Larval Fish Abundance and Habitat Associations in Backwaters and Main Channel Borders of the Kanawha River

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Thesis submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

Master of Science

in

Fisheries and Wildlife Sciences

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November 1988

Blacksburg, Virginia

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(ABSTRACT)

Larval fish distributions were determined in the lower Winfield Pool, Kanawha River, West Virginia, using a 0.5-m plankton net and a 1-m^2 dropbox. Five habitats were sampled with the plankton net, 3 habitats with the dropbox. The 5 deep water water habitats, greater than 1.5-m in depth, sampled by the plankton net included surface tows in Bill's Creek backwater, main channel border upstream and downstream of Little Guano backwater, and Little Guano Creek backwater, where deep tows (1.5 m deep) were also taken. The 3 shallow water habitats, less than 1 m in depth, sampled by the dropbox included open water over silt substrate, open water over a sand substrate, and emergent vegetation. *Lepomis* species, emerald shiners (*Notropis atherinoides*), and gizzard shad (*Dorosoma cepedianum*) were the dominant taxa. The emerald shiner taxa could also have included some larvae of *Notropis* species which are also present in the Kanawha River but whose larvae have not been described. Overall, the mean total larval density did not differ between the backwater or the main channel borders but the species associated with each habitat differed greatly. The *Lepomis* larvae were found predominantly in backwater areas. These areas provide suitable spawning sites for many centrarchids of this river. Upon leaving the nest, the *Lepomis* larvae moved into the deeper open water areas within the backwater. After reaching the juvenile stage, these same larvae returned to the shallow water habitats where they inhabited vegetated areas. Emerald shiner larvae, while present in both backwater and main channel habitats, were most abundant in the main channel borders. This is probably a result of their parent's pelagic spawning strategy. In all habitats, emerald shiner larvae predominated in the upper 1 m of water. Upon becoming

larger, the emerald shiner larvae appeared in the backwaters. This increase in numbers could be due to movement, differential mortality, or higher growth rates. Other cyprinids (excluding emerald shiners and carp) were equally abundant in both backwater and main channel areas. These other cyprinid larvae were also distributed equally. Gizzard shad larvae were found predominantly in the main channel borders. Presumably, these higher densities were the result of main channel spawning. The gizzard shad larvae present in the backwater areas were distributed evenly throughout the water column. Overall, the backwaters were important for the nest-building species found in the river and also for the larger larvae of the pelagic species, and thus acts as a nursery area for these species. Therefore, the backwaters do seem to be important for the fishery of the Kanawha River.

Acknowledgements

I wish to thank the West Virginia Department of Natural Resources for providing funding which allowed this study to take place. In particular, I would like to thank and for directing me to Virginia Tech.

I would also like to express my gratitude to Dr. Larry A. Nielsen, the chairperson of my committee, for his sound advice, inovative ideas, and the hours of time involved in this study, as well as my funded project. Thanks also go out to Drs. Donald J. Orth and Robert H. Giles, Jr. for their support as committee members.

, my larval fish mentor, deserves special recognition for his assistance in this study. Without his expertise, this study would have been a much more difficult undertaking. I would also like to thank for his help in the preliminary part of my study.

My most heart-felt thanks go out to my parents, for their sound guidance and unwavering support throughout my college career.

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Introduction

In this study, larval fish distributions were measured in main channel and backwater areas in a navigable river. Larval fish are delicate organisms and may be adversely affected by navigation. For this reason, sheltered areas such as backwaters may be important areas for larvae and juveniles of many river species. Morpholologically, backwaters vary greatly among the different river systems. Thus, this study documents the importance of previously unstudied backwaters to the fish population in a navigable river, the Kanawha River, West Virginia.

Navigation Impacts on Backwaters

Navigation Impacts

In recent years, concern has increased over the effects of commercial navigation on aquatic ecosystems. Studies in the Mississippi River have shown that commercial barge traffic affects the biological community in several general ways: increased turbidity, resuspension of particulate matter, physical damage from waves, pressure changes, and increased shoreline

erosion (UMRBC 1982). These disturbances can affect larval fish both directly and indirectly. Direct effects on larval fish may be caused by collision with the barges, displacement due to waves (Bhowmik et al. 1982), physiological problems caused by pressure changes, and de-watering due to drawdown which can leave the eggs and larvae stranded out of water (Holland 1987). Indirectly, commercial navigation may adversely affect the habitats used by the larval fish. The shallow areas are filling in due in part to the resuspension of particulate matter, shorelines are being eroded, and increased turbidity decreases the larvae's ability to perceive food and predators.

Sensitivity of Important Areas

Backwaters and main channel borders, because of their warm temperatures, high productivity, and other important features, are ideal habitats for larval and juvenile fish. Because backwaters and shoreline zones are shallow, they are sensitive to barge effects, especially to resuspension of particulate matter, increased shoreline erosion, and drawdown. Resuspension of particulate matter by barges may increase the rate at which the backwaters, such as those on the Mississippi River, fill in. That is, the backwaters slowly become swamps which can no longer be used by either larval or adult fish. Increased shoreline erosion affects primarily the main channel borders. This erosion can negatively affect these areas in two ways: destroying important habitats and interfering with nesting activity.

Kanawha River Backwaters

Backwater areas vary greatly from river to river. The backwaters in the Mississippi River studies are of an entirely different type than those found on the Ohio and Kanawha Rivers in West Virginia. The backwaters of the Kanawha River are, in essence, inundated creek mouths as opposed to the "true backwaters" or sloughs of the Mississippi River (Nielsen et al. 1986).

Many of the Kanawha River backwaters are fed by several streams which add to the available habitat types present within the backwater. While the importance of the Mississippi backwaters has been documented (Sheaffer and Nickum 1986, Holland and Sylvester 1983), no such studies have been reported for the Kanawha River backwaters.

The Kanawha River receives less commercial boat traffic than the Mississippi River. The navigational use of the Kanawha River is limited primarily to barge traffic from the chemical and coal industries located within the region. In 1980, a mean of 11.1 tows/day used the Winfield Locks and Dam, and this commercial traffic is expected to increase 65% by the year 2000 (USACE 1983). A mean of 12.7 tows/day used the Winfield Locks and Dam in 1987 (USACE 1988). In a study conducted by VPI&SU (1985), barge traffic on the section of the Kanawha River from Charleston, West Virginia, downstream to the Ohio River was projected to exceed lock capacities at the Winfield Locks-and-Dam by the year 1990.

The fishery of the Kanawha River has improved in both abundance and species diversity in recent years. Leckie (1987) attributed this to water quality improvement and fish management efforts. In a 1987 creel survey conducted by the West Virginia Department of Natural Resources, the numbers of fish caught from Kanawha River tailwaters were higher than the average values of six Ohio River tailwaters. Catch and harvest rates were also higher or comparable to average Ohio River tailwater rates (Leckie 1987). In the past, game species were scarce due to the poor water quality. Local anglers' catches were limited to bullheads (*Ictalurus natalis*) and carp (*Cyprinus carpio*). At present, however, 19 species of game fish and 73 non-game species (Stauffer et al. 1982) may be found within the Kanawha River and its tributaries. Game fish such as sauger (*Stizostedion canadense*), channel catfish (*Ictalurus punctatus*), and white bass (*Morone chrysops*) are now abundant in the Kanawha River. The gizzard shad (*Dorosoma cepedianum*) and emerald shiner (*Notropis atherinoides*) have also increased in abundance and are the primary prey of most game fish.

Importance of Backwaters to Larval Fish

Previous studies have shown backwaters to be extremely productive (Nielsen et al. 1987; Rasmussen 1979). This high productivity and the higher temperatures associated with backwaters (Sheaffer and Nickum 1986) would seem to make the backwater habitat ideal for larval and juvenile fish. Several studies have documented backwaters as spawning and/or nursery habitats for larval and juvenile fish. Sheaffer and Nickum (1986) found the overall abundance of larval fish to be greater in the backwaters than in the main channel habitats. Their findings also revealed that backwaters were important for main channel species as well as for species which are characteristically found within the backwater. The backwaters of the Upper Mississippi River, by acting as rearing areas, are thought to support the species diversity and abundance of the fishes within the river (Bade 1980). Gallagher and Conner (1983) also found that backwaters had higher larval densities than main channel areas. They also stressed the importance of extrariverine areas such as backwaters and sloughs for spawning and nursery areas for many of the riverine fishes.

The overall importance of backwaters to larval fish is still debatable. While almost all of the studies associated with backwaters support the idea that backwaters are important as spawning and nursery areas, the sampling methods associated with these studies are not suited to the conditions found in most backwater areas. Because of the relatively shallow depths of backwaters, conventional sampling equipment is unsuitable and, thus, the significance of the upper littoral zone as a rearing area for larvae has not been assessed quantitatively (La Bolle et al. 1985). These aforementioned studies employed standard equipment such as push nets and bag seines and, thereby, limited their samples to the deeper littoral and limnetic zones. These types of sampling equipment also do not lend themselves to the determination of habitat preferences of the larval fish. The studies that do mention habitat, do so in general terms. Faber (1980) and Van Den Avyle and Fox (1980) ,for instance, described the habitats as merely littoral and shoreline, respectively. Backiel and Welcomme

(1980) stated, however, that larval fish are able to show definite habitat preferences at a very early age and are not primarily planktonic. La Bolle et al. (1985), using a plexiglass dropbox sampler, found the densest concentrations of larval fishes in the upper littoral margins in water 0.02 - 0.15 m deep but did not examine the specific habitat types. They used only "littoral" as a habitat descriptor. Holland and Huston (1985) found that larvae of most fish species of the upper Mississippi River occupied backwater nursery areas with submergent vegetation.

This study hypothesizes that larval distributions will be affected by several factors, one of which is habitat. The hypothesis, extended, is that the habitat associations in which larvae will be found in most navigable river systems will be influenced by four major factors: spawning strategies of the parents, mobility of larvae, abundance of food, and predation. Each of these is discussed next.

The spawning strategies of the parents will initially determine the habitat with which the larvae are associated. Until the larvae become mobile, they rely on their surrounding environment for their basic survival needs. Dependent upon the spawning strategy of the species, the larvae may be planktonic in nature or may be attached to vegetation by means of cement glands. Balon (1975) classified various spawning strategies and thereby placed fish taxa into three sections and 32 guilds. Many of these guilds are represented in the fish fauna of the Kanawha River (Table 1).

After the larvae have hatched and until they develop into juveniles with a complete set of fins, their mobility is limited. Larvae of some species (e.g., freshwater drum, *Aplodinotus grunniens*) drift passively with the current; larvae of those hatched in more lentic situations may be confined to habitats close to the spawning areas. Those species which have pelagic eggs and/or larvae rely on the flow to bring them in contact with their basic needs, primarily food and oxygen. The species in lentic habitats must rely on the available food resulting from

Table 1. Selected Guilds of Kanawha River Fishes. Adapted from Balon (1975).

Balon's (1975) Guild	Kanawha River Species Numbers of Species in ()
Nonguarders	
Open Substrate Spawners	
Pelagophils	Notropis atherinoides Aplodinotus grunniens
Litho-pelagophils	Dorosoma cepedianum
Lithophils	Notropis (3) Catostomidae (12) Stizostedion (2)
Phyto-lithophils	Notropis (3) Ictiobus bubalus Morone chrysops
Phytophils	Cyprinus carpio Notropis (3) Ictiobus (2)
Psammophils	Notropis (3)
Guarders	
Substrate Choosers	
Phytophils	Pomoxis annularis
Nest Spawners	
Lithophils	Notropis (4) Centrarchidae (10)
Phytophils	Centrarchidae (2) Etheostoma (2)
Speleophils	Ictaluridae (9) Etheostoma

the instincts of the parents and their choice of spawning habitat. If the right conditions are present, the larvae will have a good chance of surviving.

The abundance of food for the larvae can also influence where the larvae are found. Once the larvae are able to feed exogenously, food must be eaten within a certain period of time or the larvae will starve. In the early stages when mobility is limited, the larvae's survival, and thus presence, can be influenced by differential mortality. That is, while the larvae may initially be present in many habitats, only those habitats with abundant food will have larvae present once the larvae begin to feed exogenously. As stated earlier, the larvae's survival at this early stage is directly influenced by the spawning strategies of the parents. Larvae that drift, either actively or passively, must rely on the chance of encountering food. The larvae that are less mobile will survive only if the parents have chosen a spawning site in which there is ample food present over an extended time.

The activity of predators can also influence the larval fish abundance. High densities of predators can greatly reduce the larval fish densities. With their small size and abundance in surface and shallow waters, larvae are vulnerable to many types of predators including larger fish, insects, and birds. The larger larvae will be more visible to predators than the small larvae but are also more mobile. It is this mobility which allows the larvae to choose their own surroundings (i.e., habitat). Thus, the preferred habitat should ideally provide both food and shelter for the larger larvae and juveniles. For these reasons, I hypothesized that there would be a difference in densities of larvae present among the different riverine areas and also among the various habitats within the backwater.

In this study I examined the importance of Kanawha River backwaters for larval fish. I examined use by larval fish of a Kanawha River backwater and adjacent shoreline areas by comparing the relative abundance of larval fish in the backwaters and main channel borders. I also examined the habitat associations of larval fish within the backwater.

Study Site

This study was conducted in backwaters and main-channel border areas in the Winfield Pool of the Kanawha River in West Virginia. A total of 4 study sites was sampled. Little Guano Creek and Bill's Creek were the backwaters chosen. The main-channel borders upstream and downstream of Little Guano Creek backwater were the 2 main-channel sites sampled.

The Kanawha River, a sixth-order stream, originates in south-central West Virginia at the confluence of the New and Gauley Rivers. It flows 188 km through an industrialized region before joining the Ohio River at Point Pleasant, West Virginia (Figure 1). The Kanawha River is made navigable by four lock-and-dams. The four pools created by these structures are Gallipolis (river km 0-50), Winfield (river km 50-109), Marmet (river km 109-133), and London (river km 133-146). The average annual discharge at the Winfield Pool at Charleston, West Virginia (USGS Gage 03198000, river km 87.4, drainage area 29,985 km^2) is 424.8 m^3/s (Embree et al. 1987). For 1987, the maximum daily discharge is not currently available, however, 1987 was a low water year characterized by low levels of precipitation.

The Winfield Pool is a heterotrophic system relying on allochthonous energy sources (VPI&SU 1985). The upper part of the pool is lotic in nature and lacks backwater areas. The lower part of the pool is lentic and has numerous backwaters, most of which are inundated tributaries.

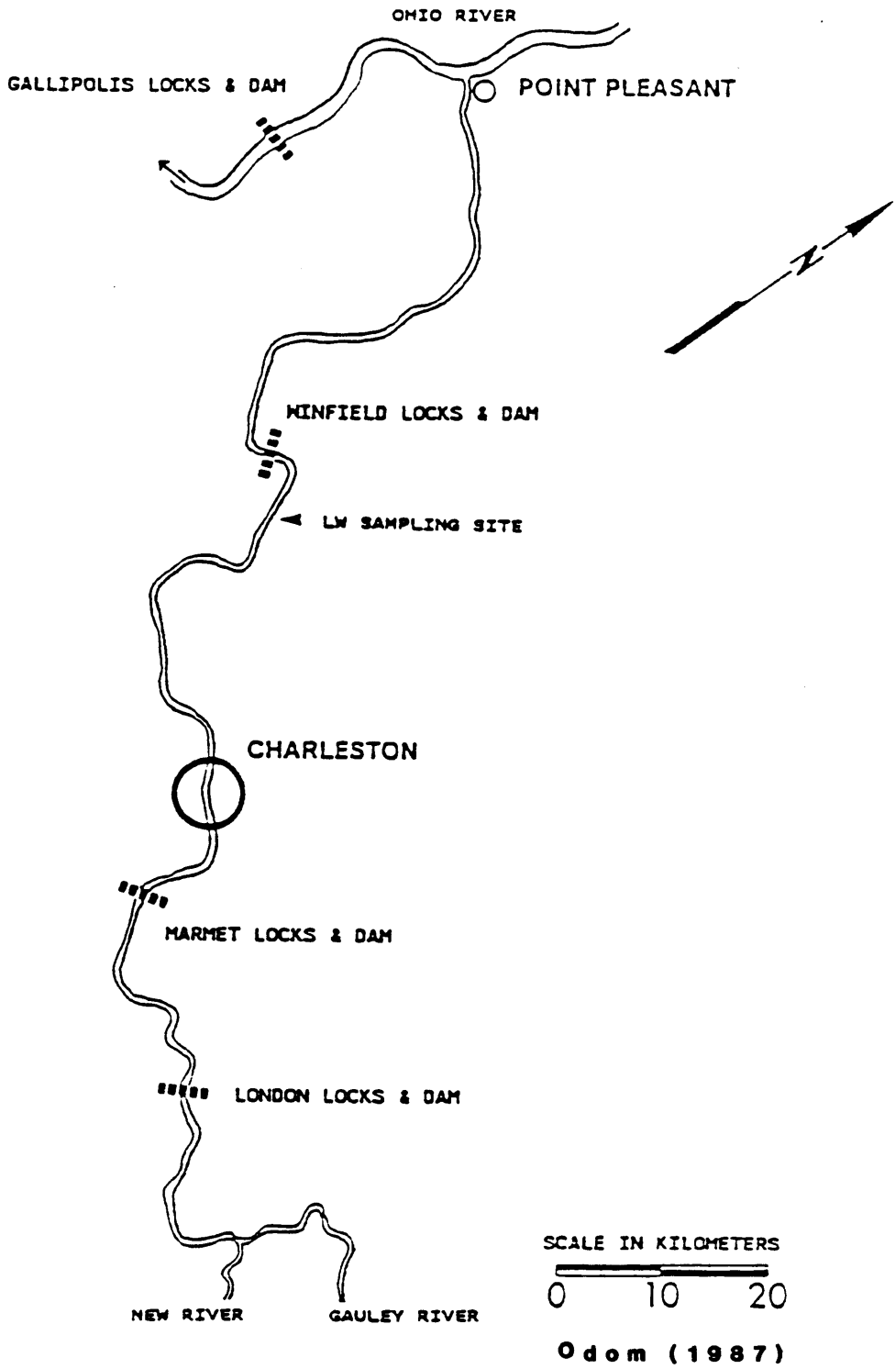


Figure 1. Map of Kanawha River, West Virginia.

Because of the abundance of backwaters, the lower section of the Winfield Pool was chosen for this study (Figure 2).

Little Guano Creek backwater was chosen as the primary backwater for the study. Little Guano Creek backwater is located between Riverside and Plymouth in Putnam County, West Virginia, at river km 54.8 on the Kanawha River (Figure 3). The backwater is approximately 225 m long and 92 m in average width. The total surface area is 20.7 hectares. Little Guano Creek has a maximum depth of 4 m, but approximately one-fourth of the area is 1 m or less in depth. Little Guano Creek is fed by 5 small tributaries which drain the nearby hollows. These streams are typically steep and rocky and are short in length. A railroad culvert constricts the mouth of the backwater and limits the flow from the main channel into and out of the backwater in periods of low water. This culvert is a large concrete structure with an opening of approximately 7 m^2 and has a flat bottom constructed of bricks. A sewage treatment plant is located on the southern shoreline approximately 75 m from the mouth of the backwater. The outflow for this plant empties directly into the Little Guano backwater. This outflow is a 4-inch PVC pipe with a small concrete spillway. The water released from this plant could affect the productivity of Little Guano Creek backwater.

Little Guano Creek backwater provided the most efficient combination of physical characteristics, habitat diversity, and accessibility deemed necessary for this study. Little Guano backwater is of sufficient size and depth to be a primary spawning and/or nursery area for many species found in the Kanawha River and has sufficient shallow water (<1 m deep) to allow sampling with a dropbox. Also, enough deep water is present to allow sampling with the 0.5-m plankton net. The range of habitat types found within the Little Guano Creek backwater is typical of most backwaters on the Kanawha River. Little Guano Creek is also readily accessible to a boat launch and can be sampled easily with the equipment types chosen for this study.

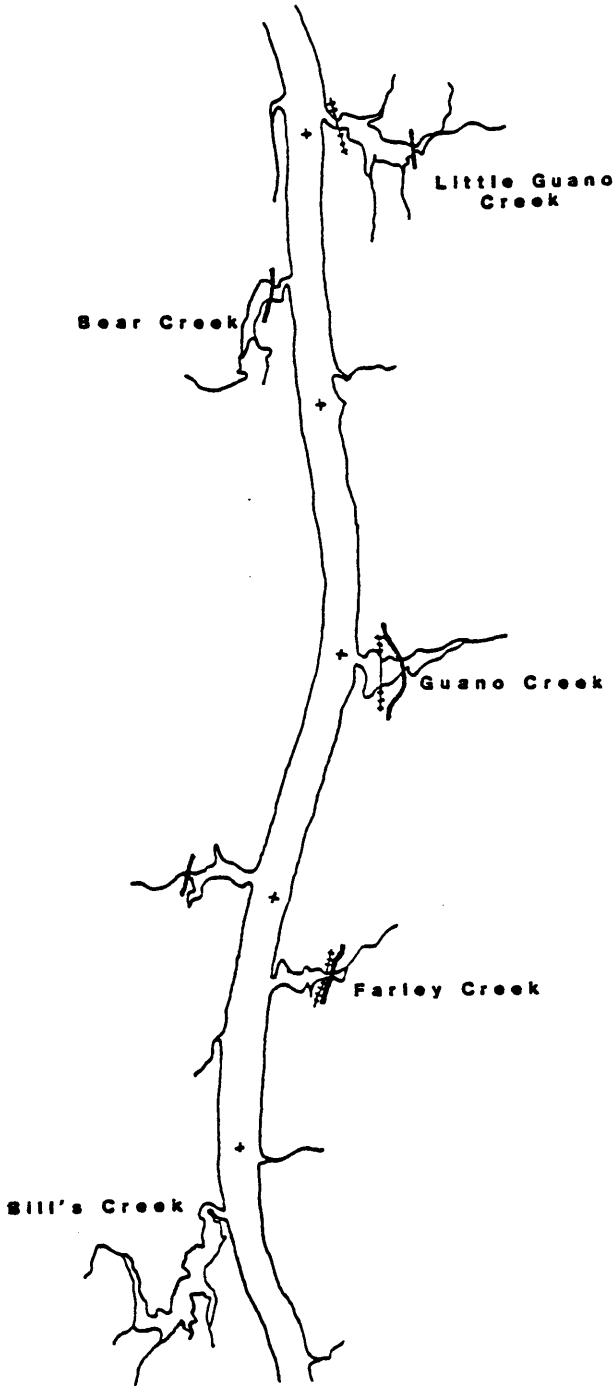
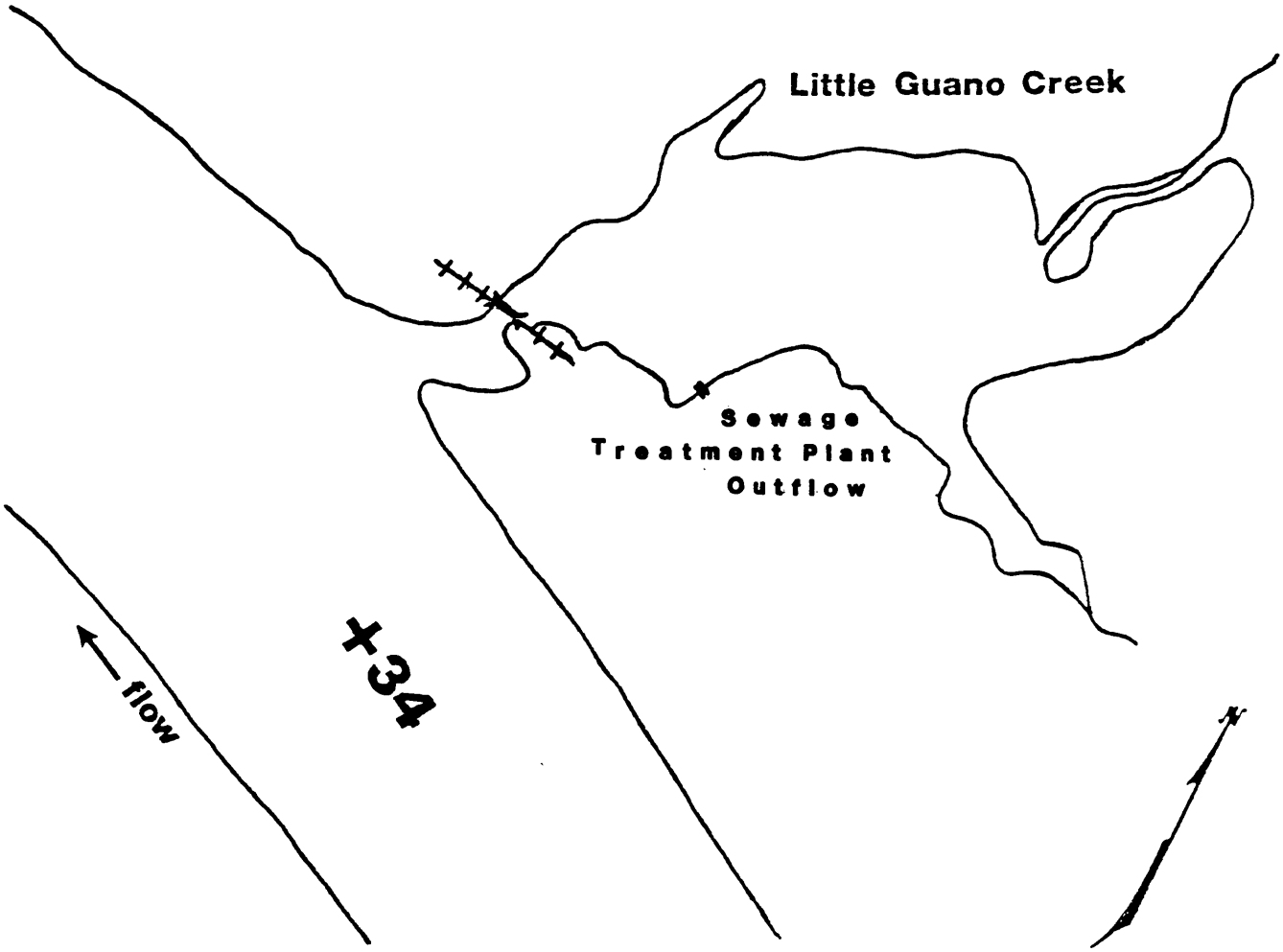


Figure 2. Map of Lower Winfield Pool.



Scale: 1" = 400'
+34 = River Mile 34

Figure 3. Map of Little Guano Creek backwater.

The Little Guano backwater has a predominantly silt substratum with sand present only on the points and in the upper end of the backwater near the creek mouths. Gravel substrate from the construction of the culvert was present in the immediate vicinity of the culvert. Emergent vegetation, primarily *Justica* spp., was found in the upper one-third of the backwater at a depth of < 0.5 m . Woody debris ranging from twigs to logs was quite common and was associated with the silt substratum.

The main channel borders immediately upstream and downstream of the Little Guano Creek backwater were lined with overhanging deciduous vegetation. Woody debris ranging from sunken logs to jams of small limbs was also present along most of the shoreline. No aquatic macrophytes were present. The substrate in this shoreline zone ranged from silt to sand-silt mixture. The shoreline, due to erosion, was steep and provided few areas with depths less than 1 m and prevented sampling with the dropbox.

Because the culvert on Little Guano Creek may have affected fish distribution, a second backwater was also included in the sampling. Bill's Creek backwater is located at river km 61.7 (Figure 4). This backwater is slightly larger than Little Guano Creek in total area (22.5 hectares), is longer (300 m), and is narrower (75 m). Bill's Creek is similar to Little Guano in all but two characterisitics. Bill's Creek backwater has only limited areas of shallow water. It also has few areas of vegetation. These areas are scattered and limited to a small number of water willows (*Justica* spp.). Bill's Creek backwater has 4 tributaries. These small streams are of the same type as those entering Little Guano Creek. The mouth of Bill's Creek is not restricted by any man-made structures. It is narrow (10 m) in width and has a maximum depth of approximately 2 m. Thus, any effects created by the culvert on Little Guano Creek should become evident in the Bill's Creek samples.

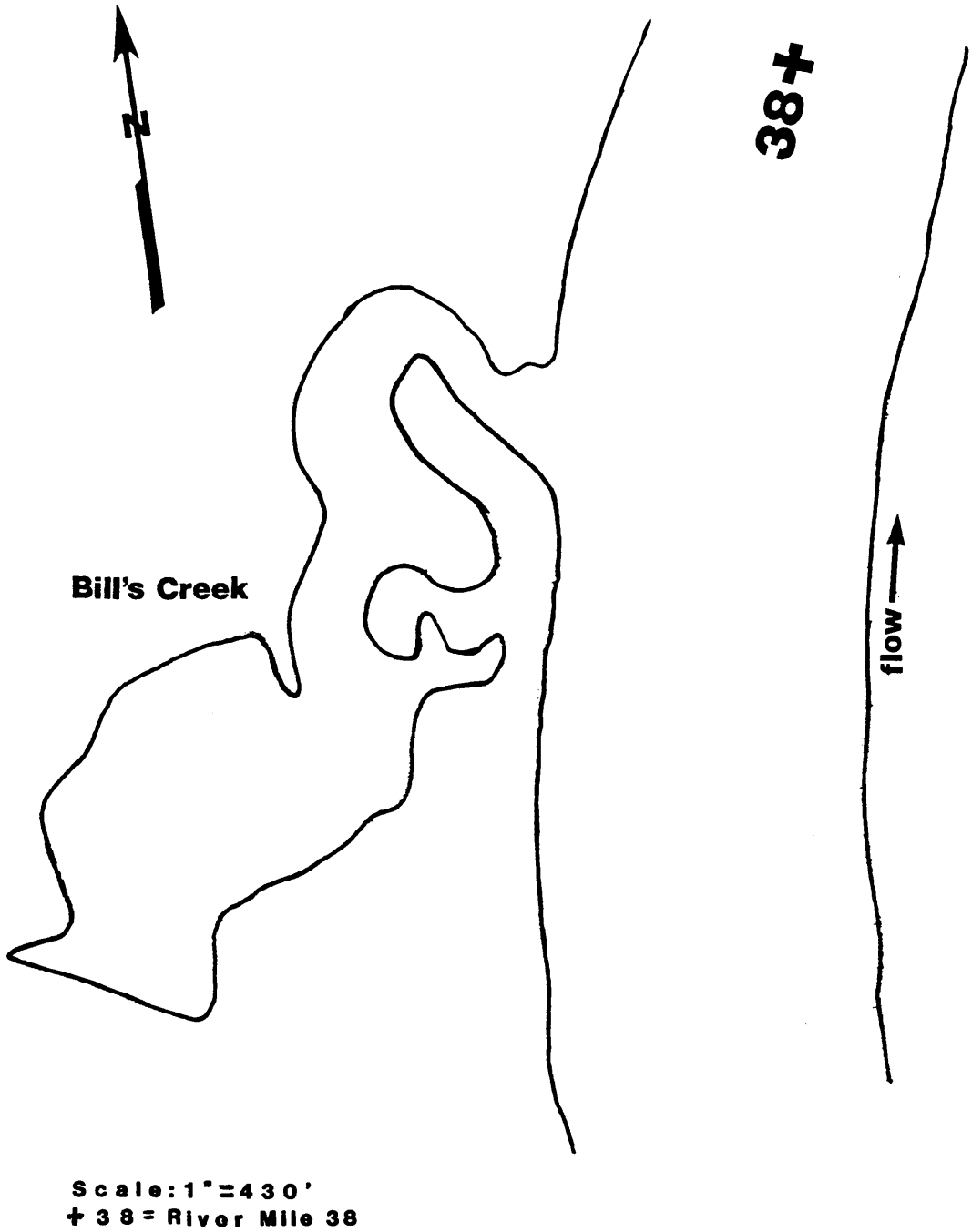


Figure 4. Map of Bill's Creek backwater.

Methods

Larval fish were collected from the backwaters and main channel borders on the Kanawha River during the 1987 larval period (May - July). The larvae were collected from 5 deep water habitats (> 1.5 m in depth) using a 0.5-m towed plankton net and from 3 shallow water habitats (< 1 m in depth) using a dropbox.

Equipment Comparison

The two equipment types used in this study, 0.5-m plankton net and dropbox, were used to sample very different habitats. Because of this, I wanted to compare the densities of larvae collected by the two equipment types in similar habitats. A site was selected which would allow the use of each equipment type in the same area. The site was in the main channel of the Winfield Pool just downstream of Bill's Creek. This site was characterized by a clay substrate ledge approximately 1.5 m in width which ran along the shoreline for approximately 200 m. Deep water was immediately adjacent to this ledge. Because of this, I was able to employ the dropbox on the ledge. I used the dropbox and 0.5-m plankton net within 1 m of each other.

This section of habitat was divided into three transects of equal length. From each transect, three dropbox samples were collected at randomly selected sites along the ledge. A tow using the plankton net was then taken immediately adjacent to this ledge. This procedure was then repeated for each of the other two transects.

Deep Water Design

The 5 deep water habitats sampled in this study included surface tows in Little Guano Creek backwater, main channel border adjacent to and upstream of Little Guano Creek, main channel border adjacent to and downstream of Little Guano Creek, and Bill's Creek backwater. Surface tows were collected by towing the plankton net within 5 cm of the water surface. The fifth habitat was the lower portion of the water column within Little Guano Creek backwater and was sampled by towing the plankton net approximately 1.5 m from the water's surface. Habitats other than Bill's Creek were sampled 15 times from late May until mid-July of 1987. Bill's Creek, a backwater which was added the second week of the study, was sampled 13 times during the same period (Table 2). Temperatures were also recorded for each habitat on each sampling date (Figure 5).

A total of 15 0.5-m plankton net samples was collected on each of the 15 sampling trips. Three tows were made in each of the 5 deep water habitats: (1) surface and (2) deep tows in Little Guano Creek, (3) upstream and (4) downstream main channel borders adjacent to Little Guano Creek, and (5) Bill's Creek (No samples were collected in Bill's Creek on May 25 and June 1, 1987). Except for the deep tows of the net (approximately 1.5 m deep) made within Little Guano Creek, all samples were collected at the surface. All tows were collected during the hours of 9:30am - 12:30pm in all sites on all dates.

Table 2. Numbers of samples taken by 0.5-m plankton net in the 5 deep water sites.

Date	Little Guano Deep	Little Guano Surface	Bill's Creek	Main Channel Upstream	Main Channel Downstream
5-25	3	3	0	3	3
5-29	3	3	3	3	3
6-01	3	3	0	3	3
6-06	3	3	3	3	3
6-08	3	3	3	3	3
6-12	3	3	3	3	3
6-15	3	3	3	3	3
6-19	3	3	3	3	3
6-22	3	3	3	3	3
6-26	3	3	3	3	3
6-29	3	3	3	3	3
7-03	3	3	3	3	3
7-06	3	3	3	3	3
7-10	3	3	3	3	3
7-13	3	3	3	3	3
Total	45	45	39	45	45

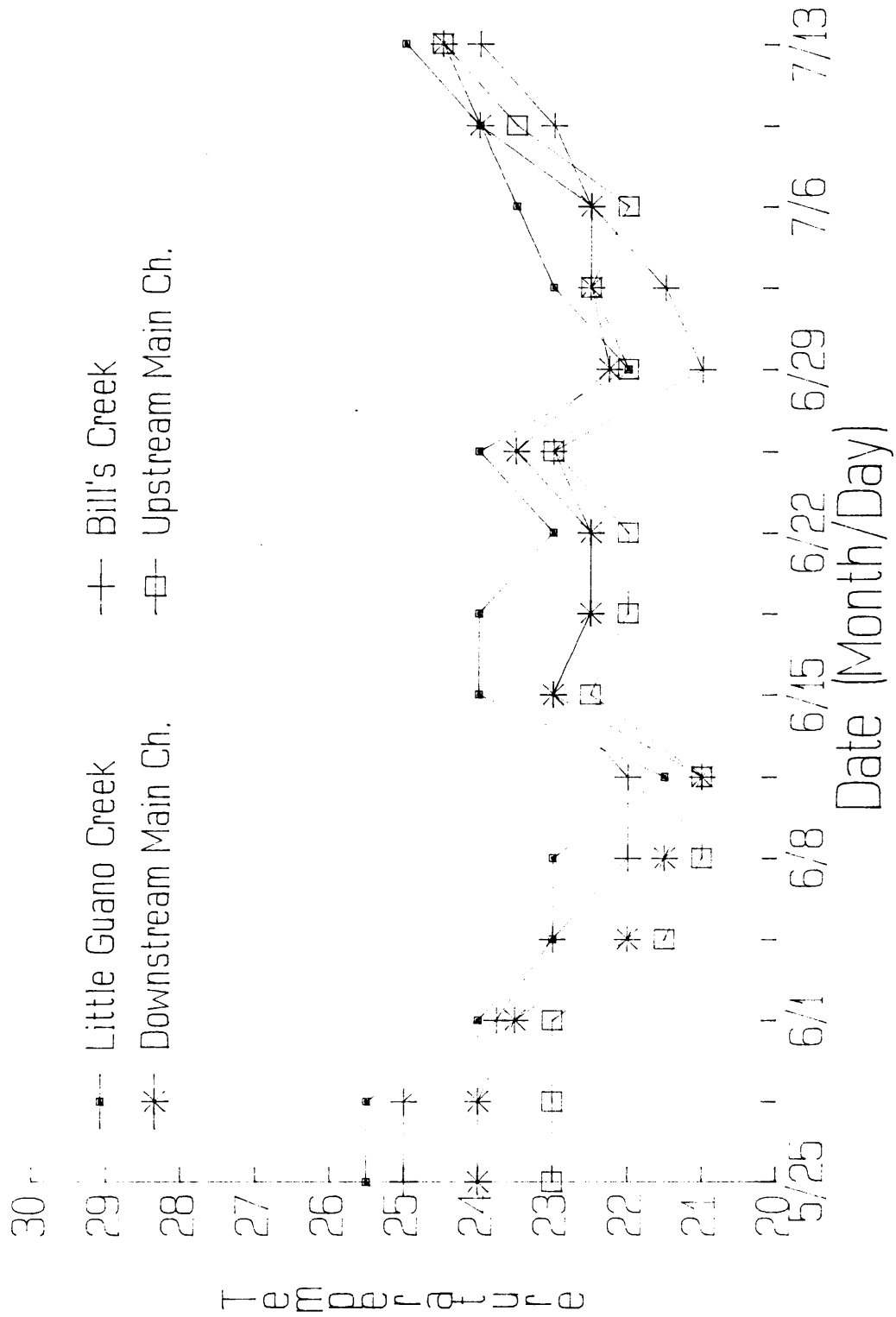


Figure 5. Temperatures in the 4 areas sampled on the Kanawha River, West Virginia.

Deep Water Sampling Procedure

Each sample was obtained by towing a 0.5-m plankton net (500-micrometer mesh) at a velocity of approximately 0.5 m/s for 4 minutes. All main channel samples were taken by towing upstream beginning at the farthest downstream site. The backwater tows were taken in areas with the fewest obstructions (i.e., stumps) and in areas which would allow thorough coverage of the backwater habitat. A General Oceanics Model 2030 flowmeter was mounted in the plankton net to record the volume of water filtered in each tow. A mean of 19.67 cubic meters of water (standard deviation = 3.40) Was filtered by the plankton net. After each tow, the larvae were removed from the net capsule and preserved in 10% formalin.

Shallow Water Design

The 3 shallow water habitats were sand substrate, silt substrate, and vegetated areas. These 3 habitats were sampled 15 times from late May until mid-July of 1987. A total of 12 dropbox samples were collected on each of the 15 sampling dates. Equal numbers of samples (4 per sampling date) were taken from each habitat (Table 3).

Little Guano Creek backwater was mapped to show the different habitats and their positions within the backwater. Each of the 3 shallow water habitats was divided into 25-m transects and each transect was given a code number specific to that habitat type. Because the silt habitat was not limited to shoreline areas within the backwater, 25-m transects extending outward perpendicularly from the shoreline were used to mark the sections of silt habitat. Due to the variable amounts of each habitat present within the backwater, the number of transects varied among the different habitat types (sand - 2 transects, emergent vegetation - 3 transects, and silt - 4 transects) (Figure 6). Within each transect, the distance was divided

Table 3. Numbers of samples taken by 1-m² dropbox in the 3 shallow water sites in Little Guano Creek backwater.

Date	Sand	Silt	Vegetation
5-25	4	4	4
5-29	4	4	4
6-01	4	4	4
6-06	4	4	4
6-08	4	4	4
6-12	4	4	4
6-15	4	4	4
6-19	4	4	4
6-22	4	4	4
6-26	4	4	4
6-29	4	4	4
7-03	4	4	4
7-06	4	4	4
7-10	4	4	4
7-13	4	4	4
Total	60	60	60

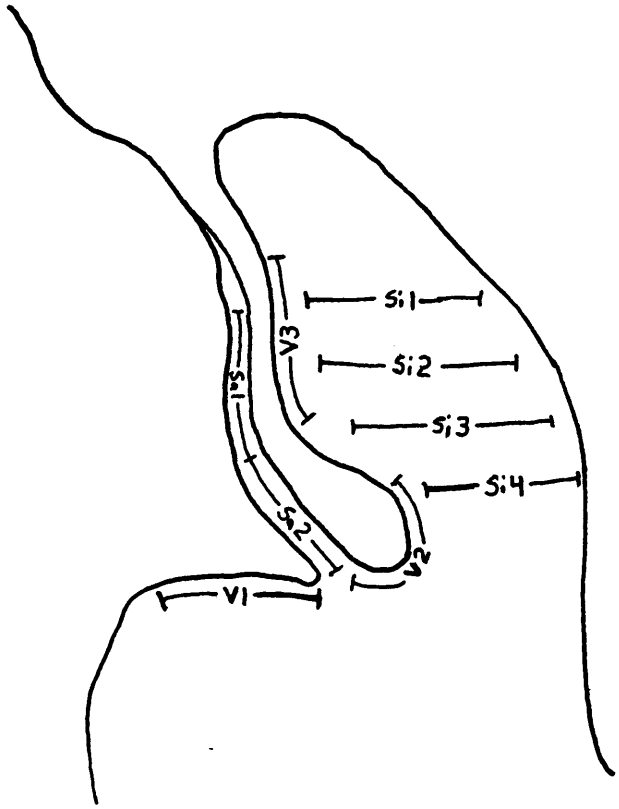
into 25 sequential 1-m lengths. These 1-m lengths would be the units for the dropbox sampling.

I used a 2-step procedure to choose sampling sites for each date. For each habitat, the first step in sampling was randomly selecting a transect of habitat from which the 4 samples would be collected on a given sampling date. The second step was to select the sites along this transect from which samples would be taken. For each transect, 6 numbers were selected randomly from a range of 1 to 25. These numbers represented the exact location (in meters from the beginning of the transect) at which the dropbox samples would be collected. Four of the 6 sites were selected for sampling. The 2 remaining sites were used as alternates in case a site could not be sampled. All numbers chosen were replaced before the next sampling date.

Description of Dropbox

The sampler used in this study is known as a dropbox. A dropbox is an enclosure of known area used to sample organisms quantitatively on a small scale and in water less than 1 m deep. The dropbox has been used in only a few studies to date. Many of these uses were restricted to invertebrates. Nielsen (1974) used a dropbox to sample freshwater shrimp in ponds. The dropbox , however, is a relatively new approach to sampling larval fish. La Bolle et al. (1985) compared the sampling efficiencies of a plexiglass dropbox and a bottom tow net on larval fish. They found no significant difference in the mean densities of larvae collected by each gear. The numbers per sample, however, varied more in the dropbox due to the small area being sampled. La Bolle et al. used the dropbox satisfactorily on substrate up to 8 cm in diameter and in vegetation densities up to 30 stems/m^2.

The dropbox used in this study sampled 1 m^2 of habitat and was constructed of PVC pipe and Nitex plankton netting (to reduce weight). The frame was made of 0.5-inch (1.27-cm) PVC pipe



V-Vegetation
Sa-Sand
Si-Silt

Figure 6. Map of Shallow Water Habitats Sampled in Little Guano Creek backwater.

(Figure 7). A sheet metal flange, approximately 0.2 m in width, was fastened to the bottom sections of the PVC frame by 0.5-inch (1.27-cm) conduits. This flange ensured a tight seal with the bottom and prevented larvae from escaping. The Nitex netting (100-micrometers) was sewn together and fitted onto the PVC corner sections through sleeves sewn into the netting. The 100-micrometer mesh was chosen on the basis of Tomljanovich and Heuer's (1986) findings on retention of larval gizzard shad in standard 505-micrometer mesh; they found an average retention of less than 13% for 1-d old gizzard shad and less than 50% for the larger 4-d old gizzard shad using 505-micrometer mesh. Therefore, I wanted to eliminate any possible larval escapement and used the 100-micrometer mesh. To remove the larvae from the dropbox, a rectangular net was made. This net was constructed of a steel rod frame covered with 335-micrometer Nitex netting. This mesh size was chosen in order to allow for reduced friction so the water would flow through the hand-held net instead of through the dropbox walls. The net had a slightly smaller width than the dropbox (0.75 m) and was of adequate height (1 m) to allow for total filtering of the enclosed area.

Shallow Water Procedure

The actual sampling procedure for the dropbox was quite simple and similar to that of LaBolle et al. (1985). I approached the area to be sampled from deeper water to minimize the disturbance to larval fish. I held the sampler motionless over the water surface for 1 minute to allow larvae to re-establish their pre-disturbance distribution. After 1 minute, I thrust the dropbox downward onto the site, forcing the flange into the substratum. The coverage of the site by woody debris and vegetation was estimated; the materials within the enclosure were then removed, washed to remove any attached larvae, and discarded.

Once the area was clear of obstructions, I positioned the sampling net against the dropbox wall opposite the wall beside which I was standing. I then pulled the net toward myself. This procedure consisted of angling the net slightly away from me and pulling the net so that the

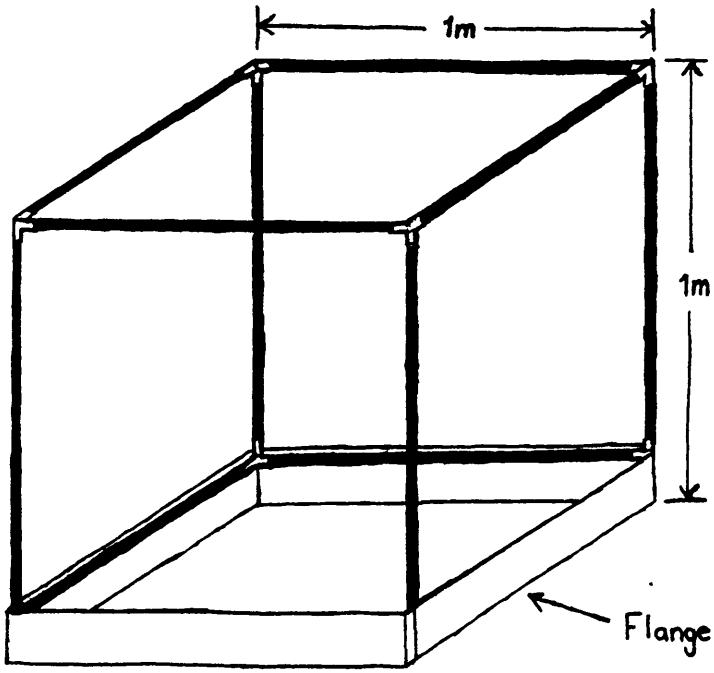


Figure 7. Diagram of dropbox.

bottom of the frame just touched the substratum. This kept the net free of silt and allowed the larvae to be removed from the net quickly and accurately. This procedure was repeated until no larvae were captured in a haul.

The larvae were rinsed from the net after each sweep and preserved in a solution of 10% formalin. Variables recorded for each sample included date, habitat type (sand substrate, silt substrate, or vegetated areas), percent vegetated code (0 - 0%, 1 - 25%, 2 - 50%, 3 - 75%, and 4 - 100%), replicate number, and water depth in sampler. A mean volume of 0.20 m^3 (standard deviation = 0.13) was sampled by the dropbox.

Laboratory Procedures

The larvae were returned to the lab and identified to the lowest taxa possible using the key *Identification of Larval Fishes of the Great Lakes Basin with Emphasis on the Lake Michigan Drainage* (Auer 1982). Larvae were identified into 10 taxa. All clupeids were identified as gizzard shad (*Dorosoma cepedianum*). Cyprinids were separated into three groups. Because some cyprinids present in the Kanawha River have never been described as larvae, species such as the river shiner (*Notropis blennius*), ghost shiner (*N. buchanani*), and the sand shiner (*N. stramineous*) may be present in one or more of the cyprinid taxa. The first taxon was emerald shiners (*Notropis atherinoides*) which were identified to species according to Auer's (1982) key. The preanal myomere count (24 or more myomeres) and the pigmentation pattern as described in the key were the distinguishing characterisitics used for the emerald shiner larvae. Emerald shiners are very prolific in the Kanawha River and, thus, the numbers of cyprinid larvae other than emerald shiner included in this taxa should be minimal. An easily identified cyprinid, common carp (*Cyprinus carpio*) , was limited to a single specimen captured in mid-June. Carp are easily identified by short, club-shaped, heavily pigmented larvae. All remaining cyprinid larvae, due to similar characteristics, were combined into one group. This group could include river shiner (*N. blennius*), spotfin shiner (*N. spilopterus*), mimic shiner

(*N. volucellus*), steelcolor shiner (*N. whipplei*), and bluntnose minnow (*Pimephales notatus*). Centrarchids were identified to two genera: *Lepomis* spp. and crappie (*Pomoxis* spp.), due to the inability to identify them accurately to species. Black bass (*Micropterus* spp.), although abundant as adults, were not collected. Of the several catostomids present in the river, only buffalo (*Ictiobus* spp.) were collected. Percids were not identified below the family level due to the lack of larval descriptions and extreme similarities in characteristics. Ictalurids were represented by a single yellow bullhead (*Ictalurus natalis*) taken by the dropbox in late May. Freshwater drum (*Aplodinotus grunniens*), although not common in shoreline samples, were easily identified to species.

Larvae of a taxon were divided into three length classes: 0-10mm, 10+mm, and juveniles. Juveniles were classified as any larvae which had a complete set of fins. Up to 30 larvae in each length class were measured. If more than 30 larvae were present in a class, a subset of 30 randomly chosen larvae was measured. The larvae in a size class were dispersed in a petri dish with a 10-mm square grid etched into the bottom. A series of random numbers was generated and used to indicate the grids from which larvae were chosen for measurement. For each number generated, all larvae were removed from that grid and measured. A larva was considered within the grid if its eye was completely within the grid. This procedure was repeated until 30 larvae had been measured.

Statistical Analyses

Densities were computed for each taxon length class and for each taxon as a whole. Orthogonal contrasts (Ott 1984) and the sign test (Hollander and Wolfe 1973) were used to determine if densities varied between habitats for the different taxa and length classes. The null hypothesis tested by the orthogonal contrasts is that the mean densities do not vary between habitats over the 15 sampling dates. The null hypothesis tested by the sign test is that the differences between the densities do not differ over the 15 dates. The orthogonal

contrasts, when used with only 2 contrasts as in this study, is equivalent to an F-test on treatments. The contrasts in this study were set up with the locations or habitats used as the treatments and the sampling dates used as the blocks. This test factors out the block effects caused by the changing larval densities encountered over the sampling period. This test assumes equal variance within a block but not between blocks and also normal data. Because of the small number of replicates per date for a location, neither variance or normality could be tested. Thus, the sign test was used to test if larval densities in one habitat were consistently higher than in a second habitat throughout the sampling period. Larval densities were compared pair-wise between two habitats for each sampling date. The reasoning behind using two tests was added information. I felt that, while the contrasts determined if densities were significantly different between habitats, the sign test would allow me to determine if these densities were consistently higher in a habitat regardless of whether they differed significantly. In case of a contradiction between the two tests, the results of the F-test were used. I felt that the F-test was better suited to testing the differences in densities for the individual taxa due to the fact that larval densities tended to peak during a short time and then remain at low levels. Since the sign test did not use the magnitude of the density differences, it would not be as sensitive to this situation. Orthogonal contrasts were also used to test the equipment comparison data. A probability of type I error value of 0.05 was used as the rejection level for this study.

Results

Equipment Comparisons

Mean total larval densities did not differ significantly ($p > 0.05$) for the two equipment types, the 0.5 m plankton net and dropbox (Table 4). The densities in the dropbox were variable due to the combined effects of the small volume of water filtered and the patchy distribution of the larvae. The plankton net filtered more water than the dropbox; therefore, the densities observed for the net were less affected by the larvae's distribution. When larvae were divided into size classes (0-10mm, 10+mm, and juveniles) densities also did not differ significantly ($p > 0.05$). The 10+mm and juvenile size classes were present in low densities in both equipment types, and this may be the reason for there being no significant difference. Larvae in the 10+mm size class were captured only once in the plankton net, while they were present in all but two samples collected in the dropbox. The juveniles were also captured only once in the plankton net but were present in all but one dropbox sample. I would have expected the plankton net to be less efficient in sampling the larger larvae because large larvae are able to detect and avoid the net. It appears that for the smaller larvae (0-10mm), which were captured in large numbers, and for total larval densities the densities collected in the two equipment types do not differ significantly. I, however, am not comfortable with the small

number of sites and feel that more sites needed to be sampled before a valid conclusion can be made.

Overall Collection

A total of 26,030 larvae was collected in the 219 plankton net samples (Table 5). Larvae were present on all 15 dates with a total mean density of 5.9 larvae/m^3. *Lepomis* was the most abundant taxon collected in the plankton net followed by emerald shiners, gizzard shad, and cyprinids (excluding emerald shiners). These four taxa composed nearly 100% of the total larvae collected (38.0, 29.0, 21.9, and 10.6, respectively).

A total of 2467 larvae was collected in 180 dropbox samples. Larvae were present on all 15 dates (Table 6). Total mean density of the larval fish collected in the dropbox was 6.7 larvae/0.1 m^3. Of the larvae collected in the dropbox, *Lepomis* was the most abundant taxon, composing approximately 89% of the total.

The numbers of taxa found in each habitat differed among the deep water and shallow water habitats (Table 7). Of the deep water habitats, the highest total number of taxa were found in the main channel areas: 9 in the downstream site and 8 in the upstream site. The mean number of taxa per date, 4.7 taxa, were equivalent for these sites. Seven taxa were collected in the Little Guano Creek surface samples while 6 taxa were found in Bill's Creek. The lowest number of taxa, 4, was found in the deep water samples taken within Little Guano Creek. The mean number of taxa per date differed only slightly among the 3 habitats with 4.0 taxa in Little Guano surface samples, 4.1 taxa in Bill's Creek, and 3.5 taxa in Little Guano deep samples. In the shallow water habitats, a total of 4 taxa were found in both the vegetated areas and over the sand substrate. A total of 5 taxa were present over the silt substrate. The mean number of taxa per date were also similar: 1.3 taxa in vegetated areas, 1.1 taxa over sand substrate, and 1.9 taxa over the silt substrate.

Table 4. Sampling equipment comparisons of larval densities (larvae/ 0.1 m^3).

Site	Tows (0.5 m net)				Dropbox (1 m^2)			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
1	15.9	4.1	0.0	20.1	31.9	2.3	0.4	34.8
					69.4	11.7	3.2	84.3
					9.9	0.0	2.1	12.1
2	134.8	0.0	0.0	134.8	30.3	18.8	5.5	54.7
					87.9	0.0	0.0	87.9
					57.0	4.5	2.6	64.3
3	8.6	0.0	0.8	9.4	21.3	2.8	1.6	25.8
					8.5	3.5	3.5	15.7
					6.8	1.1	3.4	11.4

Table 5. Totals of larvae collected by 0.5-m plankton net. (X) indicates larvae were present.

Taxa	Total Catch	Percent of Total	May 25	29	June 1	6	8	12	15	19	22	26	29	July 3	6	10	13
Cyprinids (excluding E. Shiner)	2765	10.6	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Emerald Shiner	7546	29.0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Gizzard Shad	5695	21.9	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Lepomis	9897	38.0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ictiobus	23	<1.0	X	X			X	X	X			X		X			
Percids	33	<1.0	X	X	X	X	X	X	X	X							
Crappie	54	<1.0		X	X	X	X	X		X	X						
Carp	1	<1.0					X										
Aplodinotus grunniens	16	<1.0						X									
Total	26,030	100.0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 6. Totals of larvae collected by 1 m^2 dropbox. (X) indicates larvae were present.

Taxa	Total Catch	Percent of Total	May 25	May 29	June 1	June 6	June 8	June 12	June 15	June 19	June 22	June 26	June 29	July 3	July 6	July 10	July 13
Cyprinids (excluding E. Shiner)	106	4.0	X			X	X	X	X	X	X	X		X	X	X	X
Ictiobus	124	5.0		X	X		X		X	X							
Lepomis	2186	89.0		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Percids	44	2.0		X	X	X	X		X	X	X						
Gizzard Shad	5	<1.0								X							
Ictalurus	1	<1.0		X													
Emerald Shiner	1	<1.0								X							
Total	2467	100.0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 7. Numbers of taxa present in the 8 sites sampled.

Habitat	Total Number of Taxa	Mean Number of Taxa/Date
Little Guano Deep	4	3.5
Little Guano Surface	7	4.0
Bill's Creek	6	4.1
Main Channel Upstream	8	4.7
Main Channel Downstream	9	4.7
Vegetated Areas	4	1.3
Silt Substrate	5	1.9
Sand Substrate	4	1.1

From this point on, I have structured the comparisons to move from general to specific. The first comparison will deal with the overall differences between the plankton net samples taken in the backwaters and main channel borders. I will then look at the differences within the main channel borders, upstream and downstream of Little Guano Creek backwater. Then I will discuss the backwater habitats: Little Guano Creek surface and deep samples and Bill's Creek. Any size distribution data will then be covered for all habitats sampled by the plankton net. Next, the shallow water areas (sand, silt, and emergent vegetation) sampled by the dropbox will be compared to determine habitat preferences and the overall importance of the shallow water areas as compared to the deeper areas. The size distribution data will then be discussed for these habitats.

Total Larval Densities

Mean densities of total larvae were greater in the backwaters than in the main channel areas on 10 of the 15 dates sampled. This difference is not significant (sign test, $p=0.15$). Overall mean densities were 8.2 and 5.9 larvae/m^3 in the backwater and main channel, respectively (Table 8). The difference in densities between these two areas was not significant (F-test, $p=0.1$). Peak densities of larvae were observed in mid-June in the backwaters and in late June in the main channel areas.

In the main channel areas, mean densities of total larvae were greater upstream of the Little Guano Creek mouth on 12 of the 15 sampling dates. This shows a significant difference (sign test, $p=0.02$). The overall mean density was greater upstream of the backwater mouth (7.2 larvae/m^3) than in the area downstream (4.7 larvae /m^3) (Table 8). The difference is not significant (F-test, $p=0.23$) over the 15 dates. The highest densities were found in mid- to late June and in late June in the upstream and downstream sites, respectively.

Table 8. Densities of larvae collected in 0.5-m plankton net (larvae/m³). Numbers of species in ( ).

Date	Little Guano Deep	Little Guano Surface	Bill's Creek	Mean of Backwaters	Main Channel Upstream	Main Channel Downstream	Mean of Main Channel
5-25	0.9 (3)	3.9 (5)	-	3.9 (5)	0.3 (4)	0.1 (3)	0.2 (5)
5-29	0.7 (4)	2.6 (4)	6.4 (5)	4.5 (5)	0.7 (6)	0.3 (6)	0.5 (6)
6-01	1.1 (4)	1.2 (3)	-	1.2 (3)	2.8 (5)	4.3 (5)	3.5 (6)
6-06	9.7 (3)	25.3 (4)	13.6 (4)	19.5 (4)	7.6 (6)	2.2 (6)	4.9 (6)
6-08	4.6 (3)	8.1 (4)	7.2 (4)	7.6 (4)	15.1 (7)	7.4 (7)	11.2 (8)
6-12	2.3 (4)	10.4 (4)	14.2 (5)	12.3 (5)	16.0 (8)	2.9 (7)	9.4 (8)
6-15	4.2 (4)	20.1 (6)	15.2 (4)	17.7 (6)	2.6 (4)	1.1 (4)	1.8 (4)
6-19	2.1 (4)	7.3 (4)	34.1 (4)	20.7 (4)	5.3 (6)	2.0 (5)	3.7 (6)
6-22	3.0 (4)	12.3 (4)	2.8 (4)	7.6 (4)	10.9 (4)	20.3 (5)	15.6 (5)
6-26	1.0 (4)	6.8 (4)	2.5 (4)	4.6 (4)	20.0 (4)	16.8 (5)	18.4 (5)
6-29	1.7 (4)	11.9 (4)	10.6 (4)	11.3 (4)	11.4 (4)	3.6 (4)	7.5 (4)
7-03	1.8 (4)	9.0 (4)	2.5 (4)	5.8 (4)	5.5 (3)	3.0 (3)	4.2 (4)
7-06	0.2 (2)	2.3 (4)	1.2 (4)	1.7 (4)	3.7 (4)	2.1 (3)	2.9 (4)
7-10	0.5 (2)	3.1 (3)	3.0 (3)	3.1 (3)	0.9 (3)	1.2 (4)	1.1 (4)
7-13	0.7 (3)	5.2 (3)	4.5 (4)	4.8 (4)	4.9 (3)	2.7 (3)	3.8 (4)
Means	2.3	8.6	7.8	8.2	7.2	4.7	5.9
Std. Error	0.409	1.626	1.543	1.115	1.043	0.965	0.719

Within the backwaters, total larval mean densities at the surface were greater in Little Guano Creek than in Bill's Creek on 10 of 13 sampling dates. This is a significant difference (sign test, $p=0.046$). Overall mean densities were quite similar, 8.6 larvae/m^3 in Little Guano Creek and 7.8 larvae/m^3 in Bill's Creek (Table 8). This similarity is reflected in the F-test which showed no significant difference (F-test, $p=0.83$) between the 2 backwaters. Of the samples taken within Little Guano Creek, greater densities were observed in the surface samples than in the deep samples on all 15 dates. Thus, this is significant (sign test, $p=0.00$). The overall mean density was 2.3 larvae/m^3 for the deep water areas. The differences in density between the surface and deep water habitats is also statistically significant (t-test, $p=0.004$). Peak densities occurred in early to mid-June in both backwaters. The peak density in the deep water habitat occurred in early June.

Of the three habitat types sampled by the dropbox, lower densities were observed in the sand habitat than in either the silt or vegetated habitats on 10 and 12 sampling dates (sign test, $p=0.15$ and $p=0.02$) , respectively (Table 9). This shows that the only significant difference is between the sand and the vegetated areas. The overall mean density in the sand substrate was 1.3 larvae/0.1 m^3. Densities were higher in the silt habitat than in the vegetated habitat on only 8 of the 15 dates. This is not a significant difference (sign test, $p=0.50$). The overall mean densities were also similar with 8.5 larvae/ 0.1 m^3 in the silt and 9.3 larvae/0.1 m^3 in the emergent vegetation. Of the three habitats, only the densities found in the sand were significantly different (F-test, $p=0.05$) from the silt and emergent vegetation. The densities in the silt and vegetated habitats did not differ significantly from each other (F-test, $p=0.82$). The peak density in the sand habitat occurred in late May, in the silt habitat in mid-June, and in the emergent vegetation in mid-July.

Table 9. Densities of larvae collected in 1-m^2 dropbox (larvae/0.1 m^3). Numbers of species in ( ).

Date	Sand	Silt	Vegetation
5-25	0.0 (-)	0.0 (-)	0.2 (1)
5-29	8.5 (2)	28.2 (2)	8.4 (2)
6-01	1.1 (1)	0.6 (1)	7.9 (1)
6-06	3.3 (1)	9.4 (2)	5.3 (1)
6-08	0.2 (1)	15.7 (4)	3.7 (1)
6-12	0.0 (-)	12.3 (3)	0.7 (1)
6-15	2.0 (2)	24.9 (3)	1.1 (1)
6-19	0.9 (3)	21.9 (4)	5.2 (2)
6-22	0.6 (2)	3.5 (1)	8.0 (2)
6-26	0.0 (-)	2.5 (2)	1.0 (1)
6-29	0.8 (1)	0.4 (1)	13.0 (1)
7-03	1.3 (1)	3.9 (2)	0.0 (-)
7-06	0.5 (1)	0.3 (1)	9.0 (2)
7-10	0.0 (-)	3.0 (2)	40.9 (1)
7-13	0.2 (1)	0.8 (1)	35.6 (2)
Means	1.3	8.5	9.3
Std. Error	0.504	2.465	1.495

Lepomis

Lepomis were present throughout the sampling period in both backwater and main channel areas. However, the mean densities were greater in the backwater on all 15 sampling dates. Thus, the difference is significant (sign test, $p=0.00$). Overall mean *Lepomis* densities were 20-times greater in the backwaters (6.2 larvae/m^3) than in the main channel areas (0.3 larvae/m^3) (Table 10). This difference was shown to be significant (F-test, $p=0.0001$). Peak *Lepomis* densities occurred in mid-June in the backwater and in late June in the main channel areas.

In the main channel habitats, higher *Lepomis* densities were found upstream of Little Guano Creek on 8 of the 15 dates sampled. There is no significant difference (sign test, $p=0.5$). Overall mean *Lepomis* densities were slightly greater in the upstream site (0.5 larvae/m^3) than in the downstream site (0.2 larvae/ m^3) (Table 11). Over the sampling period, however, there were no significant differences in density (F-test, $p=0.85$) between the two main channel sites. Peak densities occurred in late June both upstream and downstream of Little Guano Creek.

In the two backwaters sampled, higher mean *Lepomis* densities were found in Little Guano Creek on 8 of the sampling dates. No significant differences were evident (sign test, $p=0.29$). The highest overall mean density (6.9 larvae/m^3) was observed in Bill's Creek (Table 12) and was not significantly greater than the 5.6 larvae/m^3 found in Little Guano Creek (F-test, $p=0.61$). Higher densities were found in the Little Guano Creek surface samples than in the deep water samples on all 15 dates (sign test, $p=0.00$). The overall mean density for the deep water samples is low (0.7 larvae/m^3) and differs significantly from the surface samples (F-test, $p=0.001$). The highest densities were observed in early to mid-June in both backwaters. The peak density of *Lepomis* in the deep water samples occurred in early to mid-June.

Table 10. Densities of *Lepomis* larvae collected in 0.5-m plankton net (larvae/m^3). A (-) indicates no larvae present.

Date	Main Channel Mean				Backwater Surface Mean			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	-	-	-	-	3.6	-	-	3.6
5-29	<0.1	-	-	<0.1	3.5	-	-	3.5
6-01	<0.1	-	-	<0.1	0.8	-	-	0.8
6-06	0.1	-	-	0.1	13.8	0.2	-	13.9
6-08	0.2	-	-	0.2	5.9	-	-	5.9
6-12	0.2	-	-	0.2	8.5	-	-	8.5
6-15	0.1	-	-	0.1	15.7	<0.1	-	15.7
6-19	0.5	-	-	0.5	16.3	<0.1	-	16.3
6-22	1.9	-	-	1.9	3.6	-	-	3.6
6-26	0.1	-	-	0.1	1.4	<0.1	-	1.4
6-29	1.8	-	-	1.8	6.7	0.1	-	6.8
7-03	<0.1	-	-	<0.1	3.5	-	<0.1	3.5
7-06	<0.1	-	-	<0.1	0.9	-	-	0.9
7-10	<0.1	-	-	<0.1	1.1	<0.1	-	1.1
7-13	0.1	-	-	0.1	3.8	<0.1	<0.1	3.9
Means	0.3	-	-	0.3	5.8	<0.1	<0.1	6.2
Std. Error				0.100				0.936

Table 11. Densities of *Lepomis* larvae collected in 0.5-m plankton net (larvae/m³). A (-) indicates no larvae.

Date	Downstream Main Channel Border				Upstream Main Channel Border			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	-	-	-	-	-	-	-	-
5-29	<0.1	-	-	<0.1	<0.1	-	-	<0.1
6-01	0.1	-	-	0.1	<0.1	-	-	<0.1
6-06	0.1	-	-	0.1	0.1	-	-	0.1
6-08	0.1	-	-	0.1	0.4	-	-	0.4
6-12	-	-	-	-	0.5	-	-	0.5
6-15	0.1	-	-	0.1	0.2	-	-	0.2
6-19	<0.1	-	-	<0.1	1.0	-	-	1.0
6-22	2.5	-	-	2.5	1.2	-	-	1.2
6-26	0.1	-	-	0.1	0.1	-	-	0.1
6-29	0.3	-	-	0.3	3.3	-	-	3.3
7-03	-	-	-	-	<0.1	-	-	<0.1
7-06	-	-	-	-	0.1	-	-	0.1
7-10	<0.1	-	-	<0.1	-	-	-	-
7-13	-	-	-	-	0.2	-	-	0.2
Means	0.2	-	-	0.2	0.5	-	-	0.5
Std. Error				0.137				0.143

Table 12. Densities of *Lepomis* larvae collected in 0.5-m plankton net (larvae/m^3). A (-) indicates no larvae.

	Bill's Creek				Little Guano Surface				Little Guano Deep			
Date	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	-	-	-	-	3.6	-	-	3.6	0.5	-	-	0.5
5-29	4.6	-	-	4.6	2.3	-	-	2.3	0.3	-	-	0.3
6-01	-	-	-	-	0.8	-	-	0.8	0.1	-	-	0.1
6-06	11.6	0.3	-	11.9	16.0	-	-	16.0	0.9	-	-	0.9
6-08	6.4	-	-	6.4	5.4	-	-	5.4	1.2	-	-	1.2
6-12	11.5	-	-	11.5	5.5	-	-	5.5	0.6	-	-	0.6
6-15	12.9	-	-	12.9	18.5	<0.1	-	18.5	2.7	-	-	2.7
6-19	28.1	<0.1	-	28.1	4.5	-	-	4.5	0.3	-	-	0.3
6-22	1.0	-	-	1.0	6.1	-	-	6.1	0.6	-	-	0.6
6-26	1.3	<0.1	-	1.3	1.5	<0.1	-	1.5	0.3	-	-	0.3
6-29	6.4	0.2	-	6.7	7.0	-	-	7.0	0.6	-	-	0.6
7-03	1.5	-	<0.1	1.5	5.5	-	-	5.5	1.2	-	-	1.2
7-06	0.4	-	-	0.4	1.3	-	-	1.3	0.1	-	-	0.1
7-10	0.3	<0.1	-	0.4	1.9	-	-	1.9	0.3	-	-	0.3
7-13	3.5	<0.1	<0.1	3.5	4.2	-	-	4.2	0.6	-	-	0.6
Means	6.9	<0.1	<0.1	6.9	5.6	<0.1	-	5.6	0.7	-	-	0.7
Std. Error				1.493				1.183				0.148

Of the *Lepomis* collected in the plankton net, the larger individuals (10+mm and juveniles) were collected only in the backwater areas and occurred in small numbers. Within the backwaters, greater numbers of larger *Lepomis* (10+mm and juveniles) were observed in Bill's Creek.

In the three shallow water habitats, the densities observed in the silt habitat were higher on 9 and 11 of the 15 dates than the emergent vegetation and the sand substrate, respectively (sign test, $p=0.30$ and $p=0.06$). Thus, there were no significant differences between the silt and the other 2 habitats. The sand substrate was not significantly different from the vegetated habitat either, with higher densities in the emergent vegetation on 11 of the 15 dates (sign test, $p=0.06$). Overall mean densities of *Lepomis* collected in the dropbox were equivalent in silt and emergent vegetation (7.8 larvae/ 0.1 m^3 for each) but were nearly 40 times higher than in sand habitat (0.2 larvae/0.1 m^3) (Table 13). Thus, the densities in sand were significantly different the densities in either the silt or emergent vegetation (F-test, $p=0.048$).

The nature of the differences between the 3 habitats is revealed further in the distribution of the 3 sizes of *Lepomis* (0-10mm, 10+mm, and juveniles). Higher densities of 0-10mm and 10+mm larvae were found in the silt habitat, 2.5 and 3.4 larvae/0.1 m^3 , respectively, than in the sand or the emergent vegetation. While both 0-10mm and 10+mm *Lepomis* larvae were found almost exclusively in the silt habitat, neither the 0-10mm or 10+mm larval densities were significantly different (F-test, $p=0.07$) than those same size categories in the other habitats. Juveniles were present in all three habitats, but were found primarily in the vegetation habitat (7.8 larvae/0.1 m^3). The densities of juvenile *Lepomis* found in the emergent vegetation differed significantly (F-test, $p=0.002$) from each of the other habitats (1.9 larvae/m^3 in the silt and 0.2 larvae/m^3 in the sand).

The peak densities for the 0-10mm and 10+mm *Lepomis* larvae in the silt habitat occurred during late May and mid-June, respectively (Figure 8). The peak densities for the juvenile *Lepomis* were observed in mid-July in the emergent vegetation habitat (Figure 9). This

Table 13. Densities of *Lepomis* larvae collected in 1-m² dropbox (larvae/0.1 m³). A (-) indicates no larvae.

Date	Sand Substrate				Silt Substrate				Vegetation			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	-	-	-	-	-	-	-	-	-	-	-	-
5-29	-	-	-	-	22.7	5.2	-	27.9	-	-	-	-
6-01	-	-	-	-	0.2	-	0.4	0.6	-	-	-	-
6-06	-	-	-	-	-	8.6	0.5	9.1	-	-	5.3	5.3
6-08	-	-	-	-	4.6	2.8	7.5	15.0	-	0.7	3.0	3.7
6-12	-	-	-	-	3.5	6.7	2.0	12.1	-	-	0.7	0.7
6-15	-	0.1	0.1	0.2	-	12.4	9.9	22.2	-	-	1.1	1.1
6-19	-	-	0.2	0.2	5.5	12.7	2.3	20.4	-	-	1.4	1.4
6-22	-	-	0.4	0.4	0.4	1.9	1.3	3.5	-	-	7.4	7.4
6-26	-	-	-	-	-	0.1	2.3	2.4	-	-	1.0	1.0
6-29	-	-	0.8	0.8	-	-	0.4	0.4	-	-	13.0	13.0
7-03	-	-	1.3	1.3	0.4	1.3	1.2	2.9	-	-	-	-
7-06	-	-	0.5	0.5	-	-	0.3	0.3	-	-	8.7	8.7
7-10	-	-	-	-	-	-	0.8	0.8	-	-	40.9	40.9
7-13	-	-	0.2	0.2	-	-	-	-	-	-	34.1	34.1
Means	-	<0.1	0.2	0.2	2.5	3.4	1.9	7.8	-	<0.1	7.8	7.8
Std. Error				0.189				0.2.836				1.907

difference in peaks implies movement between the habitats. The graph of densities of the 3 size classes over time shows the larval *Lepomis*, along with a few juveniles, present in the silt until June 22, 1987. From this date on, *Lepomis* were found almost exclusively in the emergent vegetation as juveniles.

The boxplots of *Lepomis* densities versus both percent of vegetation and depth support this movement of larger *Lepomis* into the shallow vegetated areas. The boxplots of densities versus percent vegetation show a positive relationship between the densities of juvenile *Lepomis* and the presence of vegetation. The smaller *Lepomis* were all found primarily at low percentages of vegetation (Figure 10) while the *Lepomis* juveniles frequent the vegetated areas. This shows the preference of juvenile *Lepomis* for emergent vegetation. The boxplots of densities versus depth show increasing densities of juveniles with decreasing depth. The 0-10mm larvae are found only in the deeper samples (Figure 11) with the 10+mm larvae being somewhat spread out through the depths. These boxplots also show a definite movement of the juvenile *Lepomis* into the shallow areas.

Emerald Shiners

Emerald shiners were present on all dates sampled in both backwater and main channel habitats. The mean densities were greater in the main channel areas than in the backwaters on 9 of the 15 sampling dates. This shows no significant difference (sign test, $p=0.30$). The overall mean density was over 2-times greater in the main channel (2.8 larvae/m^3) than in the backwaters (1.2 larvae/m^3) (Table 14). This is statistically significant (F-test, $p=0.01$). Peak densities occurred in late June in both areas.

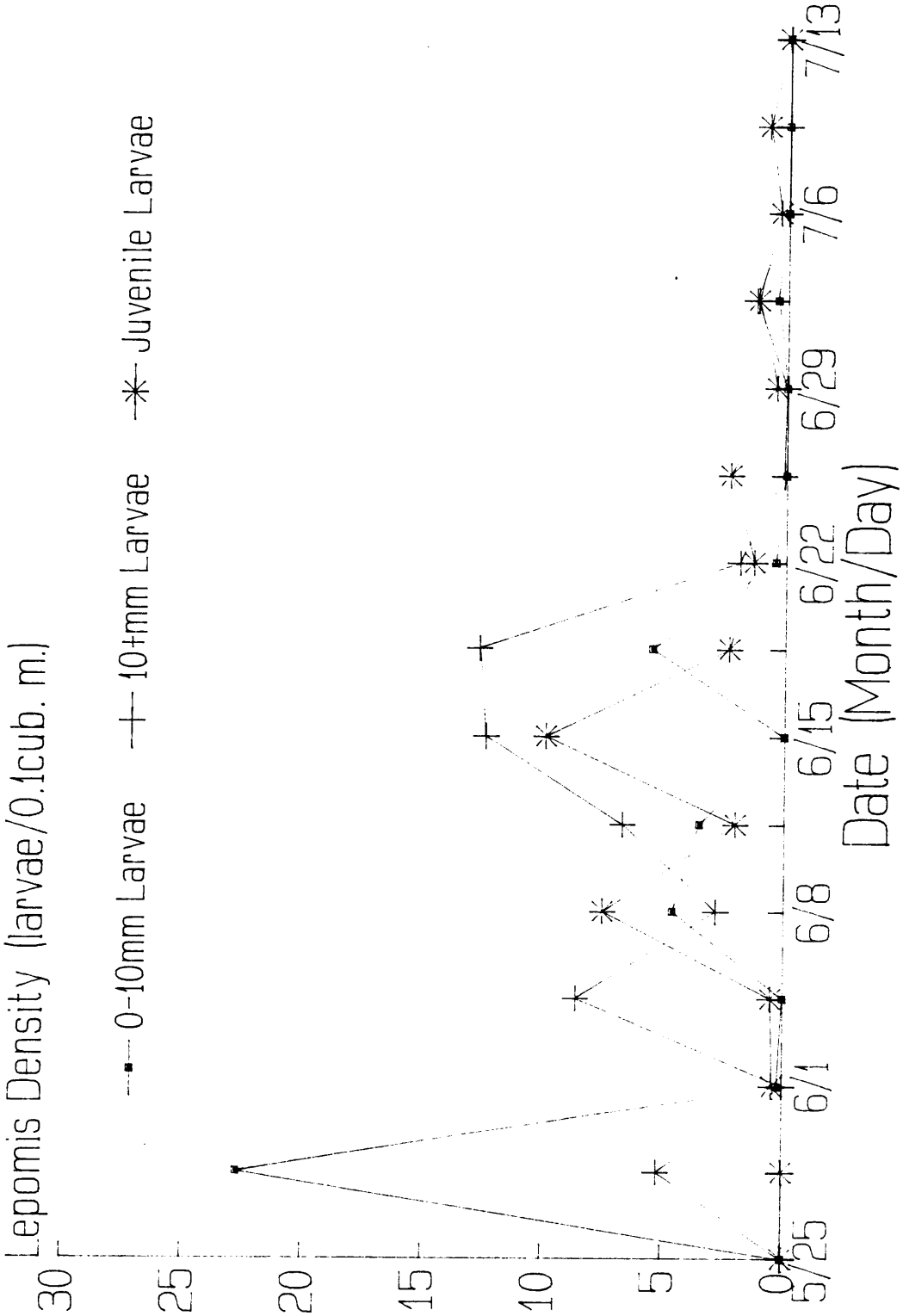


Figure 8. Larval Lepomis densities in the silt substrate.

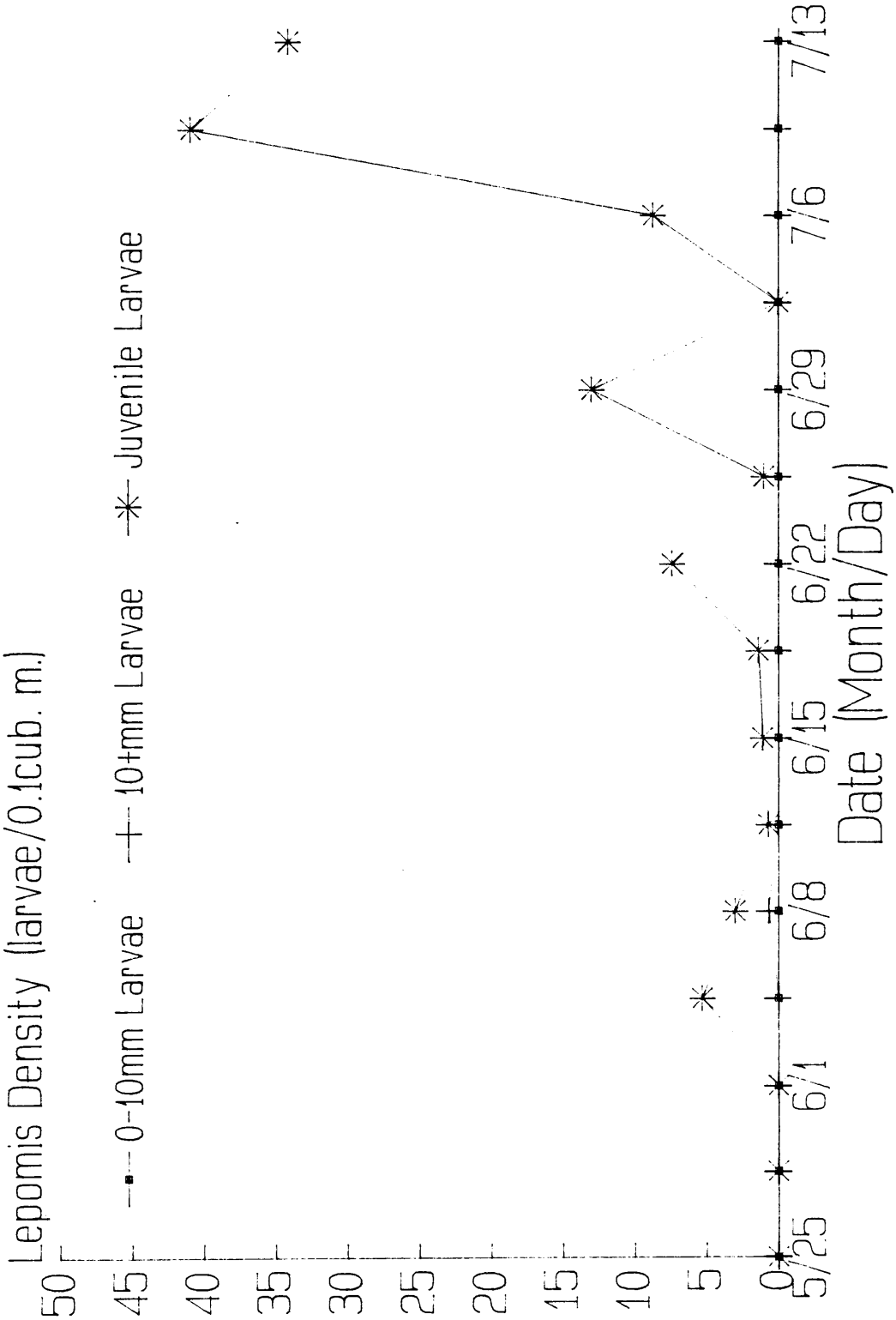


Figure 9. Larval Lepomis densities in the vegetation.

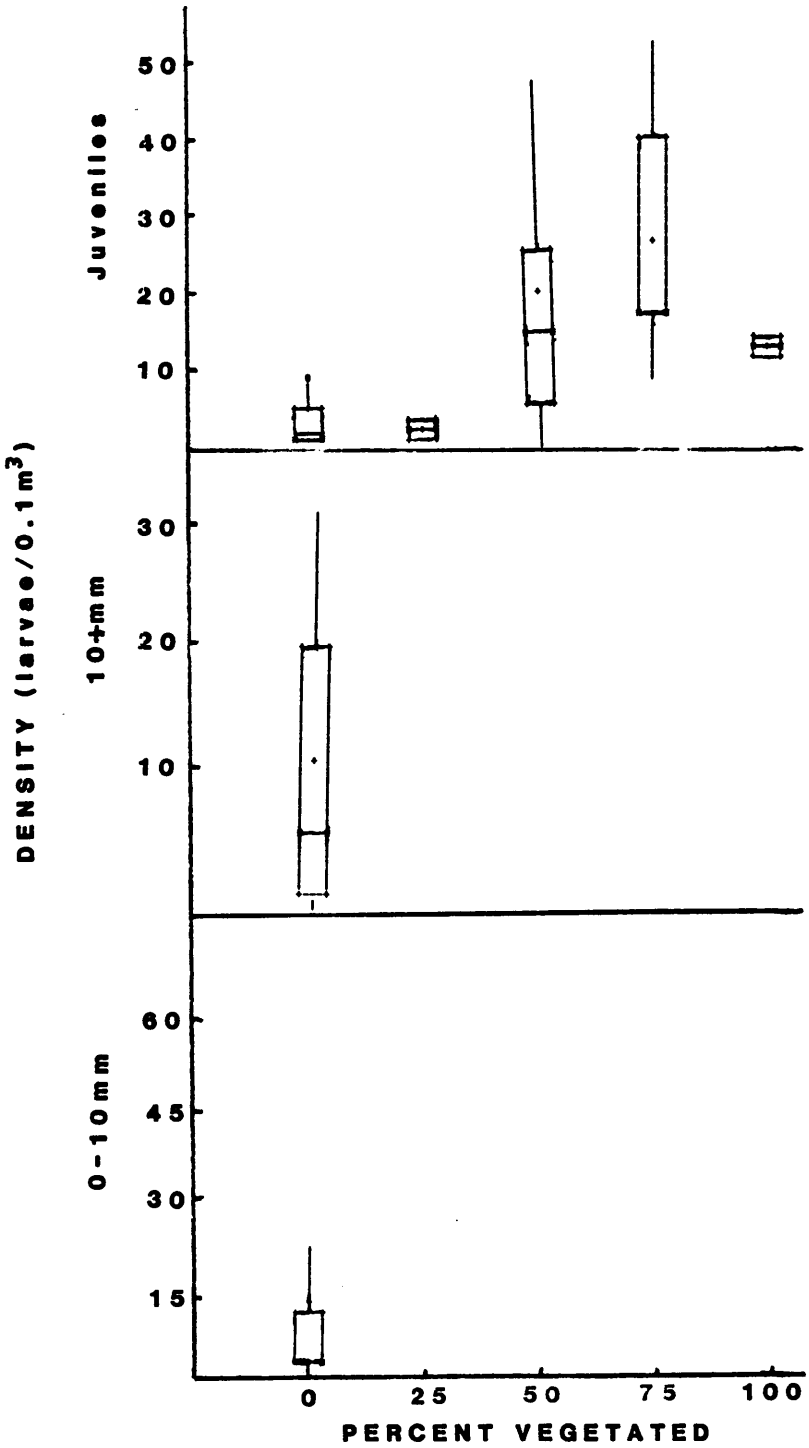


Figure 10. Boxplots of Lepomis densities versus percent of area sampled with vegetation.

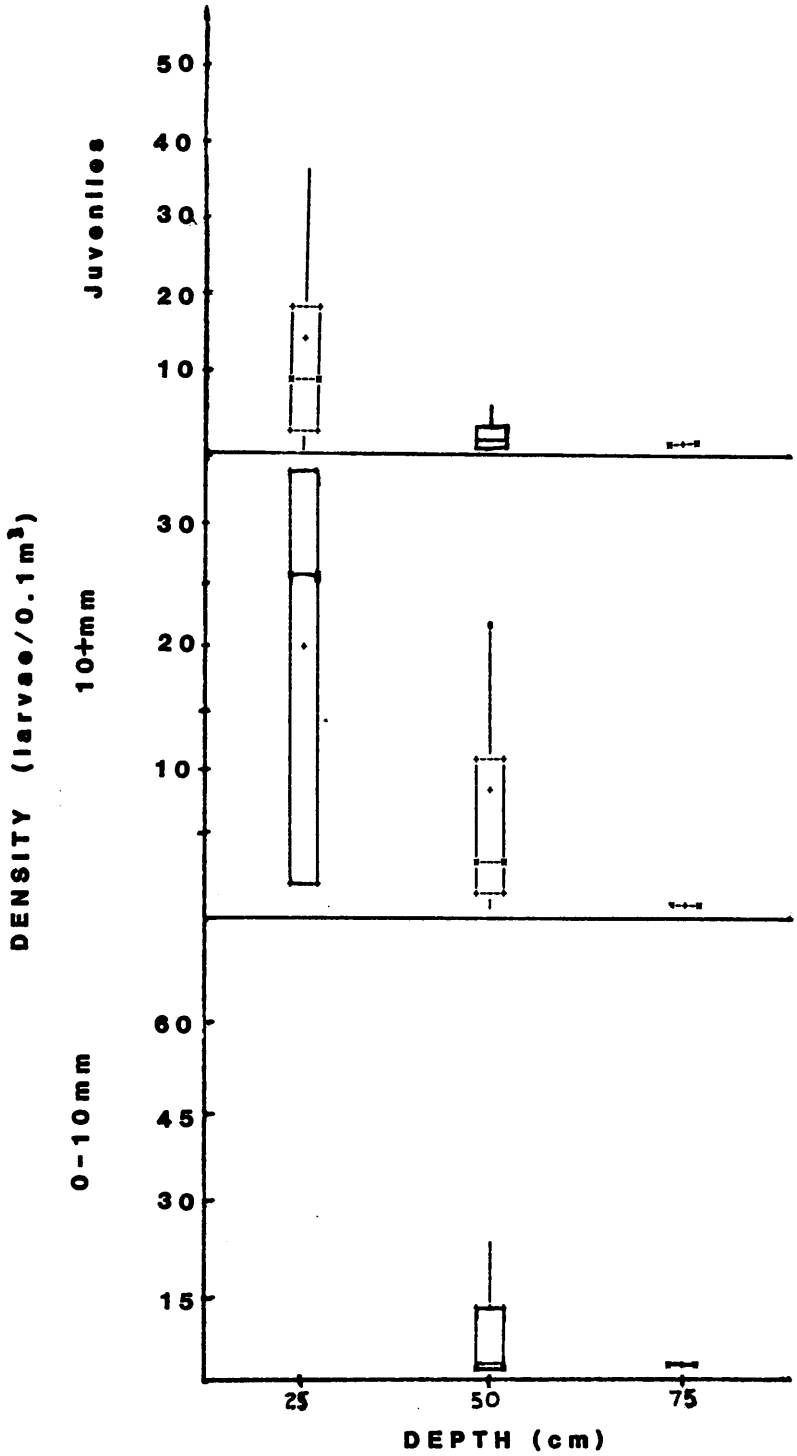


Figure 11. Boxplots of Lepomis densities versus depth.

Table 14. Densities of emerald shiner larvae collected in 0.5-m plankton net (larvae/m^3). A (-) indicates no larvae.

Date	Main Channel Mean				Backwater Mean			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	0.1	-	-	0.1	0.2	-	-	0.2
5-29	0.4	-	-	0.4	0.4	<0.1	-	0.4
6-01	1.3	-	-	1.3	0.2	-	-	0.2
6-06	1.2	<0.1	-	1.3	3.4	<0.1	-	3.4
6-08	0.4	<0.1	-	0.4	1.3	-	-	1.3
6-12	8.0	-	-	8.0	1.1	<0.1	-	1.1
6-15	1.3	-	-	1.3	0.8	-	-	0.8
6-19	1.0	-	-	1.0	1.0	<0.1	-	1.1
6-22	4.8	-	-	4.8	2.1	0.1	-	2.2
6-26	14.2	-	-	14.2	1.8	<0.1	-	1.8
6-29	3.7	-	-	3.7	2.1	0.1	-	2.2
7-03	1.5	<0.1	-	1.5	1.0	<0.1	-	1.0
7-06	1.7	-	-	1.7	0.2	<0.1	-	0.2
7-10	0.6	-	-	0.6	0.9	0.2	-	1.1
7-13	1.3	-	-	1.3	0.5	-	-	0.5
Means	2.8	<0.1	-	2.8	1.1	<0.1	-	1.2
Std. Error				0.473				0.191

Main channel emerald shiner densities were higher upstream than downstream of Little Guano Creek on 10 of the 15 dates. This does not show a significant difference (sign test, $p=0.15$). Overall emerald shiner densities differed with 3.4 larvae/m^3 being collected upstream and 2.2 larvae/m^3 downstream of the backwater mouth (Table 15). This was not significant (F-test, $p=0.19$). The highest emerald shiner densities were observed in mid- to late June upstream of the backwater mouth and in late June downstream of the mouth.

Higher densities were found in Little Guano Creek than in Bill's Creek on 12 of the 13 dates sampled. Thus, this shows a significant difference (sign test, $p=0.002$). The higher overall mean density of 1.8 larvae/m^3 was also found in Little Guano Creek and was 3-times greater than the 0.6 larvae/m^3 found in Bill's Creek (Table 16). However, this difference was not significant (F-test, $p=0.14$). Within Little Guano Creek, the emerald shiners had higher densities in the surface samples on all 15 dates. This is a significant difference (sign test, $p=0.0$). The overall mean density of the deep samples was 0.1 larvae /m^3. This is significantly different from the surface samples (F-test, $p=0.049$). The highest densities of emerald shiners occurred in late June in both backwaters. The peak densities occurred in the deep water samples during the same period as the surface samples, late June.

Large emerald shiner larvae (10+mm) occurred more often in the backwaters than in the main channel. No tests were done on the data, however, due to the low densities. Within the backwaters, larger emerald shiners were virtually absent from the deep samples while, although not numerous, they occurred frequently in the surface samples.

Emerald shiners were almost nonexistent in the dropbox samples. One specimen was found in the silt habitat on June 19. Since emerald shiners are pelagic in nature, I expected this low number.

Table 15. Densities of emerald shiner larvae collected in 0.5-m plankton net (larvae/m³). A (-) indicates no larvae.

Date	Downstream Main Channel Border				Upstream Main Channel Border			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	<0.1	-	-	<0.1	0.2	-	-	0.2
5-29	0.2	-	-	0.2	0.6	-	-	0.6
6-01	1.4	-	-	1.4	1.2	-	-	1.2
6-06	0.9	-	-	0.9	1.6	<0.1	-	1.6
6-08	0.2	<0.1	-	0.3	0.5	<0.1	-	0.6
6-12	2.4	-	-	2.4	13.7	-	-	13.7
6-15	0.8	-	-	0.8	1.8	-	-	1.8
6-19	1.2	-	-	1.2	0.9	-	-	0.9
6-22	6.5	-	-	6.5	3.2	-	-	3.2
6-26	12.4	-	-	12.4	16.1	-	-	16.1
6-29	2.4	-	-	2.4	5.0	-	-	5.0
7-03	0.9	<0.1	-	0.9	2.1	-	-	2.1
7-06	1.3	-	-	1.3	2.1	-	-	2.1
7-10	0.9	-	-	0.9	0.4	-	-	0.4
7-13	1.7	-	-	1.7	1.0	-	-	1.0
Means	2.2	<0.1	-	2.2	3.4	<0.1	-	3.4
Std. Error				0.516				0.790

Table 16. Densities of emerald shiner larvae collected in 0.5-m plankton net (larvae/m^3). A (-) indicates no larvae.

	Bill's Creek				Little Guano Surface				Little Guano Deep			
Date	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	-	-	-	-	0.2	-	-	0.2	<0.1	-	-	<0.1
5-29	0.7	<0.1	-	0.7	0.2	-	-	0.2	<0.1	-	-	<0.1
6-01	-	-	-	-	0.2	-	-	0.2	<0.1	-	-	<0.1
6-06	1.1	-	-	1.1	5.6	<0.1	-	5.6	-	-	-	-
6-08	0.4	-	-	0.4	2.1	-	-	2.1	-	-	-	-
6-12	0.9	<0.1	-	0.9	1.3	<0.1	-	1.3	0.1	-	-	0.1
6-15	0.4	-	-	0.4	1.3	-	-	1.3	0.1	-	-	0.1
6-19	0.3	-	-	0.3	1.7	0.1	-	1.8	0.1	-	-	0.1
6-22	0.5	0.1	-	0.5	3.8	0.1	-	3.9	0.2	<0.1	-	0.2
6-26	0.2	<0.1	-	0.2	3.4	-	-	3.4	0.2	-	-	0.2
6-29	0.7	0.1	-	0.9	3.4	-	-	3.4	0.3	-	-	0.3
7-03	0.2	0.1	-	0.3	1.7	<0.1	-	1.7	0.2	-	-	0.2
7-06	0.2	<0.1	-	0.2	0.3	-	-	0.3	-	-	-	-
7-10	0.8	0.3	-	1.0	1.1	<0.1	-	1.1	-	-	-	-
7-13	0.2	-	-	0.2	0.8	-	-	0.8	-	-	-	-
Means	0.4	<0.1	-	0.6	1.8	<0.1	-	1.8	0.1	<0.1	-	0.1
Std. Error				0.067				0.329				0.020

Gizzard Shad

Gizzard shad were abundant throughout the sampling period and were found in both backwater and main channel borders. Mean gizzard shad densities were higher in the main channel than in the backwaters on 7 of 15 sampling dates. No significant difference was evident (sign test, $p > 0.5$). Overall mean densities were 2.5-times higher in main channel sites (1.8 larvae /m^3) as compared to the densities found in the backwaters (0.7 larvae/m^3) (Table 17). This difference was significant (F-test, $p = 0.03$). Peak densities occurred from early to mid-June in both areas.

Mean densities of gizzard shad in the main channel were greater upstream of Little Guano Creek mouth on 8 of the 15 sampling dates. This shows no difference (sign test, $p = 0.5$). The highest overall mean density was 2.2 larvae/m^3 upstream of the backwater mouth while a lower density of 1.4 larvae/m^3 was found downstream of the backwater (Table 18). This difference was not significant (F-test, $p = 0.29$). Peak densities, in both upstream and downstream sites, occurred in early June and again in late June.

No comparisons among backwaters showed any significant difference. Higher shad densities were found in Little Guano Creek on 8 of the 15 days sampled (sign test, $p = 0.5$). The overall mean density was almost 2-times higher in Little Guano Creek (0.9 larvae/m^3) than in Bill's Creek (0.5 larvae/m^3) (F-test, $p = 0.49$) (Table 19). In the two habitats sampled in Little Guano Creek (surface and deep water), deep water mean densities were higher on 8 of the 15 dates sampled (sign test, $p = 0.5$). The overall mean for the deep water samples (1.3 larvae/m^3) was slightly greater than that found in the surface samples (F-test, $p = 0.57$). Peak densities occurred during early June in Little Guano Creek while the highest gizzard shad densities in Bill's Creek were observed during mid-June. Peak densities in the deep samples from Little Guano corresponded with the peak in the Little Guano surface samples.

Table 17. Densities of gizzard shad larvae collected in 0.5-m plankton net (larvae/m^3). A (-) indicates no larvae.

Date	Main Channel Mean				Backwater Mean			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	0.1	-	-	0.1	<0.1	<0.1	-	<0.1
5-29	<0.1	-	-	<0.1	0.4	<0.1	-	0.4
6-01	2.1	-	-	2.1	0.2	-	-	0.2
6-06	3.0	<0.1	-	3.0	1.6	0.1	-	1.7
6-08	10.2	<0.1	-	10.2	0.2	<0.1	-	0.2
6-12	0.7	-	-	0.7	1.7	0.1	-	1.8
6-15	0.3	-	-	0.3	0.1	<0.1	-	0.1
6-19	1.6	<0.1	-	1.6	0.7	1.1	-	1.8
6-22	7.6	-	-	7.6	0.7	0.7	-	1.3
6-26	0.7	-	-	0.7	0.4	0.5	-	0.9
6-29	0.7	<0.1	-	0.7	0.4	0.5	-	0.9
7-03	-	-	-	-	0.2	0.5	-	0.7
7-06	<0.1	<0.1	-	<0.1	<0.1	<0.1	-	0.1
7-10	0.1	-	-	0.1	-	-	-	-
7-13	<0.1	-	-	<0.1	-	<0.1	-	<0.1
Means	1.8	<0.1	-	1.8	0.4	0.2	-	0.7
Std. Error				0.365				0.156

Table 18. Densities of gizzard shad larvae collected in 0.5-m plankton net (larvae/m^3). A (-) indicates no larvae.

Date	Downstream Main Channel Border				Upstream Main Channel Border			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	0.1	-	-	0.1	<0.1	-	-	<0.1
5-29	<0.1	-	-	<0.1	<0.1	-	-	<0.1
6-01	2.7	-	-	2.7	1.5	-	-	1.5
6-06	0.8	-	-	0.8	5.2	<0.1	-	5.2
6-08	6.7	-	-	6.7	13.7	0.1	-	13.7
6-12	0.4	-	-	0.4	1.0	-	-	1.0
6-15	0.2	-	-	0.2	0.4	-	-	0.4
6-19	0.4	-	-	0.4	2.7	0.1	-	2.8
6-22	9.3	-	-	9.3	5.9	-	-	5.9
6-26	0.4	-	-	0.4	1.0	-	-	1.0
6-29	0.1	-	-	0.1	1.2	<0.1	-	1.2
7-03	-	-	-	-	-	-	-	-
7-06	<0.1	-	-	<0.1	<0.1	<0.1	-<0.1	
7-10	<0.1	-	-	<0.1	0.1	-	-	0.1
7-13	<0.1	-	-	<0.1	-	-	-	-
Means	1.4	-	-	1.4	2.2	<0.1	-	2.2
Std. Error				0.464				0.562

Table 19. Densities of gizzard shad larvae collected in 0.5-m plankton net (larvae/m^3). A (-) indicates no larvae.

	Bill's Creek				Little Guano Surface				Little Guano Deep			
Date	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	-	-	-	-	<0.1	<0.1	-	<0.1	0.4	<0.1	-	0.4
5-29	0.7	<0.1	-	0.8	0.1	-	-	0.1	0.5	-	-	0.5
6-01	-	-	-	-	0.1	-	-	0.1	0.9	<0.1	-	0.9
6-06	0.1	0.1	-	0.2	3.1	0.1	-	3.3	8.2	0.2	-	8.4
6-08	<0.1	<0.1	-	0.1	0.3	0.1	-	0.3	2.6	0.4	-	3.0
6-12	<0.1	<0.1	-	0.1	3.3	0.2	-	3.5	1.3	<0.1	-	1.4
6-15	<0.1	-	-	<0.1	0.1	0.1	-	0.2	1.0	0.1	-	1.1
6-19	0.9	1.8	-	2.7	0.5	0.4	-	0.9	1.4	0.2	-	1.5
6-22	0.2	0.5	-	0.8	1.1	0.8	-	1.9	1.7	0.3	-	1.9
6-26	0.2	0.2	-	0.4	0.6	0.8	-	1.4	0.3	0.2	-	0.4
6-29	0.2	0.7	-	0.9	0.5	0.4	-	0.9	0.3	0.1	-	0.4
7-03	0.1	0.2	-	0.3	0.2	0.8	-	1.1	0.1	<0.1	-	0.1
7-06	-	<0.1	-	<0.1	0.1	0.1	-	0.2	-	-	-	-
7-10	-	-	-	-	-	-	-	-	-	-	-	-
7-13	-	<0.1	-	<0.1	-	-	-	-	<0.1	-	-	<0.1
Means	0.2	0.2	-	0.5	0.7	0.3	-	0.9	1.2	0.1	-	1.3
Std. Error				0.123				0.269				0.345

Gizzard shad in the 0-10mm and 10+mm size classes were collected in both backwater and main channel habitats. Larger gizzard shad larvae (10+mm) were collected upstream of the backwater mouth while none were found downstream. While gizzard shad larvae, as a whole, were more abundant in the main channel, larger shad (10+mm) were much more numerous in backwaters (0.2 larvae/m^3) than in the main channel (<0.1 larvae/m^3), and made up approximately one-third of the gizzard shad collected in the backwaters. The size distribution of gizzard shad in the two backwaters did not differ significantly for the 0-10mm or the 10+mm larvae (F-test, $p=0.98$ and $p=0.13$, respectively). However, the peak densities did differ with the 0-10mm and 10+mm larvae in Bill's Creek peaking simultaneously in mid-June, while the 0-10mm larvae in Little Guano Creek had highest densities in early to mid-June and the 10+mm larvae peaked in late June. The gizzard shad larvae collected in the deep water samples were primarily 0-10mm (1.2 larvae/m^3). With a p-value approximately equal to 0.1, the difference in 0-10mm larvae between the surface and deep water samples is not significant. The peak densities for gizzard shad in the deep water areas coincided with those in the surface samples.

Gizzard shad were occasionally collected in the dropbox in small numbers in the silt habitat. These shad were captured from early to late June. As with the emerald shiner, I expected this trend due to the pelagic nature of the gizzard shad. Therefore, when they do appear in shallow water, they are found only in the open water of the silt habitat.

Cyprinids (excluding emerald shiners)

Cyprinids, other than emerald shiners, were common throughout the sampling period and had greater densities in the backwaters on 8 of the 15 sampling dates. This shows no significant difference (sign test, $p=0.5$). Although higher densities occurred in the backwaters the

majority of the time, the highest overall mean density was found in the main channel, 0.9 larvae/m^3, as compared to 0.6 larvae/m^3 for the backwaters (Table 20). This difference was not significant (F-test, $p=0.12$). The highest densities were observed in mid-June in the backwaters and in late June to early July in the main channel borders.

Of the main channel borders, the higher density was found upstream of the Little Guano Creek mouth on 9 of the 15 dates sampled. This was not a significant difference (sign test, $p=0.30$). The overall mean density for cyprinids was greatest in the area upstream of the backwater mouth (1.1 larvae/m^3) while the downstream density was only slightly less (0.8 larvae/m^3) and was not significantly different (F-test, $p=0.35$) (Table 21). Highest densities were observed in late June and early July in both locations.

Of the 2 backwaters, higher mean densities were found in Bill's Creek on 10 of 13 dates sampled. This is a significant difference (sign test, $p=0.046$). The peak density was observed earlier in Bill's Creek than in Little Guano Creek (mid-June as opposed to late June and early July). The overall mean density for cyprinids was also greater in Bill's Creek (1.1 larvae/m^3) than in Little Guano Creek (0.3 larvae/m^3) (Table 22). This proved to be significant (F-test, $p=0.03$). Densities in the Little Guano Creek deep water samples were higher than those found in the surface samples on only 6 of the dates sampled. This showed no evident difference during the period (sign test, $p>0.5$). The overall mean density was just less than in the surface samples (0.2 larvae/m^3). This was not significantly different (F-test, $p=0.75$).

Overall mean densities of cyprinids taken in the dropbox were low for all three habitats: sand (<0.1 larvae/0.1 m^3), silt (0.4 larvae/0.1 m^3), and emergent vegetation (0.2 larvae/0.1 m^3) (Table 23). (Due to low densities, no tests were performed on these data.) In the sand, cyprinids occurred only on June 19 and were 10+mm larvae. In the emergent vegetation, primarily juveniles were collected and appeared from late June into mid-July. Most cyprinids captured in the dropbox were found in the silt habitat and were equally divided between the size classes with the larger larvae appearing later in the year.

Table 20. Densities of cyprinid larvae collected in 0.5-m plankton net (larvae/m^3). A (-) indicates no larvae.

Date	Main Channel Mean				Backwater Mean			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	<0.1	-	-	<0.1	0.1	-	-	0.1
5-29	0.1	-	-	0.1	0.2	-	-	0.2
6-01	<0.1	-	-	<0.1	-	-	-	-
6-06	0.5	-	-	0.5	0.5	-	-	0.5
6-08	0.2	-	-	0.2	0.3	-	-	0.3
6-12	0.2	-	-	0.2	0.9	-	-	0.9
6-15	0.2	-	-	0.2	1.0	-	-	1.0
6-19	0.2	-	-	0.2	1.5	-	-	1.5
6-22	1.3	-	-	1.3	0.5	-	-	0.5
6-26	3.3	-	-	3.3	0.4	<0.1	-	0.5
6-29	1.3	-	-	1.3	1.4	-	-	1.4
7-03	2.7	-	-	2.7	0.6	<0.1	-	0.6
7-06	1.2	-	-	1.2	0.5	-	-	0.5
7-10	0.4	-	-	0.4	0.8	-	-	0.8
7-13	2.4	-	-	2.4	0.5	<0.1	-	0.5
Means	0.9	-	-	0.9	0.6	<0.1	-	0.6
Std. Error				0.187				0.160

Table 21. Densities of cyprinid larvae collected in 0.5-m plankton net (larvae/m^3). A (-) indicates no larvae.

Date	Downstream Main Channel Border				Upstream Main Channel Border			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	<0.1	-	-	<0.1	-	-	-	-
5-29	<0.1	-	-	<0.1	0.1	-	-	0.1
6-01	<0.1	-	-	<0.1	<0.1	-	-	<0.1
6-06	0.4	-	-	0.4	0.6	-	-	0.6
6-08	0.2	-	-	0.2	0.1	-	-	0.1
6-12	<0.1	-	-	<0.1	0.3	-	-	0.3
6-15	<0.1	-	-	<0.1	0.3	-	-	0.3
6-19	0.3	-	-	0.3	0.2	-	-	0.2
6-22	2.0	-	-	2.0	0.6	-	-	0.6
6-26	3.9	-	-	3.9	2.8	-	-	2.8
6-29	0.8	-	-	0.8	1.8	-	-	1.8
7-03	2.1	-	-	2.1	3.4	-	-	3.4
7-06	0.8	-	-	0.8	1.5	-	-	1.5
7-10	0.3	-	-	0.3	0.5	-	-	0.5
7-13	1.0	-	-	1.0	3.8	-	-	3.8
Means	0.8	-	-	0.8	1.1	-	-	1.1
Std. Error				0.139				0.402

Table 22. Densities of cyprinid larvae collected in 0.5-m plankton net (larvae/m^3). A (-) indicates no larvae.

	Bill's Creek				Little Guano Surface				Little Guano Deep			
Date	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	-	-	-	-	<0.1	-	-	<0.1	-	-	-	-
5-29	0.3	-	-	0.3	<0.1	-	-	<0.1	<0.1	-	-	<0.1
6-01	-	-	-	-	-	-	-	-	<0.1	-	-	<0.1
6-06	0.4	-	-	0.4	0.5	-	-	0.5	0.4	-	-	0.4
6-08	0.3	-	-	0.3	0.3	-	-	0.3	0.4	-	-	0.4
6-12	1.7	-	-	1.7	0.1	-	-	0.1	0.2	-	-	0.2
6-15	1.9	-	-	1.9	0.2	-	-	0.2	0.3	-	-	0.3
6-19	2.9	-	-	2.9	0.1	-	-	0.1	0.1	-	-	0.1
6-22	0.5	-	-	0.5	0.2	<0.1	-	0.4	0.4	-	-	0.4
6-26	0.5	-	-	0.5	0.4	<0.1	-	0.4	0.1	-	-	0.1
6-29	2.2	-	-	2.2	0.6	-	-	0.6	0.3	-	-	0.3
7-03	0.3	<0.1	-	0.3	0.8	-	-	0.8	0.3	-	-	0.3
7-06	0.6	-	-	0.6	0.5	-	-	0.5	0.1	-	-	0.1
7-10	1.6	-	-	1.6	<0.1	-	-	<0.1	0.2	<0.1	-	0.2
7-13	0.7	<0.1	-	0.7	0.2	-	-	0.2	0.2	-	-	0.2
Means	0.9	<0.1	-	1.1	0.3	<0.1	-	0.3	0.2	<0.1	-	0.2
Std. Error				0.231				0.112				0.067

Table 23. Densities of cyprinid larvae collected in 1-m² dropbox (larvae/0.1 m³). A (-) indicates no larvae.

Date	Sand Substrate				Silt Substrate				Vegetation			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	-	-	-	-	-	-	-	-	-	0.2	-	0.2
5-29	-	-	-	-	-	-	-	-	-	-	-	-
6-01	-	-	-	-	-	-	-	-	-	-	-	-
6-06	-	-	-	-	0.3	-	-	0.3	-	-	-	-
6-08	-	-	-	-	-	0.1	-	0.1	-	-	-	-
6-12	-	-	-	-	-	0.1	-	0.1	-	-	-	-
6-15	-	-	-	-	-	0.1	-	0.1	-	-	-	-
6-19	-	0.2	-	0.2	0.4	0.8	0.1	1.3	-	-	-	-
6-22	-	-	-	-	-	-	-	-	-	-	0.6	0.6
6-26	-	-	-	-	-	0.1	-	0.1	-	-	-	-
6-29	-	-	-	-	-	-	-	-	-	-	-	-
7-03	-	-	-	-	0.2	0.2	0.7	1.0	-	-	-	-
7-06	-	-	-	-	-	-	-	-	-	-	0.3	0.3
7-10	-	-	-	-	0.4	0.5	1.1	2.1	-	-	-	-
7-13	-	-	-	-	-	-	0.8	0.8	-	-	1.5	1.5
Means	-	<0.1	-	<0.1	0.1	0.1	0.2	0.4	-	<0.1	0.2	0.2

Percids

Percids appeared rarely in the plankton net samples and, thus, densities were too low to discern any trends in the data. The few percids collected in the plankton net were lumped into the Other Taxa section. However, larval percids, primarily *Etheostoma nigrum*, were common in the sand habitat sampled by the dropbox. Therefore, these percid larvae collected by the dropbox in the shallow water habitats were separated out from the gross category of Other Taxa for analyses. These percid larvae did not appear in the silt and emergent vegetation. The overall mean density for the sand habitat was 0.5 larvae/0.1 m^3 (Table 24). Peak densities occurred in early June with the percids disappearing completely by late June.

All three size classes were present in the sand habitat with juveniles having the highest density (0.4 larvae/0.1 m^3) followed by 10+mm larvae (0.2 larvae/0.1 m^3) and 0-10mm larvae (<0.1 larvae/0.1 m^3). The smaller larvae peaked in late May while the juveniles had peak densities in mid-June.

Other Taxa

Taxa, other than the aforementioned, were lumped into one gross category due to low densities. These Other Taxa occurred more often in the main channel borders than in the backwaters but densities in both areas were extremely low (0.1 larvae/m^3 in the main channel and <0.1 larvae/m^3 in the backwaters) (Table 25). These other taxa were made up of crappie, *Ictiobus* spp., freshwater drum, common carp. (Note: Percids, probably not *Etheostoma nigrum*, were included in the plankton net estimates but not in the dropbox estimates.)

Table 24. Densities of percid larvae collected in 1-m² dropbox (larvae/0.1 m³). A (-) indicates no larvae.

Date	Sand Substrate				Silt Substrate				Vegetation			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	-	-	-	-	-	-	-	-	-	-	-	-
5-29	0.3	0.7	-	1.0	-	-	-	-	-	-	-	-
6-01	-	0.7	0.4	1.1	-	-	-	-	-	-	-	-
6-06	-	1.1	2.2	3.3	-	-	-	-	-	-	-	-
6-08	-	-	0.2	0.2	-	-	-	-	-	-	-	-
6-12	-	-	-	-	-	-	-	-	-	-	-	-
6-15	-	-	1.8	1.8	-	-	-	-	-	-	-	-
6-19	-	-	0.6	0.6	-	-	-	-	-	-	-	-
6-22	-	-	0.3	0.3	-	-	-	-	-	-	-	-
6-26	-	-	-	-	-	-	-	-	-	-	-	-
6-29	-	-	-	-	-	-	-	-	-	-	-	-
7-03	-	-	-	-	-	-	-	-	-	-	-	-
7-06	-	-	-	-	-	-	-	-	-	-	-	-
7-10	-	-	-	-	-	-	-	-	-	-	-	-
7-13	-	-	-	-	-	-	-	-	-	-	-	-
Means	<0.1	0.2	0.4	0.5	-	-	-	-	-	-	-	-

Table 25. Densities of other larvae collected in 0.5-m plankton net (larvae/m^3). A (-) indicates no larvae.

	Main Channel Mean				Backwater Mean			
Date	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	<0.1	-	-	<0.1	0.1	-	-	0.1
5-29	<0.1	-	-	<0.1	<0.1	-	-	<0.1
6-01	<0.1	-	-	<0.1	-	-	-	-
6-06	<0.1	-	-	<0.1	-	-	-	-
6-08	<0.1	-	-	<0.1	-	-	-	-
6-12	0.1	-	-	0.1	-	<0.1	-	<0.1
6-15	-	-	-	-	<0.1	-	-	<0.1
6-19	0.1	-	-	0.1	-	-	-	-
6-22	<0.1	-	-	<0.1	-	-	-	-
6-26	<0.1	-	-	<0.1	-	-	-	-
6-29	-	-	-	-	-	-	-	-
7-03	<0.1	-	-	<0.1	-	-	-	-
7-06	-	-	-	-	-	-	-	-
7-10	-	-	-	-	-	-	-	-
7-13	-	-	-	-	-	-	-	-
Means	<0.1	<0.1	-	<0.1	<0.1	-	-	<0.1

In the main channel borders, these other taxa had equally low densities in both the upstream and downstream sites (<0.1 larvae /m^3)(Table 26). Within the backwaters, these taxa were present occasionally into early June but only in small numbers (<0.1 larvae/m^3) (Table 27).

Mean densities for the less abundant taxa sampled in the dropbox were highest in the emergent vegetation habitat (1.3 larvae/0.1 m^3) followed by sand (0.5 larvae/0.1 m^3) and silt (0.2 larvae/0.1 m^3) (Table 28). These densities, however, are somewhat misleading because the other taxa occurred only early in the sampling period and, when present, occurred in large numbers. The taxa represented in these dropbox estimates were primarily *Ictiobus* species (0-10mm and 10+mm) and one yellow bullhead juvenile (*Ictalurus natalis*). Most of these other taxa were in the 10+mm size class.

Table 26. Densities of other larvae collected in 0.5-m plankton net (larvae/m^3). A (-) indicates no larvae.

Date	Downstream Main Channel Border				Upstream Main Channel Border			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	-	-	-	-	<0.1	-	-	<0.1
5-29	<0.1	-	-	<0.1	<0.1	-	-	<0.1
6-01	<0.1	-	-	<0.1	<0.1	-	-	<0.1
6-06	<0.1	-	-	<0.1	<0.1	-	-	<0.1
6-08	<0.1	-	-	<0.1	<0.1	-	-	<0.1
6-12	<0.1	-	-	<0.1	0.1	-	-	0.1
6-15	-	-	-	-	-	-	-	-
6-19	<0.1	-	-	<0.1	0.1	-	-	0.1
6-22	<0.1	-	-	<0.1	-	-	-	-
6-26	<0.1	-	-	<0.1	-	-	-	-
6-29	-	-	-	-	-	-	-	-
7-03	<0.1	-	-	<0.1	-	-	-	-
7-06	-	-	-	-	-	-	-	-
7-10	-	-	-	-	-	-	-	-
7-13	-	-	-	-	-	-	-	-
Means	<0.1	-	-	<0.1	<0.1	-	-	<0.1

Table 27. Densities of other larvae collected in 0.5-m plankton net (larvae/m^3). A (-) indicates no larvae.

Date	Bill's Creek				Little Guano Surface				Little Guano Deep			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	-	-	-	-	<0.1	-	-	<0.1	-	-	-	-
5-29	<0.1	-	-	<0.1	<0.1	-	-	<0.1	-	-	-	-
6-01	-	-	-	-	-	-	-	-	-	-	-	-
6-06	-	-	-	-	-	-	-	-	-	-	-	-
6-08	-	-	-	-	-	-	-	-	-	-	-	-
6-12	-	<0.1	-	<0.1	-	-	-	-	-	-	-	-
6-15	-	-	-	-	<0.1	-	-	<0.1	-	-	-	-
6-19	-	-	-	-	-	-	-	-	-	-	-	-
6-22	-	-	-	-	-	-	-	-	-	-	-	-
6-26	-	-	-	-	-	-	-	-	-	-	-	-
6-29	-	-	-	-	-	-	-	-	-	-	-	-
7-03	-	-	-	-	-	-	-	-	-	-	-	-
7-06	-	-	-	-	-	-	-	-	-	-	-	-
7-10	-	-	-	-	-	-	-	-	-	-	-	-
7-13	-	-	-	-	-	-	-	-	-	-	-	-
Means	<0.1	<0.1	-	<0.1	<0.1	-	-	<0.1	-	-	-	-

Table 28. Densities of other larvae collected in 1-m² dropbox (larvae/0.1 m³). A (-) indicates no larvae.

Date	Sand Substrate				Silt Substrate				Vegetation			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	-	-	-	-	-	-	-	-	-	-	-	-
5-29	0.3	7.2	-	7.6	-	0.3	-	0.3	-	8.1	0.3	8.4
6-01	-	-	-	-	-	-	-	-	-	7.9	-	7.9
6-06	-	-	-	-	-	-	-	-	-	-	-	-
6-08	-	-	-	-	0.2	0.4	-	0.6	-	-	-	-
6-12	-	-	-	-	-	-	-	-	-	-	-	-
6-15	-	-	-	-	-	2.6	-	2.6	-	-	-	-
6-19	-	-	-	-	-	-	-	-	-	3.7	-	3.7
6-22	-	-	-	-	-	-	-	-	-	-	-	-
6-26	-	-	-	-	-	-	-	-	-	-	-	-
6-29	-	-	-	-	-	-	-	-	-	-	-	-
7-03	-	-	-	-	-	-	-	-	-	-	-	-
7-06	-	-	-	-	-	-	-	-	-	-	-	-
7-10	-	-	-	-	-	-	-	-	-	-	-	-
7-13	-	-	-	-	-	-	-	-	-	-	-	-
Means	<0.1	0.5	-	0.5	<0.1	0.2	-	0.2	-	1.3	<0.1	1.3

Discussion

Lepomis

The larvae of *Lepomis* species were found primarily within the backwaters of the Kanawha River as expected. Few larvae were present in the main channel borders. The significance of this difference is reflected in the average densities found in each location. The backwater density (6.2 larvae/m^3) was 20-times greater than the main channel density (0.3 larvae/m^3). Ten of the 12 centrarchids present in the Ohio River (Pearson and Krumholz 1984) are classified as nest spawning lithophils (Balon 1975). Nest spawning lithophils deposit eggs on cleaned rocks or in pits dug in gravel and often provide parental care (Balon 1975). In large rivers, this spawning strategy would be most successful in areas such as backwaters. These lentic areas provide protection for the nests from such phenomena as high water which would wash out the nest. Other studies (Holland 1986b; Sheaffer and Nickum 1986; Hess and Winger 1976) also found *Lepomis* larvae predominantly in the backwaters. In fact, Hergenrader et al. (1982) collected 98% of centrarchid larvae in backwater areas away from the main river. While the spawning strategies of centrarchids may be the reason the larvae are present in the backwaters originally, abundant food is the reason the *Lepomis* larvae remain in the

backwaters. Western (1984) found cladocerans, a primary food for larval bluegills (*L. macrochirus*) (Keast 1978), to be more abundant in the more lentic environments in the main channel over mud substrates. These conditions are also present in the Kanawha River backwaters. He also found rotifers, another possible food source, in these same type areas and found that the numbers of rotifers increased in lentic environments.

While most *Lepomis* larvae were found in backwaters, a few did occur in the main channel borders. Peak densities, however, occurred later in the main channel than in the backwaters. These peaks could have been caused by several factors. The warmer water in the backwaters (Figure 5) possibly allowed early spawning. One highly accepted idea is that the larvae drift from the backwater into the main channel. In this instance, I feel that the *Lepomis* larvae found in the main channel were spawned in the main channel because downstream densities were less than those found upstream of the backwater.

Within the backwater areas, *Lepomis* larvae were found predominantly at the surface. Sheaffer and Nickum (1986) also found high larval *Lepomis* densities at the surface. There are several possible reasons for the larvae using the surface waters: higher temperatures, abundant food, and visibility. Higher temperatures allow the larvae to metabolize food faster and, in conjunction with the abundant food, cause increased growth rates. By growing faster, the larvae become larger and more mobile and, thus, shorten the period of time in which they are the most vulnerable to predation. These higher temperatures may also lead to increases in primary production, which leads to an increase in available food for the larvae. Also, early in the season, the surface layers in the backwaters may be warmer than the water in the main channel. Therefore, the backwaters are at a higher rate of productivity earlier than the rest of the river system. Thus, phytoplankton and zooplankton will be more abundant in the backwaters during the time of year when larvae are most abundant. While food, i.e. zooplankton, is more abundant in the backwater areas as a whole, most zooplankton species migrate downward into deeper water during the day (Wetzel 1975). Western (1984) found that cladocerans in the Kanawha River also exhibited this diel vertical migration. This downward

migration would seemingly make them less available to the larvae at the surface during the period sampled in this study. The high productivity of the backwaters, however, decreases light penetration. Thus, the zooplankton may not migrate as deeply. Wetzel (1975) found shorter diel migration distances in turbid water. Shorter migrations may increase the availability of the zooplankton to the larval fish. Western (1984), however, found greater numbers of herbivorous rotifers in the upper 1 m of water with other rotifers being equally distributed throughout the water column. Thus, the larvae may actively feed on the cladocerans during the crepuscular periods and feed on the rotifers during periods of intense light (i.e. mid-day). The decrease in light penetration associated with the increase in primary productivity also hinders the visibility of larvae to perceive the zooplankton. Blaxter (1986) stated that most larvae feed by sight and require a sufficient amount of light to feed. Thus, visibility could be a limiting factor in the vertical distribution of larvae. During daylight hours, the larvae may have to compromise between high visibility/low zooplankton at the surface or low visibility/high zooplankton deeper in the water column. The energy cost of feeding deeper in the water column could limit the larvae to the upper layers of water where the larvae may possibly switch to the more plentiful rotifers.

Larval *Lepomis* showed definite habitat preferences throughout the sampling period. The habitat used seemed to be a function of the size of the larvae. The smallest larvae (0-10mm) were found primarily in the open water areas over silt substrate. Juvenile *Lepomis* were found exclusively in the emergent vegetation (*Justica* spp.). The movement between these habitats was evident in the locations of the peak densities of the three size classes. The 0-10mm size class peaked in the open water areas in early to mid-June (Figure 9). *Lepomis'* nests were evident in the shallow areas of Little Guano Creek and would account for the numbers of *Lepomis* larvae found in the shallow area. Once the *Lepomis* larvae left the nest, however, they apparently moved into the deeper areas of the backwater. This is seen in the high densities collected at the backwater surface by the plankton net. The 10+mm size class was found predominantly in the shallow open water areas and peaked in mid-June (Figure 9). Only

juvenile *Lepomis* were collected in the emergent vegetation and peaked in mid-July (Figure 10). Thus, the segregation of the peak densities for the three size classes between the different habitats clearly indicates the movement of *Lepomis* between the deeper open water (0-10mm size class) to shallow open water (10+mm) and then to vegetated areas (juveniles). The boxplots of size class density versus percent of vegetation coverage (Figure 11) shows juvenile *Lepomis* associated with highly vegetated areas while 0-10mm larvae are found only in areas with no vegetation. The boxplots of density versus depth (Figure 12) shows the 3 size classes at different depths. The 0-10mm larvae were found in the deeper areas while the juveniles were found only in the shallower habitats. Again, the high densities of 0-10mm *Lepomis* larvae collected at the surface in the deep areas (not included in graph) emphasizes the 0-10mm larvae's abundance in deep water. This graph, however, does not mean that juvenile *Lepomis* prefer shallow water. This association with shallow water is probably due to the fact that the only vegetation available (*Justica* spp.) is in the shallow areas. Nevertheless, these 2 graphs support the movement of *Lepomis* larvae between habitats as suggested by the size-class peak densities.

Studies such as Holland and Huston (1985) and Holland (1986b) also stressed the importance of vegetation in early life stages. Other studies (Keast 1978, Keast 1980, Hall and Werner 1977) observed that the *Lepomis* larvae moved into the deep open-water habitat after leaving the nest but, upon reaching an age of 3-4 weeks, the larvae moved into dense inshore weedbeds. This movement parallels the movement seen in Little Guano Creek. The advantages of moving into vegetation are protection and abundant food. Holland and Huston (1985) also found vegetation provided cover and abundant food. As the larvae mature into juveniles, they become more accessible to predators because of their larger size. Emergent and submergent vegetation provides protection for the juveniles in several ways. The young *Lepomis* are not as visible to predators when hiding in the masses of vegetation. Also, the larvae can escape larger predators by fleeing deeper into the vegetation. Brown and Colgan (1982) observed the use of vegetation for predator avoidance in both bluegills (*L. macrochirus*) and pumpkinseeds

(*L. gibbosus*). The second advantage, abundant food, could be due to larger prey (i.e. invertebrates) living in the vegetation. Wetzel (1975) stated that a rich fauna of macroinvertebrates is commonly associated with the littoral zone. A study conducted by Keast (1980) found that as much as 91% of the diets of larval bluegill and pumpkinseeds (4.5 - 7mm in length) consisted of prey 0.08 - 0.28mm in length. Upon reaching a length of 15 - 20mm (juveniles), only 2% of their diet consisted of prey 0.08 - 0.28mm in length, while prey 1.3 - 2.4mm and greater than 2.4mm in length made up 17% and 24%, respectively. Keast (1978) found cladocerans to be the primary food of young-of-the-year bluegill (24mm in length) but also found that the bluegill preyed upon chironomids and insect nymphs. Western (1984) stated that cladocerans found in river systems such as the Kanawha River are often associated with periphyton during the day. Thus, the juvenile *Lepomis* could be feeding on the cladocerans found in the periphyton around the vegetation. The smaller zooplankton, abundant in the open water areas, are not as economical for the larger juveniles. Therefore, the juveniles move into the vegetated areas and begin feeding on the larger macroinvertebrates, possibly insects. In Bill's Creek backwater, larger *Lepomis* larvae, which were virtually absent in Little Guano Creek plankton net samples, consistently appeared in the surface samples. This phenomenon may be caused by the lack of vegetation in Bill's Creek. Thus, the 10+mm larvae and juveniles are forced to remain in the deeper open-water areas.

In summary, the *Lepomis* larvae are found predominantly in backwater areas. These areas provide suitable spawning sites for many of a navigable river's centrarchids. Upon leaving the nest, the larvae move into the deeper open water areas within the backwater. After reaching the juvenile stage, they return to the shallow areas where they inhabit vegetated areas.

Emerald Shiners

The second most abundant taxon, emerald shiners (*Notropis atherinoides*), was found in the main channel borders. Average densities of emerald shiner larvae were 2-times higher along the main channel borders (2.8 larvae/m^3) than in the backwater areas (1.2 larvae/m^3). Because emerald shiners are pelagic spawners (Balon 1975; Holland 1986b; Pearson and Krumholz 1984; Snyder 1987), this distribution of larvae was expected. Emerald shiners, classified as pelagophils (Balon 1975), have semi-buoyant eggs and larvae which are adapted to highly oxygenated waters (Pearson and Krumholz 1984). Thus, the eggs and larvae are best suited to lotic-type environments such as those found in the main channel areas. Holland and Sylvester (1983a) found that emerald shiners consistently used the main channel. Hess and Winger (1976), however, noted that young emerald shiners were collected at equal densities in both river and backwater habitats. Sheaffer and Nickum (1986) also found emerald shiners to be abundant in both backwater and main channel areas. The backwater in Hess and Winger's study was an inundated creek similar to those found on the Kanawha River. Therefore, there is evidence to suggest that emerald shiner larvae do use some backwaters. In the Kanawha River, the emerald shiners appear to use the main channel area as their primary habitat.

Independent of the habitat, emerald shiner larvae were found predominantly at the surface. Of the average 1.9 larvae/m^3 collected in the Little Guano Creek backwater, only 0.1 larvae/m^3 were found in the deep samples. Sheaffer and Nickum (1986) also found emerald shiners to be the most abundant taxon taken at the surface. The reasons for using the surface layer are the same as those for *Lepomis* larvae: higher temperatures, abundant food, and visibility. Emerald shiners, however, are different in one respect. Because the emerald shiner larvae are pelagic in nature and tend to be semi-buoyant, they may be physically unable to move any deeper in the water column. Thus, in an extremely lentic habitat, the larvae may have trouble

acquiring enough food due to the patchiness of zooplankton and the larvae's lack of mobility. In a lotic habitat, however, the river's flow presumably mixes the larvae and their food so larvae come in contact with larger numbers of zooplankton.

Another effect of the emerald shiner larvae's pelagic nature is seen in their absence in shallow water habitats. No larvae were collected in any of the shallow habitats by the dropbox. The larvae tend to congregate at the surface in the deeper areas. Once the emerald shiner larvae grow larger (10+mm and juveniles), however, they become more numerous in the backwater areas. The larger, more mobile larvae may actively move into the backwater areas or this difference may be due to differential mortality. The backwaters may simply have a higher growth rate than the main channel. Sheaffer and Nickum (1986) found juveniles of all taxa almost exclusively in the backwaters. They felt that once the larvae were able to swim, they moved out of the fast current and into the backwater. By moving into the backwaters, the emerald shiner larvae take advantage of this productive area. The abundant food, slow current, and higher temperatures allow the larvae to find more food, expend less energy, and feed at a higher rate. All of these factors result in faster growth of the larvae.

In summary, emerald shiner larvae while present in both backwater and main channel habitats, prefer the main channel borders. This is probably a result of their pelagic nature. In all habitats, the larvae are found predominantly in the surface layers. The larger larvae are found more often in the backwaters due to several possible reasons: movement, differential mortality, or higher growth rates.

Gizzard Shad

In the Kanawha River, gizzard shad (*Dorosoma cepedianum*) were present in both backwater and main channel habitats. The greatest gizzard shad densities, however, were found in the main channel borders (1.8 larvae/m^3), 2.5-times higher than the density in the backwater (0.7 larvae/m^3). Gizzard shad are believed to spawn in low current backwaters (Holland 1986b; Hess and Winger 1976). The larvae, due to their semi-buoyant nature, are subject to drifting with the current into the main channel (Balon 1975). Holland (1986b), however, felt that the backwaters are the primary habitat for the larvae but juveniles move into the main channel. Sheaffer and Nickum (1986) found gizzard shad to be abundant in backwaters. Hergenrader et al. (1982) also collected more gizzard shad in backwater areas than in main channel areas. The gizzard shad in the Kanawha River were found primarily in the main channel border. This occurrence is opposite that in the studies just mentioned. Odom (1987), whose study also took place in the Winfield Pool, found no difference in gizzard shad densities between the upper and lower main channel sites even though the upper Winfield site has few backwaters. Thus, the gizzard shad must be spawning in both backwater and main channel areas.

Gizzard shad were found rarely in the shallow water areas. In the deep water areas, they were spread throughout the water column. In fact, the gizzard shad density from the deep water Little Guano Creek samples (1.3 larvae/m^3) was greater, although not significantly, than the surface density (0.9 larvae/m^3). Matthews (1984) also found gizzard shad larvae distributed throughout the water column. Odom (1987) found gizzard shad concentrated at mid-depths during daylight hours. Sheaffer and Nickum (1986) found that gizzard shad were abundant in both surface and deep samples taken in the water column. Holland and Sylvester (1983) and Gallagher and Conner (1983) found gizzard shad primarily at the surface. Larval gizzard shad are known to concentrate closer to the surface in periods of turbidity (Matthews 1984).

As stated earlier, Holland (1986b) observed that juveniles move from the backwater into the main channel when schooling behavior develops. The larger (10+mm) gizzard shad in the Kanawha River, however, had highest densities in the backwater area. A few large gizzard shad were collected upstream of the backwater while no large gizzard shad were found downstream. Thus, a movement into the backwater from the main channel areas seems to be taking place. Differential mortality, a possible reason for this occurrence, is not likely in this situation. Because backwaters tend to enhance the productivity downstream of the backwater mouth, the larger gizzard shad should be found in the downstream location rather than the upstream site if differential mortality was affecting the gizzard shad larvae in the main channel. Sheaffer and Nickum (1986) found gizzard shad juveniles to be more abundant in backwater areas than in main channel areas. They also found the greatest densities of juvenile shad at the surface. The distribution in Little Guano Creek was very similar. The larger (10+mm) shad were found in higher densities at the surface.

In summary, the gizzard shad larvae were found predominantly in the main channel borders. These high densities presumably were due to adults spawning in main channel areas. The larvae present in the backwater areas were distributed evenly throughout the water column.

Cyprinids (excluding emerald shiners)

Cyprinids, excluding emerald shiners, were present throughout the year in both backwater and main channel areas. The densities from these two areas (0.9 larvae/m^3 in the main channel and 0.6 larvae/m^3 in the backwater) indicate that both are equally used by cyprinids. Hergenrader et al. (1982) and Holland (1986b) found cyprinids to be more abundant in backwaters than in main channel areas. Sheaffer and Nickum (1986), however, found that three cyprinid groups were more abundant in main channel areas. They found that cyprinids

which could not be included in any of the groups were found in main channel and backwater areas. The discrepancies in these studies could be due to differences in species composition. Sheaffer and Nickum (1986) was the only study which attempted to separate the cyprinids into groups of similar larvae. In the Kanawha River, the cyprinid species composition may be substantially different from that found in the other studies. Several species of cyprinids are common in the Winfield Pool. Species such as river shiner (*Notropis blennius*), spotfin shiner (*N. spilopterus*), mimic shiner (*N. volucellus*), steelcolor shiner (*N. whipplei*), and bluntnose minnow (*Pimephales notatus*) are all common as adults (VPI&SU 1985). Species such as the spotfin shiner spawn in crevices while the bluntnose minnow spawns in a nest on the undersides of submerged objects (Auer 1982). Both also prefer to spawn in areas with shoals. Areas such as this are found only in the upper Winfield Pool. Due to their spawning strategies, the larvae of these species would not be readily accessible to the plankton net except for drift in the main channel. The mimic shiner is thought to spawn in deep areas possibly over weeds. Areas such as those in the lower Winfield Pool, especially in the backwaters, are well suited to this strategy. Thus, the mimic shiner larvae should be found in the plankton net samples taken in both main channel and backwater habitats. Little is known about the spawning strategies of the other cyprinids, river shiner, sand shiner, ghost shiner, and steelcolor shiner, present in the Winfield Pool.

One difference between the backwater and main channel areas on the Kanawha River is the timing of the cyprinid peak densities. The peak density in the backwater areas is noticeably earlier than the peak in the main channel areas. This could be due to the warmer temperatures found in the backwaters. This trend could also be caused by the timing of the various cyprinid spawns. Those which spawn in the backwaters may do so earlier than the species which spawn in the main channel. Holland (1986b) observed similar peak densities in both backwater and main channel areas during mid-June.

Of the two Kanawha River backwaters in the study, Bill's Creek had significantly more cyprinids than Little Guano Creek. There are several possible reasons for this distribution.

First, the culvert on Little Guano Creek may have restricted the entry of the cyprinids into the backwater. The cyprinids were present in both backwaters, as were the emerald shiners. Thus, the culvert did not restrict entry. A second reason may be found in habitat differences between the two backwaters. Little Guano Creek is lentic in nature and has more shallow vegetated areas while Bill's Creek is slightly more lotic with more deep (>1m) water. Therefore, the use of different habitats by the various cyprinids seems to be a logical reason for this difference. Spawning in the backwater tributaries is also a possible reason for the cyprinid distribution. The inflowing creek in Little Guano Creek backwater had no cyprinid larvae present, however. The inflowing creeks in Bill's Creek are not as large as those in Little Guano Creek. Therefore, the tributaries do not appear to visibly affect the cyprinid distribution in either backwater.

Within the backwaters, the cyprinids were equally distributed in all habitats. Floyd et al. (1982) found most cyprinids were distributed in all habitats. The cyprinids were equally abundant in surface and bottom samples. Sheaffer and Nickum (1986) also found unidentified minnows to be equally abundant at the surface and bottom. In the shallow water habitats, the cyprinids were found in all three habitats but were predominantly found in the silt habitat. Holland and Sylvester (1983b) found cyprinids showed slight preferences for littoral areas during most of the day. This wide distribution is probably an artifact of clumping all cyprinids except emerald shiners into one taxa. The different species may be found in specific habitat types. When grouped together, however, they appear in most habitats.

In summary, the cyprinids (excluding emerald shiners) were equally abundant in both backwater and main channel areas. Of the 2 backwaters, cyprinids were more abundant in Bill's Creek than in Little Guano Creek. They were also distributed equally throughout the water column within the backwater.

Other Taxa

Percids, primarily johnny darters (*Etheostoma nigrum*), were found only in the shallow water sand habitat. This area was lotic in nature (an inflowing tributary) with sand and gravel substrate. Thus, the percids' appearance in this habitat was expected. Larger percids (10+mm and juveniles) were found in greater numbers. Floyd et al. (1982) found that some darter larvae, which are spawned in riffles, are undoubtedly washed downstream but are not displaced far. Thus, the percids must be spawning in this general area. Johnny darters, *Etheostoma nigrum*, are classified as guarding speleophils (Balon 1975). Speleophils spawn on the cleaned undersides of rocks and the nest is guarded by the male. With the abundance of cobble-sized rocks present in the sand habitat, johnny darters could have spawned there.

Ictiobus were found in both deep water and shallow water habitats. They were more abundant in the shallow water areas, however. The smallmouth buffalo is the most abundant *Ictiobus* in the Winfield Pool. Little is known about the smallmouth buffalo's breeding habits (Pflieger 1975). Auer (1982) reported that they are thought to spawn in shallows scattering eggs over the substrate or on submerged or floating vegetation. The *Ictiobus* larvae found in this study were concentrated in the shallow, vegetated areas within the backwater. This is in agreement with Auer's findings. Sheaffer and Nickum (1986) found higher densities of *Ictiobus* in the main channel than in backwater areas. Odom (1987) found no difference between *Ictiobus* densities in the upper and lower sections of the Winfield Pool. He felt that this indicated spawning activity in the main channel. I feel that a significant amount of *Ictiobus* spawning takes place in the backwater areas.

Crappie (*Pomoxis* spp.) were found only in the deep water habitats and primarily in the main channel areas. The larvae were small (3-5mm) and probably had been washed out of the nest. Crappie are guarding phytophils that usually spawn in deep water areas (Pflieger 1975;

Holland and Huston, 1983). The other studies with information regarding crappie spawning locations are contradictory. Holland and Huston (1983) and Holland and Sylvester (1983) found highest crappie densities in backwater areas of the Mississippi River with drift into the main channel occurring at dusk. Pearson and Krumholz (1984), however, found that Ohio River backwaters were not used by the crappie. Odom (1987) felt that the crappie in the Kanawha River were also utilizing the main channel areas for spawning. The results of my study are in agreement with Odom's findings.

Freshwater drum (*Aplodinotus grunniens*) appeared only once in the samples. They were collected in the main channel border in low numbers. Other studies are in agreement with this distribution. Odom (1987) found freshwater drum larvae to be abundant in the main channel area but absent in the shoreline areas. Gallagher and Conner (1983) and Holland and Sylvester (1983) found freshwater drum larvae to be essentially absent from backwater and shoreline areas during daylight collections.

Only one larval carp (*Cyprinus carpio*) was collected. It was found in the main channel border. Odom (1987) collected no carp along the shoreline during daylight sampling . They were present, however, in his nocturnal samples along the shoreline and in his nocturnal main channel samples. He also collected larval carp in his bottom daylight samples. Thus, the larval carp appear to remain near the bottom in the main channel areas and move only into the shallows and surface waters after dark.

Stizostedium species, although abundant in the river as adults, were not collected in this study. These species spawn early in the year and the larvae were not present when this study took place.

No *Micropterus* species were collected in this study. While they are abundant throughout the river as adults, no nests or larvae were seen over the duration of the study. Odom (1987) also failed to collect *Micropterus* larvae in any of his main channel or shoreline samples.

Conclusions

The results of this study indicate that the backwaters of the Kanawha River, West Virginia, are important areas for larvae of many species. This importance is evident in the species present in the backwater areas and in the numbers of larger main channel larvae also found in the backwaters.

Kanawha River backwaters are typically the result of dams placed on the river system in order to make it navigable. These dams resulted in many changes in the river. The river is changed from free-flowing to a series of pools grading from lotic to lentic conditions. Also, if the river is heavily travelled, much of the shallow areas along the shore are either destroyed or disturbed through wave action or erosion. However, backwaters are also created by these dams and have the capability of providing large expanses of sheltered areas. After impoundment, the abundance of the fish species present in the river is dependent upon the ability of each species to adapt to the new environment. Species well adapted to lentic environments would benefit while those adapted to lotic habitats would have to adapt or decrease in abundance. The species who have pelagic eggs and/or larvae should have been less impacted by these changes than the nest-building species and were able to continue using the main channel border areas. The nest-building species whose main channel nesting areas may have been disturbed by the navigational changes found the lentic backwater areas to be ideal spawning sites.

In this study, the *Lepomis* species were the most abundant species overall and were found almost exclusively in the backwater areas. Because *Lepomis* are nest-builders, the backwaters have now become their primary spawning areas. The other centrarchids present in the river, primarily *Micropterus* species, are also nest-builders and, although not collected, would also be expected to frequent the backwaters, especially largemouth bass (*Micropterus*

salmoides). Centrarchids are highly-prized gamefish and their adult populations are closely monitored by the state agencies. However, little work has been done with the centrarchid larvae, especially in backwaters. Any future efforts to manage the centrarchid population, especially *Lepomis* species, should include the maintenance of these productive, shallow-water vegetation flats in their plans.

Another important use of Kanawha River backwaters is as a nursery area. In this study, larger larvae and juveniles of many species, including the pelagic species, were more numerous in the backwater areas than in the main channel. This implies that there is some movement from the main channel into the sheltered backwaters with their high productivity (Nielsen et al. 1987). The shallow vegetated areas are important areas within these backwaters. In Little Guano Creek, these areas were used exclusively by juvenile *Lepomis*.

The Kanawha River backwaters appear to support much of the river's centrarchid population as well as acting as a nursery/rearing area for the larvae of many other species. Therefore, the backwaters of the Kanawha River are important for the river's fishes, particularly the centrarchid fishery. Management efforts should be directed toward the preservation and maintenance of the existing backwaters. These sensitive areas are subject to a great deal of sedimentation from entering tributaries. The culvert on Little Guano Creek backwater may also hinder the movement of sediments from the backwater into the main channel; and, thereby, increase the rate at which Little Guano Creek is filling up. It is, however, the warm shallow areas and high productivity which make backwaters so suitable for the *Lepomis* spawners. Another problem of Kanawha River backwaters is the chemical and biological degredation associated with the many industrial and sewage plants located on several of the backwaters. Future efforts must emphasize the clean-up of existing backwaters and the management of the shallow vegetated areas.

The main channel borders appear to be important for early-life stages of the pelagic species. Odom (1987) found densities of up to 2 orders of magnitude higher in these shoreline areas

than in the main channel. The densities in his study were slightly higher than those found in my study; however, this difference may be due to gear avoidance or annual variation. Nevertheless, both studies indicate that the shoreline areas are heavily used by the larvae of several species of fish, primarily those with pelagic eggs or young. The use of the shoreline areas also increases at night (Odom 1987). Species such as carp are collected primarily during this period. Overall, the densities found in the shoreline borders both upstream and downstream of the backwater mouth are comparable to those found in the backwater. The species found in this shoreline zone vary from those found in the backwaters and, thus, indicate the importance of both habitats in the total ecosystem of the Kanawha River.

The shallow littoral zone, which is thought to be used heavily by larvae, was indeed an important area for larval fish in Little Guano Creek backwater. The densities in this shallow area were as much as 10-times greater than the densities found in the productive surface waters of the backwater. *Lepomis* made up the the bulk of the larvae using the shallow littoral zone. Cyprinids, excluding emerald shiners, were common in this area in densities higher than the cyprinid densities found in the surface waters of the Little Guano Creek backwater. The densities of cyprinids collected at the surface in deep water, however, were significantly higher in Bill's Creek than in Little Guano Creek. Perhaps the lack of these shallow vegetated areas in Bill's Creek forced the cyprinids to remain in the surface waters instead of moving into the shallows. *Ictiobus* were also found in this shallow vegetated zone early in the season (May - mid-June).

The distributions of larvae determined in this study indicate that once the larvae of most species become larger and more mobile they become more abundant in the backwaters due to movement, differential mortality, or higher growth rates. Thus, commercial navigation would have little effect on these larvae. The smaller larvae of the pelagic spawners (emerald shiners and gizzard shad) which are found in the main channel borders will have the greatest chance of being affected by the navigation. Because these larvae concentrate so heavily in the shoreline zone, waves generated by the passing barges and drawdown would be the only

navigational impacts which could negatively affect them. The larvae of the freshwater drum, however, which are found primarily in the main channel and not in the shoreline zones are in the sailing line of the barges and may be affected in several ways: impact with the barges, pressure changes, and entrainment into the propwash.

The basic question answered by this study was where are the larvae (i.e. species distribution). Why the larvae were in the specific areas was only speculated. Future studies should deal with this issue. Of the 4 factors influencing the habitats where larvae are found, only spawning strategies and mobility of the larvae were covered in this study. The effects of spawning strategies are well documented and were easily determined. Larval mobility determination was limited to the shallow areas sampled with the dropbox and only larval *Lepomis* movements between the shallow water habitats were determined. Other studies must address these factors in greater detail. A future study might want to restrict entrance to a backwater in order to determine which species are entering the backwater only to spawn and which species are backwater residents. Many studies have documented larval movements between areas and also diel movements. In future studies, these movements should be studied relative to the larval fish's stage of growth in order to determine the habitat preferences of the species.

A question arising in this study was related to the association of larvae with zooplankton. Most larvae feed heavily on zooplankton during their first year of life. Zooplankton, however, migrate deeper in the water column and sometimes into the substrate during the day. Larvae, on the other hand, need a sufficient amount of light to feed. How does the distribution of zooplankton during the periods of daylight and darkness influence the distribution of the larvae of the various species? Migrations of zooplankton are well-documented. The relationship of larval fish movements to zooplankton movements, however, has yet to be fully understood. Predation is a difficult facter to study. While it is known to exist and is observed occasionally, it would be difficult to determine accurately the effects of predation on larval fish. Because of their small size, the larvae are quickly digested in the guts of larger predators.

Thus, one would have to sample often in order to determine the rates of predation on the larvae. The effects of small predators (i.e. *Odonata* spp.) would simply be difficult to determine accurately and would require many hours of observing the larvae in the different environments. A possibility may be to observe the larvae and predators in an enclosure.

No *Micropterus* larvae were collected in this study. They are noticeably absent in many other larval fish studies. Where do they go upon leaving the nest? Potter et al. (1978) collected larval smallmouth bass (*Micropterus dolomieui*) and spotted bass (*M. punctulatus*) in drift nets suspended in the current. Largemouth bass (*M. salmoides*) were not collected in his study, however. A study following the *Micropterus* through their early life stages in a large navigable river system might answer some of these questions.

If this study were to be repeated, several improvements may be in order. A pushnet would likely yield better results than the plankton nets. A pushnet is simply a drift net mounted on a metal frame extending out in front of the boat. A pushnet would probably increase the number of larger larvae captured in the deep water areas because of less time that fish have to react to the sampling gear. Tinsley et al. (1988) stated that pushnets are selective for surface dwelling species. In this study, however, most larvae were on the surface. Therefore, this bias should pose no problem. Thus, using a pushnet would give a more accurate picture of the movements of the early-life stages of the river's fishes. The smaller stages are well-represented in the towed plankton net, however. The pushnet also allows for better control in the area being sampled. Also, a pushnet system has been improved in order to allow for sampling at variable depth (D.C. Hershfeld, pers. comm., U.S. Army Corps of Engineers, Huntington District 1988) Thus, the problem of consistent sampling methods would be minimized. The equipment used for the shallow water habitats, the dropbox, worked well on substrates ranging from fine silt to sand/gravel with interspersed cobble. It also worked well in the emergent vegetation. The size, 1 m^2, made the dropbox a bit cumbersome to use, however. A smaller box, perhaps 0.5 m^2, would be much easier to handle and transport. The smaller size, however, would force the researcher to take more samples from any given area

due to the smaller area of water being sampled. Thus, any future studies using a dropbox should use the largest dropbox that can be handled by the researcher. In this study, I was quite comfortable using the $1m^2$ dropbox.

Improvements could also be made involving the habitats sampled. The shallow water habitats should be sampled more thoroughly. Instead of taking all samples from one transect, it may be best to take samples from all transects; thus, minimizing differences in the habitat transects which are not easily identified by humans. Also, data such as temperature and dissolved oxygen would provide important clues as to why larvae are or are not using an area. Shallow water areas in other backwaters and in the main channel borders, where possible, should also be sampled to gain an accurate picture of the overall importance of Kanawha River backwaters and main channel areas. Improvements could also be made in sampling the deep water areas. Other Kanawha River backwaters and their associated main channel borders should be sampled. Ideally, the backwaters sampled should cover all available types, from those lentic in nature to the more lotic types. This would provide more insight into what types of backwaters are used and by what species. Also, bottom samples should be taken in the main channel borders in order to compare vertical distributions of larvae between the backwater and main channel borders.

A change should also be made in the length and times of the sampling period. Sampling should be started early enough in the year to sample the early spawning taxa such as *Stizostedium* species and some catostomids. Samples should also continue until the numbers of larvae have diminished. The sampling times should also include night samples in order to determine diel distributions.

Overall Conclusions

The backwater areas of the Kanawha River are different from those of the Mississippi River (Nielsen et al. 1986). These inundated creek mouths were observed to be important areas for nest-building species. These backwaters are also used by the larger larvae of the pelagic species. Within the backwaters, larger larvae tend to move to specific habitats. This seems to indicate that these areas are important as nursery and rearing areas for most of the riverine species. And while the backwaters comprise only a small fraction of the total river area, the densities of *Lepomis* within the backwaters, were as much as 20-times higher than those found in the main channel borders and were as much as 300-times those found in Odom's (1987) near shore samples. Thus, the backwaters of the Kanawha River obviously are very important for the nest-building species, primarily *Lepomis* and also for the larger larvae of other species which use backwaters as nursery areas. Efforts should be made to ensure the well-being and continued existence of these productive areas.

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Appendices

Appendix 1. Densities of larvae collected in 1-m^2 dropbox (larvae/m^3). Numbers of species in ( ).

Date	Sand	Silt	Vegetation
5-25	0 (-)	0 (-)	2 (1)
5-29	85 (2)	282 (2)	84 (2)
6-01	11 (1)	6 (1)	79 (1)
6-06	33 (1)	94 (2)	53 (1)
6-08	2 (1)	157 (4)	37 (1)
6-12	0 (-)	123 (3)	7 (1)
6-15	20 (2)	249 (3)	11 (1)
6-19	9 (3)	219 (4)	52 (2)
6-22	6 (2)	35 (1)	80 (2)
6-26	0 (-)	25 (2)	10 (1)
6-29	8 (1)	4 (1)	130 (1)
7-03	13 (1)	39 (2)	0 (-)
7-06	5 (1)	3 (1)	90 (2)
7-10	0 (-)	30 (2)	409 (1)
7-13	2 (1)	8 (1)	356 (2)
Means	13	85	93

Appendix 2. Densities of *Lepomis* larvae collected in 1-m² dropbox (larvae/m³). A (-) indicates no larvae.

Date	Sand Substrate				Silt Substrate				Vegetation			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	-	-	-	-	-	-	-	-	-	-	-	-
5-29	-	-	-	-	227	52	-	279	-	-	-	-
6-01	-	-	-	-	2	-	4	6	-	-	-	-
6-06	-	-	-	-	-	86	5	91	-	-	53	53
6-08	-	-	-	-	46	28	75	150	-	7	30	37
6-12	-	-	-	-	35	67	20	121	-	-	7	7
6-15	-	1	1	2	-	124	99	222	-	-	11	11
6-19	-	-	2	2	55	127	23	204	-	-	14	14
6-22	-	-	4	4	4	19	13	35	-	-	74	74
6-26	-	-	-	-	-	1	23	24	-	-	10	10
6-29	-	-	8	8	-	-	4	4	-	-	130	130
7-03	-	-	13	13	4	13	12	29	-	-	-	-
7-06	-	-	5	5	-	-	3	3	-	-	87	87
7-10	-	-	-	-	-	-	8	8	-	-	409	409
7-13	-	-	2	2	-	-	-	-	-	-	341	341
Means	-	<1	2	2	25	34	19	78	-	<1	78	78

Appendix 3. Densities of cyprinid larvae collected in 1-m^2 dropbox (larvae/m^3). A (-) indicates no larvae.

Date	Sand Substrate				Silt Substrate				Vegetation			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	-	-	-	-	-	-	-	-	-	2	-	2
5-29	-	-	-	-	-	-	-	-	-	-	-	-
6-01	-	-	-	-	-	-	-	-	-	-	-	-
6-06	-	-	-	-	3	-	-	3	-	-	-	-
6-08	-	-	-	-	-	1	-	1	-	-	-	-
6-12	-	-	-	-	-	1	-	1	-	-	-	-
6-15	-	-	-	-	-	1	-	1	-	-	-	-
6-19	-	2	-	2	4	8	1	13	-	-	-	-
6-22	-	-	-	-	-	-	-	-	-	-	6	6
6-26	-	-	-	-	-	1	-	1	-	-	-	-
6-29	-	-	-	-	-	-	-	-	-	-	-	-
7-03	-	-	-	-	2	2	7	10	-	-	-	-
7-06	-	-	-	-	-	-	-	-	-	-	3	3
7-10	-	-	-	-	4	5	11	21	-	-	-	-
7-13	-	-	-	-	-	-	8	8	-	-	15	15
Means	-	<1	-	<1	1	1	2	4	-	<1	2	2

Appendix 4. Densities of percid larvae collected in 1-m^2 dropbox (larvae/m^3). A (-) indicates no larvae.

Date	Sand Substrate				Silt Substrate				Vegetation			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	-	-	-	-	-	-	-	-	-	-	-	-
5-29	3	7	-	10	-	-	-	-	-	-	-	-
6-01	-	7	4	11	-	-	-	-	-	-	-	-
6-06	-	11	22	33	-	-	-	-	-	-	-	-
6-08	-	-	2	2	-	-	-	-	-	-	-	-
6-12	-	-	-	-	-	-	-	-	-	-	-	-
6-15	-	-	18	18	-	-	-	-	-	-	-	-
6-19	-	-	6	6	-	-	-	-	-	-	-	-
6-22	-	-	3	3	-	-	-	-	-	-	-	-
6-26	-	-	-	-	-	-	-	-	-	-	-	-
6-29	-	-	-	-	-	-	-	-	-	-	-	-
7-03	-	-	-	-	-	-	-	-	-	-	-	-
7-06	-	-	-	-	-	-	-	-	-	-	-	-
7-10	-	-	-	-	-	-	-	-	-	-	-	-
7-13	-	-	-	-	-	-	-	-	-	-	-	-
Means	<1	2	4	5	-	-	-	-	-	-	-	-

Appendix 5. Densities of other larvae collected in 1-m^2 dropbox (larvae/m^3). A (-) indicates no larvae.

Date	Sand Substrate				Silt Substrate				Vegetation			
	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total	0-10mm	10+mm	Juvenile	Total
5-25	-	-	-	-	-	-	-	-	-	-	-	-
5-29	3	72	-	76	-	3	-	3	-	81	3	84
6-01	-	-	-	-	-	-	-	-	-	79	-	79
6-06	-	-	-	-	-	-	-	-	-	-	-	-
6-08	-	-	-	-	2	4	-	6	-	-	-	-
6-12	-	-	-	-	-	-	-	-	-	-	-	-
6-15	-	-	-	-	-	26	-	26	-	-	-	-
6-19	-	-	-	-	-	-	-	-	-	37	-	37
6-22	-	-	-	-	-	-	-	-	-	-	-	-
6-26	-	-	-	-	-	-	-	-	-	-	-	-
6-29	-	-	-	-	-	-	-	-	-	-	-	-
7-03	-	-	-	-	-	-	-	-	-	-	-	-
7-06	-	-	-	-	-	-	-	-	-	-	-	-
7-10	-	-	-	-	-	-	-	-	-	-	-	-
7-13	-	-	-	-	-	-	-	-	-	-	-	-
Means	<1	5	-	5	<1	2	-	2	-	13	<1	13

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