Lukas Bell-Dereske
EEB 320
Professor Amy Schrank
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The Prevalence of Different Species of Fish in Four Different Habitats of Douglas Lake

Abstract

How fish abundance and diversity varies with habitats is very important for understanding the biota in aquatic systems. We studied how fish abundance and diversity varied with habitat in Douglas Lake during mid to late summer. Our habitat types were sandy (Big Shoal), cobbled (Boat-well), vegetated (Hook Point), and woody (Grapevine Point) because they are the most prevalent on Douglas Lake. At each site, we set out a line of five minnow traps and collected the fish every two days, three times.

We found that there was a trend of the vegetated site having the highest species diversity, richness, and abundance of fish. The sandy site had the second highest CPUE, but only contained one species of fish. The cobble and woody habitats were relatively equal in abundance, diversity, and richness. The depths of traps were relatively equal at each site, so depth had very little effect on our results. Since we found a trend toward the vegetated habitat having more species abundance, the vegetated site seems to provide the greatest amount of shelter and food of all of the sites.

Introduction

Fish choose there habitat for many reasons including predation, shelter, and amount and quality of food (Persson and Eklov 1995). Areas with a high density of vegetation are good shelters, foraging locations, and tend to have high fish abundance (Werner and Hall 1979, Werner et al. 1983, Werner and Hall 1977, Tonn 1985). For example, Centrarchids are usually found in the deep vegetated areas of lakes (Werner and Hall 1979). In Werner and Hall's 1977 study of Lawrence Lake, they found bluegill occurred above the macrophytes in the deeper littoral zone of the lake. In addition, bluegill live primarily in vegetation when there no other centrachids to compete for the habitat (Werner and Hall 1977). Vegetated habitats are the most profitable habitats for many types of fish.

Vegetated habitats offer protection from predation. For example, small yellow perch are typically found in areas of increased shelter and use their shelters more effectively when

piscivorous fish are present (Persson and Eklov 1995). Percids in Douglas Lake use vegetation to avoid predation and escape their enemies (Reighard 1915). In addition, MacRae and Jackson (2001) observed higher abundance of fishes in the vegetated habitats in the presence of piscivorous smallmouth bass.

Many fish species do a great deal of their foraging in vegetated areas. Centrachids such as sunfish and bluegill feed in vegetated areas because vegetation houses the greatest amount of food (Werner and Hall 1977). Reighard (1915) found the stomach contents of sampled bluegill to be composed mostly of leave buds taken from rooted macrophytes. Yellow perch feed on the benthic organisms in rooted macrophytes when they reach a level of maturity (Persson and Greenberg 1990). In addition, Reighard (1915) found that small yellow (2 and 1/4 inches to 6 inches) perch feed heavily in vegetated habitats in Douglas Lake. Vegetated areas are ideal in environment for foraging by fish species.

Fish habitat preferences change with life stages and some species experience ontogenetic niche shifts, such as yellow perch. For example, Persson and Greenberg (1990) found that very young yellow perch live in the pelagic zone feeding on zooplankton; once they get slightly older, they move into the littoral zone and begin to feed more on benthic organisms. Very young yellow perch can be forced into vegetated in the presence of a more efficient filter feeder fish can control the amounts of other organisms including benthic organisms and zooplankton (Bergman et al. 1994).

Whereas some species show strong habitat preferences, others such as cyprinids, seem to ubiquitous. Cyprinids tend to live and travel in schools, so they do not show as much habitat preference compared to other fish species (Reighard 1915). Cyprinids can be found in sandy or relatively unsheltered habitats because they use schooling to avoid predation (Reighard 1915).

Douglas Lake is located close to the tip of lower Michigan in Cheboygan County, at about 46° 30' N. The lake is semi-oligotrophic and temperate with a maximum depth of 89 feet. Most of the shelf of the lake is relatively shallow until a depth of 3 to 6 feet where the shelf drops off. The lake is a kettle and kame glacier formation with approximately 14 miles of shoreline. The most prominent habitat on the lake is sandy shoal (Rieghgard 1915). The bay where University of Michigan Biological Station sits is relatively undeveloped. The eastern end of Douglas Lake is heavily developed with summer homes and boat docks.

We hope to find what habitats are home to the greatest amount of fish species diversity, richness, and numbers. We hypothesize that we will find the highest species diversity of fish and the highest number of fish caught in the vegetated site because of the great amount of shelter it provides. In addition, we hypothesis we will find more Centrarchids in the vegetation and a small number in the sandy site. We hypothesize we will see more Percids in the vegetated habitats than in any other area. Finally, we hypothesize Cyprinids will be found mainly in the sandy area and in high abundance.

Materials and Methods

We studied four different sites in Douglas Lake: Big Shoal was our sandy site, west of the UMBS boat-well was our cobble site, Hook Point was our vegetated site, and Grapevine Point was our woody debris site (Fig. 1). Hook Point was a monoculture of water lilies and our minnow traps at Grapevine Point went parallel with a felled trees going perpendicular to the shore.

In order to sample the distribution of fishes at each site we set out five minnow traps (Ton and Magnuson 1985); traps were set 1.5 meters apart. In general, traps were set

perpendicular to the shore, but in the cases of Hook Point and the Boat-well, we set the traps diagonal to the shore to maintain representative habitats.

Traps were set three times for 48 hours each, with the expectation of one 72 hour sampling period for Big Shoal. Fish were counted, identified, and released. When species identification was unsure, we took samples to the lab for identification.

At each trap, we measured water temperature using a thermometer, depth (m) with a meter stick, and substrate and surface cover using 1-meter-by-1-meter quadrat. With this data, we categorized our habitats by woody, sandy, vegetated, or cobbled.

Statistical Analysis

We used the Kruskal-Wallis (K-W) test to determine if mean fish CPUE differed among sites. We used the same test to compare species diversity and richness among sites. Finally, we used hierarchal cluster analysis and dendrograms to analysis the relationships between fishes habitat prevalence and the relationships between the fish species found at each site.

Results

The average CPUE was much higher for Hook Point (the vegetated site), than any other site. The other three habitats were similar, with Big Shoal (cobbles substrate) having slightly higher CPUE than the other two habitats (Fig.2). The K-W statistic for the difference in mean CPUE between habitats was not significant at p-value= .068.

The average species richness was higher for Hook Point than any other site. Grapevine was slightly higher than the Boat-well, and Big Shoal had the lowest species richness with one species (Fig. 3). The K-W statistic for the difference in mean species richness between habitats was not significant at p-value= .155.

The average species diversity per site was the highest at Hook Point, with Grapevine Point slightly higher than the Boat well. Big Shoal was zero for species richness (Fig. 4). The K-W statistic for the difference in mean Shannon-Wiener species diversity between habitats was not significant at p-value= .128.

Crappy, bullhead, largemouth bass, rock bass seem to be found together most frequently. Largemouth bass and pumpkinseeds were related to each other in habitat prevalence. Smallmouth bass seem to be slightly correlated with the other Centrarchids. The greatest difference in habitat prevalence was between bluegill and pumpkinseeds. Yellow perch and bluegill show some similarities in habitat prevalence (Fig.5).

The Boat-well was dominantly coble until the fourth trap where the substrate became dominated by sandy and around 5% cobble. The surface-cover of Grapevine Point was dominated by woody debris with a mostly sandy substrate at all traps. The composition of the substrate Big Shoal was almost entirely dominated by sandy substrate with a few rocks randomly distributed. The surface cover of Hook Point was entirely dominated by water lilies with a silt substrate (Table 2).

The species found at the Boat-well, Grapevine Point, and Big Shoal were the most similar. Hook Point was the most different in terms of community composition (Fig. 6).

The depths of minnow traps at Grapevine Point varied in depth from 20 cm to 48.5 cm. The depths of minnow traps at Big Shoal varied in depth from 27 cm to 35 cm. The depths of minnow traps at the Boat-well varied in depth from 22 cm to 53 cm. The depths of minnow traps at Hook Point varied in depth from 25 cm to 67 cm.

The water and air temperature did not vary a great deal from site to site, but Big Shoal had the highest average temperature (Fig.7).

Discussion

Hook Point was the habitat with the highest fish abundance and diversity. Vegetated areas usually have the highest species diversity because of the amount of prey and shelter they provide. For example, Centrarchids do a great deal of their foraging for food in vegetated areas (Werner et al. 1983). A study of Lawrence Lake in Lower Michigan found Centrarchids above rooted macrophytes in the pelagic zone. In addition, Mark J. Butler (1988) found a strong correlation between bluegill and areas of high vegetation.

Yellow perch was the second most prevalent fish species at Hook Point. This is consistent with Reighgard's 1915 study of Douglas Lake. He found many small perch in the vegetated habitat because of the protection it affords from predation, and Percids feed on the food within the vegetation (Reighgard 1915).

We collected only smallmouth bass at our sandy site. The sandy substrate does not provide a complex shelter, so mostly fish with other traits to avoid predation would be able to live there. The sandy substrate and clear water are well-known habitats for smallmouth bass (Reighard 1915). We would expect Cyprinids to be present at Big Shoal because of the behavior of schooling to escape predation (Reighard 1915). One reason we may not have seen Cyprinids was that smallmouth bass were present, and smallmouth bass feed on Cyprinids (MacRae and Jackson 2001). In addition, there have been reports of seeing young smallmouth bass chasing Cyprinids near the location of our traps in Douglas Lake, and the smallmouth bass we caught were just large enough to feed on young of the year Cyprinids. The lack of Cyprinids in the sandy habitat could mean either piscivorous smallmouth bass are affecting their distribution or our traps were in a patch between populations of Cyprinids.

Grapevine Point contains the second highest diversity because the woody debris is a complex shelter and may create a good refuge from predation. For example, Percids are found in areas of complex structures in the presence of piscivores (Persson and Eklov 1995); this is a mechanism for escaping predation. There are large piscivores in Douglas Lake (Rieghgard 1915).

One possible reason we caught the fewest number of individuals at the Boat-well was the lack of complex shelters. Centrarchids and Percids are found heavily in complex environments when predators are present (Werner and Hall 1979, Persson and Eklov 1995). On the other hand, Reighard (1915) found a great number of young of the year in the sandy and cobbled habitats. In addition, we would expect there to be a high amount of benthic feeders in the cobbled area because of the increased amount of surface for benthic organisms to attaché (Reighard 1915).

One possible reason we did not observe species in habitats we believed they would be prevalent in is the relatively few replications. With more replication and a greater amount of data, we would increase the significance of our test. In other words, there needs to be additional experiments to draw stronger conclusions about the prevalence of species in habitats.

Rock bass, crappy, and largemouth bass are found in many of the same environments because they share many family traits. Reighard (1915) found all three species almost exclusively in vegetated habitats of Douglas Lake. We found one bullhead at Grapevine point, so the appearance of habitat relationships between it and rock bass, crappy, and largemouth bass is anecdotal at best. Reighard (1915) found bullhead to appear not to be abundant in Douglas Lake.

One reason that bluegill and pumpkinseed do not show the same habitat trait is bluegill and pumpkinseed have been found to compete with each other for habitats leading to neither fish living in the same habitat type (Werner and Hall 1979). Either fish in a lake by itself will be

found in vegetation, but with the presence of the other then they both move out of the vegetated area (Werner and Hall 1979).

All of the sites were closely related in species presence except for Hook Point and Big Shoal. Hook Point contains much more diversity, richness, and abundance than any other site because of the amount of vegetation. Vegetated areas provide the most food and shelter for fish species (Werner and Hall 1979). The reason for the difference between Big Shoal and the other two habitats is we caught only smallmouth bass at Big Shoal, but we caught at least four different species at every other habitat.

There is relatively little difference in depths between the sites, so I believe that this factor plays little to no role in the prevalence of species at each site. The temperature at Big Shoal was the highest of all of the sites because of the lack of shade and lack complex shelters.

The vegetated area was home to the greatest species richness and diversity combined with the greatest amount of fish caught because it provides the most complex shelter and a good place for fish to forage for food (Werner and Hall 1979). The woody debris area was the next best place for species diversity and richness because the debris made a great shelter for fish to escape predation. The cobbled habitat was near the bottom in terms of species diversity and richness because the lack of complex shelters. The sandy area was the most open and lacked complex structures, which lead to only one species caught at the site. The only way to provide strong evidence of species prevalence in different habitats is more experiments with more replicates.

Work Cited

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Table 1 Catch statistics per site for data compiled over three sampling periods.

Catch Statistics (Average CPUE)				
	Boatwell	Grapevine	Big Shoal	Hook Point
Bluegill	0.17	0.00	0.00	5.83
Pumpkinseed	0.00	0.00	0.00	1.50
Rock Bass	0.33	0.17	0.00	0.67
Crappie	0.00	0.33	0.00	0.00
Largemouth Bass	0.00	0.33	0.00	0.33
Smallmouth Bass	0.50	0.00	2.17	0.00
Yellow Perch	0.33	0.17	0.00	3.17
Bullhead	0.00	0.17	0.00	0.00

Table 2 A chart of groundcover and surface cover and type over each trap per habitat.

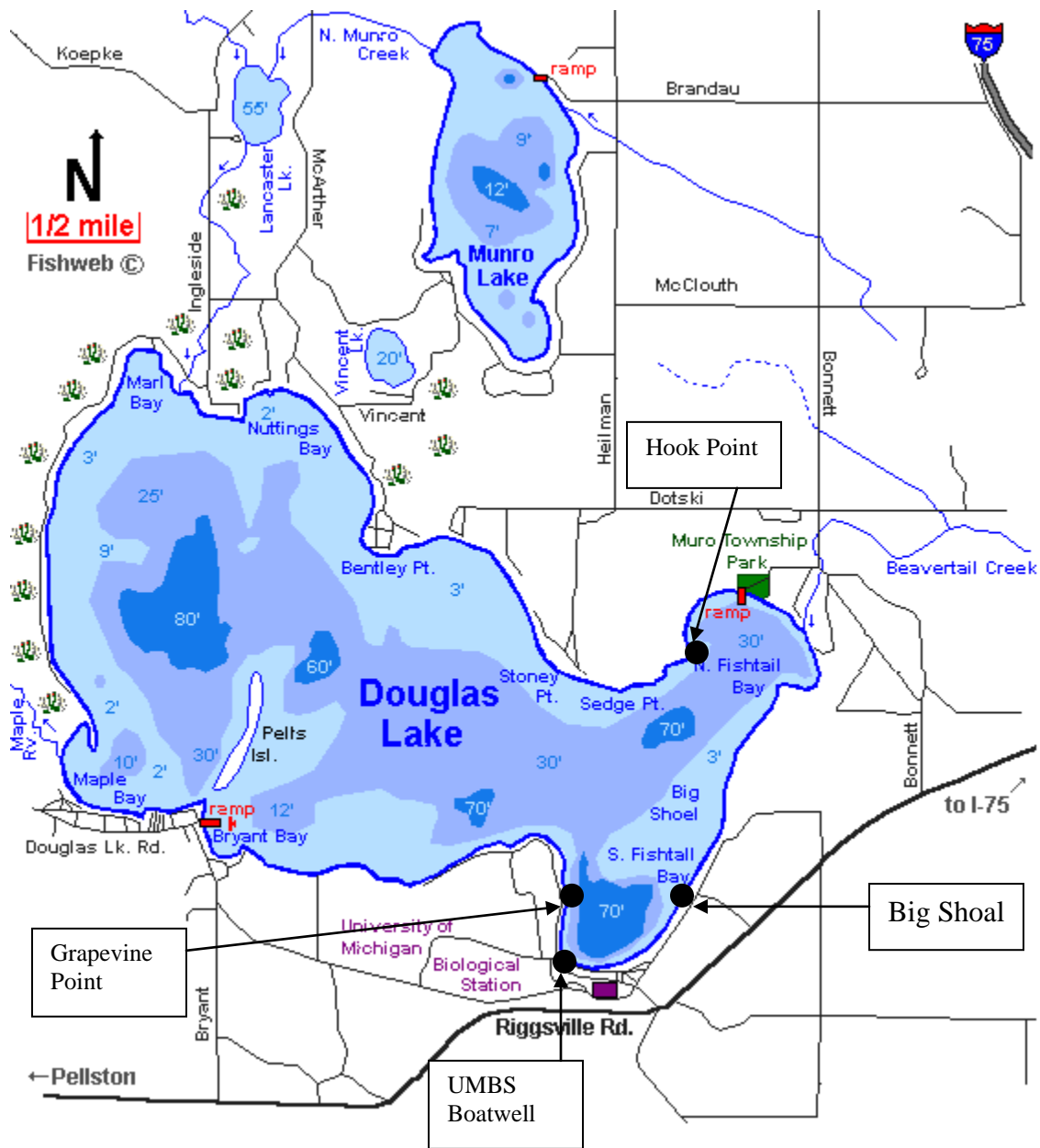| Trap Number	Boatwell (cobble ground cover)	Grapevine	Big Shoal	Hook Point
1	60-70%	50% wood debris, 1% rock, sandy	<1%pebbles/shells and sandy	75% water lily (silt substrate)
2	50-60%	30% woody, 1 % rock, sandy	<1%pebbles/shells and sandy	80-90% water lily (silt substrate)
3	30-40%	50% wood, 5% rock, sandy	<1%pebbles/shells and sandy	60% water lily (silt substrate)
4	5%	30% woody, 1 % rock, sandy	<1%pebbles/shells and sandy	75% water lily (silt substrate)
5	5%	30% woody, no rocks, sandy	<1%pebbles/shells and sandy	75% water lily (silt substrate)

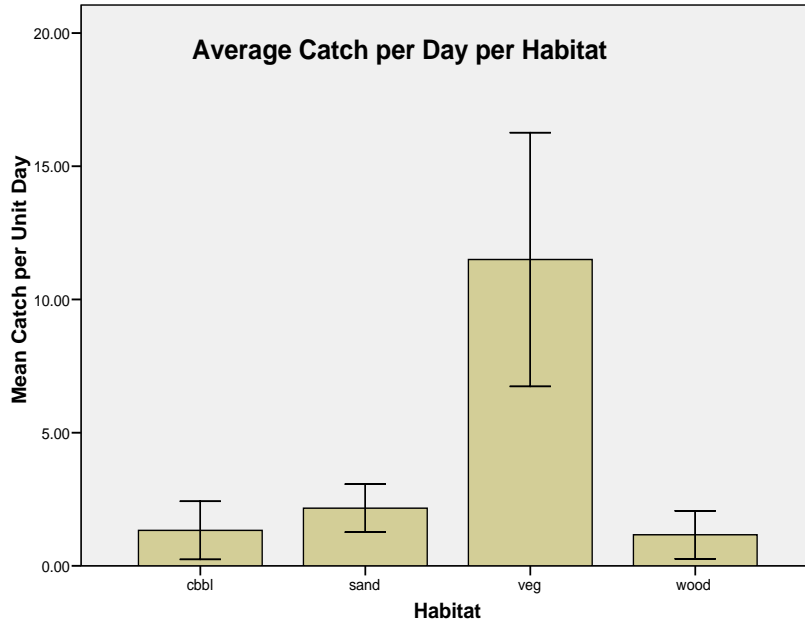**Figure 1:** Map of sampling locations in Douglas Lake.

Figure 2: Average catch per day for each site; data values were average over three sampling periods.

cbbl: Cobble (Boatwell)
sand: Sandy (Big Shoal)
veg: Vegetated (Hook Point)
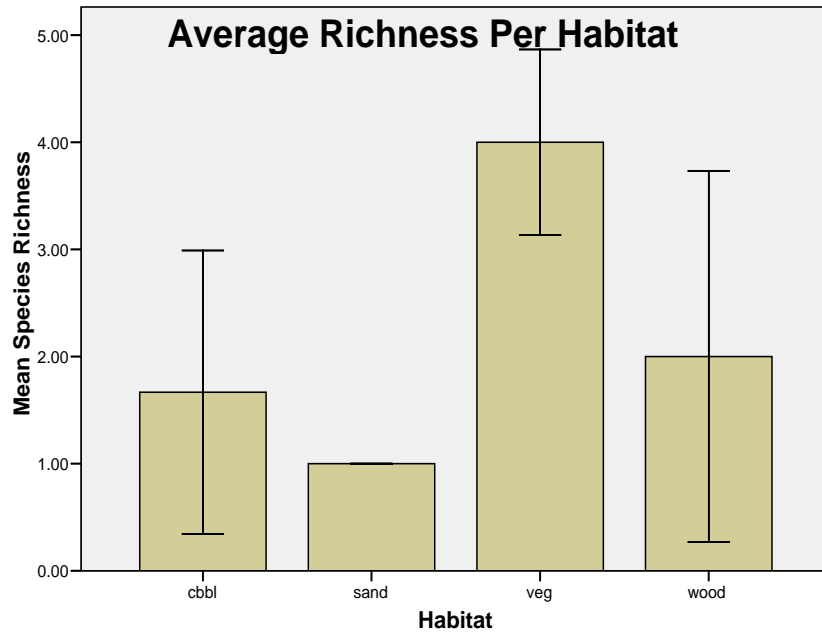wood: Woody Debris (Grapevine)

Figure 3: Average species richness per day for each site; data values were average over three sampling periods with error bars showing two standard errors.
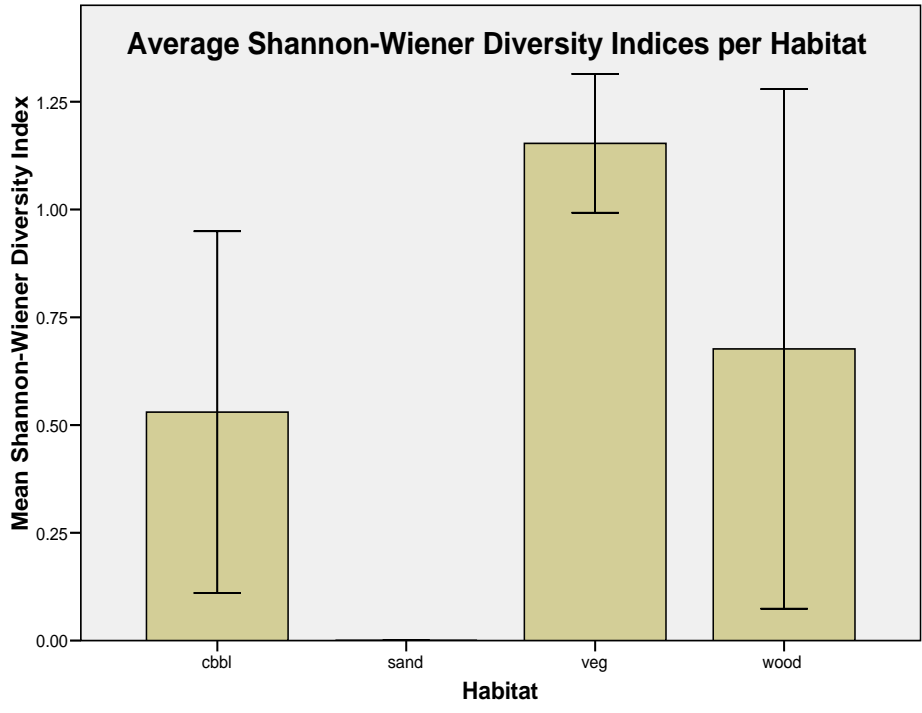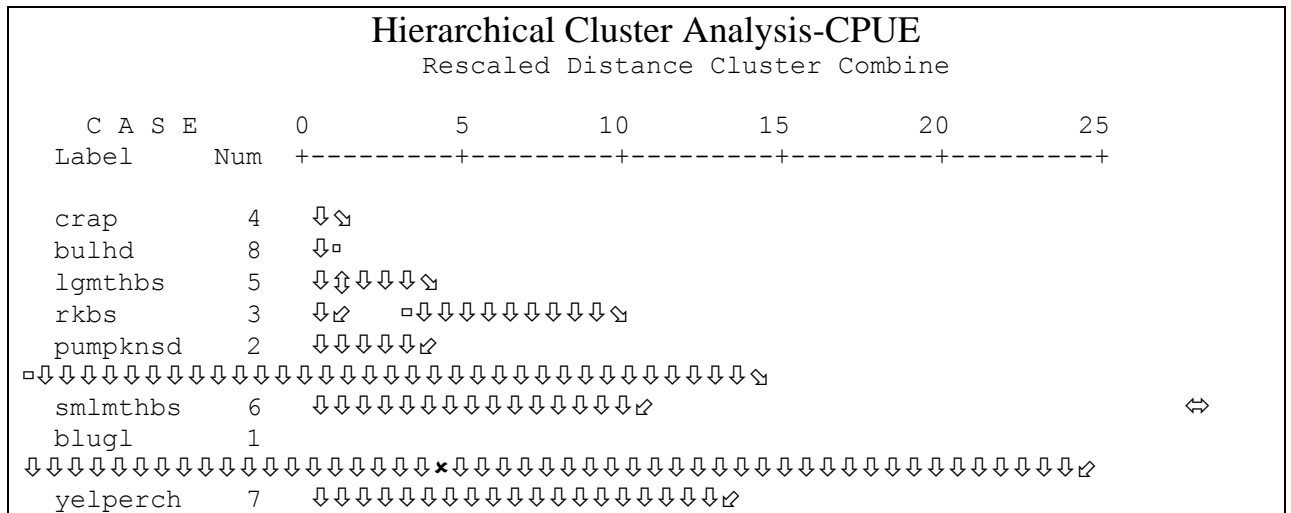
Figure 4: Species diversity was averaged per day for data values were average over three sampling sessions with error bars showing two standard errors.

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                     Hierarchical Cluster Analysis-CPUE
                     Rescaled Distance Cluster Combine

   C A S E        0         5        10        15        20        25
  Label      Num  +---------+---------+---------+---------+---------+

  crap        4   ⇩⇘
  bulhd       8   ⇩▫
  lgmthbs     5   ⇩⇧⇩⇩⇩⇘
  rkbs        3   ⇩⇗   ▫⇩⇩⇩⇩⇩⇩⇩⇩⇘
  pumpknsd    2   ⇩⇩⇩⇩⇩⇗
▫⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇘
  smlmthbs    6   ⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇗                                  ⇔
  blugl       1
⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩✖⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇗
  yelperch    7   ⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇗
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Key:

crap: Crappy	pumpknsd: Pumpkinseed
bulhd: Bullhead	smlmthbs: Smallmouth Bass
lgmthbs: Largemouth Bass	blugl: Bluegill
rkbs: Rockbass	yelperch: Yellow Perch

Figure 5: Dendrogram showing hierarchical cluster analysis of CPUE for each species with error bars showing two standard errors.

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                Hierarchical Cluster Analysis by Site


                       Rescaled Distance Cluster Combine

   C A S E          0         5        10        15        20        25
   Label      Num   +---------+---------+---------+---------+---------+

   Boatwell    1
   Grapevine   2

   Big Shoal   3
   Hook Point  4
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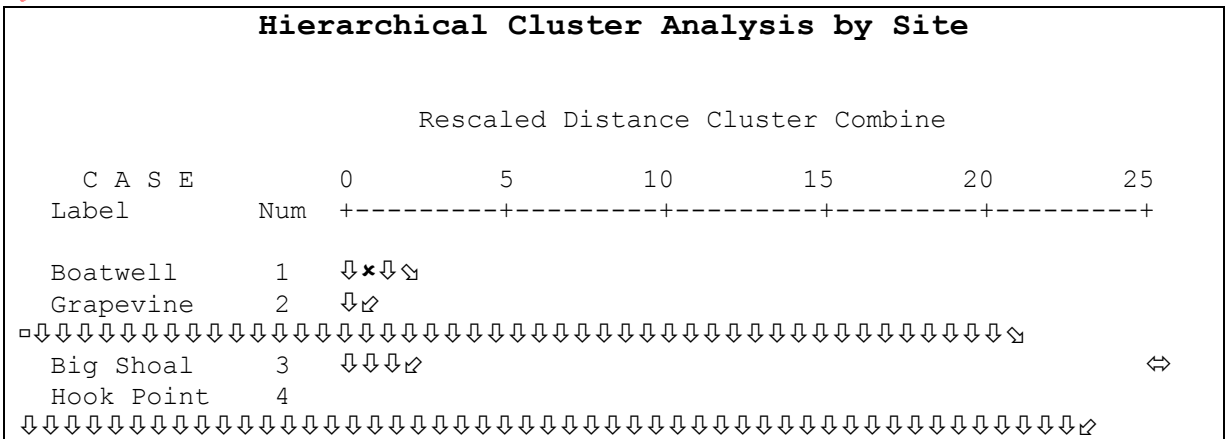
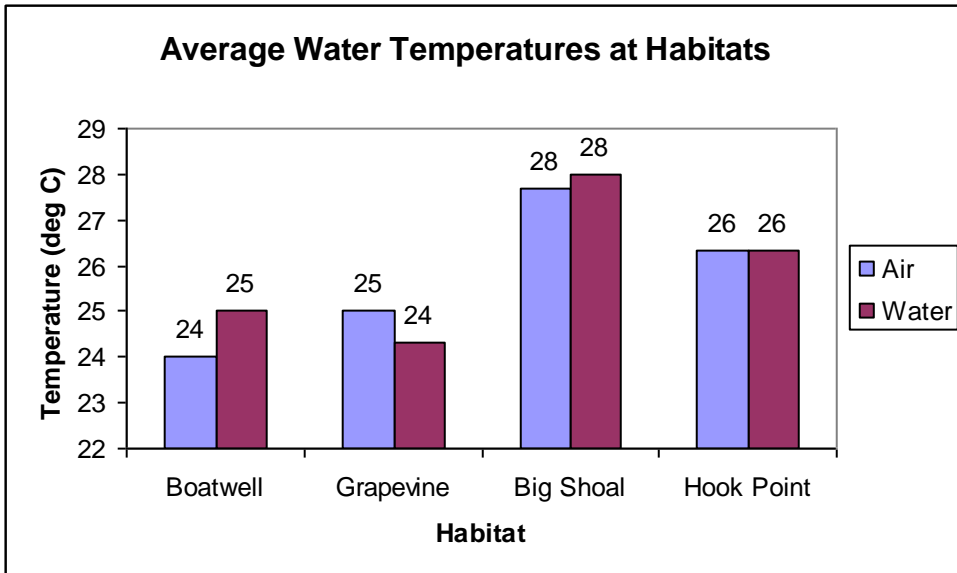**Figure 6:** Dendrogram showing hierarchical habitat cluster analysis by site.

Figure 7: A bar graph of the mean temperatures of air and water at each site.