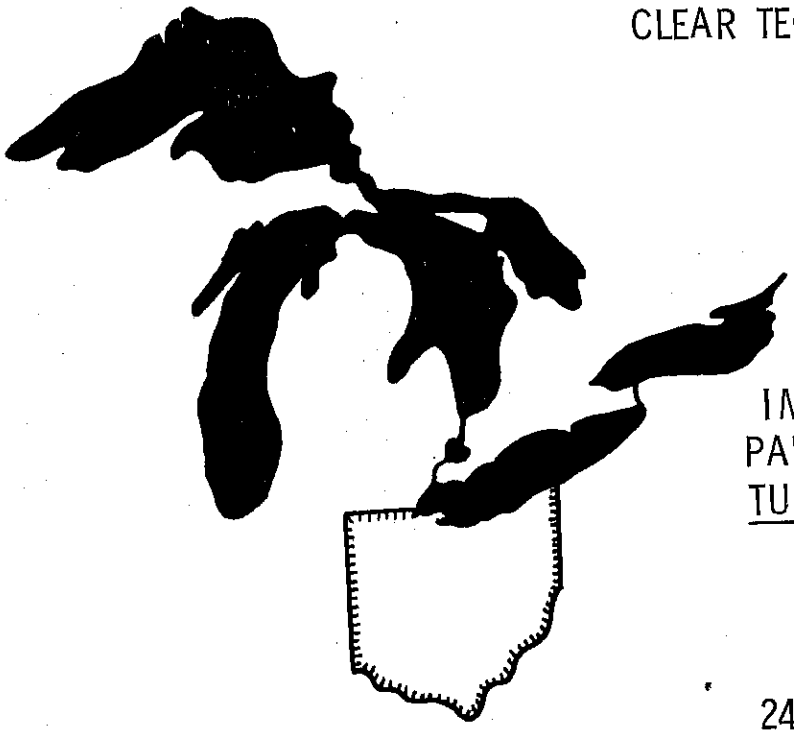
CLEAR TECHNICAL REPORT NO. 171



IMPACT OF THE NEMATODE PARASITE EUSTRONGYLIDES TUBIFEX ON YELLOW PERCH IN LAKE ERIE

First Project Segment
24 July 1978 - 30 June 1979
Project No. 3-298-R-1

Prepared by

John L. Crites, Ph.D.

Prepared for

Ohio Department of Natural Resources
Division of Wildlife
and
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

THE OHIO STATE UNIVERSITY
CENTER FOR LAKE ERIE AREA RESEARCH
COLUMBUS, OHIO

September, 1979

United States
Department of Commerce

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
State-Federal Relationships Division
Branch of Federal Aid

COMMERCIAL FISHERIES RESEARCH AND DEVELOPMENT PROJECT

PERFORMANCE REPORT

State: Ohio

CFRD Project No.: 3-298-R-1

Grant No.:

CFRD Project Title: Yellow Perch Project

Study No.: 1

Study Title: Impact of the Nematode Parasite Eustrongylides tubifex on Yellow Perch in Lake Erie

Period Covered: 24 July 1978 - 30 June 1979

Prepared By: John L. Crites
Prof. John L. Crites
Project Leader

Date: 21 September 79

Approved By: Jeffrey M. Reutter
Dr. Jeffrey M. Reutter
Project Manager

Date: 21 Sept. 1979

Approved By:
Thomas E. Wasson
Executive Administrator
Fish Management and Research

Date:

ABSTRACT

We sampled and examined 2055 yellow perch from the Western Basin of Lake Erie and 220 yellow perch from the Central Basin in 1978. The majority of yellow perch, 63.4 percent, were of the 1+ age class (1977 year class), 13.1 percent were young-of-the-year, and only 4.2 percent were 4+ age class or older. A total of 73.63 percent of all the yellow perch sampled were infected with one of the three parasites observed in this project; 45.8 percent were infected with the nematode parasite Eustrongylides tubifex, 38.5 percent were infected with the nematode Philometra cylindracea and 46.7 percent were infected with the plerocercoids of the tapeworm Triaenophorus nodulosus. The greatest numbers of infected yellow perch sampled were also in the 1+ age class. The highest rates of infection with E. tubifex occur in older yellow perch, while the lowest rates of infection with E. tubifex are in the young-of-the-year class. The rate increases in the 1+ age class through the 3+ age class and is highest in older yellow perch. Infections with P. cylindracea and T. nodulosus were highest in 1+ age class and young-of-the-year yellow perch. This reflects the life cycles of these parasites and the forage feeding habits of younger yellow perch.

A general pattern for seasonal rates of infection was ascertained when the three parasites occur in combination or when E. tubifex is considered alone. This pattern was irregular throughout June and July of 1978, the infections increased throughout August and peaked in September. When T. nodulosus and P. cylindracea were considered alone, infections with each of them increased in percentage during September and October.

The mean worm burden of all three parasites increased in September and October.

Eustrongylides tubifex larvae evoke the formation of granulomatous tumor-like capsules in yellow perch. The nematode develops, grows, molts, and is sustained in the capsules for long periods of time. The capsules are formed in four different tissue sites; they are most prevalent in the mesenteries; but they occur in the liver, the gonads, and on the body wall. A study of the histopathology of this infection reveals that the capsules in the mesenteries, the liver, and on the body wall are true cancerous granulomas. The capsular granulomas on the body wall do not become benign and may enlarge to such an extent that they kill the perch. The nematodes within the capsules may reach a length of 93.37 mm, longer than many of their yellow perch hosts. Both the nematodes and the tumorous capsules utilize energy which the perch could use for other purposes. When the body temperature of a captured perch is raised the nematodes migrate from the capsules and into the flesh (muscles) of the fish.

A study of the sensory papillae of third and fourth-stage E. tubifex accomplished by the use of stereo-electron scanning microscopy is presented in this report. These papillae can be used to distinguish E. tubifex larvae from other species of Eustrongylides which parasitize fishes.

In the last section of this report seven questions are raised and answered, as best we could, based on only one year's data. These are questions which should be basic to the development of management strategies for yellow perch in western and central Lake Erie. It is shown

that yellow perch become infected with E. tubifex during their first year, and that during 1978, yellow perch of the 1+ age class had the greatest numbers of both infected and uninfected individuals in the sampled populations. This particular age class will be of value in following parasite infections and their effects over the next two years. The importance of mean worm burdens in ascertaining the effects of E. tubifex infections in yellow perch is discussed. It is demonstrated that yellow perch of the 1+ age class with the highest mean worm burdens attained the least average weight. There is also reason to believe that perch with eight or more encapsulated E. tubifex larvae may die, but this should be confirmed by more data and further study. The utility of an index sampling station is demonstrated. Evidence is presented that different areas of the Western Basin may be different in infection rates of yellow perch and that yellow perch in the Central Basin of Lake Erie have fewer parasites, that they are longer, weigh more, and have better condition factors.

CONTENTS

STUDY OBJECTIVE

To specify the impact of pathological damage to yellow perch caused by the parasite Eustrongylides tubifex on growth and survival in the perch populations of the Western and Central Basins of Lake Erie and to develop management recommendations.

LIST OF TABLES

LIST OF TABLES (Cont.)

LIST OF TABLES (Cont.)

LIST OF FIGURES

LIST OF FIGURES (Cont.)

LIST OF FIGURES (Cont.)

LIST OF FIGURES (Cont.)

LIST OF FIGURES (Cont.)

JOB 1-a

PREVALENCE OF EUSTRONGYLIDES TUBIFEX IN LAKE ERIE YELLOW PERCH.

Objectives

To determine the seasonal prevalence of the nematode parasite, Eustrongylides tubifex, in yellow perch by size and age class in the Western and Central Basins of Lake Erie.

Procedures

The majority of samples were collected from the Western Basin of Lake Erie by otter-trawl from the motor-vessel Bio-Lab in the vicinity of Green and Rattlesnake Islands from 19 June 1978 to 30 October 1978[1]. Samples were collected prior to 24 July by personnel from the Center for Lake Erie Area Research at no cost to the project. This also occasionally allowed the collection of more than two samples per month in the Western Basin. Two samples per month could not be obtained from the Central Basin due to scheduling problems with the motor vessel Explorer. Following the approval of this project, 24 July 1978, it was decided that the collecting station in the area of Green and Rattlesnake Islands would become an index station which would furnish a data base for comparison of other samples from other areas of Lake Erie. Other samples examined were: a trap-net sample taken from Fisheries Bay, South Bass Island, 10 July 1978; a sample taken between Middle and West Sister Islands, Western Basin, 15 August 1978; and a sample taken off Cleveland Harbor, Central Basin, 12 October 1978. The Middle-West Sister and Cleveland samples were collected by otter-trawl from the motor vessel, Explorer, by members of the staff of the Ohio State Fisheries Research Laboratory, ODNR, at Sandusky, Ohio.

---

[1] All work scheduled for this project segment was done as planned. The spring 1979 work will be reported in the Annual Performance Report for the next project segment.

The following is a log of the yellow perch sampled and examined:

Samples Collected 1978

Number of Yellow Perch	Date	Area
105	June 19	Green and Rattlesnake Islands
82	June 22	Green and Rattlesnake Islands
99	June 28	Green and Rattlesnake Islands
154	July 3	Green and Rattlesnake Islands
94	July 10	Fisheries Bay, South Bass Island
97	July 12	Green and Rattlesnake Islands
174	July 17	Green and Rattlesnake Islands
176	July 24	Green and Rattlesnake Islands
96	August 1	Green and Rattlesnake Islands
120	August 7	Green and Rattlesnake Islands
115	August 15	West Sister Island
107	August 23	Green and Rattlesnake Islands
124	August 28	Green and Rattlesnake Islands
102	September 5	Green and Rattlesnake Islands
109	September 12	Green and Rattlesnake Islands
94	September 18	Green and Rattlesnake Islands
60	September 25	Green and Rattlesnake Islands
82	October 2	Green and Rattlesnake Islands
220	October 12	Off Cleveland Harbor
65	October 30	Green and Rattlesnake Islands
2275	Total Yellow Perch Examined	

All yellow perch were iced immediately after removal from the trawl while on board the boats, and they remained on ice until they were measured, weighed, and necropsied in the laboratory.

The following parameters were measured and the following data recorded for each yellow perch: total length in millimeters; standard length in millimeters; height in millimeters; a first weight, measured in grams to one-tenth of a gram; and a second weight (after the yellow perch had been eviscerated) of only flesh, bone, and gills. Key area scales were removed from each yellow perch, pressed into plastic, and read on a scale reader to determine the age, which was recorded.

The viscera of each yellow perch was removed and placed in a dish of "Ringer's Cold" salt solution, and the body cavity was rinsed with salt

solution into the same dish. The viscera were examined with a stereoscopic binocular dissection microscope and the following data were recorded: the number of Eustrongylides tubifex larvae removed from capsules or free in the body cavity (the body wall was always examined for larvae); the number of Philometra cylindracea adults present, and the number of partial adult, female P. cylindracea encapsulated; the extent of liver infected with the plerocercoid stage of the tapeworm, Triaenophorus nodulosus, (this infection was scored light (1-5), medium (6-10), and heavy (10 or more)).

The nematodes, E. tubifex and P. cylindracea, were removed from the viscera and fixed immediately in AFA, Alcohol-Formalin-Acetic Acid, solution and preserved for later study.

Two separate sets of computer cards were prepared by two separate operators for each yellow perch. The two sets of cards were checked against one another for mistakes. The data concerning lengths, heights, weights, ages, and numbers of different parasites were punched into each card. All data and analyses were stored on a computer disc. The data were analyzed on an AMDAHL 470 computer using the Statistical Analysis System, SAS (Barr et al., 1976).

JOB 1-b

DESCRIPTION OF PATHOLOGY OF EUSTRONGYLIDES TUBIFEX IN YELLOW PERCH.

Objectives

Define through anatomical investigations the pathological impact of Eustrongylides tubifex upon the growth and survival of western and central Lake Erie yellow perch.

Procedures

Tissues and capsules containing parasitic worms were removed from yellow perch (collected in Job 1-a) at necropsy and fixed in Alcoholic Bouin's Solution. Many of the capsules processed during 1978 were poorly fixed internally because of slowness of penetration. We now realize the need to inject capsules with fixing solution during 1979. Fixed tissues were imbedded in paraplast parafin and sectioned with a microtome at eight to ten micrometers. After dehydration, the tissues were stained with a modified Mallory's Triple Stain or with haemotoxylin and eosin and mounted in microscope slides.

Nematodes were often studied and photographed alive using light microscopy. Some parasitic nematodes, after fixation, were placed in glycerine alcohol and dehydrated until all alcohol was removed and mounted in pure glycerine for study. During the summer of 1978, specimens of third and fourth stage larvae of E. tubifex were fixed with either AFA or Tris-buffered gluteraldehyde. These specimens were later prepared for stereo-electron microscopy. They were dehydrated, freeze-dried in a critical point dryer, coated with gold, and mounted in stubs. The nematode larvae so prepared were photographed using a Hitaschi 5-500 stereo-electron-microscope.

JOB 1-c

DEVELOPMENT OF MANAGEMENT STRATEGIES WHICH WOULD OPTIMIZE THE YELLOW PERCH FISHERIES IN LAKE ERIE.

Objectives

Develop feasible management recommendations that would optimize the benefits from western and central Lake Erie yellow perch by analyses of seasonal pathological variances.

Procedures

Commercial and sport fishing harvest results were reviewed in an effort to correlate season and location of harvest with infection rates by season and location. Personal conferences with commercial fishermen and personnel from the Ohio Division of Wildlife were utilized in a further effort to evaluate the harvest. During these conferences a series of management alternatives were given a preliminary airing. Information was gathered to determine the current data base and the state-of-the-art knowledge available on yellow perch in Lake Erie in an effort to determine if enough information was available to allow the use of a computerized management program.

STUDY FINDINGS AND ANALYSIS

Background

This project had its origin in requests from the public, sport and commercial fishermen, physicians, and governmental agencies concerning a "red worm" which occurs in the flesh of yellow perch in the Western Basin of Lake Erie. These large red worms were contacted by fishermen in the body cavity and fillets of yellow perch, Perca flavescens, as they cleaned and filleted their catch. This tissue invading parasite had become an economic factor in that its presence caused the rejection of yellow perch fillets and some fishermen avoided fishing waters where it occurred. It was a pest even for those who removed the worms from the fillets. Government agencies wanted to know what harm was caused to yellow perch. This situation still exists.

Our first step in investigating this nematode was to identify it. We determined by morphological characteristics that it belonged to the nematode genus Eustrongylides in the Order Dioctophymatida. The stages of this genus which occur in fishes are larval stages and adults occur in fish eating birds (Jagerskiold, 1909; Karmanova, 1968). In 1972, we fed larval stages of Eustrongylides obtained from Lake Erie yellow perch to uninfected, hatchery-raised mallard ducks, Anas platyrhynchos. The infection experiments were successful and we recovered adult nematodes from the proventriculus of infected mallards which could be utilized for the proper identification of this nematode to species. Specimens of the genus Eustrongylides were obtained from the U.S. National Museum. Helminthological Collection and these were studied and compared with our specimens from experimentally infected mallards. We determined that our

specimens most closely fit specimens of Eustrongylides tubifex (Nitsch, 1819; Jagerskiold, 1909).

Nitzsch originally described Strongylus tubifex in a Rudolphi publication of 1819. Jagerskiold (1909) established the genus Eustrongylides for a group of nematodes from the glandular stomach or proventriculus of aquatic birds. Jagerskiold (1909) redescribed the type species E. tubifex utilizing five females and one male from the Vienna Museum of Natural History taken from the loons Gavia stellata and Gavia arctica and an additional male specimen from his Finland collection from G. arctica. Jagerskiold (1909) synonymized E. tubifex with Strongylus papillosus (Rudolphi, 1809), Strongylus tubifex (Nitzsch in Rudolphi, 1819), Eustrongylus tubifex (Nitzsch, 1819; Diesing, 1851), Hystrichis tubifex (Nitzsch, 1819; Molin, 1861), and Hystrichis elegans (Olfers, 1816; Railliet, 1895). Kontrimavichus and Bakhmeteva (1960) redescribed Eustrongylides tubifex from one G. arctica and two G. stellata. Karmanova (1968) again redescribed E. tubifex from G. stellata. Neither of these Russian publications stated the number of specimens of E. tubifex utilized in their redescriptions. We have found the existing redescriptions confusing and incomplete. In order to alleviate much of the taxonomic confusion of this genus, we redescribed E. tubifex from American specimens and included a key to the different species of Eustrongylides (Fastzkie and Crites, 1977).

We still did not know which aquatic birds were the principal natural definitive hosts for this parasite in western Lake Erie--a host which would account for the high rates of infection in the fish intermediate hosts in Lake Erie. Between 1972 and 1975 we examined 12 species of

piscivorous birds collected in the Western Basin of Lake Erie. Eustrongylides was found in five bird species but only a few patent female worms were recovered. Only red-breasted mergansers, Mergus serrator, harboured patent adult female E. tubifex, and we consider the Merganser to be the primary definitive host of E. tubifex in the Western Basin of Lake Erie (Cooper, Crites, and Fastzkie, 1978). What first intermediate host is involved in the transfer of E. tubifex from birds to fish hosts is as yet undetermined.

In 1974, we surveyed 400 yellow perch from the Western Basin of Lake Erie to find what other parasites were present and which ones might be harmful. Most parasites were limited to the lumen of the intestine and we found only worms which invaded tissues and could be considered pathogenic to yellow perch. These parasites were the plerocercoid state of a tapeworm, Triaenophorus nodulosus which occurs in cysts in the liver; Philometra cylindracea, a long thin nematode which occurs in the body cavity; and E. tubifex, itself, which is found in capsules in the tissues (Ashmead and Crites, 1975; Cooper, Ashmead, and Crites, 1977).

Requests for information continued to come in. We still did not know the pathological effects of E. tubifex in individual yellow perch or its possible effects on populations. There was no assessment of the prevalence of Eustrongylides tubifex in different age classes of yellow perch. There were many questions. At what age did yellow perch become infected with E. tubifex? Were some age classes more infected than others? Were there seasonal variations? Did infected perch lose weight, was there an effect in the condition of infected yellow perch? Do E. tubifex larvae sometimes kill infected fish? Was there a synergistic

effect when E. tubifex was present with one or both of the other two harmful parasites, P. cylindracea and T. nodulosus? Were yellow perch in some areas of Lake Erie more infected than those in other areas? Was it possible to establish an index station in the Western Basin where a data base could be built from sampled natural populations, a data base to which data from other sampled populations from other areas of the lake could be compared? Could recommendations be made which were useful in the management of yellow perch in Lake Erie? These were questions which led to the proposal of this project. They are questions which we are trying to answer.

Job 1-a: Prevalence of Eustrongylides tubifex in Yellow Perch in Lake Erie.

This section of the report considers the actual infections with the three parasites Eustrongylides tubifex, Philometra cylindracea and Treainophorus nodulosus in different age classes of yellow perch. The data presented here represents totals and percentages for the entire 1978 collecting season (June through October). In the last part of this section the data is broken down by trawls on specific dates, only those trawls between Green and Rattlesnake Islands in the Western Basin of Lake Erie are included as we had only one sample from the Central Basin.

We have complete data for 2055 yellow perch collected from the Western Basin of Lake Erie during 1978. Table 1 (Appendix) presents the number of yellow perch in each age class collected in 1978 from the Western Basin and the percentage of the entire combined total which each age class comprised. Figure 1 presents the same data graphically. When considering the total 1978 collection the 1+ age class or 1977 year class comprised 63.4 percent of all the yellow perch examined. When one studies

Figure 1

Age Class Distribution (Total Numbers) of Yellow Perch Collected in the Western Basin of Lake Erie During 1978.

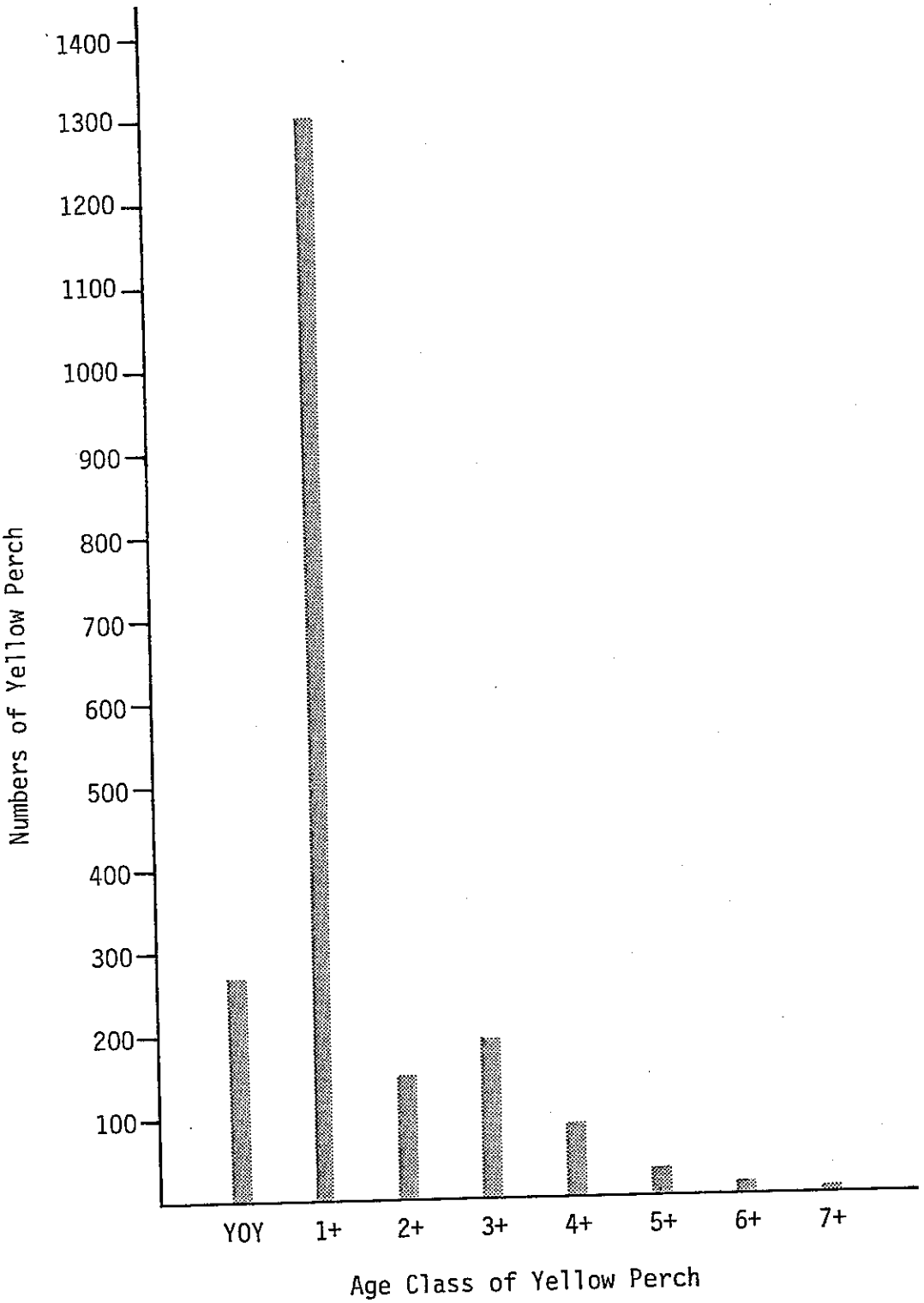


Figure 1, it is obvious that only 2.28 percent of the yellow perch examined from the Western Basin were more than four years old.

Uninfected Yellow Perch

The number of yellow perch examined from the Western Basin totaled 2055, of these, 478 (23.27 percent) were uninfected and 1577 (76.73 percent) were infected with at least one of the three parasites involved in this study.

Table 2 (Appendix) and Figure 2 present the data for uninfected yellow perch from the Western Basin. YOY, 1+ and 2+ age class yellow perch made up 96.8 percent of the uninfected perch collected during 1978. Older fish comprised such a small percentage of the sample that they were insignificant for comparative purposes. Uninfected yellow perch of the 1+ age class made up by far the largest age class and represented 62.9 percent of the uninfected yellow perch and 14.65 percent of the total number of yellow perch examined from the Western Basin.

Infected Yellow Perch

Infected yellow perch, perch infected with any one of the three parasites involved in this study, composed the largest group of yellow perch examined, a total of 1577 or 76.6 percent of the yellow perch examined during 1978.

Table 3 (Appendix) and Figure 3 present the data for infected yellow perch. Again the 1+ age class contained the highest numbers and the highest percentage of infected yellow perch, 63.5 percent of all the infected fish were in this age class and 49.8 percent of all the fish examined from the Western Basin were infected fish of this age class. Age classes YOY, 2+, 3+, 4+, and 5+ of the infected yellow perch also have

Figure 2

Actual Numbers of Yellow Perch from the Western Basin Which Were Uninfected With Any of the 3 Parasites.

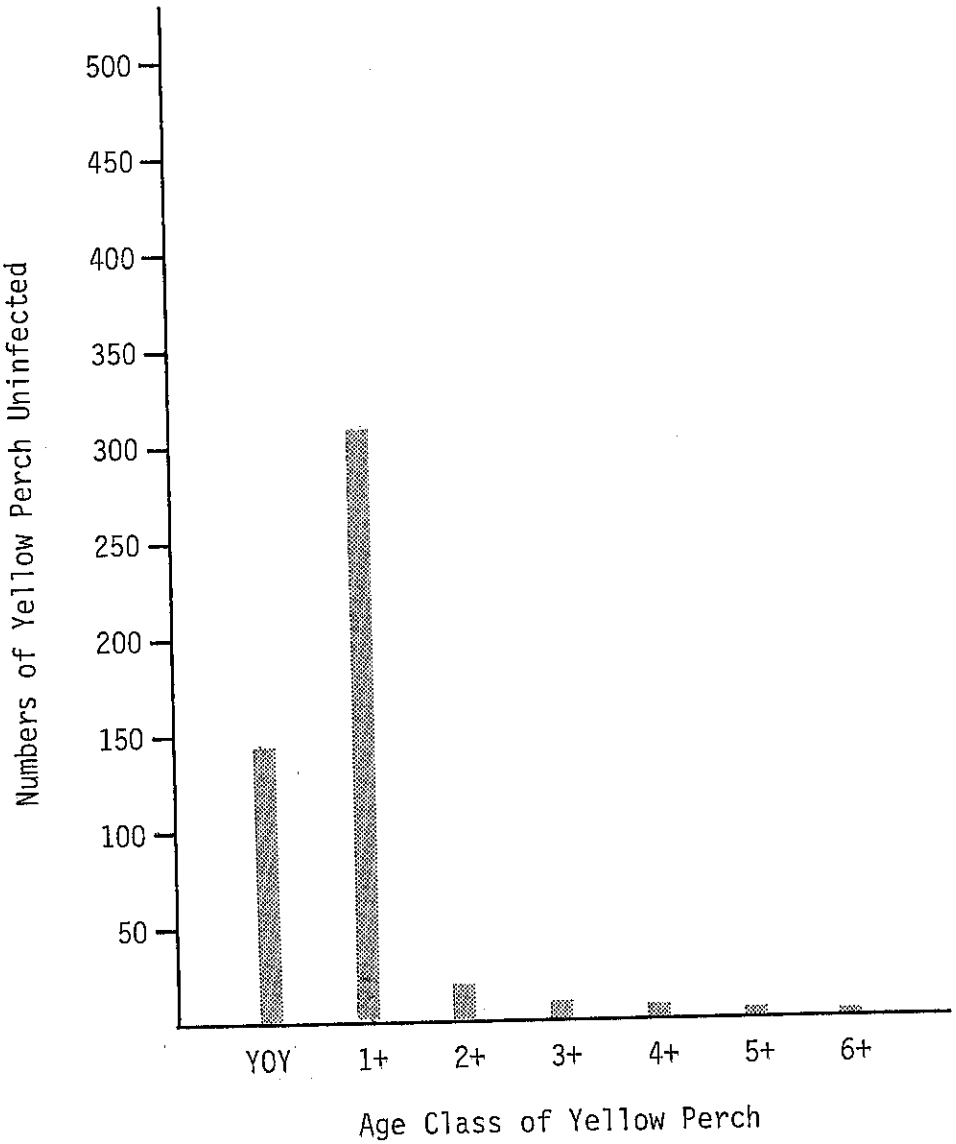
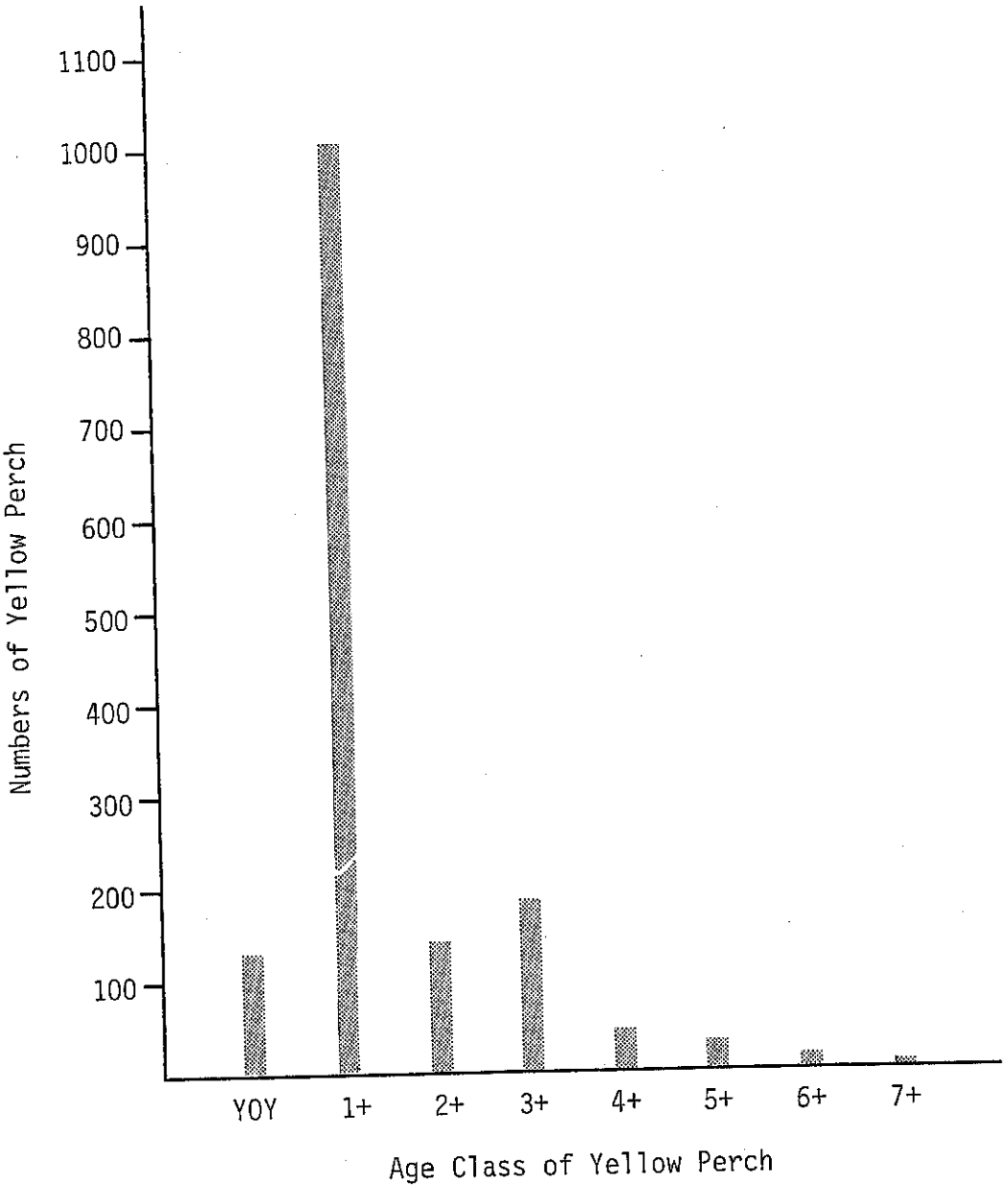


Figure 3

Age Class Distribution (Total Numbers) of Yellow Perch Infected with *Eustrongylides*, *Triaenophorus*, or *Philometra*. Western Basin 1978.



fairly large numbers of infected fish and when combined they make up 35.7 percent of the infected yellow perch from this basin, but there are few uninfected yellow perch in the age classes 3+, 4+, and 5+ for comparative purposes (Figure 2). This point must be remembered and reiterated in future analyses of data.

Figure 4 illustrates that the most prevalent age classes are also the age classes with the highest percentages of infected fishes. This does not mean that the 1+ age class had a higher rate of infection than the 7+ age class which was composed of one fish and was 100 percent infected. It means that of all the infected fishes 63.5 percent were in the 1+ age class. Figure 4 illustrates that there is remarkable correlation between percentage of fishes of a given age class (Figure 1) and the overall percentage of infected fish in that age class. The greater the number of fish in a given age class the greater the number and percentage of infected fish, from all of the infected yellow perch. Again this does not represent the percentage of infection or rate of infection within a given age class.

As stated earlier 76.7 percent of all the yellow perch examined from the Western Basin of Lake Erie were infected with at least one of the three species of parasites involved in this project. Table 4 (Appendix) and Figure 5 present the data concerning the rate or percentage of infection of each individual age class of yellow perch examined during 1978. Of the 270 young-of-the-year captured, 46.7 percent were infected while 76.9 percent of the 1303 1+ age class perch were infected. The rate of infection increases to 88.6 percent for 2+ age class and rate of infection is above 90 percent for age classes 3+ through 7+.

Figure 4

Percentage Age Class Composition of All Yellow Perch Examined from the Western Basin, 1978, vs Percentage of Infected Yellow Perch by Age Class, 1978.

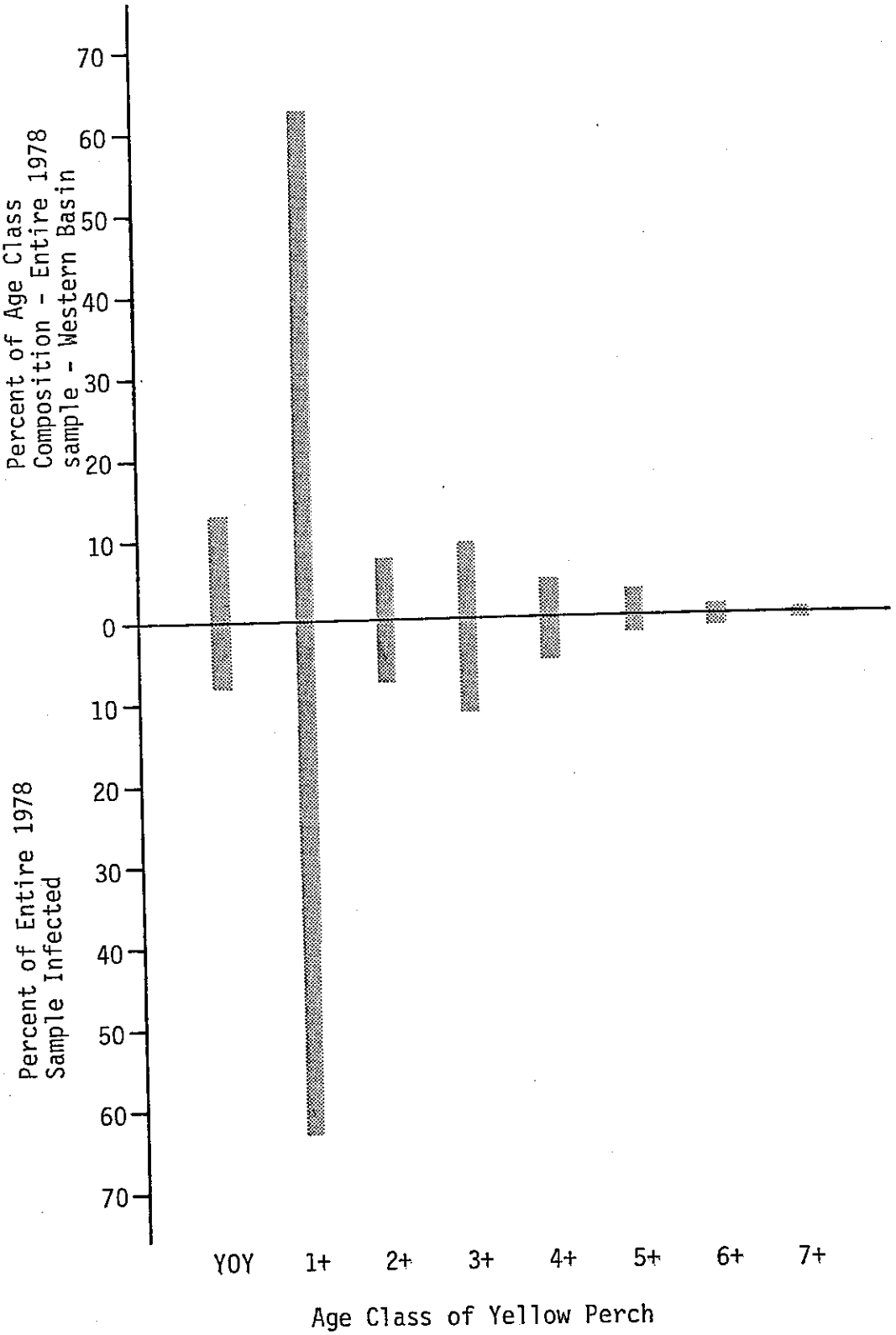
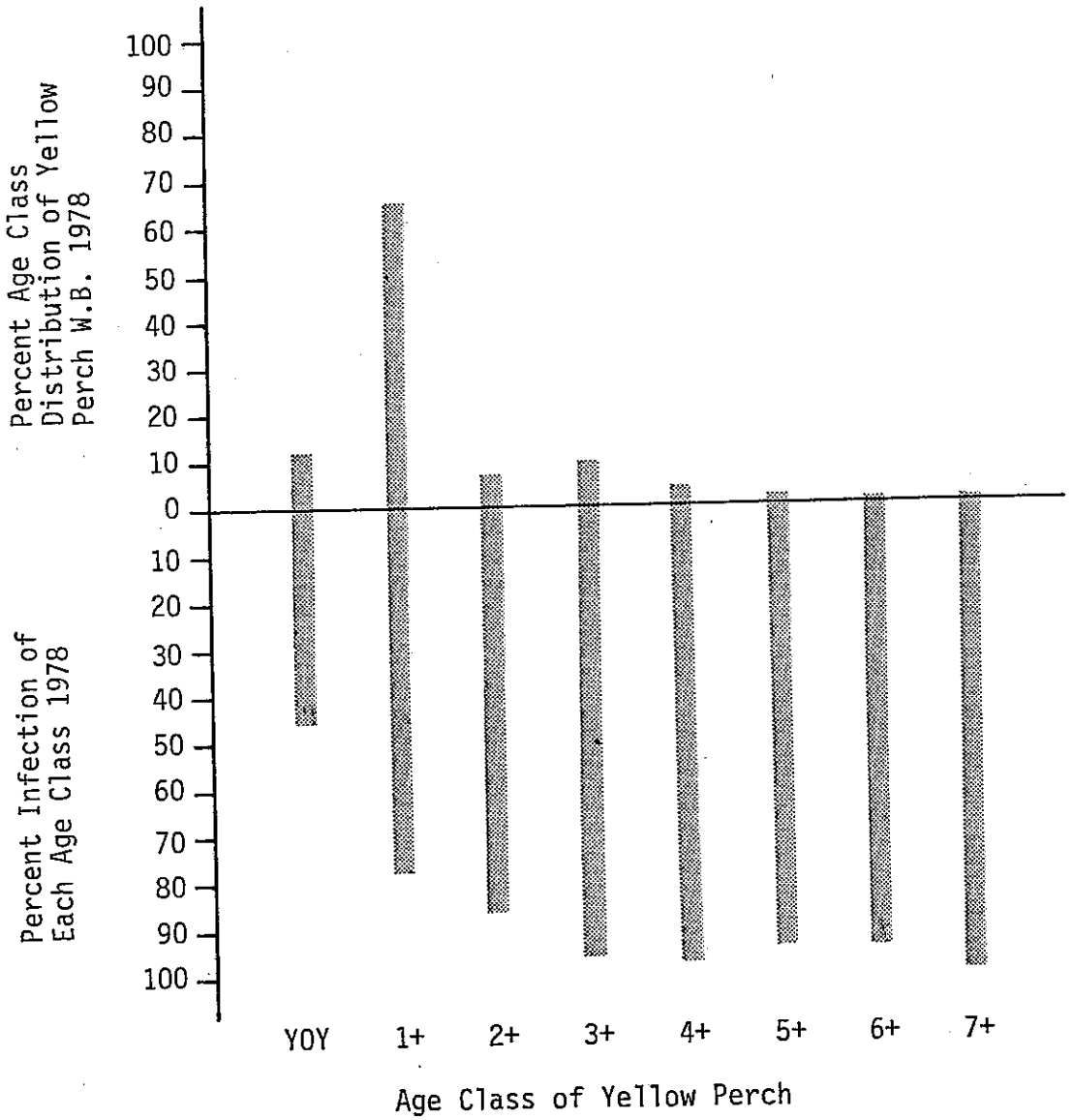


Figure 5

Age Class Distribution of Yellow Perch - Western Basin - 1978 Vs Percentage of Infection of Each Age Class with Eustrongylides Triaenophorus or Philometra.



As stated earlier we are concerned here with a different phenomenon than the age class distribution considered in Figures 1 through 4. The rate of infection (percentage) of each age class appears to be related to the age of the host yellow perch. The percentage of infection increases as the perch grow older, young-of-the-year through the 3+ age class. We would predict from this data that the 1978 young-of-the-year class and 1+ age class will show an increased rate of infection during 1979.

The upper portion of Figure 5 is the same as the upper portion of Figure 4 and illustrates the percentage distribution of age classes of yellow perch during 1978. The lower portion of Figure 5 is different and illustrates the rate (percent) of infection of each age class during 1978. One can readily observe that older yellow perch have a higher percent of infection but that there was a great decrease in the percentage of these perch in the population sampled after the 1+ age class. What may be showing in the 3+ through 7+ age classes is a remnant of a once highly infected population. Whether the parasites are partially responsible for this decrease in older yellow perch from the Western Basin of Lake Erie remains yet to be demonstrated, but the correlations presented here are at least suggestive that they play a part in natural mortality. Our problem is that the numbers of yellow perch in the 4+ through 7+ age classes from the population sampled are so low in both the infected and uninfected groups that comparisons of these two groups in these age classes may not be significant. We are fortunate in having a reasonable young-of-the-year age class and a strong 1+ age class to follow and study during the next two years (Figure 1).

Eustrongylides tubifex Infections

The age class distribution of yellow perch infected with Eustrongylides tubifex is given in Figure 6. The yellow perch represented in Table 5 (Appendix) and illustrated in Figure 6 were infected with E. tubifex larvae alone or in combination with the plerocercoid stages of Triaenophorus nodulosus and Philometra cylindracea (encapsulations or adults). E. tubifex larvae were present in 942 of 2055 (45.8 percent) of the yellow perch examined from the Western Basin. The vast majority, 560 infected yellow perch, were in the 1+ age class.

The percentage or rate of infection in each age class is illustrated in Figure 7 (Appendix, Table 6). Fish 3+ age and older have the highest rates of infection with E. tubifex. The percentage of infection with E. tubifex increases in each age class as the yellow perch age from young-of-the-year to the 3+ age class. The infection fluctuates slightly in the age class 4+ through 7+ but remains very high (65 percent or more). This increase in the percent of fish infected may be due to an accumulative affect, older perch eating younger infected fish and the worm transferring to the older perch, or the increased probability that the older perch will contact some infected invertebrate intermediate host. More 1+ age class yellow perch were infected with E. tubifex than any other age class sampled, 59.4 percent of the perch infected belonged to this age class (Figure 6). However, there were more yellow perch in this age class than any other (Figure 1) and the rate of infection of 1+ age class yellow perch was only 42.9 percent (Figure 7). It will be interesting to see whether or not this percentage of infection increases as this age class grows older.

Figure 6

Distribution of Yellow Perch Infected with Eustrongylides tubifex by Age Class. Western Basin, Lake Erie 1978. (Actual Numbers)

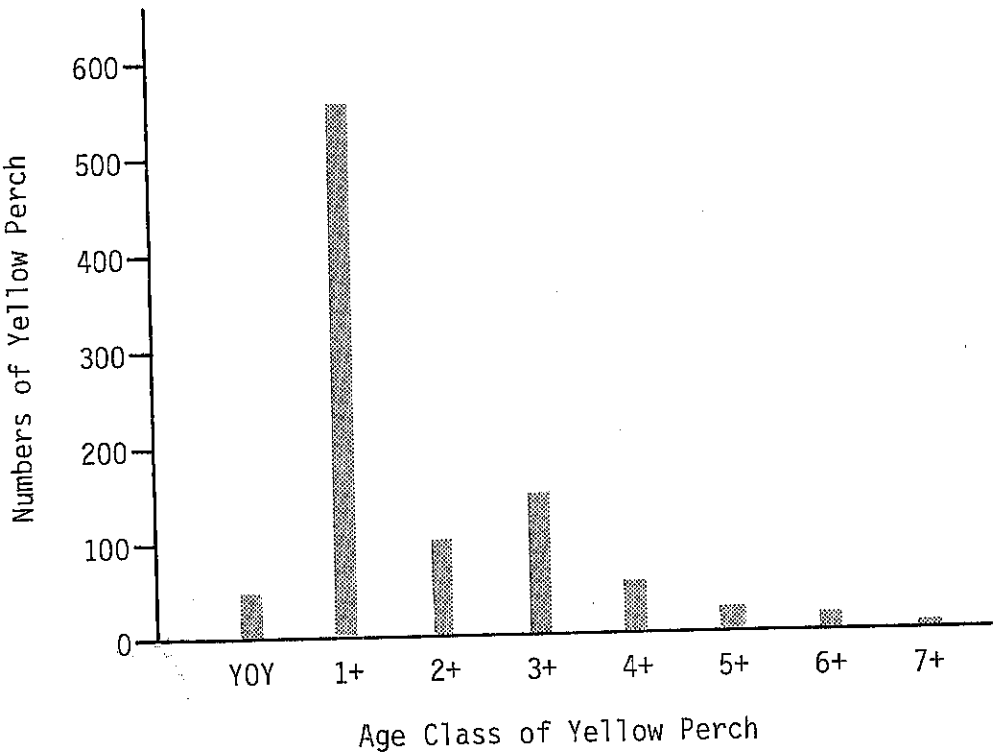


Figure 7

Percentage or Rate of Infection of Each Age Class of Yellow Perch with Eustrongylides tubifex. Western Basin, 1978.

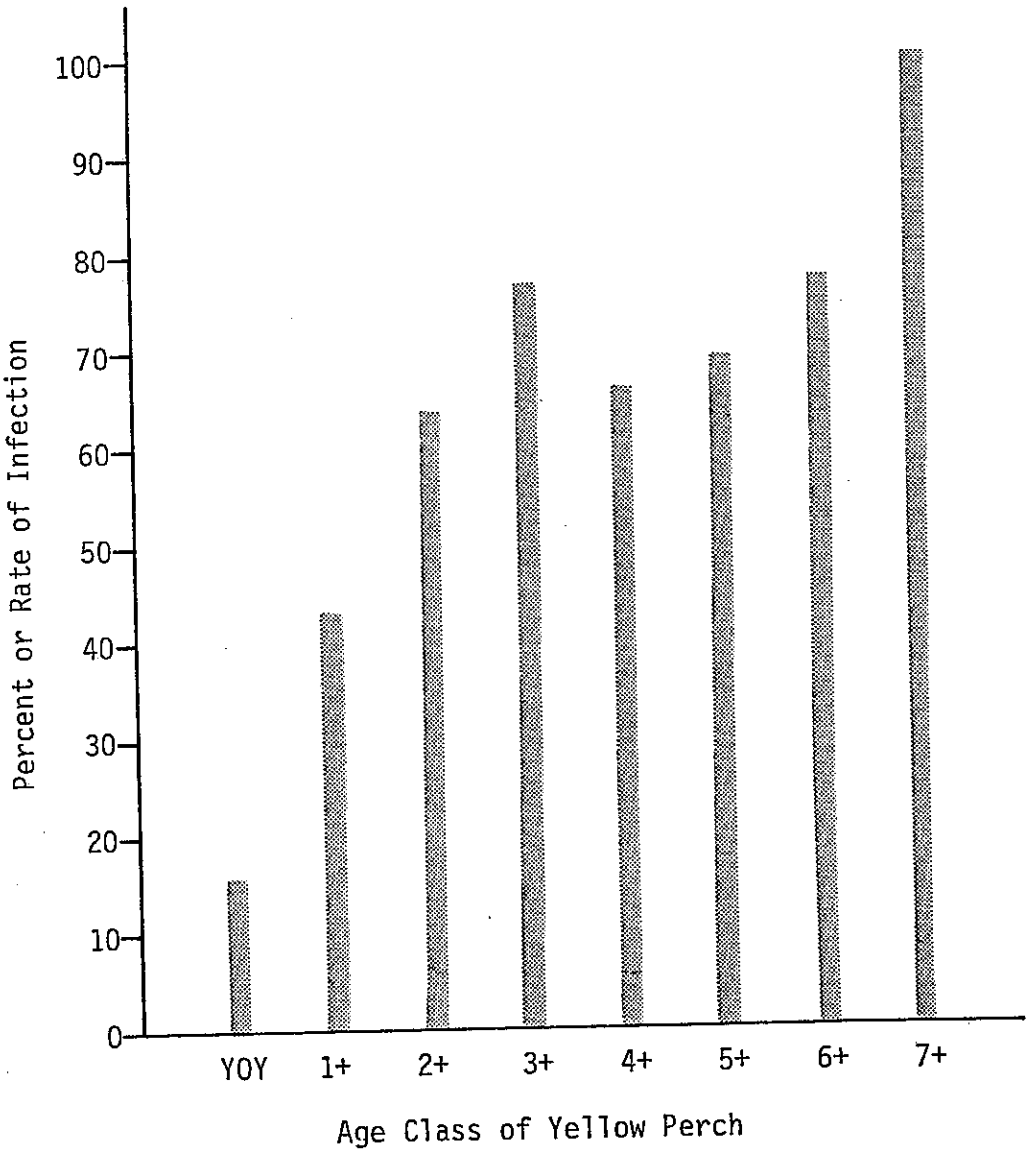


Table 7 (Appendix) presents the age class distribution data for yellow perch from the Western Basin which were infected with Eustrongylides tubifex only, i.e. yellow perch which were not infected with Triaenophorus nodulosus plerocercoids or any stage of Philometra cylindracea but were infected with one or more larvae of E. tubifex. A total of 339 yellow perch from the Western Basin would fit this category. This is 16.5 percent of all the yellow perch examined from the basin and 36.0 percent of all the yellow perch which were infected with E. tubifex alone or in any combination. The distribution of infected yellow perch in age classes for this category follows the pattern already established and is not graphed (Appendix, Table 7). The majority and highest percentage of yellow perch in this category were in the 1+ age class. As the fish grow older there is a decrease in each subsequent age class.

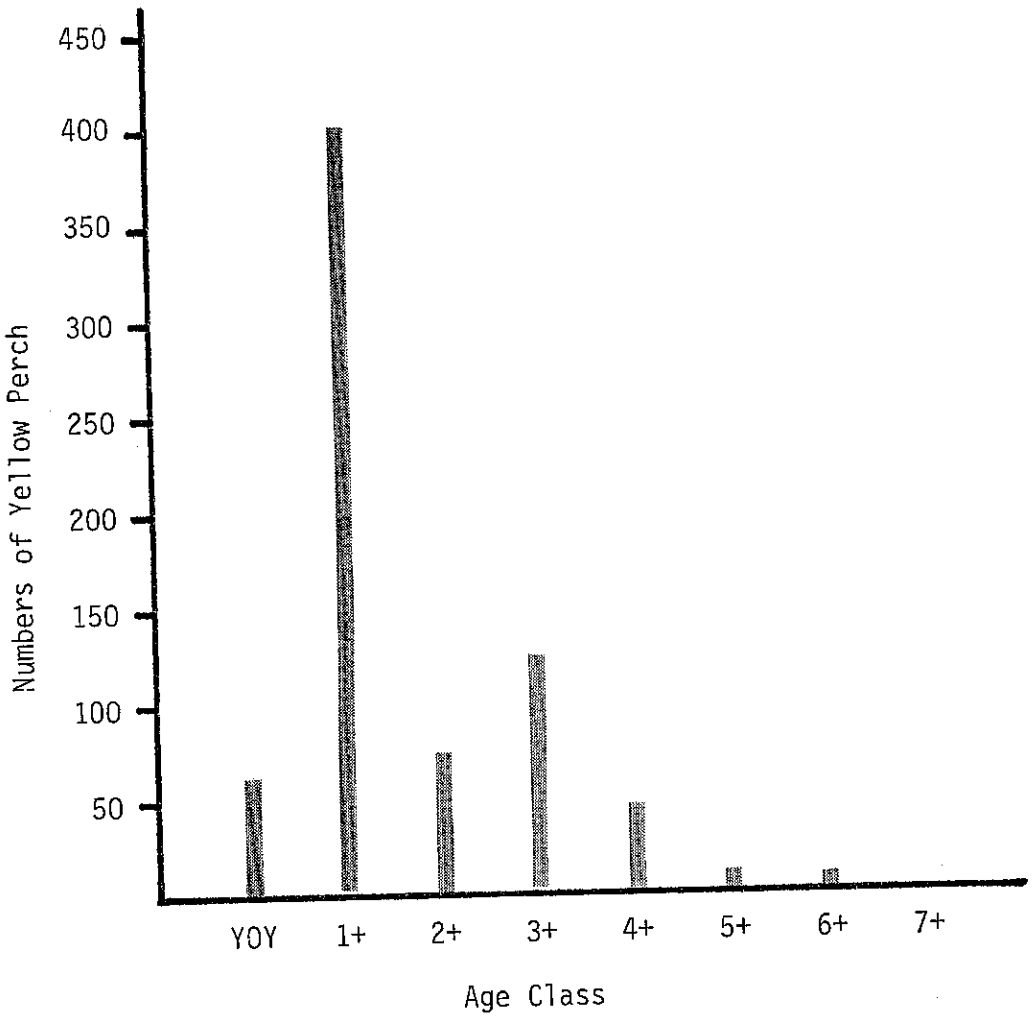
Table 8 (Appendix) covers the data for the percentage or rate of infection of each age class of yellow perch infected with E. tubifex only during 1978 in the Western Basin of Lake Erie. In general the rates of infection for E. tubifex only also follow the pattern alread established and the data is not graphed. The percentages of infection for this category are lower because there were fewer fish, 64 percent of those harbouring E. tubifex were also infected with one of the other two parasites. Young-of-the-year and 1+ yellow perch had the lowest rates of infection and older yellow perch had the highest rates of infection, perhaps due to the causes discussed earlier.

Infection with Philometra cylindracea

Yellow perch infected with some stage of P. cylindracea, perch infected with P. cylindracea alone or in combination with one or both of the other two parasites, totaled 735 (Figure 8). This was 46.6 percent of

Figure 8

Age Class Distribution of Yellow Perch Collected from the Western Basin of Lake Erie During 1978, Infected with Philometra cylindracea (any stage). Actual numbers.



the infected yellow perch examined and 35.8 percent of all yellow perch examined from the Western Basin of Lake Erie during 1978 (Figure 9).

While the life cycle of Philometra cylindracea is not completely known, we do know from some of our previous studies, that different stages are found in yellow perch at different times of the year. Small mature adults occur in the coelom of yellow perch in the late fall; gravid, larvigerous females in the spring and early summer months, and encapsulations of spent females throughout the year. The encapsulations serve as markers of earlier infections.

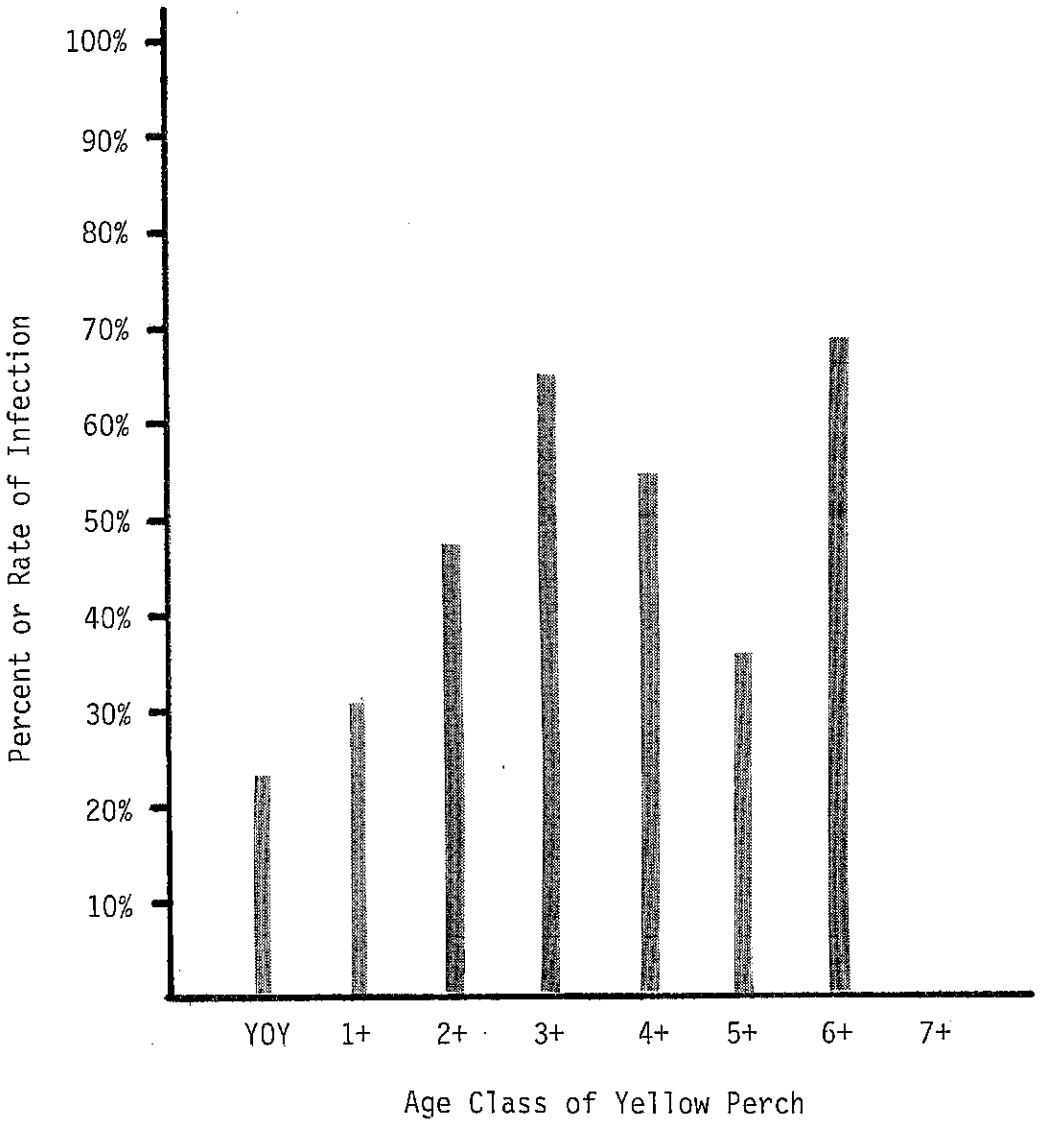
The age class distributions for yellow perch infected with any stage (adults or encapsulations) of P. cylindracea are graphed in Figure 8 (Appendix, Table 9). Again, as with E. tubifex, the vast majority of perch infected with P. cylindracea were of the 1+ age class, 58.4 percent of the infected perch. When one considers all of the fish examined from the Western Basin during 1978, infected and uninfected, 19.6 percent of the perch infected were of the 1+ age class.

When one studies only the 735 yellow perch infected with P. cylindracea (Figure 8), it can be ascertained that 97.1 percent of the infected fish were distributed in age classes YOY through 4+.

The percentage or rate of infection of each age class with P. cylindracea, any stage, is (Appendix, Table 10) graphed in Figure 9. This data reveals that the number of fish in each succeeding age class (with exception of the 3+ class) and the number of infected perch in each age class also declines (with the exception of the 3+ class). However, the percentage or rate of infection is less in younger perch. The rate of infection increases from YOY through the 3+ classes and then remains high but irregular. It must be considered that the numbers of yellow perch

Figure 19

Percentage or Rate of Infection of Each Age Class of Yellow Perch with P. cylindracea (any stage) Western Basin Lake Erie, 1978.



examined in age class 5+ through 7+ were comparatively small as they were fewer in the sampled population. The data for P. cylindracea, any stage, in any combination, parallels very closely the situation as presented for E. tubifex in Figure 7.

The age class distribution for yellow perch infected with any stage of P. cylindracea only, no combinations with E. tubifex or T. nodulosus, is presented in Table 11 (Appendix) and Figure 10. There were only 132 perch in this category, 18 percent of all the perch infected P. cylindracea and 6.4 percent of all the perch examined from the Western Basin. The majority of P. cylindracea infections occurred in combination with one or both of the other two parasites. The majority of infected perch in this category were also distributed in the 1+ age class, 58 percent, but 22 percent were in the YOY age class. The intermediate hosts for the transmission of P. cylindracea are cyclopoid copepods. YOY perch may become infected in the fall of their first year and adult females carry over the winter to the next spring when these fish become 1+ age class. In the summer the adult females release their larvae and become partially encapsulated. This is reflected somewhat in the data which follows but a detailed analysis of seasonal distribution of this parasite will be presented later in this report.

Figure 11 shows the rate or percent of infection of each age class of yellow perch infected with P. cylindracea only (no combinations) (Appendix, Table 12). The data demonstrates that YOY perch are the most heavily infected. Here the 1+ age class does not have the highest rate of infection. The 4+ age class also has a high rate of infection but as shown in Table 14 (Appendix) the stage involved here is capsules and not adult worms.

Figure 10

Age Class Distribution of Yellow Perch Collected from the Western Basin of Lake Erie During 1978, Infected with Philometra cylindracea only (any stage). Actual numbers.

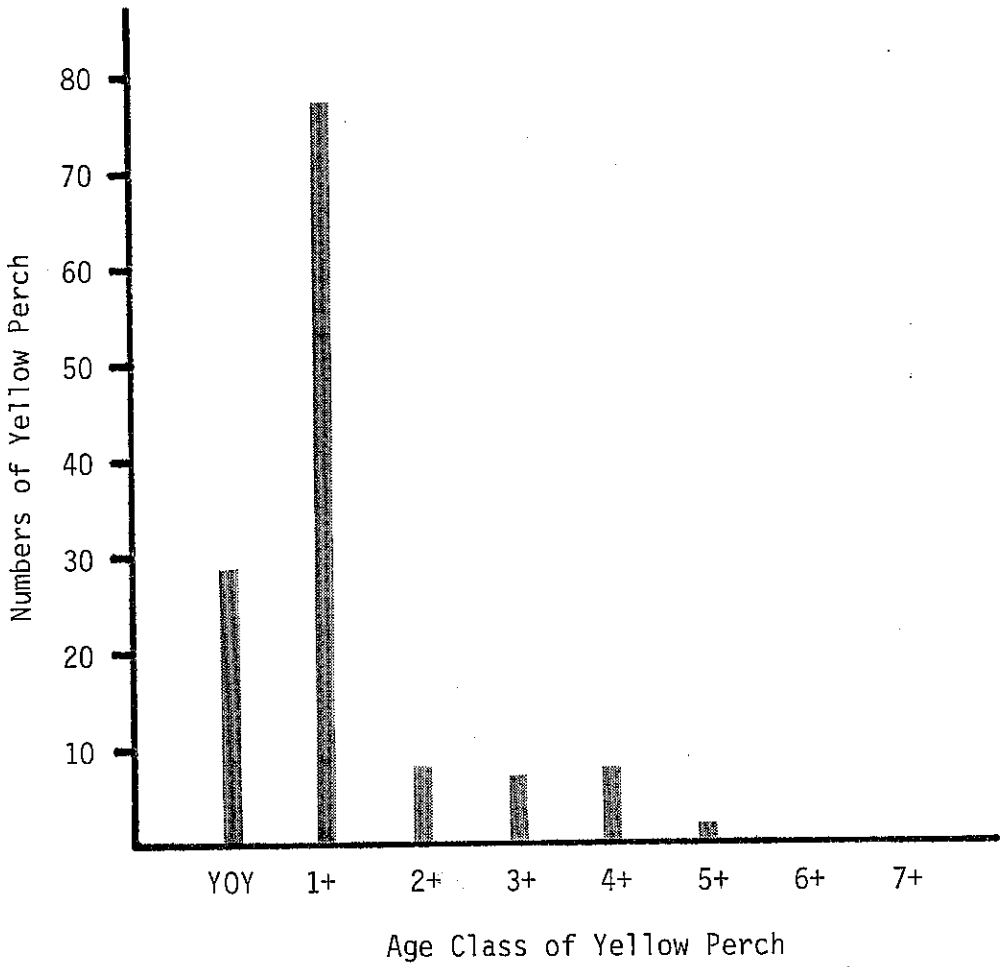
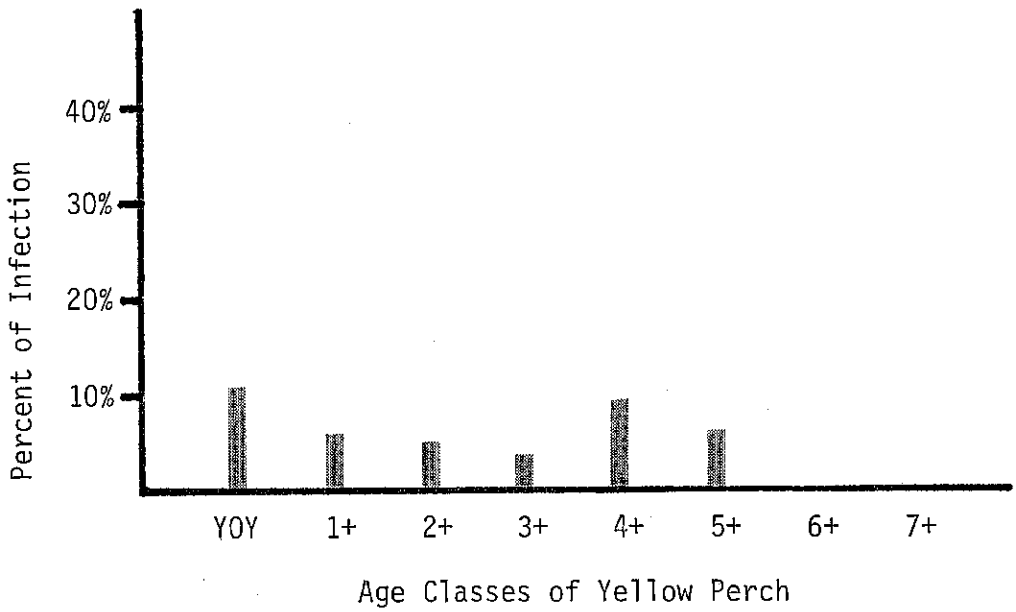


Figure 11

Percentage or Rate of Infection of Each Age Class of Yellow Perch Infected With P. cylindracea only (any stage) Western Basin Lake Erie, 1978.



The age class distribution of yellow perch infected with P. cylindracea adults only is presented in Figure 12 (Appendix, Table 13). This data shows that 91 percent of the adult worms were distributed in YOY and 1+ age classes. No adults were recovered from age classes 5+ through 7+ and one infected fish was present in each of the 3+ and 4+ age classes.

The percentage or rate of infected of each age class of yellow perch infected with P. cylindracea adults only is graphed in Figure 13 (Appendix, Table 14). The highest rate of infection is in the YOY perch followed by the 1+ and 2+ age classes.

The rate of infection and the distribution of infected perch in the YOY and 1+ age classes again reflects the forage feeding of younger perch and the life cycle of P. cylindracea.

The age class distribution of yellow perch collected in the Western Basin during 1978 infected with P. cylindracea encapsulations only is presented in Table 15 (Appendix) and the rate of infection is presented in Table 16 (Appendix). The age class distribution is graphed in Figure 14 and the rate of infection of each age class is graphed in Figure 15. The data from these tables and figures fits well with the data just given above. The YOY age class perch have very few encapsulations but most encapsulations occur in the 1+ age class following the infections with adults in YOY perch. Encapsulations decrease in numbers and the rate of infection decreases as the fish grow older. The pathology involved as a result of infection with P. cylindracea is not well understood or documented at present.

Figure 12

Age Class Distribution of Yellow Perch Collected from the Western Basin of Lake Erie During 1978, Infected with Philometra cylindracea only (Adults). Actual Numbers.

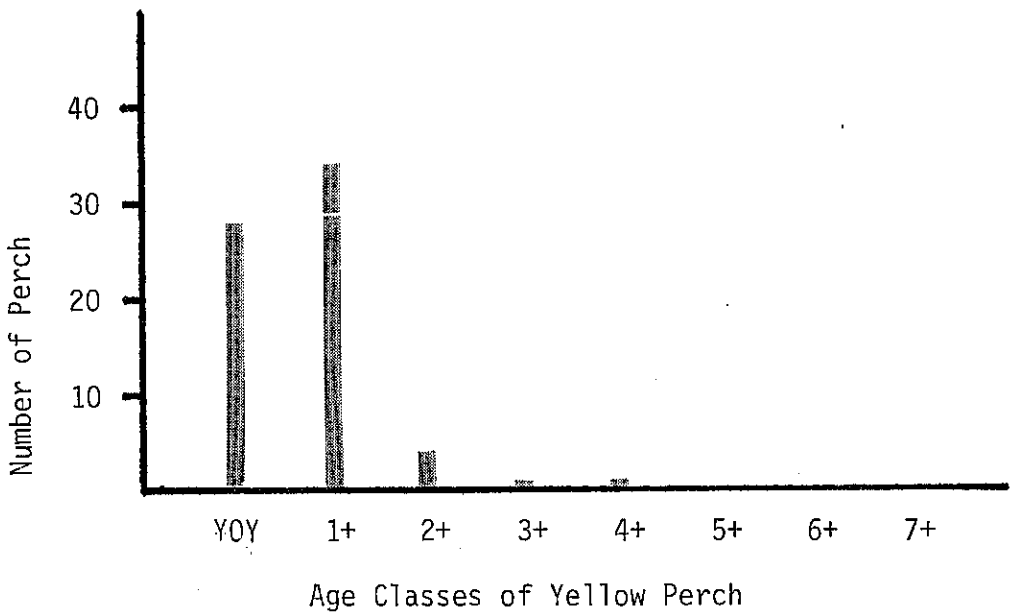


Figure 13

Percentage or Rate of Infection of Each Age Class of Yellow Perch Infected With *P. cylindracea* only (Adults) Western Basin of Lake Erie, 1978.

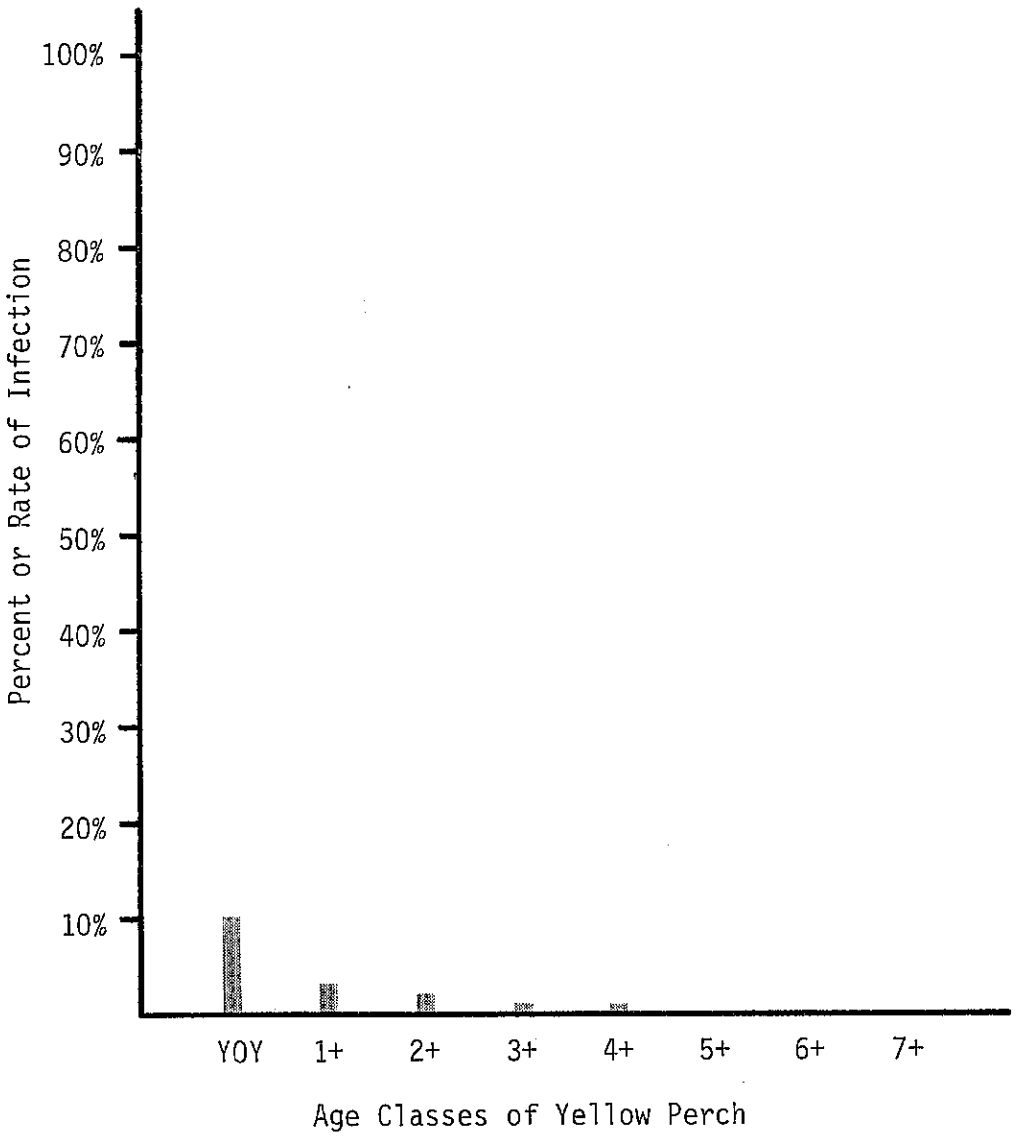


Figure 14

Age Class Distribution of Yellow Perch Collected in the Western Basin of Lake Erie During 1978, Infected With Philometra cylindracea only (Encapsulations). Actual Numbers.

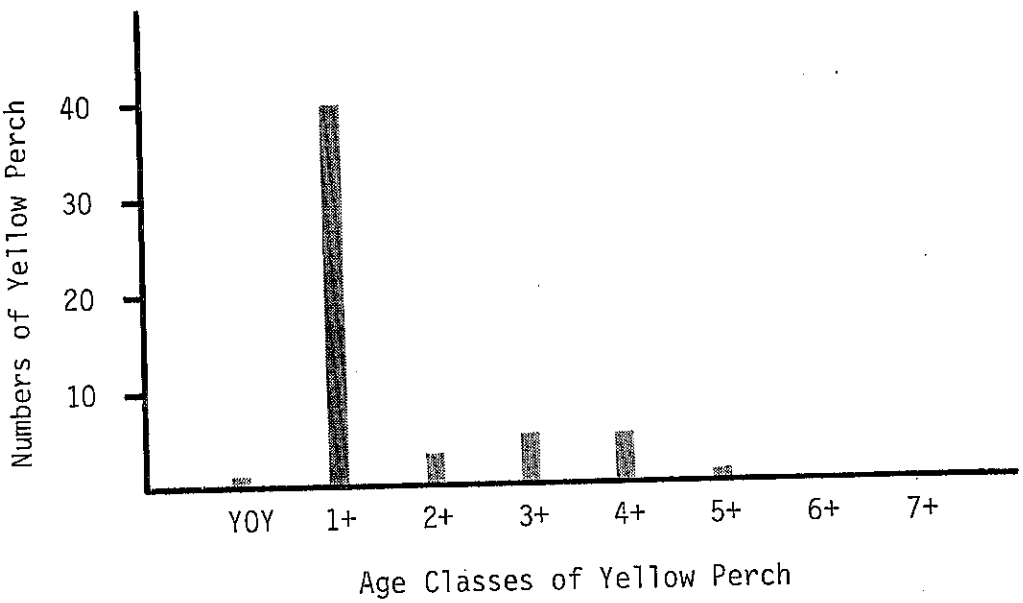
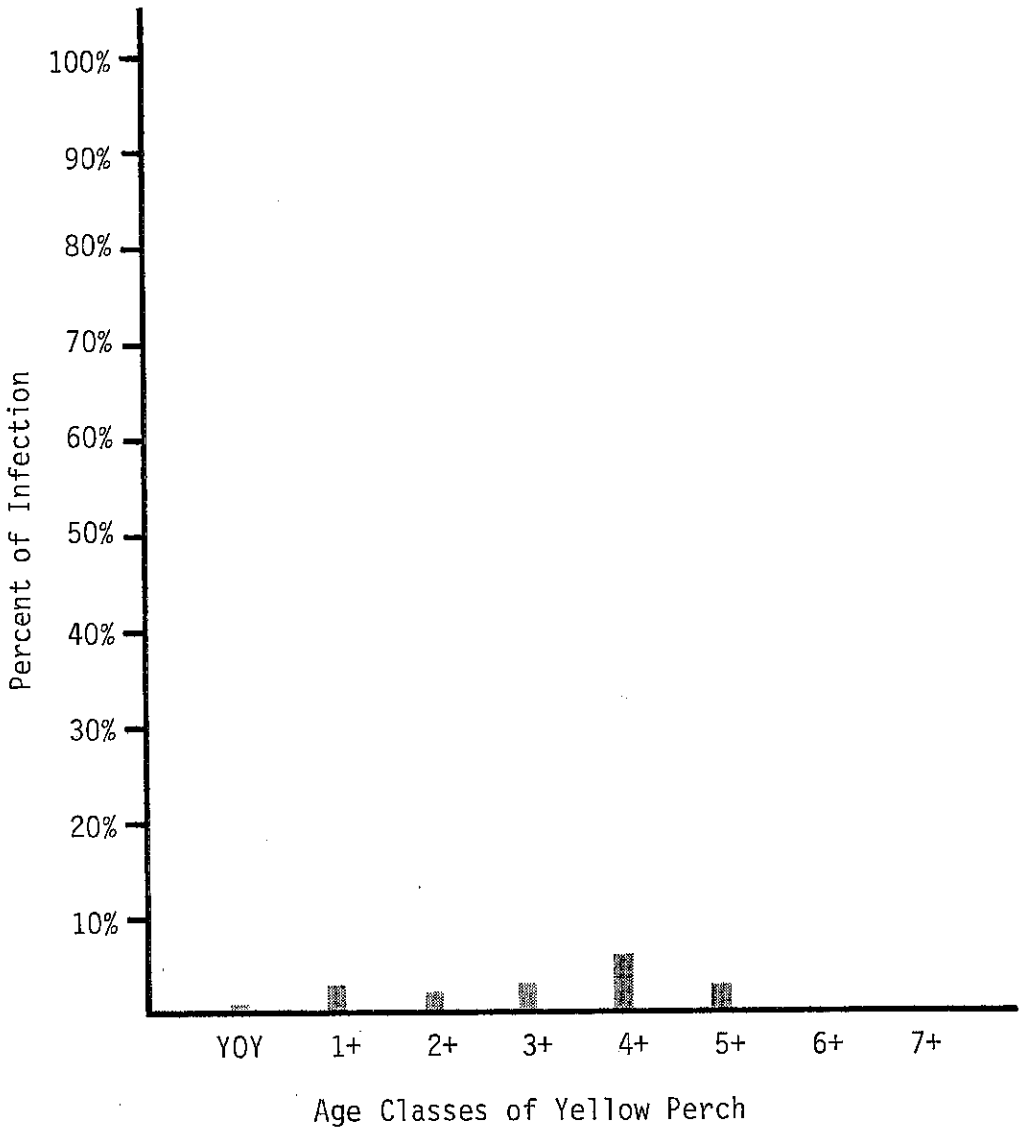


Figure 15

Percentage or Rate of Infection of Each Age Class of Yellow Perch Infected With *P. cylindracea* only (Encapsulations) Western Basin Lake Erie, 1978.



Infection with Triaenophorus nodulosus

Triaenophorus nodulosus infected 959 yellow perch or 46.7 percent of the perch examined from the Western Basin of Lake Erie during 1978. The age class distribution of yellow perch infected with T. nodulosus alone or in combination with E. tubifex and/or P. cylindracea is presented in Figure 16 (Appendix, Table 17). The greatest number of infected yellow perch 633 (66.0 percent) were in the 1+ age class and the numbers decrease in each succeeding age class, with the exception of the 3+ age class. Again this infection distribution, as with the others, seems to be roughly proportional to the size of the age class.

The percentage or rate of infection of each age class of yellow perch infected with T. nodulosus only or in combination with E. tubifex and/or P. cylindracea is graphed in Figure 17 (Appendix, Table 18). The rate of infection increases from YOY perch through the 3+ age class and then decreases through 6+ age class. We don't yet have a reasonable explanation for this pattern but several hypotheses could be suggested and tested.

The age distribution of yellow perch infected with T. nodulosus only is graphed in Figure 18 (Appendix, Table 19). In this case the pattern of distribution changes very little. YOY perch do become infected, 11.4 percent of the infected fish were in this age class. The greatest number of perch infected were distributed in the 1+ age class. Each succeeding age class has a decreasing number of infected fish. This also may reflect the life cycle and the forage feeding habits of YOY and 1+ age class yellow perch. Perca flavescens becomes infected with T. nodulosus by feeding on copepods which harbor the procercoid stage. In the perch the

Figure 16

Age Class Distribution of Yellow Perch Collected from the Western Basin of Lake Erie During 1978, Infected with Triaenophorus nodulosus alone or in combination with Eustrongylides and Philometra (Actual Numbers).

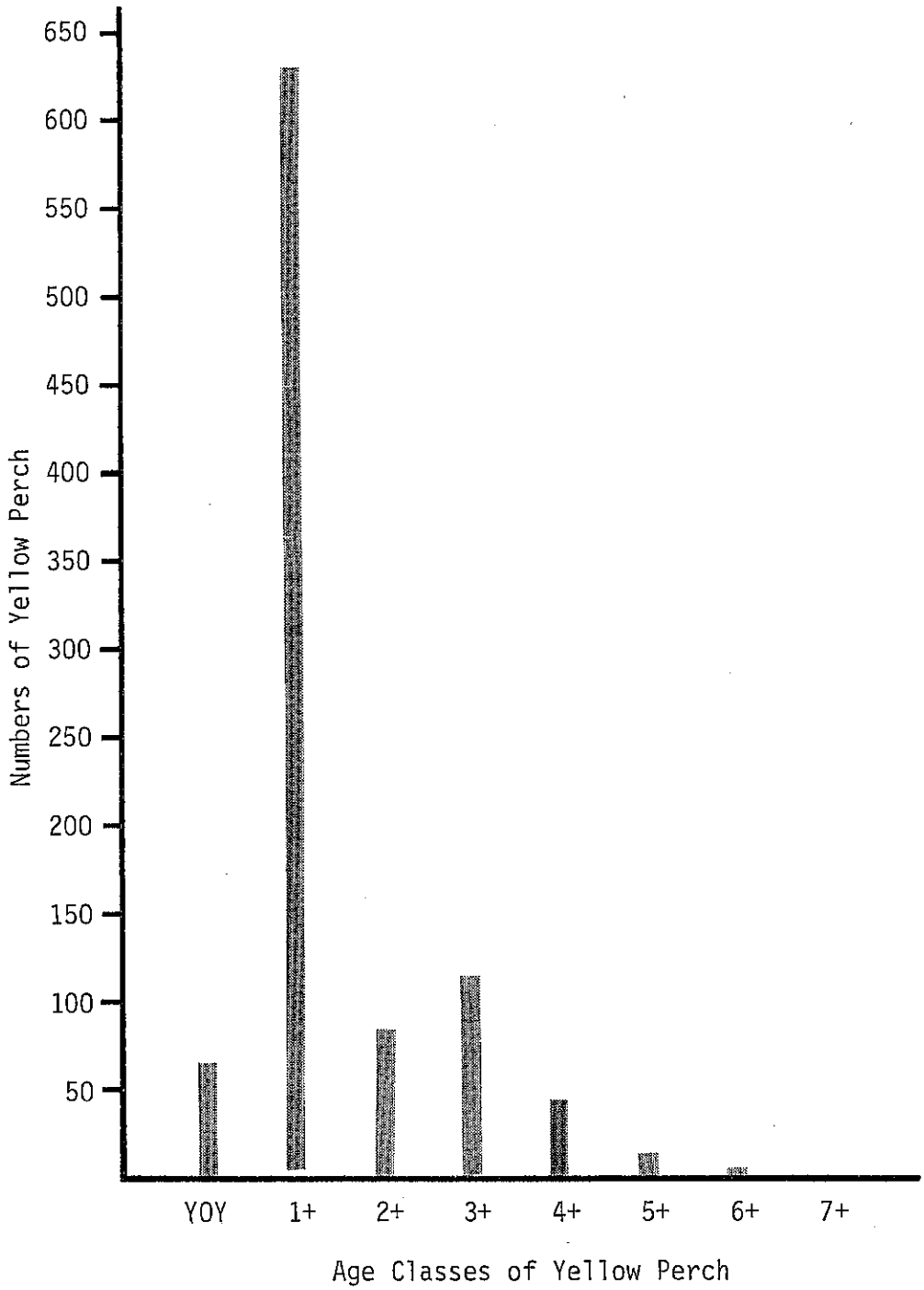


Figure 17

Percentage or Rate of Infection of Each Age Class of Yellow Perch Infected With T. nodulosus alone or in Combination with Eustrongylides or Philometra, Western Basin Lake Erie, 1978.

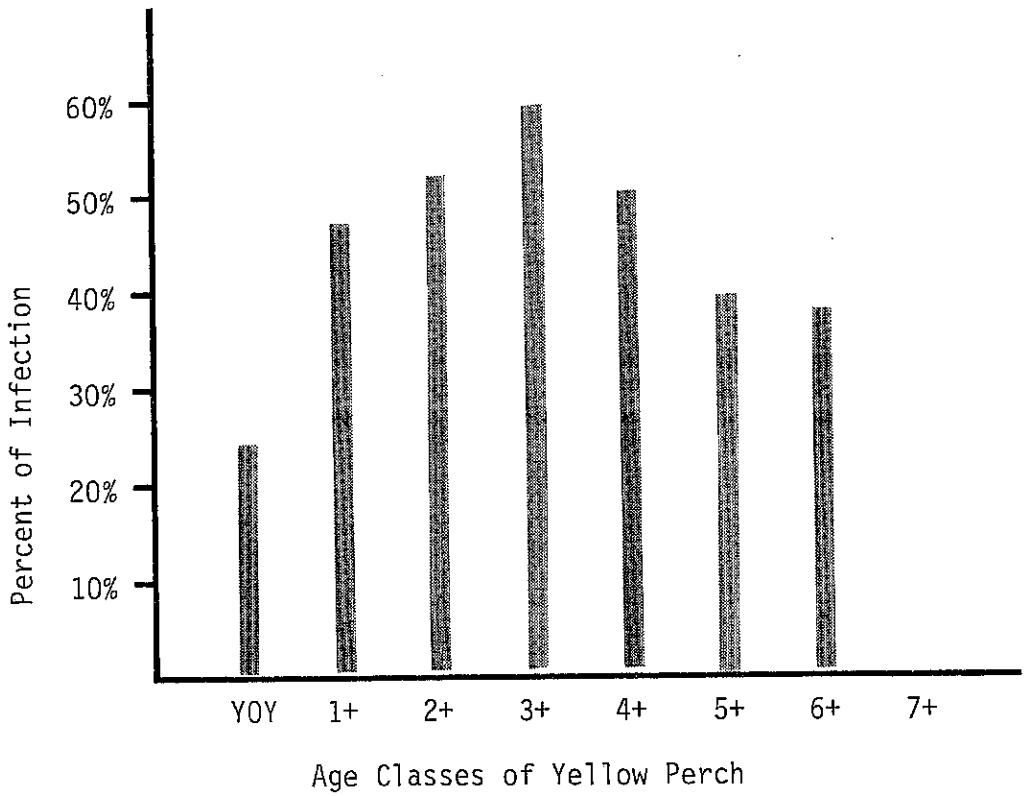
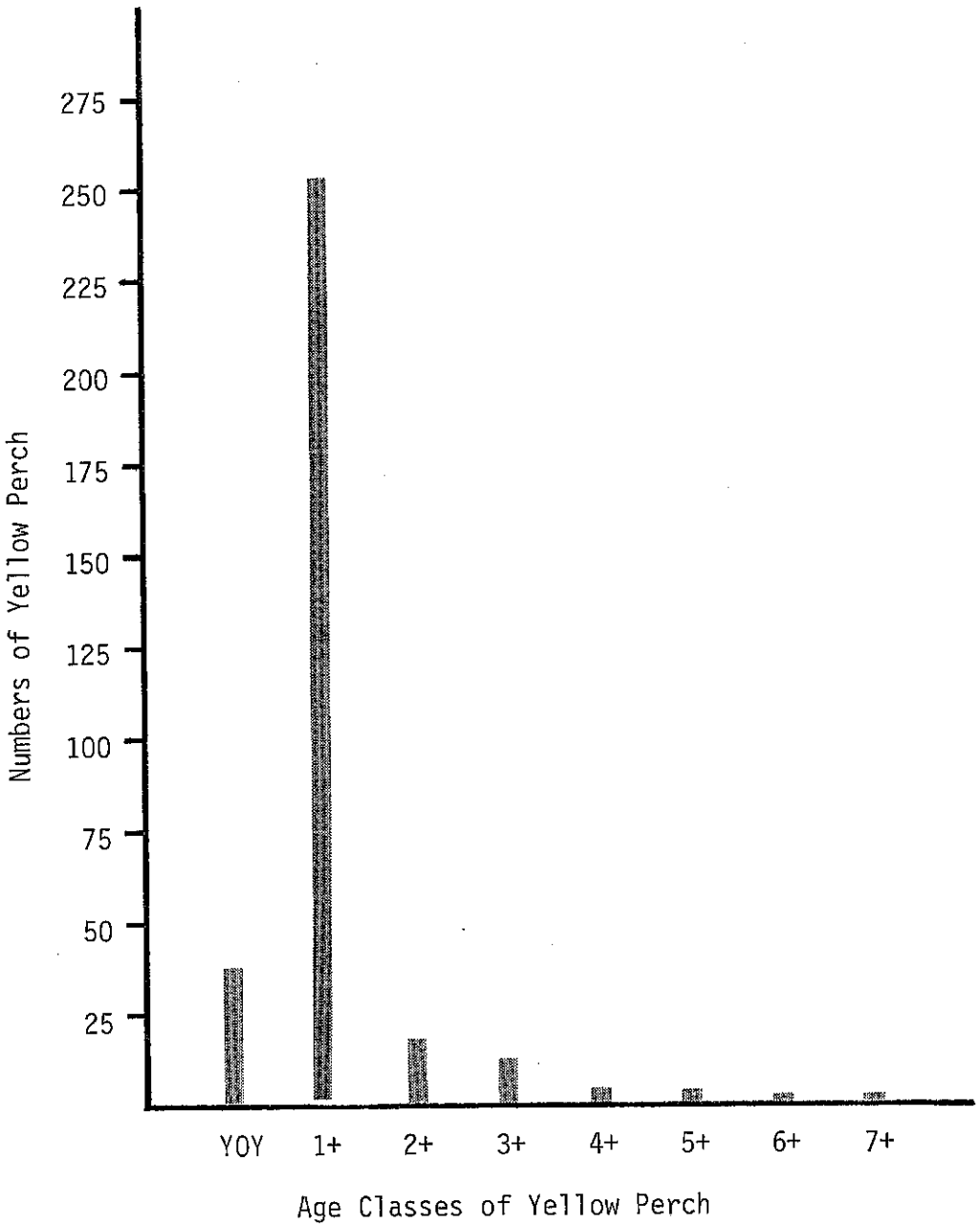


Figure 18

Age Class Distribution of Yellow Perch Collected from the Western Basin of Lake Erie During 1978, Infected with Triaenophorus nodulosus, alone (Actual Numbers).



plerocercoid stage of the tapeworm develops in the liver. The length of life of the plerocercoid is not definitely known but it is not believed to exceed three years. This biological data is also reflected in the rate of infection presented next.

The percentage or rate of infection of each age class of yellow perch infected with T. nodulosus alone is presented in Figure 19 (Appendix, Table 20). The rate of infection is highest in age classes YOY through 2+. The rate then decreases except for the 5+ age class. The 12.1 percent rate in the 5+ age class may be a sampling anomaly as actual numbers of fish sampled are small.

Figures 20 and 21 summarize the overall data. Figure 20 illustrates the actual numbers of yellow perch infected with any one of the three parasites, alone or in any combination. Figure 21 presents the percentage of yellow perch infected with any one of the three parasites during the 1978 collecting season.

Seasonal Rates of Infection of Yellow Perch from the Western Basin of Lake Erie

We consider the seasonal distribution of the different parasites involved in this project in this section of the report. The data is broken down by trawls on specific dates, only those trawls taken between Green and Rattlesnake Islands in the Western Basin of Lake Erie are included. We had only one sample from off Cleveland Harbor in the Central Basin and one sample from between Middle Sister and West Sister Islands for comparison.

We have computerized data showing the seasonal distribution of each of the three different parasites and each of the parasite combinations for

Figure 19

Percent or Rate of Infection of Each Age Class of Yellow Perch Infected With T. nodulosus alone, Western Basin Lake Erie, 1978.

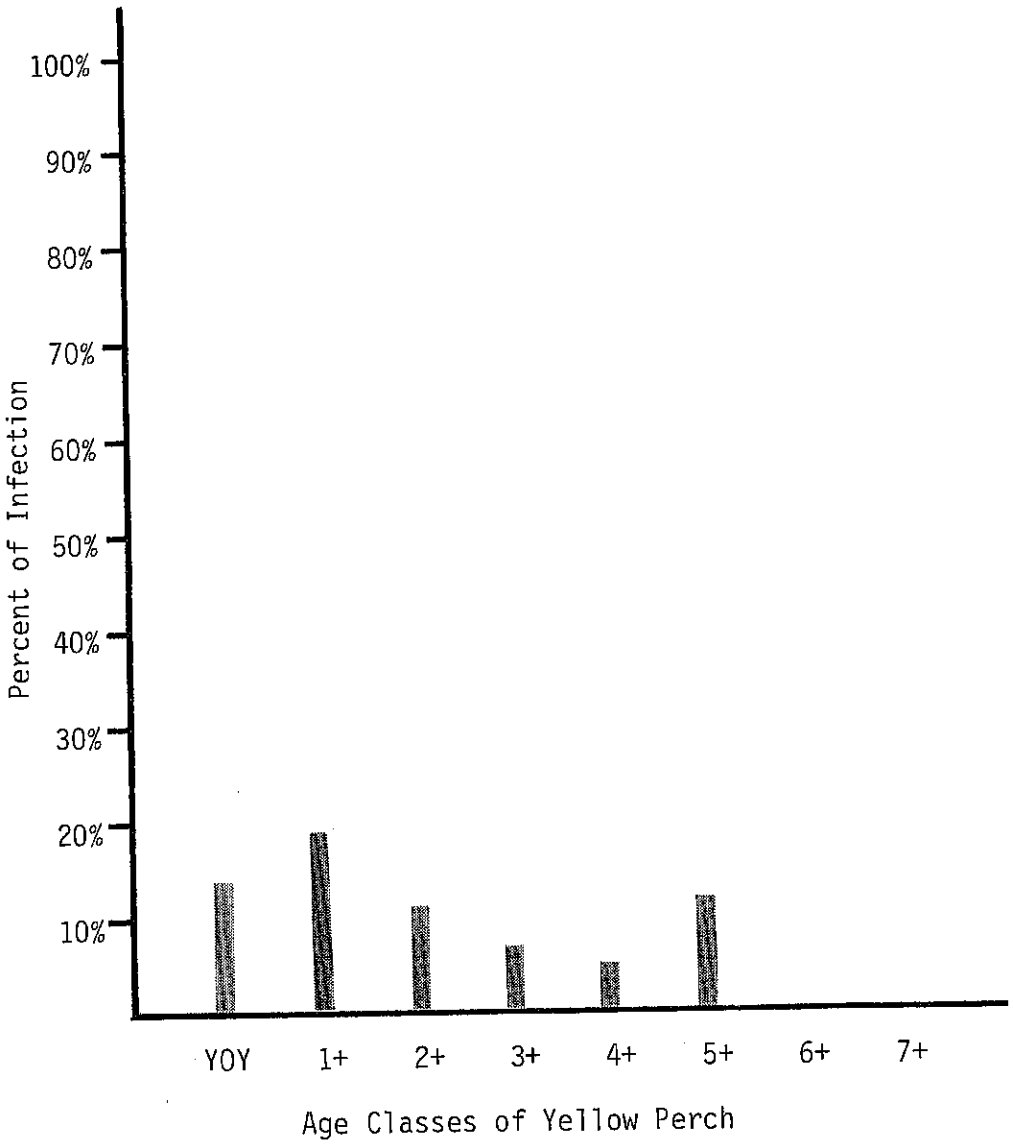


Figure 20

Numbers of Yellow Perch Collected in the Western Basin of Lake Erie During 1978, Infected with Eustrongylides, Triaenophorus, and Philometra.

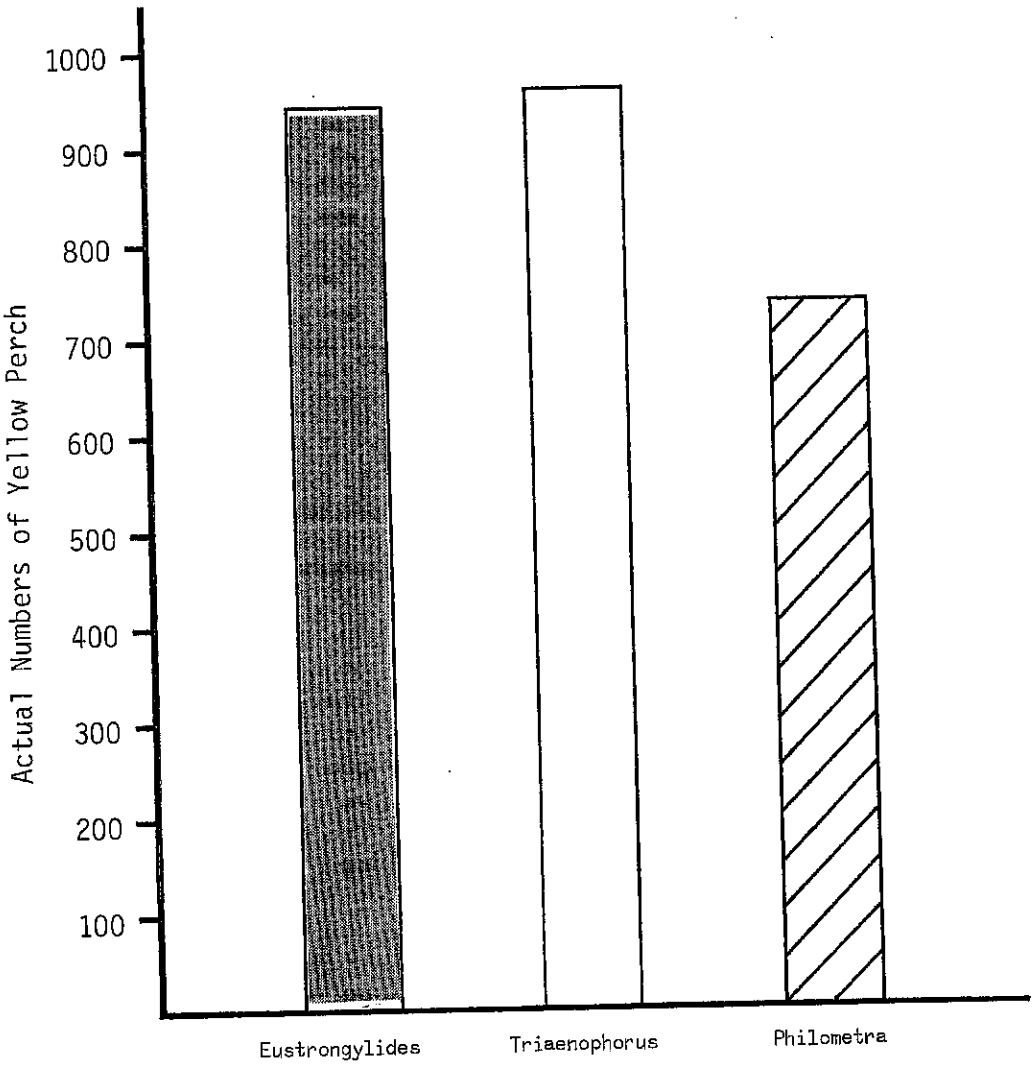
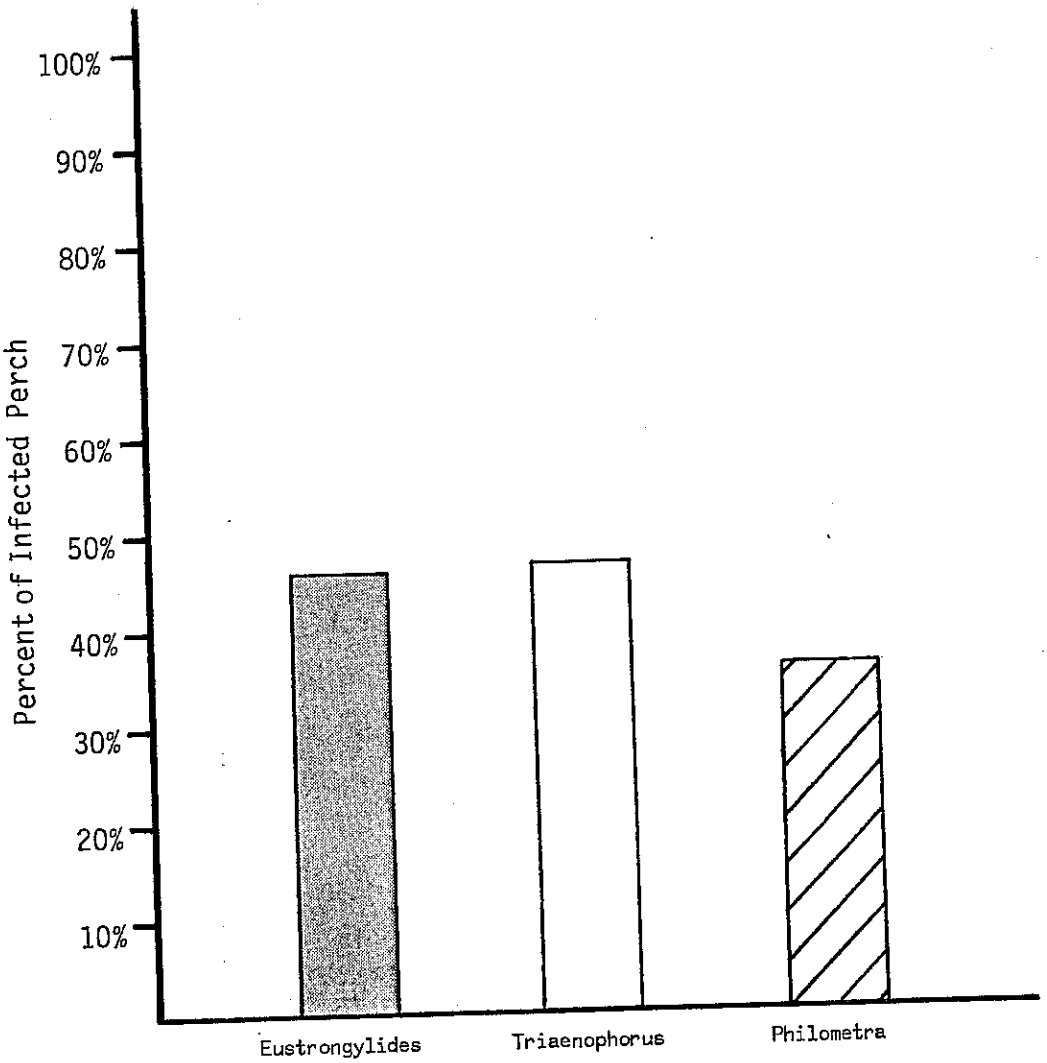


Figure 21

Percentage of Infection with Eustrongylides, Triaenophorus, and Philometra from Yellow Perch Collected in the Western Basin of Lake Erie During 1978.



each age class of yellow perch for each trawl during 1978. This data with its many permutations is not presented here for the sake of brevity but ideas gained from it are given. The data presented in this section summarize the seasonal distribution with all age classes for each trawl grouped as a sample. Future work may show that there is variation from year to year. However, at the present time we can only make inferences about the data based on our present knowledge of these parasites during 1978.

A. Seasonal Rate of Infection with All Three Parasites Combined:

Figure 22 is a graph representing the infection of the yellow perch sampled during 1978 with any one of the three parasites alone or in any combination. This means that the graph includes any fish infected with one of these parasites or more, this is presented in tabular form in Table 21, Column 1 (Appendix). The infections rise irregularly until July 17 then they increase steadily to a peak on September 18. After the peak on September 18 they decrease gradually until 30 October. The infection is always greater than 53.3 percent, and, at its peak, reaches 94.7 percent. During late September and October it decreases but only to 76.9 percent. The mean percentage of infection is 77.04 percent over the entire season. This is an extremely high rate of infection or parasitism for any sampled population(s) of fishes. This pattern with peak infections in September is repeated in several of the figures which follow but there are exceptions.

B. Seasonal Rates of Infection of Yellow Perch with Triple Infections, Only:

Figure 22. Rate of Infection of Yellow Perch with any of the Three Parasites, Alone or in any Combination. Trawls Taken Between Green and Rattlesnake Islands. Western Lake Erie, 1978.

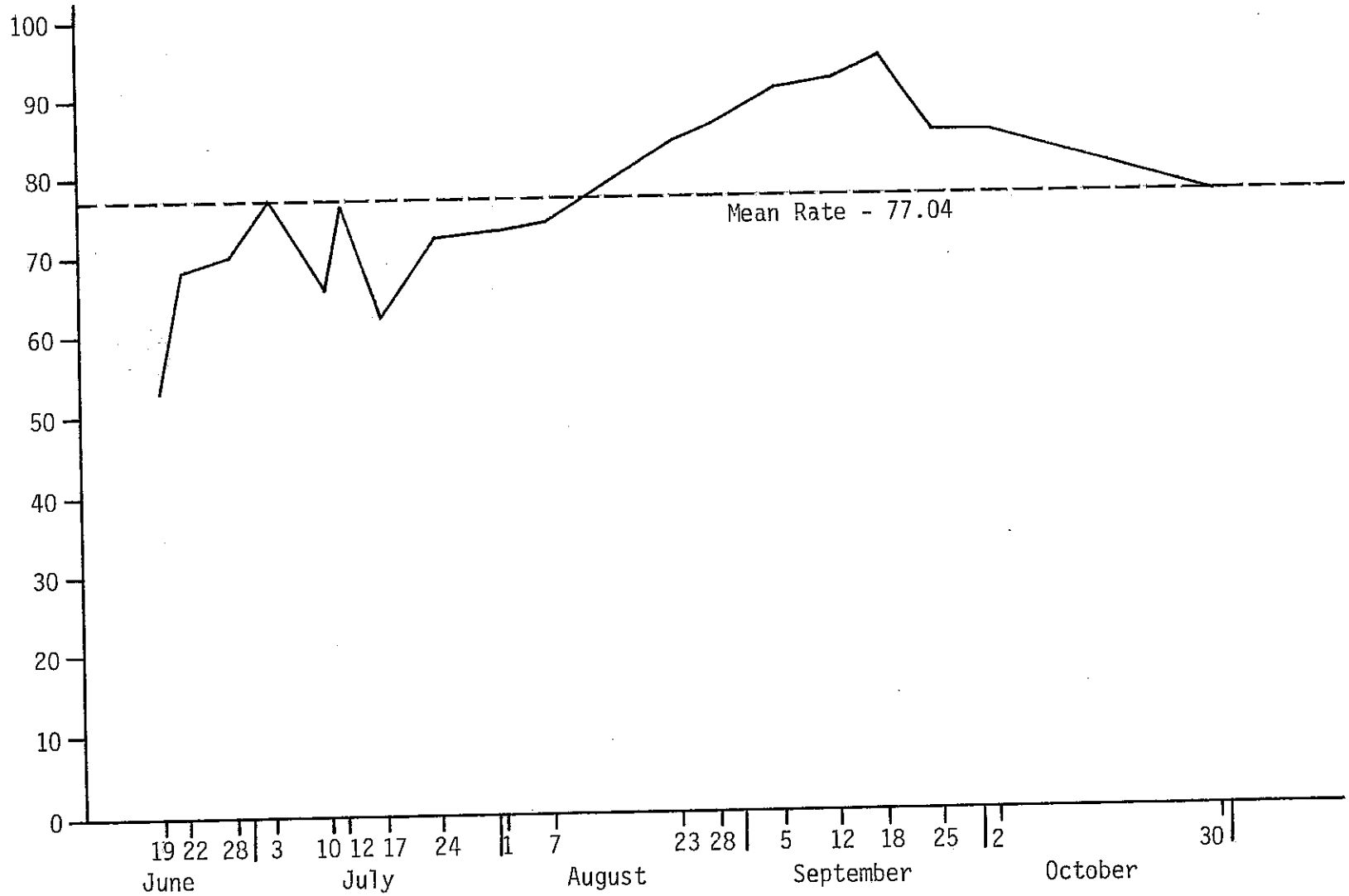


Figure 23 (Appendix Table 21, Column 2) presents data for those yellow perch sampled in the Western Basin of Lake Erie during 1978 with triple infections only, no other combinations. The rate of infection is comparatively low, a mean rate of 15 percent, but Figure 23 shows the same general pattern as Figure 22. The infections are irregular until 1 August and then they increase to a peak of 42.2 percent on 12 September; there is a decline to below the mean rate by 30 October. The decline from the peak in mid-September through October is not easily explained. Perhaps the most plausible explanation is the increase in the proportion of the YOY age class in the samples during this time (Figure 33) and the fact that these fish have rates of infection lower than the other age classes.

C. Seasonal Rates of Infection of Yellow Perch with Eustrongylides Alone or in Combination with Triaenophorus and/or Philometra (any stage):

The seasonal data for this combination is presented in Figure 24 (Appendix, Table 21, Column 3). This data would include any yellow perch which was infected with Eustrongylides tubifex taken in our samples during 1978. Again the pattern is similar to that previously discussed. The rate of infection with E. tubifex is irregular until 1 August and then increases to a peak of 68 percent in September, the rate then decreases to 43 percent, slightly below the mean, by 30 October. The mean rate of 46.94 percent is very high for any parasitic infection, almost half of the yellow perch sampled were infected with this parasite. The decrease during late September and October is perhaps a reflection of the proportional increase in the YOY class yellow perch during that time. Only 2.1 percent of yellow

Figure 23. Rate of Infection of Yellow Perch With Triple Infections Only, No Other Combinations, Trawls Taken Between Green and Rattlesnake Islands, Western Lake Erie, 1978.

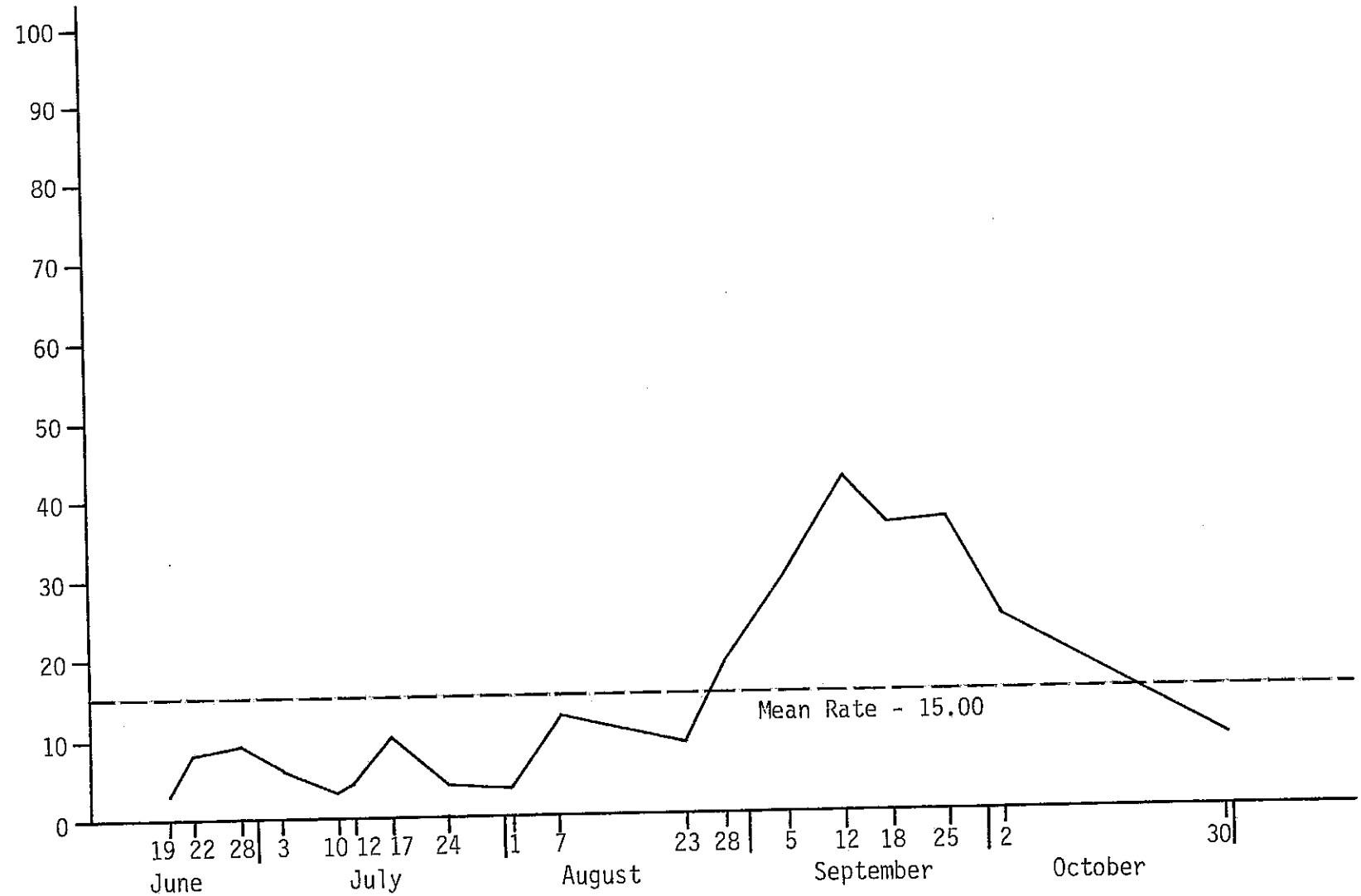
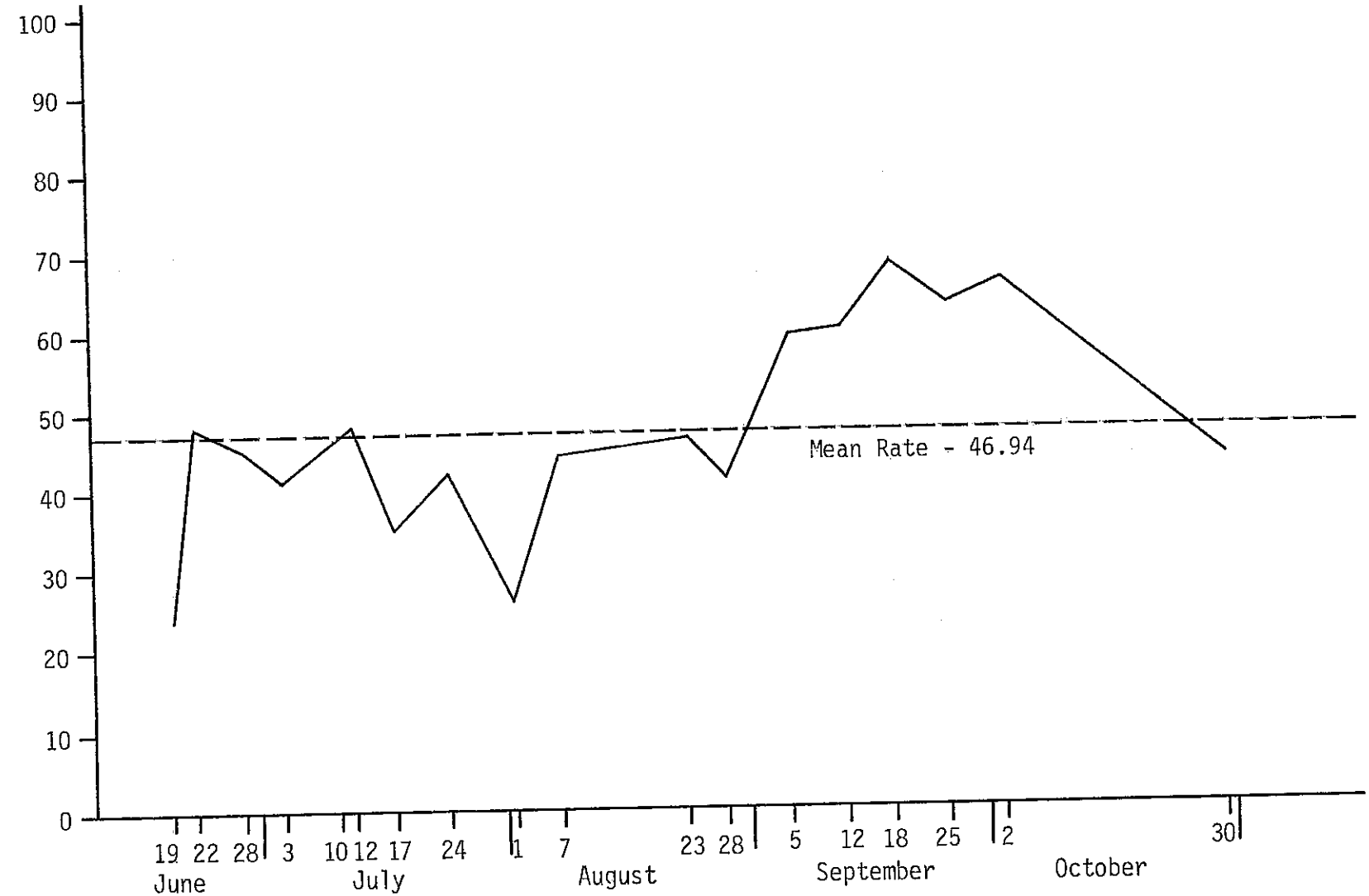


Figure 24. Rate of Infection of Yellow Perch With Eustrongylides, Alone or in Combination With Trianophorus and/or Philometra. Trawls Taken Between Green and Rattlesnake Islands, Western Lake Erie, 1978.



perch infected with E. tubifex during 1978 were in this year class (Figure 6).

D. Seasonal Rate of Infection with Eustrongylides and Philometra (any stage) in Combination:

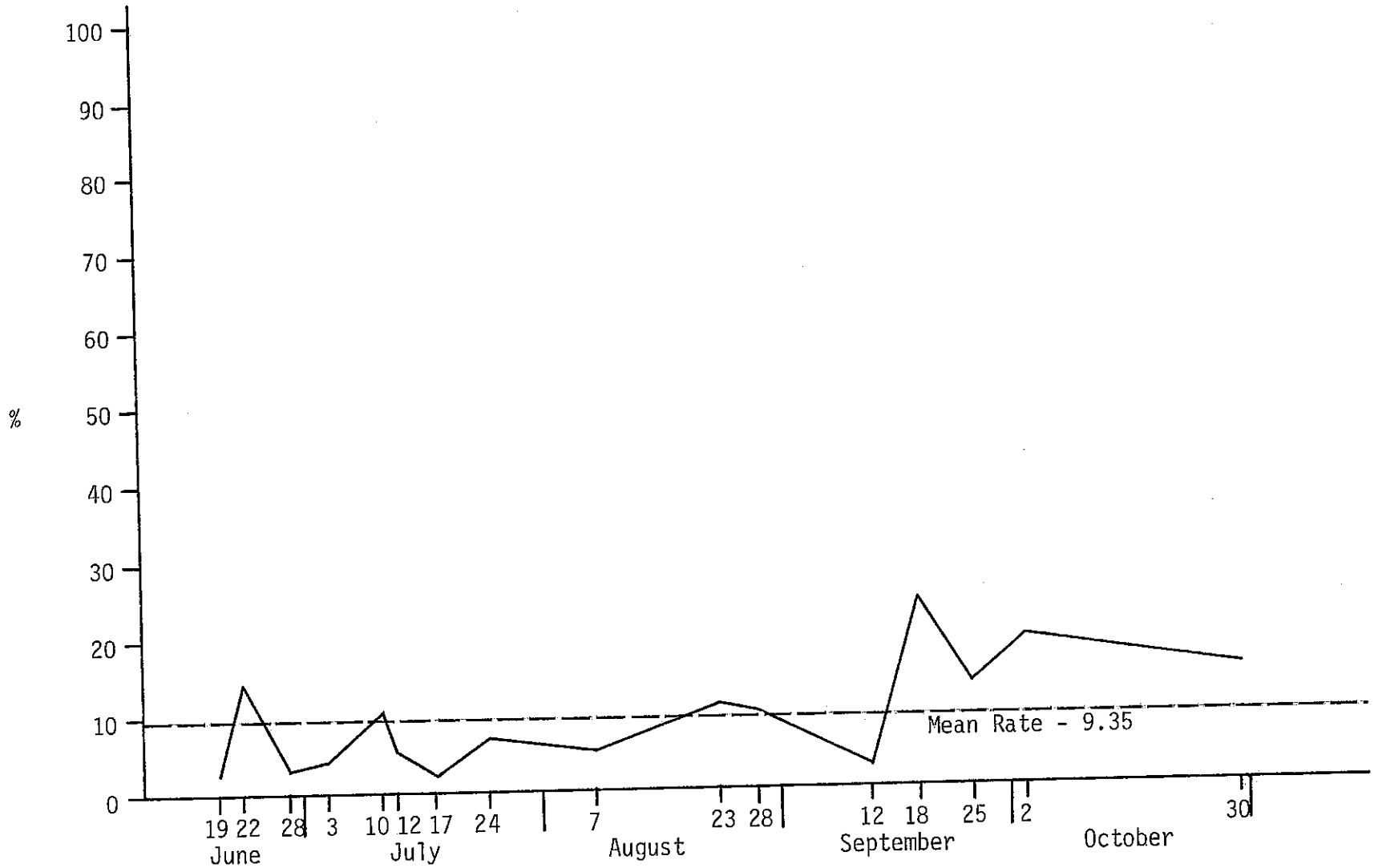
The seasonal data for this combination is presented in Figure 25 (Appendix, Table 21, Column 4). The data presented here is only for this particular combination of parasites and it reflects the biology of both of these parasites. Their life cycles and development are quite different.

This combination shows an irregular rate of infection until 12 September. This longer period of irregularity and the decrease during late August and early September is probably a reflection of the loss of one generation of P. cylindracea adults at that time. The infection then increases sharply and reaches a peak (25 percent) on 18 September and declines to 15.4 percent, well above the mean, by 30 October.

While E. tubifex is present only in a very low percentage in YOY yellow perch, the opposite is true for P. cylindracea. P. cylindracea is primarily a parasite of YOY, 1+ and 2+ age class yellow perch (see Figures 12 and 13). A new generation, a small adult P. cylindracea is entering the younger yellow perch in the autumn, thus the decline is not as great during this time when these two parasites are considered in combination. This particular combination is never very prevalent and the mean rate (percent) of infection is only 9.35 percent.

E. Seasonal Rate of Infection with Eustrongylides and Triaenophorus in Combination:

Figure 25. Rate of Infection of Yellow Perch With Eustrongylides and Philometra in Combination. Trawls Taken Between Green and Rattlesnake Islands, Western Lake Erie, 1978.



The seasonal distribution of rates of infection for this combination is presented in Figure 26 (Appendix, Table 21, Column 5). Figure 26 illustrates that there were two peaks during 1978, the first occurred on 3 July followed by a decline in rate of infection to 1 August. A second peak was reached on 5 September followed by a decline to 25 September. During late September and October there is a slight increase in the rate of infection with this combination. This particular combination of parasites alone was never very prevalent and had a mean rate of only 8.17 percent. It is our opinion that the data graphed relates more closely to T. nodulosus than to E. tubifex although the second peak may reflect a peak in rate of infection with both parasites during September. The seasonal rates of infection in this case also reflects the proportion and feeding habits of different ages of yellow perch infected with this particular combination.

F. Seasonal Rate of Infection with Eustrongylides tubifex Alone:

The seasonal rate of infection with E. tubifex alone (no combinations) is presented in Figure 27 (Appendix, Table 21, Column 6). This category of infection occurred at a mean rate of 16.37 percent. The rate of this infection was also irregular during June and the first three weeks of July. The rate declines from 24 July through 12 September then increases only to the mean, 2 October, and declines through the remainder of October. The decline during September illustrated in Figure 27 was real for this particular category, but it is in some ways misleading. It must be remembered that this graph represents infections of E. tubifex alone. As indicated in Figure 24

Figure 26. Rate of Infection of Yellow Perch With Eustrongylides and Triaenophorus in Combination. Trawls Taken Between Green and Rattlesnake Islands, Western Lake Erie, 1978.

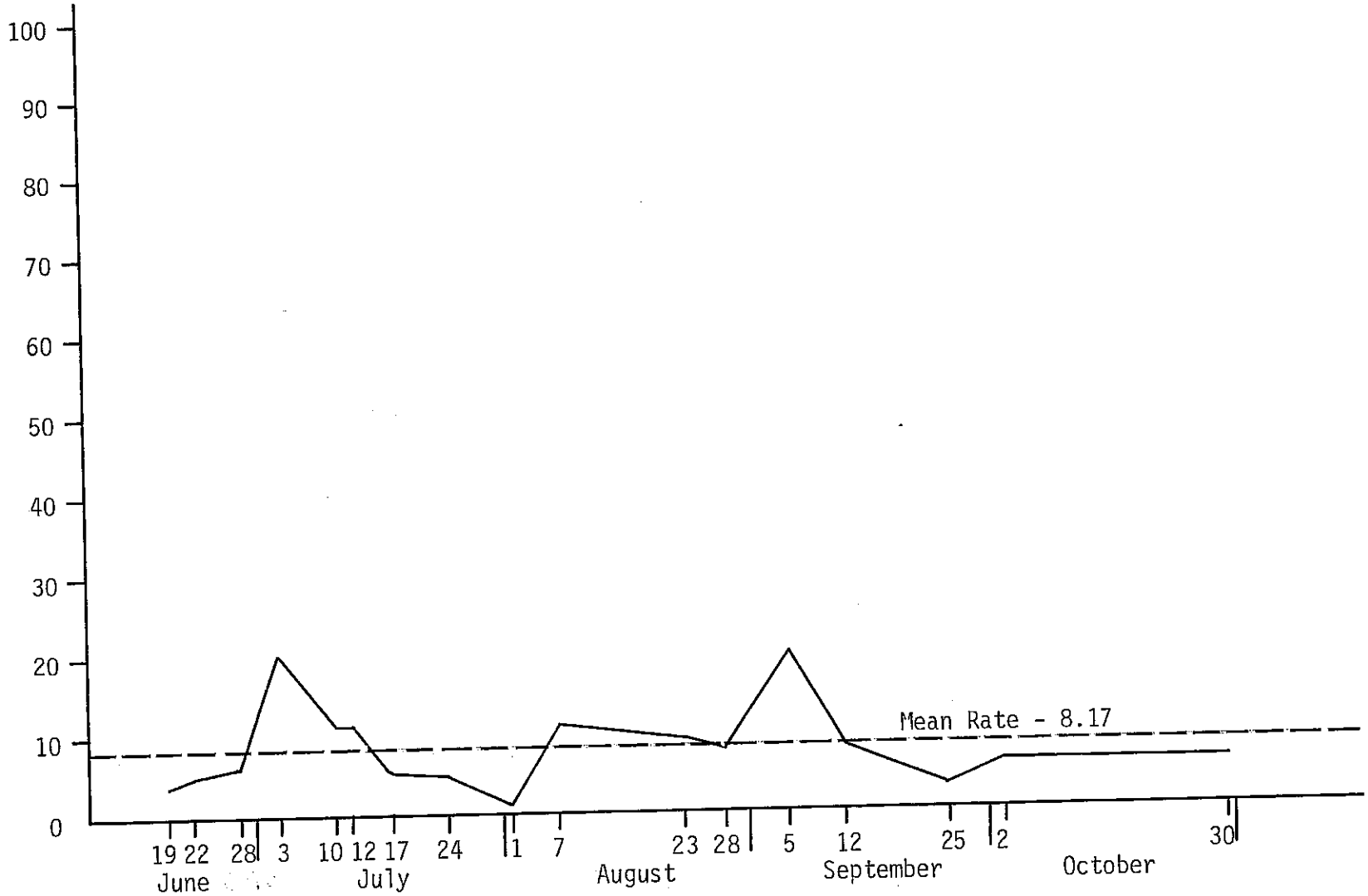
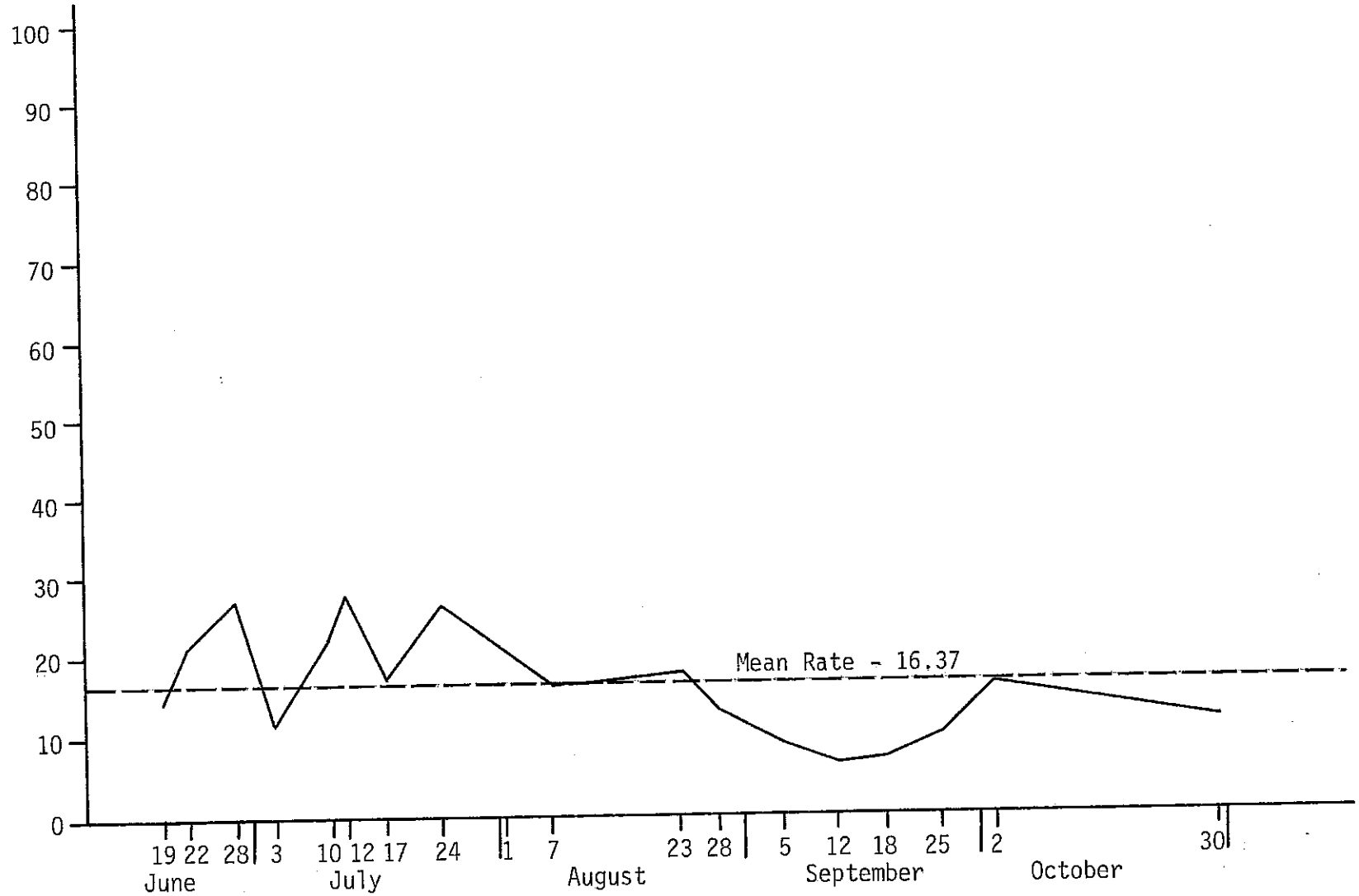


Figure 27. Rate of Infection of Yellow Perch With Eustrongylides Only, Trawls Taken Between Green and Rattlesnake Islands, Western Lake Erie, 1978.

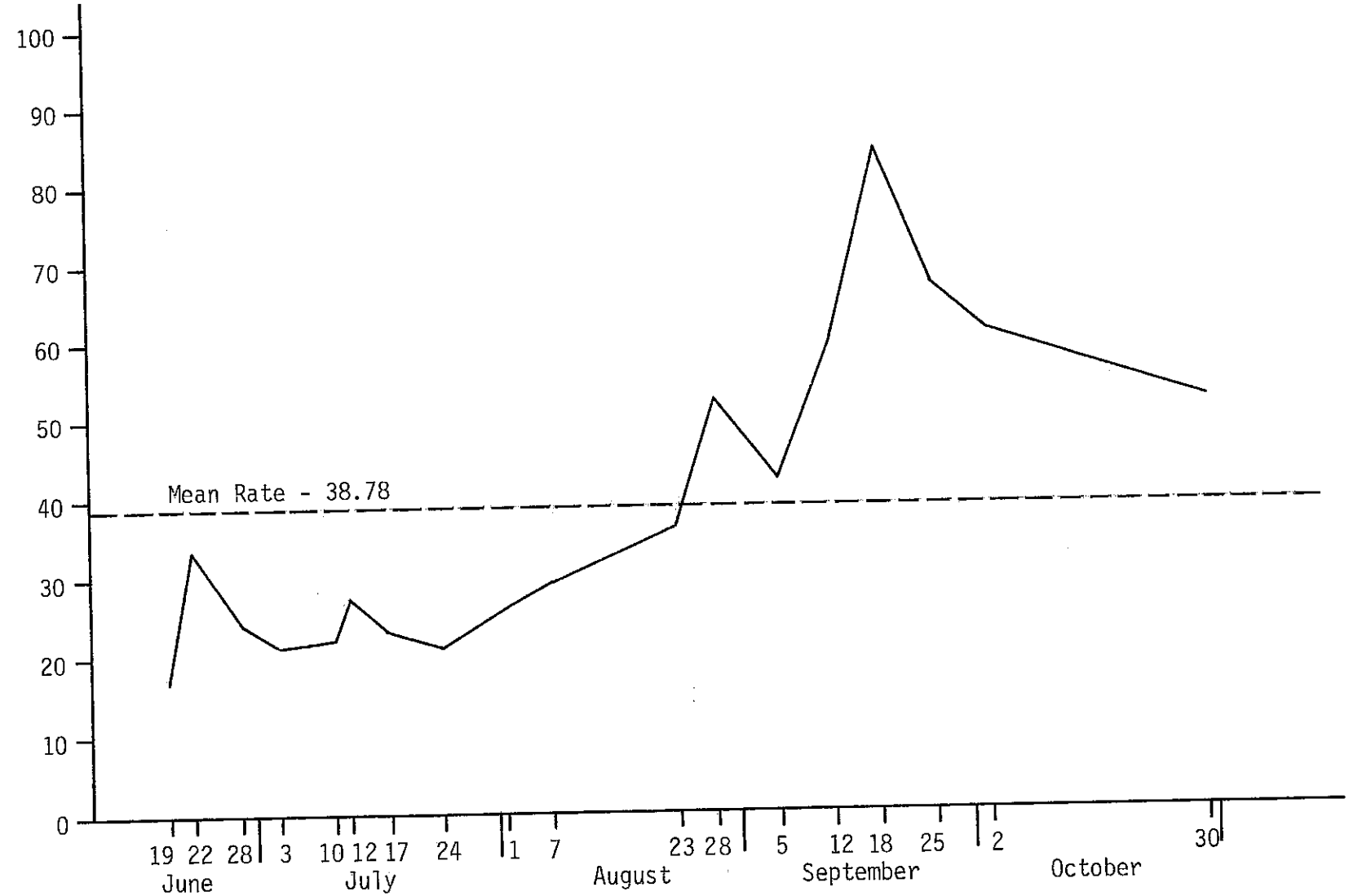


and some of the figures which follow, E. tubifex was present at a high rate of infection during September but in combination with some stage of P. cylindracea or T. nodulosus. It occurred alone in above mean rates only during June, July, and part of August. There were 942 yellow perch infected with E. tubifex alone or in some combination with the other two parasites. There were 339 yellow perch infected with E. tubifex alone, and 603 occurred in combination with one of the other parasites or both of them (Appendix, Tables 6 and 7). Older yellow perch show a higher rate of infection with E. tubifex, when all age classes are grouped (as they were for these figures) the rate declines as the YOY yellow perch increase proportionally in the samples (Figure 33).

G. Seasonal Rate of Infection with Philometra cylindracea (any stage) Alone or in Combination with Eustrongylides tubifex and/or Triaenophorus nodulosus:

The seasonal data for the rate of occurrence of P. cylindracea, any stage, alone or in combination with one or both of the other two genera of parasites is presented in Figure 28 (Appendix, Table 21, Column 7). This data includes any yellow perch which was infected with any stage of P. cylindracea during 1978. The overall pattern is similar to that discussed previously. The rate of infection is irregular until 24 July and then increases from 21.2 percent to a peak of 84.04 percent on 18 September. From this peak it decreases to 52.3 percent on 30 October, a rate much higher than the mean of 38.7 percent. The peak is largely due to the increase of P. cylindracea encapsulations and a new generation P. cylindracea adults. As will be

Figure 28. Rate of Infection of Yellow Perch With Philometra (any stage) Alone or in Combination With Eustrongylides and/or Triaenophorus, Trawls Taken Between Green and Rattlesnake Islands, Western Lake Erie, 1978.



shown in the next two sections P. cylindracea actually increases in rate of infection when not in combination with E. tubifex during the late autumn.

H. Seasonal Rate of Infection of Philometra cylindracea (any stage) in Combination with Triaenophorus nodulosus:

The seasonal data for the rate of infection of yellow perch with P. cylindracea (any stage) in combination with T. nodulosus are presented in Figure 29 (Appendix, Table 21, Column 8). The rate of this infection was irregular until a first peak of 18.29 percent on 1 August. There is a second peak of 15.32 percent on 28 August. Following the second peak there is a decline until 2 October and the rate increases in October and is above the mean (8.37 percent) by 30 October. The first peak corresponds with a peak on the same date when T. nodulosus occurs alone. The second peak corresponds with an increase in the new encapsulations of P. cylindracea.

I. Seasonal Rate of Infection with Philometra cylindracea Alone (any stage):

The seasonal data for the rate of infection of P. cylindracea alone (any stage) is presented in Figure 30 (Appendix, Table 21, Column 9). The rate of infection is irregular through June and July and gradually decreases until 7 August. At this time in August almost all adult female P. cylindracea have released their larvae and died, part of each spent female worm becomes encapsulated. The rate of increase from 7 August to August 28 is possibly due to an increase in encapsulations. The rate increases again from 25 September through 30 October, this reflects a new generation of P. cylindracea entering

Figure 29. Rate of Infection of Yellow Perch With Philometra (any stage) and Triaenophorus, in Combination Only, Trawls Taken Between Green and Rattlesnake Islands, Western Lake Erie, 1978.

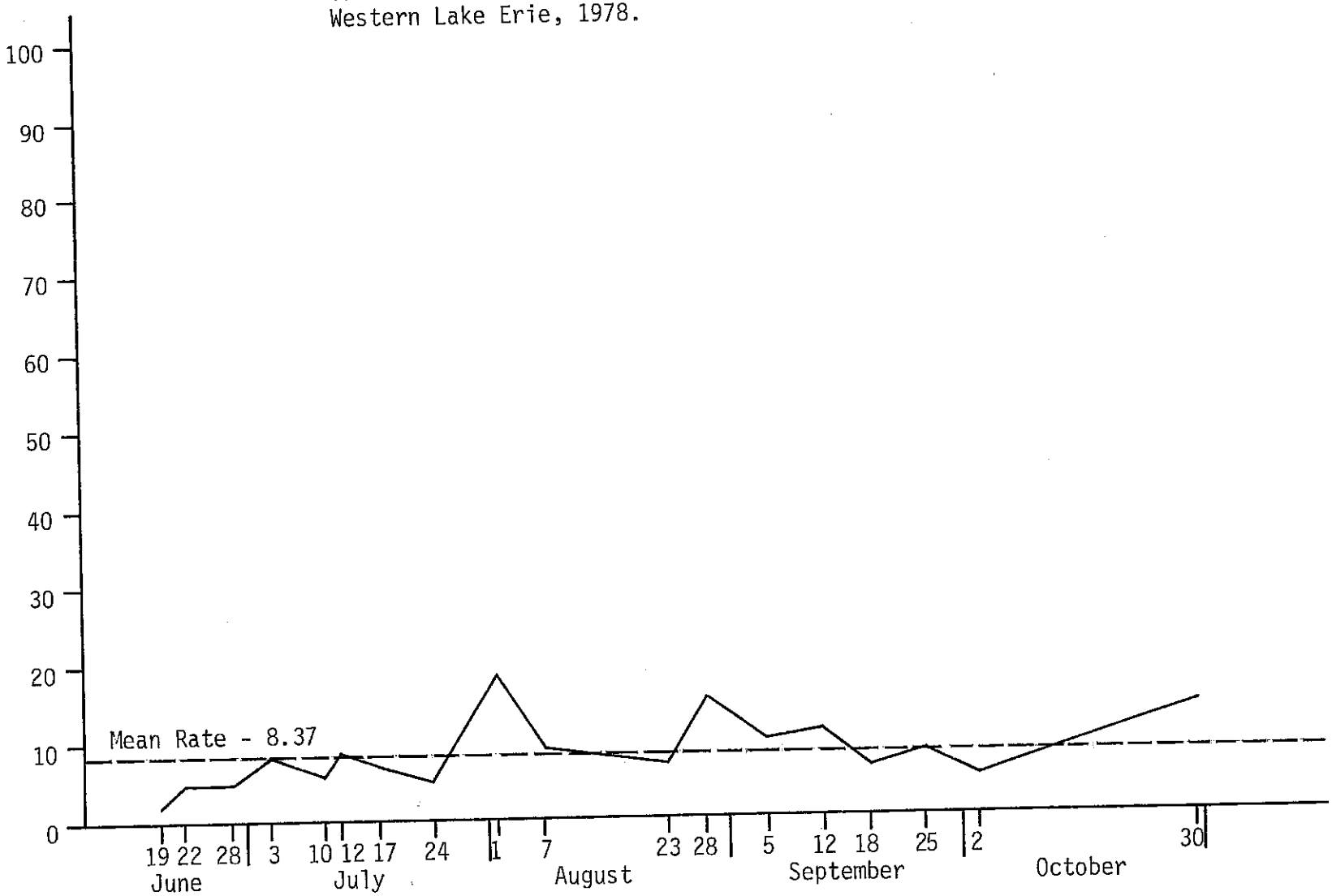
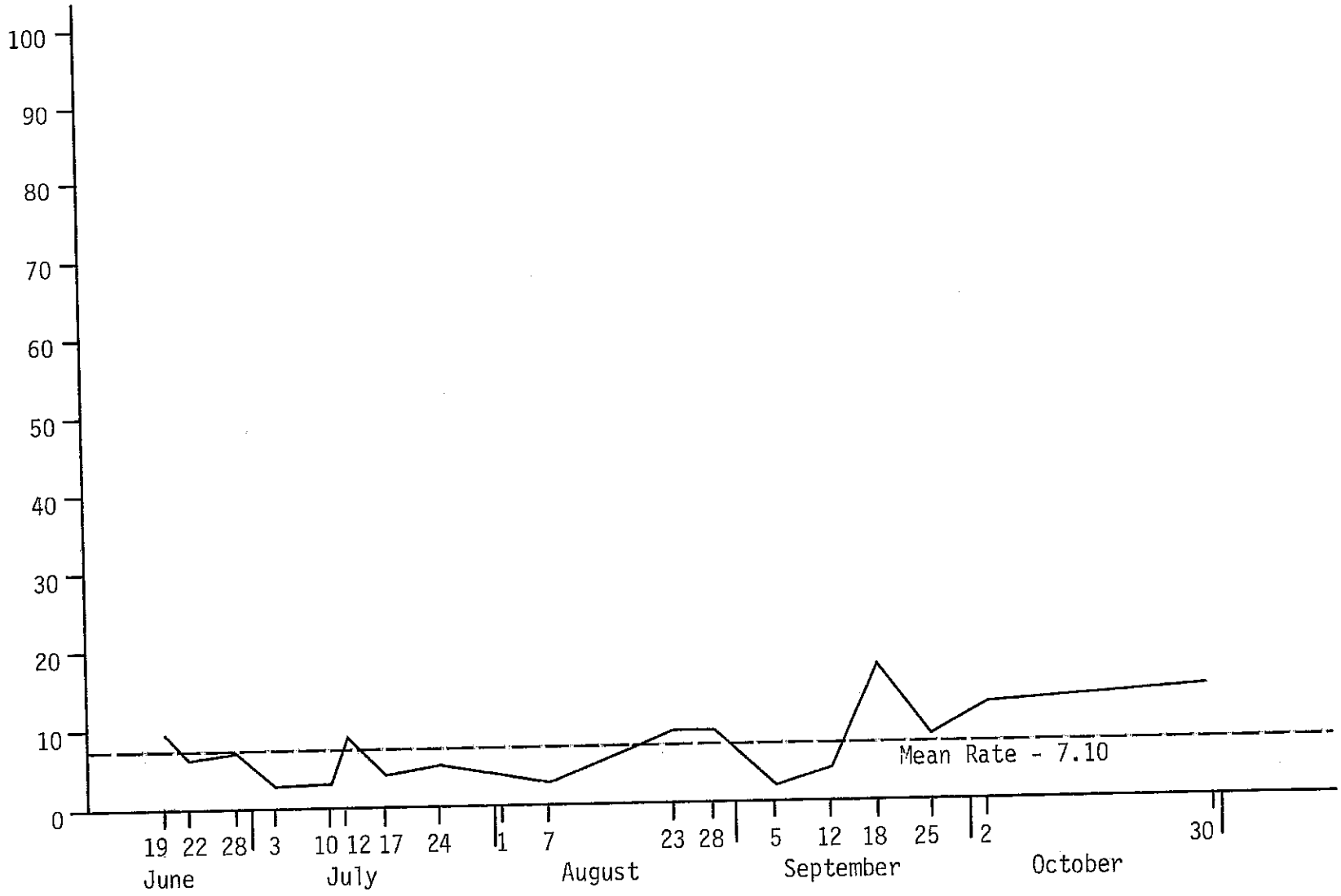


Figure 30. Rate of Infection of Yellow Perch With Philometra (any stage) Only, Trawls Taken Between Green and Rattlesnake Islands, Western Lake Erie, 1978.



the yellow perch. P. cylindracea usually occurs in combination with one of the other two parasites. The mean rate when it occurred alone during 1978 reached only 7.1 percent.

J. Seasonal Rate of Infection with Triaenophorus nodulosus Alone, or in Combination with Philometra cylindracea (any stage) and/or Eustrongylides tubifex:

The seasonal data for the rate of occurrence of T. nodulosus alone or in combination with one or both of the other two parasites is presented in Figure 31 (Appendix, Table 21, Column 10). This data includes any yellow perch which was infected with T. nodulosus during 1978. This combination of infections follows the pattern established earlier. The infection increases irregularly from 26.7 percent to a peak of 80.3 percent on 5 September. From this peak it decreases through the remainder of the collecting season. It reaches an autumn low of 35.38 percent on 30 October, below the mean of 45.27 percent. This is a high mean rate of infection. The analysis of this pattern of T. nodulosus would be the same as that presented previously where this pattern occurred and is not repeated here.

K. Seasonal Rate of Infection with Triaenophorus nodulosus Alone.

The data for the rate of occurrence of T. nodulosus alone in yellow perch are presented in Figure 32 (Appendix, Table 21, Column 11). The mean rate of infection of T. nodulosus alone (no combinations) was 14.18 percent. This was the highest rate of infection of any of the three parasites infecting yellow perch without being in a combination. The rate of infection is irregular throughout June and July. There was a peak on 3 July. This peak

Figure 31. Rate of Infection of Yellow Perch With Triaenophorus, Alone or in Combination With Philometra (any stage) and/or Eustrongylides. Trawls Taken Between Green and Rattlesnake Islands, Western Lake Erie, 1978.

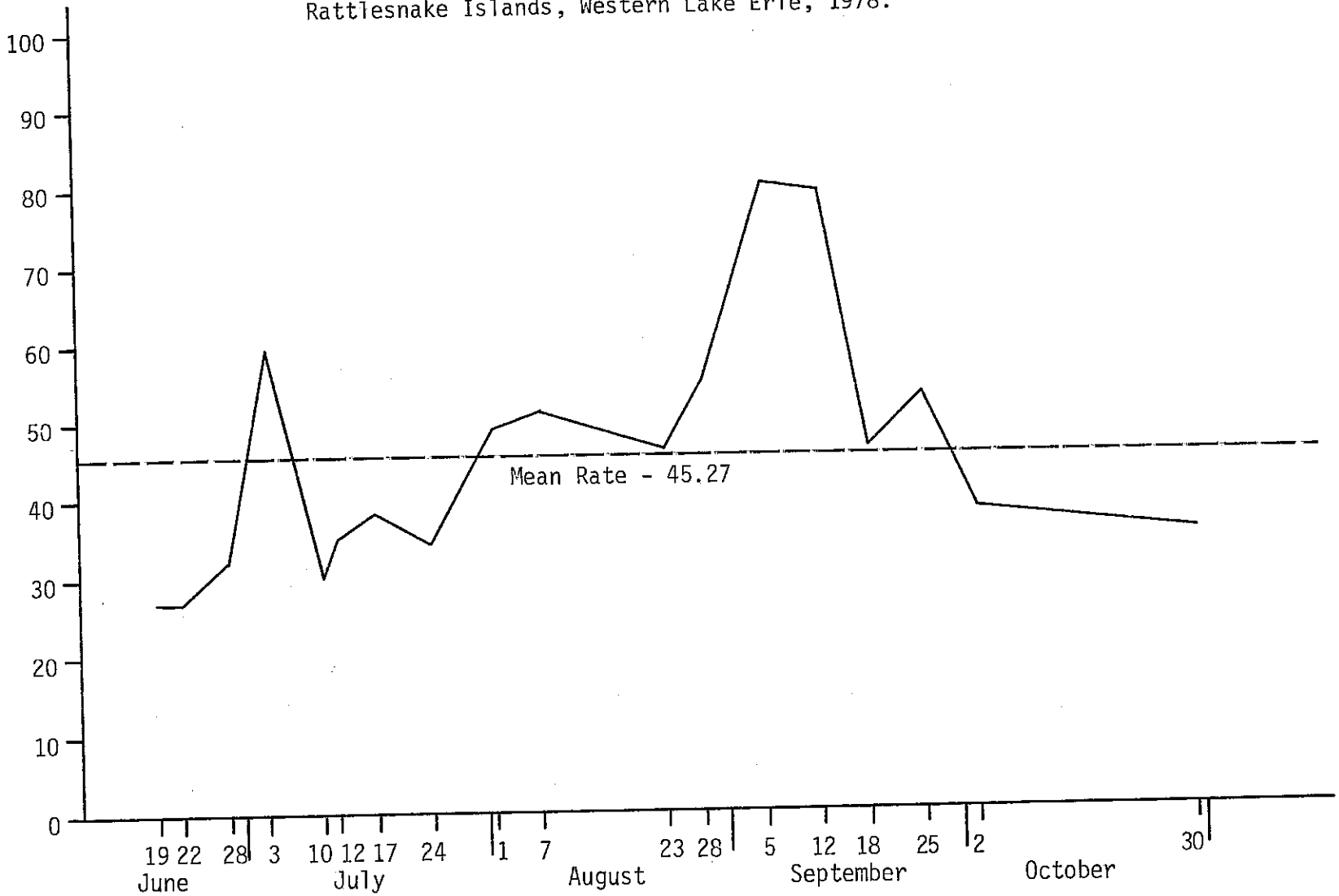
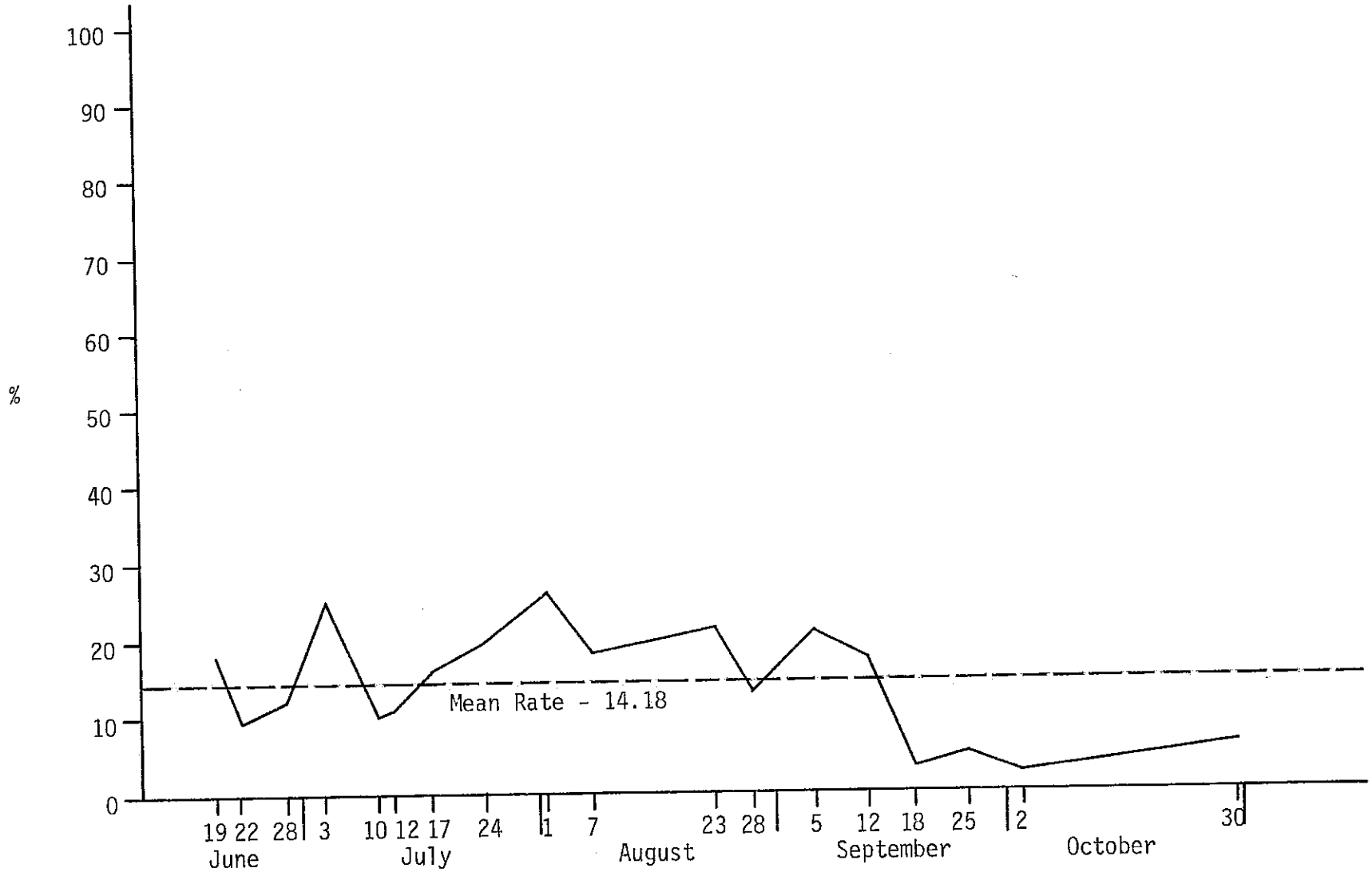


Figure 32. Rate of Infection of Yellow Perch With Triaenophorus Only, Trawls Taken Between Green and Rattlesnake Islands, Western Lake Erie, 1978.



occurs on all figures representing T. nodulosus infections except for the combination of Philometra-Triaenophorus. It may be that the 3 July peak represents an early summer peak in the rate of infection of yellow perch and was correlated with the spring and early summer peak of copepod populations in western Lake Erie. There is a second peak of infection on 5 August and then an irregular decline in the rate to 18 September. The decline from 5 August to 18 September also occurs when T. nodulosus infects yellow perch in combination with the other two parasites. Figure 32 also demonstrates that during October the infection with T. nodulosus alone increases slightly. This probably reflects the increase of YOY class yellow perch which increased in the sample at this time and were still plankton feeders. They probably ingested infected copepod intermediate hosts.

L. The Percentage Distribution of Age Classes (YOY, 1+, 2+, 3+) of Yellow Perch in Samples Trawled During the 1978 Collecting Season, Western Basin of Lake Erie.

Figure 33 presents the percentage of each age class of yellow perch which were present in each trawl sample throughout the 1978 collecting season from the station between Green and Rattlesnake Islands, Western Basin of Lake Erie. Only the YOY, 1+, 2+, and 3+ age classes are represented on the graph. This is 93.6 percent of the yellow perch collected. The 4+, 5+, 6+, and 7+ age classes combined comprised only 6.4 percent of the entire 1978 sample and were considered insignificant for graphic purposes (Figure 1).

YOY yellow perch decrease in the samples during June and the 1+ year class increases proportionally. The new YOY class entered our

samples strongly on 17 July, perhaps having reached a length to be captured by our nets (mesh size). They were present, increasing in mean numbers, throughout the remainder of the collecting season.

The 1+ age class was always the most abundant age class in our samples throughout the entire collecting season. It reached its highest numbers and percentage of sample composition during late June and early July (87 percent). This age class gradually irregularly declined from 10 July through 30 October (46 percent) as the YOY class increased proportionally in our samples.

The 2+ age class was the least prevalent of the age classes represented in Figure 33. This age class did make up a significant part of our samples. It gradually increased proportionally throughout the entire collecting season (10.7 percent on 30 October) as the 1+ age class declined in numbers and percentage.

The 3+ age class comprised 9.34 percent of the sampled yellow perch during the 1978 collecting season. They were present in all samples. The percentages of this age class were low, usually less than 5 percent in June and July, but they increased proportionally to 7 August and remained at a prevalence of more than 10 percent throughout the remainder of the collecting season.

There was a marked lack of older age classes in the yellow perch sampled at this station and those older perch which were examined were highly parasitized (Figure 5). Whether there is a true correlation between parasitism and the death or decline in numbers of older yellow

perch is yet to be determined as other environmental factors need to be assessed. It is suggested that parasitism probably plays some part in the complex of mortality factors affecting these fish.

Summary Job 1-a:

1. The majority of yellow perch examined from the Western Basin of Lake Erie during 1978 were young-of-the-year (13.1 percent) and 1+ age class (63.4 percent).
2. The greatest number and percent of infected yellow perch (any category) are distributed in the 1+ age class. This was true for all three parasites at all times of the collecting season.
3. Our samples of uninfected yellow perch are weak from the 4+ through 7+ age classes. We may not be able to make significant comparisons between uninfected and infected perch in these age classes.
4. The highest rates of infection (percentage) with E. tubifex are in older yellow perch. The rate of infection is lowest in young-of-the-year, increases in the 1+ class and increases further through the 3+ age class, and then remains high in older yellow perch.
5. When P. cylindracea infections are not separated by stage and when they are considered in total and in combinations with E. tubifex and T. nodulosus, the distribution in age classes and the rates of infection have a pattern similar to that demonstrated for E. tubifex. The greatest numbers and percent of infected yellow perch are in the 1+ age class. The highest percents of infection are in the older perch. The rates increase through the 4+ age class and then remain high but irregular.

6. When infections with only P. cylindracea are studied and when infections with adults and encapsulations are separated a different pattern emerges. YOY and 1+ age class perch have the greatest numbers and the highest rates of infection with adult P. cylindracea and older yellow perch harbor the greatest numbers and have the highest rates of infections with encapsulations of spent female worms. Age classes 5+ through 7+ have little or no infection with either stage. This pattern reflects the life cycle of the nematode and the feeding habits of yellow perch.
7. We are fortunate in having a reasonable young-of-the-year class and a strong 1+ age class. We predict that infections will increase in these perch in the Western Basin as they grow older. We will be able to follow these age classes and make year to year comparisons over the next two years.
8. A general pattern for seasonal rates of infections is established for the three parasites studied, whether they occur alone or in different combinations. In general, this pattern was irregular throughout June and July of 1978. The infections increased throughout August and peaked in September, there was usually a slight decline during October.
9. When Triaenophorus nodulosus and Philometra cylindracea were considered alone, each showed an increase during October. This is attributed to the fact each of these parasites were present in YOY class fishes which were still plankton feeders and this age class increased proportionally in our samples during September and October. Each of these parasites utilize copepods as intermediate hosts.

10. Different combinations of the three different parasites follow the general established pattern.

Job 1-b: Description of Pathology of Eustrongylides tubifex in Yellow Perch

Eustrongylides tubifex is usually encountered by fishermen in the body cavity or flesh of yellow perch. This is not a natural situation. While very small specimens, third-stage larvae, are occassionally found free in the coelom most specimens occur in granulomatous, tumor-like, tissue capsules. The nematodes migrate from these capsules only when the body temperature of yellow perch is raised above 17°C. The longer the fish are held at these temperatures or at higher temperatures the farther the larvae migrate from their capsules, often into the body wall. All of our samples were immediately iced as soon as the perch were removed from the trawl nets aboard the boat and held on ice until they were necropsied. The nematodes do not migrate from their capsules under these conditions.

Gross Pathology

The first cause of pathology which should be noted is the migration of third-stage larvae across the wall of the alimentary canal. Larvae first enter the body cavity of yellow perch by migrating from the lumen through the wall of the alimentary canal, usually through the wall of the stomach or the anterior one-fifth of the intestine. The means by which the third-stage penetrate the tissues has not yet been determined, but it is probably by the secretion of cytolysins from the eosophageal glands. While this penetration by the parasite may cause an opening which could be secondarily invaded by bacteria, we could find no serious pathology associated with it.

The smallest E. tubifex larvae in the coelom were found wandering free. They were delicate nematodes 8.9 mm long, whitish to pink in color. Since these larvae had entered the perch in some intermediate host and penetrated the wall of the alimentary canal, we designated them third-stage larvae following the work of Karmanova (1968). The third-stage larvae apparently penetrate tissues of some of the visceral organs and their presence evokes a tissue reaction on the part of the yellow perch host. The larvae coil in a flattened spiral and become encapsulated in the tissues of the organs they have penetrated. The larvae continue to grow and develop within the capsules. The smallest larvae, 9.2-32.0 mm long, were found in small, slightly flattened, thin walled, pink capsules 0.15 to 1.5 cm in diameter. These were all third-stage larvae. Once the larvae reach a length of 31 to 34 mm they become enclosed in a molted cuticle and at this point we have designated them fourth-stage larvae. The fourth-stage larvae reach lengths as long as 93.37 mm. As the larval nematodes continue to grow the wall of the capsule thickens, becomes granular, and darkens in color. These more developed capsules range in diameter from 1.5 to 3.2 cm (averaged 2.1 cm during 1978).

We found encapsulated E. tubifex larvae most prevalent in four tissue cites: (1) in mesenteries; (2) in the liver; (3) in the gonads, usually just under the epithelial lining; and (4) on the body wall. The great majority of capsules (85 percent) were found in the mesenteries. Mesenteric capsules were tumor-like, yellowish-brown in color, and granular in appearance, resembling a granuloma. The capsules in the liver (10 percent) were similar in external appearance to those in the mesenteries. The capsules in the gonads were usually clear and transparent and

as they became larger they became more transparent. These gonadal capsules were rare, about 3.0 percent. The largest capsules, 3 cm in diameter were found on the body wall. These large tumor-like capsules were granular, dark reddish brown in appearance, and pulpy; they crowd into the coelom. There is some evidence that these body wall capsules continue to grow and enlarge. They cause pressure on the viscera and may castrate or even kill infected perch.

Histopathology

Several larger, granulomatous, mesenteric capsules were sectioned during 1978. We found that the outer covering of the capsule wall was composed of fat cells and mesenteric epithelial cells. The middle wall was composed of a mixture of cells: pancreatic cells, liver cells, smooth muscle cells, and connective tissue cells, particularly fibroblasts. The middle wall of the capsule is laced with a network of arterioles, capillaries, and venules. There is a strong blood supply to each capsule. The inner layer of the capsule surrounding the central lumen shows a marked fibrosis and is composed of fibrous connective tissue. The central lumen is filled with lymph which bathes the nematode parasite and there is some evidence of leucocytic infiltration.

The characteristics described here, a capsule composed of different kinds of cells, a strong blood supply, a granular appearance, are all typical of a cancerous tumor, a granuloma. The nematode larvae stimulate the formation of tumorous capsules. Our investigations to this point indicate that the mesenteric tumors become benign once the nematode reaches its full growth within the tumor.

The capsules within the liver have fewer cell types, liver and pancreatic cells. The capsules also have a strong blood supply and there is a thick inner layer of fibrous connective tissue surrounding the lumen with some leucocytic infiltration (Figure 34). These are characteristics of a hepatoma, but if the tumorous capsules break through the surface of the liver, the outer wall also becomes granular and has a yellowish-brown appearance.

The question arises, can yellow perch be reinfected with E. tubifex? Perch with multiple infections of this nematode have both small and large capsules and this indicated that they can be reinfected. When we fed third-stage larvae removed from capsules in one yellow perch by gavauge to a second yellow perch the larvae penetrated through the intestinal wall and became reincapsulated in the second fish.

We have now established that E. tubifex larvae can live for a long time in their capsules, at least as long as a year and a half. Yellow perch held 18 months in captivity, when necropsied, showed a mesenteric capsule containing viable, well-developed E. tubifex larvae (Crites, unpublished Franz Theodore Stone Laboratory Research Project). There was usually only one nematode per capsule but there were occassionally two. This may be the result of the merger of two closely adjacent capsules during their development.

The results of this years study of both the gross and histopathology caused by E. tubifex larvae have demonstrated that they are a serious threat to the health of yellow perch in the western Lake Erie. Not only are the yellow perch invaded by large parasites which migrate through their tissues and develop and survive at their expense; but these parasites evoke the formation of cancerous tissues in the development of

Figure 34

Capsule in Liver.

tumor-like granulomatous capsules surrounding the nematodes. The granulomatous capsules are also formed and maintained at an energy expense to the tissues and organs of the yellow perch.

Stereoscan Microscopy of Eustrongylides tubifex Larvae

The larvae of Eustrongylides tubifex have never been formally or properly described in a scientific publication. As a part of this project we proposed to describe the third and fourth-stage larvae so that they may be distinguished from other species which may occur in other fishes in other geographic locations. Parasitologists have, for some time, taxonomically weighted the number, arrangement, and types of sensory papillae when considering the taxonomy of a group. Before writing a formal description of E. tubifex larvae we wanted to study their sensory papillae in some detail. We did this during 1978.

We have studied the cephalic, lateral, and caudal papillae of the third and fourth-stage larvae of E. tubifex using both ordinary light and stereoelectron scanning microscopy. All of the larvae nematodes studied were removed from mesenteric capsules of yellow perch collected between Green and Rattlesnake Islands in the Western Basin of Lake Erie.

All E. tubifex larvae have 12 cephalic papillae arranged in two circles of six each, two lateral, and four submedian (Figures 35, 39, and 40). Papillae of the inner circle are always smaller than those of the outer circle. There are four small lateral papillae, arranged in an arc, between the papillae of the inner and outer circles and a single, small ventral papillae outside the external circle. In all larvae examined, a single row of lateral papillae extend from the median members of the outer

Figure 35

En Face View, of the 3rd Stage Larva of E. Tubifex

circle to the posterior end on both sides (Figure 38). These papillae form a double row of crescent shape over the outer surface of the bursa in males (Figure 37). All papillae are surrounded by a ring form depression in the cuticle of the nematodes (Figures 34, 36, and 37). In the third-stage larvae the cephalic papillae of the inner circle have a circular ring-like base and a cone-shaped, almost spine-like, central projection (Figure 36). In the fourth-stage larvae, a papilliform central core raises from the basal ring and the cone-like spine extends from its apex (Figures 39 and 40). Papillae of the outer circle in the third-stage larvae protrude very slightly above the surface of the cuticle, there is no cone or spine (Figures 35 and 37). In the fourth-stage larvae papillae of the outer circle have a definite elevated outer band, a mound-shaped core with a crenulated surface which extends upward from the basal band. Amphids are associated with the external, lateral papillae (Figures 39 and 40).

During the next year we will prepare a more formal description of the third and fourth-stage larvae based on their other features and measurements.

Job 1-c: Development of Management Strategies Which Would Optimize the Yellow Perch Fisheries in Lake Erie.

Discussions with Ohio Division of Wildlife personnel and commercial fishermen indicated that 56 percent of the perch harvested from Ohio waters in 1978 were collected by sport fishermen. Gill nets accounted for 91 percent of the perch collected by commercial fishermen indicating that the fish were collected from the Central Basin, while a large number of those collected by sport fishermen were collected in the Western Basin.

Figure 36

Spine-like Papilla of the Inner Circle,
3rd Stage Larva

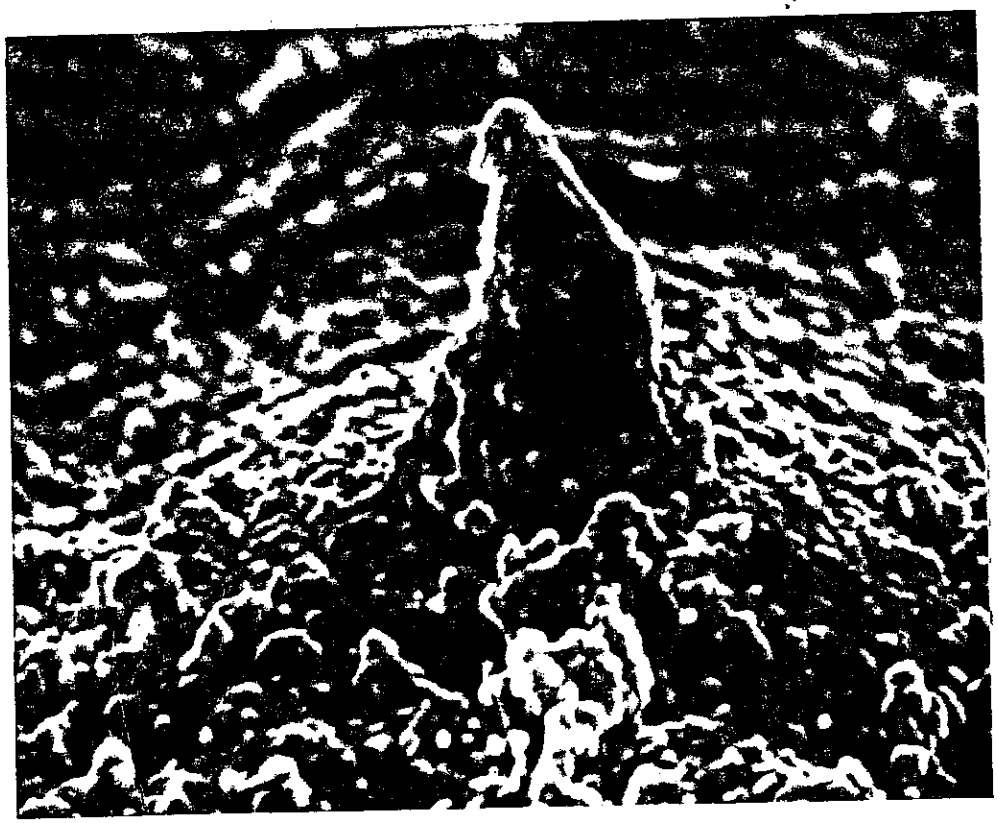


Figure 37

Papilla of the Outer Circle, 3rd Stage Larva.

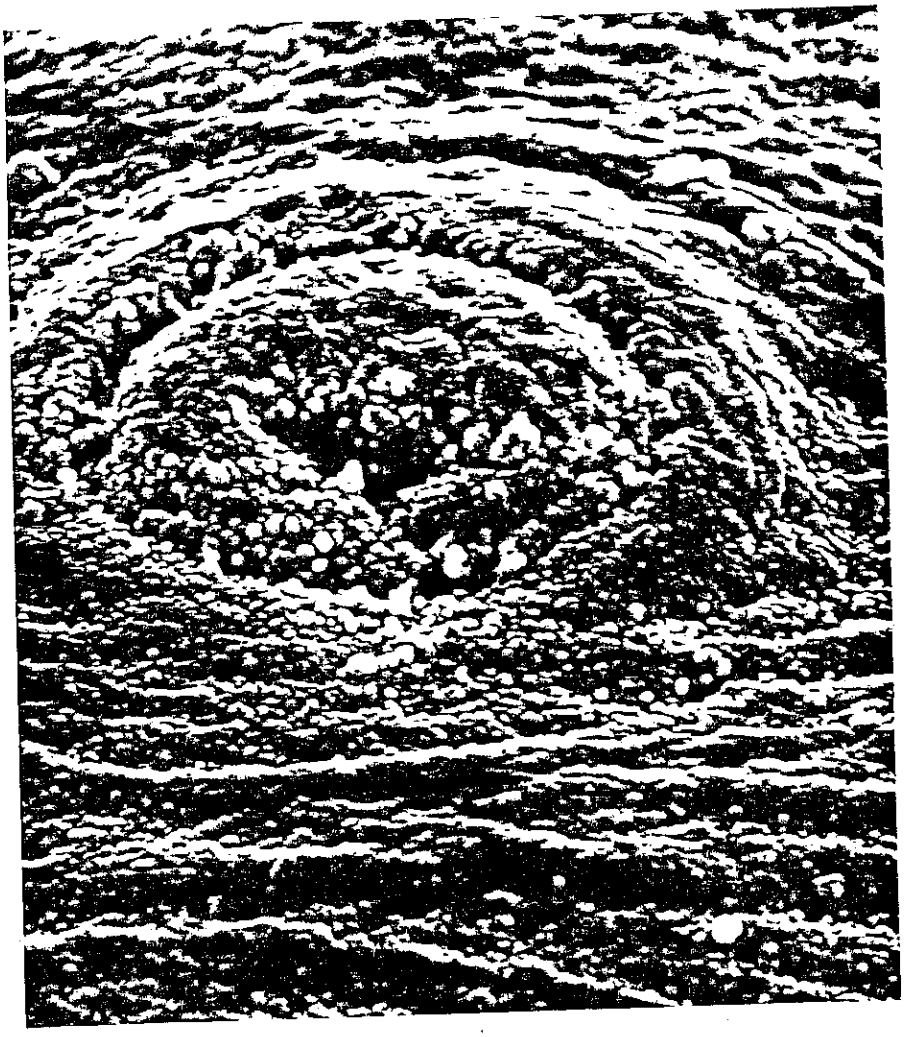


Figure 38

Lateral Papillae of the 3rd Stage Larva.

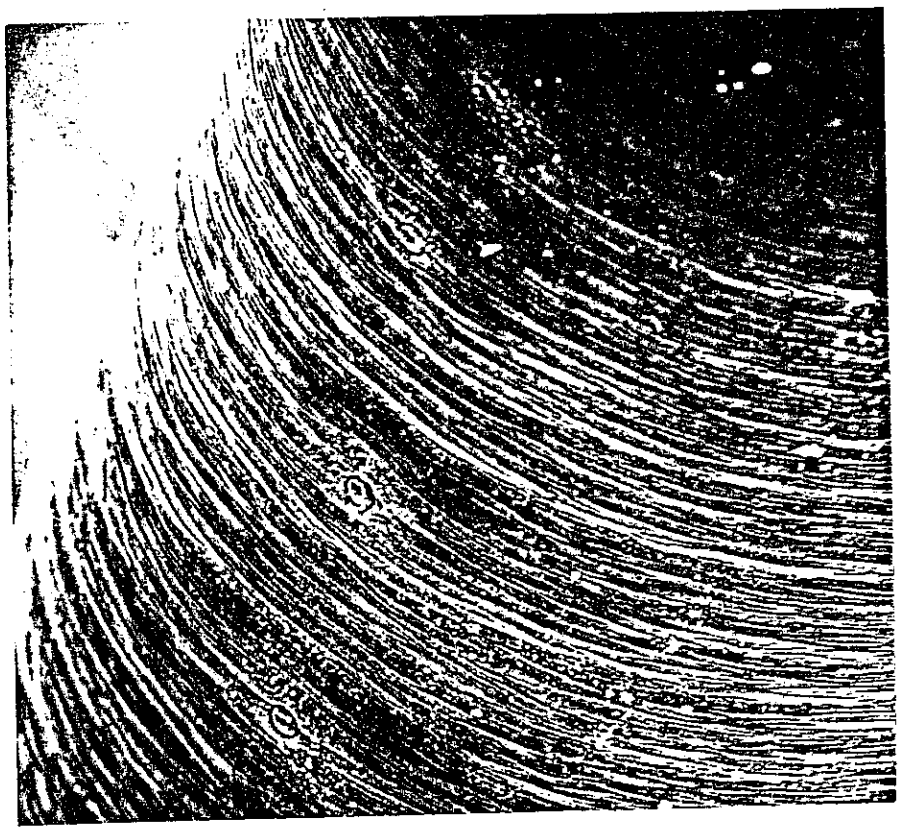


Figure 39

En Face View of the 4th Stage Larva.

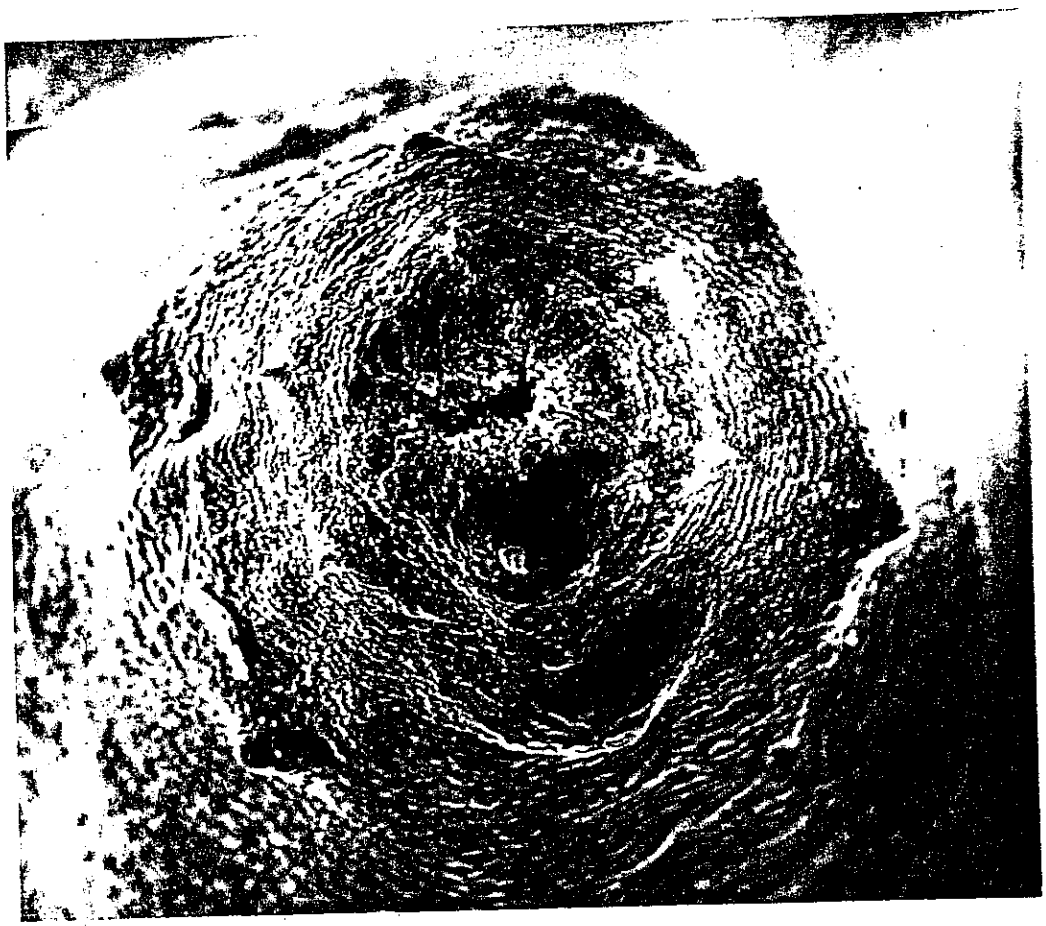


Figure 40

Lateral View of the Anterior End of
the 4th Stage Larva.

The observed infection gradient from west (highest) to east (lowest) would indicate that the commercial fishery is operating in an optimal environment and harvesting fish with low infection rates. It was also learned that the perch harvest is greatest during the spring and fall. Large harvests during the spring are preferable to large harvests during the fall since it appears that the infection rate increases during the fall. In summary, "preliminary results" indicate that the optimal time and location of harvest to reduce the likelihood of infection with Eustrongylides tubifex is during the spring or early part of the year and as far eastward as possible.

The Division is currently conducting a project to further assess perch populations and determine if the populations of the Western and Central Basins are two distinct populations. This information is imparative if we are to perform evaluations of the effect of shifting the location of the fishing pressure.

In the course of our discussions with commercial fishermen and the Ohio Division of Wildlife fish managers, many management-related questions were asked. The seven most commonly asked questions with our answers follow. It should be noted that the answers to these questions provide the foundation upon which management recommendations must be based.

Question one. At what age do yellow perch become infected with Eustrongylides tubifex larvae? They become infected as young-of-the-year perch. Figures 4, 5, 6, and 7 of this report give the percentages of

sampled yellow perch in western Lake Erie which became infected as young-of-the-year. The YOY class yellow perch did not enter our trawl samples between Green and Rattlesnake Islands in the Western Basin until Julian date 198, 17 July, as shown in Figure 41, a scatter-diagram of all yellow perch collected during 1978. Young-of-the-year perch were continuously infected with E. tubifex larvae from Julian day 240 on through the remainder of the 1978 season as shown in scatter-diagram, Figure 42. As we shall demonstrate later, prevalence is not just a matter of percentage of infected perch, "worm burden" or "parasite load" is also important. The mean number of E. tubifex larvae in infected YOY yellow perch increased from 1 on 1 August to 1.5 by 30 October. All larvae removed from YOY perch were third-stage larvae. This does not mean that older perch do not become infected or that perch can not become reinfected. Our data quite clearly shows that yellow perch become infected at any age. We have taken third-stage E. tubifex larvae from small thin capsules and fourth-stage larvae in large granulomatous capsules from the same fish in age classes 1+ through 5+. These fish would have to have been reinfected. Our results for 1978 indicate that most yellow perch examined were first infected at 1+ or YOY class.

Question two. Were some age classes of yellow perch more infected than others? This question was answered in the Findings and Analysis section of this report in Job 1-a and in the previous question. In short, the 1+ age class was the strongest age class in the sample population(s) during 1978 and it had the greatest number of infected yellow perch. The highest rates of infection with E. tubifex larvae and P. cylindracea occurred in older perch. The highest rates of infection with T. nodulosus

Figure 41

Plot of Total Length of Yellow Perch by Sample Date 1978.

Legend: A = 1 fish, B = 2 fish, etc.

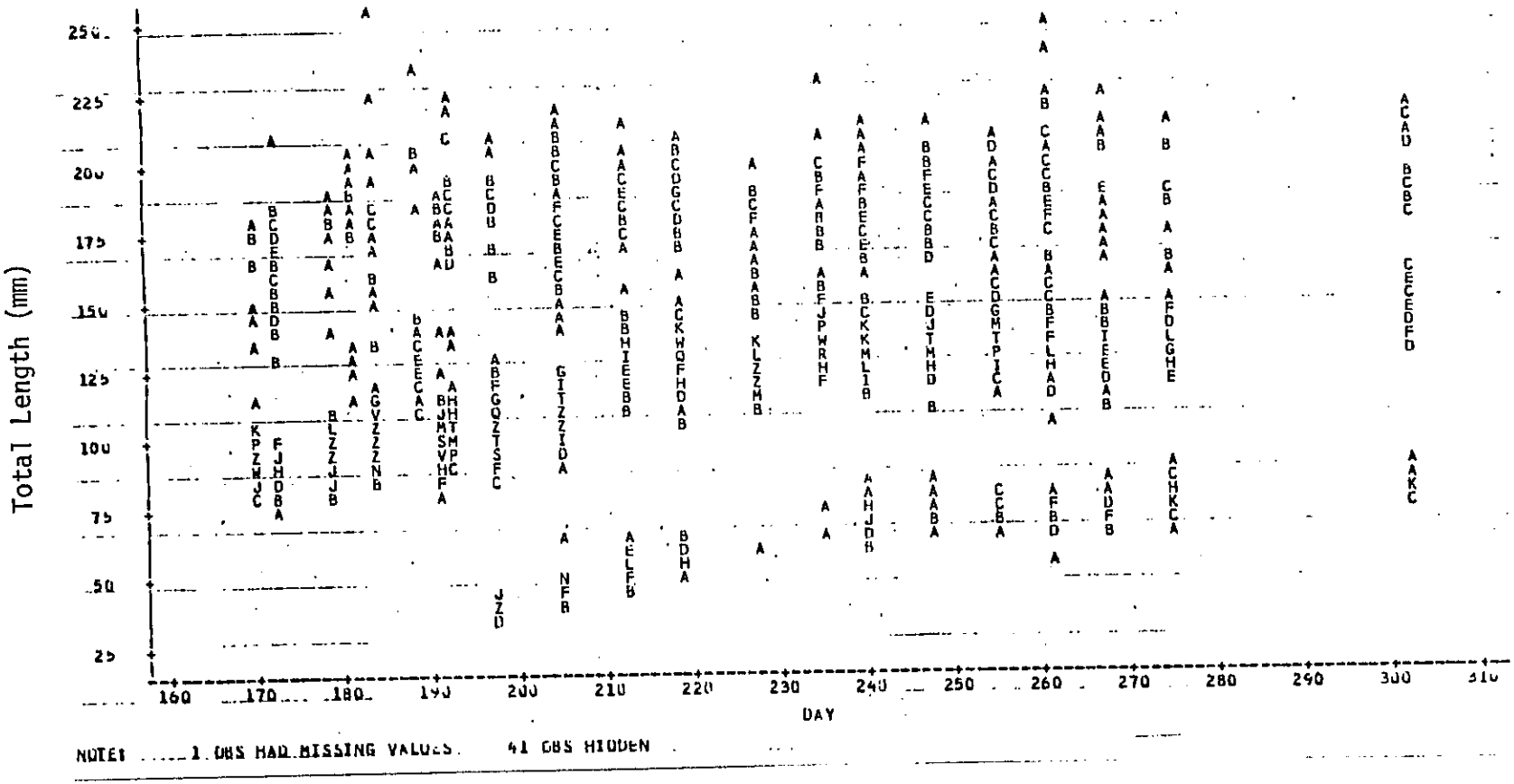
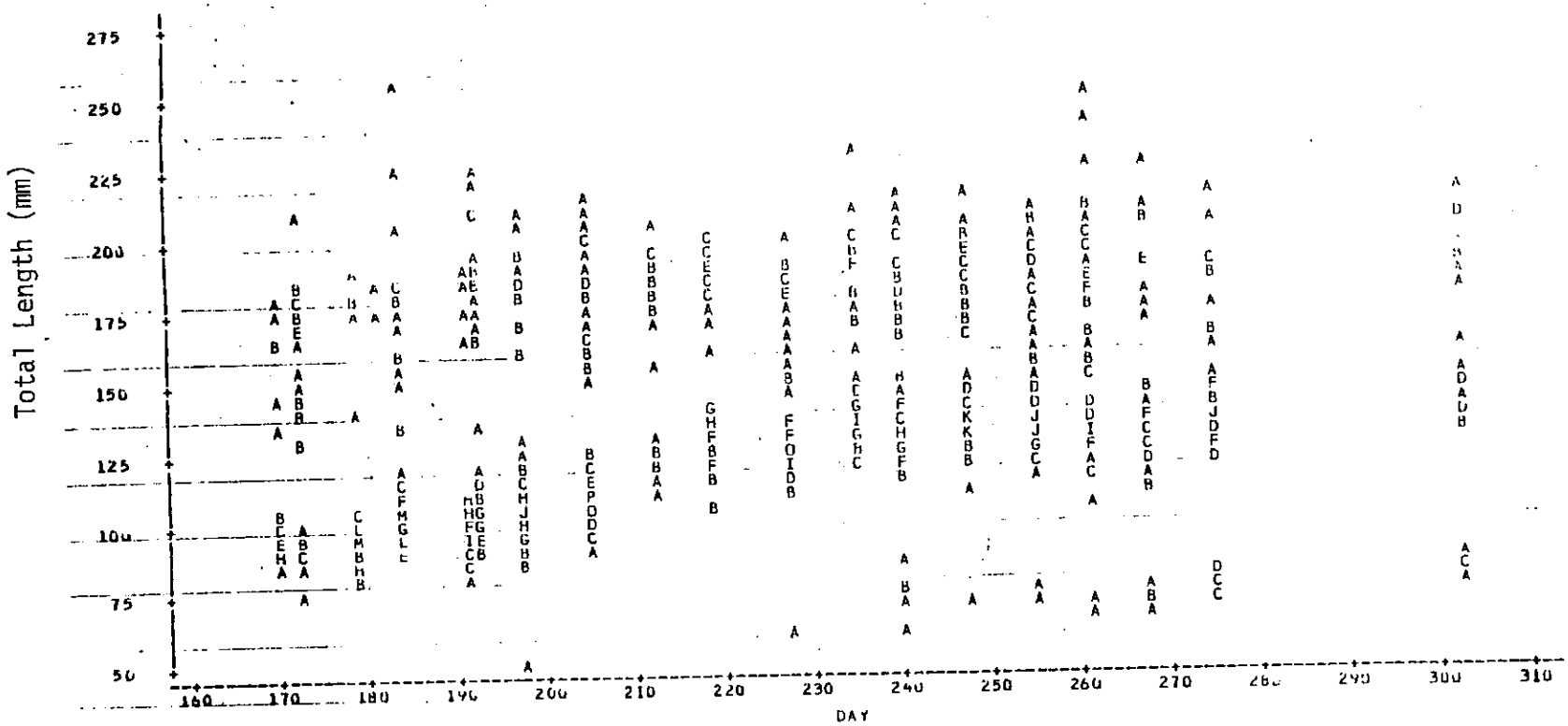


Figure 42

Plot of Total Length of Yellow Perch Infected With Eustrongylides tubifex by Sample Date.

Legend: A = 1 fish, B = 2 fish, etc.



occurred in YOY and 1+ class yellow perch. E. tubifex larvae attained their highest mean worm burdens in perch 2+ or older (Figures 1 through 16).

Question three. Were there seasonal variations in the occurrence of the parasites? The seasonal variation in the rate of infection for each parasite alone or in combination with one or both of the other parasites is graphed and discussed in the section on Job 1-a (Figures 22 through 33). The discussion in that section does not cover mean worm burden. Worm burdens with P. cylindracea are greater from 1 September through October when a new generation of larvae enter the young perch which feed on copepods. The mean worm burdens with T. nodulosus were also higher in September and October. The prime target parasite of this study was E. tubifex and it occurred in most significant numbers in the 1+ age class perch which will be used as an example. Our samples in western Lake Erie during 1978 yielded 1303 1+ age class yellow perch of which 560 were infected with E. tubifex. The data presented here are also reflective of the age classes YOY through 3+. Table 22 gives the data of the 1+ age class arranged by Julian dates for 1978. There was some variation in mean worm burden of E. tubifex from day 170 through day 219. There is an increase in the worm burden of infected 1+ age class perch beginning on day 227 and continuing through the sampling season to 30 October. The highest mean numbers E. tubifex larvae were in late September and in October. There appears to be a gradual accumulation of E. tubifex throughout the spring and summer months and the highest numbers of this parasite occur in the autumn before the fish enter the winter season.

Table 22. Mean Worm Burden of Eustrongylides tubifex from Samples Between Green and Rattlesnake Islands, Western Basin, Lake Erie, 1978.

Day	Mean Worm Burden (Eustrongylides)
170	1.200
172	1.125
179	1.4782
184	1.4
191	1.2777
193	1.6363
198	1.1000
205	1.5625
213	1.2000
219	1.2857
227	1.4375
235	1.5625
240	1.4545
248	1.5000
255	1.8333
261	1.8666
268	3.6666
275	2.0000
303	2.0000

Question four. Did some infected yellow perch fail to gain weight? The answer to this question is that infected fish usually weigh less and the higher the mean worm burden with E. tubifex the greater the loss of weight. The assessment of weight loss is complicated by several factors when working with only one years data. Yellow perch could only be compared reasonably for weight loss when they were collected in the same sample and when they were of the same age class and even then there is great variability when working with yellow perch from the Western Basin. Perch from different sampling sites have different weights and lengths. Another problem is that the percentage of infection in some age classes is so high that it is difficult to find a significant number of uninfected yellow perch for comparison. We have again chosen to use our samples of 1+ class perch because there were more numbers of both uninfected and infected fish and the examples used are specific sample dates. The examples used here would be fairly representative of most age classes in most trawl dates. We have in our files mean weight versus age class of yellow perch for each type of parasite on each collection date. Figure 43 is a computer plot of 1+ age perch on day 198 from the Western Basin, and Figure 44 is a similar plot for day 205 from the Western Basin. Figure 45 is a similar plot taken on day 285 in the Central Basin, the fish in this plot are larger, but results of infection with E. tubifex larvae are the same. These plots are not our most clear-cut, but they are typical. These figures indicate that the higher the number of E. tubifex present within an age class the less the fish weigh. The infected fish either do not gain weight or they lose weight. Table 23 contains correlation coefficients of weight versus worm burden (number of worms) for each

Figure 43

Plot of Whole Weight Versus Number of Eustrongylides tubifex Nematodes per Fish for Age Class 1 Fish on 1 July from the Western Basin.

Legend: A = 1 fish, B = 2 fish, etc.

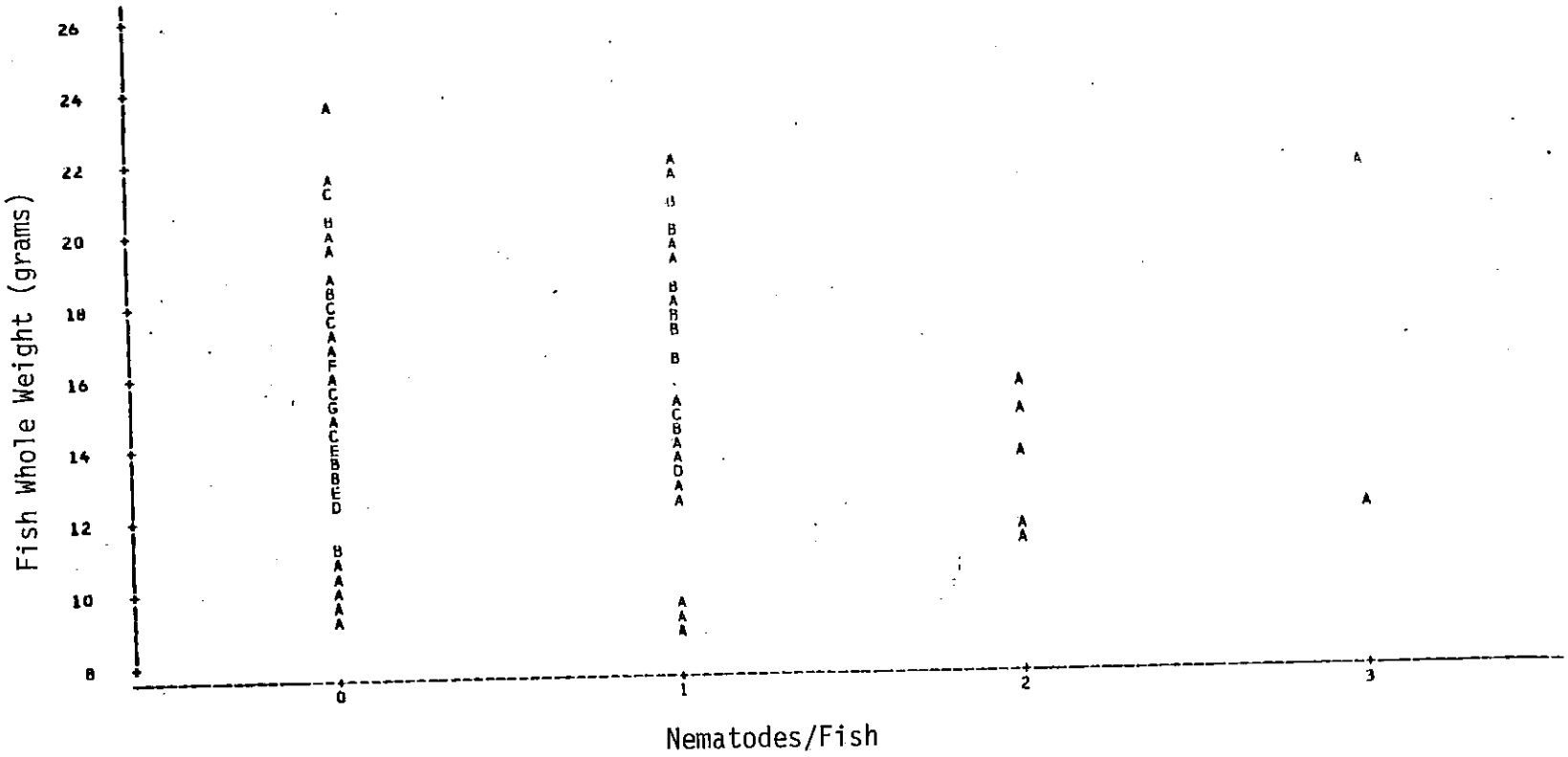


Figure 44

Plot of Whole Weight Versus Number of Eustrongylides tubifex Nematodes per Fish for Age Class 1 Fish on 24 July from the Western Basin.

Legend: A = 1 fish, B = 2 fish, etc.

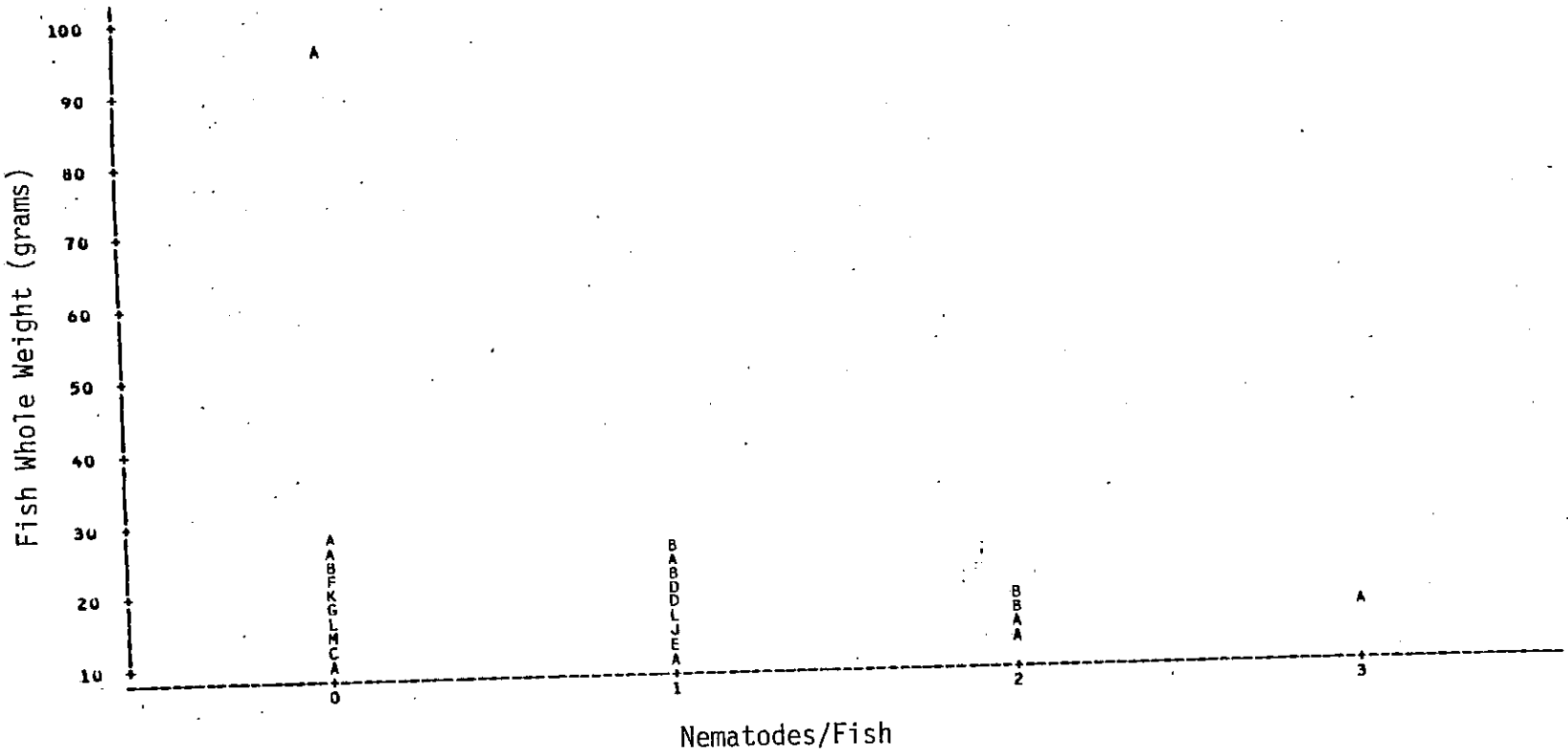


Figure 45

Plot of Whole Weight Versus Number of Eustrongylides tubifex Nematodes per Fish for Age Class 1 Fish on 12 October from the Central Basin.

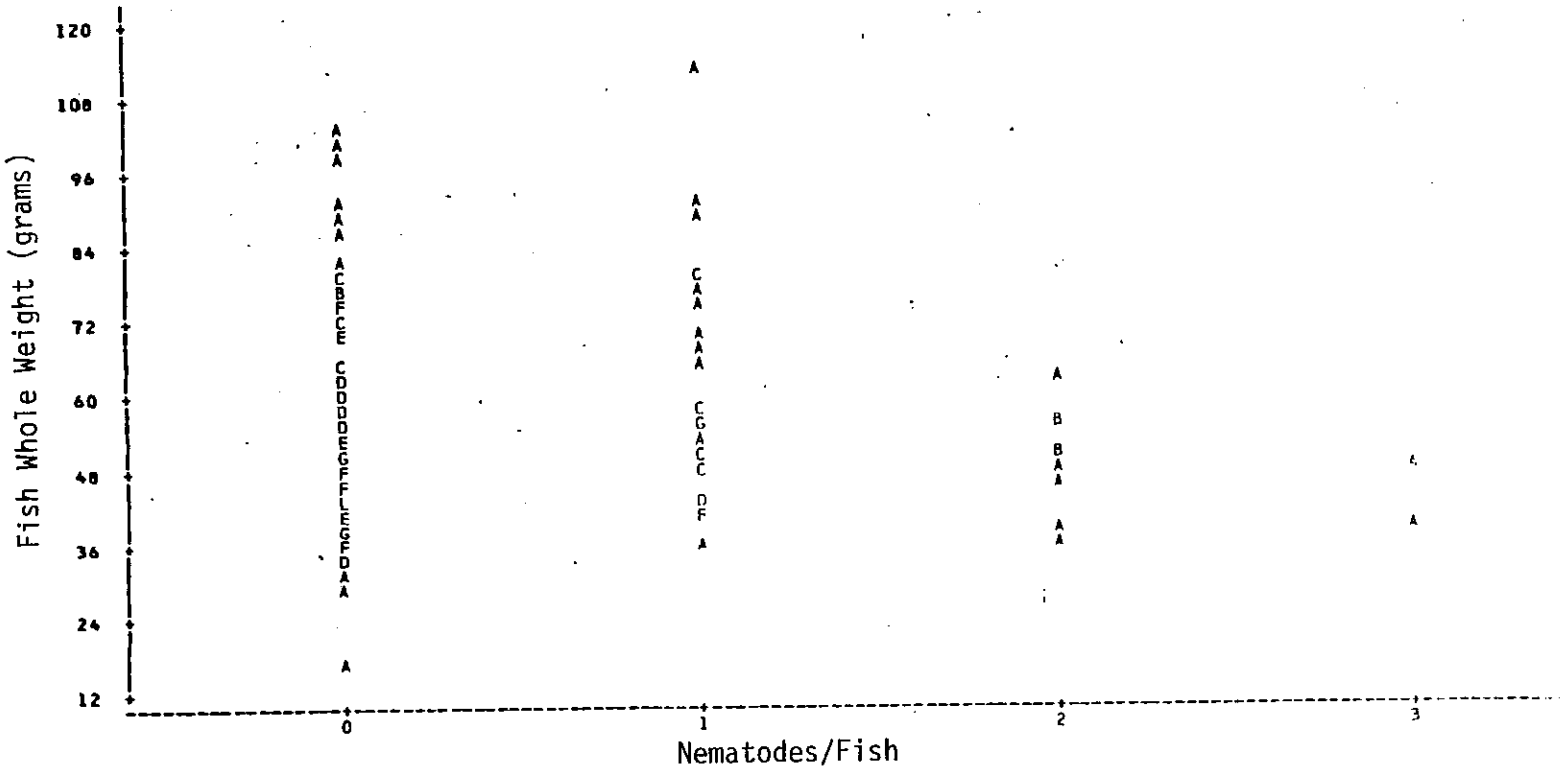


Table 23. Correlation Coefficients for Weight Versus Worm Burden with *Eustrongylides tubifex* for Age Class 1 Perch on Each Date[a]

	WESTERN BASIN	
Day	Weight 1 [b]	Weight 2 [c]
170	0.08673 0.5289	0.04847 0.7253
173	0.40788 0.0122	0.39865 0.0145
179	-0.08900 0.4123	-0.09515 0.3807
184	-0.00716 0.9341	-0.05051 0.5607
189	0.00000 1.0000	0.00000 1.0000
191	-0.03240 0.7768	-0.04218 0.7120
193	-0.15579 0.2081	-0.17490 0.1569
198	-0.00467 0.9619	-0.02016 0.8367
205	-0.15269 0.1181	-0.18765 0.0541
213	-0.40351 0.0180	-0.39517 0.0252
219	-0.26147 0.0225	-0.16800 0.1469
227	-0.07667 0.4676	-0.11192 0.2882
235	-0.08543 0.4341	-0.07962 0.4662
240	-0.17280 0.1867	-0.19663 0.1321

Table 23. (Continued)

Day	Weight 1 [b]	Weight 2 [c]
	WESTERN BASIN	
248	-0.22072 0.0821	-0.23049 0.0692
255	-0.41281 0.0004	-0.42118 0.0003
261	-0.40939 0.0087	-0.43530 0.0050
268	-0.09446 0.6534	-0.08762 0.6770
275	-0.03748 0.8232	-0.05536 0.7413
303	-0.23780 0.2323	-0.26762 0.1772
	CENTRAL BASIN	
285	-0.03796 0.6380	-0.02447 0.7617

[a] Date presented as the correlation coefficient over the probability of obtaining a larger coefficient by chance alone. Probabilities of 0.05 or less are generally considered significant. A negative correlation indicates that the greater the worm burden, the less the fish weighed.

[b] Weight of whole fish.

[c] Weight of fish after being gutted.

sample of 1+ class perch infected with from zero to six E. tubifex by Julian date. A negative (-) coefficient indicates that infected yellow perch weighed less than uninfected yellow perch. Note that from day 191 on throughout the remainder of the season that all coefficients were negative. These correlations are not always highly statistically significant, but any percent of weight loss in a population(s) of yellow perch in Lake Erie is important.

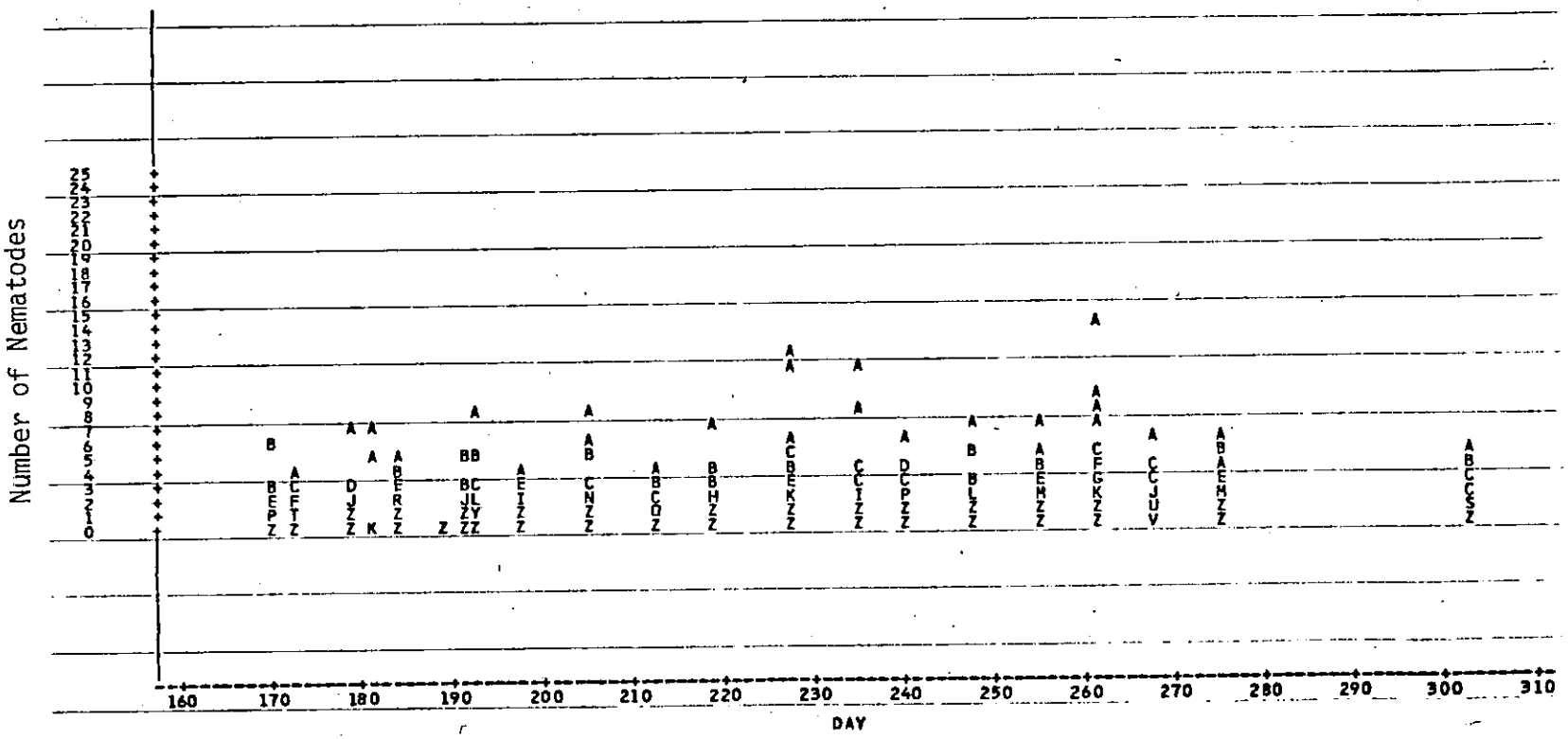
Question five. Do Eustrongylides tubifex sometimes kill yellow perch? From the viewpoint of pathology there is no doubt that these parasites are harmful, particularly E. tubifex. E. tubifex larvae are not only harmful in their on right, but they cause the formation of cancerous tumors in the form of capsules surrounding the nematodes. As we pointed out earlier (see Job 1-b) a capsule formed in the body wall does not become benign, it continues to grow and eventually kills the yellow perch host. These are rare, but they do occur. What are the effects of the encapsulated larvae in other tissue sites? Figure 46 presents the number of perch containing a given number of nematodes on each sampling date. The data plotted in this figure indicate that few perch are encountered with over six to eight worms (E. tubifex). This appears to indicate that greater infections are lethal. These results should be considered with caution at the present time, our work over the next two years will give us more data to study this effect.

Question six. Were there synergistic effects when E. tubifex larvae are present with one or both of the other two parasites, T. nodulosus or P. cylindracea? We really do not have a satisfactory answer to this question at this time. We have graphed the weights of yellow perch which

Figure 46

Plot of Number of Eustrongylides tubifex per Fish on Each Sampling Date (all age classes combined).

Legend: A = 1 fish, B = 2 fish, etc.



have E. tubifex infections alone versus those which have triple infections and those with triple infections weigh slightly less, but the number of perch involved was so small that results are not significant.

Question seven. Were yellow perch in some areas of Lake Erie more infected than those in other areas? Was it possible to establish an index station in the Western Basin of Lake Erie where a data base could be built based on a sampled natural population(s), a data base to which data from sample populations could be compared? We believe that we have now built a solid data base from a sampling station between Green and Rattlesnake Islands in the Western Basin of Lake Erie. We sampled more than two thousand yellow perch from that station during 1978. The samples were all taken from the same boat, with the same trawling equipment and the perch were all weighed, measured, and examined by the same investigators. We have samples for each week of each month for the 1978 collecting season with the exception of October when weather permitted our taking only two samples. No other known investigation has ever examined as many fish for any parasite from one station. Comparisons of different samples from different stations are best made on a closest date basis and on an age class basis. We now have weight, length, age, condition factor, and correlative parasite data for this index station. An example of the utility of this index data follows. A sample was collected by otter-trawl for our examination by the staff of the ODNR Sandusky Fisheres Research Laboratory from the motor vessel, Explorer, on 12 October 1978 off Cleveland Harbor in the Central Basin. This sample was compared with the closest dated sample from our index station taken on 2 October 1978. Table 24 presents the comparative data for rates of infection of yellow

TABLE 24

Comparison of Rates of Infection of Each Age Class of Yellow Perch, Infected with Any of the Three Parasites, from the Western and Central Basins of Lake Erie.

Year Class	Western Basin [1]		Central Basin [2]	
	N	% Infected	N	% Infected
0	27	66.7	1	100.0
1	38	94.7	156	62.2
2	10	90.0	50	56.0
3	5	100.0	10	12.0
4	2	100.0	1	100.0
	82		218	
	85.4% of Total Yellow Perch Infected		61% of Total Yellow Perch Infected	

1 Sample collected on 2 October 1978 from Green and Rattlesnake Island station.

2 Sample collected on 12 October 1978 off Cleveland Harbor.

perch by age class with all of the parasites involved in this study. Table 25 presents similar comparative data for perch infected with E. tubifex. Tables 26 and 27 give the lengths, weights and condition factors for age classes YOY through 4+ perch examined from these two sites. The yellow perch from the Central Basin site were less parasitized and definitely had fewer E. tubifex infections. The Central Basin perch were longer, weighed more, and had better condition factors in each age class.

We believe that during this first year of investigations we have made progress toward answering questions basic to the development of management strategies which will lead to a more efficient utilization of the yellow perch fishery in Lake Erie.

TABLE 25

Comparison of Rates of Infection of Each Age Class of Yellow Perch Infected with *Eustrongylides tubifex* from the Western and Central Basins of Lake Erie.

Year Class	Western Basin [1]		Central Basin [2]	
	N	% Infection	N	% Infection
0	27	37.0	1	0
1	38	76.3	156	32.0
2	10	90.0	50	38.0
3	5	100.0	10	40.0
4	2	50.0	1	100.0
	82		218	
	65.8% of Total Yellow Perch Infected with *E. tubifex*		33.9% of the Total Yellow Perch Infected with *E. tubifex*	

[1] Sample collected on 2 October 1978 from Green and Rattlesnake Island station.

[2] Sample collected on 12 October 1978 off Cleveland Harbor.

TABLE 26

SUMMARY STATISTICS FOR YELLOW PERCH FROM WESTERN BASIN - GREEN AND RATTLESNAKE ISLANDS - Bio-Lab - 2 OCTOBER 1978.

VARIABLE	N	MEAN	STANDARD DEVIATION	STD ERROR OF MEAN	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
				DAY=275 SCALE=0			
TOTLEN	27	77.37037037	5.47826579	1.05429274	30.01139601	67.00000000	92.0000000
WGHT1	27	5.42222222	1.08533346	0.20887252	1.17794872	3.60000000	8.7000000
WGHT2	27	4.78148148	1.06121738	0.20423138	1.12618234	3.10000000	8.1000000
KFACT1	27	1.16061922	0.08434732	0.01623265	0.00711447	1.03515625	1.3274074
KFACT2	27	1.02024047	0.08053806	0.01549956	0.00648638	0.89807309	1.1455361
				DAY=275 SCALE=1			
TOTLEN	38	132.00000000	9.25903503	1.50201382	85.72972973	118.00000000	165.0000000
WGHT1	38	26.25526316	6.74864140	1.09477420	45.54416074	17.40000000	56.3000000
WGHT2	38	23.83947368	5.99335395	0.97225040	35.92029161	15.30000000	48.7000000
KFACT1	38	1.12162123	0.05787422	0.00938844	0.00334942	1.03148577	1.3128080
KFACT2	38	1.01861352	0.05799823	0.00940856	0.00336379	0.92967418	1.2193263
				DAY=275 SCALE=2			
TOTLEN	10	155.90000000	23.50626394	7.43333333	552.54444444	136.00000000	213.0000000
WGHT1	10	45.45000000	24.08873642	7.61752730	580.26722222	26.60000000	105.4000000
WGHT2	10	41.37000000	22.14151706	7.00176248	490.24677778	24.40000000	97.6000000
KFACT1	10	1.12146476	0.06558946	0.02074121	0.00430198	1.02769604	1.2128897
KFACT2	10	1.02081222	0.05175595	0.01636667	0.00267868	0.93833116	1.0977335
				DAY=275 SCALE=3			
TOTLEN	5	191.80000000	8.04363102	3.59722115	64.70000000	187.00000000	206.0000000
WGHT1	5	86.06000000	12.31332611	5.50668684	151.61800000	73.40000000	106.6000000
WGHT2	5	76.36000000	8.86639724	3.96517339	78.61300000	67.80000000	91.4000000
KFACT1	5	1.21482715	0.07555231	0.03378802	0.00570815	1.08720301	1.2845602
KFACT2	5	1.08012571	0.05550626	0.02482315	0.00308094	1.00425564	1.1392825
				DAY=275 SCALE=4			
TOTLEN	2	197.50000000	13.43502884	9.50000000	180.50000000	188.00000000	207.0000000
WGHT1	2	100.90000000	27.01147904	19.10000000	729.62000000	81.80000000	120.0000000
WGHT2	2	87.45000000	30.75914498	21.75000000	946.12500000	65.70000000	109.2000000
KFACT1	2	1.29198779	0.08616276	0.06092627	0.00742402	1.23106152	1.3529140
KFACT2	2	1.10995696	0.17139538	0.12119483	0.02937638	0.98876212	1.2311517

TABLE 27

SUMMARY STATISTICS FOR YELLOW PERCH FROM CENTRAL BASIN - OFF CLEVELAND HARBOR - EXPLORER - 12 OCTOBER 1978.

VARIABLE	N	MEAN	STANDARD DEVIATION	STD ERROR OF MEAN	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
				DAY=285 SCALE=0			
TOTLEN	1	110.00000000	.	.	.	110.00000000	110.000000
WGHT1	1	15.30000000	.	.	.	15.30000000	15.300000
WGHT2	1	14.10000000	.	.	.	14.10000000	14.100000
KFACT1	1	1.14951165	.	.	.	1.14951165	1.14951
KFACT2	1	1.05935387	.	.	.	1.05935387	1.059353
				DAY=285 SCALE=1			
TOTLEN	156	160.96153846	15.24800764	1.22081766	232.50173697	110.00000000	207.000000
WGHT1	156	54.88525641	16.64792849	1.33290103	277.15352316	15.80000000	113.700000
WGHT2	156	48.97243590	15.40013227	1.23299737	237.16407403	13.30000000	104.400000
KFACT1	156	1.27984387	0.08420563	0.00674185	0.00709059	1.08573537	1.574048
KFACT2	156	1.13832739	0.07449627	0.00596447	0.00554969	0.97722316	1.366273
				DAY=285 SCALE=2			
TOTLEN	50	163.06000000	18.00953262	2.54693253	324.34326531	136.00000000	225.000000
WGHT1	50	58.62400000	23.62137185	3.34056644	557.96920816	30.60000000	146.200000
WGHT2	50	52.46200000	21.09128740	2.98275847	444.84240408	27.90000000	131.600000
KFACT1	50	1.29145516	0.09099924	0.01286924	0.00828086	1.07619555	1.533103
KFACT2	50	1.15624307	0.08455764	0.01195826	0.00714999	0.98550492	1.392224
				DAY=285 SCALE=3			
TOTLEN	10	185.70000000	23.87025113	7.54843619	569.78888889	148.00000000	212.000000
WGHT1	10	87.19000000	29.98293774	9.48143742	898.97655556	43.40000000	139.000000
WGHT2	10	77.08000000	27.34165727	8.64619120	747.56622222	37.10000000	124.300000
KFACT1	10	1.31945921	0.12486178	0.03948476	0.01559046	1.16801580	1.567125
KFACT2	10	1.16162262	0.10972441	0.03469791	0.01203945	1.03948897	1.401393
				DAY=285 SCALE=4			
TOTLEN	1	186.00000000	.	.	.	186.00000000	186.000000
WGHT1	1	77.80000000	.	.	.	77.80000000	77.800000
WGHT2	1	69.30000000	.	.	.	69.30000000	69.300000
KFACT1	1	1.20904026	.	.	.	1.20904026	1.209040
KFACT2	1	1.07694718	.	.	.	1.07694718	1.076947

STUDY RECOMMENDATIONS

The 1+ age class was the strongest and most numerous age class of yellow perch in the Western Basin of Lake Erie during 1978. We have predicted it will be the strongest age class as it grows to its 2+ year in 1979. We should closely observe what happens to this age class in the coming year. It will provide a group of perch in which we can continue to monitor the parameters we have already studied and it will enable us to study other phenomena such as comparative growth and condition factors in uninfected and infected fish.

Factors such as worm burden need more emphasis in our analyses during the coming year. There appears to be a correlation between the numbers of Eustrongylides tubifex and a reduction in rate of weight gain. There also seems to be a correlation between the number of E. tubifex larvae present and the death of yellow perch.

We would suggest the use of a "prevalence index" which would take into account both the percentage of yellow perch infected in a sample, or in a given age class in a sample, and the mean worm burden with a given species of parasite. The P-index is obtained by multiplying the percent of perch in a sample infected with a given species of parasite times the mean worm burden of infected perch in the sample. For example:

$$\left(\begin{matrix}\%\text{ infection} \\ \underline{\text{E. tubifex}}\end{matrix}\right)\left(\begin{matrix}\text{mean worm burden} \\ \underline{\text{E. tubifex}}\end{matrix}\right) = \text{P. index}$$

This index could be used for comparison of samples from the same site in different seasons of the year, and it could be used for comparison of samples from different collecting sites.

We have built a solid data base with our weekly samples from the Green-Rattlesnake Island area of Lake Erie. This weekly sampling should

be continued in 1979, it will provide data which can be used as a basis of comparison of both uninfected and infected yellow perch from year to year and with perch from other collecting sites. We need to examine more samples from other sites in Lake Erie.

We should make more detailed histopathological studies of tumorous capsules formed around E. tubifex larvae from tissue sites other than the mesenteries. We also should make more detailed studies of a series of capsules from small to large size to study their development.

LITERATURE CITED

Ashmead, R. and J.L. Crites. 1975. A description of the male and a redescription of the female of Philometra cylindracea Ward and Magath, 1916 (Nematoda: Philometridae). Proc. Helm. Soc. Wash. 42(2): 143-145

Barr, J., J.H. Goodnight, J.P. Sall, and J.T. Helwig. 1976. A user's guide to SAS 76. SAS Institute, Inc., Raleigh, N.C. 329 pp.

Cooper, C.L., R.R. Ashmead, and J.L. Crites. 1977. Prevalence of certain endoparasitic helminthes of yellow perch from western Lake Erie. Proc. Helm. Soc. of Wash. 44(1): 33-34

Cooper, C.L., J.L. Crites, and J.S. Fastzkie. 1978. Experimental and natural infections of Eustrongylides sp. (Nematoda: Deoctophymatida) in waterfowl and shore birds. Avian Diseases 22(4): 790-792

Fastzkie, J.S. and J.L. Crites. 1977. A redescription of Eustrongylides tubifex (Nitsch, 1819) Jagerskiold, 1909 (Nematoda: Dioctophymatida) from Mallards (Anos platyrhenchos). J. Parasit. 63(4): 707-712

Karmanova, E.M. 1968. (Dioctophymidea of animals and man and their causation of disease. Essentials of Nematology xx). Ed. K. I. Skrijabin. Izclatelstvo Nauk, Moscow. AN SSR. (In Russian.)

Jagerskiold, L.A. 1909. Zur kenntnis der nematoden gattungen Eustrongylides and Hystrichis. Nova Acta Regiae Soc. Sci. Ups. Ser. IV. 2(3): 1-48

APPENDIX

TABLE 1

Age Class Distribution of Yellow Perch Collected in the Western Basin of Lake Erie During 1978

Age Class	N	% Composition
YOY	270	13.1
1+	1303	63.4
2+	158	7.6
3+	192	9.3
4+	85	4.1
5+	33	1.6
6+	13	0.63
7+	1	0.05
	Total = 2055	

TABLE 3

Age Class Distribution of Infected Yellow Perch Collected in the Western Basin of Lake Erie During 1978

Age Class	N	% of the 1577 Infected Yellow Perch	% of the Entire 2055 Yellow Perch Examined
YOY	126	8.0	6.1
1+	1002	63.5	49.8
2+	140	8.9	2.0
3+	183	11.6	8.9
4+	82	5.2	3.9
5+	31	2.0	1.5
6+	12	0.8	0.58
7+	1	0.6	0.05
	N = 1577		

Table 4

The Percentage or Rate of Infection of Each Age Class of Yellow Perch Examined from the Western Basin of Lake Erie, 1978

Age Class	Number of Perch Examined N	Number of Perch Infected N	% of Each Age Class Infected
YOY	270	126	46.7
1+	1303	1002	76.9
2+	158	140	88.6
3+	192	183	95.6
4+	85	82	96.6
5+	33	31	93.9
6+	13	12	92.3
7+	1	1	100.0
	N = 2055	N = 1577	$\bar{x}$ = 86.3
			S.D.= 17.2

TABLE 5

Age Class Distribution of Yellow Perch
Collected from the Western Basin of Lake Erie During 1978,
Infected with *Eustrongylides tubifex*

Age Class	N	% of 942 Yellow Perch Infected with *E. tubifex*	% of the Entire 2055 Yellow Perch Examined
YOY	43	4.5	2.1
1+	560	59.4	27.5
2+	101	10.7	4.9
3+	148	15.7	7.2
4+	56	5.9	2.7
5+	23	2.4	1.1
6+	10	1.06	0.48
7+	1	0.11	0.05
	N = 942		

Table 6

The Percentage or Rate of Infection of Each Age Class of Yellow Perch Infected with E. tubifex Western Basin, Lake Erie, 1978

Age Class	Number of Perch Examined	Number of Perch Infected	% of Each Age Class Infected
YOY	270	43	15.9
1+	1303	560	42.9
2+	158	101	63.9
3+	192	148	77.1
4+	85	56	65.9
5+	33	23	69.7
6+	13	10	76.9
7+	1	1	100.0
——	N = 2055	N = 942	$\bar{x}$ = 64.0 S.D. = 25.1

TABLE 7

Age Class Distribution of Yellow Perch
Collected from the Western Basin of Lake Erie During 1978.
Infected with *Eustrongylides tubifex* Only.

Age Class	N	% of 339 Yellow Perch Infected with *E. tubifex* Only.	% of the Entire 2055 Yellow Perch Examined
YOY	22	6.5	1.07
1+	219	64.6	10.66
2+	32	9.4	1.56
3+	26	7.6	1.27
4+	21	6.1	1.02
5+	15	4.4	0.72
6+	3	0.9	0.14
7+	1	0.3	0.05
	N = 339		

TABLE 8

The Percentage or Rate of Infection of Each Age Class of Yellow Perch Infected with E. tubifex only. Western Basin, Lake Erie, 1978

Age Class	Number of Perch Examined	Number of Perch Infected with E. tubifex only	% of Each Age Class Infected
YOY	270	22	8.1
1+	1303	219	16.8
2+	158	32	20.2
3+	192	26	13.5
4+	85	21	24.7
5+	33	15	45.5
6+	13	3	23.1
7+	1	1	100.0
	N = 2055	N = 339	$\bar{x}$ = 33.7 S.D.= 15.8

Table 9

Age Class Distribution of Yellow Perch
Collected from the Western Basin of Lake Erie During 1978,
Infected with Philometra cylindracea (any stage)

Age Class	N	% of 735 Yellow Perch Infected with P. cylindracea	% of Entire 2055 Yellow Perch Examined
YOY	63	8.5	3.0
1+	403	54.8	19.6
2+	75	10.2	3.6
3+	126	17.1	6.1
4+	47	7.0	2.3
5+	12	1.6	0.6
6+	9	1.2	0.4
7+	0	0.0	0.0
	N=735		

Table 10

The Percentage or Rate of Infection of Each Age Class of Yellow Perch Infected with P. cylindracea (any stage), Western Basin, Lake Erie, 1978

Age Class	Number of Perch Examined	Number of Perch Infected	% of Each Age Class Infected
YOY	270	63	23.3
1+	1303	403	30.9
2+	158	75	47.4
3+	192	126	65.6
4+	85	47	55.2
5+	33	12	36.3
6+	13	9	69.2
7+	1	0	0.0

Table 11

Age Class Distribution of Yellow Perch

Collected from the Western Basin of Lake Erie During 1978,

Infected with *Philometra cylindracea*, (any stage)

Age Class	N	% of 132 Yellow Perch Infected with *P. cylindracea* Only	% of the Entire 2055 Yellow Perch Examined
YOY	29	22.0	1.4
1+	78	59.0	3.8
2+	8	6.0	0.4
3+	7	5.3	0.3
4+	8	6.0	0.4
5+	2	1.5	0.1
6+	0	0.0	0.0
7+	0	0.0	0.0

Table 12

The Percentage or Rate of Infection
of Each Age Class of Yellow Perch
Infected with P. cylindracea only (any stage)
Western Basin, Lake Erie, 1978

Age Class	Number of Perch Examined	Number of Perch Infected	% of Each Age Class Infected
YOY	270	29	10.7
1+	1330	78	6.0
2+	158	8	5.1
3+	192	7	3.6
4+	85	8	9.4
5+	33	2	6.1
6+	13	0	0.0
7+	1	0	0.0
	N=2055	N=132	

Table 13

Age Class Distribution of Yellow Perch
Collected from the Western Basin of Lake Erie During 1978,
Infected with Philometra cylindracea only (Adults)

Age Class	N	% of 68 Yellow Perch Infected with P. cylindracea Adults only	% of Entire 2055 Yellow Perch Examined
YOY	28	41.2	1.4
1+	34	50.0	1.6
2+	4	5.8	0.2
3+	1	1.4	0.05
4+	1	1.4	0.05
5+	0	0.0	0.0
6+	0	0.0	0.0
7+	0	0.0	0.0
	N=68		

Table 14

The Percentage or Rate of Infection
of Each Age Class of Yellow Perch
Infected with P. cylindracea only (Adults)
Western Basin Lake Erie, 1978

Age Class	Number of Perch Examined	Number of Perch Infected	% of Each Age Class Infected
YOY	270	28	10.4
1+	1330	34	2.6
2+	158	4	2.5
3+	192	1	0.5
4+	85	1	1.8
5+	33	0	0.0
6+	13	0	0.0
7+	1	0	0.0
	N=2055	N=68	

Table 15

Age Class Distribution of Yellow Perch
Collected in the Western Basin of Lake Erie During 1978,
Infected with Philometra cylindracea only (encapsulations)

Age Class	N	% of 55 Yellow Perch Infected with P. cylindracea Encaps only	% of Entire 2055 Yellow Perch Examined
YOY	1	1.8	0.05
1+	40	72.7	1.9
2+	3	5.4	0.15
3+	5	9.1	0.24
4+	5	9.1	0.24
5+	1	1.8	0.05
6+	0	0.0	0.0
7+	0	0.0	0.0
	N=55		

Table 16

The Percentage or Rate of Infection
of Each Age Class of Yellow Perch
Infected with P. cylindracea only (Encapsulations)
Western Basin Lake Erie, 1978

Age Class	Number of Perch Examined	Number of Perch Infected	% of Each Age Class Infected
YOY	270	1	0.37
1+	1330	40	3.07
2+	158	3	1.9
3+	192	5	2.6
4+	85	5	5.8
5+	33	1	3.0
6+	13	0	0.0
7+	1	0	0.0
	N=2055	N=55	

Table 17

Age Class Distribution of Yellow Perch
Collected from the Western Basin of Lake Erie During 1978,
Infected with *Triaenophorus nodulosus* alone
or in Combination with *Eustrongylides* and *Philometra*

Age Class	N	% of 959 Yellow Perch Infected with *T. nodulosus*	% of Entire 2055 Yellow Perch Examined
YOY	66	6.9	3.2
1+	633	66.0	30.8
2+	83	8.7	4.0
3+	115	11.7	5.6
4+	44	4.5	2.1
5+	13	1.4	0.6
6+	5	0.5	0.2
7+	0	0.0	0.0
	N=959		

Table 18

The Percentage or Rate of Infection
of Each Age Class of Yellow Perch
Infected with T. nodulosus only or in Combination
with Eustrongylides or Philometra, Western Basin Lake Erie, 1978

Age Class	Number of Perch Examined	Number of Perch Infected	% of Each Age Class Infected
YOY	270	66	24.4
1+	1330	633	47.5
2+	158	83	52.5
3+	192	115	59.9
4+	85	43	50.6
5+	33	13	39.9
6+	13	5	38.4
7+	1	0	0.0
	N=2055	N=959	

Table 19

Age Class Distribution of Yellow Perch
Collected from the Western Basin of Lake Erie During 1978,
Infected with Triaenophorus nodulosus alone

Age Class	N	% of 331 Yellow Perch Infected with T. nodulosus alone	% of Entire 2055 Yellow Perch Examined
YOY	38	11.4	1.9
1+	254	76.4	12.3
2+	18	5.4	0.9
3+	13	3.9	0.6
4+	4	1.2	0.2
5+	4	1.2	0.2
6+	0	0.0	0.0
7+	0	0.0	0.0
	N=331		

Table 20

The Percentage or Rate of Infection of Each Age Class of Yellow Perch Infected with T. nodulosus alone, Western Basin Lake Erie, 1978

Age Class	Number of Perch Examined	Number of Perch Infected	% of Each Age Class Infected
YOY	270	38	14.1
1+	1303	254	19.5
2+	158	18	11.4
3+	192	13	6.8
4+	85	4	4.7
5+	33	4	12.1
6+	13	0	0.0
7+	0	0	0.0
	N=2055	N=331	

TABLE 21

Rate of Infection of Yellow Perch.
Trawls Taken Between Green and Rattlesnake Islands,
Western Basin, Lake Erie, 1978

Date	1 % of Infection Any Parasite Alone and/or Any Combination	2 % of Infection, Triple Infections Only
June 19	53.33	2.86
June 22	68.25	7.94
June 28	69.70	9.09
July 3	76.77	5.81
July 10	65.56	3.33
July 12	76.09	4.35
July 17	62.21	9.88
July 24	72.41	4.02
Aug. 1	73.17	3.66
Aug. 7	74.17	12.50
Aug. 23	82.93	8.93
Aug. 28	86.29	18.55
Sept. 5	91.18	30.39
Sept. 12	91.74	42.20
Sept. 18	94.68	36.17
Sept. 25	85.00	36.67
Oct. 2	85.36	24.39
Oct. 30	76.92	9.23
	$\bar{x}$ = 77.04	$\bar{x}$ = 15.00

TABLE 21(Con't.)

Rate of Infection of Yellow Perch.

Trawls Taken Between Green and Rattlesnake Islands,

Western Basin, Lake Erie, 1978

	3	4
Date	% of Infection with Eustrongylides, and/or Triaenophorus and/or Philometra (any stage)	% of Infection with Eustrongylides and/or Philometra (any stage)
June 19	23.81	2.86
June 22	47.62	14.29
June 28	45.45	3.03
July 3	40.64	3.87
July 10	46.67	10.00
July 12	47.83	5.44
July 17	34.88	2.33
July 24	41.95	6.90
Aug. 1	25.61	0.00
Aug. 7	44.17	5.00
Aug. 23	46.43	10.71
Aug. 28	41.13	9.68
Sept. 5	58.82	0.00
Sept. 12	59.63	2.75
Sept. 18	68.08	24.47
Sept. 25	63.33	13.33
Oct. 2	65.85	19.51
Oct. 30	43.08	15.38
	$\bar{x}$ = 46.94	$\bar{x}$ = 9.35

TABLE 21 (Con't.)

Rate of Infection of Yellow Perch.

Trawls Taken Between Green and Rattlesnake Islands,

Western Basin, Lake Erie, 1978

Date	5 % of Infection with *Eustrongylides* and *Triaenophorus*	6 % of Infection with *Eustrongylides* Alone
June 19	3.81	14.29
June 22	4.76	20.63
June 28	6.06	27.27
July 3	20.00	10.97
July 10	11.11	22.22
July 12	10.87	27.17
July 17	5.23	17.44
July 24	4.60	26.44
Aug. 1	1.22	20.73
Aug. 7	10.83	15.83
Aug. 23	8.93	17.86
Aug. 28	8.06	12.90
Sept. 5	19.61	8.82
Sept. 12	8.26	6.42
Sept. 18	0.00	7.45
Sept. 25	3.33	10.00
Oct. 2	6.10	15.85
Oct. 30	6.15	12.31
	$\bar{x}$ = 8.17	$\bar{x}$ = 16.37

TABLE 21 (Con't.)

Rate of Infection of Yellow Perch.

Trawls Taken Between Green and Rattlesnake Islands,

Western Basin, Lake Erie, 1978

Date	7 % of Infection with *Philometra* (any stage) and/or *Eustrongylides* and/or *Triaenophorus*	8 % of Infection with *Triaenophorus* and *Philometra* (any stage)
June 19	17.14	1.90
June 22	33.33	4.76
June 28	24.24	5.05
July 3	20.64	8.39
July 10	22.22	5.56
July 12	27.17	8.70
July 17	23.26	6.98
July 24	21.26	5.17
Aug. 1	25.61	18.29
Aug. 7	29.17	9.17
Aug. 23	35.71	7.14
Aug. 28	52.42	15.32
Sept. 5	42.16	9.80
Sept. 12	59.63	11.01
Sept. 18	84.04	6.38
Sept. 25	66.67	8.33
Oct. 2	60.98	4.88
Oct. 30	52.31	13.85
	$\bar{x}$ = 38.78	$\bar{x}$ = 8.37

TABLE 21 (Con't.)

Rate of Infection of Yellow Perch.

Trawls Taken Between Green and Rattlesnake Islands,

Western Basin, Lake Erie, 1978

Date	9 % of Infection with *Philometra* (any stage) Alone	10 % of Infection with *Triaenophorus* and/or *Eustrongylides* and/or *Philometra* (any stage)
June 19	9.52	26.67
June 22	6.35	26.98
June 28	7.07	32.32
July 3	2.58	59.35
July 10	3.33	30.00
July 12	8.70	34.78
July 17	4.07	38.37
July 24	5.17	33.91
Aug. 1	3.66	48.78
Aug. 7	2.50	50.83
Aug. 23	8.93	46.43
Aug. 28	8.87	54.84
Sept. 5	1.96	80.39
Sept. 12	3.67	78.90
Sept. 18	17.02	45.74
Sept. 25	8.33	53.33
Oct. 2	12.20	37.80
Oct. 30	13.85	35.38
	$\bar{x}$ = 7.10	$\bar{x}$ = 45.27

TABLE 21 (Con't.)

Rate of Infection of Yellow Perch.

Trawls Taken Between Green and Rattlesnake Islands,

Western Basin, Lake Erie, 1978

11

Date	% of Infection with *Triaenophorus* Alone	
June 19	18.10	
June 22	9.52	
June 28	12.12	
July 3	25.16	
July 10	10.00	
July 12	10.87	
July 17	16.28	
July 24	20.11	
Aug. 1	25.61	
Aug. 7	18.33	
Aug. 23	21.43	
Aug. 28	12.90	
Sept. 5	20.59	
Sept. 12	17.43	
Sept. 18	3.19	
Sept. 25	5.00	
Oct. 2	2.44	
Oct. 30	6.15	
	$\bar{x}$ = 14.18	

Figure 42

Plot of Total Length of Yellow Perch Infected With Eustrongylides tubifex by Sample Date.

Legend: A = 1 fish, B = 2 fish, etc.

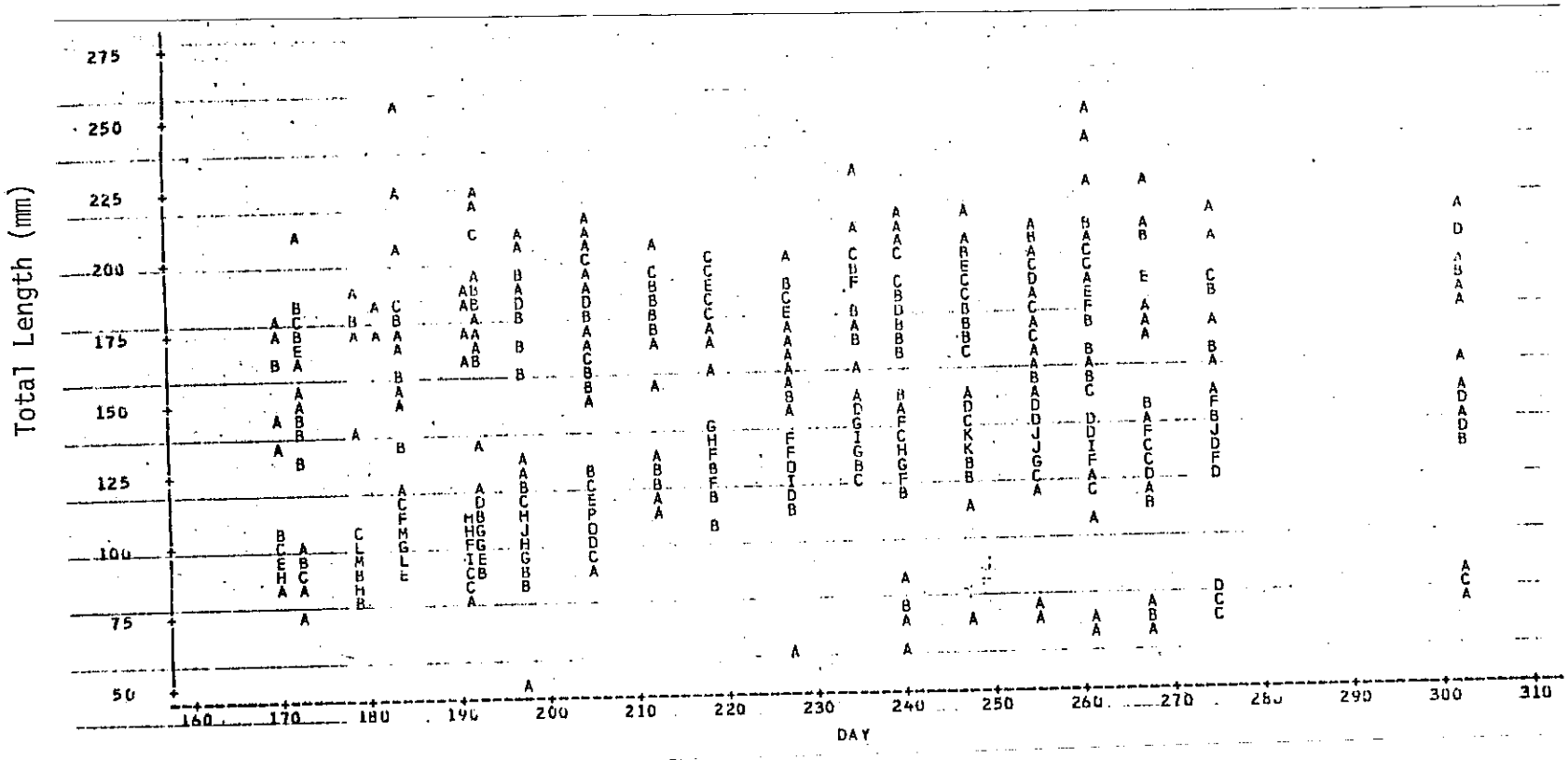


Figure 43

Plot of Whole Weight Versus Number of Eustrongylides tubifex Nematodes per Fish for Age Class 1 Fish on 1 July from the Western Basin.

Legend: A = 1 fish, B = 2 fish, etc.

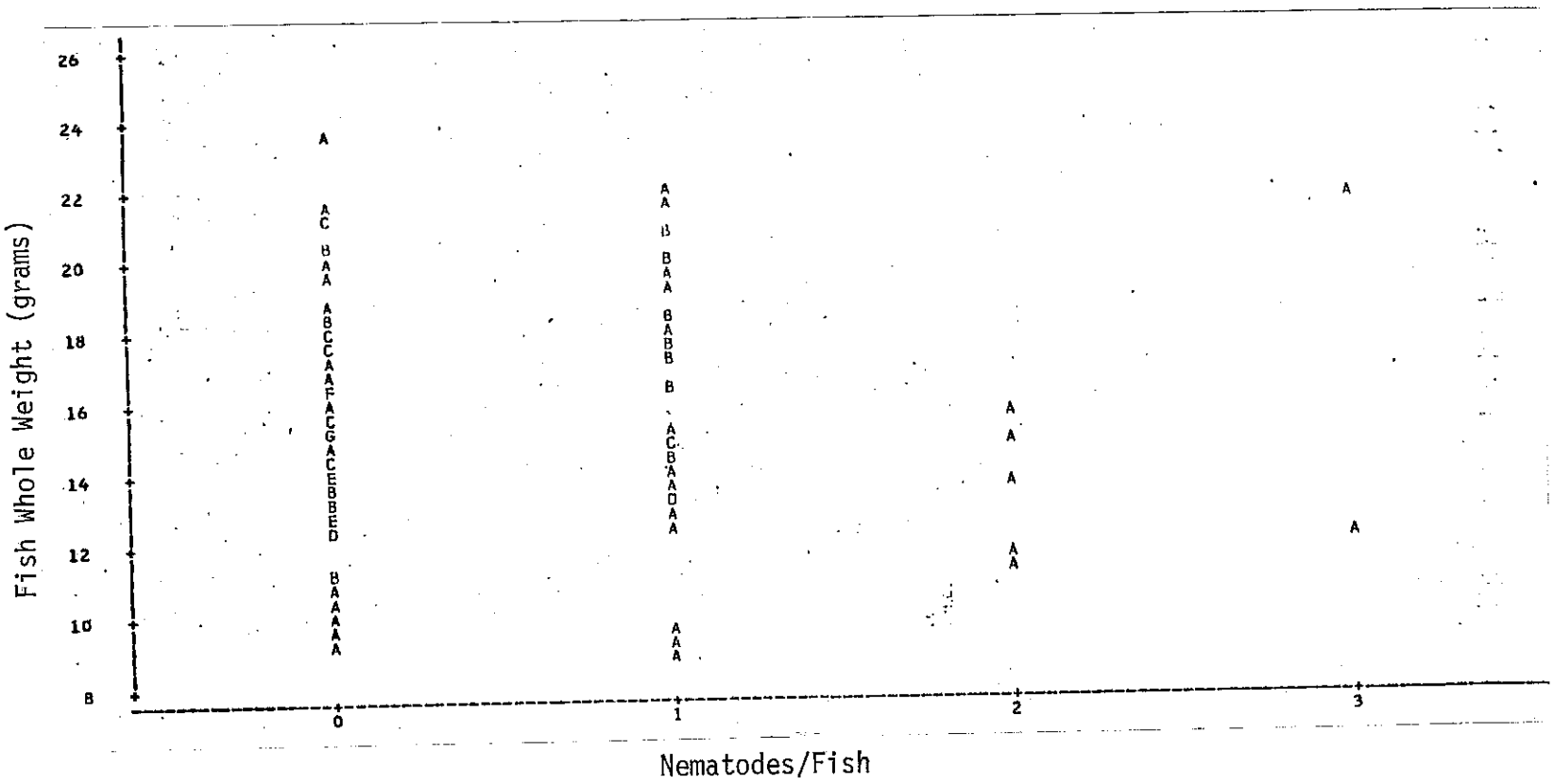


Figure 44

Plot of Whole Weight Versus Number of Eustrongylides tubifex Nematodes per Fish for Age Class 1 Fish on 24 July from the Western Basin.

Legend: A = 1 fish, B = 2 fish, etc.

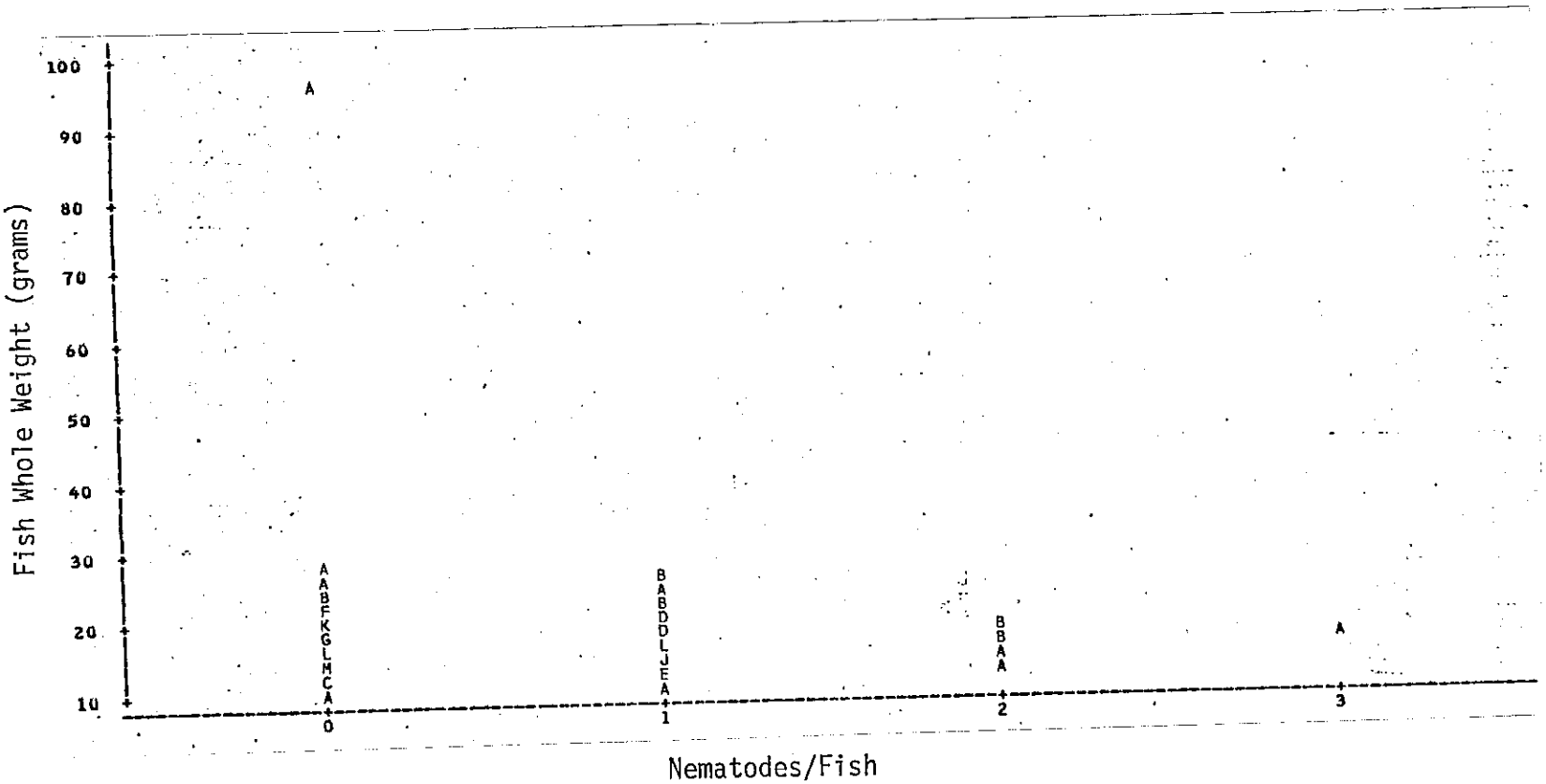


Figure 45

Plot of Whole Weight Versus Number of Eustrongylides tubifex Nematodes per Fish for Age Class 1 Fish on 12 October from the Central Basin.

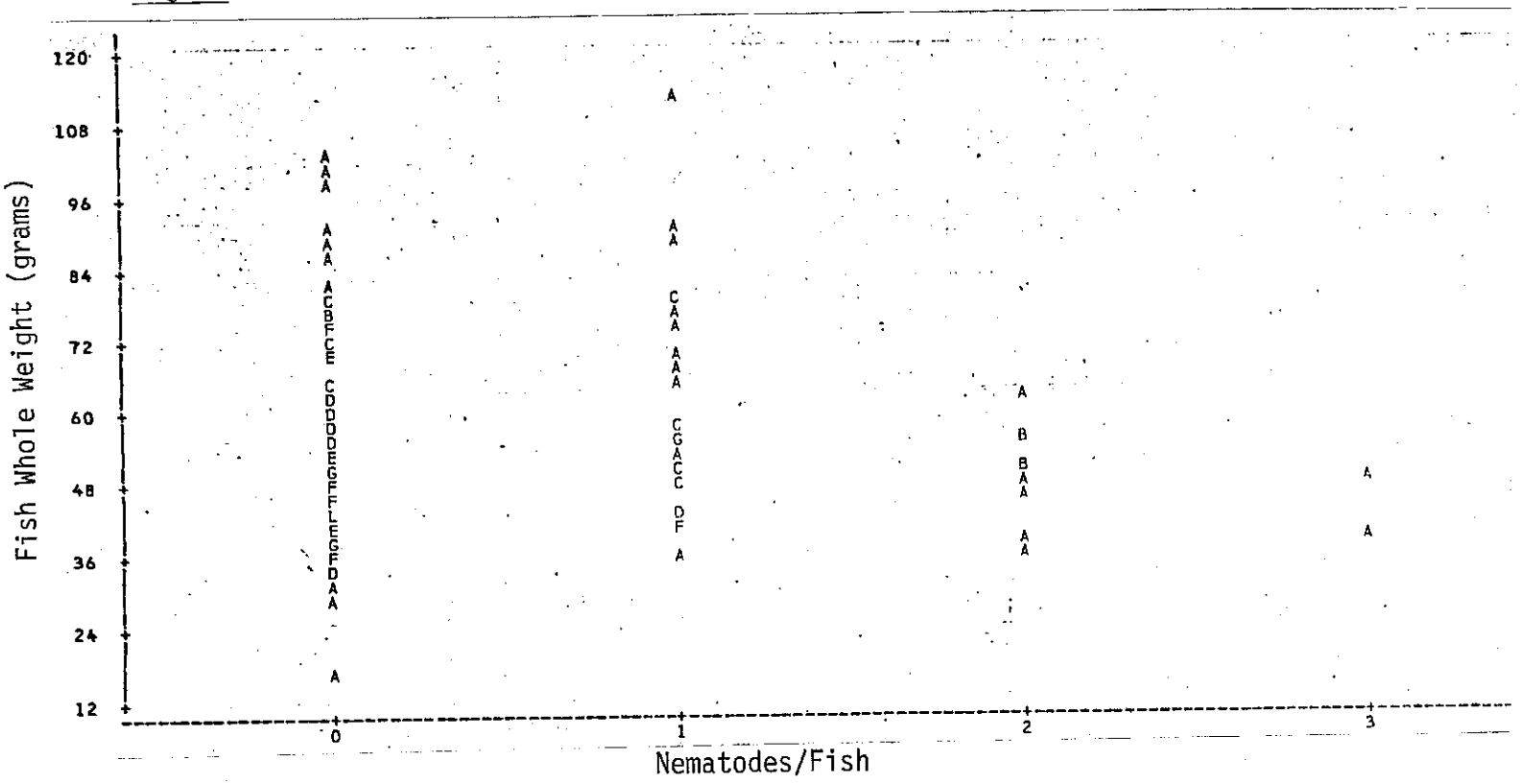


Figure 46

Plot of Number of Eustrongylides tubifex per Fish on Each Sampling Date
(all age classes combined).

Legend: A = 1 fish, B = 2 fish, etc.

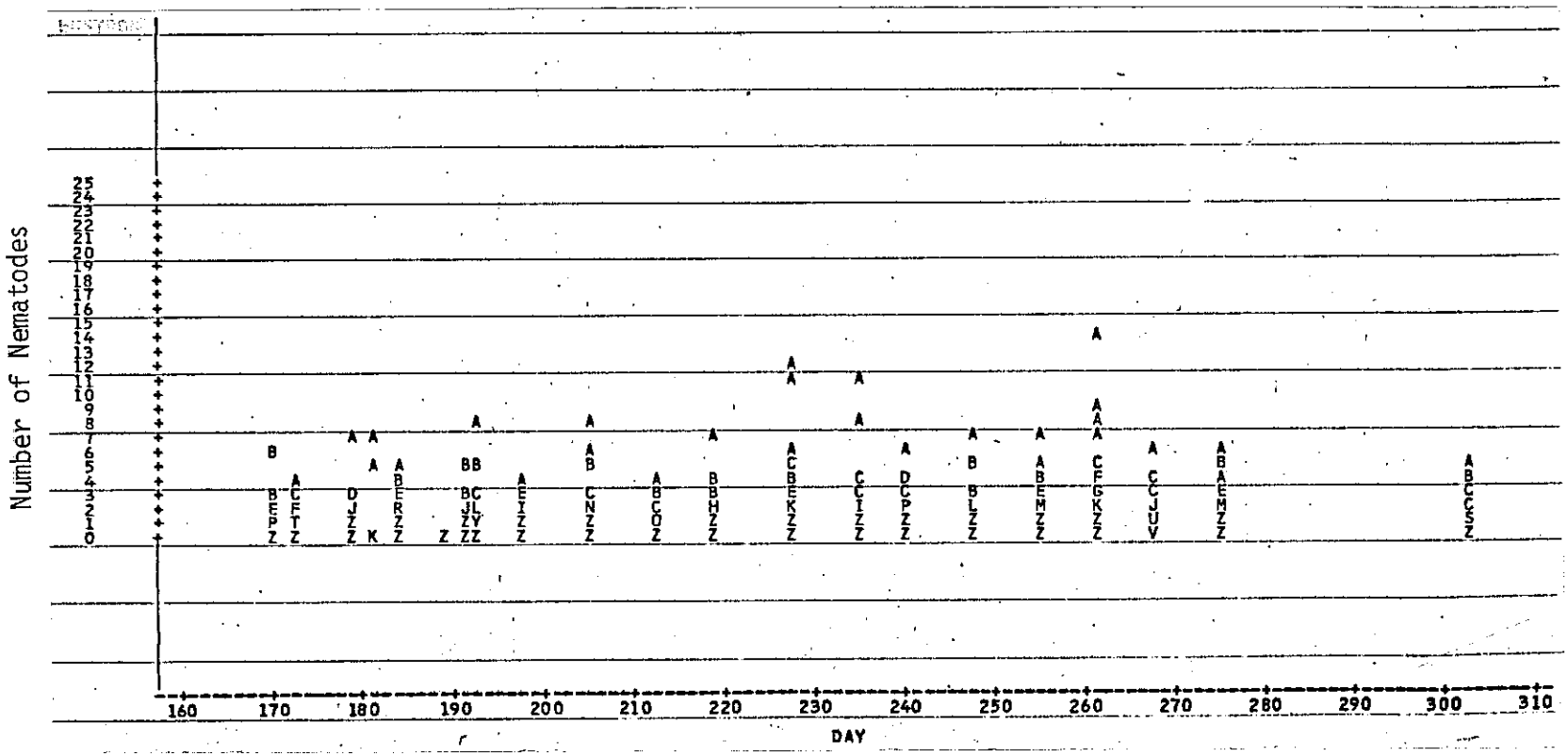


TABLE 26

SUMMARY STATISTICS FOR YELLOW PERCH FROM WESTERN BASIN - GREEN AND RATTLESNAKE ISLANDS - Bio-Lab - 2 OCTOBER 1978.

VARIABLE	N	MEAN	STANDARD DEVIATION	STD ERROR OF MEAN	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
				DAY=275 SCALE=0			
TOTLEN	27	77.37037037	5.47826579	1.05429274	30.01139601	67.00000000	92.0000000
WGHT1	27	5.42222222	1.08533346	0.20887252	1.17794872	3.60000000	8.7000000
WGHT2	27	4.78148148	1.06121738	0.20423138	1.12618234	3.10000000	8.1000000
KFACT1	27	1.16061922	0.08434732	0.01623265	0.00711447	1.03515625	1.3274074
KFACT2	27	1.02024047	0.08053806	0.01549956	0.00648638	0.89807309	1.1455361
				DAY=275 SCALE=1			
TOTLEN	38	132.00000000	9.25903503	1.50201382	85.72972973	118.00000000	165.0000000
WGHT1	38	26.25526316	6.74864140	1.09477420	45.54416074	17.40000000	56.3000000
WGHT2	38	23.83947368	5.99335395	0.97225040	35.92029161	15.30000000	48.7000000
KFACT1	38	1.12162123	0.05787422	0.00938844	0.00334942	1.03148577	1.3128080
KFACT2	38	1.01861352	0.05799823	0.00940856	0.00336379	0.92967418	1.2193263
				DAY=275 SCALE=2			
TOTLEN	10	155.90000000	23.50626394	7.43333333	552.54444444	136.00000000	213.0000000
WGHT1	10	45.45000000	24.08873642	7.61752730	580.26722222	26.60000000	105.4000000
WGHT2	10	41.37000000	22.14151706	7.00176248	490.24677778	24.40000000	97.6000000
KFACT1	10	1.12146476	0.06558946	0.02074121	0.00430198	1.02769604	1.2128897
KFACT2	10	1.02081222	0.05175595	0.01636667	0.00267868	0.93833116	1.0977335
				DAY=275 SCALE=3			
TOTLEN	5	191.80000000	8.04363102	3.59722115	64.70000000	187.00000000	206.0000000
WGHT1	5	86.06000000	12.31332611	5.50668684	151.61800000	73.40000000	106.6000000
WGHT2	5	76.36000000	8.86639724	3.96517339	78.61300000	67.80000000	91.4000000
KFACT1	5	1.21482715	0.07555231	0.03378802	0.00570815	1.08720301	1.2845602
KFACT2	5	1.08012571	0.05550626	0.02482315	0.00308094	1.00425564	1.1392825
				DAY=275 SCALE=4			
TOTLEN	2	197.50000000	13.43502884	9.50000000	180.50000000	188.00000000	207.0000000
WGHT1	2	100.90000000	27.01147904	19.10000000	729.62000000	81.80000000	120.0000000
WGHT2	2	87.45000000	30.75914498	21.75000000	946.12500000	65.70000000	109.2000000
KFACT1	2	1.29198779	0.08616276	0.06092627	0.00742402	1.23106152	1.3529140
KFACT2	2	1.10995696	0.17139538	0.12119483	0.02937638	0.96876212	1.2311517

TABLE 27

SUMMARY STATISTICS FOR YELLOW PERCH FROM CENTRAL BASIN - OFF CLEVELAND HARBOR - EXPLORER - 12 OCTOBER 1978.

VARIABLE	N	MEAN	STANDARD DEVIATION	STD ERROR OF MEAN	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
DAY=285 SCALE=0							
TOTLEN	1	110.00000000	.	.	.	110.00000000	110.000000
WGHT1	1	15.30000000	.	.	.	15.30000000	15.300000
WGHT2	1	14.10000000	.	.	.	14.10000000	14.100000
KFACT1	1	1.14951165	.	.	.	1.14951165	1.14951
KFACT2	1	1.05935387	.	.	.	1.05935387	1.059353
DAY=285 SCALE=1							
TOTLEN	156	160.96153846	15.24800764	1.22081766	232.50173697	110.00000000	207.000000
WGHT1	156	54.88525641	16.64792849	1.33290103	277.15352316	15.80000000	113.700000
WGHT2	156	48.97243590	15.40013227	1.23299737	237.16407403	13.30000000	104.400000
KFACT1	156	1.27984387	0.08420563	0.00674185	0.00709059	1.08573537	1.574048
KFACT2	156	1.13832739	0.07449627	0.00596447	0.00554969	0.97722316	1.366273
DAY=285 SCALE=2							
TOTLEN	50	163.06000000	18.00953262	2.54693253	324.34326531	136.00000000	225.000000
WGHT1	50	58.62400000	23.62137185	3.340566 44	557.96920816	30.60000000	146.200000
WGHT2	50	52.46200000	21.09128740	2.98275847	444.84240408	27.90000000	131.600000
KFACT1	50	1.29145516	0.09099924	0.01286924	0.00828086	1.07619555	1.533103
KFACT2	50	1.15624307	0.08455764	0.01195826	0.00714999	0.98550492	1.392224
DAY=285 SCALE=3							
TOTLEN	10	185.70000000	23.87025113	7.54843619	569.78888889	148.00000000	212.000000
WGHT1	10	87.19000000	29.98293774	9.48143742	898.97655556	43.40000000	139.000000
WGHT2	10	77.08000000	27.34165727	8.64619120	747.56622222	37.10000000	124.300000
KFACT1	10	1.31945921	0.12486178	0.03948476	0.01559046	1.16801580	1.567125
KFACT2	10	1.16162262	0.10972441	0.03469791	0.01203945	1.03948897	1.401393
DAY=285 SCALE=4							
TOTLEN	1	186.00000000	.	.	.	186.00000000	186.000000
WGHT1	1	77.80000000	.	.	.	77.80000000	77.800000
WGHT2	1	69.30000000	.	.	.	69.30000000	69.300000
KFACT1	1	1.20904026	.	.	.	1.20904026	1.209040
KFACT2	1	1.07694718	.	.	.	1.07694718	1.076947