ILLINOIS NATURAL HISTORY SURVEY

Evaluation of Walleye Stocking Program

Annual Report, F-118-R1

Center for Aquatic Ecology

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Lisa Einfalt, and David H. Wahl**

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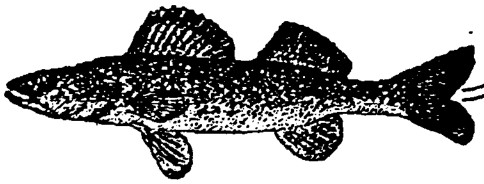

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ANNUAL PROGRESS REPORT

EVALUATION OF WALLEYE STOCKING PROGRAM

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Submitted to

Division of Fisheries
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Job 101.1. Factors affecting survival and growth of walleye fry.

OBJECTIVE: To evaluate factors affecting survival and growth of walleye fry stocked in impoundments.

INTRODUCTION:

Walleye are an extremely important sportfish and have attracted an increasing amount of interest from anglers and researchers over the past two decades (see literature summaries in Ebbers 1988, Davin et al. 1989). From these studies it has become clear that success of walleye fry and fingerling stockings is highly variable (Laarman 1978). Stocking success probably depends upon a variety of physical and biotic factors.

Previous work with walleye and other stocked sportfish has identified several potential factors which might influence stocking success of walleye fry and fingerlings in a given impoundment. One of the more important of these potential factors is forage base (Forney 1977; Li and Mathias 1982; Carline et al. 1986; Wahl and Stein 1988). As zooplankton are the first food eaten by walleye fry, their stocking success may be related to zooplankton density and size composition (Mathias and Li 1982, Hokanson and Lien 1986, Fox et al. 1989, Confer et al. 1990, and Fox and Flowers 1990). Other important factors influencing success may include resident predators (Wahl and Stein 1989a), physical-chemical conditions (Koonce et al. 1977), and stocking stress (Carmichael et al. 1984; Mather and Wahl 1989).

METHODS:

Fry were stocked into Ridge Lake (Coles Co.) and Lake Shelbyville (Moultrie Co.) (Table 1). Ridge Lake is a 14 acre impoundment with a maximum depth of 21 ft. In contrast, Lake Shelbyville is an 11,000 acre flood control reservoir. Major fish species (excluding forage) present in Ridge Lake in addition to walleye include largemouth bass, bluegill, black crappie, and channel catfish. These same species plus muskellunge, Morone spp., and various non-game species occur in Lake Shelbyville.

All fry were reared at the Jake Wolf Memorial fish hatchery by the Illinois Department of Conservation. Fry for Lake Shelbyville were marked by immersion in oxytetracycline. In order to asses mortality due to stocking stress, subsamples from each fry stocking (N=100) were held in three 132.5 L (35 gal) plastic tubs for 48 hours. Water temperature, dissolved oxygen and turbidity were recorded at the time of stocking and at weekly intervals for four weeks thereafter. Secchi disc depth was recorded as a measure of turbidity. Zooplankton density and species composition were also sampled at these same intervals by repeated vertical tows with a 0.5m (20 inch) diameter, 64um mesh zooplankton net. Samples were preserved with a sucrose-10% formalin solution. In the laboratory samples were adjusted to a constant volume (100ml) and subsampled by 1 ml (1/100) aliquots. Numbers of major groups of zooplankton were identified and counted. Electrofishing and trap-netting CPUE were used as an index of walleye fry survival. All walleye collected were measured to determine growth rates and for comparison of length frequency distributions between fall and spring.

RESULTS:

Mortality of fry associated with stocking stress was low, < 3.1% for the Lake Shelbyville and Ridge Lake stockings (Table 2). Water temperatures at stocking were similar for all three stockings suggesting no differential effects of thermal stress on survival.

Low numbers of stocked fry (N=5) were collected in extensive electrofishing during the fall of 1991 from both Lake Shelbyville (N=3) and Ridge Lake (N=2). The numbers were not sufficient to estimate survival or growth rates of walleye fry. Difficulty in collecting stocked fry throughout the summer and fall is consistent with past experience at Ridge Lake (Santucci and Wahl 1990).

Numbers of major taxa of zooplankton have been counted for selected dates after stocking in both Ridge Lake and Lake Shelbyville (Table 3). The densities seen in Lake Shelbyville on these dates were markedly lower and may be too low for efficient walleye fry foraging (Fig. 4, 5 and 6).

RECOMMENDATIONS:

Sampling during the spring and fall of 1992 should be conducted in order to provide an estimate of the survival and growth rates of the stocked fry. Previous studies have indicated that catch rates from electrofishing increase after the first winter following stocking. As few walleye stocked as fry were collected in the first fall, those returned during future sampling will provide a measure of survival and growth rates.

Evidence obtained thus far indicates there is variability in zooplankton populations among different lakes at the time when fry are stocked. Our work will evaluate if efforts should be made to match fry stocking to lakes which have optimum zooplankton populations on dates when fry are available.

Lakes currently included for study in this job were also used to evaluate the relative benefits of fry versus fingerling stockings (see Job 101.3). In subsequent years, additional lakes will be chosen solely for evaluation of fry stocking success.

Job 101.2. Factors affecting survival and growth of walleye fingerlings.

OBJECTIVE: To determine mechanisms affecting survival and growth of fingerling walleye after stocking in impoundments.

INTRODUCTION: The success of walleye fingerling stocking, like that of fry stocking, has been highly variable (Laarman 1978). While Hauber (1983) indicated that fingerling stocking can be successful in increasing year class strength in some cases, the reasons for these successes are often unknown. Variable success probably results from the interaction of a number of physical and biotic factors. Forage is probably one of the most important factors influencing stocking success of walleye fingerlings. The temporal abundance and species composition of the forage base, as well as the size distribution of prey, relative to walleye size, may all play an important role (Smith and Pycha 1960, Forney 1974, Hauber 1983, Mandenjian et al. 1991).

Predation is also likely to have an impact on walleye fingerling stocking success. Recent evidence suggests predation can be an important source of mortality (Santucci and Wahl 1990). Size of stocked fish can affect susceptibility to predation (Hanson et al. 1986; Wahl and Stein 1989a); predation is probably higher for small walleye fingerlings than for larger size groups (Santucci and Wahl 1990). The role of predator abundance and size distribution in determining mortality rates of stocked walleye has not yet been evaluated.

As with fry stocking, physical-chemical conditions, including thermal stress at stocking, may influence fingerling stocking success. Temperature may also be important in determining growth and survival during post-stocking periods. Serns (1982) found that density and growth of age-0 walleye in natural populations were related to June water temperatures; these relationships may also apply to stocked fingerlings.

METHODS: Fingerling stocking evaluations were conducted in five lakes and impoundments in northern and central Illinois (Table 1). Lake George (Rock Island County) is a 68 hectare impoundment with a watershed area of 1883 hectares, a maximum depth of 19 m, and an average depth of 7 m. The lake contains a moderate but diverse aquatic plant population, consisting of American pondweed, Illinois pondweed, coontail, and elodea. Major fish species (excluding forage) present in addition to walleye include largemouth bass, bluegill, white crappie, muskellunge, channel catfish, common carp, green sunfish, and longear sunfish. Lake Le-Aqua-Na (Stephenson County) is a 16 hectare impoundment with a watershed area of 932 hectares, a maximum depth of 8 m, and an average depth of 4 m. Major fish species present in addition to walleye include largemouth bass, bluegill, northern pike, black crappie, and channel catfish. Pierce Lake (Winnebago County) is a 66 hectare impoundment with major fish species including largemouth bass, bluegill, black and white crappie, muskellunge, yellow perch, channel catfish, and gizzard shad. Descriptions of Ridge Lake and Lake Shelbyville appear in Job 101.1.

In order to assess mortality of walleye fingerlings due to stocking stress, subsamples of fish from each stocking were held in floating cages (1.5 m deep x 0.75 m dia, 3.2 mm mesh) for 48 hours. The number of fingerlings alive and dead was determined at 24 and 48 h. A subsample (N=100) fish were measured (total length, mm) and weighed (g) to allow for evaluation of growth when walleye were collected in subsequent sampling.

As with walleye fry, fall (September-December) electrofishing and trap net catch-per-unit-effort were used as an index of walleye fingerling survival. All walleye collected were measured, to determine growth rates and allow for a comparison of length frequency distributions between fall and spring sampling periods. Stomach contents of fingerling walleye were examined by gastric flushing (Foster 1977) or by dissection. Walleye were given an upper caudal fin clip, and modified Schnabel mark-recapture population estimates were calculated for fingerling stockings from which three or more recaptures were obtained. Wherever possible, comparisons were made between catch-per-unit-effort values and mark-recapture estimates.

Physical, chemical, and biotic conditions were monitored in all impoundments at the time of stocking, at bi-weekly intervals for the first two months following stocking, and at monthly intervals thereafter, to evalute their possible influence on walleye survival and growth following stocking. Water temperature, dissolved oxygen, and turbidity were determined as described in Job 101.1. Forage base and predator populations were also monitored at these same intervals. The role of forage base in determining growth and survival of walleye was evaluated by comparing walleye diets with the species composition, density, and size distribution of prey available in each impoundment. Zooplankton density and species composition was sampled as described in Job 101.1. Benthic invertebrates were sampled using a Ponar or Ekman grab sampler. One liter of sediment was removed from the sample, filtered through a #30 sieve, and preserved in a 70% ethanol and rose bengal solution. Benthic organisms were later removed and identified to lowest possible taxonomic group. Available forage fish were sampled using standard ichthyoplankton tows with 0.5 m, 500 um larval fish nets and by standardized shoreline seining (9 x 2 m seine, 3 mm mesh). Forage fish were identified, counted, and measured to the nearest mm (seine samples). Following each of the lake stockings we determined losses of walleye to resident predators. Predators were collected by trapnetting and electrofishing standardized transects. All potential predators on walleye fingerlings were identified, measured (total length, mm), and given a right pelvic fin clip. Mark-recapture estimates of predator numbers were calculated as described for walleye fingerlings. Stomach contents of largemouth bass were examined using acrylic tubes (Van Den Avyle and Roussel 1980); walleye stomachs were examined using gastric flushing (Foster 1977). Number of walleye in predator stomachs were combined with population estimates of the number of predators to determine the total number of stocked walleye lost to predation.

RESULTS: Mortality of walleye fingerlings immediately following stocking ranged from 0-31% (Table 3). There was an apparent trend in mortality related to temperature, with higher initial mortality occurring at higher temperatures. However, this pattern might also be explained in part by the size of the fingerlings at stocking. The intermediate and large fingerlings stocked at Ridge Lake that experienced no mortality were also the largest fingerlings stocked.

We had only limited success in collecting stocked walleye fingerlings by electrofishing on most lakes, and no stocked walleye were collected in trap nets. In addition, we had difficulty in identifying stocked fish from those already present in the lake, as length frequencies often overlapped. This has traditionally been a problem in studies of walleye fingerling stocking success (Buttner et al 1991, Hauber 1983). Based on length frequency data and information from limited collection of fingerling walleye scales, we determined maximum lengths for young-of-year walleye in fall samples (Table 4). CPUE of stocked fingerlings in fall electrofishing was less than 1.0 fish/h in three of the five study lakes (Table 4). In Lake Le-Aqua-Na the population estimate for age-0 walleye was 4.2 fish/hectare (95% confidence interval; 2.0 - 20.6 fish/hectare), indicating that stocked walleye experienced about 93% (range; 67-97%) mortality over a 3-4 month period. This is consistent with results from previous studies (Hauber 1983, Santucci and Wahl 1990, Buttner et al 1991).

The limited number of fingerlings collected in fall sampling and the uncertainty of age-0 identification make comparisons of growth difficult. Fish from Lake Le-Aqua-Na, which were the most abundant in fall samples and most distinctly separate from the established population (Figure 1), had an average length of 168 mm. This is within the range observed for other walleye populations (Serns 1982, Buttner et al 1991, Mandenjian 1991). The range of growth observed among the five lakes examined demonstrates the variability that can occur among and within walleye populations.

Differences in survival and growth of fingerling walleye among lakes may be due to variable predation pressure and differences in forage base among lakes (Forney 1974, 1976, Hauber 1983). Forage fish were collected in all study lakes, but these data have not yet been analyzed. Density of benthic organisms was determined in each lake (Table 5). Diet of stocked fish collected in fall sampling consisted primarily of Lepomis spp., and included gizzard shad, Atherinidae, and chironomids (Figure 2). Fish (N=5) collected in August on Lake Le-Aqua-Na contained large numbers zooplankton (primarily Cladocerans and Copepods). Forty-four percent of stocked walleye stomachs examined during fall sampling were empty.

There were a number of potential predators in the lakes stocked with walleye, including largemouth bass, smallmouth bass, adult walleye, crappie, northern pike, and muskellunge. Micropterus spp. were the most numerous predators in all lakes. In only two of the lakes were stocked walleye found in bass stomachs following stocking (Table 6). In Lake Le-Aqua-Na, predation accounted for only a small percentage of observed mortality. While predators appeared to play only a small role in determining survival, they may be somewhat more important than these initial numbers indicate. Santucci and Wahl (1990) reported intermediate walleye fingerling mortality due to predators of as high as 28%. Additional data concerning predation on walleye fingerlings will allow us to evaluate the magnitude of this source of mortality and to make recommendations regarding the appropriate predator populations in which to stock various sizes of walleye.

RECOMENDATIONS: The current sampling schedule should be maintained following stockings in subsequent years. Evaluation of mortality at stocking will allow us to continue to examine the relationship of this portion of mortality to water temperature and size of stocked walleye. We will also continue to evaluate the role of forage base and predators in determining survival of stocked walleye. In addition, monitoring and assessment of factors influencing walleye growth in the year after stocking will be continued. This monitoring will be important, given the high variability in growth observed in the lakes studied. In addition to the current sampling schedule, some additions and modifications should be included.

Walleye will be collected by trap netting and electrofishing in spring (April-June) to evaluate over-winter survival and growth. We should continue to closely monitor the adult walleye population in each of the study lakes, both to evaluate potential effects on subsequent stockings and because the success of walleye stockings may be more accurately evaluated in older age classes (Hauber 1983).

Due to the difficulty of identifying age-0 fish in the current study lakes, all fish stocked in subsequent years of the study should be marked by fin-clipping, chemically, or through the use of coded wire tags. Scales and otoliths should be collected from all size groups of walleye in each study lake to allow for more accurate evaluation of growth and survival.

Lakes chosen for subsequent sections of the study should be chosen to provide a range in temperature, predator, forage, and habitat conditions that might influence fingerling growth and survival.

Job 101.3. Size-specific survival, growth, and food habits of walleye fry and fingerlings.

OBJECTIVE: To compare size-specific survival, growth, and food habits of walleye fry and fingerlings stocked in impoundments.

INTRODUCTION: Two basic strategies have developed for stocking walleye to supplement natural populations or to add an additional fish for the benefit of anglers. The first is to stock large numbers of walleye fry in hopes that, despite relatively poor survival to juvenile and yearling classes, a percentage of that stocking will survive and contribute to or create a strong year class. The second strategy has been to stock smaller numbers of intermediate to advanced fingerlings in hopes that large size and increased survival will lead to strong year classes. In weighing these two options, considerations include hatchery production costs, ease of stocking, and relative survival of stocked walleye.

The most effective way to obtain conclusive evidence regarding the relative benefits of fry versus fingerling stocking is to obtain data from lakes where mixed size stockings are conducted. In those situations, it could be expected that the physical, chemical, and biological conditions that dictated year-class strengths would apply to both the fry and fingerlings, allowing meaningful comparisons of differences in survival. In this job, we compared the mechanisms influencing survival following two stockings where different size groups were stocked into the same lake during the same year. Ultimately, data obtained in this portion of the study will be used to construct a bioeconomic model to investigate the survival and stocking success of different sizes of walleye as a function of costs of rearing.

METHODS: In addition to the fry stockings discussed in job 101.1, both Lake Shelbyville and Ridge Lake were stocked with fry and two-inch fingerlings (Table 1). Ridge Lake also recieved stockings of five- and eight-inch fingerlings. Stocking evaluations on these two lakes were conducted as described in Jobs 101.1 and 101.2.

RESULTS: For fry stockings, mortality due to stocking stress was low; less than 4% in all cases (see Job 101.1). Mortality due to stocking stress for fingerlings ranged from 0-31%. As discussed in Job 101.2, there was a trend in fingerling mortality related to water temperature at stocking, but the effects of fingerling size and water temperature could not be seperated, since no two-inch fingerlings were stocked at temperatures comparable to the low water temperature at large fingerling stocking. There was no difference in initial mortality between five- and eight-inch fingerlings at Ridge Lake (both 0%); cool water temperature probably contributed to the high survival of both groups. In previous years at Ridge Lake, mortality at stocking ranged from 7-55% for two-inch fingerlings, 0-6% for five-inch fingerlings, and 0-2% for eight-inch fingerlings.

No walleye fry or fingerlings were collected from predator stomachs at Ridge Lake. Previously, largemouth bass predators have consumed from 17-39% of the total number of walleye (fry and fingerling combined) stocked at Ridge Lake. Walleye were found in nine largemouth bass stomachs (11% of those examined) in Lake Shelbyville. A largemouth bass population estimate was not made on Lake Shelbyville, but CPUE during collection of bass for diet analysis was greater than 25 fish/h. These numbers indicate that numbers of largemouth bass in the area of Lake Shelbyville adjacent to the stocking site were as high or higher than those at other lakes stocked (Figure 3).

Comparison of growth rates and diet was difficult at Ridge Lake as only two fry and no fingerlings were collected. Total lengths of the fry collected were 160 and 180 mm, comparable to other reported values (see Job 101.2). Collection of fry and fingerlings was more successful on Lake Shelbyville. Three fry and twenty-four fingerlings were collected after September during night electrofishing. Mean total length of the fry collected was 263 mm and mean total length of the fingerlings collected was 231 mm. Diet consisted primarily of brook silversides *Labidesthes sicculus*.

RECOMENDATIONS: The current sampling schedule should be maintained; modifications described in Job 101.2 that are applicable to Job 101.3 should be adopted.

As in previous studies, a high proportion of first-year mortality of both fry and fingerling stockings was unexplained. Hauber (1983) indicated that population estimates of age-0 walleye may underestimate year-class strength and suggested that smaller fish are not sampled efficiently. Effort should be devoted in this study to continued sampling of fingerling walleye during the spring and second fall following stocking and to developing improved sampling methods for fingerling walleye collection. These data can then be used to provide a better understanding of the important factors influencing first year survival and growth of stocked walleye. Additional lakes should also be selected for stocking of fry and fingerling walleye in 1992, following the guidelines outlined in Job 101.2.

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Job 101.4. Laboratory and pond experiments.

OBJECTIVE: To evaluate the role of forage base and predators in determining the survival and growth of walleye fry and fingerlings in laboratory and pond experiments.

INTRODUCTION:

Available forage and resident predators are important factors influencing stocking success of walleye fry or fingerlings (Jobs 101.1 and 101.2). Controlled experiments in the laboratory and in ponds can provide insight into the mechanisms which may control growth and survival in the field. Impoundment stockings provide information on growth and survival rates of walleye fry or fingerlings. However, they do not provide information as to why a particular rate of growth or survival was observed. Laboratory experiments will allow us to examine specific food items chosen by fry or fingerlings and the benefits obtained from them. Similar experiments will examine which sizes and species of predators consume young walleye fry, and their respective rates of consumption.

METHODS:

Walleye fry-zooplankton interactions

We conducted laboratory experiments to examine the relationship between zooplankton density and walleye growth and survival. Ten fry were starved overnight in 30 L aquaria. Zooplankton was collected from area lakes by towing a 0.5m diameter, 64 um mesh net. This zooplankton mixture was subsampled to determine abundance and species composition. Organisms were identified to major taxonomic groups (Rotifers, Cladocerans, and Copepods). Appropriate volumes of this zooplankton mix were added to each aquarium to produce a total density with equal numbers of Copepods and Cladocerans of 10, 50, 100, 150, 200, 400 and 600 zooplankters per liter. Each treatment of zooplankton density was replicated in three aquaria. Walleye fry were allowed to feed for one hour after which time they were removed from the aquaria and preserved in 70% ethanol. The aquaria were drained and remaining zooplankton preserved in a sucrose-10% formalin solution. Gut contents of each fish were removed, identified to the lowest possible taxonomic group, and measured (nearest .01 mm). This procedure was repeated with small (mean=10.2mm), medium (mean=11.3mm) and large (>20mm) fry. Numbers of fry per aquaria (N=10) were reduced for the large fry(N=1).

We also evaluated the relationship between zooplankton density and the growth and survival of larval walleye in pond experiments. We established low medium and high zooplankton densities (Table 7) in 0.1 acre ponds (N=3 per treatment) and stocked each pond with 4-d old walleye fry (N=2,000). Walleye growth, zooplankton density and diversity, benthic macro-invertebrates, and chlorophyll-A were monitored in each pond every 4-5 d for the 350-d duration of the experiment. Walleye growth was monitored by light trapping or seining up to ten fish per pond on each sampling date. To monitor zooplankton, water samples were collected from the entire water column using a three-inch clear acrylic tube. Each water sample was measured, poured through a 0.0025 in. mesh filter, and preserved in a 10% formalin/sucrose solution. Benthos was collected with a two-inch core sample whereas chlorophyll-A samples were obtained by filtering at least one liter of water using the procedures described in Standard Methods. Results of these pond experiments will not be presented here as analysis of the data is in progress.

Walleye fingerling feeding

Laboratory experiments were conducted to examine prey size preference of fingerling walleye (25-200 mm). Prey species included golden shiner, bluegill, and gizzard shad, ranging in size from 5 mm to 90 mm. For size-selection experiments, prey were divided into 5-mm length groups separated by 6 mm. Walleye were also divided into length groups (millimeters): 25-35, 50-60, 75-85, 100-110, 125-135, 150-160, 175-185, and 200-210. Individual walleye were acclimated in 72-L aquaria two weeks prior to the start of experiments at temperatures of 19-21 C. Experiments began by adding one prey from each of six length groups into the tank of a walleye; the size and number of these prey length groups were adjusted depending upon the length of the walleye. Observations were made on the prey size chosen by the walleye, handling time (time from capture to complete ingestion of prey), and the number of captures per strike. We attempted to complete 30 experiments for each walleye length class and each prey species.

To evaluate the influence of forage base on walleye growth and survival, we stocked 500 fingerling walleye into each of nine, 1-acre ponds containing one of three different species and/or sizes of forage. Different forage bases were established by stocking (1) three ponds with 60 "pre-spawn" adult gizzard shad (*Dorosoma cepedianum*)in late March and early April, (2) three ponds with 68 "ripe" adult gizzard shad and (3) three ponds with 60 adult bluegill (*Lepomis macrochirus*) in mid-May. Each pond was sampled bi-weekly to monitor walleye growth, size and relative abundance of the forage base, benthos, and zooplankton. Results of these pond experiments will not be presented here as analysis of the data is in progress.

Predation on walleye fry

We completed laboratory experiments to examine the potential impact of predators feeding on walleye fry. Observational experiments were conducted in 76-L aquaria. One of three size classes of walleye fry; postlarval I fry (8.5-11mm), postlarval II fry (11-19 mm),and juveniles (>19mm) (Mathias and Li 1982), were introduced at densities of 1, 10, 25, 50, 75, 100, 200, or 300 per aquaria. Each aquarium contained a single predator either; largemouth bass, (99-115mm), bluegill, (50-71mm) or walleye, (132-144)). Data recording began immediately, and predator behaviors were coded directly into a Datamyte event recorder (Electro/General Corporation, Minnetonka, Minnesota). Behaviors were recorded as: (1) inactive: not orienting toward prey or little/no movement (2) search: orienting toward or following prey (3) strike: striking at prey and (4) capture: grasping prey. Predators were allowed to feed for one hour or until all prey was consumed. Fry remaining after one hour were removed from the aquaria and counted.

Non-observational experiments were conducted using two insect predators [diving beetles (Dytiscidae) and backswimmers (Notonecidae)]. Walleye fry were added to the aquaria at lower densities of 1, 5, 10, or 25. After two hours live and dead fry were removed and counted from the tanks.

RESULTS:

Walleye fry-zooplankton interaction

Walleye diets changed with varying zooplankton densities commonly observed in the field. More zooplankton was consumed at higher densities for both size classes of fry (Fig. 4, 5 and 6). There was strong selection for Cladocerans, especially at higher prey densities, followed by Copepods and Rotifers (Fig. 4, 5 and 6). Mathias and Li (1982) found that large walleye fry (19-30mm) consumed more zooplankton at higher prey densities, but these fish reached a peak feeding level at a lower prey density (100 prey/L) than in our experiments. Small fry used in our experiments had increasing feeding rates at prey densities of up to 600 prey organisms per liter, whereas medium fry increased feeding rates up to about 400 prey/L. The smaller fry used in these experiments consumed fewer organisms on average than the larger fry examined by Mathias and Li (1982). The smaller fry are much less efficient strike feeders and may require higher prey densities to feed successfully. The medium-sized fry ate a larger number of prey organisms and had fewer empty stomachs for a given density than the smaller fry (Fig. 7). These results may have important implications for survival of stocked fry in lakes and reservoirs. Data for the largest size class of fry (>20mm) is currently being analyzed.

Walleye fingerling feeding

Cost-benefit curves (handling time/prey dry weight) for each prey length group were used to determine optimal prey sizes for each length class of walleye. Preliminary results for the size-selection experiments show walleye select smaller bluegill (13-23% of total length) than either gizzard shad (20-27%) or golden shiner (25-32%).

Predation on walleye fry

All three fish predators and both insect predators examined consumed walleye fry in aquaria (Figures 8, 9, 10, and 11). These results would indicate that all of these are potential predators of stocked fry. Largemouth bass consumed the greatest numbers of both small and large fry, followed by walleye and bluegill. All three fish predators fed at increasing rates as fry density increased. Maximum consumption occurred at lower levels for bluegill and walleye (100 fry/aquarium) than for largemouth bass. These high densities of fry may be similar to situations encountered by predators in impoundments shortly after fry are stocked and before the fry have dispersed. In the case of the predacious diving beetles, large fry were less vulnerable to predation than the smaller, slower fry. With backswimmers, both size classes of fry appeared to be vulnerable. Although the numbers of fry consumed by insect predators were far less than those consumed by individual fish predators, these insects occur in greater numbers in impoundments and may therefore constitute a considerable source of mortality to stocked fry.

Further analysis of behavior patterns of the individual predators will provide additional information on their efficiency in consuming walleye fry and the potential impact that they may have on the mortality of stocked fry.

RECOMMENDATIONS:

Laboratory and pond experiments have provided valuable information on the role of forage base and predators in determining growth and survival of walleye fingerlings. They are particularly helpful in explaining patterns of growth and survival observed in the field. Experiments conducted in 1991 should be repeated in 1992 to increase sample sizes and provide more complete results. Additional related experiments should be conducted. These include experiments examining (1) the growth rates of walleye fry fed on individual taxa of zooplankton at different densities, (2) species-specific attack strategies by walleye fry on different zooplankton taxa and (3) predation on walleye fry at densities similar to those in the field after stocked fry have dispersed.

Job 101.5. Analysis and reporting.

OBJECTIVE: To prepare annual and final reports which develop management guidelines for stocking walleye in Illinois impoundments.

RESULTS AND RECOMMENDATIONS: Relevant data were analyzed and reported in individual jobs of this report (see Job 101.1 - 101.4).

REFERENCES:

Buttner, J. K, D. B. MacNeill, D. M. Green, and R. T. Colesante. 1991. Angler associations as partners in walleye management. Fisheries 16:12-17.

Carline, R.F., R.A. Stein, and L.M. Riley. 1986. Effects of size at stocking, season, largemouth bass predation, and forage abundance on survival of tiger muskellunge. Am. Fish. Soc. Spec. Publ. 15: 151-167.

Carmichael, G.J., J.R. Tomasso, B.A. Simco, and K.B. Davis. 1984. Characterization and alleviation of stress associated with hauling largemouth bass. Trans. Am. Fish. Soc. 113: 778-785.

Confer, J. L., E. L. Mills, and L. O'Bryan. 1990. Influence of prey abundance on species and size selection by young yellow perch (Perca flavescens). Can. J. Fish. Aquat. Sci. 47:882-887.

Davin, W.T., R.C. Heidinger, R.J. Sheehan, and C.C. Kohler. 1989. Supplemental stocking and spillway escapement literature review and synopsis. Final report. Federal Aid in Sport Fish Restoration. F-77-R. Springfield, IL.

Ebbers, M.A. 1988. Walleye-sauger bibliography. Minnesota Dept. Nat. Res. Invest. Rep. No. 396, St. Paul.

Forney, J. L. 1974. Interactions between yellow perch abundance, walleye predation, and survival of alternate prey in Oneida Lake, New York. Trans. Am. Fish. Soc. 103:15-24.

Forney, J.L. 1976. Year-class formation in the walleye (Stizostedion vitreum vitreum) population of Oneida Lake, New York, 1866-1973. J. Fish. Res. Board Can. 33:783-792.

Forney, J.L. 1977. Evidence of inter- and intraspecific competition as factors regulating walleye (Stizostedion vitreum vitreum) biomass in Oneida Lake, New York. J. Fish. Res. Board Can. 34:1812-1820.

Foster, J.R. 1977. Pulsed gastric lavage: an efficient method of removing the stomach contents of live fish. Prog. Fish-Cult. 39: 166-169.

Fox, M. G., J. A. Keast, and R. L. Swainson. 1989. The effect of fertilization regime on juvenile walleye growth and prey utilization in rearing ponds. Environ. Biol. Fish. 26:131-144.

Fox, M. G. and D. D. Flowers. 1990. Effect of fish density on growth, survival, and food consumption by juvenile walleyes in rearing ponds. Trans. Am. Fish. Soc. 119:112-121.

Hauber, A. B. 1983. Two methods for evaluating fingerling walleye stocking success and natural year-class densities in Seven Island Lake, Wisconsin, 1977-1981. N. Amer. J. Fish. Management 3:152-155.

Hanson, D.A., M.D. Staggs, S.L. Serns, L.D. Johnson, L.M. Andrews. 1986. Survival of stocked muskellunge eggs, fry, and fingerlings in Wisconsin Lakes. Am. Fish. Soc. Spec. Publ. 15: 216-228.

Hokanson, K. E. F. and G. J. Lien. 1986. Effects of diet on growth and survival of larval walleyes. Prog. Fish-Cult. 48:250-258.

Koonce, J.P., T.B. Bagenal, R.F. Carline, K.E.F. Hokanson, and M. Nagiec. 1977. Factors influencing year-class strength of percids: a summary and model of temperature effects. J. Fish. Res. Board Can. 34:1900-1909.

Laarman, P. 1978. Case histories of stocking walleyes in inland lakes, impoundments, and the great Lakes - 100 years with walleyes. Am. Fish. Soc. Spec. Publ. 11:254-260.

Li, S. and J. A. Mathias. 1982. Causes of high mortality among cultured walleyes. Trans. Am. Fish. Soc. 111:710-721.

Mandenjian, C. P., B. M. Johnson, and S. R. Carpenter. 1991. Stocking strategies for fingerling walleyes: an individual-based model approach. Ecol. Appl. 1:280-288.

Mathias, J. A. and S. Li. 1982. Feeding habits of walleye larvae and juveniles: comparative laboratory and field studies. Trans. Am. Fish. Soc. 111:722-735.

Mather, M.E., and D.H. Wahl. 1989. Comparative mortality in three esocids due to stocking stress. Can. J. Fish. Aq. Sci. 46: 214-217.

Santucci, V.J., Jr., and D. H. Wahl. 1990. Evaluation of the contribution of walleye to the sport fishery of a centrarchid-dominated impoundment and evaluation of size-specific survival in stocked channel catfish. Annual report. Federal Aid in Sport Fish Restoration Project F-51-R-3. Illinois Department of Conservation, Springfield, IL.

Serns, S. L. 1982. Influence of various factors on density and growth of age-0 walleyes in Escanaba Lake, Wisconsin, 1958-1980. Trans. Am. Fish. Soc. 111:299-306.

Smith, Jr., L.L., and R. L. Pycha. 1960. First year growth of the walleye (Stizostedion vitreum vitreum Mitchill), and associated factors in the Red Lakes, Minnesota. Limn. Oceanogr. 5:281-290.

Van Den Avyle, M. J., and J. E. Roussel. 1980. Evaluation of a simple method for removing food items from live black bass. Prog. Fish-Cult. 42:222-223.

Wahl, D.H., and R.A. Stein. 1988. Selective predation by three esocids: the role of prey behavior and morphology. Trans. Am. Fish. Soc. 117: 142-151.

Wahl, D.H., and R.A. Stein. 1989a. Comparative vulnerability of three esocids to largemouth bass (Micropterus salmoides) predation. Can. Jour. Fish. Aq. Sci. 46: 2095-2103.

Wahl, D. H., and R. A. Stein. 1989b. Evaluation of stocking northern pike, muskellunge, and tiger muskellunge into Ohio Lakes: A comparative approach. Final Report. Ohio Department of Natural Resources, Federal Aid Project F-57-R, Columbus, Ohio, USA.

Table 1. Summary of walleye fry and fingerling stockings in Illinois impoundments. Total lengths of a subsample (N = 100) of walleye were measured (nearest mm) prior to stocking.

Lake	Stocking Date	Number of Fish	Number per Hectare	Mean length (mm)
George	May 29	8,350	123	41
Le-Aqua-Na	Jul 16	1,000	63	107
Pierce	May 21	8,350	127	40
Shelbyville	Apr 14	7,700,000	700	fry
	Apr 21	3,400,000	309	fry
	Jun 15	26,500	6	52
Ridge	Apr 12	40,000	7,156	fry
	Jun 13	800	143	58
	Nov 21	350	62	110
	Nov 21	106	19	204

Table 2. Zooplankton density (number/l) at and following stocking of walleye fry at Ridge Lake and Lake Shelbyville.

	Zooplankton Group			
Date	Rotifer	Nauplii	Copepods	Cladocerans
	Ridge Lake			
Apr 12	71	293	149	41
Apr 21	110	74	52	36
Apr 27	196	314	54	64
May 30	3	<1	<1	<1
Jun 13	22	3	12	6
Jun 27	4	3	<1	<1
	Lake Shelbyville			
Apr 11	47	3	<1	<1
Apr 15	68	4	2	<1
Apr 25	14	<1	<1	<1
May 2	366	20	11	2

Table 3. Summary of fry and fingerling stocking mortality and lake surface temperatures on the date of stocking.

Lake	Size (mm)	Temperature (C)	Percent Mortality
George	41	28	22.2
Le-Aqua-Na	107	26	22.0
Pierce	40	20	6.7
Shelbyville	fry	13	2.3
	52	27	12.0
Ridge	fry	11	1.6
	58	27	31.0
	110	11	0
	204	11	0

Table 4. Fall (September-November) length (mm) and catch-per-unit-effort of stocked walleye fingerlings. Maximum total length is the size used to delineate stocked fingerlings from walleye present in the lake prior to stocking. Growth increment is the difference between size at stocking and length in fall collections.

Lake (Maximum total length, mm)	Fall mean TL (mm)	Increment (mm)	Number Collected	CPUE (fish/h)
George (225)	191	150	2	0.17
Le-Aqua-Na (200)	168	61	29	7.24
Pierce (230)	221	181	5	0.55
Ridge (200)	---	---	0	----
Shelbyville (300)	300	183	30	1.20

Table 5. Mean densities (#/m3 of sediment x 1,000) of benthic organisms on walleye study lakes. Values represent averages from all samples (N=3-6) collected at a given lake in each month. Values in parentheses represent maximum densities.

	Lake			
Month	George	Le-Aqua-Na	Pierce	Shelbyville
May	2.7 (7)	----	2.7 (7)	----
June	16.7 (65)	----	40.0 (190)	3.3 (10)
July	----	6.0 (15)	63.7 (105)	0.4 (1)
August	4.0 (7)	33.3 (39)	11.0 (17)	18.0 (19)
September	----	14.3 (25)	----	----

Table 6. Numbers of stocked walleye fingerlings consumed by largemouth bass during the first three days following stocking. Walleye length is mean length of fingerlings at stocking. Minimum length for largemouth bass capable of consuming stocked walleye and associated population estimates are based on a predator:prey ratio of 0.57. Percentage of stocked walleye consumed by largemouth bass is indicated for each lake.

Lake	Walleye length (TL, mm)	Minimum largemouth bass length (TL, mm)	Largemouth bass population estimate	Number of LMB examined	Walleye per stomach	Percent walleye consumed
George	41	72	805	138	0	0
Le-Aqua-Na	107	188	381	69	0.04	2
Pierce	40	70	310	42	0	0
Ridge	58	102	759	34	0	0
	110	193	683	27	0	0
	204	358	0	0	0	0
Shelbyville	52	91	---	84	0.17	---

Table 7. Treatment dates and application rates for hay, inorganic fertilizer(20-20-5), and copper sulfate (CuSO4) used to produce low, medium, and high densities of zooplankton. Each treatment was comprised of a single application except for the inorganic fertilizer which was applied 3 times at weekly intervals. Rates are expressed as lbs/acre except for CuSO4, which is expressed as parts per million.

Treatment	Application Date	Zooplankton Density		
		Low	Medium	High
Hay	1-29-91	None	480	2180
20-20-5	3-29-91	None	None	100
CuSO4	4-18-91	0.5	None	None

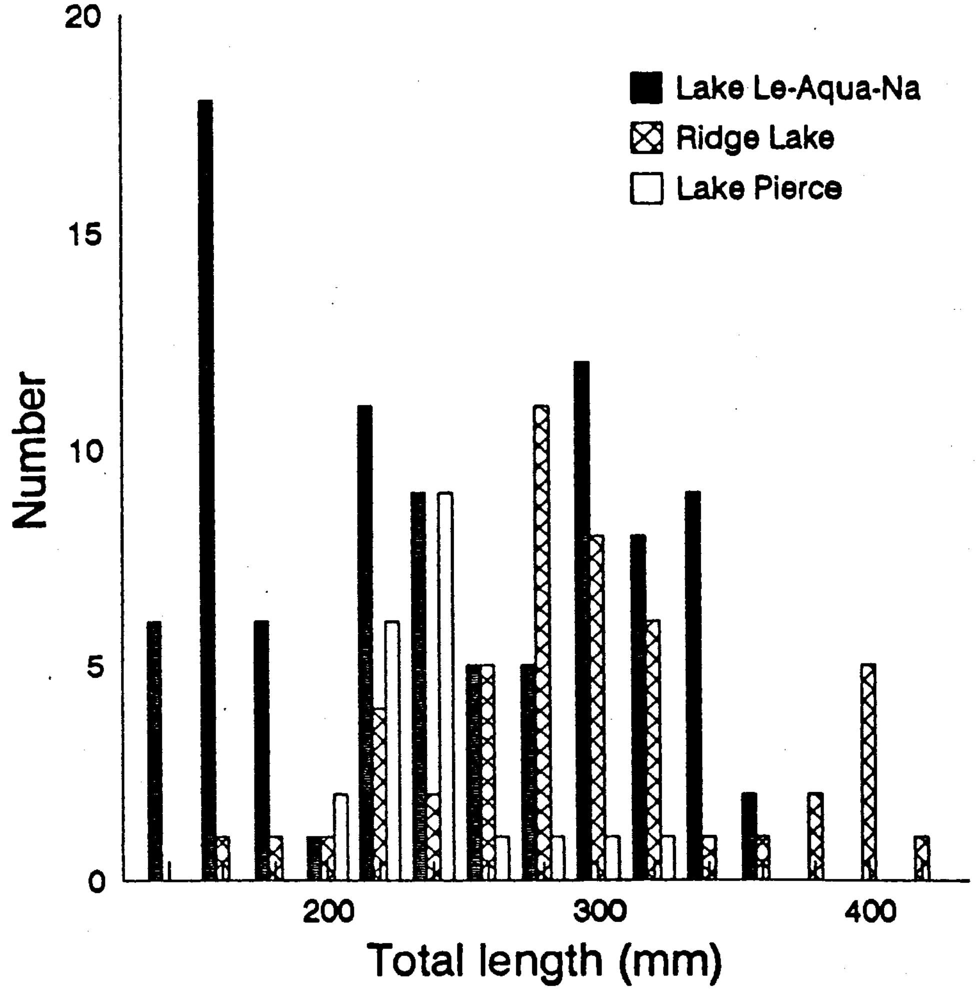

Figure 1. Fall length frequency distribution of walleye populations in three study lakes. Walleye were not collected in sufficient numbers for analysis on Lake George and Lake Shelbyville.

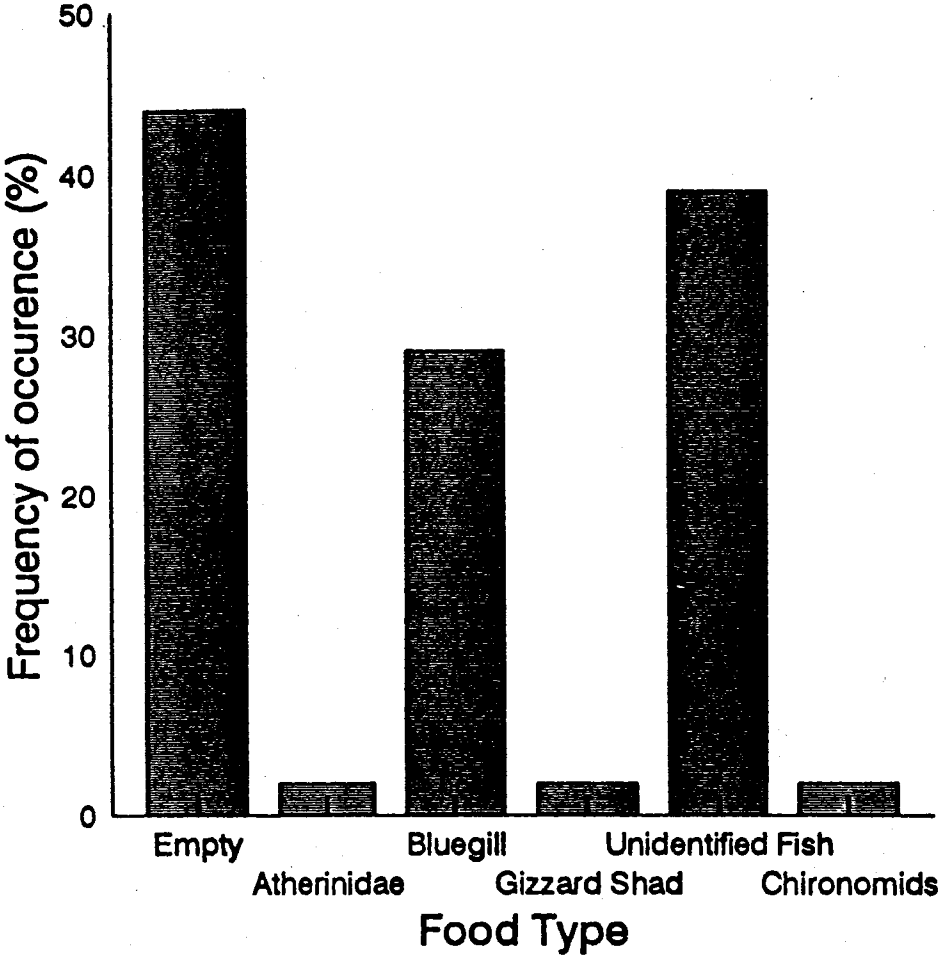

Figure 2. Diet of stocked fingerling walleye based on stomachs (N=41) examined during fall sampling. Data represents combined information from Lakes Le-Aqua-Na, George, and Pierce.

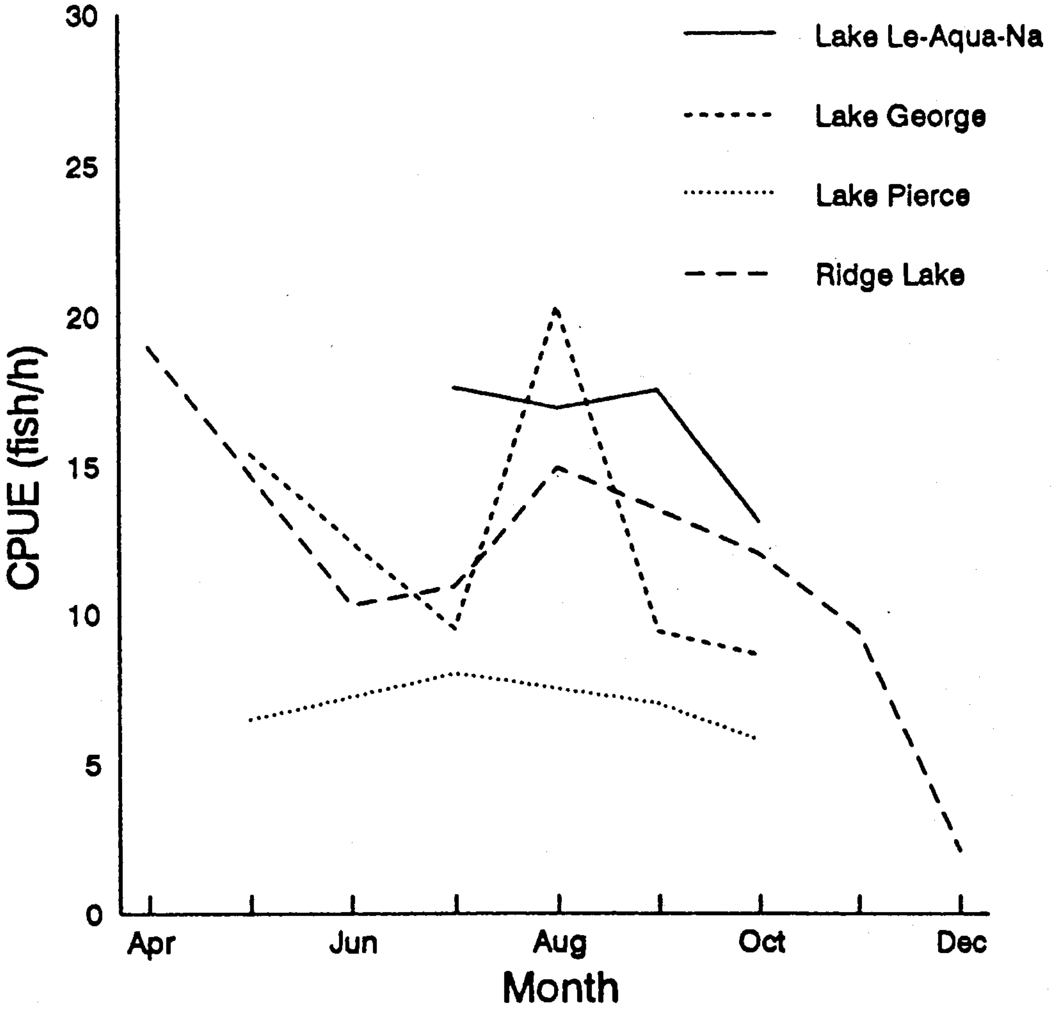

Figure 3. Monthly catch-per-unit-effort for largemouth bass on four walleye study lakes. Value for June electrofishing on Lake Shelbyville is reported in text.

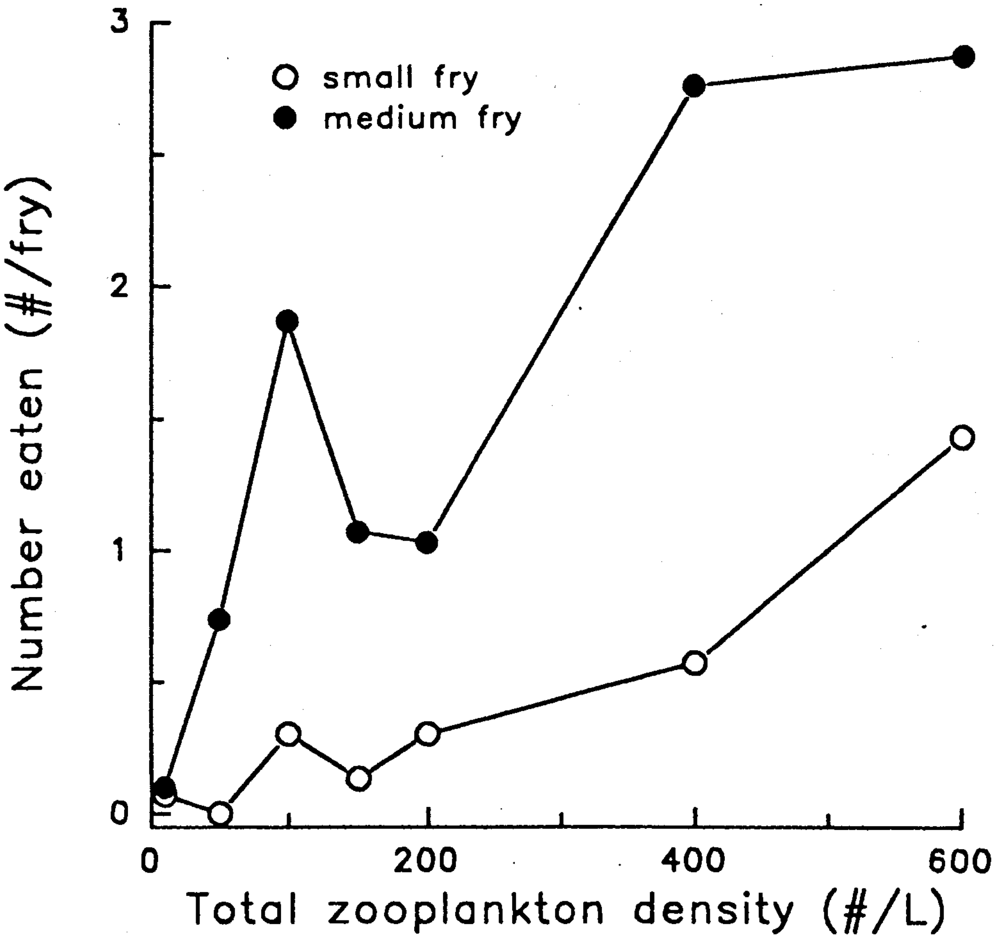

Figure 4. Average number of total zooplankton eaten by small and medium walleye fry during one hour laboratory experiments.

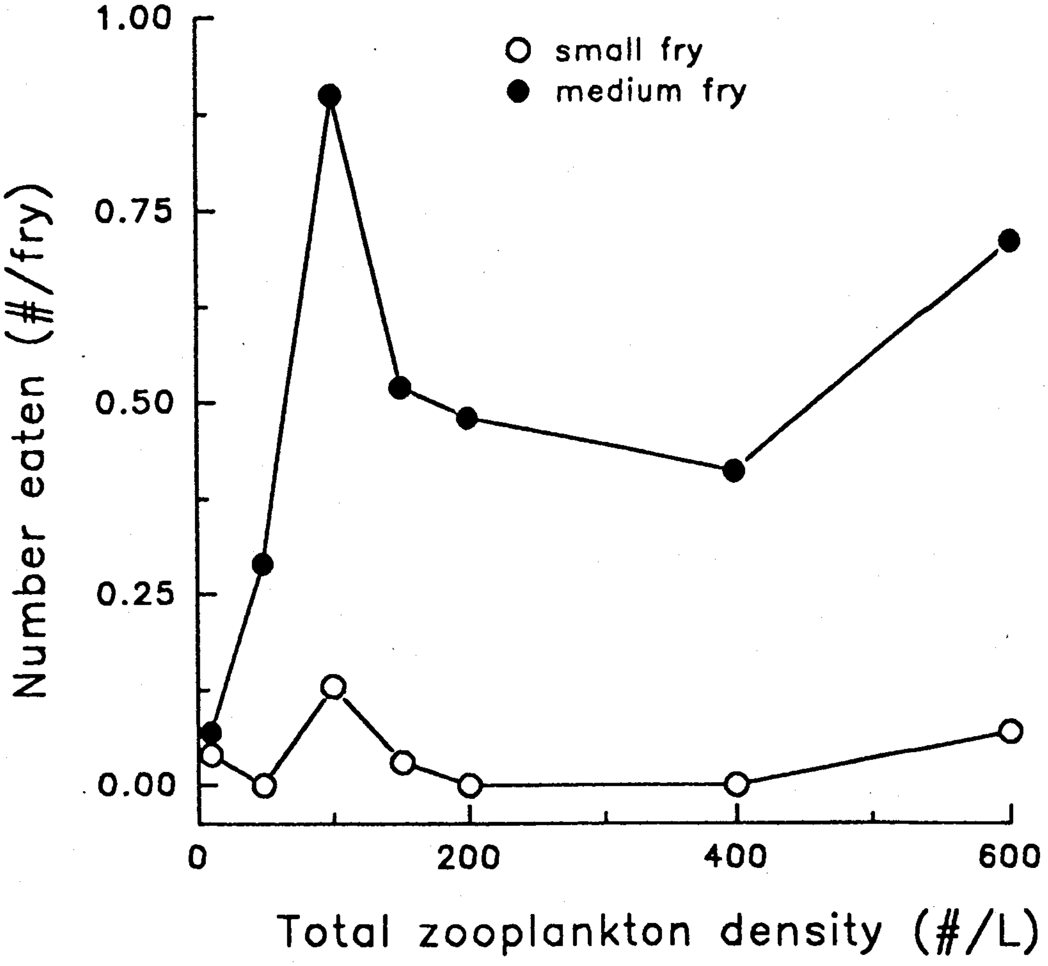

Figure 5. Average number of copepods eaten by small and medium walleye fry during one hour laboratory experiments.

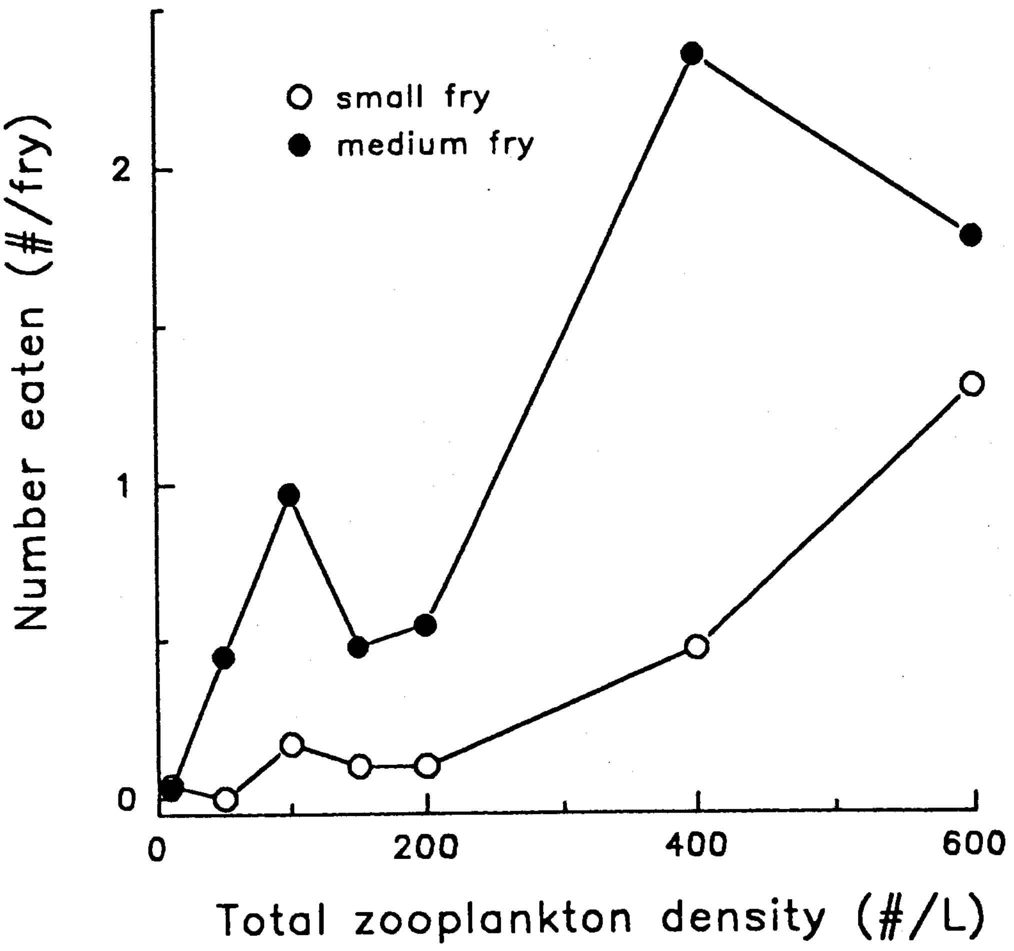

Figure 6. Average number of Cladocerans eaten by small and medium walleye fry during one hour laboratory experiments.

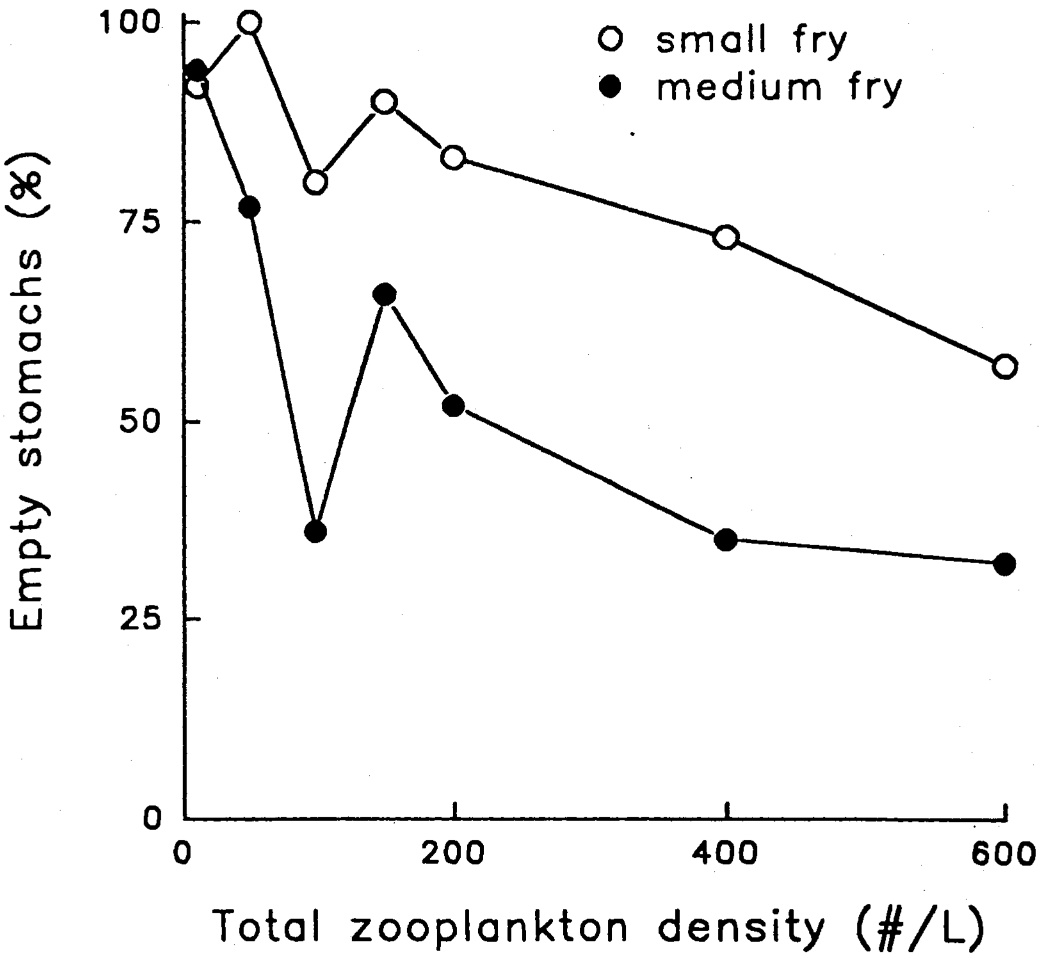

Figure 7. Percent empty walleye fry stomachs after one hour feeding at different prey densities.

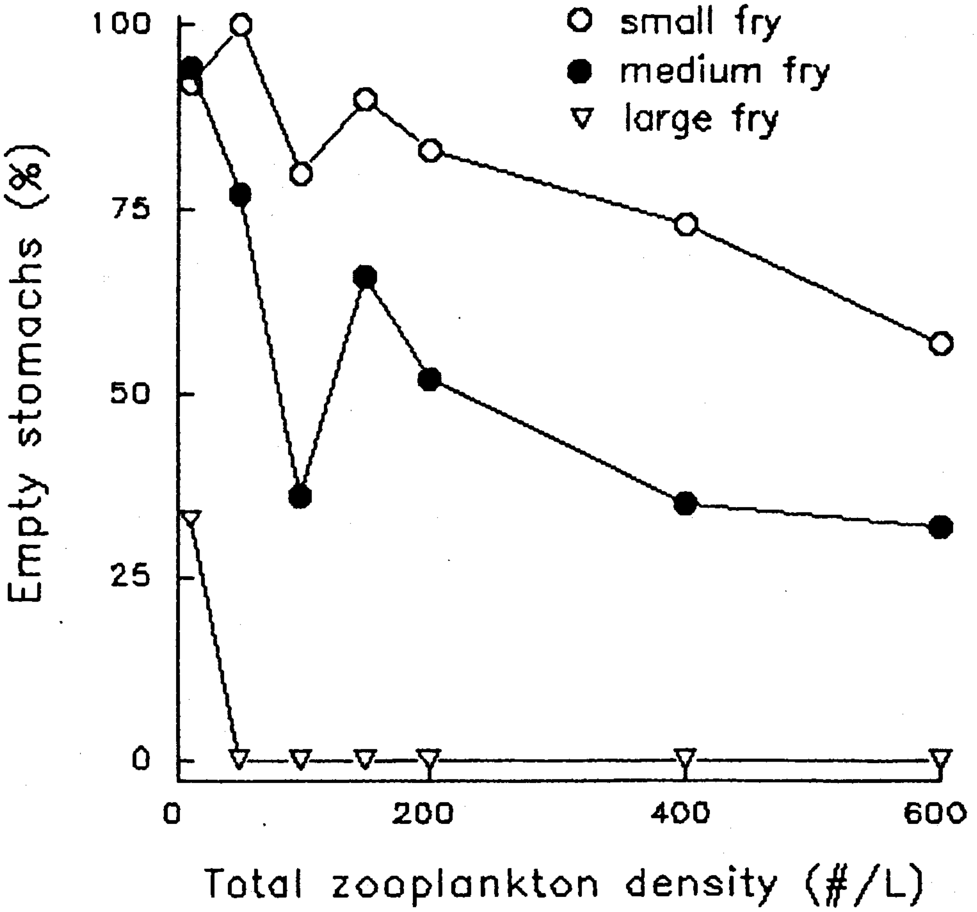

Figure 7. Percent empty walleye fry stomachs after one hour feeding at different prey densities.

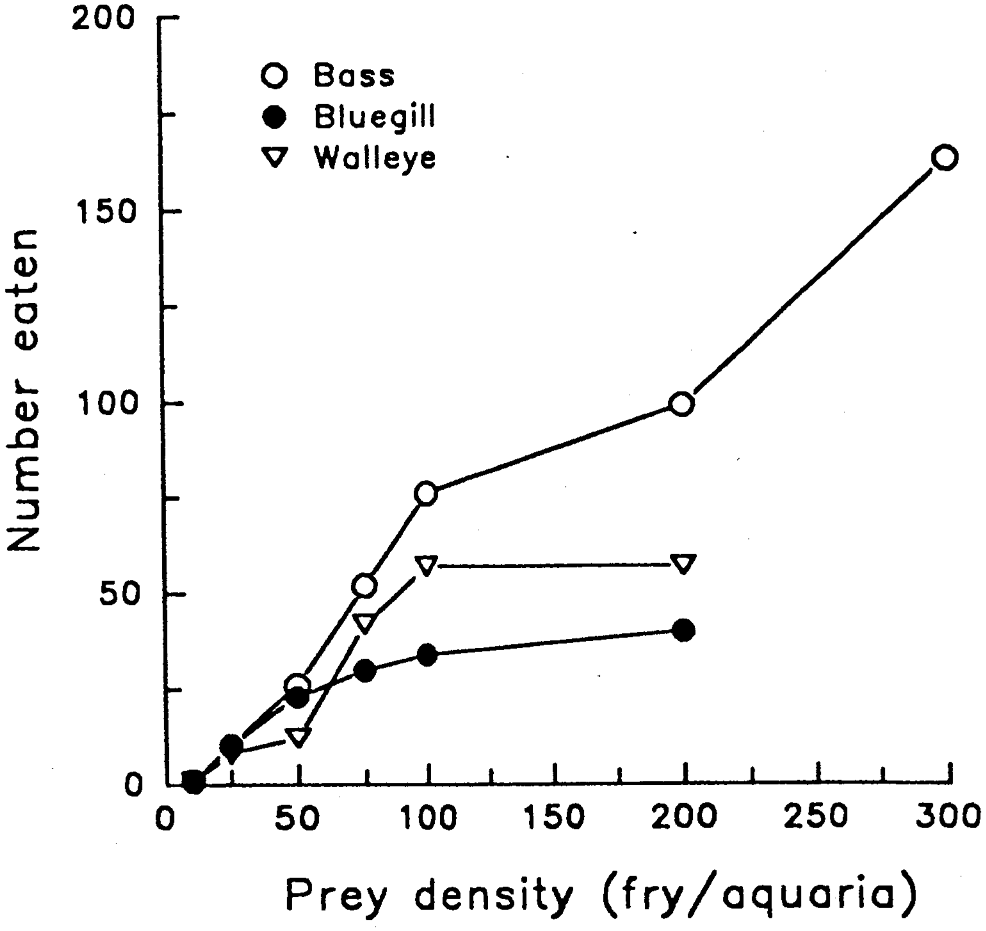

Figure 8. Average number of postlarval I walleye fry eaten by fish predators during one hour laboratory experiments.

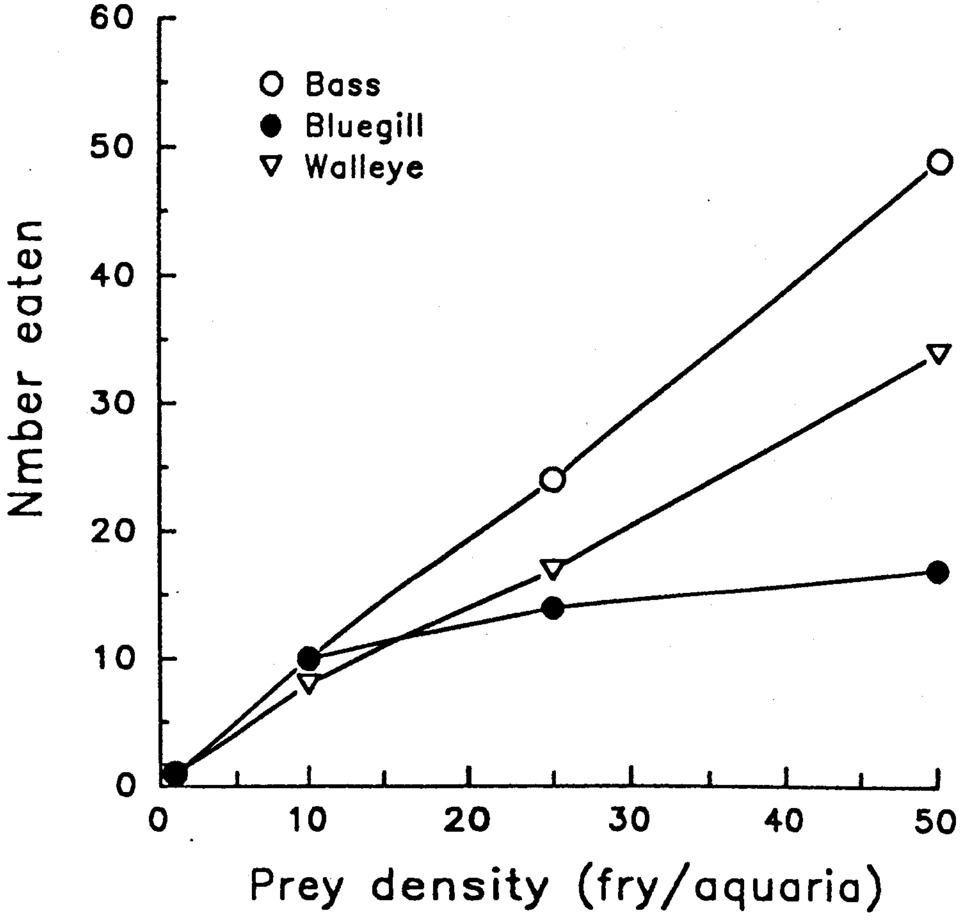

Figure 9. Average number of postlarval II walleye fry eaten by fish predators during one hour laboratory experiments.

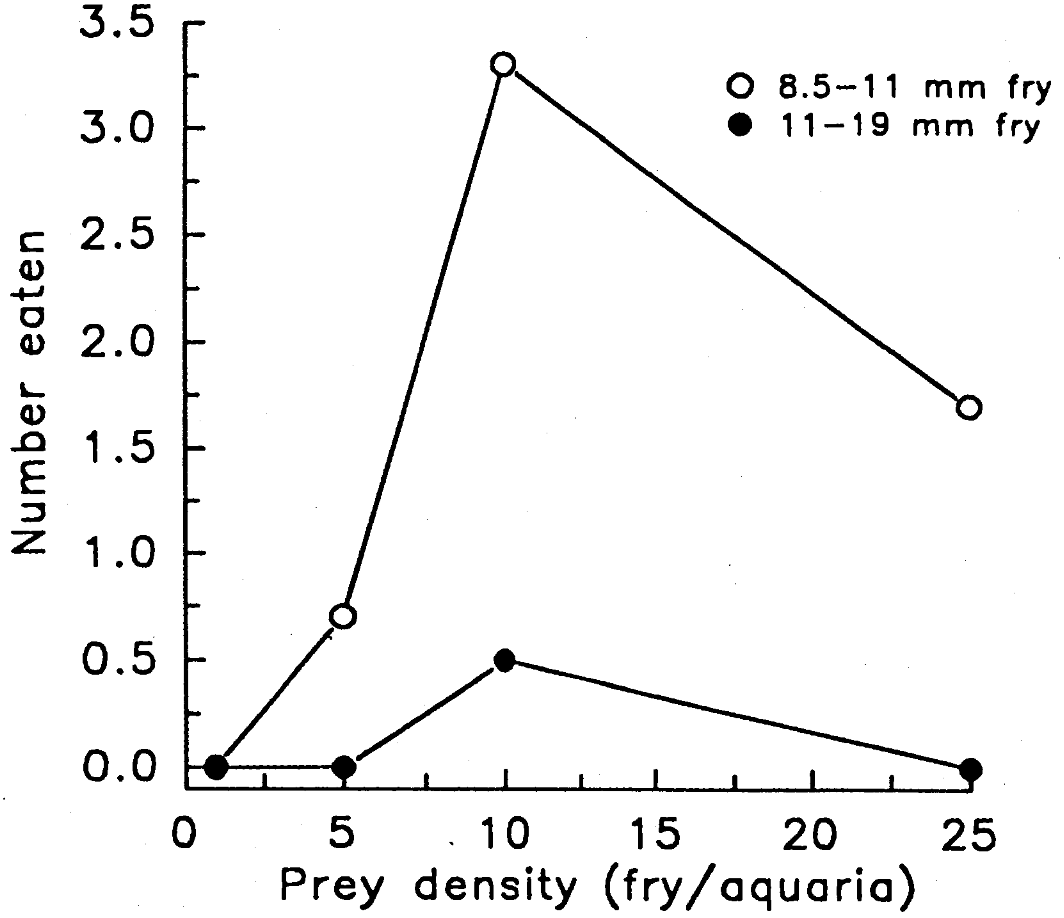

Figure 10. Average number of two sizes of walleye fry eaten by beetles during two hour laboratory experiments.

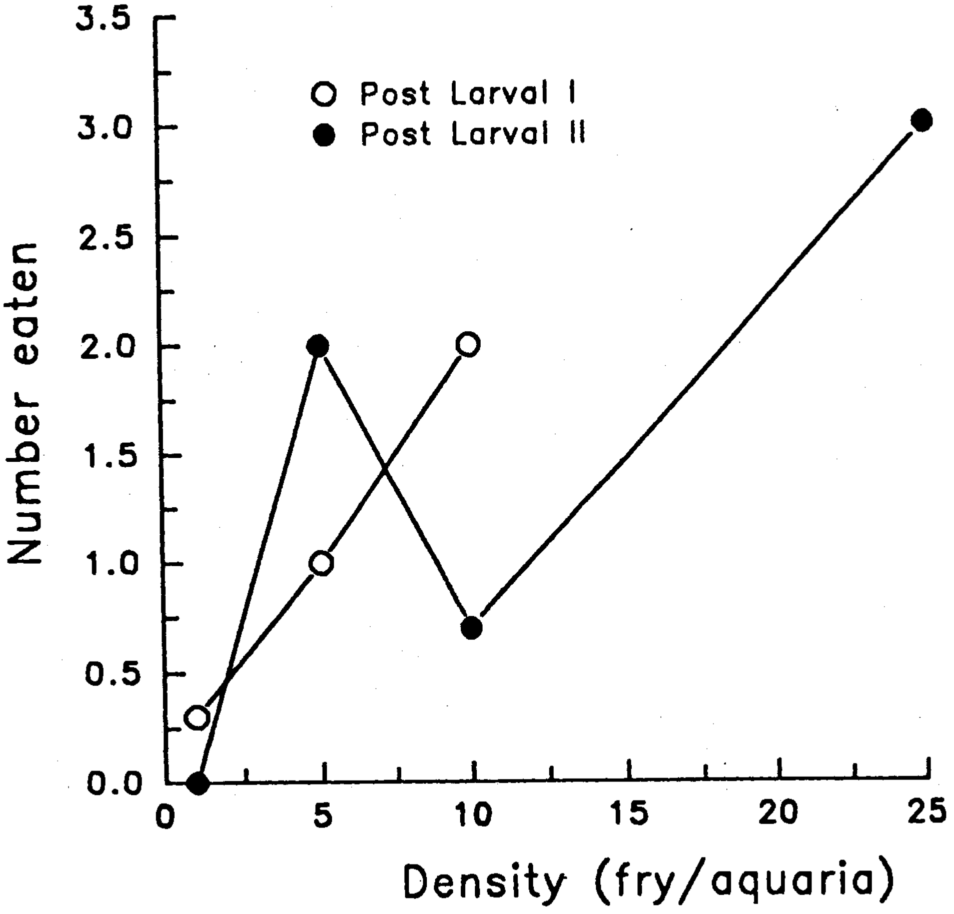

Figure 11. Average number of two sizes of walleye fry eaten by backswimmers during two hour laboratory experiments.