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Dietary Overlap of Native White Bass and Introduced Yellow Bass in Barren River

Micaela L. Montgomery
Western Kentucky University, micaela.montgomery547@topper.wku.edu

DIETARY OVERLAP OF NATIVE WHITE BASS AND INTRODUCED YELLOW BASS IN BARREN RIVER

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By

Micaela L. Montgomery

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Western Kentucky University

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CE/T Committee:

Professor Philip Lienesch, Advisor

Professor Steve Huskey

Professor Benjamin LaPoe

Approved by:

____

Advisor
Department of Biology

ABSTRACT

In the Barren River Lake of south central Kentucky, native white bass, *Morone chrysops,* has experienced a decline in population after the introduction of yellow bass, *Morone mississippiensis*. These species are competing for resources due to an overlapping diet, likely contributing to the decline of the white bass. To explore this hypothesis, I examined the stomach contents and otoliths of white and yellow bass caught during their spawning time in spring 2012. There were 40 yellow bass and 128 white bass collected in Barren River upstream of Barren River Lake. Analysis of stomach contents revealed that both white and yellow bass had a diet that relied heavily on crayfish and insect larvae. Yellow bass were found to have fish eggs present in 8% of stomachs directly after the white bass spawning period. This study supports that there is a dietary overlap between white and yellow bass in Barren River and explores the implications for the white bass and surrounding ecosystem.

Keywords: White bass, yellow bass, invasive, dietary overlap, Barren River Lake

Dedicated to my parents, Mark and Alina Montgomery.

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VITA

October 24, 1992…………………………....Born – Louisville, Kentucky

2011…………………………………………Carol Martin Gatton Academy of Mathematics and Science, Bowling Green, Kentucky

2015………………………………………....Bachelor of Science, Biology, Western Kentucky University

PUBLICATIONS

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FIELDS OF STUDY

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CHAPTER 1

INTRODUCTION

The stocking of fish is now a common practice that gained popularity over the last century without much consideration to the impact on the native ecosystem (Pearsons and Hopley, 1999). Stocking can be used to boost a struggling native fish's population, but it can also be used to introduce new fishes, often resulting in negative effects. In 1999, the United States Invasive Species Executive Order (13112) was enacted to coordinate several agencies with the goal of preventing further introduction of invasive species, controlling the invasive species that were already present, and minimizing the negative impacts on the economy, ecosystem, and human health (Helfman, 2007).

Today, the states with the most introduced fish are California, Florida, Colorado, Texas, and Nevada (Ruiz and Carlton, 2003). Factors contribute to this outside of planned stocking. For example, in California a fairly common source of introduced species is the release of tropical aquarium fish as they can survive in the warm climate. This includes aquarium plants, such as *Caulerpaearned sp.,* coined "Killer Algea". In 2000, it infected two lagoons in Southern California and ended up costing $6 million to remove (Oskin, 2013). In Florida, the majority of introductions are due to the presence of fish farms breeding a wide-array of invasive species (Ruiz and Carlton, 2003). Should these species escape their farm, they pose a threat to the surrounding aquatic ecosystem.

Although unintentional release of wildlife into new areas does occur, the main source for the introduction of many species comes from their intentional release by fish and wildlife agencies. In Nevada, over half of the fish species are introduced from elsewhere and over half of those were intentionally introduced to support fishing opportunities (Rahel, 2000). The body of water that is examined in this study, Barren River Lake in southcentral Kentucky, has had rainbow trout (*Oncorhynchus mykiss*), striped bass (*Morone saxatilis*), threadfin shad (*Dorosoma petenense)*, and Lake Erie strain walleye (*Sander vitreus*) introduced into it by the Kentucky Department of Fish and Wildlife Resources (Kentucky Department of Fish and Wildlife Resources, 2006). This pattern of introduction of non-native species continues to the present. Since 2000, the Kentucky Department of Fish and wildlife has introduced a native strain of walleye and blue catfish (*Ictalurus furcatus*), a species that is native to large rivers like the Ohio River and Mississippi River but was not native to the Barren River drainage.

There are other ways for aquatic organisms to be introduced. They may enter new bodies of water through flooding or strange weather occurrences (Degrandchamp and Garvey, 2008; Sigler and Sigler, 1990), transportation of eggs and larvae by birds and insects (Thienemann, 1950), building of extensive canal systems that disperse fishes (Ruiz and Carlton, 2003), or unintentional release of bait fish or their eggs and larvae (Crossman, 1991).

Flooding in areas containing multiple bodies of water can result in the transfer of species between them. Some species of fish have evolved to take advantage of flooding and depend on seasonal floods to complete their reproductive cycle (Pearsons *et al*., 1992). There have been rare documented incidences of a water spout vortex picking up fish and depositing them in a new location (Sigler and Sigler, 1990). Wading birds, such as ducks, are considered a potential vector in the spread of freshwater organisms to previously uninhabited bodies of water. Eggs and larvae can become attached to the plumage, legs, and feet of birds as they rest and feed at the water's surface (Thienemann, 1950), allowing them to be transported to a new location. Man-made canals offer a way for fish to move between different bodies of water. For instance, the Panama Canal allows for species transfer between the Pacific Ocean and the Atlantic Ocean (Appleton, 2015). Movement of bait and fishing tools, such as clothing items and boats, between separate bodies of water can result in the transfer of fish eggs. Fish eggs that are kept within soil on these objects have been shown to remain viable for up to two weeks (Thienemann, 1950).

According to the U.S. Forest Service, a species becomes invasive when they can tolerate various habitats, grow and reproduce quickly, lack natural enemies, and compete aggressively for resources (U.S. Forest Service, 2014). Invasive plants in temperate climates are characterized by their ability to avoid drying out as well as tolerate cool or freezing temperatures (Simberloff and Rejmánek, 2011). Invasive species that grow quickly often have evolved to rapidly consume abundant resources in their environment. This becomes a problem when they are put into an environment dominated by species with slow growth and the efficient use of resources. These fast-growing, invasive species out-compete the slower-growing, native species (Reich, 1997; Diaz, 2004). For example, Kudzu, *Pueraria lobate*, is a plant that was introduced to the United States in the 1800's to hold soil in place and feed livestock. Kudzu vines grow very fast and can completely cover a tree, resulting in the tree's death due to sunlight deprivation (Hartman and

Meshbesher, 2012). When species are introduced into an environment in which they did not evolve, their expansion can remain mostly unchecked due to a lack of natural predators (Nichols and Williams, 2009).

Resource competition can occur when the native species and the introduced species are consuming the same resources (Simberloff, 2013). For example, introduction of the comb jelly, *Mnemiopsis leidyi*., lead to a drastic decline in native fishes in the Caspian Sea due to a shared diet (Bilio and Niermann, 2004). Another source of damage can be altering the "trophic cascade". This occurs when an invasive species consumes a native species, thereby reducing the native species contribution to the ecosystem; the native species may have been feeding a predatory species or eating a nuisance species. For example, when the alewife was introduced to the Great Lakes, there was a decrease in zooplankton, its main source of food, which led to major declines in native fish populations and the animals that fed on them (Simberloff, 2013). Stocking of freshwater opossum shrimp, *Mysis relicta*, into Flathead Lake caused a decline in landlocked sockeye salmon, *Oncorhynchus nerka*, due to dietary competition for zooplankton. The loss of landlocked sockeye salmon seriously affected birds, bears, and other mammals in the area (Mooney and Hobbs, 2000). The relationship between the white and yellow bass carries these toxic themes of an invasive and native species having an overlapping diet, potentially affecting the entire ecosystem.

While the white bass was a part of a supplemental stocking program used across Kentucky, including Barren River Lake, from 2002 to 2010 to boost dwindling numbers (Kentucky Department of Fish and Wildlife Resources, 2006, 2013), there is no record of yellow bass being introduced in a similar manner. White bass (Figure 1) are found throughout the Mississippi River Basin and are native to Barren River Lake and its main tributary, the upper Barren River (Etnier and Wayne, 1993). The yellow bass (Figure 2) is native to large rivers in Kentucky but there is no record of it being intentionally introduced to Barren River Lake. Yellow bass were first detected in Barren River in 2001 and have become very abundant since then.

White bass reach sexual maturity between the ages of 2 and 3, while yellow bass reach sexual maturity closer to the age of 2 (Ruelle, 1971). White bass can live up to 9 years, with an average age of 5 or 6, and yellow bass have a maximum life span of 7 years, with an average of 4 (Schultz, 2004). White bass have a growth and reproductive disadvantage because they need to stay alive longer than the yellow bass in order to reach a reproductive age. White bass are not expected to exceed a weight of 2 kg while yellow bass are not expected to exceed 1.02 kg (Etnier and Wayne, 1993). This size difference makes white bass more desirable than the scrawny yellow bass to fishermen (Etnier and Wayne, 1993). A yellow bass may be released by fishermen and go on to reproduce, while a white bass may be more likely to be kept for food.

Both white and yellow bass adults compete for dietary resources such as small fishes, insects, and crayfish (Harrell, 1997; McCraren, 1984). White bass typically spawn during a two month period in which the water temperature reaches 16.5–22.5°C (Teletchea *et. al*., 2009; Ross and Brenneman, 2001). The yellow bass spawn in late spring when the temperature reaches 21°C (Pflieger and Smith, 1997). This overlap has adult yellow bass within the spawning area during the same time white bass eggs and larvae are maturing, presenting the opportunity for yellow bass to consume the white bass' eggs and larvae (Fose, 2013).

Since the 2000's, the introduced yellow bass has been showing up on the Kentucky Department of Fish and Wildlife Resources' Fishing Forecast and Tips guide for the Barren River Lake. White bass have consistently been forecasted as "poor to fair" fishing as "overall numbers remain low". Comparatively, the yellow bass have been forecasted as "excellent" fishing since 2012 (Kentucky Department of Fish and Wildlife Resources, 2012). The forecast is determined by a spring electrofishing survey at Barren River Lake to collect information on rate of growth and recruitment, or presence of new fish (Kentucky Department of Fish and Wildlife Resources, 2003).

On the most basic level, white and yellow bass are likely competing for dietary resources, potentially contributing to the decline of the former (Harrell, 1997; McCraren, 1984). Yellow bass competition with white bass for food, and direct predation on white bass eggs and larvae, may be altering the community structure, impacting other animals in the ecosystem (Simberloff, 2013; Fose, 2013). I hypothesized that dietary overlap between the white and yellow bass is contributing to the decline of the white bass and interfering with the Barren River ecosystem. The white bass stocking program used from 2006 to 2010 did not stop the decline of the white bass (Kentucky Department of Fish and Wildlife Resources, 2013). It is important to better understand the ways in which yellow bass negatively impact white bass and the surrounding ecosystem so that effective programs can be introduced for controlling these effects.

CHAPTER 2

MATERIALS AND METHODS

The study sites (Figure 3) were located upstream of the Barren River Lake in Allen County, Kentucky. They were selected according to known spawning habitat preferences for white bass and accessibility (Pflieger, 1997). Fish were obtained from graduate student Jacob Fose using gill nets and hook-and-line angling between April 6, 2012 and June 22, 2012 during 11 trips (Fose, 2013). The nets were put across the river before night fall and retrieved the following morning. Specimens were stored on ice until dissection. Stomachs were removed and stored in a solution of 70% ethanol. Stomachs were analyzed under a dissecting microscope and contents were recorded to determine dietary overlap between white and yellow bass. Otoliths were removed and stored in dry paper envelopes. They were used to determine age by counting annuli. The experimental average age of the population compared to the expected average age of the population contributes to our understanding of whether or not a species is being successful in a particular environment.

Analyzing Stomach Contents

Jars containing stomach contents preserved in 70% ethanol were unsealed and poured into a dish for examination under a Leica S6E dissecting microscope. The stomachs were cut open with a scalpel and contents were gently separated using forceps.

When the stomach contents contained large amounts of particulate matter, diH_2O was used to rinse them away for better viewing. Viewing of stomach contents occurred from 0 to 40X magnification. Contents were recorded based on seven categories: fish larvae, fish eggs, post-larval fish, crayfish, insect larvae, empty, and other. These categories were put into a bar graph using Excel to show the frequency at which they were found in white and yellow bass stomachs. The categories were also calculated as a percent of the white and yellow bass' total diet and organized into a pie chart. After inspection, dish contents were returned to their jar.

Using Otoliths to Age Specimens

Otoliths were examined under a light microscope at various magnifications with an additional side-light to make the otoliths appear more translucent. They were maneuvered using forceps. The age of a fish can be determined by counting the opaque and translucent circuli (bands of material) on the otolith. Opaque material is deposited during the slow growth that occurs in winter. The translucent material is deposited during periods of fast growth during the summer. Each year of growth consists of 1 translucent band and 1 opaque band.

CHAPTER 3

RESULTS

A sample of 40 yellow bass and 128 white bass were collected during 11 fishing trips from April 6, 2012, to June 22, 2012 (Figure 4).

Analyzing Stomach Contents

The main sources of dietary overlap between white and yellow bass were graphed in two ways: by the frequency at which they were found in stomachs in any amount, including an empty state (Figure 5), and by the percentage a particular food item contributed to overall composition when food was present.

Fish larvae were found in 3.31% of white bass stomachs and 2.5% of yellow bass stomachs (Figure 6). Fish eggs were found in 0% of the white bass stomachs and 10% of the yellow bass stomachs (Figure 7). Post-larval fish were found in 2.34% of white bass stomachs and 5% of yellow bass stomachs. Crayfish were found in 3.9% of white bass stomachs and 60% of yellow bass stomachs. Insect larvae were found in 36.7% of white bass stomachs and 37.5% of yellow bass stomachs (Figure 8). Contents considered as "other" were in 9.38% of the white bass stomachs and 15% of yellow bass stomachs. An empty state occurred in 56.2% of the white bass stomachs but only 15% of the yellow bass stomachs (Figure 9).

By stomach content percent composition, the average white bass diet (Figure 10) consisted of 6% fish larvae, 0% fish eggs, 4% post-larval fish, 7% crayfish, 66% insect larvae, and 17% other. The average yellow bass diet (Figure 11) consisted of 2% fish larvae, 8% fish eggs, 4% post-larval fish, 46% crayfish, 29% insect larvae, and 11% other.

Using Otoliths to Age Specimens

The white bass has a maximum life span of 9 years compared to 7 years for the yellow bass. The average age expected from a population of white bass is 5-6 years compared to 4 years for the yellow bass (Schultz, 2004). The average age of the 128 white bass was 2.12 years and the average age of the 40 yellow bass was 5.0 years.

CHAPTER 4

DISCUSSION

When comparing the stomach contents of captured white and yellow bass, there is a general trend of the yellow bass having more in their stomachs compared to the white bass. This likely has to do with the hatching temperature preferences of their food sources. White bass used in this study were caught during their spawning period, which occurs at a temperature too low, 18.5°C, for crayfish and many insects to be hatching (Fose, 2013). The preferred habitat of crayfish, genus *Cambaridae*, widely varies from permanent lakes and streams to flooded swamps, but includes the area in which the white and yellow bass spawn. Maturation of crayfish occurs optimally at temperatures of 21–27°C, which is during the spawning period of the yellow bass (Gherardi and Holdich, 1999). The yellow bass used in this study were collected when temperatures in Barren River were around 23°C (Fose, 2013). Insects can also be hatching during this time. For example, grasshoppers of the genus *Shistocerca* are common to Kentucky and their eggs hatch optimally in aerated water at 20°C. Insects of genus *Oncopeltus* and *Cimex* can be expected to hatch at cooler temperatures of 13°C and 8°C, respectively (Yadav, 2003). Despite the samples being taken at times of varying food availability, an overlap in diet can be identified.

White and yellow bass do not eat much, or at all, during spawning, but are hungry as they leave the spawning area (Graham, 1973). As the white bass in the study were entering and leaving the spawning area, the temperature had not yet risen enough for there to be a lot of their preferred food available. Due to this, 56.2% of the white bass caught had an empty stomach. The peak of yellow bass spawning had the majority of yellow bass entering and leaving the spawning area while food was becoming increasingly available, especially crayfish. Yellow bass stomachs were empty in only 15% of those captured. Only 3.9% of white bass stomachs were found to have crayfish, despite crayfish being a staple of the white bass diet (Payment, 2012). Crayfish was found in 60% of yellow bass stomachs. This is because crayfish were beginning to hatch at 21°C, which is after the white bass' peak spawning temperature and during the yellow bass' peak spawning temperature.

Many insect eggs are able to hatch at a variety of temperatures (Yadav, 2003), so they were present as white and yellow bass entered and left the spawning area. Due to this, the percent composition of insect larvae in white and yellow bass stomachs in Barren River was relatively similar, at 36.7% and 37.5%, respectively. Fish larvae and post-larval fish were found in small amounts in both white and yellow bass stomachs. Fish eggs were found in 0% of white bass stomachs and 10% of yellow bass stomachs. The yellow bass may be consuming white bass eggs and larvae as they enter the spawning area following white bass usage (Fose, 2013).

Consumption of fish eggs when species share a spawning area is not uncommon. White perch, *Morone americana*, often prey on the eggs and larvae of the white bass and walleye, *Sander vitreum vitreum*, reducing their population (Patterson and Patterson, 2010). Yellow bass are already known for their propensity to consume the eggs of other fish, so it is likely that they are engaging in the predation of white fish eggs and larvae when sharing the spawning area (Wallus and Simon, 2006; Fose, 2013). The predation of white bass eggs is made easier in part by the white bass being a species that does not build a nest or guard their eggs in any way (Scalet *et. al*., 1996).

The life span of white bass is, on average, between 5 and 6 years with a maximum age of 9 years (Ruelle, 1971). Despite this, the mean age of the 128 fish collected from Barren River was only 2.12 years. This means that, due to white bass reaching sexual maturity between the ages of 2 and 3, most of the fish captured were spawning for the first time. The majority of the white bass population captured was born during spring of 2010, possibly related to the white bass stocking program that occurred from 2002 to 2010 (Kentucky Department of Fish and Wildlife Resources, 2013).

The life span of yellow bass is, on average, around 4 years of age with a maximum expected life span of 7 years (Schultz, 2004). The mean age of the 40 yellow bass collected from Barren River was 5.0 years, higher than expected. This signifies that the yellow bass population is thriving and many of the bass caught may have been spawning for the third or fourth time in their life. The lack of older year classes of white bass could be due to white and yellow bass dietary overlap, potential consumption of white bass eggs by yellow bass, and human preference for harvesting white bass over yellow bass (Schultz, 2004).

There are other aquatic species in Barren River that largely consume crayfish and insects, such as the smallmouth bass, *Micropterus dolomieu*, and spotted bass, *Micropterus punctulatus* (Gammon, 1998). Smallmouth bass and spotted bass also share the white bass' lower temperature preference of 16-20°C during spawning (Clouser and Nichols, 2007; Weiss, 2001). In Barren River Lake, the population size for these two fish, like the white bass, have been rated as “fair” in recent years compared to the yellow bass’ “excellent” rating (Kentucky Department of Fish and Wildlife Resources, 2012). Perhaps there is a connection between the decline of other early spawning native fishes and the presence of later spawning introduced species.

Future studies would benefit from taking samples of native species that spawn at lower temperatures and comparing their stomach contents to the yellow bass and other later spawning species to possibly identify a trend of later spawning leading to dietary success. Spawning during the time in which crayfish and some insect species are hatching may be beneficial. It would also be useful to take samples of fish outside of their spawning time to evaluate the diets of fish throughout the year. Studying this would allow for the determination of whether one species is consistently consuming more than others during periods when food is more abundant. It is important to also take into consideration the effect of fishing on the decline of white bass. If white bass are truly kept more frequently than yellow bass when caught, it would be worthwhile to interview frequent fishers on how often they catch white and yellow bass, and how likely they are to keep either fish. This information could be used to determine how much white bass populations are being effected by human predation.

In this study, I found evidence for dietary overlap between native white bass and the introduced yellow bass in Barren River. In addition, the egg predation by yellow bass may be resulting in direct predation by yellow bass on the white bass. The arrival of yellow bass on the spawning grounds at the end of the white bass spawning may make the next generation of white bass particularly susceptible to predation by yellow bass. These factors would be expected to have negative effects on the white bass population and may be contributing to the decline of white bass in Barren River Lake. Knowledge of these interactions will aid fishery managers in their attempts to reverse the decline of white bass in Barren River Lake.

FIGURES

Figure 1. White bass caught from the Barren River, Allen County, Kentucky, in spring 2012.

Figure 2. Yellow bass caught from the Barren River, Allen County, Kentucky, in spring 2012.

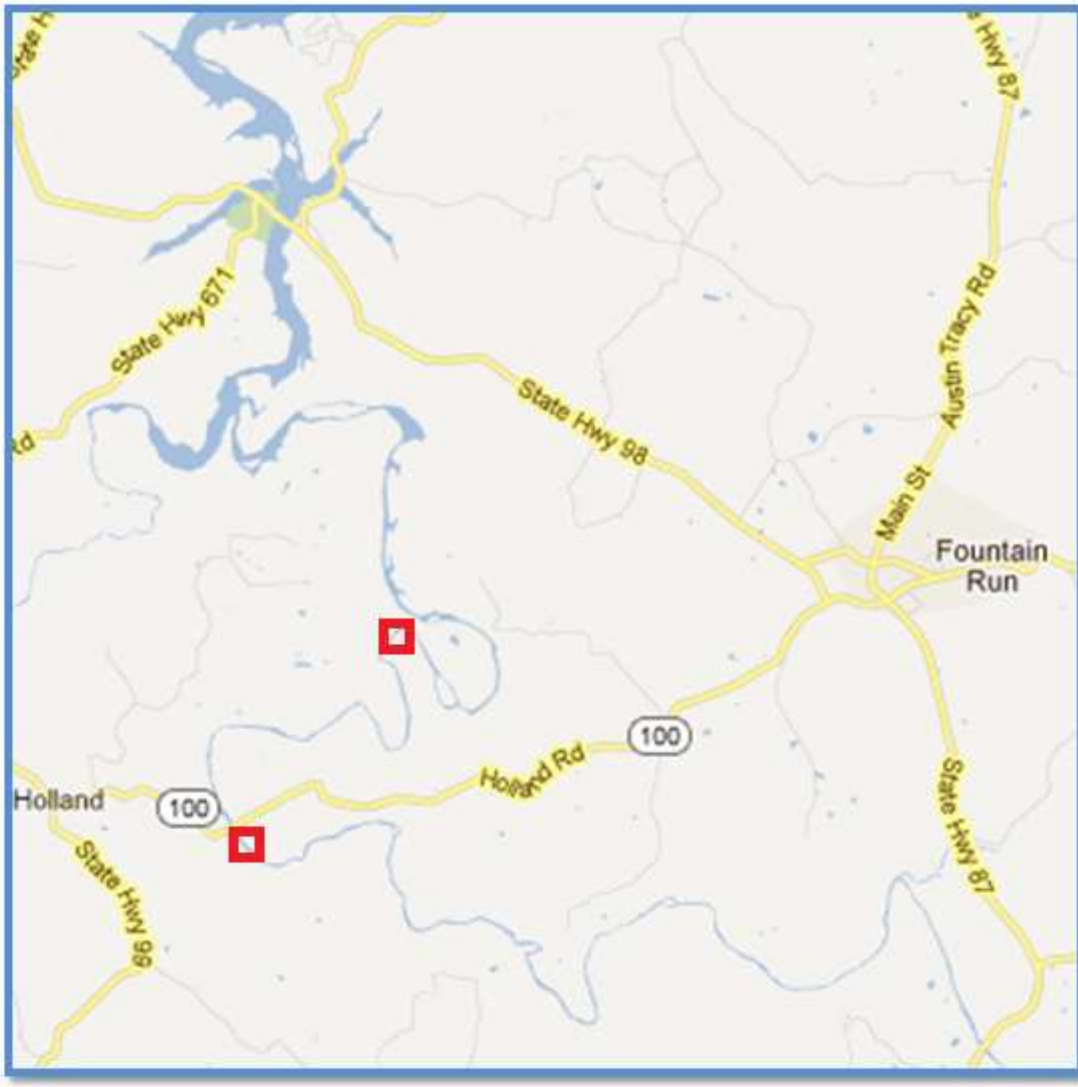

Figure 3. Google earth ® image of sampling sites in Allen County, Kentucky. Sites labeled with red squares. Each site is located on the Barren River upstream of Barren River Lake.

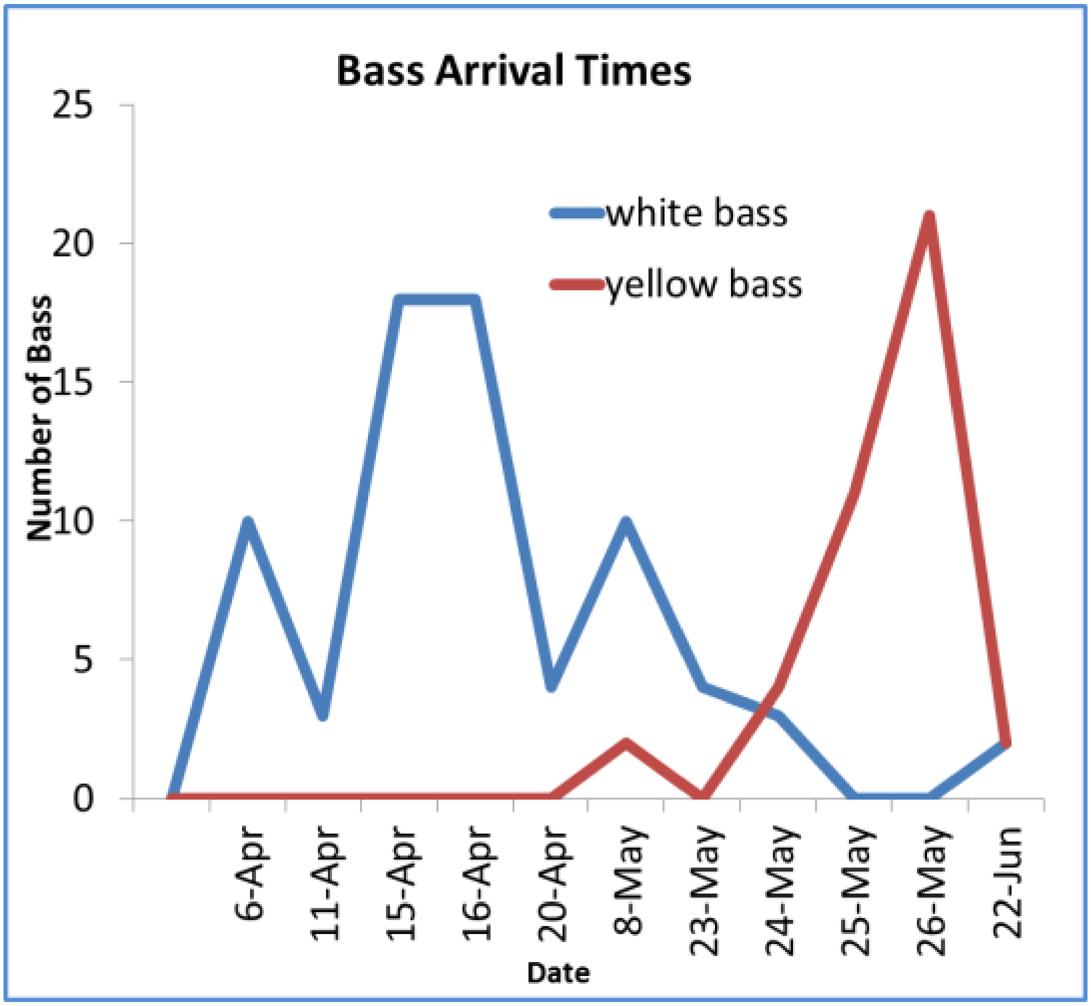

Figure 4. Number of yellow and white bass caught on the spawning area in Barren River, Allen County, Kentucky, by date during spring 2012.

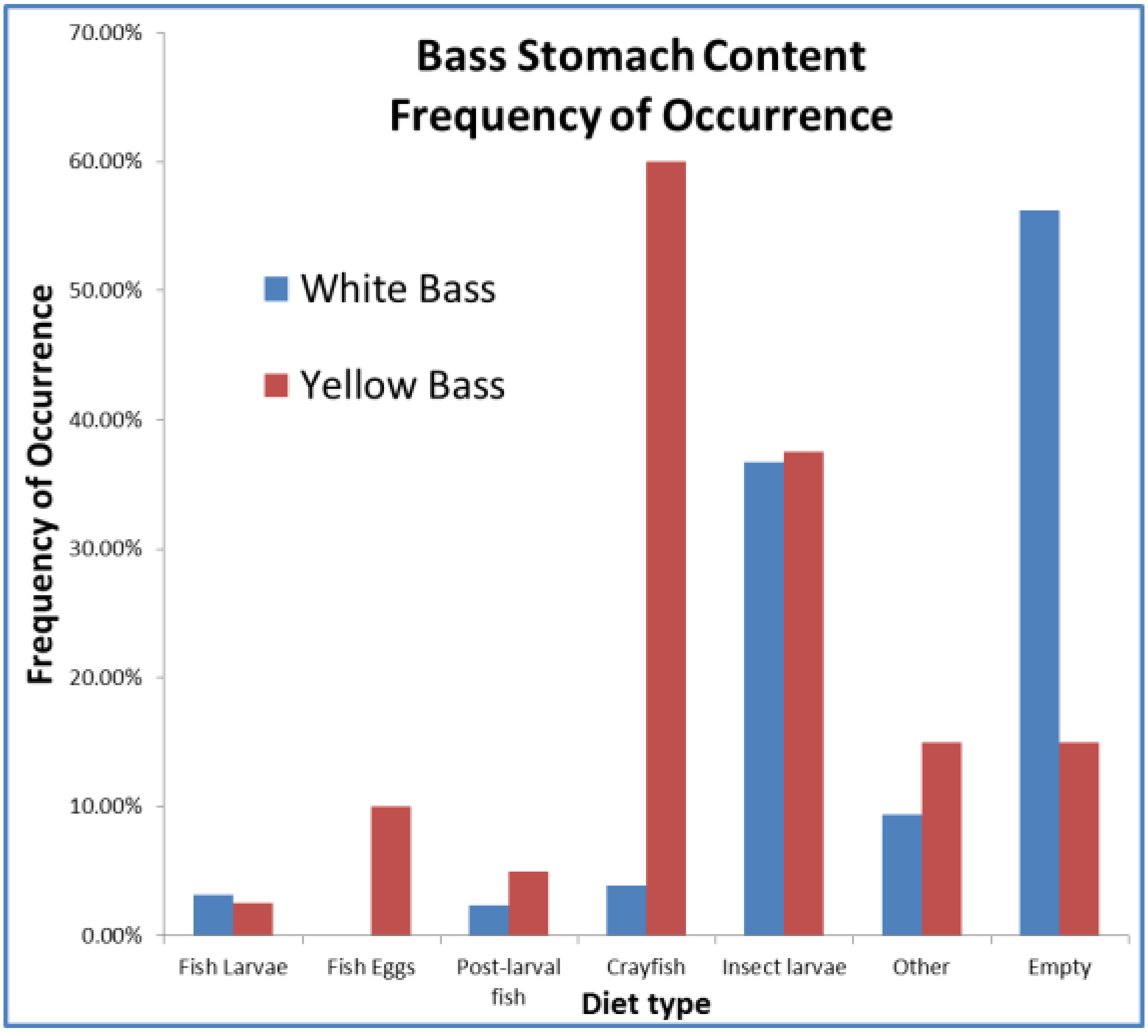

Figure 5. Frequency at which diet items were found inside the stomachs of white and yellow bass collected from the Barren River in Allen County, Kentucky.

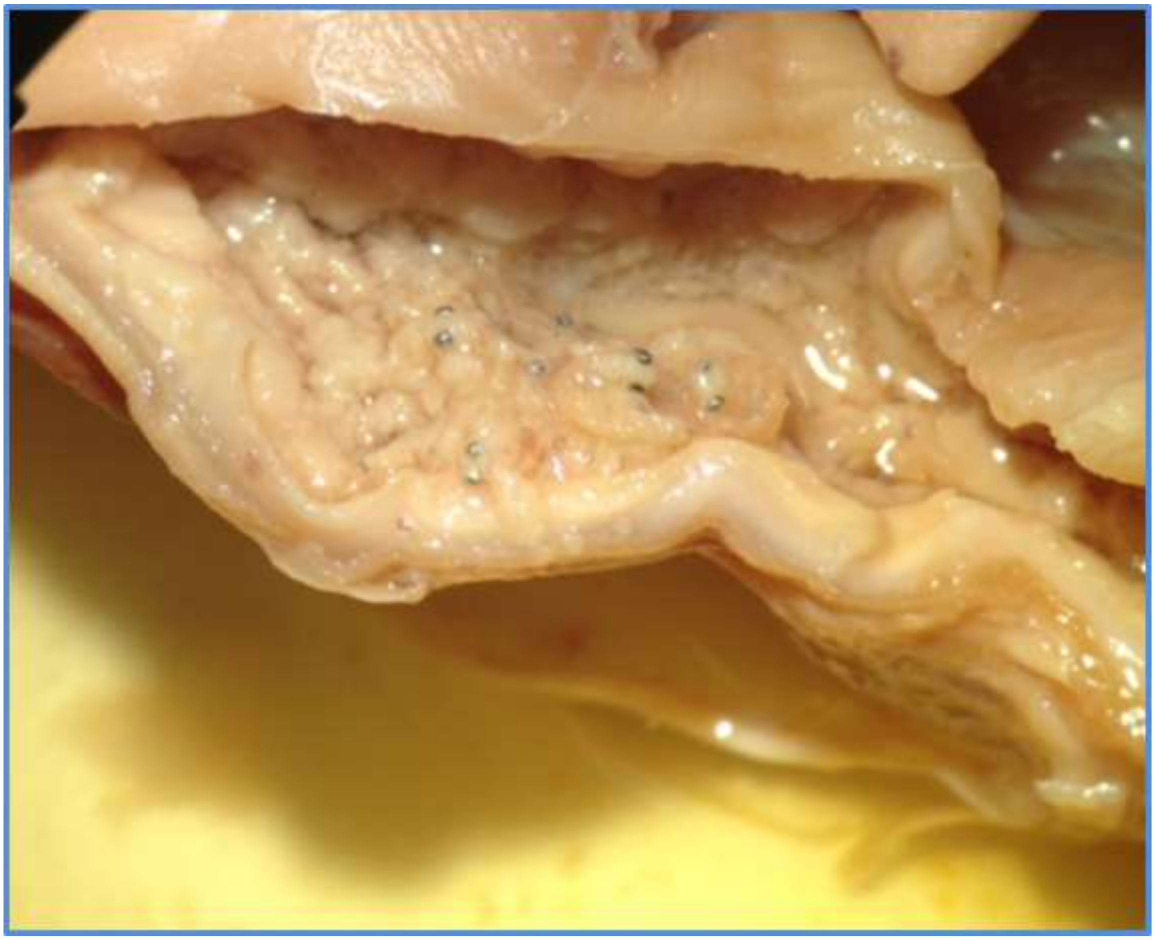

Figure 6. White bass stomach containing fish larvae.

Figure 7. Yellow bass stomach containing fish eggs.

Figure 8. Yellow bass stomach containing crayfish and insect larvae.

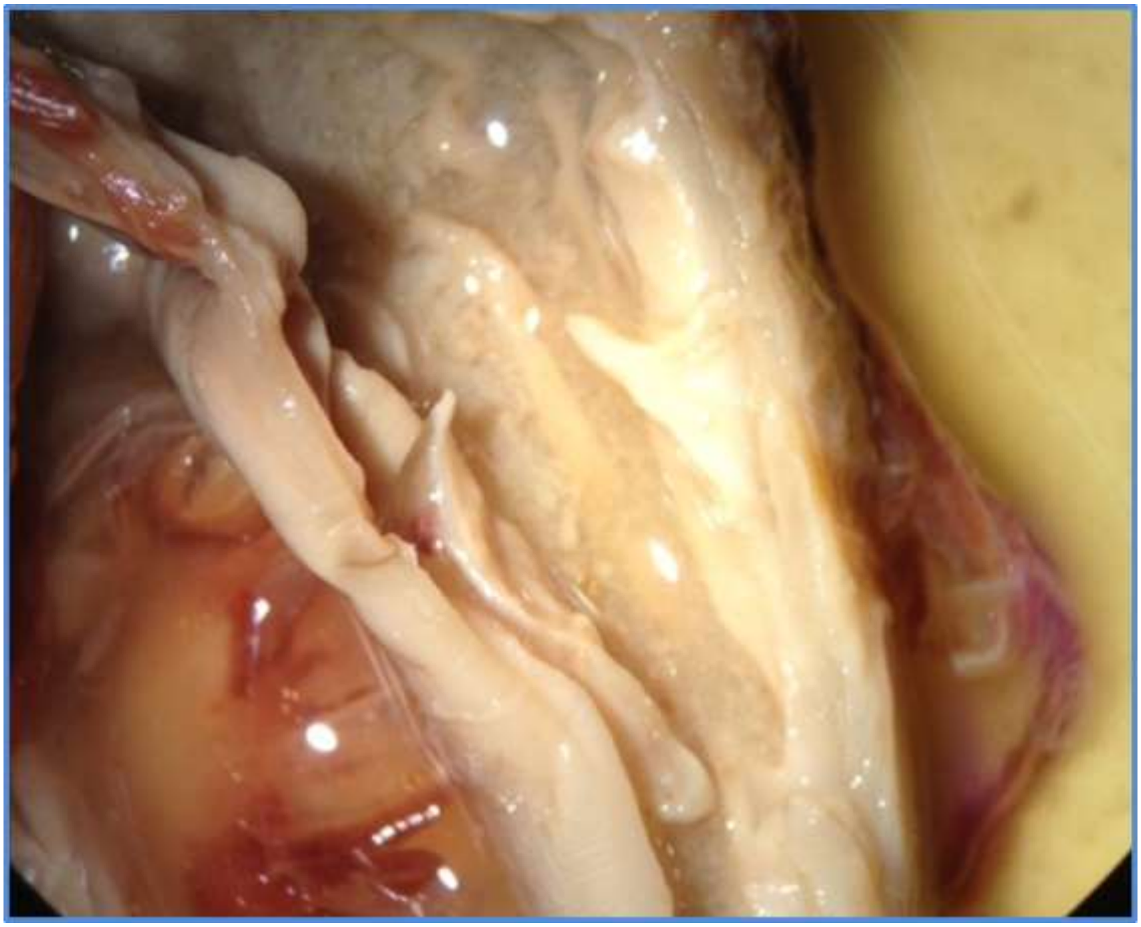

Figure 9. White bass with an empty stomach.

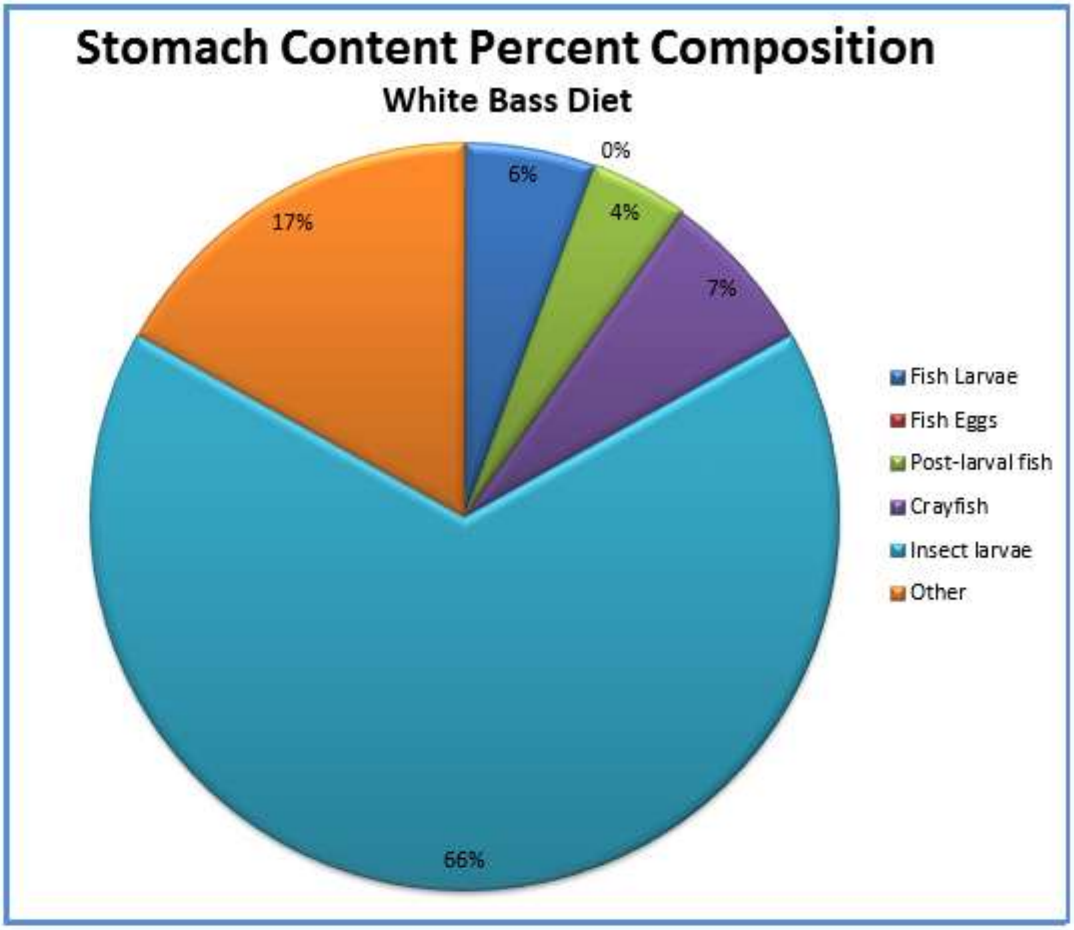

Figure 10. Diet of all white bass collected from Barren River, Allen County, Kentucky, in spring 2012.

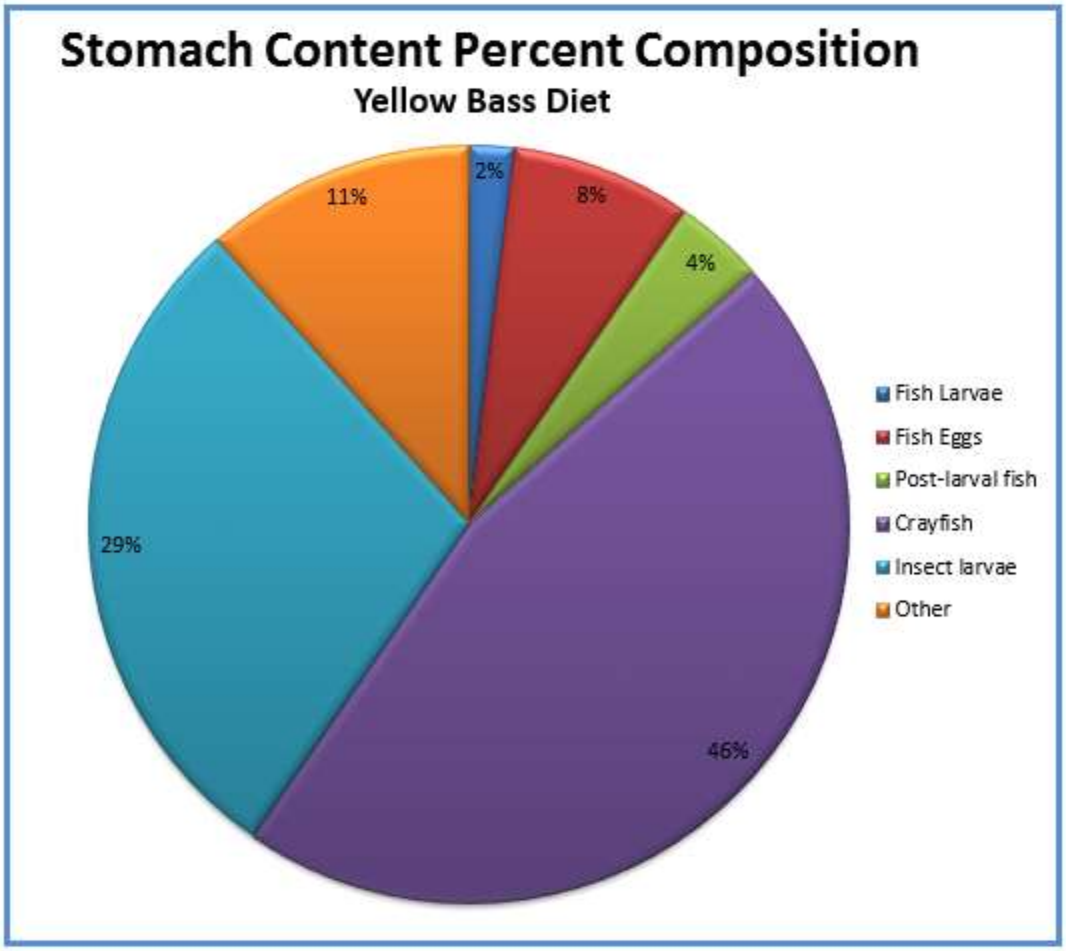

Figure 11. Diet of all yellow bass collected from Barren River, Allen Country, Kentucky, in spring 2012.

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