# DIET AND CONDITION OF AMERICAN ALLIGATORS (*Alligator mississippiensis*) IN THREE CENTRAL FLORIDA LAKES

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

UNIVERSITY OF FLORIDA

2004

## ACKNOWLEDGMENTS

I am very grateful to Dr. J. Perran Ross who made it possible for me to be involved in such an amazing project. Dr. Ross was always patient and provided encouragement when needed. He taught me many things that will stay with me throughout my career. My parents, John and LeeLonee Rice, graciously supported me throughout my graduate work. Their support and earlier guidance gave me what I needed to be successful. My other committee members, Dr. H. Franklin Percival and Dr. Mike S Allen, both contributed to my success during my graduate work.

Many people helped me learn the necessary skills to handle this job. Notable among them were P. Ross, Allan “Woody” Woodward, Chris Tubbs, Dwayne Carbonneau, Arnold Brunnell, Chris Visscher, and John White. Woody Woodward was especially helpful with understanding basic alligator ecology and with fieldwork. Field techs C. Tubbs, Esther Langan, Rick Owen, Jeremy Olson, and Chad Rischar were essential to the project. Many great volunteers helped late into the night catching and lavaging alligators.

The Florida Museum of Natural History’s (FLMNH) ornithology, mammology, ichthyology, herpetology, and zoo archaeology collection managers and their reference collections were invaluable with species identification. My lab assistants E Langan, Anthony Reppas, and Patricia Gomez were all very helpful in painstakingly sorting through the stomach samples. Richard Franz, Mark Robertson, Dr. Kenny Krisko, Cameron Carter, Rob Robbins, Christa Zweig, Jamie Duberstein, and Hardin Waddle were all valued contributors to this effort.  Many friends and family members were also supportive of me throughout my graduate career.  The St. Johns River Water Management District, Lakewatch Lab, and the Volusia County Environmental Lab willingly shared their water quality data.  The St. Johns River Water Management District, Lake County Water Authority, Florida Fish and Wildlife Conservation Commission, Florida Museum of Natural History and the Florida Cooperative Fish and Wildlife Research Unit provided essential funding, facilities, and/or equipment for this project.

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Requirements for the Degree of Master of Science

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May 2004

Chair: H. Franklin Percival
Major Department: Natural Resources and Environment

Understanding the diet of crocodilians is important because diet affects condition, behavior, growth, and reproduction. By examining the diet of crocodilians, valuable knowledge is gained about predator-prey interactions and prey utilization among habitats. In this study, I examined the diet and condition of adult American alligators (*Alligator mississippiensis*) in three central Florida lakes, Griffin, Apopka, and Woodruff. Two hundred adult alligators were captured and lavaged from March through October 2001, from April through October 2002, and from April through August 2003.

Alligators ate a variety of vertebrate and invertebrate prey, but vertebrates were more abundant and fish dominated alligator diets in the lakes. Species composition of fish varied among the lakes. The majority of the diet of alligators from Lakes Apopka and Woodruff was fish, 90% and 84% respectively. Lake Apopka alligators consumed a significantly (P = 0.006) higher proportion of fish in their diet. Fish were 54% of the diet of Lake Griffin alligators and the infrequent occurrence of reptiles, mammals, birds, and

amphibians often resulted in a large biomass. Differences in alligator diets among lakes may be due to differences in sample size (higher numbers of samples from Lake Griffin), prey availability, habitat, prey vulnerability, or prey size.

Alligator condition (Fulton's Condition Factor, K) was significantly ($P < 0.001$) different among the lakes. Alligators from Lake Apopka had the highest condition, followed by those from Lake Griffin, and alligators from Lake Woodruff had the lowest condition. Composition of fish along with diversity and equitability of fish in alligator diets may have contributed to differences in condition among lakes. Condition was probably also due to factors other than diet such as alligator hunting behavior, alligator density, or year-round optimal temperature that prolongs feeding. The observed diet and condition differences probably reflect both habitat differences and prey availability in these three lakes.

# CHAPTER 1
# INTRODUCTION

Understanding the diet of crocodilians is important because diet affects condition, behavior, growth, and reproduction (Chabreck 1972, Delany and Abercrombie 1986). Many crocodilian food habits studies have been conducted (Fogarty and Albury 1968, Chabreck 1972, Valentine et al. 1972, Taylor 1979, Webb et al. 1982, Delany and Abercrombie 1986, Taylor 1986, Magnusson et al. 1987, Wolfe et al. 1987, Delany et al. 1988, Delany 1990, Platt et al. 1990, Webb et al. 1991, Thorbjarnarson 1993, Barr 1994, Santos et al. 1996, Tucker et al. 1996, Barr 1997, Delany et al. 1999, Silveira and Magnusson 1999, Platt et al. 2002, Pauwels et al. 2003). Diet explains much about predator-prey interactions and prey utilization among habitats. This allows managers to better assess the importance of crocodilians in the ecosystem. In this study, I compared the diet and condition of adult American alligators (*Alligator mississippiensis)* among populations from three central Florida lakes, Griffin, Apopka, and Woodruff.

American alligators inhabit fresh and brackish wetlands throughout their range in the southeastern United States including all of Florida. American alligators are considered a species of special concern in Florida, are listed federally as threatened due to similarity of appearance because of their resemblance to the endangered American crocodile (*Crocodylus acutus)*, and are listed under CITES Appendix II (Ross 1998).

Condition analyses provide scientists with an easy mechanism to explore the health of a species in its ecosystem (Murphy et al. 1990). Taylor (1979, p 349) defined condition as "the relative fatness of the crocodile, or how much its food intake exceeds that needed for homeostasis and growth….it is a measure of how well that animal is coping with its environment." The various condition indices provide a numerical condition score that is based on a skeletal length and a volumetric measurement (Zweig 2003). Crocodilian condition has been shown to vary among habitats and be associated with crocodilian diets (Taylor 1979, Santos et al. 1994, Delany et al. 1999). In this study, I compared condition of alligators among three lakes.

There is a need to assess and explore how crocodilian diets and condition vary in lakes with different habitats because as lakes change over time the prey available to the alligators changes, thus changing their diet. This modification in alligator diets may affect and change their overall condition. Many of Florida's lakes have changed from a macrophyte-dominated lake to a polluted algae-dominated lake (Fernald and Purdum 1998). These lake changes, which are mostly due to anthropogenic causes, affect the predators and prey that occupy them.

In addition to the need to compare alligator diets and condition among habitats, both Lakes Griffin and Apopka have experienced alligator mortality that is unexplained (Woodward et al. 1993, Schoeb et al. 2002) and may or may not be related to their diet and condition. Between 1997 and 2003, 442 sub-adult and adult alligators on Lake Griffin died (D. Carbonneau, Florida Fish and Wildlife Conservation Commission, personal communication). The cause for this alligator mortality has been investigated, but no clear conclusions have emerged (Schoeb et al. 2002). Nutritional deficiencies, specifically thiamine deficiencies, in alligator diets (i.e., alligator ingestion of fish with high levels of thiaminase) were speculated as a cause and therefore an investigation of alligator diets was warranted (Schoeb et al. 2002). Between 1980 and 1989 juvenile alligator populations and clutch viability (number hatch/total eggs in a clutch) declined in Lake Apopka and there were reports of adult alligator mortality on the lake as well (Woodward et al. 1993, Rice 1996). The cause of this is also unknown but may have been related to pesticides that entered the lake through agriculture, or a chemical spill of the pesticide dicofol that occurred in 1980 near the southwest part of Lake Apopka (Woodward et al. 1993). Dicofol contained DDT and, therefore, its impact on the system and wildlife was a cause for concern (Rice 1996). Lake Woodruff has had little agriculture and development associated with it and alligators on Lake Woodruff have had a consistently high reproductive rate (Woodward et al. 1999), indicating that this system is overall the healthiest of the three and therefore it was considered the reference lake in this study. This study does not attempt to explore or determine the cause of the alligator mortality on the lakes, but rather it will offer diet and condition data that may or may not be associated or related to the problems.

## Study Site

Three central Florida lakes, Griffin, Apopka, and Woodruff National Wildlife Refuge (NWR) were chosen to compare the alligator diets and condition across populations (Figure 1-1). Lake Griffin is located in Lake County, Florida (28º 50’ N, 81º 51’ W) (Figure 1-2); Lake Apopka is located in Lake and Orange Counties, Florida (28º 37’ N, 81º 37’ W) (Figure 1-3); and Lake Woodruff NWR is located in Volusia County, Florida (29º 06’ N, 81º 25’ W) (Figure 1-4). This study was conducted on Lake Woodruff and the surrounding areas including Spring Garden Lake, Spring Garden canal, Mud Lake, and the canal that connects Lake Woodruff to Mud Lake (Figure 1-4), which are all part of the Lake Woodruff NWR.

Lakes Griffin and Apopka are hypereutrophic, alkaline, polymictic, shallow water bodies and are a part of the Ocklawaha chain of lakes (Table 1-1). Throughout much of the early 1900's both lakes were clear, macrophyte-dominated lakes known for their excellent largemouth bass (*Micropterus salmoides)* fishing. However, between 1950 and 1970 both lakes dramatically changed due to water level controls, diking associated marshes and runoff from urban areas, sewage, agriculture and citrus farming effluent. Rapid trophic changes as well as pollution from organo-chemicals resulted.

Since the late 1990's both lakes experienced restoration efforts conducted by the St. Johns River Water Management District (SJRWMD). External phosphorus loading was reduced by elimination of farming on adjacent land (Fernald and Purdum 1998). Both citrus farming, which ended in the mid-1980's due to several freezes, and muck farming ended and marsh flow-way filtration systems were constructed. This wetland filtration was designed to filter the lake water and remove suspended solids and phosphorus. Lake water was circulated through a restored marsh on the former farms and this is designed to filter the entire lake twice a year (Bachmann et al. 2001). Gizzard shad were removed from the lake as a way to remove phosphorus and reduce bioperturbation. Finally, macrophytes were planted in shallow areas to encourage game-fish habitat (Lowe et al. 2001).

Lake Woodruff NWR is a macrophyte-dominated, eutrophic, alkaline lake and is part of the St. Johns River system (Table 1-1). Lake Woodruff has little human development on its perimeter and has been affected far less from anthropogenic causes compared to Lakes Griffin and Apopka.

## Objectives

One objective of this study was to investigate the hose-Heimlich technique for accuracy and dependability in obtaining the stomach contents from live adult American alligators. The main objective of this study was to analyze and compare the diet and condition of adult American alligators across populations and among habitats.

Table 1-1. Lake characteristics and water chemistry data. Water quality data are given by means with ± the standard deviation.

| Lake | Mean Depth (m) | Total Surface Area (ha) | Open Water Surface Area (ha) | Year | pH | Total Phosphorus (µg/l) | Total Nitrogen (µg/l) | Chlorophyll *a* (µg/l) | Secchi Depth (m) |
|---|---|---|---|---|---|---|---|---|---|
| Griffin[1] | 2.67 | 5742.2 | 3963.8 | 2001 | 8.7 | 77.6 ± 21 | 4046 ± 898 | 108 ± 49.5 | 0.35 ± 0.15 |
| | | | | 2002 | 8.5 | 57 ± 16 | 3013 ± 902 | 70 ± 50.4 | 0.48 ± 0.18 |
| | | | | 2003 | 8.8 | 50 ± 7 | 2492 ± 241 | 45 ± 27 | 0.57 ± 0.24 |
| Apopka[1] | 1.65 | 12960.2 | 12169.7 | 2001 | 8.9 | 152 ± 19 | 5264 ± 986 | 72 ± 16 | 0.27 ± 0.03 |
| | | | | 2002 | 8.9 | 190 ± 48 | 6450 ± 1427 | 86 ± 25 | 0.25 ± 0.04 |
| | | | | 2003 | 9.5 | 159 ± 33 | 5071 ± 677 | 86 ± 22 | 0.29 ± 0.02 |
| Woodruff[2] | 1.84 | 6553.7 | 1269 | 2001 | 8.3 | 98 ± 1 | 1470 ± 116 | 32 ± 14 | 1.55 ± 0.21 |
| | | | | 2002 | 7.3 | 80 ± 16 | 1341 ± 176 | 22 ± 19 | 2.1 ± 0.38 |
| | | | | 2003 | 7.4 | 77 ± 16 | 1160 ± 138 | 4.8 ± 4.3 | 0.83 ± 0.15 |

[1]Data provided by St. Johns River Water Management District

[2]Data provided by Volusia County Environmental Lab

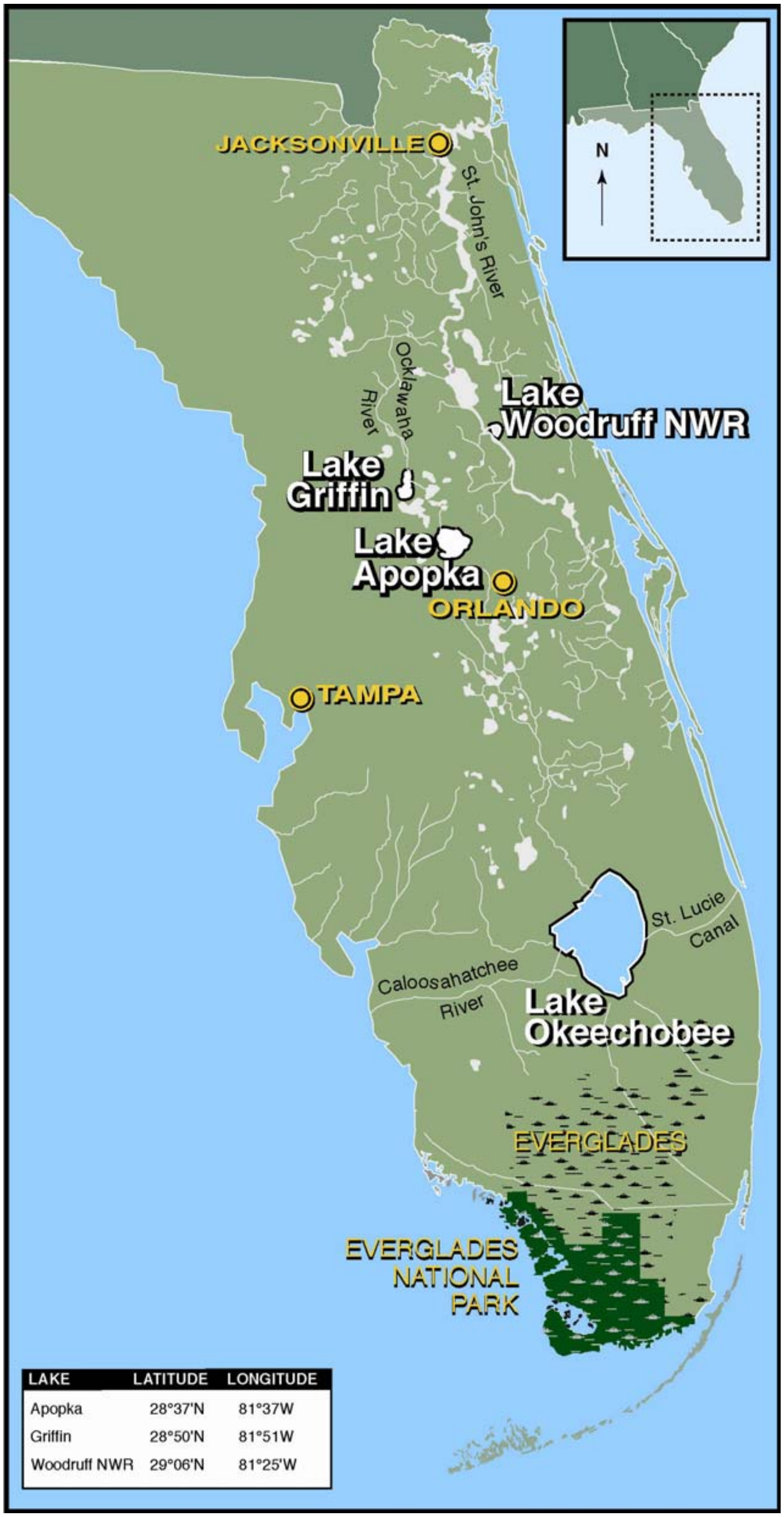


Figure 1-1. Location of study site, Lakes Griffin, Apopka, and Woodruff, in Florida.

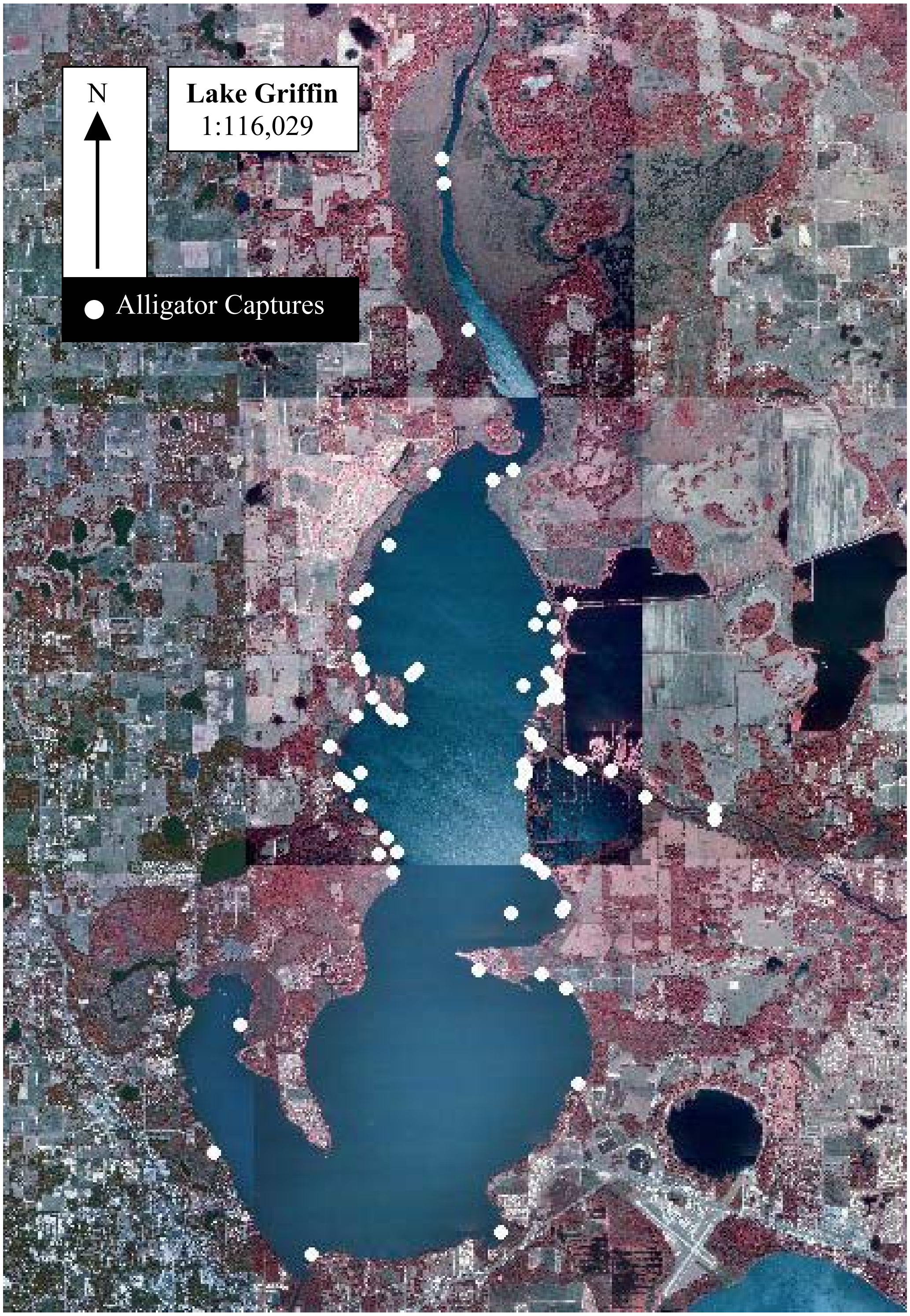


Figure 1-2. Aerial photo of Lake Griffin, Lake County, Florida. Note extensive urban development on the south and west sides. The dark area on the central east side is the restored marsh on previous agriculture land.

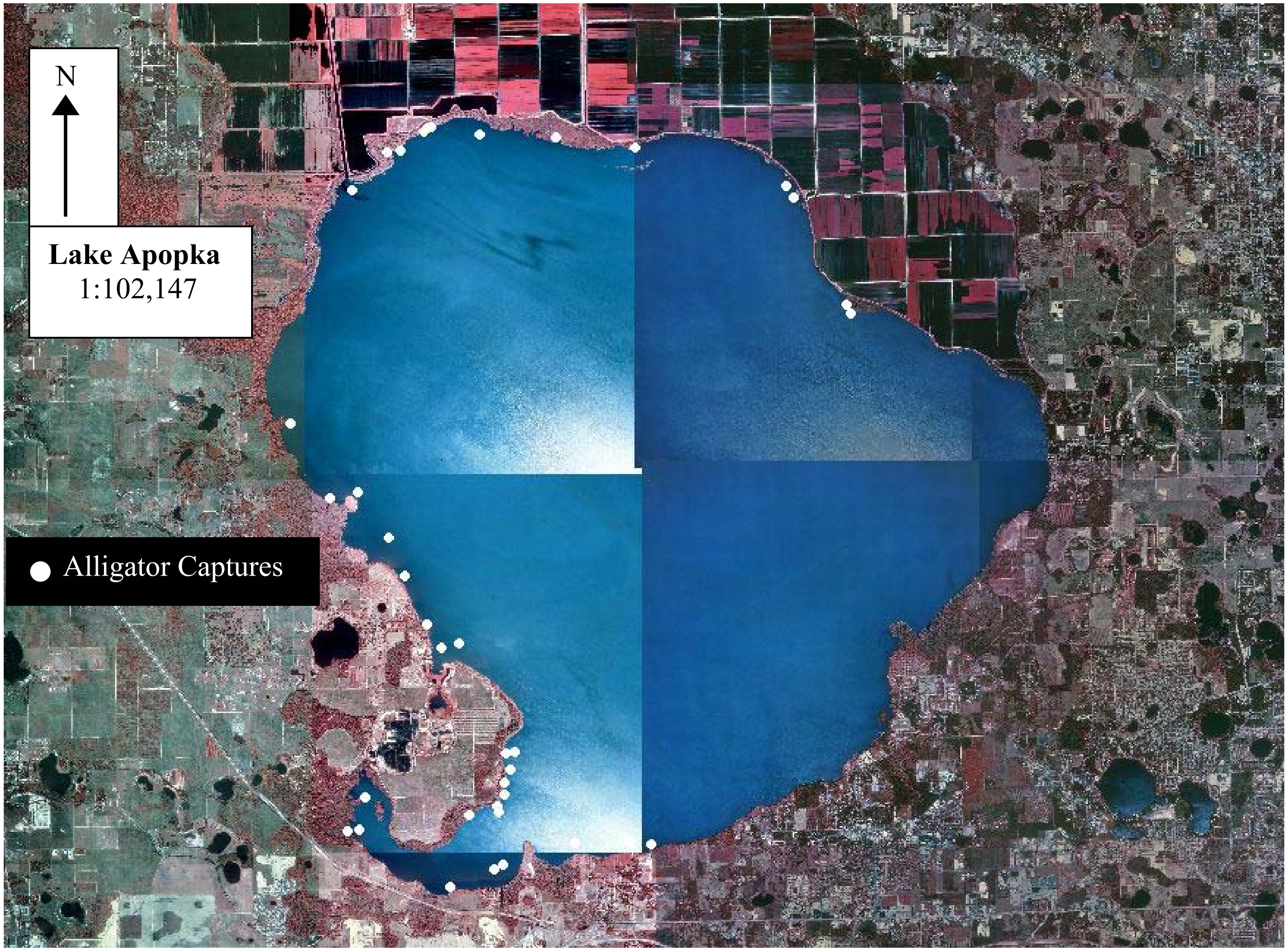


Figure 1-3. Aerial photo of Lake Apopka, Lake and Orange Counties, Florida. The dark rectangular sections on the north side are former agricultural land now reverted to restored marsh.

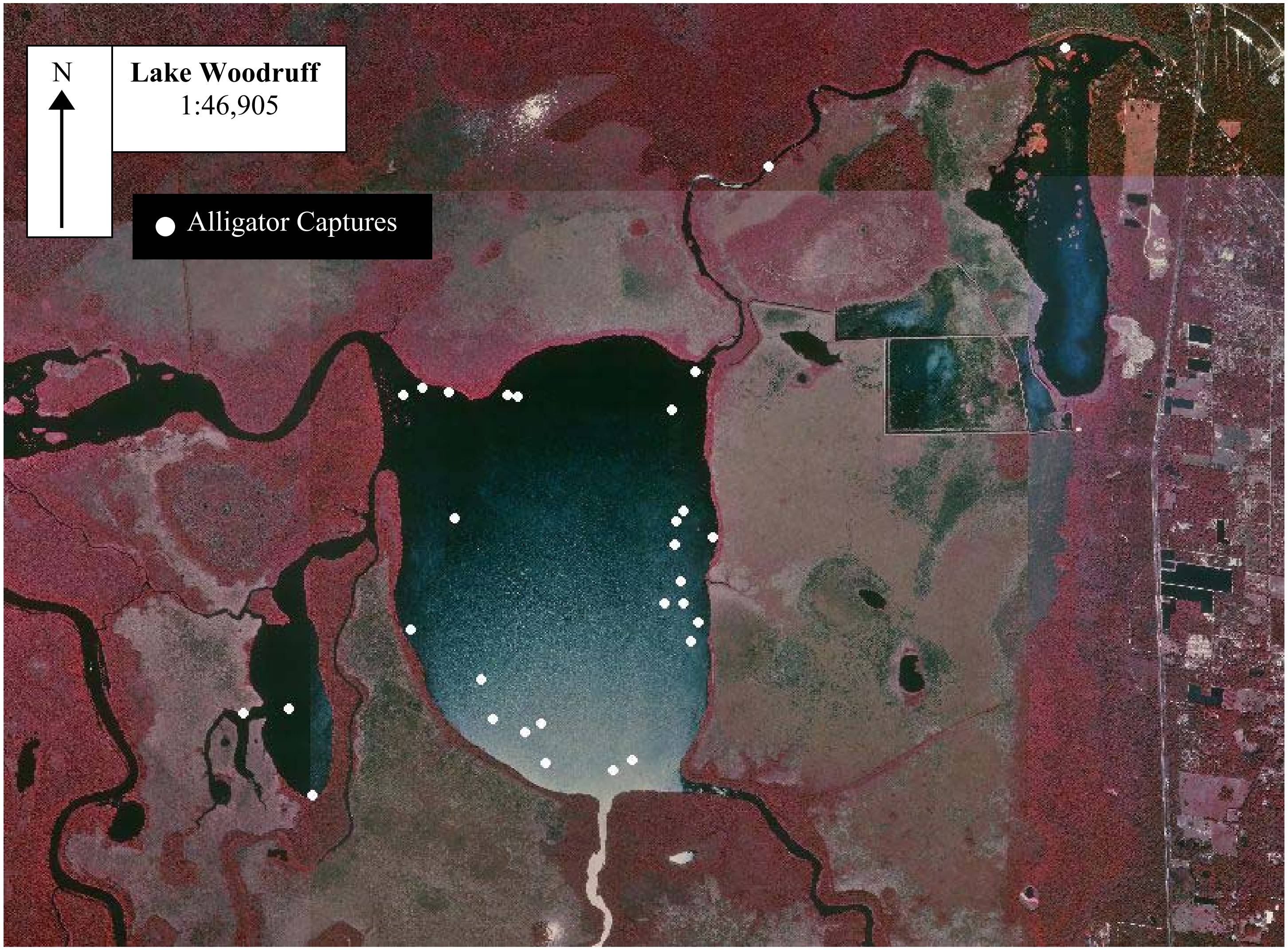


Figure 1-4. Aerial photo of Lake Woodruff and surrounding areas, Volusia County Florida. Notice the general absence of human settlement around the lakes.

# CHAPTER 2
# HOSE-HEIMLICH TECHNIQUE

## Introduction

Animal diets can be studied by observing what it eats, feeding trials on captive animals, biochemical and isotope analysis, or most simply by obtaining samples of the ingested food from the stomachs of wild animals. Stomach contents can be obtained post-mortem from specimens killed for that purpose or collected incidentally from commercial harvests, and several alligator diet studies used stomachs from hunter harvested alligators (Table 2-1). However, many crocodilian species are threatened or endangered and there are ethical and practical constraints on killing animals for study. Therefore, non-lethal methods have been developed to obtain stomach contents from live animals without causing harm.

Non-lethal methods used to obtain the stomach contents fall into three categories: invasive scoops that mechanically retrieve material through the esophagus (Taylor et al. 1978), irrigation methods that introduce water and flush material from the stomach (Taylor et al. 1978) and combinations of the former two (Webb et al. 1982) (Table 2-1). In this study, I used the hose-Heimlich technique (Fitzgerald 1989). My application of this method is described in detail below and combined water flushing, gravity and squeezing to expel the crocodilian stomach contents. This method was compared and tested against other stomach flushing techniques and it was found to be less invasive than the scoops and the most reliable (Fitzgerald 1989). The hose-Heimlich technique removed 100% of the food items; however, a few of the subject animals retained some rocks (Fitzgerald 1989). The hose-Heimlich technique is superior for obtaining the stomach contents of live crocodilians and it was used in this study.

All of the stomach flushing methods caused minor irritations to the esophagus and cardiac sphincter; however, no long-term effects have been observed (Fitzgerald 1989). In some studies, the animals were held in captivity for several days or recaptured after release and in both cases, the crocodilians showed no long lasting effects from the stomach flushing procedures (Taylor et al. 1978, Webb et al. 1982, Fitzgerald 1989).

There are advantages and disadvantages to the stomach flushing techniques. Although it provides the best results, the hose-Heimlich technique requires water under pressure, while the various scoop and pump methods are more portable and do not require water under pressure (Fitzgerald 1989). The hose-Heimlich technique has been modified to be more portable by using a bilge pump or a gas-powered motor (Barr 1994, 1997). This allows researchers to lavage the crocodilian in the field where a domestic water source may not be available. Considering that the hose-Heimlich technique can be performed in the field, it was the method of choice because it provides the best results.

## Method

I first tested the accuracy and reliability of the hose-Heimlich technique on 20 alligators, which were lavaged and then examined at necropsy to determine the proportion of contents recovered. In addition, we checked for any irritations to the esophagus or stomach due to the insertion of the hose.

To perform the hose-Heimlich technique, the alligator was strapped to a 245 cm x 31 cm plywood board and placed at an incline, resting on a wood sawhorse. The jaws were secured opened with a heavy-duty PVC pipe (200 mm length, between 60 and 150 mm diameter) of appropriate size. The soft Teflon hose of appropriate size (5 mm to 15 mm diameter) was coated with mineral oil and inserted into the esophagus and then into the stomach of the alligator (Figure 2-1). An external marker indicating the posterior end of the stomach (fourth whirl of scutes anterior to hind legs) allowed confirmation of proper placement of the hose. The lavaging hose was connected to a garden hose, which was connected to the water source. The water source was from a domestic water supply, or from the lake using a 2839 liters per hour bilge pump or a 3.5 hp Briggs and Stratton motor driven pump, and all provided around 50 liters per minute of water.

The alligator was then angled down with its mouth positioned over a 68-liter bucket. With the water source running, the animal was squeezed in a 'Heimlich maneuver' (Heimlich 1975) resulting in the expulsion of stomach content and water into the bucket. This lavaging process was repeated until only clear water was entering the bucket. The contents in the bucket were poured through a 0.5 mm mesh nylon strainer and collected in 10% buffered formalin in 1L plastic jars labeled with lake, date, and identification numbers on each jar.

## Results

The hose-Heimlich technique (process described above) was an effective way to obtain the stomach contents from live alligators. In 2001, this technique was tested on 20 alligators that were destined for euthanasia and necropsy. In all but one case, all contents were obtained through this process with little ill effect on the alligators. Minor irritations were observed on the alligator's esophagus and cardiac sphincter. In addition, during this study we recaptured three alligators that had been previously lavaged. These alligators appeared healthy with no ill effects from the hose-Heimlich technique.

During our initial testing, we observed one instance where the hose-Heimlich technique was incomplete. During the necropsy, we found a large piece of gar

(*Lepisosteus spp.)* that was blocking the sphincter and not allowing water and contents to exit the alligator. Therefore, an incomplete hose-Heimlich process was characterized by low water and content output from the alligator and bloating of the stomach area making it impossible to squeeze. During this study, an incomplete sample occurred four times and on these rare occasions, the samples were not used in any of the diet analyses.

The hose-Heimlich technique was used as a portable method to obtain stomach contents. The work up area at Lake Woodruff had no electricity or running water, therefore, we used either a bilge pump (2839 liters per hour) or a gas powered motor (3.5 horse power) to obtain water under pressure. Both optional water sources worked as well as water from a domestic water source.

The hose-Heimlich technique was most successful on alligators under 304 cm total length (TL). Two separate attempts to lavage alligators 304 cm TL failed because of insufficient power available to squeeze the alligator's large abdominal area. The largest alligator that was successfully lavaged was 290 cm TL. Therefore, the hose-Heimlich technique was a reliable method to obtain stomach contents on live alligators ≤ 290 cm TL.

## Discussion

The hose-Heimlich technique has been used in several studies where it was a successful way to obtain the stomach contents from live crocodilians (Fitzgerald 1989, Barr 1994, 1997). This study also showed the reliability and effectiveness of the hose-Heimlich technique. Fitzgerald (1989) tested the hose-Heimlich technique for effectiveness on spectacled caiman (*Caiman crocodilus*) and found that it was the best stomach flushing technique and it removed 100% of the caiman's food content. However, Fitzgerald (1989) did find that some caiman retained some stones in their stomach. After evaluating this technique, we also found that there were times when recovery of the stomach contents was incomplete. Some researchers did not evaluate the effectiveness of the technique, and accepted Fitzgerald's (1989) extensive evaluation of the method (Barr 1994, 1997). However, by evaluating the technique I became convinced in its effectiveness and was confident in using this technique to compare food habits among lakes.

The hose-Heimlich technique did cause minor irritations to the alligator's esophagus and cardiac sphincter. Fitzgerald (1989) evaluated any ill effects due to the hose-Heimlich technique and found that only minor irritations to the esophagus occurred. He concluded that these were not long lasting effects. We also found some abrasions on the alligator's esophagus and cardiac sphincter, but believe that these were minor and temporary. Animals kept in captivity and those recaptured all appeared normal after receiving the hose-Heimlich technique (Fitzgerald 1989, Barr 1997).

American alligators are a very abundant species of crocodilian and nine diet studies obtained stomachs from harvested animals (Table 2-1). In addition to using the hose-Heimlich technique to obtain stomach samples, I utilized stomachs from alligators killed for other research. There was 100% reliability of obtaining all the stomach contents when the alligators were killed. In addition, harvested alligators may be preferable when investigating the diet of large alligators (i.e., > 290 cm TL). However, there are non-lethal methods, such as the hose-Heimlich technique that offer a way to reliably obtain the stomach contents from live alligators.

There are some disadvantages to using the hose-Heimlich technique in an alligator food habit studies. Fitzgerald (1989) identified the need for water under pressure as a disadvantage to the hose-Heimlich technique. However, by using a bilge pump or gas powered motor, we adapted the method for use where a domestic water source was unavailable. Barr (1997) also used a portable water pump to flush hundreds of alligator stomachs. In addition, during this study the hose-Heimlich technique proved to be most effective on alligators ≤ 290 cm TL, therefore this technique may not be effective to use on alligators > 290 cm TL. The largest caiman Fitzgerald (1989) tested the hose-Heimlich technique on was 108 cm snout vent length (SVL) and the largest alligator Barr (1997) used this technique on was 317 cm TL.

Table 2-1. Summary of methods used to obtain the stomach contents from crocodilians.

| **Method** | **Crocodilian** | **Size Range** | **Reference** |
|---|---|---|---|
| Harvest | American alligator (*Alligator mississippiensis)* | ≤ 121 cm TL | Fogarty and Albury 1967 |
| Harvest | American alligator | < 182 cm TL | Chabreck 1972 |
| Harvest | American alligator | 60 - 335 cm TL | Valentine et al. 1972 |
| Harvest | American alligator | 220 cm (mean TL) | McNease and Joanen 1977 |
| Scoop and Pump | Saltwater crocodile (*Crocodylus porosus*) | < 180 cm TL | Taylor 1979 |
| Scoop with water method | Freshwater crocodile (*Crocodylus johnstoni)* | 16 - 122 cm TL | Webb et al. 1982 |
| Harvest | American alligator | 130 - 390 cm TL | Delany and Abercrombie 1986 |
| Harvest | American alligator | 183 - 373 cm TL | Taylor 1986 |
| Scoop with water method | Spectacled caiman (*Caiman crocodilus)*<br>Black caiman (*Melanosuchus niger)*<br>Dwarf caiman (*Paleosuchus palpebrosus)*<br>Smooth fronted caiman (*P. trigonatus)* | 10 - 60 cm SVL | Magnusson et al. 1987 |
| Harvest | American alligator | 150 - 300 cm | Wolfe et al. 1987 |
| Harvest | American alligator | 130 - 370 cm | Delany et al. 1988 |
| Harvest | American alligator | < 41 - 122 cm TL | Delany 1990 |
| Pump method | American alligator | 49 - 121 cm TL | Platt et al. 1990 |
| Scoop with water | Saltwater crocodile (*Crocodylus porosus)* | 30 - 120 cm TL | Webb et al. 1991 |
| Harvest | Spectacled caiman (*Caiman crocodilus*) | 20 - 90 cm SVL | Thorbjarnarson 1993 |
| Hose-Heimlich | American alligator | 82 - 122 cm TL | Barr 1994 |
| Scoop method | Yacare caiman (*Crocodylus yacare)* | < 50 cm - > 70 cm SVL | Santos et al. 1996 |
| Scoop and Pump | Freshwater Crocodile | 13 - 125 SVL | Tucker et al. 1996 |
| Hose-Heimlich | American alligator | < 38 cm - 317 cm TL | Barr 1997 |
| Harvest | American alligator | 109 - 389 cm TL | Delany et al. 1999 |
| Scoop with water method | Spectacled caiman (*Caiman crocodilus*) | 15 - 115 cm SVL | Silveira and Magnusson 1999 |
| Pump method | Morelet's crocodile (*Crocodylus moreletii)* | hatchlings | Platt et al. 2002 |
| Drowned animals | Slender-snouted crocodile (*Crocodylus cataphractus)* | 201 - 233 cm TL | Pauwels et al. 2003 |

Figure 2-1.  Hose-Heimlich technique on American alligator.

# CHAPTER 3
# ALLIGATOR DIET AND CONDITION

## Introduction

Alligators are opportunistic and adaptive predators that occupy a variety of habitats and exhibit a highly variable diet. Alligator diet studies have been concentrated in Louisiana (Valentine et al. 1972, Taylor 1986, Wolfe et al. 1987, Platt et al. 1990), north central and central Florida (Delany and Abercrombie 1986, Delany 1990, Delany et al. 1999), and southern Florida (Fogarty and Albury 1968, Barr 1994, 1997). All studies supported the general conclusions that small alligators ate invertebrates and larger animals ate more vertebrates, and that diet depended on prey availability and habitat. Alligators in these three regions of the southeastern US exhibited different dominant prey types, which reflected the different areas inhabited by the alligators and the prey availability in those habitats (Delany and Abercrombie 1986, Wolfe et al. 1987, Barr 1997). In this study, I compared the diet of the alligators among three lakes.

Alligator condition was analyzed in this study in order to determine if condition varies among habitats and across populations. Fulton’s condition factor was used in this study due to its ability to compare across populations. This condition index does have some limitations, including the assumption of isometric growth and there are no biological references for a “good” or a “bad” Fulton’s condition score (Zweig 2003). In addition, Fulton’s K should only be used to compare animals of similar lengths (Cone 1989, Anderson and Neumann 1996). Zweig (2003) examined condition indices in

American alligators and concluded that Fulton's K was the best condition index to use when comparing across populations.

## Methods

### Field Methods

Alligators were captured from lakes Griffin, Apopka, and Woodruff from March through October 2001, from April through October 2002, and from April through August 2003. I sampled adult alligators that were captured from an airboat, between 2000 and 0400 hours, by a capture dart and snare. Each alligator was marked with two Monel self-piercing tags (Natl. Band and Tag Co., Newport, Ky.) one in the third single dorsal scute of the tail and one in the middle web of the right rear foot. The sex of each alligator was determined by manual palpation. TL (tip of snout to tip of tail), SVL (tip of snout to posterior end of cloaca), tail girth (TG – circumference of the third whirl of scutes on the tail from back legs), and head length (HL – tip of snout to posterior end of scull) were measured with a flexible tape to the nearest 0.1 cm. Alligators were suspended in a canvas sling and weighed to the nearest 2 kg using a spring scale.

Stomach samples were obtained within three hours of capture using the hose-Heimlich technique (Fitzgerald 1989). Upon completion of the hose-Heimlich technique, alligators were released at or near the site of capture. Additional stomach samples were obtained during necropsy of alligators by other researchers. The stomach was removed from the alligator and stomach contents were extracted, washed with water through a 0.5 mm mesh nylon strainer, and stored in 10% buffered formalin.

### Laboratory Methods

Alligator stomach content samples obtained in the field were taken to the laboratory for analysis. Each sample was washed with water through a 0.5 mm mesh nylon strainer and then preserved in 70% ethanol. Samples were sorted in the lab by dividing the contents into major prey groups: fish, reptiles, mammals, birds, amphibians, gastropods, insects, crustaceans, or bivalves. Non-prey items were also divided up and labeled as either: plant material, wood, rocks, sand, nematodes, artificial objects, or other. Prey items were then identified to the lowest possible taxa by comparing them to reference collections (preserved specimens and skeletal collections) of the Florida Museum of Natural History (FLMNH). Minimum numbers of individuals were identified based on the occurrence of specific items, e.g., occurrence of each atlas vertebrae confirmed one specimen.

**Gastric Digestive Rate**

All prey items recovered in every stomach sample were categorized as either freshly ingested (fresh) or not freshly ingested (old) (Barr 1994, 1997, Delany and Abercrombie 1986). This process was very important to avoid over-representation of indigestible prey because alligators are unable to digest chitin and keratin (Garnett 1985, Magnusson et al. 1987). The following guidelines were established based on available literature to categorize each prey item as either "fresh" or "old."

**Fish.** Fish digest very quickly in alligator stomachs (Delany and Abercrombie 1986); however, not all fish digest at the same rate and only shiners (*Notemigonus crysoleucas)* were used in a digestive rate experiment by Barr (1994). Some fish may have less digestible, thus more persistent, body parts (i.e., thick scales or spines). In this study, fish were considered fresh if anything of the fish remained, except for scales or spines and old if only scales or spines remained.

**Turtles.** Turtle scutes, consisting of keratin, can persist in alligator stomachs, thus over representing the occurrence and importance of turtles in alligator diets (Barr 1997, Janes and Gutzke 2002). In this study, turtles were considered fresh if the turtle was intact or if portions of bone remained along with scutes and the beak and old if only the scutes and beak, or scutes alone remained.

**Snakes.** Snake scale, consisting of keratin, can persist in alligator stomachs (Barr 1997). In this study, a snake was considered freshly ingested if an intact body was found, or some body sections along with vertebrae and scales were identified and old if only scales remained.

**Mammals.** Mammal hair, consisting of keratin can persist in alligator stomachs (Barr 1997). In this study, mammals found in the samples were considered fresh if large pieces were recovered including the skull, vertebrae or long bones and hair and old if only hair persisted in the sample.

**Birds.** Bird feathers, consisting of keratin can persist in alligator stomachs (Barr 1997). In this study, birds were considered fresh if large parts of the body were recovered including long bones and feathers and old if only feathers were found in the sample.

**Amphibians.** Frogs are possibly under-represented in an alligator diet study due to their rapid digestibility (Barr 1997). In this study, any evidence of a frog in the sample was considered fresh. No frogs identified were considered old. Aquatic salamanders digest quickly in alligator stomachs (Delany and Abercrombie 1986). In this study, any evidence of aquatic salamanders was considered fresh.

**Gastropods.** The opercula of freshwater snails contain chitin, which is indigestible by alligators and therefore they can accumulate in alligator stomachs (Garnett 1985, Barr 1994, 1997). In this study, snails with flesh attached and flesh recently detached were considered fresh and samples containing opercula and shell pieces only were old.

**Bivalves.** Freshwater mussels occurred in some samples; however, no digestive rate studies have included bivalves. In this study, bivalves were treated similarly to gastropods, meaning samples with flesh were considered fresh and samples with only the shell were considered old.

**Insects.** An insect's exoskeleton contains chitin and is indigestible by alligators (Garnett 1985). In this study, only intact insects were considered fresh and insects found in pieces were considered old.

**Crustaceans.** Chelipeds from crayfish (*Procambarus spp.)* can remain in alligator stomachs for over 108 hours (Barr 1997). In this study, only intact crustaceans (main body – cephalothorax and abdomen) were considered fresh. Evidence of crustaceans by other parts of the body was considered old.

**Biomass of Fresh Prey**

Prey from the alligator stomach content samples identified as fresh were further analyzed to estimate their live mass. This was accomplished in several ways. The majority of live mass of the fresh prey was determined through allometric scaling. This method was based on a linear measurement of a skeletal item (e.g., the atlas vertebrae) to determine live fresh mass (Casteel 1974, Reitz et al. 1987, Brown and West 2000). This included measuring a well preserved part of the prey (e.g., the skull or vertebrae) and comparing it to the linear relationship to obtain both standard length and mass of the ingested prey.

Available field data were also used to determine live mass. The standard length of the prey was first determined by comparison of the same preserved species in the

FLMNH. The average live mass of the same size prey was estimated from field data. In some cases, the live mass was obtained directly from museum specimens that had weight data. In addition, three reference books (Burt and Grossenheider 1980, Dunning 1993, Hoyer and Canfield 1994) were used to estimate live mass by obtaining the average adult mass for a specific species of prey. Fresh mass of invertebrates (except for the Gastropods) was determined by directly weighing them to the nearest 0.01 g. The intact invertebrates were stored in 70% ethanol for various lengths of time; therefore, this estimation method represented their lowest possible mass due to the drying effects of ethanol. Nevertheless, I decided that this was a close approximation to their live mass and it was used in this analysis. Table 3-1 summarizes the biomass estimation methods that were used for each prey group.

## Analysis

### Quantitative diet analysis

The diet data were analyzed to detect differences in the diet of the alligators among the lakes. Frequency of occurrence and percent composition by live mass were used to quantitatively analyze the diet data (Bowen 1996). The equation for frequency of occurrence was:

$$n/t * 100$$

where n = the number of stomach content samples containing a given food item and t = the total number of stomach content samples. This analysis included all stomach content samples and was applied to stomach content samples containing fresh prey as a comparison.

Percent composition by live mass utilized the estimated biomass data; therefore, this analysis only included stomach content samples with fresh prey. Percent composition by live mass was calculated by adding all the individual specimen biomass estimations for a prey group and dividing that by the total biomass for the lake. This was calculated for each prey group in all three lakes and this established the percentage of the diet each prey group represented. Percent composition by live mass was also used to calculate the percentage of the diet made up by each prey taxa within each lake. This was calculated by dividing the prey taxa biomass by the total biomass for the lake.

The alligator diet data were expressed in a clear and meaningful manner by categorizing all prey items as fresh or old, reporting frequency of occurrence for all samples and samples containing only fresh prey items, and by reporting percent composition by live mass. This recipe for analyzing crocodilian diets reported all the data, while emphasizing an in depth analysis on fresh prey items. With this method, over-representation of certain prey items was avoided, while the truly important prey items were clearly identified and quantified.

**Condition analysis**

A condition score was calculated for each alligator sampled to compare the overall condition of alligators among lakes. The Fulton's Condition factor, K, (Zweig 2003) was used in this study to determine each alligator's condition. The equation for K was:

$$K = W/L^3 * 10^n$$

where W = mass of the alligator in kg, L = SVL in cm, and n = 5. The range of condition scores for alligators in all lakes was also divided into quartiles for a comparison and assigned a rank. The mean condition score for the alligators in the lakes fell into one of the following four ranks: low condition, low to average condition, average to high condition, or high condition.

The condition of smaller alligators ranging in size from 182 to 304 cm TL from all lakes was also compared because the proportion of alligators in each quartile was not equally distributed among the lakes. This analysis was compared against the overall condition analysis to see if the disproportionate sizes of the alligators caught among the lakes affected the overall condition results.

**Diversity and equitability**

The Shannon-Wiener Diversity Index, H' (Krebs 1999) was used to compare the diversity of alligator diets among the lakes. The formula for calculating the Shannon-Wiener diversity index, H', was:

$$H' = \sum_{i=1}^{s} (Pi)(LNPi)$$

where s = the number of taxonomic categories, Pi = the proportion of samples of the i$^{th}$ taxon and the natural log of the proportions was used (Krebs 1999).

Sheldon's Equitability Index, E (Ludwig and Reynolds 1988), was used to determine if the alligators were consuming prey evenly and to compare it among lakes. The formula for calculating the Sheldon's Equitability Index, E, was:

$$E = H'/LNs$$

where H' = the Shannon-Wiener Diversity Index, s = the number of taxonomic categories, and the natural log was used in the analysis (Ludwig and Reynolds 1988).

The Shannon-Wiener Diversity Index and the Sheldon's Equitability Index were calculated using the minimum number of taxa (MNT) identified in the stomach samples for each lake. MNT included all prey identified to species level and also included prey identified to genus or family when no other members were identified to a lower taxa in the same group. For example, if the prey identified included *Dorosoma spp.*, *Dorosoma* *cepedianum, Lepomis spp.,* Centrarchidae, and *Lepisosteus spp.*, the MNT would be three. *Dorosoma spp* would be lumped with *Dorosoma cepedianum* and Centrarchidae would be lumped with *Lepomis spp.* The MNT method allowed us to avoid artificially over representing the diversity of prey consumed (i.e., using all the taxa) and avoid under representing the diversity of the prey consumed (i.e., lump by family groups). This enabled us to clearly identify the diversity and equitability of prey consumed by the alligators and this was applied to samples containing fresh prey, and samples containing fresh fish. The diversity index ranges from zero to five and a greater diversity was indicated by a score closer to five (Krebs 1999, Ludwig and Reynolds 1988). The equitability index ranged from zero to one and a greater equitability of prey was indicated with a score closer to one (Ludwig and Reynolds 1988)

**Statistical analysis**

All statistical analyses were performed using SPSS software (SPSS 2000). The diet data did not meet the requirements of normality and homogeneity of variances; therefore, non-parametric statistics were utilized. Three statistical tests were used on the stomach content samples with fresh prey to identify any differences in the diet of alligators among lakes.

A chi-square test was performed to compare the frequency of occurrence of fish and other prey among the lakes. Mammals, birds, reptiles, and amphibians were lumped together to form the other prey group due to low cell count. The Kruskal-Wallis analysis of variance rank test was used to look for significant differences in the following two tests. The mean biomass for the samples containing fresh prey was compared among lakes. I hypothesized that the amount of prey consumed by the alligators would vary and therefore the mean biomass consumed by the alligators would be different among lakes.

Percent composition of fish for each sample containing fresh prey was compared among the lakes. Percent composition of fish was calculated as fish biomass/total sample biomass * 100. I hypothesized that the proportion of fish in the alligator diets would be different and that alligators with the largest proportion of fish in their diet may also have the highest condition. When significant differences were found among lakes using the Kruskal-Wallis test, lakes were compared pair-wise using the Mann-Whitney U test.

Condition data were analyzed using parametric tests. The general linear model was used to detect differences in the condition of alligators. The LSD post hoc test was used to detect differences among lakes. Values for both diet and condition data were expressed as the mean ± one standard error unless otherwise indicated. Both diet and condition statistical tests used an alpha of 0.10, with the null hypothesis of no differences. The alpha was set at 0.10 due to the low sample size and in an effort to avoid a Type II error and increase the power in the analysis (Peterman 1990, Searcy-Bernal 1994).

**Abnormal Lake Griffin alligators**

Abnormal Lake Griffin alligators were sampled along with normal alligators during 2001. These alligators displayed neurological impairment (Schoeb et al. 2002) and these samples were analyzed separately and not compared among the lakes. These samples were analyzed in the same manner as the other samples, i.e., sorting to the lowest possible taxa and minimum number of individuals, categorizing prey as fresh and old, and estimating the fresh prey biomass. These samples will be reported and discussed separately from normal alligator samples.

# Results

## Alligator Diets among Lakes

American alligators ranging in size from 182 cm to 304 cm TL were captured from lakes Griffin, Apopka, and Woodruff from March to October 2001, from April to October 2002, and from April to August 2003. A total of 200 stomach content samples were obtained from the three lakes (Table 3-2). Twenty-five samples were dropped from the diet analyses because they were a recapture, an incomplete hose-Heimlich process occurred (described in Chapter 2), or the alligator was considered abnormal. Abnormal alligators were detected on Lake Griffin and were characterized as lethargic and unresponsive to humans. These alligators were known to suffer a neurological impairment of unknown causes (Schoeb et al. 2002), that might affect their feeding. When a recapture occurred, the first sample was used in all analyses. One hundred and thirty-seven of the 175 total stomach content samples for analysis were obtained from the hose-Heimlich method (Table 3-3); and 38 stomach content samples were obtained through alligator necropsies (Table 3-3).

Prey composition in the stomach samples varied greatly. Some samples contained intact or partially digested fresh prey specimens, some samples contained old mostly digested prey, some samples contained a combination of both, and some samples contained no food items. The three samples that contained no food items (Table 3-2) did contain non-prey items and therefore no empty stomachs were recovered in this study. Most of the samples contained fresh prey (Table 3-2) indicating that the alligators were eating frequently and the percent of stomach samples that contained fresh prey was similar among lakes.

The prey biomass in the stomach samples also varied greatly. Some samples contained a small number of fresh prey items and had small biomass, some samples contained a single fresh prey item with large biomass, and some samples contained many fresh prey items that together contributed a lot to biomass. The alligator diet biomass ranged from 0.50 g to 4705 g among the lakes. This extensive range of prey mass found in the alligator stomachs was evident in all the lakes. Lake Griffin alligators had the highest mean biomass (mean = 594.4 ± 95.9), followed by Lake Apopka alligators (mean = 536.5 ± 102.1) and Lake Woodruff alligators had the lowest mean biomass (mean = 459.7 ± 144.6) (Figure 3-1). No significant difference in the mean biomass were found among the lakes ($P = 0.103$).

The alligators ate a wide variety of prey, including both vertebrates and invertebrates. The majority of the prey consumed by the alligators was vertebrates. Vertebrates occurred more frequently and made up a larger percentage of the biomass than invertebrates (Table 3-4). The minimum number of fresh prey taxa identified in all the samples was 83 (Tables 3-5, 3-6, 3-7). Lake Woodruff alligators had the highest diversity and equitability of fresh prey and Lakes Apopka and Griffin alligators followed this with equal fresh prey diversity (Table. 3-8). Lake Apopka alligator prey consumption was a little higher in equitability than Lake Griffin alligator prey consumption (Table 3-8). Lake Griffin alligators consumed the most prey taxa overall, however, their diversity tied for the lowest. This low diversity for Lake Griffin alligators was a result of an abundance of certain prey (e.g., apple snails, *Pomacea paludosa* and grass shrimp, *Palaemonetes intermedius*) that affected the overall diversity results. The equitability measure further exemplified this abundance of certain prey and revealed that

Lake Griffin alligators had the lowest equitability of fresh prey consumption among the lakes.

**Abnormal Lake Griffin alligators**

Thirteen abnormal alligators were samples from Lake Griffin during 2001 (Schoeb et al. 2002) and they exhibited some similarities and some differences to normal Lake Griffin alligator diets. Eight out of the 13 samples contained old food and most were almost completely empty (Table 3-9). This large proportion of samples containing old prey (62%) was higher than the amount of normal samples containing old prey, indicating that abnormal alligators were not eating as frequently as the normal alligators or that abnormal alligators had not eaten within a few days of capturer. The fresh prey identified in the samples included fish, reptiles and invertebrates, and this was similar to normal samples. Two of the abnormal samples that contained fresh prey contained multiple specimens of gizzard shad and many of the samples with old prey contained fish scales that could not be identified beyond fish (Table 3-9). The consumption of shad among normal Lake Griffin alligators in this study was minimal and this may have been due to a shad removal by the SJRWMD in the spring of 2002 (Table 3-10).

**Fish**

Fish were the most important prey group in frequency of occurrence and in percent composition by live mass for all lakes. Frequency of occurrence of fish was high for all samples and the occurrence of fresh fish dropped only slightly (Figures 3-2, 3-3). Lake Apopka alligators had the highest occurrence of fresh fish (64%), followed by Lake Woodruff alligators (57%) and Lake Griffin alligators had the lowest occurrence of fresh fish in their diet (44%) (Figure 3-3).

Fish represented the largest part of the diet in biomass for the alligators in the lakes. Total fish biomass for Lake Griffin alligators was 20,309 g or 54% of the diet (Figure 3-4). Fish made up an overwhelming percentage of alligator diets from Lakes Apopka (15,868.9 g or 90% of the diet) and Woodruff (13,586 g or 84% of the diet) (Figures 3-5, 3-6, respectively). While fish were the dominant prey in all lakes, the species composition and number of fish consumed varied among the lakes. Lake Griffin alligators (Table 3-5) most commonly consumed catfish (Ictaluridae). Lake Apopka alligators consumed a large number of shad (Clupeidae) (Table 3-6) and the largest portion of fish consumed by the Lake Woodruff alligators was sunfish and bass (Centrarchidae) (Table 3-7). Alligators from all lakes consumed gar (*Lepisosteus spp*.) infrequently, but it had the potential to contribute a lot to biomass. For example, gar occurred in 4.5% of the Lake Apopka samples and comprised 2826 g or 16% of the diet.

The diversity and equitability of fish in alligator diets differed among the lakes. The minimum number of fresh fish taxa consumed by the alligators in the lakes was 31 (Tables 3-5, 3-6, 3-7). Lake Woodruff alligators had the highest diversity and equitability of fish in their diet, followed by Lake Griffin alligators, and Lake Apopka alligators had the lowest diversity and equitability of fish in their diet (Table 3-11). The diversity and equitability of Lake Apopka alligator fish consumption stood out as much lower and their minimum number of fish taxa consumed was also the lowest at seven (Table 3-11). This difference may be due to habitat variations, meaning that Lake Apopka alligators were possibly taking advantage of locally abundant prey (i.e., shad) that were not available to the alligators in the other two lakes.

Percent composition of fish ranged from zero to 100%. Some samples contained no fish, while other samples were comprised entirely of fish. Lake Apopka alligators had the highest mean percent composition of fish in their diet (mean = 79.9% ± 6.76), followed by Lake Woodruff alligators (mean = 62.2% ± 7.38) and Lake Griffin alligators had the lowest mean percent composition of fish in their diet (mean = 48.5% ± 6.05) (Figure 3-7). There was a significant difference in the percent composition of fish among the lakes ($P = 0.006$). Percent composition of fish for Lake Apopka alligators was higher and significantly different from Lakes Griffin and Woodruff alligators (Mann-Whitney U test: $P = 0.002$, $P = 0.036$, respectively). Percent composition of fish for Lakes Griffin and Woodruff alligators was not significantly different (Mann-Whitney U test: $P = 0.249$).

**Other vertebrate prey groups**

Other vertebrate prey groups (reptiles, mammals, birds, and amphibians) were less important in the diet of alligators among the lakes. The occurrence of reptiles in all samples for alligators from Lakes Griffin and Apopka was high (Figure 3-2), however, this was due to the high incidence of turtle scutes and the occurrence dropped dramatically when looking at only fresh reptiles (Figure 3-3). The occurrence of reptiles in all samples for Lake Woodruff alligators was low (Figure 3-2) and also dropped when looking at fresh reptiles (Figure 3-3). The occurrence of mammals, birds, and amphibians were low for all samples among the lakes (Figure 3-2), and dropped slightly for only fresh mammals, birds, and amphibians (Figure 3-3).

Lake Griffin alligators had the highest occurrence of other vertebrate prey groups. This large occurrence of non-fish prey for Lake Griffin alligators was possibly due to the larger sample size (Table 3-2). The chi-square test revealed differences in the diet of alligators among the lakes ($\chi^2 = 7.64$, df = 2, P = 0.02). The difference was largely due to Lake Griffin alligator diets. Significantly fewer fish occurred than expected, while significantly more other prey occurred than expected in Lake Griffin alligator diets (Table 3-12). In addition, significantly less other prey occurred in the Lake Woodruff alligator diets (Table 3-12). Lake Griffin alligator diets appeared to be different from Lakes Apopka and Woodruff alligator diets, due to the greater occurrence of non-fish prey and the lower occurrence of fish in Lake Griffin alligator diets.

The biomass for other vertebrate prey groups was highly variable and these infrequent non-fish prey items had the potential to comprise a lot in biomass. The large infrequent prey items were most commonly mammals and birds and were more frequent in Lake Griffin alligators. Two mammal specimens, a raccoon (*Procyon lotor*) and a hispid cotton rat (*Sigmodon hispidus*) together made up 4,860 g or 13% of the diet for Lake Griffin alligators (Table 3-5, Figure 3-4). In addition, four bird specimens made up 5,763 g or 15% of the diet for Lake Griffin alligators (Table 3-5, Figure 3-4).

Mammals and birds comprised a less significant portion of alligator diets from Lakes Apopka and Woodruff, therefore, the occurrence of a large infrequent prey item was less. Lake Apopka alligators consumed two mammals (Table 3-6), representing only 331 g or 2% of the diet (Figure 3-5). One Lake Apopka alligator ate an anhinga (*Anhinga anhinga*), which had an estimated weight of 1,235 g or 7% the diet (Figure 3-5). A single round-tailed muskrat (*Neofiber alleni*) (Table 3-7) was identified from Lake Woodruff samples and the estimated mass of this mammal was 289 g or 1.8% of the diet (Figure 3-6). No fresh birds were identified in any Lake Woodruff samples.

Reptiles were the most commonly consumed non-fish vertebrate prey and were most frequently consumed by Lake Griffin alligators. The most common reptiles consumed by alligators were turtles, specifically the stinkpot turtle (*Sternotherus odoratus)*. Alligators in all the lakes also consumed aquatic snakes and there was evidence of alligators. None of the alligators consumed in this study were considered fresh prey items and they were all represented by FWC hatchling tags that had remained in the stomach for an unknown amount of time. Alligator eggshells were found in two Lake Griffin alligator samples (one female and one male alligator) and in one Lake Woodruff alligator sample (female alligator).

Reptiles, specifically turtles had the potential to be a large prey items and one Lake Griffin alligator ate a redbelly turtle (*Pseudemys nelsoni*) estimated at 1148 g. Lake Griffin alligators ate reptiles more frequently and these reptiles totaled 3,755 g or 10% of the diet (Figure 3-4). Reptiles comprised a smaller portion of alligator diets for Lakes Apopka (158 g or 1.6% of the diet) and Woodruff (108 or 0.6% of the diet) (Figs. 3-5, 3-6, respectively). Three gopher tortoises (*Gopherus polyphemus*), a terrestrial species, were consumed by alligators. Lake Griffin alligators consumed two gopher tortoises (Table 3-5) and a Lake Apopka alligator consumed one gopher tortoise (Table 3-6).

Amphibians were not a significant portion of the alligator diets from any lakes, but large species (e.g., *Rana catesbiana, Siren lacertina*) had the potential to be a large meal. Amphibians consumed by the alligators included frogs and aquatics salamanders (sirens and amphiumas). Lake Griffin alligators consumed the greatest number of amphibian taxa (3) and the greatest number of amphibian specimens (5) (Table 3-5). The total amphibian biomass for Lake Griffin alligators was 1,374.4 g or 4% of the diet (Figure 3-

4). No amphibians were identified in any Lake Apopka samples. Lake Woodruff alligators consumed two greater sirens (*Siren lacertina*) that totaled 1,325 g or 8% of the diet in biomass (Figure 3-6). One of these sirens was 1000 g (Table 3-7).

**Invertebrates**

Invertebrates were not a significant part of alligator diets based on both frequency of occurrence and percent composition by live mass. Invertebrates included gastropods, insects, crustaceans, and bivalves. The occurrence of invertebrates in all samples was high among the lakes, however, the occurrence dropped dramatically for fresh invertebrates. For example, the occurrence of gastropods consumed by Lake Griffin and Lake Woodruff alligators was 74% and 89%, respectively for all samples, however, the occurrence of fresh gastropods dropped to 28% and 41%, respectively (Figures 3-2, 3-3). In addition, the occurrence of insects consumed by Lake Apopka alligators was 61% for all samples, however, the occurrence of fresh insects dropped to 9% (Figures 3-2, 3-3). This drop in invertebrate occurrence was due to the accumulation of indigestible invertebrate parts made of chitin in alligator stomachs, which were discarded during fresh invertebrate analysis.

Fresh invertebrates were a small proportion of biomass for alligators in all the lakes. The only invertebrate that contributed significantly in biomass was the apple snail. Lake Griffin alligators ate 941 apple snails, however, only 64 of those were considered fresh (Table 3-5). Total fresh apple snail biomass for Lake Griffin alligators was 1,321.9 g or 4% of the diet (Figure 3-4). Thirty out of the 303 apple snails consumed by Lake Woodruff alligators were fresh and these 30 apple snails (along with two small banded mystersnails, *Viviparus georgianus*) made up 695.4 g or 4% of the diet (Table 3-7, Figure 3-6). Both Lake Griffin and Lake Woodruff alligators consumed freshwater mussels, *Utterbachia spp.* (Tables 3-5, 3-7). Insects and crustaceans only comprised trace amounts of biomass for alligators among the lakes (Figures 3-4, 3-5, 3-6).

**Non-prey items**

Non-prey items were commonly found in alligator stomachs. Non-prey items were analyzed by frequency of occurrence (Table 3-13). Plant material (aquatic vegetation, seeds, and nuts) was commonly found in alligator stomachs among the lakes. Wood was also commonly found in alligator stomachs among the lakes. Rocks were more common in Lake Apopka alligator stomachs and were least commonly found in Lake Woodruff alligator stomachs. Sand was found in Lakes Griffin and Apopka alligator stomachs, but not in Lake Woodruff samples.

Nematodes were found in almost every sample among the lakes. Nematodes from ten samples were analyzed to identify species and this resulted in the identification of three nematode species. The three nematodes identified were: *Dujardinascaris waltoni, Brevimulticaecum tenuicolle,* and *Ortleppascaris antipini*. Artificial objects were identified in many of the samples and these included toys, golf balls, fishing lures and hooks, shot gun shells, a lighter, spark plugs, and glass.

**Alligator Condition among Lakes**

Alligator condition, a measure of relative fatness was compared among the lakes. Forty-four samples out of 200 were dropped from the condition analysis due to lack of measurement data, recaptures, or the animal was categorized as abnormal by the field biologist (Table 3-14). I used SVL and mass data (Table 3-15) in the Fulton's condition factor, K, to obtain a condition score for each alligator.

Alligator condition scores from lakes Griffin, Apopka, and Woodruff ranged from 1.63 to 4.13 and differed significantly among the lakes. Lake Apopka alligators were clearly bigger and heavier in comparison to the alligators from the other two lakes. Lake Woodruff alligators had the lowest condition scores among the lakes and appeared the skinniest of them all. Lake Griffin animals on average were intermediate in size and their mean condition score ranged between Lakes Apopka and Woodruff alligators.

Alligators compared in the condition analysis ranged from 182 to 304 cm TL; however, a comparison of size class by quartile revealed that the proportion of alligators in each quartile was not equally distributed among the lakes (Figure 3-18). A larger proportion of smaller Lake Woodruff alligators were captured compared to smaller size alligators caught from Lakes Griffin and Apopka. Larger alligators were generally hard to catch on all three lakes, but the capture of large Lake Woodruff alligators posed an even greater challenge. Data collected during night light surveys on the three lakes (A. R. Woodward, Florida Fish and Wildlife Conservation Commission unpublished data) revealed a greater proportion of smaller alligators on Lake Woodruff compared to Lakes Griffin and Apopka; however, the proportion captured in this study does not exactly correspond with the estimated natural population (Figure 3-9).

The K for all Lake Griffin alligators ranged from 1.63 to 3.70 (mean = 2.66 ± 0.045), while the K for all Lake Apopka alligators ranged from 2.15 to 4.13 (mean = 2.99 ± 0.059) and the K for all Lake Woodruff alligators ranged from 1.86 to 3.08 (mean = 2.48 ± 0.041) (Figure 3-10). The mean Fulton's K score for the lakes was significantly different ($P < 0.001$). The LSD post hoc test revealed that the condition of the alligators among the lakes was significantly different (Table 3-16). The comparison of smaller alligators (182 – 213 cm TL) also showed that there was a significant difference in the mean alligator condition among the lakes ($P < 0.001$). The LSD post hoc test also revealed that the condition of these smaller alligators among the lakes was significantly different and therefore the disproportionate sizes of alligators sampled did not affect the overall condition results.

The range of condition scores for all alligators (1.63 – 4.13) was divided up into quartiles and assigned a rank because Fulton's K does not have biological standards for a "low" or a "high" condition score (Table 3-17). Alligators from Lakes Griffin and Woodruff were both categorized as having a low to average condition; however, the Lake Woodruff alligators were at the bottom of this range and the Lake Griffin alligators were at the top of this range. Lake Apopka alligators fell into the fourth quartile and were categorized as having a high condition. The condition of the Lake Apopka alligators stood out as much higher (i.e., relatively more robust) than alligators from the other two lakes even though they were all significantly different.

## Discussion

### Alligator Diets among Lakes

American alligators in this study consumed a wide variety of prey and this was consistent with other adult alligator diet studies (Delany and Abercrombie 1986, Delany et al. 1988, Delany et al. 1999, Wolfe et al. 1987). Diverse diets may be due to habitat type, local prey abundance, prey vulnerability, and prey size. The prey composition and prey biomass in alligator stomach samples in this study varied greatly. This variety included samples containing fresh intact or partially digested prey, samples containing old mostly digested prey, or a combination of both. However, most of the samples did contain fresh prey indicating that the alligators were eating frequently. The number of specimens and estimated biomass of the fresh prey also varied greatly. For example, one sample contained six small fresh prey specimens, which was estimated at 80 g in biomass. While another sample contained one large fresh prey item that was estimated at 4705 g. This diversity of prey composition and prey weight in the stomach samples occurred in other adult alligator diet studies (Delany and Abercrombie 1986, Delany et al. 1988, Delany et al. 1999, Wolfe et al. 1987, Barr 1997).

Adult crocodilians mostly consumed vertebrates and depending on habitat type, repeatedly consumed certain prey types (Delany and Abercrombie 1986, Magnusson et al. 1987, Thorbjarnarson 1993, Barr 1997, Delany et al. 1999). The majority of prey consumed by the alligators in this study was vertebrates. These adult alligators did consume invertebrates; however, fresh invertebrates did not occur often and did not contribute significantly in biomass. The alligators in this study repeatedly ate certain prey items (e.g., fish, stinkpot turtles, and apple snails) and this may be due to prey abundance, habitat type, or ease of capture.

**Variation among habitats**

Habitat, prey availability, and prey abundance play a huge role in alligator diets. Alligators inhabit a variety of water systems including freshwater lakes, coastal marshes, rivers, swamps and ponds. These areas can have different trophic levels (freshwater systems), different prey available, and different prey abundance, which all affect alligator diets because alligators are opportunistic predators. In this study, Lakes Griffin and Apopka have similar characteristics of being algae-dominated, hypereutrophic systems, while Lake Woodruff is a macrophyte-dominated, eutrophic lake. Lakes Griffin and Apopka were once macrophyte-dominated, game fishing lakes with clear water, however, due to many factors (e.g., hurricane winds, point source pollution, and agriculture runoff) throughout the last six decades the lakes have changed (Canfield et al. 2000, Bachmann et al. 2001). As lakes change either through eutrophication or through restoration, the fish community within a lake will also change (Bachmann et al. 1996). Many game fish (e.g., largemouth bass) require aquatic macrophytes to survive and when the macrophytes are eliminated, the game fish population will also be eliminated, thus changing the fish community (Canfield et al. 2000). Gizzard shad become much more productive in lakes with increasing chlorophyll *a* levels and shad often become the dominate fish species in hypereutrophic lake systems (Bachmann et al. 1996, Allen et al. 2000). Managers need to be aware that changes in lakes due to either trophic state changes or restoration will affect the fish community. Because alligators are opportunistic and adaptable animals, their diet will also change.

Adult alligators inhabiting Florida have a different diet from alligators inhabiting Louisiana, due to the different habitats that support different prey. Adult alligators in north central and central Florida predominantly ate fish (Delany and Abercrombie 1986, Delany et al. 1999), while, adult alligators in Louisiana predominantly ate mammals (Valentine et al. 1972, McNease and Joanen 1977, Taylor 1986, Wolfe et al. 1987). Nutria (*Myocastor coypus*), an aquatic rodent, inhabit Louisiana wetlands and were an abundant prey item for the alligators there. Nutria did not occur on my study lakes. Apple snails were common prey items for alligators of all sizes in Florida (Fogarty and Albury 1967, Delany and Abercrombie 1986, Delany et al. 1988, Barr 1994, 1997, Delany et al. 1999), but do not occur in Louisiana and therefore were not available to the alligators there. Louisiana alligators consumed more crustaceans and insects instead of apple snails (Valentine et al. 1972, McNease and Joanen 1977, Wolfe et al. 1987).

Sub-adult alligators inhabiting different habitat types within Louisiana had different diets (Chabreck 1972). Chabreck (1972) sampled 10 sub-adult alligators from a freshwater environment and 10 sub-adult alligators from a saline environment. The alligators from both habitat types consumed crustaceans the most, however, the species composition of crustaceans varied between the habitat types. The freshwater inhabitants ate more vertebrates and crawfish (*Procambarus clarki*), while the saline inhabitants ate more blue crabs (*Callinectes sapidus*) (Chabreck 1972).

Within Florida, there were distinct differences in the diet of adult alligators. Fish dominated the diet of alligators from north central and central Florida (Delany and Abercrombie 1986, Delaney et al. 1999), whereas reptiles and amphibians dominated the diet of alligators in the Everglades (Barr 1997). Even more specifically the diets differed among lakes in this study. Fish dominated the alligators diet among lakes; however, the species composition and number of fish specimens differed greatly. This may be due to trophic lake differences, habitat differences, differences in local prey abundance, or overall differences in prey availability.

**Fish**

Fish are an important prey group for many adult crocodilian species, including the American alligator (Delany and Abercrombie 1986, Thorbjarnarson 1993, Santos et al. 1996, Delany et al. 1999, Silveira and Magnusson 1999). Fish were the dominant prey group for adult alligators (180 – 300 cm TL) in Florida, except for alligators in the Everglades (Delany and Abercrombie 1986, Barr 1997, Delany et al. 1999). In this study, fresh fish had the highest occurrence and the highest percent composition by live mass for all prey groups for the alligators among the lakes.

Fish dominated the diet of the alligators among the lakes, but fish were especially important in alligator diets from Lakes Apopka and Woodruff compared to the Lake Griffin alligator fish consumption. This similarity of a dominant fish diet from Lakes

Apopka and Woodruff alligators may be due to the similar sample size for those lakes. The sample size for Lake Griffin alligators was almost twice as large as the sample size for Lakes Apopka and Woodruff (Table 3-2), thus providing an accumulation of more prey species and specimens (Figure 3-11). Lake Griffin alligators were sampled more and therefore there were more species identified in their samples, and there was a greater chance to find the infrequent large prey item in their diet. This may explain the difference in the fish dominance between Lake Griffin alligators and alligators from Lakes Apopka and Woodruff.

Although fish dominated the diet of the alligators in all the lakes, species composition and diversity and equitability of fish consumed by the alligators were different. All alligators ate some same fish species (e.g., gizzard shad, catfish, gar, and black crappie); however, the dominant species consumed differed among the lakes. Lake Griffin alligators consumed the second highest diversity of fish and consumed mostly catfish. This high diversity could be due to the larger sample size obtained for Lake Griffin alligators. Lake Apopka alligators consumed mostly shad, which were gizzard shad (*Dorosoma cepedianum*) and small gizzard shad or threadfin shad (*Dorosoma petenense*). Lake Apopka alligators had the lowest diversity and equitability in their fish consumption. Lake Woodruff alligators consumed mostly sunfish and bass and had the highest diversity and equitability in their fish consumption. These differences may be due to different habitats occupied by the alligators in this study, which will be explored below.

Other adult alligator studies in Florida have shown that a lake's trophic state may play a role in alligator diets and therefore alligators from different lakes with similar trophic states may exhibit similar diets and alligators from different lakes with different trophic states may exhibit different diets. Delany and Abercrombie (1986) found no significant differences in the diet of alligators among three lakes in north central Florida that were all considered eutrophic. However, Delany et al. (1999) found that alligator fish consumption differed among lakes with different trophic states. Fish were more dominant in the diet of alligators from lakes with higher chlorophyll *a* concentrations (Delany et al. 1999). Fish densities increase with an increase in concentrations of lake total phosphorus, total nitrogen, and chlorophyll *a* and with decreasing Sechhi depth (i.e., increasing trophic state) (Bachmann et al. 1996). Therefore, alligators occupying lakes with a higher trophic state would inhabit a lake system with the greatest fish density. In this study, both Lakes Griffin and Apopka are hypereutrophic, algae-dominated lakes and Lake Woodruff is a eutrophic, macrophyte-dominated lake. However, fish overwhelmingly dominated alligator diets from Lakes Apopka and Woodruff, suggesting that trophic state alone may not predict fish consumption by alligators.

A few factors may have contributed to this difference in fish dominance in the diet compared to trophic state. Lake Griffin is a hypereutrophic lake; however, the SJRWMD removed one million pounds of gizzard shad and 25,000 pounds of gar in the spring of 2002 as part of their restoration efforts, just prior to our alligator sampling. This shad removal altered fish populations in the lake (personal observation) and, thus, availability to alligators. Along with this, the larger sample size for Lake Griffin alligators allowed for a greater chance to encounter a large infrequent non-fish prey item. Lake Apopka is a hypereutrophic lake and alligators there had a significantly larger proportion of fish in their diet compared to the other two lakes. Lake Apopka alligators ate mostly shad, which do increase in density with increasing trophic state (Bachmann et al. 1996). Lake Woodruff is a eutrophic lake and alligators there had a high diversity and equitability of fish in their diets. These Lake Woodruff alligators did have an overwhelming part of their diet from fish, however it did not compare to the proportion of fish in the Lake Apopka alligators diet. Lake Woodruff alligators did consume fish often, but they also often consumed invertebrates such as apple snail, possibly a part of the difference.

The consumption of fish with high levels of thiaminase causing depressed thiamin in alligators was one hypothesis for the cause of the Lake Griffin alligator mortality (P. Ross, FLMNH, personal communication). Gizzard shad in Lakes Griffin and Apopka had high levels of thiaminase (P. Ross, FLMNH, unpublished data); however, the alligators from Lake Griffin did not eat many shad during this study (Table 3-10). Lake Apopka alligators did eat large amounts of shad during this study (Table 3-6); however, there was not a case of adult mortality on that lake during this study. The SJRWMD removal of shad in 2002 on Lake Griffin may have affected this result of only one shad found in the Lake Griffin alligator diets after 2001 (Table 3-10). A dietary cause to the alligator mortality of Lake Griffin needs to be explored further and cannot be determined based on this study.

**Other vertebrate prey groups**

Other vertebrate prey groups (reptiles, mammals, birds, and amphibians) were less important in alligator diets among the lakes in both frequency of occurrence and in percent composition by live mass. The occurrence of non-fish prey occurred significantly more in Lake Griffin alligator diets. These non-fish vertebrate prey items in Lake Griffin alligator diets tended to be large and comprised a lot in biomass. For example, one Lake Griffin alligator ate one raccoon (*Procyon lotor*) that was estimated at

4705 g. The large and infrequent prey item occurred in alligator diets from Lakes Apopka and Woodruff, but less frequently. Other studies have mentioned the occurrence of a large prey item in crocodilian diets that comprised a lot in weight (Wolfe et al. 1987, Webb et al. 1991). Wolfe et al. (1987) reported that alligators in Louisiana frequently ate both nutria (*Myocastor coypus*) and muskrat (*Ondatra zibethicus*) comprising over 83% of alligator diets. Webb et al. (1991) reported that juvenile saltwater crocodiles (*Crocodylus porosus*) in the Northern Territory of Australia consumed large rats (*Rattus colletti*) infrequently, but they contributed a large portion of mass. If prey are equally available and vulnerable then alligators should take the largest possible prey item to maximize feeding efficiency (Wolfe et al. 1987).

Reptiles were the most frequently eaten non-fish prey item among the alligators, especially with Lake Griffin alligators. Most reptiles consumed by alligators were turtles, but snakes and American alligators were consumed also. Evidence of cannibalism was found in this study, and cannibalism has been reported in other alligator diet studies (Valentine et al. 1972, McNease and Joanen 1977, Delany and Abercrombie 1986, Delany et al. 1988, Barr 1997, Delany et al. 1999). Reptiles were also an important prey group for alligators in other Florida diet studies (Delany and Abercrombie 1986, Barr 1997, Delany et al. 1999). Delany and Abercrombie (1986) found that reptiles, specifically turtles, occurred second after fish in dominance for alligators 200 – 300 cm TL and that reptiles were the most important prey group for alligator > 300 cm TL. Reptiles were not an important prey group for adult alligators in Louisiana (Valentine et al. 1972, Wolfe et al. 1987). Wolfe et al. (1987) reported that snakes occurred more and comprised greater mass than turtles, but overall reptiles comprised only 3% of alligator diets. The most frequently eaten reptile in Louisianan was the cottonmouth (*Agkistrodon piscivorus*) (Wolfe et al. 1987). Reptiles were an important prey group for adult Everglades alligators, where snakes were the most prevalent, followed by turtles (Barr 1997). Reptile occurrence and importance in adult alligator diets are highly variable and depend on habitat type, prey availability and size of the alligators.

The occurrence of terrestrial gopher tortoises (*Gopherus polyphemus*) was unexpected. Nevertheless, they were found in three alligators from two lakes and they were estimated to be an adult, a sub-adult, and a juvenile. Gopher tortoises may be taken at the waters edge, after being washed into the lake, or as a result of the disposal of carcasses illegally caught by people.

Alligator eggshells were recovered in some alligator stomachs in this study and have been recovered in other crocodilian diet studies (McNease and Joanen 1977, Delany and Abercrombie 1986, Wolfe et al. 1987). In this study, three alligators (one male and two females) had alligator eggshells in their stomachs. Female alligators are known to open their hatchling eggs by carefully crushing them in their jaws and then releasing the hatchlings in the water. Kushlan and Simon (1981) observed female alligators aiding the release of her hatchlings and observed the female ingesting infertile eggs. The female alligator may be ingesting nutrients from the infertile egg and this may explain the occurrence of alligator eggshells in the stomachs (Kushlan and Simon 1981). One of the alligators with eggshells in its stomach was a male alligator and in this case, the male may have eaten the eggshells post hatching.

Amphibians have been shown to be an insignificant part of alligator diets throughout its range, except for the Everglades alligators (Valentine et al. 1972, McNease and Joanen 1977, Delany and Abercrombie 1986, Taylor 1986, Wolfe et al. 1987, Delany et al. 1988, Tucker et al. 1996, Barr 1997). Everglades alligators consumed larger aquatic salamanders (sirens and amphiumas) frequently and this was the highest recorded amphibian consumption by alligators (Barr 1997). Amphibians, especially frogs, digest quickly in alligator stomachs (Delany and Abercrombie 1986, Barr 1997) and therefore some studies may not sample frequently enough to detect amphibians in alligator stomachs. In this study, Lake Griffin alligators consumed one greater siren (*Siren lacertina*), one two-toed amphiuma (*Amphiuma means*) and three frog specimens (*Rana spp.*) and Lake Woodruff alligators consumed two greater sirens. Frogs are an abundant amphibian species that are densely populated throughout the alligator's range. However, frogs were rarely reported as alligator prey and if they were reported their occurrence was low, indicating their unimportance in alligator diets (Valentine et al. 1972, McNease and Joanen 1977, Delany and Abercrombie 1986, Taylor 1986, Wolfe et al. 1987, Delany et al. 1988, Platt et al. 1990, Barr 1994, Tucker et al. 1996, Barr 1997, Delany et al. 1999). Amphibians may not be an important prey group for alligators (except in the Everglades) or more frequent sampling resulting in a larger sample size may be needed to detect their presence in the diet, due to their rapid digestion rate.

**Invertebrates**

As alligators get larger, it becomes less energetically efficient to consistently prey on invertebrates. Adult alligators in this study did consume invertebrates; however, the amount and occurrence of fresh invertebrates were minimal. This trend of reducing invertebrate consumption with increasing size of the alligator was also evident in other alligator diet studies (Valentine et al. 1972, Delany and Abercrombie 1986, Barr 1997, Delany et al. 1999). It may seem that adult alligators consume large amounts of invertebrates, however, when alligator gastric digestive rate was taken into account, invertebrates become only a minimal part of the diet. Alligators are unable to digest chitin (Garnett 1985), which occurs in insect exoskeleton and snail opercula and prey items containing chitin can be over-represented in a diet study unless they are categorized as fresh or old. When only fresh invertebrates are analyzed in detail, then over-representation will be avoided. Since invertebrate parts containing chitin are indigestible they either accumulate in alligator stomachs, are digested in alligator intestines, or the alligators regurgitate the chitinous parts (Garnett 1985, Barr 1994). Barr (1994) reported that opercula can remain in alligator stomachs for up to 200 days and observed many captive alligators regurgitating the opercula. Fresh invertebrates generally do not constitute much in biomass showing the true amount of invertebrates in adult alligator diets.

Apple snails are an important prey item for juvenile alligators inhabiting Florida and they remain part of the diet of adult alligators in Florida (Fogarty and Albury 1967, Delany and Abercrombie 1986, Delany et al. 1988, Barr 1994, Barr 1997, Delany et al. 1999). However, apple snails can be greatly over-represented unless they are categorized as fresh or old. In this study, apple snails were the only invertebrate that contributed much in biomass, especially with alligators from Lakes Griffin and Woodruff. The occurrence of snails (*Pomacea spp.*) was also common in the diets of some caiman in South America (Diefenbach 1979, Thorbjarnarson 1993, Santos et al. 1996) and were unimportant in the diet of hatchling morelet's crocodile (*Crocodylus moreletii*) (Platt et al. 2002).

Louisiana alligators consumed insects and crustaceans, instead of apple snails (Chabreck 1972, Valentine et al. 1972, McNease and Joanen 1977, Wolfe et al. 1987, Platt et al. 1990). Blue crabs (*Callinectes sapidus*) were a common invertebrate identified in alligator diets from Louisiana (Chabreck 1972, Valentine et al. 1972, McNease and Joanen 1977, Wolfe et al. 1987, Platt et al. 1990). Apple snails do not occur in Louisiana and therefore are not a part of alligator diets there.

**Non-prey items**

Non-prey items are commonly found in the stomach of crocodilians (Fogarty and Albury 1967, Valentine et al. 1972, McNease and Joanen 1977, Diefenbach 1979, Webb et al. 1982, Delany and Abercrombie 1986, Taylor 1986, Magnusson et al. 1987, Wolfe et al. 1987, Delany et al. 1988, Platt et al. 1991, Webb et al. 1991, Thorbjarnarson 1993, Barr 1994, Tucker et al. 1996, Barr 1997, Delany et al. 1999, Silveira and Magnusson 1999, Platt et al. 2002, Pauwels et al. 2003). Non-prey items commonly found in crocodilian stomachs were plant material, wood, rocks, and artificial objects. These items provide no nutritional value to the crocodilians (Coulson and Hernandez 1983) and are probably ingested incidental to prey capture.

The alligators in the study had a high occurrence of plant material, wood and nematodes among the lakes. Most of the plant material was aquatic vegetation, seeds and nuts. Captive American alligators have been observed eating vegetation including elderberry (*Sambucus canadensis*), citrus fruits, and leafy greens (Brueggen 2002). These captive alligators received a nutritionally balanced captive diet and therefore the cause of the plant ingestion was unknown (Brueggen 2002).

Some crocodilian diet studies have reported the occurrence of parasitic worms in crocodilian stomachs (Valentine et al. 1972, Webb et al. 1982, Delany and Abercrombie

1986, Delany et al. 1988, Webb et al. 1991, Thorbjarnarson 1993). However, there are few investigations on parasitic worms inhabiting the stomachs of American alligators (Hazen et al. 1978, Cherry and Ager 1982, Scott et al. 1997). In this study nematodes occurred in most of the alligator stomachs and two of the three nematodes identified inhabiting the alligators stomach were also identified in other alligator diet studies and parasitic investigations (Hazen et al. 1978, Cherry and Ager 1982, Delany and Abercrombie 1986, Delany et al. 1988, Scott et al. 1997). The nematode, *Ortleppascaris antipini* was found in both Lakes Griffin and Woodruff alligator stomachs and this species of nematode was not previously reported in alligator stomachs.

**Alligator Condition among Lakes**

Body condition analyses investigate an animal's energy store compared to its body size and are affected by abiotic and biotic components in its ecosystem (Cone 1989, Green 2001). Condition analyses are often used to compare a population of animals over time, compare the condition of animals across populations, or compare the condition of animals among habitats within the same population. Comparing condition across populations and among habitats has rarely been done with crocodilians but it can give insight into how condition differs among habitats (Taylor 1979, Santos et al. 1994, Delany et al. 1999).

Condition of alligators in this study was different among the lakes. Lake Apopka alligators had the highest condition, followed by Lake Griffin alligators and Lake Woodruff alligators had the lowest condition. Other research showed differences in condition among habitats. Santos et al. (1994) compared condition of *Caiman yacare* among different habitats within the Pantanal in Brazil. He found that caiman condition was significantly different among habitats and found that caimans from "Miranda" river had the highest condition. Condition differences here may be due to prey availability among the habitats (Santos et al. 1994). Taylor (1979) compared juvenile and sub-adult saltwater crocodile (*Crocodylus porosus*) condition among habitats and found great variation. Saltwater crocodiles from upper mangroves had the highest condition and saltwater crocodiles from freshwater swamps had the lowest condition. Saltwater crocodiles from both habitats ate insects frequently and therefore a dietary cause to the condition difference may not fit here (Taylor 1979).

American alligator condition comparisons also showed differences among habitats. Zweig (2003) compared the condition of alligators among habitats using the Fulton's K factor and found great variation. She compared alligator condition from Lake Griffin, FL, Lochloosa Lake, FL, Orange Lake, FL, Santee, SC, Lake Woodruff, FL, Everglades, FL, and Newnans Lake, FL, and showed a high variation in alligator condition. Lake Griffin alligators had the highest condition and the Everglades alligators had the lowest condition (Zweig 2003). This type of comparison encompasses a huge geographic range of alligator habitat and offers an insight into the diverse alligator condition among habitats. Zweig (2003) also noted that Everglades alligators have had a consistently low condition over time and that this should not be cause for alarm. Delany and Abercrombie (1986) found significant differences in alligator condition among lakes in north central Florida, however, the diet of the alligators in these three lakes was not significantly different.

Delany et al. (1999) found differences in alligator condition among lakes in Florida and found that a high condition correlated with a fish dominated diet. In this study, alligators from Lakes Apopka and Woodruff both had a fish dominated diet, however, Lake Apopka alligators had the highest condition and Lake Woodruff alligators had the lowest condition. The condition of the alligators may be due to more than just dietary intake and other factors within a habitat probably play a role in alligator condition.

In this study, diversity, equitability, and proportion of fish in alligator diets varied among habitats and this may affect alligator condition. Lake Apopka alligators had the highest condition and had the lowest diversity and equitability of fish in their diet. They also had the largest proportion of fish in their diet and repeatedly ate shad. This large dominance of fish in Lake Apopka alligator diets may be due to local abundance and availability of shad in Lake Apopka and this may influence their high condition. Lake Woodruff alligators had the lowest condition among the lakes and the highest diversity and equitability of fish in their diet. Lake Woodruff alligators did not eat many fish repeatedly, but ate fish more evenly. This may correspond to a more even prey availability in Lake Woodruff. There may be no dominant fish taxa in Lake Woodruff as there is in Lake Apopka. Lake Woodruff alligators had the second highest proportion of fish in their diet. These alligators often ate fish but also often ate apple snails. This shows how a macrophyte-dominated lake like Lake Woodruff may have more suitable habitat for some prey species (e.g., apple snails). Lake Apopka alligators rarely ate invertebrates and often had multiple specimens of fish in their stomachs. Since Lake Apopka is algae-dominated, the habitat may not be as suitable for apple snails or other invertebrates. Lake Griffin alligators had the lowest proportion of fish in their diet and ate more non-fish vertebrate prey. Lake Griffin alligator condition fell between the condition of alligators from Lakes Apopka and Woodruff. The different habitats the alligators in this study inhabited may partially affect their condition due to either an abundance of prey in the habitat and consumed by the alligators (i.e., Lake Apopka alligators high condition) or a more evenness of prey consumption by the alligators (i.e., Lake Woodruff alligators low condition).

Alligator condition may also be affected by alligator density differences among the habitats. I used night-light survey data to estimate the population of alligators ≥ 182 cm TL on the three lakes (A. R. Woodward unpublished data, Woodward et al. 1996) (Table 3-18). The density of Lake Apopka alligators was much lower than the densities of alligators on the other two lakes, which were almost the same (Table 3-18) (although Lake Apopka is a large lake with great amount of open water that is largely uninhabited by alligators). Evert (1999) also found that the density of Lake Apopka alligators was lower than Lake Griffin alligator density (Lake Woodruff was not included in his research) and he found a positive correlation of alligator density with macrophyte coverage and an inverse correlation of alligator density with human development on lakes. Lake Woodruff is macrophyte-dominated and has little development, therefore it fits that there would be a high alligator population density on Lake Woodruff, however, Lake Woodruff does not have an abundance of any one species of fish. This combination of a high density of alligators and no abundant prey may cause more intra-specific competition for prey among the alligators and account for their low condition. A combination of low alligator density with high resource base (i.e., shad) may account for the Lake Apopka alligator high condition (i.e., less or no intra-specific competition for prey).

Condition analyses use morphometric measurements to obtain a condition score with the assumption that heavier animals of similar lengths (i.e., high condition score) are in better health (Sutton et al. 2000). This assumption can be misleading in crocodilian condition analyses because alligator populations with a high condition may not necessarily live in the best environment (Delany et al. 1999, Zweig 2003). The alligators in this study with the highest condition inhabited Lake Apopka, which is a highly polluted lake that has experienced a fluctuating, but overall low reproductive rate for the last two decades (Woodward et al. 1993, Rice 1996, Woodward et al. 1999). The alligators with the lowest condition inhabited Lake Woodruff, which is the most pristine lake out of the three in this study and alligators there have experienced a consistently high reproductive rate (Woodward et al. 1999). Alligators may take advantage of abundant resources in a hypereutrophic ecosystem, i.e., Lake Apopka alligators large consumption of shad in this study, and this may increase their fat reserves and account for their overall high condition. Lake Apopka alligators may not be the healthiest alligators among the lakes and there may be a point where a high condition actually indicates an excess of fat store. Therefore, caution should be used when equating health to high condition in alligator populations.

Crocodilian condition often differs among habitats and across populations and this may be due to resource availability. Factors affecting crocodilian diets may also affect their condition. For example, alligators may take advantage of locally abundant prey items in their habitat and therefore have a high condition. In a lake with more evenly distributed prey, alligators would not have this disproportionately high resource base and they may be smaller alligators. Alligator condition may change over time if the lake goes through an eutrophication process. For example, if a pristine macrophyte-dominated lake changes to an algae-dominated polluted lake supporting an abundance of prey then the alligators may be able to take advantage of the excess prey available. In this case, the alligator condition may increase. On the other hand, if a lake goes through a restoration effort where certain prey are eliminated from the lake, then over time alligator condition may decline due to the absence of the once abundant resource. Differences in condition may also be due to a fresh or saline environment inhabited and may not be closely associated with their diet. Other factors may contribute to alligator condition, such as alligator hunting behavior, year round optimal temperature that prolongs feeding, distinct wet and dry seasons affecting prey, or resource limitations. Regardless, estimating crocodilian condition is an easy mechanism that can give insight into their health in their habitat and it is often good to compare with a diet study, compare over time, and compare across populations.

Table 3-1. Summary of methods used to estimate fresh mass for each prey group.

| **Summary of Fresh Mass Estimation Methods** | |
|---|---|
| Prey Group | Type of Biomass Estimation |
| Fish | Allometric scaling, Hoyer and Canfield 1994 |
| Reptiles | Field Data |
| Amphibians | Field Data |
| Birds | Field Data, Dunning 1993 |
| Mammals | Field Data, museum specimens, Burt and Grossenheider 1980 |
| Gastropods | Allometric scaling |
| Bivalves | Field Data |
| Insects | Direct Mass |
| Crustaceans | Direct Mass |

Table 3-2. Summary of samples among the lakes, including samples dropped, samples containing fresh prey, samples containing no food items, and showing the percentage of the samples containing fresh prey.

| Lake | Total Samples | # Samples Dropped | Total Diet Samples | Total Fresh Diet Samples | Contained No Food | % Total Fresh Diet Samples |
|---|---|---|---|---|---|---|
| Griffin | 102 | 17 | 85 | 63 | 2 | 74 |
| Apopka | 49 | 5 | 44 | 33 | 0 | 75 |
| Woodruff | 49 | 3 | 46 | 35 | 1 | 76 |
| | 200 | 25 | 175 | 131 | 3 | |

Table 3-3. Summary of method used to collect the stomach samples.

| Lake | Total Diet Samples | Hose-Heimlich Method | Necropsy Method |
|---|---|---|---|
| Griffin | 85 | 69 | 16 |
| Apopka | 44 | 40 | 4 |
| Woodruff | 46 | 28 | 18 |
| | 175 | 137 | 38 |

Table 3-4. Estimated total biomass of stomach content samples for alligators among the lakes, including both vertebrate and invertebrate biomass and percentage of the diet.

| Lake | Total Biomass g | Vertebrate Biomass g | % of Diet | Invertebrate Biomass g | % of Diet |
|---|---|---|---|---|---|
| Griffin | 37447.5 | 36061.9 | 96 | 1385.6 | 4 |
| Apopka | 17705.1 | 17592.9 | 99 | 112.2 | 1 |
| Woodruff | 16088.9 | 15308 | 95 | 780.9 | 5 |

Table 3-5. Lake Griffin alligator diet data including minimum number of individuals (mni), percent occurrence, estimated mass in grams, and percentage of the diet for prey groups and for taxa within prey groups.

| Preys | # Total mni | % Occurrence | Total # Fresh mni | Fresh % Occurrence | Estimated Mass g | % of diet |
|---|---|---|---|---|---|---|
| **Fish Total** | **78** | **58** | **55** | **44** | **20309.5** | **54** |
| Shad *Dorosoma spp.* | 4 | 2.4 | 2 | 2.4 | 1322 | 3.5 |
| Gizzard Shad *Dorosoma cepedianum* | 9 | 4.7 | 8 | 3.5 | 3296 | 8.8 |
| Centrarchidae | 3 | 2.4 | 3 | 2.4 | 103.1 | 0.3 |
| Sunfish *Lepomis spp.* | 1 | 1.2 | 1 | 1.2 | 80 | 0.2 |
| Black crappie *Pomoxis nigromaculatus* | 2 | 2.4 | 2 | 2.4 | 785 | 2.1 |
| Gar *Lepisosteus spp.* | 7 | 8.2 | 6 | 7.1 | 4489 | 12 |
| Catfish *Ameiurus spp.* | 18 | 18.8 | 11 | 10.6 | 3890 | 10.4 |
| Brown Bullhead *Ameiurus nebulosus* | 11 | 11.8 | 11 | 11.8 | 4586 | 12.2 |
| Yellow Bullhead *Ameiurus natalis* | 2 | 1.2 | 2 | 1.2 | 577 | 1.5 |
| Mosquito fish *Gambusia holbrooki* | 2 | 2.4 | 2 | 2.4 | 0.2 | 0.001 |
| Tilapia *Oreochromis spp.* | 1 | 1.2 | 1 | 1.2 | 700 | 1.9 |
| Bowfin *Amia calva* | 1 | 1.2 | 1 | 1.2 | 411 | 1.1 |
| Sailfin Molly *Poecilia latipinna* | 1 | 1.2 | 1 | 1.2 | 0.4 | 0.001 |
| Killifish *Fundulus spp.* | 2 | 1.2 | 2 | 1.2 | 8.6 | 0.02 |
| Lake Eustis pupfish *Cyprinodon variegatus hubbsi* | 1 | 1.2 | 1 | 1.2 | 1.2 | 0.003 |
| Fish species undetermined | 12 | 14.1 | 1 | 1.2 | 60 | 0.2 |
| Needlefish *Strongylura marina* | 1 | 1.2 | 0 | 0 | 0 | 0 |
| | | | | | | |
| **Birds Total** | **10** | **12** | **4** | **5** | **5763** | **15** |
| Birds undetermined | 4 | 4.7 | 0 | 0 | 0 | 0 |
| Anhinga *Anhinga anhinga* | 2 | 2.4 | 1 | 1.2 | 1235 | 3.3 |
| Double crested cormorant *Phalacrocorax auritus* | 2 | 2.4 | 2 | 2.4 | 3628 | 9.7 |
| White Ibis *Eudocimus albus* | 1 | 1.2 | 1 | 1.2 | 900 | 2.4 |
| Common Moorhen/American coot *Gallinula chloropus/Fulica americana* | 1 | 1.2 | 0 | 0 | 0 | 0 |

Table 3-5. Continued

| Prey | # Total mni | % Occurrence | Total # Fresh mni | Fresh % Occurrence | Estimated Mass g | % of diet |
|---|---|---|---|---|---|---|
| **Reptiles Total** | **45** | **42** | **15** | **14** | **3755** | **10** |
| Turtle undetermined | 4 | 4.7 | 0 | 0 | 0 | 0 |
| Kinosternidae | 6 | 7.1 | 1 | 1.2 | 105 | 0.3 |
| Stinkpot turtle *Sternotherus odoratus* | 12 | 12.9 | 6 | 7.1 | 385 | 1.0 |
| Loggerhead musk turtle *Sternotherus minor* | 2 | 1.2 | 2 | 1.2 | 150 | 0.4 |
| Redbelly turtle *Pseudemys nelsoni* | 5 | 5.9 | 1 | 1.2 | 1148 | 3.1 |
| Turtle *Pseudemys spp.* | 3 | 3.5 | 1 | 1.2 | 13 | 0.03 |
| Gopher tortoise *Gopherus polyphemus* | 2 | 2.4 | 1 | 1.2 | 582 | 1.6 |
| Florida softshell turtle *Apalone ferox* | 1 | 1.2 | 1 | 1.2 | 386 | 1.0 |
| Alligator *Alligator mississippiensis* | 6 | 5.9 | 0 | 0 | 0 | 0 |
| Cottonmouth *Agkistrodon piscivorus* | 3 | 3.5 | 1 | 1.2 | 686 | 1.8 |
| Brown water snake *Nerodia taxispilota* | 1 | 1.2 | 1 | 1.2 | 300 | 0.8 |
| | | | | | | |
| **Mammals Total** | **8** | **11** | **2** | **2** | **4860** | **13** |
| Mammals undetermined | 6 | 8.2 | 0 | 0 | 0 | 0 |
| Hispid cotton rat *Sigmodon hispidus* | 1 | 1.2 | 1 | 1.2 | 155 | 0.4 |
| Raccoon *Procyon lotor* | 1 | 1.2 | 1 | 1.2 | 4705 | 12.6 |
| | | | | | | |
| **Amphibians Total** | **6** | **7** | **5** | **6** | **1374.4** | **4** |
| Amphibian undetermined | 1 | 1.2 | 0 | 0 | 0 | 0 |
| Greater Siren *Siren lacertina* | 1 | 1.2 | 1 | 1.2 | 387 | 1 |
| Two-toed Amphiuma *Amphiuma means* | 1 | 1.2 | 1 | 1.2 | 287 | 0.8 |
| Frog *Rana spp.* | 3 | 3.5 | 3 | 3.5 | 700.4 | 1.9 |

Table 3-5. Continued

| Prey | # Total mni | % Occurrence | Total # Fresh mni | Fresh % Occurrence | Estimated Mass g | % of diet |
|---|---|---|---|---|---|---|
| **Gastropods Total** | **941** | **74** | **64** | **28** | **1321.9** | **4** |
| Apple snails *Pomacea paludosa* | 941 | 72.9 | 64 | 28 | 1321.9 | 4 |
| | | | | | | |
| **Bivalves Total** | **5** | **4** | **3** | **4** | **45.0** | **0.1** |
| Mussel - *Utterbachia spp.* | 5 | 4 | 3 | 4 | 45.0 | 0.1 |
| | | | | | | |
| **Crustaceans Total** | **162** | **19** | **101** | **9** | **16.1** | **0.04** |
| Crayfish - *Procambarus spp.* | 3 | 3.5 | 1 | 1.2 | 2.3 | 0.006 |
| Grass shrimp *Palaemonetes intermedius* | 159 | 15.3 | 100 | 8.2 | 13.8 | 0.037 |
| | | | | | | |
| **Insects Total** | **37** | **31** | **8** | **8** | **2.6** | **0.01** |
| Eastern lubber grasshoppers *Romalea guttata* | 9 | 8.2 | 0 | 0 | 0 | 0 |
| Dragonfly - Aeschnidae | 5 | 5.9 | 0 | 0 | 0 | 0 |
| Water scorpion *Ranatra spp.* | 2 | 2.4 | 2 | 2.4 | 0.2 | 0.001 |
| Water bug *Belostoma spp.* | 3 | 3.5 | 2 | 2.4 | 0.2 | 0.001 |
| Giant water bug *Lethocerus spp*. | 1 | 1.2 | 1 | 1.2 | 0.8 | 0.002 |
| Green june beetle *Cotinus nitida* | 1 | 1.2 | 1 | 1.2 | 1 | 0.003 |
| Grasshopper - Orthoptera | 9 | 5.9 | 2 | 2.4 | 0.4 | 0.001 |
| Pioneer bug - Dermaptera | 1 | 1.2 | 0 | 0 | 0 | 0 |
| Insect undetermined | 6 | 7.1 | 0 | 0 | 0 | 0 |

Table 3-6. Lake Apopka alligator diet data including minimum number of individuals (mni), percent occurrence, estimated mass in grams, and percentage of the diet for prey groups and for taxa within prey groups.

| Prey | # Total mni | % Occurrence | Total # Fresh mni | Fresh % Occurrence | Estimated Mass g | % of diet |
|---|---|---|---|---|---|---|
| **Fish Total** | **104** | **84** | **78** | **64** | **15869** | **90** |
| Shad *Dorosoma spp.* | 46 | 38.6 | 42 | 36.4 | 3854 | 21.8 |
| Gizzard shad *Dorosoma cepedianum* | 21 | 29.5 | 10 | 13.6 | 3210 | 18.1 |
| Gar *Lepisosteus spp.* | 3 | 6.8 | 2 | 4.5 | 2826 | 16 |
| Catfish *Ameiurus spp.* | 14 | 25.0 | 7 | 13.6 | 1387 | 7.8 |
| Brown bullhead *Ameiurus nebulosus* | 2 | 4.5 | 2 | 4.5 | 701 | 4 |
| Tilapia *Oreochromis spp.* | 8 | 13.6 | 8 | 13.6 | 3378 | 19.1 |
| Centrarchidae/Cichlidae | 2 | 4.5 | 1 | 2.3 | 200 | 1.1 |
| Black Crappie *Pomoxis nigromaculatus* | 1 | 2.3 | 1 | 2.3 | 253 | 1.4 |
| Bluegill *Lepomis macrochirus* | 4 | 2.3 | 4 | 2.3 | 26 | 0.1 |
| Golden shiner *Notemigonus crysoleucas* | 1 | 2.3 | 1 | 2.3 | 34 | 0.2 |
| Fish species undetermined | 2 | 4.5 | 0 | 0 | 0 | 0 |
| | | | | | | |
| **Birds Total** | **3** | **7.0** | **1** | **2.0** | **1235** | **7** |
| Birds undetermined | 2 | 4.5 | 0 | 0 | 0 | 0 |
| Anhinga *Anhinga anhinga* | 1 | 2.3 | 1 | 2.3 | 1235 | 7 |
| | | | | | | |
| **Reptiles Total** | **20** | **36** | **3** | **7** | **158** | **1** |
| Kinosternidae | 2 | 4.5 | 0 | 0 | 0 | 0 |
| Stinkpot turtle *Sternotherus odoratus* | 5 | 11.4 | 1 | 2.3 | 35 | 0.2 |
| Florida Mud Turtle - *Kinosternun subrubrum* | 1 | 2.3 | 0 | 0 | 0 | 0 |
| Gopher tortoise *Gopherus polyphemus* | 1 | 2.3 | 1 | 2.3 | 113 | 0.6 |
| Florida softshell turtle *Apalone ferox* | 1 | 2.3 | 0 | 0 | 0 | 0 |
| Turtle undetermined | 4 | 9.1 | 0 | 0 | 0 | 0 |
| Alligator *Alligator mississippiensis* | 4 | 11.4 | 0 | 0 | 0 | 0 |
| Mud Snake *Farancia abacura* | 1 | 2.3 | 1 | 2.3 | 10 | 0.1 |
| Cottonmouth *Agkistrodon piscivorus* | 1 | 2.3 | 0 | 0 | 0 | 0 |

Table 3-6. Continued

| Prey | # Total mni | % Occurrence | Total # Fresh mni | Fresh % Occurrence | Estimated Mass g | % of diet |
|---|---|---|---|---|---|---|
| **Mammals Total** | **5** | **11** | **2** | **5** | **331** | **2** |
| Mammals undetermined | 3 | 6.8 | 0 | 0 | 0 | 0 |
| Eastern wood rat *Neotoma floridana* | 1 | 2.3 | 1 | 2.3 | 291 | 1.6 |
| Cotton mouse *Peromyscus gossypinus* | 1 | 2.3 | 1 | 2.3 | 40 | 0.2 |
| | | | | | | |
| **Gastropods Total** | **134** | **45** | **10** | **9** | **69** | **0.4** |
| Apple Snails *Pomacea paludosa* | 107 | 36.4 | 3 | 4.5 | 68 | 0.4 |
| Banded mysterysnail *Viviparus georgianus* | 10 | 4.5 | 1 | 2.3 | 0.2 | 0.001 |
| Mesa-rams-horn *Planorbella scalaris* | 17 | 4.5 | 6 | 2.3 | 1 | 0.003 |
| | | | | | | |
| **Crustaceans Total** | **23** | **20** | **9** | **11** | **15** | **0.1** |
| Crayfish *Procambarus spp.* | 5 | 11.4 | 2 | 4.5 | 13 | 0.1 |
| Grass shrimp *Palaemonetes intermedius* | 18 | 11.4 | 7 | 6.8 | 2 | 0.01 |
| | | | | | | |
| **Insects Total** | **55** | **61** | **8** | **9** | **28** | **0.2** |
| Water bug *Belostoma spp.* | 1 | 2.3 | 1 | 2.3 | 0.2 | 0.001 |
| Eastern lubber grasshopper *Romalea guttata* | 6 | 6.8 | 3 | 2.3 | 21 | 0.1 |
| Grasshopper - Orthoptera | 21 | 25 | 2 | 2.3 | 5 | 0.03 |
| Dragonfly - Aeschnidae | 3 | 4.5 | 1 | 2.3 | 1.3 | 0.01 |
| Insect undetermined | 12 | 20.5 | 1 | 2.3 | 0.5 | 0.003 |
| Beetle - Elatheridae | 2 | 2.3 | 0 | 0 | 0 | 0 |
| Green June Beetle *Cotinus nitida* | 10 | 20.5 | 0 | 0 | 0 | 0 |

Table 3-7. Lake Woodruff alligator diet data including minimum number of individuals (mni), percent occurrence, estimated mass in grams, and percentage of the diet for prey groups and for taxa within prey groups.

| Preys | # Total mni | % Occurrence | Total # Fresh mni | Fresh % Occurrence | Estimated Mass g | % of diet |
|---|---|---|---|---|---|---|
| **Fish Total** | **42** | **65** | **33** | **57** | **13,586** | **84** |
| Gizzard shad *Dorosoma cepedianum* | 4 | 4.3 | 4 | 4.3 | 1830 | 11 |
| Catfish *Ameiurus spp.* | 5 | 10.9 | 3 | 6.5 | 1600 | 10 |
| Gar *Lepisosteus spp.* | 2 | 4.3 | 1 | 2.2 | 424 | 3 |
| Centrarchidae | 7 | 15.2 | 6 | 13.0 | 503 | 3 |
| Sunfish *Lepomis spp.* | 5 | 10.9 | 5 | 10.9 | 351 | 2 |
| Warmouth *Lepomis gulosus* | 1 | 2.2 | 1 | 2.2 | 144 | 1 |
| Redear sunfish *Lepomis microlophus* | 3 | 6.5 | 3 | 6.5 | 257 | 2 |
| Spotted sunfish *Lepomis punctatus* | 1 | 2.2 | 1 | 2.2 | 136 | 1 |
| Largemouth bass *Micropterus salmoides* | 4 | 4.3 | 4 | 4.3 | 6066 | 38 |
| Black Crappie *Pomoxis nigromaculatus* | 1 | 2.2 | 1 | 2.2 | 80 | 0.5 |
| Needdlefish *Strongylura marina* | 3 | 6.5 | 2 | 4.3 | 182 | 1 |
| Bowfin *Amia calva* | 1 | 2.2 | 1 | 2.2 | 1763 | 11 |
| Catfish *Pterygoplichthys spp.* | 1 | 2.2 | 1 | 2.2 | 250 | 2 |
| Fish species undetermined | 4 | 8.7 | 0 | 0.0 | 0 | 0 |
| | | | | | | |
| **Birds Total** | **2** | **4.3** | **0** | **0** | **0** | **0** |
| Birds undetermined | 2 | 4.3 | 0 | 0 | 0 | 0 |
| | | | | | | |
| **Reptiles Total** | **10** | **15** | **1** | **2** | **108** | **0.6** |
| Stinkpot *Sternotherus odoratus* | 2 | 4.3 | 1 | 2.2 | 108 | 0.6 |
| Loggerhead musk turtle *Sternotherus minor* | 1 | 2.2 | 0 | 0.0 | 0 | 0 |
| Kinosternidae | 1 | 2.2 | 0 | 0.0 | 0 | 0 |
| Alligator *Alligator mississippiensis* | 5 | 4.3 | 0 | 0.0 | 0 | 0 |
| Snake undetermined | 1 | 4.3 | 0 | 0.0 | 0 | 0 |

Table 3-7. Continued

| Prey | # Total mni | % Occurrence | Total # Fresh mni | Fresh % Occurrence | Estimated Mass g | % of diet |
|---|---|---|---|---|---|---|
| **Mammals Total** | **6** | **13.0** | **1** | **2** | **289** | **1.8** |
| Mammals undetermined | 5 | 10.9 | 0 | 0 | 0 | 0 |
| Round-tailed muskrat *Neofiber alleni* | 1 | 2.2 | 1 | 2.2 | 289 | 1.8 |
| | | | | | | |
| **Amphibians Total** | **2** | **4.3** | **2** | **4.3** | **1325** | **8.2** |
| Greater siren *Siren lacertina* | 2 | 4.3 | 2 | 4.3 | 1325 | 8.2 |
| | | | | | | |
| **Gastropods Total** | **305** | **89.1** | **32** | **41** | **695.4** | **4.4** |
| Apple Snails *Pomacea paludosa* | 303 | 89.1 | 30 | 34.8 | 694.1 | 4.3 |
| Banded mysterysnail *Viviparus georgianus* | 2 | 2.2 | 2 | 2.2 | 1.3 | 0.01 |
| | | | | | | |
| **Bivalves Total** | **8** | **13** | **3** | **4** | **45** | **0.3** |
| Mussel - *Utterbachia spp.* | 8 | 13 | 3 | 4 | 45 | 0.3 |
| | | | | | | |
| **Crustaceans Total** | **15** | **22** | **11** | **15** | **38.5** | **0.2** |
| Grass shrimp *Palaemonetes intermedius* | 8 | 6.5 | 7 | 4.3 | 1.3 | 0.01 |
| Crayfish *Procambarus spp.* | 2 | 4.3 | 0 | 0 | 0 | 0 |
| Crayfish *P. paeninsularus* | 1 | 2.2 | 1 | 2.2 | 19.2 | 0.1 |
| Crayfish *P. fallax* | 4 | 6.5 | 3 | 6.5 | 18 | 0.1 |
| | | | | | | |
| **Insects Total** | **14** | **28.0** | **5** | **13** | **2** | **0.01** |
| Insect undetermined | 4 | 8.7 | 1 | 2.2 | 0.1 | 0.001 |
| Water bug *Belostoma spp.* | 5 | 8.7 | 3 | 8.7 | 1.4 | 0.009 |
| Dragonfly - Aeschnidae | 2 | 4.3 | 1 | 2.2 | 0.5 | 0.003 |
| Giant water bug *Lethocerus spp.* | 1 | 2.2 | 0 | 0 | 0 | 0 |
| Beetle *Stratgus spp.* | 2 | 2.2 | 0 | 0 | 0 | 0 |
| Bessbug Passalidae | 2 | 4.3 | 0 | 0 | 0 | 0 |

Table 3-8. Shannon-Weiner diversity index (H') and Sheldon's equitability index (E) results for alligator samples containing fresh prey. MNT represents the minimum number of taxa consumed by the alligators for each lake.

| Lake | MNT | H' | E |
|---|---|---|---|
| Griffin | 37 | 2.17 | 0.6 |
| Apopka | 23 | 2.17 | 0.69 |
| Woodruff | 23 | 2.56 | 0.82 |

Table 3-9. Summary of abnormal Lake Griffin stomach content samples. These samples were not used in the diet and condition analyses, and were abnormal based on Schoeb et al. (2002).

| | Total Samples | Total Fresh Diet Samples | Contained No Food | % Total Fresh Diet Samples |
|---|---|---|---|---|
| Griffin | 13 | 5 | 8 | 38 |

Table 3-10. Lake Griffin alligator shad consumption summary for this study. All fresh shad were consumed by the alligators in 2001.

| | Number of Stomach Samples | Number of Shad | % Occurrence | % of Diet in Biomass |
|---|---|---|---|---|
| 2001 | 24 | 10 | 16 | 12 |
| 2002 | 42 | 0 | 0 | 0 |
| 2003 | 19 | 1[a] | 5 | 0 |

[a]This shad was considered old, therefore no biomass estimation was made

Table 3-11. Shannon-Weiner diversity index (H') and Sheldon's equitability index (E) results for alligator samples containing fresh fish. MNT represents the minimum number of taxa of fish consumed by the alligators for each lake.

| Lake | MNT | H' | E |
|---|---|---|---|
| Griffin | 13 | 2.13 | 0.83 |
| Apopka | 7 | 1.15 | 0.59 |
| Woodruff | 11 | 2.19 | 0.91 |

Table 3-12. Chi-square test of the occurrence of fish compared to the occurrence of other prey (reptiles, mammals, birds, and amphibians) among the lakes. P-value indicates significant difference. Significant differences observed than expected in this study have a cell chi-square value greater than 1.

| Lake | | | Prey Type: Fish | Prey Type: Other |
|---|---|---|---|---|
| Lake | Lake Griffin | Frequency | 37 | 22 |
| | | Expected Frequency | 44 | 15 |
| | | Cell Chi-Square | **1.01** | **2.88** |
| | Lake Apopka | Frequency | 28 | 6 |
| | | Expected Frequency | 25 | 9 |
| | | Cell Chi-Square | 0.32 | 0.92 |
| | Lake Woodruff | Frequency | 26 | 4 |
| | | Expected Frequency | 22 | 8 |
| | | Cell Chi-Square | 0.65 | **1.85** |
| | | Total Chi-Square | 7.64 | |
| | | P-Value for Chi-Square | 0.02 | |

Table 3-13. Frequency of occurrence for non-prey items among the lakes.

| | Lake Griffin | Lake Apopka | Lake Woodruff |
|---|---|---|---|
| | % occurrence | % occurrence | % occurrence |
| Plant Material | 86 | 86 | 95 |
| Wood | 79 | 84 | 83 |
| Rocks | 22 | 41 | 7 |
| Sand | 26 | 43 | 0 |
| Nematodes | 85 | 98 | 96 |
| Artificial Objects | 17 | 11 | 24 |

Table 3-14. Condition analysis sample summary.

| Lake | Total Samples | # Samples Dropped | Total Condition Samples |
|---|---|---|---|
| Griffin | 102 | 37 | 65 |
| Apopka | 49 | 4 | 45 |
| Woodruff | 49 | 3 | 46 |
| | 200 | 44 | 156 |

Table 3-15. Alligator SVL and mass summaries from each study area.

| | Lake Griffin | | Lake Apopka | | Lake Woodruff | |
|---|---|---|---|---|---|---|
| | SVL cm | Mass kg | SVL cm | Mass kg | SVL cm | Mass kg |
| Mean | 114 | 45 | 116 | 49 | 111 | 37 |
| Minimum | 78 | 14 | 88 | 22 | 88 | 16 |
| Maximum | 151 | 96 | 156 | 108 | 166 | 112 |
| Standard Dev. | 17 | 20 | 16 | 21 | 20 | 24 |

Table 3-16. LSD post hoc test results comparing the mean condition among the lakes. P-value contrast and mean differences.

| | P-value contrast | | | Mean Difference | | |
|---|---|---|---|---|---|---|
| Lake | Griffin | Apopka | Woodruff | Griffin | Apopka | Woodruff |
| Griffin | - | <0.001* | 0.009* | - | -0.3341 | 0.1781 |
| Apopka | - | - | <0.001* | - | - | 0.5122 |

* significant difference

Table 3-17. Condition score range for all alligators divided into quartiles with assigned ranks.

| Quartile | Condition Score Range | Rank |
|---|---|---|
| 1st | 1.69 - 2.46 | low condition |
| 2nd | 2.47 - 2.67 | low to average condition ■ |
| 3rd | 2.68 - 2.93 | average to high condition |
| 4th | 2.94 - 4.13 | high condition ● |

■ Lake Griffin mean condition 2.66
■ Lake Woodruff mean condition 2.48
● Lake Apopka mean condition 2.99

Table 3-18. Estimated alligator densities among the lakes.

| Lake | Estimated Alligator Population ≥ 182 cm TL[1] | Total Surface Area (ha) | Alligators per hectare |
|---|---|---|---|
| Griffin | 1300 | 5742 | 0.23 |
| Apopka | 1280 | 12960 | 0.09 |
| Woodruff | 1600 | 6553 | 0.24 |

[1]based on night light surveys and Woodward et al. 1996

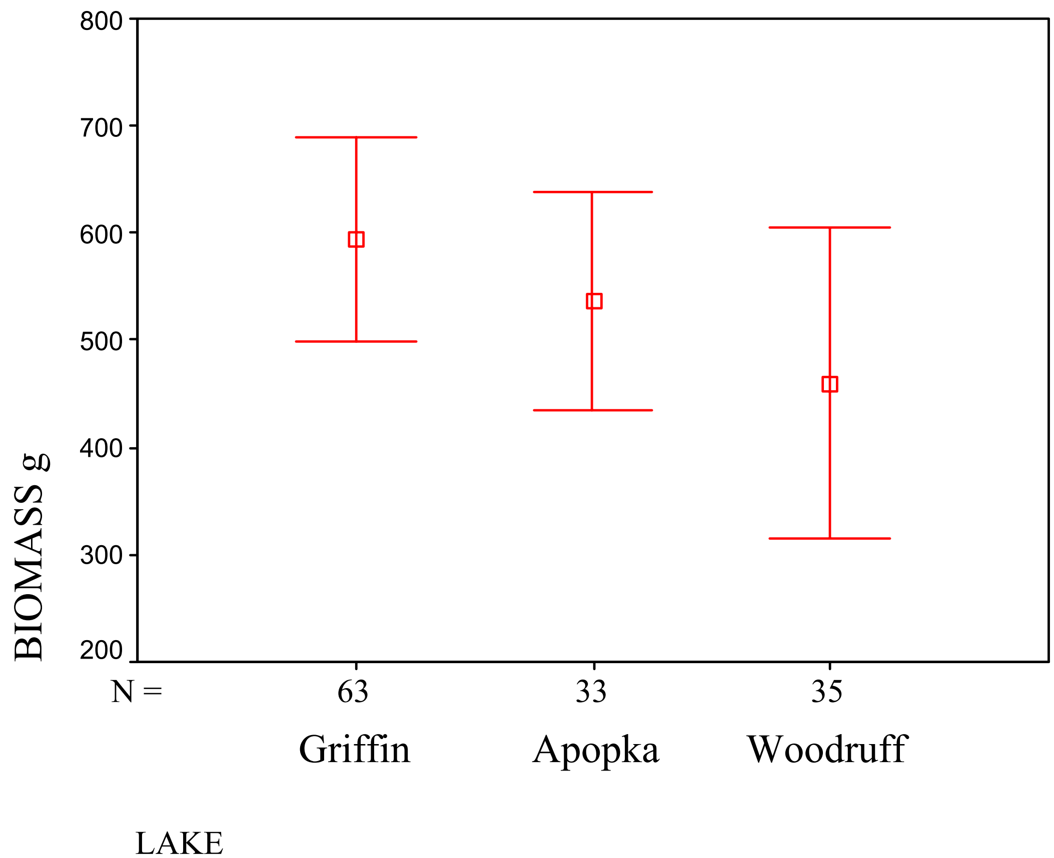


Figure 3-1.  Mean biomass (±SE) consumed by the alligators among lakes.

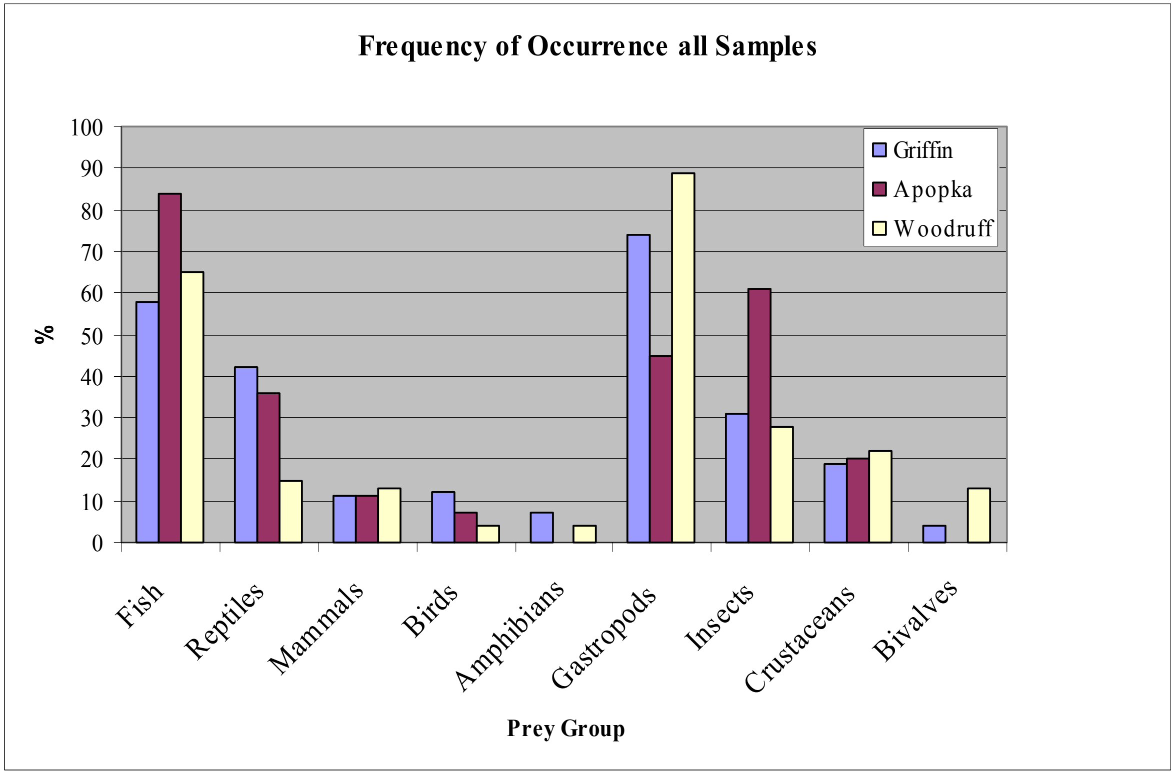


Figure 3-2. Frequency of occurrence of prey groups for all prey in all samples for Lake Griffin (n=85), Lake Apopka (n=44), and Lake Woodruff (n=46).

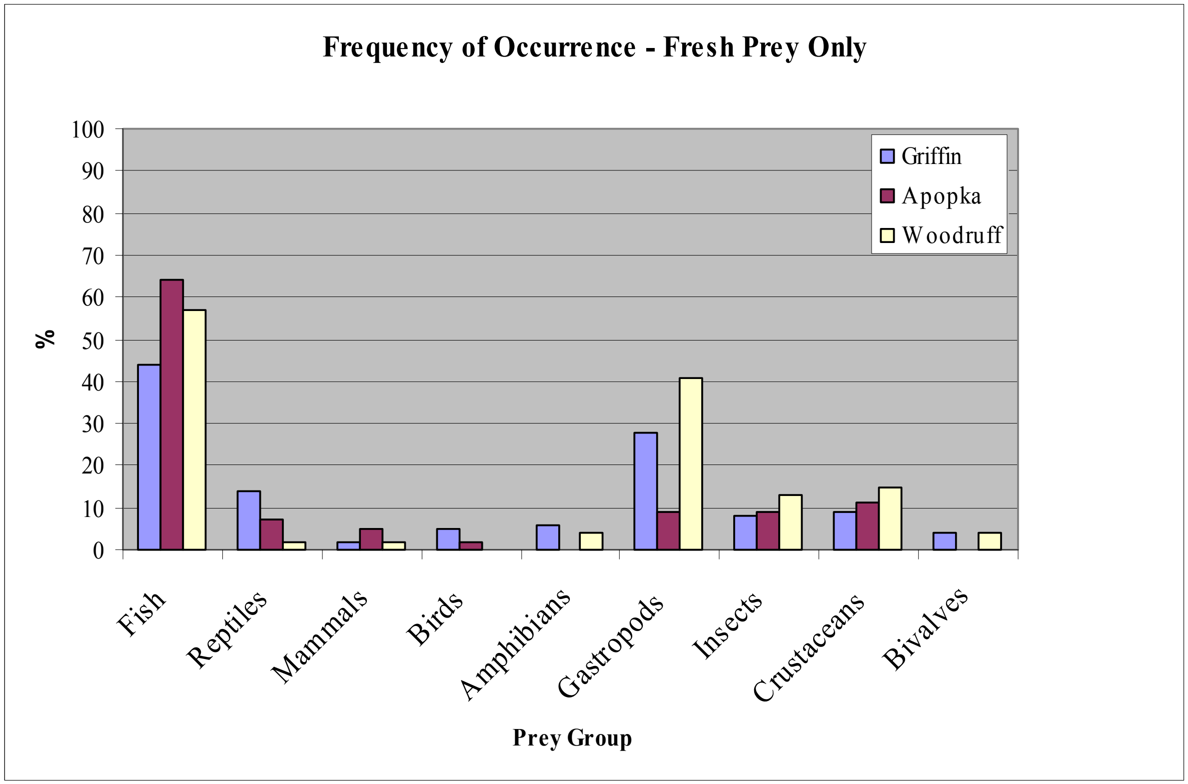


Figure 3-3. Frequency of occurrence of prey groups for samples containing fresh prey only for Lake Griffin (n=63), Lake Apopka (n=33), and Lake Woodruff (n=35).

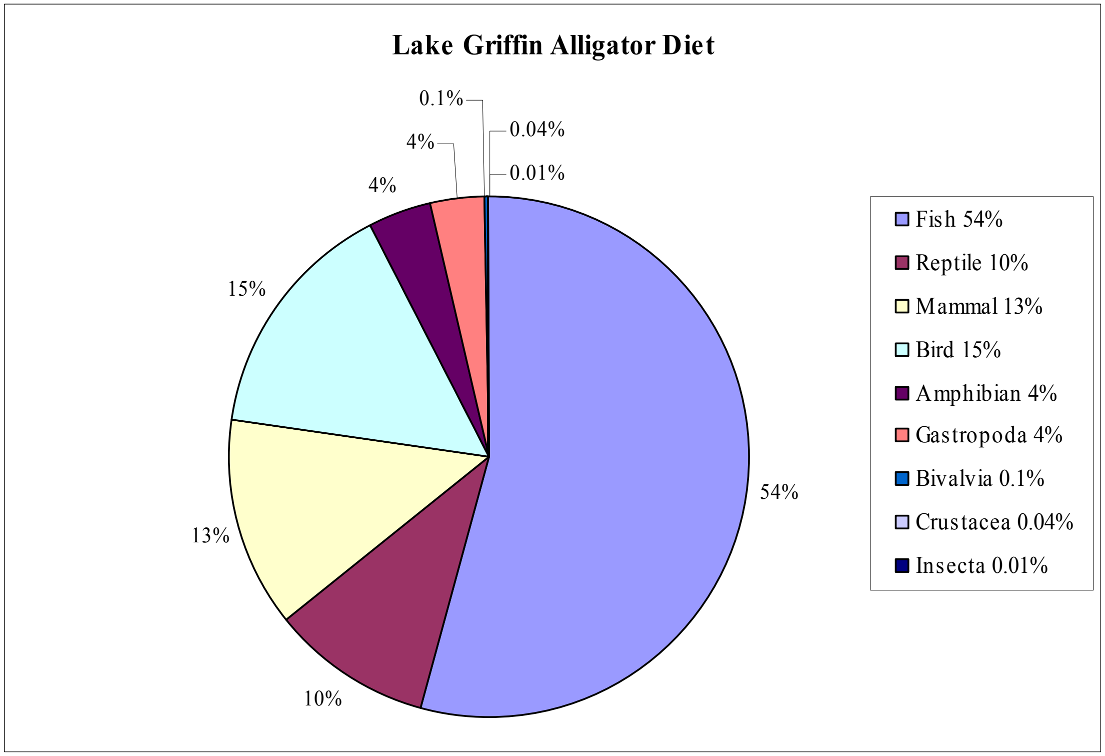


Figure 3-4. Percent composition by live mass for Lake Griffin alligators (N = 85).

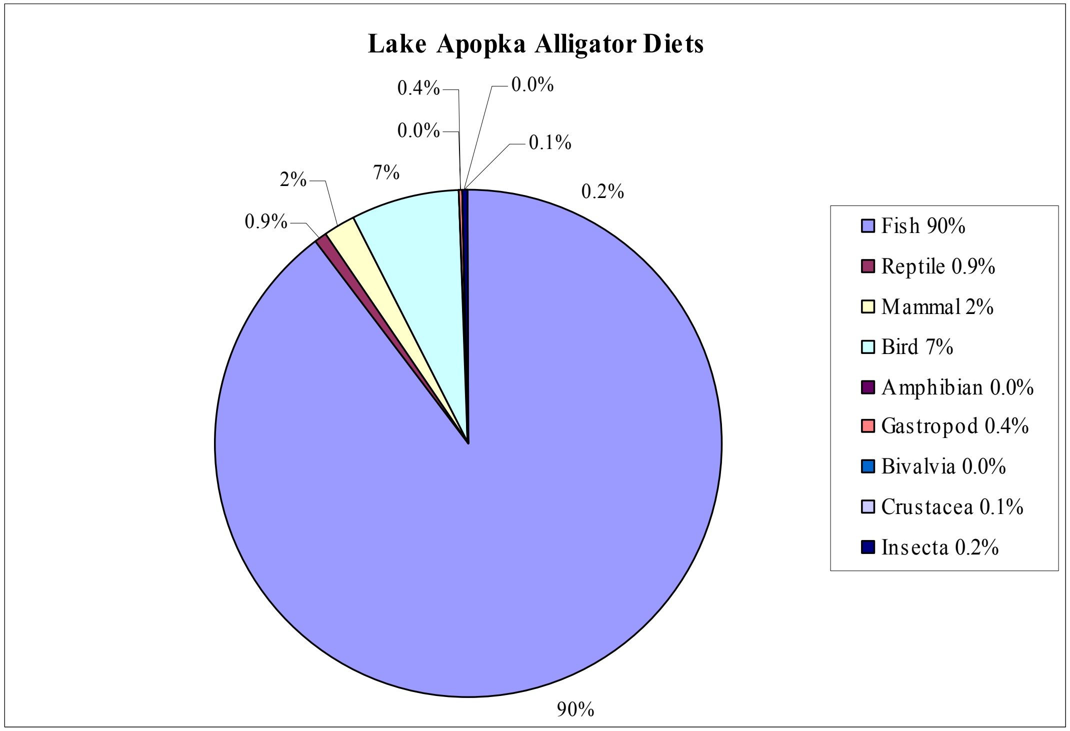


Figure 3-5. Percent composition by live mass for Lake Apopka alligators (N = 44).

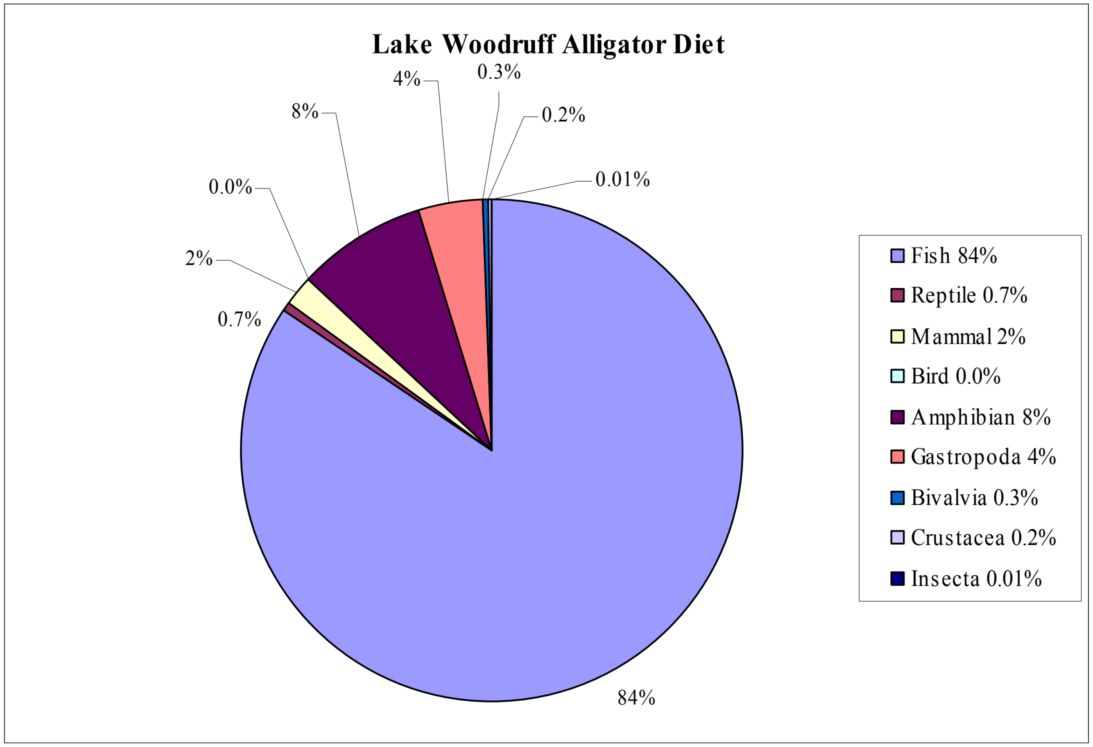


Figure 3-6. Percent composition by live mass for Lake Woodruff alligators (N = 46).

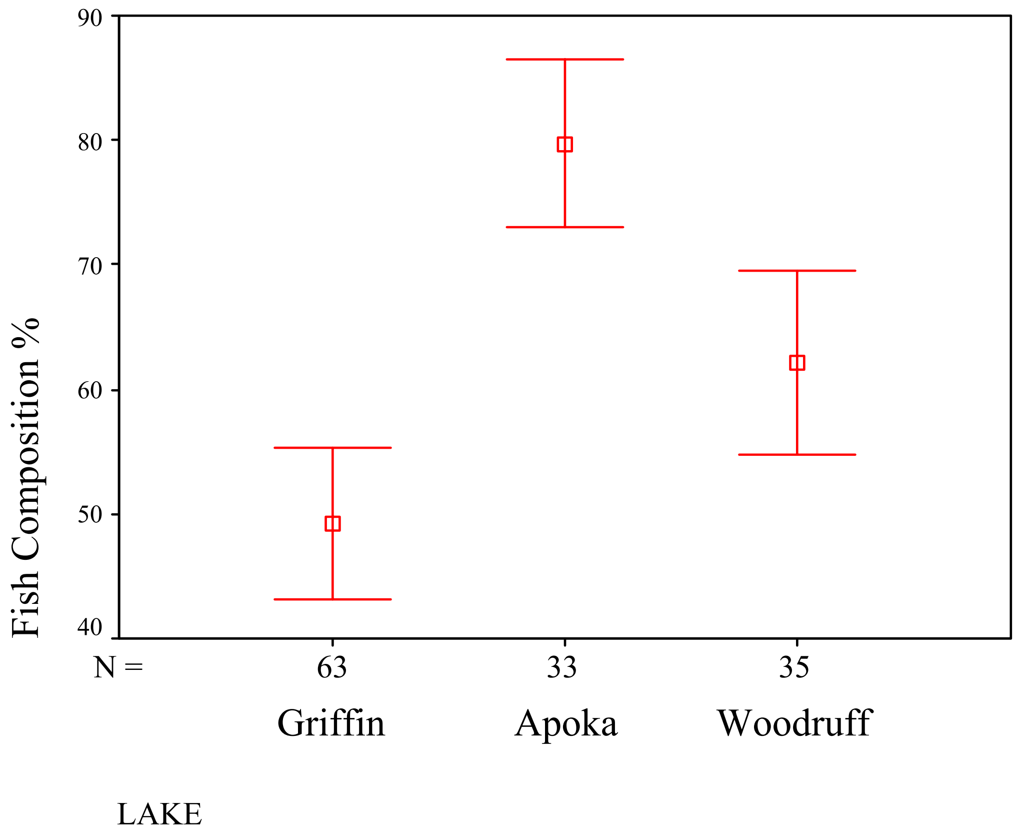


Figure 3-7. Mean fish composition (±SE) for alligators among the lakes.

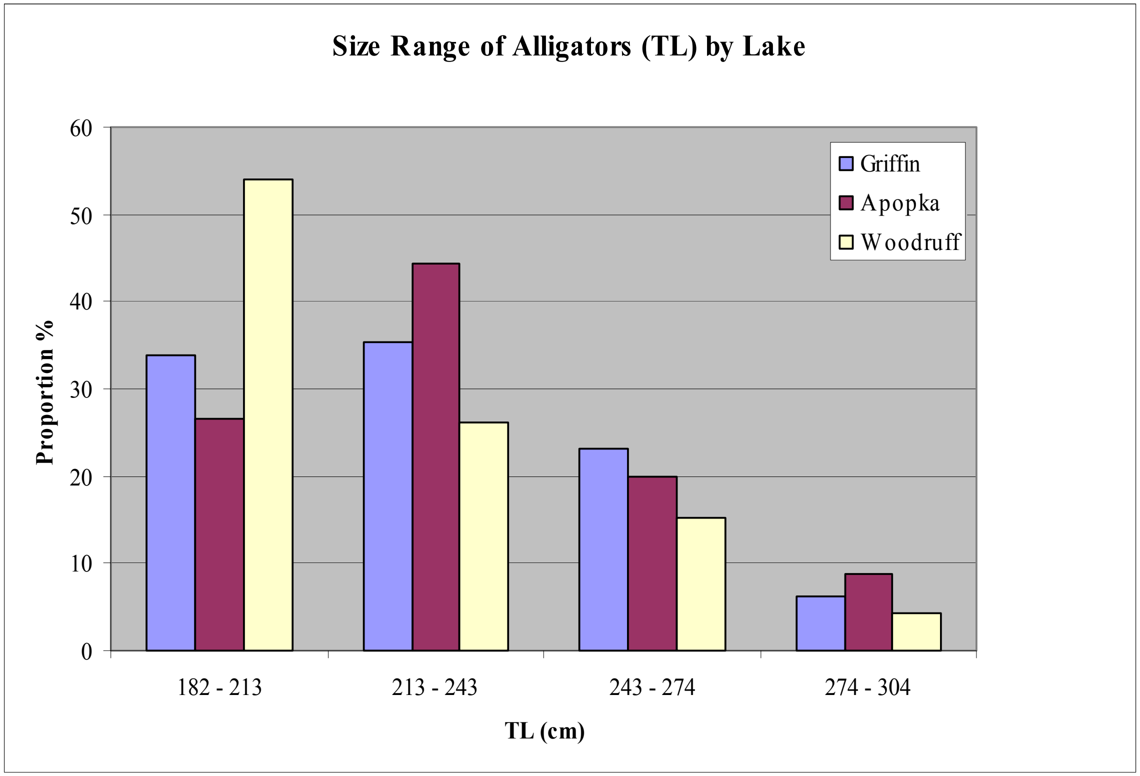


Figure 3-8. Size (TL) of alligators sampled in this study divided into quartiles and compared among the lakes.

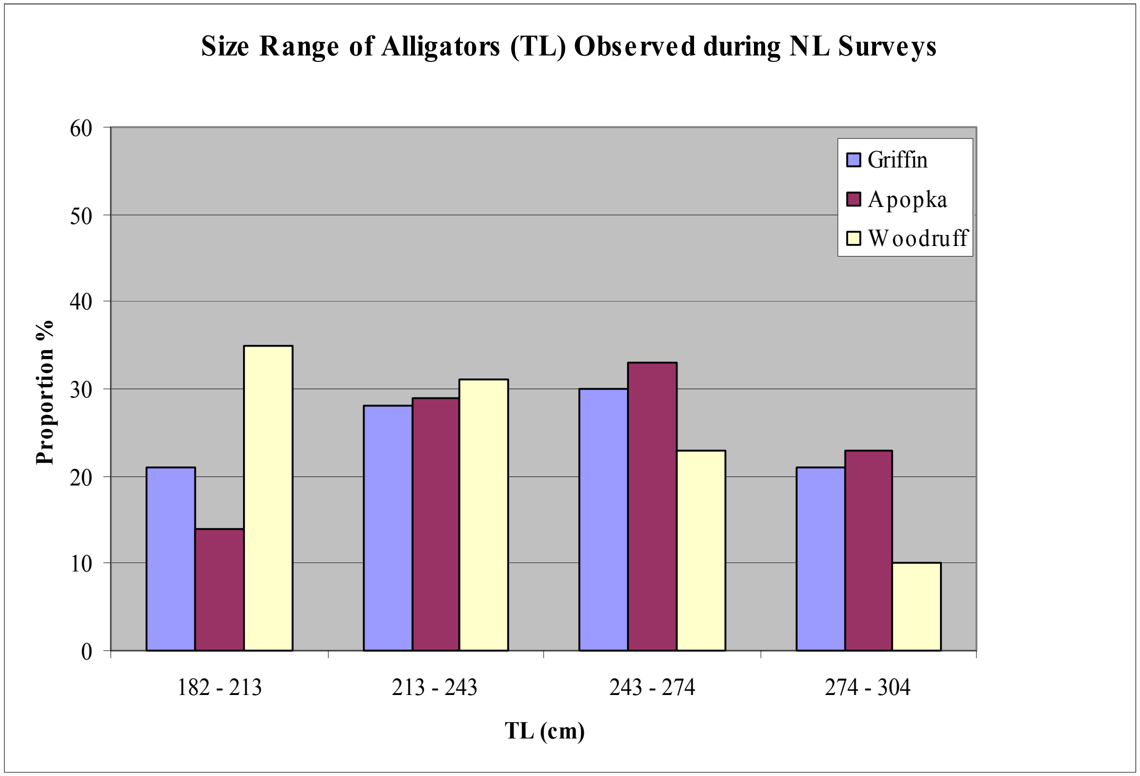


Figure 3-9. Estimated sizes (TL) of alligators observed during night light surveys from each study area (A. R. Woodward, Florida Fish and Wildlife Conservation Commission unpublished data).

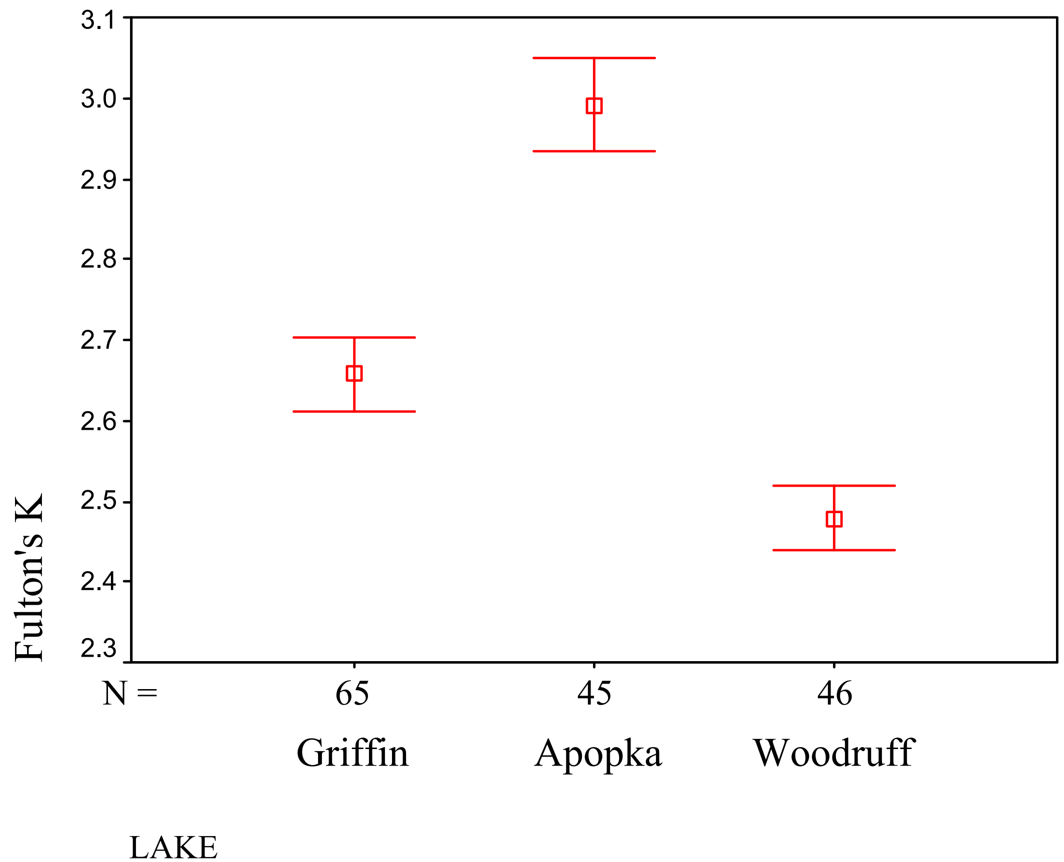


Figure 3-10. Mean condition (± SE) of alligators among lakes.

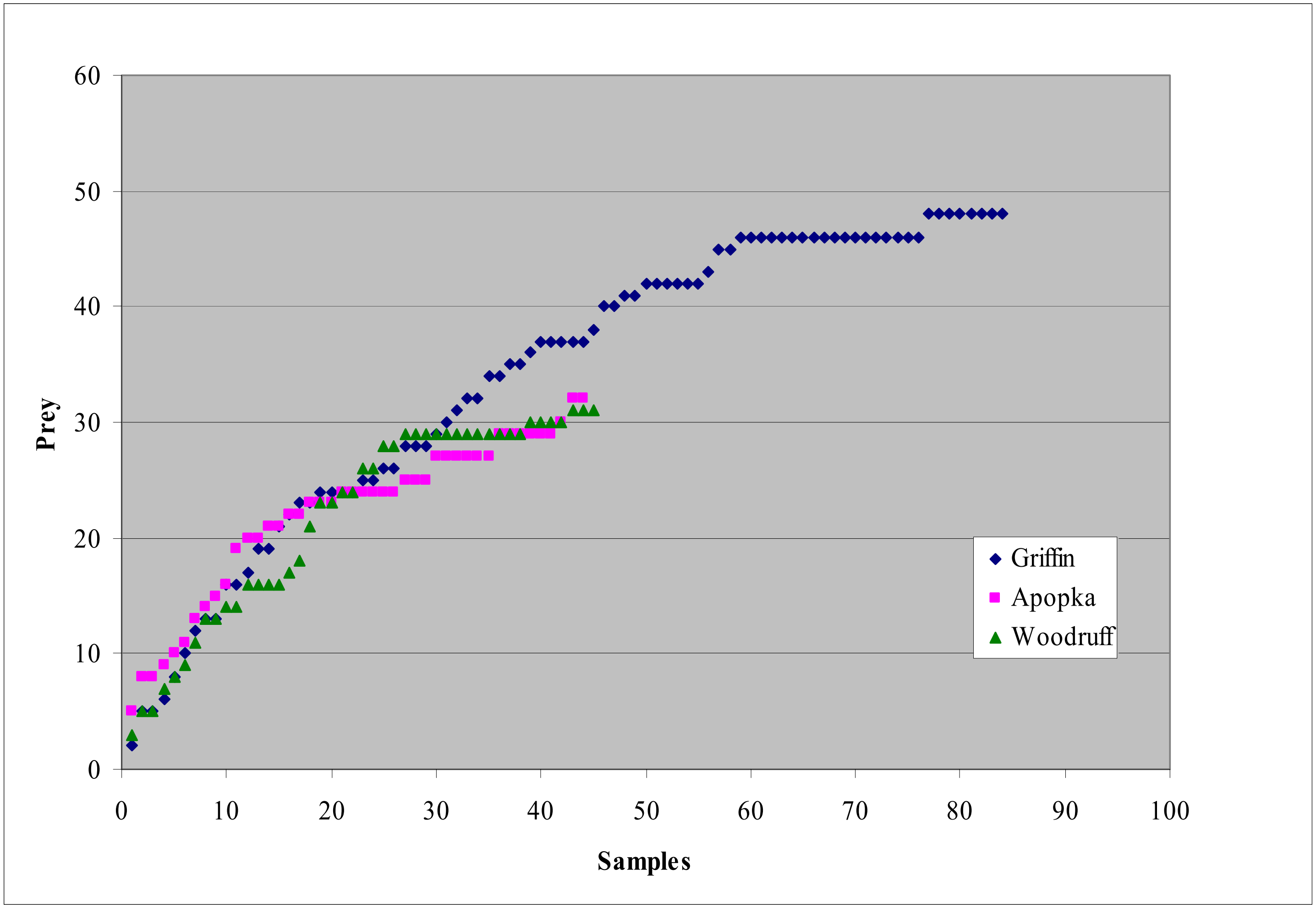


Figure 3-11. Cumulative species recorded with increased sample size.

# CHAPTER 4
# CONCLUSION

The hose-Heimlich technique was an effective and efficient way of obtaining the stomach contents from live adult alligators ≤ 290 cm TL. Analysis of the stomach contents was successfully completed by examining frequency of occurrence of all prey, frequency of occurrence of fresh prey, and with percent composition by live mass for fresh prey. These quantitative analyses complemented each other and provided the best means to examine the diet of the alligators among the lakes.

Alligator diets varied among the lakes. Fish was the number one prey group for all alligators among the lakes, but there were large differences in species composition consumed and number of fish consumed among the lakes. Lake Griffin alligators had the lowest percentage of fish in their diet and ate more non-fish prey groups. Lake Apopka alligators had the lowest diversity and equitability of fish in their diet and repeatedly ate shad. Lake Woodruff alligators had the highest diversity and equitability of fish in their diet and ate more sunfish and bass.

Habitat and prey availability may play a role in alligator diets. Lakes with different trophic states may have different prey available. Lakes occupying different geographic locations may offer different prey. In addition, as lakes change either through eutrophication or through restoration, the prey available to the alligators will also change. Therefore, managers need to be aware that changes in lakes due to either trophic state changes or restoration will affect the fish community. Because alligators are very opportunistic predators that occupy a variety of habitats, they will take advantage of locally available and abundant prey items.

The recent adult alligator mortality on Lake Griffin may or may not have been associated with their diet. The diet of the alligators may give clues to their health and a diet of shad with high level of thiaminase may cause a thiamin deficiency in alligators, but there are probably other factors in Lake Griffin that are contributing to their mortality. This seems especially plausible because Lake Apopka alligators consumed a great abundance of shad, which had high levels of thiaminase and that lake was not experiencing a great amount of adult alligator mortality. More research needs to be done to truly understand the cause of the Lake Griffin alligator mortality.

The Fulton's condition factor provided a quick assessment of alligator condition and allowed for a comparison across populations. Alligator condition varied among habitats and this may or may not be due to alligator diets. Lake Apopka alligators had the highest condition and the highest proportion of fish in their diet. Lake Griffin alligators had the median condition, ate more non-fish prey items, and Lake Woodruff alligators had the lowest condition, ate fish more evenly with a high diversity and had the second highest proportion of fish in their diet. Other factors such as alligator density, alligator hunting behavior, genetics, prolonged feeding period, or wet/dry seasons could play a role in alligator condition. In addition, caution should be used when equating a high condition to better health. Lake Apopka alligators had the highest condition; however, that system has been severely polluted over the last half century and the alligators there have experienced a low reproductive rate. Lake Woodruff alligators inhabit the most pristine environment out of the three and their condition was the lowest overall.

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# BIOGRAPHICAL SKETCH

Amanda N. Rice was born in Leesburg, Florida, on 8 October 1974 and grew up in Mount Dora, Florida. Amanda was always fascinated with animals and the outdoors and decided she wanted to devote her life to working with animals. She obtained her A.S. degree in the Zoo Animal Technology program from Santa Fe Community College in August 1995 and then went on to obtain a B.S. degree in zoo science from Friends University in May 1997. Amanda then proceeded to work at the Jacksonville Zoological Gardens from July of 1997 until August of 2001. While working there, her love for animals grew even stronger as she was able to work with a variety of exotic mammal species. Amanda primarily worked with primates and absolutely loved working with the gorillas. After four years of devotion to the Jacksonville Zoo, she decided to fulfill her goal of obtaining a master's degree and began graduate work at the University of Florida. Amanda's devotion to captive animal care shifted and she became very interested in working with native Florida wildlife. While in graduate school, Amanda fell into the alligator world and became a member of the Florida Alligator Research Team. Prior to graduation Amanda obtained a job as a biological scientist working with amphibians, alligators, and crocodiles and plans to continue her career working with Florida's wildlife.