Interannual and Swan Herbivory Effects on Submergent Aquatic Macrophytes in Brown Lake, Kickapoo Lake, and the Interconnecting Wetland

Bios 569: Practicum in Aquatic Biology

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1998

Abstract

Macrophytes are an important aspect of aquatic ecosystems. They affect and are affected by many freshwater environments. Every aspect of macrophyte life and growth is influenced by light, water temperature, availability of nutrients, sediment composition, inorganic carbon, and herbivory. The purpose of this study was to first determine, through comparison with 1997 data, the interannual variability for Brown Lake, Kickapoo Lake, and the interconnecting channel; and secondly to ascertain the impact of herbivory influences on the submergent macrophyte biomass. This goal was accomplished through transect sampling of Brown and Kickapoo Lakes at 0.5m, 1.0m, 1.5m, and 2.0m and at the edge and middle of the interconnecting wetland channel.

Based on the results that were obtained during the summer of 1998 in comparison to those of 1997, it was concluded that Brown Lake, Kickapoo Lake, Brown Channel, and Kickapoo Channel all had both higher dried submergent macrophyte biomass and more species variation during 1998. It has been proposed that much of this increase in macrophyte activity was the result of increased temperature and light exposure during the summer of 1998. As a result of this finding, it was determined that significant effects of swan herbivory were not seen in the sampled area.

Introduction

Macrophytes play an integral role in many freshwater ecosystems. They both affect and are affected by the physical environment. Some important factors in the environment for macrophytes are light, water temperature, nutrient availability, sediment composition, and availability of inorganic carbon (Barko et al 1986). Because these factors may differ within lakes, from lake-to-lake, and change from year-to-year, they can cause spatial and temporal heterogeneity in the presence, abundance, and distribution of the macrophytes.

Likewise, changes in macrophytes can change the pH and oxygen levels, thus affecting the biota of the lake (Carpenter and Lodge 1986). Certainly, organisms for which macrophytes are an important food source will change in abundance and species composition as macrophytes change.

There are many variables that enter into the equation determining how useful a macrophyte is as a food source, such as the nutrient content, which in many cases is the amount of nitrogen reaped from consuming the plant (Lodge et al. 1998). However, the idea, which has been around since the beginning of the century, is that the herbivory impact on macrophytes is very minimal (Lodge 1991). However, this is at odds with the evidence gathered in recent years (Lodge et al 1998). Most of the previous experimentation that has taken place concerns only a few, small species of herbivores (Lodge 1991). This limitation of species does not allow for the possible effects of the entire biota, especially those exerted by larger animals. Little inquiry has taken place concerning larger animals such as mammals, birds, crayfish, and fish, but those examined have had a much greater impact than suggested by the conventional idea (Lodge 1991; Lodge et al. 1998).

One previously unconsidered large herbivore is the endangered Trumpeter Swan (*Cygnus Buccinator*), which was hunted to near extinction in Midwestern North America the late 1930's (Zimmer 1996). The regrowth of the population of this species has been unusually slow since they have single broods, delayed maturation, a high winter mortality rate. Thus, recently their numbers have increased rather than dwindled (Mitchell 1994).

It has been difficult to rebuild the Trumpeter swan population. Trumpeter swans are tactile and visual foragers that require large, protected bodies of water with little or no human contact (Mitchell 1994). They are herbivorous and eat mostly submergent macrophyte vegetation. During cooler months, before the plants appear, the swan will forage underwater by submerging their long necks for roots and tubers. Trumpeter swans are generalists. It is thought that their typical diet includes a favorite macrophyte that varies depending on the season and what is available (Squires and Anderson 1995).

The Wisconsin Department of Natural Resources chose Kickapoo Lake, Brown Lake, and their inter-lake stream, which are located on the University of Notre Dame environmental research Center (UNDERC) on the upper peninsula of Michigan, to reintroduce two subadult Trumpeter swans in May 1998. In conjunction with the introduction of the Trumpeter swans, I conducted a comparative experiment to determine what change appeared in the submergent macrophyte composition. First by comparison with similar data from 1997, the experiment was designed to determine normal interannual variability for habitats not used by swans, which is advantageous in determining how much change can be contributed to herbivory influences. Secondly, my observations were designed to ascertain the impact of swan herbivory on submergent macrophyte biomass, by comparing transects with and without herbivory influences after taking into account interannual variability.

Materials and Methods

Site Description

The outlets of Kickapoo Lake and Brown Lake join in an extensive wetland to form Brown Creek in the Upper Peninsula of Michigan (46°, 89°). Kickapoo Lake is a moderately stained lake. It has a surface area of 15 acres, a maximum depth of 3.25m with a steep drop off of about 1.0m at the edge of a fringing sedge mat, and flocculent, organic sediments. Brown Lake is a moderately stained, productive, turbid, 63-acre lake with a maximum depth of 5.49m. Sediments in Brown Lake range from sand-gravel to flocculent and organic matter.

Aboveground Submergent Macrophytes

Plants were collected in Brown Creek (16 and 19 June 1998), Brown Lake (18 June 1998), and Kickapoo Lake (24 June 1998) at three pre-existing transects at 0.5m, 1.0m, 1.5m, and 2.0m depths (Japlit 1997). Some of the "existing" transects, could not be located, so new transects were set up using Japlit's maps from the previous year (Figures 1 and 2). On the basis of Japlit's maps, I am confident these new transects are located on the same site as the originals.

While snorkeling, I collected the aboveground submergent macrophytes for each site using a 0.0625 m^2 PVC quadrat. The quadrat was placed randomly on the sediments while the area was cleared of all macrophytes. As the macrophytes were pulled out by hand, they were placed in a labeled zip lock bag, which was refrigerated until the samples were processed within 20 days of collection.

Data Collection

Each plastic bag's contents were rinsed over a 4mm sieve to rid the sample of dirt. The roots and tubers were then detached by hand from the aboveground macrophyte parts and discarded, while the aboveground sample was separated by species. Aboveground parts were allowed to air dry before being placed in a brown paper sack. All the samples were then placed in a drying oven at 60°C for 48 hours, after which a dry weight was obtained and a percentage of dry biomass by species was calculated.

Representative samples of many of the macrophyte species were pressed and saved for future reference.

Results

Site Composition

16 species were found in Brown Lake, Kickapoo Lake and the extensive adjoining wetland (Table 1). For clarity, the wetland will be divided into two areas by which lake is in closest proximity and henceforth will be called Brown Channel and Kickapoo Channel (Figures 1 and 2). The only macrophyte species found in all four locations (Brown Lake, Kickapoo Lake, Brown Channel, and Kickapoo Channel) were *Ceratophyllum demersum, Elodea canadenis,* and *Lemna trisulca*. There were also some species found only in one site: *Utricularia vulgaris* and *Sparganium spp.* were only found in Kickapoo channel, *Vallisneria americana* was only found in Brown Lake, and *Nuphar variegatum* was only found in Brown Channel. The rest of the

identified macrophyte species were found in multiple habitats, while no species were found only in Kickapoo Lake.

After the compilation of the species data (Table 1), the dry weights for each macrophyte species were used to determine their total relative abundance for each location (Figures 3 and 4). Therefore, it is noted that not only do the species differ between Brown Lake, Kickapoo Lake, Brown Channel, and Kickapoo Channel, but the percentage of the species occurrence differs too.

It was observed that the lakes had more species than the channel habitats (Table 1). Thus, the percentages for each individual species are much lower (Figures 3 and 4). Whereas, the channels seem to have fewer species; therefore, each species is represented with a higher percentage.

Compositional variation within transects

The species not only varied between habitats, but also within habitats by depth (Figures 5, 6, 7, and 8). This is shown for Brown Lake in Figure 5 where it demonstrates how specific macrophytes, such as *C. demersum*, start out strong with 63%, then its presence slowly trails off to 2%. Finally by 1.5m, the species was no longer be detected. Similar trends are shown for Kickapoo Lake in Figure 6, Brown Channel in Figure 7, and for Kickapoo Channel in Figure 8.

Amount of Present Macrophytes

It was found that the middle of Brown and Kickapoo Channels contained more dried biomass than the edges (Figure 9). However, in Brown Channel the difference between the middle and the edge was enough to be statistically significant, whereas there was no statistical difference found in Kickapoo Channel.

In the lake habitats there was no significant difference between any of the transects of Brown Lake; however, there are large differences between the grams of dried biomass found at different depths (Figure 10). The data shows that there is no significant difference in amount of biomass gathered at 0.5m, 1.5m and 2.0m in Brown Lake. There were some statistical differences found in Kickapoo Lake though. There was a statistical difference found between the 2.0m and the 0.5m depths and also between the 2.0m and the 1.0m depths. However, there was no significant relationship between the 1.5m depth and any other depth (Figure 10).

In all cases, except for the 2.0m depth, the Brown habitat (Lake and Channel) had more submergent macrophyte biomass than the Kickapoo habitat (Lake and Channel) did at an equivalent depth or location (Figures 9 and 10).

Discussion

Species Composition

The previously collected vegetative data for the summer of 1997 shows the macrophyte composition of Brown Channel to be *Ceratophyllum demersum, Elodea canadensis, Potamogeton filiformis*, and *Potamogeton robinisii*, which are very different from the vegetative species found in the summer of 1998 (Japlit 1997). This same pattern was also found in all other sampled habitats. In each case, there was more diversity found in the summer of 1998 than 1997 (Japlit 1997). Some of the discrepancies in the number of types of biomass found between the two summers are thought to be attributable to wrongful identification of macrophyte species during the summer of 1997. This was concluded from the fact that in 1997, as in 1998, examples of sampled species were saved for further reference and upon consulting of this source discrepancies were found with the key. One example of a misidentification that was found was a plant labeled as *Vallisneria americana* was actually found to be a species of *Sparaganium.*

Based on the review of environmental conditions on submersed aquatic vegetation found in Barko et al. (1986), it is thought that temperature and light were the main factors affecting the interannual distribution and composition. During the summer of 1998, the weather was noted to be "surprisingly" warm, having many days that reached record highs, with the snow vanishing much sooner than normal. It is thought that these unusual temperature conditions led to changes in the lake environment. Since seasonal changes promote water temperature changes, it is presumed that the earlier seasonal change will cause the water warm to summer temperatures sooner, which will cause the macrophytes to quicken their growth and reproductive cycles. Running along this logic, it is thought that the water will ultimately reach an increased average temperature. It has been shown most aquatic plants optimize their growth at higher temperatures than are commonly found in Northern Wisconsin water systems, so those with a competitive advantage for cold temperatures will have lost their advantage letting new 'unnatural' species grow. Light availability was also noted to have changed with the lack of ice covering the water earlier in the year, this too may have led to a change in interspecies composition causing more diversity in the summer of 1998.

Barko also discussed that nutrients, sediment composition, and inorganic carbon change the macrophyte make-up; however, it is not likely that these conditions changed between years in the same habitat.

It was also noted that there were certain species that only appear in lakes or in channels, but not found in the other type of habitat. This is thought to occur because the similarities of their environments. The close proximity of the lakes to their adjoining channel also causes some similarities from the migration of species out of their original habitat into the adjoining habitat (i.e. moving from the channel into the lake by tuber extension).

Whole Habitat Comparisons

As it was stated above, there are many similarities between the studied habitats with similar environmental traits. However, these ideas apply only to the species composition found in the area, not to the quantity of submerged macrophyte biomass. In comparing the data from the summer of 1998 to that collected in 1997, it was found that on an overall basis the summer of 1998 was more productive (Japlit 1997). It was found sometimes the total aboveground biomass was three or four times the magnitude it had been a year earlier. The reason for this great increase in macrophyte biomass is thought to be related to the increase in water temperature and earlier light exposure, which both were discussed above.

Changes in Depth Pattern

Carpenter and Titus (1984) suggest that variations within transects come in three main types: (a) gradual composition change along the transect, (b) abrupt shifts between common and rare species, and (c) abrupt shifts among common species. Examples of each variation type were found in the transects of the present study as well as those of the study of Big Muskellunge Lake. The most common of the transect shifts in the present study are those involving gradual changes in macrophyte composition. It has been found that many times these gradual shifts are the result of the changing slope of the sediment (Carpenter and Titus 1984). This change in bottom depth also affects amount of light available to be received by macrophytes at that depth. Therefore, a decline in total biomass results (Barko et al 1986). Another notable pattern that changes with depth is the species composition. This is also a result of the amount of light that reaches the plants, since the amount of light decreases substantially as the depth of the water increases.

Herbivory Effects

The herbivory effects of the introduced Trumpeter Swans will be difficult to note for two reasons: 1. the swans were introduced before the macrophyte biomass of the 1998 year could be examined and 2. the swans moved freely between the different habitats. The swans were seen feeding within the transect areas, thus one would think if the swans had a significant impact on the submergent macrophytes the biomass would have decreased. However, the biomass was noted to have greatly increased from the summer of 1997 to the summer of 1998 and there seemed to be no percentage change in species that swans have been shown to favor (Japlit 1997). Even with this information the idea of significant effects of swan herbivory on aquatic macrophytes cannot be discounted, since Hyder (1998) found that swans to fed mainly outside the sampling area.

Acknowledgements

I would to thank The Bernard J. Hank Family Endowment for the funds to run the course of which this project was a part and Dr. Ronald Hellanthal the Gillen director of that program. I would also like to thank Adrienne Froelich, Jeff Runde, and Dr. William Perry for sharing their knowledge and technical support. I would like to thank Allison Vogt for all of her help while we were studying in Australia and help fending off swans while sampling. I would also like to thank Joseph Hyder my partner in all this madness for his patience, hard work, help, company, and ability to grab a swan by the neck while jumping on its back. Last but not least I would like to thank my advisor Dr. David Lodge who has listened to my gripes, mishaps, computer malfunctions, and everyday problems from halfway around the world while always finding the best solution.

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Zimmer, 1996.

Brown Channel

Ceratophyllum demersum
Elodea canadensis
Lemna trisulca
Nuphar variegatum
Nymphaea odorata
Potamogeton filiformis

Kickapoo Channel

Ceratophyllum demersum
Elodea canadensis
Lemna trisulca
Megalodonta beckii
Myriophyllum spp.
Nymphaea odorata
Potamogeton amplifolius
Potamogeton robinisii
Sagittaria spp.
Sparganium spp.
Utricularia vulgaris

Brown Lake

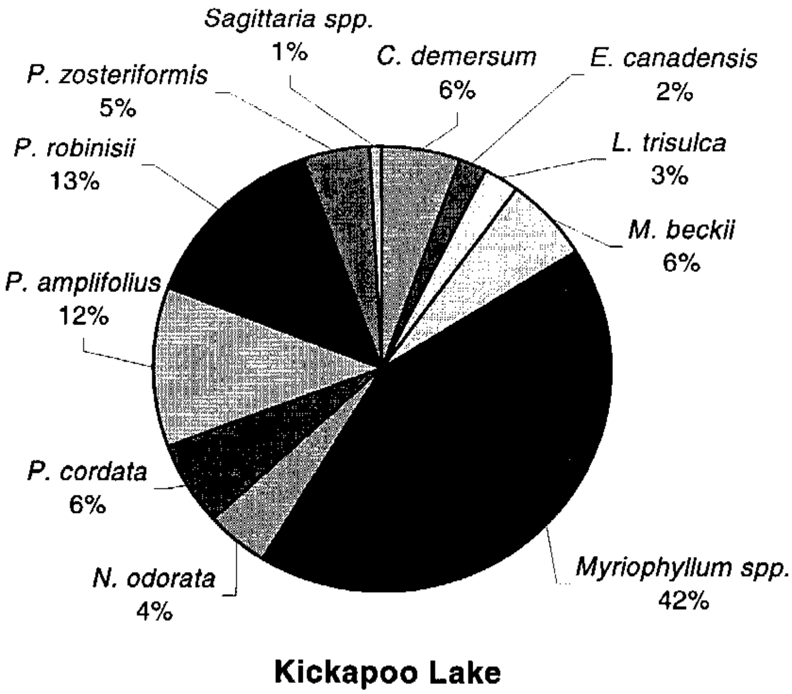
Ceratophyllum demersum
Elodea canadenis
Lemna trisulca
Pontederia cordata
Potamogeton amplifolius
Potamogeton filiformis
Potamogeton robinisii
Potamogeton zosteriformis
Sagittaria spp.
Vallisneria americana

Kickapoo Lake

Ceratophyllum demersum
Elodea canadenis
Lemna trisulca
Megalodonta beckii
Myriophyllum spp.
Nymphaea odorata
Pontederia cordata
Potamogeton amplifolius
Potamogeton robinisii
Potamogeton zosteriformis
Sagittaria spp.

Table 1: Macrophyte Species Sampled in Each of the Four Habitats

16 different species were found in the four habitats. Some species differed between the habitats, yet some species were found in all habits.



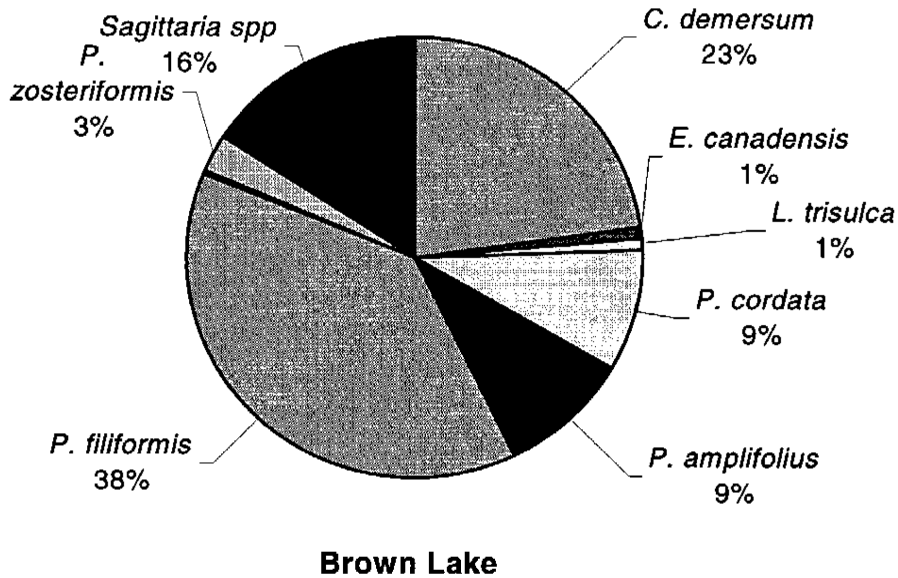
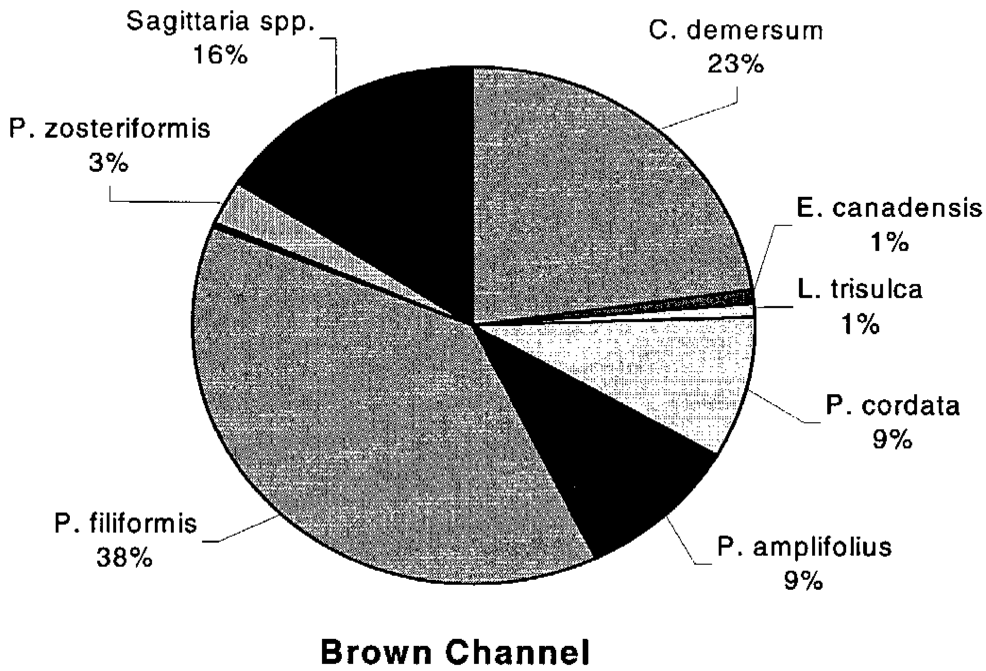


Figure 3: Brown and Kickapoo Lakes Percentage Total Aboveground Submergent Dry Biomass

Percent abundances of the dry biomass were averaged from all depths (0.5m, 1.0m, 1.5m, and 2.0) to obtain total lake macrophyte abundance for each species.



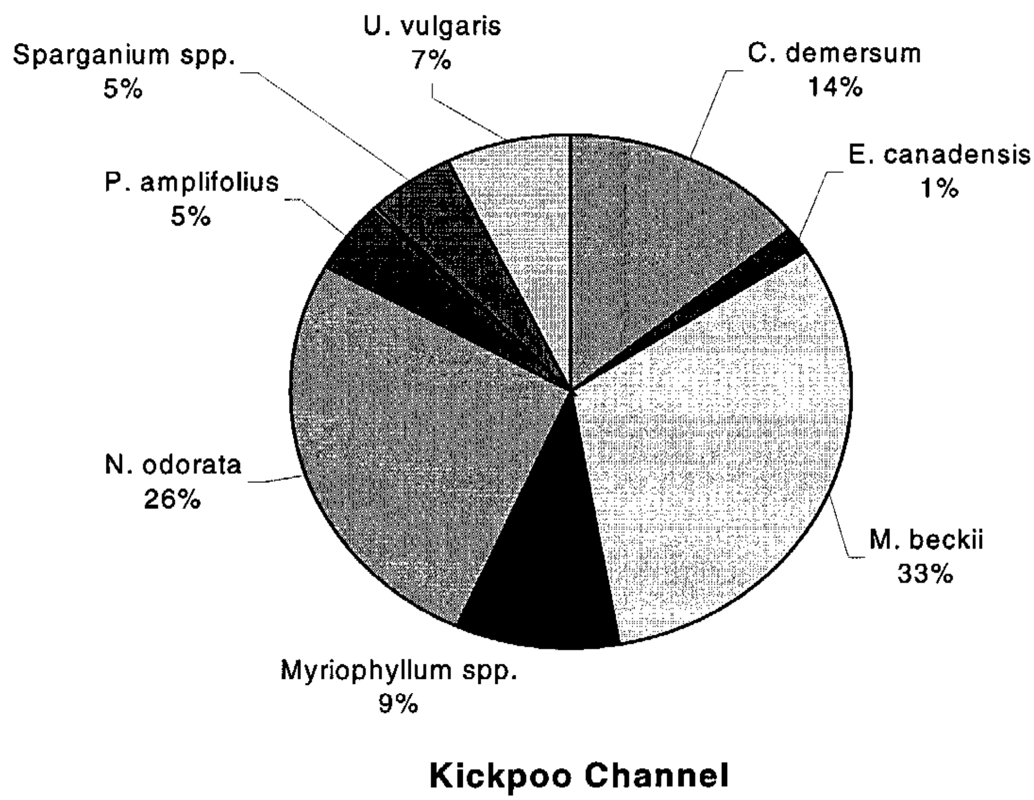


Figure 4: Brown and Kickapoo Channel Percentage Total Aboveground Submergent Dry Biomass

Percent abundances of the dry biomass were averaged from all depths (edge and middle) to obtain total lake macrophyte abundance for each species.

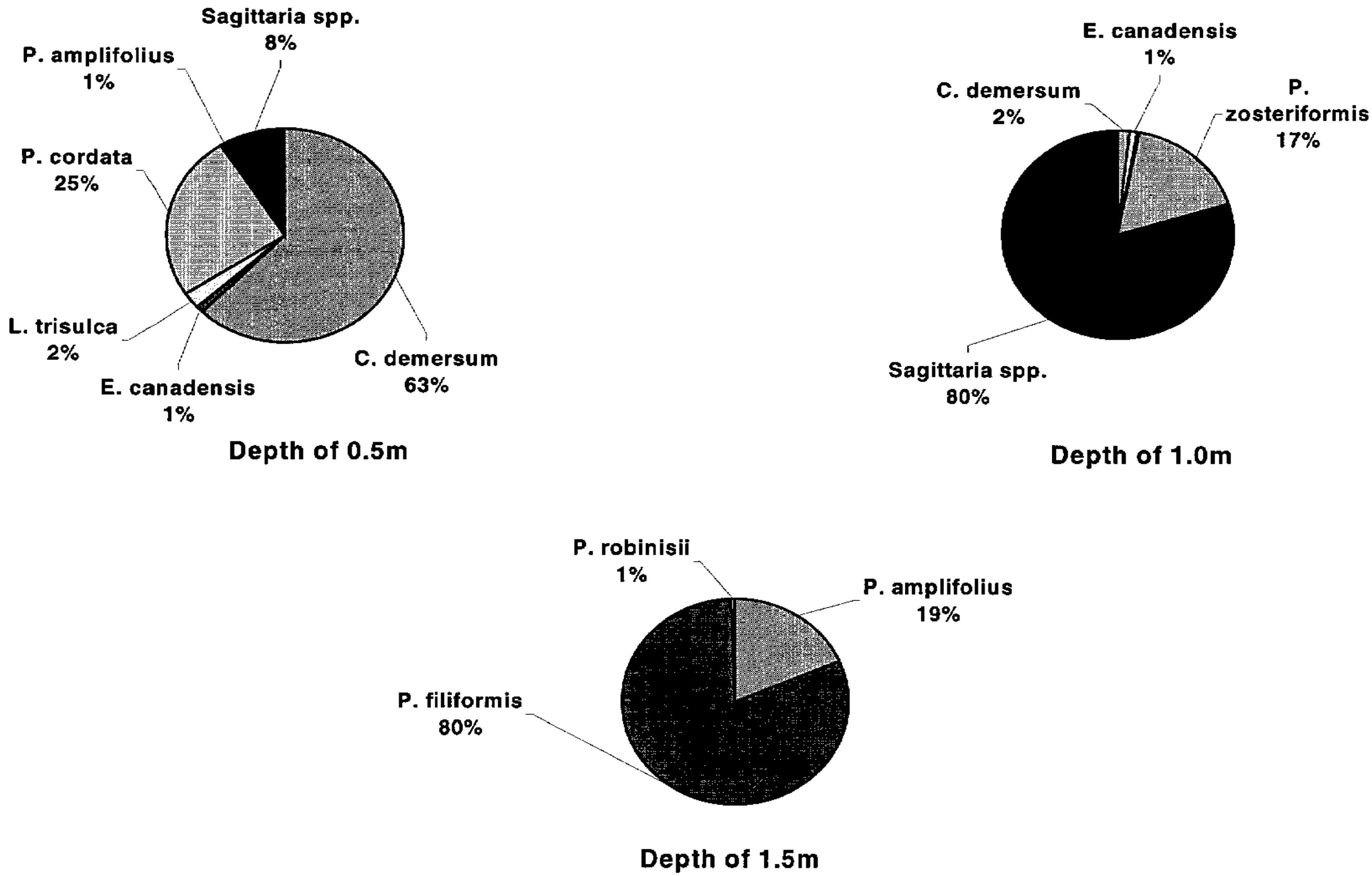


Figure 5: Percentage of Macrophyte Dry Biomass Composition of Brown Lake at Each of Three Depths

Replicate samples were averaged within each depth to give a mean percent abundance for that particular depth. There were no macrophytes at the 2.0m depth.

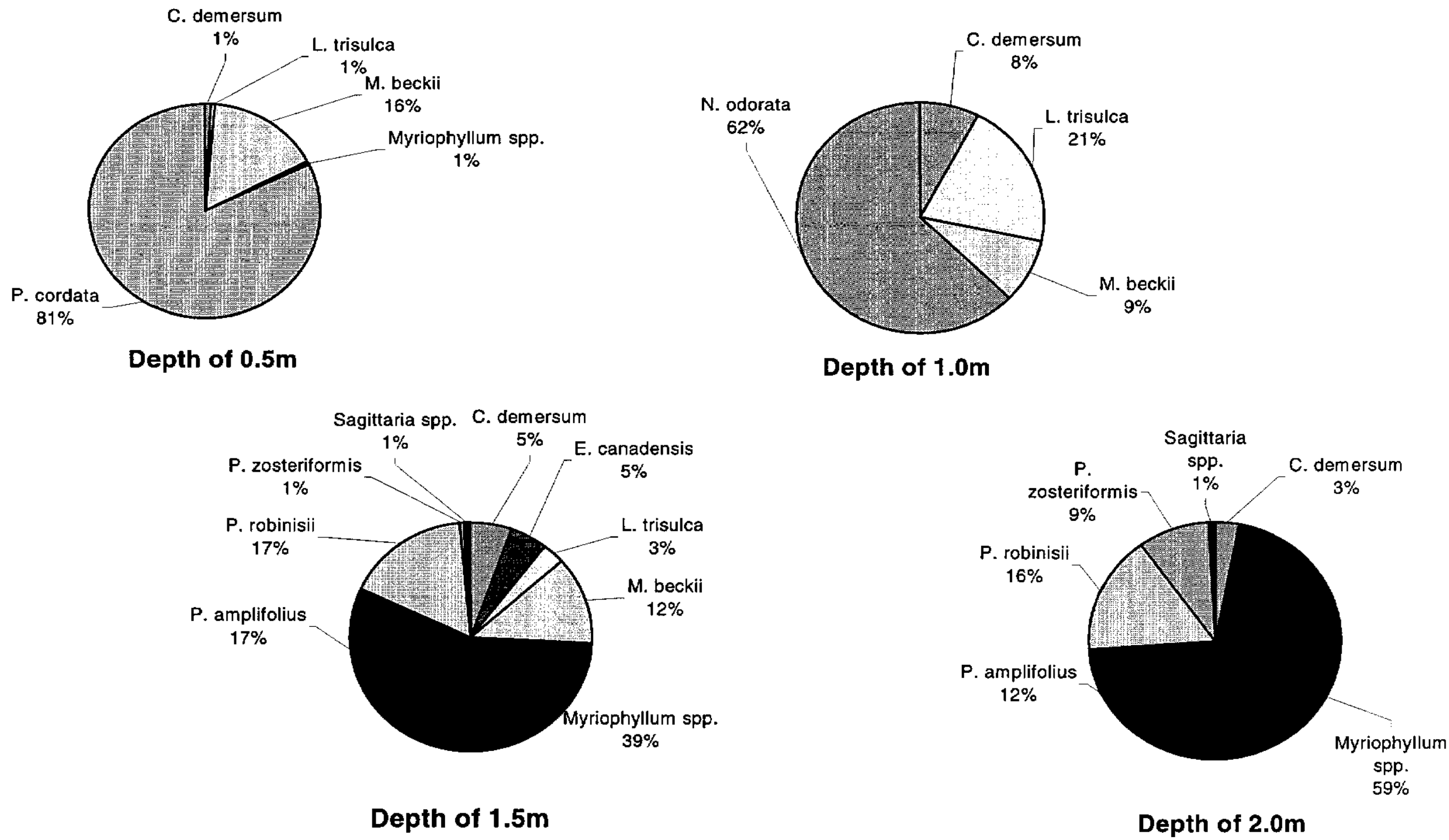
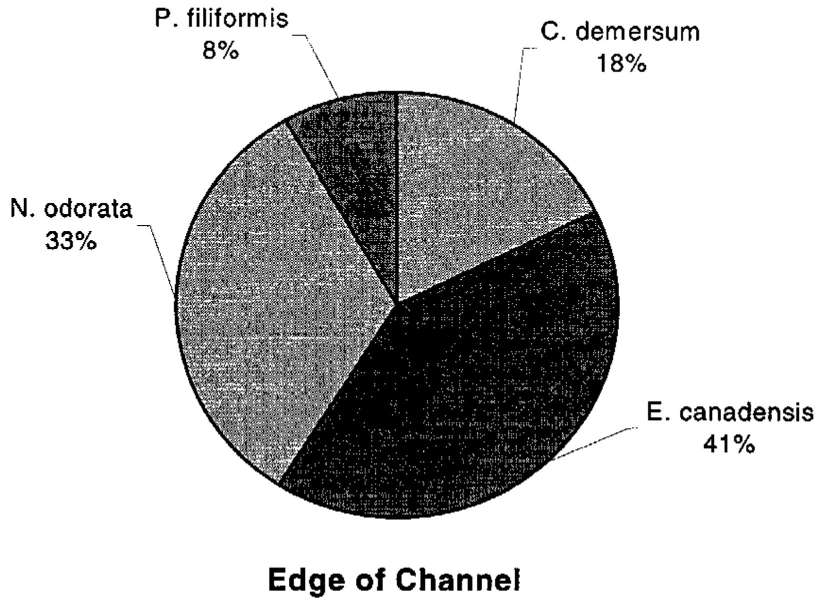


Figure 6: Percentage of Macrophyte Dry Biomass Composition of Kickapoo Lake at Each of Three Depths

Replicate samples were averaged within each depth to give a mean percent abundance for that particular depth.



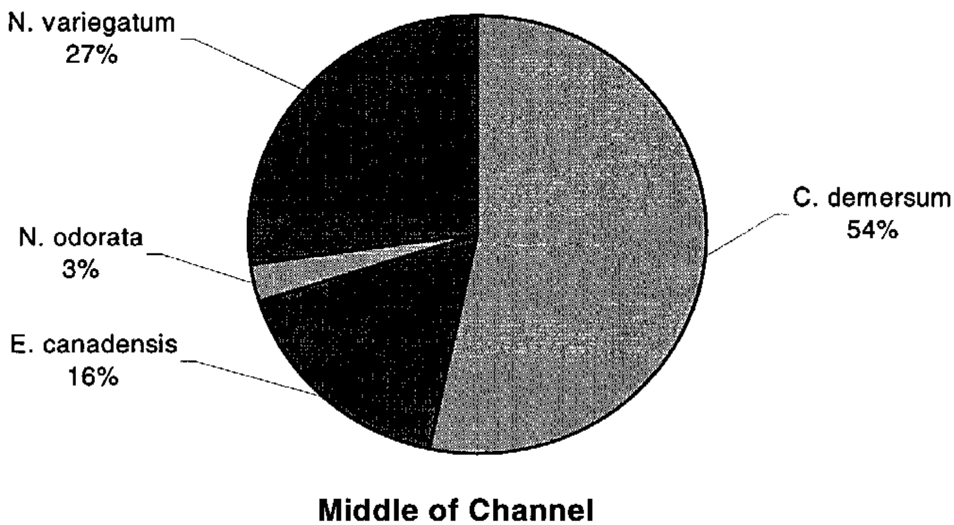
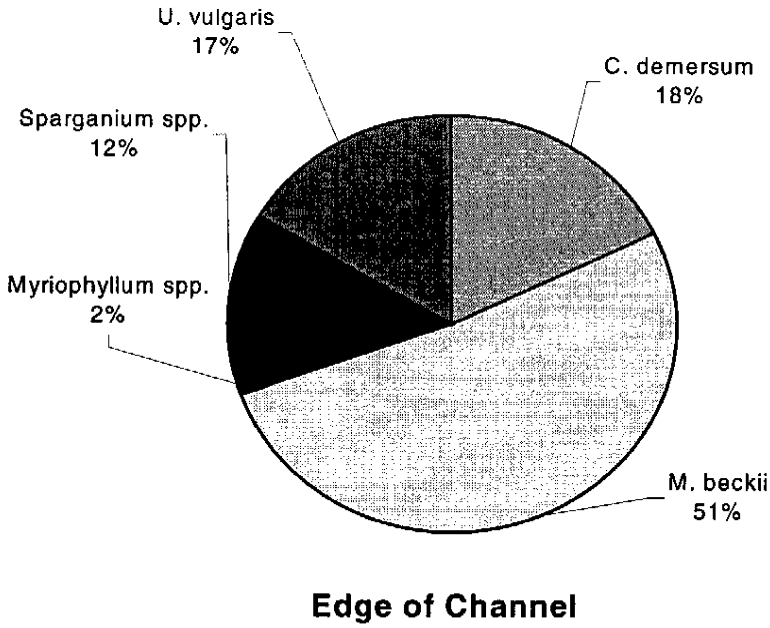


Figure 7: Percentage of Macrophyte Dry Biomass Composition of Brown Channel at Two Locations
Replicate samples were averaged within each channel location to give a mean percent abundance for that particular depth.



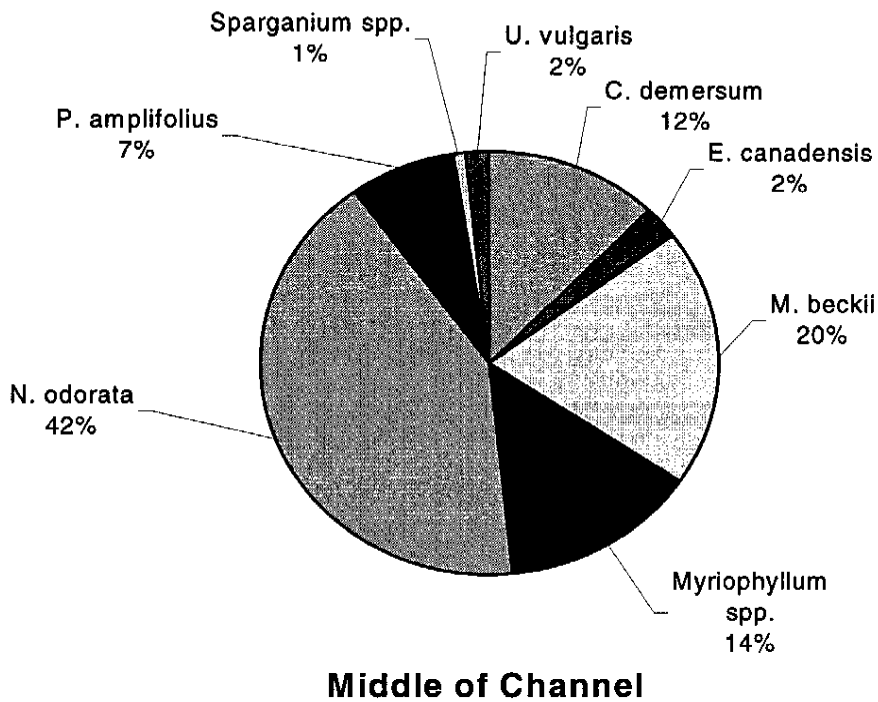


Figure 8: Percentage of Macrophyte Dry Biomass Composition of Kickapoo Channel at Two Locations
Replicate samples were averaged within each channel location to give a mean percent abundance for that particular depth.

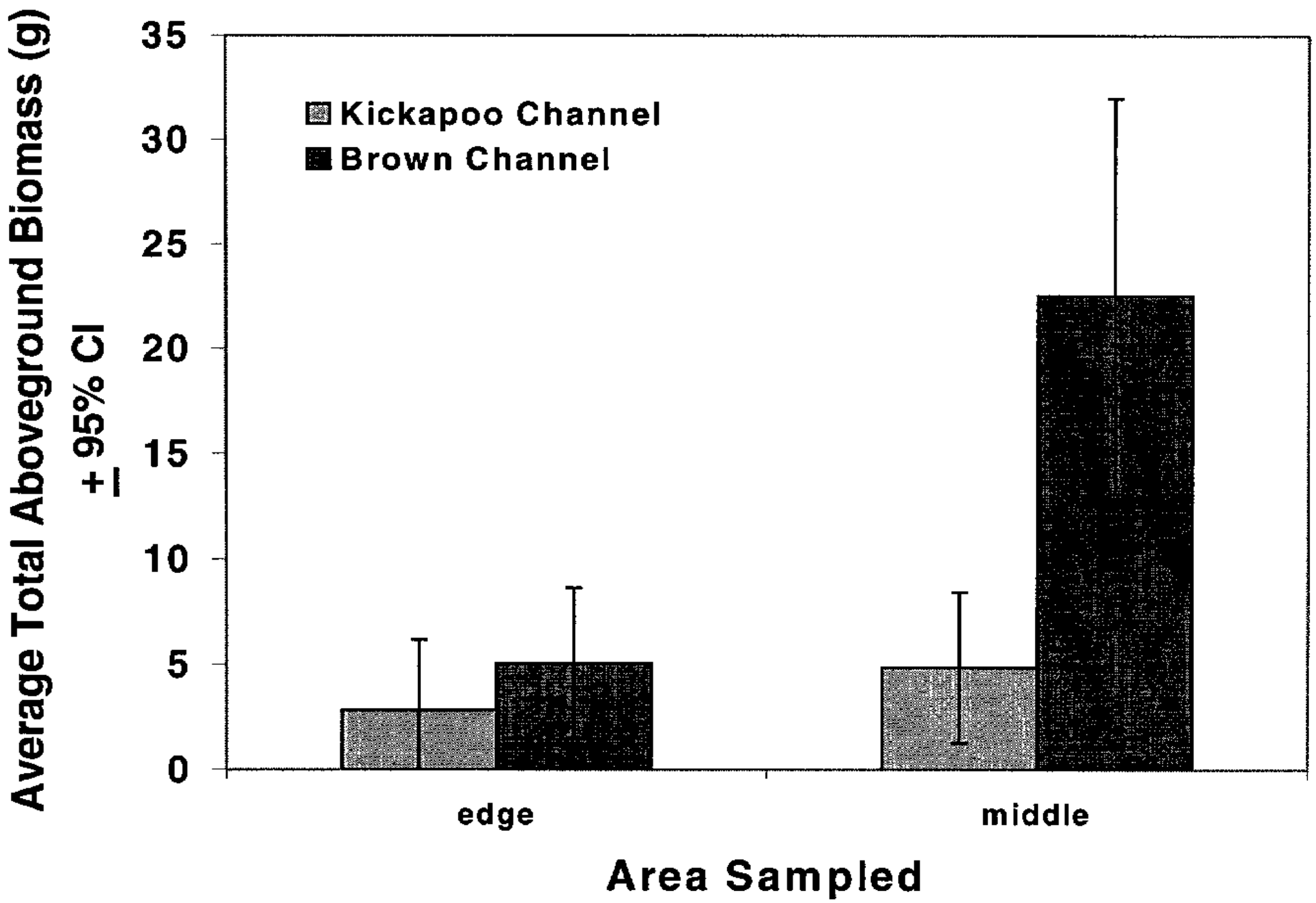


Figure 9: Total Aboveground Biomass for Brown and Kickapoo Lake
All sumbergent macrophyte species were tallied and averaged to obtain a separate mass number for each sampled depth (0.5m, 1.0m, 1.5m, and 2.0m).

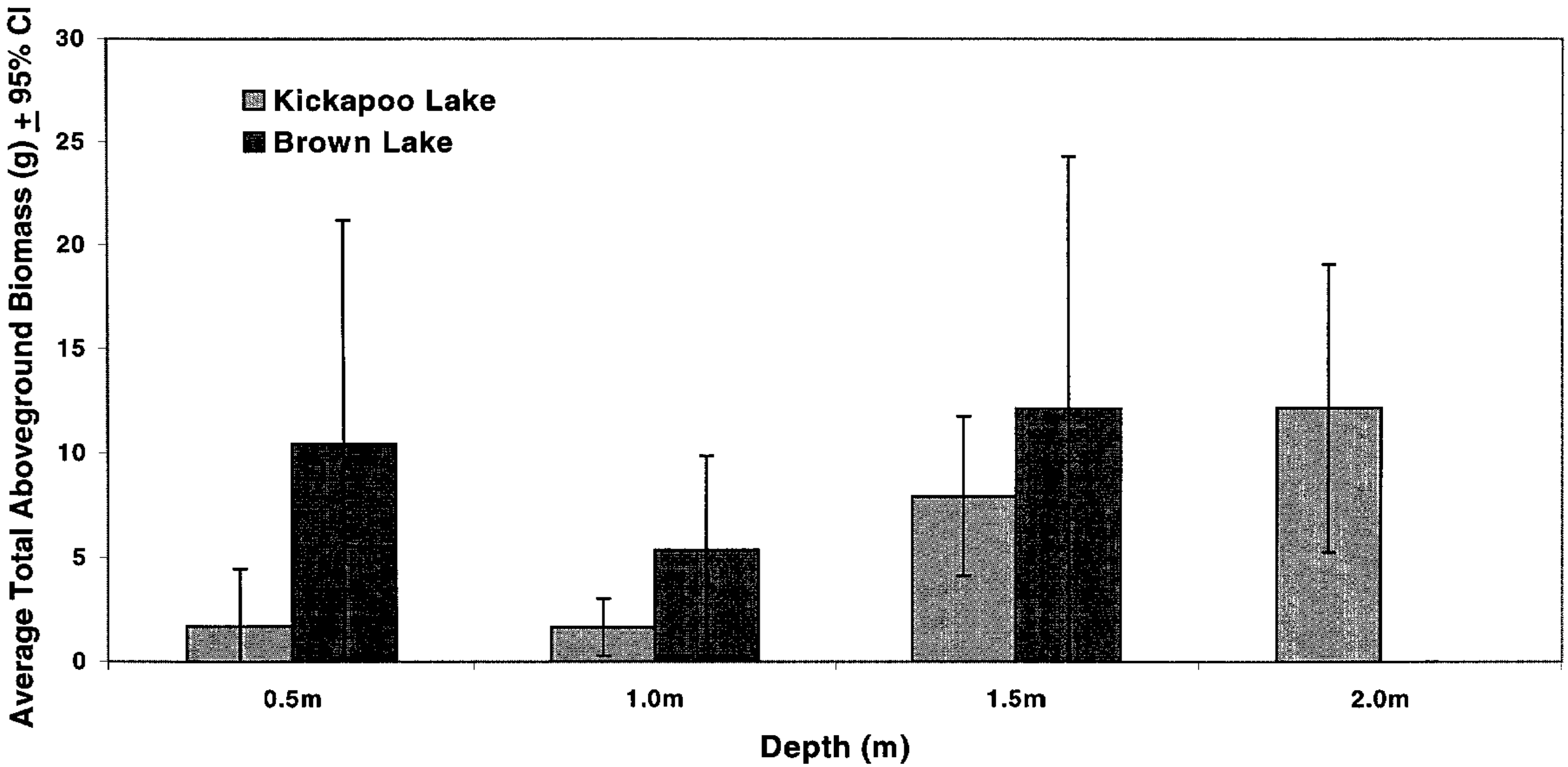


Figure 10: Total Aboveground Biomass for Brown and Kickapoo Lake
All sumbergent macrophyte species were tallied and averaged to obtain a separate mass number for each sampled depth (0.5m, 1.0m, 1.5m, and 2.0m).