (Hermann et al., 1969). The sudden appearance of perch in September gut samples coincides with their transition to deeper water where they are vulnerable to predation.

Other studies reported that the influx of YOY crayfish into the environment did not appear to substantially shift selectivity to the smaller size classes. Their secretive behavior and small size combined to eliminate predatory mortality by predators greater than 10 cm (Stein, 1977). Since small size classes are relatively less exposed than larger sizes classes, the increased search time to obtain small size classes appears to decrease their susceptibility relative to more available intermediate size classes.

The relative abundance of O. virilis in the diet showed a significant increase in September. O. virilis grow quickly in a series of steps, molting twice during the summer, thus increasing their vulnerability to predation as they pass through the size window of adult O. propinquus in late summer (Quinn, 1987). Continued growth makes them too large to be taken by perch. Stein (1977) observed that crayfish 16 - 20 mm were eaten first by small mouth bass (Micropterus dolomieu); those less than 14 mm or greater than 22 mm were less susceptible to predation. This size range corresponds exactly to the length of crayfish found in highest frequency in stomach analysis. Of the 342 measurable crayfish, 193 or 56% were in the 16 - 20 mm range. Lower frequencies of O. virilis are encountered earlier and later in the season because adults are too large.

Diel Feeding Periodicity

The increase in perch feeding coincided with the hours of twilight showing a higher peak at sunrise and a lower one at sunset. This is similar to reports by Keast and Welsh (1968), Collette et al. (1977), and Helfman (1981). The effect of a photoperiod was not as strong a stimulus to feed as the availability of prey since feeding continued throughout the night. This may be the case, at least, in relation to crayfish.

A high degree of crayfish activity and low shelter occupancy at night was reported by Stein and Magnuson (1976). Crayfish are more active and easily captured by divers using hand nets after sunset. No crayfish were seen at pre-sunset whilst there was still light. At sunrise, only a few crayfish were seen, and after sunrise a few were fighting for shelter (J. Quinn, pers. comm.)

Crayfish consumed during the night, however, do contribute significantly to the diet. Live crayfish were found in the stomachs of perch netted after midnight. Yellow perch may be able to successfully forage for prey continuously through the night as a result of the light from the adjacent highway and city. During my study SCUBA divers found that perch encountered during dives were active, sometimes following crayfish when a light was suddenly directed at them (Janssen and Quinn, pers. comm.). This is in contrast with the observations of Helfman (1979) who found perch from a small lake resting on or near the bottom where they remained motionless until the morning changeover. The activity of yellow perch at night may show variation with habitat much as the diet varies with habitat.

CONCLUSION

I collected 745 yellow perch on seven dates between 12 June and 10 September, 1984. There was a seasonal change in the species consumed by yellow perch. Crayfish (Orconectes propinquus and O. virilis) were the most important prey. Crayfish represented 90% of the total prey in late summer and occurred in 87% of the stomachs. The significance of fish in the diet ranked second behind crayfish. Young-of-the-year perch were consumed by 60% of the fish, and made up 68% of the total prey in September. Prey specimens found in perch stomachs were identified and compared to standards of known digestion intervals to determine their digestion state (1 - 5). The digestion states were treated as numerical estimates of relative digestion for statistical analysis. A peak in foraging was revealed for the period after dawn with continued feeding throughout the day. The perch did forage at night, however, in contrast to other reports.

Table 1

Length of time net was set for each time period. Time intervals are hours and minutes before (-) and after (+) period.

Date	- Sunset +	- Sunrise +
12 June	0:30-0:00	1:05-3:05
28 June	3:00-0:29	1:31-3:46
11 July	2:09-1:06	1:34-3:04
26 July	2:46-0:46	1:15-2:45
8 Aug	1:00-0:00	1:15-3:00
26 Aug	1:34-1:04	1:26-3:26
9 Sept	0:43-0:33	1:49-6:49

Table 2

Taxa consumed by yellow perch on each collection date.

Prey	Date						
	1	2	3	4	5	6	7
<u>Orconectes propinquus</u>	x	x	x	x	x	x	x
<u>Orconectes virilis</u>	x	x	x	x	x	x	x
<u>Cottus bairdi</u>	x	x	x	x	x	x	x
<u>Perca flavescens</u>	x				x		x
<u>Alosa pseudoharengus</u>	x						x
<u>Osmerus mordax</u>	x				x		
<u>Pungitius pungitius</u>	x						
<u>Etheostoma nigrum</u>	x		x				
<u>Rhinichthys cataractae</u>							x
<u>Percopsis omiscomyacus</u>							x
<u>Athripsodes</u>		x	x	x	x	x	
<u>Stenonema</u>	x	x	x	x	x		
<u>Chironomus</u>		x	x				
<u>Gyraulus</u>	x			x			
<u>Amnicola</u>	x	x	x	x			
<u>Physa</u>	x				x		
<u>Gammarus</u>	x					x	
Annelids	x	x	x			x	x
Non-food	x	x	x	x			x
Total	15	9	10	8	8	6	9

FREQUENCY OF OCCURENCE OF MAJOR PREY

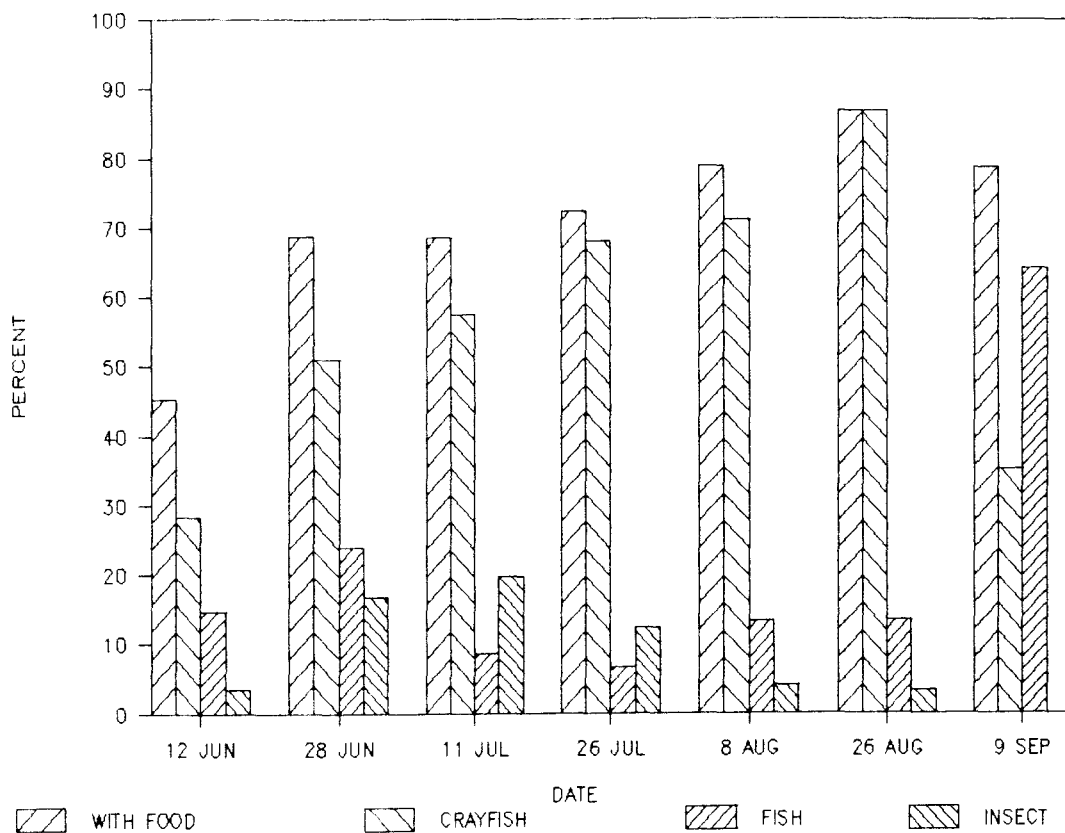


Figure 1. Frequency of Occurrence of Major Prey

The percent of yellow perch with food in stomachs and percent frequency of occurrence of crayfish, fish, and insects as a function of date.

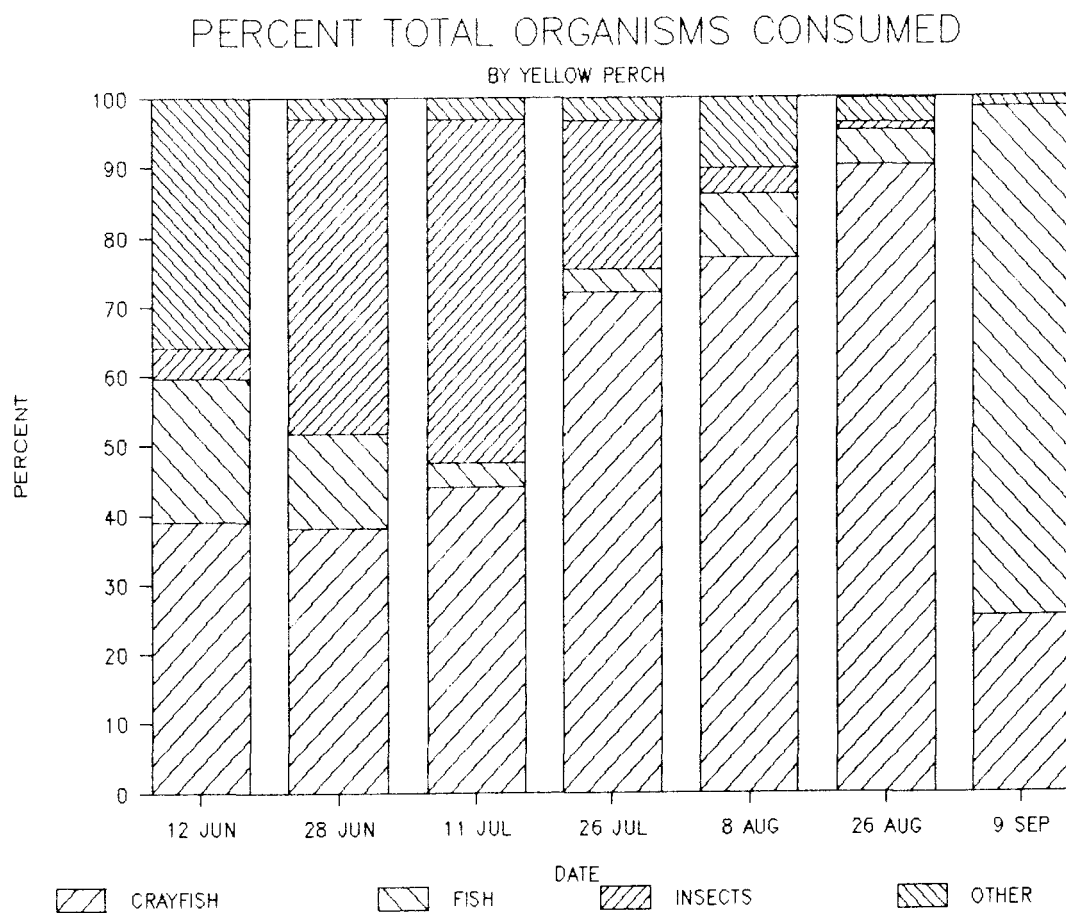


Figure 2. Percent Total Organisms Consumed by Yellow Perch

The percent of total organisms represented by crayfish, fish, insects, and incidental prey identified from stomach contents as a function of date.

MEAN NUMBER OF PREY CONSUMED

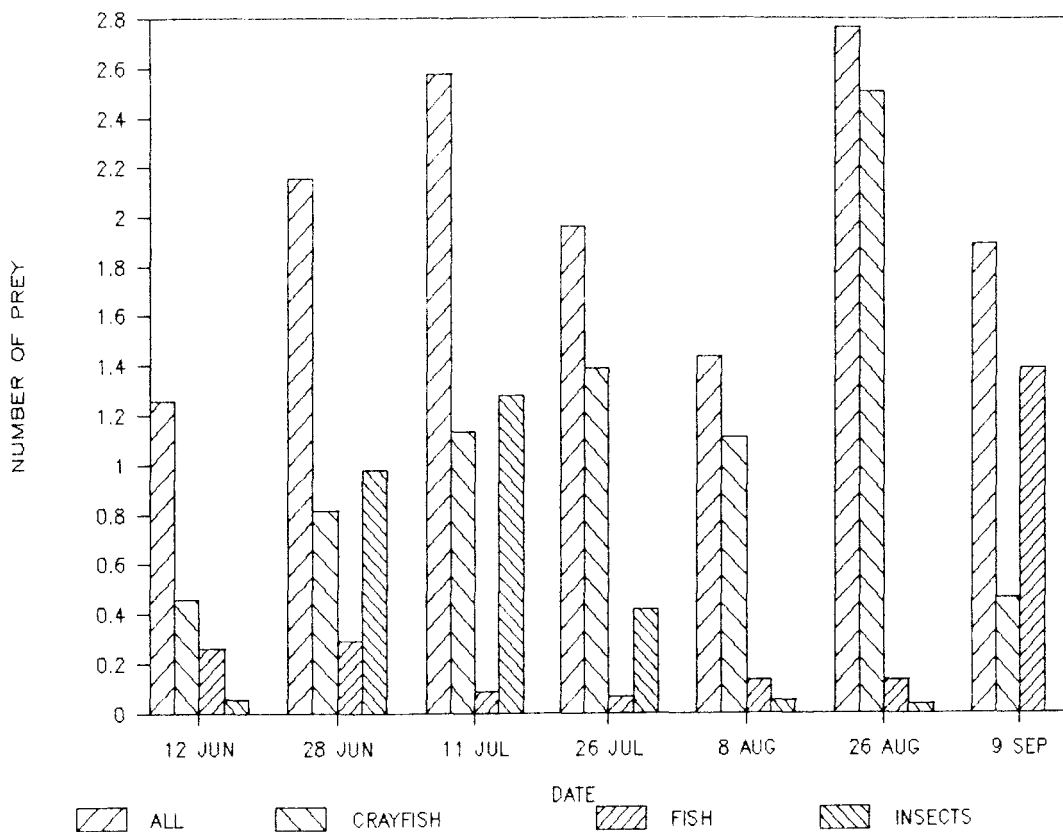


Figure 3. The Mean Number of Prey Consumed

The mean number of total prey consumed by yellow perch with reference to crayfish, fish, and insects as a function of date.

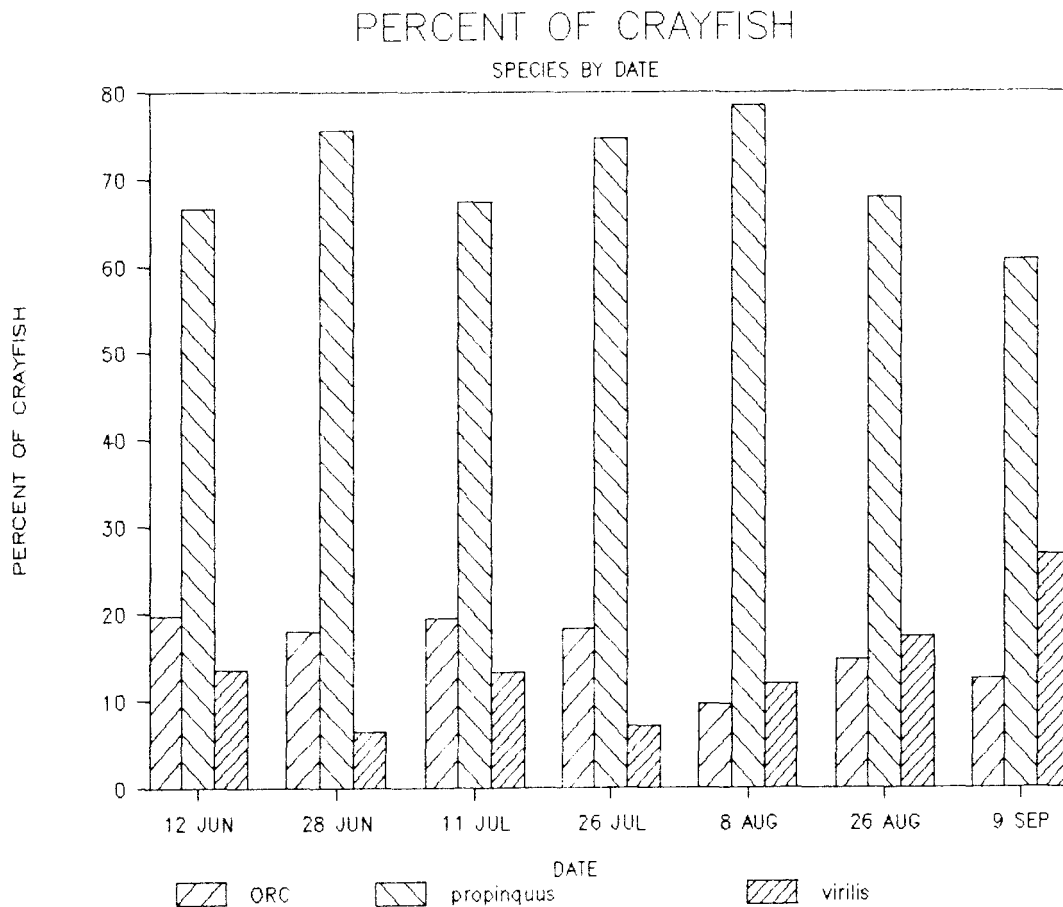


Figure 4. Percent of Crayfish Species by Date

The relative abundance of crayfish species as a function of date. ORC - Represents the specimens not identified to definite species (eg. cheli, telson, or eyes).

LENGTH RELATIONSHIP BETWEEN PERCH
AND CRAYFISH PREY

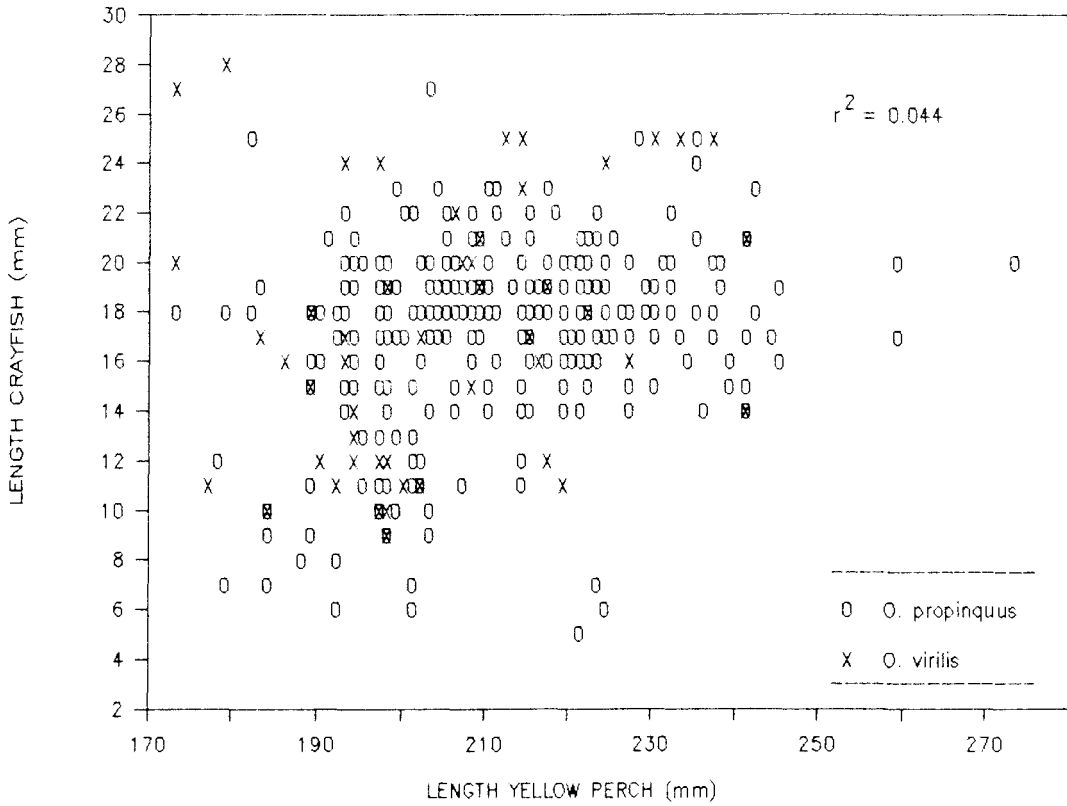


Figure 5. Length Relationship Between Yellow Perch and Crayfish Prey

The carapace length (mm) of crayfish consumed by yellow perch as a function of total length (mm) of the fish.

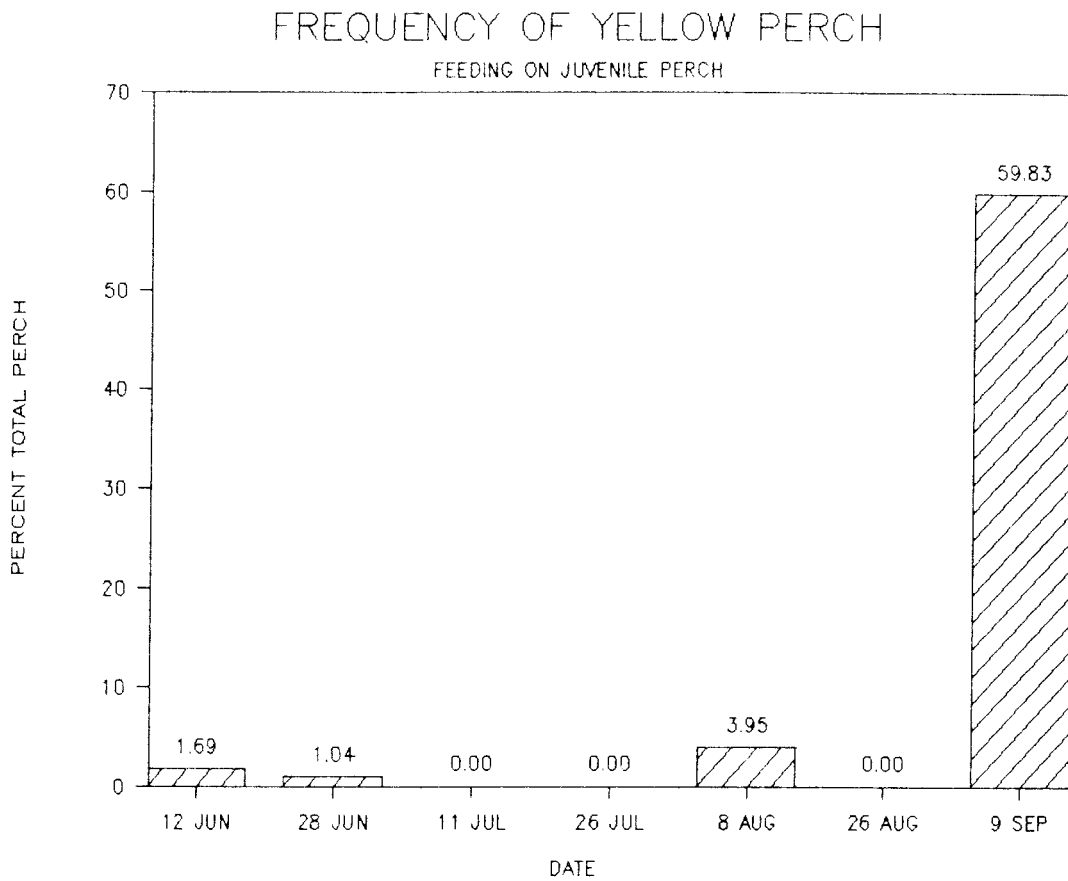


Figure 6. Frequency of Perch Feeding on Juvenile Perch

The percent of yellow perch feeding on juvenile perch as a function of date.

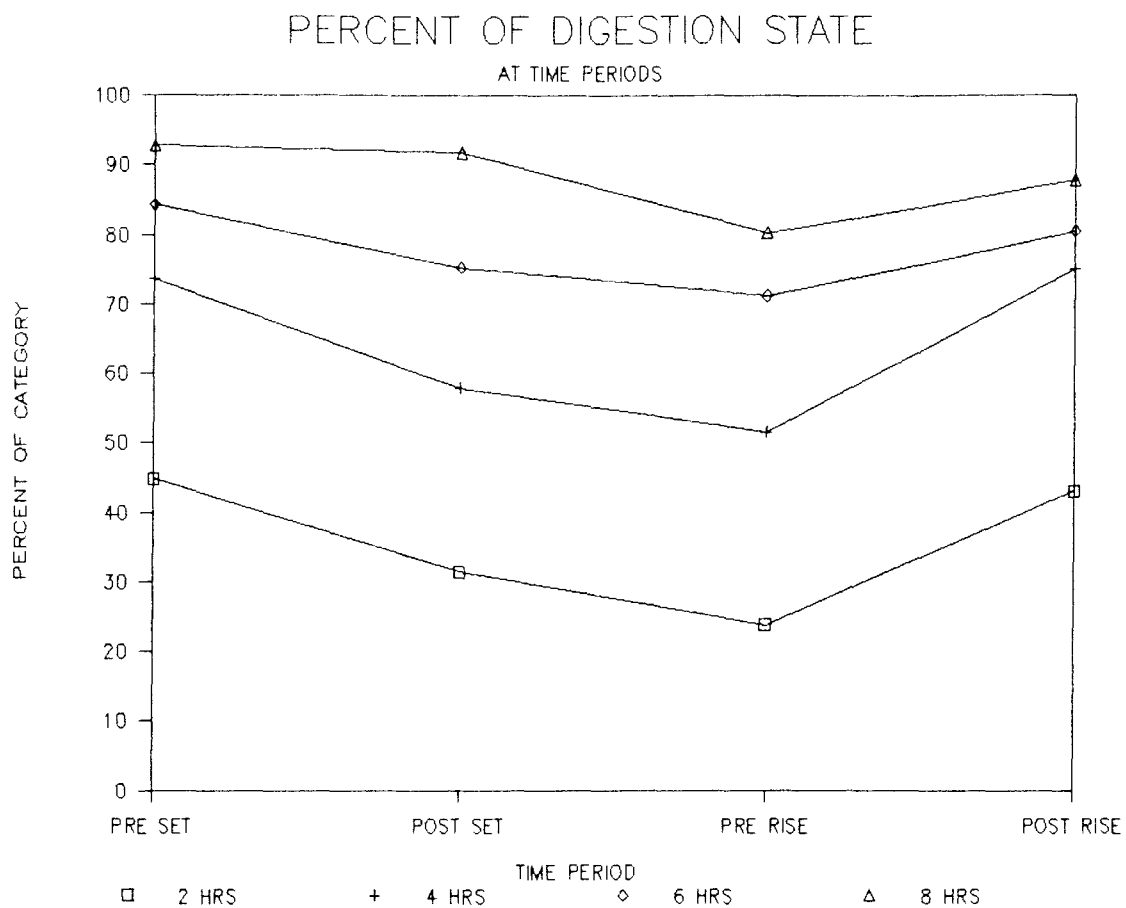


Figure 7. Percent of Digestion State At Time Periods

The relative percent of specimens fitting digestion states 1 through 5 for each time period.

REFERENCES

- Brazo, Dan C. 1973. Fecundity, food habits, and certain allometric features of the yellow perch, Perca flavescens (Mitchill), before operation of a pumped storage plant on Lake Michigan. Masters Thesis, Michigan State University, Ann Arbor, Michigan.
- Collette, B. B., M. A. Ali, K. E. F. Hokanson, M. Nagiec, S. A. Smirnov, J. E. Thorpe, A. H. Weatherley, and J. Willemsen. 1977. Biology of the percids. J. Fish. Res. Board Can. 34:1890-1899.
- Collins, N. C., H. H. Harvey, A. J. Tierney, and D. W. Dunham. 1983. Influence of predatory fish density on trapability of crayfish in Ontario lakes. Can. J. Fish. Aquat. Sci. 40:1820-1828.
- Fisk, Leonard O. 1953. Food habits of yellow perch in two northern Colorado reservoirs. Masters Thesis. Colorado Agricultural and Mechanical College, Fort Collins, Colorado. 1953. 79 pp.
- Forney, J. L. 1971. Development of dominant year classes in a yellow perch population. Trans. Amer. Fish. Soc. 100(4):739-749.
- Hazlett, B., D. Rittschof, and C. Ameyaw-Akumfi. 1979. Factors affecting the daily movements of the crayfish Orconectes virilis (Hagen, 1870) (Decapoda, Cambaridea), Crustaceana, Suppl. 5:121-130.
- Helfman, G. S. 1981. Twilight activities and temporal structure in a freshwater fish community. Can. J. Fish. Aquat. Sci. 38:1405-1420.
- Helfman, G. S. 1979. Twilight activities of yellow perch, Perca flavescens. J. Fish. Res. Board Can. 36:173-179.
- Herman, E., W. J. Wisby, L. Wiegert, and M. Burdick. 1964. The yellow perch, its life history, ecology and management. Wis. Conserv. Dep. Publ. 228:1-14.
- Janssen J. and J. P. Quinn. 1985. Biota of the naturally rocky area of southwestern Lake Michigan with emphasis on potential fish prey. In Artificial Reefs: Marine and Freshwater Applications, ed. F. M. D'Itri, pp. 431-442. Lewis Publ., Inc.

- Jude, D. J., F. J. Tesar, J. A. Dorr III, T. J. Miller, P. J. Rago and D. J. Stewart. 1975. Inshore Lake Michigan Fish Populations Near The Donald C. Cook Nuclear Power Plant, 1973. Great Lakes Research Division, University of Michigan, Ann Arbor, Michigan. Special Report No. 52, 267pp.
- Keast, Allen and Linda Welsh. 1968. Daily feeding periodicities, food uptake rates, and dietary changes with hour of day in some lake fishes. J. Fish. Res. Board Can. 25:1133-1144.
- Kraft, Clifford. 1982. Green Bay's yellow perch fishery. University of Wisconsin Sea Grant Public Information Report WIS-SG-82-425.
- Quinn, J. P. 1987. The biology of two species of crayfish in southwestern Lake Michigan. Masters Thesis. Loyola University of Chicago, Chicago, Illinois. 38 pp.
- Schaefer, Wayne F. 1975. A study of the growth patterns, food habits and seasonal depth distribution of the yellow perch, Perca flavescens in southwestern Lake Michigan. Masters Thesis. University of Wisconsin. Milwaukee, Wisconsin. 1975. 55 pp.
- Scott, W. B. 1981. Freshwater Fishes of Eastern Canada. second ed., University of Toronto Press. Toronto, Canada. 137 pp.
- Stein, R. A. 1977. Selective predation, optimal foraging, and the predator-prey interaction between fish and crayfish. Ecology 57:751-761.
- Stein, R. A., and John J. Magnuson. 1976. Behavioral response of crayfish to a fish predator. Ecology 57:751-761.
- Tarby, Martin J. 1974. Characteristics of Yellow Perch cannibalism in Oneida Lake and the relation to first year survival. Trans. Amer. Fish. Soc. 103:462-471.
- Tharratt, Robert C. 1957. Food habits of the yellow perch, Perca flavescens (Mitchill), in Saginaw Bay, Lake Huron. Masters Thesis. University of Michigan. 1957.
- Thorpe, J. E. 1977. Daily ration of adult perch, Perca fluviatilis L. during summer in Loch Leven, Scotland. J. Fish. Biol. 11:55-68.

- Thorpe, J. E. 1977. Morphology, physiology, behavior, and ecology of Perca fluviatilis L. and P. flavescens Mitchill. J. Fish. Res. Board Can. 34:1504-1514.
- Wells, L. 1968. Seasonal depth distribution of fish in southeastern Lake Michigan. U.S. Fish. Wild. Serv. Fish. Bull. 67:1-15.
- Wells, LaRue. 1977. Changes in yellow perch (Perca flavescens) populations of Lake Michigan, 1954-75. J. Fish. Res. Board Can. 34:1821-1829.
- Wells, L., and A. L. McLain. 1973. Lake Michigan: man's effects on native fish stocks and other biota. Great Lakes Fish. Comm. Tech. Rep. 20:55 p.

APPROVAL SHEET

The thesis submitted by Ronald J. Abrant has been read and approved by the following committee:

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Dr. Edward E. Palincsar
Professor, Biology, Loyola

Dr. Jan Savitz
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The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the thesis is now given final approval by the Committee with reference to content and form.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Science.

10-20-88
Date


Director's Signature