CHAPTER 11. BENTHIC MACROINVERTEBRATES, APPENDIX 11.D FINAL REPORT FROM 2009 FIELD STUDY

by

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2011

MACROINVERTEBRATE COMMUNITY ANALYSIS FOR DEVELOPING A MONITORING PROTOCOL TO DETECT EFFECTS OF WATER WITHDRAWAL FROM THE UPPER ST. JOHNS RIVER

K. W. Cummins and R. W. Merritt. March, 2011

INTRODUCTION

Our use of freshwater benthic invertebrates to monitor changes in the upper and middle St. Johns River ecosystem has involved three general steps:

1. Gather baseline data to serve as the freshwater invertebrate default standard for the pre-water withdrawal condition of the upper and middle St Johns River. We recommend that these data be used for comparison to future years when water is withdrawn from the river.
2. Using analyzed baseline data, identify the most probable macroinvertebrate parameters predicted to respond to water withdrawal from the upper and middle St. Johns River. In addition, the analyses should identify those measurements that are **not** likely to show effects and should not receive a high priority for routine monitoring.
3. Recommend measurements of macroinvertebrates to be made and methods of collection and analysis to be used to monitor the effects of water withdrawal from the upper and middle St. Johns River.

ASSUMPTIONS

Based on the patterns of macroinvertebrate taxonomic and community structure in the middle and upper St Johns River, we contend that the on-going status of certain of these patterns can be assessed in future monitoring. Although we believe it is always better to use biomass data when employing invertebrates to evaluate river ecosystem conditions, in many cases numerical data will suffice to establish the same patterns because it is the relative differences at different water levels resulting from water withdrawals that will be critical. For example, as described below, when patterns of macroinvertebrate community structure are expressed as ratios of functional feeding groups (FFG) using biomass data, the same ratios expressed numerically often compare favorably, as long as the focus is on threshold levels. Because financial, personnel, and time constraints usually dictate that only numerical data be collected and analyzed, our recommendations assume that the normal procedure will be numerical analysis.

Samples collected from the three sites on the upper St. Johns River (Lake Monroe, Near Yankee Lake, and Poinsett) yielded highly variable data as shown by large and overlapping standard errors. When the error bars (1 standard error of the mean) overlapped, e.g. for a given parameter when comparing sites, we concluded that the differences were not significant and would provide little information suitable to determine or predict changes attributable to altered water levels. Because of this high variability, we recommend focusing on specific rather than general comparisons. For example, monitor by making comparisons of a specific aquatic plant habitat, from one site at the same season from year to year, rather than average trends across all three sites and all plant and marsh habitats. Furthermore, the taxonomic comparisons should be of individual taxa collected from each season, site and habitat separately from year to year. And, because the numbers of individuals (and their biomass) of a given taxon are so variable, the functional feeding group (FFG) approach described below is recommended as one of the more significant group of metrics. This approach, which combines taxa into groups (guilds), has been proposed as the most promising method to detect river ecosystem and food chain effects of water withdrawals.

Also, we have concluded that diversity analyses (Shannon, Simpson, evenness) and several other metrics normally used in rivers and wetlands provided little useful information for distinguishing sites, seasons (flow levels), or habitat types because essentially all the error bars overlapped.

INTERPRETATIONS AND RECOMMENDATIONS

Materials and Methods

Macroinvertebrate Sampling and Processing

This study was conducted in July (average flow) and November (low flow) 2009 in three reaches: Lake Monroe, Lake Poinsett, and near Yankee Lake on the upper and middle St. Johns River watershed in Florida, U.S.A. (**Fig. 1).** Macroinvertebrates were collected from four different vegetation types including: mixed emergent marsh vegetation, bulrush, *Nuphar* and *Hydrilla*. We collected 6 samples near Yankee Lake in both July and November, 25 samples in July and 24 samples in November in Lake Poinsett, and 30 samples in July and 33 samples in November from Lake Monroe. More samples were collected in Lake Monroe because this was the only place that also had a submergent vegetation zone of *Hydrilla*. In total, we collected 61 samples in July 2009 and 63 samples in November 2009. Sampling was conducted by boat and macroinvertebrates were collected with a D-frame dip net (500 µm mesh) within a 1 m^2 PVC frame (randomly selected) to delineate areas to be sampled in each vegetation type. Macroinvertebrate sample collections were timed (30 sec. effort), similar to techniques used in the Kissimmee and Caloosahatchee Rivers in Merritt et al. (1996; 1999, 2002). Macroinvertebrate specimens in each sample were washed through a 500 µm mesh sieve, labeled, and preserved in whirl pak© bags and 70% ethanol. Samples were then transported to Michigan State University's aquatic entomology lab for further processing and identification. In the lab, larger benthic samples were split in half with an Aquatic Research Instruments Folsom Plankton Splitter© into two sub-samples. Only one sub-sample was then processed to reduce sorting time. Macroinvertebrates were then picked out of detritus in the samples using forceps and a dissecting microscope. The invertebrates were enumerated and identified to the lowest practicable taxon (usually generic level) using Thorp and Covich (2001) and Merritt et al. (2008) (**Table 1**). Non-insect invertebrates were typically identified to family and genus and insect taxa were identified to genus and species (except the Chironomidae which were combined at the family level). Invertebrates also were assigned to a functional feeding group (FFG; as described in Merritt et al. 2008) or other functional designation using data in Merritt et al (2008). All specimens were measured to the nearest mm to allow for biomass estimates using published length-dry mass regression data from Benke et al. (1999) and a computer program INVERTCAL, previously used by Merritt and Cummins (Merritt et al. 2002). Samples were processed in Merritt's lab and QA/QC of the identifications was done in Cummins's lab using a reference collection that was prepared during the sorting and identification process.

Taxonomic Composition

The macroinvertebrate taxa collected in the samples from all three sites, both seasons, and all plant habitat types are listed in **Table 1**. The mean relative % abundances of five selected taxa expressed as biomass and density (mean number per sample) are summarized in **Table 2.** A compendium of actual biomass and numbers of each taxon collected at the three sites in the upper and middle St. Johns River are given by sample in the **Appendix.**

MACROINVERTEBRATE RESPONSES TO WATER WITHDRAWAL

Comparisons of Taxa by Site, Season, and Plant Habitat

As stated under point 2 in the Introduction above, "…the analyses should identify those measurements that are **not** likely to show effects and should not receive a high priority for routine monitoring. Therefore, only selected taxa are treated here as important candidates for monitoring, but analyses of all taxa collected in the samples are given in the Appendix**.** Odonata, Hemiptera, Dytiscidae, *Bellura*, and *Palaemonetes* were selected because of their potential as game fish food and/or their long life cycles which make them good candidates for monitoring the effects of water withdrawal (**Table 2**).

The shredder-detritivore grass shrimp *Palaemonetes* dominated the biomass, and was also one of the numerical dominants, when all sites and habitats were considered in both seasons (Appendix). These shrimp are the dominant consumer of coarse particulate organic matter (CPOM) detritus derived from vascular aquatic and marsh plant dieback. *Palaemonetes* played a similar dominant ecological role in the Kissimmee River in south Florida (Merritt et al 1996). Grass shrimp in the St Johns River would be expected to reflect any increases in the availability of CPOM detritus associated with greater plant dieback and increased CPOM food supply for shredder-detritivores resulting from lower water levels. In as much as *Palaemonetes* is an important food supply for largemouth bass, as it was in the Kissimmee River, an increase in CPOM could have significant food chain effects.

The large predators (Odonata and Hemiptera) constitute a special case of interest because of their large size and long life cycles. Most are semi-voltine (life cycles > 1 yr.) which renders them particularly susceptible to annual changes in water level that limit the availability of wetted habitat. These large predators undoubtedly constitute an important component of the food of river fishes, so a reduction in their populations would be reflected in measurable food chain effects. Because adult anisopteran Odonata (dragonflies) are showy, large, and brightly colored

as adults, and consume large numbers of human-biting insects, they receive attention from the public. As such, changes in population numbers would be noticed by those recreating on the river. Odonata were collected in both seasons at all three sites and in all aquatic vascular plant habitats and on the emergent marsh. However, only the smaller zygopteran Odonata (damselflies) were abundant enough to rank among the top taxa collected (Appendix).
The large lepidopteran shredder-herbivore *Bellura* (**Table 2**) was limited to *Nuphar* beds where the larvae bore into the plant's stems. Therefore, *Bellura* populations would be expected to increase or decrease with the expansion or contraction of the *Nuphar* beds. The role of this moth larva in fish food chains awaits further study, but its large size suggests it could be an important fish food organism, at least as adults. If water withdrawal reduces the total cover of *Nuphar* beds or increases the isolation of these clonal plant beds from one another, this could significantly impact dispersal and reduce the size of the *Bellura* populations inhabiting the upper river.

The microcrustaceans (Ostracoda, Cladocera, Copepoda) collected in samples from the upper river represent a classic case of invertebrates that dominate numerically but, because of the small size of individuals, represent negligible biomass (4.7% of numbers in July and18.2% in Nov.). But, they undoubtedly represent an important food supply for juvenile fishes because of their appropriate size, great abundance, and availability in the water column. However, these very features make it unlikely that the predicted changes in water depth associated with water withdrawal would have any measurable effect on their food chain contribution. Similarly, the mayflies (Ephemeroptera) collected in samples from the upper and middle river were an abundant group of small individuals representing negligible biomass (Appendix). Only Baetidae and Caenidae, which are both gathering collector groups feeding on FPOM, were found in the samples. Ephemeroptera were collected in both seasons from all three sites and in all aquatic vascular plant habitats and on the emergent marsh (Appendix). The primary reason for monitoring the Ephemeroptera, other than their contribution to the calculation of FFG surrogate ratios discussed below, is their susceptibility to a reduction in dissolved oxygen (DO) levels (**Table 3).** Reduced DO levels might be expected to accompany reduction in water levels and flows resulting from water withdrawals. For example, if the general upper river environment becomes heterotrophic because of increased die back of aquatic vascular plants that would be expected to accompany water withdrawals, oxygen demand would be expected to increase resulting in stress on those aquatic invertebrates respiring in the water.

The dominant algal scrapers in the upper and middle river habitats were gastropod mollusks and the amphipod *Hyalella* with a combined biomass of 4.1% (July) and 5.9% (Nov.) and combined numbers of 19.7% (July) and 34.4% (Nov.). *Hyalella* accounted for 14.8 % in July and 27.1 % of the numbers when all samples were totaled and gastropods accounted for 4.9% (July) and 7.3% (Nov.) of the numbers (Appendix). Both *Hyalella* and gastropods were found at all sites in both seasons and in all aquatic vascular plant habitats and on the emergent marsh. Any reduction in periphytic algal abundance resulting from drying of attachment sites as water levels are reduced would be expected to have a negative effect on the populations of these two scraper taxa.

As summarized in the data sheets in the Appendix, the Oligochaeta constituted a significant portion of the macroinvertebrate density (especially Lake Monroe = 15%) but this taxon is so broad ecologically that unless more detailed taxonomic work is done we do not recommend using this group in a monitoring protocol to evaluate the effects of water withdrawal. If detailed taxonomic work was done on the oligochaetes, they might provide useful data for monitoring, but the expense involved would be difficult to justify as long as other taxonomic groups can provide sufficient insight into macroinvertebrate community structure. The same ambiguity applies to the Chironomidae (midges). If future samples were to be examined at the subfamily and tribe levels, the midges might be useful in following the effects of changes in water levels. For example, the relative dominance of the Tanytarsini might be influenced by reductions in flow that deliver their fine particulate organic matter (FPOM) food resource (Merritt et al.2008). Of course, if the chironomid taxonomy was taken to the genus level, considerable insight would likely be gained because the group is so dominant and generic differences in ecology are, in many cases, quite significant. A perusal of the ecological tables in Merritt et al.(2008) makes it clear the advantages that would accrue with generic level resolution. However, as with the oligochaetes, the expense of conducting more detailed taxonomic work with the midges can be avoided by relying on other taxa to evaluate the effects of water withdrawal.

Invertebrate Functional Groups

Five examples of macroinvertebrate community characteristics that would be most likely to be affected by water withdrawal are summarized in **Table 3**. The categories reflect river ecosystem attributes for which the invertebrates can serve as surrogates, such as reduced river primary production, replacement of true (year around) aquatic habitat by semi-aquatic wetland, or loss of stable substrate attachment sites for macroinvertebrates. The river invertebrates can be classified according to their methods of acquiring their food resources; for example algae, submerged portions of rooted aquatic vascular plants, coarse (CPOM) and fine(FPOM) particulate organic matter derived from the die back of aquatic plants or the input of terrestrial plant litter. The classification of invertebrates into functional groups allows diverse taxonomic units to be clustered together into groups or guilds that share, through adaptive convergent evolution, common morphological and behavioral traits in achieving the same function (e.g. acquiring food, modes of respiration or dispersal, etc.). Freshwater functional feeding groups (FFG) and their food resources are summarized in **Table 4**.

Macroinvertebrate Surrogates for River Ecosystem Attributes

Invertebrates have been used extensively for the evaluation of the condition, or “health,” of running water ecosystems because of their sensitivity to contamination or thermal and flow changes. In addition, the invertebrates integrate river ecosystem attributes or conditions over the portion of their life cycle spent in the river. The probability of directly measuring a particular short-lived stressor to the biology of a river system might be very low; but the invertebrates with life cycles spanning the period of stress will be effected and the effect can be detected by their presence or absence at times removed from the actual time of the stress (Table 3).

Autotrophy/Heterotrophy, or P/R, Index. Direct measurements of St. Johns River ecosystem attributes would provide a tool for evaluating a reach of the river or section of the river (in this case, the upper and middle river). However, such measurements are usually difficult and costly to make and most frequently they are made only over short time periods (hours to days at best), which then requires extrapolation to monthly, seasonal, or annual estimates. The resulting integration of short term direct measurements to achieve an estimate of a longer time span carries with it an associated high variance. For example, an estimate of the autotrophic – heterotrophic index (P/R), which is arguably the most fundamental ecosystem level assessment that could be made, would be the best candidate for monitoring overall ecosystem function. Direct measurement of P/R usually involves the use of *in situ*, closed, re-circulating chambers (Vannote et al. 1980). Changes in oxygen levels are recorded over periods of several hours at a time in daylight and at night in the chamber in which natural river water, substrates, and/or rooted aquatic vascular plants are enclosed. The amount of oxygen produced photosynthetically during day light hours is expressed as a ratio to the oxygen consumed over 24 hours (including that consumed by photosynthesizing algae and aquatic vascular plants). This ratio is the autotrophic – heterotrophic index and is the ratio of gross primary production to total community respiration, or P/R. If gross primary production exceeds community respiration, which would yield a ratio of P/R = >1, the river or river reach would be classified as autotrophic. In this case, the river reach, or river section as a whole, must be storing organic matter produced in that reach or section in the sediments or exporting it down river. If P/R = < 1, more organic matter is being consumed than is being produced in the river reach or section, which then would be termed heterotrophic. In this case, the organic matter being consumed (respired) must come from outside of the river proper from plants growing along the river side (riparian zone) and/or the areal emergent portions of rooted aquatic vascular plants, or it may be supplied as export from autotrophic reaches and tributaries up river. An autotrophic river reach will support large populations of aquatic invertebrates that consume algae (Scrapers), or the vascular aquatic plants (Shredder-herbivores), termed autotrophs, and a lesser abundance of those invertebrates that are adapted to feed on detrital organic matter (CPOM fed upon by Shredders-detritivores and FPOM fed on by gathering and filtering Collectors), termed heterotrophs (Table 4).. Therefore, a ratio of P/R > 1 measured directly would predict a ratio of autotrophic invertebrates > heterotrophic invertebrates. An invertebrate surrogate P/R = 0.75 corresponds to a directly measured P/R =1 (Merritt et al 1996). The ecosystem P/R = 1.0 and invertebrate surrogate P/R = 0.75 represents the *threshold* between autotrophy (any value above 1.0 and 0.75) and heterotrophy (below 1.0 and 0.75). We propose that invertebrates be used to provide a long term assessment of the P/R ecosystem attribute by virtue of their linkages to these alternate foundations of river food webs – primary production or detritus.

The macroinvertebrate surrogate for the St Johns River P/R measured at the three sampling sites: Lake Monroe (LM), Near Yankee Lake (NYL), and Poinsett (P) are plotted as biomass in **Fig. 1A** and as density (numbers) in **Fig. 1B**. With the data plotted either way, all three sites were near or above the threshold for autotrophy. When plotted as biomass (Fig. A1), the sites are significantly different (non-overlapping standard deviations) and range from autotrophic (LM) to very autotrophic (NYL) to highly autotrophic (P). When expressed numerically, only NYL is significantly more autotrophic than the other two sites. Because the invertebrate P/R threshold response measured as either biomass or numbers is at or above the autotrophy range at the site level (LM, NYL, or P), numerical data would suffice for monitoring. This is beneficial because determination of biomass requires significant lab time where as numerical FFG data can be rapidly determined in the field or the lab.

The site data (Figs. A1, A2) are expressed by season, summer (July) and winter (November), in terms of biomass in **Fig. 3A** or as numbers in **Fig. 3B**. The biomass invertebrate surrogate P/R data for both seasons at the three sites were all above the autotrophic threshold (**Fig. 2A**). The seasonal difference was significant only for the Poinsett site where the July ratio indicated an extremely high level of autotrophy. When the same data are plotted numerically (Fig. 3B), all but November at Poinsett was statistically indistinguishable from the autotrophic/heterotrophic threshold and only November at Near Yankee Lake was significantly higher than the others. Therefore, with the possible exception of Poinsett in November, invertebrate P/R surrogate thresholds could be determined from numerical data as a substitute for biomass during either season.

When the macroinvertebrate surrogate ratio data for the ecosystem attribute P/R are analyzed by plant bed habitat type, or emergent marsh habitat, autotrophy/heterotrophy differences are apparent. Analysis by biomass of the *Nuphar* beds indicated that the beds were autotrophic in all seasons at all three sites **Fig. 4A**). The pattern is essentially the same as that described above in which all the data were combined by season, including the highest level of autotrophy in July at Poinsett (**Fig. 2A**). Similarly, when the data from *Nuphar* beds are plotted numerically by season, the pattern is the same as for all seasons at the three sites (**Fig. 4B**).

Analysis of invertebrate P/R by biomass of the Bull Rush beds revealed an heterotrophic pattern (**Fig. 5A**). Bull Rush beds were not prevalent enough to sample at the NYL site. In summer (July), the threshold values indicated the beds were autotrophic, but in winter, they were significantly heterotrophic (**Fig 5A**). Most likely the winter heterotrophy was due to die back of the plants and accumulation of the resulting detrital CPOM that served as food for grass shrimp (*Palaemontetes*). If the Bull Rush data are expressed numerically (**Fig. 5B**), summer and winter at both sites were heterotrophic and the sites did not vary significantly.

Hydrilla beds were sufficiently abundant to sample only at the LM site. Both biomass (**Fig. -6A**) and numbers (**Fig. 6B**) were solidly in the heterotrophic range in July, but not in November when the data are expressed numerically.

The emergent marsh habitat samples which came from a variety of mixed wet land plant species produced highly variable macroinvertebrate surrogate ratios for the ecosystem attribute P/R. Considering the biomass P/R data, that consisted of six estimates (two seasons at three sites), all but one was heterotrophic (**Fig. 7A**). At each of the three sites (LM, NYL, P), the seasonal differences were significantly different, but there was no consistent pattern. July was significantly autotrophic. For the numerical data, four of the six estimates were autotrophic (three strongly so) and two were heterotrophic. Seasonal differences were not significant at LM where both seasons were autotrophic (**Fig. 7B**). At the other two sites, seasons were significantly different and, in both cases, summer was heterotrophic and winter was autotrophic. These highly variable data, either as biomass or numbers (**Fig. 7**), and the lack of any general pattern, likely resulted from the patchy and variable distribution of the complex plant and soil conditions of the emergent marsh.

Mobility Index. This is the ratio of those invertebrate taxa with low or very low inter-habitat mobility as compared to those with high mobility. Those taxa with low capabilities for dispersal cannot move readily to habitats that remain wetted while others dry up. Loss of non-mobile forms that are unable to avoid the detrimental effects of water withdrawal, many of which are important food organisms for fish, likely would have significant food web effects. The mobile taxa would be largely unaffected by water withdrawal as they would merely follow the receding water levels or migrate to other suitable sections of the river or adjacent wet lands. The taxa with low inter-habitat mobility would include *Hyallela, Palaemonetes,* and mollusks while all the St Johns River aquatic insects, except Collembola, have winged adults and have a much higher, although variable, potential for dispersal. . One third of the taxa (15) collected were classified as having low or very low mobility and two thirds of the taxa collected (46) were classified as highly mobile, yielding a taxa-based ratio value of 0.33 (**Table 3**).

Dissolved Oxygen Requirement Index. This is the ratio of those taxa that respire dissolved oxygen to those that are air breathers. The taxa that require dissolved oxygen (DO), such as the mayflies, caddisflies, and odonates, would be vulnerable to reduced DO levels resulting from decreased flows or increased decomposition of plant die-back related to falling water levels. The terrestrial air breathers would be unaffected by loss of DO and the Chirinomini, which have hemoglobin, are adapted to survive low DO for extended periods. Increases of both these groups would indicate loss of aquatic habitat suitable for invertebrates many of which are food for fish. Twice as many (52) aquatic dissolved oxygen (DO) breathing taxa (i.e., having gills and/or cutaneous respiration) were collected from the upper and middle St. Johns River as were terrestrial air breathers (26). This yields a taxa-based ratio of air breathers (+ Chironomini with hemoglobin) to aquatic breathers of 0.5.

Voltinism Index. This is the ratio of long life cycle (semivoltine, > 1 yr.) macroinvertebrates to those with shorter lifecycles (univoltine, 1 yr. or less, polyvoltine). The length of life cycle, that is, egg to adult, would be an indicator of the rapidity with which a given taxon could respond to loss of habitat resulting from water withdrawal. If the abundance of the long life cycle taxa is reduced, the food supply for fish larger than young of the year would be less. This is particularly true because individuals in these taxa tend to be larger than polyvoltine ones. Of the 78 taxa collected (**Table 1**), only 13 (20%) were provisionally classified as semivoltine. This yields a ratio of long life cycle to short life cycle macroinvertebrate taxa of 0.5, indicating that the majority of the fauna would not be vulnerable to water withdrawal because of life cycle length. However, as discussed above, most of the long lived taxa have large individuals and likely represent important food organisms for fish larger than young of the year.

Habitat Stability Index. This is the ratio of those taxa that require stable habitats for grazing attached periphyton (e. g. gastropods and *Hyallela*) or filtering suspended FPOM (e.g. Polycetropodidae) to those that do not require a stable substrate such as swimmers and burrowers. Scrapers like *Hyallela* are important fish food organisms (Merritt et al. 1996, Wessell et al. 2001) and most filtering collectors are important food for drift feeding fish. Of the 78 macroinvertebrate taxa collected, 34 (43%) were classified as requiring a stable substrate for feeding on attached algae (scrapers) or maintaining a location to feed on suspended FPOM (filtering Collectors). The ratio of those taxa requiring stable substrates to those that do not was 1.6, indicating that the fauna would be susceptible to water withdrawal because of the loss of stable substrates.

Conclusions

Based on the analyses presented in this report, the simplest and least costly monitoring of macroinvertebrates in the upper and middle St Johns River, with the goal of evaluating the effects of future planned water withdrawals, would be as follows:

1.Randomly collect dip net samples during the dry and wet seasons from at least 25 lily (*Nuphar*) and 25 bull rush (*Scirpus*) plant beds in the upper and middle reaches of the river.

2. Enumerate and record the individuals (> 1 mm) in each taxon collected in each sample. Preserve representatives of each taxon for a reference collection. The enumerations should be recorded in the field. Calculate the mean number of samples containing each taxon in all samples combined and in lily and bull rush beds separately.

3. If the PVC frame is used to collect 30 second timed dip net collections, these samples should be labeled, preserved and returned to the lab. If support is available for processing these samples, they can be treated like those described in this report (including analysis with INVERTCALC). In either case, the data should be used to calculate the functional group ratios listed in **Table 1** and the resulting values should be compared to the proposed thresholds to determine any changes that can be related to changes in water levels.

4. Special attention should be directed to Odonata, Hemiptera, Dytiscidae, *Bellura*, and *Palaemonetes* because, as described in this report, they can provide particular insights regarding the ecosystem level impacts of reduced water levels.

Acknowledgements

We would like to thank the following individuals who either participated in preparing the tables, figures and Appendix for this final report or who helped us in field and/or lab sampling for macroinvertebrates on this project: Emily Campbell, Mollie McIntosh, Bridgette Vandeneeden, Marty Berg, Brett Merritt, Osvaldo Hernandez, Ryan Kimbirauskas, May Lehmensiek, and Bethany Coggins. We would like to especially acknowledge Rob Mattson for his expert assistance on this project.

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Table 1. Functional Feeding Group (FFG) designations and sites where they were collected for each macroinvertebrate taxon from the upper St Johns River. PR=predator, SC= scraper, PA= parasitic, CF= collector-filterer, CG= collector-gatherer, SH-DT= shredder-detrital, HB-PI= herbivore-piercer, SH-HB= shredder herbivore.

		Lake Monroe		Near Yankee River		Poinsett	
Taxa	FFG	July	November	July	November	July	November
Cnidaria							
Anthomedusae							
Hydridae							
Hydra	PR	×	×			×	
Platyhelminthes							
Turbellaria	SC	×	×				
Nematoda	PA		×		×		×
Mollusca							
Gastropoda	SC					×	
Hydrobiidae	SC	×					
Viviparidae	SC				×		
Planorbidae	SC	×	×	×	×	×	×
Helisoma	SC		×				×
Gyraulus	SC						×
Prosobranchia	SC	×	×	×		×	×
Ancylidae	SC	×	×	×	×	×	×
Physidae	SC	×	×		×	×	×
Physa	SC	×					
Lymnaeidae	SC		×		×		×
Bivalvia							
Unionidae	CF						×
Sphaeriidae							
Pisidium	CF		×	×			×
Annelida							
Oligochaeta	CG	×	×	×	×	×	×
Hirudinea	PR	×	×	×			×
Crustacea							
Ostracoda	CF	×	×	×	×	×	×
Cladocera	CF	×	×	×	×	×	×
Copepoda	CG	×	×	×	×	×	×
Argulus	CG	×					
Harpacticoida	CG		×			×	×
Amphipoda							
Hyalella	SC	×	×	×	×	×	×
Isopoda							
Asellidae	SH-DT	×	×	×	×	×	×

		Lake Monroe		Near Yankee River		Poinsett	
Taxa	FFG	July	November	July	November	July	November
Asellidae	SH-DT	×	×	×	×	×	×
Decapoda	PR	×			×		
Cambaridae	PR	×	×			×	×
Palaemonidae							
Palamonetes	SH-DT	×	×	×	×	×	×
Collembola	CG	×	×		×	×	×
Arachnida							
Araneae	PR	×	×	×	×	×	×
Acari	CG	×	×	×	×	×	×
Hydracarina	CG	×				×	
Insecta (aquatic)							
Ephemeroptera							
Baetidae	CG	×					
Callibaetis	CG	×	×	×	×	×	×
Caenidae							
Caenis	CG	×	×	×	×	×	×
Odonata							
Anisoptera	PR	×	×	×		×	×
Aeshnidae	PR	×	×		×		
Coryphaeschna	PR		×				
Macromiidae	PR						×
Corduliidae	PR		×		×		
Somatochlora							×
Libellulidae	PR	×	×			×	
Erythemus	PR		×				×
Libellula	PR	×					
Pachydiplax	PR	×					×
Sympetrum	PR		×				×
Zygoptera							
Coenagrionidae	PR	×	×	×	×	×	×
Enallagma	PR	×					
Ischnura	PR	×	×	×		×	
Hemiptera							
Hydrometridae							
Hydrometra	PR	×	×			×	
Belostomatidae	PR	×					×
Belastoma	PR	×	×			×	×
Lethocerus	PR		×				
Nepidae							
Ranatra	PR	×	×	×		×	×
Pleidae			×				
Paraplea	PR				×	×	×

		Lake Monroe		Near Yankee River		Poinsett	
Taxa	FFG	July	November	July	November	July	November
Naucoridae							
Ambrysus	PR		×				
Pelocoris	PR	×	×				
Corixidae	HB-PI	×	×			×	
Trichocorixa	PR	×	×				
Mesoveliidae							
Mesovelia	PR	×	×	×	×	×	×
Hebridae	PR	×	×			×	×
Trichoptera							
Polycentropodidae	CF					×	×
Cyrnelus	CF	×				×	×
Hydroptilidae	HB-PI	×	×			×	
Orthotrichia	HB-PI	×	×		×		×
Oxyethira	HB-PI	×					
Leptoceridae	CG					×	
Nectopsyche	SH-HB	×	×				
Oecetis	PR	×	×	×		×	×
Lepidoptera							
Crambidae	SH-HB		×				
Argyractis	SH-HB		×				
Noctuiidae	SH-HB	×	×		×	×	×
Bellura	SH-HB	×		×		×	
Pyralidae							
Parapoynx	SH-HB	×	×		×		
Coleoptera							
Haliplidae							
Peltodytes	SH-HB		×			×	
Dytiscidae	PR	×	×			×	
Acilius	PR					×	
Agabus	PR					×	
Celina	PR					×	
Desmopachria	PR					×	
Liodessus	PR		×				
Thermonectus	PR						×
Noteridae	PR	×					
Hydrocanthus	PR	×	×			×	×
Suphis	PR		×			×	
Suphisellus	PR		×			×	×
Ptilidae	SC					×	
Hydrophilidae	PR	×			×	×	×
Berosus	HB-PI	×				×	×
Derallus	CG					×	×

		Lake Monroe		Near Yankee River		Poinsett	
Taxa	FFG	July	November	July	November	July	November
Enochrus	CG						×
Paracymus	HB-PI	×					
Tropisternus	PR			×		×	
Hydraenidae	PR	×	×		×	×	×
Chrysomelidae	SH-HB						×
Diptera							
Ceratopogonidae		×	×				×
Forcipomyia	CG	×	×				×
Mallochohelea	PR	×	×				
Probezzia	PR		×				×
Chaoboridae	PR						×
Chaoborus	PR		×				×
Chironomidae		×	×	×	×	×	×
Culicidae							
Aedes	CF					×	
Anopholes	CF		×			×	
Culex	CF	×	×				
Mansonia	CG		×				
Uranotaenia	CF					×	
Psychodidae	CG		×				×
Simuliidae	CF		×				
Stratiomyidae	CG	×	×	×	×	×	×
Odontomyia	CG	×	×			×	
Ephydridae	CG		×			×	×
Cirrula	SH-HB	×					
Sciomyzidae	PR		×				
Insecta (terrestrial)							
Thysanoptera							
Thripidae		×	×			×	×
Psocoptera		×				×	
Orthoptera							
Gryllus						×	
Hemiptera							
Fulgoridae		×					×
Reduviidae						×	×
Cicadellidae						×	
Alydidae							×
Aphididae			×		×	×	×
Cercopidae			×				
Pentatomidae		×					×
Lepidoptera							×
Geometridae							×

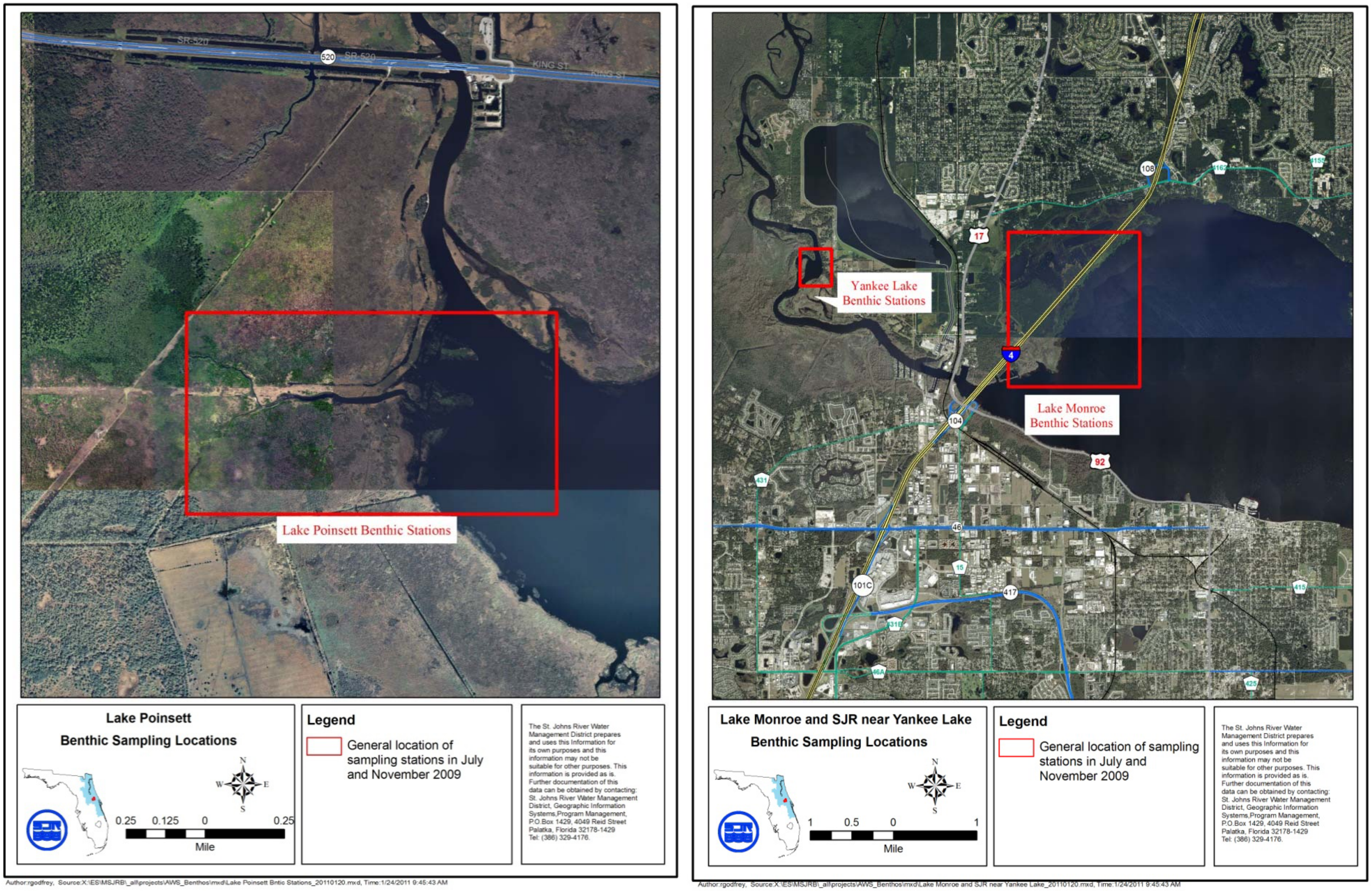
		Lake Monroe		Near Yankee River		Poinsett	
Taxa	FFG	July	November	July	November	July	November
Coleoptera							
Anthicidae						×	×
Coccinellidae					×		
Curculionidae		×	×		×	×	×
Staphylinidae		×	×				×
Hymenoptera		×	×		×	×	×
Diapriidae			×				
Formicidae			×			×	

	Nuphar		Emergent Marsh		Hydrilla		Bullrush	
Taxon	% occurrence by biomass	% occurrence by numbers	% occurrence by biomass	% occurrence by numbers	% occurrence by biomass	% occurrence by numbers	% occurrence by biomass	% occurrence by numbers
Odonata	0.86	2.55	1.46	2.75	1.87	5.05	1.52	2.45
Dytiscidae	0	0	0.54	0.24	0	0	0	0
Bellura	13.76	0.19	0	0	0	0	0	0
Palaemonetes	35.77	3.61	70.63	3.32	85.34	7.24	73.05	6.15
Belastoma	0.02	<0.0001	3.24	0.17	0	0	0.43	0.01

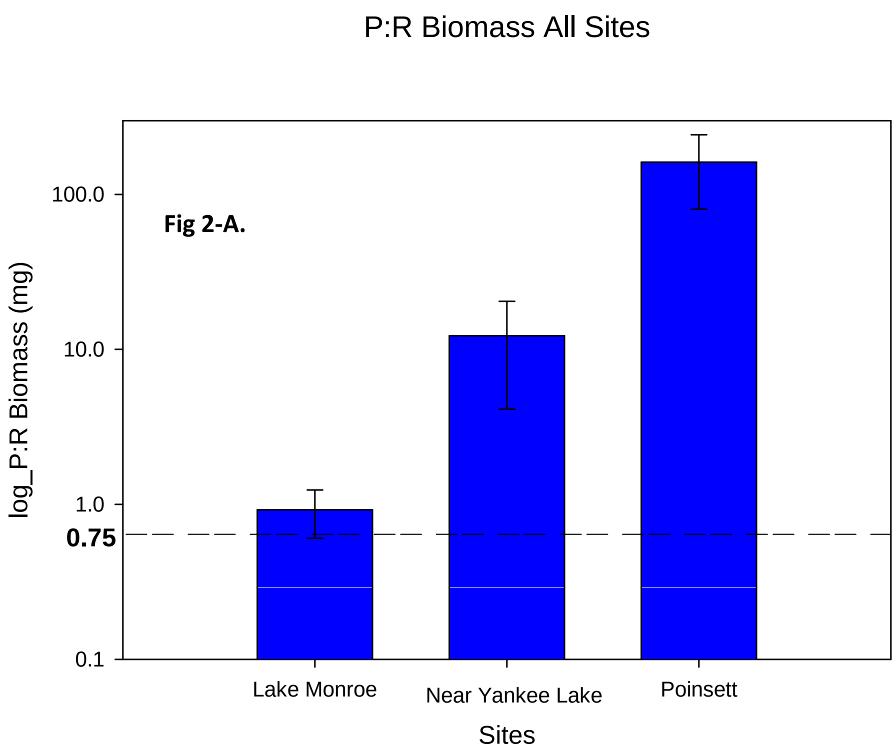
Ecosystem/ Community Index	Components of Ecosystem/Community Attribute	Macroinvertebrate Surrogate Ratio for Ecosystem/Community Index	Threshold Values
P/R or Autotrophy – Heterotrophy Index	Ratio of Gross Primary Production (P) to Total Community Respiration	Ratio of Scrapers + Herbivore Shredders to Detritivore Shredders + Total Collectors (P/R)	>0.75 = Autotrophic Ecosystem
Mobility Index	Ratio of Macroinvertebrate Taxa with Low (L) or Very Low (VL) mobility to Macroinvertebrates with High Mobility (H)	Ratio of Macroinvertebrates with No Mobile Life Stag to Adult Winged Aquatic Insects + Amphipoda and Behavioral Drifters (L + VL/H)	>0.50 = Community Vulnerable to Water Withdrawal
Oxygen Requirement Index	Ratio of Macroinvertebrate Taxa with Gills (G) or Cutaneous Respiration (CR) to Macroinvertebrate Taxa Air Breathers (AB) or those with Hemoglobin (H)	Ratio of Macroinvertebrates Requiring Little or No Dissolved Oxygen (AB + H) to Macroinvertebrates Requiring Dissolved Oxygen (G + CR)	>0.50 = Community Vulnerable to Water Withdrawal
Voltinism Index	Ratio of Semivoltine Macroinvertebrate Taxa (SV) to Polyvoltine (PV) + Univoltine (UV) Macroinvertebrate Taxa	Ratio of Macroinvertebrate Taxa Requiring More than One Year per Generation (SV) to Macroinvertebrate Taxa Having One (UV) or more than one (PV) Generation per Year (SV/UV + PV)	>0.50 = Community Vulnerable to Water Withdrawal
Habitat Stability Index	Ratio of Functional Groups Requiring Stable Surfaces for Feeding or Attachment to Functional Groups not requiring Stable Surfaces	Ratio of Scrapers (Sc) + Herbivore Shredders (HS)+ Attached Filtering Collectors (AFC) to Detrital Shredders (DS) + Gathering Collectors (GC) (SC + HS + AFC/DS + GC)	>0.50 = Community Vulnerable to Water Withdrawal

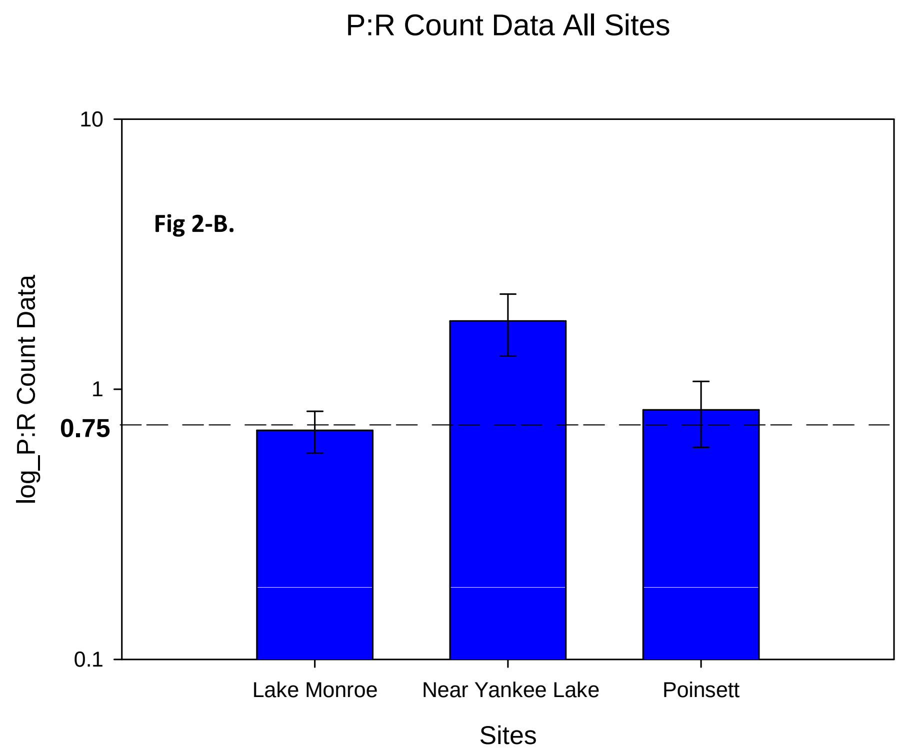
Table 3. Macroinvertebrate surrogate index ratios for ecosystem macroinvertebrate community attributes predicting (before) or evaluating (after) effects of water withdrawal.

Figure 1. Maps of Lake Poinsett and the middle St. Johns River showing general areas where sampling stations were located for the short-term field study of benthic communities in 2009. (LM= Lake Monroe, NYL= Near Yankee Lake and P= Poinsett)

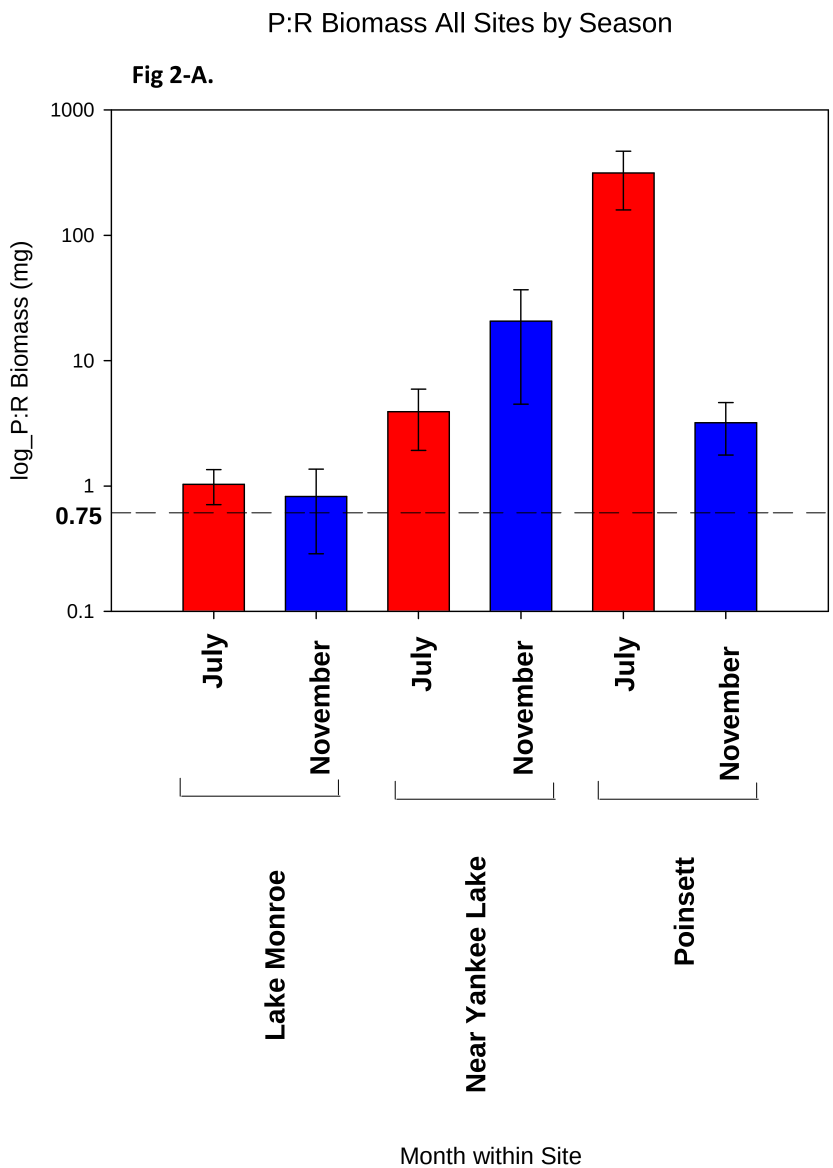


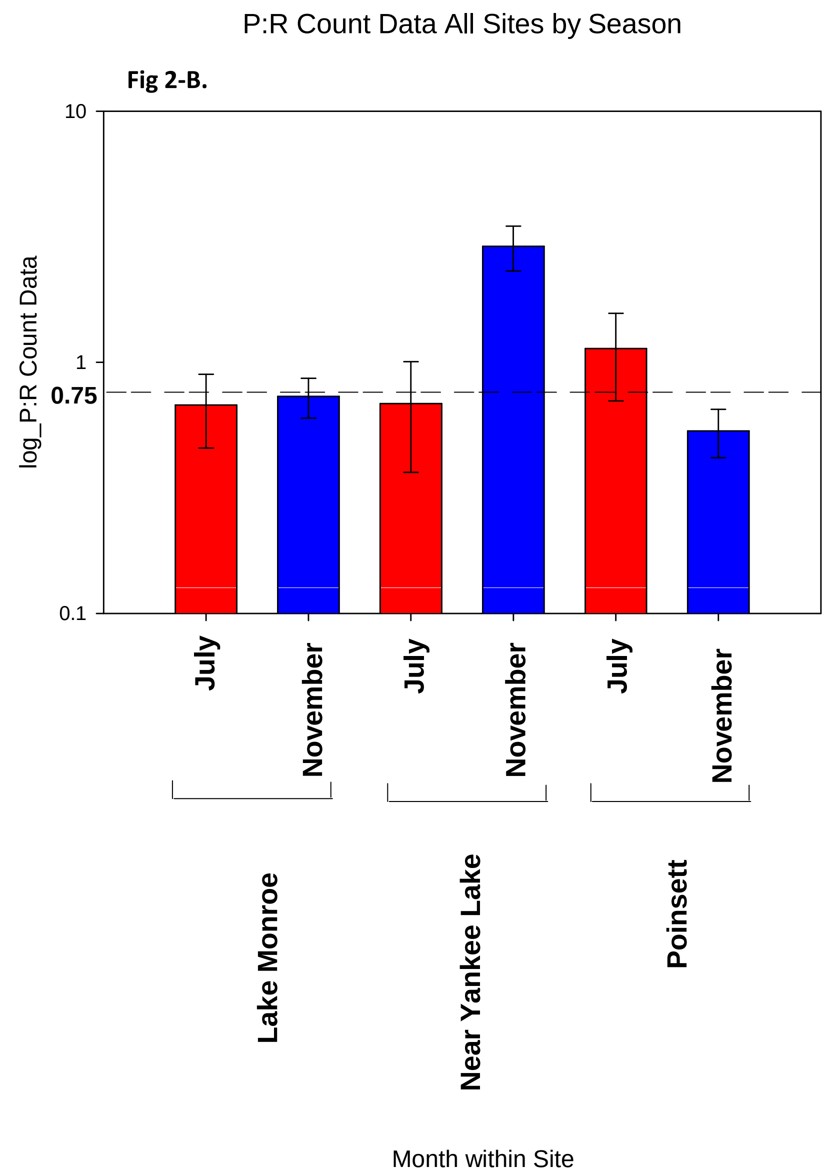
Figures 2-A and 2-B. Invertebrate P/R by site. FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder herbivores (live vascular aquatic plants) + scrapers + piercer herbivores / Shredder detritivores (CPOM) + total collectors





Figures 2-A and 2-B. Invertebrate P/R by site by season. FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder herbivores (live vascular aquatic plants) + scrapers + piercer herbivores / Shredder detritivores (CPOM) + total collectors

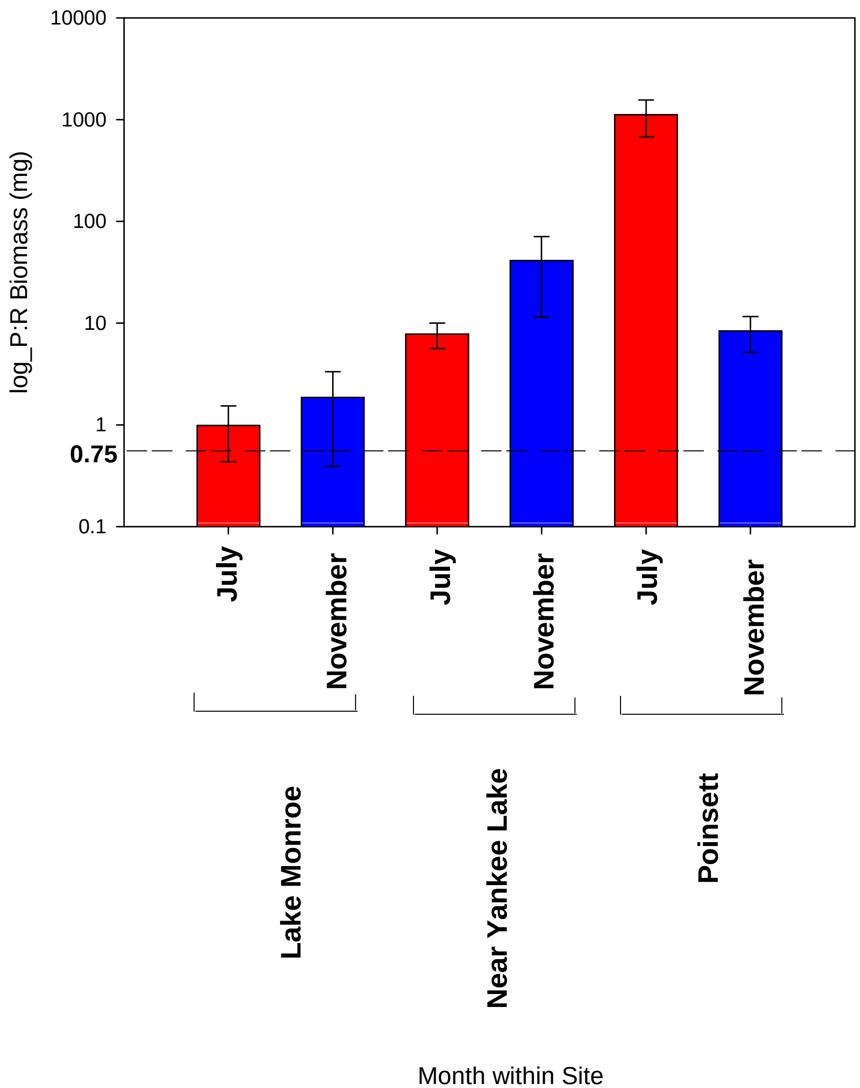




Figures 3-A and 3-B. Invertebrate P/R in *Nuphar* beds by site and season. FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder herbivores (live vascular aquatic plants) + scrapers + piercer herbivores / Shredder detritivores (CPOM) + total collectors

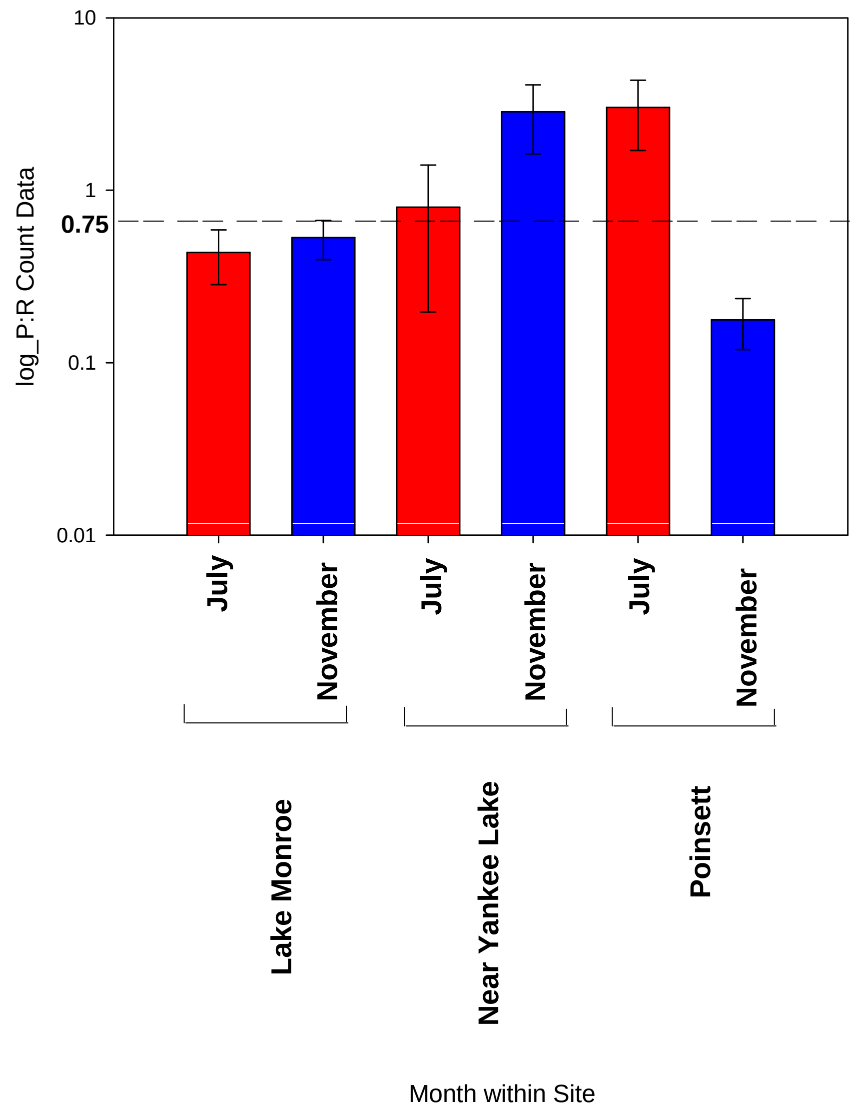
P:R Biomass *Nuphar*

Fig 3-A.

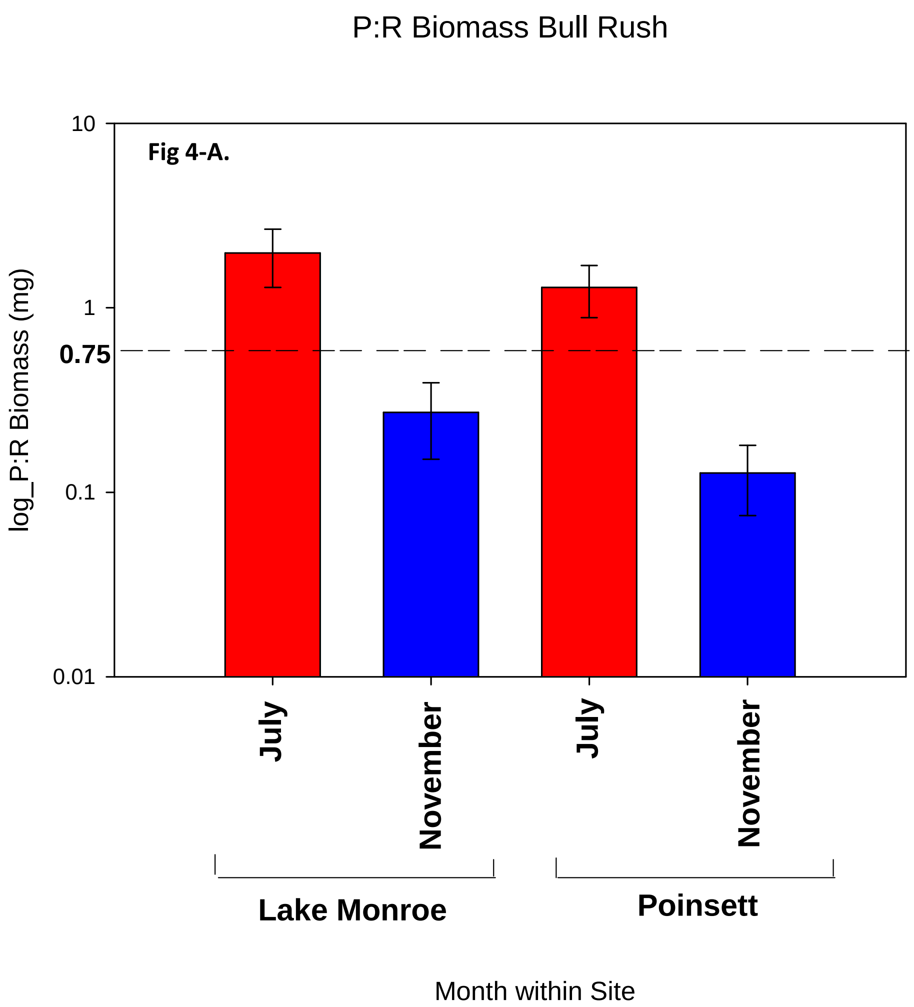


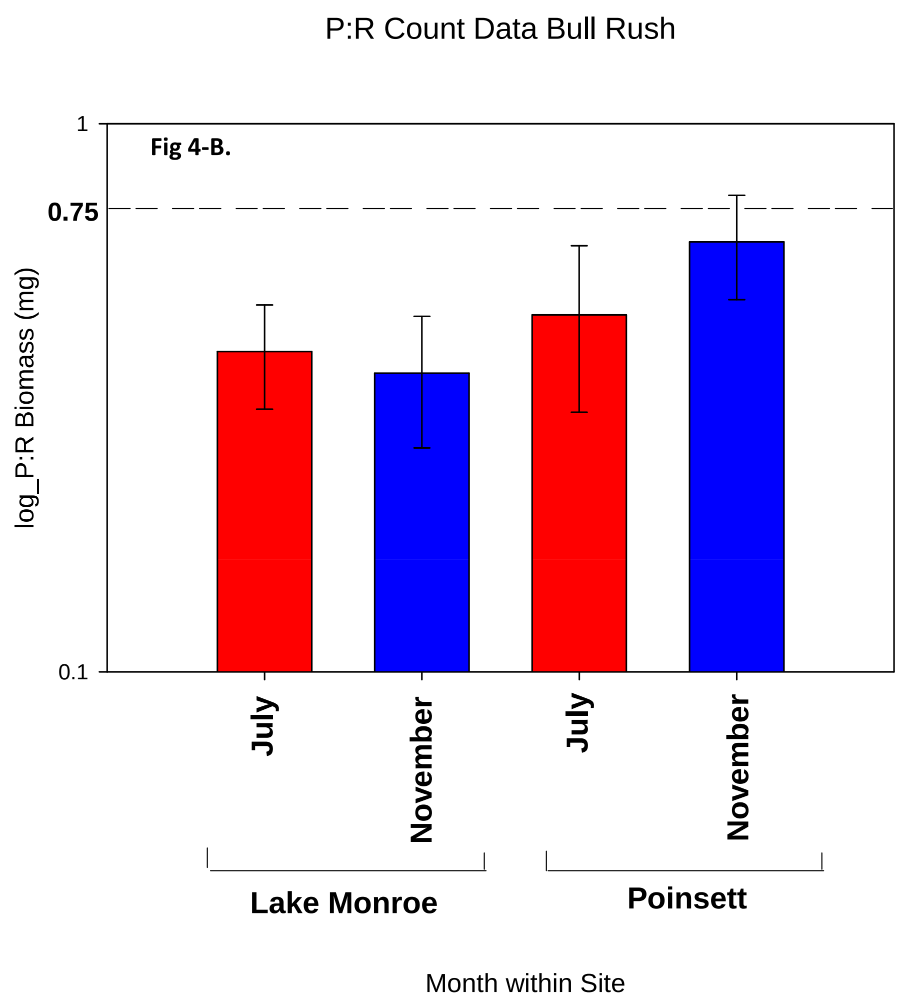
P:R Count Data *Nuphar*

Fig 3-B.

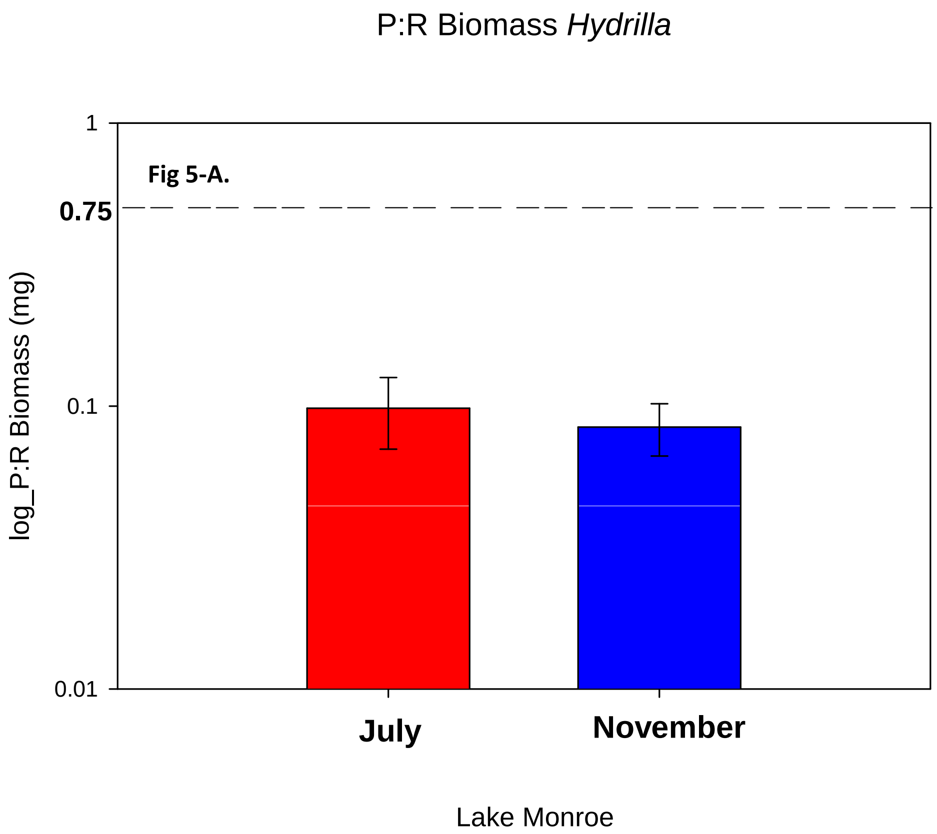


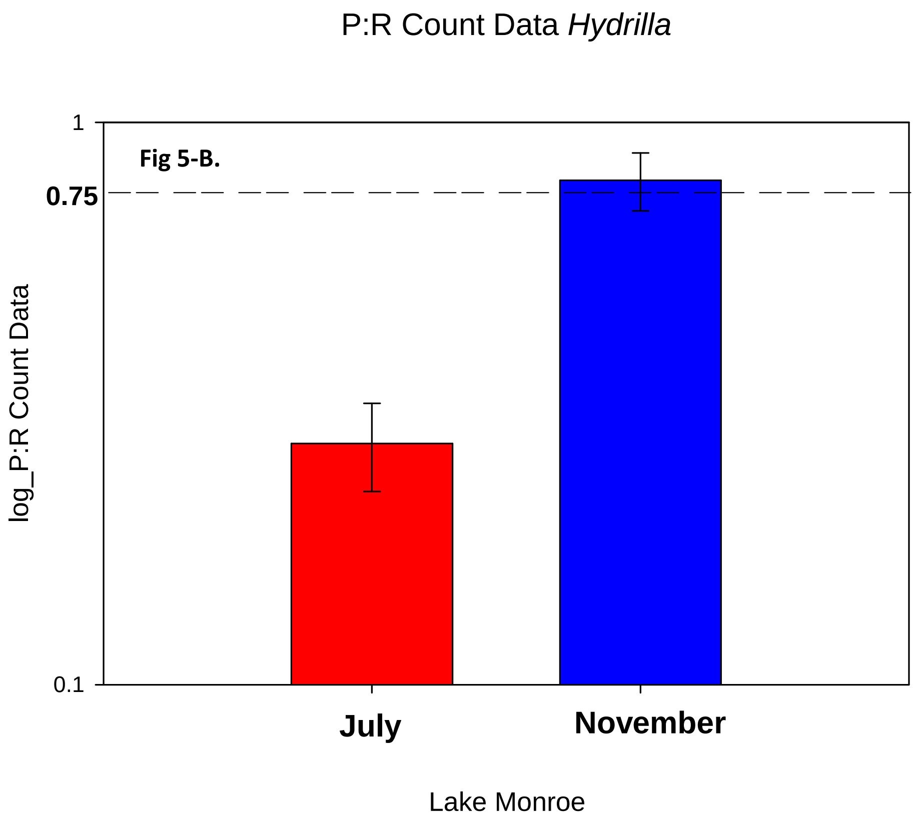
Figures 4-A and 4-B. Invertebrate P/R in Bullrush beds by site and season. FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder herbivores (live vascular aquatic plants) + scrapers + piercer herbivores / Shredder detritivores (CPOM) + total collectors





Figures 5-A and 5-B. Invertebrate P/R in *Hydrilla* beds by site and season. FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder herbivores (live vascular aquatic plants) + scrapers + piercer herbivores / Shredder detritivores (CPOM) + total collectors





Figures 6-A and 6-B. Invertebrate P/R on emergent marsh by site and season. FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder herbivores (live vascular aquatic plants) + scrapers + piercer herbivores / Shredder detritivores (CPOM) + total collectors

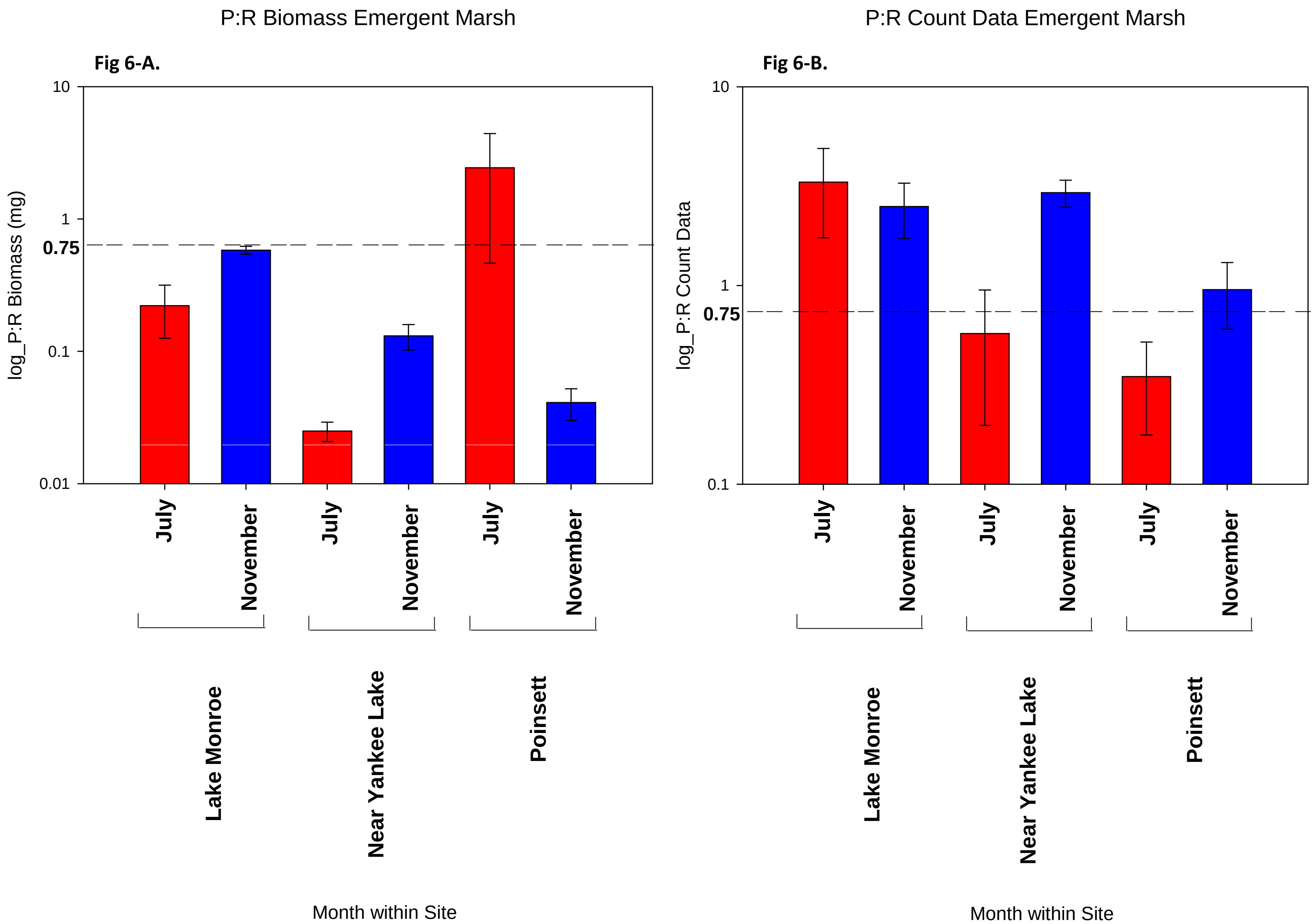


Figure 1. % Gastropoda count data all sites

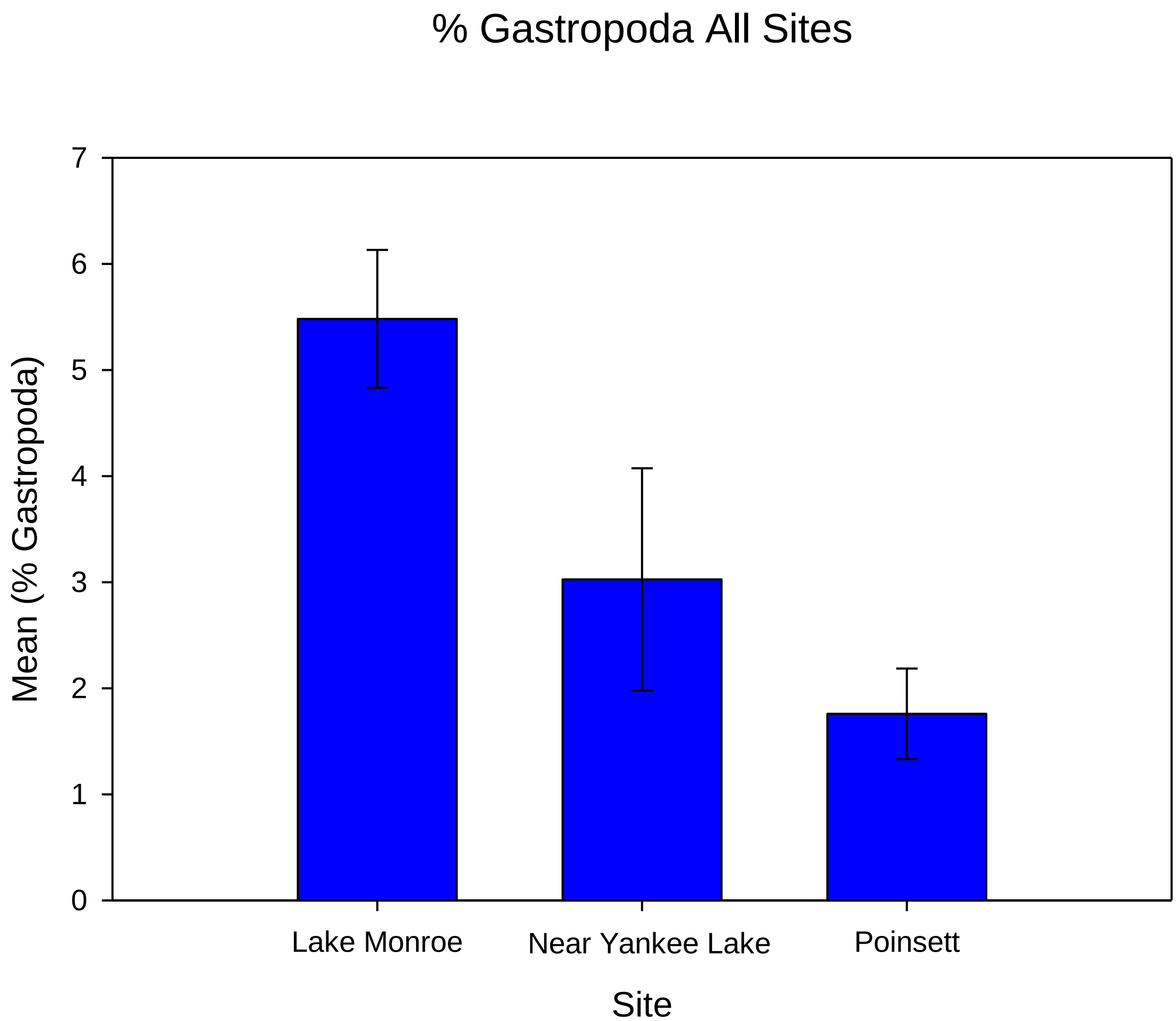


Figure 2. % Gastropoda count data all sites by season

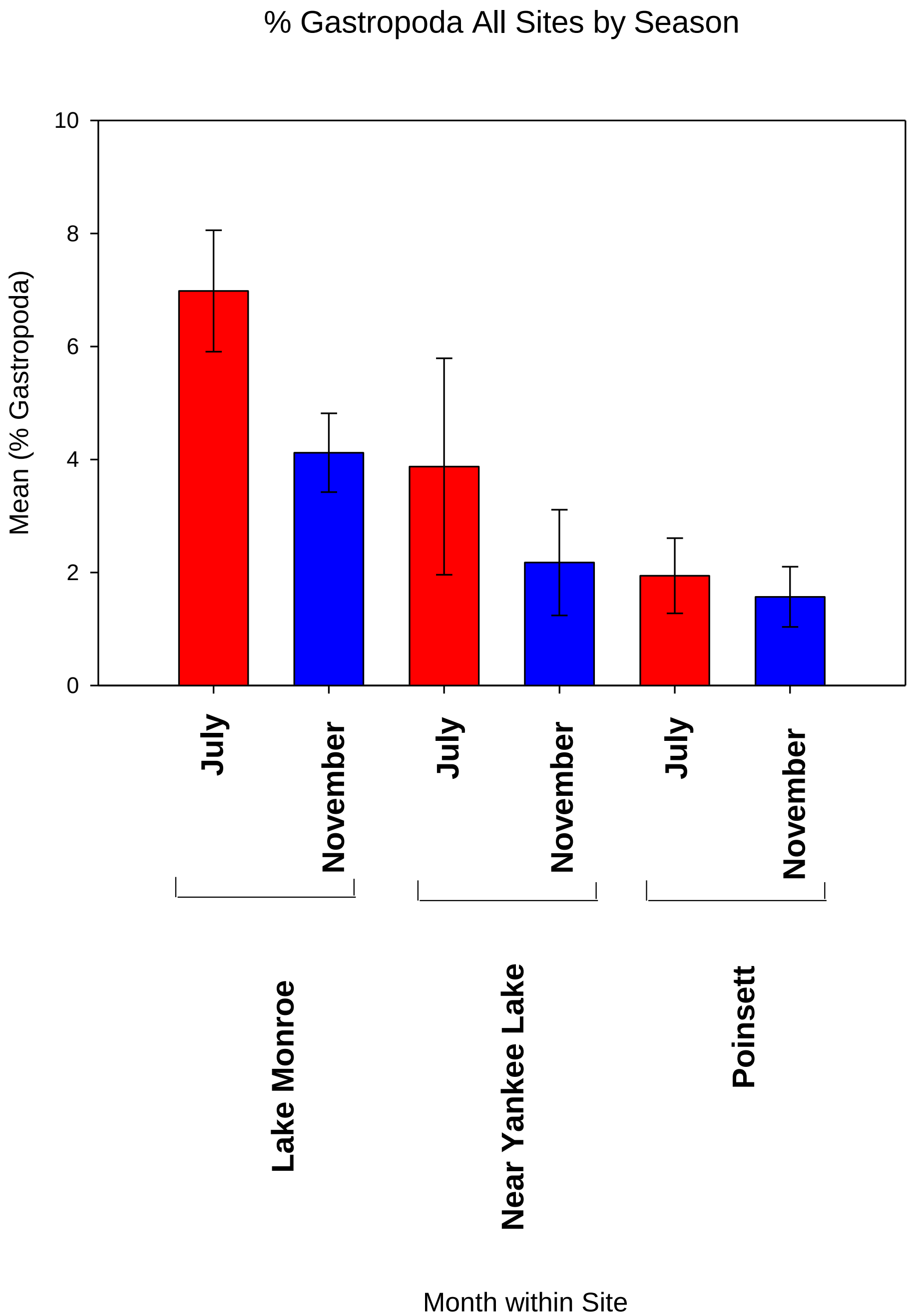


Figure 3. % Gastropoda count data Bull Rush

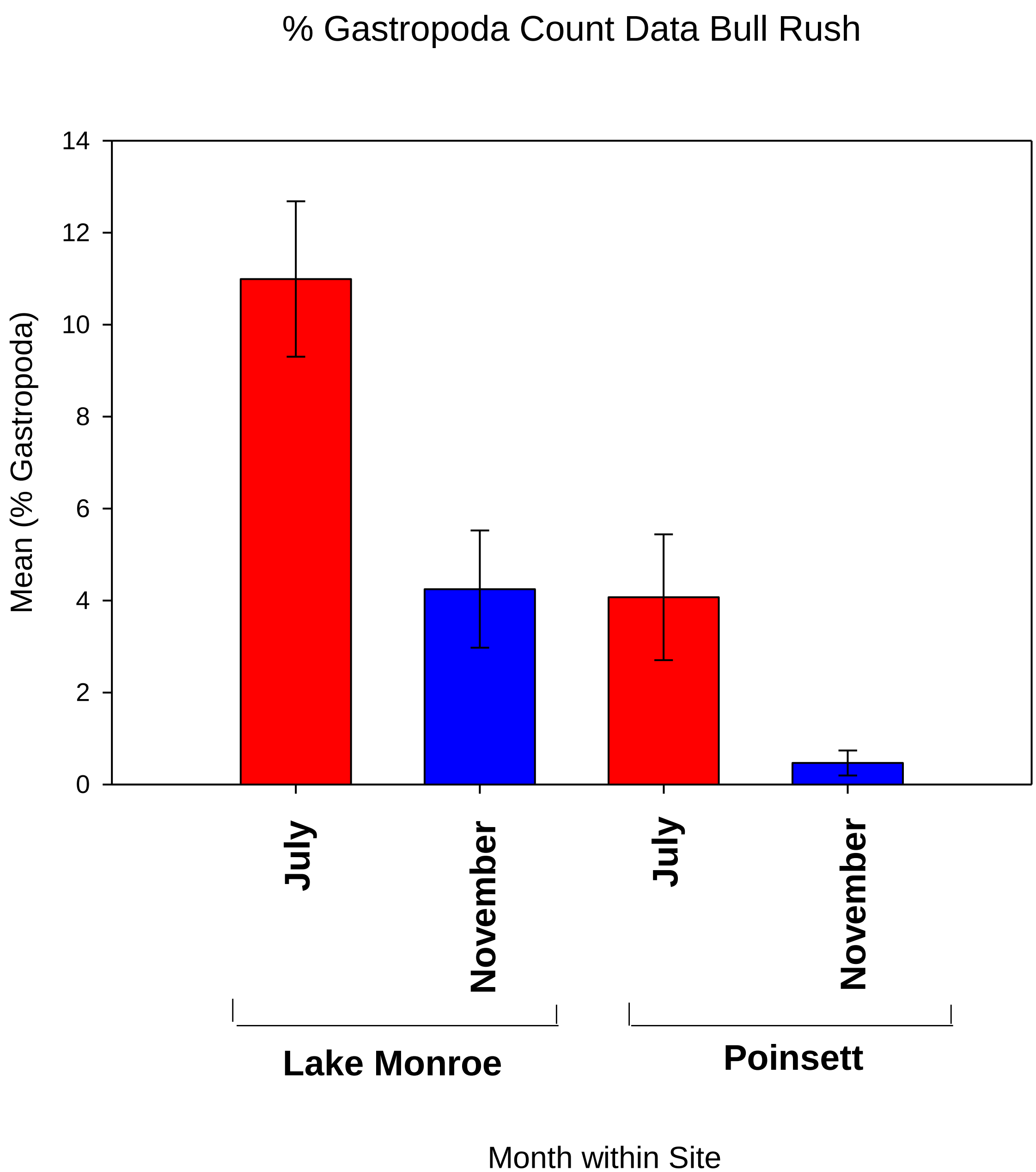


Figure 4. % Gastropoda count data Nuphar

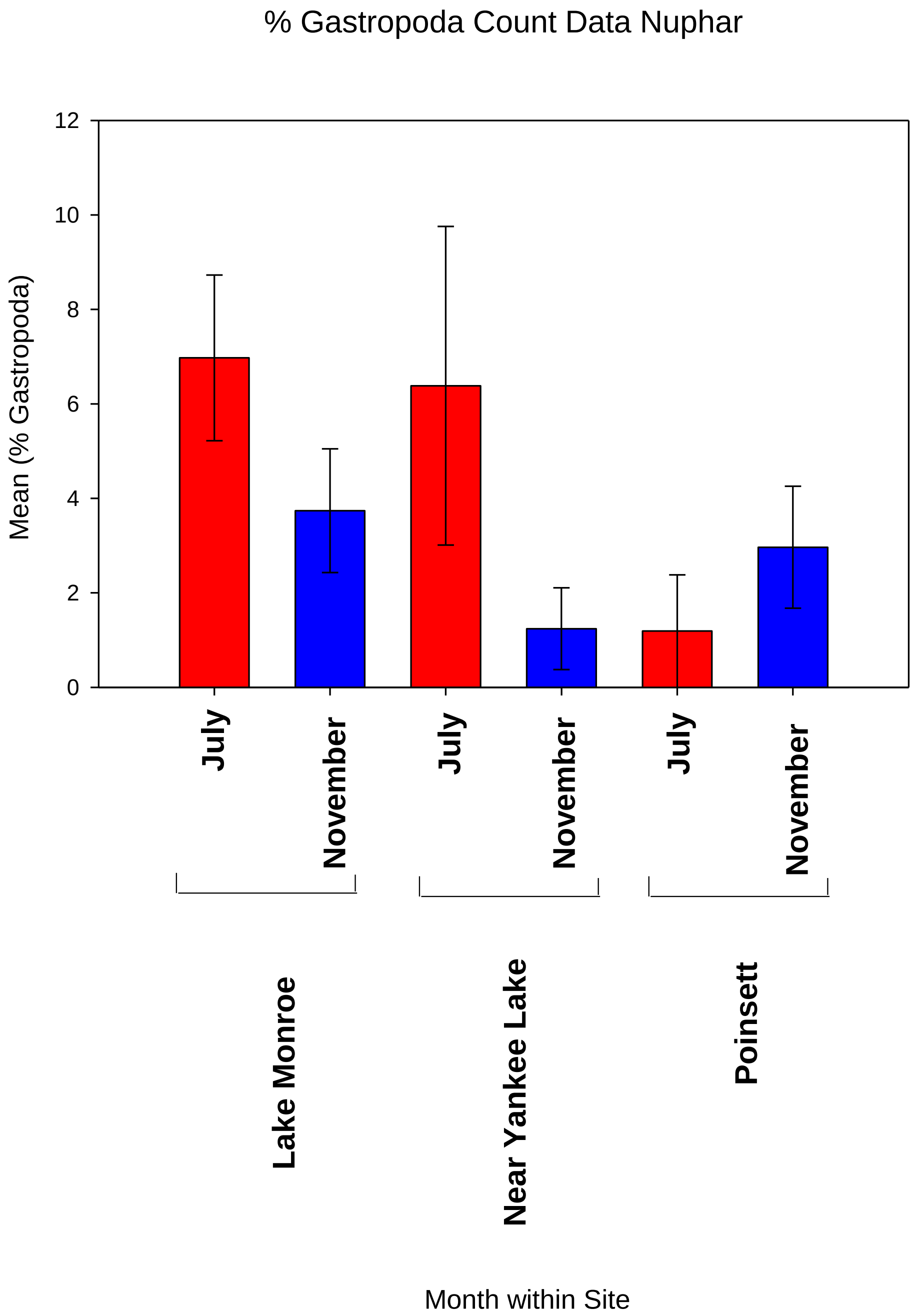


Figure 5. % Gastropoda count data Hydrilla

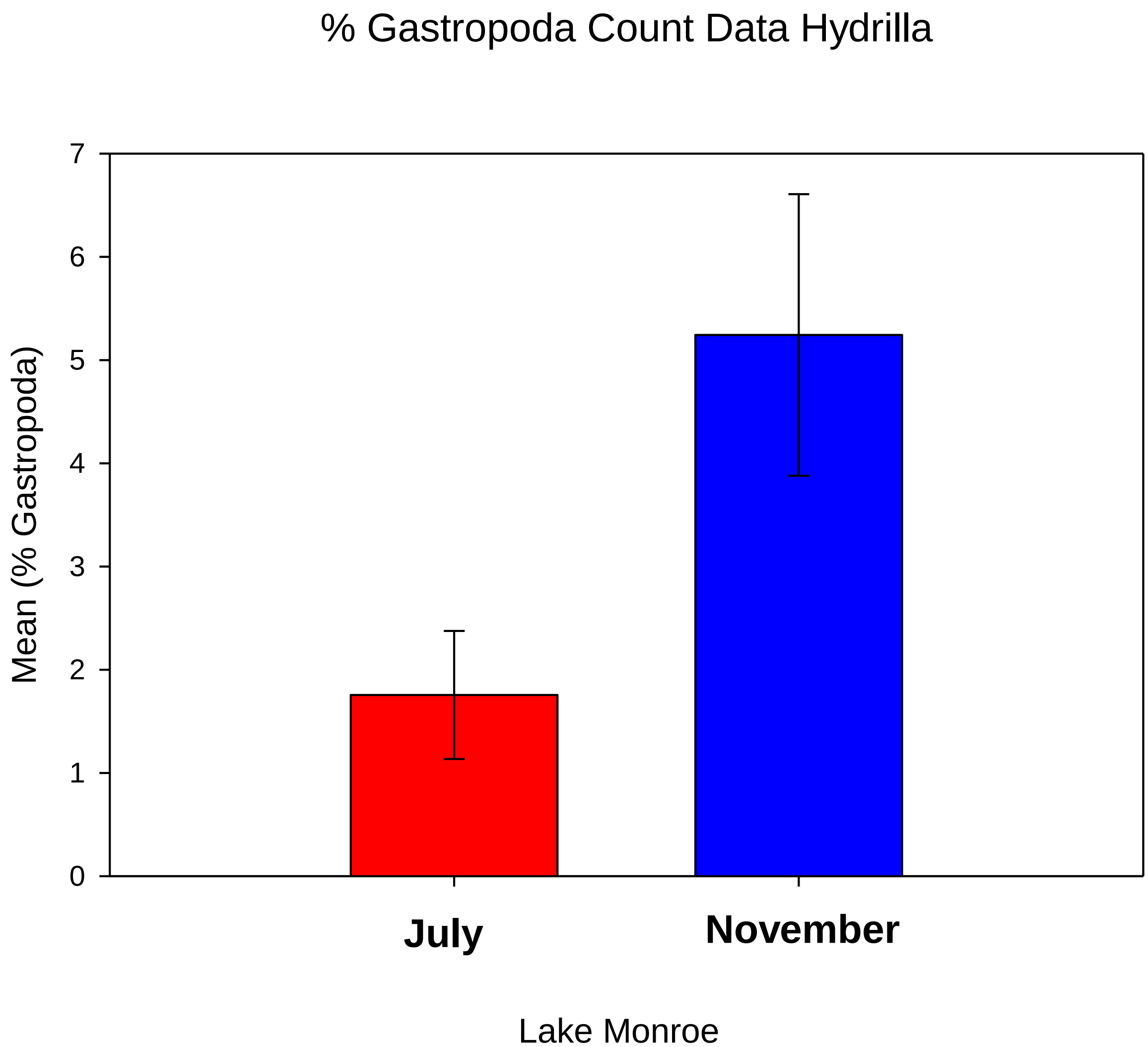


Figure 6. % Gastropoda count data Emergent Marsh

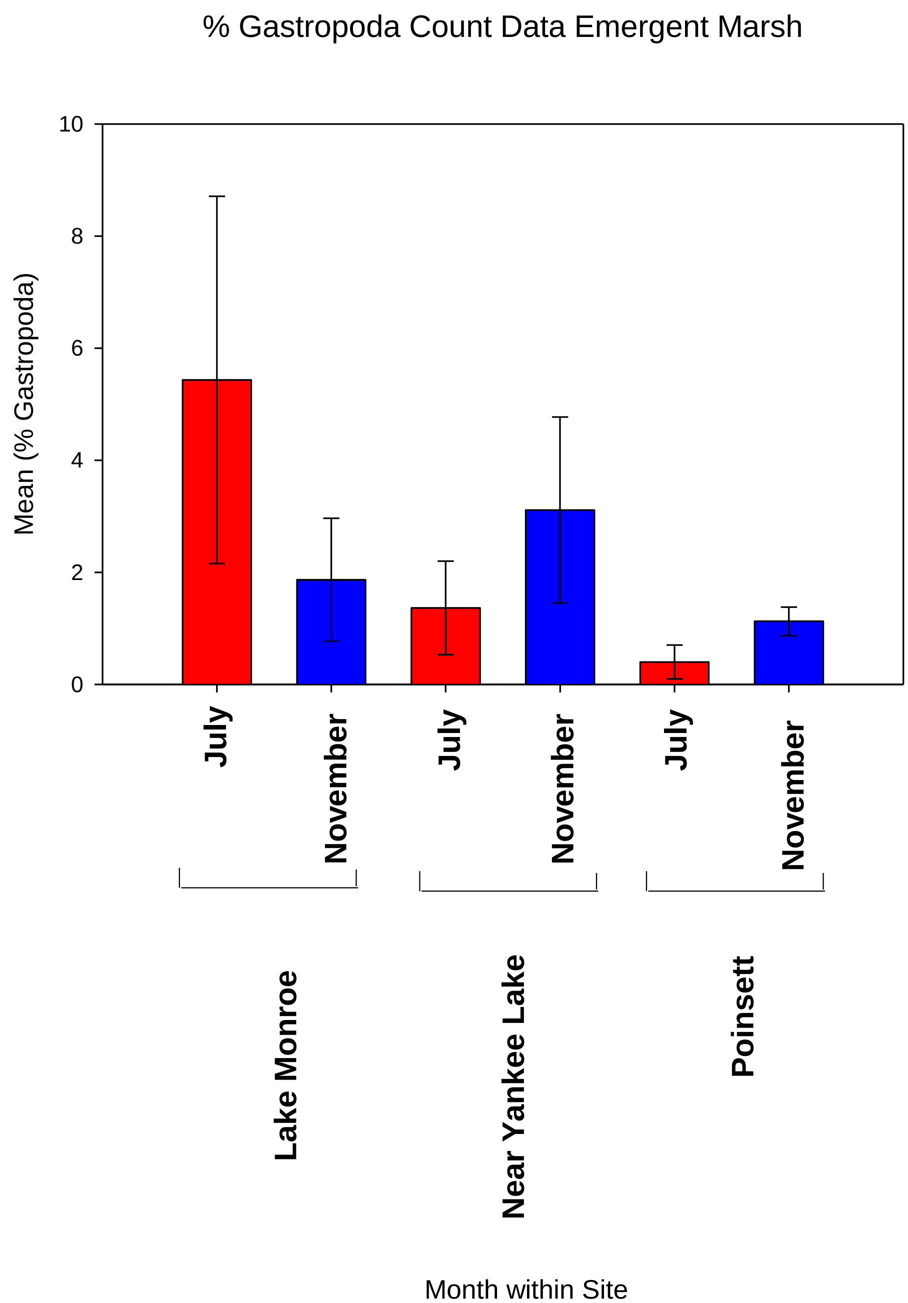


Figure 7. % *Hyalella* count data all sites

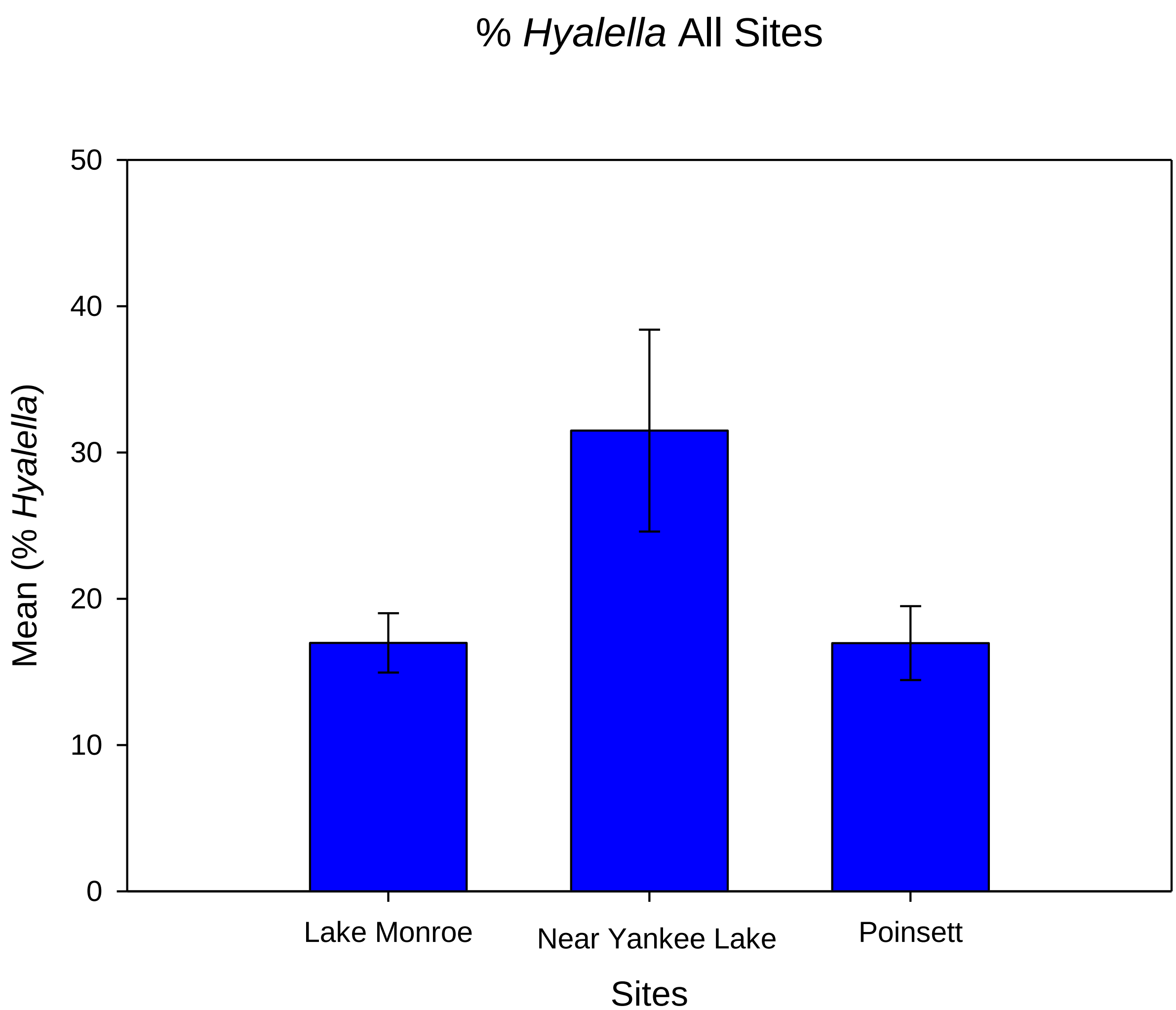


Figure 8. % *Hyalella* count data all sites by season

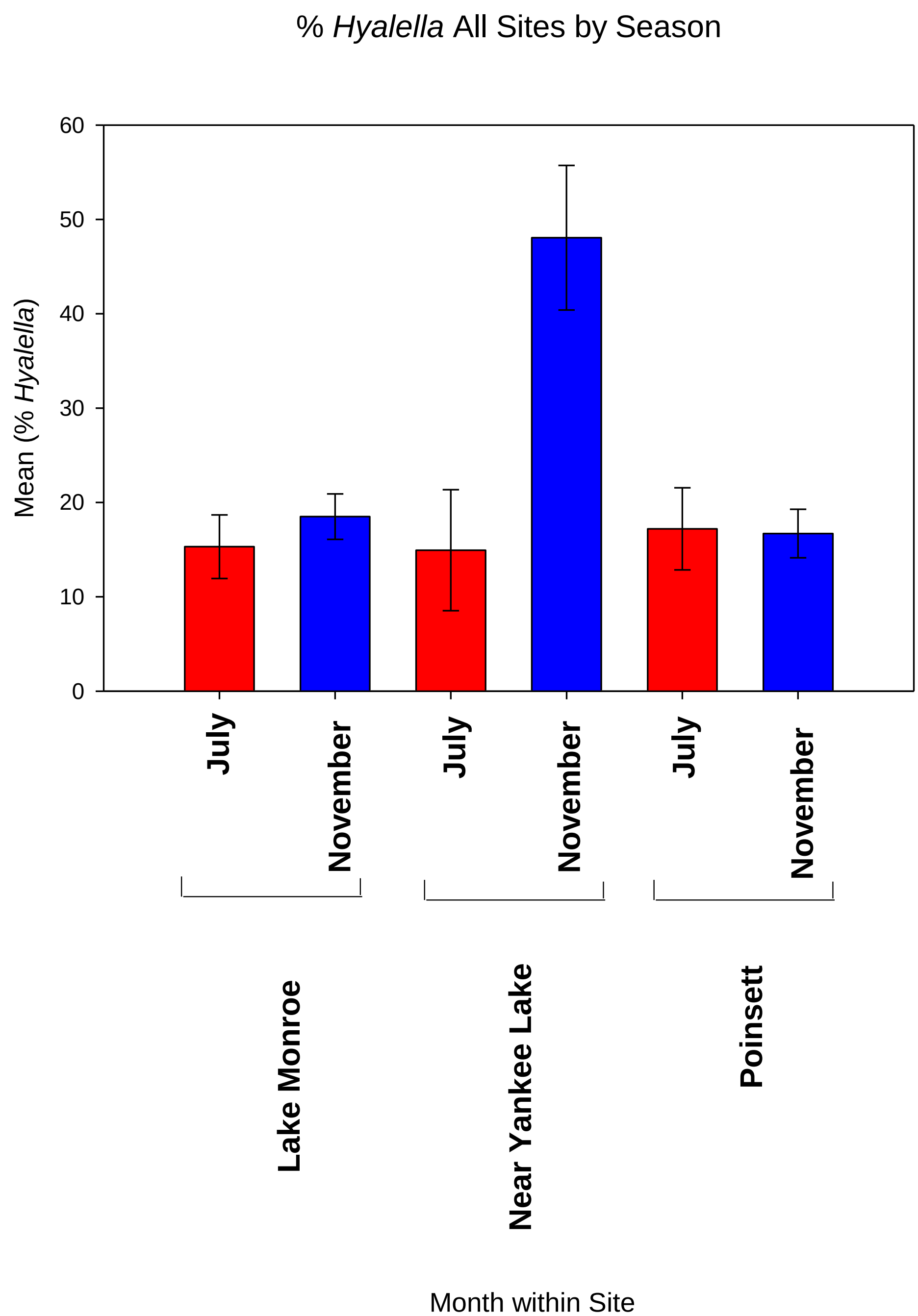


Figure 9. % *Hyalella* count data Bull Rush

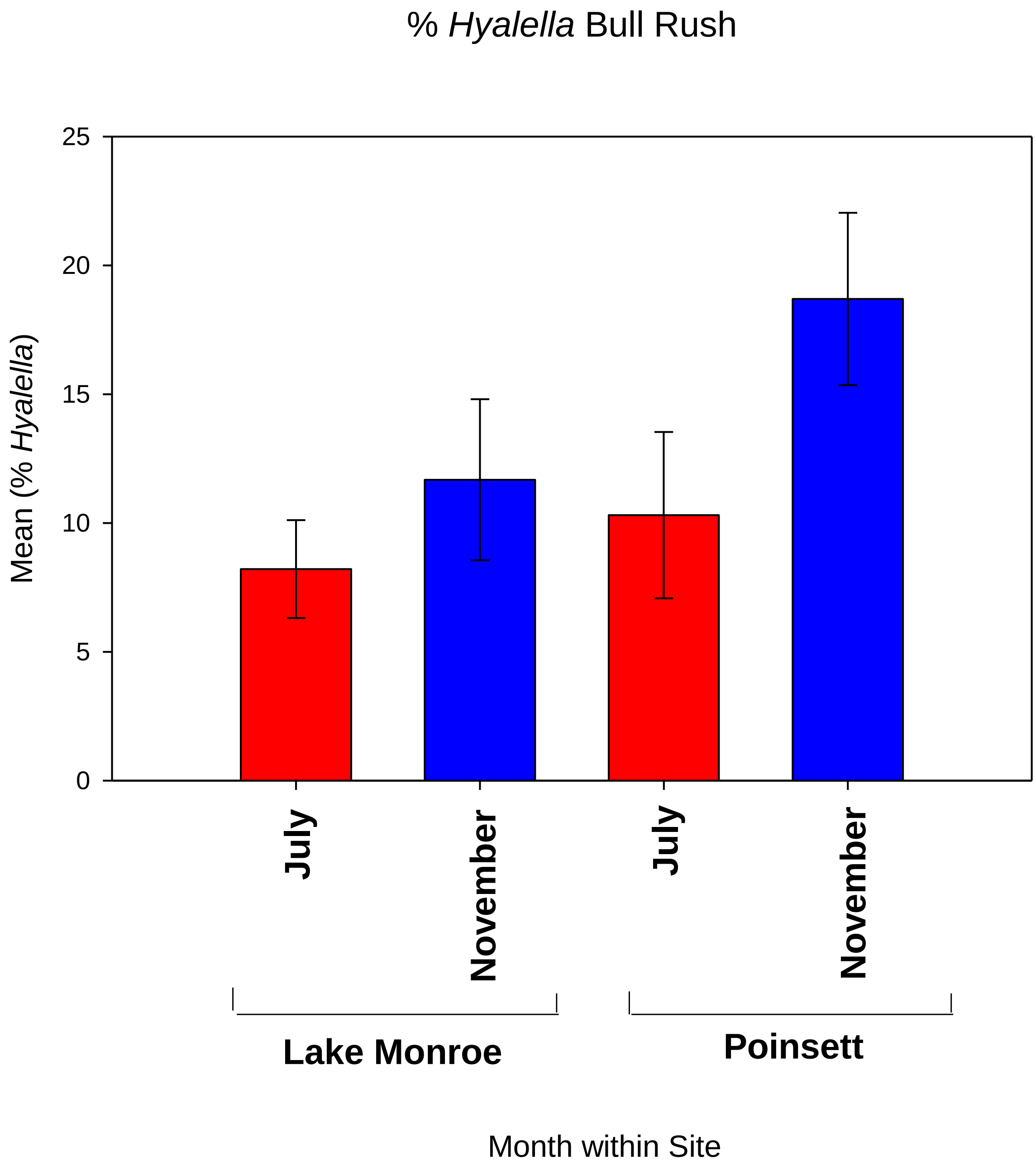


Figure 10. % *Hyalella* count data Nuphar

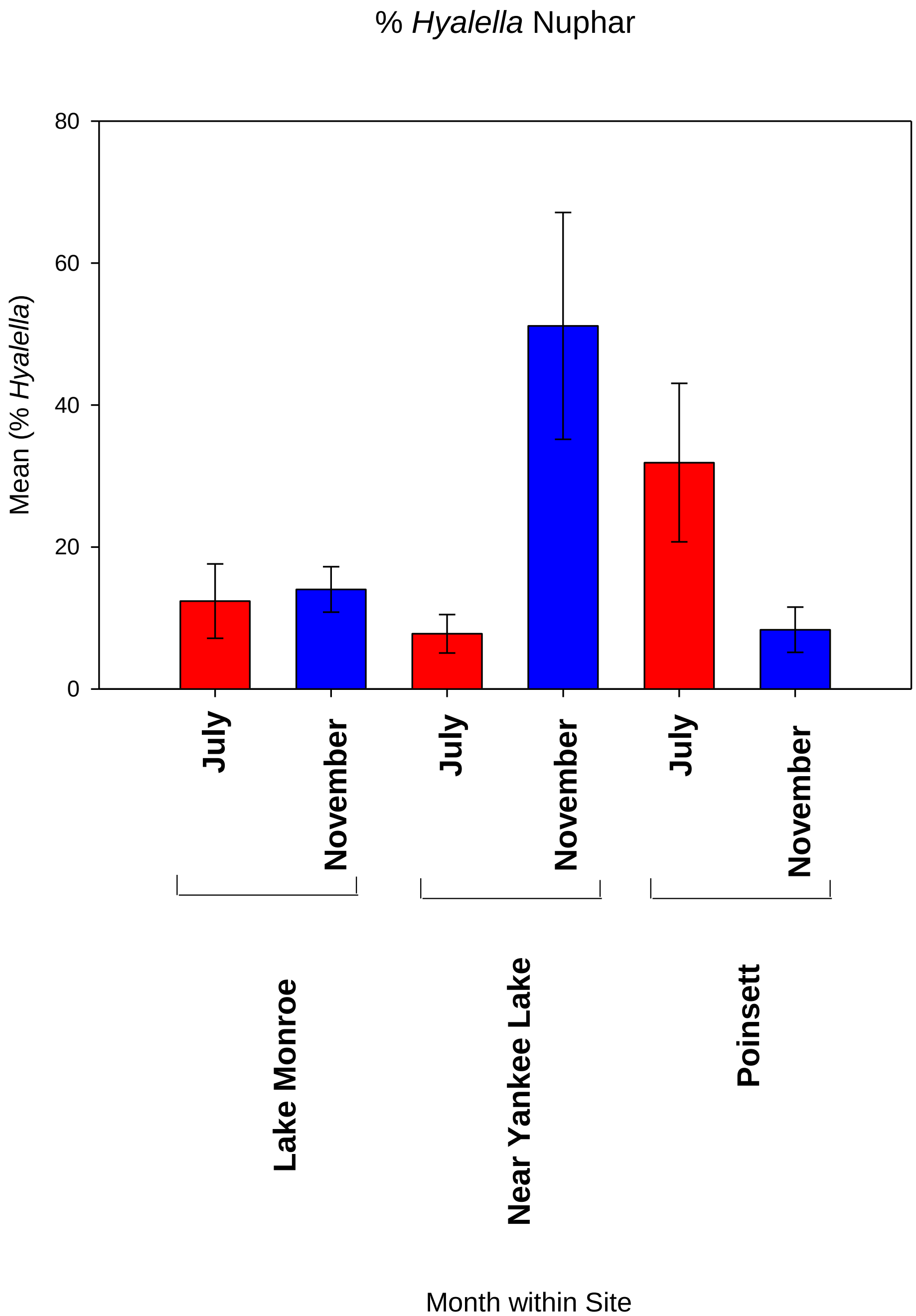


Figure 11. % *Hyalella* count data Hydrilla

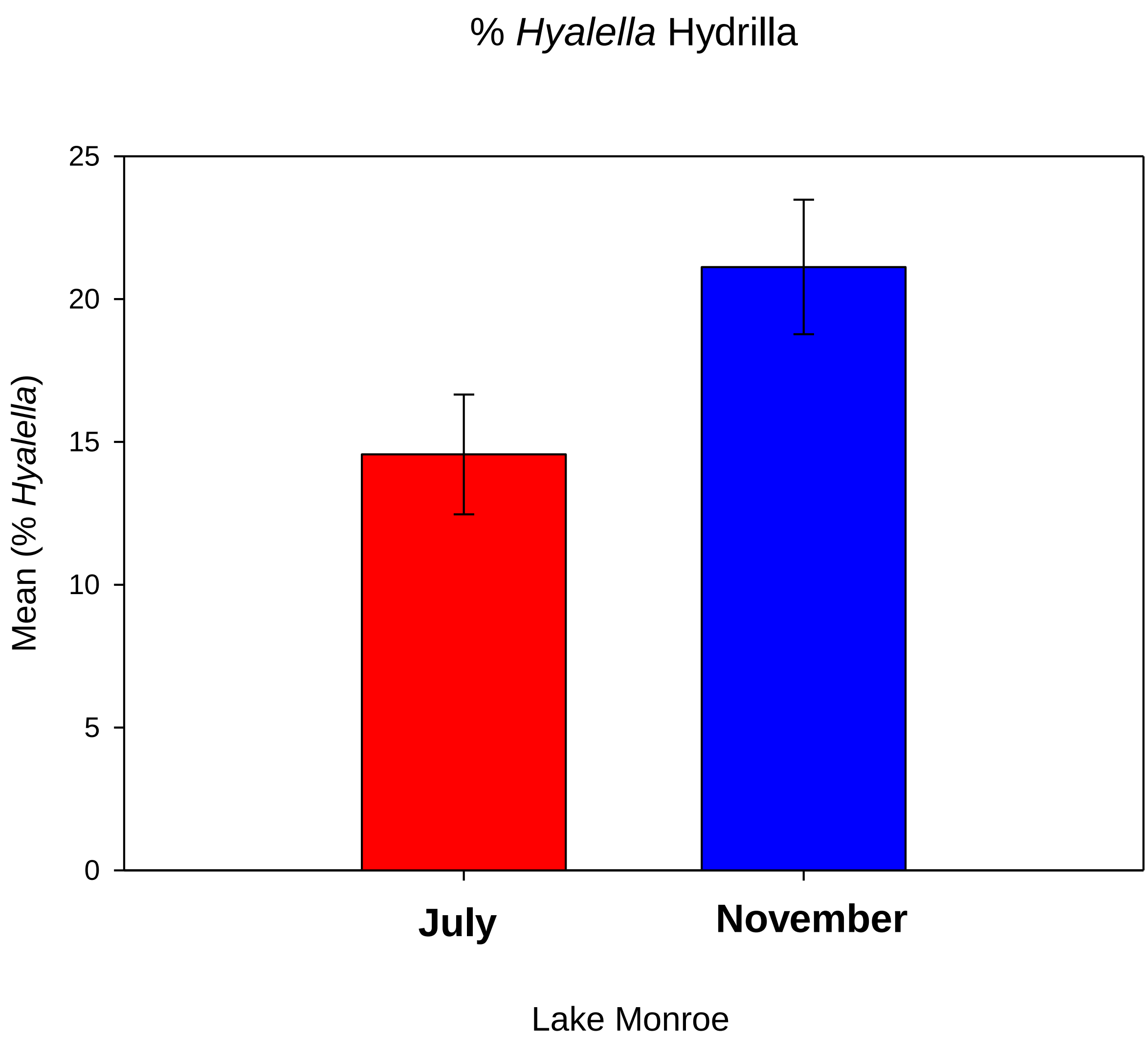


Figure 12. % *Hyalella* count data Emergent Marsh

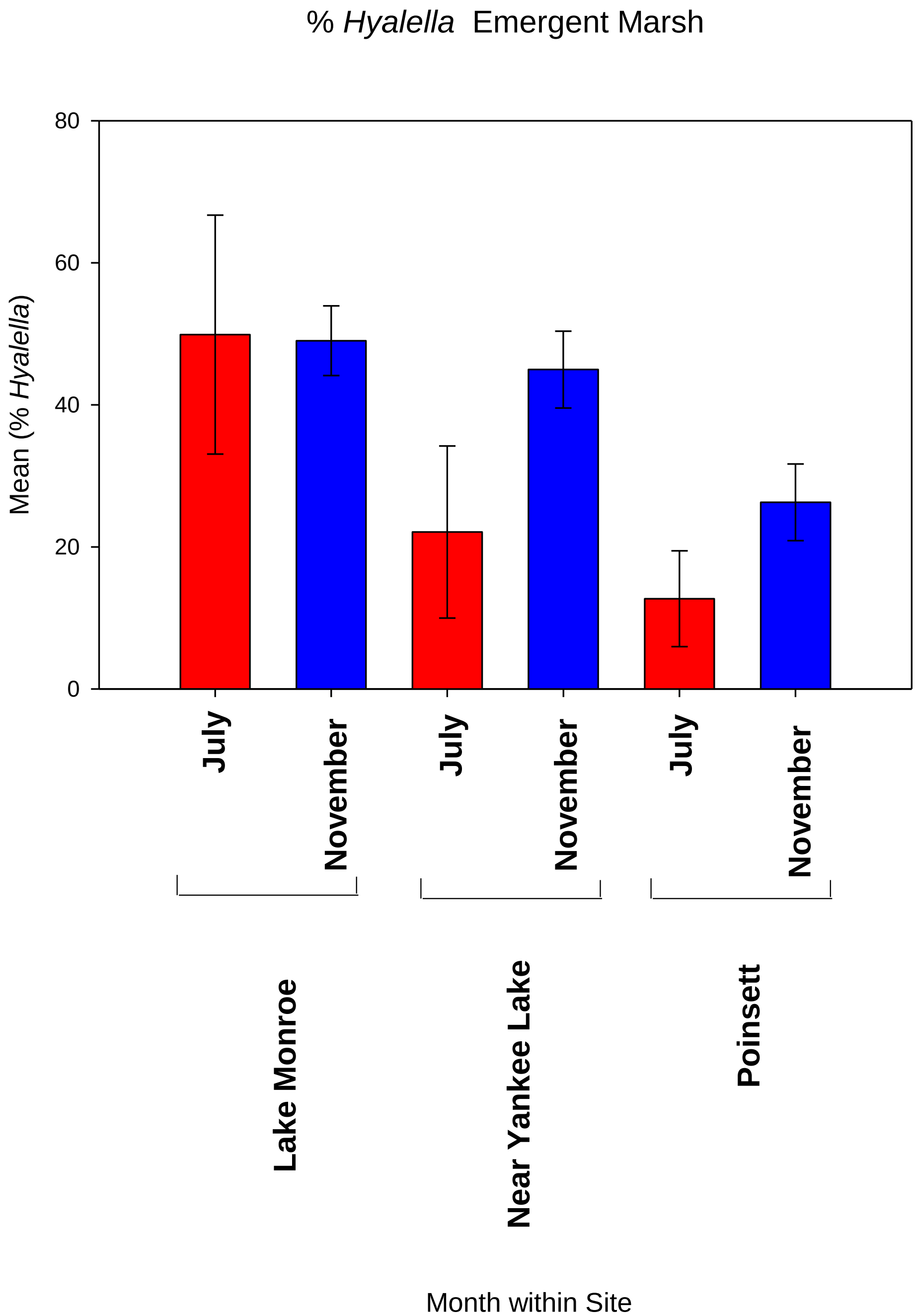


Figure 13. % Odonata count data all sites

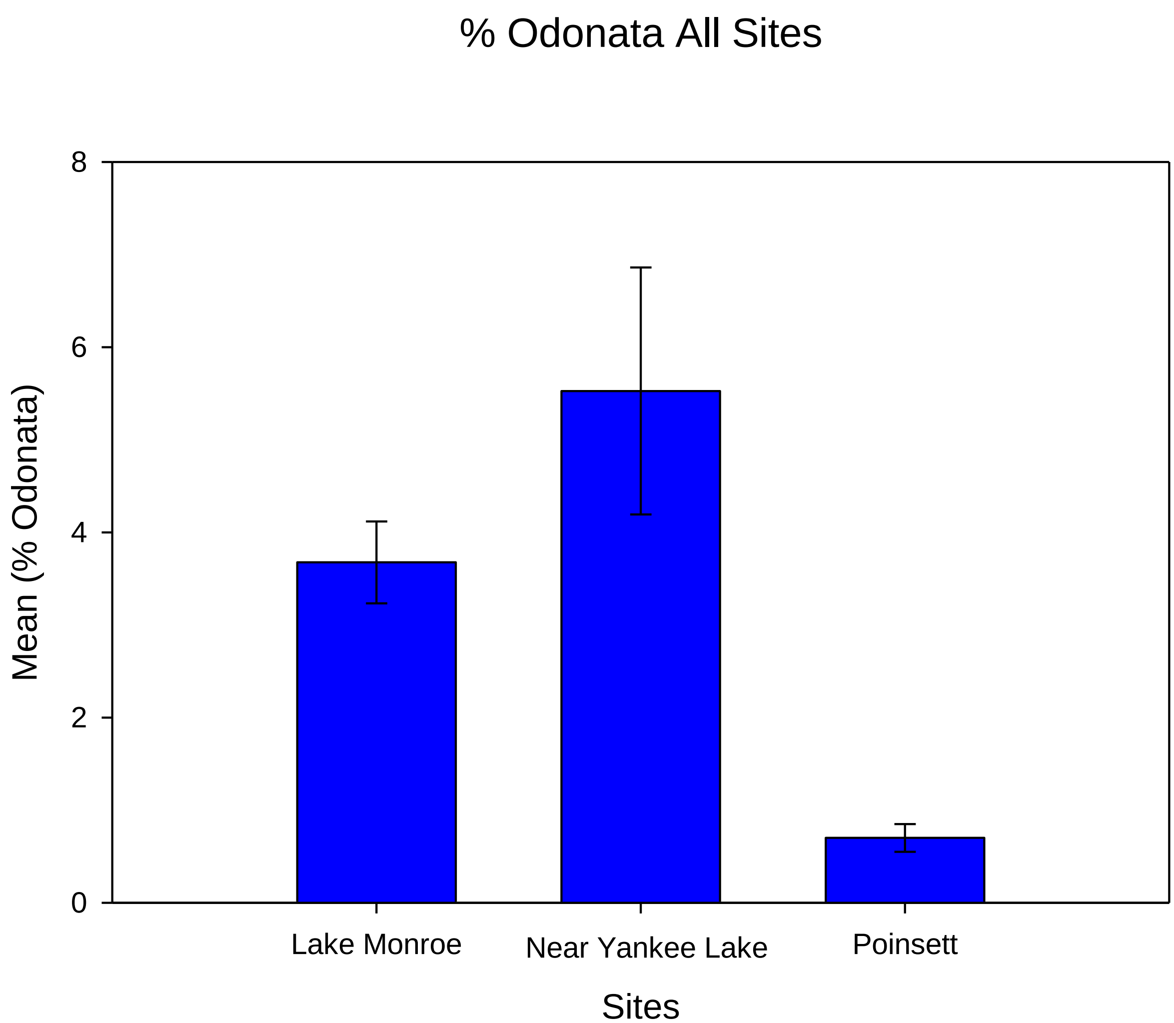


Figure 14. % Odonata count data all sites by season

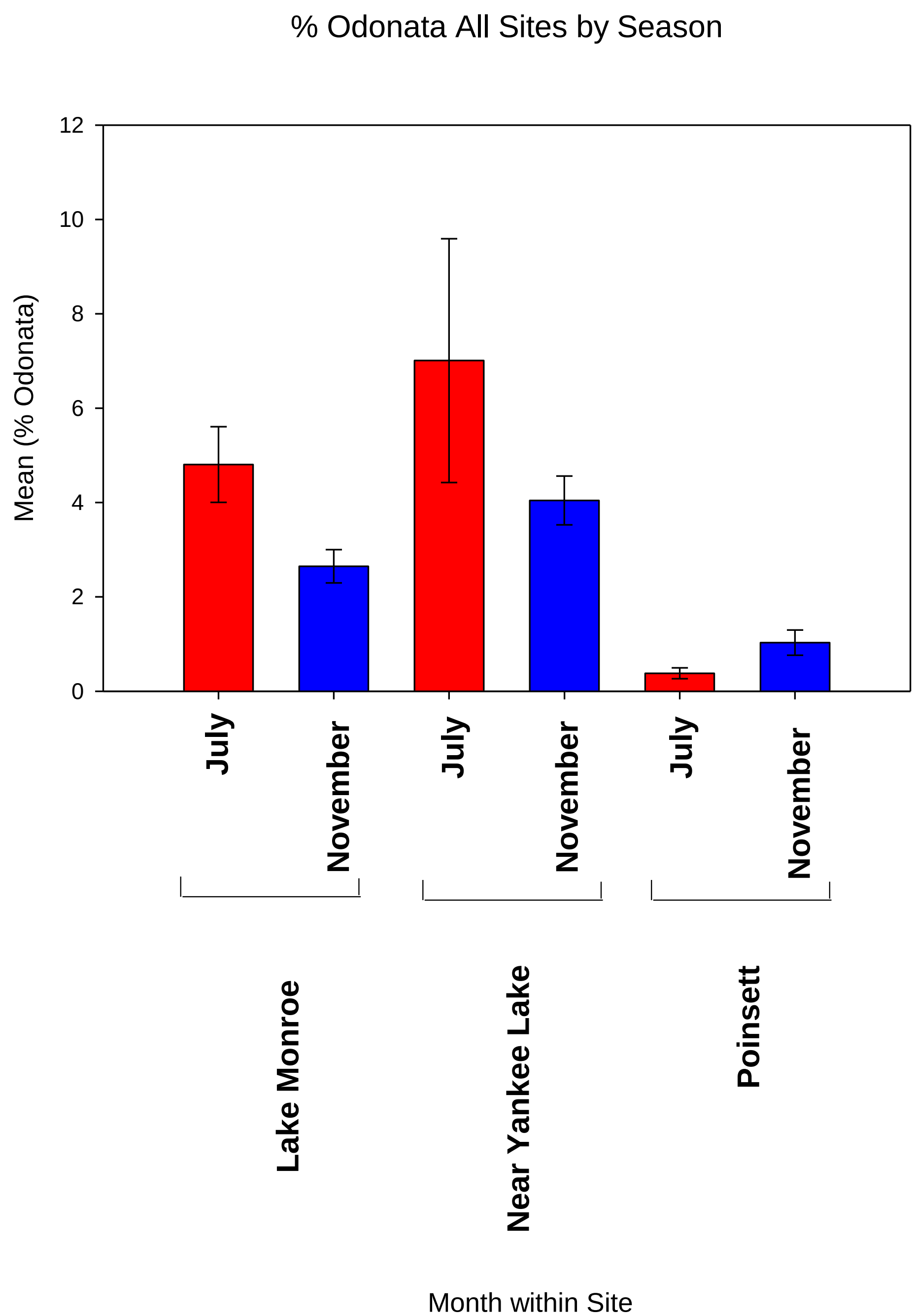


Figure 15. % Odonata count data Bull Rush

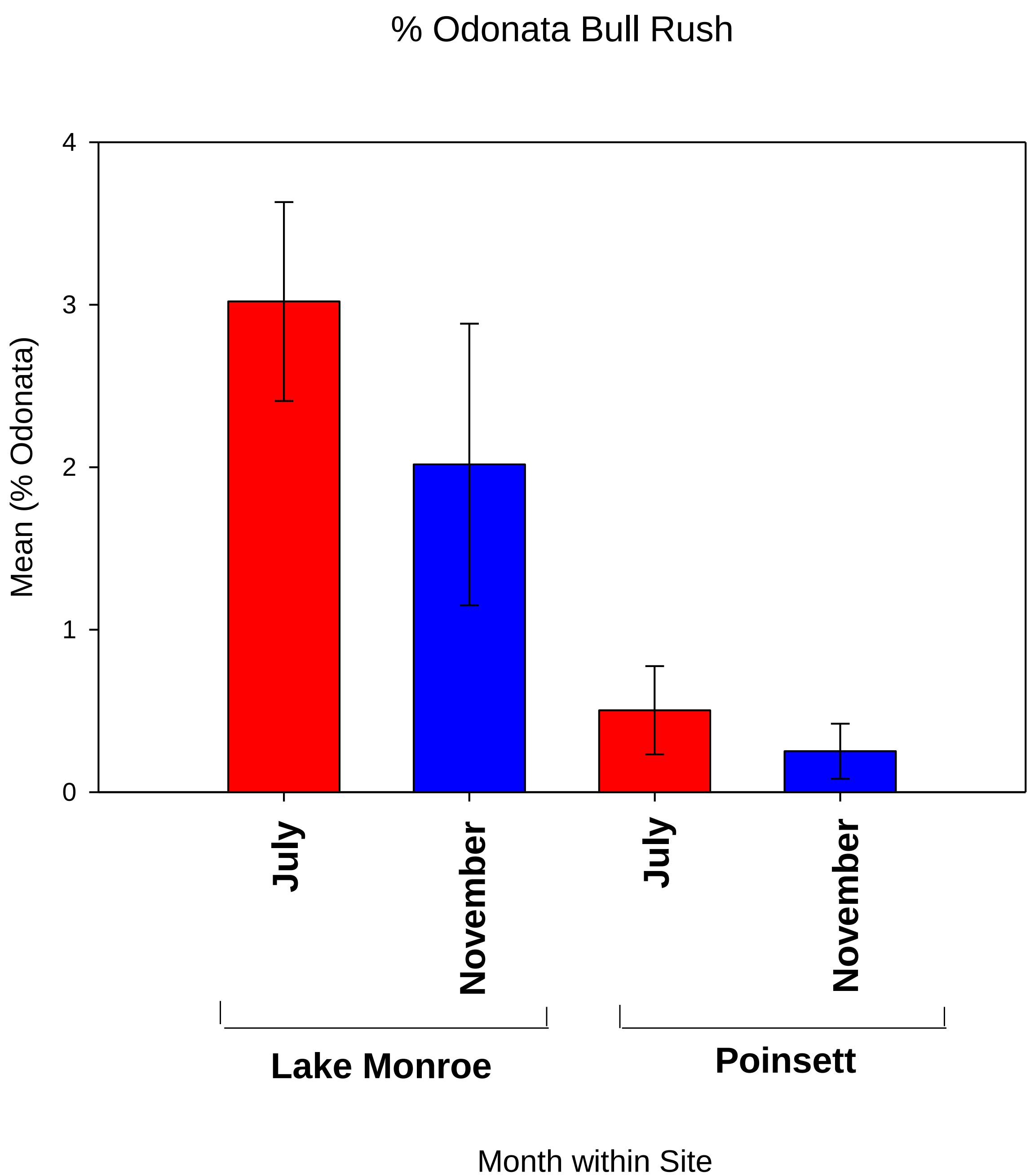


Figure 16. % Odonata count data Nuphar

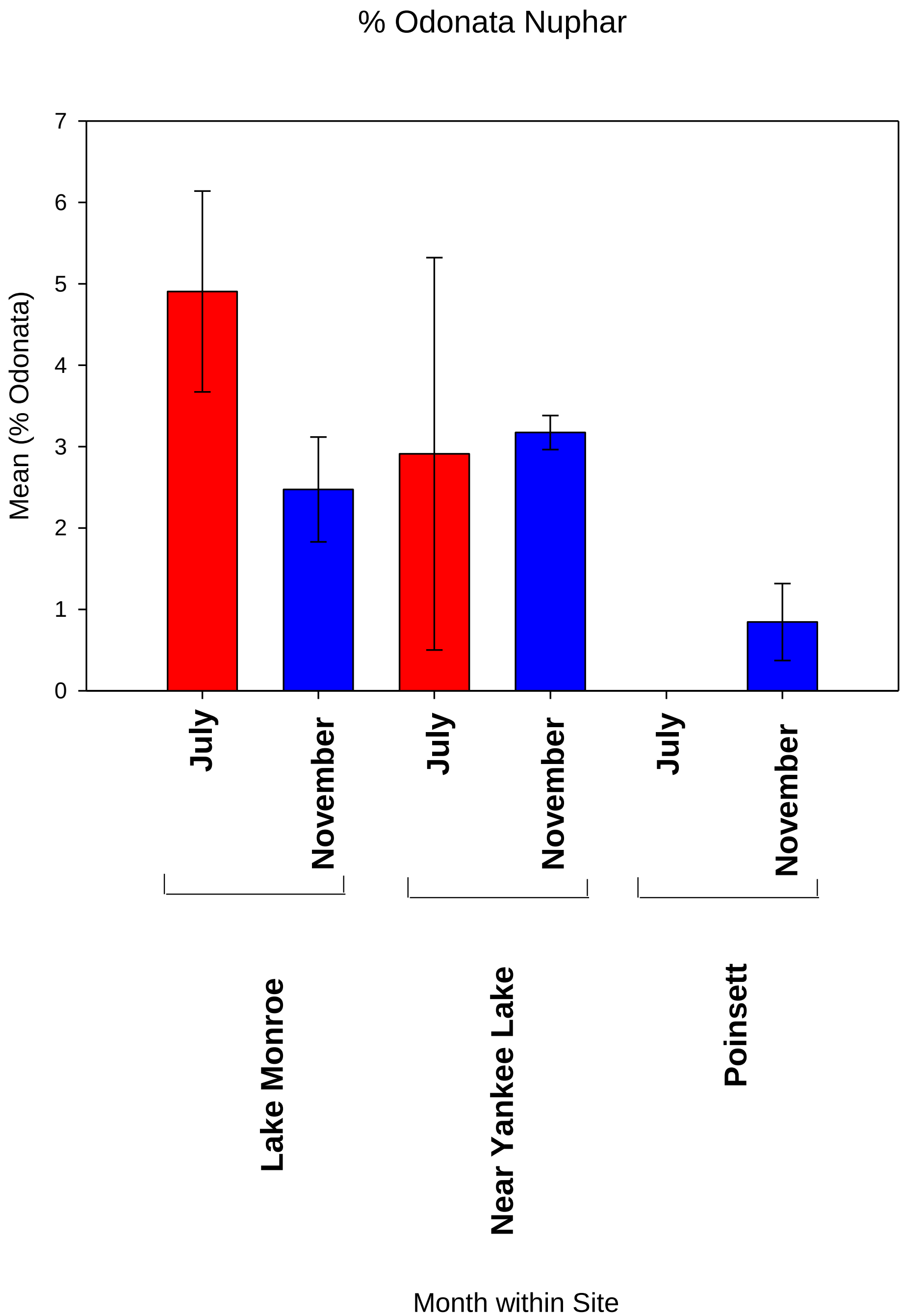


Figure 17. % Odonata count data Hydrilla

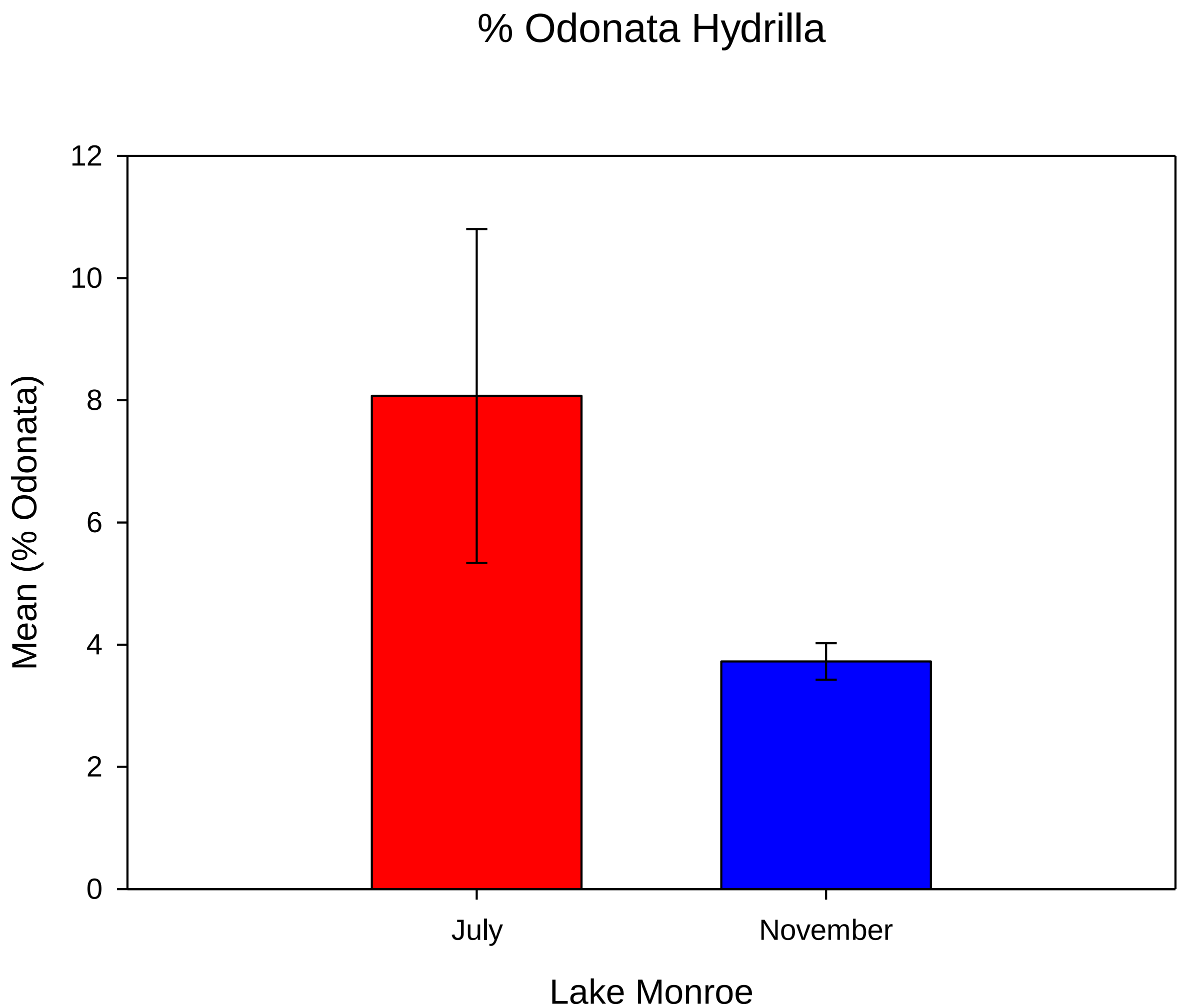


Figure 18. % Odonata count data Emergent Marsh

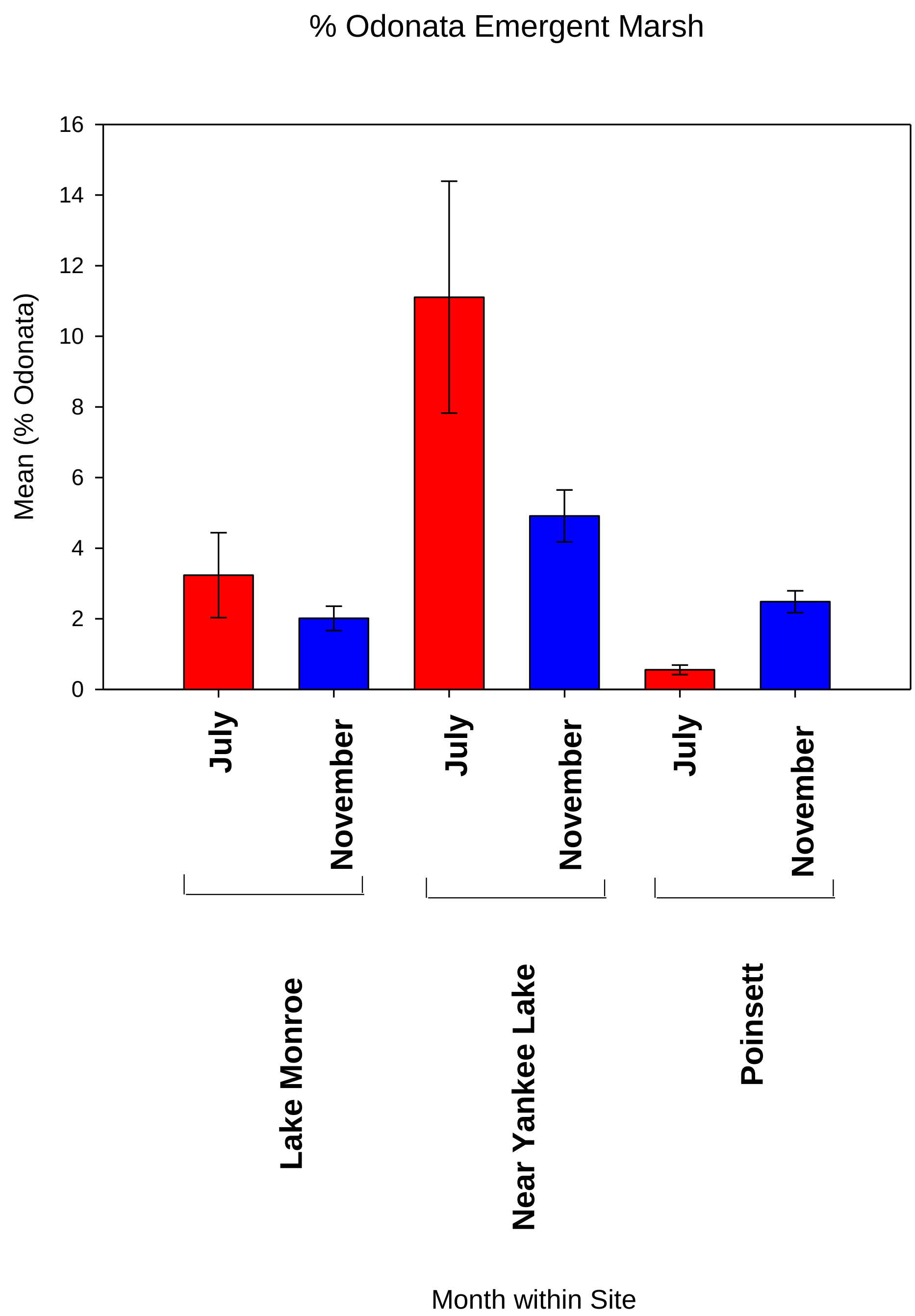


Figure 19. % Ephemeroptera count data all sites

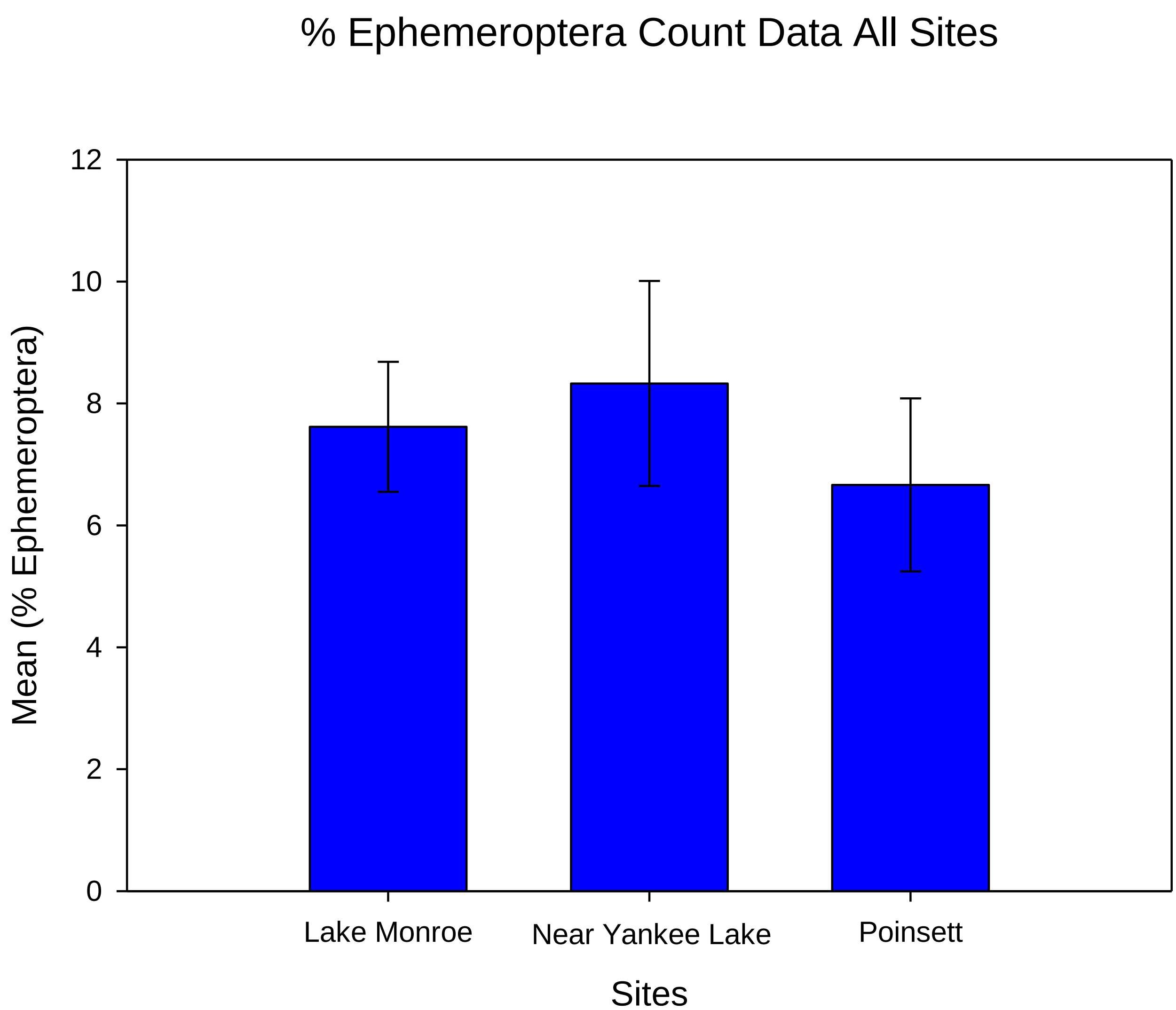


Figure 20. % Ephemeroptera count data all sites by season

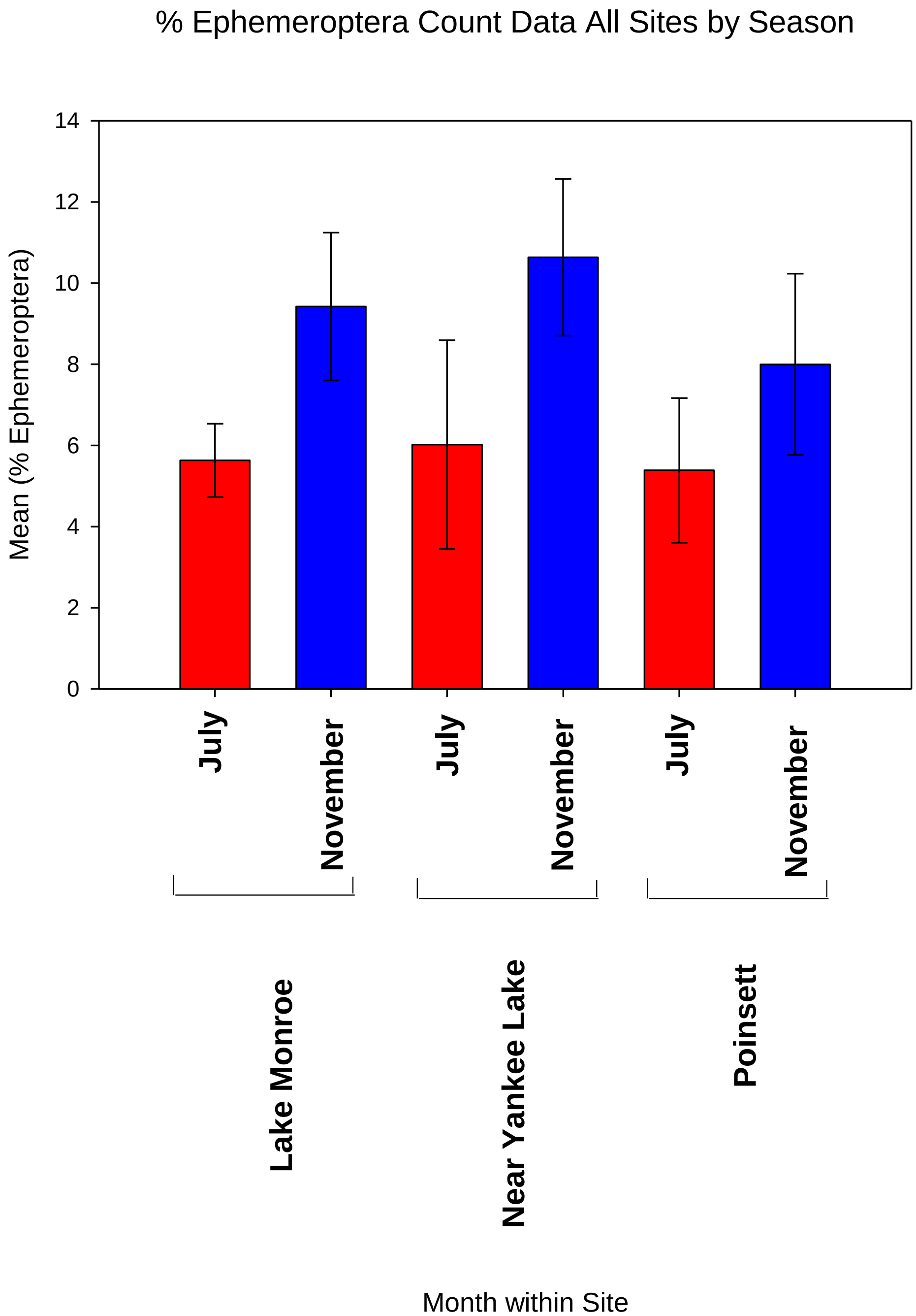


Figure 21. % Ephemeroptera count data Bull Rush

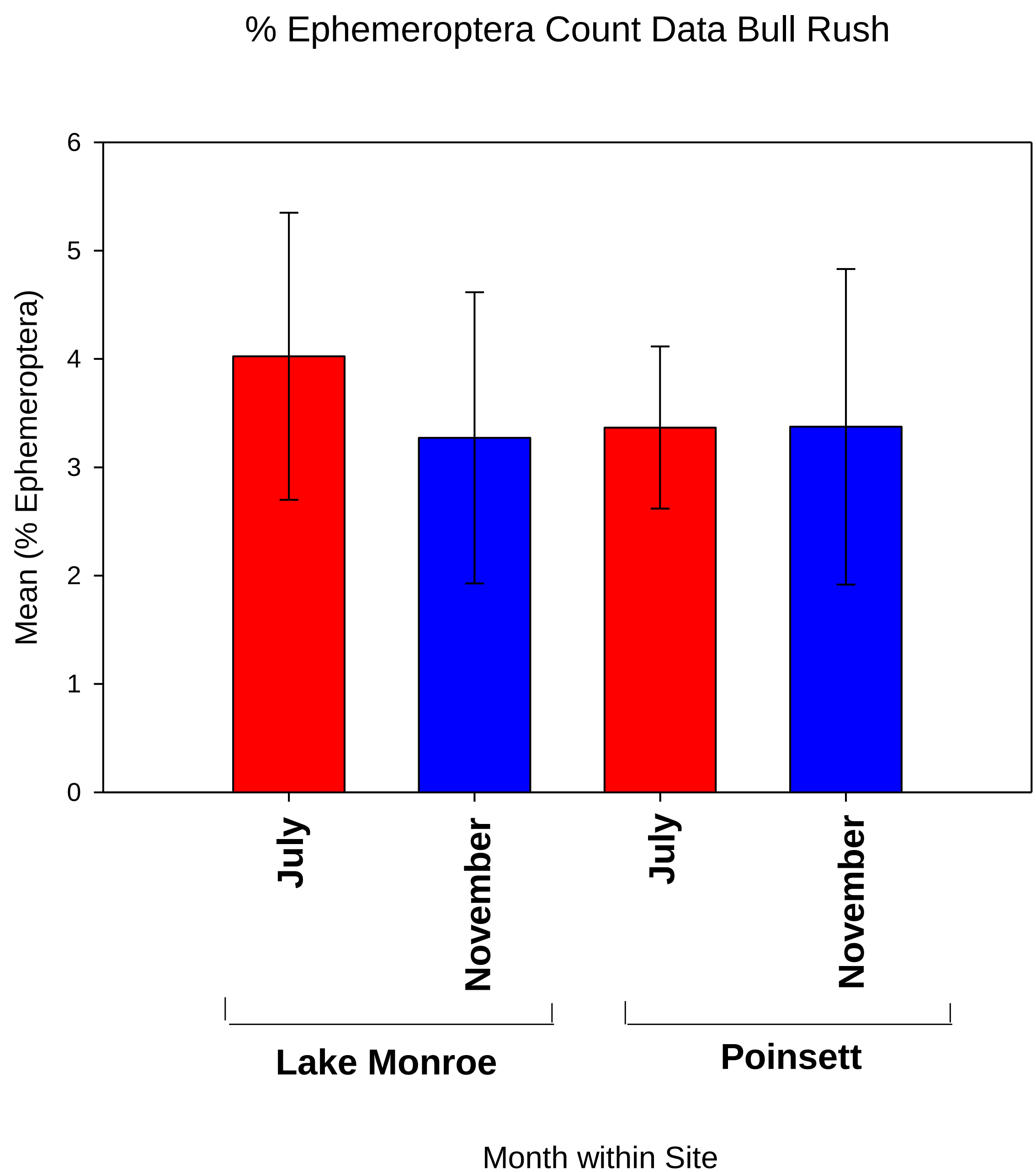


Figure 22. % Ephemeroptera count data Nuphar

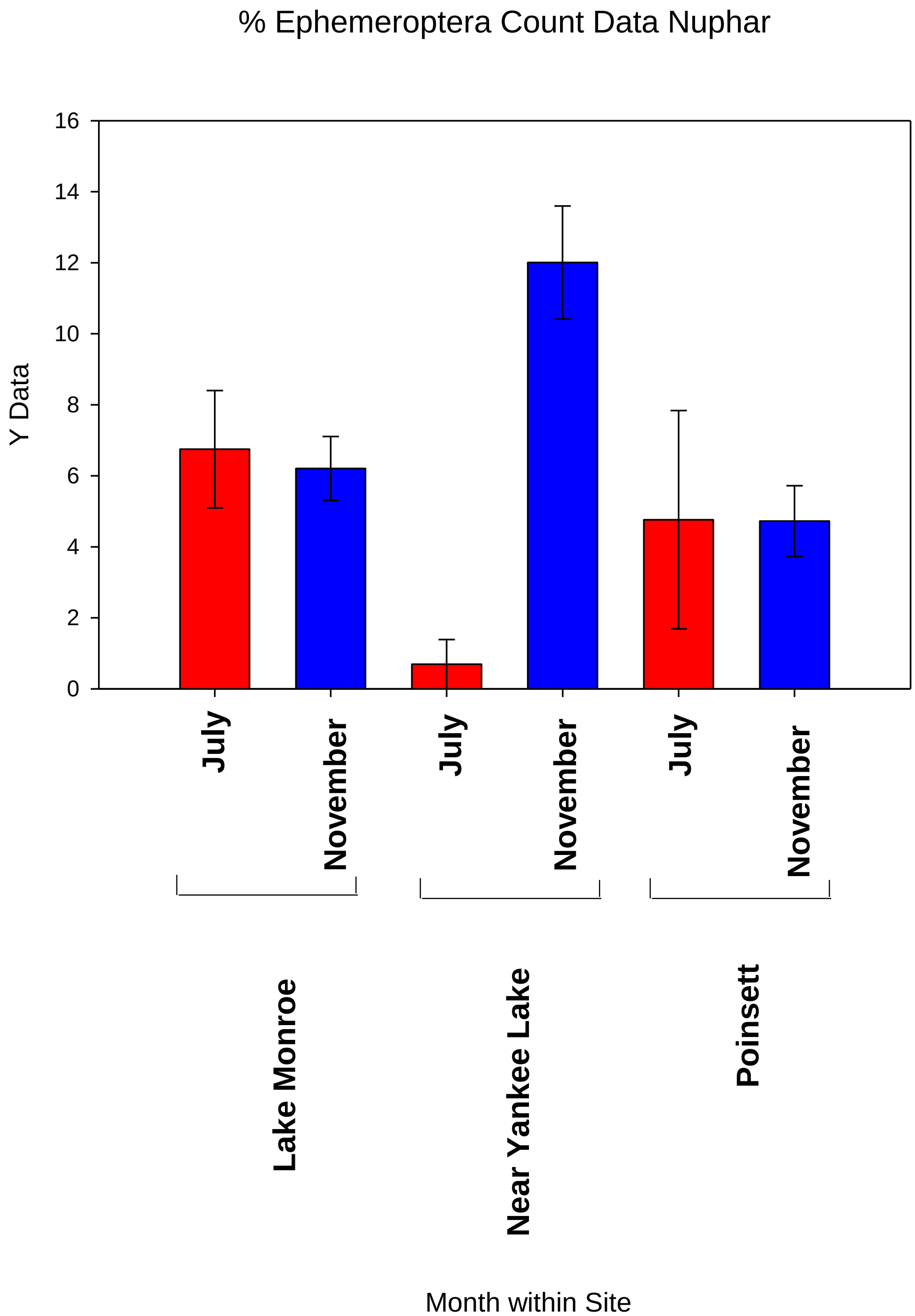


Figure 23. % Ephemeroptera count data Hydrilla

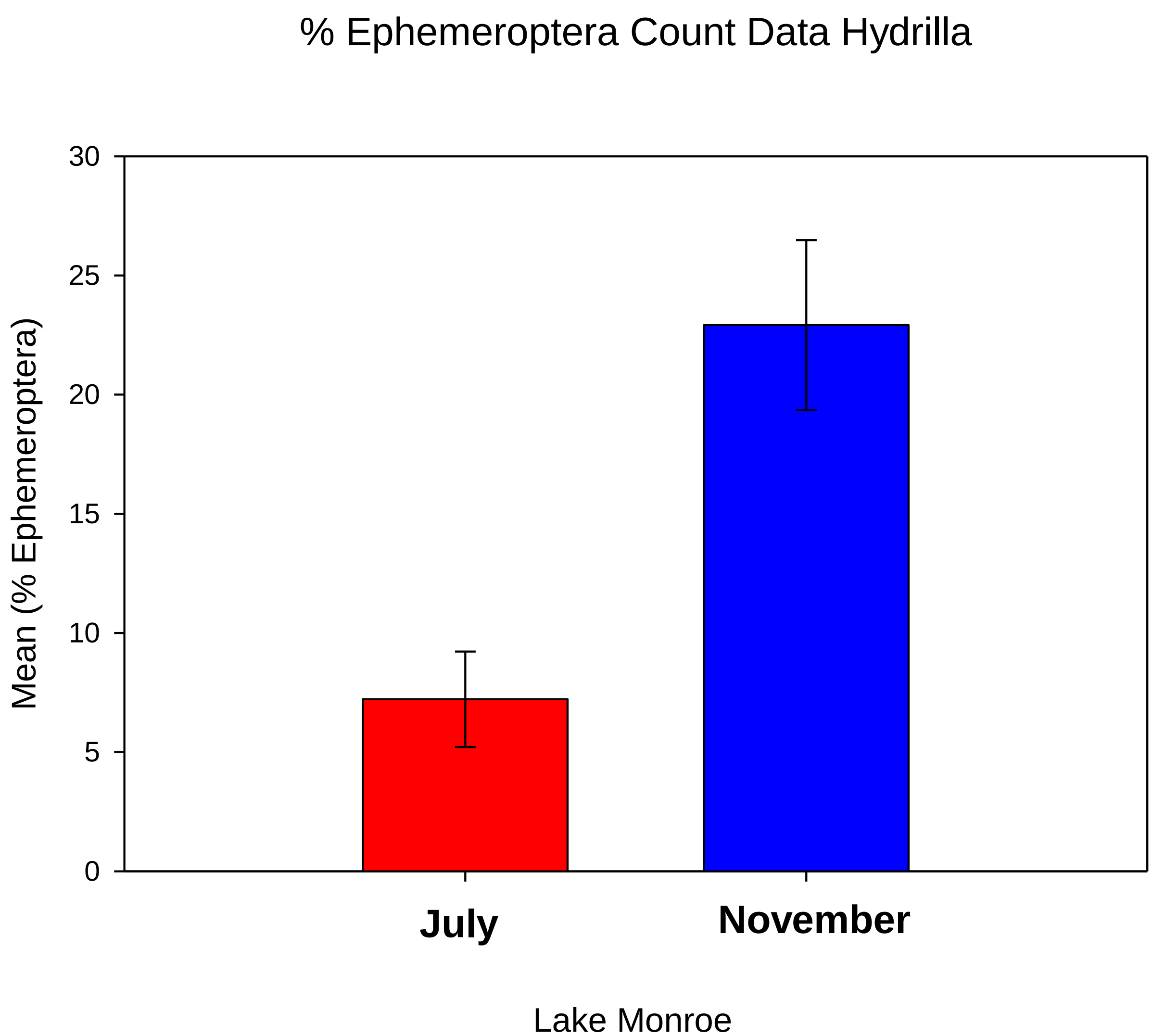


Figure 24. % Ephemeroptera count data Emergent Marsh

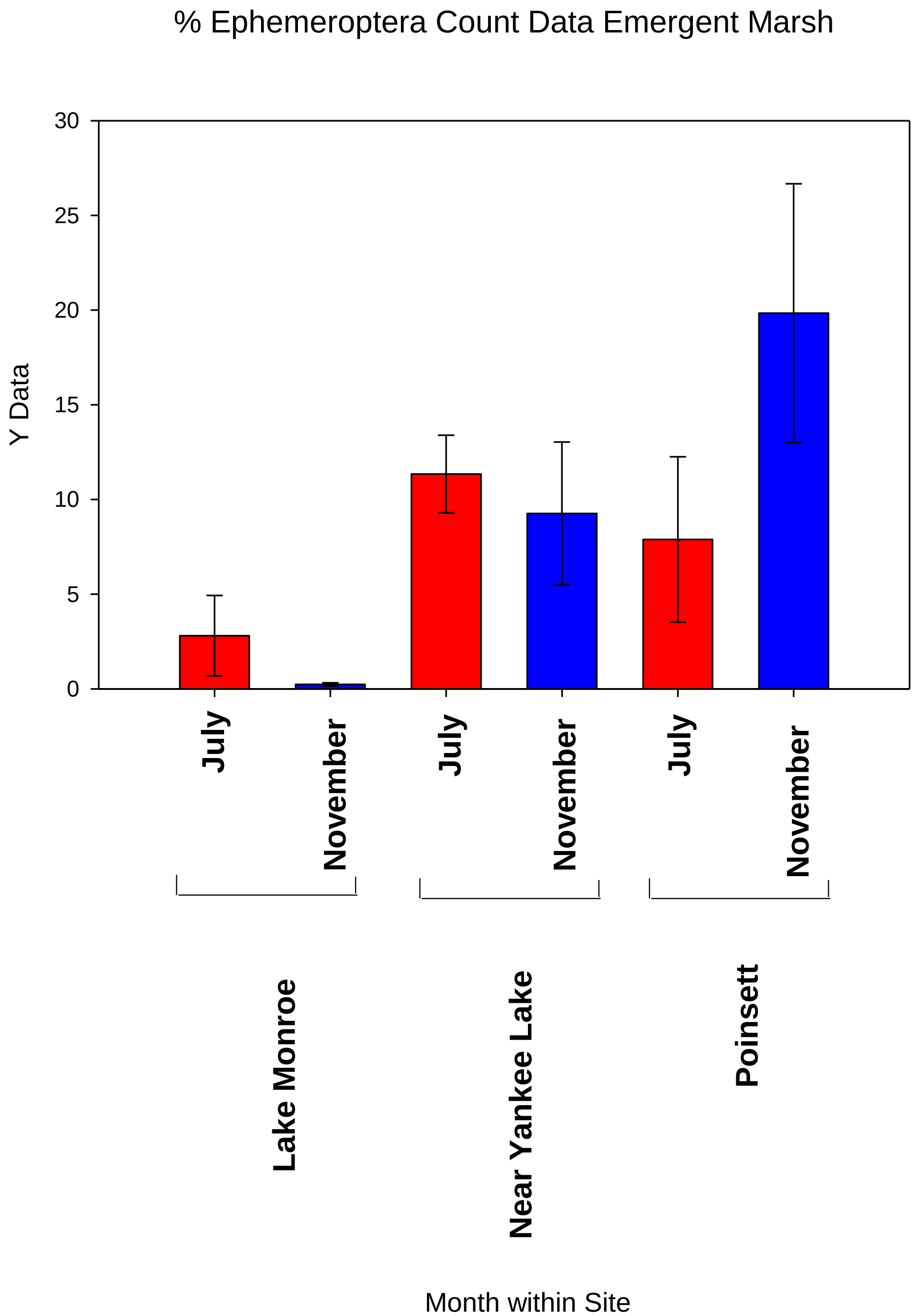


Figure 25. % Coleoptera count data all sites

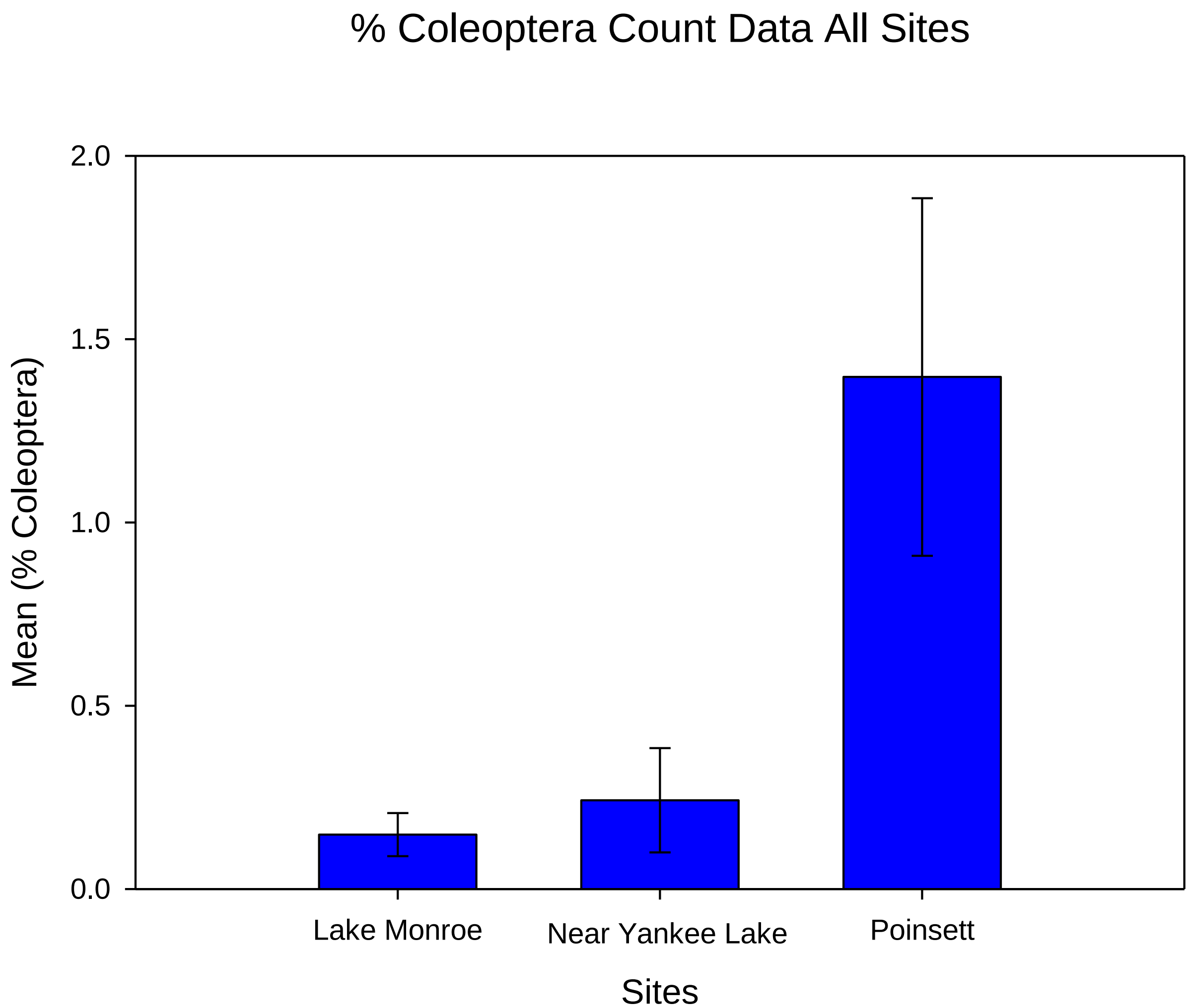


Figure 26. % Coleoptera count data all sites by season

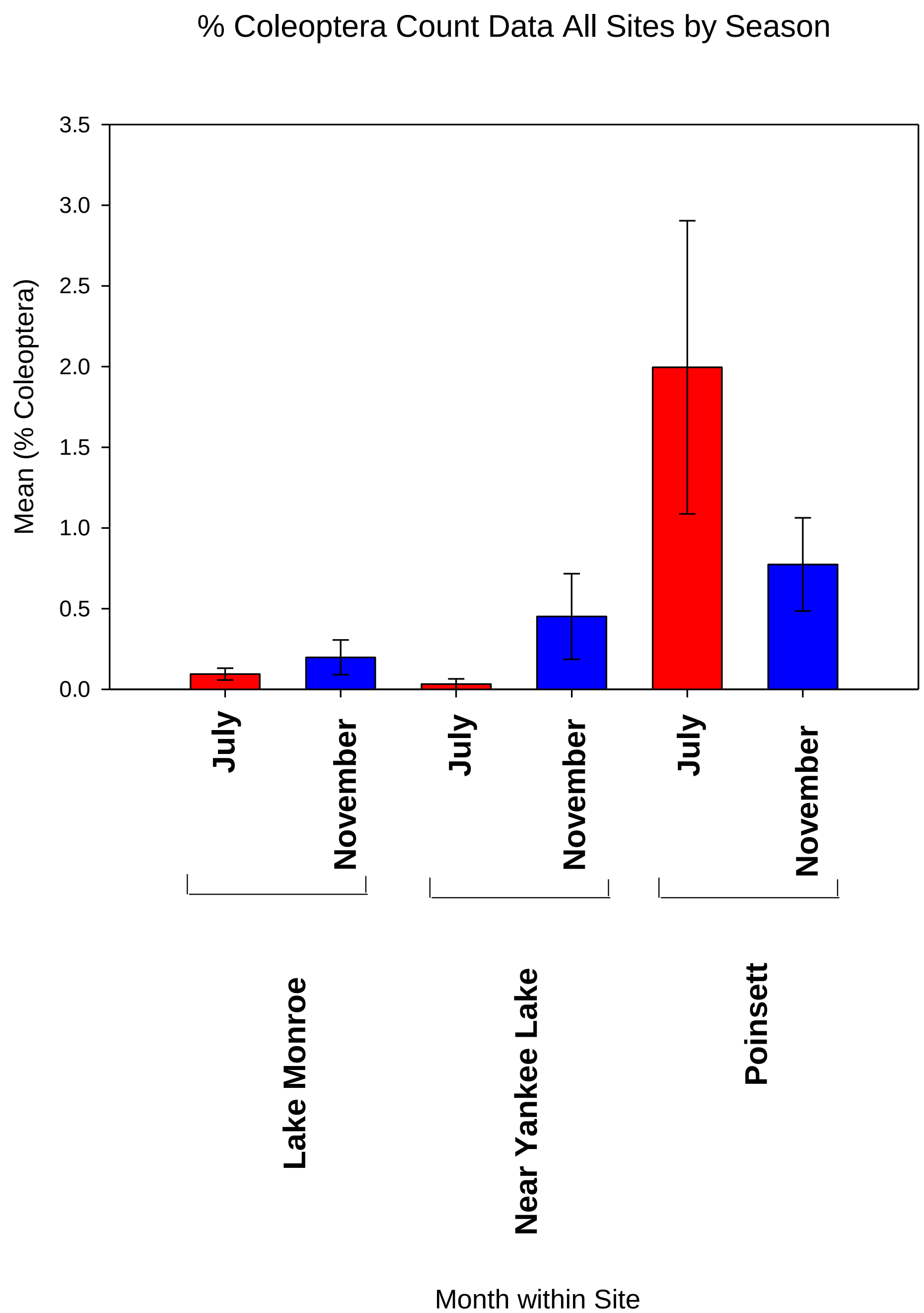


Figure 27. % Coleoptera count data Bull Rush

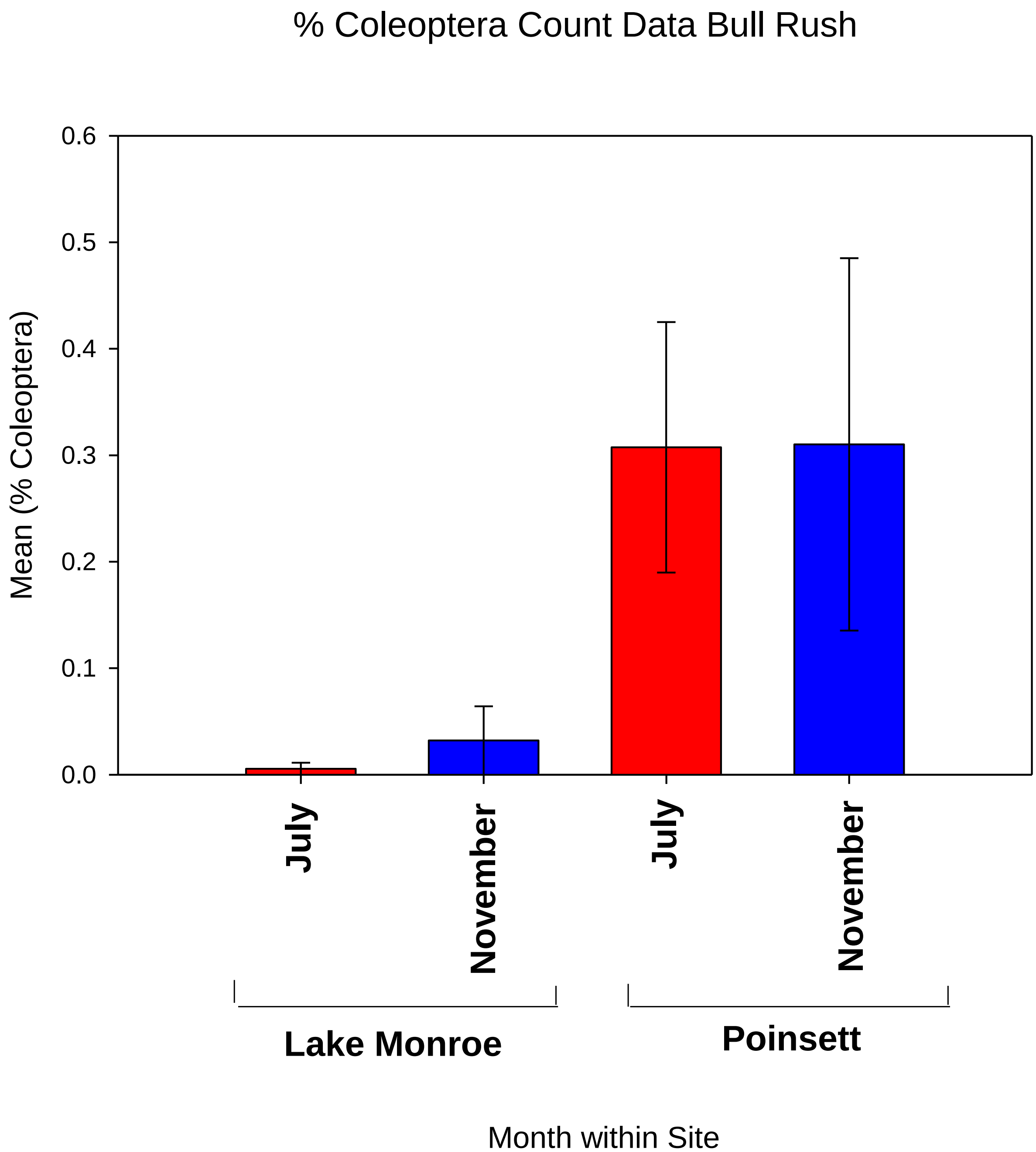


Figure 28. % Coleoptera count data Nuphar

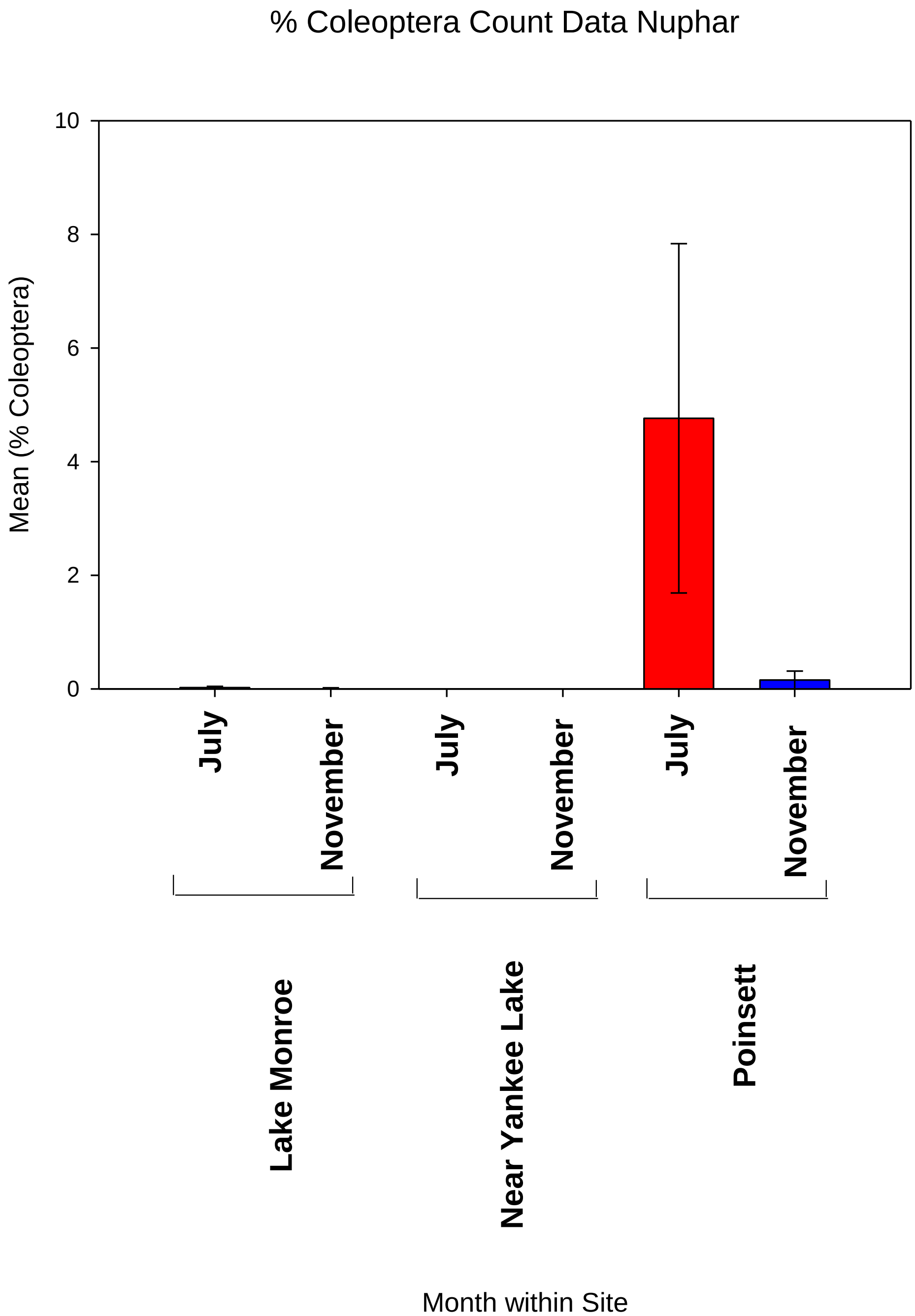


Figure 29. % Coleoptera count data Hydrilla

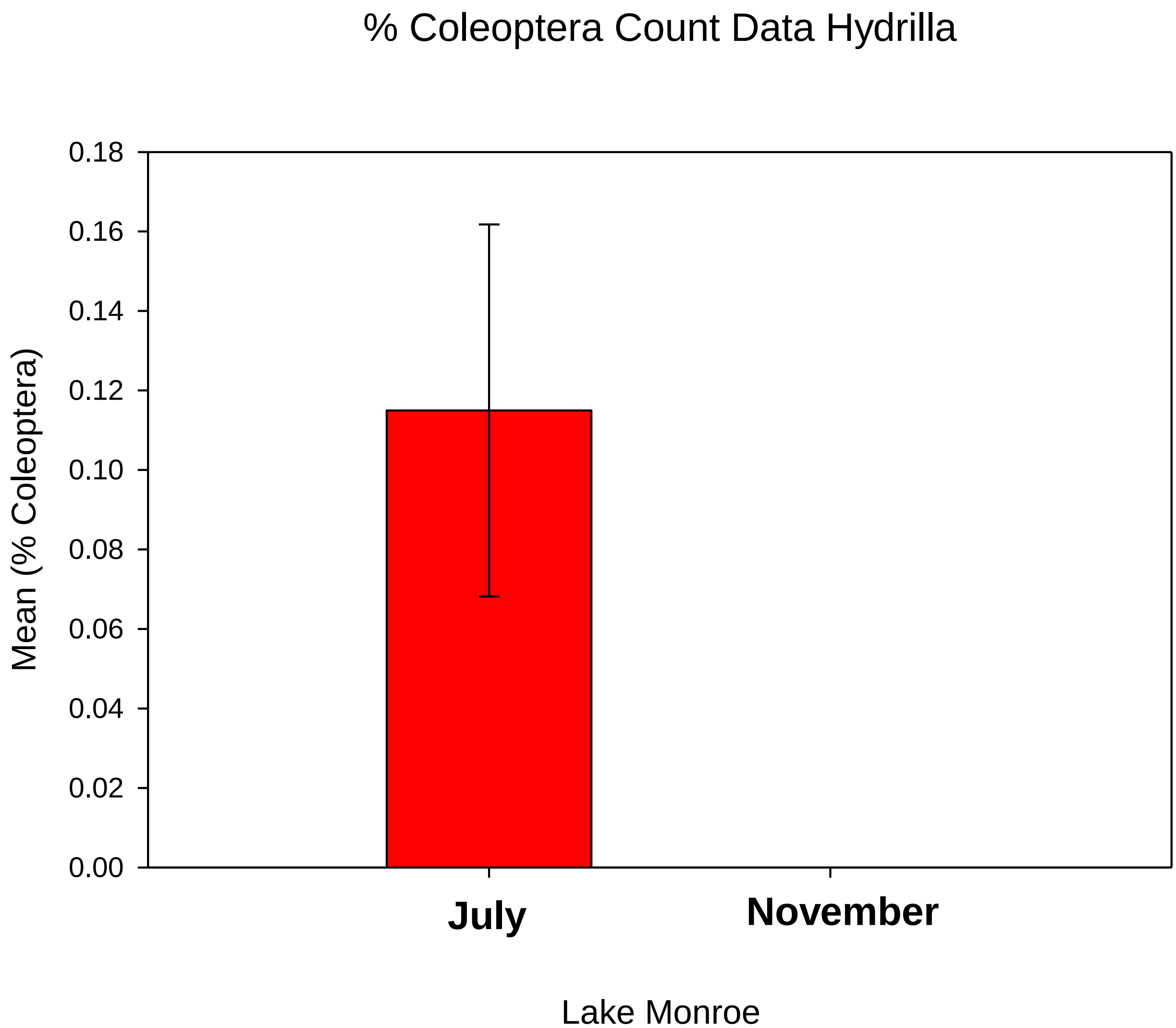


Figure 30. % Coleoptera count data Emergent Marsh

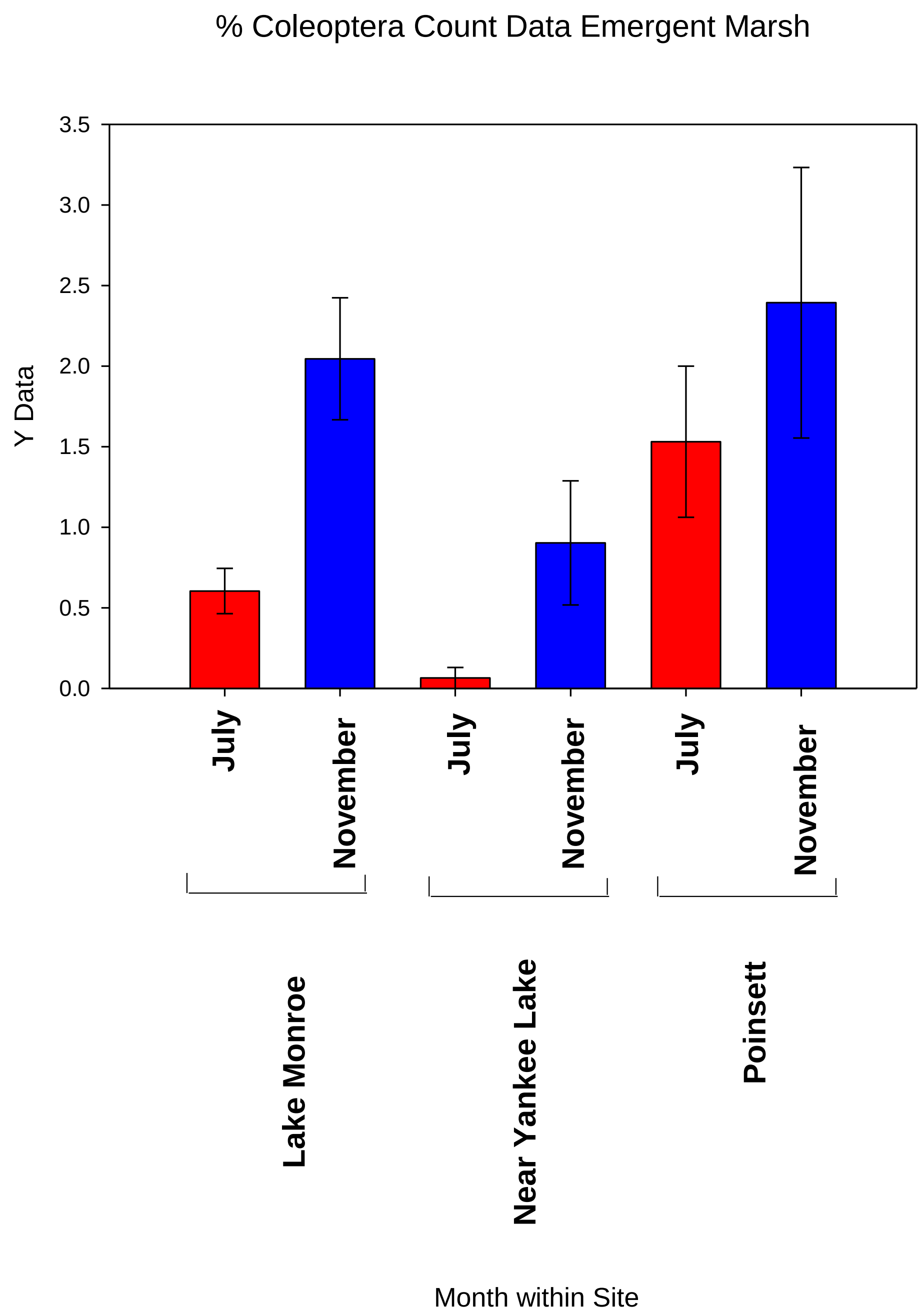


Figure 31. Functional Feeding Group (FFG) Biomass All Sites

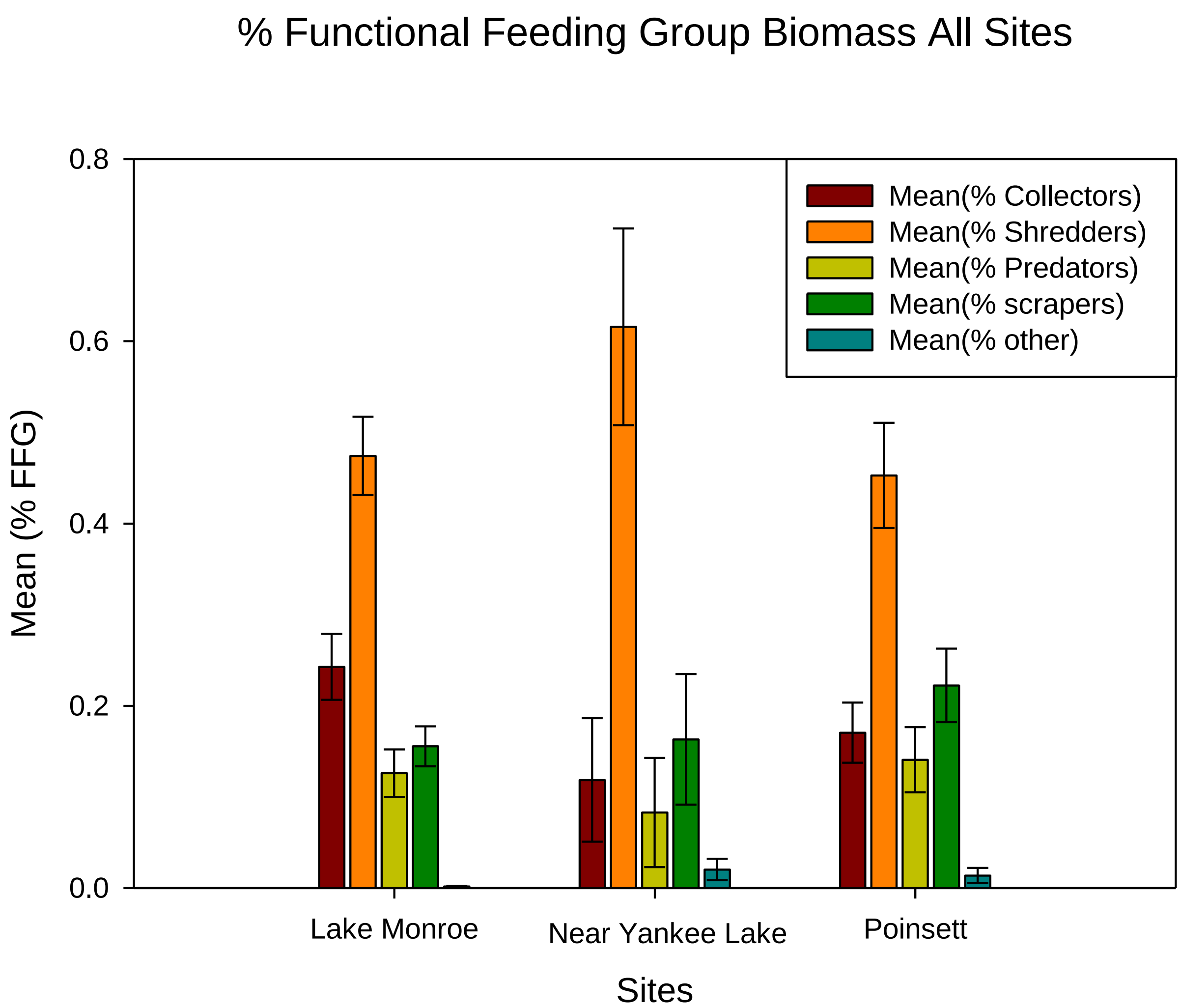


Figure 32. Functional Feeding Group (FFG) Count Data All Sites

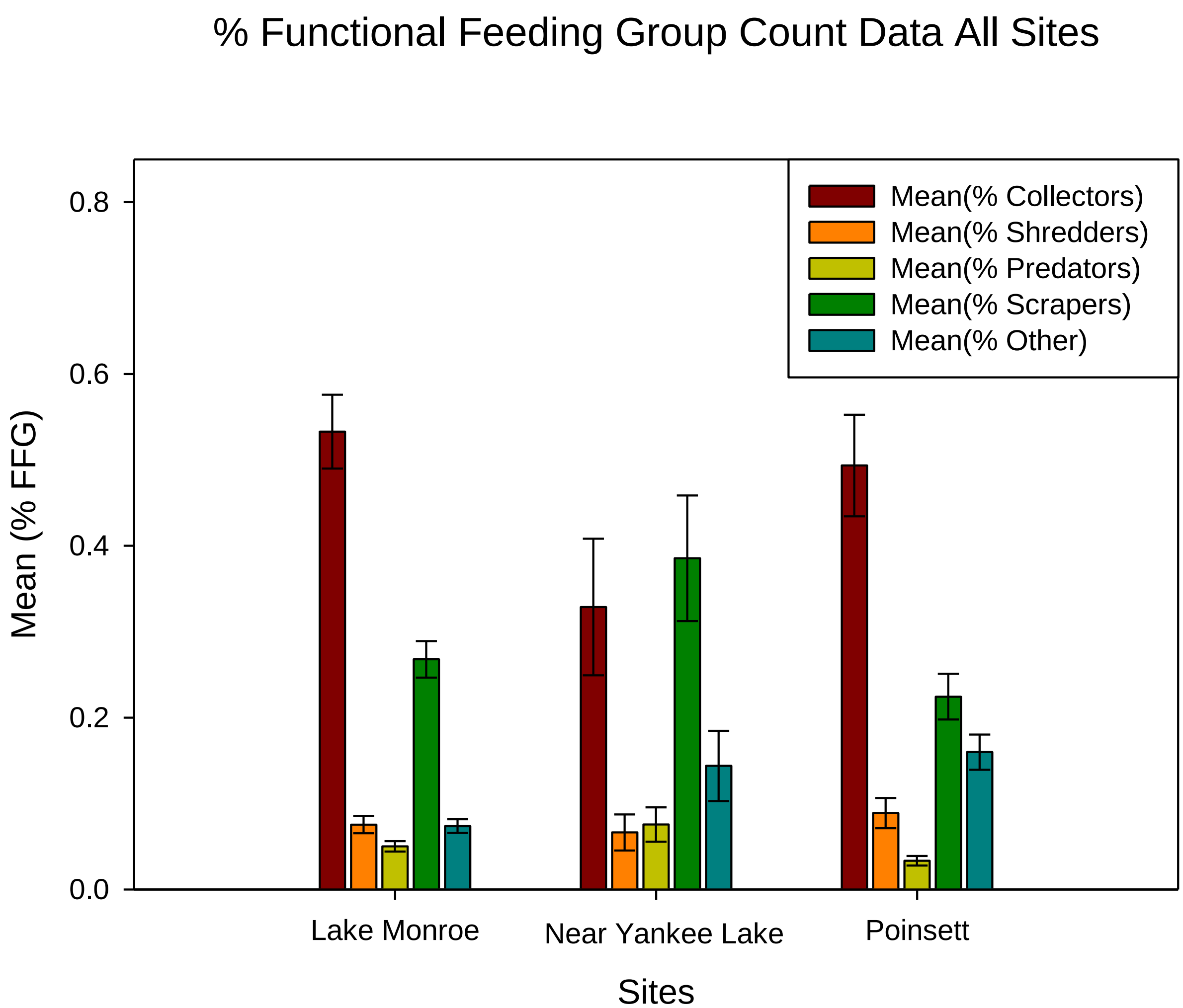


Figure 33. Functional Feeding Group (FFG) Biomass All Sites by Season

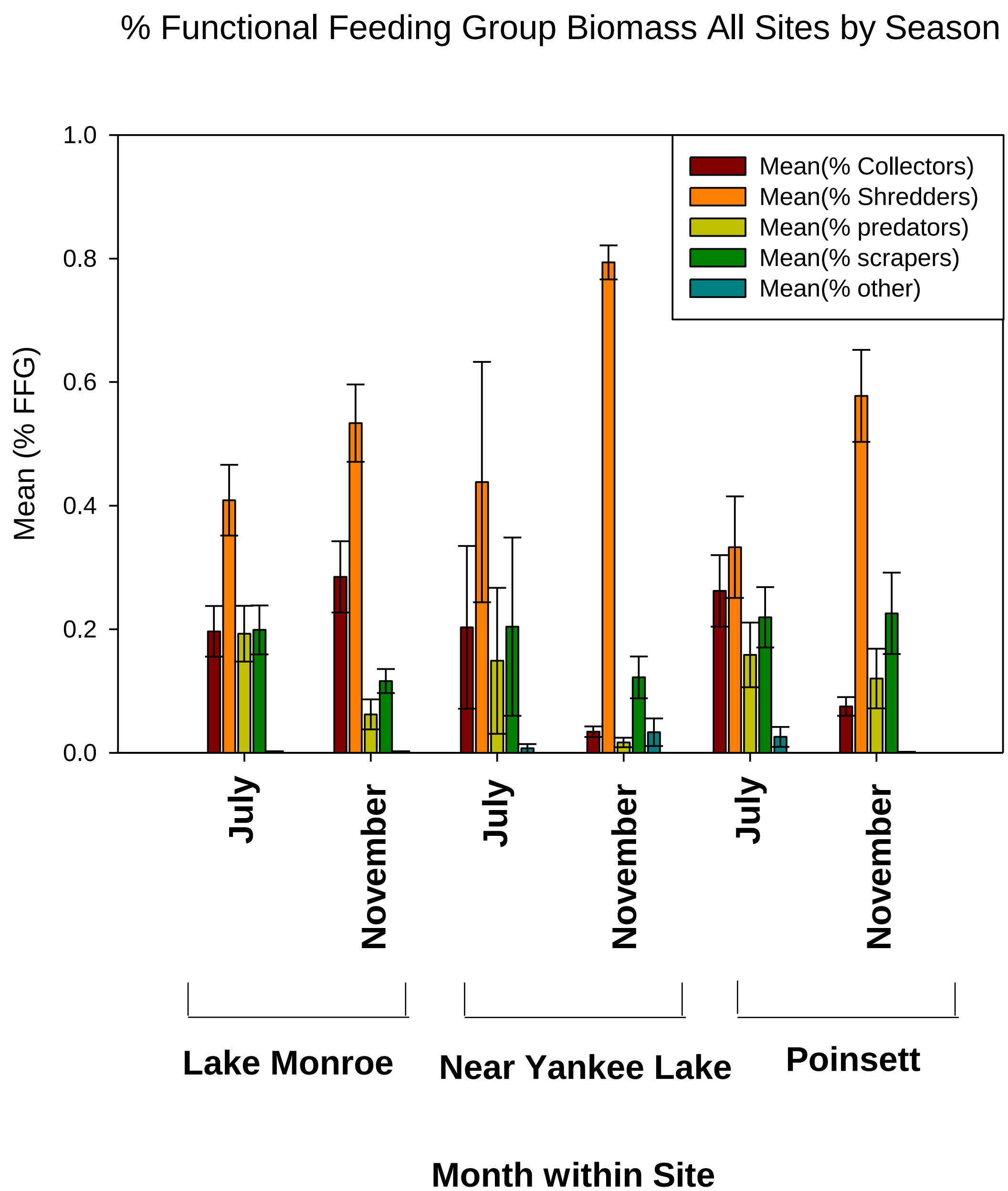


Figure 34. Functional Feeding Group (FFG) Count Data All Sites by Season

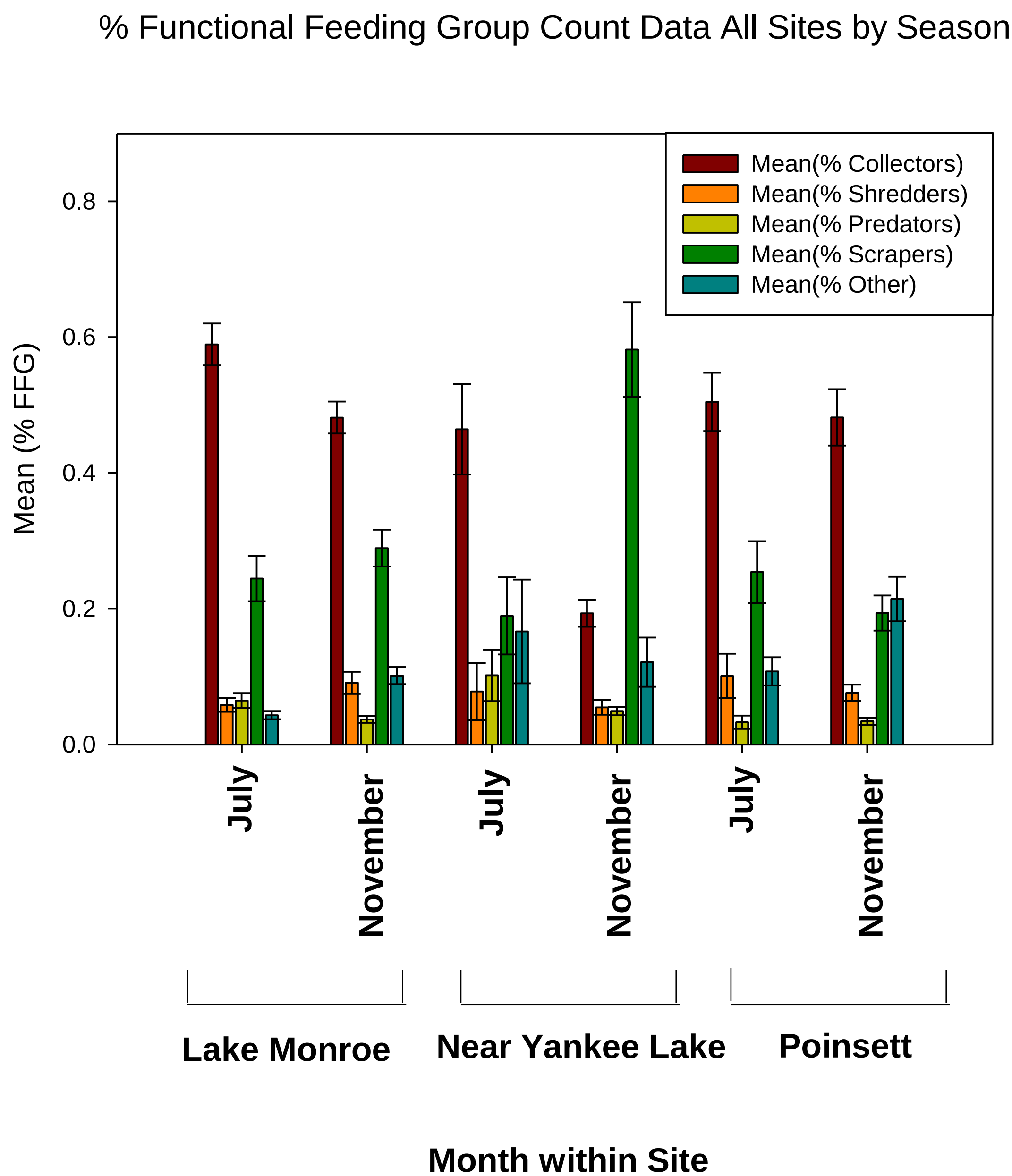


Figure 35. Functional Feeding Group (FFG) Biomass Bull Rush

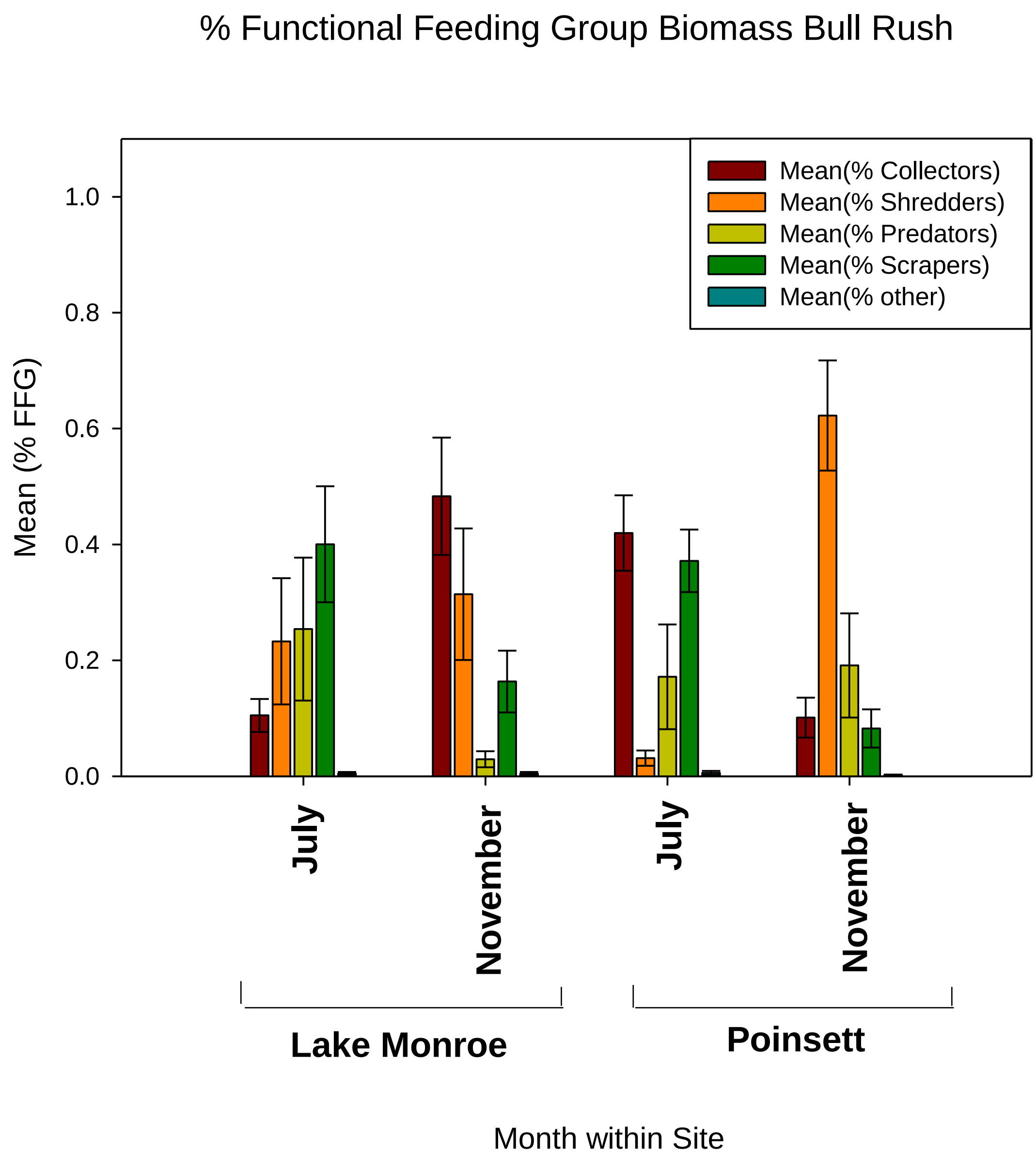


Figure 36. Functional Feeding Group (FFG) Count Data Bull Rush

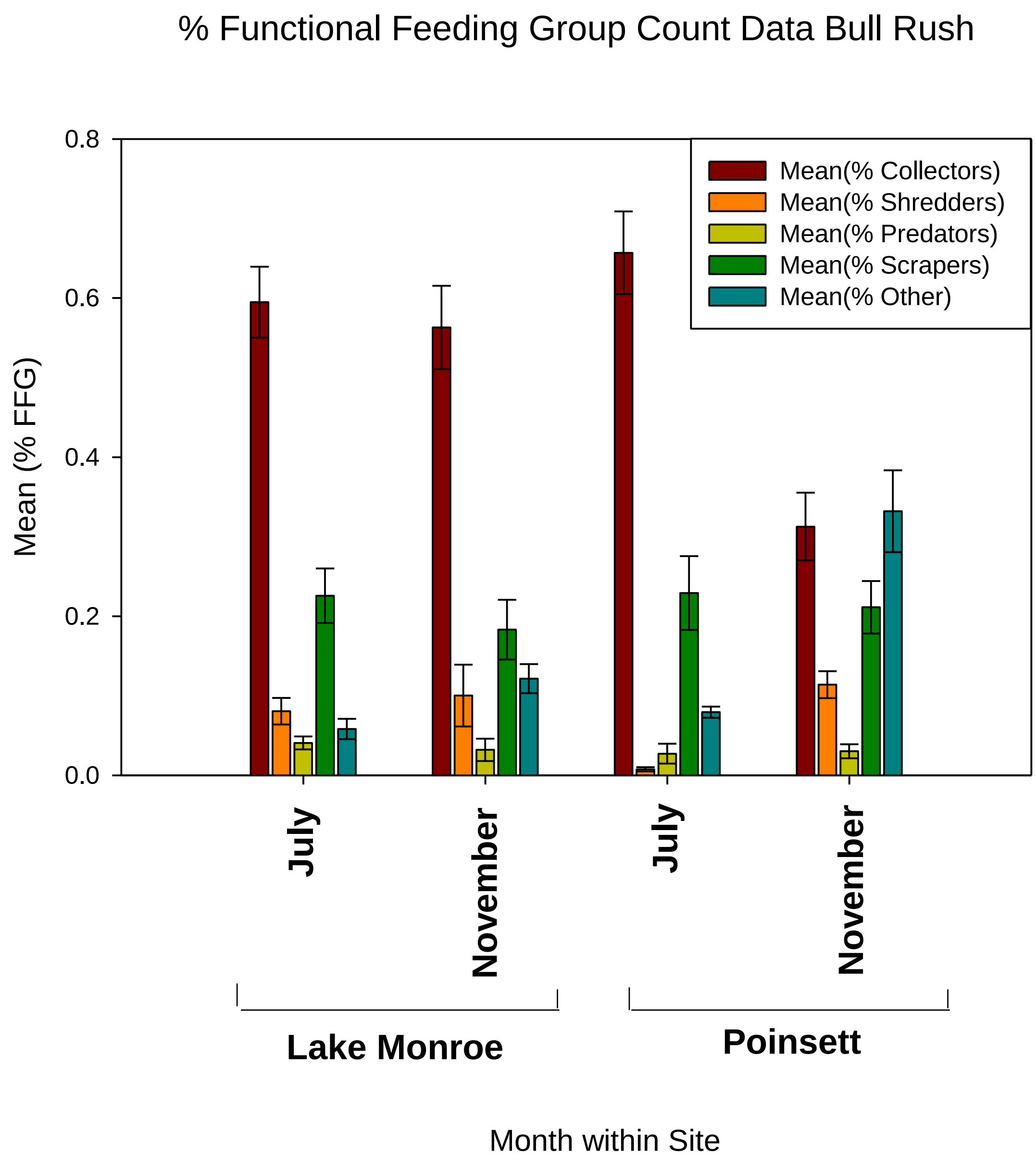


Figure 37. Functional Feeding Group (FFG) Biomass Nuphar

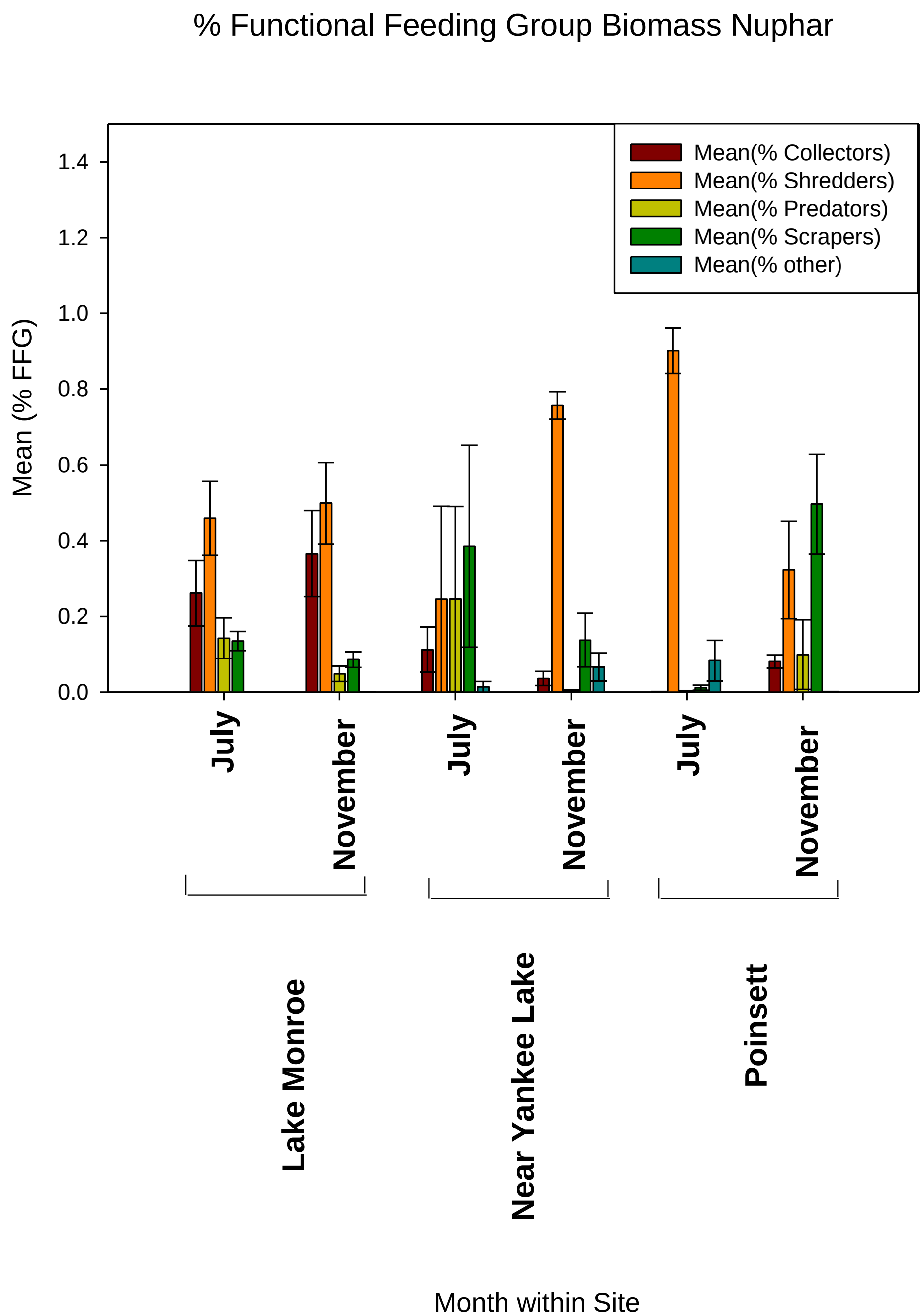


Figure 38. Functional Feeding Group (FFG) Count Data Nuphar

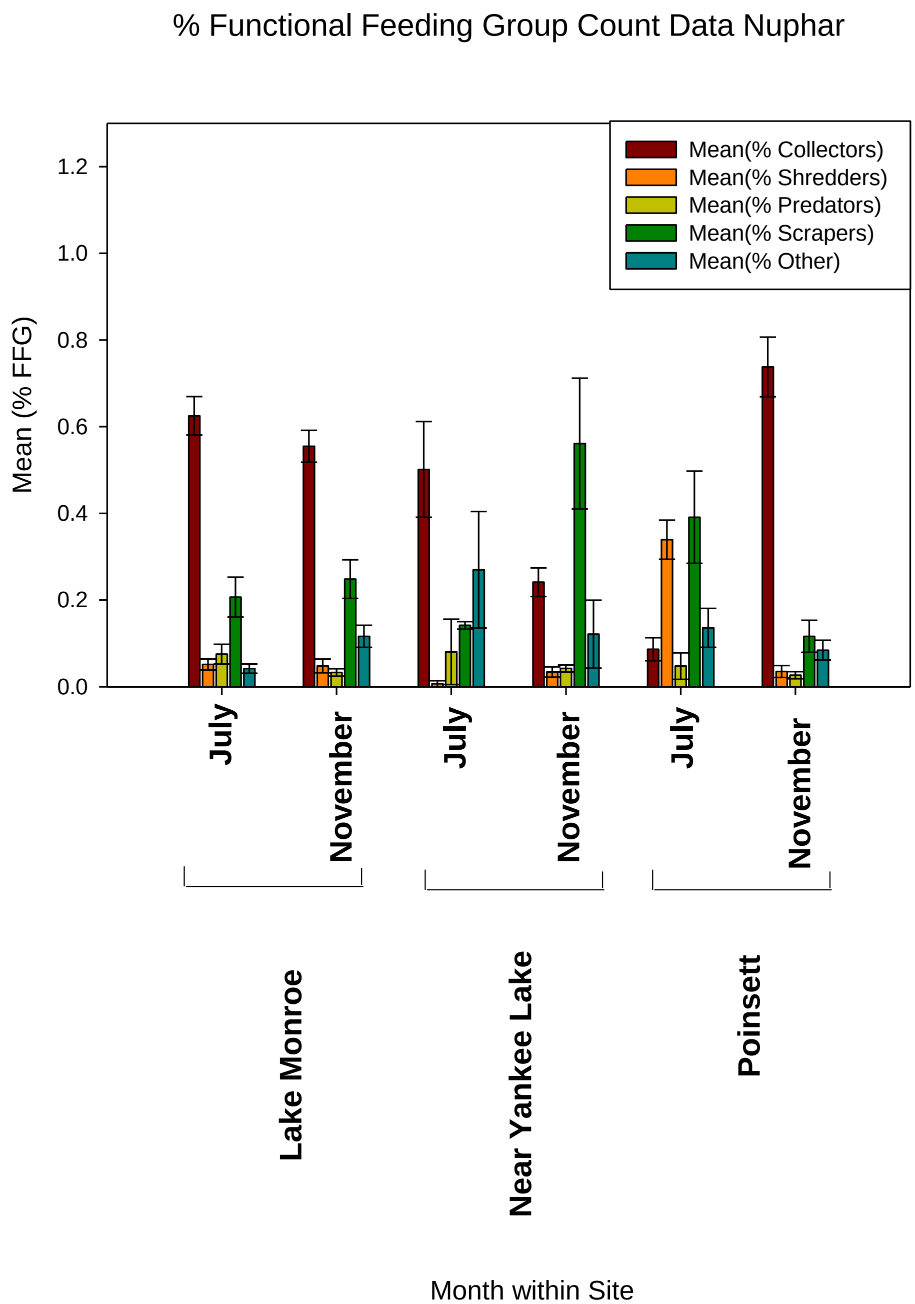


Figure 39. Functional Feeding Group (FFG) Biomass Hydrilla

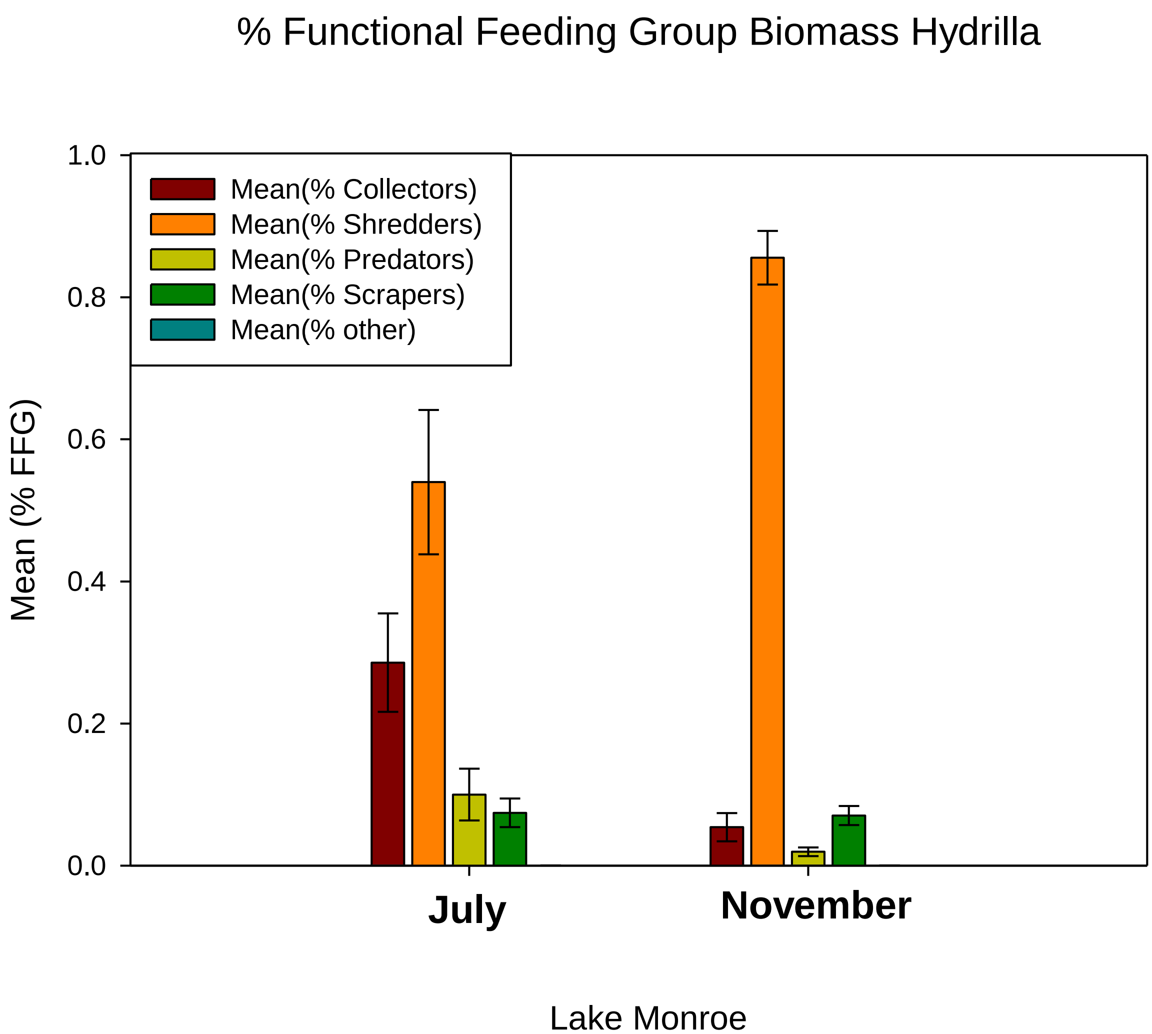


Figure 40. Functional Feeding Group (FFG) Count Data Hydrilla

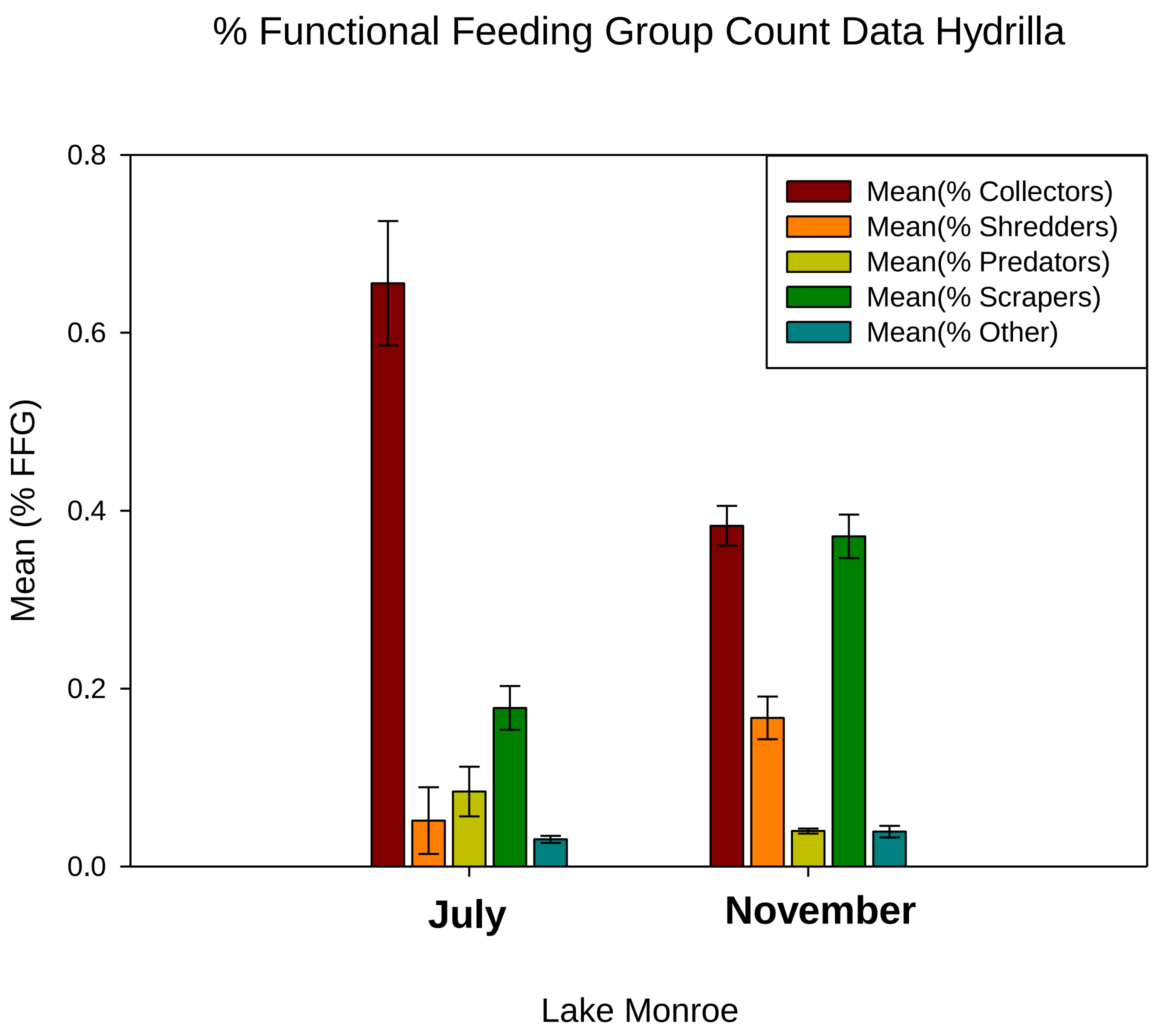


Figure 41. Functional Feeding Group (FFG) Biomass Emergent Marsh

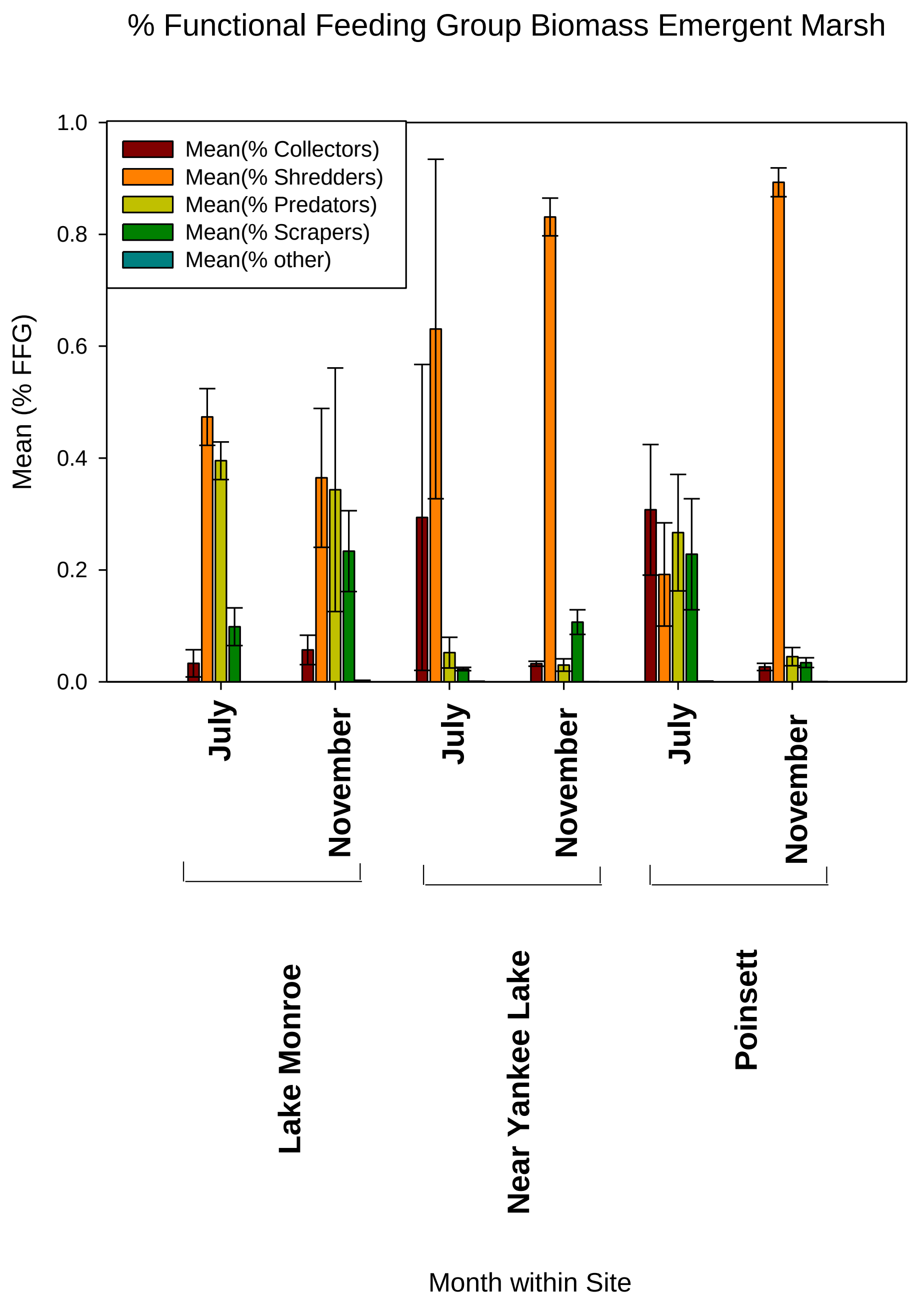


Figure 42. Functional Feeding Group (FFG) Count Data Emergent Marsh

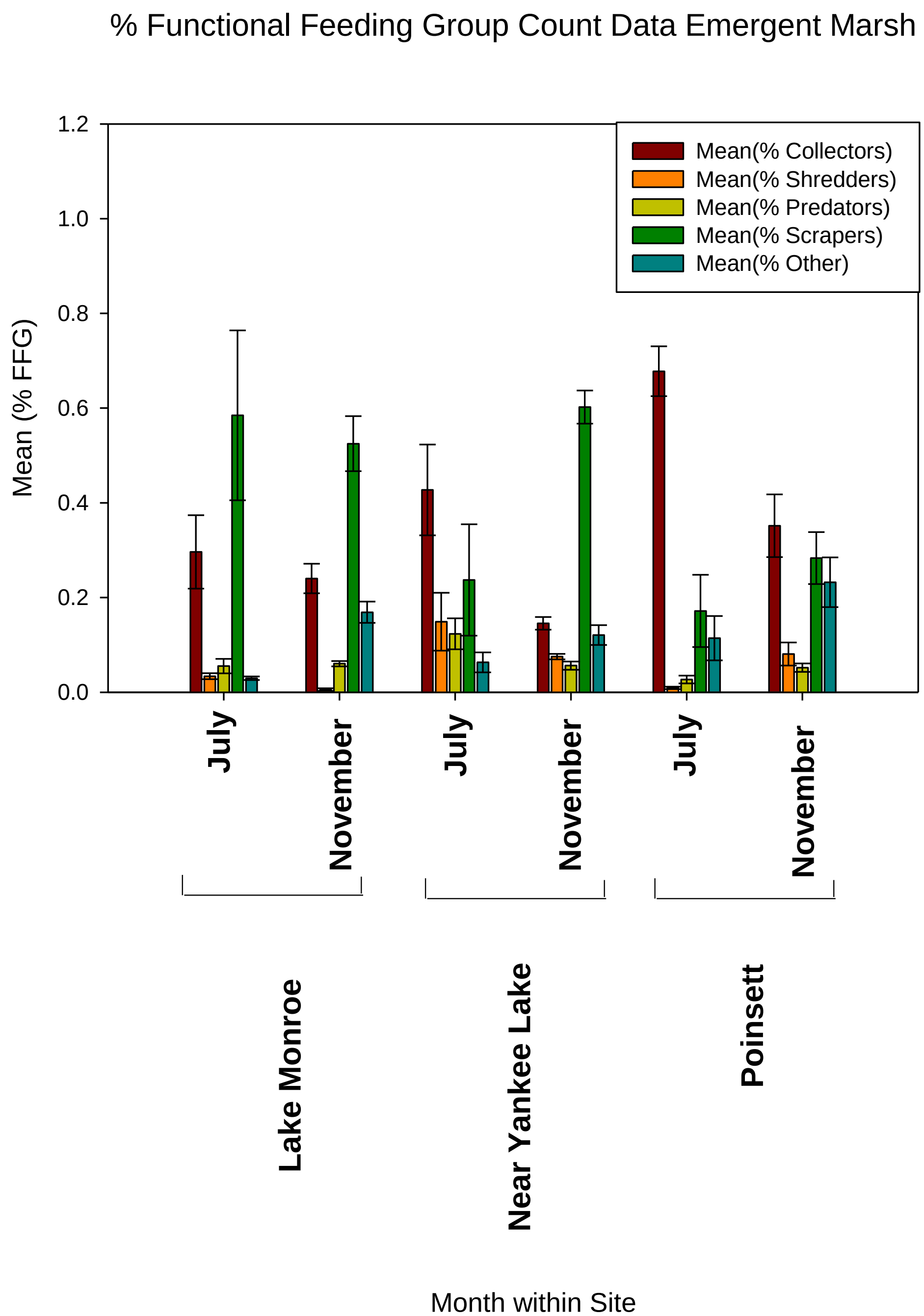


Figure 43. P:R = FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder(live plants)+Scrapers+Shredder(piercers)/Shredder(CPOM)+Total Collectors

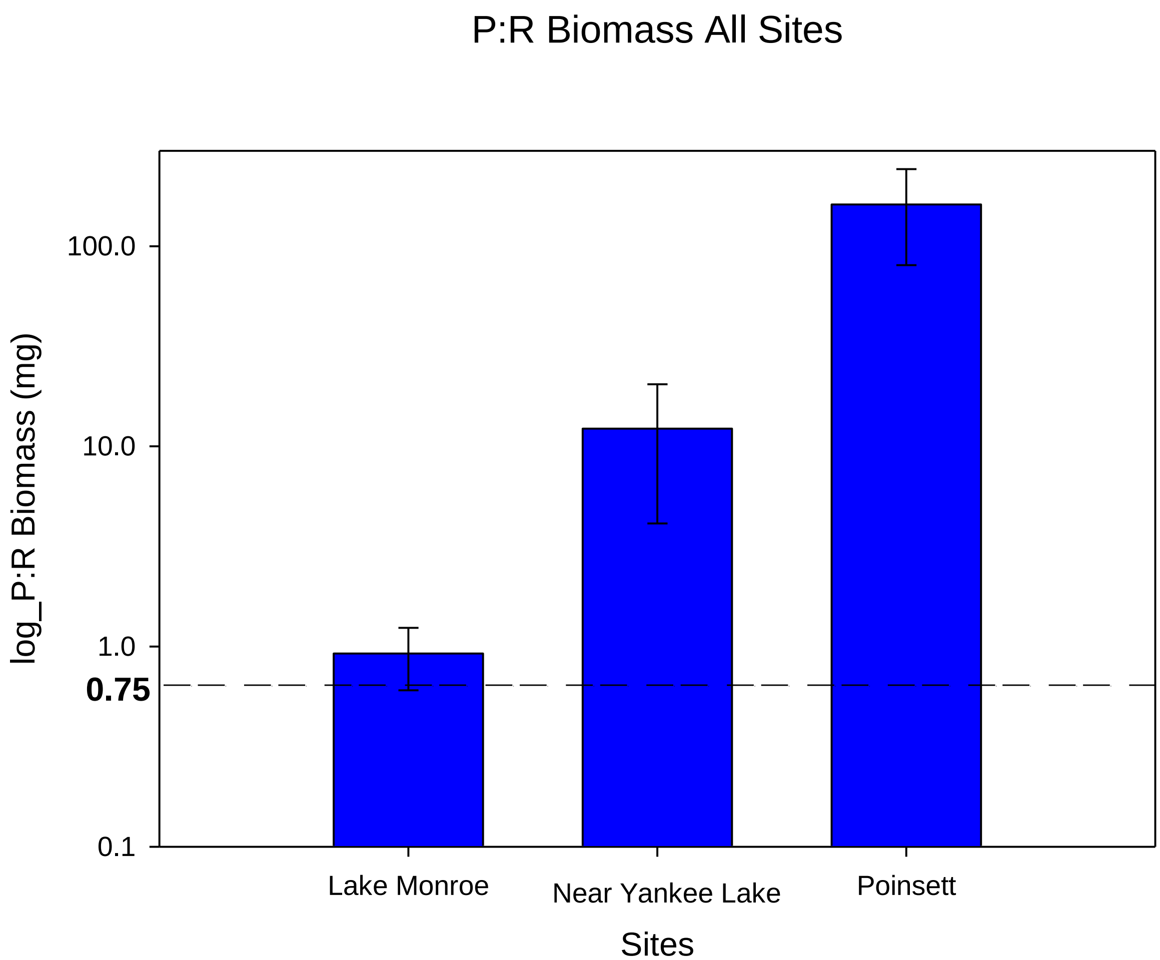


Figure 44. P:R = FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder(live plants)+Scrapers+Shredder(piercers)/Shredder(CPOM)+Total Collectors

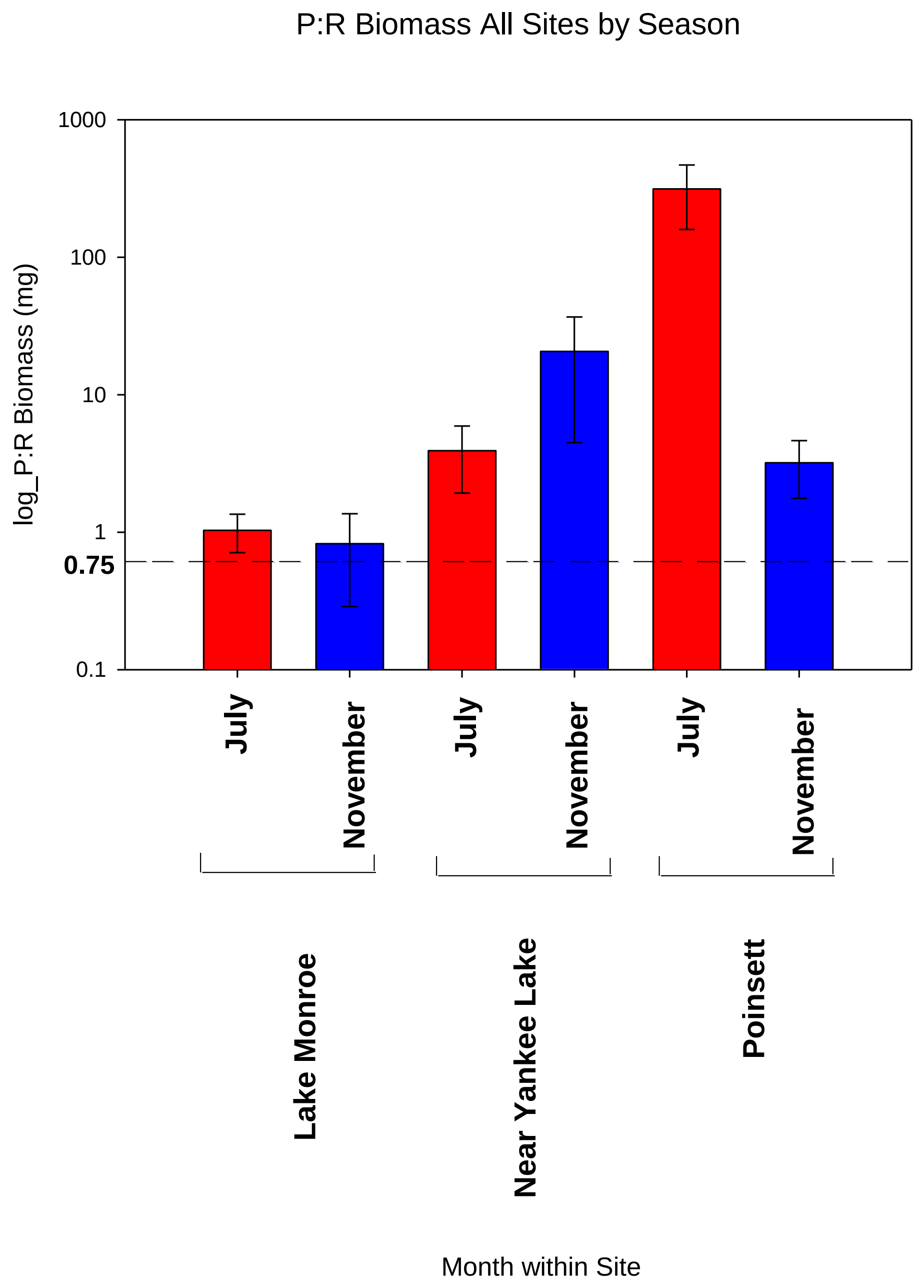


Figure 45. P:R = FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder(live plants)+Scrapers+Shredder(piercers)/Shredder(CPOM)+Total Collectors

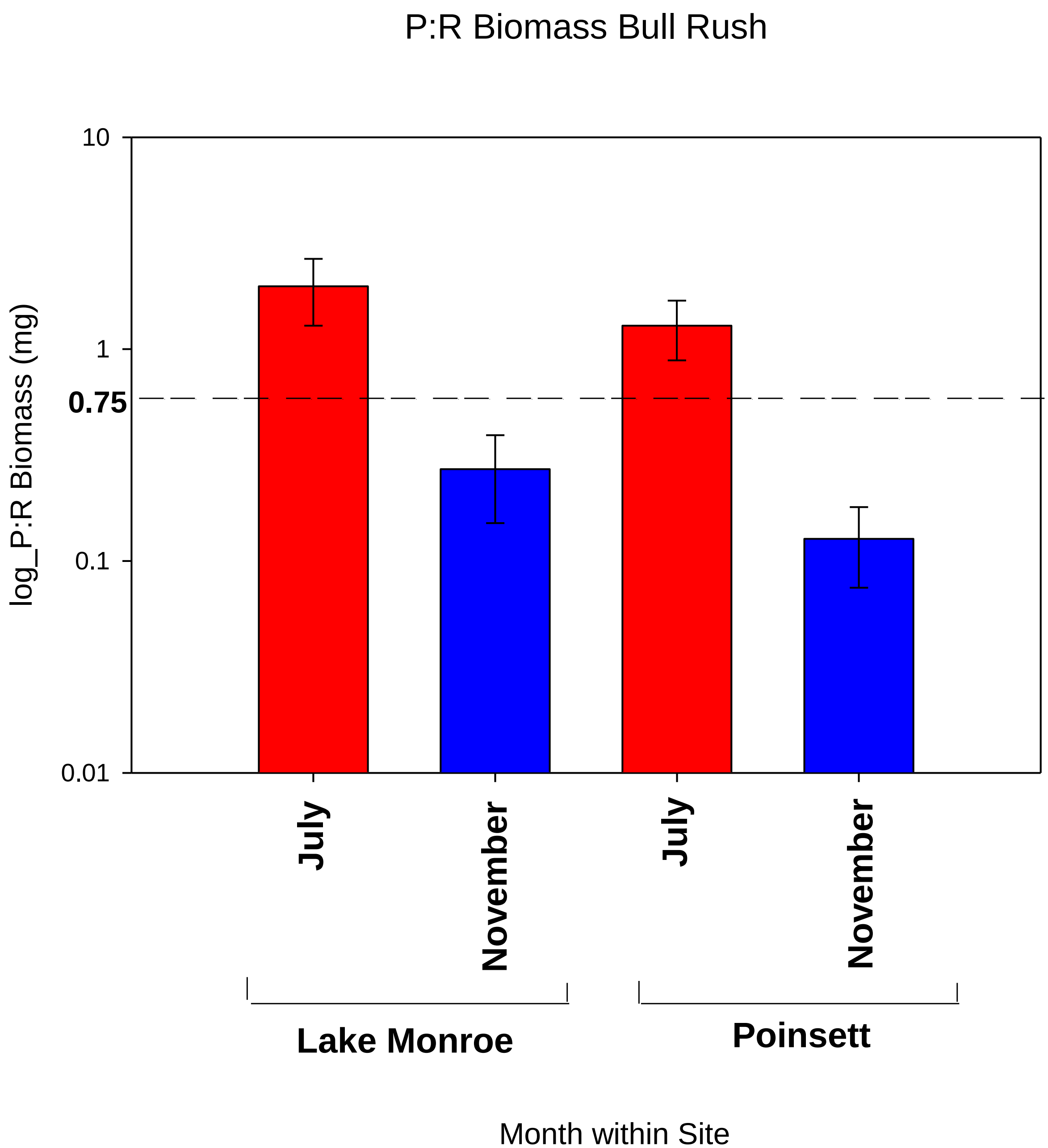


Figure 46. **P:R =** FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder(live plants)+Scrapers+Shredder(piercers)/Shredder(CPOM)+Total Collectors

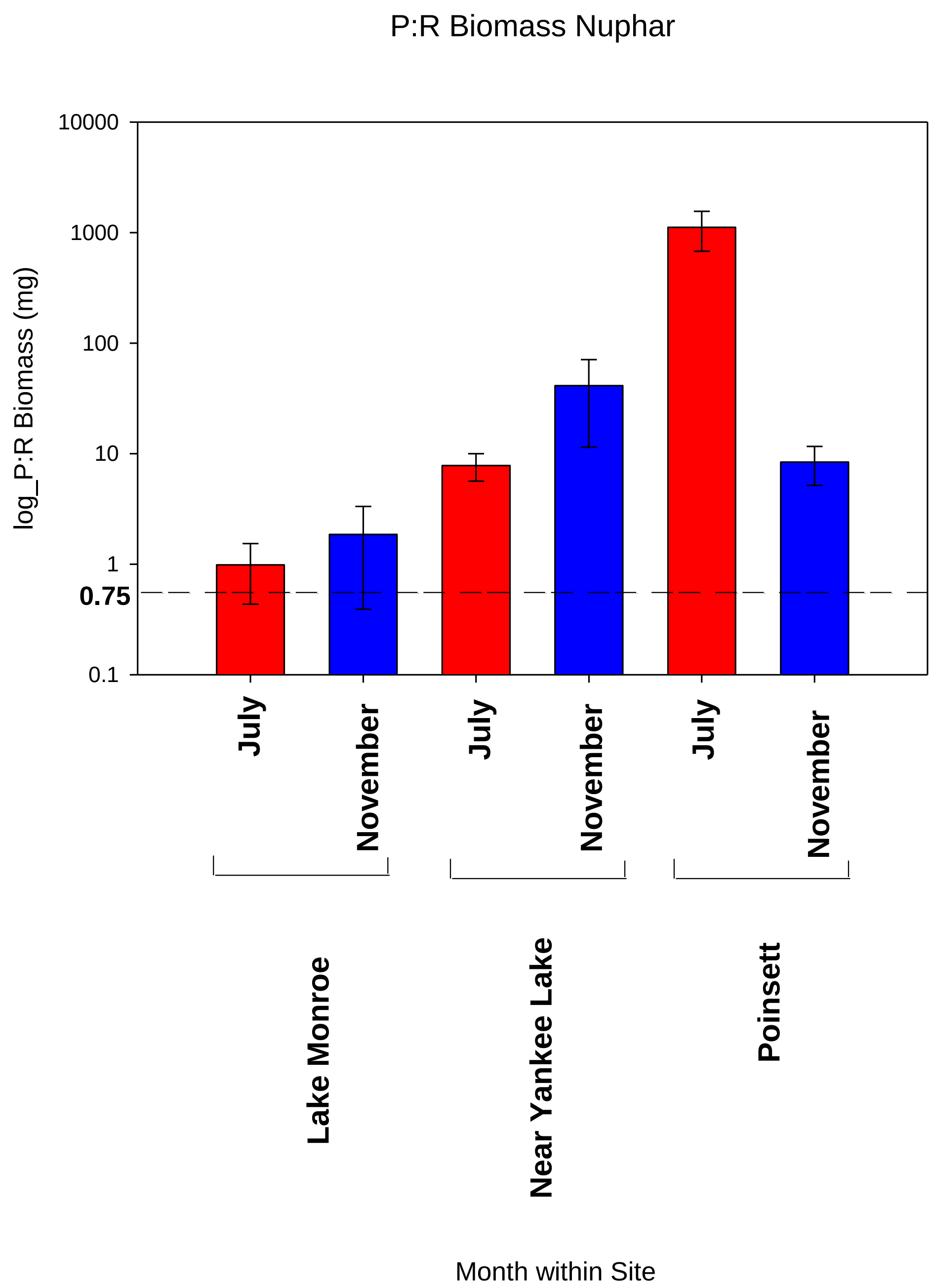


Figure 47. P:R = FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder(live plants)+Scrapers+Shredder(piercers)/Shredder(CPOM)+Total Collectors

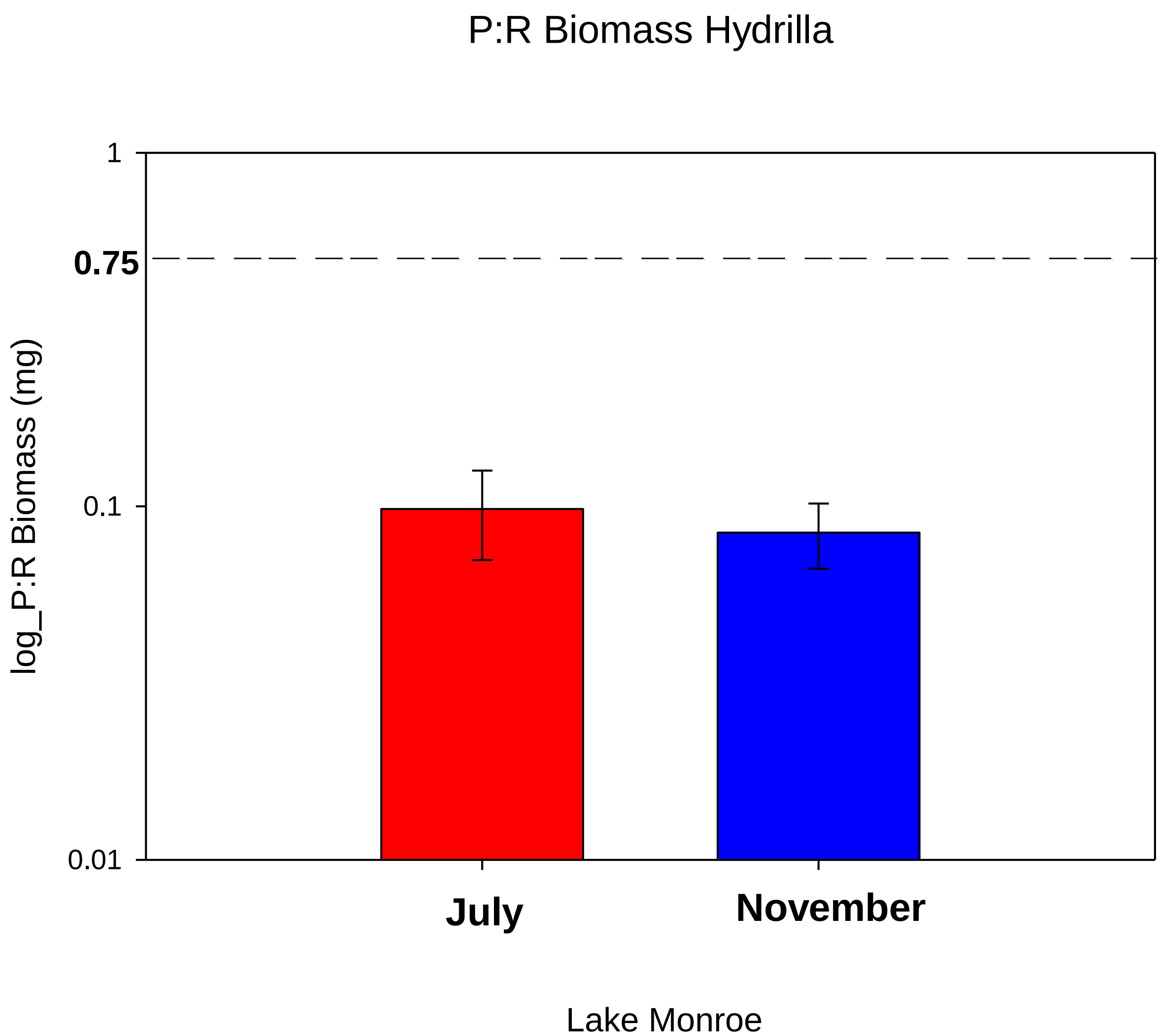


Figure 48. P:R = FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder(live plants)+Scrapers+Shredder(piercers)/Shredder(CPOM)+Total Collectors

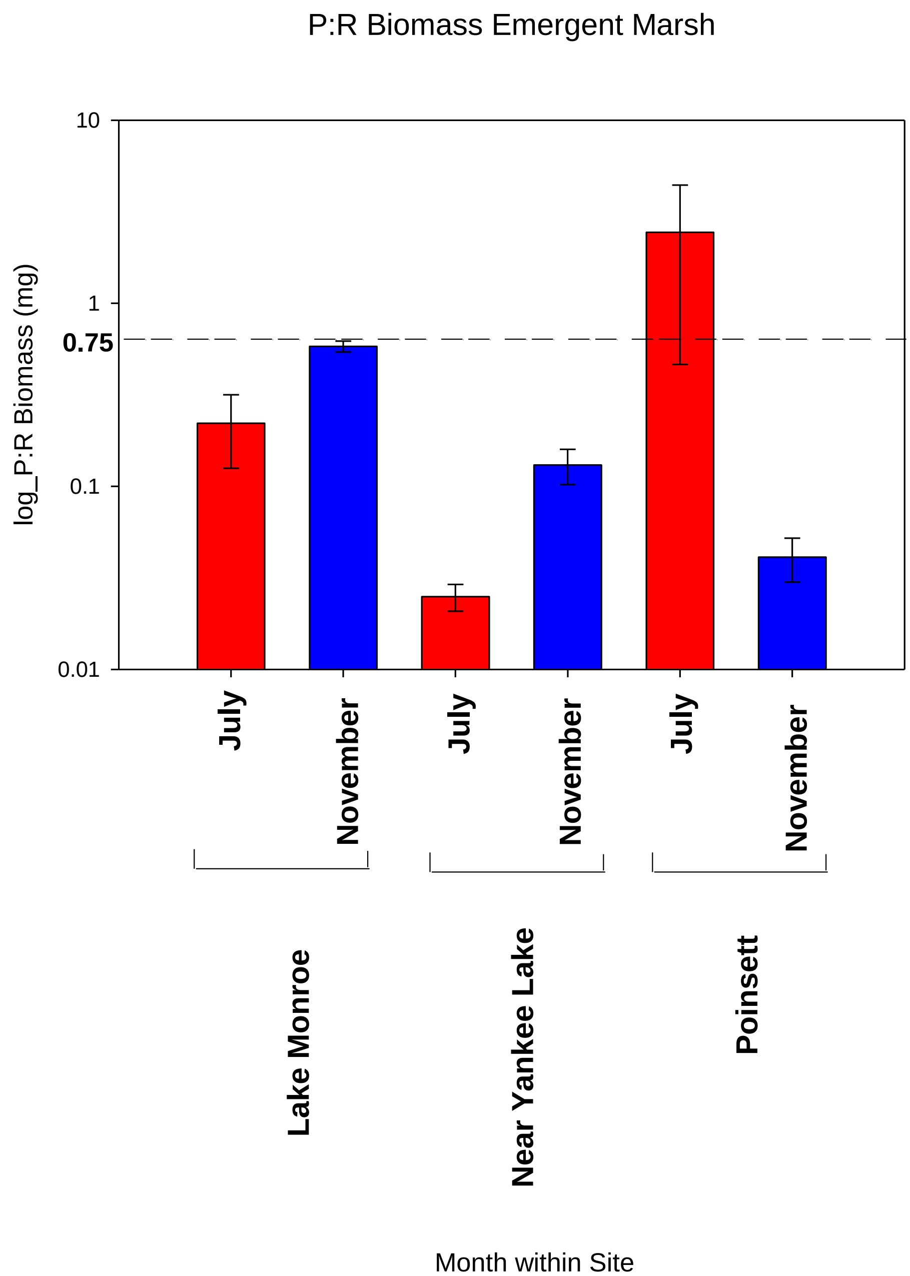


Figure 49. P:R = FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder(live plants)+Scrapers+Shredder(piercers)/Shredder(CPOM)+Total Collectors

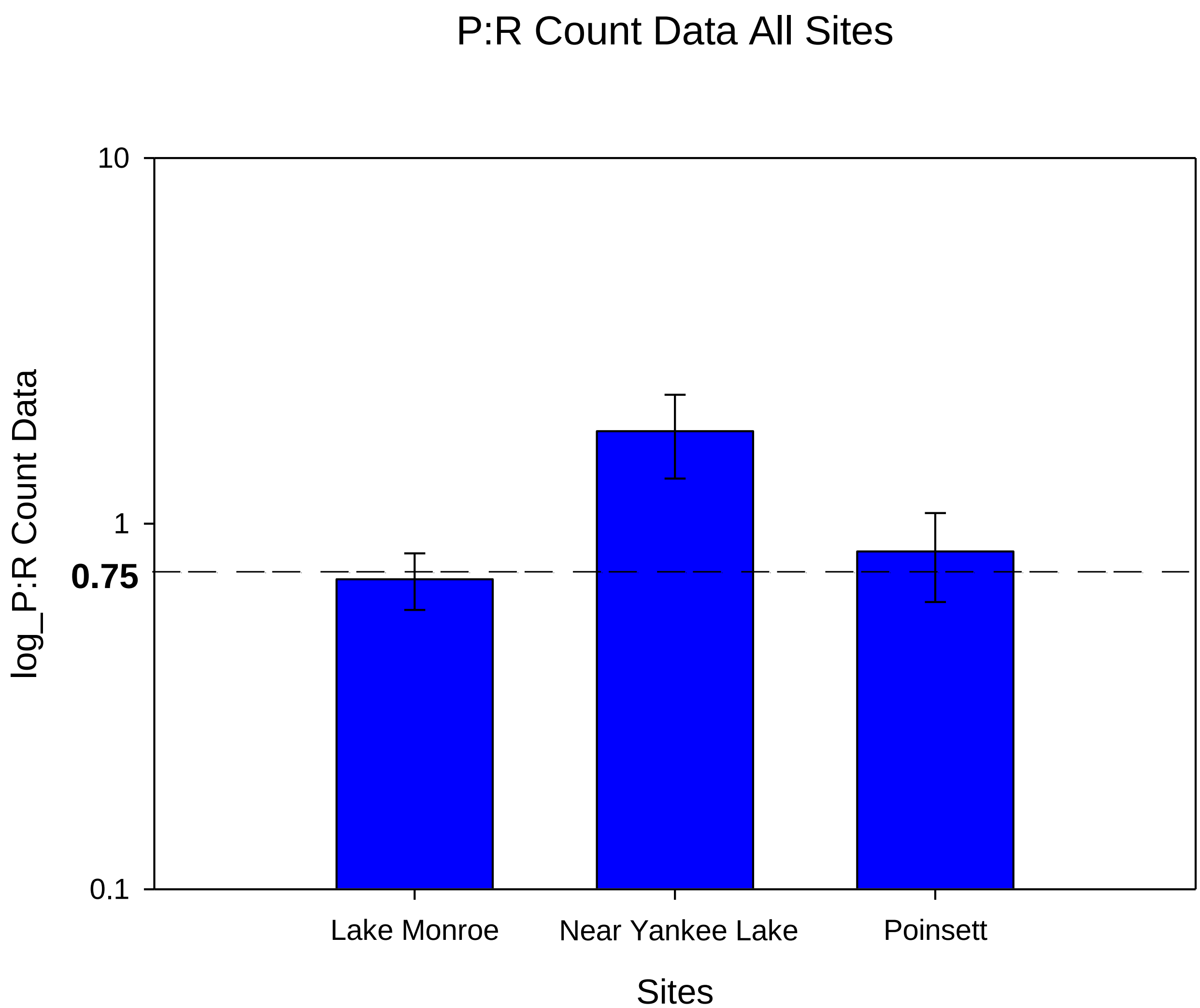


Figure 50. P:R = FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder(live plants)+Scrapers+Shredder(piercers)/Shredder(CPOM)+Total Collectors

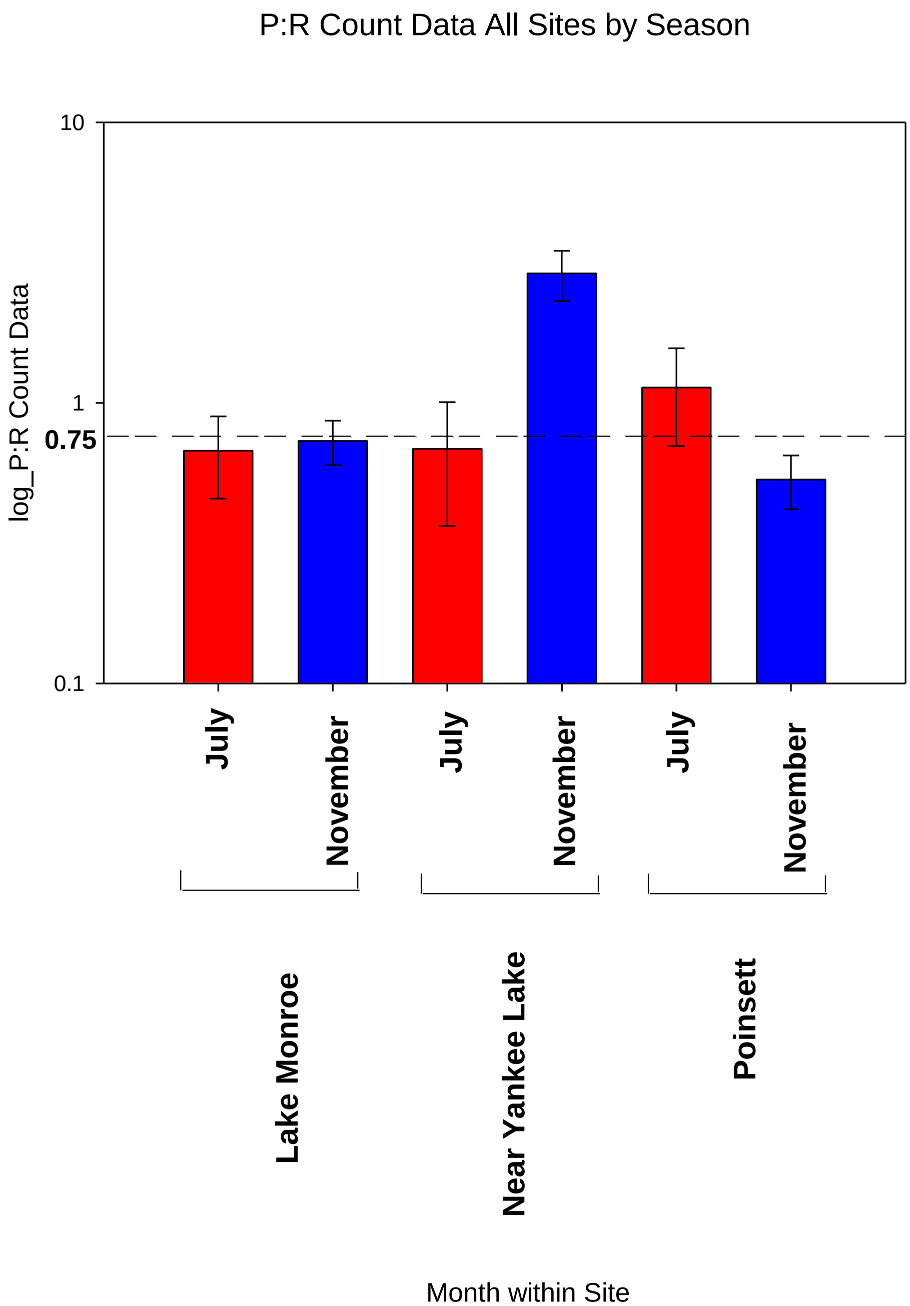


Figure 51. P:R = FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder(live plants)+Scrapers+Shredder(piercers)/Shredder(CPOM)+Total Collectors

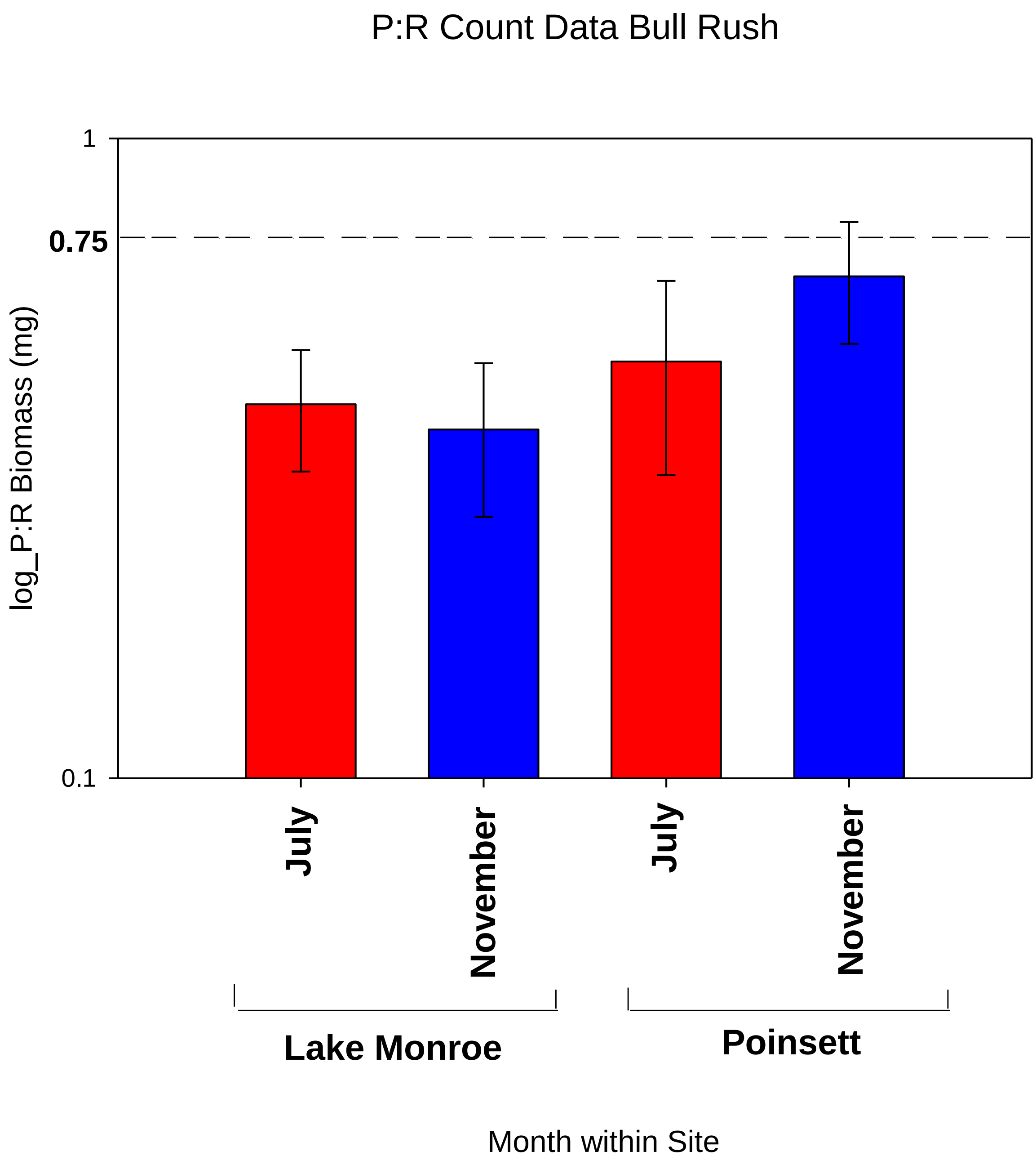


Figure 52. P:R = FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder(live plants)+Scrapers+Shredder(piercers)/Shredder(CPOM)+Total Collectors

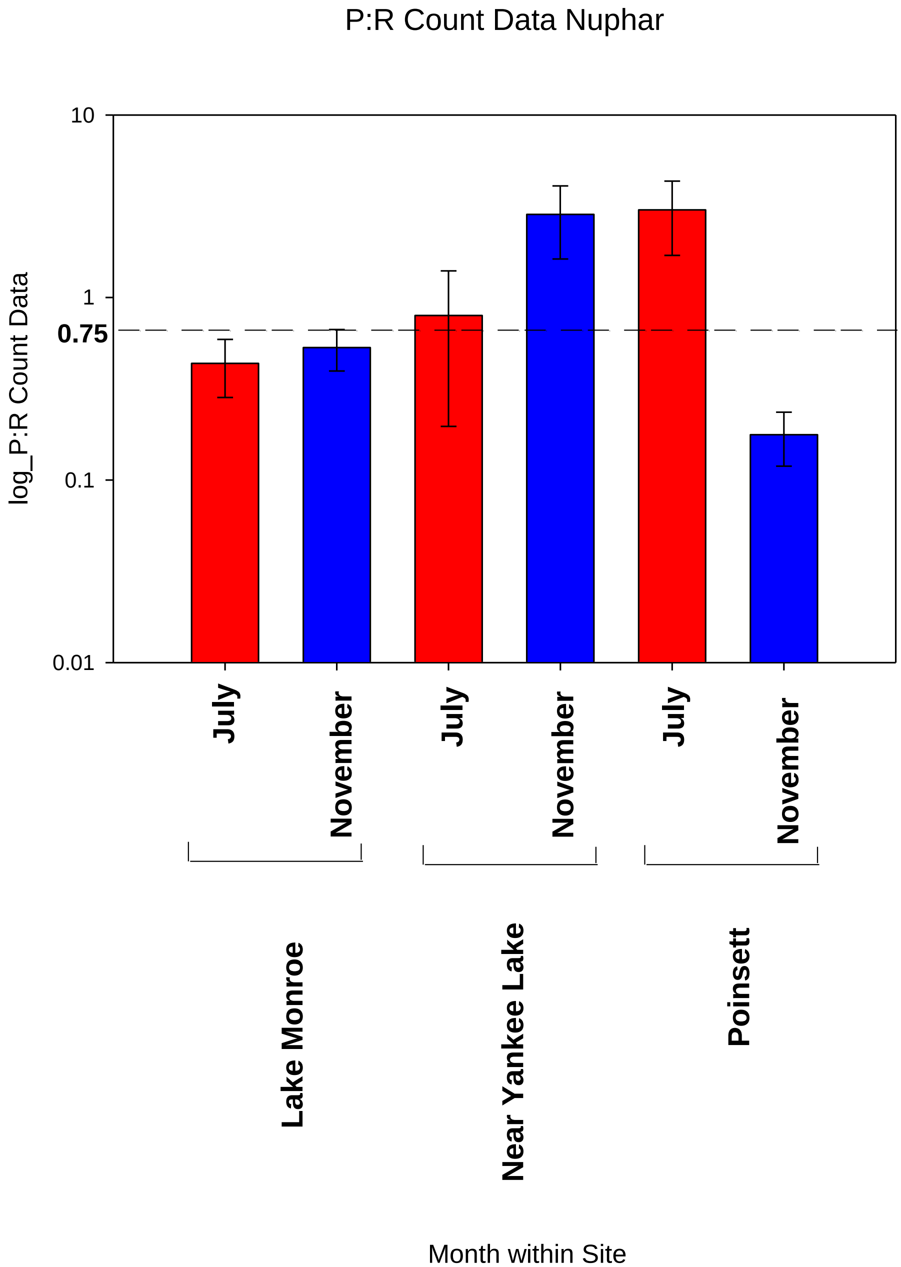


Figure 53. P:R = FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder(live plants)+Scrapers+Shredder(piercers)/Shredder(CPOM)+Total Collectors

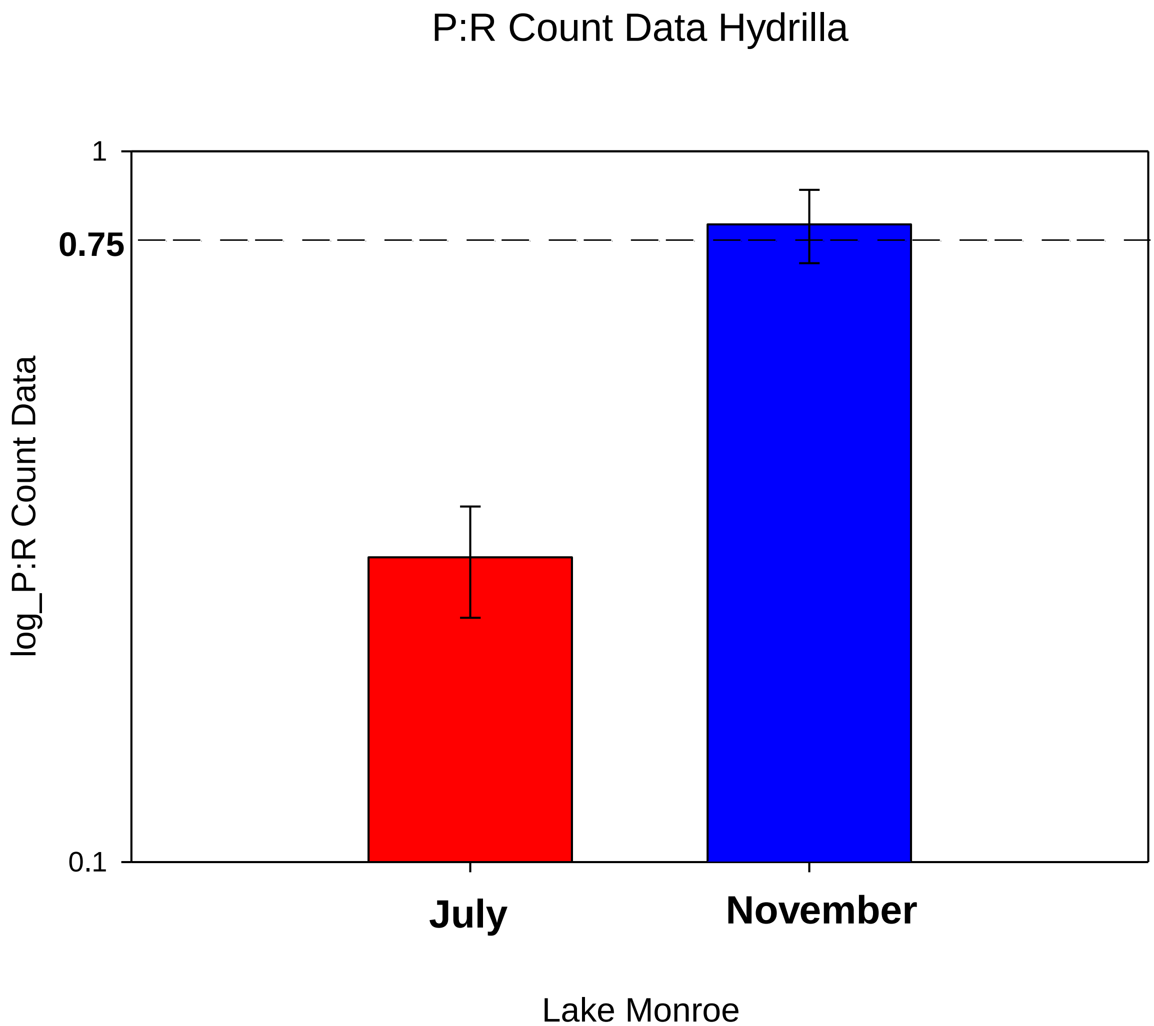
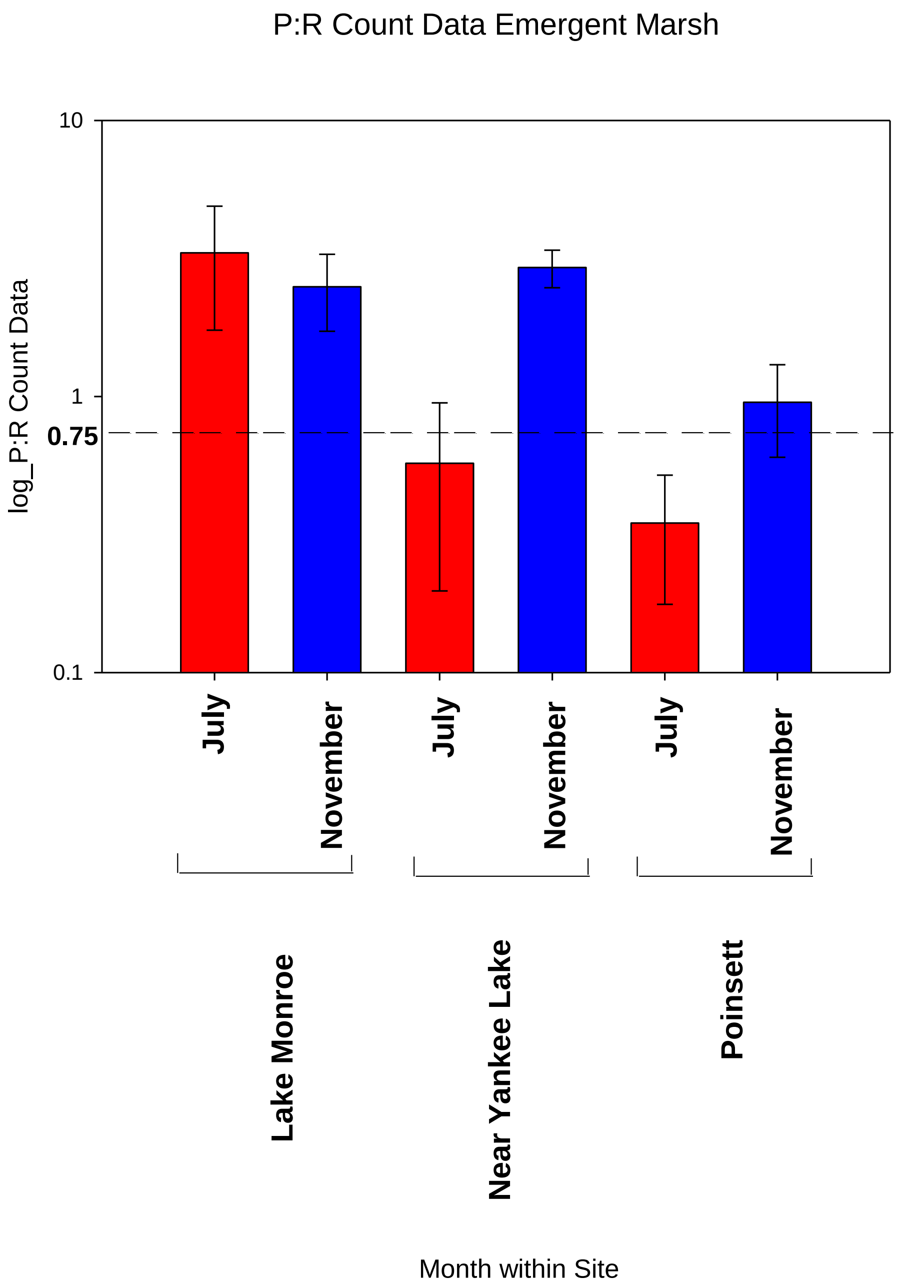
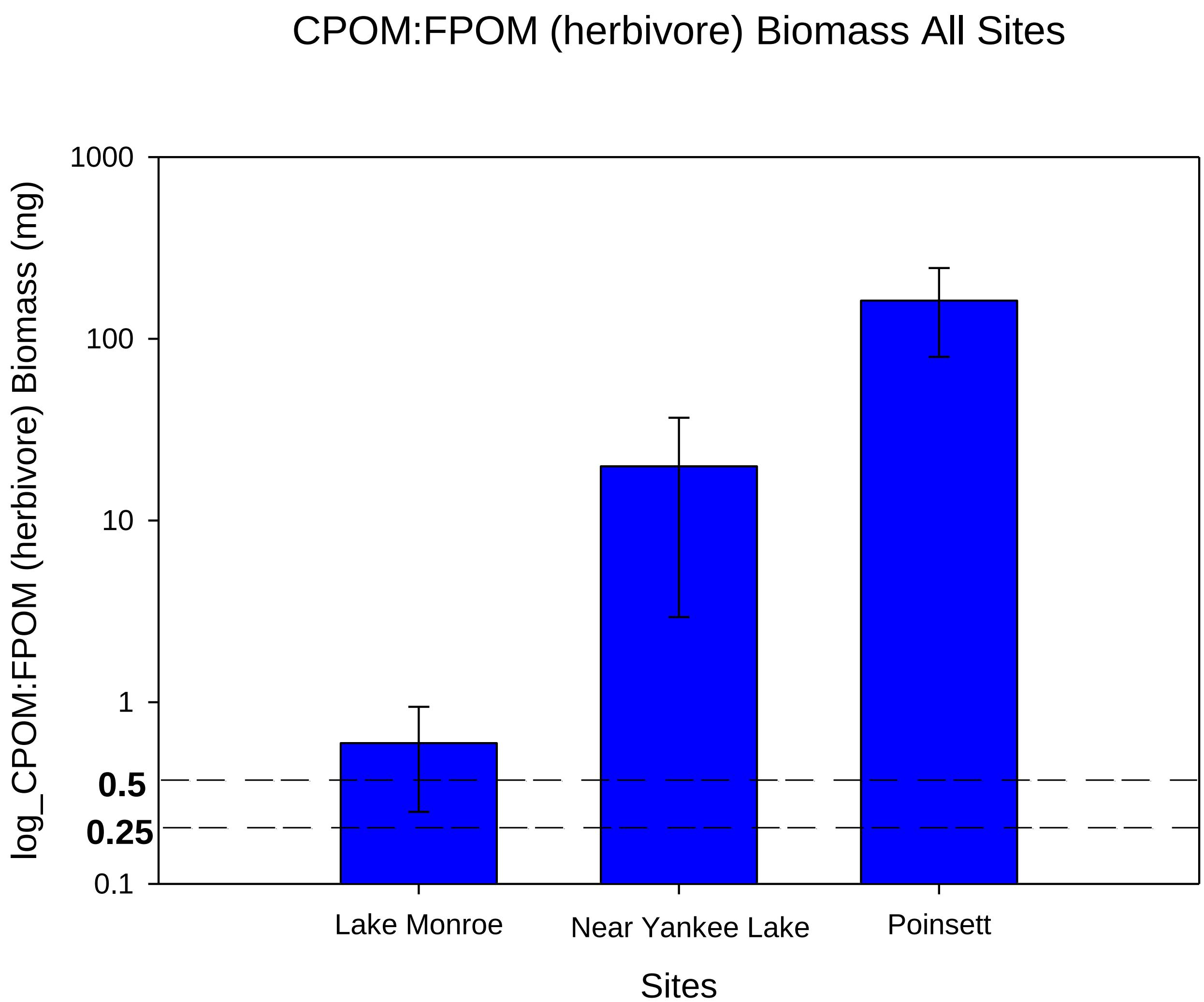


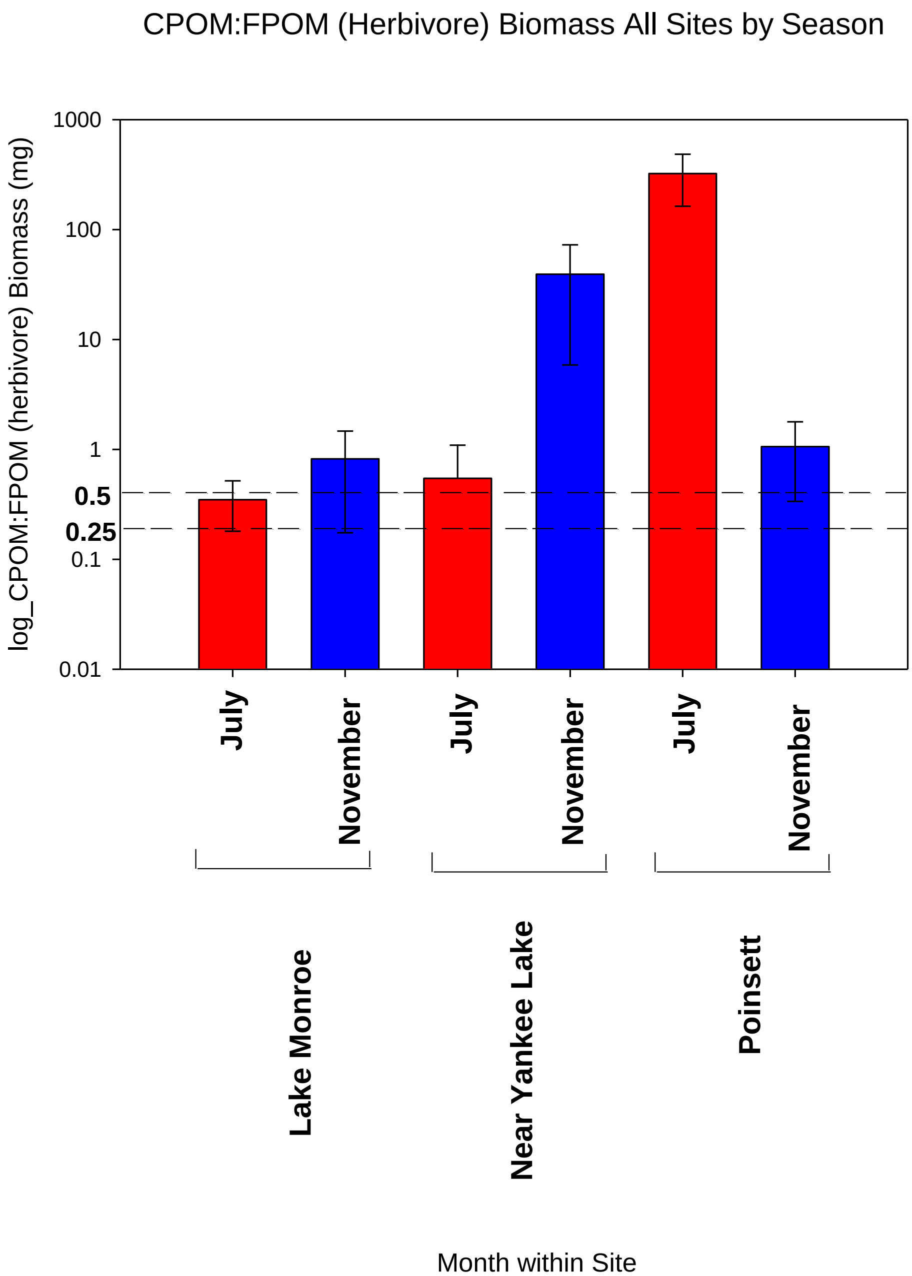
Figure 54. P:R = FFG surrogate ratio for river ecosystem autotrophic/heterotrophic index = Shredder(live plants)+Scrapers+Shredder(piercers)/Shredder(CPOM)+Total Collectors



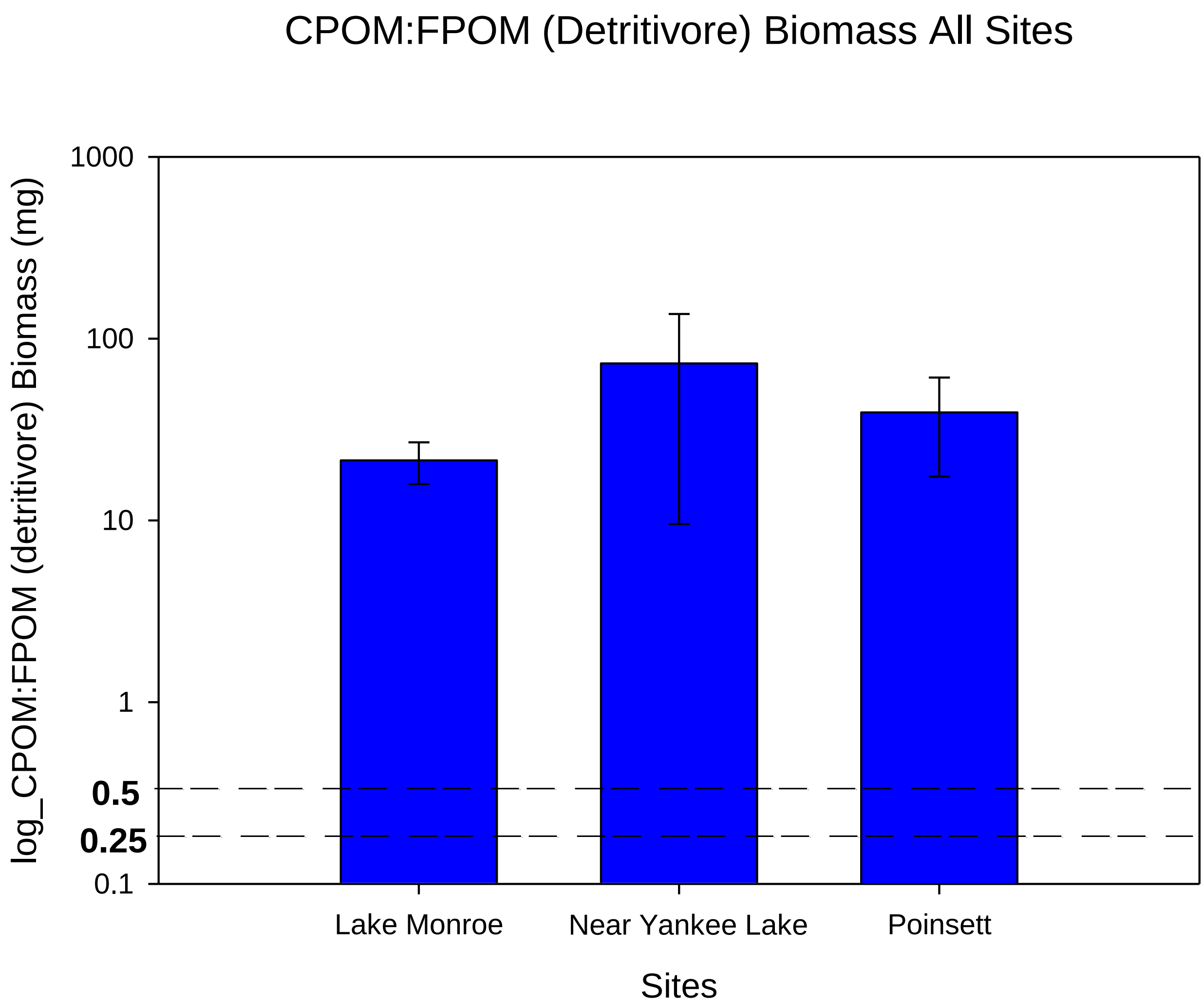
Figures 55. CPOM:FPOM (Herbivore)= FFG surrogate ratio for river ecosystem coarse to fine organic matter index = (Herbivore Shredders)/(Total Collectors)



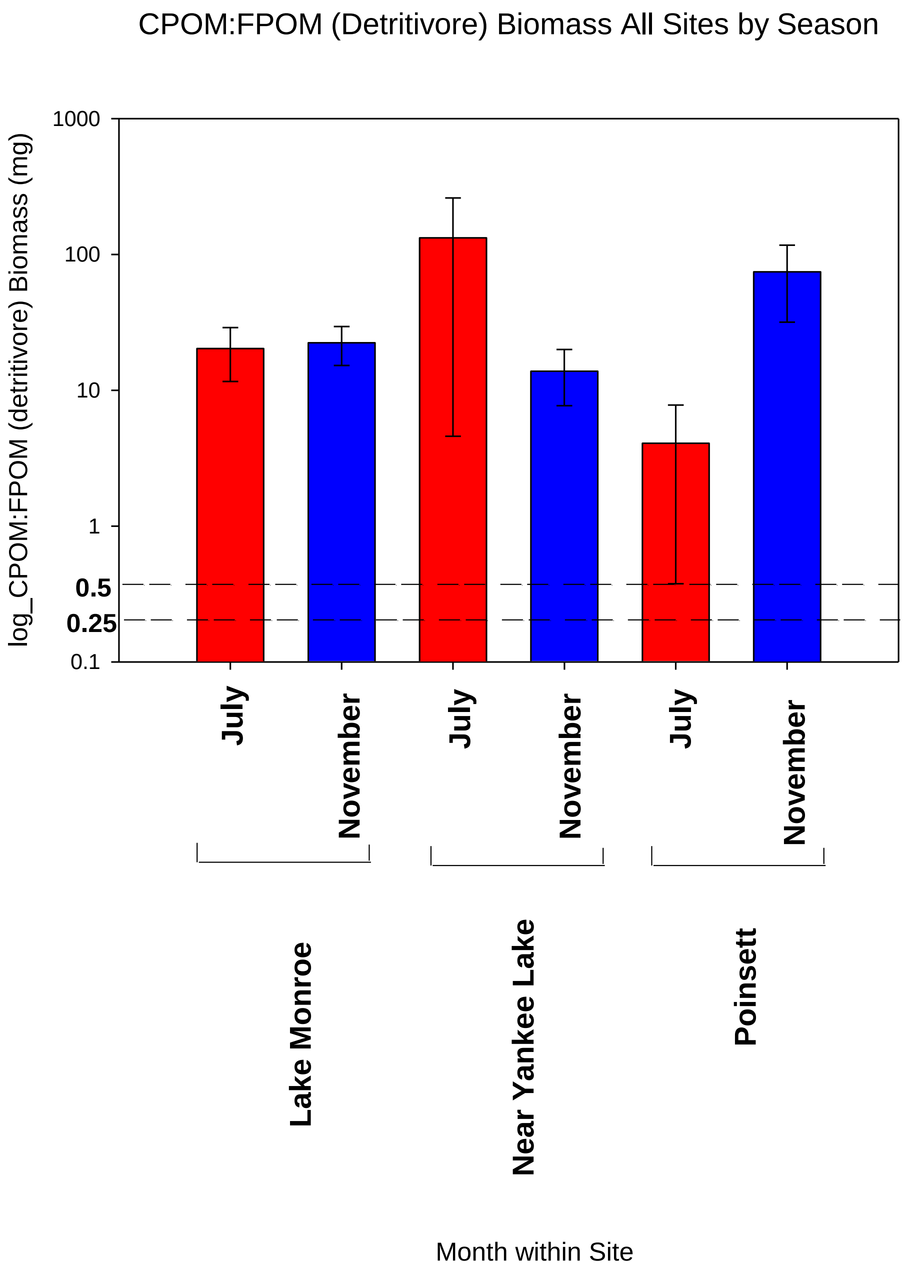
Figures 56. CPOM:FPOM (Herbivore)= FFG surrogate ratio for river ecosystem coarse to fine organic matter index = (Herbivore Shredders)/(Total Collectors)



Figures 57. CPOM:FPOM (Detritivore)= FFG surrogate ratio for river ecosystem coarse to fine organic matter index = (Detritivore Shredders)/(Total Collectors)



Figures 58. CPOM:FPOM (Detritivore)= FFG surrogate ratio for river ecosystem coarse to fine organic matter index = (Detritivore Shredders)/(Total Collectors)



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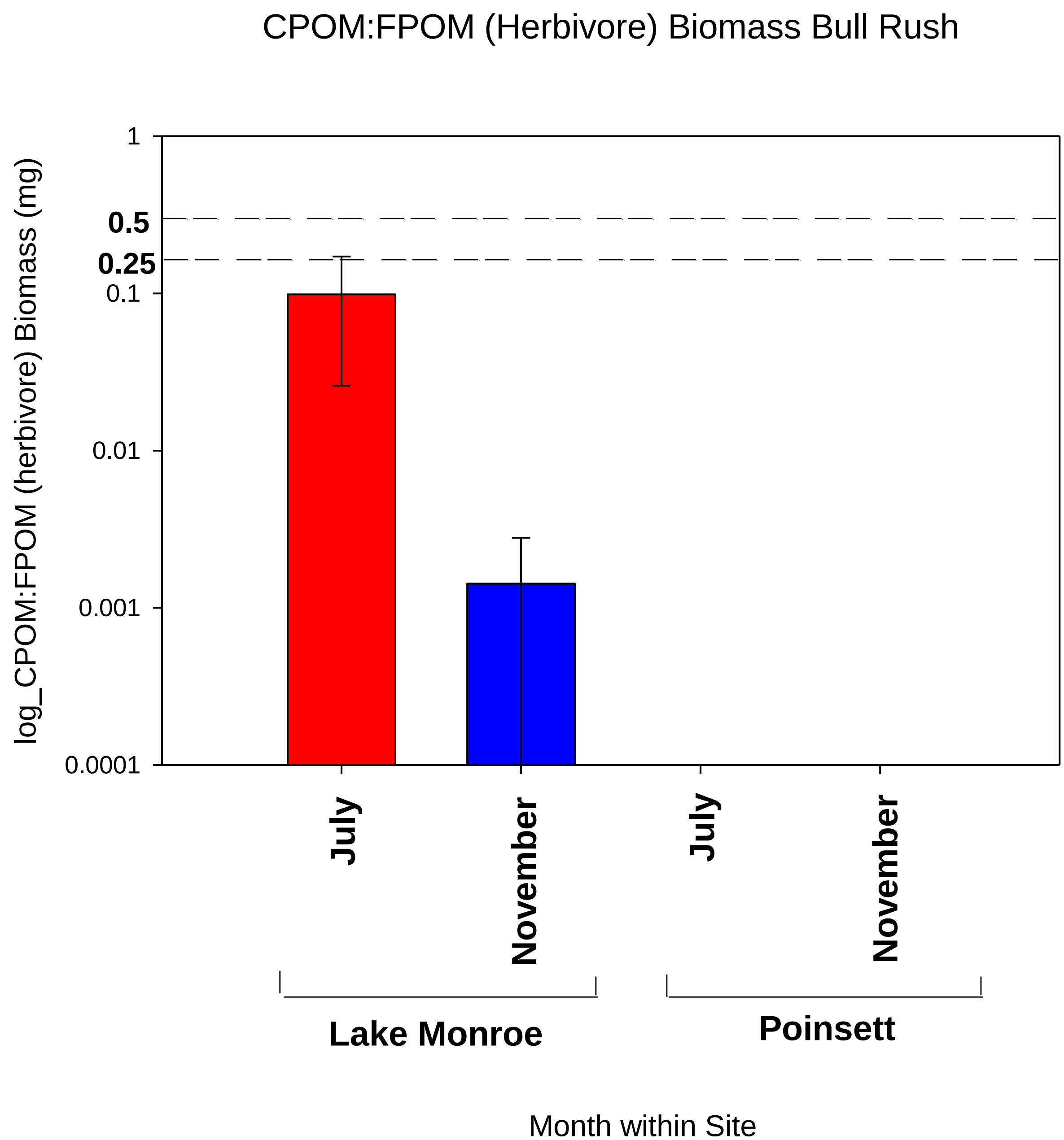
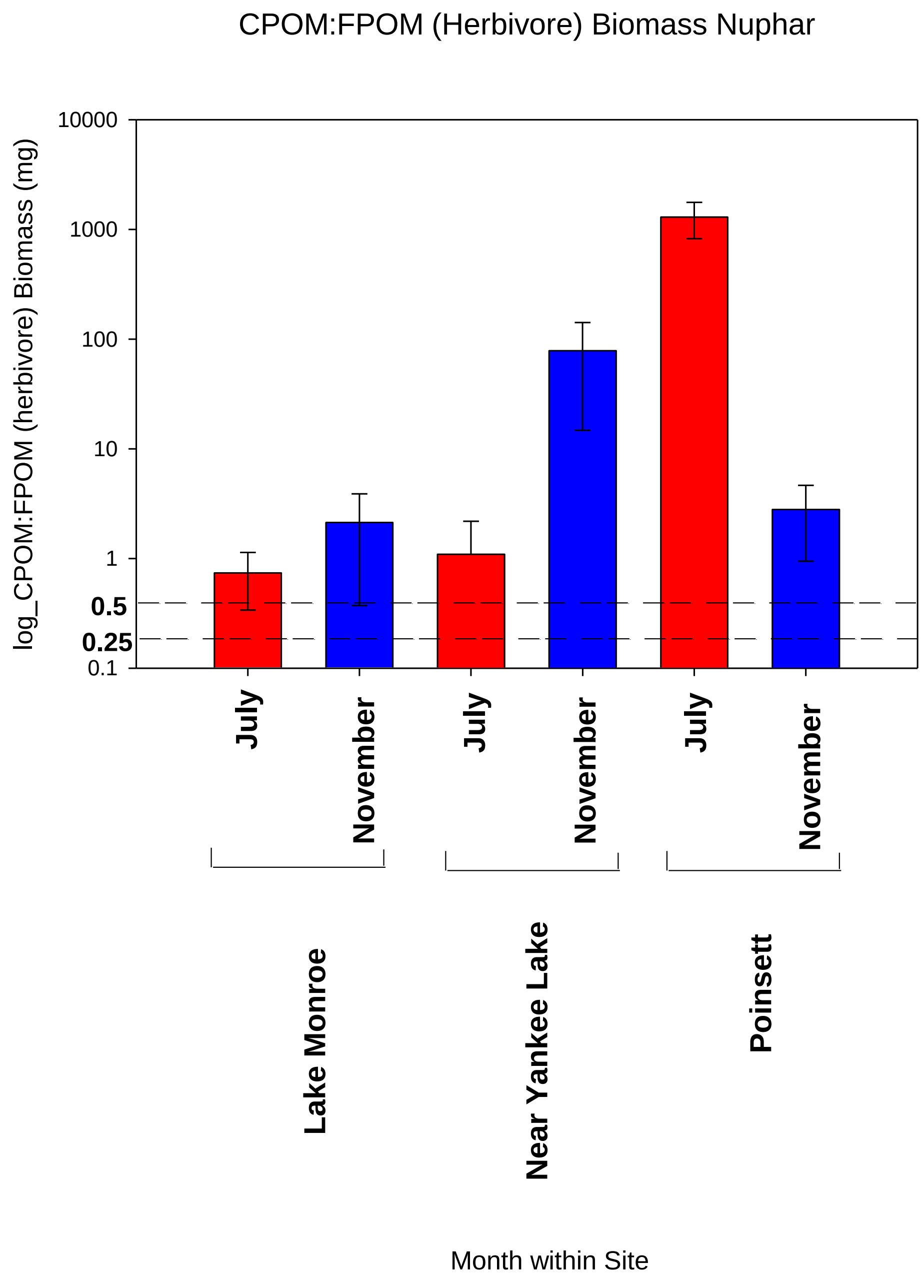
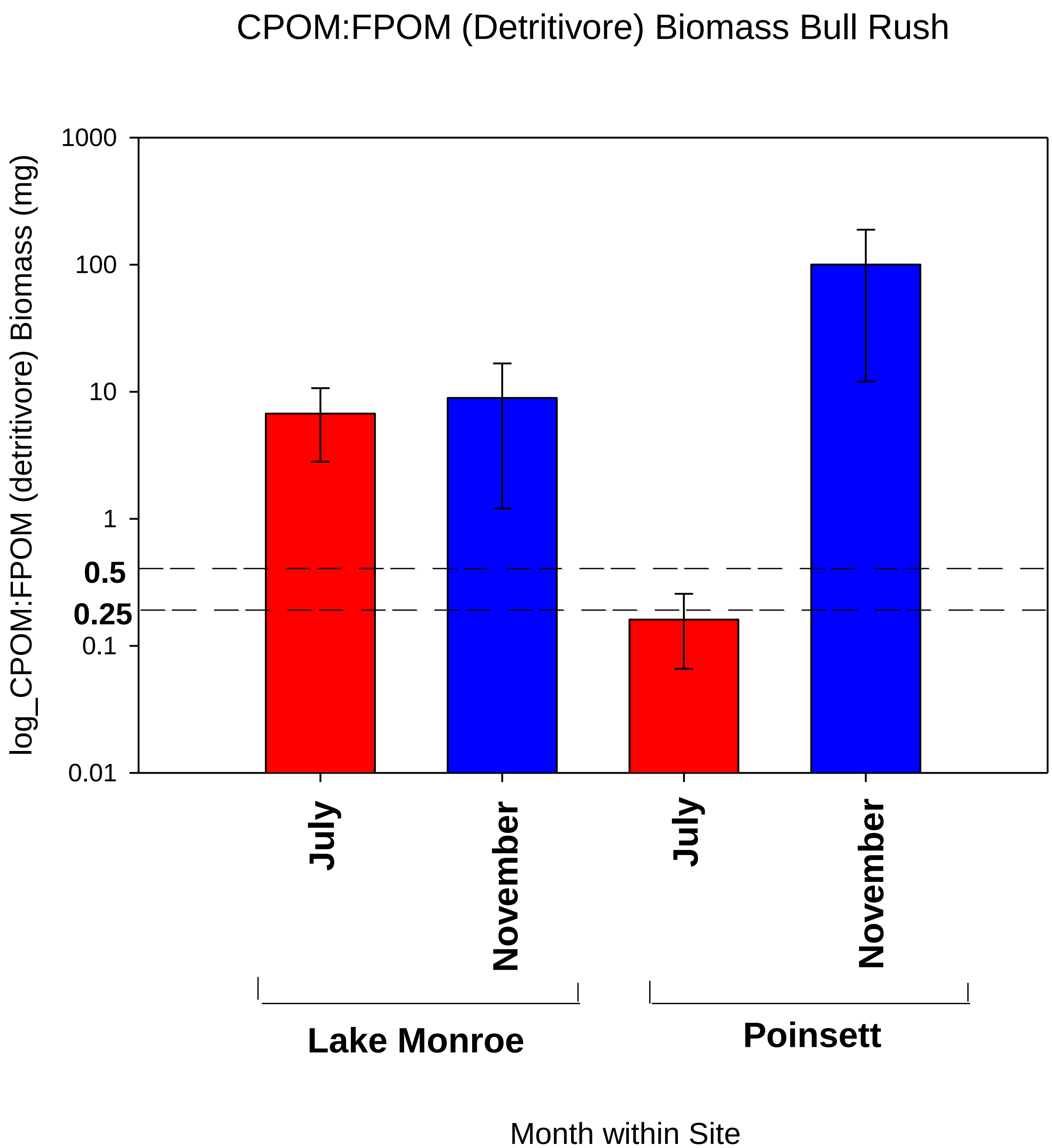


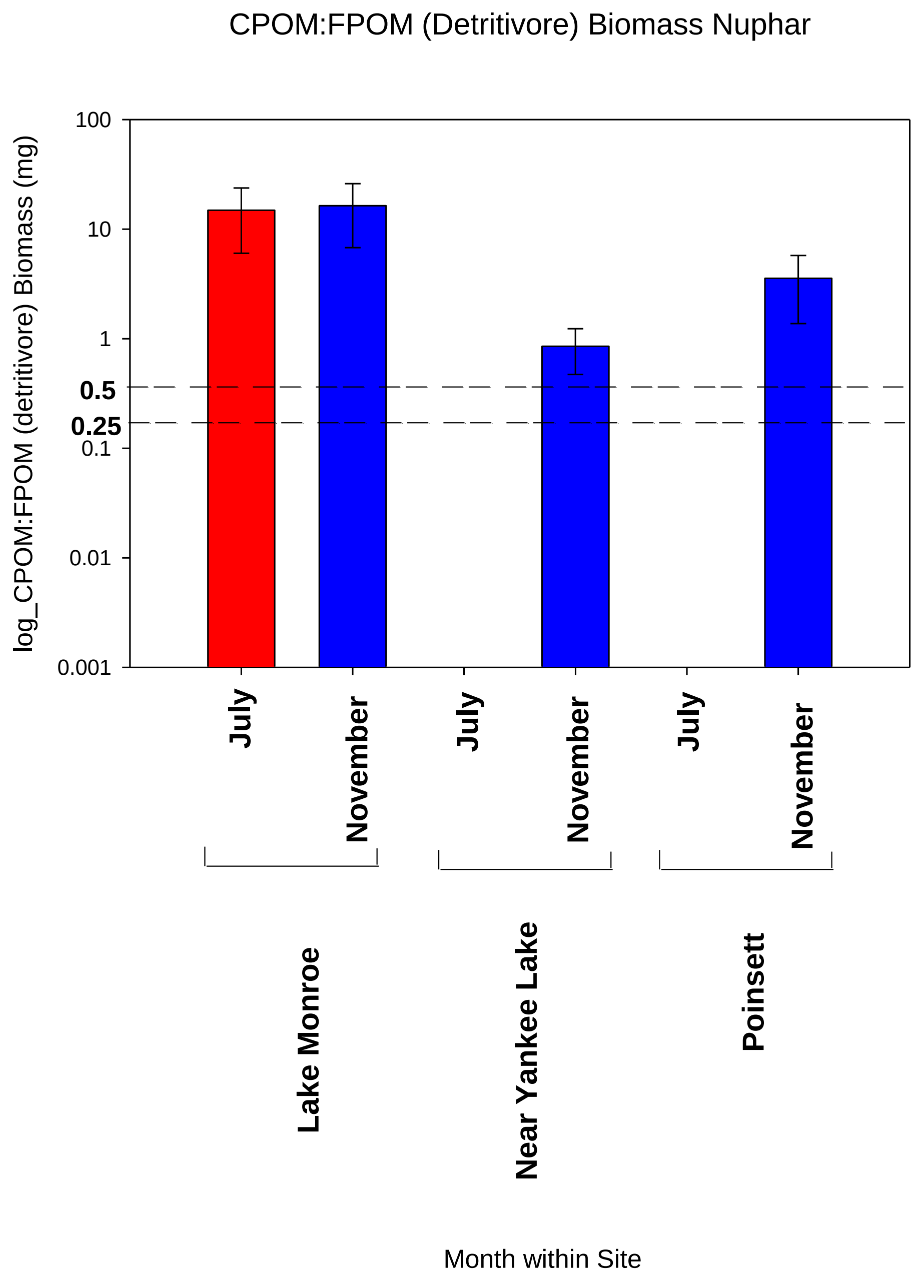
Figures 60. CPOM:FPOM (Herbivore)= FFG surrogate ratio for river ecosystem coarse to fine organic matter index = (Herbivore Shredders)/(Total Collectors)



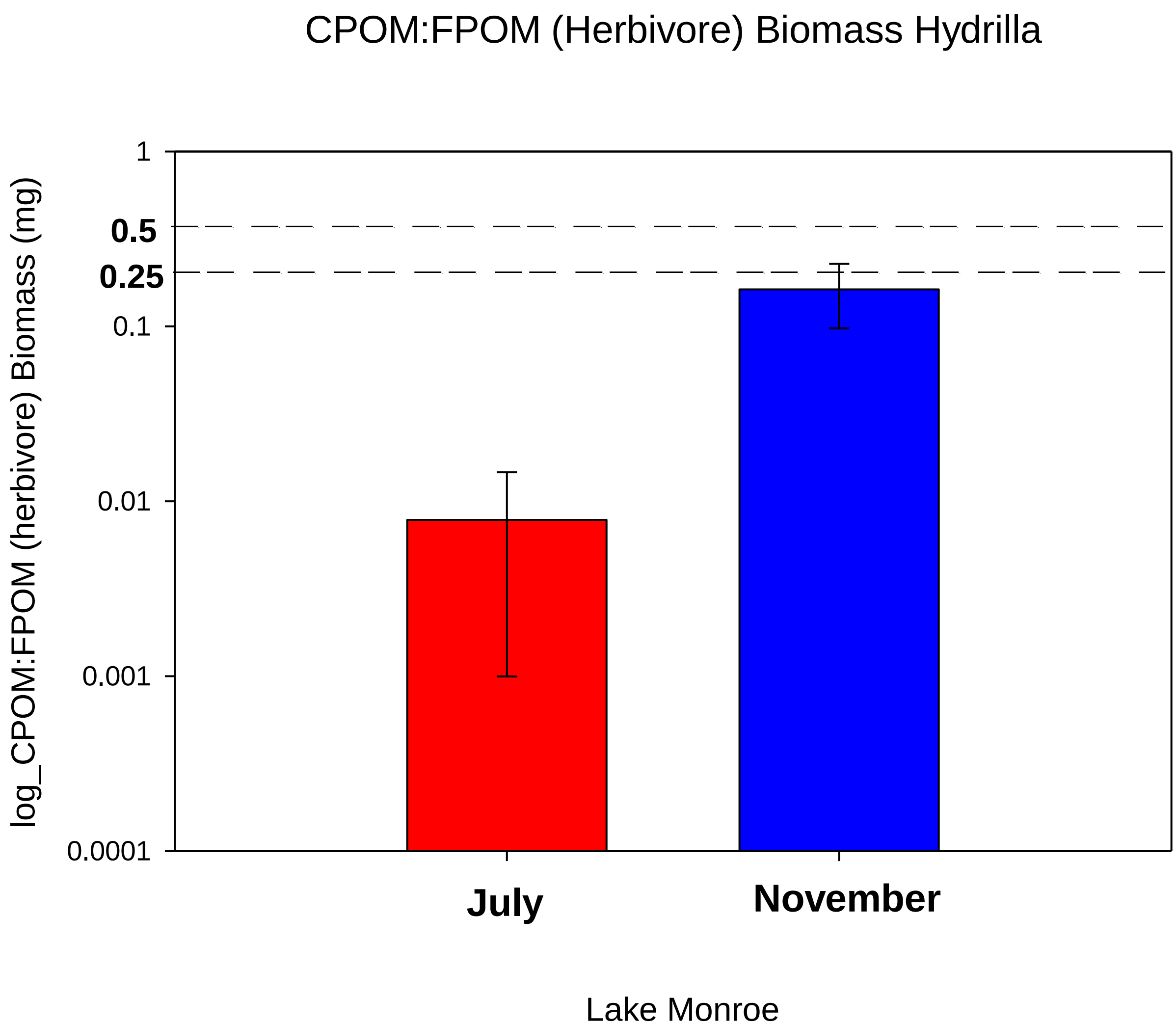
Figures 61. CPOM:FPOM (Detritivore)= FFG surrogate ratio for river ecosystem coarse to fine organic matter index = (Detritivore Shredders)/(Total Collectors)



Figures 62. CPOM:FPOM (Detritivore)= FFG surrogate ratio for river ecosystem coarse to fine organic matter index = (Detritivore Shredders)/(Total Collectors)



Figures 63. CPOM:FPOM (Herbivore)= FFG surrogate ratio for river ecosystem coarse to fine organic matter index = (Herbivore Shredders)/(Total Collectors)



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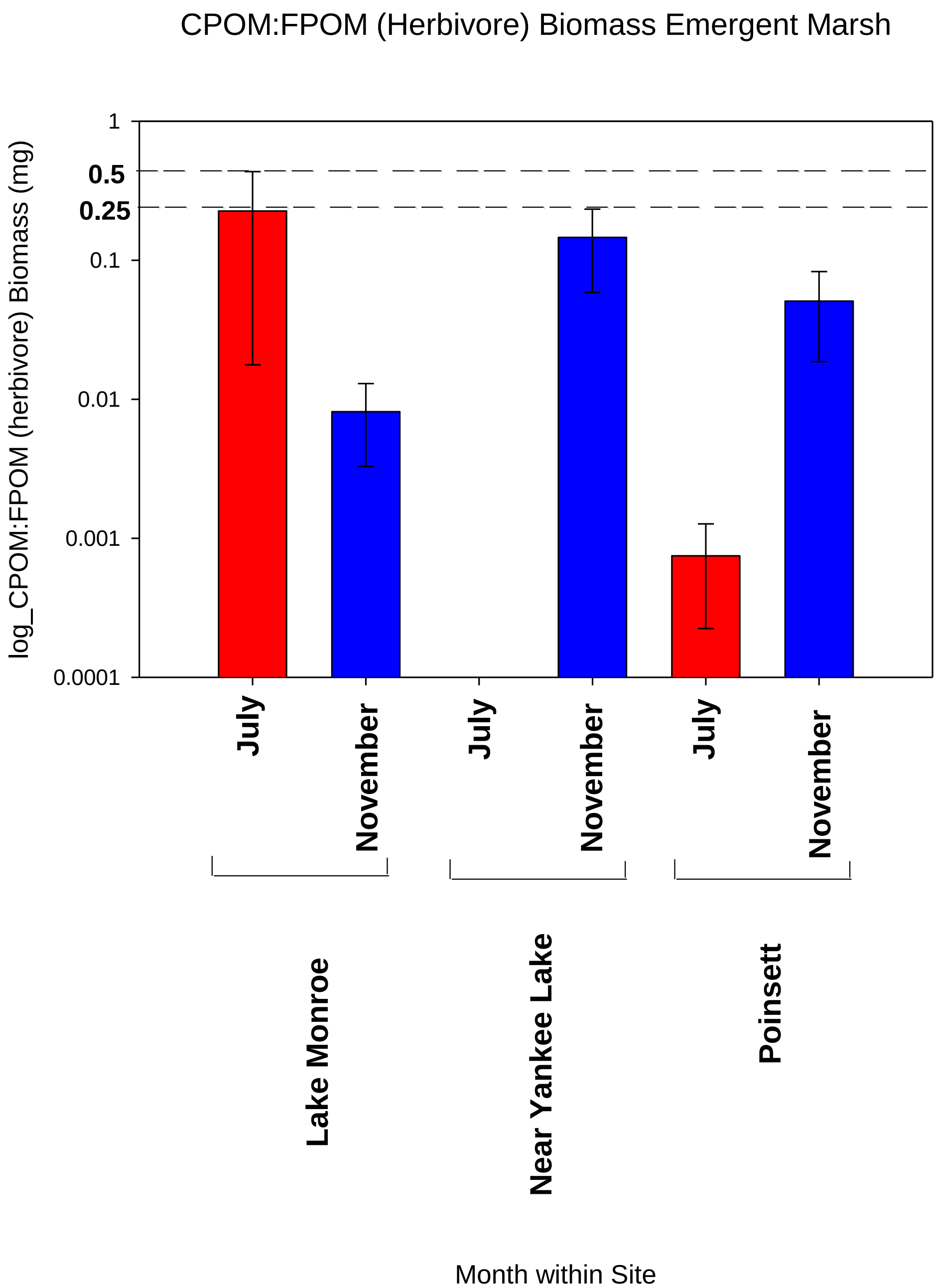

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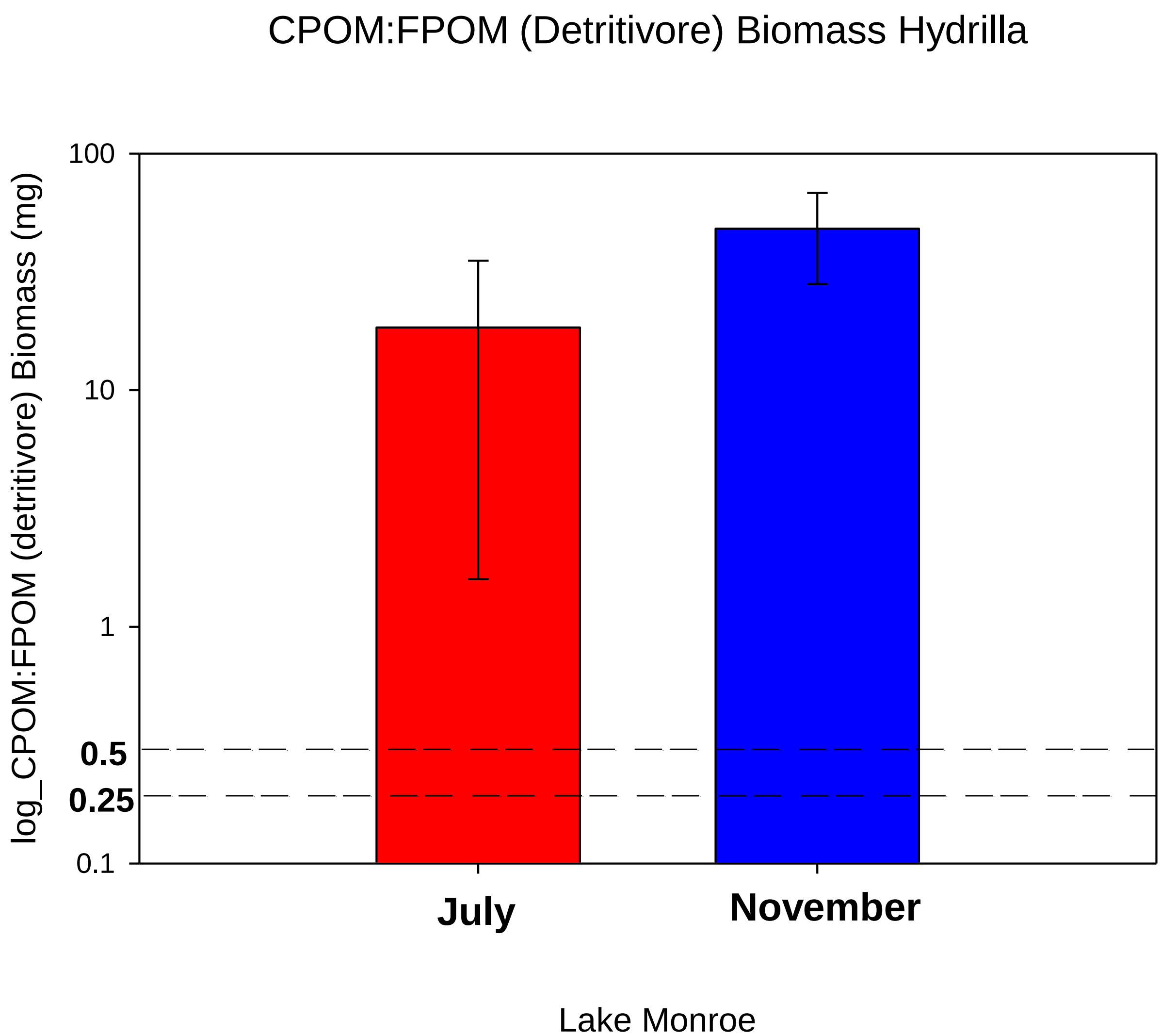
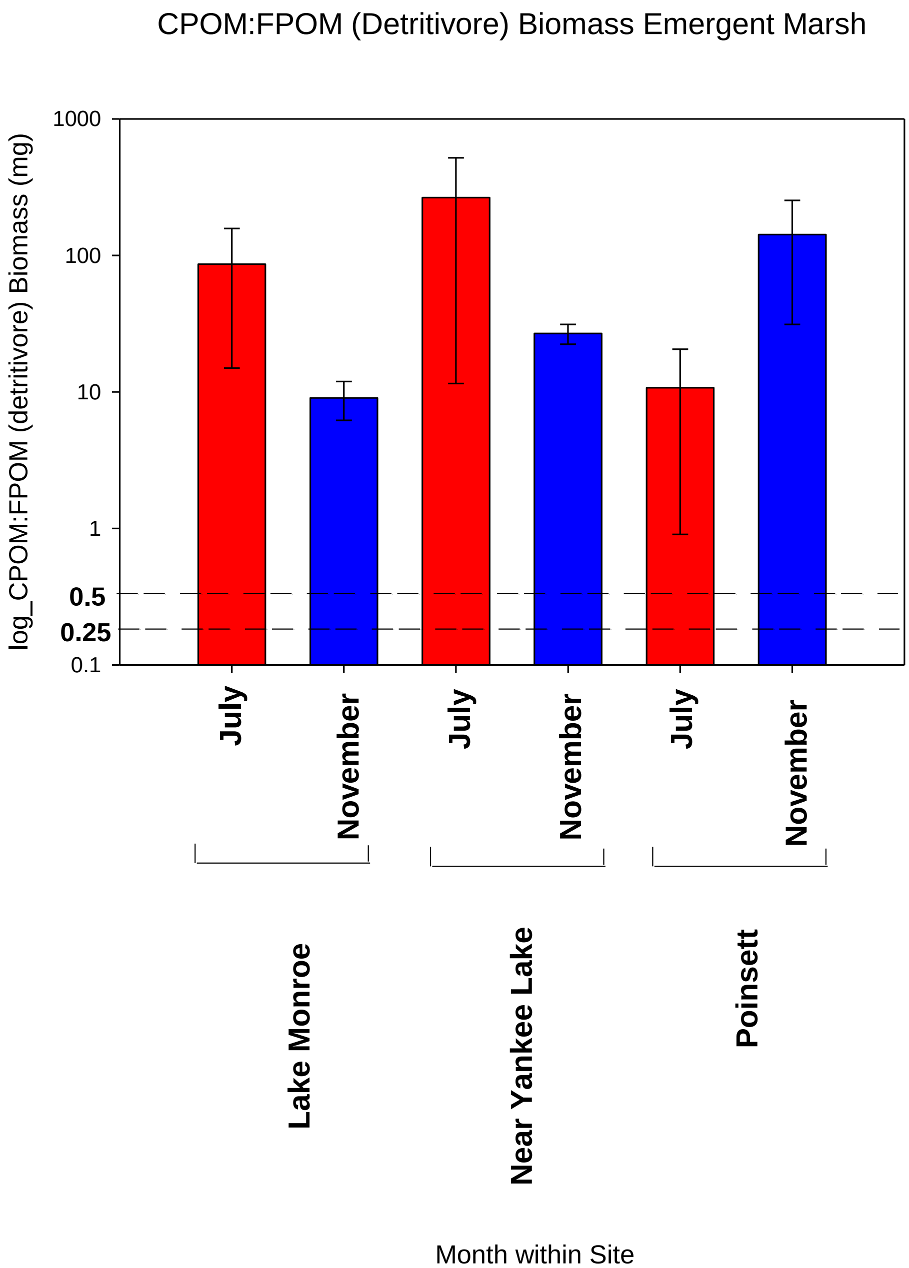
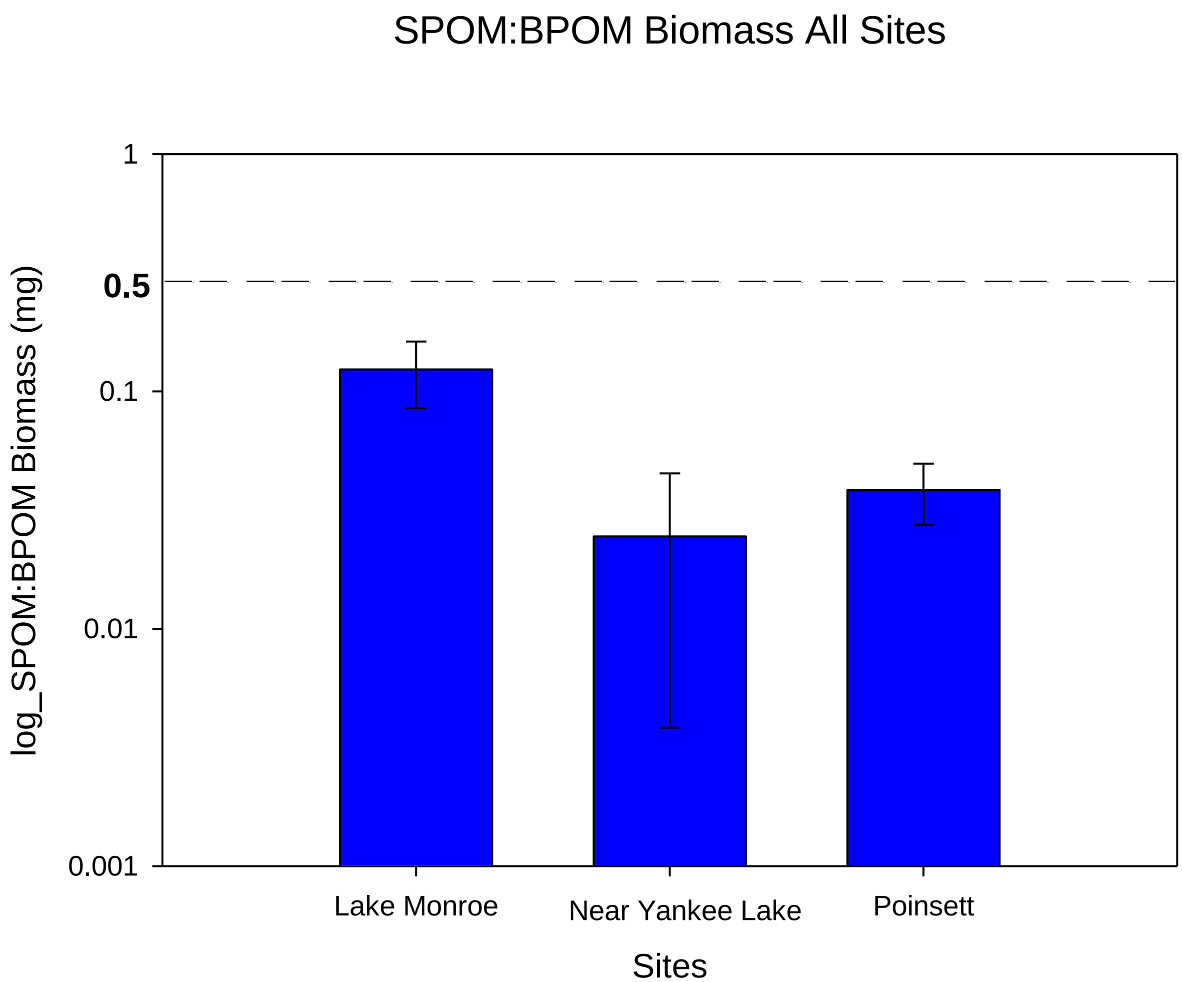


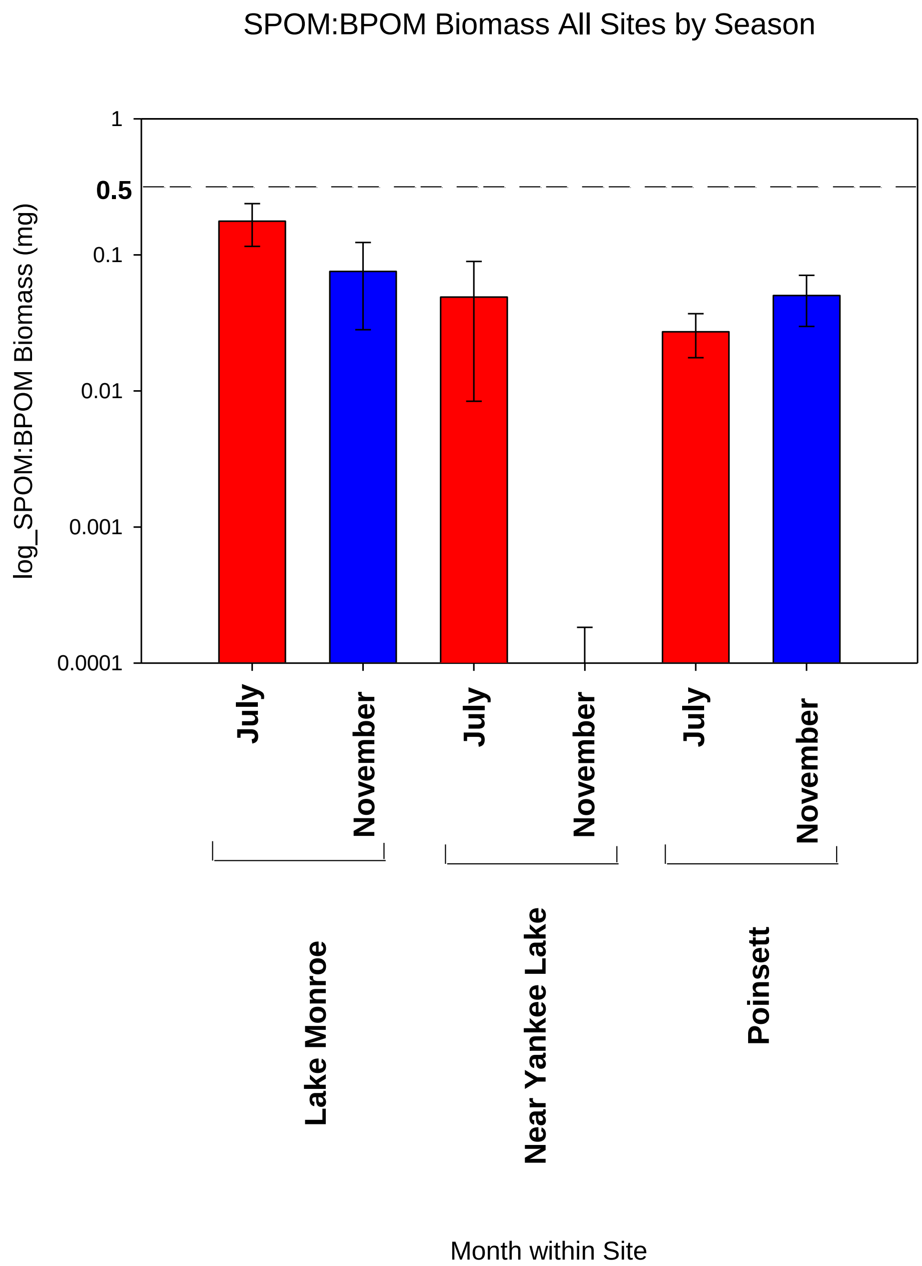
Figures 66. CPOM:FPOM (Detritivore)= FFG surrogate ratio for river ecosystem coarse to fine organic matter index = (Detritivore Shredders)/(Total Collectors)



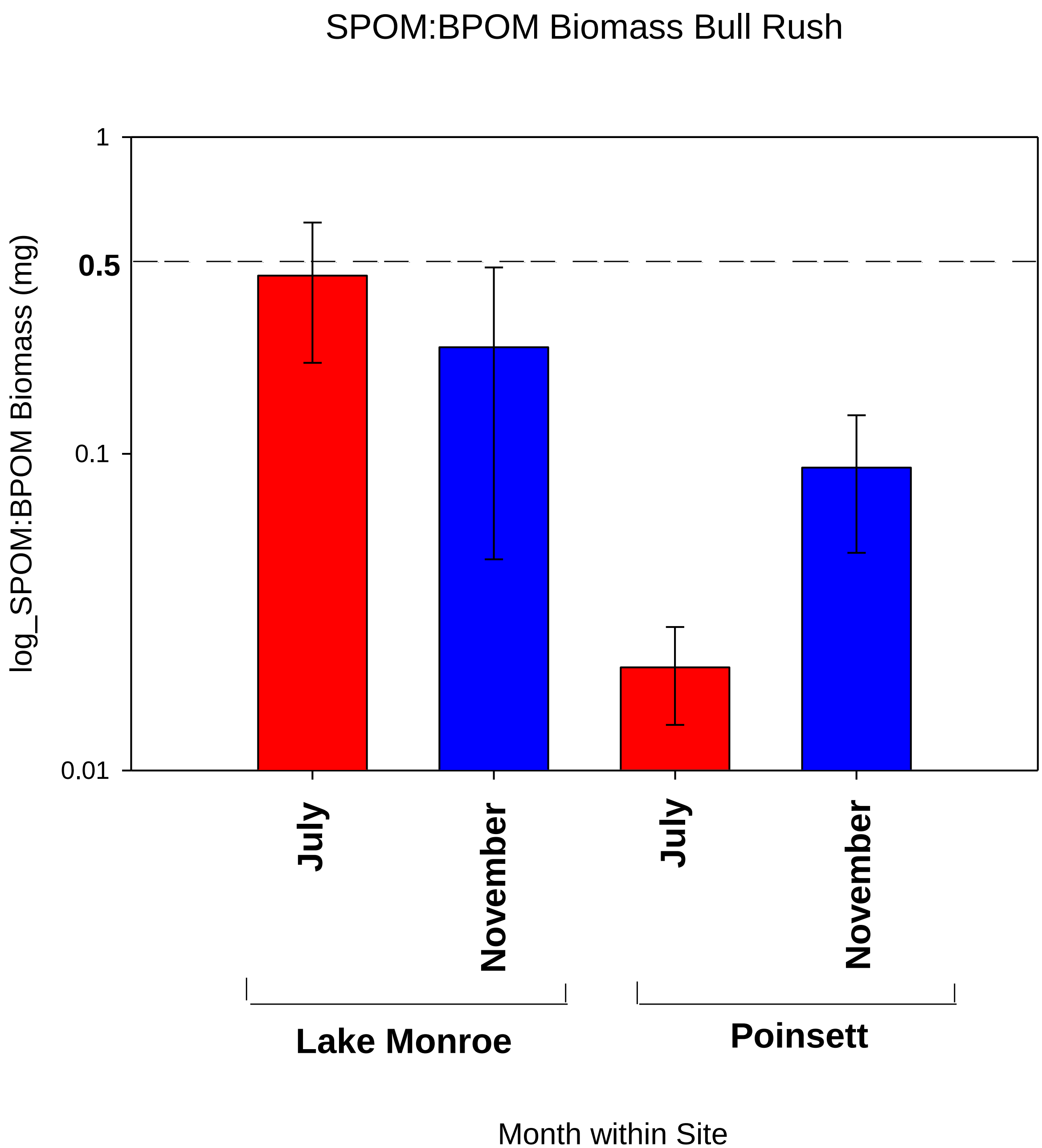
Figures 67. SPOM:BPOM = FFG surrogate ratio for river ecosystem suspended to deposited organic matter index = (Filtering Collectors)/(Gathering Collectors)



Figures 68. SPOM:BPOM = FFG surrogate ratio for river ecosystem suspended to deposited organic matter index = (Filtering Collectors)/(Gathering Collectors)



Figures 69. SPOM:BPOM = FFG surrogate ratio for river ecosystem suspended to deposited organic matter index = (Filtering Collectors)/(Gathering Collectors)



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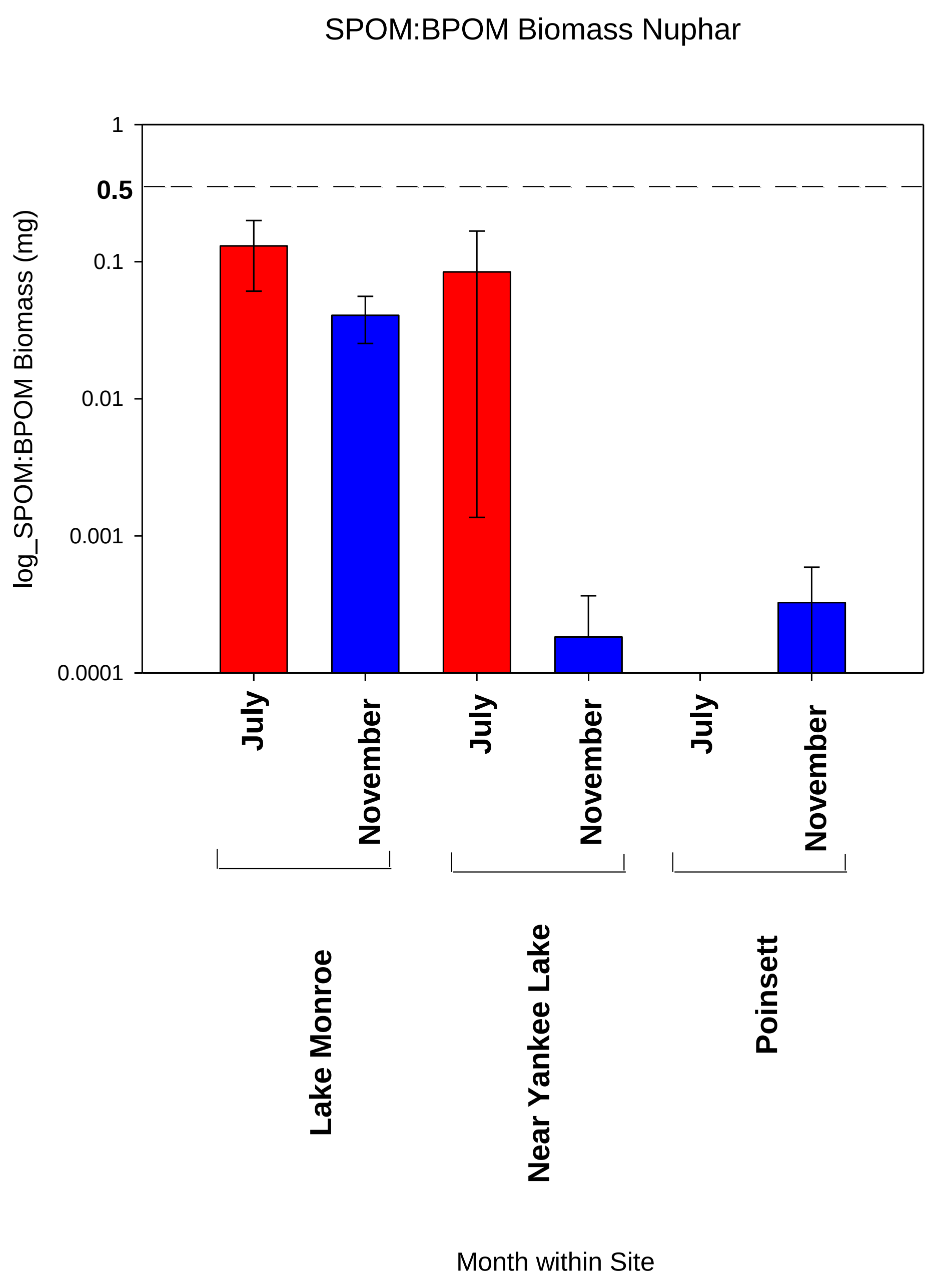
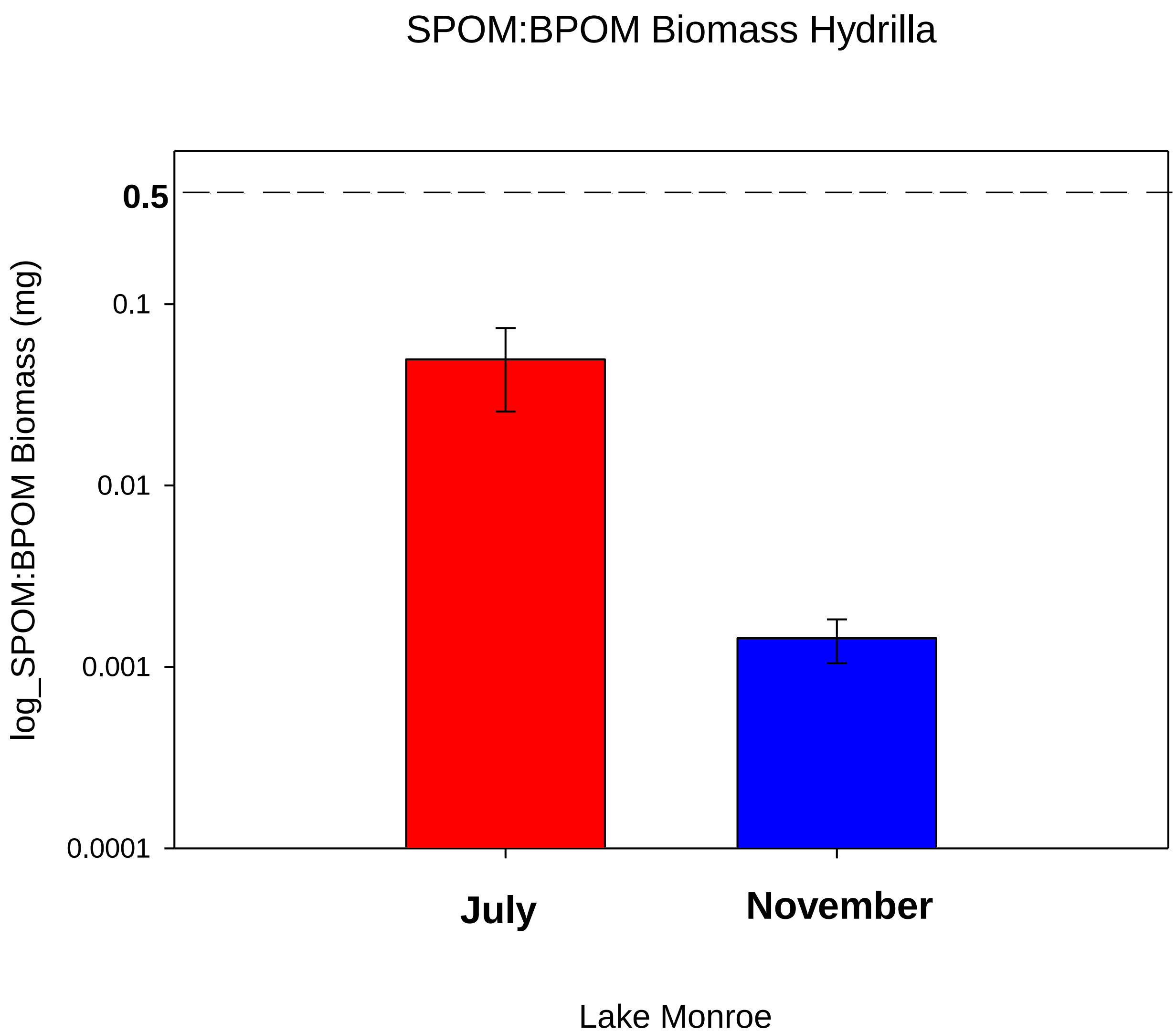


Figures 71. SPOM:BPOM = FFG surrogate ratio for river ecosystem suspended to deposited organic matter index = (Filtering Collectors)/(Gathering Collectors)



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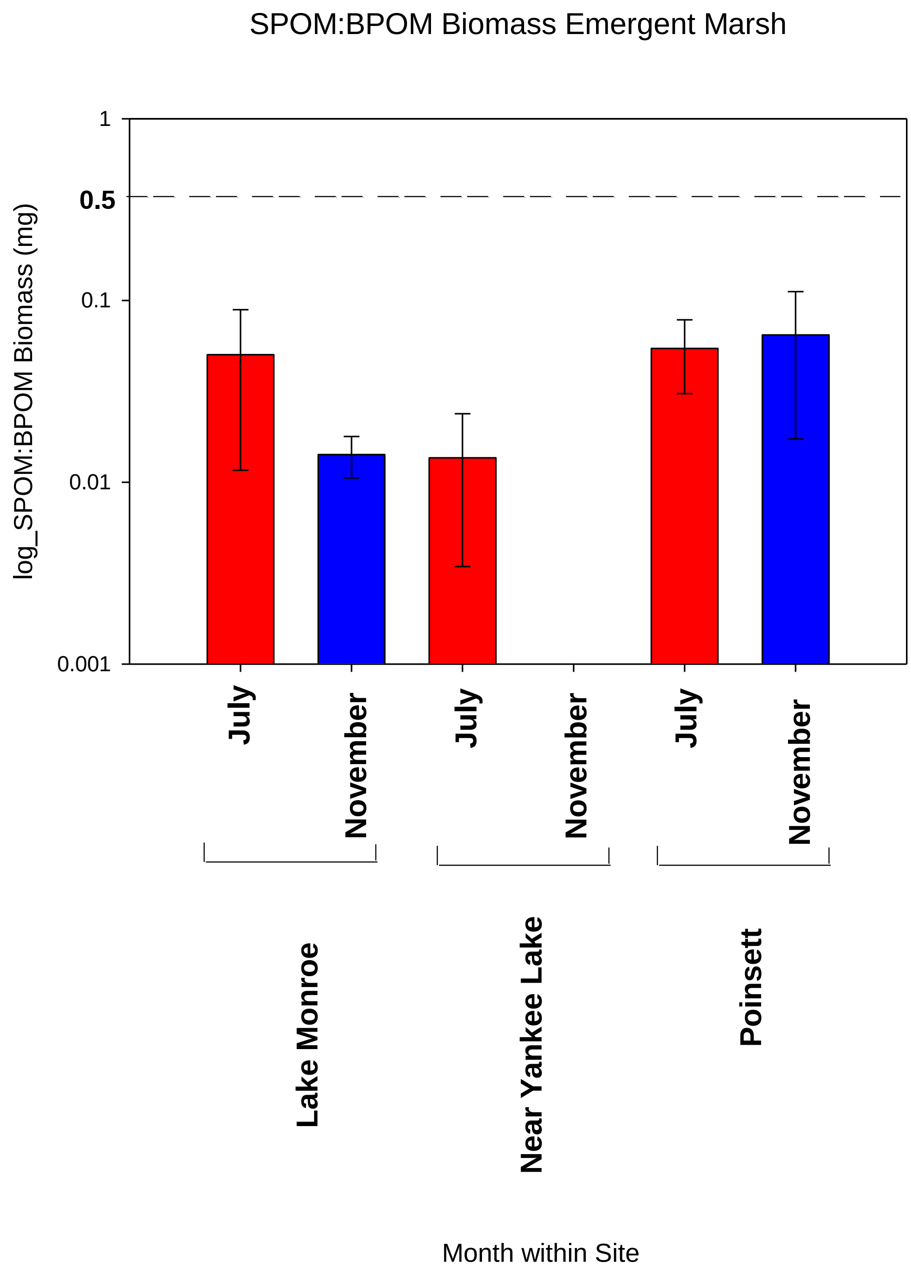
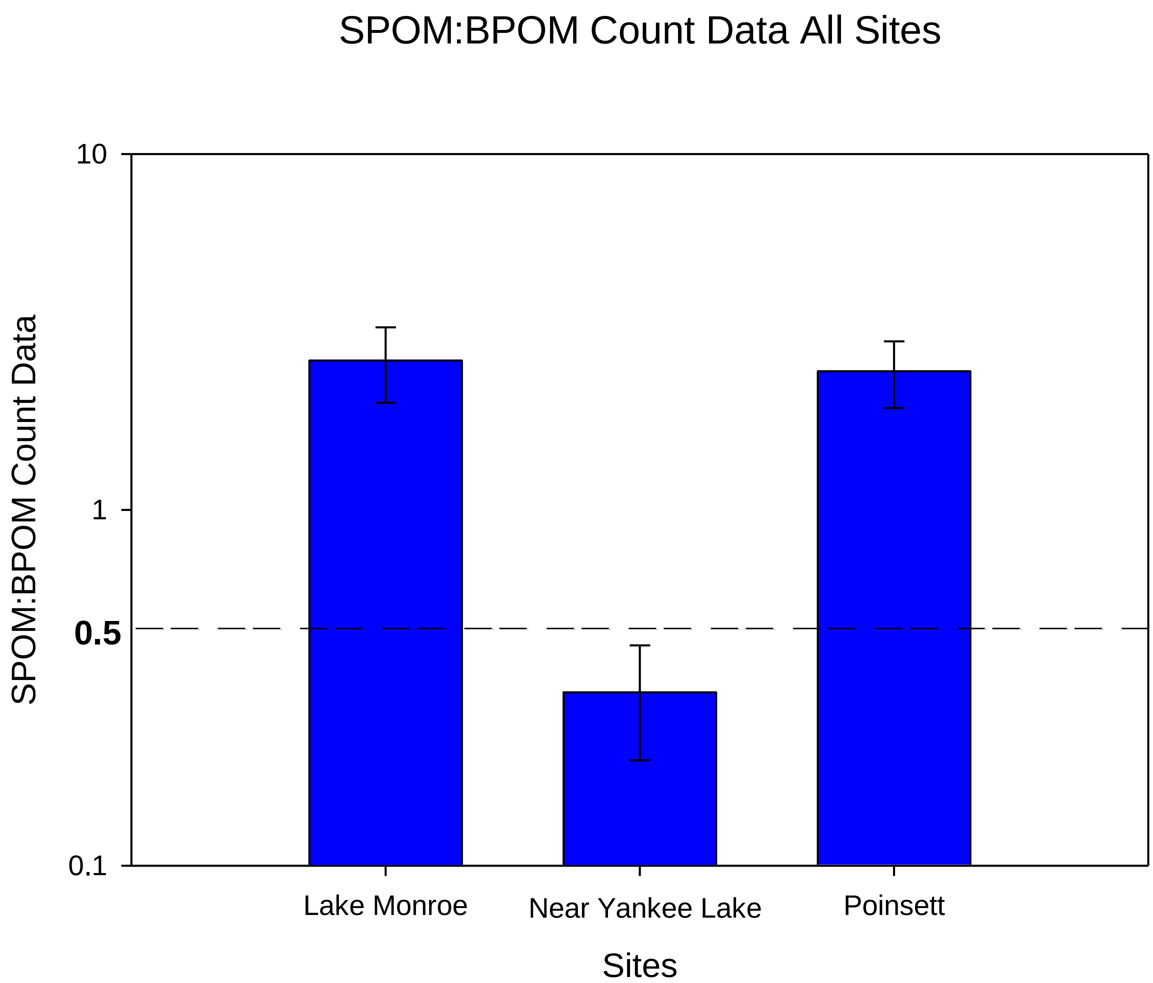
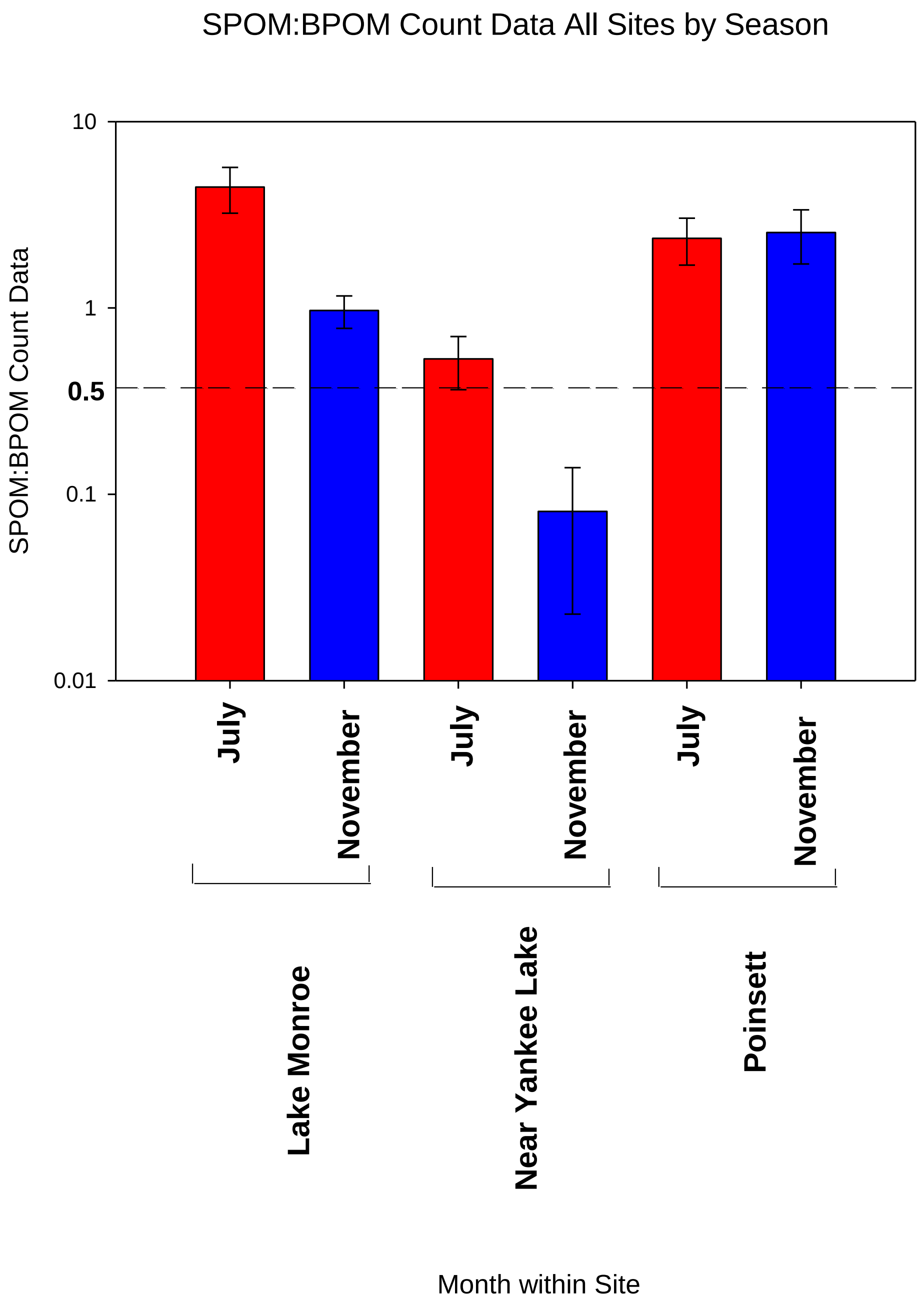


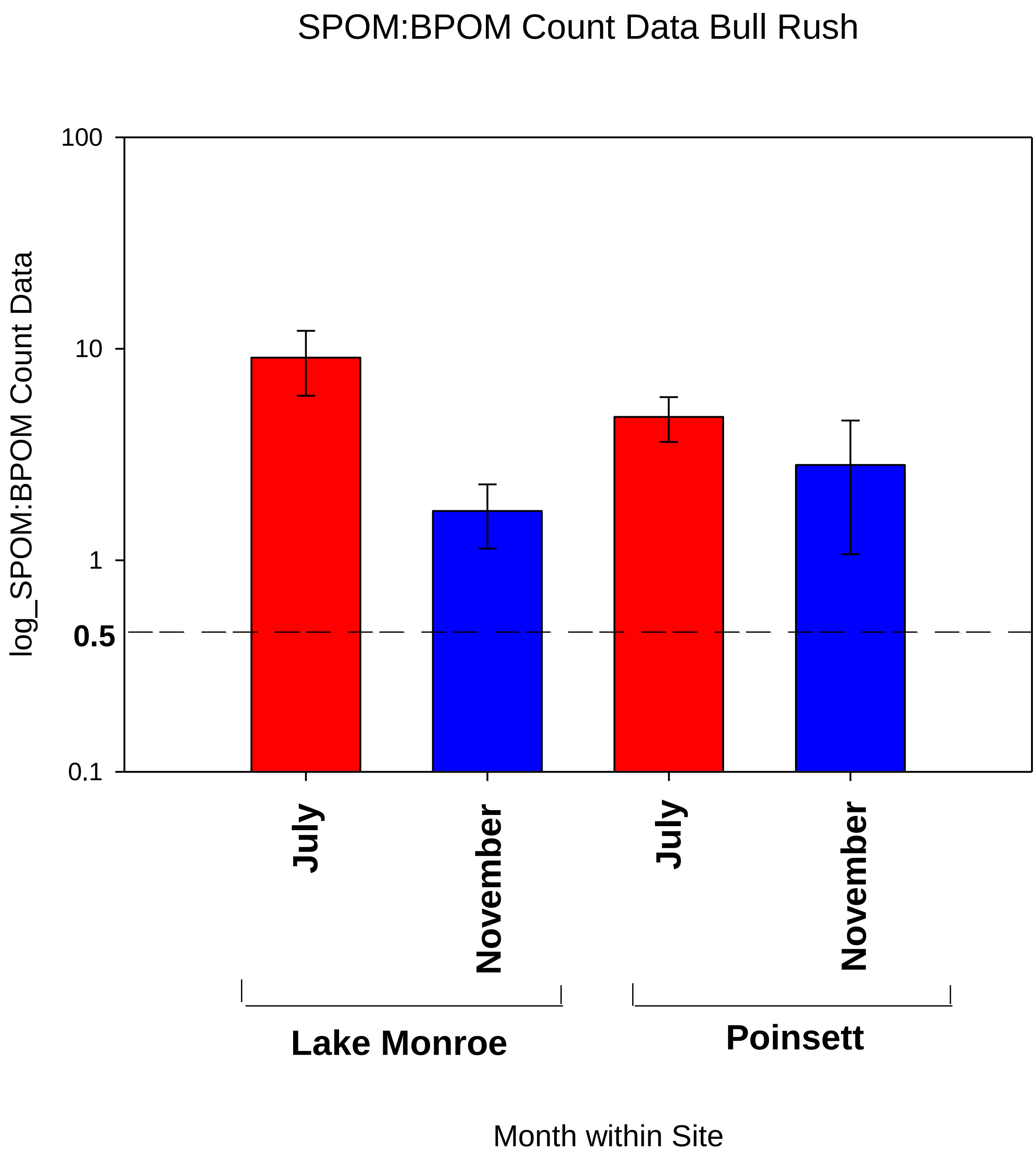
Figures 73. SPOM:BPOM = FFG surrogate ratio for river ecosystem suspended to deposited organic matter index = (Filtering Collectors)/(Gathering Collectors)



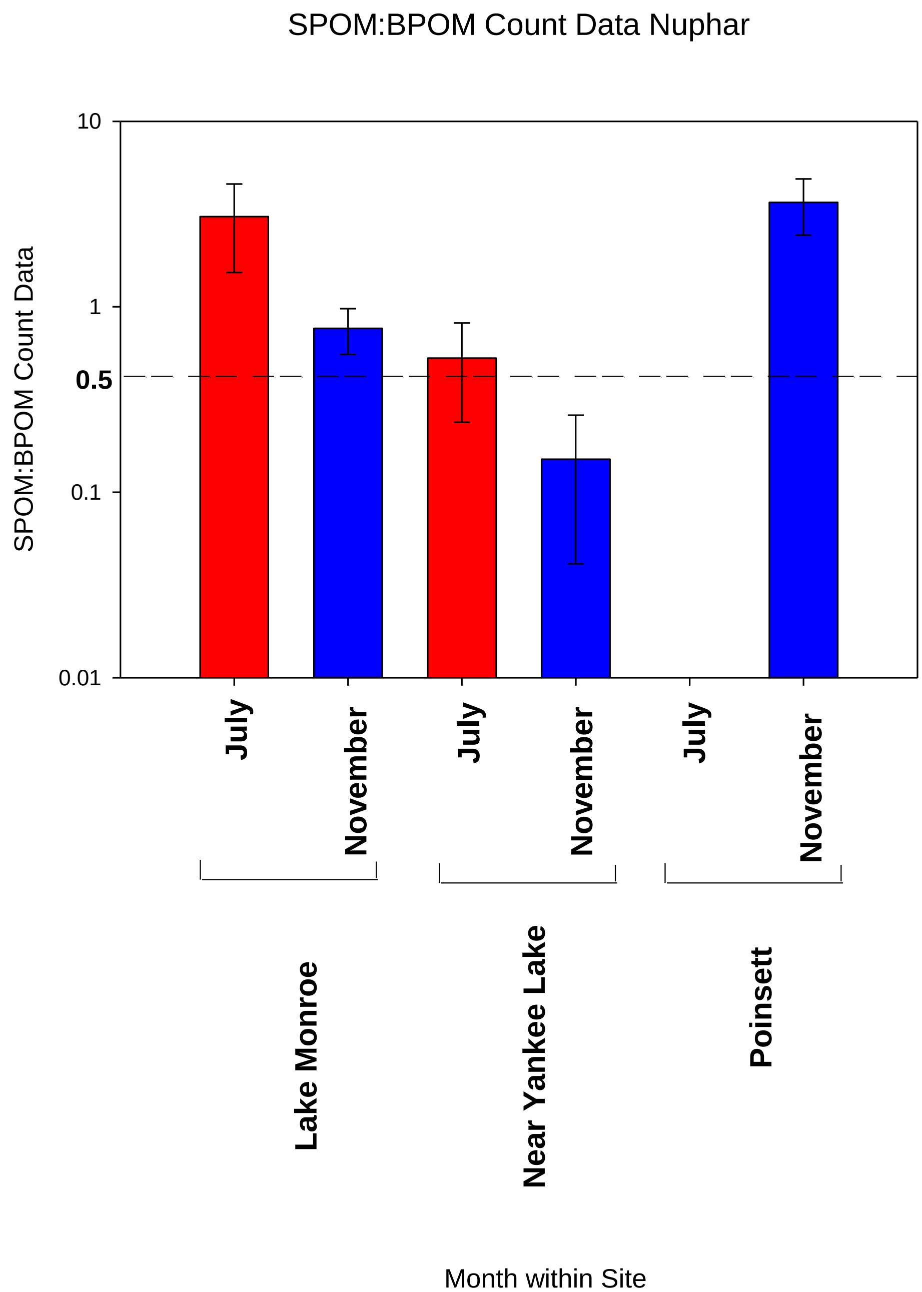
Figures 74. SPOM:BPOM = FFG surrogate ratio for river ecosystem suspended to deposited organic matter index = (Filtering Collectors)/(Gathering Collectors)



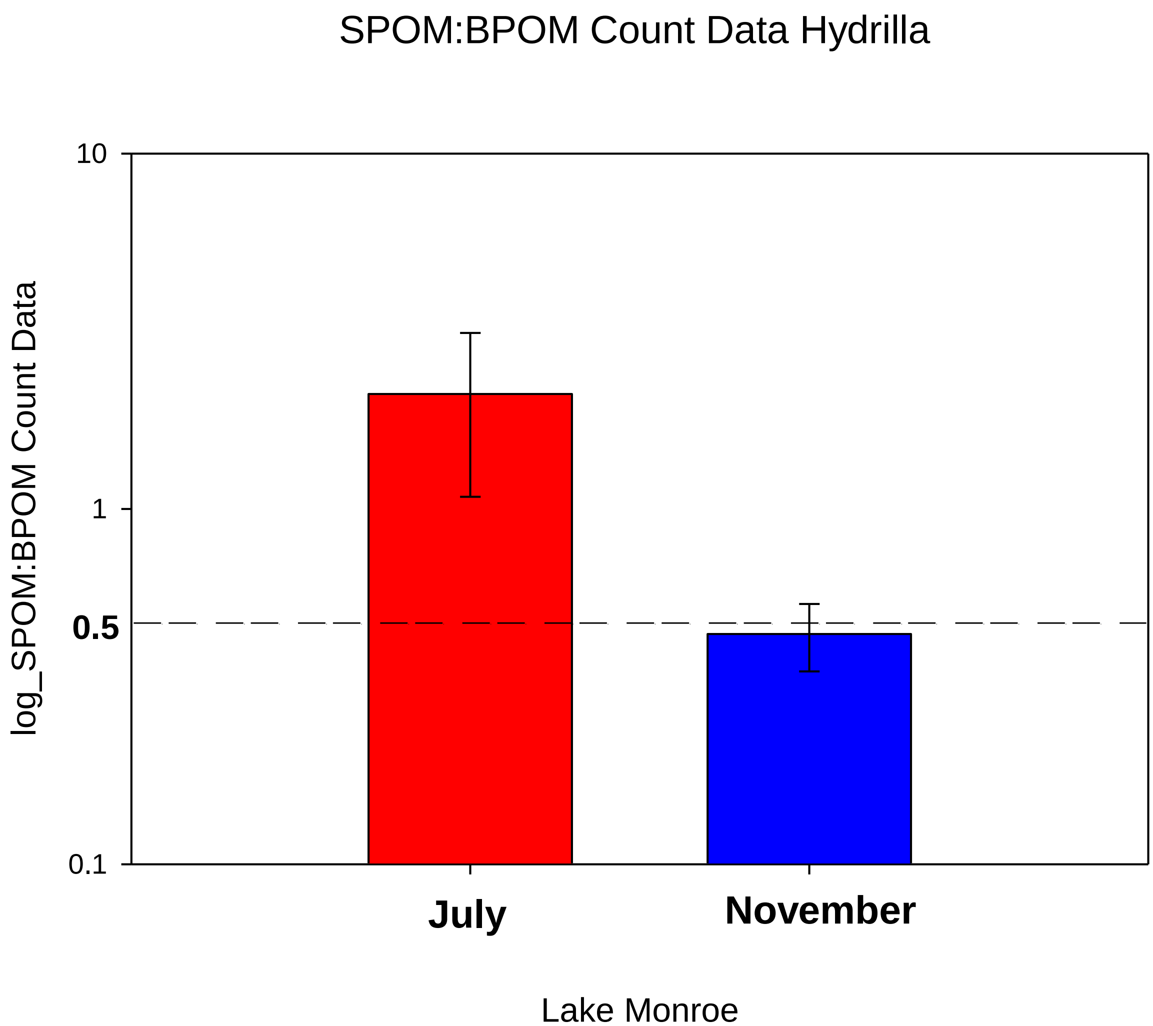
Figures 75. SPOM:BPOM = FFG surrogate ratio for river ecosystem suspended to deposited organic matter index = (Filtering Collectors)/(Gathering Collectors)



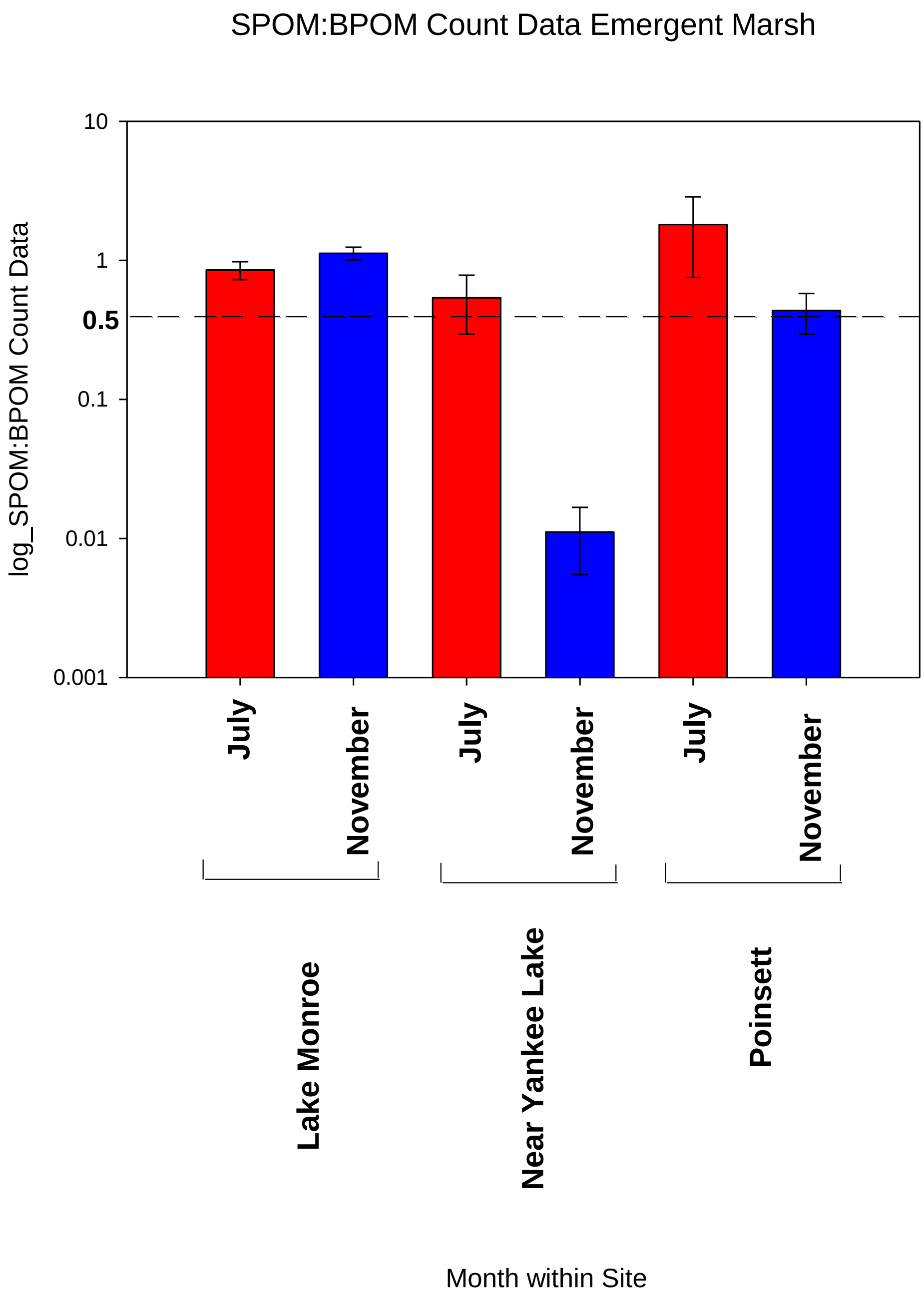
Figures 76. SPOM:BPOM = FFG surrogate ratio for river ecosystem suspended to deposited organic matter index = (Filtering Collectors)/(Gathering Collectors)



Figures 77. SPOM:BPOM = FFG surrogate ratio for river ecosystem suspended to deposited organic matter index = (Filtering Collectors)/(Gathering Collectors)

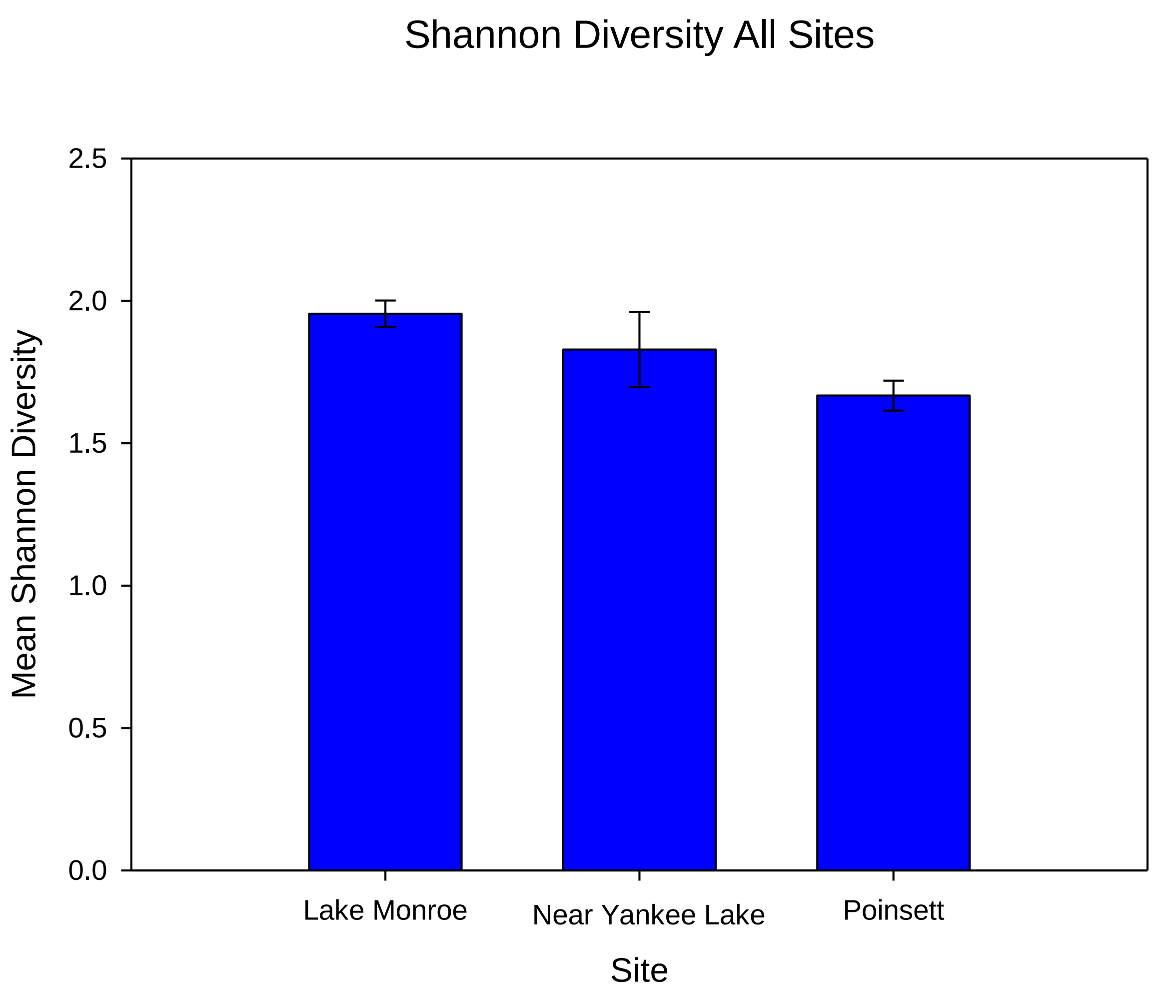


Figures 78. SPOM:BPOM = FFG surrogate ratio for river ecosystem suspended to deposited organic matter index = (Filtering Collectors)/(Gathering Collectors)

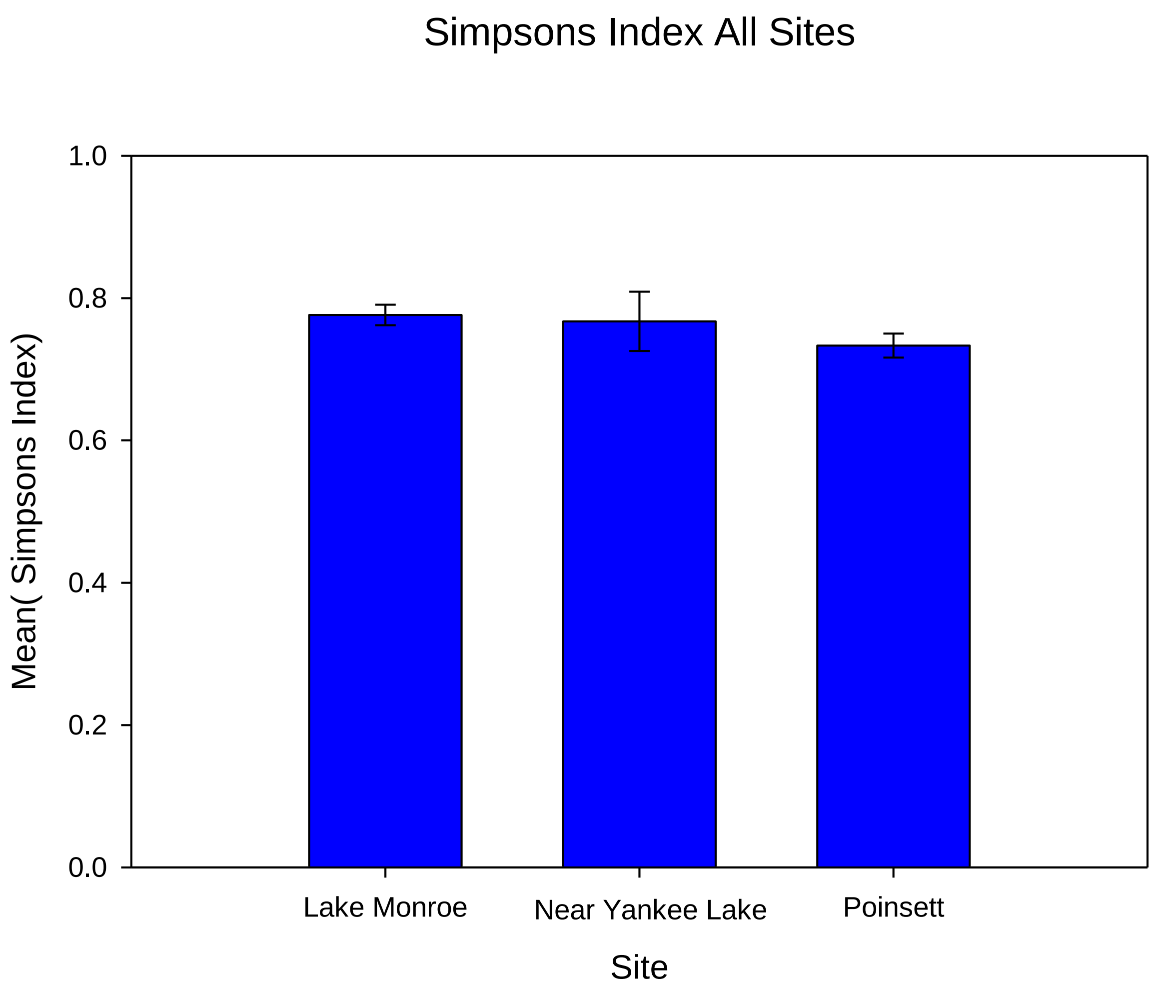


Appendix 1 (Figures 79-96)

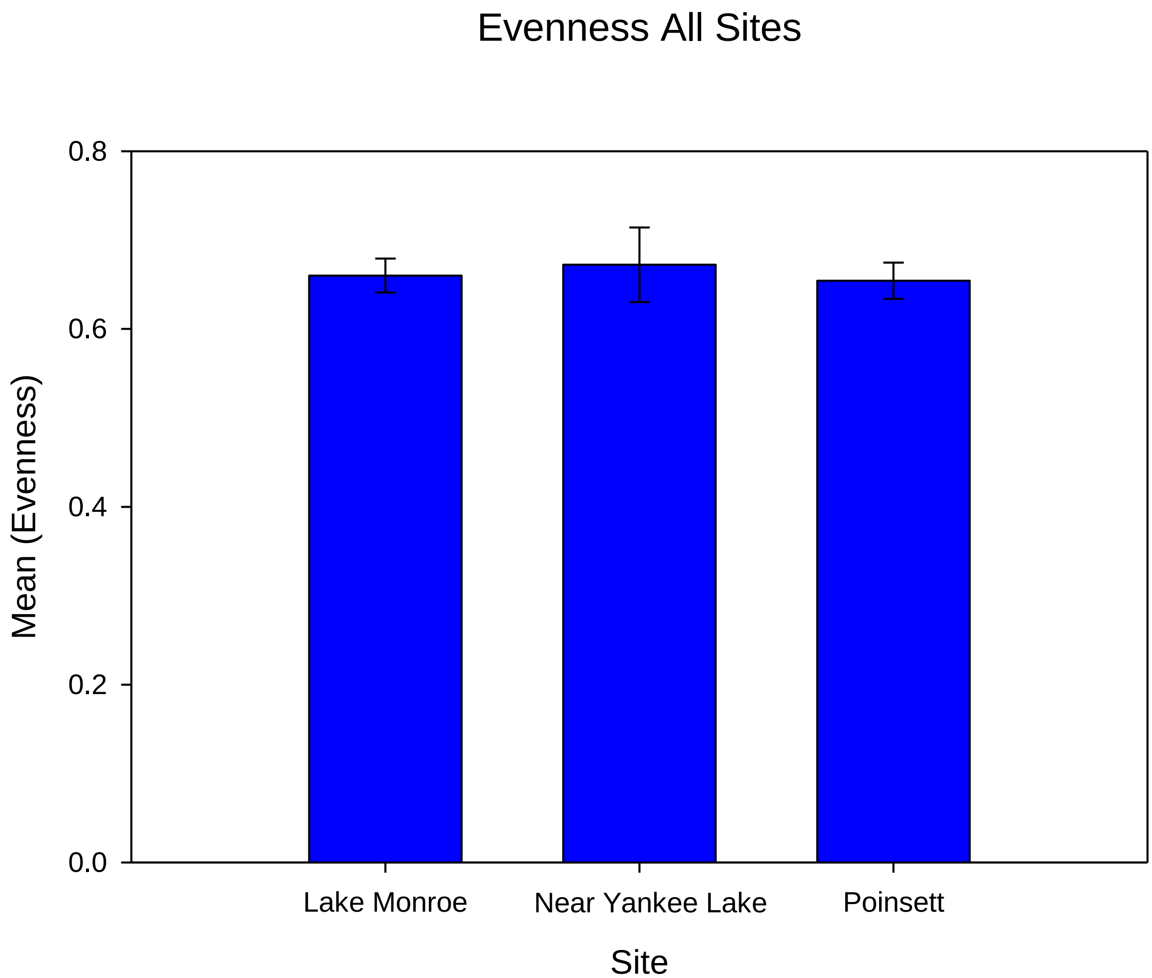
Figures 79. Shannon Diversity at all sites



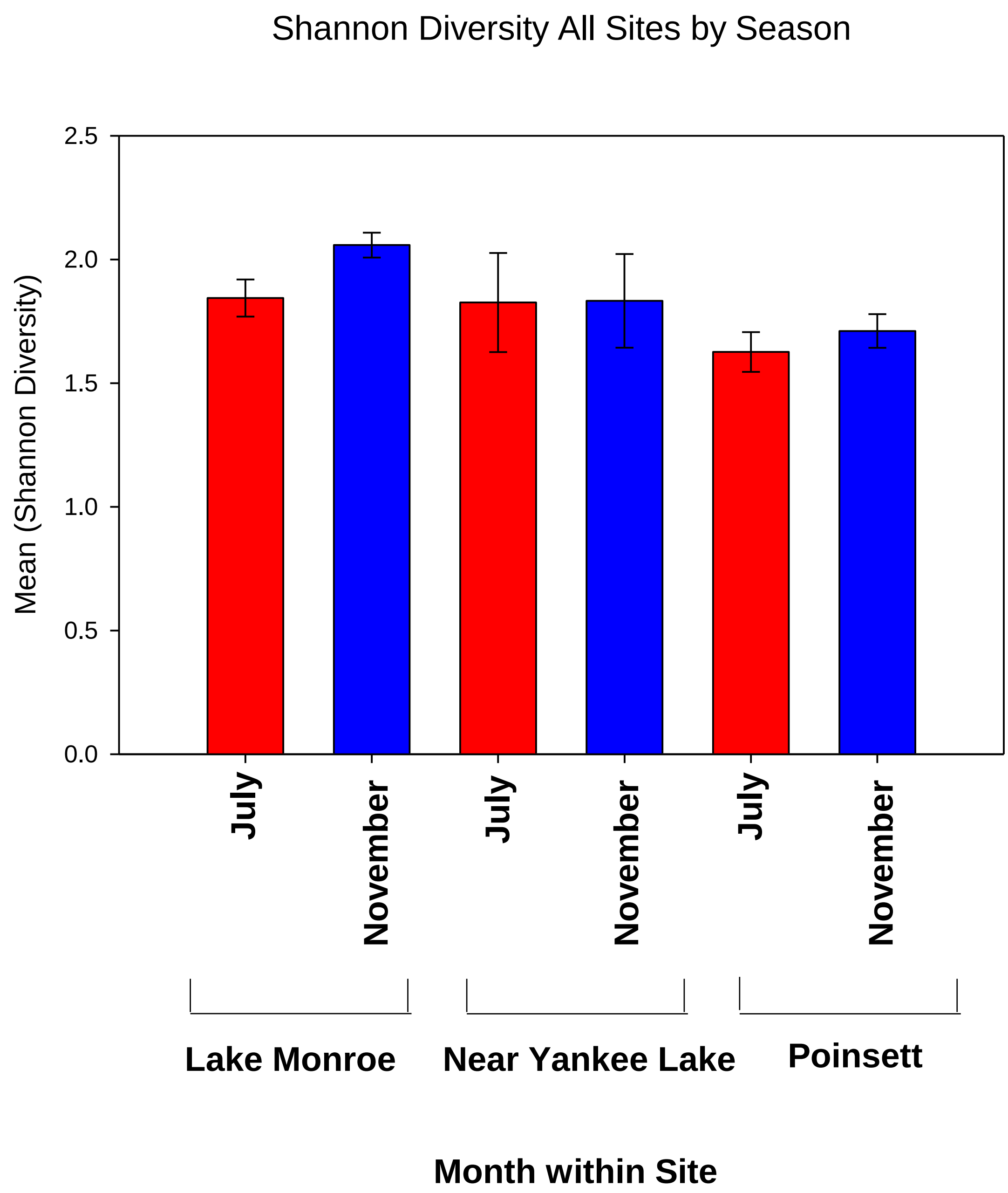
Figures 80. Simpsons Index at all sites



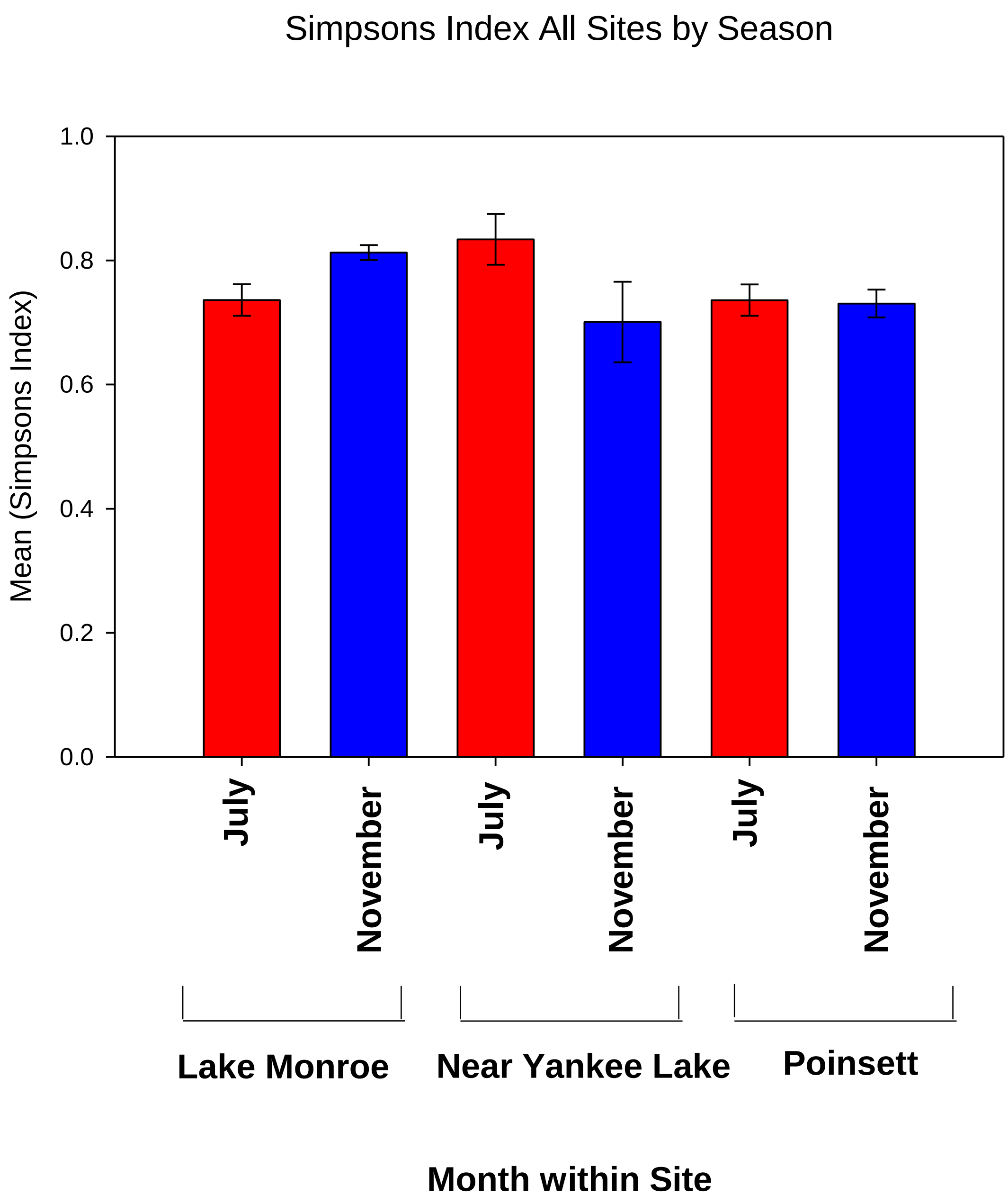
Figures 81. Evenness at all sites



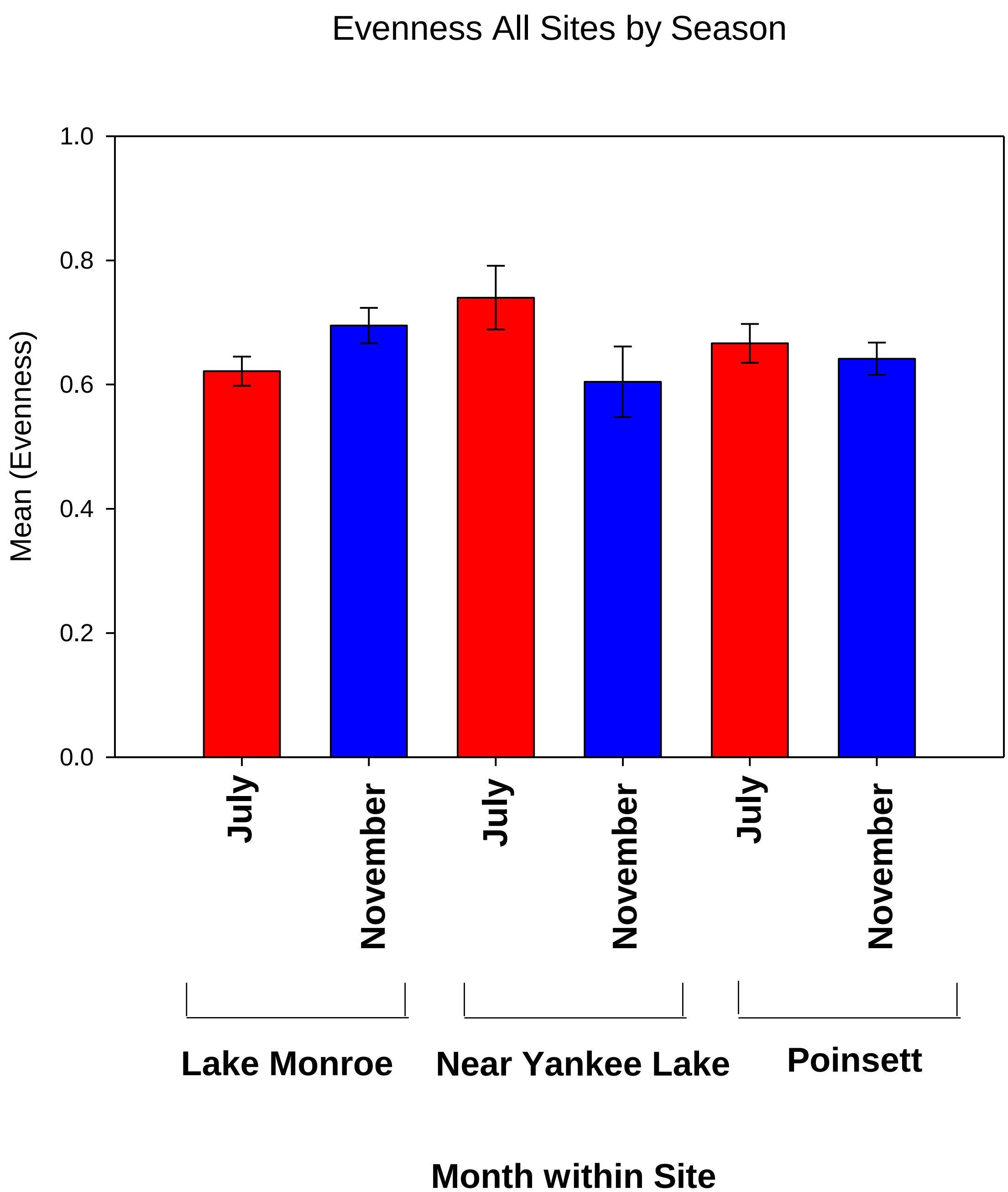
Figures 82. Shannon Diversity at all sites by season



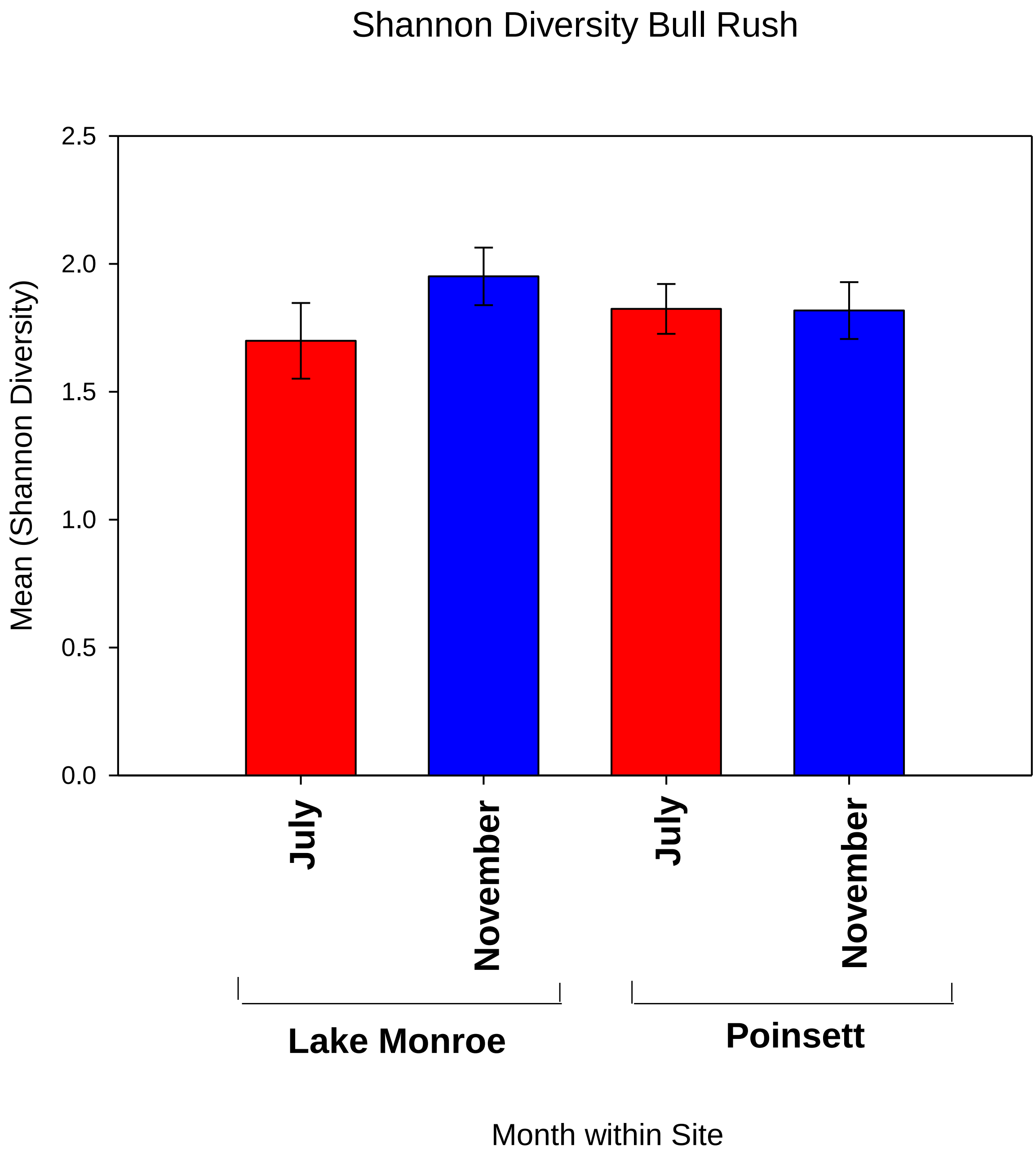
Figures 83. Simpsons Index at all sites by season



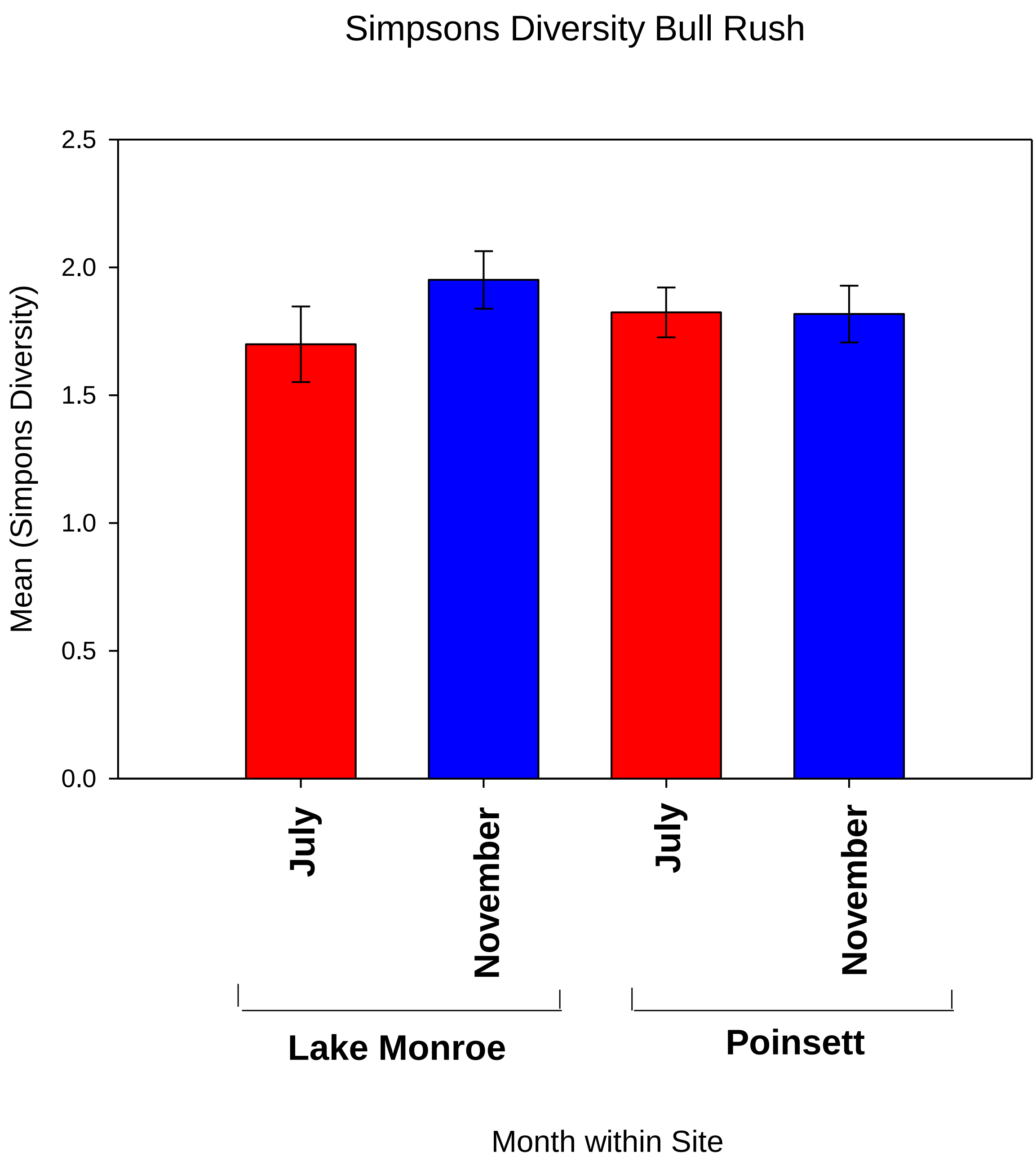
Figures 84. Evenness at all sites by season



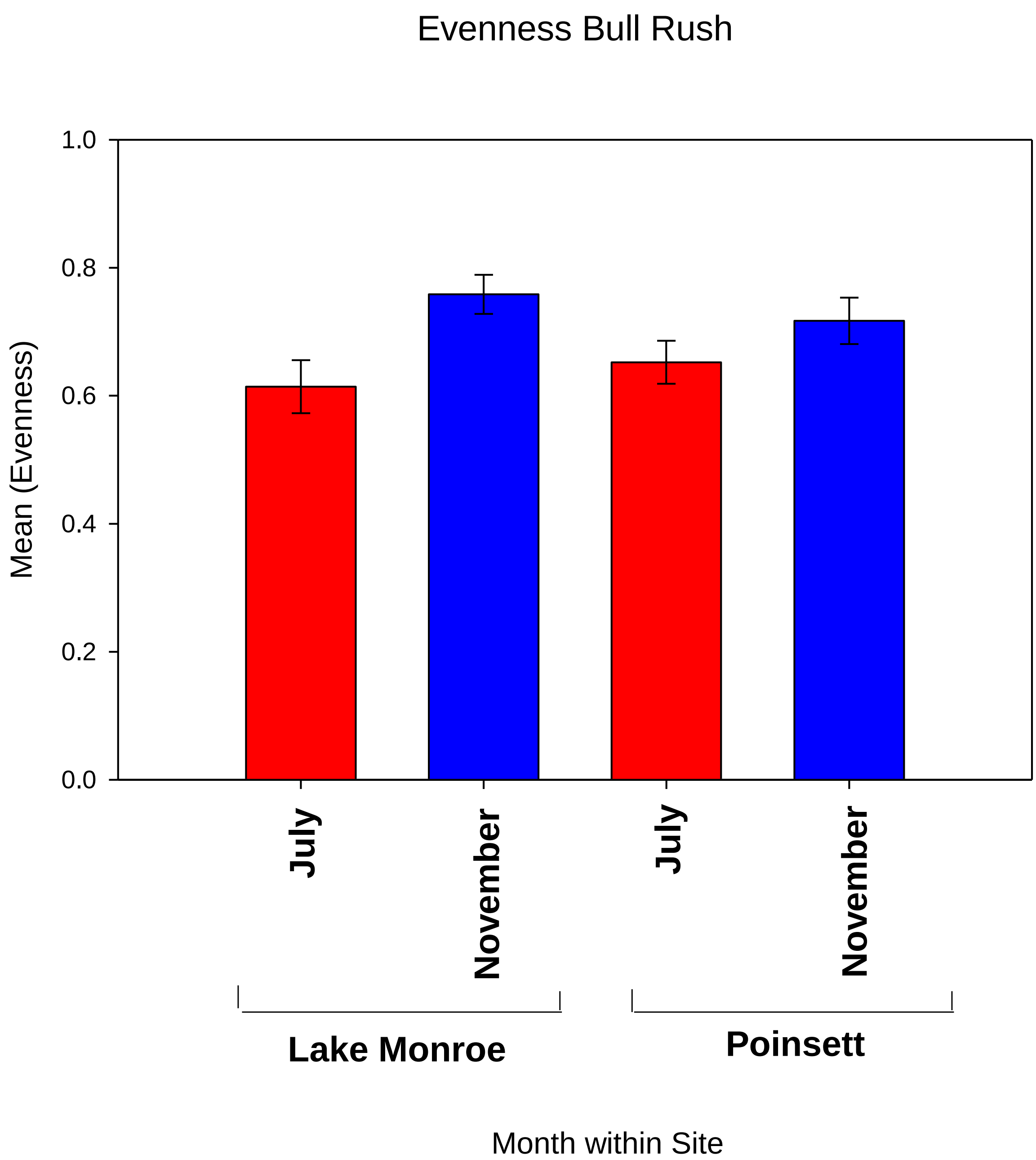
Figures 85. Shannon Diversity at Bull Rush



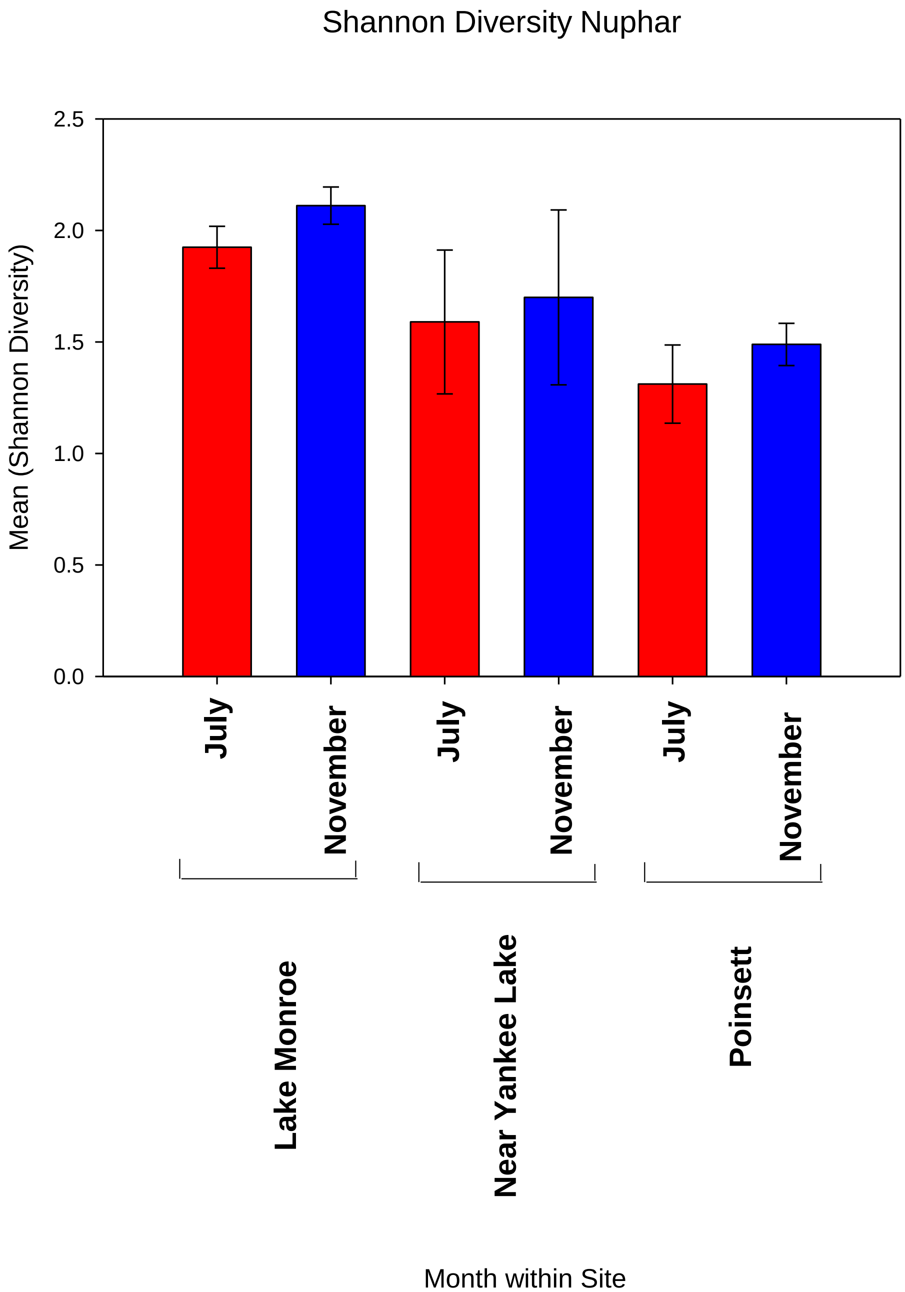
Figures 86. Simpson Index at Bull Rush



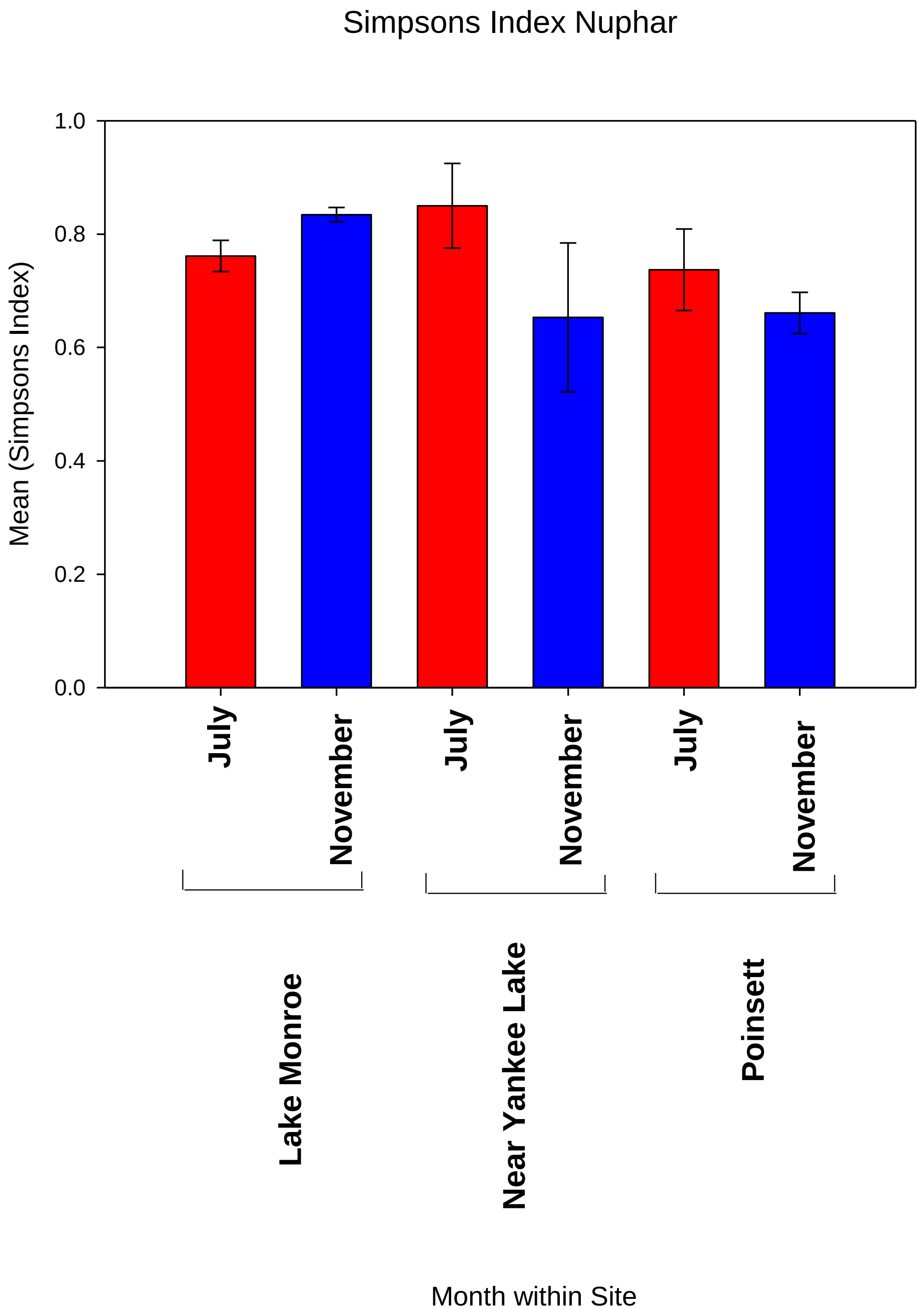
Figures 87. Evenness at Bull Rush



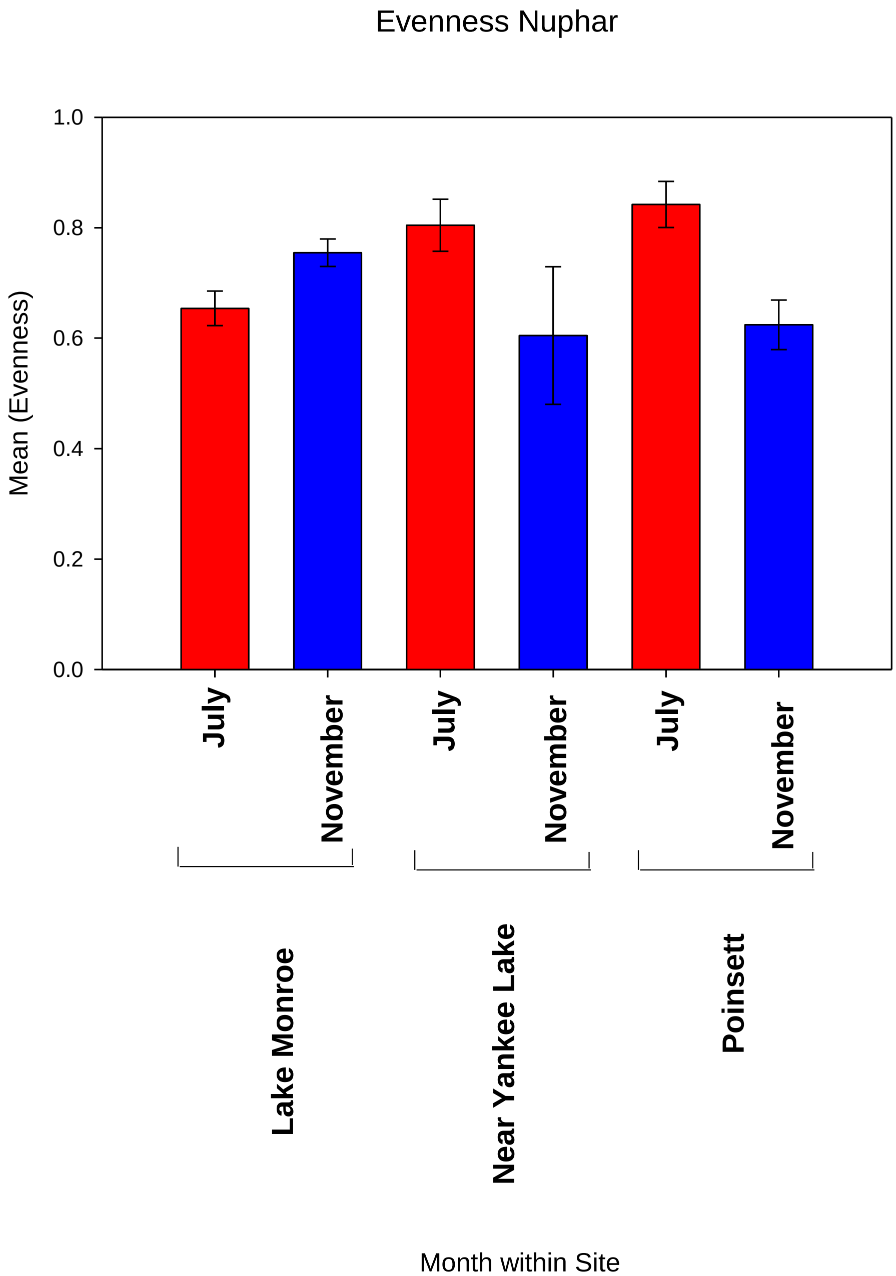
Figures 88. Shannon diversity at Nuphar



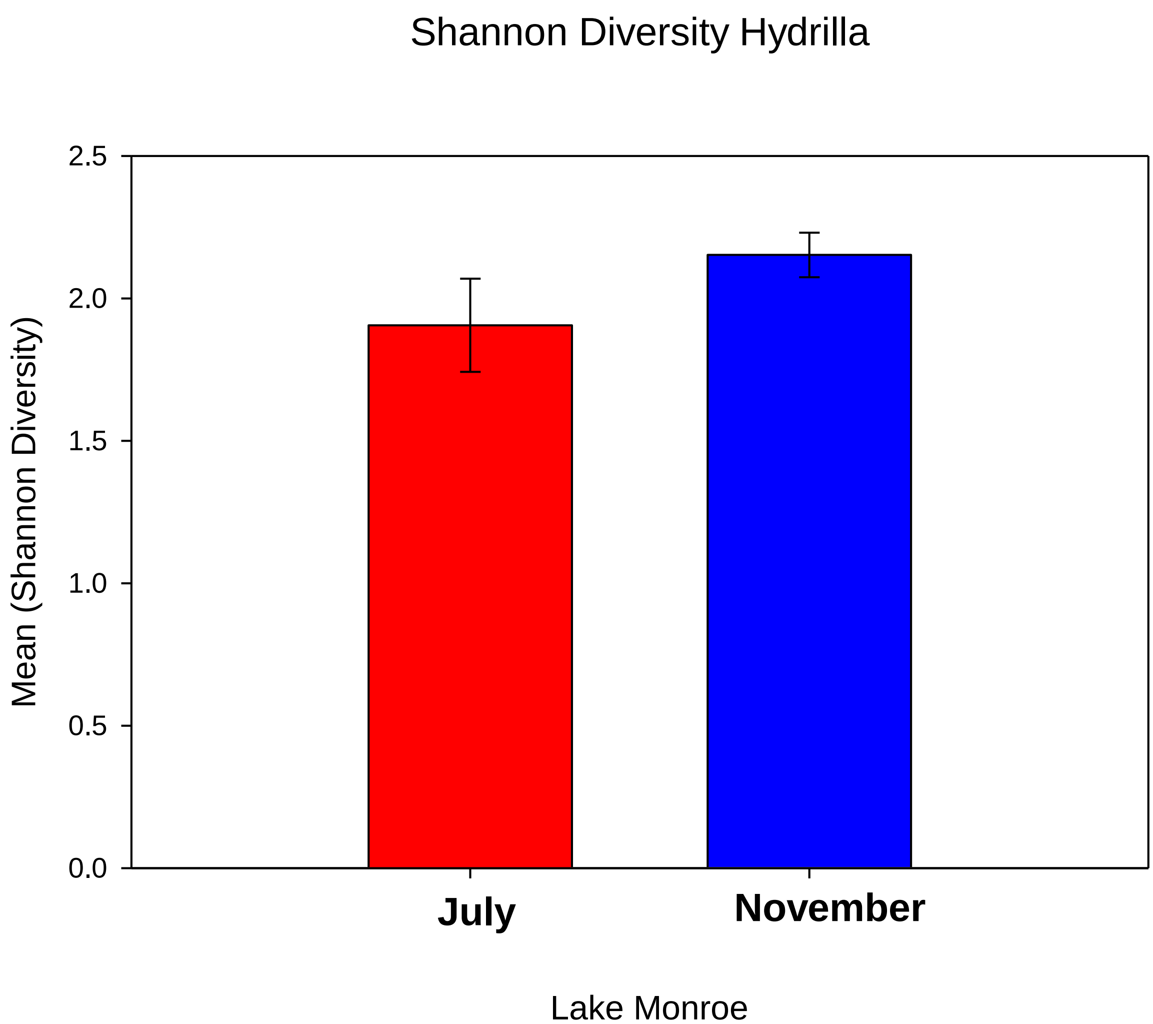
Figures 89. Simpsons index at Nuphar



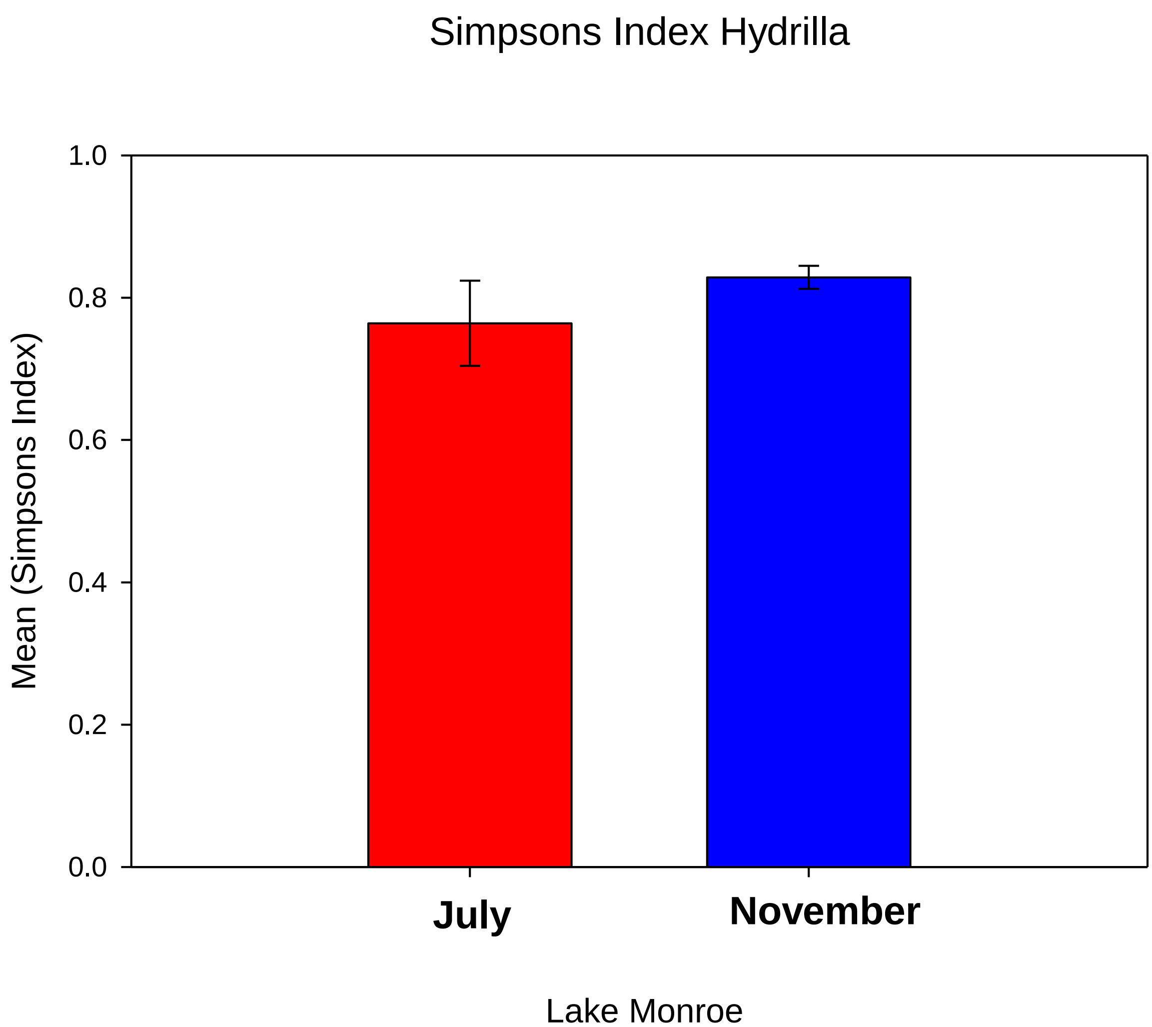
Figures 90. Evenness at Nuphar



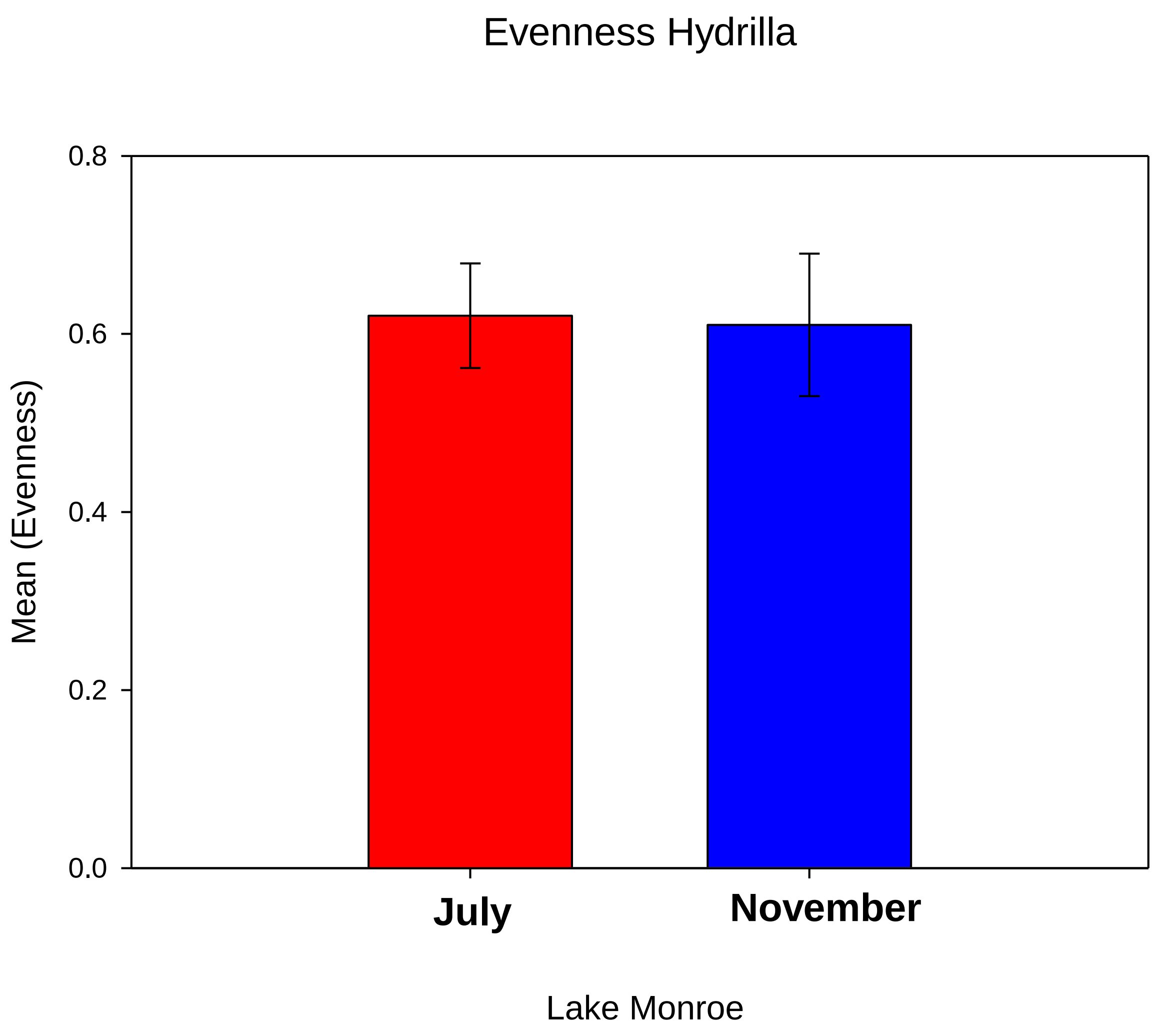
Figures 91. Shannon Diversity at Hydrilla



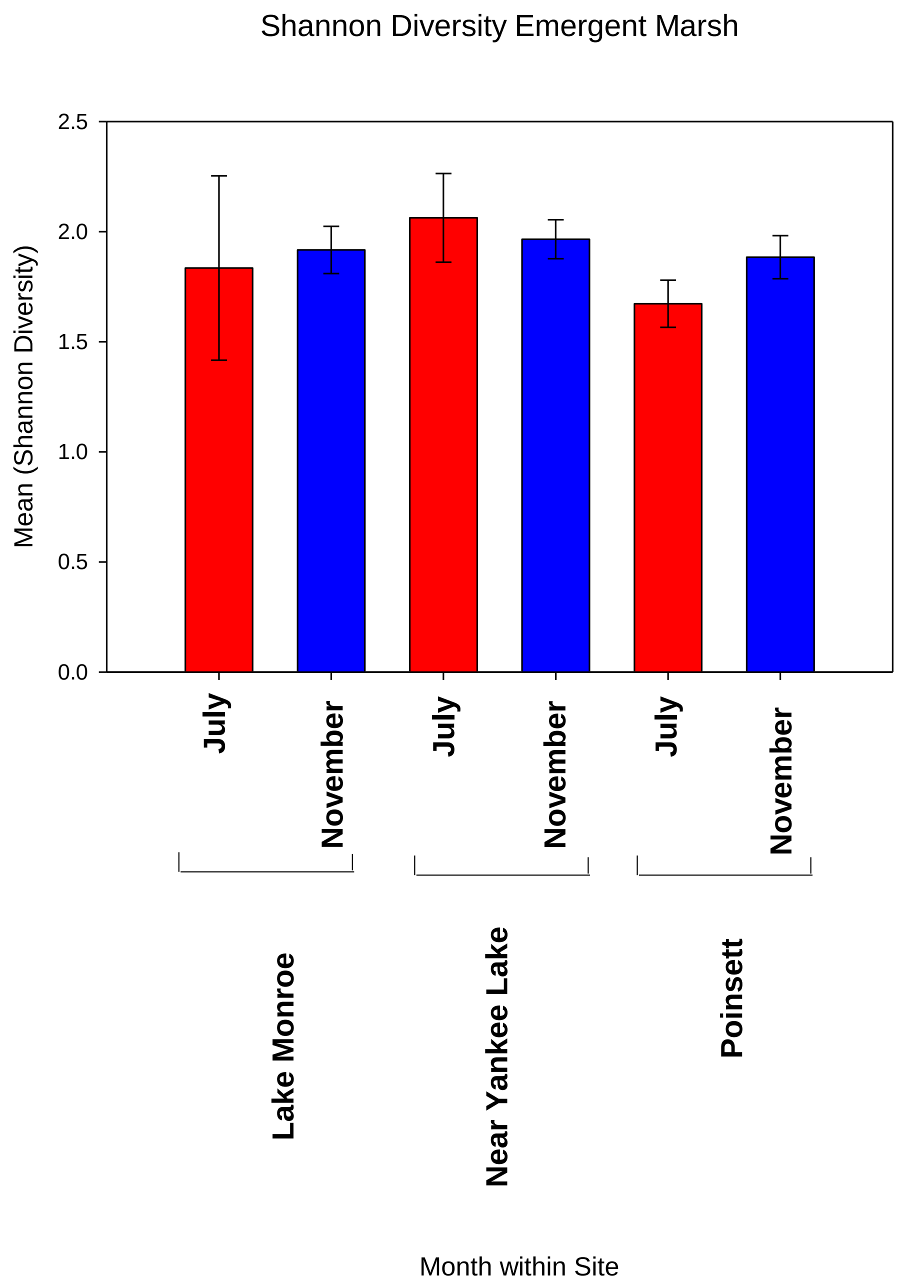
Figures 92. Simpsons Index at Hydrilla



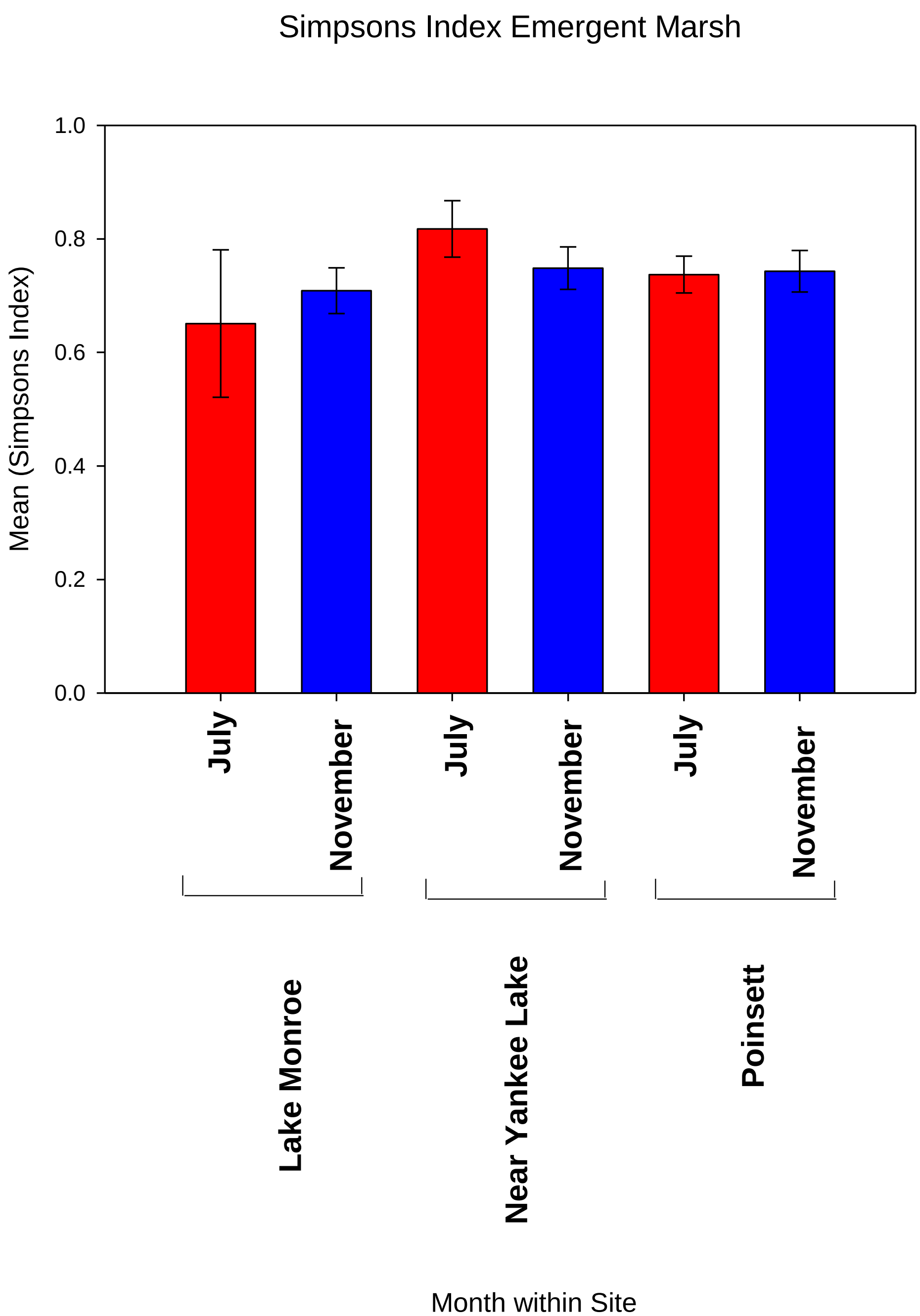
Figures 93. Evenness at Hydrilla



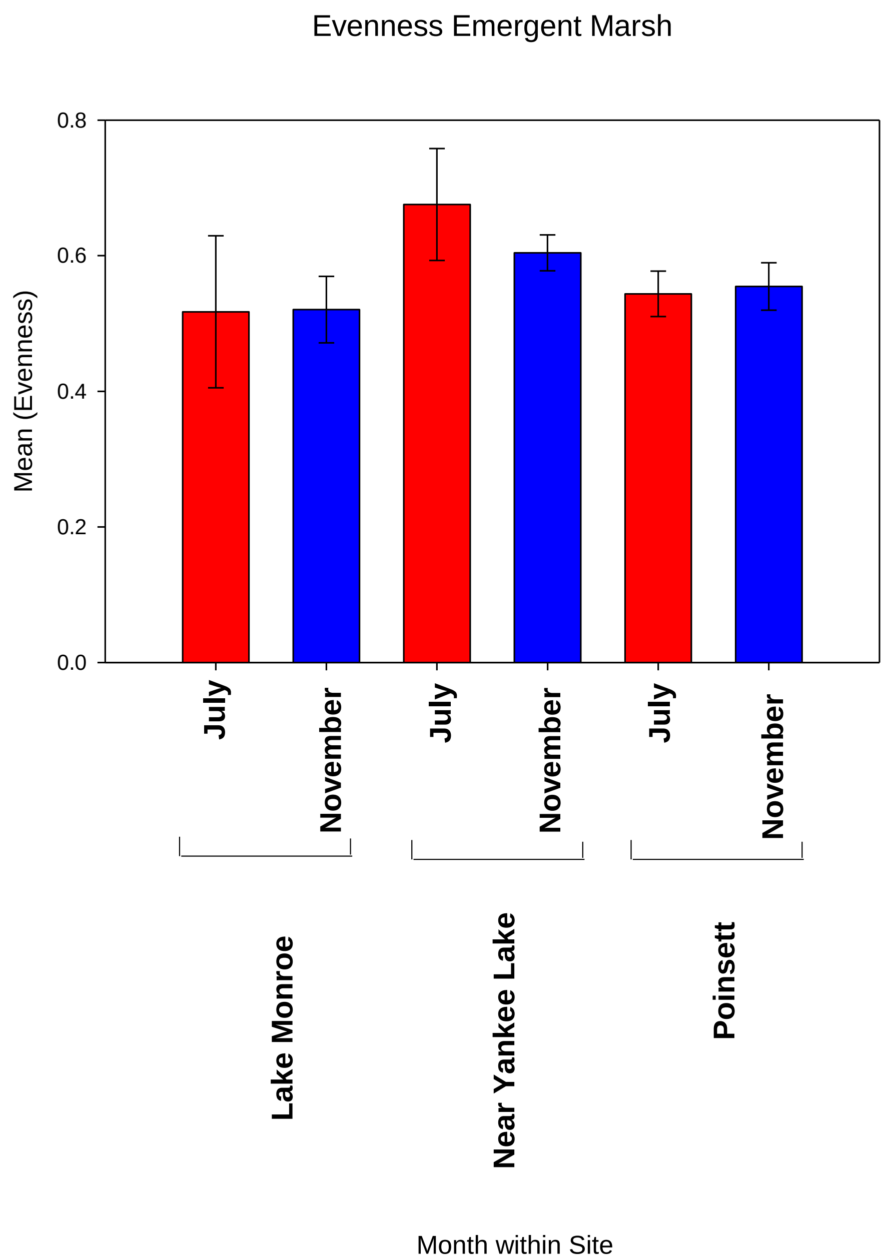
Figures 94. Shannon Diversity at Emergent Marsh



Figures 95. Simpsons Index at Emergent Marsh

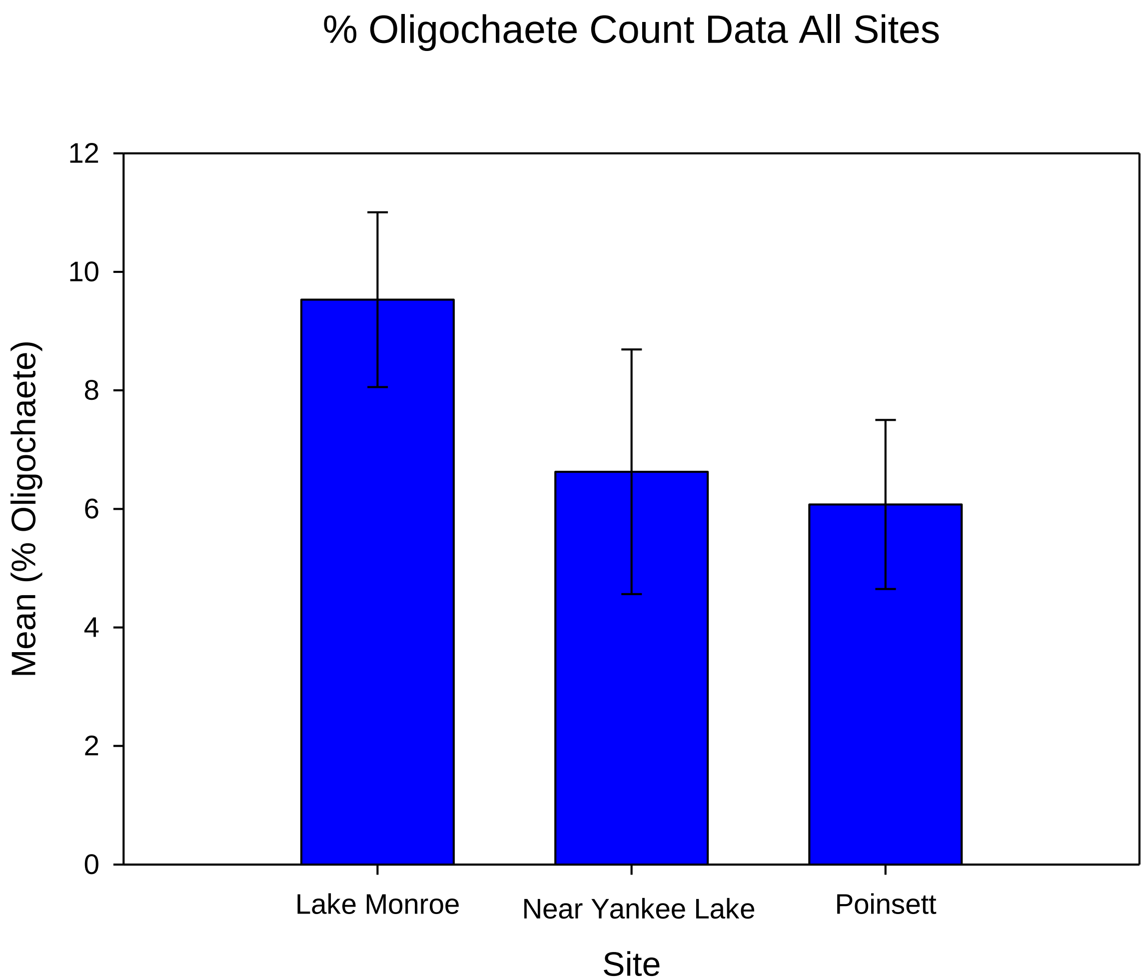


Figures 96. Evenness at Emergent Marsh

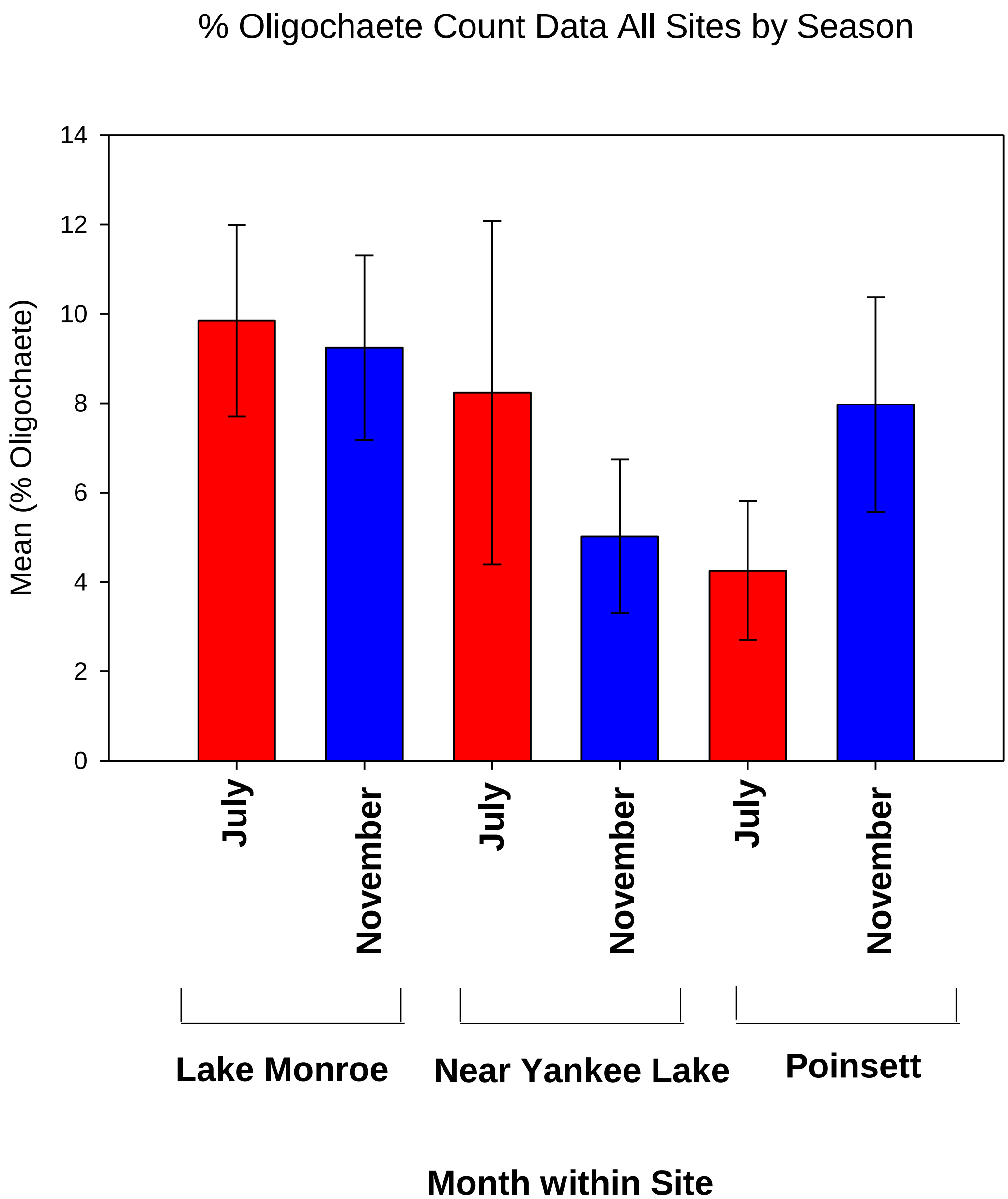


Appendix 2 (Figures 97-102)

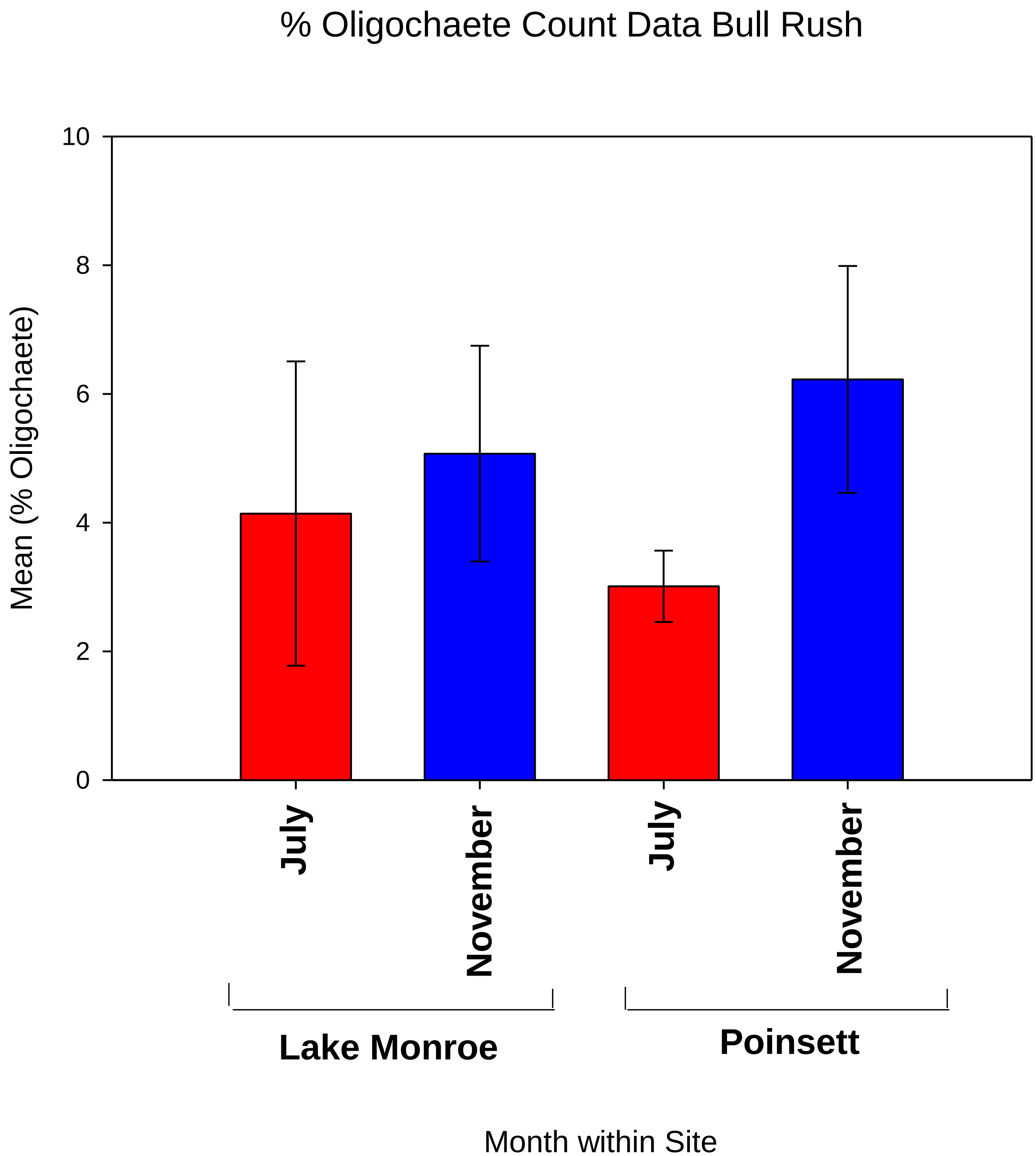
Figures 97. % Oligochaete at All Sites



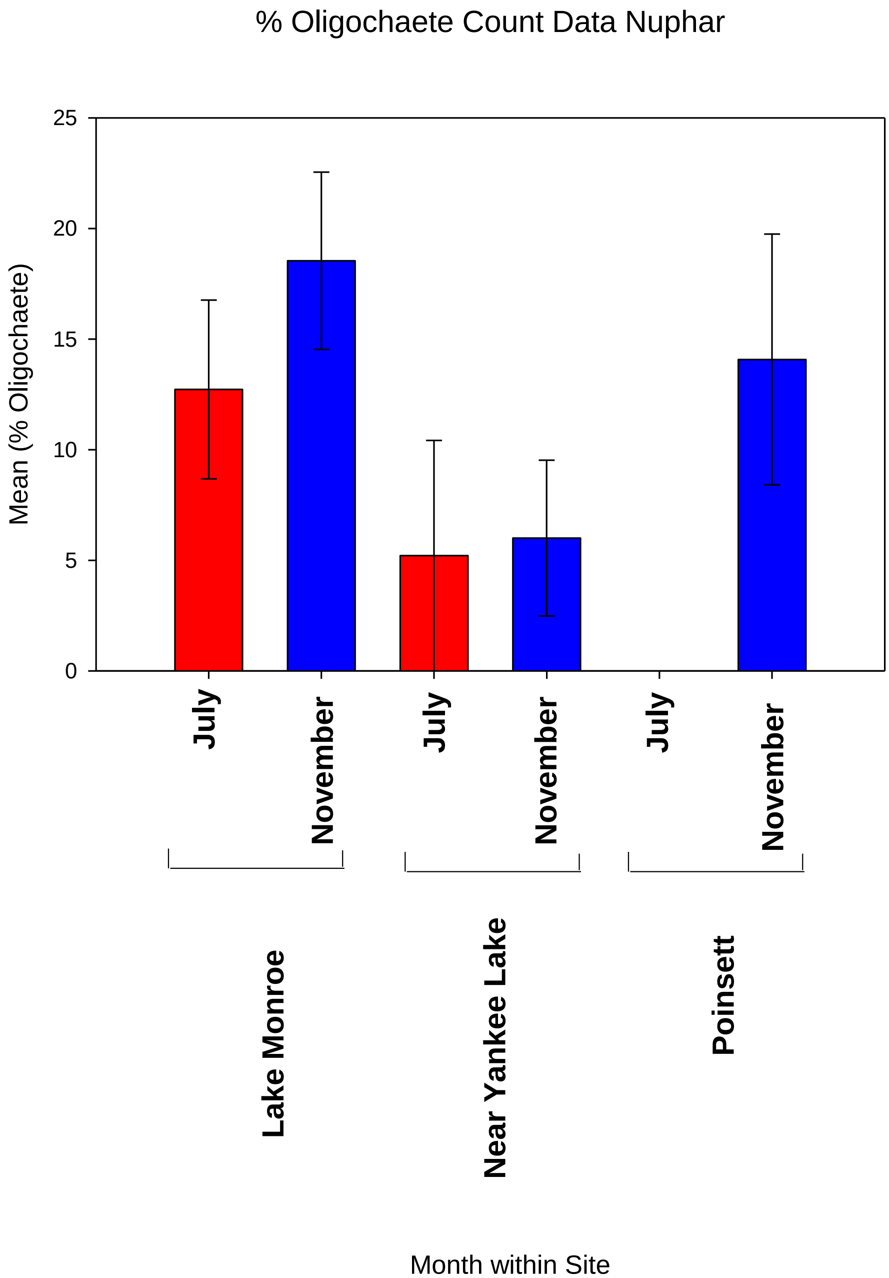
Figures 98. % Oligochaete at All Sites by Season



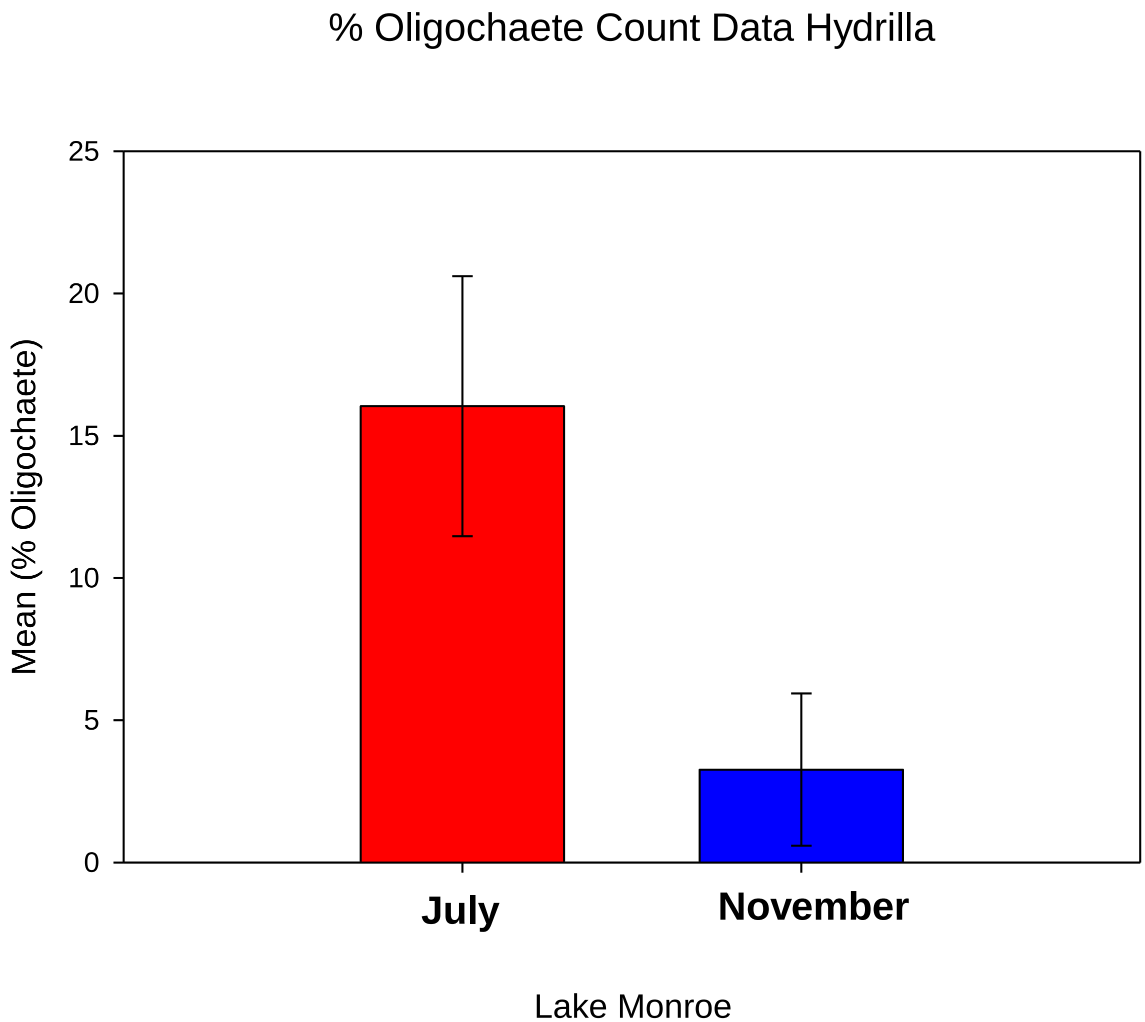
Figures 99. % Oligochaete at Bull Rush



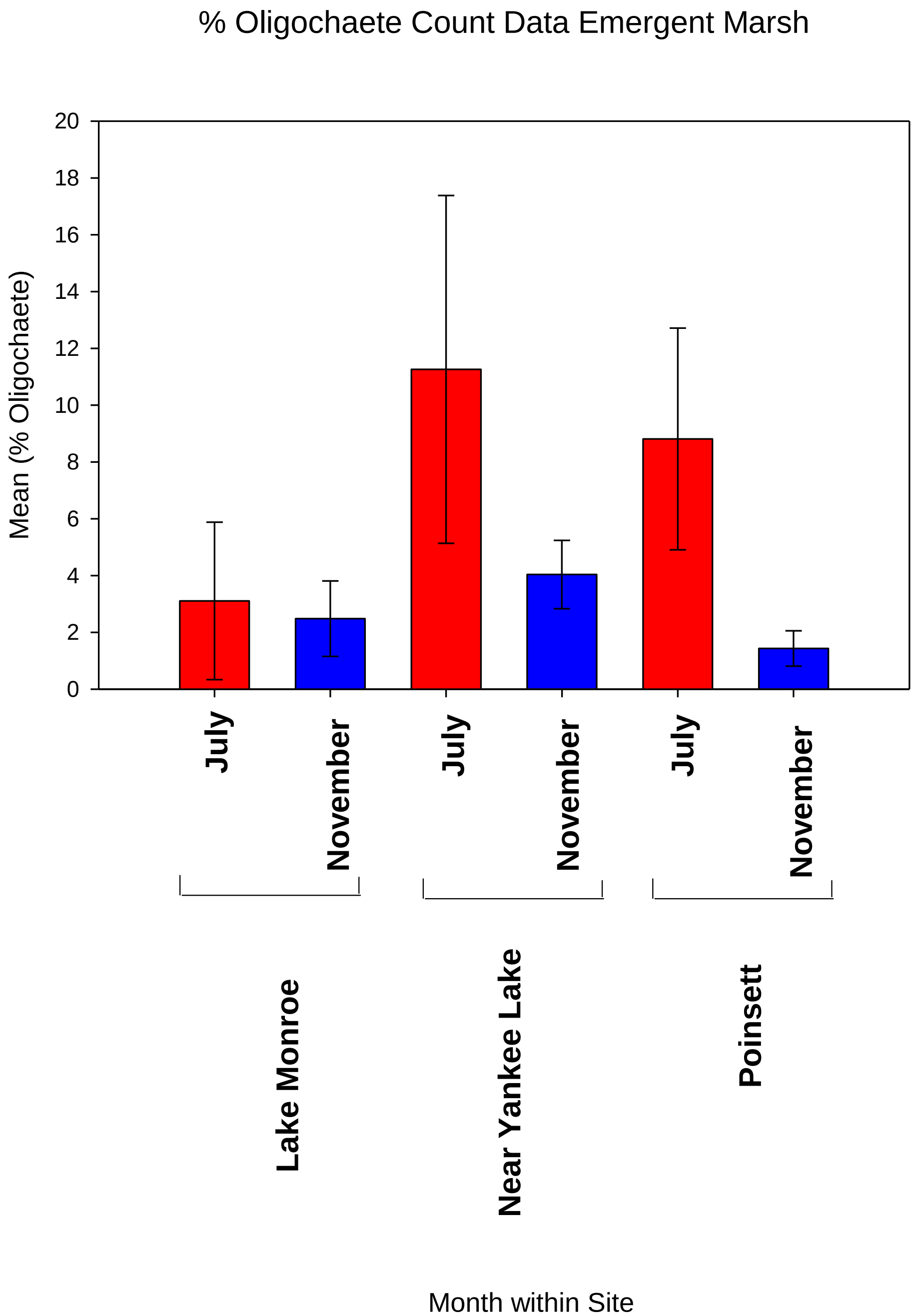
Figures 100. % Oligochaete at Nuphar



Figures 101. % Oligochaete at Hydrilla

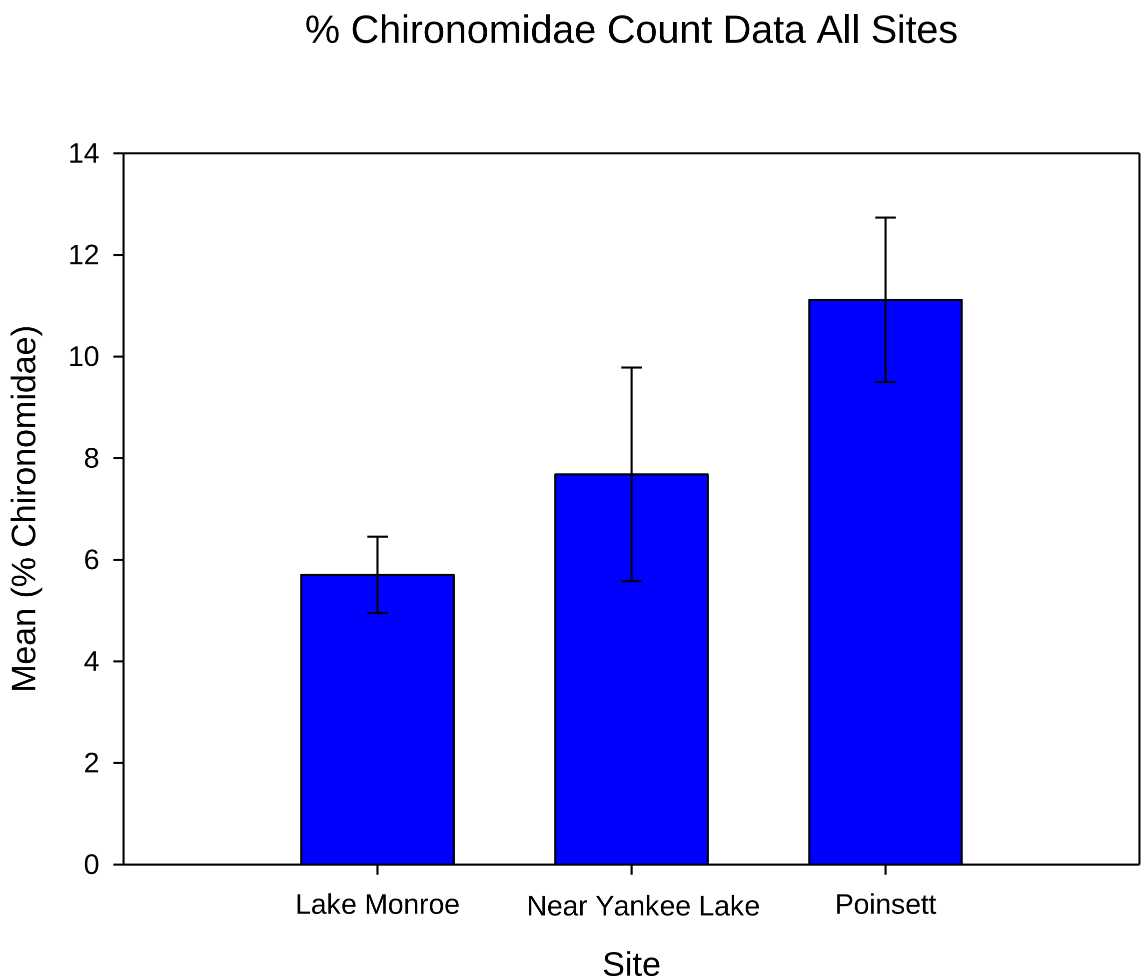


Figures 102. % Oligochaete at Emergent Marsh

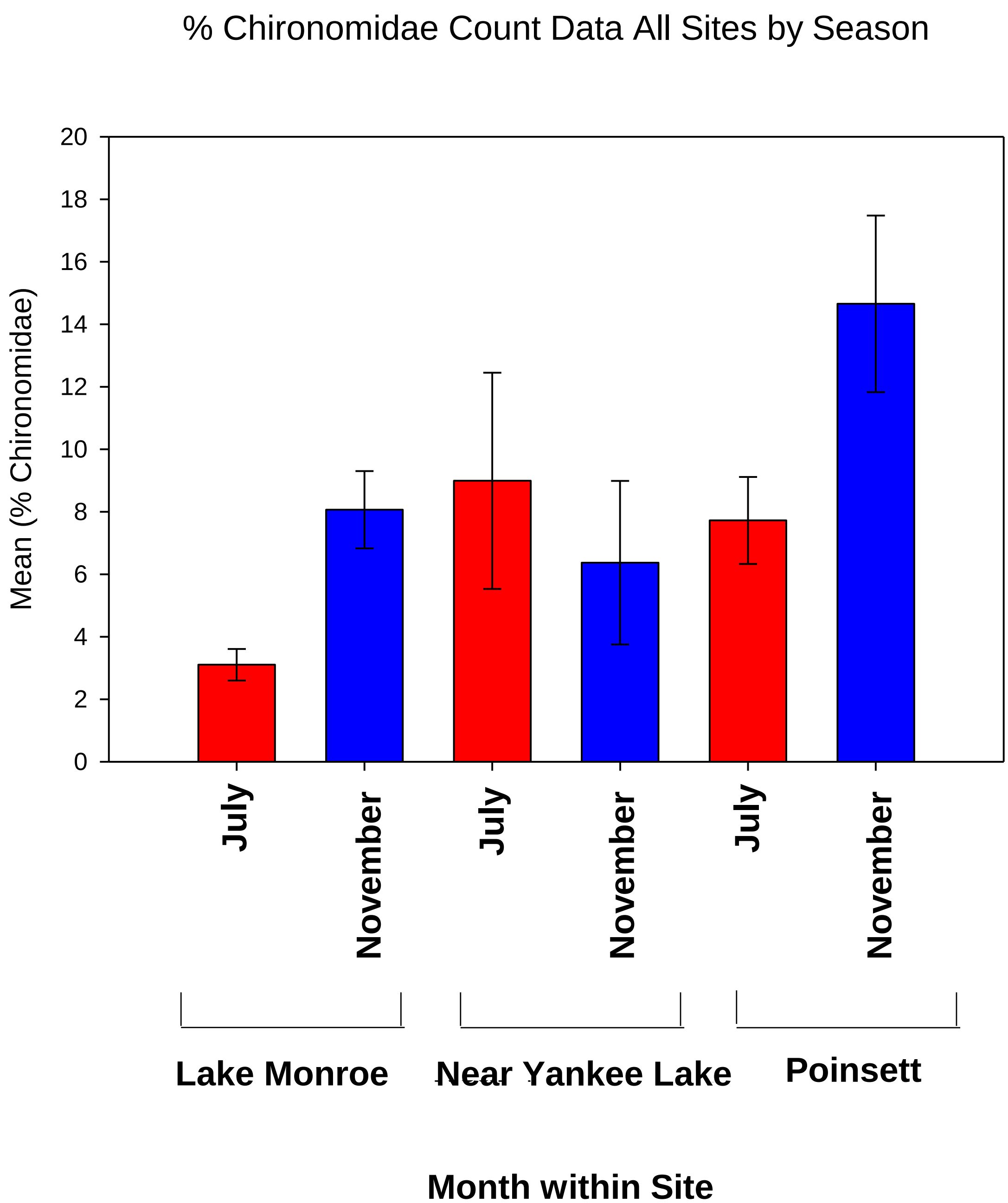


Appendix 3

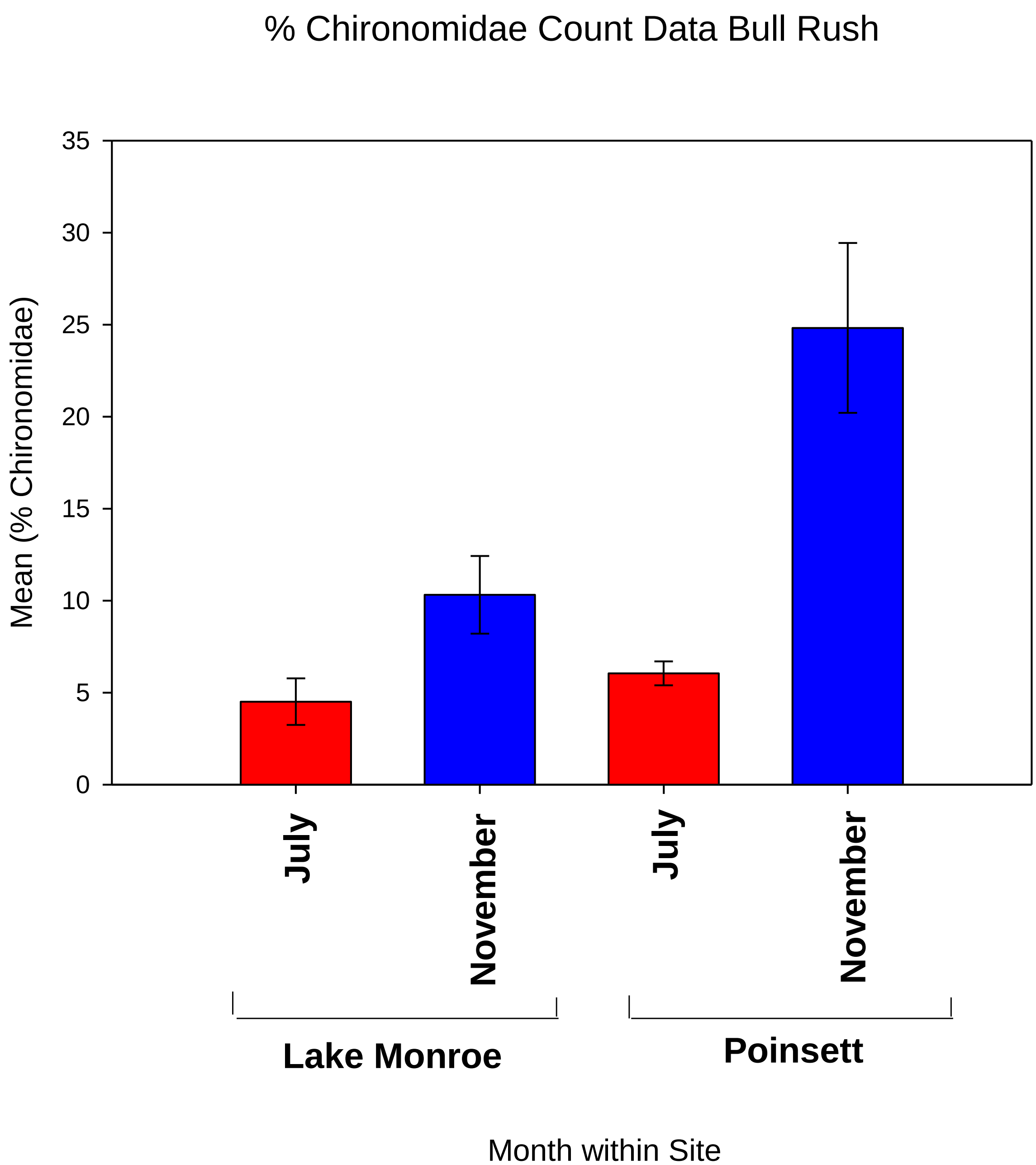
Figures 103. % Chironomidae at All Sites



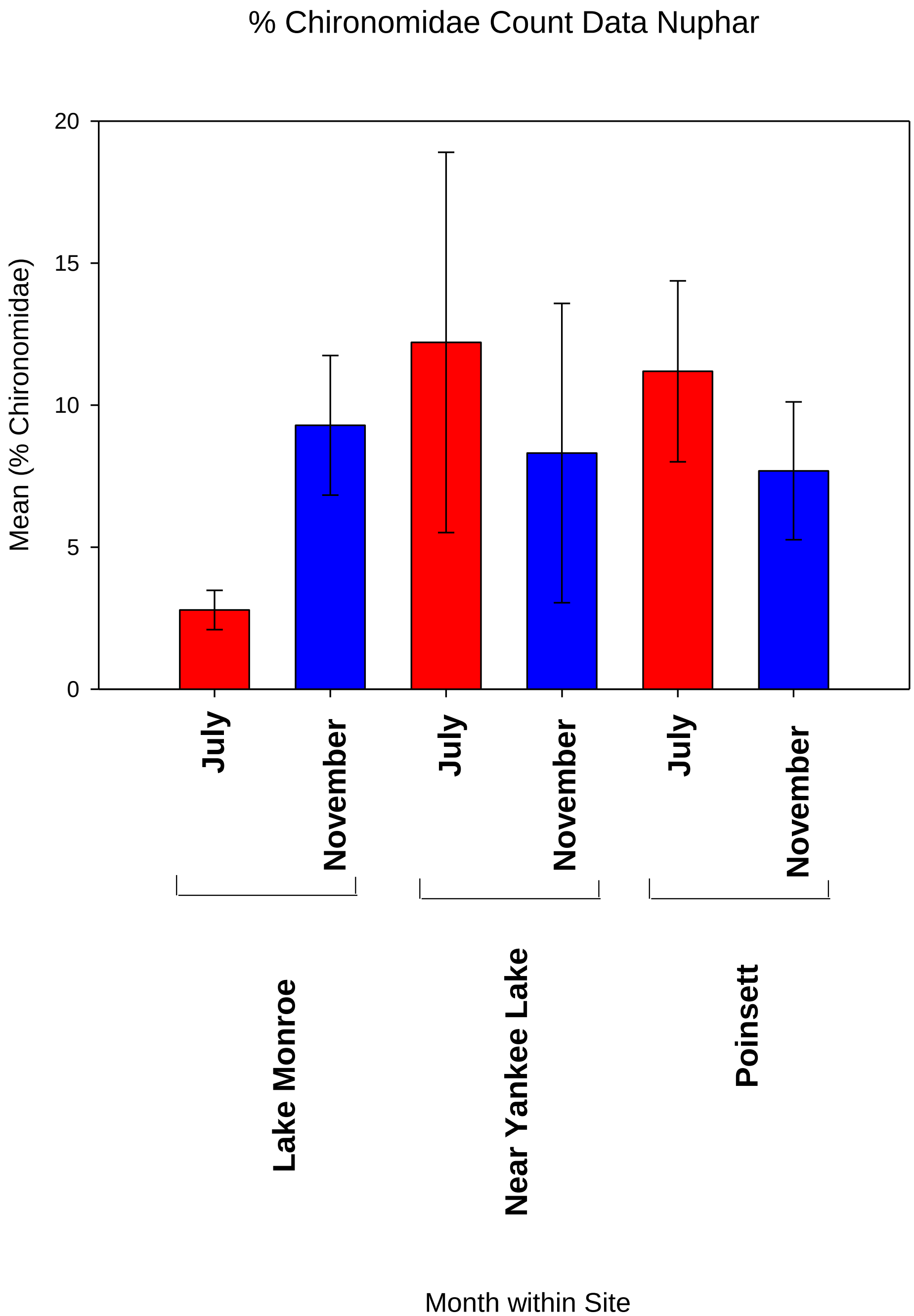
Figures 104. % Chironomidae at All Sites by Season



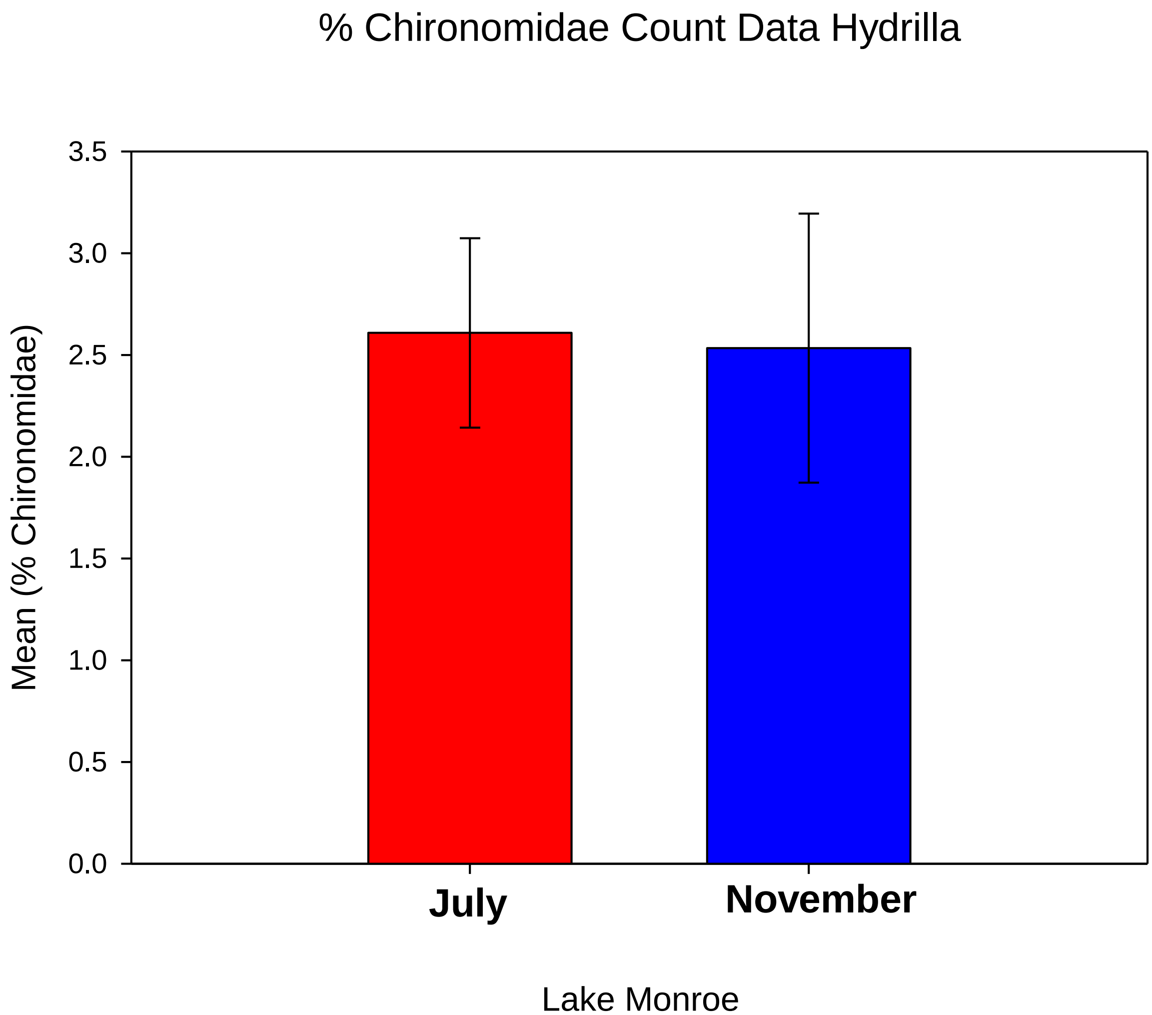
Figures 105. % Chironomidae at Bull Rush



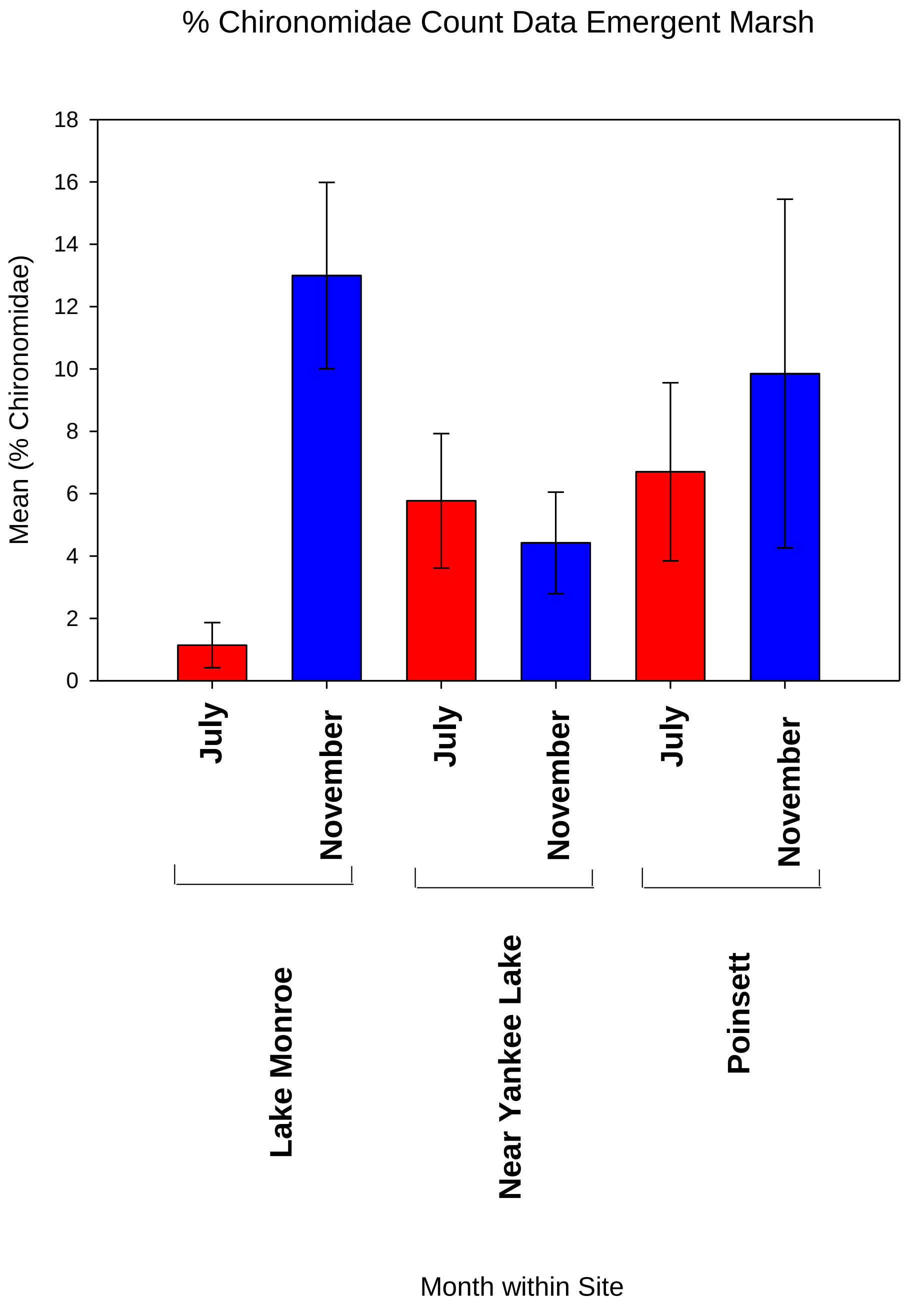
Figures 106. % Chironomidae at Nuphar



Figures 107. % Chironomidae at Hydrilla



Figures 108. % Chironomidae at Emergent Marsh



Appendix 11.D Table 1. Functional Feeding Group (FFG) designations and sites where they were collected for each macroinvertebrate taxon from the St Johns River. PR=predator, SC= scraper, PA= parasitic, CF= collector-filterer, CG= collector-gatherer, SH-DT= shredder-detrital, PR= predator, HB-PI= herbivore-piercer, SH-HB= shredder herbivore.

		Monroe		Near Yankee Lake		Poinsett	
Taxa	FFG	July	November	July	November	July	November
Cnidaria							
Anthomedusae							
Hydridae							
Hydra	PR	×	×			×	
Platyhelminthes							
Turbellaria	SC	×	×				
Nematoda	PA		×		×		×
Mollusca							
Gastropoda	SC					×	
Hydrobiidae	SC	×					
Viviparidae	SC				×		
Planorbidae	SC	×	×	×	×	×	×
Helisoma	SC		×				×
Gyraulus	SC						×
Prosobranchia	SC	×	×	×		×	×
Ancylidae	SC	×	×	×	×	×	×
Physidae	SC	×	×		×	×	×
Physa	SC	×					
Lymnaeidae	SC		×		×		×
Bivalvia	CF						
Unionidae	CF						×
Sphaeriidae	CF						
Pisidium	CF		×	×			×
Annelida							
Oligochaeta	CG	×	×	×	×	×	×
Hirudinea	PR	×	×	×			×
Crustacea							
Ostracoda	CF	×	×	×	×	×	×
Cladocera	CF	×	×	×	×	×	×
Copepoda	CG	×	×	×	×	×	×
Argulus	CG	×					
Harpacticoida	CG		×			×	×
Amphipoda							
Hyalella	SC	×	×	×	×	×	×
Isopoda							

		Monroe		Near Yankee Lake		Poinsett	
Taxa	FFG	July	November	July	November	July	November
Asellidae	SH-DT	×	×	×	×	×	×
Decapoda	PR	×			×		
Cambaridae	SH-DT/PR	×	×			×	×
Palaemonidae							
Palamonetes	SH-DT	×	×	×	×	×	×
Collembola	CG	×	×		×	×	×
Arachnida							
Araneae	PR	×	×	×	×	×	×
Acari	CG	×	×	×	×	×	×
Hydracarina	CG	×				×	
Insecta (aquatic)							
Ephemeroptera							
Baetidae	CG	×					
Callibaetis	CG	×	×	×	×	×	×
Caenidae	CG						
Caenis	CG	×	×	×	×	×	×
Odonata							
Anisoptera	PR	×	×	×		×	×
Aeshnidae	PR	×	×		×		
Coryphaeschna	PR		×				
Macromiidae	PR						×
Corduliidae	PR		×		×		
Somatochlora	PR						×
Libellulidae	PR	×	×			×	
Erythemus	PR		×				×
Libellula	PR	×					
Pachydiplax	PR	×					×
Sympetrum	PR		×				×
Zygoptera	PR						
Coenagrionidae	PR	×	×	×	×	×	×
Enallagma	PR	×					
Ischnura	PR	×	×	×		×	
Hemiptera							
Hydrometridae	PR-PI						
Hydrometra	PR-PI	×	×			×	
Belostomatidae	PR-PI	×					×
Belastoma	PR-PI	×	×			×	×
Lethocerus	PR-PI		×				
Nepidae	PR-PI						
Ranatra	PR-PI	×	×	×		×	×
Pleidae	PR-PI		×				
Paraplea	PR-PI				×	×	×

		Monroe		Near Yankee Lake		Poinsett	
Taxa	FFG	July	November	July	November	July	November
Naucoridae	PR-PI						
Ambrysus	PR-PI		×				
Pelocoris	PR-PI	×	×				
Corixidae	HB-PI	×	×			×	
Trichocorixa	PR-PI	×	×				
Mesoveliidae	PR-PI						
Mesovelia	PR-PI	×	×	×	×	×	×
Hebridae	PR-PI	×	×			×	×
Trichoptera							
Polycentropodidae	CF					×	×
Cyrnelus	CF	×				×	×
Hydroptilidae	HB-PI	×	×			×	
Orthotrichia	HB-PI	×	×		×		×
Oxyethira	HB-PI	×					
Leptoceridae	CG					×	
Nectopsyche	SH-HB	×	×				
Oecetis	PR	×	×	×		×	×
Lepidoptera	SH-HB						
Crambidae	SH-HB		×				
Argyractis	SH-HB		×				
Noctuiidae	SH-HB	×	×		×	×	×
Bellura	SH-HB	×		×		×	
Pyralidae							
Parapoynx	SH-HB	×	×		×		
Coleoptera							
Haliplidae	SH-HB						
Peltodytes	SH-HB		×			×	
Dytiscidae	PR	×	×			×	
Acilius	PR					×	
Agabus	PR					×	
Celina	PR					×	
Desmopachria	PR					×	
Liodessus	PR		×				
Thermonectus	PR-PI						×
Noteridae	PR	×					
Hydrocanthus	PR	×	×			×	×
Suphis	PR		×			×	
Suphisellus	PR		×			×	×
Ptilidae	SC					×	
Hydrophilidae (larvae)	PR	×			×	×	×
Hydrophilidae (adults)	CG	×			×	×	×
Berosus	HB-PI	×				×	×
Derallus	CG					×	×

		Monroe		Near Yankee Lake		Poinsett	
Taxa	FFG	July	November	July	November	July	November
Enochrus	CG						×
Paracymus	HB-PI	×					
Tropisternus	PR			×		×	
Hydraenidae	PR	×	×		×	×	×
Chrysomelidae	SH-HB						×
Diptera							
Ceratopogonidae		×	×				×
Forcipomyia	CG	×	×				×
Mallochohelea	PR	×	×				
Probezzia	PR		×				×
Chaoboridae	PR						×
Chaoborus	PR		×				×
Chironomidae		×	×	×	×	×	×
Culicidae							
Aedes	CF					×	
Anopholes	CF		×			×	
Culex	CF	×	×				
Mansonia	CG		×				
Uranotaenia	CF					×	
Psychodidae	CG		×				×
Simuliidae	CF		×				
Stratiomyidae	CG	×	×	×	×	×	×
Odontomyia	CG	×	×			×	
Ephydridae	CG		×			×	×
Cirrula	SH-HB	×					
Sciomyzidae	PR		×				
Insecta (terrestrial)							
Thysanoptera							
Thripidae		×	×			×	×
Psocoptera		×				×	
Orthoptera							
Gryllus						×	
Hemiptera							
Fulgoridae		×					×
Reduviidae						×	×
Cicadellidae						×	
Alydidae							×
Aphididae			×		×	×	×
Cercopidae			×				
Pentatomidae		×					×
Lepidoptera							×
Geometridae							×

		Monroe		Near Yankee Lake		Poinsett	
Taxa	FFG	July	November	July	November	July	November
Coleoptera							
Anthicidae						×	×
Coccinellidae					×		
Curculionidae		×	×		×	×	×
Staphylinidae		×	×				×
Hymenoptera		×	×		×	×	×
Diapriidae			×				
Formicidae			×			×	