An assessment of the prevalence of the bass tapeworm, *Proteocephalus ambloplitis*, and other parasites in five species of basses from river and lake ecosystems in West Virginia.

A thesis presented to the faculty of the graduate school Marshall University

In partial fulfillment of the requirements for the degree Master of Science

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August 1998

This thesis was accepted on August 24 1998
month day year

as meeting the requirement for the Master's Degree.

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ACKNOWLEDGMENTS

I would like to first of all thank the U. S. Corps of Engineers and the West Virginia Division of Natural Resources who have historically worked closely together in the construction and management of the large state reservoir projects. This study is only one of many which brings in entities on a consulting or grant basis to provide expertise that may not reside within the workforce of either the Corps or WVDNR.

I want to acknowledge Dr. George Kincaid of the U. S. Army Corps of Engineers for the gathering and assessment of pertinent data for problem solving and interactions of professionals from multiple agencies.

Cooperation of the WVDNR personnel was essential to the successful completion of this work. For organizing collection efforts of both rotenone and gill netting surveys, I would like to thank Bernard Dowell, Michael Hoeft, Clovis Doerfer, Mike Shingleton, Kevin Yokum, Keith Krantz, and Scott Morrison. Thank you to the remaining half-dozen or so unnamed WVDNR personnel who helped with the collection and sorting of host specimens at all field locations.

It must also be recognized that some collections were made by local anglers. Thank you Greg Perry and several other local anglers for your contributions of basses to this project.

I would like to thank Dr. Tartar for his help on fish anatomy and taxonomy questions, as well as directing me with my thesis project. Work on assembling hosts for storage, host necropsies, record keeping, and collection and preparations of parasites for study was prepared with the aid of research assistants Clara Crank and Frank Chirico.

For the invaluable assistance in administration of grant funds, I would like to thank Kim Wells, Ron Shelling, Rod Phillips, and Mike Donally of the Marshall University Research Corporation.

My deepest respect and gratitude go to Dr. James Joy. Thank you so very much for your advice and guidance in aiding me to pursue a field with which I am fascinated. I also want to thank you for taking the time to go with me to each collection site and confirming identifications of each parasite. Thank you again for all your help, advice, and guidance over the years.

Lastly, I would like to thank my family, in particular my mother, without whose encouragement and love this would not be possible, as well as the support of my sister Rachel Nida and friends.

ABSTRACT

Two-hundred and fifteen basses were collected from four river sites (Racine Locks and Dam; Robert C. Byrd Locks and Dam; Ashland, KY--Ohio River; London Locks and Dam--Kanawha River) and five reservoir sites (Beech Fork Lake, East Lynn Lake, Summersville Lake, Burnsville Lake, and Stonewall Jackson Lake,). The five species of bass caught were: largemouth bass, *Micropterus salmoides*; smallmouth bass, *Micropterus dolomieui*; spotted bass, *Micropterus punctulatus*; white bass, *Morone chrysops*; and hybrid bass, *Morone chyrsops* x *Morone saxatilis*. Basses were collected by three methods: 1) local anglers (hook and line); 2) gill netting surveys; and 3) rotenone surveys. Collections were made from May 26, 1997 through November 5, 1997. Within these 215 basses, 21 different species of parasites were collected from the gills and viscera. Dominant species were "small form" monogenetic trematodes (i. e. *Clavunculus* sp., *Haplocleidus* sp., and *Urocleidus* sp. combined) from both river and lake hosts; *Bucephalus polymorphus*, a digenetic trematode from river systems; *Proteocephalus ambloplitis* (pleurocercoids), the bass tapeworm from lake systems; and *Neoechinorhynchus* sp., an acanthocephalan also from lake systems. Comparisons were made between infections of hosts in river versus lake systems to determine if there were any correlations between parasite species and types of aquatic ecosystems. Pleurocercoids (i. e. larval stages) of the bass tapeworm *Proteocephalus ambloplitis* were the most destructive parasitic forms, causing extensive fibrosis of the liver and viscera of certain basses, particularly young-of-the-year largemouth bass, and adult smallmouth and spotted basses.

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DESCRIPTION OF THE DIFFERENT GROUPS OF FISH PARASITES

1) **Branchiura:** Louse-like arthropods that are dorsoventrally flattened and ovoid in appearance. Second maxillae modified as two distinct "suction cups" for attaching to the host. Example, *Argulus* sp. the "fish louse."

2) **Copepoda:** With small first antennae and large second antennae modified for attachment to gills of host within the present study. Usually only females with ovisacs are found. Example, *Ergasilus* sp.

3) **Hirudinea:** Flattened dorsoventrally or only slightly flattened; body segmented; anterior and posterior suckers may be larger or smaller than body diameter. Example, the leech, *Piscicola* sp.

4) **Bivalvia:** Larval clams called glochidia that become encapsulated in fins and gills, of fish hosts.

5) **Trematodes-- Monogenea:** Body flattened dorsoventrally; no true suckers; mouth usually opens into muscular pharynx; posterior organ of attachment (haptor) which bears chitinoid hooks or clamps. Example, *Haplocleidus* sp.

6) **Trematodes--Digenea:** Body flattened dorsoventrally; with oral and ventral suckers except in gasterostomes. Young forms (i.e. metacercaria) may resemble adults. Monecious. Example, *Leuceruthrus* sp.

7) **Cestoda:** Bodies flattened dorsoventrally; adults monoecious, segmented; anterior holdfast structure, the scolex, usually bears suckers, hooks, or suctorial grooves. Larval forms contain microscopically conspicuous calcareous concretions; larval scolex identical to that of adult.

8) **Nematoda:** Body cylindrical with rigid cuticle, one or both ends attenuated. May or may not have organs of attachment. Dioecious. Example, *Spinitectus* sp.

9) **Acanthocephala**: Body cylindrical, sometimes slightly flattened. Distinct anterior hook-bearing eversible proboscis used for the attachment to hosts' intestinal wall. Dioecious. Example, *Leptorhynchus* sp.

(modified from Hoffman, 1967)

LIST OF PARASITES FOLLOWED BY HOST ORGAN IN WHICH THEY WERE FOUND IN BASS OF WEST VIRGINIA IN RIVER AND LAKE ECOSYSTEMS

ARTHROPODA

Crustacea (Branchiopoda):

Argulus sp.	Location*: stomach, intestine

Crustacea (Copepoda):

Ergasilus centrachidarum	Location: gills

ANNELIDA

Hirudinea (Rhynchobdellida):

Piscicola sp.**	Location: gills

MOLLUSCA

Bivalvia (Lamellabranchia):

clam glochidium	Location: gills

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*This species is normally found on the body surface of a variety of fish hosts. These host sites are believed to be anomolies; perhaps these individuals were ingested by the host.
**immature

PLATYHELMINTHES

Trematoda (Monogenea):	
small form*	Location: gills
Actinocleidus sp.	Location: gills
Trematoda (Digenea):	
Bucephalus polymorphus	Location: stomach, pyloric caeca, intestine
Leuceruthrus micropteri	Location: intestine
Pisciamphistoma reynoldsi	Location: stomach, intestine
Posthodiplostomulum sp. **	Location: liver, heart
Cestoda (Proteocephaloidea):	
*Proteocephalus ambloplitis***	Location: liver, stomach, pyloric caeca, intestine, pancreas, reproductive structures, heart, swim bladder, mesentery
Proteocephalus ambloplitis	Location: intestines
Cestoda (Pseudophyllidea):	
Bothriocephalus sp.	Location: intestines

**Clavunculus* sp., *Haplocleidus* sp., and *Urocleidus* sp. combined.
**Larval stages: metacercaria for *Posthodiplostomulum* sp.; pleurocercoid for *Proteocephalus ambloplitis*.

ASCHELMINTHES

Nematoda (Spiruroidea):

Camallanus oxycephalus	Location:	stomach, pyloric caeca, intestines, liver, reproductive structures, gills
Spinitectus sp.	Location:	stomach, intestine
Spiroxys sp.	Location:	intestine

Nematoda (Filaroidea):

Philometra sp.*	Location:	liver, mesentery

Nematoda (unidentified):

larval form**	Location:	intestinal lumen, mesenteries

Acanthocephala (Paleoacanthocephala):

Pomphorhynchus bulbocolli	Location:	stomach, intestine
Leptorhynchus sp.	Location:	intestine

Acanthocephala (Eoacanthocephala):

Neoechinorhynchus sp.	Location:	intestine

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*Larval stage

**Unidentified nematode larvae found in host mesenteries and in the lumen of the small intestine. These forms may be different species.

"........very few of us realize the full meaning of conservation. To my mind real conservation implies a thoroughgoing knowledge of the objects to be conserved, coupled with an intelligent application of the factors controlling their preservation. We must possess more knowledge concerning the diseases of the lower animals because it is of prime importance in all conservation programs, in that it may be helpful in preventing great losses of animals which are beneficial to man..."

Fasten (1922)

CHAPTER I

INTRODUCTION

In 1984, studies began in West Virginia on monogenetic trematodes in largemouth bass, *Micropteri salmoides*, at Beech Fork Lake. By 1988, there was an increasing perception among area anglers that Beech Fork Lake was a relatively poor game fishing impoundment. Some large basses were taken from the lake, but these types of catches were infrequent. This perception was not solely in the minds of anglers but also James Woodrum of the West Virginia Division of Natural Resources (WVDNR). Mr. Woodrum expressed concerns that bass populations were not at levels expected for the lake. The view regarding the decline of bass was thought to be that 1) food sources were inadequate and that 2) several winters preceding the spring of 1981 might have resulted in the death of many basses in this relatively shallow impoundment. Because of his extensive field experience and curiosity, Woodrum suspected that disease might be a factor as well, and sought a preliminary survey of native basses for pathogenic parasites (Joy, 1998). Because of the tendency for biologists to discount that which cannot be easily seen, the role that disease agents play in regulating wildlife populations is often overlooked. Parasitic diseases follow a chronic course in which they are responsible for subtle reductions in host growth rates and reproduction which does not trigger noticeable host die-off. We also have to remember that these are naturally occurring organisms and that without these bass hosts they could not survive. Many of these parasites which live within these hosts are usually passed on to birds or mammals. Joy and Madan (1989) worked on the pathology of black bass hepatic tissue infected with larvae of the tapeworm, *Proteocephaus amblopliti*s. They wanted to investigate pleurocercoid induced liver pathology and obtain information on prevalence and intensity of the larval tapeworm infection at Beech Fork Lake. In their findings, there was widespread replacement of liver parenchyma in smaller hosts. Discoloration of the liver due primarily to bile-stasis and blood vessel congestion was recorded for adult basses. The liver was also enlarged in the adults due to host tissue response to the larval tapeworms.

Still, studies of parasitic pathogens of basses are limited to a few locales in West Virginia. Studies have also employed small host sample sizes, and have been confined to brief time frames. Because game fish are important economically, one needs to find pathogens/ diseases that could result in reproductive loss or mortality among the species. The present study involved far more locations, included both rivers and lakes, throughout West Virginia. This report also covers a sevenmonth period, May through November. A comparison between river and lake diseases/ pathogens could aid wildlife biologists and those responsible for managing the states fisheries in finding what role these parasites play in nature.

CHAPTER II

REVIEW OF THE LITERATURE

Many field, laboratory, and theoretical studies have focused primarily on competition or preditor-prey interactions which help to regulate populations and influence geographical distribution of a species (May, 1983). On the other hand, these thoughts of competition or preditor-prey interactions may be interwoven in with the interaction or transmission of diseases, specifically those of parasites. Parasitism plays an important role in limiting growth and reproduction of fish (Bangham, 1928). There are many disease agents (e. g. cestodes-- tapeworms or myxosporidean) that can potentially affect the numbers of bass in lakes and streams. Unfortunately, it is difficult to measure the amount of damage parasitic organisms inflict on their hosts. Occasionally, basses are subject to large die-offs in nature, but in hatchery conditions where monocultures (i.e. same species) crowding large numbers of hosts may increase the risk of parasite epizootics. Almost all bass species of all ages carry parasites. Young fish are especially susceptible to parasitic attacks. If young hosts survive, their growth is retarded and they usually fall prey to larger carnivorous fish (Bangham, 1928). It is of both zoological interest and economical importance to know the parasites of fish in any body of water because so little is known of the effects of parasites and how to treat and prevent infections (Vernard, 1940). Hatcheries may serve as breeding places for parasites, as well as fish. When the fish are distributed from hatcheries among lakes or other game areas parasites may be introduced into new territories. Various groups of fish parasites, and their relationships to hosts, are discussed in the remaining pages of this section.

MONOGENETIC TREMATODES

Monogenetic trematodes are primarily ectoparasites of fishes even though their have been few cases of endoparisitism of these forms reported (Cheng, 1973). Gills are often attacked by these forms which can do considerable damage. Treatment of ectoparasites by the use of weak solutions of alum, copper sulfate, acetic acid can keep the parasites in check and at a reduced number so that no harm will come to the fish. Seven species of such trematodes, in the subfamily *Ancyrocephalinae*, are known from largemouth bass (Joy, 1984). Mizelle and Crane (1964) noted that no more than four of the seven species occured at any one locality. Rawson and Rogers (1972) believed this may be because of competition within species groups or the difficulty encountered in separating these species. Indeed separation of these species is a difficult task. Hoffman (1967) believes that *Urocleidus* sp. and *Haplocleidus* sp. are the same organism. When present in large numbers monogenetics sometimes cause pathologic conditions, especially in those fish kept in captivity (e.g. hatcheries). Life cycles in monogenetic trematodes are short therefore, monogenetics are constantly reproducing. Because of this special adaptation, epizootic outbreaks of this species occurs in hatcheries or confined/ crowded areas of small ponds or lakes (Meyer, 1962).

ARTHROPODS

Ergasilus centrachidarum is a copepod that attaches itself to the host's gills by the use of its second antennae which is formed into a modified claw (Pennak, 1953; Roberts, 1970). Nourishment for this organism is obtained by ingesting tissue from the host, especially the gill filament. Only the adult female is parasitic, immature females and males are free-living (Pennak, 1953; Roberts, 1970). Since Wright first described

E. centrachidarum in 1882, this species has received some attention by various investigators working in southern Canada, the mid western states south to Tennessee and Georgia (Roberts, 1970). That ergasilids have not attracted considerable attention from fisheries biologists is likely due to the fact that they are seldomly associated with fish disease or population declines. Many of the earlier descriptions of species in the genus *Ergasilus*, however, are incomplete, inaccurate, or both (Yamaguti, 1963). Description of these ergasilids was done by Roberts (1970) to gain a better understanding of the synonomy of each species.

Fifteen species of *Argulus* parasitize fresh-water fishes in North America are not usually collected because they leave the fish quickly when pulled from the water and are transparent in color (Pennak,1953; Hugghins, 1972). *Argulus* sp. are not host specific and are commonly referred to as "fish lice" attaching themselves around the gills/ mouth of its host (Roberts and Janovy, 1996; Bangham, 1928). Species of this genus are normally ectoparasites found on the body surface or in the branchial chambers of fishes (Cheng, 1973). They leave their host periodically and become free-swimming to infect other host individuals (Cheng, 1973). These modified arthropods, possess a preoral sting equipped with a poison gland in which it pierces its host to obtain a blood meal. Feeding habits of both male and female argulids, such as ingestion of the hosts' blood and body fluids, causes injuries to the host. In nature, the numbers of parasites are generally sparse so that no serious effects are noticeable (Cheng, 1973). While fish lice are normally of minor importance they occassionally lead to epizootics such as those which occurred in 1956 at both Brant Lake and Lake Poinsette, South Dakota where Hugghins (1972) found up to 805 argulids on a single fish with 300 to 400 argulids common per fish. Hugghins (1972) reported that at Lake Poinsette, 1958, an outbreak of *Argulus* affected and killed hundreds of bigmouth buffalo. Apparently argulids predispose hosts to secondary infections, and mortalities occur as a result of infection with the watermold, *Saprolegnia*. After killing their hosts these parasites leave fish soon after death.

ANNELIDA

Young leeches contain a sucker at each end of the body and often resemble adults. They are ectoparasitic and attach around the gills, fins, or body surface of freshwater fishes. Known to temporarily affect its host when they need to feed and then leaving it, leeches are considered transitory parasites (Hugghins, 1972). Leeches are the largest of the external parasites and if many of these are found on a single host they may greatly weaken it. Very rarely do they attack bass in large numbers. Principal damage of leeches does not result from sucking blood but by sores/ wounds left in the fish which provides for the invasion of fungi and bacteria. One such occurence of leech attack was in Rock River in Illinois where some fish were very thin, while others were bleeding and contained inflamed flesh (Hugghins, 1972).

MOLLUSCA

Larvae of most freshwter clams which are generally oval, roughly triangular, or rounded in shape, must go through a parasitic stage on the gills or fins of fish. Most larvae are brought in by the respiration action, or by the brushing action of the host's fins against the substrate, over the gills and other parts of the body (Pennak, 1953; Meyer, 1962). Larvae become enveloped by the host's inflammatory response after clamping tightly to the gill filament. Parasitism by these organisms lasts from 10-30 days or as long as 190 days. During this time, young feed on superficial tissues and possibly even blood (Cheng, 1973). Young mussels then ruptures out of the cyst drops to the streambed and becomes free-living (Pennak, 1953). Some species of glochidia are found on only particular host, while others have little or no host specificity. If glochidia become numerous within the gills, fish may die due to lack of oxygen (Hoffman, 1967). Glochidia also predisposes the host to secondary bacterial or mycotic infections. Fish hosts may develop an immunity to such infestations and glochidia may be sloughed off before they can complete their development (Cheng, 1973).

The chief damage caused by adult external parasites, such as fish lice, leeches, and monogenetic trematodes, is mechanical injury too the tissues at the point of attachment, which very commonly lead to secondary infections by fungi and bacteria. However, under natural conditions these ectoparasitic organisms rarely occur in great numbers, and they do little harm.

DIGENETIC TREMATODES

Digenetic trematodes; *Bucephalus polymorphus*, *Leuceruthrus micropteri*, *Posthodiplostomulum* sp., and *Pisciamphistoma reynoldsi* are all endoparasites. Not much is known about these forms of digenetics. Life cycles of some species (i.e. *Bucephalus polymorphus*) involve mussels (clams) while in others the life cycle is unknown (i.e. *Pisciamphistoma reynoldsi*) (Hoffman, 1967). *Bucephalus polymorphus* use freshwater mussels as their first intermediate host and fish are the second intermediate and final hosts. This fluke matures in the stomach, pyloric caeca or intestines of the fish host (Hugghins, 1972), although they may be found in almost any organ (Cheng, 1973). *Leuceruthrus micropteri* was first described by Marshall and Gilbert,1905, in largemouth bass. It was later described from black bass of Wisconsin and Indiana by Goldberger in 1911 (Bangham, 1926). Bangham (1926) found both larval forms of this species and gravid adults in the stomach of largemouth and smallmouth basses. This organism was found only from fish taken from Lake Erie not from state hatcheries or streams (Bangham, 1926). Later, a study by Williams (1968) recovered immature *L. micropteri* from the stomachs of young smallmouth blackbass, three days after these bass were fed *Cercaria stephanocauda* Faust. These cercariae were shed by the snail, *Pleurocera acuta* from Tippecanoe River in Indiana. Life history studies of *L. micropteri* were conducted in 1935 by Smith, but escaped the attention of Yamaguti (1958), as well as Hoffman (1967). Virtually nothing is known about *Pisciamphistoma reynoldsi*. The only information on *P. reynoldsi* is that it is a parasite of fishes (Yamaguti, 1958; Schell, 1970). *Posthodiplostomulum* sp. also known as the "white grub" has been recorded from 97 species of freshwater fishes. A parasite primarily from the liver, *Posthodiplostomulum* has been found in other organs (i.e. kidneys and heart) (Hugghins, 1972). The final hosts for *Posthodiplostomulum* sp. are the great blue heron and the black-crowned night heron (Hugghins, 1972). These internal flukes are probably the least harmful of the bass parasites (Bangham, 1928).

CESTODES

While adult tapeworms, which are found in the small intestine, are rarely associated with pathologies in fishes, the larval forms (i.e. pleurocercoids) may cause extensive damage to various internal organs (Bangham, 1928; Joy and Madan, 1989). There are six species found in bass from Ohio, but an individual fish will usually only harbor one species and at most two species at a time (Bangham, 1928). The bass tapeworm, *Proteocephalus ambloplitis* Weinland, 1858, is the most common of these species and does the greatest harm to the host (Wardle et al., 1974). The larval stage forms damages the liver, mesenteries, and reproductive organs and can cause sterilization of adult bass (Bangham, 1928; Bakewell, 1982; McCormick and Stokes, 1982). The distribution of this form is limited in Ohio to bass of Lake Erie and smaller lakes (Bangham, 1928) but is found extensively in basses and other fish species throughout the eastern United States (Hoffman, 1967).

Proteocephaus ambloplitis pleurocercoids appears to be of greatest importance in smallmouth and largemouth basses. In studies by Bangham (1925), fish acquire their infections very early because 80-90% of the food of young basses (i.e. < 40mm) is copepods which harbor the first stage or procercoid tapeworm larva. After attaining lengths exceding 40 mm bass reduce their feeding on these microcrustaceans. Thus reducing their chance of tapeworm infections. The procercoids ingested by young bass mature to larger pleurocercoids and these latter larval stages migrate through various visceral organs doing much damage. Larger basses become infected either by accidently ingesting copepods infected with procercoids, or by feeding on those smaller fish hosts that are carrying pleurocercoids. In the former case, the procercoids mature to pleurocercoids as in smaller basses, and cause tissue damage. In the latter case, the pleurocercoids mature to adults in the intestine of the larger bass (Bangham, 1927).

The bass tapeworm had long been implicated in the reduced spawning success in fishes (Hunter, 1928; Esch and Huffines, 1973). Destruction of the oocytes makes nutrient rich yolk material available to the developing pleurocercoid (McCormick and Stokes, 1982), and initiates an aggressive host inflammatory response that often results in extensive fibrosis (Bakewell, 1982). This inflammatory response, accompanied by blood pooling, has been noted in other visceral organs as well (Joy and Madan, 1989). Reproductive impairment by *P. ambloplitis* infected females, and maybe also males, may be a significant factor in the regulation of game fish populations since Holmes and Mullan (1965), as well as, McCormick and Stokes (1982) have observed that the number of young bass produced in a body of water is inversely correlated with the incidence of the parasite.

Bass from flowing waters are seldomly infected due to absence or fewer numbers of small copepods, in which the cestode egg developes in for the infective stage (Vernard, 1940). As a result breeding stock for hatcheries perhaps should be obtained from streams not lakes.

The first North American record of *Bothriocephalus* was established by Leidy in 1855 but Rudolphi typed the genus *Bothriocephalus* in 1808 (Wardle and McLeod 1968; Kahlil et al., 1994). Species of *Bothriocephalus* are very difficult to distinguish between and are found within a variety of fish hosts. Procercoids (i.e. larval stage) are found in copepods which are eaten by small fish hosts to mature into pleurocercoids. As these pleurocercoids develop into adults, they move into the intestinal tract where they will remain until either the fish host dies or the tapeworm dies (Hugghins, 1972).

NEMATODES

Nematodes or roundworms sometimes prove to be serious pests to certain species of fish. Dolphins parasitized by the nematode genus *Crassicauda* sp. caused lesions on the skulls of dolphins, which resulted in the mortality among young dolphins (Perrin and Powers, 1980). The nematodes in the present study are not believed to cause mortalities among bass.

Camallanous oxycephalus Ward and Magath 1916 is a common parasite of freshwater fishes and is widely distributed throughout eastern North America (Stromberg and Crites, 1975a; Kelly et al., 1989). Even though it is abundant in nature, little is known about its biology. Perhaps the most extensive studies of *C. oxycephalus* are those by Stromberg and Crites (1975a and b) in Ohio. Stromberg and Crites (1975b) showed that *C. oxycephalus* takes blood meals and changes in host physiology, temperature-related or otherwise, may act directly upon these worms. Apparently, female worms protrude form the anus of fish to release infective first stage larvae (Stomberg and Crites, 1975a).

Less common nematodes of fishes are *Spiroxys* sp., *Spinitectus* sp.and *Philometra* sp. *Spiroxys* Schneider, 1866, are found in the stomach of tortoises and intestines of amphibians. The larval form is found in fish (Hoffman, 1967; Yamaguti, 1961). *Spinitictus* Fourment 1883 is parasitic in the stomach and intestines of fishes and frogs (Hoffman, 1967); whereas, *Philometra* Costa 1845 is parasitic in body cavities or tissues of fishes (Yamaguti, 1961). Not much is known about these organisms or the harm they may or may not cause to their hosts.

Infection patterns of helminths in fish populations are influenced by the availability of infective larvae, feeding habits of hosts, mortality of parasites, and abiotic factors such as temperature. The interaction of these factors frequently results in an extreme variability in the prevalence and intensity of infection and overdispersion of parasites in fish populations (Stromberg and Crites, 1975b).

ACANTHOCEPHALANS

The acanthocephalans, or thorny headed worms, live in the intestine of bass with their long spiny heads embedded in the host's intestinal wall. There are often hundreds in one fish, and the damage made by their hooks may cause severe injury to the host. These are among the most common and widely distributed of the bass parasites. Smallmouth bass are usually more heavily infested with these thorny-headed worms than largemouth bass (Bangham, 1928). Protrusible proboscis which is covered with spines is anchored in the tissue lining the host's intestines (Hugghins, 1972). Few of the life cycles of the Acanthocephala of fishes are known (Meyer, 1962). Three species commonly found in freshwater fishes are *Pomphorhynchus bulbocolli*, *Neoechinorhynchus* sp., and *Leptorhynchus* sp.

Pomphorynchus bulbocolli Linkins 1919 contains a spherical bulb between a short proboscis and a long slender neck. Only species of the genus, *Pomphorhynchus*, recorded from North American fishes until Joy, et al. (1986) reported *P. rocci*, a marine or coastal freshwater form, from freshwater drum in the Ohio River. The life cycle of this species is unknown (Hugghins, 1972). *Pomphorhynchus bulbocolli* equally infect all age groups of fishes and remain at fairly constant levels (Joy et al.,1986).

Nineteen species of *Neoechinorhyncus* Hamann, 1892, are presently known from various species of freshwater fish in North America (Amin, 1985; Amin, 1986). In this genus the proboscis is short, globular, armed with small number of hooks. The proboscis is capable of eversion/ retraction (Amin, 1987c). Numerical and structural variations in the giant nuclei attributed to developemental stages in *Neoechinorhynchus* sp. were studied by Amin and Vignieri (1986). Some adults bore through the digestive tract to lie within the body cavity where they become encysted in the viscera, or lodged in other organs such as the liver (Meyer, 1962). Among all the acanthocephalans, *Neoechinorhychus* sp. are the most primitive (Amin, 1987b).

Species of *Leptorhynchus* use a variety of fish hosts, but the most common hosts are basses. Since basses harbor larger numbers of worms and show a higher prevalence of infection, they are regarded as the normal host of this species. Meyer (1962) states that adult worms live in the intestines, especially the pyloric caeca.

Acanthocephalans do damage to host tissues. Pathogenicity is usually presumed on basis of: 1) depth of penetration of the proboscis; and 2) presence of large numbers of worms in a sick or dying animal (Bullock, 1963).

CHAPTER III

DESCRIPTION OF STUDY SITES

Fishes representing two families of basses, Centrarchidae and Percichthyidae, were collected from nine sites in or near West Virginia and examined for parasitic helminths, leeches, molluscs, and arthropods. Target (i. e. host) species were: *Micropterus salmoides*, *M. dolomieui*, *M. punctulatus*, *Morone chrysops*, *M. chrysops* x *M. saxatilis*. Of these nine sites, eight were in waters of West Virginia and the other one in the vicinity of Ashland, Kentucky (Fig. 1). Three of the sites were on the Ohio River (Racine Locks and Dam, Robert C. Byrd Locks and Dam, and Ashland, Kentucky), one site on the Kanawha River (London Locks and Dam), and five U. S. Army Corps of Engineers Reservoir sites (Beech Fork Lake, East Lynn Lake, Summersville Lake, Burnsville Lake, and Stonewall Jackson Lake). The following section offers a brief discussion on the history and characterization of each of these nine sites.

History of Ohio River Basin

In 1540, the Ohio River, a 981-mile course of an unimproved natural river between Pittsburgh, Pennsylvania and Cairo, Illinois, was used by Europeans for transportation of goods. The reason immigrants chose to use this waterway was because it was safer than land trails, which were subject to Indian attacks. There were, however, the accompanying problems of wrecking on rocky rapids, grounding on shallow sand bars, or ramming submerged and unseen snags. British efforts to seize the Ohio River Valley region had begun in 1753, and by 1758 this was accomplished. During periods of adequate water flow, the river was used to trade with the indigenous Indian tribes of the

Figure 1. Collection sites for West Virginia fish parasite survey.

I. River Sites:

Ohio River

1. Racine Locks and Dam (R)
2. Robert C. Byrd Locks and Dam (A)
3. Ashland, KY (A)

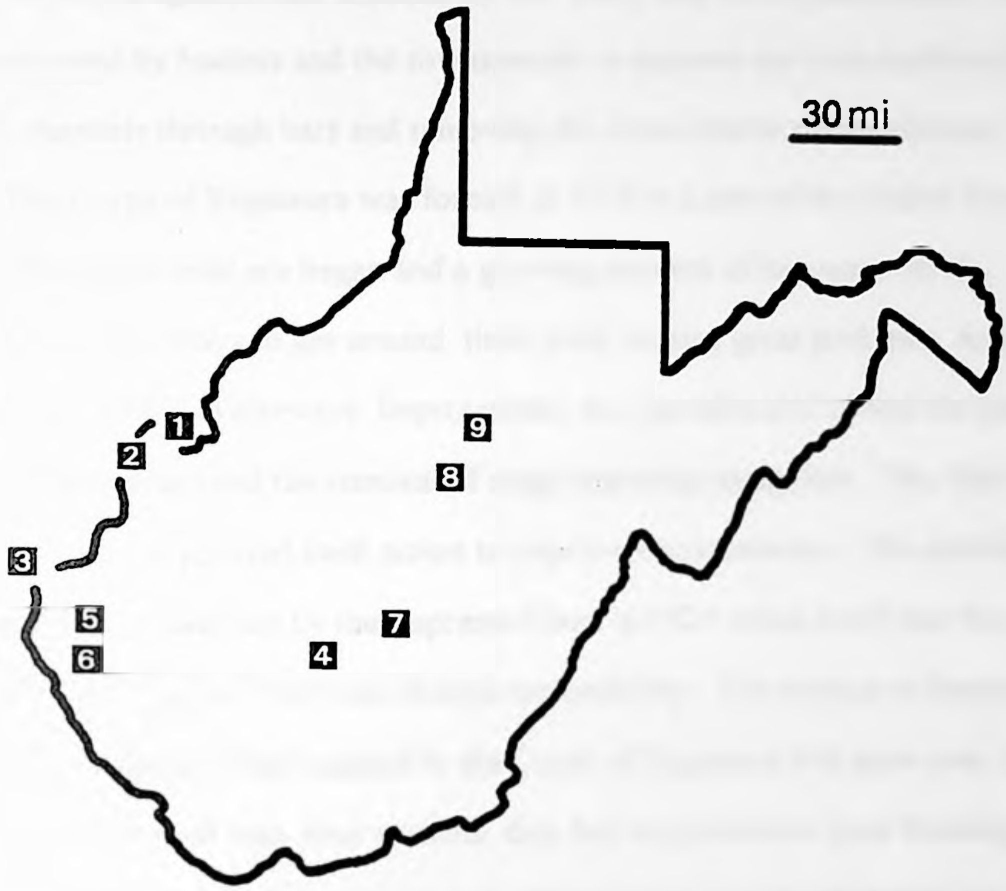
Kanawha River

4. London Locks and Dam (R)

II. Reservoir Sites:

5. Beech Fork Lake (G, R)
6. East Lynn Lake (G)
7. Summersville Lake (G, R)
8. Burnsville Lake (G)
9. Stonewall Jackson Lake (R)

Fish samples were obtained from local anglers (A), gill netting (G), and by rotenone (R) surveys.

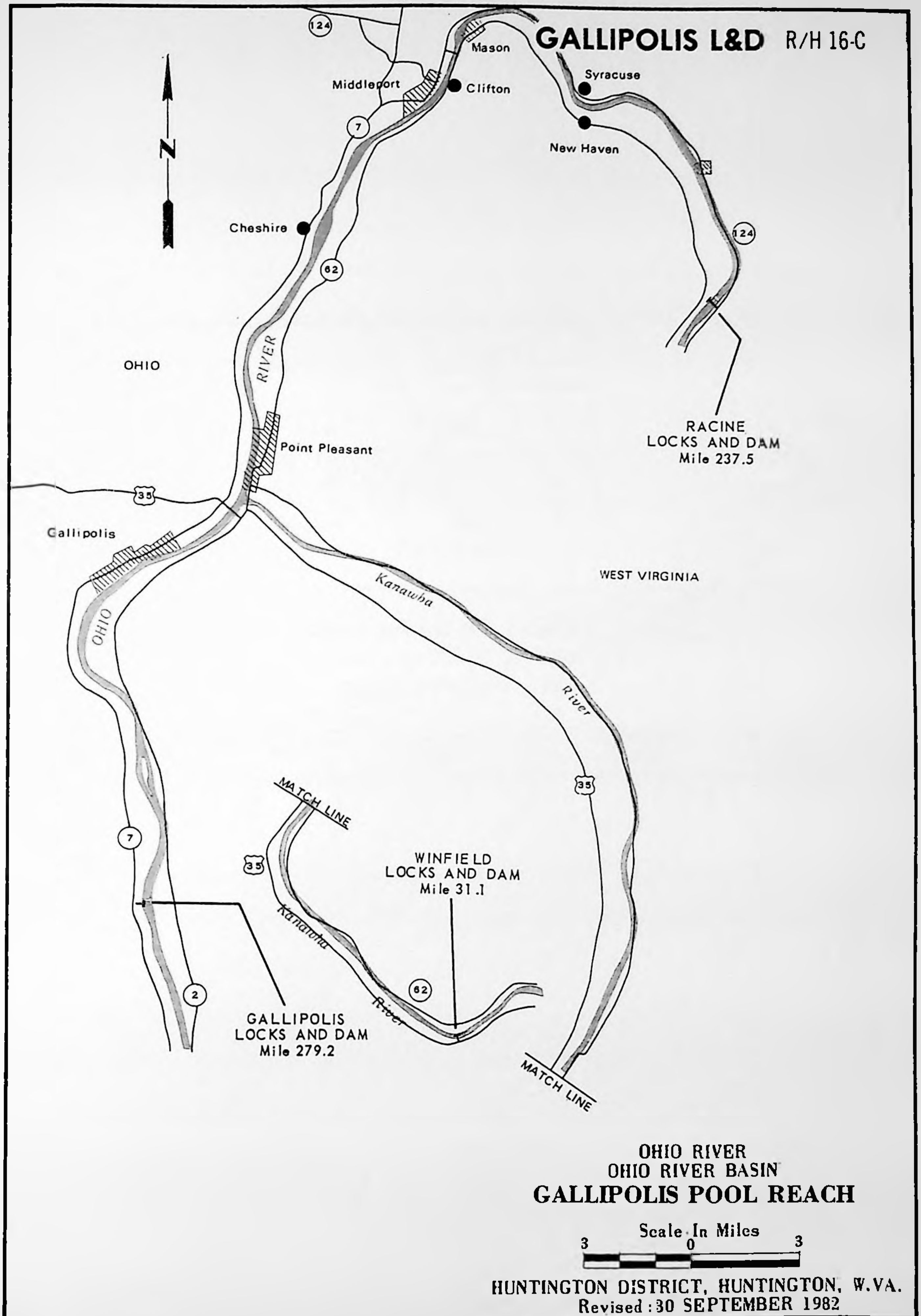

30 mi
1
2
3
4
5
6
7
8
9

region. When navigation was impeded by low water flow in the summertime, many jobs were performed by boaters and the townspeople to improve the river conditions by scraping channels through bars and removing the worst obstructions (Johnson, 1977).

The Corps of Engineers was formed in 1775 as a part of the United States Army. In 1811, the steam boat era began and a growing concern of low water levels, obstructions, and delays to get around them were causing great problems. As a result, by 1824 the first Inland Waterways Improvement Act was allocated to find the best way of coping with sandbars and the removal of snags impeding navigation. The 18th Congress, meeting in 1824, supported swift action to improve transportation. This action was accompanied by a decision by the Supreme Court in 1824 which ruled that the interstate commerce on navigable rivers was federal responsibility. The mission of improving the Ohio River navigation was assigned to the Corps of Engineers that same year. Because most towns were built near river systems, they had no protection from flooding. Flood victims in 1832 believed there was no way of preventing floods and had to use their own resources in recovering and rebuilding after flood events. In 1850, Charles Ellot advocated the use of reservoirs for the prevention, or mitigation, of extensive flooding. Ellot was not taken seriously at the time. In 1898, Congress approved the use of flood walls and levees to control flooding of towns (Johnson, 1977).

The idea of levees and dams to control floods was put into practice in the early 1900's. Dams were characterized by the use of wickets which were lowered and raised by a crew of men which took 2 hours to lower and 6 hours to raise, but only if conditions were optimum, to control severe flooding (Johnson, 1977). In 1922, the Huntington district was formed. It is responsible for 45,000 square miles in parts of five states West Virginia, Kentucky, Virginia, Ohio, and North Carolina. The first project of a dam and

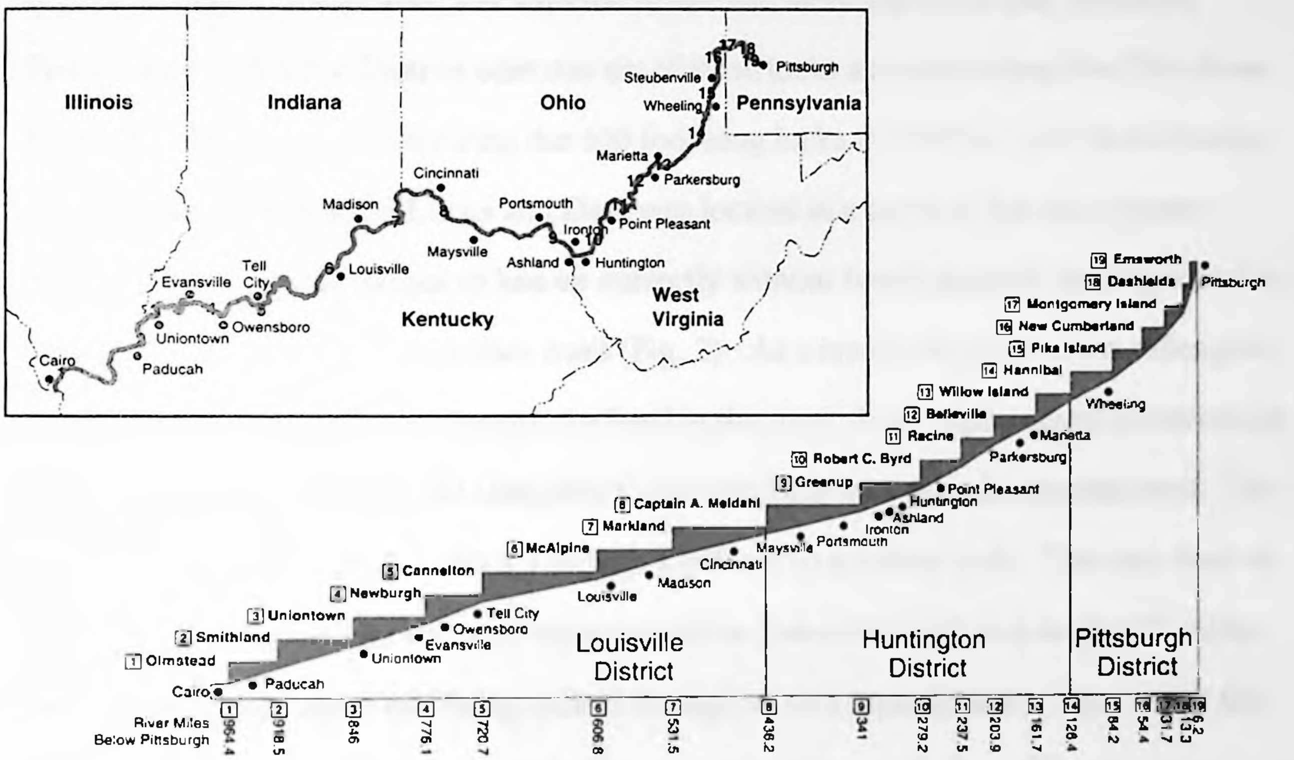
Figure 2. The decommissioned Gallipolis Locks and Dam (Source: U. S. Army Corps of Engineers, 1988).



OHIO RIVER
OHIO RIVER BASIN
GALLIPOLIS POOL REACH

HUNTINGTON DISTRICT, HUNTINGTON, W.VA.
Revised : 30 SEPTEMBER 1982

Figure 3. Various Locks and Dams within U. S. Army Corps of Engineers Ohio River jurisdiction (Source: U. S. Army Corps of Engineers, Huntington District).


Illinois
Indiana
Ohio
Pennsylvania
Kentucky
West Virginia
Pittsburgh
Steubenville
Wheeling
Marietta
Parkersburg
Point Pleasant
Huntington
Ironton
Ashland
Portsmouth
Maysville
Cincinnati
Madison
Louisville
Tell City
Evansville
Owensboro
Uniontown
Paducah
Cairo
Emsworth
Dashields
Montgomery Island
New Cumberland
Pike Island
Hannibal
Willow Island
Belleville
Racine
Robert C. Byrd
Greenup
Captain A. Meldahl
Markland
McAlpine
Cannelton
Newburgh
Uniontown
Smithland
Olmstead
Louisville District
Huntington District
Pittsburgh District
River Miles Below Pittsburgh
964.4
918.5
846
776.1
720.7
606.8
531.5
436.2
341
279.2
237.5
203.9
161.7
126.4
84.2
54.4
31.7
13.3
6.2

reservoir occurred in 1932 by Fred W. Herman to Congress (Bluestone Dam and Reservoir now Bluestone Lake) (Johnson, 1977). The Ohio River locks and dam system comprised of 50 lock and dam structures in 1929 has been reduced to a 19 lock and dam system. Many of these were lost with the newer and more improved lock chambers. Today the Huntington District operates six of these locks and dams along the Ohio River. Projects consisted of modernizing the 600 foot long locks of 1929 to 1,200 feet of today.

The old Gallipolis Locks and Dam was located in a curve in the river system making it hard for the barges to line up correctly without breaking apart, running into the lock gates, or running into the dam itself (Fig. 2). As a result, the project was redesigned to put a large canal straight through the bend in the river. Lock replacement construction began in late 1987 and the old Gallipolis Locks and Dam was then decommissioned. The new lock chamber is now 1,200 x 110 with a 600 x 110 auxiliary lock. This was done so that an entire tug with its series of barges could be locked through as a single unit rather than being broken apart and being locked through as two separate units. As a result the locking procedure now takes about half the amount of time as before. The dam was dedicated October 19, 1992. The name change was a result of a congressional delegate Congressman Nick Rahall because Robert C. Byrd had provided the first funding for the dam. Renaming of the Dam to Robert C. Byrd Locks and Dam occurred on January 3, 1993 (S. Wright, per. comm.).

Today, the Huntington District, U. S. Army Corps of Engineers, jurisdiction on the Ohio River extends from river mile 126.4 to 436.2 (Fig. 3). There are six locks and dams within this stretch of the river. Two of the six locks and dams within this stretch of the river, Racine Locks and Dam and Robert C. Byrd Locks and Dam, were utilized as collection sites. These were selected because they were on the West Virginia Division of Natural Resources (WVDNR) rotenone schedule for gathering fish census data.

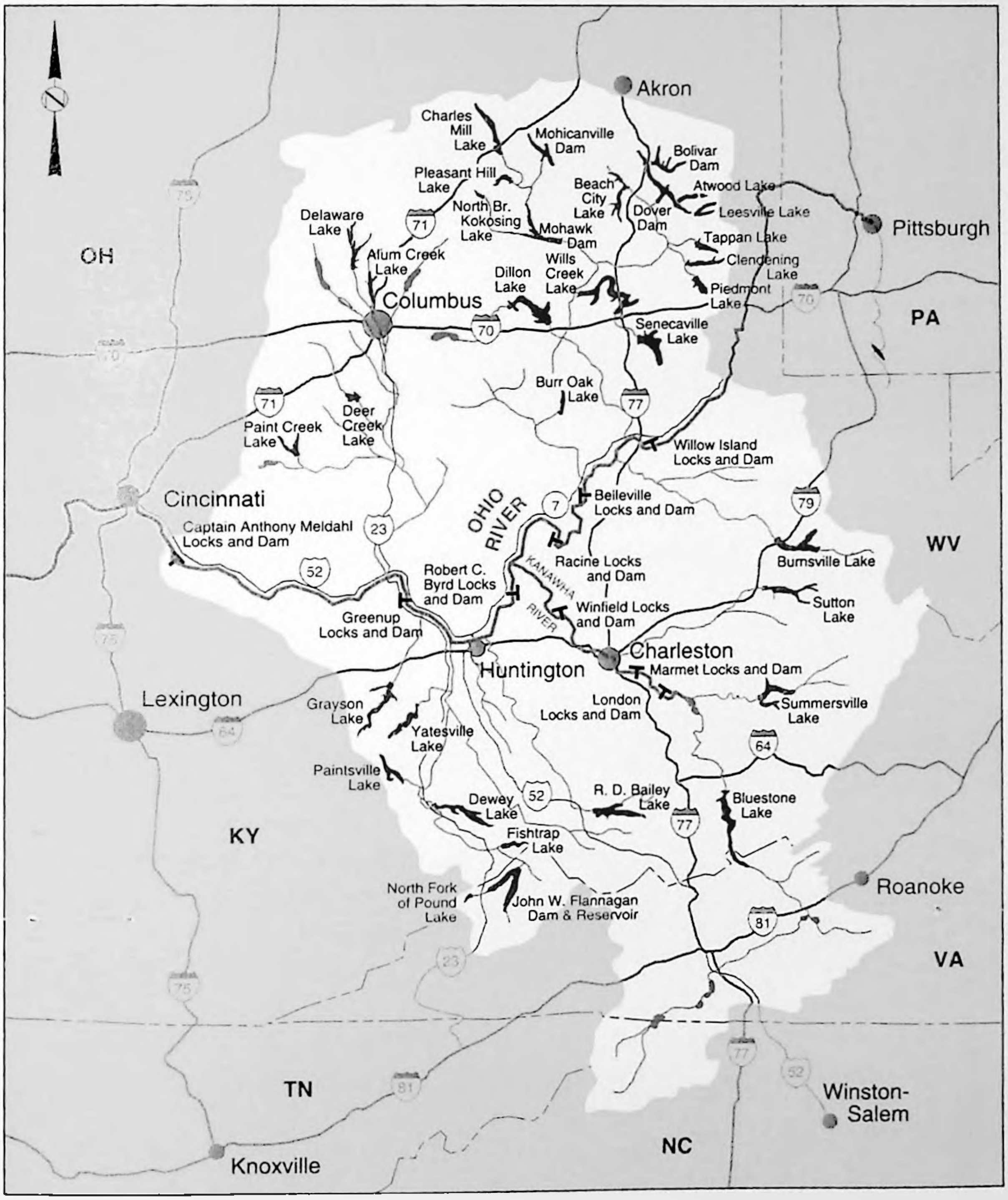
Racine Locks and Dam --Ohio River (Fig. 1, Site #1; Fig. 3; Fig. 4)

Racine, located at river mile point 273.5, was the fourth of the series of modern navigation structures built in the Huntington District Corps of Engineers. Construction of Racine Dam began in 1966 and was directed by Bill McCraw, the resident engineer at Meldahl near Maysville, Kentucky (Johnson, 1977). This structure, placed in operation in 1967, has dual locks and a non-navigable dam with 8 tainter gates mounted between 9 piers. With the lock size' of 110 x 600 (land locked) and 110 x 1200 and a lift of 22 feet, there are lift differences in elevation from one navigational pool to the next (U. S. Army Corps of Engineers, 1979). Racine replaced old locks and dams numbers 21, 22, and 23.

Robert C. Byrd Locks and Dam--Ohio River (Fig. 1, Site #2; Fig. 3; Fig. 4; Fig. 5)

Robert C. Byrd Locks and Dam, actually represents an important expansion of the old Gallipolis Locks and Dam located at mile point 279.2 approximately 14 miles downstream from the mouth of the Kanawha River at Point Pleasant. Construction of the original Gallipolis Locks and Dam was recommended by the Corps of Engineers in 1932 for modernization and was approved by Congress in 1933 as part of a program to improve water traffic on the Kanawha River, but was operated as a unit in the Ohio River navigation system (U. S. Army Corps of Engineers, 1979). The original dam, built by Dravo Corporation and Beltzhoover, was opened for river traffic in 1937. The first year of operation, Gallipolis saw 5 million tons of traffic, but by 1967 handled approximately 27 million tons of river traffic, which were locked through this facility (Johnson, 1977).

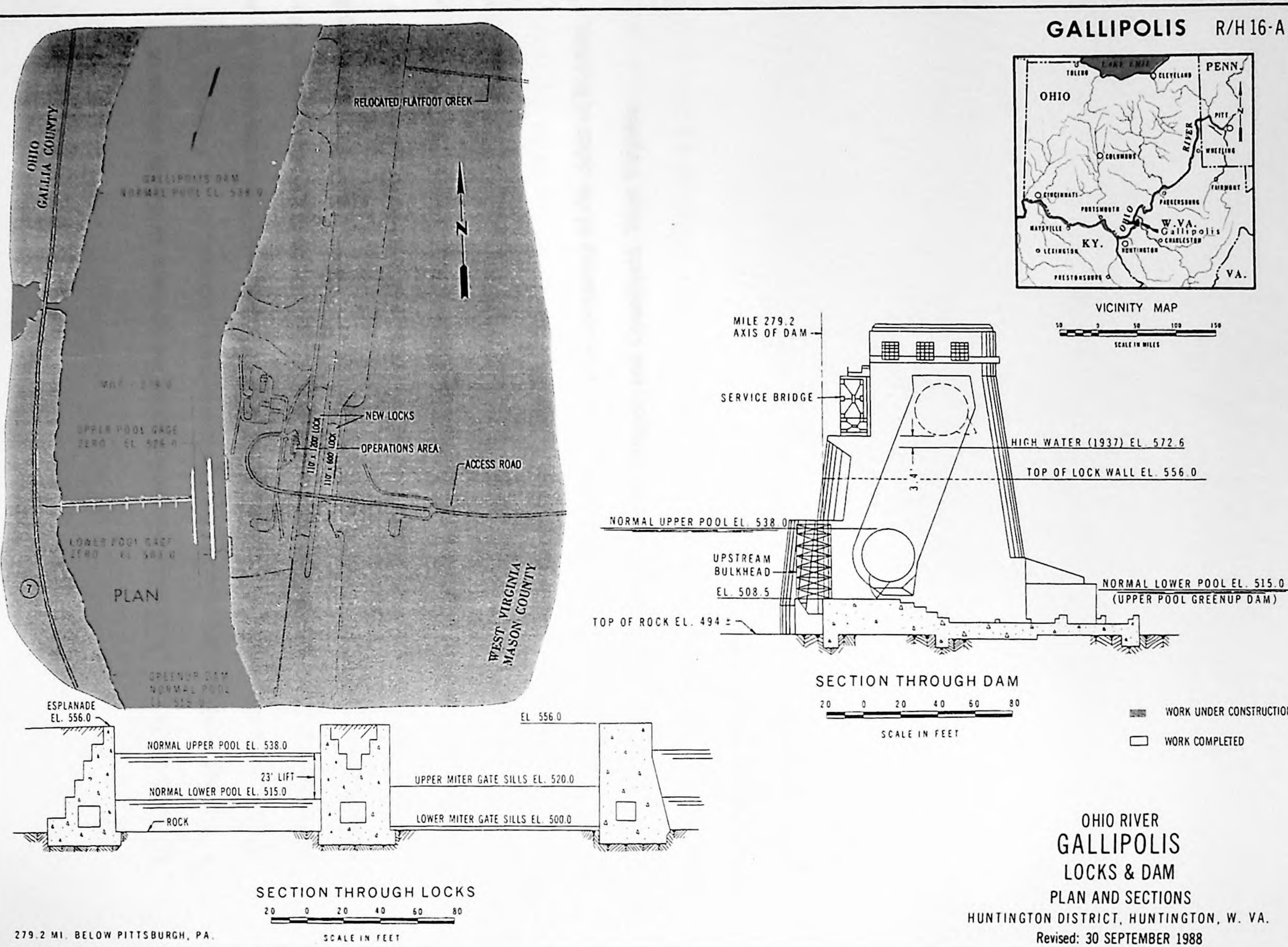
Figure 4. Study site areas for the present project along the Ohio River and the Kanawha River (Source: U. S. Army Corps of Engineers, Huntington District).



Akron
Pittsburgh
OH
PA
WV
KY
VA
TN
NC
Columbus
Cincinnati
Huntington
Charleston
Lexington
Roanoke
Knoxville
Winston-Salem
Charles Mill Lake
Mohicanville Dam
Pleasant Hill Lake
Bolivar Dam
Beach City Lake
Dover Dam
Atwood Lake
Leesville Lake
Tappan Lake
Clendening Lake
Piedmont Lake
Delaware Lake
North Br. Kokosing Lake
Mohawk Dam
Alum Creek Lake
Dillon Lake
Wills Creek Lake
Senecaville Lake
Burr Oak Lake
Paint Creek Lake
Deer Creek Lake
Willow Island Locks and Dam
Belleville Locks and Dam
OHIO RIVER
Captain Anthony Meldahl Locks and Dam
Racine Locks and Dam
Robert C. Byrd Locks and Dam
KANAWHA RIVER
Winfield Locks and Dam
Greenup Locks and Dam
Burnsville Lake
Sutton Lake
Marmet Locks and Dam
London Locks and Dam
Summersville Lake
Grayson Lake
Yatesville Lake
Paintsville Lake
Dewey Lake
R. D. Bailey Lake
Bluestone Lake
Fishtrap Lake
North Fork of Pound Lake
John W. Flannagan Dam & Reservoir
71
70
77
7
79
23
52
64
75
81

Figure 5. Both the decommissioned Gallipolis Locks and Dam the new Robert C. Byrd Locks and Dam (Source: U. S. Army Corps of Engineers, Huntington District).

GALLIPOLIS R/H 16-A



OHIO RIVER
GALLIPOLIS
LOCKS & DAM
PLAN AND SECTIONS
HUNTINGTON DISTRICT, HUNTINGTON, W. VA.
Revised: 30 SEPTEMBER 1988

By 1973, Gallipolis locks and dams needed extensive repairs to handle the amount of traffic and in 1974 a proposal for twin locks was made (Johnson, 1977). Gallipolis, the largest of the four modernization structures, was the largest roller dam in the world. It is only one of 20 federally-built navigation projects, taking four years for construction, with locks that are 110 x 600 feet long auxiliary lock and 110 x 360 feet with a navigable depth of 9 feet. The dam is now 1116 feet long and equipped with eight roller gates each 125.5 feet long, separated by 16-foot piers (U. S. Army Corps of Engineers, 1979).

Ashland, Kentucky--Ohio River (Fig. 1, Site #3; Fig. 3)

Ashland, Kentucky, a part of the tristate area consisting of the cities of Ironton, Ohio, Cattlettsburg, Kentucky, and Huntington and Gyandotte, West Virginia.

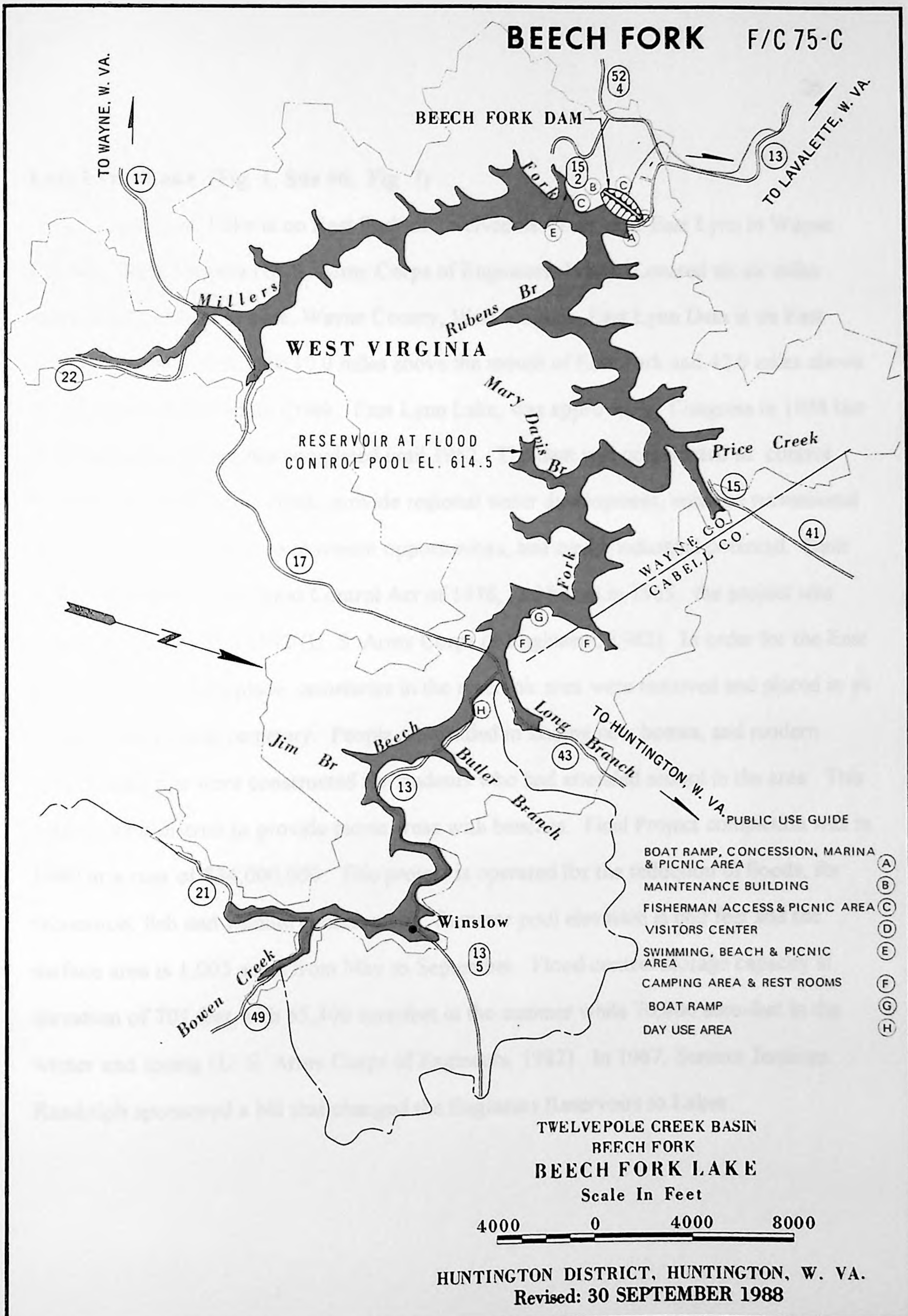
London Locks and Dam--Kanawha River (Fig. 1, Site #4; Fig. 3; Fig. 4)

Dam projects on the Kanawha River began in 1875 and were completed in 1898. The Kanawha River was the first river in the United States to be incorporated as a canal with moveable wickets. These low lift structures were replaced from 1931 to 1937 with 4 high-lift structures, London Locks and Dam being one of these. London Locks and Dam, approved in 1931, was built by Dravo Corporation of Pittsburgh on the basis of traffic forecast to rise to 2,300,000 tons (Johnson, 1977). From 1929-1950 the Kanawha River had predominantly one-way downbound commerce using only wicket dams. Single locks with lifts of only 9.5 feet were replaced by a more balanced two-way traffic, dual locks 56 x 360 feet and high-lift dams with average lift of 23 feet (Johnson, 1977). High lift dams could furnish longer and deeper pools and gates could be opened at floodtime to pass river discharge without severely affecting flood stages. The London Locks and Dam was completed in 1934.

Beech Fork Lake--(Fig. 1, Site #5; Fig. 6)

Beech Fork Lake is located on Beech Fork of Twelvepole Creek in Wayne and Cabell counties, West Virginia. Authorized in 1962 by the Flood Control Act and located near Huntington, West Virginia, the dam was under construction by 1970 (Johnson, 1977). The 1,070 foot long earthfill dam is two miles southeast of Lavalette and 9 miles south of Huntington, controlling drainage of 78 square miles. It was completed in 1976 but impounding did not begin until early 1978 with streambed elevation at 557 feet. The entire project was completed in 1984. Beech Fork Lake is operated as a unit in the comprehensive plan for flood control in the Ohio River Valley. Flood water control storage capacity elevation was 614.5 feet ranges from 28,360 acre-feet in the summer to 33,340 acre-feet in the winter. A minimum pool elevation of 583.5 feet with surface area of 450 acres in the winter and a seasonal pool elevation of 592 feet with surface area of 720 acres in the summertime. Part of the project was to operate as a state park which includes 3,144 acres of government land leased to the state (U. S. Army Corps of Engineers, 1982).

Figure 6. Beech Fork Lake, U. S. Army Corps of Engineers Reservoir Site, Wayne and Cabell Counties, West Virginia (Source: U. S. Army Corps of Engineers, 1988).

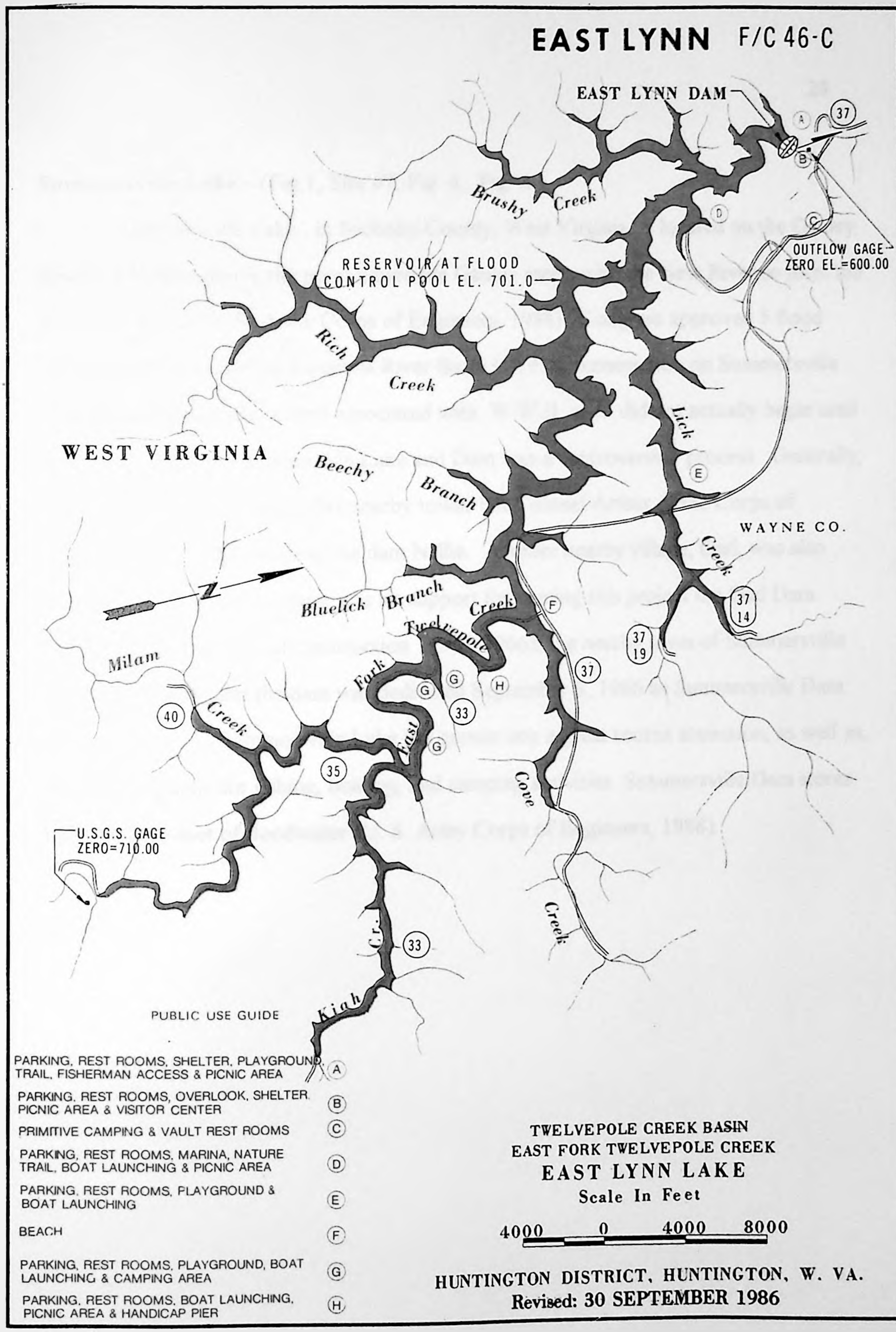


BEECH FORK F/C 75-C
TO WAYNE, W. VA.
BEECH FORK DAM
TO LAVALETTE, W. VA.
52
4
15
2
13
17
Fork
Millers
Rubens Br
WEST VIRGINIA
22
Mary Davis Br
RESERVOIR AT FLOOD
CONTROL POOL EL. 614.5
Price Creek
15
41
WAYNE CO.
CABELL CO.
Fork
17
Long Branch
TO HUNTINGTON, W. VA.
Jim Br
Beech
Butler Branch
43
13
21
Winslow
13
5
Bowen Creek
49
PUBLIC USE GUIDE
BOAT RAMP, CONCESSION, MARINA & PICNIC AREA (A)
MAINTENANCE BUILDING (B)
FISHERMAN ACCESS & PICNIC AREA (C)
VISITORS CENTER (D)
SWIMMING, BEACH & PICNIC AREA (E)
CAMPING AREA & REST ROOMS (F)
BOAT RAMP (G)
DAY USE AREA (H)
TWELVEPOLE CREEK BASIN
BEECH FORK
BEECH FORK LAKE
Scale In Feet
4000 0 4000 8000
HUNTINGTON DISTRICT, HUNTINGTON, W. VA.
Revised: 30 SEPTEMBER 1988

East Lynn Lake (Fig. 1, Site #6; Fig. 7)

East Lynn Lake is on East Fork of Twelvepole Creek near East Lynn in Wayne County, West Virginia (U. S. Army Corps of Engineers, 1982). Located six air miles south-south-east of Wayne, Wayne County, West Virginia, East Lynn Dam is on East Fork of Twelvepole Creek 10.0 miles above the mouth of East Fork and 42.0 miles above the mouth of Twelvepole Creek. East Lynn Lake, was approved by Congress in 1938 but planning studies were not completed until 1962. The dam was constructed to control flooding on Twelvepole creek, provide regional water development, enhance recreational activities, establish new employment opportunities, and create industrial potential. Built under authority of the Flood Control Act of 1938, and began in 1965, the project was placed in operation in 1972 (U. S. Army Corps of Engineers, 1982). In order for the East Lynn project to take place, cemeteries in the reservoir area were removed and placed in an 13 acre reinterment cemetery. People were aided in finding new homes, and modern school buildings were constructed for students who had attended school in the area. This was the first district to provide picnic areas with benches. Final Project completion was in 1980 at a cost of $34,000,000. This project is operated for the reduction of floods, for recreation, fish and wildlife conservation. Summer pool elevation is 662 feet and the surface area is 1,005 acres from May to September. Flood control storage capacity at elevation of 701 feet with 65,300 acre-feet in the summer while 70,800 acre-feet in the winter and spring (U. S. Army Corps of Engineers, 1982). In 1967, Senator Jennings Randolph sponsored a bill that changed the Engineers Reservoirs to Lakes.

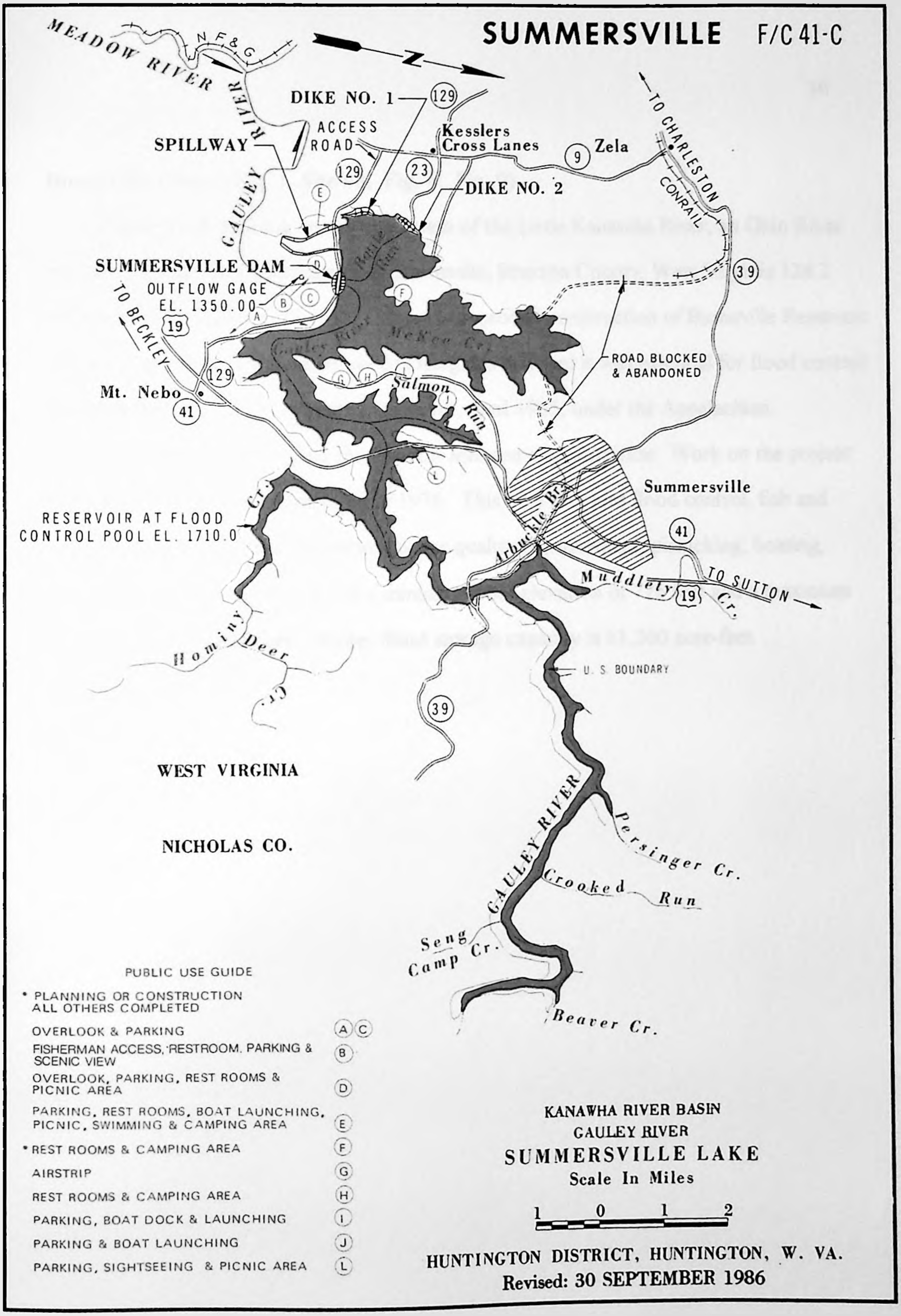
Figure 7. East Lynn Lake, U. S. Army Corps of Engineers Reservoir Site, Wayne County, West Virginia (Source: U. S. Army Corps of Engineers, 1988).


EAST LYNN F/C 46-C
EAST LYNN DAM
OUTFLOW GAGE ZERO EL.=600.00
Brushy Creek
RESERVOIR AT FLOOD CONTROL POOL EL. 701.0
Rich Creek
Lick Creek
WEST VIRGINIA
Beechy Branch
WAYNE CO.
N
Bluelick Branch
Creek
Twelvepole
East Fork
Milam Creek
Cove Creek
U.S.G.S. GAGE ZERO=710.00
Kiah Cr.
37
37 14
37 19
40
33
35
PUBLIC USE GUIDE
A PARKING, REST ROOMS, SHELTER, PLAYGROUND, TRAIL, FISHERMAN ACCESS & PICNIC AREA
B PARKING, REST ROOMS, OVERLOOK, SHELTER, PICNIC AREA & VISITOR CENTER
C PRIMITIVE CAMPING & VAULT REST ROOMS
D PARKING, REST ROOMS, MARINA, NATURE TRAIL, BOAT LAUNCHING & PICNIC AREA
E PARKING, REST ROOMS, PLAYGROUND & BOAT LAUNCHING
F BEACH
G PARKING, REST ROOMS, PLAYGROUND, BOAT LAUNCHING & CAMPING AREA
H PARKING, REST ROOMS, BOAT LAUNCHING, PICNIC AREA & HANDICAP PIER
TWELVEPOLE CREEK BASIN
EAST FORK TWELVEPOLE CREEK
EAST LYNN LAKE
Scale In Feet
4000 0 4000 8000
HUNTINGTON DISTRICT, HUNTINGTON, W. VA.
Revised: 30 SEPTEMBER 1986

Summersville Lake --(Fig 1, Site #7, Fig. 4; Fig. 8)

Summersville Lake , in Nicholas County, West Virginia, is located on the Gauley River 34.5 miles above the point where the Gauley meets with the New River to form the Kanawha River (U. S. Army Corps of Engineers, 1988). Congress approved 5 flood control reservoirs for the Kanawha River Basin in 1938, construction on Summersville was delayed initially by events associated with W.W.II, so it did not actually begin until 1960. Naming the Summersville Lake and Dam was a controversial process. Generally, lakes (or dams) are named after nearby towns but Colonel Arthur of the Corps of Engineers objected to naming the dam Nellie. Another nearby village, Gad, was also deemed inappropriate as there was no support for naming this project the Gad Dam. During the seven years of construction (1960-1966), the nearby town of Summersville grew appreciably and the dam was dedicated September 3, 1966 as Summersville Dam (Johnson, 1977). Summersville Lake has grown into a great tourist attraction, as well as, serving the public for fishing, boating, and camping activities. Summersville Dam stores 150,000 acre-feet of floodwater (U. S. Army Corps of Engineers, 1988).

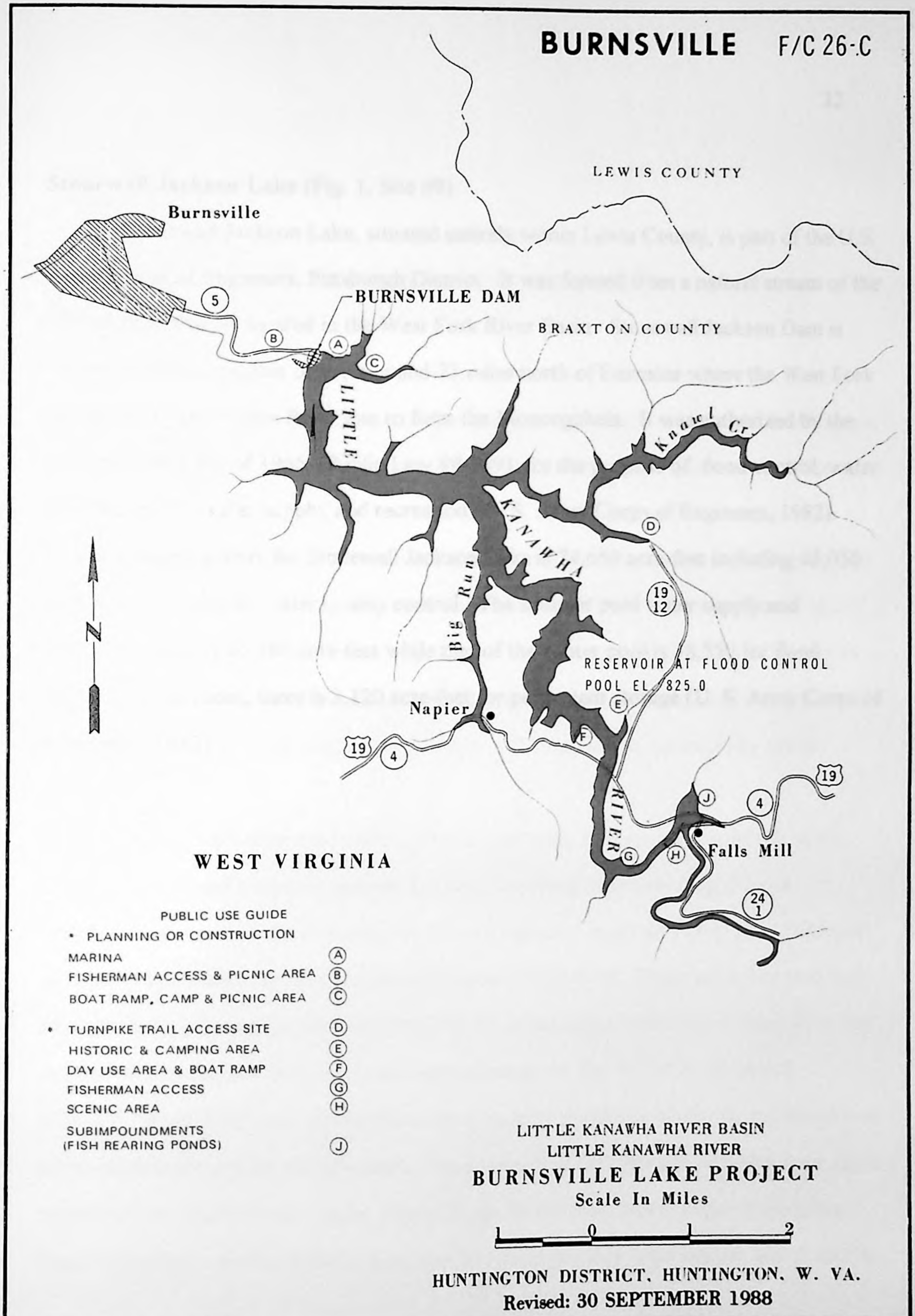
Figure 8. Summersville Lake, U. S. Army Corps of Engineers Reservoir Site, Nicholas County, West Virginia (Source: U. S. Army Corps of Engineers, 1988).


SUMMERSVILLE F/C 41-C
MEADOW RIVER
N F & G
GAULEY RIVER
DIKE NO. 1
129
SPILLWAY
ACCESS ROAD
Kesslers Cross Lanes
23
9
Zela
TO CHARLESTON
CONRAIL
DIKE NO. 2
SUMMERSVILLE DAM
OUTFLOW GAGE EL. 1350.00
TO BECKLEY
19
Mt. Nebo
41
Gauley River
McKee Cr.
Battle Run
Salmon Run
ROAD BLOCKED & ABANDONED
39
Summersville
RESERVOIR AT FLOOD CONTROL POOL EL. 1710.0
Arbuckle Br.
Muddlety Cr.
TO SUTTON
Hominy Cr.
Deer Cr.
U. S. BOUNDARY
WEST VIRGINIA
NICHOLAS CO.
GAULEY RIVER
Persinger Cr.
Crooked Run
Seng Camp Cr.
Beaver Cr.
PUBLIC USE GUIDE
• PLANNING OR CONSTRUCTION ALL OTHERS COMPLETED
OVERLOOK & PARKING (A) (C)
FISHERMAN ACCESS, RESTROOM, PARKING & SCENIC VIEW (B)
OVERLOOK, PARKING, REST ROOMS & PICNIC AREA (D)
PARKING, REST ROOMS, BOAT LAUNCHING, PICNIC, SWIMMING & CAMPING AREA (E)
• REST ROOMS & CAMPING AREA (F)
AIRSTRIP (G)
REST ROOMS & CAMPING AREA (H)
PARKING, BOAT DOCK & LAUNCHING (I)
PARKING & BOAT LAUNCHING (J)
PARKING, SIGHTSEEING & PICNIC AREA (L)
KANAWHA RIVER BASIN
GAULEY RIVER
SUMMERSVILLE LAKE
Scale In Miles
1 0 1 2
HUNTINGTON DISTRICT, HUNTINGTON, W. VA.
Revised: 30 SEPTEMBER 1986

Burnsville Lake--(Fig. 1, Site #8; Fig. 4; Fig. 9)

Burnsville Lake is on the main stem of the Little Kanawha River, an Ohio River tributary, three miles upstream from Burnsville, Braxton County, West Virginia 124.2 miles above the mouth. In 1938, Congress approved construction of Burnsville Reservoir and 1939 the West Virginia House of Delegates believed it was essential for flood control. The first funds were not provided, however, until 1965, under the Appalachian Development Program during the Lyndon Johnson administration. Work on the project began in 1972 and was completed in 1976. This lake provides flood control, fish and wildlife recreation, water recreation, water quality improvement, picnicking, boating, camping, and sight seeing. It has a minimum pool elevation of 776 feet and a maximum pool elevation of 825 feet. Winter flood storage capacity is 61,300 acre-feet.

Figure 9. Burnsville Lake, U. S. Army Corps of Engineers Reservoir Site, Braxton County, West Virginia (Source: U. S. Army Corps of Engineers, 1988).


BURNSVILLE F/C 26-C
LEWIS COUNTY
Burnsville
BURNSVILLE DAM
BRAXTON COUNTY
LITTLE
KANAWHA
Knawl Cr.
Big Run
RESERVOIR AT FLOOD CONTROL
POOL EL. 825.0
Napier
RIVER
Falls Mill
N
WEST VIRGINIA
PUBLIC USE GUIDE
• PLANNING OR CONSTRUCTION
MARINA (A)
FISHERMAN ACCESS & PICNIC AREA (B)
BOAT RAMP, CAMP & PICNIC AREA (C)
• TURNPIKE TRAIL ACCESS SITE (D)
HISTORIC & CAMPING AREA (E)
DAY USE AREA & BOAT RAMP (F)
FISHERMAN ACCESS (G)
SCENIC AREA (H)
SUBIMPOUNDMENTS
(FISH REARING PONDS) (J)
LITTLE KANAWHA RIVER BASIN
LITTLE KANAWHA RIVER
BURNSVILLE LAKE PROJECT
Scale In Miles
1 0 1 2
HUNTINGTON DISTRICT, HUNTINGTON, W. VA.
Revised: 30 SEPTEMBER 1988

Stonewall Jackson Lake (Fig. 1, Site #9)

Stonewall Jackson Lake, situated entirely within Lewis County, is part of the U.S. Army Corps of Engineers, Pittsburgh District. It was formed from a natural stream of the Monongahela River located in the West Fork River Basin. Stonewall Jackson Dam is located 3 miles upstream of Weston and 73 miles north of Fairmont where the West Fork River and Tygart Valley River join to form the Monongahela. It was authorized by the Flood Control Act of 1966, (Public Law 89-789), for the purpose of flood control, water quality control, water supply, and recreation (U. S. Army Corps of Engineers, 1982). Gross storage capacity for Stonewall Jackson Lake is 74,650 acre-feet including 45,050 acre-feet allocated for water quality control. The summer pool water supply and recreational use is 26,480 acre-feet while that of the winter pool is 38,550 for flood control. At all times, there is 3,120 acre-feet for permanent storage (U. S. Army Corps of Engineers, 1982).

CHAPTER IV

MATERIALS AND METHODS

Two-hundred and fifteen basses were collected between May 26, 1997, through November 5, 1997, from local anglers, gill netting, and rotenone surveys. Gill netting and rotenone surveys were conducted under the direction of the personnel with the West Virginia Division of Natural Resources (WVDNR). While general site locations are shown in Figure 1; specific site locations, dates of collections, methods of collection and specific numbers of the host bass species, are outlined in Tables 1 through 5 and Figure 1. Species and numbers of bass hosts sampled from lake sites are given in Table 3, with lake basses separated by sex of host summarized in Table 5. Species and sample of bass hosts sampled from river sites are shown in Table 2, with river basses separated by sex in Table 4.

At each collection site where rotenone was used, bass were scooped out of the water with nets and placed in separate buckets according to species (Fig. 10 and 11). Other hosts were obtained from anglers or were captured in gill nets (Fig. 12). Methods of capture and collection sites are summarized in Tables 6-10. Hosts were then returned to shore to be processed, measured (from the tip of the snout to the tip of the tail) to the nearest centimeter, and weighed to the nearest ounce, by the WVDNR personnel (Fig. 13). They were then placed immediately in large cooler ice chests for transportation to the laboratory at Marshall University. Upon arrival at the laboratory, basses were again separated into the different species, placed in plastic zip-lock freezer bags, or even larger bags if necessary, labeled with the date, species, and how they were caught, and placed in

Figure 10. Rotenone survey on the Kanawha River in the London Lock and Dam chamber carried out by personnel from the West Virginia Department of Natural Resources, October 1997.

Figure 11. WVDNR personnel collecting fish in a rotenone survey, October 1997, on the Kanawha River in the London Dam lock chamber.

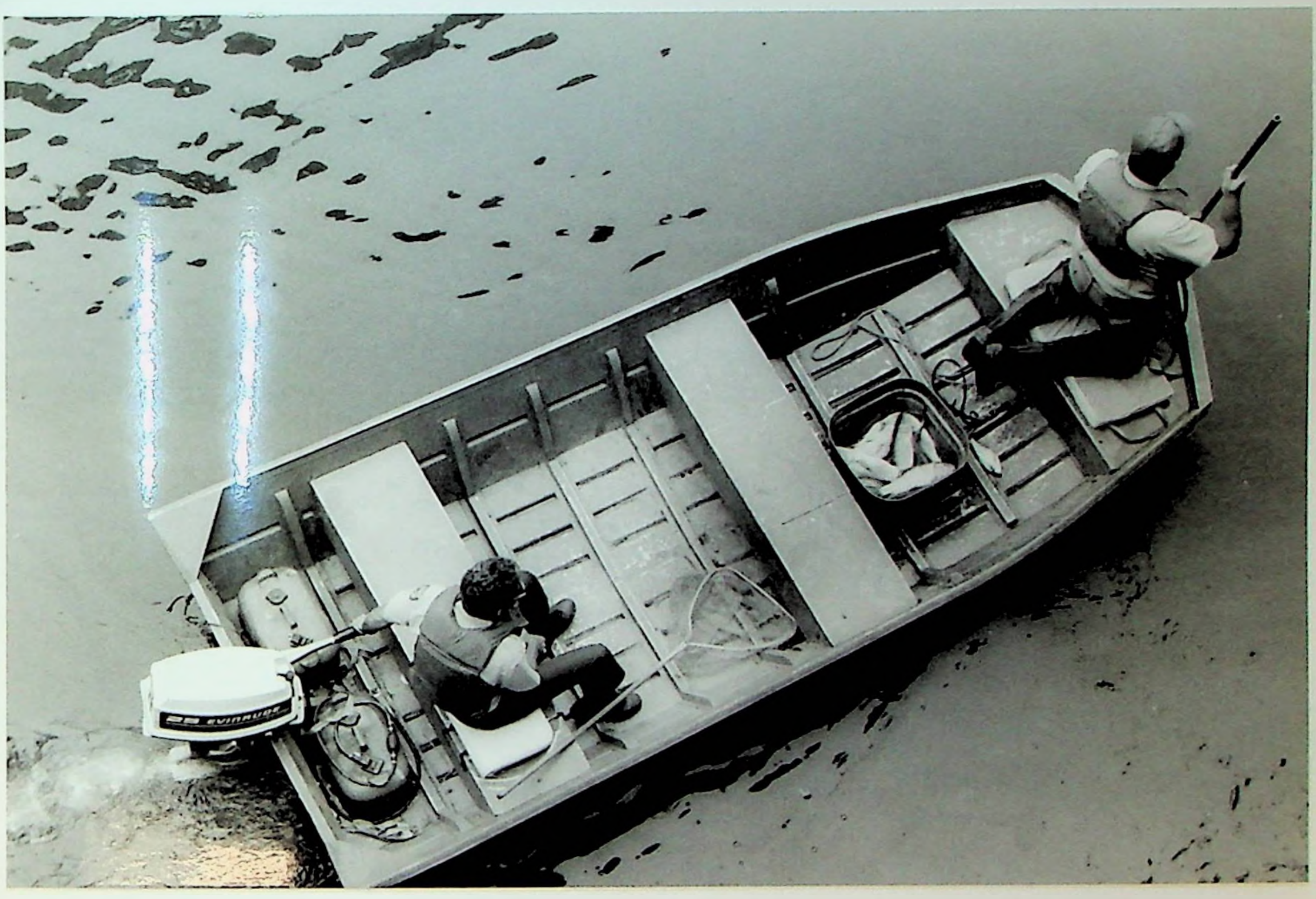

EVINRUDE

Figure 12. Gill netting, November 1997, at Beech Fork Lake directed by Clovis Doerfer (WVDNR).

Figure 13. Fish census taken by a rotenone survey at Racine Locks and Dam, Ohio River, September 1997. Mike Hoeft (WVDNR, lower left) coordinates teams of investigators from WVDNR (census), Marshall University (parasitic infections), Viriginia Tech (fisheries consulting), Ohio River Sanitation Commission (ORSANCO), and the U. S. EPA (fish tissue analyses).

the freezer. Some bass hosts were necropsied as soon as the other fish were placed in the freezer in order to observe living parasitic organisms. Necropsies or dissections of each fish were performed almost daily from May 26, 1997, and were completed by January 3, 1998. Only three to four fish were removed from the freezer and allowed to thaw for each necropsy session. Thawing at times occurred by running cool water over the fish (only one at a time). Thawed fish were measured for total length in centimeters. Necropsy of each fish took from one to two hours. Gills, still partially frozen, were placed in jars of water (30 ml), with a few drops of buffered formalin, and shaken to release monogenetic trematodes and copepods attached to the gill filaments. Freezing releases these types of parasites from their attachment sites, and breaks up host mucous secretions allowing for easier examination of the gills. The presence of monogenetics and copepods were examined from water the gills were in with the aid of a stereomicroscope. The entire gill was examined stereomicroscopically to locate any protozoan cysts, or any metazoan parasites that may have remained after shaking. Parasites found in the gill filaments were removed with jewelers forceps or micropipettes and placed in labeled (i. e. collection site, date, host identification number, and host species) bottles containing a 10 percent formalin acetate solution.

Visceral organs, which were classified as stomach, pyloric cecae, liver, spleen, intestinal tract, reproductive organs, and heart were removed from each bass. As the viscera was removed, fat deposits were examined then discarded. Basses were sexed upon examination of the viscera, and the sex of each host recorded. Body cavities and mesenteries were also examined. Visceral organs, mesenteries, and body cavities were examined grossly under a stereomicroscope and/or magnifying lens. Those parasites encountered during gross examination were removed and placed in appropriately labeled bottles containing 10 percent formalin acetate to ensure proper preservation. The mesentery was then cut away and each organ was then separated and placed in separate petri dishes with a small amount of water to keep the tissues moist. Then the stomach, pyloric cecae, and intestines were cut open with a small pair of scissors and the inner contents of these organs examined for endoparasites. As for the stomach and intestines, after picking through them and placing the parasites in the appropriate collection jar of formalin acetate, I would turn the organ over and shake it out in the water so that any remaining parasites, which might not have been observed within the tissue, would fall out. Then I would sift back through the water and remove, with jewelers forceps or micropipette, any remaining parasites. Liver, spleen, and reproductive organs were teased apart using jewelers forceps, and any parasites found were then placed in labeled bottles with 10 percent formalin acetate.

After necropsies were completed, I began preparing the parasites for identification. Gill parasites (i. e. monogenetic trematodes and copepods) were examined in water mounts and photographed using a Zeiss photomicrographic system at magnifications of 100x and 400x. Some of these gill parasites were washed in distilled water and stained overnight in Semichon's acetic carmine which was prepared in 70 percent ethanol. Stained gill parasites were then dehydrated in an ethanol series, cleared in xylene, and mounted in Permount ® for permanent study specimens. A necropsy data sheet was kept on all fish hosts of the parasites found in each and where (i.e. organ) the parasite was found. Spreadsheets were then made containing host, host number, collection site, sex of the bass, and parasite species.

All flatworms (i.e. digenetic trematodes and tapeworms) within the viscera, in the gut lumen, or migrating in mesenteries or other organs, were stained in Semichon's acetic carmine and prepared as permanent study specimens as previously described for the gill parasites. Acanthocephalans, also known as "thorny-headed worms," were also stained in Semichon's acetic carmine. Nematodes were examined under a Zeiss compound microscope after placing them in temporary mounts of lactophenol consisting of lactic acid, phenol, glycerine, and water, (Cable, 1964).

Examination of prepared slide material of gill and visceral helminths was done with a Zeiss compound microscope. Measurements of these specimens and their anatomical structures, where necessary, was done with a calibrated ocular micrometer. Selected specimens of visceral parasites were photographed with a Zeiss photomicrographic system using Kodak TMax 400 film and/or Kodak Ektachrome 400 slide film. Photographs of organs infected with parasites (gross photographs) were taken with an Olympus macro lens system employing photographic films cited previously.

Identification keys utilized to identify parasites were those by Hoffman (1967), Khalil, et al. (1994); Schmidt (1970 and 1996); Wardle and McLeod (1952); and Yamaguti (1958, 1959, 1961, and 1963). The term prevalence is used in accordance with the definition provided by Margolis, et al. (1982) and revised by Bush, et al. (1997). In the present study, only the prevalence of parasites is reported because the number of parasitic organisms of each species encountered in each animal was not counted. Chi-Square analyses were calculated after procedures described by Swinscow (1978). Student's t-tests were based on procedures in Sokal and Rohlf (1995). In all cases statistical tests were considered significant at the $P < 0.05$ level.

CHAPTER V

RESULTS

Twenty-three different species of parasites were collected from a total sample size of 215 basses representing five host species from four river and five lake collection sites in West Virginia (Tables 1 through 3). Partitioning of the host sample by host sex, or immature individuals, is shown in Tables 4 and 5 for hosts in river and lake ecosystems, respectively. *Micropterus salmoides* (Lacepede), largemouth bass, *Micropterus dolomieui* Lacepede, smallmouth bass, *Micropterus punctulatus* (Rafinesque), spotted bass, *Morone chrysops* (Rafinesque), white bass, and *Morone chrysops* (Rafinesque) x *Morone saxatilis* (Walbaum), hybrid bass (Eddy and Underhill, 1978), were collected from May 26, 1997, through November 5, 1997, by local anglers, rotenone, and gill netting surveys. Specific collection dates, and methods of collection and sample sizes are given for each host species in Tables 6 through 10.

Clearly, most species of basses collected in the present study were not evenly distributed between river and lake ecosystems (Table 1). White bass were represented only in river systems while spotted bass and largemouth bass were represented in only lake systems (Tables 1 through 3). Only hybrid basses were collected in both river and lake ecosystems in numbers high enough to make some statistical comparisons of parasite prevalences in hosts from both of those aquatic environments (Tables 1 through 3). With the exception of largemouth basses, female hosts outnumbered males in catches (Tables 4 and 5). The female : male host sex ratio of 1.85 : 1.00 for host captures in river ecosystems (Table 4) was significantly ($X^2 = 1.565$; 1 df; $P < 0.05$) different from an expected 1.00 : 1.00 ratio. The ratio of 1.30 : 1.00 favoring females in lake captures (Table 5) was not significantly different from a 1.00 : 1.00 ratio ($X^2 = 1.565$; 1 df, $P > 0.05$). Overall, the combination of females and males from both river and lake sites shows that the female : male sex ratio of 1.52 : 1.00 was significantly different from an expected ratio of 1.00 : 1.00 ($X^2 = 7.249$; 1 df; $P < 0.01$). Again, with the exception of largemouth basses, immature individuals made up a relatively small portion of the host sample (Tables 4 and 5).

Eight different species of gill parasites were found in basses from both river and lake ecosystems. These were the three small monogenetic trematodes (*Clavunculus* sp., *Haplocleidus* sp., and *Urocleidus* sp.) that are virtually indistinguishable from one another and are thus combined as "small form" monogenetics; a "large form" monogenetic, *Actinocleidus* sp.; the arthropods *Argulus* sp. and *Ergasilus centrachidarum*; a leech, *Piscicola* sp.; and an unidentified species of clam glochidium (clam larvae). With the exception of clam glochidium, which caused clubbing within the gill filament or swelling at the base of a few gill filaments, there was no observable gill damage in hosts infected by these species of parasites.

GILL PARASITES

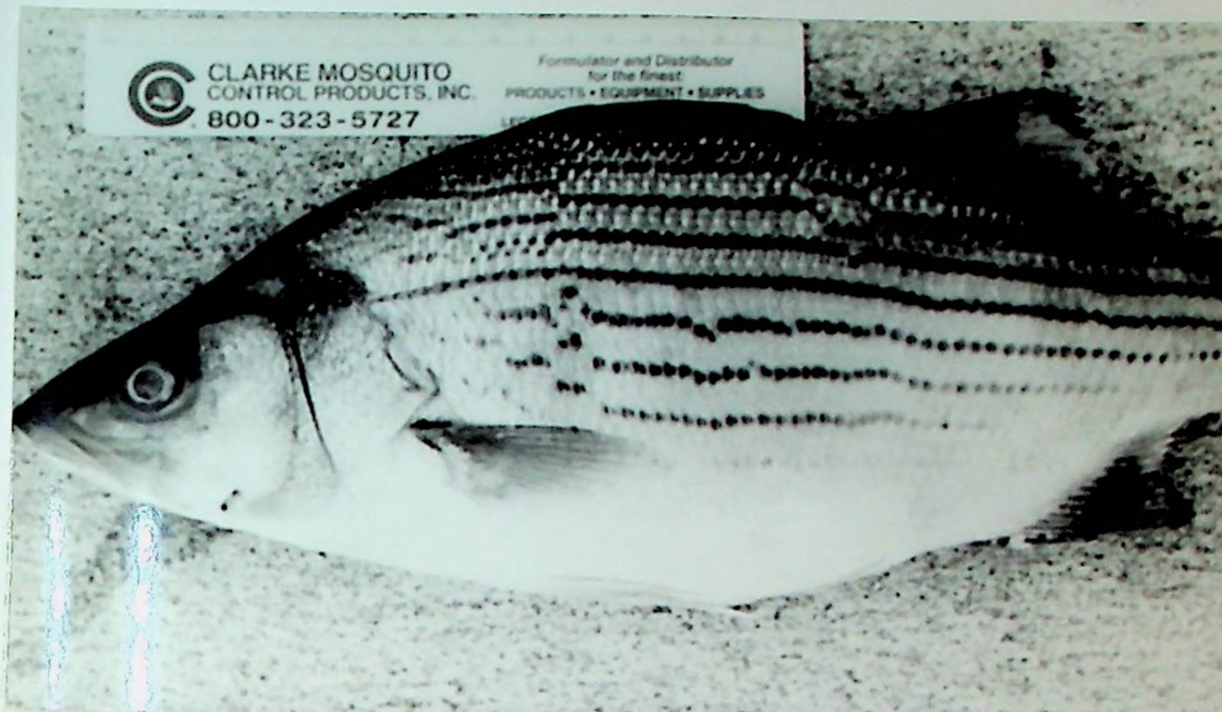
Monogenetic Trematodes:

"Small form" monogenetic trematodes were the most frequently encountered gill parasites in all five host species (Table 11, Figure 14); being present on hosts from both river and lake ecosystems (Tables 12 and 13). Prevalences were highest for "small form" monogenetic trematodes in largemouth bass (70%) in lakes (Tables 13 and 14). White basses were particularly susceptible with a prevalence of 83% in river systems (Table 12). Conversely, only 21% of the spotted basses were infected by these gill parasites. The overall prevalence of 68% for "small form" monogenetics in all river basses (Table 15) was significantly higher than the prevalence of 47% for these monogenetics in lake basses (Table 16) ($X^2 = 9.56$; 1df; $P < 0.05$). *Actinocleidus* sp., or "large form" monogenetic

Figure 14. Hybrid bass, *Morone chrysops* x *Morone saxatilis*.

Monogenetic trematode (*Clavunculus* sp., *Haplocleidus* sp., or *Urocleidus* sp.)

Posterior end (opisthaptor) bears hooks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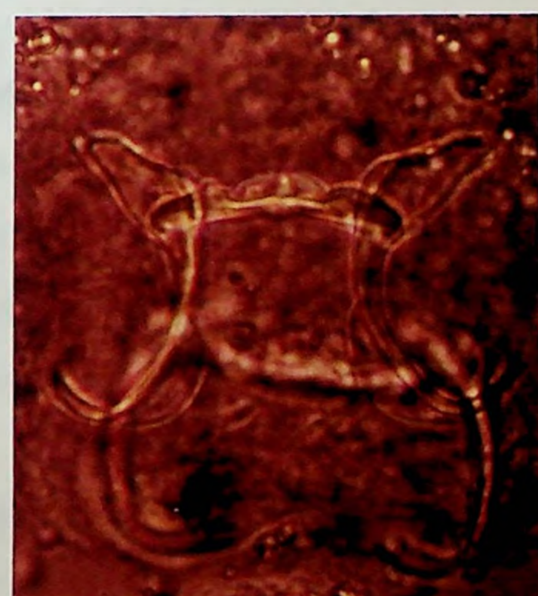


trematodes, was found in 29% of all bass hosts from both river and lake ecosystems combined (Table 11). Prevalence rates were highest (at 41%) in hybrid basses and lowest (at 11%) in smallmouth basses (Table 13 and 14). Like the "small form" monogenetic infections, prevalence of *Actinocleidus* sp. in river hosts (at 39% in Table 12) was significantly higher than the prevalence of 22% for this monogenetic species in lake basses (Table 13) ($X^2 = 126$; 1df; $P < 0.05$). No gross pathology was found associated with any monogenetic trematode species.

Arthropoda, Hirudinea, and Mollusca:

Another organism that was found at relatively high prevalences was the copepod *Ergasilus centrachidarum* (Figure 15). *Ergasilus centrachidarum* was found in hosts from both river and lake ecosystems (Table 11). Prevalence for *E. centrachidarum* in river basses (at 29% in Table 12) was not significantly higher than lake basses (at 11% in Table 13) ($X^2 = 336.5$; 1df; $P < 0.05$). Hybrid basses were particularly susceptible, with a prevalence of 33%, as were white bass, at 20%. On the other hand, largemouth bass (at 4%) and spotted bass (at 7%) exhibited the lowest prevalences. In river systems, hybrid bass (at 35%) were just as susceptible to infections as hybrid bass in lake systems (at 29%) (Tables 12 and 13) ($X^2 = .32$; 1df; $P > 0.05$).

Gill parasites other than monogenetic trematodes and copepods were found in both river and lake ecosystems in low prevalences; therefore, prevalences for these remaining species were considered too small for statistical comparisons between river versus lake hosts (Tables 14 through 16).

Prevalences of gill parasites for each host species by host sex and young-of-the-year are shown in Tables 14 through 18. In most cases, sample sizes for each host sex (or immatures) class are too small for statistically valid comparisons. Where sample sizes are adequate (e.g. largemouth basses, Table 14; and hybrid basses, Table 18)

Figure 15. Arthropods found within basses from both river and lake ecosystems:

The "fish louse," *Argulus* sp., (entire).

The copepod, *Ergasilus centrachidarum*, (entire).

prevalences are relatively constant for adult female and males, and immatures (i.e. there does not seem to be any particular "at risk" infection category by sex or immatures). All categories of hybrid basses in river ecosystems have higher prevalences than their lake ecosystem counterparts (Table 18), which is to be expected given that monogenetics are found with significantly greater frequencies in river hosts (Tables 12 and 13).

Intensity of gill parasite infections (i.e. the number of parasites per infected host) were not calculated because intensities were generally very low. There were a few rare cases where monogenetics were found in large numbers (>100 individuals), but many infected hosts carried 10 or fewer monogenetic trematode individuals. The arthropods *Argulus* sp.(Figure 15) and *Ergasilus centrachidarum* (Figure 15) were always found in low numbers (<5 individuals per infected host), and there were only five leeches, *Piscicola* sp. (Figure 16) collected in the entire study. Clam glochidia (Figure 17) are occasionally seen in high numbers on gills of fishes, but very few were observed during the course of the present investigation.

The Platyhelminthes (Visceral Flatworms)

Six different flatworm parasite species (4 digenetic trematodes and 2 tapeworms) were found within the viscera of 215 hosts representing five bass species. These parasite species were: *Bucephalus polymorphus*, *Leuceruthrus micropteri*, *Pisciamphistoma reynoldsi*, and *Posthodiplostomulum* sp. (digenetic trematodes), and the tapeworms *Proteocephalus ambloplitis* (adult and larvae) and *Bothriocephalus* sp. (adult).

Digenetic Trematodes:

With an overall prevalence of 28% (Table 19), *Bucephalus polymorphus* (Figure 18) was the dominant species of digenetic trematode collected in this study.

Figure 16. Immature form of the leech, *Piscicola* sp., (entire).

Figure 17. Clam glochidium.

Example of clam glochidium infection in freshwater fish hosts. This particular infection was from a freshwater drum, *Aplodinotus grunniens*, collected at Marmet (Kanawha River), West Virginia. Glochidium infection in the present study were infrequently found and at low intesity levels.

Bucephalus polymorphus was found almost exclusively in white and hybrid basses taken from river ecosystems (Tables 20 and 21). Intensity of infections (i.e. the numbers of individuals per infected host) were generally moderate (20 or 30 per host), but on a few occasions more than 100 worms were present. Even in the occasional heavy infection there was no observable damage to the lining of the host's stomach, pyloric cecae, or intestinal tract. Among white bass, the difference in mean length of infected hosts (at 22.4 cm) and the mean length of uninfected hosts (at 26.2 cm) in river ecosystems was not statistically significant ($t_{.05[28]} = 0.891$; $P > 0.05$). Conversely, hybrid bass did show a significant difference in mean host lengths between uninfected (at 24.8 cm) and infected (at 32.55 cm). Mean length of hybrid bass infected with *B. polymorphus* were significantly larger than the uninfected bass ($t_{.05[63]} = 2.685$; $P< 0.05$). All classes (i.e. sex and young-of-year) of white bass appeared equally susceptible to *B. polymorphus* infection (Table 25), although numbers for immatures and male hosts are to small for valid statistical testing. Hybrid bass (Table 26) females were not more susceptible than males for *B. polymorpus* infection in river systems than there counterparts in lake systems ($X^2 = 3.6$; 1 df, $P <0.05$). Largemouth and spotted basses appear to be exempt from the infection of *B. polymorphus*; however, two smallmouth bass found in a lake system, a female and a male, were infected with *B. polymorphus* (Table 22 and 23).

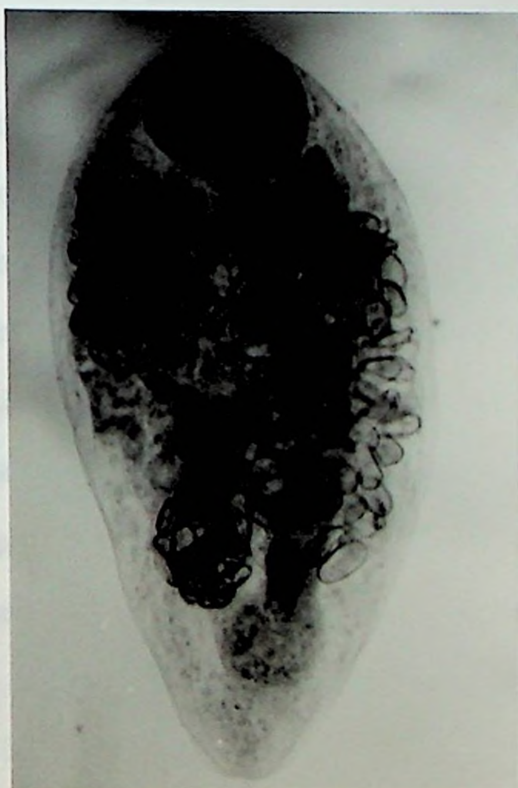
Leuceruthrus micropteri (Figure 18) was also a parasite of river basses (Table 20). It was collected from smallmouth, white, and hybrid basses from river systems with the exception of one hybrid bass from Beech Fork Lake (Table 26). Even though *L. micropteri* was found with far less frequency than *B. polymorphus*, this former species was still fairly common in river hosts with a prevalence of 18% (Table 20). Unlike *B. polymorphus* infection intensities were generally low (< 10 per infected host). Infection among host sexes and immatures of white bass are relatively equal (Table 25). In hybrid

Figure 18. Digenetic Trematodes:

Bucephalus polymorphus
adult, (entire)

Pisciamphistoma reynoldsi
adult, (entire).

Leuceruthrus micropteri
adult, (entire)



bass, females are not more susceptible to infection ($X^2 = 1$; 1df; $P > 0.05$) than the males (Table 26). There was no gross pathology seen in the lining of the intestinal tracts of hosts infected by *L. micropteri*.

Unlike *B. polymorphus* and *L. micropteri*, the digenetic trematode *Pisciamphistoma reynoldsi* (Figure 18) was strictly a parasite of lake basses (Tables 20 and 21). In addition, *P. reynoldsi* was found in largemouth, smallmouth, and spotted basses (Table 21), rather than the white and hybrid basses parasitized by the two former digeneans. Because there were only 9 fish infected, and those came from 3 different species, no statistical comparisons between prevalences could be made. No gross pathology was associated with this organism.

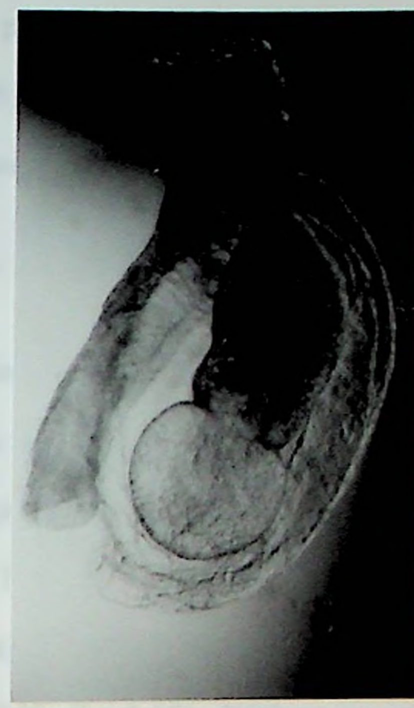
Posthodiplostomulum sp. (Figure 19), a holostome type of digenetic trematode, was found only in the larval form (i.e. metacercaria), encysted in various organs. This parasite was seen in all host species except white basses from lake systems (Table 21). Only smallmouth bass were infected by this holostome in river systems (Table 20). Intensities of infection were moderate (20 to 30 per infected host) and prevalences were higher among basses of lake systems (14%) compared to that of river systems at 4% (Tables 20 and 21). All host sexes and immatures were equally susceptible to the infection of *Posthodiplostomulum* sp. in largemouth bass (Table 22). Largemouth bass also contained the highest intensity (> 30) compared to other host basses. In smallmouth, spotted, and hybrid basses, *Posthodiplostomulum* sp. individuals were found among female basses only (Tables 23, 24, and 26).

Prevalences of digenetic trematodes for each host species by host sex and young-of-the-year are shown in Tables 22 through 26. In most cases, sample sizes for each reproductive categories are adequate for comparison of the prevalence of parasites (e.g. white basses, Table 25; and hybrid basses , Table 26). We can see, however, that all

Figure 19. Larval forms of a digenetic trematode, *Posthodiplostomulum* sp. or "white grub":

Metacercaria encysted in liver.

Immature form excysted in liver.



reproductive categories of hybrid basses in river ecosystems have higher prevalences than their lake ecosystem counterparts (Table 26). This is to be expected given that *B. polymorphus* and *L. micropteri* are found with significantly greater frequencies in river hosts (Tables 20 and 21).

Cestodes:

Two tapeworms, *Proteocephalus ambloplitis* and *Bothriocephalus* sp., were found primarily from basses in lake systems with but a few exceptions. A relatively low number of *Proteocephalus ambloplitis* pleurocercoids were found in smallmouth, white and hybrid basses in river systems (at 12% Table 20). Prevalence of *P. ambloplitis* pleurocercoid from river systems were significantly lower than similar infection prevalence in lake hosts (at 72% Table 21) ($X^2 = 73$; 1df; $P < 0.05$). With an overall prevalence of 48%, pleurocercoids (i.e. larval forms) of the bass tapeworm, *Proteocephalus ambloplitis*, were the most commonly encountered visceral parasites during the course of this study (Table 19). Not only did these organisms exhibit a high prevalence, they were often found in such high numbers in some hosts (i.e. intensity of infection) that it was impossible to count them (Figure 20). The highest prevalence occurred among largemouth bass (96%) (Fig. 21) and smallmouth bass (87%) (Table 19). White basses were refractory to this parasite species, while spotted and hybrid basses exhibited moderate prevalence rates at 21% and 19%, respectively (Table 19). All sexes and immatures of the largemouth bass were infected at a 90% prevalence rate or higher (Table 22). The highest intensities (being to many to count) occurred among immature largemouth bass and adult spotted bass (Fig. 20). The same is true for adult smallmouth bass (Table 23). In hybrid bass, *P. ambloplitis* pleurocercoids were not as prevalent for these species (Table 26). *Proteocephalus ambloplitis* pleurocercoids are distributed evenly across all classes of hosts by sex/ immatures among these bass species.

Figure 20. Pleurocercoid (*Proteocephalus ambloplitis*) infection:

Spotted bass, *Micropterus punctulatus*, showing massive fibrosis of visceral organs.

Fibrosis of visceral (enlarged) showing some pleurocercoids (arrows), was so extensive that the organs cannot be separated. Heavy pleurocercoid infection, was commonly encountered in this host species.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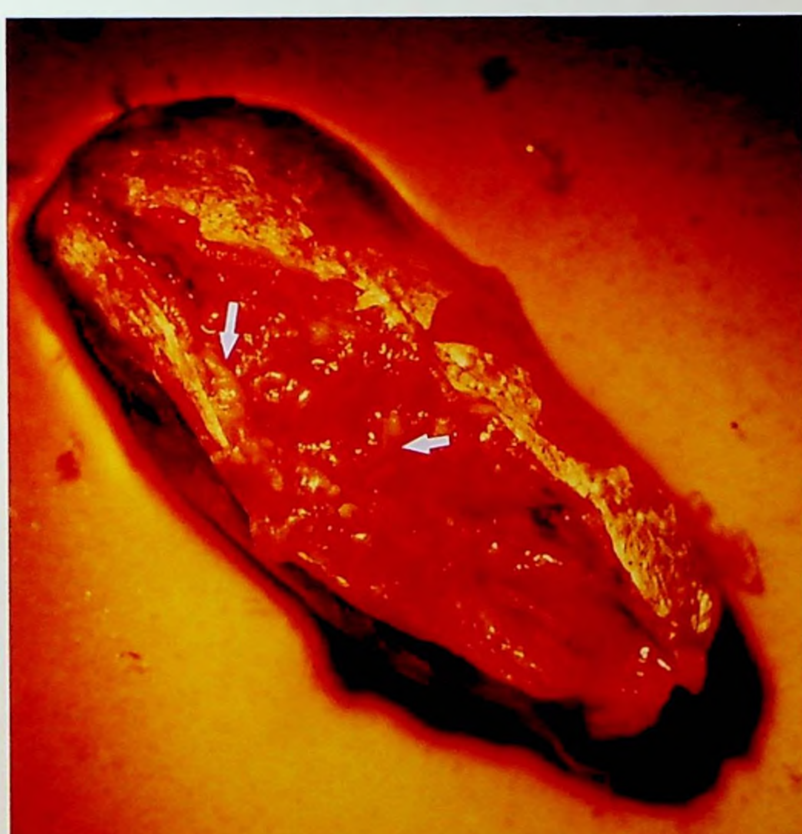


Figure 21. Largemouth bass, *Micropterus salmoides*.

Pleurocercoid, Proteocephalus ambloplitis, infection within the viscera (arrows).

Pleurocercoid, *Proteocephalus ambloplitis* (entire).

NORTHERN LARGEMOUTH BLACKBASS

Micropterus salmoides salmoides (Lacepède)

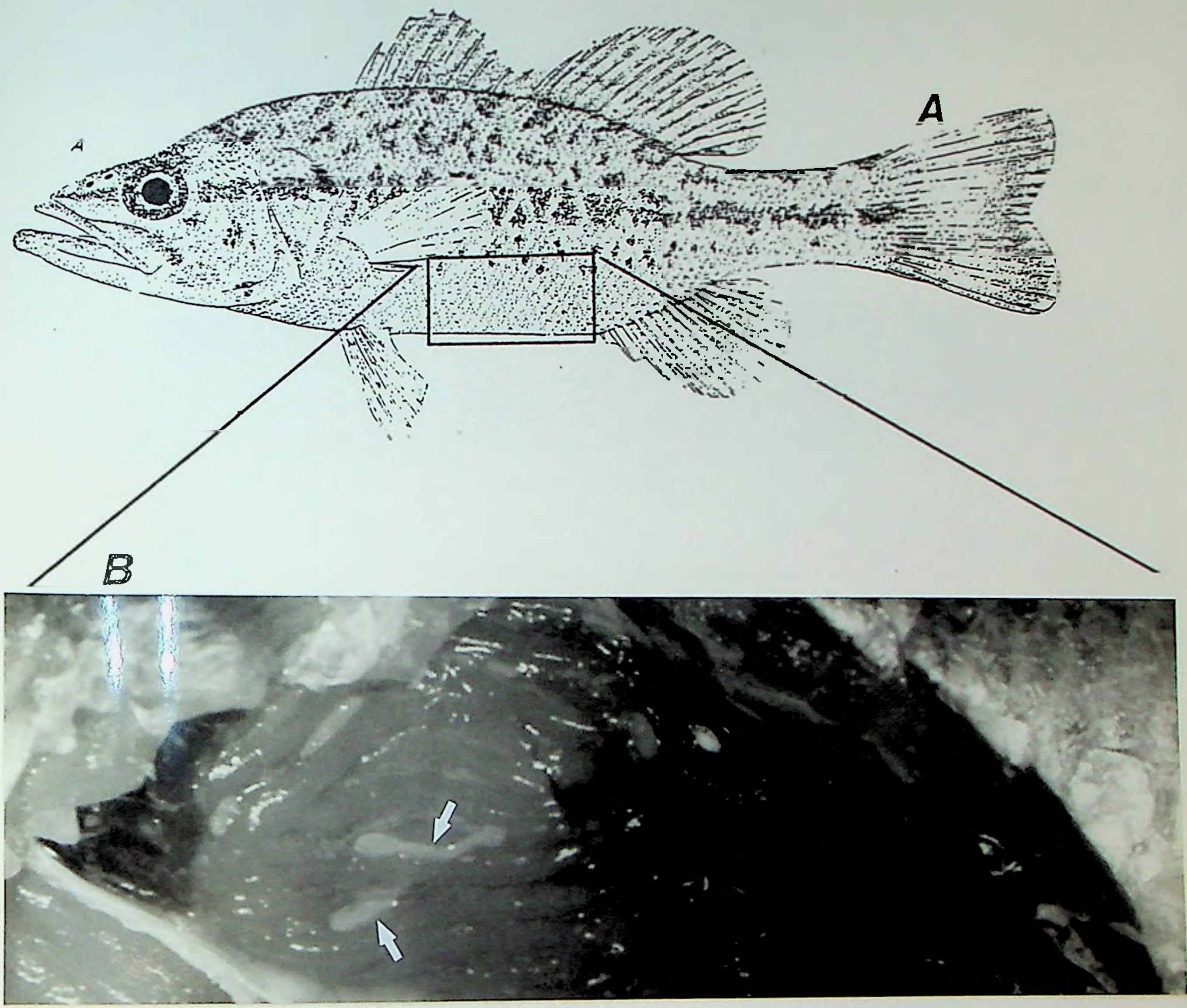


Figure 22. *Proteocephalus ambloplitis* pleurocercoids (right arrow) in liver and pyloric cecae of largemouth bass, *Micropterus salmoides*. The nematode larva, *Philometra* sp. (arrow at far left), was also found within the viscera of this host. Length of the pleurocercoid indicated by middle arrow is approximately 26 mm. P = pyloric cecae, and U = uterus.

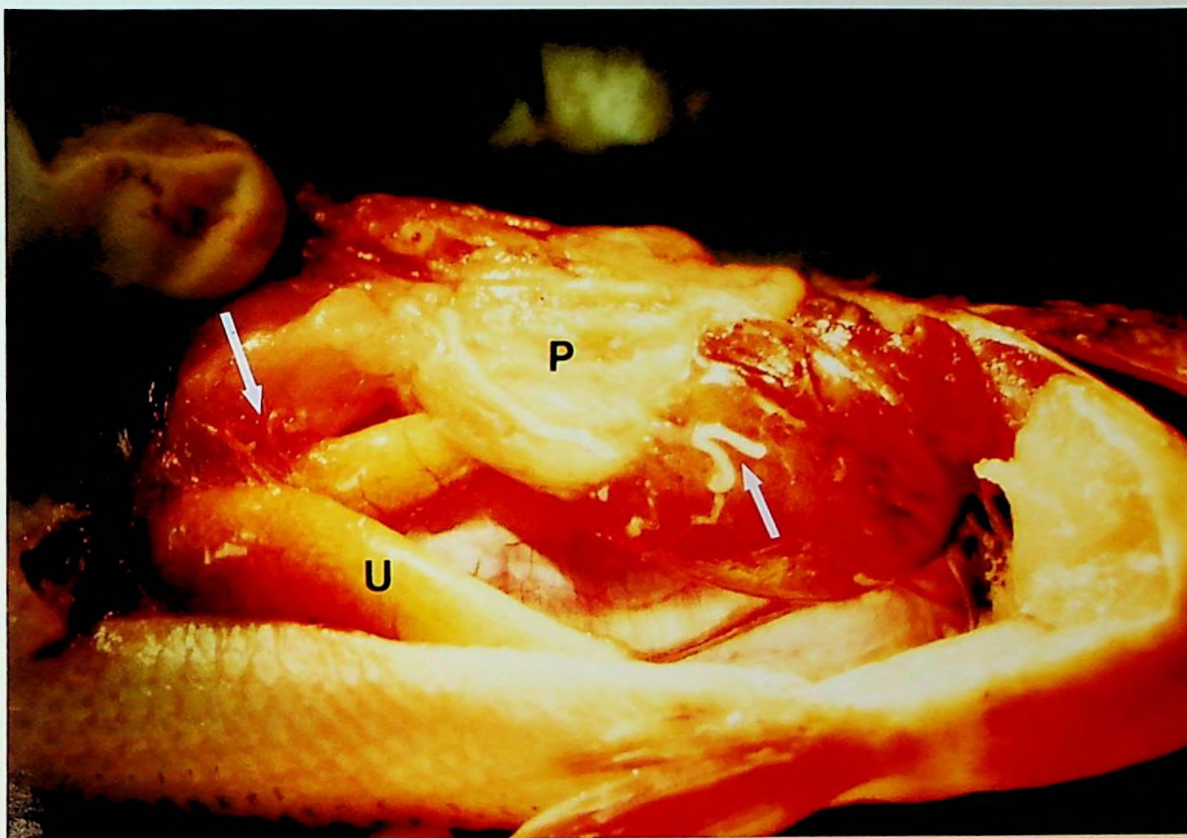
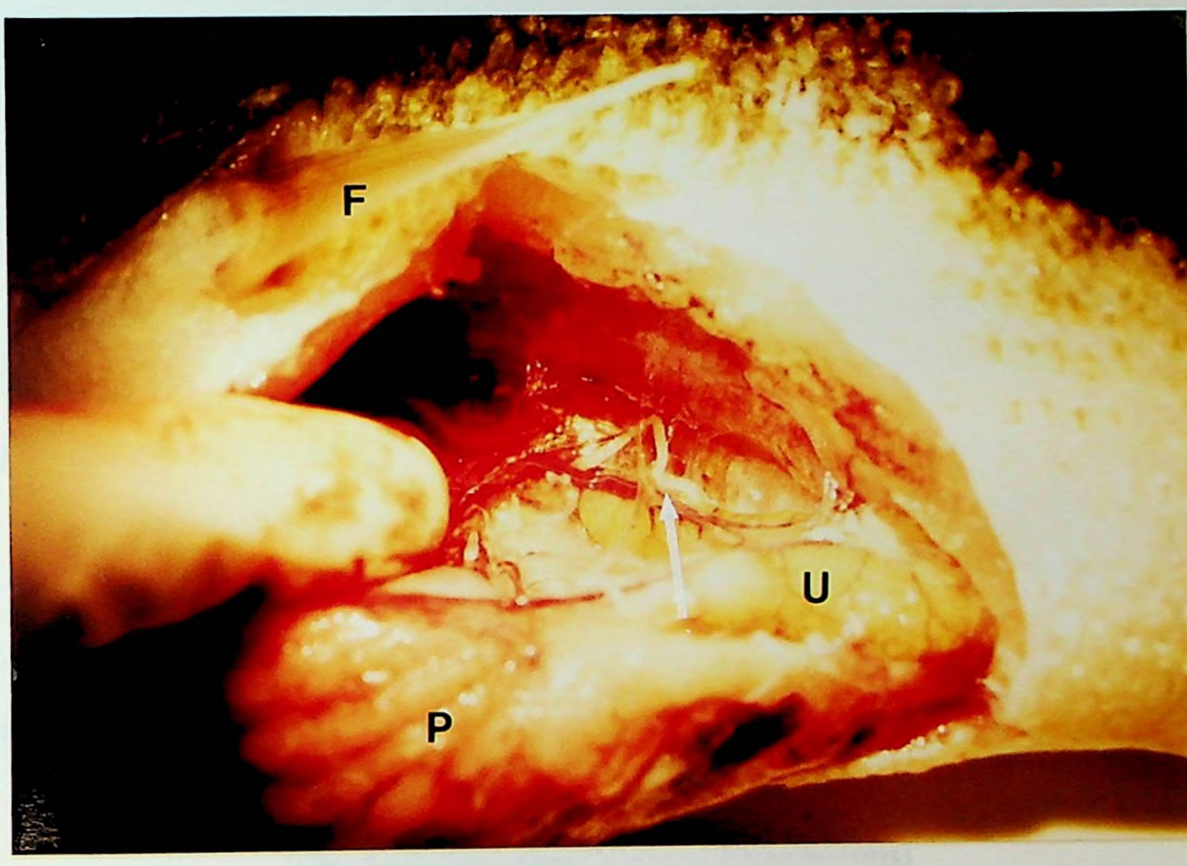

P
U

Figure 23. Swim bladder of largemouth bass cut away to expose the body cavity. *Proteocephalus ambloplitis* pleurocercoid (arrow) lies within the dorsal part of the swim bladder. Relatively light infections shown here and in Figure 10 were typical for adult largemouth basses. Length of pleurocercoid approximately 20 mm. P = pyloric cecae, F = pelvic fin, and U = uterus.


F
U
P

Because pleurocercoids of the bass tapeworm were so prevalent within some hosts (Figure 20), it resulted in fibrosis of the viscera that was so extensive that individual organs could not be separated from one another (Figure 20). This pathologic picture was common for immature largemouth bass and some adult spotted bass. Adult largemouth and smallmouth basses contained light infections (Fig. 22 and 23). Pleurocercoid infections in bass of river systems (smallmouth, white, and hybrid basses) contained relatively low intensities (<10 per infected host).

Bothriocephalus sp., with all five bass host species combined, had only a 2% infection rate (Table 19). It affects only those fish hosts from lakes, specifically smallmouth and spotted basses (Tables 21, 23, and 24).

Overall, prevalences of adult tapeworms, *Proteocephalus ambloplitis* and *Bothriocephalus* sp. were very low at 1% and 2%, respectively (Table 19). Then too, adult tapeworms were found only in those hosts taken from lake ecosystems (Tables 20 and 21).

The Aschelminthes (Visceral Roundworms)

Eight species of roundworm parasites (five nematodes and three acanthocephalans) were found in the viscera of a sample population of 215 basses representing five different host species.

Nematoda:

The nematode *Camallanus oxycephalus* (Figure 24), was found in all host species with the exception of spotted bass, in both rivers and lakes at a prevalence of 29% (Table 27). There is no significant difference for prevalence of *C. oxycephalus* in river (27%) versus lake (30%) hosts (X^2 = .097; 1df; $P > 0.05$) (Tables 28 and 29). In lakes

Figure 24. Nematodes found within the intestines of bass:

Camallanus oxycephalus, anterior showing large buccal capsule with characteristic longitudinal chitinous ridges.

Spinitectus sp. with itscharacteristic rows of spines encircling the body at the anterior end of the nematode

Spiroxys sp. with small but distinct U-shaped anterior buccal capsule.

versus rivers, smallmouth bass caught in lakes contained the highest prevalence (Table 31) followed by hybrid bass (Table 34). Lowest prevalences were among largemouth bass (Table 30) and white bass (Table 33). Among lake host sexes and immatures, *C. oxycephalus* appears to be evenly distributed among both sexes and immatures of smallmouth bass. In hybrid bass, females appeared to be more susceptible to infections than males and immatures (Table 34). White and hybrid basses were the most susceptible to infections of *C. oxycephalus*. Females of white bass were more susceptible to infection than males and immatures (Table 33) and the same was true for hybrid basses (Table 34). Those basses least infected were in lake systems (largemouth, smallmouth, and spotted basses) (Tables 30 through 33).

The genus *Spinitectus* sp. (Figure 24) was found in all five host species (Table 27), and in hosts from both rivers and lakes (Tables 28 and 29). Prevalence of this organism appears to be highest from river systems (33%) compared to lake systems (8%) (Tables 28 and 29) ($X^2 = 19$; 1df; $P < 0.05$). Prevalence is highest among white bass females (47%) (Table 33) and hybrid bass males at 42% (Table 34).

Adults of the nematode *Spiroxys* sp. (Figure 24) were found only in river systems (Table 28) with low prevalence among white bass females at 6% and female hybrid basses at 3% (Table 39). Due to low prevalences in river systems (at 2%; Table 33) and not being found among lake systems, the numbers were too low for any statistical comparisons.

Unidentified larval nematodes (Figure 25) were generally found in lake basses, specifically smallmouth bass (37% in rivers and lakes combined), at total prevalences of 8% (Table 32). Only 1% of the hosts were found among river systems; whereas, 12% were found among lake systems. Equal prevalence numbers were found among females and male basses in lake systems (Table 36).

Figure 25. Nematodes found within the mesentery:

Unidentified nematode larva encysted in mesentery.

Philometra sp., anterior end with small mouth capsule; encircling cuticular ridges or "bosses."

Larvae of the nematode genus *Philometra* sp. (Figure 25), were found only in largemouth, smallmouth, and spotted bass. *Philometra* sp. is a parasitic species confined to lake basses (Table 32 and 34). Intensities of infection were very low, 1 or 2 per infected host. Highest prevalences occurred among smallmouth and spotted basses (Tables 36 and 37). Lowest prevalence was in largemouth bass with only two fish being infected, 1 young-of-the-year and 1 male. This nematode species was non-existent in white and hybrid bass. It appears that females and males were equally susceptible to the parasitism of *Philometra* sp. in smallmouth and spotted basses (Tables 36 and 37). Males of smallmouth bass contained the highest prevalence at 43% (Table 34).

Acanthocephalans:

Three acanthocephalans were found in basses from river and lake ecosystems. Two acanthocephalans, *Leptorhynchus* sp. and *Pomphorhynchus bulbocolli*, were collected only from river basses. *Neoechinorhynchus* sp. was collected from only lake basses (Table 34).

Leptorhynchus sp. (Figures 26) was collected only from a female white bass (Tables 33). *Pomphorhynchus bulbocolli* was found within the stomach of smallmouth bass and the intestines of white and hybrid basses. Prevalence was relatively low (at 5%) in river systems. From what has been found, only adult fishes were affected (Tables 33 and 34) (Fig. 27).

Neoechinorhynchus sp. among lake hosts were found in 48% of the bass species (Fig. 26). This parasite was found within the intestinal tract of largemouth, smallmouth, and spotted basses. The highest prevalence was found among smallmouth bass (90%) in lake ecosystems. Spotted bass was next at 83%, and lastly largemouth bass at 6% (Table 34).

Figure 26. Acanthocephalans located within the intestinal tract of basses:

Neoechinorhyncus sp. with characteristic globular proboscis armed with relatively few hooks.

Leptorhynchus sp. adult, (entire).

Leptorhynchus sp. proboscis with many rows of hooks.

Figure 27. *Pomphorhyncus bulbicoli*:

Adults in situ. Proboscis, bulb, and a smoothe neck region that is nearly as long as the body, are found deeply embedded in the intestinal wall. Note pronounced inflammation. Bodies of worms are approximately 20 mm long.

Anterior end, proboscis above bulb containing rows of hooks

Prevalence among host sexes occurred equally among male and female smallmouth bass and was non-existent in immature. The same was true for spotted bass. Only 2 male largemouth basses were infected with *Neoechinorhynchus* sp. No statistical comparisons were made because the number of infected hosts in lake systems are so obvious.

Table 1. Five species of basses collected from both RIVER and LAKE ecosystems in West Virginia. Letters in parentheses following each common name are database indicators/abbreviations for each host species and are used in subsequent tables. n = total number of each host species collected (i. e. sample size).

Common Name	**Scientific Name**		**River (n)**	**Lake (n)**
Largemouth bass (LMB)	*Micropterus salmoides*	(Lacepede)	0	47
Smallmouth bass (SMB)	*Micropterus dolomieui*	Lacepede	6	40
Spotted bass (SPB)	*Micropterus punctulatus*	(Rafinesque)	0	29
White bass (WHB)	*Morone chrysops*	(Rafinesque)	30	0
Hybrid bass (HYB)	*Morone chrysops*	(Rafinesque)		
	x *Morone saxatilis*	(Walbaum)	49	14
		Totals =	85	130

Table 2. Basses collected from RIVER ecosystem in 1997, by species and sample size (n). General site locations shown in Figure 1.

River Sites:

rash = Ashland, Kentucky (Ohio River)

rrcb = Rober C. Byrd Locks and Dam (Ohio River)

rrac = Racine Locks and Dam (Ohio River)

rlon = London Locks and Dam (Kanawha River)

	River Sites				
Host Species	**rash**	**rrcb**	**rrac**	**rlon**	**Total n**
LMB					0
SMB			3	3	6
SPB					0
WHB	3	9	17	1	30
HYB	2	13	32	2	49
Totals =	5	22	52	6	85

Table 3. Basses collected from LAKE sites in 1997, by species and sample number (n). General site locations shown in Figure 1.

Lake Sites:

lbf = Beech Fork Lake

lel = East Lynn Lake

lbur = Burnsville Lake

lsj = Stonewall Jackson Lake

lsum = Summersville Lake

	Lake Sites					
Host Species	**lbf**	**lel**	**lbur**	**lsj**	**lsum**	**n**
LMB	44			1	2	47
SMB	0		1		39	40
SPB	4	5	20			29
WHB	0					0
HYB	14					14
Totals	62	5	21	1	41	130

Table 4. Basses collected in RIVER ecosystems by host sex. Basses from all river sites combined. ND = Not Determined; n = total sample size.

Host Species	females	males	immatures	ND	Total n
LMB					0
SMB	4	1	1		6
SPB					0
WHB	17	7	6		30
HYB	29	19	1		49
Total =	50	27	8	0	85

Table 5. Basses collected in LAKE ecosystems by host sex. Basses from all lake sites combined. ND = Not determined; n = total sample size.

Host Species	females	males	immatures	ND	Total n
LMB	10	11	24	2	47
SMB	21	16	2	1	40
SPB	17	10	0	2	29
WHB	0	0	0	0	0
HYB	4	3	7	0	14
Totals	52	40	33	5	130

Table 6. Largemouth bass (LMB), *Micropterus salmoides*, collections by site, date, and method of capture. Letters in parentheses following each collection site name are database abbreviations/ indicators (see Figure 1; Table 4).

Collection Site	**Collection Date (1997)**	**Collection Method**	**Number in Sample (n)**
Beech Fork Lake (lbf)	12 Sep	Rotenone	41
	05 Nov	Gill Net	3
Stonewall Jackson Lake (lsj)	05 Sep	Rotenone	1
Summersville Lake (lsum)	29 Jul	Rotenone	2
			Total n = 47

Table 7. Smallmouth bass (SMB), *Micropterus dolomieui*, collections by site, date, and method of capture. Letters in parentheses following each collection site name are database abbreviations/ indicators (see Figure 1; Table 2 and 4).

Collection Site	**Collection Date (1997)**	**Collection Method**	**Number in Sample (n)**
Burnsville Lake (lbur)	15 Oct	Rotenone	1
Summersville Lake (lsum)	29 Jul	Rotenone	7
	28 Oct	Gill Net	32
London Locks (rlon)	07 Oct	Rotenone	3
Racine Locks (rrac)	18 Sep	Rotenone	3
			Total n = 46

Table 8. Spotted bass (SPB), *Micropterus punctatus*, collections by site, date, and method of capture. Letters in parentheses following each collection site name are database abbreviations/ indicators (see Figure 1; Table 4).

Collection Site	Collection Date (1997)	Collection Method	Number in Sample (n)
Beech Fork Lake (lbf)	12 Sep	Rotenone	2
	05 Nov	Gill Net	2
Burnsville Lake (lbur)	15 Oct	Gill Net	20
East Lynn Lake (lel)	05 Nov	Gill Net	5
			Total n = 29

Table 9. White bass (WHB), *Morone chrysops*, collections by site, date, and method of capture. Letters in parentheses following each collection site name are database abbreviations/ indicators (see Figure 1; Table 2).

Collection Site	Collection Date (1997)	Collection Method	Number in Sample (n)
Ashland, KY (rash)	26 Jun	Anglers	3
Robert C. Byrd Locks (rrcb)	1 Jul	Anglers	9
London Locks (rlon)	07 Oct	Rotenone	1
Racine Locks (rrac)	18 Sep	Rotenone	17
			Total n = 30

Table 10. Hybrid bass (HYB), *Morone chrysops x Morone saxatilis*, collections by site, date, and method of capture. Letters in parentheses following each collection site name are database abbreviations/ indicators (see Figure 1; Tables 2 and 4).

Collection Site	Collection Date (1997)	Collection Method	Number in Sample (n)
Beech Fork Lake (lbf)	12 Sep	Rotenone	7
	05 Nov	Gill Net	7
Ashland, KY (rash)	26 Jun	Anglers	2
Racine Locks (rrac)	18 Sep	Rotenone	32
Robert C. Byrd Locks (rrcb)	3 and 15 May 15 Jul	Anglers	13
London Locks (rlon)	07 Oct	Rotenone	2
			Total n = 63

Table 11. Prevalence of GILL parasites in ALL bass hosts from both RIVER and LAKE ecosystems. Host sexes and immatures are combined in the n-value (i.e. host sample size in brackets), as well. [Note: Prevalences of gill parasites in basses from RIVER and LAKE ecosystems are shown in Tables 15 and 16. respectively. Prevalences of gill parasites, for each of the five host species, by host sex from RIVER versus LAKE ecosystems are given in Tables 17 through 21]. Capital letter designators for host species given in Table 1. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

Gill Parasites	LMB [47]	SMB [46]	SPB [29]	WHB [30]	HYB [63]	Totals [215]
Trematodes:						
small form*	33(70)	20(43)	6(21)	25(83)	34(54)	118(55)
Actinocleidus sp.	16(34)	5(11)	6(21)	9(30)	26(41)	62(29)
Arthropods:						
Argulus sp.	1(2)	0	0	0	1(2)	2(1)
Ergasilus centrachidarum	2(4)	8(17)	2(7)	6(20)	21(33)	39(18)
Annelid:						
Piscicola sp	0	2(4)	0	0	3(5)	5(2)
Mollusca:						
clam glochidium	0	3(7)	0	1(3)	0	4(2)

**Clavunculus* sp., *Haplocleidus* sp., and *Urocleidus* sp. combined.

Table 12. Prevalence gill parasite species in basses from RIVER ecosystems. Host sexes and immatures combined in the n-value (i. e. host sample size in brackets). Numbers in the table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses; [n] = sample size of host.

	RIVER Host Species [n]					
Gill Parasites	**LMB [0]**	**SMB [6]**	**SPB [0]**	**WHB [30]**	**HYB [49]**	**Totals [85]**
Trematodes:						
small form*		2(33)		25(83)	31(61)	58(68)
Actinocleidus sp.		0		9(30)	24(49)	33(39)
Arthropods:						
Argulus sp.		0		0	1(2)	1(1)
Ergasilus centrachidarum		2(33)		6(20)	17(35)	25(29)
Annelid:						
Piscicola sp.		1(17)		0	3(6)	4(5)
Mollusca:						
clam glochidium		1(17)		1(3)	0	2(2)

**Clavunculus* sp., *Haplocleidus* sp., and *Urocleidus* sp. combined.

Table 13. Prevalence of gill parasite species in basses from LAKE ecosystems. Host sexes and immatures combined in the n-value (i. e. host sample size in brackets). Numbers in the table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses; [n] = sample size.

	LAKE Host Species [n]					
Gill Parasites	**LMB [47]**	**SMB [40]**	**SPB [29]**	**WHB [0]**	**HYB [14]**	**Totals [130]**
Trematodes:						
small form*	33(70)	19(45)	6(21)		3(21)	61(47)
Actinocleidus sp.	16(34)	5(13)	6(21)		2(14)	29(22)
Arthropods:						
Argulus sp.	1(2)	0	0		0	1(1)
Ergasilus centrachidarum	2(4)	6(15)	2(7)		4(29)	14(11)
Annelid:						
Piscicola sp.	0	1(3)	0		0	1(1)
Mollusca:						
clam glochidium	0	2(5)	0		0	2(2)

**Clavunculus* sp., *Haplocleidus* sp., and *Urocleidus* sp. combined.

Table 14. Prevalences of gill parasite species in largemouth bass (LMB), segregated by host sex and immatures, from RIVER versus LAKE ecosystems. y = young-of-the-year; f = female; m = male; nd = sex not determined; [n] = sample size. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

	Ecosystem							
	RIVER				LAKE			
Gill Parasites	**y [0]**	**f [0]**	**m [0]**	**nd [0]**	**y [24]**	**f [10]**	**m [11]**	**nd [2]**
Trematodes:								
small form*					11(46)	10(100)	10(91)	2(100)
Actinocleidus sp.					5(21)	4(40)	6(55)	1(50)
Arthropods:								
Argulus sp.					1(4)	0	0	0
Ergasilus centrachidarum					0	1(10)	1(9)	0
Annelid:								
Piscicola sp.					0	0	0	0
Mollusca:								
clam glochidium					0	0	0	0

**Clavunculus* sp., *Haplocleidus* sp., and *Urocleidus* sp. combined.

Table 15. Prevalences of gill parasite species in smallmouth bass (SMB), segregated by host sex and immatures, from RIVER versus LAKE ecosystems. y = young-of-the-year; f = female; m = male; nd = not determined; [n] = sample size. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

	Ecosystem							
	RIVER				LAKE			
Gill Parasites	**y [1]**	**f [4]**	**m [1]**	**nd [0]**	**y [2]**	**f [21]**	**m [16]**	**nd [1]**
Trematodes:								
small form*	0	2(50)	0		2(100)	10(48)	6(38)	1(100)
Actinocleidus sp.	0	0	0		1(50)	1(5)	2(13)	1(100)
Arthropods:								
Argulus sp.	0	0	0		0	0	0	0
Ergasilus centrachidarum	0	2(50)	0		0	2(10)	4(25)	0
Annelid:								
Piscicola sp.	0	1(25)	0		0	0	1(6)	0
Mollusca:								
clam glochidium	0	0	1(100)		0	2(10)	0	0

**Clavunculus* sp., *Haplocleidus* sp., and *Urocleidus* sp. combined.

Table 16. Prevalences of gill parasite species in spotted bass (SPB), segregated by host sex and immatures, from RIVER versus LAKE ecosystems. y = young-of-the-year; f = female; m = male; nd = not determined; [n] = sample size. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

	Ecosystem							
	RIVER				LAKE			
Gill Parasites	**y** [0]	**f** [0]	**m** [0]	**nd** [0]	**y** [0]	**f** [17]	**m** [10]	**nd** [2]
Trematodes:								
small form*						2(12)	3(30)	1(50)
Actinocleidus sp.						4(24)	2(20)	0
Arthropods:								
Argulus sp.						0	0	0
Ergasilus centrachidarum						1(6)	1(10)	0
Annelid:								
Piscicola sp.						0	0	0
Mollusca:								
clam glochidium						0	0	0

**Calvunculus* sp., *Haplocleidus* sp., and *Urocleidus* sp. combined.

Table 17. Prevalences of gill parasite species in white bass (WHB), segregated by host sex and immatures, from RIVER versus LAKE ecosystems.
y = young-of-the-year; f = female; m = male; nd = not determined; [n] = sample size. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

	Ecosystem							
	RIVER				LAKE			
Gill Parasites	**y** [6]	**f** [17]	**m** [7]	**nd** [0]	**y** [0]	**f** [0]	**m** [0]	**nd** [0]
Trematodes:								
small form*	5(83)	13(77)	7(100)					
Actinocleidus sp.	2(33)	4(24)	3(43)					
Arthropods:								
Argulus sp.	0	0	0					
Ergasilus centrachidarum	2(33)	3(18)	1(14)					
Annelid:								
Piscicola sp.	0	0	0					
Mollusca:								
clam glochidium	1(17)	0	0					

**Clavunculus* sp., *Haplocleidus* sp., and *Urocleidus* sp. combined.

Table 18. Prevalences of gill parasite species in hybrid bass (HYB), segregated by host sex and immatures, from RIVER versus LAKE ecosystems. y = young-of-the-year; f = female; m = male; nd = not determined; [n] = sample size. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

	Ecosystem							
	RIVER				LAKE			
Gill Parasites	**y** [1]	**f** [29]	**m** [19]	**nd** [0]	**y** [7]	**f** [4]	**m** [3]	**nd** [0]
Trematodes:								
small form*	1(100)	18(62)	12(63)		1(14)	1(25)	1(33)	
Actinocleidus sp.	1(100)	12(41)	11(58)		2(29)	0	0	
Arthropods:								
Argulus sp.	0	1(4)	0		0	0	0	
Ergasilus centrachidarum	0	11(38)	6(32)		4(57)	0	0	
Annelid:								
Piscicola sp.	0	1(4)	2(11)		0	0	0	
Mollusca:								
clam glochidium	0	0	0		0	0	0	

**Clavunculus* sp., *Haplocleidus* sp., and *Urocleidus* sp. combined.

Table 19. Prevalences of visceral flatworm parasites in ALL bass hosts from both RIVER and LAKE ecosystems. Host sexes and immatures are combined in the n-value (i.e. host sample size in brackets), as well. [Note: Prevalences of flatworms in basses from RIVER and LAKE ecosystems are shown in Tables 23 and 24, respectively. Prevalences of flatworms, for each of the five host species, by host sex from RIVER versus LAKE ecosystems are given in Tables 25 through 29. Capital letter designators for host species given in Table 1. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

	Host Species [n]					
Flatworm Species	**LMB [47]**	**SMB [46]**	**SPB [29]**	**WHB [30]**	**HYB [63]**	**Totals [215]**
Trematodes:						
Bucephalus polymorphus	0	2(4)	0	19(63)	40(64)	61(28)
Leuceruthrus micropteri	0	1(2)	0	5(17)	10(16)	16(7)
Pisciamphistoma reynoldsi	3(6)	4(9)	2(7)	0	0	9(4)
Posthodiplostomulum sp.*	15(32)	4(9)	1(4)	0	1(2)	21(10)
Tapeworms:						
Bothriocephalus sp.	0	4(9)	1(4)	0	0	5(2)
Proteocephalus ambloplitis	0	2(4)	0	0	0	2(1)
*Proteocephalus ambloplitis***	45(96)	40(87)	6(21)	1(3)	12(19)	104(48)

*metacercariae and/ or immature forms
**pleurocercoids (i.e. larval forms)

Table 20. Prevalences of VISCERAL FLATWORM species in basses from RIVER ecosystems. Host sexes and immatures combined in the n-value (i. e. host sample size in brackets).

Flatworm Species	RIVER Host Species LMB [0]	SMB [6]	SPB [0]	WHB [30]	HYB [49]	Totals [85]
Trematodes:						
Bucephalus polymorphus		0		19(63)	40(82)	59(69)
Leuceruthrus micropteri		1(6)		5(17)	9(18)	15(18)
Pisciamphistoma reynoldsi		0		0	0	0
Posthodiplostomulum sp.*		3(50)		0	0	3(4)
Tapeworms:						
Bothriocephalus sp.		0		0	0	0
Proteocephalus ambloplitis		0		0	0	0
*Proteocephalus ambloplitis***		2(33)		1(3)	7(14)	10(12)

*metacercariae and/ or immature forms
**pleurocercoids (i. e. larval forms)

Table 21. Prevalence of visceral flatworm species in basses from LAKE ecosystems. Host sexes and immatures combined in the n-value (i. e. host sample size in brackets).

	LAKE Host Species [n]					
Flatworm Species	**LMB [47]**	**SMB [40]**	**SPB [29]**	**WHB [0]**	**HYB [14]**	**Totals [130]**
Trematodes:						
Bucephalus polymorphus	0	2(5)	0		0	2(2)
Leuceruthrus micropteri	0	0	0		1(7)	1(1)
Pisciamphistoma reynoldsi	3(6)	4(10)	2(7)		0	9(7)
Posthodiplostomulum sp.*	15(32)	1(3)	1(4)		1(7)	18(14)
Tapeworms:						
Bothriocephalus sp.	0	4(10)	1(4)		0	5(4)
Proteocephalus ambloplitis	0	2(5)	0		0	2(2)
*Proteocephalus ambloplitis***	45(96)	38(95)	6(21)		5(36)	94(72)

*metacercariae and/ or immature forms
**pleurocercoids (i. e. larval forms)

Table 22. Prevalences of VISCERAL FLATWORM species in largemouth bass (LMB), segregated by host sex and immatures, from RIVER versus LAKE ecosystems. y = young-of-the-year; f = female; m = male; nd = not determined; [n] = sample size. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

	Ecosystem							
	RIVER				LAKE			
Flatworm Species	**y [0]**	**f [0]**	**m [0]**	**nd [0]**	**y [24]**	**f [10]**	**m [11]**	**nd [2]**
Trematodes:								
Bucephalus polymorphus					0	0	0	0
Leuceruthrus micropteri					0	0	0	0
Pisciamphistoma reynoldsi					2(8)	1(10)	0	0
Posthodiplostomulum sp.*					3(13)	5(50)	7(64)	0
Tapeworms:								
Bothriocephalus sp.					0	0	0	0
Proteocephalus ambloplitis					0	0	0	0
*Proteocephalus ambloplitis***					23(96)	9(90)	11(100)	2(100)

*metacercariae and/ or immature forms
**pleurocercoids (i. e. larval forms)

Table 23. Prevalences of VISCERAL FLATWORM species in smallmouth bass (SMB), segregated by host sex and immatures, from RIVER versus LAKE ecosystems. y = young-of-the-year; f = female; m = male; nd = not determined; [n] = sample size. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

	Ecosystem							
	RIVER				LAKE			
Flatworm Species	**y [1]**	**f [4]**	**m [1]**	**nd [0]**	**y [2]**	**f [21]**	**m [16]**	**nd [1]**
Trematodes:								
Bucephalus polymorphus	0	0	0		0	1(5)	1(6)	0
Leuceruthrus micropteri	0	1(25)	0		0	0	0	0
Pisciamphistoma reynoldsi	0	0	0		0	2(10)	2(13)	0
Posthodiplostomulum sp.*	0	3(75)	0		0	1(5)	0	0
Tapeworms:								
Bothriocephalus sp.	0	0	0		0	3(14)	1(6)	0
Proteocephalus ambloplitis	0	0	0		0	1(5)	1(6)	0
*Proteocephalus ambloplitis***	1(100)	1(25)	0		0	21(100)	16(100)	0

*metacercariae and/ or immature forms
**pleurocercoids (i. e. larval forms)

Table 24. Prevalences of VISCERAL FLATWORM species in spotted bass (SPB), segregated by host sex and immatures, from RIVER versus LAKE ecosystems. y = young-of-the-year; f = female; m = male; nd = not determined; [n] = sample size. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

	Ecosystem							
	RIVER				LAKE			
Flatworm Species	**y** [0]	**f** [0]	**m** [0]	**nd** [0]	**y** [0]	**f** [17]	**m** [10]	**nd** [2]
Trematodes:								
Bucephalus polymorphus						0	0	0
Leuceruthrus micropteri						0	0	0
Pisciamphistoma reynoldsi						1(6)	1(10)	0
Posthodiplostomulum sp.*						1(6)	0	0
Tapeworms:								
Bothriocephalus sp.						1(6)	0	0
Proteocephalus ambloplitis						0	0	0
*Proteocephalus ambloplitis***						3(18)	2(20)	1(50)

*metacercariae and/ or immature forms
**pleurocercoids (i. e. larval forms)

Table 25. Prevalences of VISCERAL FLATWORM species in white bass (WHB), segregated by host sex and immatures, from RIVER versus LAKE ecosystems. y = young-of-the-year; f = female; m = male; nd = not determined; [n] = sample size. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

	Ecosystem							
	RIVER				LAKE			
Flatworm Species	y [6]	f [17]	m [7]	nd [0]	y [0]	f [0]	m [0]	nd [0]
Trematodes:								
Bucephalus polymorphus	4(67)	11(65)	4(57)					
Leuceruthrus micropteri	1(17)	3(18)	1(14)					
Pisciamphistoma reynoldsi	0	0	0					
Posthodiplostomulum sp.*	0	0	0					
Tapeworms:								
Bothriocephalus sp.	0	0	0					
Proteocephalus ambloplitis	0	0	0					
*Proteocephalus ambloplitis***	0	1(6)	0					

*metacercariae and/ or immature forms
**pleurocercoids (i. e. larval forms)

Table 26. Prevalences of VISCERAL FLATWORM species in hybrid bass (HYB), segregated by host sex and immatures, from RIVER versus LAKE ecosystems. y = young-of-the-year; f = female; m = male; nd = not determined; [n] = sample size. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

	Ecosystem							
	RIVER				LAKE			
Flatworm Species	**y** [1]	**f** [29]	**m** [19]	**nd** [0]	**y** [7]	**f** [4]	**m** [3]	**nd** [0]
Trematodes:								
Bucephalus polymorphus	0	26(90)	14(72)		0	0	0	
Leuceruthrus micropteri	0	6(21)	3(16)		1(14)	0	0	
Pisciamphistoma reynoldsi	0	0	0		0	0	0	
Posthodiplostomulum sp.*	0	0	0		0	1(25)	0	
Tapeworms:								
Bothriocephalus sp.	0	0	0		0	0	0	
Proteocephalus ambloplitis	0	0	0		0	0	0	
*Proteocephalus ambloplitis***	0	5(17)	2(11)		3(43)	1(25)	1(33)	

*metacercariae and/ or immature forms
**pleurocercoids (i. e. larval forms)

Table 27. Prevalences of visceral roundworm parasites in ALL bass hosts from both RIVER and LAKE ecosystems. Host sexes and immatures are combined in the n-value (i.e. host sample size in brackets), as well. [Note: Prevalences of roundworms in basses from RIVER and LAKE ecosystems are shown in Tables 33 and 34, respectively. Prevalences of roundworms, for each of the five host species, by host sex from RIVER versus LAKE ecosystems are given in Tables 35 through 39. Capital letter designators for host species given in Table 1. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

	Host Species [n]					
Roundworm Species	**LMB [47]**	**SMB [46]**	**SPB [29]**	**WHB [30]**	**HYB [63]**	**Totals [215]**
Nematode:						
Camallanus oxycephalus	2(4)	34(74)	0	2(7)	24(38)	62(29)
unidentified larva*	0	17(37)	0	0	0	17(8)
Philometra sp.	2(4)	15(33)	5(17)	0	0	22(10)
Spinitectus sp.	2(4)	3(7)	5(17)	11(37)	18(29)	39(18)
Spiroxys sp.	0	0	0	1(3)	1(2)	2(1)
Acanthocephalans:						
Leptorhynchus sp.	0	0	0	1(3)	0	1(.5)
Neoechinorhynchus sp.	3(6)	36(78)	24(83)	0	0	63(29)
Pomphorhynchus bulbocolli	0	2(4)	0	1(3)	1(2)	4(2)

*unidentified larvae in gut lumen or encysted in mesentery.

Table 28. Prevalences of visceral roundworm species in basses from RIVER ecosystems. Host sexes and immatures combined in the n-value (i.e. host sample size in brackets).

	RIVER Host Species [n]					
Flatworm Species	**LMB [0]**	**SMB [6]**	**SPB [0]**	**WHB [30]**	**HYB [49]**	**Totals [85]**
Nematodes:						
Camallanus oxycephalus		2(33)		2(7)	19(39)	23(27)
unidentified larva*		1(17)		0	0	1(1)
Philometra sp.		0		0	0	0
Spinitectus sp.		1(17)		11(37)	16(33)	28(33)
Spiroxys sp.		0		1(3)	1(2)	2(2)
Acanthocephalans:						
Leptorhynchus sp.		0		1(3)	0	1(1)
Neoechinorhynchus sp.		0		0	0	0
Pomphorhynchus bulbocolli		2(33)		1(3)	1(2)	4(5)

*unidentified larvae in gut lumen or encysted in mesentery.

Table 29. Prevalences of visceral roundworm species in basses from LAKE ecosystems. Host sexes and immatures combined in the n-value (i.e. host sample size in brackets).

	LAKE Host Species [n]					
Flatworm Species	LMB [47]	SMB [40]	SPB [29]	WHB [0]	HYB [14]	Totals [130]
Nematodes:						
Camallanus oxycephalus	2(4)	32(80)	0		5(36)	39(30)
unidentified larva*	0	16(40)	0		0	16(12)
Philometra sp.	2(4)	15(38)	5(17)		0	22(17)
Spinitectus sp.	2(4)	2(5)	5(17)		2(14)	11(8)
Spiroxys sp.	0	0	0		0	0
Acanthocephalans:						
Leptorhynchus sp.	0	0	0		0	0
Neoechinorhynchus sp.	3(6)	36(90)	24(83)		0	63(48)
Pomphorhynchus bulbocolli	0	0	0		0	0

*unidentified larvae in gut lumen or encysted in mesentery.

Table 30. Prevalences of visceral roundworm species in largemouth bass (LMB), segregated by host sex and immatures, from RIVER versus LAKE ecosystems. y = young-of-the-year; f = female; m = male; nd = not determined; [n] = sample size. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

	Ecosystem							
	RIVER				LAKE			
Roundworm Species	**y** [0]	**f** [0]	**m** [0]	**nd** [0]	**y** [24]	**f** [10]	**m** 11]	**nd** [2]
Nematodes:								
Camallanus oxycephalus					0	1(10)	1(9)	0
unidentified larva*					0	0	0	0
Philometra sp.					1(4)	0	1(9)	0
Spinitectus sp.					1(4)	1(10)	0	0
Spiroxys sp.					0	0	0	0
Acanthocephalans:								
Leptorhynchus sp.					0	0	0	0
Neoechinorhynchus sp.					0	0	2(18)	1(50)
Pomphorhynchus bulbocolli					0	0	0	0

*unidentified larvae in gut lumen or encysted in mesentery.

Table 31. Prevalences of visceral roundworm species in smallmouth bass (SMB), segregated by host sex and immatures, from RIVER versus LAKE ecosystems. y = young-of-the-year; f = female; m = male; nd = not determined; [n] = sample size. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

	Ecosystem							
	RIVER				LAKE			
Roundworm Species	y [1]	f [4]	m [1]	nd [0]	y [2]	f [21]	m [16]	nd [1]
Nematodes:								
Camallanus oxycephalus	0	2(50)	0		0	17(81)	14(88)	1(100)
unidentified larva*	1(100)	0	0		0	10(48)	6(38)	0
Philometra sp.	0	0	0		0	9(43)	6(38)	0
Spinitectus sp.	0	0	1(100)		0	2(10)	0	0
Spiroxys sp.	0	0	0		0	0	0	0
Acanthocephalans:								
Leptorhynchus sp.	0	0	0		0	0	0	0
Neoechinorhynchus sp.	0	0	0		0	21(100)	15(94)	1(100)
Pomphorhynchus bulbocolli	0	1(25)	1(100)		0	0	0	0

*unidentified larvae in gut lumen or encysted in mesentery.

Table 32. Prevalences of visceral roundworm species in spotted bass (SPB), segregated by host sex and immatures, from RIVER versus LAKE ecosystems. y = young-of-the-year; f = female; m = male; nd = not determined; [n] = sample size. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

	Ecosystem							
	RIVER				LAKE			
Roundworm Species	**y** [0]	**f** [0]	**m** [0]	**nd** [0]	**y** [0]	**f** [17]	**m** [10]	**nd** [2]
Nematodes:								
Camallanus oxycephalus						0	0	0
unidentified larva*						0	0	0
Philometra sp.						3(18)	2(20)	0
Spinitectus sp.						2(12)	3(30)	0
Spiroxys sp.						0	0	0
Acanthocephalans:								
Leptorhynchus sp.						0	0	0
Neoechinorhynchus sp.						14(82)	10(100)	0
Pomphorhynchus bulbocolli						0	0	0

*unidentified larvae in gut lumen or encysted in mesentery.

Table 33. Prevalences of visceral roundworm species in white bass (WHB), segregated by host sex and immatures, from RIVER versus LAKE ecosystems. y = young-of-the-year; f = female; m = male; nd = not determined; [n] = sample size. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

	Ecosystem							
	RIVER				LAKE			
Roundworm Species	**y** [6]	**f** [17]	**m** [7]	**nd** [0]	**y** [0]	**f** [0]	**m** [0]	**nd** [0]
Nematodes:								
Camallanus oxycephalus	1(17)	0	1(14)					
unidentified larva*	0	0	0					
Philometra sp.	0	0	0					
Spinitectus sp.	1(17)	8(47)	2(29)					
Spiroxys sp.	0	1(6)	0					
Acanthocephalans:								
Leptorhynchus sp.	0	1(6)	0					
Neoechinorhynchus sp.	0	0	0					
Pomphorhynchus bulbocolli	0	1(6)	0					

*unidentified larvae in gut lumen or encysted in mesentery.

Table 34. Prevalences of visceral roundworm species in hybrid bass (HYB), segregated by host sex and immatures, from RIVER versus LAKE ecosystems. y = young-of-the-year; f = female; m = male; nd = not determined; [n] = sample size. Numbers in table indicate number of n hosts infected, followed by the percent of hosts infected in parentheses.

	Ecosystem							
	RIVER				LAKE			
Roundworm Species	**y [1]**	**f [29]**	**m [19]**	**nd [0]**	**y [7]**	**f [4]**	**m [3]**	**nd [0]**
Nematodes:								
Camallanus oxycephalus	0	12(41)	7(37)		1(14)	3(75)	1(33)	
unidentified larva*	0	0	0		0	0	0	
Philometra sp.	0	0	0		0	0	0	
Spinitectus sp.	0	8(28)	8(42)		1(14)	1(25)	0	
Spiroxys sp.	0	1(3)	0		0	0	0	
Acanthocephalans:								
Leptorhynchus sp.	0	0	0		0	0	0	
Neoechinorhynchus sp.	0	0	0		0	0	0	
Pomphorhynchus bulbocolli	0	1(3)	0		0	0	0	

*unidentified larvae in gut lumen or encysted in mesentery.

CHAPTER VI

DISCUSSION

MONOGENETIC TREMATODES

In a study conducted May through October 1981, it was reported that at least seven species of Ancyrocephalinae are known to be found in largemouth bass but only four would occur at any one locality (Joy, 1984). This may be due to competition within species groups or the inability of parasitologists to separate these species. Joys' 1981 work over a 6-month period was conducted with a sample size of < 50 individual hosts of largemouth and spotted basses collected from Beech Fork Lake. Joy (1984) reported that 88% of the largemouth bass were parasitized with one of these forms. The same is true for the present study, in which 70% of largemouth bass were parasitized with these forms. On the other hand, Joy (1984) recorded 61.9% of the spotted bass being infected with monogenetics; while, the present study only shows 21% of the spotted bass being infected. This may be because the present study, 1997, was considerably more extensive due to 1) a larger sample size consisting of five host species of basses; 2) a seven month collection period (May through November); and 3) collections of hosts from both river and lake ecosystems. Like former studies, present findings showed that monogenetic trematodes occur at relatively high prevalences and low numbers per infected host having no observable effects upon host populations.

There is however some controversy over the synonomy of these trematodes. Hoffman (1967), a leading authority on parasites of North American freshwater fishes, admitted that he was not qualified to resolve the controversy of the synonomy of these trematodes. Even in his own writings, Hoffman (1967) places *Haplocleidus* sp. and *Urocleidus* sp. as being the same species. No other authors have tackled this problem since Hoffmans' writing. Therefore, because of the uncertain taxonomic status of these taxa and inability of parasitologists to make definitive species identification in this group they were labeled "small form" monogenetic trematodes. In the present study, these monogenetic trematodes representing the genera *Clavunculus* sp., *Haplocleidus* sp., and *Urocleidus* sp. were combined and placed into a "small form" category for reporting purposes.

While *Actinocleidus* sp. ("large form") monogenetic trematode was found in all five species of basses examined in the present study (Table 11), comparisons of prevalences of this species can be made only with data given by Joy (1984). In the present study the 34% of largemouth bass was comparible to 43% reported by Joy (1984). *Actinocleidus* sp. was also found in 21% of spotted bass in the present study which was comparible to that of 16.7% reported by Joy (1984). While, white and hybrid basses were the most commonly infected host species in river ecosystems (Table 15) no comparisons could be made with other authors due to lack of information. It appears that both host sexes: females, males, and immatures are equally susceptible to infection by monogenetic trematodes in both river and lake ecosystems (Table 14 through 18). This also conforms to Joy (1984) who noted that "... prevalences of infestation on male basses was not significantly different from that found in females..."

ARTHROPODS

Other ectoparasites were arthropod parasites-- branchiurans and copepods which occurred less frequently than the monogenetic trematodes (Table 14) on hosts from both river and lake ecosystems. Both males and females of the fish louse, *Argulus* sp., are parasitic on North American freshwater fishes (Cheng, 1973). They are normally found on the body surface around the gills or mouth under the mucosa of the fish. Species of *Argulus* sp. are transparent in color and thus are not easily seen on fish (Pennak, 1953). *Argulus* sp. was found in the stomach of largemouth bass from Beech Fork Lake and another was found anterior of the small intestine of a hybrid bass from the Ohio River. These organs of location are believed to be anomalies; perhaps, these individuals were accidentally ingested by the host (Table 17 and 21). Bangham (1941) recorded only 11% of white bass from Buckeye Lake, Ohio parasitized by *Argulus stizostethii* Kellicott. This was considerably higher than prevalence found in the present study (Table 11).

The branchiuran, *Argulus* sp., is rarely found in large numbers, but when there is an increase in population, they are responsible for large fish kills such as that which occurred in South Dakota (Allum and Huggins, 1959). Death usually occurs due to a combination of injected toxins by large numbers of fish lice and the invasion of *Saprolegnia* through wounds left by the parasites, fish lice (Allum and Huggins, 1959). There are also indications that the fish lice attack one fish species at a time. Under natural conditions parasitic arthropods are rarely present in large enough numbers to cause serious harm to the host. However, in hatchery ponds, fish are crowded in a limited amount of space; therefore, allowing greater opportunity for the free-swimming immature stages to find a host possibly resulting in heavy and serious infections (Pennak, 1953). Very few basses were infected in West Virginia and thus this arthropod should be of little concern to fisheries biologists.

The copepod, *Ergasilus centrachidarum*, was collected from hosts in both river and lake ecosystems (Tables 15 and 16). Joy and Pritchard (1984), reported low prevalences and intensities of ergasilids on gills of basses at Beech Fork Lake. They concluded that this arthropod represented no threat to the native bass populations in that reservoir. This copepod was found in all host species in the present study. Even so, since infection intensities were generally fewer than 10 ergasilids per infected host, and overall prevalence was 18%, this ectoparasite species is not considered a threat to native bass populations. A few other direct comparisons can be made. Bangham (1941) reported that

38% of smallmouth bass from Buckeye Lake, Ohio; where as, in the present study only 15% of smallmouth bass from lake ecosystems where parasitized with *Ergasilus centrachidarum*. Largemouth bass were also examined by Bangham (1941) and found that 47% where parasitized in Buckeye Lake compared to 4% of largemouth bass being infected with *E. centrachidarum* in the present study. In another study by Bangham (1944), fish from eight lakes parasitized by another ergasilid, *E. caeruleus* (at 8%). The same is true for the present study (1997). Only the female is parasitic in most cases but there have been cases where males have been found on the gills (Pennak, 1953). Similar results were found by Vernard 1940 in that only five largemouth bass out of 29 from Reelfoot Lake were infected with *E. caeruleus*.

Vernard (1940) and Bangham (1944) found that gill copepods were scarce and not significant in the economy of the fish. *Ergasilus centrachidarum* appears to have caused no observable damage to the gill filaments of the bass species from neither river nor lake hosts within the present study.

ANNELIDA

A leech is readily recognized by its somewhat flattened body, two distinct suckers at each end and by distinct segmentation. Many species of leeches take blood meals and then will leave until it need to feed again (Meyer, 1962). The entry wound left in the host may provide an avenue of entrance for fungi or bacteria. Occasionally, leeches occur in epizootic proportions and cause extensive damage. An example of this was reported from Rock River, Illinois where an epidemic occurred among the red-mouthed buffalo. These fish were so emaciated that they were discarded by fishermen (Rupp and Meyer, 1954). Generally, a leech only temporarily parasitise its host (Meyer, 1962).

Only five individuals of the genus *Piscicola* sp. (Fig. 16) were recovered from adult smallmouth, white and hybrid basses in both river (Ohio and Kanawha Rivers) and lake (Summersville Lake) ecosystems (Tables 18, 20, and 21).

Contrary to some of the findings of Hugghins (1972) and Rupp and Meyer (1954) there was no observable evidence of gill tissue damage or sores around the gills attributed to this annelid parasite. Bangham (1944) noted that *P. punctata* is a common leech of largemouth bass in Reelfoot Lake fishes, off the Mississippi River even though he only removed two specimens from 29 fish. Bangham (1944) reported that it is not unusual to find open sores in the mouths of fish infected with leeches of the genus, *Piscicola*.

MOLLUSCA

A parasite requiring only one host, are the larvae of freshwater mussels. These larvae are known as glochidia, which may occur in such large numbers as to be harmful to the host fish. Larvae are drawn in by the respiration action of the fish. Once they cling firmly to the host, they are overgrown by the hosts' tissue, which forms a protective cyst after about a day. Clam glochidia may stay attached from 10 days to a month or more depending on water temperature, season, and host species attacked. The cyst ruptures and the young mussels become free-living, completing their life cycle in the substrate (Meyer, 1962).

In this study, clam glochidia (Fig. 17) were found in the gills of smallmouth bass from Summersville Lake and smallmouth and white bass from river systems (Ohio and Kanawha Rivers). These young mussels were found with low intensities (< 10 per fish host). The only host response that occurred was clubbing at the end of the gill filament or swelling at the base of the filament.

DIGENETIC TREMATODES

Digenetic trematodes are endoparasites of vertebrates. The most commonly found trematode species in river and lake ecosystems was *Bucephalus polymorphus*. *Bucephalus polymorphus* was found at the highest prevelence (28%) among river and lake digenetic trematodes in the present study. In a study conducted by Bangham (1955), *Bucephalus* sp. was found in (67%) of the white bass examined. Bangham's prevalence rate is not very helpful, however, because his total white bass sample size was only 3 individuals. In the present study, I found that *B. polymorphus* is primarily a river host parasite with the exception of two smallmouth individuals from Summersville Lake (Tables 22 through 26). The reason for this may be because the intermediate host for *B. polymorphus* are river bivalves. The two smallmouth individuals infected with *B. polymorphus* may have traveled from the Gauley River into this region.

Leuceruthrus micropteri Goldberger 1911, a digenetic trematode, was described from the black bass of Wisconsin and Indiana. Bangham (1926) reported small numbers of these flukes in the stomachs of largemouth bass in Lake Erie but not in hosts from Ohio hatcheries or streams. This may be due to *L. micropteri* being confined to smaller bodies of water. The heaviest infestation occurred in a largemouth bass of Lake Erie where the host contained 10 *L. micropteri* in the stomach (Bangham, 1926). *Leuceruthrus micropteri* occurred more frequently in largemouth bass than smallmouth bass (Bangham, 1926). In the present study *L. micropteri* (Fig. 18) was found in 7% of all basses examined (Table 19). It is primarily found in hosts from river systems because river snails, *Pleurocera acuta*, is the intermediate host with the exception of one hybrid bass from Beech Fork Lake.

There is no prevalence data in the literature on *Pisciamphistoma reynoldsi* (Fig. 18) to make any comparison between my data and other data but unlike the former digenetic species it is a lake species.

Posthodiplostomulum sp. was found in 4 of the 5 host species examined in the present study (Table 19). The species *Posthodiplostomum minimum* MacCallum, 1921, the "white grub" (Fig. 19) of the liver, had been recorded from 97 species of 18 families of freshwater fishes (Hugghins, 1972). The final host are the blue heron and the black-crowned night heron. *Posthodiplostomum minimum* may also occur in the heart and kidneys of fish (Hugghins, 1972). Bangham (1944) found three out of 102 largemouth bass from 18 different bodies of water were infected with *P. minimum*. This is far lower than the 32% prevalence of *Posthodiplostomulum* sp. in largemouth bass for the present study. In addition, 10% of all basses sampled from West Virginia waters were infected with this digenetic larval stage. Vernard (1940) found *P. minimum* in the livers and kidneys of 66% (19 of 29) basses from Reelfoot Lake in Tennessee.

CESTODES

Several fish tapeworm studies were conducted throughout the 1900's primarily on largemouth bass and smallmouth bass. Bangham (1941) reported *P. ambloplitis* pleurocercoids found in largemouth and smallmouth bass from Buckeye Lake, Ohio. Pleurocercoids were encysted in 18% of the largemouth bass and 44% of the smallmouth. In the present study, both largemouth bass at 96% and smallmouth bass at 95% in lake systems (Table 21) were considerably higher then what Bangham had reported. Later, Bangham (1955) conducted another study around Lake Huron on Manitoulin Island where he collected white bass, smallmouth bass, and largemouth bass. Bangham found

P. ambloplitis pleurocercoids in 33% of the white bass and 20% of the largemouth bass in his study. Bangham's total sample sizes, however, at 3 for the former host species and 5 for the latter host species are too small for valid comparisons with *P. ambloplitis* pleurocercoid infections in similar hosts of the present work. His sample size of smallmouth yielded a prevalence of 55% which is considerably lower than the 95% for the same host species examined at sites in West Virginia.

In a more recent study by Joy and Madan (1989) at Beech Fork Lake, pleurocercoids were found within 84.6% of the largemouth bass which is comparible to the 96% of largemouth bass infected in the present study (Fig. 21). Infections in spotted bass (at 91.3%) was much higher than that found in spotted bass (at 21%) of the present study (Table 21). Joy and Madan (1989) reported hybrid bass were resistent to from pleurocercoid infection; however, in the present study 36% of hybrid bass were infected with the larval stage of *P. ambloplitis*. All five host speceis observed in the present study were found to contain pleurocercoids, *P. ambloplitis*.

Adult *P. ambloplitis* were found by Bangham (1941) in 3% of largemouth bass and 6% of smallmouth bass but in the present study only two smallmouth bass (at 4%) from lake ecosystem were infected with the adult tapeworm, *P. ambloplitis* (Table 21).

Intensities among immature largemouth bass and adult smallmouth and spotted bass (>100) were so high that the entire viscera was very difficult to seperate (Fig. 20). Host tissue response was aggresive, resulting in an extensive fibrosis of all visceral organs to the extent that they could not be easily seperated from one another (Fig. 20). Reproductive success of basses carrying such infections would be impaired, or even destroyed (McCormick and Stokes, 1982). Proper functioning of other organ systems also seems unlikely (Fig. 28). Growth rates may be affected at these high levels of

Figure 28. *Proteocephalus ambloplitis* pleurocercoids within vital organs for reproduction and normal physiological function:

Pleurocercoid (arrow) in the uterus of largemouth bass.

Pleurocercoids (arrow) within the liver of largemouth bass shown on the left. Normal liver shown on the right. (Both livers preserved in formalin). From Joy and Madan 1989, with permission.


METRIC 1
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intensity or may even be detramental to host populations (Bakewell, 1982). The extent of this impact is, however, difficult to measure.

Another cestode found within this study was *Bothriocephalus* sp. In a study by Vernard (1940) in Bayou du Chien, Mississippi, one female largemouth bass host with two *Bothriocephalus* sp. within it (the sample size of largemouth bass was not found). *Bothriocephalus* sp. in the present study were found in only five fish of two host species, smallmouth and spotted bass, in lake ecosystems (Table 24). Buckner (1980) recovered only two *Hiodon alosoides*, goldeye, in Kentucky with *Bothriocephalus texomensis*.

Tapeworms are of the greatest importance as bass parasites. Six species where found in Ohio bass, but an individual fish usually harbors but one or at most two species at a time (Bangham, 1928). It is thought that number of young bass produced in a body of water is inversely correlated with the incidence of the parasite (Holmes and Mullan, 1965).

NEMATODES

The dominant nematode found throughout this study was *Camallanus oxycephalus* Ward and Magath 1916 (Stromberg and Crites, 1975a). *Camallanus oxycephalus* (Fig. 24) is a widely distributed and common parasite of Eastern North American freshwater fish but little is known about the biology of this worm (Stomberg and Crites, 1975b). Bangham and Hunter (1939) listed 28 species of fish which harbor the parasite *C. oxycephalus*. Stromberg and Crites (1975a) and Hugghins (1972) revealed that the parasite is very abundant in Lake Erie fish and fish from South Dakota, respectively. They also found that female worms protrude from the anus of fish to release first stage larvae into the water.

Stomberg and Crites (1975b) reported that the highest frequency of *C. oxycephalus* were in predatory fishes (e.g. *Morone chrysops*, white bass). In all the studies by Stomberg and Crites (1975b), white bass were the most frequently and heavily parasitized with *C. oxycephalus*. In adult white bass 37% were parasitized with *C. oxycephalus* in the 1975 study. This is similar to the 30% of white bass infected with *C. oxycephalus* in the present study (Table 29). Stomberg and Crites (1975b) showed that *C. oxycephalus* occurred in all size groups of white bass. Populations of *C. oxycephalus* were composed of all adults during all months except July and August. In the present study, only 2-3 adult *C. oxycephalus* were found. Most were the larval forms because these worms live about one year. Adult worms die in the summer and their larvae reinfect fish during July and August. Collections for the present study had been made throughout the summer and fall. From 1970-1972, 88% of the white bass collected were infected with *C. oxycephalus* (Stomberg and Crites, 1975b) which is considerably higher than that of white bass found within the present study. Other parasitologists such as Bangham (1944) found *C. oxycephalus* in 18% of the smallmouth bass from Wisconsin. This is, however, lower than the 80% of *C. oxycephalus* found within lake systems of the present study (Table 29). Twelve percent of largemouth bass recorded by Bangham (1944) at 11% and that of Vernard (1940) at 10% showed that prevalences of the parasite *C. oxycephalus* was comparable to that recorded in the present study at 4% among largemouth bass examined.

Other nematodes found far less frequently than *C. oxycephalus* were *Spinitectus* sp., *Spiroxys* sp., and *Philometra* sp. *Spinitectus* sp. Fourment 1883 parasitic in the stomach and intestines of fishes and frogs (Hoffman, 1967) (Fig. 24). *Spinitectus carolini* was reported by Bangham (1944) in only 16% of the smallmouth bass and 15% of largemouth bass examined from Bullhead Lake, Northern Wisconsin. This is slightly higher than prevalences found within the present study, 4% of largemouth and 5% of smallmouth examined contained *Spinitectus* sp.

Spiroxys sp. Schneider, 1866 larva are found within the intestines of fish hosts. Adult *Spiroxys* sp. are found in stomach of tortoises and intestines of amphibians (Hoffman, 1967; Yamaguti, 1961). Adult *Spiroxys* sp. were found within fish hosts, white basses (at 3%) and hybrid basses (at 2%). This organism was found only in river systems (Table 31) and was most likely accidentally ingested by the wrong host species. *Philometra* sp. Costa 1845 parasitic in body cavities or tissues of fishes (Yamaguti, 1961). Bangham (1944) reported that 2% of all smallmouth bass examined were infected with *Philometra* sp. which is considerably lower thant eh 38% infected in the present study (Tables 32 and 34). *Philometra* sp. was found in three hosts, largemouth, smallmouth, and spotted basses in lake systems only.

Nematodes or roundworms prove to be a serious pest to certain species of fish. Infection patterns of helminths in fish populations are influenced by the availability of infective larvae, feeding habits of hosts, mortality of parasites, and abiotic factors such as temperature. The interaction of these factors frequently results in an extreme variability in the prevalence and intensity of infection and overdispersion of parasites in fish populations (Stromberg and Crites, 1975b). Most studies have shown that there is no relationship between host sex and parasite distribution but host size and age have frequently been related to infection patterns (Stromberg and Crites, 1975b). The nematodes in the present study are not believed to cause mortalities among bass.

ACANTHOCEPHALANS

Nineteen different species of *NeoechinorhyncHus* are known in various species of fresh water fish in North America (Amin, 1986). Bangham (1926) noted that acanthocephalans were found in large numbers attached to the intestinal wall of adult bass. Amin (1987b) also noted that different parasitic species are found in different types of bodies of water such that *Neoechinorhynchus* sp. are lake type due to its effect on the composition of the invertebrate fauna accomodation. The dominant acanthocephalan within the present study was *Neoechinorhynchus* sp., found attached to the inner wall of the intestinal tract primarily in smallmouth bass.

Amin (1986) recorded *N. cylindratus* from two lake systems, Silver Lake and Tichigan Lake in Wisconsin from 1976-1984, showed (94%) in largemouth bass and 100% (4 of 4) in smallmouth bass infected with this parasite. Comparisons between smallmouth bass could not be made due to small sample sizes in work by Amin (1986). As for largemouth bass, only 6% (Table 94) were infected with *Neoechinorhynchus* sp. which is a much smaller prevalence than that of Amin (1986).

Two other acanthocephalans, *Pomphorhynchus bulbocolli* and *Leptorhynchus* sp., were found with low prevalence (5% and 1% respectively) and low intensities (< 5) within basses from the Ohio River. *Pomphorhyncus bulbicoli* are widely distributed in North American freshwater fishes having been reported from 81 host species. Few species appear to be able to support breeding populations of *P. bulbicoli* (Amin, 1987a). Other forms of *Pomphorhyncus* sp. such as *Polymorphus botulus* have lead to the death of eider ducks along the New England Coast (Bullock, 1963). Hosts for *P. bulbocolli* depend on fish species, host feeding behavior, temperature, availability of intermediate host, and type of water body (Amin, 1987a). *Pomphorhynchus bulbocolli* are more frequent and have increased infections in rivers and eutrophic lakes rather than landlocked lakes. Amin (1987a) considers centrachids as an occasional host due to sporadic and light infections; where as, the preferred hosts are catostomids. The same study by Amin (1987a) showed that only 1% of largemouth bass examined were infected in a landlocked lake; while, only 1% largemouth bass in a eutrophic lake was infected. This is comparable to *P. bulbocolli* found in river hosts at 5% in the present study. Joy (1986) discovered *P. rocci*, a marine and coastal fresh water fish parasites not normally found this far inland, in fresh water drum from the Ohio River. In the present study (1997), *P. bulbocolli* was found in smallmouth, white, and hybrid bass of the Ohio and Kanawha Rivers. Because identifing *P. bulbocolli* from *P. rocci* is very difficult and the Ohio River and Kanawha River contains both species there may or may not be an inaccuracy of this particular species.

Leptorhynchus sp. was also found within this study. It is a widespread parasite of freshwater fish in this country. The adult lives in the intestines. In Bangham (1944), fish were collected from lakes in northern Wisconsin. Of the fish collected 33% of white bass, 81% of smallmouth bass, and 40% of largemouth bass were infected with *Leptorhynchus* sp. The present study shows that only 3 percent of white bass were infected; while, smallmouth bass and largemouth bass were exempt from this parasite.

CHAPTER VII

SUMMARY AND CONCLUSIONS

1) Two-hundred and fifteen basses were collected from four river sites (Racine Locks and Dam, Robert C. Byrd Locks and Dam, Ashland, Kentucky--Ohio River; London Locks and Dam--Kanawha River) and five U. S. Army Corps of Engineers Reservoir sites (Beech Fork Lake, East Lynn Lake, Summersville Lake, Burnsville Lake, and Stonewall Jackson Lake).

2) These 215 basses consisted of five species largemouth bass, *Micropterus salmoides*, smallmouth bass, *Micropterus dolomieui*, spotted bass, *Micropterus punctulatus*, white bass, *Morone chrysops*, and hybrid bass, *M. chrysops* x *M. saxatilis*.

3) Twenty-one different species of parasites found in the gills or viscera of bass.

4) Gill parasites consisted of monogenetic trematodes, arthropods, annelids, and molluscs.

5) Visceral parasites consisted of digenetic trematodes, cestodes, nematodes, and acanthocephalans.

6) The most prevalent gill parasites were that of the "small form" monogenetic trematodes (*Clavunculus* sp., *Haplocleidus* sp., and *Urocleidus* sp.) in both river and lake ecosystems.

7) Arthropods, annelids, and molluscs were found with relatively low prevalences in river and lake ecosystems.

8) No observable gill damage was caused by any of the gill parasite species.

9) The most prevalent visceral parasite of digenetic trematodes of river systems was *Bucephalus polymorphus* found in white and hybrid basses.

10) The most prevalent visceral parasite of lake systems was *Posthodiplostomulum* sp., a digenetic trematode in all bass species except white bass.

11) The other digenetic trematodes, *Leuceruthrus micropteri* and *Pisciamphistoma reynoldsi*, were found in low prevalences.

12) Of the cestodes, *Proteocephalus ambloplitis* pleurocercoids were found in highest prevalences among lake fishes.

13) Highest prevalence of *P. amblopitis* pleurocercoids were in largemouth and smallmouth bass.

14) Adult *P. amblopitis* were only found in smallmouth bass.

15) Another cestode was found in low prevalence was the adult *Bothriocephalus* sp. were found in both smallmouth and spotted bass of lake ecosystems.

16) Acanthocephalans found within this study are *Leptorhyncus* sp., *Neoechinorhynchus* sp., and *Pomphorhynchus bulbocolli*.

17) *Leptorhynchus* sp. was only found in a river host, white bass.

18) *Neoechinorhynchus* sp. were found in high prevalences among lake hosts, particulary smallmouth bass.

19) *Pomphorhynchus bulbocolli* was only found in river hosts.

20) Inflammation of the intestinal tract occurred due to *P. bulbocolli*.

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